Attn: Margaret

DEPARTMENT OF GENERAL PLANNING
CITY AND COUNTY OF HONOLULU
650 SOUTH KING STREET
HONOLULU, HAWAII 96813

FRANK F. FASI
MAYOR

BENJAMIN B. LEE
CHIEF PLANNING OFFICER

ROLAND D. LIBBY, JR.
DEPUTY CHIEF PLANNING OFFICER

RECEIVED

'92 MAY 12 P3:52

BS

May 8, 1992

Mr. Brian Choy, Director
Office of Environmental Quality Control
Central Pacific Plaza
220 South King Street, 4th Floor
Honolulu, Hawaii 96813

Dear Mr. Choy:

Acceptance Notice for the Proposed
Ewa Marina Phase I, Increment 2
Final Supplemental Environmental Impact Statement
and Addendum Report

We are notifying you of our acceptance of the Final Supplemental Environmental Impact Statement (SEIS) and Addendum Report for the proposed Ewa Marina Phase I, Increment 2 project. Pursuant to Section 11-200-23(e), Chapter 200, Title 11 ("Environmental Impact Statement Rules") of the Hawaii Administrative Rules, this acceptance notice should be published in the May 23, 1992 OEQC BULLETIN.

We have attached our Acceptance Report of the Final SEIS for the Ewa Marina Phase I, Increment 2 project and the "DOCUMENT FOR PUBLICATION IN THE OEQC BULLETIN." Should you have any questions on the matter, please contact Brian Suzuki of our staff at 527-6073.

Sincerely,

BENJAMIN B. LEE
Chief Planning Officer

BBL:ft

cc: Earl Matsukawa, Wilson Okamoto & Assoc.
Tyrone Kusao
Nelson Lee, Haseko (Ewa), Inc.

Attachments

1992 - Oahu - FEIS - Ewa Marina

FILE COPY

EWA MARINA
Phase I, Increment 2

FINAL SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

Prepared for:

HASEKO (EWA) INC.

Prepared by:

WILSON OKAMOTO & ASSOCIATES, INC.

April 1992

FINAL
SUPPLEMENTAL
ENVIRONMENTAL
IMPACT STATEMENT

EWA MARINA
Phase I, Increment 2

Prepared for:

HASEKO (EWA), INC.

Prepared by:

WILSON OKAMOTO & ASSOCIATES, INC.

April 1992

PREFACE

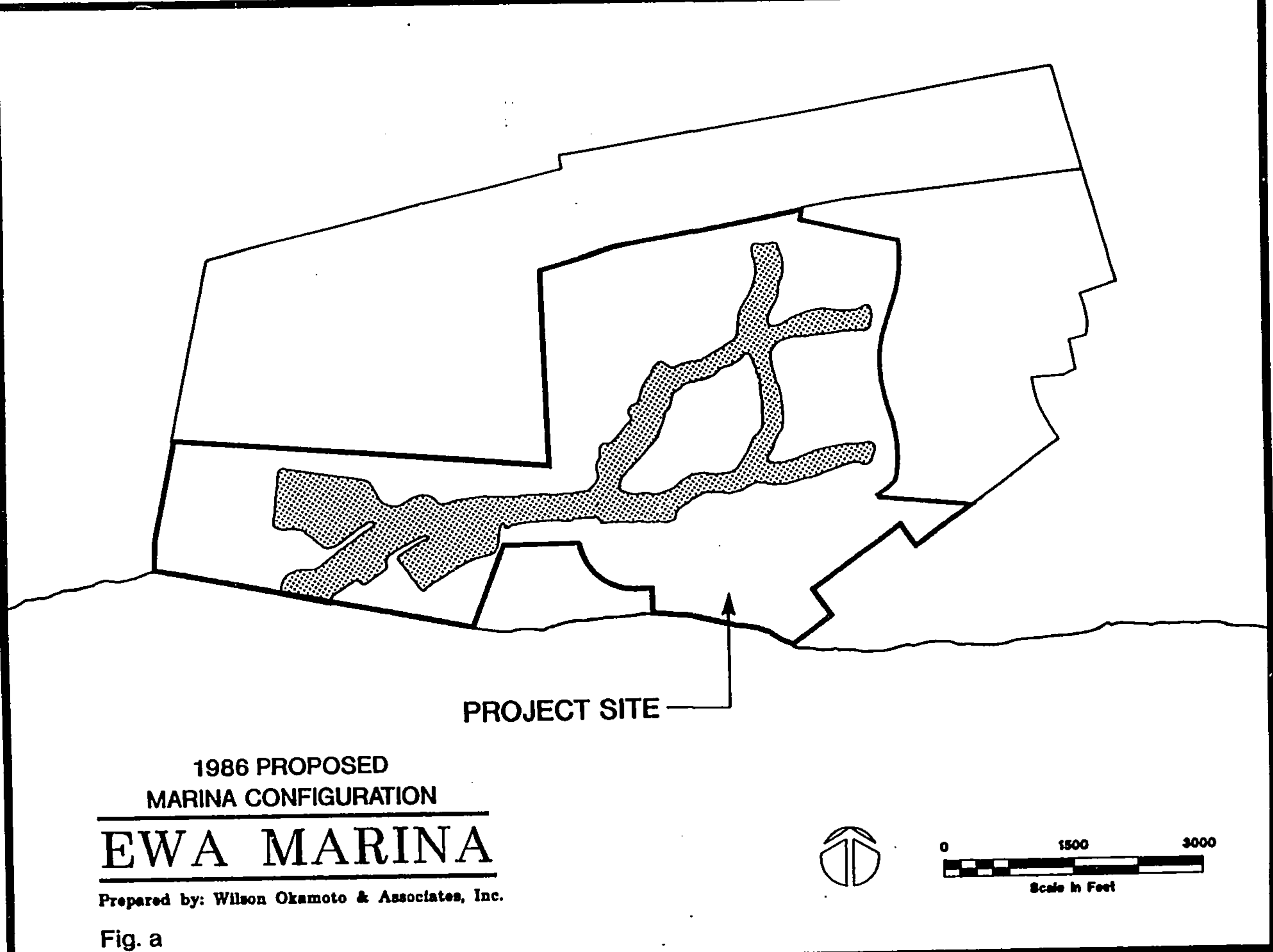
This Final Supplemental Environmental Impact Statement (EIS) is prepared pursuant to Chapter 343, Hawaii Revised Statutes (Environmental Impact Statements) and Title 11, Chapter 200, State of Hawaii Administrative Rules (Environmental Impact Statement Rules). Proposed is an applicant action by Haseko (Ewa), Inc.

This document is required in conjunction with an application for amending the City and County of Honolulu Ewa Development Plan Land Use Map. Thus, the accepting agency is the City and County Department of General Planning. In addition to fulfilling requirements for amending the Development Plan, this EIS will also be submitted in conjunction with applications for a Special Management Area Permit and Shoreline Variance to the City and County Department of Land Utilization and for a Conservation District Use Application to the State Department of Land and Natural Resources.

The various components of the Ewa Marina development have been and are presently being reviewed through an array of land and water use permit and approval processes. Several environmental disclosure documents have been filed in conjunction with the project. The first EIS encompassing the area now known as Ewa Marina Phase I was accepted on February 20, 1981. This "programatic" EIS was accepted subject to the requirement that more detailed supplements to the EIS be prepared for specific increments based on firmer and more detailed development concepts which were not available at the time. The first of these EIS supplements addressed Increment 1 and was accepted on April 16, 1984. Next, a supplemental EIS for Increment 2 was filed and subsequently accepted by the DLU in 1986. This current document supplements the 1986 Final EIS and is required due to some recent project modifications in Increment 2. In general, the projects are similar since both encompass the same project area and propose the same number and types of residential units, overall character of development and major infrastructure.

The primary modification of the project is the reconfiguration of the marina in response to environmental considerations identified through on-going review and discussion with various governmental agencies, particularly the U.S. Army Corps of Engineers (See Figures a and b, and Appendix A). The change in marina configuration, in relation to the configuration proposed and assessed in the 1986 Final EIS, includes the following:

1. The interior channel location adjacent to Oneula Beach Park has been shifted approximately 200 feet north to avoid archaeological remains that the consulting archaeologist has recommended for preservation (See Appendix N).



1986 PROPOSED
MARINA CONFIGURATION

EWA MARINA

Prepared by: Wilson Okamoto & Associates, Inc.

Fig. a

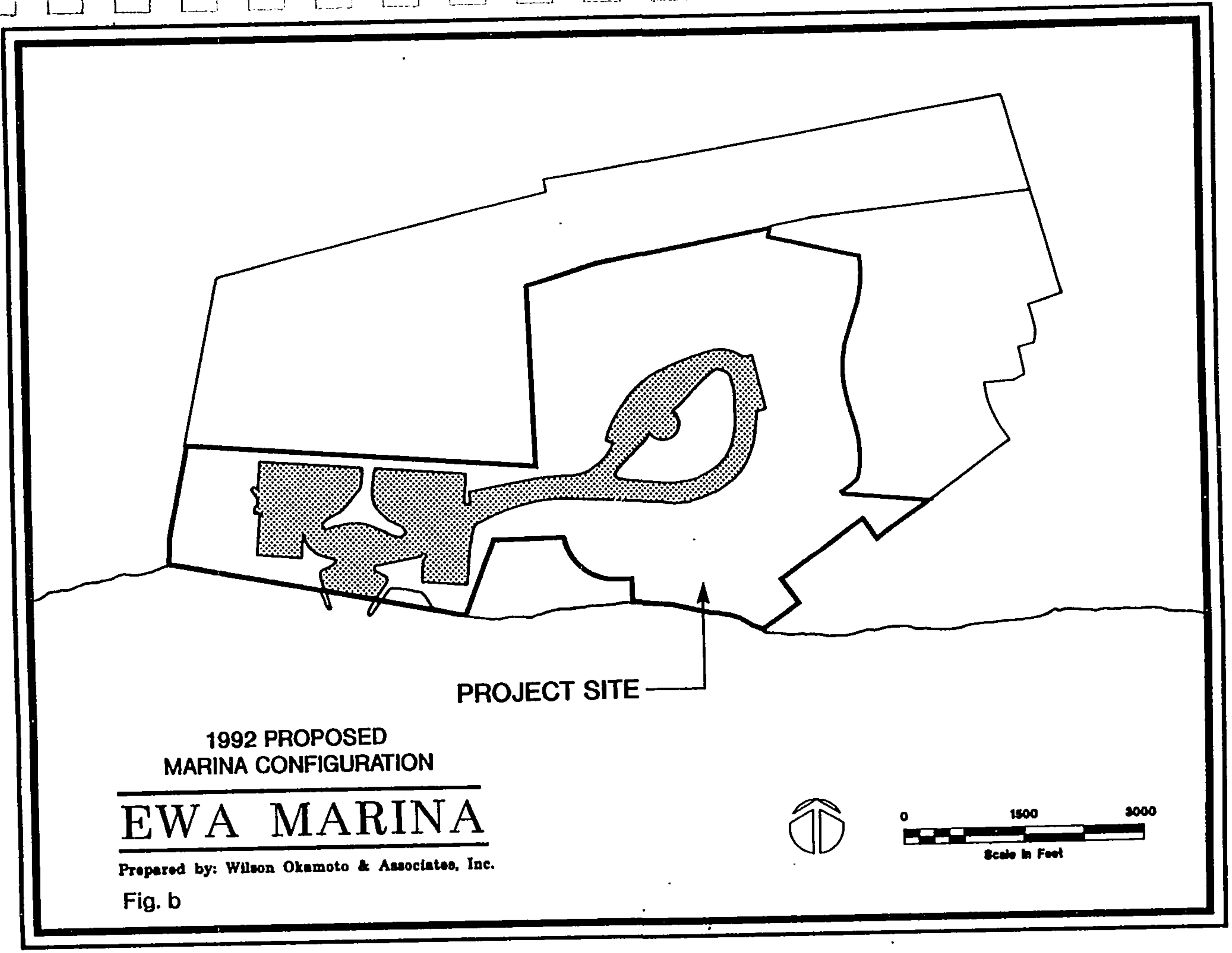

PROJECT SITE
1992 PROPOSED
MARINA CONFIGURATION
EWA MARINA
Prepared by: Wilson Okamoto & Associates, Inc.
0
1500
3000
Scale in Feet

Fig. b

2. The inward extent of the marina has been reduced by eliminating all inland reaching channels from the main basin. This was done to limit project-related effects on the caprock aquifer and to improve water quality (See Appendix B).

3. To eliminate adverse impacts on surf sites, the entrance channel and jetties have been reconfigured. The entrance channel has been shifted approximately 1,000 feet to the west of the entrance on the existing Development Plan Land Use (DPLU) map (see Figure 22) and roughly 500 feet east of the entrance accepted in the 1986 SEIS (see Figure a). The size of the jetties has been reduced (See Appendix L).

4. The internal layout of the marina waterways and basins have been modified to accommodate the above changes, to provide the additional wave attenuation needed as the result of the shorter jetties and to improve water circulation. (See Appendix E).

This Supplemental EIS updates the 1986 EIS by discussing the most recent studies conducted in conjunction with the processing of development permits for the marina. Some of these studies, such as those for traffic, social impact and infrastructure address the cumulative impact of the entire Ewa Marina development which now includes the recent Phase II proposal. Although Phase II was addressed in a separate EIS that was processed and accepted by the City and County Department of General Planning in June, 1991, this document addresses cumulative impacts of the entire development where appropriate.

TABLE OF CONTENTS

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TABLE OF CONTENTS (cont.)

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LIST OF APPENDICES

APPENDIX I	Marine Algae Surveys for the Ewa Marina Coastline, AECOS, Inc., June and September 1991.
APPENDIX J	Potential for Impact of Proposed Ewa Marina, Ewa, Oahu on Seasonally-Resident Humpback Whales, Behavioral Research Consultants, March 1991.
APPENDIX K	Assessment of Sea Turtle Populations in the Vicinity of the Proposed Ewa Marina, Oahu, Hawaii Cumulative Report No. 9, Marine Research Consultants, October 1991.
APPENDIX L	Ewa Marina Evaluation of Project Impacts on Surf Sites, Moffatt & Nichol, Engineers, November 1990.
APPENDIX M	Visual Impact Assessment, Visualizations and Wilson Okamoto and Associates, Inc. January 1992.
APPENDIX N	Archaeological Mitigation Plan, Ewa Marina Community Project - Phase I, Paul H. Rosendahl, Ph.D., Inc., February 1991.
APPENDIX O	Traffic Impact Assessment Report for Ewa Marina Phase I - Increment II and Phase II, Pacific Planning and Engineering, Inc., October 1991.
APPENDIX P	Ewa Marina Social Impact Assessment, Earthplan, January 1992.

LIST OF FIGURES

LIST OF TABLES

GLOSSARY OF ACRONYMS

ACHP	Advisory Council on Historic Preservation
AE	Reference to Flood Insurance Rate Map (Level of Hazard Significance)
ALISH	Agricultural Lands of Importance to the State of Hawaii
APZ	Accident Potential Zone
BWS	Honolulu Board of Water Supply (City and County of Honolulu)
CDUA	Conservation District Use Application
cfs	cubic feet per second
CZM	Coastal Zone Management Program (State of Hawaii)
DGP	Department of General Planning (City and County of Honolulu)
DLNR	Department of Land and Natural Resources (State of Hawaii)
DLU	Department of Land Utilization (City and County of Honolulu)
DOH	Department of Health (State of Hawaii)
DOT	Department of Transportation (State of Hawaii)
DP	Development Plan (City and County of Honolulu)
DPLU	Development Plan Land Use Map (City and County of Honolulu)
DPPF	Development Plan Public Facilities Map (City and County of Honolulu)
DPW	Department of Public Works (City and County of Honolulu)
DTS	Department of Transportation Services (City and County of Honolulu)
EA	Environmental Assessment
EIS	Environmental Impact Statement

GLOSSARY OF ACRONYMS

EPA	Environmental Protection Agency (United States)
EPWDC	Ewa Plain Water Development Corporation
FIRM	Flood Insurance Rate Map
FTE	Full-Time Equivalent (Employment)
HECO	Hawaiian Electric Company
HIA	Honolulu International Airport
IPP	Iroquois Point Puuloa Military Housing
Ldn	Measure of Average Day-Night Noise Levels
LOS	Levels of Service (qualitative measure describing operational conditions at unsignalized intersections)
LSB	Land Study Bureau
LUO	Land Use Ordinance
mgd	million gallons per day
mllw	mean lower low water level
MOA	Memorandum of Agreement
NASBP	Naval Air Station Barbers Point
NMFS	National Marine Fisheries Service (United States)
NPDES	National Pollutant Discharge Elimination System
NRHP	National Register of Historic Places
OCRI	Oahu Coral Reef Inventory (U.S. Army Corps of Engineers)
OHA	Office of Hawaiian Affairs (State of Hawaii)
OSCo	Oahu Sugar Company

OSP	Office of State Planning (State of Hawaii)
SHPO	State Historic Preservation Office (State of Hawaii)
SMA	Special Management Area
SSV	Shoreline Setback Variance
TMK	Tax Map Key
USFWS	United States Fisheries and Wildlife Service

Chapter I

Background Information

I. BACKGROUND INFORMATION

A. Location and Ownership

The proposed Ewa Marina development is located at Honouliuli in the Ewa District of Oahu. It lies along the shoreline between the Ewa Beach community and the Naval Air Station Barbers Point (NASBP), about 20 miles west of Honolulu (See Figure 1). This area is located within Tax Map Key (TMK) plats 9-1-11 (parcels 1 through 7) and 9-1-12 (parcels 2, 3, por. 5, por. 6, por. 7, 8 through 17, and por. 23) (See Figure 2). The Ewa Marina development consists of two major components, hereinafter referred to as Phase I and Phase II (See Figure 2). The term "Phase" does not refer to development phasing but originates from the status of land use approvals being sought.

Phase I, comprising the southern portion of the development, consists of Increments 1 and 2. The proposed project (hereafter referred to as the Project) assessed in this EIS lies within Increment 2 (hereafter also referred to as the Project Area or Property). For permitting purposes, the increment designation indicates the different stage of land use approval each property is at. Increment 1 contains primarily residential uses, does not involve marina construction, and lies outside the Special Management Area; all the approvals needed to develop this area were obtained in the early 1980's. Because of this, it is not included in the current application, and this document discusses it only so far as it is necessary to gain an understanding of the Increment 2 area. The use of the term "increment" stems from the original intention to develop the project in phases, with the area requiring the least infrastructure development and environmental and land use permitting proceeding first. The development approach of Haseko (Ewa), Inc. (a fully owned subsidiary of Haseko (Hawaii), Inc. and hereafter referred to as the Applicant), calls for the coordinated development of the entire Ewa Marina project without regard to the phases or increments. Because of this, construction will not be initiated until approvals have been granted for the entire development.

All land within the Property is owned by the Applicant which acquired it from the Estate of James Campbell in 1989. The northern half of the Property presently is leased to Oahu Sugar Company (OSCo) for sugar cultivation, while the southeastern portion is occupied by the Applicant's on-site property caretaker and two private camping sites. The remainder of the Property is undeveloped. Portions of the Property, particularly along Papipi Road and the area around the City and County of Honolulu Oneula Beach Park, are used as an unauthorized dumping ground for abandoned vehicles and trash. The shoreline fronting the Property is accessible by the public from Oneula Beach Park and offers opportunities for alongshore hiking, fishing, and beachcombing, and for accessing surf sites offshore. Access to Oneula Beach Park, which is completely surrounded by the Applicant's property, is via an access easement.

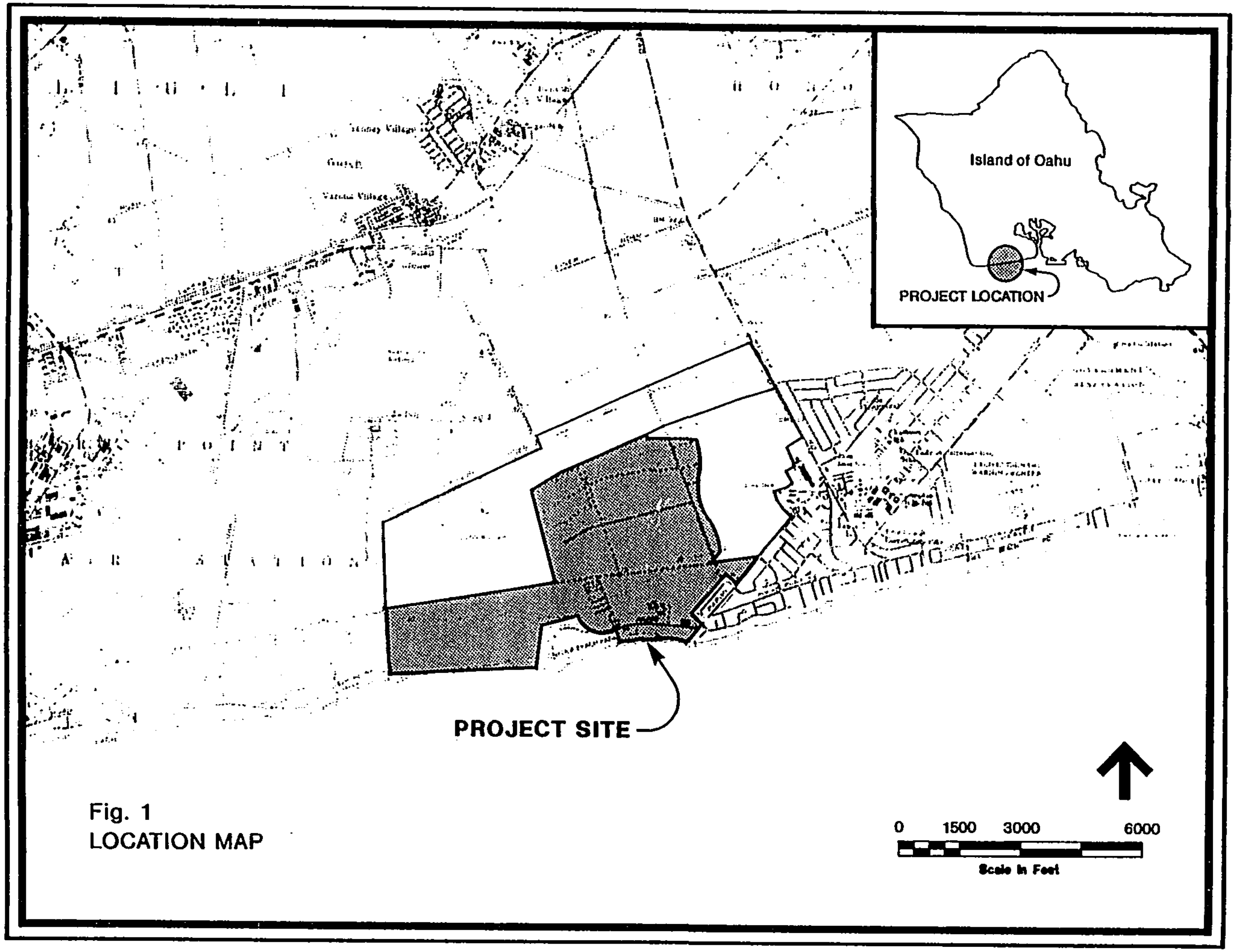
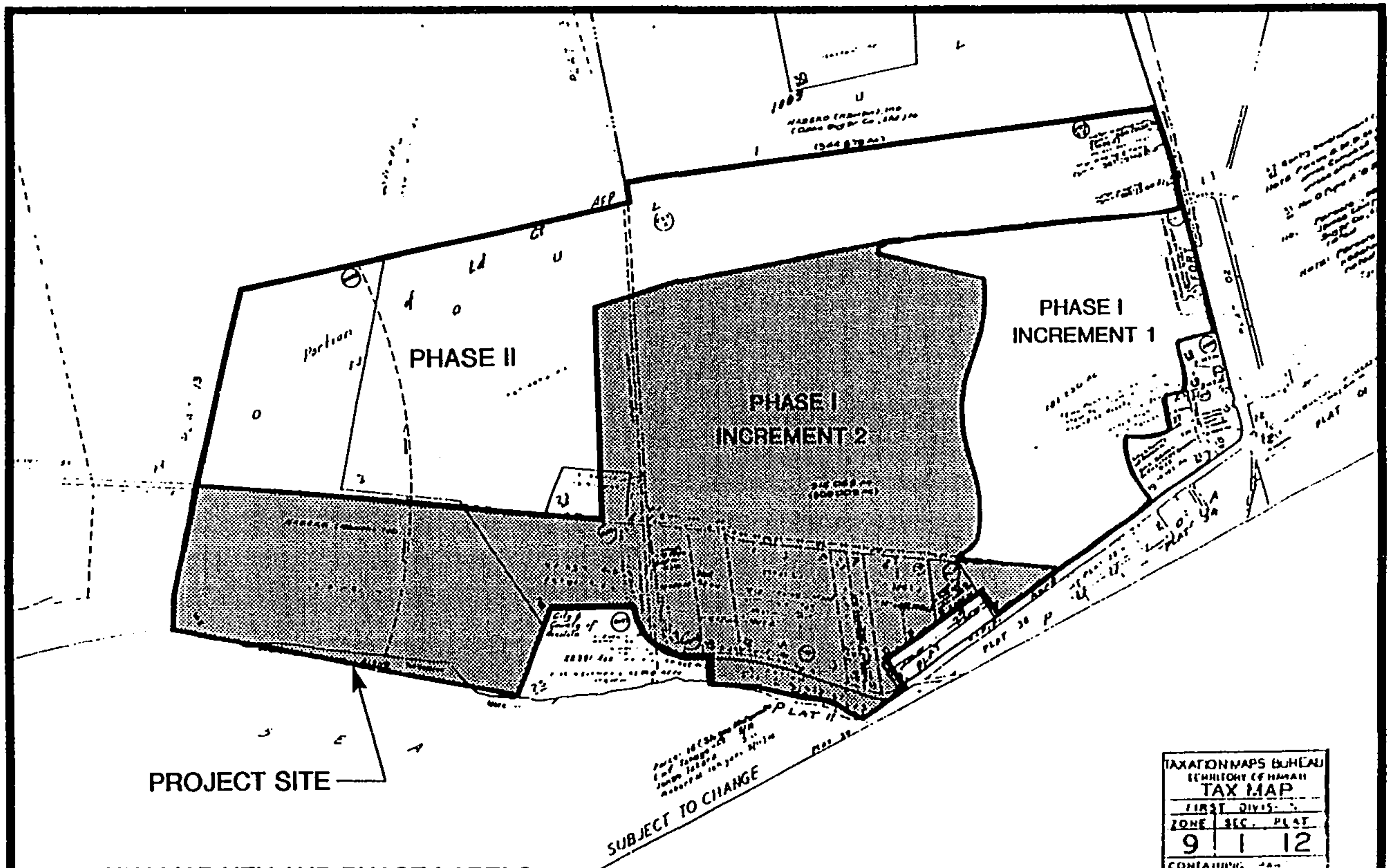


Fig. 1
LOCATION MAP



TAX MAP KEY AND PHASE LABELS

EWA MARINA

Prepared by: Wilson Okamoto & Associates, Inc.

Fig. 2

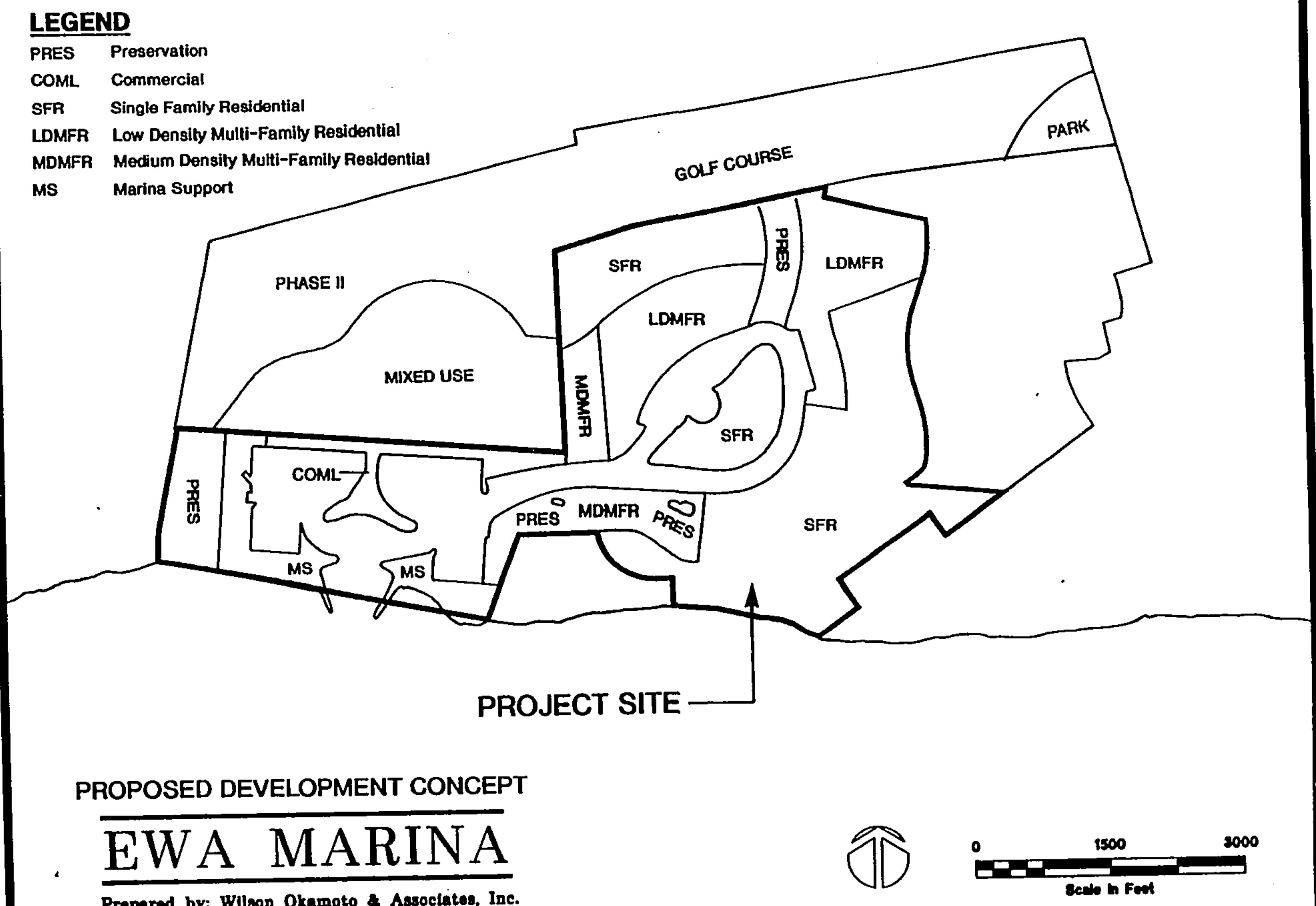
B. Project Need

The entire Ewa Marina development (Phases I and II) will encompass approximately 1,110 acres. It is a recreation-oriented development featuring a marina and golf course, with residential, commercial and marina-support areas, as well as a mixed-used complex including visitor accommodations. Phase I, Increment 1 consists of approximately 172 acres which is presently zoned mostly for residential use and will be developed in a manner consistent with that zoning. Increment 2, the Property, is comprised of approximately 535 acres within which the marina, residential, and commercial uses are proposed.

An application to amend the City and County of Honolulu Ewa Development Plan Land Use (DPLU) Map has been filed with the Department of General Planning (DGP) for Increment 2. If approved, the Property will then need to be rezoned to accommodate these uses. Portions of the Property also lie in the City and County of Honolulu Special Management Area (SMA) and will require an SMA Use Permit. Improvements at the marina mouth will require a shoreline setback variance and construction of the channel entrance will additionally require various Federal and State permits.

Phase II, which was assessed in a separate environmental impact statement (EIS) accepted by the DGP in June, 1991, includes a 27-hole golf course (approximately 272 acres) and a mixed use area (approximately 114 acres). A clubhouse, including a 19-court tennis facility, is planned in conjunction with the golf course. The mixed-use complex will complement the marina, providing goods and services related to boating and water sports activities. Other facilities being proposed are intended as enhancements which would focus on the transportation and recreational qualities of the marina. Specific facilities include an International Health and Fitness Promotion Center, 1,500 units in hotels and garden suites, an exhibition area and conference facilities. The mixed-use complex is supported in a City and County General Plan Amendment adopted in December, 1991. The amendment encourages the development of a major marina and associated maritime commercial center, including visitor units. The Honolulu City Council soon thereafter amended the Development Plan to allow development of the maritime commercial center, but placed a 950-room ceiling on the number of hotel rooms allowable in the area. (This document is based on the analyses and technical studies that assumed 1,500 units would be developed in the area. The reduced unit count would lessen potentially adverse environmental and social impacts assessed in this document to some degree. Potentially beneficial economic impacts would also be reduced in such areas as jobs created in the short and long terms and potential tax revenues.)

Ewa Marina Phase I (including Increments 1 and 2) is proposed to be a marina-oriented residential community with a marina/waterway component, a marina/commercial component and a residential component (See Figure 3). Also proposed is a circulation



PROPOSED DEVELOPMENT CONCEPT

EWA MARINA

Prepared by: Wilson Okamoto & Associates, Inc.

Fig. 3

system which includes a series of parks and open spaces interconnected by pedestrian ways, as well as a vehicular roadway system. The need for Ewa Marina Phase I is summarized below, by its components:

1. Marina and Waterway Component

The proposed marina will serve several important needs, including providing much demanded public boating berths, opportunities for recreational boating and flood control for the Kaloi Gulch drainage basin.

The need for boat berthings in the State has been examined by the Harbors Division of the State of Hawaii Department of Transportation (DOT) in a report entitled Statewide Planning for Marina Facilities. The report demonstrates a large unfulfilled demand for berths with a waiting list extending back at least a decade (See Table 1). On the south shore of Oahu, demand for berths has exceeded the supply by the greatest amount. (See Table 2). A portion of the berthing spaces in Ewa Marina, primarily those closest to the residential areas of the eastern end of the proposed marina, would be offered first to residents within the development.

TABLE 1
STATE TRENDS: STATE FACILITIES

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Total Berths	1,088	1,088	1,254	1,215	1,215	1,228	1,268	1,365	1,365	1,393
Filled Berths	1,037	1,048	1,124	1,084	1,077	1,067	1,141	1,232	1,194	1,195
Total Moorings	951	930	812	774	807	770	687	700	663	625
Filled Moorings	754	766	685	642	638	654	601	591	565	516
Waiting List	1,656	1,795	1,764	1,562	1,523	1,524	1,683	1,807	2,095	1,939
Temp. Permits	197	164	357	303	515	538	471	455	417	472

Source: DOT/H Records, June 30, 1979 through June 30, 1988
Revised: 9/27/91, Eugene P. Dashiell, AICP, Planning Services, Honolulu

TABLE 2
WAITING LISTS FOR STATE MARINAS ON OAHU: 1991

	State Marinas					Oahu Total
	Ala Wai	Haleiwa	Heeia Kea	Keehi	Waianae	
Total Berths	699	64	22	355	146	1,286
Total Moorings	62	14	53	52	1	182
Waiting List	2,026	39	53	239	3	2,360
Project Moorage	0	0	0	360	0	360
Projected Berthing Increase Due to Federal or State Projects	0	0	0	0	0	0

Source: State Department of Transportation, Harbors Division, Small Craft Mooring Facilities, Utilization Report. Quarter ending June 30, 1991.

The public boat launching ramps in the public marina support area will provide significant ocean access opportunities since the nearest public ramps are currently at Pokai Bay to the west and Keehi Lagoon towards Honolulu. Public ramps are planned at the nearby Ko Olina Marina. Enhanced boating access to fishing resources as a result of marina development will also address recreational and commercial fishing demands.

The Ewa Marina Development will serve as a settling basin for storm water runoff from the Ewa Plain. At the seaward terminus of the Kaloi Gulch drainage basin, the golf course in Phase II and, secondarily, the marina in Phase I will act as large detention basins, buffering the impact of stormwater flowing into the ocean, providing flood control and reducing offshore siltation. For this function to be effective, however, developers of land mauka of the Property must provide for flood and silt control on their own property and provide any necessary drainage improvements in Kaloi Gulch.

2. Marina/Commercial Component

The Project will establish a major marina-related industry in the Ewa area, stimulating investments and creating new employment opportunities. The 120-acre marina, with its approximately 1,400 boat slips, will create a demand for businesses engaged in boat maintenance and repair, the sale of boats and other marine equipment and businesses offering instruction and services relating to various watersports activities. Further, the marina will also attract services such as restaurants and retail shops which could benefit from the atmosphere and activity centered on the marina. The marina will also be large enough to facilitate staging of major boating events which cannot easily be accommodated by existing facilities in Hawaii.

3. Residential Component

The residential component of the Ewa Marina development, including Increments 1 and 2, will be a planned residential community which will serve the housing needs of a wide variety of income groups from the upper end of the market to low-moderate income housing which must comprise a minimum of 10% of units, according to conditions of the State Land Use District Boundary Amendment for Phase I and as required by the zoning approval for Increment 1. The housing component will also provide a larger residential base for expanded and improved community facilities and programs related to parks and recreation, public transportation, commercial activity, education, and professional services. Nearby communities, including the existing Ewa Beach community, will benefit from the expansion and improvements of these facilities and programs.

Given the continuation of strong demand for housing on Oahu, the growing level of urbanization within the Ewa District, the historical performances of other major development programs, and the relative lack of similar amenity-oriented development, the Project can fulfill a significant portion of residential demand over its development period.

4. Circulation Component

The pedestrian circulation system will be comprised of a series of parks around the marina linked by pedestrian ways. The existing Oneula Beach Park and all existing ocean shoreline frontage will also be accessible by the public, as will commercial esplanades and public marina-support facilities such as automobile and boat trailer parking, "dry" boat storage and launch ramp areas. This will provide new opportunities for highly demanded shoreline recreation in an area where such recreation has been limited due to inadequate access and supporting infrastructure as well as vandalism and lack of maintenance. The pedestrian ways will provide opportunities for highly demanded recreational walking, jogging and bicycling as well as passive enjoyment of scenic settings to be created by the marina.

C. Intended Market

The intended market for the marina will be the general public as well as residents of the Ewa Marina community. The marina commercial component will appeal to marina-related retail and service industries. Other retail outlets, including shops and restaurants, would benefit from the atmosphere of a well-designed marina facility. The residential component would target a broad range of the housing market.

Chapter II

Project Description

II. PROJECT DESCRIPTION

A. Development Concept

The Proposed Development Concept for the Property is illustrated in Figure 3. The residential unit count for Phase I will total 4,850, of which approximately 3,560 are planned within the Property (Increment 2), and will be distributed among the "Single Family Residential," "Low Density Multi-Family Residential," and "Medium Density Multi-Family Residential" uses. The publicly-accessible "Marina-Support" areas are proposed to support the approximately 1,400 boat slips in the marina in conjunction with "Commercial" uses.

1. Marina and Waterway Component

Approximately 1,400 boat slips will be developed in the berthing areas within the 120-acre marina. Boat launching facilities will be available to the general public in the marina-support areas, most likely on the western side of the entrance channel. A landscaped walkway in the multi-family residential areas, and an esplanade through the marina/commercial component will provide pedestrian/ bicycle access around the marina. This access will be primarily along the water's edge except where uses requiring direct access to the water. Such uses may include, but are not limited to, a ferry terminal, dry-stack storage facilities, boat launching ramps, sewage pump-out facilities, fueling docks, commercial fishing facilities and marina-fronting single-family residences.

2. Marina Support/Commercial Component

The marina support/commercial component includes uses which complement and support marina uses. In the area opposite the marina entrance channel, a variety of retail, office, restaurant and community service uses integrated by a pedestrian esplanade will focus on the marina. Other commercial pockets along the marina will also be pedestrian-oriented, focusing on the marina. Uses in the "Marina-Support" area will include publicly accessible marina accessories and marina-related uses such as a fuel dock, sewage pump out station, dry boat storage facilities, boat launching ramps, trailer parking, canoe storage and launching areas, boat maintenance areas, charter fishing, diving and sailing outlets, as well as waterfront parks, general public accessways along the marina's edge, a yacht club facility, restaurant, snack, beverage and ice retailers, and a commercial boating facility. Additionally, the potential for an intra-island commuter ferry terminal incorporated as part of the public support system has been discussed with the State Department of Transportation.

3. Residential Component

The residential component will be a marina-oriented community with a mixture of single family residential and low and medium density multi-family structures. Ewa Marina Phase I will contain 4,850 residential units, which is the same number proposed in the original development concept assessed in the EIS accepted by the City and County Department of Land Utilization in 1986. Of these 4,850 units, the Property (Increment 2) will contain approximately 3,560 units.

4. Circulation System

The circulation system includes both a vehicular and pedestrian circulation system. The pedestrian circulation system will be comprised of a series of parks along the marina linked by pedestrian ways. This system will provide public access to marina neighborhood parks along the water's edge, and link up with the City park to be provided by the developer at Fort Weaver Road and public access to and along the shoreline. The existing Oneula Beach Park and all existing shoreline frontage will be accessible by the public, as will commercial esplanades and "Marina-Support" areas adjacent to the marina. The publicly accessible "Marina-Support" areas will offer parking and access to the shoreline on both sides of the entrance channel. On the west side of the channel, lateral shoreline access will extend to the Naval Air Station Barbers Point (NASBP) property, and roadways will allow vehicular access to public parking near the shoreline. On the east side of the channel, public access will be available in the "Marina-Support" area through Oneula Beach Park. To the east of Oneula Beach Park lateral public access will be available from the park along the shoreline fronting residential ocean-front lots. Public shoreline accessways will also be provided through this residential area from the public road serving these residences as well as one from the terminus of Papipi Road. The distance between the shoreline accessways beginning at Oneula Beach Park would be less than the one-fourth mile interval used by the City and County of Honolulu Department of Parks and Recreation (DPR) as a policy guide for the provision of shoreline accessways in urban areas.

5. Preservation

Several areas have been designated for "Preservation" on the proposed land use map. These include the 6.2-acre *Batis* wetland at the western extreme of the Property, three archaeological sites along the waterway, and the flood channel at the head of the marina. The *Batis* wetland area will be preserved "as is" within a 22-acre preservation area. Public access will not be encouraged and some portions along the adjoining "Marina Support" area may be fenced to discourage public access. The shoreline fronting the wetland area, however, will provide alongshore public pedestrian access up to the NASBP property. Additional controls on public access into the wetland may be implemented, as deemed necessary.

The three archaeological sites in two areas along the makai edge of the waterway north of Oneula Beach Park will be generally accessible to the public. Landscaping and an interpretive program yet to be formulated in conjunction with several Federal and State agencies is intended to protect the sites as well as offer opportunities for public awareness and appreciation.

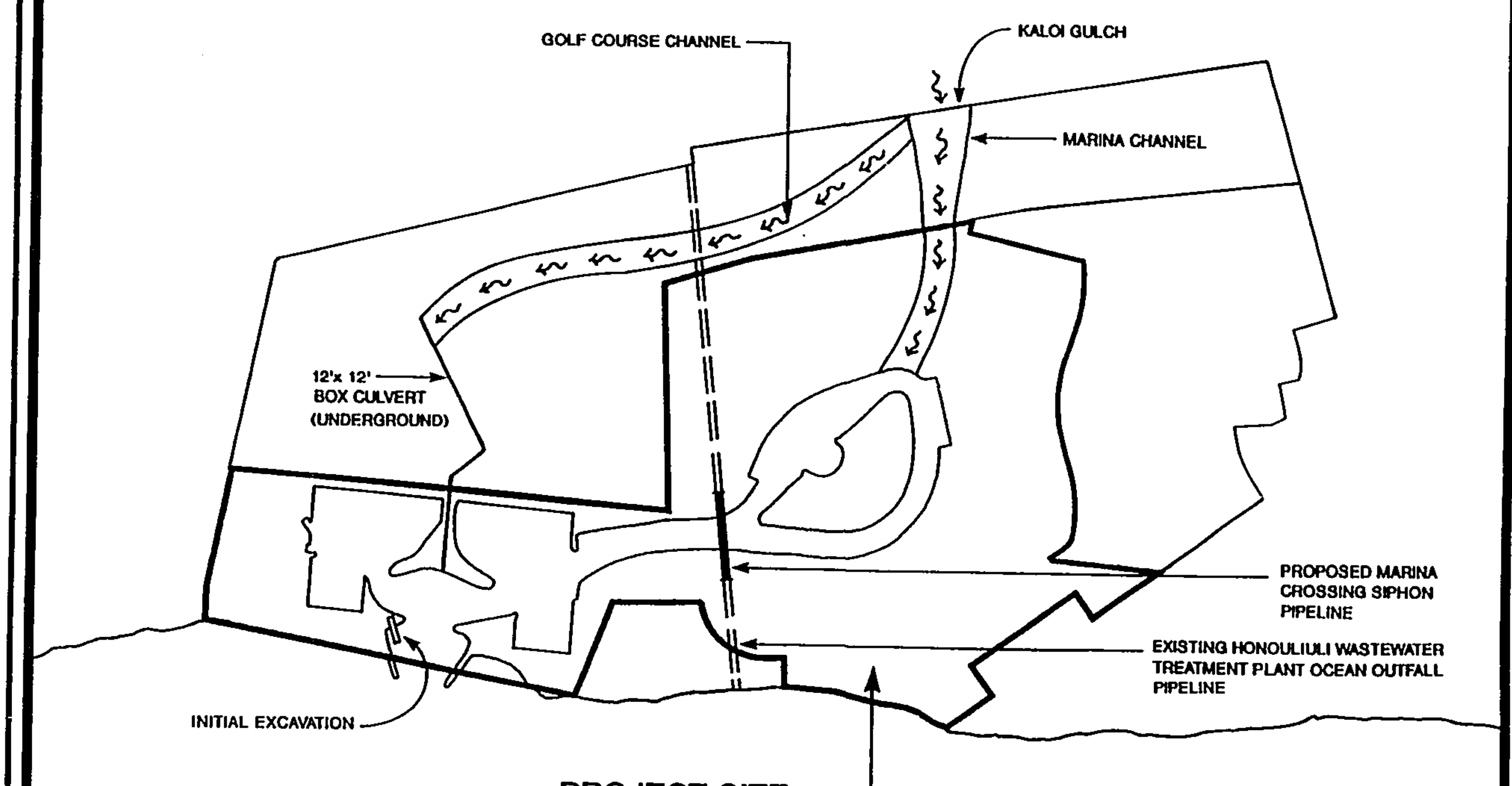
The flood channel at the head of the marina will serve as a retention basin and overflow channel for stormwater runoff from mauka lands. The channel is integral to a storm drainage system which also includes the golf course in Phase II of the project.

6. Mitigation Features

The development concept also includes several important features intended to mitigate the anticipated impacts of the development:

* The ocean outfall pipe from the Honouliuli Wastewater Treatment passes through the Property and enters the ocean at the eastern side of Oneula Beach Park. (See Figure 4) The outfall line carries sewage effluent that has received primary treatment at the plant and discharges it approximately two miles offshore. Although the outfall pipeline lies below ground, its depth is less than the planned depth of the marina. Therefore, the Applicant proposes to lower the line to achieve the design depth using a new siphon in that segment of line.

* The initial phase of construction will consist of the construction of a short segment of the internal waterways and entrance channel, as well as the adjoining portion of the western jetty. As shown in Figure 4, the excavation will be approximately 30 feet wide and will extend approximately 200 feet inland and 100 feet seaward of the existing shoreline. Monitoring wells will be installed on either side of the excavation both inland and offshore on the jetty. Data from these monitoring wells will indicate the extent to which the existing hydrologic barrier effect reasserts itself. If the data indicate a need for artificial measures to supplement the natural hydrologic barrier effect, a determination will be made during this



MITIGATION FEATURES

EWA MARINA

Prepared by: Wilson Okamoto & Associates, Inc.

Fig. 4

initial phase as to the effectiveness and cost efficiency of various ground water management techniques (e.g., salt water injection along the inland perimeter of the marina) and structural measures (e.g., grouting, sheet piling, etc.). Prior to full-scale construction of the marina, a comprehensive mitigation plan will be developed in cooperation with the Commission on Water Resources Management to comply with performance standards established by it.

* The Applicant proposes to construct an artificial reef as mitigation for unavoidable impacts on the aquatic environment associated with construction of the marina entrance channel and jetties. The artificial reef is intended to provide replacement habitat for fish and marine organisms.

  Although the existing habitat has little bathymetric relief which results in relatively low fish diversity and abundance, the objective is to satisfy the "no net habitat loss" policy of the National Marine Fisheries Service (NMFS). The location and composition of the artificial reef has yet to be determined in conjunction with NMFS, the State Department of Land and Natural Resources (DLNR), and the U.S. Army Corps of Engineers.

* The Applicant proposes to implement a drainage plan intended to accommodate storm runoff from lands mauka of the Property. Technically, this is not a mitigation measure since the anticipated increase in runoff will result from the development of those lands, as opposed to the Property. It will, however, reduce offshore siltation and provide flood control.

  The volume of discharge received on the Property through Kaloi Gulch could range from the estimated 550 cubic feet per second (cfs) currently received to as much as 10,000 cfs when lands mauka of Ewa Marina are developed, according to the City and County of Honolulu's design standards for a 100-year storm event. A preliminary concept plan is to divert the initial 2,200 cfs of flow westward through the Phase II golf course into the marina near its mouth (See Figure 4). Retention basins in the golf course would allow runoff to percolate into the ground and silt to settle out before the flows enter the marina. The discharge point near the marina mouth is deeper and has better circulation and mixing than interior portions of the marina and is, thus, better suited to accommodate such discharges. Flows greater than 2,200 cfs would enter a retention basin mauka of the head of the marina and then into the marina. The marina itself will function as a retention basin during larger storms. For this plan to be effective, however, developers of land mauka of the Property must provide for flood and silt control on their own property and provide any necessary drainage improvements in Kaloi Gulch.

B. Construction Requirements

The marina basin includes the approximately 120 acre submerged portion which will lie below sea level as well as emergent lands along the edge of the marina which will be lowered to a few feet above sea level. The material excavated from the marina basin will be comprised of slightly more than 200,000 cubic yards of soils and approximately 5 million cubic yards of limestone. The excavated material will be used to raise the average elevation of the land around the marina basin to conform with flood hazard requirements and to establish drainage patterns through the Property. Existing topsoils will be stockpiled for use in landscaping.

The interior waterways and berthing basins will be excavated before the marina is connected to the entrance channel. The intent is to use the marina as a retention basin for runoff and silt generated by the marina excavation during its construction. Thus, material disturbed during construction will not directly enter the ocean. The techniques that will be used to excavate the basins and waterways will be determined following detailed geotechnical investigations and the selection of a contractor. For the most part, it is anticipated that mechanized equipment will be able to fracture the limestone by ripping, spudding and chipping. Explosives may be required to accomplish this task where the limestone is not susceptible to efficient excavation by mechanized equipment.

The docks, piers, marine railway (if constructed), other in-water facilities associated with boat fueling, maintenance, and repair, will probably be constructed after the marina is open to the ocean.

Dredging of the entrance channel is anticipated to be conducted using two techniques. In the outer two thirds of the channel where wave action is less of a problem, use of conventional barge-mounted dredging equipment such as a cutterhead suction dredge, clamshell dredge or dragline dredge is envisioned. Dredging the approximately 1,000 feet of channel closer to the shoreline will be more difficult due to waves. Preliminary studies suggest that either a steel trestle or a filled causeway would be constructed. A crawler-mounted clamshell or dragline dredge operating from the trestle or causeway would excavate a 125- to 150-foot wide channel, which could then be widened to its full 400-foot width design using the same barge-mounted dredge employed on the outer two-thirds of the channel. If a filled causeway is constructed, it may later be incorporated as a jetty. Explosives may be required where the limestone is not susceptible to efficient excavation by mechanized equipment.

The material removed from the ocean floor would be placed in a barge and transported to the United States Environmental Protection Agency approved South Oahu Dredged Material Ocean Dumping Site or, with proper approval from the State and City and County, used as on-land fill.

Two jetties will be constructed to reduce wave energy, protect the interior waterways, prevent wave-induced longshore currents from creating a navigation hazard, and prevent any occasional littoral drift from shoaling the channel. Each structure will be approximately 400 feet long and have a crest height of about 8 feet above mean sea level. The armor stone will need to be at least 3.5 tons, but larger stone may be required for the outer portion of the structures. It is anticipated that the jetties will be constructed from the mauka side prior to dredging the entrance channel. Core material would be available from the excavation work on the interior marina basins, and using coralline material excavated from below the water table would minimize the potential for adverse effects on water quality.

Final grading of the landward areas, installation of infrastructure and utilities and subsequent construction of structures will employ conventional land-based techniques.

C. Development Timetable

Central to the development of the Project is the planned marina component because of its important role in the drainage system for the eastern Ewa DP area. It is projected that construction of the marina will start in late 1993 or early 1994. Completion of major excavation and grading will take two years. Within two years after the marina is completed, a petition will be filed with the Land Use Commission to reclassify the land developed for the marina waterways to the Conservation District. Pursuant to the master plan for the Project, required on-site infrastructure will be installed prior to the construction of above-ground structures. Thus, it will be at least three years from the date of this EIS before building construction will begin on the Property. Thereafter, it will take at least ten additional years before the mixed-use commercial complex and all residential housing units are completed.

D. Approximate Cost/Schedule

Development costs for the Project are expected to total approximately $250 - $300 million. Included in this estimate are marina improvements, infrastructure, general sitework and utilities. Excluded are costs for build-out of residential, commercial and marina support areas.

Chapter III

Physical Environment

III. PHYSICAL ENVIRONMENT

A. The Region

The State of Hawaii is made up of eight major islands and 124 minor islands. The eight major islands are Oahu, Kauai, Molokai, Lanai, Hawaii, Maui, Niihau (privately-owned), and Kahoolawe (an uninhabited island, presently used by the U.S. Navy). The State of Hawaii encompasses 6,450 square miles of which 6,425 are land and 25 are inland waters. Hawaii is encompassed by a coastline of about 750 miles, fourth longest among the states and territories.

Oahu is the third largest island in the State of Hawaii. Its 593 square miles of land comprise 9.4 percent of the State's total area. With a 1989 population of approximately 841,600 (75 percent of the State's total), it is the most populous of all the islands and the location of the State capital of Honolulu.[1]

B. Climate

The Hawaiian Islands lie in the northern fringe of the Tropic of Cancer, placing them within the belt of northeasterly trade winds which persist for the major part of the year. These "trades" are occasionally interrupted by southerly or "Kona" winds. Intermittent breakdown of typical trade wind flows occurs when deep low-pressure centers form and move slowly from west to east. This produces southerly winds and more rain in many otherwise dry places.

On Oahu, the trade winds are prevalent for 90 percent of the time between May and October. From November to April, Hawaii's winter season, the "trades" drop in frequency to about 50 percent. The "winter" season brings intense rains that account for practically all of the rain that falls on the leeward plains.

The climate in the area of the Project site is typical of the leeward coastal lowlands of Oahu. This climate is characterized by long southern exposure; temperatures ranging from an average daily maximum of 79.9 degrees Fahrenheit to an average daily minimum of 70.7 degrees Fahrenheit; persistent northeasterly trade winds, ranging from 8 to 18 mph; and an average mean rainfall of 15.6 inches.

[1]State of Hawaii Department of Business, Economic Development and Tourism, *State of Hawaii Data Book 1990; a Statistical Abstract.* p.16.

C. Landward Environment

1. Geology

The Island of Oahu is composed of the remnants of two elongated shield volcanoes, the Waianae and Koolau ranges, which are connected by the Schofield plateau. The Koolau volcano is the younger of the two and emerged east, sending lava flows westward to overlap and bank against the Waianae flank. After a long period of volcanic quiet during which deep canyons were carved out of the Koolau shield, a series of lava flows, cinder cones, and tuff cones emerged on the eastern portion of Oahu. These eruptions are known as the Honolulu Volcanic Series, and they include such landmarks as Koko Head Crater, Diamond Head Crater, and Punchbowl.

The Ewa Coastal Plain is composed of a sequence of marine sediments underlain by volcanic basalts of the Koolau series at depths of 800 to 1,000 feet beneath the Property. The overlying sedimentary deposits are often referred to as "caprock," which is composed of fossil coral reefs layered between silt and clay of marine and terrestrial origin.

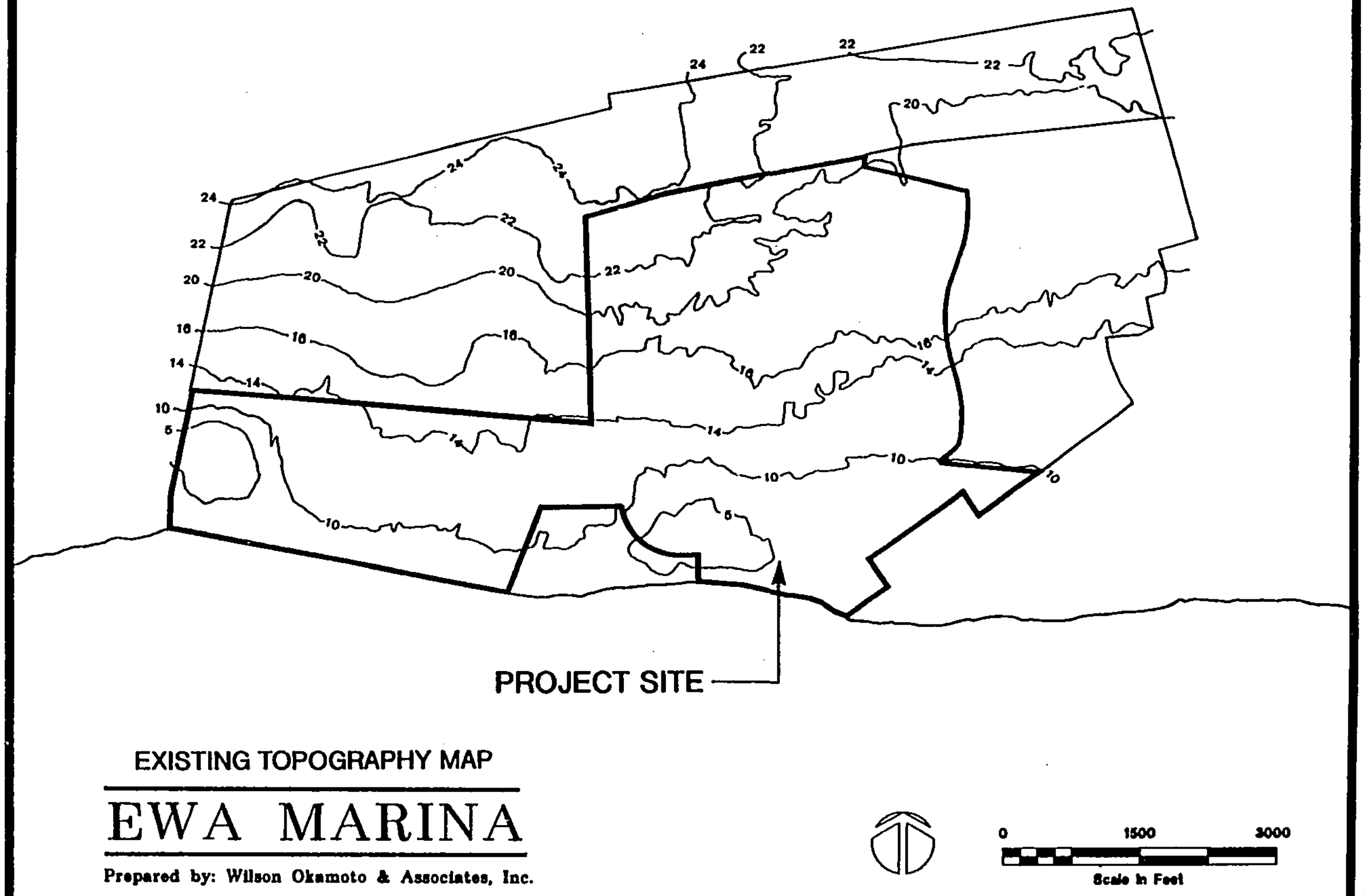
The Project site coastline was altered for coastal defenses in the early 1940's. The remnant concrete structures, tank traps, and anti-aircraft emplacements can still be seen along the shoreline today. Portions of the Project site were cleared by bulldozers in the past and unimproved roads cross the site.

Geophysical investigations conducted for the Honouliuli Wastewater Treatment Plant Outfall System (which traverses the Property) found no evidence of subsurface seismic motion or faulting, or fault-related structures.[2]

2. Topography/Drainage

The Property is situated on the southern edge of the Ewa Coastal Plain, which has a relatively regular surface that slopes gently to the sea at about 20 feet per mile. The Property is relatively flat with elevations ranging from 4 feet above mean sea level at the shoreline to elevation 22 feet above mean sea level at the mauka border. The shoreline is fronted by a 3 to 5 foot high wave cut escarpment which rises in elevation towards the west (See Figure 5).

[2] R.M. Towill, Final EIS for Honouliuli Wastewater Treatment Plant and Barbers Point Ocean Outfall System.



EXISTING TOPOGRAPHY MAP

EWA MARINA

Prepared by: Wilson Okamoto & Associates, Inc.

Fig. 5

With regard to surface water drainage, the Property lies at the seaward terminus of the ten square mile Kaloi Gulch watershed which extends back to the Waianae Range. Above Farrington Highway, there are a number of relatively deeply-eroded ditches. In the reach from Farrington Highway to just above Mango Tree Road, the channels join into a single channel which has the appearance of an excavated feature rather than a naturally-eroded one. Its limited capacity, which is further restricted by small culverts under Oahu Sugar Company road crossings, results in periodic flooding of adjacent cane fields. The channel reach which extends from Mango Tree Road to a point about 1,800 feet from the Project's shoreline is two earthen levees with a nominal conveyance capacity. The bottom of the channel is at the same elevation as the adjacent ground outside the levees. Under most conditions, surface flows are absorbed through infiltration and do not reach the sea. During extreme storms, peak flows overflow the levees and spread out onto the surrounding sugar cane fields. Very little runoff reaches the shoreline, instead ponding in inland areas and evaporating or percolating into the ground.

Until relatively recently, the Kaloi Gulch watershed was comprised mostly of sugar cane fields which facilitated infiltration of surface water. The 100-year storm event is estimated to currently discharge 550 cubic feet per second (cfs) of runoff onto the Project site. Recognizing that on-going urbanization will increase surface runoff, the City and County has required developers mauka of the Project to construct drainage systems, including silt and flood control improvements, that ultimately direct excess runoff from these properties into Kaloi Gulch. Based on City and County of Honolulu drainage standards, that storm flows during a 100-year storm event could reach 10,000 cubic feet per second (cfs) into the Property from Kaloi Gulch.

3. Hydrology

The same interbedding of coral and alluvial deposits which play an important role in Oahu's geology also influenced the hydrological character of Oahu's leeward coastline.

Groundwater on the Ewa Plain occurs in two types of aquifers: the Koolau Volcanic series, at a depth of approximately 1,000 feet, and an overlying caprock aquifer (See Appendix B). While the deeper volcanic aquifer contains fresh water further inland, directly beneath the Property, it probably contains brackish or salty water. The overlying limestone layer is underlain by a 40- to 50-foot thick bed of marine and alluvial mud which prevents water in the upper layer from mixing with the water found in the deeper volcanic aquifer. Although a shallow brackish water lens in the limestone layer is too saline for potable use, it is used for irrigating the overlying sugarcane fields. Water in this upper caprock aquifer generally flows quite rapidly through the highly permeable limestone towards the ocean, but there appears to be a narrow band of impermeable material which acts as a barrier restricting the outflow of water at the salt-freshwater interface in the caprock aquifer.

The caprock aquifer is recharged by rainfall and, at its mauka extreme, by leakage from the underlying basaltic aquifer; however, the most significant recharge source is infiltrating irrigation water from extensive sugar cane fields mauka of the Property. In these mauka fields, fresh water is imported from the basalt aquifer for irrigation. If irrigation of these fields were to cease or be drastically reduced, the inflow of fresh water to the caprock aquifer would also be sharply reduced, lowering the water table and increasing the salinity of the water in it to the point where it may no longer be a viable source of brackish irrigation water. Currently, the brackish water in the caprock aquifer is drawn to irrigate the makai sugar cane fields.

4. Soils

Soils Conservation Service maps indicate that two types of soils are present at the Project site: fill land and coral outcrops.

The fill land is a mixture of coralline/algal carbonates, peat deposits, volcanic rocks and residual clays excavated from adjacent uplands as well as bagasse and slurry disposed of by sugar mills. The coral outcrops consists of coral, cemented calcareous sands, and limestone. Some loose sand also occurs in isolated pockets. In some small voids and depressions, limestone degradation has produced natural clay-enriched Mamala soil.

The shoreline and intertidal area of the Property consists of a beachrock (limestone) scarp 1-2 meters high. At the bottom of the scarp is a solid, flat platform interspersed with small patches of white beach sand.

a. Land Study Bureau

The Land Study Bureau (LSB) prepared the Detailed Land Classification which classifies all lands in the State (except those in the urban district) into homogeneous land types, based on soil properties, topography and climate. General ratings range from "A" to "E", with "A" representing the class with the highest agricultural productivity to "E", the lowest. All remaining lands are classified "U" for "urban." The classifications for the Property are primarily "E115" in the makai Property area and "B77*i*" in the mauka area (See Figure 6). Small areas of the Property are classified as "C72*i*" and "U". In the mauka portion, if irrigated, the class "B" soil is identified as suitable for sugarcane, pineapple, vegetable and forage and the class "C" soil is identified as suitable for sugarcane, grazing and orchard. If not irrigated, the soils are unsuitable for any type of agriculture. The class "E" soils are not suitable for any type of agriculture.

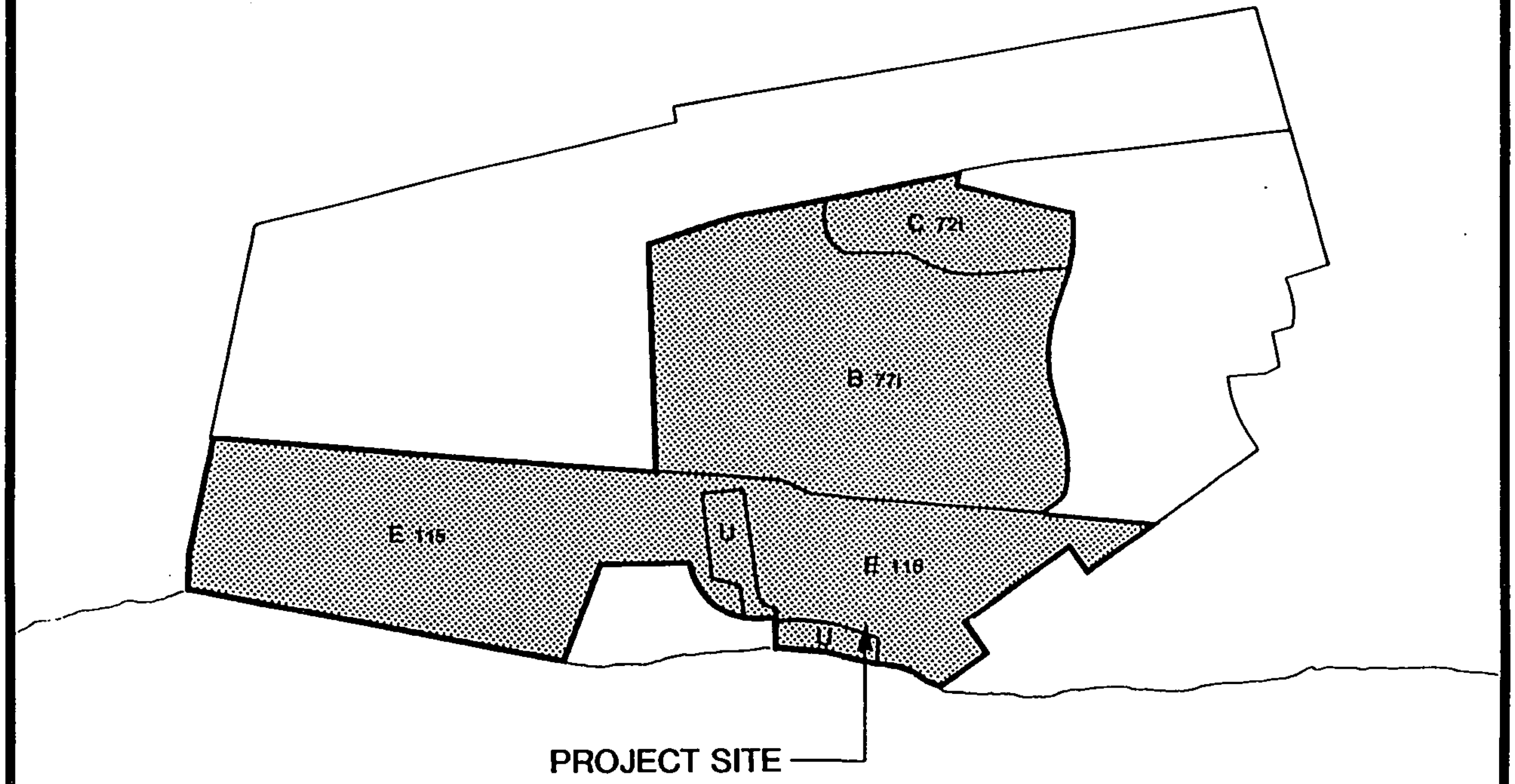
b. Agricultural Lands of Importance to the State of Hawaii (ALISH)

The Agricultural Lands of Importance to the State of Hawaii (ALISH) Study classifies agriculturally important lands into three categories, which are "Prime", "Unique", and "Other" "farm lands of state-wide and local importance." The Property contains lands classified as "Prime" and Unique" (See Figure 7). A small portion of the Property at the mauka end is classified as "Prime Agricultural Land." This is land which has the soil quality, growing season, and moisture supply needed to produce sustained high yields of crops economically when treated and managed according to modern farming methods. Most of the mauka portion of the Property is in "Unique Agricultural Land." This is land that has the special combination of soil quality, location, growing season and moisture supply needed to produce sustained high quality and or high yields of a specific crop when treated and managed according to modern farming methods. The rest of the Property is unrated.

5. Biota

a. Flora

Six different types of plant communities can be found in the vicinity of the Ewa Marina Project site. Four of these communities are relatively undisturbed (littoral strand, *Batis* "pickleweed" wetland, Pluchea scrub, and Propsis (kiawe) forest while two are disturbed (previously cleared areas and cane fields). Of the undisturbed communities, the coastal (littoral) strand and *Batis* Wetland are notable and described below. The Pluchea Scrub community is relatively common in the area, as is the kiawe forest which is a mature strand. Figure 8 illustrates the vegetative communities present on the Project site.



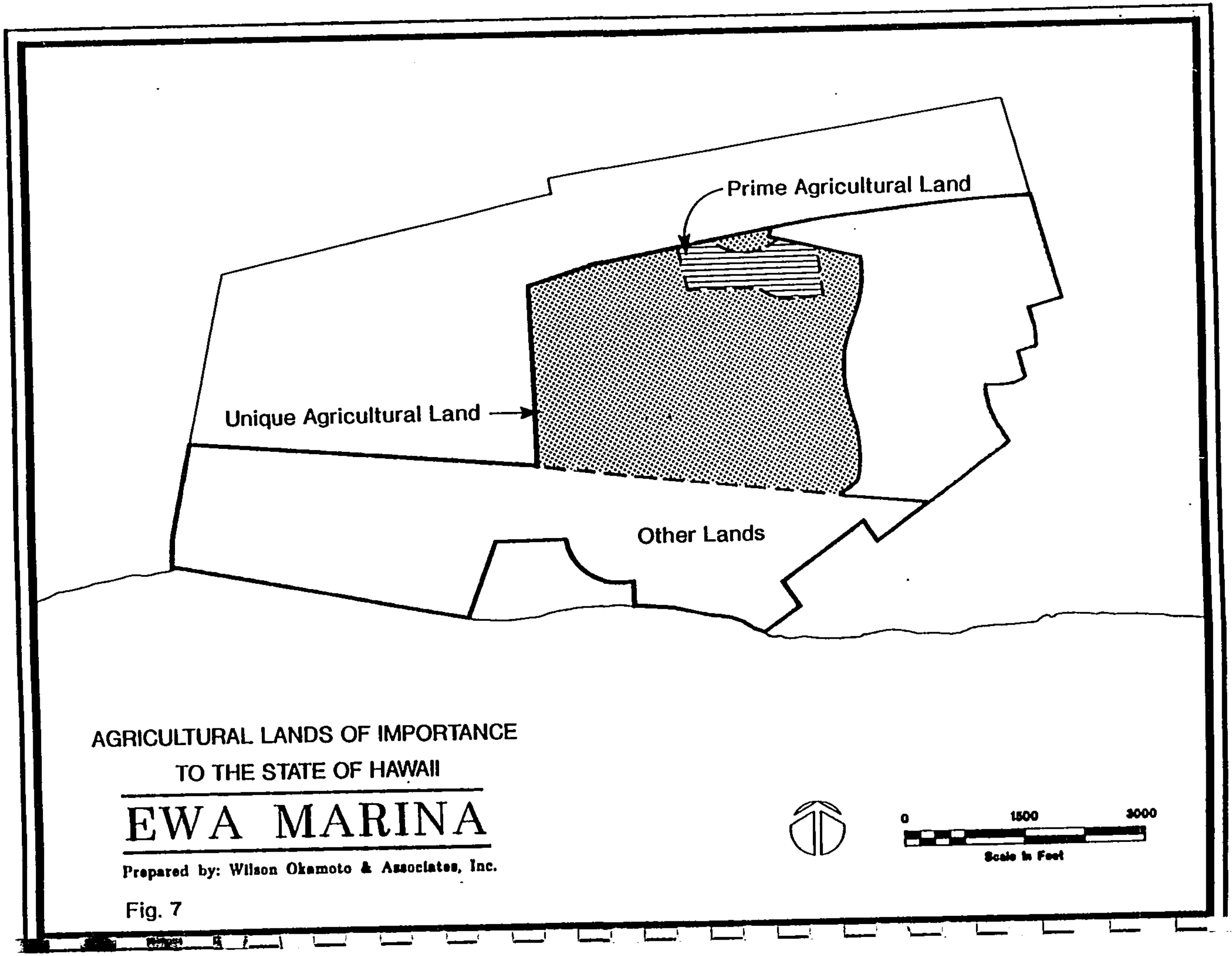
LAND STUDY BUREAU MAP

EWA MARINA

Prepared by: Wilson Okamoto & Associates, Inc.

Fig. 6

0 1500 3000
Scale in Feet


Prime Agricultural Land
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Other Lands
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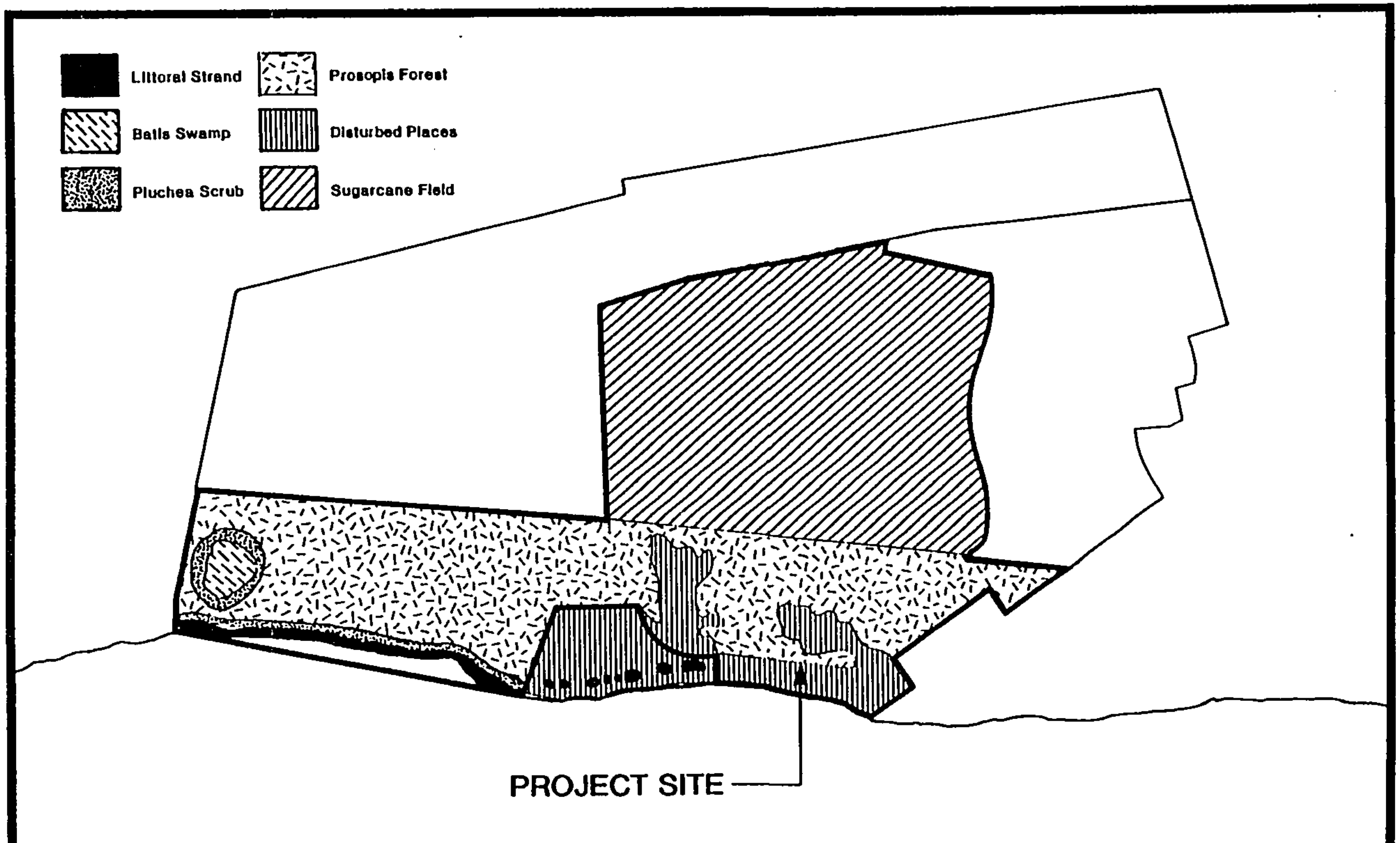
AGRICULTURAL LANDS OF IMPORTANCE
TO THE STATE OF HAWAII
EWA MARINA
Prepared by: Wilson Okamoto & Associates, Inc.

Fig. 7



VEGETATION COMMUNITIES

EWA MARINA

Prepared by: Wilson Okamoto & Associates, Inc.

Fig. 8

1) Coastal (Littoral) Strand

While the kiawe and haole koa dominate the shoreline area, scattered patches of coastal strand adjacent to the shoreline contain endemic plants listed in Table 3. A few specimens of naio were found in strand vegetation near the NASBP.[3] Char and Balakrishnan recommended naio for endangered status in 1979, but the plant has not been listed by the U.S. Fish and Wildlife Service. Coastal strand vegetation dominated the rocky shoreline and is characterized by *Sesuvium portalacastrum* (‘akulikuli), occasionally with *Batis maritima* (pickleweed) and *Lycium sandwicense* (‘ohelo-kai). Sandy areas support grasses such as *Sporobolus virginicus* (‘aki‘aki) and *Cynodon dactylon* (Bermuda grass).

Table 3
Endemic Vegetation in the Coastal Strand

SPECIES	COMMENTS
Heliotropium anomalum var. argenteum	Prostrate perennial herb with dense silvery leaves found in the strand vegetation. Sighted during September 1980 survey (Char, 1980)
H. curassavicum	Prostrate perennial herb with pale bluish-green leaves found in the strand vegetation and in soils where there is a deposit of silt
Santalum ellipticum	Broad tree, 3 to 4 meters tall, with slender branches. A few plants are in the kiawe forest near the Barbers Point Naval Air Station. The species occurs on the Ewa coral plains as *S. ellipticum var. gracilis* (coastal sandalwood)
Lycium sandwicense	Small, spreading shrub found in the strand vegetation up to 1 meter tall with shiny red globose fruit

[3] Char, W., and N. Balakrishnan, *Ewa Plains Botanical Survey.* US Fish and Wildlife Service, Honolulu, Mimeograph. 1979.

2) *Batis* Wetland

The Property also contains a coastal saltmarsh habitat, dominated by the introduced succulent, pickleweed (*Batis Maritima*). The marsh developed in what appears to be a limestone sinkhole having a circular area of about 6.2 acres, (See Figure 8). Low spots within the almost level marsh contain small, shallow pools and stands of tall sedges (*Scirpus maritimus* var. *paludosus*). Dense thickets of the introduced woody shrub, *Pluchea indica*, separate the saltmarsh from the surrounding kiawe trees.

While wildlife use of this wetland has not been reported, it is possible that Hawaiian waterbirds, such as the black-crowned night heron, Hawaiian stilt or Hawaiian coot, could rest or forage in the area, particularly following heavy rains that may flood the wetland. Native migratory shorebirds such as the Pacific golden plover, ruddy turnstone, sanderling, and wandering tattler may also use this coastal wetland for resting or foraging.

If OSCo ceases its operations and sugar cane irrigation, head levels in the caprock aquifer will decrease. This could drop the caprock aquifer water level to below that required to maintain the *Batis* wetland. Although silty soils in the wetland may perch rainwater after storm events, the character of the wetland would change if it is isolated from the brackish caprock aquifer groundwater.

b. Fauna

A terrestrial wildlife survey conducted in 1979 by Berger found no threatened or endangered animal or bird species at the Property. Only three species of mammals were found on the Property: the house mouse, domestic dog, and Indian mongoose. The site is also suitable habitat for three types of rat which have not been found, but are probably present. These exotic species are the roof rat, the Norway rat and the Polynesian rat. All of the reptiles found at the site are exotic species (the house gecko, the tree gecko, and the metallic skink). In addition, the giant neotropical toad and the mourning gecko are also probably present, but were not found.

Twenty-four species of avifauna were identified at the Property. Only five species were native and none were threatened or endangered. Of the five indigenous species, four (the Pacific golden plover, wandering tattler, ruddy turnstone and sanderling) are migratory birds which spend the winter in Hawaii and return to north temperate regions where they breed. The black-crowned night heron is the only indigenous resident species. During a 1984 study the heron's presence was confirmed, as was the presence of the non-native barn owl. Both species had been listed as only "probably present" in earlier studies. Another non-native species, the peafowl, was added to the list of avifauna.

c. Anchialine Pool

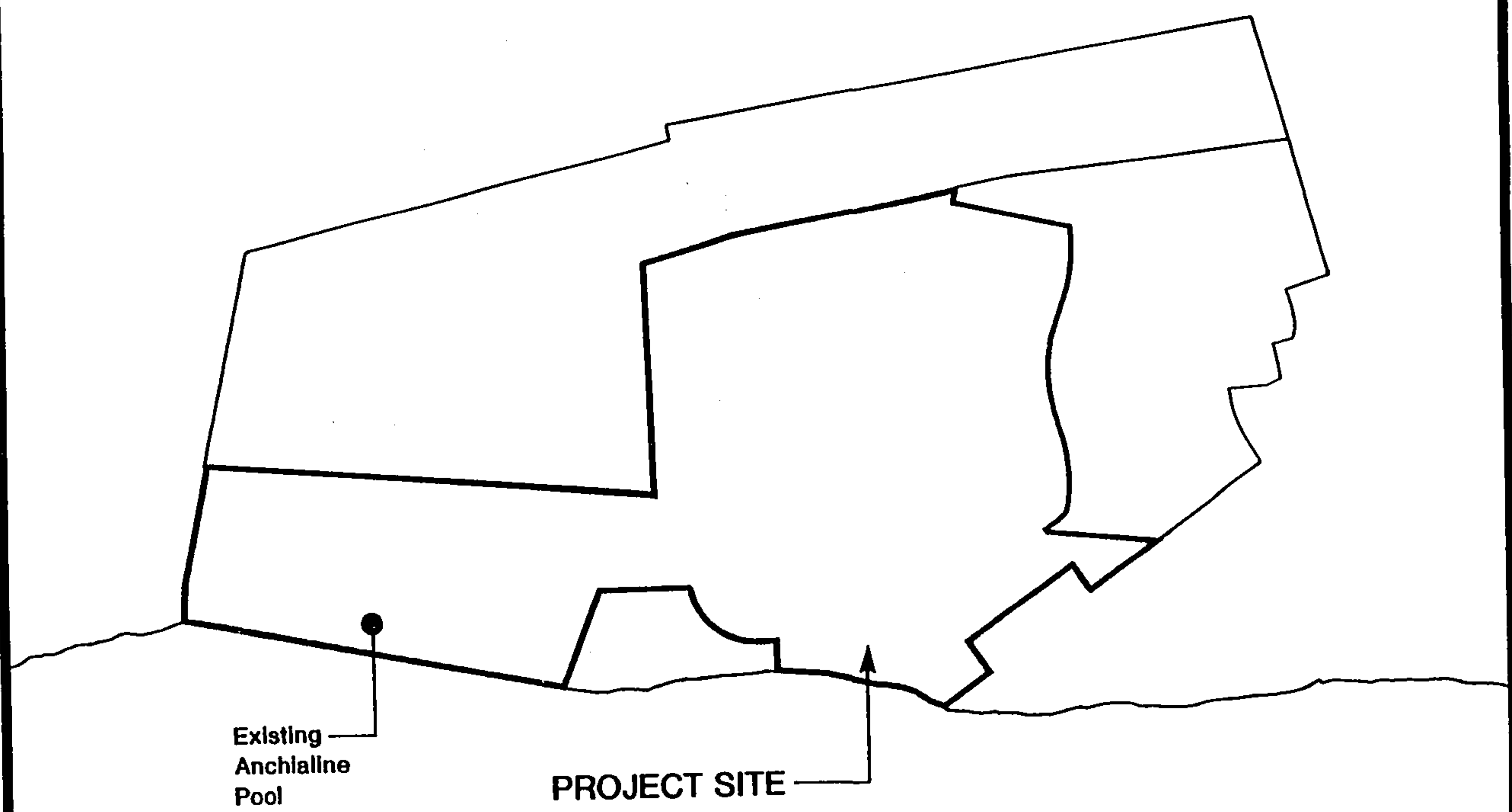
Anchialine pools are landlocked brackish water features that lack a surface connection to the ocean, yet have measurable salinities and exhibit damped tidal fluctuations. These habitats are found in coastal areas on the islands of Oahu, Maui and Hawaii. An Anchialine pool has been identified on the Property (See Figure 9). It appears to be a sinkhole excavated to form a shallow well. It is approximately five feet in diameter and five feet deep. Water is present only about 10 percent of the time. At its greatest depth, the water is less than 1 foot deep and the surface area of the water is approximately 2 square feet. Both species of small red shrimp, opae u'la (*Halcaridna rubra* and *Metabetaeus lohena*) which inhabit such pools have been found in the pool at Ewa Marina but only at extreme high tides (greater than +2.5 foot tides). If OSCo ceases its sugar cane irrigation and, hence, its freshwater recharge of the caprock aquifer, head levels in the aquifer could decrease to a point where water no longer enters the pool.

d. Endangered Species

No federally listed threatened or endangered species are known to reside in the Project site. While it is possible that the endangered Hawaiian coot (*Fulica americana alai*) or stilt (*Himantopus mexicanus knudseni*) may visit the site, in late 1987, the U.S. Fish and Wildlife Service found no jeopardy to either of these species from the proposed marina development.

6. Air Quality

According to a study conducted by J.W. Morrow, air quality in the vicinity of the Project site is believed to be in compliance with State and Federal standards although there is no air monitoring station in the area. (See Appendix C) This is due to the undeveloped nature of the area. The nearest major stationary sources of emissions are at Campbell Industrial Park which are downwind of the Project site under the prevailing northeasterly trade winds and, thus, would



LOCATION OF ANCHIALINE POOL

EWA MARINA

Prepared by: Wilson Okamoto & Associates, Inc.

Fig. 9

impact the Project site air quality only under infrequent southwesterly wind conditions. The State Health Department's Barbers Point air monitoring station, located some six miles southwest, indicates compliance with State and Federal standards despite being located adjacent to Campbell Industrial Park.

Air sampling conducted during peak traffic hours found carbon monoxide (CO) levels in the 2-4 milligrams per cubic meter (mg/m^3) range along Fort Weaver Road in the vicinity of Geiger Road and the Kunia Interchange. Such levels are well within the State and Federal one-hour standards of 10 mg/m^3 and 40 mg/m^3, respectively. Winds during the sampling were light but gusty tradewinds from the north-northwest and northeast.

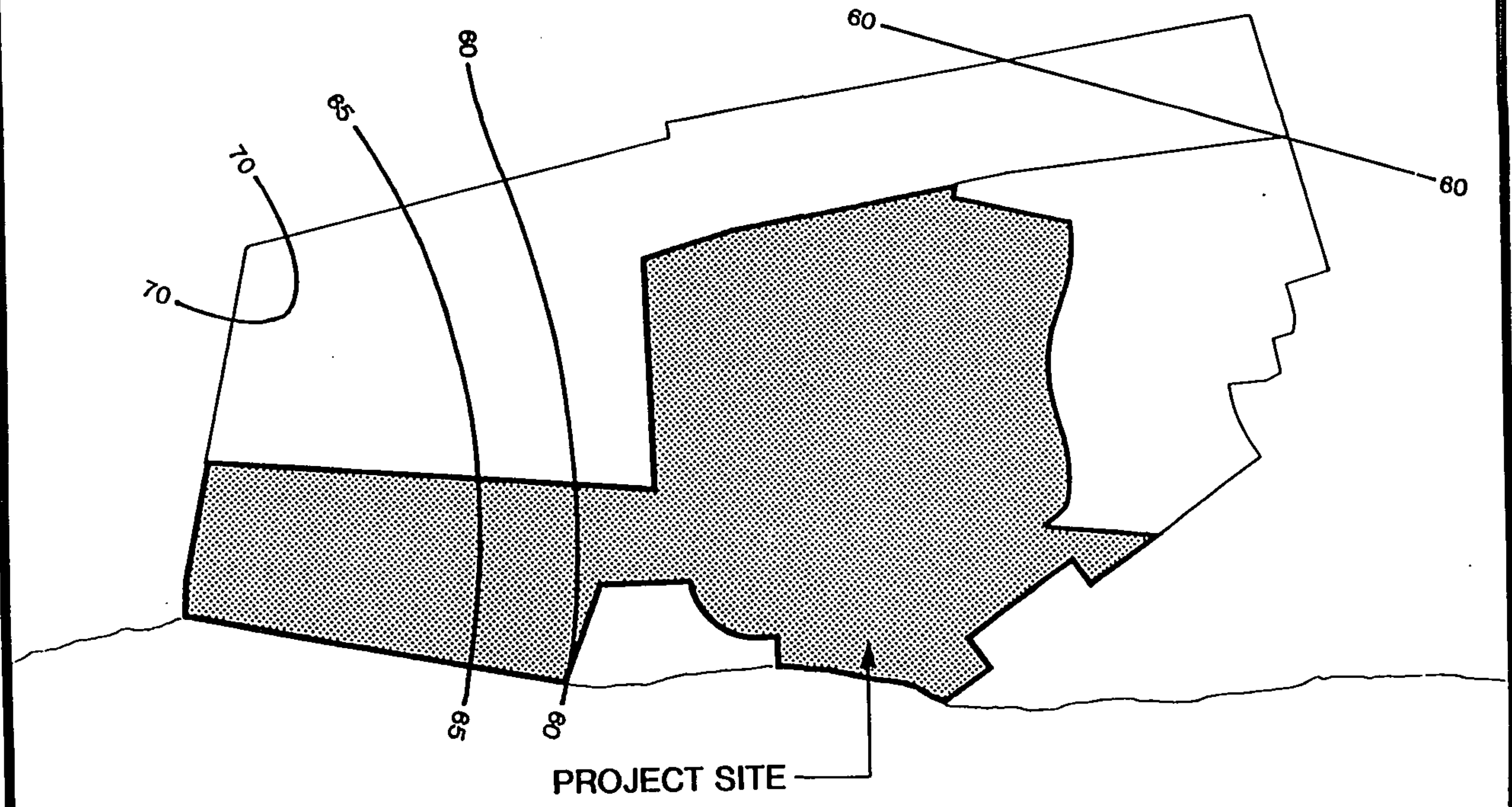
On an annual basis, wind conditions in the area are predominated by brisk northeasterly tradewinds; however, there is a marked seasonal difference in the velocity and persistence of such winds. The tradewinds tend to decline in the fall and winter months turning into more light and variable winds, often with a more southerly component, which can contribute to higher pollutant concentrations.

7. Noise

The Property is currently subjected to overflights, noise, and other intrusions, associated with aircraft utilizing the runways of Honolulu International Airport (HIA) and NASBP. The existing combined (due to HIA and NASBP operations) day-night average sound level (Ldn) at the Property is estimated to range from about 55 Ldn to over 65 Ldn (See Figure 10 and Appendix D).

The Ewa DP Special Provisions for the Ewa Marina Special Area (Section 32-3.2(b)(3)) disallows development of residential and apartment units in areas exposed to aircraft noise in excess of 62.5 Ldn and requires sound attenuation in units subject to noise levels between 60 and 62.5 Ldn. In addition, Section 471-31, Hawaii Revised Statutes requires that all prospective buyers, lessees and tenants of property within noise exposure areas be notified of potential noise impacts. Property lying in the 55 Ldn or greater contour on noise maps prepared pursuant to Federal Aviation Regulations Part 150 are subject these requirements as well as noise exposure areas identified on the Air Installation Compatibility Use Zone (AICUZ) maps prepared for military airports.

Part of the Property is also subject to restrictions pursuant to an easement in favor of the United States of America. The easement prohibits the construction of homes or other noise sensitive improvements, such as residential units, in an area approximately 80 acres in size in the western portion of the project site.



HIA & NASBP Ldn NOISE CONTOUR MAP

EWA MARINA

Prepared by: Wilson Okamoto & Associates, Inc.

Fig. 10

D. Marine Environment

1. Bathymetry

The bathymetry, or submarine topography, seaward of the shoreline is an irregular extension of the Ewa Coastal Plain at a slightly steeper slope of about 8 feet per 1,000 feet. About 7,000 feet directly offshore of the Property, and at a depth of about 60 feet, there is a steep incline to a depth of 80 feet; from there, the seafloor slopes at about 20 feet per 1,000 feet. At a depth of 150 feet, the seafloor slopes dramatically at almost 200 feet per 1,000 feet to depths in excess of 1,000 feet.

2. Water Quality

Ocean waters immediately offshore of Ewa Beach are designated as Class A waters (Appendix E). Beneficial uses of Class A waters are fishing, swimming, surfing, water contact recreational activities, aesthetic enjoyment, and support and propagation of marine life. Open coastal water standards for "dry" conditions apply to the Ewa Marina site because this area receives less than 3 million gallons of groundwater outflow per mile of coastline per day.

Historical local coastal water quality data are available for Ewa Beach Park (2.4 miles east of Oneula Beach Park, closer to the entrance of Pearl Harbor), where the State Department of Health performed approximately 40 water quality analyses over a 5-year period.[4] Average values for the parameters measured are listed in Table 4.

The levels of total nitrogen and total phosphorus each exceed State Water Quality Standards, suggesting that Ewa Plain groundwater is enriching the coastal zone with respect to these constituents.

Water quality in the Project site is not influenced by the Honouliuli Wastewater Treatment Plant outfall, which traverses the Property and discharges in the ocean approximately two miles from shore, according to water quality studies conducted by the City and County of Honolulu Division of Wastewater Management. In support of its application for a waiver of U.S. Environmental Protection Agency (EPA) requirements for the treatment plant, the Division collects water samples along the reef-front between Barbers Point and the entrance to Pearl Harbor. No

[4]Dames and Moore. *Increment II Proposed Ewa Marina Community. Ewa, Oahu, Hawaii. Final Addendum to the Final EIS.* Prepared for M.S.M. and Associates, Inc. Honolulu, Hawaii, July 1986.

influence from the outfall was detectable at shoreline stations, and only rarely was any influence seen at the nearshore stations in 30-foot water depths.[5]

Table 4
Existing Marine Water Quality

Parameter	Value	Unit	State Standard (dry)
Temperature	25.7	°C	-
Turbidity	19.9	NTU	-
Dissolved Oxygen	6.70	mg/L	-
pH	8.11	-	-
Salinity	33,100	ppm	-
Total Nitrogen	0.28	mg/L	0.250
Total phosphorus	0.05	mg/L	0.045

Water quality in the area is also unaffected by the Fort Kamehameha Wastewater Treatment Plant, which discharges at the mouth of Pearl Harbor. Again, the outfall influence is largely confined to the zone of mixing, with no influence noted at shoreline stations.

In the immediate Project area, water quality samples were collected from June to July 1990 by Marine Research Consultants to establish preconstruction nearshore water chemistry baseline conditions (See Appendix F). The samples indicate the following:

a. A substantial number of water samples exceeded State DOH standards in open ocean waters, under dry conditions for NO_3^- (nitrate and nitrite nitrogen), TN (total nitrogen), NH_4^+ (ammonium nitrogen), turbidity and Chl*a* (chlorophyll a). While the high levels of NO_3^- and TN may be partly attributable to shoreline activity, it is evident that the natural input of groundwater at the shoreline will result in concentrations which exceed DOH standards. Turbidity values in excess of DOH

[5]M&E Pacific, Inc. *Detailed Bathymetric Survey of Proposed Ewa Marina Project Site.* 1984 From Moffatt and Nichol, Engineers. *Ewa Marina: Evaluation of Project Impacts on Adjacent Beaches.* 1990.

standards are likely a result of sediment resuspension from wave stirring.[6]

b. The influence of groundwater inputs is indicated by the gradient of several dissolved nutrients ($NO_3^- + NO_2^-$, TN and Si-silica) where highest values were recorded at the stations closest to shore and lowest values at the most seaward sampling sites. Salinity was also lowest closest to the shoreline, indicating the influence of groundwater.

c. Other water chemistry constituents that are not related to groundwater input also displayed decreasing values with distance from shore. Such a pattern for turbidity and Chl*a* is likely a result of resuspension of sediment by wave stirring.

d. Gradients in temperature are a likely result of solar radiation, both in terms of warming of shallow nearshore water relative to offshore waters, and of diurnal warming through the course of the daily cycle.

e. There is no indication of vertical stratification within the water column. The lack of low density surface layers is likely a result of substantial stirring of the entire water column by wave action.

3. Currents

Currents in the vicinity of the Property are influenced by winds, tides and wave action. Flood tides enter Mamala Bay from the east around Diamond Head and from the west around Barbers Point. These flows appear to meet off Ewa Beach. The direction of the convergence of these flows is controlled by tidal phase, with a general west to southwestward, offshore flow during ebb tides, and a general southeastward to southward flow during flood tides. This pattern occurs during tradewinds. During Kona conditions, a stronger onshore flow component would be expected. Measured currents offshore of the Property were generally slow, with a mean speed of 4 cm/sec.[7]

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[6]Marine Research Consultants. *Ewa Marina Marine Environmental Monitoring Program Water Chemistry, Report 1-90.* September 1990.

[7]Bathan, Karl H. "Circulation Atlas for Oahu, Hawaii" *University of Hawaii Sea Grant Program, Miscellaneous Report.* UNIHI-SEAGRANT-MR-78-05. 1978.

4. Littoral Processes

According to a study prepared in November 1990 by Moffatt and Nichol, Engineers (See Appendix G), approximately half of the shoreline between Pearl Harbor and Barbers Point is composed of pocket beaches, and the other half consists of beach rock and exposed coralline reef limestone. The beaches are composed of a medium-sized, calcareous sand, and are typically 50 to 100 feet wide and extend up to an elevation of 9 to 10 feet. The beach sand is perched on the reef rock. Where sand is thin or absent, a 3- to 6-foot escarpment has been cut by the waves into the reef rock. The reef rock is interspersed with shallow, sand-filled channels and pockets.

Most of the sand transport is onshore-offshore, and longshore transport is less important.[8] The sand channels and the beaches constitute a reservoir/beach system that remains more or less in equilibrium. The sand in the nearshore reef channels represents a sand reservoir, the volume of which fluctuates in response to waves and currents. Increases in beach sand volumes are accompanied by decreases in the offshore reef channel reservoir volumes, and vice-versa.

Oneula Beach is located immediately east of the proposed marina site. It is a small beach, containing about 36,000 cubic yards (yd^3) of sand in its 3,000-foot length.[9] Using the vegetation line on aerial photographs as an indicator of beach change, Hwang noted that Oneula Beach changed little from 1950 to 1976.[10] In a followup study, Sea Engineering indicated that the east end of the beach has

[8]Campbell, J.H. "Erosion and Accretion of Selected Hawaiian Beaches, 1962-1972." *University of Hawaii Sea Grant Program, Miscellaneous Report.* (Prepared under the National Sea Grant Program, National Oceanic and Atmospheric Administration) 1972. Moberly, Ralph and Theodore Chamberlain. *Hawaiian Beach Systems--Final Report and Appendices A and B.* Hawaii Institute of Geophysics, University of Hawaii. (Prepared for State of Hawaii Department of Transportation, Harbors Division) 1964.

[9]Moffatt and Nichol, Engineers, *Ewa Marina Evaluation of Project Impacts on Adjacent Beaches.* Prepared for Haseko (Hawaii), Inc. Long Beach, California, November, 1990.

[10]Hwang, Dennis. *Beach Changes on Oahu as Revealed by Aerial Photographs.* Urban and Regional Planning Program and the Hawaii Institute of Geophysics, University of Hawaii, Cooperative Report UNIHI-SEAGRANT-CR-81-07. Prepared for the State of Hawaii, Department of Planning and Economic Development. 1981.

remained stable, while about 20 feet of erosion has occurred in the shoreline area east of the proposed marina channel.[11]

The proposed marina entrance channel is located within a 2,000-foot-long stretch of rocky shoreline west of Oneula Beach. No large sand reservoirs have been documented or observed off shore for this reach of shoreline.[12]

5. Winds

Open ocean winds around the Hawaiian Islands are dominated by the northeast trades. Wind data from the adjacent NASBP shows 85 percent of the winds from the northeast quadrant with an average speed of 9 knots.

6. Tides

Tides in Hawaii are semi-diurnal with a diurnal inequality. The average tidal range in Honolulu Harbor (the nearest gaging station) is 1.9 feet, with a mean sea level 0.81 feet above mean lower low water (mllw). The maximum annual tidal range is 3 feet.

7. Tsunami

The Project site lies within a tsunami inundation zone. Since 1946, four significant tsunamis were measured in the Ewa Beach area, with run-up ranging from 3 to 9 feet above mllw as evidenced by the high water mark left by a tsunami.[13] (See Table 5.) According to observers' reports, these four tsunamis were characterized by rapid rise and fall of sea level. Occupied floors of structures must be at an elevation above the projected tsunami inundation levels (See also Section F.1., Flood Hazard.).

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[11] Sea Engineering. *Oahu Shoreline Study - Part 1 - Data on Beach Changes.* Prepared for City and County of Honolulu, Department of Land Utilization. 1989.

[12] Moffatt & Nichol, Engineers. *Ewa Marina: Evaluation of Project Impacts on Adjacent Beaches.* November 1990.

[13] idem. *Tsunami Effects on the Ewa Marina Community Development.* Prepared for M.S.M. and Associates. March 1986.

Table 5
Tsunami Runup Measured at Ewa Beach and Honolulu

Year	Tsunami Origin	Ewa Beach	Honolulu
1946	Aleutian Islands	3 feet	4.1 feet
1952	Kamchatka Peninsula	5 feet	4.4 feet
1957	Aleutian Islands	9 feet	3.2 feet
1960	Chile	9 feet	5.5+ feet
1964	Gulf of Alaska	- -	2.7 feet

8. Benthic Environment

From the shoreline out to a depth of 60 feet (approximately 1.2 miles), the ocean bottom is composed of a wide, predominately flat, calcium carbonate (limestone) platform, a majority of which is covered by sand and rubble. A short algal turf covers most of the flat reef platform. In some areas, shallow sand-filled channels and depressions intersect the reef platform. Extensive sand deposits occur in deeper areas of the reef platform, from 40 to 60 feet.

9. Marine Habitats

a. Corals

Macroinvertebrate abundance off the entire Ewa Marina site is considered deficient compared to many other areas of the south coast of Oahu. The lack of suitable substratum complexity to afford shelter, near constant abrasion from shifting sand, and concussive force of breaking waves, are all factors limiting the abundance of corals and benthic invertebrates in this location.

Sparse coral growth is comprised of relatively common species such as *Porites lobata*. Other species identified include *Pocillapora meandrina, P. damincornis, P. ligulata, Porites compressa, Psammacora stellata, Montipora patula, M. verrucosa,* and *Pavon varians* (See Appendix H).

b. Marine Algae

Overall, algal abundance and diversity was noted to be greatest at nearshore sampling sites, which harbored turf-forming species and fine-branching, calcareous red algae (e.g., *Janis*, *Corallina*, and *Ceramium*) which tend to trap sediment on the limestone substrata (See Appendix I). Algal cover was generally sparse at most offshore stations and usually dominated by *Codium edule*, *Asparagopsis taxiformis*, and *Jania* sp. Midreef areas harbored *Hypnea cervicornis*, *Halimeda opuntia*, and *Padina japonica* in addition to dominant species found off the reef margin. Other species observed between the midreef and inshore areas included *Hypnea multiformis*, *Laurencia nidifica*, *Sargassum obtusifolum*, and *Wrangelia pencillata*.

10. Fish

Fish communities adjacent to the marina site were low in diversity and abundance (See Appendix H). The environment throughout most of the study area hampers the development of corals and, therefore fish communities as well. In general, coral reef fish abundance and diversity has been correlated with the degree of topographical relief.[14] Substantial locai fishing, noted during the monitoring survey, has affected the abundance, size and behavior of sought after target species.

11. Endangered and Threatened Species

The habitat range of the humpback whale, which is an endangered species, and the green sea turtle, which is a threatened species in Hawaii, are known to extend into the area offshore of the Property. However, their numbers are not significant.

a. Humpback Whales

In Hawaii, humpback whales generally arrive in November to calve and breed and depart in May. (See Appendix J). The whales are almost

[14]Brock, R.E. and R.M. Bulkley and R.A. Grace. "An Artificial Reef Enhancement Program for Nearshore Hawaiian Waters." *Artificial Reefs: Marine and Freshwater Applications.* Chelsea, MI: Lewis Publishers, Inc. 1985.

exclusively found in water less than 100 fathoms (600 feet) in depth, with the preferred depth range being 120 to 500 feet.[15]

The lowest incidence of whale observations (less than 4.9 whale sightings per hour) occurs in the region of the southern shoreline of Oahu between Barbers Point and Koko Head. Aerial censuses indicate that the Ewa offshore region is not a preferred habitat for whales. Whales sighted in this area were in transit to and from the north shore of Oahu, which is a preferred area of aggregation.[16]

The greatest change from the 1980 data occurred for the Kauai/Niihau region, which displayed a more than threefold increase. The highest concentrations of whales (more than 20 sightings per hour) occurred over the large shallow banks (Penguin Banks) between Molokai and Oahu.

b. Green Sea Turtles

Recent surveys of turtles conducted during daytime hours found green sea turtles in offshore areas on either side of the Property but not fronting it (See Appendix K). The absence of turtles in the vicinity of the Property is probably due to the absence of benthic features offering shelters used for resting. Turtles were found one kilometer west of the proposed marina entrance, in the area offshore of White Plains Beach at NASBP. There, the bottom is characterized by numerous crevices and ledges used as rest areas. Some ledges in this area evidence long term presence of turtles as they have been worn smooth by contact with turtle shells. To the east, turtles were found near a sunken barge about 1 kilometer from the proposed marina entrance (See Figure 11).

Several general comments can be made about the turtles observed to date. The population has resided in the area for a considerable time. Their abundance suggests they are utilizing locally available food sources. Most turtles have been mature individuals; few small adults or juveniles observed. Few turtles have been sighted in the areas characterized by the kind of flat hardpan bottom that is characteristic of the proposed marina channel alignment. To date, observations suggest that the resident

[15]Behavioral Research Consultants, *Potential for Impact of Proposed Ewa Marina, Ewa, Oahu on Seasonally-Resident Humpback Whales*, 1991.

[16] ibid.

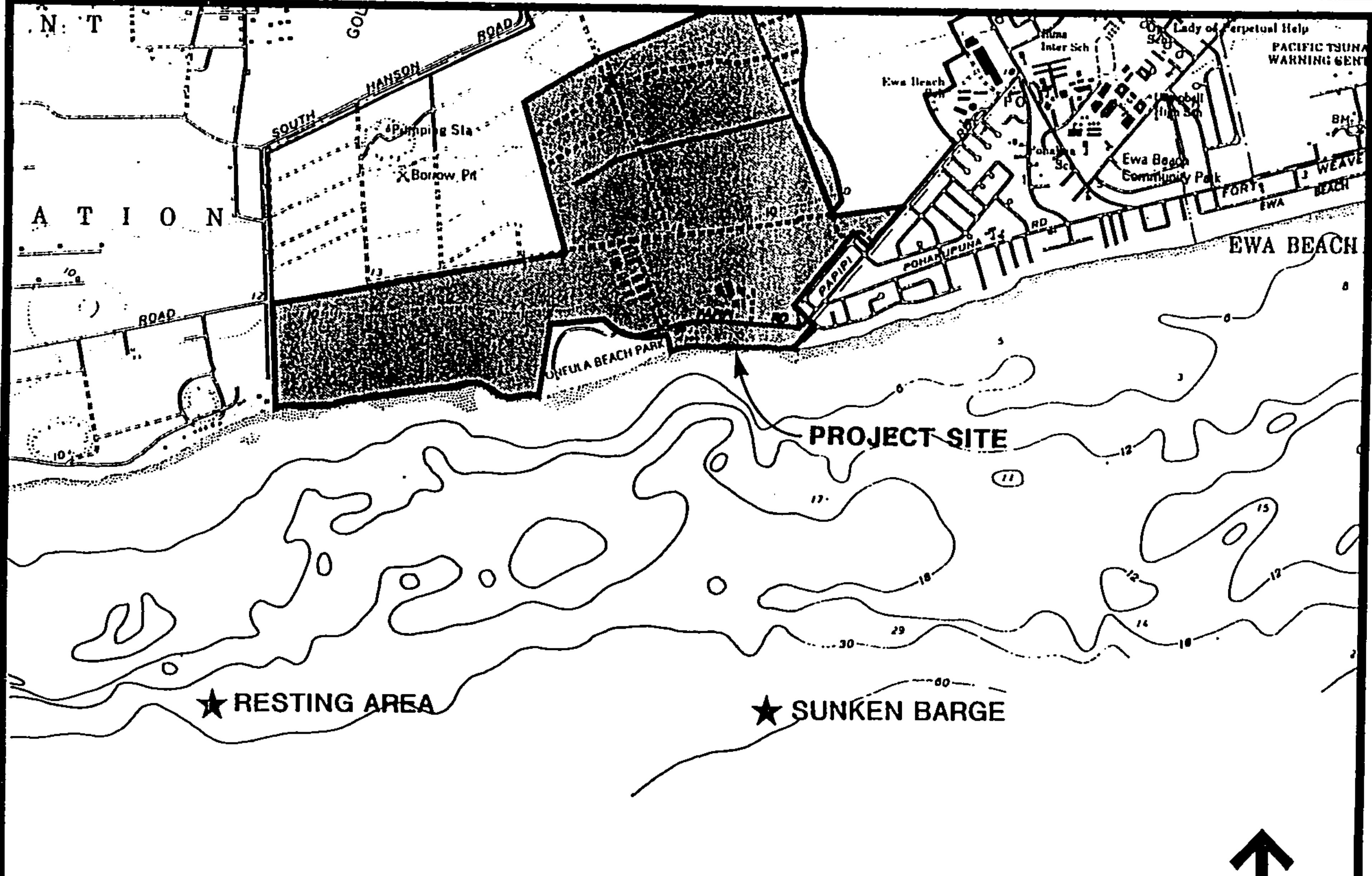

Fig. 11
LOCATIONS OF SEA TURTLE HABITAT

Source: Marine Research Consultants, 1990

Prepared by: Wilson Okamoto & Associates, Inc.

population eligible for breeding generally is not migrating during breeding season.

Toward assessing the availability of food sources which may be attracting sea turtles to nearshore areas adjacent to the Property during nighttime foraging, two surveys of favored algal food sources were conducted. Of the nine macroalgal genera or species that make up most of the turtle's food source in the Hawaiian Islands, five taxa account for 77 percent of the algal community biomass found at the Ewa Marina site.[17] The algae within the Ewa Marina nearshore area could thus provide an abundant food source for the turtles found resting offshore. A favored food of the turtle, the algae *Pterocladia capillacea*, occurs in greatest abundance on the frontal slope of the marine bench in two places--just east off Oneula Beach Park, and off Ewa Beach.

E. Community Resources

1. Shoreline Access

Several public shoreline access routes are available in the vicinity of the Property, of which Oneula Beach Park is central. Oneula Beach Park provides direct public access to the fronting shoreline and from there alongshore to both the east and west sides of the park. To the east, alongshore access from Oneula Beach Park is the only way for the public to get to the beach which fronts the Property. Alongshore pedestrian access extends westward to the NASBP boundary fence. Unauthorized access by all-terrain vehicles also occurs on a private dirt road through the Property west of Oneula Beach Park. This road terminates near the shoreline at approximately one-half of the distance to NASBP. Access to White Plains Beach, which lies beyond the fence, is through NASBP which allows public access only during special events held on base.

2. Beaches

Several beaches have been identified within the vicinity of the Property including those fronting the Property and Oneula Beach Park, Ewa Beach Park, White Plains Beach (also known as Nimitz Officer's Beach) and Nimitz Beach (See Figure 12). These beaches are used for swimming, surfing, snorkeling, and fishing.

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[17]AECOS, Inc. *Marine Algae Surveys for the Ewa Marina Coastline.* (Prepared for Belt Collins and Associates) June 1991.

Oneula Beach is situated east of the proposed marina entrance. Although nearshore waters are safe year-round, reef rock and beachrock at the shore and frequently murky waters contribute to poor swimming conditions. More desirable swimming conditions are available near the park's eastern boundary. Pole, net and spear fishing is popular along the western portion of Oneula Beach Park. The park provides 44 parking spaces.

Open to the general public, Ewa Beach Park is located on Fort Weaver Road, about 2-1/2 miles east of Oneula Beach Park. Activities at this 5-acre park include diving, pole fishing, snorkeling, surfing, swimming and throw-netting. The beach is also known for its abundance in edible seaweed, although the water is often murky with many rock outcroppings near shore.

White Plains Beach, formerly known as Nimitz Officers Beach, is located within a short distance to the west of the Property. It is located on NASBP and is not available to the public. A fence extending into the ocean prevents alongshore access, and authorized access can only be gained through the NASBP. General public access is allowed only during special events, such as Armed Forces Day, held on base.

Nimitz Beach, located west of White Plains Beach, is reserved for officers stationed on NASBP. Formerly referred to as "Horseshoe Beach" because of its shape, this beach is presently linear and sandy. The surfing break offshore from the beach provides an excellent place for novices to learn to surf. The beach is used primarily by military dependents. The ocean bottom is shallow and the shoreline is comprised of patches of reef and pockets of sand.

3. Surf Sites

Six surfing sites were identified in the vicinity of the Project site by the Hawaii Department of Planning and Economic Development's SCORP Studies in 1971: Officers, Coves, Johns, Sand Tracks, Hau Bush, and Shark Country. This study was updated by the Department of Land and Natural Resources (DLNR).[18]

In July 1978, the U. S. Army Corps of Engineers initiated a comprehensive inventory of nearshore marine environments in the State, catalogued by islands. The Oahu Coral Reef Inventory (OCRI) considered the island's entire coastline

[18]Moffatt and Nichol, Engineers. *Ewa Marina: Evaluation of Project Impacts on Surf Sites. Technical Study.* Prepared for HASEKO (Hawaii), Inc. November 1990. From "The Board Surfing Sites Survey" (unpublished report). Division of State Parks, Outdoor Recreation and Historic Sites. Department of Land and Natural Resources. 1976.

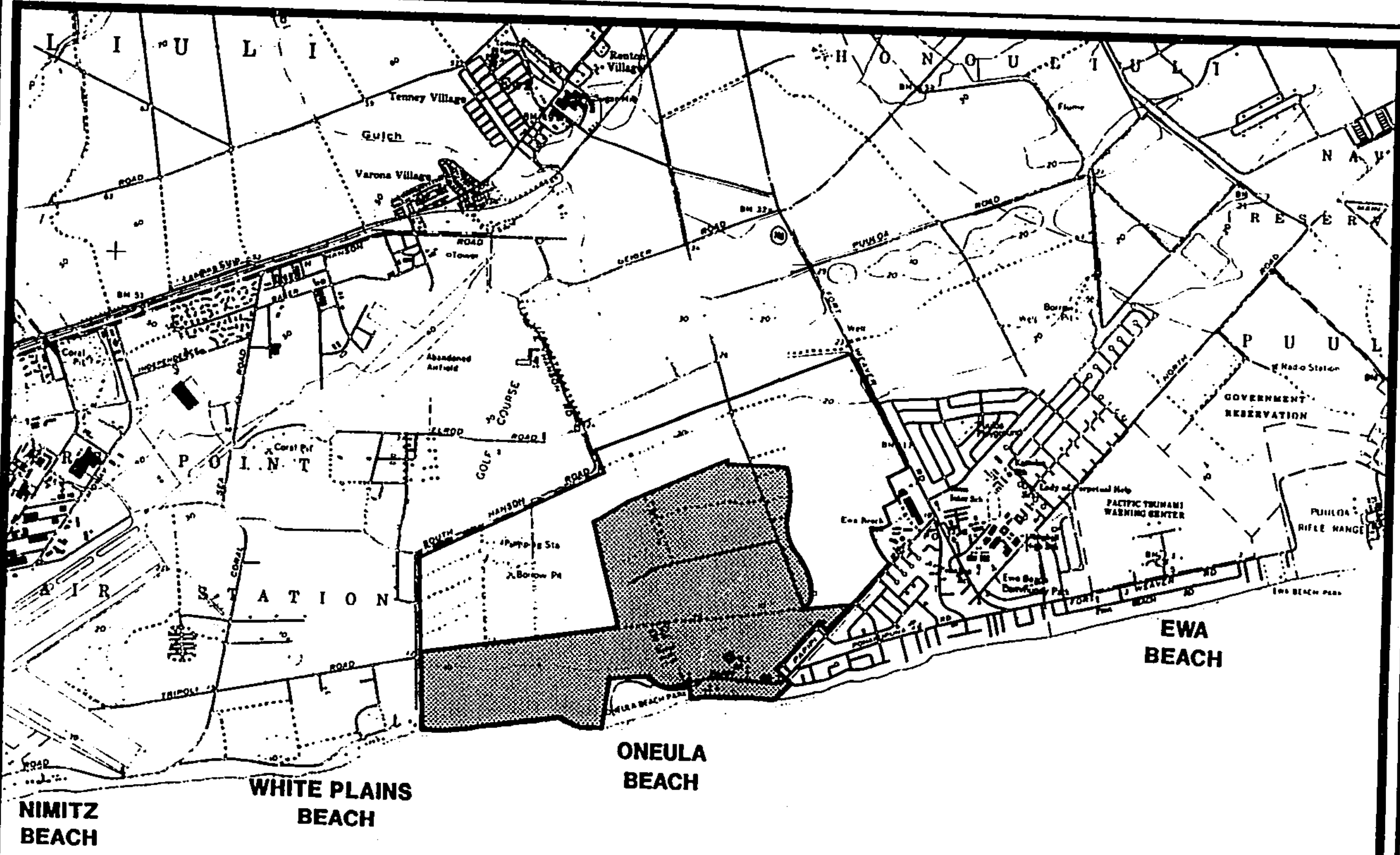


Fig. 12

LOCATIONS OF NEARBY BEACHES

Source: Moffat & Nichols Engineering, 1990

Prepared By: Wilson Okamoto & Associates, Inc.

from the terrestrial maritime zone seaward to water depths of about 100 feet. The Oahu Coastal Zone Atlas, prepared in conjunction with the OCRI identified two surf sites, "Coves" and "Officers", near the NASBP eastern boundary, and a third site, "Hau Bush", near Oneula Beach Park's eastern boundary. Additionally, a wave break was identified off Keku Point just west of Oneula Beach Park as favorable for body surfing or paipo board surfing during summer months.

In a study prepared by Moffatt and Nichol, Engineers, in November 1990 (See Appendix L) a number of local surfers were asked to locate these surf sites on a map. Seven surf sites were identified and include: Officers, Coves, Johns, Sand Tracks, Hau Bush, Shark Country and Tree Stumps (See Figure 13). Coves and Tree Stumps were also identified through historical aerial photographs and a bathymetric analysis. The waves near the Property are generally described as less dramatic and powerful than those of the north and west shores of Oahu. Shark Country was described as the best and most popular of the seven sites, and could accommodate up to 40 surfers at one time. The Coves site was described as a reef break, breaking both ways but primarily to the left (west) away from the adjacent headland. The "lefts" are ridden until the water becomes too shallow. The site typically breaks at 2 to 3 feet, is at its best 3 to 4 feet, can hold waves from 6 to 8 feet, and then either the wave closes out or the break moves farther offshore. Tree Stumps was described as one of the least surfed sites because of short rides. It was described as breaking to the right (east) only. The waves closed out when they exceeded 4 feet.

4. Visual And Aesthetic Resources

Inasmuch as Ewa Marina is located at the seaward edge of the broad, flat Ewa coastal plain, there is very little relief offering views of or from the Property. From the H-1 freeway, the Property can be seen in the distance and is identifiable as cane land set against a dark kiawe forest and the ocean. The existing Ewa Beach community can be seen as forming the eastern boundary. There are no distinguishing landforms in the vicinity and most development is characterized by low-rise residential structures set against cane fields. There are no obvious landmarks relating to the Property.

Driving down Fort Weaver Road, the topography is essentially flat and views are limited by structures, landscaping and cane fields lining the road. There are no significant view corridors toward the Property and ocean beyond. (See Appendix M).

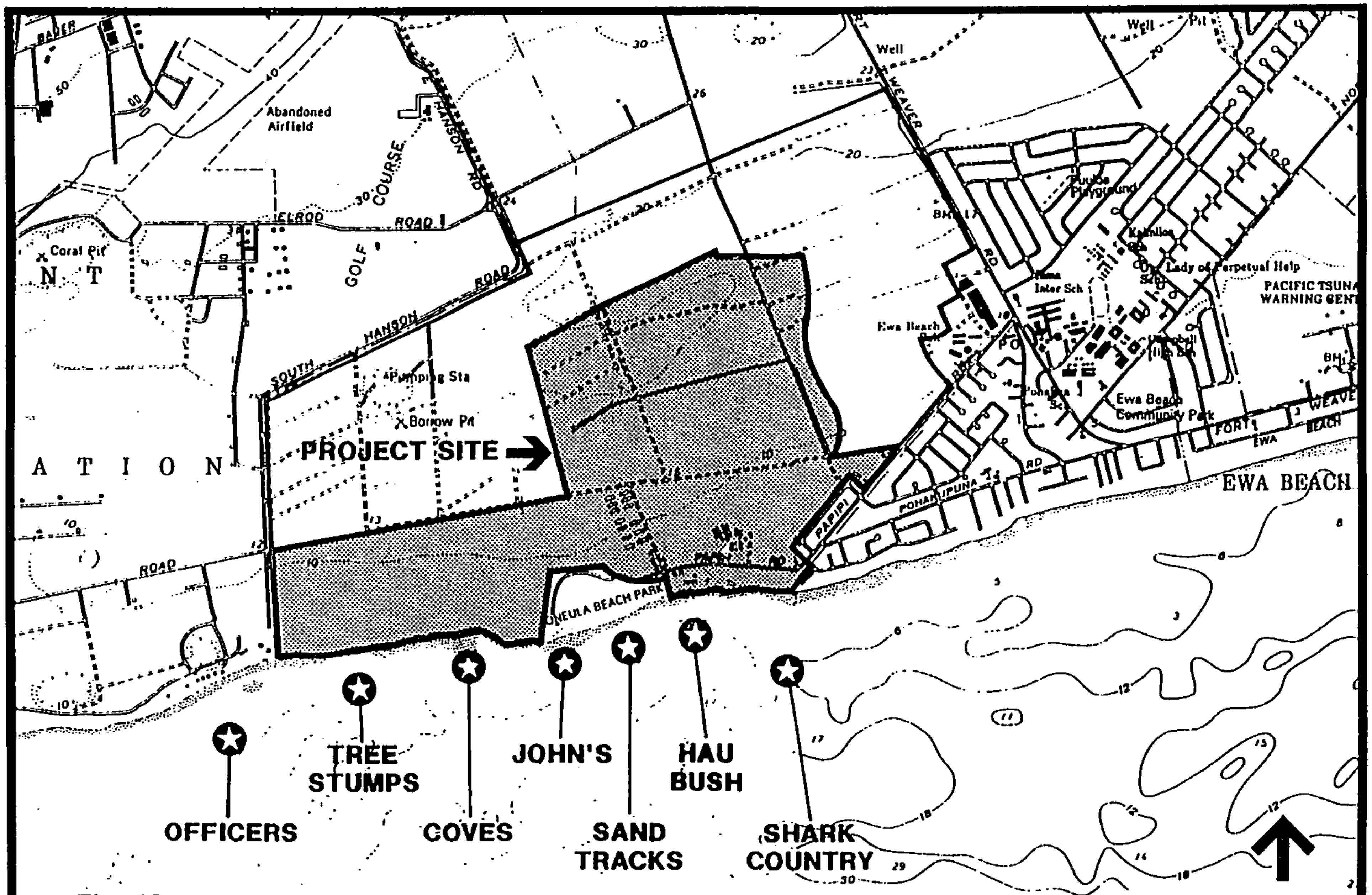


Fig. 13

LOCATIONS OF NEARBY SURF SITES
(1990 SURVEY)

Source: Moffat & Nichols Engineering, 1990

Prepared By: Wilson Okamoto & Associates, Inc.

At Oneula Beach Park, views in the mauka direction are limited by mature kiawe trees. Ocean and alongshore views are prominent near the water's edge. Similar views are available to those walking in either direction alongshore from the park. Much of the shoreline views are blighted by litter and abandoned vehicles.

5. Historic Resources

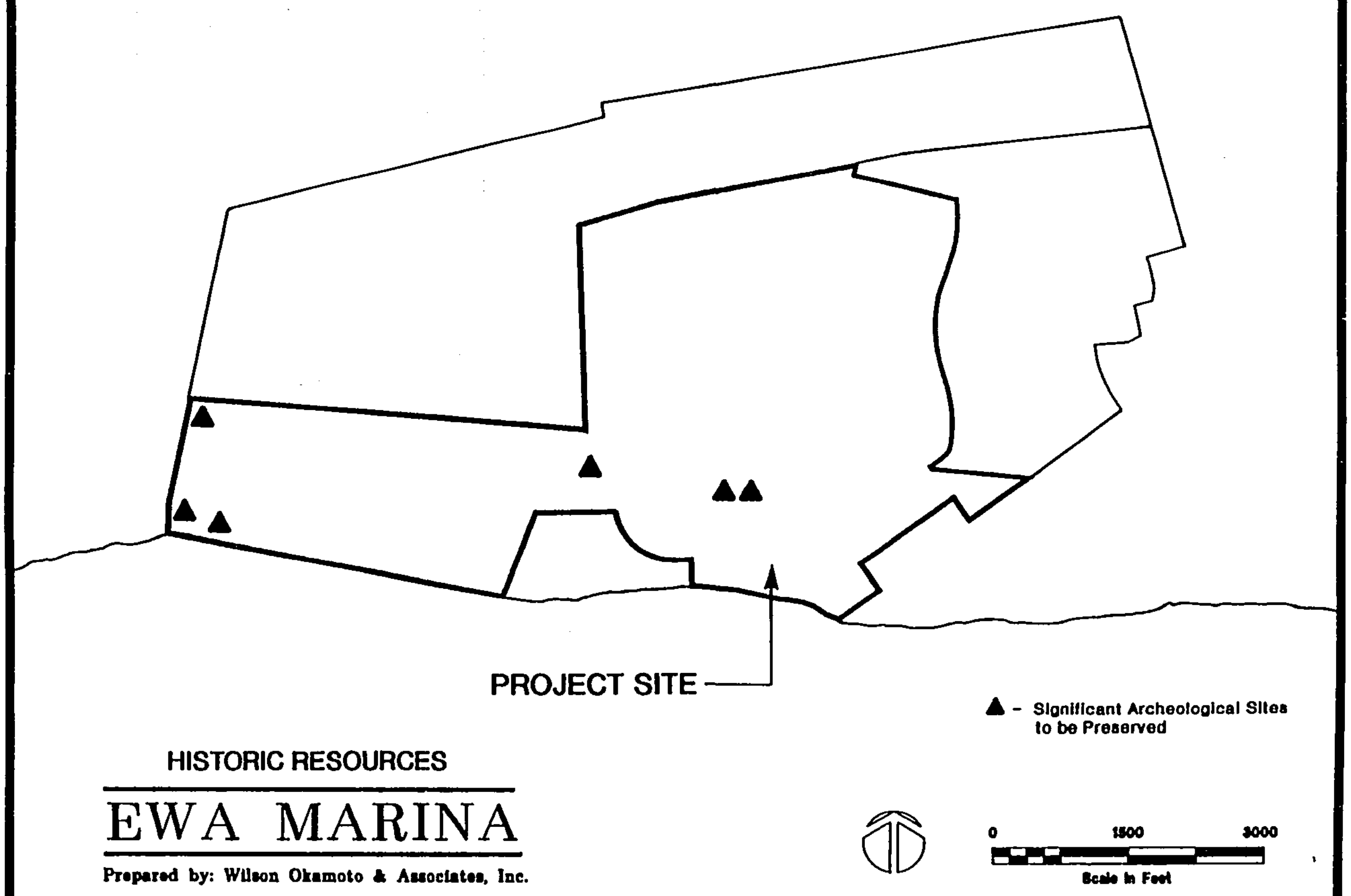
The Property constitutes almost the entire Oneula Archaeological District, a district determined eligible for inclusion on the National Register of Historic Places (NRHP). Overall, the sites range in condition from good to poor, with most being in fair to poor condition. Much of the area has been subjected to a variety of modern, twentieth century disturbances, including bulldozing of roads and vegetation, refuse dumping, sugar cane cultivation, and kiawe cutting.

In a recent archaeological survey, PHRI, in consultation with the Hawaii State Historic Preservation Office (SHPO) determined that 53 sites consisting of 312 features were identified (See Appendix N). Of the 53 sites identified within the Ewa Marina Project area, 47 were assessed as significant solely for information content. No further work was recommended for 32 of the 47 sites. At 14 of the 47 sites, further data collection was recommended. For one of the 47 sites, further data collection was recommended and preservation "as is" was provisionally recommended, pending further data collection results. Subsequent data collection indicates that no preservation is required. The remaining six sites were assessed as significant for information content and as excellent examples of site types (See Figure 14). Further data collection and preservation with some level of interpretive development were recommended.

F. Hazards

1. Flood Hazard

The Federal Emergency Management Agency's Flood Insurance Rate Map places areas along the shoreline in Zones A and AE, which are designated as special flood hazard areas inundated by the 100-year flood (See Figure 15). The mauka portion of the Property is designated Zone D, areas in which flood hazards are undetermined. As indicated on the map, the base flood elevations in Zone AE ranges from elevation 6 to 8 feet above mean sea level. No flood elevations have been determined for Zone A. The flood hazards associated with Zone A represent coastal flooding due to hurricanes, whereas Zone AE is associated with coastal flooding due to tsunamis. The tsunami phenomenon in this area would be that of rapidly rising and declining sea levels. (See Tsunami, Section D.7.)

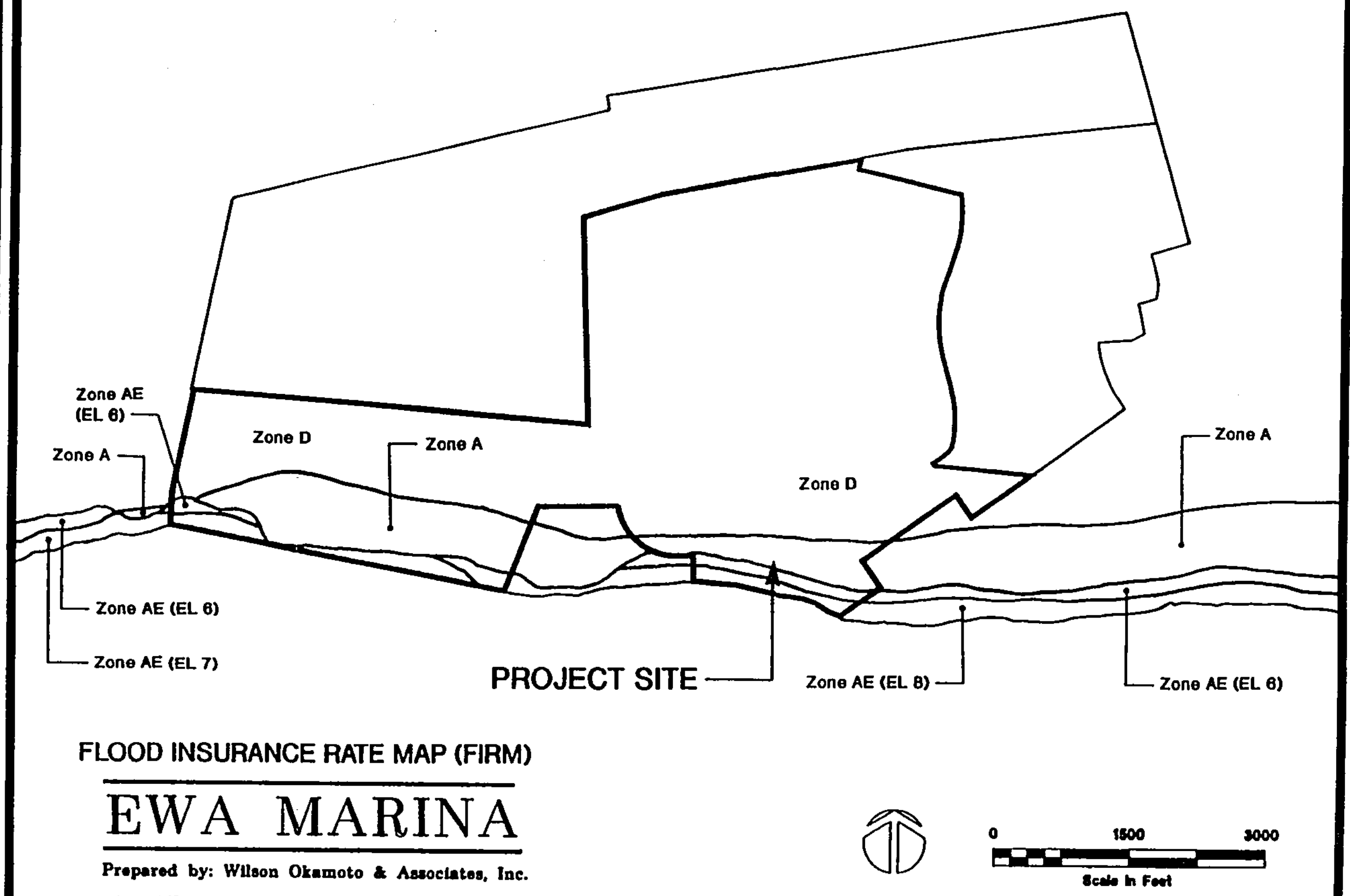


HISTORIC RESOURCES

EWA MARINA

Prepared by: Wilson Okamoto & Associates, Inc.

Fig. 14



FLOOD INSURANCE RATE MAP (FIRM)

EWA MARINA

Prepared by: Wilson Okamoto & Associates, Inc.

Fig. 15

2. Restrictive Easement

A portion of the Project site lies within a restrictive easement in favor of the U.S. Navy. This easement was established between the United States of America and Campbell Estate, the fee owner of the Property at that time. The easement resolved concerns pertaining to aircraft noise as well as the NASBP Accident Potential Zone (APZ). APZs are areas located within aircraft flight paths which potentially expose them to aircraft accidents.

A restrictive easement (See Figure 16), filed with the Land Court in 1989, covers approximately 80 acres on the western side of the Project and restricts the allowable uses of the easement area to those such as recreational activities, including but not limited to golf courses and clubhouses, marina, marina services and water recreation; resorts and group camps; parks and other cultural, entertainment and recreational uses.

3. Earthquake

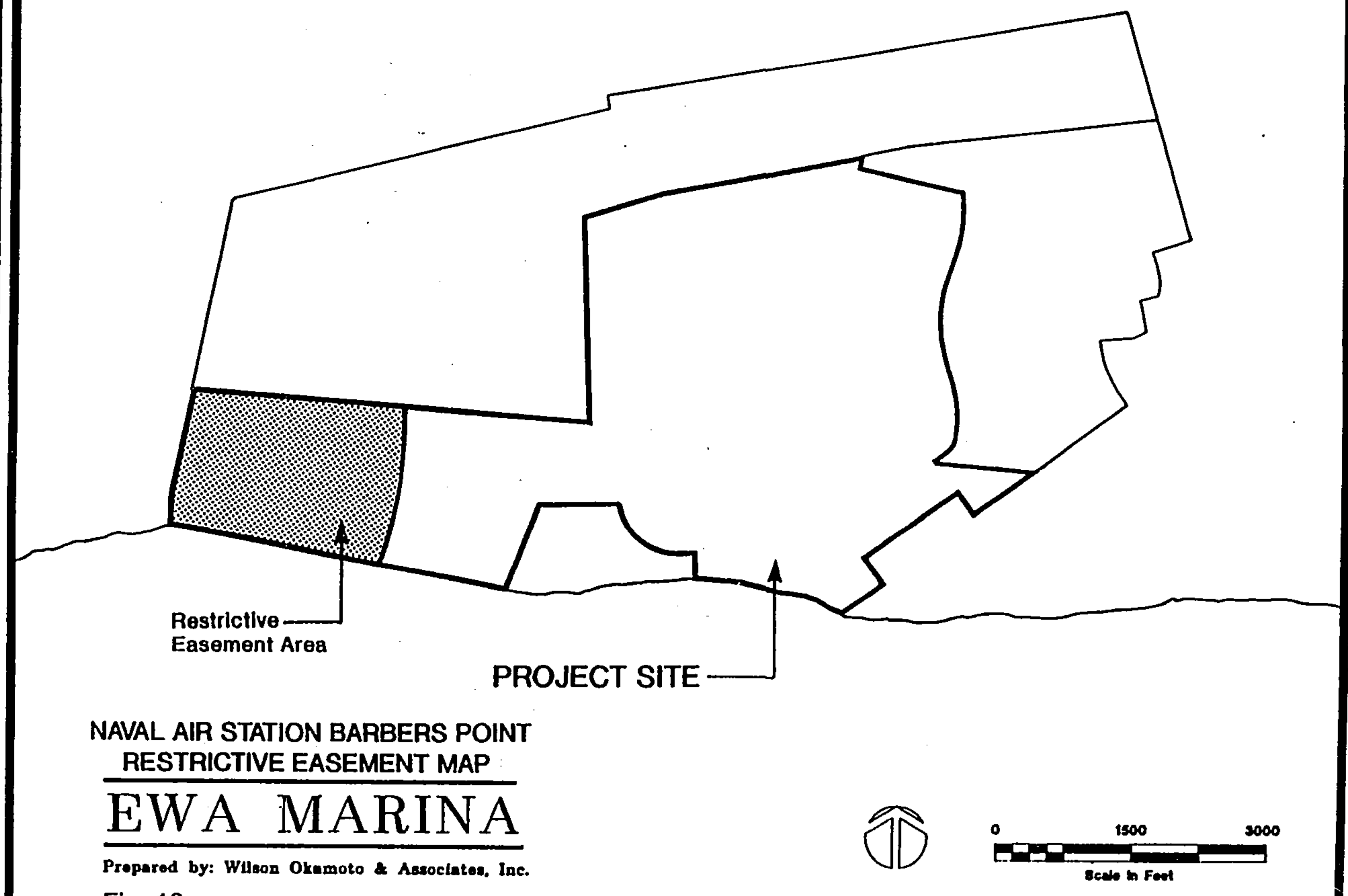
Implementing a recommendation by the Seismic Zonation Committee of the Structural Engineers Association of Hawaii, the Honolulu Building Code was recently revised to upgrade the seismic zone for Oahu from Zone 1 to Zone 2A. Zone 2A acknowledges a greater seismic threat to buildings than Zone 1. All structures in the Property must be designed to meet Zone 2A requirements.

4. Rising Sea Level

The potential for rising sea levels has been a concern expressed in recent years. Central to this concern is the "Greenhouse Effect," which, in theory, could melt glaciers and expand near-surface ocean water in a global ocean warming. Worldwide sea level rise has been about 12 cm (4.72 in.) over the past 100 years or about 1.2 mm (0.05 in.) per year. The average rate of sea level rise at Honolulu has been 1.5 mm (0.06 in.) per year for the years 1905 through 1968.[19] The highest rise considered possible is approximately 10 cm (3.9 in.) over the next 25 years or about 4 mm (0.16 in.) per year. This projection also accounts for the island of Oahu subsiding at a rate of about 0.4 mm (0.016 in.) per year.[20] Over the next 50 years, sea level rise is forecasted to continue,

[19] National Oceanic and Atmospheric Administration, Sea Level Variations for the United States 1855-1986, 1988.

[20] Committee on Engineering Implications of Changes in Relative Mean Sea Level of the National Research Council, Responding to Changes in Sea Level, National Academy Press, Washington D.C. 1987.



NAVAL AIR STATION BARBERS POINT
RESTRICTIVE EASEMENT MAP

EWA MARINA

Prepared by: Wilson Okamoto & Associates, Inc.

Fig. 16

reaching between 16 cm (6.3 in.) and 38 cm (15 in.), with 27 cm (10.6 in.) being the most likely rise.

G. Infrastructure

1. Traffic/Roadways

The Ewa area is served by regional and local roadways which include the H-1 Freeway, Farrington Highway, Fort Weaver and Kunia Road. Access to and from the Project site is provided exclusively by Fort Weaver Road, which spans about 5 miles from the H-1 Freeway to Ewa Beach. Fort Weaver Road also serves the communities of Waipahu, West Loch Estates, Ewa Beach, Iroquois Point Military Housing, NASBP, Ewa Villages and Ewa by Gentry.

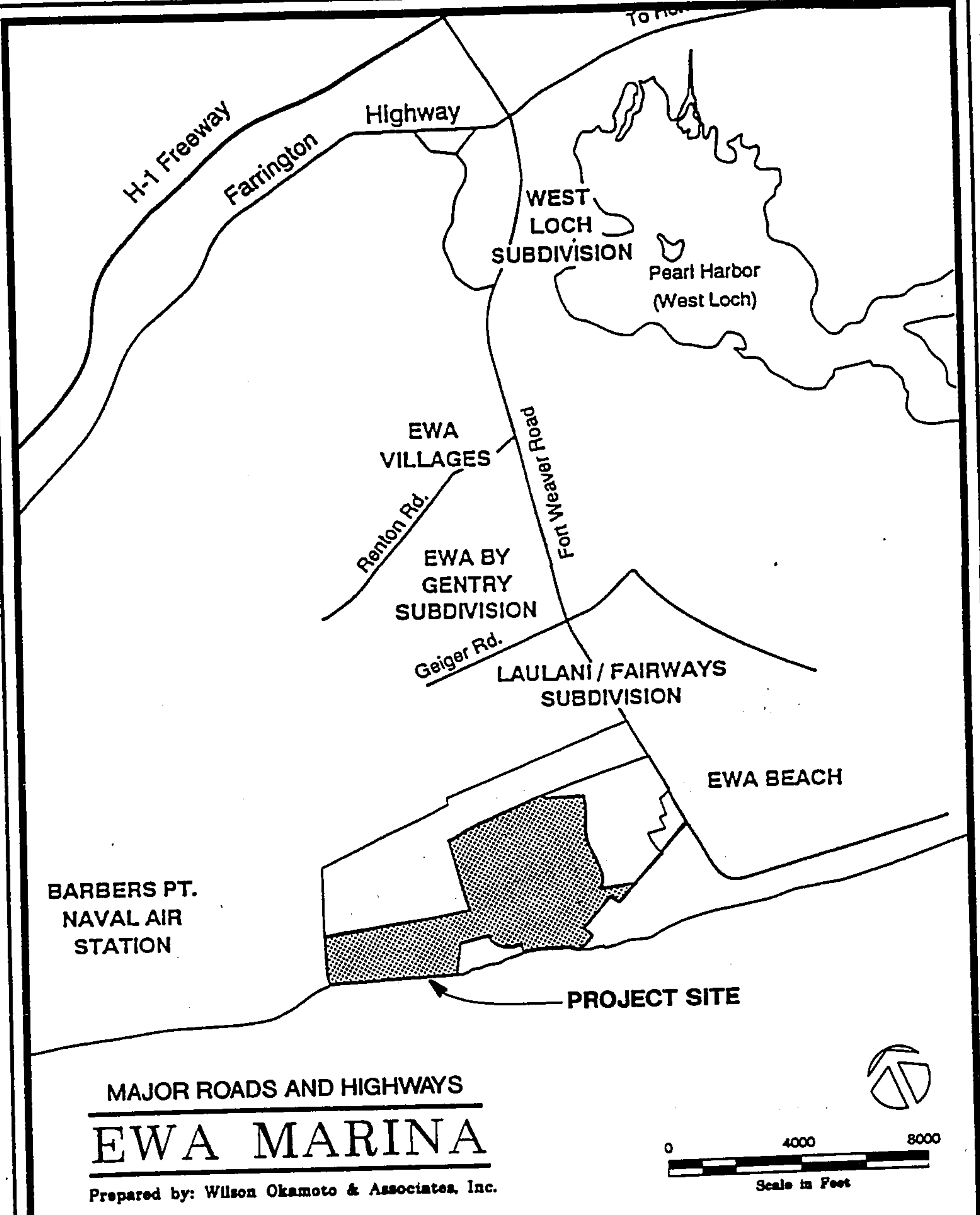
Secondary streets which branch off of Fort Weaver Road in the vicinity of the Project site include Hanakahi Street, Kuhina Street and Papipi Road (See Figure 17).

The DOT has substantially completed its widening of Fort Weaver Road in the vicinity of the Project to a four-lane divided arterial with turn lanes at intersections. Between intersections, the center lane is designated for use as two-way left turn lanes.

The Ewa Beach community, which borders the Project area, is also served by TheBUS, a public mass transit system which is operated and maintained by the City and County of Honolulu. Route 50 (Ewa Beach) provides service to Fort Weaver Road and Fleming Road to its terminus at Gate 2 at NASBP. Route 91 (Ewa Beach Express) provides express service on Fort Weaver Road with six morning trips to Honolulu and six afternoon trips from Honolulu.

Manual traffic counts were taken for the intersection of Fort Weaver Road and Papipi Road, as well as at the intersection of Papipi Road and Hailipo Street on July 24, 1991 from 3:00 to 5:15 p.m. and July 25, 1991 from 6:00 to 8:15 a.m. (See Appendix O). Additionally, traffic volumes in the vicinity of proposed Ewa Marina Access Roads A and B along Fort Weaver Road were derived from manual traffic counts obtained at the intersection of Fort Weaver Road and Hanakai Street.

The traffic conditions at the study intersections, using the planning analysis for signalized intersections, were characterized as under, near or over capacity according to the following traffic volumes:



MAJOR ROADS AND HIGHWAYS

EWA MARINA

Prepared by: Wilson Okamoto & Associates, Inc.

Fig. 17

Source : Pacific Planning & Engineering

- Under capacity: Less than or equal to 1,200 vehicles per hour.
- Near capacity: Between 1,201 and 1,400 vehicles per hour.
- Over capacity: Greater than 1,400 vehicles per hour.

Results of the analysis for existing conditions at the signalized intersection of Fort Weaver Road with Papipi Road indicated an under capacity condition during both morning and afternoon peak periods, with critical volumes of 906 and 988, respectively.

The methodology employed for unsignalized intersections provides results in terms of Levels-of-Service (LOS) for turning movements at intersections. LOS is based on a qualitative measure describing operational conditions. An LOS definition involves factors such as speed and travel time, freedom to maneuver, traffic interruptions, comfort and convenience and safety. There are six LOS designations from A representing the best operating conditions to F representing the worst. The turning movements at the unsignalized intersection of Papipi Road with Hailipo Road is currently operating at LOS A during both morning and afternoon peak periods.

In response to major developments planned for the Ewa region, the State Director of Transportation imposed a requirement for an Ewa Region Highway Master Plan. A Working Group involving State and City agencies, Campbell Estate, and major developers of the Ewa Region (including the Applicant) was then formed by the DOT to identify roadway system improvements which are necessary to accommodate forecasted future traffic. The Plan would also allocate fair share improvement costs to the major developers in the Ewa region. The joint efforts of the Working Group have resulted in the identification of the North-South Road as one of the major roadways which will be required in the Ewa Region.

2. Water

The Property is located within the Waianae District of the BWS water system. The existing Ewa Beach community is served by the Kunia and Hoaeae wells in Waipahu. Existing BWS infrastructure in the area includes a 30-inch water main running along Farrington Highway between Waipahu and the Barbers Point storage system and a 16-inch transmission main which branches off the 30-inch Farrington Highway main and runs the length of Fort Weaver Road to supply Honouliuli, Ewa Beach and Ewa Village with water.

In 1984, the Estate of James Campbell commissioned the Ewa Water Master Plan which established a water facilities plan to accommodate all planned developments in the Ewa area, including Ewa Marina. The Ewa Plain Water Development

Corporation (EPWDC) was created as a result on December 5, 1985. Members of the EPWDC include West Beach Estates, Gentry, the Estate of James Campbell and the Applicant. The EPWDC is responsible for water development in the Ewa area and the costs for these improvements are shared proportionately among its members.

The Ewa Water Plan (August, 1987) prepared by the EPWDC, establishes guidelines for water use in the Ewa area and was approved by the Board of Water Supply on October 15, 1987. Recently, a variety of new installations, including a 36-inch water main under Fort Weaver Road, water reservoirs, wells and pumping systems were completed in accordance with the approved master plan. These improvements will be dedicated to the BWS, adding to the BWS system described previously. The Applicant has contributed its proportionate share of the costs for these improvements which will provide water service to Ewa Marina.

3. Wastewater

Wastewater from the Ewa Beach community is collected by the City and County of Honolulu's Ewa Beach sewer system. This system consists of a gravity collection network which terminates at the Ewa Beach Sewage Pump Station where the collected wastewater is pumped into a 30-inch force main within Fort Weaver Road. The force main ties into an 84-inch gravity sewer line within Geiger Road. From there, wastewater flows into the Honouliuli Wastewater Treatment Plant.

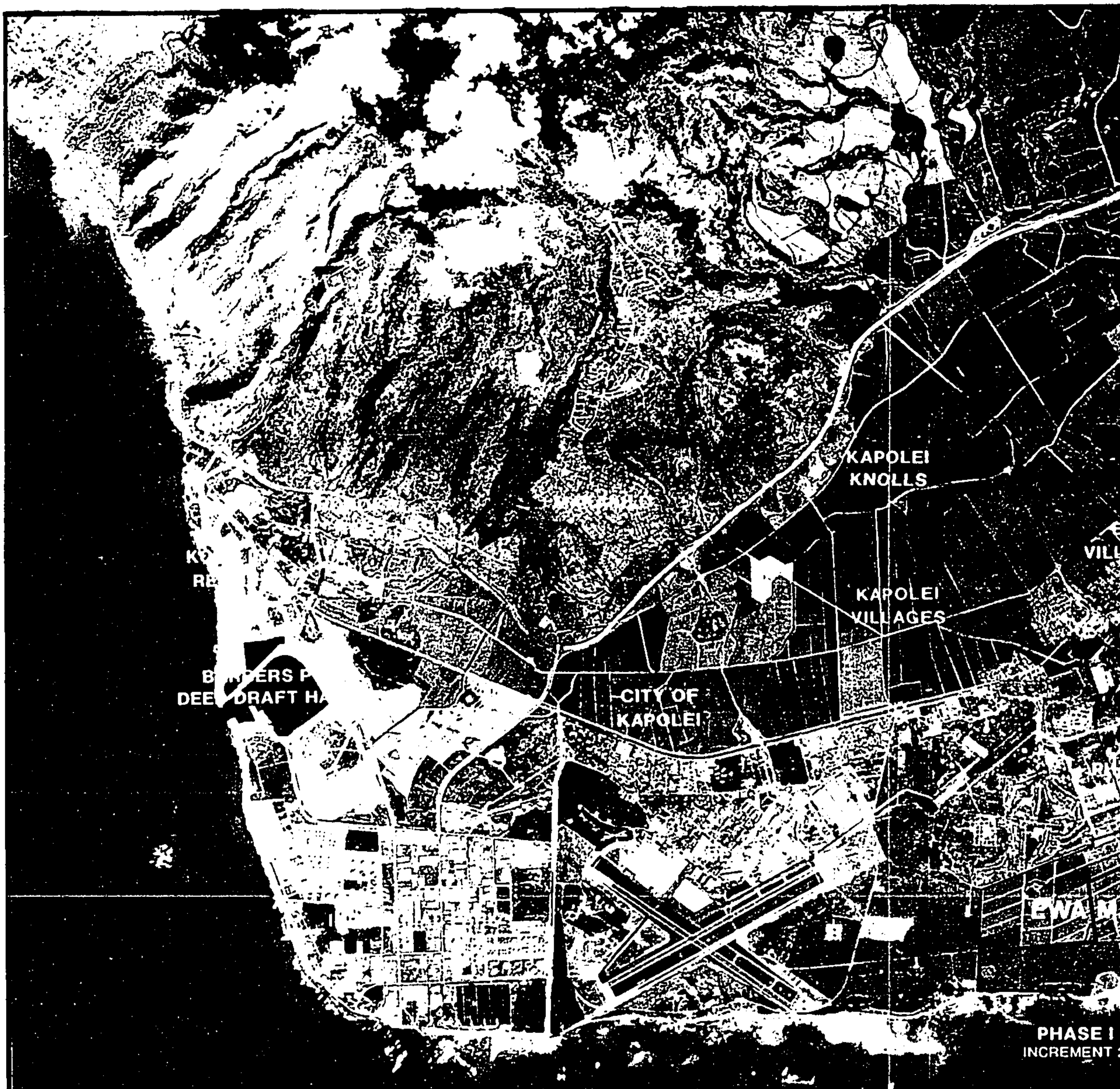
The Honouliuli Wastewater Treatment Plant has a capacity of 25 million gallons per day (mgd) and is presently operating near that capacity. The City and County of Honolulu Division of Wastewater Management has informed developers of the Ewa area that additional allocations for service will not be made until 1993 when a plant expansion to increase capacity to 38 mgd is scheduled to be completed.

4. Surrounding Land Uses

Existing uses in the vicinity of the Property include the James Campbell Industrial Park and the Barbers Point Harbor, and the existing communities of Makakilo, Ewa Beach, Iroquois Point Puuloa Military Housing, Ewa Villages, Honouliuli, Honokai Hale, and Nanakai Gardens (See Figure 18). Most of the remaining land is in sugar cane cultivation or lies fallow.

New residential developments in close proximity to the Property include the Ewa by Gentry 7,500-unit subdivision to the north, and the City and County of Honolulu's 1,500-unit West Loch development to the northeast.

Other major developments in the vicinity include the Applicant's adjoining Ewa Marina Phase II golf course and mixed-use development, the Kapolei Town Center, the State of Hawaii's 5,000-unit Kapolei Villages planned community, the 500-unit Kapolei Knolls residential project, the City and County of Honolulu's 1,805-unit Laulani/Fairways affordable housing project, the 1,130-unit Ewa Villages Revitalization project, the expansion of Makakilo by 2,200 units and the Ko Olina Resort, which will contain 5,200 resort residential units and 4,000 visitor units.



PREPARED BY: WILSON OKAMOTO & ASSOCIATES, INC

SURROUNDIN

SURROUNDING USES MAP Fig. 18

Chapter IV

Socio-Economic Environment

IV. SOCIO-ECONOMIC ENVIRONMENT

A. Profile of the Existing Community

Earthplan, a Honolulu-based consulting firm, has studied the socio-economic environment of the Ewa Region. Its findings are presented in this chapter (See Appendix P). The Ewa region's primary employment generator in 1985 was military activity, as shown in Figure 19, with about 39 percent of the total 11,121 region jobs held in Ewa. Service jobs were the next largest category at 16 percent of the total jobs. Figure 20 shows that about half of the jobs in the Ewa region were located at the NASBP, which is adjacent to Ewa Marina. The Ewa region experienced population growth double the Oahu rates over the past twenty years. Ewa's population has grown from 24,087 persons in 1970, to 38,324 in 1980 to 42,983 in 1990, as illustrated in Figure 21. This means that the area grew 4.2 percent a year in the 1970s, and 1.7 a year in the 1980s. These rates are about double the islandwide rates. From 1970 to 1980, Oahu's population grew at an average rate of 1.9 percent, and the islandwide rate dropped to slightly less than one percent from 1980 to 1990. Table 6 contains the average annual growth rates for Ewa and Oahu.

Table 6

Average Annual Growth Rate for the Ewa Development Plan Area: 1970 - 1990

	1970-1980	1980-1990	1970-1990
City and County of Honolulu	1.9%	0.9%	1.4%
Ewa Development Plan Area	4.2%	1.7%	2.9%

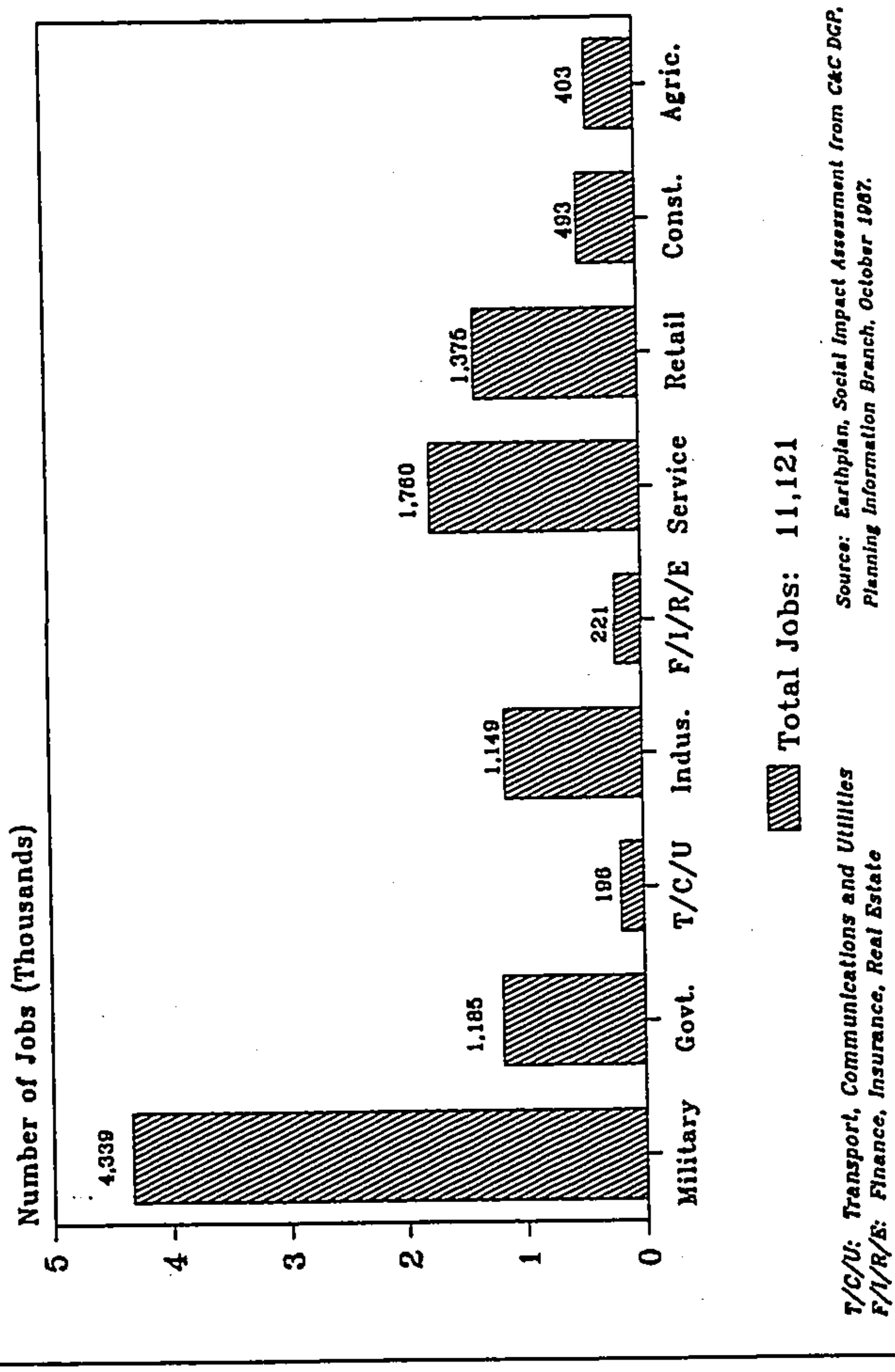
Source: Earthplan, *Social Impact Assessment*, 1992

In 1990, Ewa had 11,734 housing units, as shown on Table 7. Unlike the islandwide steady increase of multi-family units, Ewa's housing supply continues to be dominated by single-family units which accounted for 82 percent of the total housing stock.

Tables 8, 9 and 10 contain demographic, household and housing information for certain communities in Ewa. The highest proportion of single-family units is found in Ewa Villages where 95 percent are in that category. Ewa Beach, the community adjacent to the eastern portion of the project, also contains a high proportion, with 85 percent of its housing stock being single-family units.

Figure 19

Number of Ewa Jobs by Category in 1985



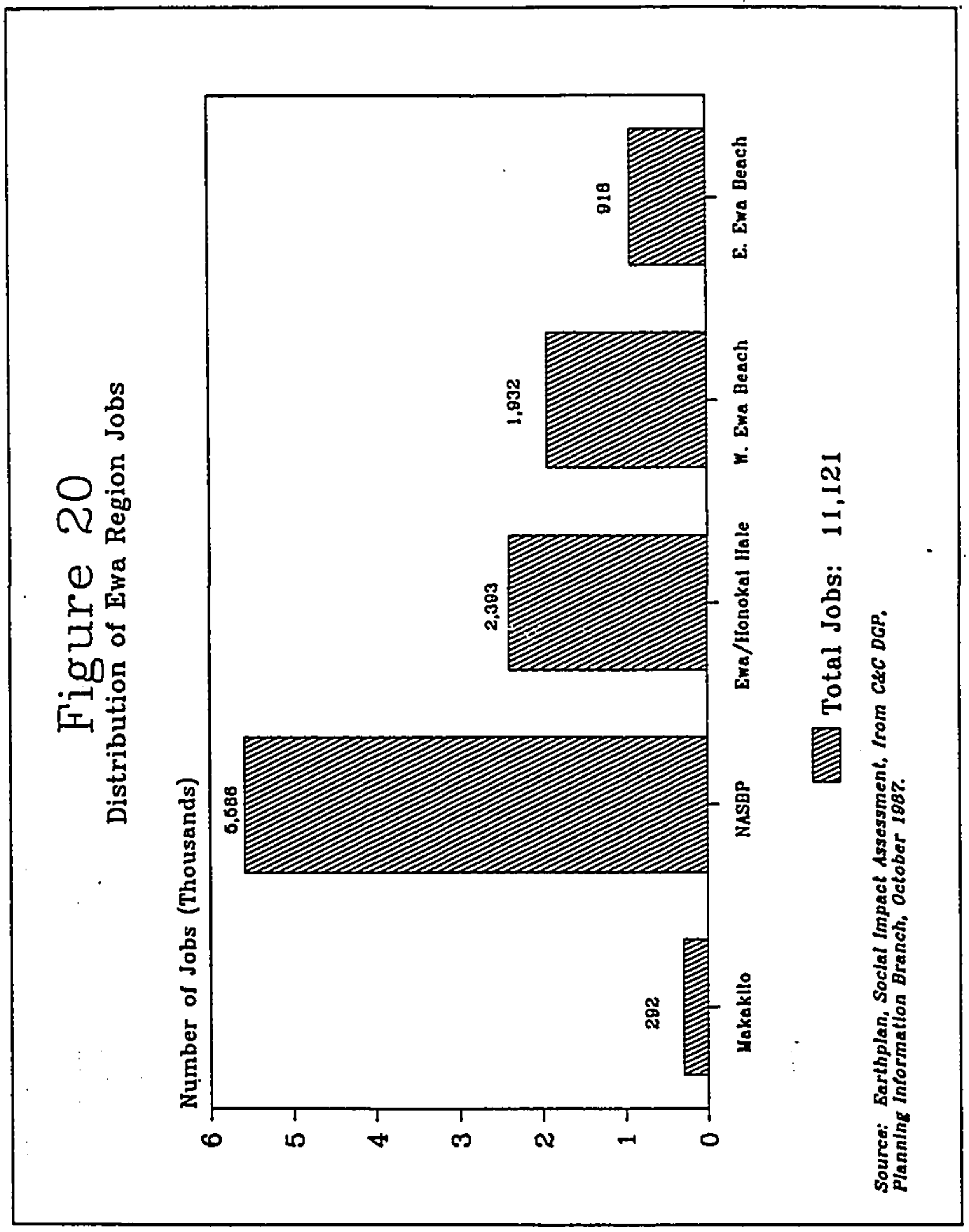
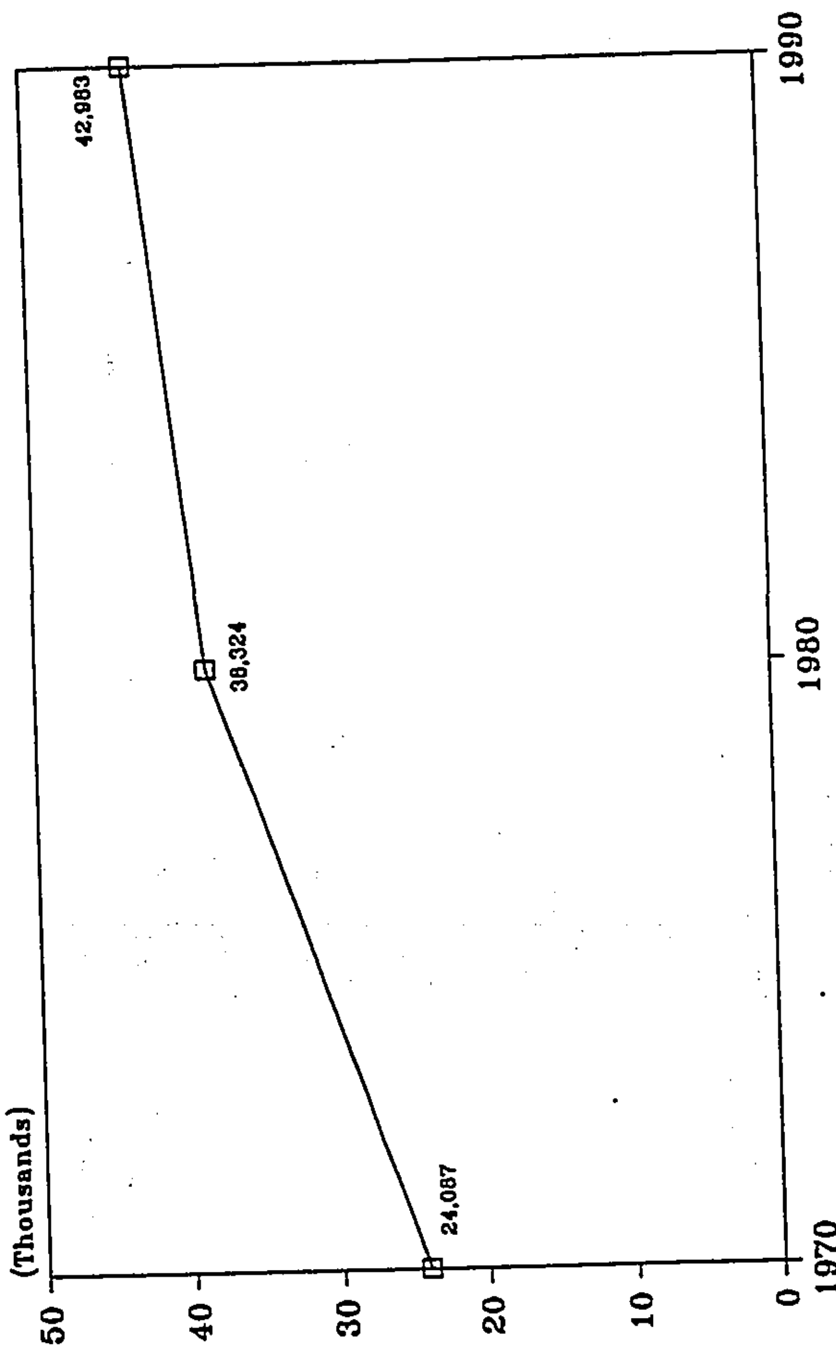


Figure 20
Distribution of Ewa Region Jobs
Number of Jobs (Thousands)
6
5
4
3
2
1
0
292
5,588
2,393
1,932
918
Makakilo
NASBP
Ewa/Honokai Hale
W. Ewa Beach
E. Ewa Beach
Total Jobs: 11,121
Source: Earthplan, Social Impact Assessment, from C&C DGP, Planning Information Branch, October 1987.

Figure 21

Ewa Population Trend: 1970–1990



Source: Earthplan, Social Impact Assessment, from U.S. Department of Commerce, Bureau of the Census, 1983 & 1991.

Table 7

Demographic and Housing Information for the Ewa Development Plan Area, 1990

Resident Population	**42,983**
Persons Living in Group Quarters	2.7%
Total Households	11,434
1-person	9.5%
2-person	21.7%
Over 2-person	68.8%
Average Household Size	3.66 persons
Total Housing Units	**11,734**
Types of Units	
Single-family	82.1%
Multi-family	16.4%
Mobile/other	1.5%
Total Vacant Units	300
Market Units	46.3%
Usual home elsewhere	5.7

Source: Earthplan, *Social Impact Assessment*, from U.S. Bureau of the Census, 1991, as compiled by the City Department of General Planning, Planning Information Branch

Table 8

Demographic Characteristics of Oahu and CDPs in the Ewa Development Plan Area, 1990

	Oahu	Barbers Point	Ewa Beach	Ewa Gentry	Ewa Villages	Iroquois Point	Makakilo City
Total Population	836,231	2,218	14,315	1,992	3,780	4,188	9,828
% Male	50.9%	52.8%	50.9%	51.4%	50.5%	50.9%	51.8%
% Female	49.1%	47.2%	49.1%	48.6%	49.5%	49.1%	48.2%
Ethnicity							
Caucasian	31.6%	75.6%	23.0%	31.3%	8.4%	79.6%	47.1%
Asian/Pacific Islander	63.0%	10.8%	72.6%	64.3%	89.4%	9.6%	46.9%
Black	3.1%	9.6%	1.4%	2.2%	0.2%	7.3%	3.3%
American Indian/Eskimo	0.4%	0.7%	0.3%	0.7%	0.4%	0.9%	0.5%
Other	1.9%	3.3%	2.7%	1.6%	1.6%	2.7%	2.2%
Age							
Less than 5 years	7.4%	19.3%	7.4%	10.0%	6.6%	17.8%	8.3%
5 to 17 years	17.1%	9.6%	23.1%	15.0%	21.2%	24.9%	19.0%
18 to 64 years	64.5%	70.9%	62.9%	72.3%	56.9%	57.0%	69.6%
65 or more years	11.0%	0.2%	6.7%	2.7%	15.2%	0.3%	3.2%
Median Age	32.2	24.7	28.6	28.4	32.4	25.6	29.8

Source: Earthplan, *Social Impact Assessment*, from U.S. Bureau of the Census, 1991.

Table 9

Household Characteristics of Oahu and CDPs in the Ewa Development Plan Area, 1990

	Oahu	Barbers Point	Ewa Beach	Ewa Gentry	Ewa Villages	Iroquois Point	Makakilo City
Total Population	836,231	2,218	14,315	1,992	3,780	4,188	9,828
Persons Living in Group Quarters	4.1%	3.0%	0.1%	0.0%	0.0%	0.0%	0.0%
Total Households	265,304	854	3,355	708	902	1,174	2,978
Non-Family Households	68,010	171	381	207	101	22	601
Family Households	197,294	683	2,974	501	801	1,152	2,377
As % of Total Hshlds	74.4%	80.0%	88.6%	98.1%	88.8%	98.1%	79.8%
Married Couples	80.3%	90.5%	80.7%	90.6%	79.0%	96.3%	87.5%
Other Family Hshlds	14.1%	9.5%	19.3%	9.4%	21.0%	3.7%	12.5%
Persons Per Household	3.02	2.52	4.26	2.81	4.19	3.57	3.30

Source: Earthplan, *Social Impact Assessment*, from U.S. Bureau of the Census, 1991.

Table 10

Housing Unit Characteristics of Oahu and CDPs in the Ewa Development Plan Area, 1990

	Oahu	Barbers Point	Ewa Beach	Ewa Gentry	Ewa Villages	Iroquois Point	Makakilo City
Total Housing Units	281,683	866	3,426	752	939	1,180	3,050
Single-family	44.9%	49.3%	85.6%	49.7%	94.6%	96.3%	79.1%
Multi-family	53.6%	48.4%	13.0%	48.9%	2.9%	2.6%	19.9%
Mobile/other	1.5%	0.3%	1.4%	1.3%	2.6%	1.1%	1.0%
Total vacant units	5.8%	1.4%	2.1%	5.9%	3.9%	0.5%	2.4%
Total occupied units	265,304	854	3,355	708	902	1,174	2,978
With 1+ persons per room	16.4%	4.8%	31.6%	16.7%	41.8%	4.3%	11.9%
Owner-occupied	52.0%	0.4%	69.1%	79.8%	65.5%	0.6%	73.6%
Renter-occupied	48.0%	99.6%	30.9%	20.2%	34.5%	99.4%	26.4%
Median cash rent	$615	$644	$701	$907	$100	$758	$960
Median value of owner-occupied units(*)	$283,600	$275,000	$216,000	$277,600	$116,500	$125,000	$246,600

* Median values are for non-condominium housing units.

Source: Earthplan, *Social Impact Assessment*, from U.S. Bureau of the Census, 1991.

Though the 1990 median values of owner-occupied homes were lower in Ewa when compared to islandwide statistics, median rent exceeded the Oahu median. Median values ranged from a low of $116,500 in Ewa Villages to a high of $277,600 in Ewa Gentry; these communities are adjacent to each other. The Oahu median home value was $283,600.

The highest rents were found in the relatively newer communities of Makakilo and Ewa Gentry, where respective monthly rents of $960 and $901 exceeded the islandwide median by about $300.

In spite of these high rents, however, Ewa region homes were sought after, as indicated by very low vacancy rates. Whereas Oahu has a total vacancy rate of 5.8 percent, Ewa Beach and Makakilo had rates at less half the islandwide figure, with 2.1 and 2.4 percent, respectively. The military communities had especially low vacancies with 1.4 percent for NASBP and 0.5 percent for IPP Military Family Housing.

Demographic and household characteristics are summarized as follows:

1. Ethnicity and Age.

The older communities in Ewa retain a few distinctions from the Oahu averages when it comes to ethnicity. Ewa Villages and Ewa Beach are well-represented in Asians and Pacific Islanders with 89 and 73 percent, respectively, in this category. NASBP and IPP Military Family Housing have significantly high proportions of Caucasians (76 and 80 percent, respectively). Ewa Gentry, the area's newest community, has ethnic proportions similar to Oahu.

Ewa region communities tend to be slightly younger than the Oahu-wide community. The military communities are the youngest. NASBP has a median age of 24.7 years; IPP, 25.6 years. With a median age of 32.4 years, Ewa Villages is the only community which exceeds the islandwide median age (32.2 years).

2. Family Households.

In 1990, 74 percent of Oahu's total households were family households. Most of Ewa's communities exceeded this proportion. The highest proportion of family households was found in IPP Military Family Housing (98.1 percent), followed by Ewa Villages (88.8 percent) and Ewa Beach (88.6 percent). Ewa Gentry was the only community with a proportion lower than that of the island, with only 71 percent of its households being family households.

3. Household Size.

Ewa has traditionally had larger-than-average households, and the 1990 Census reveals a continuation of this trend in the region's older communities. The largest households were found in Ewa Beach (4.26 persons) and Ewa Villages (4.19 persons). The households in both communities contained 1+ more person than the average islandwide household of 3.02 persons. The only community with households smaller than the islandwide average was Ewa Gentry, with an average household size of 2.81 persons.

B. Public Services And Facilities

1. Police Protection

Ewa is in District III, which extends from Red Hill to Kaena Point and Kipapa Ridge and is served by the Pearl City Police Station. Currently 18 beat officers operate in the Ewa DP area daily.

Long-term plans include adding a new full-service station in Kapolei, with the establishment of Ewa and the Waianae Coast as a new district. The Kapolei station would be the headquarters for five beats in Ewa and eight beats along the Waianae Coast. In addition, two substations are proposed by the Police Department. Both are long-term in nature.

2. Fire Protection

First Alarm at the project site is handled by the Ewa Beach and Waipahu Fire Stations. The Makakilo Fire Station provides backup. Currently, there are 15 firefighters per shift at the Ewa Beach Fire Station.

To accommodate anticipated growth in Ewa, four new fire protection facilities are being planned. First, planning and design funds have been allocated for a new fire station at the James Campbell Industrial Park. This is envisioned as an engine-and-ladder company and will have a battalion chief. Second, the Ko Olina Phase 1 fire station would also be an engine and ladder company, with twelve firefighters per shift. Third, there have been tentative plans for the relocation of the existing Ewa Beach Fire Station to Ewa Marina. Finally, another fire station is planned at Ewa Villages, but no time frame has been determined.

3. Recreational Facilities

The Ewa DP area contains four beach parks, four community parks and four neighborhood parks. In addition, there is also Kapolei Park, which is a 28-acre undeveloped regional park.

4. Public Education

Ewa Marina is in the Campbell High Education Complex (hereby called Campbell Complex) of the State Department of Education. The elementary schools in this complex include Barbers Point, Ewa, Ewa Beach, Iroquois, Kaimiloa, Makakilo, Mauka Lani, and Pohakea Elementary Schools. These schools all feed into Ilima Intermediate and Campbell High Schools.

Table 11 contains enrollment information for these schools. The elementary schools have experienced slight decreases in enrollment, while the upper schools have been increasing in students.

Table 11

School Enrollment Trends for Certain Campbell Schools

School	1989*	Projected 1991*	Actual 1991**	Difference Between Projected and Actual 1991	Difference Between Actual 1989 and Actual 1991
Ewa Beach Elementary	403	523	399	-23.7%	-1.0%
Pohakea Elementary	558	525	550	4.8%	-1.4%
Ilima Elementary	969	1,067	1,013	-5.1%	4.5%
Campbell High	1,634	1,865	1,652	-11.4%	1.1%

* From State Department of Education, 1990.
** Personal communication with Tom Saka, Demographics Specialist, State Department of Education, September 11, 1991.
Source: Earthplan, *Social Impact Assessment.*

In anticipation of residential growth, State public education officials have been planning school facility additions and administrative changes. Four new schools are being planned for the Ewa region including two elementary, one intermediate and one high school. With these schools, the Ewa region public schools will have a design enrollment of 13,700. It is anticipated that, eventually, the western schools in the Campbell Complex, including those in Kapolei and Makakilo, will feed into a new Kapolei High School Complex.

5. Child Care

Because of the increase in residential population and on-site employees, the provision of child care facilities is an increasingly significant concern. Currently three sites have been committed for child care facilities: West Loch and Royal Kunia both have a 5.3 acre site for a park-and-ride facility with a 30,000 square foot child care center. Ko Olina has one acre for child care and other public facilities. In addition, three potential child care centers are being explored in Kapolei.

6. Medical And Emergency Services

The St. Francis-West Hospital is located approximately 4.5 miles north of Ewa Marina and is accessible via Fort Weaver Road. The general community hospital contains 136 acute care beds and has 130 resident physicians. The hospital offers X-ray, Laboratory, obstetrics and emergency services. Two other hospitals are also within reasonable travelling distance of the project site -- the Kaiser Foundation Health Plan in Moanalua and the Pali Momi Medical Center near the Pearl Ridge Shopping Center. In addition, the area contains numerous medical clinics and doctors' offices.

As Kapolei City progresses, additional medical facilities will be required to serve the increased population.

Emergency services are provided by City ambulances located in Aiea. Further, the Waipahu Fire Station contains an ambulance unit which serves Pearl City, Waipahu, Ewa Beach, Makakilo and parts of Waianae. Also eight-hour service is provided to the Makakilo Fire Station by the Waipahu unit. Twenty-four hour ambulance service at the Makakilo Fire Station is currently in the planning stage.

C. Existing Community Issues on Ewa Marina

Earthplan has monitored and examined existing Ewa community issues over the past few years and has analyzed issues specific to the Ewa Marina development, including Phases I and II (See Appendix P). Social issues are reactions to community events and will change over time, as people's priorities and values change. The following summarizes and analyzes community issues regarding Ewa Marina:

1. Increasing apprehension towards development and its changes

As Ewa is developed, the realities of development temper the community's earlier enthusiasm. New communities are coming up, and roads are being improved. Compared to just a few years ago, there is more traffic, new children are attending local schools, and new faces are seen at the shopping centers.

Whereas the Ewa Neighborhood Board has previously endorsed most changes in Ewa, Board members are increasingly scrutinizing new projects and placing conditions on their positions. Likewise, during interviews conducted by Earthplan, there was a tendency to mention traffic, water and sewerage as major concerns.

2. Acceptance of and support for Ewa Marina continues

Ewa Marina has been discussed for over a decade and community leaders in Ewa Beach have consistently supported the project. The most recent endorsement was in April 1991, when the Ewa Neighborhood Board No. 23 voted to support Phase II of Ewa Marina with conditions.

3. Recent opposition to the project

Until 1990, testimony at public hearings was generally in favor of Ewa Marina. In June 1990, however, at the State Land Use Commission hearing for Urban designation for Phase II, a spokesperson for the Save Ewa Beach Ohana cited a petition with over 2,400 signatures. It appears that no signatures have been added to the petition in the following year as a 2,400-signature petition was submitted to the City and County of Honolulu Planning Commission in September, 1991. The extent of opposition to Ewa Marina is unclear at this time and the only way to realistically gauge the extent of opposition is to conduct a statistical poll under controlled conditions.

4. Direct correlation between one's attitude towards community change and one's view of Ewa Marina

Earthplan's analysis of community reactions on Ewa Marina suggests that one's support or opposition to the overall project can be directly correlated to one's attitude towards change. There are those who are optimistic about community changes already occurring or being planned for Ewa. These people generally see changes, including Ewa Marina, as the solution to current problems such as the housing shortage, crime, and lack of recreation and youth activities. They believe that the project will bring social diversity, more facilities, and generally a better quality of life for Ewa residents.

Those who are generally apprehensive or pessimistic about community changes tend to see development as the root of problems. To them, development will bring a greater shortage of affordable housing, more crime, and newcomers who will change the community. This latter group is already concerned about changes which are occurring, such as Ewa Gentry and West Loch. Ewa Marina is perceived by them as an even bigger threat because it would be the closest to Ewa Beach.

5. Attitude towards tourism and tourists

The statewide tourism survey indicates two important tendencies with Ewa residents. First, the majority of respondents liked tourists; they had pleasant experiences on a one-to-one basis. Further, Ewa respondents felt very positive about the benefits of tourism; they believed that tourism benefits outweigh its problems.

The second tendency appeared contradictory. Ewa respondents also believed that tourism had negative impacts on existing major community problems. They felt that tourism made the cost of housing and traffic worse. Most people didn't want any more hotels because of these apprehensions.

The basic difference is that the first tendency is based on one's actual experience, whereas the second tendency emerges when a person looks at tourism symbolically.

The interviews by Earthplan indicated similar tendencies. Those interviewed did not object to having tourists in their area, but some had very strong feelings against the hotels. They feared that tourism will negatively affect the residential character of the area, and essentially produce another Waikiki. The have/have-not syndrome was a problem also, especially if affluent tourists were attracted to the area. To these people, the negative connotations of tourism could be realized if Ewa Marina contains hotels.

6. Shift in interest in employment

When Ewa Marina was first introduced to Ewa, the sheer increase in the number of jobs was a major plus to Ewa residents. As unemployment decreases and as the employment prospects for Kapolei and Ko Olina become more evident, "jobs" is no longer development's big plus. Rather, Ewa residents are now looking at the types of jobs. They want to see a diversity of jobs, and, more importantly, opportunities for local residents to have upward mobility in the job market.

7. More specific questions and concerns about ecological and environmental impacts

The community's awareness of potential environmental issues has grown in the last few years. People who read newspapers and attend public meetings are becoming knowledgeable about groundwater, shoreline habitats and air quality. Whereas people were formerly concerned about Ewa Marina's impact on "the environment," they are now more informed and direct their questions to more specific issues.

D. Recreational Activities

Existing shoreline activities along the Property and the perceived impact of the proposed Ewa Marina development on those activities is a significant issue to the Ewa community. The following is a summary of a study of ocean activities.[21]

1. Fishing and Crabbing

Fishing use is moderate along the western portion of the Property because improved access is limited to Oneula Beach Park. Pole fishing from shore is the most popular activity and catches of papio, ulua, 'o'io, and goatfish are reported. Both net- and spearfishing take place from the beaches. Pole fishing from boats also takes place offshore. In deep water, octopus and lobster have been trapped.

The shoreline from Oneula Beach Park to the NASBP fence is a low coral bench, and the primary activity along this reach is pole fishing, either shore casting or whipping. The fishers often spend the day or camp with their families on weekends. They fish for papio, ulua, and moi. This rocky shoreline is also a good area for catching a'ama crabs, the common black rock crabs which are a popular raw dish at luaus.

Development of the area and convenient public access will likely attract more fishers. This may increase competition for the preferred existing fishing sites.

[21] Clark, John. Assessment. Earthplan.

The impact of additional pole fishing pressure on fish populations as a result of improved public access will likely be insignificant in this well fished area. Disruption of the benthic habitat as a result of constructing the marina and related structures is also anticipated to increase fish populations in the area. In conjunction with the project, to implement the policy of no net loss of habitat, an artificial reef will be constructed, although the site has yet to be determined in coordination with federal and state agencies.

More crabbers will also be attracted to the area, and this will put additional pressure on the crab population. Although the jetties will provide additional crab habitat, some crabbers have noted that, in other harbor areas, such as the Ala Wai Boat Harbor, the increased pedestrian traffic makes the crabs skittish and harder to catch.

The boat channel will cut off continuous lateral access along the shoreline from Oneula Beach Park to NASBP fence. The project will, however, provide public access to both the west and east sides of the channel through a vehicular and pedestrian circulation system.

2. Seaweed (Limu) Gathering

A variety of seaweeds grow on the shallow ocean bottom offshore the beach. These seaweeds are dislodged by water movement, transported onshore, and deposited on the sand. The beach provides an important seaweed gathering site for residents of Ewa Beach and other surrounding communities. Seaweed is gathered by waders from "limu piles" or concentrations of seaweed floating nearshore, and by skin divers who harvest the seaweed directly from the ocean bottom. In recent years harvests have declined significantly in the area. Many attribute the cause for this decline to offshore harvesters who pull seaweed by the roots, leaving nothing to regenerate.

All of the seaweeds commonly gathered at the beach are used for home consumption, but the limu wawae'iole is also sold commercially to stores and at the local farmers' market. Commercial seaweed gathering is illegal without a permit, but many informants indicate that this occurs anyway.

Those interviewed by Earthplan did not feel that Ewa Marina will have an impact on the present seaweed population or seaweed gathering activities. During the construction phase, it was felt that some siltation would occur, and that the prevailing currents would probably carry the plume in a westerly direction, away from the beach and seaweed grounds.

3. Swimming/Snorkeling/SCUBA Diving

Nearshore waters are safe all year, but reef rock and beach rock at the shore contribute to poor swimming conditions at the beach park. The waters are usually murky, which limits snorkeling opportunities. The best swimming area is in front of a rock-free section of shoreline at the boundary of Oneula Beach Park and the beach to the east. The rest of the beach is made up of patches of coral outcropping along the water's edge.

Poor underwater visibility and lack of bottom relief limit sport diving opportunities near shore. Further offshore, however, steep drops to terraces in deep water are visited by scuba divers. Commercial dive shops run charters to the offshore drop-offs.

The eastern portion of the beach fronting the private camping sites, popularly known as Hau Bush for the large stands of hau in the backshore, is used by campers for traditional beach activities, such as swimming and sunbathing. The nearshore bottom, however, is shallow and rocky, offering only marginal swimming sites appealing mostly to children. Although the western portion of the site is primarily rocky, there are several small pockets of sand in the rocks that are used by children as swimming holes.

Ewa Marina would probably not impact the present swimming and sunbathing activities. Some concern was noted regarding the potential for beach-goers to trespass onto White Plains Beach, an attractive white sand beach fronting NASBP which is separated from the project site by a chain link fence.

Some skin diving for reef fish, octopus and lobster occurs along the rocks. From all accounts, however, visibility is poor for most of the year. Hence, most of the in-water fishing consists of laying nets. Some scuba diving and spear fishing occur from boats.

Diving is also limited by the fear of sharks. There is both a community and islandwide belief that the Ewa Beach waters are shark-infested. This belief has some accuracy and is a perpetuated by numerous shark sightings by surfers and divers. The surfing site "Shark Country" has been so named for at least 30 years. Fishers commonly find large holes in their nets caused by sharks, and over the years, many large sharks, primarily tigers and hammerheads, have been caught in this area.

Informants felt that development of the area and convenient public access will attract more divers, thus increasing fishing pressures on fish, lobster and octopus populations. The potential increase in divers may also lead to conflicts between the pole fishers and the divers.

Many informants feel that the boat channel and the marina will attract sharks to the area since sharks are scavengers and are commonly known to frequent bays and harbors. With the apparent proliferation of sharks in the area now, the new channel and marina may be a natural focal point for sharks.

4. Surfing

Although the islandwide surfing community does not regard Ewa Beach as one of the best places for surfing, it does recognize that the area has several excellent primary surfing sites and a number of good secondary sites. The majority of these sites are found offshore of the project site. These sites include Seawalls, Shark Country, Hau Bush, Chicken Creek, Sand Tracks, Johns, Coves and Tree Stumps. Of all of these sites, Coves is generally recognized as having the best waves on a good south swell. Resident area surfers felt that its left side is comparable to that at Ala Moana Bowls in Waikiki, one of the best south shore surfing sites in the state. Others would dispute this comparison; and it is unlikely that Coves would be named as a top-notch south shore surfing site by the surfing community. The Ewa Beach surfing sites however, are regarded as excellent for beginning and novice surfers. Surfing contests are held annually offshore Oneula Beach Park at Sand Tracks or Johns. Bodyboarding is another important wave riding sport practiced at all of the Ewa Beach breaks.

Informants interviewed expressed significant concern about Ewa Marina's potential impact on surfing. Since the earlier alignment of the boat channel would have destroyed Coves, one of the best surfing sites in this area, project engineers have realigned the boat channel.

It was pointed out that all of the Ewa Beach surfing sites are important, in light of the residential growth planned for the Ewa Plain; the regional surfing population is expected to grow substantially. Further, surfing sites are ocean parks which many feel cannot be replaced or duplicated. In spite of scientific claims that new surf sites can be created, many surfers feel that the hundreds of years of coral reef formation -- which creates a surfing site -- cannot be duplicated. They fear that the jetties lining the boat channel may exert a negative influence on the surfing sites by altering normal wave patterns. Although some informants acknowledged the possibility of creating new sites, most anticipated a negative impact.

5. Boating

At present, little boating activity occurs near the project area. The water is normally too murky to attract skin or scuba divers and too far from existing boat ramps to attract other boaters. The area is also subject to surf at all times of the year, particularly during the summer. The boats that do visit the area are usually smaller motor boats, 17 feet in length or less, or inflatable boats, such as Zodiacs or Avons. These boaters tend to be local divers familiar with the area who know when visibility would be good enough for diving. Little or no sailing or windsurfing occurs in this area.

There is general agreement that Ewa Marina will improve the supply of recreational boating facilities. Public boat ramps on Oahu are few and far between; a new public boat ramp would meet a major need in the boating community. Boat owners also need more support facilities and the project will provide marina support facilities such as a service station for gas, a store for ice and supplies, and parking for trucks and trailers.

It is anticipated that the marina will offer a refuge for boats in distress which are caught offshore in rough seas, or which experience engine or other problems. At the same time, more boating traffic offshore will likely lead to more boating accidents, such as boats going aground on the reef, boats overturning in high surf, and boat fires.

It was expressed that more boaters may lead to increased user conflict incidents between boaters and other user groups, such as surfers, nearshore skin divers and shoreline fishers.

6. Outrigger Canoe Paddling and Kayaking

Outrigger canoe paddling is not presently practiced in Ewa Beach. The former Ewa Beach Canoe Club, now known as the Kuakini Canoe Club, has been inactive for approximately four years. Canoe paddling season is usually during the summer months, and summer surf made nearshore training difficult.

Ewa Marina is viewed as promoting the revival of canoe paddling in Ewa Beach. The marina and the boat channel would (1) provide the sheltered waters that canoe paddlers prefer for training and (2) still give them access to the open ocean.

Suggestions offered include installing a floating dock area which would offer them a place to launch, land, and secure their canoes, and could be used by kayakers as well. These floating docks should be located away from the boat launching ramp to avoid potential hazards to canoe paddlers and kayakers by motor-powered crafts.

Chapter V

Relationship To Plans, Policies and Controls

V. RELATIONSHIP TO PLANS, POLICIES AND CONTROLS

A. Plans

1. Hawaii State Plan

The Hawaii State Planning Act, HRS, Chapter 226, sets forth long-range goals, objectives, policies and priority guidelines designed for the betterment and development of the State. Its overall goal is to achieve a strong, viable economy and a desirable physical environment that will promote the physical, social and economic well-being of Hawaii's individuals, families and communities. (HRS Sec. 226-1.) The proposed development is consistent with the following objectives and policies of the Hawaii State Plan:

§ 226.6. Objectives and policies for the economy--in general.

(a) Planning for the State's economy in general shall be directed toward achievement of the following objectives.

(1) Increased and diversified employment opportunities to achieve full employment, increased income and job choice, and improved living standards for Hawaii's people.

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

(b) To achieve the general economic objectives, it shall be the policy of this State to:

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

(14) Encourage businesses that have favorable financial multiplier effects within Hawaii's economy; and,

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

Comment: The development of the Project will promote a sustained level of construction activity in the State over the course of its anticipated 12 year construction and building period. In the longer term, the Project will benefit the Ewa area by the additional employment opportunities it will create in goods and service industries required by the new community. Notably, the proposed 1,400-slip marina in the Property is expected to initiate a new marina-related industry in the Ewa Area, creating a demand for businesses engaged in boat support services, the sale of marine equipment and supplies, the sale of ocean sports equipment, as well as a demand for businesses providing a variety of related services. Therefore, the development of the Project will be in concert with the policies and objectives of the State Plan relating to diversified employment opportunities.

* * *

§ 226-12. <u>Objective and policies for the physical environment -- scenic, natural beauty, and historic resources</u>.

(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 multi-cultural/historical resources.*

(b) *To achieve the scenic, natural beauty, and historic resources objective, it shall be the policy of this State to:*

(1) *Promote the preservation and restoration of significant natural and historic resources;*

(3) *Promote the visual and aesthetic enjoyment of mountains, ocean vistas, scenic landscapes, and other natural features; and,*

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

Comment: The Project will preserve all six archaeological site complexes which have been recommended for "Preservation with interpretive development" in the current Section 106 consultation with the U.S. Army Corps of Engineers. These complexes were determined to be among the most intact and least disturbed of any archaeological features within the

Property. A 22-acre preservation area contains three of these complexes on the western portion of the Project.

The development of the marina will advance the State's objective of preserving views and vistas, and enhancing the visual and aesthetic enjoyment of mountains, oceans, scenic landscapes and other natural features. Attendant enhancements to the area's open space as well as recreational value will include neighborhood and pocket parks and active and passive recreation areas. The planned residential component will contain well-designed homes of carefully-planned and landscaped aesthetic quality. Overall, the Project will provide more opportunities for visual variety, spanning housing, commerce and recreation, the sum of which will enhance the area's aesthetic qualities.

* * *

§ 226-14. Objective and policies for facility systems -- in general.

(a) *Planning for the State's facility systems in general shall be directed towards achievement of the following objective of water, transportation, waste disposal, and utility systems that support state-wide social, economic, and physical objectives.*

(b) *To achieve the general facility systems objective, it shall be the policy of this State to:*

(1) *Accommodate the needs of Hawaii's people through coordination of facility systems and capital improvement priorities in consonance with state and county plans;*

(2) *Encourage flexibility in the design and development of facility systems to promote prudent use of resources and accommodate changing public demands and priorities; and,*

(4) *Pursue alternative methods of financing programs and projects and cost-saving techniques in the planning, construction, and maintenance of facility systems.*

Comment: The Applicant is a member of the Ewa Plain Water Development Corporation (EPWDC), which is developing new water sources and storage and transmission systems for the Ewa area. To date, the Applicant has expended more than $10 million to develop potable water and transmission lines for Ewa Marina. Similarly, the Applicant will contribute its share to improve the transportation and waste disposal systems which service the Ewa Marina project. Thus, through these endeavors, the Applicant is contributing to the improvement of the state's and county's facility system.

* * *

§ 226-15. Objectives and policies for facility systems -- solid and liquid wastes.

(a) *Planning for the State's facility systems with regard to solid and liquid wastes shall be directed towards the achievement of the following objectives.*

(1) *Maintenance of basic public health and sanitation standards relating to treatment and disposal of solid and liquid wastes.*

(2) *Adequate sewer infrastructure facilities for physical and economic activities that alleviate problems in housing, employment, mobility and other areas.*

(b) *To achieve solid and liquid waste objectives, it shall be the policy of this State to:*

(1) *Encourage the adequate development of sewer systems that complement planned growth.*

Comment: Solid waste will be transported to the nearby HPOWER energy recovery incinerator facility for disposal. Alternative disposal sites include the Kalaheo Landfill in Kailua, the Waimanalo Gulch Landfill near the Kahe Power Plant and the Waipahu Incinerator.

The Honouliuli Wastewater Treatment Plant has a planned capacity of 51 million gallons per day (mgd). The existing capacity is 25 mgd and present flows are approaching this capacity. The Project will be tied into the regional wastewater collection and treatment system. Allocation of service capacity for the Project will be subject to City approval. A Sewer Master Plan approved by the City Department of Public Works (DPW) will be required in conjunction with processing a rezoning request for the Property.

* * *

§ 226-16. Objective and Policies for facility systems -- water.

(a) *Planning for the State's facility systems with regard to water shall be directed towards achievement of the objective of the provision of water to adequately accommodate domestic, agricultural, industrial, recreational, and other needs within resources capacities.*

(b) *To achieve the facility systems water objective, it shall be the policy of this State to:*

(1) *Relate growth activities to existing and potential water supply;*

(2) *Support research and development of alternative water sources; and,*

(4) *Assist in improving the quality, efficiency, service, and storage capabilities of water systems for domestic and agricultural use.*

Comment: As aforementioned, the Applicant is a member of EPWDC, which is developing new water sources and storage, and transmission systems for the Ewa area, and the Applicant has also spent millions of dollars toward potable water development. Moreover, the projected potable water requirements for the development will be reduced substantially through the use of a dual water system. A dual system will provide both potable water for domestic consumption, and non-potable water for irrigation.

* * *

§ 226-17. Objectives and policies for facility systems -- transportation.

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

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

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

(b) *To achieve the transportation objectives, it shall be the policy of this State to:*

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

(3) *Encourage a reasonable distribution of financial responsibilities for transportation among participating governmental and private parties; and,*

(6) *Encourage the use of transportation systems that serve as a means of accommodating present and future development needs of communities.*

Comment: The Applicant will be financially accountable for its fair share of costs to improve existing highways and develop new transportation facilities to mitigate the impact of the Project. Presently, the Applicant participates in a working group comprised of representatives from government agencies and private interests. The working group is studying the types of improvements and facilities which will be required to manage the additional traffic which will be generated by the combined projects in the Ewa region.

* * *

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

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

(1) *Greater opportunities for Hawaii's people to secure reasonably-priced, safe, sanitary, livable homes located in suitable environments that satisfactorily accommodate the needs and desires of families and individuals.*

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

(b) *To achieve the housing objectives, it shall be the policy of this State to:*

(1) *Effectively accommodate the housing needs of Hawaii's people, especially the elderly, handicapped, displacees of redevelopment areas, and newly-formed households;*

(2) *Stimulate and promote feasible approaches that increase housing choices for low-income, moderate-income, and gap-group households;*

(3) *Increase homeownership and rental opportunities and choices in terms of quality, location, cost, densities, style, and size of housing;*

(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; and,*

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

Comment: The Applicant proposes to develop approximately 3,560 residential units. A broad variety of housing types are envisioned to provide a large selection for prospective homebuyers.

The Project is designed to take into account the physical setting, including visual and aesthetic amenities, and its location will provide easy access to public facilities and services within the overall Ewa Marina development. Also, the Project design has incorporated a parkway system around the marina, and neighborhood and pocket parks reflecting Hawaii's traditional outdoor orientation.

This residential component of the Ewa Marina Phase I development has made provisions to accommodate affordable housing demand to be targeted for sale to low-income and gap-group households.

§ 226-23. Objectives and policies for socio-cultural advancement -- leisure.

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

(b) To achieve the leisure objective, it shall be the policy of this State to:

(2) Provide a wide range of activities and facilities to fulfill the recreation needs of all diverse and special groups;

(4) Promote the recreational and educational potential of natural resources having scenic, open space, cultural, historical, geological, or biological values; and,

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

Comment: The 120-acre marina will provide a new facility with diverse recreational opportunities which will be readily available to the public.

Boating waterways, existing surfing sites, beaches, parks, and waterfront perimeter parkways will stimulate public enjoyment in and around the marina. Also, the residential component will include neighborhood and pocket parks.

2. State Functional Plans

The Hawaii State Plan directs appropriate State agencies to prepare Functional Plans which address statewide needs, problems and issues, and recommend policies and actions to mitigate those problems. Fourteen Functional Plans were prepared to implement the goals, objectives, policies and priority guidelines of the State Plan in the areas of agriculture, transportation, conservation lands, education, tourism, water resources, energy, recreation, historic preservation, health, housing, higher education, employment, and human services.

The proposed development is consistent with the following Functional Plans.

a. Housing Functional Plan

The purpose of the State Housing Functional Plan is to develop and implement a plan of action in response to Hawaii's current housing needs. The residential component of the Project is in compliance with the following policy:

Policy E(1)

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

Comment: The Ewa region has been identified as suitable for development as Oahu's new secondary urban center to accommodate most of the expected influx of population into the region between 1985 and 2005. The Project, located in the Ewa region, is planned in consonance with general and development plans. Moreover, the Project is in close proximity to existing and planned urban developments and social infrastructure.

The residential development within the Property, which will consist of approximately 3,560 low and medium density units, will complement and support the employment and recreational opportunities associated with the Project. The residential development will also have ready access to public facilities and services.

b. Recreation Functional Plan

The State Recreation Functional Plan identifies a need for new recreation facilities and improvements in the Ewa area. The proposed Project complies with the following objective of this functional plan.

Objective C(1)

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

Comment: The planned park and open space in the development will help to preserve views and provide active and passive recreational opportunities within neighborhood and shoreline areas. The Project will accommodate the recreational activity needs of residents and visitors by providing a variety of recreational opportunities. As aforementioned, the 120-acre marina will provide a new recreational facility in itself, which will promote diverse recreational opportunities which will be readily available to the public.

3. Oahu General Plan

First adopted in 1977, the City and County of Honolulu General Plan was subsequently amended in 1979, 1982, 1985, 1987, 1988, and 1991. The Plan specifies long-range objectives and policies to guide both the quantity and quality of future growth on Oahu. The Plan is a statement of the long-range social, economic, environmental, and design objectives for the general welfare and prosperity of the people of Oahu and also provides broad policies which facilitate the attainment of the objectives of the Plan.

The long-range General Plan goal of the City and County of Honolulu is to encourage economic development of the Ewa DP area as a Secondary Urban Center with an urban fringe segment. Thus, the Ewa-Honouliuli region is experiencing substantial growth. This growth will result in the conversion of 8,000 acres of Oahu sugar cultivation to residential/resort/commercial land uses.

The Project is consistent with the following General Plan objectives and policies.

<u>*Population Objectives and Policies*</u>

<u>*Objective C, Policy 2*</u>

Encourage development within the secondary urban center at Kapolei and the Ewa and Central Oahu urban-fringe areas to relieve developmental pressures in the remaining urban-fringe and rural areas and to meet housing needs not readily provided in the primary urban center.

Comment: The Project supports and is consistent with the designation of Ewa as the Secondary Urban Center for growth and development on Oahu. The Project is a residential community centered around a marina with supporting commercial and other public uses. The marina will be unique with no comparable development in the primary urban center.

<u>*Economic Activity*</u>

<u>*Objective G, Policy 1*</u>

Direct major economic activity and government services to the primary and secondary urban centers.

<u>*Objective G, Policy 3*</u>

Maintain sufficient land in appropriately located commercial and industrial areas to help ensure a favorable business climate on Oahu.

Comment: Employment opportunities and activities generated by the proposed Project will assist in directing economic activity to the Ewa district. Further, the commercial development proposed in this Project would provide retail and office space which will help meet the needs of the anticipated growth in the Ewa district.

<u>*Natural Environment*</u>

<u>*Objective C, Policy 3*</u>

Encourage residential development near employment centers.

Comment: The Project will include both residential and employment opportunities in one development. This will contribute to reducing the number of residents having to commute to Honolulu for employment.

Physical Development and Urban Design

Objective C, Policy 6

Encourage the development of the Ewa Marina community as major residential and recreation area emphasizing recreational boating activities through the provision of a major marina and a related maritime commercial center containing light-industrial, commercial, and visitor accommodation uses.

Comment: The Project will include the components listed in the above Policy 6.

B. Land Use Plans and Policies

1. State Land Use District Classification

The State Land Use Law is intended to preserve, protect, and encourage the development of lands in the State for uses which are best suited to the public health and welfare of Hawaii's people. All lands in the State are classified in one of four districts: Urban, Agricultural, Conservation, and Rural. The Property is located entirely within the Urban District and, as such, the proposed use and development is fully consistent with its Urban land use designation. The Property received its Urban classification through approval of a State Land Use District Boundary Amendment in 1984. As one of the conditions of approval, the Applicant is required to petition the Land Use Commission to reclassify the marina waterways to the Conservation District within two years after the marina is completed.

2. Ewa Development Plan

The City's Development Plans guide the desired sequence, patterns and characteristics of future development in further specification of the General Plan. As one of eight plans for Oahu, the Ewa DP Area includes the area from Waipahu and Pearl Harbor to Nanakuli, encompassing the southwestern corner of the island.

a. Consistency with Common Provisions.

1. General Urban Design Principles and Controls.

Open Space

The proposed marina and park areas in the Property are consistent with the objective of providing visibility, preservation, enhancement and accessibility of open space areas. The Applicant notes that maintaining such areas as open space is given high priority under the DP Common Provisions.

Vehicular and Pedestrian Routes

The circulation system includes both a vehicular and pedestrian circulation system. The roadway system for vehicles will conform with City and County of Honolulu standards, as required. The pedestrian circulation system will be comprised of a series of parks along the marina linked by pedestrian ways. The existing Oneula Beach Park and all existing shoreline frontage will be accessible by the public, as will commercial esplanades and "Public Facility" designated areas adjacent to the marina.

2. General Principles and Controls for Parks, Recreation and Preservation Areas

The Project will include neighborhood and pocket parks and a variety of marina and ocean front open space areas linked by the pedestrian circulation system. The Project will also include a 22 acre preservation area encompassing important archaeological sites and a wetland at its western extreme adjacent to NASBP.

3. Identification of Areas, Sites and Structures of Historical Significance

The archaeological survey and data recovery program conducted for the Project site indicates that marina construction will have no significant adverse impacts on historic properties or cultural resources. All sites recommended for "as is" preservation will be preserved, and a Memorandum of Agreement will be executed to ensure that significant adverse impacts are avoided. Should any unknown archaeological resources such as shells, charcoal deposits, or human remains be encountered during construction, the Applicant will immediately cease work in the impacted area and notify the Historic Preservation Division of the State Department of Land and Natural Resources (DLNR). The Project will preserve all six archaeological site complexes which have been recommended for "Preservation with interpretive development" in the current Section 106 consultation with the U.S. Army Corps of Engineers.

4. Thoroughfares, Highways and Streets

The Applicant will consult with the City's Chief Engineer and DOT to ensure that roadways in the development conform to applicable standards.

The Applicant will be financially accountable for its fair share of costs to improve existing highways and develop new transportation facilities to mitigate the impact of the Project. Presently, the Applicant participates in a working group comprised of representatives from government agencies and private interests. The working group is studying the types of improvements and facilities which will be required to manage the additional traffic which will be generated by the combined projects in the Ewa region.

5. Public Buildings and Public or Private Facilities for Utilities, Terminals and Drainage

The Ewa Marina development, including the golf course in Phase II and the marina in Phase I will buffer the impact of stormwater flowing from the Kaloi watershed into the ocean and provide flood control. The golf course will accommodate storm flows up to 2,200 cubic feet per second and provide detention basins to control silt. The marina itself will also act as an auxiliary detention basin should flows exceed that volume.

6. Sequencing Policies

The proposed development will be consistent with the City's objective relating to the sequencing of public facilities. Since the

Applicant, at its own cost, is proposing to install infrastructure such as roadways, appurtenant drainage facilities, sewer and water lines within the development as well as contributing its fair share toward regional infrastructure such as State highways and water system improvements outside of the Property and regional drainage improvements at the terminus of Kaloi Gulch, the City can use its capital improvement budget to provide public facilities in other areas of Oahu.

b. Consistency with Ewa DP Special Provisions

The Ewa DP provides for the development of a new secondary urban center in the Ewa Region to accommodate most of the expected influx of population into the area between now and the year 2000. The plan also provides for the retention of sufficient agricultural land in Ewa to maintain the viability of the sugar industry.

The DP provides urban design principles and controls for open space, public views, heights, and density. The Special Provisions also identify selected areas, allowable uses, their location, setbacks, landscaping, and the provision of public facilities. Such Special Provisions have been developed for the Ewa Marina area which is referred to in the Ewa DP as the "Ewa Marina Special Area". The plan in Section 32-3.2(b)(3) provides that:

> *Phase I of the Ewa Marina project consists of an area containing approximately 707 acres located between the Ewa Beach community and the Barbers Point Naval Air Station. It shall contain a mixture of Residential, Low Density Apartment, Medium Density Apartment, Commercial, Public Facility (including a marina), Park, and Preservation (waterway and flood control areas) uses.*

The Project provides a complement of residential, recreational, and commercial facilities as specified above. Adequate public facilities exist or will be provided by the developer to accommodate the Project.

c. Consistency with DP Land Use (DPLU) Map for Ewa

The DPLU map depicts a land use pattern that is consistent with the objectives and policies of the General Plan and is used as the basis for public facility planning. The DPLU map for Ewa presently provides for a mixture of residential, low density apartment, medium density apartment, commercial, public facilities, and park uses on the Project site. (See Figure 22). The Applicant has requested to reconfigure these existing designations within the Property. There will be no changes to the density or intensity of development (See Figure 23).

d. Consistency with DP Public Facilities (DPPF) Map for Ewa

The DPPF map for the Ewa area identifies public and private proposals for parks, streets and highways, major public buildings, utilities, terminals, and drainage. Within the Property, several facilities are indicated as planned or programmed on the existing DPPF map. (See Figure 24). Sewer, potable and non-potable water, and drainage systems, additional rights-of-way for new streets, and a sewage pump station are all depicted as facilities to be privately funded. The Applicant proposes to develop these facilities on the Property, although their locations will be different from those shown in the Ewa DPPF map. A DPPF map amendment will be processed to maintain consistency with the Applicant's proposal.

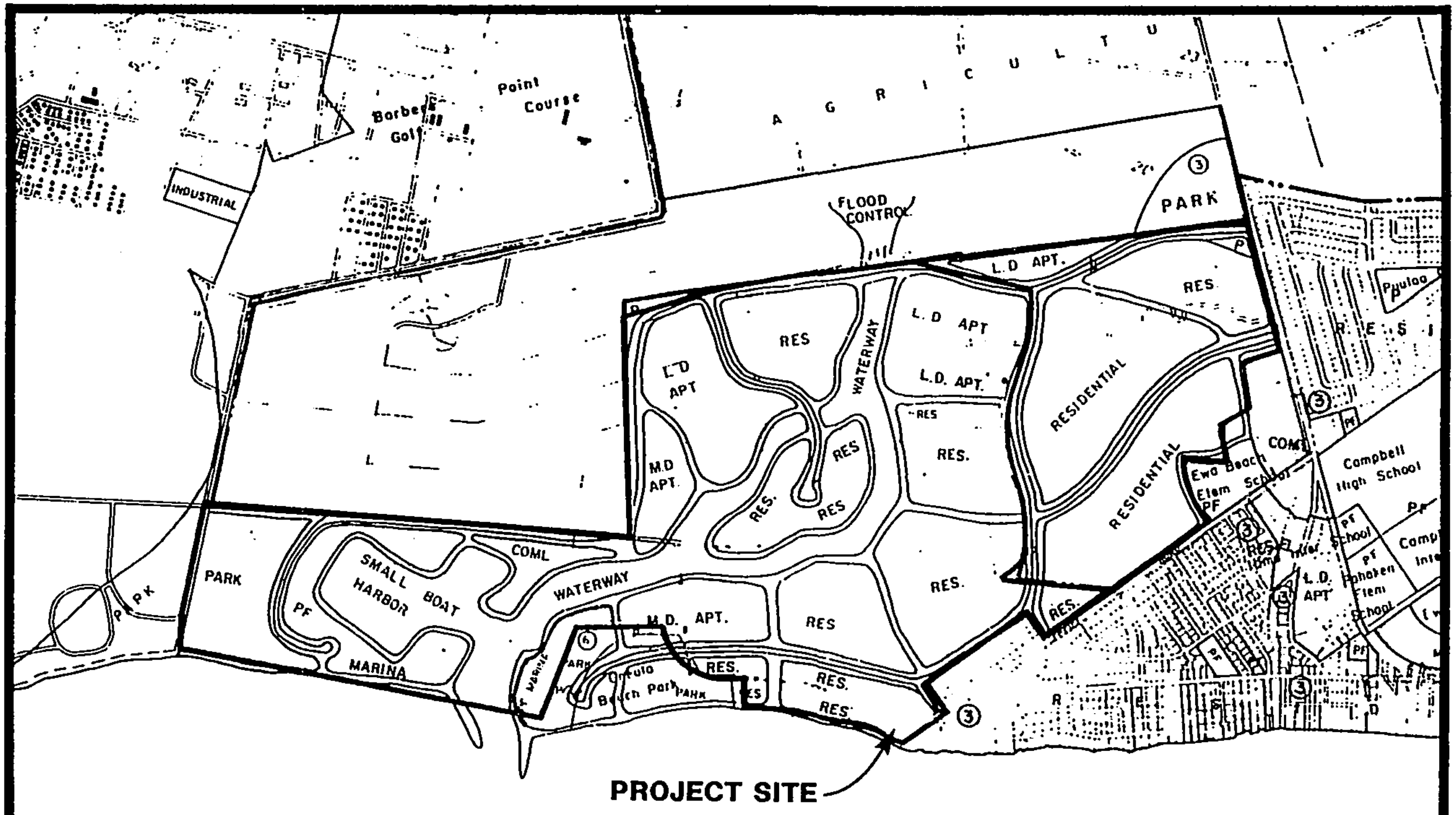
3. County Zoning

The City and County of Honolulu Land Use Ordinance (LUO) and accompanying maps define the allowable uses of land zoned for residential, apartment, business, resort, industrial, agricultural, preservation, and mixed uses. Of the 535 acres comprising the Property, the City and County of Honolulu has zoned about 363 acres AG-2 "General Agricultural District," and about 172 acres R-5 "Residential District" for single-family dwellings in minimum 5,000 square foot lots (See Figure 25). Rezoning of the Property will be required to implement the proposed reconfiguration of the DPLU Map. The Applicant plans to initiate rezoning proceedings as soon as allowable by law.

C. Environmental Permits

1. U.S. Army Corps of Engineers

The U.S. Army Corps of Engineers (the "Corps"), Honolulu District, regulates activities in Hawaii's waters, including ocean and coastal waters, inland and tidal waters, tidal ponds, fishponds, rivers, streams, and adjacent wetlands, perched wetlands, and intermittent streams. The Corps is responsible for administering (a) Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. 403) which prohibits the obstruction or alteration of navigable waters of the United States

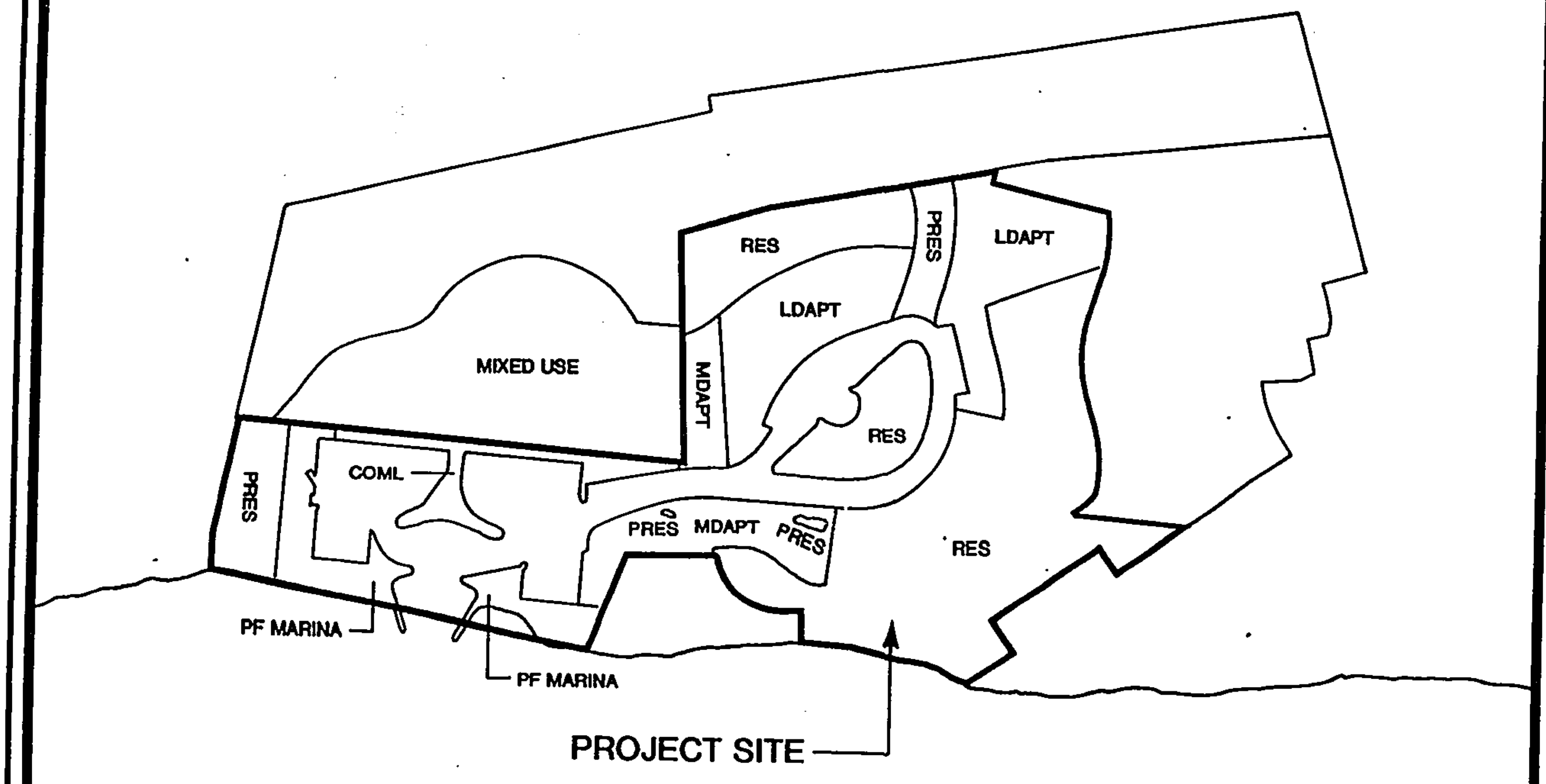


EXISTING DEVELOPMENT PLAN
LAND USE MAP

EWA MARINA

Prepared by: Wilson Okamoto & Associates, Inc.

Fig. 22

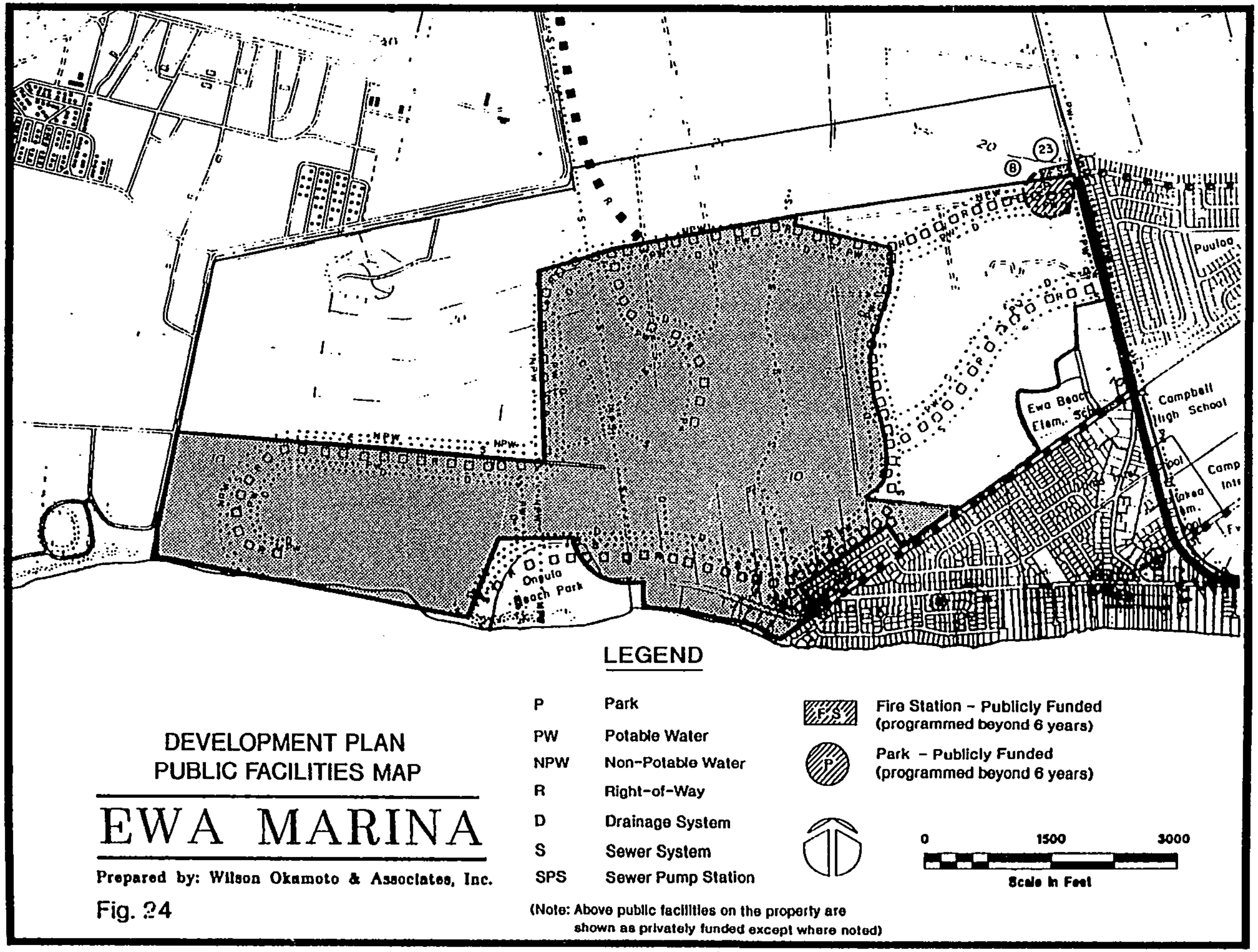


PROPOSED DEVELOPMENT PLAN
LAND USE MAP

EWA MARINA

Prepared by: Wilson Okamoto & Associates, Inc.

Fig. 23

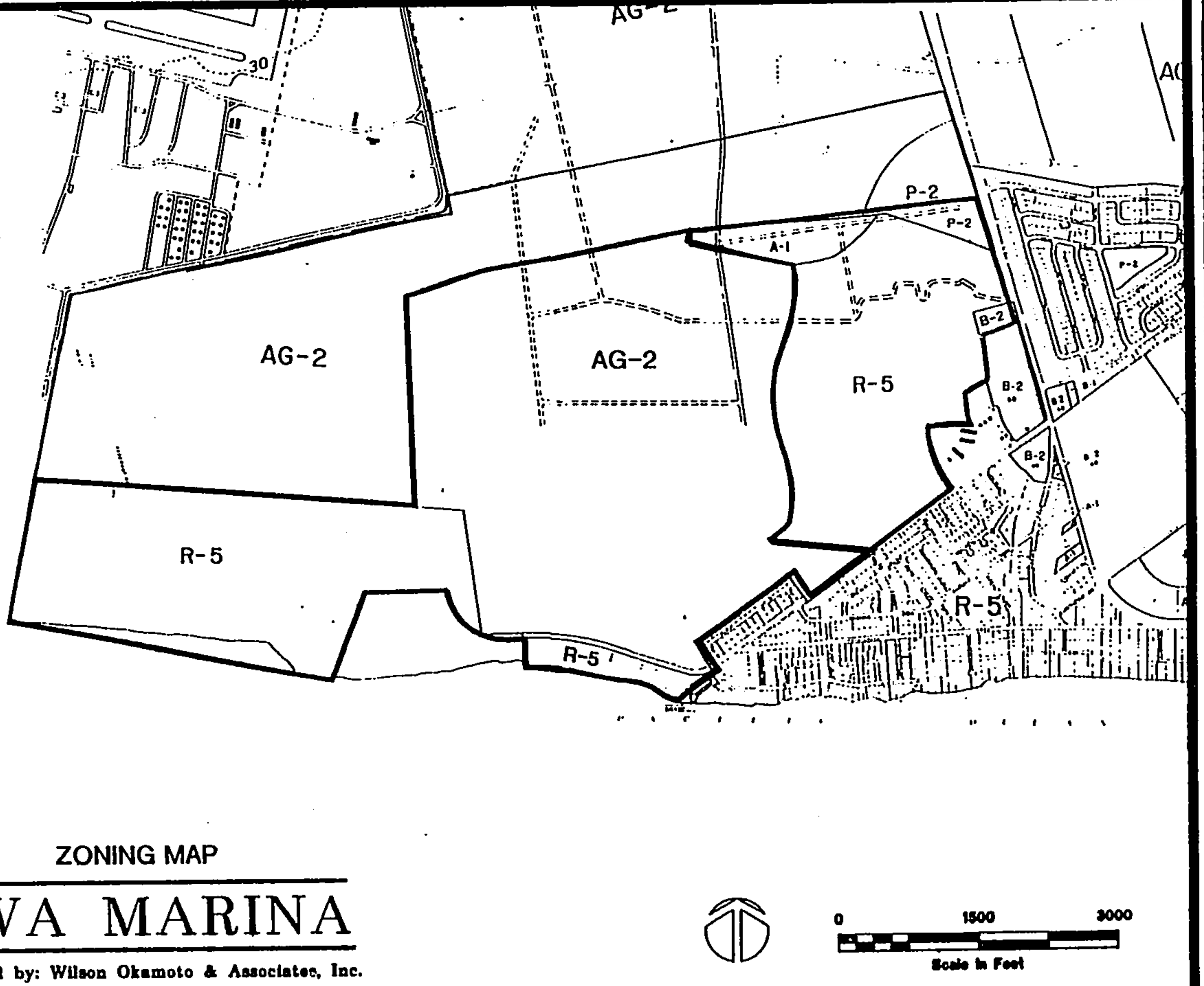


DEVELOPMENT PLAN
PUBLIC FACILITIES MAP

EWA MARINA

Prepared by: Wilson Okamoto & Associates, Inc.

Fig. 24



ZONING MAP

EWA MARINA

Prepared by: Wilson Okamoto & Associates, Inc.

Fig. 25

without a permit from the Corps, (b) Section 404 of the Clean Water Act (33 U.S.C. 1344) which prohibits the discharge of dredged or fill material into waters of the United States without a permit from the Corps, and (c) Section 103 of the Marine Protection, Research, and Sanctuaries Act of 1972, as amended (33 U.S.C. 1413) which authorizes the Corps to issue permits for the transportation of dredged material for the purpose of dumping it into ocean waters.

The Environmental Protection Agency (EPA), the National Marine Fisheries Service (NMFS), the U.S. Fish and Wildlife Service (USFWS), and other appropriate federal and state agencies have the opportunity to review and comment on the permit applications submitted to the Corps.

Issuance of these permits is based on an evaluation of the probable impact of the proposed activity on the public interest, reflecting national concern for both protection and utilization of important resources. Factors considered include those relating to: conservation, economics, aesthetics, cultural values, flood hazards, land use, navigation, recreation, water supply, water quality, energy needs, safety, food production, and, in general, the needs and welfare of the people.

Comment: In connection with its plans to construct a viable marina on the Ewa Plain to help meet Oahu's existing and projected needs for boat storage slips and marina facilities, the Applicant applied for a Corps dredge and fill permit, PODCO 2117, on October 20, 1989. The permit application was prepared pursuant to Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act. In conjunction with the permit application, the Corps is preparing a Federal EIS with the U.S. Coast Guard as a cooperating agency.

The proposed marina will provide approximately 1,400 boat slips in 120 acres of waterways excavated inland of the shoreline. Infrastructure elements of the marina include internal wave absorbers, floating and fixed docks, boat ramps, bridge crossings, and marina facilities associated with boat fueling, maintenance and repair. An entrance channel approximately 400 feet wide, 3,000 feet long, and 20 feet deep will be dredged to connect the marina to the ocean. Two rock jetties, each 400 feet long with a crest height of approximately 6 to 8 feet above mean lower low water ("MLLW"), will be placed on either side of the entrance channel to protect the marina basin from waves and prevent littoral drift from shoaling in the channel.

A public hearing was held by the Corps on December 17, 1990. Throughout the entire processing to date, the Applicant has worked with the Corps and other agencies to address the public's concerns with respect to the factors enumerated above. Studies addressing these concerns have been conducted or are on-going throughout the entire project.

2. Hawaii Coastal Zone Management (CZM) Program Federal Consistency Review

In conjunction with a Section 404 Permit, the Corps requires that the Applicant obtain a certification from the State that the Project complies with the State's CZM Program. Section 307 of the National CZM Act of 1972 (16 U.S.C. et. seq.). Hawaii's CZM Program, established pursuant to Chapter 205A HRS, was Federally approved in 1977, and is administered by the State of Hawaii Office of State Planning (OSP).

Before the Federal permit can be issued, OSP must determine the Project's consistency with the enforceable policies of the Hawaii CZM Program. These policies encompass broad concerns such as impact on recreational resources, historic and archaeological resources, coastal scenic resources and open space, coastal ecosystems, coastal hazards, and the management of development.

Comment: The Applicant submitted its request for a CZM consistency certification to OSP on October 20, 1989. Since then, there have been numerous discussions between OSP and the Applicant to facilitate and expedite OSP's review of the Project for the consistency certification.

3. Section 401 Water Quality Certification

The Corps also requires that, in conjunction with the 404 Permit, the Applicant obtain a certification from the State that its Project will meet the State water quality standards set forth in its guidelines. The State Department of Health (DOH) is charged with the responsibility of establishing and administering a State certification system pursuant to Section 401 of the Clean Water Act and Section 342-32(13), HRS. Water quality certification is required of any applicant for a Federal license or permit to conduct any activity that may result in any discharge into navigable water. This includes the permits described above which are issued by the Corps.

Comment: The Applicant submitted its request for water quality certification to the DOH on August 10, 1990, and is working with the DOH in providing information and studies which demonstrate that the Applicant will comply with the water quality standards set forth in the guidelines. On January 2, 1992 the DOH issued a Notice for Public Comment and by February 3, 1992, the deadline for comments, only one comment had been received.

4. Conservation District Use Application (CDUA)

Any use of lands, including submerged lands within the State's Conservation District, as established by the State Land Use Commission, are subject to review pursuant to Chapter 183, HRS and Title 13, Chapter 2, Administrative Rules of the Department of Land and Natural Resources. Approval by the State Board of Land and Natural Resources will be required for all dredging and construction offshore in the Conservation District. Additionally, the Commission on Water Resource Management has jurisdiction over the caprock aquifer and will establish standards for protection of its viability as a non-potable water resource.

5. Special Management Area (SMA) Use Permit

The CZM Law (Chapter 205A, HRS) has charged the Counties with designating and administering SMAs along the State's coasts. Any "development", as defined by Law, within the SMA requires an SMA Use Permit, which is administered by the City and County of Honolulu, DLU, pursuant to Ordinance No. 84-4. A portion of the Property is located within the SMA boundary and, as such, is subject to review under the SMA permit procedures (See Figure 26). SMA Use Permits are approved based upon a project's consistency with the objectives, policies and guidelines of the CZM Law. The following discusses the relevant objectives and policies for Recreational Resources and Coastal Hazards as they apply to the Project.

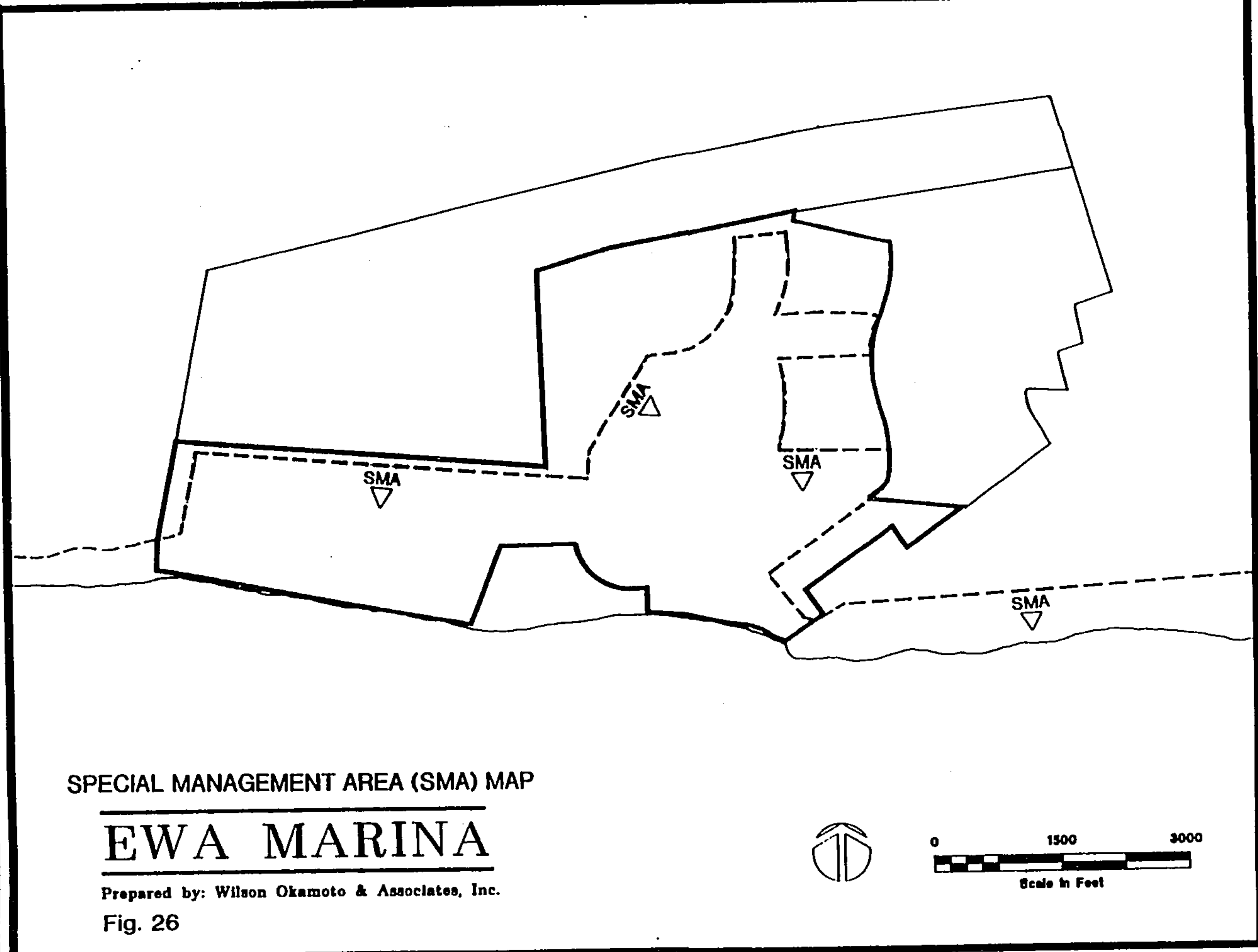
§ 205A-2. Coastal zone management program; objectives and policies.

Recreational Resources

Objective (A): *Provide coastal recreational opportunities accessible to the public.*

Policy (B): *Providing adequate, accessible, and diverse recreational opportunities in the coastal zone management area.*

(ii) Requiring replacement of coastal resources having significant recreational value, including but not limited to surfing sites and sandy beaches, when such resources will be unavoidably damaged by development; or requiring reasonable monetary compensation to the State for recreation when replacement is not feasible or desirable;



SPECIAL MANAGEMENT AREA (SMA) MAP

EWA MARINA

Prepared by: Wilson Okamoto & Associates, Inc.

Fig. 26

(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; and*

(vii) *Developing new shoreline recreational opportunities, where appropriate, such as artificial lagoons, artificial beaches, artificial reefs for surfing and fishing.*

Comment: The construction of marina jetties will displace existing, eliminate benthic habitat, which are considered to be relatively poor with respect to recreational fisheries. The Applicant proposes to construct an artificial reef to satisfy the "no net habitat loss" policy of the National Marine Fisheries Service. While this artificial reef will provide additional habitat diversity for all types of marine organisms, as well as recreational opportunities for fishing its location has yet to be determined.

Access to a series of parks, commercial areas, and marina support areas along the waterway and the entire ocean shoreline will be available via internal pedestrian ways. Further, the accessibility of the coastal area between Oneula Beach Park and the proposed marina entrance channel will be enhanced by the roadways, parking areas, and pedestrian paths. On the east side of Oneula Beach Park, lateral shoreline access will be available as will accessways to the shoreline. These accessways would fulfill the one-quarter mile interval between accessways required by the City and County Department of Parks and Recreation for urban areas.

The proposed plan calls for public uses in the entire shoreline area west of the proposed marina entrance channel and jetties. However, construction of the channel will interrupt alongshore movement. The Project's internal roadways will make it possible for individuals with vehicles to continue to reach the shoreline area on the western side of the entrance channel by driving around the marina. Pedestrian public access along the shoreline will continue to be available from the western side of the entrance channel up to the NASBP fence.

The marina will provide a new recreational facility which, in itself, will offer diverse recreational opportunities readily available to the public. Boating waterways, existing surfing sites, beaches, parks, and waterfront perimeter parkways will stimulate public enjoyment in and around the marina. Additionally, the residential component of the Project will include neighborhood and pocket parks.

Coastal Hazards

Objective (A): *Reduce hazard to life and property from tsunami, storm waves, stream flooding, erosion, and subsidence*

Policy (A): *Developing and communicating adequate information on storm wave, tsunami, flood, erosion, and subsidence hazard*

Policy (B): *Controlling development in areas subject to storm wave, tsunami, flood, erosion, and subsidence hazard.*

Comment: The proposed marina will act as a receiving embayment for storm water runoff from the Kaloi watersheds, buffering the impact of stormwater flowing into the ocean and providing flood control. The proposed Ewa Marina Phase II golf course will be used as a detention area, and together with silt basins incorporated in the design of the drainage system, will minimize the amount of silt entering the marina. During the most severe storms, the marina itself could serve as a large detention basin. All structures within the Project shall comply with City and County of Honolulu flood protection requirements, including minimum elevation requirements for habitable structures.

Chapter VI

Physical Impacts

Chapter VI

Physical Impacts

VI. PHYSICAL IMPACTS

A. Overview

Potential impacts of the proposed development have been divided into several categories to facilitate assessment. Short-term construction related impacts are transitory and are expected to occur only during the construction phase of the project. Within the short-term impacts category, both landward impacts and marine impacts are assessed since construction spans the land/water interface, each with unique concerns. Long-term impacts relate to the permanent alteration of the landward and marine environments as a result of developing the project.

B. Short-Term Impacts - Landward

1. Traffic

During construction of the proposed development, various types of construction vehicles, such as earthmovers and heavy trucks transporting equipment and building materials will be travelling to and from the Project Site. In addition, construction workers will be commuting to and from the Project Site. The traffic generated will use H-1 Freeway and other roadways for access and egress. If deemed necessary, the movement of heavy equipment and commuting times of construction workers can be coordinated to avoid peak traffic hours.

Inasmuch as material excavated from the marina will be used on-site as fill, it is anticipated that the volume of earthen material to be either exported from or imported to the Project Site will be insignificant. Thus, transportation requirements and associated traffic generation would be negligible in this regard.

2. Noise

In the short term, development of the Project will involve excavating the marina, filling of areas around the marina, grading the Property, dredging the marina entrance channel, and constructing infrastructure and buildings. The most significant noise impacts are anticipated to occur during earthwork operations. While much of the noise associated with marina excavation and channel dredging will be attenuated by the distance from residential areas, grading of areas near the eastern Property boundary will be close to homes on Papipi and Fort Weaver Roads. State Department of Health regulations, which require a permit if construction noise is to exceed certain threshold levels, will be complied with. In this event, permit conditions will include restrictions on permissible operating hours and noise restrictions.

If blasting is required, either onshore or offshore, a detailed blasting plan that incorporates measures to adequately protect neighbors against noise and vibration damage will be developed and circulated to the public for review and comment before proceeding.

In the past, nearby communities have experienced construction blasting during the excavation of the Barbers Point Deep Draft Harbor. In that case, "bulldozing" style blasting was used. The explosions created spectacular water geysers, and the noise and accompanying vibrations disturbed people far from the blasting site. For the proposed Project, alternative methods of employing explosives will be used which have much less impact on surrounding areas. These methods include pre-drilling, where the explosives are set into pre-drilled holes in the hard material before detonation, and using shaped charges. Shaped charges can focus the power of the explosion into the rock, allowing much smaller charges to be used.

3. Air Quality

Fugitive dust will be generated during the project construction phase as a result of earthwork operations (See Appendix C). To a lesser extent, exhaust emissions from stationary and mobile construction equipment and workers' vehicles may also affect air quality during the construction phase. Heavy construction vehicles using nearby roadways could also reduce roadway capacity causing localized traffic congestion and increased exhaust emissions.

State air pollution control regulations require that there be no visible fugitive dust emissions at the property line. The most serious concern in complying with this requirement are earthwork operations for excavating, stockpiling and reapplication of topsoil as well as grading using fill material excavated from the marina. The excavation of the marina is less of a concern since the excavated material will be saturated with groundwater. An effective dust control plan will be implemented to achieve compliance with state regulations. The plan will likely include measures such as limiting the acreage of land worked at any given time, watering active work areas, covering open-bodied trucks, paving, grassing or otherwise landscaping areas early in the construction schedule, and using dust control fencing. A favorable factor in providing additional control over dust is the direction of the prevailing tradewinds, which will blow fugitive dust out to sea. Some residences along Papipi Road, however may be in the path of tradewind blown dust during some phases of construction. This area, in particular, may require more mitigation, such as dust control fencing and more frequent watering.

Construction vehicle exhausts are primarily controlled by proper maintenance of vehicle engines to insure efficient operation. The impact on Fort Weaver Road can be reduced by minimizing construction vehicle movement during peak traffic hours.

4. Shoreline Access

The proposed project will begin to affect shoreline access when the short segment of the channel that makes up the first phase of the project is constructed. This portion of the channel, which will be approximately 30 feet wide, 20 feet below sea level, and extend 200 feet inland, will obstruct a portion of the dirt road that pedestrians and off-road vehicles currently use to reach the western end of the property. To mitigate this impact, an alternate pedestrian way will be constructed around the inland edge of the channel segment. A fence will be installed around the excavation to provide security for hikers. The trail will be for pedestrian use only. Hence, individuals would no longer be able to drive their all-terrain vehicles along the private property immediately behind the shoreline to reach the NASBP perimeter of the property. To accommodate them, a temporary parking area large enough to accommodate a few vehicles will be constructed on the eastern side of the channel. This initial phase of marina construction is expected to take one to two years, and will subsequently be incorporated into the marina channel and basin when the marina is fully-constructed. In the unlikely event that construction of the marina is halted, the excavation will be refilled.

Alongshore pedestrian access will be generally available while the marina is being constructed and the entrance channel is being dredged since the marina will not be opened to the ocean until much of its construction is completed. While the entrance channel is being dredged and the jetties are being constructed, it may be necessary to restrict access from time to time for safety reasons as heavy equipment and materials are transported across the shoreline. From the west side of the channel, alongshore pedestrian access will continue to be available westward to the NASBP fence.

C. Short-term Impacts - Marine

1. Runoff

During construction of the marina and grading of the upland portions of the property, proper management practices and erosion control measures will be applied to minimize the potential for runoff into the ocean. The Applicant will be required to comply with National Pollutant Discharge Elimination System (NPDES) regulations governing non-point source discharges originating from the Property, as well as local erosion control regulations for land clearing and grading operations. A comprehensive erosion control plan will be prepared for approval prior to land clearing and construction.

Notably, grading and drainage improvements for the entire Ewa Marina development will be coordinated to minimize the potential for runoff. A key role in controlling runoff during construction will be that of the marina. The marina will serve as a detention basin for runoff before it is connected to the ocean. This connection will not be made until the drainage system for accommodating storm runoff from adjacent mauka properties is implemented.

2. Dredge Silt

Dredging of the marina entrance channel, including possible blasting, will produce and redistribute fine sedimentary materials. These disturbances of sediments will result in substantial, temporary increases in water turbidity. While temporarily significant, these water quality changes are unlikely to produce lasting impacts because the area is already a turbid habitat in which bottom sediment resuspension and high turbidity are frequent occurrences. Alongshore currents will relatively quickly disperse plumes generated during dredging. Subsequent breaching of the shoreline to connect the marina to the ocean will allow wave action to enter the marina and stir up sediments which have settled on the bottom. Sediments from the marina could be discharged continuously over a longer period of time, resulting in a more tenacious plume. Best management practices as determined with the State Department of Health, shall be employed prior to breaching the shoreline to minimize the volume of sediments subject to resuspension.

3. Marine Traffic and Navigation

Before the entrance channel and jetties are built, notice to mariners will be published in U.S. Coast Guard publications and other newspapers of general circulation, describing where and when offshore construction activity will occur. Private aids to navigation will be constructed, installed and maintained by the Applicant in the entrance channel, on the jetties, bridge and piers, and along the edge of the marina pursuant to Coast Guard requirements. The Coast Guard District Commander's approval will be obtained prior to installation of these aids to navigation.

4. Fish

Blasting, if required during excavation of the entrance channel, may result in localized damage to fish and invertebrates from underwater shock waves. Most fish are expected to relocate to adjacent, less disturbed areas during construction. Because fish populations are relatively sparse in this area, significant impacts from blasting are not anticipated. In addition, the Applicant will prepare and obtain Corps approval for a blasting plan designed to minimize adverse environmental impacts.

5. Ciguatera

A potential concern associated with the excavation of the entrance channel and nearshore environment is an increase in the incidence of fish poisoning termed *ciguatera*. It has been hypothesized, though never verified, that cases of ciguatera are somehow linked to the initial algal colonization of substrata exposed by construction activities such as channel dredging. Ciguatera monitoring was conducted during and after construction of the Barbers Point Deep Draft Harbor and the marina and swimming lagoons at the Ko Olina Resort. This monitoring did not show any relationship between the dredging and excavation for these facilities and incidences of ciguatera. Based on this evidence, the proposed project is not expected to increase the incidence of ciguatera poisoning. Nonetheless, monitoring for ciguatera has been included in the proposed water quality monitoring program. Should evidence linking the construction activity to increased ciguatera, the activity that is causing the problem will be modified or halted and warnings will be issued to the public.

6. Threatened and Endangered Species

The habitat range of the endangered humpback whale and the threatened green sea turtle extends in to the area offshore of the Property. However, their numbers in the area are not significant. Under the requirements of the Endangered Species Act, the National Marine Fisheries Service (NMFS) is evaluating the potential impact of the project on these species. During construction of the Barbers Point Deep Draft Harbor, as well as the marina and swimming lagoons at Ko Olina, conservation measures and precautions were imposed as conditions to the Corps of Engineers' permits and no threatened or endangered species were known to have been harmed. NMFS is currently in the process of evaluating studies of both humpback whales and green sea turtles prepared for the Project. (See Appendix J and K, respectively) The results of those studies are summarized below:

a. Humpback Whales

Because the waters off Ewa are little used by humpback whales, construction of the marina should not be detrimental to migrating whale populations. The Applicant will comply with mitigation measures required by NMFS to protect humpback whales. Any Corps of Engineers' permit would be conditioned upon development of a blasting plan to minimize the potential impacts on marine life, including whales. If blasting is required, the Applicant will prepare and obtain Corps of Engineers approval for a blasting plan, which will contain special provisions for avoiding adverse impacts on whales. Prior to blasting, the blast area will be surveyed for whales. If whales are present, blasting will be delayed until the whales have departed. Other techniques, as described in the previous section on construction noise impacts (B.2), will be employed to reduce the intensity and size of underwater shock waves (See Appendix J).

b. Green Sea Turtles

During construction of the deep draft harbor at Barbers Point and the swimming lagoons and marina at Ko Olina, green sea turtles populations in the vicinity appeared to have increased. Turtles may have been attracted to the new lagoons or turbidity plumes associated with construction. Although blasting was used at both of these projects, no turtles were known to have been killed. Over the term of turtle studies at Ko Olina, the size and diversity of the turtle population increased with the appearance of more young turtles. Similarly, no significant adverse impacts to turtles are expected from the proposed action. Some localized, temporary adverse impacts on marine algae preferred as a food source by the turtles will occur during construction of the entrance channel and jetties. However, the surrounding shoreline has an abundance of algae and the overall availability of such algae will not be significantly reduced. Based on the experience of other marine construction along the Ewa-Barbers Point shoreline, the proposed marina is not expected to deplete food sources for the turtle (See Appendix K).

The Applicant will comply with mitigation requirements set by NMFS to protect green sea turtles. If blasting is required, the Applicant will prepare and obtain Corps of Engineers approval for a blasting plan which minimizes adverse impacts to marine life, including green sea turtles. Any permit issued for the project would require the Applicant to temporarily suspend dredging operations if turtles are present.

7. Coral and Benthos

Dredging the entrance channel and constructing the jetties would eliminate any sessile or slow-moving bottom dwelling marine life and limu from within the footprint of these features. Sedimentation during construction of the entrance channel will also eliminate or stress benthic organisms in the vicinity. While individual organisms will be displaced during construction, recolonization will likely follow. Marine surveys reveal no significant marine resources in the area that will be impacted; corals are sparse while limu, sea cucumbers and sea urchins are the predominant benthic organisms (See Appendix H).

8. Seaweed (Limu)

The marina entrance channel will occupy about 500 feet of the 4,000 foot long shoreline of the Applicant's property. Alteration of the intertidal zone within the entrance channel footprint will displace algae in this area during construction. Offshore channel construction will result in temporary, short-term increases in water turbidity and local redistribution of bottom sediments. Increased turbidity will reduce light penetration, limiting photosynthesis and the growth of photoplankton and attached benthic algae. Once construction in a particular area is completed, wave action and mixing will quickly dilute the turbid water, restoring light penetration and plant photosynthesis to pre-construction levels.

D. Long-Term Impacts - Landward

The proposed development will permanently change the land uses in the Project area. The greatly intensified use of the Property is anticipated to have the following long-term impacts in the area.

1. Topography/Drainage

The topography and drainage through the Property will be significantly altered by the excavation of the marina basin and filling of surrounding areas with the excavated material. Approximately 200,000 cubic yards of soils and approximately 5 million cubic yards of limestone will be excavated to construct the marina. Approximately 120 acres of submerged marina will be excavated to depths below sea level. Along the marina perimeter, the land will be excavated to a few feet above sea level to establish the final elevation of the waterfront. Sloping upward and away from the waterfront area, the Property will be built-up above present grade to establish drainage patterns, meet flood requirements, and provide topographic relief. The highest elevation will be approximately 40 feet above sea level.

Drainage within the site will be towards the marina. Storm drainage systems designed in accordance with City and County of Honolulu standards will serve the Project site.

Drainage from lands mauka of the Property which occurs during storms is directed into the Property by Kaloi Gulch. The volume of future discharge could range from the currently estimated 550 cubic feet per second (cfs) to as much as 10,000 cfs according to the City and County of Honolulu's design standards of a 100-year storm event, ignoring all upstream conveyance capacity limitation in the watershed. According to a preliminary concept plan, the initial 2,200 cfs of storm flow received through Kaloi Gulch would be diverted westward through the Phase II golf course and into the marina near its mouth. This diversion will utilize permanent detention basins in the golf course to allow runoff to percolate into the ground and silt to settle out before the flows enter the marina. The discharge point near the marina mouth is deeper and has better circulation and mixing than interior portions of the marina and is, thus, better suited to accommodate such discharges. Flows greater than 2,200 cfs would enter a detention basin mauka of the head of the marina and then into the marina. The marina itself will function as a retention basin during such larger storms. For this plan to be effective, however, developers of land mauka of the Property must provide for flood and silt control on their own property and provide any necessary drainage improvements in Kaloi Gulch.

2. Hydrology

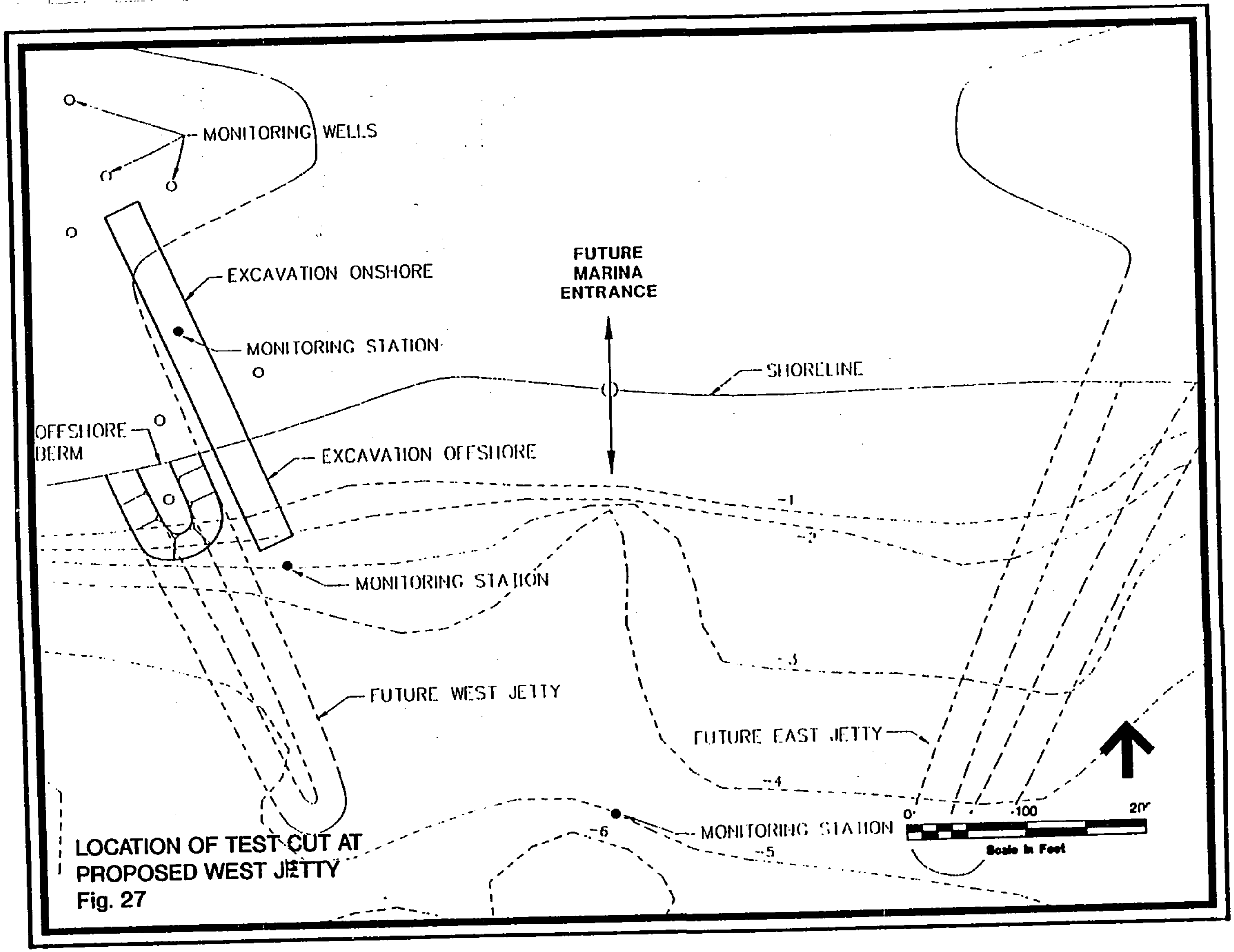
The project's potential impact on groundwater resources is confined to the brackish caprock aquifer which lies in the uppermost reef limestone layer. Marina excavation will displace 120 acres of this aquifer and breach the shoreline barrier confining it. No effects on the basalt aquifer would occur, as it is physically remote and hydrologically separate from the proposed marina construction.

Expected future land use changes and water use patterns will substantially alter conditions in the caprock aquifer whether or not the marina project proceeds. As development displaces sugarcane cultivation on the Ewa Plain, the very large amounts of pumpage from OSCo's seven caprock wells will be replaced by lesser withdrawals from numerous, smaller irrigation wells. Results of these land and water use changes are likely to raise groundwater levels and reduce salinity in the aquifer. Both of these effects are considered favorable to preserving the aquifer.

If OSCo goes out of business entirely and their sugar cane irrigation operations cease, a major source of groundwater recharge for the aquifer will be lost. OSCo's fields at the inland margin of the caprock are irrigated with water imported from basalt aquifer wells. Excess irrigation water percolates from these fields and moves both vertically and laterally into the caprock aquifer. During the furrow irrigation period, this irrigation return flow was approximately 45 percent of total recharge. This recharge was reduced by the conversion to the drip irrigation method, however it is still 25 to 30 percent of total recharge. If this recharge source is lost, groundwater levels may subside and salinity may increase.

Tom Nance Water Resource Engineering and Mackie-Martin Associates, Pty. conducted a recent study of the caprock aquifer and the changes which may result from marina construction (See Appendix B). The study identified potential impacts to the caprock aquifer as a result of breaching the hydrologic barrier.

Results of this study suggest that there are natural processes which may cause the hydrologic barrier effect to reassert itself. This phenomena has been observed elsewhere, including the Barbers Point Deep Draft Harbor on Oahu and at Mindarie Keys in Australia. The effectiveness of this natural reassertion of this hydrologic barrier effect will be intensively monitored during the initial phase of construction of the marina. During this initial phase, the Applicant will construct a short segment of the internal waterways and entrance channel, as well as the adjoining portion of the western jetty.



LOCATION OF TEST CUT AT PROPOSED WEST JETTY
Fig. 27

Monitoring wells will be installed and used to collect data showing the caprock aquifer's response to the excavation and this data will be used to determine the extent to which natural hydrologic barrier effect needs to be augmented.

If the data indicate that the hydrologic barrier effect has fully reestablished itself, no artificial mitigation measures may be needed. If, on the other hand, the data show the reestablishment of the barrier is incomplete, a determination will be made during this initial construction phase as to which method, e.g., grouting, sheet piling, salt water injection, is the most effective and cost-efficient. Prior to full-scale construction of the marina, a comprehensive mitigation plan, including long-term groundwater monitoring and alternative mitigation plans, will be developed in cooperation with the Commission of Water Resource Management to comply with performance standards established by it.

3. Soils

Excavation of the marina will permanently remove soil from its 120 acres. Approximately 200,000 cubic feet of soil would be excavated. Topsoil will be stockpiled for use in landscaping after grading, thus, much of the native soil will be restored on site.

4. Wetland and Anchialine Pool

a. *Batis* Wetland

The six acre *Batis* wetland located near the western boundary of the Property will be preserved intact. Much of the wetland area is a surface expression of brackish water from the caprock aquifer. As long as groundwater levels remain at present elevations and the identified low permeability interface is maintained around the perimeter of the marina excavation, adverse impact to the areas of the *Batis* wetland associated with the aquifer is not anticipated. This will be achieved by measures taken to preserve head levels in the caprock aquifer. The Applicant will remove junked automobiles and appliances, as well as old tires, trash, and litter from the wetland during development of the Property. Grading plans around the wetland will maintain existing surface water flows and a vegetative buffer strip of appropriate width will be maintained around the preserved wetland.

b. Anchialine Pool

The location of the proposed entrance channel is the result of a major effort to minimize adverse effects on surfing sites, historical remains and other environmental resources. However, its construction in this location would lead to the loss of an anchialine pool known to be present on the site. Because the

State DOH water quality regulations establish a "no discharge" policy for anchialine pools, a concerted effort has been made to develop a replacement pond that would mitigate for the loss of this pool. Thus far, one replacement pond has already been excavated and additional holes are being excavated. Shrimp have begun to appear in the newly created pond and the scientist leading the investigations has indicated that he sees no reason why colonization of additional ponds should not occur.

5. Biota

a. Flora

Vegetation in and around the *Batis* wetland will be preserved while most of the rest of the property site will be graded and grubbed. The loss of endemic coastal strand vegetation from areas to be graded or excavated will be reduced by transplanting and using endemic species to supplement plants to be used in landscaping. The kiawe/haole koa and scrub vegetation is not considered to provide high quality habitat and no mitigation measures are required for its loss.

b. Fauna

Construction and operation of the marina is not expected to have adverse impacts on birds. Because no federally listed threatened or endangered species have been identified as residing at the project site, no effect on any such species listed under the Endangered Species Act is anticipated. The United States Fish and Wildlife Service has been consulted in accordance with section 7 of the Endangered Species Act. In 1987 the Service issued a finding of "no jeopardy" for two species of birds, the Hawaiian stilt and coot, stating that the marina project would not jeopardize the continued existence of these species.

c. Endangered and Threatened Species

The terrestrial wildlife surveys showed that no threatened or endangered animal or bird species have been found at the marina site. While the *Batis* wetland area is suitable habitat for the endangered Hawaiian coot and stilt, neither of these birds have been found at the site. Because the wetland will be completely preserved, construction of the marina will have no significant adverse impact upon this potential habitat.

6. Air Quality

The primary long-term impacts on air quality in the vicinity of the project site will indirectly result from vehicular traffic associated with the proposed development.

Long-term indirect impacts are also possible due to the project's electrical power demands and solid waste disposal requirements. Both power generation and incineration of refuse at the H-Power Garbage to Energy Plant may contribute air pollutants to the atmosphere. Quantitative estimates of these potential impacts were not made; however, based upon estimated emission rates involved, attendant impacts are insignificant in relation to present and future power demands and solid waste disposal requirements islandwide (See Appendix C).

E. Long-Term Impacts - Marine

1. Bathymetry

Construction of the entrance channel will replace about 27.5 acres of shallow bottom substrate with a channel 3,000 feet long, 400 feet wide with water depths of about 20 feet.

2. Water Quality

A detailed analysis of the water quality impacts of marina construction and operation, along with a proposed monitoring program, was submitted to DOH on October 25, 1991 as part of the Clean Water Act Section 401 Water Quality Certification process for the marina. Computer simulations demonstrate that the marina is expected to be within the state water quality standards for "wet" embayments. The water exiting the marina will not meet the "wet" open coastal water standards in the immediate nearshore area of the channel entrance. Dilution will occur further offshore of the channel entrance. The standards for a "wet" embayment will be applied to the marina because the total daily inflow of groundwater is likely to exceed 1 percent of the volume of the marina basins and waterways. The marina has been designed to maximize tidal flushing rates and minimize residence times. A comprehensive water quality monitoring program and adherence to federal, state and local water quality standards will ensure that water quality impacts are minimized.

Ongoing development of the Ewa Plain will lead to increased storm runoff. To the extent that the proposed golf course and marina will act as detention basins for trapping silt, overall future ocean water quality would be better than if the anticipated future runoff were to be discharged directly into the ocean. To the extent that groundwater which would otherwise flow into the ocean directly would enter the marina, water quality in the marina will not be better than that of existing coastal waters.

To minimize the potential for algal blooms that could adversely affect marina aesthetics and create odor, the marina bottom is terraced and oriented parallel to prevailing tradewinds to maximize water exchange rates with the ocean. The potential for algal blooms will also be controlled naturally since phosphorous levels in entering groundwater will be much lower relative to nitrate and total nitrogen levels. The limited availability of phosphorous will be the controlling factor for algal growth (See Appendix E. Moffat and Nichol, 1990 (Appendix D) and OCEES, 1991).

3. Marine Habitats

The area to be occupied by the proposed jetty consists of about one-tenth of one percent (0.1%) corals. Further offshore, in the outer reaches of the proposed channel, coral coverage increases to about ten percent (10%) and the channel averages four percent (4%) over its entire length.

Although dredging and jetty construction will displace some corals, it is possible that the newly-created surfaces will not substantially reduce the suitability of the habitat for settling and growth of benthic organisms. Inspection of the channel walls of the Barbers Point Deep Draft Harbor, the Waianae Small Boat Harbor, and the Honokohau Harbor wall reveal settlement of corals, algae, sponges and various echinoids. Because the newly-bared substratum may require an initial conditioning period, settlement may not commence immediately. At the Barbers Point Deep Draft Harbor, which is most similar in design and habitat to the proposed Ewa Marina project, many small corals were observed on the channel walls seven years after the completion of dredging. By virtue of the vertical orientation of the channel walls, settlement may be enhanced owing to the absence of sediment accumulation and scouring that occurs on flat bottoms.

In addition, channel walls at the Barbers Point Deep Draft Harbor were not smooth, but consisted of small ledges, holes, and undercuts. Such relief provided a complex of habitat space for small fishes and other motile forms. It is likely that similar characteristics of the channel walls will occur at the Ewa Marina.

The Applicant is also proposing an artificial reef as mitigation for the destruction of existing benthic habitat that will occur during construction. If this mitigation measure is provided in the vicinity of the Project area, an additional enhancement of the habitat in the channel area could result (See Appendix H).

4. Currents and Littoral Drift

Construction of the jetties may locally alter shoreline currents. One of the purposes of the jetties is to provide safe navigation through the surf zone, which can be subject to longshore rip currents. Overall, the jetties alteration of shoreline current impacts on littoral processes will be minimal along the rocky shoreline.

The majority of sand transport in the vicinity of Oneula Beach is onshore-offshore, part of a local reservoir system that remains essentially in equilibrium. The direction of onshore-offshore sand transport is determined by wave conditions. A much smaller component, longshore movement, is primarily to the west and related to wind direction. The entrance channel is not expected to have significant impacts on longshore sand transport because:

1) The entrance channel will penetrate a rocky section of the coastline with little or no sand;

2) There is no evidence that a beach ever occurred in this rocky stretch of coastline;

3) Onshore-offshore littoral transport at the site is essentially in equilibrium;

4) No large sand reservoirs have been documented offshore of this reach of coastline; and,

5) Shoaling of the entrance channels at Ala Wai and Kewalo Basin has been insignificant over the years and maintenance dredging has not been required.

If sand accretes in fillets at the base of the jetties, this sand will be periodically bypassed to nourish downcoast beaches. Because longshore sand transport is minimal and infrequent, such bypass operations are not anticipated (See Appendix G).

5. Fish

The excavated marina berthing basins and waterways will provide additional sheltered habitat for fish. In addition, the change in bottom relief from the entrance channel and jetties may create additional habitat which could increase the abundance and diversity of fishes in the area.

The Applicant has initiated a reef community monitoring program to document existing conditions, and monitor changes during and after construction of the entrance channel and jetties. Long-term enhancement of fish populations is expected, the Applicant will also construct an artificial reef to mitigate the loss of benthic habitat beneath the proposed jetties and in the entrance channel. The location of this reef has yet to be determined.

6. Threatened & Endangered Species

a. Humpback Whales

Potential conflict between increased boating traffic generated by the proposed Ewa Marina and humpback whales was investigated (See Appendix J). Humpback whales are present in Hawaiian waters during the winter months, however, the potential for conflict is low due to the following reasons:

* Whale survey data indicates that the densities of whales in waters adjoining the Property are among the lowest observed in the entire state and that this low density is a stable condition; and,

* The incidence of whale pods with calves (a focus of concern for species recovery efforts) was alsc very low, indicating that cow-calf pods avoid these waters.

b. Green Sea Turtles

Due to the absence of turtle habitats in the immediate vicinity of the project site, turtle habitats will not be affected in the long-term as a result of development. (See Appendix K). Although no adverse impacts to green sea turtles are anticipated, the Applicant's artificial reef proposal could provide additional habitat for the species, depending on where it is located.

7. Coral and Benthos

The proposed channel entrance and jetties will alter the existing benthic habitat. The jetty footprint area consists of about one-tenth of one percent (0.01 %) coral. Further offshore, in the outer reaches of the channel, coral coverage increases to about ten percent (10%) and averages about four percent (4%) over the entire channel length.

On the other hand, the intertidal habitat created by the jetties, as well as the marina walls and piers, wharves and pilings, may provide a more sheltered habitat for benthic organisms than currently exists. Overall, the increase in habitat diversity could result in an increase in species abundance and diversity. The Applicant has also proposed to construct an artificial reef to satisfy the "no net habitat loss" policy of the National

Marine Fisheries Service. This artificial reef will provide additional habitat diversity for all types of marine organisms (See Appendix H). The location of the artificial reef, however, has yet to be determined in conjunction with federal and state agencies.

Algal habitat should similarly be increased by the construction of the jetties. Thus, in the long term, construction of the entrance channel and jetties and operation of the marina is not anticipated to have significant adverse impacts on algal species diversity or abundance.

F. Community Resources

1. Agricultural Lands

Sugar is the dominant agricultural product of Ewa, and OSCo is the sugar producer of the area. The agricultural land currently under cultivation within the proposed site produces relatively low yields of sugarcane (9.34 tons per acre).

The immediate effect of developing the Property will be a reduction of land available to OSCo for its sugar production. However, according to OSCo the withdrawal of this land to accommodate the proposed residential community will not have a major impact on their cultivation of sugarcane on the Honouliuli Plain. Because the Property is located on the outskirts of the plantation, OSCo's irrigation system and cane haul roads will not be significantly interrupted. Moreover, with the withdrawal of the Property, the sugar plantation will become more compact, resulting in shorter, and less expensive trucking distances to the mill. Furthermore, because the development of the Property will eliminate inferior quality plantation lands, average yields for the plantation may actually increase. In addition, OSCo has said that because of the historically lower yield per acre of the fields on the Property as compared with most other fields on the plantation, any voluntary reduction in Honouliuli production acreage would start with the Property.

The long-term future of OSCo will remain uncertain whether the Applicant develops the Property or not. This is so because of flat sugar prices combined with inflation-driven operating costs, the uncertainty of continued federal price supports, and scheduled expiration of all of OSCo's leases by the mid-1990's. The proposed project is part of the long-planned urbanization of Ewa as the designated Secondary Urban Center of Oahu. Moreover, given the development plans of other landowners in the project area and those of the State and City, it is unlikely that sugarcane cultivation would continue even if the Project were not constructed.

Development of the Property will also not adversely affect diversified agriculture, for the following reasons:

* Extensive amounts of prime-agricultural lands and water sources have already been freed in other parts of Oahu from sugarcane and pineapple production, thereby making those other lands available for diversified agriculture;

* There is a probability that even more lands and water will be freed from sugarcane production due to the marginal profitability of sugar;

* Most sugar producers would make their lands available for more profitable replacement crops, to the extent that such other crops become available; and,

* Only a small amount of land and water is required to grow those known crops which do have a realistic potential for being commercially feasible.

Thus, given that the supply of available agricultural lands greatly exceeds the demand, the development of the Property will not hinder the growth of diversified agriculture in Hawaii.

2. Shoreline Access

Roadways in the proposed project will provide vehicular and pedestrian access to Oneula Beach Park, the proposed public marina facilities, and other planned recreational facilities to the east of the proposed entrance channel. Within the Property, access to a series of parks, commercial areas, and marina support areas along the waterway and the entire ocean shoreline will be available via internal pedestrian ways. This access will be primarily along the water's edge except where uses require direct access to the water. Such uses may include, but are not limited to, a ferry terminal, dry-stack storage facilities, boat launching ramps, sewage pump-out facilities, fueling docks, commercial fishing facilities and marina fronting single-family residences.

The accessibility of the coastal area between Oneula Beach Park and the proposed marina entrance channel will be enhanced by the roadways, parking areas, and pedestrian paths that would be constructed as part of the proposed project. This is likely to be appreciated by the majority of the potential users of the area, but will change the rough character and relative isolation enjoyed by the few individuals who currently reach the area on foot or via four-wheel drive vehicles. On the east side of Oneula Beach Park, public access to the shoreline will be provided at intervals of one-fourth mile or less in compliance with the City and County Department of Parks and Recreation policy for shoreline accessways in urban areas.

The proposed plan calls for public uses in the entire shoreline area west of the proposed marina entrance channel and jetties. However, construction of the channel will interrupt alongshore movement. The Project's internal roadways will make it possible for individuals with vehicles to continue to reach the shoreline area on the western side of the entrance channel by driving around the marina. But the distance is so great that pedestrians are likely to limit their movements to one side or another of the channel. Pedestrian public access along the shoreline will continue to be available from the western side of the entrance channel up to the NASBP fence. The 22-acre preservation area may be fenced, however, above the shoreline.

The possibility of preserving the ability to move continuously along the shoreline through the use of a pedestrian bridge or tunnel was previously considered. However, the height of the bridge that would be needed to clear taller sailing vessels expected to use the marina made a bridge both aesthetically undesirable and costly, while the required depth of a pedestrian underpass (at least 35 feet below sea level in order to clear the channel bottom) was also too costly. It should be noted that such an interruption in alongshore movement is virtually unavoidable. The only existing marina on Oahu where a road/pedestrian way has been provided is in Hawaii Kai, and the presence of the Kalanianaole Highway Bridge over the outlet to that marina has seriously limited its use by sailing craft and motor vessels with more than minimal clearance requirements.

3. Beaches

As previously noted, the proposed entrance channel and jetties will be constructed along a rocky stretch of shoreline. This, together with the fact that sand movement in the area is principally on-/off-shore (rather than alongshore), indicates that there is little likelihood that they would interfere with the natural processes that affect the size and location of existing beaches. However, some accretion at the base of the jetties is possible. Should this occur, the Applicant will remove the sand from the accreting side of the channel and redeposit it on the down-drift side, thereby preserving the natural pattern of sand movement, as well as insuring minimal effect on the nourishment of the area's beaches.

4. Surf Sites

The proposed channel entrance location presently shown on the City and County of Honolulu DP Land Use Map was determined as having a potential adverse impact on the "Coves" surfing site. The 1986 EIS accepted by the City proposed a new channel location further west which appeared to run between "Coves" and "Tree Stumps," another surfing site. A subsequent study of surf sites in 1990, however, indicated that this alignment actually overran the "Tree Stumps" site (See Appendix L). Further studies were performed to determine the currently proposed channel alignment which would virtually eliminate the adverse impacts to "Tree Stumps" while preserving the more popular "Coves" site. Because adverse impacts to "Tree Stumps" and "Coves" are avoided, no significant adverse impacts on existing surfing opportunities will result.

The entrance channel may possibly enhance surfing as the alteration in wave energy along the edge of the channel enhances surfable wave conditions, similar to conditions at the Kewalo Basin and Ala Wai areas.[22] Because the marina entrance channel will cut through the public shoreline, local shoreline users will have to walk or drive around the marina to access the other side of the shoreline. Roadway access and parking will be provided on the west side of the entrance channel. From there, pedestrian access along the shoreline will be available up to the NASBP fence.

5. Fisheries

Construction of the entrance channel and jetties is expected to result in a net increase in fish habitat immediately offshore of the marina. The marina itself will also become a fish habitat once connected to the ocean. The Applicant also is planning to construct an artificial reef as mitigation for unavoidable aquatic impacts associated with construction. This artificial reef will provide additional habitat for fish and marine organisms.

The marina itself will provide increased opportunities for both commercial and recreational fishing by providing Oahu with additional boat slips and launching ramps. This improved access to the ocean, combined with enhancement of the existing marine habitats, will benefit commercial and recreational fishing. The available information indicates that marina construction and operation will not have significant adverse environmental impacts on such fisheries. The location of the artificial reef, however, has yet to be determined in conjunction with federal and state agencies.

6. Other Water-Related Recreation

The marina will benefit numerous types of water-related recreation. The marina will directly benefit boating, providing berthing for boats within the marina, land space for dry stack storage, and public boat launching ramps. The Applicant is working with the surrounding community to ensure that the marina serves their recreational needs, as well as the needs of new residents moving into the area as the Ewa Plain develops into Oahu's secondary urban center.

Shoreline recreational opportunities will also improve because of improvements allowing increased parking and access. These improvements will increase use of the area by surfers, windsurfers, canoe clubs, beach fishermen, and beach-goers.

[22]Moffatt and Nichol, Engineers. *Ewa Marina: Evaluation of Project Impacts on Surf Sites. Technical Study.* Prepared for HASEKO (Hawaii), Inc. November 1990.

7. Navigation

The entrance channel and jetties are designed to enhance navigation and permit vessels to safely enter and exit the marina. The width of the channel (400 feet) conforms to the U.S. Army Corps of Engineers design standards (300 feet for the first 1,000 boats, plus 100 feet for each additional 1,000 boats) while the depth (20 feet) is based on the water depth needed to prevent waves from breaking in the channel under all but the most extreme conditions. The entrance and jetties will be clearly marked in accordance with Coast Guard regulations. As a result, no significant adverse impacts to navigation or navigability are anticipated.

Concerns have been raised regarding the impact that increased boat traffic might have on the operation of the tanker off-loading facilities at Barbers Point. Should the need arise, the marina operator may include educational material, such as information packets concerning safe boating procedures in the vicinity of the tanker, to owners of vessels berthed at the marina.

8. View Planes

The Ewa Marina project is located along the shoreline of the broad Ewa coastal plain. Thus, views of the Project site from any elevated vantage point can only see the project in the distance. From the H-1 Freeway, the Project is visible in the distance at a very low angle. Computer-generated views of the project from this vantage point revealed very little discernable change. Actually, a viewer should be able to identify the marina and the change in the landscape texture from an agricultural-to-urban setting. More noticeable would be the urbanization of agricultural lands closer to the viewer.

Along Fort Weaver Road, the primary makai access corridor, the site would be obscured by features lining the roadway, including homes and sugarcane fields. Even without such obstructions, the flat topography offers little to see in the direction of the Project. A computer-generated view toward the Project from cleared fields makai of homes in the Ewa by Gentry development showed no evidence of the Ewa Marina development, including the 90-foot high buildings in Ewa Marina Phase II.

The most significant change in views will be at the shoreline. In this area, the ocean and waves, rocky shoreline and kiawe forests are the dominant features. Trash and abandoned vehicles blight the landscape. Development of the Project will change the character of the area, offering an urban image with low-rise structures, substantial open space along the shoreline, and tended landscaping. The taller structures in Ewa Marina Phase II would be visible in the distance.

Computer-generated images of an early conceptual development plan indicate that the taller structures in Ewa Marina Phase II and a very low-angle view of the marina may be visible from Oneula Beach Park (See Appendix M, photograph of existing condition in View 1 and corresponding computer-generated image of the proposed development on facing page). It should be noted that the existing vegetation seen in the photograph would completely obscure the Ewa Marina development. In the computer-generated image, this vegetation has been stripped away and some conceptual landscaping has been added. The addition of more strategically-sited landscaping or preservation of some of the existing vegetation could effectively block out views of the Project from Oneula Beach Park.

The most dramatic change in view would be along the shoreline, such as the view from Oneula Beach Park (See photograph of existing condition in View 2 and corresponding computer-generated image of the proposed development on facing page). The rock jetty would somewhat alter the texture and configuration of the shoreline, particularly as it is approached by a pedestrian walking along the shoreline. Low-rise buildings in the marina-support area would also be visible.

Within the project, planned open space will include neighborhood and pocket parks and active and passive recreation areas. Overall, the Project will offer more opportunities for visual variety which will enhance the area's aesthetic qualities. Views within the Project will include the marina, marina-support activities and residential development.

Proposed structures in the Project will not be obtrusive, and design and construction will be dictated by height and density controls set by the City and County of Honolulu Land Use Ordinance and Development Plan Special Provisions for the Ewa area. The maximum height for structures in the Project will be 60 feet, defined by use as follows: Single Family Residential - 25 feet; Low-Density Multi-Family - 30 feet; Medium-Density Multi-Family - 60 feet; and Commercial - 60 feet.

9. Historic and Archaeological Resources

In accordance with the recommendations of the consulting archaeologist and the Hawaii State Historic Preservation Office (SHPO), the proposed development plan preserves all sites that have significant interpretive and/or preservation value. A draft Memorandum of Agreement (MOA) and accompanying archaeological mitigation plan provides for this, and, together with a plan for archaeological salvage work needed to recover scientific information from sites determined to have research value, have been prepared and approved by the SHPO. The preservation and interpretive plan is pending review by SHPO. The MOA is to be executed among the U.S. Army Corps of Engineers, the Officer of SHPO, the Office of Hawaiian Affairs (OHA), and the Advisory Council on Historic Preservation (ACHP) in connection with the U.S. Department of Army Permit.

G. Hazards

1. Flooding

The proposed marina will act as a receiving embayment for storm water runoff from the Kaloi watersheds, including the Property as well as lands mauka of the Property which are slated for development. The proposed drainage plan involves the diversion of flow through the proposed Ewa Marina Phase II golf course, as well as the marina when necessary, to buffer the impact of stormwater runoff into the ocean and provide flood control.

2. Restrictive Easement

The Applicant's development plan for the easement area established in 1988 in favor of the United States of America complies with the terms of the restrictive easement (See Figure 16). Uses proposed within the easement area encompassing the Property include a marina, marina services and preservation areas. The Applicant's compliance with the restrictions set by the United States addresses concerns pertaining to aircraft noise and the Accident Potential Zone (APZ).

3. Rising Sea Level

Sea level rise will be considered among the design parameters of new facilities at Ewa Marina, especially those which will be in proximity to the entrance channel and along the coastline.

H. Infrastructure

1. Roads

The proposed Project will include an internal roadway system to be constructed by the Applicant. This system will tie into existing and planned regional road systems.

Long-term traffic impacts of the proposed development will result from the development of traffic generating uses at the project site. Proposed residential development associated with Ewa Marina will increase traffic along Fort Weaver Road and H-1 Freeway during peak traffic hours. The Applicant, together with other major developers of the Ewa region and various City and State agencies, have been working with DOT in an effort to mitigate the anticipated transportation impacts. The Applicant has also expressed a willingness to pay its fair share of such improvements as is necessary.

Based on current development plans in the region, preliminary highway improvements such as a North-South Road and East-West Road were assumed to be built by the year 1997 (See Figure 28). The North-South Road would extend north from Ewa Marina through the Ewa by Gentry development and connect to Farrington Highway and the H-1 Freeway. North of the Gentry development, the North-South Road would connect to the proposed East-West Road which would take traffic to Kapolei City and Campbell Industrial Park.

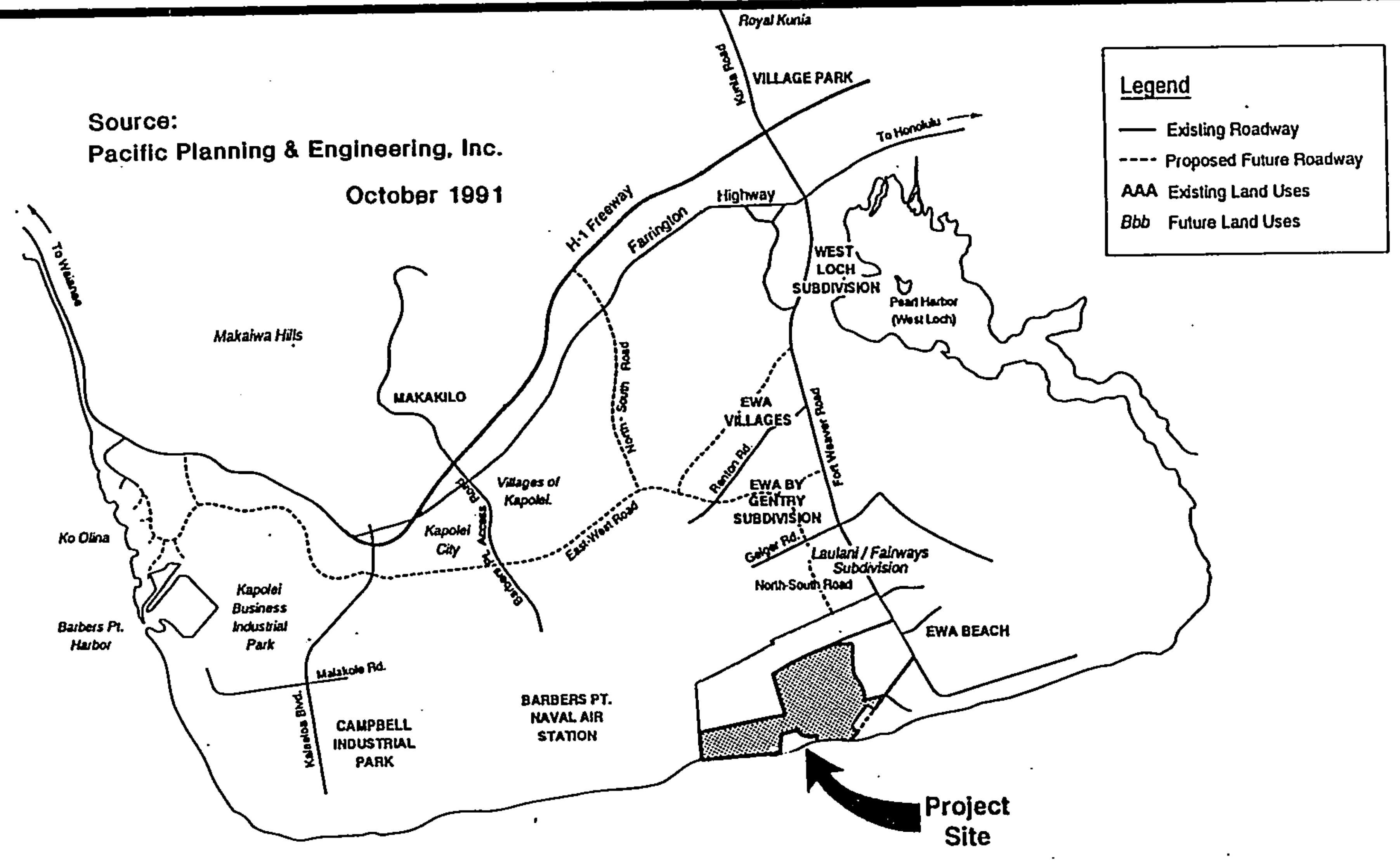
Future traffic forecasts at three proposed signalized accessways and one proposed unsignalized accessway, in both "with project" and "without project" scenarios were estimated for the year 2009 (Accessways are presented in Figure 29). The forecasts assume that the proposed North-South Road and East-West Road have been constructed. The analysis for the three signalized intersections indicates under-capacity conditions in most cases, with the exception of the "with project" scenario at the intersection of Fort Weaver Road and Access Road A. Here, projected traffic volumes would approach "near capacity" conditions (See Table 12).

Forecast results for the proposed unsignalized accessway (which included one intersection at Papipi Road and Hailipo Street, and Hailipo Street and Access Road C) were estimated in terms of LOS (See Table 13). With the exception of one "with project" turning movement, conditions are projected to be LOS A, indicating little or no delay during morning and afternoon peak hours. Only the eastbound left turn from Access Road C onto Papipi Road is less than LOS A in the "with Project" scenario. During the morning peak period, this movement is projected to be at LOS B while in the afternoon peak period conditions would deteriorate to LOS D.

The conclusions of this traffic study confirmed the previous 1986 study by Kaku Associates for the project, which indicated that despite the widening of Fort Weaver Road to a four-lane divided highway, a second north-south road would be required parallel to Fort Weaver Road to link the Ewa Marina/Ewa Beach area and the H-1 Freeway.

With the currently proposed land uses, no other mitigating actions would be necessary for the Fort Weaver Road intersection at the project Access Roads A and B if the following recommendations from the 1986 Kaku report are implemented:

- Provide double left-turn lanes on Access Roads A and B with separate right-turn lanes on Fort Weaver Road for southbound traffic and left-turn lanes for northbound traffic at these two intersections. Fort Weaver Road would need four travel lanes, two in each direction.

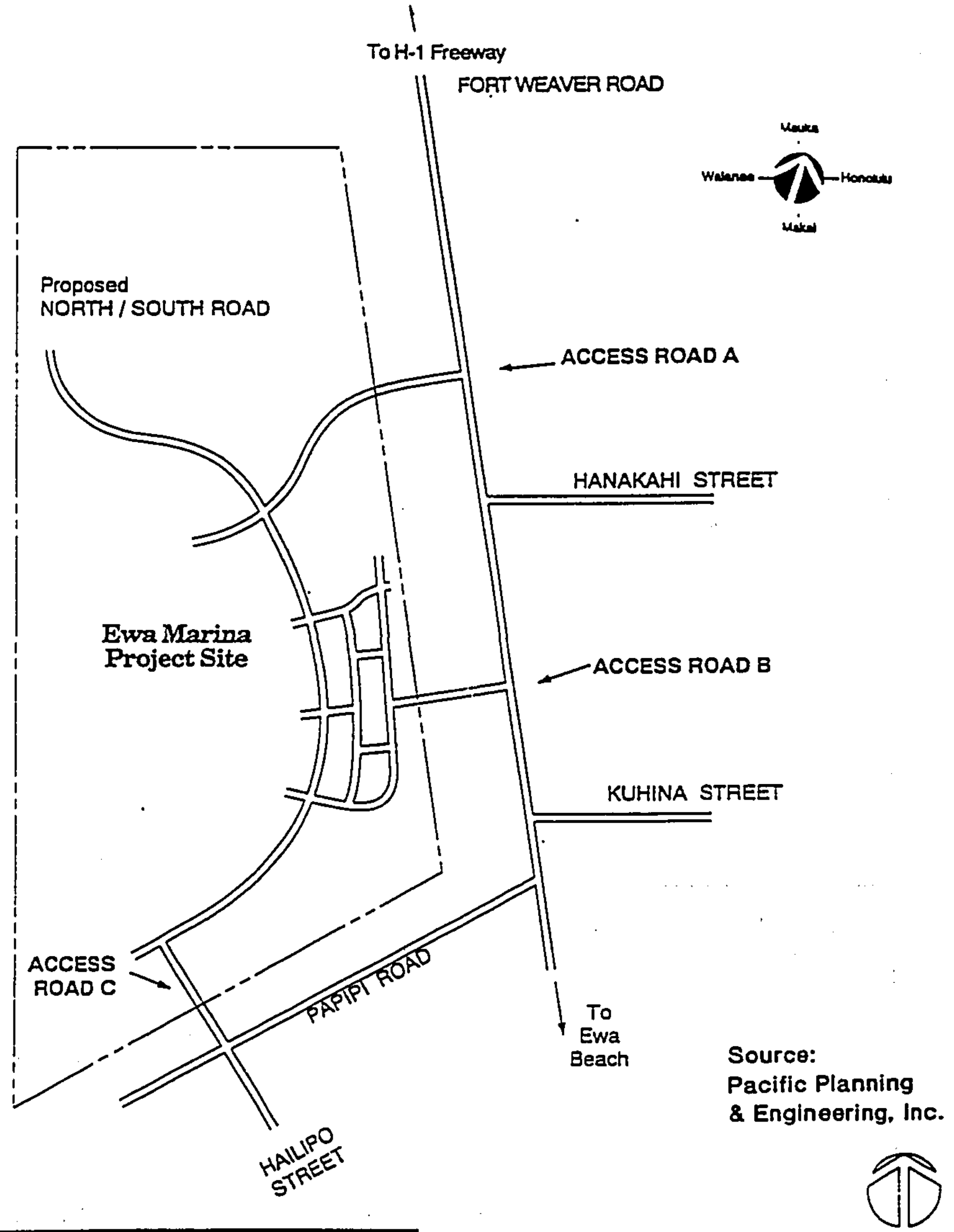


PRELIMINARY LOCATIONS OF ROADWAY IMPROVEMENTS IN THE EWA REGION

EWA MARINA

Prepared by: Wilson Okamoto & Associates, Inc.

Fig. 28



EWA MARINA

Prepared by: Wilson Okamoto & Associates, Inc.

October 1991 · Not to Scale

Fig. 29
PROPOSED ACCESSWAYS

TABLE 12
2009 PEAK HOUR PLANNING ANALYSIS
FOR SIGNALIZED INTERSECTIONS

Signalized Intersection	Year 2009 Without Project AM	Year 2009 Without Project PM	Year 2009 With Project AM	Year 2009 With Project PM
Fort Weaver Road and Access Road A				
Capacity Condition	Under	Under	Near	Near
Critical Volumes	959	1,001	1,249	1,392
Fort Weaver Road and Access Road B				
Capacity Condition	Under	Under	Under	Under
Critical Volumes	615	649	839	990
Fort Weaver Road and Access Road B				
Capacity Condition	Under	Under	Under	Under
Critical Volumes	488	503	630	696

Source: Pacific Planning and Engineering, Inc., *Traffic Assessment Report for Ewa Marina Phase I - Increment II and Phase II*, October 1991.

TABLE 13
2009 PEAK HOUR ANALYSIS
FOR UNSIGNALIZED INTERSECTIONS

Signalized Intersection	Year 2009 Without Project AM	Year 2009 Without Project PM	Year 2009 With Project AM	Year 2009 With Project PM
Papipi Road with Hailipo Road and Access Road C				
Papipi Road				
Eastbound left turn	A	A	B	D
Westbound left turn	A	A	A	A
Hailipo Road				
Shared left/right turn lane	A	A	A	A
Access Road C				
Shared left/right turn lane	A	A	A	A

Source: Pacific Planning and Engineering, Inc., *Traffic Assessment Report for Ewa Marina Phase I - Increment II and Phase II*, October 1991.

- Provide traffic signals where Fort Weaver Road intersect with Access Roads A and B.

Regarding the intersection of Papipi Road, Hailipo Street and Access Road C, an unsignalized intersection would be sufficient to serve the forecasted traffic volumes. For the Access C approach, a single lane to serve left, through and right turn movements would be adequate.

The Oahu Intraisland Commuter Ferry System was not considered in the traffic study. Its implementation could also improve traffic conditions since a terminal is planned for Ewa Marina.

2. Water

The Ewa Water Master Plan of August 1987 sets forth guidelines for water use in the Ewa District and was approved by the Board of Water Supply (BWS). In accordance with the Ewa Water Master Plan, the Applicant has contributed over $10 million to date towards the development of a regional water system and expects to commit additional funds before the system is completed. Recently, a variety of new installations, including a 36-inch main under Fort Weaver Road, water reservoirs, wells and pumping systems were completed and will be dedicated to BWS. The developments are being coordinated by EPWDC, of which the Applicant is a member.

The Property will use a dual water system providing both potable and non-potable water:

a. Potable Water

For domestic use, potable water will be provided in accordance with BWS standards. Potable water has been allocated to the Project in sufficient volumes to meet the required demand.

b. Non-Potable Water

Non-potable water will be provided for irrigation in compliance with the State of Hawaii Water Commission and BWS requirements.

3. Wastewater

Wastewater flows from the Property as well as flows from the golf course and mixed use development in Phase II will be collected and directed to one or more sewage pump stations within the Phase I development. From there, it will be pumped through underground force mains to the Honouliuli Wastewater Treatment Plant. A Sewer

Master Plan approved by the City Department of Public Works (DPW) will be required in conjunction with processing a rezoning request for the Property. Additionally, building permits will not be issued until adequate wastewater facilities are demonstrated to be available. Although the plant's present 25 mgd capacity is currently being approached, there are plans by the City to increase this capacity to 51 mgd, which would accommodate the Project as well as other planned developments in the vicinity.

A portion of the sewer outfall from the Honouliuli Wastewater Treatment Plan bisects the Property in a north south direction. The only feature of the Project that would affect the outfall is the marina. To allow boat passage through the marina, the outfall must be lowered to the marina bottom using a siphon system. The siphon will be designed and constructed to City and County of Honolulu DPW standards and subject to that agency's approval. It will be constructed at the developer's expense prior to excavating the marina.

4. Solid Waste

Solid waste will be transported to the nearby HPOWER energy recovery incinerator facility for disposal. Alternative disposal sites include the Kalaheo Landfill in Kailua, the Waimanalo Gulch landfill near the Kahe Power Plant and the Waipahu Incinerator. Due to the limited capacity of these landfills, the City and County has adopted diversion goals and may, in the future, require developers on Oahu to prepare operational plans for reducing waste destined for landfills.

5. Electricity

Hawaiian Electric Company (HECO) will provide electrical power to the Property. HECO will be constructing a new substation to meet the demands which Ewa Marina and other developments in the area will generate and to supplement the service already being provided by the Ewa Beach and proposed Fort Weaver Substations which are located mauka of the Property. New 46 kV lines will be built to serve the new Ewa Marina Substation.

6. Telephone

Hawaiian Telephone Company will provide telephone services to the Property through existing lines along Fort Weaver Road and through new underground lines in the Property. A switching station within the Ewa Marina development may be required.

Chapter VII

Socio-Economic Impacts

VII. SOCIO-ECONOMIC IMPACTS

A. Overview

Social impacts relate to the long-term changes the proposed project may have on the population in the vicinity. The Social Impact Assessment prepared by Earthplan examines the cumulative impact of the entire Ewa Marina development (See Appendix P). The findings of the study are summarized below. Where appropriate, impacts of the Property or Project (Phase I, Increment 2) are noted. Impacts of other phases are also discussed as part of the broad impact which the development will have on the community.

B. Population Impacts

1. Resident Population

Based on a household size of 2.8 persons per household, the Project would directly add an estimated population of 13,580 persons at full build-out in 2010. The General Plan population projection for Ewa in 2010 range from 119,940 to 132,934. This means that the future Ewa Marina residents would account for eleven to twelve percent of the Ewa region population in 2010.

2. Visitor Population

Decision Analysts Hawaii, Inc. estimated that, at 80 percent occupancy, the hotel units in Phase II would generate a visitor population of 1,300 persons. The hotel garden suites would generate 900 visitors based on 75 percent occupancy. In total, the daily average visitor census would be 2,200 visitors.

The average statewide visitor census is estimated at 264,000 for 2010. Oahu's share is projected at 113,000 daily visitors. Ewa Marina's visitors would account for 0.8 percent of the statewide daily census, and 1.9 percent of Oahu's total.

3. Employment

Construction of Ewa Marina will annually generate 900 construction jobs over a period of 15 years. Marina construction in Phase I, Increment 2 would be the initial activity, and this may occur between late 1992 and 1994.

In terms of long-term operational employment, Ewa Marina's Mixed Use Commercial Complex in Phase II will be a major source of jobs. Decision

Analysts Hawaii, Inc. estimated that approximately 2,230 jobs will be generated by Phase II. On-site visitor accommodations in Phase II will be the largest employment generator, with 1,500 jobs. The other jobs will be generated by the commercial complex (510 jobs), the International Fitness Promotion Center (60 jobs), the yacht club (40 jobs), the golf course and clubhouse (70 jobs) and the tennis complex (50 jobs).

The marina and housing components of Phase I will generate far fewer jobs, but will nevertheless create jobs in harbor support, park maintenance, landscaping, security and maintenance. Hence, the total Ewa Marina development would generate over 2,300 long-term and permanent jobs.

C. Change In Land Use Pattern In Ewa

The eastern half of the Ewa region, generally the area along both sides of Fort Weaver Road, is intended primarily for residences. West Loch and Ewa Gentry are already contributing to the residential character, and the recently-proposed Laulani/Fairways Subdivision project will further add to the suburban character.

Although Phase I of Ewa Marina is in keeping with this residential ambiance, the Mixed Use Commercial Complex of Phase II would essentially change this land use pattern by creating an urban center in the midst of predominantly residential uses. Although Phase II would be at a much smaller scale than the City of Kapolei, the proposed project would essentially serve as an urban center for the eastern half of the Ewa region. The effects of this change in land use pattern are as follows:

1. *The project would be the major employment generator of the eastern half of the Ewa region* -- Phase II would create approximately 2,230 full-time-equivalent (FTE) jobs in this area. No other projects in the eastern half of Ewa are expected to achieve this magnitude of employment.

2. *Existing Ewa Beach and Ewa Village residents will have a major job site in proximity to their residences* -- The proposed project will provide jobs near the existing communities, thus adding convenience and decreased commuting time for existing residents who choose to work at Ewa Marina Phase II.

3. *The Mixed-Use Commercial Complex of Ewa Marina Phase II will provide additional shopping and service convenience to existing residents* -- The proposed project will increase the area's commercial amenities and thereby decrease dependency on facilities in the western half of Ewa.

4. *By creating another urban center, Ewa Marina will help nearby residents in justifying increased public services and facilities* -- Currently, the public facilities being planned for the eastern portion of Ewa will be designed to serve residential uses, which imply a smaller scale than the urban-oriented facilities in the City of Kapolei. Ewa Marina will likely result in a greater need for public services and facilities. Such increased requirements could potentially strain the public service system and compete with residential needs. On the other hand, the development will also help nearby residents in justifying higher levels of public services and facilities. The rest of the Ewa community will, in turn, have direct access to these upgraded public services and facilities.

5. *The Ewa Marina development will be consistent with recently-approved policies of the City and County of Honolulu General Plan* -- The Ewa Marina project site is in the Urban-fringe area, but separate General Plan policies guide the development of the project. In December 1991, the Honolulu City Council passed a General Plan resolution "to encourage the development of a major marina and associated maritime commercial center including visitor units as part of the Ewa Marina community."

6. *Ewa Marina will result in two visitor destinations in the Ewa region* -- The proposed project will result in two visitor destinations at opposite ends of the Ewa region. Although both will operate separately and cater to different market segments, a potential effect of these non-contiguous and distant visitor destinations is the independent creation of visitor-related facilities linking the two destinations. Major planning efforts have been made to achieve orderly and manageable development in the Ewa region. To avoid this type of arbitrary hotel development, public officials will need to establish and uphold planning policies prohibiting such development. Note that, with the presence of Ko Olina, the possibility of independent hotel development still exists and, thus, this situation could occur with or without Ewa Marina.

D. Regional Impacts Of Specific Project Components

1. Probable Non-project Changes

By 2010, the Ewa region could accommodate a population two to three times that of the current Ewa population. As Ewa Marina is being built, the existing community will already be undergoing a gradual adaptation to this major influx of new people. Some of the changes which may have occurred prior to project implementation are as follows:

* *Population and cultural diversification* -- With the onset of Ewa Marina, the residential profile of the Ewa area, including the eastern half, will begin to reflect more of a cross-section of the islandwide community, given the housing mix of various residential projects. With these changes will come cultural diversity. Adaptation will begin with competition for jobs at the new clubhouses and commercial centers, shared use of new shopping centers, altered make-up of schools and community organizations and shared new recreation areas.

* *Disruption of the slow-paced lifestyle* -- The initial impact of impending change is a change in the current slow-paced lifestyle which characterizes the Ewa Beach and Ewa Villages communities. A 1989 poll found that the majority of Ewa Beach residents favored development; if this is still a prevalent sentiment, then Ewa Beach residents are willing to alter the current lifestyle. Nevertheless, the existing communities may experience difficulty in adjusting to the changes which are likely to develop, such as an increase in traffic and crime; disturbance of community cohesion due to economic disparities; crowding at recreational and commercial facilities; and transitional effects of new schools.

* *Competition for public, particularly recreational, facilities* -- As the other developments in the Ewa region are implemented, Ewa will be frequented by visitors and islandwide residents. In the immediate vicinity, new people will visit the area's recreational facilities, including beach parks, public marina and the new Ko Olina beaches.

* *Shift in employment patterns and increased job competition* -- By the time Ewa Marina is implemented, the Ewa region will already have experienced an increased diversity in types of employment, particularly at the City of Kapolei, nearby clubhouses at golf courses, day care centers, schools and new hotels. The new residents of Ewa Marina, Gentry, West Loch and other developments will also be competing for the same jobs.

* *Introduction of visitor industry to the Ewa region* -- Ewa residents will have begun to adapt to having a resort community at Ko Olina in their region. Many residents, including those in nearby Ewa Beach, will have visited the restaurants and shops and some will be employees at these facilities.

2. Residential Component

Possible changes in the population composition of the Ewa area to which Ewa Marina will contribute include (1) a higher percentage of residents participating in the labor force; (2) an increase in the overall family income level; (3) diversification of the region's labor force; and (4) a change in age, ethnicity and educational characteristics to resemble islandwide characteristics. Ewa Marina will contribute to a diversity in the makeup of an already changing community. To some, this change may be an opportunity for increased social exchange and interaction. To others, this change may threaten a seemingly homogeneous community.

E. Marina and Support Facilities

The proposed marina in Phase I, Increment 2 will benefit the island-wide community by providing both much-needed berthing and marine support facilities. Further, the marina and its support facilities are envisioned as a major catalyst for the expansion of Oahu's boating industry.

The Ewa region will experience the same islandwide benefits of the marina, with the additional positive impacts of proximity, local use and diversification of employment.

* Proximity to boating facilities -- Ewa boat owners will be in proximity to public boat launching facilities at Ewa Marina; they would have the advantage of minimal transport time.

* Local use of marina facilities -- Ewa Beach residents also have the advantage of easy access to the marina for non-boating activities. Some have indicated interest in using the marina for canoe paddling activities, with related facilities at the nearby Oneula Beach Park. As the project progresses, the Applicant will be examining the various possibilities for this type of use.

* Diversification in job types -- As the region develops, Ewa residents will have a wide variety of jobs in proximity to their homes. Whereas there is currently a predominance of military and service jobs in Ewa, the future will bring more industrial, professional, managerial and retail jobs to Ewa. The project's marina support facilities will add another dimension to the job supply by introducing marina-related employment.

1. Mixed-Use Commercial Complex

The proposed Mixed-Use Commercial Complex in Phase II will be a major feature of Ewa Marina. Its potential effects on the community will depend to a large extent on how the then-existing Ewa community will have adapted to likely non-project changes identified in the previous section. This section presents some considerations on how this project component may change, affect and enhance the existing community.

* *The Mixed-Use Commercial Complex will increase the de facto population in Ewa* -- Although the Mixed Use Commercial Complex will not directly increase the residential population, it will contribute to the influx of new people by accommodating visitors and attracting non-Ewa residents. Approximately 2,200 visitors will be on-site daily, and over 2,200 people will work at the commercial complex. Further, Oahu-wide residents will likely be attracted to the proposed facilities, such as restaurants and shopping area, as well as the improved Oneula Beach Park.

* *The proposed visitor complex is symbolic of positive and negative aspects of tourism* -- Regardless of the specialty nature of the proposed visitor accommodations, it is highly likely that Ewa residents will apply their own stereotypes and expectations to the Mixed-Use Commercial Complex. In the 1989 statewide tourism impact study, Hawaii and Ewa respondents felt very positive about the benefits of tourism; they believe that tourism benefits outweigh its problems. They appreciated contributions to Hawaii's employment base, as well as amenities which can be shared by residents. Hawaii and Ewa respondents also believed, however, that tourism had negative impacts on existing major community problems. They felt that tourism made the cost of housing and traffic worse, and this sentiment was especially strong in areas where there was a high density of visitor units.

  It is very likely that the proposed visitor complex may be viewed as both a community asset, as well as the cause of problems. Problems which may be particularly associated with the visitor complex are (1) traffic and (2) changes in outdoor resources.

* *Visitors will tend to remain at self-contained area* -- Regardless of the type of development at the project site, there will be an increase in traffic. The estimated visitor contribution to this situation is the subject of the traffic impact study prepared for Phase II (Final EIS Ewa Marina Phase II) but it is helpful to examine trends for visitors to travel in cars or buses

to off-site locations and thus generate traffic. Tourists tend to remain on-site at the larger resorts, except for occasional side trips around the island or into Honolulu or Waikiki. Compared to Waikiki tourists who rent cars and visit off-site recreation areas, rural resort visitors leave their destination area at about 15 percent total per day. It is expected that with the hotels and commercial complex, a similar pattern would prevail, particularly in light of the targeted niche markets.

* *Nearby outdoor recreation areas may be frequented by project visitors* -- At Kuilima, a non-Waikiki visitor destination, it was found that visitors from the resort complex do not frequent public recreation areas near the resort site but prefer going some distance, such as Waikiki when they do travel off-site. At Ewa Marina, however, the project's water and marina orientation will attract visitors who would be interested in using the nearby Oneula Beach Park and other shoreline resources.

  The effects of the influx of new people will likely be felt by adolescents and young adults who will find their recreation areas, surfing spots and beaches infringed upon by those wanting these areas for alternate activities. Loitering at beach parks, partying after hours, loud music and cars, and military-local interface invite confrontations which will lead to resident complaints.

* *Existing residents will experience increased interaction with visitors -- this can be both positive and negative* -- According to the statewide tourism impact study, Ewa residents experience low levels of interaction with tourists now. Whenever there was interaction, the experience tended to be pleasant even in the high density visitor areas.

  On a personal level, the diversity of visitors, mainland and foreign born, can be a culturally enriching experience for workers and nearby residents. There is also a tendency for Hawaii residents to view visitors as a class, however. There is a sense of competition, particularly in high-density visitor areas, of whether the area is "our place" or "their place." This type of impersonal class distinction becomes increasingly problematic when communication barriers increase.

* *There is a potential for economic disparity as long as residents view a tourist as a symbol of something* -- The presence of affluent and corporate executives could create an, "us-them" perception in the minds of some residents. This perception might become a focal aggravation to the extent that Hawaii-born residents are committed to employment within the visitor

industry or are excluded from employment because of lack of skills or training. Research has shown that, as the economic dependency on tourism increases, there is not necessarily a corresponding increase in "Aloha Spirit" toward the industry. As people feel that they are losing political and economic control over their fate to absentee power-brokers in the industry, residents are more likely to direct their animosity toward the visible tourist, who becomes a symbol of the power structure.

* *The Mixed-Use Commercial Complex will expand the area's recreational resources* -- The visitor complex will include a tennis complex and fitness center. These facilities can be welcomed as assets to the community, providing there is sufficient means for the average resident to access these facilities. At the tennis complex, the developer should consider community-oriented programs such as low membership or use rates for residents and junior or school-based tennis education programs. At the fitness center, there should be programs to encourage local companies to use the center.

2. Golf Course

The golf course component will improve the recreational resources in the area. Nearby residents will be able to choose among a number of golf courses proposed for the Ewa region. To ensure community access to the Ewa Marina golf course, programs such as junior golf lessons, kamaaina rates and group discounts should be evaluated.

F. Public Services

1. Police Protection

Ewa Marina will impact police protection services because it will increase the resident and de facto population. The increased demand could be met, however, if current plans for police protection services are implemented. In anticipation of growth in Ewa, public officials are planning major improvements and additions to police services and facilities.

Ewa Marina could help mitigate the impact on police protection services. First, public officials and the Applicant have been discussing the possibility of establishing a new police sub-station in Ewa Marina. Locating this facility within the project will benefit both the proposed and existing communities. Second, at full build-out, Ewa Marina will comprise several distinct neighborhoods. These neighborhoods can minimize the need for police protection by providing on-site security measures and/or personnel who will monitor suspicious activities and handle minor problems.

2. Fire Protection

Ewa Marina will increase the demand for fire protection services by increasing the resident and de facto population and introducing more urban uses. Mitigation measures include working with public officials to locate a fire station on-site or making an otherwise appropriate contribution to regional fire protection services.

3. Recreational Facilities

Ewa Marina will have two types of effects on the existing parks. First, the added population will increase the demand for these resources and cause crowding. This impact will be offset, however, by a corresponding increase of project and non-project recreational resources. All of the residential projects proposed for Ewa will contain recreational resources and a 73-acre regional park will eventually be located in Kapolei.

The second project effect is a positive one. Ewa Marina is envisioned as a recreation-oriented community and will provide land- and ocean-based recreational amenities for Ewa Marina and existing residents. The Applicant has been actively seeking ideas and input from the community about the proposed on-site parks, and Section 5 of the Ewa Marina Social Impact Assessment (Appendix P) contains more information regarding this public input process. The following items outline predominant ideas about the proposed parks at this time. Note that these ideas will likely evolve and be modified as community discussions continue.

a. Gateway Park

The proposed Ewa Marina Gateway Park was generally seen as a facility which would be used by Ewa Beach residents as well as by the new Ewa Marina community. This park can be used as a gathering place, a central place to socialize, meet and just gather. Further, the facilities can contain service facilities which could serve Ewa Beach and Ewa Marina residents.

b. Oneula Beach

Shoreline parks are scarce in this area, and the need for beach parks will greatly increase as Ewa develops. Thus, the improvement and development of Oneula Beach Park is seen as a big plus by community leaders. Oneula Beach Park is seen as a place for fishers, surfers, divers, boaters, wind surfers, sunbathers and general recreation. Community leaders want to see these activities accommodated as much as possible, and it was felt that an ocean recreation center was appropriate for this site.

In addition to these larger parks, Ewa Marina will contain numerous small community and neighborhood parks to meet the needs of on-site residents.

4. Public Education

The existing schools which would be affected by Ewa Marina are Ewa Beach, and Pohakea Elementary Schools, and Ilima and Campbell High Schools. Ewa Marina is projected to house 800 elementary school aged children, 190 intermediate school students, and 360 high school students, as contained in Table 14. The current plan is that half of the elementary students will attend Ewa Beach and Pohakea Elementary Schools; Ilima Intermediate and Campbell High will serve the older students.

Table 14

Ewa Marina Projected School Enrollment

Level	**Projected Enrollment**
Elementary	800
Intermediate	190
High School	360
Total	**5,400**

Note: Projection is very conservative. DOE used a base residential unit count of 5,000.

Source: Earthplan, *Social Impact Assessment*, from the Hawaii State Department of Education, 1990.

If current plans are implemented, Ewa Marina should be adequately served by the public education facilities. State Department of Education officials will continue to monitor the need for and timing of additional facilities and improvements.

5. Child Care

At present, there is no rule of thumb in projecting child care needs and requirements. Specific development proposals are currently determined on a case-by-case basis. Options to address child care needs at Ewa Marina Phase II include (1) providing a site for a child care facility and (2) employer-based options. The latter includes major employer subsidy of on-site care, pre-tax contributions to qualified employees, and a direct voucher provided by employers to employees who demonstrate their use of qualified child care facilities.

6. Medical And Emergency Services

The proposed project is expected to be adequately served by the existing and planned additional medical facilities.

G. Recreational Activities

1. Fishing

During construction of the marina, entrance channel and jetties, opportunities for shoreline fishing may be limited within the area of the shoreline under construction. Opportunities for fishing will increase upon completion of the marina. Fishing in the area will not be discouraged and is expected to increase, because the entrance channel and jetties will provide increased fish habitat. The increased amount of habitat is expected to increase the abundance and diversity of fish species in the area, providing for better fishing.

2. Seaweed (Limu) Gathering

The entrance channel and jetties will not significantly affect the growth of edible algae, and may support abundant growth. The Applicant will not discourage limu gathering. During construction of the entrance channel and jetties, certain portions of the shoreline under construction will not be available for limu gathering; however, the areas of greatest limu gathering activity are to the east of the entrance channel in an area that will not be affected. Overall, no long-term impacts or reductions in the opportunities for limu gathering will occur.

3. Swimming/Snorkeling/Scuba Diving

Existing site conditions, such as beach rock, reef rock and murky waters, contribute to the poor quality of the immediate shoreline area for swimming, snorkeling and scuba diving. Although turbidity is expected to increase in the vicinity of the entrance channel during construction, overall no significant impacts to swimming, snorkeling or scuba diving are expected to result. Snorkeling and scuba diving along the broader leeward coastline via small boats will be enhanced by the proposed marina facilities.

4. Sunbathing/Walking/Jogging

The marina development will not adversely affect sunbathing, beach walking or jogging. The public promenades and sidewalks along the marina berthing basins and waterways will increase opportunities for walking and jogging in the area.

H. Government Revenue (Taxes)

The State and County will experience a substantial increase in revenue as a result of the proposed development. For the City and County, recent property tax revenues from existing sugar and other operations have been very low. Similarly, for the State, revenue has been negligible because sugar is exempt from excise taxes and also because OSCo's operations have only been marginally profitable.

If the Property is developed as planned, the County will accrue a substantial increase in property tax revenues since the marina community will have a much higher value. The State will likewise accrue considerable revenue from excise taxes which will be collected from marina support and commercial operations.

In comparison to revenue gain, the State and County capital improvement expenditures for the Property will be relatively modest because the Applicant will be providing its own on-site infrastructure and will be contributing its fair share of the cost of off-site improvements.

I. Housing Impacts

1. Increase Supply

According to estimates by the Department of General Planning, the Ewa Development Plan area in 1988 contained 9,945 housing units, or about 3.5 percent of the total Oahu housing stock of 280,692 units. Existing residential communities in the Ewa area include: Makakilo (2,700 units), Ewa Beach (3,465 units), Ewa Villages (900 units), West Loch Estates (68 units), Ewa by Gentry (540 units), Honokai Hale/Nanakai Gardens (286 units), and NASBP (850 military housing units).

Planned developments which would substantially increase the housing stock over the next 10 to 15 years include: Ko Olina Resort (5,200 units), the Makakilo area (3,187 units), the Ewa Villages Revitalization project (1,130 units), Ewa by Gentry (7,150 units), Kapolei Village (4,871 units), Kapolei Knolls (500 units), Laulani/Fairways Subdivision (1,805 units), and West Loch Estates (1,500 units).

The approximately 3,500 single- and multi-family housing units to be developed on the Property are expected to contribute to the viability of the Ewa communities in terms of increasing the quantity and variety of housing choices in the area and providing a larger residential base for expanded and improved community facilities and programs such as parks and recreation, public transportation, commercial facilities, and professional services. With the islandwide need for housing and the direction of growth towards the Secondary Urban Center, the residential component of the Project will contribute to accommodating the projected population increase anticipated in Ewa.

Given the continuation of strong demand for housing on Oahu, the growing level of urbanization within the Ewa District, the historical performances of other major development programs, and the relative lack of competitive ocean front and amenity-oriented developments, the Project should be able to achieve a market penetration of approximately 500 to 550 units per year over its development period without adversely affecting the housing market.

Loss of open space currently occupied by agricultural and other private recreation areas with limited accessibility and usability is expected to be mitigated by development of usable and publicly accessible open space in the form of boating waterways, parks, and waterfront perimeter parkways.

2. Affordable Units

Pursuant to conditions imposed by the State Land Use Commission in amending the state land use designation for the Property from Agriculture to Urban and by the City in its zoning approval of Phase I, Increment 1, ten percent of the 4,850 units in Ewa Marina Phase I must be affordable. Thus, the Project will contribute toward easing Oahu's affordable housing shortage.

Chapter VIII

Alternatives and Mitigation

VIII. ALTERNATIVES AND MITIGATION

A. Alternatives to the Proposed Action

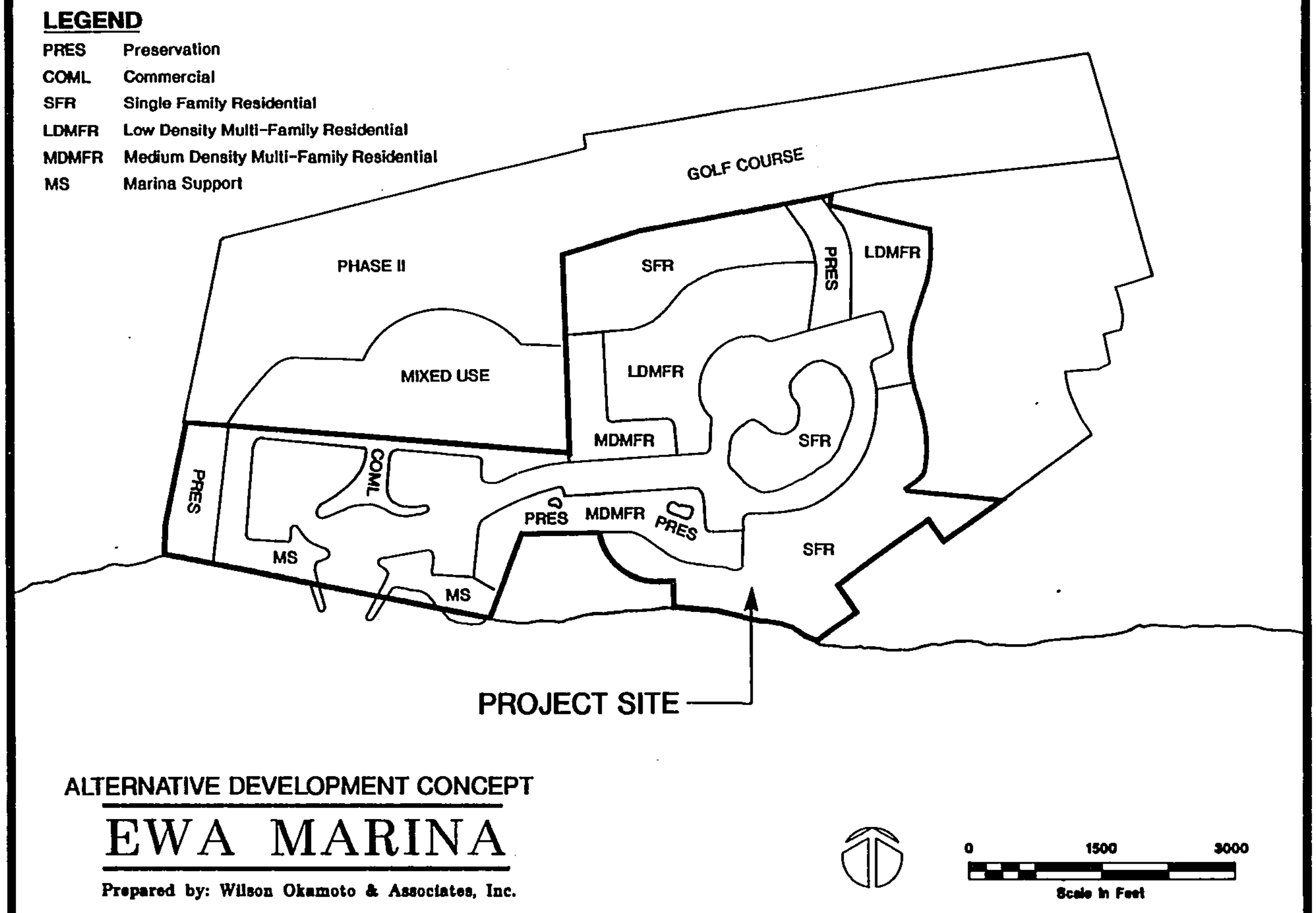
The current proposal is based on a refinement of the marina configuration in response to environmental considerations such as protecting surf sites and archaeological resources, limiting impacts on the caprock aquifer, and assuring adequate water circulation and wave attenuation within the marina, as summarized in the Preface of this document. Other alternative marina and land use configurations are possible within parameters established by these environmental considerations and the housing unit count of 4,850 in Phase I, of which 3,650 units would be within the Project area (Increment II). One potential configuration is shown in Figure 30. This alternative which shows a larger marina area (140 acres) and a greater boat berthing count (1,600 berths). The difference in environmental and social impact of this alternative in relation to the proposed Project would be insignificant. Further project refinement within the above-mentioned parameters are possible based on continuing discussions with various Federal, State and City agencies.

The "no-action" alternative would be inconsistent with State and City plans for the development of a Secondary Urban Center in Ewa and would not address needs such as housing, boating facilities and providing storm runoff control from properties mauka of the Project, as discussed in Section I.

B. Unavoidable Adverse Project Impacts

Development of the Project will involve a number of unavoidable impacts during the short-term construction phase as well as in the long-term. In the short-term, construction of the Project will have landward impacts, including the generation of noise and dust, increases in emissions from vehicles, increases in vehicular traffic and changes in alongshore public access as discussed in Section VI.B. To some degree, these impacts can be minimized, however, they cannot be entirely avoided. Similarly, unavoidable impacts on the marine environment during construction will include runoff from landward construction activities, siltation from dredging - including potential blasting, changes in marine traffic, loss of fish and other organisms from blasting, and loss of benthic organisms and habitats as discussed in Section VI.C. Again, measures to minimize these impacts will be implemented in compliance with Federal, State and City requirements.

In the long-term, unavoidable adverse impacts on the landward environment will include the loss of an anchialine pool as discussed in Section VI.D.4.b.; loss of much of the existing vegetation and associated faunal habitats, as discussed in Section VI.D.5.; and, a slight localized deterioration of ambient air quality as a result of increased vehicular



ALTERNATIVE DEVELOPMENT CONCEPT

EWA MARINA

Prepared by: Wilson Okamoto & Associates, Inc.

Fig. 30

traffic and, indirectly, through increased electrical consumption and solid waste generation as discussed in VI.D.6.

In the long-term, the project is not anticipated to have any unavoidable adverse impacts on the marine environment. Although construction of the marina entrance channel and jetties will permanently eliminate the existing benthic habitat, this loss is expected to be more than compensated by the creation new intertidal habitats associated with the marina and the proposed artificial reef.

Long-term adverse impacts on community resources in the area may include the loss of agricultural land, although this loss is viewed as a tradeoff for establishment of a Secondary Urban Center for Oahu in State and City policies. Shoreline access will be changed as a result of developing the Project. Although continuous alongshore access will be interrupted by the marina entrance channel, other opportunities for public shoreline will be created, as discussed in Section VI.F.2. The visual character of the area will change as a result of the project although no adverse effect on significant view planes has been identified. Archaeological sites have been identified and a mitigation plan prepared. This plan includes the loss of a number of archaeological features, however six sites recommended for preservation "as-is" will be preserved as discussed in Section III.E.5 and Section VI.F.9.

C. Short-Term Use Versus Long-Term Productivity

The proposed project involves the long-term commitment of the site to urban types of uses. With respect to productivity, the site appears to offer no economically viable alternatives to such urban uses. The economic viability of existing sugar production in the long-term is uncertain and there are no readily-identifiable agricultural alternatives with potential for strong economic feasibility. The proposed use is also consistent with the Oahu General Plan's designation of a Secondary Urban Center.

D. Irreversible and Irretrievable Commitment to Resources

The Ewa Marina Phase I project will result in an irreversible and irretrievable commitment of capital, labor, land, and energy for the design and development of the project. Construction materials and human resources (labor) will be committed and land, when fully developed, will be irretrievably committed to the new marina-oriented community.

The proposed project will commit land to urban-type uses and the site topography will be permanently altered to build the marina and implement drainage and flood control improvements. While these changes would curtail other potential uses of the land, the only other economically viable uses would probably be variations of the proposed project, including a community with a smaller marina. Continuation of existing sugar production is marginally viable and there are no apparent alternative agricultural uses. Leaving the land vacant would preserve future options but would also be economically unfeasible, particularly since the proposed uses are consistent with City and County policies expressed in the Oahu General Plan and Ewa Development Plan.

E. Proposed Mitigation Measures

A variety of mitigation measures will be implemented to address both short and long-term impacts of the project. These are discussed in Chapter II, Project Description as well as in relation to the various short and long term impacts in Chapter VI. Among these, the most significant mitigation measures are those mitigation measures necessary to protect the caprock aquifer, the construction of an artificial reef, construction of a storm drainage system to accommodate flows from land mauka of the Property, and the changes in the marina configuration to avoid surf sites, archaeological sites, and reduce impacts on the caprock aquifer.

F. Issues to be Resolved

1. Affordable Housing

Pursuant to the terms and conditions of the Land Use Commission Decision and Order, the Applicant is committed to provide 10% of the housing units in Phase I for low-moderate income families. The location and phasing plan for the development of these units have not been determined. The Applicant is working with the State and City agencies to reach an understanding of an acceptable housing program that may include affordable housing for sale or rent.

2. Regional Drainage

The Applicant proposes a drainage plan intended to receive storm runoff from lands mauka of the Property through Kaloi Gulch. The drainage plan would accommodate projected volumes of flow based on the City and County of Honolulu's design standards for a 100-year storm event. To control the amount of silt entering the ocean, the plan provides for retention basins within the golf course in Ewa Marina Phase II and uses the marina as an auxiliary retention basin, if necessary, for the largest storm events. For the plan to be effective, developers of land mauka of the Property must provide for silt control on their property, direct storm runoff into Kaloi Gulch, and provide any necessary drainage improvements to Kaloi Gulch itself. While the Department of Public Works is requiring developers within the watershed to provide such drainage improvements, there is no formal regional drainage plan for the watershed. To the extent that the provision of drainage improvements on lands mauka of the Property is beyond the Applicant's control, the broader issue of managing future drainage in the region cannot be addressed at this time.

3. Caprock Aquifer

The general nature of the groundwater system is well understood and has been successfully modeled. The Applicant is committed to the utilization of the caprock aquifer as a non-potable water source and has developed a program in coordination with the Commission on Water Resource Management for preservation of this resource. This program involves the initial construction of a small segment of the marina entrance channel and internal waterways. An intensive monitoring program during this initial construction phase will provide data for the development of a comprehensive mitigation plan, including long-term groundwater monitoring and alternative mitigation plans, in cooperation with the Commission of Water Resource Management to comply with performance standards established by it.

4. Artificial Reef

The Applicant proposes to construct an artificial reef as mitigation for unavoidable impacts on the aquatic environment associated with construction of the marina entrance channel. Although the existing habitat has little bathymetric relief which results in relatively low fish diversity and abundance, the objective is to satisfy the "no net habitat loss" policy of the National Marine Fisheries Service (NMFS). The location and composition of the artificial reef has yet to be determined in conjunction with NMFS, the State Department of Land and Natural Resources (DLNR) and the U.S. Army Corps of Engineers.

5. Regional Transporation

Regional traffic improvements which will serve the Ewa region, including the proposed Project, are being addressed through the Ewa Region Highway Master Plan which is being prepared by a Working Group of State and City agencies, Campbell Estate, and major developers of the Ewa Region (including the Applicant). The Plan would identify roadway system improvements which are necessary to accommodate forecasted future traffic and allocate fair share improvement costs to the major developers of the Ewa region. Inasmuch as the efforts of the Working Group are on-going, accommodation of regional traffic demands are still in the process of being resolved.

6. Construction Methods and Mitigation

The construction methods, phasing and potential mitigation measures discussed in this Supplemental EIS are necessarily conceptual in nature and reflect reasonable assumptions on how construction will proceed. Detailed construction plans describing methods, schedules and mitigation measures will be required for various components of the Project in order to process permits and approvals for activities such as dredging, excavation, grading, grubbing and stockpiling. Preparation of such plans will be deferred to later design stages.

Consultation

CONSULTATION

GENERAL CONSULTATION

Over the last ten years, the public has had extensive opportunities to provide input on the Ewa Marina project through public hearings and independent reviews associated with Federal State, and City and County of Honolulu land use processing.

After purchasing the Property in December 1988, Haseko (Ewa), Inc. commissioned a telephone survey of 500 Ewa Beach households to determine attitudes toward the project. Thirteen personal interviews were also conducted with community, business, and government leaders from Ewa Beach. The phone survey and personal interviews were used to form the basis of the Applicant's community involvement effort.

The Applicant has been meeting with neighborhood residents and community organizations in addition to the neighboring community of Waipahu on an ongoing basis during the past 2-1/2 years. Boating and ocean recreation groups island-wide have also been invited to presentations. The following is a list of presentations conducted by the Applicant that have offered opportunities for public input.

EWA BEACH NEIGHBORHOOD PRESENTATIONS

August 1, 2, 8, 21 and 30, 1990
September 5 and 6, 1990
October 3, 4, 10, 17, 18 and 23, 1990
November 1, 7 and 15, 1990
March 18, 19, 20, 27 and 28, 1991
April 2, 8, 9, 10, 15, 16 and 17, 1991
October 8, 17, 22 and 30, 1991
November 5 and 12, 1991
February 3, 4 and 5, 1992

EWA BEACH COMMUNITY ORGANIZATIONS

Ewa Beach Community Association
February 28, 1989 - Acquisition Presentation
October 25, 1989 - Project Presentation
November 27, 1990 - Corps of Engineers Permit
March 26, 1991 - Phase II

West Loch Community Association
November 4, 1991 - Project Presentation

Makakilo Community Association
February 6, 1991 - Project Presentation

Ewa Neighborhood Board
September 14, 1989 - Phase I
March 1, 1990 - Phase II
December 13, 1990 - Corps of Engineers Permit
March 25, 1991 - Development Plan Informational Briefing
April 11, 1991 - Phase II Development Plan Amendments
October 10, 1991 - Development Plan (IC for Reconfiguration)

Ewa Neighborhood Board, Planning/Zoning/Housing Committee
November 5, 1990 - Corps of Engineers Permit Briefing
April 3, 1991 - Development Plan Amendments
October 4, 1991 - Development Plan (IC for Reconfiguration)

Ewa Beach Lions Club
April 24, 1991
October 23, 1991

Ewa Beach Shopping Center Merchants
September 7, 1989 - Phase I
March 8, 1990 - Phase II
July 5, 1990 - Project Update
December 6, 1990 - Corps of Engineers Permit

Ewa Beach Laborers Union Members
May 2, 1991 - Project Briefing

OTHER COMMUNITY ORGANIZATIONS

Waipahu Neighborhood Board
March 15, 1990 - Project Presentation
July 31, 1990
May 16, 1991 - Update on Phase II

Boating and Ocean Recreation Users
June 6, 1991 - Pearl Harbor Yacht Club
June 18, 1991 - Hawaii Yacht Club
August 13, 1991 - Waikiki Yacht Club
September 30, 1991 - Kaneohe Yacht Club

Boating and Maritime Community
October 30, 1990
November 7, 13 and 14, 1990
December 4, 1990
April 24 and 30, 1991

Further, the Applicant has consulted with non-profit organizations concerning various interests in the project such as: a) Archaeological sites on the property examined by the Historic Hawaii Foundation; b) Inclusion of maritime educational facilities and institutional slips proposed by the Hawaii Maritime Center; and c) Job training and career development related to the proposed marina activities assisted by West Oahu Employment.

Lastly, discussions of various aspects of the project have also been pursued with Federal, State and City and County of Honolulu government agencies including: a) Federal - Coast Guard, Army Corps of Engineers, Navy, Fish and Wildlife Service, and National Marine Fisheries Service; b) State - Department of Land and Natural Resources, Office of State Planning, Department of Transportation, Department of Health, State Historic Preservation Office, Advisory Council on Historic Preservation and Office of Hawaiian Affairs; and City - Department of Land Utilization, Department of General Planning, Department of Parks and Recreation, Department of Public Works, Department of Transportation Services, Board of Water Supply, Honolulu Fire Department and Honolulu Police Department.

SEIS PREPARATION NOTICE CONSULTATION

As part of the Draft Supplemental EIS preparation, an EIS Preparation Notice was published for the project in the Office of Environmental Quality Control Bulletin on November 25, 1991. This was followed by the 30-day formal review period which ended on December 24, 1991. Various agencies, organizations and individuals were consulted, whereupon, all comment and response letters received are reproduced herein. No requests for consultation were received during this period. The following is a list of consulted parties. Those who formally responded are identified with an asterisk (*) and those who provided substantive comments are identified with a double asterisk (**) on the EIS Preparation Notice. All correspondence received by December 24, 1991 was reproduced in the Draft SEIS. Consulted parties identified with a plus (+) provided comments received after the December 24, 1991 deadline and, therefore, did not appear in the Draft SEIS. These comments, along with their responses, are included in this Final SEIS.

FEDERAL

** U.S. Army Corps of Engineers+
U.S. Fish and Wildlife Service
** U.S. Navy (NAS Barbers Point)+
National Marine Fisheries Service

STATE AGENCIES

Department of Agriculture
** Department of Health+
** Department of Land & Natural Resources
** DLNR Aquatics Resources Division
DLNR Office of Environmental & Conservation Affairs
** DLNR State Historic Preservation Division+
Department of Transportation
Office of State Planning

CITY AND COUNTY OF HONOLULU

* Board of Water Supply
** Board of Water Supply (2nd letter)+
** Department of General Planning+
** Department of Land Utilization
** Department of Parks and Recreation
** Department of Public Works

CONSULTATION

Department of Transportation Services
* Fire Department
** Police Department

UNIVERSITY OF HAWAII

Environmental Center

OTHERS

Ewa Neighborhood Board
* Hawaiian Electric Company, Inc.
* GTE Hawaiian Telephone Company

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
BUILDING 230
FT. SHAFTER, HAWAII 96858-5440

December 23, 1991

REPLY TO
ATTENTION OF:

Planning Division

RECEIVED
JAN 0 . 1992
WILSON OKAMOTO & ASSOCIATES

City and County of Honolulu
Department of General Planning
Attention: Mr. Brian Suzuki
650 South King Street, 8th Floor
Honolulu, Hawaii 96813

Dear Sir/Madam:

We have reviewed the Supplemental Environmental Impact Statement Preparation Notice (SEISPN) for Ewa Marina, Phase I, Ewa, Oahu. The following comments are provided pursuant to Corps of Engineers authorities to disseminate flood hazard information under the Flood Control Act of 1960 and to issue Department of the Army (DA) permits under the Clean Water Act; the Rivers and Harbors Act of 1899; and the Marine Protection, Research and Sanctuaries Act.

a. The Corps of Engineers is processing a DA permit for the construction of the marina (file number PODCO 2117, as noted on page IV-1 of the EISPN) and is preparing a federal Environmental Impact Statement for the project. If you require additional information, please contact Mr. Warren Kanai at Operations Division (438-9258).

b. According to the Federal Emergency Management Agency's Flood Insurance Rate Map, Panel 150001-0135-C, dated September 28, 1990 (copy enclosed), the project site is located in the following zones: Zone A (areas inundated by the 100-year flood; base flood elevations and flood hazard factors not determined); Zone AE (areas inundated by the 100-year flood, with a base flood elevation of 6 to 8 feet above mean sea level); and Zone D (areas in which flood hazards are undermined).

Sincerely,

ORIGINAL SIGNED

Kisuk Cheung, P.E.
Director of Engineering

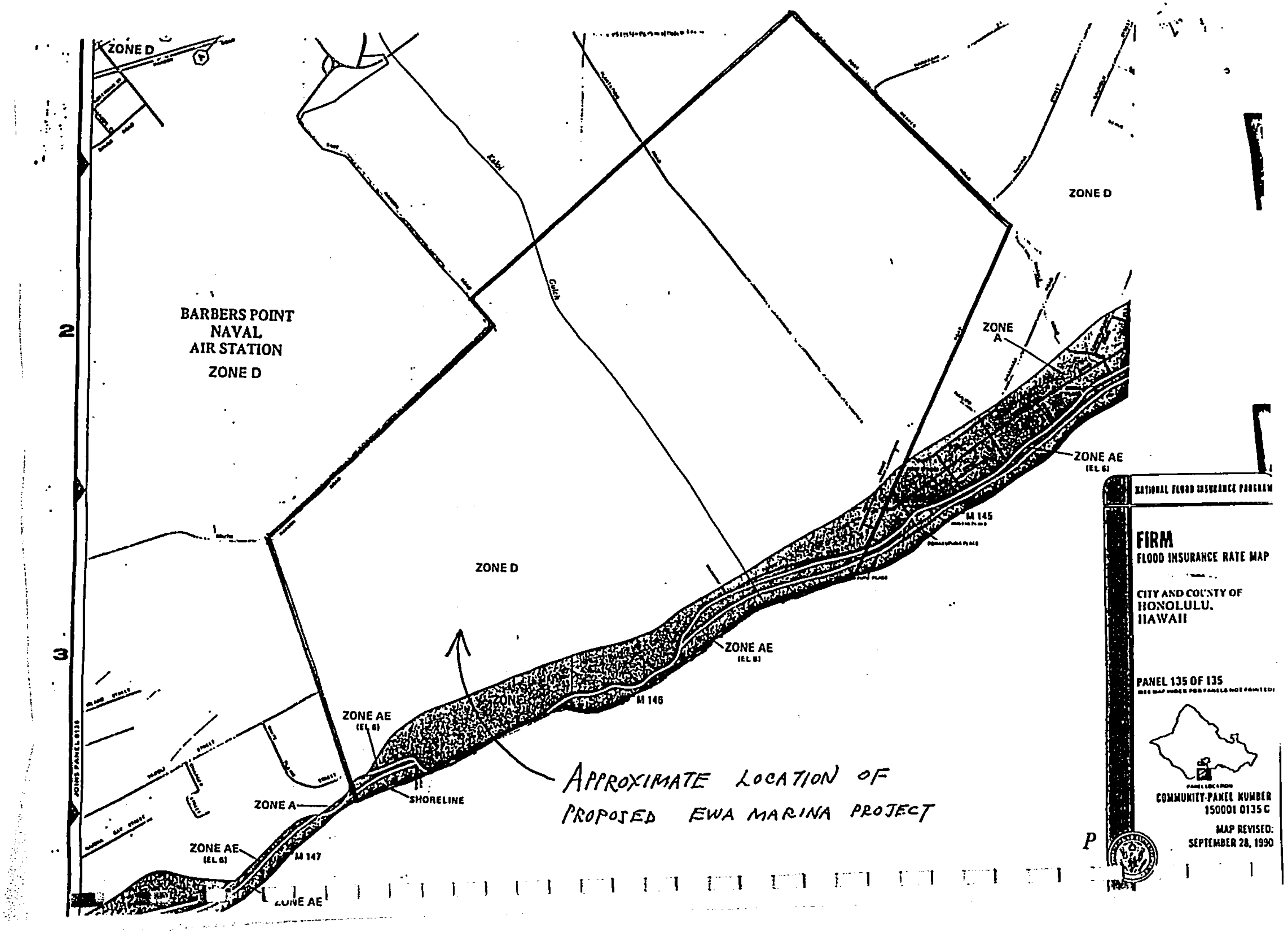
Enclosure

Copies Furnished:

Wilson Okamoto & Associates, Inc.
Attention: Mr. Earl Matsukawa
P.O. Box 3530
Honolulu, Hawaii 96811

Haseko (Hawaii), Inc.
Attention: Mr. Nelson W. G. Lee
820 Mililani Street, Suite 820
Honolulu, Hawaii 96813

Office of Environmental Quality Control
465 South King Street, Room 104
Honolulu, Hawaii 96813


ZONE D
BARBERS POINT
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SHORELINE
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ZONE AE
(EL 6)
M 147
ZONE AE
APPROXIMATE LOCATION OF
PROPOSED EWA MARINA PROJECT
NATIONAL FLOOD INSURANCE PROGRAM
FIRM
FLOOD INSURANCE RATE MAP
CITY AND COUNTY OF
HONOLULU,
HAWAII
PANEL 135 OF 135
COMMUNITY-PANEL NUMBER
150001 0135 C
MAP REVISED:
SEPTEMBER 28, 1990
P

WILSON OKAMOTO & ASSOCIATES, INC.
ENGINEERS
ARCHITECTS
PLANNERS

3053-04
April 6, 1992

Mr. Kisuk Cheung, P.E.
Director of Engineering
U.S. Engineer District, Honolulu
Building 320
Fort Shafter, Hawaii 96858-5440

Subject: Ewa Marina Phase I
Supplemental Environmental Impact Statement
Preparation Notice
Tax Map Key: 9-1-12: 2, 3, 5 (por.), 6 (por.), 7 (por.), 8 through 17, and 23 (por.)
9-1-11: 1 through 7
Ewa, Oahu, Hawaii

Dear Mr. Cheung:

Thank you for your letter of December 23, 1991 commenting on the subject Preparation Notice. Due to the schedule required to process the Supplemental Environmental Impact Statement (SEIS), we were unable to address EISPN comments received after December 24, 1991 for inclusion in the Draft SEIS. Since your comments were received on January 6, 1992, they will be reproduced in the Final SEIS along with this response. The Draft SEIS was filed with the OEQC on January 6, 1992 and copies of the document have been sent to your agency for review and comment in the 45-day public review period.

We offer the following in response to your numbered comments, respectively:

1. No response required.

2. Thank you for the flood hazard information. We have included a section of flood hazards affecting the project site in the Draft SEIS.

We hope that we have adequately responded to your comments. Your letter, together with this response, will be reproduced in the Final SEIS. We appreciate your interest and participation in the consultation phase of the environmental review process.

Sincerely,

Earl K. Matsukawa
Project Manager

cc: Office of Environmental Quality Control
HASEKO (Ewa) Inc.

DEPARTMENT OF THE NAVY
COMMANDER
NAVAL BASE PEARL HARBOR
BOX 110
PEARL HARBOR, HAWAII 96860-5020

IN REPLY REFER TO
11000
Ser 00F(238)/3440
16 JAN 1992

Mr. Brian Suzuki
Department of General Planning
City & County of Honolulu
650 South King Street
Honolulu, HI 96813

Dear Mr. Suzuki:

APPLICATION FOR EWA MARINA, PHASE I-INCREMENT II
DEVELOPMENT PLAN AMENDMENTS AND ENVIRONMENTAL ASSESSMENT

We have reviewed the subject Ewa Marina Phase I development plan amendments and environmental assessment (EA), and the following comments are provided:

a. Page I-11, Section B.1., Property Boundary. The boundaries for Ewa Marina Phase I do not appear to affect the electrical distribution lines located along the east side of NAS Barbers Point. However, Ewa Marina Phase II boundary seems to intersect the electrical distribution line in the vicinity of the corner of Essex Road, near the tee-off for the 5th hole of the existing golf course. Request review of this potential conflict and comment. See enclosure (1) for location of existing electrical distribution line.

b. Page IV-6, Section 226-15, Objectives and policies for facility system--solid and liquid. Under Comment section, "The marina will be tied into the regional wastewater collection and treatment system, and construction of wastewater-generating elements...subject to City approval." Recommend define what "wastewater-generating elements" are.

c. Page V-8, Section D-2., Water. NAS Barbers Point obtains potable water from the Navy's Barbers Point shaft. Any additional water pumpage from the Waianae aquifer may have an adverse impact on the water quality of the Barbers Point shaft. Recommend any potential water impacts to the Navy's Barbers Point shaft due to the development of other sources in the vicinity of the shaft be addressed.

d. Page V-13, Figure 14, Ldn Noise Contour Map. Recommend 62.5 Ldn contour and the proposed housing sites be shown to correspond with narrative addressed in Section E., Environmental Impact.

e. Page V-24, Section 6.a., Accident Potential Zone (APZ). Navy's restrictive easement also restricts building elevations. Recommend include a statement on building height restrictions and whether or not project complies with these restrictions.

11000
Ser 00F(238)/3440

Thank you for the opportunity to review the application plan for the proposed Ewa Marina Phase I project. Should you have questions, the Navy point of contact is Mr. Bill Liu, telephone 471-3234.

Sincerely,

W. K. Lee

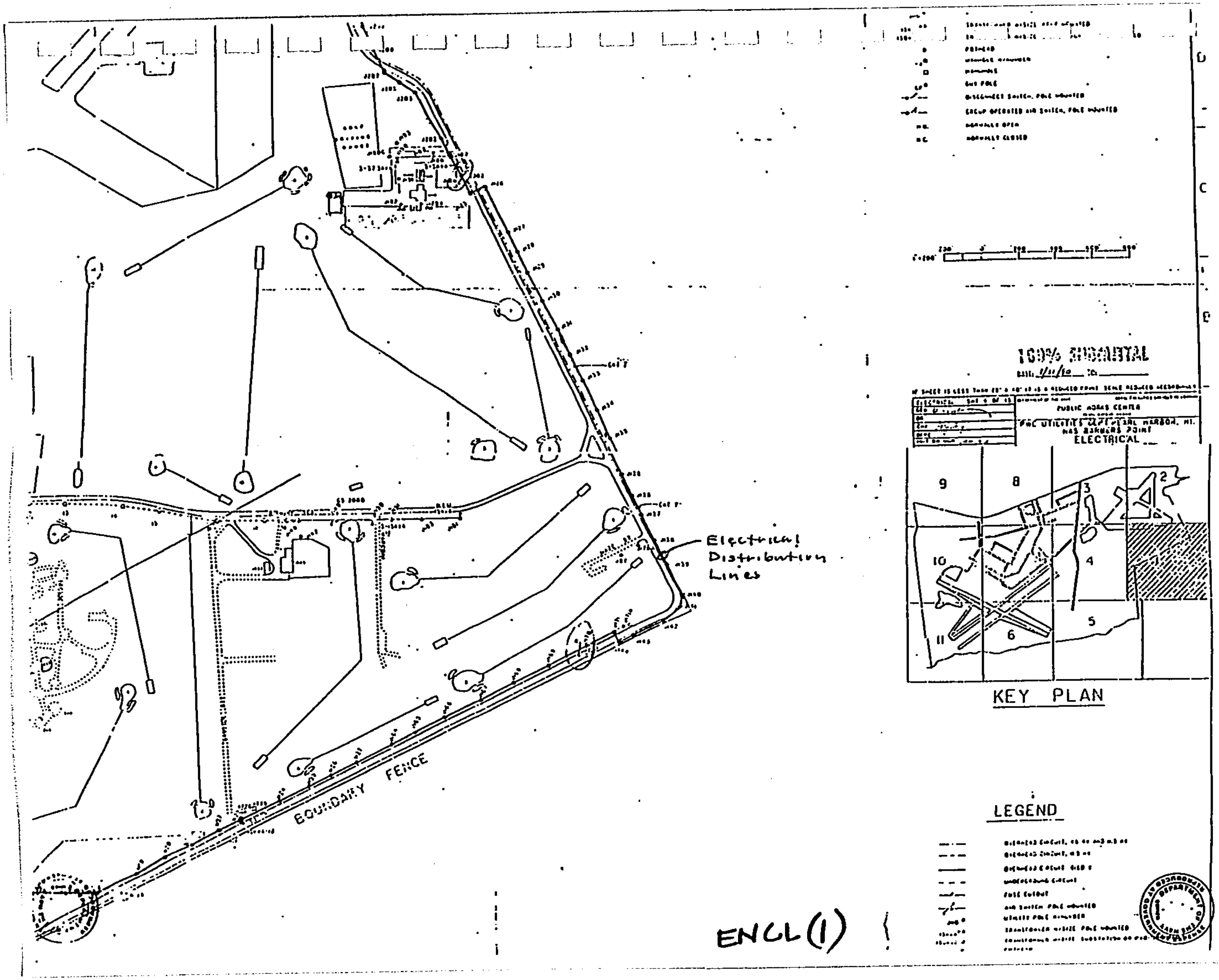
W. K. LEE
Assistant Base Civil Engineer
By direction of
the Commander

Encl:
(1) Location of Existing
Electrical Distribution
Line

Copy to:
Haseko (Hawaii), Inc.
Attn: Mr. N. W.G. Lee
820 Mililani St., Suite 820
Honolulu, HI 96813

Wilson Okamoto & Assoc., Inc.
Attn: Mr. E. Matsukawa
P. O. Box 3530
Honolulu, HI 96811

Office of Environmental Quality Control
State of Hawaii
220 South King St., 4th Floor
Central Pacific Plaza
Honolulu, HI 96813


Electrical Distribution Lines
BOUNDARY FENCE
100% SUBMITTAL
PUBLIC WORKS CENTER
NAS BARBERS POINT
ELECTRICAL
KEY PLAN
LEGEND
ENCL (1)

WILSON OKAMOTO & ASSOCIATES, INC.
ENGINEERS ARCHITECTS PLANNERS
1150 South King Street
Honolulu, Hawaii 96814
Phone: (808) 531-5261

3053-04
April 6, 1992

Commander
Naval Base Pearl Harbor
Box 110
Pearl Harbor, Hawaii 06860-5020

Attention: Mr. W.K. Liu, Assistant Base Civil Engineer

Subject: Ewa Marina Phase I
Supplemental Environmental Impact Statement
Preparation Notice
Tax Map Key: 9-1-12: 2, 3, 5 (por.), 6 (por.), 7 (por.), 8 through 17, and 23 (por.)
9-1-11: 1 through 7
Ewa, Oahu, Hawaii

Dear Mr. Liu:

Thank you for your letter of January 16, 1992 commenting on the subject Preparation Notice. Due to the schedule required to process the Supplemental Environmental Impact Statement (SEIS), we were unable to address EISPN comments received after December 24, 1991 for inclusion in the Draft SEIS. Since your comments were received after that date, they will be reproduced in the Final SEIS along with this response. The Draft SEIS was filed with the OEQC on January 6, 1992 and copies of the document have been sent to your agency for review and comment. We offer the following in response to your comments, respectively:

a. The subject Supplemental EIS addresses only Phase I, Increment 2 of the Ewa Marina development. Nevertheless, we will have our civil engineers review the potential for conflict and coordinate with your agency outside of the EIS process.

b. The statement in the EIS Preparation Notice incorrectly referred to the "marina" being tied to the wastewater system. It should have read "Project," which includes all wastewater generating uses. The City must approve any new allocation of wastewater treatment service for the Project. These points will be clarified in the Final SEIS. Wastewater generating uses are those which must dispose of their wastewater in the municipal sewer system according to policies of the Department of Public Works.

c. The Ewa Plain Water Development Corporation, of which the Applicant is a member, is responsible for water development in the Ewa area. The Project has received an allocation sufficient to meet its projected demand.

d. According to a noise impact report prepared for the Project and appended in the Final SEIS, only a small sliver of land designated for residential development may be impacted by the 60 Ldn contour. This area, designated for medium density multi-family residences, lies on the east side of the marina's western basin. Based on the narrowness of the area affected, it is unlikely that any land designated for residential use will be impacted by a noise contour greater than 60 Ldn.

e. The City and County Ewa Development Plan limits the tallest building heights in the Project area to a maximum of 60 feet. Taking future ground elevation into account, the maximum elevation of structures in the Project area will be well within those prescribed in the Navy's restrictive easement.

We hope that we have adequately responded to your comments. Your letter, together with this response, will be reproduced in the Final SEIS. We appreciate your interest and participation in the consultation phase of the environmental review process.

Sincerely,

Earl K. Matsukawa
Project Manager

cc: Office of Environmental Quality Control
HASEKO (Ewa), Inc.

JOHN WAIHEE
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF HEALTH
P. O. BOX 3378
HONOLULU, HAWAII 96801

JOHN C. LEWIN, M.D.
DIRECTOR OF HEALTH

In reply, please refer to:

February 24, 1992

91-447/epo

Mr. Earl Matsukawa
Project Manager
Wilson Okamoto and Associates, Inc.
P.O. Box 3530
Honolulu, Hawaii 96811

Dear Mr. Matsukawa:

Subject: Supplemental Environmental Impact Notice (EIS) Preparation Notice for Ewa Marina, Phase I

Thank you for allowing us to review and comment on the subject notice. We have the following comments to offer:

Underground Injection Control

The Department continues to have serious concerns about the excavation into the caprock for the construction of marinas. Such excavations may disrupt the integrity of the caprock aquifer causing leakage of a resource that will be vitally needed for nonpotable purposes. This disruption may also jeopardize the viability of implementing wastewater effluent reuse in the Ewa Plains.

The report on the effect of the proposed marina on the Ewa Limestone Aquifer by Tom Nance of Water Resources Engineering and Mackie Martin & Associates, Pty. Ltd. should be included in the appendices of the EA and EIS as it reportedly identifies potentially adverse impacts to the caprock aquifer. These potentially adverse impacts should also be specifically identified in the appropriate sections of the EA (e.g., section 5.a., Water Resources) and EIS. The Safe Drinking Water Branch would like to be provided a copy of the final report prepared by Tom Nance, preferably before the drafting of the EIS.

If you should have any questions, please contact Mr. Stuart Yamada of the Safe Drinking Water Branch at 586-4258.

Wastewater

The subject project is located within the county sewer service system for the Honouliuli Sewage Treatment Facility. As the area is sewered, the proposed development must be connected to the public sewers. The applicant should check with the City and County of Honolulu to determine if adequate sewage capacity is available at the treatment facility.

If you should have any questions on this matter, please contact Ms. Lori Kajiwara of the Wastewater Branch at 586-4290.

Solid Waste

The proposal does not address the impacts of waste generated during construction or operation on our limited landfill capacity (including the Ash Monofill which handles the ash resulting from H-Power operations), nor does it propose any alternatives.

Based on State and City and County diversion goals (State: 25% by 1995, 50% by 2000; City and County: 30% by 1995, 75% by 2000), alternatives must be considered for the disposal of wastes generated from land clearing and construction activities. Provision of space, facilities, and an operational plan to reduce generation once the development is operational should also be considered.

If you should have any questions, please contact Mr. John Harder at 586-4240.

Noise

1. Construction activities must comply with the provisions of the Department of Health Administrative Rules, Chapter 11-43, Community Noise Control for Oahu.

   a. The contractor must obtain a noise permit if the noise levels from the construction activities are expected to exceed the allowable levels of the regulations.

   b. Construction equipment and on-site vehicles requiring an exhaust of gas or air must be equipped with mufflers.

   c. The contractor must comply with the requirements specified in the rules and conditions issued with the permit.

2. Traffic noise from heavy vehicles travelling to and from the construction site must be minimized near existing residential areas and must comply with the provisions of the Department of Heath Administrative Rules, Chapter 11-42, Vehicular Noise Control for Oahu.

If you should have any questions on this matter, please contact Mr. Jerry Haruno at 586-4700.

Very truly yours,

JOHN C. LEWIN, M.D.
Director of Health

WILSON OKAMOTO & ASSOCIATES, INC.
ENGINEERS
ARCHITECTS
PLANNERS

3053-04
April 6, 1992

Dr. John C. Lewin, M.D.
Director of Health
Department of Health
State of Hawaii
P.O. Box 3378
Honolulu, Hawaii 96801

Subject: Ewa Marina Phase I
Draft Supplemental Environmental Impact Statement
Preparation Notice
Tax Map Key: 9-1-12: 2, 3, 5 (por.), 6 (por.), 7 (por.), 8 through 17, and 23 (por.)
9-1-11: 1 through 7
Ewa, Oahu, Hawaii

Dear Dr. Lewin:

Thank you for your letter of February 24, 1992 commenting on the subject Preparation Notice. Due to the schedule required to process the Supplemental Environmental Impact Statement (SEIS), we were unable to address EISPN comments received after December 24, 1991 for inclusion in the Draft SEIS. Since your comments were received on February 27, 1992, they will be reproduced in the Final SEIS along with this response. The Draft SEIS was filed with the OEQC on January 6, 1992 and copies of the document have been sent to your agency for review and comment.

We offer the following in response to your comments:

Underground Injection Control

We acknowledge your concerns regarding the Project's potential impact on the caprock aquifer. This subject is addressed in detail in the Draft SEIS and the report by Tom Nance of Water Resources Engineering and Mackie Martin & Associates, Pty. Ltd. has been reproduced in the Draft SEIS which has been sent to your agency for review and comment.

Wastewater

As discussed in EISPN, all wastewater from the project, including marina facilities, will be collected through a sewer system for treatment at the Honouliuli

Sewage Treatment Facility. The Applicant continues to work closely with the City and County to assure that the proposed Project will be accommodated.

Solid Waste

Solid waste generated during construction and operation of the Project will ultimately be disposed of at municipal landfill(s). While we acknowledge that these landfills have a limited capacity, the potential contribution of the Project would be only a small percentage of the total waste stream generated on Oahu. The Applicant will comply with any future requirements for solid waste diversion, including the preparation of an operational plan if required by the Department of Public Works.

Noise

The Draft and Final SEIS state that State Department of Health regulations must be complied with during construction of the Project.

We hope that we have adequately responded to your comments. Your letter, together with this response, will be reproduced in the Final SEIS. We appreciate your interest and participation in the consultation phase of the environmental review process.

Sincerely,

Earl K. Matsukawa
Project Manager

cc: Office of Environmental Quality Control
HASEKO (Ewa), Inc.

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
MANABU TAGOMORI
Dan T. Kochi

AQUACULTURE DEVELOPMENT PROGRAM
AQUATIC RESOURCES
CONSERVATION AND ENVIRONMENTAL AFFAIRS
CONSERVATION AND RESOURCES ENFORCEMENT
CONVEYANCES
FORESTRY AND WILDLIFE
HISTORIC PRESERVATION PROGRAM
LAND MANAGEMENT
STATE PARKS
WATER AND LAND DEVELOPMENT

REF:OCEA:ES

FILE NO.: 92-340
DOC. NO.: 2253E

Mr. Earl Matsukawa, Project Manager
Wilson, Okamoto & Associates, Inc.
P.O. Box 3530
Honolulu, Hawaii 96814

Dear Mr. Matsukawa:

Subject: Supplemental Environmental Impact Statement (EIS) Preparation Notice for Ewa Marina, Phase I

Thank you for giving our Department the opportunity to comment on the subject Supplemental Environmental Impact Statement (SEIS) Preparation Notice. We have reviewed the document and have the following comments:

- Additional information should be provided on the proposed artificial reef [including composition and proposed location(s)].

- The SEIS should clarify the algae/sea turtle situation.

- The SEIS should discuss access to the jetties/entrance channel area as well as the shoreline to the west of the jetties/channel area as this area will be curtailed because of construction. This loss of use should be compensated for during and after the construction period.

  Specifically, access to the shoreline area west of the jetties/channel entrance area should be addressed. The loss of the shoreline area from jetties/channel entrance construction can be partially mitigated by providing access to jetties (for fishing) and to the marina's waterway parks (for fishing) by the public. We favor a bridge to allow the public to cross the channel along the beach area.

- Excessive caprock water loses resulting from the excavation of the marina should be expeditiously controlled with mitigative measures. The test cut should determine what control measures will be needed.

- The commitment to carry out the Archaeological Mitigation Plan (AMP) for this project is made in a Memorandum of Agreement (MOA) among the U.S. Army Corps of Engineers, the Hawaii State Historic Preservation Officer, the Office of Hawaiian Affairs, and the Advisory Council on Historic Preservation. This MOA is in draft form.

  The AMP Specifies that buffer zones will be established around six sites assessed as valuable for information content and as excellent examples of site types. We note that development plans have been altered to avoid adverse impacts to historic sites, but can not determine that the current marina configuration will have "no adverse effect" on historic sites until the buffer zones are established and an acceptable interpretive plan is in place.

- As noted on page I-2 of the EISPN, the entrance channel has been shifted approximately 1,000 feet to the west of the location shown on the DPLU map. The SEIS should provide a description of the effected environment and any potential impacts and/or mitigation measures that may arise from this relocation.

- The SEIS should discuss the availability and proposed fee structure for the public boat slips and other public facilities (such as the boat launching facilities, dry boat storage facilities, trailer parking, etc.). Are live-aboards proposed?

- On page 6-20 of the December 5, 1985 Final Environmental Impact Statement for Increment II Proposed Ewa Marina Community, Ewa, Oahu, Hawaii reference is made to increased small vessel traffic close to the Pearl Harbor entrance that could create safety problems due to interference with naval operations. What is the status of resolving this potential conflict?

- Please update the 1985 Final EIS regarding the potential for ciguatera blooms as a result of the implementation of the proposed project.

Thank you for your cooperation in this matter. Please feel free to call me or Cathy Tilton at our Office of Conservation and Environmental Affairs, at 587-0377, should you have any questions.

Very truly yours,

WILLIAM W. PATY

cc: OEQC
Sue Rutka, Belt Collins and Associates

WILSON OKAMOTO & ASSOCIATES, INC.
ENGINEERS ARCHITECTS PLANNERS

January 6, 1992

Mr. William W Paty, Chairperson
Department of Land and Natural Resources
State of Hawaii
P.O. Box 621
Honolulu, Hawaii, 96809

Dear Mr. Paty:

Subject: Ewa Marina Phase I
Supplemental Environmental Impact Statement
Preparation Notice
Tax Map Key 9-1-11:1 through 7
Ewa, Oahu, Hawaii

Thank you for your letter of December 13, 1991 regarding the subject project. We offer the following responses in the respective order of you comments:

1. The Applicant has retained a consultant who is examining the functions, potential composition and siting for the proposed artificial reef. Further discussion with your agency, the U.S. Army Corps of Engineers and the National Marine Fisheries Service will be pursued to determine the reef's composition and location.

2. The Draft Supplemental EIS contains, as appendices, the reports of two studies conducted in conjunction with the proposed project: a survey of turtle populations; and, a survey of macroalgae preferred as a food source by the green sea turtles. The findings of these studies are discussed in the text of the EIS.

3. Public shoreline access to and along the shoreline during and following construction, as well as mitigation measures for lost access are discussed in the Draft Supplemental EIS. The Applicant will not prohibit access to the jetties for pole and line fishing and is investigating potential liability considerations of providing access that may promote public fishing at the jetties. Reasonably safe fishing activities, such as pole and line fishing will be allowed from waterfront parks along the marina. The Applicant has considered a bridge access across the marina mouth but the unsightly visual impact on the coastal area greatly outweighs the marginal benefits of a bridge due to restricted shoreline access beyond NASBP. The approach and bridge height required for the anticipated use of the marina by sailing craft would make such a bridge unfeasible. Further, by providing public

vehicular access to the area west of the channel entrance, which is currently attained through unauthorized use of the private dirt road, the concern for public access to this area is largely addressed.

4. The role of the test trench in determining potential mitigation measures which may be necessary to control caprock water losses is discussed in the Draft Supplemental EIS.

5. The Applicant will continue to pursue discussions with your office regarding the establishment of specific buffer zones and formulation of an acceptable interpretive program. We will clarify in the Draft Supplemental EIS that these details have yet to be formalized and that your review is on-going.

6. The Draft Supplemental EIS shall discuss the similarity of the environment at both the former and current marina entrance channel locations. Except for protecting a surf site, the environmental impact of the current channel location is similar to that of the former entrance channel location.

7. A majority of the berthing spaces will be made available to the public, while the remainder will be offered to property owners in the surrounding residential development. Fee structures for berthings have yet to be determined. Fees for public boat launching ramps and trailer parking will be determined primarily by operational and maintenance costs for these facilities. Dry storage and other boating facility costs would likely be market-driven. No live-aboards will be permitted in the marina.

8. The Applicant has invited participation by the U.S. Navy in all public public forums. To date, no concerns have been expressed about the increased potential for conflicts with naval operations.

9. The discussion regarding ciguatera blooms has been updated in the Draft Supplemental EIS.

We hope that the we have satisfactorily responded to your comments and that the information contained in the Draft Supplemental EIS will meet your expectations. Your letter, together with this response, will be reproduced in the forthcoming Draft Supplemental EIS. We appreciate your interest and participation in the consultation phase of the environmental review process.

Sincerely,

Earl K. Matsukawa
Project Manager

cc: Office of Environmental Quality Control
HASEKO (Ewa), Inc.

JOHN WAIHEE
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
DIVISION OF AQUATIC RESOURCES
1151 PUNCHBOWL STREET
HONOLULU, HAWAII 96813

WILLIAM W. PATY, CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES

DEPUTIES

AQUACULTURE DEVELOPMENT PROGRAM
AQUATIC RESOURCES
CONSERVATION AND ENVIRONMENTAL AFFAIRS
CONSERVATION AND RESOURCES ENFORCEMENT
CONVEYANCES
FORESTRY AND WILDLIFE
HISTORIC PRESERVATION
STATE PARKS
WATER RESOURCE MANAGEMENT

December 9, 1991

Mr. Earl Matsukawa, Project Manager
Wilson Okamoto and Associates, Inc.
P.O. Box 3530
Honolulu, HI 96811

Dear Mr. Matsukawa:

Thank you for your letter of November 22, 1991 requesting review and comment on the Environmental Assessment/EIS Preparation Notice for Ewa Marina, Phase I. This Department's Office of Conservation and Environmental Affairs (OCEA) has also requested our review of the same document and will coordinate a Departmental response. As such, we will be providing our comments to them. Thank you for providing us this opportunity to comment.

Sincerely,

HENRY M. SAKUDA, Administrator
Division of Aquatic Resources

WILSON OKAMOTO & ASSOCIATES, INC.
ENGINEERS
ARCHITECTS
PLANNERS
1150 SOUTH KING STREET
HONOLULU, HAWAII 96814
PHONE: (808) 531-5261
Mailing address:
P.O. Box 3530
Honolulu, Hawaii 96811

January 6, 1992

Mr. Henry M. Sakuda, Administrator
Division of Aquatic Resources
Department of Land and Natural Resources
1151 Punchbowl Street
Honolulu, Hawaii, 96813

Dear Mr. Sakuda:

Subject: Ewa Marina Phase I
Supplemental Environmental Impact Statement
Preparation Notice
Tax Map Key 9-1-11:1 through 7
Ewa, Oahu, Hawaii

Thank you for your letter of December 9, 1991 regarding the subject project. We have received your Department's comments, which we understand includes those of your Division, and shall prepare responses to them. Your letter will be reproduced in the forthcoming Draft Supplemental Environmental Impact Statement. We appreciate your interest and participation in the consultation phase of the environmental review process.

Sincerely,

Earl K. Matsukawa
Project Manager

cc: Office of Environmental Quality Control
HASEKO (Hawaii), Inc.

JOHN WAIHEE
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
STATE HISTORIC PRESERVATION DIVISION
33 SOUTH KING STREET, 6TH FLOOR
HONOLULU, HAWAII 96813

WILLIAM W. PATY, CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES

DEPUTIES
KEITH W. AHUE
MANABU TAGOMORI
DAN T. KOCHI

AQUACULTURE DEVELOPMENT PROGRAM
AQUATIC RESOURCES
CONSERVATION AND ENVIRONMENTAL AFFAIRS
CONSERVATION AND RESOURCES ENFORCEMENT
CONVEYANCES
FORESTRY AND WILDLIFE
HISTORIC PRESERVATION PROGRAM
LAND MANAGEMENT
STATE PARKS
WATER RESOURCE MANAGEMENT

December 23, 1991

LOG NO: 4177
DOC NO: 0480T

Earl Matsukawa, Project Manager
Wilson Okamoto & Associates, Inc.
1150 South King Street
Honolulu, Hawaii 96814

Dear Mr. Matsukawa:

SUBJECT: Supplemental Environmental Impact Statement Preparation Notice for Ewa Marina, Phase I
Honouliuli, 'Ewa, O'ahu
TMK: 9-1-11: 1-7; 9-1-12: 2, 3, 5-17

The commitment to carry out the Archaeological Mitigation Plan (AMP) for this project is made in a Memorandum of Agreement (MOA) among the U.S. Army Corps of Engineers, the Hawaii State Historic Preservation Officer, the Office of Hawaiian Affairs, and the Advisory Council on Historic Preservation. This MOA is in draft form. The AMP specifies that buffer zones will be established around six sites assessed as valuable for information content and as excellent examples of site types. We note that development plans have been altered to avoid adverse impacts to historic sites, but can not determine that the current marina configuration will have "no adverse effect" on historic sites until the buffer zones are established and an acceptable MOA is in place.

Sincerely,

DON HIBBARD, Administrator
State Historic Preservation Division

TD:jle

WILSON OKAMOTO & ASSOCIATES, INC.
ENGINEERS ARCHITECTS PLANNERS
1150 SOUTH KING STREET
HONOLULU, HAWAII 96814
PHONE: (808) 531-5261
Mailing address: P.O. Box 3530
Honolulu, Hawaii 96811

January 6, 1992

Mr. Don Hibbard, Administrator
State Historic Preservation Division
Department of Land and Natural Resources
33 South King Street, 6th Floor
Honolulu, Hawaii, 96813

Dear Mr. Hibbard:

Subject: Ewa Marina Phase I
Supplemental Environmental Impact Statement
Preparation Notice
Tax Map Key 9-1-11:1 through 7
Ewa, Oahu, Hawaii

Thank you for your letter of December 23, 1991 regarding the subject project. The Applicant will continue to pursue discussions with your office regarding the establishment of specific buffer zones and formulation of an acceptable interpretive program. We will clarify in the Draft Supplemental Environmental Impact Statement (DSEIS) that these details have yet to be formalized and that your review is on-going.

Your letter, together with this response, will be reproduced in the forthcoming DSEIS. We appreciate your interest and participation in the consultation phase of the environmental review process.

Sincerely,

Earl K. Matsukawa
Project Manager

cc: Office of Environmental Quality Control
HASEKO (Ewa) Inc.

BOARD OF WATER SUPPLY
CITY AND COUNTY OF HONOLULU
630 SOUTH BERETANIA STREET
HONOLULU, HAWAII 96843

December 19, 1991

Mr. Earl Matsukawa
Wilson Okamoto & Associates
P.O. Box 3530
Honolulu, Hawaii 96811

Dear Mr. Matsukawa:

Subject: Your Letter of November 22, 1991 Regarding the Supplemental Environmental Impact Statement Preparation Notice for the Proposed Ewa Marina, Phase I, TMK: 9-1-12: 2, 3, 5-17; 9-1-11: 1-7

We are still evaluating the proposed project and will complete our review by January 3, 1991.

If you have any questions, please contact Bert Kuioka at 527-5235.

Very truly yours,

KAZU HAYASHIDA
Manager and Chief Engineer

Pure Water . . . man's greatest need – use it wisely

WILSON
OKAMOTO
& ASSOCIATES, INC.

ENGINEERS
ARCHITECTS
PLANNERS
1150 SOUTH KING STREET
HONOLULU, HAWAII 96814
PHONE: (808) 531-5261
Mailing address:
P.O. Box 3530
Honolulu, Hawaii 96811

January 6, 1992

Mr. Kazu Hayashida
Manager and Chief Engineer
Board of Water Supply
City and County of Honolulu
630 South Beretania Street
Honolulu, Hawaii, 96813

Dear Mr. Hayashida:

Subject: Ewa Marina Phase I
Supplemental Environmental Impact Statement
Preparation Notice
Tax Map Key 9-1-11:1 through 7
Ewa, Oahu, Hawaii

Thank you for your letter of December 19, 1991 indicating your intent to submit formal comments subject project by January 3, 1991. We must proceed in a timely manner with our submittal for the January 8th Bulletin of the Office of Environmental Quality Control. As such, your January 3rd letter will be included in the Final Supplemental Environmental Impact Statement (FSEIS) which will follow the forthcoming Draft Supplemental Environmental Impact Statement (DSEIS). However, your letter dated December 19, 1991, together with this response, will be reproduced in the DSEIS. We appreciate your interest and participation in the consultation phase of the environmental review process.

Sincerely,

Earl K. Matsukawa
Project Manager

cc: Office of Environmental Quality Control
HASEKO (Ewa) Inc.

BOARD OF WATER SUPPLY
CITY AND COUNTY OF HONOLULU
630 SOUTH BERETANIA STREET
HONOLULU HAWAII 96843

January 17, 1992

Mr. Earl Matsukawa
Wilson Okamoto & Assoc.
P. O. Box 3530
Honolulu, Hawaii 96811

Dear Mr. Matsukawa:

Subject: Your Letter of November 22, 1991 Regarding the Supplemental Environmental Impact Statement Preparation Notice (EISPN) for the Proposed Ewa Marina, Phase I, TMK: 9-1-11: 1-7; 9-1-12: 2, 3, 5-17:

Thank you for the opportunity to review and comment on the proposed Ewa Marina Phase I supplemental EISPN. We have the following comments to offer:

1. We reiterate our previous comments on the adverse effects of the marina on the brackish water limestone aquifer. The increase in the marina's area from 90 acres to 140 acres could increase this potential. Therefore, the developer should be required to maintain the integrity of the caprock resource with proven mitigative measures.

2. The developer should submit a detailed water master plan for the proposed Ewa Marina development for our review and approval.

If you have any questions, please contact Bert Kuioka at 527-5235.

Very truly yours,

Kazu Hayashida

KAZU HAYASHIDA
Manager and Chief Engineer

WILSON OKAMOTO & ASSOCIATES, INC.
ENGINEERS
ARCHITECTS
PLANNERS
Mailing address
P.O. Box 3530

3053-04
April 6, 1992

Mr. Kazu Hayashida
Manager and Chief Engineer
Board of Water Supply
City and County of Honolulu
630 South Beretania Street
Honolulu, Hawaii 96843

Subject: Ewa Marina Phase I
Supplemental Environmental Impact Statement
Preparation Notice
Tax Map Key: 9-1-12: 2, 3, 5 (por.), 6 (por.), 7 (por.), 8 through 17, and 23 (por.)
9-1-11: 1 through 7
Ewa, Oahu, Hawaii

Dear Mr. Hayashida:

Thank you for your letter of January 17, 1992 commenting on the subject EIS Preparation Notice. Due to the schedule required to process the Supplemental Environmental Impact Statement (SEIS), we were unable to address EISPN comments received after December 24, 1991 for inclusion in the Draft SEIS. Since your comments were received on January 23, 1992, they will be reproduced in the Final SEIS along with this response. The Draft SEIS was filed with the OEQC on January 6, 1992 and copies of the document have been sent to your agency for review and comment in the 45-day public review period.

We offer the following in response to your numbered comments, respectively:

1. We acknowledge your concerns regarding potential project impacts on the caprock aquifer. The Draft and Final SEIS discuss a proposed monitoring program to determine appropriate mitigation measures for protecting this aquifer.

2. A water master plan shall be submitted to your department in conjunction with the filing of a rezoning application.

We hope that we have adequately responded to your comments. Your letter, together with this response, will be reproduced in the Final SEIS. We appreciate your interest and participation in the consultation phase of the environmental review process.

Sincerely,

Earl K. Matsukawa

Earl K. Matsukawa
Project Manager

cc: Office of Environmental Quality Control
HASEKO (Ewa) Inc.

DEPARTMENT OF GENERAL PLANNING
CITY AND COUNTY OF HONOLULU
650 SOUTH KING STREET
HONOLULU, HAWAII 96813

BS 11/91-3610

December 27, 1991

RECEIVED
JAN 05 1992
WILSON OKAMOTO & ASSOCIATES

Wilson Okamoto & Associates, Inc.
1150 S. King St.
Honolulu, Hawaii 96814

Attn: Earl Matsukawa, Project Manager

Gentlemen:

Comments on the Supplemental Environmental Impact Statement Preparation Notice (EISPN) for the Ewa Marina, Phase I project

In response to the Supplemental Environmental Impact Statement Preparation Notice (EISPN), dated November 22, 1991, for the subject project, we submit the following comments:

1. Section I: Background; A.3.c., Clarifying language of the Ewa Development Plan (DP) Special Provisions:

This section states the need to "clarify" language contained in the Ewa Marina Special Area (Section 32-3.2(b)(3)) related to the provision of a shoreline park system and public access to the system. The proposed text amendment would add a "series of privately owned and maintained" parks and delete the word "shoreline" from the provisions.

In the Final Environmental Impact Statement (FEIS) prepared in 1986, the previous applicant committed to providing public access via a "continuous landscaped esplanade around the perimeter of the Marina." The FEIS stated that "public access to the esplanade Greenbelt system and beach would be unrestricted." Further, the shoreline greenbelt system would be a "community greenbelt system" that would "consist of pedestrian and bicycle pathways."

We consider the proposed amendment a significant modification to the existing language in the DP Special Provisions for the Ewa Marina Special Area. We believe the development of an "unrestricted" shoreline landscaped esplanade system around the perimeter of the marina to be an essential urban design feature of the Ewa Marina Special Area.

The DEIS should address the issue of where and how public access would be provided and what improvements (i.e. public easements, pathways, etc.) will be provided by the developer. Further, the DEIS should address the issue of providing for a continuous shoreline park system around the perimeter of the marina.

2. Section I; B.3., Description of Property: Existing Use:

This section should include as "other major proposed developments in the vicinity" the City's proposed Laulani Fairways affordable housing project that will be located adjacent to the applicant's project.

3. Section II: Development Proposal:

This section should also address land use issues related to the Phase I (Increment 2) project area including exhibits showing acreage, number of residential units and net residential densities for the following land uses shown on the applicant's proposed amendments to the Development Plan Land Use Map: Residential, Low Density Apartment, Medium Density Apartment, Commercial, Parks & Recreation, Preservation, Public and Quasi-Public, and Undesignated (for roadways and all marina water areas).

4. Section IV: Governmental Plans & Programs; C.2.a.1.b.,Ewa Development Plan: Consistency with Common Provisions:

This section should clarify the statement that the Ewa Development Plan, Common Provisions, consists of language that allows for a pedestrian circulation system "comprised of a series of privately-owned and maintained parks along the marina linked by pedestrian ways." This statement does not relate to any existing provisions within the DP Special Provisions for Ewa or DP Common Provisions.

5. Section IV; C.2.a.5., Public Buildings and Public or Private Facilities for Utilities, Terminals and Drainage:

This section states that the proposed marina will act as a "receiving embayment" and "sediment trap" for storm water runoff "from the Kaloi watersheds."

The DEIS should clarify this statement. The DP Special Provisions for the Ewa Marina Special Area states that "silting ponds mauka of the site shall be developed to preserve the water quality so that their use for recreational purposes and aesthetic enjoyment shall not be limited in any way."

This provision was based on the original project drainage plan that showed at least two siltation basins "upstream" or mauka of the marina (Final Addendum FEIS: Ewa Marina, 1986) to retain storm runoff generated by the Kaloi Gulch watershed area. This mitigation measure would allow only runoff directly attributable to the development of Phase I to flow directly into the marina. This drainage scheme would: (1) minimize the flow of detrimental pollutants generated by upstream runoff from entering into the marina; and (2) preserve and maintain a high level of water quality within the marina and its waterways.

The statements in this section suggest that the marina itself will act as a siltation basin and sediment trap for runoff attributed to the project area as well as upstream storm runoff from Kaloi Gulch.

The DEIS should address drainage design parameters for the project and indicate how much, if any, runoff generated by the project and the Kaloi Gulch watershed will be allowed to flow into the marina. If the marina will serve as both a siltation basin and sediment trap for all runoff, we would have serious concerns as to how a high level of water quality in the marina will be maintained and preserved.

6. Section V: Impacts; A.1., Demographic Impacts: Residential Population:

This section states that the project will have a population impact of 10,404 persons based on 3,500 units and "an overall occupancy average of 2.89 persons per household based on 1987-1989 average household size for the State according to the State of Hawaii Data Book 1990: A Statistical Abstract."

It should be pointed out that the Department of General Planning does not utilize this methodology to calculate household size in determining a projects' impact on the General Plan's population objectives and policies.

We request that this section include the department's population projection figures for the project and how the calculated figure relates to the City's General Plan population distribution guidelines for the Ewa DP area. Further, this section should discuss the cumulative demographic impacts of the proposed project in relation to other residential projects in the region.

7. Section V; C.1., Housing Impacts: Increase Supply:

This section should be updated to also include a discussion of the City's proposed Laulani Fairways affordable housing development.

8. Section V; C.2., Housing Impacts: Affordable Units:

This section should address and discuss the following issues: (1) providing affordable housing for resort employees within Phase I based on the current proposal for Ewa Marina Phase II, which may include up to 950 visitor accommodation units; and (2) providing additional affordable housing units above the State Land Use Commission's ten percent requirement.

9. Section V; E.1., Environmental Impacts: Noise:

This section should clarify the statement that the Ewa Marina Special Area "restricts development of residential and apartment units in areas exposed to aircraft noise in excess of 62.5 Ldn."

The Ewa Marina Special Area not only restricts development but also states that "residential and apartment units shall not be developed" in areas exposed to aircraft noise levels beyond 62.5 Ldn.

10. Section V; E.4., Environmental Impacts: Historic and Archaeological Resources:

The proposed DP Land Use Map for the project area indicates two proposed historic/archaeologic sites that are to be designated as "Parks and Recreation."

We are concerned that such a designation might jeopardize the historic and archaeological resources of the sites if actually used as public park space. We believe a more appropriate designation for the sites is "Preservation." The Development Plan Common Provisions (Sec. 32-1.3(11)(B) Revised Ordinances of Honolulu (ROH) 1990, as amended) definition for "Preservation" includes "Lands necessary for the conservation, preservation and enhancement of sites with scenic, historic, archaeologic or ecologic significance."

11. Section V; E.5.a., Natural Features: Water Resources:

This section should be expanded to review and evaluate the impact of marina construction on the caprock aquifer. The section should point out that the Progress Report on the Effect of HASEKO's Proposed Marina on the Ewa Limestone Aquifer conducted by Tom Nance analyzed the potential impacts of marina construction through the extensive use of computer modeling.

We recommend that the results of the computer analysis should be correlated with data from on-site testings of the caprock aquifer to determine the potential impacts of the marina on the regional aquifer and groundwater table. This section should address alternative actions, mitigation measures and contingency plans should on-site excavations and testings of the caprock aquifer reveal that the caprock will not naturally seal itself.

12. Section V; E.5.c., Natural Features: Wetlands Protection:

The proposed DP Land Use Map for the project area indicates the proposed wetlands site is to be designated as "Parks and Recreation."

We are concerned that such a designation for the sites might lead to the eventual destruction of the unique wetland site if the area were to be used as public park space. We believe a more appropriate designation for the sites is "Preservation." The Development Plan Common Provisions (Sec. 32-1.3(11)(C) ROH 1990) definition for "Preservation" includes "Lands necessary for providing and preserving park lands, wilderness and beach reserves, and for conserving natural ecosystems of endemic plants, fish and wildlife, for forestry, and other related activities to these uses."

We note that other various impacts of the project (i.e. development impacts on transportation facilities, etc.) will be comprehensively addressed in the Draft Environmental Impact Statement (DEIS). We will reserve any additional comments or concerns pending the publication and review of the DEIS.

Thank you for the opportunity to review the subject EISPN. Should you have any questions, please contact Brian Suzuki of our staff at 527-6051.

Sincerely,

BENJAMIN B. LEE
Chief Planning Officer

BBL:ft

WILSON OKAMOTO & ASSOCIATES, INC.
ENGINEERS ARCHITECTS PLANNERS
1150 SOUTH KING STREET
HONOLULU, HAWAII 96814
PHONE: (808) 531-5261
Mailing address P O Box 3530 Honolulu, Hawaii 96811

3053-04
April 6, 1992

Mr. Benjamin B. Lee
Chief Planning Officer
Department of General Planning
City and County of Honolulu
650 South King Street
Honolulu, Hawaii, 96813

Subject: Ewa Marina Phase I
Supplemental Environmental Impact Statement
Preparation Notice
Tax Map Key: 9-1-12: 2, 3, 5 (por.), 6 (por.), 7 (por.), 8 through 17, and 23 (por.)
9-1-11: 1 through 7
Ewa, Oahu, Hawaii

Dear Mr. Lee:

Thank you for your letter of December 27, 1991 commenting on the subject EIS Preparation Notice. Due to the schedule required to process the Supplemental Environmental Impact Statement (SEIS), we were unable to address EISPN comments received after December 24, 1991 for inclusion in the Draft SEIS. Since your comments were received on January 3, 1992 they will be reproduced in the Final SEIS along with this response. The Draft SEIS was filed with the OEQC on January 6, 1992 and copies of the document have been sent to your agency for review and comment in the 45-day public review period.

On January 15, 1992 we filed a revised application for amending the Ewa Development Plan Land Use Map with your office. As you will note in that application, we have omitted our earlier request to amend the Ewa Marina Special Provisions. Thus, several of your comments addressing these Special Provisions are no longer applicable.

We offer the following in response to your numbered comments, respectively:

1. The revised DP amendment application (January 15, 1992) omits the request to amend the Ewa Marina Special Provisions.

   The Draft SEIS contains a more detailed description of public access within the project.

2. The revised DP Application and the Final SEIS shall include the Laulani/Fairways project in their respective discussions of major proposed developments in the vicinity of the Project.

3. A table showing proposed acreage for the various DP Land Use designations has been included in the revised DP amendment application in Section I.A, "Essential Information." A table showing proposed net densities in relation to Density Controls in the DP Special Provisions for Ewa (Section 32-3.2.(a)(4)) is contained in the revised DP Application, in Section IV, "Federal, State and City Plans and Programs Involved."

4. Your comment regarding the existing DP Special and Common Provisions is appreciated. We have eliminated the statement so as to avoid any confusion or misconception.

5. The Draft SEIS and revised DP amendments clarify that both the marina and the golf course in Ewa Marina Phase II will provide detention functions for runoff from lands mauka of the Project. Under the preliminary conceptual drainage plan, the initial 2,200 cfs of storm flow received through Kaloi Gulch would be directed into a series of detention ponds through the golf course before discharging into the marina near its mouth. Flows in excess of 2,200 cfs would flow into the marina at its head. Drainage from the Project Site would be directed into the marina. For this plan to be effective, developers of lands mauka of the Property must provide flood and silt control on their property and other necessary improvements to Kaloi Gulch itself.

6. Based on discussions with staff from your office, the figure used to calculate household size for the Project will be revised to encompass a probable range, which will be provided by our consultant for the Social Impact Assessment. In addition, the relationship between the City and County of Honolulu's General Plan and the population estimated to be generated by the Project will be addressed.

7. The Laulani/Fairways project has been included in this discussion.

8. Pursuant to the terms and conditions of the Land Use Commission Decision and Order, the Applicant is committed to provide 10% of the

housing units in Phase I for low-moderate income families. The issue of providing additional affordable housing for employees of Ewa Marina Phase II would best be addressed in the context of reviewing that development.

9. The DP application and Draft SEIS shall be modified to state that residential units are disallowed in areas exposed to aircraft noise in excess of 62.5 Ldn.

10. We have changed the proposed designation of areas containing significant historic sites from "Park" to "Preservation" based on your suggestion.

11. The points raised in your comment concerning potential effects on the caprock aquifer are well taken. This issue is discussed in Chapter VI.D.2 of the Draft SEIS, which you have now received. However, the topic is an important one, and it is worth reiterating several key points here.

    The general nature of the groundwater system is well understood and has been successfully modeled. Calibration of the computer modeling that is detailed in Tom Nance Water Resources/Mackie Martin's Progress Report on the Effect of HASEKO's Proposed Marina on the Ewa Limestone Aquifer relied heavily on field data collected from new holes as well as data from previous studies. Thus, a good deal of the correlation that you requested has already been accomplished.

    The Applicant is committed to the utilization of the caprock aquifer as non-potable water source and has developed a program in coordination with the Commission on Water Resource Management for preservation of this resource. This program involves the initial construction of a small segment of the marina entrance channel and internal waterways. An intensive monitoring program during this initial construction phase will provide data for the development of a comprehensive mitigation plan, including long-term groundwater monitoring and alternative mitigation plans, in cooperation with the Commission of Water Resource Management to comply with performance standards established by it.

12. We have changed the proposed designation of the wetland area from "Park" to "Preservation" based on your suggestion.

We hope that we have adequately responded to your comments. Your letter, together with this response, will be reproduced in the Final SEIS. We appreciate your interest and participation in the consultation phase of the environmental review process.

Sincerely,

Earl K. Matsukawa
Project Manager

cc: Office of Environmental Quality Control
HASEKO (Ewa) Inc.

DEPARTMENT OF LAND UTILIZATION
CITY AND COUNTY OF HONOLULU
650 SOUTH KING STREET
HONOLULU, HAWAII 96813 • (808) 523-4432

FRANK F. FASI
MAYOR

DONALD A. CLEGG
DIRECTOR

LORETTA K.C. CHEE
DEPUTY DIRECTOR

LU11/91-9155(ASK)

December 26, 1991

Mr. Earl Matsukawa
Wilson Okamoto & Associates, Inc.
P.O. Box 3530
Honolulu, Hawaii 96811

Dear Mr. Matsukawa:

Supplemental Environmental Impact Statement
Preparation Notice (EISPN) for Ewa Marina, Phase I

We have reviewed the supplemental EISPN for the Ewa Marina Phase I project which is being prepared in conjunction with an application for Development Plan (DP) Land Use Map and Special Provisions amendments.

The following is a list of information which should be included in the Supplemental Environmental Impact Statement. This information is needed to fully assess the project, including its particular impact on coastal resources.

The Supplemental Environmental Impact Statement (EIS) should include:

1. A description of impacts to coastal views. A discussion of existing and proposed views and open space along the shoreline should be provided.

2. A description of archaeological resources.

3. A map showing the location of the wetlands and a description of any impacts to the wetlands, including the marina impact on water quality or other critical aspects of the wetlands. A management plan for the wetlands should also be discussed.

4. A description of impacts to groundwater resources and proposed method of wastewater disposal.

5. Information on drainage including proposed drainage patterns and the resulting impacts. Describe impacts to water quality including how composition of drainage flow will change as a result of the development and proposed uses. Discuss water quality in the marina and coastal waters.

6. A discussion of the effect of the project on coastal hazards as described in Section 205A-2 (a) Hawaii Revised Statutes (HRS).

7. Information on impacts to coastal ecosystems.

8. A description of how the project is consistent with policies for recreational resources as described in Section 205A-2, HRS.

9. It appears that the proposed DP Land Use Map and Special Provisions amendments could significantly impact the availability of public recreational resources as conceived under the previous plan. While the EISPN states in several locations that parks and access to certain facilities will be provided the specific provisions must be further detailed. Included in the information presented in the EISPN should be a description of how lateral access along and to the shoreline areas will be provided and whether lateral access will be provided along the banks of the Marina as depicted in the existing DP Land Use Map.

10. Mitigation measures which will be utilized for each of these areas of concern should be identified.

As discussed in a December 18, 1991 meeting with Art Challacombe and Ardis Shaw-Kim of our staff, the Supplemental EIS should also describe any other aspects of the development which will impact coastal resources as identified in Section 205A, HRS and Chapter 33 Revised Ordinances of Honolulu.

Should you have questions, contact Ardis Shaw-Kim of our staff at 527-6274.

Very truly yours,

Donald Clegg

DONALD A. CLEGG
Director of Land Utilization

earl.ask

WILSON
OKAMOTO
& ASSOCIATES, INC.

ENGINEERS
ARCHITECTS
PLANNERS

January 6, 1992

Mr. Donald A. Clegg, Director
Department of Land Utilization
City and County of Honolulu
650 South Beretania Street
Honolulu, Hawaii, 96813

Dear Mr. Clegg:

Subject: Ewa Marina Phase I
Supplemental Environmental Impact Statement
Preparation Notice
Tax Map Key 9-1-11:1 through 7
Ewa, Oahu, Hawaii

Thank you for your letter of December 26, 1991 indicating your concerns about the subject project. Your recommendations will be discussed in the forthcoming Draft Supplemental Environmental Impact Statement (DSEIS). Your letter, together with this response, will be reproduced in the DSEIS. We appreciate your interest and participation in the consultation phase of the environmental review process.

Sincerely,

Earl K. Matsukawa
Project Manager

cc: Office of Environmental Quality Control
HASEKO (Ewa) Inc.

DEPARTMENT OF PARKS AND RECREATION
CITY AND COUNTY OF HONOLULU
650 SOUTH KING STREET
HONOLULU, HAWAII 96813

FRANK F. FASI
MAYOR

WALTER M. OZAWA
DIRECTOR

ALVIN K.C. AU
DEPUTY DIRECTOR

December 13, 1991

Mr. Earl Matsukawa
Wilson Okamoto & Associates, Inc.
P. O. Box 3530
Honolulu, Hawaii 96811

Dear Mr. Matsukawa:

Subject: Supplemental Environmental Impact Statement Notice (EISPN) for Development Plan Land Use Map and Special Provisions Amendments and Environmental Assessment for Ewa Marina, Phase I, Tax Map Key 9-1-12: 2, 3, 5 through 17 and 9-1-11: 1 through 17

We have reviewed the supplemental EISPN for the Ewa Marina Phase I and make the following comments and recommendations.

The public parks and shoreline access system for the Ewa Marina Phases I and II was accepted "conceptually" in our 1991 Ewa Development Plan Review. Two public parks were established with an understanding that public accesses to and along the shoreline would be provided in the project.

Since our review, we have had limited discussions with Haseko (Hawaii), Inc. in attempt to arrive at a more detailed recreational park plan that would be acceptable to our department.

There are a number of parks and recreational concerns in the report that require clarification and correction. These concerns will need to be corrected and included in the applicant's proposed Development Plan Zoning and Shoreline Management Applications proposed to be submitted to the City.

Please contact Jason Yuen of our Advance Planning Branch at 527-6315 to discuss our recreational concerns for the Ewa Marina Project.

Sincerely,

WALTER M. OZAWA, Director

WMO:ei

Attachments

cc: Haseko (Hawaii), Inc.
Department of General Planning
Department of Land Utilization
Office of Environmental Quality Control

WILSON
OKAMOTO
& ASSOCIATES, INC.
ENGINEERS
ARCHITECTS
PLANNERS
1150 SOUTH KING STREET
HONOLULU, HAWAII 96814
PHONE: (808) 531-5261
Mailing address:
P.O. Box 3530
Honolulu, Hawaii 96811

January 6, 1992

Mr. Walter M. Ozawa, Director
Department of Parks and Recreation
City and County of Honolulu
650 South King Street
Honolulu, Hawaii, 96813

Dear Mr. Ozawa:

Subject: Ewa Marina Phase I
Supplemental Environmental Impact Statement
Preparation Notice
Tax Map Key 9-1-11:1 through 7
Ewa, Oahu, Hawaii

Thank you for your letter of December 13, 1991 regarding the subject project. We acknowledge your concerns regarding public parks and adequate access, and have included more detailed discussions in the forthcoming Draft Supplemental Environmental Impact Statement (DSEIS). We also anticipate that increasingly specific discussions and commitments will be required in the processing of applications for Development Plan amendment, rezoning and Shoreline Management Area permit.

Your letter, together with this response, will be reproduced in the forthcoming Draft Supplemental Environmental Impact Statement. We appreciate your interest and participation in the consultation phase of the environmental review process.

Sincerely,

Earl K. Matsukawa
Project Manager

cc: Office of Environmental Quality Control
HASEKO (Ewa) Inc.

DEPARTMENT OF PUBLIC WORKS
CITY AND COUNTY OF HONOLULU
650 SOUTH KING STREET
HONOLULU, HAWAII 96813

FRANK F. FASI
MAYOR

SAM CALLEJO
DIRECTOR AND CHIEF ENGINEER

C. MICHAEL STREET
DEPUTY DIRECTOR

ENV 91-265

December 17, 1991

Mr. Earl Matsukawa, Project Manager
Wilson Okamoto and Associates, Inc.
P. O. Box 3530
Honolulu, Hawaii 96811

Dear Mr. Matsukawa:

Subject: Supplemental Environmental Impact Statement (EIS) Preparation Notice for Ewa Marina, Phase I, TMK:9-1-12:2,3,5 through 17; 9-1-11:1 through 7

We have reviewed the subject environmental document and have the following comments:

1. We have no objections to the proposed Ewa Marina, Phase I Project.

2. The City has a 50-foot wide easement through the property for the Barbers Point Sewer Outfall. Accordingly, no structures will be allowed to be built over the easement area other than fences, roads or other such appurtenances, unless first approved by the Department of Public Works. Also, no trees can be planted in or near the sewer easement area.

3. As a reminder, no new sewer connections will be allowed to the Honouliuli Wastewater Treatment Plant until at least 1993 when the expansion of the primary treatment capacity from 25 mgd to 38 mgd is completed. The recently issued 301(h) permit includes a limitation of the mass emission rate (MER) discharged from the plant. The City intends to

apply for an increase of the MER. If such request is denied, connections cannot be allowed until the end of 1995 when secondary facilities are programmed for construction.

Very truly yours,

C. Michael Street

SAM CALLEJO
Director and Chief Engineer

WILSON
OKAMOTO
& ASSOCIATES, INC.
ENGINEERS
ARCHITECTS
PLANNERS
1150 SOUTH KING STREET
HONOLULU, HAWAII 96814
PHONE: (808) 531-5261
Mailing address:
P.O. Box 3530
Honolulu, Hawaii 96811

January 6, 1992

Mr. Sam Callejo
Director and Chief Engineer
Department of Public Works
City and County of Honolulu
650 South King Street
Honolulu, Hawaii, 96813

Dear Mr. Callejo:

Subject: Ewa Marina Phase I
Supplemental Environmental Impact Statement
Preparation Notice
Tax Map Key 9-1-11:1 through 7
Ewa, Oahu, Hawaii

Thank you for your letter of December 17, 1991 indicating that you have no objections to the subject project. The restrictions specified in your letter have been duly noted and will be adhered to. Your letter, together with this response, will be reproduced in the forthcoming Draft Supplemental Environmental Impact Statement. We appreciate your interest and participation in the consultation phase of the environmental review process.

Sincerely,

Earl K. Matsukawa
Project Manager

cc: Office of Environmental Quality Control
HASEKO (Ewa) Inc.

FIRE DEPARTMENT
CITY AND COUNTY OF HONOLULU
1455 SOUTH BERETANIA STREET, ROOM 305
HONOLULU, HAWAII 96814

FRANK F. FASI
MAYOR

LIONEL E. CAMARA
FIRE CHIEF

DONALD S.M. CHANG
DEPUTY FIRE CHIEF

December 4 1991

Mr. Earl Matsukawa, Project Manager
Wilson Okamoto and Associates Inc.
P. O. Box 3530
Honolulu, Hawaii 96811

Dear Mr. Matsukawa:

SUBJECT: Supplemental Environmental Impact Statement (EIS) Preparation Notice for Ewa Marina, Phase I

We have reviewed the subject material provided and have no additional comments.

Should you have any questions, please call Acting Assistant Chief Attilio Leonardi of our Administrative Services Bureau at 943-3838.

Sincerely,

LIONEL E. CAMARA
Fire Chief

AKL:ny

WILSON OKAMOTO & ASSOCIATES, INC.
ENGINEERS
ARCHITECTS
PLANNERS
1150 SOUTH KING STREET
HONOLULU, HAWAII 96814
PHONE: (808) 531-5261
Mailing address:
P.O. Box 3530
Honolulu, Hawaii 96811

January 6, 1992

Mr. Lionel Camara, Fire Chief
Fire Department
City and County of Honolulu
1455 South Beretania Street, Room 305
Honolulu, Hawaii, 96814

Dear Mr. Camara:

Subject: Ewa Marina Phase I
Supplemental Environmental Impact Statement
Preparation Notice
Tax Map Key 9-1-11:1 through 7
Ewa, Oahu, Hawaii

Thank you for your letter of December 4, 1991 indicating that you have no comments regarding the subject project. Your letter will be reproduced in the forthcoming Draft Supplemental Environmental Impact Statement. We appreciate your interest and participation in the consultation phase of the environmental review process.

Sincerely,

Earl K. Matsukawa
Project Manager

cc: Office of Environmental Quality Control
HASEKO (Ewa), Inc.

POLICE DEPARTMENT

CITY AND COUNTY OF HONOLULU

1455 SOUTH BERETANIA STREET
HONOLULU, HAWAII 96814 - AREA CODE (808) 943-3111

FRANK F. FASI
MAYOR

MICHAEL S. NAKAMURA
CHIEF

HAROLD M. KAWASAKI
DEPUTY CHIEF

OUR REFERENCE KN-LK

December 18, 1991

Mr. Earl Matsukawa, Project Manager
Wilson Okamoto and Associates, Inc.
1150 South King Street
Honolulu, Hawaii 96814

Dear Mr. Matsukawa:

We have reviewed the materials for the proposed development and would like to reiterate the concerns we have for the entire Ewa Plain development.

The collective result of the proposed Ewa Marina Phase I and other developments that will make up the "second city" in Ewa will increase the demand for police services provided by the Pearl City District.

Our ability to adequately meet the greater demand will depend primarily on the availability of funds for sufficient police personnel, equipment, and facilities: another district and two substations.

The increase in facilities and workforce is essential to our efforts to proactively prepare for the needs of the growing community: more beats, more patrol units, effective traffic management within and to/from Ewa, and the necessary support staff.

Thank you for the opportunity to comment.

Sincerely,

MICHAEL S. NAKAMURA
Chief of Police

By [signature]
CHESTER E. HUGHES
Assistant Chief of Police
Support Services Bureau

WILSON OKAMOTO & ASSOCIATES, INC.

ENGINEERS
ARCHITECTS
PLANNERS

1150 SOUTH KING STREET
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Mailing address:
P.O. Box 3530
Honolulu, Hawaii 96811

January 6, 1992

Mr. Michael S. Nakamura
Chief of Police
Police Department
City and County of Honolulu
650 South King Street
Honolulu, Hawaii, 96813

Dear Mr. Nakamura:

Subject: Ewa Marina Phase I
Supplemental Environmental Impact Statement
Preparation Notice
Tax Map Key 9-1-11:1 through 7
Ewa, Oahu, Hawaii

Thank you for your letter of December 18, 1991 regarding the subject project. We acknowledge the need for increased police services as a result of the project, and have addressed this concern in the forthcoming Draft Supplemental Environmental Impact Statement (DSEIS). Your letter, together with this response, will be reproduced in the DSEIS. We appreciate your interest and participation in the consultation phase of the environmental review process.

Sincerely,

[signature]

Earl K. Matsukawa
Project Manager

cc: Office of Environmental Quality Control
HASEKO (Ewa) Inc.

Hawaiian Electric Company, Inc. • PO Box 2750 • Honolulu, HI 96840-0001

William A. Bonnet
Manager
Environmental Department

December 16, 1991

Mr. Earl Matsukawa
Wilson Okamoto and Associates, Inc.
1150 South King Street
Honolulu, Hawaii 96814

Dear Mr. Matsukawa:

Subject: Supplemental Environmental Impact Statement (EIS)
Preparation Notice for Ewa Marina, Phase I

We have reviewed the subject EIS, and have no comments at this time on the proposed project. HECO shall reserve further comments pertaining to the protection of existing powerlines bordering and servicing the area until construction plans are finalized.

Sincerely,

[signature]

cc: Haseko (Hawaii), Inc. (P. Jordan)

WILSON OKAMOTO & ASSOCIATES, INC.
ENGINEERS ARCHITECTS PLANNERS
1150 South King Street
Honolulu, Hawaii 96814
Phone: (808) 531-5261
Mailing Address: P.O. Box 3530
Honolulu, Hawaii 96811

January 6, 1992

Mr. William A. Bonnet, Manager
Environmental Department
Hawaiian Electric Company, Inc.
P. O. Box 2750
Honolulu, Hawaii, 96840-0001

Dear Mr. Bonnet:

Subject: Ewa Marina Phase I
Supplemental Environmental Impact Statement
Preparation Notice
Tax Map Key 9-1-11:1 through 7
Ewa, Oahu, Hawaii

Thank you for your letter of December 16, 1991 indicating that you have no comments on the subject project at this time. Your letter, together with this response, will be reproduced in the forthcoming Draft Supplemental Environmental Impact Statement. We appreciate your interest and participation in the consultation phase of the environmental review process.

Sincerely,

[signature]

Earl K. Matsukawa
Project Manager

cc: Office of Environmental Quality Control
HASEKO (Ewa) Inc.

GTE HAWAIIAN TEL
Beyond The Call

P.O. Box 2200
Honolulu, Hawaii 96841
Telephone(808)546-2095

Larry L. Hartshorn
Manager - Exchange Planning

NOVEMBER 27, 1991

Mr. Earl Matsukawa
Wilson Okamoto & Associates, Inc.
P. O. Box 3530
Honolulu, Hawaii 96811

Dear Earl:

SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT (EIS)
PREPARATION NOTICE FOR EWA MARINA, PHASE I

We have reviewed the Ewa Marina Phase I (EIS) preparation notice and have no objections to the project.

We are also working with your consultants in incorporating the telecommunication requirements onto the master plan.

If you have any questions on this matter, please call Stanley Suzuki at 546-3787.

Sincerely,

Larry Hartshorn

LH:SS

c: P. Jordan - Haseko (Hawaii), Inc.

WILSON OKAMOTO & ASSOCIATES, INC.
ENGINEERS ARCHITECTS PLANNERS
1150 SOUTH KING STREET
HONOLULU, HAWAII 96814
PHONE: (808) 531-5261
Mailing address:
P.O. Box 3530
Honolulu, Hawaii 96811

January 6, 1992

Mr. Larry L. Hartshorn, Manager
Exchange Planning
GTE Hawaiian Tel
P. O. Box 2200
Honolulu, Hawaii, 96813

Dear Mr. Hartshorn:

Subject: Ewa Marina Phase I
Supplemental Environmental Impact Statement
Preparation Notice
Tax Map Key 9-1-11:1 through 7
Ewa, Oahu, Hawaii

Thank you for your letter of November 27, 1991 indicating that you have no objections to the subject project. Your letter will be reproduced in the forthcoming Draft Supplemental Environmental Impact Statement. We appreciate your interest and participation in the consultation phase of the environmental review process.

Sincerely,

Earl K. Matsukawa
Project Manager

cc: Office of Environmental Quality Control
HASEKO (Ewa), Inc.

DRAFT SEIS CONSULTATION

The Draft SEIS for the Project was filed with the Office of Environmental Quality Control (OEQC) on January 8, 1992 which initiated the 45-day public review period. Subsequently, a revision to the Draft SEIS was made and all parties receiving the Draft SEIS were notified of these revisions. The deadline for public review was also extended to March 8 1992. Notice of this extension was published in the January 23, 1992 OEQC Bulletin.

All comment letters received by the March 8, 1992 deadline, as well as a few which were received soon after the deadline are reproduced herein. The following is a list of consulted parties for the Draft SEIS. Those who formally responded are identified with an asterisk (*) and those who provided substantive comments are identified with a double asterisk (**).

FEDERAL

	U.S. Environmental Protection Agency Regional Division
	Army Directorate of Facilities Engineer
	Naval Base, Pearl Harbor
**	Soil Conservation Service
**	U.S. Army Corps of Engineers
	U.S. Coast Guard
	U.S. Fish and Wildlife Service
*	U.S. Geological Survey
**	U.S. Navy (NAS Barbers Point)
	National Marine Fisheries Service

STATE AGENCIES

**	Office of Environmental Quality Control
	Department of Agriculture
*	Department of Accounting and General Services
*	Department of Defense
	Department of Health
**	Department of Land & Natural Resources (DLNR)
**	DLNR Aquatics Resources Division
	DLNR Office of Environmental & Conservation Affairs
	DLNR State Historic Preservation Division
**	Department of Transportation
	Office of State Planning
	Department of Business, Economic Development and Tourism (DBED&T)

** DBED&T Land Use Commission
DBED Library
* DBED State Energy Office
* Housing Finance and Development Corporation

CITY AND COUNTY OF HONOLULU

** Board of Water Supply
* Building Department
Department of Housing and Community Development
Department of General Planning
** Department of Land Utilization
** Department of Parks and Recreation
* Department of Public Works
* Department of Transportation Services
* Fire Department
Municipal Reference and Records Center
** Police Department

UNIVERSITY OF HAWAII

** Environmental Center
Water Resources Research Center

NEWS MEDIA

Honolulu Star Bulletin
Honolulu Advertiser
Sun Press

LIBRARIES

University of Hawaii, Hamilton Library
Legislative Reference Bureau
State Main Library
Kaimuki Regional Library
Kaneohe Regional Library
Pearl City Regional Library
Hilo Regional Library
Wailuku Regional Library
Kauai Regional Library
Aiea Library

Ewa Beach Community School Library
Mililani Public Library
Waipahu Library

OTHERS

Ewa Neighborhood Board
* Hawaiian Electric Company, Inc.
** Hawaiian Electric Company, Inc. (2nd letter)
* GTE Hawaiian Telephone Company
American Lung Association
Office of Hawaiian Affairs
** Ewa Beach Community Association
** W.D. Balfour
** Save Ewa Beach Ohana

UNITED STATES DEPARTMENT OF AGRICULTURE — SOIL CONSERVATION SERVICE — P. O. BOX 50004, HONOLULU, HAWAII 96850

January 30, 1992

RECEIVED
WILSON OKAMOTO & ASSOCIATES

Mr. Earl Matsukawa
Wilson Okamoto and Associates
1150 South King Street, Suite 800
Honolulu, Hawaii 96814

Dear Mr. Matsukawa:

Subject: Draft Supplemental Environmental Impact Statement (EIS) for Ewa Marina, Phase I, Increment 2

We have reviewed the Supplemental EIS for Ewa Marina, Phase I, Increment 2, as requested and would like to offer the following comments:

1) The Soil Conservation Service is always concerned about the conversion of important agricultural lands to non-agricultural uses. While we are well aware of the need for affordable housing, we believe that the lost of "Prime" and "Unique" agricultural land should be avoided whenever possible.

2) We are also concerned about the potential for damage to the caprock aquifer that may occur with marina construction. We support careful testing and evaluation of the effects of excavation on the aquifer. If mitigation is required, we believe that the mitigation measures should be required to be maintained for the entire life of the marina.

Thank you for the opportunity to comment on this proposed project. We would appreciate reviewing the final EIS when it is completed.

Sincerely,

WARREN M. LEE
State Conservationist

WILSON OKAMOTO & ASSOCIATES, INC.
ENGINEERS ARCHITECTS PLANNERS

3053-04
April 6, 1992

Mr. Warren M. Lee
State Conservationist
Soil Conservation Service
U.S. Department of Agriculture
P.O. Box 50004
Honolulu, Hawaii 96850

Dear Mr. Lee:

Subject: Ewa Marina Phase I
Draft Supplemental Environmental Impact Statement
Tax Map Key: 9-1-12: 2, 3, 5 (por.), 6 (por.), 7 (por.), 8 through 17, and 23 (por.)
9-1-11: 1 through 7
Ewa, Oahu, Hawaii

Thank you for your letter of January 30, 1992 commenting on the subject Draft Supplemental Environmental Impact Statement. We offer the following in response to your numbered comments, respectively:

1. We acknowledge your concern regarding the loss of important agricultural lands to non-agricultural uses. Both the Draft and Final EIS documents disclose the potential loss of agricultural land to the proposed use. It should be noted that State and City policy regarding the conversion of the project area from agricultural to urban uses has been established.

2. The Applicant is committed to the utilization of the caprock aquifer as non-potable water source and has developed a program in coordination with the Commission on Water Resource Management for preservation of this resource. This program involves the initial construction of a small segment of the marina entrance channel and internal waterways. An intensive monitoring program during this initial construction phase will provide data for the development of a comprehensive mitigation plan, including long-term groundwater monitoring and alternative mitigation plans, in cooperation with the Commission of Water Resource Management to comply with performance standards established by it.

WILSON
OKAMOTO
& ASSOCIATES, INC.

We hope that we have adequately responded to your comments. Your letter, together with this response, will be reproduced in the Final SEIS. We appreciate your interest and participation in the public review phase of the environmental review process.

Sincerely,

Earl K. Matsukawa
Project Manager

cc: Office of Environmental Quality Control
HASEKO (Ewa) Inc.

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
BUILDING 230
FT. SHAFTER, HAWAII 96858-5440

REPLY TO ATTENTION OF:

January 29, 1992

Planning Division

RECEIVED
JAN 31 1992
WILSON OKAMOTO & ASSOCIATES

Wilson Okamoto and Associates
Attention: Mr. Earl Matsukawa
1150 South King Street, Suite 800
Honolulu, Hawaii 96814

Dear Sir/Madam:

We have reviewed the Draft Supplemental Environmental Impact Statement (DSEIS) for Ewa Marina, Phase I, Increment 2, Ewa, Oahu. The following comments are provided pursuant to Corps of Engineers authorities to disseminate flood hazard information under the Flood Control Act of 1960 and to issue Department of the Army (DA) permits under the Clean Water Act; the Rivers and Harbors Act of 1899; and the Marine Protection, Research and Sanctuaries Act.

a. As noted in our previous comments in response to the Preparation Notice (letter dated December 23, 1991; copy enclosed), the Corps of Engineers is processing a DA permit for the construction of the marina (file number PODCO 2117) and is preparing a federal Environmental Impact Statement for the project.

b. The flood hazard information presented on page III-32 of the DSEIS is correct, except that the flood hazards associated with Zone A represent coastal flooding due to hurricanes, not to tsunami as stated in paragraph F.1. Zone AE is associated with coastal flooding due to tsunami, as correctly indicated in paragraph F.1.

Sincerely,

Kisuk Cheung, P.E.
Director of Engineering

WILSON OKAMOTO & ASSOCIATES, INC.
ENGINEERS
ARCHITECTS
PLANNERS
1150 SOUTH KING STREET
HONOLULU, HAWAII 96814
PHONE: (808) 531-5261
Mailing address:
P.O. Box 3530
Honolulu, Hawaii 96811

3053-04
April 6, 1992

Mr. Kisuk Cheung, P.E.
Director of Engineering
U.S. Engineer District, Honolulu
Building 320
Fort Shafter, Hawaii 96858-5440

Subject: Ewa Marina Phase I
Draft Supplemental Environmental Impact Statement
Tax Map Key: 9-1-12: 2, 3, 5 (por.), 6 (por.), 7 (por.), 8 through 17, and 23 (por.)
9-1-11: 1 through 7
Ewa, Oahu, Hawaii

Dear Mr. Cheung:

Thank you for your letter of January 29, 1992 commenting on the subject Draft Supplemental Environmental Impact Statement. We offer the following in response to your numbered comments, respectively:

1. No response required.

2. Thank you for the flood hazard information. We have incorporated the correction you provided in the Final EIS.

We hope that we have adequately responded to your comments. Your letter, together with this response, will be reproduced in the Final SEIS. We appreciate your interest and participation in the public review phase of the environmental review process.

Sincerely,

Earl K. Matsukawa
Project Manager

cc: Office of Environmental Quality Control
HASEKO (Ewa) Inc.

United States Department of the Interior
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION
677 Ala Moana Boulevard, Suite 415
Honolulu, Hawaii 96813

February 19, 1992

RECEIVED
FEB 20 1992
WILSON OKAMOTO & ASSOCIATES

Wilson Okamoto and Associates, Inc.
1150 South King Street, Suite 800
Honolulu, Hawaii 96814
Attn: Earl Matsukawa

Dear Mr. Matsukawa:

Subject: Draft Supplemental Environmental Impact Statement (EIS) for Ewa Marina, Phase I, Increment 2

We have reviewed the subject EIS and have no comments. Thank you for the opportunity to review the EIS.

Sincerely,

Richard Fontaine
for William Meyer
District Chief

4212

WILSON OKAMOTO & ASSOCIATES, INC.
ENGINEERS
ARCHITECTS
PLANNERS
1150 SOUTH KING STREET
HONOLULU, HAWAII 96814
PHONE: (808) 531-5261

3053-04
April 6, 1992

Mr. William Meyer, District Chief
United States Department of the Interior
Geological Survey
Water Resources Division
677 Ala Moana Boulevard, Suite 415
Honolulu, Hawaii 96813

Subject: Ewa Marina Phase I
Draft Supplemental Environmental Impact Statement
Tax Map Key: 9-1-12: 2, 3, 5 (por.), 6 (por.), 7 (por.), 8 through 17, and 23 (por.)
9-1-11: 1 through 7
Ewa, Oahu, Hawaii

Dear Mr. Meyer:

Thank you for your letter of February 19, 1992 indicating that you have no comments on the Draft Supplemental Environmental Impact Statement (SEIS). Your letter, together with this response, will be reproduced in the forthcoming Final SEIS. We appreciate your interest and participation in the public review phase of the environmental review process.

Sincerely,

Earl K. Matsukawa
Project Manager

cc: Office of Environmental Quality Control
HASEKO (Ewa), Inc.

E11

DEPARTMENT OF THE NAVY
COMMANDER
NAVAL BASE PEARL HARBOR
BOX 110
PEARL HARBOR, HAWAII 96860-5020

IN REPLY REFER TO
11000
Ser 00F(23)/1285
2 [illegible] MAR 92

RECEIVED
[illegible]
WILSON OKAMOTO & ASSOCIATES

Mr. Earl K. Matsukawa
Project Manager
Wilson Okamoto & Assoc., Inc.
1150 South King Street
Honolulu, HI 96814

Dear Mr. Matsukawa:

EWA MARINA PHASE I, INCREMENT 2, DRAFT SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT (DSEIS) (JANUARY 1992), TAX MAP KEY 9-1-11:1 THROUGH 7 EWA, OAHU, HAWAII

We have reviewed the subject Ewa Marina Phase I, Increment 2 DSEIS, and the following comments are provided:

a. The DSEIS proposes a westerly shift of 1000 feet in the marina entrance from the 1986 proposed marina configuration (Figure a). This puts the proposed channel entrance significantly closer to Naval Air Station, Barbers Point's White Plains Beach. This beach area is normally covered with sand and is an attractive and well used recreation area.

Appendix E, Executive Summary, page ii, states "Adverse effects on nearby beaches as a result of the project can be largely or completely avoided if the sand accumulating in the jetty fillets and channel is bypassed whenever a significant buildup occurs." Section 5, paragraph 7, pages 41-42, further states that "The sand that will occasionally collect in fillets at the base of the jetties (primarily the east jetty) will need to be periodically bypassed" and the "bypassing of sand" at the jetty fillets or the channel itself may include natural movement as well as movement by man. Section 6 states "This material should be bypassed to nourish the downcoast beaches and to maintain navigable depth in the entrance channel." These statements from the "Moffatt and Nichol, Engineers report of November 8, 1990", Appendix E appear to conflict with the DSEIS statement found in Chapter VI, Physical Impacts, paragraph 4, Currents and Littoral Drift, "Because longshore sand transport is minimal and infrequent, such bypass operations are not anticipated (See Appendix E)."

As an adjacent land owner, the Navy is concerned that the "littoral sand displacement" must be properly monitored and managed throughout the life of the Ewa Marina development beyond construction. If not, the proposed channel and jetty system which will "modify the littoral sand movements" could have a detrimental affect on Naval Air Station's beaches for continued recreational uses. Recommend that an "agent" be designated to monitor and implement "bypassing" actions as necessary to ensure continued "nourishing of the downcoast beaches."

11000
Ser 00F(23)/1285

b. As discussed during your telephone conversation with Mr. Melvin Kaku on February 25, 1992, we have enclosed a copy of our letter to Mr. Brian Suzuki dated January 16, 1992 in which the Navy provided comments on your application for Ewa Marina, Phase I - Increment 2 Development Plan Amendments and Environmental Assessment.

Thank you for the opportunity to review the DSEIS for the proposed Ewa Marina Phase I, Increment II project. Should you have any questions, the Navy point of contact is Mr. Bill Liu, telephone 471-3324.

Sincerely,

O.K. Liu

Encl:
(1) Copy of Dept. of Gen Plng ltr of 16 Jan 92

Copy to (w/o encl):
Haseko (Hawaii), Inc.
Attn: Mr. N. W. G. Lee
820 Mililani St., Suite 820
Honolulu, HI 96813

Office of Environmental Quality Control
State of Hawaii
220 South King St., 4th Floor
Central Pacific Plaza
Honolulu, HI 96813

Commanding Officer
Naval Air Station Barbers Point
Attn: Ms. Myra R. Imings
AICUZ Officer (Code 00H)
Barbers Point, HI 96862-5050

WILSON
OKAMOTO
& ASSOCIATES, INC.

ENGINEERS
ARCHITECTS
PLANNERS

3053-04
April 6, 1992

Commander
Naval Base Pearl Harbor
Box 110
Pearl Harbor, Hawaii 06860-5020

Attention: Mr. W.K. Liu, Assistant Base Civil Engineer

Subject: Ewa Marina Phase I
Draft Supplemental Environmental Impact Statement
Tax Map Key: 9-1-12: 2, 3, 5 (por.), 6 (por.), 7 (por.), 8 through 17, and 23 (por.)
9-1-11: 1 through 7
Ewa, Oahu, Hawaii

Dear Mr. Liu:

Thank you for your letter of March 20, 1992 commenting on the subject Draft Supplemental Environmental Impact Statement (SEIS). We offer the following in response to your comments, respectively:

a. Although the need for bypass operations is not anticipated, the Draft EIS states in the preceding sentence that "If sand accretes in fillets at the base of the jetties, this sand will be periodically bypassed to nourish downcoast beaches." This commitment is repeated in on Page VI-18, paragraph 3, "Beaches." The Applicant will monitor sand deposition around the jetties and conduct bypass operations as needed to ensure that downcoast beaches are not adversely affected.

b. Thank you for the copy of your earlier comments on the environmental assessment. We will be responding to those comments in a separate transmittal.

We hope that we have adequately responded to your comments. Your letter, together with this response, will be reproduced in the Final SEIS. We appreciate your interest and participation in the public review phase of the environmental review process.

Sincerely,

Earl K. Matsukawa

Earl K. Matsukawa
Project Manager

cc: Office of Environmental Quality Control
HASEKO (Ewa) Inc.

STATE OF HAWAII
OFFICE OF ENVIRONMENTAL QUALITY CONTROL
220 SOUTH KING STREET
FOURTH FLOOR
HONOLULU, HAWAII 96813
TELEPHONE (808) 586-4185

BRIAN J. J. CHOY
Director

March 5, 1992

RECEIVED
MAR 09 1992
WILSON OKAMOTO & ASSOCIATES

Mr. Brian Suzuki
City and County of Honolulu
Department of General Planning
650 South King Street, 8th Floor
Honolulu, Hawaii 96813

Dear Mr. Suzuki:

Subject: Draft Supplemental Environmental Impact Statement for the Ewa Marina Phase 1, Increment 2

Thank you for the opportunity to review the subject document. We have the following comment:

1) Pursuant to §11-200-17(c), Hawaii Administrative Rules, please provide a table of contents in the document.

If you have any questions, please call Jeyan Thirugnanam at 586-4185.

Sincerely,

Brian J. J. Choy
Director

BC:jt

c: Haseko (Ewa), Inc.
Wilson Okamoto & Associates, Inc.

WILSON OKAMOTO & ASSOCIATES, INC.
ENGINEERS
ARCHITECTS
PLANNERS

3053-04
April 6, 1992

Mr. Brian J.J. Choy, Director
Office of Environmental Quality Control
220 South King Street, Fourth Floor
Honolulu, Hawaii 96813

Subject: Ewa Marina Phase I
Draft Supplemental Environmental Impact Statement
Tax Map Key: 9-1-12: 2, 3, 5 (por.), 6 (por.), 7 (por.), 8 through 17, and 23 (por.)
9-1-11: 1 through 7
Ewa, Oahu, Hawaii

Dear Mr. Choy:

Thank you for your letter of March 5, 1992 commenting on the subject Draft Supplemental Environmental Impact Statement (SEIS). As far as we know, all of the other copies of the subject Draft SEIS contain a table of contents. We regret any inconvenience that may have resulted by its inadvertent omission from your copy.

We appreciate your interest and participation in the public review phase of the environmental review process.

Sincerely,

Earl K. Matsukawa
Project Manager

cc: Office of Environmental Quality Control
HASEKO (Ewa), Inc.

STATE OF HAWAII
DEPARTMENT OF ACCOUNTING AND GENERAL SERVICES
DIVISION OF PUBLIC WORKS

RUSSEL S. NAGATA
COMPTROLLER
ROBERT P. TAKUSHI
[redacted]

LETTER NO. (P)1078.2

JAN 29 1992

RECEIVED
JAN 31 1992
WILSON OKAMOTO & ASSOCIATES

Wilson Okamoto and Associates
1150 South King Street, Suite 800
Honolulu, Hawaii 96814

Attention: Mr. Earl Matsukawa

Gentlemen:

Subject: Ewa Marina, Phase 1, Increment 2
Draft Supplemental EIS

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. Ralph Yukumoto of the Planning Branch at 586-0488.

Very truly yours,

TEUANE TOMINAGA
State Public Works Engineer

RY:jk
cc: Haseko (Ewa), Inc.
Dept. of General Planning, City and County of Honolulu
Office of Environmental Quality Control

WILSON OKAMOTO & ASSOCIATES, INC.
ENGINEERS
ARCHITECTS
PLANNERS

3053-04
April 6, 1992

Mr. Russell S. Nagata, Comptroller
Division of Public Works
Department of Accounting and General Services
P.O. Box 119
Honolulu, Hawaii 96810

Attention: Teuane Tominaga, State Public Works Engineer

Subject: Ewa Marina Phase I
Draft Supplemental Environmental Impact Statement
Tax Map Key: 9-1-12: 2, 3, 5 (por.), 6 (por.), 7 (por.), 8 through 17, and 23 (por.)
9-1-11: 1 through 7
Ewa, Oahu, Hawaii

Dear Mr. Nagata:

Thank you for your letter of January 29, 1992 indicating that you have no comments on the Draft Supplemental Environmental Impact Statement (SEIS). Your letter, together with this response, will be reproduced in the forthcoming Final SEIS. We appreciate your interest and participation in the public review phase of the environmental review process.

Sincerely,

Earl K. Matsukawa
Project Manager

cc: Office of Environmental Quality Control
HASEKO (Ewa), Inc.

JOHN WAIHEE
GOVERNOR

STATE OF HAWAII
DEPARTMENT OF DEFENSE
OFFICE OF THE ADJUTANT GENERAL
3949 DIAMOND HEAD ROAD, HONOLULU, HAWAII 96816-4495

EDWARD V. RICHARDSON
MAJOR GENERAL
ADJUTANT GENERAL

MYLES M. NAKATSU
COLONEL
DEPUTY ADJUTANT GENERAL

January 22, 1992

RECEIVED
JAN 24 1992
WILSON OKAMOTO & ASSOCIATES

Engineering Office

Mr. Earl Matsukawa
Wilson Okamoto and Associates
1150 South King Street, Suite 800
Honolulu, Hawaii 96814

Subject: Draft Supplemental Environmental Impact Statement for Ewa Marina, Phase I, Increment 2

Dear Mr. Matsukawa:

Thank you for providing us the opportunity to review the above mentioned Supplemental Environmental Impact Statement.

We have no comments to offer at this time regarding the project.

Sincerely,

Jerry M. Matsuda
Lieutenant Colonel
Hawaii Air National Guard
Contracting and Engineering Officer

Enc.

NATIONAL GUARD
Americans At Their Best.

WILSON OKAMOTO & ASSOCIATES, INC.
ENGINEERS ARCHITECTS PLANNERS
1150 SOUTH KING STREET
HONOLULU, HAWAII 96814
PHONE: (808) 531-5261
Mailing address: P.O. Box 3530 Honolulu, Hawaii 96811

3053-04
April 6, 1992

Lieutenant Colonel Jerry M. Matsuda
Contracting and Engineering Officer
State of Hawaii
Department of Defense
Office of the Adjutant General
Engineering Office
3949 Diamond Head Road
Honolulu, Hawaii 96816-4495

Subject: Ewa Marina Phase I
Draft Supplemental Environmental Impact Statement
Tax Map Key: 9-1-12: 2, 3, 5 (por.), 6 (por.), 7 (por.), 8 through 17, and 23 (por.)
9-1-11: 1 through 7
Ewa, Oahu, Hawaii

Dear Colonel Matsuda:

Thank you for your letter of January 22, 1992 indicating that you have no comments on the Draft Supplemental Environmental Impact Statement (SEIS). Your letter, together with this response, will be reproduced in the forthcoming Final SEIS. We appreciate your interest and participation in the public review phase of the environmental review process.

Sincerely,

Earl K. Matsukawa
Project Manager

cc: Office of Environmental Quality Control
HASEKO (Ewa), Inc.

JOHN WAIHEE
GOVERNOR OF HAWAII

RECEIVED
FEB 2 1992
WILSON OKAMOTO & ASSOCIATES

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
John P. Keppeler, II
Dona L. Hanaike

AQUACULTURE DEVELOPMENT PROGRAM
AQUATIC RESOURCES
CONSERVATION AND ENVIRONMENTAL AFFAIRS
CONSERVATION AND RESOURCES ENFORCEMENT
CONVEYANCES
FORESTRY AND WILDLIFE
HISTORIC PRESERVATION PROGRAM
LAND MANAGEMENT
STATE PARKS
WATER AND LAND DEVELOPMENT

REF:OCEA:SKK

FILE NO.: 92-427
DOC. NO.: 153

FEB 21 1992

The Honorable Benjamin Lee
Chief Planning Officer
Department of General Planning
City and County of Honolulu
650 South King Street
Honolulu, HI 96813

Dear Mr. Lee:

SUBJECT: Draft Supplemental Environmental Impact Statement for the Ewa Marina Phase I, Increment 2 at Ewa, Oahu, Hawaii
Tax Map Key 9-1-11: 1 through 7

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.

The impact assessment made for marine habitat and nearshore fisheries is inadequate because it fails to account for the dredging that would impact almost 500 feet of the shoreline destroying intertidal habitat and 28 acres of subtidal habitat. The developer's marine studies are static inventories which only characterize what is observed. The natural habitat (observed as depauperate by the developer) is still more productive than the sandy, grainy bottom that will result from dredging.

The existing marine substratum is relatively flat and would appear insignificant. However it contains pockets, gouges, crevices which "house" a myriad of marine organisms which play an integral part in the marine food chain that sustain commercially and recreationally important marine species. For example, octopus or he'e require a habitat that is relatively flat but with pockets or crevices in which to hide, rest, etc... Marine algae which is classified as abundant inshore waters and possibly significant as a food source for marine turtles of the area, may not thrive on a sand/sediment bottom.

The draft Supplemental Environmental Impact Statement describes the jetties as enhancing marine habitat. Simply increasing surface area and vertical relief does not guarantee an increase in diversity. An example of this would be an examination of jetties and breakwaters around Oahu. Many are barren and devoid of significant marine life. This may also hold true for the proposed marina's walls and edges.

The proposed artificial reef is expected to enhance the area's fish diversity as well. While this is not unanticipated, the present philosophy is to place artificial structures offshore. This would benefit only the boaters and not the shoreline fishermen. There are alternatives that can be pursued with respect to enhancing fisheries for the shoreline fishermen. The developer is urged to consult with our Division of Aquatic Resources.

While artificial reefs and habitat alteration may partially enhance the productivity of the marine habitat, this enhancement may be more than offset by the expected increases in fishing pressure to the area that would result from the development. The subject area's relative isolated situation both by land and by water temporarily protects it from increased anthropogenic insults such as point and non-point source pollution, habitat alteration, and increased fishing pressure. Increased access from improved roads, more secure parks, restroom facilities, and the presence of the marina and boat launch ramps will all serve to increase consumptive pressure on marine resources. It is inevitable with such proposed development and to conclude otherwise appears to be incorrect.

Our Historic Preservation Division commented directly to the preparers of this document, Wilson Okamoto & Associates, Inc. on the Supplemental Environmental Impact Statement Preparation Notice. At that time they noted that the commitment to carry out the Archaeological Mitigation Plan (AMP) for this project is made in a Memorandum of Agreement (MOA) among the U.S. Army Corps of Engineers, the Hawaii State Historic Preservation Officer, the Office of Hawaiian Affairs, and the Advisory Council on Historic Preservation. This MOA is in draft form. The AMP specifies that buffer zones will be established around six sites assessed as valuable for information content and as excellent examples of site types.

We note that development plans have been altered to avoid adverse impacts to historic sites, but can not determine that the current marina configuration will have "no adverse effect" on historic sites until the buffer zones are established and an acceptable MOA is in place. These circumstances are reflected in the draft Supplemental Environmental Impact Statement.

Thank you for your cooperation in this matter. Please feel free to call me or Cathy Tilton at our Office of Conservation and Environmental Affairs, at 587-0377, should you have any questions.

Very truly yours,

for WILLIAM W. PATY

cc: Nelson W. G. Lee, Haseko (Ewa), Inc.
Earl K. Matsukawa, Wilson Okamoto and Associates, Inc.

WILSON
OKAMOTO
& ASSOCIATES, INC.

ENGINEERS
ARCHITECTS
PLANNERS

3053-04
April 6, 1992

Mr. William W. Paty, Chairperson
Department of Land and Natural Resources
P. O. Box 621
Honolulu, HI 96809

Subject: Ewa Marina Phase I
Draft Supplemental Environmental Impact Statement
Tax Map Key: 9-1-12: 2, 3, 5 (por.), 6 (por.), 7 (por.), 8 through 17, and 23 (por.)
9-1-11: 1 through 7
Ewa, Oahu, Hawaii

Dear Mr. Paty:

Thank you for your letter of February 21, 1992 commenting on the subject Draft Supplemental Environmental Impact Statement (SEIS). We offer the following responses to your comments:

1. We appreciate having had the opportunity to meet with staff from your Division of Aquatic Resources (DAR) and Office of Conservation and Environmental Affairs (OCEA) on February 27, 1992 to discuss your comments regarding the project's impact on marine habitats. It was a fruitful meeting in which a variety of concerns were addressed. The following summarizes our understanding of the results of the meeting:

   a. The DAR generally agreed that the marine studies conducted for the project are appropriate for assessing the impacts of the proposed project.

   b. While it felt the analysis was adequate, the DAR expressed some concern over what it felt was an overly one-sided discussion of the habitat changes that could be anticipated as a result of the dredging and the placement of the protective jetties. The Applicant agreed to revise the text in the Final SEIS to reflect more uncertainty with respect to conclusions about habitat adjustments. It was also agreed that the Applicant's consultants would provide additional backup information concerning anticipated coral recolonization based on observations of a comparable channel entrance and submerged structures (e.g. the entrance to the Barbers Point Deep Draft Harbor and Waianae Boat Harbor). This information would provide further support for the conclusion that the presence of the

jetties and vertical relief on the channel would provide an enhanced habitat for many species.

   c. The DAR expressed that they should be consulted regarding the construction of the artificial reef since it will most likely be placed on submerged lands owned by the State and because they are the agency most familiar with the siting and construction of such reefs. The Applicant agreed that the DAR's expertise in artificial reefs is invaluable and is committed to keeping the DAR involved in discussions concerning the reef.

2. State Historic Preservation Office - no response required.

We hope that we have adequately responded to your comments. Your letter, together with this response, will be reproduced in the Final SEIS. We appreciate your interest and participation in the public review phase of the environmental review process.

Sincerely,

Earl K. Matsukawa
Project Manager

cc: Office of Environmental Quality Control
HASEKO (Ewa), Inc.

04-01-92 16:11 805 531 8166   002

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
COMMISSION ON WATER RESOURCE MANAGEMENT
P. O. BOX 621
HONOLULU, HAWAII 96809

MAR 31 1992

Mr. Benjamin Lee
Chief Planning Officer
Department of General Planning
City and County of Honolulu
650 South King Street
Honolulu, Hawaii 96813

Dear Mr. Lee:

This Commission on Water Resource Management offers the following comments regarding the Draft Supplemental Environmental Impact Statement for Phase I, Increment 2, of the Ewa Marina Project.

The Commission is responsible for managing the Ewa caprock aquifer and has regulatory authority over actions that might affect it. We consider the aquifer to be an important brackish water resource that can be used to meet many of the irrigation and other non-potable water needs of the Ewa Plain. Consequently, the Commission is determined to see that the quality and usefulness of this resource is not adversely affected.

In the last several months, the Commission has met with the applicant and we concur that the construction of a short, narrow trench across the shoreline, may be the best way to obtain the information needed to refine predictions concerning the marina's effect on the aquifer.

The Commission will continue to monitor the applicant's progress in safeguarding this water source. Approval of the State Conservation District Use Permit for and construction of the project will be conditioned on the Applicant's agreement to meet and comply with the performance standards established by the Commission.

Thank you for this opportunity to comment.

Very truly yours,

WILLIAM W. PATY

WILSON OKAMOTO & ASSOCIATES, INC.
ENGINEERS ARCHITECTS PLANNERS

3053-04
April 6, 1992

Mr. William W. Paty, Chairperson
Commission on Water Resource Management
Department of Land and Natural Resources
P.O. Box 621
Honolulu, Hawaii 96809

Subject: Ewa Marina Phase I
Draft Supplemental Environmental Impact Statement
Tax Map Key: 9-1-12: 2, 3, 5 (por.), 6 (por.), 7 (por.), 8 through 17, and 23 (por.)
9-1-11: 1 through 7
Ewa, Oahu, Hawaii

Dear Mr. Paty:

Thank you for your letter of March 31, 1992. We appreciate the cooperative efforts of the Commission on Water Resource Management in working with the Applicant to address concerns related to the protection of the caprock aquifer as an important non-potable water source. The Applicant acknowledges the Commission's regulatory authority over actions that might affect this resource and is committed to developing a comprehensive mitigation plan in cooperation with the Commission to comply with performance standards established by it.

We hope that we have adequately responded to your comments. Your letter, together with this response, will be reproduced in the Final SEIS. We appreciate your interest and participation in the public review phase of the environmental review process.

Sincerely,

Earl K. Matsukawa
Project Manager

cc: Office of Environmental Quality Control
HASEKO (Ewa), Inc.

JOHN WAIHEE
GOVERNOR

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
869 PUNCHBOWL STREET
HONOLULU, HAWAII 96813-5097

REX D. JOHNSON
DIRECTOR

DEPUTY DIRECTORS
AL PANG
JOYCE T. OMINE
JEANNE K. SCHULTZ
CALVIN M. TSUDA

IN REPLY REFER TO:
STP 8.4606

February 19, 1992

RECEIVED
FEB 24 1992
WILSON OKAMOTO & ASSOCIATES

Mr. Benjamin B. Lee
Chief Planning Officer
Department of General Planning
City and County of Honolulu
650 South King Street
Honolulu, Hawaii 96813

Dear Mr. Lee:

Subject: Draft Environmental Impact Statement
Ewa Marina, Phase I, Increment 2

We have the following comments on the draft EIS for the Ewa Marina, Phase I, Increment 2 development proposal:

1. We recommend that the developer update the composite Honolulu International Airport and Naval Air Station Barbers Point Ldn Noise Contour Map (Figure 10, Page III-15) to verify whether the noise contours are still valid. More then 5 years have elapsed since this map was prepared and we feel an update is appropriate at this time. If the update indicates an increase in noise levels, then the development in the noise impacted areas should be modified accordingly.

2. We support the proposed development of the marina and boat launching ramp because they will be opened to the public to help meet some of the demand for these types of facilities. A map indicating the location of the public berthing areas and ramp facility should be included in the report.

3 In conjunction with the State's Water Transit System for Oahu, we appreciate the developer incorporating a ferry terminal facility in the marina to serve Ewa Marina, Ewa, and the surrounding communities. As a significant and important element of the marina development, we feel the report should discuss in greater detail the location of the terminal and the role the ferry transit service will play in helping to reduce traffic congestion.

4. The developer should submit a construction phasing schedule for the entire Ewa Marina project. This should include required roadway improvements needed to adequately accommodate the development.

5. The traffic impact report should reflect the full buildout of the Ewa plain.

6. Operational analyses (in lieu of planning analyses) should be submitted for the roadways intersecting Fort Weaver Road including the intersections with Kuhina Street, Hanakahi Street, and Geiger Road.

7. The location of Roads A and B must conform to State Design Standards regarding the spacing of intersections. In addition, right turn lanes out of Road A and B should be provided.

8. The EIS (Chapter VI, H. Infrastructure, 1. Roads) should explicitly cite the responsibilities of the developer in providing required roadway improvements by stating specifically that the developer will bear the cost of all project related improvements, identifying what these measures are, and commit to paying his prorata share of other regional improvements. These improvements should be implemented prior to occupancy of the development's units.

9. Plans for construction work within the State highway right-of-way must be submitted for our review and approval.

We appreciate this opportunity to provide comments.

Sincerely,

Rex D. Johnson
Director of Transportation

bc: Mr. Earl K. Matsukawa
Wilson Okamoto and Associates, Inc.

WILSON OKAMOTO & ASSOCIATES, INC.
ENGINEERS
ARCHITECTS
PLANNERS

3053-04
April 6, 1992

Mr. Rex D. Johnson
Director of Transportation
State Department of Transportation
869 Punchbowl Street
Honolulu, HI 96813-5097

Subject: Ewa Marina Phase I
Draft Supplemental Environmental Impact Statement
Tax Map Key: 9-1-12: 2, 3, 5 (por.), 6 (por.), 7 (por.), 8 through 17, and 23 (por.)
9-1-11: 1 through 7
Ewa, Oahu, Hawaii

Dear Mr. Johnson:

Thank you for your letter of February 19, 1992 commenting on the subject Draft Supplemental Environmental Impact Statement (SEIS). We offer the following in response to your numbered comments, respectively:

1. The composite Honolulu International Airport (HIA) and Naval Air Station Barbers Point Ldn Contour Map (Figure 10, Page III-15) was prepared in January, 1991 in conjunction with the EIS for Ewa Marina Phase II. It is based on the latest noise studies available for the two airports. A report supporting the composite Ldn contour was included in that EIS. A summary of findings from that report, as it pertains to Ewa Marina Phase I, Increment 2, has been prepared for inclusion in the Final SEIS. Both the report and the summary utilize Ldn contours provided in the following studies:

    a. Honolulu International Airport Master Plan Update and Noise Compatibility Program, Volume 2, Part I, FAR Part 150 - Noise Exposure Maps and Noise Compatibility Program, prepared by KFC Airports, Inc. and Edward K. Noda & Associates, Inc. (December, 1989).

    b. Naval Air Station Barbers Point Air Installation Compatible Use Zone (AICUZ) Noise Contours and Supporting Data, prepared by Harris, Miller, Miller and Hanson, Inc., July, 1989. This report used 1987 Honolulu International Airport operations based on inputs from the Airports Division, DOT, and Edward K. Noda and Associates, Inc.

The 1987 and 1992 Ldn contours from the first report were approved by the Federal Aviation Administration on October 15, 1991. The 1987 contours were base on reconstructions of actual 1987 operations while the 1992 contours were based on projected operations.

Although the composite Ldn contours are based on the latest available information, we understand that your comment refers to the availability of updated data on HIA aviation operations. Specifically, actual aviation operation data are now available for 1989 and projections have been prepared for 1995. While such data are the basis for preparing noise studies, we further understand that the Airports Division has not initiated an update of the FAR Part 150 Noise Compatibility Study using this data. Thus, new Ldn contours for HIA have not been prepared for FAA approval.

Notably, with respect to how the Ldn contours may change in the future, projections beyond 1992 were prepared in conjunction with the 1989 FAR Part 150 Noise Study. While the FAA does not approve such contours, they indicate essentially the same noise impact into the years 2005 and 2007 in spite of increased aviation operations. This trend reflects the phase out of noisier Stage 2 aircraft and replacement by quieter Stage 3 aircraft.

Our noise consultants have advised us that while it is possible to update the HIA Ldn contours based on the updated aviation operation data, the rationale for doing so is unclear. A developer-prepared Ldn contour study may raise questions regarding its objectivity since a range of discretionary assumptions are required which could significantly affect the results. These results could also have significant implications regarding interests of surrounding landowners as well as on airport operators' liabilities relating to their noise impacts.

Moreover, it is uncertain what the Ldn contours would be used for. For example, the City's Ewa Development Plan subjects the proposed project to conditions for the siting of residential uses and provision of noise attenuation measures depending on the Ldn contours. Thus, the City may have an interest in which studies those contours are based on. On the other hand, Section 467-31, Hawaii Revised Statutes is clear as to which

Ldn contours should be used to determine disclosure requirements for property transactions involving lands subject to noise exposure. It specifically applies to lands "within the boundaries of the noise exposure area shown on <u>maps prepared by the department of transportation in accordance with Federal Aviation Regulation Part 150 - Airport Noise Compatibility Planning</u>.(14 Code of Federal Regulations Part 150) for any public airport."

2. Based on the conceptual master plan presently under consideration, the public boat launching ramps and public berthings will be located in the western basin as shown in the attached map.

3. The conceived location of the ferry terminal is also shown on the attached map. Inasmuch as the details of the State's Water Transit System operation and potential ridership projections are not available, however, we note in our Draft SEIS that the ferry service could reduce traffic if it is implemented.

4. The Applicant's engineering consultants have contacted staff from your Highway Planning Division to pursue discussions addressing your concerns regarding construction phasing. A detailed construction phasing schedule shall be prepared as the project progresses.

5. The traffic impact report identifies the roadway improvements needed for the Project and does consider the traffic from other projects in the nearby area. The Ewa Region Highway Master Plan being prepared for the Developers Working Group (of which the Applicant is a member) addresses the regional roadway system needed to support the development of the Ewa Plain.

6. The intersections mentioned in your letter are beyond the Ewa Marina project limits and would be more appropriately addressed within the context of the Ewa Region Highway Master Plan effort discussed above. Also, because of the long time frame, the planning analysis for the signalized intersections is the appropriate methodology to apply for future conditions as it assesses the adequacy of the laneage configuration for signalized intersections.

7. The Applicant's engineering consultants met with staff of your Highway Planning Division on March 17, 1992 to discuss the location of Roads A and B. Due to existing constraints, the staff concurred that the proposed locations of the Road A and Road B intersections are appropriate.

8. We will revise the Final SEIS (Chapter VI. H. Infrastructure, 1. Roads) by reiterating that the Applicant will construct the internal roadway system. We will also clarify that the Applicant has joined with other developers as members of the Ewa Region Developers Working Group. Moreover, as a condition of the State Land Use Commission approvals of the project, the Applicant is committed to contributing its fair share toward regional roadway improvements needed to accommodate the growth planned for Ewa.

9. The Applicant will comply with the requirement to submit plans for construction work within the State highway right-of-way to your agency for review and approval.

We hope that we have adequately responded to your comments. Your letter, together with this response, will be reproduced in the Final SEIS. We appreciate your interest and participation in the public review phase of the environmental review process.

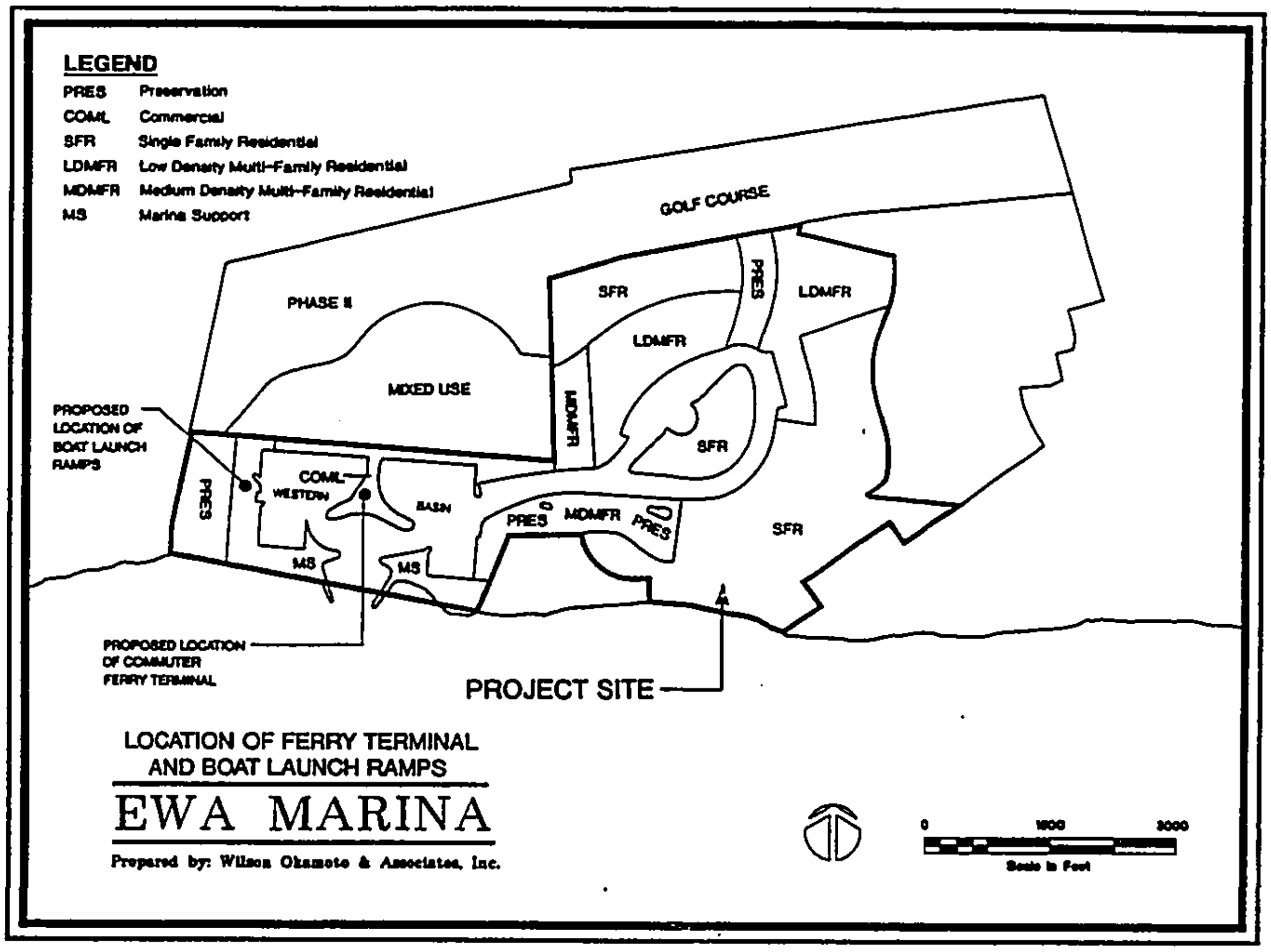
Sincerely,

Earl K. Matsukawa

Earl K. Matsukawa
Project Manager

cc: Office of Environmental Quality Control
HASEKO (Ewa), Inc.

attachment



LOCATION OF FERRY TERMINAL AND BOAT LAUNCH RAMPS

EWA MARINA

Prepared by: Wilson Okamoto & Associates, Inc.

JOHN WAIHEE
GOVERNOR

STATE OF HAWAII
DEPARTMENT OF BUSINESS, ECONOMIC DEVELOPMENT & TOURISM
LAND USE COMMISSION
Room 104, Old Federal Building
335 Merchant Street
Honolulu, Hawaii 96813
Telephone: 587-3822

ESTHER UEDA
EXECUTIVE OFFICER

RECEIVED
FEB 2 '92
WILSON OKAMOTO & ASSOCIATES

February 20, 1992

Mr. Earl K. Matsukawa
Project Manager
Wilson Okamoto and Associates
1150 South King Street, Suite 800
Honolulu, Hawaii 96814

Dear Mr. Matsukawa:

Subject: Draft Supplemental Environmental Impact Statement for the Ewa Marina, Phase I, Increment 2

The Department of Business, Economic Development and Tourism has referred the subject Draft Supplemental Environmental Impact Statement ("DSEIS") to our office for response.

Based on our review of the DSEIS for the second increment of Haseko's Ewa Marina Phase I ("Project Area"), we confirm that the Project Area is located in the State Land Use Urban District.

Approximately 181 acres of this Project Area was reclassified into the Urban District from the Agricultural District by the State Land Use Commission ("Commission") in Docket No. A83-558/MSM & Associates, Inc.

Based on the Commission's Decision and Order ("Order") dated September 21, 1984 for this area, we would like to point out the following:

1) The reclassification of this area was subject to eleven (11) conditions specified by the Order.

2) The DSEIS states that the marina and waterways have been reconfigured due to archaeological, surf site, caprock aquifer and internal circulation considerations.

The current 120 acre marina and waterway configuration differs significantly from that which was approved by the Commission. Pursuant to the Commission's Order, the marina and waterways were to encompass a smaller 110 acre area (Phase I comprising 98 acres and Phase II, 12 acres).

Despite this larger area, we note that the number of slips to be created has been reduced from 2,500 to 1,600.

3) Condition No. 9 of the Commission's Order required that the completed marina be reclassified from the State Land Use Urban to the Conservation District within two years of completion. Condition No. 9 of the Commission's Order reads as follows:

9. "The Petitioner shall petition the Land Use Commission to reclassify the land actually developed for the marina waterways to the Conservation District within two years of completion of the marina."

This required action should be included in Summary Sheet on Page iv, Required Permits and Approvals; Chapter II, C. Development Timetable; Chapter V, B. 1. State Land Use District Classification, and other appropriate sections of the DSEIS.

We have no further comments to offer at this time.

Thank you for the opportunity to comment on this matter. If you have any questions, please call me or Steve Tagawa of my staff at 587-3822.

Sincerely,

[signature]

ESTHER UEDA
Executive Officer

EU:fl

cc: DBED
DGP
OEQC
Nelson Lee

WILSON OKAMOTO & ASSOCIATES, INC.

ENGINEERS
ARCHITECTS
PLANNERS

3053-04
April 6, 1992

Ms. Esther Ueda, Executive Director
Land Use Commission
Department of Business, Economic Development,
and Tourism
335 Merchant Street, Room 104
Honolulu, HI 96813

Subject: Ewa Marina Phase I
Draft Supplemental Environmental Impact Statement
Tax Map Key: 9-1-12: 2, 3, 5 (por.), 6 (por.), 7 (por.), 8 through 17, and 23 (por.)
9-1-11: 1 through 7
Ewa, Oahu, Hawaii

Dear Ms. Ueda:

Thank you for your letter of February 20, 1992 commenting on the subject Draft Supplemental Environmental Impact Statement (SEIS). We offer the following responses to your comments:

As you note in your letter, the plan for the marina has undergone a number of changes since the Decision and Order in Docket No. A83-558/MSM & Associates, Inc. was issued in 1984 by the Land Use Commission ("LUC"). The changes include an increase in the marina size to approximately 120 acres, and a decrease in the number of boat slips to approximately 1,400, from the figures discussed in the 1984 LUC Decision and Order, taken as a whole. However, the changes discussed in the Draft SEIS represent positive steps taken by HASEKO (Ewa), Inc. ("Haseko") to lessen any potential adverse impacts of the Project.

The channel location next to Oneula Beach Park has been moved about 200 feet north to avoid archaeological remains recommended for preservation. The inland-reaching channels of the marina have been eliminated to limit potential effects on the caprock aquifer and to improve water quality. To reduce impacts on existing surf sites, the entrance channel has been moved 1,000 feet to the west and the size of the jetties reduced. The marina configuration has also been changed to, among other things, improve water circulation and provide more wave attenuation to offset the effect of the shorter jetties.

The marina is still in the planning stages, and may be revised further as circumstances require. However, Haseko is cognizant of the conditions to the

1984 Decision and Order, and notes that the changes to the marina discussed in the Draft SEIS are in compliance with those conditions.

As you have requested, Condition No. 9 of the 1984 Decision and Order, requiring a petition to reclassify the land developed for the marina waterways to the Conservation District within two years of completion, shall be included in the appropriate sections of the Final SEIS.

We hope that we have adequately responded to your comments. Your letter, together with this response, will be reproduced in the Final SEIS. We appreciate your interest and participation in the public review phase of the environmental review process.

Sincerely,

Earl K. Matsukawa
Project Manager

cc: Office of Environmental Quality Control
HASEKO (Ewa), Inc.

DEPARTMENT OF BUSINESS, ECONOMIC DEVELOPMENT & TOURISM
ENERGY DIVISION, 335 MERCHANT ST., RM. 110, HONOLULU, HAWAII 96813 PHONE: (808) 587-3800 FAX: (808) 587-3820

JOHN WAIHEE, Governor
MURRAY E. TOWILL, Director
BARBARA KIM STANTON, Deputy Director
RICK EGGED, Deputy Director
TAKESHI YOSHIHARA, Deputy Director

January 9, 1992

RECEIVED
JAN 15 1992
WILSON OKAMOTO & ASSOCIATES

Mr. Benjamin Lee, Chief Planning Officer
Department of General Planning
Municipal Office Building, 8th Floor
650 South King Street
Honolulu, Hawaii 96813

Dear Mr. Lee:

Subject: Draft Supplemental Environmental Impact Statement (EIS) for Ewa Marina, Phase I, Increment 2

We wish to inform you that we have no comments to offer on the subject draft environmental impact statement. We are therefore returning the draft EIS.

Thank you for the opportunity to review the document.

Sincerely,

Maurice H. Kaya
Energy Program Administrator

MHK:hkeis40

cc: Wilson Okamoto and Associates
Haseko (Ewa), Inc.

WILSON OKAMOTO & ASSOCIATES, INC.
ENGINEERS
ARCHITECTS
PLANNERS

3053-01
April 6, 1992

Mr. Maurice H. Kaya, Energy Program Administrator
State of Hawaii
Department of Business and Economic Development & Tourism
Energy Division
335 Merchant Street, Rm. 110
Honolulu, Hawaii 96813

Subject: Ewa Marina Phase I
Draft Supplemental Environmental Impact Statement
Tax Map Key: 9-1-12: 2, 3, 5 (por.), 6 (por.), 7 (por.), 8 through 17, and 23 (por.)
9-1-11: 1 through 7
Ewa, Oahu, Hawaii

Dear Mr. Kaya:

Thank you for your letter of January 9, 1992 indicating that you have no comments on the Draft Supplemental Environmental Impact Statement (SEIS). Your letter, together with this response, will be reproduced in the forthcoming Final SEIS. We appreciate your interest and participation in the public review phase of the environmental review process.

Sincerely,

Earl K. Matsukawa
Project Manager

cc: Office of Environmental Quality Control
HASEKO (Ewa), Inc.

JOHN WAIHEE
GOVERNOR

STATE OF HAWAII
DEPARTMENT OF BUDGET AND FINANCE
HOUSING FINANCE AND DEVELOPMENT CORPORATION
SEVEN WATERFRONT PLAZA, SUITE 300
500 ALA MOANA BOULEVARD
HONOLULU, HAWAII 96813
FAX [redacted]587-0600

JOSEPH K. CONANT
EXECUTIVE DIRECTOR

IN REPLY REFER TO:
92:PPE/632jt

February 20, 1992

RECEIVED
FEB 25 1992
WILSON OKAMOTO & ASSOCIATES

Mr. Earl Matsukawa
Wilson Okamoto and Associates
1150 South King Street, Suite 800
Honolulu, Hawaii 96814

Dear Mr. Matsukawa:

Re: Draft Supplemental EIS for Ewa Marina, Phase I, Increment 2

Thank you for the opportunity to review the supplemental dEIS. We provided comments to the draft EIS in March 1991 and have no additional comments to make.

Sincerely,

Joseph K. Conant
Executive Director

WILSON OKAMOTO & ASSOCIATES, INC.
ENGINEERS
ARCHITECTS
PLANNERS
1150 SOUTH KING STREET
HONOLULU, HAWAII 96814

3053-04
April 6, 1992

Mr. Joseph K. Conant, Executive Director
Housing Finance and Development Corporation
Department of Budget and Finance
Seven Waterfront Plaza, Suite 300
500 Ala Moana Boulevard
Honolulu, Hawaii 96813

Subject: Ewa Marina Phase I
Draft Supplemental Environmental Impact Statement
Tax Map Key: 9-1-12: 2, 3, 5 (por.), 6 (por.), 7 (por.), 8 through 17, and 23 (por.)
9-1-11: 1 through 7
Ewa, Oahu, Hawaii

Dear Mr. Conant:

Thank you for your letter of February 20, 1992 indicating that you have no comments on the Draft Supplemental Environmental Impact Statement (SEIS). Your letter, together with this response, will be reproduced in the forthcoming Final SEIS. We appreciate your interest and participation in the public review phase of the environmental review process.

Sincerely,

Earl K. Matsukawa
Project Manager

cc: Office of Environmental Quality Control
HASEKO (Ewa), Inc.

BOARD OF WATER SUPPLY
CITY AND COUNTY OF HONOLULU
630 SOUTH BERETANIA STREET
HONOLULU HAWAII 96843

February 25, 1992

Mr. Earl Matsukawa
Wilson Okamoto & Associates, Inc.
P.O. Box 3530
Honolulu, Hawaii 96811

FEB 28 1992

Dear Mr. Matsukawa:

Subject: Your Letter of January 6, 1992 Regarding the Supplemental Draft Environmental Impact Statement (SDEIS) for the Proposed Ewa Marina, Phase I, Increment 2, TMK: 9-1-11: 1-7; 9-1-12: 2, 3, 5-17

Thank you for the opportunity to review and comment on the proposed Ewa Marina Phase I, Increment 2, SDEIS. We have the following comments to offer:

1. We recognize that the reconfiguration of the marina to reduce its inward extent is to minimize the adverse effects on the brackish water limestone aquifer. The developer will still be required to maintain the integrity of the caprock resource with proven mitigative measures such as full grout curtains or sheet piling around the marina prior to dredging. The results of the trial cut into the aquifer to test the natural resealing theory should be submitted for our review.

2. The developer should coordinate the installation of the off-site water system facilities with the Ewa Plain Water Development Corporation (EPWDC) and obtain the necessary water allocations for the proposed developments from the EPWDC.

3. The developer will be required to submit a detailed water master plan for the proposed Ewa Marina development for our review and approval.

4. The proposed development will be subject to the Board of Water Supply's cross-connection control requirements which apply to dual water systems. Approved reduced pressure principle backflow prevention assemblies will be

required immediately after the property valves of all potable water meters serving lots containing a nonpotable system.

If you have any questions, please contact Bert Kuioka at 527-5235.

Very truly yours,

KAZU HAYASHIDA
Manager and Chief Engineer

WILSON OKAMOTO & ASSOCIATES, INC.

ENGINEERS
ARCHITECTS
PLANNERS
1150 South King Street
Honolulu, Hawaii 96814
Phone: (808) 531-5261

3053-04
April 6, 1992

Mr. Kazu Hayashida
Manager and Chief Engineer
Board of Water Supply
City and County of Honolulu
630 South Beretania Street
Honolulu, Hawaii 96843

Subject: Ewa Marina Phase I
Draft Supplemental Environmental Impact Statement
Tax Map Key: 9-1-12: 2, 3, 5 (por.), 6 (por.), 7 (por.), 8 through 17, and 23 (por.)
9-1-11: 1 through 7
Ewa, Oahu, Hawaii

Dear Mr. Hayashida:

Thank you for your letter of February 25, 1992 commenting on the subject Draft Supplemental Environmental Impact Statement (SEIS). We offer the following in response to your numbered comments, respectively:

1. The Commission on Water Resources Management is responsible for managing the Ewa caprock aquifer and has regulatory authority over actions that might affect it. The Applicant is committed to using the caprock aquifer as a non-potable water source and has developed a program in coordination with the Commission for preserving this resource. This program involves the initial construction of a small segment of the marina entrance channel and internal waterways. An intensive monitoring program during this initial construction phase will provide data for the development of a comprehensive mitigation plan in cooperation with the Commission to comply performance standards established by it. In view of the Commission's regulatory authority in this matter, we suggest that inquiries regarding its on-going review procedures be directed to that body.

2. The Applicant has continued to participate in the installation of the off-site water system facilities through the Ewa Plain Water Development Corporation (EPWDC). The water allocation for the proposed development has been obtained.

3. A detailed water master plan for the proposed development will be submitted to your agency in conjunction with the processing of a rezoning application.

4. The proposed development will comply with all applicable requirements for the dual water system facilities.

We hope that we have adequately responded to your comments. Your letter, together with this response, will be reproduced in the Final SEIS. We appreciate your interest and participation in the public review phase of the environmental review process.

Sincerely,

Earl K. Matsukawa

Earl K. Matsukawa
Project Manager

cc: Office of Environmental Quality Control
HASEKO (Ewa), Inc.

RECEIVED
JAN 16 1992
WILSON OKAMOTO & ASSOCIATES

PB 92-34

January 14, 1992

MEMO TO: BENJAMIN LEE, CHIEF PLANNING OFFICER
DEPARTMENT OF GENERAL PLANNING

FROM: HERBERT K. MURAOKA
DIRECTOR AND BUILDING SUPERINTENDENT

SUBJECT: EWA MARINA, PHASE I, INCREMENT 2
DRAFT SUPPLEMENTAL ENVIRONMENTAL IMPACT
STATEMENT (EIS)

We have reviewed the Draft Supplemental EIS for the subject project and have no comments to offer.

HERBERT K. MURAOKA
Director and Building Superintendent

JH:jo
cc: J. Harada
Office of Environmental Quality Control
Haseko (Ewa), Inc.
Wilson Okamoto & Assoc. (E. Matsukawa)

WILSON OKAMOTO & ASSOCIATES, INC.
ENGINEERS
ARCHITECTS
PLANNERS

3053-04
April 6, 1992

Mr. Herbert K. Muraoka, Director and Building Superintendent
City and County of Honolulu
Building Department
650 South King Street
Honolulu, Hawaii 96813

Subject: Ewa Marina Phase I
Draft Supplemental Environmental Impact Statement
Tax Map Key: 9-1-12: 2, 3, 5 (por.), 6 (por.), 7 (por.), 8 through 17, and 23 (por.)
9-1-11: 1 through 7
Ewa, Oahu, Hawaii

Dear Mr. Muraoka:

Thank you for your memo of January 9, 1992 indicating that you have no comments on the Draft Supplemental Environmental Impact Statement (SEIS). Your letter, together with this response, will be reproduced in the forthcoming Final SEIS. We appreciate your interest and participation in the public review phase of the environmental review process.

Sincerely,

Earl K. Matsukawa
Project Manager

cc: Office of Environmental Quality Control
HASEKO (Ewa), Inc.

DEPARTMENT OF LAND UTILIZATION
CITY AND COUNTY OF HONOLULU
650 SOUTH KING STREET
HONOLULU, HAWAII 96813 • (808) 523-4432

FRANK F. FASI
MAYOR

DONALD A. CLEGG
DIRECTOR

LORETTA K.C. CHEE
DEPUTY DIRECTOR

March 6, 1992

RECEIVED
MAR 09 1992
WILSON OKAMOTO & ASSOCIATES

(AC)

Mr. Earl Matsukawa
Wilson Okamoto & Associates, Inc.
P. O. Box 3530
Honolulu, Hawaii 96811

Dear Mr. Matsukawa:

Draft Supplemental Environmental Impact Statement (DEIS)
for Ewa Marina, Phase I

The Department of Land Utilization (DLU) has reviewed the DEIS and offer the following comments:

1. The final EIS should address the potential water quality impacts associated with the marina support/commercial component. The proposed uses such as the fuel dock and boat maintenance areas may create conditions which could adversely impact water quality within the marina basin and off-shore waters. The final EIS should discuss the management techniques to be utilized which will ensure adequate containment of hazardous materials and pollutants.

2. The DEIS states that management of the 6.2 acre Batis wetland will consist of preserving it "as is." The DEIS does not consider adequately, however, the possible adverse impacts of groundwater withdrawal resulting from excavation of the marina. The DEIS also implies that the Batis wetland may be in jeopardy, regardless of whether the marina is constructed, due to the reduction of infiltrating irrigation water from adjacent sugar cane fields.

   The DEIS should provide a more detailed analysis of the hydrological dynamics of the Batis wetland as well as definite conclusions regarding the Batis wetland's long term viability.

3. The DEIS states that longshore sediment transport from Barber's Point to Pearl Harbor plays an ancillary role in nourishing beaches along this coastline while the primary littoral transport in the area is onshore and offshore. This analysis appears to be based primarily on data obtained from aerial photographs and precious studies.

   The DLU's experience in reviewing and processing variance requests for shoreline structures suggests that longshore transport plays a very important role in beach nourishment at Ewa.

   The DEIS should provide an in-depth analysis which details the relationship between the offshore sand deposits and longshore transport at the proposed marina site.

   The DEIS should also provide a more detailed discussion regarding the proposed sand bypassing along the harbor entrance. Any equipment, pipes or pumping systems must be included as part of the Special Management Area Permit application.

Should you have any questions, please contact Art Challacombe of our staff at 523-4107.

Very truly yours,

Donald Clegg

DONALD A. CLEGG
Director of Land Utilization

DAC:fm

WILSON
OKAMOTO
& ASSOCIATES, INC.

ENGINEERS
ARCHITECTS
PLANNERS

3053-04
April 6, 1992

Mr. Donald A. Clegg
Director of Land Utilization
Department of Land Utilization
City and County of Honolulu
650 South King Street
Honolulu, Hawaii 96813

Subject: Ewa Marina Phase I
Draft Supplemental Environmental Impact Statement
Tax Map Key: 9-1-12: 2, 3, 5 (por.), 6 (por.), 7 (por.), 8 through 17, and 23 (por.)
9-1-11: 1 through 7
Ewa, Oahu, Hawaii

Dear Mr. Clegg:

Thank you for your letter of March 6, 1992 commenting on the subject Draft Supplemental Environmental Impact Statement (SEIS). We offer the following in response to your numbered comments, respectively:

1. All facilities with the potential for adversely affecting water quality in the marina or in offshore areas will be designed in accordance with applicable Federal, State, and City and County requirements. Features such containment systems, monitoring wells and oil separators will be incorporated as required to insure that the potential for accidental water pollution is minimized.

2. The Applicant has developed a program in coordination with the Commission on Water Resource Management for preservation of the caprock aquifer. This program involves the initial construction of a small segment of the marina entrance channel and internal waterways. An intensive monitoring program during this initial construction phase will provide data for the development of a comprehensive mitigation plan, including long-term groundwater monitoring and alternative mitigation plans, in cooperation with the Commission of Water Resource Management to comply with performance standards established by it.

   Hydrologic studies of the caprock aquifer prepared by the Applicant and coordinated with the Commission on Water Resource Management and the Department of Land and Natural Resources, indicate that regional ground water head levels and quality are significantly affected by irrigation practices outside the Applicant's control. Analysis of such irrigation practices were not within the scope of study, however, since they are not related to the Project.

3. As stated in the Draft SEIS, the study by Moffatt and Nichol (1990), which was commissioned by the Applicant, concluded that the shoreline has always been

rocky and sand movements in this area is principally on-and offshore, rather than along the coastline.

This is unlike the long sandy beach which stretches from Ewa Beach to Oneula Place where erosion problems have occurred when longshore sand movements were interfered with. The Applicant's ocean engineers have reviewed a 1983 study by Edward K. Noda on the erosion caused by the drainage canal built for Ewa Estates along this stretch of beach. Dr. Noda was hired by the parties who eventually persuaded the City and County to terminate the canal at the beach. The methodology used by Dr. Noda in his analysis is very similar to the methodology used by Moffat and Nichol. In fact, Dr. Noda was retained by the Applicant to conduct the beach profile survey and current measurements contained in the beach impact study for Ewa Marina.

Due to the apparently minor role of longshore sand transport in the vicinity of the marina entrance, installation of a permanent sand bypass system across the entrance is not anticipated to be necessary. Depending on the location and volume of sand that accumulates, it may be removed for transport to a selected placement area using a clamshell dredge or hydraulic pump system operating from shore, the jetties, or a barge.

We hope that we have adequately responded to your comments. Your letter, together with this response, will be reproduced in the Final SEIS. We appreciate your interest and participation in the public review phase of the environmental review process.

Sincerely,

Earl K. Matsukawa

Earl K. Matsukawa
Project Manager

cc: Office of Environmental Quality Control
HASEKO (Ewa), Inc.

DEPARTMENT OF PARKS AND RECREATION

CITY AND COUNTY OF HONOLULU

January 21, 1992

RECEIVED JAN 2 · 1992 WILSON OKAMOTO & ASSOCIATES

Mr. Earl Matsukawa, Project Manager
Wilson Okamoto and Associates, Inc.
P. O. Box 3530
Honolulu, Hawaii 96811

Dear Mr. Matsukawa:

Subject: Draft Supplemental Environmental Impact Statement (EIS) for Ewa Marina, Phase I, Increment 2
Tax Map Key 9-1-12: Por. 5 & 6

We have reviewed the Draft Supplemental EIS for Ewa Marina and make the following comments and recommendations.

There are several parks and recreational concerns that require resolution prior to a zone change or special management area use permit for Ewa Marina. These issues have been discussed but not resolved in meetings with Haseko (Hawaii), Inc.

While we have agreed with the "concept" of a 20-acre district park along Fort Weaver Road, Haseko (Hawaii), Inc. has not yet proposed an acceptable park configuration. The district park configuration must be suitable for active recreational use rather than pie-shaped.

The size, configuration and location of the park proposed at the northwest corner of Ewa Marina is also not acceptable for a public neighborhood park.

Statements in the Draft Supplemental EIS concerning this Department's shoreline access policy should be corrected to reflect standards set in the Development Plan Common Provision for urbanized areas. EIS proposals for public shoreline parking and improved lateral access west of Oneula Beach Park are acceptable in concept, but details need to be resolved. We also recommend that Ewa Marina provide improved public access to and along the shoreline east of Oneula Beach Park.

Please contact Jason Yuen of our Advance Planning Branch at 527-6315 to discuss our recreational concerns for the Ewa Marina project.

Sincerely,

WALTER M. OZAWA, Director

WMO:ei

cc: Haseko (Hawaii), Inc.
Department of General Planning
Department of Land Utilization
Office of Environmental Quality Control

WILSON OKAMOTO & ASSOCIATES, INC.
ENGINEERS ARCHITECTS PLANNERS

3053-04
April 6, 1992

Mr. Walter M. Ozawa
Director
Department of Parks and Recreation
City and County of Honolulu
650 South King Street
Honolulu, Hawaii 96813

Subject: Ewa Marina Phase I
Draft Supplemental Environmental Impact Statement
Tax Map Key: 9-1-12: 2, 3, 5 (por.), 6 (por.), 7 (por.), 8 through 17, and 23 (por.)
9-1-11: 1 through 7
Ewa, Oahu, Hawaii

Dear Mr. Ozawa:

Thank you for your letter of January 21, 1992 commenting on the subject Draft Supplemental Environmental Impact Statement. We offer the following in response to your numbered comments, respectively:

1. Since the 20-acre district park site lies within Phase II, it is not within the project area addressed by the subject EIS document. The site also lies outside of the Special Management Area (SMA). Nevertheless, the Applicant fully intends to pursue discussions with your office regarding its configuration for final resolution in the rezoning process.

2. The park designation in the northwest corner of the property has been proposed for elimination in the current Development Plan Land Use Map amendment request. The Applicant will fully comply with the City's park dedication requirements in providing for public neighborhood parks.

3. The statements regarding your Department's shoreline access policy shall be corrected to reflect the standards set in the Development Plan Common Provision for urbanized areas. Public access to and along the shoreline east side of Oneula Beach Park shall be provided in compliance with these standards. Further discussions to resolve details of public shoreline access along the Property's entire ocean shoreline shall be pursued with your Department for resolution in the rezoning and SMA permit processes.

We hope that we have adequately responded to your comments. Your letter, together with this response, will be reproduced in the Final SEIS. We appreciate your interest and participation in the public review phase of the environmental review process.

Sincerely,

Earl K. Matsukawa
Project Manager

cc: Office of Environmental Quality Control
HASEKO (Ewa) Inc.

DEPARTMENT OF PUBLIC WORKS

CITY AND COUNTY OF HONOLULU

650 SOUTH KING STREET
HONOLULU, HAWAII 96813

FRANK F. FASI
MAYOR

SAM CALLEJO
DIRECTOR AND CHIEF ENGINEER

C. MICHAEL STREET
DEPUTY DIRECTOR

ENV 92-08

January 9, 1992

RECEIVED
JAN 15 1992
WILSON OKAMOTO & ASSOCIATES

Mr. Earl K. Matsukawa
Project Manager
Wilson Okamoto and Associates, Inc.
1150 South King Street
Honolulu, Hawaii 96814

Dear Mr. Matsukawa:

Subject: Draft Supplemental Environmental Impact Statement (DSEIS) - Ewa Marina, Phase I, Increment 2
TMK:9-1-12:2, 3, 5 to 17; 9-1-11:1 to 7

We have reviewed the subject document and have no additional comments to offer at this time.

Very truly yours,

C. Michael Street

for SAM CALLEJO
Director and Chief Engineer

WILSON OKAMOTO & ASSOCIATES, INC.

ENGINEERS
ARCHITECTS
PLANNERS

3053-04
April 6, 1992

Mr. Sam Callejo, Director and Chief Engineer
City and County of Honolulu
Department of Public Works
650 South King Street
Honolulu, Hawaii 96813

Subject: Ewa Marina Phase I
Draft Supplemental Environmental Impact Statement
Tax Map Key: 9-1-12: 2, 3, 5 (por.), 6 (por.), 7 (por.), 8 through 17, and 23 (por.)
9-1-11: 1 through 7
Ewa, Oahu, Hawaii

Dear Mr. Callejo:

Thank you for your letter of January 9, 1992 indicating that you have no comments on the Draft Supplemental Environmental Impact Statement (SEIS). Your letter, together with this response, will be reproduced in the forthcoming Final SEIS. We appreciate your interest and participation in the public review phase of the environmental review process.

Sincerely,

Earl K. Matsukawa

Earl K. Matsukawa
Project Manager

cc: Office of Environmental Quality Control
HASEKO (Ewa), Inc.

DEPARTMENT OF TRANSPORTATION SERVICES
CITY AND COUNTY OF HONOLULU

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FEB 27

TE-0086
PL92.1.010

February 25, 1992

Mr. Earl K. Matsukawa
Wilson Okamoto & Associates
1150 South King Street, Suite 800
Honolulu, Hawaii 96814

Dear Mr. Matsukawa:

Subject: Ewa Marina - Phase I, Increment 2
Draft Environmental Impact Statement
TMK: 9-1-12: 2, 3, 5-17; 9-1-11: 1-7

This is in response to your letter dated January 6, 1992 requesting our comments on the Draft Environmental Impact Statement (EIS) for the subject development.

Based on our review of the document and on meetings held with representatives of the developer, we have no objections to the approval of the Draft EIS.

However, during the progress of this project, we will require the submittal of a roadway master plan for this development. The roadway master plan will assist our department in the review of subsequent submittals for this project. The master plan should indicate proposed roadway widths, alignments, access points, and cross-sections and include the anticipated completion date, land use, and size of each phase of the project. The plan should also include and assess improvements to roadways adjacent to this development, which will be impacted by this project.

Should you have any questions, please contact Mel Hirayama of my staff at 523-4119.

Sincerely,

JOSEPH M. MAGALDI, JR.
Director

WILSON OKAMOTO & ASSOCIATES, INC.
ENGINEERS ARCHITECTS PLANNERS

3053-04
April 6, 1992

Mr. Joseph M. Magaldi, Jr., Director
Department of Transportation Services
City and County of Honolulu
650 South King Street
Honolulu, HI 96813

Subject: Ewa Marina Phase I
Draft Supplemental Environmental Impact Statement
Tax Map Key: 9-1-12: 2, 3, 5 (por.), 6 (por.), 7 (por.), 8 through 17, and 23 (por.)
9-1-11: 1 through 7
Ewa, Oahu, Hawaii

Dear Mr. Magaldi:

Thank you for your letter of February 25, 1992 stating that you have no objections to the proposed project. A roadway master plan will be prepared for the project and submitted thereafter for your review in conjunction with the proposed rezoning request.

Your letter, together with this response, will be reproduced in the Final SEIS. We appreciate your interest and participation in the public review phase of the environmental review process.

Sincerely,

Earl K. Matsukawa
Project Manager

cc: Office of Environmental Quality Control
HASEKO (Ewa), Inc.

FIRE DEPARTMENT

CITY AND COUNTY OF HONOLULU

1455 SOUTH BERETANIA STREET, ROOM 305
HONOLULU, HAWAII 96814

FRANK F. FASI
MAYOR

LIONEL E. CAMARA
FIRE CHIEF

DONALD S M. CHANG
DEPUTY FIRE CHIEF

January 9, 1992

RECEIVED
JAN 15 1992
WILSON OKAMOTO & ASSOCIATES

Mr. Earl K. Matsukawa, Project Manager
Wilson Okamoto and Associates
1150 South King Street, Suite 800
Honolulu, Hawaii 96814

Dear Mr. Matsukawa:

We have reviewed the subject material provided and have no additional comments.

Should you have any questions, please call Acting Assistant Chief Attilio Leonardi of our Administrative Services Bureau at 943-3838.

Very truly yours,

LIONEL E. CAMARA
Fire Chief

AKL:ny

Enclosure: EIS Draft

WILSON OKAMOTO & ASSOCIATES, INC.

ENGINEERS
ARCHITECTS
PLANNERS

3053-04
April 6, 1992

Mr. Lionel E. Camara, Fire Chief
City and County of Honolulu
Fire Department
1455 South Beretania Street, Room 305
Honolulu, Hawaii 96814

Attention: Attilio Leonardi, Assistant Chief

Subject: Ewa Marina Phase I
Draft Supplemental Environmental Impact Statement
Tax Map Key: 9-1-12: 2, 3, 5 (por.), 6 (por.), 7 (por.), 8 through 17, and 23 (por.)
9-1-11: 1 through 7
Ewa, Oahu, Hawaii

Dear Chief Camara:

Thank you for your letter of January 9, 1992 indicating that you have no comments on the Draft Supplemental Environmental Impact Statement (SEIS). Your letter, together with this response, will be reproduced in the forthcoming Final SEIS. We appreciate your interest and participation in the public review phase of the environmental review process.

Sincerely,

Earl K. Matsukawa
Project Manager

cc: Office of Environmental Quality Control
HASEKO (Ewa), Inc.

POLICE DEPARTMENT

CITY AND COUNTY OF HONOLULU

MICHAEL S. NAKAMURA
CHIEF

HAROLD M. KAWASAKI
DEPUTY CHIEF

KH-LK

February 21, 1992

RECEIVED

Mr. Earl K. Matsukawa, Project Manager
Wilson Okamoto and Associates
1150 South King Street, Suite 800
Honolulu, Hawaii 96814

Dear Mr. Matsukawa:

Subject: Draft Supplemental Environmental Impact Statement (EIS) for Ewa Marina, Phase I, Increment 2

We have reviewed the subject materials and would like to accentuate our needs to adequately service this and other "Second City" projects as stated on page VII-8 of the Draft Supplemental EIS and our previous (December 18, 1991) response.

Sincerely,

MICHAEL S. NAKAMURA
Chief of Police

By [signature]
CHESTER E. HUGHES
Assistant Chief of Police
Support Services Bureau

WILSON OKAMOTO & ASSOCIATES, INC.
ENGINEERS
ARCHITECTS
PLANNERS

3053-04
April 6, 1992

Mr. Michael S. Nakamura, Chief of Police
City and County of Honolulu
Police Department
1455 South Beretania Street
Honolulu, Hawaii 96814

Attention: Chester Hughes, Assistant Chief

Subject: Ewa Marina Phase I
Draft Supplemental Environmental Impact Statement
Tax Map Key: 9-1-12: 2, 3, 5 (por.), 6 (por.), 7 (por.), 8 through 17, and 23 (por.)
9-1-11: 1 through 7
Ewa, Oahu, Hawaii

Dear Chief Nakamura:

Thank you for your letter of February 21, 1992. We concur that adequate municipal resources must be allocated for your department to meet the increased demand for service resulting from the on-going urbanization of the Ewa region. The Final SEIS discusses the increased demand for police services as a social impact

We hope that we have adequately responded to your comments. Your letter, together with this response, will be reproduced in the Final SEIS. We appreciate your interest and participation in the public review phase of the environmental review process.

Sincerely,

[signature]

Earl K. Matsukawa
Project Manager

cc: Office of Environmental Quality Control
HASEKO (Ewa), Inc.

University of Hawaii at Manoa

Environmental Center
A Unit of Water Resources Research Center
Crawford 317 • 2550 Campus Road • Honolulu, Hawai
Telephone: (808) 956-7361

March 9, 1992
RE:0599

Department of General Planning
City and County of Honolulu
Attention: Brian Suzuki
650 South King Street, 8th Floor
Honolulu, Hawaii 96813

Dear Mr. Suzuki:

Draft Environmental Impact Statement (DEIS)
Ewa Marina Phase 1, Increment 2
Ewa, Oahu

The Ewa Marina Phase 1, Increment 2 project proposes to reconfigure development of a 535 acre, 3,560 unit residential community located on oceanfront land. The applicant proposes to reconfigure land uses depicted on the Ewa Development Plan (DP) Land Use Map and to attempt to clarify language contained in the Ewa DP Special Provisions. Principal components of the proposed project include the marina, a marina/commercial component, a residential component and a circulation system for vehicles and pedestrians.

The Environmental Center has reviewed the referenced document and comments have been provided with the assistance of Frank Peterson, Geophysics; Yu-Si Fok and Henry Gee, Water Resources Research Center; Karl Kim, Urban and Regional Planning; Jon Matsuoka, School of Social Work; Doak Cox (Emeritus) and Alex Buttaro, Environmental Center.

Hazards (Section III.F, page 32)

The Federal Emergency Management Agency's flood elevations (text and Figure 15) should be identified as estimated 100-year elevations. The statement that "there is no indication of tsunami hazard associated with fast moving water in the form of large waves and backwash" is somewhat misleading. Although "the tsunami phenomena in this area would be that of rapidly rising and declining sea levels," these changing sea levels could result in considerable landward and seaward currents in the case of a tsunami, causing extensive inundation.

Rising Sea Level (Section III.F, page 35 and Section VII.G page 23)

The actual rate of eustatic sea-level rise is highly uncertain because of the difficulty of separating this rise from its effects on the depression of crust beneath the ocean (See K.O. Emery and D.G. Aubrey, Sea Levels, Land Levels, and Tide Gages, Springer-Verlag, 1991). Hence the absolute rate of sinking or rising of Oahu is very difficult to determine. The average rate of rise of sea level relative to the land is of practical importance in the context of this DEIS. At Honolulu this rate has been 1.5 mm/yr or 0.005 ft/yr for the years 1905 thru 1986 (Sea Level Variations for the United States 1855-1986, NOAA 1988).

We recommend that it would be helpful to provide English equivalents to metric measures in order to maintain consistency with the rest of the DEIS and so this document may be of greater use to the average reader.

Hydrology (Section VI.D.2, page 8)

The effectiveness of the supposed near-shore "hydrologic barrier" on the caprock aquifer may not be as great as postulated and it is possible that it may not exist. If it does exist there are reasons to suppose it cannot be reestablished after construction of the marina by a natural resealing process, and the effective substitution of a grout curtain or sheet piling is likely to be a very difficult and potentially problematic task. Because there will be extensive breaching of the low permeability caprock barrier and caprock aquifer quality will be degraded, this action poses the most significant potential adverse impact on groundwater. We note the EIS discusses this problem in considerable detail and proposes construction of a test trench to study the possible impacts. However, our reviewers expressed serious concern that any resealing mechanisms may entail a long-term process and for this reason we strongly recommend that the EIS include a schedule for testing and subsequent phasing of actual construction to ensure that marina construction does not begin before conclusive test results become available. We recommend that any pertinent permits granted should be conditioned upon the applicant's proposed mitigation strategies.

Water Quality

The EIS states that "The limited availability of phosphorous will be the controlling factor for algal growth (See Appendix A)" (section VI.E.2, page 13). Our reviewers were unable to locate information in Appendix A that supports the idea that phosphorus is the limiting nutrient in preventing algal blooms. Where exactly in Appendix A is this information? What are the limiting concentrations of phosphorus in sea water?

We note that because Appendix A consists of approximately 100 pages, it would be quite helpful to include page numbers when material from this section is cited.

Our reviewers suggest that the circulation of water in the marina should be better studied to ensure against water stagnation and the accompanying biological decompostion and foul odors.

Irreversable and Irretrievable Commitment to Resources and Unavoidable Adverse Project Impacts (Section VIII.B, page 1 and Section VIII.D, page 2)

We note that the unavoidable adverse impacts section did not address the loss of approximately 140 acres of prime waterfront land area which will be displaced by the construction of the marina. What is the basis for this omission, and what will be the adverse socio-economic and socio-cultural implications for the residents of the immediate area, the region, and the island as a whole? We note that the creation of substantial water areas out of flat, well-drained useable land on an island already short of land should warrant some discussion of the adverse social impacts. For instance, how many more housing units could be built on the water area to be dredged and what would be the social, economic, and environmental implications stemming from such possibility?

Traffic

Appendix H (page 22) states "Table 5 shows the number of trips generated by future developments in the area." To what "area" does this statement refer? We note that this table is site-specific and does not appear to reflect the influence of surrounding areas and their future development.

The statement is made that "Trips to and from the proposed project are based on the distribution of population and employment on Oahu" (Appendix H, page 28). What "distribution" is this statement refering to, and how are future distribution expectations taken into account?

What cumulative local and regional traffic impacts are expected to occur in areas adjacent and affected by the proposed project?

Socio-economics

Our reviewers note that the section describing the effects of changing land use patterns (section VII.B[1-3]) presents a limited discussion based on employment to be created and therefore does not seriously address both sides of the development picture. Why did this section neglect discussion of any potential adverse impacts?

The author contends that the increased need of public services and facilities will shed light on the issue therefore justifying higher levels of public services and facilities. This logic is based on very little evidence. We note that if public services have been keeping pace with development as this EIS suggests, then there would not be a shortage of public services, infrastructure, human services, etc., as is presently experienced throughout many of the islands'areas undergoing rapid growth.

Assumptions about future land use and water requirements should be discussed in greater detail.

The EIS states "As Ewa Marina is being built, the existing community will already be undergoing a gradual adaptation to this major influx of people" (section VII.D.1, page 3). What is meant by this statement? It appears to equate construction-related impacts to those impacts related to the project's completion. Each should be discussed separately.

The "Population and Cultural Diversification" section (section VII.D.1, page 3) mentions new people comming into the Ewa community. What are the expected demographics of these new people and how will they impact existing communities? Our reviewers note that introducing economically or culturally stratifying foreign elements into a local community often results in culture conflict, and social polarization. Diversity in the context of this project may not necessarily entail a positive impact. Does this development pose a potential for community divisiveness?

The section discussing the "Disruption of the slow-paced lifestyle" (section VII.D.1, page 4) should refer to the 1989 poll that found a majority of Ewa residents favored development. Who conducted the poll and what was the methodology?

The description of the introduction of visitor industry to the Ewa region (section VII.D.1, page 4) should discuss how adaptation to the new economy occurs. Will it be an easy transition? What are some of the anticipated problems?

Section VII.E.2 (page 8) discusses the golf course. On what basis will the decision to incorporate kamaaina rates and group discounts be made? Is there a target percentage for community utilization? If not, how can reasonable availability to the surrounding community be assured?

Our reviewers note that in general this Draft Supplemental EIS discusses many aspects of this project in sufficient detail. However, the socio-economic descriptions appear to place great emphasis on promoting the benefits of the proposed development, while similtaneously de-emphasizing the potential direct and indirect negative socio-cultural impacts.

Thank you for the opportunity to review this document and we hope our comments are helpful.

Sincerely,

John T. Harrison, Ph.D.
Environmental Coordinator

cc: Haseko (Ewa), Inc.
Wilson Okamoto and Associates, Inc.
Roger Fujioka
Doak Cox
Karl Kim
Jon Matsuoka
Frank Peterson
Yu-Si Fok

WILSON OKAMOTO & ASSOCIATES, INC.
ENGINEERS
ARCHITECTS
PLANNERS

3053-04
April 6, 1992

Dr. John T. Harrison
Environmental Coordinator
Environmental Center
University of Hawaii at Manoa
Crawford 317
2550 Campus Road
Honolulu, Hawaii 96822

Subject: Ewa Marina Phase I
Draft Supplemental Environmental Impact Statement
Tax Map Key: 9-1-12: 2, 3, 5 (por.), 6 (por.), 7 (por.), 8 through 17, and 23 (por.)
9-1-11: 1 through 7
Ewa, Oahu, Hawaii

Dear Dr. Harrison:

Thank you for your letter of March 9, 1992 commenting on the subject Draft Supplemental Environmental Impact Statement (SEIS). We offer the following in response to your comments, respectively:

a. Hazards

The intent of the statement you refer to is to differentiate between the A or AE 100 year flood designation and the V or VE designation which indicates "Coastal flood with velocity hazard (wave action)" according to the Flood Insurance Rate Map. There is no V or VE designation on the Property. To eliminate any confusion, however, we have omitted the statement from the Final SEIS.

b. Rising Sea Level

Your information on the nature of rising sea levels on Oahu is appreciated. We will incorporate the rate of sea level rise on Oahu that you provided in the Final SEIS to supplement our discussion.

We have also provided the English equivalents to the metric measures in this discussion.

c. Hydrology

The general nature of the groundwater system is well understood and has been successfully modeled. The Applicant is committed to the utilization of the caprock aquifer as a non-potable water source and has developed a program in coordination with the Commission on Water Resource Management for preservation of this resource. This program involves the initial construction of

a small segment of the marina entrance channel and internal waterways. An intensive monitoring program during this initial construction phase will provide data for the development of a comprehensive mitigation plan, including long-term groundwater monitoring and alternative mitigation plans, in cooperation with the Commission of Water Resource Management to comply with performance standards established by it.

d. Water Quality

The appendix reference in the Draft SEIS which you refer to was incorrect. The reference should have been to Appendix C, "Ewa Marina Water Quality Studies," which addresses plankton growth in its Appendix D.

e. Irreversible and Irretrievable Commitment

The irreversible commitment of land to the proposed marina use is clearly stated in the Draft SEIS. The preclusion of continued agricultural use of the land is also discussed. Alternative land uses within the marina area, particularly residential uses, are constrained by aircraft noise impacts in the marina's western basin which comprises more than one-half of the proposed the marina area. In addition, the waterways comprising the eastern portion of the marina are integral to accommodating regional storm drainage needs. These factors were taken into account by the City and County of Honolulu Ewa Development Plan Land Use Map and Special Provisions which reflect a long standing commitment to a marina.

f. Traffic

Table 5 provides the estimate of the trip generation for the project. Thus, the last sentence on page 22 should be revised to "Table 5 shows the number of trips generated by the project land uses." The traffic volumes expected to be generated by other future projects in the area are identified in Table 3.

The "distribution of population and employment on Oahu" refer to the M-K projections developed by DBEDT and allocated by the City DGP for Oahu. Future expectations of population and employment distributions are inherent in the DGP allocation estimates because the City policies, such as a secondary urban center in Ewa, are included in the development of the estimates.

The traffic impact study (Appendix M) identifies the local traffic impacts of the project and does consider the traffic volumes from other future projects in the nearby area. The Ewa Region Highway Master Plan being prepared for the

Developers Working Group (of which the Applicant is a member) addresses the cumulative traffic impacts of the various Ewa developments on the regional roadway system.

g. Socio-Economics

Potential Adverse Impacts of Employment.

Potential adverse impacts are discussed throughout Chapter VII. For example, adverse impacts from the development of the entire region is discussed in Section VII.D. Although the Ewa Marina mixed use commercial complex is not within the Project Area, its impacts, both positive and negative, are discussed in Section VII.E.1. A more complete discussion of the socio-economic impacts of the Project are found in Appendix N.

Increased Need for Public Services and Facilities.

As discussed in Section 4.3 (4) of Appendix N, public facilities and services have been planned on a smaller scale for eastern Ewa because of the residential nature of the Urban Fringe area. The Earthplan report suggested that the higher level of urban activity proposed by Ewa Marina will help the community justify more public services and facilities more in keeping with an urban environment.

Gradual Adaptation to Major Influx of People.

The statement is made to convey the fact that Ewa Marina is neither the first nor the only development project in the area. As the discussion in that section indicates, socio-economic impacts on the Ewa region are cumulative of the several new developments in the area.

Population and Cultural Diversification

Section 4.4.2 of Appendix N and page VII-5 of the DEIS discuss the changes in demographics anticipated because of the Project.

The entire region is evolving in terms of residential makeup. It is anticipated that most of the increase in resident population of the area will be a result of other local (Hawaii) residents moving into Ewa. Adjustments will need to be made by existing residents, and understandably, some of the adjustments will be difficult. A fuller discussion of these impacts is found in Appendix N.

1989 Poll

Section 5.2.2 of Appendix N describes the 1989 poll and methodology.

Introduction of the Visitor Industry Complex.

The Mixed Use Commercial complex, which will include the visitor complex, is not within the Project Area. However, some of the impacts are discussed on pages VII-6 through VII-8, as well as pages 40 through 44 of Appendix N.

Golf Course

The golf course is not within the Project Area. Also, at this stage of the Project's development, it is premature to discuss with specificity the items you raised.

We hope that we have adequately responded to your comments. Your letter, together with this response, will be reproduced in the forthcoming Final SEIS. We appreciate your interest and participation in the public review phase of the environmental review process.

Sincerely,

Earl K. Matsukawa
Project Manager

cc: Office of Environmental Quality Control
HASEKO (Ewa), Inc.

Hawaiian Electric Company, Inc. • PO Box 2750 • Honolulu, HI 96840

William A. Bonnet
Manager
Environmental Department

RECEIVED
JAN 30 1992
WILSON OKAMOTO & ASSOCIATES

January 27, 1992

Mr. Benjamin B. Lee
Chief Planning Officer
City and County of Honolulu
Department of General Planning
650 South King Street
Honolulu, Hawaii 96813

Dear ~~Mr.~~ Ben Lee:

Subject: Ewa Marina Phase I, Increment 2
Draft Supplemental Environmental Impact Statement (DSEIS)
Tax Map Key 9-1-11:1 through 7
Ewa, Oahu, Hawaii

We have reviewed the subject DSEIS, and have no comments at this time on the proposed project. HECO shall reserve further comments pertaining to the protection of existing powerlines bordering and servicing the area until construction plans are finalized.

Sincerely,

Bill Bonnet

cc: Mr. Nelson W. G. Lee, Haseko (Ewa), Inc.
Mr. Earl K. Matsukawa, Wilson Okamoto and Associates, Inc.

An HEI Company

WILSON OKAMOTO & ASSOCIATES, INC.
ENGINEERS
ARCHITECTS
PLANNERS

3053-04
April 6, 1992

Mr. William A. Bonnet, Manager
Environmental Department
Hawaiian Electric Company, Inc.
P.O. Box 2750
Honolulu, Hawaii 96840

Subject: Ewa Marina Phase I
Draft Supplemental Environmental Impact Statement
Tax Map Key: 9-1-12: 2, 3, 5 (por.), 6 (por.), 7 (por.), 8 through 17, and 23 (por.)
9-1-11: 1 through 7
Ewa, Oahu, Hawaii

Dear Mr. Bonnet:

Thank you for your letter of January 27, 1992 indicating that you have no comments on the Draft Supplemental Environmental Impact Statement (SEIS). Your letter, together with this response, will be reproduced in the forthcoming Final SEIS. We appreciate your interest and participation in the public review phase of the environmental review process.

Sincerely,

Earl K. Matsukawa

Earl K. Matsukawa
Project Manager

cc: Office of Environmental Quality Control
HASEKO (Ewa), Inc.

Hawaiian Electric Company, Inc. • PO Box 2750 • Honolulu, HI 96840-0001

William A. Bonnet
Manager
Environmental Department

February 10, 1992

Wilson Okamoto and Associates
1150 South King Street, Suite 800
Honolulu, Hawaii 96814
Attention: Mr. Earl Matsukawa

Dear Mr. Matsukawa:

Subject: Ewa Marina Phase I, Increment 2
Draft Supplemental Environmental Impact Statement (DSEIS)
Tax Map Key 9-1-11:1 through 7
Ewa, Oahu, Hawaii

We have reviewed the subject DSEIS, and have the following comment. The "Electricity" section on page VI-29 should read:

"Hawaiian Electric Company (HECO) will provide electrical power to the Property. HECO will be constructing a new substation to meet the demands which Ewa Marina and other developments in the area will generate and to supplement the service already being provided by the existing Ewa Beach and proposed Fort Weaver Substations which are located mauka of the Property. New 46 kV lines will be built to serve the new Ewa Marina Substation."

HECO will reserve further comments pertaining to the protection of existing powerlines bordering and servicing the area until construction plans are finalized.

Sincerely,

[signature]

An HEI Company

3053-04
April 6, 1992

WILSON OKAMOTO & ASSOCIATES, INC.
ENGINEERS
ARCHITECTS
PLANNERS
1150 SOUTH KING STREET
HONOLULU, HAWAII 96814
PHONE: (808) 531-5261
Mailing address:
P.O. Box 3530
Honolulu, Hawaii 96811

Mr. William A. Bonnet, Manager
Environmental Department
Hawaiian Electric Company, Inc.
P.O. Box 2750
Honolulu, Hawaii 96840

Subject: Ewa Marina Phase I
Draft Supplemental Environmental Impact Statement
Tax Map Key: 9-1-12: 2, 3, 5 (por.), 6 (por.), 7 (por.), 8 through 17, and 23 (por.)
9-1-11: 1 through 7
Ewa, Oahu, Hawaii

Dear Mr. Bonnet:

Thank you for your letter of February 10, 1992 commenting on the subject Draft Supplemental Environmental Impact Statement (SEIS). We have incorporated the information you provided regarding electrical services in the Final SEIS. Your letter, together with this response, will be reproduced in the Final SEIS. We appreciate your interest and participation in the public review phase of the environmental review process.

Sincerely,

[signature]

Earl K. Matsukawa
Project Manager

cc: Office of Environmental Quality Control
HASEKO (Ewa), Inc.

GTE HAWAIIAN TEL
Beyond The Call

P.O. Box 2200
Honolulu, Hawaii 96841
Telephone(808)546-2095

Larry L. Hartshorn
Manager - Exchange Planning

RECEIVED
JAN 17 1992
WILSON OKAMOTO & ASSOCIATES

JANUARY 15, 1992

Mr. Earl K. Matsukawa
Wilson Okamoto & Associates, Inc.
P. O. Box 3530
Honolulu, Hawaii 96811

Dear Earl:

DRAFT SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT (EIS)
FOR EWA MARINA, PHASE I, INCREMENT 2

We have reviewed the draft environmental impact statement for the Ewa Marina, Phase I, Increment 2 development project and have no comments to make at this time. However, please keep us informed of your design progress, service requirements and the occupancy dates. We will be looking forward to working with you on this Ewa Marina development project.

Should you have any questions, please call Stanley Suzuki at 546-3787.

Sincerely,

Larry Hartshorn

LH:SS

c: P. Jordan - Haseko (Hawaii), Inc.

WILSON OKAMOTO & ASSOCIATES, INC.
ENGINEERS
ARCHITECTS
PLANNERS

3053-04
April 6, 1992

Mr. Larry L. Hartshorn, Manager
Exchange Planning
GTE Hawaiian Tel
P.O. Box 2200
Honolulu, Hawaii 96841

Subject: Ewa Marina Phase I
Draft Supplemental Environmental Impact Statement
Tax Map Key: 9-1-12: 2, 3, 5 (por.), 6 (por.), 7 (por.), 8 through 17, and 23 (por.)
9-1-11: 1 through 7
Ewa, Oahu, Hawaii

Dear Mr. Hartshorn:

Thank you for your letter of January 15, 1992 indicating that you have no comments on the Draft Supplemental Environmental Impact Statement (SEIS). Your letter, together with this response, will be reproduced in the forthcoming Final SEIS. We appreciate your interest and participation in the public review phase of the environmental review process.

Sincerely,

Earl K. Matsukawa
Project Manager

cc: Office of Environmental Quality Control
HASEKO (Ewa), Inc.

EBCA

EWA BEACH COMMUNITY ASSOCIATION

P.O. BOX 2003 - 0003, EWA BEACH, HAWAII 96706

February 12, 1992

RECEIVED
FEB 18 1992
WILSON OKAMOTO & ASSOCIATES

Wilson Okamoto and Associates
1150 South King Street
Honolulu, Hawaii 96814
Attention: Earl Matsukawa

Dear Sir

Members of the Ewa Beach Community Association's Board of Directors reaffirm their support of the Ewa Marina project, however, there are several items in the EIS that need to be emphasized: temporary roads should be used to avoid traveling within Ewa Beach; dust control methods will require dust control fencing for the entire length of Papipi Road and perhaps along the shopping center and along Ft. Weaver Road; stock piling of soil and coral caused problems at the Barbers Point Deep Draft Harbor and the Hawaii Prince Golf Course; and blasting was also a problem at the Deep Draft Harbor and extreme care should be taken to inform the residents when blasting will take place and to monitor the effect on the residents

Very truly yours,

Glenn Oamilda
President
Ewa Beach Community Asssociation

WILSON OKAMOTO & ASSOCIATES, INC.

ENGINEERS
ARCHITECTS
PLANNERS

3053-04
April 6, 1992

Mr. Glenn Oamilda, President
Ewa Beach Community Association
P. O. Box 2003-0003
Ewa Beach, HI 96706

Subject: Ewa Marina Phase I
Draft Supplemental Environmental Impact Statement
Tax Map Key: 9-1-12: 2, 3, 5 (por.), 6 (por.), 7 (por.), 8 through 17, and 23 (por.)
9-1-11: 1 through 7
Ewa, Oahu, Hawaii

Dear Mr. Oamilda:

Thank you for your letter of February 12, 1992 reaffirming support for the proposed project by your association's Board of Directors. We acknowledge your concern regarding potential impacts from construction-related traffic, dust, and blasting. We also acknowledge the value of your input regarding impacts which you or members of your organization have experienced during other comparable construction activities in the vicinity. In this regard, we note that as demonstrated at the nearby West Beach development, construction can be conducted to meet stringent standards for minimizing adverse impact. The Applicant (Haseko (Ewa), Inc.) will continue to consult with your organization as the project proceeds through construction to assure that your concerns are addressed. Specific mitigation measures and their timing will need to be determined in the conjunction with a construction schedule to assure that all Federal, State and County requirements will be complied with.

Your letter, together with this response, will be reproduced in the Final SEIS. We appreciate your interest and participation in the public review phase of the environmental review process.

Sincerely,

Earl K. Matsukawa
Project Manager

cc: Office of Environmental Quality Control
HASEKO (Ewa), Inc.

P. O. BOX O
WAIPAHU, HI 96797

March 3, 1992

RECEIVED
MAR 04 1992
WILSON OKAMOTO & ASSOCIATES

Mr. Benjamin B. Lee
Chief Planning Officer
City and County of Honolulu
Department of General Planning
650 South King Street
Honolulu, Hawaii 96813

Subject: DRAFT SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT (DSEIS) FOR EWA MARINA, PHASE I, INCREMENT 2

Dear Mr. Lee:

I have reviewed the subject DSEIS prepared for Haseko (Ewa) Inc.'s application for Development Plan Land Use Map and Special Provisions amendments, by Wilson Okamoto and Associates dated January 1992. My comments follow and are those of a private citizen and do not reflect those of Oahu Sugar Company, Limited, of which I serve as Vice President and Manager:

1. I am extremely concerned about the project's proposed excavation of the marina and the anticipated degradation of the water quality and storage of the caprock aquifer. OSCo and others have utilized water from this aquifer for irrigation and non-potable uses.

2. The DSEIS indicates that there is a hydrologic barrier that exists along the shoreline edge of the caprock aquifer that functions to maintain water storage and quality in the aquifer. Breaching the barrier as proposed by the marina will cause loss of storage volume and degradation of water quality in the caprock aquifer.

3. The applicant theorizes that the hydrologic barrier is a naturally occurring phenomenon associated with dissolution and re-precipitation of reef material; and theorizes that subsequent to the excavation of the marina, a new barrier surrounding the marina will occur to re-seal the aquifer and restore the aquifer to its

"original" condition. If the dissolution and re-precipitation of reef material is the source of the hydrologic barrier, the DSEIS contends that the re-sealing will occur in a relatively short time frame.

4. Based on OSCo's experience with the caprock rock aquifer, I do not believe that the re-sealing process will occur quickly enough to prevent significant short term (5 to 10 years) degradation of the aquifer. I do not feel that it or the community in general can suffer the short term degradation of the aquifer.

5. It is my belief that should the marina be allowed to be excavated, mitigative measures to retain the hydrologic barrier (such as the proposed sheet piling or grouting) should be required from the onset of the project.

6. I would like to acknowledge and recognize Haseko (Ewa) Inc. and its hydrologic consultant for their forthright and responsible attitude and approach to dealing with my concerns regarding the project's effect on the caprock aquifer.

7. The applicant has proposed to make a 30' wide x 200' long test cut to further investigate the nature of the shoreline hydrologic barrier, the resealing phenomenon and the physical means to mitigate the effect of the marina excavation. On the condition that adequate design, control and an emergency plan to re-seal the breach in the aquifer are provided for, I concur that this test cut is the appropriate next step in the investigation of the marina's effect on the caprock aquifer. I would also suggest that a 10' wide cut would give the same results as a 30' cut.

8. I would suggest that the EP27 well site be included as a head and water quality monitoring location, should the test cut procedure be done.

9. The DSEIS identifies "mitigative measures to protect the caprock aquifer which may be affected by the excavation of the marina" as the primary unresolved issue; I concur. I urge further extensive investigation into this subject before action to approve the requested DP maps and special provisions amendments is taken.

I thank you for considering my comments. Should you have any questions or desire further information, please call me at 677-3577.

Very truly yours,

W. D. Balfour, Jr.

W. D. Balfour, Jr.

WDB:yk

cc: Office of Environmental Quality Control
Nelson W.G. Lee, Haseko (Ewa), Inc.
Earl K. Matsukawa, Wilson Okamoto and Associates, Inc.
DLNR, Water Commission

WILSON
OKAMOTO
& ASSOCIATES, INC.

ENGINEERS
ARCHITECTS
PLANNERS

3053-04
April 6, 1992

Mr. W.D. Balfour
P.O. Box O
Waipahu, Hawaii 96797

Subject: Ewa Marina Phase I
Draft Supplemental Environmental Impact Statement
Tax Map Key: 9-1-12: 2, 3, 5 (por.), 6 (por.), 7 (por.), 8 through 17, and 23 (por.)
9-1-11: 1 through 7
Ewa, Oahu, Hawaii

Dear Mr. Balfour:

Thank you for your letter of March 3, 1992 commenting on the subject Draft Supplemental Environmental Impact Statement (SEIS). We acknowledge your concerns and your familiarity with the caprock aquifer. We have also duly noted the suggestions you have offered.

The general nature of the groundwater system is well understood and has been successfully modeled. The Applicant is committed to the utilization of the caprock aquifer as a non-potable water source and has developed a program in coordination with the Commission on Water Resource Management for preservation of this resource. This program involves the initial construction of a small segment of the marina entrance channel and internal waterways. An intensive monitoring program during this initial construction phase will provide data for the development of a comprehensive mitigation plan, including long-term groundwater monitoring and alternative mitigation plans, in cooperation with the Commission of Water Resource Management to comply with performance standards established by it.

We hope that we have adequately responded to your comments. Your letter, together with this response, will be reproduced in the Final SEIS. We appreciate your interest and participation in the public review phase of the environmental review process.

Sincerely,

Earl K. Matsukawa
Project Manager

cc: Office of Environmental Quality Control
HASEKO (Ewa), Inc.

02/92 - 3-7-1

JEFF ALEXANDER
Construction Consultant
All Phases of Construction

91-092 Parish Drive
Ewa Beach, Hawaii 96706
Telephone (808) 689-3164

OEQC
220 S. King st.
Honolulu, Hawaii

Re: Ewa Marina Phase 1 Project

I am Chairman of The Save Ewa Beach Ohana, we are a registered non-profit organization opposed to the Ewa Marina Project. We formed 2 years ago and collected over 2,600 signatures in the Ewa Beach community against the Marina project.

We feel with all the environmental concerns over the project, ocean, caprock aquifer, pollution, etc. this project should not be allowed. The Environmental Protection Agency is against the project. The developer states they will answer all this, well they are the ones paying for the studies.

Sincerely,

Jeff Alexander, Chairman
The Save Ewa Beach Ohana

cc: C&C of Honolulu
Dept. of General Planning

RECEIVED

WILSON OKAMOTO & ASSOCIATES, INC.
ENGINEERS ARCHITECTS PLANNERS

3053-04
April 6, 1992

Mr. Jeff Alexander
91-092 Parish Drive
Ewa Beach, Hawaii 96706

Subject: Ewa Marina Phase 1
Draft Supplemental Environmental Impact Statement
Tax Map Key: 9-1-12: 2, 3, 5 (por.), 6 (por.), 7 (por.), 8 through 17, and 23 (por.)
9-1-11: 1 through 7
Ewa, Oahu, Hawaii

Dear Mr. Alexander:

Thank you for your undated letter commenting on the subject Draft Supplemental Environmental Impact Statement (SEIS). Since your comments do not address the contents of the Draft SEIS, we have no responses to offer. Your letter will be reproduced in the Final SEIS. We appreciate your interest and participation in the public review phase of the environmental review process.

Sincerely,

Earl K. Matsukawa
Project Manager

cc: Office of Environmental Quality Control
HASEKO (Ewa), Inc.

PREPARERS OF THE EIS

APPLICANT

HASEKO (Ewa), Inc.	Nelson Lee, Development Director Miles Nishijima Paul Jordan

EIS CONSULTANTS

Wilson Okamoto and Associates, Inc.	Earl Matsukawa, Project Manager Laura Fujioka Edwin Kagawa

Belt Collins and Associates, Inc.

Tyrone T. Kusao, Inc.

Kimura International, Inc.

Gray Hong Bills and Associates, Inc.

TECHNICAL STUDIES

AECOS, Inc.
Behavioral Research Consultants
Earthplan
J.W. Morrow
Mackie Martin and Associates Pty Ltd.
Marine Research Consultants
Moffatt and Nichol, Engineers
Pacific Planning and Engineering, Inc.
Paul H. Rosendahl, Ph.D, Inc
Tom Nance Resources Engineering
Visualizations

References

REFERENCES

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Appendices

Appendix A

Ewa Marina
Practicable Alternative Analysis of
Marina Entrance Design

EWA MARINA
PRACTICABLE ALTERNATIVES ANALYSIS OF MARINA ENTRANCE DESIGN

Prepared for

HASEKO (Hawaii), Inc.
820 Mililani Street, Suite 820
Honolulu, Hawaii 96813

Prepared by

MOFFATT & NICHOL, ENGINEERS
250 W. Wardlow Road
Long Beach, California 90807

File 2612-08

March 1991

CONTENTS

1.0 INTRODUCTION

1.1 Background

The channel alignment and jetty configuration used as the basis for HASEKO (Hawaii), Inc.'s application for a Department of the Army permit was developed by MSM Associates. The plan resulted from the environmental study and review process that accompanied preparation of a State Chapter 343, Hawaii Revised Statutes) Environmental Impact Statement (EIS) for the proposed project.

There were two principal driving forces behind the proposed design. The first was the need to provide safe operations for small-craft entering and leaving the harbor. The second was the desire to avoid adverse impacts on surf sites. Based on the information available at that time, the EIS concluded that the design used as the basis of the current Department of the Army permit application would best achieve those goals.

A more recent study conducted in conjunction with the present permit application (Moffatt & Nichol, Engineers, November 7, 1990, Ewa Marina Evaluation of Project Impacts On Surf Sites) concluded that the design which emerged out of the 1986 EIS process was the best that could be found from the viewpoint of minimizing impacts on surf sites.

However, individuals who spoke at the Public Hearing held by the Corps of Engineers on December 17, 1990, continued to express concern over potential adverse effects on surfing sites. As a result of the testimony that was given at the hearing and additional input from the Corps' technical staff, HASEKO commissioned a further analyses of the issue to determine if adverse impacts on surfing could be further reduced. This report presents the results of an additional analysis of the entrance channel alignment, configuration, and location that was conducted in response to those concerns.

1.2 Purpose

The purpose of this study is to evaluate practicable alternatives to the marina entrance channel configuration presented in the pending application for a Corps of Engineers permit in order to minimize potential adverse surf site and beach impacts, while maintaining a safe navigation entrance and effective project design.

1.3 Scope

The following summarizes the scope of work conducted for this study:

1. Evaluate design criteria and site constraints for the marina entrance channel configuration, alignment and location.

2. Evaluate entrance channel width requirements based upon considerations of safe navigation and acceptable levels of boat traffic congestion.

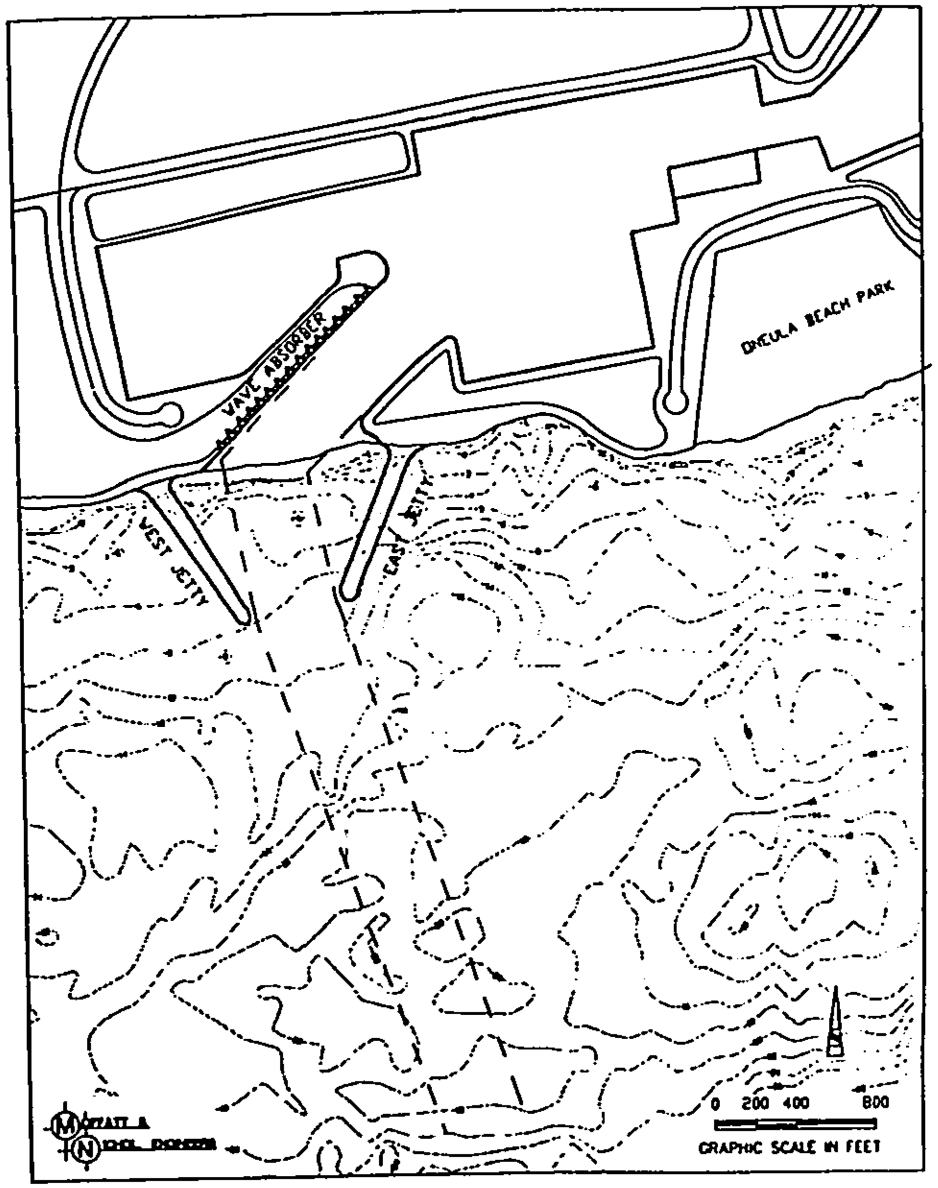
3. Investigate alternative combinations of entrance channel alignment and protective structures that would be functionally satisfactory while reducing adverse impacts on surf sites.

4. Summarize analyses of entrance channel alternatives conducted in prior studies.

2.0 PROJECT DESCRIPTION

The entrance channel design used as the basis of the Department of the Army permit application now being processed by the Corps of Engineers is shown in Figure 2-1 (hereinafter referred to as Entrance A). It calls for an entrance channel that is approximately 400 feet wide and 2,900 feet long. The proposed minimum channel depth is 20 feet, the minimum depth needed to reduce the probability of waves breaking in the entrance channel to an acceptably low level and to allow the safe passage of boats during periods of large swells. The arrowhead jetty configuration and the interior wave absorber included in this design are intended to reduce wave heights in the entrance channel and in the inner berthing areas to acceptable levels.

The entrance channel design submitted to the Corps included 700 foot long rock jetties on either side of the entrance channel; these jetties would extend offshore to the eight- to ten-foot depth contour. The proposed jetty cross-section is shown in Figure 2-2. The crest elevation, side-slope and armor stone specified for the proposed jetties was designed for stability during periods of high waves. The section allows for wave overtopping to occur. The porous, sloping sides that are part of the design absorb rather than reflect wave energy. Final jetty design will consider the need for reduction of the jetty permeability to preclude transmission of sand, including possible construction of an impermeable diaphragm. The design also allows for the jetties to be provided with a concrete cap to facilitate its use by fishermen and by surfers.



ENTRANCE A

FIGURE 2-1

3.0 MARINA ENTRANCE DESIGN CRITERIA

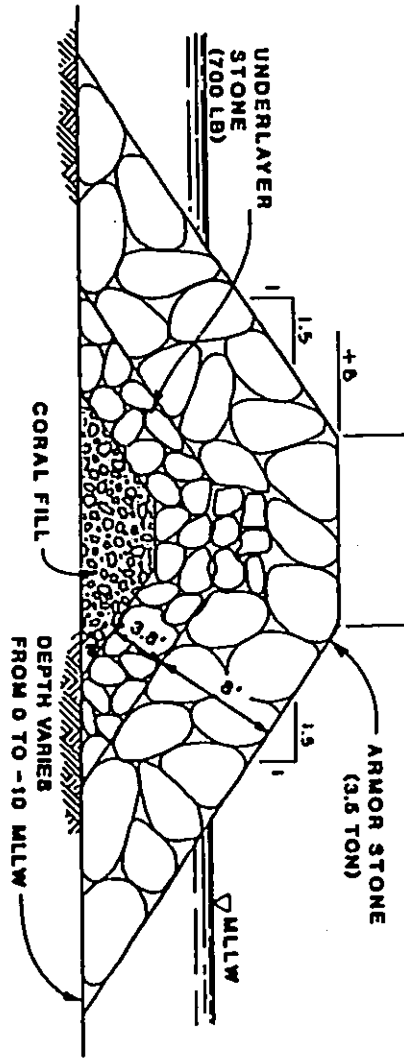
Navigation in or near the surf zone is difficult and dangerous for the recreational boater. Large, steep, or breaking waves can overwhelm steering control and cause a boat to broach, capsize, run aground, or collide with another boat. Because of this, it is important that the entrance configuration used protect against these occurrences. A marina entrance channel should provide a surf-free pathway into the harbor. This requires that either its jetties extend seaward beyond the zone of breaking waves or the channel be deep enough to prevent waves from breaking. The keel of the largest boat should also be kept from striking hard bottom as it traverses the channel at low tide through penetrating swells. The Ewa Marina project site is not afforded the protection by the shallow reefs typically found at other Oahu marinas. Special consideration of navigation safety and mitigation of wave conditions within the harbor is therefore required.

In addition to providing a surf-free pathway into the harbor, another consideration in designing an entrance channel through a reef is the angle of wave approach in the channel. Boaters may experience difficult navigation in quartering or broadside seas. Waves breaking over reefs can induce longshore currents which may interfere with navigation, especially near the shore boundary.

The design of a functional and safe marina entrance channel requires consideration of prevailing environmental site conditions as well as the number and type of berthed craft within the harbor. An effective entrance channel design should also attempt to incorporate some or all of the following features:

1. Align the channel between 45 and 135 degrees to the prevailing wind direction to minimize the amount of tacking required for sailboats within the channel.

2. Provide protection to reduce wave penetration through the entrance channel to acceptable levels. Accepted "rules of thumb" for tolerable



TYPICAL JETTY SECTION

FIGURE 2-2

wave conditions within a small-craft marina are generally expressed as wave heights reduced to less than 4 feet within entrance channels, and less than one foot within berthing areas on an annual basis and less than 1.5 feet during a 25-year storm event.

3. Minimize channel bends or abrupt alignment changes.

4. Provide ample navigable channel width and depth to allow for safe navigation during hours of peak usage and/or during adverse wave or weather conditions.

5. The channel and wave attenuator structures must also be compatible with the interior basins and land-use plan.

Another important marina entrance design issue is the need for jetties. Jetties constructed along the entrance channel would serve three main purposes:

1. To protect the marina basin from waves: The jetties act as breakwaters to attenuate wave to acceptable levels before they reach the interior marina basins. An arrowhead jetty alignment spreads and dissipates wave energy through diffraction.

2. To prevent wave-induced longshore currents from creating a navigation hazard: The jetties provide a barrier to cross-channel rip currents that may be created by waves breaking over adjacent reefs.

3. To prevent littoral drift from shoaling the channel: The jetties act as barriers to littoral drift that would otherwise be deposited in the navigation channel thereby causing a potential navigation hazard and temporary loss of beach sand.

4.0 ANALYSIS OF ALTERNATIVES

4.1 Overview of New Alternatives Evaluated

Comments received during the public review process have led the Corps of Engineers to request that additional channel sizes and alignments and jetty configurations be evaluated to determine if possible effects on surf sites could be further reduced. The Corps also asked that the need for the proposed jetties be documented and re-evaluated.

4.2 Channel Width Requirements

Safety and convenience of the boaters are the most important factors to be considered to design the width of a navigation channel. The commonly used guideline presented in "Small Craft Harbors: Design, Construction, and Operation - Special Report No. 2," (U.S. Army Corps of Engineers, 1974) states that the channel should be 300 feet wide for the first 1,000 boats and 100 feet for each additional 1,000 boats. This guideline applies to Corps of Engineers projects and was developed based upon experience of marinas with long entrance channels such as Newport, Marina Del Rey and Alamitos Bay in California. The entrance width enables a number of vessels to pass in a confined area. Deviation from guidelines is permitted, with justification for specific cases. Instances can be cited of channels which are narrower and wider. Traffic controls have been setup in many channels to correct congestion and safety problems.

Ewa Marina plans 1,600 permanent slips, launchings from ramps and dry storage, and other vessel traffic. Direct application of the guideline indicates a 360 foot wide channel would be satisfactory for berthed vessels. There are other factors to consider which indicate that both a narrower and wider channel could be constructed. The site is directly exposed to trade winds and waves as well as cross currents. The channel can be marked as it goes through the reef, but the channel is not well protected from forces which would cause boats to drift from the channel. Under most conditions, the vessels can navigate under sail on a single tack both in and out of the marina. However, during times of large waves and associated wave-induced currents, or when winds are aligned with the channel requiring multiple tacks, a wider channel would enhance safety. These circumstances would require a large enough channel for tacking sail boats during peak hours to safely navigate amongst other vessels. While use of the channel could be restricted to boats under power, this is neither a necessary nor enforceable rule.

Table 4-1 lists the number of slips and channel characteristics of several marinas an Oahu and in California. Figure 4-1 plots the number of berths versus channel width for these marinas.

TABLE 4-1
HAWAII AND CALIFORNIA MARINA ENTRANCE CHANNEL CHARACTERISTICS

Harbor Name	Number of Slips	Entrance Channel Width (Feet)	Entrance Channel Length (Feet)
Hawaii			
Ala Wai	702	250	2,500
Kewalo Basin	122	200	2,000
Haleiwa	250	120	740
Waianae	300	150	830
California			
Santa Cruz	960	150	900
Morro Bay	499	400	3,600
Santa Barbara	1,008	400	1,200
Ventura	2,015	300	1,750
Channel Islands	2,502	300	1,650
Marina del Rey	6,000	1,000	5,100
Redondo Beach	1,566	400	1,600
Alamitos Bay	2,535	550	6,500
Huntington Harbour	2,211	200	3,000
Newport Beach	5,654	500	4,100
Dana Point	2,502	600	1,600
Oceanside	868	350	1,100
Mission Bay	670	670	5,200

As can be seen on Figure 4-1, the 400-foot width that has been proposed for the Ewa Marina project falls very close to the line representing the Corps of Engineer's design criteria. The additional 40 feet of width is intended to

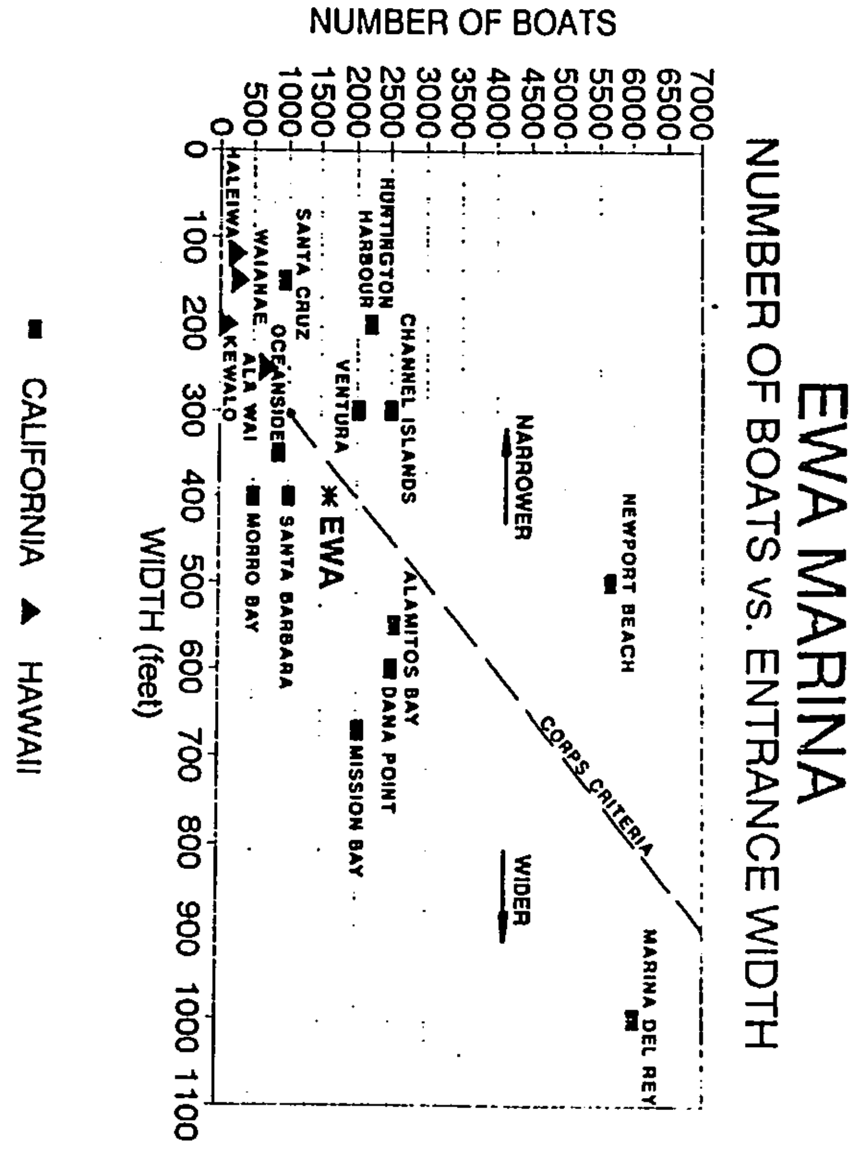


FIGURE 4-1

account for the additional boat traffic that is expected to result from the launching ramps and dry storage facilities that are planned for the marina. It is expected that these would generate as much boat traffic as 400 slips. Thus, a 400-foot width appears to be justified.

As shown by the graph, existing marinas have both greater and lesser widths than indicated by the Corps design criteria. However, most of the marina channel widths that do not meet or exceed the Corps criteria have special circumstances or operating problems. More specifically:

1. The entrance channels to the Channel Islands and Ventura marinas were constructed at a time when their berthing capacity was markedly less than it now is. It is now generally acknowledged that additional channel width is desirable at these locations, and the feasibility of widening the Channel Islands entrance channel is already underway.

2. Huntington Harbour is primarily a water-oriented residential development rather than a full-service marina. More importantly, a low bridge across the entrance to the harbor makes it unsuitable for sailing craft. Because a substantial amount of the width requirement reflected in the Corps of Engineers' standard is associated with the requirements of sailing craft, Huntington Harbour functions adequately despite the below-standard width. Because the proposed Ewa Marina project is intended to serve sailboats as well as power craft, such a narrow width would be inappropriate.

3. Oahu marinas whose channel width falls below the Corps' design guidelines are Haleiwa and Waianae. Both have short channels, and this, together with the fact that they have relatively few slips, minimizes the problems that this narrowness causes. Because the entrance channel to the proposed Ewa Marina project is over three times as long as the entrance channels to these existing facilities, such a relatively narrow channel would be inappropriate.

4.3 Channel Alignment

It is desirable from a navigation safety standpoint to align the channel approximately normal to the nearshore bottom and reef contours to minimize the occurrence of quartering or broadside seas and to reduce construction costs. Waves generally approach the shore in the vicinity of the project site from the south-southeast; wave crests tend to align parallel with the bottom contours. A 340 degree azimuth is approximately normal to the bottom contours. Since it is desirable for an entrance channel to be aligned with the prevailing wave conditions, a channel azimuth within 10 degrees of the shore-normal azimuth is considered acceptable.

Channel alignment relative to the prevailing wind conditions is also an important channel design consideration. It is desirable to provide sailboats the opportunity to navigate in the long channel without having to tack. Moffatt & Nichol (1990c) provided a detailed analysis of available wind data in the project vicinity. The study found that a channel within 10 degrees azimuth of 350 degrees would minimize tacking in the entrance channel, for the prevailing east-northeast wind direction. Channel alignments ranging from 340 degrees to due north are recommended based upon both wave and wind alignment considerations. The channel alignment within this range has no significant change to surf site impacts.

4.4 Analysis of Alternative Channel Locations and Jetty Configurations

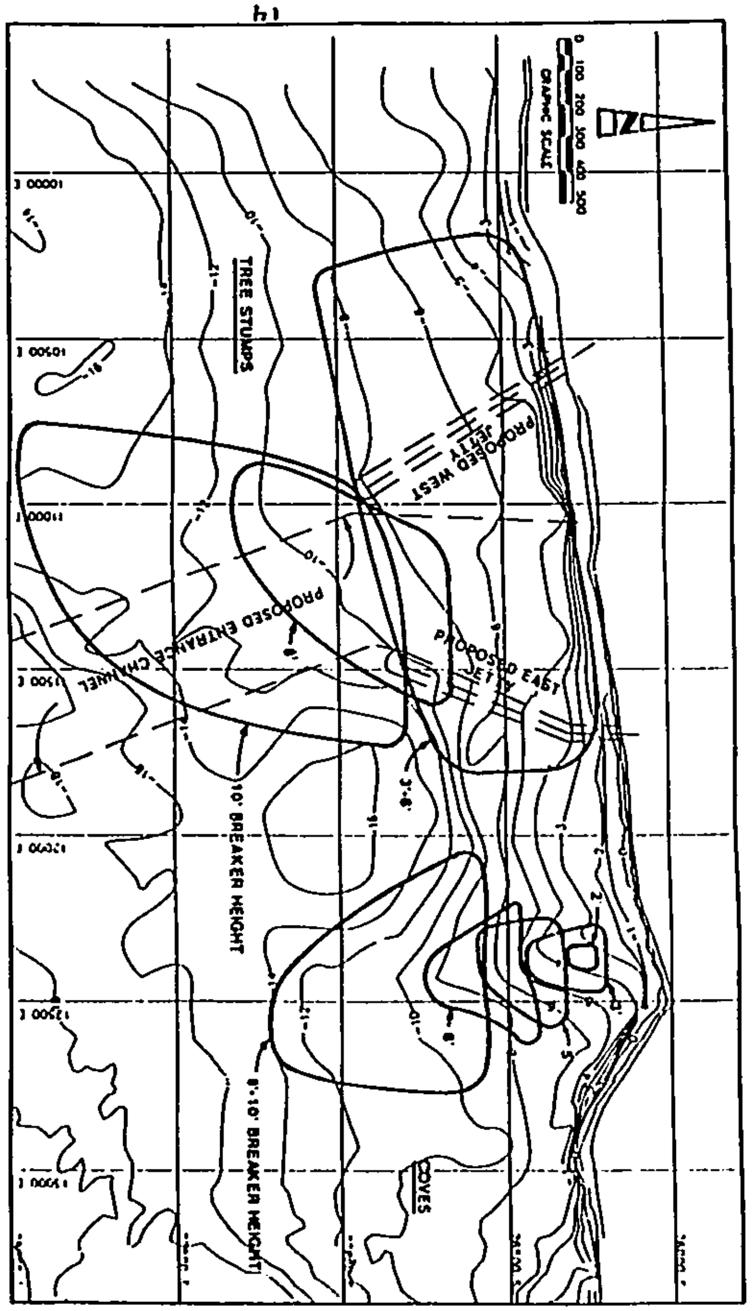
Marina entrance alternatives have been evaluated in prior studies which are summarized in the Appendix. The Final Addendum to the Final EIS (Dames & Moore, 1986) concluded that the rocky reach of shoreline west of Oneula Beach Park would be the best location for the marina entrance. Channel alignments within Oneula Beach Park and to the east have a considerably higher potential to trap sand and adversely affect Oneula Beach. Existing surf sites may also be impacted in this area.

Two recent studies of site impacts, Ewa Marina - Evaluation of Project Impacts on Adjacent Beaches, (Moffatt & Nichol, 1990a) and Ewa Marina - Evaluation of Project Impacts on Surf Sites, (Moffatt & Nichol, Engineers, 1990b), concluded that the entrance channel location which emerged out of the 1986 EIS process was the best that could be found from the viewpoint of minimizing impacts on adjacent beaches and surf sites. However, whereas the beach impact study concluded that the entrance channel was not expected to have a significant impact on adjacent beaches, the surf site impact study predicted partial destruction of an existing surf site.

The entrance channel which evolved from the 1986 EIS process is located between two surf sites currently known as Coves and Tree Stumps (see Figure 4-2). Detailed analyses performed in the surf site study indicated the Coves site to the east to be a more popular site with a well-defined break over a broad range of wave conditions. The Trees Stumps site to the west was found to consist of a discrete outer break and an ill-defined inner break. This site has been observed to be one of the least surfed sites in the project vicinity due to infrequent large surf for the outer break and the relatively short rides associated with the inner break. Both were found to be adversely impacted due to encroachment of the entrance channel into the site. The study suggested that the more popular and better defined Coves site should be fully preserved at the expense of direct impacts to the Tree Stumps site.

The purpose of this study is to provide an analysis of alternatives to the entrance channel design presented in the Corps of Engineers permit application which would minimize adverse effects on surf sites. Specifically, it is desired to develop an alternative plan which would reduce or eliminate direct impacts on the Tree Stumps surf site without creating any adverse impacts on the Coves surf site. Components of the marina entrance design which are evaluated include entrance channel location, alignment, and jetty configuration.

Mitigation of surf site impacts requires first a reduction of direct encroachment on the surf riding area and a reduction of indirect impacts. Direct impacts include placement of structures or modification to the bottom in the immediate area where surfing occurs, or when the waves are significantly altered in the riding zone. Indirect impacts include wave reflection or changes to wave patterns due to the presence of structures not located directly in the surf riding zone.



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BATHYMETRY FROM NOAA (NOVEMBER 1990)

COVES AND TREE STUMPS SURF BREAK LOCATIONS WITH ENTRANCE 'A' CONFIGURATION

4.4.1 Entrance A

Entrance A shown in Figure 2-1 is the entrance channel design which evolved out the 1986 EIS process and is presented in the Corps of Engineers permit application. This design avoids impacts on the Coves surf site which is generally deemed the superior of the two surf sites in the area where an entrance channel is most feasible. This channel alignment does, however, have an adverse direct impact on the Tree Stumps surf site.

Evaluation of the Entrance A configuration in light of the five operational criteria presented in Section 3.0 is as follows:

1. The minimum channel depth of 20 feet will provide for safe operation during hours of high wave conditions. The recommended 400-foot channel width will allow for safe navigation during peak usage hours and/or adverse weather and wave conditions.

2. The alignment of the channel seaward of the jetty entrance is perpendicular to the prevailing wind conditions which will result in a minimum of tacking required for sailboats wishing to navigate the channel under sail. Tacking will be required as the vessels proceed into the interior fairways.

3. The entrance channel exhibits a relatively sharp, 60 degree dogleg within the jettied entrance. This geometry is required for sufficient wave attenuation to reduce wave energy entering the berthing basins. This turn is considered acceptable from a navigation safety standpoint as long as a view corridor is maintained over the corner of the turn.

4. The arrowhead jetty configuration allows reduction of wave heights within the entrance due to the lateral spreading of wave energy through diffraction. Wave heights are further reduced through dissipation along the interior long wave absorber section along the seaward side of the west basin mole.

5. The channel and wave attenuation structure is compatible with the location and configuration of the interior basins and land use plan.

In addition to protecting the marina basins from waves, the jetties will prevent cross-channel rip currents caused by waves breaking over the adjacent reefs from creating a navigation hazard. They will also act as barriers to littoral drift which will otherwise be deposited into the navigation channel and cause a potential navigation hazard.

Inspection of Figure 4-2 indicates that the jettied portion of the Entrance A channel impacts the nearshore Tree Stumps break, whereas the offshore dredged channel impacts the outer surf break. It was estimated in the recent surf site impact study (Moffatt & Nichol, 1990b) that the entrance channel in its proposed configuration (Entrance A) could be relocated no more than 100 feet to the east to reduce Tree Stumps impacts without inducing either direct or indirect adverse impacts on the Coves site. These adverse impacts would result primarily from the east jetty.

A. <u>Jetty Configuration</u>

Marinas provide protected water for berthing and safe access to the ocean. The entrance configuration must provide adequate wave protection in the channel and berthing basins to provide for safe navigation in the marina entrance and minimize dock and vessel damage within the berthing basins. Waves can be attenuated by breakwaters, jetties, wave absorbers or by providing large basins. Jetties and internal wave absorbers are the appropriate method for Ewa Marina.

It is preferable to reduce the amount of wave energy entering the harbor as opposed to reliance upon internal dissipation since this will allow for safer navigation into and out of the marina. The Entrance A configuration was developed based upon this preference.

B. <u>Wave Penetration Analysis</u>

A preliminary numerical wave model was used to evaluate wave penetration for alternative marina entrance configurations. The model included diffraction of the waves due to sudden restriction at the marina entrance and absorption effects of side boundaries. The sides of the main channel interior to the shoreline will have armored side slopes similar to the jetty section.

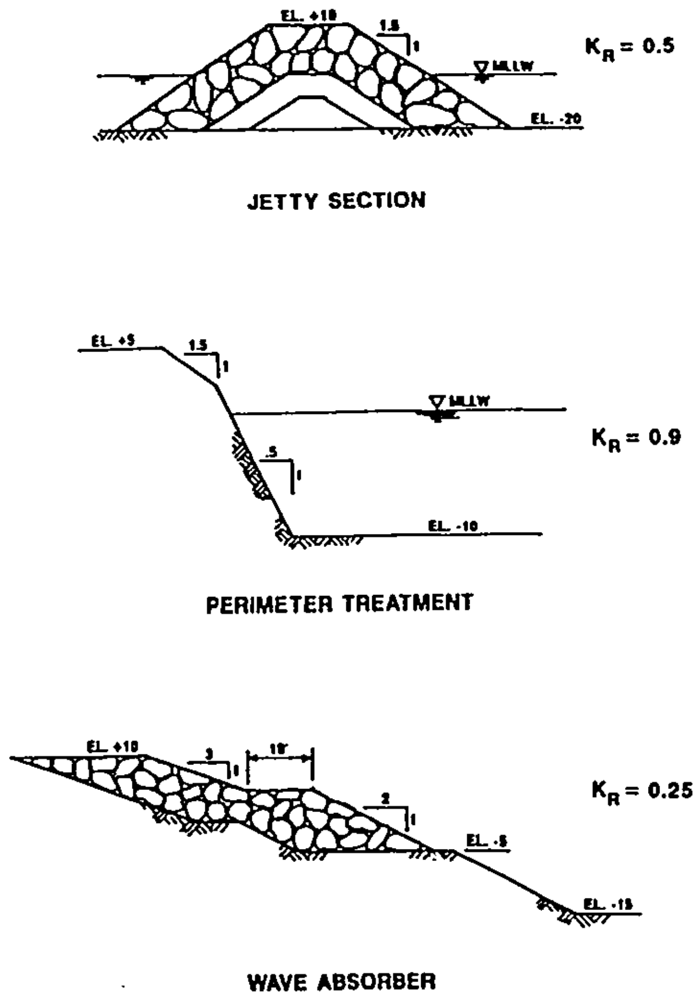
Incident waves were assumed to be monochromatic. The jetties, perimeter protection, and wave absorber sections were modeled as partially reflective side boundaries. The sides of the main channel interior to the shoreline will have armored side slopes similar to the jetty section. Cross sections of marina boundaries and associated estimated wave reflection coefficients are shown in Figure 4-3.

Model results are based on the assumption that the waves arrive from the same direction for a long duration of time. The wave heights determined from the model correspond to a steady-state condition which represents a superposition of the incident waves after diffraction and reflection. In nature, incident waves would be irregular in approach direction and period. The predicted wave heights will therefore tend to be higher than heights expected to occur in nature.

A 10 foot high, 12 second period wave was selected as the test wave representing an extreme wave condition at the marina entrance. This wave is representative of a kona storm wave condition. Kona storm waves of this severity are rare. It is assumed for purposes of this study that this wave condition represents a 25-year design wave.

The model calculated wave heights in the entrance channel adjacent to the wave absorber to be reduced to below 4 feet. The maximum wave height measured in the east berthing basin was 1.8 feet. However, this height was measured in a localized corner of the basin opposite the marina entrance. The next highest wave height measured in the basin was 1.4 feet along the northern basin perimeter. The maximum wave height measured in the west berthing basin was 0.6 feet.

The maximum wave of 1.8 feet measured in the east basin slightly exceeds the recommended maximum wave criteria of 1.5 feet for berthing areas during design wave conditions. However, a small wave absorber section in this localized area, or other simple modifications to the basin configuration should allow this maximum wave to be reduced to an acceptable level.



WAVE REFLECTION COEFFICIENTS

FIGURE 4-3

The wave penetration analysis indicates that offshore jetties are required to attenuate waves to acceptable levels within the entrance channel and interior berthing basins. However, alternative configurations are considered which require smaller jetties at the expense of a greater wave attenuation requirement within the harbor. This will be addressed in Section 4.3.2 - Entrance B.

C. <u>Wave Refraction Analysis</u>

As previously discussed, the jettied portion of Entrance A impacts the nearshore Tree Stumps surf break and the offshore dredged channel portion impacts the outer Tree Stumps break. The wave penetration analysis described in the preceding section indicated that although jetties will be required to attenuate waves to acceptable levels, some reduction in jetty size could be feasible. This will allow relocation of the jettied portion of the entrance channel to the east to reduce impacts to the inner Tree Stumps surf break.

This section provides a detailed analysis of the impacts of the dredged offshore channel associated with Entrance A relative the existing, no-project conditions. These results will be used to help determine the feasibility of relocating the channel farther to the east in order to minimize impacts to the outer Tree Stumps break without compromising the Coves site.

Impacts of channels can be assessed by comparing the wave refraction patterns for the proposed alternative with the existing, no-project conditions. Wave refraction diagrams were prepared using detailed bathymetry data provided by Edward K. Noda & Associates (1990). Wave refraction and shoaling calculations were performed using a numerical model employing linear wave theory. A breaker height index of $H_b/d_b = 0.78$ was used to determine depths at which waves will break. This index is low for waves breaking over a Hawaiian reef, but favors an expanded surf area in the analysis. In other words, this is a conservative assumption.

Test waves of varying height, period and direction which represent the general range of surfing wave conditions at the site were selected for the analyses. A total of 21 wave conditions were analyzed and are summarized in Table 4-2.

TABLE 4-2

TEST WAVE PARAMETERS

Deepwater Wave Azimuth (Degrees)	Wave Period (Seconds)	Deepwater Wave Height (Feet)
157	10	2 4 8
180	10	2 4 8
	16	2 4 8
202	10	2 4 8
	16	2 4 8
225	10	2 4 8
	16	2 4 8

Detailed nearshore wave refraction diagrams were prepared for the existing shoreline and the Entrance A channel configuration. Selected sample diagrams are reproduced in Figures 4-4 and 4-5. The plotted wave rays are travel paths which are perpendicular to the wave crests. Wave rays terminate nearshore where the computed wave height exceeds the depth-limited wave height. The dashes plotted along the wave rays illustrate successive crest locations. Wave crests are plotted at 5.0 second intervals.

Wave refraction diagrams prepared for prior EIS studies in 1986 and reproduced in the beach impact report (Moffatt & Nichol, 1990a) indicate that predominant waves approach the site from south-southeast. This is roughly perpendicular to the bottom contours and shoreline at the site. This is significant because

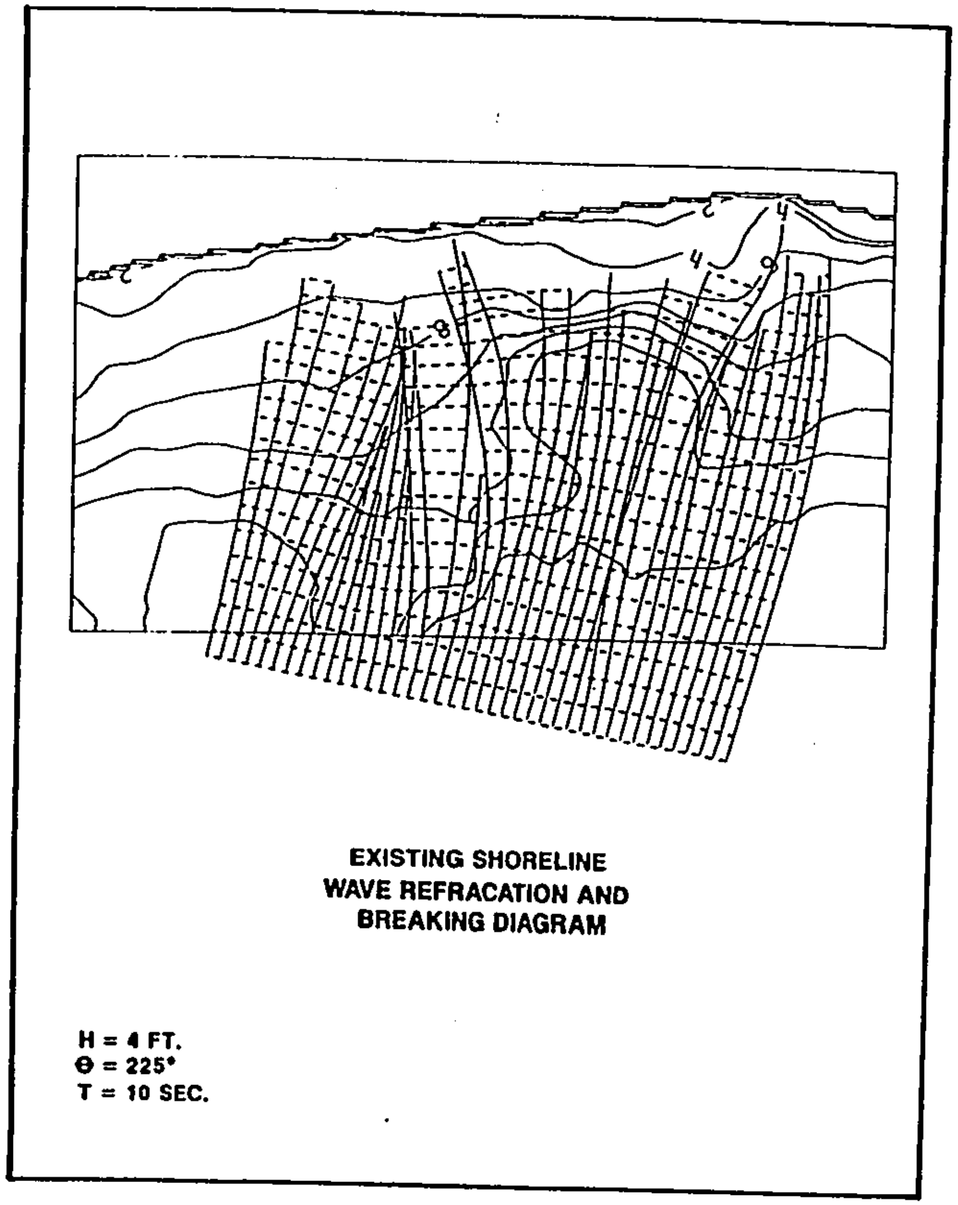


FIGURE 4-4

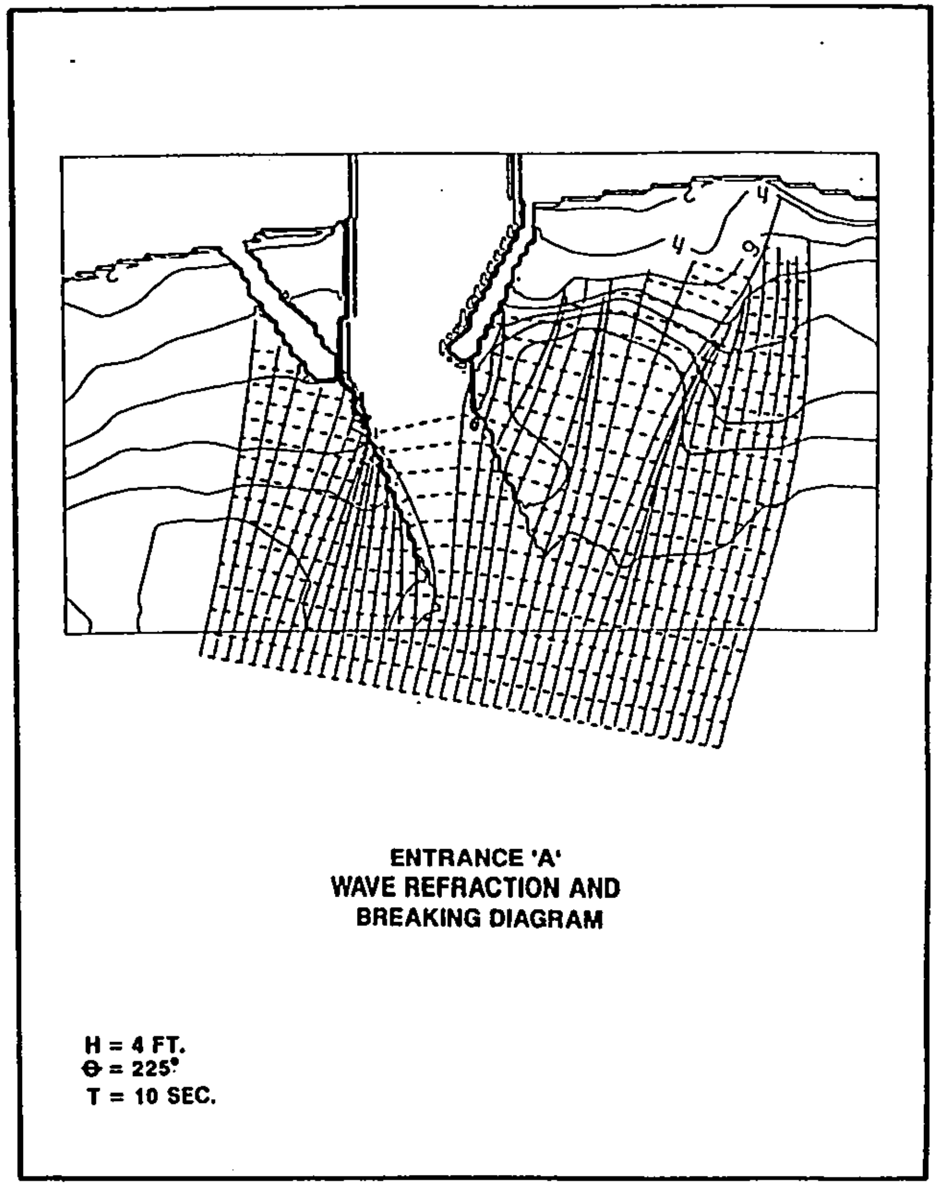


FIGURE 4-5

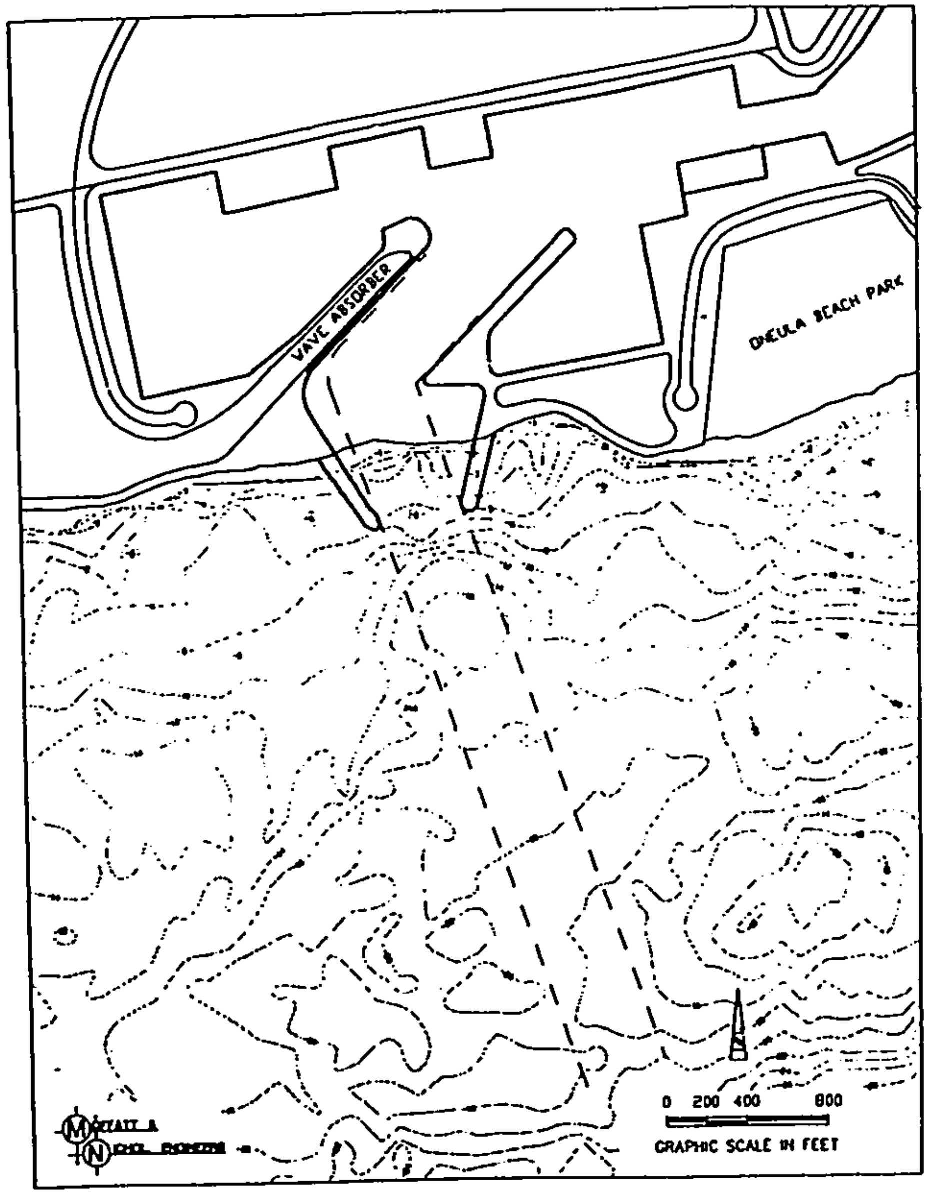
waves approaching from east of south reach the Coves site without being directly altered by the proposed configuration of the dredged entrance channel. Only the shorter period waves approaching from deepwater directions west of south approach the site from the south-southwest. These waves will be altered by the dredged entrance channel before they arrive at the surf site. Longer period waves from deepwater directions west of south are more affected by refraction in water deeper than the entrance channel; they tend to align with the bottom contours as they approach shore.

Entrance A neither directly nor indirectly impacts the Coves surf site for the range of wave conditions studied. This entrance configuration does directly encroach onto the Tree Stumps site. However, out of the 21 test waves analyzed, 17 demonstrated indistinguishable surf breaks at Tree Stumps under present, no-project conditions. Three of the wave cases with Entrance A showed an existing right peeling wave to be lost, and one showed this ride to be shortened.

It should be noted here that although a majority of the test waves demonstrated an ill-defined break at Tree Stumps, closeout waves and shorebreak which appears to be typical of the Tree Stumps site can be popular for a range of users including bodysurfers and beginning board surfers. It is important for purposes of this study, however, to investigate the specific characteristics of surf breaks since there are only a limited number of "classic" surf breaks with well-defined peeling waves in the project vicinity.

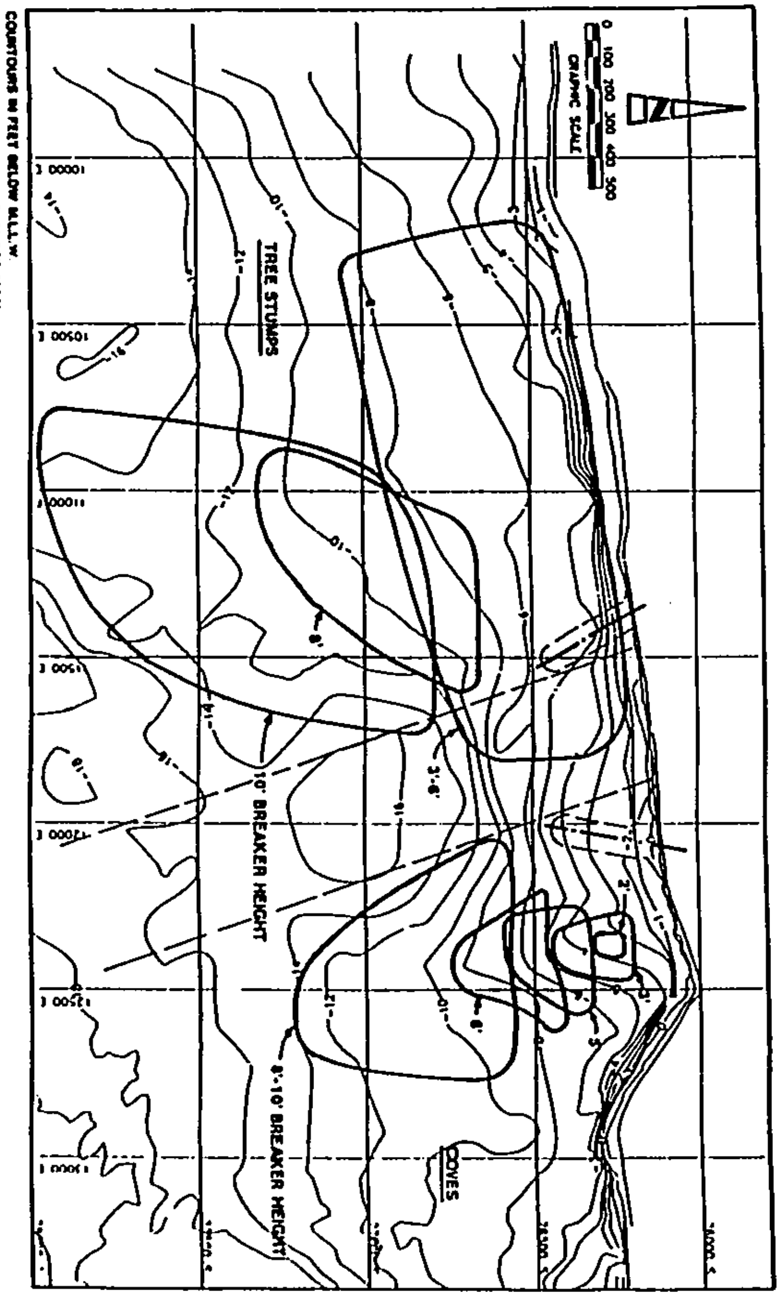
4.4.2 Entrance B

The Entrance B marina entrance configuration shown in Figure 4-6 was developed in an attempt to minimize adverse impacts on surf sites as identified in the recent study <u>Ewa Marina-Evaluation of Project Impacts on Surf Sites</u>, (Moffatt & Nichol, Engineers, 1990b) while maintaining a safe and effective entrance design. Figure 4-7 illustrates the location of the entrance channel relative to the Coves and Tree Stumps surf sites.



ENTRANCE B

FIGURE 4-6



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BATHYMETRY FROM NOAA (NOVEMBER 1990)

COVES AND TREE STUMPS SURF BREAK LOCATIONS WITH ENTRANCE 'B' CONFIGURATION

The entrance channel is located between the two surf sites, approximately 600 feet east of the Entrance A channel location. The jetty lengths had to be significantly reduced from 700 feet to 400 feet for this entrance location such that no adverse impacts on the Coves site resulted. The primary difference between Entrance B and Entrance A is the reduced jetty lengths. This required a configuration with greater wave attenuation characteristics within the jettied entrance. This was achieved by excavation of land to create a diffraction basin inside the entrance and the inclusion of a short "breakwater" section at the landward end of the east jetty. This area was formerly designated as a navigable, "sail-drop" area under Entrance A. Entrance B also includes an armored mole section separating the east berthing basin from the main channel. This area was designated for slips for Entrance A.

Evaluation of the Entrance B in light of the five operational criteria presented in Section 3.0 is as follows:

1. The minimum channel depth of 20 feet and 400 foot width are the same as for Entrance A, and will therefore provide the same level of navigational safety and convenience.

2. The 340 degree channel alignment seaward of the jetty entrance is perpendicular to the prevailing wind conditions which will result in a minimum of tacking required for sailboats wishing to navigate the channel under sail. This alignment is the same as for Entrance A.

3. The entrance channel exhibits a 65 degree dogleg within the jettied entrance which is minimal 5 degree increase from Entrance A. As for Entrance A, this turn is considered acceptable for navigation.

4. The bathymetric chart shows a 16-foot deep depression 600 feet offshore. It would be impractical to extend the jetties into the hole, hence they have been shortened. The jetty orientation is also much more shore-normal relative to the arrowhead configuration associated with Entrance A. This allows significant reduction in direct impacts to the Tree Stumps surf site and preservation of the Coves surf site at the expense of a greater wave attenuation

requirement inside the harbor. Wave attenuation characteristics of this configuration are addressed in this section.

5. Entrance B is generally compatible with the location and configuration of the interior basins and land use plan with only minor modifications.

The reduced jetty lengths associated with Entrance B results in a greater length of entrance channel that is exposed to cross-channel rip currents caused by waves breaking over the adjacent reefs. However, inspection of the detailed wave refraction diagrams described in Section 4.4.1 C indicates a general divergence of wave energy seaward of the Entrance B jettied channel due to the 16-foot deep depression directly offshore. A westerly current may be generated by waves breaking Coves during moderate to high wave conditions. However, once this flow reaches the dredged channel, the short jetties will deflect the flow seaward, thereby producing a minimal navigation hazard. In summary, the Entrance B configuration should provide for adequate protection from cross-channel currents which have the potential to create navigational hazards.

A. Jetty Configuration

Entrance B incorporates an interior wave diffraction basin, similar in concept to Entrance A, to reduce wave heights entering the harbor. However, with the jetty length reduced to roughly 400 feet, Entrance B requires an interior wave diffraction basin which extends approximately 300 feet inland to a width of over 800 feet.

B. Wave Penetration Analysis

The wave attenuation characteristics of the Entrance B were evaluated with the numerical wave penetration model as described in Section 4.4.1.B. Wave heights in the entrance channel are attenuated to less than four feet by the midpoint of the dogleg channel section. The maximum wave height in the east berthing basin was calculated to be 1.0 feet. The maximum wave height along the northern boundary opposite to the marina entrance was calculated to be 1.3 feet. The maximum calculated wave height in the west berthing basin was 1.3

feet. The model results therefore indicate that Entrance B provides an acceptable level of wave attenuation for safe navigation in the entrance and safe berthing within the harbor. Further reductions in jetty length would result in an increase in wave penetration into the interior channel and berthing basins beyond acceptable levels for the test wave conditions analyzed. It should be reiterated here that these findings are preliminary in nature to be used for planning purposes only. Final entrance channel design will performed with a physical hydraulic model.

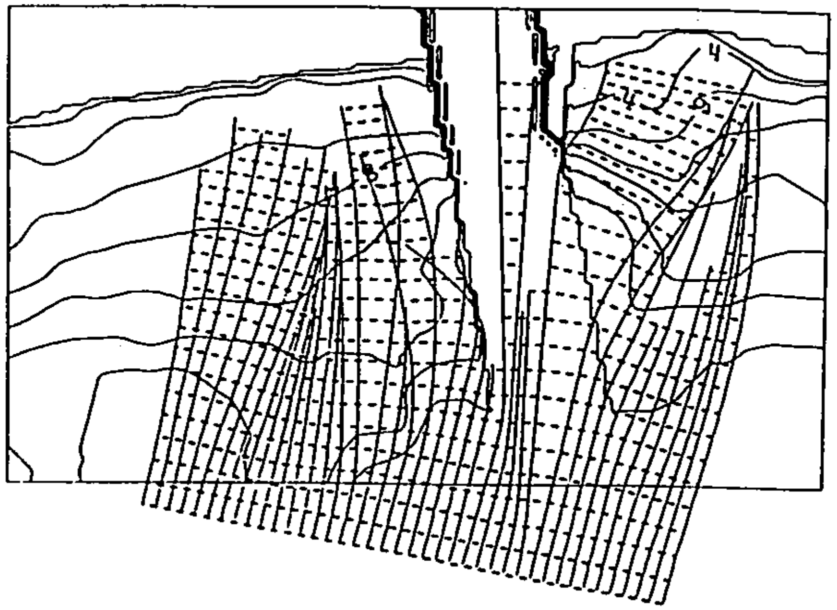
C. Wave Refraction Analysis

The same detailed wave refraction and breaking analysis that was performed for the Entrance A location was also done for the Entrance B location in order to verify that no adverse impacts to the Coves surf site were created at the expense of impact reduction at the less popular Tree Stumps site. The same 21 test waves previously described were used in the analysis. Figure 4-8 shows a sample wave refraction diagram developed for the Entrance B configuration.

The Entrance B channel was found not to have a negative indirect impact on surfing at the Coves site. Ten of the test waves exhibited no change for the Entrance B configuration relative to the existing shoreline conditions. Seven waves appeared to have improved rides, either extending the right and increasing its peel angle, or by enhancing the left along the channel similar to Ala Moana Bowl. For the remaining four, it could not be determined whether the minor changes would be beneficial or adverse.

The Entrance B configuration did not induce adverse impacts on surf breaks at Tree Stumps relative to the no-project conditions for 16 of the 21 test waves. Two of the test waves appeared to be enhanced due to improvement of the right break; one test wave had significantly better defined peel conditions. Changes for the remaining two test waves were minor and inconclusive.

In summary, Entrance B eliminates most of the negative direct impacts on Tree Stumps by relocating the proposed entrance channel while having minor and generally positive indirect impacts on Coves site. Reflection from the jetties will not enter the site due to the angle of the jetty relative to the indirect waves.



ENTRANCE 'B'
WAVE REFRACTION AND
BREAKING DIAGRAM

H = 4 FT.
Θ = 225°
T = 10 SEC.

FIGURE 4-8

4.5 Alternative Impacts on Littoral Processes

In the prior study entitled, <u>Ewa Marina - Evaluation of Project Impacts on Adjacent Beaches</u>, (Moffatt & Nichol, Engineers, 1990a), the impacts of the Entrance A configuration on littoral processes was evaluated. The findings of that study are briefly summarized in the following. The comparative impacts that the Entrance B configuration would have on littoral processes are then addressed. A comparison of the physical characteristics of the two entrance configurations is also included.

4.5.1 Entrance A Impacts on Littoral Processes

1. Littoral transport in the marina project vicinity is primarily onshore-offshore; longshore transport of sediment is low. White Plains Beach and Nimitz Beach to the west of the project site do not appear to be nourished by sand transported from Oneula Beach which lies to the east of the project. There is no evidence that supports that there was ever a beach along the 2,000 foot long reach of rocky shoreline at which the entrance channel would be located. It therefore appears that little sand transport will be affected by the Entrance A channel.

2. Small amounts of sand may accrete on the east jetty on occasion, particularly during strong, persistent northeast trades or a storm.

3. The entrance channel would form a sediment trap regardless of whether jetties are constructed. If littoral drift is intercepted by the jetties, an accretion fillet would form on the upcoast jetty. Without jetties, this littoral drift material would be deposited into the dredged entrance channel.

4. The jetties will reflect waves. Reflected waves can increase the local longshore transport rate potential on an erodible shoreline. However, the entrance channel would be located on a rocky shoreline where such wave reflection should have no impact.

5. Sand may occasionally collect in the fillets at the base of the jetties (primarily the east jetty) and need to be periodically bypassed to nourish downcoast beaches and to maintain a navigable depth in the entrance channel.

4.5.2 Comparative Impacts of Entrance A and Entrance B on Littoral Processes

Entrance B was developed to reduce the impacts on surf sites associated with Entrance A, while maintaining a safe and efficient design. Reduction of surf site impacts was achieved by relocating the entrance channel approximately 600 feet to the east and reducing the jetty lengths from 700 feet to approximately 400 feet.

The following provides a comparison of the impacts associated with Entrance A and Entrance B on littoral processes.

1. Both Entrance A and Entrance B are located within a 2,000 foot long reach of rocky shoreline between White Plains Beach to the west and Oneula Beach Park to the east. As for Entrance A, little sand transport will be affected by the Entrance B channel.

2. Sand may occasionally accrete at the Entrance B east jetty. The shorter jetties associated with Entrance B represent a shorter barrier to littoral transport relative to Entrance A. The Entrance A jetties have a maximum accretion fillet volume of approximately 25,000 cubic yards, whereas the Entrance B jetties will hold only about 10,000 cubic yards before the jetty is bypassed and littoral drift is deposited into the entrance channel. There should be no operational constraints to providing more frequent bypassing. Furthermore, Entrance B could therefore require more frequent bypassing. However, longshore sand transport is likely to be small and infrequent.

3. There will be less reflected waves associated with Entrance B due to the shorter jetties. However, wave reflection impacts on littoral processes will be minimal on a rocky shoreline.

4.6 Summary of the Physical Characteristics of the Entrance Alternatives

Table 4-3 summarizes the physical characteristics of Entrance A and Entrance B. The jetty footprint area was calculated by taking the average jetty base width between the shoreline and seaward end of the jetty multiplied by the jetty length. The channel footprint area is the dredged channel area between the shoreline and the seaward extent of the channel at the -20 feet Mean Lower Low Water (MLLW) contour.

TABLE 4-3
PHYSICAL CHARACTERISTICS OF ENTRANCE ALTERNATIVES

Dimension	Entrance A	Entrance B (400' Width)	Entrance B (300' Width)
Jetty Length (Feet)	700	400	400
Jetty Footprint Area (Acres)	1.64	0.83	0.83
Channel Footprint Area (Acres)	27.5	27.5	22.0
Channel Dredge Volume (Cubic Yards)	272,000	184,000	138,000

5.0 FINDINGS AND RECOMMENDATIONS

5.1 Summary of Findings

The purpose of this study was to evaluate practicable alternatives to the proposed Ewa Marina entrance configuration which would minimize adverse impacts to surf sites. Entrance design parameters evaluated included channel width, location, alignment and configuration of protective structures. The study findings are as follows:

1. A minimum entrance channel width of 360 feet is based upon current Corps of Engineers marina entrance channel design criteria. However, a wider channel of 400 feet is recommended based upon the relatively exposed location, boat ramp-generated traffic and dry storage-generated traffic. The potential for high wave action and cross-channel currents in the unprotected, open-ocean portion of the channel favors a wider channel.

2. Consideration of both wind and wave effects on the navigability of the entrance channel indicates a channel alignment approximately perpendicular to the bathymetric contours to be desirable. The associated channel alignment could range from 340 degrees to 350 degrees in order to achieve this desirable alignment. Varying the channel alignment within this range has no significant change to surf site impacts.

3. Relocation of the entrance channel toward the east will reduce or eliminate adverse impacts to the Tree Stumps surf site. The entrance channel design used in the current Corps of Engineers permit application (Entrance A) could be relocated up to 100 feet to the east which would preserve an additional part of the Tree Stumps site from direct impacts. The jetties in this configuration are required for wave attenuation. If the jetties were moved farther east, the east jetty would encroach into the 16-foot deep hole. This would require

significantly larger armor stone and jetty volume and would start to influence surf conditions at Coves.

4. Shortening and straightening the jetties would result in a significant reduction in the "footprint" area of the entrance, allowing relocation of the channel up to 600 feet to the east (Entrance B). This channel location minimizes impacts to Tree Stumps without impacting the Coves surf site. In order to reduce wave energy entering the marina, land must be excavated to create a wave diffraction basin put inside the entrance. Entrance B has acceptable wave heights in the entrance channel and berthing areas. The "sail drop" area in Entrance A is not possible with Entrance B. This is a minor inconvenience.

5. The Entrance B jetties are the shortest that the computer modeling carried out to date shows will attenuate waves within the entrance channel and marina basins to acceptable levels. It is anticipated that more detailed investigations of the minimum jetty size, including physical model studies, will be conducted once the Corps permit has been issued and other major permit approvals have been granted. If the results of these follow-on studies indicate that the size of these structures can be further reduced without jeopardizing safe operations of the facility, this will be done.

6. Neither Entrance A nor Entrance B are predicted to have a significant impact on adjacent beaches.

In summary, Entrance A meets the desirable criteria for entrance channel design, including provision for safe navigation within the entrance channel and an acceptable level of wave attenuation within the harbor berthing areas; however, this entrance has significant adverse impacts on Tree Stumps. Entrance B represents an entrance configuration which has reduced jetty lengths and passes between the two surf sites. This configuration has acceptable wave heights in the channel and berthing areas.

5.2 Recommendations

Marina Entrance B is the recommended configuration based upon analyses of alternatives.

Both jetties and a basin near the entrance are required based on the numerical analysis to dissipate waves entering the channel and berthing areas. The design is more sensitive to wave absorber performance in comparison to Entrance A, and this issue shall be dealt with in detail during final design. The west jetty also protects the interior from direct short wave period penetration from the southwest direction.

A 400-foot wide entrance channel aligned at 340 degrees to due north is recommended.

6.0 REFERENCES

Dames & Moore (1985). "Final Environmental Impact Statement - Increment II - Proposed Ewa Marina Community - Ewa, Oahu, Hawaii."

Department of Planning and Economic Development (1971), SCORP studies.

Division of State Parks, Outdoor Recreation and Historic Sites Department of Land and Natural Resources (CIRCA 1976), "The Board Surfing Sites Survey" (unpublished report).

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Moffatt & Nichol, Engineers (1990a). "Ewa Marina - Evaluation of Project Impacts on Adjacent Beaches," (prepared for Haseko, Hawaii, Inc.).

Moffatt & Nichol, Engineers (1990b). "Ewa Marina - Evaluation of Project Impacts on Surf Sites," (prepared for Haseko (Hawaii), Inc.).

Moffatt & Nichol, Engineers (1990c). "Navigation Channel Design Considerations," (prepared for Haseko (Hawaii), Inc.).

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Moffatt & Nichol, Engineers (1978). "Oceanographic Criteria for Design of Ewa Marina," (prepared for Pearson & Wuesthoff).

Noda, Edward K., and Associates (1990), Nearshore Bathymetric Survey of Proposed Ewa Marina Project.

U.S. Army Corps of Engineers (1974). "Small Craft Harbors" Design Construction and Operation - Special Report No. 2.

Walker, James R. (1974). "Recreational Surf Parameters," Look Lab TR-30, University of Hawaii, Department of Ocean Engineering, Honolulu, Hawaii.

APPENDIX: REVIEW OF PRIOR STUDIES

This appendix provides a review of previous studies of marina entrance alternatives for the Ewa Marina project.

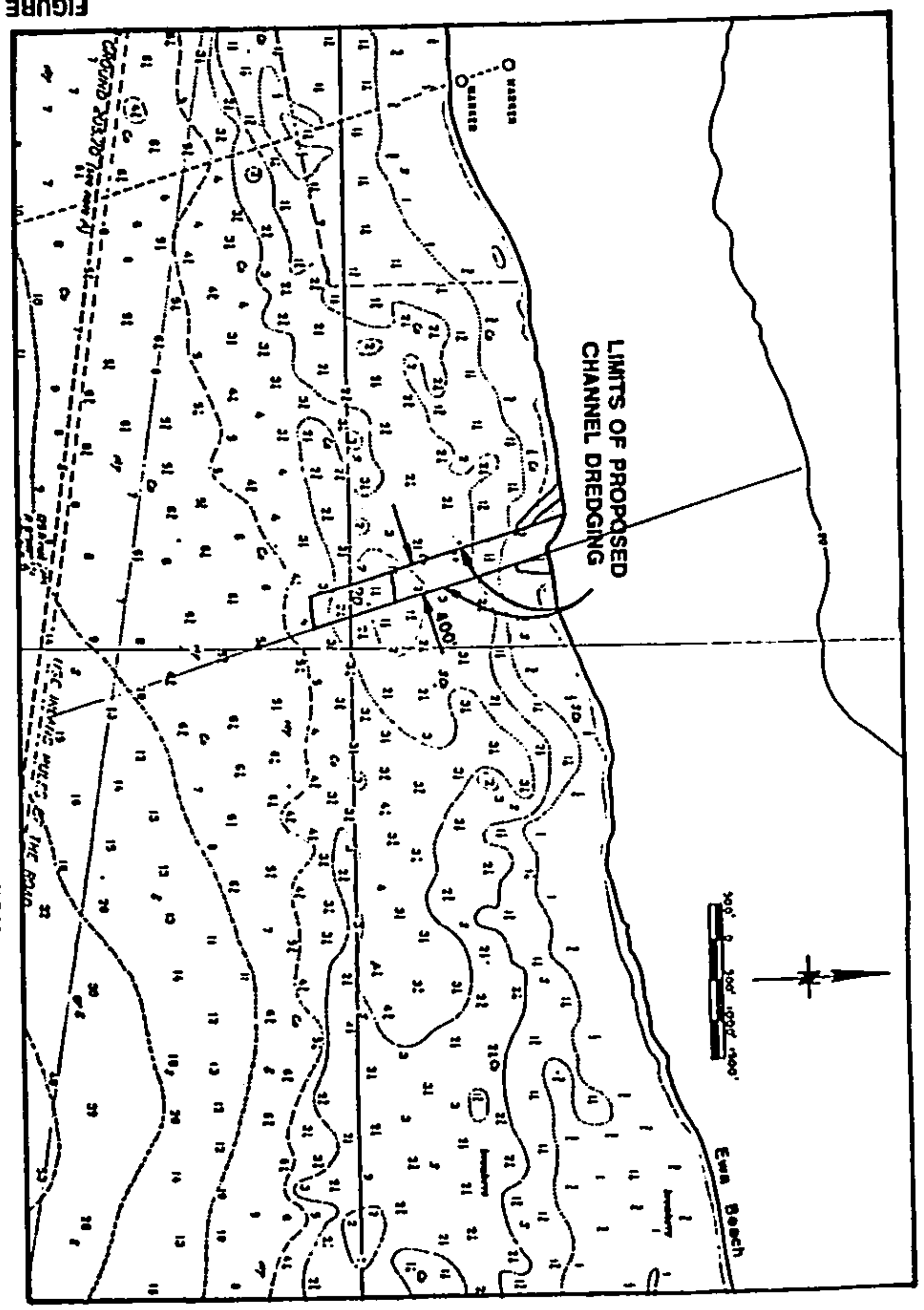
A. Oceanographic Criteria for Design of Ewa Marina, prepared for Pearson & Wuesthoff (Moffatt & Nichol, Engineers, 1978)

Three alternative entrance channel locations and configurations were investigated in this preliminary study. The study stated that a 400-foot wide, 20-foot deep entrance channel on a 340 degree azimuth emanating from the rocky headland at the Kaloi Gulch drainage ditch would be the most desirable entrance (see Figure A-1). The recommended entrance configuration included short jetties designed to reduce the wave energy entering the marina and to prevent sand transported by littoral drift from filling the channel. The proposed channel alignment was adjacent to Oneula Beach Park and passed through an offshore reef.

B. Final Environmental Impact Statement - Increment II - Proposed Ewa Marina Community - Ewa, Oahu, Hawaii, (Dames & Moore, 1985)

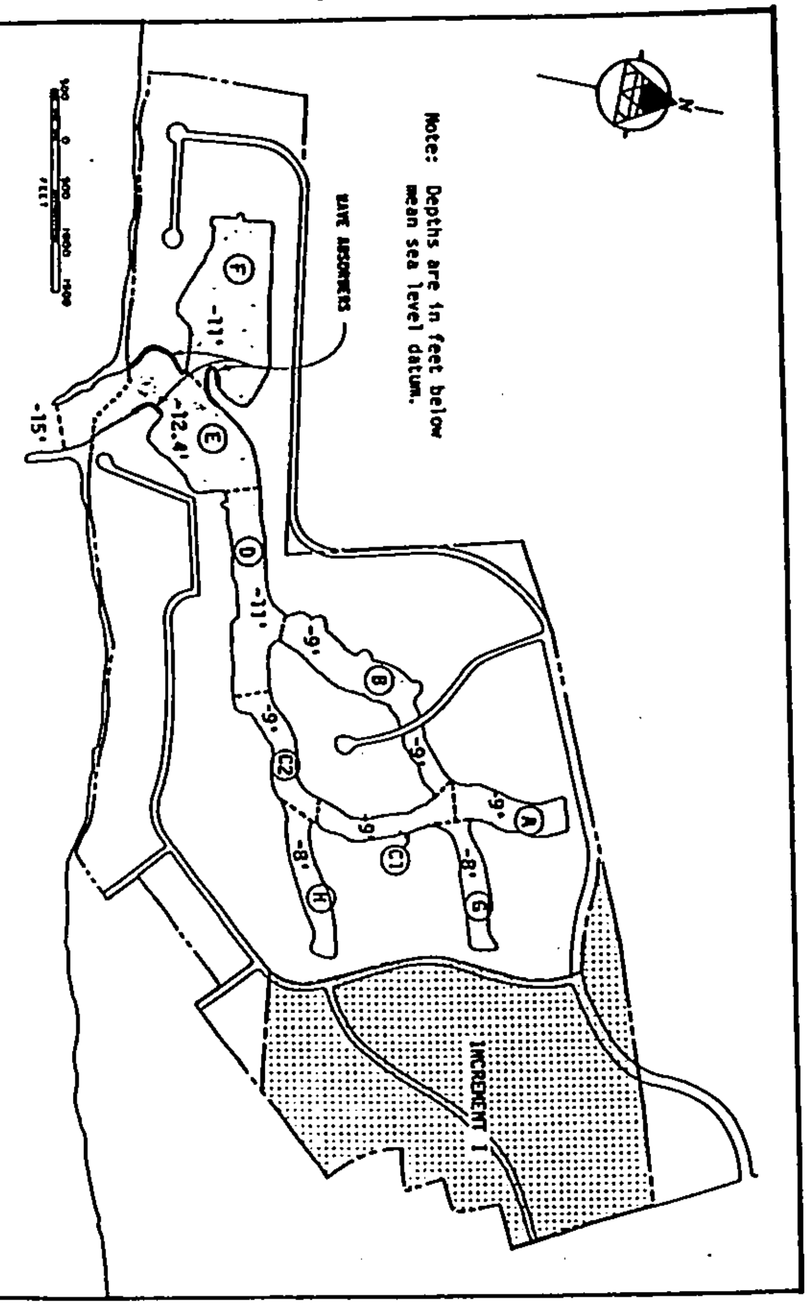
The Ewa Marina configuration evaluated in the 1985 EIS studies was based upon the findings of the Moffatt & Nichol, Engineers (1978) study and is shown in Figure A-2. The report states that 500-foot long rock jetties would be constructed along the entrance channel, although detailed wave analysis would be used to determine the final jetty configuration.

The 1985 EIS listed six surf sites in the vicinity of the Ewa Marina project. These had been identified by the Department of Planning and Economic Development in studies conducted in 1971 as part of the update of the State Comprehensive Outdoor Recreation Plan (SCORP) and in a subsequent update report entitled The Board Surfing Sites Survey prepared by the State Department of Land and Natural Resources in 1976. The EIS noted that the entrance channel that was then being proposed encroached directly on a surfing area known as "Sand Tracks" (see Figure A-3).



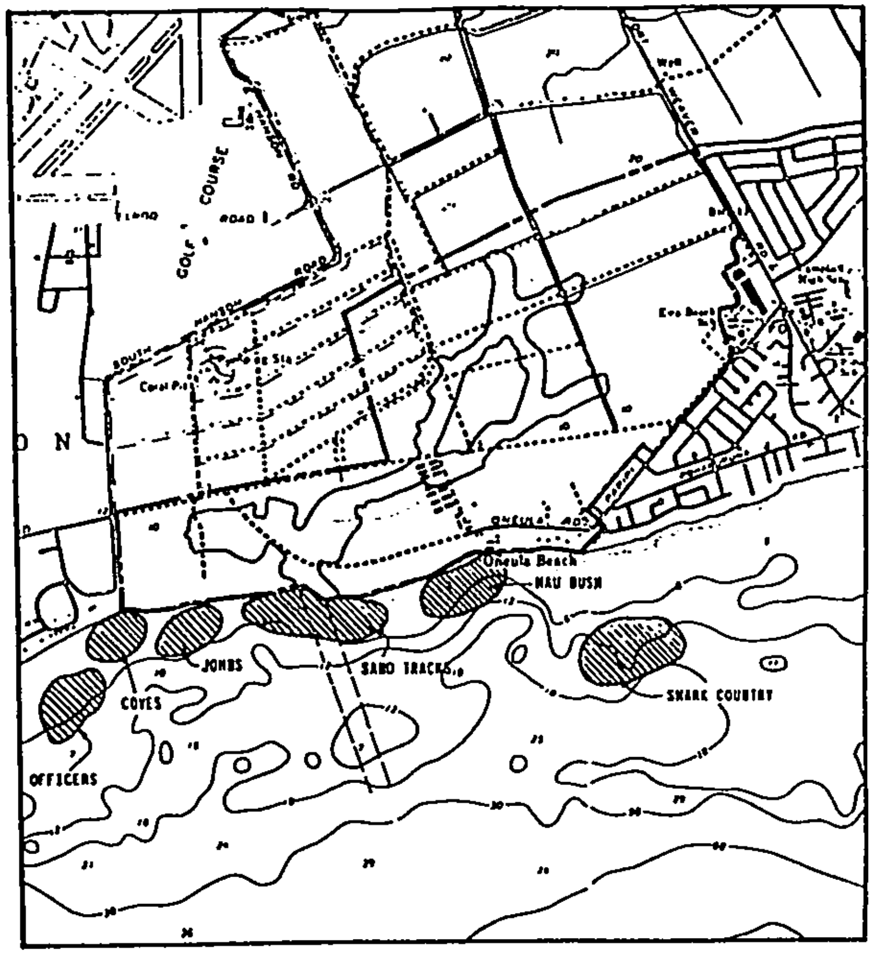
RECOMMENDED ENTRANCE CONFIGURATION
(MOFFATT & NICHOL, ENGINEERS, 1978)

FIGURE A-1



PROPOSED MARINA ENTRANCE CONFIGURATION
(FROM DAMES & MOORE, 1985)

FIGURE A-2



Sources:

Unpublished Study, "The Board Surfing Sites Survey", Division of State Parks, Outdoor recreation and historic sites, Dept. Land and Natural Resources.

From copy in Harbors Division, Dept. of Transportation, Original work generated through Dept. Planning and Economic Development 1971 SCORP Studies.

Base Map - U.S.G.S Topographic Map; Ewa, Puuloa, Oahu, Hawaii; 1968.

SURFING SITES
(FROM DAMES & MOORE, 1985)

FIGURE A-3

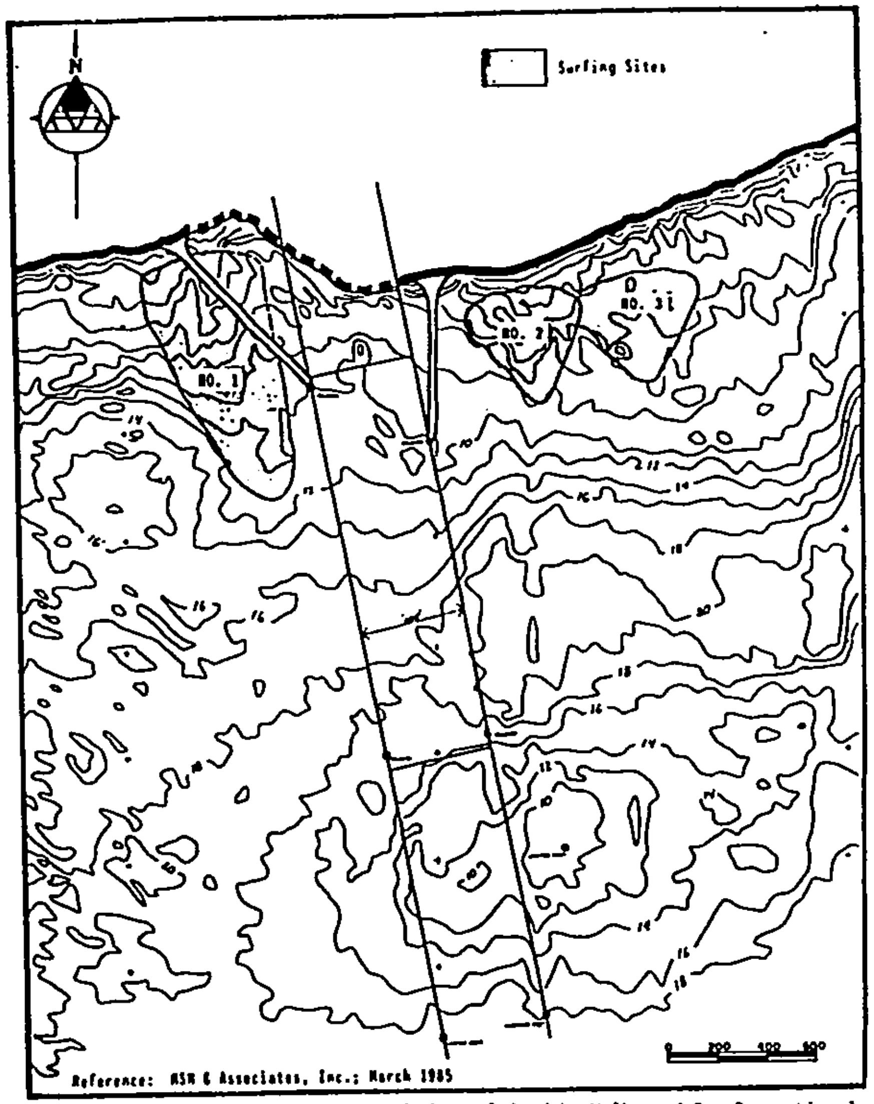
The 1985 EIS also presented the results of a surf site analysis that was prepared by Moffatt & Nichol, Engineers, (1985) in support of the MSM proposal. Moffatt & Nichol's analysis used a methodology described by Walker (1974) to evaluate the potential impacts of its entrance on known surfing sites.

The analysis focused on the entrance channel location that was then being proposed. Figure A-4 shows the three areas in the vicinity of the alignment identified as being viable surfing areas. They encompass only a portion of the area that had been identified as "Sand Tracks" in the earlier SCORP study. Based on its analysis, Moffatt & Nichol recommended that the channel location be adjusted slightly to reduce effects on the Sand Tracks surf site. However, even with the adjustments, it was apparent that the west jetty would partially destroy "Surf Site No. 1" (see Figure A-4).

The study also evaluated three alternative channel alignments (see Figures A-5, A-6, and A-7) and one alternative that used the proposed alignment, but without jetties; these were developed to explore means of mitigating potential effects on surf sites. Of the alternatives examined, Alternative 3 was found to have fewer impacts on surf sites, but was rejected because it resulted in longer water residence time in the marina, increased internal travel times in the marina, increased the land and dredging costs, and increased the automobile traffic bound for the commercial area through the community and park.

C. <u>Final Addendum to the Final Environmental Impact Statement for Increment II - Proposed Ewa Marina Community - Ewa, Oahu, Hawaii.</u> (Dames & Moore, 1986)

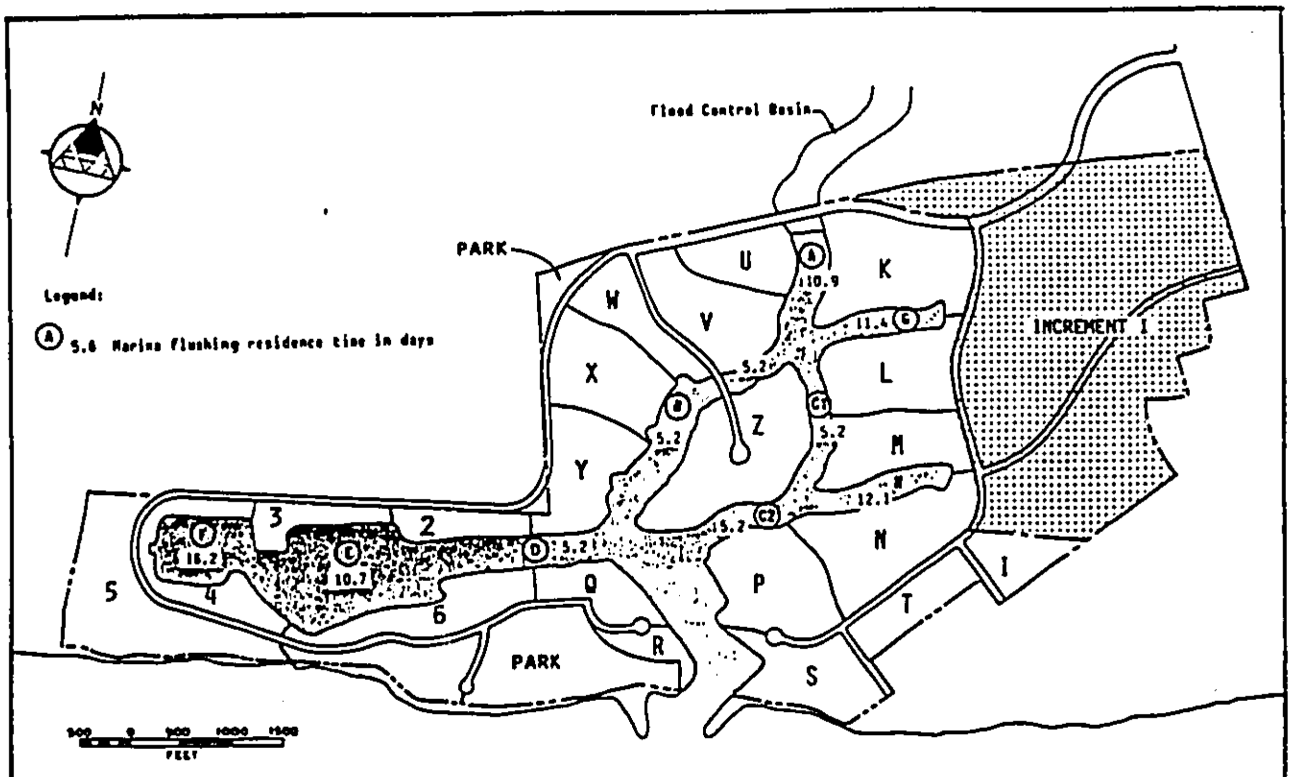
In their letter of December 20, 1985, the Hawaii Department of Land Utilization (DLU) determined the EIS to be inadequate in four areas, including the analysis of alternative entrance channel alignments. An addendum to the Final EIS was subsequently prepared which included a more thorough investigation of entrance channel alignment alternatives. This resulted in the proposal of Alternative 3 identified in the Final EIS as the new marina entrance channel alignment, although the Alternative 3 configuration was modified to eliminate the jetties and adjust the angle of the inner channel to



Note: Sites are identified using methods explained by Walker, J.R. Recreational Surf Parameters, University of Hawaii, TR 73-30, 1972.

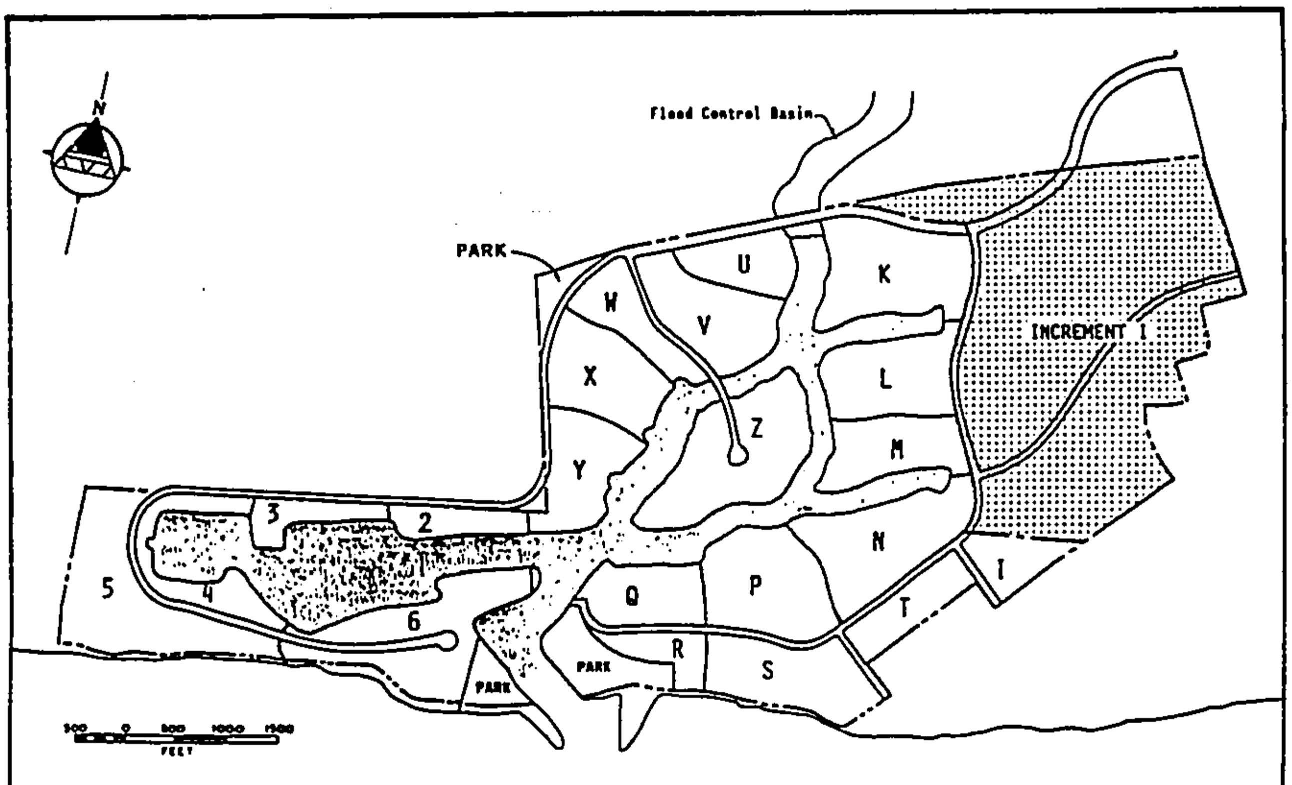
SURFING SITES
(FROM DAMES & MOORE, 1985)

FIGURE A-4



ALTERNATE MARINA CONFIGURATION
ALTERNATIVE NO. 2
(FROM DAMES & MOORE, 1985)

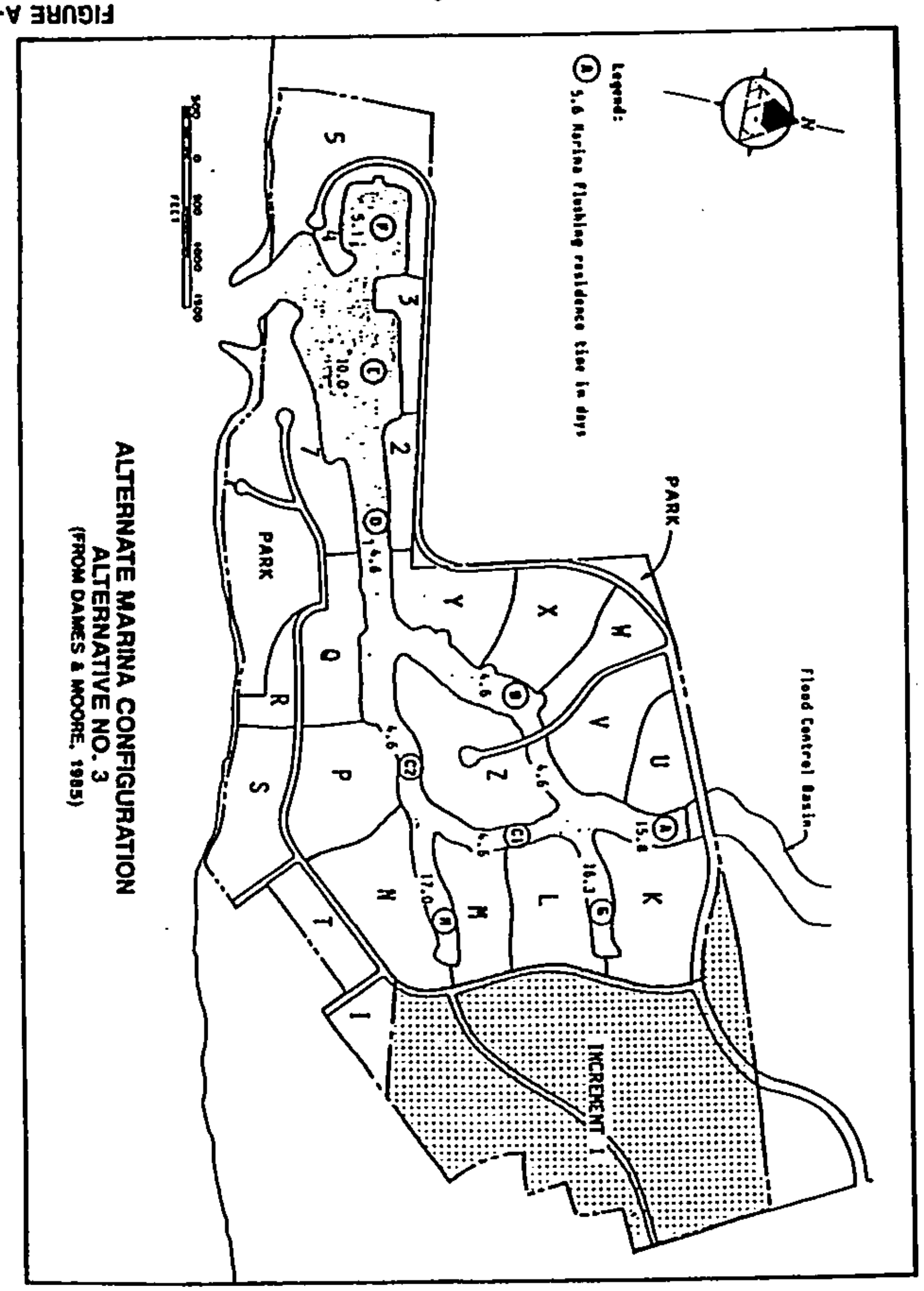
FIGURE A-6



ALTERNATE MARINA CONFIGURATION
ALTERNATIVE NO. 1
(FROM DAMES & MOORE, 1985)

FIGURE A-5

FIGURE A-7



ALTERNATE MARINA CONFIGURATION
ALTERNATIVE NO. 3
(FROM DAMES & MOORE, 1985)

provide improved water circulation in the marina. This marina entrance alternative, identified in the Final Addendum document as the West Entrance, is illustrated in Figure A-8. The former proposed channel alignment shown in Figure A-2 was referred to as the East Entrance.

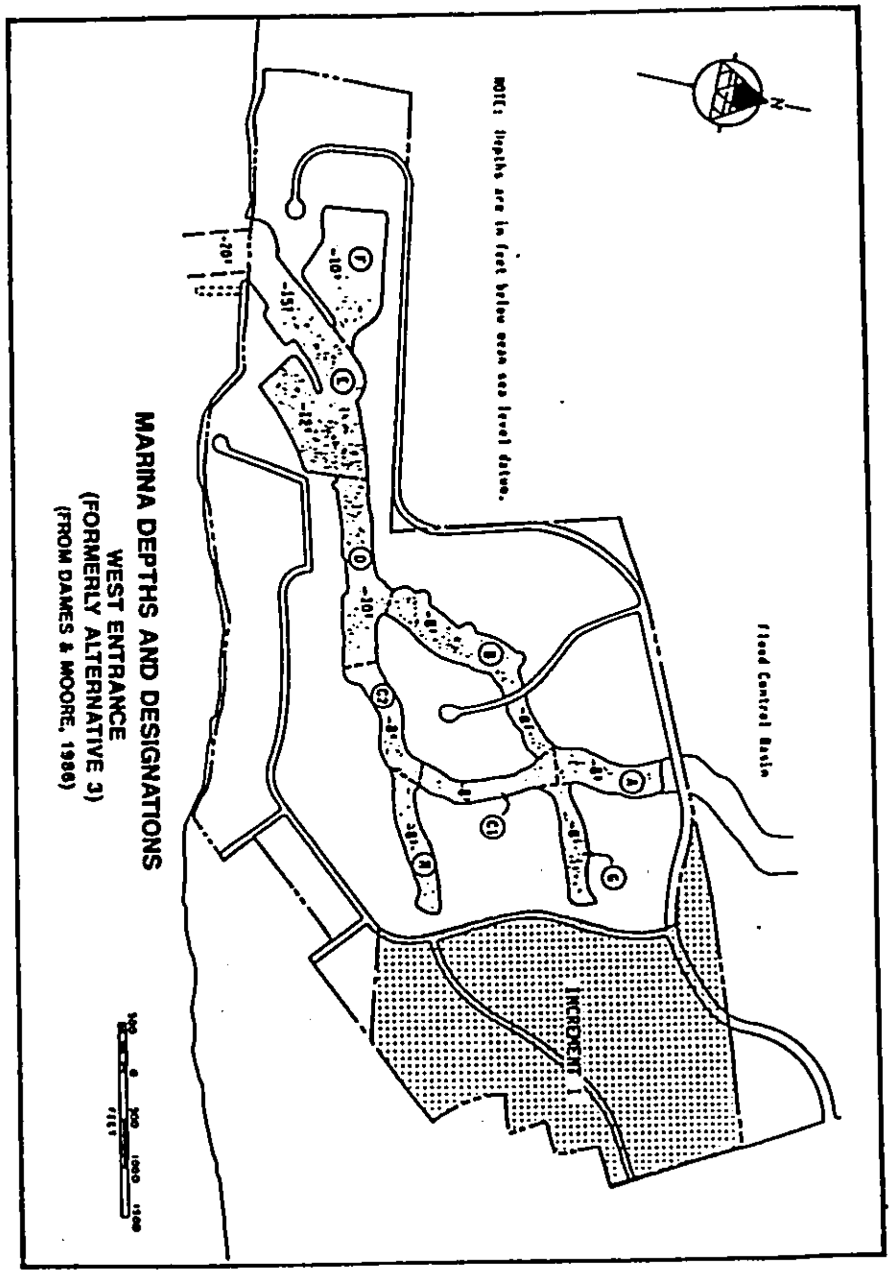
The modified Alternative 3 configuration without jetties required major modifications to the marina interior to allow for adequate wave attenuation. Approximately 1000 linear feet of berthing area was eliminated. This entrance configuration also provided no protection from cross-currents which can create navigation hazard.

The Final Addendum document discussed the relative impacts of the alternatives. Regarding impacts to coastal processes, the West Entrance was assessed to have lesser impacts due to its location on a rocky reach of shoreline which has little or no sand. The East Entrance alignment was considered to be within the Oneula Beach system with a higher potential to trap sand and adversely affect Oneula Beach. Additionally, the West Entrance was considered to have minimal adverse impact on surf sites (based upon the SCORP studies) since it is located between two surf sites, whereas the East Entrance is located through the middle of a surf site (see Figure A-9). The West Entrance channel location and alignment was subsequently adopted as the currently proposed entrance channel.

D. Ewa Marina - Evaluation of Project Impacts on Adjacent Beaches, (Moffatt & Nichol, Engineers, 1990a) and Ewa Marina - Evaluation of Project Impacts on Surf Sites, (Moffatt & Nichol, Engineers, 1990b)

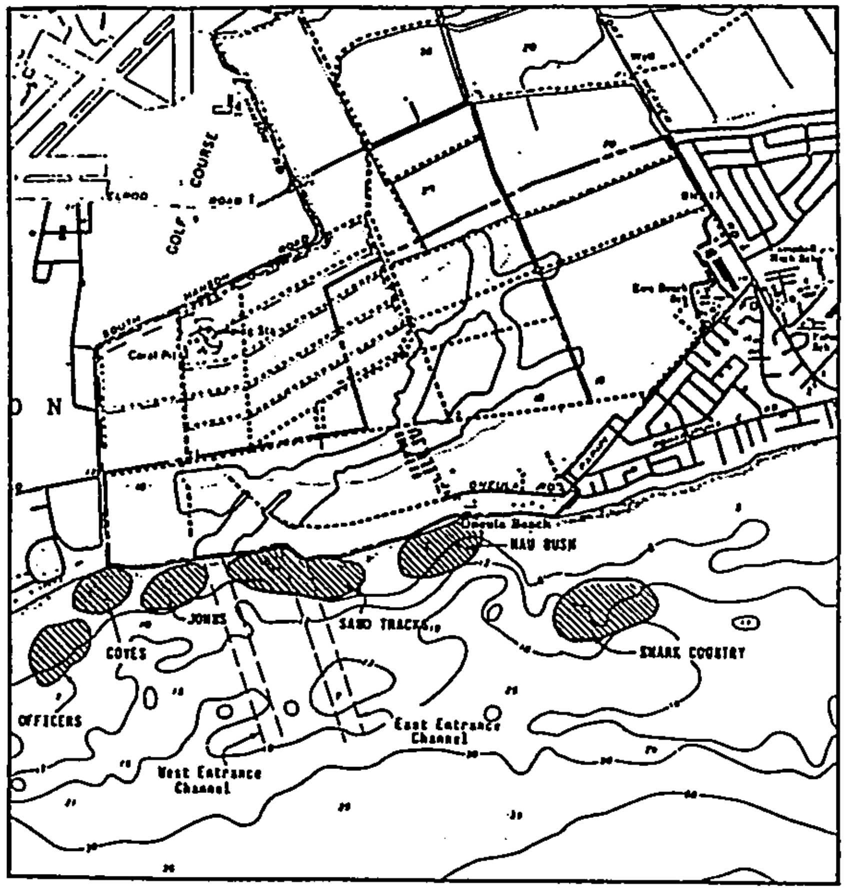
These two supporting studies were conducted in preparation for the U.S. Army Corps of Engineers permit process to investigate potential impacts of the project on adjacent beaches and surf sites. These studies evaluated impacts of the currently proposed marina entrance location and configuration only (see Figure 2-1); specific analyses of entrance channel alternatives were not included in these studies.

The beach impact study evaluated the littoral processes that may impact and be impacted by a marina entrance channel at the proposed location and configuration. The results indicated that construction of an entrance channel



MARINA DEPTHS AND DESIGNATIONS
WEST ENTRANCE
(FORMERLY ALTERNATIVE 3)
(FROM DAMES & MOORE, 1986)

FIGURE A-8



Sources:

Unpublished Study, "The Board Surfing Sites Survey", Division of State Parks, Outdoor recreation and historic sites, Dept. Land and Natural Resources.

From copy in Harbors Division, Dept. of Transportation, Original work generated through Dept. Planning and Economic Development 1971 SCORP Studies.

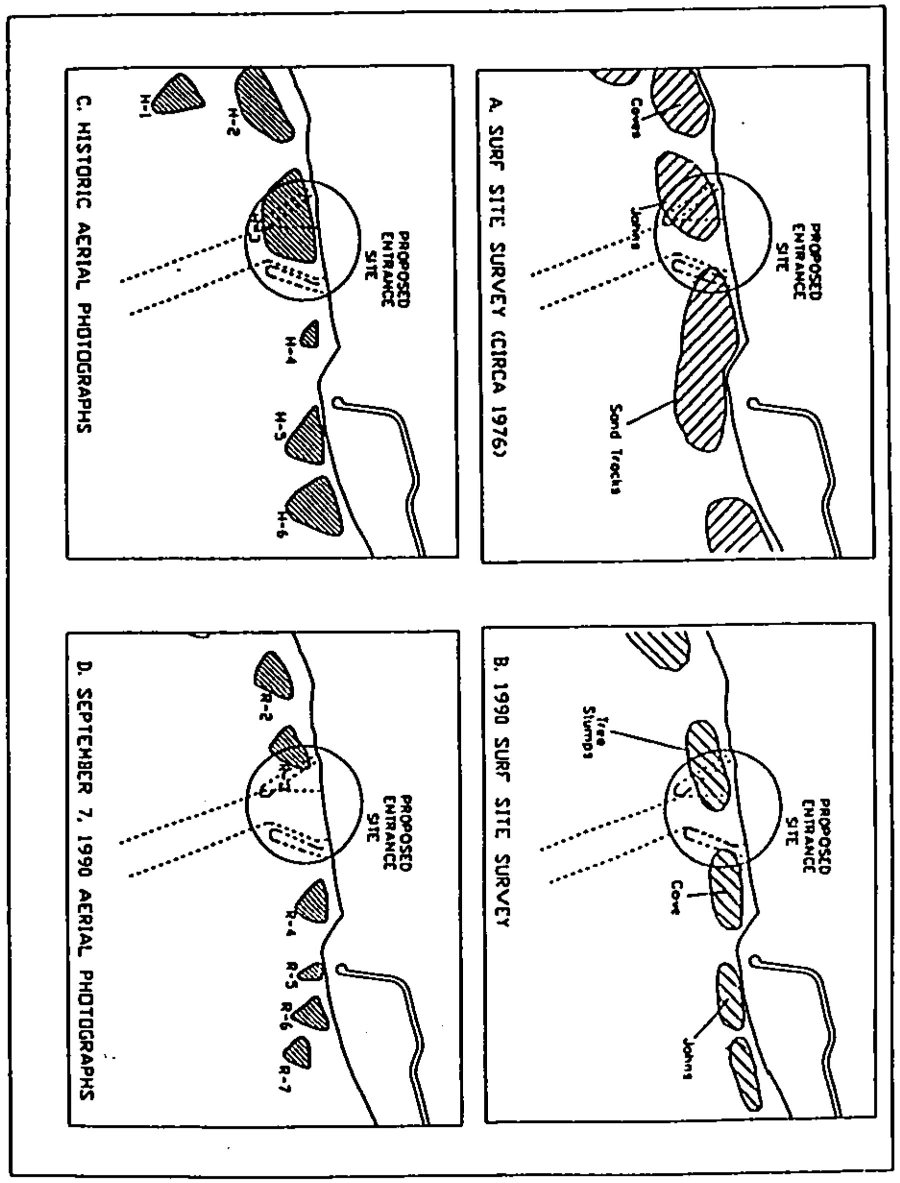
Base Map - U.S.G.S Topographic Map; Ewa, Puuloa, Oahu, Hawaii; 1968.

SURFING SITES
(FROM DAMES & MOORE, 1986)

FIGURE A-9

at the proposed site is not expected to have a significant impact on adjacent beaches.

The surf site impact study included a detailed analysis of the existing surf sites in the project vicinity. The study more accurately located and described the location and characteristics of surf site locations. Figure A-10 compares surf site locations determined by various methods. Detailed bathymetric analysis and study of historic aerial photographs were used to further define the surf sites in terms of aerial extent and range of surfing conditions. The study found that, in general, the proposed marina entrance channel is at the best location along the project reach for the minimization of adverse impacts on surf sites. This alignment favored completely preserving the Coves site from both direct and indirect impacts, but would have directly encroached at a less popular and less defined surf area of Tree Stumps. The report suggested that some minor relocation of the channel toward the east could reduce some of the impacts on one of the identified sites without compromising the adjacent site.



IDENTIFIED SURF SITES ADJACENT TO PROPOSED MARINA ENTRANCE

FIGURE A-10

Appendix B

Progress Report on the Effect of HASEKO's Proposed Marina on the Ewa Limestone Aquifer

Progress Report on the Effect of HASEKO's Proposed Marina on the Ewa Limestone Aquifer

Prepared by
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and
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March 1991

Table of Contents

List of Figures *

List of Tables

S U M M A R Y

HASEKO (Hawaii), Inc. intends to develop approximately 1100 acres of land in Ewa for residential, recreational, and commercial use. A 140-acre excavated marina, the focal point of the project, would extend 1600 to 3700 feet into the reef limestone. This formation supports an important brackish groundwater aquifer which presently provides 15 million gallons per day (MGD) for Oahu Sugar Company's (OSCO) irrigation use. As development on the Ewa Plain proceeds, much of the sugar cane use will shift to golf course and other landscape irrigation, so the continued viability of the aquifer is a significant concern.

This report details progress of an investigation on the potential effect of excavating the marina into the reef limestone aquifer. Hydraulic and water quality computer models have been developed as the principal means to evaluate the aquifer's performance and the potential effects of the marina. To calibrate the models, a number of monitoring wells were installed at the marina site and elsewhere on the Ewa Plain. Measured water levels in these wells, particularly their response to tidal variations, have enabled the aquifer's hydraulic characteristics to be quantified. Water chemistry and mineralogical analyses have been made to understand how the aquifer's observed characteristics came to be. Geophysical surveys have been correlated with borehole data to enable the specific borehole information to be extended over a larger portion of the Ewa Plain.

Results and conclusions of the investigative work to date can be summarized as follows:

1. Good calibration of the areal hydraulic model, the areal water quality model, and the vertical slice, saltwater interface model has been achieved using field data and historic records of pumpage and water quality.

2. The areal and vertical slice water quality models have been able to simulate past and present salinity levels in the aquifer. It is clear from this work that concentration of salts by irrigation return flow, rather than sea water intrusion, is the most important contribution to the aquifer's salinity.

3. Initial efforts to calibrate the areal hydraulic model before the borehole data was available strongly suggested that a hydrologic barrier effect occurs near or at the shoreline. This effect causes groundwater levels to be higher than if uniform permeability existed throughout the reef limestone.

4. Extensive field work has been undertaken to confirm, quantify, and understand this shoreline barrier effect. Key aspects of this work are as follows:

   a. Water level monitoring and attenuation of the tidal signal moving through the aquifer conclusively demonstrate that the shoreline barrier effect exists all along the shoreline of the marina site and along the Campbell Industrial Park shoreline as well.

   b. The possibility that this effect is simply a hydraulic phenomenon caused by accumulated shoreline sediment, cemented beachrock, or exceedence of laminar flow conditions in the aquifer near its shoreline discharge has been considered. However, field testing and computer simulation indicate that this is not the most probable explanation.

   c. Dissolution of reef material in the fresher portion of the aquifer and re-precipitation in the aquifer's transition or saline zones at depth appears to be a more likely explanation of the barrier effect. Water chemistry of the boreholes supports this interpretation. All cores retrieved from the boreholes show that leaching of the reef skeleton has occurred in upper strata and extensive cementation has taken place at depth. However, testing in boreholes at the marina site has been unable to verify that this micro-scale dissolution/re-precipitation process has caused significant, macro-scale permeability differences among the strata.

   d. Monitoring tidal attenuation in boreholes inland of Barbers Point Deep Draft Harbor and similar work done at Mindarie Keys in Australia, both sites of recent excavation into reef limestone, has demonstrated that the hydrologic barrier effect exists at these newly formed shorelines as well. If the dissolution/re-precipitation process is the basis for this effect, the natural "re-sealing" occurs in a relatively short time frame.

5. Computer modeling results of existing and future land use scenarios, done to illustrate aquifer conditions with and without the proposed marina excavation, allow the following tentative conclusions to be drawn:

   a. The present viability of the aquifer as an irrigation supply is largely dependent on irrigation return flow from OSCO cane fields mauka of the railroad R.O.W. These fields are irrigated by inland wells which draw from the Koolau basalt aquifer. If this irrigation is discontinued or significantly curtailed, the salinity of water in the reef limestone would rise and the aquifer would become unusable for irrigation. To offset this, a 10 to 20 MGD alternative source of aquifer recharge would be needed.

   b. Future urban development will displace cane fields makai of the railroad R.O.W. These fields are irrigated primarily by pumping from the limestone aquifer. As these cane fields are displaced, total pumpage from the reef limestone will be reduced, groundwater levels will rise, and the adverse effect of saline irrigation return flow will be lessened. Continuation of OSCO's irrigation of its mauka fields would be necessary to achieve this, however.

   c. If the marina is excavated and the shoreline hydrologic barrier effect is not re-asserted around its perimeter, the marina would function as a point sink for groundwater discharge. Sixty to seventy percent of groundwater now discharging along the 6-mile shoreline of the computer model would be diverted into the marina. Groundwater levels would drop and salinity increases would occur, primarily inland and east of the marina. Irrigation use such as for the Meyers-Seibu and Puuloa golf courses would be adversely affected.

   d. If a hydrologic barrier effect does re-occur around the marina's perimeter, then the impact of the project would be dramatically reduced. Future groundwater levels would rise and water quality would actually improve. The beneficial effect of reducing total pumpage and irrigation return flow resulting from sugar cane displacement would more than offset the effect of the marina.

   e. It is expected that this natural "re-sealing" phenomenon will occur to at least some extent along the marina's new shoreline. If it is not sufficiently effective, however, a man-made seal such as interlocking sheet piles or a dense pattern of probe and grouting would be necessary. Computer simulation indicates that the artificial seal would have to extend through the full depth of the brackish lens.

A better understanding of the shoreline hydrologic barrier effect and an ability to predict its effectiveness if the marina is constructed are necessary. The best way to obtain this knowledge, and perhaps the only way to obtain it conclusively, is to make a test excavation into the shoreline at the site of the marina entrance. The excavation should be to the marina's proposed depth, at least 30 feet wide, and extend at least 200 feet inland. Boreholes around the perimeter of this cut can be used to quantify the changes in aquifer characteristics parameters during and following the excavation. This will enable more accurate predictions of the re-sealing phenomenon to be made and to test artificial sealing measures, should that be necessary. The cut would be small enough to avoid adversely affecting ongoing groundwater use and the shoreline could be fully restored following the test if that is appropriate.

1.0 Introduction

HASEKO (Hawaii), Inc. purchased approximately 1100 acres of land from Campbell Estate for residential/commercial development on the Ewa plain, Oahu, Hawaii (Figure 1). An integral part of the proposed development is a 140-acre marina which would extend inland 1600 to 3700 feet.

The Ewa area currently supports a variety of activities, including sugar cane cultivation, military facilities, golf courses and residential development. All of these land uses require water for irrigation and potable supply. Some portion of the irrigation water is derived from the underlying shallow aquifer comprised of reef limestone. The aquifer is known locally and is referred to herein as the caprock. Potable and additional irrigation water is obtained from the basalt aquifer system which underlies the caprock and extends inland.

In recent years, the caprock aquifer has supplied 15 to 25 MGD for sugar cane irrigation. Much of the aquifer's recharge is comprised of irrigation return flow. Some of this is generated by irrigation directly above the limestone aquifer but a far greater portion is derived from basalt water irrigation of inland fields.

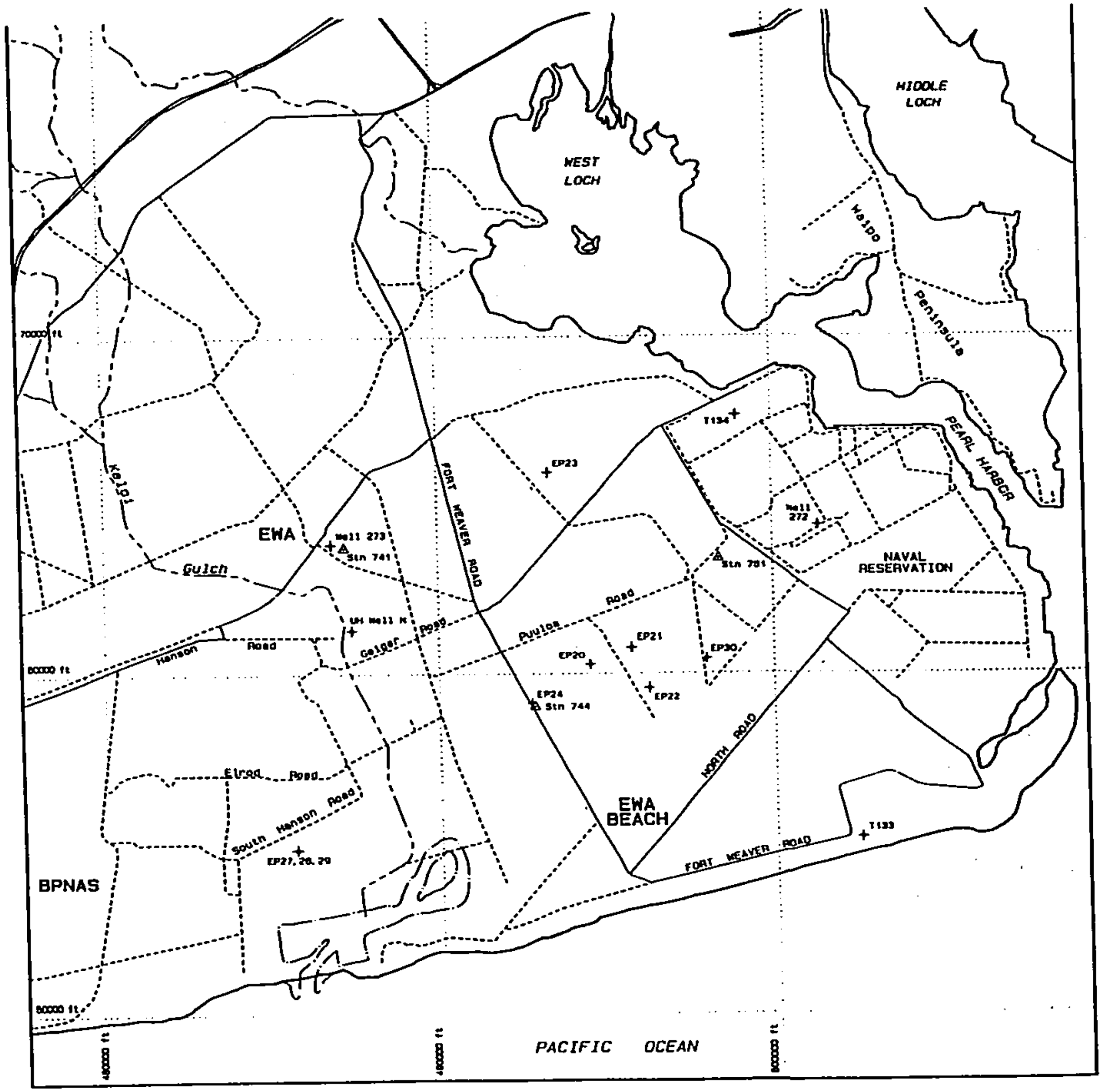
The potential impact of cutting the marina into the shallow aquifer system has initiated a detailed groundwater investigation on behalf of the marina developers, HASEKO. The most important tool of the investigation has been the development of a numerical model of the groundwater flow within the shallow aquifer system to simulate the impact of marina construction. Field investigations were also conducted to assist in model calibration and test some of its findings.

This technical report details the three independent numerical models established to address areal hydraulic responses, seawater-groundwater interface movement, and regional salinity distribution. For each of these models, the impact of changing land use and the associated changes in water budgets were incorporated to construct a picture of the long-term viability of the caprock aquifer system as a groundwater resource. The impact of the proposed marina development and possible remedial actions are presented with each model.

2.0 Hydrogeological Setting

2.1 Project Location

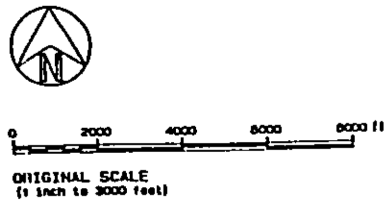
The Ewa Marina project is located on the Ewa plain on the south western coast of Oahu, between the Barbers Point Naval Air Station and the Ewa Beach community. The plain has an area of approximately



EWA MARINA
GROUNDWATER IMPACT
ASSESSMENT
On Behalf of
BELT COLLINS & ASSOCIATES

LEGEND:

- Coastline
- Major Roads
- Minor Roads (tracks)
- Surface water channels (gulches)
- Proposed Marina
- Rainfall Stations



LOCATION MAP

FIGURE 1

Mackie Martin & Associates
Groundwater Engineers

28 square miles and is bounded to the north by the Waianae Range, the Pacific Ocean to the south and west, and Pearl Harbor to the east. Relief is low, with a gentle grade towards the shoreline of 10 to 20 feet per mile.

The Ewa plain receives about 20 inches of rainfall per annum, ranging from 18.3 inches at Barbers Point to 23.5 inches at station 702.2. Rainfall stations 741, 744 and 751, in the vicinity of the proposed development (Figure 1) have long-term average rainfalls of 21.5, 21.1 and 21.1 inches, respectively. Most of this rainfall occurs during the winter months as a result of cyclonic storms. Pan evaporation across the plain is high. The limited data available suggests an annual average of 82 inches. Experimental data indicates that the average evapotranspiration (ET) by sugar cane with continuous access to moisture is approximately equal to the pan evaporation. A figure of 80 to 85 inches for ET on the plain is generally used.

2.2 Regional Geology

The Ewa plain is formed by a sequence of marine sedimentary deposits (wedges), referred to as caprock, overlying a sloping volcanic basalt basement (Figure 2). While reef development is the dominant process, downslope transport of terrestrial alluvium is locally significant. In addition, sea level changes in recent geological times are superimposed upon these processes.

The resulting statigraphic profile of the caprock is comprised of coral reef horizons at various levels separated by layers of silt and clay of marine and terrestrial origin. The caprock starts several miles inland and increases in thickness to a maximum of about 1100 feet in the south east. There is a very good correlation of the major horizons from well logs across the entire coastal plain.

The uppermost stratum of the caprock is relatively 'clean' fossil reef limestone, exposed over the southern two-thirds of the Ewa plain and covered by alluvium over the remainder. This stratum has a thickness of about 150 to 200 feet at the coast and thins inland, terminating at the northern extent of the caprock. Based on test hole drilling, this stratum is underlain by gray and brown mud, generally of marine origin closer to the shoreline with increasing amounts of volcanic origin moving inland. There is evidence of a marl/soil/sand layer overlying the caprock in the north eastern margin of the plain along the shoreline of Pearl Harbor's West Loch (bore T134).

2.3 Hydrogeology

The schematic representation of the aquifer systems illustrates the two distinct water bearing formations. A deeper, highly permeable basalt aquifer underlies the whole of the plain. This aquifer

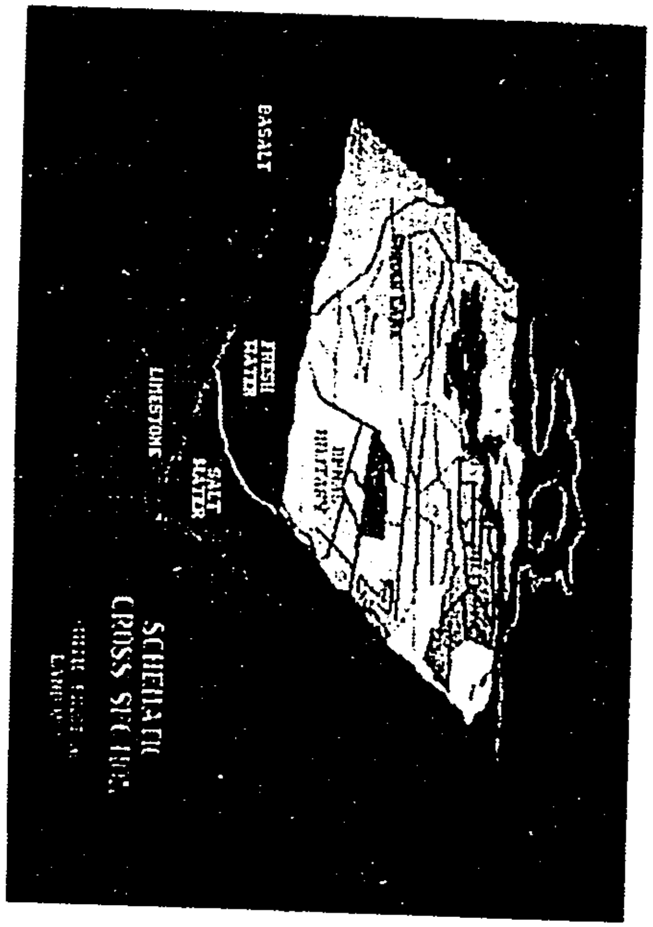


FIGURE 2

is effectively separated from contact with sea water and the shallow fresh system by the weathered surface of the volcanics and the interlayered marine and alluvial muds.

2.3.1 Basalt Aquifer

A relatively thick lens of fresh water has accumulated within the basalt aquifer. Recharge occurs in the high rainfall highlands via direct infiltration or temporary storage in dike compartments and subsequent percolation to the aquifer. Inland of the alluvial plain, irrigation water from basalt wells and Waiahole Ditch is also recycled to the aquifer.

Where the basalt aquifer is not confined by caprock, discharge along the shore occurs at or below sea level. Where the seaward flow is blocked by caprock, discharge occurs over the top, under the toe or through openings in the caprock. This is evident as a number of springs discharging into Pearl Harbor. Flow from these springs is now in the range of 40 to 60 MGD and varies directly with head in the aquifer.

Annual fluctuations in wells in the basalt aquifer inland of the east side of the Ewa plain are of the order of 6 to 8 feet, in response to seasonal variations in recharge, discharge, and draft. Long-term head declines in excess of 20 feet over a number of decades have resulted from development of the basal groundwater for domestic, irrigation, and municipal purposes.

2.3.2 Caprock Aquifer

With the exception of the uppermost fossil reef, the caprock system contains saline groundwater. The surface aquifer has developed upon a 40 to 50 feet thick bed of marine and alluvial mud which functions as an aquiclude. Fresh and slightly brackish water recharges this aquifer from rainfall, irrigation return and leakage from the basalt aquifer.

Groundwater flow within the uppermost limestone aquifer is predominately southwards toward the ocean. The rate of discharge is controlled by vertical recharge and draft rates over the extent of the aquifer and by horizontal inflow at its northern boundary. Vertical recharge resulting from the application of excess irrigation water appears to be the dominant factor in the existing water quality and availability. Prior to development of the plain for sugar cane (i.e., prior to irrigation), the salinity of the aquifer was significantly higher.

Although the aquifer is known to be highly transmissive, permeability data is scarce. Dale (1964) computed a permeability of 25,000 feet per day based upon tidal response and Williams (1976)

calculated a value of 20,822 feet per day. In contrast, Dames and Moore (1986) estimates a permeability of 4000 feet per day and Mink et al (1988) considers 2500 feet per day to be a reasonable value. Far less work has been done on the aquifer's storage coefficient, but values in the range of 0.10 to 0.20 are generally used.

Recorded water table elevations across the eastern part of the Ewa plain range up to 2.5 feet above sea level (Table 1). A series of investigations holes completed during initial studies for the proposed Ewa Marina (Dames and Moore, 1986) indicate a sharp rise away from the coast to a height of about 2 feet approximately 1000 feet inland. Further inland the water table is relatively flat, with a maximum elevation of 2.5 feet recorded at EP20. Local groundwater levels, away from abstraction points, may be higher.

Table 1

Recorded Water Levels

Well	Distance From Coast (Ft.)	Measured Head (Ft.)
EM1	4250	1.98 - 2.26
EM2	3530	1.91 - 2.03
EM4	2810	1.99 - 2.07
EM5	2150	1.78 - 2.17
EM6	1680	2.08 - 2.34
EM7	1640	1.93 - 2.17
EM8	1270	1.83 - 2.22
EM9	1030	1.71 - 2.09
EM10	1170	1.94 - 2.18
EM11	290	0.61 - 0.83
EM12	1030	1.98 - 2.24
EP20	7300	1.50 - 2.46
EP21	7800	1.70 - 2.44
EP22	6300	> 1.80
EP23	5000	> 1.80
EP24	6800	> 1.80

2.3.3 Salt Water Interface

As illustrated in Figure 2, the caprock aquifer contains a relatively thin fresh to brackish lens which floats upon sea water near the coast and intersects the underlying aquiclude inland. Although the inland extent of the salt water wedge is not known precisely, drilling adjacent to the Honouliuli STP through the aquifer into the aquiclude (11,000 feet inland) did not encounter salt water; in fact, the salinity was essentially constant through the entire vertical profile. In this well, the aquiclude was intersected at approximately 75 feet below sea level (Lau et al., 1986). It is widely accepted and was specifically demonstrated during field work for this study that a Ghyben-Herzberg lens exists across the coastal margin. Based on the results, it is estimated that the transition zone intersects the underlying aquiclude approximately two miles inland.

The Ghyben-Herzberg definition of the groundwater/seawater interface location assumes the interface is sharp and the underlying sea water is static. An interface position is then calculated based upon the density difference between fresh water and sea water, resulting in an interface depth below sea level equal to 40 times the elevation of groundwater above sea level.

Cooper (1959) described the circulation of seawater beneath the fresh water lens and mixing between the two bodies of water due to advection, dispersion and diffusion. The resulting transition zone thickness is dependent upon hydrogeological constraints. Under certain conditions, the width of the transition zone may be small relative to the thickness of the aquifer and the interface is assumed to be sharp (an abrupt interface). In this case, the Ghyben-Herzberg assumption is a reasonable approximation.

Volker (1980) suggested a dimensionless quantity, the pore Peclet number (Pe), which characterizes groundwater flow within the aquifer and the nature of the interface. The pore Peclet number is defined as;

$$Pe = ud/D\Theta$$

where, u = Darcy velocity at the upstream freshwater boundary,
d = aquifer thickness,
D = characteristic dispersion coefficient,
Θ = effective porosity.

A high value of Pe occurs when advection dominates dispersion, indicating a sharp interface. Conversely, a low value of Pe corresponds to the greater influence of dispersion and therefore a broader interface zone.

Although the longitudinal and lateral dispersion coefficients are unknown for the Ewa limestone aquifer, the expected values lie near the low end of the range 8 to 80 feet and 1 to 25 feet, respectively. Correspondingly, a range in Pe from 200 to 300 is expected, which suggests the presence of a relatively sharp interface and that the Ghyben-Herzberg approximation is valid. This conclusion has been generally confirmed with downhole salinity data from test holes in the vicinity of the marina site.

2.4 Existing Land and Water Use

Previous assessments of groundwater availability across the Ewa plain have used geographical boundaries to define management sectors (Mink et al., 1988). Land and water use in the four sectors covering the eastern part of the plain (Figure 3) are summarized as follows:

- Honouliuli Sector

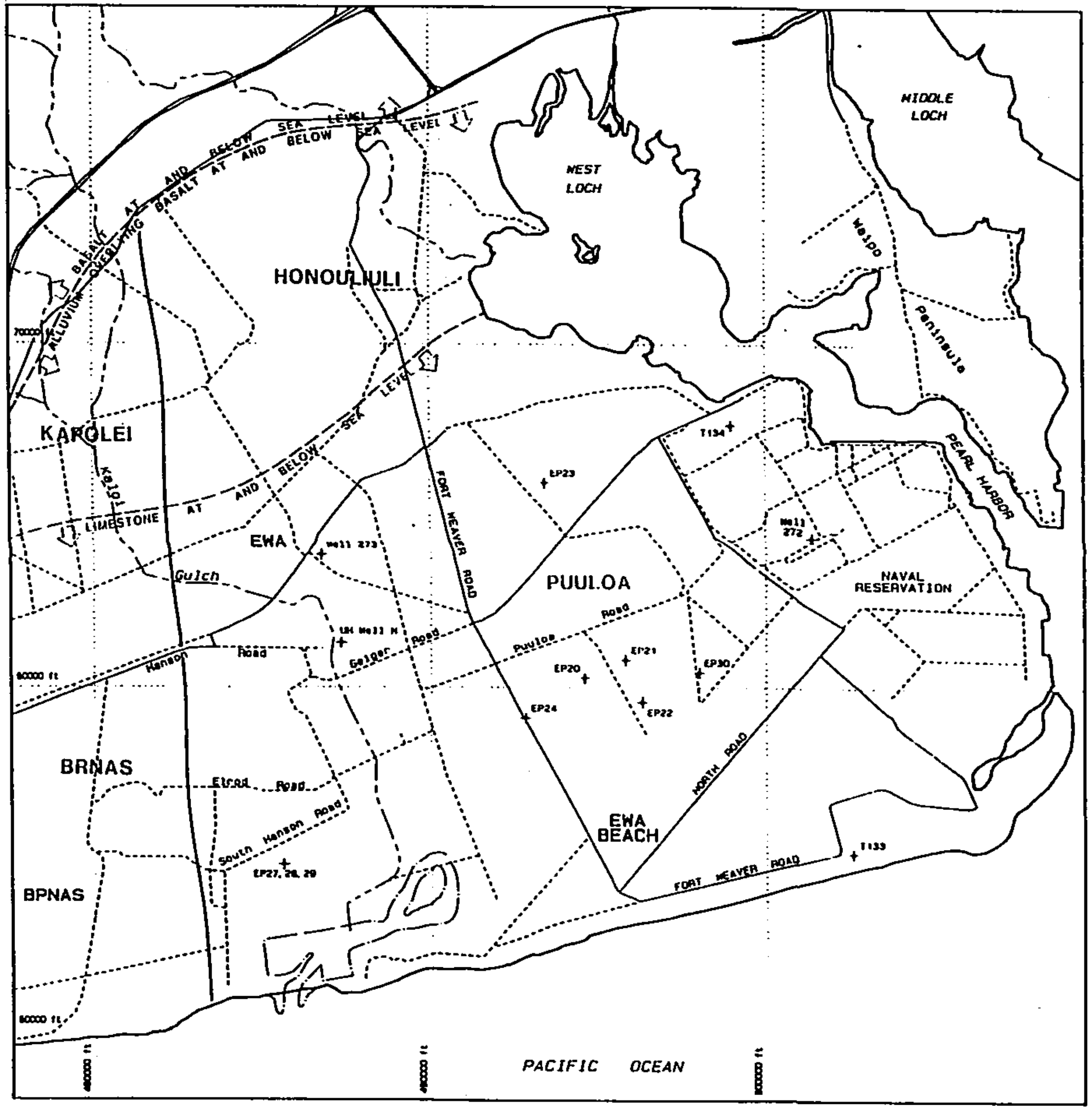
  The Honouliuli sector comprises 4.0 square miles, from the inland margin of the caprock to the north, to the railroad to the south. To the east, it is terminated by West Loch and the western boundary is the assumed location of the subsurface Koolau/Waianae unconformity. Most of this sector (78%) has been planted in sugar cane irrigated by groundwater drawn from the Koolau basalt aquifer. Of the total sector area, 40% consists of alluvium overlying limestone (with 650 acres of sugar) and 60% alluvium overlying basalt (1350 acres of sugar).

- Puuloa Sector

  Immediately down gradient of the Honouliuli sector, all of the Puuloa sector (11.5 square miles) is exposed limestone with a thin (1- to 5-foot) alluvial soil covering. It is also bounded to the west by the Koolau/Waianae unconformity and to the east by West Loch. In the past, about 2500 acres of sugar cane (34% of the sector) irrigated with caprock groundwater and 400 acres (6% of sector) irrigated with basalt groundwater were cultivated. The remainder of the area is used for military and residential purposes. Caprock groundwater has been extensively used for irrigation. Future conversion from sugar cane to other land uses within this sector will have significant impacts upon the regional caprock aquifer system.

- Kapolei Sector

  The Kapolei sector (3.0 square miles) consists of alluvium overlying basalt in the north (33%) and limestone in the south (67%). In the past, virtually the entire sector was planted in sugar cane and most of these fields were irrigated by basalt groundwater. Much of this sector is designated for future residential development.



EWA MARINA
GROUNDWATER IMPACT
ASSESSMENT
On Behalf of
BELT COLLINS & ASSOCIATES

LEGEND:
- Coastline
- Major Roads
- Minor Roads (tracks)
- Surface Water Channels (gulches)
- Proposed Marina
- Geological Boundary (sector boundary)
- Sector Boundary

0 2000 4000 6000 8000 ft
ORIGINAL SCALE
(1 inch to 3000 feet)

WATER MANAGEMENT SECTORS

FIGURE 3

Mackie Martin & Associates
GROUNDWATER ENGINEERS

- Barbers Point Naval Air Station (BPNAS)

  This sector has an area of 4.6 square miles, all of which is exposed limestone. The military base occupies the entire sector and land uses include the airfield itself, military housing, a golf course, and significant areas of scrub vegetation.

2.5 Groundwater Abstractions and Recharge

Exploitation of the basalt aquifer for sugar cane irrigation of the fields in the northern part of Ewa plain has been taking place since the 1880s. Groundwater abstraction from the limestone aquifer for irrigation commenced in the 1930s, coincident with expansion of the cultivated area southwards.

Complete historical data for caprock pumpage and chloride levels recorded at EP20 and EP23 (after Mink et al., 1988) is presented in Figure 4. Two distinct periods are evident from this data, corresponding to pre-drip and post-drip irrigation periods. Prior to 1974, all sugar cane fields (supplied by basalt or caprock water) were furrow irrigated. Over the period from 1974 to 1982, most fields were converted to drip (Figure 5).

Drip irrigation is a more efficient water use, resulting in lower supply requirements but also lower return flow to the underlying aquifer. Groundwater abstraction from caprock wells for the period 1983 to 1988 is presented in Table 2. An extended version of this table which includes the estimated basalt water imported and the corresponding application rate (expressed in MGD per 100 acres) is presented as Table 3. Significant variations in application rates result from rainfall variations, field management practices (fallow fields and crop cycling), and inaccuracies of the data.

Table 2
Summary of Pumpage From OSCO Limestone Aquifer Wells* 1983 to 1988

Well	Irrigated Area (Acres)	Pumpage (MGD) 1983	1984	1985	1986	1987	1988
EP20	198.65	1.63	0.83	0.15	0.75	1.79	0.90
EP21	278.57	1.93	1.43	1.52	1.65	1.85	1.56
EP22	210.45	1.87	0.73	1.80	1.51	1.66	1.18
EP23	875.71	8.93	8.21	7.23	7.45	4.05	4.17
EP24	190.62	1.80	0.97	1.50	1.27	1.40	1.71
EP27	826.10	8.04	6.31	6.68	5.37	6.40	3.47
EP30	147.67	1.10	0.79	1.12	0.86	1.24	0.88
Totals	2727.77	25.30	19.27	19.98	18.86	18.39	13.87

* An OSCO pump east of Barbers Point Access in a coral pit is not included in this summary as it is beyond the area of this study.

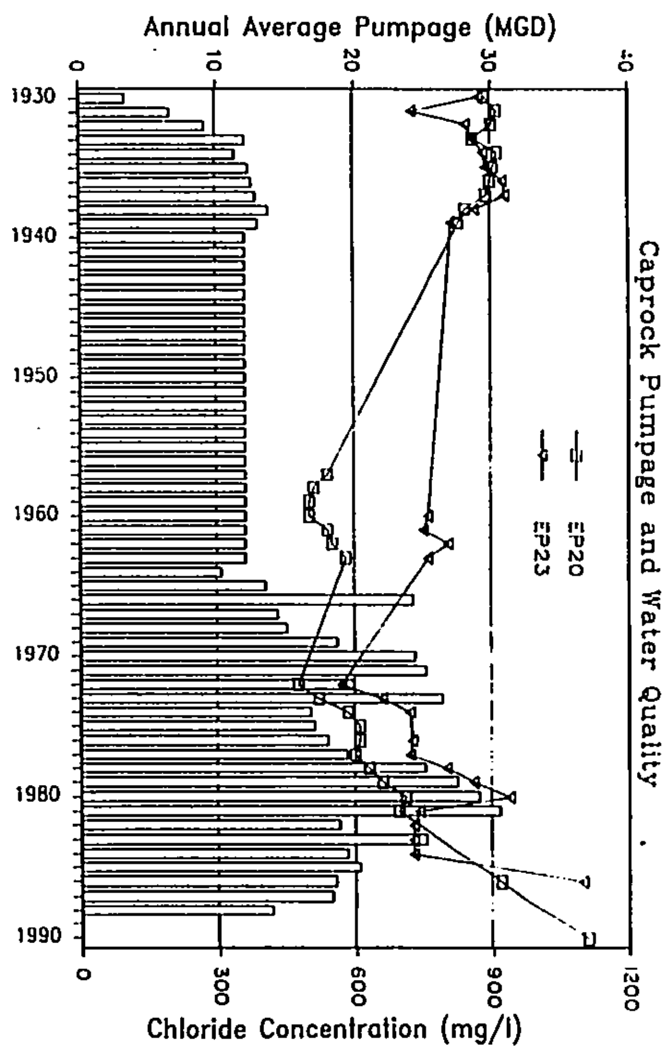
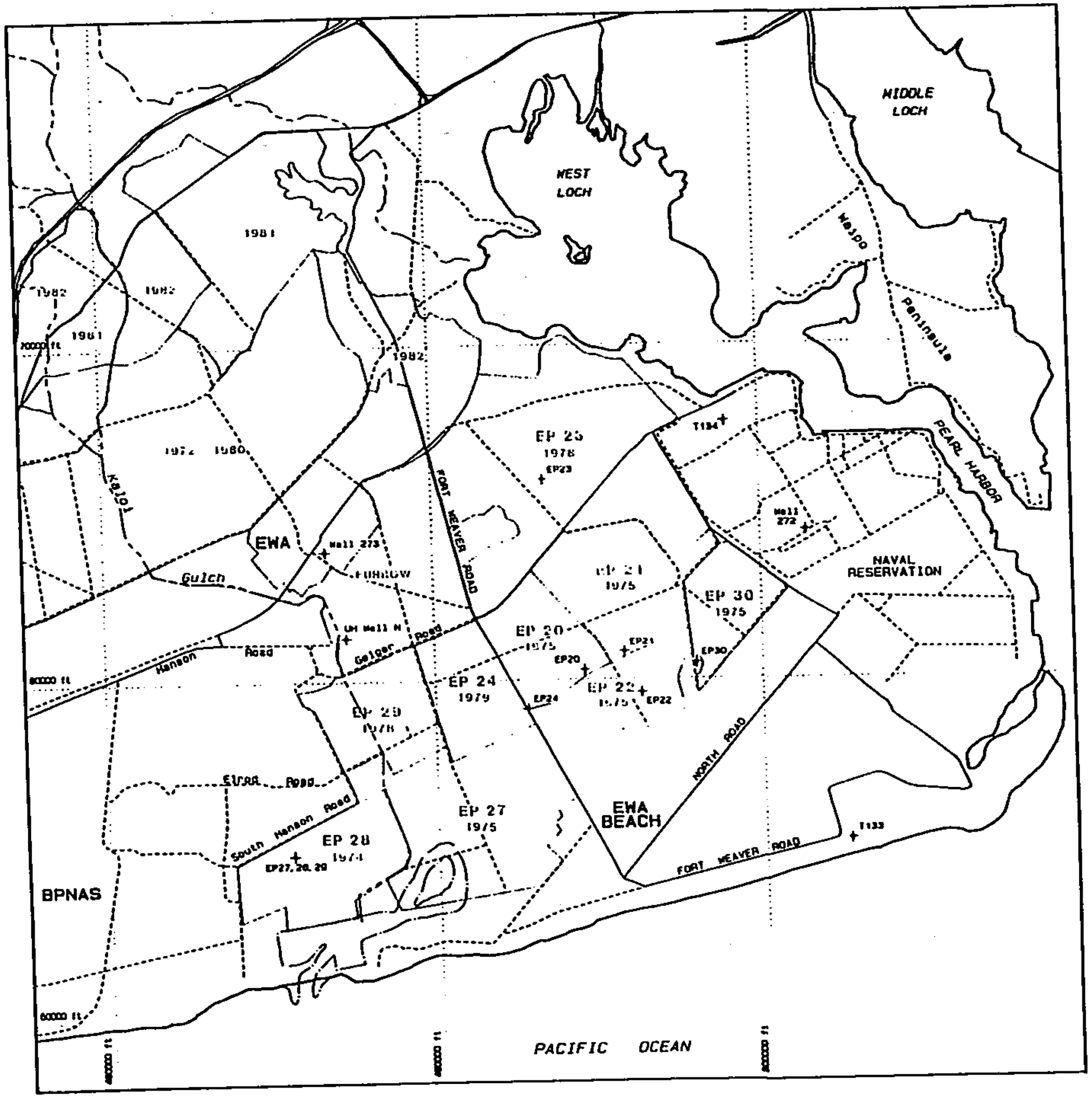


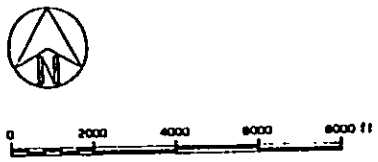
FIGURE 4

EWA MARINA
GROUNDWATER IMPACT
ASSESSMENT
On Behalf of
BELT COLLINS & ASSOCIATES



LEGEND

- Coastline
- Major Roads
- Minor Roads (tracks)
- Surface Water Channels (gulches)
- Proposed Marina
- Field Boundary
- Date of Conversion from Furrow to Drip Irrigation



ORIGINAL SCALE
(1 inch to 3000 feet)

IRRIGATION CONVERSION SCHEDULE

FIGURE 5

Mackie Martin & Associates
GROUNDWATER ENGINEERS

Between 1974 and 1989, the total annual draft from the caprock aquifer on the east side of the Ewa plain ranged from 16.60 MGD to 26.48 MGD (Table 3). The estimated volume of basalt water imported to irrigate these fields ranged from 0 MGD to 10 MGD. A corresponding range in average application rates of 0.68 MGD/100 acres to 1.23 MGD/100 acres (for a total irrigated area of 2728 acres) is calculated.

Calculation of recharge due to the return of irrigation water is based upon the assumption that sugar cane transpires at a rate equal to the pan evaporation rate. Experimental data has shown that the ratio of sugar cane evapotranspiration (ET) to pan evaporation varies between 0.8 and 1.2 (Mink et al., 1988). A median ratio of 1.0 is assumed for furrow irrigation (where ET fluctuates in accordance with water availability). For drip irrigation, water is available continuously to the sugar cane, suggesting a ratio of 1.0 is also appropriate. Net irrigation return flow to the aquifer is therefore described by the following equation:

Return = Irrigation Application + Rainfall - Pan Evaporation

The Ewa plain is characterized by low rainfall and high pan evaporation. Consequently, irrigation practices dominate the water budget for the aquifer. Pre-drip estimates of recharge suggest an average return of 50% of the applied irrigation water, reducing to an average of 31% under drip irrigation.

It is important to note that the change in water circulation resulting from the conversion to drip irrigation implies a degrading of return water quality. If it assumed that chlorides are conservative, then all chloride applied as irrigation water is returned to the aquifer as recharge; only insignificant amounts are lost to plant uptake and evapotranspiration. For example, if the initial chloride concentration in the irrigation water is 700 mg/l (for example), under furrow irrigation the return water quality will show 1400 mg/l chlorides as opposed to 2100 mg/l chlorides with drip irrigation. This aspect is addressed subsequently with the areal water quality (mixing) model.

Inflow at the upstream boundary of the study area is a combination of irrigation return and lateral and perhaps upwards leakage from the underlying basalt aquifer. Mink et al. (1988) employed similar water balance calculations to those described above to estimate irrigation return over the basalt irrigated fields. For the furrow irrigation period, 14 MGD return in Honouliuli sector and 11 MGD in the Kapolei sector was calculated. Subsequent to the conversion to drip irrigation those returns reduced to 8 MGD and 7 MGD, respectively. All of this return water flows southwards, resulting in the recharge to the upper limestone aquifer.

	[illegible]			[illegible]			[illegible]			[illegible]			[illegible]			[illegible]			[illegible]			Annual Total		
	Caprock Pumpage (MGD)	Basalt Import (MGD)	Rate Applied (MGD/100 Ac)	Caprock Pumpage (MGD)	Basalt Import (MGD)	Rate Applied (MGD/100 Ac)	Caprock Pumpage (MGD)	Basalt Import (MGD)	Rate Applied (MGD/100 Ac)	Caprock Pumpage (MGD)	Basalt Import (MGD)	Rate Applied (MGD/100 Ac)	Caprock Pumpage (MGD)	Basalt Import (MGD)	Rate Applied (MGD/100 Ac)	Caprock Pumpage (MGD)	Basalt Import (MGD)	Rate Applied (MGD/100 Ac)	Caprock Pumpage (MGD)	Basalt Import (MGD)	Rate Applied (MGD/100 Ac)	Caprock Pumpage (MGD)	Basalt Import (MGD)	Average Rate Applied
1974	.13	1.40	.94	.51	1.57	.97	1.38	.71	.55	5.11	1.21	.95	.27	1.44	.89	4.92	.00	.60	.81	1.31	.85	22.35	10.69	1.19
1975	.21	1.07	.79	.83	1.35	.78	1.07	.99	.81	4.83	1.74	1.09	.12	2.11	1.13	4.89	.00	.59	.16	.13	.74	13.21	10.09	1.23
1976	1.01	.15	.50	.36	.46	.47	1.70	.03	.25	4.74	1.61	.73	.39	.71	.43	5.35	.46	.41	.13	.22	.16	17.17	1.14	.74
1977	.15	.10	.57	.76	.47	.45	1.12	.06	.91	5.57	1.21	.75	.09	.71	.43	5.09	.03	.62	.33	.29	.53	17.75	2.25	.76
1978	.33	.02	.50	.70	.02	.28	1.31	.00	.88	7.19	.00	.59	2.22	.36	.63	4.11	.06	.76	1.25	.30	.64	19.93	.90	.73
1979	.10	.03	.05	.35	.00	.38	2.02	.09	.46	8.61	.00	.93	2.30	.30	1.22	7.46	.00	.32	1.31	.00	.29	22.91	.09	.84
1980	1.67	.00	.66	1.60	.00	.60	2.05	.09	.97	8.53	.09	.37	1.49	.03	.78	7.47	.00	.55	.18	.00	.46	24.25	.03	.89
1981	1.37	.00	.99	1.03	.00	.68	2.27	.50	1.08	8.45	.03	.57	1.33	.00	1.04	8.56	.00	1.44	1.35	.00	.92	36.40	.00	.97
1982	1.40	.30	.71	.33	.00	.22	1.38	.00	.42	7.29	.03	.93	1.40	.99	.71	6.35	.00	.76	.46	.03	.45	18.83	.06	.68
1983	1.42	.30	.81	1.94	.06	.69	1.37	.00	.73	8.97	.03	1.02	1.35	.06	.91	7.81	.30	.55	1.13	.09	.76	25.14	.06	.82
1984	.31	.60	.41	1.44	.00	.52	.75	.00	.15	8.21	.03	.56	.97	.00	.51	6.17	.00	.27	.42	.00	.35	19.36	.00	.71
1985	.15	.00	.08	1.54	.02	.55	1.11	.00	.46	7.25	.02	.56	1.51	.30	.79	6.75	.00	.82	1.13	.00	.77	20.26	.00	.76
1986	.76	.00	.30	1.40	.00	.57	1.40	.03	.70	7.51	.03	.36	1.35	.00	.66	5.79	.00	.61	.35	.00	.57	18.73	.00	.63
1987	1.78	.00	.90	1.84	.10	.78	1.65	.00	.75	6.81	1.29	.67	1.40	.30	.71	6.33	.02	.77	1.34	.00	.84	20.26	2.10	.82
1988	.99	.35	.66	1.56	.26	.65	1.18	.10	.65	4.17	1.93	.70	1.71	.00	.90	3.47	.00	.42	.83	.09	.66	16.60	2.71	.71
1989	.53	.60	.75	1.56	.47	.73	1.10	.26	.73	4.17	2.30	.75	1.71	.03	.90	1.17	.30	.13	.33	.19	.72	13.87	4.86	.83

Table 3: Caprock Pumpage from [illegible] Wells 1974 to 1989, Imported Basalt Water Estimated by Well and Irrigation Application Rate

In addition, an estimated inflow to the caprock aquifer of 4 to 5 MGD results from leakage from the basalt aquifer. Thus, a total inflow to the inland margin of the aquifer within the Honouliuli sector of 19 to 20 MGD is estimated during the furrow era, reducing to 12 to 13 MGD under drip irrigation.

Additional sources of recharge to the caprock aquifer are derived from importation and irrigation of basalt water on the BPNAS Golf Course and within residential areas. Recharge at the BPNAS golf course is estimated at 0.2 MGD for an irrigation rate of 0.5 MGD. Recharge within residential areas results predominantly from lawn irrigation and cesspools. Estimated recharge of 0.8 MGD for the Ewa Beach Community and 0.2 MGD for Iroquois Point has been assigned.

2.6 Land Use Scenarios and Corresponding Water Budgets

A number of land use scenarios have been considered in this study, each corresponding to key events within the short- to medium-term future. The impact of changing land and water uses have been compared initially to the existing water levels and fluxes. For longer term management scenarios, the interim land use without the proposed marina, defined as the expected land use in the early to mid-1990s, is referred to as a base case.

2.6.1 Pre-Existing Land Use

A pre-existing land use period has been considered to assess the impact of the conversion from furrow to drip in the irrigated areas and provide a refinement to areal water quality modeling. Conversion of fields commenced in 1974 and proceeded through 1982. Figure 5 illustrates the distribution of basalt and caprock irrigated fields and approximate conversion dates to drip irrigation. Figure 6A shows the land use which prevailed in this period.

Prior to 1974, annual average caprock pumpage fluctuated yearly by up to 10 MGD and chloride varied from 475 mg/l to 1037 mg/l (as indicated by sparse data in Mink et al., 1988). In the early 1970s chloride levels on the order of 500 to 700 mg/l prevailed. As this followed a long period of stable land use, changes in water management since the 1970s have had a significant impact upon the caprock aquifer.

The net water budget varies substantially over this period. Figure 6B presents the estimated water budget for 1974, which indicates a discharge along the shoreline 26.2 MGD.

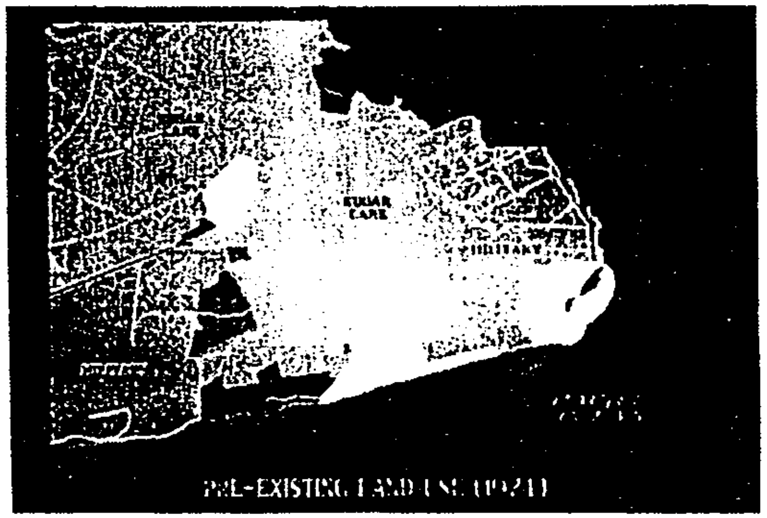


FIGURE 6A

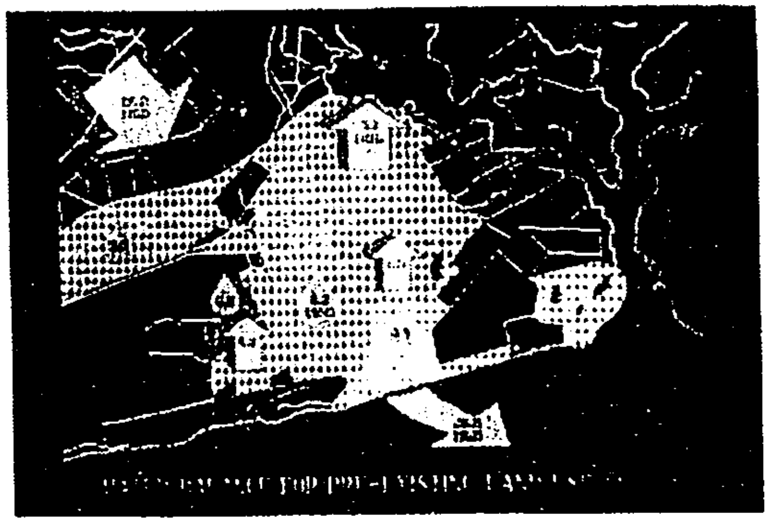


FIGURE 6B

BOUNDARY INFLOW OUTFLOW
CAPROCK PUMPAGE
RECHARGE IN MGD

2.6.2 Existing Land Use

Land use in the 1988-89 period is referred to herein as Existing Land Use. It reflects complete conversion to drip irrigation for sugar cane and initial development of Ewa by Gentry development (Figure 7A). The Gentry area shown as 'Open' in Figure 7A was previously irrigated with basalt groundwater. All other areas south of the old railroad were and remain under caprock irrigation, with inland fields irrigated with basalt water.

The water budget, presented in Figure 7B, illustrates the groundwater fluxes used for numerical model of the existing land use. Groundwater abstraction from the caprock aquifer for cane irrigation totals 15.3 MGD, of which 4.7 MGD (31%) is returned to the aquifer. Upstream boundary inflow is fixed at 17.4 MGD which is generally in accord with the estimated 15 MGD across the Puuloa sector boundary in Mink et al., 1988.

The net water balance for this scenario shows an upstream boundary inflow of 17.4 MGD, an internal deficit (excess pumpage over recharge) of 6.6 MGD and a resulting discharge to the ocean of 10.8 MGD.

2.6.3 Interim Land Use

The interim land use scenario depicts conditions in the early to mid-1990s when construction of the marina would begin. At this time, Ewa by Gentry would be almost fully developed and sugar cane would be removed from all fields west of Fort Weaver Road (Figure 8A). The golf courses of Seibu, Puuloa, and within the Gentry project would be completed and in operation.

Reduction of the sugar cane acreage results in a decrease in pumpage from 15.3 MGD to 7.7 MGD and corresponding decline in recharge from the irrigated fields (Figure 8B). However, significant recharge is anticipated from new residential areas. Also counteracting the reduction in sugar cane irrigation would be three new golf courses, two of which are presently under construction (the Puuloa and Myur-Seibu golf courses). Each of these will be irrigated with groundwater from caprock wells, with approximately 30% of the draft from wells abstraction returning to the aquifer as recharge. Pumpage at two of these courses is estimated at 1.0 MGD each. The 27 hole Myur-Seibu course will be 1.5 MGD

The net water balance for this scenario shows an upstream boundary inflow of 17.4 MGD, an internal deficit (excess pumpage over recharge) of 2.6 MGD and a resulting discharge to the ocean of 14.8 MGD. This represents a 4.0 MGD increase in shoreline discharge over existing conditions

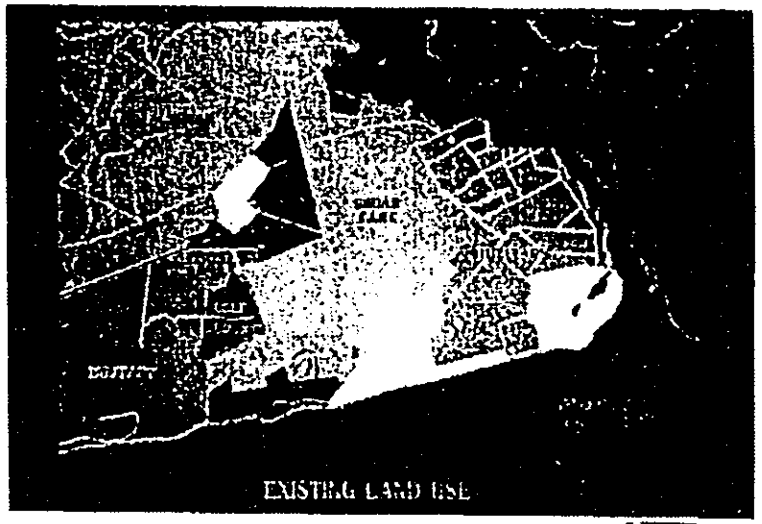


FIGURE 7A

FIGURE 7B

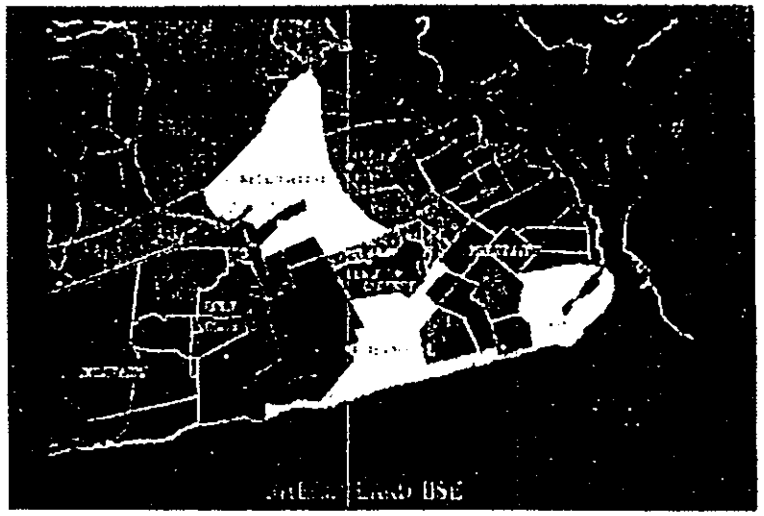


FIGURE 8A

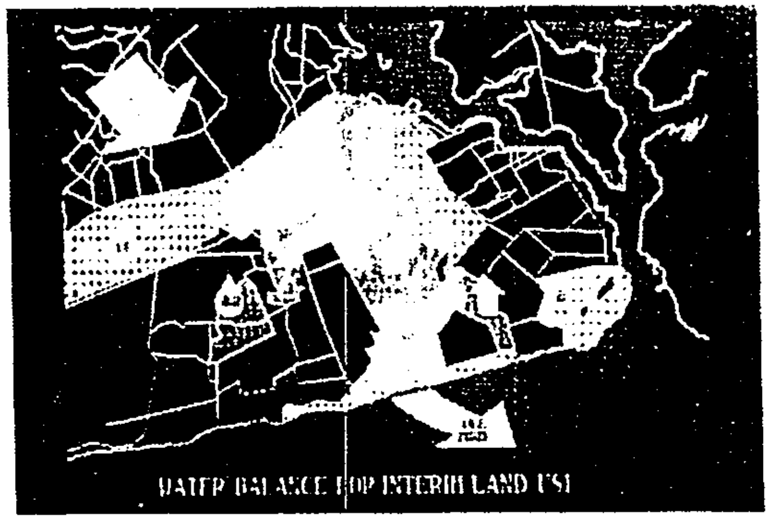


FIGURE 8B

BOUNDARY INFLOW-OUTFLOW   CAPROCK PUMPAGE   RECHARGE IN MGD

2.6.4 Future Land Use

The future land use scenario (Figure 9A) depicts the fully developed Ewa plain corresponding to Campbell Estate's Long Range Master Plan. Within the modelled area, sugar cane is only retained within the Blast Zone adjacent to West Loch. The remainder of the plain is predominantly residential. An important assumption in this scenario is the continuation of cane irrigation inland of the numerical model boundary as well as within the Blast Zone. Thus, the upstream inflow to the caprock aquifer is still 21.8 MGD.

Additional abstraction is assigned to the Ewa Marina Golf Course (1.0 MGD) and the low density apartment (LDA) areas which will have landscape irrigation by caprock wells (Figure 9B). A combined pumpage of 1.7 MGD is estimated for the LDA areas.

The net water balance for this scenario shows an upstream boundary inflow of 17.4 MGD, an internal deficit (excess pumpage over recharge) of 3.7 MGD and a resulting discharge to the ocean of 13.7 MGD.

2.6.5 Potential Long-Term Land Use

This land use scenario was included to assess the potential impact of the end of sugar cane cultivation and its important return flow input at the inland margin of the numerical model. It is assumed that residential development would occur over all of the cane fields removed except those within the Blast Zone which would remain fallow (Figure 10A).

The net water balance for this scenario (Figure 10B) shows an upstream boundary inflow of 8.0 MGD, an internal deficit (excess pumpage over recharge) of 0.5 MGD and a resulting discharge to the ocean of 7.5 MGD. Upstream inflow has been calculated as 6.5 MGD of leakage component from the basal aquifer and 1.5 MGD return from residential recharge.

3.0 Field Investigations

Numerical models solved by computer are the primary tools used to study potential effects of the marina's construction. A full discussion of the areal hydraulic model, and areal water quality model and vertical slice, water quality model follows in Sections 4.0 and 5.0 of this report. Initial work to calibrate these models strongly suggested that a hydrologic barrier effect occurs along the shoreline creating higher groundwater levels immediately inland. Since such an effect had not been previously documented or even observed, a number of field investigations were undertaken to confirm that the

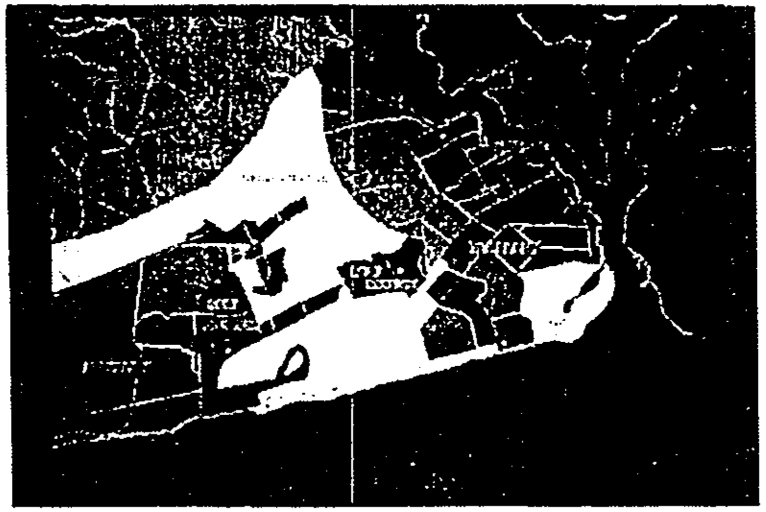


FIGURE 9A

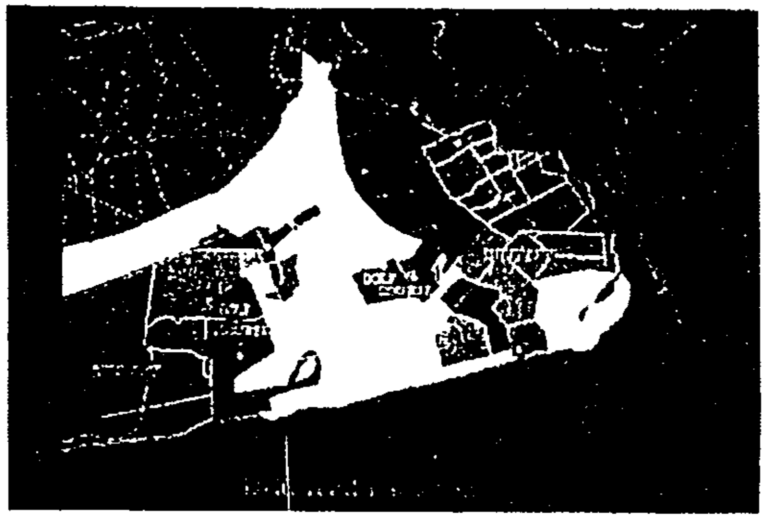


FIGURE 10A

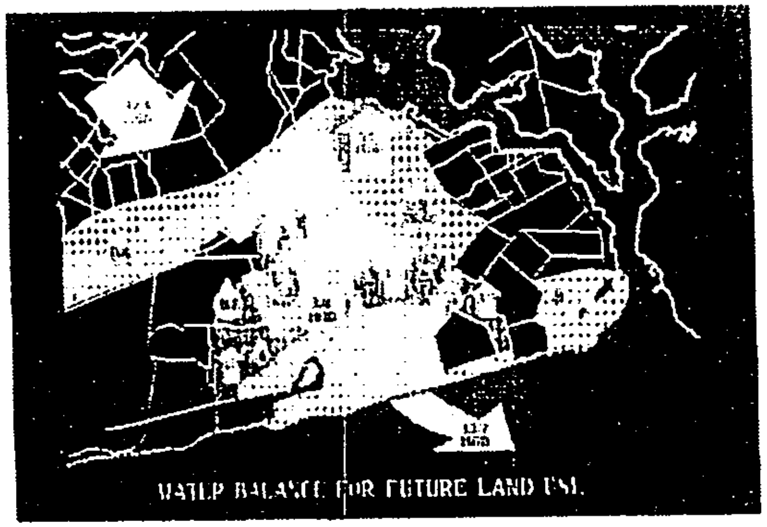


FIGURE 9B

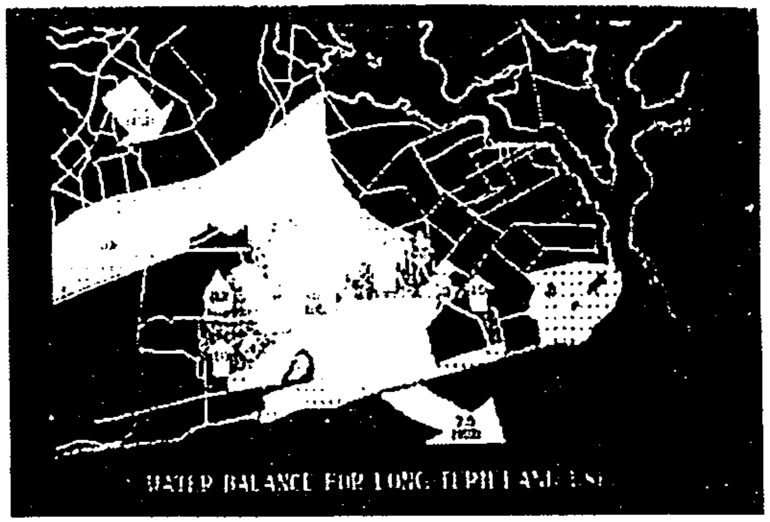


FIGURE 10B

effect does, in fact, exist, to understand the mechanisms which create it, and to be able to predict the aquifer's response to the marina's excavation through this barrier.

Field work conducted in support of the marina evaluation consisted of the following:

1. Construction of Monitoring Wells. Core drilling of 11 boreholes within the Ewa Marina site, three holes at the inland margin of Barbers Point Harbor, and three more holes in Campbell Industrial Park was undertaken.

2. Mineralogic Analysis of Recovered Cores. The carbonate mineralogy of recovered Ewa Marina cores was studied using low power petrographic examination of prepared thin sections and x-ray powder diffraction techniques. Results of this work are reported in detail in Appendix A and are briefly summarized in Section 3.1.1.

3. Groundwater Level Monitoring. Water levels were measured on a continuous basis in the boreholes and in a tide gage constructed at the shoreline to determine mean groundwater levels and tide-induced variations. This work quantified the hydrologic barrier effect at the shoreline. Calculations of formation permeability have been made from the attenuation of the tidal signal moving inland.

4. Salinity Profiles. A conductivity probe was lowered down the boreholes, enabling profiles of salinity as a function of depth to be developed. These results served as a check on the mean groundwater levels determined by level measurements (using the Ghyben-Herzberg relationship). They were also used to determine sampling depths for hydro-chemical analysis.

5. Hydrochemical Analysis. Geochemical processes, particularly carbonate dissolution in the freshwater zone of the aquifer and subsequent re-precipitation in the lower, saline zone, were investigated by detailed water sampling and analysis.

6. Frequency Domain Surveys. In order to generalize the salinity distribution measured in specific boreholes over a larger extent of the shoreline, frequency domain electromagnetic (FDEM) measurements were made. Results of this work performed by Blackhawk Geosciences, are reported in Appendix B. A good correlation of brackish water lens thickness observed in boreholes and calculated from geophysical data was obtained. It is reasonable to conclude that the water levels and lens thicknesses determined at the boreholes are representative of a greater extent of the shoreline.

3.1 Development and Testing of Monitoring Wells Along the Shoreline of the Ewa Plain

Locations of the 11 test holes developed on the Ewa Marina site and six holes on the west side of the Ewa Plain are shown on Figure 11. All of these were core drilled and subsequently completed with the installation of 2-inch PVC casing and silica sand in the annular space outside the casing. Figure 12 provides details on the depths and other dimensions of the test holes. The initial holes were drilled to fully penetrate the brackish lens into the saltwater zone. Subsequently, only holes open at specific depths were added at the Ewa Marina site to monitor tidal responses in specific strata within and below the brackish lens. This second group of holes are identified as 1A, 1B, 1C, 1D, 5A, and 6 on Figure 12.

3.1.1 Carbonate Mineralogy of the Reef Limestone at the Ewa Marina Site

Appendix A contains a report by Rolf Arvidson of the Department of Oceanography, Marine Geochemistry Division of the University of Hawaii on the carbonate mineralogy of cores recovered from the Ewa Marina boreholes. Investigative techniques consisted of petrographic analysis of prepared thin sections, x-ray diffraction analysis of powdered samples, and visual inspection of the balance of the core samples. With regard to the ability of various strata of the reef limestone to store and convey groundwater, the following characterizations can be derived from this work:

1. Contrasts among the various strata in the reef limestone, which have excellent correlation among the boreholes, are far more dramatic than lateral changes associated with distance from the shoreline. This is a reasonable expectation, given the reef building process. It would also be expected to translate into greater vertical differences in permeability than in lateral ones.

2. Based on lithologic character, skeletal composition, and degree of leaching or cementation, each of the cores studied are comprised of five similar layers:

   a. The uppermost layer consists of intact coral in a matrix of algal debris. Pore spaces remain open, dissolution and cementation are of minor importance, and the layer's permeability is presumed to be relatively high. The thickness of this layer was 20 to 40 feet in the cores and averaged 30 feet.

   b. The second layer was dominately porous coral-red algal rock, with the coralline microstructure fully preserved. Substantial dissolution of the coral has left a very porous network. Porosity is on the order of 50 percent and its permeability is

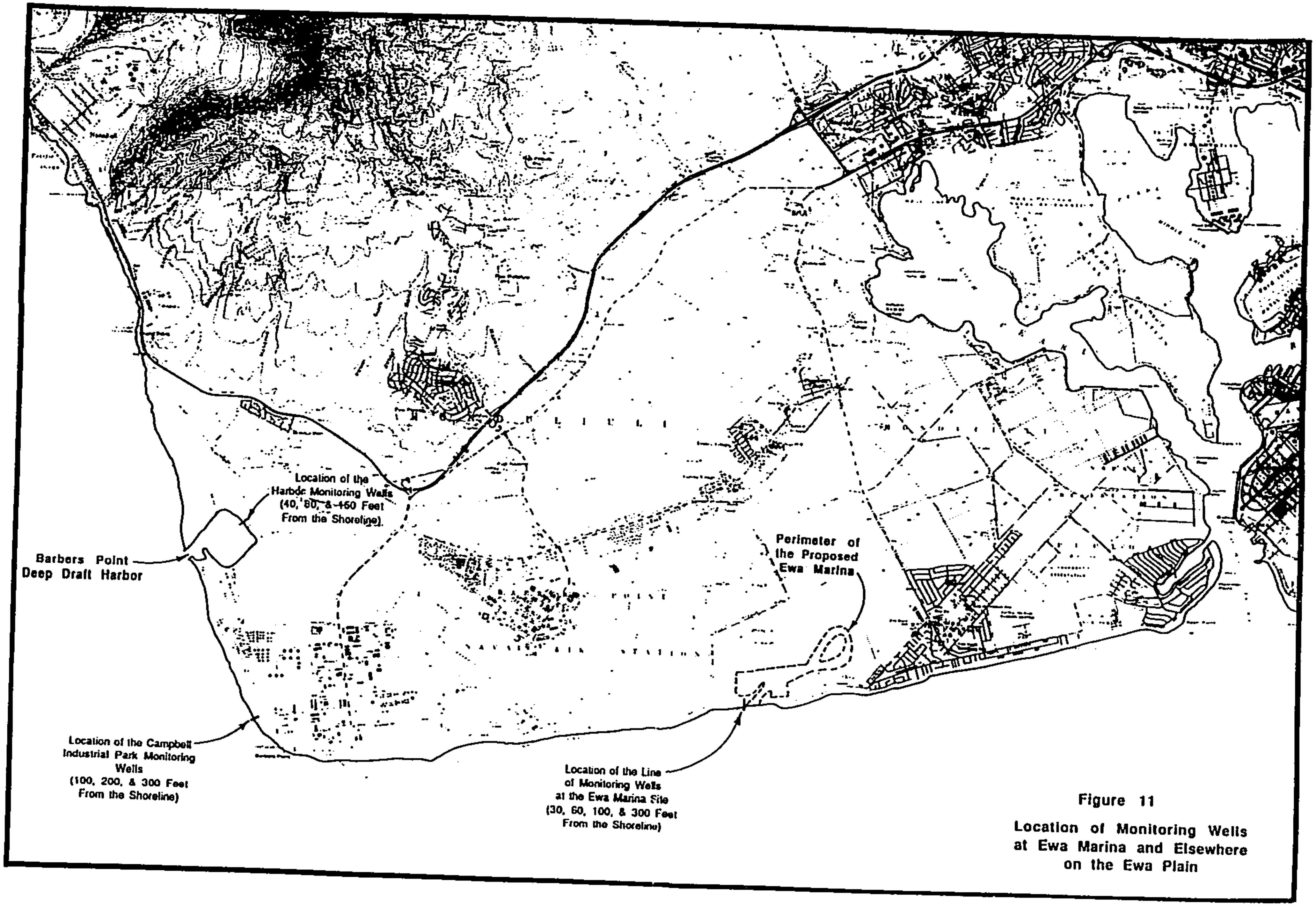


Figure 11

Location of Monitoring Wells at Ewa Marina and Elsewhere on the Ewa Plain

Test Holes at Ewa Marina

Borehole No.	Distance from Shoreline (Feet)	A Measuring Point Elevation (Feet msl)	B Elevation at Top of Well Screen (Feet msl)	C Elevation at Bottom of Hole (Feet msl)	D Length of Solid Casing (Feet)	E Length of Well Screen (Feet)	F Total Depth (Feet)
1	30	8.23	(-) 1.8	(-) 52	10	50	60
1A	30	8.42	(-) 3.6	(-) 14	12	10	22
1B	30	8.42	(-) 19.0	(-) 29	27	10	37
1C	30	7.90	(-) 63.0	(-) 73	71	10	81
1D	30	7.90	(-) 97.0	(-) 108	106	10	116
2	60	8.60	(-) 1.4	(-) 72	10	71	81
3	100	8.72	(-) 1.3	(-) 71	10	70	80
4	300	10.44	(+) 0.4	(-) 80	10	80	90
5	600	11.08	(+) 1.0	(-) 116	10	105	115
5A	600	11.08	(-) 94.0	(-) 116	105	10	115
6	600	11.02	(+) 1.0	(-) 14	10	15	25

Test Holes on the West Side of the Ewa Plain

Borehole No.	Distance from Shoreline (Feet)	D Length of Solid Casing (Feet)	E Length of Well Screen (Feet)	F Total Depth (Feet)
JCIP-1	100	5	40	45
JCIP-2	200	5	40	45
JCIP-3	300	5	40	45
BP Harbor-1	40	10	40	50
BP Harbor-2	80	10	40	50
BP Harbor-3	150	10	50	60

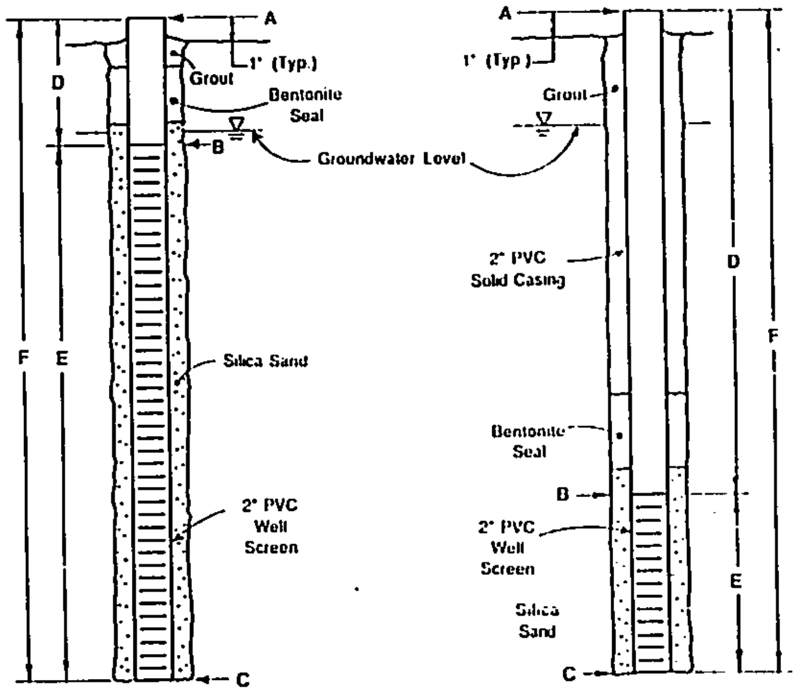


Figure 12

Dimensions and Depths of Monitoring Wells Installed on the Ewa Plain undoubtedly very high. Thickness of this section was variable, from one to 18 feet, and averaged 8.5 feet.

c. The third layer, a red algal grainstone, was modest in size, not present in all cores, and of minor significance to the movement of water in the formation.

d. The fourth layer down is cemental coral-red algal rock, with basically the same skeletal structure as the second layer. However, extensive calcite cementation has occurred, obliterating much of the original microstructure and reducing porosity to 5 to 10 percent. This layer is 15 to 40 feet thick in the boreholes, with an average thickness of 28 feet. Based on appearance and porosity, its permeability is very low in comparison to the two upper layers.

e. The fifth and lowest layer penetrated consists of skeletal grains and other coral debris with virtually no cementation. Smaller pore spaces appear to be molds of unidentified grains; the larger pore spaces are mollusc valve molds. The pore spaces are not generally connected, making them relatively ineffective for the conveyance of water.

As a generalization, the upper two layers, with combined thickness of 25 to 50 feet, appear to have substantially greater permeability than the two lowest layers. Dissolution by groundwater appears to be a significant contributor to the permeability of the second of the two upper layers. In contrast, cementation in the fourth layer down appears to have greatly reduced the permeability of that layer.

3.1.2 Groundwater Levels and Tidal Responses

Stevens Type F recorders and Wesdata (solid state) loggers were employed to monitor groundwater fluctuations in the monitoring wells in response to tidal variations at the shoreline (as measured at a temporary tide gage). Records of these measurements enabled mean groundwater levels to be determined at each borehole. The attenuation and lag of the tidal signal has been used to compute the permeability coefficient of the intervening reef limestone. This work provides conclusive evidence that a hydrologic barrier effect does occur along the shoreline and has allowed the effect to be quantified.

Figure 13 depicts the mean groundwater levels determined at the Ewa Marina boreholes on three separate occasions. The relatively high levels which occur near the shoreline are significant. In a subsequent section, the lower levels that would prevail without a hydrologic barrier effect, that is the levels that would result from uniform permeability in the reef limestone, are compared to these measured levels (Figure 23 in Section 4.1.1). It is also significant to note that the levels declined

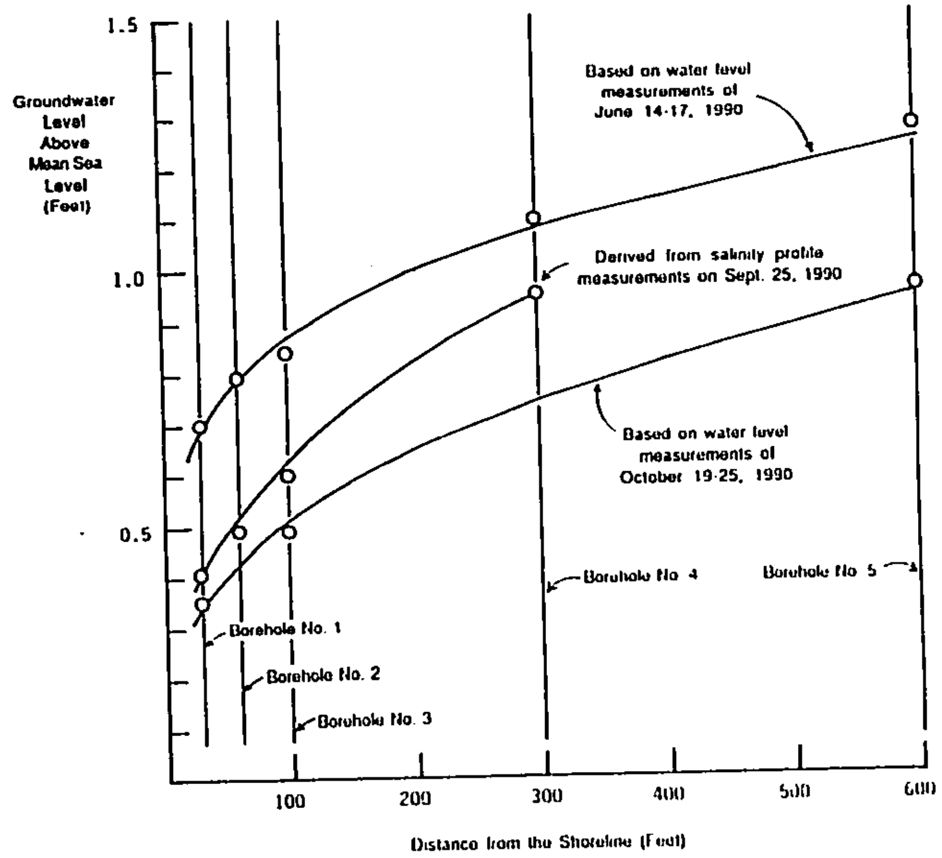


Figure 13

Groundwater Levels in the Ewa Marina Boreholes steadily from the initial measurements in June 1990 through October 1990 period. A subsequent set of measurements, from December 28, 1990 to January 4, 1991, produced levels virtually identical to the October 1990 results. The declining levels are assumed to reflect the aquifer's response to heavy irrigation pumping by Oahu Sugar during the summer months.

Permeability coefficients of the reef limestone at Ewa Marina, computed using the attenuation of the tidal signal, are listed in Table 4. Two very significant findings emerge: (1) there is a dramatic increase in permeability with distance inland; and (2) a variation in permeability among various strata, an expected result from the study of the carbonate mineralogy, has not been demonstrated by the measured tidal variation. Similar tidal measurements and calculations were made for the Campbell Industrial Park and Barbers Point Harbor drill holes. Increasing permeability with distance inland was computed from measured levels in these holes as well (see Table 5).

With regard to evaluating the potential effect of the marina's excavation, the importance of confirming and quantifying the nearshore, hydrologic barrier effect cannot be overstated. Aspects of this phenomenon are as follows:

1. The present barrier effect should be viewed as a beneficial one, retarding the escape of groundwater and inhibiting seawater intrusion.

2. The possibility that the barrier effect is simply a hydraulic resistance phenomenon caused by groundwater movement near the shoreline discharge exceeding laminar flow velocity seems remote. The tidal signal moves through the aquifer as a wave, not as groundwater flow.

3. The barrier effect cannot be effectively simulated as if it were caused by cemented beach rock or an accumulation of lower permeability littoral debris at the shoreline; to produce the measured effect requires a more extensive feature or aquifer property.

4. The effect appears to be related to prevailing groundwater conditions, being more pronounced where the brackish lens in thicker and groundwater flux is higher. For example groundwater flow in the vicinity of Ewa Marina is substantially greater than at Campbell Industrial Park or Barbers Point Harbor.

5. If the effect is attributable to dissolution in the fresh to brackish lens and reprecipitation in the saline zone below, then lesser permeability should occur at depth. Such an interpretation is generally supported by the mineralogical investigation. However, monitoring the tidal signal in

Table 4

Permeability of the Upper Limestone Formation at Ewa Marina Between the Shoreline and Test Hole Measuring Points

Borehole Number*	Distance from the Shoreline (Feet)	Permeability Coefficient (Feet per Day)
1	30	25 to 45
1A	30	25 to 30
1D	30	20 to 30
2	60	100 to 120
3	100	200 to 300
4	300	1700 to 1900
5	600	5600
5A	600	5700
6	600	5000 to 6000
EP-27	3750	30,000

<u>Notes</u>: 1. The permeability coefficients have been determined using the attenuation of the tide as it moves inland through the aquifer. The defining equation

$$\frac{hx}{ho} = e^{-x\sqrt{\frac{\pi S}{to\,Kb}}}$$

where

$\frac{hx}{ho}$ = ratio of tidal signal in the aquifer to the ocean tide

x = distance from the shoreline

S = storage coefficient, assumed to be 0.20

to = tidal period of one half a day

K = permeability coefficient

b = aquifer thickness, assumed to be 150 feet

Table 5

Permeability of the Upper Limestone Formation on the West Side of the Ewa Plain Between the Shoreline and Test Hole Measuring Points

Borehole	Distance from the Shoreline (Feet)	Permeability Coefficient (Feet per Day) *
JCIP-1	100	7000
JCIP-2	200	30,000 to 40,000
JCIP-3	300	50,000 to 60,000
BP Harbor-1	40	600
BP Harbor-2	80	1000 to 1200
BP Harbor-3	150	2000 to 2200

Notes: 1. The permeability coefficients have been determined using the attenuation of the tide as it moves inland through the aquifer. The defining equation

$$\frac{hx}{ho} = e^{-x\sqrt{\frac{\pi S}{to\,Kb}}}$$

where

$\frac{hx}{ho}$ = ratio of tidal signal in the aquifer to the ocean tide

x = distance from the shoreline

S = storage coefficient, assumed to be 0.20

to = tidal period of one-half a day

K = permeability coefficient

b = aquifer thickness, assumed to be 150 feet

strata completely above and completely below the transition zone failed show a difference in permeability (compare the results for holes 1A and 1D and holes 5A and 6, for example).

6. Despite the modest groundwater lens and low groundwater flow at Barbers Point Harbor, a barrier effect along its recently excavated shoreline was measured. A natural re-establishment of the shoreline barrier effect has occurred at this site. A similar result has been measured at a marina recently excavated into limestone in Australia (section 3.2 below).

3.1.3 Salinity Profiles

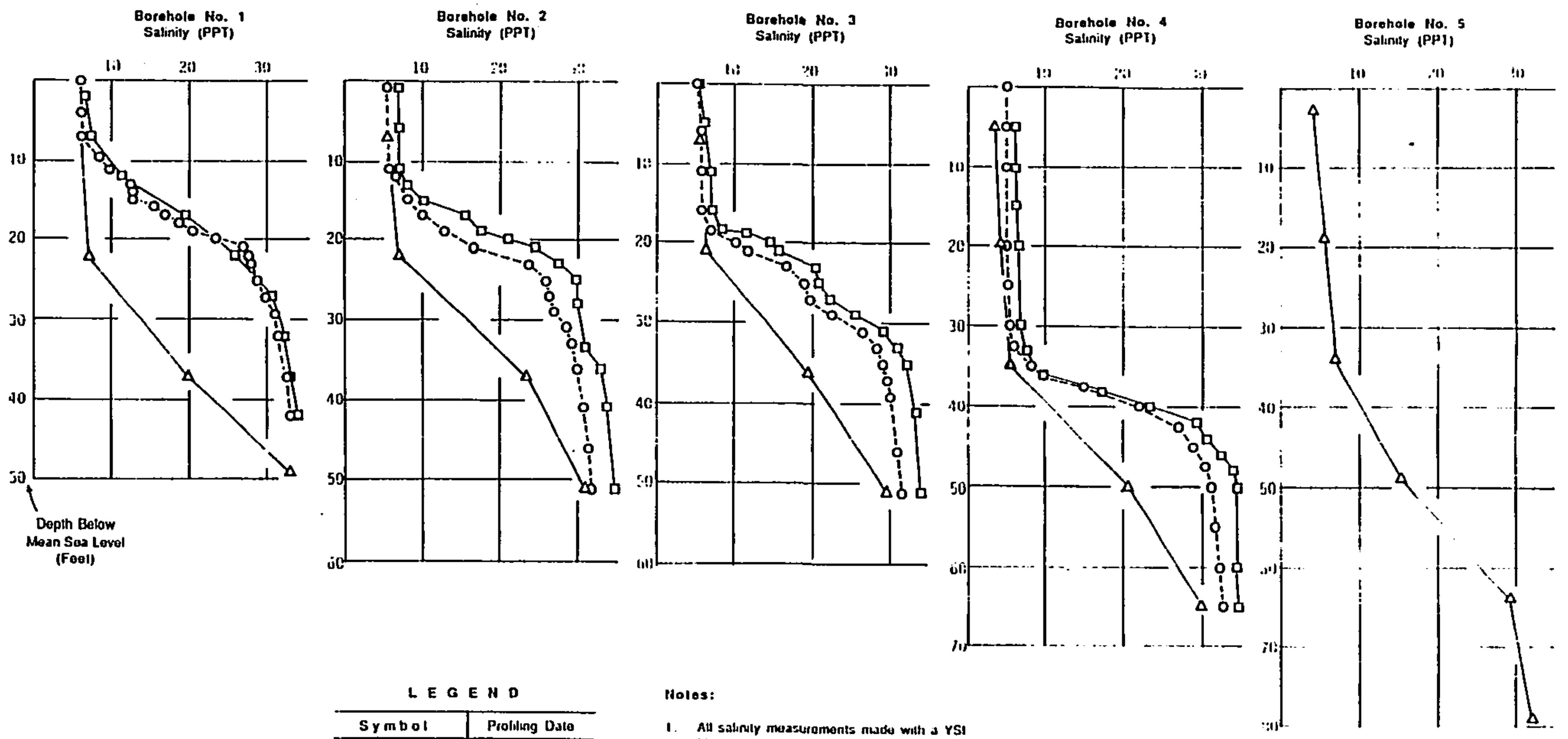
Salinity profiles of the groundwater lens at each of the monitoring well sites were made on a number of occasions between July and December of 1990. Figure 14 presents these results for the Ewa Marina boreholes. The gradual shrinking of the groundwater lens through the summer months defined by water level measurements is confirmed by these profiles. There is also reasonable confirmation of the Ghyben-Herzberg 40:1 ratio if the midpoint of the transition zone is used to define lens thickness.

Figure 15 illustrates the measured salinity profiles at Campbell Industrial Park and Barbers Point Harbor. Lens thickness and salinity show remarkably little change among the three Campbell Industrial Park holes. At Barbers Point Harbor, the groundwater lens is very small, indicative of very limited groundwater flow.

3.2 Comparative Studies at Mindarie Keys

Field investigations at and adjacent to the Mindarie Keys marina were undertaken in conjunction with the Water Authority of Western Australia. This marina, located approximately 20 miles north of Perth in Western Australia, was excavated at the beginning of 1988. During construction a limited monitoring program was instigated to assess the impact of dewatering activities associated with marina excavation. Data for this period is sparse and serves only to provide representative local water levels. Shallow and deep monitoring wells 295 feet to the north of the marina were re-established during October 1990. Well SKP-WHITE has a present depth of 15.5 feet and depth to water of approximately 14 feet. Well SKP-GREEN is open to 20 feet below ground level and then filled with rubble (depth to water is also about 14 feet). Original drilled depths for these wells are unknown.

In June 1990, the Water Authority constructed six saltwater interface monitoring wells as an adjunct to the North Coastal Groundwater Schemes Investigation (Smith, 1990). Five of these wells are completed along a line perpendicular to the coastline (1600 feet north of the marina) and one well was completed adjacent to the marina (Figure 16). A schematic cross sectional diagram of well locations,



L E G E N D

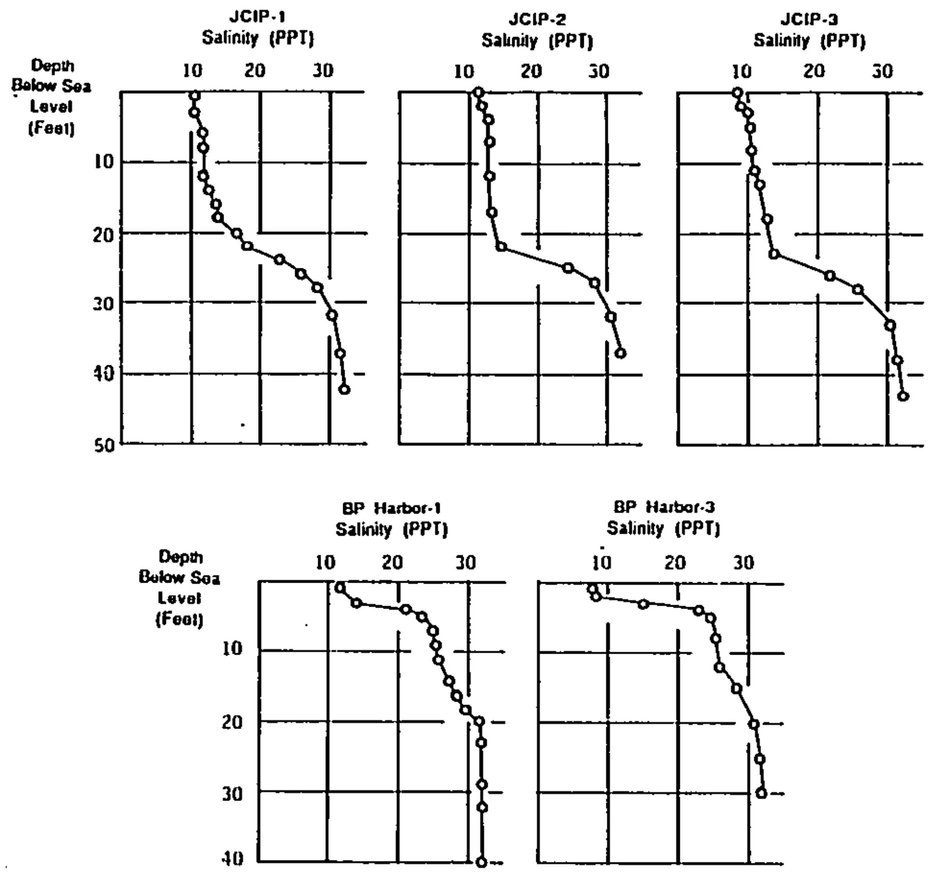
Symbol	Profiling Date
—△—△—	July 2, 1990
---○---○---	Sept. 25, 1990
—□—□—	Dec. 1, 1990

Notes:

1. All salinity measurements made with a YSI Model 33 S-C-T Meter.
2. Profile of July 2, 1990 done with samples obtained by thief sampler.
3. Profiles of September 25 and December 1 are continuous conductivity profiles.

Figure 14

Salinity Profiles of the Ewa Marina Boreholes



Notes:

1. All measurements made with a YSI Type 33 S-C-T meter.
2. The conductivity probe was lowered in each borehole for in-situ measurements.

Figure 15

Salinity Profiles in Boreholes on the West Side of the Ewa Plain

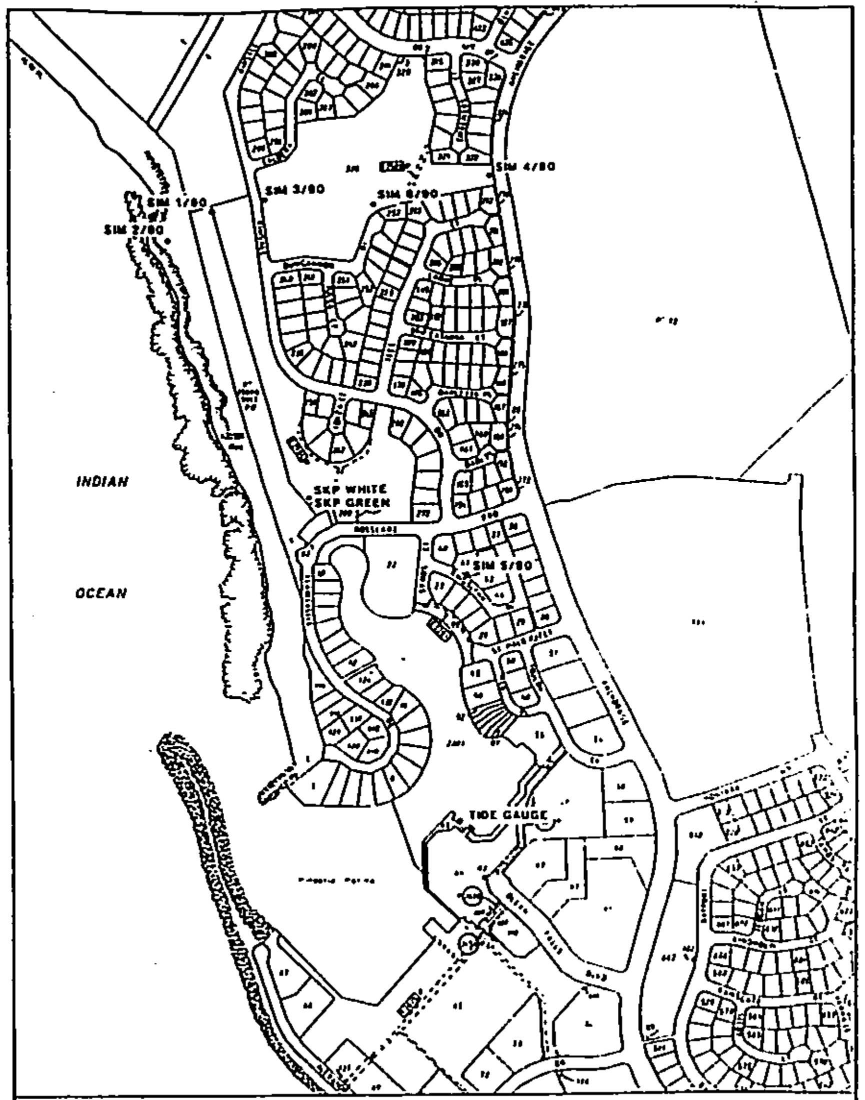


FIGURE 16

MINDARIE KEYS
MONITORING WELL LOCATIONS

screen positions and interpreted geology is presented as Figure 17. All saltwater monitoring wells have been screened over 1 meter (3.3 feet) at or near the bottom of the drilled hole. Although these wells are only slotted over a 1 meter section of the casing, no backfill was placed and hydraulic connection over the entire vertical section is inferred. Reduced levels presented in Figure 17 are referenced to Australian Height Datum (AHD) which is approximately 0.76 meters (2.5 feet) above mean sea level.

Water quality sampling since the installation of the monitoring wells suggests wells SIM2/90 and SIM1/90 have penetrated the upper part of the transition zone between fresh water and salt water (Figure 17). The remaining wells are completed within the freshwater aquifer.

Water level data was logged at fifteen minute intervals over a 64-day period from the 16th November 1990 in each of the monitoring wells, the two observation wells (SKP-Green and SKP-White) and in a tide gage within the marina. Composite plots of recorded levels are included as Figures 18 and 19.

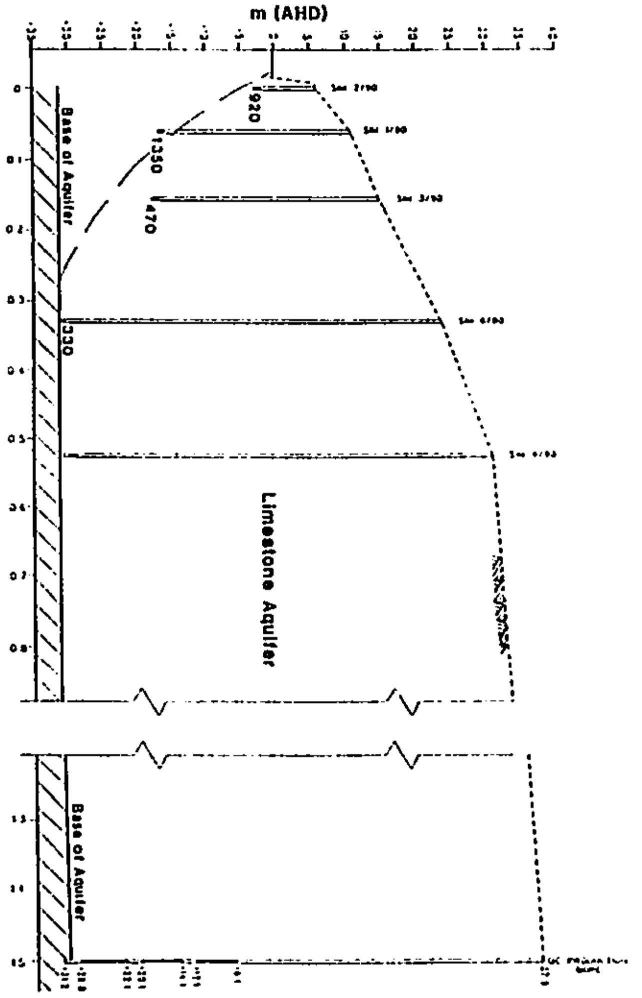
Two trends are apparent in the data sets presented. Near the coast, wells show a diurnal response corresponding to the measured tidal signal and long term trend corresponding to the long term fluctuation in mean sea level. Diurnal response generally diminishes with distance inland, reducing to approximately 1.5 centimeters (0.05 feet) at well SIM4/90 (located approximately 1120 feet inland).

Average water levels, tabulated against distance inland in Table 6 show similar trends to those recorded at the Ewa marina site. Permeabilities calculated for the decay of the tidal signal are also included in this table. Steeper regional hydraulic gradients and smaller build-up of water levels at the coast observed in the vicinity of Mindarie (as compared to Ewa) are attributed to the order of magnitude lower regional permeability at Mindarie.

The small water level variation between wells SIM 2/90 and SIM 1/90 may correspond to local aquifer heterogeneities. However, it is noted that SIM 1/90 shows the greatest penetration of the transition zone (Figure 17) and an apparently low water level may be due to density effects.

FIGURE 17

QUINNS ROCKS - SALTWATER INTERFACE MONITORING SECTION



LEGEND

I SLOTTED INTERVAL

---- APPROXIMATE GROUND LEVEL

920 GROUNDWATER TDS (mg/l)

NOTE: BASE PLOT AFTER WAWA (1991)

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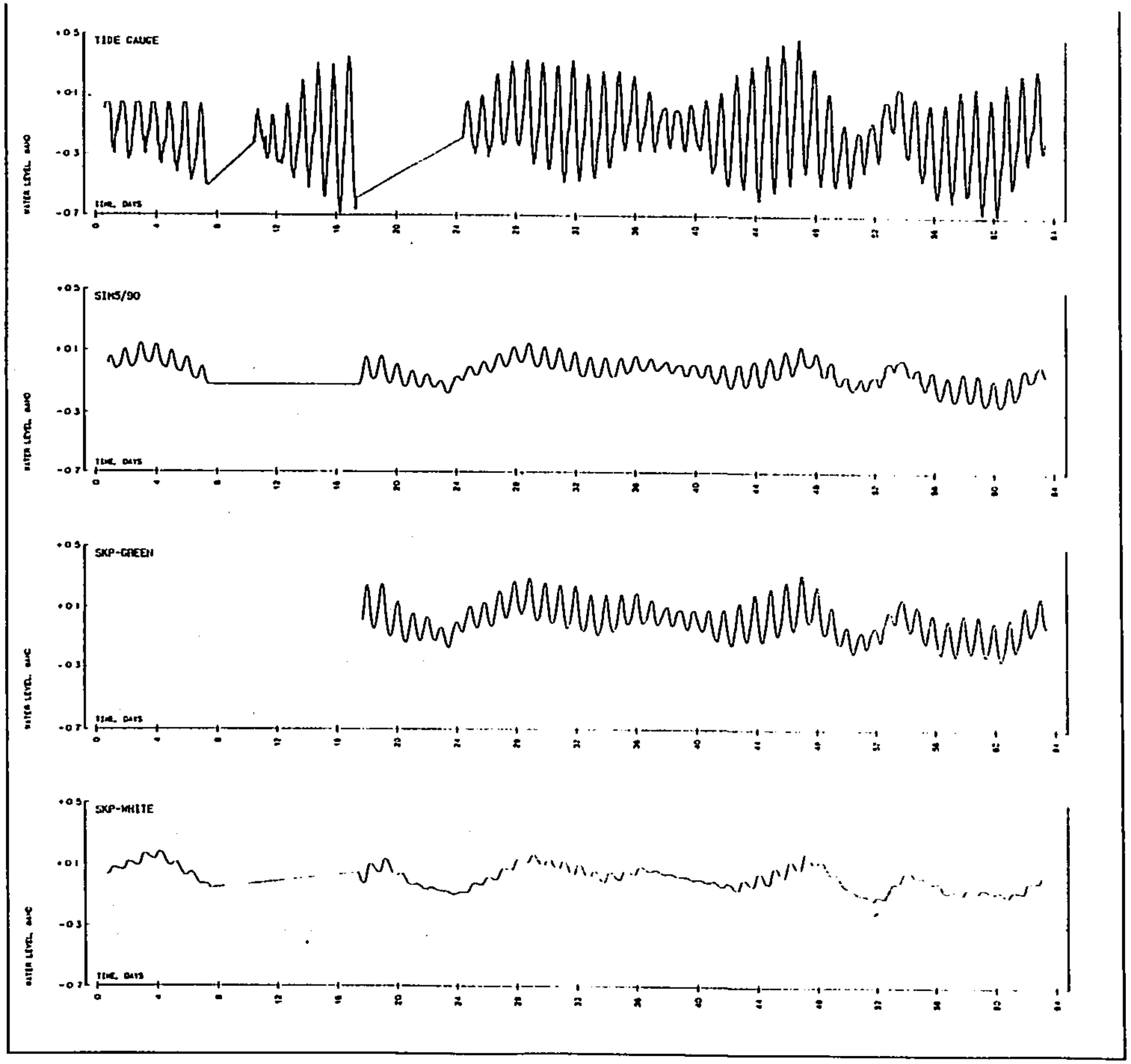
GROUNDWATER ENGINEERS & EARTH SCIENTISTS



SALT WATER INTERFACE
MONITORING
AT MINDARIE KEYS
In Conjunction With
WATER AUTHORITY OF
WESTERN AUSTRALIA
PERTH WESTERN AUSTRALIA

Note. Water level data recorded at 15 minute intervals using WESDATA loggers

RECORDED WATER LEVEL DATA

FIGURE 18

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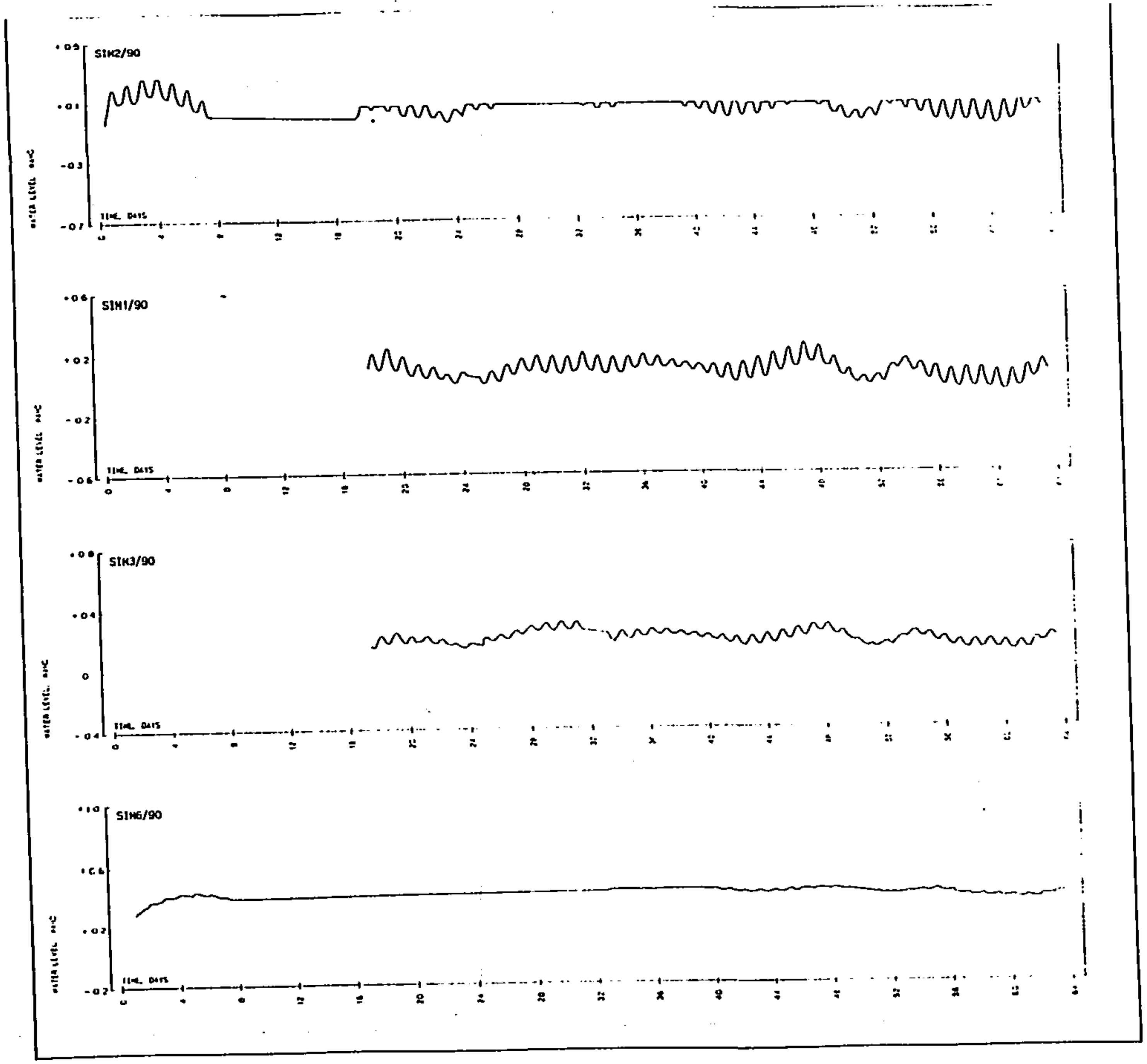
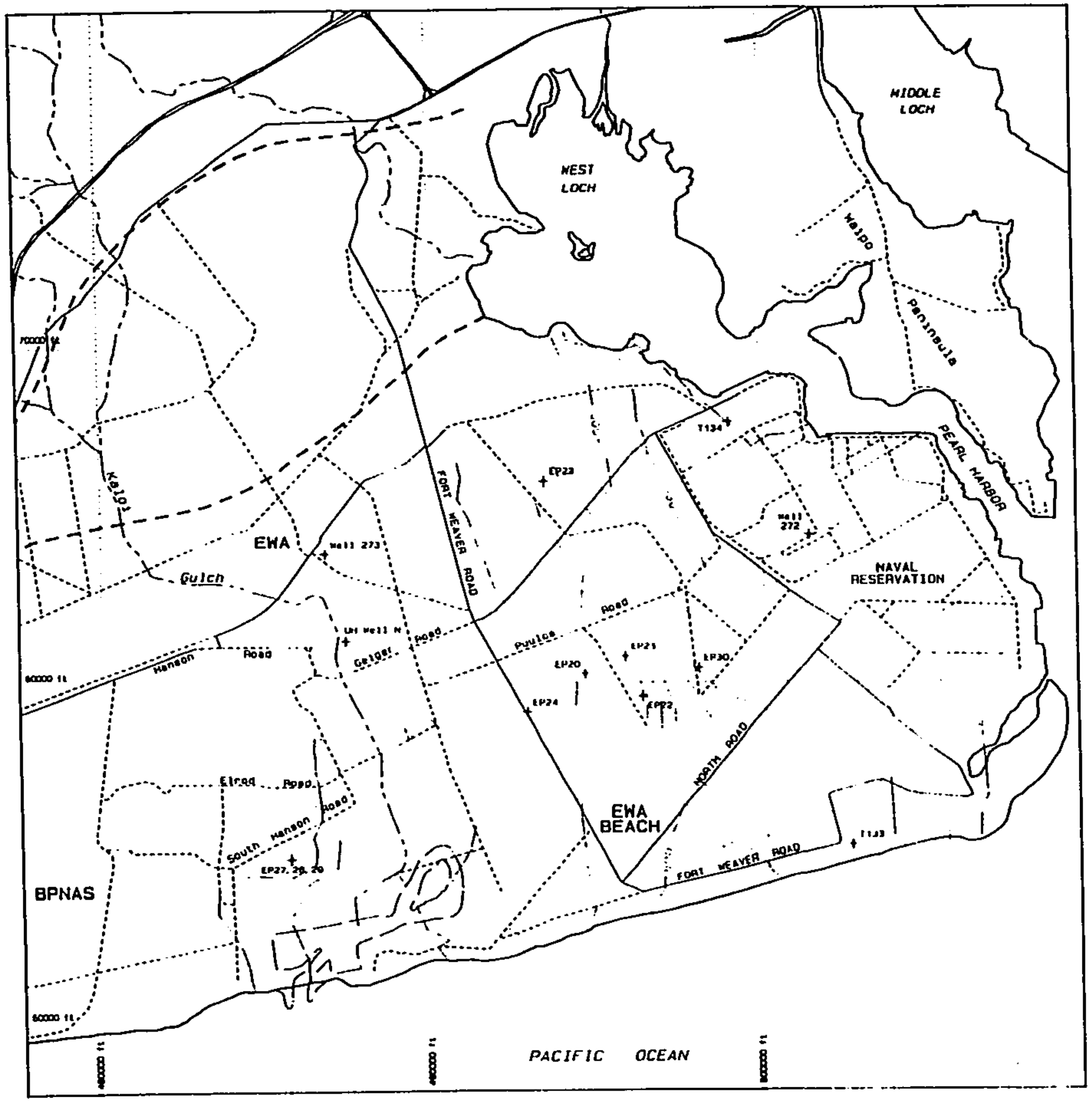


SALT WATER INTERFACE
MONITORING
AT MINDARIE KEYS
In Conjunction With
WATER AUTHORITY OF
WESTERN AUSTRALIA
PERTH WESTERN AUSTRALIA

Note: water level data recorded at ... minute intervals using WESDATA loggers

RECORDED WATER LEVEL
DATA

FIGURE 19



EWA MARINA
GROUNDWATER IMPACT
ASSESSMENT
On Behalf of
BELT COLLINS & ASSOCIATES

LEGEND

- Coastline
- Major Roads
- Minor Roads (tracks)
- Surface Water Channels (gulches)
- Proposed Marina
- Geological Boundary (sector boundary)
- Isochlor (mg/l)

0 2000 4000 6000 8000 ft
ORIGINAL SCALE
(1 inch to 3000 feet)

SIMULATED CHLORIDE
CONCENTRATIONS FOR 1974

FIGURE 27

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GROUNDWATER ENGINEERS

Table 6

Salt Water Interface Monitoring Results for Mindarie Keys

Monitoring Well	Distance Inland (Feet)	Water Level (Feet Above Mean Sea Level)	Permeability (Feet/Day)
SIM 2/90	80	0.61	22
SIM 1/90	280	0.64	228
SIM 3/90	610	1.03	562
SIM 6/90	1120		772
SIM 5/90	260	0.29	265
SKP-GREEN	310	0.50	1032
SKP-WHITE	310	0.45	155

General trends in average water levels indicate some impact of the marina immediately inland (SIM 5/90), however limited regional impact is apparent. Water level data recorded 1500 feet north of the marina is consistent with regional gradients in the vicinity of the coast. A marginal decline in the water table is suggested 300 feet north of the marina at the SKP wells. It is of interest to note that the tidal responses observed in wells SIM 2/90 and SIM 5/90 show identical amplitude and long term water level trends. These wells are located 80 feet and 260 feet from the coast, respectively.

Regional permeabilities reported for the limestone aquifer are of the order of 1000 ft/d (WAWA, 1991). Analysis of tidal response between inland monitoring wells shows similar permeabilities (1220 ft/d is estimated between SIM 3/90 and SIM 6/90). At the coast a marked decline in permeability is calculated (Table 6).

It is concluded that aquifer anisotropy plays an important role in limiting the impact of the marina. Some of the mechanisms which introduce vertical anisotropy (dissolution processes) will have similar effects transverse to the direction of groundwater flow. To date, this aspect has not been addressed for the Ewa plain.

It should also be noted that groundwater flow conditions at Mindarie are close to those expected in an undisturbed state. Natural recharge occurring inland passes directly into the coastal limestone aquifer, maintaining the fresh water lens at the coast. Little movement in the interface position would be expected during recent times. In contrast, the present condition of the caprock aquifer system at Ewa has been generated by the importation of basalt water for sugar cane cultivation. The resulting hydrochemistry within the aquifer appears to be aggressive and may be dynamically altering the aquifer composition.

In summary, monitoring results at Mindarie Keys suggest a number of factors influence the response of the aquifer to marina development. Insufficient pre-marina data is available at Mindarie to conclusively determine the impact of the marina. However, favorable geological conditions appear to have limited the potential water level decline.

3.3 HYDROCHEMISTRY

Preliminary assessment of geological and hydraulic data suggested that geochemical processes involving dissolution and subsequent re-precipitation may be occurring within the limestone aquifer. This is contrary to most published data, which documents dissolution and increased aquifer permeability within the transition zone between fresh and seawater in carbonate aquifers.

Detailed groundwater sampling was undertaken on three occasions to compile a water quality database. Comprehensive sample analysis included determination of anion/cations, nutrients and metals. Interpretation of water quality data has included spreadsheet analysis and speciation modeling. While a number of trends are apparent in these analyses, it has not been possible to specifically match hydrogeochemical cementation in the aquifer's transition zone with the observed permeability reduction in the limestone along the shoreline. The following discussion illustrates some of the trends noted between sampling points at different sampling times.

Comparison of constituent variations along a flow line from fresh water to sea water indicates a consistent transition, which is characteristic of conservative mixing processes. A plot of chloride against potassium indicates linearity over most of the trend, with slight non-linear behavior at high salinities (Figure 20) .

A plot of potassium against bicarbonate, presented as Figure 21, also demonstrates an approximate conservative mixing process in the vicinity of the marina (potassium greater than about 50 mg/l). Initially, recharge waters (mainly basaltic in origin) are low in potassium and bicarbonate. The presence of carbon dioxide in the vadose zone rapidly increases the bicarbonate content of recharge waters until a level of approximately 500 mg/l is reached. Bicarbonate levels then decrease as potassium increases due to the mixing with saline waters. The sea water end member is characterized by 400 mg/l potassium and 150 mg/l bicarbonate. Departures from the conservative mixing trend occur when bicarbonate decreases at a greater rate than potassium increases. This may represent zones of increased precipitation.

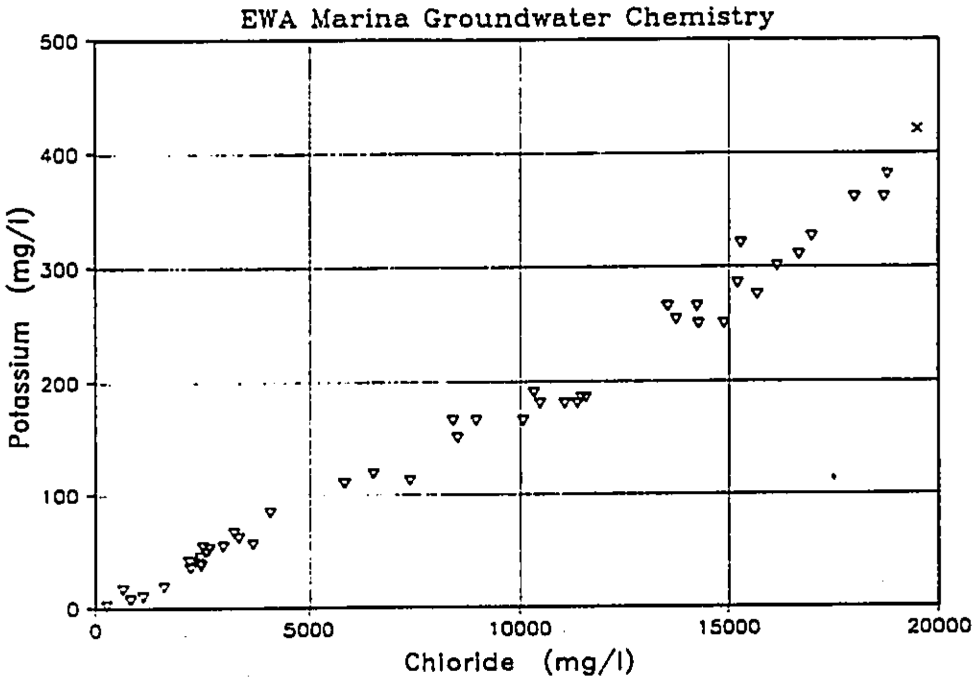


FIGURE 20
POTASSIUM LEVEL AS A
FUNCTION OF CHLORIDE CONCENTRATION

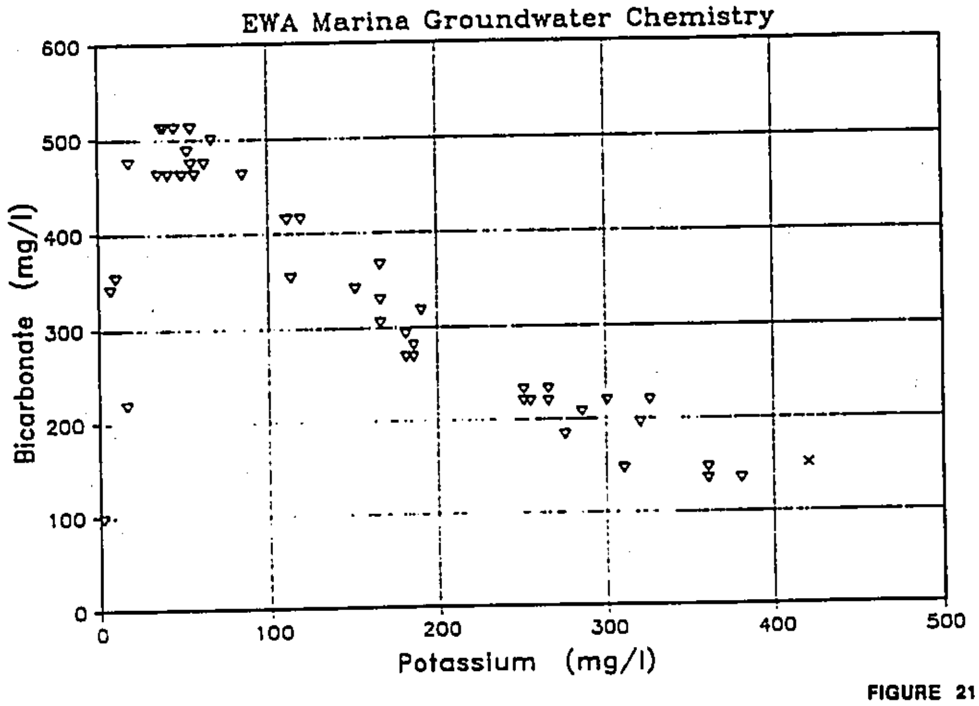


FIGURE 21
BICARBONATE LEVEL AS A
FUNCTION OF POTASSIUM CONCENTRATION

For example, data points over the range of 185 to 265 mg/l potassium coincide with a decrease in bicarbonate from 410 mg/l to 210 mg/l. The relative decrease in bicarbonate is greater than the increase in potassium and suggests that factors other than conservative mixing may be decreasing bicarbonate concentrations (such as precipitation). Data examined in this instance are located between 15 and 22 feet below sea level (ftBSL) in Borehole No. 1, 17 to 22 ftBSL in Borehole No. 2 and 21 to 25 ftBSL in Borehole No. 3. Data from other holes was not included in this correlation as they were sampled at different times.

Saturation indicies for calcite, aragonite and dolomite were examined in order to determine the capacity of the groundwater to dissolve or precipitate these minerals from or into the reef limestone which comprises the aquifer. Calcite saturation was noted to be positive (i.e., likely to precipitate calcite) at all sample points. However, observations of core samples indicated that this was not occurring. It may be that the calcite was being buffered by other minerals or elements. Dolomite exhibits similar trends. Aragonite saturation indicies are characterized by positive values above the mixing zone and negative values within and below. This situation would more accurately reflect predicted field conditions where aragonite precipitation may be occurring above the mixing zone, while dissolution is actively proceeding within and below this zone.

The preceding interpretation is consistent with the geological stratigraphy developed from the detailed petrographic analysis of the carbonate (aquifer) mineralogy in Appendix A. The conclusions from the petrographic work demonstrate systematic diagenetic changes with depth. These are summarized as follows:

- The shallow surface interval is comprised of skeletal debris which preserve the primary mineralogies of magnesian rich calcite and aragonite;
- The intermediate interval is characterized by coral boundstones and red algal crusts which exhibit extensive leaching and consequent high porosity (and, presumably, permeability), with inversion of aragonite to calcite;
- The basement interval displays extensive recrystallization and cementation by calcite, but lacking aragonite, with substantial reduction in porosity.

The shallow lithology is dominated by aragonite precipitation and some calcification. The intermediate zone is characterized by dissolution and consequent high permeability, while the lower interval is dominated by precipitation products.

4.0 AQUIFER MODELING

It is difficult to assess the relative contribution of the various components in a hydrogeologic system using classical analytical methods. These methods generally assume aquifer homogeneity in the form of 1-dimensional equations and are more applicable in the assessment of local aquifer response. With a computer based numerical model, it is possible to more accurately simulate regional conditions and to explore the impact of land use and water budget changes by introducing spatial and temporal variability. The development of a numerical model at an early stage of impact assessment also facilitates sensitivity analyses which will define the dominant parameters and mechanisms.

Three different 2-dimensional numerical models were developed during this study using two software packages. Regional hydraulic modeling was undertaken using AQUIFEM-N (Townley, 1988). Regional water quality modeling and vertical section salt-water interface modeling was done using SUTRA (Voss, 1984). Both of these packages rely on finite element techniques to solve the groundwater flow equations.

The finite element method requires discretization of the modeled area into a mesh of triangles or quadrilaterals. Each triangle/quadrilateral is defined by the corner nodes. The unknown parameters (either water table elevation or chloride concentration) are solved for at each node point, with interpolation between node points defined by basis functions within the model. The triangular mesh used with AQUIFEM-N employs linear basis functions (thus individual elements may be considered as planes). SUTRA employs second order (quadratic) basis functions resulting in non-linear interpolation across quadrilateral elements.

The detail which can be achieved with numerical models depends upon mesh density. This also defines the time stepping required to meet stability criteria. With a known interpolating function for the finite element method, it is possible to construct a variable density mesh to provide the level of accuracy required in areas of interest while maintaining numerical efficiency of the model as a whole. A fine mesh is constructed in areas where hydraulic gradients vary more rapidly and a sparse mesh is defined in distant areas. The final mesh design also incorporates important geological and geographical features. In the case of areal modeling, elements are aligned with land use boundaries to enable the correct assessment of land use impacts (such as recharge) by area.

In the sections following, each of the models established for this study are outlined, appropriate boundary conditions are defined, and the resulting calibrated parameters presented and discussed

4.1 Areal Hydraulic Model

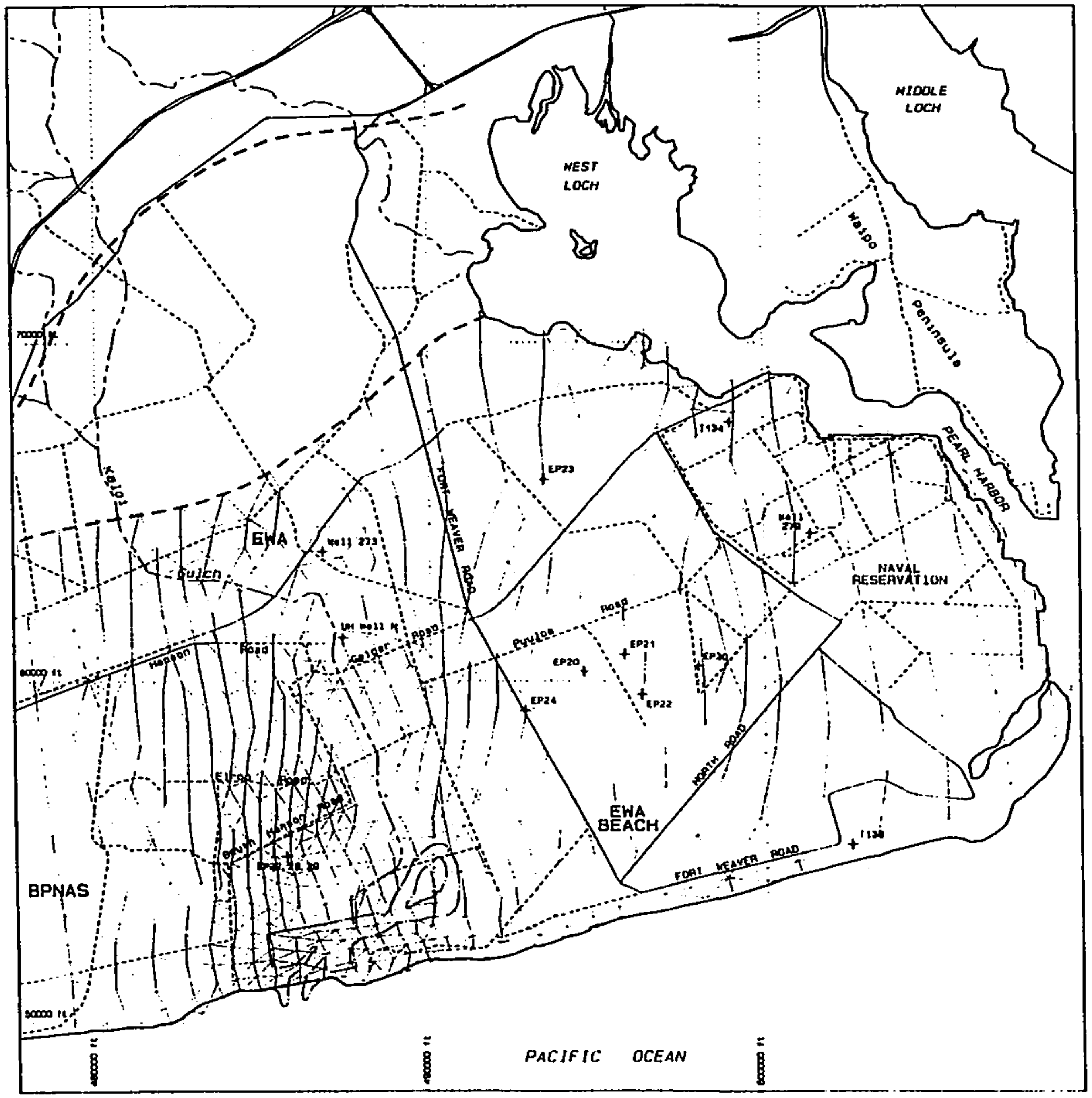
Regional hydraulic modeling has been completed using the AQUIFEM-N package across the eastern section of the Ewa plain. The mesh of 949 triangular elements defined by 513 nodes (Figure 22), extends northwards to the mauka limit of the contiguous limestone formation at and below sea level. Further to the north, the limestone formation is interbedded with alluvial material. The western boundary of the model is aligned perpendicular to the shoreline, approximately 6000 feet west of the proposed marina development. The east boundary is West Loch of Pearl Harbor and the south boundary is the shoreline. In the context of the management sectors described in Mink et al., (1988), the model comprises the entire Puuloa sector, the southern part of the Honouliuli sector, the south-eastern part of the Kapolei sector and the eastern third of the BPNAS sector.

Areas of high element density in the model include the entire coastline (where significant head gradients occur) and in the vicinity of the proposed marina where a higher degree of resolution is required.

Imposed boundary conditions are as follows:

- A specified flux derived from water budget calculations is applied at the northern boundary.
- A constant (sea level) head is specified all along the ocean boundary and along the harbor boundary as far north as the overlying calcareous marl.
- Zero flux is specified across the harbor boundary where it coincides with the marl barrier.
- Zero flux occurs across the western boundary of the model which was chosen to coincide with a groundwater streamline. In other words, this boundary was fixed far enough to the west to be beyond the potential influence of the marina.

To account for the Ghyben-Herzberg lens, the aquifer thickness has been defined as 40 times the hydraulic head (calculated directly by the numerical model). It has been assumed that the salt water interface intercepts the underlying aquiclude at 80 feet below sea level, corresponding to a hydraulic head of 2 feet above sea level. Inland of this, the lens is not present and the bottom of the aquifer is defined by the depth to the mud layer.



EWA MARINA
GROUNDWATER IMPACT
ASSESSMENT
On Behalf of
BELT COLLINS & ASSOCIATES

LEGEND
- Coastline
- Major Roads
- Minor Roads (tracks)
- Surface Water Channels (gulches)
- Proposed Marina
- Geological Boundary (sector boundary)
- Finite Element Mesh

0 2000 4000 6000 8000 ft
ORIGINAL SCALE
(1 inch to 3000 feet)

AQUIFEM FINITE ELEMENT MESH

FIGURE 22

Mackie Martin & Associates
Groundwater Engineers

4.1.1 Model Calibration

Calibration of the numerical model involves an iteration process of repeatedly running the model with minor adjustments to parameters until it is tuned to observed field measurements. Fluxes through the model and predicted water levels are directly coupled to the aquifer permeability. Under steady state conditions, almost identical water levels will be obtained for a range of permeabilities provided the ratio between permeability and recharge is held constant. Consequently, a unique solution to the groundwater flow equations is seldom attained. Nevertheless, the calibration process integrates all available data to represent the conceptual hydrogeological model and reasonably simulate aquifer performance.

Initial calibration parameters were based upon relatively low permeabilities and inflow/irrigation return defined by published literature. Water level data of much of the inland area modeled is sparse and the accuracy of survey data uncertain. Water levels compiled from available data were subsequently augmented by field investigations completed during this study.

As part of the calibration process, the model has been used to identify hydrogeological features which were then investigated in the field. This iteration between field and numerical model studies has ensured that the evolving model most accurately represents field conditions. In addition, both areal hydraulic and water quality models were run in parallel to enhance data utilization and interpretation.

Steady state water levels were simulated for two distinct periods corresponding to steady state furrow and drip irrigation periods. Representative years, 1974 and 1986, were selected for furrow irrigation and for drip irrigation, respectively. The appropriate water usage and recharge estimates for these years are presented in Table 7. Complete water budgets for the calibration years (1974 and 1986) are presented in Figures 7B and 8B.

Table 7
Summary of Water Budgets for 1974 and 1986

	1974	1986
Total caprock pumpage	16.72	18.85
Total imported basalt water	16.00	8.65
Recharge from caprock irrigation	8.36	5.88
Recharge from basalt irrigation	8.00	2.70
Recharge from BPNAS Golf Course	0.20	0.20
Recharge from residential areas	0.98	0.98
'Internal' balance	+ 0.82	- 9.09

Note: Total imported basalt water includes water supplied to basalt irrigated fields and augmented caprock irrigated fields.

Water budgets presented in Table 7 indicate a substantial 'internal' deficit within the caprock aquifer system. This deficit must be exceeded by upstream inflow to maintain a seaward flux of groundwater. Inflow at the mauka boundary is estimated at 26.2 MGD for 1974 and 17.4 MGD for 1986, corresponding to the furrow and drip irrigation of inland fields using basalt aquifer water, respectively.

Water level data presented in Section 2.3.2 has been extended during the course of this study, particularly in the vicinity of the proposed marina. Study of the line of new boreholes described in Section 3.1 has considerably enhanced the understanding of the nearshore groundwater regime. Caprock water levels are extremely flat across the majority of the Ewa plain and there is a relatively steep decline to sea level at the coast (Figure 23).

To accommodate the steep hydraulic gradients required at the coastline, the 500-foot wide band of nodes/elements along the coast were assigned low permeabilities (Figure 22). Subsequent field investigations have determined that this low permeability band is much narrower than 500 feet. However, the regional impacts of the band used in the model are expected to be representative of actual conditions.

Predicted groundwater levels are plotted in cross section on Figure 23 for the case of uniform permeability and for a band of low permeability adjacent to the coast. With uniform permeability, some steepening of hydraulic gradients and thinning of aquifer thickness are predicted at the coast. However, observed water level data and attenuation of the tidal signal moving inland through the aquifer clearly confirm the existence of a low permeability band at the coast. Resulting regional water levels predicted for pre-existing and existing land use conditions are presented on Figures 24 and 25.

The calibrated permeability distribution required to achieve the groundwater levels presented in these figures ranges from 500 ft/d at the coast up to 25,000 ft/d inland. Such high permeabilities are approaching the upper limit of what may have been previously considered reasonable. However, such values have been confirmed using tidal signal attenuation (Section 3.1.2). Using a lower regional permeability in the model would require substantially less inflow at the inland boundary of the model to replicate observed water levels. However, such a reduction in flux through the model produces flow reversal in the vicinity of OSCO's pumping wells, resulting in locally predicted water levels that are below sea level. Discharge along the shoreline would also be dramatically reduced

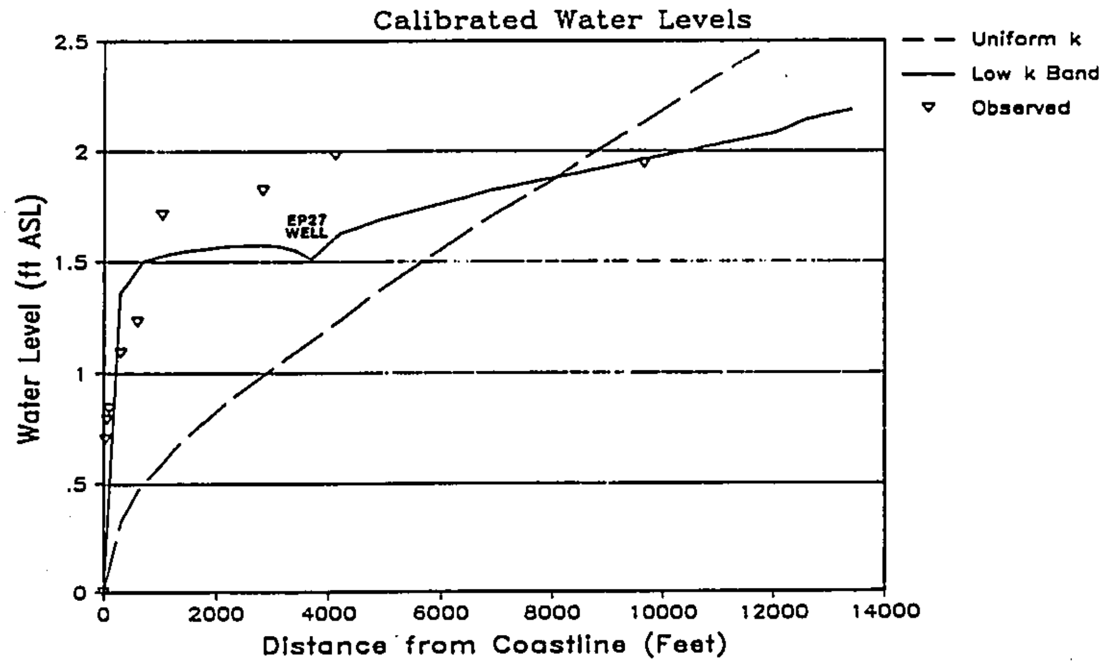
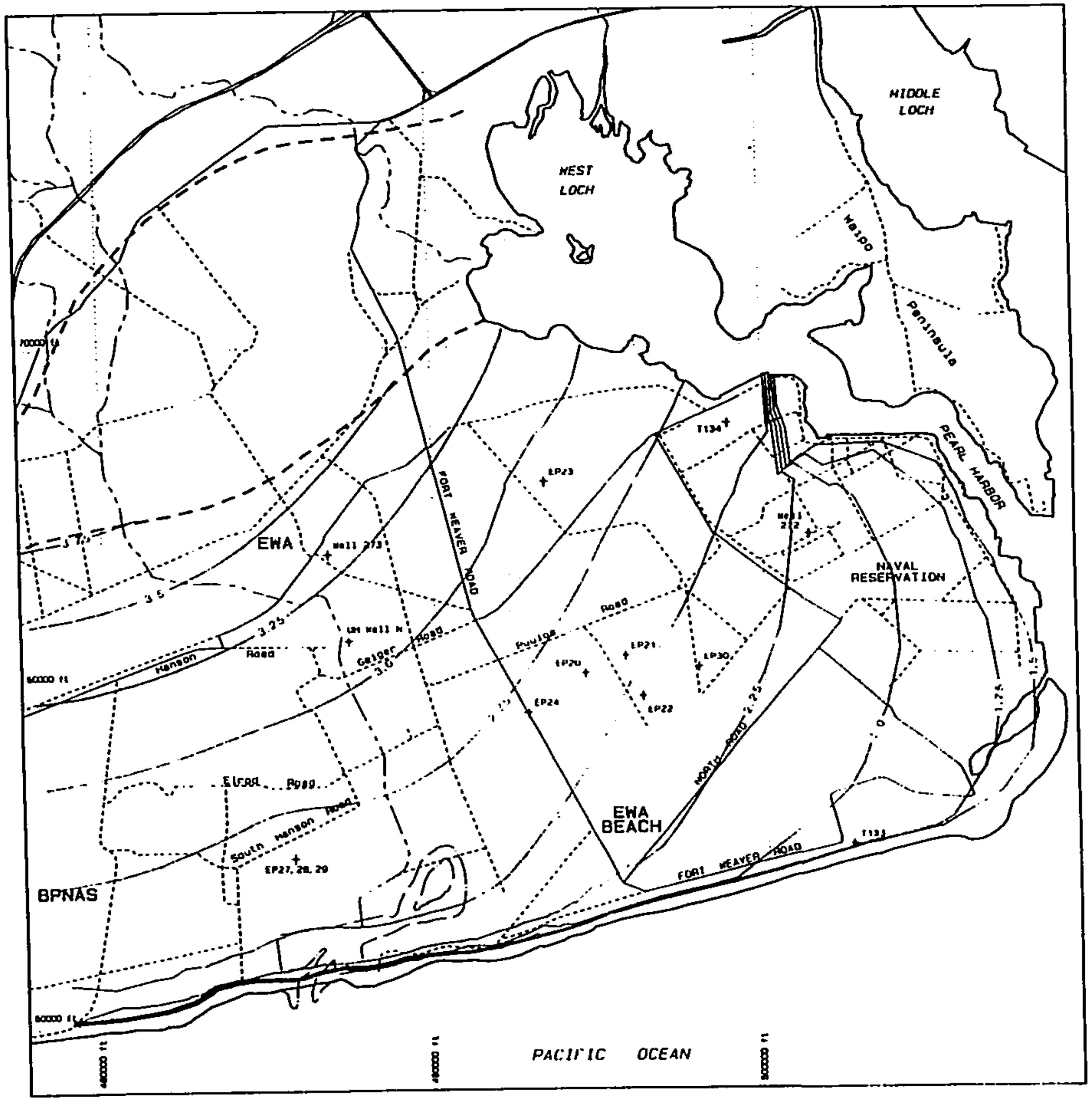


FIGURE 23
GROUNDWATER LEVEL AS A
FUNCTION OF DISTANCE FROM THE SHORELINE



EWA MARINA
GROUNDWATER IMPACT ASSESSMENT
On Behalf of
BELT COLLINS & ASSOCIATES

LEGEND:

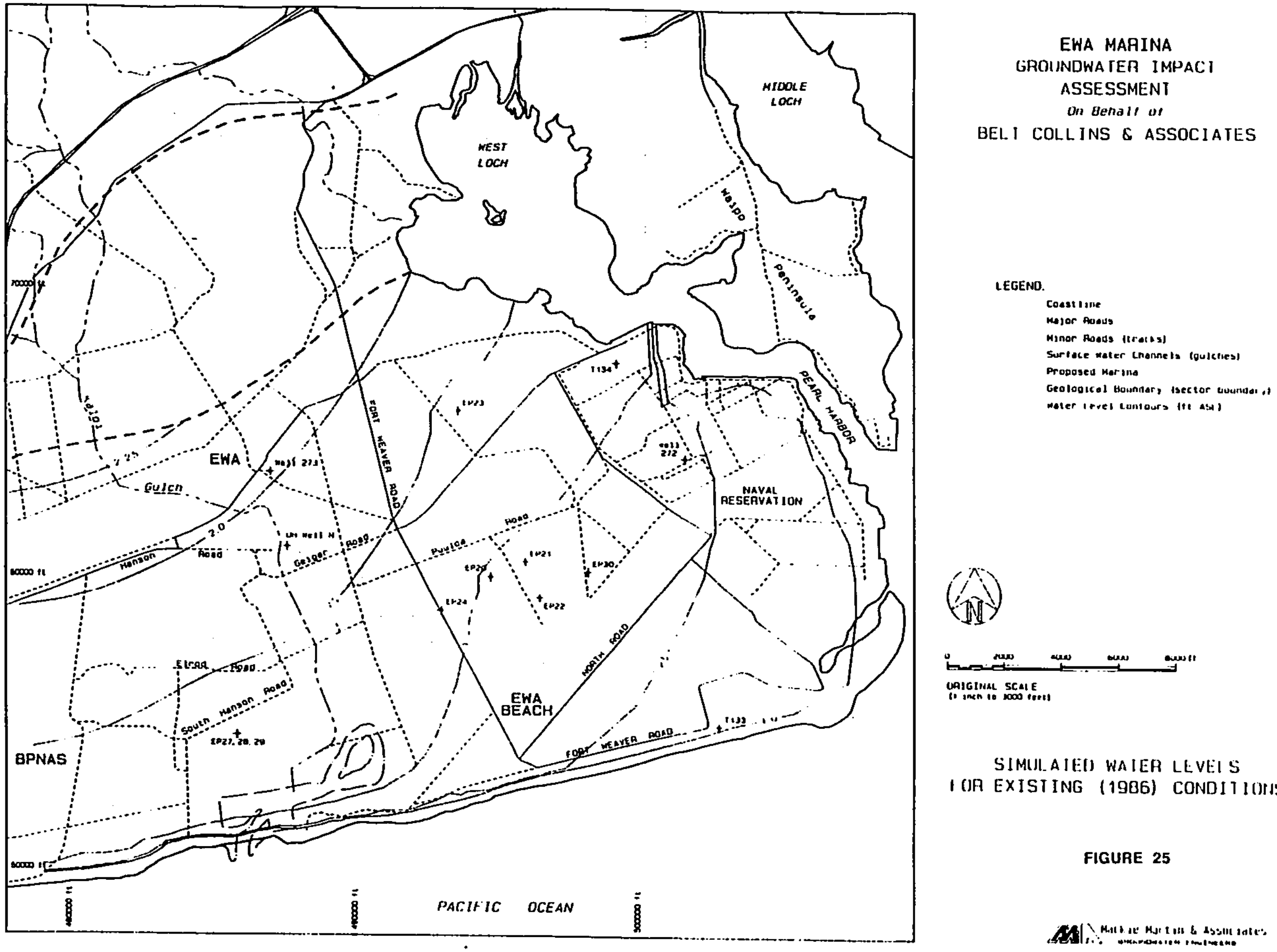
- Coastline
- Major Roads
- Minor Roads (tracks)
- Surface Water Channels (gulches)
- Proposed Marina
- Geological Boundary (sector boundary)
- Water Level Contours (ft ASL)

ORIGINAL SCALE
(1 inch to 3000 feet)

SIMULATED WATER LEVELS
FOR PRE-EXISTING (1974) CONDITIONS

FIGURE 24

Mackie Martin & Associates
GROUNDWATER ENGINEERS



EWA MARINA
GROUNDWATER IMPACT
ASSESSMENT
On Behalf of
BELT COLLINS & ASSOCIATES

LEGEND.
- Coastline
- Major Roads
- Minor Roads (tracks)
- Surface Water Channels (gulches)
- Proposed Marina
- Geological Boundary (sector boundary)
- Water Level Contours (ft ASL)

SIMULATED WATER LEVELS
FOR EXISTING (1986) CONDITIONS

FIGURE 25

Mink & Yuen? — Mathie Martin & Associates

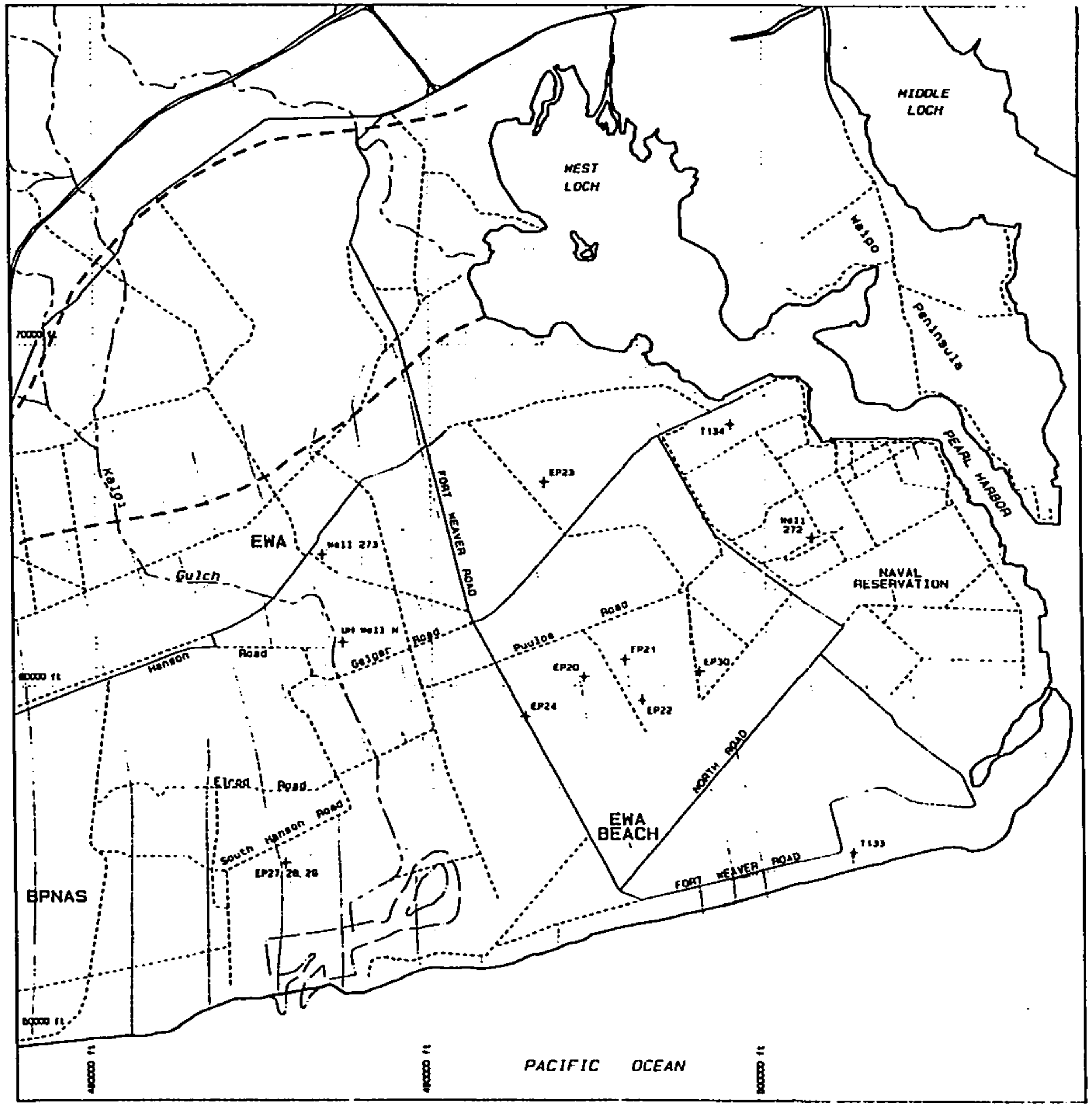
Regional water level plots (Figures 24 and 25) illustrate both the local impact of pumping and the regional impact of variations in water management. Predicted heads in the vicinity of the Ewa by Gentry project vary from 3.25 feet during the furrow irrigation regime down to 1.97 feet under existing conditions. The measured water level in the Palm Court irrigation well within the Gentry project was 1.94 feet in October 1990.

4.2 AREAL WATER QUALITY MODEL

Regional water quality modeling has been completed using the SUTRA package over the same geographic area of the hydraulic model. The mesh, comprised of 490 elements defined by 279 nodes, is presented in Figure 26. Element configuration is designed primarily to reflect land use boundaries which correspond to recharge water qualities. Hydraulic parameters and boundary conditions were determined by the regional hydraulic modeling. Boundary conditions have been imposed as follows:

- Hydraulic boundary conditions were identical to the areal hydraulic model.
- An initial boundary inflow concentration of 550 mg/l chloride is specified at the inland margin of the model.
- The basalt irrigation water chloride concentration was taken to be 300 mg/l.
- The irrigation return water contains all chloride ions present in the applied irrigation water (a calculation of return water quality is completed automatically by the model at each time step).
- Longitudinal and transverse dispersion coefficient values of 50 and 10 feet, respectively, were used.
- Effective aquifer porosity was taken to be 0.10.

In addition, historical variations in plantation management and irrigation practices (outlined in Section 2.5) have been incorporated. This requires yearly modification of irrigation method and upstream boundary inflow (to match the conversion from furrow to drip conversion), and irrigation water quality (to account for basalt and caprock sources of irrigation water). Water management for transient simulations is outlined in Table 3, which has provided the basis for temporal changes within the model.



EWA MARINA
GROUNDWATER IMPACT
ASSESSMENT
On Behalf of
BELT COLLINS & ASSOCIATES

LEGEND

- Coastline
- Major Roads
- Minor Roads (tracks)
- Surface Water Channels (gulches)
- Proposed Marina
- Geological Boundary (sector boundary)
- Finite Element Mesh

0 2000 4000 6000 8000 ft
ORIGINAL SCALE
(1 inch to 3000 feet)

AREAL SUTRA FINITE ELEMENT MESH

FIGURE 26

Mink Yuen Martin & Associates

Basalt recharge water quality and chloride levels for the mauka boundary inflow were based upon the irrigation method and the proportion of basalt aquifer leakage to basalt water applied, respectively. Table 8 presents the components, estimated after Mink et al. (1988), that define the inflow water quality for 1974 and 1986. The corresponding chloride levels are presented for a range of basalt aquifer chlorides in Table 9.

Table. 8

Composition of Mauka Boundary Inflow in MGD

	Honouliuli Sector	Model Total	Basalt Return	Basalt Leakage
1974 (furrow)	18.0	26.16	19.62	6.54
1986 (drip)	12.0	17.44	10.90	6.54

Table 9

Calculated Chloride Concentration for Mauka Boundary Inflow as a Function of Initial Basalt Water Quality

Irrigation Period	Basalt Aquifer Chloride Level (mg/l) 250	300	350
1974 (furrow)	437	525	613
1986 (drip)	599	675	837

4.2.1 Model Calibration

As with the areal hydraulic modeling, calibration of the water quality model focused upon the two distinct irrigation regimes. Although details of practices prior to 1980 are less reliable, sufficient data is available to complete transient calibration of the model. Sensitivity analysis indicates that dramatic changes in water management practices require on the order of ten years for equilibrium in the aquifer to be attained.

Initial conditions for the transient simulations were obtained by assigning land and water use for 1974 (Figures 6A and 6B) and running the model until a steady state condition was attained. The resulting areal chloride distribution was then input as an initial condition for the transient simulation. The predicted chloride distribution at the start of this calibration period (1974) is presented as Figure 27.

The calibrated model input (chlorides), for both the basalt irrigated areas within the model and mauka boundary inflow are detailed in Table 10.

Table 10

Temporal Variations in Chloride Input Levels

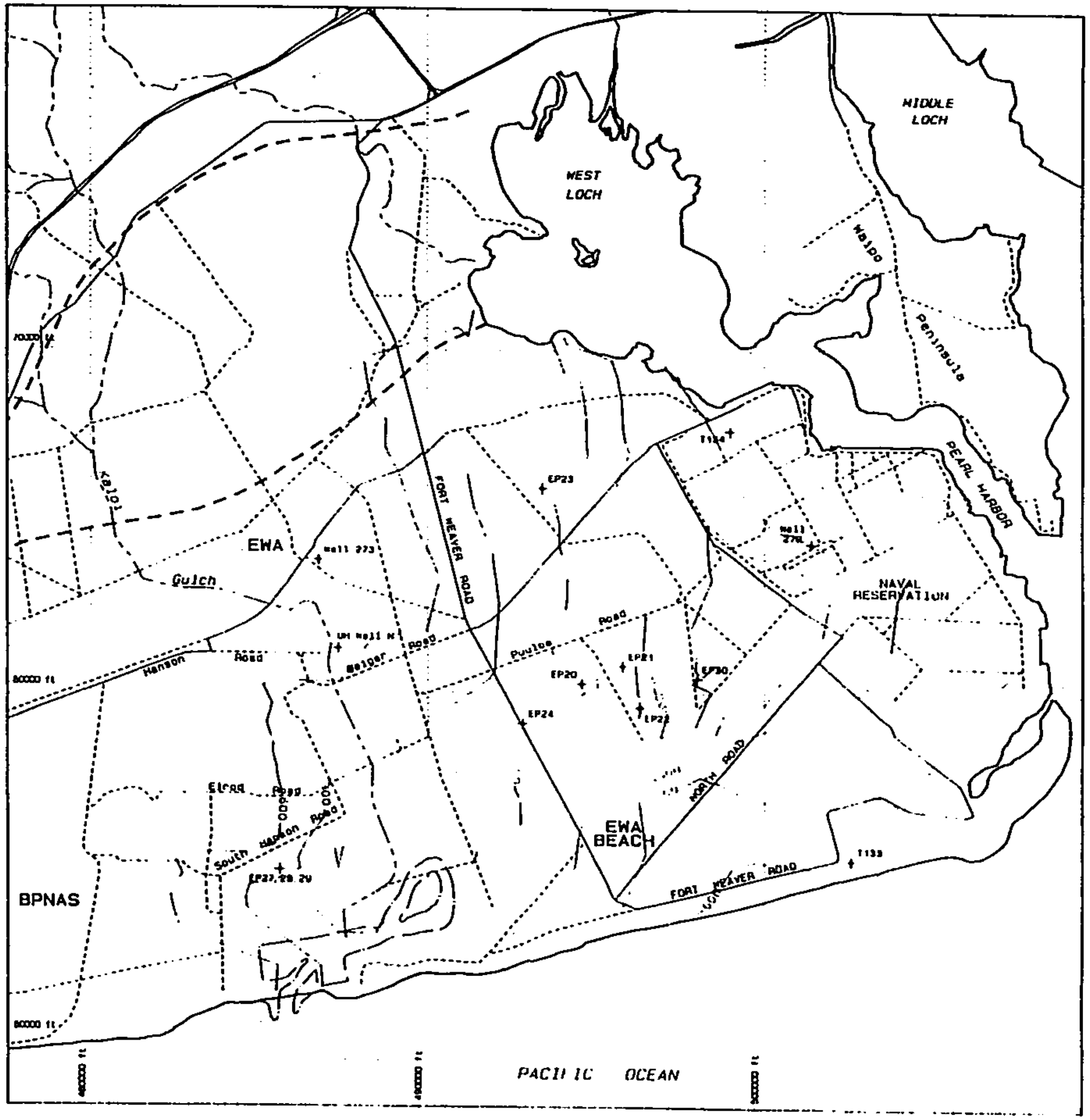
Year	Basalt Irrig. Return (mg/l)	Mauka Inflow (mg/l)
Pre-1981	550	550
1981	600	600
1982	650	650
1983-84	700	700
Post-1984	750	700

Figure 28 illustrates the predicted chlorides immediately after completion of the conversion of all fields to drip irrigation (1982) and Figure 29 shows the corresponding predictions after approximately 10 years of drip irrigation (1988). Elevated chloride levels are predicted downstream of OSCO's pumping wells, particularly in the area of EP20 to EP30. Notably, the areal water quality model is very sensitive to groundwater flux, inflow chlorides at the mauka boundary, and the irrigation method.

During the furrow irrigation period, sufficient groundwater flux is maintained to flush the chloride build-up due to the re-concentration of irrigation return flow. Peak chlorides predicted for 1974 are of the order of 750 mg/l downstream of EP22. The maximum measured chloride concentration at this time is 720 mg/l in EP23.

Conversion of the fields to drip irrigation dramatically reduced the volume of recharge as boundary inflow while increasing the chloride concentration of the irrigation return water. Although water quality predicted by the model reasonably matches observed conditions, chloride levels immediately downstream of the pumping wells are higher than actual. This is due to hydraulic boundary conditions within the water quality model itself, as well as the reduced groundwater flushing under drip irrigation.

While chloride concentrations simulated by the model do show some variation from the sparse observed data, it is felt that general trends due to changing land uses will be reasonably depicted. This is confirmed by the predicted improvement in water quality associated with recent (1988) re-introduction of basalt water to the caprock irrigation areas.



EWA MARINA
GROUNDWATER IMPACT
ASSESSMENT
On Behalf of
BELT COLLINS & ASSOCIATES

LEGEND
- Coastline
- Major Roads
- Minor Roads (tracks)
- Surface Water Channels (gulches)
- Proposed Marina
- Geological Boundary (sector boundary)
- Isochlor (mg/l)

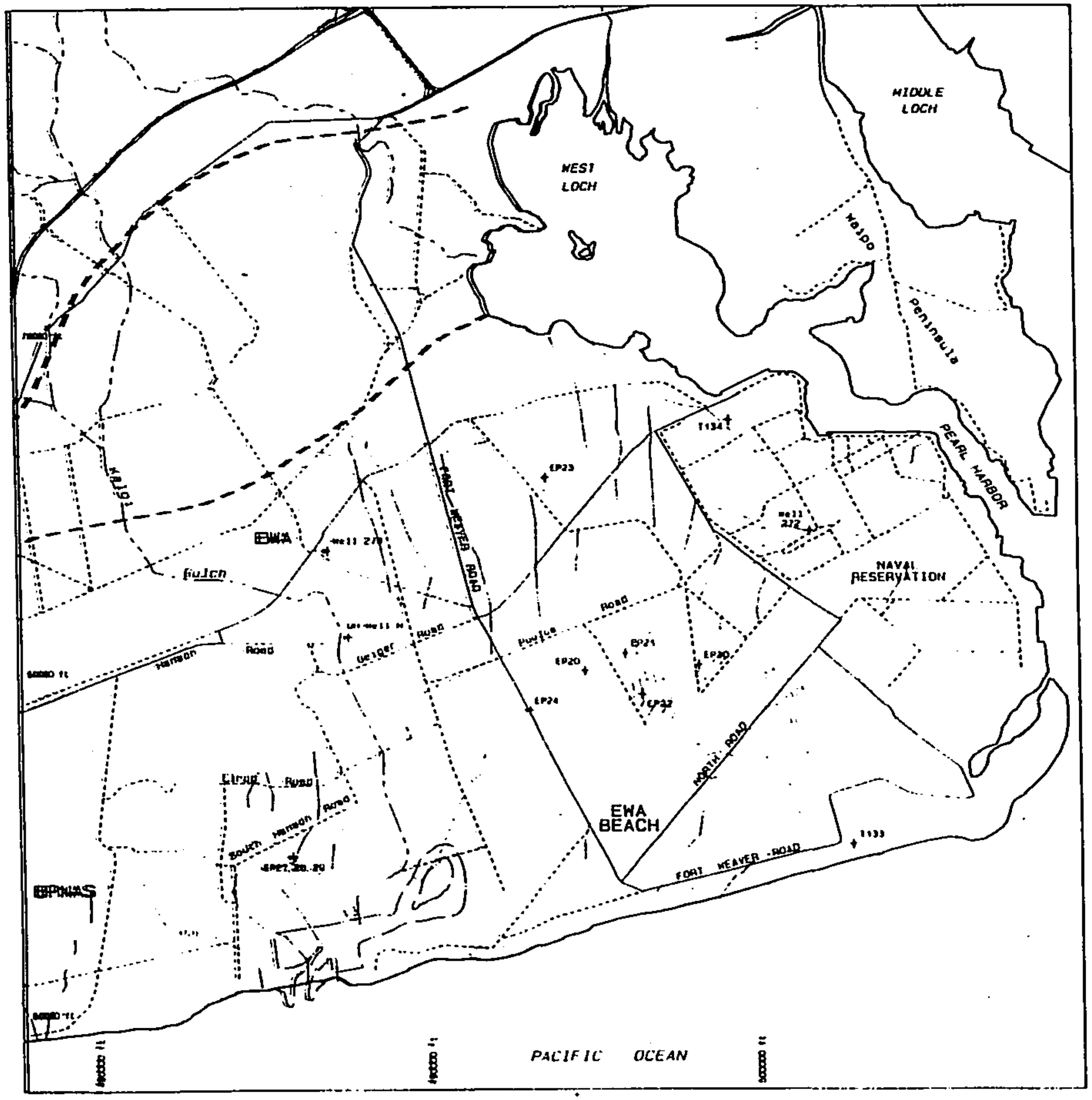
0 2000 4000 6000 8000 ft
ORIGINAL SCALE
(1 inch to 3000 feet)

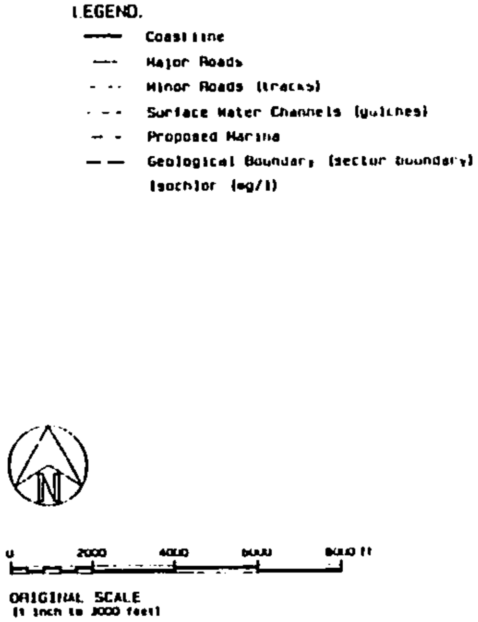
SIMULATED CHLORIDE
CONCENTRATIONS FOR 1982

FIGURE 28

Mink Yuen Martin & Associates

EWA MARINA
GROUNDWATER IMPACT
ASSESSMENT
On Behalf of
BELT COLLINS & ASSOCIATES





SIMULATED CHLORIDE
CONCENTRATIONS FOR 1988

FIGURE 29

Mink Yuen Martin & Associates

4.3 SALT WATER INTERFACE MODEL

In coastal aquifers, a dynamic equilibrium exists between the outflow of groundwater and the inflow of seawater. This process results in the denser sea water intruding below the overlying groundwater lens. The areal modeling described above has assumed that the groundwater/seawater interface is abrupt and that no mixing occurs across this interface.

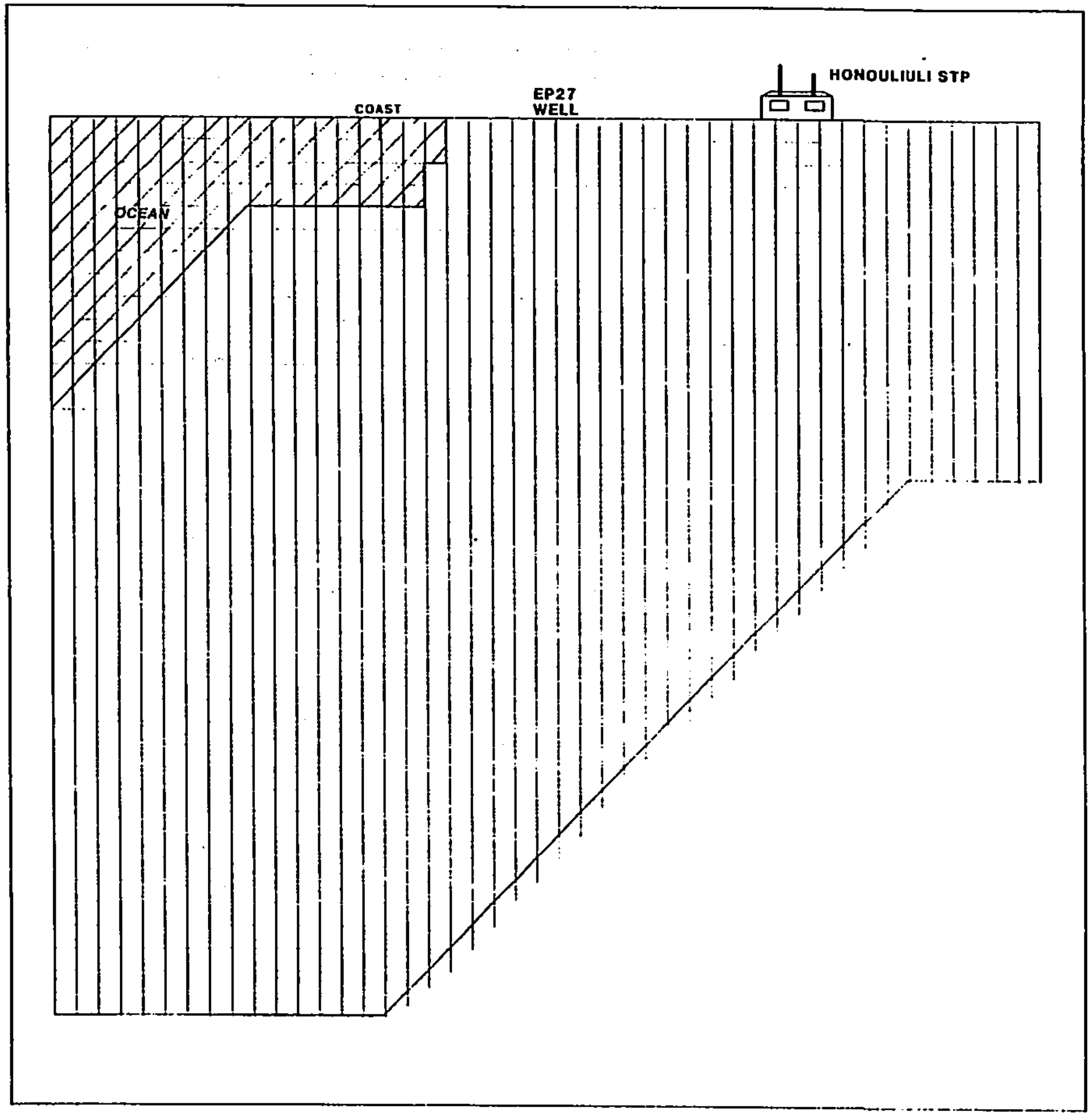
A vertical section model (of unit width) was developed to evaluate the interface dynamics in response to changing land and water use. A representative section, perpendicular to the coast and through the proposed marina site was selected. The SUTRA mesh employed, defined by 790 nodes and 1448 elements (Figure 30), consists of quadrilateral elements with horizontal length of 500 feet and vertical length of 5 feet. Aquifer thickness ranges from 80 feet at the inland margin to 200 feet at the shoreline. The model also includes offshore bathymetry and extends 7500 feet beyond the coast shoreline.

Input parameters are derived from the results of areal modeling. Hydraulic properties of the aquifer include a horizontal to vertical anisotropy of 200 to 1 to overcome numerical instabilities. A range of dispersivities and anisotropic ratios were tested to define the optimal combination for the model's geometry.

As discussed in Section 2.3.3, solution of the advection-dispersion equations for high pore Peclet numbers with numerical methods is ill-posed. This limitation is overcome by constraining the model to effectively permit the dominance of advective processes in a dispersion-dominated model. Furthermore, it is quite likely that actual anisotropic permeability does exist, as a result of the horizontal deposition of marine material and formation dissolution in the direction of groundwater flow (which is generally horizontal).

Inflow at the mauka boundary matches the flux applied in the interim land use scenario. It, as well as with recharge, is calculated on a unit width basis. An estimate of the caprock pumpage was assigned based upon an average zone of influence. Calibration of the model involved refinement of pumpage levels to obtain a match with observed water table gradients (to accommodate a three-dimensional boundary condition in the two-dimensional model).

The narrow band of low permeability along the shoreline used in the areal models (to match observed groundwater levels) was included as a band of elements with a horizontal permeability of 500 ft/d. This band was aligned with the expected interface position (Figure 30). Trial simulations were also run with various other configurations of the low permeability band to evaluated the sensitivity of the



EWA MARINA
GROUNDWATER IMPACT
ASSESSMENT
On Behalf of
BELT COLLINS & ASSOCIATES

LEGEND
Finite Element Mesh

ORIGINAL SCALE

SUTRA FINITE ELEMENT MESH
FOR VERTICAL SECTION MODEL

FIGURE 30

Mackie Martin & Associates

model. It was concluded from this exercise that features such as 'Beach Rock' could not alone create the sharp change in hydraulic gradients at the coast.

Predicted salinity contours (expressed as percent sea water) for the existing land use are presented in Figure 31. The toe of the interface is located approximately 6000 feet inland. Minor upconing is predicted beneath EP27 as a result of pumpage from this well.

Schematic flux vectors included on this plot illustrate the movement of both groundwater and seawater within the aquifer. Groundwater moves through the aquifer toward the ocean and 'floats' over the denser seawater. Groundwater movement is driven by the recharge (flux) which generates the hydraulic gradient toward the coast. Due to the viscous nature of fluids, entrainment and mixing of sea water occurs at the interface between groundwater and seawater, inducing circulation within the seawater section of the aquifer.

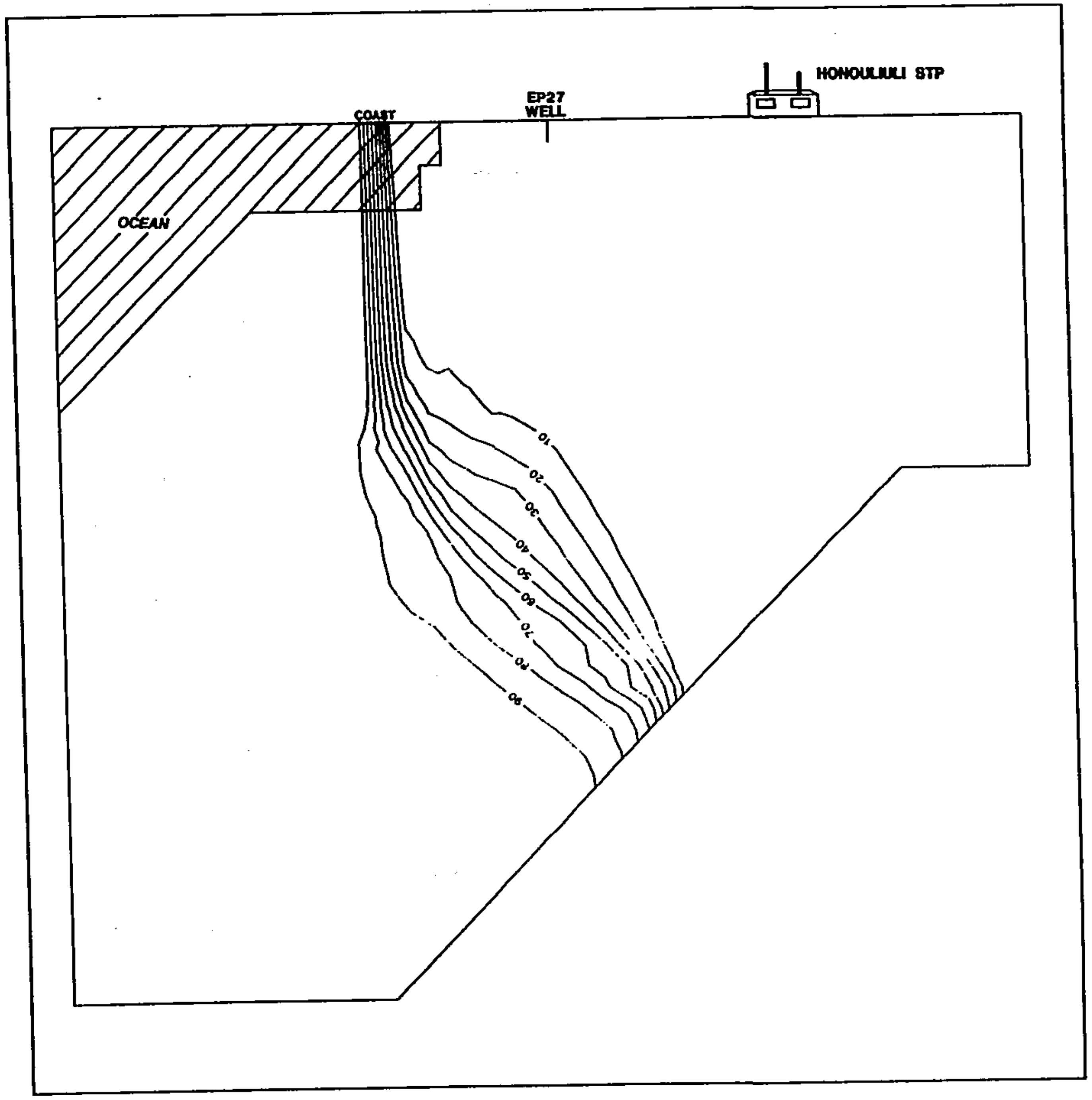
The calibrated model has been employed to evaluate the interface dynamics in response to changing land use and the proposed cutting of the marina into the aquifer.

5.0 IMPACT OF THE PROPOSED MARINA FOR VARIOUS LAND USE SCENARIOS

5.1 Interim Land Use

The interim land use scenario (refer back to Figure 8A) represents the expected state of development at the time of marina construction. At this time, the Ewa by Gentry project would be completed and sugar cane would be almost entirely contracted to the Blast Zone.

A significant increase in flux through the aquifer over existing conditions would result from the removal of sugar cane (and therefore caprock pumpage). This would be offset, to some extent, by pumpage for golf courses and the anticipated reduction in imported basalt water for irrigation. As a result, predicted water level response due to these developments, presented in Figure 32, indicates a water level rise of approximately 0.1 feet over most of the plain. Minor inflections in water level contours would occur in the vicinity of the Myers-Seibu and Chiyoda Golf Courses in response to pumpage from golf course irrigation wells. The hydraulic model also predicts a head of 1.5 feet adjacent to the coast near the marina.



EWA MARINA
GROUNDWATER IMPACT
ASSESSMENT
On Behalf of
BELT COLLINS & ASSOCIATES

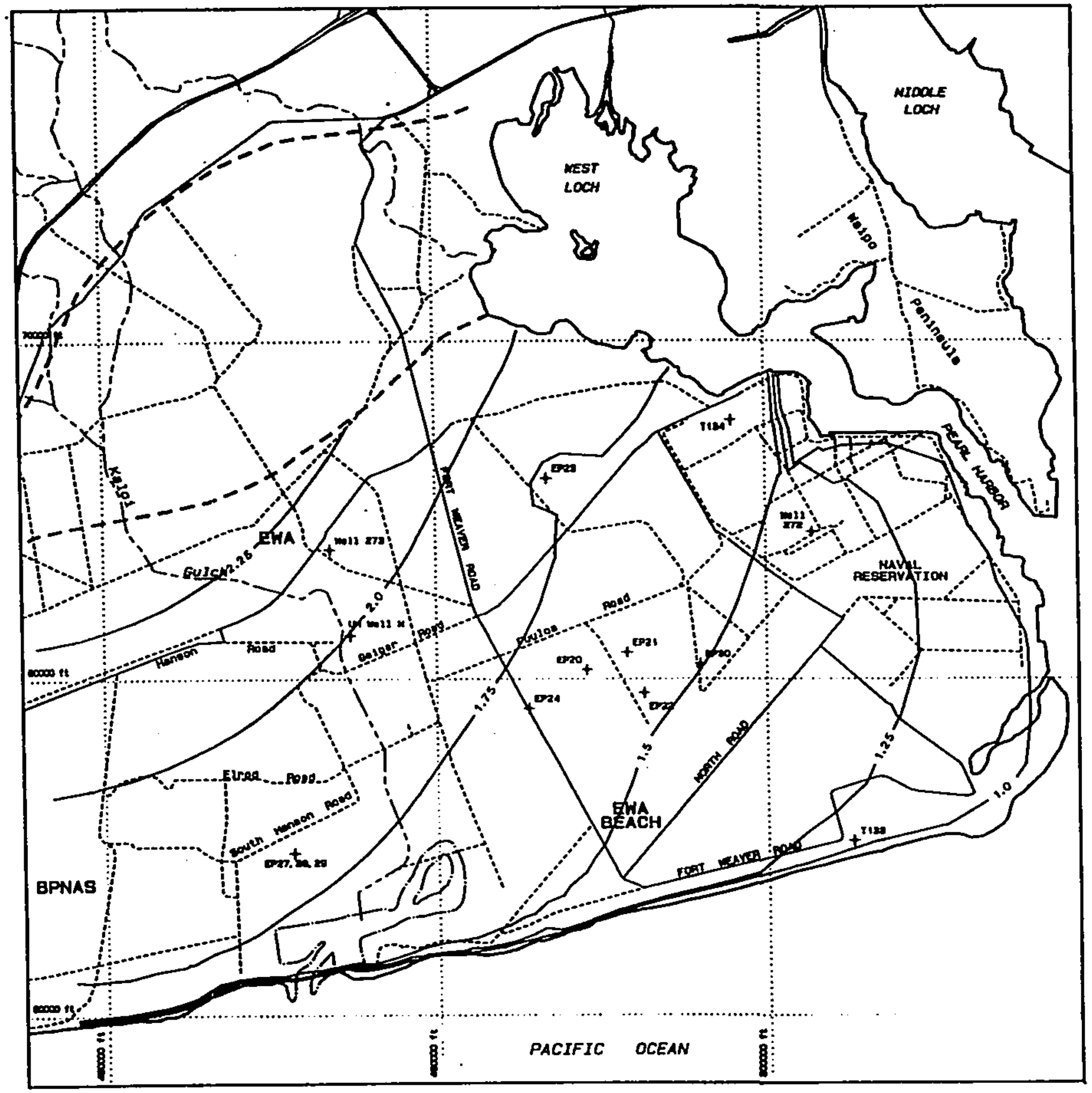
LEGEND:
—— % Sea Water Contour

0 20 40 60 ft
ORIGINAL SCALE
(HORIZONTAL: VERTICAL SCALE = 100:1)

SIMULATED SALT WATER INTERFACE
FOR EXISTING LAND USE

FIGURE 31

Mackie Martin & Associates
GROUNDWATER ENGINEERS



EWA MARINA
GROUNDWATER IMPACT ASSESSMENT
On Behalf of
BELT COLLINS & ASSOCIATES

LEGEND:
- Coastline
- Major Roads
- Minor Roads (tracks)
- Surface Water Channels (gulches)
- Proposed Marina
- Geological Boundary (sector boundary)
- Water Level Contours (ft ASL)

0 2000 4000 6000 8000 ft
ORIGINAL SCALE
(1 inch to 2000 feet)

PREDICTED WATER LEVELS
FOR INTERIM LAND USE

FIGURE 32

Mackie Martin & Associates
GROUNDWATER ENGINEERS

Corresponding chloride contours produced with the areal water quality model show a substantial reduction in chloride levels (Figure 33). This is primarily due to the reduction in caprock water re-cycling (for sugar cane irrigation). The highest chloride concentration, approximately 950 mg/l, is predicted within the Blast Zone area; elsewhere, chloride levels would be less.

Salinity contours calculated with the vertical section model (Figure 34) also show a positive response to water budget changes under interim land use conditions. In addition to the seaward movement of the interface, the interface thickness is reduced as a result of lower caprock pumpage and increased flux. Groundwater pumpage at EP27 for sugar cane would be terminated (due the removal of cane fields for residential development) and the effects of upconing would not occur.

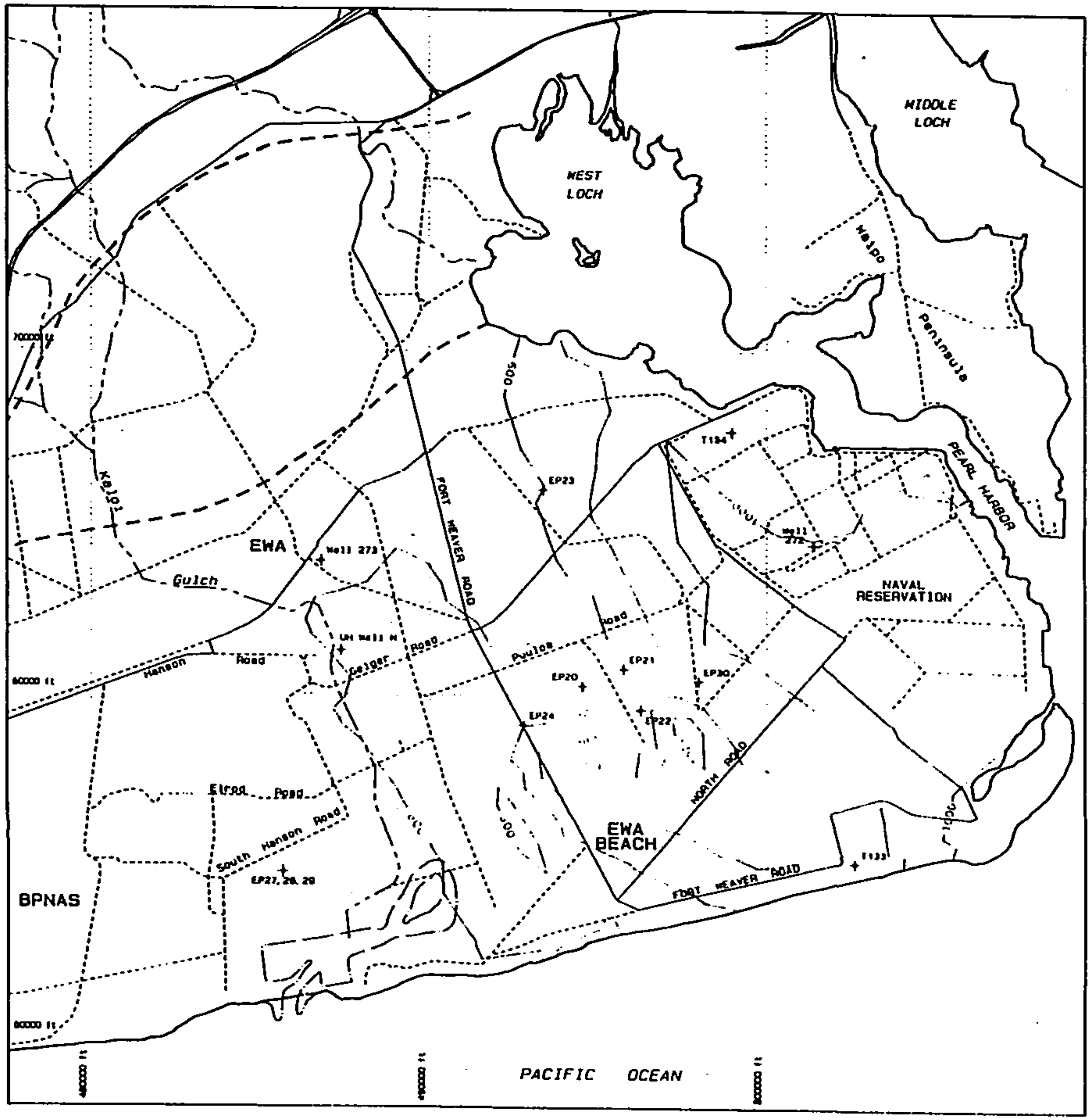
5.1.1 Impact of Marina Under Interim Land Use

Incorporation of the proposed marina in the areal models is accomplished by assigning coastal boundary conditions around the perimeter of the marina. Sufficient detail (within the finite element mesh) in the hydraulic model was included to ensure representative hydraulic responses near the marina.

Predicted water levels (Figure 35) show a decline of approximately 0.5 feet in the Gentry area due to the cutting of the marina (compared with Figure 32). At the mauka end of the marina, water levels which prior to marina construction were about 1.7 feet have been reduced to sea level. Groundwater flow is focussed toward the marina as a result of the re-configuration of the (effective) coastline and the removal of the low permeability band of the coast at this location. Of the total discharge from the aquifer to the ocean (17.5 MGD), the model estimates that approximately 12 MGD would exit through the marina. This has a marked impact upon the eastern side of the model, with heads declining to less than 1.5 feet at EP23. Predicted water levels at EP27, adjacent to the marina, show a decline from 1.8 feet without the marina to 0.7 feet after the marina is constructed.

This impact is further reflected in the water quality model (Figure 36), which suggests a significant deterioration in quality across the eastern section due to the decline in flushing. A peak chloride concentration of 1200 mg/l is predicted near the Myer-Seibu Golf Course.

Incorporation of the marina in the salt water interface model is achieved by replacing aquifer elements with ocean elements corresponding to an approximate profile of the marina. This model shows the expected inland movement of the interface (Figure 37). The toe of the interface is approximately 7500 feet inland, about 1500 feet further inland than for existing land use conditions and 5000 feet for interim land use without the marina. In addition, the fresh water lens thins immediately inland of the marina due to the flatter hydraulic gradients.



EWA MARINA
GROUNDWATER IMPACT
ASSESSMENT
On Behalf of
BELT COLLINS & ASSOCIATES

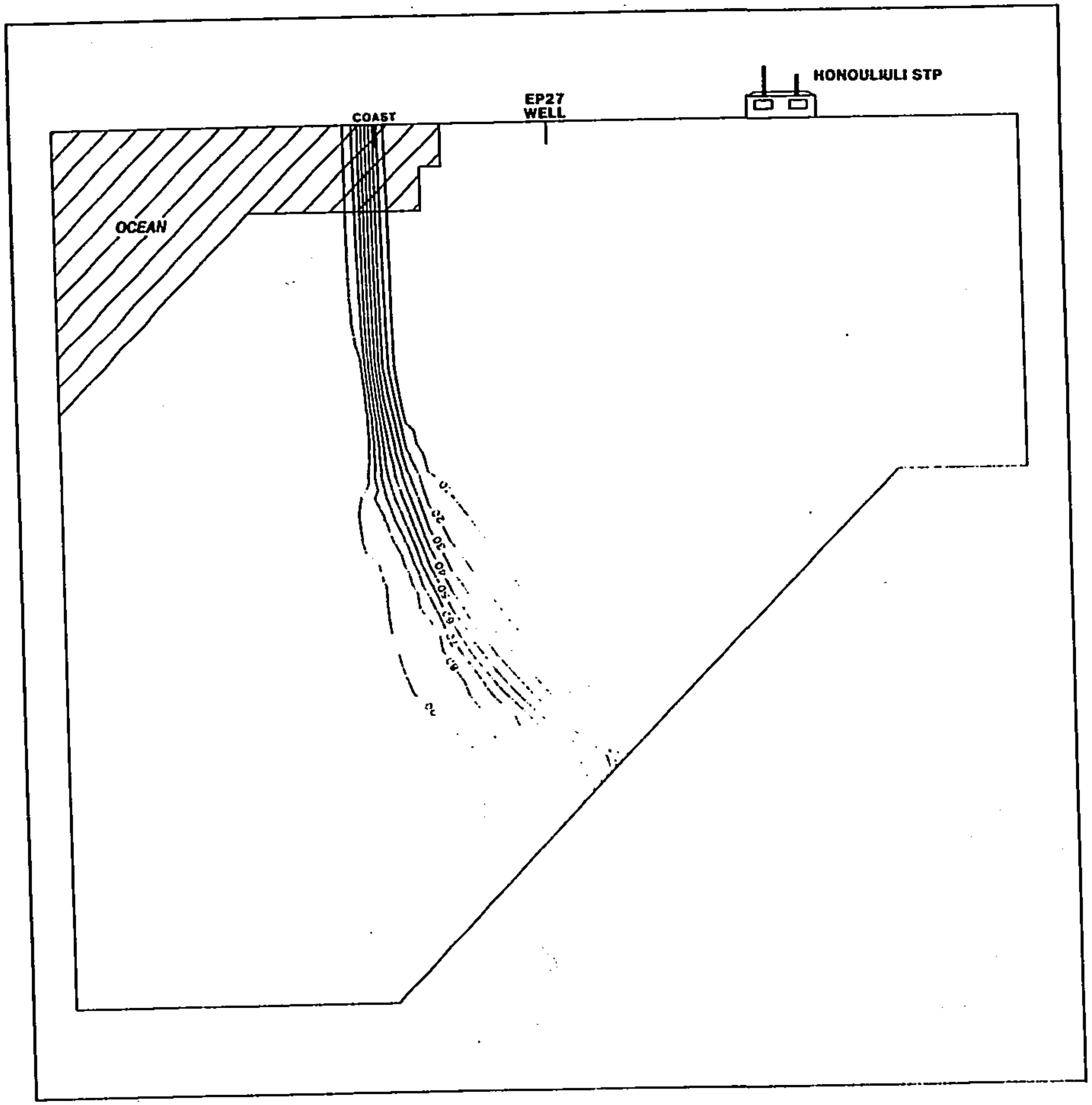
LEGEND.
- Coastline
- Major Roads
- Minor Roads (tracks)
- Surface Water Channels (gulches)
- Proposed Marina
- Geological Boundary (sector boundary)
- Isochlor (mg/l)

0 2000 4000 6000 8000 ft
ORIGINAL SCALE
(1 inch to 3000 feet)

PREDICTED CHLORIDE CONCENTRATION
FOR INTERIM LAND USE

FIGURE 33

Mackie Martin & Associates
GROUNDWATER ENGINEERING



EWA MARINA
GROUNDWATER IMPACT
ASSESSMENT.
On Behalf of
BELT COLLINS & ASSOCIATES

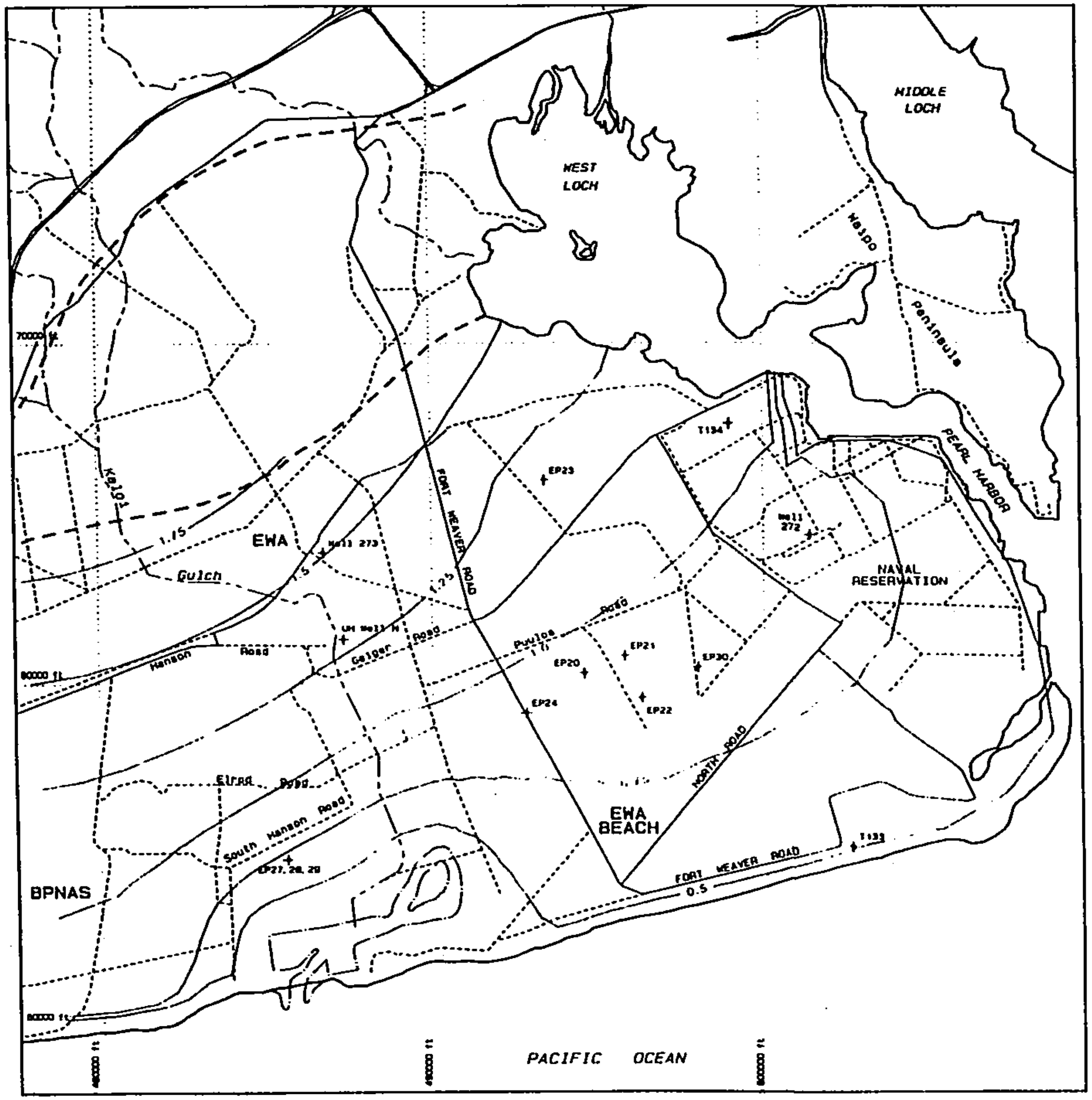
LEGEND:
% Sea Water Contour

0 20 40 60 ft
ORIGINAL SCALE
HORIZONTAL VERTICAL SCALE = 100:1

PREDICTED SALT WATER INTERFACE
FOR INTERIM LAND USE

FIGURE 34

Mackie Martin & Associates
GROUNDWATER ENGINEERS



EWA MARINA
GROUNDWATER IMPACT
ASSESSMENT
On Behalf of
BELT COLLINS & ASSOCIATES

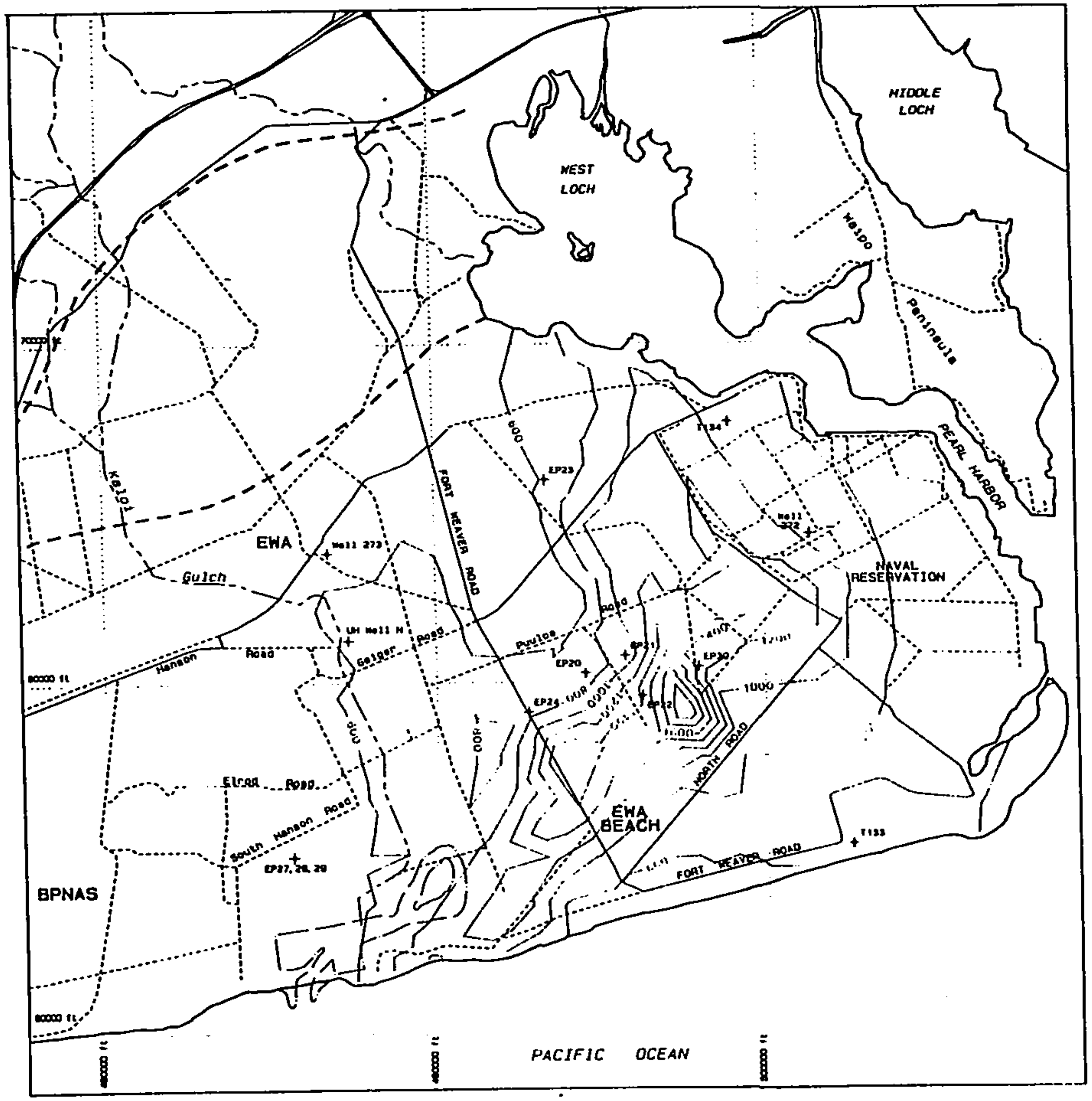
LEGEND:
- Coastline
- Major Roads
- Minor Roads (tracks)
- Surface Water Channels (gulches)
- Proposed Marina
- Geological Boundary (sector boundary)
- Water Level Contours (ft ASL)

0 2000 4000 6000 8000 ft
ORIGINAL SCALE
(1 inch to 3000 feet)

PREDICTED WATER LEVELS
FOR INTERIM LAND USE
WITH MARINA

FIGURE 35

Mackie Martin & Associates
Groundwater Engineers



EWA MARINA
GROUNDWATER IMPACT
ASSESSMENT
On Behalf of
BELT COLLINS & ASSOCIATES

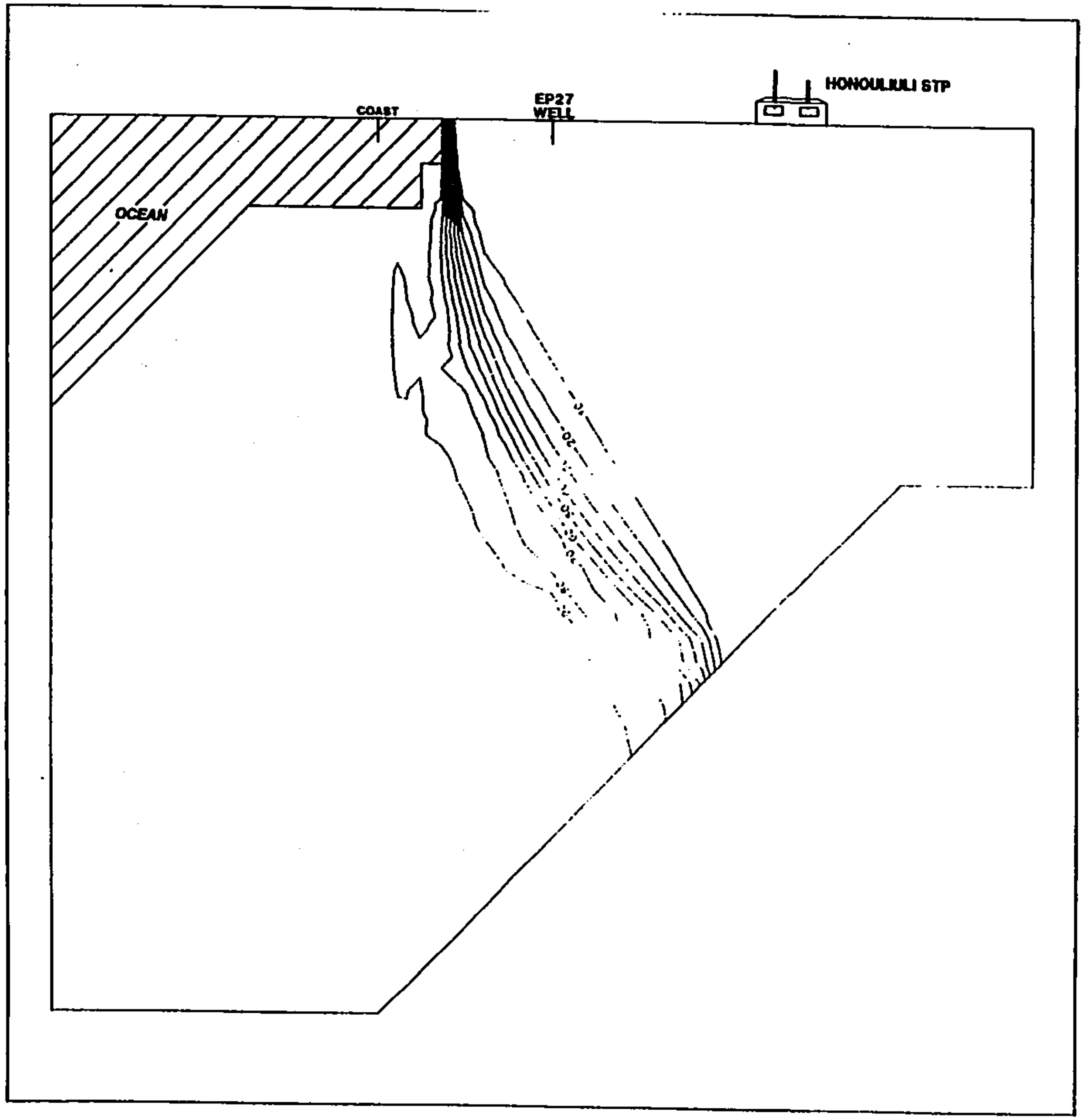
LEGEND:
- Coastline
- Major Roads
- Minor Roads (tracks)
- Surface Water Channels (gulches)
- Proposed Marina
- Geological Boundary (sector boundary)
- Isochlor (mg/l)

0 2000 4000 6000 8000 ft
ORIGINAL SCALE
(1 inch to 3000 feet)

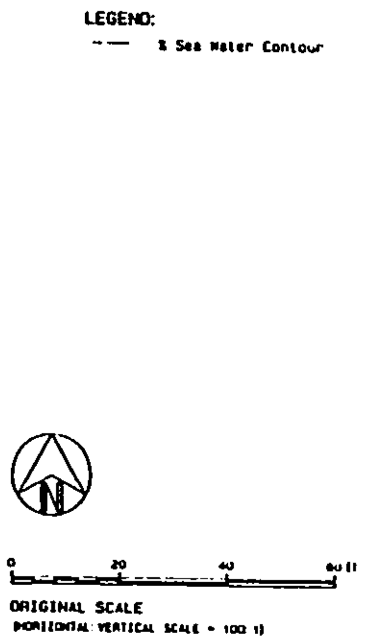
PREDICTED CHLORIDE CONCENTRATION
FOR INTERIM LAND USE WITH MARINA

FIGURE 36

Mackie Martin & Associates
Groundwater Engineering



EWA MARINA
GROUNDWATER IMPACT
ASSESSMENT
On Behalf of
BELT COLLINS & ASSOCIATES



PREDICTED SALT WATER INTERFACE
FOR INTERIM LAND USE WITH MARINA

FIGURE 37

Mackie Martin & Associates

5.2 Future Land Use

The future land use scenario, which corresponds to Campbell Estate's Long Range Master Plan, has the entire modeled area developed with residences and golf courses, with the exception of military controlled areas (including the Blast Zone adjacent to West Loch). The water budget for this scenario (refer back to Figure 9B) shows additional caprock pumpage assigned to the Ewa Marina Golf Course (1.0 MGD) and the low density apartment areas (1.7 MGD). Recharge is also reduced in areas which were previously basalt irrigated cane fields, from the previous 1.6 MGD to 0.8 MGD under residential use.

The net impact of future land use conditions is portrayed in Figure 38. This plot indicates that a small water level decline (of the order of 0.1 feet) occurs due to the additional land development. Consequently, the impact of the marina under future land use conditions shows similar water level, chloride and interface responses to those depicted for the interim land use condition.

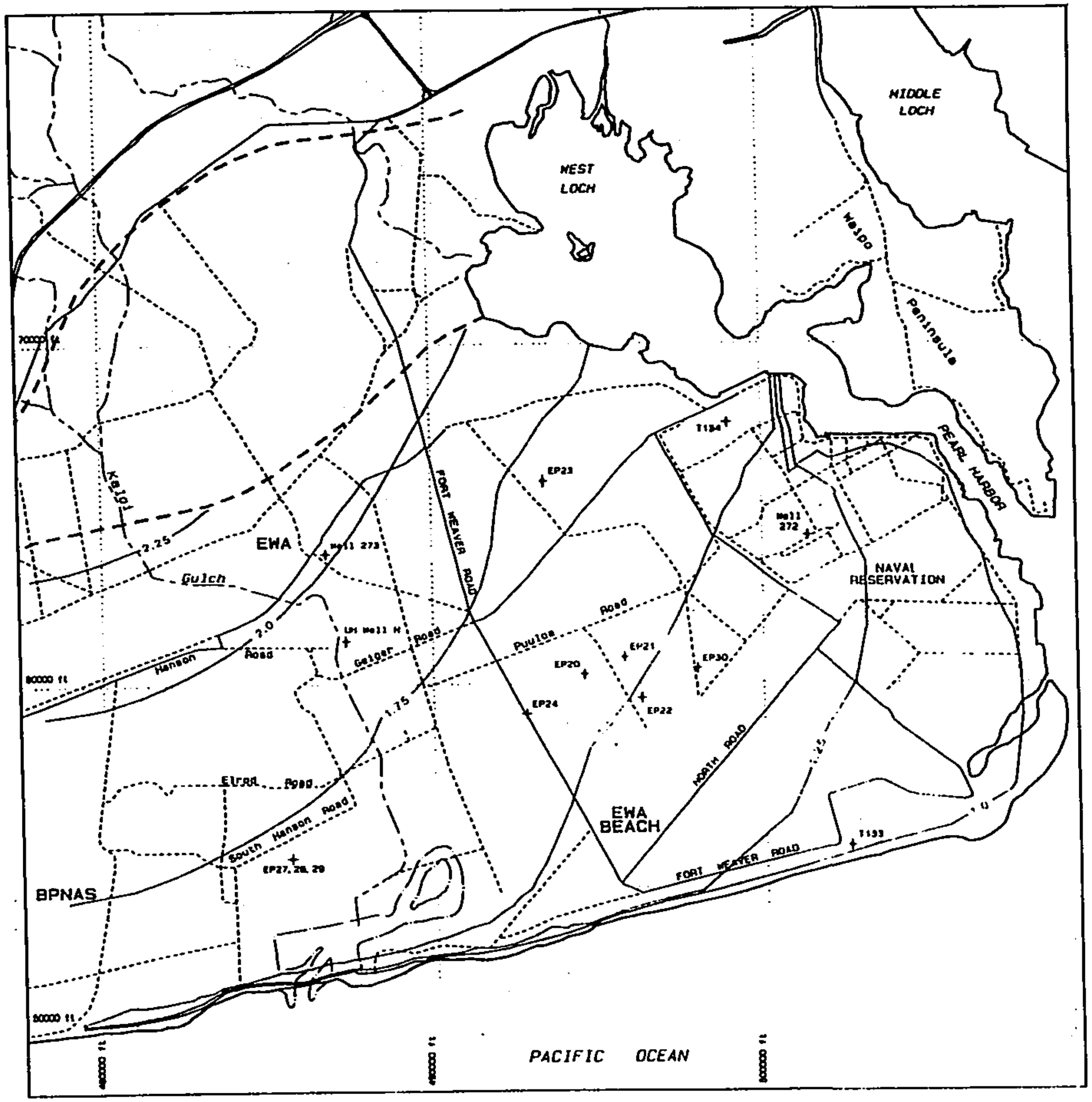
6.0 MITIGATION STRATEGIES

6.1 Natural Re-Sealing

Observations at the Barbers Point Deep Draft Harbor and Mindarie Keys in Australia suggest that a natural "re-sealing" of the perimeter of the excavated marina is likely to occur, ultimately achieving a band of lower permeability which exists along the present shoreline. Simulations of such a re-sealing have been completed with each numerical model using the interim land use scenario. This was implemented by placing additional low permeability elements at the equivalent location with respect to the 'new' coastline, the marina's shoreline.

Water levels predicted by the areal hydraulic model, presented in Figure 39, show that water levels would approximately be the same as if the marina was not constructed. The decline of water level across most of the plain would be less than 0.1 foot, a result of the effective relocation of the coastline.

Similarly, results of areal water quality and salt water interface modeling which include re-sealing suggest that the marina would have minimal impact. Predicted regional chloride concentrations show no discernible difference to those predicted for interim land use without the marina (Figure 33).



EWA MARINA
GROUNDWATER IMPACT
ASSESSMENT
On Behalf of
BELT COLLINS & ASSOCIATES

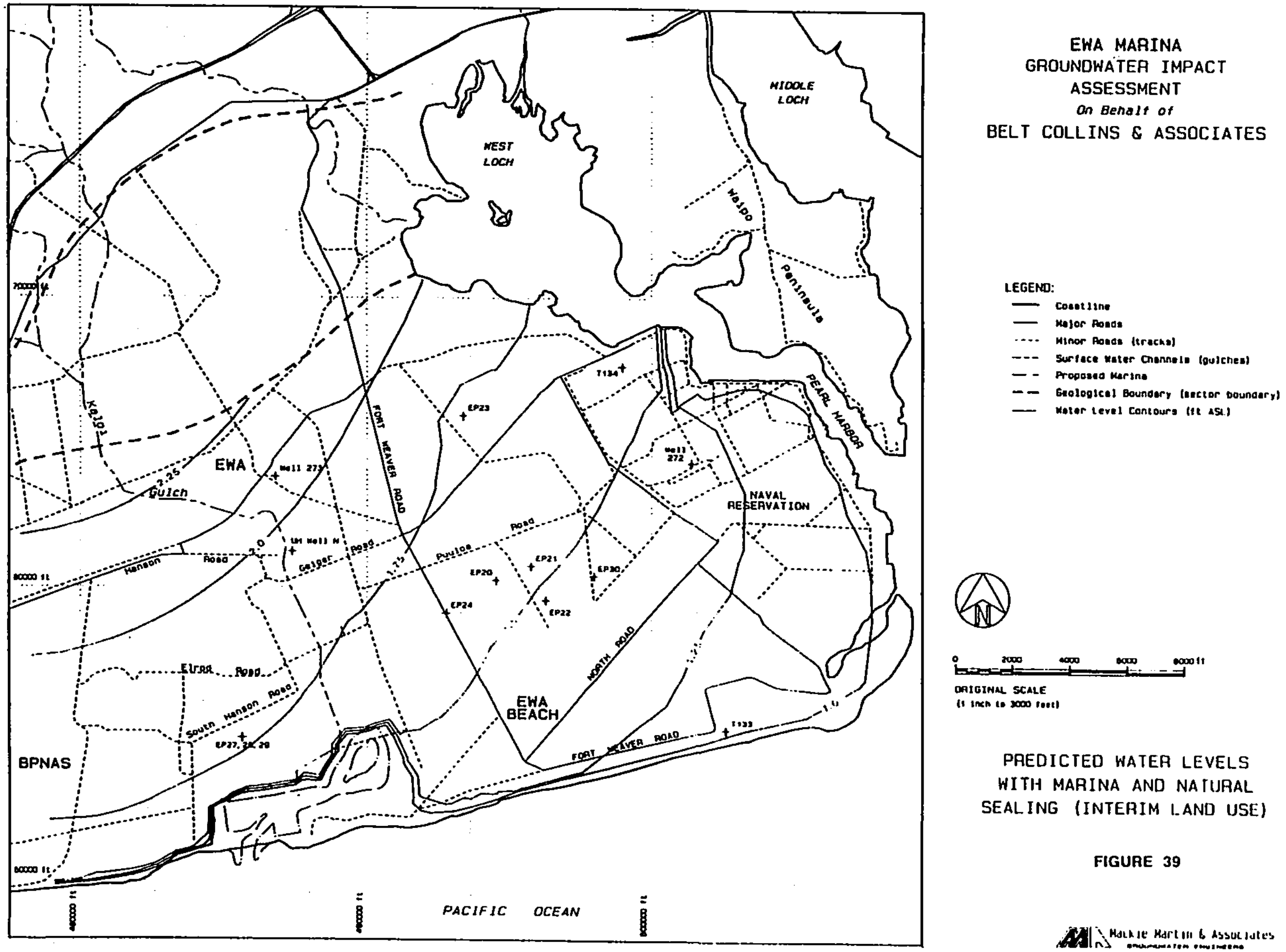
LEGEND:
- Coastline
- Major Roads
- Minor Roads (tracks)
- Surface Water Channels (gulches)
- Proposed Marina
- Geological Boundary (sector boundary)
- Water Level Contours (ft ASL)

0 2000 4000 6000 8000 ft
ORIGINAL SCALE
(1 inch to 3000 feet)

PREDICTED WATER LEVELS
FOR FUTURE LAND USE
(WITHOUT MARINA)

FIGURE 38

Mackie Martin & Associates
GROUNDWATER ENGINEERS



EWA MARINA
GROUNDWATER IMPACT
ASSESSMENT
On Behalf of
BELT COLLINS & ASSOCIATES

PREDICTED WATER LEVELS
WITH MARINA AND NATURAL
SEALING (INTERIM LAND USE)

FIGURE 39

Mackie Martin & Associates

Simulation of the re-sealing mechanism in the salt water interface model has assumed that a second reduced permeability band would form at the new interface position. Under this scenario, the original low permeability band remains except that the upper 20 feet is cut away by the marina. The predicted interface configuration (Figure 40) reflects the additive nature of the two low permeability sections of the aquifer. The interface becomes thinner and moves seaward, as movement of water between the groundwater and seawater horizons is further inhibited.

6.2 Engineering Solutions

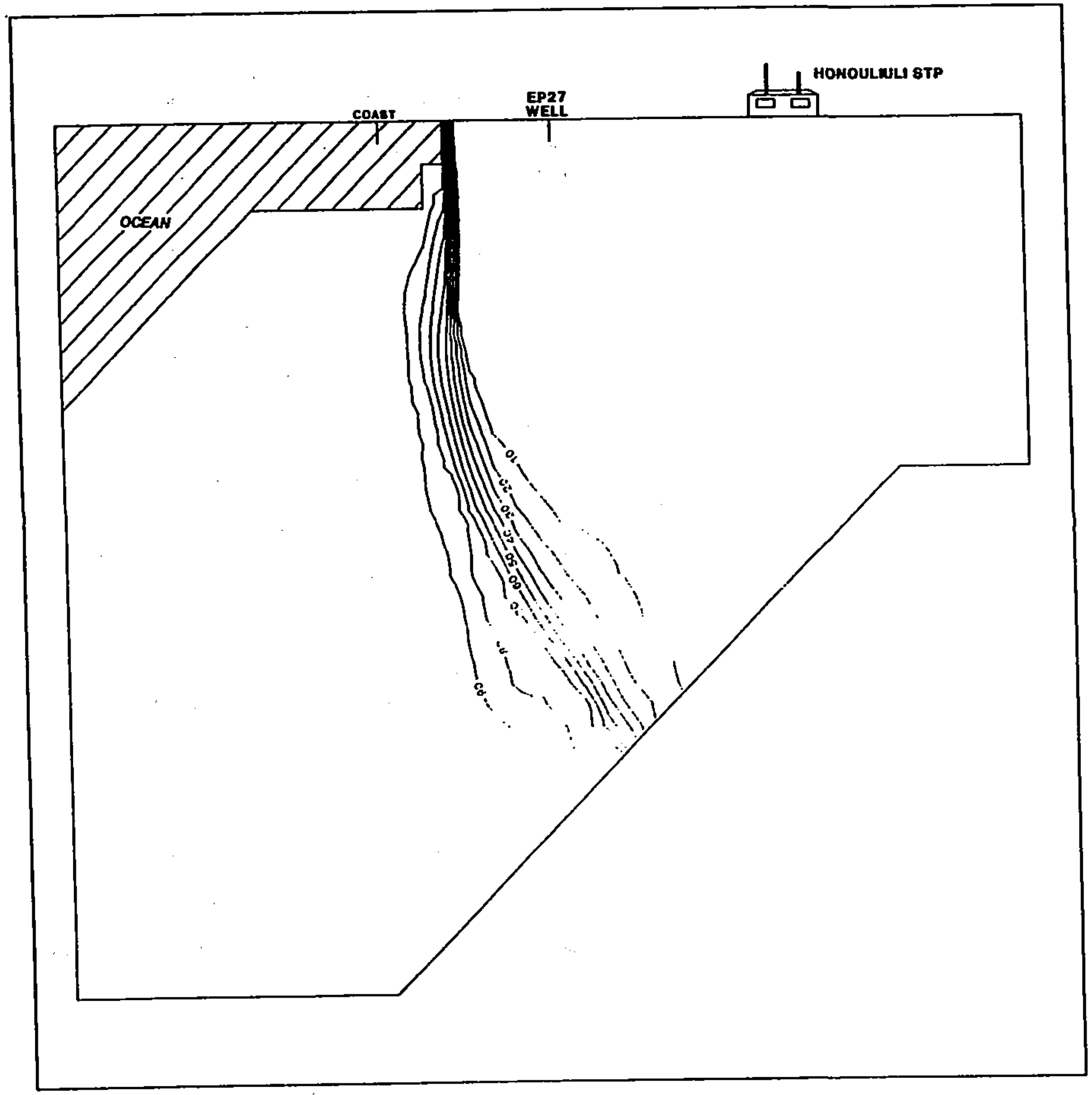
A number of engineering solutions are possible to mitigate against the potential adverse impact of the marina on regional water levels and quality. Simulations have included permeability reductions which could be achieved using grout curtains, sheet piling, or a combination of the two. In addition, artificial recharge inland of the marina could offset this potential effect.

In view of the high permeability demonstrated across the marina site and significant local variations in aquifer permeability (such as due to cementation, cavities, and solution channels), achieving an effective grout curtain around the marina could pose major technical problems. Preliminary simulations with a 50% reduction in permeability around the perimeter of the marina indicated that this would be insufficient to offset the impact of the marina. Further assessment of grouting techniques would be required to demonstrate its ability to produce the required permeability reduction.

On the other hand, installation of sheet piling could provide substantial reduction in permeability to the depth of the piling. Simulation of a complete barrier to groundwater flow (with permeability reduced to 1 ft/d) has been completed with the areal hydraulic model and the salt water interface model. Predicted water levels from the areal hydraulic model, presented in Figure 41, show a rise of about 0.2 feet from predicted interim levels without the marina. This results because the marina would no longer be a 'sink' for groundwater discharge but would become an obstacle which the groundwater would have to flow around the areal model assumes that sheet piles are effective over the entire thickness of groundwater flow. If the piling is not that deep, the model overestimates the water level rise.

Preliminary assessment of the depth of piling required was undertaken with the salt water interface (vertical section) model. Limitations of this model arise from the fact that, as a vertical slice, it does not reflect the lateral diversion around the entire marina. However, the combination of predictions from both the areal and vertical slice models does provide an indication of the engineering works required to offset the adverse impact of the marina.

EWA MARINA
GROUNDWATER IMPACT
ASSESSMENT
On Behalf of
BELT COLLINS & ASSOCIATES



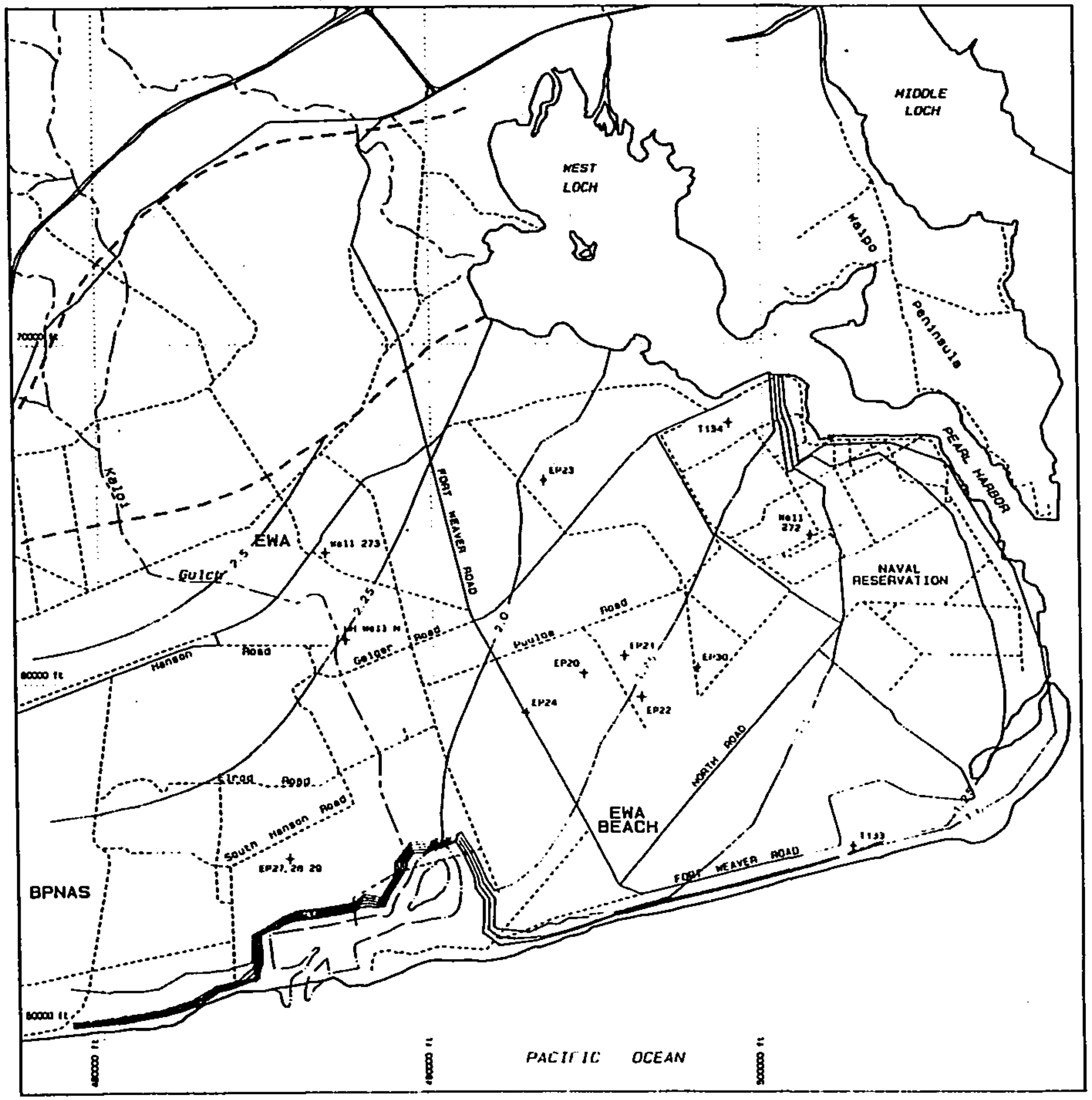
LEGEND:
% Sea Water Contour

0 20 40 80 ft
ORIGINAL SCALE
HORIZONTAL VERTICAL SCALE = 100 ft

PREDICTED SALT WATER INTERFACE
WITH MARINA AND NATURAL SEALING

FIGURE 40

Mink Martin & Associates
GROUNDWATER ENGINEERS



EWA MARINA
GROUNDWATER IMPACT
ASSESSMENT
On Behalf of
BELT COLLINS & ASSOCIATES

LEGEND:
- Coastline
- Major Roads
- Minor Roads (tracks)
- Surface Water Channels (gulches)
- Proposed Marina
- Geological Boundary (sector boundary)
- Water Level Contours (ft ASL)

0 2000 4000 6000 8000 ft
ORIGINAL SCALE
(1 inch to 3000 feet)

PREDICTED WATER LEVELS
WITH MARINA AND SHEET
PILING (INTERIM LAND USE)

FIGURE 41

Mackie Martin & Associates
Groundwater Engineers

The predicted interface location for an 80 feet sheet pile barrier, illustrated in Figure 42, shows little seawater intrusion inland of the marina. Some numerical instability in the model does occur immediately makai of the sheet pile, resulting from the forcing of water beneath the barrier and the vertical flow as fresh water discharges to the ocean. Predicted water levels inland of the sheet pile show a 15% rise over predicted interim water levels.

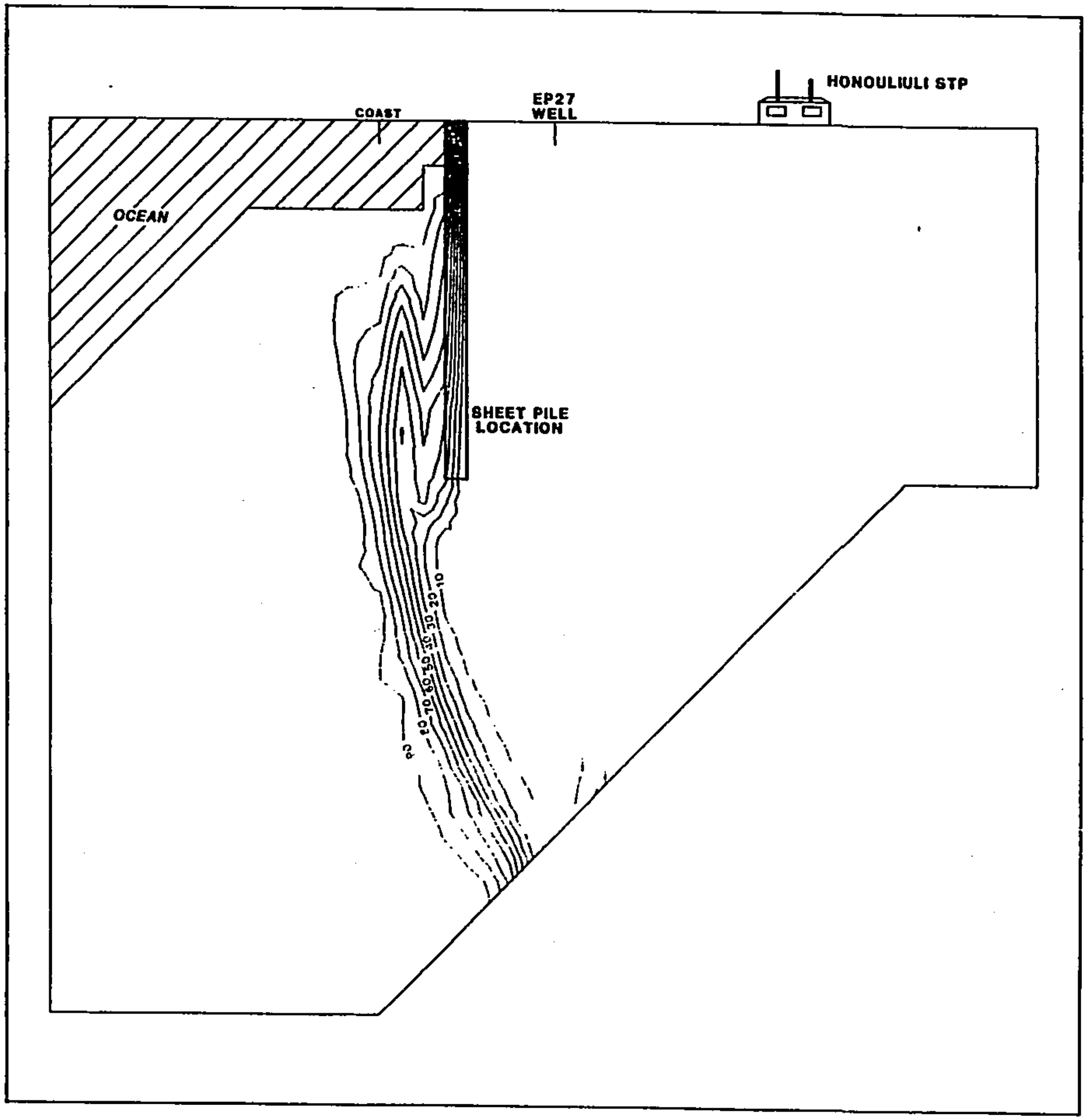
7.0 CONCLUSIONS AND RECOMMENDATIONS

Extensive geological, hydraulic, and hydrochemical investigation has been undertaken to define the prevailing hydrogeology and groundwater chemistry and assess the potential impact of the marina. Field investigations have included the drilling and coring of a total of 17 wells at the marina site, at Campbell Industrial Park, and next to the Barbers Point Deep Draft Harbor. Water level monitoring, salinity profiling, and water quality sampling data have been compiled for these boreholes and other, existing wells across the Ewa plain over the period July 1990 to February 1991.

Hydrogeochemistry data suggests that natural precipitation mechanisms may be responsible for the reduction in permeability measured in boreholes adjacent to the shoreline. Mineralogy of the cores from the test boreholes support this interpretation. If this is the controlling mechanism, the reduced permeability should vary from high values within the lens to low values in the transition or saline zones. However, hydraulic testing in the boreholes to date has been able to demonstrate this. Rather, this testing indicates that the reduced permeability is more likely to have a vertical, rather than horizontal, orientation. A better understanding of this phenomenon is needed to more confidently predict the marina's effect.

Three independent numerical models were developed to address areal hydraulic responses, salt-water interface movement, and regional chloride (water quality) distribution. These models were calibrated with data generated for this study and by previous investigations. For each model, the impacts of changing land use and the associated changes in water budgets were evaluated and implications for the long term viability of the caprock aquifer system were assessed. The impact of the proposed marina on these future land use and water budget scenarios was evaluated and the response to possible remedial action was presented.

Numerical modeling results suggest that without a natural or artificial re-sealing around the perimeter of the marina, a groundwater level decline of the order of 0.5 feet across the plain could occur due to the construction of the marina. Further, up to 70 percent of the groundwater discharging along the shoreline could be diverted through the marina.



EWA MARINA
GROUNDWATER IMPACT
ASSESSMENT
On Behalf of
BELT COLLINS & ASSOCIATES

LEGEND:
—— % Sea Water Contour

ORIGINAL SCALE
(HORIZONTAL VERTICAL SCALE = 100 1)

PREDICTED SALT WATER
INTERFACE WITH MARINA
AND SHEET PILING
(INTERIM LAND USE)

FIGURE 42

Mackie Martin & Associates
Groundwater Engineers

Regional water quality modeling indicates that a significant improvement in chloride concentration would occur with the reduction of sugar cane activities in the study area as long as the remainder of sugar cane activities directly inland are continued. Predicted chloride concentrations are derived from the balance between irrigation return flow and flushing by through flow. With the construction of the marina and its potential to focus groundwater discharge if re-sealing does not occur, a degradation in water quality could occur across the eastern section of the plain. Irrigation use such as at the Myers-Seibu and Puuloa Golf Courses would be adversely affected.

If natural resealing would not occur around the perimeter of the marina, other, artificial mitigation strategies must be considered. Model results for the effect of a sheet pile barrier confirm that appropriately designed engineering works could offset the potential adverse impacts if the marina is constructed and natural re-sealing does not occur.

The cut would be made within the area of the proposed marina entrance to a depth of approximately 15 feet below sea level, a width of about 30 feet, and extend at least 200 feet inland from the shoreline. Adjacent boreholes could be used to define aquifer parameters before the test and to monitor the response, including the re-sealing effect, during and after the cut is made. The scale of such a test would be large enough to make confident predictions regarding the marina. However, it would be small enough to avoid adverse impact on present groundwater use and for the excavated area to be fully restored if necessary.

The proposed marina is a large-scale project which could have a substantial impact on a valuable irrigation supply. This groundwater investigation must be able to confidently predict that the effect of the marina's excavation will be offset by the expected natural re-sealing or that practical artificial mitigation measures are available to offset the effect. This information must be available to regulatory agencies which will authorize the project. It must also be available to HASEKO (Hawaii), Inc., as it will have to fund the artificial measures that are necessary. The best way to make conclusive predictions is to undertake a trial cut from the shoreline into the aquifer.

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EVALUATION OF CARBONATE MINERALOGY AT EWA MARINA

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Department of Oceanography
Marine Geochemistry Division
University of Hawaii

February 1991

INTRODUCTION AND PURPOSE

Reactions between marine reef carbonates and groundwater in shallow aquifers are driven principally by the differences in thermodynamic solubility between the mineral polymorphs of calcium carbonate, aragonite and calcite. Calcite precipitated in equilibrium with seawater also typically incorporates a variable amount of magnesium substituting for calcium in solid solution (magnesian calcite), the fraction of $MgCO_3$ dependent on, in the case of biogenic calcite, the organism involved (e.g., red algae and echinoderms); magnesian calcite, as well as aragonite, can both also form abiogenically as marine cement. Modern shallow coral reefs are composed primarily of biogenic aragonite, with associated skeletal material and marine cement contributing aragonite or magnesian calcite.

Once brought into contact with undersaturated groundwater, marine aragonite and magnesian calcite will dissolve until saturation is reached. This saturation is governed by equilibrium with a magnesium-poor calcite (the Mg content of shallow groundwater being much less than seawater), whose solubility is lower than that of either aragonite or magnesian calcite. This difference in solubility thus drives the dissolution of marine carbonate and its reprecipitation as low-Mg, diagenetic calcite. The relative amounts of diagenetic calcite and remaining magnesian calcite and aragonite is then an index of the intensity of the interaction of meteoric water and carbonate bedrock.

The distinction between aragonite and magnesian calcite versus low-Mg calcite can be accomplished relatively easily under low-power petrographic examination: both of the former tend to assume a fibrous or acicular habit, while low-Mg calcite typically forms blocky, euhedral crystal faces. The distinction can also be made by routine X-ray powder diffraction analysis (XRD). Both of these techniques have been employed in the examination of a series of cores taken from Ewa Marina, with the intention of establishing qualitatively the extent of dissolution-reprecipitation reactions within the reefal limestone aquifer. These cores are located along a north-south transect normal to the shoreline, at distances of 30, 60, 100, 300, and 600 feet from shore, and cut to depths of 61(#1), 80(#2), 80(#3), 91(#4), and 116(#5) feet from surface, respectively. A general lithologic description of these cores was made, and 12 samples were selected for petrographic and XRD analysis.

METHODS

Twelve samples of coralline limestone and associated facies were chosen from cores #1 and #3. One split was powdered by initial grinding of dried sample in a ball mill, and final grinding with mortar and pestle. Powders were packed in aluminum sample cups, a small amount of CaF_2 added as an external standard, and irradiated by Cu-K radiation in an automated SCINTAG PADV powder diffractometer, operated at 45 kV-40 mA in fast continuous scan mode at a speed of 2 degrees 2 /minute from 2 to 70 degrees 2 .

The remaining bulk sample splits were vacuum-impregnated with epoxy resin, and standard, unpolished thin sections prepared for petrographic analysis. Photomicroscopy was performed using a Nikon OPTIFOT polarizing microscope with automated shutter and EKTAR 125 ASA color print film.

DISCUSSION OF CARBONATE FACIES PETROGRAPHY

The stratigraphic succession recovered in the Ewa Marina cores can be profitably organized into a simple five-fold facies division based on general lithologic character, skeletal composition, and evidence of leaching and secondary cementation. This system does not reflect the variation in lithology present in all the cores, particularly in the upper part of the section, but it does serve to highlight aspects that bear specifically on water-rock interaction. These facies are described below, and their lateral and vertical distribution appears in Figure 1.

Vuggy mollusc-coral packstone

This uppermost facies consists predominantly of small coral heads set in a matrix of molluscan and red algal debris. Continuous reef boundstone sections are rare. This facies is variably leached, with small vugs typically formed by dissolution of aragonitic mollusc valves. Coralline aragonite is crystallographically intact (see Figure 2), and appears to have suffered only minor dissolution. Secondary cementation by low-Mg calcite is also relatively minor (see Figure 3), and pore spaces formed by dissolution of skeletal material have remained open. This facies is typically slightly over 30 feet in thickness.

Porous coral-red algal boundstone

This facies consists entirely of coralline boundstone interbedded with caps of encrusting red algal laminates. Coralline microstructure as been preserved, and aragonite trabeculae can be clearly distinguished in thin section (see Figure 4). Considerable dissolution has taken place in this facies (as can been verified by comparison with coralline boundstone fabric in Figure 2). This dissolution has created a porous network, with porosity estimated at c. 50 percent.

Ferruginous red-algal grainstone

This facies is limited in distribution, and is conspicuous only in cores 3 and 1, residing between the sparry coral-red algal boundstone below and the porous coral-red algal boundstone above. There is evidence of a previous episode of meteoric cementation prior to dissolution. Figure 5 shows echinoderms grains with meteoric syntaxial calcite overgrowths showing corroded boundaries. Neighboring echinoderm grains show syntaxial overgrowths that are relatively euhedral by comparison. Red algal grains show fine-grained to micritic cement rims that may be of marine origin. Figure 5 also shows formation of micrite envelopes and later dissolution of mollusc or coral grains. Porosity in this facies is variable depending on the extent of meteoric cementation, but probably averages 25 percent. Prominent Fe staining is characteristic of this facies.

Sparry coral-red algal boundstone

This facies is identical in skeletal composition to the porous coral-red algal boundstone facies, but differs dramatically in diagenetic fabric. Sparry cement is conspicuous in hand specimen, and has all but obliterated the original microstructure. Figure 6 shows a detail of coral skeleton that has been heavily overprinted with sparry calcite cement. No intact trabecular structure is visible, and sparry calcite interfacial contacts crosscut relict skeletal fabric. Porosity is variable but low throughout this section, probably averaging less than 10 percent.

Moldic mollusc packstone

This facies is found at the base of all cores with the exception of #1. It consists dominantly of moldic pore spaces with scattered intact skeletal grains, typically coral debris (see Figure 7). The caliber of pore spaces varies from large cm-sized mollusc valve molds to unidentified mm-sized grain molds. Sparry cement is rare or absent. Matrix material is micritic carbonate.

DISCUSSION OF XRD POWDER DATA

Figure 8 plots selected X-ray diffractograms ordered by increasing depth in the #3 core. Three distinct mineral phases can be identified in samples EM1A:6, 20.5, 31.5, and 34 (Figure 8A). EM1A:6 and EM1A:20.5 (vuggy mollusc-coral packstone facies) shows peaks belonging to magnesian calcite (HMC), aragonite (A), and calcite (C) (Fluorite, F, was the calibration standard used). Magnesian calcite can be seen as a distinct doublet in the primary calcite peak, and is probably contributed by red algae. Aragonite is contributed by coral and molluscan material, and primary or diagenetic low-Mg

calcite is sourced from either skeletal debris or cement. Sample EM1A:34, taken from the top of the porous coral-red algal boundstone facies, shows aragonite as a major phase, thus confirming the identification of aragonite in thin section. In contrast, Figure 8B exhibits only calcite peaks for samples EM1A:53 (ferruginous red-algal grainstone), EM1A:60 and 63 (sparry coral-red algal boundstone), and EM1A:76 (moldic mollusc packstone). This lack of diversity in mineralogy does not reflect the primary polymineralic composition of these facies: magnesian calcite sourced from echinoderm and red algal debris in the red-algal grainstone, aragonite from the sparry coral-red algal boundstone, and aragonite from coral and mollusc debris in the moldic mollusc packstone. Comparison of powder data from core #1 (not shown), although not sampled intensively, also reveals a homogeneous calcite mineralogy.

CONCLUSIONS

Petrographic and XRD powder data taken from selected samples of two cores at Ewa Manna, and visual comparison with core samples taken farther inland, reveal a systematic loss of primary marine aragonite and magnesian calcite and replacement by low-Mg calcite. Mollusc-coral packstones and coral-red algal boundstones high in the stratigraphic section preserve primary mineralogy despite large mass losses due to dissolution (porous coral-red algal boundstone facies). In contrast, coralline boundstones lower in the section show evidence of intense phreatic cementation by low-Mg calcite, and loss (either by leaching or in situ inversion) of aragonite and magnesian calcite.

Porosity does not vary linearly with depth, but is distributed in discrete boundstone intervals, where it reaches values greater than 50 percent. Porosity deeper in the section may not be effective, as it arises largely from the dissolution of discrete skeletal clasts that do not form a communicating network.

1. North-south core transect at Ewa Marina. Note distribution of carbonate facies with depth and distance from shore.

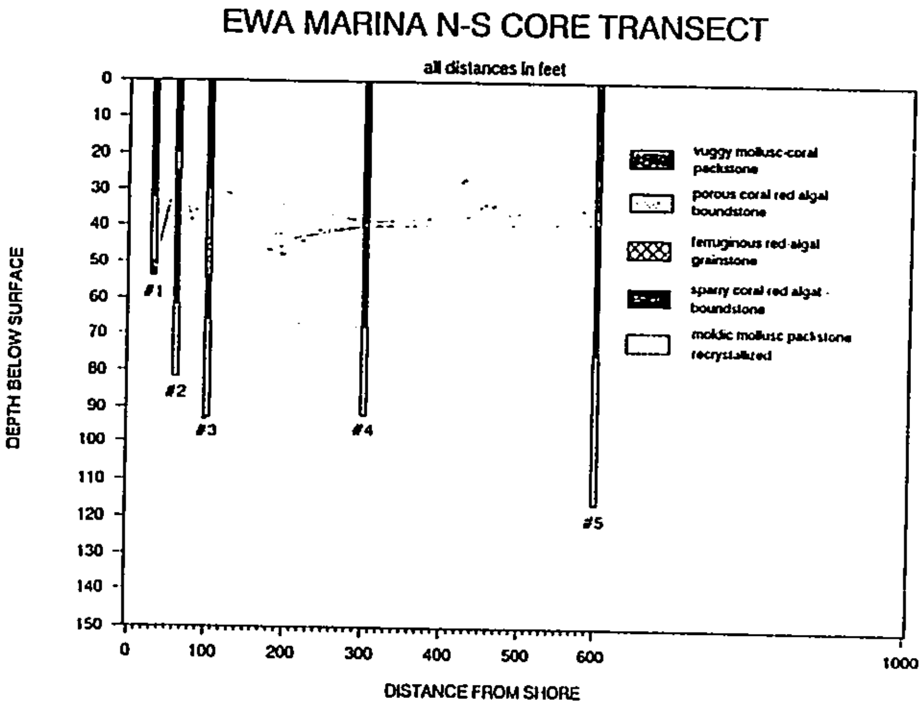


Figure 2. Vuggy mollusc-coral packstone facies. Detail of coralline microstructure, showing preservation of fibrous aragonite (a); p=porosity.

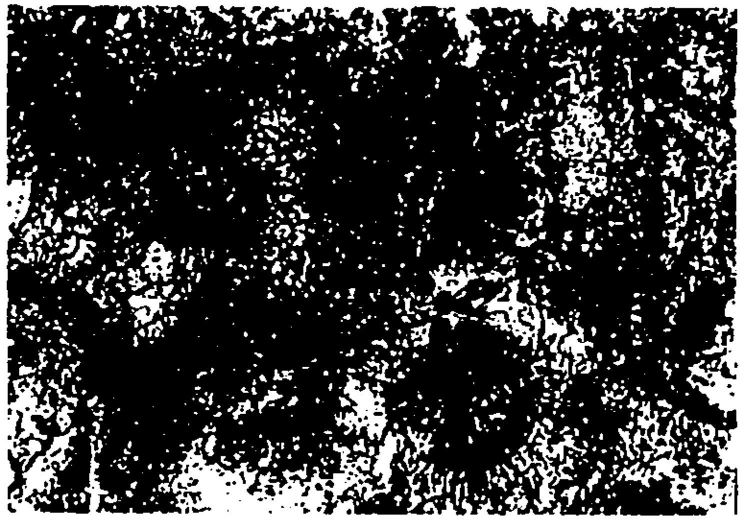


Figure 3. Vuggy mollusc-coral packstone facies. Red algal (r) and coral (c) debris, with minor calcite cement lining pore space (p).

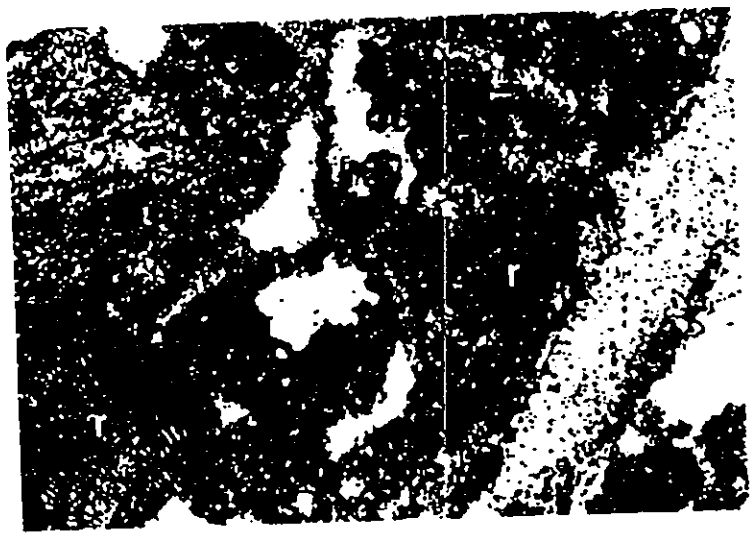


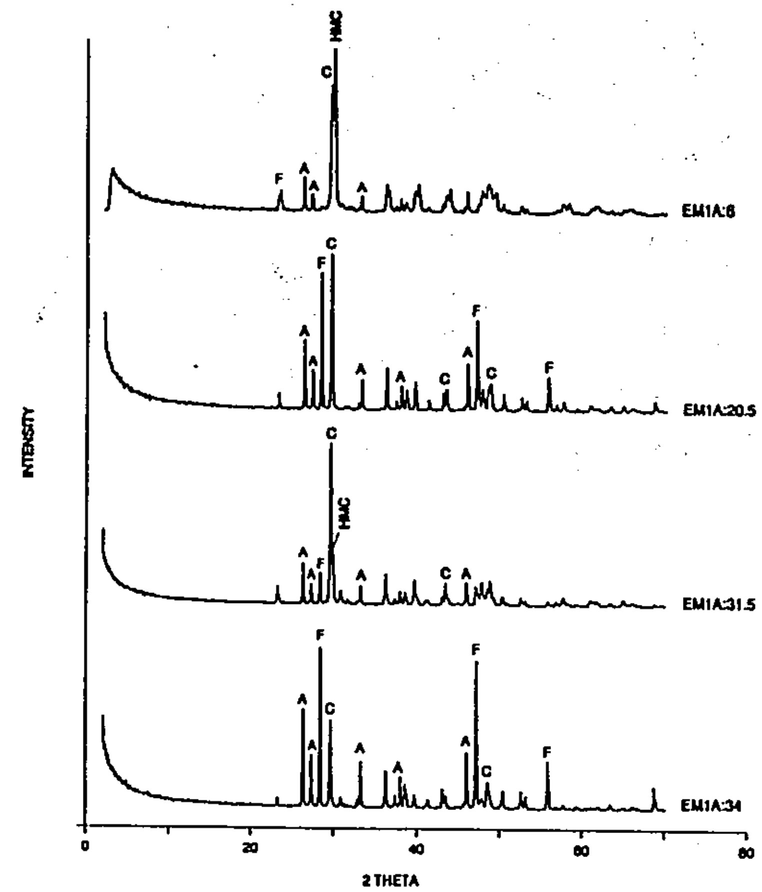
Figure 4. Porous coral red algal boundstone facies. Detail of coral skeleton showing preservation of aragonite trabecular microstructure (a) and pore space (p) due to dissolution. Note communication of pores spaces, and lack of secondary cementation along pore walls.

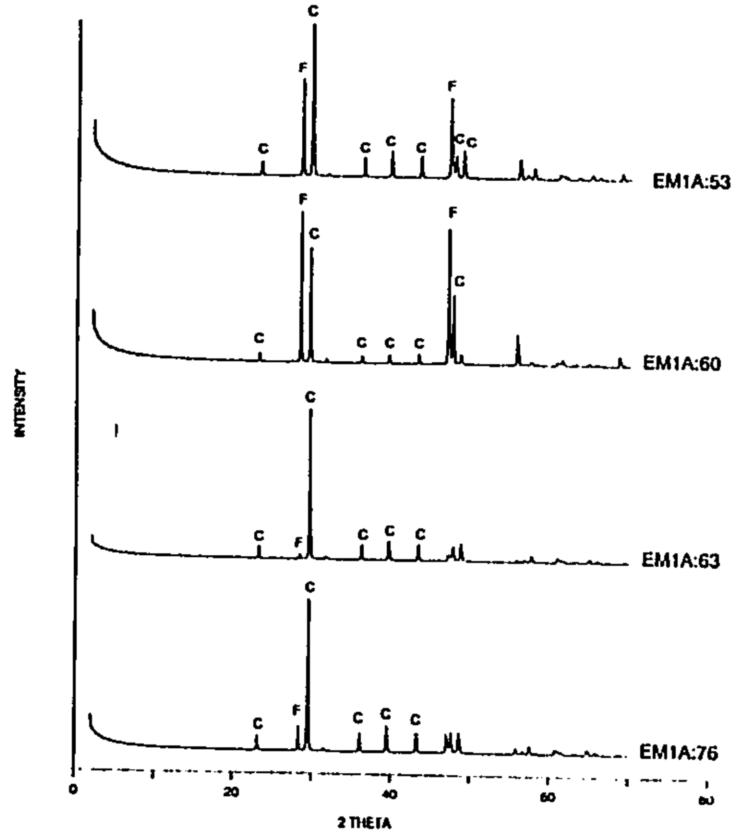
Figure 5. Ferruginous red-algal grainstone facies. Note echinoderms grains (c) with meteoric syntaxial calcite overgrowths showing corroded (c) and euhedral (h) boundaries. Corrosional boundary is evidence of dissolution following initial cementation. Fine-grained cement rims on red algal grains (r) may be of marine origin. Also note micrite envelopes and later dissolution of mollusc or coral grains, leaving pore space (p).

Figure 6. Sparry coral-red algal boundstone facies. Detail of coral skeleton (a) that has been heavily overprinted with sparry calcite cement (c). Note lack of trabecular structure, and crosscutting of relict skeletal fabric by cement crystal boundaries. Pore space (p).

Figure 7. Moldic mollusc packstone facies. Note abundant moldic pore spaces (p), micritic matrix (m), and coral debris (c).

Figure 8A and 8B. X-ray powder diffractograms from core #1A samples, ordered by increasing depth. Note presence of aragonite (A), calcite (C), and magnesian calcite (HMC) in upper section of core (8A). Lower section (8B), in contrast, shows only calcite peaks (c) despite skeletal material of originally diverse mineralogy. Fluorite (F) is calibration standard.


INTENSITY
EM1A:6
EM1A:20.5
EM1A:31.5
EM1A:34
HMC
2 THETA


INTENSITY
EM1A:53
EM1A:60
EM1A:63
EM1A:76
2 THETA

GEOPHYSICAL SURVEYS
WITH FDEM METHODS
EWA MARINA, CAMPBELL INDUSTRIAL PARK
AND BARBERS POINT HARBOR
OAHU, HAWAII

Prepared For:

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August 8, 1990

(Our Job #90029)

Table of Contents

1.0 EXECUTIVE SUMMARY

A geophysical survey was conducted in three areas in the vicinity of the Barbers Point Naval Air Station on Oahu, Hawaii. The areas are designated as Ewa Marina, Campbell Industrial Park, and Barbers Point Harbor.

The objective of the survey was to infer from the geophysical data information about the thickness of a brackish water lens floating on saline water in the limestone aquifer of this region. A geophysical method was employed that allows relatively quick areal coverage for determining lateral variation in the thickness of the brackish water lens. To also derive from the survey information about the thickness of the brackish water lens, the geophysical data was correlated to salinity observations in boreholes placed in the three survey areas.

The results of the survey are given as profiles of the thickness of the brackish water lens along lines generally perpendicular to the shore. The profiles are mainly characterized by a rapid increase in the thickness of the brackish water lens in the first 150 ft from the shore. The thickness of the brackish water lens varies from about 100 ft in the Ewa Marina area to less than 50 ft in the Barbers Point Harbor area.

2.0 INTRODUCTION

This report contains the results of geophysical surveys conducted on the island of Oahu, Hawaii for Haseko (Hawaii) Inc. (Haseko) by Blackhawk Geosciences, Inc. (BGI).

The objective of the work was to infer from electrical resistivity measurements information about salinity distribution in ground water. In this coastal plain area the bedrock is a limestone/dolomite and a lens of brackish water rests on highly saline water. The thickness of this lens changes rapidly with distance from the shore. The mapping of the lateral and vertical variation in the thickness of this brackish water lens was the dominant objective of this survey at specific areas on the coastal plain near the Barbers Point Naval Air Station. Surveys were conducted at three sites; Ewa Marina, Barbers Point Harbor, and Campbell Industrial Park. In some of the areas construction of marinas alters the distribution of salinity. The geophysical surveys were utilized to both determine base line data prior to construction, as well as changes caused by construction.

The geophysical method utilized was frequency domain electromagnetic (FDEM) measurements with the Geonics EM-34. The EM-34 is a rapid and inexpensive method sensitive to lateral changes in resistivity. Data coverage in the three areas was limited by cultural noise and access constraints.

Although the particular geophysical method employed finds its main utility in mapping lateral changes, it can also be utilized for determining vertical salinity distribution when borehole information is available for calibration. A number of salinity profiles measured in boreholes placed near the three survey areas was made available and was used to derive vertical salinity variations also.

3.0 DATA ACQUISITION

3.1 GENERAL

The field work was performed by two BGI geophysicists from June 1 to June 6, 1990. Data was acquired at three sites near the southwest shore of the island of Oahu. The sites and locations at boreholes and survey lines are shown on Figure 3-1 for Ewa Marina, Barbers Point Harbor, and Campbell Industrial Park. Prior to this survey, test data were acquired on May 22, 1990 along lines 1400W and 0 to evaluate the usefulness of the method. A report covering the results of the test survey were delivered to Haseko in May 1990. The data from the previous test survey have been incorporated into this report. The area surveyed and specific acquisition problems for the sites were as follows:

(1) At Ewa Marina, surveys were conducted along pre-existing roads and brushed lines perpendicular to the shoreline with one additional line traversed parallel to the shore. Eight of the thirteen survey lines required a brush cutting crew due to the thick vegetation.

(2) At Barbers Point Harbor five lines were surveyed perpendicular to the new harbor. No lines were possible at the original shoreline due to the presence of facilities, such as gas pipelines and utility lines.

(3) At Campbell Industrial Park three lines were surveyed perpendicular to the shore.

The instrument employed was the Geonics EM-34. The manufacturer's specifications and principles of operation for the EM-34 are given in Appendix A. A daily log of field activities is given in Table 3-1.

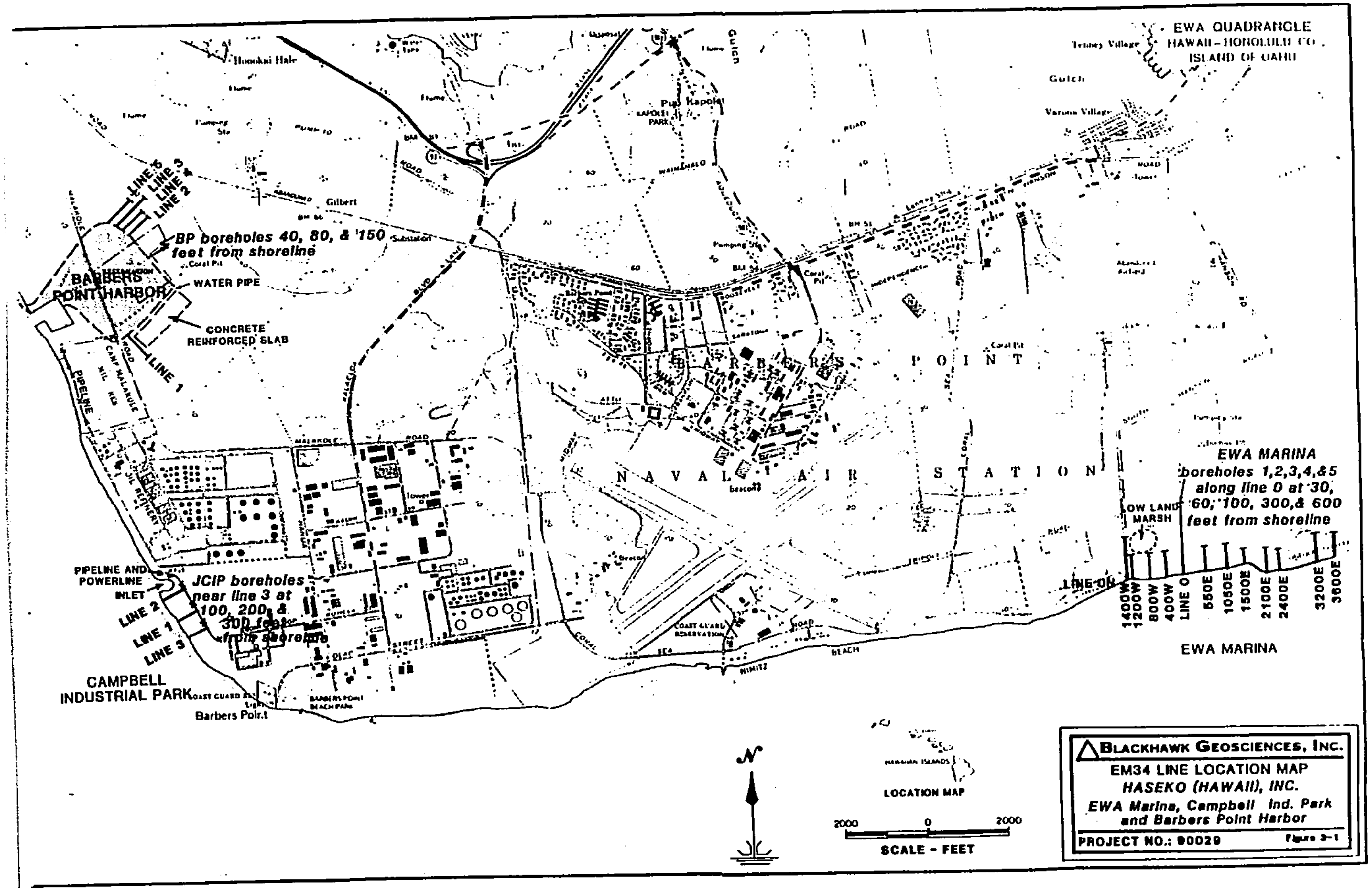
The EM-34 measurement stations along lines perpendicular to the shore were usually separated by 25 ft intervals for the first 300 ft and by 50 ft intervals thereafter. The readings of conductivity (in mmhos/m) were taken with 10 m, 20 m and 40 m transmitter-receiver separations with both coils vertical and coplanar. The effective depth of exploration of the EM-34 at 10 m, 20 m and 40 m separation is approximately 25 ft, 50 ft and 100 ft, respectively. Prior to interpretation field conductivity readings were corrected for non-linearity at high values of conductivity (Appendix A).

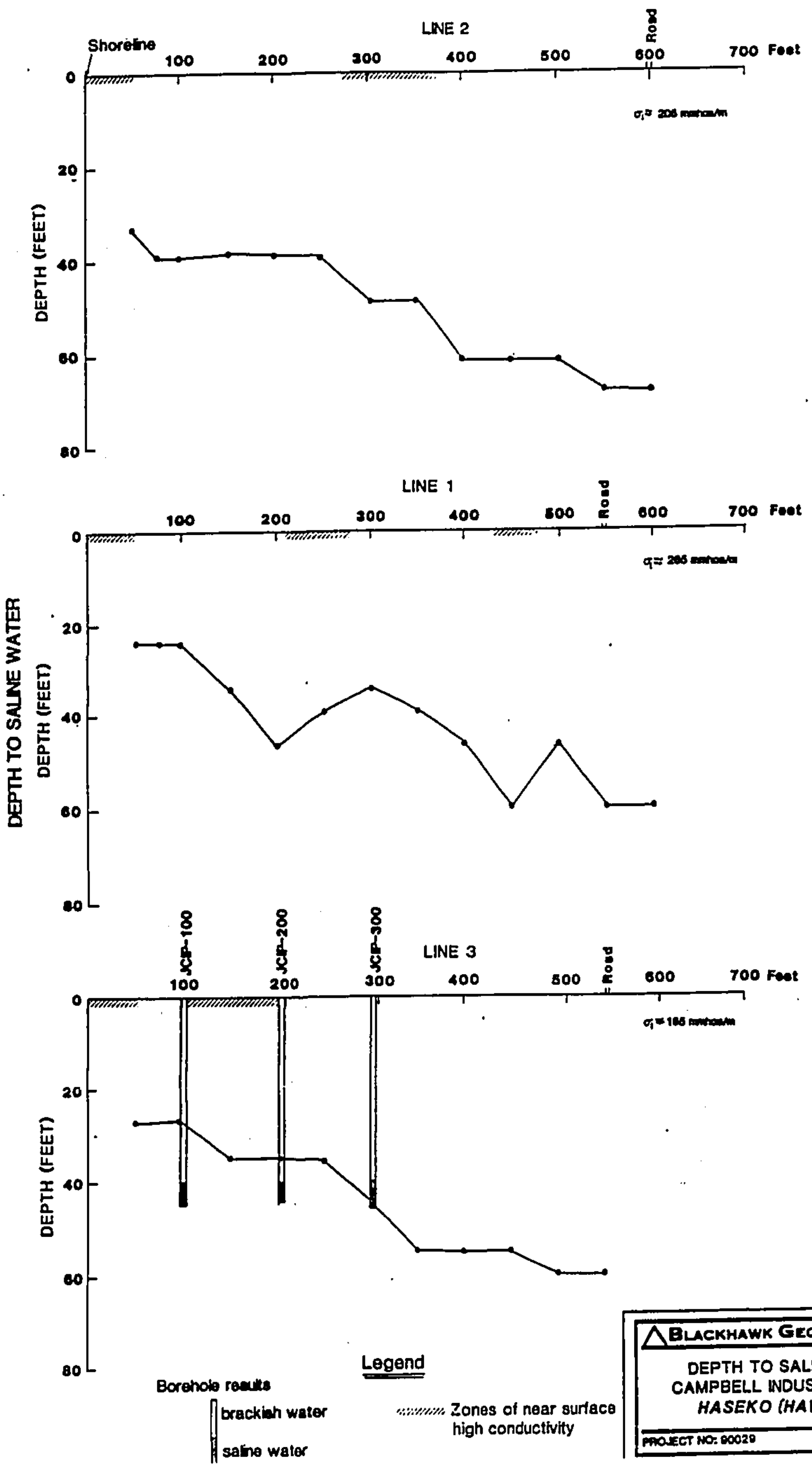
Table 3-1. ***Daily Log of Field Activity***

Date (1990)	Activity
May 31	BGI personnel mobilize from other Hawaii geophysical surveys to Honolulu, HI.
June 1	Meet with Tom Nance to discuss EM-34 survey areas. Establish survey grid for Ewa Marina area. (Use benchmark located on shoreline and road junction (Line 0) as 0,0 for survey grid). Start brush crew on survey lines. Data taken on Line 0N, STA 0 to 1400W and STA 0 to 2000E (10, 20 and 40 m coil separations).
June 2	Ewa Marina Area. Data taken on Line 0N, STA 2000E to 3600E. Data taken on Line 3600E, STA 0N to 400N. Data taken on Line 3200E, STA 0N to 650N.
June 3	Move to Barbers Point Harbor Area. Allow for brush crew to get ahead. Data taken on Line 1, STA 0N to 600N. Data taken on Line 2, STA 0N to 600N. Data taken on Line 3, STA 0N to 1000N. Data taken on Line 4, STA 0N to 600N. Data taken on Line 5, STA 0N to 600N.
June 4	Ewa Marina Area. Data taken on Line 400W, STA 0N to 600N. Data taken on Line 800W, STA 0N to 600N. Data taken on Line 1200W, STA 0N to 600N. Data taken on Line 1400W, STA 0N to 600N.
June 5	Move to Campbell Industrial Park Area. Allow for brush crew to get ahead. Data taken on Line 1, STA 0N to 600N. Data taken on Line 2, STA 0N to 600N. Data taken on Line 3, STA 0N to 600N. Ewa Marine Area. Data taken on Line 550E, STA 0N to 600N. Data taken on Line 1050E, STA 0N to 600N.

Table 3-1. ***(Continued)***

Date (1990)	Activity
June 6	Ewa Marina Area. Data taken on Line 1500E, STA 0N to 300E (line not brushed). Data taken on Line 2100E, STA 0N to 600E. Data taken on Line 2400E, STA 0N to 500E.
June 7	Demobilize BGI personnel and equipment to Golden, CO.


EWA QUADRANGLE
HAWAII-HONOLULU CO.
ISLAND OF OAHU
BP boreholes 40, 80, & 150 feet from shoreline
BARBERS POINT HARBOR
WATER PIPE
CONCRETE REINFORCED SLAB
LINE 1
LINE 2
LINE 3
LINE 4
LINE 5
PIPELINE
CAMP MALAKOLE
OIL REFINERY
PIPELINE AND POWERLINE
INLET
JCIP boreholes near line 3 at 100, 200, & 300 feet from shoreline
CAMPBELL INDUSTRIAL PARK
Barbers Point
Gilbert
Honokai Hale
Puu Kapolei
BARBERS POINT
NAVAL AIR STATION
Gulch
Varona Village
Tenney Village
EWA MARINA
boreholes 1,2,3,4,&5 along line 0 at 30, 60, 100, 300, & 600 feet from shoreline
LOW LAND MARSH
LINE 0
1400W
1200W
800W
400W
LINE 0
550E
1050E
1500E
2100E
2400E
3200E
3600E
EWA MARINA
N
LOCATION MAP
2000
0
2000
SCALE - FEET
BLACKHAWK GEOSCIENCES, INC.
EM34 LINE LOCATION MAP
HASEKO (HAWAII), INC.
EWA Marina, Campbell Ind. Park and Barbers Point Harbor
PROJECT NO.: 90029
Figure 3-1



BLACKHAWK GEOSCIENCES, INC.

DEPTH TO SALINE WATER
CAMPBELL INDUSTRIAL PARK
HASEKO (HAWAII), INC.

PROJECT NO: 90029 | Figure 4-6

4.0 INTERPRETATION RESULTS

4.1 GENERAL

The EM-34 geophysical instrument is mainly used to obtain lateral changes in ground conductivity. The effective exploration depth of the EM-34 measurements was varied from about 25 ft to 100 ft, so that lateral changes in salinity within a depth of about 100 ft in principle are reflected in the measurements. The EM-34 surveys are generally not used to determine vertical changes in resistivity because too few data points at different effective exploration depths are obtained to perform meaningful inversions.

In this survey, however, vertical changes in salinity can be inferred from the geophysical data by carefully correlating the geophysical readings with salinity profiles measured in boreholes near the survey lines. The borehole salinity profiles were made available by Tom Nance.

4.2 CORRELATING GEOPHYSICAL DATA TO SALINITY PROFILES MEASURED IN BOREHOLES

The thickness of the brackish water lens (depth to brackish water-saline water interface) was measured in a series of wells perpendicular to the shore near each site (for line and well locations see Fig. 3-1). The well information was provided by Tom Nance and is summarized in Figures 4-1, 4-2 and 4-3. Because accurate vertical survey control (elevation) was not established along the geophysical survey lines, in all further discussions depths will be referenced from the surface of the ground.

The borehole information from Ewa Marina (Fig. 4-1) typically shows a zone of constant salinities (less than 7 parts per thousand) for the upper 20 ft, followed by a zone of rapid increase in salinities (transition zone) followed by a leveling off of salinities in the bottom of the holes at values between 25 and 28 parts per thousand. The boreholes at the Campbell Industrial Park follow this same general pattern (Fig. 4-2). However, boreholes at Barbers Point Harbor area exhibit a different pattern of salinity versus depth (Fig. 4-3). In boreholes BP40 and BP150 the transition zone occurs at shallow depth (less than 10 ft) and borehole BP80 displays salinity values greater than 24 parts per thousand from near surface to the bottom of the hole.

For purposes of further analysis, saline water is defined by salinity values in excess of 24 parts per thousand, or at the end of the transition zone in the salinity profile. Using this definition, depth to saline water for each borehole is tabulated in Table 4-1. Table 4-1 shows that the largest variation in depth to saline water is observed in the boreholes at Ewa Marina.

For that reason the borehole data at Ewa Marina is best suited for calibration of the geophysical data.

Table 4-1. Depth to saline water from borehole salinity logs

Borehole	Approximate Depth to Saline Water (ft below surface)
	(Ewa Marina Data from 07/02/90)
#1	47 ft
#2	50 ft
#3	63 ft
#4	70 ft
#5	86 ft
	(Campbell Industrial Park data from 07/27/90)
JCIP-100	40 ft
JCIP-200	40 ft
JCIP-300	40 ft
	(Barbers Point Data from 07/27/90)
BP-40	≈ 15 ft
BP-80	0 ft
BP-150	≈ 15 ft

A cross-plot of EM-34 readings at 40 m coil separation adjacent to boreholes versus the thickness of the brackish water lens measured in those holes for the Ewa Marina area is shown in Figure 4-4. To verify the consistency of the observed relationship with theoretical concepts, calculations were performed using the theory set forth in Appendix A for the data from Ewa Marina. The following assumptions were made in these computations:

(1) The physical setting of a brackish water lens floating on saline water was approximated by a two-layer conductivity model. The conductivity of the first layer corresponds to brackish water saturated rock, and the conductivity of the second layer to saline water saturated rock. The model thus contains three variables, i.e.,

- conductivity of first layer, σ_1 (brackish water)
- conductivity of second layer, σ_2 (saline water)
- thickness of first layer, h_1 (depth from surface to saline water).

The objective is to determine the thickness of the first layer, therefore values for σ_1 and σ_2 must be obtained or assumed to compute h_1.

(2) The value of σ_1 was set equal to the conductivity reading with the EM-34 at 20 m coil separation. The justification for this is that the effective exploration depth at 20 m is about 50 ft, and the depth to saline water in boreholes #2, #3, #4 and #5 at Ewa Marina is greater than 50 ft. The EM-34 reading at 20 m coil separation, is, therefore, mainly influenced by the limestone saturated with brackish water. The EM-34 readings at 10 m coil separation were not used for this purpose, because near surface variation in conductivity (e.g., near surface salt water in marshes) have a major influence on these readings.

(3) The conductivity, σ_2, of the saline water was derived by matching the value of h_1 observed in boreholes with computed values for the EM-34 at 40 m coil separation. The value for σ_2 that best matches the data was 778 mmhos/m.

Using the approach described above, the data in Figure 4-4 shows that a reasonable agreement exists between the thickness of the brackish water lens measured in boreholes and thicknesses computed from theoretical considerations. The relation displayed by the solid line was subsequently used to derive profiles for the thickness of the brackish water lens along the survey lines at Ewa Marina.

The relation shown on Figure 4-4 was derived using salinity profiles measured in boreholes in the Ewa Marina area. Similar relations could not be established for the two other areas, mainly because the thickness of the brackish water lens did not vary much between the boreholes. At Campbell Industrial Park and Barbers Point Harbor a value for σ_1 was obtained from the average of the 10 m data, the value for σ_2 was left at 778 mmhos/m, and the depth was directly calculated using formulae outlined in Appendix A.

4.3 EWA MARINA

Profiles of the calculated thicknesses of the brackish water lens are shown in Figure 4-5. Changes in elevation along the lines have not been compensated for. The results for the conductivity profile taken parallel to the shore (line 0N) was highly influenced by its proximity to the ocean, and so no depth calculations were performed for this line. The field data for this line and all other field data are listed in Attachment 1. Also, the readings recorded on line 1400W were influenced by its

proximity to a metal fence, and the results along this line are omitted from Figure 4-5.

From the profiles shown in Figure 4-5 several features are apparent:

(1) On all lines the brackish water lens thickens rapidly with distance from the shore. At distances greater than about 300 ft from the shoreline the lens thickness is relatively constant.

(2) A comparison of the thickness of the lens observed in boreholes with calculated thicknesses from geophysical data on line 0 shows good agreement.

(3) Line 400W shows the thickest brackish water lens at about 110 ft. Lines east and west of 400W show lens thicknesses typically on the order of 80 ft to 100 ft.

On all lines at Ewa Marina high conductivity values were observed in the EM-34 data at 10 m coil separation near the shoreline because of its shallow effective exploration depth. On two lines (1200W and 800W) near surface high conductivities were also recognized on the north sides of the line. The high conductivities are likely caused by near surface high salinities in low lying marsh areas.

4.4 CAMPBELL INDUSTRIAL PARK

The locations of the three lines surveyed at the Campbell Industrial Park area are shown in Figure 3-1. The calculated profiles of depth to saline water for these lines are given in Figure 4-6, and the field data are given in the attachment. The borehole information has been superimposed upon the depth profile for line 3 in Figure 4-6.

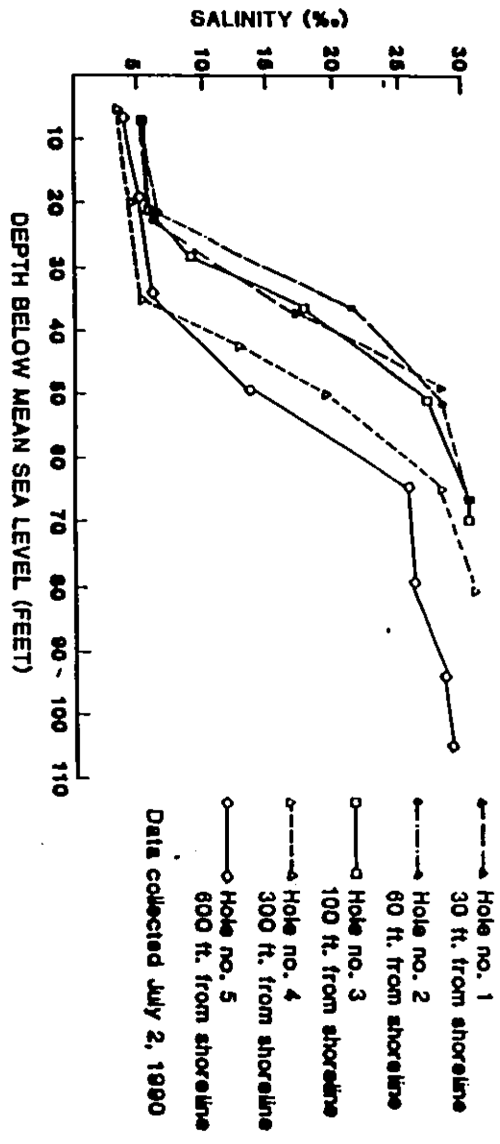
The discrepancy between borehole results and calculated depths along line 3 occurs near the shoreline and is believed to be mainly due to two factors:

(1) The recordings with the EM-34 at 40 m coil separation averages ground conditions over an area of about 40 m (120 ft) compared to a few inches in a borehole. This is an important consideration in areas with steep gradients in the thickness of the brackish water lens.

(2) The computations do not adequately take into account the near surface pockets of high salinity.

4.5 BARBERS POINT HARBOR

The calculated depth to saline layer along the five survey lines at Barbers Point Harbor are shown in Figure 4-7. The boreholes were not placed along these lines and have, therefore, not been superimposed on the computed profiles in Figure 4-7. The profiles are characterized by relatively small thicknesses of the brackish water lens, generally less than 50 ft. That information is consistent with the off-line boreholes that also show saline water to occur at shallow depth.



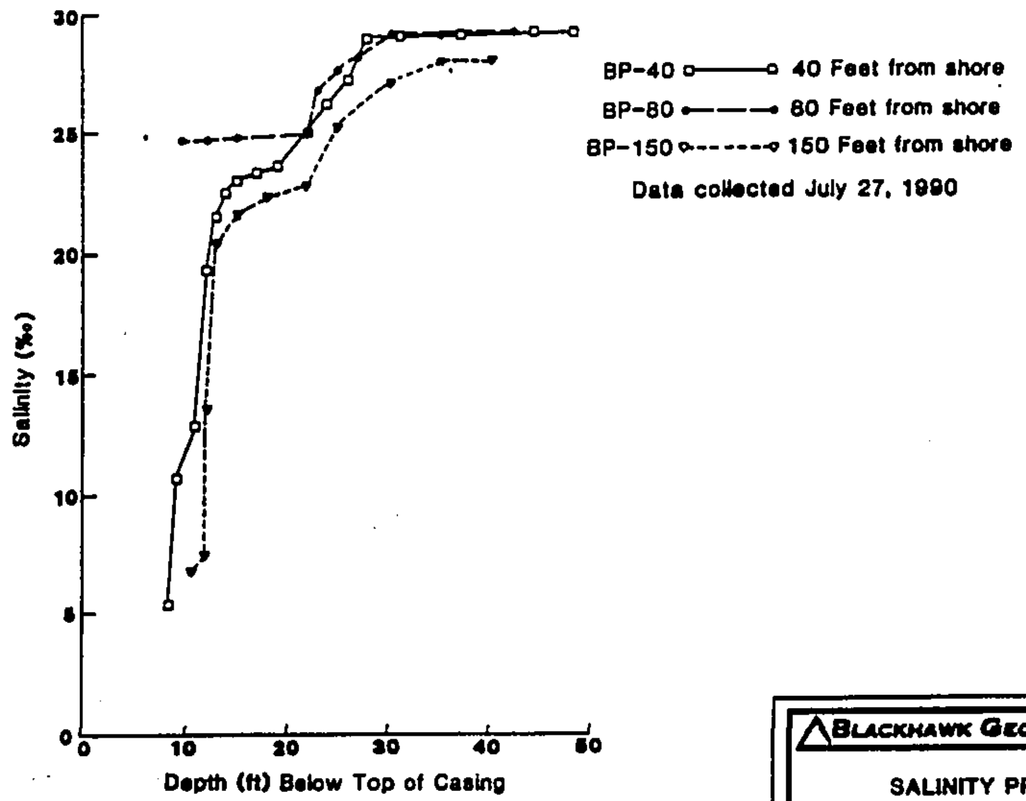
BLACKHAWK GEOSCIENCES, INC.

SALINITY PROFILES

EWA MARINA

HASEKO (HAWAII), INC.

PROJECT NO: 90029 | Figure 4-1

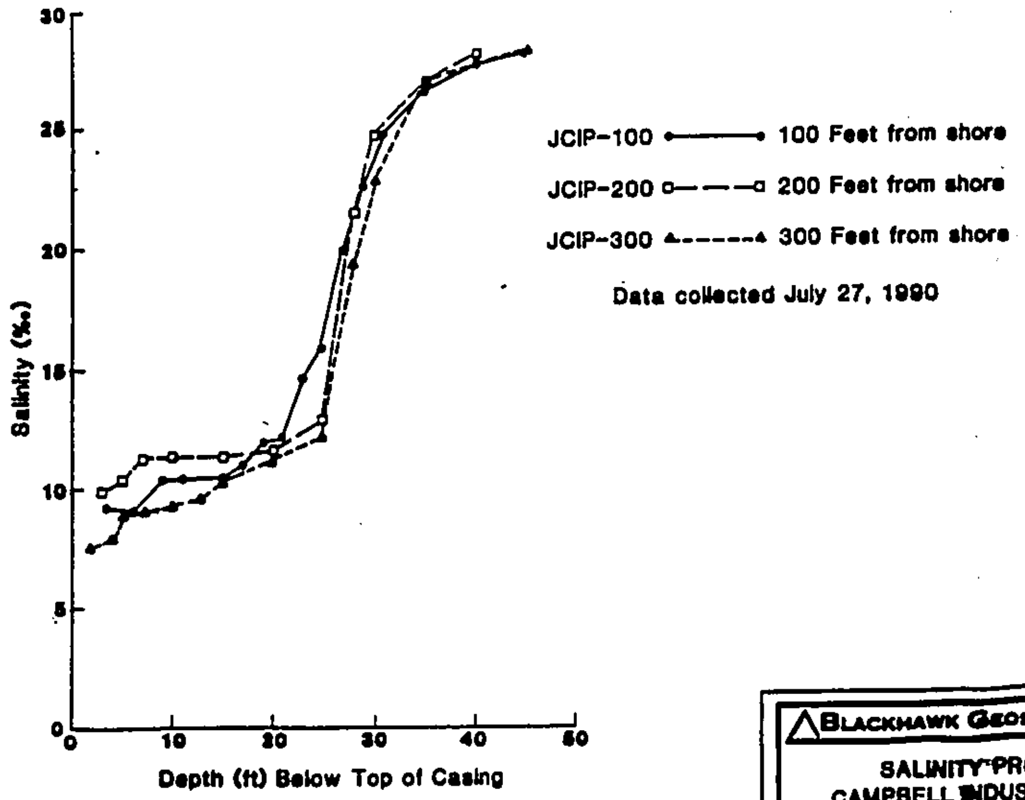


TOP OF CASING 11 FEET ABOVE MEAN SEA LEVEL

BLACKHAWK GEOSCIENCES, INC.

SALINITY PROFILES
BARBERS POINT HARBOR
HASEKO (HAWAII), INC.

PROJECT NO: 90029 Figure 4-3

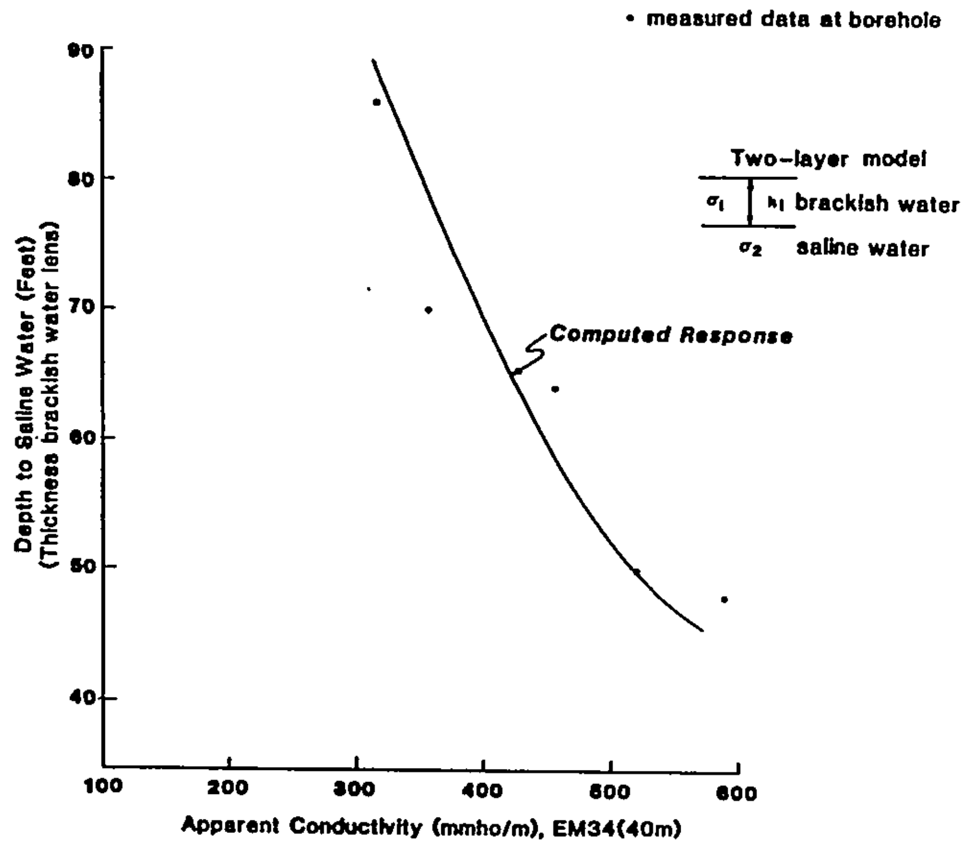


TOP OF CASING 4 FEET ABOVE MEAN SEA LEVEL

BLACKHAWK GEOSCIENCES, INC.

SALINITY PROFILES
CAMPBELL INDUSTRIAL PARK
HASEKO (HAWAII), INC.

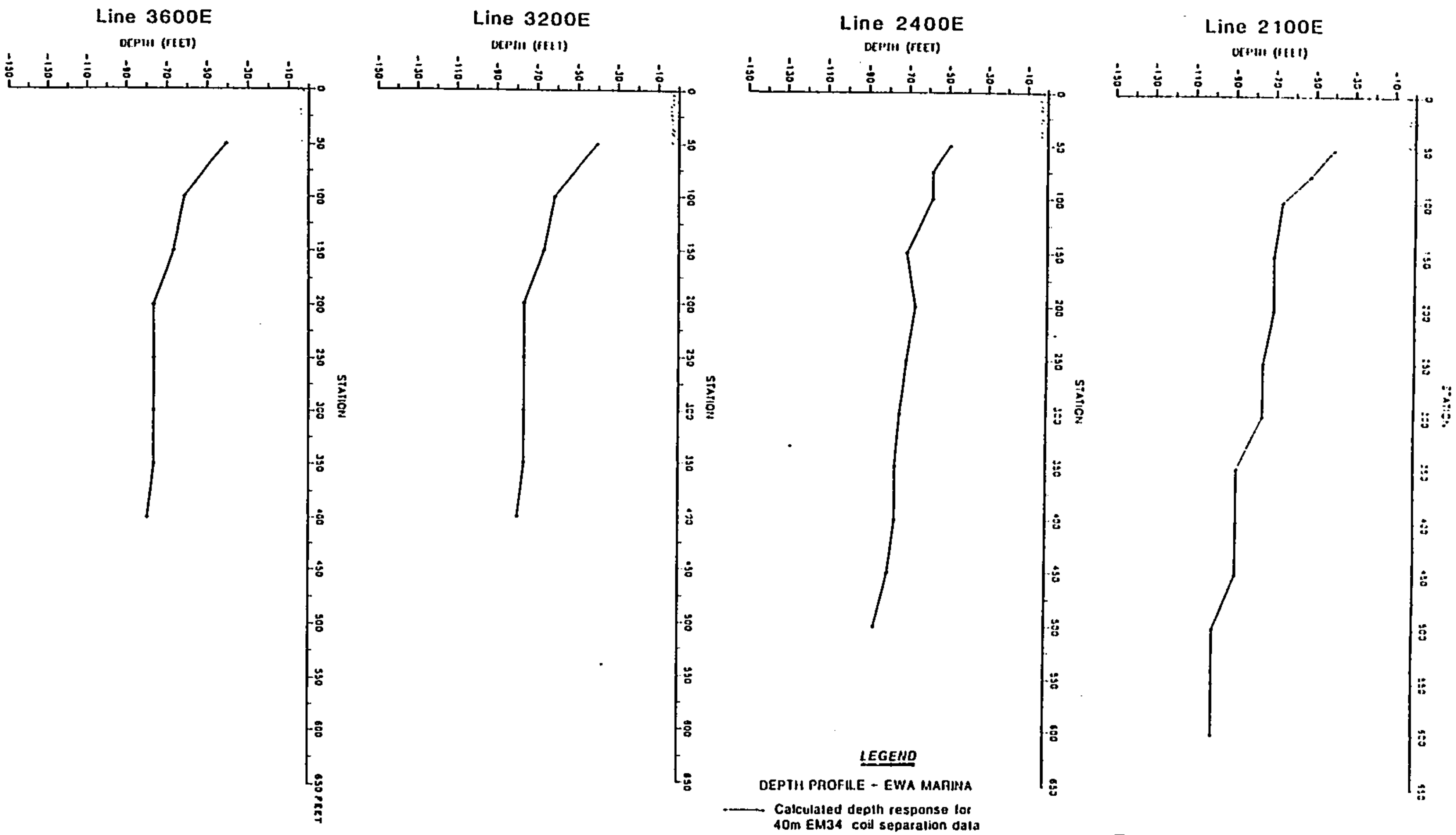
PROJECT NO: 90029 Figure 4-2



BLACKHAWK GEOSCIENCES, INC.

INSTRUMENT (EM34) READING
VERSUS BRACKISH WATER
LENS THICKNESS
HASEKO (HAWAII), INC.

PROJECT NO: 90029 — Figure 4-4



LEGEND

DEPTH PROFILE - EWA MARINA

Calculated depth response for 40m EM34 coil separation data

BOREHOLE RESULTS

Brackish water lens

Saline water saturated limestone

Area of near surface high conductivity

BLACKHAWK GEOSCIENCES, INC.

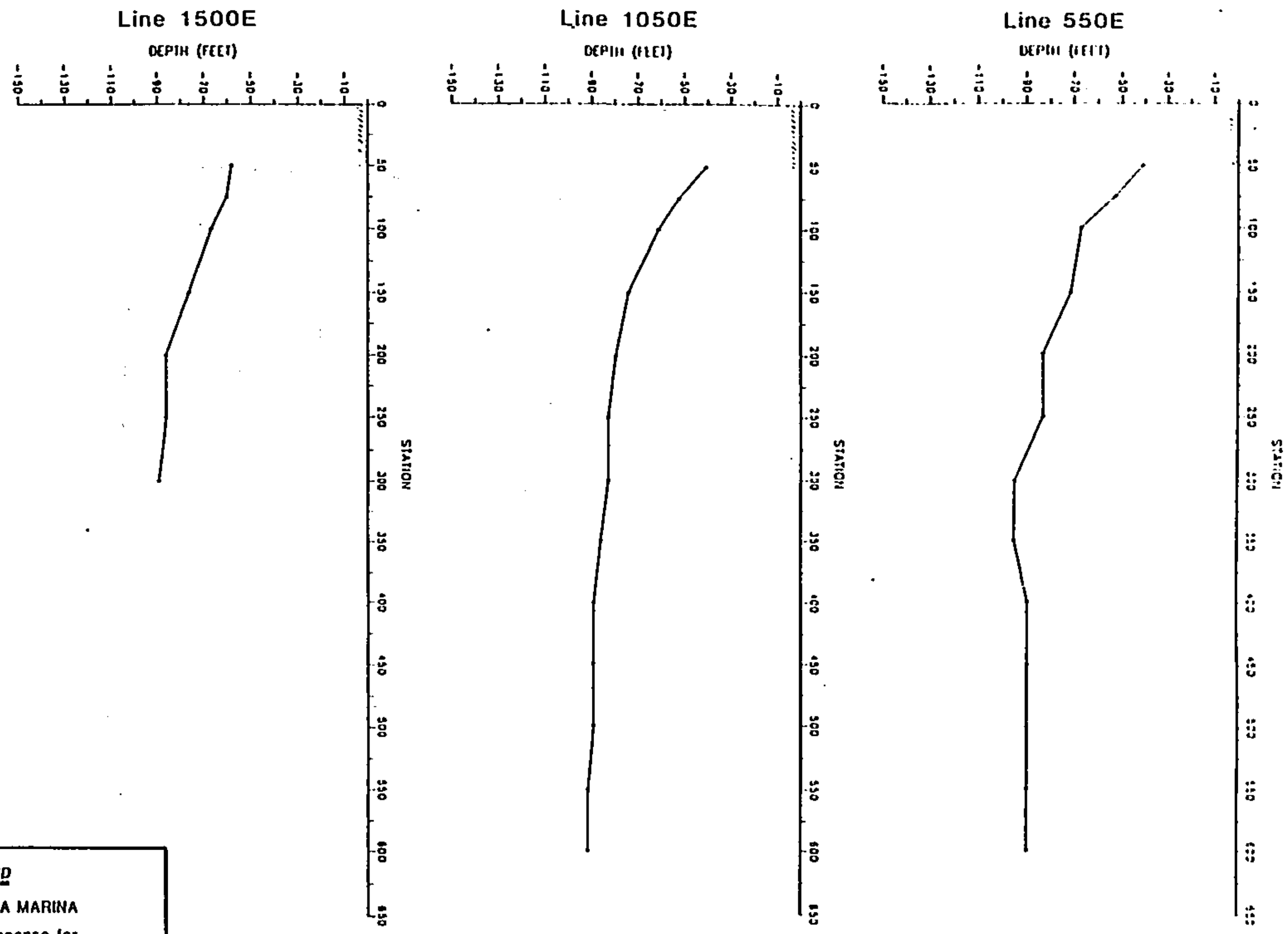
DEPTH TO SALINE WATER

EWA MARINA

HASEKO (HAWAII), INC.

PROJECT NO: 90029

Figure 4-5



LEGEND

DEPTH PROFILE - EWA MARINA

Calculated depth response for 40m EM34 coil separation data

BOREHOLE RESULTS

Brackish water lens

Saline water saturated limestone

Area of near surface high conductivity

BLACKHAWK GEOSCIENCES, INC.

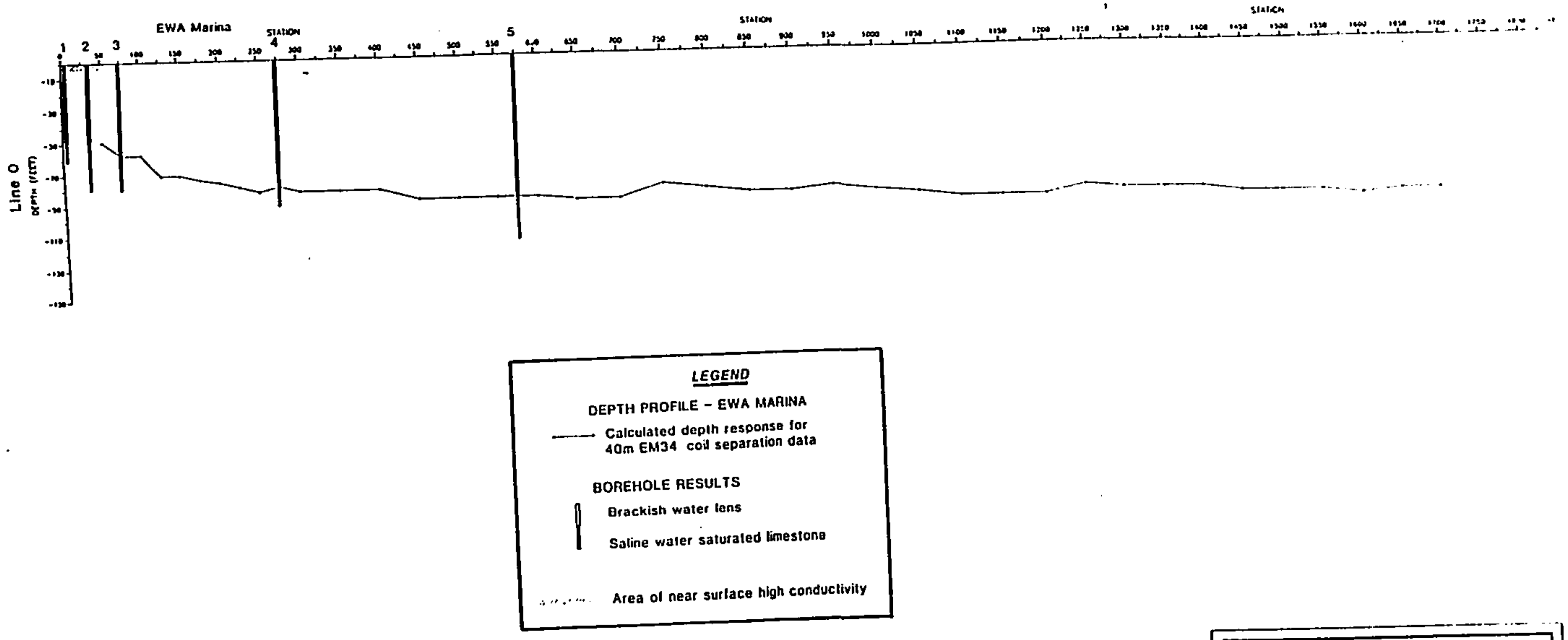
DEPTH TO SALINE WATER

EWA MARINA

HASEKO (HAWAII), INC.

PROJECT NO: 90029

B Figure 4-5



BLACKHAWK GEOSCIENCES, INC.

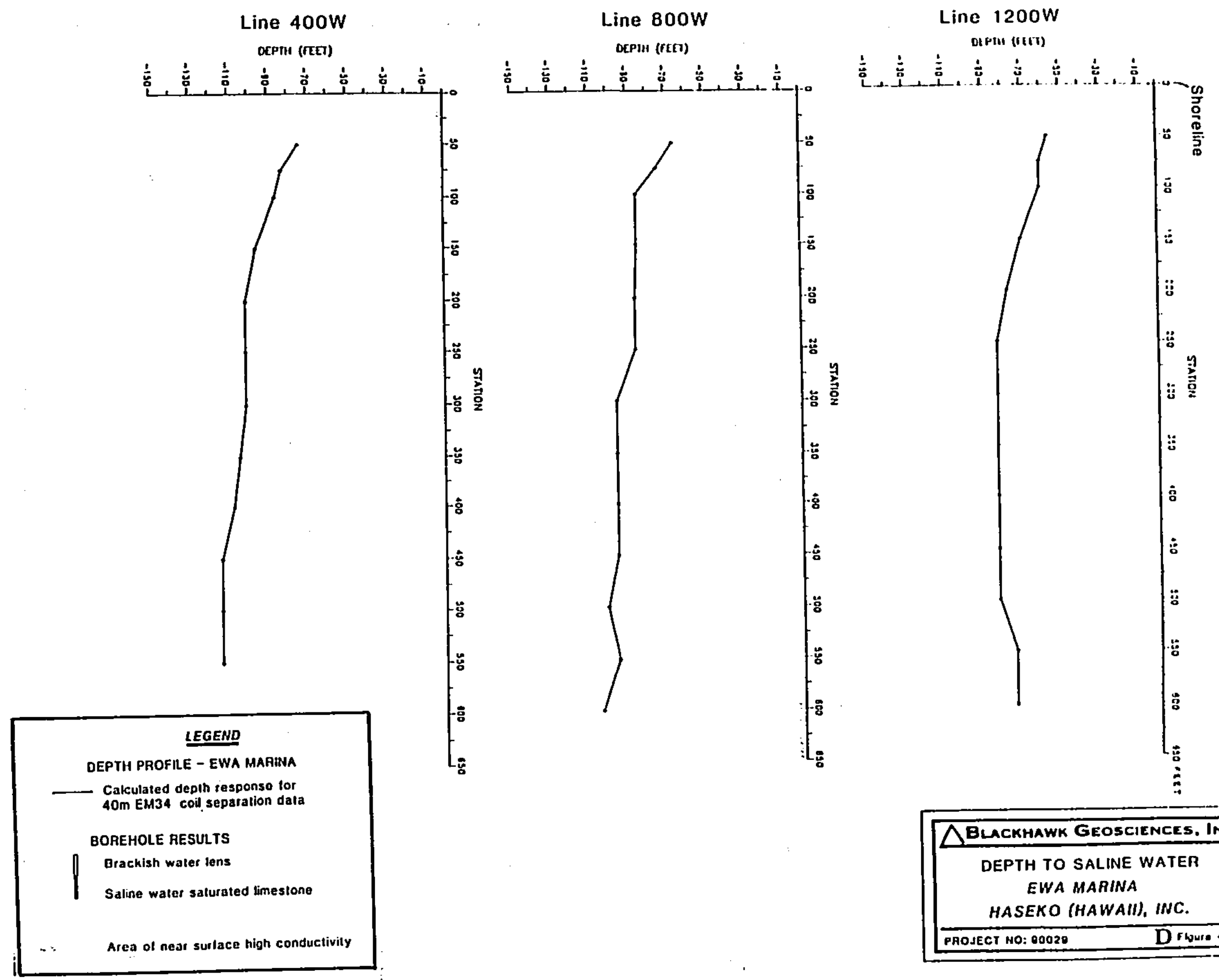
DEPTH TO SALINE WATER

EWA MARINA

HASEKO (HAWAII), INC.

PROJECT NO: 90029

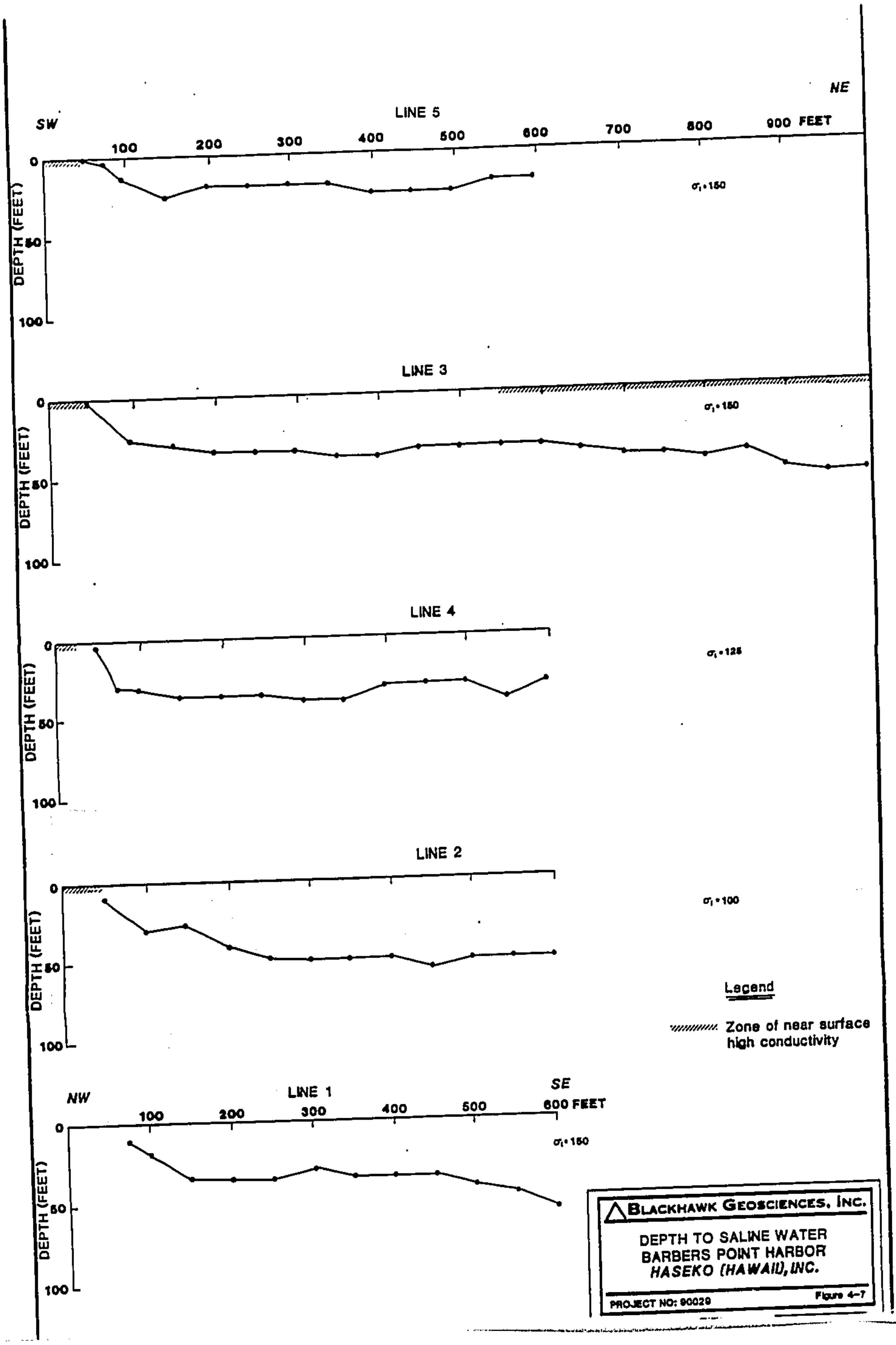
Figure 4-5



BLACKHAWK GEOSCIENCES, INC.

DEPTH TO SALINE WATER
EWA MARINA
HASEKO (HAWAII), INC.

PROJECT NO: 90029 D Figure 4-5



LINE 5
SW
NE
100 200 300 400 500 600 700 800 900 FEET
DEPTH (FEET)
0
50
100
σ_1=150
LINE 3
σ_1=150
LINE 4
σ_1=125
LINE 2
σ_1=100
Legend
Zone of near surface high conductivity
LINE 1
NW
SE
100 200 300 400 500 600 FEET
σ_1=150
BLACKHAWK GEOSCIENCES, INC.
DEPTH TO SALINE WATER
BARBERS POINT HARBOR
HASEKO (HAWAII), INC.
PROJECT NO: 90029
Figure 4-7

5.0 CONCLUSIONS AND RECOMMENDATIONS

The EM-34 data have been used to generate depth to saline water profiles by using correlations with nearby borehole salinity logs.

At Ewa Marina the depth to saline water is typically between 80 and 100 ft at distances greater than 300 ft from the shoreline. Near the shoreline the depth to saline water is shallow and rapidly increases with distance away from the shoreline. There is good agreement between the borehole results and EM-34 calculated depth to saline water.

At Campbell Industrial Park the depth to saline water calculated from the EM-34 data generally shows a smoothly varying increase from the shoreline to the end of the lines. The depths vary from about 20 to 30 ft near the shore to about 60 to 70 ft at the end of the line. The correlation between the boreholes and EM-34 data is influenced by averaging effects of surface geophysics and near surface pockets of high salinity.

At the Barbers Point Harbor the depth to saline water derived from the EM-34 data show a pattern similar to Ewa Marina, i.e., a rapid increase in depth near the shoreline, with a leveling out of the depth at distances greater than about 200 ft from the shore. However, the maximum depth to saline water at Barbers Point Harbor (about 50 ft) is much less than at Ewa Marina.

A qualitative comparison of salinities in the brackish water layer can be obtained by comparing the EM-34 data at 20 m separation for the three areas. In Table 5-1 typical values for the EM-34 data at 20 m for the areas are given.

Table 5-1. Typical EM-34 (20 m) data values

Area	Data Range (mmhos/m)
Ewa Marina	125 to 250
Campbell Industrial Park	200 to 350
Barbers Point Harbor	200 to 325

The comparison in Table 5-1 shows that the brackish water layer should be less saline at Ewa Marina than at the other two areas. This is confirmed in the borehole salinity profiles for the three areas (Figs. 4-1, 4-2 and 4-3). Using this same qualitative comparison, the salinity of the brackish water layer at Campbell Industrial Park and Barbers Point Harbor should be similar. However, the borehole salinity profiles at Barbers Point Harbor show higher salinities in the near surface than at Campbell Industrial Park. If this comparison is valid it suggests that the boreholes at Barbers Point Harbor may have been

placed in an area not representative of the salinity distribution around the rest of the Harbor.

Accuracies of determining the depth to saline water along the profiles at Ewa Marina is expected to be approximately ± 5 ft. At Barbers Point Harbor and Campbell Industrial Park the accuracies are expected to be somewhat less because an experimental relationship between borehole salinity profiles and EM-34 data could not be directly obtained.

ATTACHMENT A

GEOPHYSICAL SURVEYS
WITH FDEM METHODS
EWA MARINA, CAMPBELL INDUSTRIAL PARK
AND BARBERS POINT HARBOR
OAHU, HAWAII

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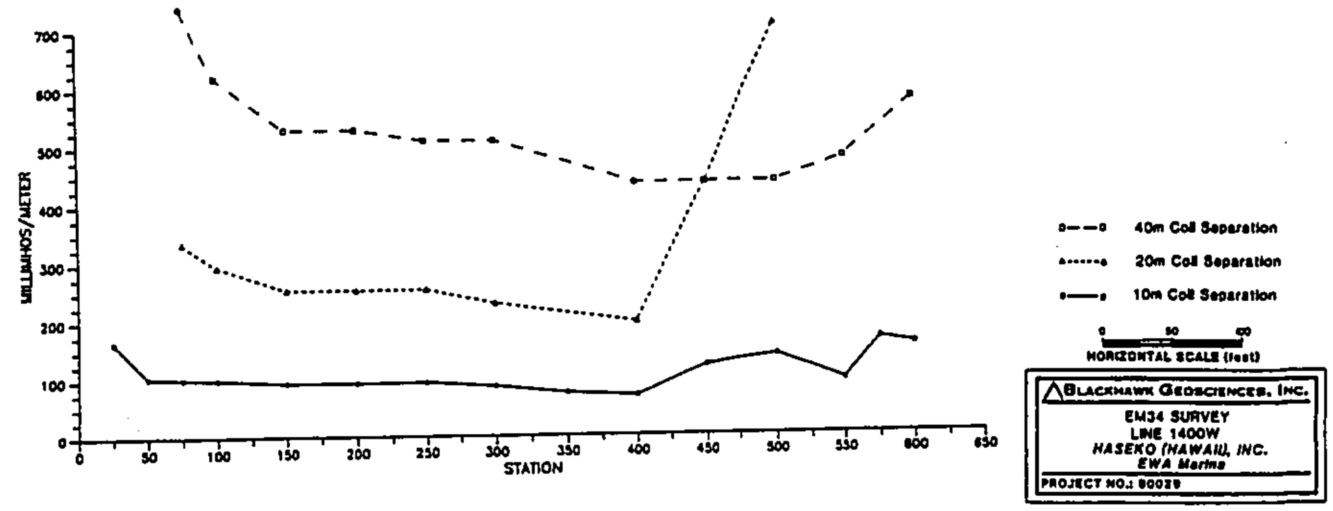
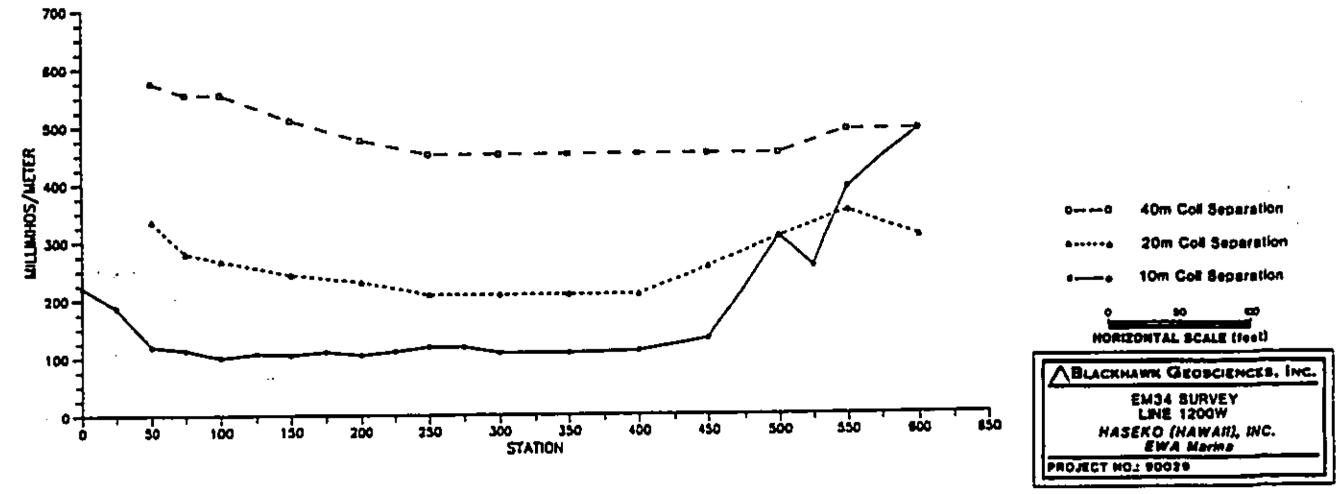


MILLIMHOS/METER
STATION
0
100
200
300
400
500
600
700
50
150
250
350
450
550
650
40m Coil Separation
20m Coil Separation
10m Coil Separation
HORIZONTAL SCALE (feet)
BLACKHAWK GEOSCIENCES, INC.
EM34 SURVEY
LINE 1400W
HASEKO (HAWAII), INC.
EWA Marina
PROJECT NO.: 90029



MILLIMHOS/METER
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20m Coil Separation
10m Coil Separation
HORIZONTAL SCALE (feet)
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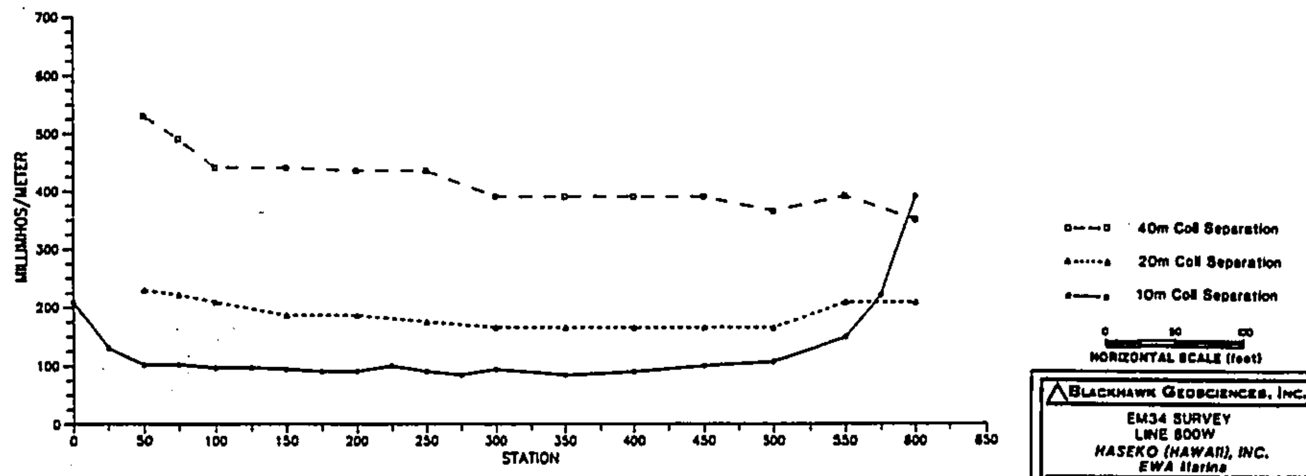
LINE 1200W
HASEKO (HAWAII), INC.
EWA Marina
PROJECT NO.: 90029



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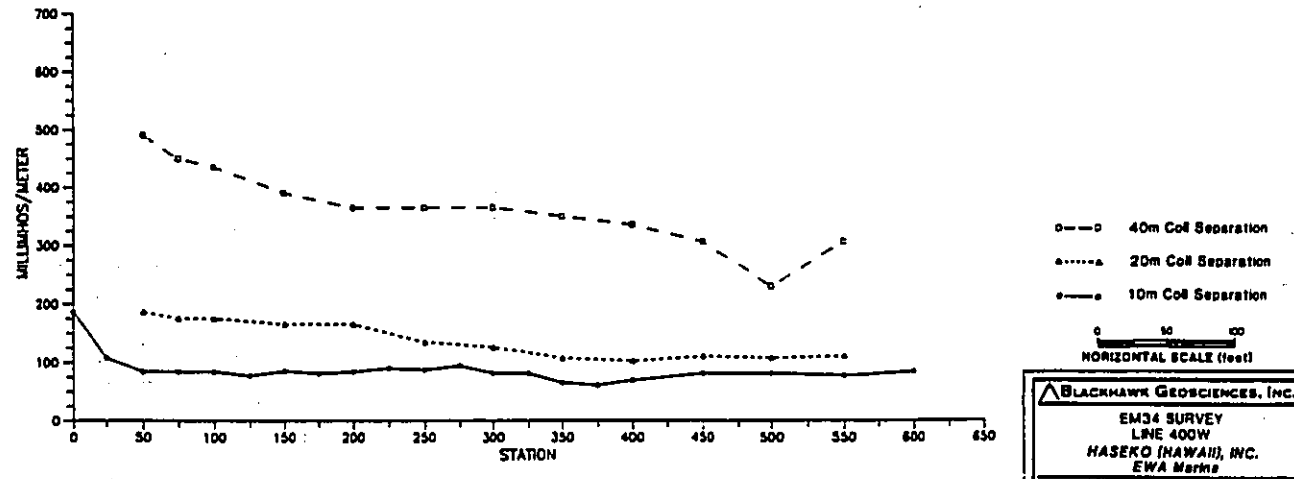

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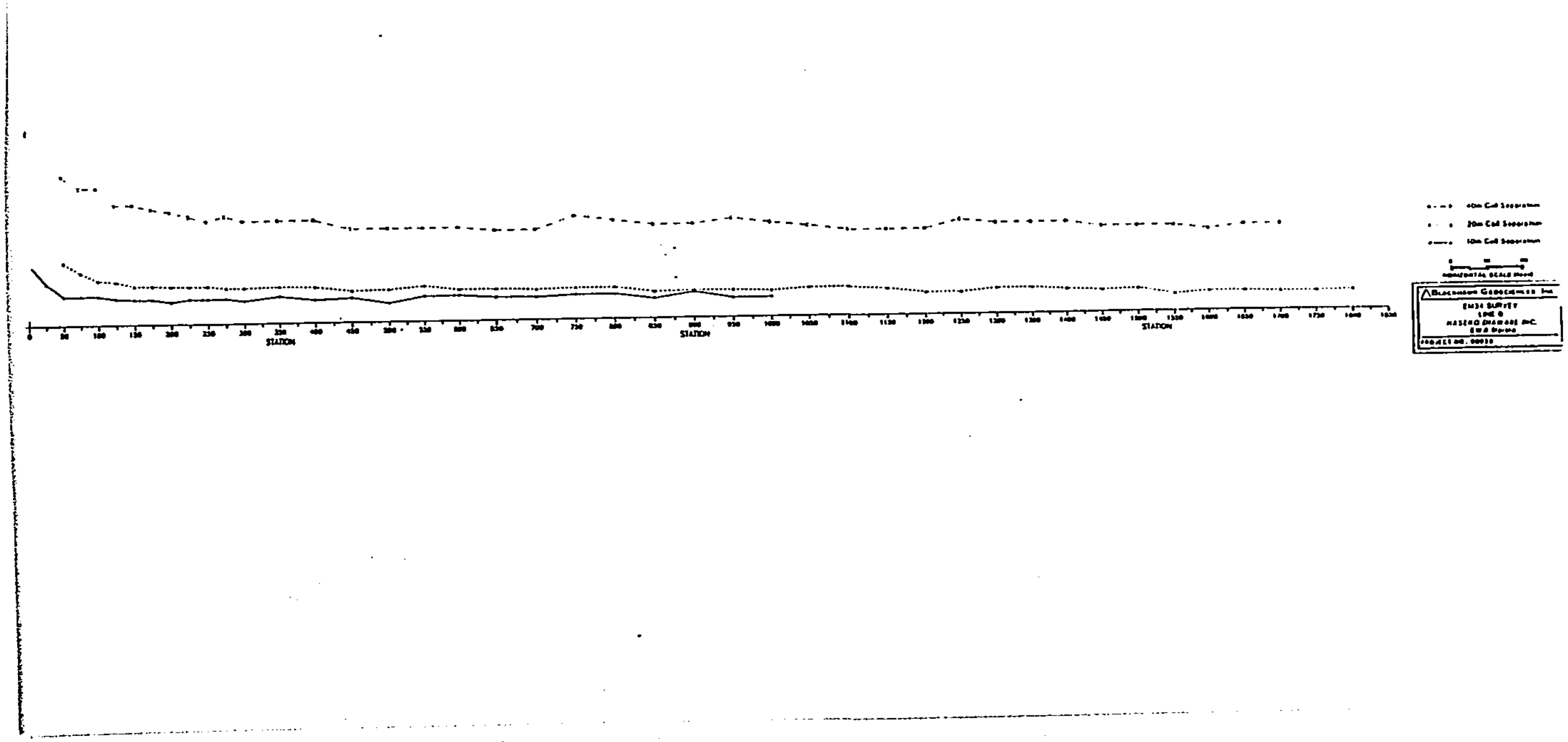

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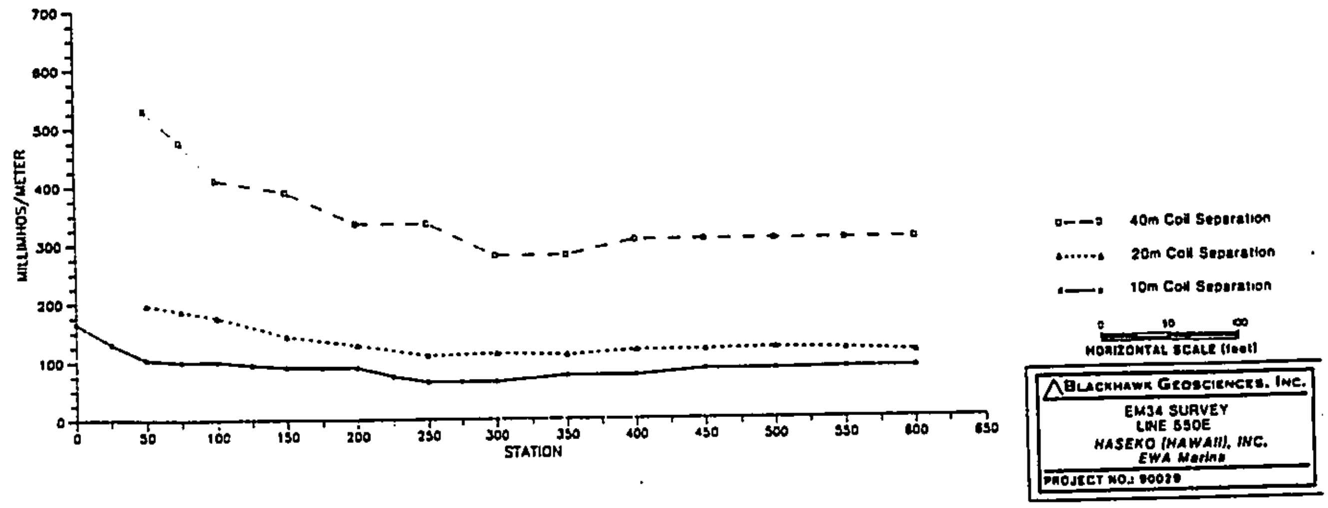

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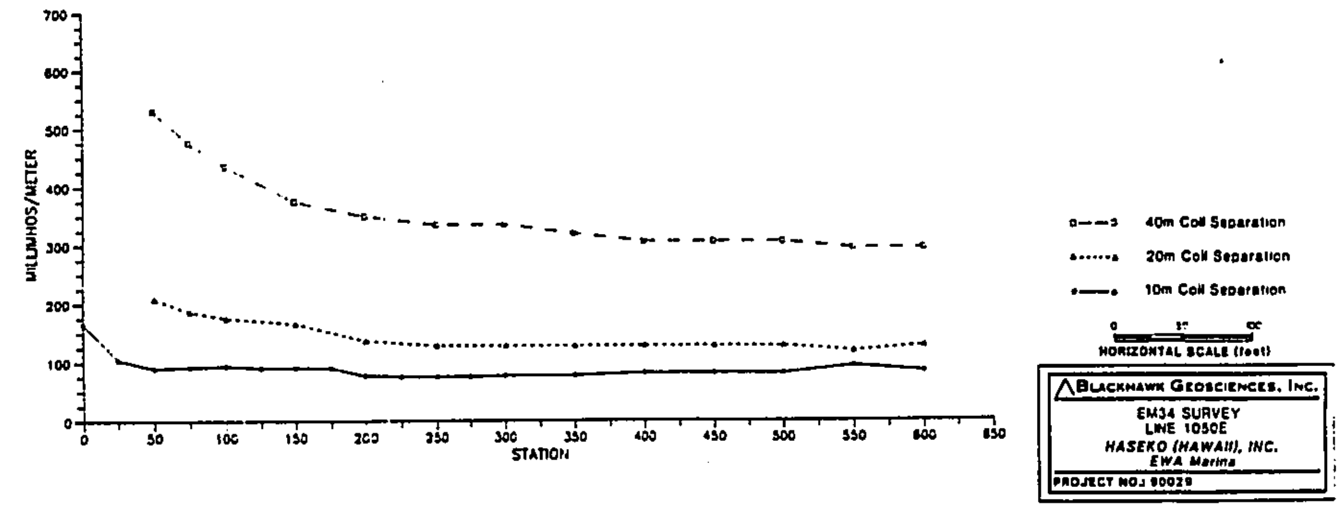
EWA Marina
PROJECT NO.: 90029



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HORIZONTAL SCALE (feet)
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EWA Marina
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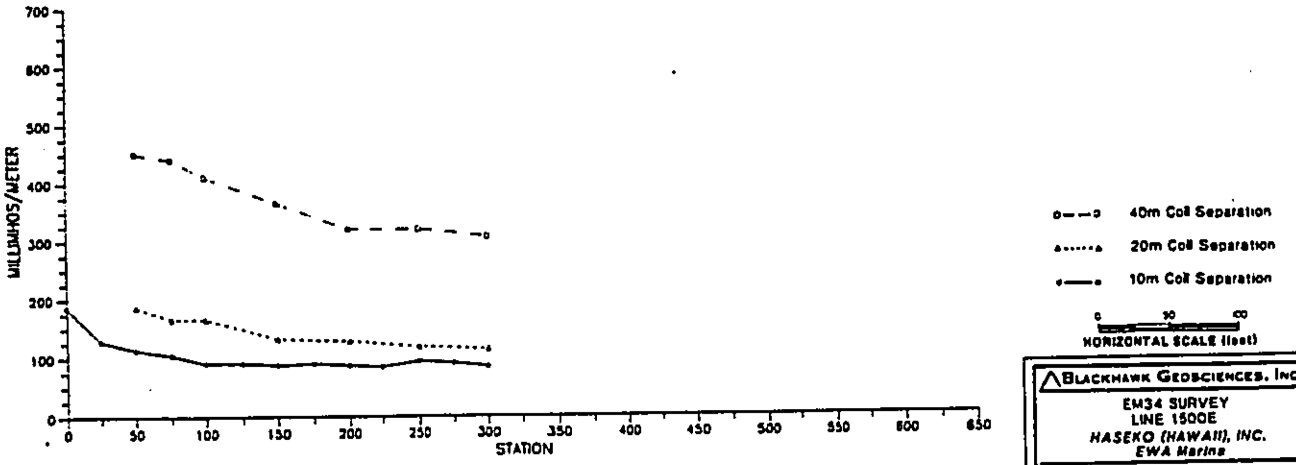

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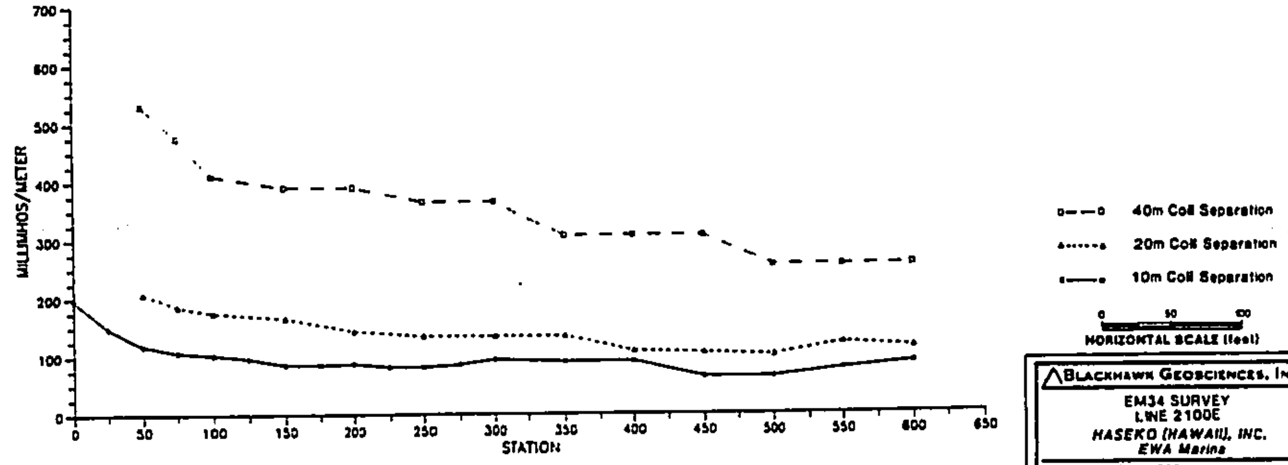
HASEKO (HAWAII), INC.
EWA Marina

PROJECT NO.: 90028



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EWA Marina

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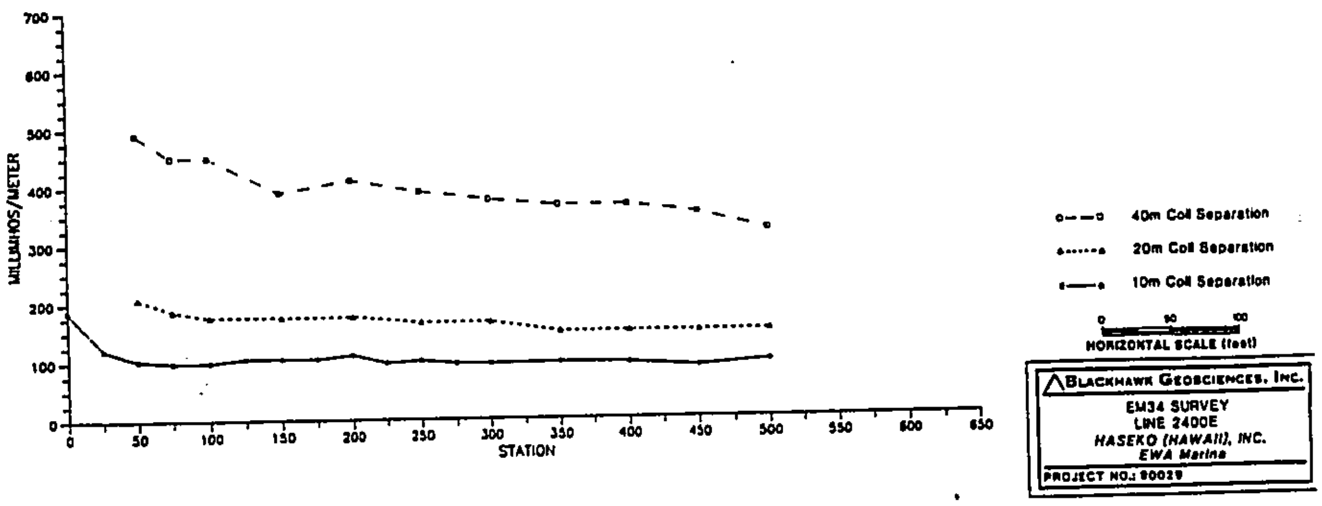
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EWA Marina
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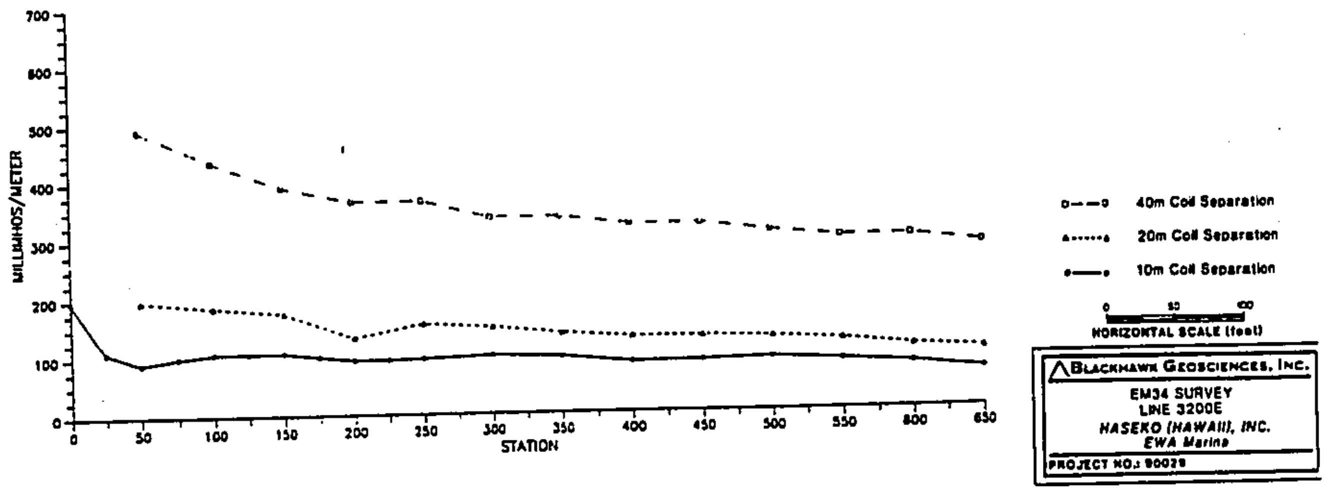
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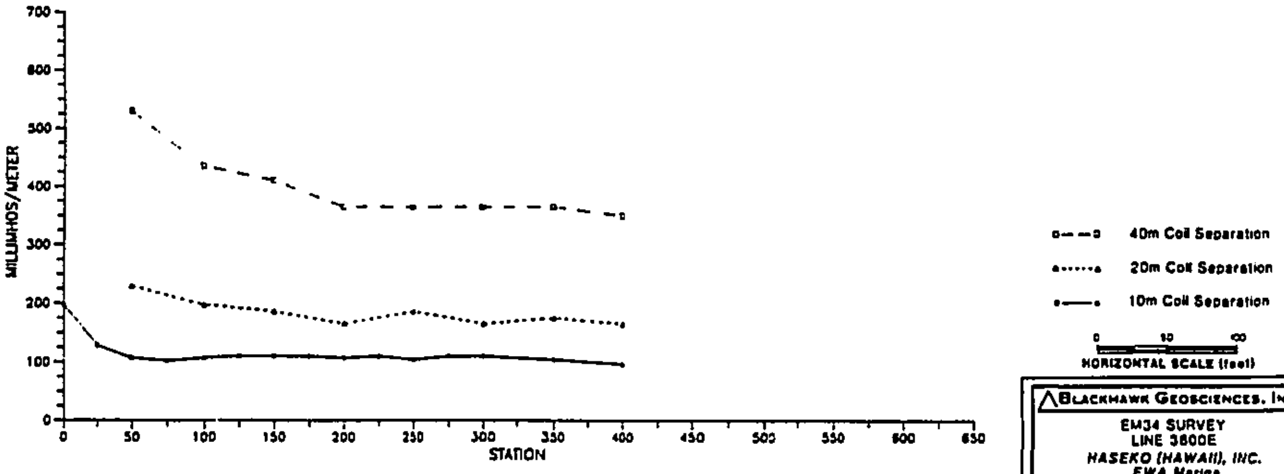
EWA Marina
PROJECT NO.: 90029



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EWA Marina

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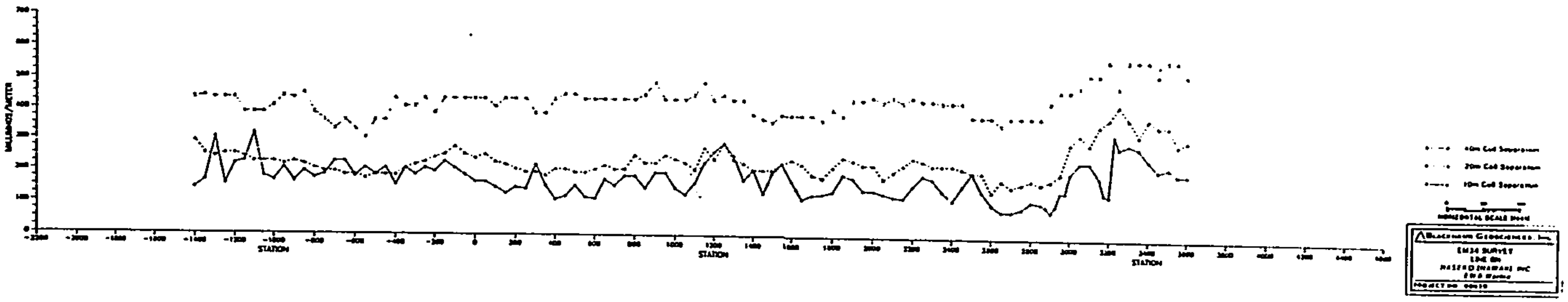
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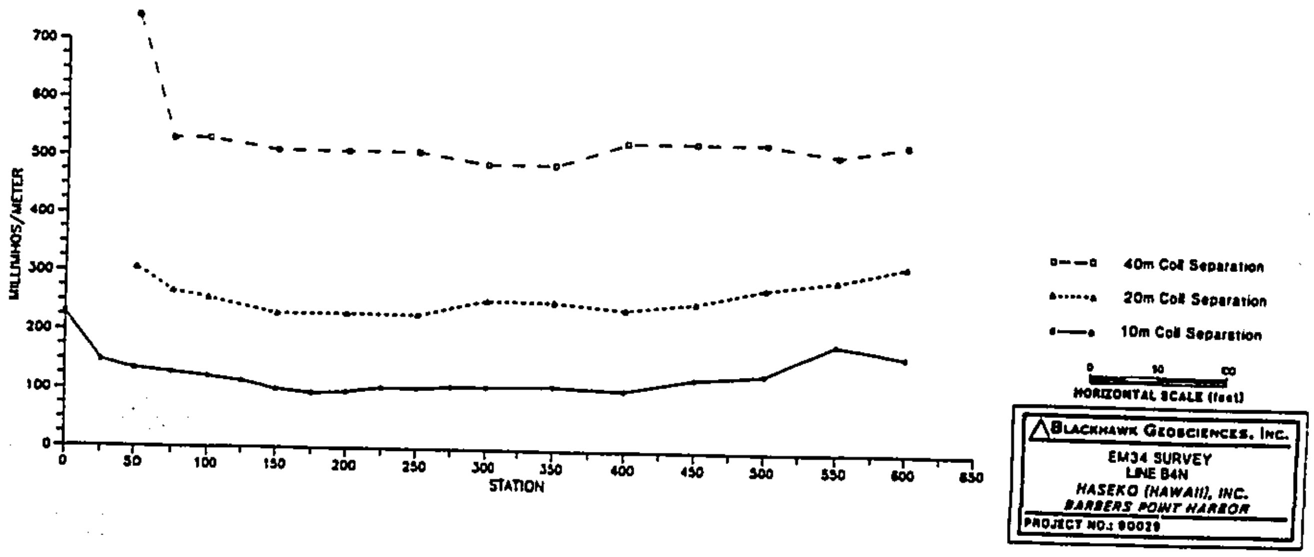

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HORIZONTAL SCALE (feet)
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EM34 SURVEY
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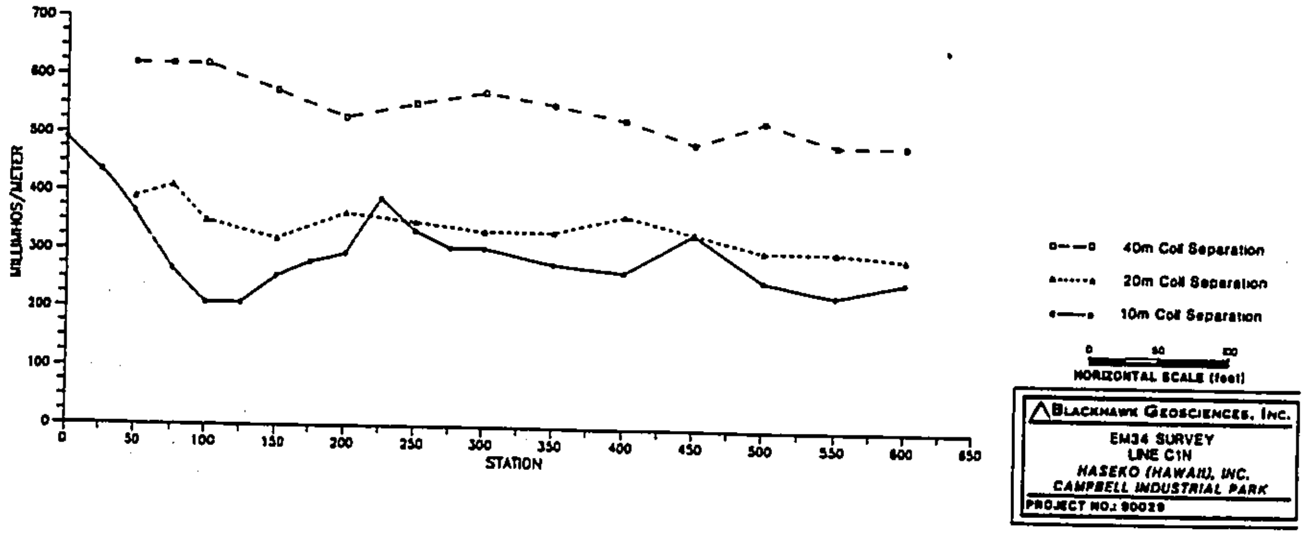
HASEKO (HAWAII), INC.
BARBERS POINT HARBOR
PROJECT NO.: 90029



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STATION
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HORIZONTAL SCALE (feet)
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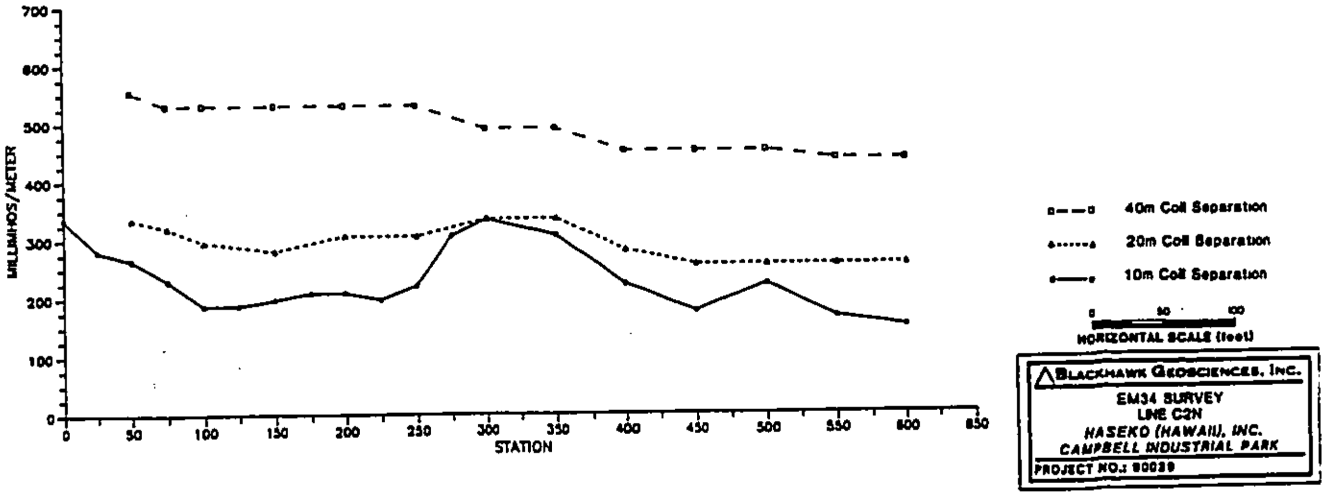
EM34 SURVEY
LINE C1N
HASEKO (HAWAII), INC.
CAMPBELL INDUSTRIAL PARK
PROJECT NO.: 90029



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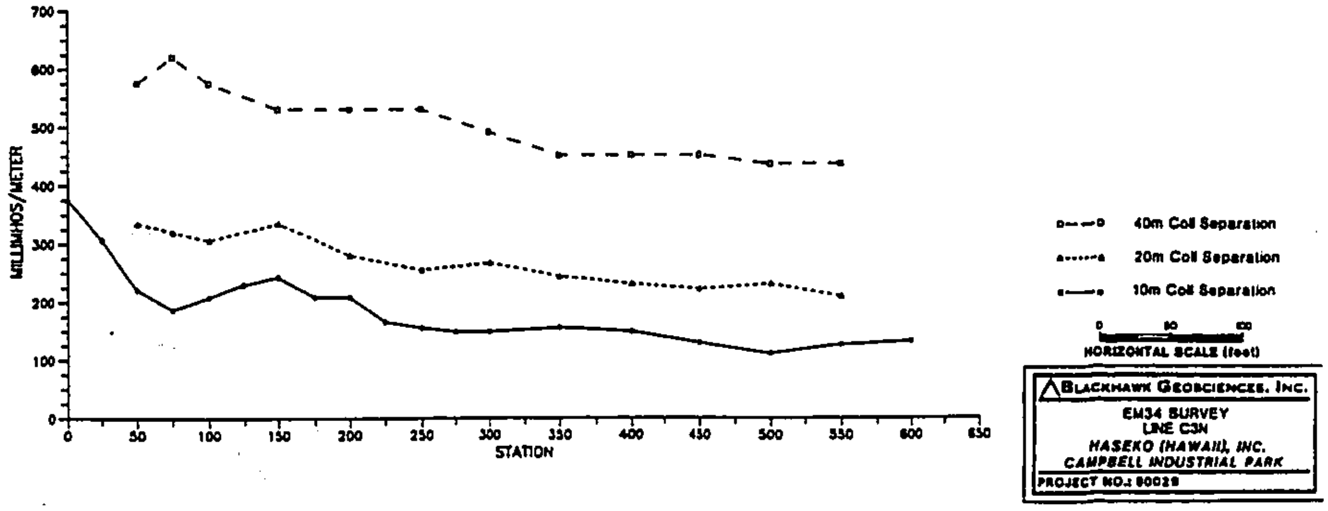
HORIZONTAL SCALE (feet)
BLACKHAWK GEOSCIENCES, INC.
EM34 SURVEY
LINE C2N
HASEKO (HAWAII), INC.
CAMPBELL INDUSTRIAL PARK
PROJECT NO.: 90029



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HORIZONTAL SCALE (feet)
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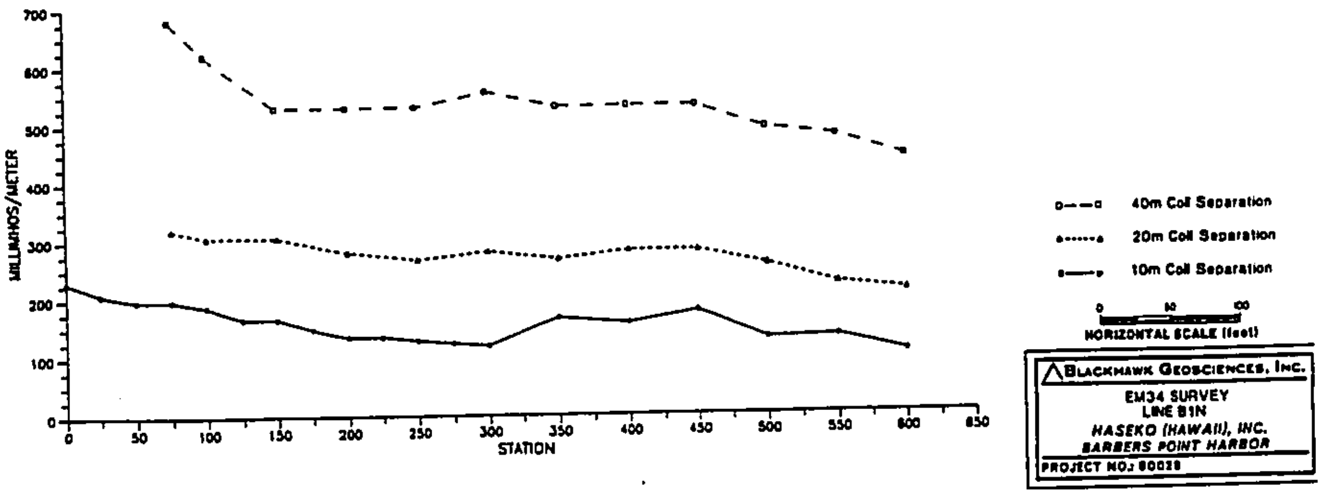
LINE C3N
HASEKO (HAWAII), INC.
CAMPBELL INDUSTRIAL PARK
PROJECT NO.: 90029



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10m Coil Separation
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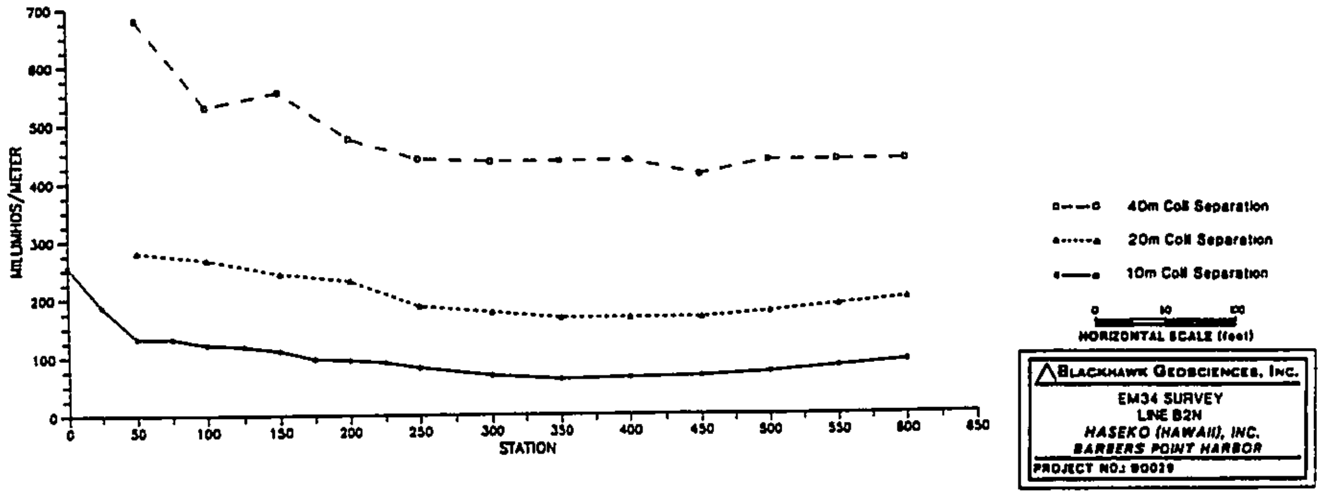
EM34 SURVEY
LINE B1N
HASEKO (HAWAII), INC.
BARBERS POINT HARBOR



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STATION
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HORIZONTAL SCALE (feet)
BLACKHAWK GEOSCIENCES, INC.
EM34 SURVEY
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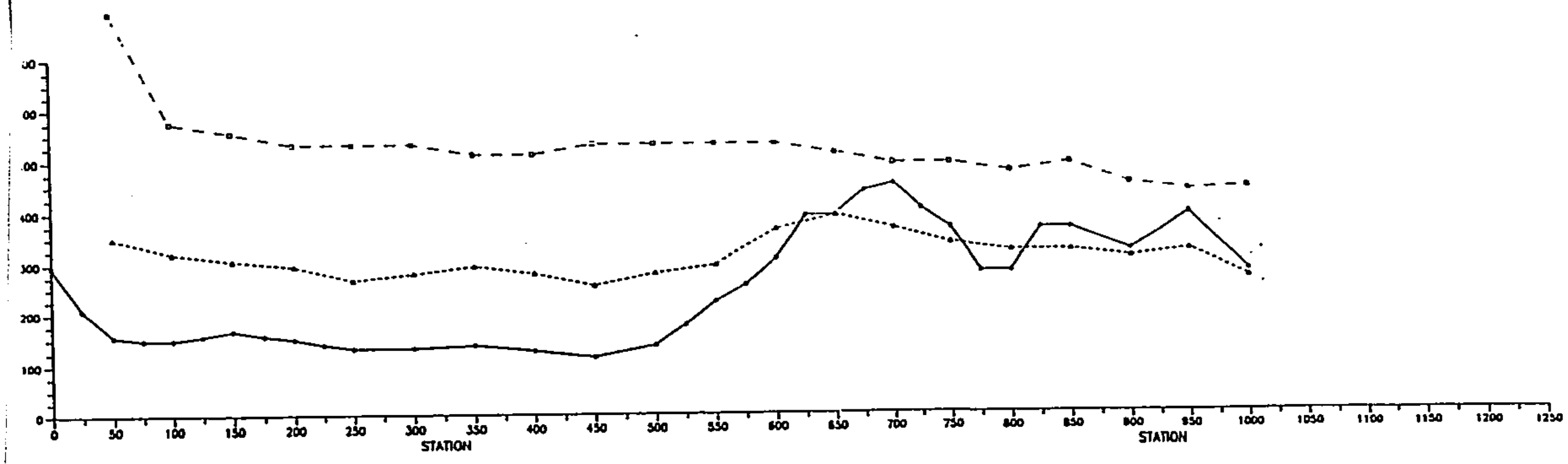
HASEKO (HAWAII), INC.
BARBERS POINT HARBOR



40m Coil Separation
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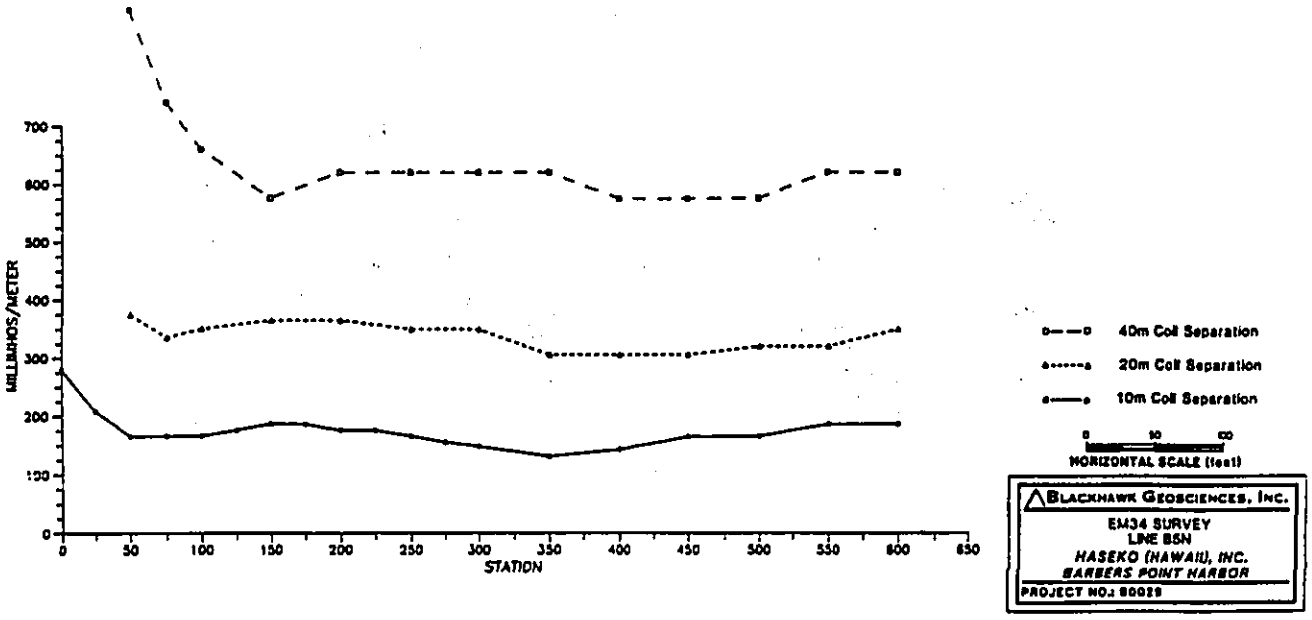
HORIZONTAL SCALE (feet)

BLACKHAWK GEOSCIENCES, INC.

EM34 SURVEY
LINE B3N
HASEKO (HAWAII), INC.
BARBERS POINT HARBOR

PROJECT NO.: 90029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STATION
40m Coil Separation
20m Coil Separation
10m Coil Separation
HORIZONTAL SCALE (feet)
BLACKHAWK GEOSCIENCES, INC.
EM34 SURVEY
LINE 85N
HASEKO (HAWAII), INC.
BARBERS POINT HARBOR
PROJECT NO.:

28 square miles and is bounded to the north by the Waianae Range, the Pacific Ocean to the south and west, and Pearl Harbor to the east. Relief is low, with a gentle grade towards the shoreline of 10 to 20 feet per mile.

The Ewa plain receives about 20 inches of rainfall per annum, ranging from 18.3 inches at Barbers Point to 23.5 inches at station 702.2. Rainfall stations 741, 744 and 751, in the vicinity of the proposed development (Figure 1) have long-term average rainfalls of 21.5, 21.1 and 21.1 inches, respectively. Most of this rainfall occurs during the winter months as a result of cyclonic storms. Pan evaporation across the plain is high. The limited data available suggests an annual average of 82 inches. Experimental data indicates that the average evapotranspiration (ET) by sugar cane with continuous access to moisture is approximately equal to the pan evaporation. A figure of 80 to 85 inches for ET on the plain is generally used.

2.2 Regional Geology

The Ewa plain is formed by a sequence of marine sedimentary deposits (wedge) referred to as caprock, overlying a sloping volcanic basalt basement (Figure 2). While reef development is the dominant process, downslope transport of terrestrial alluvium is locally significant. [illegible] sea level changes in recent geological times are superimposed upon these processes.

The resulting stratigraphic profile of the caprock is composed of coral reef [illegible] separated by layers of silt and clay of marine and terrestrial origin. The caprock [illegible] inland and increases in thickness to a maximum of about 1100 feet at the coast [illegible] good correlation of the major horizons from well logs across the entire coastal plain.

The uppermost stratum of the caprock is relatively clean fossil reef limestone [illegible] the southern two-thirds of the Ewa plain and covered by alluvium near the foothills. [illegible] thickness of about 150 to 200 feet at the coast and thins inland, terminating [illegible] the caprock. Based on test hole drilling, this stratum is underlain by gray and brown [illegible] marine origin closer to the shoreline with increasing [illegible] evidence of a marl/silt/sand layer overlying the caprock [illegible] the shoreline of Pearl Harbor's West Loch (Figure 11).

2.3 Hydrogeology

The schematic representation of the aquifer system [illegible] formations. A deeper, highly permeable basalt aquifer [illegible]

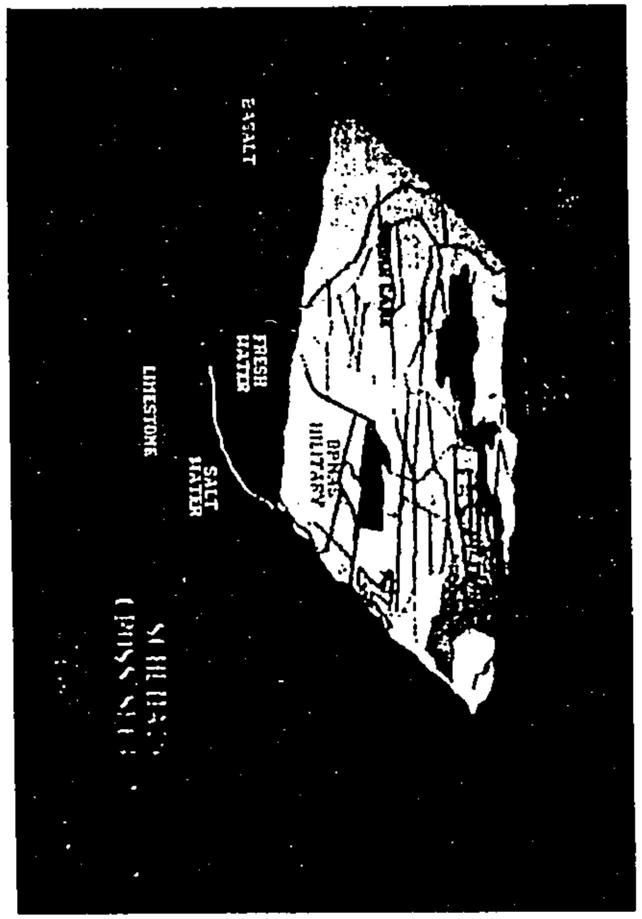


FIGURE 2

In addition, an estimated inflow to the caprock aquifer of 4 to 5 MGD results from leakage from the basalt aquifer. Thus, a total inflow to the inland margin of the aquifer within the Honouliuli sector of 19 to 20 MGD is estimated during the furrow era, reducing to 12 to 13 MGD under drip irrigation.

Additional sources of recharge to the caprock aquifer are derived from importation and irrigation of basalt water on the BPNAS Golf Course and within residential areas. Recharge at the BPNAS golf course is estimated at 0.2 MGD for an irrigation rate of 0.5 MGD. Recharge within residential areas results predominantly from lawn irrigation and cesspools. Estimated recharge of 0.8 MGD for the Ewa Beach Community and 0.2 MGD for Iroquois Point has been assigned.

2.6 Land Use Scenarios and Corresponding Water Budgets

A number of land use scenarios have been considered in this study, each corresponding to key events within the short- to medium-term future. The impact of changing land and water use has been compared initially to the existing water levels and flows. For longer term management [illegible], the interim land use without the proposed marina, defined as the expected land use [illegible] mid 1990s, is referred to as a base case.

2.6.1 Pre-Existing Land Use

A pre-existing land use period has been considered to assess the impact of the [illegible] to drip in the irrigated areas and provide a refinement to aid water quality modeling. [illegible] fields commenced in 1974 and proceeded through 1982. Figure 5 illustrates the [illegible] and caprock irrigated fields and approximate conversion dates to drip irrigation. Figure [illegible] the land use which prevailed in this period.

Prior to 1974, annual average caprock pumpage fluctuated yearly by up to 10 MGD [illegible] from 475 mg/l to 1047 mg/l [illegible] Mink et al. [illegible] chloride levels on the order of 500 to 700 mg/l prevailed. [illegible] changes in water management [illegible] aquifer.

The net water budget varies substantially over this period. Figure 6B presents the [illegible] water budget for 1974 which indicates a discharge along the shoreline [illegible] MGD.

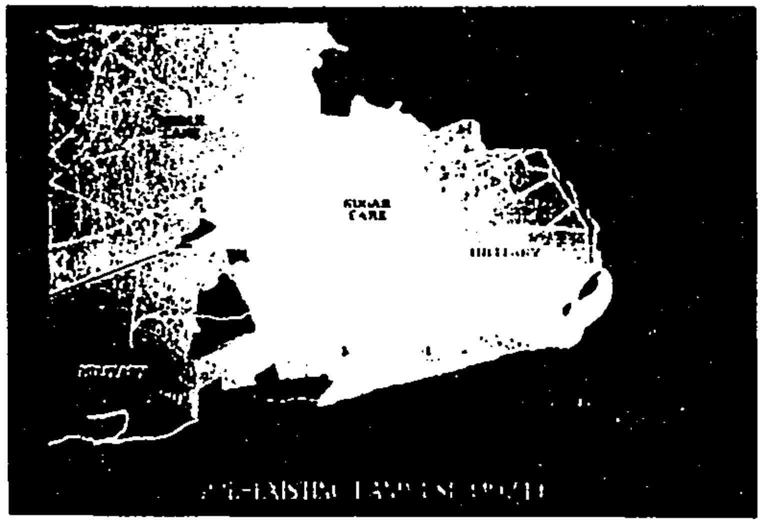


FIGURE 6A

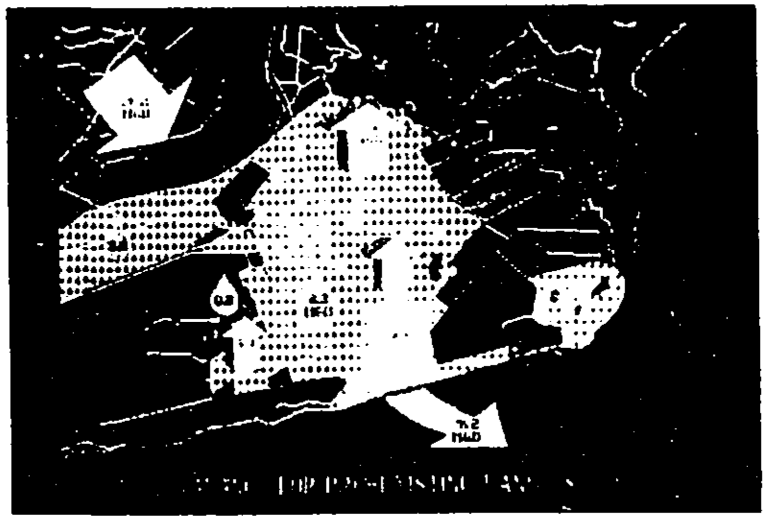


FIGURE 6B

2.6.2 Existing Land Use

Land use in the 1988-89 period is referred to herein as Existing Land Use. It reflects complete conversion to drip irrigation for sugar cane and initial development of Ewa by Gentry development (Figure 7A). The Gentry area shown as "Open" in Figure 7A was previously irrigated with basal groundwater. All other areas south of the old railroad were and remain under caprock irrigation, with inland fields irrigated with basalt water.

The water budget, presented in Figure 7B, illustrates the groundwater fluxes used for numerical model of the existing land use. Groundwater abstraction from the caprock aquifer for cane irrigation totals 15.3 MGD, of which 4.7 MGD (31%) is returned to the aquifer. Upstream boundary inflow is fixed at 17.4 MGD which is generally in accord with the estimated 15 MGD across the Pouhala sector boundary in Mink et al., 1988.

The net water balance for this scenario shows an upstream boundary inflow of 17.4 MGD, an [illegible] deficit (excess pumpage over recharge) of 6.6 MGD and a resulting discharge to the [illegible] of [illegible] MGD.

2.6.3 Interim Land Use

The interim land use scenario depicts conditions in the early to mid 1990s when construction of the marina would begin. At this time Ewa by Gentry would be almost fully developed and sugar cane would be removed from all fields west of Fort Weaver Road (Figure 8A). The golf courses of [illegible] and within the Gentry project would be completed and in operation.

Reduction of the sugar cane acreage results in a decrease in pumpage from 15.3 MGD to 7.7 MGD and corresponding decline in recharge from the irrigated fields (Figure 8B). However, [illegible] recharge is anticipated from new residential areas. Also counteracting the reduction in sugar cane irrigation would be three new golf courses, two of which are presently under construction (the Pouhala and [illegible] golf courses). Each of these will be irrigated with groundwater from caprock wells, with approximately 10% of the draft from wells [illegible] returning to the aquifer [illegible] at two of these courses is estimated at 1.0 MGD each. The [illegible] course [illegible] MGD.

The net water balance for this scenario shows an upstream boundary inflow of [illegible] MGD, [illegible] deficit (excess pumpage over recharge) of 2.6 MGD and a resulting discharge to the [illegible] of [illegible] MGD. This represents a 4.0 MGD increase in [illegible] discharge over existing conditions.

FIGURE 7A

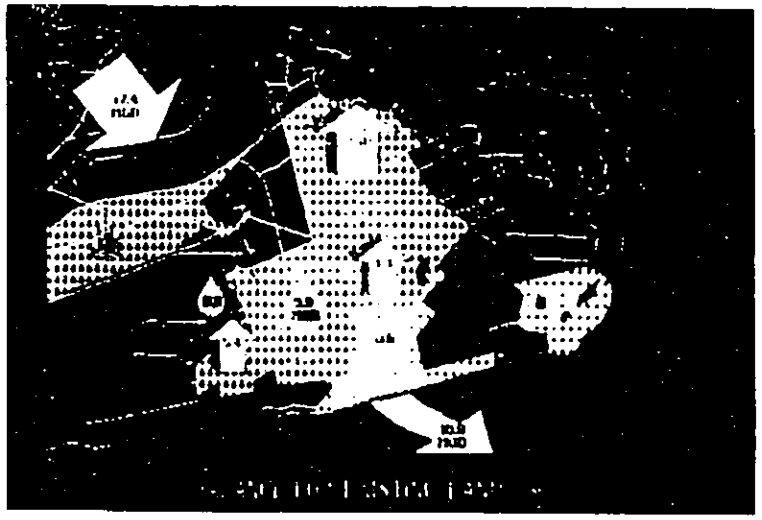


FIGURE 7B

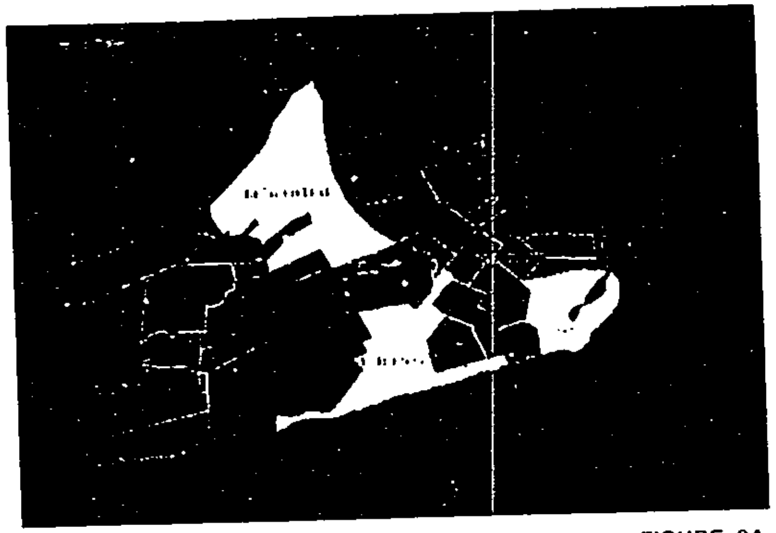


FIGURE 8A

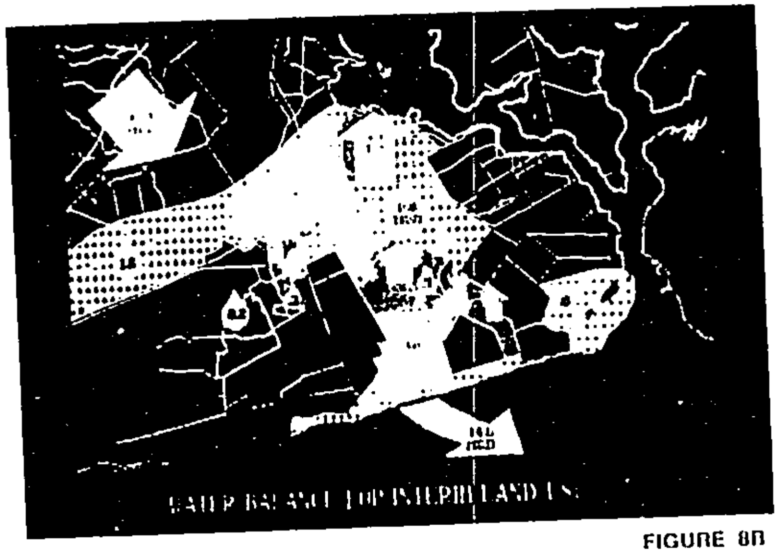


FIGURE 8B

2.6.4 Future Land Use

The future land use scenario (Figure 9A) depicts the fully developed [illegible] Campbell Estate's Long Range Master Plan. Within the modelled area [illegible] the Blast Zone adjacent to West Loch. The remainder of the plan is [illegible] important assumption in this scenario is the continuation of [illegible] model boundary as well as within the Blast Zone. Thus, the [illegible] and 21.8 MGD.

Additional abstraction is assigned to the Ewa Marina Golf Course [illegible] MGD and the [illegible] apartment (EDA) areas which will have landscape irrigation by [illegible] pumpage of 1.7 MGD is estimated for the EDA areas.

The net water balance for this [illegible] MGD and [illegible]

2.6.5 Potential Long Term Land Use

This land use scenario was included [illegible] the potential impact [illegible] and its important future flow input [illegible] residential development would [illegible] Zone which would remain fallow (Figure 10A).

The net water balance for this scenario (Figure 10B) shows [illegible] an internal deficit (net of pumpage [illegible] MGD and [illegible] MGD). Upstream inflow has [illegible] MGD [illegible] uptake and 1.5 MGD return flow [illegible]

3.0 Field Investigations

[illegible] conditions. A [illegible] and vertical [illegible] water quality [illegible] calibrate these models [illegible] that a hydrologic feature [illegible] having higher groundwater [illegible] the number of [illegible]

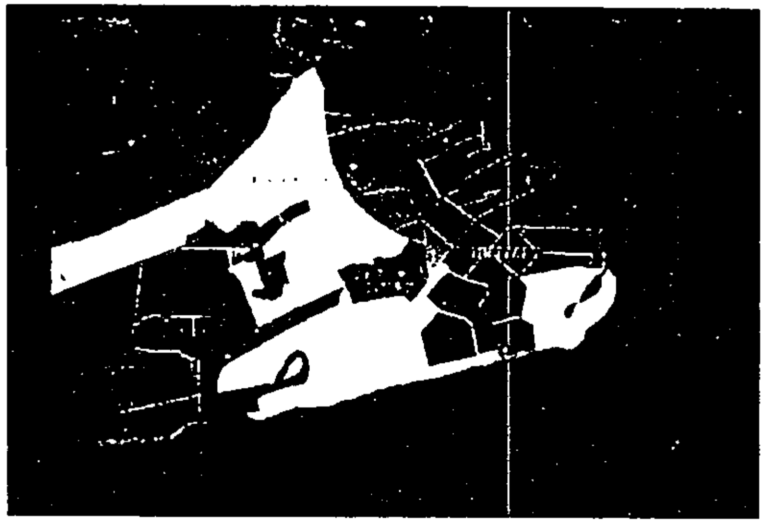


FIGURE 9A

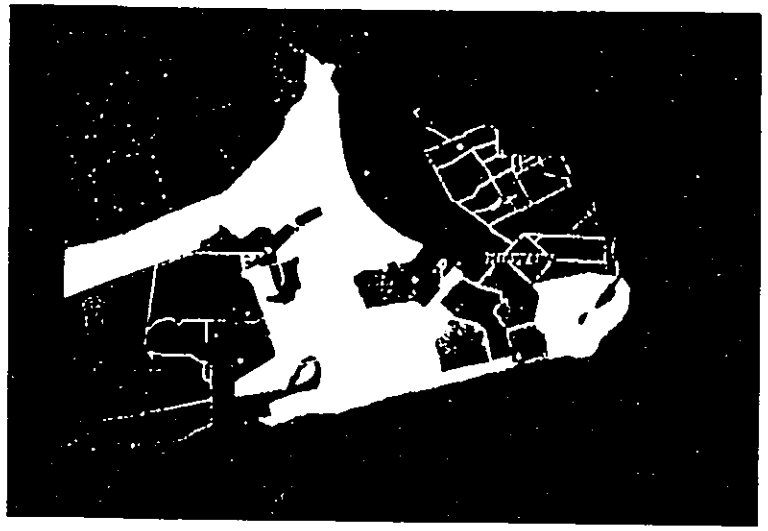


FIGURE 10A

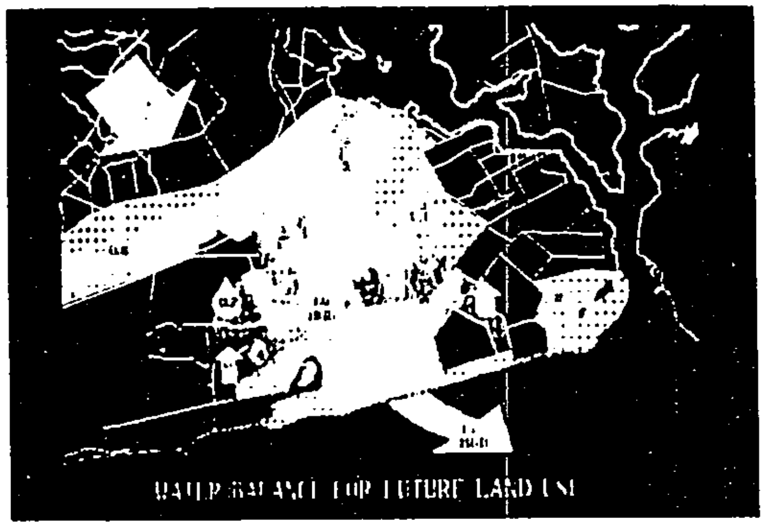


FIGURE 9B

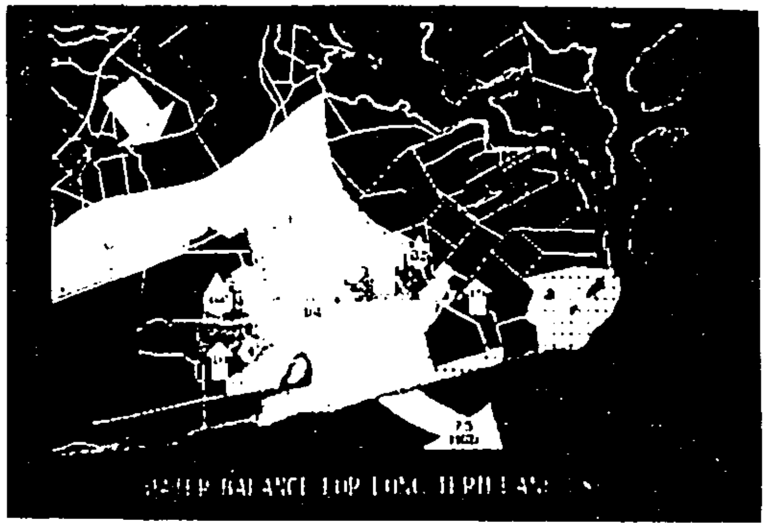


FIGURE 10B

Appendix C

Air Quality Impact Report
Ewa Marina Phase I
(Increment 2) and Phase II

AIR QUALITY IMPACT REPORT

EWA MARINA
PHASE I (INCREMENT 2) AND PHASE II
December 31, 1991

Prepared for

HASEKO (Hawaii), Inc.

Prepared by

J. W. MORROW
ENVIRONMENTAL MANAGEMENT CONSULTANT
KAILUA, HAWAII

TABLE OF CONTENTS

TABLE OF CONTENTS (Con't)

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

EXISTING AIR QUALITY

While there is no air monitoring station in the project area, air quality is believed to be in compliance with state and federal standards due to the essentially undeveloped nature of the area. The nearest major stationary sources at Campbell Industrial Park are downwind of the project site under the prevailing northeasterly tradewinds and thus would impact project site air quality only under infrequent southwesterly wind conditions. The State Health Department's Barbers Point air monitoring station, located some six miles southwest, indicates compliance with state and federal standards despite being located adjacent to Campbell Industrial Park.

Air sampling conducted during peak traffic hours found carbon monoxide (CO) levels in the 2 - 4 milligrams per cubic meter (mg/m^3) range along Fort Weaver Road in the vicinity of Geiger Road and the Kunia Interchange. Such levels are well within the state and federal 1-hour standards of 10 mg/m^3 and 40 mg/m^3, respectively. Winds during the sampling were light but gusty trade winds from the north-northwest and northeast.

On an annual basis, wind conditions in the area are predominated by brisk northeasterly tradewinds; however, there is a marked seasonal difference in the velocity and persistence of such winds. The tradewinds tend to decline in the fall and winter months turning into more light and variable winds, often with a more southerly component, which can contribute to higher pollutant concentrations.

AIR QUALITY IMPACTS AND MITIGATION

During the construction phase, 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 50% reduction in fugitive dust emissions can be accomplished by twice daily watering. Construction vehicle exhausts are primarily controlled by proper maintenance of vehicle engines to insure efficient operation. The impact on Fort Weaver Road can be reduced by minimizing construction vehicle movement during peak traffic hours.

Offsite short-term impacts associated with construction include the operation of asphalt concrete and concrete batch plants to provide the material for road building and foundations. Those plants will emit pollutants while they are producing product for the proposed project. Such plants must have Department of Health permits to operate and must have demonstrated their ability to meet federal and state air quality standards in order to receive those permits; thus, the production of materials for the Ewa Marina I/II project can be considered as part of their normal operation and thus in compliance with air pollution control rules.

The primary long-term impact of the project will be associated with the motor vehicle traffic generated by it. An air quality impact analysis based on cumulative traffic volumes indicated that while there will be an increase in carbon monoxide levels along Fort Weaver Road with or without the project, federal air quality standards will continue to be met, but there may be exceedances of state carbon monoxide standards in close proximity (<10 meters) to the proposed Access Road "A" intersection with Fort Weaver Road. A variety of mitigation can either be implemented or encouraged by the project developer. These include carpooling, development and use of public transit, limited parking facilities, development of near-home employment opportunities.

The project will cause an increase in electrical demand which in turn will result in greater emissions from power plants. This increase was estimated at less than 0.5% of Oahu's latest available emissions inventory. These emissions can be reduced by design and practices which reduce electrical demand. The State Department of Business, Economic Development and Tourism has suggested a list of such measures, too lengthy to include here, which could contribute significantly to both energy conservation and pollution reduction. These are summarized in the full report.

The project will also generate solid waste which will likely be burned at the newly opened resource recovery facility, HPOWER, resulting in pollutant emissions. Measures aimed at reducing waste generation, such as recycling and composting, should be provided to help mitigate both the solid waste and air pollution impacts.

Pesticide use associated with golf course maintenance will have a potential for air quality impact if the pesticides are improperly applied under strong wind conditions. Estimated concentrations of typical herbicides, insecticides, and fungicides used on golf courses indicated concentrations well below standards and effects levels. The primary mitigation means is to insure that applicators adhere strictly to label instructions. Alternatively, other non-chemical means of pest control can be sought out and implemented.

1. INTRODUCTION

HASEKO (Hawaii), Inc. is proposing to develop the second increment of Phase I as well as Phase II of the Ewa Marina project. The project is located in leeward Oahu between Ewa Beach and Naval Air Station Barbers Point on former sugar cane lands (Figure 1). It will consist of the following major components:

PHASE I (Increment 2):	
Single-family residential	910 units
Multi-family residential	2,650 units
PHASE II:	
Visitor condominium	600 rooms
Marina hotels	500 rooms
Fitness Promotion Center	400 rooms
Retail shops	40,000 ft²
Restaurant complex	40,000 ft²
Commercial offices	70,000 ft²
Tennis complex	10 courts
Yacht club	12,000 ft²
Parks	17 acres
27-hole golf course	272 acres

The purpose of this report is to assess the air quality impact of the proposed development. The project can be considered an "indirect source" of air pollution as defined in the federal Clean Air Act [1] since it will attract mobile sources of air pollution, i.e., motor vehicles. Thus, much of the focus of this analysis is on the project's ability to generate traffic and the resultant impact on air quality. Air quality impact was evaluated for existing (1991) and future (2009) conditions.

The following direct and indirect impacts have also been addressed:

- offsite impacts due to electrical generation
- refuse disposal at a resource recovery facility
- pesticides use at the golf course
- onsite and offsite construction impacts

2. AIR QUALITY STANDARDS

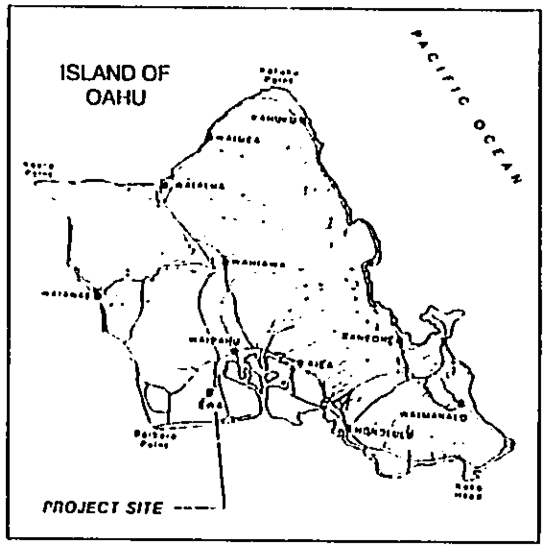
A summary of State of Hawaii and national ambient air quality standards is presented in Table 1 [2,3]. Note that Hawaii's standards are not divided into primary and secondary standards as are the Federal standards.

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 (NO_x), and

FIGURE 1
PROJECT LOCATION AND EXISTING CONDITIONS



Project Location

Existing Site Conditions

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 (SO_2)	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 (NO_2) (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. Photochemical Oxidants (as O_3) (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

photochemical oxidants (O_x), 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 235 micrograms/cubic meter (ug/m^3) [8]. The carbon monoxide (CO), particulate matter, sulfur dioxide (SO_2), and nitrogen dioxide (NO_2) standards have been reviewed, but no new standards were proposed.

Finally, the State of Hawaii also has fugitive dust regulations for particulate matter (PM) emanating from construction activities [9]. 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: o total suspended particulates (TSP)

o particulate matter microns (PM_{10})

o sulfur dioxide (SO_2)

o carbon monoxide (CO)

o ozone (O_3)

o lead (Pb)

In the case of TSP, PM_{10}, and SO_2, measurements are made on a 24-hour basis to correspond with the averaging period specified in the 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. Note that the lead standard is a quarterly average.

While there is no Department of Health (DOH) air monitoring station in the immediate vicinity of the project site, there has been a station at the Campbell Industrial Park, some 6 miles to the southwest, for many years. The DOH also monitors air quality at its downtown Honolulu building some 10 miles east of the Ewa Marina project.

3.2 Department of Health Monitoring Sites. Recent data from the Barbers Point and Honolulu stations are summarized in Tables 2 - 4. The data indicate that total suspended particulate (TSP) and sulfur dioxide (SO_2) standards are being met. In fact, much of the time sulfur dioxide concentrations are below the detectable limit of the measurement method being employed. Carbon monoxide (CO) levels are also below State standards most of the time with only occasional exceedances.

Photochemical oxidants are secondary pollutants formed in the atmosphere largely as a result of anthropogenic emissions of hydrocarbons and oxides of nitrogen. Since there are no ambient standards for

TABLE 2
AIR MONITORING DATA
BARBERS POINT, OAHU
1974-90

	PARTICULATES*			SO_2			NO_2		
YEAR	RANGE	MEAN	≥AQS	RANGE	MEAN	≥AQS	RANGE	MEAN	≥AQS
1974	23-132	47	1	<5-10	<5	0	<20-40	25	0
1975	13-137	52	1	<5-11	<5	0	< 5-25	11	0
1976	12-101	40	1	<5- 7	<5	0	< 5-29	14	0
1977	25-134	54	1	<5-18	<5	0	------	--	-
1978	22-127	48	1	<5-40	<5	0	------	--	-
1979	23-223	76	--	<5-27	<5	0	------	--	-
1980	29-158	53	2	<5-10	<5	0	------	--	-
1981	26-188	51	2	<5-40	<5	0	------	--	-
1982	15- 63	41	0	<5-12	<5	0	------	--	-
1983	28-193	--	2	<5-95	<5	1	------	--	-
1984	17-112	50	1	<5-<5	<5	0	------	--	-
1985*	24-138	57	3	<5-25	<5	0	------	--	-
1986*	7-66	26	0	<5-10	<5	0	------	--	-
1987*	10-40	22	0	<5-13	<5	0	------	--	-
1988*	10-48	24	0	<5-19	<5	0	------	--	-
1989*	10-44	25	0	<5-20	<5	0	------	--	-
1990*	12-60	28	0	<5-<5	<5	0	------	--	-

NOTES

1. Particulates = 1974-84, total suspended particulates (TSP) ;1985-90, particulate matter <10 microns (PM_{10})
2. SO_2 = sulfur dioxide
3. NO_2 = nitrogen dioxide
4. >AQS = number of violations of state air quality standard
5. All concentrations are in micrograms per cubic meter of air
6. Sampling station was moved from Barbers Point Lighthouse to the Chevron Refinery site due to salt spray from the ocean on 17 March 1972.
7. The samplers were elevated to a rooftop on 7 August 1979.
8. Source: State Department of Health

TABLE 3
SUMMARY OF AEROMETRIC DATA COLLECTED AT
THE DEPARTMENT OF HEALTH BUILDING AND SAND ISLAND
1990

	Concentration (ug/m^3)							
	TSP		SO_2		CO		O_3	
Month	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Jan	23-42	35	<5-<5	<5	0.1-7.1	1.8	10-29	16
Feb	20-45	35	<5-<5	<5	0.3-4.8	1.8	4-29	14
Mar	24-44	31	<5-<5	<5	0.5-3.3	1.7	10-104	51
Apr	28-36	32	<5-<5	<5	0.5-5.3	1.6	33-88	55
May	23-34	29	<5-<5	<5	0.3-2.1	1.0	10-90	46
Jun	29-36	33	<5-<5	<5	0.3-1.6	0.8	20-65	37
Jul	13-30	20	<5-<5	<5	0.3-2.3	1.1	18-116	32
Aug	26-40	30	<5-<5	<5	0.3-2.4	1.1	20-63	37
Sep	19-34	25	<5-<5	<5	0.3-2.8	1.6	20-75	34
Oct	17-31	24	<5-<5	<5	0.3-2.3	1.1	10-59	34
Nov	18-47	32	<5-<5	<5	0.3-4.6	2.0	20-75	42
Dec	20-46	34	<5-<5	<5	0.3-4.5	2.3	20-65	37
Annual	13-46	30	<5	<5	0.1-4.8	1.5	4-116	36

hydrocarbons, there is no monitoring. In the case of NO_2, the State ceased routine monitoring in 1976. As indicated by federal and state standards, ozone is monitored at Sand Island as a surrogate for photochemical oxidants. Recent monitoring data from that station indicate that the state's 1-hour standard is being met over 99% of the time.

As noted above, the State also has been having particulate samples analyzed for lead content, and Table 4 summarizes ambient lead levels in recent years. Generally, airborne lead levels have declined as expected due to the federal program for gradual phaseout of leaded gasoline. Particulate lead accumulated over the years in roadside soils and plants, however, will remain indefinitely in the area and provide inhalation exposure whenever dust is re-entrained in the air as a result of scouring winds or mechanical disturbance due to vehicular motion.

TABLE 4
LEAD MONITORING DATA
HONOLULU, OAHU
1970-90

	CONCENTRATION (ug/m^3)			
YEAR	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
1970	0.78	0.81	0.65	0.92
1971	1.65	0.63	0.65	1.05
1972	---	0.75	0.65	0.48
1973	0.52	0.52	0.72	0.55
1974	0.84	0.61	0.70	0.92
1975	0.65	0.81	0.59	1.05
1976	0.91	0.65	0.99	1.00
1977	0.89	0.59	0.48	0.80
1978	---	---	---	0.72
1979	0.39	0.25	0.26	0.42
1980	0.41	0.23	0.21	0.20
1981	0.25	---	---	----
1982	0.21	0.16	0.09	0.21
1983	n/a	n/a	n/a	n/a
1984	0.3	0.2	0.2	0.3
1985	0.1	0.03	0.02	0.1
1986	0.1	0.0	0.0	0.0
1987	0.0	0.0	0.0	0.0
1988	0.0	0.0	0.0	0.01
1989	0.0	0.02	0.01	n/a
1990	0.0	0.0	0.0	0.0

Source: Department of Health

3.3 Onsite Carbon Monoxide Sampling. In September 1989, air sampling was conducted along Fort Weaver Road at Geiger Road and the Kunia Interchange (Figure 2).

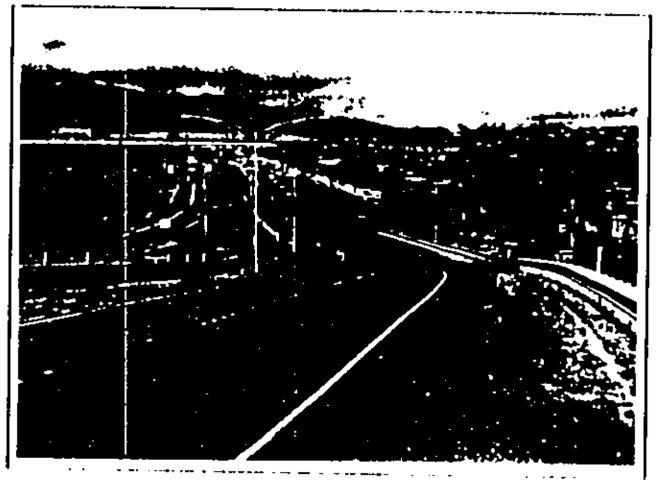
In each case, the actual sampling site was within 10 meters of the road edge and on the west side due to the winds prevailing at the time. A continuous carbon monoxide (CO) instrument was set up and operated during the a.m. and p.m. peak traffic hours based on the results of the traffic impact study [10]. An anemometer and vane were installed to record onsite surface winds. A simultaneous manual count of traffic along Fort Weaver Road was also made. The variability of each of the parameters measured during the peak hours is clearly seen in Figures 3 - 6.

A summary of the average values is presented in Table 5. Onsite surface winds were generally northwesterly and almost parallel to Fort Weaver Road during the a.m. periods, but turned to northeasterly during the afternoon hours. Wind speeds were quite low during a.m. and p.m. periods ranging from 0.5 - 2.2 meters per second (m/sec). Atmospheric stability was neutral in the morning and slightly to moderately unstable during the afternoon.

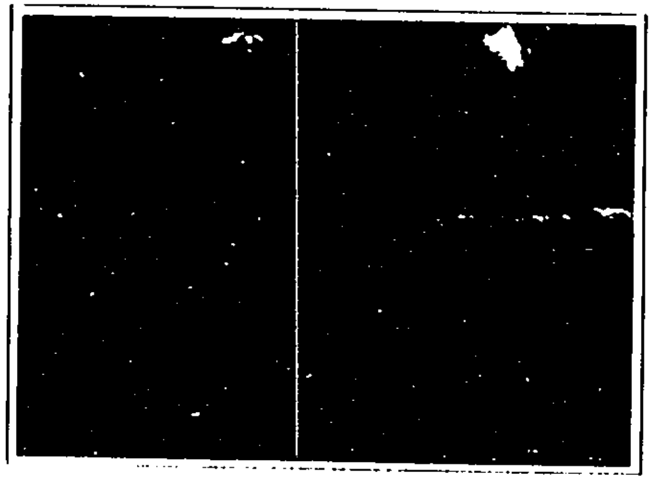
Peak-hour measurements were again made in December 1990. Procedures were essentially the same as in 1989 with the exception that the sampling site at the Geiger Road intersection was moved from the northwest to the southwest side of the intersection due to traffic and wind conditions.

A summary of the 1-hour average results are included with the 1989 data in Table 5. At the Kunia intersection on 19 - 20 December, winds were from the north-northwest during both the a.m. and p.m. periods (Figures 7 and 8). At the Geiger Road intersection on 20 - 21 December, winds turned more northeasterly (Figures 9 and 10). Wind speeds on all three days were somewhat higher than during the 1989 sampling and atmospheric stability was predominantly neutral; thus CO levels were slightly lower.

FIGURE 2
FORT WEAVER ROAD AT GEIGER ROAD AND KUNIA INTERCHANGE



Fort Weaver Road South of H-1 (facing Northwest)



Fort Weaver Road at Geiger Road (facing Southeast)

FIGURE 3
A.M. PEAK HOUR CONDITIONS
FORT WEAVER ROAD AT GEIGER ROAD
SEPTEMBER 21, 1989

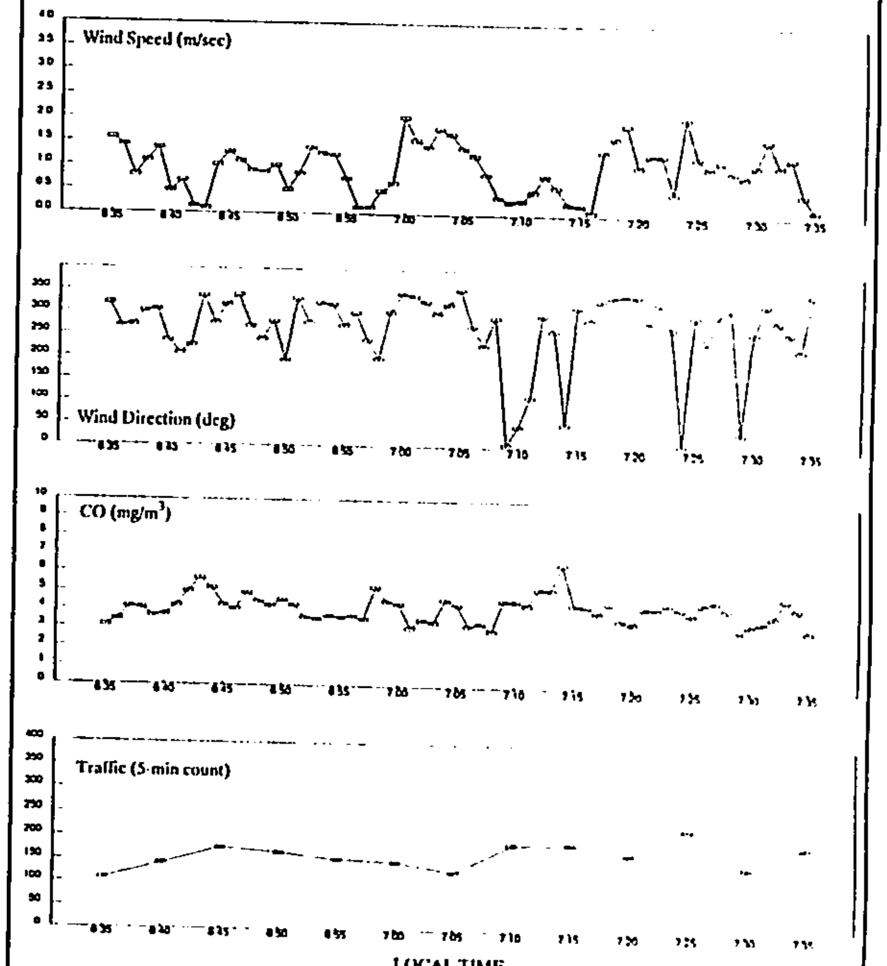


FIGURE 4
P.M. PEAK HOUR CONDITIONS
FORT WEAVER ROAD AT GEIGER ROAD
SEPTEMBER 21, 1989

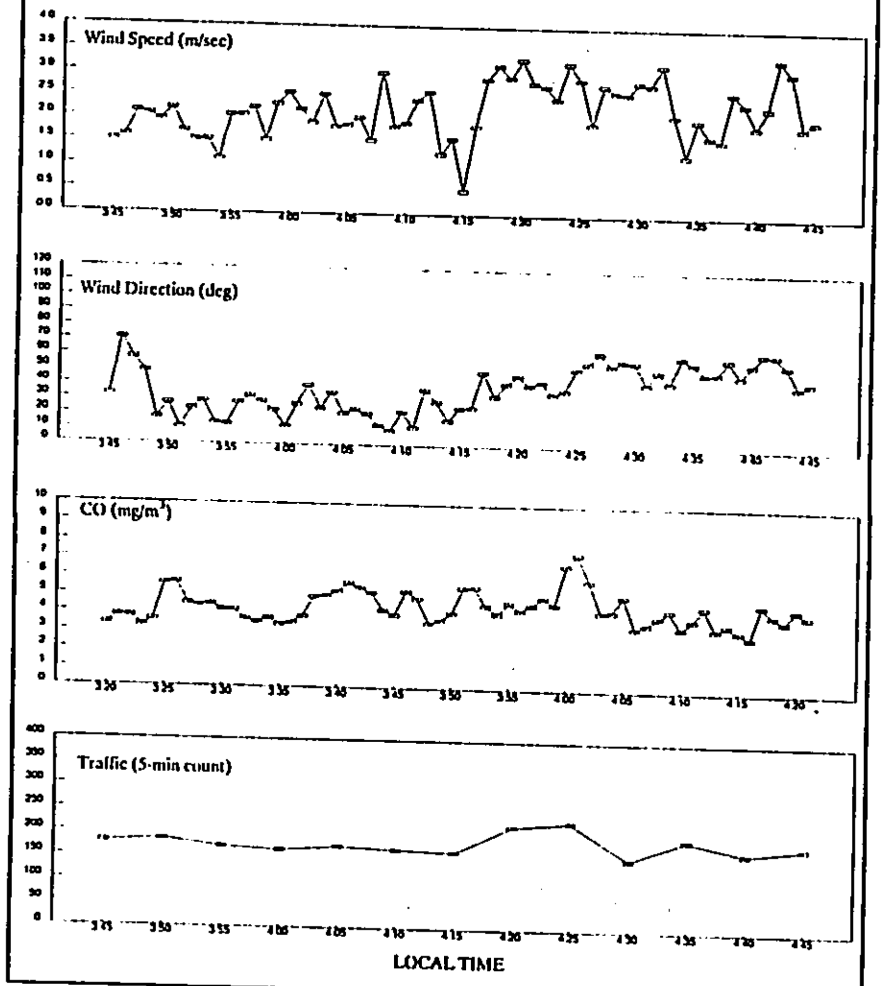


FIGURE 5
A.M. PEAK HOUR CONDITIONS
FORT WEAVER ROAD AT KUNIA INTERCHANGE
SEPTEMBER 28, 1989

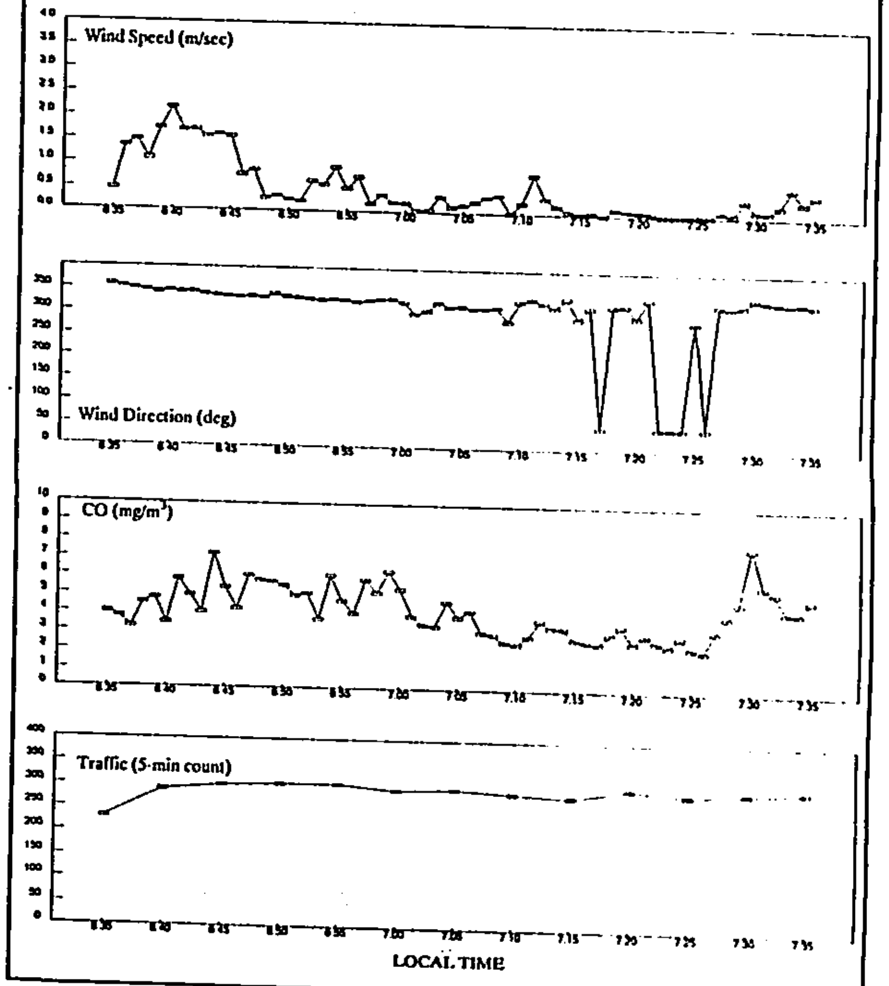


FIGURE 6
P.M. PEAK HOUR CONDITIONS
FORT WEAVER ROAD AT KUNIA INTERCHANGE
SEPTEMBER 28, 1989

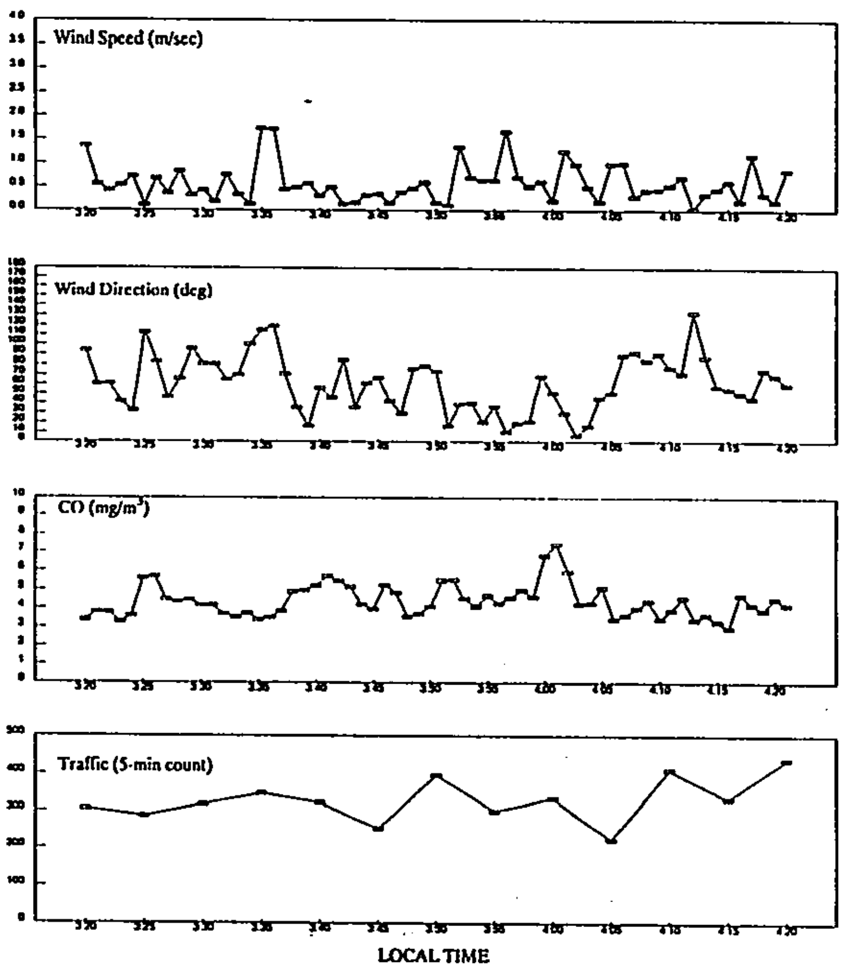


FIGURE 7
P.M. PEAK HOUR CONDITIONS
FORT WEAVER ROAD AT KUNIA INTERCHANGE
DECEMBER 19, 1990

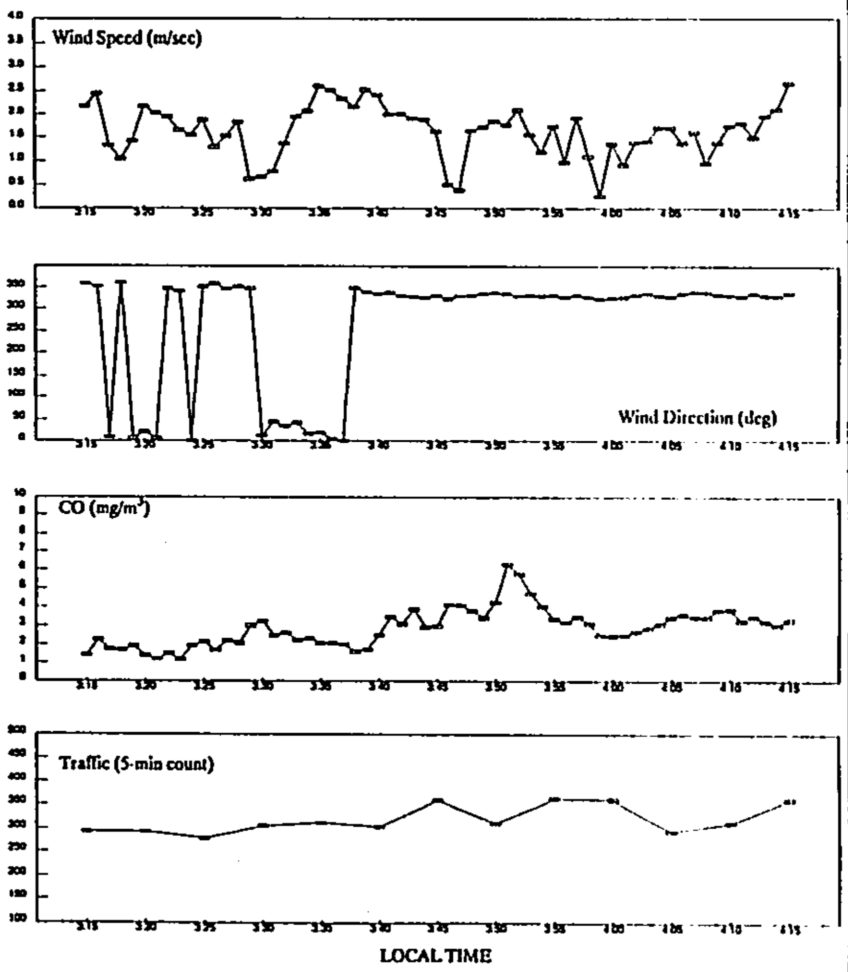


FIGURE 8
A.M. PEAK HOUR CONDITIONS
FORT WEAVER ROAD AT KUNIA INTERCHANGE
DECEMBER 20, 1990

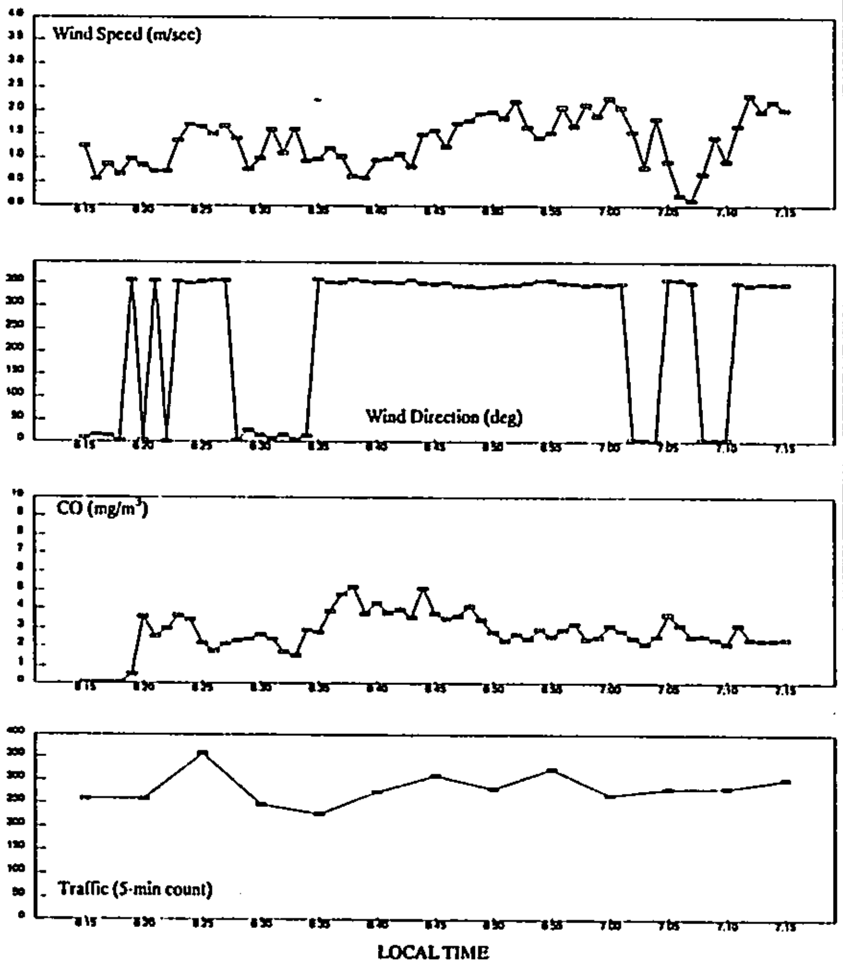


FIGURE 9
P.M. PEAK HOUR CONDITIONS
FORT WEAVER ROAD AT GEIGER ROAD
DECEMBER 20, 1990

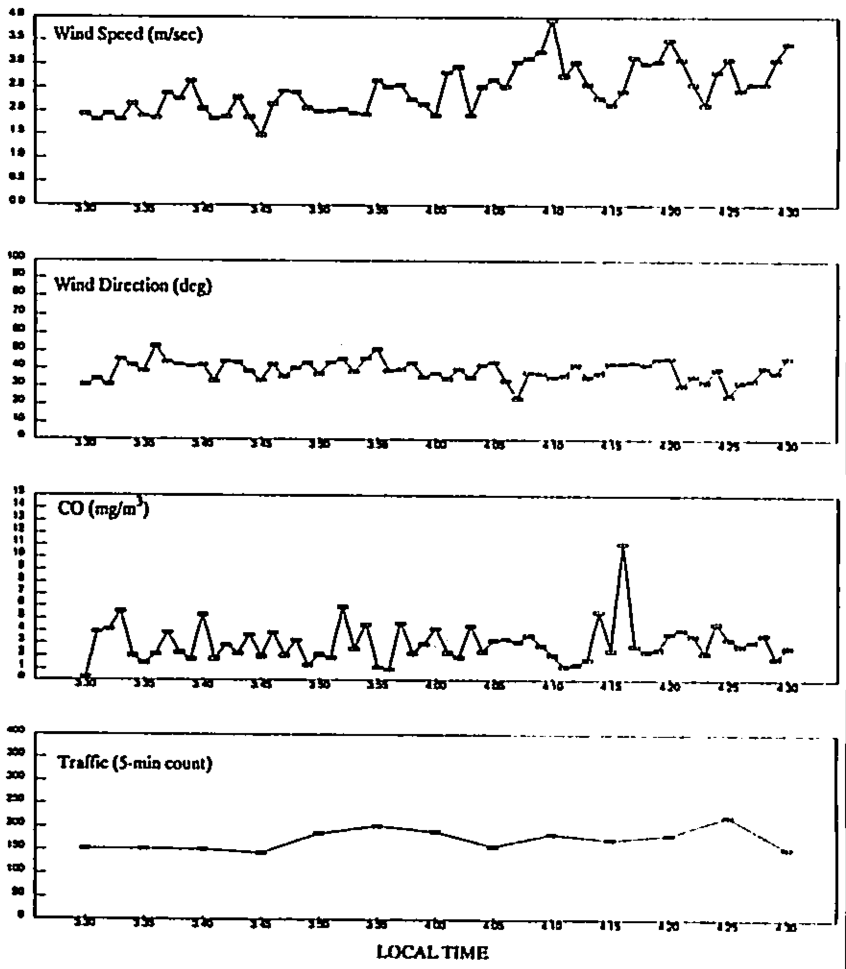


FIGURE 10
A.M. PEAK HOUR CONDITIONS
FORT WEAVER ROAD AT GEIGER ROAD
DECEMBER 21, 1990

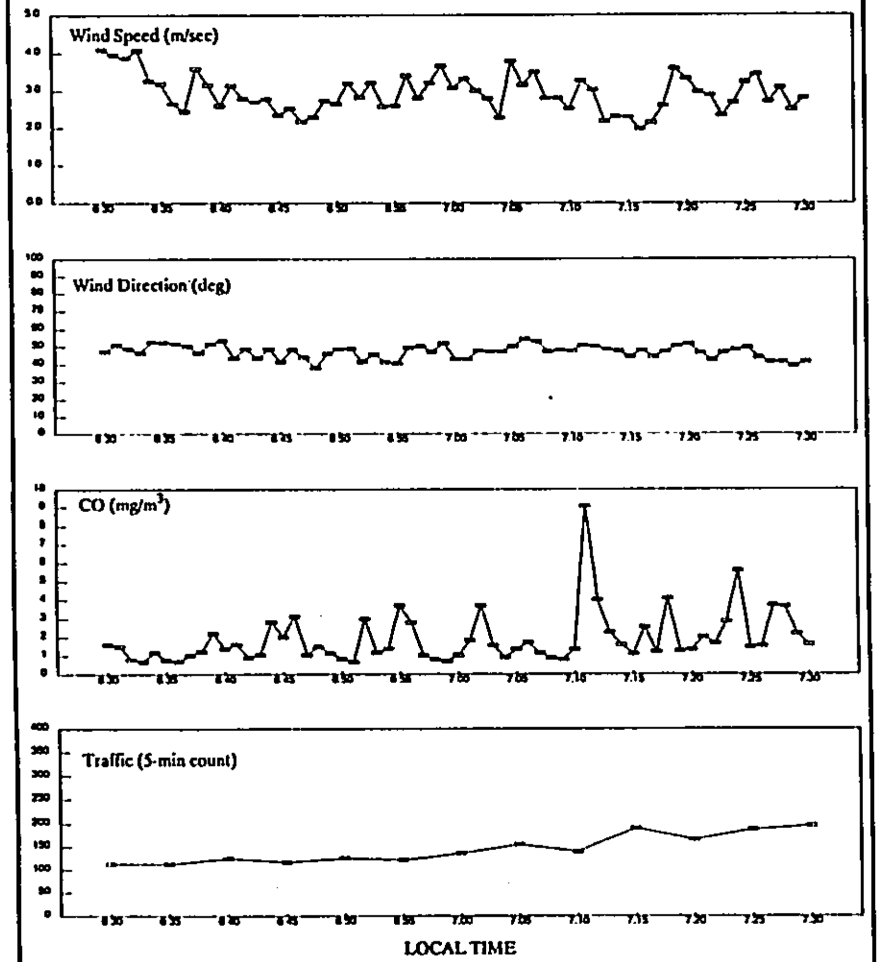


TABLE 5
ONSITE CARBON MONOXIDE SAMPLING RESULTS
FORT WEAVER ROAD
SEPTEMBER 1989 AND DECEMBER 1990

Date	Day of Week	Time	Location	Side of Road	CO mg/m^3	Onsite Weather WD deg [s.d.]	Onsite Weather WS m/s
21 Sep 89	Thu	6:35 - 7:35 am	Geiger Rd	West	4.2	309 [72]	1.0
		3:45 - 4:45 pm	Geiger Rd	West	4.2	040 [19]	2.2
28 Sep 89	Thu	6:35 - 7:35 am	Kunia Int	West	4.3	338 [14]	0.5
		3:20 - 4:20 pm	Kunia Int	West	4.4	058 [24]	0.6
19 Dec 90	Wed	3:15 - 4:15 pm	Kunia Int	West	2.9	075 [14]	1.6
20 Dec 90	Thu	6:15 - 7:15 am	Kunia Int	West	2.8	085 [17]	1.4
		3:30 - 4:30 pm	Geiger Rd	South-west	3.1	039 [14]	2.4
21 Dec 90	Fri	6:30 - 7:30 am	Geiger Rd	South-west	1.9	047 [13]	2.9

4. CLIMATE & METEOROLOGY

4.1 Temperature & Rainfall. The National Climatic Data Center in its 1982 annual summary for Honolulu notes that:

"Hawaii's equable temperatures are associated with the small seasonal variation in the amount of energy received from the sun and the tempering effect of the surrounding ocean. The range of temperature averages only 7 degrees between the warmest months (August and September) and the coolest months (January and February) and about 12 degrees between day and night. Daily maximums run from the high 70's in winter to the mid-80's in summer, and daily minimums from the mid-60's to the low 70's. However, the Honolulu Airport area has recorded as high as 93 degrees and as low as 53° [11].

Based on historical records from the National Weather Service at Honolulu International Airport and the U.S. Navy at Barbers Point Naval Air Station, rainfall in the project area averages about 20 inches per year [11,12]. In accordance with Thornwaite's scheme for climatic classification, the area is considered a semiarid steppe [13].

4.2 Surface Winds. Meteorological records were reviewed from the Honolulu International Airport and Hickam Air Force Base (AFB). It is quite evident that northeast tradewinds predominate during much of the year (Table 6). A closer examination of the data, however, indicates that low velocities (less than 10 mph) occur frequently and that the "normal" northeasterly tradewinds tend to breakdown in the Fall giving way to more light, variable wind conditions through the Winter and on into early Spring. It is during these times that Honolulu generally experiences elevated pollutant levels. This seasonal difference in wind conditions can be seen clearly in Figures 11 and 12.

Of particular interest from an air pollution standpoint were the stability wind roses prepared for the period January 1955 to December 1968 at Hickam Air Force Base [14]. These data indicated that stable conditions, i.e., Pasquill-Gifford stability categories E and F [15], occur about 28% of the time. It is under such conditions that the greatest potential for air pollutant buildup from groundlevel sources exists.

5. HIGHWAYS AND TRAFFIC

As noted previously the principal access road to the project site is Fort Weaver Road which exists as a 4-lane divided highway from its intersection with Farrington Highway south to Hanakahi Road. From that point southward to Ewa Beach, it is a 2-lane rural roadway currently undergoing widening to four lanes. Current speed limits are 45 mph from Farrington Highway to the Geiger Road intersection, 35 mph from Geiger to Hanakahi Street, and 25 mph from Hanakahi to Ewa Beach. Refer to Figure 2 for a depiction of the current road configuration north of Hanakahi Street.

At the Farrington Highway Intersection, Fort Weaver Road becomes Kunia Road and extends northward to the major interchange with the H-1 Freeway and thence north to Wahiawa. The speed limit is 45 mph on Kunia Road to the Kunia Interchange and is 55 mph on the H-1 Freeway.

The traffic data provided by Pacific Planning & Engineering, Inc. [10] focused on the Fort Weaver Road south of Geiger Road. Traffic data from that study and State Department of Transportation (DOT) counts [16] indicated a.m. and p.m. peak hours in the 5:30 - 7:30 a.m. and 3:30 - 5:00 p.m. range, respectively. Traffic counts made in conjunction with the air sampling conducted for this project were generally consistent with those data. Projections for future traffic volumes were taken from the Pacific Planning & Engineering, Inc. data.

6. MOBILE SOURCE IMPACT

6.1 Emission Factors. Automotive emission factors for carbon monoxide (CO) were generated for calendar years 1991 and 2009 using the Mobile Source Emissions Model (MOBILE-3) [17]. To localize emission factors as much as possible, the August, 1988 age distribution for the City & County of Honolulu [18] was input in lieu of the national statistics normally used.

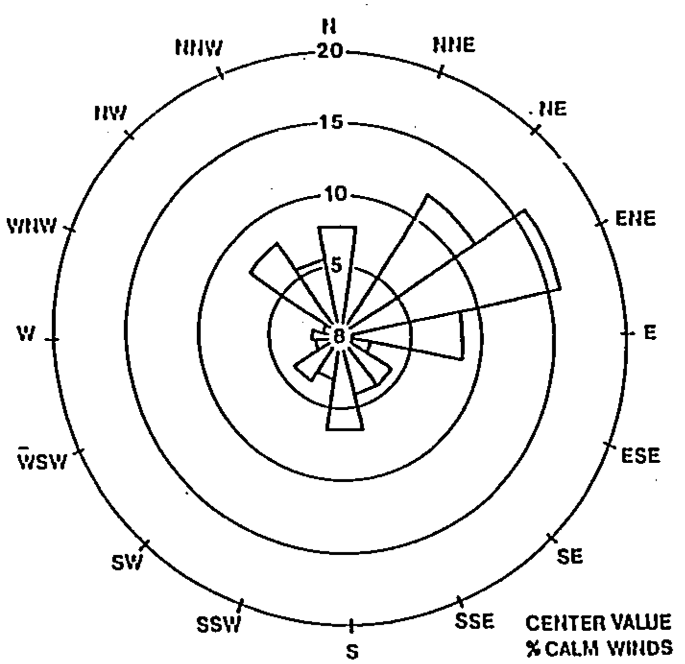
6.2 Microscale Analysis. Analyses such as this generally involve estimation of concentrations

TABLE 6
HONOLULU INTERNATIONAL AIRPORT
ANNUAL WIND ROSE

	Wind Speed (Kts)						
Direction	0 - 3	4 - 7	8 - 12	13 - 18	19-24	≥24	TOTAL
N	0.0149	0.0261	0.0075	0.0020	0.0002	0.0000	0.0506
NNE	0.0114	0.0219	0.0106	0.0046	0.0005	0.0000	0.0490
NE	0.0114	0.0449	0.0829	0.0853	0.0204	0.0018	0.2466
ENE	0.0088	0.0637	0.1559	0.1209	0.0224	0.0014	0.3731
E	0.0039	0.0179	0.0329	0.0210	0.0023	0.0001	0.0782
ESE	0.0021	0.0056	0.0050	0.0015	0.0003	0.0001	0.0146
SE	0.0021	0.0059	0.0091	0.0049	0.0006	0.0002	0.0228
SSE	0.0023	0.0074	0.0123	0.0038	0.0008	0.0002	0.0268
S	0.0025	0.0104	0.0127	0.0033	0.0005	0.0003	0.0296
SSW	0.0011	0.0041	0.0053	0.0017	0.0003	0.0000	0.0125
SW	0.0007	0.0031	0.0058	0.0022	0.0003	0.0001	0.0122
WSW	0.0006	0.0017	0.0031	0.0022	0.0005	0.0001	0.0082
W	0.0019	0.0030	0.0021	0.0009	0.0002	0.0001	0.0082
WNW	0.0027	0.0051	0.0012	0.0003	0.0001	0.0000	0.0094
NW	0.0084	0.0153	0.0031	0.0008	0.0003	0.0000	0.0279
NNW	0.0087	0.0166	0.0041	0.0012	0.0002	0.0000	0.0308
TOTAL:	0.0835	0.2527	0.3534	0.2567	0.0496	0.0043	1.0002

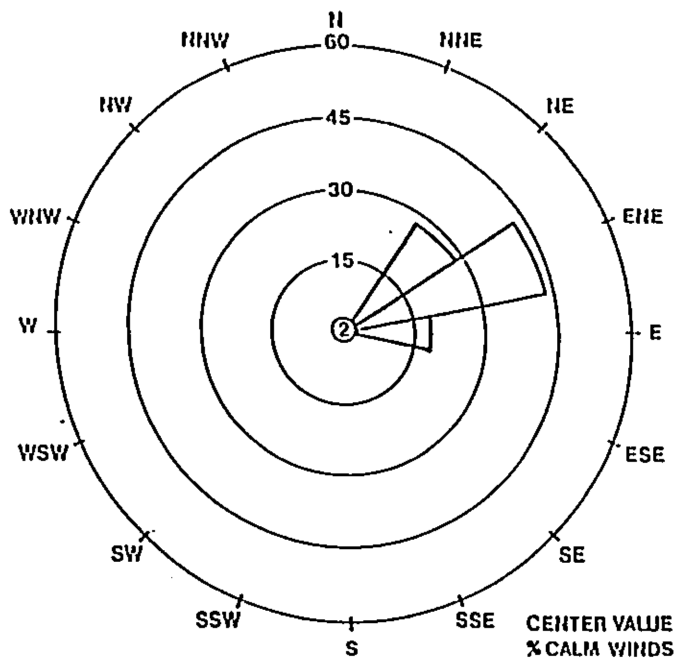
SOURCE: National Weather Service, Honolulu

FIGURE 11
JANUARY WIND ROSE
HONOLULU INTERNATIONAL AIRPORT



SOURCE: National Weather Service, Honolulu (1940-67)

FIGURE 12
AUGUST WIND ROSE
HONOLULU INTERNATIONAL AIRPORT

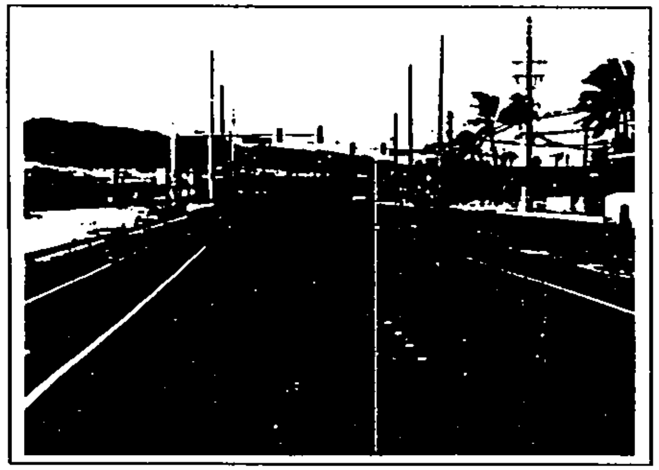


SOURCE: National Weather Service, Honolulu (1940-67) of non-reactive pollutants. This is due to the complexity of modeling pollutants which undergo chemical reactions in the atmosphere and are subject to the effects of numerous physical and chemical factors which affect reaction rates and products. For projects involving motor vehicles as the principal air air pollution source, carbon monoxide is normally selected for modeling because it has a relatively long half-life in the atmosphere (about 1 month) [19], and it comprises the largest fraction of automotive emissions.

In this instance, a microscale screening analysis was performed for the Fort Weaver Road intersections with proposed Access Roads "A" and "B". This is the same segment of Fort Weaver Road that the traffic analysis focused on, and its current configuration is depicted in Figure 13. The updated version of an EPA guideline model CALINE-4 [20,21] was employed with an array of receptors spaced at distances of 10 - 30 meters from the road edge. Because of the growing level of urbanization and traffic in the area, a background CO concentration of 1.0 milligram per cubic meter (mg/m^3) was assumed.

Worst case meteorological conditions were selected for the a.m. and p.m. peak traffic hours. A wind speed of 1 meter per second, an acute wind/road angle, stable atmosphere (Pasquill-Gifford Class "F") in the a.m. and neutral atmosphere (Pasquill-Gifford Class "D")

FIGURE 13
FORT WEAVER ROAD IN THE VICINITY OF PROPOSED ACCESS ROADS "A" AND "B"



[15] in the p.m., were all selected to maximize concentration estimates in the vicinity of the intersections. Review of the traffic data and preliminary modeling indicated that northeasterly winds were most likely to produce the maximum CO concentrations near the intersections under study; thus, these wind directions were input for the modeling.

Maximum one-hour carbon monoxide (CO) concentrations were then computed for the peak traffic hours. The analyses were performed for existing conditions (1991) and future conditions (2009) both with and without the proposed project. The results are summarized in Figures 14 and 15.

7. OFF-SITE STATIONARY SOURCE IMPACT

7.1 Electrical Generation. The estimated 44.5 million kilowatt hours of annual electrical demand by full buildout of the proposed facilities will necessitate the generation of electricity by power plants. Currently, most of Oahu's electrical energy is generated at Hawaiian Electric Company's (HECO) Kahe Generating Station located near Nanakuli on the leeward coast of Oahu. This is currently a six-unit, approximately 650-megawatt facility firing low-sulfur fuel oil. A seventh 150-megawatt unit was proposed by HECO [22], but two out-of-state companies proposed and have since built a gas turbine and coal-fired power plant at Campbell Industrial Park to sell power to the utility [23]. For the purposes of this analysis, oil-firing was assumed. Estimates of annual emissions were computed based on EPA emission factors and the fuel required to meet a 44.5 million Kwhr demand. The results are presented in Table 7.

7.2 Solid Waste Disposal. The refuse generated by the thousands of occupants of the residential, hotel and condominium units as well as the commercial establishments in Ewa Marina will require disposal. Presently, about 80% of Oahu's refuse is being landfilled with the remaining 20% being burned at the Waipahu Incinerator [24]. With the recent opening of the City's new resource recovery facility (HPOWER) at Campbell Industrial Park, most refuse will be pre-processed and burned leaving less mass to be landfilled. This facility was originally designed to handle most of Oahu's domestic refuse (1,800 tons/day). Estimates of annual emissions attributable to the combustion of Ewa Marina I/II refuse at that facility are included in Table 7.

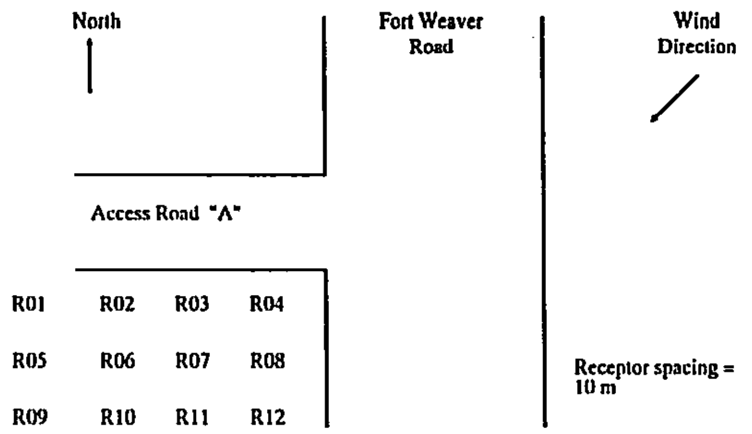
TABLE 7
Estimates of Annual Emissions Due to Electrical Generation and Solid Waste Disposal
Year 2009

	Emissions (T/yr)	
Pollutant	Electrical Generation	Solid Waste Disposal
Nitrogen oxides	165	22
Sulfur oxides	125	4.4
Particulate Matter	12.6	1.8
Carbon monoxide	7.8	19
Volatile Organics	1.6	1.1

8. OTHER LONG-TERM IMPACTS

8.1 Agricultural Burning. Burning of sugar cane fields prior to harvest is a long-standing practice in Hawaii's sugar industry. Unfortunately, however, as urbanization closes in around agricultural operations, it is inevitable that complaints about air pollution will arise.

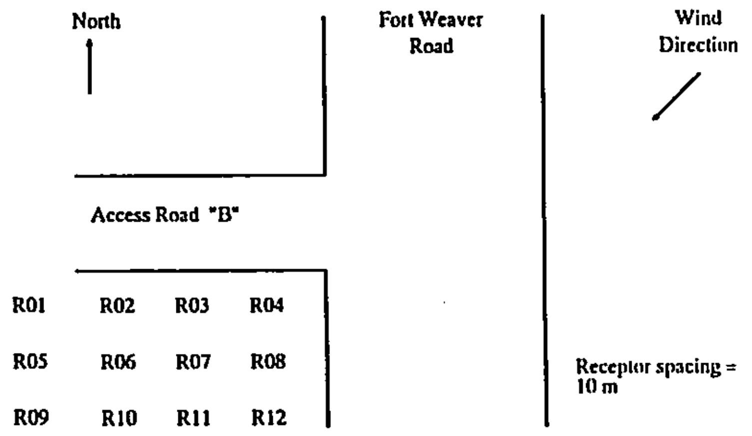
FIGURE 14
ESTIMATES OF MAXIMUM 1-HOUR
CARBON MONOXIDE CONCENTRATIONS
Fort Weaver Road at Access Road "A"
Peak Traffic Hours
1991 - 2009



Receptor	A.M. 1991	A.M. 2009 w/o	A.M. 2009 w/proj	P.M. 1991	P.M. 2009 w/o	P.M. 2009 w/proj
R01	2.1	4.7	6.4	2.1	5.0	5.2
R02	2.2	6.4	8.8	2.2	6.7	7.1
R03	2.4	8.5	11.9	2.4	9.0	9.5
R04	2.8	7.2	9.3	3.1	7.5	8.1
R05	2.1	4.9	6.5	2.1	4.9	5.1
R06	2.2	5.4	7.0	2.2	5.4	5.7
R07	2.4	4.9	6.0	2.4	4.9	5.2
R08	2.8	3.9	4.3	3.1	4.0	4.2
R09	2.1	4.1	5.1	2.1	4.0	4.2
R10	2.2	3.9	4.7	2.2	3.8	4.0
R11	2.4	3.5	3.9	2.4	3.4	3.6
R12	2.8	3.5	3.8	3.1	3.5	3.9

Concentration (ug/m^3)

FIGURE 15
ESTIMATES OF MAXIMUM 1-HOUR
CARBON MONOXIDE CONCENTRATIONS
Fort Weaver Road at Access Road "B"
Peak Traffic Hours
1991 - 2009



Receptor	A.M. 1991	A.M. 2009 w/o	A.M. 2009 w/proj	P.M. 1991	P.M. 2009 w/o	P.M. 2009 w/proj
R01	1.9	3.1	4.7	1.8	2.7	4.0
R02	1.9	3.9	6.3	1.9	3.2	5.0
R03	2.2	4.9	8.1	2.2	3.8	6.5
R04	2.5	5.1	6.7	2.6	3.9	5.9
R05	1.9	3.3	4.8	1.8	2.7	3.9
R06	1.9	3.8	5.2	1.9	3.0	4.3
R07	2.2	3.9	4.7	2.2	3.1	4.1
R08	2.5	3.9	3.9	2.6	3.2	3.9
R09	1.9	3.2	4.0	1.8	2.5	3.4
R10	1.9	3.3	3.9	1.9	2.6	3.3
R11	2.2	3.3	3.5	2.2	2.7	3.3
R12	2.5	3.5	3.6	2.6	3.2	3.6

Concentration (ug/m^3)

Cane fires result in the emission of particulates, carbon monoxide, and trace amounts of other organics. This was most recently demonstrated in an EPA study of cane burning on Maui [25]. Concentrations of particulates can reach high levels within about one mile of the fires [26]. A complete quantitative characterization of cane smoke, however, has yet to be performed. Fortunately, fires are generally infrequent and only last about 20 - 30 minutes.

8.2 Campbell Industrial Park. The industrial sources at Campbell Industrial Park obviously affect air quality in the Ewa area. The maximum concentrations of total suspended particulates (TSP) and sulfur dioxide, however, are in compliance with existing federal and state air quality standards. Neither monitoring nor computer modeling show violations of the current standards. Historically, there has been a problem meeting the State's TSP standard, and even with adoption of the less stringent federal standards, this may continue to be a problem as levels in the past have on occasion even exceeded those standards. As noted in Section 2, the state and federal particulate standards are once again different and while recent monitoring data indicate that the federal PM_{10} standard is being met, the state TSP standard continues to be threatened. SO_2 standards are being gradually approached as new sources come in and existing sources expand. The impending completion of the City's resource recovery facility and the future construction of a gas turbine and coal-fired power plant as well as other as yet unidentified sources in the industrial park will all contribute additional increments of regulated and unregulated pollutants to the Ewa air. The responsible government agencies will have to watch the situation closely to insure that standards continue to be complied with.

8.3 Pesticide Use. The use of pesticides is routinely required at golf courses in order to maintain fairways and greens. Typical pesticide use at a 27-hole golf course was obtained from another report previously prepared for this project [27].

The herbicides MSMA, glyphosate, metribuzin, and bensulide all have relatively low mammalian toxicities with oral LD_{50} values on the order of hundreds or thousands of milligrams active agent per kilogram body weight (mg/kg) [28, 29]. MSMA and metribuzin have OSHA air standards of 0.5 $mg/^3$ and 5 $mg/^3$, respectively [29]. These are 8-hour time-weighted averages.

The insecticide chlorpyrifos is a moderately toxic organophosphate which can affect the normal functioning of mammalian nervous systems through its inhibition of the enzyme cholinesterase. It has oral LD_{50} values in the range of 60 - 82 mg/kg. The OSHA standard for airborne concentrations of chlorpyrifos is 0.2 mg/m^3 as an 8-hour average [29].

The fungicides metalaxyl and chlorothalonil have relatively low acute toxicities with oral LD_{50} values in the hundreds and thousands of mg/kg [29]. Chlorothalonil, however, has also demonstrated some carcinogenic potential in animals [29].

If properly used in accordance with label instructions, all of the aforementioned chemicals should present no hazard to the properties or owners of properties adjoining the proposed golf course. In fact, the greatest risk in using such chemicals is generally to the users themselves if they do not strictly follow label instructions. This is because the user may

come in contact with the concentrated product while nearby properties and people may only be exposed to the greatly diluted and dispersed application solution.

The potential for significant airborne concentrations of these chemicals is relatively slight when one considers the dilution factor in application solutions plus the coarse spray that is normally used to assure adequate coverage in the desired area and avoidance of drift. Should a user improperly apply these chemicals under wind conditions which would contribute to drift, then there would be an increased possibility of downwind exposure of property and people. In order to assess the possible impact of such an event on people, a dispersion modeling analysis was performed for each of the chemicals. The results of this modeling are summarized in Table 8.

TABLE 8
ESTIMATES OF DOWNWIND PESTICIDE CONCENTRATIONS

Product	Active Agent Concentration
MSMA	10 ug/m^3
Bensulide	63
Trimec	5
Metribuzin	4
Glyphosate	8
Chlorpyrifos	5
Metalaxyl	7
Chlorothalonil	42

Conditions:

Windspeed:	4.5 m/sec
Stability category:	D (neutral)
Downwind distance:	100 m
Exposure duration:	5 - 10 minutes
Treated area:	1 acre
Application height:	0.5 m
Active agent drift:	0.4%

9. CONSTRUCTION IMPACT

The principal source of short-term air quality impact will be construction activity. Construction vehicle activity will increase automotive pollutant concentrations along the principal access roads as well as in the vicinity of the project site itself. During off-peak hours, 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 thereby contributing to additional air pollution emissions.

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 precipitation/evaporation (P/E) index of 50 [30].

Since a significant fraction of the onsite soils were silty clay loams, in all probability having silt content comparable to the 30% cited above, and the computed P/E Index for the area is 24 implying drier conditions than in the EPA case, it may be assumed that there is a potential for fugitive dust problems. In addition to the onsite impacts attributable to construction activity, there will also be offsite impacts due to the operation of concrete batching plants needed for construction. Since it is also too early to identify specific facilities that will be providing the concrete, the discussion of air quality impacts is necessarily generic.

Design and operating features of a typical concrete batching plant were obtained for this analysis. This plant (Rex Transit Mix Batch Plant, Model LO GO 5) [31], is a portable unit capable of producing up to 100 cubic yards of concrete per hour.

Assuming 8 hours/day operation and published EPA emission factors [30] for both direct plant emissions and fugitive dust emissions, estimates of worst case ambient impact were derived using the PTPLU screening model [32]. Ninety percent control of particulate emissions from the plant itself and 60% control of fugitive dust emissions from the process were assumed. One-hour concentration estimates were adjusted to 8-hour averages using an EPA-recommended factor [33] and then to 24-hour averages based on a weighted averaging technique. The worst case concentration of total suspended particulates (TSP) was thus estimated to be 105 micrograms/cubic meter (ug/m^3) due to the plant operation.

Since it is not known where exactly the plant(s) will be located and thus what the background concentration of TSP will be, it is somewhat difficult to predict cumulative concentrations for comparison with standards. However, if the batch plant's 105 ug/m^3 were assumed to be all <10 microns and were added to the second highest 24-hour PM_{10} concentration (48 ug/m^3) from the 1990 DOH Barbers Point data, the sum would exceed the federal 24-hour standard of 150 ug/m^3.

10. DISCUSSION OF RESULTS

10.1 Microscale Analysis. The 1-hour "worst case" concentration estimates at both the proposed Access Road "A" and "B" intersections with Fort Weaver Road (Figures 14 and 15) generally indicated compliance with federal and state 1-hour CO standards under both current and projected peak traffic conditions. Only one possible exceedance of the State's 1-hour standard was predicted within 10 meters of the Access "A" intersection during the a.m. peak hour in 2009. The general trend is towards increasing CO levels despite the effect of lower new vehicle emissions resulting from the federal motor vehicle emissions control program. This is due primarily to the change from a free-flow road segment to an intersection with some queuing at approachs. The difference between the "with" and "without" project scenarios is in the range of 0 - 72% with the "with project" scenario showing the higher CO levels during peak hours.

Compliance with the federal and state 8-hour standards can also be determined by applying an EPA-recommended "persistence" factor of 0.6 to the 1-hour maximum CO values [34]. When using this approach, any CO concentration greater than 8.4 mg/^{3} would indicate exceedance of the State's 8-hour standard. Similarly, any 1-hour concentration over 15.7 mg/^{3} would indicate exceedance of the federal 8-hour standard. In this case, the results indicate possible exceedances of the state 8-hour standards within close proximity (<10 meters) to the Access "A" intersection. These predictions occurred both during a.m. and p.m. peak hours in 2009 with or without the project.

10.2 Stationary Source Impacts. The emissions estimates for electrical generation and solid waste disposal may be compared to the latest available county emissions inventory in Table 9 in order to provide some perspective on their significance. The project's contribution to county emissions appears to be less than 0.5%.

AIR QUALITY IMPACT REPORT
EWA MARINA PHASE I (INCREMENT 2) AND PHASE II
December 31, 1991

TABLE 9
1980 EMISSIONS INVENTORY
CITY & COUNTY OF HONOLULU

SOURCE CATEGORY	EMISSIONS (Tons/Year) PM	SOx	NOx	CO	HC
Steam Electric Power Plants	2092	36,736	12,455	1,065	18
Gas Utilities	14	0	199	0	0
Fuel Combustion in Agricultural Industry	1088	579	358	0	31
Refinery Industry	622	7,096	2,149	266	2,584
Petroleum Storage	0	0	0	0	1,261
Metallurgical Industries	28	96	40	0	0
Mineral Products Industry	6,884	1,883	597	0	31
Municipal Incineration	42	145	2,029	0	184
Motor Vehicles	1,413	1,014	17,270	239,198	22,853
Construction, Farm and Industrial Vehicles	184	193	2,507	3,729	338
Aircraft	382	145	1,751	5,594	1,476
Vessels	42	386	438	533	123
Agricultural Field Burning	1,399	0	0	15,982	1,692
TOTAL:	14,191	48,274	39,792	266,367	30,758

SOURCE: State Department of Health

10.3 Other Long-Term Impacts. As noted in Section 8, there will be at times exposure to the smoke from agricultural field burning. Until urbanization entirely replaces sugar cane cultivation in the Ewa District, this will result in some human exposure and complaints about cane fire smoke. The State Department of Health and federal EPA have indicated that they are continuing efforts to better characterize the exposure and potential health effects [35]. Depending on the results of those efforts, the smoke exposure may be reduced or eliminated before cane cultivation ceases in Ewa.

In the case of industrial air pollution sources at Campbell Industrial Park, the likelihood of those sources significantly affecting Ewa Marina seems rather low given the distance (about 5 miles) and low frequency of winds which would carry source emissions toward the development. A screening of the 1967-71 wind data from Barbers Point indicated that winds heading from the industrial park towards Ewa Marina occurred about 1% of the time.

The estimated downwind pesticide concentrations presented in Table 8 indicate the level of human exposure possible under adverse conditions of high wind speed and proximity to the source. Downwind pesticide concentration estimates were low (microgram quantities versus the miligram quantities in toxic effects studies) and of short duration (5 - 10 minutes per acre treated upwind). Because of the number of variables, e.g., nozzle pressure, spray height, spray volumes, wind speed, etc, these estimates have an error factor of 2 to 3. True concentrations could be up to 3 times greater or 1/3 as much. In either case, the concentrations and duration of exposure suggest low risk. Only in the case of a carcinogen might there be some basis for questioning the "acceptability" of the concentration.

10.4 Short-Term Impact. Since as noted in Section 9, there is a 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. 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 soonest possible landscaping of completed areas will also help. Use of dust screens may be necessary when excavation and other construction activities occurr in close proximity to existing dwellings.

11. Conclusions and Mitigation

11.1 Conclusions. Based on the foregoing analysis, the following conclusions may be drawn:

- o Traffic generated by the proposed project will contribute to reduced air quality along the major roadways serving the area. Federal air quality standards will be met, but the state's carbon monoxide standards may be exceeded in close-proximity (<10 meters) to the Access Road "A" intersection with Fort Weaver Road.
- o Electrical demand and solid waste disposal resulting from the project will cause an increase in county emissions amounting to less than 0.5%.
- o Project residents may at times be affected by emissions from the surrounding environment, specifically: agricultural field burning which should decline as urbanization replaces agriculture in Ewa; Campbell Industrial Park which has a low probablity to due prevailing wind directions; and pesticide use which should be minimal if label instructions are complied with.
- o Construction activities will have a short-term impact on local air quality due to the additional construction vehicle activity and fugitive dust from construction activities.

11.2 Mitigation

11.2.1 Motor vehicle activity: The types of measures that could help reduce the predicted traffic-related adverse impacts include:

- o additional highway improvements to increase capacity o development and use of a mass transit system
- o increased bus service to the project area
- o encouragement of car-pooling
- o limited parking facilities to encourage use of public transportation
- o development of employment opportunities near Ewa Marina
- o implementation of an inspection/ maintenance (I/M) program to reduce individual motor vehicle emissions

While many of these measures would have to be initiated by government, the project developer can encourage such initiatives as well as implement those measures within his own capability.

11.2.2 Electrical generation: Measures that will reduce offsite emissions at electrical power plants and save energy include the following recommendations of the State Department of Business, Economic Development and Tourism:

- o east/west orientation of streets for the long dimensions of houses to minimize heat gains in the morning and afternoon.
- o adequate system of walkways and bikeways to encourage walking and bicycling between home, school, park and commercial areas.
- o selection and placement of landscape materials to provide shading for minimization of heat gains in the morning and afternoon.
- o maximize shading of paved areas by trees, awnings, trellises, roofing or houses.
- o use drought-resistant plants for landscaping to reduce energy use associated with irrigation.
- o install operable windows and orient opening towards prevailing winds
- o install eves (minimum 30 inches), louvers, trellises, or shade screen to shade windows, especially on west, south, and east sides
- o include attics ventilated by devices such as louvers at or near the roof ridge
- o include radiant barriers in attics

- o use light colored finishes on roofs and walls
- o install heat pump water heaters, or
- o install solar water heaters or provide for future installation by pre-plumbing and pre-wiring
- o install the most energy efficient appliances
- o install ceiling fans or provide for future installation by pre-wiring
- o install time switches to high-usage applications or equipment such as electric water heaters
- o install fluorescent lights with high efficiency ballasts

11.2.3 Solid waste disposal: The following measures will help reduce emissions resulting from burning of solid wastes:

- o provide a recycling program for the project
- o provide a composting facility for the project

11.2.4 Pesticide use at golf course: The following measures will help reduce any possible air quality impacts associated with pesticide use:

- o full compliance with label use instructions
- o use of integrated pest control measures
- o minimize pesticide use
- o maximize use of non-chemical pest control measures
- o use of low-toxicity/nonpersistent chemicals

11.2.5 Construction impacts: The following measures will help reduce the short-term impacts associated with construction activities:

- o compliance with state/county dust control requirements
- o covers for open trucks transporting dusty materials
- o frequent watering of exposed soil areas
- o soonest possible landscaping of exposed soil areas
- o concrete and asphalt plants in compliance with DOH permits

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Appendix D

Environmental Noise Impact Assessment

D.L. ADAMS ASSOCIATES, LTD
dba
DARBY
& ASSOCIATES
ACOUSTICAL CONSULTANTS

#92-09
March 17, 1992

Mr. Paul Jordan
HASEKO (Ewa) Inc.
820 Mililani St., Suite 610
Honolulu, Hawaii, 96813

<u>RE: Aircraft Noise Impact Assessment - Ewa Marina Phase I, Increment 2
Ewa Beach, Oahu</u>

Dear Mr. Jordan:

We have reviewed the proposed site layout for the Ewa Marina Development, Phase 1, Increment 2. In order to assess the potential aircraft noise impact at the project site, we have assimilated, and presented herein, various noise regulations, noise studies and measurements that have been conducted within the last few years.

1. GENERAL

The existing acoustical environment at the project is dominated by aircraft flight activities associated with the Naval Air Station Barbers Point (NASBP) and Honolulu International Airport (HNL).

Noise generated by touch-and-go activities, which overfly the project site, dominate the overall noise from aircraft associated with the NASBP. Flight activities at the HNL which affect the project site comprise civilian and military aircraft approaching to land on Runway 08L.

2. NOISE REGULATIONS AND GUIDELINES

Noise regulations set forth by the U.S. Environmental Protections Agency (EPA), and Department of Housing and Urban Development (HUD) specify 65 dBA Day-Night Average Sound Level (Ldn) as a maximum allowable level for residential and other noise sensitive areas. The State Department of Transportation (DOT) sets a more stringent

guideline of 60 dBA Ldn for aircraft noise. See Table I-A. HUD also has a design goal of 45 dBA for the interior spaces of dwellings.

The Land Use Compatibility Tables prepared by the Department of Defense (DOD) and the FAA Part 150 Program provide for unconditional compatibility for residential land use below 65 dBA Ldn. The Land Use

Compatibility Tables also address commercial, public and industrial land use guidelines.

3. NOISE STUDIES

The following noise surveys presented herein are, to our knowledge, the most recent data obtained for the project site in question. The data serves to assess the impact on the various zoning uses under this development phase.

A. In Figure 1 we have superimposed the Ldn contours from the 1987 Noise Exposure Map (Reference 1) for operations conducted at Honolulu International Airport (HNL) onto the project site plan. These contours have been approved by the FAA Part 150 Program in a letter to DOT dated October 15, 1991.

B. In Figure 2 we have superimposed the AICUZ Ldn contours (Reference 2) on the project site plan. The figure presents Ldn contours that include a projected 10.7 percent increase in the annual level of operations relative to a Base Year (1987) without the TACAMO activity.

C. Figure 3 presents the Ldn curves from the combined operations from NASBP and HNL. The Ldn curves superimposed on the site plan in Figure 3 represent mean year operations without the TACAMO activity at NASBP (Reference 2) and with landings on runway 08L at HNL based on Reference 1.

D. The above noise studies were also used in our report on Ewa Marina Phase II dated January 19, 1991 (Reference 3). In this study we also evaluated single event noise levels (SEL and Lmax) associated with aircraft operating on the flight tracks shown in Figure 4 for NASBP and HNL. A total of 239 aircraft noise events were measured at the locations shown in Figure 5. Note that these measured noise levels are also applicable to Phase I, Increment 2, specifically: (a.) noise measurement locations 1 through 6 are applicable to the various non-residential land uses in Phase I, Increment 2 below the north-south flight tracks from NASBP; and (b.) noise measurement locations 9 and 10 yielded worst case single event noise levels for residential housing affected by flight tracks 17 through 20 to HNL.

4. ASSESSMENT OF POTENTIAL AIRCRAFT NOISE IMPACT

4.1 Residential Land Use

Based on the Ldn contours shown in Figures 1 through 3, the majority of the Residential areas are outside the Ldn 60 contour. The noise contours indicate that the aircraft noise impact is primarily due to operations at NASBP. All areas designated as Low Density Multi-Family Residential and Single Family Residential (SFR) and the Medium Density Multi-Family (MDMFR) area abutting Phase II are clearly outside of Ldn 60. The noise exposure for these areas complies with all referenced guidelines, including the more stringent guideline set forth by the DOT without implementing noise mitigation measures.

From Figures 2 and 3, it can be seen that some of the MDMFR units along the Marina are on the Ldn 60 contour. Though these residential units would satisfy all Federal criteria, they will require noise mitigation measures to comply with the DOT guideline. Thus, it is recommended that the medium density structures facing the Marina, which would be impacted Ldn 60 or greater, be designed with airconditioning (rather than be naturally ventilated) so noise sensitive occupants can close doors and windows during noisy operations from NASBP.

In summary, all areas for Phase I, Increment 2 zoned for Residential use comply with all Guidelines and Regulations pertaining to aircraft noise impact if noise mitigation measures are implemented in the MDMFR Units facing the Marina which may experience Ldn 60 or greater.

4.2 Commercial Land Use

Based on the Ldn contours shown in Figures 2 and 3, this area intersects Ldn contours 60 and 65, therefore, the Commercial land use area lies within the Ldn 55 to 70 range. The noise contours in this area represent noise emanating from NASBP operations and are not affected by HNL's operations.

As presented in enclosed Table IA from Reference 4, Commercial land use (e.g., retail trade, restaurants, shopping centers) is unconditionally compatible below Ldn 65. Commercial structures within Ldn 65 to 70 may require construction modifications to afford the required noise level

reduction (NLR) for noise sensitive spaces as defined in Notes for Table IA. The DOD table allows unconditional Commercial land use compatibility up to Ldn 69. At Ldn 70 to 74 an NLR 25 is required for the building envelope.

In the Commercial area inside the Ldn 60 contour, consideration should be given to the fact that the Ldn values are the result of a few noisy operations from NASBP, e.g. discussed below in an extract from the Phase II study (Reference 3):

> "The measurement results indicate that noise levels generated by KC-135 and F-15 aircraft on a touch-and-go pattern BP-04RT6 are the most severe with Lmax and SEL levels reaching as high as 104 and 108 dBA, respectively. According to the flight operation information provided in the AICUZ, the daily annual average for such an event is about 3.4 for the KC-135 and about 1.8 for the F-15. It should be noted that these numbers are obtained by dividing the total annual operations by the number of days in a year and, therefore, they are by no means representative of typical daily operations. It has been our experience that, for military bases, the flight activity patterns are extremely sporadic. That is, there could be several days or even weeks during which certain flights do not occur. On the other hand, there can be a small number of days on which there are extremely high levels of activity. Thus, on the relatively small number of occasions when KC-135 and F-15 aircraft perform the flight pattern described above, the noise impact at the mixed use site would be severe."

Thus, not only should offices, stores, financial institutions, etc. be closed and air conditioned with conventional fixed plate glass windows and insulation in the walls, but any "outdoor" facilities, e.g., restaurants, bars, shops, etc. should be designed for temporary closure and ventilation or air conditioning when noisy aircraft events do occur.

In summary, the designated Commercial land use areas comply with all regulations and guidelines pertaining to aircraft noise; however, noise sensitive buildings (e.g., offices, retail, restaurants) should incorporate standard NLR construction. It is also recommended that special consideration be made to open-air facilities (e.g., restaurants) in regard to aircraft noise interrupting conversation and other activities.

4.3 Preservation Land Use

The various Preservation areas (PRES) designated in the site plan are located in three general areas ranging from Ldn<55 located on the eastern side of the development, to Ldn 65 to 70 located on the western side.

Areas zoned as Preservation in local noise ordinances typically follow requirements set forth for residential land use (i.e., 45 dBA daytime noise limit, 55 dBA nighttime limit). It could be interpreted that the Ldn guidelines for Preservation would also fall under the residential guidelines. However, it is our understanding that these areas were located in the development to provide visual and auditory buffer zones and were designated as such to prevent future development on these buffer zones; thereby preserving the intended function.

The uses and structures permitted in Preservation areas which possibly may occur in this project are: aquaculture, public uses, recreational facilities, and utility installations. These land uses are addressed in Table IA which states land use compatibility up to Ldn 70.

In summary, the areas designated for Preservation land use is considered compatible with all aircraft noise guidelines and regulations.

4.4 Marina Support Land Use

The Marina Support areas (MS) designated in the site plan are located within Ldn 60 to 70. Since Marina Support land uses would typically include Commercial use, as well as less noise sensitive boat repair and maintenance facilities, this designation is, therefore, similar in scope to that of Commercial use discussed above. It is understood that living aboard boats in the marina will not be allowed.

In summary, the designated Marine Support use areas comply with all regulations and guidelines pertaining to aircraft noise, however, noise sensitive buildings (e.g., offices, retail, restaurants) should incorporate NLR construction.

5. SUMMARY

All areas in Ewa Marina, Phase I, Increment 2, are in compliance with guidelines and regulations pertaining to aircraft noise impact if the MDMFR units facing the Marina (which may experience Ldn 60 or greater) are capable of being closed and airconditioned. Also,

structures containing noise sensitive activities in the zones designated for Commercial and Marine Support land uses should incorporate noise mitigating construction.

This concludes our draft version of the environmental noise impact review for the Ewa Marina, Phase I, Increment 2. Please call if you have any questions or comments.

Sincerely,

Ronald A. Darby, P.E.

MBB/RAD.21t

Encl.

REFERENCES

1. Existing (1987) Noise Exposure Map Showing Non-Compatible 1985 Land Use & Noise Sensitive Public Buildings, Fig. 4-5, Honolulu International Airport Master Plan Update and Noise Compatibility Program, Prepared by KFC Airport, Inc., for State of Hawaii Department of Transportation Airports Division, December 1989.

2. Naval Air Station Barbers Point Air Installation Compatible use Zone (AICUZ) Noise Contours and Supporting Data, Prepared by Harris Miller Miller & Hanson, Inc., July 1989

3. "Environmental Noise Impact Assessment, Ewa Marina Phase II, Ewa Beach, Oahu," Prepared by Darby & Associates to HASEKO (HAWAII), Inc., January 19, 1991

4. "Study Recommendations for Local Land Use Compatibility with Yearly Day-Night Average Sound Levels", Received from Department of Transportation, Airports Division, Honolulu, Hawaii, July 31, 1991

NOISE CRITERIA AND GUIDELINES

1. "Towards a national Strategy for Noise Control", U.S. Environmental Protection Agency, April 1977.

2. "HUD Environmental Criteria and Standards," Department of Housing & Urban Development, Federal Register, Vol. 44, No 135, July 12, 1979. amended 49 FR 880, January 6, 1984.

3. "Noise Control and Compatibility Planning for Airports," Federal Aviation Administration, August 5, 1983.

4. "Guidelines for Considering Noise in Land Use Planning and Control," Federal Ineragency Committee on Urban Noise, June 1980.

5. "Environmental Protection-Planning in the Noise Environment," Department of the Air Force, the Army, and the Navy, June 15, 1978.

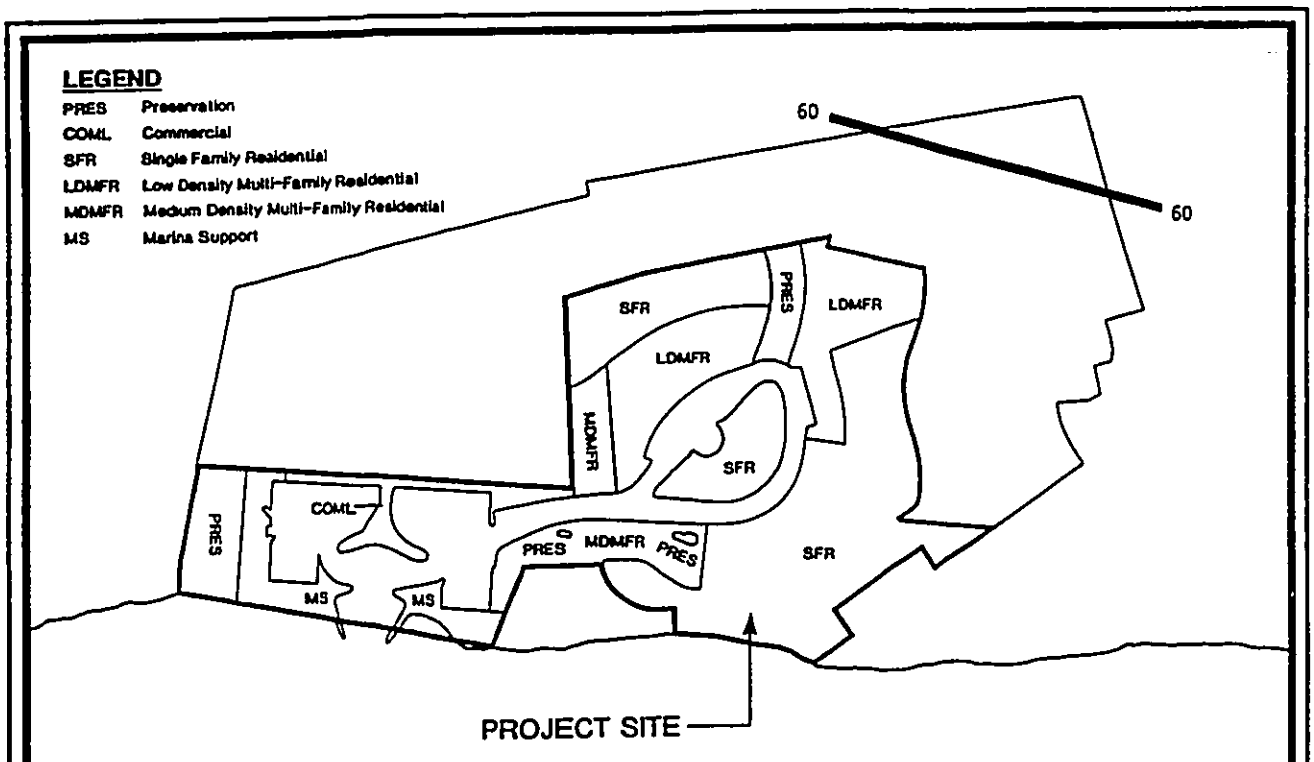
6. American National Standard for Sound Level Descriptors for Determination of Compatible Land Use, American National Standards, ANSI S3.,23-1980, May 30, 1980.

7. "Chapter 43 - Community Noise Control for Oahu," Department of Health, State of Hawaii, Administrative Rules, Title 11, 1981.

TABLE 1A

STUDY RECOMMENDATIONS FOR LOCAL
LAND USE COMPATIBILITY WITH YEARLY DAY-NIGHT AVERAGE SOUND LEVELS

LAND USE	****Yearly Day-Night Average Sound Level***					
	Below 60	60-65	65-70	70-75	75-80	80-85
Residential						
Low density residential, resorts, and hotels with extensive outdoor use ..	Y(a)	N(b)	N	N	N	N
Low density apartment with moderate outdoor use	Y	N(b)	N	N	N	N
High density apartment with limited outdoor	Y	N(b)	N(b)	N	N	N
Transient lodgings with limited outdoor use	Y	N(b)	N(b)	N	N	N
Public Use						
Schools, day-care centers, libraries, and churches	Y	N(c)	N(c)	N(c)	N	N
Hospitals, nursing homes, clinics, and health facilities	Y	Y(d)	Y(d)	Y(d)	N	N
Indoor auditoriums and concert halls	Y(c)	Y(c)	N	N	N	N
Government services and office buildings serving the general public	Y	Y	Y(d)	Y(d)	N	N
Transportation and Parking	Y	Y	Y(d)	Y(d)	Y(d)	Y(d)
Commercial and Government Use						
Offices--government, business, and professional	Y	Y	Y(d)	Y(d)	N	N
Wholesale and retail--building materials, hardware and heavy equipment ...	Y	Y	Y(d)	Y(d)	Y(d)	Y(d)
Airport businesses--car rental, tours, lei stands, ticket offices, etc. ..	Y	Y	Y(d)	Y(d)	N	N
Retail trade, restaurants, shoping centers, financial institutions, etc. .	Y	Y	Y(d)	Y(d)	N	N
Power plants, sewage treatment plants and base yards	Y	Y	Y(d)	Y(d)	Y(d)	N
Studios without outdoor sets, broadcasting, production facilities, etc. ..	Y(c)	Y(c)	N	N	N	N
Manufacturing, Production, and Storage						
Manufacturing, general	Y	Y	Y(d)	Y(d)	Y(d)	N
Photographic and optical	Y	Y	Y(d)	Y(d)	N	N
Agriculture (except livestock) and forestry	Y	Y(e)	Y(e)	Y(e)	Y(e)	Y(e)
Livestock farming and breeding	Y	Y(e)	Y(e)	N	N	N
Mining and fishing, resource production and extraction	Y	Y	Y	Y	Y	Y



PROPOSED DEVELOPMENT CONCEPT

EWA MARINA

Prepared by: Wilson Okamoto & Associates, Inc.

FIGURE 1 - Location of HNL's 60 dB Ldn Contour (Reference 1)

Recreational

Outdoor sports arenas and spectator sports	Y	Y(f)	Y(f)	N	N	N
Outdoor music shells, amphitheaters	Y(f)	N	N	N	N	N
Nature exhibits and zoos, neighborhood parks	Y	Y	Y	N	N	N
Amusements, beach parks, active playgrounds, etc.	Y	Y	Y	Y	N	N
Public golf courses, riding stables, cemeteries, gardens, etc.	Y	Y	N	N	N	N
Professional/resort sport facilities, locations of media events, etc.	Y(f)	N	N	N	N	N
Extensive natural wildlife and recreations areas	Y(f)	N	N	N	N	N

Numbers in parentheses refer to notes.

KEY TO TABLE 1A:

Y(Yes) = Land Use and related structures compatible without restrictions.
N(No) = Land Use and related structurese are not compatible and should be prohibited.

NOTES FOR TBLE 1A:

(a) A noise level of 60 Ldn does not eliminate all risks of adverse noise impacts from aircraft noise. However, the 60 Ldn planning level has been selected by the State Airports Division as an appropriate compromise between the minimal risk level of 55 Ldn and the significant risk level of 65 Ldn

(b) Where the community determines that these uses must be allowed. Noise Level Reduction (NLR) measures to achieve interior levels of 45 Ldn or less should be incorporated into building codes and be considered in individual approvals. Normal local construction employing natural ventilation can be expected to provide an average NLR of approximately 9 dB. Total closure, plus air conditioning may be required to provide additional outdoor to indoor NLR, and will not eliminate outdoor noise problems.

(c) Because the Ldn noise descriptor system represents a 24-hour average of individual aircraft noise events, each of which can be unique in respect to amplitude, duration, and tonal content, the NLR requirements should be evaluated for the specific land use, interior acoustical requirements and properties of the aircraft noise events. NLR requirements should not be based solely upon the exterior Ldn exposure level.

(d) Mesures to achieve required NLR must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise sensitive areas, or where the normal noise level is low.

(e) Residential buildings require NLR. Residential buildings should not be located where noise is greater than 65 Ldn.

(f) Impact of amplitude, duration, frequency, and tonal content of aircraft noise events should be evaluated.

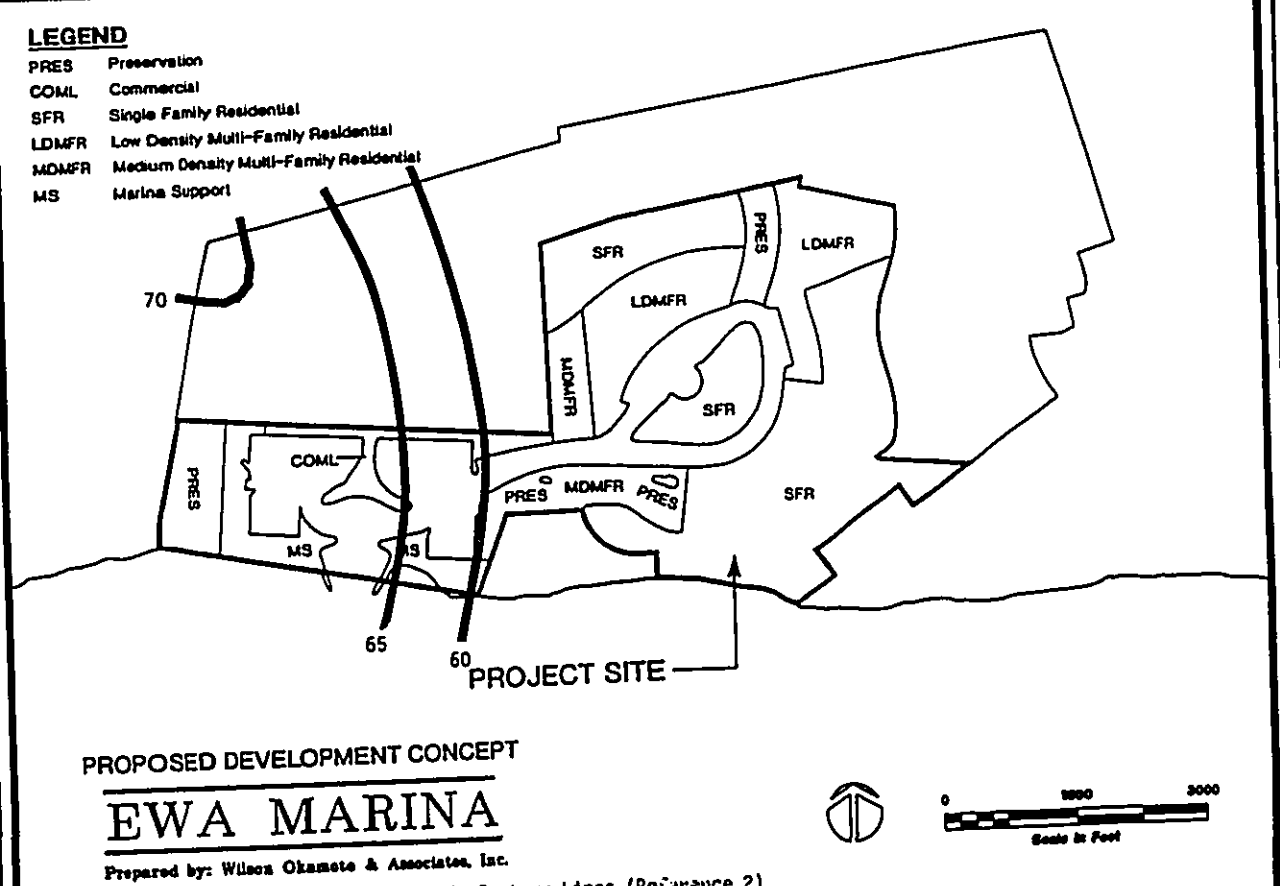


FIGURE 2 - Location of NASBP's Ldn Contour Lines (Reference 2)

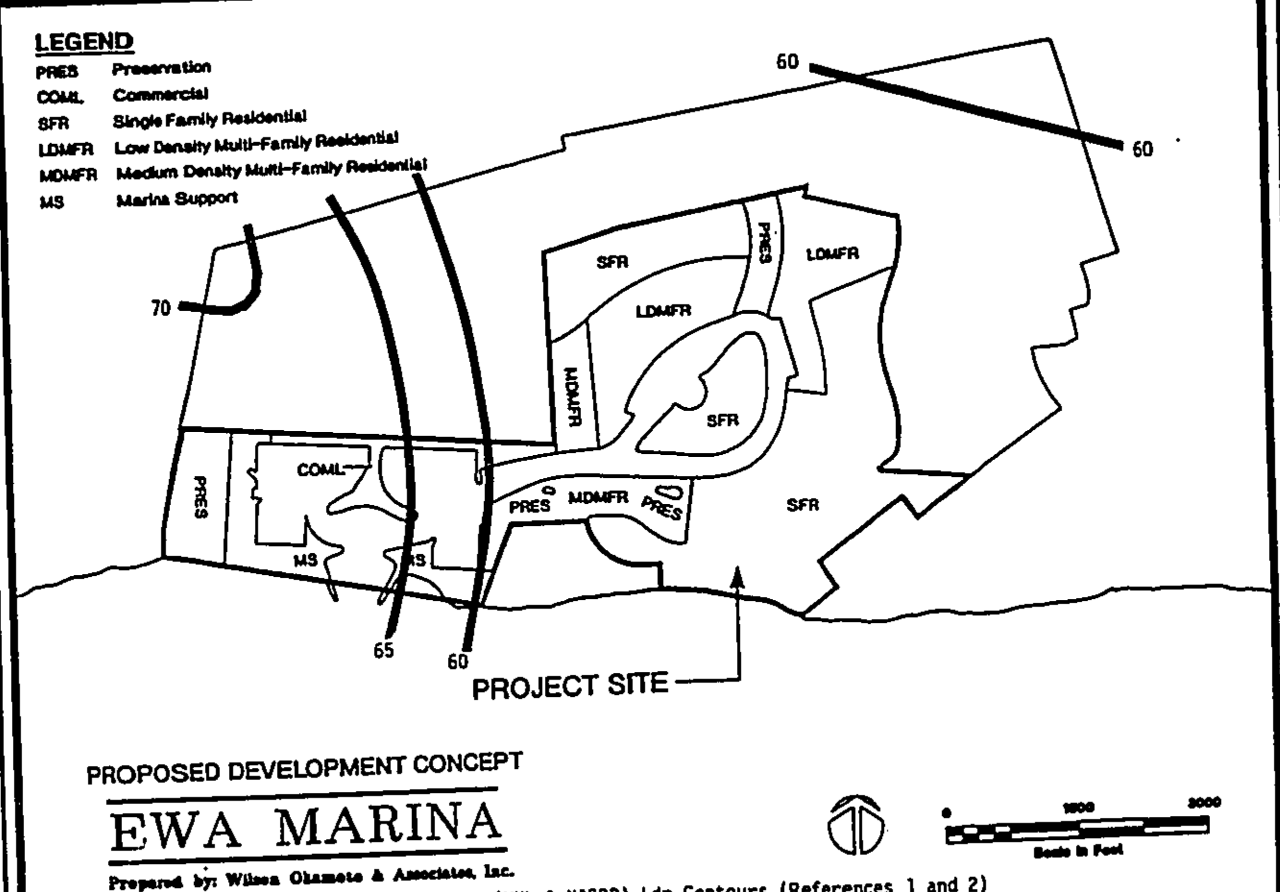


FIGURE 3 - Location of the Combined (NHL & NASBP) Ldn Contours (References 1 and 2)

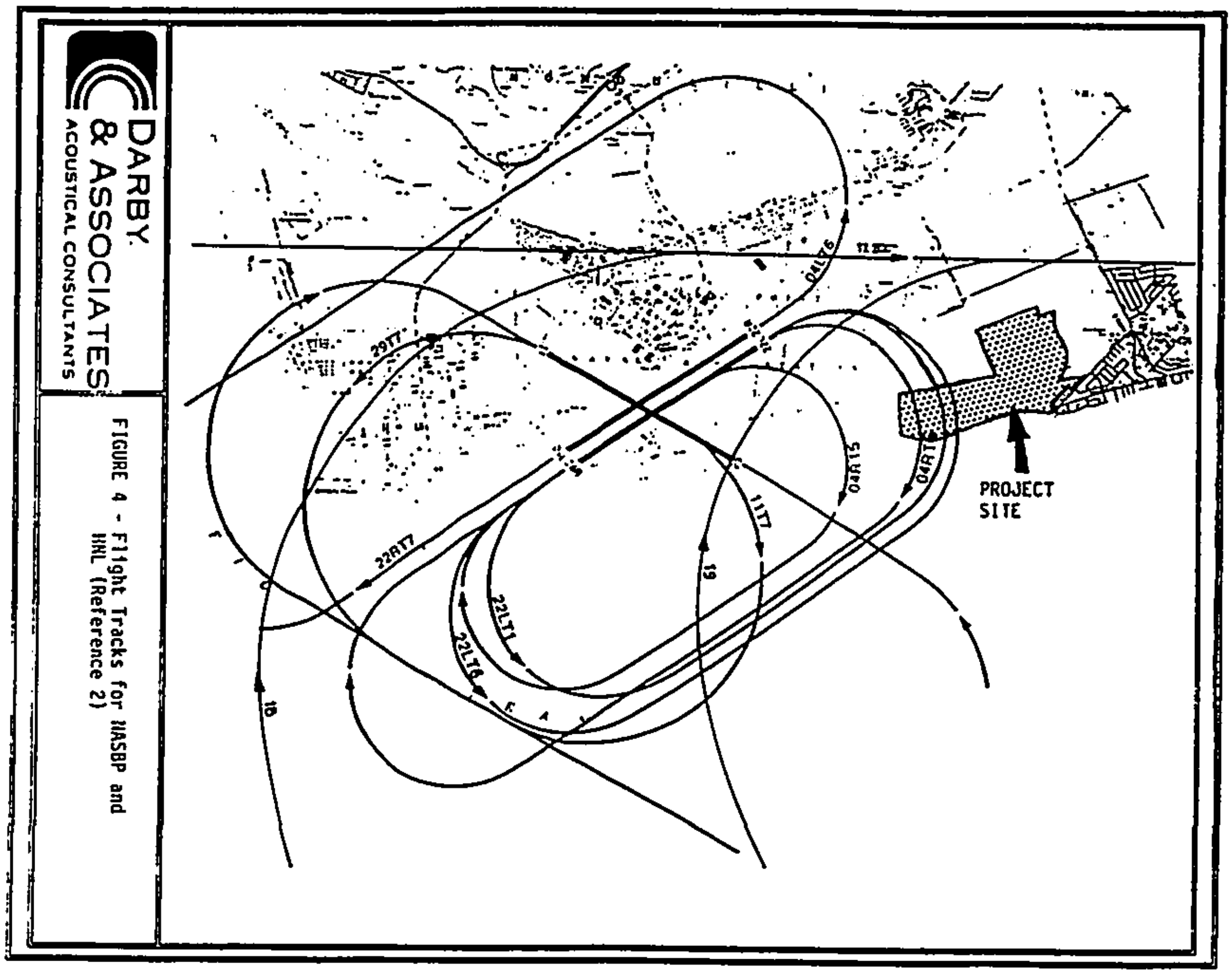


FIGURE 4 - Flight Tracks for NASBP and NAL (Reference 2)

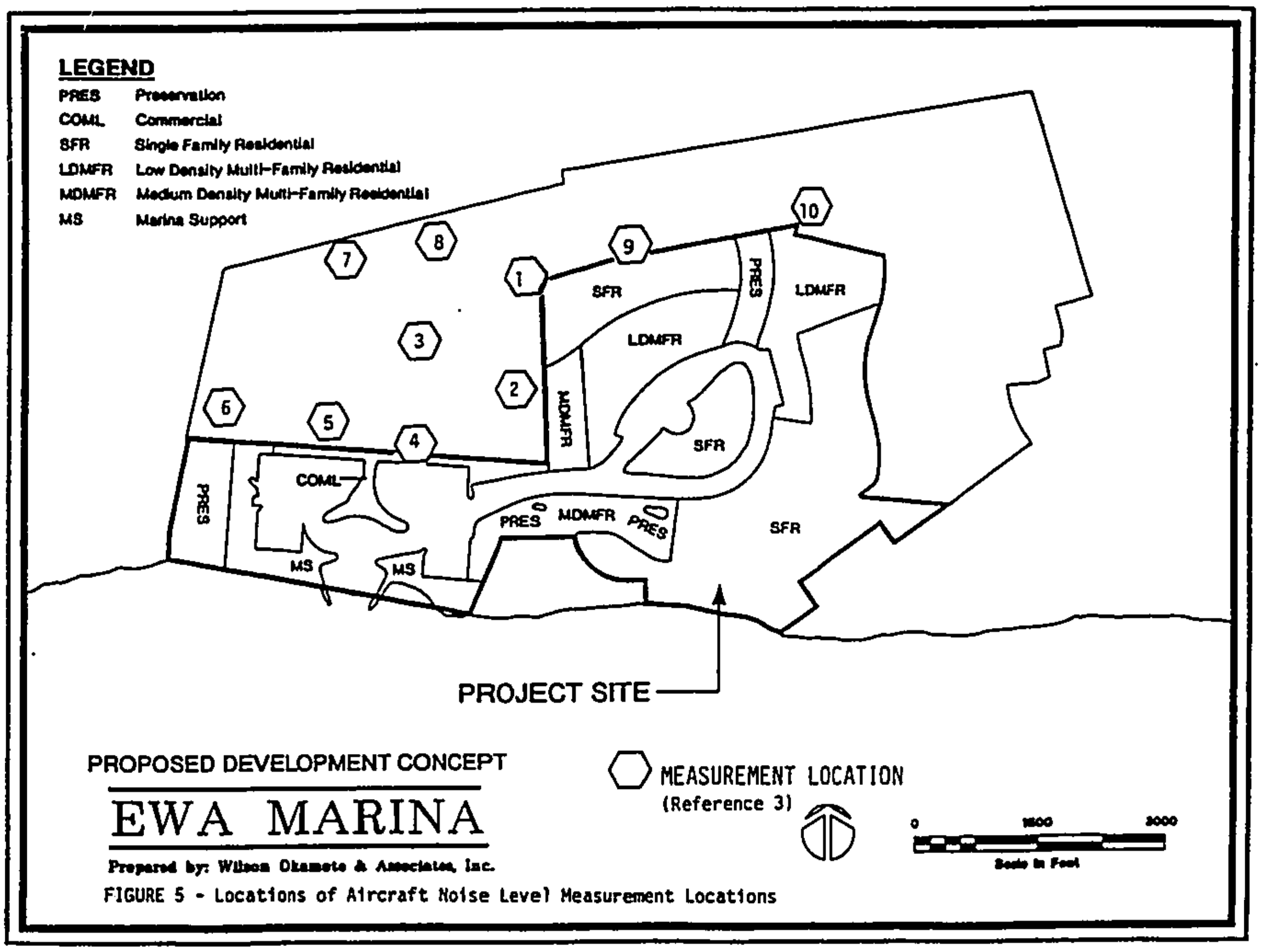


FIGURE 5 - Locations of Aircraft Noise Level Measurement Locations

Appendix E

Ewa Marina Water Quality Studies

Evaluation of the Proposed Ewa Marina Water Quality

(Updates Appendix A of preceding report)

Ewa Marina Exchange Rate and Water Quality

EWA MARINA WATER QUALITY STUDIES

Prepared for

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November 7, 1990

TABLE OF CONTENTS

INTRODUCTION

Ewa Marina will be a new, manmade embayment on Oahu's south shore, excavated out of the coralline caprock. Water quality is important to its primary beneficial use as a recreational boat harbor. The main consideration is aesthetics, but it is also desirable that the water be suitable for swimming and that it support a range of marine life typical of a sheltered salt water bay. The State Health Department standards for Class A coastal waters and Class A embayments are applicable[1]. They consist of statistical limitations on certain physical and chemical characteristics, including nitrogen compounds, phosphorus, turbidity, and chlorophyll. Nitrogen and phosphorus are nutrients which stimulate the growth of microscopic algae; chlorophyll is an indicator constituent of algal cells, and the cells contribute to water turbidity. There are also specific limits on a number of toxic substances.

The surface area of the marina is about 140 acres. Water depth in it will range from a maximum of 20 feet at the entrance to a minimum of 8 feet in the inner channels fronting residential property (all datum are mean lower low water). The public boat basins will be 10 feet deep. The total number of boat slips to be provided is 1,600.

Maintenance of good water quality depends on keeping the input rates of suspended solids, nutrients, and other substances covered by the standards low enough that their concentrations are held to acceptable levels by tidal flushing and other removal mechanisms. The principal input sources to the proposed marina will be (1) boating activities, (2) surface runoff, and (3) groundwater inflow.

INPUT SOURCES

Boating Activities

Boat engines contribute a certain amount of lead, oil, and fuel-derived organic residues to the water; amounts can be estimated through boat usage and fuel consumption, together with

data on measured emissions per unit of fuel consumed[2]. Copper is released from antifouling bottom paint, and the total rate of release to the environment can be approximated from statistics on paint usage and copper content[3]. Organotin-based paints that have also been available in recent years have been associated with destruction of intertidal biota in marinas, but their sale is now illegal in Hawaii and many other states; hence, they are not expected in significant concentrations in the proposed marina. Discharges from heads and galleys into the marina are another potential source of organic pollution, but these are prohibited by existing State Department of Health regulations, and are not expected to be significant at Ewa Marina.

Contributions of copper and fuel residues from 1,600 moored boats are estimated as follows:

Copper	11.00 lb/day
Oil	3.00 lb/day
Organic fuel residues as (C.O.D.)	18.00 lb/day
Lead	0.01 lb/day

Storm Runoff

In terms of total volume of material, storm runoff is expected to be the most significant input source to the marina. Kaloi Gulch, which comprises a watershed of approximately 10.5 square miles, has distinctly different forms across its length.

- Above Farrington Highway there are a number of channels, all of which are relatively deeply eroded and have adequate capacity to accommodate peak flood flows.
- In the reach from Farrington Highway to just above Mango Tree Road, the several channels are joined, and this single channel has the appearance of an excavated feature rather than a naturally eroded one. Only a nominal flowrate, not more than 1,500 cubic feet per second (cfs), or about one-fourth the existing channel

capacity, can be conveyed to the lower reaches of the channel below the railroad right-of-way.

- The channel reach which extends from just below Mango Tree Road to a point about 1,800 feet from the shoreline is simply two earthen levees formed with rocks and boulders removed in clearing nearby cane fields. The bottom of the channel is not excavated; rather it is at the same elevation as the adjacent ground outside the levees.

- The levees end just seaward of the lowest cane field. Stormwater exiting the defined channel at this point spills out and ponds in localized low points or moves as sheet flow generally towards the shoreline.

Flow in Kaloi Gulch is very intermittent, particularly in the reaches seaward of Farrington Highway.

Ongoing development inland of the Ewa Marina project will substantially alter the existing drainage conditions. As the Ewa by Gentry project is constructed and Ewa Village is redeveloped, channel capacities through them will be increased to between 8,000 and 10,000 cfs. The net effect of these changes will be to eliminate flow in the existing channel during minor (2- to 5-year) storms and to substantially increase the flow during very severe storms as a result of berm overflow. At any rate, the peak flows following completion of the upstream drainage improvements to City & County of Honolulu design standards will be approximately 11,000 cfs. This will be discharged into the inland side of the marina through a discharge structure. In addition to the Kaloi Gulch drainage, portions of the Ewa Marina site will also drain directly into the marina.

The sediment load carried by storm runoff in Kaloi Gulch has been estimated by Moffat & Nichol as being on the order of 10,000 tons per year[4]. However, the rates suggested by data contained in the Statewide Silt Basin Investigation prepared by Fukunaga and Associates, Inc., for the State Department of Land and

Natural Resources are lower. Because of the existing upstream drainage constraints, virtually none of the runoff now reaches the ocean; hence, almost all of the material that is eroded from the upland part of the watershed is deposited in the sugarcane fields and other areas that are periodically flooded. While the areas inland of the Ewa Marina site that are currently being developed are using wide, gently sloping drainageways that encourage deposition to accommodate storm flows, large storms will still convey substantial quantities of suspended sediment to the marina.

Because of the large runoff volumes and relatively fine-grained nature of most of the material, sediment basins are not an effective means of removing this material before it enters the marina. The Statewide Silt Basin Investigation final report recognizes this and states, in part:

> The Ewa Plain is especially suitable for innovative drainage systems....Parklands, golf courses and landscaped areas should be fully utilized as temporary ponding areas; use of wide, unlined low-velocity channels should be encouraged. Marinas and harbors readily accessible to dredging equipment should be recognized as functional sedimentation areas.

The design of the Ewa Marina project is entirely consistent with this recommendation. Thus, it is anticipated that the upper end of the marina will become turbid during and immediately following the relatively infrequent rainfall events that are large enough to induce substantial runoff through Kaloi Gulch.

In addition to sediment, the storm runoff will contain nitrogen and phosphorus compounds, organic matter, and bacteria. Estimates of total nitrogen and phosphorus concentrations in the runoff can be inferred from sampling carried out during a Navy study of Pearl Harbor water quality[7]; storm drainage inputs analyzed in that study averaged 0.33 mg/l in Kjeldahl N and 0.25 mg/l in total P. Data from Fujiwara[8] on runoff from a Honolulu residential watershed showed averages for biochemical oxygen demand (B.O.D.) of about 10 mg/l and total coliform about 10,000 per 100 ml.

Groundwater Discharge

The upper aquifer over the Ewa Plain is composed of fractured coralline limestone (caprock) whose depth increases toward the south to over 1,000 feet at the shoreline. Groundwater in the caprock flows toward the coast at a rate which has been estimated by John Mink for Dames and Moore[9] as between 230 and 420 gallons per day per foot of aquifer width. A more detailed ongoing study by Tom Nance Water Resources Engineering and Mackie Martin Associates is utilizing water budget estimates and a computer-aided, finite-difference groundwater model. This study places groundwater shoreline discharge at 12.0 MGD across a 40,000-foot long portion of the limestone aquifer that includes the project site. This is equivalent to 300 gallons day per foot. This same study indicates that between 4 and 7 million gallons per day of this flow may be intercepted by the marina.

Analyses made in 1986 on water samples from Oahu Sugar Company wells directly north of the marina site showed average concentrations of 7 mg/l nitrate nitrogen and 0.02 mg/l total phosphorus[10]. The nitrate is a residue of fertilizer applied to the cane fields; concentrations may change in the future as a result of land urbanization. Based on these rates, it is estimated that around 350 pounds of nitrogen and one pound of phosphorus will be discharged into the marina each day as part of this groundwater flow.

Water quality inside the marina is strongly influenced by the rate of exchange between ocean water at the marina entrance and the quality of the ocean water. Appendix A presents typical water quality data for the coastal and offshore waters between Ewa Beach and Barbers Point Naval Air Station. Past sampling for chemical parameters along the shoreline has been quite sparse; however a substantial sampling at the marina entrance site was made by Marine Research Consultants in the summer of 1990, and the results are given in Appendix B. Salinity and temperature profiles show little evidence of stratification in the nearshore water out to a depth of 10 meters.

Table I below compares average offshore data from Appendix A (surface samples, all stations, four quarterly samplings ending

February 1989), averages of the inshore data from Appendix B (with beach samples excluded), and the State median standards for "dry" coastline (receiving less than 3 mgd of fresh water inflow per shoreline mile (568 gallons/day/foot). Allowing for the statistical variance of the sampled data, it appears that the offshore and nearshore average values are about equal. They are all of the same order of magnitude as the State standards.

Table I
COMPARISON OF CHEMICAL PARAMETERS WITH STATE STANDARDS

PARAMETER	Offshore	Nearshore	St.Standard
Total Nitrogen, ug/l	113	91	110.00
Total Phosphorus, ug/l	10	12	16.00
Light Extinction, units	0.08	--	0.10
Turbidity, ntu	0.12	0.16	0.20
Chlorophyll a, ug/l	0.18	0.20	0.15

FLUSHING ANALYSIS

The effects of pollutant inputs can be quantified through numerical simulation of the tidal flushing process. One useful result of such calculations is the mean residence times at different points within the marina. Residence times are a measure of the rate of flushing, and they can be used to estimate the intensity of turbidity due to the growth of planktonic algae. An appropriate numerical model was set up and operated by OCEES International. Appendix C describes the procedures incorporated into the model and presents the detailed results of the simulation.

The model was constructed by partitioning the marina horizontally into a series of interconnected basins, or "boxes". Because of the relatively large fresh water inflow, the marina will be vertically stratified, and so each box was further subdivided into upper and lower layers. Intercepted fresh groundwater was assumed to flow seaward in the upper layer, while the tide alternated its direction of flow in the lower layer. The model transfers water volumes among the boxes in simulation of the tide and freshwater inflows. An accounting was maintained of the mean ages of the water in all boxes, until they levelled off to steady values.

The groundwater influx distributed around the landward edges of the basins totalled approximately 6 mgd. The mean tidal flow was 120 mgd, equivalent to one 2.48-foot tide per day. Computed residence times increased generally toward the inland end of the marina. With the estimated groundwater input, the range of computed residence times in the upper layer was from zero at the entrance to 8 days at its inland edge; the residence times in the lower layer at the same two locations ranged from 3 days to 6 days.

The implications of the computed residence times are discussed in Appendix D, a follow-on report by OCEES International. Chlorophyll concentration in the marina water is estimated from its level in the ambient ocean water by applying an appropriate net growth rate over the residence time. The net growth rate is based on observations made under similar environmental conditions. The growth rate used for the surface layer was 25 percent per day, based on data from Hawaii Kai Marina and the expected level of phosphorus input from surface drainage. Since the bottom layer will receive much less phosphorus, a net growth rate of 12 percent per day was assumed there. The resulting value of 0.95 micrograms per liter is well below the Health Department's 1.5 ug/l limit for the geometric mean. However, the modeling results suggest that the water carried from the marina to the ocean will probably slightly exceed the ocean water standards for total nitrogen, turbidity, and chlorophyll, until it is diluted by mixing with the water offshore. This is typically the case at the interface between embayments and open coastal waters, and the nutrients, of course, are already reaching the ocean. However, the existing groundwater discharge is more evenly distributed along the shoreline than it will be with the marina in place, and so the existing zone of mixing is smaller than it will be with the project.

In principle, the box model can be used to calculate concentrations of various materials throughout the marina if the input rates are known at all sections. With only rough estimates

available for the inputs, approximate concentrations can be obtained directly from the computed residence times by assuming that the inputs are distributed uniformly throughout the marina water volume.

For the assumed case of groundwater inflow and stratification, the residence time in the box farthest inland was approximately 8 days. Of the inputs from boating activity, only copper and tributyl tin from antifouling paints are significant, because of their toxicity at low concentrations. The Health Department chronic toxicity standard for tributyl tin is 0.01 ug/l; to assure compliance with this standard, material should be disqualified by ordinance for use on any boat moored in the marina. If all of the estimated copper input remained in the water column, concentrations would be on the order of 20 ug/l. However, much of the copper sloughed from boat hulls will remain on the bottom in solid form, and so it is not anticipated that copper concentrations in the water column will reach the level at which they are toxic to phytoplankton. This conclusion is supported by the fact that copper toxicity has not been reported as a problem in numerous salt water marinas having higher boat densities and longer residence times than the proposed Ewa Marina will have.

The nitrate input from the groundwater is not uniformly distributed, since it enters at the surface and is concentrated along the northerly marina shoreline, but it will be present at relatively high concentration throughout the marina interior except near the ocean entrance. Using a 4-day average residence time as a rough approximation, the 350-lb/day input will appear as a concentration of around 0.45 mg/l.

Storm drainage inputs will be fairly large on the occasion of heavy storms. Runoff statistics cannot be reliably estimated, but the case of a 6-inch, 48-hour storm may be used to illustrate magnitudes. Total storm flow, assuming 10 percent runoff, would be 336 acre-feet. The concentrations of constituents in the drainage water, and their corresponding values in the marina after immediate dilution, are estimated as follows:

Pollutant	Concentrations, mg/l Discharge	Marina
Suspended solids	200	46
Organic matter (B.O.D.)	10	2.3
Total nitrogen	0.5	0.6
Total phosphorus	0.25	0.07

Runoff will cease quickly once rainfall has dropped to low intensity, and the high concentrations would begin to fall, returning to normal levels after several days. Recovery will be most rapid in the low-residence-time areas near the entrance. The ocean will also be temporarily affected by the storm runoff, but less so than if the Kaloi Gulch channel alignment were to bypass the marina and discharge directly into the ocean, which is what would have to be done if the marina were not constructed.

REFERENCES

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(3) Young, D.R., T.C. Heesen, D.J. McDermott, and P.E. Smokler: "Marine Inputs of Polychlorinated Biphenyls and Copper from Vessel Antifouling Paints", So. Calif. Coastal Water Research Project, Report TM 212, May 1974.

(4) Moffatt & Nichol, Engineers: Oceanographic Criteria for Design of Ewa Marina, March 1978.

(5) Hawaii, State of, Department of Land and Natural Resources, Division of Water and Land Development. Statewide Silt Basin Investigation. Prepared by Fukunaga and Associates, Inc. December 1980.

(6) Tom Nance Water Resources, Inc. Personal communication. November 1990.

(7) Evans, E.C. (ed): Pearl Harbor Biological Survey--Final Report, Naval Undersea Center, San Diego, CA, Report NUC TN 1128, August 1974.

(8) Fujiwara, T.O.: Characterization of Urban Stormwater Discharges from Separate Storm Sewers, M.S. in C.E. Thesis, Univ. Hawaii, May 1973.

(9) Dames & Moore: Final Groundwater Study, Proposed Ewa Marina, 1986.

(10) Dames & Moore: Final Addendum to the Final EIS, Ewa Marina Community, Increment II, July 1986.

APPENDIX A

EWA MARINA WATER QUALITY

OCEES International, Inc.
3786 Pukalani Place
Honolulu, Hawaii 96816

March 22, 1990

EWA MARINA WATER QUALITY

The water quality characteristics that can be expected in the proposed Ewa Marina depend not only on the configuration and size of the marina basin but also on the quantity and quality of the water entering the marina from the ocean and from the land. Four sources of water are of importance in the evaluation of the expected water quality in the proposed marina. These are: (1) surface runoff (which is the primary source of the nutrient phosphorus), (2) ground water inflow (the average flow rate of which indicates the degree of stratification), (3) new coastal water (which is expected to make up by far the largest fraction of incoming water), and (4) reentering exit water (expected to be a small fraction because of the likely two layered flow and small marina mouth).

With minimum surface water inflow the growth of phytoplankton is very likely to be phosphorus limited. This means that the growth would occur at a slower rate than with larger and more constant surface water inflow. With large quantities of fresh water inflow (either from ground water or surface water sources) the water column in the marina will be stratified. This means that the basin and channel will have to be evaluated using a two layer model. All of these considerations, along with the geometry of the marina, are important in the prediction of water quality inside the marina as well as the quality of water exiting the marina into the nearshore waters off the Ewa coastline.

The starting point in this evaluation is the background water quality in the coastal waters. Very reliable and reasonably complete information is available for the waters outside the reef in this area. Quarterly samples have been taken (and more are continuing to be taken) by the City and County of Honolulu to evaluate the effect of the discharge from the Barbers Point outfall. This outfall presently discharges an average of about 21 MGD of primary effluent at a depth of about 200 feet. The monitoring program is in support of the application by the City and County of Honolulu for a waiver of the Secondary Treatment Requirements for the Honouliuli Wastewater Treatment Plant.

The existing data has been evaluated with respect to its public health importance by M & E Pacific Inc. The resulting report was submitted to the City and County of Honolulu in mid 1989. Most of the information discussed herein comes from that data base and the M & E Pacific Inc. summary report. An additional part of the information is from ongoing studies of the currents off Ewa being done by Look Laboratory. Also, recently completed studies by Hans Krock and M & E Pacific of the Fort Kamehameha Wastewater Treatment Plant, which discharges at the mouth of Pearl Harbor, contributed to the discussion.

Two general groups of water quality stations were used by the City and County. The off-shore stations are representative of the background

water quality conditions for coastal waters outside of the reef area. The station locations are shown in Figure IV-1 taken from the M & E Pacific Summary Report. The second set of stations are at the shore line and at the thirty foot depth contour. These are given in Figure IV-2. The measurements of this second set of stations is limited to bacteriological parameters and is therefore not too helpful in evaluating many of the watr quality parameters important to the dynamics of the proposed marina. These parameters include: total nitrogen, total phosphate, turbidity, chlorophyll-a, salinity and temperature.

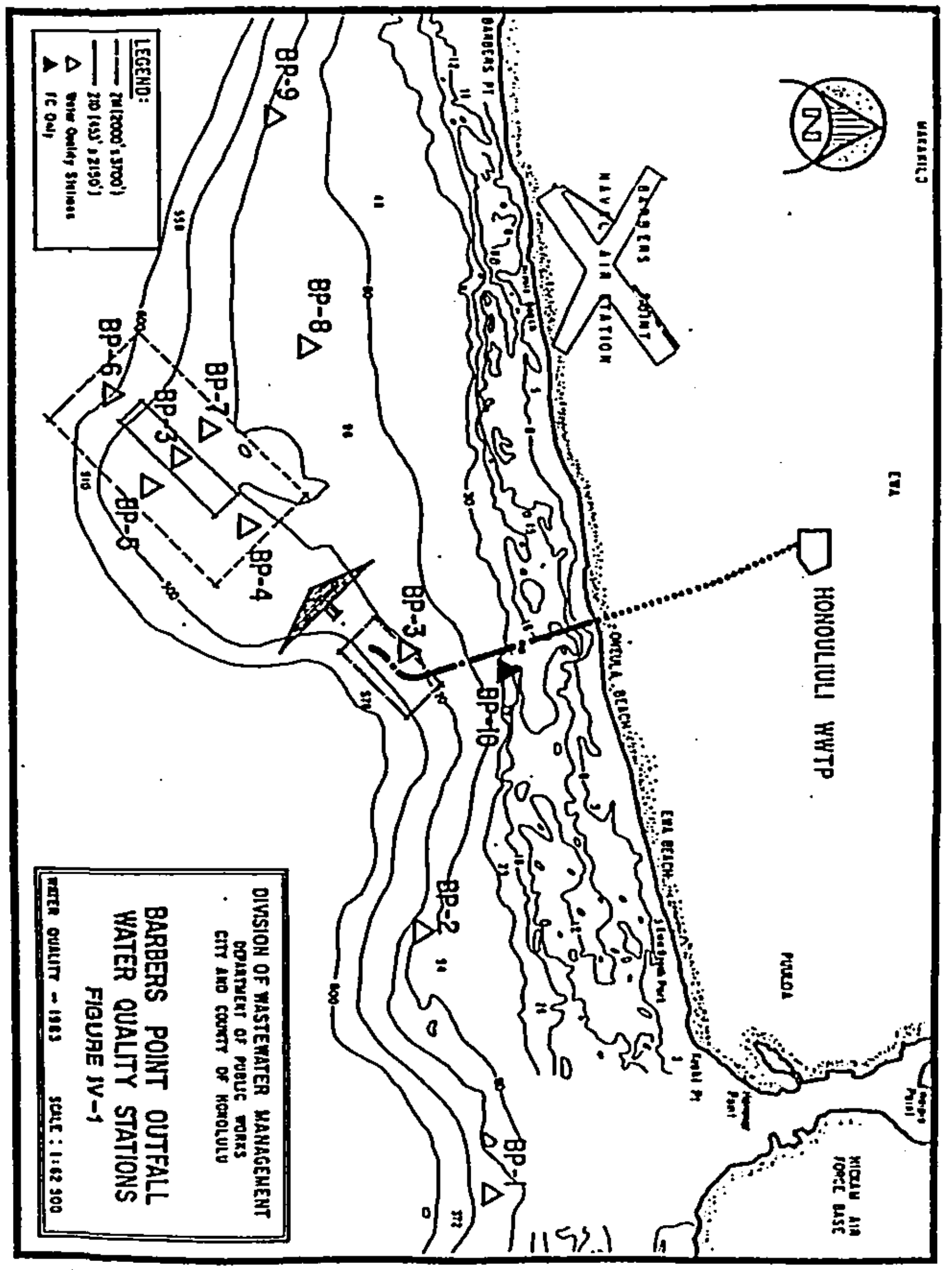
Both of these data sets indicate the degree of influence of the discharge from the Barbers Point outfall and the outflow from Pearl Harbor. The outfall influence is largely confined to the zone of mixing with some rare indication at the nearshore stations but none at the shore line stations. The Pearl Harbor outflow however does have a more profound and somewhat more consistant influence on the stations of interest to the Ewa Marina Development.

Summary values for some of the parameters are given in Tables IV-1, IV-2. The relevant data set is given in pages IV-A-1 through IV-A-29 from the Appendix to the M & E Pacific Summary Report.

RECOMMENDATION

Because of the lack of good data directly applicable to the evaluation of the probable inflowing water to the proposed Ewa Marina, it is recommended that a series of four sampling runs be made. The stations should be in a line from the shore to 30 foot depth contour at the proposed entrance channel location. Parameters to be measured include: TP, TN, turbidity, chlorophyll-a and temperature. The sampling times should include one flood tide, one ebb tide, one high slack and one low slack. If possible, one of these four should be during a Kona wind condition.

The results of such a water quality assessment, along with the existing data base, can be used in a "box" model evaluation of alternative marina designs.



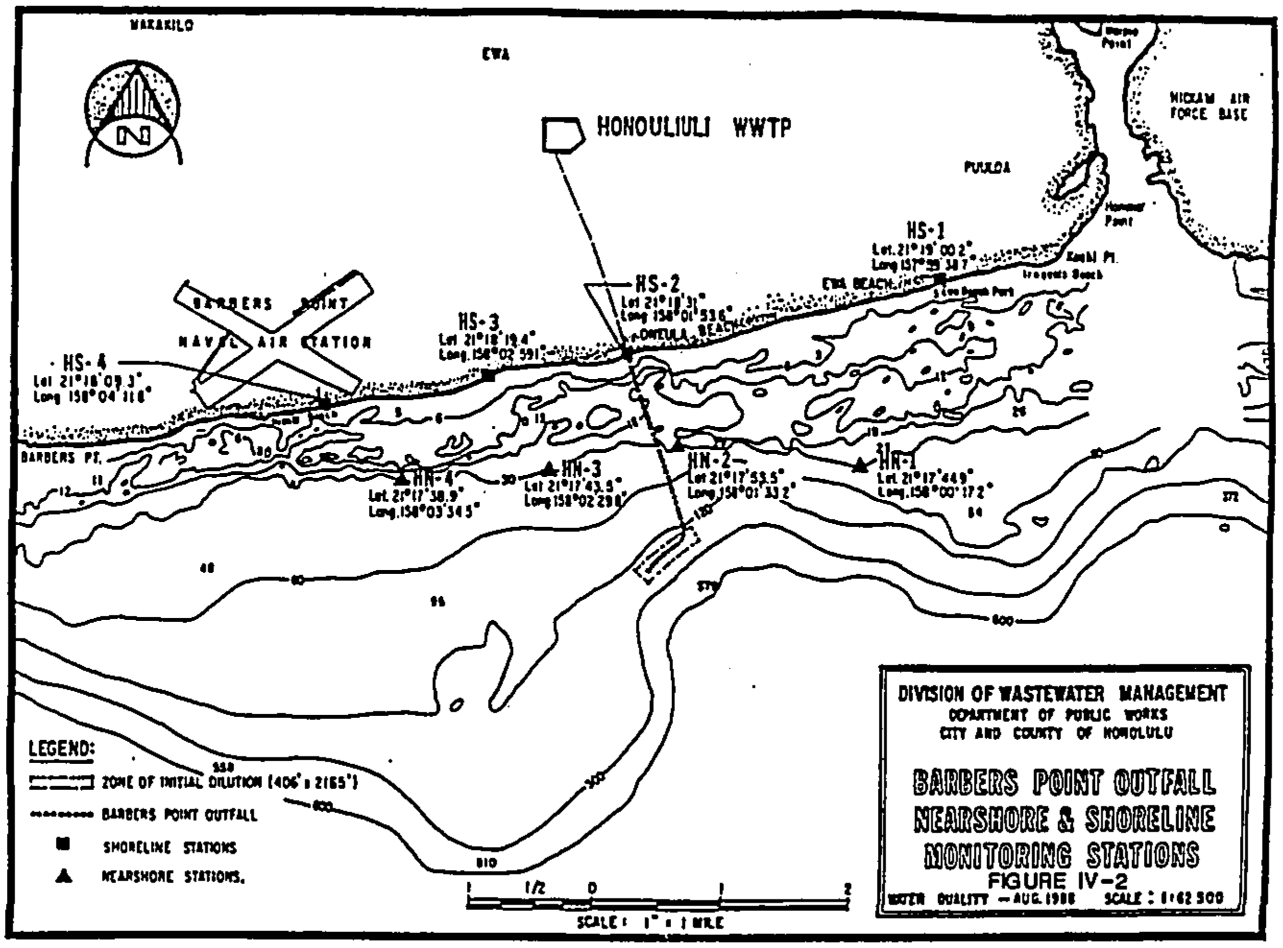


TABLE IV-1
TURBIDITY AND CHLOROPHYLL VALUES
FOR THE BARBERS POINT OUTFALL RECEIVING WATERS
Values are for log normal distribution.

	TURBIDITY (NTU)				CHLOROPHYLL (ug/l)		
Date	n	mean	std.dev.	98%-tile	mean	std.dev.	98%-tile
2/15/89	25	0.13	1.75	0.39	0.30	1.54	0.71
11/22/88	25	0.10	1.13	0.13	0.10	2.09	0.44
9/16/88	25	0.11	1.36	0.20	0.07	1.66	0.19
5/23/88	25	0.10	1.33	0.18	0.05	1.62	0.13
2/18/88	25	0.09	1.19	0.13	0.10	1.93	0.37
11/9-10/87	25	0.12	1.53	0.28	0.06	1.80	0.19
7/10/87	25	0.08	1.23	0.12	0.05	1.78	0.16
4/7/87	22	0.08	1.29	0.13	0.05	1.45	0.10
1/9-12/87	22	0.08	1.26	0.13	0.08	1.57	0.20
10/2-3/86	22	0.12	1.23	0.18	0.09	2.08	0.39
7/3-7/86	22	0.36	1.28	0.59	0.11	1.91	0.40
4/17-21/86	22	0.32	1.51	0.73	0.10	1.29	0.17
2/24-25/86	22	0.65	2.79	5.06	0.15	1.78	0.47
10/15-16/85	22	0.50	1.34	0.90	0.12	1.56	0.29
7/3-5/85	22	0.31	1.34	0.56	0.11	2.30	0.58
4/8-9/85	22	0.38	1.86	1.32	0.06	1.60	0.15
2/13-14/85	22	0.54	1.60	1.38	0.11	1.54	0.26
10/5-9/84	22	0.43	1.38	0.82	0.08	1.56	0.19
9/4-5/84	22	0.20	1.24	0.31	0.09	1.69	0.26
4/5-6/84	22	0.38	1.57	0.94	0.06	1.51	0.14
1/9-10/84	22	0.34	1.49	0.76	0.07	1.87	0.24
10/3-4/83	22	0.39	1.23	0.59	(not analyzed)		
4/6-7/83	22	0.38	1.48	0.25	0.09	1.68	0.25
2/1-2/83	21	0.55	1.82	1.83	0.09	1.67	0.25

TABLE IV-2

Summary of the bacteriological data for the shoreline adjacent to the BARBERS POINT OUTFALL. All values are in numbers per 100 ml. Statistics are from a log normal distribution.*

SHORELINE[1]							
	Enterococci/100 ml				Fecal Coliform/100 ml		
Station	n	x	σ	95% tile	x	σ	95% tile
Nanner Point	35	4.2	5	106	3.8	4.2	65
Iroquois Beach	36	1.6	2.2	7.6	1.5	.2	6
HS1	34	1.7	2.9	14.5	1.8	4.1	30
HS2	36	2.3	2.8	17.8	1.4	1.8	4.6
HS3	38	1.4	2.2	6.9	1.4	2.3	7.5
HS4	37	1.4	2.1	6.3	1.2	1.7	3.4

NEARSHORE[2]							
	Enterococci/100 ml				Fecal Coliform/100 ml		
Station	n	x	σ	95% tile	x	σ	95% tile
NH1	20	1.6 1.9	4.1 5.3	27** 53	2.3 2.7	8.1 10.1	149 275
NH2	19 18	1.4 2.2	2 3.4	5.4 26	1.6 4.5	3.9 8.7	25 337
NH3	19 20	1.5 1.3	2.9 2.2	13 6.4	1.5 1.5	3.4 3.6	17 20
NH4	18 18	1.3 1.3	2.1 1.6	5.5 3.4	1.4 1.8	2.8 2.7	11 4

[1]Data from April 13, 1988 to March 2, 1989.

[2]Data from July 20, 1988 to January, 1989.

*n = number of samples
σ = standard deviation
x = geometric mean

**surface and 10-meter depth

WATER QUALITY MONITORING PROGRAM

DIVISION OF WASTEWATER MANAGEMENT
DEPARTMENT OF PUBLIC WORKS

BARBERS POINT
DATE 2/1-2/89

STA. DATE & TIME	DEPTH (meters)	DENSITY	TEMP (°C)	SALINITY (0/00)	OXYGEN (mg/l)	NITROGEN (µg/l) NITRATE+NITRITE	AMMONIA	KJELDAHL	TOTAL	PHOSPHORUS (µg/l) ORTHO-PHOSPHATE	TOTAL	SS (mg/l)	.500- (mg/l)	PH	LIGHT EXT. COEF	TURBIDITY (NTU)	CHLOROPHYLL a (µg/l)	SECCHI DEPTH (meters)	FECAL STREP	COLIFORM (No./100ml) TOTAL	FECAL	WIND VEL.	WIND DIR.	SEA HGT.	SEA DIR.
1	5	22.75	24.14	33.85	*	5	8	90	95	4	.7	<1		8.17	0.050	.39	.24	21.3				5-10	N	2-3	SW
	30	22.73	24.20	33.85		2	4	100	102	4	7	<1		8.18		.08	.25								
2	5	22.69	24.15	33.70		1	2	40	42	3	6	<1		8.17	0.050	.75	.12	21.3				5-10	N	2-3	SW
	30	22.77	24.20	33.84		2	4	120	122	6	7	<1		8.17		.45	.17								
3	5	22.58	24.32	33.70		2	4	100	102	9	10	<1		8.16	0.050	.72	.06	21.3	116	<1500	1500	15-25	NE	3-4	NE
	15	22.63	24.36	33.79		4	2	110	114	8	9	<1		8.17		.69	.07								
	30	22.63	24.32	33.76		2	2	130	132	6	8	1.5		8.18		.67	.08								
4	5	22.01	24.43	33.74		1	2	70	71	8	12	<1		8.18	0.077	.57	.06	18.3	224	<1500	1500	15-25	NE	3-4	NE
	30	22.67	24.28	33.80		2	2	50	52	6	8	<1		8.19		.74	.06								
5	5	22.63	24.30	33.76		1	2	60	61	9	11	<1		8.20	0.062	.42	.06	19.8	230	<2000	2000	15-25	NE	3-4	NE
	30	22.64	24.32	33.70		4	2	50	54	6	9	<1		8.20		.55	.08								
6	5	22.63	24.30	33.76		3	3	120	123	9	12	<1		8.18	0.050	.50	.08	21.3	224	<2000	2000	15-25	NE	3-4	NE
	15	22.64	24.34	33.70		9	4	120	129	9	11	1		8.18		1.0	.08								
	30	22.61	24.30	33.74		1	6	140	141	6	8	<1		8.19		1.05	.07								
7	5	22.63	24.32	33.76		3	2	130	133	9	12	<1		8.18	0.050	.73	.07	21.3	400	<2000	2000	15-25	NE	3-4	NE
	30	22.73	24.34	33.90		4	2	70	74	7	9	<1		8.18		.06	.07								
8	5	22.85	24.18	34.00		5	5	70	75	6	8	<1		8.19	0.041	.31	.16	22.9				5-10	N	2-3	SW
	30	22.81	24.12	33.92		4	6	40	44	7	10	<1		8.19		.54	.26								
9	5	22.94	24.30	33.64		5	2	30	35	5	8	<1		8.20	0.050	.35	.06	21.3				15-25	NE	3-4	NE
	15	22.74	24.30	33.90		3	3	80	83	5	8	<1		8.19		.66	.06								
	30	22.74	24.30	33.90		2	3	90	93	4	9	<1		8.19		.54	.07								
10	5																		1	<1	<1				
	30																								

*: Meter Malfunction

WATER QUALITY MONITORING PROGRAM

DIVISION OF WASTEWATER MANAGEMENT
DEPARTMENT OF PUBLIC WORKS

BARBERS POINT
DATE 4/6-7/83

STA DATE & TIME	DEPTH (meters)	DENSITY	TEMP. (°C)	SALINITY (0/00)	OXYGEN (mg/l)	NITROGEN (µg/l)				PHOSPHORUS (µg/l)		SS (mg/l)	PH	LIGHT EXT. COEF (K)	TURBIDITY (NTU)	CHLOROPHYLL a (µg/l)	SECCHI DEPTH (meters)	COLIFORM (No/100ml)		WIND	SEA
						NITRATE+ NITRITE	AMMONIA	KJELDAHL	TOTAL	ORTHO-PHOSPHATE	TOTAL							TOTAL	FECAL	VEL & DIR	HGT & DIR
4/6 1 8:00	5	22.61	24.53	33.82	6.4	2	2	120	122	3	6	<1	8.30	0.015	0.46	.26	30			3-5 NW	Flat -
	30	22.76	24.40	33.97	6.2	2	2	100	102	3	7	<1	8.32		0.42	.09					
4/6 2 8:10	5	22.66	24.58	33.90	5.8	3	1	120	123	3	7	<1	8.32	0.030	0.52	.28	25			3-5 NW	Flat -
	30	22.78	24.33	33.96	5.8	1	1	80	81	4	5	<1	8.31		0.42	.06					
4/6 3 8:32	5	22.65	24.40	33.82	5.6	2	3	100	102	5	5	<1	8.32	0.040	0.36	.09	23	9600	6400	3-5 NW	Flat -
	15	22.74	24.40	33.94	5.6	3	2	110	113	4	5	<1	8.33		0.40	.09					
	30	22.84	24.35	34.05	5.6	2	2	100	102	4	6	<1	8.32		0.46	.07					
4/6 4 9:45	5	22.70	24.60	33.96	5.6	2	1	120	122	4	6	<1	8.33	0.011	0.50	.07	32	<10	<10	3-5 NW	Flat -
	30	22.86	24.38	34.08	5.4	2	1	90	92	4	6	<1	8.34		0.44	.07					
4/6 5 9:53	5	22.67	24.60	33.92	5.6	2	1	120	122	4	6	<1	8.34	0.015	0.24	.11	30	<10	<10	3-5 NW	Flat -
	30	22.81	24.34	34.01	5.5	2	1	80	82	4	7	<1	8.33		0.22	.06					
4/6 6 9:00	5	22.81	24.57	34.10	5.6	2	2	100	102	4	7	<1	8.33	0.011	0.32	.09	32	<10	<10	3-5 NW	Flat -
	15	22.86	24.45	34.12	5.5	3	1	90	91	4	6	1	8.33		0.24	.07					
	30	22.83	24.35	34.04	5.4	2	2	100	102	4	6	1	8.33		0.34	.08					
4/6 7 9:30	5	22.70	24.65	33.99	5.4	1	1	120	122	4	5	1	8.34	0.011	0.20	.07	32	<10	<10	3-5 NW	Flat -
	30	22.87	24.46	34.11	5.1	2	1	100	102	4	6	1	8.34		0.40	.10					
4/7 8 9:25	5	22.87	24.37	34.10	6.3	1	1	80	81	4	7	<1	8.33	0.015	0.42	.07	30			0-3 VAR	2-3 S
	30	22.85	24.23	34.02	6.0	2	1	60	62	4	6	<1	8.34		0.26	.10					
4/7 9 9:30	5	22.79	24.45	34.02	6.1	2	1	70	72	4	6	1	8.34	0.011	0.40	.07	32			0-3 VAR	2-3 S
	15	22.78	24.36	33.98	6.0	2	1	70	72	4	9	1	8.34		0.28	.05					
	30	22.86	24.27	34.05	5.9	2	1	50	62	4	6	1	8.34		0.56	.07					
4/8 10 10:05	5	22.34	25.08	33.68	4.5	2	3	90	92	4	9	2	8.32		1.20	.37	5 bottom	<4	<4	3-5 NW	Flat -

WATER QUALITY MONITORING PROGRAM

DIVISION OF WASTEWATER MANAGEMENT
DEPARTMENT OF PUBLIC WORKS

BARBERS POINT
DATE 10/3-4/83

STA DATE & TIME	DEPTH (meters)	DENSITY	TEMP. (°C)	SALINITY (0/00)	OXYGEN (mg/l)	NITROGEN (µg/l)				PHOSPHORUS (µg/l)		SS (mg/l)	PH	LIGHT EXT. COEF (K)	TURBIDITY (NTU)	CHLOROPHYLL a (µg/l)	SECCHI DEPTH (meters)	COLIFORM (No/100ml)		WIND	SEA
						NITRATE+ NITRITE	AMMONIA	KJELDAHL	TOTAL	ORTHO-PHOSPHATE	TOTAL							TOTAL	FECAL	VEL & DIR	HGT & DIR
10/3 1 0810	5	22.46	26.68	34.50	6.60	3	3	50	53	3	6	0.5	8.26	0.081	.37	*	18	—		15-20 KTS NE	2 FT E
	30	22.31	26.68	34.30	6.50	2	2	60	62	4	7	<0.5	8.26		.56						
10/4 2 0800	5	22.53	26.55	34.53	6.60	3	3	60	63	4	7	0.5	8.24	0.017	.32		29			3-5 KTS NE	1-2 FT E
	30	22.56	26.68	34.60	6.50	3	2	60	63	4	6	1.0	8.24		.38						
10/3 3 0835	5	22.31	26.70	34.30	6.60	2	4	50	52	4	7	<0.5	8.26	0.046	.48		22	7	<1	15-20 KTS NE	2 FT E
	15	22.25	26.70	34.26	6.55	3	4	60	63	4	8	1.0	8.25		.48						
	30	22.49	26.60	34.50	6.50	4	6	60	64	4	8	1.0	8.25		.40						
10/3 4 0905	5	21.96	26.65	33.82	6.55	3	4	50	53	3	6	<0.5	8.26	0.020	.34		28	27	<1	15-20 KTS NE	2 FT E
	30	22.25	26.68	34.22	6.45	2	2	60	62	3	5	<0.5	8.25		.40						
10/3 5 0855	5	22.20	26.62	34.13	6.55	2	3	60	62	2	5	<0.5	8.24		.43		27	5	<1	15-20 KTS NE	2 FT E
	30	22.38	26.70	34.40	6.50	2	3	50	52	3	5	0.5	8.25		.52						
10/3 6 0840	5	22.08	26.70	34.00	6.60	3	3	60	63	3	5	<0.5	8.25	0.023	.28		27	12	1	15-20 KTS NE	2 FT E
	15	22.31	26.70	34.30	6.60	2	2	50	52	3	5	<0.5	8.25		.40						
	30	22.41	26.69	34.43	6.50	2	3	60	62	3	6	1.0	8.25		.36						
10/3 7 0930	5	22.15	26.73	34.10	6.55	2	3	60	62	4	6	0.5	8.24	0.040	.38		23	14	<1	15-20 KTS NE	2 FT E
	30	22.09	25.70	33.60	6.60	3	3	60	63	4	6	0.5	8.23		.54						
10/4 8 0925	5	22.49	26.60	34.50	6.40	3	4	70	73	3	8	<0.5	8.24	0.017	.36		29			3-5 KTS NE	1-2 FT E
	30	22.46	25.98	34.28	6.45	2	4	80	82	4	9	1.0	8.25		.40						
10/4 9 0835	5	22.45	26.60	34.45	6.50	2	3	80	82	4	5	<0.5	8.25	0.030	.32		25			3-5 KTS NE	1-2 FT E
	15	22.43	26.60	34.42	6.45	2	2	60	62	3	5	1.0	8.25		.24						
	30	22.38	26.60	34.36	6.50	2	2	60	62	4	4	<0.5	8.26		.34						
10/3 10 0925	5	22.44	26.50	34.40	6.50	3	3	60	63	3	6	<0.5	8.21		.42			180	<1	15-20 KTS NE	2 FT E

* Fluorometer out of service

WATER QUALITY MONITORING PROGRAM

DIVISION OF WASTEWATER MANAGEMENT
DEPARTMENT OF PUBLIC WORKS

BARBERS POINT
DATE 1/9-10/84

STA DATE & TIME	DEPTH (meters)	DENSITY	TEMP (°C)	SALINITY (0/00)	OXYGEN (mg/l)	NITROGEN (µg/l) NITRATE+NITRITE	AMMONIA	KJELDAHL	TOTAL	PHOSPHORUS (µg/l) ORTHO-PHOSPHATE	TOTAL	SS (mg/l)	PH	LIGHT EXT. COEF (K)	TURBIDITY (NTU)	CHLORO-PHYLL a (µg/l)	SECCHI DEPTH (meters)	COLIFORM (No/100ml) TOTAL	FECAL	WIND VEL & DIR	SEA HT & DIR
1 1/9	5	23.23	24.77	34.73	7.05	<1	3	70	70	1	4	1	8.18	0.061	.60	.06	20	110	16	3-5 kts E	1-2 ft E
	30	23.23	23.88	34.38	7.00	<1	2	80	80	2	4	1	8.18		.52	.04					
2 1/10	5	23.04	24.82	34.50	7.00	<1	2	70	70	2	4	1	8.19	0.015	.28	.04	30			3-5 kts NE	1 ft E
	30	23.13	24.88	34.65	6.95	<1	2	90	90	2	4	1	8.19		.30	.07					
3 1/9	5	22.87	24.70	34.23	7.00	<1	1	90	.90	2	4	1	8.18	0.023	.36	.17	27	2	<1	3-5 kts E	1-2 ft E
	15	22.94	24.90	34.40	7.00	<1	2	90	90	1	3	1	8.19		.44	.06					
	30	22.92	24.85	34.35	7.00	<1	2	100	100	1	3	1	8.19		.32	.06					
4 1/9	5	22.88	24.65	34.72	6.95	<1	2	80	80	2	4	2	8.19	0.025	.50	.26	30	3	<1	3-5 kts E	1-2 ft E
	30	22.97	24.86	34.42	6.95	<1	1	70	70	1	3	1	8.19		.32	.08					
5 1/9	5	22.84	24.72	34.20	6.95	<1	1	70	70	2	5	1	8.19	0.015	.46	.23	30	3	<1	3-5 kts E	1-2 ft E
	30	23.01	24.92	34.50	6.95	<1	1	70.	70	1.	4	1	8.20		.48	.08					
6 1/9	5	22.76	24.80	34.12	6.95	1	2	80	81	2	5	1	8.20	0.030	.24	.04	25	1	1	3-5 kts E	1-2 ft E
	15	22.81	24.95	34.25	6.95	<1	1	90	90	1.	4	1	8.20		.42	.07					
	30	22.83	24.88	34.35	7.00	1	9	130	131	-	5	1	8.20		.34	.10					
7 1/9	5	22.82	24.80	34.20	7.10	<1	2	90	90	2	5	1	8.19	0.023	.42	.21	27	<1	<1	3-5 kts E	1-2 ft E
	30	22.86	24.90	34.30	7.00	<1	2	100	100	1	3	1	8.20		.32	.12					
8 1/10	5	22.90	24.86	34.33	7.00	1	2	90	91	2	4	1	8.19	0.007	.20	.04	35			3-5 kts NE	1 ft E
	30	23.04	24.76	34.49	6.95	<1	3	100	100	2	4	1	8.19		.24	.08					
9 1/10	5	22.92	24.92	34.38	7.05	<1	2	110	110	2	4	1	8.20	0.015	.14	.03	30			3-5 kts NE	1 ft E
	15	22.87	24.87	34.30	7.00	1	2	100	102	1	4	1	8.20		.22	.07					
	30	23.00	24.71	34.40	6.95	<1	3	110	110	1	3	1	8.20		.26	.04					
10 1/9	5	22.74	24.54	34.00	6.80	<1	3	110	110	6	6	1	8.18	0.326	.80	.04	6 (BOT)	<1	<1	3-5 kts E	1-2 ft E

WATER QUALITY 4-25-83

WATER QUALITY MONITORING PROGRAM

DIVISION OF WASTEWATER MANAGEMENT
DEPARTMENT OF PUBLIC WORKS

BARBERS POINT
DATE 4/5-6/84

STA DATE & TIME	DEPTH (meters)	DENSITY	TEMP (°C)	SALINITY (0/00)	OXYGEN (mg/l)	NITROGEN (µg/l) NITRATE+NITRITE	AMMONIA	KJELDAHL	TOTAL	PHOSPHORUS (µg/l) ORTHO-PHOSPHATE	TOTAL	SS (mg/l)	PH	LIGHT EXT. COEF (K)	TURBIDITY (NTU)	CHLORO-PHYLL a (µg/l)	SECCHI DEPTH (meters)	COLIFORM (No/100ml) TOTAL	FECAL	WIND VEL & DIR	SEA HT & DIR
0750 1 4/5	5	22.47	24.76	33.73	6.40	<1	3	70	70	3	8	<1.0	8.22	0.015	.44	.06	30	<1	<1	15-20 KTS E	3-4 FT E
	30	22.69	24.84	34.05	6.40	<1	2	80	80	3	8	<1.0	8.22		.28	.07					
0805 2 4/6	5	22.88	24.83	34.30	6.40	<1	4	80	80	2	7	<1.0	8.18	0.030	.24	.05	25			15-20 KTS NE	3-4 FT E
	30	22.88	24.83	34.30	6.35	<1	3	60	60	2	7	<1.0	8.19		.23	.05					
3 4/5	5	22.90	24.98	34.38	6.40	1	10	90	91	2	7	<1.0	8.22	0.040	.78	.05	23	740	76	15-20 KTS E	3-4 FT E
	15	22.85	24.94	34.30	6.35	<1	3	80	80	3	8	<1.0	8.22		.42	.09					
	30	22.87	24.92	34.32	6.35	<1	2	90	90	3	7	<1.0	8.22		.36	.10					
4 4/5	5	22.82	24.90	34.25	6.30	<1	2	90	90	3	8	<1.0	8.22	0.040	.28	.07	23	<1	<1	15-20 KTS E	3-4 FT E
	30	22.74	24.92	34.15	6.30	<1	2	80	80	3	8	<1.0	8.22		.49	.09					
5 4/5	5	22.87	24.84	34.28	6.35	<1	2	60	60	3	8	<1.0	8.23	0.030	.42	.07	25	<1	<1	15-20 KTS E	3-4 FT E
	30	22.80	24.82	34.18	6.35	<1	2	80	80	3	8	1.0	8.22		.52	.09					
6 4/5	5	22.88	24.90	34.32	6.40	<1	2	70	70	3	8	<1.0	8.22	0.040	.20	.04	23	<1	<1	15-20 KTS E	3-4 FT E
	15	22.86	24.90	34.30	6.40	<1	2	70	70	2	8	<1.0	8.21		.22	.02					
	30	22.86	24.90	34.30	6.35	<1	2	70	70	3	8	<1.0	8.21		.36	.04					
7 4/5	5	22.82	24.90	34.24	6.40	<1	2	50	50	2	8	<1.0	8.20	0.046	.25	.04	22	<1	<1	15-20 KTS E	3-4 FT E
	30	22.89	24.90	34.33	6.35	<1	2	60	60	3	8	1.0	8.20		.42	.04					
8 4/6	5	22.95	24.78	34.37	6.30	<1	3	60	60	3	8	1.0	8.20	0.030	.54	.04	25			15-20 KTS NE	3-4 FT E
	30	22.94	24.82	34.37	6.35	<1	3	70	70	3	9	<1.0	8.20		.24	.07					
9 4/6	5	22.85	24.88	34.28	6.35	<1	3	70	70	3	8	1.0	8.20	0.040	.64	.08	23			15-20 KTS NE	3-4 FT E
	15	22.83	24.97	34.28	6.40	<1	3	80	80	3	8	<1.0	8.21		.27	.09					
	30	22.84	24.89	34.27	6.35	<1	2	80	80	3	6	1.0	8.21		.56	.09					
10 4/5	5	23.00	24.00	34.12	6.05	<1	4	70	70	7	14	3.3	8.19	0.375	1.10	.09	7	8	<1	15-20 KTS E	3-4 FT E

WATER QUALITY 4-25-83

WATER QUALITY MONITORING PROGRAM

DIVISION OF WASTEWATER MANAGEMENT
DEPARTMENT OF PUBLIC WORKS

BARBERS POINT
DATE 9/4-5/84

STA DATE & TIME	DEPTH (meters)	DENSITY	TEMP. (°C)	SALINITY (0/00)	OXYGEN (mg/l)	NITROGEN (µg/l) Nitrate+Nitrite	Ammonia	Kjeldahl	Total	PHOSPHORUS (µg/l) Ortho-Phosphate	Total	SS (mg/l)	pH	LIGHT EXT. COEF (k)	TURBIDITY (NTU)	CHLORO-PHYLL a (µg/l)	SECCHI DEPTH (meters)	COLIFORM (No./100ml) Total	Fecal	WIND VEL & DIR	SEA HGT & DIR
1 9/4	S	21.97	26.92	33.95	6.30	<1	4	50	50	2	8	<1	8.26	0.063	0.21	.12	19.8	1	<1	3-5 KT.NE	1' E
	30	21.93	26.70	33.80	6.30	<1	5	80	80	3	9	<1	8.25		0.24	.08					
2 9/5	S	21.92	27.16	33.98	6.50	<1	7	60	60	2	8	<1	8.26	0.027	0.26	.06	25.9			•	1-2' E
	30	21.97	26.94	33.96	6.35	<1	6	60	60	3	9	1	8.28		0.32	.09					
3 9/4	S	21.81	26.98	33.76	6.40	<1	5	40	40	3	8	1	8.26	0.033	0.20	.14	24.4	1	<1	•	1' E
	15	21.93	26.75	33.82	6.50	1	7	60	61	3	8	<1	8.26		0.18	.08					
	30	21.96	26.40	33.72	6.60	<1	3	50	50	3	8	1.5	8.26		0.16	.10					
4 9/4	S	21.86	26.98	33.83	6.35	<1	5	40	40	4	9	<1	8.26	0.041	0.18	.22	22.9	<1	<1	•	1' E
	30	22.01	26.43	33.80	6.40	<1	8	40	40	3	8	1.5	8.26		.18	.07					
5 9/4	S	21.77	26.58	33.70	6.20	<1	6	30	30	4	9	<1	8.26	0.051	0.20	.16	21.3	<1	<1	•	1' E
	30	21.81	26.85	33.71	6.45	<1	6	50	50	4	9	1.5	8.27		0.27	.08					
6 9/4	S	21.79	27.08	33.75	6.25	<1	9	30	30	4	9	<1	8.26	0.063	0.18	.10	19.8	1	<1	•	1' E
	15	21.90	26.33	33.83	6.40	<1	6	50	50	2	8	<1	8.26		0.17	.09					
	30	21.90	26.33	33.60	6.55	<1	6	80	80	3	9	1	8.26		0.15	.09					
7 9/4	S	21.80	27.00	33.76	6.30	<1	6	90	90	3	10	1	8.26	0.051	0.17	.12	21.3	<1	<1	•	1'E
	30	21.88	26.42	33.42	6.50	<1	7	80	80	2	9	<1	8.26		0.16	.07					
8 9/5	S	21.62	27.10	33.55	6.50	<1	3	60	60	2	9	1	8.28	0.041	0.28	.06	22.9			•	1-2' E
	30	21.68	26.85	33.53	6.55	1	4	100	101	2	10	1	8.28		0.22	.09					
9 9/5	S	21.82	27.04	33.80	6.50	<1	6	60	60	2	9	<1	8.28	0.041	0.22	.07	22.9			•	1-2' E
	15	21.76	27.06	33.72	6.60	<1	2	10	10	2	9	<1	8.28		0.28	.02					
	30	21.76	26.82	33.63	6.50	<1	4	100	100	2	10	1	8.28		0.24	.08					
10 9/4	S	21.78	27.04	33.75	6.30	<1	9	80	80	3	10	<1	8.75	0.426	0.22	.24	6.1 Bottom	<1	<1	•	1' E

WATER QUALITY 4-26-83

WATER QUALITY MONITORING PROGRAM

DIVISION OF WASTEWATER MANAGEMENT
DEPARTMENT OF PUBLIC WORKS

BARBERS POINT
DATE 10/5 & 10/9/84

STA DATE & TIME	DEPTH (meters)	DENSITY	TEMP (°C)	SALINITY (0/00)	OXYGEN (mg/l)	NITROGEN (µg/l) Nitrate+Nitrite	Ammonia	Kjeldahl	Total	PHOSPHORUS (µg/l) Ortho-Phosphate	Total	SS (mg/l)	pH	LIGHT EXT. COEF (k)	TURBIDITY (NTU)	CHLORO-PHYLL a (µg/l)	SECCHI DEPTH (meters)	COLIFORM (No./100ml) Total	Fecal	WIND VEL & DIR	SEA HGT & DIR
1 10/5	S	21.85	27.15	33.88	5.90	1	6	50	51	11	11	1	8.19	0.061	0.58	0.18	20	<1	<1	3-5 KTS VAR	1-2 FT E
	30	22.01	26.55	33.84	6.15	1	5	70	71	3	8	<1	8.19		0.46	0.17					
2	S	21.78	27.48	33.93	6.40	<1	4	50	50	1	7	<1	8.23	0.030	0.50	0.05	25		•	10-15 KTS E	3-4 FT E
	30	21.80	27.35	33.90	6.35	<1	5	80	80	2	8	<1	8.18		0.34	0.06					
3 10/5	S	21.26	27.12	33.88	6.20	<1	2	60	60	2	7	<1	8.21	0.01	0.38	0.06	33	8	3	3-5 KTS VAR	1-2 FT E
	15	21.95	26.82	33.88	6.15	<1	6	90	90	2	8	<1	8.22		0.22	0.07					
	30	22.12	26.52	33.98	6.10	1	30	100	101	9	18	<1	8.22		0.46	0.09					
4 10/5	S	21.85	27.18	33.90	6.20	<1	4	100	100	2	9	<1	8.22	0.004	0.28	0.05	39	<1	<1	3-5 KTS VAR	1-2 FT E
	30	21.96	26.62	33.80	6.20	<1	5	70	70	2	10	<1	8.22		0.38	0.20					
5 10/5	S	21.84	27.22	33.90	6.25	<1	7	50	50	2	8	<1	8.22	0.007	0.40	0.05	35	<1	<1	3-5 KTS VAR	1-2 FT E
	30	21.93	26.70	33.80	6.20	<1	4	40	40	1	7	<1	8.23		0.36	0.10					
6 10/5	S	21.83	27.15	33.86	6.20	<1	4	60	60	1	8	1	8.24	0.01	0.52	0.07	33	<1	<1	3-5 KTS VAR	1-2 FT E
	15	21.87	26.88	33.80	6.20	<1	8	70	70	1	7	1	8.24		0.30	0.06					
	30	21.96	26.50	33.75	6.15	<1	6	70	70	3	8	<1	8.24		0.32	0.17					
7 10/5	S	21.82	27.05	33.80	6.20	1	8	60	61	1	7	<1	8.23	0.004	0.40	0.05	40	<1	<1	3-5 KTS VAR	1-2 FT E
	30	21.93	26.50	33.72	6.15	<1	5	40	40	2	8	2	8.24		0.48	0.10					
8	S	21.66	27.42	33.74	6.40	<1	4	90	90	1	8	<1	8.23	0.01	0.48	0.06	33			10-15 KTS E	3-4 FT E
	30	21.77	27.30	33.84	6.35	<1	6	60	60	2	8	<1	8.24		0.55	0.10					
9	S	21.78	27.42	33.90	6.40	1	8	100	101	26	57	1	8.24	0.03	1.10	0.07	25		•	10-15 KTS E	3-4 FT E
	15	21.74	27.36	33.83	6.40	<1	6	70	70	2	7	1	8.25		0.46	0.07					
	30	21.81	27.35	33.92	6.40	<1	8	70	70	1	8	<1	8.24		0.50	0.09					
10 10/5	S	21.88	27.05	33.88	5.90	<1	4	60	60	2	7	<1	8.24	0.375	0.58	0.11	7 Bottom	<1	<1	3-5 KTS VAR	1-2 FT E

WATER QUALITY 4-26-83

WATER QUALITY MONITORING PROGRAM

DIVISION OF WASTEWATER MANAGEMENT
DEPARTMENT OF PUBLIC WORKS

BARBERS POINT
DATE 2/13-14/85

STA DATE & TIME	DEPTH (meters)	DENSITY	TEMP (°C)	SALINITY (0/00)	OXYGEN (mg/l)	NITROGEN (µg/l) NITRATE+NITRITE	AMMONIA	KJELDAHL	TOTAL	PHOSPHORUS (µg/l) ORTHO-PHOSPHATE	TOTAL	SS (mg/l)	PH	LIGHT EXT. COEF (K)	TURBIDITY (NTU)	CHLOROPHYLL a (µg/l)	SECCHI DEPTH (meters)	COLIFORM (No/100ml) TOTAL	FECAL	WIND VEL & DIR	SEA HGT & DIR
1 2/13	S	22.48	24.22	33.53	6.85	2	6	60	60	4	9	<1.0	8.08		.80	.31	18	<1	<1	3-5KTS N	1-2 FT E
	30	23.18	24.00	34.36	6.75	1	5	90	91	2	7	<1.0	8.11		.46	.06					
2 2/14	S	22.52	24.03	33.50	6.80	<1	6	50	50	3	7	<1.0	8.20		.24	.10	20			3-5 KTS NNE	1-2 FT E
	30	22.48	23.92	33.40	6.75	1	6	70	71	3	7	<1.0	8.20		.38	.09					
3 2/13	S	22.44	24.01	33.39	6.85	1	4	60	62	2	8	<1.0	8.09		.44	.15	15	2	<1	5-10 KTS N	1-2 FT E
	15	22.43	24.01	33.38	6.85	<1	5	80	80	2	8	<1.0	8.10		.68	.10					
	30	22.61	23.86	33.56	6.75	2	11	70	72	4	10	<1.0	8.10		.50	.15					
4 2/13	S	22.31	24.10	33.25	6.85	1	9	90	91	3	8	<1.0	8.10		1.00	.17	15	1	<1	•	•
	30	22.33	23.85	33.38	6.70	2	20	120	122	11	17	<1.0	8.10		.86	.09					
5 2/13	S	22.30	24.10	33.24	6.80	2	9	80	82	3	8	<1.0	8.11		.88	.12	18	1	<1	•	•
	30	22.35	23.95	38.25	6.70	2	20	90	92	2	7	<1.0	8.11		.90	.13					
6 2/13	S	22.32	24.06	33.25	6.85	2	12	120	122	6	14	<1.0	8.09		.88	.11	17	250	89	•	•
	15	22.30	24.00	33.70	6.80	<1	12	80	80	3	8	<1.0	8.12		.62	.12					
	30	22.35	23.92	33.23	6.75	1	14	50	51	2	7	<1.0	8.11		.70	.12					
7 2/13	S	22.36	24.00	33.28	6.85	<1	13	50	50	2	7	<1.0	8.11		.64	.13	18	133	62	•	•
	30	22.28	23.94	33.15	6.75	1	18	50	51	5	13	<1.0	8.09		.74	.11					
8 2/14	S	22.43	24.08	33.40	6.75	<1	6	50	50	2	7	<1.0	8.19		.70	.07	26			3-5 KTS NNE	1-2 FT E
	30	22.44	23.98	33.38	6.70	<1	10	50	50	2	7	<1.0	8.16		.42	.13					
9 2/14	S	21.98	24.10	32.82	6.75	<1	11	70	70	3	7	<1.0	8.16		.35	.07	26			•	•
	15	21.81	24.06	32.57	6.70	<1	13	60	60	2	7	<1.0	8.17		.26	.07					
	30	22.49	23.95	33.43	6.70	<1	13	70	70	3	7	<1.0	8.14		.46	.06					
10 2/13	S	22.30	24.02	33.21	6.65	2	13	80	82	4	9	<1.0	8.08		.86	.26	8 (bottom)	2	1	5-10 KTS N	1-2 FT E

WATER QUALITY 4-26-83

WATER QUALITY MONITORING PROGRAM

DIVISION OF WASTEWATER MANAGEMENT
DEPARTMENT OF PUBLIC WORKS

BARBERS POINT
DATE 4/8 - 9/85

STA DATE & TIME	DEPTH (meters)	DENSITY	TEMP (°C)	SALINITY (0/00)	OXYGEN (mg/l)	NITROGEN (µg/l) NITRATE+NITRITE	AMMONIA	KJELDAHL	TOTAL	PHOSPHORUS (µg/l) ORTHO-PHOSPHATE	TOTAL	SS (mg/l)	PH	LIGHT EXT. COEF (K)	TURBIDITY (NTU)	CHLOROPHYLL a (µg/l)	SECCHI DEPTH (meters)	COLIFORM (No/100ml) TOTAL	FECAL	WIND VEL & DIR	SEA HGT & DIR
1	S	22.59	23.62	33.44	6.65	1	4	90	91	3	8	<1.0	8.22	0.035	.29	.04	24	<1	<1	5-8 KTS NE	1-2 FT E
	30	22.43	23.55	33.20	6.70	2	4	80	82	3	7	<1.0	8.22		.31	.09					
2	S	22.72	23.45	33.54	6.65	1	3	80	81	4	8	<1.0	8.20	0.023	.27	.04	27			3-5 KTS NE	1-2 FT E
	30	22.57	23.51	33.37	6.65	<1	3	80	80	4	9	<1.0	8.20		.30	.07					
3	S	22.52	23.57	33.33	6.80	<1	4	70	.70	3	8	<1.0	8.22	0.026	.29	.06	26	<1	<1	5-8 KTS NE	1-2 FT E
	15	22.43	23.55	33.20	6.70	<1	4	70	70	3	7	<1.0	8.22		.50	.07					
	30	22.49	23.60	33.29	6.75	1	5	70	71.	4	7	<1.0	8.23		.58	.07					
4	S	22.50	23.56	33.30	6.75	1	3	70	71	3	8	<1.0	8.22	0.035	.44	.07	24	<1	<1	5-8 KTS NE	1-2 FT E
	30	22.47	23.56	33.25	3.70	1	3	90	91	3	6	<1.0	8.22		.48	.08					
5	S	22.50	22.57	33.30	6.75	2	3	70	72	3	7	<1.0	8.23	0.026	.90	.08	26	<1	<1	5-8 KTS NE	1-2 FT E
	30	22.54	23.63	33.37	6.75	1	4	70	71	3	8	<1.0	8.23		1.00	.09					
6	S	22.48	23.57	33.27	6.70	2	4	80	82	3	8	<1.0	8.23	0.023	.44	.02	27	<1	<1	5-8 KTS NE	1-2 FT E
	15	22.50	23.58	33.30	6.70	2	3	80	82	3	6	<1.0	8.22		.34	.05					
	30	22.45	23.58	33.24	6.70	1	3	90	91	4	7	<1.0	8.22		.36	.06					
7	S	22.51	23.55	33.30	6.75	4	8	120	124	21	37	<1.0	8.23	0.053	.60	.09	21	960	136	5-8 KTS NE	1-2 FT E
	30	22.66	23.60	33.52	6.70	1	4	70	71	3	8	<1.0	8.22		.16	.09					
8	S	22.71	23.45	33.53	6.55	2	6	70	72	3	8	<1.0	8.20	0.023	.50	.02	27			3-5 KTS NE	1-2 FT E
	30	22.56	23.49	33.35	6.60	2	5	90	92	4	8	<1.0	8.21		.76	.08					
9	S	22.61	23.46	33.40	6.60	1	4	80	81	3	9	<1.0	8.19	0.023	.19	.03	27			3-5 KTS NE	1-2 FT E
	15	22.66	23.51	33.48	6.60	1	5	70	71	3	8	<1.0	8.19		.06	.03					
	30	22.62	23.44	33.41	4.55	2	8	80	82	3	6	<1.0	8.20		.26	.07					
10	S	22.54	23.45	33.30	6.55	1	5	80	81	3	7	<1.0	8.22	0.284	.48	.05	9	<1	<1	5-8 KTS NE	1-2 FT E

WATER QUALITY 4-26-83

WATER QUALITY MONITORING PROGRAM

DIVISION OF WASTEWATER MANAGEMENT
DEPARTMENT OF PUBLIC WORKS

BARBERS POINT
DATE 7-3,5-85

STA DATE & TIME	DEPTH (meters)	DENSITY	TEMP (°C)	SALINITY (0/00)	OXYGEN (mg/l)	NITROGEN (ug/l) NITRATE + NITRITE	AMMONIA	KJELDAHL	TOTAL	PHOSPHORUS (ug/l) ORTHO-PHOSPHATE	TOTAL	SS (mg/l)	PH	LIGHT EXT. COEF (K)	TURBIDITY (NTU)	CHLOROPHYLL a (ug/l)	SECCHI DEPTH (meters)	COLIFORM (No/100ml) TOTAL	FECAL	WIND VEL & DIR	SEA HGT & DIR
1	S	21.85	26.00	33.40	6.25	1	4	100	101	6	10	<1	8.26	0.093	.30	.04	17	<1	<1	10-15 KTS NE	2 FT S
	30	22.28	24.33	33.30	6.30	2	6	80	82	5	11	<1	8.27		.62	.14					
2	S	21.89	25.90	33.41	6.45	1	1	80	81	5	10	<1	8.22	0.026	.20	.08	26			"	1-2 FT E
	30	21.88	25.76	33.35	6.40	1	1	90	91	6	10	<1	8.22		.22	.06					
3	S	21.76	26.05	33.30	6.20	1	4	70	71	5	10	<1	8.26	0.040	.30	.07	23	<1	<1	"	2 FT S
	15	21.79	25.83	33.25	6.20	1	4	90	91	5	10	<1	8.26		.42	.30					
	30	21.96	25.26	33.25	6.30	1	5	60	61	4	10	<1	8.26		.36	.23					
4	S	21.78	25.98	33.30	6.20	1	2	100	101	4	10	1	8.27	0.080	.38	.20	18	<1	<1	"	"
	30	22.17	25.05	33.44	6.30	1	4	90	91	5	19	1	8.26		.30	.17					
5	S	21.82	26.04	33.38	6.15	1	2	100	101	4	10	1	8.27	0.053	.26	.04	21	<1	<1	"	"
	30	22.17	24.63	33.78	6.15	1	4	90	91	4	10	<1	8.27		.28	.26					
6	S	21.79	26.06	33.35	6.10	1	1	90	91	4	9	<1	8.27	0.053	.22	.06	21	<1	<1	"	"
	15	21.90	25.66	33.33	6.10	<1	3	90	90	5	10	<1	8.27		.32	.11					
	30	22.18	24.75	33.33	6.20	1	1	100	101	4	11	<1	8.27		.32	.27					
7	S	21.75	26.06	33.30	5.90	1	4	80	81	5	10	<1	8.27	0.080	.34	.22	18	<1	<1	"	"
	30	22.15	24.80	33.32	5.90	1	4	60	61	4	10	<1	8.27		.38	.17					
8	S	21.85	25.98	33.40	6.20	<1	1	60	60	4	9	<1	8.22	0.011	.22	.05	32			"	1-2 FT E
	30	21.79	25.82	33.25	6.20	<1	3	80	80	6	10	<1	8.22		.28	.07					
9	S	21.80	25.98	33.33	6.00	1	1	50	51	4	10	<1	8.23	0.023	.28	.03	27			"	1-2 FT E
	15	21.83	25.85	33.31	6.00	<1	1	60	60	4	10	<1	8.23		.32	.03					
	30	22.02	25.70	33.50	5.95	1	1	90	91	4	9	<1	8.23		.26	.06					
10	S	21.72	26.04	33.24	5.70	1	2	120	122	5	11	1	8.27	0.261	.62	.56	9.6 bottom	1	<1	"	2 FT S

WATER QUALITY 4-26-83

WATER QUALITY MONITORING PROGRAM

DIVISION OF WASTEWATER MANAGEMENT
DEPARTMENT OF PUBLIC WORKS

BARBERS POINT
DATE 10/15-10/16/85

STA DATE & TIME	DEPTH (meters)	DENSITY	TEMP. (°C)	SALINITY (0/00)	OXYGEN (mg/l)	NITROGEN (ug/l) NITRATE + NITRITE	AMMONIA	KJELDAHL	TOTAL	PHOSPHORUS (ug/l) ORTHO-PHOSPHATE	TOTAL	SS (mg/l)	PH	LIGHT EXT. COEF (K)	TURBIDITY (NTU)	CHLOROPHYLL a (ug/l)	SECCHI DEPTH (meters)	COLIFORM (No/100ml) TOTAL	FECAL	WIND VEL & DIR	SEA HGT & DIR
10/15 1 0820	5	22.50	26.24	34.37	6.10	<1	6	60	60	5	11	<1	8.00	0.063	.58	.22	19.8	4	<1	5-10 kts N	1-2 ft. E
	30	22.87	25.11	34.40	6.70	<1	5	70	70	3	9	1	8.00		.62	.20					
10/16 2 0805	5	22.63	26.28	34.56	6.35	<1	6	50	50	5	9	<1	8.10	0.011	.30	.06	32.0			0-3 kts N	1 ft. from E
	30	22.47	26.30	34.35	6.30	<1	2	60	60	4	9	<1	8.12		.40	.06					
10/15 3 0850	5	22.48	26.40	34.40	6.40	<1	5	60	60	4	10	1	8.02	0.033	.44	.11	24.4	2	<1	5-10 kts N	1-2 ft. E
	15	22.40	26.32	34.27	6.40	<1	5	80	80	4	10	<1	8.01		.42	.22					
	30	22.47	26.24	34.32	6.45	<1	4	70	70	3	9	<1	8.02		.48	.18					
10/15 4 0910	5	22.39	26.40	34.28	6.50	<1	5	60	60	4	9	<1	8.07	0.033	.32	.13	24.4	<1	<1	3-5 kts E	1-2 ft. E
	30	22.49	26.20	34.34	6.50	<1	5	90	90	5	11	<1	8.06		.44	.20					
10/15 5 0905	5	22.39	26.38	34.28	6.50	<1	3	60	60	4	10	<1	8.07	0.033	.40	.12	24.4	1	1	3-5 kts E	1-2 ft. E
	30	22.17	26.25	35.26	6.50	<1	5	70	70	4	9	1	8.10		.88	.18					
10/15 6 0900	5	22.43	26.30	34.30	6.45	<1	5	70	70	4	9	2	8.13	0.033	.46	.10	24.4	<1	<1	3-5 kts E	1-2 ft. E
	15	22.42	26.40	34.33	6.45	<1	5	100	100	4	8	1	8.13		.52	.13					
	30	22.52	26.25	34.40	6.50	<1	5	80	80	5	10	<1	8.14		.88	.13					
10/15 7 0925	5	22.38	26.45	34.30	6.50	<1	5	70	70	5	10	1	8.14	0.027	.43	.10	25.9	<1	<1	3-5 kts E	1-2 ft. E
	30	22.55	26.15	34.39	6.45	<1	5	70	70	5	10	1	8.14		.49	.22					
10/16 8 0815	5	22.42	26.34	34.30	6.30	<1	2	80	80	4	9	<1	8.15	0.014	.45	.08	30.5			0-3 kts N	1 ft. from E
	30	22.45	26.25	34.30	6.40	<1	4	70	70	4	9	<1	8.18		.41	.07					
10/16 9 0825	5	22.46	26.45	34.40	6.40	<1	4	70	70	4	10	<1	8.18	0.014	.36	.10	30.5			0-3 kts N	1 ft. from E
	15	22.46	26.42	34.39	6.40	<1	5	90	90	4	9	<1	8.18		.40	.08					
	30	22.46	26.30	34.34	5.35	<1	4	90	90	4	8	<1	8.18		.55	.08					
10/15 10 0940	5	22.39	26.44	34.30	5.10	<1	5	90	90	7	16	2	8.16	0.276	.96	.21	9.2 (bottom)	<1	<1	3-5 kts N	1-2 ft. E

WATER QUALITY 4-26-83

WATER QUALITY MONITORING PROGRAM

DIVISION OF WASTEWATER MANAGEMENT
DEPARTMENT OF PUBLIC WORKS

BARBERS POINT
DATE 2/24-25/86

STA DATE & TIME	DEPTH (meters)	DENSITY	TEMP (°C)	SALINITY (0/00)	OXYGEN (mg/l)	NITROGEN (µg/l) NITRATE + NITRITE	AMMONIA	KJELDAHL	TOTAL	PHOSPHORUS (µg/l) ORTHO-PHOSPHATE	TOTAL	SS (mg/l)	PH	LIGHT EXT COEF (k)	TURBIDITY (NTU)	CHLORO-PHYLL a (µg/l)	SECCHI DEPTH (meters)	COLIFORM (no/100ml) TOTAL	FECAL	WIND VEL & DIR	SEA HGT & DIR
2-24 1 0810	5	23.13	23.72	34.19	6.10	<1	1	90	90	5	12	<1	8.13	0.214	.62	.97	11	3	<1	0-3 kts Variable	1-2 ft. S
	30	23.16	23.66	34.21	6.25	<1	1	80	80	3	7	<1	8.15		.32	.20					
2-25 2 0845	5	23.35	24.18	34.46	6.55	<1	2	80	80	3	6	<1	8.20	0.284	.36	.12	9			15 kts SSW	2-4 ft. S
	30	23.29	24.18	34.58	6.55	<1	1	80	80	3	6	<1	8.21		.42	.18					
2-24 3 0840	5	23.05	24.05	34.26	6.20	<1	2	120	120	3	9	<1	8.15	0.432	1.10	.21	6	9	<1	0-3 kts Variable	1-2 ft. S
	15	23.06	24.02	34.21	6.30	<1	2	90	90	4	10	<1	8.15		.78	.24					
	30	23.19	23.76	34.28	6.25	<1	5	110	110	6	12	<1	8.15		.72	.19					
2-24 4 0900	5	23.20	23.96	34.37	6.35	<1	3	100	100	5	9	<1	8.17	0.432	1.08	.22	6	6	<1	0-3 kts Variable	1-2 ft. S
	30	23.18	23.86	34.31	6.10	<1	5	130	130	6	8	<1	8.17		.44	.12					
2-24 5 0915	5	23.22	23.98	34.41	6.40	<1	2	90	90	4	7	<1	8.17	0.326	.82	.17	8	2	1	0-3 kts Variable	1-2 ft. S
	30	23.24	23.89	34.40	6.15	<1	3	90	90	4	7	<1	8.17		.46	.10					
2-24 6 0930	5	23.08	24.06	34.26	6.25	<1	2	120	120	6	13	<1	8.18	0.326	.78	.19	8	2	<1	0-3 kts Variable	1-2 ft. S
	15	23.16	24.04	34.36	6.15	<1	2	90	90	4	6	<1	8.17		.64	.10					
	30	23.25	23.79	34.38	5.95	<1	3	80	80	5	10	<1	8.17		.36	.12					
2-24 7 0950	5	23.10	24.11	34.30	6.40	<1	3	80	80	4	6	<1	8.18	0.432	11.00	.18	6	3	<1	0-3 kts Variable	1-2 ft. S
	30	23.18	23.71	34.25	6.15	3	10	130	133	11	14	2	8.18		.44	.13					
2-25 8 0915	5	23.27	24.16	34.55	6.40	1	2	80	81	3	7	<1	8.20	0.186	.28	.22	12			15 kts SSW	2-4 ft. S
	30	23.44	23.86	34.66	6.55	<1	3	80	80	3	7	<1	8.20		.36	.10					
2-25 9 0945	5	23.29	24.12	34.56	6.50	<1	3	90	90	3	6	<1	8.21	0.122	.25	.07	15			15 kts SSW	2-4 ft. S
	15	23.18	24.25	34.46	6.55	<1	3	90	90	3	7	<1	8.22		.22	.07					
	30	23.30	24.10	34.56	6.55	<1	3	80	80	3	7	<1	8.21		.30	.09					
2-24 10 1020	5	22.98	24.27	34.20	6.15	3	6	100	103	6	10	<1	8.18	0.326	11.50	.08	8	<1	<1	0-3 kts Variable	1-2 ft. S

WATER QUALITY 4-26-83

WATER QUALITY MONITORING PROGRAM

DIVISION OF WASTEWATER MANAGEMENT
DEPARTMENT OF PUBLIC WORKS

BARBERS POINT
DATE 4/17 & 21/86

STA DATE & TIME	DEPTH (meters)	DENSITY	TEMP (°C)	SALINITY (0/00)	OXYGEN (mg/l)	NITROGEN (µg/l) NITRATE + NITRITE	AMMONIA	KJELDAHL	TOTAL	PHOSPHORUS (µg/l) ORTHO-PHOSPHATE	TOTAL	SS (mg/l)	PH	LIGHT EXT. COEF (k)	TURBIDITY (NTU)	CHLORO-PHYLL a (µg/l)	SECCHI DEPTH (meters)	COLIFORM (no/100ml) TOTAL	FECAL	WIND VEL & DIR	SEA HGT & DIR
4/17 1 0830	5	23.37	24.23	34.70	6.80	<1	2	50	50	3	9	<1	8.30	0.073	.14	.10	18.7	<1	<1	5-10 kts. SE	2-3 ft. E
	30	23.45	23.42	34.50	6.80	1	4	60	61	3	8	<1	8.30		.34	.14					
4/21 2 0920	5	23.34	24.28	34.68	6.80	<1	4	60	60	3	8	<1	8.25	0.090	.26	.10	17.2			5-10 kts. SE	2-3 ft. E
	30	23.25	23.85	34.40	6.80	2	5	70	72	2	8	<1	8.26		.32	.09					
4/17 3 0845	5	23.46	23.80	34.66	6.80	2	2	90	92	3	9	<1	8.31	0.073	.12	.08	18.7	1	6	10-15 kts. NE	2-3 ft. E
	15	23.45	23.44	34.50	6.80	1	2	90	91	3	8	<1	8.31		.22	.10					
	30	23.58	23.25	34.60	6.70	<1	4	80	80	2	8	<1	8.31		.30	.13					
4/17 4 0855	5	23.22	23.70	34.30	6.70	2	2	80	82	3	9	<1	8.31	0.047	.10	.07	21.8	<1	<1	5-10 kts. SE	2-3 ft. E
	30	23.50	23.25	34.50	6.70	2	3	80	82	2	7	<1	8.31		.78	.12					
4/17 5 0910	5	23.43	23.65	34.56	6.70	2	3	80	82	3	8	<1	8.31	0.047	.44	.07	21.8	<1	<1	5-10 kts. SE	2-3 ft. E
	30	23.53	23.15	34.50	6.70	2	4	80	82	2	7	<1	8.32		.41	.15					
4/17 6 0925	5	23.29	23.76	34.42	6.80	<1	3	70	70	3	8	<1	8.32	0.047	.34	.07	21.8	<1	<1	5-10 kts. SE	2-3 ft. E
	15	23.46	23.25	34.42	6.80	1	4	80	81	3	7	<1	8.32		.22	.12					
	30	23.59	23.20	34.60	6.80	3	4	70	73	2	7	<1	8.32		[illegible]	[illegible]					
4/17 7 0940	5	23.28	23.75	34.40	6.80	<1	4	80	80	2	8	<1	8.32	0.038	.24	.07	20.3	<1	<1	5-10 kts. SE	2-3 ft. E
	30	23.56	23.18	34.55	6.80	<1	2	80	80	2	6	<1	8.32		.42	.10					
4/21 8 0940	5	23.18	24.36	34.50	6.75	<1	4	90	90	2	8	<1	8.28	0.113	.44	.10	15.6			10-15 kts. NE	2-3 ft. E
	30	23.68	23.42	34.80	6.80	<1	4	100	100	2	7	<1	8.28		.30	.09					
4/21 9 1000	5	23.23	24.22	34.52	6.80	<1	4	70	70	2	7	<1	8.28	0.073	.34	.07	18.7			10-15 kts. NE	2-3 ft. E
	15	23.24	24.30	34.56	6.80	<1	4	90	90	2	8	<1	8.28		.46	.10					
	30	23.36	24.10	34.64	6.80	<1	6	100	100	2	8	<1	8.29		.48	.12					
4/17 10 0955	5	23.08	24.42	34.40	6.40	<1	3	80	80	5	13	<1	8.31	0.336	.66	.15	7.8			5-10 kts. SE	2-3 ft. E

WATER QUALITY 4-26-83

WATER QUALITY MONITORING PROGRAM

DIVISION OF WASTEWATER MANAGEMENT
DEPARTMENT OF PUBLIC WORKS

BARBERS POINT
DATE 7/3 & 7/7/86

STA DATE & TIME	DEPTH (Meters)	DENSITY	TEMP (°C)	SALINITY (0/00)	OXYGEN (mg/l)	NITROGEN (µg/l) NITRATE+NITRITE	AMMONIA	KJELDAHL	TOTAL	PHOSPHORUS (µg/l) ORTHO-PHOSPHATE	TOTAL	SS (mg/l)	PH	LIGHT EXT. COEF (K)	TURBIDITY (NTU)	CHLORO-PHYLL a (µg/l)	SECCHI DEPTH (Meters)	COLIFORM (No./100ml) TOTAL	FECAL	WIND VEL & DIR	SEA HGT & DIR
0810 1 7/3	5	22.77	25.60	34.46	6.50	2	4	80	92	1	6	<1	8.22	0.122	.32	.07	15	<2	<2	10-15 kts E	2-3 ft. E
	30	22.72	25.60	34.40	6.40	<1	4	100	100	1	6	<1	8.21		.40	.07					
0840 2 7/7	5	22.08	26.76	34.02	6.55	1	3	80	81	3	6	<1	8.22	0.061	.22	.04	20	-	-	15-20 kts E	2-3 ft. Choppy
	30	22.12	26.62	34.02	6.50	<1	3	90	90	3	8	<1	8.23		.21	.05					
0840 3 7/3	5	22.67	25.72	34.38	6.50	1	3	90	91	1	10	<1	8.24	0.141	.42	.20	14	10	<2	10-15 kts E	2-3 ft. E
	15	22.61	25.73	34.30	6.50	<1	3	90	90	2	7	<1	8.24		.44	.22					
	30	22.65	25.65	34.32	6.50	2	2	80	82	2	7	<1	8.24		.54	.21					
0900 4 7/3	5	22.66	25.70	34.36	6.60	2	2	90	92	2	8	<1	8.25	0.141	.46	.22	14	12	<2	10-15 kts E	2-3 ft. E
	30	22.74	25.68	34.44	6.60	2	4	120	122	2	8	<1	8.26		.51	.22					
0920 5 7/3	5	22.69	25.70	34.40	6.50	<1	4	90	90	2	7	<1	8.26	0.122	.38	.09	15	<2	<2	10-15 kts E	2-3 ft. E
	30	22.74	25.64	34.44	6.50	3	4	90	93	2	7	<1	8.26		.42	.11					
0945 6 7/3	5	22.72	25.64	34.48	6.50	<1	3	110	110	2	6	<1	8.26	0.122	.40	.18	15	6	<2	10-15 kts E	2-3 ft. E
	15	22.75	25.66	34.46	6.55	<1	4	110	110	2	7	<1	8.26		.38	.17					
	30	22.71	25.64	34.40	6.55	<1	4	90	90	2	7	<1	8.26		.36	.20					
0950 7 7/3	5	22.75	25.70	34.48	6.50	<1	4	80	80	2	7	<1	8.25	0.141	.32	.21	14	2	<2	10-15 kts E	2-3 ft. E
	30	22.76	25.68	34.48	6.55	<1	5	100	100	2	6	<1	8.25		.44	.21					
0915 8 7/7	5	22.23	26.70	34.20	6.50	<1	2	110	110	3	7	<1	8.23	0.035	.29	.06	24	-	-	15-20 kts NE	2-3 ft. Choppy
	30	22.33	26.52	34.25	6.50	<1	2	80	80	3	8	<1	8.23		.36	.08					
0940 9 7/7	5	22.15	26.60	34.05	6.40	<1	3	70	70	2	6	<1	8.23	0.080	.36	.04	18	-	-	15-20 kts NE	2-3 ft. Choppy
	15	22.19	26.54	34.08	6.50	<1	3	110	110	5	8	<1	8.24		.32	.05					
	30	22.21	26.52	34.10	6.50	<1	3	90	90	2	7	<1	8.23		.26	.07					
1020 10 7/3	5	22.59	25.76	34.30	6.30	3	5	100	103	4	8	<1	8.25	0.214	.46	.24	11	<2	<2	10-15 kts E	2-3 ft. E

WATER QUALITY 6-26-83

WATER QUALITY MONITORING PROGRAM

DIVISION OF WASTEWATER MANAGEMENT
DEPARTMENT OF PUBLIC WORKS

BARBERS POINT
DATE 10/2-3/86

STA DATE & TIME	DEPTH (Meters)	DENSITY	TEMP (°C)	SALINITY (0/00)	OXYGEN (mg/l)	NITROGEN (µg/l) NITRATE+NITRITE	AMMONIA	KJELDAHL	TOTAL	PHOSPHORUS (µg/l) ORTHO-PHOSPHATE	TOTAL	SS (mg/l)	PH	LIGHT EXT. COEF (K)	TURBIDITY (NTU)	CHLORO-PHYLL a (µg/l)	SECCHI DEPTH (Meters)	COLIFORM (No./100ml) TOTAL	FECAL	WIND VEL & DIR	SEA HGT & DIR
10/2 1 0800	5	21.67	28.60	34.27	6.00	2	2	50	52	1	6	<1	8.23	0.095	.14	.08	16.8	<1	<1	3-5 kts Variable	1-2 ft. E
	30	21.88	27.86	34.23	6.05	1	1	60	61	2	7	<1	8.23		.16	.30					
10/3 2 0810	5	21.89	28.44	34.50	6.00	<1	2	60	60	2	7	<1	8.25	0.041	.15	.10	22.8	5	1	10-15 kts NE	2-3 ft. E
	30	21.86	28.40	34.44	6.10	<1	3	50	50	1	5	<1	8.26		.12	.06					
10/2 3 0845	5	21.57	28.70	34.18	6.00	<1	3	70	70	2	6	<1	8.25	0.023	.11	.04	26.8	<1	<1	3-5 kts Variable	1-2 ft. E
	15	21.71	28.60	34.33	6.05	1	3	70	71	1	6	<1	8.25		.11	.04					
	30	21.84	27.84	34.16	6.10	1	2	110	111	2	8	<1	8.23		.13	.12					
10/2 4 0855	5	21.71	28.40	34.33	5.90	1	2	30	31	2	7	<1	8.25	0.023	.12	.09	26.8	<1	<1	3-5 kts Variable	1-2 ft. E
	30	21.82	27.88	34.42	6.05	1	1	50	51	2	7	<1	8.24		.10	.16					
10/2 5 0905	5	21.71	28.53	34.30	5.95	1	2	60	61	2	6	<1	8.25	0.009	.16	.03	33.5	<1	<1	3-5 kts Variable	1-2 ft. E
	30	22.07	27.66	34.40	6.10	<1	2	60	60	3	7	<1	8.23		.11	.15					
10/2 6 0925	5	21.83	28.35	34.38	5.90	<1	1	70	70	2	6	<1	8.25	0.014	.10	.03	30.5	2	<1	3-5 kts Variable	1-2 ft. E
	15	21.90	28.43	34.50	6.00	1	2	70	71	2	5	<1	8.26		.12	.03					
	30	22.09	27.62	34.40	6.10	1	1	110	111	3	8	<1	8.24		.18	.14					
10/2 7 0935	5	21.83	28.40	34.40	6.00	1	2	60	61	2	6	<1	8.25	0.027	.12	.10	25.9	<1	<1	3-5 kts Variable	1-2 ft. E
	30	22.20	27.10	34.33	6.30	<1	1	50	50	3	7	<1	8.24		.08	.15					
10/3 8 0900	5	21.72	28.55	34.32	6.00	<1	3	60	60	2	6	<1	8.29	0.077	.11	.13	18.3	1	<1	10-15 kts NE	2-3 ft. E
	30	21.97	27.76	34.33	6.10	<1	2	60	60	4	7	<1	8.29		.15	.16					
10/3 9 0925	5	21.82	28.40	34.38	6.00	1	2	60	61	2	6	<1	8.29	0.041	.14	.13	22.8	<1	<1	10-15 kts NE	2-3 ft. E
	15	21.76	28.38	34.30	6.05	1	2	70	71	1	6	<1	8.27		.12	.04					
	30	22.08	28.00	34.30	6.10	<1	2	90	90	1	6	<1	8.26		.09	.04					
10/2 10 0940	5	21.37	28.78	33.95	5.80	1	2	140	140	3	6	<1	8.23	—	.17	.35	10.4 Bottom	<1	<1	3-5 kts Variable	1-2 ft. E

WATER QUALITY 6-26-83

WATER QUALITY MONITORING PROGRAM

DIVISION OF WASTEWATER MANAGEMENT
DEPARTMENT OF PUBLIC WORKS

BARBERS POINT
DATE 1/9/87-1/12/87

STA DATE & TIME	DEPTH (meters)	DENSITY	TEMP (°C)	SALINITY (0/00)	OXYGEN (mg/l)	NITROGEN (ug/l) Nitrate+Nitrite	Ammonia	Kjeldahl	Total	PHOSPHORUS (ug/l) Ortho-Phosphate	Total	SS (mg/l)	pH	LIGHT EXT COEF (k)	TURBIDITY (NTU)	CHLORO-PHYLL a (ug/l)	SECCHI DEPTH (meters)	COLIFORM (no/100ml) Fecal Strep	Fecal	WIND VEL & DIR	SEA HGT & DIR
1/9/87 1 0910	S	23.05	24.92	34.55	6.30	1	1	90	91	7	13	<1	8.32	0.119	0.16	0.14	15.2	<1	<1	0-3 kts Var	1 ft East
	30	23.34	24.90	34.93	6.30	1	1	60	61	2	8	<1	8.34		0.09	0.12					
1/12/87 2 1010	S	23.31	24.90	34.89	6.30	1	2	70	71	5	10	<1	8.25	0.035	0.06	0.04	23.9	<1	<1	20-25 kts East	3-5 ft East Choppy
	30	23.31	24.90	34.89	6.20	1	2	80	81	3	7	<1	8.29		0.07	0.05					
1/9/87 3 0945	S	23.16	25.32	34.87	7.10	2	2	60	62	2	6	<1	8.35	0.042	0.09	0.07	22.7	1	<1	0-3 kts Var	1 ft East
	15	23.26	25.10	34.91	7.10	1	1	60	61	3	7	<1	8.35		0.08	0.12					
	30	23.30	25.03	34.93	7.00	1	2	50	51	2	7	<1	8.35		0.09	0.10					
1/9/87 4 1000	S	23.22	25.20	34.89	6.85	1	2	70	71	2	7	<1	8.35	0.013	0.08	0.06	31.2	2	<1	0-3 kts Var	1 ft East
	30	23.32	25.00	34.94	6.65	1	1	60	61	2	6	<1	8.35		0.09	0.12					
1/9/87 5 1015	S	23.18	25.26	34.87	7.00	1	1	60	71	3	6	<1	8.35	0.016	0.07	0.05	29.4	<1	<1	0-3 kts Var	1 ft East
	30	23.29	24.98	34.90	6.85	1	1	50	51	3	6	<1	8.35		0.07	0.13					
1/9/87 6 1030	S	23.21	25.18	34.88	6.70	2	2	50	52	2	7	<1	8.35	0.027	0.06	0.06	25.8	<1	<1	0-3 kts Var	1 ft East
	15	23.30	25.00	34.92	6.45	1	1	50	51	3	6	<1	8.35		0.08	0.10					
	30	23.34	24.93	34.95	6.40	1	1	60	61	3	6	<1	8.35		0.08	0.16					
1/9/87 7 1045	S	23.22	25.14	34.87	6.45	1	1	50	51	3	7	<1	8.35	0.027	0.07	0.06	25.8	<1	<1	0-3 kts Var	1 ft East
	30	23.31	25.02	34.94	6.30	1	1	50	51	3	6	<1	8.35		0.07	0.15					
1/12/87 8 09[illegible]	S	23.29	24.90	34.87	6.60	1	2	70	71	3	7	<1	8.28	0.042	0.08	0.06	22.7	2	<1	20-25 kts East	3-5 ft East Choppy
	30	23.31	24.90	34.89	6.60	2	1	100	102	4	7	<1	8.29		0.06	0.07					
1/12/87 9 0934	S	23.30	24.95	34.90	6.90	1	2	90	91	3	8	<1	8.29	0.063	0.09	0.06	19.7	<1	<1	20-25 kts East	3-5 ft East Choppy
	15	23.29	24.95	34.89	6.90	2	1	90	92	3	7	<1	8.29		0.08	0.05					
	30	23.30	24.90	34.88	6.90	1	1	90	91	3	6	<1	8.30		0.07	0.06					
1/9/87 10 1100	S	23.19	25.10	34.81	6.35	3	1	50	51	5	8	<1	8.32		0.13	0.18	12.1 Bottom	<1	<1	0-3 kts Var	1 ft East

WATER QUALITY MONITORING PROGRAM

DIVISION OF WASTEWATER MANAGEMENT
DEPARTMENT OF PUBLIC WORKS

BARBERS POINT
DATE 4-7-87

STA DATE & TIME	DEPTH (meters)	DENSITY	TEMP (°C)	SALINITY (0/00)	OXYGEN (mg/l)	NITROGEN (ug/l) Nitrate+Nitrite	Ammonia	Kjeldahl	Total	PHOSPHORUS (ug/l) Ortho-Phosphate	Total	SS (mg/l)	pH	LIGHT EXT. COEF (k)	TURBIDITY (NTU)	CHLORO-PHYLL a (ug/l)	SECCHI DEPTH (meters)	COLIFORM (no/100ml) Enterococcus	Fecal	WIND VEL & DIR	SEA HGT & DIR
4-7 1 0700	S	23.19	24.18	34.45	6.70	<1	8	90	90	3	10	<1	8.06	.097	0.07	0.04	16.7	7	2	3-5 kts NE	2-3 ft East
	30	23.26	24.04	34.49	6.70	1	8	90	91	5	11	<1	8.05		0.08	0.07					
4-7 2 0730	S	23.22	24.14	34.47	6.20	<1	7	70	70	4	9	<1	8.04	.065	0.07	0.04	19.5	<1	<1	3-5 kts NE	2-3 ft East
	30	23.26	24.06	34.50	6.40	<1	6	80	80	4	9	<1	8.05		0.06	0.05					
4-7 3 0750	S	23.21	24.10	34.45	6.20	<1	7	80	80	4	13	<1	8.06	.051	0.07	0.05	21.3	3	35	3-5 kts NE	2-3 ft East
	15	23.23	24.10	34.47	6.10	<1	7	100	100	5	14	<1	8.05		0.08	0.05					
	30	23.24	24.10	34.48	6.20	<1	7	90	90	5	13	<1	8.05		0.12	0.06					
4-7 4 0800	S	23.26	24.04	34.48	6.50	<1	7	60	60	4	12	<1	8.07	.043	0.07	0.04	22.5	4	37	3-5 kts NE	2-3 ft East
	30	23.23	24.10	34.47	6.30	<1	7	70	71	5	13	<1	8.06		0.12	0.06					
4-7 5 0810	S	23.22	24.12	34.47	6.40	<1	8	80	80	6	10	<1	8.07	.011	0.07	0.04	32.0	<1	3	3-5 kts NE	2-3 ft East
	30	23.25	24.10	34.49	6.30	1	8	90	91	7	10	<1	8.08		0.08	0.06					
4-7 6 0820	S	23.24	24.12	34.49	6.35	1	6	80	81	6	11	<1	8.08	.029	0.07	0.04	25.3	9	18	3-5 kts NE	2-3 ft East
	15	23.24	24.12	34.49	6.40	1	6	90	91	4	10	<1	8.10		0.06	0.04					
	30	23.22	24.15	34.48	6.30	1	7	80	81	4	13	<1	8.08		0.08	0.04					
4-7 7 0830	S	23.23	24.10	34.47	6.40	1	6	90	91	4	7	<1	8.07	.027	0.08	0.04	25.9	2	8	3-5 kts NE	2-3 ft East
	30	23.22	24.14	34.47	6.30	1	6	90	91	5	11	<1	8.08		0.08	0.04					
4-7 8 0853	S	23.25	24.05	34.48	6.30	2	6	100	102	6	12	<1	8.07	.013	0.09	0.08	14.6	<1	<1	3-5 kts NE	2-3 ft East
	30	23.26	24.05	34.49	6.30	2	7	90	92	7	11	<1	8.07		0.06	0.08					
4-7 9 0905	S	23.24	24.10	34.48	6.35	1	7	100	101	6	10	<1	8.09	.011	0.07	0.04	32.0	18	<1	3-5 kts NE	2-3 ft East
	15	23.21	24.10	34.48	6.35	1	6	80	81	7	11	<1	8.08		0.07	0.04					
	30	23.13	24.06	34.44	6.30	1	6	100	101	6	9	<1	8.07		0.08	0.04					
4-7 10 0840	S	23.14	24.02	34.32	6.60	3	6	100	103	10	13	<1	8.07	.236	0.18	0.18	10.3	<1	<1	3-5 kts NE	2-3 ft East

WATER QUALITY MONITORING PROGRAM

DIVISION OF WASTEWATER MANAGEMENT
DEPARTMENT OF PUBLIC WORKS

BARBERS POINT
DATE 7/10/87

STA. DATE & TIME	DEPTH (meters)	DENSITY	TEMP. (°C)	SALINITY (0/00)	OXYGEN (mg/l)	NITROGEN (µg/l) NITRATE+NITRITE	AMMONIA	KJELDAHL	TOTAL	PHOSPHORUS (µg/l) ORTHO-PHOSPHATE	TOTAL	SS (mg/l)	PH	LIGHT EXT. COEF.(K)	TURBIDITY (NTU)	CHLORO-PHYLL a (µg/l)	SECCHI DEPTH (meters)	COLIFORM (no/100ml) ENTEROCOCCUS	FECAL	WIND VEL & DIR	SEA HGT & DIR
7/10 1	5	22.75	26.45	34.79	6.50	<1	1	80	80	4	10	<1	8.08		0.08	0.11	27.4	1	<1	3-5 KTS NE	2-3 FT E
0815	30	23.00	25.89	34.88	6.35	1	2	100	101	4	12	<1	8.07		0.12	0.17					
7/10 2	5	22.79	26.40	34.82	6.30	<1	1	90	90	3	10	<1	8.08		0.06	0.04	32.0	<1	<1	3-5 KTS NE	2-3 FT E
0831	30	22.86	26.12	34.80	6.10	<1	1	90	90	3	10	<1	8.07		0.09	0.04					
7/10 3	5	22.70	26.54	34.76	6.20	1	1	80	81	4	12	<1	8.06		0.08	0.09	32.0	<1	<1	3-5 KTS NE	2-3 FT E
	15	22.76	26.42	34.79	6.05	<1	1	80	80	5	13	<1	8.07		0.08	0.04					
0854	30	23.06	25.64	34.86	6.15	<1	1	80	80	3	10	<1	8.06		0.11	0.04					
						DATA ON 2nd REPORT SHEET															
7/10 6	5	22.70	26.54	34.75	6.10	<1	5	90	90	4	10	<1	8.11		0.09	0.01	38.7	<1	<1	3-5 KTS NE	2-3 FT E
	15	22.75	26.43	34.78	6.05	<1	1	80	80	4	9	<1	8.10		0.09	0.05					
0916	30	23.01	25.64	34.80	6.05	1	1	60	61	4	9	<1	8.10		0.10	0.06					
						DATA ON 2nd REPORT SHEET															
7/10 8	5	22.67	26.68	34.78	5.75	<1	2	50	50	4	8	<1	8.09		0.09	0.05	31.7	<1	<1	3-5 KTS NE	2-3 FT E
0955	30	23.05	25.62	34.84	6.15	<1	8	70	70	4	9	<1	8.09		0.09	0.08					
7/10 9	5	22.74	26.58	34.82	6.00	<1	4	100	100	4	8	<1	8.09		0.07	0.04	35.3	<1	<1	3-5 KTS NE	2-3 FT E
	15	22.78	26.40	34.80	5.90	<1	2	50	50	4	9	<1	8.10		0.08	0.05					
1008	30	22.98	25.92	34.87	5.80	<1	1	40	40	4	8	<1	8.09		0.07	0.05					
7/10 10	5	22.73	26.44	34.75	5.80	<1	1	60	60	4	9	<1	8.10		0.08	0.09	7.0	<1	<1	3-5 KTS NE	2-3 FT E
0935																					

WATER QUALITY MONITORING PROGRAM

DIVISION OF WASTEWATER MANAGEMENT
DEPARTMENT OF PUBLIC WORKS

BARBERS POINT
DATE 7/10/87

STA. DATE & TIME	DEPTH (meters)	DENSITY	TEMP. (°C)	SALINITY (0/00)	OXYGEN (mg/l)	NITROGEN (µg/l) NITRATE+NITRITE	AMMONIA	KJELDAHL	TOTAL	PHOSPHORUS (µg/l) ORTHO-PHOSPHATE	TOTAL	SS (mg/l)	PH	LIGHT EXT. COEF.(K)	TURBIDITY (NTU)	CHLORO-PHYLL a (µg/l)	SECCHI DEPTH (meters)	COLIFORM (no/100ml) ENTEROCOCCUS	FECAL	WIND VEL & DIR	SEA HGT & DIR
7/10	5	22.70	26.51	34.74	6.25	1	2	80	81	4	10	<1	8.07		0.12	0.10	38.1	<1	<1	3-5 KTS NE	2-3 FT E
4	15	22.79	26.37	34.80	6.10	<1	1	80	80	4	9	<1	8.09		0.07	0.04					
0902	30	22.89	26.10	34.82	6.10	<1	1	90	90	4	9	<1	8.07		0.08	0.06					
7/10	5	22.74	26.53	34.80	6.10	<1	1	80	80	3	9	<1	8.13		0.06	0.02	35.6	<1	<1	3-5 KTS NE	2-3 FT E
5	15	22.78	26.39	34.80	5.95	<1	1	100	100	3	9	<1	8.13		0.07	0.05					
0910	30	22.89	26.10	34.82	6.00	<1	1	70	70	3	10	<1	8.12		0.12	0.03					
7/10	5	22.73	26.44	34.75	5.95	1	1	130	131	4	8	<1	8.11		0.11	0.08	35.0	<1	<1	3-5 KTS NE	2-3 FT E
7	15	22.81	26.30	34.80	5.85	<1	1	80	80	4	9	<1	8.09		0.07	0.04					
0926	30	23.15	25.50	34.93	5.90	<1	3	60	60	3	9	<1	8.08		0.07	0.07					

WATER QUALITY MONITORING PROGRAM

DIVISION OF WASTEWATER MANAGEMENT
DEPARTMENT OF PUBLIC WORKS

BARBERS POINT
DATE 11/9-10/87

STA DATE & TIME	DEPTH (meters)	DENSITY	TEMP (°C)	SALINITY (0/00)	OXYGEN (mg/l)	NITROGEN (µg/l) NITRATE+NITRITE	AMMONIA	KJELDAHL	TOTAL	PHOSPHORUS (µg/l) ORTHO-PHOSPHATE	TOTAL	SS (mg/l)	PH	LIGHT EXT. COEF. (k)	TURBIDITY (NTU)	CHLORO-PHYLL a (µg/l)	SECCHI DEPTH (meters)	COLIFORM (no./100ml) ENTEROCOCCUS	FECAL	WIND VEL & DIR	SEA HGT & DIR
11/9 1 0825	5	22.18	27.34	34.40	6.50	<1	5	70	70	3	7	<0.5	8.43		0.06	0.03	22.8	1	2	3-5 kts NE	2-3 ft E
	30	22.31	27.30	34.56	6.40	<1	5	70	70	3	8	<0.5	8.43		0.10	0.04					
11/10 2 0820	5	22.39	27.20	34.63	6.25	<1	4	80	80	3	8	<0.5	8.42		0.07	0.04	30.5	<1	1	5-10 kts NE	2-3 ft E
	30	22.36	27.20	34.60	6.40	<1	4	80	80	3	8	<0.5	8.45		0.08	0.06					
11/9 3 0850	5	22.33	27.23	34.56	6.15	<1	11	120	120	8	13	<0.5	8.42		0.12	0.05	24.4	14	11	3-5 kts NE	2-3 ft E
	15	22.34	27.23	34.57	6.10	<1	13	120	120	8	14	<0.5	8.42		0.08	0.06					
	30	22.33	27.30	34.59	6.10	<1	7	100	100	5	11	<0.5	8.43		0.12	0.06					
						DATA ON 2nd REPORT SHEET															
11/9 6 0925	5	22.37	27.24	34.63	6.20	<1	6	110	110	3	8	<0.5	8.41		0.20	0.06	31.7	3	1	3-5 kts NE	2-3 ft E
	15	22.40	27.24	34.66	6.10	<1	8	120	120	4	9	<0.5	8.40		0.10	0.04					
	30	22.39	27.30	34.67	6.10	<1	8	120	120	4	9	<0.5	8.42		0.13	0.06					
						DATA ON 2nd REPORT SHEET															
11/10 8 0840	5	22.34	27.22	34.56	6.15	<1	6	100	100	4	9	<0.5	8.45		0.10	0.04	29.9	6	1	5-10 kts NE	2-3 ft E
	30	22.30	27.28	34.54	6.10	<1	6	140	140	5	10	<0.5	8.44		0.20	0.09					
11/10 9 0840	5	22.34	27.20	34.56	6.25	<1	5	120	120	3	9	<0.5	8.45		0.10	0.15	29.9	<1	1	5-10 kts NE	2-3 ft E
	15	22.32	27.21	34.53	6.10	<1	5	100	100	3	9	<0.5	8.44		0.08	0.21					
	30	22.33	27.27	34.59	6.00	<1	5	90	90	4	8	<0.5	8.43		0.12	0.12					
11/9 10 0945	5	22.36	27.16	34.56	5.65	<1	8	80	80	5	11	0.5	8.37		0.52	0.12	8.8	6	4	3-5 kts NE	2-3 ft E

WATER QUALITY MONITORING PROGRAM

DIVISION OF WASTEWATER MANAGEMENT
DEPARTMENT OF PUBLIC WORKS

BARBERS POINT
DATE 11/9-10/87

STA DATE & TIME	DEPTH (meters)	DENSITY	TEMP. (°C)	SALINITY (0/00)	OXYGEN (mg/l)	NITROGEN (µg/l) NITRATE+NITRITE	AMMONIA	KJELDAHL	TOTAL	PHOSPHORUS (µg/l) ORTHO-PHOSPHATE	TOTAL	SS (mg/l)	PH	LIGHT EXT. COEF. (k)	TURBIDITY (NTU)	CHLORO-PHYLL a (µg/l)	SECCHI DEPTH (meters)	COLIFORM (no./100ml) ENTEROCOCCUS	FECAL	WIND VEL & DIR	SEA HGT & DIR.
4	5	22.31	27.29	34.56	6.10	<1	14	120	120	8	14	<0.5	8.41		0.11	0.04	23.5	17	5	3-5 kts NE	2-3 ft E
	15	22.34	27.30	34.60	5.80	<1	8	100	100	4	10	<0.5	8.41		0.11	0.06					
	30	22.33	27.30	34.60	5.95	<1	5	100	100	3	8	<0.5	8.42		0.12	0.04					
5	5	22.37	27.24	34.63	6.20	<1	9	110	110	5	12	<0.5	8.41		0.10	0.04	29.0	11	3	3-5 kts NE	2-3 ft E
	15	22.36	27.24	34.60	6.20	<1	8	150	150	3	8	<0.5	8.41		0.16	0.04					
	30	22.35	27.23	34.59	6.15	<1	6	110	110	3	9	<0.5	8.41		0.10	0.04					
7	5	22.36	27.34	34.65	5.90	<1	7	100	100	3	8	<0.5	8.42		0.09	0.06	24.4	1	1	3-5 kts NE	2-3 ft E
	15	22.33	27.34	34.65	5.90	<1	9	120	120	3	8	<0.5	8.41		0.16	0.30					
	30	22.33	27.28	34.59	5.90	<1	13	100	100	7	13	<0.5	8.41		0.12	0.04					

WATER QUALITY MONITORING PROGRAM

DIVISION OF WASTEWATER MANAGEMENT
DEPARTMENT OF PUBLIC WORKS

BARBERS POINT
DATE 2/18/88 and 2/22/88

STA. DATE & TIME	DEPTH (meters)	DENSITY	TEMP (°C)	SALINITY (0/00)	OXYGEN (mg/l)	NITROGEN (µg/l) NITRATE + NITRITE	AMMONIA	KJELDAHL	TOTAL	PHOSPHORUS (µg/l) ORTHO-PHOSPHATE	TOTAL	SS (mg/l)	pH	LIGHT EXT. COEF.(K)	TURBIDITY (NTU)	CHLORO-PHYLL a (µg/l)	SECCHI DEPTH (meters)	Bact (No./100ml) Ent.	FECAL	WIND VEL & DIR	SEA HGT & DIR
2/18 1	5	23.25	24.94	34.83	6.80	< 1	8	80	80	3	8	< 0.5	8.27		0.06	0.02	29.5	< 1	< 1	3-5 KTS NE	1-2 FT E
0925	30	23.29	24.92	34.87	6.75	< 1	7	80	80	4	9	< 0.5	8.27		0.08	0.03					
2/22 2	5	23.14	24.93	34.68	5.60	2	4	80	82	5	10	< 0.5	8.33		0.12	0.38	18.6	1	< 1	0-3 KTS N	1-2 FT NE
0830	30	23.35	24.70	34.86	5.70	< 1	5	80	80	4	8	< 0.5	8.34		0.10	0.27			–		
2/18 3	5	23.21	24.95	34.78	6.35	< 1	15	90	90	6	11	< 0.5	8.27		0.11	0.10	24.7	220	1150 (EST)	3-5 KTS NE	1-2 FT E
	15	23.21	24.96	34.78	6.40	< 1	11	80	80	5	10	< 0.5	8.27		0.08	0.11					
0855	30	23.21	24.98	34.79	6.30	1	13	99	91	5	10	< 0.5	8.27		0.10	0.10					
2/18 6	5	23.22	24.97	34.80	6.20	2	16	90	92	7	12	< 0.5	8.27		0.10	0.09	23.4	200	150	3-5 KTS NE	1-2 FT E
	15	23.25	24.98	34.84	6.10	2	17	90	92	6	11	< 0.5	8.27		0.10	0.11					
0925	30	23.28	24.90	34.86	6.10	4	10	100	104	5	10	< 0.5	8.28		0.08	0.12					
2/22 8	5	23.25	24.98	34.84	5.75	< 1	5	90	90	4	9	< 0.5	8.35		0.08	0.36	27.4	8	4	0-3 KTS N	1-2 FT NE
0905	30	23.35	24.70	34.86	5.70	1	5	90	91	4	9	< 0.5	8.34		0.08	0.15					
2/22 9	5	23.25	24.99	34.85	5.75	< 1	4	80	80	3	8	< 0.5	8.34		0.08	0.05	30.5	< 1	< 1	0-3 KTS N	1-2 FT NE
	15	23.37	24.75	34.91	5.80	< 1	4	70	70	4	8	< 0.5	8.35		0.09	0.05					
0918	30	23.43	24.53	34.90	5.70	< 1	6	70	70	4	8	< 0.5	8.34		0.08	0.12					
2/22 10	5	23.23	25.00	34.83	5.75	1	5	80	81	5	9	< 0.5	8.33		0.14	0.38	8.2 (Bottom)	5	5	3-5 KTS N	1-2 FT NE
0850																					

WATER QUALITY MONITORING PROGRAM

DIVISION OF WASTEWATER MANAGEMENT
DEPARTMENT OF PUBLIC WORKS

BARBERS POINT
DATE 2/18/88 and 2/22/88

STA. DATE & TIME	DEPTH (meters)	DENSITY	TEMP (°C)	SALINITY (0/00)	OXYGEN (mg/l)	NITROGEN (µg/l) NITRATE + NITRITE	AMMONIA	KJELDAHL	TOTAL	PHOSPHORUS (µg/l) ORTHO-PHOSPHATE	TOTAL	SS (mg/l)	pH	LIGHT EXT. COEF.(K)	TURBIDITY (NTU)	CHLORO-PHYLL a (µg/l)	SECCHI DEPTH (meters)	Bact (No./100ml) Ent.	FECAL	WIND VEL & DIR	SEA HGT & DIR
2/18	5	23.24	24.94	34.81	6.30	1	10	80	81	4	10	< 0.5	8.27		0.08	0.09	28.6	55	550	3-5 KTS NE	1-2 FT E
4	15	23.26	24.93	34.84	6.25	2	10	80	82	5	9	< 0.5	8.27		0.11	0.11					
0905	30	23.24	24.93	34.81	6.20	1	17	80	81	5	10	< 0.5	8.27		0.10	0.11					
2/18	5	23.24	24.98	34.83	6.25	< 1	12	80	80	5	10	< 0.5	8.28		0.10	0.07	27.7	25	1000 (EST)	3-5 KTS NE	1-2 FT E
5	15	23.26	24.95	34.85	6.20	< 1	9	80	80	4	10	< 0.5	8.28		0.08	0.07					
0915	30	23.23	24.92	34.80	6.10	1	10	80	81	.5	10	< 0.5	8.27		0.10	0.10					
2/18	5	23.27	24.94	34.86	6.30	1	11	80	81	5	10	< 0.5	8.27		0.08	0.08	29.2	35	15	3-5 KTS NE	1-2 FT E
7	15	23.25	24.98	34.85	6.20	5	9	90	95	4	10	< 0.5	8.27		0.10	0.09					
0935	30	23.25	24.96	34.84	6.20	2	10	100	102	5	13	< 0.5	8.27		0.10	0.13					

WATER QUALITY MONITORING PROGRAM

DIVISION OF WASTEWATER MANAGEMENT
DEPARTMENT OF PUBLIC WORKS

BARBERS POINT
DATE 5/23/88

STA. DATE & TIME	DEPTH (meters)	DENSITY	TEMP. (°C)	SALINITY (0/00)	OXYGEN (mg/l)	NITROGEN (µg/l)				PHOSPHORUS (µg/l)		SS (mg/l)	PH	LIGHT EXT. COEF.(K)	TURBIDITY (NTU)	CHLORO-PHYLL a (µg/l)	SECCHI DEPTH (meters)	COLIFORM (No./100ml)		WIND	SEA
						NITRATE + NITRITE	AMMONIA	KJELDAHL	TOTAL	ORTHO-PHOSPHATE	TOTAL							ENTERO-COCCUS	FECAL	VEL & DIR	HGT & DIR
5/23 1 0515	5	22.93	25.87	34.79	6.30	< 1	3	130	130	5	10	< 0.5	8.49		0.09	0.06	25.9	< 1	< 1	10-15 kts NE	2-3 ft E
	30	22.95	25.75	34.76	6.35	1	4	150	151	6	11	< 0.5	8.49		0.14	0.12					
5/23 2 0830	5	22.80	26.12	34.72	6.40	< 1	4	110	110	5	10	< 0.5	8.48		0.06	0.03	28.9	< 1	< 1	10-15 kts NE	2-3 ft E
	30	22.86	25.90	34.70	6.50	< 1	5	100	100	6	10	< 0.5	8.47		0.07	0.04					
5/23 3 0855	5	22.83	25.98	34.69	6.45	< 1	25	180	180	13	19	< 0.5	8.46		0.09	0.05	29.8	900	4800	10-15 kts NE	2-3 ft E
	15	22.84	25.90	34.67	6.50	< 1	6	150	150	5	10	< 0.5	8.47		0.10	0.04					
	30	22.84	25.90	34.67	6.50	1	7	140	141	5	10	< 0.5	8.46		0.08	0.03					
5/23 6 0940	5	22.88	25.90	34.73	6.50	< 1	22	160	160	7	10	< 0.5	8.47		0.07	0.04	29.2	48	5	10-15 kts NE	2-3 ft E
	15	22.84	25.90	34.68	6.50	< 1	9	130	130	5	10	< 0.5	8.48		0.08	0.04					
	30	22.89	25.83	34.72	6.50	1	7	110	111	5	10	< 0.5	8.48		0.13	0.04					
5/23 8 1005	5	22.86	25.95	34.72	6.45	2	6	120	122	5	10	< 0.5	8.48		0.09	0.06	28.0	< 1	1	10-15 kts NE	2-3 ft E
	30	22.91	25.86	34.75	6.40	1	7	80	81	6	10	< 0.5	8.47		0.16	0.14					
5/23 9 1015	5	22.82	26.00	34.69	6.55	1	7	110	111	5	10	< 0.5	8.48		0.09	0.04	27.4	< 1	< 1	10-15 kts NE	2-3 ft E
	15	22.87	25.90	34.71	6.50	< 2	7	100	100	5	10	< 0.5	8.48		0.14	0.04					
	30	22.87	25.90	34.71	6.50	< 1	7	80	80	6	10	< 0.5	8.48		0.10	0.04					
5/23 10 0958	5	22.86	25.92	34.71	6.40	1	7	90	91	6	12	< 0.5	8.47		0.20	0.21	9.1 (Bottom)	< 1	< 1	10-15 kts NE	2-3 ft E

WATER QUALITY MONITORING PROGRAM

DIVISION OF WASTEWATER MANAGEMENT
DEPARTMENT OF PUBLIC WORKS

BARBERS POINT
DATE 5/23/88

STA. DATE & TIME	DEPTH (meters)	DENSITY	TEMP. (°C)	SALINITY (0/00)	OXYGEN (mg/l)	NITROGEN (µg/l)				PHOSPHORUS (µg/l)		SS (mg/l)	PH	LIGHT EXT. COEF.(K)	TURBIDITY (NTU)	CHLORO-PHYLL a (µg/l)	SECCHI DEPTH (meters)	COLIFORM (No./100ml)		WIND	SEA
						NITRATE + NITRITE	AMMONIA	KJELDAHL	TOTAL	ORTHO-PHOSPHATE	TOTAL							ENTERO-COCCUS	FECAL	VEL & DIR	HGT & DIR
4	5	22.85	25.94	34.71	6.50	< 1	8	140	140	5	10	< 0.5	8.46		0.09	0.03	25.9	< 1	< 1	10-15 kts NE	2-3 ft E
	15	22.87	25.90	34.71	6.50	1	8	160	161	10	10	< 0.5	8.46		0.11	0.03					
	30	22.87	25.90	34.71	6.50	< 1	4	100	100	7	10	< 0.5	8.47		0.10	0.04					
5	5	22.87	25.90	34.72	6.55	< 1	6	120	120	5	11	< 0.5	8.48		0.08	0.04	27.7	< 1	< 1	10-15 kts NE	2-3 ft E
	15	22.90	25.85	34.74	6.50	1	5	110	111	6	10	< 0.5	8.49		0.09	0.04					
	30	22.89	25.83	34.72	6.50	4	6	130	134	5	10	< 0.5	8.48		0.09	0.04					
7	5	22.88	25.90	34.73	6.50	1	7	130	131	5	10	< 0.5	8.48		0.15	0.04	25.8	< 1	< 1	10-15 kts NE	2-3 ft E
	15	22.83	25.94	34.68	6.50	< 1	6	150	150	5	10	< 0.5	8.48		0.10	0.05					
	30	22.87	25.90	34.71	6.50	1	6	120	121	5	10	< 0.5	8.48		0.08	0.04					

BARBERS POINT
DATE 9/16/88

WATER QUALITY MONITORING PROGRAM

DIVISION OF WASTEWATER MANAGEMENT
DEPARTMENT OF PUBLIC WORKS

STA. DATE & TIME	DEPTH (meters)	DENSITY	TEMP (°C)	SALINITY (0/00)	OXYGEN (mg/l)	NITROGEN (ug/l) NITRATE+NITRITE	AMMONIA	KJELDAHL	TOTAL	PHOSPHORUS (ug/l) ORTHO-PHOSPHATE	TOTAL	SS (mg/l)	PH	LIGHT EXT. COEF.	TURBIDITY (NTU)	CHLOROPHYLL a (ug/l)	SECCHI DEPTH (meters)	COLIFORM ENTEROCOCCI	FECAL	WIND VEL & DIR	SEA HGT & DIR
9/16 1 0819	5	22.39	27.72	34.85	6.20	1	3	100	101	5	9	<0.5	8.09	0.048	0.08	0.05	35.3	<1	<1	5-7 KTS E	1-2 FT E
	30	22.49	27.45	34.86	6.05	2	2	120	122	6	8	<0.5	8.09		0.11	0.03					
9/16 2 0840	5	22.39	27.73	34.85	6.20	2	3	90	92	4	8	<0.5	8.09	0.046	0.11	0.09	36.9	<1	<1	5-7 KTS E	1-2 FT E
	30	22.49	27.34	34.82	6.20	1	3	90	91	4	8	<0.5	8.09		0.08	0.04					
9/16 3 0907	5	22.37	27.80	34.86	6.25	2	8	160	162	3	8	<0.5	8.09	0.048	0.17	0.06	35.0	<1	<1	5-7 KTS E	1-2 FT E
	15	22.45	27.60	34.87	6.30	2	5	100	102	2	8	<0.5	8.10		0.10	0.07					
	30	22.43	27.55	34.83	6.25	1	4	100	101	4	8	<0.5	8.10		0.07	0.04					
9/16 6 0935	5	22.46	27.55	34.86	6.25	4	6	100	104	4	8	<0.5	8.10	0.053	0.13	0.06	32.3	<1	<1	9-13 KTS E	1-2 FT E
	15	22.48	27.30	34.79	6.20	3	17	140	143	8	16	<0.5	8.09		0.17	0.06					
	30	22.54	27.23	34.84	6.10	2	7	90	92	5	10	<0.5	8.09		0.10	0.10					
9/16 8 1020	5	22.37	27.69	34.80	6.15	1	7	90	91	4	9	<0.5	8.09	0.066	0.12	0.09	25.6	<1	<1	9-13 KTS E	1-2 FT E
	30	22.44	27.50	34.82	6.15	1	7	120	121	4	10	<0.5	8.09		0.09	0.13					
9/16 9 1033	5	22.45	27.70	34.92	6.20	3	7	110	113	4	9	<0.5	8.10	0.053	0.10	0.03	32.0	<1	<1	9-13 KTS E	1-2 FT E
	15	22.42	27.62	34.85	6.20	2	5	100	102	4	9	<0.5	8.10		0.12	0.05					
	30	22.46	27.32	34.86	6.25	<1	6	90	90	4	8	<0.5	8.09		0.08	0.04					
9/16 10 1048	5	22.32	27.70	34.75	5.80	1	6	100	101	6	11	<0.5	8.06	0.243	0.27	0.14	7.0 Bottom	<1	<1	9-13 KTS E	1-2 FT E

BARBERS POINT
DATE 9/16/88

WATER QUALITY MONITORING PROGRAM

DIVISION OF WASTEWATER MANAGEMENT
DEPARTMENT OF PUBLIC WORKS

STA. DATE & TIME	DEPTH (meters)	DENSITY	TEMP. (°C)	SALINITY (0/00)	OXYGEN (mg/l)	NITROGEN (ug/l) NITRATE+NITRITE	AMMONIA	KJELDAHL	TOTAL	PHOSPHORUS (ug/l) ORTHO-PHOSPHATE	TOTAL	SS (mg/l)	PH	LIGHT EXT. COEF.	TURBIDITY (NTU)	CHLOROPHYLL a (ug/l)	SECCHI DEPTH (meters)	COLIFORM ENTEROCOCCI	FECAL	WIND VEL & DIR.	SEA HGT & DIR
9/16 4 0915	5	22.42	27.65	34.85	6.15	4	6	130	134	4	9	<0.5	8.09	0.052	0.17	0.09	32.9	<1	<1	9 KTS E	1-2 FT E
	15	22.42	27.51	34.80	6.25	1	4	80	81	3	8	<0.5	8.09		0.09	0.08					
	30	22.49	27.41	34.84	6.15	2	8	110	112	5	10	<0.5	8.09		0.10	0.13					
9/16 5 0925	5	22.45	27.62	34.89	6.20	2	5	110	112	5	8	<0.5	8.10	0.049	0.15	0.07	34.7	1	<1	9-13 KTS E	1-2 FT E
	15	NO DATA	NO DATA	34.88	NO DATA	2	5	100	102	3	8	<0.5	8.10		0.10	0.04					
	30	22.51	27.38	34.86	6.25	1	5	90	91	3	8	<0.5	8.09		0.08	0.05					
9/16 7 0948	5	22.48	27.43	34.84	6.20	2	5	90	92	4	9	<0.5	8.09	0.066	0.09	0.07	25.9	<1	<1	9-13 KTS E	1-2 FT E
	15	22.49	27.43	34.85	6.20	2	11	110	112	6	12	<0.5	8.09		0.12	0.14					
	30	22.54	27.25	34.85	6.20	1	14	140	141	5	12	<0.5	8.09		0.12	0.17					

BARBERS POINT
DATE: 11-22-88

WATER QUALITY MONITORING PROGRAM

PUBLIC WORKS/DIVISION OF WASTEWATER MANAGEMENT

STA. DATE & TIME	DEPTH (meters)	DENSITY	TEMP. (°C)	SALINITY (o/oo)	OXYGEN (mg/l)	NITROGEN (ug/l)				PHOSPHORUS (ug/l)		SS (mg/l)	pH	LIGHT EXT COEF (m)	TURBIDITY (NTU)	CHLOROPHYLL a (ug/l)	SECCHI DEPTH (meters)	BACTERIA (No/100ml)		WIND	SEA
						NITRATE+ NITRITE	AMMONIA	KJELDAHL	TOTAL	ORTHO	TOTAL							ENTERO-COCCI	FECAL	VEL (m/s) DIRECTION	HGT (m) DIRECTION
11-22 1 0815	5	22.76	26.53	34.03	6.50	2	4	130	132	3	8	<0.5	8.32	0.06	0.09	0.06	25.9	<1	<1	6.7-8.9 E	0.6-0.9 E
	30	22.80	26.50	34.07	6.40	1	4	140	141	4	7	<0.5	8.33		0.10	0.04					
11-22 2 0843	5	22.81	26.44	34.06	6.40	<1	4	100	100	4	8	<0.5	8.32	0.07	0.08	0.05	24.7	<1	1	6.7-8.9 E	0.6-0.9 E
	30	22.76	26.44	34.08	6.45	1	3	120	121	3	8	<0.5	8.32		0.10	0.09					
11-22 3 0859	5	22.76	26.47	34.03	6.40	2	5	110	112	4	10	<0.5	8.32	0.06	0.08	0.17	26.0	81	240	6.7-8.9 E	0.6-0.9 E
	15	22.76	26.50	34.02	6.35	7	6	120	127	4	12	<0.5	8.32		0.10	0.09					
	30	22.77	26.46	34.02	6.35	6	6	140	146	4	13	<0.5	8.33		0.11	0.20					
11-22 4 0912	5	22.77	26.46	34.03	6.45	3	7	110	113	4	12	<0.5	8.32	0.07	0.11	0.17	25.6	60	310	6.7-8.9 E	0.6-0.9 E
	15	22.77	26.40	34.03	6.45	4	7	100	104	4	10	<0.5	8.33		0.10	0.21					
	30	22.79	26.40	34.03	6.45	2	7	120	122	4	10	<0.5	8.33		0.10	0.09					
11-22 5 0922	5	22.81	26.45	34.06	6.50	3	4	110	113	4	9	<0.5	8.32	0.06	0.08	0.07	29.5	<1	<1	6.7-8.9 E	0.6-0.9 E
	15	22.79	26.44	34.04	6.45	3	4	110	113	3	8	<0.5	8.32		0.09	0.09					
	30	22.77	26.44	34.01	6.40	3	4	90	93	4	8	<0.5	8.32		0.10	0.08					
11-22 6 0939	5	22.78	26.42	34.01	6.45	6	4	140	146	3	9	<0.5	8.33	0.06	0.10	0.12	27.4	1	<1	6.7-8.9 E	0.6-0.9 E
	15	22.78	26.46	34.03	6.40	4	5	130	134	4	9	<0.5	8.33		0.10	0.11					
	30	22.81	26.46	34.07	6.40	2	6	120	122	3	10	<0.5	8.32		0.11	0.23					
11-22 7 0945	5	22.78	26.45	34.03	6.40	4	8	90	94	6	11	<0.5	8.33	0.07	0.11	0.10	24.7	60	17	6.7-8.9 E	0.6-0.9 E
	15	22.81	26.46	34.07	6.35	2	10	140	142	5	11	<0.5	8.33		0.11	0.24					
	30	22.77	26.46	34.02	6.35	3	10	120	123	6	10	<0.5	8.32		0.11	0.15					
11-22 8 1000	5	22.79	26.44	34.04	6.35	4	10	130	134	6	11	<0.5	8.33	0.08	0.10	0.19	31.3	60	12	6.7-8.9 E	0.6-0.9 E
	30	22.81	26.40	34.04	6.35	2	7	230	232	4	10	<0.5	8.34		0.11	0.20					
11-22 9 1025	5	22.78	26.44	34.02	6.40	2	6	100	102	3	7	<0.5	8.33	0.07	0.08	0.06	23.7	<1	<1	6.7-8.9 E	0.6-0.9 E
	15	22.79	26.45	34.04	6.45	5	4	120	125	3	8	<0.5	8.31		0.10	0.06					
	30	22.81	26.40	34.04	6.45	1	6	130	131	2	8	<0.5	8.33		0.10	0.06					
11-22 10 0950	5	22.84	26.30	34.04	6.25	2	7	140	142	4	10	<0.5	8.33	0.16	0.12	0.14	10.6 (Bottom)	14	2	6.7-8.9 E	0.6-0.9 E

BARBERS POINT *
DATE: 2-15-89

WATER QUALITY MONITORING PROGRAM

PUBLIC WORKS/DIVISION OF WASTEWATER MANAGEMENT

STA. DATE & TIME	DEPTH (meters)	DENSITY	TEMP. (°C)	SALINITY (o/oo)	OXYGEN (mg/l)	NITROGEN (ug/l)				PHOSPHORUS (ug/l)		SS (mg/l)	pH	LIGHT EXT COEF (m)	TURBIDITY (NTU)	CHLOROPHYLL a (ug/l)	SECCHI DEPTH (meters)	BACTERIA (No/100ml)		WIND	SEA
						NITRATE+ NITRITE	AMMONIA	KJELDAHL	TOTAL	ORTHO	TOTAL							ENTERO-COCCI	FECAL	VEL (m/s) DIRECTION	HGT (m) DIRECTION
2-15 1 0803	5	23.23	24.23	34.54	6.50	1	4	90	91	4	8	<0.5	8.35	0.07	0.16	0.57	25.0	2	4	2.2-3.6 North	0.3-0.6 South
	30	23.45	24.18	34.75	6.30	<1	6	100	100	4	8	<0.5	8.36		0.12	0.17					
2-15 2 0817	5	23.63	24.00	33.90	6.00	6	5	100	106	5	17	<0.5	8.35	0.08	0.30	1.40	20.4	<1	1	2.2-3.6 North	0.3-0.6 South
	30	23.55	23.70	34.09	6.05	2	8	100	102	4	9	<0.5	8.36		0.11	0.25					
2-15 3 0833	5	23.46	24.04	34.75	6.10	<1	4	110	110	3	12	<0.5	8.35	0.07	0.10	0.31	24.7	4	16	2.2-3.6 North	0.3-0.6 South
	15	23.54	24.03	34.04	6.00	1	7	110	111	4	12	<0.5	8.36		0.09	0.25					
	30	23.65	23.83	34.91	6.00	1	6	80	81	4	12	<0.5	8.36		0.10	0.23					
2-15 4 0839	5	23.42	24.14	34.73	6.00	<1	5	90	90	4	11	<0.5	8.35	0.07	0.11	0.27	24.4	3	8	2.2-3.6 North	0.3-0.6 South
	15	23.45	24.14	34.77	6.05	<1	7	90	90	6	11	<0.5	8.35		0.10	0.37					
	30	23.64	23.90	34.53	6.00	1	7	80	81	4	11	<0.5	8.35		0.08	0.22					
2-15 5 0846	5	23.44	24.06	34.73	6.00	<1	4	90	90	4	11	<0.5	8.34	0.06	0.10	0.20	30.2	4	4	2.2-3.6 North	0.3-0.6 South
	15	23.47	24.14	34.79	5.90	<1	6	90	90	5	14	<0.5	8.34		0.11	0.35					
	30	23.61	23.85	34.87	6.00	<1	7	90	90	4	14	<0.5	8.34		0.09	0.30					
2-15 6 0855	5	23.41	24.10	34.79	6.05	<1	5	100	100	4	10	<0.5	8.35	0.06	0.13	0.27	25.3	3	6	2.2-3.6 North	0.3-0.6 South
	15	23.47	24.10	34.70	6.00	<1	7	100	100	4	11	<0.5	8.36		0.10	0.33					
	30	23.61	23.94	34.91	6.00	<1	6	90	90	3	11	<0.5	8.35		0.08	0.21					
2-15 7 0903	5	23.37	24.15	34.67	6.00	<1	5	90	90	3	11	<0.5	8.36	0.07	0.10	0.29	25.0	8	3	2.2-3.6 North	0.3-0.6 South
	15	23.43	24.10	34.73	6.00	<1	7	90	90	4	11	<0.5	8.35		0.11	0.29					
	30	23.40	24.00	34.76	6.00	<1	10	90	90	6	10	<0.5	8.36		0.11	0.33					
2-15 8 0915	5	23.40	24.17	34.71	6.15	<1	7	90	90	4	9	<0.5	8.36	0.07	0.16	0.25	24.7	13	6	2.2-3.6 North	0.3-0.6 South
	30	23.59	23.96	34.80	6.00	1	7	130	131	4	7	<0.5	8.36		0.08	0.21					
2-15 9 0927	5	23.39	24.22	34.72	5.90	<1	4	100	100	6	8	<0.5	8.36	0.06	0.15	0.28	29.0	1	<1	2.2-3.6 North	0.3-0.6 South
	15	23.52	24.00	34.81	5.90	<1	5	90	90	3	7	<0.5	8.35		0.11	0.23					
	30	23.57	23.95	34.86	5.75	<1	7	90	90	3	8	<0.5	8.37		0.08	0.24					
2-15 10 0815	5	23.33	24.20	34.63	6.20	1	6	90	91	3	8	<0.5	8.36	0.21	0.34	0.62	8.3 (Bottom)	1	<1	2.2-3.6 North	0.3-0.6 South

* Heavy rains from 2/8/89 - 2/12/89

APPENDIX B

NEARSHORE WATER CHEMISTRY DATA

AT EWA MARINA ENTRANCE SITE

Marine Research Consultants
217 Prospect Street, #F2
Honolulu, Hawaii 96813

July, 1990

EWA MARINA WATER QUALITY DATA
DATE COLLECTED: 6/21/90
SEA CONDITIONS: 10-20 Kt tradewinds; 1-3 ft. seas; overcast skies.

STATION DEPTH (m)	SAMPLING DEPTH (m)	TIDE	TP (µM)	TN (µM)	TURB (ntu)	SAL (o/oo)	Chl. a (µg/L)
10	0.5	LOW	0.50	10.09	0.12	34.790	0.128
		FLOOD	0.50	6.73	0.11	34.783	0.245
		HIGH	0.49	7.07	0.11	34.788	0.224
	6	LOW	0.46	5.96	0.12	34.784	0.014
		FLOOD	0.47	6.35	0.10	34.784	0.149
		HIGH	0.43	6.48	0.11	34.786	0.014
5	0.5	LOW	0.42	7.51	0.19	34.710	0.171
		FLOOD	0.45	7.12	0.20	34.674	0.245
		HIGH	0.45	6.61	0.20	34.650	0.245
	4	LOW	0.39	6.35	0.19	34.624	0.224
		FLOOD	0.42	7.25	0.19	34.566	0.235
		HIGH	0.40	6.99	0.19	34.552	0.288
1	0.5	LOW	0.40	9.91	0.36	34.456	0.395
		FLOOD	0.43	9.44	0.39	34.374	0.443
		HIGH	0.46	10.60	0.41	34.414	0.267

T-S PROFILES 6/21/90

LOW TIDE 0800 hrs	10 M		5 m			1 m		
DEPTH (m)	TEMP. (deg. C.)	SAL. (o/oo)	DEPTH (m)	TEMP. (deg. C.)	SAL. (o/oo)	DEPTH (m)	TEMP. (deg. C.)	SAL. (o/oo)
0.5	25.3	34.790	0.5	25.4	34.710	0.5	25.1	34.456
1	25.4	34.769	1	25.4	34.713	1	25.0	34.408
2	25.4	34.783	2	25.3	34.720			
4	25.4	34.787	3	25.3	34.724			
6	25.4	34.784	4	25.3	34.624			
8	25.4	34.783						
10	25.4	34.783						

FLOOD TIDE 1100 hrs	10 M		5 m			1 m		
DEPTH (m)	TEMP. (deg. C.)	SAL. (o/oo)	DEPTH (m)	TEMP. (deg. C.)	SAL. (o/oo)	DEPTH (m)	TEMP. (deg. C.)	SAL. (o/oo)
0.5	25.5	34.783	0.5	25.4	34.674	0.5	25.1	34.374
1	25.4	34.799	1	25.4	34.670	1	25.1	34.465
2	25.4	34.789	2	25.4	34.670			
4	25.5	34.789	3	25.4	34.666			
6	25.5	34.784	4	25.4	34.566			
8	25.5	34.790						
10	25.5	34.791						

HIGH TIDE 1600 hrs	10 M		5 m			1 m		
DEPTH (m)	TEMP. (deg. C.)	SAL. (o/oo)	DEPTH (m)	TEMP. (deg. C.)	SAL. (o/oo)	DEPTH (m)	TEMP. (deg. C.)	SAL. (o/oo)
0.5	25.5	34.788	0.5	25.4	34.650	0.5	25.4	34.414
1	25.5	34.796	1	25.5	34.651	1	25.4	34.414
2	25.5	34.789	2	25.5	34.650			
4	25.5	34.791	3	25.5	34.652			
6	25.5	34.786	4	25.5	34.552			
8	25.6	34.786						
10	25.5	34.787						

EWA MARINA WATER QUALITY DATA
DATE COLLECTED: 7/6/90
SEA CONDITIONS: winds light and variable; 1-2 foot swell; sunny skies

STATION DEPTH (m)	SAMPLING DEPTH (m)	TIDE	TP (μM)	TN (μM)	TURB (ntu)	SAL (o/oo)	Chl. a (μg/L)
10	0.5	FLOOD	0.35	5.13	0.11	34.726	0.245
		HIGH	0.31	5.95	0.17	34.732	0.213
		EBB	0.31	5.87	0.14	34.731	0.243
	6	FLOOD	0.31	5.13	0.10	34.749	0.181
		HIGH	0.31	5.31	0.17	34.728	0.245
		EBB	0.31	5.27	0.12	34.729	0.203
5	0.5	FLOOD	0.32	5.69	0.20	34.684	0.235
		HIGH	0.32	7.50	0.19	34.721	0.213
		EBB	0.32	7.32	0.18	34.720	0.224
		HIGH	0.32	5.44	0.18	34.725	0.256
		EBB	0.32	5.76	0.18	34.725	0.259
1	0.5	FLOOD	0.31	9.43	0.46	34.370	0.299
		HIGH	0.29	8.73	0.65	34.503	0.272
		EBB	0.29	8.93	0.64	34.421	0.297

·S PROFILES – 7/6/90

.OOD TIDE 00 hrs	10 M		5 m			1 m		
DEPTH (m)	TEMP. (deg. C.)	SAL. (o/oo)	DEPTH (m)	TEMP. (deg. C.)	SAL. (o/oo)	DEPTH (m)	TEMP. (deg. C.)	SAL. (o/oo)
0.5	26.46	34.74	0.5	26.32	34.63	0.5	25.80	34.37
1	26.42	34.66	1	26.36	34.70	1	25.80	34.35
2	26.34	34.66	2	26.34	34.70			
3	26.20	34.62	3	26.35	34.72			
4	26.24	34.71	4	26.34	34.72			
5	26.19	34.68	5	26.36	34.71			
6	26.10	34.74						
7	26.12	34.72						
8	26.14	34.66						
9	26.10	34.68						

GH TIDE 00 hrs	10 M		5 m			1 m		
DEPTH (m)	TEMP. (deg. C.)	SAL. (o/oo)	DEPTH (m)	TEMP. (deg. C.)		DEPTH (m)	TEMP. (deg. C.)	SAL. (o/oo)
0.5	26.71	34.67	0.5	26.68	34.67	0.5	26.67	34.50
1	26.63	34.64	1	26.66	34.62	1	26.68	34.50
2	26.52	34.74	2	26.58	34.62			
3	26.52	34.78	3	26.58	34.80			
4	26.48	34.81	4	26.59	34.80			
5	26.48	34.80	5	26.59	34.72			
6	26.39	34.80						
7	26.45	34.66						
8	26.45	34.66						
9	26.45	34.67						

'B TIDE)0 hrs	10 M		5 m			1 m		
DEPTH (m)	TEMP. (deg. C.)	SAL. (o/oo)	DEPTH (m)	TEMP. (deg. C.)	SAL. (o/oo)	DEPTH (m)	TEMP. (deg. C.)	SAL. (o/oo)
0.5	26.72	34.68	0.5	26.72	34.71	0.5	26.87	34.51
1	26.63	34.63	1	26.71	34.72	1	26.86	34.52
2	26.53	34.70	2	26.62	34.68			
3	26.54	34.73	3	26.63	34.80			
4	26.47	34.78	4	26.63	34.80			
5	26.49	34.68	5	26.63	34.79			
6	26.41	34.72						
7	26.46	34.66						
8	26.45	34.66						
9	26.45	34.66						

in Table B-2 while the residence time information is given in Table B-3. It is of course obvious that the residence times here are less than when the same tidal flows were spread over the entire depth as in the previous vertically mixed situation. The same information is given in graphical form in Figure 9.

The amount of groundwater entering the various sectors is taken from a flow net constructed from the projected groundwater table gradients when the marina is excavated. This is schematically illustrated in Figure 10. The flow between the various sectors that is induced by the influx of fresh groundwater is indicated in Figure 11 while the flow quantities are listed in Table C-2.

When both tidal and fresh water induced flows are considered then the total flow in the marina is increased and residence times are decreased. The area, depth, and volume information for this case are noted in Table D-1. The flow between adjacent sectors is given in Table D-2 and illustrated in Figure 12. Finally, the residence times resulting from the combination of tidal exchange and fresh water flow are listed in Table D-3 and graphically presented in Figure 13.

These results show that the influx of significant quantities of groundwater has generally reduced the residence times available for plankton growth. The actual concentrations of plankton also depend on the net growth rates that would apply in each marina sector. The three likely growth rates are the slopes of the lines in Figure 14. Since the increases in population are exponential, maintaining acceptable water quality in the sectors with the longer residence times will require control of the input of the likely limiting nutrient, phosphorous. In the case of the proposed Ewa Marina this means primarily limiting surface runoff to the marina. Since the runoff associated with larger storm events will still have to be accommodated there will be episodes of greater plankton population density lasting several residence time periods following such storms. Except for these conditions, however, the water quality related to plankton density is expected to be within acceptable limits in the proposed Ewa Marina.

REFERENCES

1. Investigation of Hawaii Kai Marina:
Sunn, Low, Tom and Hara, Inc. Honolulu, Hawaii, May 1974

2. Kaneohe Bay Data Evaluation Study:
M&E Pacific, Inc., Honolulu, Hawaii, 1978.

3. State of Hawaii Water Quality Standards:
Revised 1989

4. Costa Baja Marina:
Gram/Phillips Associates, Inc., Pasadena, California, January 7, 1974

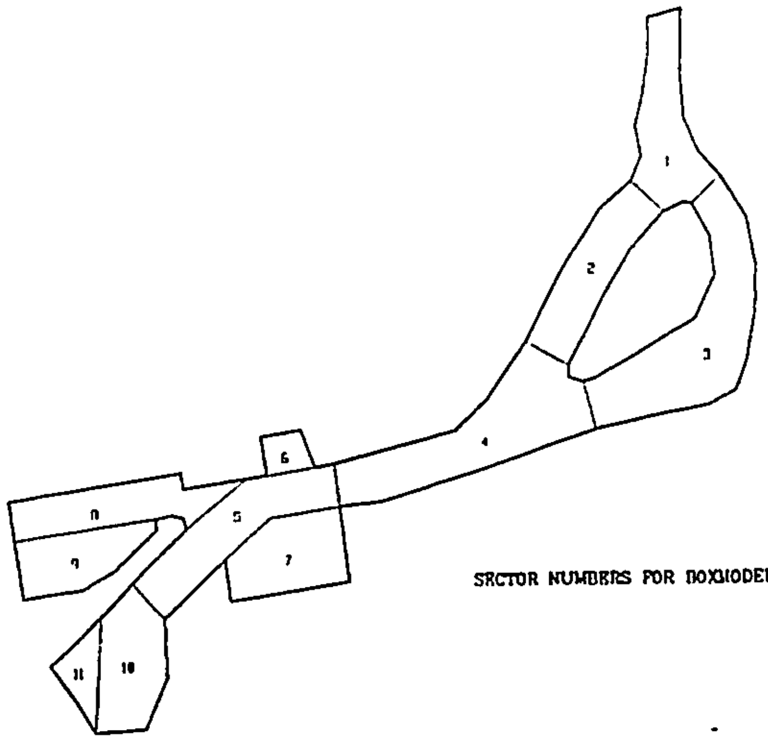


FIGURE 2

EWA MARINA WATER QUALITY STUDY
BOX MODEL DEFINITION
MODEL SECTOR NUMBERING
NO SCALE JUNE 16, 1990 NZ
FILE: 18DB030

OCEES International, Inc.
OCEAN ENGINEERING & ENERGY SYSTEMS
3786 PUKALANI PL., HONOLULU, HAWAII 96816
TEL: (808) 734-7414

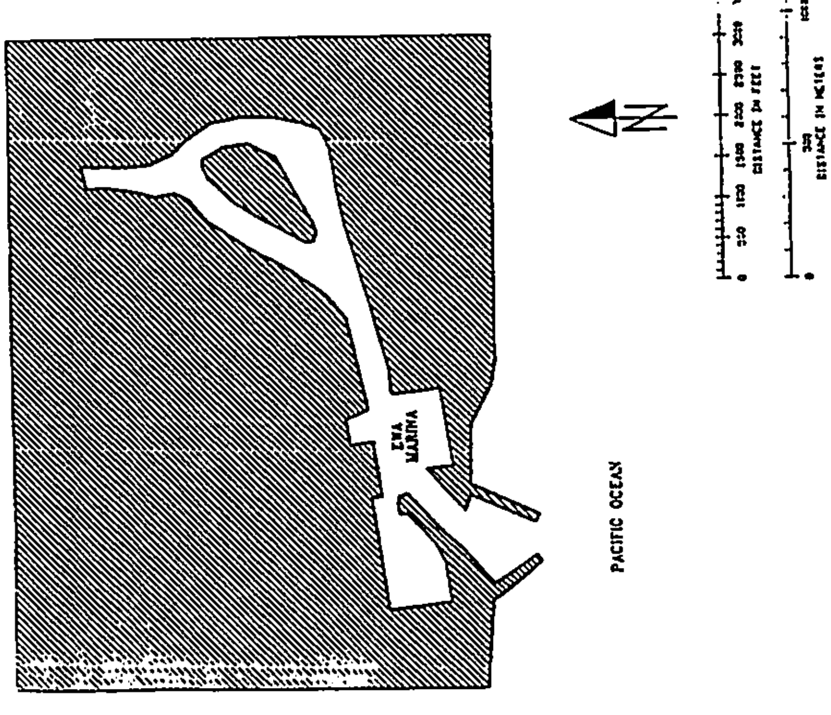


FIGURE : 1

EWA MARINA WATER QUALITY STUDY
EWA MARINA - SCHEMATIC LAYOUT
SCALE 1/16" = 100'
JUNE 16, 1990 NZ
FILE: 18DB020

OCEES International, Inc.
OCEAN ENGINEERING & ENERGY SYSTEMS
3786 PUKALANI PL. HONOLULU, HAWAII 96816
TEL: (808) 734-7414

EWA MARINA WATER QUALITY STUDY OCEES, Intern., INC JUNE 1990

GENERAL INPUT PARAMETERS

BOX SECTOR DIMENSIONS

SECTOR NUMBER	AREA [ft^2]	AVERAGE DEPTH [ft]	WIDTH OF CROSS SECTION BETWEEN SECTORS	
1	6.15E+05	9.00	1-2	375.00
2	5.90E+05	9.00	1-3	325.00
3	1.14E+06	9.00	2-4	400.00
4	1.05E+06	9.00	3-4	400.00
5	6.89E+05	15.00		
6	1.16E+05	10.00		
7	5.39E+05	10.00		
8	5.52E+05	12.00		
9	4.36E+05	10.00		
10	5.23E+05	20.00		
11	1.84E+05	10.00		

TIDAL PRISM: 2.48 [ft/day]

STRATIFICATION 5.00 [ft]

SALINITY OF SECTORS

SECTOR NUMBER	SALINITY (o/oo) Top Layer	Bot. Layer	SALINITY OF GROUNDWATER FLOW INTO MARINA
1	28.00	35.00	0.00
2	30.00	35.00	0.00
3	31.00	35.00	0.00
4	31.00	35.00	0.00
5	32.00	35.00	0.00
6	29.00	35.00	0.00
7	32.50	35.00	NA
8	29.00	35.00	0.00
9	32.00	35.00	0.00
10	32.50	35.00	NA
11	33.00	35.00	NA
TRANS	35.00	35.00	

OCEAN 35.00

EWA MARINA WATER QUALITY STUDY OCEES, Intern., INC JUNE 1990

FILE: 1EWO20 PAGE A-1

UNSTRATIFIED BOX MODEL

Calculation of residence times
Only tidal influences are considered

INPUT:

SECTOR NUMBER	AREA [ft^2]	AREA [m^2]	AVERAGE DEPTH [ft]	AVERAGE DEPTH [m]
1	6.15E+05	5.71E+04	9.00	2.74
2	5.90E+05	5.48E+04	9.00	2.74
3	1.14E+06	1.06E+05	9.00	2.74
4	1.05E+06	9.79E+04	9.00	2.74
5	6.89E+05	6.40E+04	15.00	4.57
6	1.16E+05	1.08E+04	10.00	3.05
7	5.39E+05	5.01E+04	10.00	3.05
8	5.52E+05	5.13E+04	12.00	3.66
9	4.36E+05	4.05E+04	10.00	3.05
10	5.23E+05	4.86E+04	20.00	6.10
11	1.84E+05	1.71E+04	10.00	3.05

SECTOR NUMBER	VOLUME [ft^3]	[m^3]
1	5.53E+06	1.57E+05
2	5.31E+06	1.50E+05
3	1.03E+07	2.90E+05
4	9.49E+06	2.69E+05
5	1.03E+07	2.93E+05
6	1.16E+06	3.29E+04
7	5.39E+06	1.53E+05
8	6.62E+06	1.88E+05
9	4.36E+06	1.23E+05
10	1.05E+07	2.96E+05
11	1.84E+06	5.21E+04

TABLE A-1

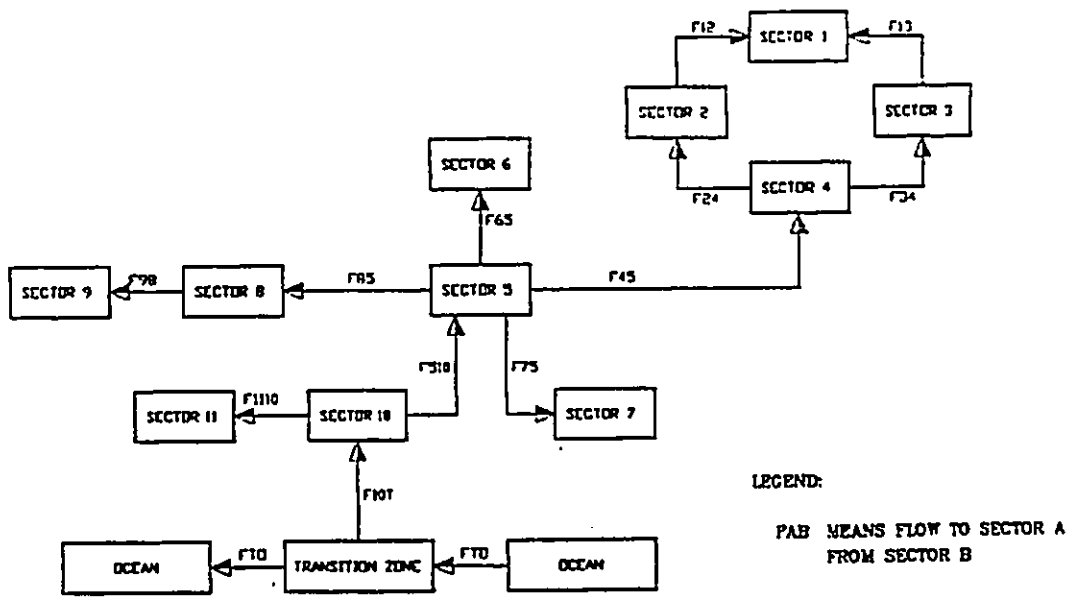


FIGURE 3

EWA MARINA WATER QUALITY STUDY
FLOW SCHEMATIC - UNSTRATIFIED MODEL
ONLY TIDAL - HERE FLOW DUE TO FLOOD
JULY 23, 1990 MZ
FILE: 18DB050

OCEES International, Inc.
OCEAN ENGINEERING & ENERGY SYSTEMS
3786 PUKALANI PL. HONOLULU, HAWAII 96816
TEL: (808) 734-7414

EWA MARINA WATER QUALITY STUDY OCEES, Intern., INC JUNE 1990

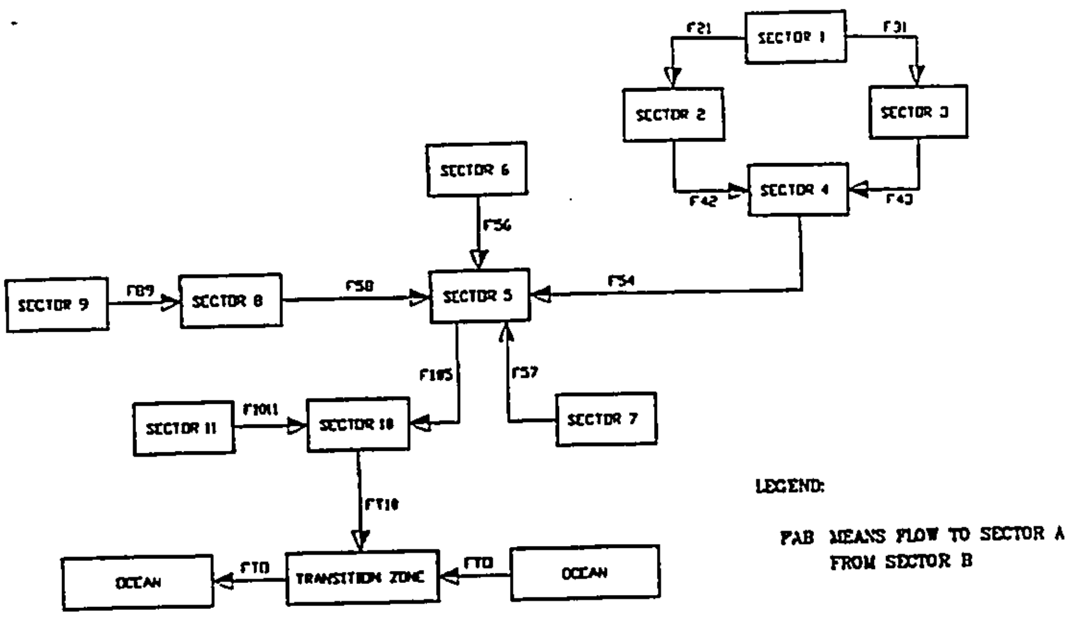
FILE: 18W020 PAGE A-2

TIDAL PRISM: 2.48 [ft/day]
0.76 [m/day]

CALCULATION OF FLOWS:

FLOOD CYCLE FLOW BETWEEN SECTORS	FLOW MAGNITUDE [cbft/day]	EBB CYCLE FLOW BETWEEN SECTORS	FLOW MAGNITUDE [cbft/day]
F12	8.184E+05	F21	8.184E+05
F13	7.093E+05	F31	7.093E+05
F24	2.284E+06	F42	2.284E+06
F34	3.539E+06	F43	3.539E+06
F45	8.441E+06	F54	8.441E+06
F65	2.884E+05	F56	2.884E+05
F75	1.339E+06	F57	1.339E+06
F98	1.083E+06	F89	1.083E+06
F85	2.454E+06	F58	2.454E+06
F510	1.423E+07	F105	1.423E+07
F1110	4.571E+05	F1011	4.571E+05
F10T	1.599E+07	FT10	1.599E+07

TABLE A-2

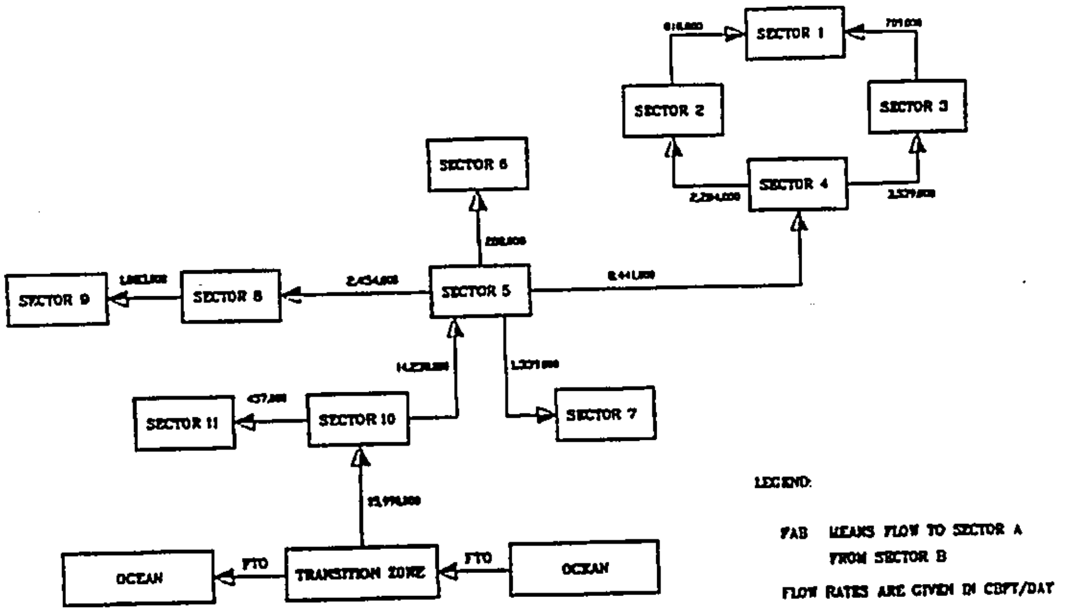


OCEES International, Inc.

EWA MARINA WATER QUALITY STUDY
FLOW SCHEMATIC – UNSTRATIFIED MODEL
ONLY TIDAL – HERE FLOW DUE TO EBB
JUNE 18, 1990 MZ
FILE: 18DB060

OCEAN ENGINEERING & ENERGY SYSTEMS
3786 PUKALANI PL., HONOLULU, HAWAII 96816
TEL.: (808) 734-7414

FIGURE: 4



OCEES International, Inc.

EWA MARINA WATER QUALITY STUDY
FLOW SCHEMATIC – UNSTRATIFIED MODEL
ONLY TIDAL – HERE FLOW DUE TO FLOOD
JUNE 18, 1990 MZ
FILE: 18DB070

OCEAN ENGINEERING & ENERGY SYSTEMS
3786 PUKALANI PL., HONOLULU, HAWAII 96816
TEL.: (808) 734-7414

FIGURE 5

EWA MARINA WATER QUALITY STUDY OCEES, Intern., INC JUNE 1990

FILE: 18JC20 PAGE A-3

CALCULATION OF RESIDENCE TIMES:
With respect to (WRT)
Immediate downstream sector

SECTOR ID		
1	3.62	[days]
2	2.32	[days]
3	2.90	[days]
4	3.62	[days]
5	4.11	[days]
6	4.03	[days]
7	4.03	[days]
8	4.48	[days]
9	4.03	[days]
10	4.31	[days]
11	4.03	[days]
TRANS.ZN.	0.26	[days]

CALCULATION OF RESIDENCE TIMES:
With respect to (WRT)
Ocean

SECTOR ID	
1	15.23
2	14.62
3	15.92
4	12.30
5	8.68
6	12.70
7	12.70
8	13.15
9	17.18
10	4.57
11	8.60
TRANS.ZN.	0.26

TABLE A-3

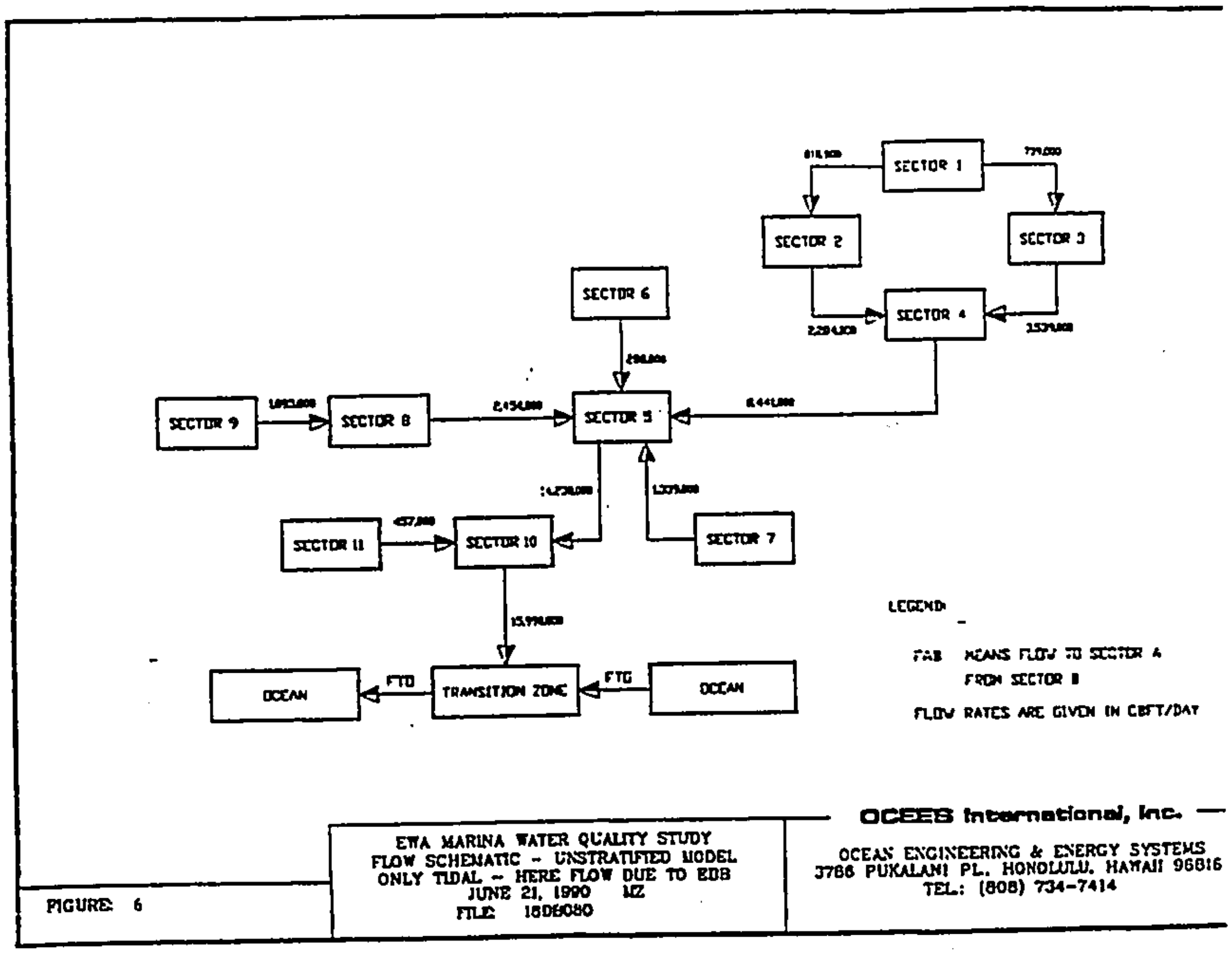


FIGURE: 6

EWA MARINA WATER QUALITY STUDY OCEES, Intern., INC JUNE 1990

FILE: 18UC20 PAGE B-1

STRATIFIED BOX MODEL

Calculation of residence times
Only tidal influences are considered
Tidal flow is restricted to bottom layer of sectors

STRATIFICATION 5.00 (ft)

INPUT:

SECTOR NUMBER	AREA (ft^2)	AREA (m^2)	AVG. DEPTH BOTTOM LAYER (ft)	AVG. DEPTH BOTTOM LAYER (m)
1	6.15E+05	5.71E+04	4.00	1.22
2	5.90E+05	5.48E+04	4.00	1.22
3	1.14E+06	1.06E+05	4.00	1.22
4	1.05E+06	9.79E+04	4.00	1.22
5	6.89E+05	6.40E+04	10.00	3.05
6	1.16E+05	1.08E+04	5.00	1.52
7	5.39E+05	5.01E+04	5.00	1.52
8	5.52E+05	5.13E+04	7.00	2.13
9	4.36E+05	4.05E+04	5.00	1.52
10	5.23E+05	4.86E+04	15.00	4.57
11	1.84E+05	1.71E+04	10.00	3.05

SECTOR NUMBER	VOLUME BOTTOM LAYER (ft^3)	VOLUME BOTTOM LAYER (m^3)
1	2.46E+06	6.97E+04
2	2.36E+06	6.68E+04
3	4.56E+06	1.29E+05
4	4.22E+06	1.19E+05
5	6.89E+06	1.95E+05
6	5.81E+05	1.64E+04
7	2.70E+06	7.63E+04
8	3.86E+06	1.09E+05
9	2.18E+06	6.17E+04
10	7.85E+06	2.22E+05
11	1.84E+06	5.21E+04

TABLE B-1

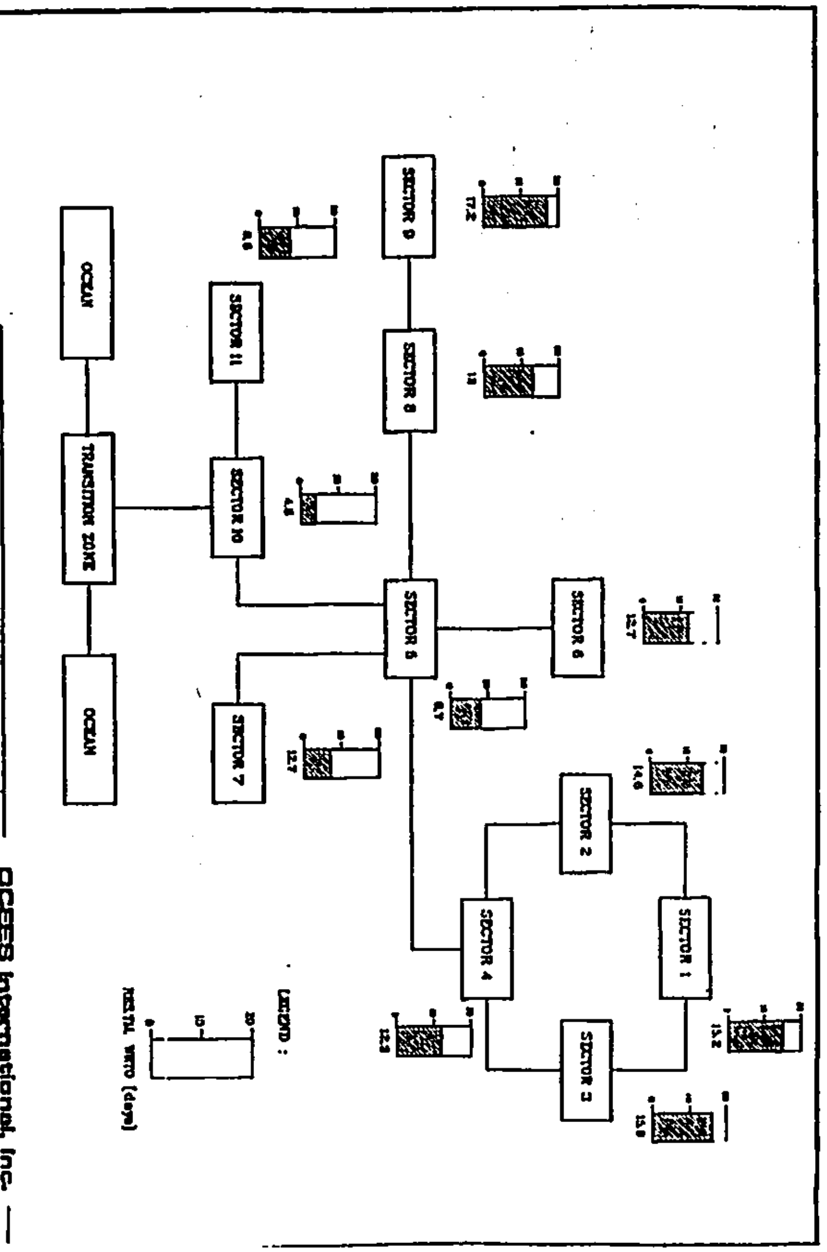


FIGURE 7

EWA MARINA WATER QUALITY STUDY
RESIDENCE TIME – UNSTRATIFIED MODEL
ONLY TIDAL – HERE FLOW DUE TO FLOOD
JUNE 18, 1990 MZ
FILE: 18DB090

OCEES International, Inc.
OCEAN ENGINEERING & ENERGY SYSTEMS
3786 PUKALANI PL. HONOLULU, HAWAII 96816
TEL.: (808) 734-7414

EWA MARINA WATER QUALITY STUDY OCEES, Intern., INC JUNE 1990

FILE: 18U020 PAGE B-2

STRATIFIED BOX MODEL

Calculation of residence times
Only tidal influences are considered
Tidal flow is restricted to bottom layer of sectors

STRATIFICATION	5.00	[ft]
TIDAL PRISM:	2.48	[ft/day]
	0.76	[m/day]

CALCULATION OF FLOWS:

FLOOD CYCLE FLOW BETWEEN SECTORS	FLOW MAGNITUDE (cbft/day)	EBB CYCLE FLOW BETWEEN SECTORS	FLOW MAGNITUDE (cbft/day)
F12	8.184E+05	F21	8.184E+05
F13	7.093E+05	F31	7.093E+05
F24	2.284E+06	F42	2.284E+06
F34	3.539E+06	F43	3.539E+06
F45	8.441E+06	F54	8.441E+06
F65	2.884E+05	F56	2.884E+05
F75	1.339E+06	F57	1.339E+06
F98	1.083E+06	F89	1.083E+06
F85	2.454E+06	F58	2.454E+06
F510	1.423E+07	F105	1.423E+07
F1110	4.571E+05	F1011	4.571E+05
F10T	1.599E+07	FT10	1.599E+07

TABLE B-2

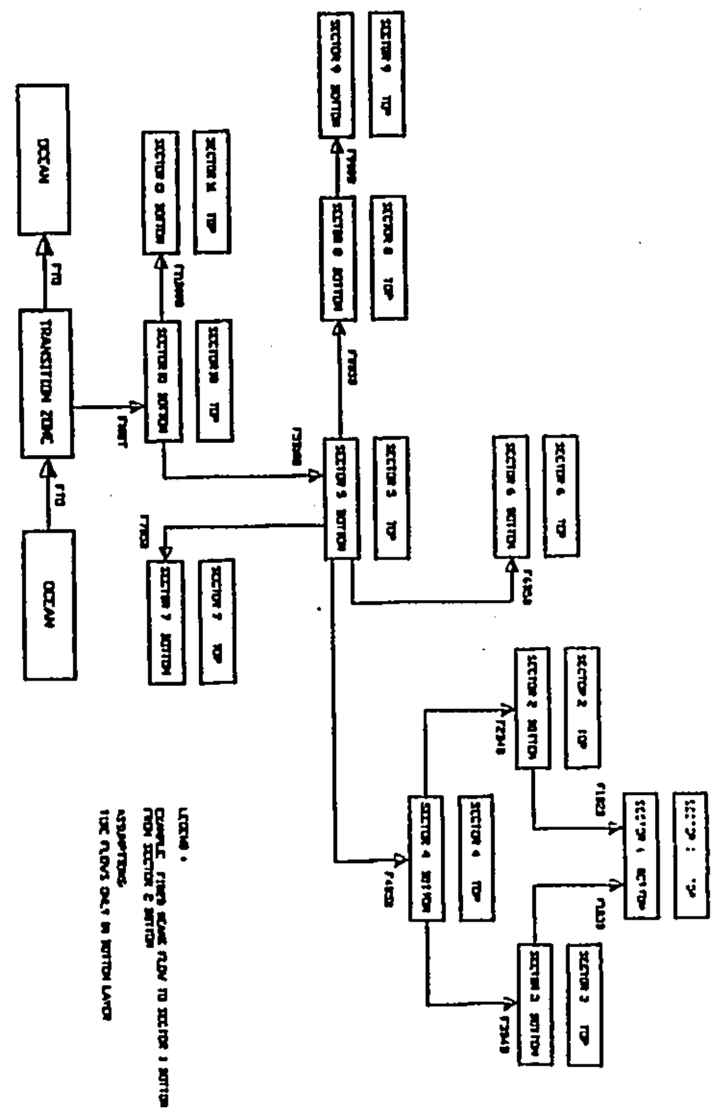


FIGURE 8

EWA MARINA WATER QUALITY STUDY
FLOW SCHEMATIC - STRATIFIED MODEL
FLOOD CYCLE - FLOW IN BOTTOM LAYER ONLY
JNUE 22, 1990 MZ
FILE: 18DB120

OCEES International, Inc.
OCEAN ENGINEERING & ENERGY SYSTEMS
3785 PUKALANI PL. HONOLULU, HAWAII 96816
TEL.: (808) 734-7414

EWA MARINA WATER QUALITY STUDY OCEES, Intern., INC JUNE 1990

FILE: 18JG20 PAGE B-3

STRATIFIED BOX MODEL

Calculation of residence time
Only tidal influences are considered
Tidal flow is restricted to bottom layer of sectors

STRATIFICATION 5.00 [ft]

CALCULATION OF RESIDENCE TIMES: With respect to (WRT) Immediate downstream sector			CALCULATION OF RESIDENCE TIMES: With respect to (WRT) Ocean		
SECTOR ID			SECTOR ID		
1	1.61	[days]	1	9.35	[days]
2	1.63	[days]	2	7.95	[days]
3	1.29	[days]	3	7.93	[days]
4	1.61	[days]	4	6.32	[days]
5	2.09	[days]	5	4.71	[days]
6	2.01	[days]	6	6.72	[days]
7	2.01	[days]	7	6.72	[days]
8	2.46	[days]	8	7.17	[days]
9	2.01	[days]	9	9.18	[days]
10	2.35	[days]	10	2.61	[days]
11	4.03	[days]	11	6.64	[days]
TRANS.ZN.	0.26	[days]	TRANS.ZN.	0.26	[days]

TABLE B-3

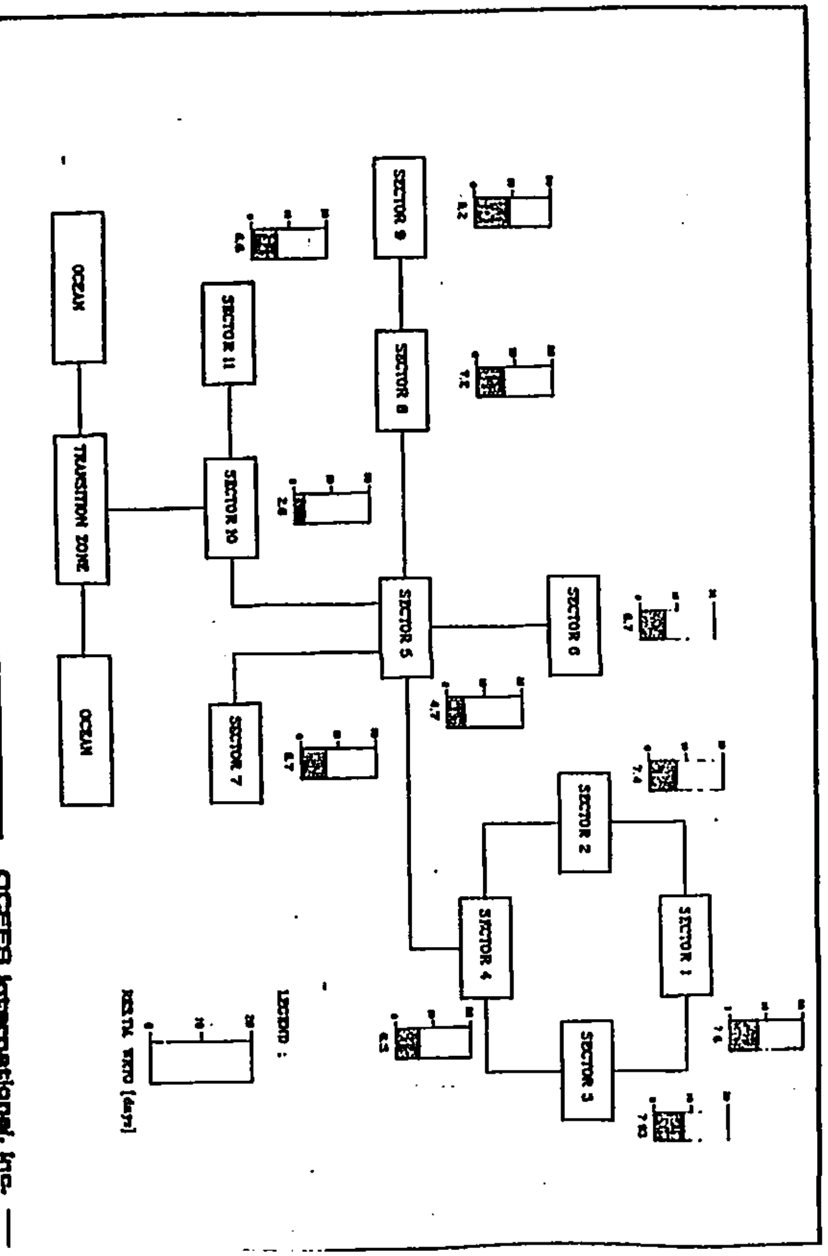
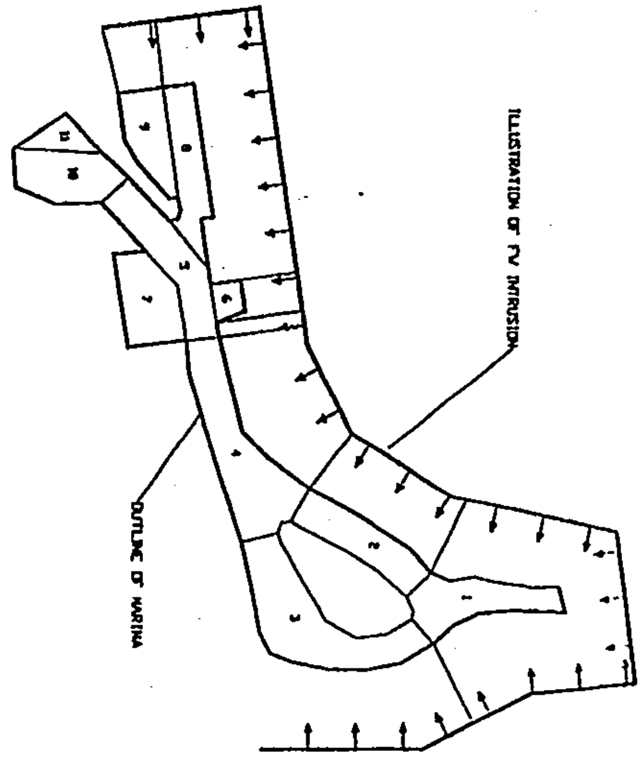


FIGURE 10

EWA MARINA WATER QUALITY STUDY
RESIDENCE TIME - STRATIFIED MODEL
ONLY TIDAL - FLOW ONLY IN BOTTOM LAYERS
JULY 23, 1990 MZ
FILE 18DB091

OCEES International, Inc.
OCEAN ENGINEERING & ENERGY SYSTEMS
3786 PUKALANI PL., HONOLULU, HAWAII 96816
TEL: (808) 734-7414

FIGURE 10



EWA MARINA WATER QUALITY STUDY.
STRATIFIED MODEL - FRESH WATER INTRUSION
ASSESSMENT OF FW INTRUSION
JULY 31, 1990
FILE: 18DB111

OCEES International, Inc.
OCEAN ENGINEERING & ENERGY SYSTEMS
3786 PUKALANI PL. HONOLULU, HAWAII 96816
TEL.: (808) 734-7414

STRATIFIED BOX MODEL

Calculation of residence times
Only FRESHWATER intrusion considered
Flow pattern only due to mixing of top and bottom layers

STRATIFICATION 5.00 [ft]

SECTOR NUMBER	AREA [ft^2]	AVERAGE DEPTH [ft]	AVG. DEPTH BOTTOM LAYER [ft]	AVG. DEPTH BOTTOM LAYER [m]
1	6.15E+05	9.00	4.00	1.22
2	5.90E+05	9.00	4.00	1.22
3	1.14E+06	9.00	4.00	1.22
4	1.05E+06	9.00	4.00	1.22
5	6.89E+05	15.00	10.00	3.05
6	1.16E+05	10.00	5.00	1.52
7	5.39E+05	10.00	5.00	1.52
8	5.52E+05	12.00	7.00	2.13
9	4.36E+05	10.00	5.00	1.52
10	5.23E+05	20.00	15.00	4.57
11	1.04E+05	10.00	10.00	3.05

SECTOR NUMBER	VOLUME TOP LAYER [cqft]	VOLUME BOTTOM LAYER [cqft]
1	3.08E+06	2.46E+06
2	2.95E+06	2.36E+06
3	5.70E+06	4.56E+06
4	5.27E+06	4.22E+06
5	3.45E+06	6.89E+06
6	5.81E+05	5.81E+05
7	2.70E+06	2.70E+06
8	2.76E+06	3.86E+06
9	2.18E+06	2.18E+06
10	2.62E+06	7.85E+06
11	9.20E+05	9.20E+05

TABLE C-1

EWA MARINA WATER QUALITY STUDY OCEES, Intern., INC JUNE 1990

FILE: 18MC20 PAGE C-2

STRATIFIED BOX MODEL

Calculation of residence times
Only FRESHWATER intrusion considered
Flow pattern only due to mixing of top and bottom layer

FLOWS IN BETW. BOTTOM LAYERS (cbft/day)		FLOWS IN BETW. TOP LAYERS (cbft/day)	
F1B2B	3.577E+05	F2T1T	4.152E+05
F1B3B	3.577E+05	F3T1T	4.790E+05
F2B4B	1.090E+06	F4T2T	1.242E+06
F3B4B	2.115E+06	F4T3T	2.417E+06
F4B5B	4.424E+06	F5T4T	4.995E+04
F6B5B	1.202E+05	F5T6T	1.451E+05
F7B5B	1.728E+05	F5T7T	1.728E+05
F8B5B	1.000E+06	F5T8T	1.174E+06
F9B8B	2.972E+05	F8T9T	3.251E+05
F5B10B	9.025E+06	F10T5T	9.827E+06
F11B10B	3.086E+05	F10T11T	3.086E+05
F10BT	1.124E+07	F1T0T	1.204E+07

GROUNDWATER INFLOW INTO SECTORS (cbft/day)		FLOWS FROM BOTTOM TO TOP LAYERS (UPWELLING) (cbft/day)	
F11	1.79E+05	F1T1B	7.153E+05
F12	9.45E+04	F2T2B	7.326E+05
F13	1.80E+05	F3T3B	1.757E+06
F14	1.17E+05	F4T4B	1.218E+06
F15	3.31E+04	F5T5B	3.307E+06
F16	2.49E+04	F6T6B	1.202E+05
F18	1.45E+05	F7T7B	1.728E+05
F19	2.79E+04	F8T8B	7.031E+05
		F9T9B	2.972E+05
	802080.00	F10T10B	1.904E+06
		F11T11B	3.086E+05

TABLE C-2

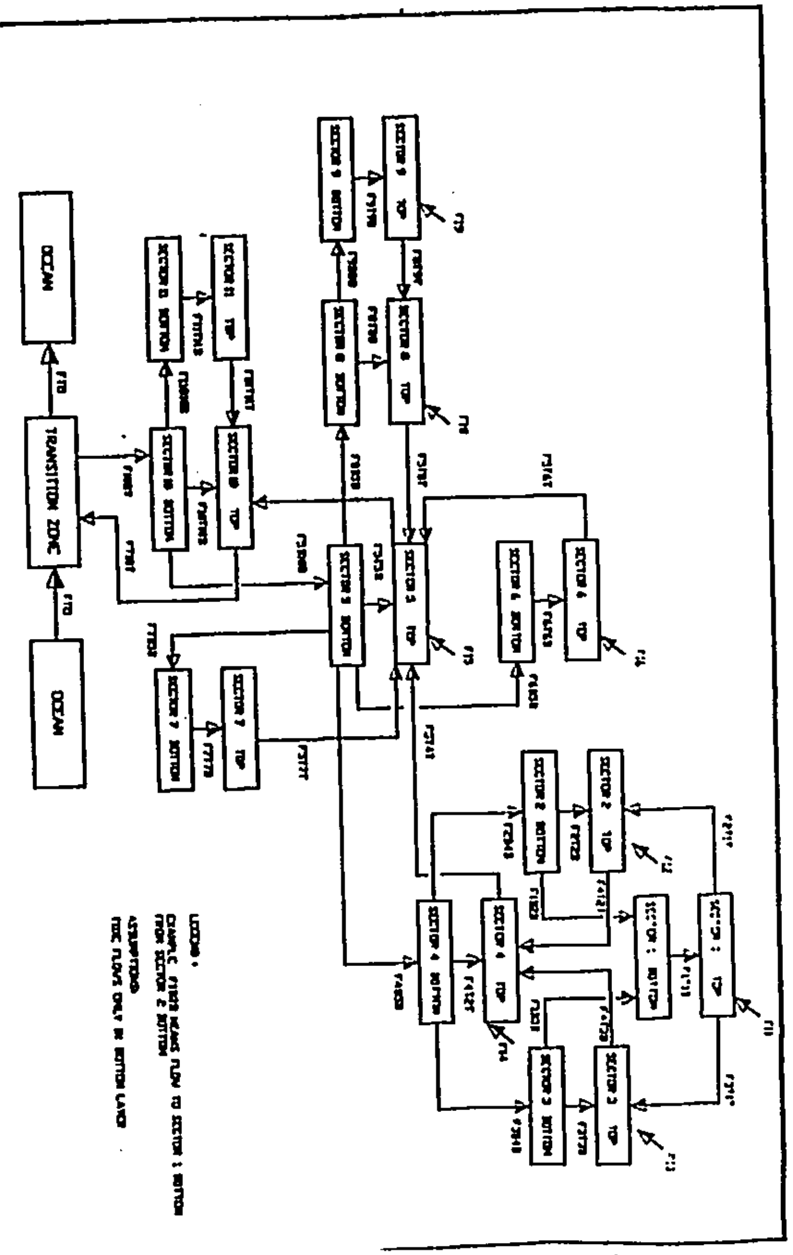


FIGURE 11

EWA MARINA WATER QUALITY STUDY
FLOW SCHEMATIC - STRATIFIED MODEL
FLOW DUE TO GROUNDWATER INTRUSION
AUGUST 2, 1990 MZ
FILE: 18DB131

OCEES International, Inc.
OCEAN ENGINEERING & ENERGY SYSTEMS
3786 PUKALANI PL. HONOLULU, HAWAII 96816
TEL: (808) 734-7414

EWA MARINA WATER QUALITY STUDY OCEES, Intern., INC JUNE 1990

FILE: 18U020 PAGE C-3

STRATIFIED BOX MODEL

Calculation of residence times
Only FRESHWATER intrusion considered
Flow pattern only due to mixing of top and bottom layers

CALCULATION OF RESIDENCE TIMES:

With respect to (WRT)
Immediate downstream sector

BOTTOM LAYER SECTOR ID		
1	3.44	[days]
2	3.34	[days]
3	2.24	[days]
4	3.07	[days]
5	3.30	[days]
6	4.83	[days]
7	2.60	[days]
8	6.04	[days]
9	1.48	[days]
10	3.35	[days]
11	0.60	[days]
TRANS.ZN.	0.26	[days]

TOP LAYER SECTOR ID		
1	3.44	[days]
2	2.37	[days]
3	2.36	[days]
4	1.06	[days]
5	0.35	[days]
6	4.00	[days]
7	2.60	[days]
8	2.35	[days]
9	1.50	[days]
10	0.22	[days]
11	0.60	[days]
TRANS.ZN.	0.26	[days]

CALCULATION OF RESIDENCE TIMES:

With respect to (WRT)
Ocean

BOTTOM LAYER SECTOR ID		
1	16.63	[days]
2	13.52	[days]
3	13.06	[days]
4	9.98	[days]
5	6.91	[days]
6	11.76	[days]
7	9.51	[days]
8	12.95	[days]
9	16.43	[days]
10	3.61	[days]
11	4.21	[days]
TRANS.ZN.	0.26	[days]

TOP LAYER SECTOR ID		
1	16.74	[days]
2	15.83	[days]
3	13.17	[days]
4	16.77	[days]
5	12.35	[days]
6	13.73	[days]
7	12.11	[days]
8	16.53	[days]
9	15.93	[days]
10	11.16	[days]
11	11.75	[days]
TRANS.ZN.	0.26	[days]

TABLE C-3

EWA MARINA WATER QUALITY STUDY OCEES, Intern., INC JUNE 1990

FILE: 18U020 PAGE D-1

STRATIFIED BOX MODEL

Calculation of residence times
SUPERPOSITION of tidal induced flow and flow due to
freshwater intrusion

STRATIFICATION 5.00 [ft]

SECTOR NUMBER	AREA [ft^2]	AVERAGE DEPTH [ft]	AVG. DEPTH BOTTOM LAYER [ft]	AVG. DEPTH BOTTOM LAYER [m]
1	6.15E+05	9.00	4.00	1.22
2	5.90E+05	9.00	4.00	1.22
3	1.14E+06	9.00	4.00	1.22
4	1.05E+06	9.00	4.00	1.22
5	6.89E+05	15.00	10.00	3.05
6	1.16E+05	10.00	5.00	1.52
7	5.39E+05	10.00	5.00	1.52
8	5.52E+05	12.00	7.00	2.13
9	4.36E+05	10.00	5.00	1.52
10	5.23E+05	20.00	15.00	4.57
11	1.84E+05	10.00	10.00	3.05

SECTOR NUMBER	VOLUME TOP LAYER [cqft]	VOLUME BOTTOM LAYER [cqft]
1	3.08E+06	2.46E+06
2	2.95E+06	2.36E+06
3	5.70E+06	4.56E+06
4	5.27E+06	4.22E+06
5	3.45E+06	6.89E+06
6	5.81E+05	5.81E+05
7	2.70E+06	2.70E+06
8	2.76E+06	3.86E+06
9	2.18E+06	2.18E+06
10	2.62E+06	7.85E+06
11	9.20E+05	9.20E+05

TABLE D-1

EWA MARINA WATER QUALITY STUDY OCEES, Intern., INC JUNE 1990

FILE: 18U020 PAGE D-2

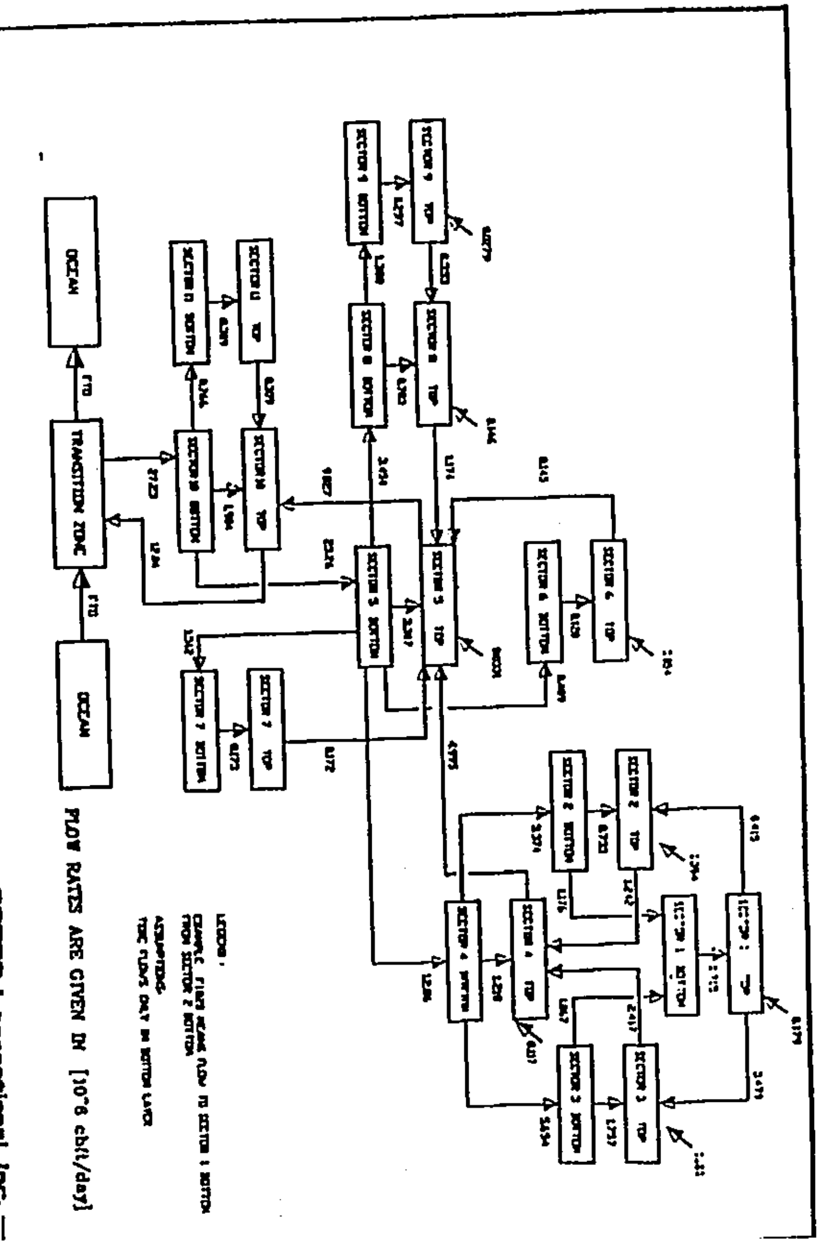
STRATIFIED BOX MODEL

Calculation of residence time
SUPERPOSITION of tidal induced flow and flow due to freshwater intrusion

FLOWS IN BETW. BOTTOM LAYERS	(cbft/day)	FLOWS IN BETW. TOP LAYERS	(cbft/day)
F1B2B	1.176E+06	F2T1T	4.152E+05
F1B3B	1.047E+06	F3T1T	4.790E+05
F2B4B	3.374E+06	F4T2T	1.242E+06
F3B4B	5.654E+06	F4T3T	2.417E+06
F4B5B	1.286E+07	F5T4T	4.995E+06
F6B5B	4.086E+05	F5T6T	1.451E+05
F7B5B	1.512E+06	F5T7T	1.728E+05
F8B5B	3.454E+06	F5T8T	1.174E+06
F9B8B	1.380E+06	F8T9T	3.529E+05
F5B10B	2.326E+07	F10T5T	9.827E+06
F11B10B	7.656E+05	F10T11T	3.086E+05
F10BT	2.723E+07	F11OT	1.204E+07

GROUNDWATER INFLOW INTO SECTORS	(cbft/day)	FLOWS FROM BOTTOM TO TOP LAYERS (UPWELLING)	(cbft/day)
F11	1.788E+05	F1T1B	7.153E+05
F12	9.445E+04	F2T2B	7.328E+05
F13	1.804E+05	F3T3B	1.757E+06
F14	1.171E+05	F4T4B	1.218E+06
F15	3.306E+04	F5T5B	3.307E+06
F16	2.487E+04	F6T6B	1.202E+05
F18	1.435E+05	F7T7B	1.728E+05
F19	2.786E+04	F8T8B	7.031E+05
		F9T9B	2.972E+05
	8.021E+05	F10T10B	1.904E+06
		F11T11B	3.086E+05

TABLE - D-3



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EWA MARINA WATER QUALITY STUDY
SUPERPOSITION OF TIDAL INDUCED FLOW
AND FLOW DUE TO GROUNDWATER INTRUSION
JULY 30, 1990 MZ
FILE 18DB141

FIGURE 13

STRATIFIED BOX MODEL

Calculation of residence time
SUPERPOSITION of tidal induced flow and flow due to
freshwater intrusion

CALCULATION OF RESIDENCE TIMES:
With respect to (WRT)
Immediate downstream sector

BOTTOM LAYER

SECTOR ID		
1	1.10	[days]
2	1.10	[days]
3	0.82	[days]
4	1.06	[days]
5	1.28	[days]
6	1.42	[days]
7	1.78	[days]
8	1.75	[days]
9	1.58	[days]
10	1.38	[days]
11	1.20	[days]
TRANS.ZN.	0.26	[days]

TOP LAYER

SECTOR ID		
1	3.44	[days]
2	2.37	[days]
3	2.36	[days]
4	1.06	[days]
5	0.35	[days]
6	4.00	[days]
7	2.60	[days]
8	2.30	[days]
9	1.48	[days]
10	0.22	[days]
11	0.60	[days]
TRANS.ZN.	0.26	[days]

CALCULATION OF RESIDENCE TIMES:
With respect to (WRT)
Ocean

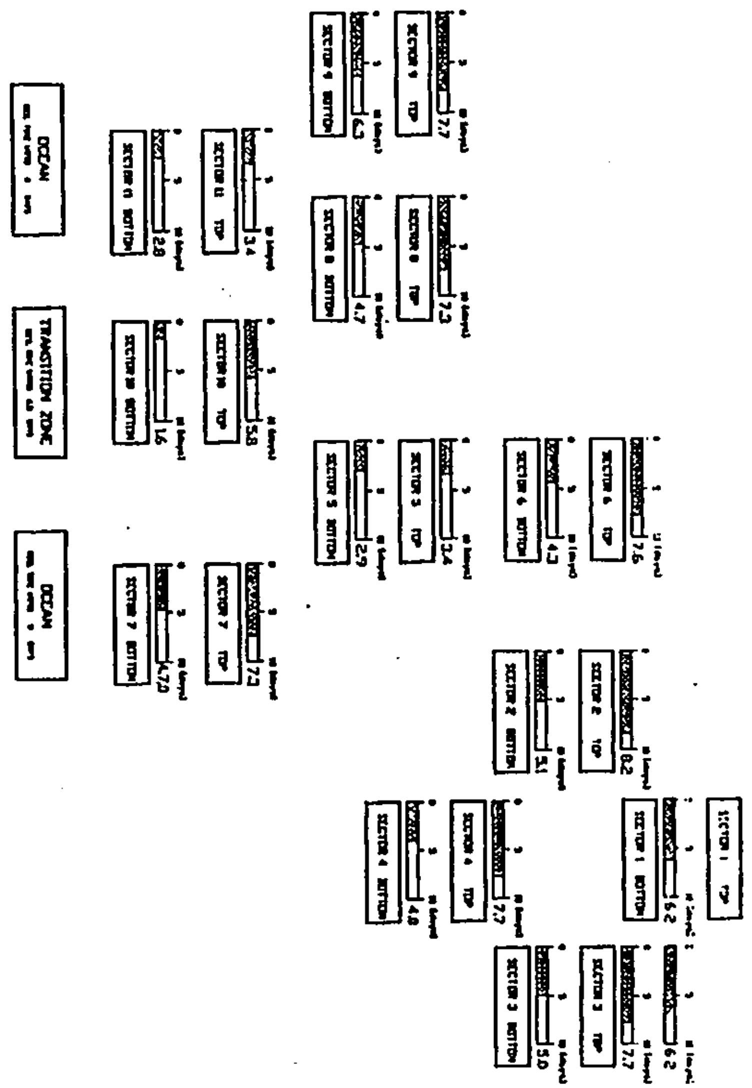
BOTTOM LAYER

SECTOR ID		
1	6.15	[days]
2	5.08	[days]
3	5.04	[days]
4	3.98	[days]
5	2.92	[days]
6	4.34	[days]
7	4.71	[days]
8	4.67	[days]
9	6.25	[days]
10	1.64	[days]
11	2.84	[days]
TRANS.ZN.	0.26	[days]

TOP LAYER

SECTOR ID		
1	8.36	[days]
2	8.16	[days]
3	7.68	[days]
4	7.77	[days]
5	6.40	[days]
6	7.60	[days]
7	7.31	[days]
8	7.30	[days]
9	7.73	[days]
10	5.79	[days]
11	3.44	[days]
TRANS.ZN.	0.26	[days]

TABLE D-3



EWA MARINA WATER QUALITY STUDY
RESIDENCE TIMES WRT OCEAN FOR SECTORS
SUPERPOSITION TIDAL – GW INTRUSION
JULY 30, 1990 MZ
FILE: 18DB151

FIGURE: 13

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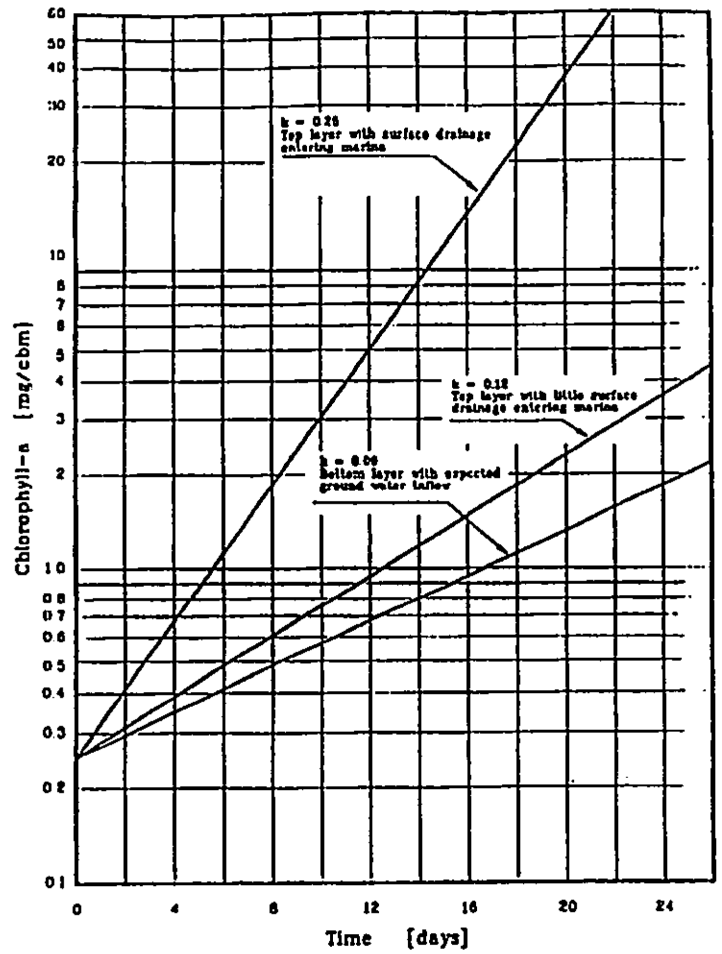

Chlorophyll-A concentration vs. estimated Sector residence time

FIGURE: 14	
EWA MARINA WATER QUALITY STUDY CHLOROPHYLL CONCENTRATION VERSUS ESTIMATED SECTOR RESIDENCE TIME JULY 30, 1990 MZ FILE: 16DB160	OCEES International, Inc. OCEAN ENGINEERING & ENERGY SYSTEMS 3786 PUKALANI PL., HONOLULU, HAWAII 96816 TEL.: (808) 734-7414

APPENDIX D

WATER QUALITY CONSIDERATIONS FOR EWA MARINA

OCEES International, Inc.
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Honolulu, Hawaii 96816

October 20, 1990

WATER QUALITY CONSIDERATIONS FOR EWA MARINA

PREPARED FOR:

Moffatt & Nichol, Engineers
P.O. Box 7707
250 West Wardlow Road
Long Beach, California 90807

PREPARED BY:

OCEES International, Inc.
3786 Pukalani Place
Honolulu, Hawaii 96816

October 20, 1990

INTRODUCTION

A general discussion of the factors that can be expected to influence the water quality of the proposed Ewa Marina was submitted to Moffatt & Nichol, Engineers by OCEES International, Inc. on March 22, 1990. This was followed on July 31, 1990 by the submission of a report giving the results of a two layer box model water exchange study for the proposed marina. The residence time projections contained in the latter study along with phytoplankton growth rate estimates form the basis for the calculations in the present study. The estimates of phytoplankton growth rates are based on experience in other marinas and embayments in Hawaii.

A comparison of the results of this study with the appropriate State of Hawaii Water Quality Standards gives some perspective on the levels of the parameters that are affected by the proposed marina.

PLANKTON GROWTH

The most variable water quality parameter that can be expected in a marina which combines very nutrient poor tropical oceanic waters with nutrient containing land derived waters is the concentration of chlorophyll-a. This parameter is important not only as a measure of the concentration of phytoplankton and the interaction with other trophic levels but also as an aesthetic parameter related to water clarity (i.e. turbidity) and color.

Three factors are important in the estimation of the chlorophyll-a concentration in the marina and in the water entering the ocean from the marina. These are:

(1) The initial chlorophyll-a concentration.
(2) The net phytoplankton growth rate.
(3) The residence time distribution.

Since water residence times in the various marina sectors have been calculated relative to the ocean, the initial chlorophyll-a concentration is that of the adjacent coastal waters entering the transition zone to the entrance of the marina. This area is influenced not only by the local ground and surface water discharges but also by the alongshore transport of exit waters from Pearl Harbor. (Fortunately another potentially detrimental influence, the Honouliuli outfall, has been shown to not affect nearshore waters because of its submerged plume and offshore transport direction.) The initial chlorophyll-a concentration can also be influenced by the fraction of water that is re-entering the marina. This re-entering fraction is expected to be very small because of the stratified flow condition in the marina exit channel and the alongshore transport in the nearshore coastal area.

The net phytoplankton growth rate is the gross growth rate minus the sum of the predation rate, the settling out rate and the

inhibition rate due to any toxic substances. In the open ocean the net growth rate is zero. This reflects the balance between the rate of growth and the removal rate due to predation and settling thus resulting in no net change in the average chlorophyll-a concentration with time. In nearshore waters, especially in estuaries, higher nutrient concentrations increase the gross growth rate more than the sum of the various removal rates and there is an increase in the chlorophyll-a concentration with timé. The time parameter in this case is the residence time in the areas with the higher nutrient concentrations.

Because of the complex interactions it is very difficult to calculate the net growth rate from basic scientific principals. However, an estimate of the net growth rate can be obtained by making measurements in analogous existing locations. Three such sets of measurements have been conducted on Oahu. These locations were in the Hawaii Kai Marina and in Kaneohe Bay (with and without municipal wastewater discharges). A prediction of water quality was also made for the then proposed Barbers Point Deep Draft Harbor using this method. Unfortunately no systematic measurement program has been conducted since the construction of that harbor to test the results of that prediction. The few data that do exist seem to be within the predicted range. Since that harbor is also in the Ewa plain area and is also influenced by nitrogen rich caprock water it would be a valuable analogy to the proposed marina.

The residence time characteristics of the proposed marina are the result of morphology, orientation, tidal range, wind speed and direction, and fresh water influx. These factors were taken into account in the exchange model which was used to calculate the average residence times in the various marina sectors with respect to the ocean. Within each sector the residence time distribution is some combination of plug flow and a completely mixed condition. Plug flow is expected to dominate because of the directionality imposed by the fresh water flow and because of the relatively narrow channels.

The net growth rate of phytoplankton in the Hawaii Kai marina was found to be 0.25 per day. The relevant characteristics of the Hawaii Kai marina include no stratification, both ground water and surface water inflow in moderate amounts (i.e. nitrogen and phosphorus addition), and no significant hard bottom community. Kaneohe bay had a net growth rate of 0.12 per day with wastewater addition and 0.09 per day without. Kaneohe bay receives surface runoff, is slightly stratified, and has a moderate hard bottom community. The proposed Ewa marina is expected to be stratified, to receive significant groundwater inflow and moderate surface flow, and to have a soft bottom community. These conditions make it likely that the net growth rate of phytoplankton will be similar to that of the Hawaii Kai marina, i.e. about 0.25 per day.

The turbidity in the Hawaii Kai marina has been shown to consist primarily of fine particulate material presumably from surface drainage and from resuspension of the soft bottom material. The plankton contribution to the turbidity was found to be less than that associated with inorganic suspended fine particulates. The proposed Ewa marina is expected to be stratified with the result that wind induced mixing energy will not reach the bottom to as great a degree as is the case in the Hawaii Kai marina. This means that resuspension of settled material will not be as significant a contributor to turbidity in the proposed Ewa marina.

The total nitrogen (TN) concentration in the proposed Ewa marina is expected to exceed the water quality criteria for "wet" embayments because of the relatively large inflow of caprock groundwater. Agricultural practices in the area upstream from the marina have resulted in an increase in the TN concentration in the groundwater of the caprock zone of the Ewa plain. The TN concentration of the coastal waters is expected to be unchanged as

a result of the proposed marina because the total flow of groundwater will be unchanged after an initial adjustment period.

The higher than usual TN concentration is, however, of no great importance since total phosphorus (TP) will very likely be the limiting nutrient. Unlike TN, TP does not move with the groundwater and is therefore added primarily as a result of surface runoff. This means that control of the surface runoff entering the proposed Ewa marina constitutes control of the chlorophyll-a concentration and of the turbidity. Unfortunately, the size and orientation of the marina require that storm water runoff drain into the marina basin for flood control purposes. Fortunately, the Ewa marina drainage basin does not receive much rainfall. Consequently, higher concentrations of TP will be associated only with those occasions where there is sufficient rainfall to result in significant surface runoff. The effect will then be apparent for one or two residence time periods. The frequency of these occurrences can be reduced by including drop manholes in the design of the drainage system. This will allow the smaller storm flows to infiltrate to the groundwater rather than enter the marina as surface runoff. The three or four larger storm flows per year will of course enter the marina as surface runoff and add to the TP concentration and subsequently to the chlorophyll-a concentration and the turbidity. These larger storm conditions will contribute to the 90 and 98 percentile in the cumulative frequency distributions of the effected water quality parameters.

The relatively large groundwater flow into the proposed marina is the primary reason for the short residence times in the various marina sectors. There is some reason to believe that the groundwater flow will be even larger than that assumed in the box model study. This would mean even shorter residence times and better water quality in the marina and in the discharge flow to the ocean.

BOAT RELATED WATER QUALITY

The detrimental water quality effects associated with boats can be minimized by enforcement of marina regulations and by readily available spill cleanup capability.

Marina regulations to maintain water quality might include restrictions on wastewater discharges as well as restrictions on the discharge of any liquid or solid waste into marina waters. Any boat repair or dry-dock operations should have provisions for the containment and proper disposal of debris, paint chips, stripping chemicals, and any other detrimental materials to prevent them from getting into marina waters. Restrictions could also be placed on the use of some types of bottom paints such as those based on tri-butyl-tin (TBT).

A rapid response capability to fuel or oil spills should be available and marina maintenance personnel should be trained and able to respond on short notice. Containment booms and spill cleanup equipment should be maintained on site. There should be frequent pickup by the marina patrol of any floating or sunken debris. Regulations designed to maintain good water quality should be strictly enforced.

An effort should be made to maintain the drainage basin of the proposed marina so as to minimize the entrance of detrimental materials to the marina during storm events which result in surface runoff to the marina. This should include the enforcement of grading permit regulations and other erosion control measures as well as litter control. If such drainage basin maintenance measures can be effectively put into place then periodic dredging of the marina would only be required at the entrance, if any significant wave induced sand transport occurs there.

WATER QUALITY

A general outline of the proposed Ewa Marina is shown in Figure 1. Groundwater flow is expected to enter along all peripheries except those facing the ocean. Surface runoff will enter primarily at the northernmost end of the marina. The main marina channel is approximately aligned with the dominant wind direction thereby enhancing mixing and transport of the surface layer. The entrance channel, however, is not aligned with the wind and, consequently, the two primary exchange mechanisms with the ocean are the tide and the fresh water induced flow.

In order to evaluate the probable exchange characteristics of the proposed marina a two layer box model was used. The marina sectors used in this model are shown in Figure 2. A schematic of the two layer exchange, including quantitative estimates of the flows due to the tide and groundwater influx, is given in Figure 3. The resulting average residence times of the water within the top and bottom layer of each sector with respect to the ocean are given in Figure 4. (The details of this box model study are given in the previous report.) As a general observation, the projected residence times in the Ewa Marina are relatively short. For example, the longest time is just over 8 days in the top layer of sector 2, while the longest time in the Hawaii Kai Marina is about 15 days in the most mauka sector. The shorter residence time in the Ewa Marina is directly due to the greater groundwater influx.

The exponential relationship of the phytoplankton concentration (as indicated by chlorophyll-a) with the residence time is given in Figure 5 under three nutrient conditions. The highest expected net growth rate, 0.25 per day, is likely to apply to the top layer of the proposed Ewa Marina most of the time because enough of the likely limiting nutrient, TP, will be entering from surface drainage. For extended periods with very little surface water input a lower net growth rate could be justified.

Since there is likely to be much less input of TP to the lower layer a smaller net growth rate, 0.12 or even 0.09 per day, could be used here.

The state of Hawaii water quality criteria for "wet" open coastal waters and embayments are given in Tables 1 and 2 respectively. These criteria are based on log-normal distributions. The criteria for TN, TP, turbidity, and chlorophyll-a are shown graphically in Figures 6 through 9 respectively for open coastal waters and in Figures 10 through 13 respectively for embayments.

The expected geometric mean (i.e. median) chlorophyll-a concentration in the surface layer discharge of the Ewa Marina (1.06 ug/l) is also shown in Figure 9. A dilution of about 13 to 1 will be required before the exit water meets the open coastal "wet" criteria (0.30 ug/l) for chlorophyll-a.

Within the marina the expected geometric mean chlorophyll-a concentration, in proportion to volume, was calculated using a net growth rate of 0.25 per day for the surface layer and 0.12 per day for the lower layer. This value, 0.95 ug/l, is also plotted in Figure 13. It is readily apparent that the "wet" embayment criteria of 1.50 ug/l is met.

Although insufficient quantitative information is available to calculate all of the expected water quality parameters the general conclusion is that the state criteria will be met within the marina but that the marina exit waters will exceed the "wet" open coastal criteria for TN, turbidity, and chlorophyll-a. Minimizing this exceedance will require limiting the entrance of TP and good marina and drainage basin maintenance.

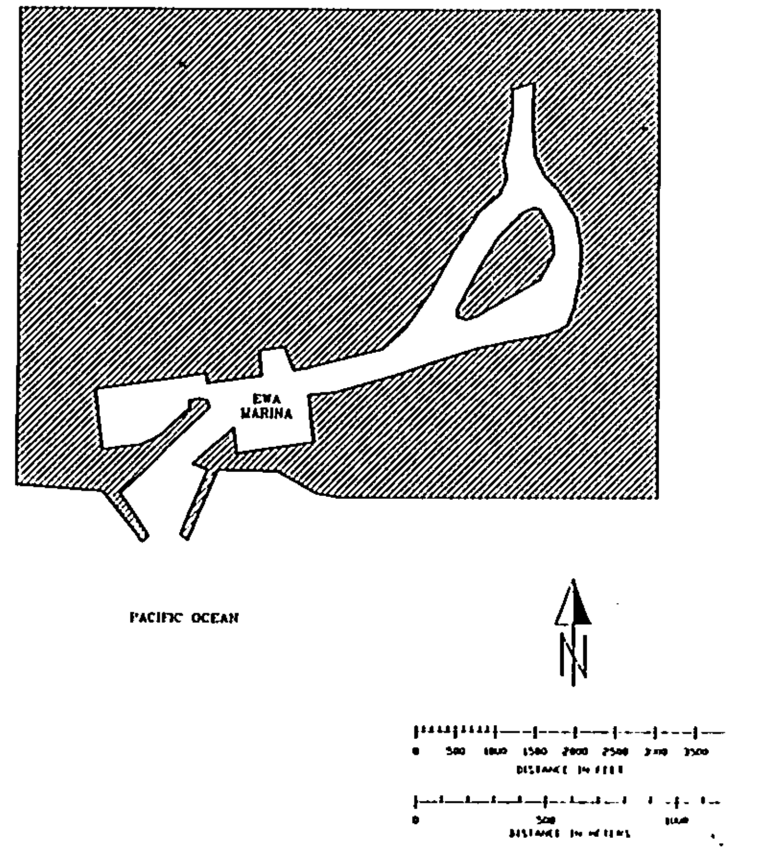

FIGURE : 1.

WATER QUALITY CONSIDERATIONS FOR EWA MARINA
EWA MARINA - SCHEMATIC LAYOUT
SCALE 1/16" = 100'
OCTOBER 20, 1990 MZ
FILE: 20DI010

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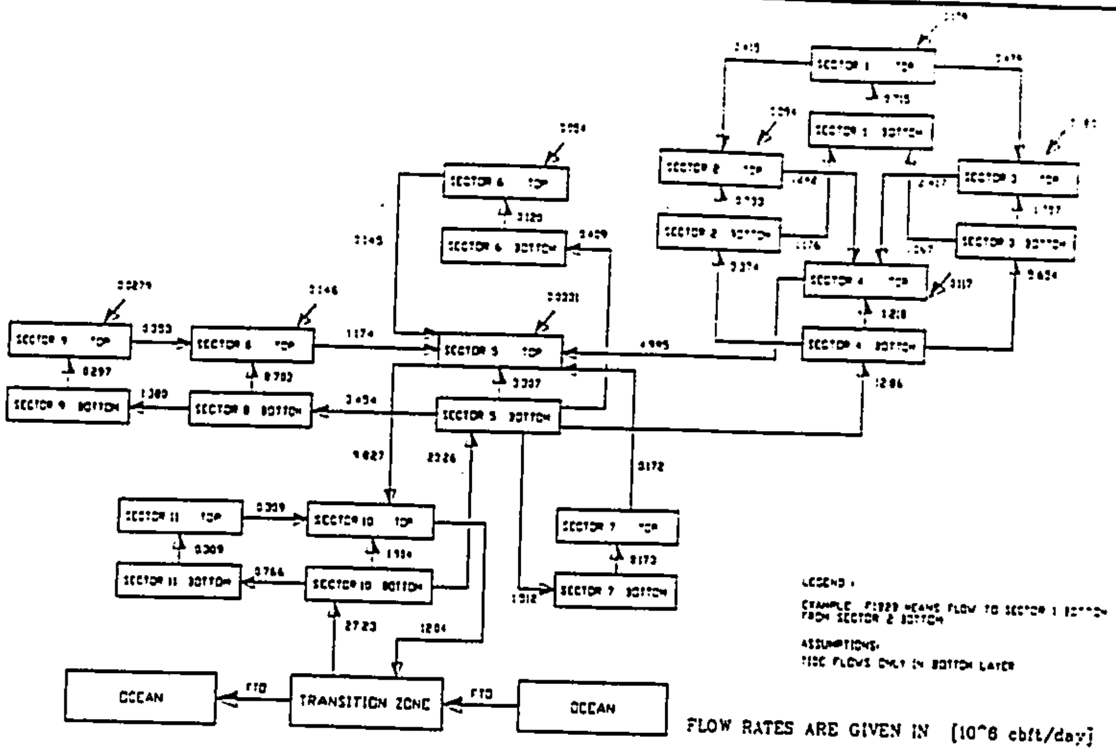
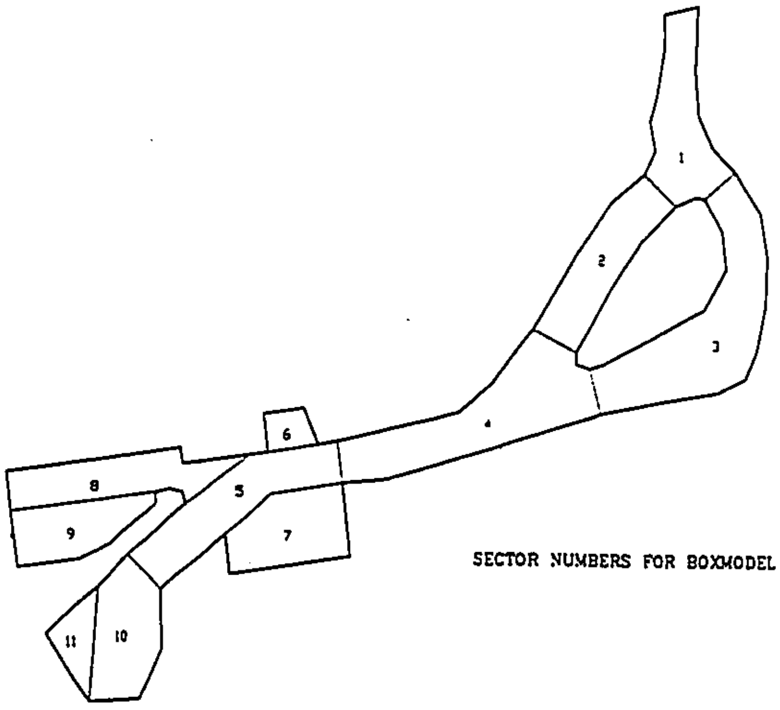


FLOW RATES ARE GIVEN IN [10^6 cbft/day]

FIGURE: 3.	WATER QUALITY CONSIDERATIONS FOR EWA MARINA SUPERPOSITION OF TIDAL INDUCED FLOW AND FLOW DUE TO GROUNDWATER INTRUSION OCTOBER 20, 1990 MZ FILE: 20DB030	OCEES International, Inc. OCEAN ENGINEERING & ENERGY SYSTEMS 3786 PUKALANI PL. HONOLULU, HAWAII 96816 TEL: (808) 734-7414



SECTOR NUMBERS FOR BOXMODEL

FIGURE. 2	WATER QUALITY CONSIDERATIONS FOR EWA MARINA BOX MODEL DEFINITION MODEL SECTOR NUMBERING NO SCALE OCTOBER 20, 1990 MZ FILE: 20DB020	OCEES International, Inc. OCEAN ENGINEERING & ENERGY SYSTEMS 3786 PUKALANI PL. HONOLULU, HAWAII 96816 TEL: (808) 734-7414

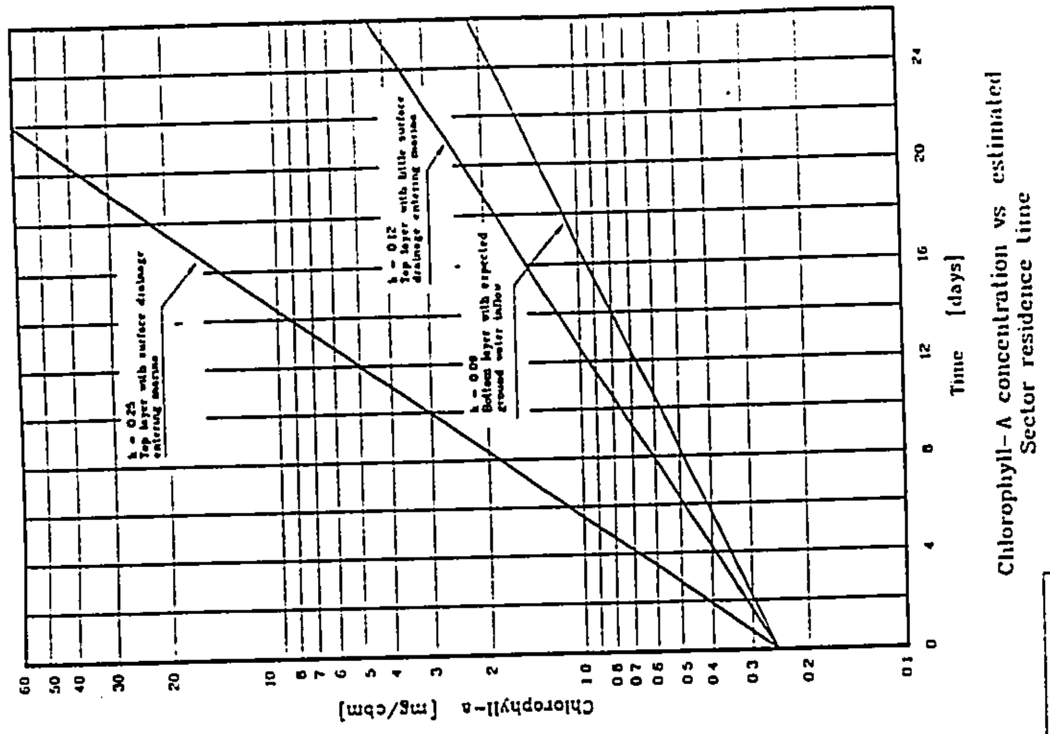


FIGURE 5.

WATER QUALITY CONSIDERATIONS FOR EWA MARINA
CHLOROPHYLL CONCENTRATION VERSUS
ESTIMATED SECTOR RESIDENCE TIME
OCTOBER 20, 1990 MZ
FILE 20DB050

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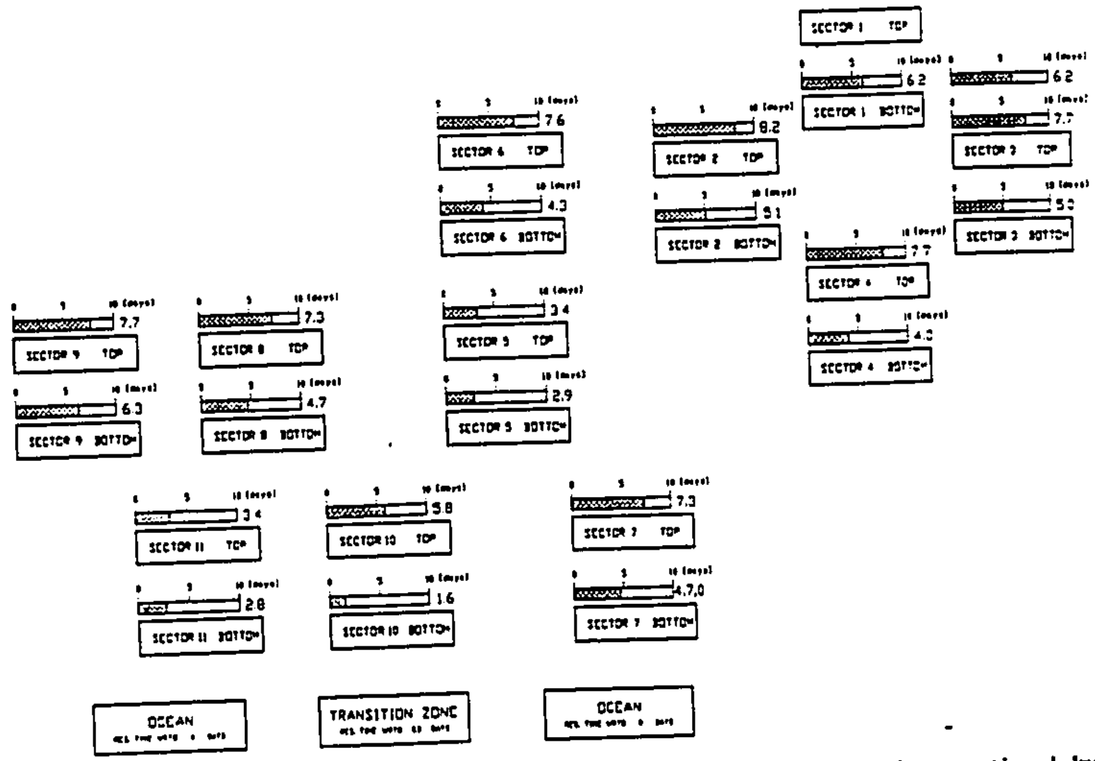

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WATER QUALITY CONSIDERATIONS FOR EWA MARINA
RESIDENCE TIMES WRT OCEAN FOR SECTORS
SUPERPOSITION TIDAL - GW INTRUSION
OCTOBER 20, 1990 MZ
FILE: 20DB040

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FIGURE 4

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 (ug N/L)	150.00 *	250.00 *	350.00 *
	110.00 **	180.00 **	250.00 **
Ammonia Nitrogen (ug NH3-N/L)	3.50 *	8.50 *	15.00 *
	2.00 **	5.00 **	9.00 **
Nitrate & Nitrite Nitrogen (ug (NO3+NO2)-N/L)	5.00 *	14.00 *	25.00 *
	3.50 **	10.00 **	20.00 **
Total Phosphorus (ug P/L)	20.00 *	40.00 *	60.00 *
	16.00 **	30.00 **	45.00 **
Light Extinction Coefficient (k units)	0.20 *	0.50 *	0.85 *
	0.10 **	0.30 **	0.55 **
Chlorophyll a (ug /L)	0.30 *	0.90 *	1.75 *
	0.15 **	0.50 **	1.00 **
Turbidity (N.T.U.)	0.50 *	1.25 *	2.00 *
	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

State of Hawaii Water Quality Criteria

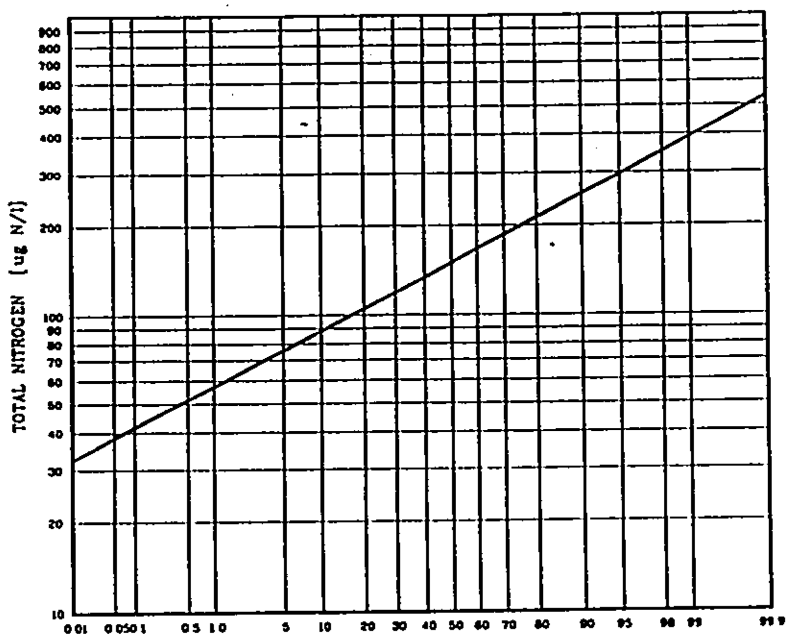
Criteria for Embayments

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

Comparison of State of Hawaii Water Quality Standards and predicted future conditions "WET" criteria for Open Coastal Waters



Total Nitrogen

FIGURE : 6

WATER QUALITY CONSIDERATIONS FOR EWA MARINA
COMPARISON OF HAWAII WQ STANDARDS
AND FUTURE WQ CONDITION PREDICTIONS
OCTOBER 29, 1990 MZ
FILE 20DB060

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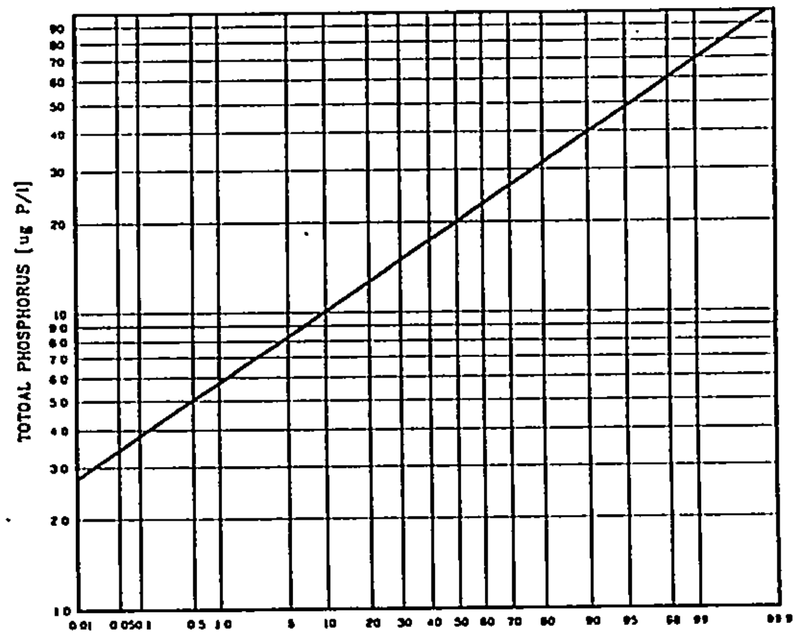
Comparison of State of Hawaii Water Quality Standards and predicted future conditions "WET" criteria for Open Coastal Waters



Total Phosphorus

FIGURE : 7.

WATER QUALITY CONSIDERATIONS FOR EWA MARINA
COMPARISON OF HAWAII WQ STANDARDS
AND FUTURE WQ CONDITION PREDICTIONS
OCTOBER 29, 1990 MZ
FILE 20DB070

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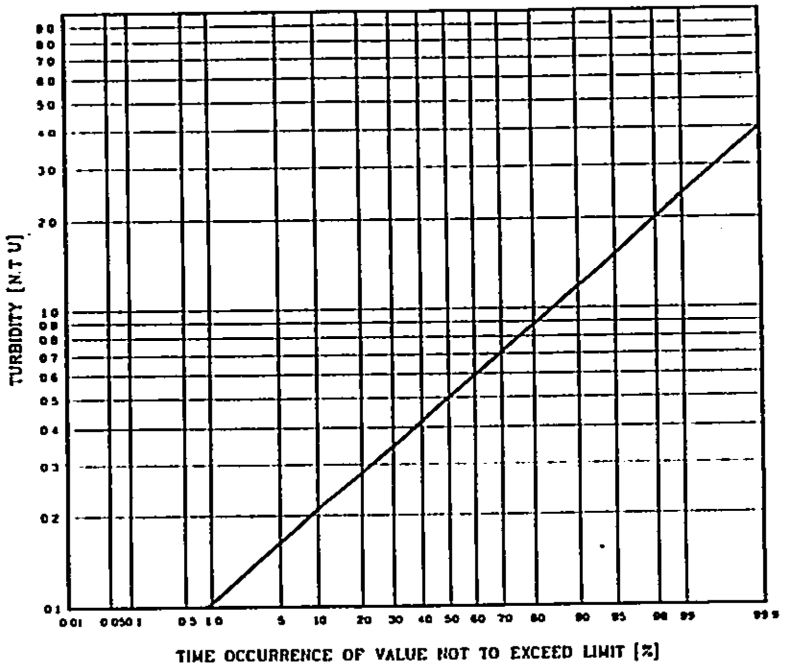
Comparison of State of Hawaii Water Quality Standards and predicted future conditions "WET" criteria for Open Coastal Waters



Turbidity [N.T.U.]

FIGURE : 8

WATER QUALITY CONSIDERATIONS FOR EWA MARINA
COMPARISON OF HAWAII WQ STANDARDS
AND FUTURE WQ CONDITION PREDICTIONS
OCTOBER 29, 1990 MZ
FILE 20DB090

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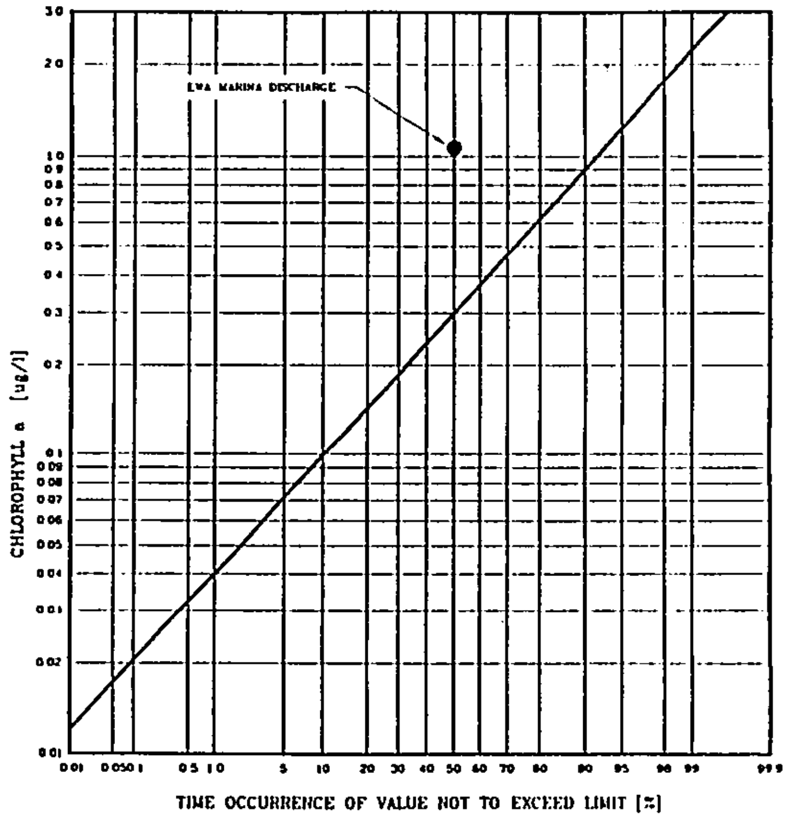
Comparison of State of Hawaii Water Quality Standards and predicted future conditions "WET" criteria for Open Coastal Waters



Chlorophyll-a

FIGURE 9.

WATER QUALITY CONSIDERATIONS FOR EWA MARINA
COMPARISON OF HAWAII WQ STANDARDS
AND FUTURE WQ CONDITION PREDICTIONS
OCTOBER 29, 1990 MZ
FILE 20DD080

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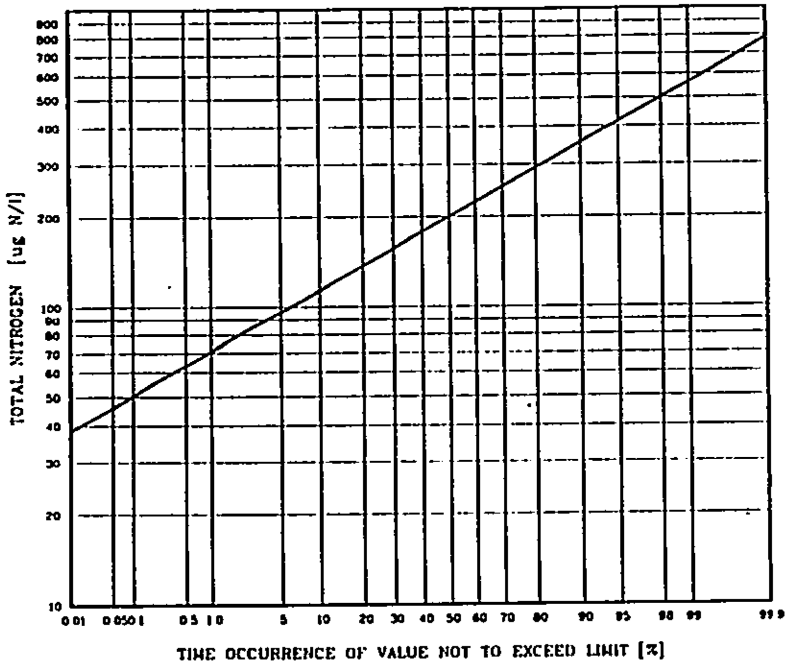
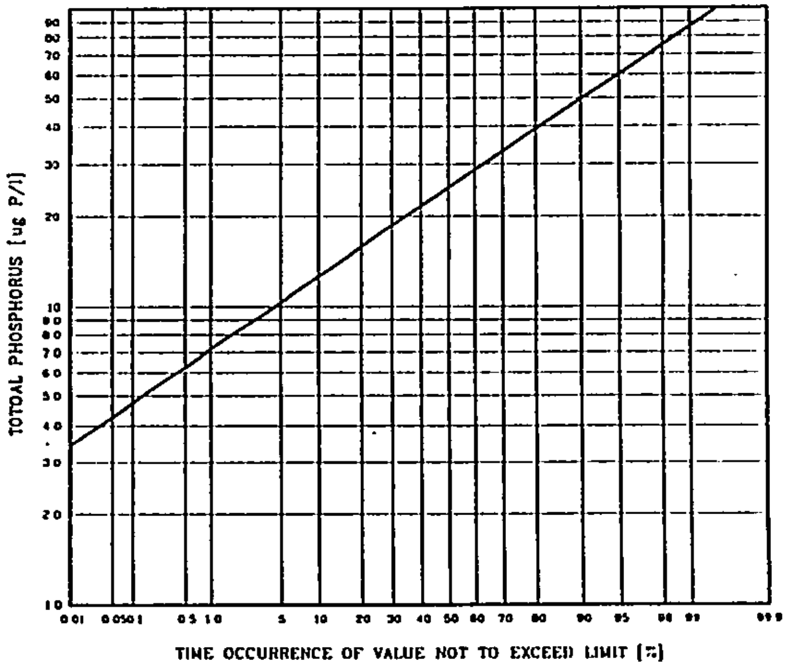
Comparison of State of Hawaii Water Quality Standards and predicted future conditions "WET" criteria for embayments



Total Nitrogen

FIGURE : 10	OCEES International, Inc.
WATER QUALITY CONSIDERATIONS FOR EWA MARINA COMPARISON OF HAWAII WQ STANDARDS AND FUTURE WQ CONDITION PREDICTIONS OCTOBER 29, 1990 MZ FILE 20DB100	OCEAN ENGINEERING & ENERGY SYSTEMS 3786 PUKALANI PL., HONOLULU, HAWAII 96816 TEL. (808) 734-7414

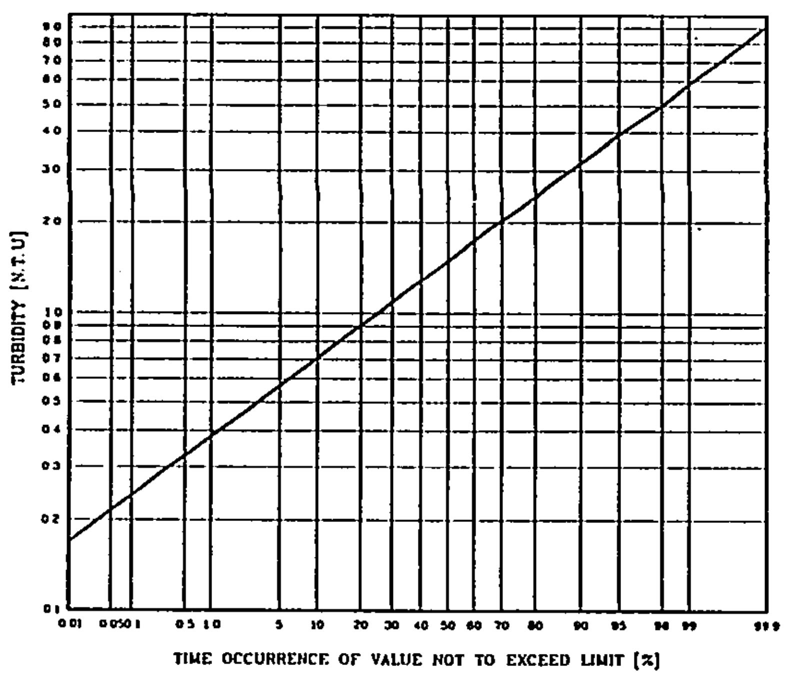
Comparison of State of Hawaii Water Quality Standards and predicted future conditions "WET" criteria for embayments



Total Phosphorus

FIGURE : 11.	OCEES International, Inc.
WATER QUALITY CONSIDERATIONS FOR EWA MARINA COMPARISON OF HAWAII WQ STANDARDS AND FUTURE WQ CONDITION PREDICTIONS OCTOBER 29, 1990 MZ FILE 20DB110	OCEAN ENGINEERING & ENERGY SYSTEMS 3786 PUKALANI PL., HONOLULU, HAWAII 96816 TEL. (808) 734-7414

Comparison of State of Hawaii Water Quality Standards and predicted future conditions "WET" criteria for embayments



Turbidity [N.T.U.]

FIGURE : 12

WATER QUALITY CONSIDERATIONS FOR EWA MARINA
COMPARISON OF HAWAII WQ STANDARDS
AND FUTURE WQ CONDITION PREDICTIONS
OCTOBER 29, 1990 MZ
FILE 20DB130

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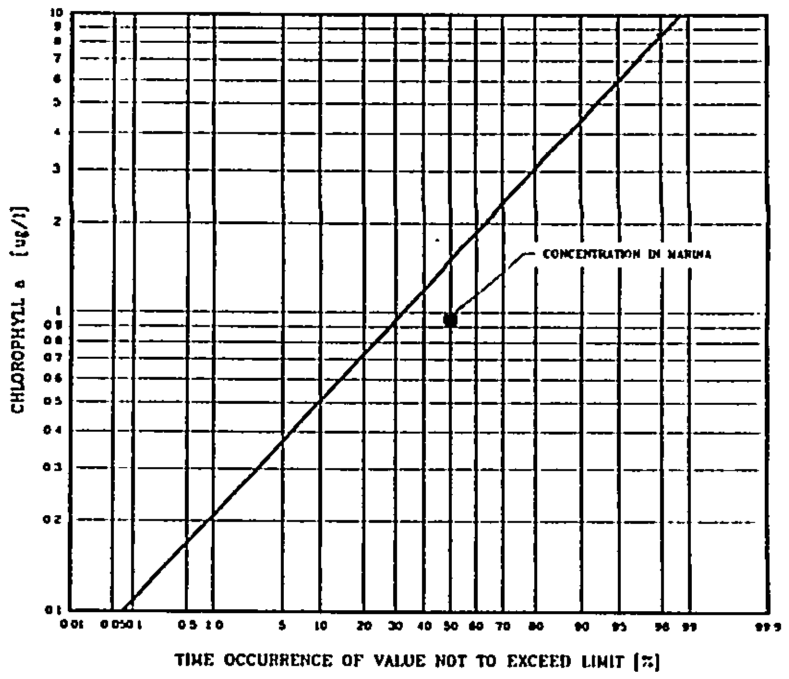
Comparison of State of Hawaii Water Quality Standards and predicted future conditions "WET" criteria for embayments



Chlorophyll-a

FIGURE : 13

WATER QUALITY CONSIDERATIONS FOR EWA MARINA
COMPARISON OF HAWAII WQ STANDARDS
AND FUTURE WQ CONDITION PREDICTIONS
OCTOBER 29, 1990 MZ
FILE 20DB120

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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

EVALUATION OF THE PROPOSED EWA MARINA WATER QUALITY

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September 16, 1991

INTRODUCTION

Three previous reports have been prepared by OCEES International, Inc. on the exchange characteristics and expected water quality of the proposed Ewa Marina. The first (March 1990) dealt with a general evaluation of the factors which influence water quality in marine water bodies, such as the Ewa Marina, receiving a significant influx of fresh water. The first report also gave the available background water quality data for the waters off Ewa.

The second report (July 1990 and revised November 1990) developed a two layer water exchange model for the proposed marina and calculated the expected average residence times for the upper and lower layers of each of the several sectors.

The third report (October 1990) made predictions of the chlorophyll-a concentration the proposed marina and in the water entering the open coastal area from the marina. This third report concluded that the waters within the marina would meet the State of Hawaii "wet" embayment standards with respect to chlorophyll-a but that the water leaving the marina would require dilution by a factor of about 13 before meeting the "wet" open coastal standard for chlorophyll-a. A similar pattern was expected for most of the other water quality parameters which are expressed in statistical form in the standards, such as turbidity, nitrate plus nitrite, ammonia and total nitrogen (TN).

The key nutrient was identified to be total phosphorus (TP) because of the elevated levels of nitrogen in the caprock groundwater in the Ewa area and the fact that phosphorus tends to be removed by passage through porous media. A similar water quality condition was found for the Barbers Point Harbor which has very similar geological and hydrological circumstances as the proposed Ewa Marina. Significant influx of phosphorus to the proposed marina is expected to be limited to those few rainfall events which result in large amounts of surface runoff.

The present report is to evaluate the water quality effects that can be expected from changes in the design of the proposed Ewa Marina. These changes include a somewhat different configuration, a slightly smaller overall surface area, and generally greater depths. There is also an increase in the expected salinity of the groundwater entering the marina. Although no radically different water quality conditions are expected from these changes, another evaluation will quantify the likely average growth response of the phytoplankton.

PHYTOPLANKTON GROWTH

The principal factors affecting the concentrations of phytoplankton (as indicated by chlorophyll-a) in the various sectors of the marina (initial concentration, net growth rate, and residence time) were discussed in the October 1990 report.

The initial concentration of chlorophyll-a for these calculations is taken to be that found in the coastal water off the proposed marina entrance; a geometric mean of 0.25 µg/l.

The residence time is discussed in a later section but is essentially the average age of the water in each sector and layer with respect to the ocean.

The net growth rates used in these calculations are based on real world observations of the net growth of phytoplankton in embayments in Hawaii and other Pacific Islands which have a wide range of nutrient concentrations. The standard kinetic relationships that have been found to accurately describe the observed relationship among the limiting nutrient concentration, the residence time and the chlorophyll-a concentration are the Michaelis-Menton equation and the exponential growth equation. The kinetic constants for the two major nutrients (TN and TP) that are most likely to be limiting in embayments and coastal waters were determined from best fit lines of the linear form of the Michaelis-Menton equation. These constants are given in table 1 while plots of the Michaelis-Menton equation are given in figures 1 and 2.

Table 1
Observed Kinetic Constants for Chlorophyll-a
in Tropical Island Embayments

Limiting Nutrient	Max μ Per Day	Ks $\mu g/l$
TP	0.5	40
TN	0.5	300

It should be stressed that these results are based on real-world factors as the day-night cycle, predation pressure on the phytoplankton and population and the symbiotic relationship between phytoplankton and bacteria in the water column with respect to nutrient cycling.

It has been suggested that it would be more conservative to use maximum growth rates measured under laboratory conditions to predict the chlorophyll-a concentration. Such pure culture growth rates are of the order of 1.0 per day (the day-night cycle is not taken into account). Since bacterial activities and the effect of other organisms on the cycling dynamics of nutrients are not included in these laboratory measurements they are generally insensitive to changes in TN or TP. (Their forte is defining the limiting inorganic nutrient concentration under very controlled pure solution conditions.) Consequently these tests have been unsuccessful as guides in evaluating the effectiveness of control measures to limit the input of phosphorus and/or nitrogen in other forms than as dissolved inorganics. Real world experience, such as with the great lakes and Kaneohe bay and many other lakes and embayments, has shown, however, that changing the TP and/or the TN concentration has a significant effect on the net phytoplankton growth rate. The likely scenario is that the limiting step is in the nutrient recycling process. In any case, assuming that the laboratory growth rate is directly applicable is not so much conservative as completely

unrealistic. For example, using the 1.0 per day growth rate (which in this case would not cange with or without the sewage outfall) for the upper layer of south Kaneohe Bay (which has a residence time of about 13 days with respect to the ocean) results in a predicted chlorophyll-a concentration of more than 88,000 $\mu g/l$. Since the actual geometric mean chlorophyll-a concentration (without the wastewater outfall) here is less than 0.7 $\mu g/l$ the predictive capability of directly using the laboratory derived growth rate is in serious doubt. Consequently, the present study relies on growth rates derived from directly analogous real-world situations for predicting the chlorophyll-a concentrations in the proposed Ewa Marina.

RESIDENCE TIME

The residence times for the individual sectors and layers of the proposed Ewa Marina were estimated on the basis of mass balances on water and salt. The general methodology was described in the July 1990 report by OCEES International. The main features of this approach are the following:

1. Selection of sector boundaries by determining major hydraulic control sections such as narrow cross-section or significant changes in direction of channels.

2. Determination of surface areas, volumes, and cross-sectional areas by planimeter and/or calculation.

3. Determination of fresh water input to each sector by using a flow net for ground water flow and drainage basin hydraulics for surface water flow.

4. Selection of stratification conditions by comparison to analogous existing embayment with comparable fresh water influx and/or by calculation of mixing energy input from wind and other sources.

5. If the fresh water influx is small relative to the mixing energy (such as in the Hawaii Kai marina) then residence time calculations can be made on the basis of a single layer system. With larger rates of fresh water influx (such as in this case) determine the thickness of the upper layer and degree of saltwater in-mixing by analogy to an existing case (Ala Wai canal or Honokauhau harbor) or by determining the amount of mixing energy

available to lift an equivalent amount of higher

6. Calculate the flood tidal inflow through each sector from the tidal prism.

7. Calculate the amount of upward mixing saltwater into each sector upper layer and determine the net seaward flow.

8. Calculate the average residence time within each sector and layer individually and cumulate the residence times with respect to the ocean.

RESULTS

A schematic of the new configuration of the proposed Ewa Marina is shown in figure 3. As noted earlier, the marina was divided into eight sectors along lines of narrow cross-sections, significant changes in depth or alignment. The areas and depths related to the new configuration are given in the two pages following figure 3 along with the fresh water intrusion assumptions. These values are based on an overall groundwater intrusion rate of 6 mgd with an assumed chlorinity of 2,000 mg/l (or salinity of 3.7 0/00). The upper layer depth of 5 feet is similar to that found in Honokauhau harbor as are the average salinities.

The notation convention for flow between the sectors is illustrated in figure 4 for the case of flood tide only (ie no fresh water inflow and hence no stratification). The volumes, residence times and flow volumes for tidal flow only are given on pages A-1, A-2, and A-3. It is interesting to note that the maximum residence time under these conditions is 21 days in sector 1.

When stratification is significant the surface layer is likely to continously flow seaward (as is the case for the Ala Wai canal) while the tidal flow is largely confined to the lower layer. This conditions is illustrated in figure 5. The associated numerical values for this flow condition are given on pages B-1 through B-3. In this case the lower layer of sector 1 has a residence time of just over 11 days. The conditions related to fresh water induced flow only are given in the next three pages (C-1 through C-3).

Finally, the tide related flow and the fresh water induced flow are added as schematically shown in figure 6. The corresponding volumes, flows and residence times are given

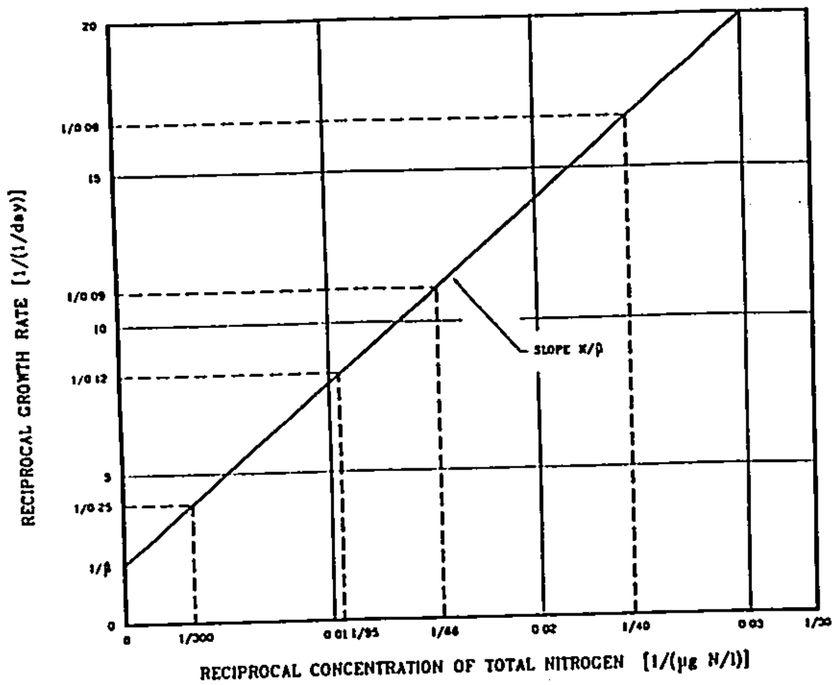
on pages D-1 through D-3. In addition, the flows are shown schematically in figure 7 while the residence times with respect to the ocean are shown in figure 8.

Using the residence time information in figure 8 for the surface layer of sector 8 (ie 5.6 days) and the 0.25 per day net growth rate in figure 9 results in an expected geometric mean chlorophyll-a concentration of 1.01 µg/l in the water entering the open coastal water from the marina. This is essentially the same as that protected for the previous design (1.06 µg/l). The open coastal "wet" criteria of 0.30 µg/l would be met only after diluting this discharge by a factor of about 14 to 1.

The expected geometric mean concentration of chlorophyll-a within the marina is expected to be about 1.10 µg/l with the new design. This is a slight increase over that of the previous design (0.95 µg/l) but still meets the "wet" embayment criteria of 1.50 µg/l for chlorophyll-a. The expected average range is from a level of 3.6 µg/l in the top layer of sector 2 to a level of 0.3 µg/l for the bottom layer of sector 8.

In sum, the water quality within the marina is expected to be within the standards while that of the exiting water will not meet the "wet" open coastal water standards without additional dilution.

Nutrient Lim'ted Net Growth in Tropical Saline Waters FOR NITROGEN



$$\frac{1}{\mu} = \frac{1}{\beta} + \frac{K}{\beta} \cdot \frac{1}{S}$$

where:

- μ = growth rate
- β = maximum growth rate (a constant)
- K = concentration of nitrogen [μg N/l] where μ = 0.5 * β
- S = concentration of nitrogen

FIGURE: 1.

EVALUATION OF THE PROPOSED EWA MARINA WQ
NUTRIENT LIMITED NET GROWTH IN
TROPICAL WATERS
SEPTEMBER 15, 1991
FILE: 23DB060

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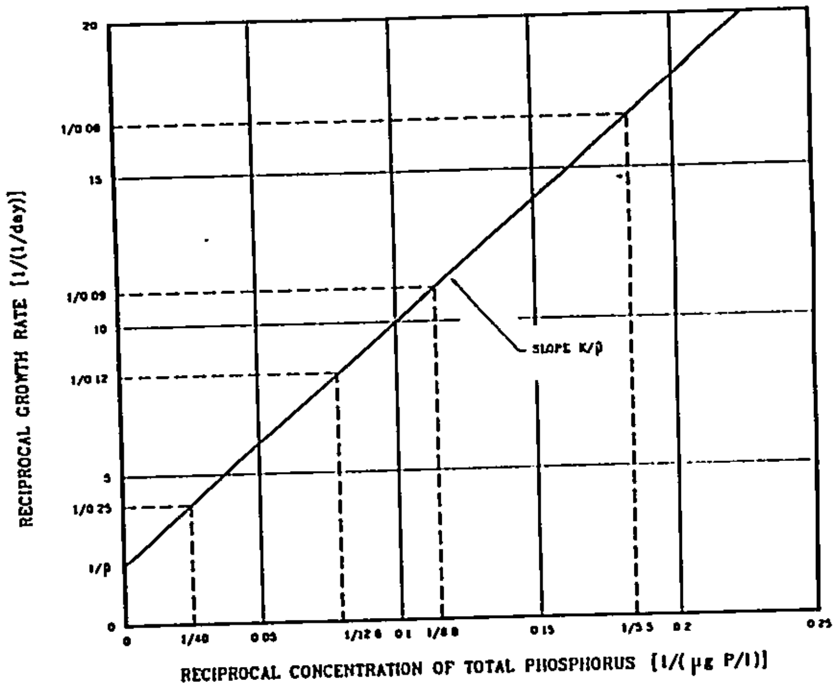
Nutrient Limited Net Growth in Tropical Saline Waters FOR PHOSPHORUS



$$\frac{1}{\mu} = \frac{1}{\beta} + \frac{K}{\beta} \cdot \frac{1}{S}$$

where:

- μ = growth rate
- β = maximum growth rate (a constant)
- K = concentration of phosphorus [μg P/l] where μ = 0.5 * β
- S = concentration of phosphorus

FIGURE: 2.

EVALUATION OF THE PREPOSED EWA MARINA WQ
NUTRIENT LIMITED NET GROWTH IN
TROPICAL WATERS
SEPTEMBER 15, 1991
FILE: 23DB070

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EVALUATION OF THE PROPOSED EWA MARINA WQ OCEES, Intern., INC SEPTEMBER 1991

EVALUATION OF THE PROPOSED EWA MARINA WATER QUALITY

FILE: 23W030

GENERAL INPUT PARAMETERS

SECTOR CHARACTERS

SECTOR NUMBER	AREA (ft^2)	AVERAGE DEPTH (ft)	BREADTH OF CROSS SECTION BETWEEN SECTORS	
1	3.67E+05	10.00	1-2	200.00
2	1.09E+06	10.00	1-3	325.00
3	5.47E+05	10.00	2-4	180.00
4	6.37E+05	10.00	3-4	200.00
5	5.90E+05	15.00		
6	6.23E+05	10.00		
7	1.02E+06	12.00		
8	9.11E+05	20.00		
	5.79E+06			

TIDAL PRISM: 2.48 (ft/day)

STRATIFICATION 5.00 (ft)

SALINITY OF SECTORS

SECTOR NUMBER	SALINITY (o/oo) Top Layer	Bot. Layer	SALINITY OF WATER INTRUSION INTO SECTOR
1	28.50	35.00	3.70
2	30.50	35.00	3.70
3	30.50	35.00	3.70
4	32.00	35.00	3.70
5	32.00	35.00	3.70
6	31.00	35.00	3.70
7	31.00	35.00	3.70
8	33.00	35.00	3.70
TRANS	35.00	35.00	
OCEAN	35.00		

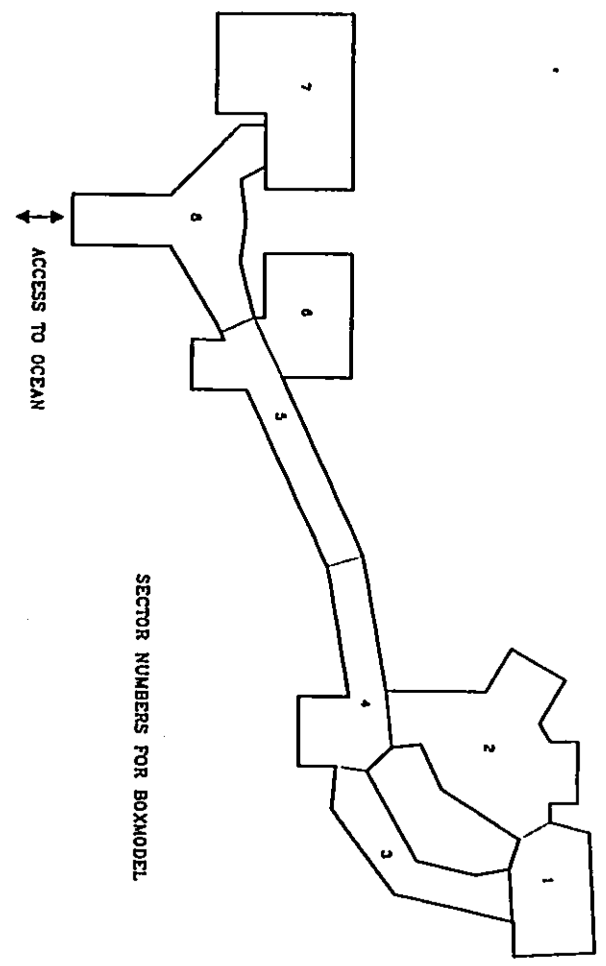

FIGURE: 3

EVALUATION OF THE PROPOSED EWA MARINA WQ
BOX MODEL DEFINITION
MODEL SECTOR NUMBERING
NO SCALE SEPTEMBER 15, 199?
FILE: 23DB020

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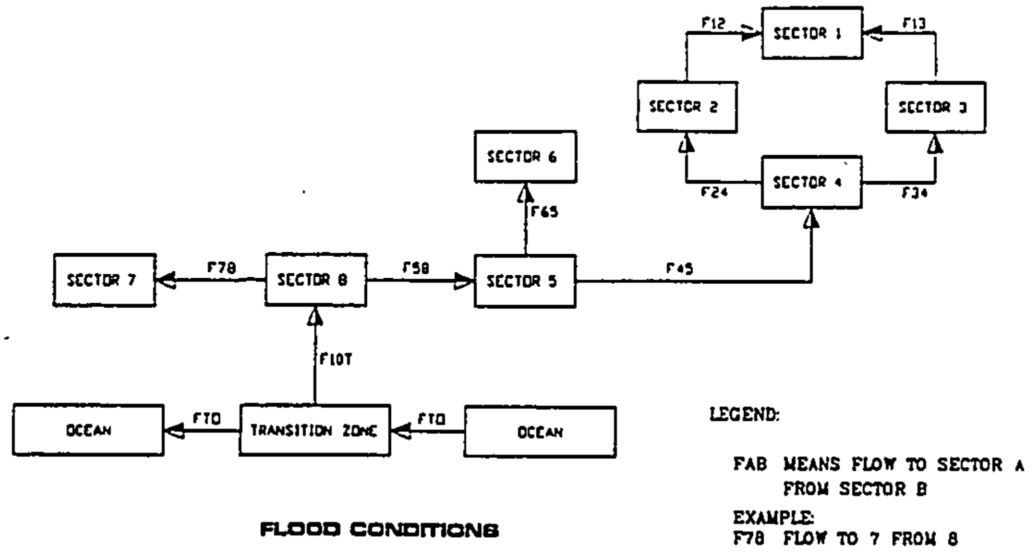

FIGURE: 4

EVALUATIONS OF THE PROPOSED EWA MARINA WQ
FLOW SCHEMATIC - UNSTRATIFIED MODEL
ONLY TIDAL - HERE FLOW DUE TO FLOOD
SEPTEMBER 15, 1991
FILE: 23DB030

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EVALUATION OF THE PROPOSED EWA MARINA WQ OCEES, Intern., INC SEPTEMBER 1991

GROUNDWATER INTRUSION
FW INTRUSION 6.00E+06 [gal/day]
FW INTRUSION 8.02E+05 [cbft/day]

SECTOR NUMBER	PROJECTED LENGTH PERP. TO SLOPE [ft]	FLOW	[cbft/day]
1	61.00	16.18	1.298E+05
2	58.00	15.38	1.234E+05
3	23.00	6.10	4.893E+04
4	26.00	6.90	5.532E+04
5	34.00	9.02	7.234E+04
6	45.00	11.94	9.574E+04
7	130.00	34.48	2.766E+05
8	0.00	0.00	0.000E+00
SUM	377.00	100.00	802080.00

FILE: 23U030 PAGE A-1

UNSTRATIFIED BOX MODEL

Calculation of residence times
Only tidal influences are considered

INPUT:

SECTOR NUMBER	AREA [ft^2]	AREA [m^2]	AVERAGE DEPTH [ft]	AVERAGE DEPTH [m]
1	3.67E+05	3.41E+04	10.00	3.05
2	1.09E+06	1.01E+05	10.00	3.05
3	5.47E+05	5.08E+04	10.00	3.05
4	6.37E+05	5.92E+04	10.00	3.05
5	5.90E+05	5.48E+04	15.00	4.57
6	6.23E+05	5.79E+04	10.00	3.05
7	1.02E+06	9.49E+04	12.00	3.66
8	9.11E+05	8.46E+04	20.00	6.10

SECTOR NUMBER	VOLUME [ft^3]	[m^3]
1	3.67E+06	1.04E+05
2	1.09E+07	3.09E+05
3	5.47E+06	1.55E+05
4	6.37E+06	1.80E+05
5	8.85E+06	2.51E+05
6	6.23E+06	1.76E+05
7	1.23E+07	3.47E+05
8	1.82E+07	5.16E+05

FILE: 23U030 PAGE A-2

TIDAL PRISM: 2.48 [ft/day]
0.76 [m/day]

CALCULATION OF FLOWS:

FLOOD CYCLE FLOW BETWEEN SECTORS	FLOW MAGNITUDE [cbft/day]	EBB CYCLE FLOW BETWEEN SECTORS	FLOW MAGNITUDE [cbft/day]
F12	3.473E+05	F21	3.473E+05
F13	5.643E+05	F31	5.643E+05
F24	3.057E+06	F42	3.057E+06
F34	1.923E+06	F43	1.923E+06
F45	6.563E+06	F54	6.563E+06
F65	1.548E+06	F56	1.548E+06
F78	2.539E+06	F58	2.539E+06
F58	9.576E+06	F105	9.576E+06
F8T	1.438E+07	FT10	1.438E+07

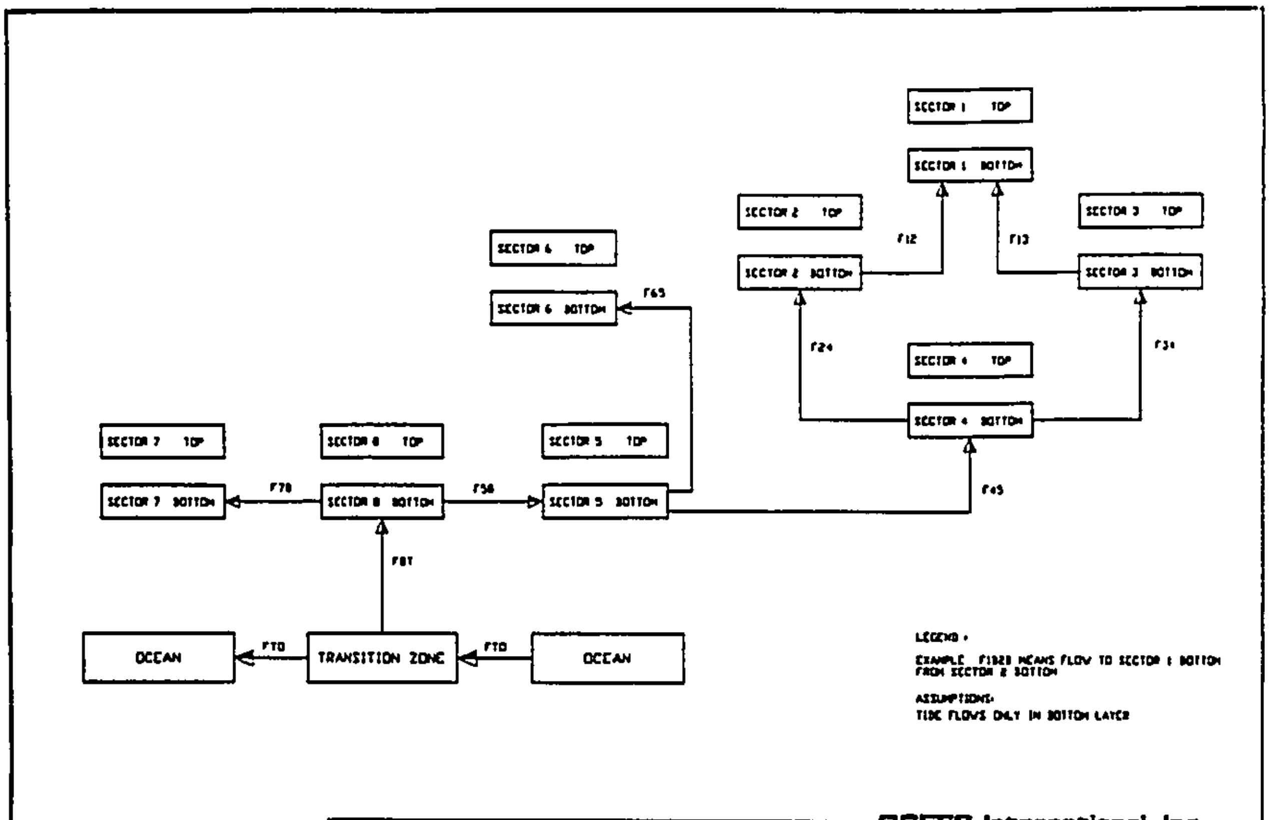

FIGURE: 5

EVALUATIONS OF THE PROPOSED EWA MARINA WQ
FLOW SCHEMATIC - STRATIFIED MODEL
FLOOD CYCLE - FLOW IN BOTTOM LAYER ONLY
SEPTEMBER 15, 1001
FILE: 23DB040

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CALCULATION OF RESIDENCE TIMES:

With respect to (WRT)
Immediate downstream sector

SECTOR ID		
1	4.03	(days)
2	4.03	(days)
3	4.03	(days)
4	4.03	(days)
5	3.68	(days)
6	4.03	(days)
7	4.83	(days)
8	5.01	(days)
TRANS.ZN.	0.26	(days)

CALCULATION OF RESIDENCE TIMES:

With respect to (WRT)
Ocean

SECTOR ID	
1	21.03
2	17.00
3	17.00
4	12.98
5	8.95
6	12.98
7	10.10
8	5.27
TRANS.ZN.	0.26

EVALUATION OF THE PROPOSED EWA MARINA WQ   OCEES, Intern., INC SEPTEMBER 1991

FILE: 23U030 PAGE B-1

STRATIFIED BOX MODEL

Calculation of residence times
Only tidal influences are considered
Tidal flow is restricted to bottom layer of sectors

STRATIFICATION 5.00 [ft]

INPUT:

SECTOR NUMBER	AREA [ft^2]	AREA [m^2]	AVG. DEPTH BOTTOM LAYER [ft]	AVG. DEPTH BOTTOM LAYER [m]
1	3.67E+05	3.41E+04	5.00	1.52
2	1.09E+06	1.01E+05	5.00	1.52
3	5.47E+05	5.08E+04	5.00	1.52
4	6.37E+05	5.92E+04	5.00	1.52
5	5.90E+05	5.48E+04	10.00	3.05
6	6.23E+05	5.79E+04	5.00	1.52
7	1.02E+06	9.49E+04	7.00	2.13
8	9.11E+05	8.46E+04	15.00	4.57

SECTOR NUMBER	VOLUME BOTTOM LAYER [ft^3]	VOLUME BOTTOM LAYER [m^3]
1	1.84E+06	5.20E+04
2	5.46E+06	1.54E+05
3	2.74E+06	7.74E+04
4	3.19E+06	9.02E+04
5	5.90E+06	1.67E+05
6	3.12E+06	8.82E+04
7	7.15E+06	2.03E+05
8	1.37E+07	3.87E+05

EVALUATION OF THE PROPOSED EWA MARINA WQ   OCEES, Intern., INC SEPTEMBER 1991

FILE: 23U030 PAGE B-2

STRATIFIED BOX MODEL

Calculation of residence times
Only tidal influences are considered
Tidal flow is restricted to bottom layer of sectors

STRATIFICATION 5.00 [ft]

TIDAL PRISM: 2.48 [ft/day]
0.76 [m/day]

CALCULATION OF FLOWS:

FLOOD CYCLE FLOW BETWEEN SECTORS	FLOW MAGNITUDE [cbft/day]	EBB CYCLE FLOW BETWEEN SECTORS	FLOW MAGNITUDE [cbft/day]
F12	3.473E+05	F21	3.473E+05
F13	5.643E+05	F31	5.643E+05
F24	3.057E+06	F42	3.057E+06
F34	1.923E+06	F43	1.923E+06
F45	6.563E+06	F54	6.563E+06
F65	1.548E+06	F56	1.548E+06
F78	2.539E+06	F87	2.539E+06
F58	9.576E+06	F85	9.576E+06
F8T	1.438E+07	FT8	1.438E+07

EVALUATION OF THE PROPOSED EWA MARINA WQ   OCEES, Intern., INC SEPTEMBER 1991

FILE: 23W030 PAGE B-3

STRATIFIED BOX MODEL

Calculation of residence times
Only tidal influences are considered
Tidal flow is restricted to bottom layer of sectors

STRATIFICATION 5.00 [ft]

CALCULATION OF RESIDENCE TIMES:
With respect to (WRT)
Immediate downstream sector

SECTOR ID		
1	2.01	[days]
2	2.01	[days]
3	2.01	[days]
4	2.01	[days]
5	2.00	[days]
6	2.01	[days]
7	2.82	[days]
8	2.99	[days]
TRANS.ZN.	0.26	[days]

CALCULATION OF RESIDENCE TIMES:
With respect to (WRT)
Ocean

SECTOR ID	
1	11.29
2	9.28
3	9.28
4	7.26
5	5.25
6	7.26
7	6.07
8	3.25
TRANS.ZN.	0.26

EVALUATION OF THE PROPOSED EWA MARINA WQ   OCEES, Intern., INC SEPTEMBER, 1991

FILE: 23W020 PAGE C-1

STRATIFIED BOX MODEL

Calculation of residence times
Only FRESHWATER intrusion considered
Flow pattern only due to mixing of top and bottom layers

STRATIFICATION 5.00 [ft]

SECTOR NUMBER	AREA [ft^2]	AVERAGE DEPTH [ft]	AVG. DEPTH BOTTOM LAYER [ft]	AVG. DEPTH BOTTOM LAYER [m]
1	3.67E+05	10.00	5.00	1.52
2	1.09E+06	10.00	5.00	1.52
3	5.47E+05	10.00	5.00	1.52
4	6.37E+05	10.00	5.00	1.52
5	5.90E+05	15.00	10.00	3.05
6	6.23E+05	10.00	5.00	1.52
7	1.02E+06	12.00	7.00	2.13
8	9.11E+05	20.00	15.00	4.57

SECTOR NUMBER	VOLUME TOP LAYER [cqft]	VOLUME BOTTOM LAYER [cqft]	TOTAL VOLUME [cqft]	
1	1.84E+06	1.84E+06	3.670E+06	3.71
2	5.46E+06	5.46E+06	1.091E+07	5.98
3	2.74E+06	2.74E+06	5.470E+06	5.03
4	3.19E+06	3.19E+06	6.370E+06	3.92
5	2.95E+06	5.90E+06	8.850E+06	4.48
6	3.12E+06	3.12E+06	6.230E+06	4.77
7	5.11E+06	7.15E+06	1.226E+07	3.79
8	4.56E+06	1.37E+07	1.822E+07	3.66

STRATIFIED BOX MODEL

Calculation of residence times
Only FRESHWATER intrusion considered
Flow pattern only due to mixing of top and bottom layer

FLOWS IN BETW. BOTTOM LAYERS (cbft/day)		FLOWS IN BETW. TOP LAYERS (cbft/day)	
F1B2B	1.886E+05	F2T1T	2.381E+05
F1B3B	3.065E+05	F3T1T	3.869E+05
F2B4B	1.029E+06	F4T2T	1.202E+06
F3B4B	7.699E+05	F4T3T	8.992E+05
F4B5B	3.372E+06	F5T4T	3.729E+06
F6B5B	6.534E+05	F5T6T	7.492E+05
F5B8B	4.957E+06		
F7B8B	1.888E+06	F8T5T	5.483E+06
F8BT	1.175E+07	F8T7T	2.164E+06
	8.021E+05	F18T	1.255E+07

GROUNDWATER INFLOW INTO SECTORS (cbft/day)		FLOWS FROM BOTTOM TO TOP LAYERS (UPWELLING) (cbft/day)	
F11	1.30E+05	F1T1B	4.952E+05
F12	1.23E+05	F2T2B	8.407E+05
F13	4.89E+04	F3T3B	4.634E+05
F14	5.53E+04	F4T4B	1.572E+06
F15	7.23E+04	F5T5B	9.321E+05
F16	9.57E+04	F6T6B	6.534E+05
F17	2.77E+05	F7T7B	1.888E+06
		F8T8B	4.906E+06

STRATIFIED BOX MODEL

Calculation of residence times
Only FRESHWATER intrusion considered
Flow pattern only due to mixing of top and bottom layers

CALCULATION OF RESIDENCE TIMES: With respect to (URT) Immediate downstream sector			CALCULATION OF RESIDENCE TIMES: With respect to (URT) Ocean		
BOTTOM LAYER SECTOR ID			BOTTOM LAYER SECTOR ID		
1	3.71	[days]	1	21.42	[days]
2	5.98	[days]	2	18.30	[days]
3	5.03	[days]	3	17.35	[days]
4	3.92	[days]	4	12.32	[days]
5	4.48	[days]	5	8.41	[days]
6	4.77	[days]	6	13.17	[days]
7	3.79	[days]	7	7.71	[days]
8	3.66	[days]	8	3.92	[days]
TRANS.ZN.	0.26	[days]	TRANS.ZN.	0.26	[days]
TOP LAYER SECTOR ID			TOP LAYER SECTOR ID		
1	2.94	[days]	1	19.91	[days]
2	4.54	[days]	2	21.28	[days]
3	3.04	[days]	3	20.55	[days]
4	0.85	[days]	4	17.87	[days]
5	0.54	[days]	5	16.26	[days]
6	4.16	[days]	6	15.65	[days]
7	2.36	[days]	7	9.09	[days]
8	0.36	[days]	8	10.54	[days]
TRANS.ZN.	0.26	[days]	TRANS.ZN.	0.26	[days]

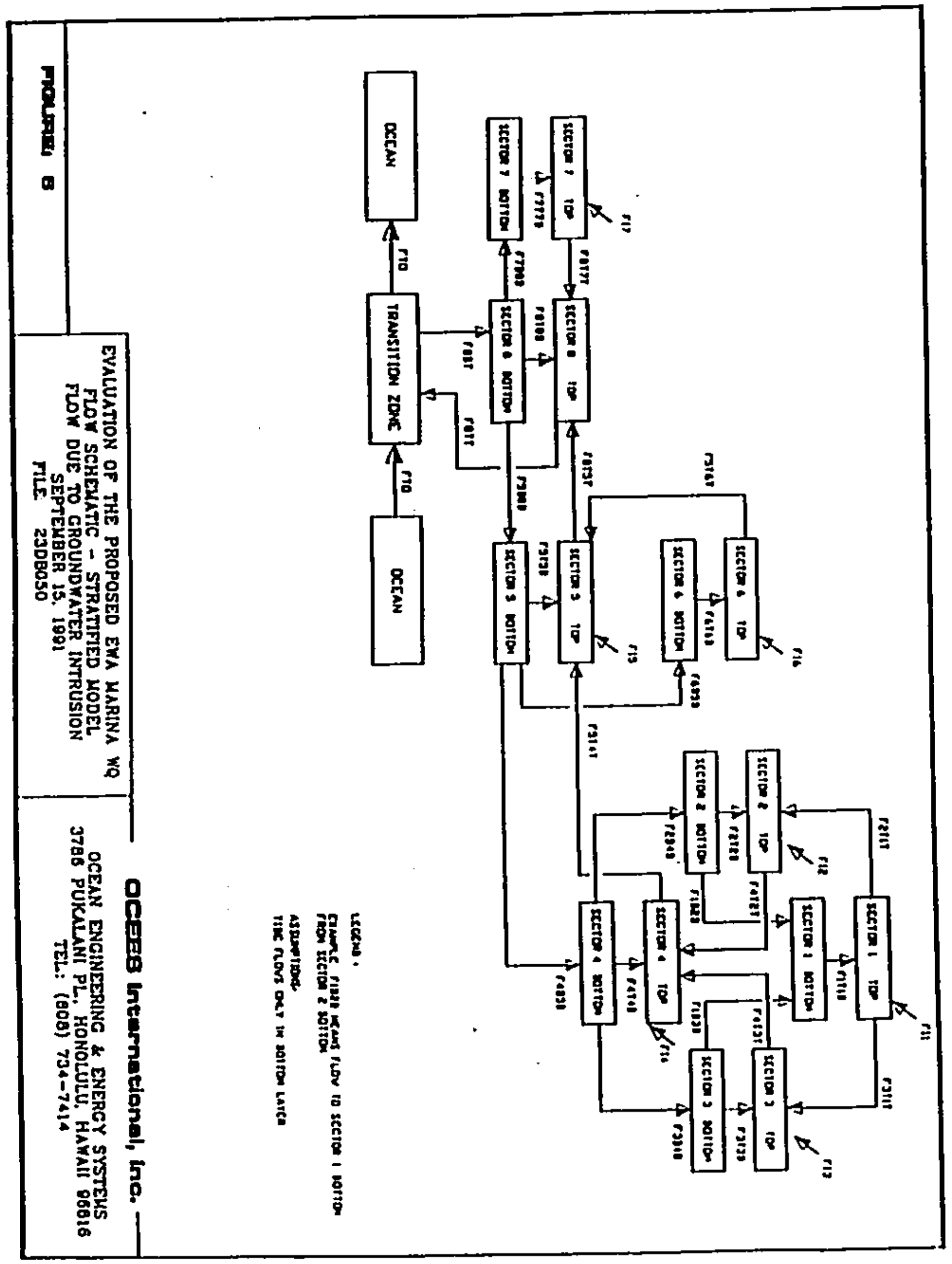
STRATIFIED BOX MODEL

Calculation of residence times
SUPERPOSITION of tidal induced flow and flow due to freshwater intrusion

STRATIFICATION 5.00 (ft)

SECTOR NUMBER	AREA (ft^2)	AVERAGE DEPTH (ft)	AVG. DEPTH BOTTOM LAYER (ft)	AVG. DEPTH BOTTOM LAYER (m)
1	3.47E+05	10.00	5.00	1.52
2	1.09E+06	10.00	5.00	1.52
3	5.47E+05	10.00	5.00	1.52
4	6.37E+05	10.00	5.00	1.52
5	5.90E+05	15.00	10.00	3.05
6	6.23E+05	10.00	5.00	1.52
7	1.02E+06	12.00	7.00	2.13
8	9.11E+05	20.00	15.00	4.57

SECTOR NUMBER	VOLUME TOP LAYER (cqft)	VOLUME BOTTOM LAYER (cqft)	TOTAL VOLUME (cqft)	
1	1.84E+06	1.84E+06	3.670E+06	1.30
2	5.46E+06	5.46E+06	1.091E+07	1.51
3	2.74E+06	2.74E+06	5.470E+06	1.44
4	3.19E+06	3.19E+06	6.370E+06	1.33
5	2.95E+06	5.90E+06	8.850E+06	1.53
6	3.12E+06	3.12E+06	6.230E+06	1.42
7	5.11E+06	7.15E+06	1.226E+07	1.42
8	4.56E+06	1.37E+07	1.822E+07	1.45



EVALUATION OF THE PROPOSED EWA MARINA WQ   OCEES, Intern., INC SEPTEMBER 1991

FILE: 23WO30   PAGE D-2

STRATIFIED BOX MODEL

Calculation of residence times
Only FRESHWATER intrusion considered
Flow pattern only due to mixing of top and bottom layer

FLOWS IN BETW. BOTTOM LAYERS (cbft/day)		FLOWS IN BETW. TOP LAYERS (cbft/day)	
F1B2B	5.359E+05	F2T1T	2.381E+05
F1B3B	8.709E+05	F3T1T	3.869E+05
F2B4B	4.087E+06	F4T2T	1.202E+06
F3B4B	2.693E+06	F4T3T	8.992E+05
F4B5B	9.934E+06	F5T4T	3.729E+06
F6B5B	2.201E+06	F5T6T	7.492E+05
F5B8B	1.453E+07		
F7B8B	4.426E+06	F8T5T	5.483E+06
F8BT	2.613E+07	F8T7T	2.164E+06
		F1BT	1.255E+07

GROUNDWATER INFLOW INTO SECTORS (cbft/day)		FLOWS FROM BOTTOM TO TOP LAYERS (UPWELLING) (cbft/day)	
F11	1.30E+05	F1T1B	4.952E+05
F12	1.23E+05	F2T2B	8.407E+05
F13	4.89E+04	F3T3B	4.634E+05
F14	5.53E+04	F4T4B	1.572E+06
F15	7.23E+04	F5T5B	9.321E+05
F16	9.57E+04	F6T6B	6.534E+05
F17	2.77E+05	F7T7B	1.688E+06
		F8T8B	4.906E+06

EVALUATION OF THE PROPOSED EWA MARINA WQ   OCEES, Intern., INC SEPTEMBER 1991

FILE: 23WO30   PAGE D-3

STRATIFIED BOX MODEL

Calculation of residence times
SUPERPOSITION of tidal induced flow and flow due to freshwater intrusion

CALCULATION OF RESIDENCE TIMES: With respect to (WRT) Immediate downstream sector			CALCULATION OF RESIDENCE TIMES: With respect to (WRT) Ocean		
BOTTOM LAYER SECTOR ID			BOTTOM LAYER SECTOR ID		
1	1.30	[days]	1	7.53	[days]
2	1.51	[days]	2	6.27	[days]
3	1.44	[days]	3	6.20	[days]
4	1.33	[days]	4	4.77	[days]
5	1.53	[days]	5	3.44	[days]
6	1.42	[days]	6	4.85	[days]
7	1.62	[days]	7	3.52	[days]
8	1.65	[days]	8	1.91	[days]
TRANS.ZN.	0.26	[days]	TRANS.ZN.	0.26	[days]
TOP LAYER SECTOR ID			TOP LAYER SECTOR ID		
1	2.94	[days]	1	8.91	[days]
2	4.54	[days]	2	10.69	[days]
3	3.06	[days]	3	10.07	[days]
4	0.85	[days]	4	8.74	[days]
5	0.54	[days]	5	8.21	[days]
6	4.16	[days]	6	8.39	[days]
7	2.36	[days]	7	5.43	[days]
8	0.36	[days]	8	5.63	[days]
TRANS.ZN.	0.26	[days]	TRANS.ZN.	0.26	[days]

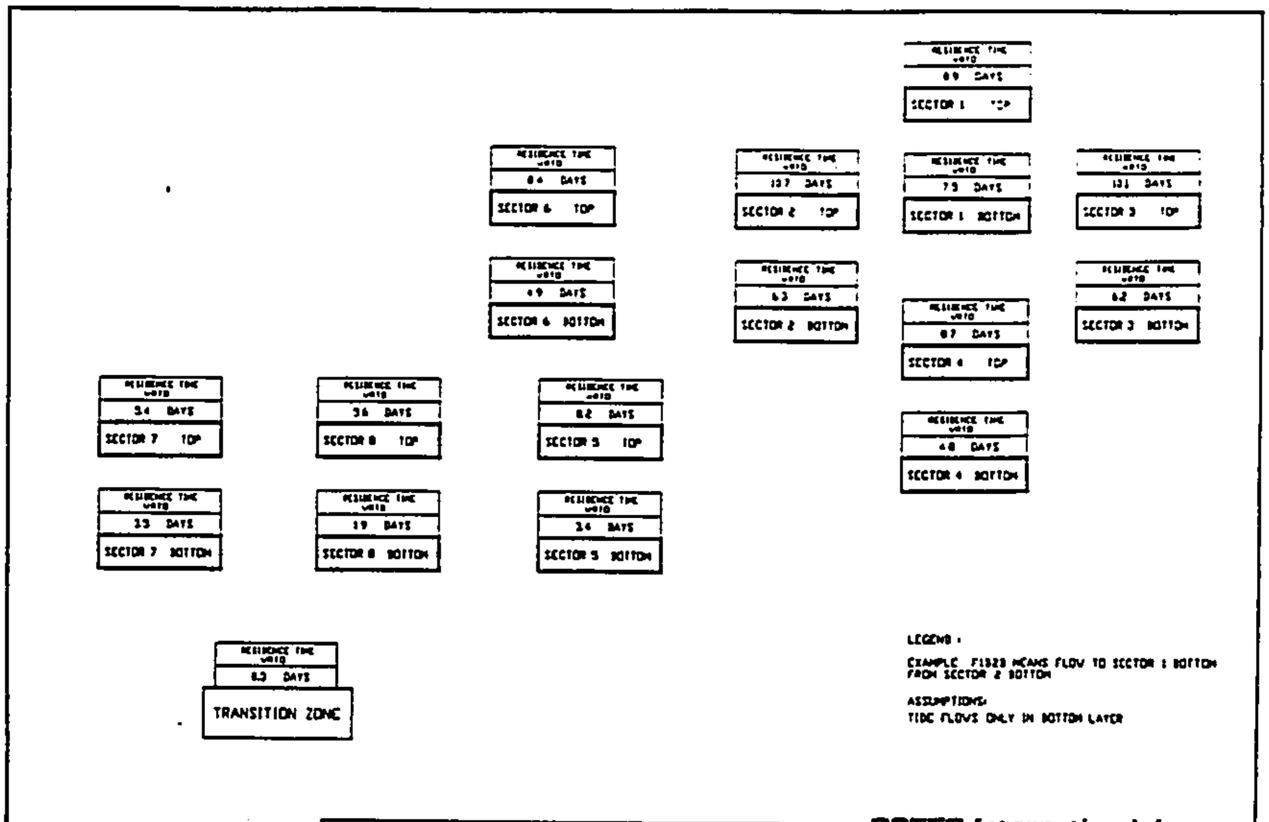


FIGURE: 8

EVALUATIONS OF THE PROPOSED EWA MARINA WQ
FLOW SCHEMATIC – STRATIFIED MODEL
SUPERPOSITION OF FLOW: GW INTRUS. AND TIDE
SEPTEMBER 15, 1991
FILE: 23DB090

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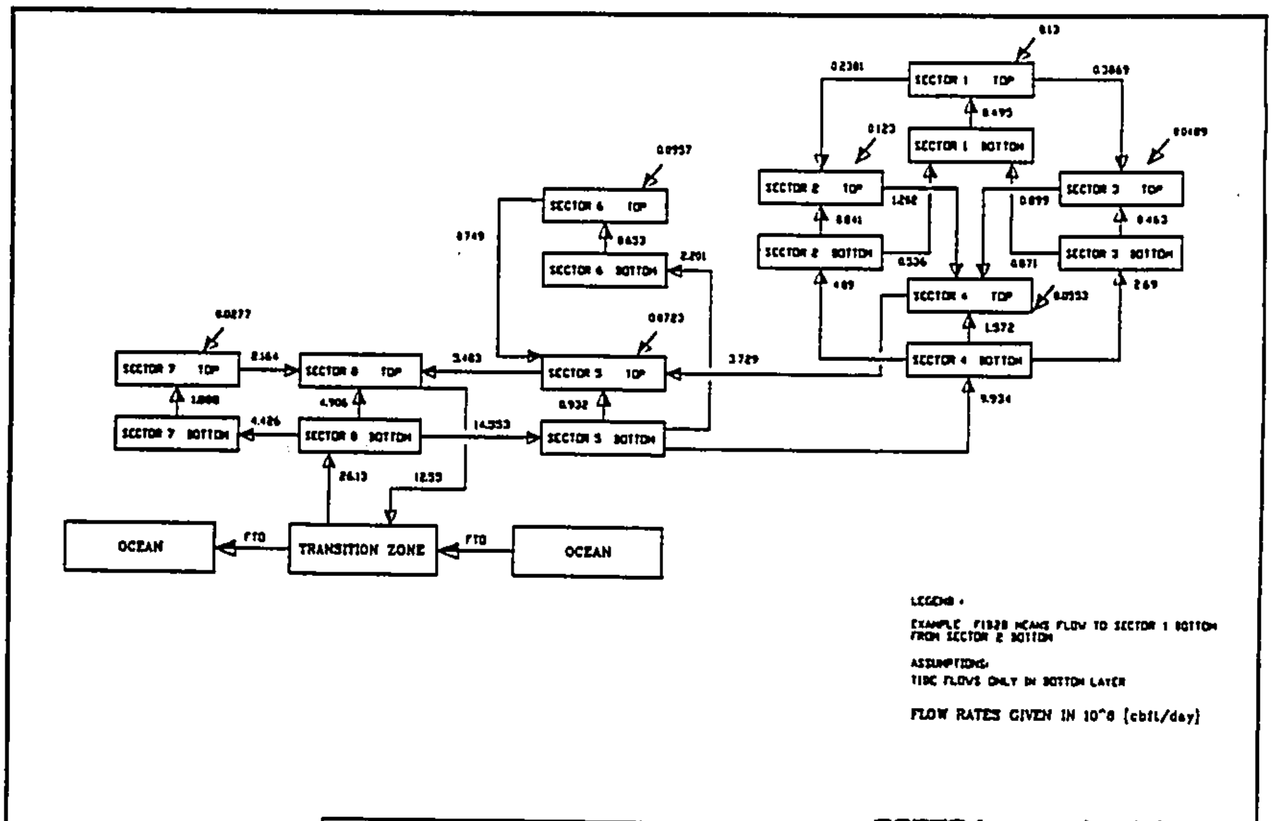

FIGURE: 7

EVALUATION OF THE PROPOSED EWA MARINA WQ
FLOW SCHEMATIC – STRATIFIED MODEL
SUPERPOSITION OF FLOW: GW INTRUS. AND TIDE
SEPTEMBER 15, 1991
FILE: 23DB080

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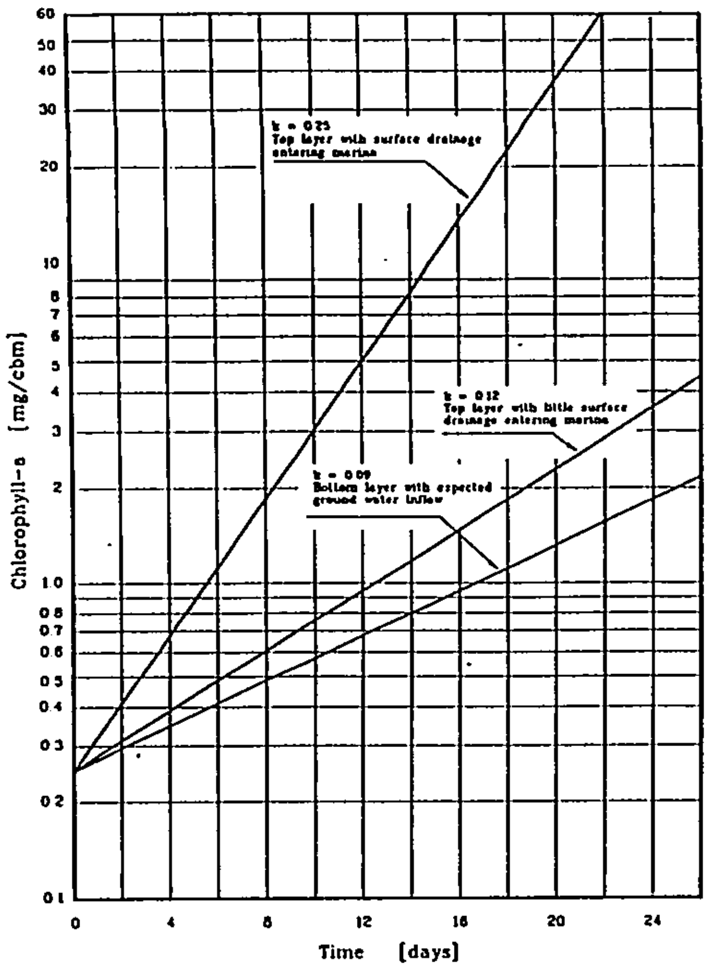

Chlorophyll-A concentration vs. estimated Sector residence time

FIGURE: 9

EVALUATION OF THE PROPOSED EWA MARINA WQ
CHLOROPHYLL CONCENTRATION VERSUS
ESTIMATED SECTOR RESIDENCE TIME
SEPTEMBER 15, 1991
FILE: 23DB100

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REFERENCES

1. Ewa Marina Water Quality, OCEES International, Inc., March 1990.

2. Ewa Marina Water Exchange Model, OCEES International, Inc., November 1990.

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4. Investigations of Hawaii Kai Marina, Sunn, Low, Tom & Hara, Inc., May 1974.

5. Kaneohe Bay Data Evaluation Study, M & E Pacific, Inc., April 1976.

6. Mauna Lani Cove Water Quality Study, OCEES International, December 1990.

7. State of Hawaii Water Quality Standards, Revised 1989.

EWA MARINA
EXCHANGE RATE AND WATER QUALITY

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Belt Collins & Associates
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PREPARED BY:
OCEES International, Inc.
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Honolulu, Hawaii 96816

February 5, 1992

INTRODUCTION

Previous reports by OCEES International, Inc. (March 1990, July 1990, October 1990, November 1990, and September 1991) outlined the approach that has been developed to estimate the exchange characteristics and expected water quality conditions of the proposed Ewa Marina. That approach consists of a two layer exchange model and real world phytoplankton kinetics. The flow in the upper layer of the exchange model is made up of fresh water inflow and the upwardly mixing salt water from the lower layer. The flow in the lower layer consists of the tidal exchange plus the inflow of salt water to supply that which is mixing to the upper layer. The thickness of the upper layer is estimated on the basis of measurements of existing estuaries and marinas in Hawaii with similar rates of fresh water inflow and mixing conditions.

The results of the exchange model give the residence times of the various marina sectors and layers which are then used to calculate the expected average chlorophyll-a concentrations. These calculations are made using kinetic constants for net phytoplankton growth rates as observed in tropical Pacific estuaries, embayments and marinas.

The results of these calculations are then used to evaluate the water quality of the proposed marina with respect to the State of Hawaii Water Quality Standards.

EXCHANGE CHARACTERISTICS

Two new alternative marina configurations are evaluated in this study. These alternatives constitute successive downsizing steps from previously evaluated marina configurations. The first of these alternatives (Alt. Alpha) is about 17% shorter in the dimension parallel to the shoreline than previous alternatives and hence would intercept approximately 17% less groundwater than previously considered configurations. The second alternative (Alt. Beta) is even shorter and would intercept only about 56% of the groundwater inflow of the previously considered configurations.

A schematic outline of Alternative Alpha is shown in Figure 1. Included in that figure are the dividing lines between the marina sectors that are used in this report to calculate the exchange characteristics. These dividing lines are located at narrow points and/or changes in depth that tend to act as hydraulic control sections. The average depth of water in the marina used in the calculations of the exchange model (Table 1) is 0.25 m deeper than that based on mean lower low water (MLLW) in order to make up the difference between MLLW and mean sea level (MSL). The sector surface areas and volumes are also given in Table 1.

The tide related and fresh water flow related fluxes are calculated separately and then combined to give an integrated picture of the exchange pattern. Figure 2 is what the exchange would be if only tidal exchange were active and no stratification existed. Table 2 gives the information for the tide related flow and residence times for Alternative Alpha if no stratification existed. Figure 3 and Table 3 show the information for tidal flow for the stratified condition where that tidal flow is essentially confined to the lower layer. Figure 4 and Table 4 give the flow and residence time information for the fresh water related flux. The total flow picture is given in Table 5.

The resulting residence times for the upper and lower layers of the several sectors is shown graphically in Figure 5. As might be expected, the innermost sectors of Alternative Alpha are projected to have somewhat shorter residence times than those of the larger marina configurations previously considered.

Alternative Beta is essentially a shortened version of Alternative Alpha in that sectors 1 and 2 are eliminated. Alternative Beta is shown schematically in Figure 6 with the physical characteristics given in Table 6.

Following the same calculating technique as previously Figure 7 and Table 7 give the tide related exchange information for the unstratified condition while the stratified condition is shown in Figure 8 and Table 8. The flow pattern for the fresh water related flow condition is given in Figure 9 and Table 9. The total picture of the exchange characteristics of Alternative Beta is given in Table 10.

The residence times for Alternative Beta are shown in Figure 10. Again it is apparent that shortening the overall dimension of the marina results in a reduction in the residence time of the innermost sector. There is, however, no dramatic change in the residence time (and hence the water quality) of the water entering the coastal waters from the marina.

WATER QUALITY

The amount of fresh water projected to enter the proposed Ewa Marina is large enough to put it in the "wet" embayment category of the state water quality standards. In addition, the adjacent coastal waters are presently classified as "wet" open coastal because of the influence of the nearby outflow from Pearl Harbor. However, at this writing there is a legal challenge being mounted by some environmental groups to reclassify this section of coastal waters to the "dry" open coastal category in order to counter the City & County of Honolulu 301 h waiver application for the Honouliuli outfall. If the "dry" open coastal classification is accepted then it will be impossible for the discharge from the proposed marina to meet the water quality standards since these standards will already be exceeded by the ambient nearshore waters. Under the assumption that the "wet" classification will be retained for the nearby open coastal waters the results of the calculations in this study are compared to the "wet" open coastal criteria.

The principal water quality parameter that will be affected by the proposed marina is the chlorophyll-a concentration due to the exposure of the phytoplankton to the higher nutrient concentration in the marina for the residence time period. Also changed, although to a lesser degree, will be the turbidity.

The relationship between the limiting nutrient (usually total phosphorus but sometimes total nitrogen in hawaiian embayments and estuaries) and the net growth rate of phytoplankton is best described by the Michaelis-Menton equation. That relationship is shown graphically in Figure 11 for TN as the limiting nutrient and in Figure 12 for TP as the limiting nutrient.

Figure 13 illustrates the relationship between the net growth rate and the residence time as it affects the chlorophyll-a concentration. This relationship is one of exponential growth. As noted in the descriptions of the three example net growth rate lines shown in Figure 13, a higher rate is expected with the introduction of surface drainage to the marina. This is because surface waters have higher concentrations of TP than groundwater since TP tends to get removed by passage through soil and other porous media. In contrast, TN and especially nitrate do not get removed from the groundwater as it flows toward the coastline. This means that marina waters will very likely be TP limited when little or no surface drainage enters the marina. To be conservative, however, projections of chlorophyll-a concentrations made here assumed the higher growth rate associated with surface runoff entering the marina. This growth rate is 0.25 per day which is similar to that measured in the Hawaii Kai marina.

The residence time of the water leaving the marine and entering the nearshore coastal waters in Alternative Alpha was calculated to be about 6.8 days. The expected geometric mean concentration of chlorophyll-a in this water is 1.37 ug/l. This would require a dilution of about 24 to 1 before the resulting mixture would meet the "wet" open coastal chlorophyll-a criteria of 0.30 ug/l. The water inside the marina in Alternative Alpha are expected to have a geometric mean chlorophyll-a concentration of about 1.15 ug/l which meets the "wet" embayment criteria of 1.50 ug/l. The expected range of average chlorophyll-a concentrations is 0.45 ug/l for the bottom layer of sector 7 to 4.18 ug/l in the top layer of sector 2.

Alternative Beta has generally longer average residence times than Alternative Alpha because there is a deeper average depth relative to the tidal prism. For Alternative Beta the chlorophyll-a concentration entering the open coastal waters is expected to have a geometric mean value of about 1.85 ug/l which will require a dilution of 32 to 1 before meeting the "wet" open coastal criteria of 0.30 ug/l. Within the marina the overall geometric mean chlorophyll-a concentration is expected to be about 1.123 ug/l which meets the 1.50 ug/l standard. The expected range of average values is from 0.52 ug/l for the bottom of sector 7 to 2.90 ug/l for the top of sector 5. It should also be noted that the volume of water entering the coastal area from Alternative Beta is less than would be entering from Alternative Alpha.

In summary, the water quality within the marina for both alternatives meets the state standards while that exiting the marina will require a zone of dilution before the "wet" open coastal standards are met. The ambient water quality of the nearshore waters do not meet the "dry" open coastal criteria even without the proposed marina.

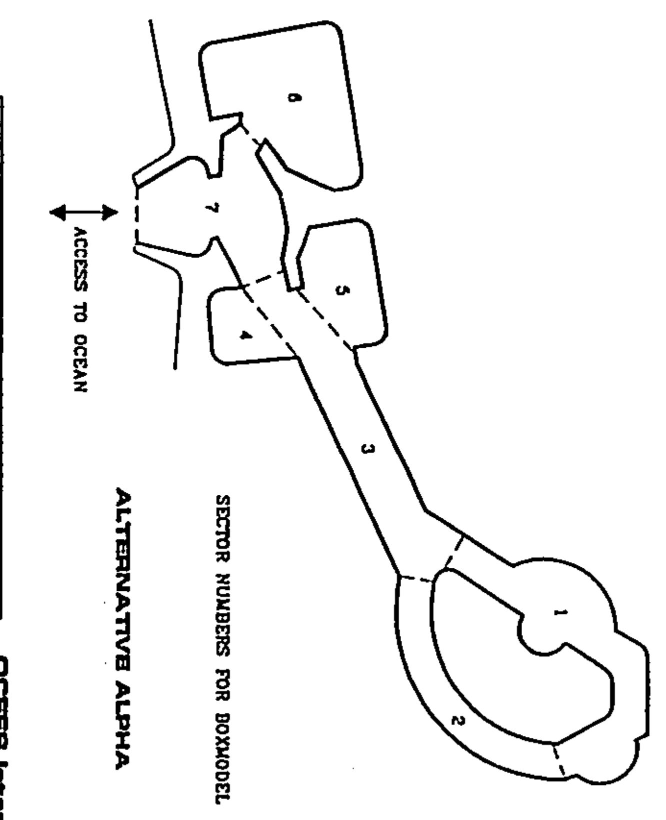

FIGURE 1

EWA MARINA: EXCHANGE RATE AND WQ
BOX MODEL DEFINITION
MODEL SECTOR NUMBERING
FEBRUARY 5, 1992
FILE: 24DB020

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EWA MARINA: EXCHANGE RATE AND WATER QUALITY
ALTERNATIVE ALPHA

FILE: 24W030

GENERAL INPUT PARAMETERS

SECTOR CHARACTERS

SECTOR NUMBER	AREA [ft^2]	AVERAGE DEPTH [ft]
1	1.01E+06	10.8
2	6.24E+05	10.8
3	9.33E+05	15.0
4	2.67E+05	10.8
5	5.36E+05	11.6
6	1.15E+06	13.2
7	9.39E+05	20.8
SUM	5.47E+06	

CROSS-SECTIONAL AREAS
@MSL
[SQFT]

1-3	2.38E+03
1-2	3.02E+03
4-3	7.34E+03

LENGTH OF SECTOR 4
PERPENDICULAR TO CROSS-SECTIONAL
AREA 4-3 500.00 [FT]
COEF. OF DIFFUSION
1.00 [FT^2/SEC]

DISTRIBUTION OF FLOW BETWEEN
SECTOR 1 AND 2, FOR BOTH
BOTTOM AND TOP LAYER
THRU SECTOR 1 60.00 [%]
THRU SECTOR 2 40.00 [%]

TIDAL PRISM: 2.48 [ft/day]

STRATIFICATION 5.00 [ft]

SALINITY OF SECTORS

SECTOR NUMBER	SALINITY [o/oo] Top Layer	Bot. Layer	SALINITY OF WATER INTRUSION INTO SECTOR
1	30.50	35.00	3.70
2	30.50	35.00	3.70
3	32.00	35.00	3.70
4	32.00	35.00	3.70
5	31.00	35.00	3.70
6	31.00	35.00	3.70
7	33.00	35.00	3.70
TRANS	35.00	35.00	
OCEAN	35.00		

TABLE 1

GROUNDWATER INTRUSION
FW INTRUSION 5.00E+06 [gal/day]
FW INTRUSION 6.68E+05 [cbft/day]

SECTOR NUMBER	UNIT PROJECTED LENGTH PERP. TO SLOPE	FLOW [%]	[cbft/day]
1	168.00	40.78	2.726E+05
2	0.00	0.00	0.000E+00
3	74.00	17.96	1.201E+05
4	0.00	0.00	0.000E+00
5	45.00	10.92	7.300E+04
6	111.00	26.94	1.801E+05
7	14.00	3.40	2.271E+04
SUM	412.00	100.00	6.684E+05

TABLE 1 (CONT.)

EWA MARINA: EXCHANGE RATE AND WQ ALTERNATIVE ALPHA OCEES, FEB. 1991

FILE: 24U030 PAGE A-1

UNSTRATIFIED BOX MODEL

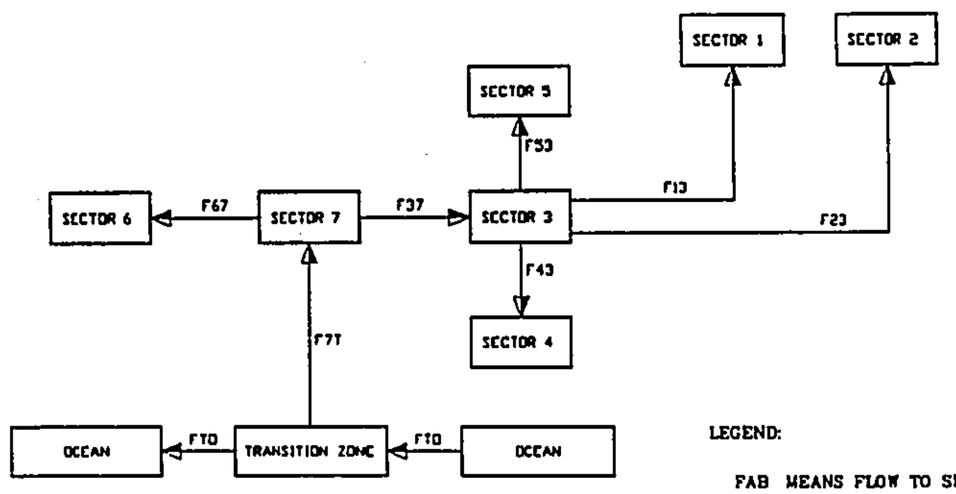
Calculation of residence times
Only tidal influences are considered

INPUT:

SECTOR NUMBER	AREA (ft^2)	AREA (m^2)	AVERAGE DEPTH (ft)	AVERAGE DEPTH (m)
1	1.01E+06	9.42E+04	10.79	3.29
2	6.24E+05	5.80E+04	10.79	3.29
3	9.33E+05	8.67E+04	15.03	4.58
4	2.67E+05	2.48E+04	10.79	3.29
5	5.36E+05	4.98E+04	11.61	3.54
6	1.15E+06	1.07E+05	13.22	4.03
7	9.39E+05	8.73E+04	20.80	6.34
SUM	5.47E+06	5.08E+05		

SECTOR NUMBER	VOLUME (ft^3)	VOLUME (m^3)
1	1.09E+07	3.10E+05
2	6.74E+06	1.91E+05
3	1.40E+07	3.97E+05
4	2.88E+06	8.17E+04
5	6.23E+06	1.76E+05
6	1.52E+07	4.31E+05
7	1.95E+07	5.53E+05
SUM	7.56E+07	2.14E+06

TABLE 2



LEGEND:

FAB MEANS FLOW TO SECTOR A FROM SECTOR B

EXAMPLE:
F53 FLOW TO 5 FROM 3

FLOOD CONDITIONS

ALTERNATIVE ALPHA

FIGURE 2

EWA MARINA: EXCHANGE RATE AND WQ
FLOW SCHEMATIC – UNSTRATIFIED MODEL
ONLY TIDAL – HERE FLOW DUE TO FLOOD
FEBRUARY 6, 1992
FILE: 24DB030

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EWA MARINA: EXCHANGE RATE AND WQ ALTERNATIVE ALPHA OCEES, FEB. 1991

FILE: 24W030 PAGE A-3

CALCULATION OF RESIDENCE TIMES:

With respect to (WRT)
Immediate downstream sector

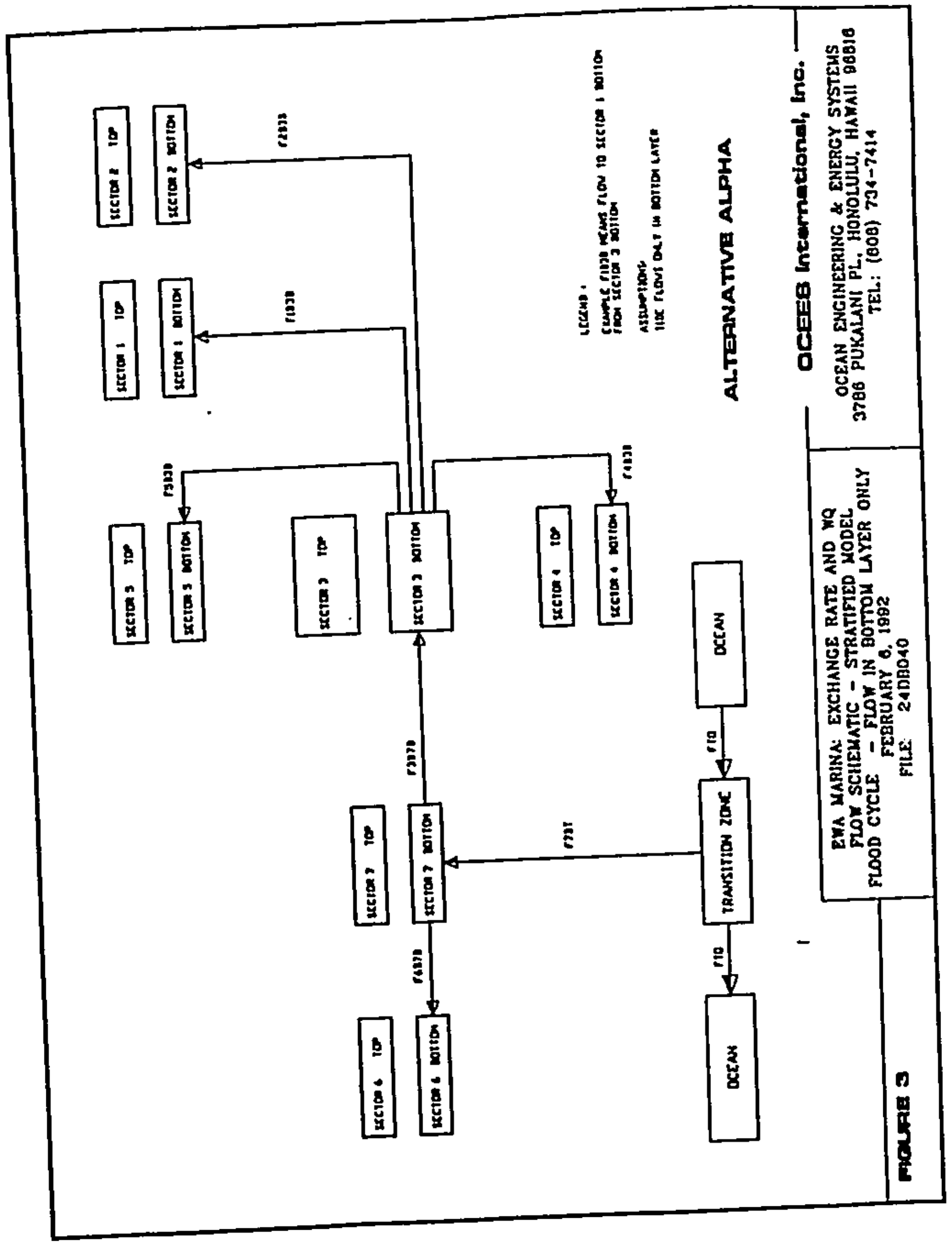
SECTOR ID		
1	4.35	(days)
2	4.35	(days)
3	4.87	(days)
4	4.35	(days)
5	4.68	(days)
6	5.32	(days)
7	5.57	(days)
TRANS.ZN.	0.26	(days)

CALCULATION OF RESIDENCE TIMES:

With respect to (WRT)
Ocean

SECTOR ID		
1	15.04	(days)
2	15.04	(days)
3	10.70	(days)
4	15.04	(days)
5	15.37	(days)
6	11.15	(days)
7	5.83	(days)
TRANS.ZN.	0.26	(days)

TABLE 2 (CONT.)



FILE: 24W030 PAGE 8-1

STRATIFIED BOX MODEL

Calculation of residence times
Only tidal influences are considered
Tidal flow is restricted to bottom layer of sectors

STRATIFICATION 5.00 (ft)

INPUT:

SECTOR NUMBER	AREA (ft^2)	AREA (m^2)	AVG. DEPTH BOTTOM LAYER (ft)	AVG. DEPTH BOTTOM LAYER (m)
1	1.01E+06	9.42E+04	5.8	1.77
2	6.24E+05	5.80E+04	5.8	1.77
3	9.33E+05	8.67E+04	10.0	3.06
4	2.67E+05	2.48E+04	5.8	1.77
5	5.36E+05	4.98E+04	6.6	2.02
6	1.15E+06	1.07E+05	8.2	2.51
7	9.39E+05	8.73E+04	15.8	4.82

SECTOR NUMBER	VOLUME BOTTOM LAYER (ft^3)	VOLUME BOTTOM LAYER (m^3)
1	5.88E+06	1.66E+05
2	3.62E+06	1.02E+05
3	9.35E+06	2.65E+05
4	1.55E+06	4.38E+04
5	3.55E+06	1.00E+05
6	9.47E+06	2.68E+05
7	1.48E+07	4.20E+05

TABLE 3

FILE: 24W030 PAGE 8-2

STRATIFIED BOX MODEL

Calculation of residence times
Only tidal influences are considered
Tidal flow is restricted to bottom layer of sectors

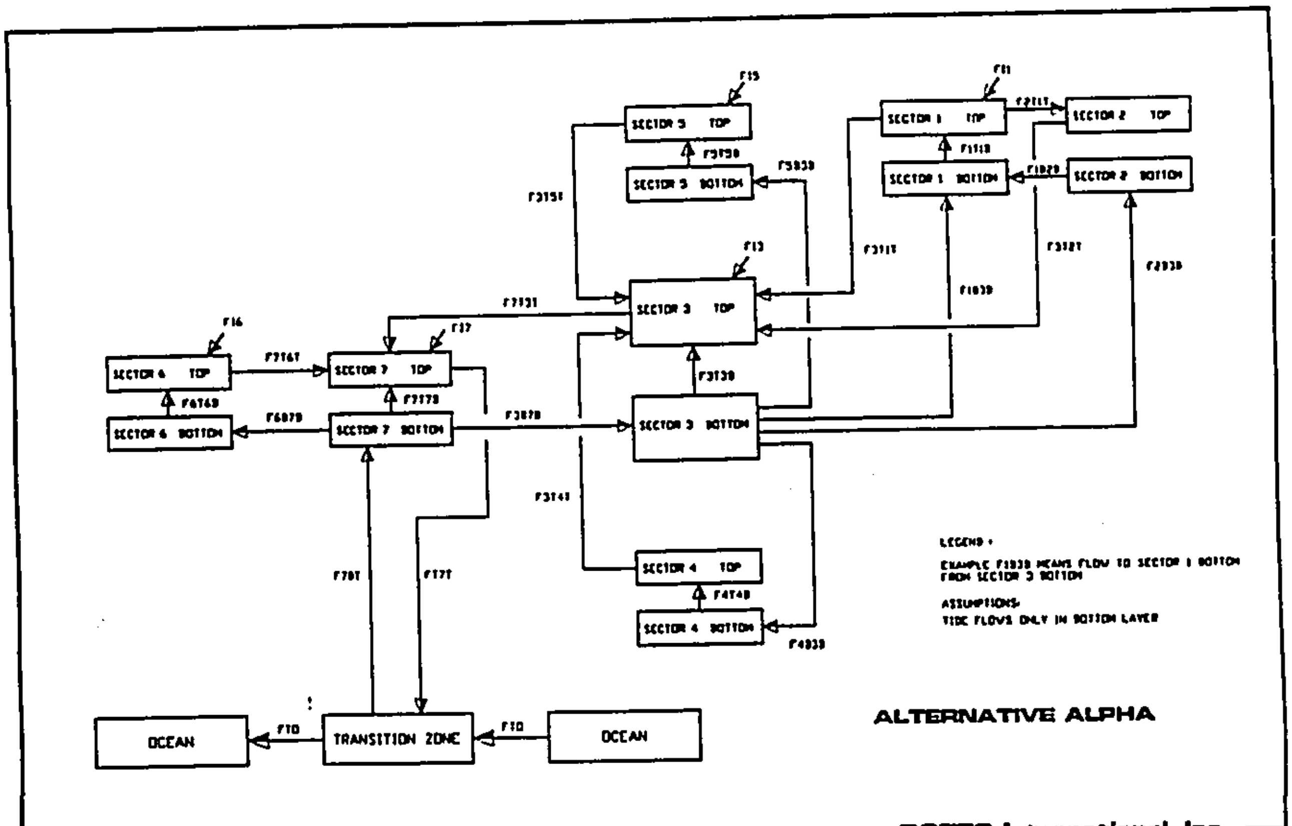
STRATIFICATION 5.00 (ft)

TIDAL PRISM: 2.48 (ft/day)
0.76 (m/day)

CALCULATION OF FLOWS:

FLOOD CYCLE FLOW BETWEEN SECTORS	FLOW MAGNITUDE (cbft/day)	EBB CYCLE FLOW BETWEEN SECTORS	FLOW MAGNITUDE (cbft/day)
F1B2B	0.000E+00	F1B2B	0.000E+00
F1B3B	2.520E+06	F1B3B	2.520E+06
F2B3B	1.550E+06	F2B3B	1.550E+06
F4B3B	6.638E+05	F4B3B	6.638E+05
F5B3B	1.331E+06	F5B3B	1.331E+06
F3B7B	8.382E+06	F3B7B	8.382E+06
F6B7B	2.862E+06	F6B7B	2.862E+06
F7BT	1.358E+07	F7BT	1.358E+07

TABLE 3 (CONT.)



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EWA MARINA: EXCHANGE RATE AND WQ
FLOW SCHEMATIC - STRATIFIED MODEL
FLOW DUE TO GROUNDWATER INTRUSIO
FEBRUARY 6, 1992
FILE: 24DB050

FIGURE 4

EWA MARINA: EXCHANGE RATE AND WQ ALTERNATIVE ALPHA OCEES, FEB. 1991

FILE: 24U030 PAGE B-3

STRATIFIED BOX MODEL

Calculation of residence times
Only tidal influences are considered
Tidal flow is restricted to bottom layer of sectors

STRATIFICATION 5.00 (ft)

CALCULATION OF RESIDENCE TIMES: With respect to (WRT) Immediate downstream sector			CALCULATION OF RESIDENCE TIMES: With respect to (WRT) Ocean		
SECTOR ID			SECTOR ID		
1	2.33	(days)	1	9.00	(days)
2	2.33	(days)	2	9.00	(days)
3	2.86	(days)	3	6.67	(days)
4	2.33	(days)	4	9.00	(days)
5	2.66	(days)	5	9.33	(days)
6	3.31	(days)	6	7.12	(days)
7	3.55	(days)	7	3.81	(days)
TRANS.ZN.	0.26	(days)	TRANS.ZN.	0.26	(days)

TABLE 3 (CONT.)

STRATIFIED BOX MODEL

Calculation of residence times
SUPERPOSITION of tidal induced flow and flow due to freshwater intrusion

STRATIFICATION 5.00 [ft]

SECTOR NUMBER	AREA [ft^2]	AVERAGE DEPTH [ft]	AVG. DEPTH BOTTOM LAYER [ft]	AVG. DEPTH BOTTOM LAYER [m]
1	1.01E+06	10.8	5.8	1.8
2	6.24E+05	10.8	5.8	1.8
3	9.33E+05	15.0	10.0	3.1
4	2.67E+05	10.8	5.8	1.8
5	5.36E+05	11.6	6.6	2.0
6	1.15E+06	13.2	8.2	2.5
7	9.39E+05	20.8	15.8	4.8

SECTOR NUMBER	VOLUME TOP LAYER [cqft]	VOLUME BOTTOM LAYER [cqft]	TOTAL VOLUME [cqft]
1	5.07E+06	5.88E+06	1.095E+07
2	3.12E+06	3.62E+06	6.736E+06
3	4.66E+06	9.35E+06	1.402E+07
4	1.34E+06	1.55E+06	2.884E+06
5	2.68E+06	3.55E+06	6.225E+06
6	5.76E+06	9.47E+06	1.523E+07
7	4.70E+06	1.48E+07	1.954E+07

TABLE 4

STRATIFIED BOX MODEL

Calculation of residence times
Only FRESHWATER intrusion considered
Flow pattern only due to mixing of top and bottom layers

FLOWS IN BETW. BOTTOM LAYERS	[cbft/day]	FLOWS IN BETW. TOP LAYERS	[cbft/day]
F1B2B	6.493E+05	F2T1T	7.583E+05
F1B3B	9.739E+05	F3T1T	1.137E+06
F2B3B	6.493E+05	F3T2T	7.583E+05
F3B7B	8.031E+06	F3T4T	1.362E+06
F4B3B	1.362E+06	F3T5T	5.713E+05
F5B3B	4.983E+05	F7T3T	8.496E+06
F6B7B	1.229E+06	F7T6T	1.409E+06
F7BT	9.415E+06	F17T	1.008E+07

GROUNDWATER INFLOW INTO SECTORS	[cbft/day]	FLOWS FROM BOTTOM TO TOP LAYERS (UPWELLING)	[cbft/day]
FI1	2.73E+05	F1T1B	1.623E+06
FI2	0.00E+00	F2T2B	0.000E+00
FI3	1.20E+05	F3T3B	4.547E+06
FI4	0.00E+00	F4T4B	1.362E+06
FI5	7.30E+04	F5T5B	4.983E+05
FI6	1.80E+05	F6T6B	1.229E+06
FI7	2.27E+04	F7T7B	1.350E+05

TABLE 4 (CONT.)

EWA MARINA: EXCHANGE RATE AND WQ ALTERNATIVE ALPHA OCEES, FEB. 1991

FILE: 24U030 PAGE D-1

STRATIFIED BOX MODEL

Calculation of residence times
SUPERPOSITION of tidal induced flow and flow due to
freshwater intrusion

STRATIFICATION 5.00 [ft]

SECTOR NUMBER	AREA [ft^2]	AVERAGE DEPTH [ft]	AVG. DEPTH BOTTOM LAYER [ft]	AVG. DEPTH BOTTOM LAYER [m]
1	1.01E+06	10.79	5.79	1.77
2	6.24E+05	10.79	5.79	1.77
3	9.33E+05	15.03	10.03	3.06
4	2.67E+05	10.79	5.79	1.77
5	5.36E+05	11.61	6.61	2.02
6	1.15E+06	13.22	8.22	2.51
7	9.39E+05	20.80	15.80	4.82

SECTOR NUMBER	VOLUME TOP LAYER [cqft]	VOLUME BOTTOM LAYER [cqft]
1	5.07E+06	5.86E+06
2	3.12E+06	3.62E+06
3	4.66E+06	9.35E+06
4	1.34E+06	1.55E+06
5	2.68E+06	3.55E+06
6	5.76E+06	9.47E+06
7	4.70E+06	1.48E+07

TABLE 5

EWA MARINA: EXCHANGE RATE AND WQ ALTERNATIVE ALPHA OCEES, FEB. 1991

FILE: 24U030 PAGE D-2

STRATIFIED BOX MODEL

Calculation of residence times
SUPERPOSITION of tidal induced flow and flow due to
freshwater intrusion

FLOWS IN BETW. BOTTOM LAYERS	[cbft/day]	FLOWS IN BETW. TOP LAYERS	[cbft/day]
F1B2B	6.493E+05	F2T1T	7.583E+05
F1B3B	3.494E+06	F3T1T	1.137E+06
F2B3B	2.199E+06	F3T2T	7.583E+05
F3B7B	1.641E+07	F3T4T	1.362E+06
F4B3B	2.026E+06	F3T5T	5.713E+05
F5B3B	1.830E+06	F7T3T	8.496E+06
F6B7B	4.091E+06	F7T6T	1.409E+06
F7BT	2.299E+07	F17T	1.008E+07

GROUNDWATER INFLOW INTO SECTORS	[cbft/day]	FLOWS FROM BOTTOM TO TOP LAYERS (UPWELLING)	[cbft/day]
F11	2.726E+05	F1T1B	1.623E+06
F12	0.000E+00	F2T2B	0.000E+00
F13	1.201E+05	F3T3B	4.547E+06
F14	0.000E+00	F4T4B	1.362E+06
F15	7.300E+04	F5T5B	4.983E+05
F16	1.801E+05	F6T6B	1.229E+06
F17	2.271E+04	F7T7B	1.550E+05

TABLE 5 (CONT.)

EWA MARINA: EXCHANGE RATE AND WQ ALTERNATIVE ALPHA   OCEES, FEB. 1991

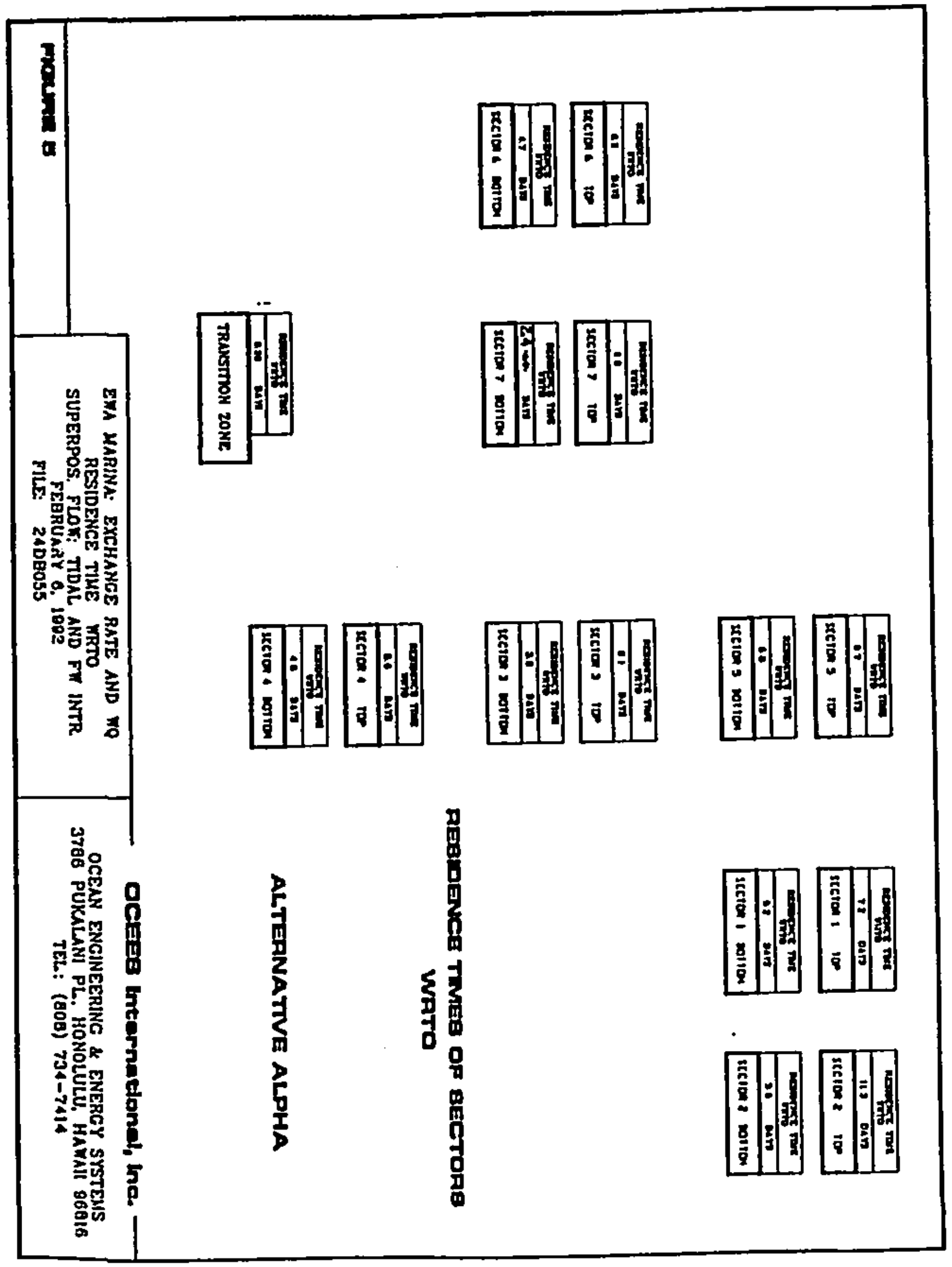
FILE: 24U030   PAGE D-3

STRATIFIED BOX MODEL

Calculation of residence times
SUPERPOSITION of tidal induced flow and flow due to
freshwater intrusion

CALCULATION OF RESIDENCE TIMES: With respect to (WRT) Immediate downstream sector			CALCULATION OF RESIDENCE TIMES: With respect to (WRT) Ocean		
BOTTOM LAYER SECTOR ID			BOTTOM LAYER SECTOR ID		
1	1.42	[days]	1	5.24	[days]
2	1.64	[days]	2	5.46	[days]
3	1.46	[days]	3	3.82	[days]
4	0.76	[days]	4	4.58	[days]
5	1.94	[days]	5	5.75	[days]
6	2.32	[days]	6	4.67	[days]
7	2.10	[days]	7	2.36	[days]
TRANS.ZN.	0.26	[days]	TRANS.ZN.	0.26	[days]
TOP LAYER SECTOR ID			TOP LAYER SECTOR ID		
1	2.68	[days]	1	7.16	[days]
2	4.11	[days]	2	11.27	[days]
3	0.55	[days]	3	6.10	[days]
4	0.98	[days]	4	5.56	[days]
5	4.69	[days]	5	9.71	[days]
6	4.09	[days]	6	8.16	[days]
7	0.47	[days]	7	6.82	[days]
TRANS.ZN.	0.26	[days]	TRANS.ZN.	0.26	[days]

TABLE 5 (CONT.)



EWA MARINA: EXCHANGE RATE AND WQ ALTERNATIVE BETA   OCEES, FEB. 1991

EWA MARINA: EXCHANGE RATE AND WATER QUALITY
ALTERNATIVE BETA

FILE: 24U040

GENERAL INPUT PARAMETERS

SECTOR CHARACTERS

SECTOR NUMBER	AREA [ft^2]	AVERAGE DEPTH [ft]
1	0.00E+00	0.0
2	0.00E+00	0.0
3	9.33E+05	15.0
4	2.67E+05	10.8
5	5.36E+05	11.6
6	1.15E+06	13.2
7	9.39E+05	20.8
SUM	3.83E+06	

CROSS-SECTIONAL AREAS
QMSL
[SQFT]

4-3   7.34E+03

LENGTH OF SECTOR 4
PERPENDICULAR TO CROSS-SECTIONAL
AREA 4-3   500.00 [FT]
COEF. OF DIFFUSION
1.00 [FT^2/SEC]

DISTRIBUTION OF FLOW BETWEEN
SECTOR 1 AND 2, FOR BOTH
BOTTOM AND TOP LAYER
THROUGH SECTOR 1   60.00 [%]
THROUGH SECTOR 2   40.00 [%]

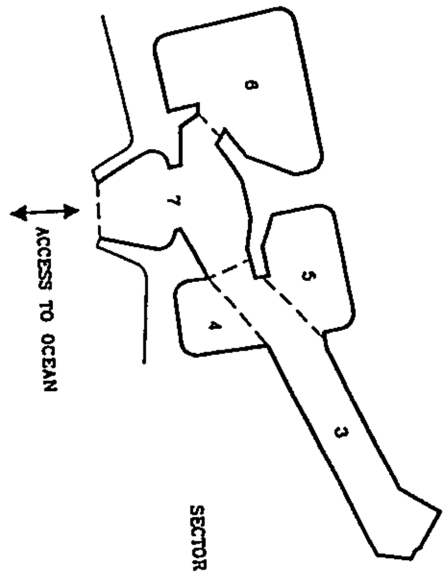
TIDAL PRISM: 2.48 [ft/day]

STRATIFICATION   5.00 [ft]

SALINITY OF SECTORS

SECTOR NUMBER	SALINITY [o/oo] Top Layer	Bot. Layer	SALINITY OF WATER INTRUSION INTO SECTOR
1	0.00	0.00	0.00
2	0.00	0.00	0.00
3	32.00	35.00	3.70
4	32.00	35.00	3.70
5	31.00	35.00	3.70
6	31.00	35.00	3.70
7	33.00	35.00	3.70
TRANS	35.00	35.00	
OCEAN	35.00		

TABLE 6



ALTERNATIVE BETA

EWA MARINA: EXCHANGE RATE AND WQ
BOX MODEL DEFINITION
MODEL SECTOR NUMBERING
FEBRUARY 5, 1992
FILE: 24DB060

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FIGURE 6

EWA MARINA: EXCHANGE RATE AND WQ ALTERNATIVE BETA OCEES, FEB. 1991

FILE: 24U040 PAGE A-1

UNSTRATIFIED BOX MODEL

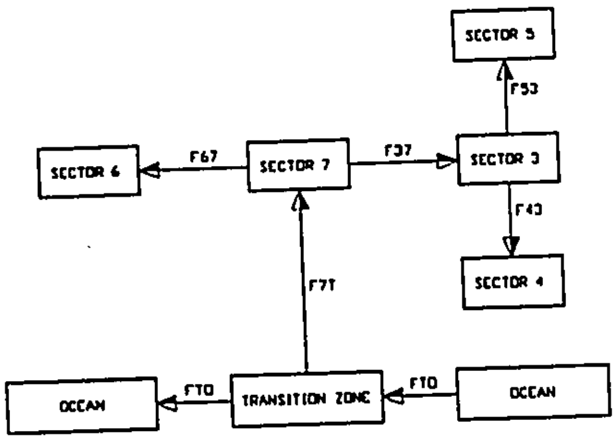
Calculation of residence times
Only tidal influences are considered

INPUT:

SECTOR NUMBER	AREA [ft^2]	AREA [m^2]	AVERAGE DEPTH [ft]	AVERAGE DEPTH [m]
1	0.00E+00	0.00E+00	0.00	0.00
2	0.00E+00	0.00E+00	0.00	0.00
3	9.33E+05	8.67E+04	15.03	4.58
4	2.67E+05	2.48E+04	10.79	3.29
5	5.36E+05	4.98E+04	11.61	3.54
6	1.15E+06	1.07E+05	13.22	4.03
7	9.39E+05	8.73E+04	20.80	6.34
SUM	3.83E+06	3.56E+05		

SECTOR NUMBER	VOLUME [ft^3]	[m^3]
1	0.00E+00	0.00E+00
2	0.00E+00	0.00E+00
3	1.40E+07	3.97E+05
4	2.88E+06	8.17E+04
5	6.23E+06	1.76E+05
6	1.52E+07	4.31E+05
7	1.95E+07	5.53E+05
SUM	5.79E+07	1.64E+06

TABLE 7



LEGEND:

FAB MEANS FLOW TO SECTOR A
FROM SECTOR B

EXAMPLE:
F53 FLOW TO 5 FROM 3

FLOOD CONDITIONS

ALTERNATIVE BETA

EWA MARINA: EXCHANGE RATE AND WQ
FLOW SCHEMATIC - UNSTRATIFIED MODEL
ONLY TIDAL - HERE FLOW DUE TO FLOOD
FEBRUARY 6, 1992
FILE: 24DB070

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FIGURE 7

EWA MARINA: EXCHANGE RATE AND WQ ALTERNATIVE BETA OCEES, FEB. 1991

FILE: 24U040 PAGE B-1

STRATIFIED BOX MODEL

Calculation of residence times
Only tidal influences are considered
Tidal flow is restricted to bottom layer of sectors

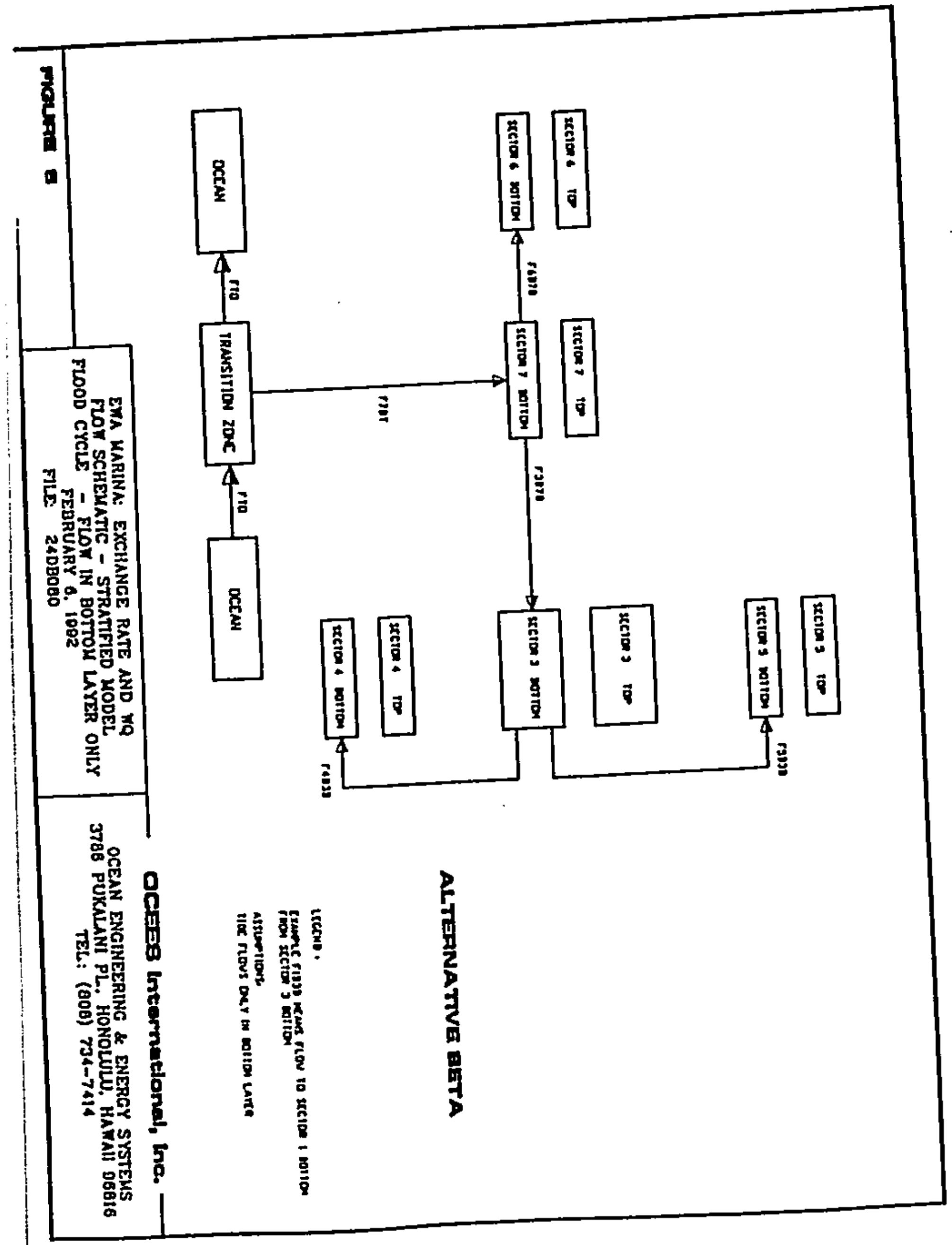
STRATIFICATION 5.00 [ft]

INPUT:

SECTOR NUMBER	AREA [ft^2]	AREA [m^2]	AVG. DEPTH BOTTOM LAYER [ft]	AVG. DEPTH BOTTOM LAYER [m]
1	0.00E+00	0.00E+00	-5.0	-1.52
2	0.00E+00	0.00E+00	-5.0	-1.52
3	9.33E+05	8.67E+04	10.0	3.06
4	2.67E+05	2.48E+04	5.8	1.77
5	5.36E+05	4.98E+04	6.6	2.02
6	1.15E+06	1.07E+05	8.2	2.51
7	9.39E+05	8.73E+04	15.8	4.82

SECTOR NUMBER	VOLUME BOTTOM LAYER [ft^3]	VOLUME BOTTOM LAYER [m^3]
1	0.00E+00	0.00E+00
2	0.00E+00	0.00E+00
3	9.35E+06	2.65E+05
4	1.55E+06	4.38E+04
5	3.55E+06	1.00E+05
6	9.47E+06	2.68E+05
7	1.48E+07	4.20E+05

TABLE 8



EWA MARINA: EXCHANGE RATE AND WQ ALTERNATIVE BETA OCEES, FEB. 1991

FILE: 24U040 PAGE B-2

STRATIFIED BOX MODEL

Calculation of residence times
Only tidal influences are considered
Tidal flow is restricted to bottom layer of sectors

STRATIFICATION	5.00	[ft]
TIDAL PRISM:	2.48	[ft/day]
	0.76	[m/day]

CALCULATION OF FLOWS:

FLOOD CYCLE FLOW BETWEEN SECTORS	FLOW MAGNITUDE [cbft/day]	EBB CYCLE FLOW BETWEEN SECTORS	FLOW MAGNITUDE [cbft/day]
F1B2B	0.000E+00	F1B2B	0.000E+00
F1B3B	0.000E+00	F1B3B	0.000E+00
F2B3B	0.000E+00	F2B3B	0.000E+00
F4B3B	6.638E+05	F4B3B	6.638E+05
F5B3B	1.331E+06	F5B3B	1.331E+06
F5B7B	4.312E+06	F5B7B	4.312E+06
F6B7B	2.862E+06	F6B7B	2.862E+06
F7BT	9.507E+06	F7BT	9.507E+06

TABLE 8 (CONT.)

EWA MARINA: EXCHANGE RATE AND WQ ALTERNATIVE BETA OCEES, FEB. 1991

FILE: 24U040 PAGE B-3

STRATIFIED BOX MODEL

Calculation of residence times
Only tidal influences are considered
Tidal flow is restricted to bottom layer of sectors

STRATIFICATION 5.00 [ft]

CALCULATION OF RESIDENCE TIMES:
With respect to (WRT)
Immediate downstream sector

SECTOR ID		
1	NA	
2	NA	
3	3.35	[days]
4	2.33	[days]
5	2.66	[days]
6	3.31	[days]
7	4.08	[days]
TRANS.ZN.	0.26	[days]

CALCULATION OF RESIDENCE TIMES:
With respect to (WRT)
Ocean

SECTOR ID		
1	NA	
2	NA	
3	7.69	[days]
4	10.02	[days]
5	10.35	[days]
6	7.65	[days]
7	4.34	[days]
TRANS.ZN.	0.26	[days]

TABLE 8 (CONT.)

EWA MARINA: EXCHANGE RATE AND WQ ALTERNATIVE BETA   OCEES, FEB. 1991

FILE: 24UOLO   PAGE C-1

STRATIFIED BOX MODEL

Calculation of residence times
SUPERPOSITION of tidal induced flow and flow due to
freshwater intrusion

STRATIFICATION   5.00 (ft)

SECTOR NUMBER	AREA [ft^2]	AVERAGE DEPTH [ft]	AVG. DEPTH BOTTOM LAYER [ft]	AVG. DEPTH BOTTOM LAYER [m]
1	0.00E+00	0.0	-5.0	-1.5
2	0.00E+00	0.0	-5.0	-1.5
3	9.33E+05	15.0	10.0	3.1
4	2.67E+05	10.8	5.8	1.8
5	5.36E+05	11.6	6.6	2.0
6	1.15E+06	13.2	8.2	2.5
7	9.39E+05	20.8	15.8	4.8

SECTOR NUMBER	VOLUME TOP LAYER [cqft]	VOLUME BOTTOM LAYER [cqft]	TOTAL VOLUME [cqft]
1	0.00E+00	0.00E+00	0.000E+00
2	0.00E+00	0.00E+00	0.000E+00
3	4.66E+06	9.35E+06	1.402E+07
4	1.34E+06	1.55E+06	2.884E+06
5	2.68E+06	3.55E+06	6.225E+06
6	5.76E+06	9.47E+06	1.523E+07
7	4.70E+06	1.48E+07	1.954E+07

TABLE 9

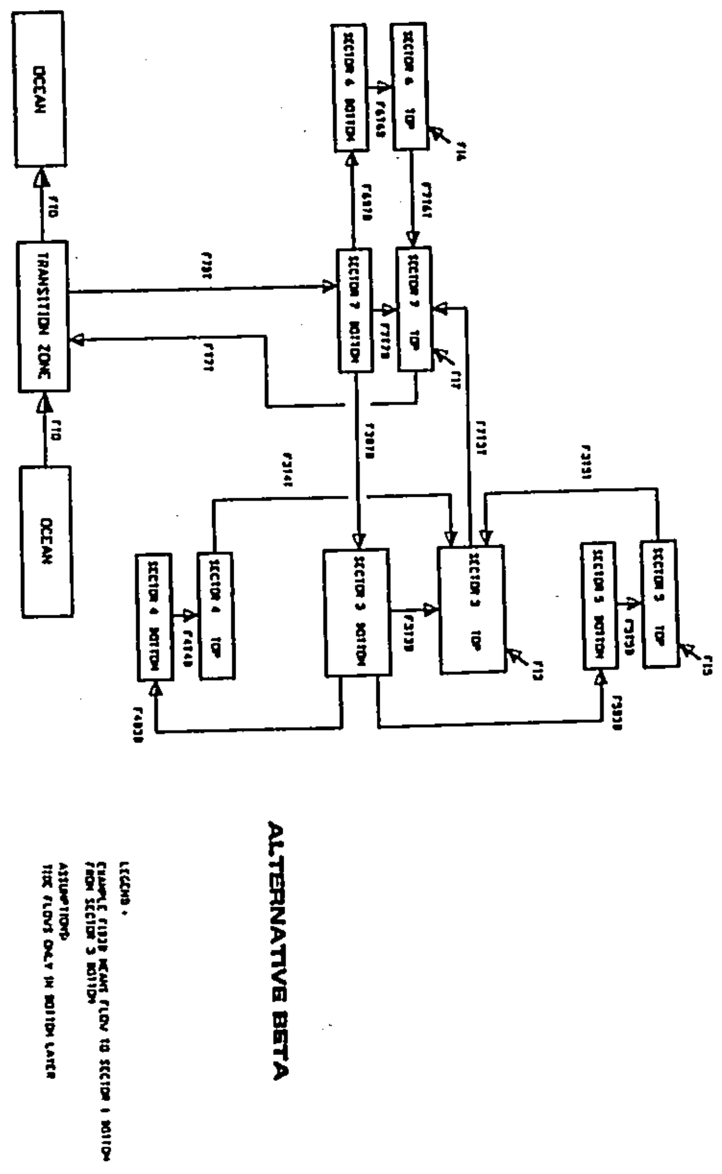


FIGURE 9

EWA MARINA: EXCHANGE RATE AND WQ
FLOW SCHEMATIC - STRATIFIED MODEL
FLOW DUE TO GROUNDWATER INTRUSIO
FEBRUARY 6, 1992
FILE: 24DB090

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FILE: 24U040 PAGE C-2

STRATIFIED BOX MODEL

Calculation of residence times
Only FRESHWATER intrusion considered
Flow pattern only due to mixing of top and bottom layer

FLOWS IN BETW. BOTTOM LAYERS (cbft/day)		FLOWS IN BETW. TOP LAYERS (cbft/day)	
F1B2B	0.000E+00	F2T1T	0.000E+00
F1B3B	0.000E+00	F3T1T	0.000E+00
F2B3B	0.000E+00	F3T2T	0.000E+00
F3B7B	3.860E+06	F3T4T	1.362E+06
F4B3B	1.362E+06	F3T5T	6.482E+05
F5B3B	5.654E+05	F7T3T	4.079E+06
F6B7B	1.395E+06	F7T6T	1.599E+06
F7BT	5.431E+06	FT7T	5.880E+06

GROUNDWATER INFLOW INTO SECTORS (cbft/day)		FLOWS FROM BOTTOM TO TOP LAYERS (UPWELLING) (cbft/day)	
FI1	0.00E+00	F1T1B	0.000E+00
FI2	0.00E+00	F2T2B	0.000E+00
FI3	1.36E+05	F3T3B	1.933E+06
FI4	0.00E+00	F4T4B	1.362E+06
FI5	8.28E+04	F5T5B	5.654E+05
FI6	2.04E+05	F6T6B	1.395E+06
FI7	2.50E+04	F7T7B	1.759E+05

TABLE 9 (CONT.)

EWA MARINA: EXCHANGE RATE AND WQ ALTERNATIVE BETA OCEES, FEB. 1991

FILE: 24U040 PAGE D-1

STRATIFIED BOX MODEL

Calculation of residence times
SUPERPOSITION of tidal induced flow and flow due to freshwater intrusion

STRATIFICATION 5.00 (ft)

SECTOR NUMBER	AREA (ft^2)	AVERAGE DEPTH (ft)	AVG. DEPTH BOTTOM LAYER (ft)	AVG. DEPTH BOTTOM LAYER (m)
1	0.00E+00	0.00	-5.00	-1.52
2	0.00E+00	0.00	-5.00	-1.52
3	9.33E+05	15.03	10.03	3.06
4	2.67E+05	10.79	5.79	1.77
5	5.36E+05	11.61	6.61	2.02
6	1.15E+06	13.22	8.22	2.51
7	9.39E+05	20.80	15.80	4.82

SECTOR NUMBER	VOLUME TOP LAYER (cqft)	VOLUME BOTTOM LAYER (cqft)
1	0.00E+00	0.00E+00
2	0.00E+00	0.00E+00
3	4.66E+06	9.35E+06
4	1.34E+06	1.55E+06
5	2.68E+06	3.55E+06
6	5.76E+06	9.47E+06
7	4.70E+06	1.48E+07

TABLE 10

STRATIFIED BOX MODEL

Calculation of residence times
SUPERPOSITION of tidal induced flow and flow due to freshwater intrusion

FLOWS IN BETW. BOTTOM LAYERS (cbft/day)		FLOWS IN BETW. TOP LAYERS (cbft/day)	
F1B2B	0.000E+00	F2T1T	0.000E+00
F1B3B	0.000E+00	F3T1T	0.000E+00
F2B3B	0.000E+00	F3T2T	0.000E+00
F3B7B	8.173E+06	F3T4T	1.362E+06
F4B3B	2.026E+06	F3T5T	6.482E+05
F5B3B	1.897E+06	F7T3T	4.079E+06
F6B7B	4.256E+06	F7T6T	1.599E+06
F7BT	1.494E+07	FT7T	5.880E+06

GROUNDWATER INFLOW INTO SECTORS (cbft/day)		FLOWS FROM BOTTOM TO TOP LAYERS (UPWELLING) (cbft/day)	
FI1	0.000E+00	F1T1B	0.000E+00
FI2	0.000E+00	F2T2B	0.000E+00
FI3	1.362E+05	F3T3B	1.935E+06
FI4	0.000E+00	F4T4B	1.362E+06
FI5	8.284E+04	F5T5B	5.654E+05
FI6	2.043E+05	F6T6B	1.395E+06
FI7	2.577E+04	F7T7B	1.759E+05

TABLE 10 (CONT.)

STRATIFIED BOX MODEL

Calculation of residence times
SUPERPOSITION of tidal induced flow and flow due to freshwater intrusion

CALCULATION OF RESIDENCE TIMES:

With respect to (WRT) Immediate downstream sector

BOTTOM LAYER SECTOR ID		
1	0.00	[days]
2	0.00	[days]
3	1.77	[days]
4	0.76	[days]
5	1.87	[days]
6	2.23	[days]
7	2.59	[days]
TRANS.ZN.	0.26	[days]

TOP LAYER SECTOR ID		
1	0.00	[days]
2	0.00	[days]
3	1.14	[days]
4	0.98	[days]
5	4.13	[days]
6	3.60	[days]
7	0.80	[days]
TRANS.ZN.	0.26	[days]

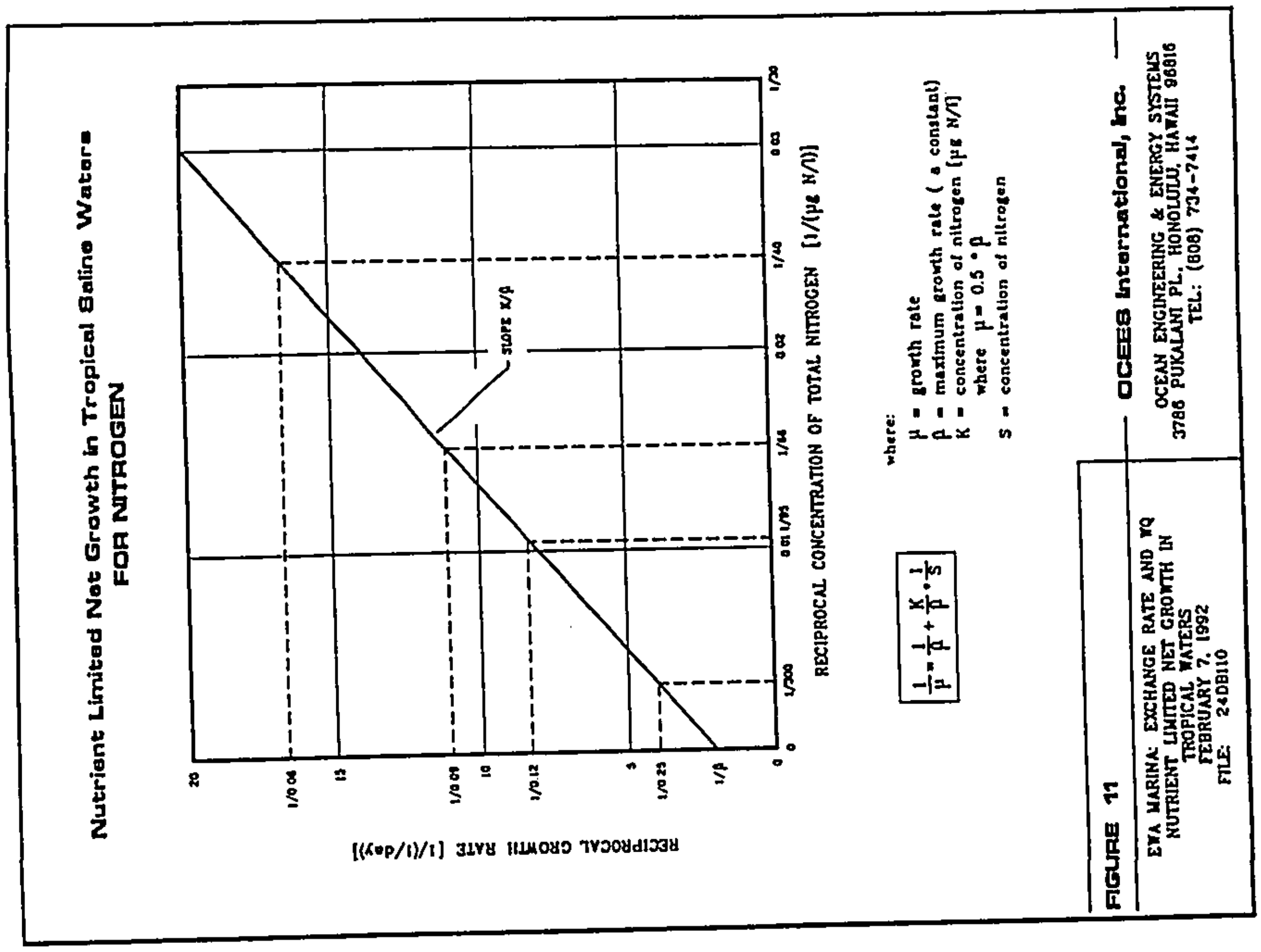
CALCULATION OF RESIDENCE TIMES:

With respect to (WRT) Ocean

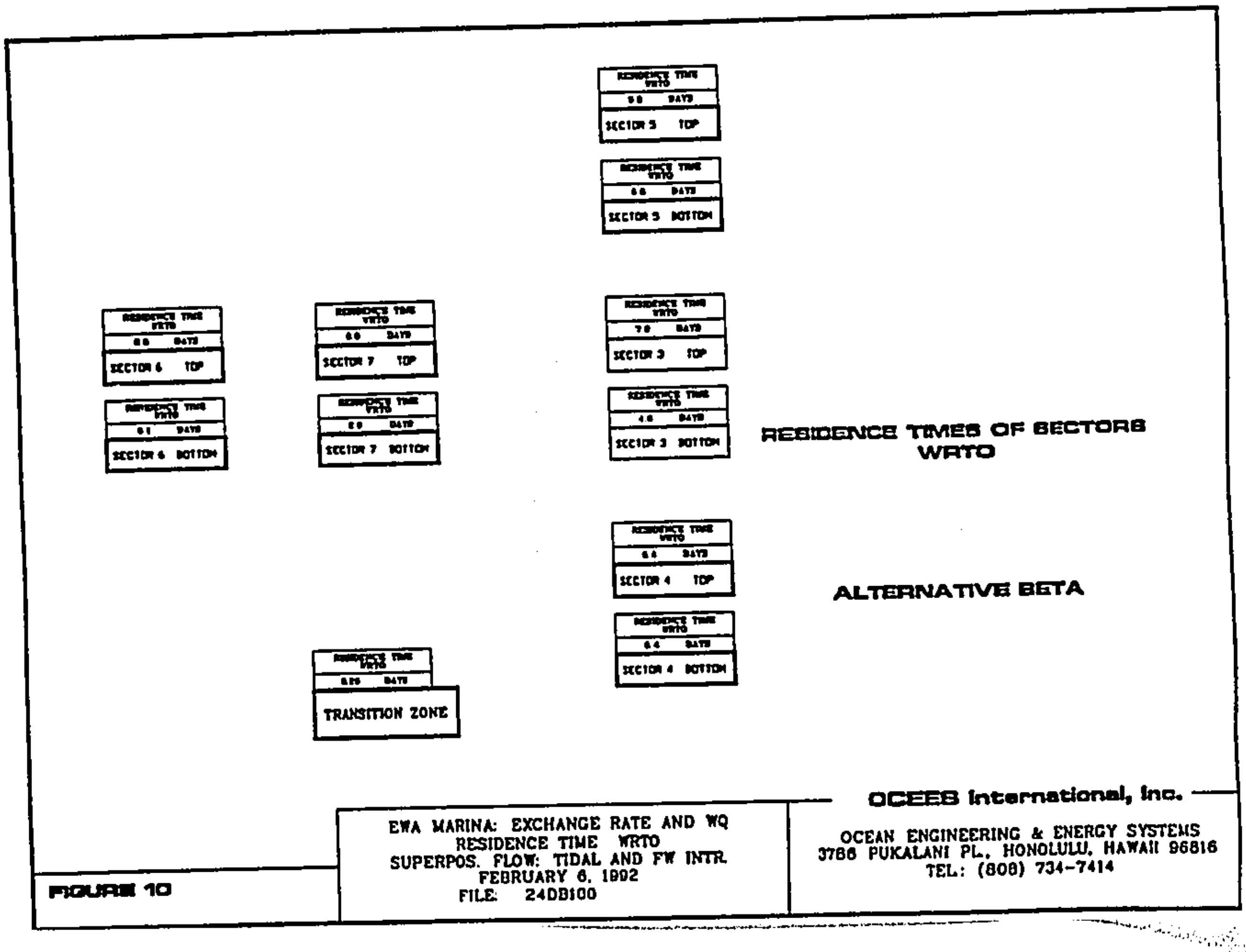
BOTTOM LAYER SECTOR ID		
1	0.00	[days]
2	0.00	[days]
3	4.62	[days]
4	5.39	[days]
5	6.49	[days]
6	5.08	[days]
7	2.85	[days]
TRANS.ZN.	0.26	[days]

TOP LAYER SECTOR ID		
1	0.00	[days]
2	0.00	[days]
3	7.02	[days]
4	6.37	[days]
5	9.80	[days]
6	8.03	[days]
7	8.00	[days]
TRANS.ZN.	0.26	[days]

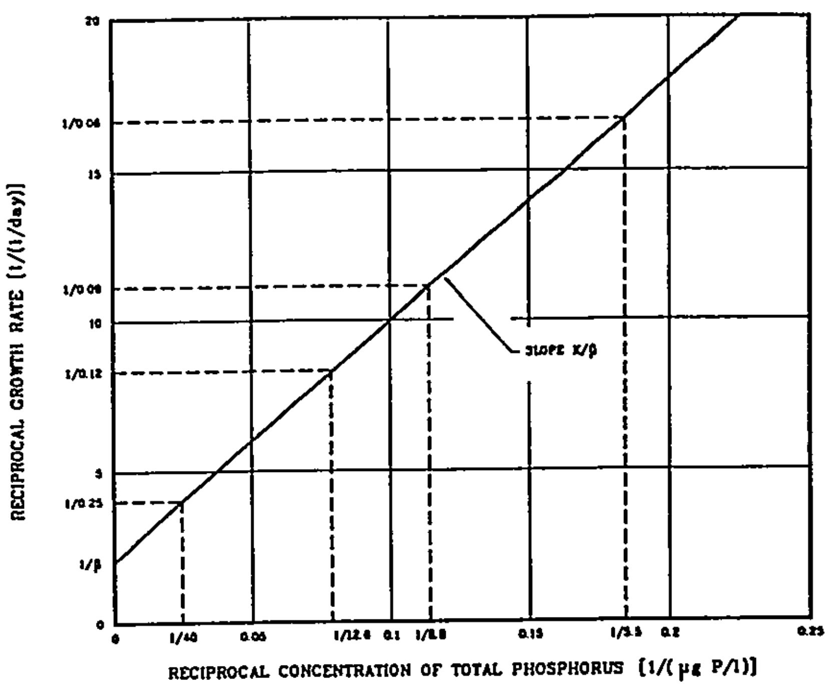
TABLE 10 (CONT.)



$$\frac{1}{\mu} = \frac{1}{\beta} + \frac{K}{\beta} \cdot \frac{1}{S}$$



Nutrient Limited Net Growth in Tropical Saline Waters FOR PHOSPHORUS



$$\frac{1}{\mu} = \frac{1}{\beta} + \frac{K}{\beta} \cdot \frac{1}{S}$$

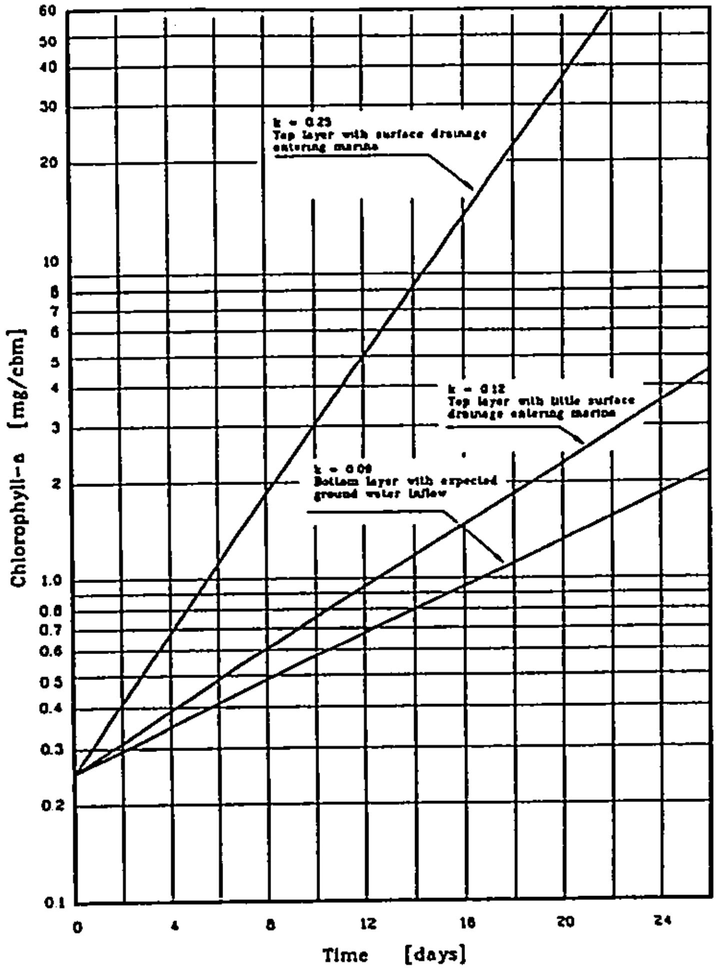
where:

- μ = growth rate
- β = maximum growth rate (a constant)
- K = concentration of phosphorus [μg P/l] where μ = 0.5 * β
- S = concentration of phosphorus

FIGURE 12

EWA MARINA: EXCHANGE RATE AND WQ
NUTRIENT LIMITED NET GROWTH IN
TROPICAL WATERS
FEBRUARY 7, 1992
FILE: 24DB120

OCEES International, Inc.
OCEAN ENGINEERING & ENERGY SYSTEMS
3786 PUKALANI PL., HONOLULU, HAWAII 96816
TEL: (808) 734-7414



Chlorophyll-A concentration vs. estimated Sector residence time

FIGURE 13

EWA MARINA: EXCHANGE RATE AND WQ
CHLOROPHYLL CONCENTRATION VERSUS
ESTIMATED SECTOR RESIDENCE TIME
FEBRUARY 7, 1992
FILE: 24DB130

OCEES International, Inc.
OCEAN ENGINEERING & ENERGY SYSTEMS
3786 PUKALANI PL., HONOLULU, HAWAII 96816
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Appendix F

Ewa Marina Marine Environmental Monitoring Program Water Chemistry Report 1-90

Ewa Marina Marine Environmental Monitoring Program Water Chemistry Report 11-91

(Updates Report 1-90)

EWA MARINA MARINE ENVIRONMENTAL MONITORING PROGRAM

WATER CHEMISTRY

REPORT 1-90

Prepared for

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by

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September 24, 1990

INTRODUCTION AND PURPOSE

Phase 1 of the proposed Ewa Marina Project is located on 735 acres of land along the south shore of Oahu between Ewa Beach and Barbers Point Naval Air Station. The Project includes residential and commercial development, and approximately 150 acres of waterway providing slips for an estimated 1600 boats. The marina will be excavated from dry lands behind the shoreline, and will be connected to the open ocean by an entrance channel that will bisect a broad fringing reef. The planned entrance channel is approximately 125 meters (m) wide and approximately 900 m long. Channel depth will be approximately 6 m at the seaward end, shoaling to about 4 m where the channel breaks through the shoreline. Preliminary calculations indicate that construction of the proposed entrance channel will involve dredging approximately 414,000 cubic yards of reef material, and will result in alteration of about 116,500 m^2 (29 acres) of habitat from dredging and emplacement of rock breakwaters.

Construction of the proposed project will likely result in alteration of the physical and chemical properties of the nearshore ocean waters in the vicinity of the Marina channel. In order to establish the extent of such environmental alterations, a monitoring program has been initiated. The component of monitoring described in this report evaluates the effects on water chemistry resulting from construction and operation of the Ewa Marina.

Water chemistry monitoring will be conducted during the preconstruction, construction, and post construction phases of the project. The preconstruction monitoring phase will establish a baseline describing the existing character of the marine environment, including aspects of temporal (seasonal) and spatial variability. Such a baseline will delineate the extent that water composition is presently affected by terrigenous inputs (sedimentation, freshwater input, nutrient subsidy, etc.) in the area that could be potentially influenced by the proposed project. Because the chemical composition of nearshore waters can be strongly influenced by terrigenous inputs, effects from the proposed project may be mitigated in large part, or amplified by existing environmental factors. This report presents the data and results of the initial phase of water chemistry evaluation in the vicinity of the proposed marina.

METHODS

Four sites in the vicinity of the proposed Ewa Marina channel alignment were selected as water chemistry sampling stations (see Figure 1). Stations 1 and 2 are located to the west and east, respectively, of the site of the proposed entrance channel; Stations 3 is located near the western end of the property, adjacent to the Barbers Point Recreational Facility. Station 4 is located off the Ewa Beach residential area to the east of Oneula Beach Park.

Water quality was evaluated at each station on transects that were oriented perpendicular to the shorelines and depth contours. Water samples were collected in tidepools located on the shoreline, and at 5 or 6 locations on each transect from just seaward of the shoreline to approximately 250 m offshore. Such a sampling scheme was designed to span the greatest range of salinity with respect to potential freshwater efflux at the shoreline. Sampling was more concentrated in the nearshore zone because this area is most likely to show the effects of shoreline modification. With the exception of the tidepools, samples were collected at two depths; a surface sample was collected within approximately 10 centimeters (cm) of the sea surface, and a bottom sample was collected within 1 m of the sea floor. In addition, samples were collected from an irrigation well located directly upslope of the proposed Marina.

Water quality parameters evaluated included the ten specific criteria designated for open coastal waters in Chapter 11-54, Section 06 (Open Coastal waters) of the State of Hawaii Department of Health (DOH) Water Quality Standards. These criteria include: total nitrogen (TN), nitrate + nitrite nitrogen ($NO_3^- + NO_2^-$, hereafter referred to as NO_3^-), ammonium nitrogen (NH_4^+), total phosphorus (TP), 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 the degree of groundwater mixing.

All fieldwork was conducted on June 23, and July 7, 1990, by divers swimming from shore. Water samples were collected by opening 1-liter polyethylene bottles at the desired depth. Subsamples for nutrient analyses were immediately placed in 125-milliliter (ml) acid-washed, triple rinsed, polyethylene bottles and stored on ice. Analyses for NH_4^+, PO_4^{3-}, and NO_3^- were performed using manual spectrophometric techniques on a Brinkman fiber-optic colorimeter. TN and TP were analyzed in a similar fashion following digestion. Dissolved organic nitrogen (DON) and dissolved organic phosphorus (DOP) were calculated as the difference between TN and dissolved inorganic N, and TP and dissolved inorganic P, respectively. The chemistry procedures were performed according to standard methods for seawater analysis (Strickland and Parsons 1968, Grasshoff 1983).

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 Monitek Model 21 nephelometer, and reported in nephelometric turbidity units (NTU). Chl a was measured by filtering 300 ml of water through glass-fiber filters; pigments on filters were extracted in 90% acetone in the dark at -5° C for 12-24 hours. Fluorescence before and after acidification of the extract was measured with a Turner Designs fluorometer. Salinity was determined using an AGE Model 2100 laboratory salinometer with a readability of 0.0001 °/oo.

In-situ field measurements included dissolved oxygen and water temperature (YSI Model 58 meter with a readability of 0.01 milligrams per liter (mg/l), and 0.1° C, respectively). pH was determined in the field with a portable meter with a readability of 0.001 pH units.

RESULTS OF WATER CHEMISTRY ANALYSES

Horizontal and Vertical Stratification

Table 1 shows results of all water chemistry analyses for samples collected off the Ewa Marina site. Concentrations of eight dissolved nutrient constituents are plotted as functions of distance from the shoreline in Figure 2. Values of salinity, turbidity, Chl a and temperature are shown in Figure 3.

Several patterns of distribution are evident in Figures 2 and 3. It can be seen in Figure 2 that the dissolved nutrients Si, NO_3^- and TN, display a marked elevation in concentration in the tidepools and sampling sites within 10 m of the shoreline. These elevated nearshore values are most evident at Stations 2 and 4 for Si, and at Station 2 for NO_3^- and TN. Salinity displays the opposite trend, with sharply lower concentrations in the nearshore zone (within 10 m of the shoreline). The lowest salinity (26.6°/oo) occurred in a tidepool at Station 4.

These patterns appear to be a result of mixing of low salinity groundwater with oceanic water. Low salinity groundwater, which contains high concentrations of Si, NO_3^-, and PO_4^{3-} (see values for irrigation well water in Table 1), percolates to the ocean at the shoreline, resulting in a nearshore zone of mixing. In many areas of the Hawaiian Islands, such groundwater percolation results in gradients of increasing salinity and decreasing nutrients moving seaward. In addition, groundwater efflux often results in a surface lens with lower salinity and higher nutrient content relative to subsurface water. At the Ewa sites, there is a general increase of salinity and certain nutrients with distance from shore. Comparison of surface and deep samples, however, indicates that vertical stratification is imperceptible. The lack of vertical stratification is likely a result of mixing of the water column by breaking surf, which occurred across the shallow nearshore zone where sampling was conducted.

Water chemistry parameters that are not associated with groundwater input do not show the same strong pattern with respect to distance from the shoreline. NH_4^+, DOP and DON do not appear to display any recognizable pattern, and are essentially invariant with distance from the shoreline (Figure 2).

PO_4^{3-} and TP display rather anomalous results. While these constituents occur in relatively high concentrations in irrigation well waters, there is no indication of increased concentrations in nearshore samples compared to offshore samples. Rather, there is an opposite trend with slight increases at each station moving seaward from the shoreline.

Examination of other water chemistry constituents reveals consistent trends at the four sampling stations. Turbidity, Chl a, and temperature display highest values at the nearshore sampling sites, with decrease with distance from shore (Figure 3). One exception is turbidity at Station 4, where the highest values were observed 100 m from the shoreline. Measurements of water temperature also display a west-to-east lateral gradient, with coolest temperatures at Station 1 and warmest at Station 4. Such a pattern may reflect solar warming, as the increasing temperature trend reflects the sequence in which samples were collected, starting in the early morning and progressing toward the afternoon.

Conservative Mixing Analyses

It is possible to evaluate the extent of nutrient input from sources other than uncontaminated groundwater efflux by plotting the concentration of a dissolved material as a function of salinity. Comparison of the curves produced by such plots with conservative mixing lines provides an indication of the origin and fate of the material in question. Figure 4 shows plots of concentrations of four dissolved nutrient constituents (Si, NO_3^-, NH_4^+, PO_4^{3-}) as functions of salinity. Each graph also shows conservative mixing lines that are constructed by connecting the endpoint concentrations of open ocean water and groundwater from the irrigation well directly upslope of the Marina site.

If the parameter in question displays purely conservative behavior (no input or removal from any process other than physical mixing), data points should fall on, or near, the conservative mixing line. If, however, external material is added to the system, data points will fall above the mixing line. If material is being removed from the system by processes such as biological uptake, data points will fall below the mixing line.

Dissolved Si represents a check on assumptions of the method, as this material is present in high concentration in groundwater, but is not a major component of fertilizer, and is not generally utilized rapidly within the nearshore environment by biological processes. It can be seen in Figure 4 that when Si concentrations are plotted as a function of salinity, data points from Stations 1-3 fall in a straight line close to the conservative mixing line. This pattern indicates that at these stations, groundwater of composition similar to irrigation water and ocean water are mixing, and that Si is demonstrating conservative behavior. Station 4, however, displays a different pattern with most data points occurring below the conservative mixing line.

NO_3^- is the form of nitrogen most common in fertilizer mixes, and is the most mobile form of nitrogen within soils and groundwater. The plot of NO_3^- versus salinity (Figure 4) shows that most of the data points from Stations 1 and 2 fall in a line above the conservative mixing line. Data points from Station 3 occur slightly below the mixing line, while data from Station 4 fall on a line substantially below the mixing line. From these data distributions, it appears that at Stations 1 and 2 there is an external input of NO_3^- to the ocean from activities on land, most likely leaching of fertilizers from neighboring sugarcane fields. The position of the data points from Stations 3 and 4 indicates that some nonconservative processes are actively taking up NO_3^- in the nearshore zone.

The other form of dissolved inorganic nitrogen, NH_4^+, shows a different relationship. There is essentially no difference in NH_4^+ concentrations between open ocean water and groundwater,

resulting in a "flat" conservative mixing line (Figure 4). Plots of data points reveal that there is no indication of increased concentrations with decreased salinity. The lack of such a relationship suggests that the source of most NH_4^+ in the nearshore ocean is not from the land, but rather from biological processes occurring in the ocean

PO_4^{3-} is also a component of fertilizer but is usually not found to leach to groundwater to the extent of nitrate nitrogen, owing to a high absorptive affinity of phosphorus in soils. It can be seen in Figure 4 that like NH_4^+, the PO_4^{3-} data points do not fall in a linear fashion with respect to salinity, and that concentrations do not appear to be higher at lower salinities. Therefore, it does not appear that PO_4^{3-} is entering the nearshore environment to a measurable extent with groundwater.

From the patterns shown in Figure 4, several conclusions can be drawn regarding nutrient dynamics at the Ewa Marina sampling stations. The most apparent result is that there are substantially different processes occuring at Station 4 compared to Stations 1-3. Station 4 was located in an area where a relatively broad and shallow reef flat abutted the shoreline. The surface of the reef flat was covered with thick growths of benthic algae that are apparently a permanent feature of the area. Owing to shoreline topography, such algal-covered reef flats did not occur at Stations 1 and 2, and were only weakly formed at Station 3. From the extremely low concentrations of NO_3^-, and depressed Si concentrations in the nearshore area of Station 4, it appears that the algal community is effective at removing nutrients contained in groundwater that is seeping out at the shoreline and moving seaward across the reef. Increased concentrations of DON and DOP at the most shoreward sampling sites (see Figure 2) are consistent with such nutrient cycling by biotic communities. In effect, the algal mats are serving as nutrient scrubbers by effectively removing most inorganic nutrients as groundwater transits the reef flat and mixes with open ocean water.

Without the benthic algal communities at Stations 1-3, dissolved nutrients are mixed with ocean water in a narrow zone near the shoreline. The relatively precise match of Si data points with the theoretical mixing line indicates that the groundwater pumped from the irrigation well is essentially the same groundwater entering the ocean at the proposed marina site. The excursion of the NO_3^- data line above the conservative mixing line suggests that there is an extraneous source, possibly as a result of leaching of sugarcane fertilizer. The occurrence of the data line above the conservative mixing line indicates subsidies beyond the level of irrigation water. It is not possible, however, to distinguish if concentrations measured in irrigation water are already contaminated with fertilizer leachate, or are essentially pristine in nature. Such patterns are not evident with dissolved PO_4^{3-} and NH_4^+, suggesting that at the Ewa sites these materials are not entering the ocean in detectable quantities from groundwater.

Compliance with DOH Criteria

Also noted in Table 1 are samples that exceed DOH water quality standards for open coastal waters under "dry" conditions. The criteria for dry conditions are applied to the Ewa site as this area probably receives less than 3 million gallons of groundwater input per mile per day (T. Nance, personal communication).

The sample set for the initial phase of monitoring was collected during what appeared to be "normal" summer tradewind weather, and is likely to represent the typical conditions that characterize the area. Comparing water chemistry results from the Ewa samples to DOH standards reveals that 23 measurements of NO_3^-, 5 measurements of NH_4^+, 13 measurements of TN, 20 measurements of turbidity, and 4 measurements of Chl a exceeded the "not to exceed more than 10% of the time" standards. TN values are essentially reflections of NO_3^-, and will not be considered further.

As discussed above, NO_3^- is a normal constituent of groundwater. The concentrations found in waters off Ewa appear to be the result of groundwater discharge at the shoreline, along with apparent subsidies at several of the stations. Assuming the irrigation water sampled for this survey is not severely contaminated with NO_3^-, it is apparent from the conservative mixing line in Figure 4 that all nearshore samples will exceed DOH criteria at salinities less than approximately $34^o/oo$ with no further nutrient subsidy from land.

Plots of NH_4^+ as functions of salinity indicate that there is little relationship between concentrations in nearshore ocean samples and inputs from land. Thus, it appears that the measurements of NH_4^+ that exceed DOH criteria are a result of normal marine processes in the area. Likewise, turbidity did not appear to be influenced by processes involving input from land, but only from resuspension of particulate material by wave action.

Thus, by comparison of the water chemistry constituents with DOH criteria, it is apparent that under the present conditions (prior to any construction activities associated with the Ewa Marina), natural processes can cause measurements of water quality that exceed specified DOH limits.

SUMMARY

1. The first phase of the Ewa Marina water chemistry monitoring program was carried out in June and July 1990. Forty water samples were collected from four stations located in the vicinity of the proposed Marina channel alignment. Water samples were collected on transects perpendicular to shore extending from shoreline tidepools to a distance of approximately 250 m offshore. Analysis of 14 water chemistry constituents included all parameters specified in DOH water quality standards.

2. Several dissolved nutrients (NO_3^-, TN, and Si) displayed horizontal gradients with highest values at the stations closest to shore and lowest values at the most seaward sampling sites. At the same stations that displayed these trends, salinity was lowest closest to the shoreline. These patterns indicate that groundwater is entering the marine environment near the shoreline and mixing with oceanic water.

3. Other water chemistry constituents that are not related to groundwater efflux also displayed decreasing values with distance from shore. Such a pattern for turbidity and Chl a. is likely a result of resuspension of sediment by wave stirring. Gradients in temperature are likely a result of solar radiation, both in terms of warming of shallow nearshore water relative to offshore waters, and of diurnal warming through the course of the daily cycle.

4. While there are horizontal gradients in some water chemistry constituents, there is no indication of vertical stratification within the water column. The lack of low density surface layers is likely a result of substantial stirring of the entire water column by wave action.

5. Scaling dissolved Si concentrations to salinity indicates that the groundwater entering the ocean at the survey stations is likely from the same source as the irrigation water that can be sampled directly upslope from the Marina site. Similar scaling of NO_3^- reveals that there is a subsidy to the nearshore ocean of this form of dissolved nitrogen at Stations 1 and 2. At Station 4, thick mats of benthic algae growing on a shoreline reef flat remove nutrients from groundwater as it enters the ocean.

6. A substantial number of water samples exceeded State DOH standards for NO_3^-, TN, NH_4^+, turbidity and Chl a. While it appears that there are subsidies of NO_3^- and TN from shoreline activity, it is also evident that unaffected natural efflux of groundwater at the shoreline will result in concentrations which exceed DOH standards. Turbidity values in excess of DOH standards are likely a result of sediment resuspension from wave stirring.

REFERENCES CITED

Grasshoff, K. 1983. Methods of seawater analysis. Verlag Chemie, Weinheim, 419 pp.

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.

TABLE 1. Water chemistry constituents measured at transect stations off the proposed Ewa Marina site on June 23, 1990
"TP" indicates tide pools; "S" indicates surface ocean sample, "D" indicates deep ocean sample
D F S. indicates distance from shore. State DOH water quality standards are for "DRY" conditions of open coastal waters.
Values in boxes are greater than the "not to exceed more than 10% of the time" criteria.
For station locations, see Figure 1.

STATION	SAMPLE	D F S (m)	PO4 (μM)	NO3 (μM)	NH4 (μM)	Si (μM)	DOP (μM)	DON (μM)	TP (μM)	TN (μM)	TURB (ntu)	SAL (o/oo)	CHL a (μg/L)	O2 (% sat)	TEMP. (deg C)
EM-1-	TP	1	0.14	12.60	0.87	23.89	0.21	8.04	0.35	21.70	0.42	33.8014	0.267	97.5	24.9
	1S	5	0.13	15.43	BDL	24.86	0.22	7.05	0.35	22.48	0.43	33.5560	0.395	95.8	25.1
	1D	5	0.16	15.56	0.18	28.35	0.18	5.83	0.32	21.57	0.40	33.5451	0.192	96.0	25.1
	2S	10	0.13	12.17	0.18	21.94	0.16	6.63	0.29	18.96	0.42	33.7334	0.267	96.1	24.9
	2D	10	0.14	10.73	0.05	20.78	0.25	11.18	0.39	21.96	0.43	33.8143	0.848	95.7	24.5
	3S	50	0.12	3.68	BDL	11.85	0.15	7.57	0.27	11.25	0.52	34.2437	0.236	98.2	24.8
	3D	50	0.10	3.37	BDL	11.07	0.22	7.62	0.32	10.99	0.42	34.2845	0.288	90.6	24.6
	4S	100	0.17	0.84	BDL	5.05	0.16	7.02	0.33	7.86	0.35	34.8007	0.171	92.0	24.8
	4D	100	0.14	0.10	0.74	3.11	0.18	7.41	0.30	8.25	0.33	34.8722	0.224	80.7	24.6
	5S	250	0.13	0.10	BDL	3.11	0.14	5.67	0.27	5.77	0.35	34.8913	0.320	98.8	24.6
	5D	250	0.17	0.83	0.07	4.86	0.19	7.03	0.36	7.73	0.29	34.8443	0.014	93.4	24.8
EM-2-	TP1	0.5	0.13	68.96	BDL	82.73	0.24	3.80	0.37	72.96	0.65	30.4471	0.363	94.8	25.2
	TP2	1	0.14	52.84	0.80	65.64	0.19	3.97	0.33	57.21	0.50	31.3274	0.081	94.5	25.2
	1S	5	0.12	29.22	0.09	47.19	0.15	5.96	0.27	35.27	0.81	32.4817	0.443	97.8	25.2
	2S	5	0.10	18.30	0.06	33.60	0.20	6.66	0.30	26.01	0.51	33.0845	0.224	98.3	25.2
	3S	10	0.10	3.29	BDL	12.23	0.13	6.14	0.23	9.43	0.43	34.1803	0.288	99.4	25.2
	3D	10	0.10	2.61	BDL	11.07	0.13	5.90	0.23	8.51	0.40	34.2309	0.089	100.4	25.3
	4S	50	0.10	3.45	0.32	13.40	0.18	7.74	0.29	11.51	0.43	34.1223	0.299	91.9	25.1
	4D	50	0.10	4.07	0.05	14.37	0.18	5.67	0.28	9.89	0.48	34.0611	0.245	89.0	25.2
	5S	100	0.13	0.16	BDL	4.47	0.14	5.35	0.27	5.51	0.35	34.8014	0.245	97.2	25.2
	5D	100	0.14	0.37	BDL	3.30	0.12	5.27	0.26	5.64	0.32	34.5900	0.235	86.7	25.1
	6S	250	0.14	0.44	BDL	4.08	0.12	4.02	0.26	4.48	0.34	34.6084	0.129	81.4	25.3
	6D	250	0.14	0.37	BDL	3.30	0.18	7.48	0.32	7.86	0.33	34.6250	0.245	79.8	25.3
EM-3-	TP1	0.5	0.08	14.39	0.08	64.96	0.23	8.69	0.31	23.18	0.66	32.1201	0.477	97.5	28.8
	TP2	1	0.08	3.20	0.08	28.52	0.18	7.69	0.24	10.87	0.71	33.5402	0.512	96.8	26.9
	1S	5	0.06	0.28	0.08	12.11	0.18	9.58	0.24	9.94	0.62	34.1096	0.299	96.0	27.2
	2S	10	0.06	0.51	0.19	11.34	0.26	9.50	0.32	10.20	0.56	34.1464	0.512	96.1	26.3
	3S	10	0.07	0.51	0.21	10.96	0.32	13.55	0.38	14.27	0.58	34.1690	0.477	86.7	25.8
	4S	50	0.06	0.84	0.19	8.99	0.23	8.40	0.29	9.43	0.40	34.2416	0.290	98.2	25.8
	4D	50	0.07	0.94	0.42	11.15	0.28	9.74	0.35	11.10	0.47	34.1065	0.299	90.6	25.7
	5S	100	0.07	0.84	0.23	7.88	0.24	8.36	0.31	9.43	0.46	34.3696	0.213	82.0	25.6
	5D	100	0.07	0.89	0.30	7.88	0.22	8.70	0.29	9.89	0.46	34.3521	0.192	90.7	25.8
	6S	250	0.08	0.10	0.23	3.06	0.24	7.64	0.32	8.01	0.33	34.6413	0.181	98.8	25.6
	6D	250	0.07	0.18	0.56	3.08	0.28	8.63	0.35	9.38	0.36	34.8207	0.096	83.4	26.2
EM-4-	TP1	0.5	0.12	1.72	0.11	81.18	0.36	18.17	0.47	20.00	0.79	28.5058	1.727	200.0	28.4
	TP2	1	0.12	0.37	0.18	24.86	0.23	13.58	0.35	14.13	0.61	31.8211	0.256	186.0	27.8
	TP3	3	0.13	0.18	0.11	6.41	0.24	12.27	0.37	12.86	0.72	33.4580	0.400	137.8	28.8
	1S	5	0.09	0.06	BDL	6.99	0.23	12.12	0.32	12.17	0.70	33.5852	0.181	144.0	28.8
	1D	5	0.08	0.00	BDL	8.99	0.15	10.47	0.24	10.47	0.68	33.5731	0.267	135.0	28.4
	2S	10	0.16	0.06	0.18	8.16	0.21	11.57	0.37	11.78	0.68	33.6472	0.213	144.0	28.6
	2D	10	0.13	0.06	0.11	6.41	0.22	12.40	0.35	12.58	0.70	33.6629	0.254	136.0	28.6
	3S	50	0.12	0.08	0.05	6.05	0.18	8.54	0.30	9.80	0.81	33.8647	0.149	134.0	26.7
	3D	50	0.12	0.08	0.09	5.05	0.15	9.28	0.27	9.43	0.50	33.8082	0.085	133.0	27.0
	4S	100	0.18	0.06	0.07	7.38	0.19	8.83	0.35	9.85	1.01	34.1614	0.117	111.0	26.7
	4D	100	0.12	0.06	BDL	5.83	0.23	10.18	0.35	10.21	0.90	34.1737	0.128	106.0	26.6
	5S	250	0.16	0.06	BDL	4.27	0.21	8.07	0.37	8.12	0.38	34.4787	0.128	99.8	26.6
	5D	250	0.18	0.05	BDL	3.69	0.20	7.03	0.38	7.08	0.33	34.4808	0.149	98.2	26.6
	IRRIG. WELL		1.14	302.30	0.40	692.11	0.00	2.80	1.14	305.88		2.0080			
DOH WATER QUAL. STDS															
NOT TO EXCEED 10%				0.71	0.33				0.97	12.86	0.50		0.50		
NOT TO EXCEED 2%				1.43	0.64				1.45	17.86	1.00		1.00		

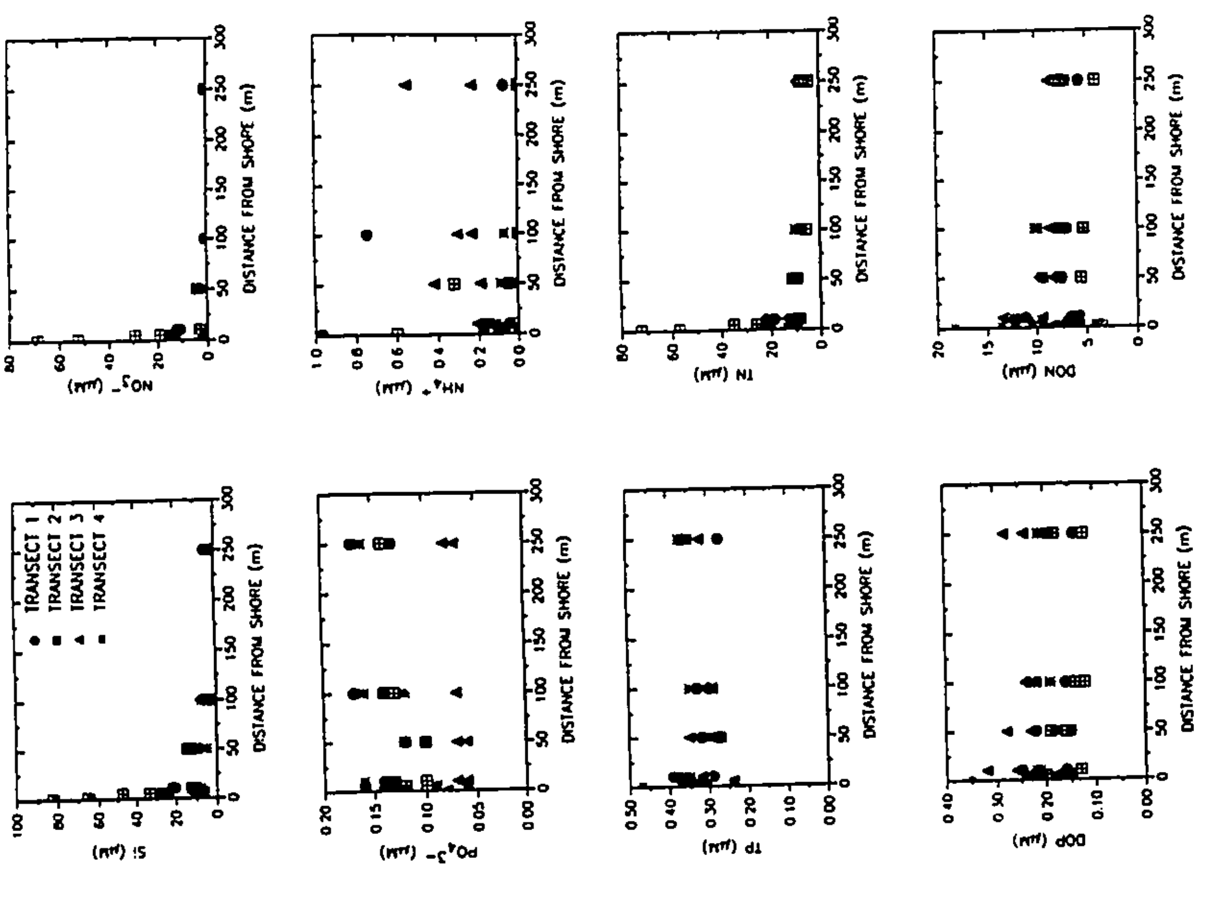

FIGURE 2. Plots of marine nutrient concentrations as functions of distance from the shoreline at the four sampling stations in the vicinity of the proposed Ewa Marina. For transect locations, see Figure 1

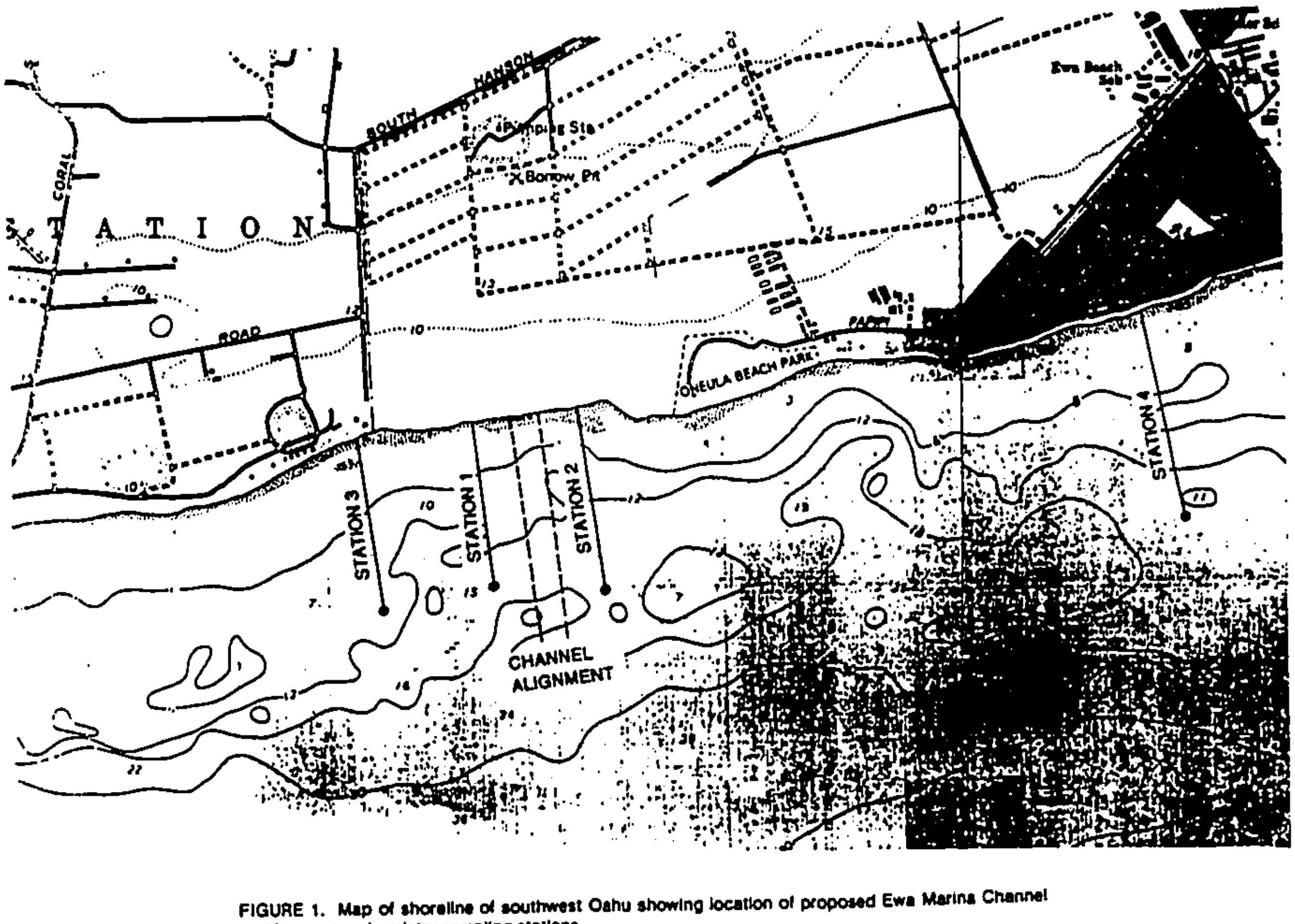

FIGURE 1. Map of shoreline of southwest Oahu showing location of proposed Ewa Marina Channel and four water chemistry sampling stations.

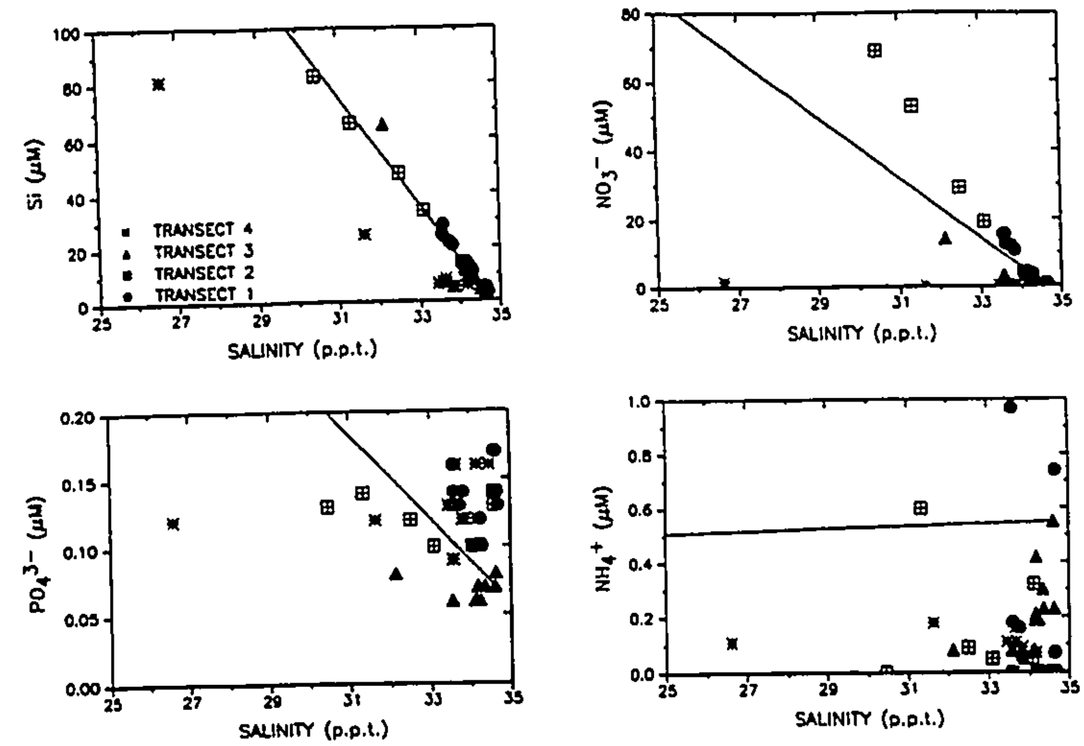

FIGURE 4. Plots of dissolved nutrient constituents as functions of salinity. Straight lines are conservative mixing lines constructed by connecting endpoint concentrations of open ocean water and irrigation well water.

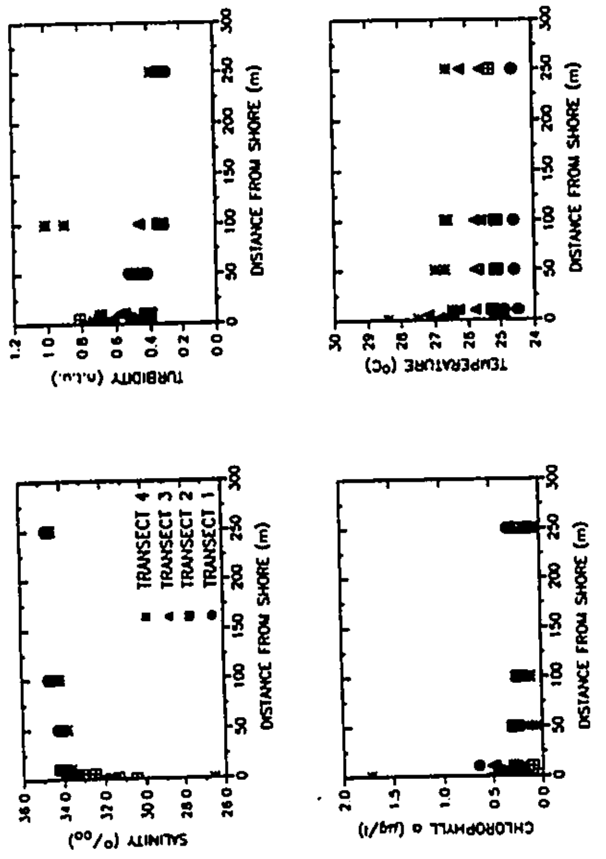

FIGURE 3. Plots of water chemistry constituents as functions of distance from the shoreline at five sampling stations in the vicinity of the proposed Ewa Marina. For transect locations, see Figure 1.

EWA MARINA MARINE ENVIRONMENTAL

MONITORING PROGRAM

WATER CHEMISTRY

REPORT II-91

Prepared for

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INTRODUCTION AND PURPOSE

Phase 1 of the proposed Ewa Marina Project is located on 735 acres of land along the south shore of Oahu between Ewa Beach and Barbers Point Naval Air Station. The Project includes residential and commercial development, and approximately 150 acres of waterway providing slips for an estimated 1600 boats. The marina will be excavated from dry lands behind the shoreline, and will be connected to the open ocean by an entrance channel that will bisect a broad fringing reef. The planned entrance channel is approximately 125 meters (m) wide and approximately 900 m long. Channel depth will be approximately 6 m at the seaward end, shoaling to about 4 m where the channel breaks through the shoreline. Preliminary calculations indicate that construction of the proposed entrance channel will involve dredging approximately 414,000 cubic yards of reef material, and will result in alteration of about 116,500 m^2 (29 acres) of habitat from dredging and emplacement of rock breakwaters.

Construction of the proposed project will result in alteration of the physical and chemical properties of the nearshore ocean waters in the vicinity of the Marina channel. In order to establish the extent of such environmental alterations, it has been deemed appropriate to establish a monitoring program with the express purpose of evaluating the effects on water chemistry resulting from construction and operation of the Ewa Marina. The monitoring program is a continuation of a baseline study, which described the existing character of the marine environment, including aspects of temporal (seasonal) and spatial variability (Marine Research Consultants, September, 1990). This following report presents the data and results from the second, third and fourth increments of the monitoring program, and contains data from water chemistry sampling conducted in November of 1990, and April and August of 1991. All sampling was conducted prior to any construction activity, and represent preconstruction conditions.

METHODS

Three sites in the vicinity of the proposed Ewa Marina channel alignment were selected as water chemistry sampling stations (see Figure 1). Stations 1 and 2 are located to the west and east, respectively, of the site of the proposed entrance channel; Stations 3 is located near the western end of the property, adjacent to the Barbers Point Recreational Facility.

Water quality was evaluated at each station on transects that were oriented perpendicular to the shorelines and depth contours. Water samples were collected in tidepools located on the shoreline, and at 5 or 6 locations on each transect from just seaward of the shoreline to approximately 500 m offshore. Such a sampling scheme was designed to span the greatest range of salinity with respect to potential freshwater efflux at the shoreline. Sampling was more concentrated in the nearshore zone because this area is most likely to show the effects of shoreline modification. With the exception of the tidepools, samples were collected at two depths; a surface sample was collected within approximately 10 centimeters (cm) of the sea surface, and a bottom sample was collected within 1 m of the sea floor. In addition, samples were collected from an irrigation well located directly upslope of the proposed Marina.

Water quality parameters evaluated included the ten specific criteria designated for open coastal waters in Chapter 11-54, Section 06 (Open Coastal waters) of the State of Hawaii Department of Health (DOH) Water Quality Standards. These criteria include: total nitrogen (TN), nitrate + nitrite nitrogen (NO_3^- + NO_2^-, hereafter referred to as NO_3^-), ammonium nitrogen (NH_4^+), total phosphorus (TP), chlorophyll a (Chl a), turbidity, 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 the degree of groundwater mixing, respectively.

Fieldwork was conducted using a small boat or by divers swimming from shore on three dates: November 3, 1990, April 15, 1991 and August 7, 1991. Water samples were collected by opening 1-liter polyethylene bottles at the desired depth. Subsamples for nutrient analyses were immediately placed in 125-milliliter (ml) acid-washed, triple rinsed, polyethylene bottles and stored on ice. Analyses for NH_4^+, PO_4^{3-}, and NO_3^- were performed with a Technicon autoanalyzer using standard methods for seawater analysis (Strickland and Parsons 1968, Grasshoff 1983). TN and TP were analyzed in a similar fashion following digestion. Dissolved organic nitrogen (DON) and dissolved organic phosphorus (DOP) were calculated as the difference between TN and dissolved inorganic N, and TP and dissolved inorganic P, respectively.

Water for other analyses was subsampled from 1-liter polyethylene bottles and kept chilled until analysis. Turbidity was determined on 60-ml subsamples fixed with $HgCl_2$ to terminate biological activity. Fixed samples were kept refrigerated until turbidity was measured on a Monitek Model 21 nephelometer, and reported in nephelometric turbidity

units (NTU). Chl a was measured by filtering 300 ml of water through glass-fiber filters; pigments on filters were extracted in 90% acetone in the dark at -5° C for 12-24 hours. Fluorescence before and after acidification of the extract was measured with a Turner Designs fluorometer. Salinity was determined using an AGE Model 2100 laboratory salinometer with a readability of 0.0001 °/oo.

In-situ field measurements included water temperature using a hand-held mercury thermometer with a readability of 0.1° C and pH using a portable meter with a readability of 0.001 pH units. During the August monitoring survey, vertical profiles of salinity, temperature and depth were obtained along each transect using an Ocean Sensors Model 100 CTD.

RESULTS OF WATER CHEMISTRY ANALYSES

Horizontal Stratification

Tables 1, 2 and 3 show results of all water chemistry analyses for samples collected off the Ewa Marina site in November 1990, April and August 1991, respectively. Concentrations of eight dissolved nutrient constituents are plotted as functions of distance from the shoreline in Figures 2, 4 and 6. Values of salinity, turbidity, Chl a and temperature are shown in Figures 3, 5 and 7.

Several patterns of distribution are evident in the plots of chemical concentration vs distance from shore. During the November 1990 sampling, it can be seen in Figure 2 that the dissolved nutrients Si, NO_3^- and TN, display a marked elevation in concentration in the sampling sites within 10 m of the shoreline. The gradient for Si is steepest at Station 3, while the gradients for NO_3^- and TN are most extreme at Stations 1 and 2. Salinity displays the opposite trend, with sharply lower concentrations in the nearshore zone at all three Stations Figure 3). The lowest salinities occurred at Station 2 during both the November survey (33.94°/oo).

Figures 4 and 5 display results from the April monitoring survey and show a similar trend of higher dissolved nutrient concentrations and lower salinity in the nearshore zone. Differences between stations is not evident and the magnitude of the concentration change is not as obvious; Si, TN and salinity change more gradually with distance from shore.

NO_3^-, however, shows a marked elevation within 10 m of the shoreline (Figure 4) and this trend is most obvious at Stations 1 and 2.

During the August 1991 survey (Figures 6 and 7) the sharp gradient in NO_3^-, Si, TN and salinity were the most extreme of any of the three surveys, and were also the most restricted with respect to distance from the shoreline. These patterns appear to be a result of mixing of low salinity groundwater with oceanic water. Low salinity groundwater, which contains high concentrations of Si, and NO_3^-, (see values for irrigation well water in Tables 1, 2 and 3), percolates to the ocean at the shoreline, resulting in the nearshore zone of mixing evident in Figures 2-7.

Dissolved nutrient species that are not associated with groundwater input do not show the same strong pattern with respect to distance from the shoreline. NH_4^+, DOP and DON do not appear to display any recognizable pattern, and are essentially invariant with distance from the shoreline (Figures 2, 4 and 6).

PO_4^{3-} and TP display rather anomalous results. While these constituents occur in relatively high concentrations in irrigation well waters, there is no indication of increased concentrations in nearshore samples compared to offshore samples. Rather, there is an opposite trend with slight increases at each station moving seaward from the shoreline.

Examination of other water chemistry constituents reveals consistent trends at the three sampling stations. Turbidity and Chl a generally display highest values at the nearshore sampling sites and decrease with distance from shore (Figures 3, 5 and 7). One exception is Chl a at Station 3 in November, where the concentrations appear to increase to a maximum value at 500 m from shore (Figure 3). Temperature remains relatively constant with distance from the shoreline at most of the stations (Figures 3, 5 and 7). Station 1 had a distinctly higher temperature nearshore in August (Figure 7) and across the entire transect in November (Figure 3) as compared to the other 2 stations.

Vertical Stratification

Groundwater efflux often results in a surface lens with lower salinity and higher nutrient content relative to subsurface water. At the Ewa sites, there is a general increase of salinity and decrease of certain nutrients with distance from shore. Comparison of values measured in surface seawater to that measured in deep water, however, indicates that vertical stratification is inconsistent and in some cases imperceptible.

Figure 2 shows that, in general, the concentrations of dissolved nutrients associated with groundwater input are slightly higher in samples collected 5 m from the shoreline but with increased distance from shore this pattern is no longer evident. Vertical stratification is absent during April and August as evidenced by an inconsistent pattern between the concentrations of water chemistry constituents in surface and deep samples (Figures 4, 5, 6 and 7). The lack of vertical stratification is likely a result of mixing of the water column by breaking surf, which occurred across the shallow nearshore zone where sampling was conducted.

Continuous vertical profiles of salinity and temperature during August at each of the sampling sites beyond 5 m from the shoreline are shown in Figures 8 and 9, respectively. These profiles verify the lack of vertical stratification at the Ewa Marina site. While both salinity and temperature are nearly constant from the surface to the limit of sampling at all sampling sites, it can be seen in Figures 8 and 9 that the entire water column cools and becomes more saline with distance from shore.

Temporal Comparison of Monitoring Results

Figures 10-15 show concentrations of water chemistry constituents from surface samples at each of the sampling sites during all four monitoring surveys to date. At Station 1, nutrients and salinity indicate that groundwater input was evident during all four surveys (Figures 10 and 11). It can be seen in Figure 10 that during June 1990 groundwater efflux appears to have an extended zone of mixing as evidenced by the elevated levels of dissolved nutrient constituents to a distance of 200 m from the shoreline.

At Stations 2 and 3, temporal patterns of groundwater efflux were not evident; the highest Si and NO_3^- values were in the nearshore samples in June at Station 2 and in November at Station 3 (Figures 12 and 14). Salinity tended to be highest in November and lowest in April at all stations and all locations offshore (Figure 10, 11 and 12).

The concentrations of DON and DOP at all stations were substantially higher in April 1991 as compared the other three surveys (Figures 10, 12 and 14). Turbidity was generally higher during April 1991 with maximum values at Station 3, as shown in Figures 11, 13 and 15. These figures also show a distinct seasonal pattern in temperature with warmest temperatures in late summer/fall (November and August) and cooler temperatures in spring/early summer (June and April). This trend is most evident at Stations 1 and 2.

At Station 3, temperatures in June were substantially higher than for this time at the other stations (Figure 15). The highest temperatures were recorded for Station 1 during November when temperatures reached a maximum value of 28.9°C (Figure 11). Chl a has no apparent temporal pattern.

These results suggest that while there is some natural variability in the input and mixing characteristics of groundwater efflux at the Ewa Marina site, water chemistry is relatively constant over the course of a seasonal cycle. With the exception of temperature and possibly DON and DOP, there is no distinct seasonal trend with respect to most water chemistry constituents. Variations in chemical constituency appears to be more a result of short term processes such as stage of the tide rather that time of the year.

Conservative Mixing Analyses

It is possible to evaluate the extent of nutrient input from sources other than uncontaminated groundwater efflux by plotting the concentration of a dissolved material as a function of salinity. Comparison of the curves produced by such plots with conservative mixing lines provides an indication of the origin and fate of the material in question. Figures 16, 17 and 18 show the concentrations of four dissolved nutrient constituents (Si, NO_3^-, NH_4^+, PO_4^{3-}) plotted as functions of salinity for November 1990, April and August 1991, respectively. Each graph also shows conservative mixing lines that are constructed by connecting the endpoint concentrations of open ocean water and groundwater from the irrigation well directly upslope of the Marina site.

If the parameter in question displays purely conservative behavior (no input or removal from any process other than physical mixing), data points should fall on, or near, the conservative mixing line. If, however, external material is added to the system, data points will fall above the mixing line. If material is being removed from the system by processes such as biological uptake, data points will fall below the mixing line.

Dissolved Si represents a check on assumptions of the method, as this material is present in high concentration in groundwater, but is not a major component of fertilizer, and is not generally utilized rapidly within the nearshore environment by biological processes. It can be seen in these figures that when Si concentrations are plotted as a function of salinity, data points fall in a relatively straight line. In November 1990 (Figure 16) the array of data points falls very close to the mixing line; in April and August 1991

(Figures 17 and 18), the distribution of data is below the mixing line. This pattern indicates that for the latter two surveys, groundwater from the sampled well contained higher concentrations of Si than groundwater entering the ocean at the shoreline.

NO_3^- is the form of nitrogen most common in fertilizer mixes, and is the most mobile form of nitrogen within soils and groundwater. The plots of NO_3^- versus salinity (Figures 16-19) show that most of the data points from Stations 1 and 2 fall above the conservative mixing line. Data points from Station 3 occur slightly below the mixing line. From these data distributions, it appears that at Stations 1 and 2 there is an external input of NO_3^- to the ocean from activities on land, most likely leaching of fertilizers from neighboring sugarcane fields.

The other form of dissolved inorganic nitrogen, NH_4^+, shows a different relationship. There is essentially no difference in NH_4^+ concentrations between open ocean water and groundwater, resulting in a "flat" conservative mixing lines (Figures 16-19). Plots of data points reveal that there is no indication of increased concentrations with decreased salinity. NH_4^+ concentrations in the nearshore ocean samples, are consistently above the mixing line, but occur in a randomly scattered pattern. The lack of a relationship with respect to salinity suggests that the source of most NH_4^+ in the nearshore ocean is not from the land, but rather from biological processes occurring in the ocean.

PO_4^{3-} is also a component of fertilizer but is usually not found to leach to groundwater to the extent of nitrate nitrogen, owing to a high absorptive affinity of phosphorus in soils. It can be seen in Figures 16-19 that like NH_4^+, the PO_4^{3-} data points do not fall in a linear fashion with respect to salinity, and that concentrations do not appear to be higher at lower salinities. Therefore, it does not appear that PO_4^{3-} is entering the nearshore environment to a measurable extent with groundwater.

When data for all four surveys is plotted (Figure 19), several temporal trends are evident. For Si, NO_3^-, and NH_4^+ the lowest input appeared to occur in April 1991. The distributions for the other three samplings were similar with respect to distribution along mixing lines. These results suggest a relatively uniform flow of nutrients into the nearshore zone from groundwater efflux at the shoreline over the seasonal cycle.

Compliance with DOH Criteria

Also noted in Tables 1, 2 and 3 are samples that exceed DOH water quality standards for open coastal waters under "wet" conditions. The criteria for wet conditions are applied to the Ewa site as this area probably receives at least 3 million gallons of groundwater input per mile per day (T. Nance, personal communication).

A comparison of water chemistry results from water samples (excluding tidepool samples) to DOH standards reveals that during November, 5 measurements of NO_3^- and 2 measurements of TN exceed the 10% criteria (Table 1). In April, 6 measurements of NO_3^- and 7 measurements of TN exceed the 10% criteria (Table 2) and in August, 4 measurements of NO_3^-, 1 measurement of NH_4^+, 2 measurements of TN, and 1 measurement of Chl a exceed the 10% criteria (Table 3). No measurements of TP or turbidity exceed the DOH 10% criteria on any date for samples other than those from tidepools. TN values are essentially reflections of NO_3^-, and will not be considered further.

As discussed above, NO_3^- is a normal constituent of groundwater. The concentrations found in waters off Ewa appear to be the result of groundwater discharge at the shoreline, along with apparent subsidies from agricultural practices. Assuming the irrigation water sampled for this survey is not severely contaminated with NO_3^-, it is apparent from the conservative mixing lines in Figures 16-19, that all nearshore samples will exceed DOH criteria at salinities less than approximately 34°/oo with no further nutrient subsidy from land.

Plots of NH_4^+ as functions of salinity indicate that there is little relationship between concentrations in nearshore ocean samples and inputs from land. Thus, it appears that the one measurement of NH_4^+ that exceeds the DOH criteria is a result of normal marine processes in the area.

Samples from tidepools exceed the DOH 10% criteria for NO_3^- and TN in nearly all cases. With the exception of one measurement of NH_4^+, 3 of turbidity and 2 Chl a measurements, tidepool samples were in compliance with the DOH criteria for these constituents.

Table 4 shows geometric mean data from samples collected over the entire course of the monitoring program. Also shown in Table 4 are the samples that exceed the DOH geometric mean limits. Twelve samples of NO_3^-, 9 measurements of TN, 5 measurements

of turbidity, and 7 measurements of Chl a exceeded the limits over the past year of monitoring. No measurements of NH_4^+ or TP were found to exceed these limits. In the tidepools, all measurements of NO_3^- and TN, 1 measurement of NH_4^+, nearly all measurements of turbidity and Chl a, and no measurements of TP exceed the DOH geometric mean limits.

Thus, by comparison of the water chemistry constituents with DOH criteria, it is apparent that over the course of the first year, existing conditions can cause measurements of water quality that exceed specified DOH limits.

SUMMARY

1. The second, third and fourth phases of the Ewa Marina water chemistry monitoring program was carried out in November 1990 and April and August 1991. Thirty water samples were collected from three stations located in the vicinity of the proposed Marina channel alignment. Water samples were collected on transects perpendicular to shore extending from shoreline tidepools to a distance of approximately 500 m offshore. Water samples were also collected from a potable well located in the Waianae range. Analysis of 14 water chemistry constituents included all parameters specified in DOH water quality standards.

2. Several dissolved nutrients (NO_3^-, TN, and Si) displayed horizontal gradients with highest values at the stations closest to shore and lowest values at the most seaward sampling sites. At the same stations that displayed these trends, salinity was lowest closest to the shoreline. These patterns indicate that groundwater is entering the marine environment near the shoreline and mixing with oceanic water within a narrow zone close to the shoreline.

3. Other water chemistry constituents that are not related to groundwater efflux also displayed decreasing values with distance from shore. Such a pattern for turbidity, is likely a result of resuspension of sediment by wave stirring. Increased Chl a at the nearshore stations may be a result of increased concentrations of benthic algal fragments or increased phytoplankton abundance.

4. While there are horizontal gradients in some water chemistry constituents, there is no indication of vertical stratification within the water column. The lack of low density

surface layers is likely a result of substantial stirring of the entire water column by wave action.

5. Comparative results of the four monitoring surveys indicate that there is some natural variability in the input and mixing characteristics of groundwater efflux at the Ewa Marina site. With the exception of temperature, there are no apparent seasonal trends with respect to most water chemistry constituents. Variations in chemical constituency appears to be more a result of short-term processes rather than time of year.

6. Scaling dissolved Si concentrations to salinity indicates that the groundwater entering the ocean at the survey stations is not always from a similar source as the irrigation water that can be sampled directly upslope from the Marina site. Similar scaling of NO_3^- reveals that there is a subsidy to the nearshore ocean of this form of dissolved nitrogen at Stations 1 and 2, probably as a result of leaching of fertilizers used on sugarcane. There is no such apparent input of PO_4^{-3} or NH_4^+ from activities on land.

6. A number of water samples exceeded State DOH standards for NO_3^-, and TN. While it appears that there are subsidies of NO_3^- and TN from shoreline activity, it is also evident that unaffected natural efflux of groundwater at the shoreline will result in concentrations which exceed DOH standards.

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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.

TABLE 1. Water chemistry measurements off the Ewa Marina site collected on November 3, 1990. Abbreviations as follows: TP = tidepool; S = surface; D = deep; BDL = below detection limit. Boxed values exceed DOH criteria for open coastal waters under "wet" conditions. For sampling station locations, see Figure 1.

STATION	NO.	DFS (m)	PO4 (µM)	NO3 (µM)	NH4 (µM)	SI (µM)	DOP (µM)	DON (µM)	TP (µM)	TN (µM)	TURB (ntu)	SAL (o/oo)	CHL a (µg/L)	TEMP. (deg C)	pH
EM-1-	TP	1	0.12	14.65	0.67	24.65	0.14	4.92	0.26	20.24	0.34	33.984	0.31	29.4	8.21
	1S	5	0.13	12.15	0.25	21.07	0.13	5.94	0.26	18.34	0.33	34.112	0.28	28.7	8.20
	1D	5	0.13	11.99	0.37	20.68	0.15	5.50	0.28	17.86	0.38	34.129	0.48	28.6	8.20
	2S	10	0.12	0.52	0.12	5.37	0.13	5.57	0.25	6.21	0.37	34.786	0.48	28.4	8.22
	2D	10	0.07	0.93	0.17	8.16	0.16	5.94	0.23	7.04	0.36	34.744	0.28	28.5	8.23
	3S	100	0.09	0.17	0.08	3.58	0.14	5.48	0.23	5.73	0.35	34.850	0.44	28.7	8.18
	3D	100	0.09	0.14	0.10	4.18	0.16	5.25	0.25	5.49	0.35	34.848	0.21	28.9	8.18
	4S	200	0.16	0.24	0.15	2.78	0.14	4.75	0.30	5.14	0.17	34.920	0.24	28.5	8.15
	4D	200	0.14	0.24	0.17	2.98	0.16	5.08	0.30	5.49	0.20	34.931	0.28	28.4	8.15
	5S	500	0.12	0.06	0.08	2.58	0.14	4.89	0.26	5.02	0.16	34.964	0.18	28.4	8.15
	5D	500	0.12	BDL	0.08	2.19	0.14	4.34	0.26	4.42	0.15	34.969	0.21	27.4	8.15
EM-2-	TP1	0.1	0.14	33.32	0.33	42.94	0.15	4.54	0.29	38.19	0.63	32.726	0.58	27.0	8.25
	TP2	1	0.09	24.76	0.17	34.39	0.16	3.75	0.25	28.68	0.53	33.184	0.28	27.1	8.27
	1S	5	0.09	10.61	0.40	19.88	0.14	4.71	0.23	15.72	0.35	33.945	0.31	26.9	8.34
	1D	5	0.09	3.38	0.25	9.74	0.14	4.36	0.23	7.99	0.48	34.482	0.33	26.7	8.32
	2S	10	0.13	0.26	0.44	4.77	0.13	5.03	0.26	5.73	0.37	34.842	0.10	26.8	8.23
	2D	10	0.12	0.21	0.40	3.98	0.14	4.88	0.26	5.49	0.29	34.857	0.19	26.8	8.23
	3S	100	0.12	0.19	0.48	3.78	0.18	5.54	0.30	6.21	0.24	34.881	0.21	26.7	8.17
	3D	100	0.13	0.14	0.10	3.18	0.20	6.80	0.33	7.04	0.26	34.886	0.27	26.7	8.19
	4S	200	0.12	0.07	BDL	2.39	0.18	6.85	0.30	6.92	0.17	34.957	0.10	26.7	8.15
	4D	200	0.10	0.05	0.04	2.58	0.19	6.71	0.29	6.80	0.19	34.959	0.14	26.7	8.15
	5S	500	0.13	0.06	0.04	2.58	0.20	6.24	0.33	6.33	0.11	34.960	0.15	26.7	8.15
	5D	500	0.12	BDL	0.04	2.58	0.26	6.40	0.38	6.44	0.14	34.955	0.11	26.7	8.15
EM-3-	TP1	0.1	0.12	17.03	BDL	69.19	0.13	6.30	0.25	23.33	0.45	32.680	0.51	26.9	8.21
	TP2	1	0.09	14.53	0.19	61.43	0.19	7.30	0.28	22.02	0.48	32.950	0.19	27.0	8.22
	TP3	5	0.09	8.66	0.19	40.36	0.21	7.23	0.30	16.08	0.51	33.611	0.14	26.9	8.22
	1S	10	0.06	3.96	0.12	29.42	0.22	6.77	0.28	10.84	0.55	34.048	0.05	27.1	8.27
	1D	10	0.04	0.17	0.10	10.14	0.19	6.89	0.23	7.16	0.48	34.613	0.19	27.2	8.21
	2S	100	0.09	0.19	0.23	9.94	0.17	7.57	0.26	7.99	0.58	34.601	0.15	27.0	8.21
	2D	100	0.04	0.21	0.15	10.14	0.24	6.80	0.28	7.16	0.67	34.590	0.25	27.0	8.21
	3S	200	0.12	0.24	0.15	3.38	0.17	6.05	0.29	6.44	0.14	34.889	0.12	26.8	8.14
	3D	200	0.12	0.21	0.15	2.98	0.17	5.97	0.29	6.33	0.14	34.890	0.16	26.8	8.14
	4S	500	0.16	0.07	0.10	2.39	0.14	5.92	0.30	6.09	0.19	34.947	0.26	26.8	8.15
	4D	500	0.16	0.07	0.06	2.98	0.16	5.98	0.32	6.09	0.19	34.947	0.12	26.8	8.15
	WELL		6.19	201.46	0.14	995.47	0.00	1.30	6.19	202.90		0.4869			
	TAP WATER		1.14	302.39	0.40	692.11	0.00	2.90	1.14	305.69		2.0090			
DOH WATER QUAL. STDS.															
NOT TO EXCEED 10%				1.00	0.61				1.29	17.85	1.25		0.90		1.25
NOT TO EXCEED 2%				1.78	1.07				1.93	25.00	2.00		1.75		2.00

TABLE 2. Water chemistry measurements off the Ewa Marina site collected on April 15, 1991. Abbreviations as follows: TP = tidepool; S = surface; D = deep; BDL = below detection limit. Boxed values exceed DOH criteria for open coastal waters under "wet" conditions. For sampling station locations, see Figure 1.

STATION	NO.	DFS (m)	PO4 (µM)	NO3 (µM)	NH4 (µM)	SI (µM)	DOP (µM)	DON (µM)	TP (µM)	TN (µM)	TURB (ntu)	SAL (o/oo)	CHL a (µg/L)	TEMP. (deg C)	pH
EM-1-	TP	1	0.11	4.18	0.20	14.43	0.28	19.16	0.39	23.54	1.09	33.681	0.48	24.4	8.24
	1S	5	0.11	4.01	0.11	13.88	0.27	17.93	0.38	22.05	0.91	33.685	0.38	24.0	8.24
	1D	5	0.10	4.23	0.14	14.07	0.34	21.91	0.44	26.28	0.78	33.667	0.51	24.0	8.25
	2S	10	0.08	1.99	0.08	11.14	0.23	18.61	0.31	20.68	0.83	33.800	0.38	23.8	8.25
	2D	10	0.10	1.62	0.14	10.78	0.22	21.68	0.32	23.42	0.81	33.835	0.09	24.1	8.25
	3S	100	0.10	0.20	BDL	7.31	0.25	15.62	0.35	15.82	0.84	34.056	0.48	24.0	8.15
	3D	100	0.10	0.20	0.06	6.58	0.24	14.81	0.34	15.07	1.19	34.079	0.30	24.0	8.15
	4S	200	0.13	0.07	BDL	7.49	0.24	16.25	0.37	16.32	0.36	34.178	0.20	23.9	8.17
	4D	200	0.13	BDL	0.06	7.49	0.22	15.26	0.35	15.32	0.41	34.223	0.27	23.9	8.18
	5S	500	0.11	BDL	0.06	4.20	0.24	14.14	0.35	14.20	0.23	34.514	0.18	23.9	8.19
	5D	500	0.11	BDL	0.06	4.20	0.19	13.02	0.30	13.08	0.21	34.482	0.13	23.8	8.19
EM-2-	TP1	0.1	0.07	4.58	0.11	14.80	0.34	21.71	0.41	26.40	1.34	33.446	0.58	24.7	8.42
	TP2	1	0.04	3.51	0.11	13.52	0.33	19.05	0.37	22.67	1.02	33.484	0.44	24.5	8.39
	1S	5	0.03	2.77	0.14	12.61	0.29	17.64	0.32	20.55	0.91	33.514	0.55	24.3	8.41
	1D	5	0.03	3.24	0.14	13.34	0.27	16.92	0.30	20.30	0.87	33.486	0.48	24.4	8.42
	2S	10	0.07	0.57	0.06	9.68	0.24	18.05	0.31	18.68	0.86	33.745	0.34	24.4	8.32
	2D	10	0.06	0.47	0.08	9.50	0.25	14.27	0.31	14.82	0.92	33.754	0.31	24.4	8.30
	3S	100	0.11	0.07	0.11	7.86	0.23	14.89	0.34	15.07	0.91	34.009	0.22	24.1	8.16
	3D	100	0.11	BDL	0.20	7.49	0.21	16.86	0.32	17.06	0.75	34.049	0.25	24.0	8.16
	4S	200	0.13	BDL	0.11	6.76	0.22	14.59	0.35	14.70	0.38	34.184	0.22	24.1	8.16
	4D	200	0.13	0.05	0.11	6.76	0.21	15.28	0.34	15.44	0.43	34.175	0.24	24.0	8.16
	5S	500	0.10	BDL	0.06	2.01	0.22	15.51	0.32	15.57	0.12	34.658	0.10	24.0	8.20
	5D	500	0.07	BDL	0.08	2.01	0.21	15.74	0.28	15.82	0.11	34.663	0.09	24.1	8.20
EM-3-	TP1	0.1	0.10	1.25	0.11	14.62	0.21	19.69	0.31	21.05	1.49	33.704	0.58	23.9	8.21
	TP2	1	0.08	0.95	0.11	13.88	0.20	17.50	0.28	18.56	1.38	33.713	0.38	23.9	8.22
	TP3	5	0.07	0.62	0.08	11.51	0.24	16.36	0.31	17.06	1.19	33.795	0.44	23.7	8.22
	1S	10	0.06	0.37	0.08	9.32	0.24	15.99	0.30	16.44	1.08	33.867	0.41	23.7	8.21
	1D	10	0.04	0.35	0.08	9.68	0.28	15.78	0.32	16.19	0.97	33.856	0.61	23.7	8.21
	2S	100	0.06	0.20	0.11	6.21	0.28	16.13	0.34	16.44	1.15	34.071	0.27	23.7	8.14
	2D	100	0.06	0.20	0.08	6.03	0.25	15.66	0.31	15.94	0.99	34.118	0.41	23.6	8.15
	3S	200	0.11	0.12	0.06	5.66	0.26	15.26	0.37	15.44	0.72	34.179	0.24	23.6	8.15
	3D	200	0.08	0.10	BDL	4.75	0.27	15.22	0.35	15.32	0.55	34.297	0.24	23.5	8.15
	4S	500	0.11	0.05	0.06	2.01	0.26	13.96	0.37	14.07	0.18	34.622	0.08	24.1	8.20
	4D	500	0.10	0.05	BDL	2.01	0.24	14.90	0.34	14.95	0.15	34.624	0.09	24.0	8.19
TAP WATER			2.75	220.33	0.03	961.50	0.00	0.59	2.75	220.95	0.07	0.4480			
DOH WATER QUAL. STDS.															
NOT TO EXCEED 10%				1.00	0.61				1.29	17.85	1.25		0.90		
NOT TO EXCEED 2%				1.78	1.07				1.93	25.00	2.00		1.75		

TABLE 3. Water chemistry measurements off the Ewa Marina site collected on August 7, 1991. Abbreviations as follows: TP = tidepool; S = surface; D = deep; BDL = below detection limit. Boxed values exceed DOH criteria for open coastal waters under "wet" conditions. For sampling station locations, see Figure 1.

STATION	NO.	DFS (m)	PO4 (µM)	NO3 (µM)	NH4 (µM)	SI (µM)	DOP (µM)	DON (µM)	TP (µM)	TN (µM)	TURB (ntu)	SAL (o/oo)	CHL a (µg/L)	TEMP. (deg C)	pH
EM-1-	TP	1	0.09	15.01	BDL	26.79	0.11	7.01	0.20	22.02	0.34	33.377	0.88	27.9	8.04
	1S	5	0.07	9.48	0.07	19.08	0.12	8.02	0.19	15.57	0.36	33.742	0.63	27.9	8.04
	1D	5	0.06	7.43	BDL	16.70	0.14	6.17	0.20	13.60	0.38	33.846	1.25	27.9	8.05
	2S	10	0.10	0.14	BDL	3.49	0.20	8.70	0.30	8.84	0.30	34.530	0.39	27.0	8.14
	2D	10	0.25	0.14	0.07	3.67	0.21	10.59	0.48	10.80	0.28	34.533	0.37	27.0	8.14
	3S	100	0.12	0.08	BDL	2.57	0.20	7.91	0.32	7.99	0.20	34.521	0.19	27.0	8.15
	3D	100	0.13	0.08	0.11	2.57	0.17	5.98	0.30	6.17	0.24	34.523	0.18	27.0	8.15
	4S	200	0.09	0.17	0.07	3.12	0.19	5.93	0.28	6.17	0.28	34.521	0.19	26.9	8.14
	4D	200	0.13	0.20	BDL	2.57	0.17	5.41	0.30	5.61	0.21	34.625	0.19	26.9	8.16
	5S	500	0.10	0.11	0.11	2.75	0.18	5.81	0.28	6.03	0.15	34.617	0.23	26.8	8.16
	5D	500	0.07	BDL	0.07	2.39	0.22	5.54	0.29	5.61	0.11	34.701	0.18	26.8	8.18
EM-2-	TP1	0.1	0.09	26.51	0.18	41.84	0.14	7.67	0.23	34.36	0.58	32.296	0.69	27.9	8.05
	TP2	1	0.04	19.21	0.18	32.29	0.16	5.57	0.20	24.96	0.45	32.780	1.06	27.9	8.08
	1S	5	0.03	14.17	0.14	26.24	0.16	7.99	0.19	22.30	0.39	33.113	0.81	27.9	8.09
	1D	5	0.03	14.31	0.14	26.97	0.17	8.55	0.20	23.00	0.36	33.091	0.43	27.9	8.09
	2S	10	0.10	0.14	0.11	2.94	0.20	5.64	0.30	5.89	0.30	34.561	0.35	26.9	8.13
	2D	10	0.09	0.17	0.11	2.57	0.19	5.47	0.28	5.75	0.33	34.559	0.09	26.9	8.15
	3S	100	0.09	0.14	0.07	3.30	0.20	5.26	0.29	5.47	0.15	34.510	0.29	26.8	8.14
	3D	100	0.10	0.17	0.25	3.49	0.19	4.49	0.29	4.91	0.22	34.514	0.12	26.9	8.15
	4S	200	0.07	0.11	0.14	2.94	0.19	4.52	0.26	4.77	0.14	34.649	0.14	26.7	8.16
	4D	200	0.12	0.11	0.14	3.12	0.17	5.50	0.29	5.75	0.19	34.671	0.22	26.7	8.17
	5S	500	0.06	0.06	0.11	2.94	0.20	5.58	0.26	5.75	0.14	34.689	0.29	26.7	8.17
	5D	500	0.25	0.06	0.53	2.57	0.18	5.02	0.43	5.61	0.09	34.757	0.25	26.7	8.20
EM-3-	TP1	0.1	0.14	16.27	0.21	62.02	0.14	6.38	0.28	22.86	0.61	32.242	1.25	27.9	8.00
	TP2	1	0.03	1.65	0.07	15.78	0.25	6.55	0.28	8.27	0.55	34.004	0.63	27.9	8.03
	TP3	5	0.03	1.80	0.21	18.88	0.26	6.55	0.29	8.56	0.49	33.963	0.14	27.9	8.03
	1S	10	0.04	0.59	0.18	8.44	0.22	6.80	0.28	7.57	0.28	34.243	0.53	26.7	8.03
	1D	10	0.14	0.20	1.20	6.97	0.19	7.01	0.33	8.41	0.30	34.457	0.47	26.7	8.08
	2S	100	0.12	0.06	0.21	2.94	0.20	5.62	0.32	5.89	0.18	34.538	0.27	26.9	8.14
	2D	100	0.23	0.11	0.14	3.49	0.22	6.90	0.45	7.15	0.18	34.539	0.18	26.9	8.15
	3S	200	0.09	0.06	0.25	3.30	0.21	5.16	0.30	5.47	0.15	34.583	0.24	26.8	8.15
	3D	200	0.16	0.08	0.25	3.30	0.22	6.12	0.38	6.45	0.14	34.679	0.29	26.8	8.18
	4S	500	0.10	BDL	0.14	2.20	0.19	5.19	0.29	5.33	0.10	34.775	0.23	26.7	8.19
	4D	500	0.13	0.08	0.11	2.20	0.20	5.84	0.33	6.03	0.10	34.776	0.16	26.7	8.19
DOH WATER QUAL. STDS.															
NOT TO EXCEED 10%				1.00	0.61				1.29	17.85	1.25		0.90		
NOT TO EXCEED 2%				1.78	1.07				1.93	25.00	2.00		1.75		

TABLE 4. Geometric means of water chemistry measurements off the Ewa Marina site collected in June and November, 1990 and April and August, 1991. Abbreviations as follows: TP = tidepool; S = surface; D = deep. Boxed values exceed DOH criteria for open coastal waters under "wet" conditions. Measurements below detection level were not included in mean calculations. For sampling station locations, see Figure 1.

STATION	NO.	DFS (m)	PO4 (µM)	NO3 (µM)	NH4 (µM)	SI (µM)	DOP (µM)	DON (µM)	TP (µM)	TN (µM)	TURB (ntu)	SAL (o/oo)	CHL a (µg/L)	TEMP. (deg C)	pH
EM-1-	TP	1	0.11	10.39	0.51	21.84	0.17	8.54	0.29	21.84	0.48	33.660	0.43	26.8	8.16
	1S	5	0.11	9.19	0.12	19.30	0.17	8.20	0.28	19.40	0.46	33.773	0.40	26.3	8.16
	1D	5	0.11	8.75	0.21	19.27	0.18	8.11	0.30	19.26	0.46	33.806	0.49	26.3	8.17
	2S	10	0.11	1.15	0.12	8.23	0.18	8.79	0.29	12.11	0.44	34.209	0.37	26.0	8.20
	2D	10	0.13	1.23	0.10	8.44	0.21	11.11	0.34	14.06	0.43	34.229	0.27	26.0	8.21
	3S	100	0.11	0.32	0.08	5.31	0.18	8.46	0.29	9.50	0.42	34.416	0.31	26.0	8.16
	3D	100	0.10	0.29	0.09	5.29	0.19	7.72	0.30	8.65	0.45	34.432	0.24	26.0	8.16
	4S	200	0.13	0.22	0.10	4.26	0.18	7.53	0.32	7.99	0.27	34.554	0.20	25.9	8.15
	4D	200	0.13	0.17	0.20	3.65	0.18	7.47	0.31	7.90	0.27	34.612	0.24	25.9	8.16
	5S	500	0.11	0.08	0.08	3.10	0.17	6.91	0.29	7.06	0.21	34.696	0.22	25.9	8.17
	5D	500	0.11	0.63	0.07	3.22	0.18	6.85	0.30	7.08	0.18	34.699	0.09	25.6	8.17
EM-2-	TP1	0.1	0.10	22.98	0.19	38.51	0.20	7.22	0.32	39.82	0.75	32.209	0.54	26.2	8.24
	TP2	1	0.07	17.22	0.21	31.51	0.20	6.30	0.28	31.04	0.59	32.683	0.30	26.1	8.25
	1S	5	0.06	10.50	0.16	23.60	0.18	7.93	0.25	22.45	0.56	33.262	0.50	26.0	8.28
	1D	5	0.05	7.42	0.13	18.52	0.19	8.05	0.25	17.65	0.53	33.531	0.35	26.0	8.28
	2S	10	0.10	0.51	0.14	6.38	0.17	7.49	0.27	8.78	0.45	34.330	0.24	25.8	8.23
	2D	10	0.09	0.46	0.15	5.73	0.17	6.89	0.27	7.94	0.43	34.348	0.15	25.8	8.23
	3S	100	0.10	0.28	0.19	6.02	0.20	7.61	0.30	8.76	0.34	34.379	0.25	25.6	8.16
	3D	100	0.11	0.46	0.13	5.88	0.19	7.32	0.30	8.69	0.38	34.376	0.21	25.7	8.17
	4S	200	0.11	0.11	0.12	3.82	0.18	7.01	0.29	7.19	0.24	34.597	0.16	25.6	8.16
	4D	200	0.12	0.10	0.09	3.66	0.17	7.38	0.29	7.64	0.27	34.598	0.20	25.6	8.16
	5S	500	0.10	0.11	0.06	2.81	0.18	6.83	0.29	7.09	0.16	34.729	0.15	25.7	8.17
	5D	500	0.13	0.15	0.12	2.58	0.21	7.84	0.35	8.19	0.15	34.750	0.15	25.7	8.18
EM-3-	TP1	0.1	0.11	8.40	0.12	44.93	0.17	9.11	0.29	22.58	0.72	32.681	0.65	26.3	8.14
	TP2	1	0.06	2.92	0.10	24.44	0.20	8.96	0.27	13.86	0.71	33.555	0.39	26.4	8.16
	1S	5	0.06	1.28	0.13	17.55	0.22	9.28	0.28	12.36	0.66	33.869	0.22	26.4	8.16
	2S	10	0.05	0.81	0.13	12.73	0.23	9.14	0.29	10.83	0.55	34.076	0.27	25.9	8.17
	3S	10	0.06	0.28	0.21	9.31	0.24	10.08	0.31	10.86	0.53	34.273	0.40	25.8	8.17
	4S	100	0.08	0.21	0.18	6.53	0.22	8.71	0.30	9.24	0.49	34.362	0.24	25.8	8.16
	4D	100	0.08	0.26	0.16	6.98	0.25	9.20	0.34	9.76	0.49	34.358	0.27	25.8	8.17
	5S	200	0.10	0.20	0.15	4.72	0.22	7.94	0.32	8.46	0.29	34.504	0.19	25.7	8.15
	5D	200	0.10	0.20	0.22	4.38	0.22	8.34	0.33	8.87	0.27	34.554	0.21	25.7	8.16
	6S	500	0.11	0.07	0.12	2.39	0.20	7.58	0.32	7.78	0.18	34.748	0.17	25.8	8.18
	6D	500	0.11	0.08	0.15	2.52	0.22	8.18	0.33	8.47	0.18	34.742	0.11	25.9	8.18
DOH WATER QUAL. STDS.				0.36	0.25				0.64	10.71	0.50		0.30		

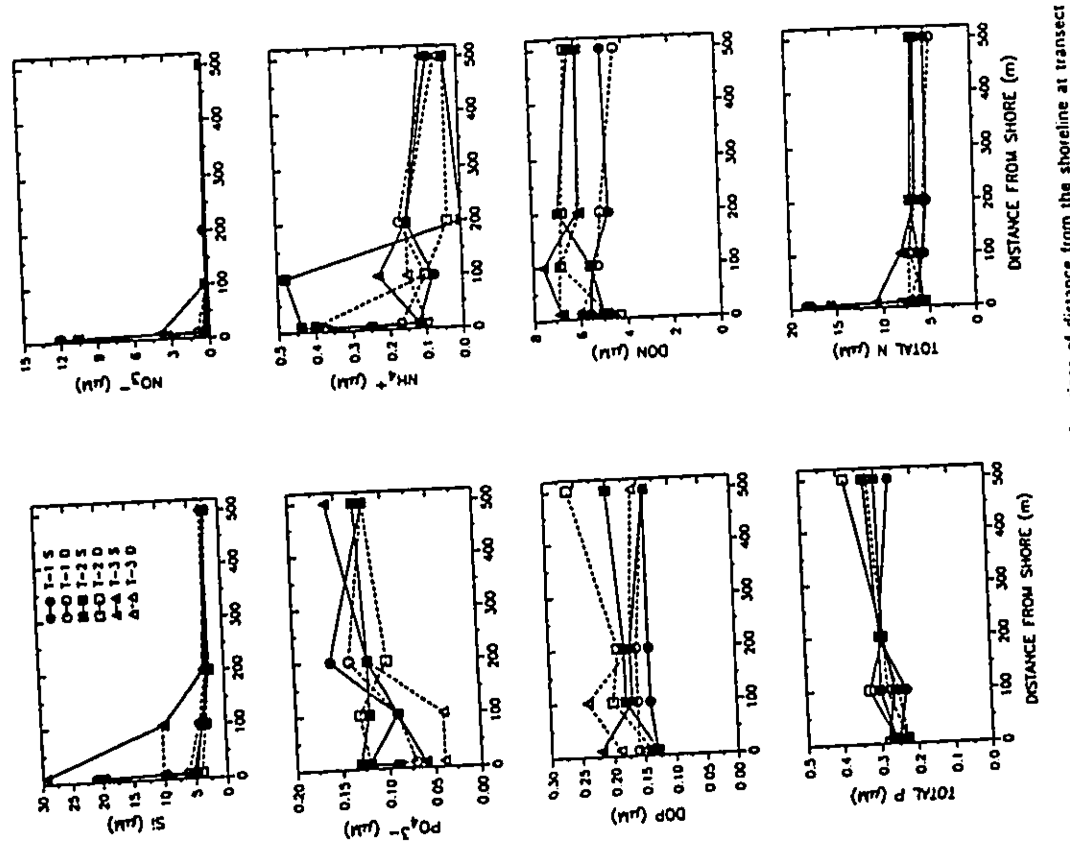

FIGURE 2. Plots of dissolved nutrients as functions of distance from the shoreline at transect stations T-1, T-2, and T-3 collected in November 1990. For station locations, see Figure 1.

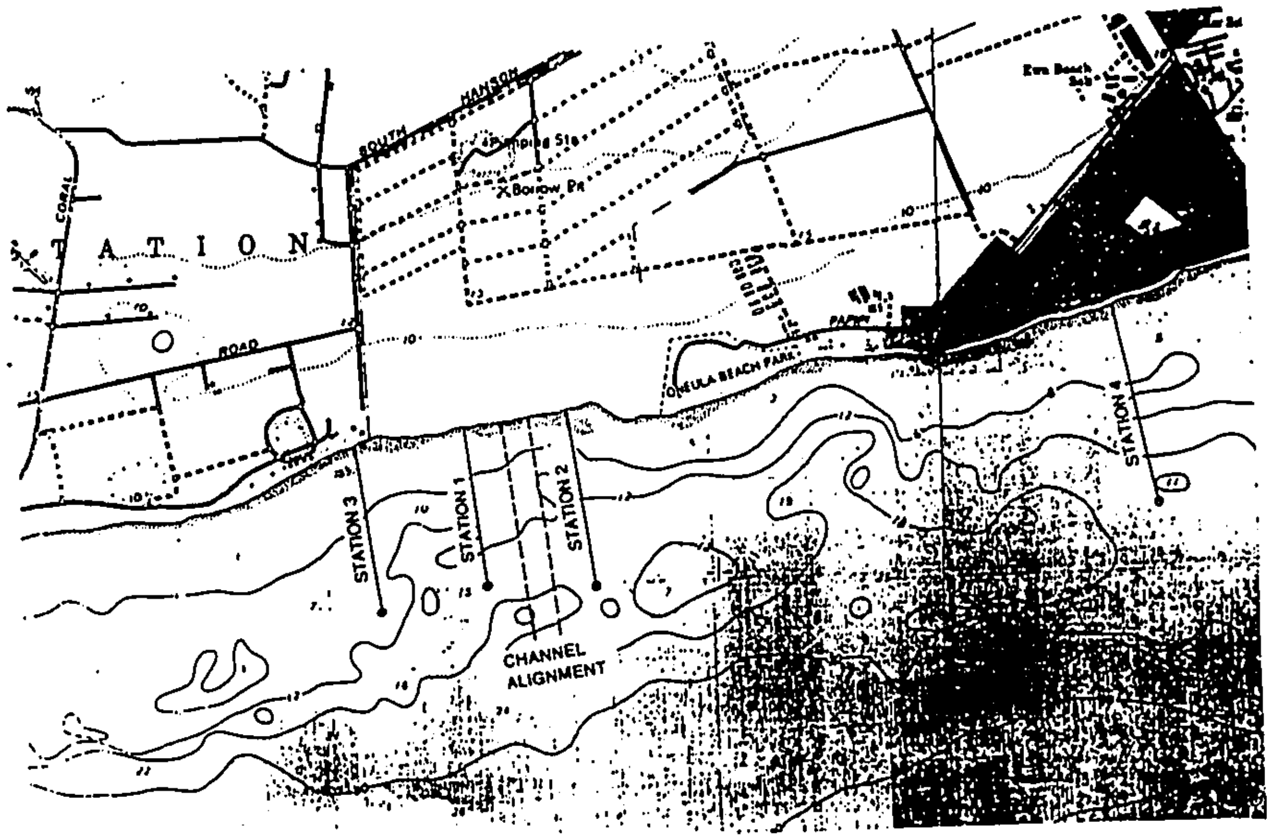

FIGURE 1. Map of shoreline of southwest Oahu showing location of proposed Ewa Marina Channel and four water chemistry sampling stations

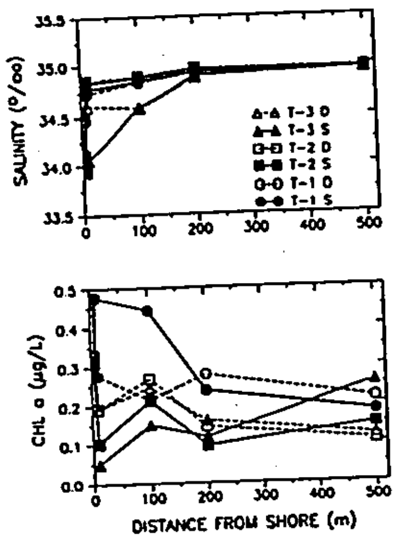

FIGURE 3. Plots of water chemistry constituents as functions of distance from the shoreline at transect stations T-1, T-2, and T-3 collected in November 1990. For station locations, see Figure 1.

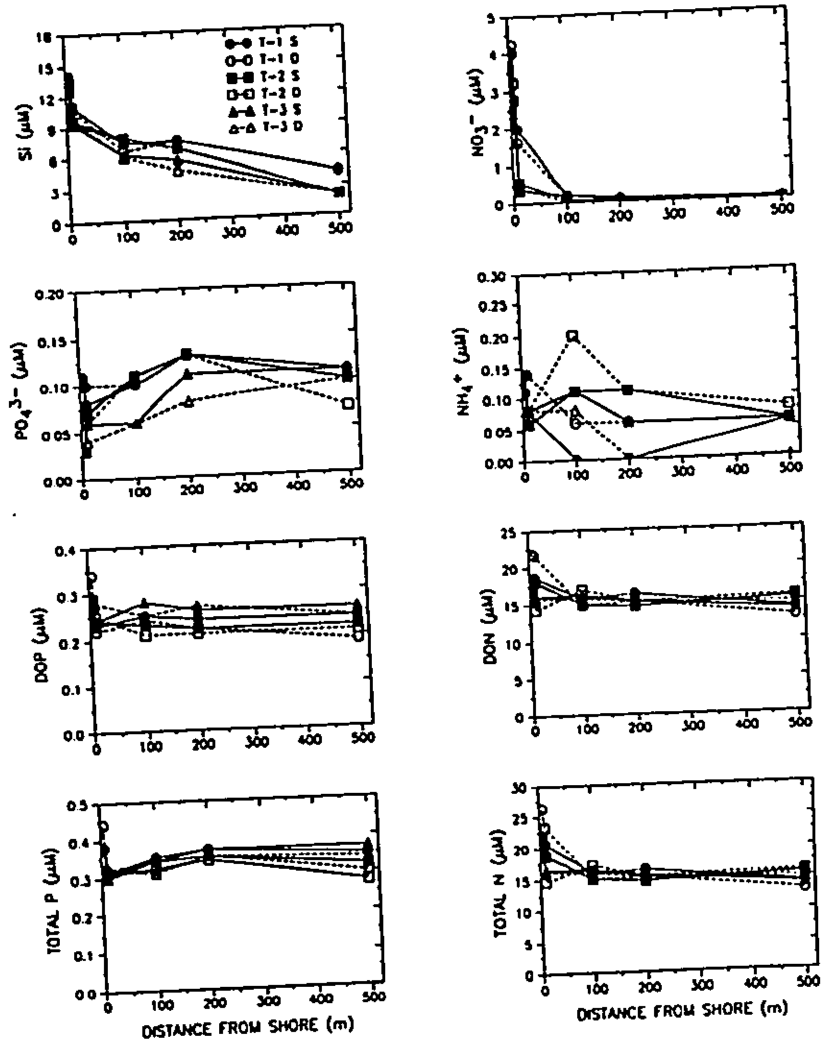

FIGURE 4. Plots of dissolved nutrients as functions of distance from the shoreline at transect stations T-1, T-2, and T-3 collected in April 1991. For station locations, see Figure 1.

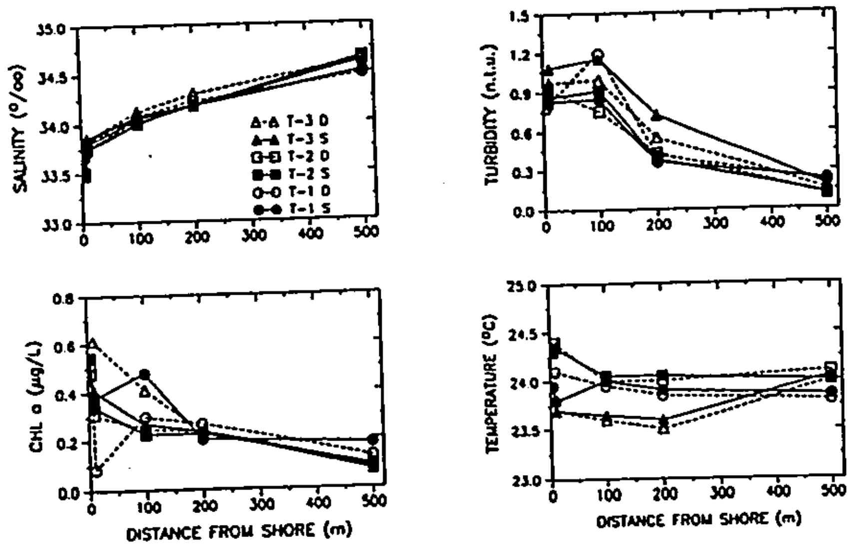

FIGURE 5. Plots of water chemistry constituents as functions of distance from the shoreline at transect stations T-1, T-2, and T-3 collected in April 1991. For station locations, see Figure 1.

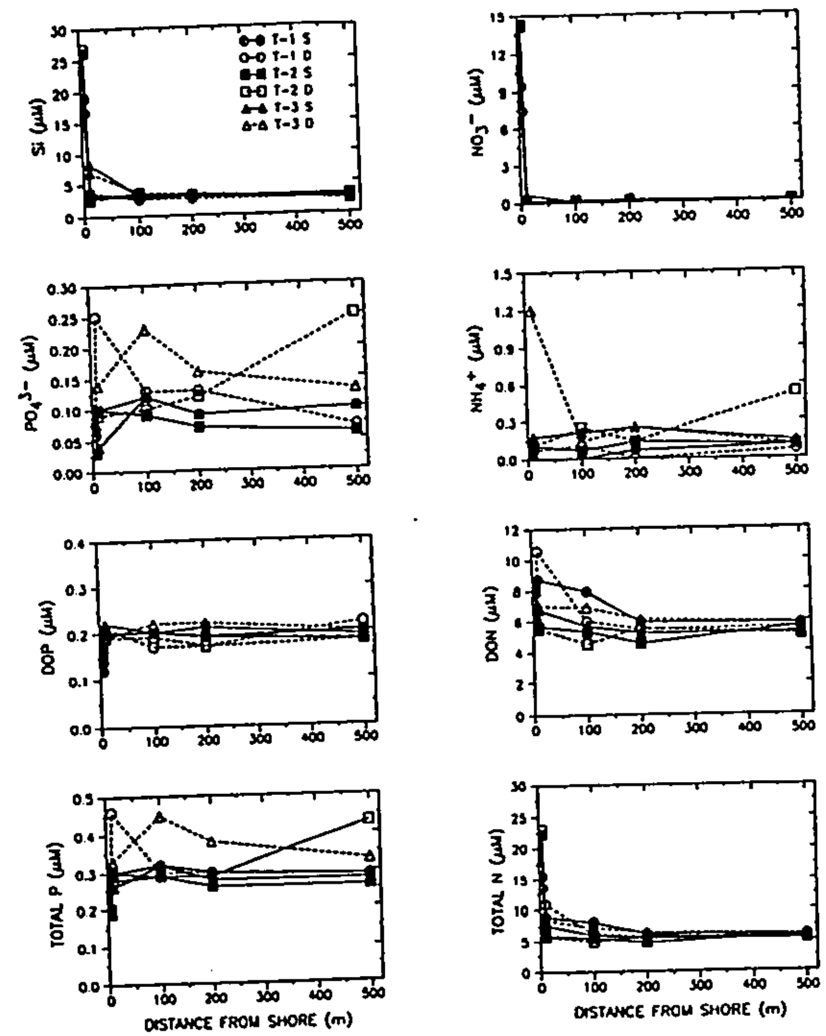

FIGURE 6. Plots of dissolved nutrients as functions of distance from the shoreline at transect stations T-1, T-2, and T-3 collected in August 1991. For station locations, see Figure 1.

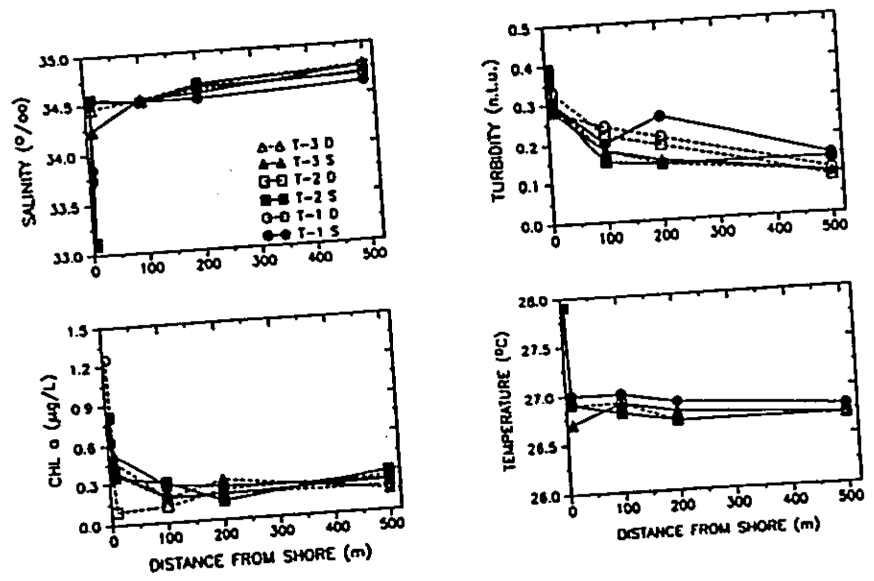

FIGURE 7. Plots of water chemistry constituents as functions of distance from the shoreline at transect stations T-1, T-2, and T-3 collected in August 1991. For station locations, see Figure 1.

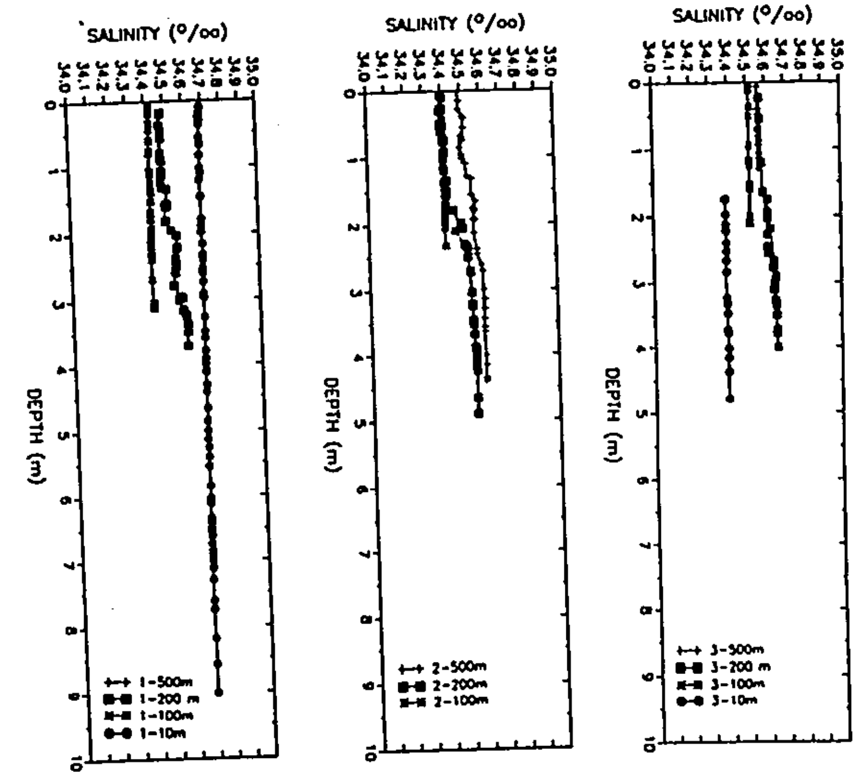

FIGURE 8. Vertical profiles of salinity at sampling sites 5 to 500 m from shore at Stations 1, 2 and 3. For station locations, see Figure 1.

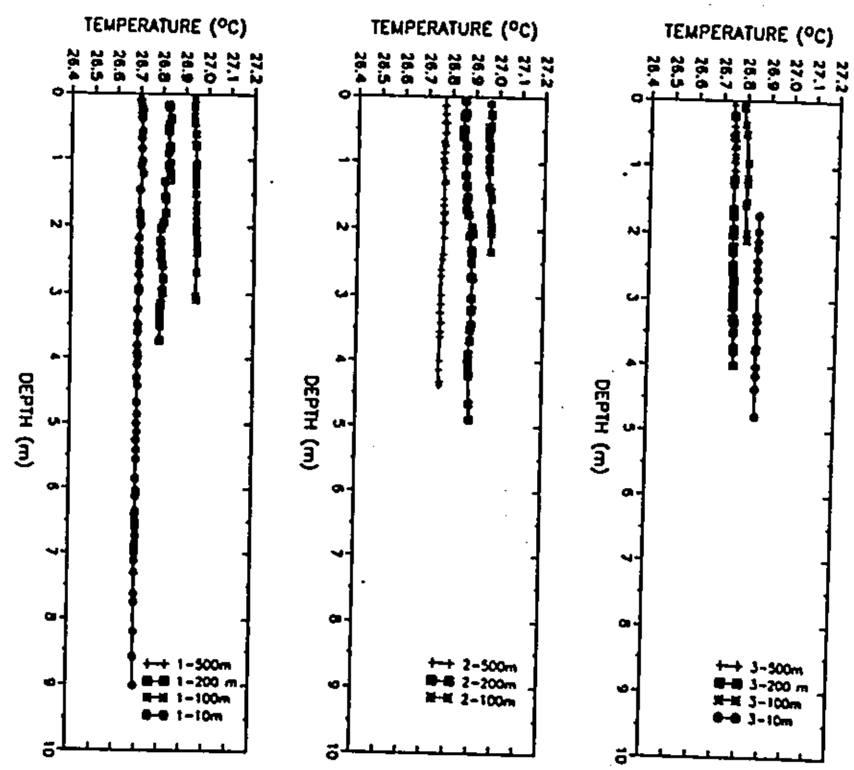

FIGURE 9. Vertical profiles of temperature at sampling sites 5 to 500 m from shore at Stations 1, 2 and 3. For station locations, see Figure 1.

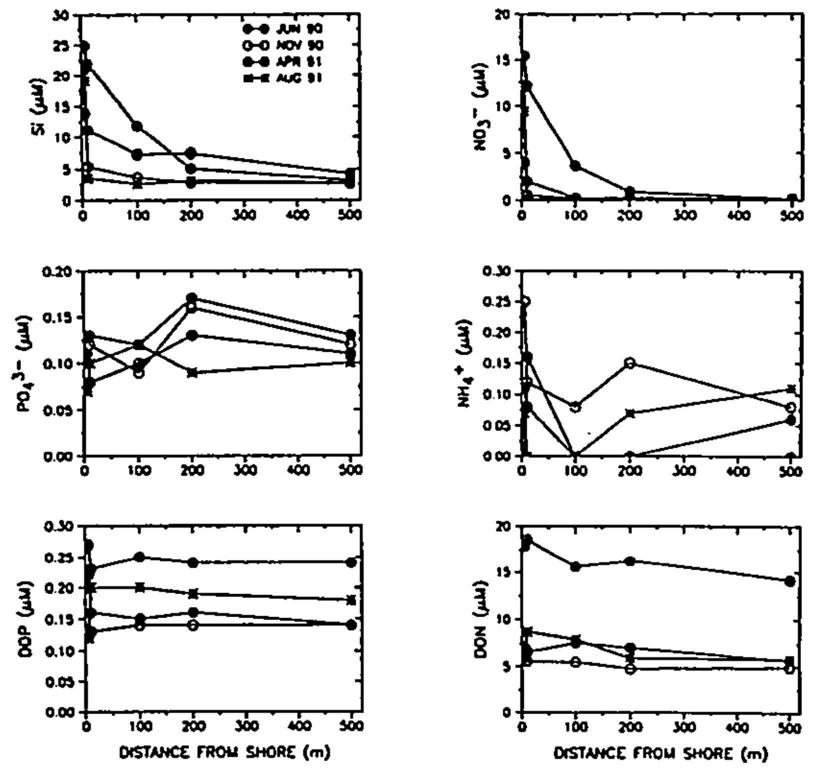

FIGURE 10. Plots of surface water dissolved nutrients as functions of distance from the shoreline at Station 1 during the four monitoring surveys in June and November 1990 and April and August 1991.

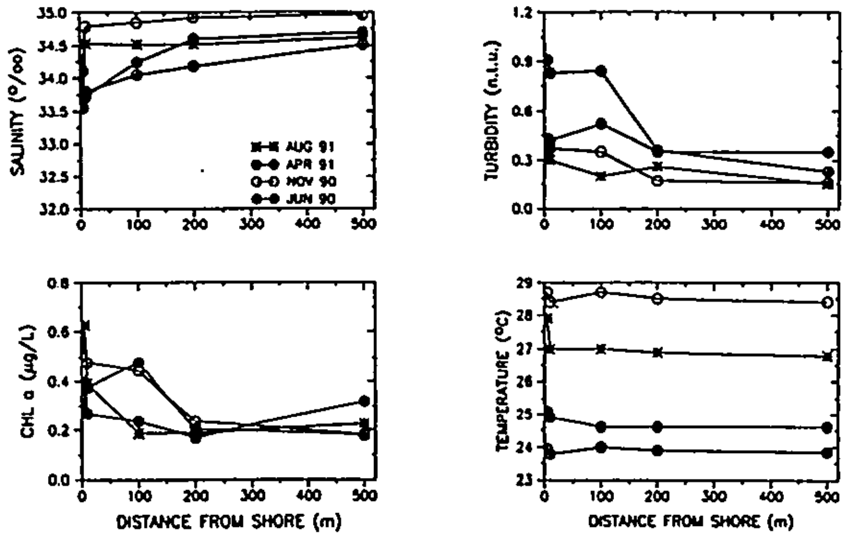

FIGURE 11. Plots of surface water chemistry constituents as functions of distance from the shoreline at Station 1 during the four monitoring surveys in June and November 1990 and April and August 1991.

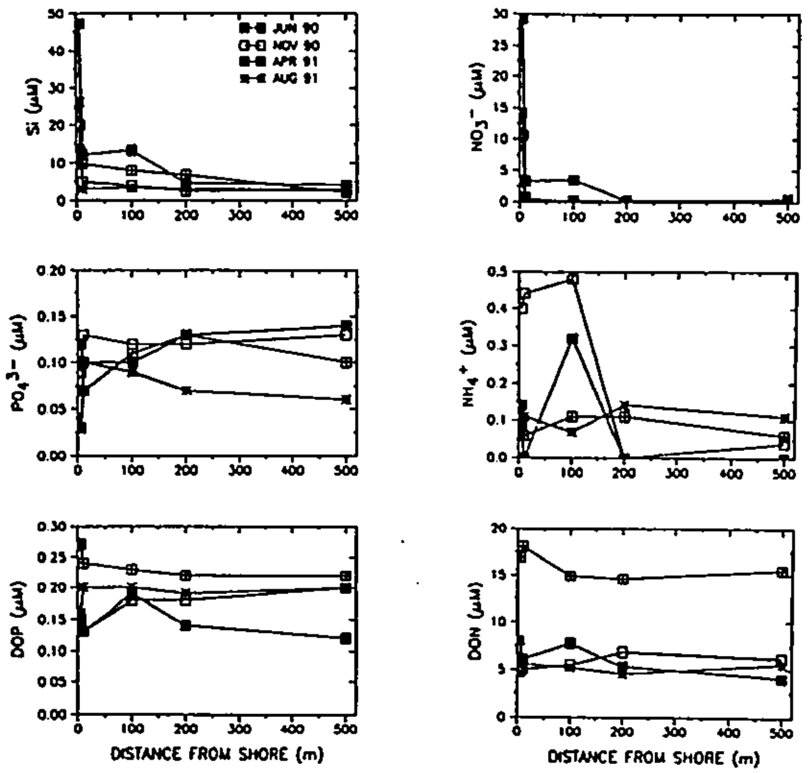

FIGURE 12. Plots of surface water dissolved nutrients as functions of distance from the shoreline at Station 2 during the four monitoring surveys in June and November 1990 and April and August 1991.

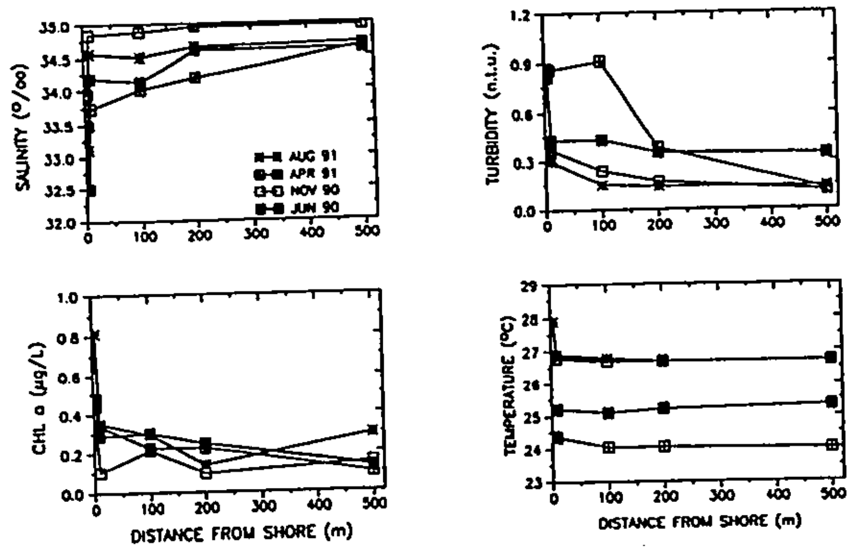

FIGURE 13. Plots of surface water chemistry constituents as functions of distance from the shoreline at Station 2 during the four monitoring surveys in June and November 1990 and April and August 1991.

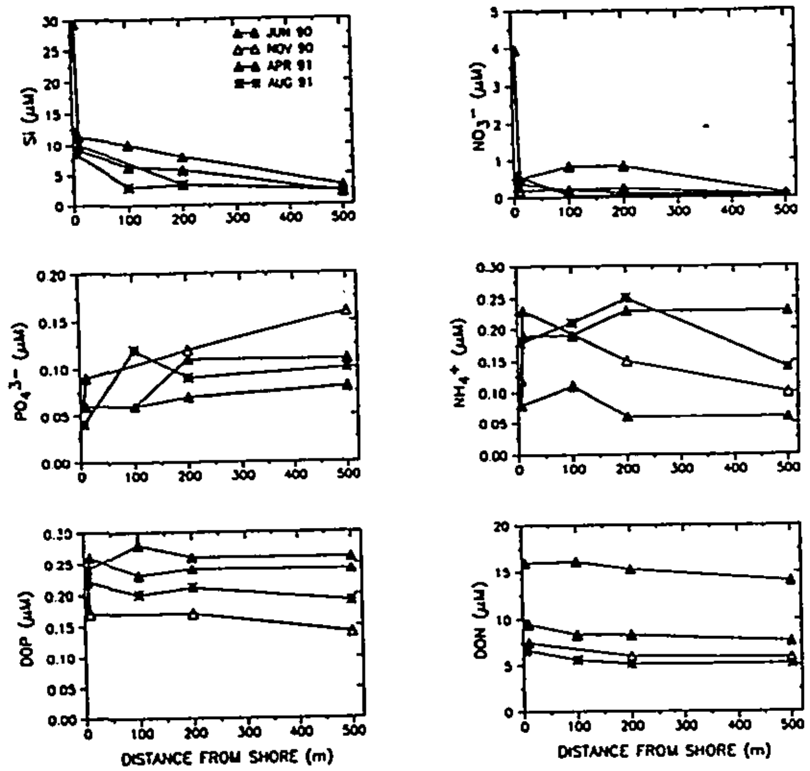

FIGURE 14. Plots of surface water dissolved nutrients as functions of distance from the shoreline at Station 3 during the four monitoring surveys in June and November 1990 and April and August 1991.

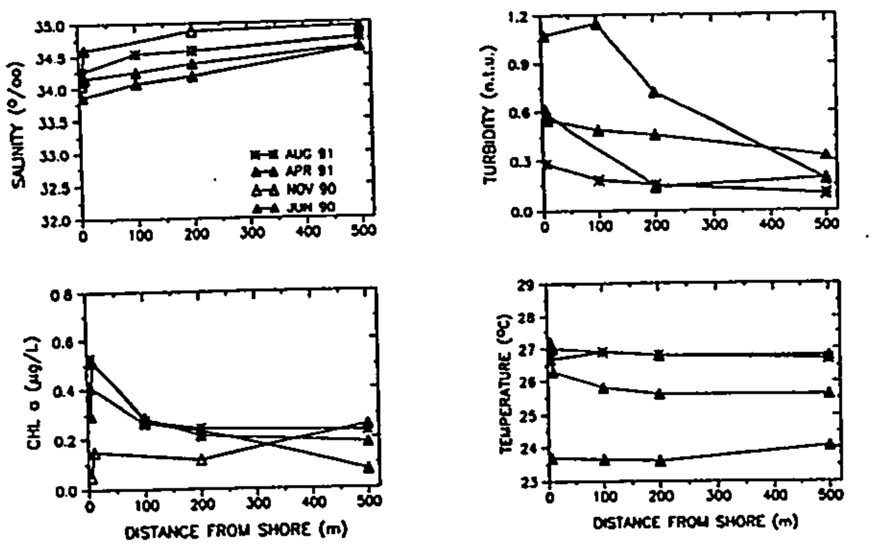

FIGURE 15. Plots of surface water chemistry constituents as functions of distance from the shoreline at Station 3 during the four monitoring surveys in June and November 1990 and April and August 1991.

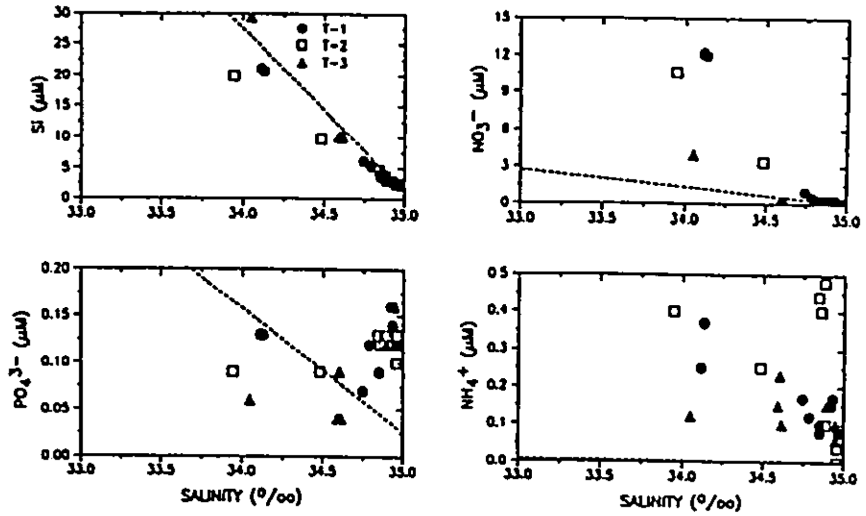

FIGURE 16. Mixing diagram showing concentration of dissolved nutrients as functions of salinity for samples collected in November 1990. Dashed line is conservative mixing line constructed by connecting endmember concentrations of well water and open coastal water.

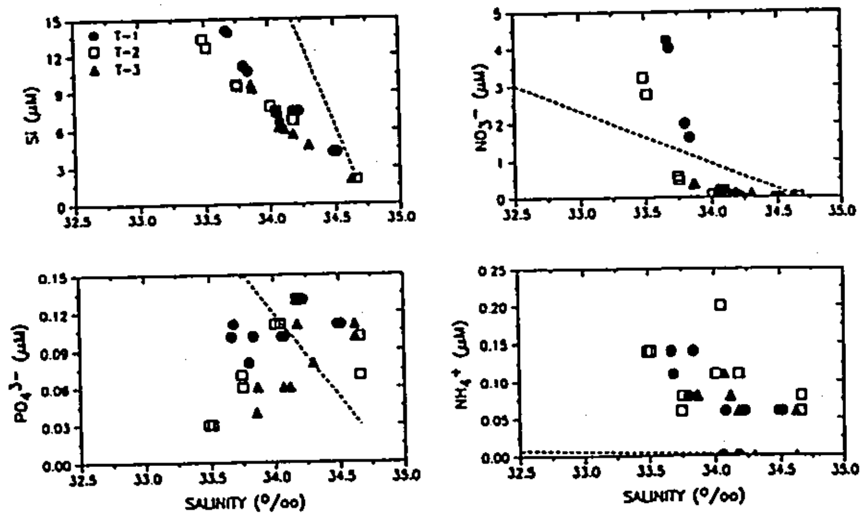

FIGURE 17. Mixing diagram showing concentration of dissolved nutrients as functions of salinity for samples collected in April 1991. Dashed line is conservative mixing line constructed by connecting endmember concentrations of well water and open coastal water.

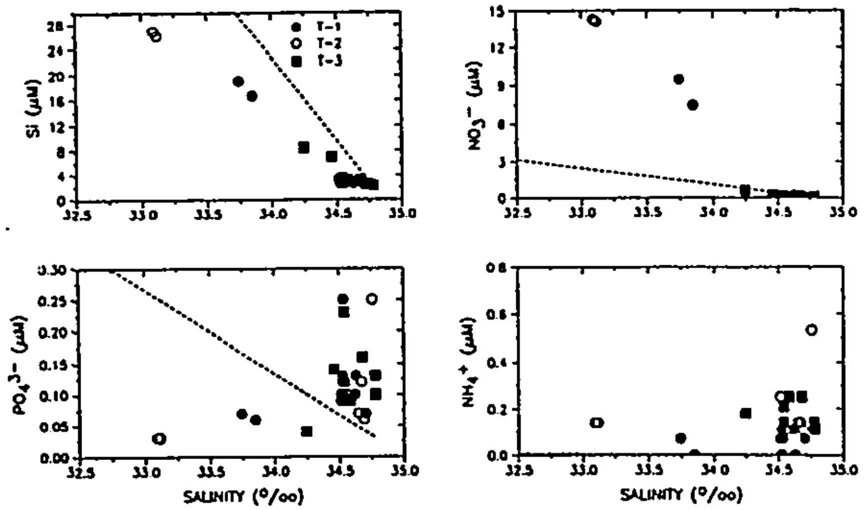

FIGURE 18. Mixing diagram showing concentration of dissolved nutrients as functions of salinity for samples collected in August 1991. Dashed line is conservative mixing line constructed by connecting endmember concentrations of well water and open coastal water.

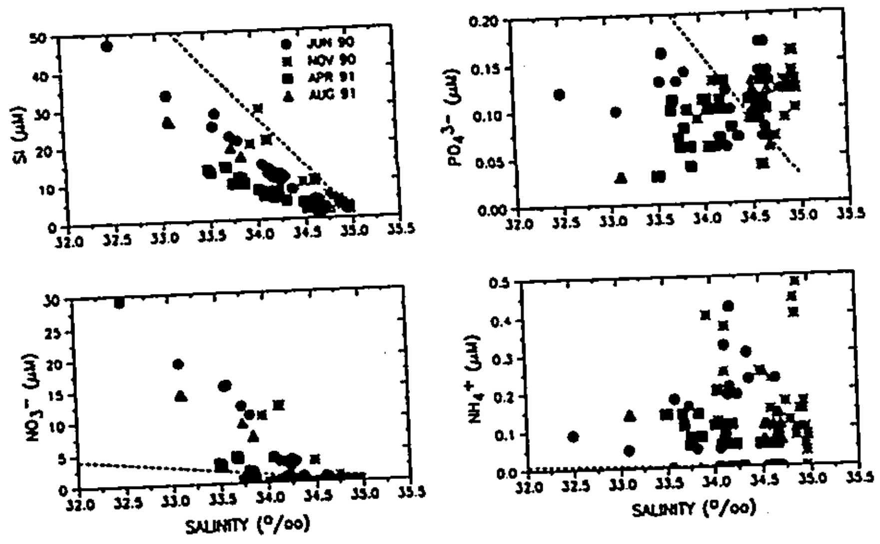

FIGURE 19. Mixing diagram showing concentration of dissolved nutrients as functions of salinity for samples collected during four monitoring surveys in June and November 1990 and April and August 1991. Dashed line is conservative mixing line constructed by connecting endmember concentrations of well water and open coastal water.

Appendix G

Ewa Marina Evaluation of Project Impacts on Adjacent Beaches

EWA MARINA
EVALUATION OF PROJECT IMPACTS ON ADJACENT BEACHES

Prepared for

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File 2612-04

November 8, 1990

EXECUTIVE SUMMARY

The proposed Ewa Marina project is located along the southern coast of Oahu, immediately west of the existing community of Ewa Beach. It involves the construction of approximately 140 acres of inland waterways connected to the ocean by a dredge channel. The proposed channel would be located approximately 1,500 feet east of the eastern boundary of Barbers Point Naval Air Station.

This report describes the results of detailed analysis of the effects that the construction and maintenance of the proposed entrance channel are likely to have on littoral processes, including sand movement and beach stability. It includes a summary of previous studies and site visits that were conducted to collect background data, a description of historical shoreline changes based upon a study of archived aerial photographs, an analysis of the theoretical longshore sand transport potential based upon wave analyses, an evaluation of the effects that channel and jetty construction are likely to have, and recommended mitigation measures.

Results of the analyses indicate the following:

- With one exception, there has been no long-term trend of shoreline erosion or accretion between Barbers Point and Pearl Harbor over the last 37 years. The exception is at Keahi Point, immediately adjacent to the Pearl Harbor entrance channel; there, the shoreline appears to have been eroding more or less continuously since the first available aerial photographs were taken in 1928.

- Beaches in the vicinity of the Ewa Marina project are characterized as belonging to a beach and sand channel system that is in long-term equilibrium. There is appreciable onshore and offshore sand transport inside the barrier reefs, while longshore movement of sand is of secondary importance.

- The limited amount of sand present in the beach cells, the position of the sand in the upper part of the littoral zone, and the presence of many small littoral barriers limit the longshore movement of sand. As a result, the actual predominant east-to-west littoral sand movement appears to be only about one-tenth the amount that could be moved by the available wave energy.

- Longshore sand transport is particularly limited in the reach of shoreline in which the proposed entrance channel is located. Most of the sand movement that is experienced probably occurs infrequently primarily during severe northeast tradewind events and storms.

- Adverse effects on nearby beaches as a result of the project can be largely or completely avoided if the sand accumulating in the jetty fillets and channel is bypassed whenever a significant buildup occurs. This will ensure that downcoast beaches continue to be nourished.

CONTENTS

1.0 INTRODUCTION

1.1 Background

HASEKO (Hawaii), Inc. has proposed a marina development as part of the Ewa Marina project. The marina would require jetties and a channel to form the entrance to the proposed marina. One of the critical considerations in the feasibility analysis of the marina is the littoral processes that may impact and be impacted by a navigable entrance at this location. This study of the littoral processes and shoreline history has been prepared to assess these impacts.

1.2 Purpose

This purpose of this study was to describe the littoral processes and historic shoreline positions in the vicinity of Ewa Beach and to evaluate the potential impacts on adjacent beaches associated with the project. Sand bypassing and management programs were investigated as mitigation measures for potential impacts.

1.3 Scope

The following summarizes the Scope of Work conducted for study:

1. Summarize site conditions based upon available data.
2. Review existing littoral processes literature and shoreline history data.
3. Conduct site visits to observe shoreline conditions.
4. Develop shoreline history through analyses of aerial photographs.
5. Analyze the potential for longshore transport of sediment in the project vicinity.

6. Determine potential impacts of proposed marina entrance and structures on adjacent shorelines.
7. Investigate mitigation measures for adverse impacts.
8. Prepare and submit a report of findings.

2.0 PROJECT DESCRIPTION

The proposed Ewa Marina project is shown in Figure 2-1. Since the project site is not afforded the protection provided by the shallow reefs typically found at other Hawaiian marinas, special consideration in this study was given to navigation safety and mitigating wave conditions within the harbor. The proposed marina entrance channel would be 400 feet wide and approximately 2,900 feet long. The channel width was determined based upon considerations of navigational safety and vessel traffic. The seaward limit of the entrance channel extends to the 20-foot depth contour to reduce the probability of waves breaking in the channel and to allow passage of boats during periods of large swell.

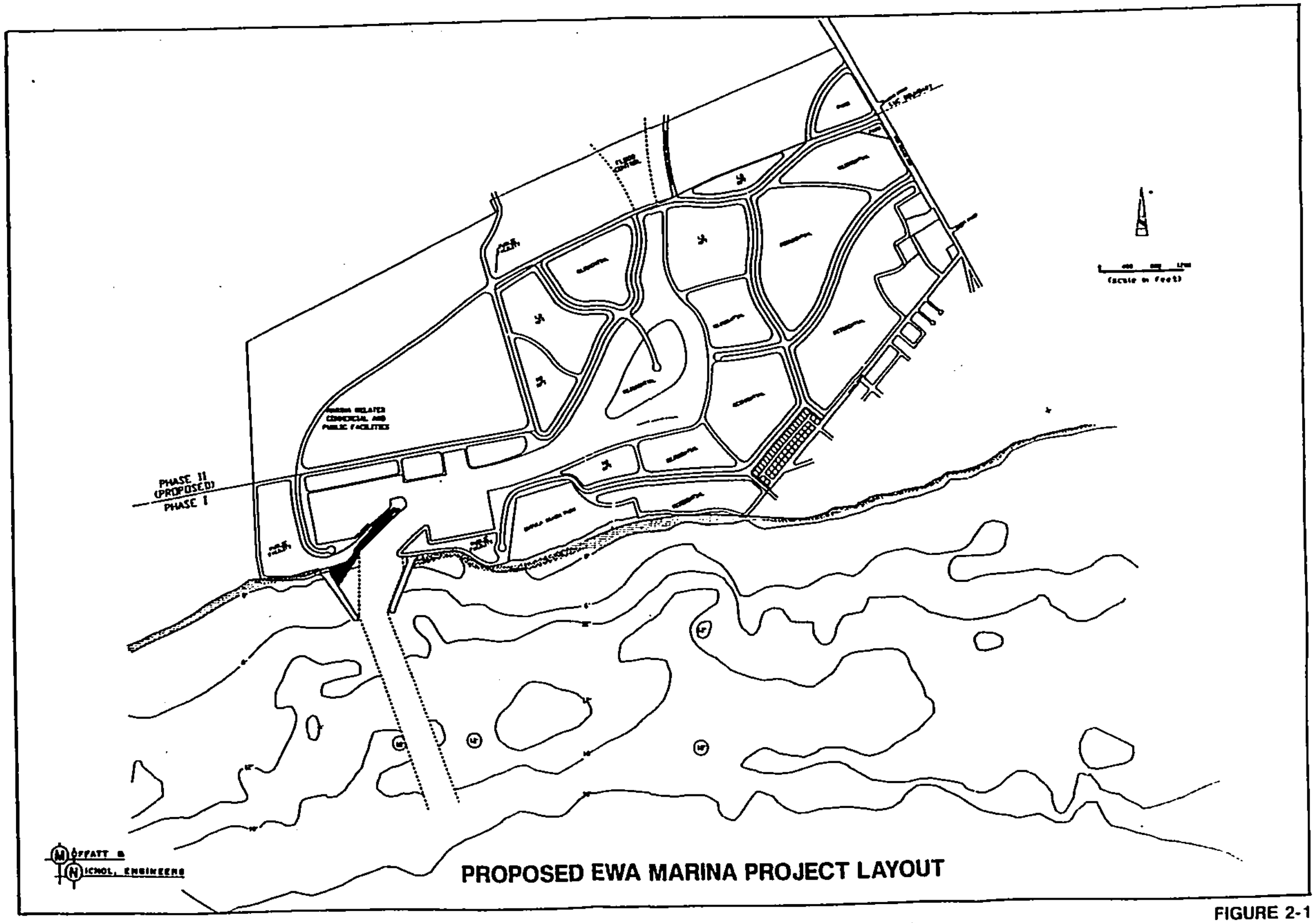
The rock jetties constructed along the entrance channel would serve three main purposes:

1. To protect the marina basin from waves: The jetties act as breakwaters to attenuate waves to acceptable levels before they reach the interior marina basins.

2. To prevent wave-induced longshore currents from creating a navigation hazard: The jetties provide a barrier to cross-channel rip currents that may be created by waves breaking over adjacent reefs.

3. To prevent littoral drift from shoaling the channel: The jetties act as barriers to littoral drift that would otherwise be deposited in the navigation channel thereby causing a navigational hazard and temporary loss of beach sand.

The jetties would be approximately 700 feet long, extending offshore to the 10 foot depth contour. The proposed jetty cross section is shown in Figure 2-2. Detailed wave analyses will be used to determine the final jetty design and configuration. The jetty section was designed using procedures described in the Shore Protection Manual (U.S. Army Corps of Engineers, 1984). The side slope and armor-stone size were designed so that the structure will resist the expected wave action. The porous side slopes tend to absorb, rather than reflect, wave energy. A concrete cap may be added to the jetty design in order to provide surf site access from the jetties.



PROPOSED EWA MARINA PROJECT LAYOUT

FIGURE 2-1

3.0 SITE CONDITIONS

3.1 Site Description

The coastline between Pearl Harbor and Barbers Point comprises a series of small pocket beaches separated by reaches of beachrock along the shoreline. A regional map is shown in Figure 3-1. The proposed marina entrance channel is located approximately 2,000 feet west of the west boundary of Oneula Beach Park and approximately 2,000 feet east of the eastern extent of White Plains Beach, as illustrated on the vicinity map shown in Figure 3-2.

The coastal area investigated for this littoral processes study is that area from Pearl Harbor west to Barbers Point. The shape of the coastline and the presence of offshore reefs in this area strongly affect the wave and current conditions, which in turn affect the littoral processes in the study area.

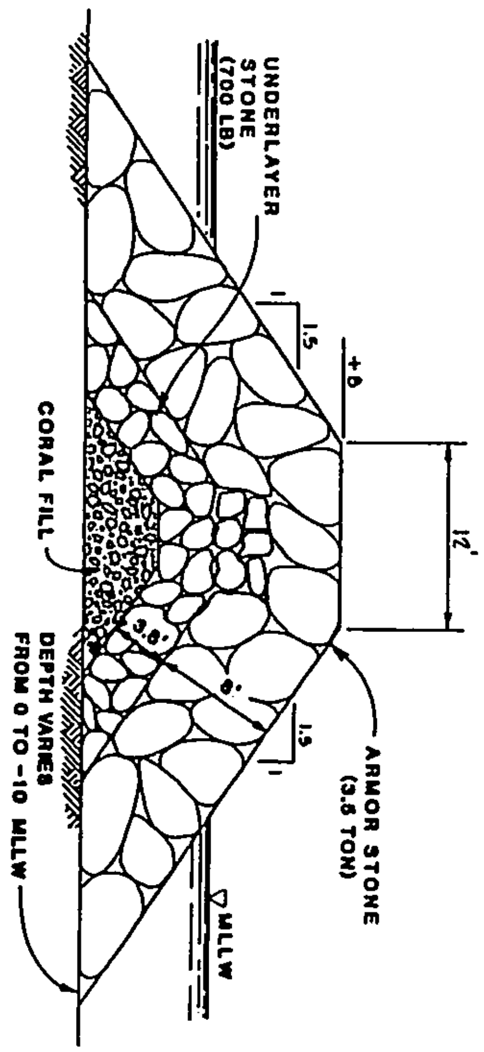
3.2 Bathymetry

A coral-algae reef slopes gently offshore into deeper water. Figure 3-3 shows a beach profile located approximately at the proposed entrance channel centerline. The reef drops more rapidly into deep water than do otherwise similar reefs found at Kaneohe and Ala Moana. The reef is interspersed with shallow, sand-filled channels and pockets.

3.3 Tides

Tides in Hawaii are semidiurnal with a diurnal inequality. The average tidal range in Honolulu Harbor (the nearest tide gage station) is 1.9 feet, with a mean sea level 0.81 feet above mean lower low water (MLLW). The maximum annual tidal range is approximately 3 feet, with the highest recorded tide 3.2 feet above MLLW.

Water level fluctuations can also be produced by storm surge and wave setup. Storm surge due to wind stress and barometric pressure reduction is a



TYPICAL JETTY SECTION

FIGURE 2-2

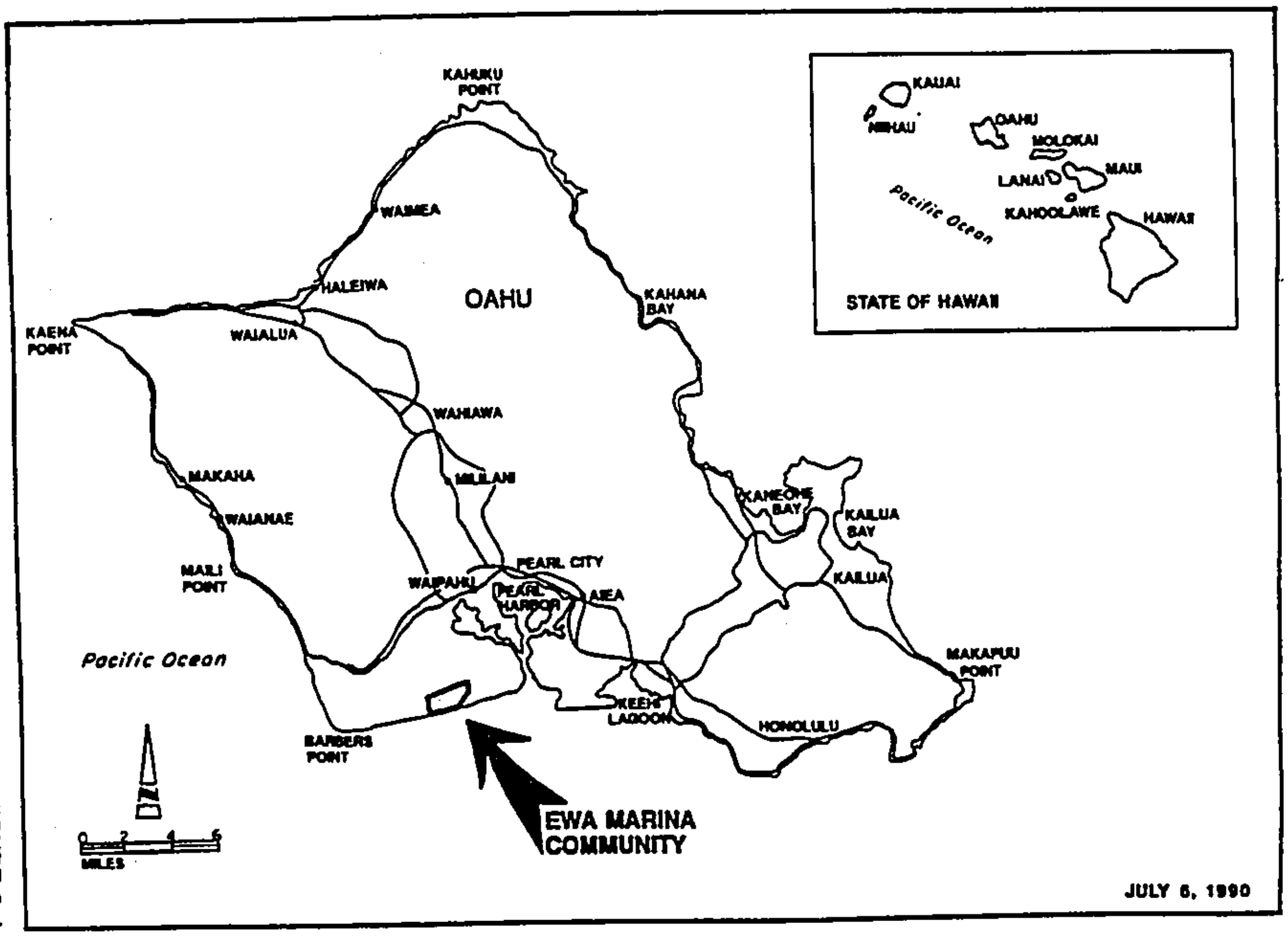
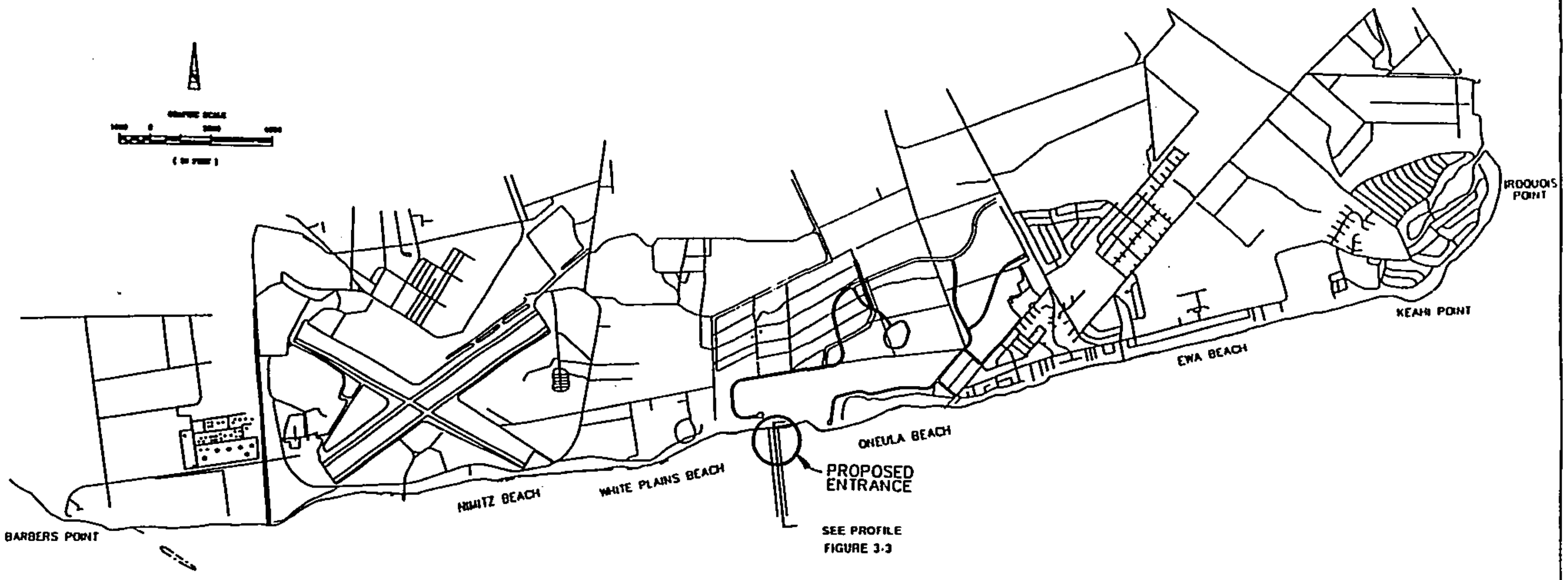


FIGURE 3-1

LOCATION MAP



VICINITY MAP

MOFFATT & NICHOL, ENGINEERS

FIGURE 3-2

relatively minor factor in Hawaiian waters, with a value of less than 1 foot for extreme events. Wave setup due to the decay of breaking waves contributes to water level fluctuations near the beach. Wave setup may be on the order of 10 percent of the breaking wave height.

3.4 Wind Climate

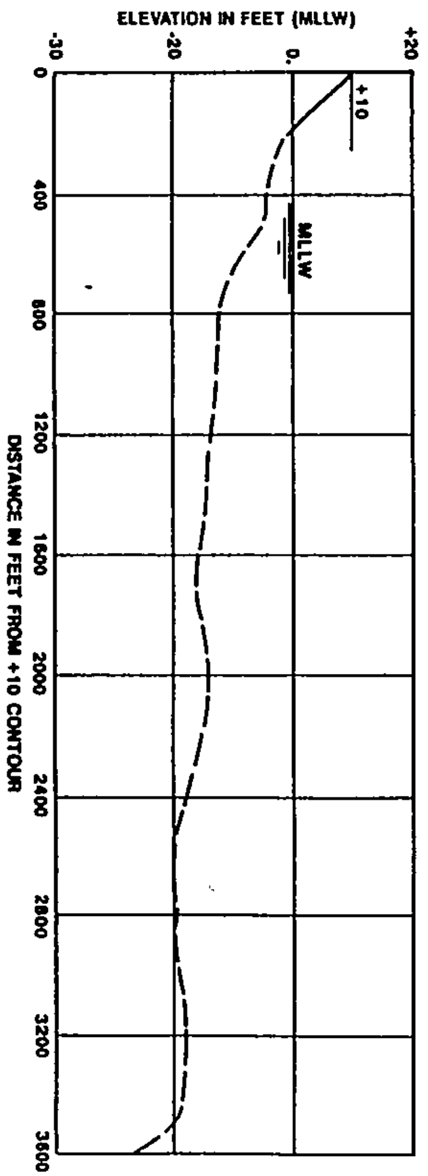
Open-ocean winds in the vicinity of the Hawaiian Islands are dominated by northeast tradewinds. Figure 3-4 shows a wind rose developed from surface wind measurement summaries obtained from Hickham Air Force Base for the period 1974 to 1983. The wind data indicate that the prevailing wind direction at the site is east-northeast, occurring approximately 40 percent of the time with a mean wind speed of 11 knots. Winds from the north to east quadrant occur approximately 75 percent of the time. Southerly Kona winds and calms occur the remainder of the time.

The project site is in the lee of the Koolau mountain range during trade wind conditions. The winter season is characterized by a weakening of the northeast tradewinds. This weakening results in a change in climatic conditions, wherein southwesterly Kona winds may be characterized by light and variable winds for a couple of days or there may be an occasional Kona storm. Kona storms have high winds; however, they occur infrequently.

3.5 Wave Conditions

The natural characteristics and behavior of Hawaiian beaches are closely associated with wave climate and exposure. Waves approaching the islands may be represented by the following general types (Marine Advisers, Inc., 1964):

1. Northeast Trade Waves - These waves are generated by the northeasterly tradewinds that prevail approximately 75 percent of the year. Northeast trade waves are characterized in deep water by wave heights of up to 20 feet and periods ranging from 5 to 12 seconds. They occur most frequently and are the largest during the months from April through November.



PROFILE - EWA/ONEULA SHORELINE
AT PROPOSED CHANNEL CENTERLINE
(FROM NOAA CHART NO. 19362)

FIGURE 3-3

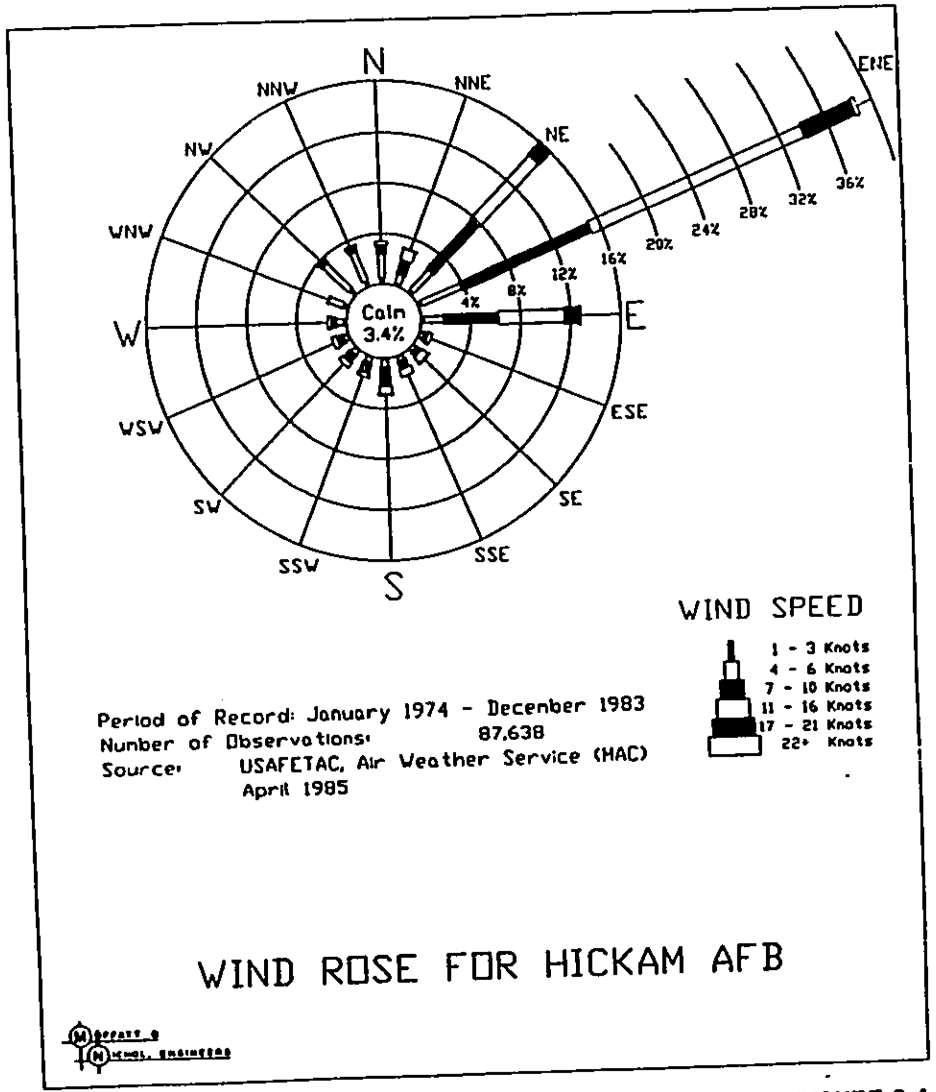


FIGURE 3-4

2. Kona Storm Waves - During the winter season, Kona winds generate waves from the south through southwest with characteristics similar to those of trade waves. Kona conditions occur most frequently from November through April. Infrequently, a Kona storm associated with a large low-pressure system generates large storm waves from the southwest.

3. North Pacific Swell - The North Pacific swell, for which the large surf on the north and northwest coasts in Hawaii has become famous, is due to the waves generated from North Pacific extra-tropical cyclones. These large waves have heights in excess of 20 feet and periods ranging from 10 to 15 seconds. The North Pacific cyclones travel eastward and generate waves that approach the northwestern exposed shores of the islands. These waves are most likely to occur from October through April.

4. Southern Hemisphere Swell - This swell is generated in the South Pacific Ocean and the Indian Ocean. Large, extra-tropical storms generate waves and swell that travel 5,000 miles with breaking wave heights ranging up to 10 to 15 feet annually. The wave heights in deep water are 3 to 6 feet, with 14 to 18 second periods. These waves are generally characterized by rather long wave lengths, and distinct wave groups, and they are independent of the local wind system.

5. Local Storms and Hurricanes - Local storms and hurricanes are infrequent. Tropical storms generated off the coast of Mexico move westward through the equatorial region and occasionally deflect northward toward the Hawaiian Islands. Hurricane Iwa in November 1982, Hurricane Dot in August 1959, and Hurricane Nina in December 1957 are the major hurricanes that have caused damage to the Hawaiian shoreline in the past 40 years.

The project site is located on the leeward side of Oahu, on a shoreline with an average azimuth of about 75 degrees. The project site is directly exposed to waves generated from the and east clockwise through 240 degrees. Diamond

Head partially protects the site from northeasterly trade waves; however, waves with easterly components can reach the site. Direct wave attack on this beach occurs occasionally; e.g., direct attack occurs during Kona storms or with a Southern Hemisphere swell. As a result, waves at the project site and adjacent beaches are generally mild. The site does, however, have a greater exposure to tradewind waves than Waikiki.

Because of the complex bathymetry of the offshore reef, a wave refraction analysis was performed to determine directions of predominant wave attack relative to shoreline orientation (Moffatt & Nichol, 1986). The results were used for the analysis of potential longshore sediment transport described in Section 4.3.4. Wave refraction diagrams were prepared by using bathymetry from NOAA Chart No. 19362 and transferring wave crest positions to a detailed local bathymetry taken from a survey by M&E Pacific (1984). The diagrams are included in Appendix A. Wave refraction computations were performed using a numerical model employing linear wave theory described by Headland (1983). The entrance channel shown on the diagrams is located at the rocky headland at the west end of Oneula Beach; the currently proposed entrance channel is located approximately 1,000 feet to the west of this location, at the extreme left side of the nearshore wave refraction diagrams. The wave refraction diagrams include azimuths from 135 degrees to 225 degrees, and wave periods from 6 to 16 seconds.

3.6 Currents

In the nearshore littoral zone, rip currents can have a pronounced effect on sediment transport. Rip currents are often found near boundaries of surfing sites (Walker, 1974). As waves break over the reef, a mass transport of water is directed toward shore and exits adjacent to the surf zone by rip currents. These rip currents can transport sand into deep water or into sand pockets on the reef for temporary deposition (Moberly and Chamberlain, 1964). At some locations, there exist currents that transport material shoreward. Results of a study of the Halekulani Channel near Waikiki Beach were discussed by Gerritsen (1972). It was observed that net littoral transport was shoreward in the Halekulani Channel. A main rip current was found to exist off the Royal Hawaiian Hotel, carrying large amounts of material offshore. Littoral

currents and rip currents contribute to sediment motion and formation of the littoral cell in the project area.

Other current types of currents such as geostophic, wind drift, and tidal, also may exist in the project area. However, these currents are of very small magnitude in the nearshore zone and will generally have little impact on littoral processes.

A current measurement program was performed to investigate longshore currents in the vicinity of the proposed entrance channel; primarily, the program was implemented to investigate potential navigational impacts due to long shoreward currents. However, the data can also provide useful information regarding the potential for longshore littoral transport. An InterOceans S-4 Current Meter was deployed on August 6, 1990, in a water depth of about 14 feet MLLW along the proposed entrance channel alignment. The meter was retrieved on September 10, 1990. Typical tradewind conditions persisted throughout this period of time with 1 to 4 foot surf on south shore beaches. Table 3-1 summarizes current measurement statistics gathered during the program.

TABLE 3-1
CURRENT MEASUREMENT SUMMARY

Total number of observations	2,441	
Mean current speed	4.00	cm/sec
Standard deviation	2.55	cm/sec
Maximum current speed	14.00	cm/sec
Minimum current speed	0.00	cm/sec

[1]cm/sec = centimeters per second

The results indicate that the current speeds at the site during the period relatively low, with a maximum measured current speed of approximately 0.25 knot.

4.0 LITTORAL PROCESSES

4.1 Description of Littoral System

Approximately 50 percent of the shoreline between Pearl Harbor and Barbers Point has a beach; the remaining shoreline is beachrock. A coral-algae reef slopes gently offshore to deeper water. The average reef width is about 3,000 feet. The beaches comprise a medium-grain size, calcareous sand, are typically 50 to 100 feet wide, and have an elevation of approximately 9 to 10 feet above mean sea level (MSL). Much of the beach sand is perched on top of the reef. Small sand dunes and beachrock are found along the shoreline. The coral-algae reef is interspersed with shallow, sand-filled channels and pockets.

Appreciable onshore and offshore transport likely occurs on barrier reefs along the project reach, and longshore transport may be of significantly less magnitude (Moberly and Chamberlain, 1964). The sand channels and the beach comprise a reservoir/beach system that remains more or less in equilibrium. The sand found in the nearshore reef channels represents a sand reservoir, the volume of which fluctuates in response to waves and currents. Increases in beach sand volumes are accompanied by decreases in the offshore reef channel reservoir volumes and vice versa.

Seasonal fluctuations of the beach and sand channel reservoirs are very pronounced in Hawaii. Beach volumes were tabulated for selected beaches on Oahu from 1962 to 1972 (Campbell, 1972). Volumes at Ewa Beach fluctuated as much as 65,000 cubic yards between June 1962 and January 1963. During the winter, the northeast tradewinds weaken and southwesterly winds (and Kona storm waves) appear. During the summer, strong northeast trades return. In addition to the large volumes of sand transported onshore and offshore, some sand is transported alongshore by currents (Moberly and Chamberlain, 1964).

Oneula Beach is located to the east of the proposed marina site (see Figure 3-2). The west boundary of Oneula Beach is approximately 2,000 feet east of the proposed marina entrance. Moberly and Chamberlain (1964) describe

Oneula as a small beach, approximately 3,000 feet long and containing 36,000 cubic yards of sand. Figure 4-1 shows the size distribution and mineralogy of the sand and where sand, coral, and beachrock existed during the survey. The beach material is a moderately well-sorted, medium calcareous sand. The mineralogy suggests that the offshore coral reef is a main contributor to the beach sand supply.

Figure 4-1 indicates a large sand channel located directly offshore from Oneula Beach. The littoral processes in the area along Oneula Beach appear to be a cellular system. Inspection of aerial photographs indicated that the shoreline is confined between two mild headlands. The primary mode of sand transport appears to be onshore/offshore transport. A surface geology map prepared by Noda and Associates (1985) for the vicinity of the proposed entrance channel is shown in Figure 4-2. The map indicates two offshore sand pockets with thicknesses of less than 2 feet. Most of the offshore reef was coral bottom or a sand and coral bottom that was characterized by scattered pockets of thin layers of sand on a flat coral bottom or a coral bottom with mild relief.

The proposed marina entrance channel is located within a 2,000 foot long reach of rocky shoreline west of Oneula Beach. No large sand reservoirs have been documented or observed offshore of this reach of shoreline.

White Plains Beach, formerly known as Nimitz Officers Beach, and Nimitz Beach lie west of the project site (see Figure 3-2). The eastern extent of White Plains Beach is located at the mild headland that separates it from the rocky shoreline to the east. This headland defines the eastern limit of the littoral cell that includes White Plains Beach and Nimitz Beach. Nimitz Beach was artificially constructed and consists of alternating reaches of sand and rock. Sand movement along this reach appears to be primarily onshore/offshore.

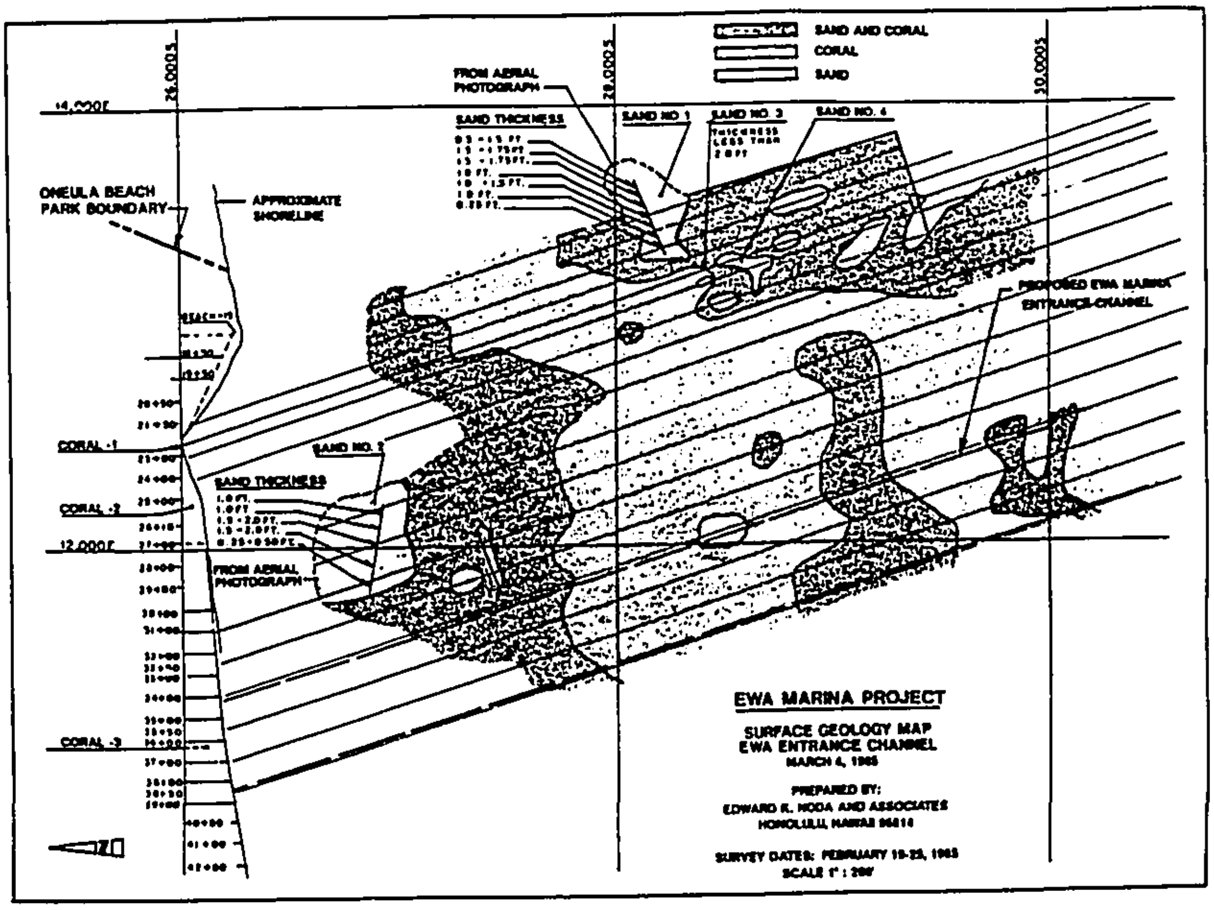


FIGURE 4-2

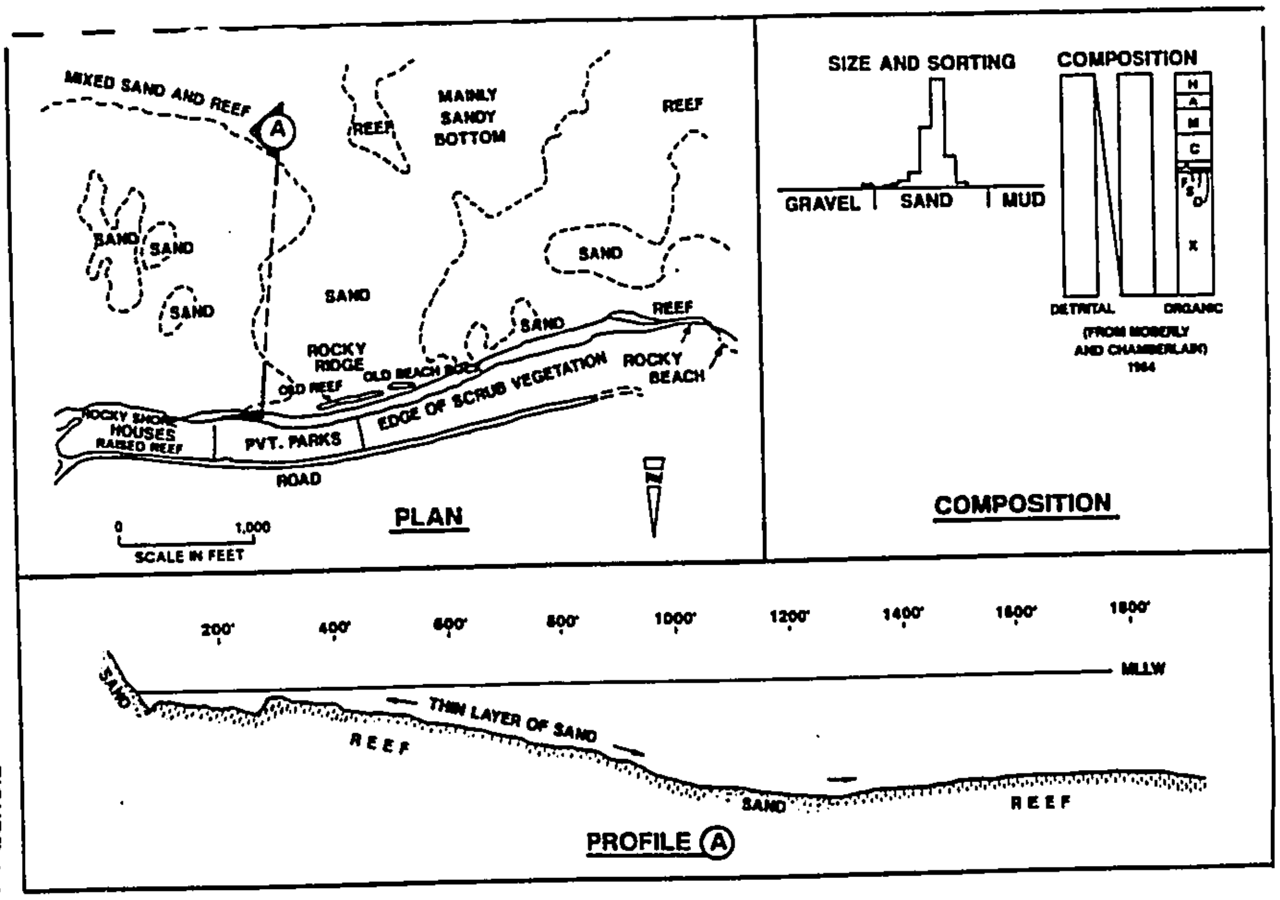


FIGURE 4-1

COMPOSITION OF ONEULA BEACH

4.2 Shoreline History

Analysis of aerial photographs can provide useful information on historic shoreline changes. The analysis can establish both long-term erosion or accretion trends and shorter-term ranges of beach width fluctuations.

Sixteen sets of aerial photographs of the southern Oahu shoreline were collected for the 32-year period from 1957 to 1989. The baseline is taken from a 1952 topographic survey map. A list of the photograph sets collected is shown in Table 4-1.

The "wetted bound" is the boundary line between sand saturated at the time of high tide and drier sand landward of that limit. This boundary line was selected as the most useful shoreline marker. On the aerial photographs, it is the line separating light and dark sand. The wetted bound does not vary appreciably over a tidal cycle (Stafford, 1971), is continuous along the reaches of sandy shoreline, and approximates the mean high water line.

A base map technique described by Everts and Wilson (1981) was used to establish the relative position of the wetted bound through time. A transfer instrument called a zoom transfer scope was used to superimpose the aerial photograph image of fixed reference features found on all aerial photos on to a base map. The base map was constructed to include these features. The wetted bound was then superimposed and recorded from the aerial photograph onto the base map. The data were then reduced to determine wetted-bound shoreline position changes.

Figure 4-3 provides an index map to the three parts of the shoreline map that are presented in Figures 4-4, 4-5, and 4-6. As is shown on the figures, shoreline positions are plotted by season and date.

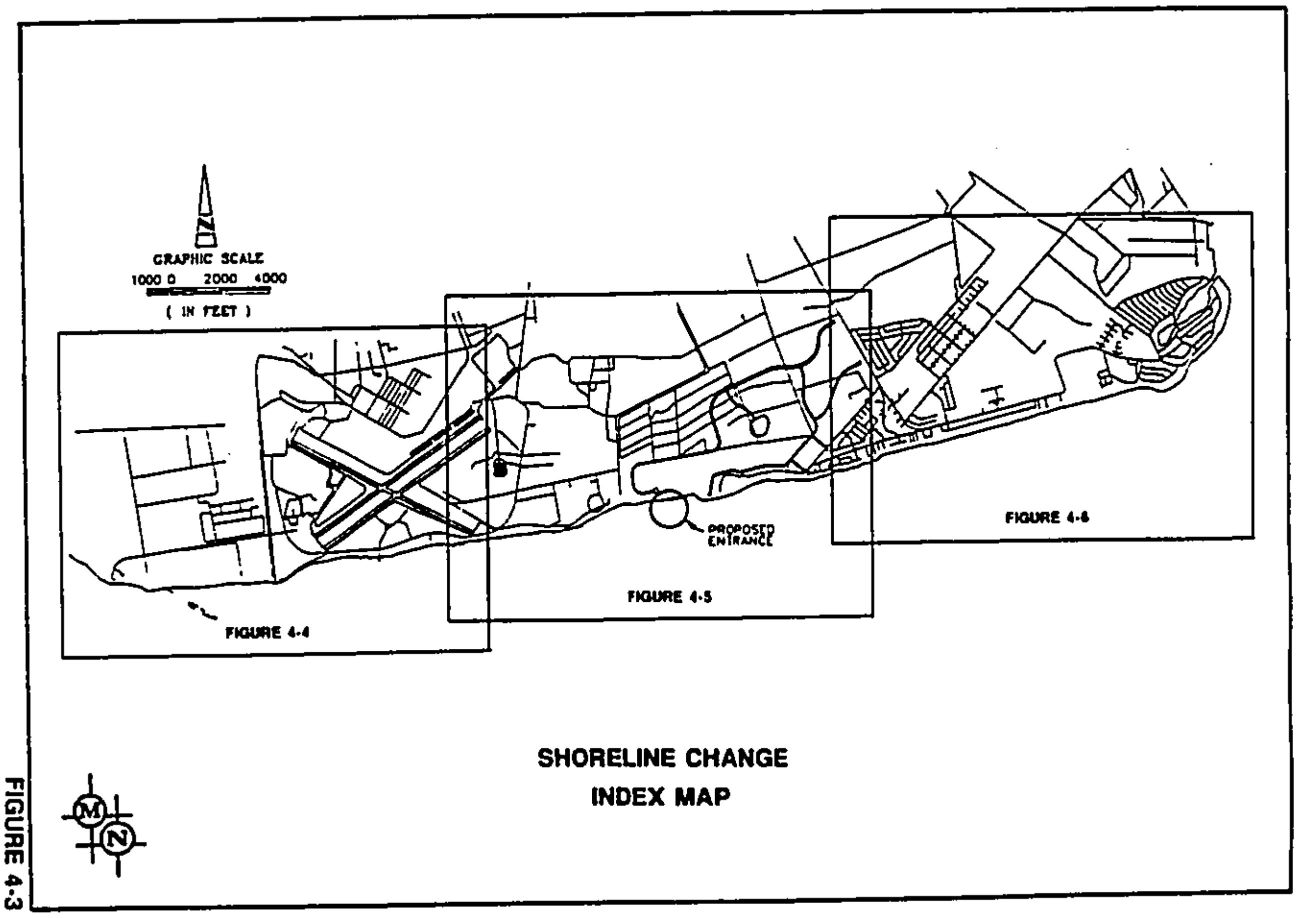
The shorelines were analyzed by measuring distance from a baseline and presenting an average value for every mile. Each mile is labeled as a shoreline zone, as shown in Figure 4-7. These zones are merely areas between mile markers and should not imply any delineation of shoreline characteristics. Shoreline measurements were taken at the transect lines

TABLE 4-1

EWA MARINA

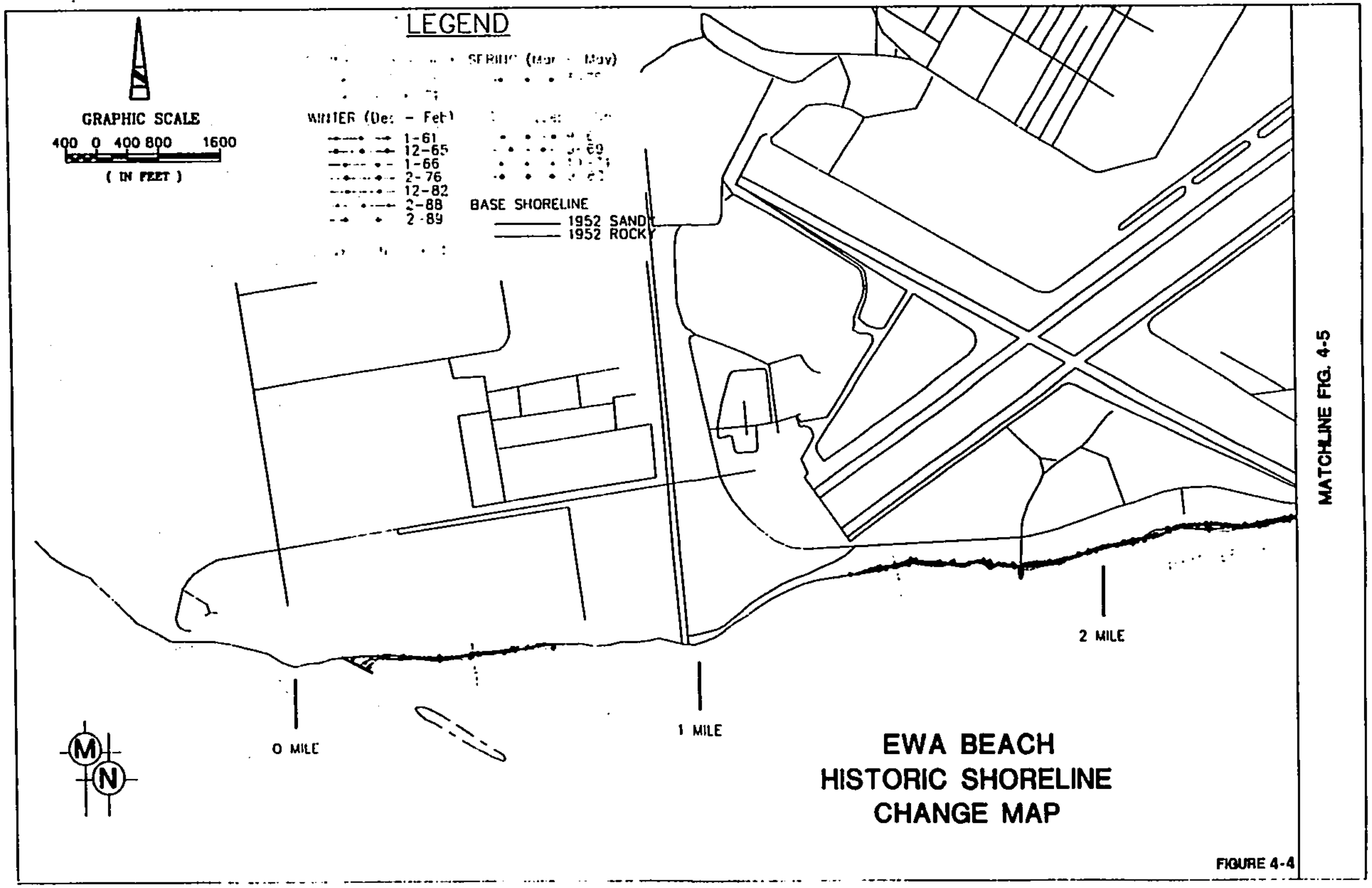
AERIAL PHOTOGRAPHS

DATE	REACH	NUMBER	SOURCE
9-7-57	EWA BEACH TO PEARL HARBOR	1610-1A TO 1610-4B	TOWILL
6-19-58	BARBERS PT. TO PUULOA RIFLE RANGE	1689-1A TO 1689-7A	TOWILL
1-20-61	BARBERS PT. TO PUULOA RIFLE RANGE	2230-11V TO 2230-18V	TOWILL
12-22-65	TIP OF AIRFIELD TO PUULOA RIFLE RANGE	3507-10 TO 3505-2	TOWILL
1-14-66	CANAL TO OBSERV.	3555-1 TO 3561-3	TOWILL
9-3-67	CANAL TO PEARL HARBOR	4337-3 TO 4338-8	TOWILL
9-17-69	BARBERS PT. TO OBSERVATORY	5046-2 TO 5046-8	TOWILL
6-29-71	IMMEDIATE AREA	5554-11 TO 5555-2	TOWILL
10-25-74	BARBERS PT. TO PEARL HARBOR	6466-4 TO 6466-12	TOWILL
3-30-75	BARBERS PT. TO KEAHI PT.	1-06 TO 1-130	AIR SURVEY
2-12-76	BARBERS PT. TO KEAHI PT.	669-2 TO 669-14	AIR SURVEY
9-21-82	BARBERS PT. TO PEARL HARBOR	8186-12 TO 8186-16	TOWILL
12-5-82	BARBERS PT. TO PEARL HARBOR	1-14 TO 1-20	AIR SURVEY
2-1-88	BARBERS PT. TO KEAHI PT.	8526-1 TO 8526-15	TOWILL
2-11-88	BARBERS PT. TO PEARL HARBOR	4-2 TO 4-8	AIR SURVEY
2-16-89	BARBERS PT. TO PEARL HARBOR	8-2 TO 8-6	AIR SURVEY



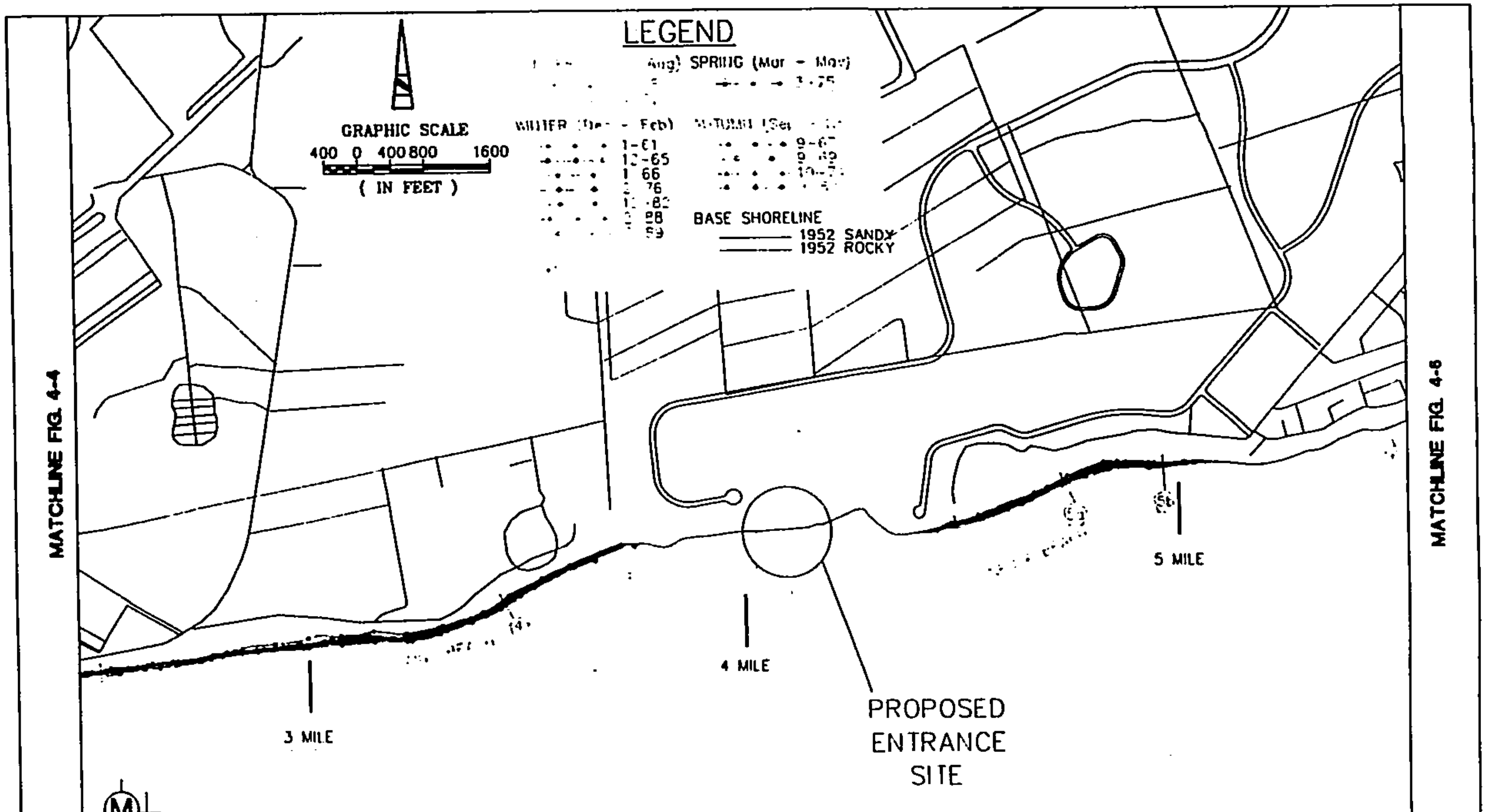
SHORELINE CHANGE INDEX MAP

FIGURE 4-3



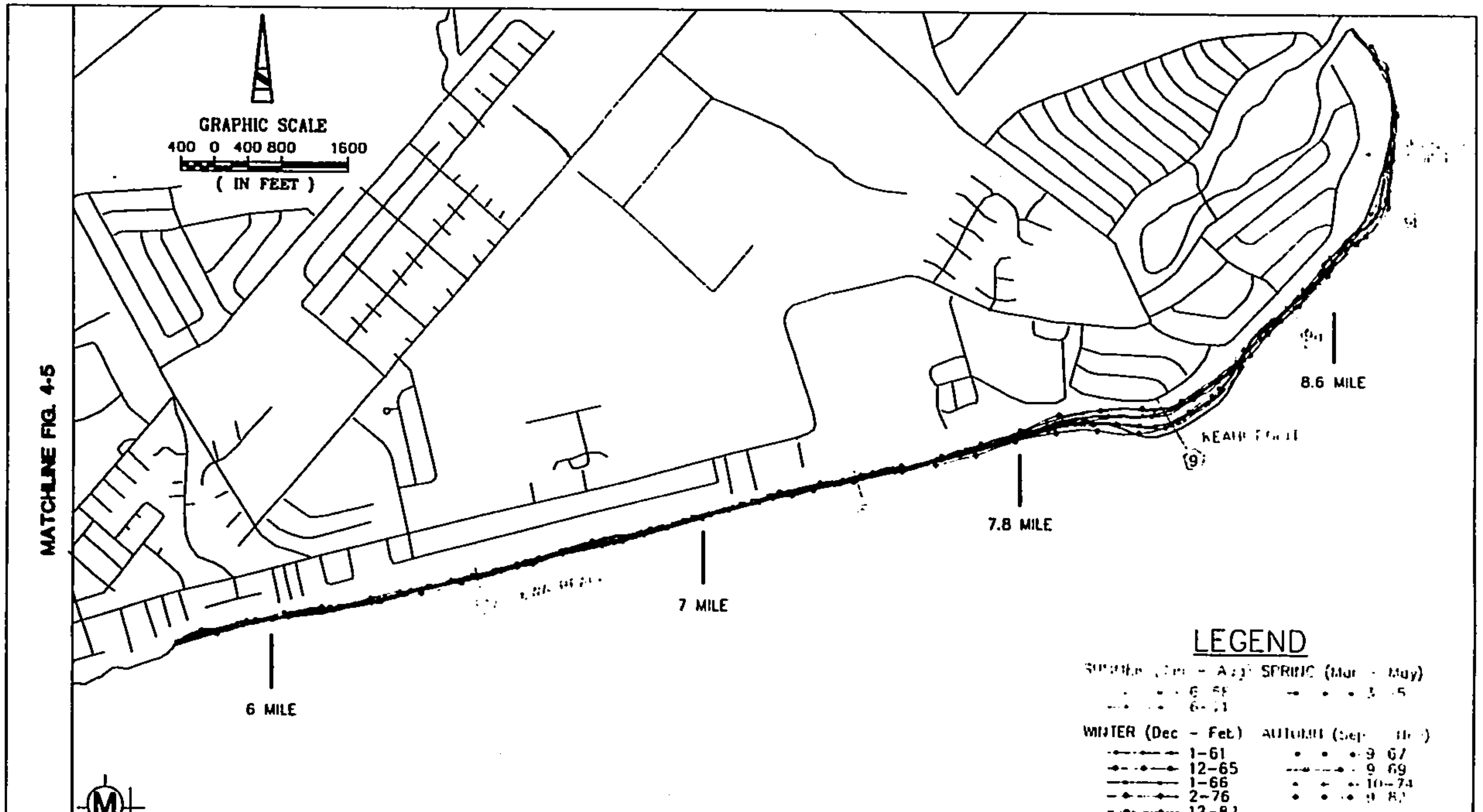
EWA BEACH
HISTORIC SHORELINE
CHANGE MAP

FIGURE 4-4



EWA BEACH
HISTORIC SHORELINE
CHANGE MAP

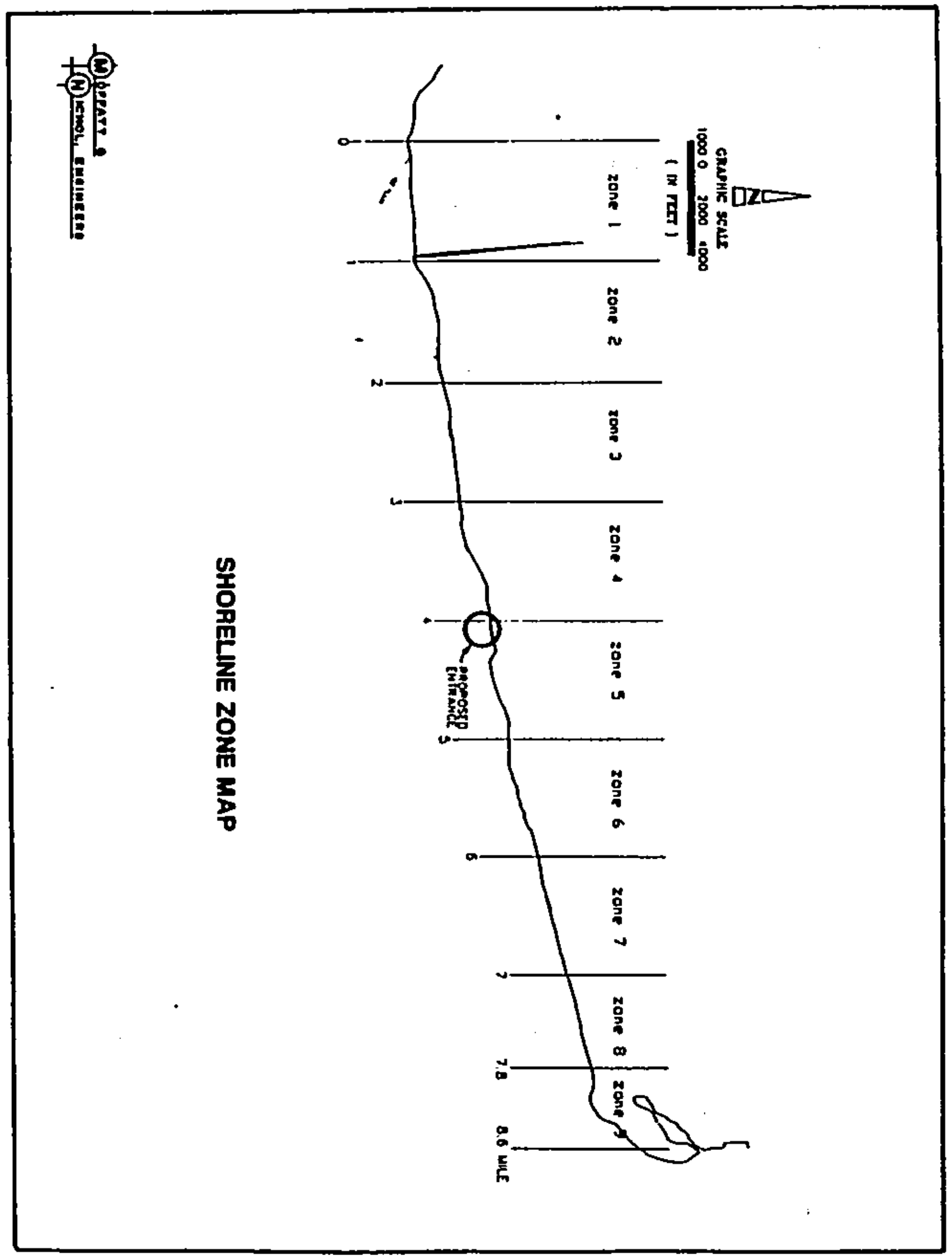
FIGURE 4-5



EWA BEACH
HISTORIC SHORELINE
CHANGE MAP

FIGURE 4-6

FIGURE 4-7



shown in Figures 4-4 through 4-7. Transect lines are typically located near the center of the shoreline zone. Additional locations of interest other than every mile were also analyzed. Plots of shoreline advance or retreat distance versus time are presented in Figures 4-8 through 4-14.

4.2.1 Barbers Point

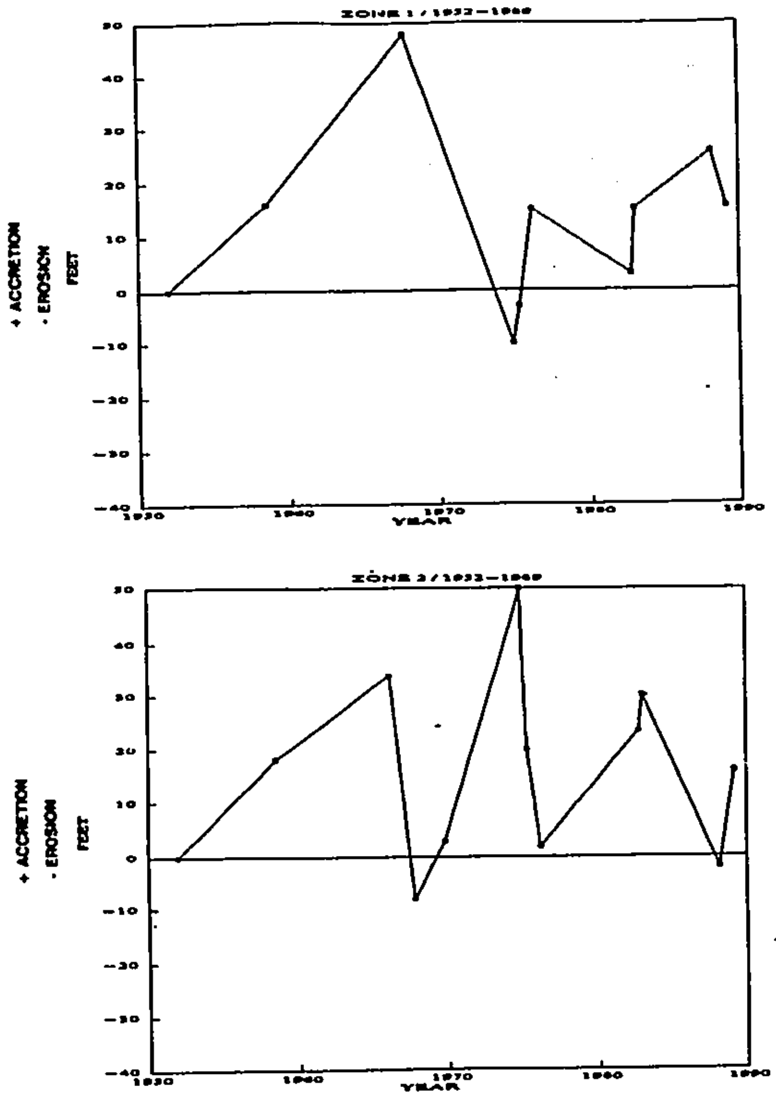
The eastern part of the Barbers Point area is covered by Zone 1 of the aerial photograph analysis. Figure 4-8 shows that this pocket beach is relatively stable, with a maximum fluctuation of 50 feet and net accretion of only 10 feet since 1952. Hwang (1981) also analyzed beach changes on Oahu through analysis of aerial photographs. The results also found the beach to the west also to be stable.

Inspection of the plotted shorelines in Figure 4-4 indicates some mild seasonal rotation of the shoreline within its boundaries. Summer shorelines tend to rotate sand within the pocket beach to the west in order to establish equilibrium with the predominant tradewind-generated westward component of longshore wave energy. The distribution of sand within this pocket beach appears to be more even in the winter in response to Kona wave conditions.

4.2.2 Nimitz Beach

This beach has had a history of a stability. Over a 37-year period, shoreline changes in Zone 2 (Figure 4-8) show a seaward growth of approximately 15 feet; Zone 3 (Figure 4-9) shows over 30 feet. However, both zones demonstrate short-term fluctuations of up to 50 feet that exceed the net long-term trends. Hwang (1981) found similar results.

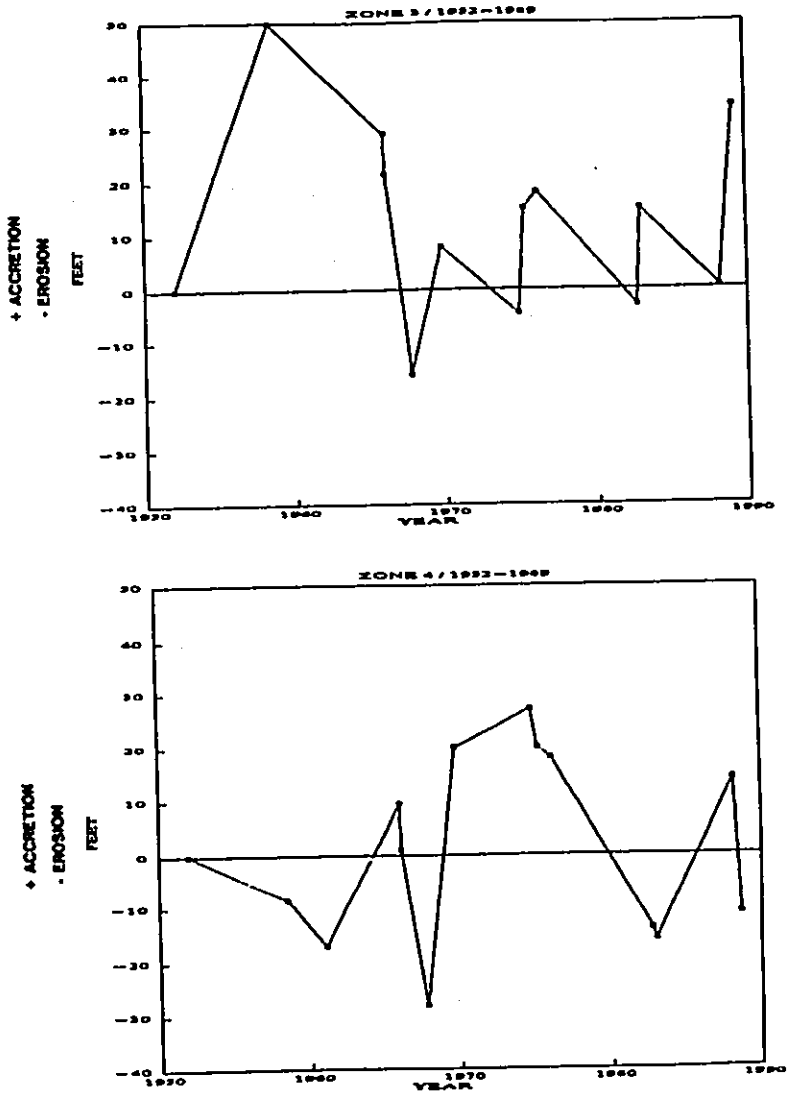
The storm drain structure located on Nimitz Beach approximately 400 feet east of the Zone 2 transect shown in Figure 4-4 acts as a partial littoral barrier, like a groin. Inspection of the historic shoreline positions in Figure 4-4 shows a general lack of sand buildup on either side of the structure. This would tend to indicate a relatively small amount of longshore sand transport in this vicinity.



SHORELINE CHANGE VS TIME

27

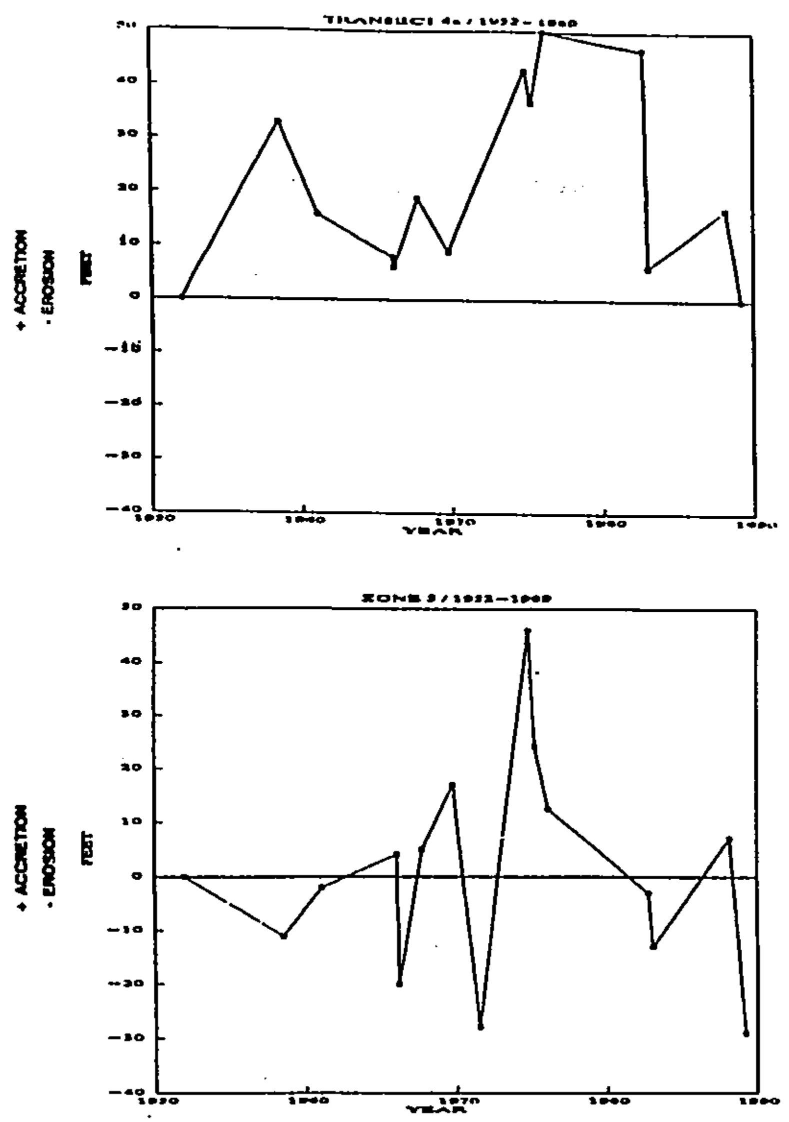
FIGURE 4-8



SHORELINE CHANGE VS TIME

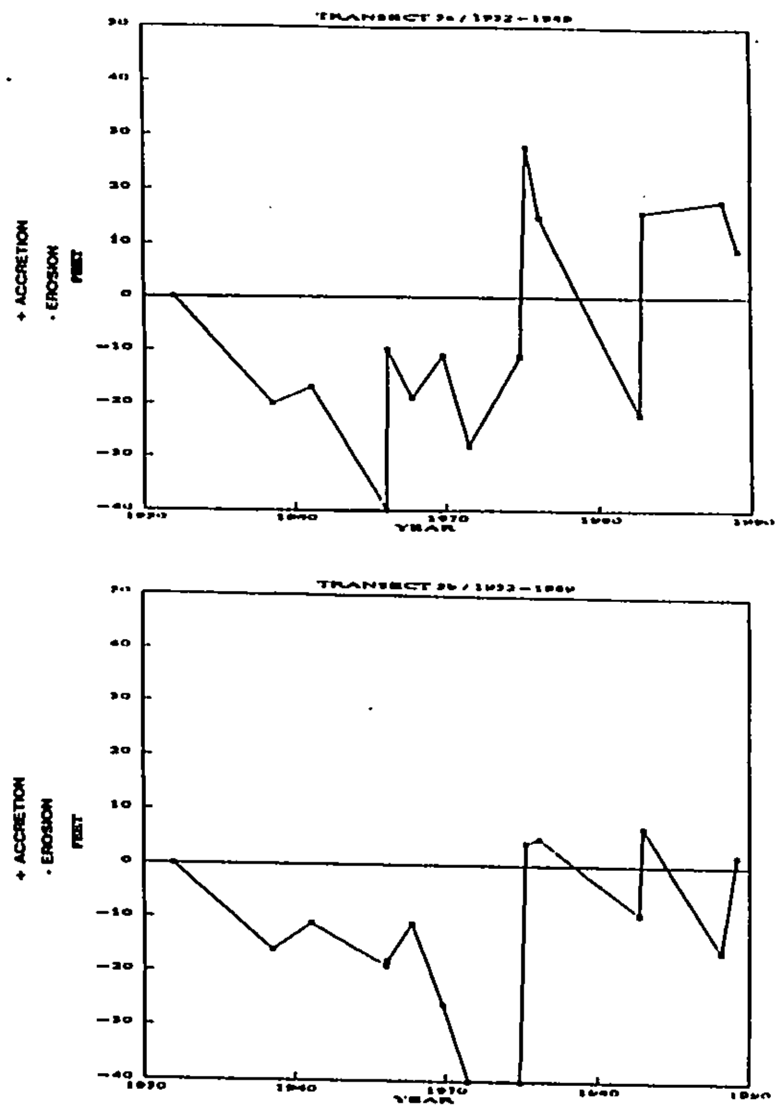
28

FIGURE 4-9



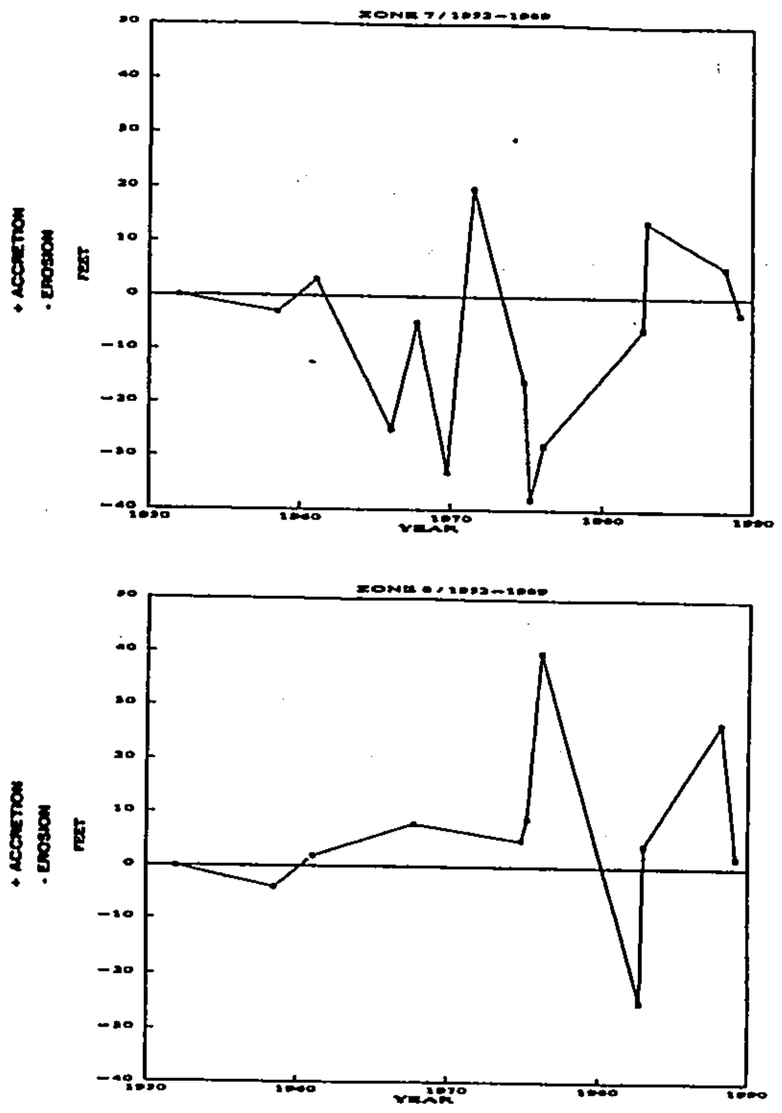
SHORELINE CHANGE VS TIME

FIGURE 4-10



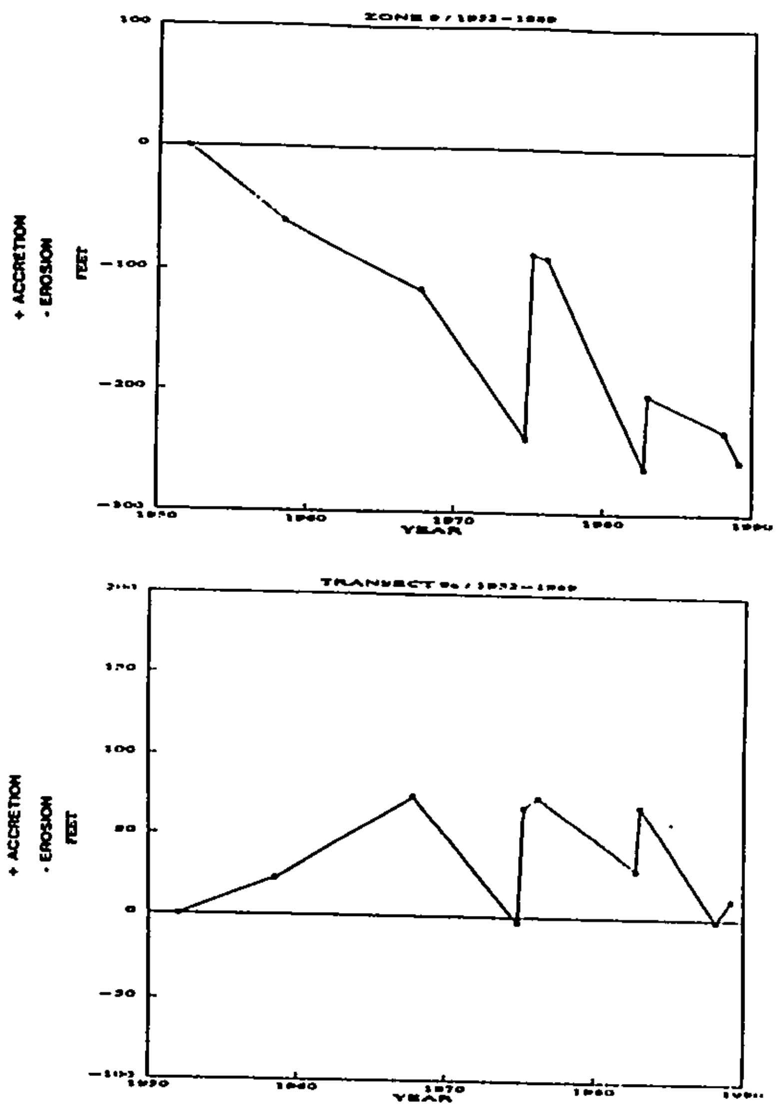
SHORELINE CHANGE VS TIME

FIGURE 4-11



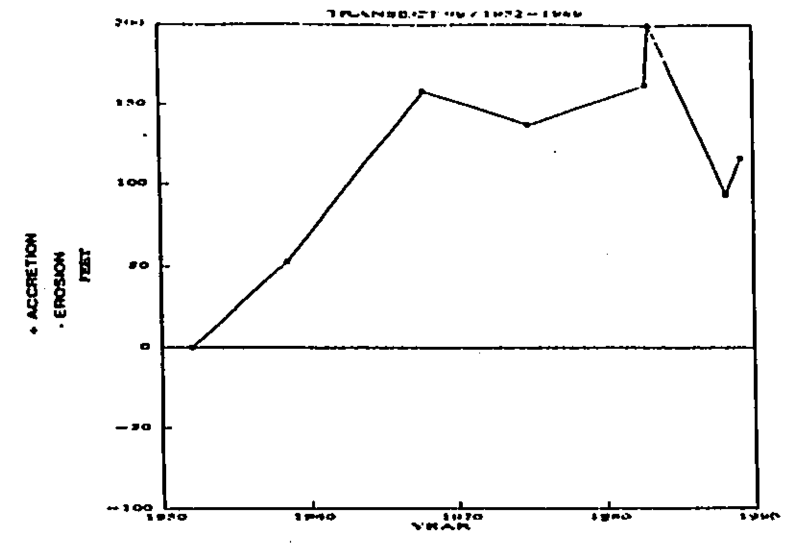
SHORELINE CHANGE VS TIME

FIGURE 4-12



SHORELINE CHANGE VS TIME

FIGURE 4-13



SHORELINE CHANGE VS TIME

FIGURE 4-14

4.2.3 White Plains Beach

White Plains Beach, which lies in Zone 4, exhibits behavior similar to that found for the beaches to the west; i.e., there is little net long-term change relative to the short-term fluctuations. The Transect 4 shoreline changes shown in Figure 4-9 indicate over 25 feet of erosion over the last 2 years although the 1989 shoreline is within 15 feet of the 1952 baseline. The shoreline changes for Transect 4a, located about 400 feet to the east of Transect 4 (Figure 4-5) are shown in Figure 4-10. No net change occurred in shoreline position relative to the 1952 baseline, although this section had accreted up to 50 feet from the late 1970's through the mid-1980's.

4.2.4 Oneula Beach

Zone 5 includes the project site and Oneula Beach (Figure 4-5). Shoreline changes shown for Transects 5, 5a and 5b (Figures 4-10 and 4-11) indicate a relatively stable shoreline. Hwang (1981) also found little change; less than 10 feet over three transects during a 26-year period. Sea Engineering (1989) restated the Hwang (1981) results that Oneula Beach was stable during the period 1950-1976, but stated that the beach is now eroding based upon a 20-foot shoreline recession near the western end of the beach during the period 1976 to 1988.

Inspection of the shoreline changes at Transect 5, which corresponds closely to the Sea Engineering (1989) transect, indicated that the shoreline receded approximately 25 feet between 1976 and 1982, but accreted nearly 20 feet between 1982 and 1988. Inspection of the changes in shoreline position indicated that the stated recession is typical of short-term fluctuations in shoreline positions for this and other reaches of shoreline on the south Oahu shore. Inspection of the shoreline changes at Transects 5a and 5b indicated that the central and eastern portions of Oneula Beach have exhibited little net change since 1952. Sea Engineering (1989) found similar results.

The proposed marina entrance channel is located approximately 2,000 feet west of the west end of Oneula Beach. Review of the 16 sets of historic aerial photographs dating back to 1957 indicated that there was never a sandy beach at this location.

4.2.5 Ewa Beach

Zones 7 and 8 encompass most of Ewa Beach (Figure 4-6). Ewa Beach is approximately 2 miles long and has an average width of 50 feet (U.S. Army Corps of Engineers, 1971). During the 1960's and mid-1970's, erosion occurred along much of Zone 7 (Figure 4-12). The losses were mostly noticeable along a 3,000-foot stretch to the west of the beach park. Numerous seawalls were constructed during this time. Prior to 1962 and after 1976, the shoreline within Zone 7 was generally stable and if some allowance had been made for small fluctuations in the shoreline prior to beach development, such remedial measures should have been unnecessary (Hwang, 1981). Zone 8 has demonstrated stability since 1952, as is shown in Figure 4-12.

4.2.6 Iroquois Point

Iroquois Point is located to the west of the Pearl Harbor entrance (Figure 4-6). Over the past 37-year period, the shape of the shoreline in this vicinity has changed significantly. Transect 9 is located at Keahi Point, which is southwest of Iroquois Point. Figure 4-13 shows that approximately 250 feet of erosion has occurred since 1952. The shoreline Transect 9a, located halfway between Keahi Point and Iroquois Point is shown in Figure 4-13 to be relatively stable. The shoreline behavior at Iroquois Point, (Transect 9b) shown in Figure 4-14 indicates accretion since 1952 of up to 200 feet.

Hwang (1981) reports that from 1928 to 1976, the vegetation line and water line receded about 180 feet at Keahi Point (Transect 9). The rates of erosion for the vegetation line were found to vary from 1.2 feet per year between the 1961 and 1967 to 4.7 feet per year between 1967 and 1976. Hwang further reports that several exposures of rock were noted to have been on a 1976 aerial photograph, which did not stabilize the beach. During a field check in September 1980, the Hwang Study found algae-covered rock to be submerged in several feet of water. This suggested the erosive trend that dates back to

1928 was still in progress. The results presented in Figure 4-13 confirm this statement.

It appears that the shoreline from Keahi Point to Iroquois Point has historically has been an active one, with sediment being transported along the shore from Keahi Point to the eastern sections of Iroquois Point, where accretion is experienced. This lack of shoreline equilibrium with the prevailing wave conditions is resulting in an ongoing erosion problem, which may ultimately threaten some existing residences that are located within the active portion of this shoreline reach.

4.3 Littoral Processes at the Proposed Marina Site

This section describes the littoral processes along the shoreline reach between Barbers Point and the Pearl Harbor entrance. Conclusions are based upon literature review, site observations, and aerial photograph analyses, as well as quantitative analysis of the potential longshore transport rates based upon an empirical wave energy model. An understanding of the littoral processes is then used in the following section to evaluate the potential impacts of the proposed Ewa Marina project on adjacent beaches.

4.3.1 Quantity of Sediment in the Littoral System

The coastal reach from Barbers Point to the Pearl Harbor entrance has only small quantities of sand. There is not nearly enough sand for waves to create a dynamic equilibrium sediment profile from the berm to the effective shorebase. The shorebase is the seaward limit of reversible, mostly seasonal, shore-normal transport. The quantity of sand in the littoral system and its (usual) location with respect to the sea surface are important parameters in estimating the actual quantity of littoral sediment that will be transported by waves and wave-generated currents.

Based upon literature review, site observations, and analysis of 16 sets of aerial photographs, the littoral system between Barbers Point and Pearl Harbor appears to exhibit these average characteristics:

1. Beach widths average about 50 feet.

2. About 50 percent of the coast has a beach; the rest is rocky (beachrock).

3. About 20 percent of the coral shelf offshore of the beach is covered with sand, and the thickness of that sand averages perhaps 1 foot.

4. The width of the coral shelf averages about 3,000 feet.

5. Onshore and offshore transport probably occur over most of the inner coral shelf.

Given these conditions, and assuming the sand thickness at the beach averages 5 feet, the total quantity of sand on the beaches along this reach of shoreline is 300,000 to 500,000 cubic yards, which is approximately 3 to 6 cubic yards per alongshore foot of shoreline. The quantity offshore is 1 to 2 million cubic yards, which is about 10 to 20 cubic yards per foot of shoreline. These volumes are an order of magnitude less than the quantity that would be in the active littoral zone along most open-ocean sandy coasts. These low volumes have important implications when evaluating the potential versus actual longshore sediment transport rates that likely occur along the project reach (see Section 4.3.4).

4.3.2 Sediment Transport at the Ends and Within the Littoral Reach

The littoral reach is south-facing and its east and west boundaries are at major changes in the shore orientation. Very little sediment is reportedly being deposited at the east boundary, which is the entrance to Pearl Harbor. The Deep Draft Harbor, located a few miles northwest of the west Barbers Point Naval Air Station boundary, has no jetties and has also reportedly suffered little sedimentation since it was constructed in the early 1980's. The lack of sediment movement at major changes in shore orientation suggests that there is a low rate of longshore sediment transport at the ends of the Barbers Point to Pearl Harbor littoral reach.

Littoral barriers within a littoral system can provide a relatively accurate measure of the longshore transport rates occurring along that reach of shoreline. A fillet will usually form upcoast of a littoral barrier with persistent longshore transport in one direction, even if the direction reverses seasonally. The barrier can be any natural or artificial hard structure that impedes the longshore movement of littoral material. The distance between the shoreline and the end of the barrier provides a clue to the potential for longshore transport past the structure: as the distance increases, the potential declines.

The proposed entrance lies in the 2,400 foot long reach between two small headlands, or rocky shore projections. The configuration of shoreline advance and retreat on a mostly seasonal basis east of the eastern projection (Oneula Beach) and west of the western projection (White Plains Beach) suggests that net east-to-west longshore transport occurs at a low rate. The shoreline on Oneula Beach occasionally (2 of 14 shorelines on aerial photographs: September 1967 and October 1974) advanced to near the seaward end of the projection. At the end of the summer, northeast tradewind-wave-generated transport to the west could move sand to the west around this projection. Conversely, at the White Plains Beach side of the smaller western projection, sand builds seaward a smaller distance. The aerial photographs showed the shoreline advanced a maximum one-third the way to the seaward end of this headland (February 1976, a Kona wave period), indicating less potential for west-to-east transport.

The lack of any significant sand accumulation between the headlands suggests either a low longshore transport rate or a high longshore transport rate with respect to neighboring reaches (sediment transport gradient, with $dQ/dx > 0$ near the proposed entrance). However, if in September 1967 and October 1974, a large quantity of sand had passed around the eastern headland from Oneula Beach, then a sand fillet would likely have formed on the east side of the western (downcoast) headland. This did not occur, suggesting that the low transport rate inference is correct.

Sediment has not accreted against the approximately 160 foot long storm drain structure at the west end of Nimitz Beach, south of the Naval Air Station runway crossing (see Figure 4-4). The narrow beach and the absence of a fillet suggest that the longshore sediment transport rate, either east or west, is low along this reach.

4.3.3 Potential Longshore Sediment Transport

The potential for waves to transport sediment along a beach can be estimated by applying an empirical factor relating littoral transport to the longshore component of wave energy flux. This transport model was used to obtain an understanding of the seasonal nature of the longshore transport, as well as of the potential transport volumes. However, since the site is confined to distinct littoral cells and the beaches are perched up on the reef, these potential transport rates cannot be realized past the project site. Details of this analysis are provided in Appendix B.

4.3.4 Potential Versus Actual Longshore Sediment Transport

Waves are refracted as they approach shore; however, refraction is sometimes not complete, as evidenced in the analysis of aerial photographs. However, the approach angle relative to shore-normal is small nearshore, where the perched beach sand is available for longshore transport. The low volume of sand, its position on the upper part of the littoral zone, and the presence of many small, rocky littoral barriers appear to preclude the longshore movement of large quantities of sediment. Although the potential for transport may be significant based upon wave energy considerations, actual transport is low for these reasons.

4.3.5 Littoral Processes Summary

- Sediment moves reversibly onshore and offshore at what appears to be a much greater rate than that at which it moves parallel to shore. In an average year, along the entire reach between Barbers Point and Pearl Harbor, perhaps 200,000 to 400,000 cubic yards moves normal to shore across the plane of the sea surface, considering a seasonal shoreline fluctuation of 30 to 40 feet, depending upon location.

- The quantity of sand in the littoral zone between Barbers Point and Pearl Harbor appears to be nearly fixed, with neither large losses nor large gains.
- Mineralogic analyses suggest that the reef is the main contributor of beach sand. Contributions from land sources are not apparent because of the calcareous (reef-type) sand that is present. Land sources would have contributed quartz and other volcanic-source minerals.
- Locations offshore of the beach, where sand was noted on aerial photographs among coral outcrops on the reef, appeared not to be continuous conduits to deep water. Only near the entrance to Pearl Harbor (Keahi Point) was there any evidence that channels in the coral continued to deep water across the reef.
- Longshore sediment transport appears to be low in the entire littoral system between Barbers Point and Pearl Harbor, and very low in the reach that includes the proposed marina entrance. The small amount of sand that does move in the proposed entrance reach probably moves predominantly from east to west. In all likelihood, westerly transport only occurs when wave-approach directions during times of northeast trades are such that sand is moved to and past the end of the headland at the west end of Oneula Beach. In this analysis, there was no evidence the sediment moves from west to east to collect against this headland on its western side.
- The possibility of longshore sediment transport at the proposed entrance exists. The quantity is sediment likely small and the direction of longshore sediment transport is primarily from east to west in infrequent spurts during severe events.

5.0 EVALUATION OF PROJECT IMPACTS ON ADJACENT BEACHES

The following summarizes the potential impacts that may be caused by and that may be experienced by a navigable entrance channel at the proposed site:

1. Littoral transport in the entrance channel vicinity is primarily onshore and offshore; longshore transport of sediment is low. White Plains Beach and Nimitz Beach do not appear to be nourished by sand transported from Oneula Beach. Furthermore, there is no evidence that supports that there was ever a beach at this location. It therefore appears that little sand transport will be affected by the entrance channel.

2. Small amounts of sand may accrete on the east jetty on occasion, particularly during strong, persistent northeast trades or a storm.

3. Accumulated sand should be bypassed in order to maintain the entrance channel at navigable depth and to nourish downcoast beaches.

4. Littoral drift will be intercepted by the entrance channel, regardless of whether jetties are constructed. Sand accumulated at a jetty fillet is more easily and effectively bypassed than sand accumulated in a channel, which must be dredged from the channel in the nearshore zone.

5. Jetties will alter nearshore currents and reflect waves. Reflected waves could increase the local longshore transport rate potential. However, this is a rocky shoreline; therefore, such wave reflection should have no impact.

6. The sand channel 1,000 feet offshore should have only minor impacts because the existing water depths are 10 feet or greater and the entrance would be 15 to 20 feet deep.

7. The sand that will occasionally collect in fillets at the base of the jetties (primarily the east jetty) will need to be periodically bypassed. Sand bypassing is defined as the hydraulic or mechanical

movement of sand from the accreting updrift side to the eroding downdrift side of an inlet or harbor entrance. The hydraulic movement may include natural movement, as well as movement by man. Bypassing of sand accreted at the jetty fillets would best be performed using dragline methods. If permit limitations prevented the construction of the jetties, sand would accumulate in the entrance channel. The resulting accumulation of sand in the entrance channel will need to be periodically removed and redeposited in the active cell on its downdrift side. It is important to note that the no-jetty alternative is much less desirable from a navigation standpoint since sand accumulation directly into the entrance channel can create a significant navigation hazard.

6.0 FINDINGS

The history of the study area, along with a coastal engineering analysis of potential longshore transport, were presented in this report. Excluding the shoreline reach from Keahi Point to Iroquois Point, near the entrance to Pearl Harbor, the shoreline has been stable against long-term erosion over the past 37 years. The beach and sand channel system typical of many Hawaiian beaches comprises a reservoir beach system that remains more or less in equilibrium.

Construction of an entrance channel at the proposed site is not expected to have a significant impact on adjacent beaches. Small amounts of sand may occasionally accumulate on the updrift (eastern) side of the channel. This material should be bypassed to nourish the downcoast beaches and to maintain navigable depth in the entrance channel.

A monitoring program consisting of beach profiles and aerial photography is being implemented to further characterize the existing adjacent shoreline beachforms and their seasonal variability. The program will continue 2 to 3 years beyond project construction to help further assess potential project impacts on adjacent beaches.

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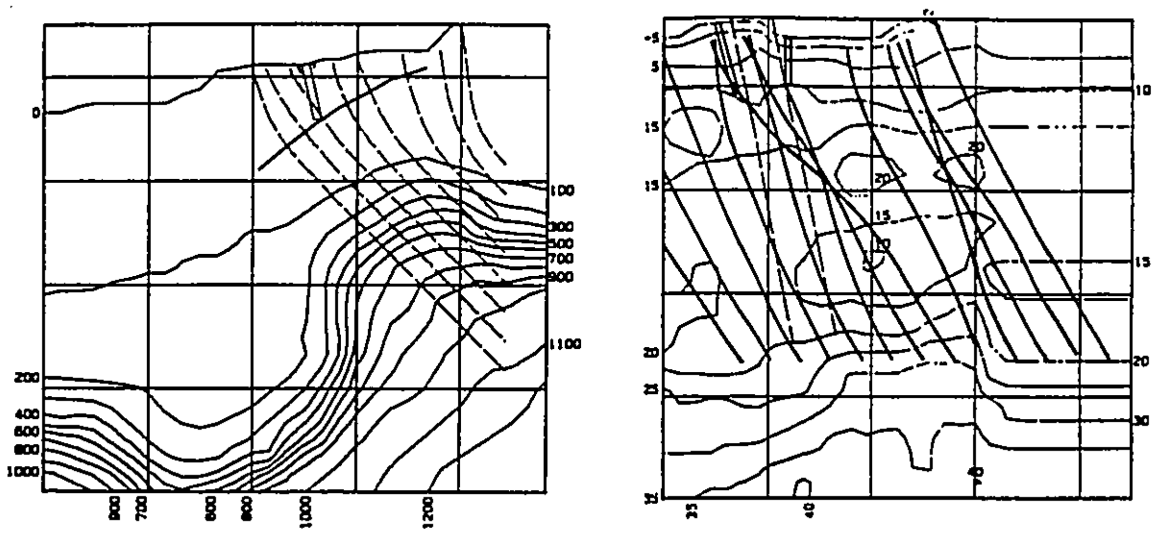
APPENDIX A

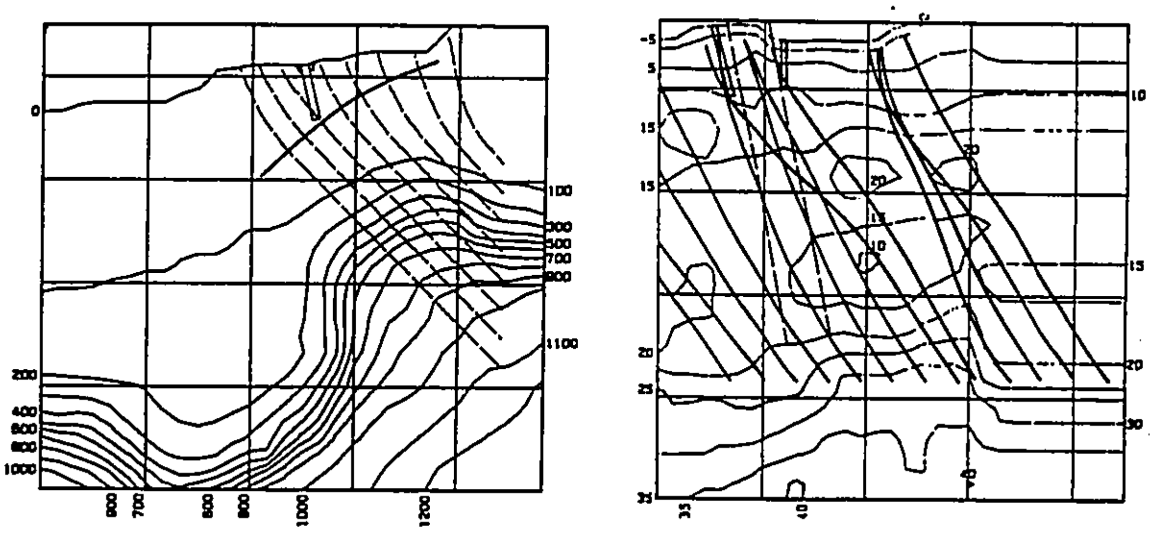
WAVE REFRACTION DIAGRAMS



DEEPWATER NEARSHORE

EWA MARINA
WAVE REFRACTION

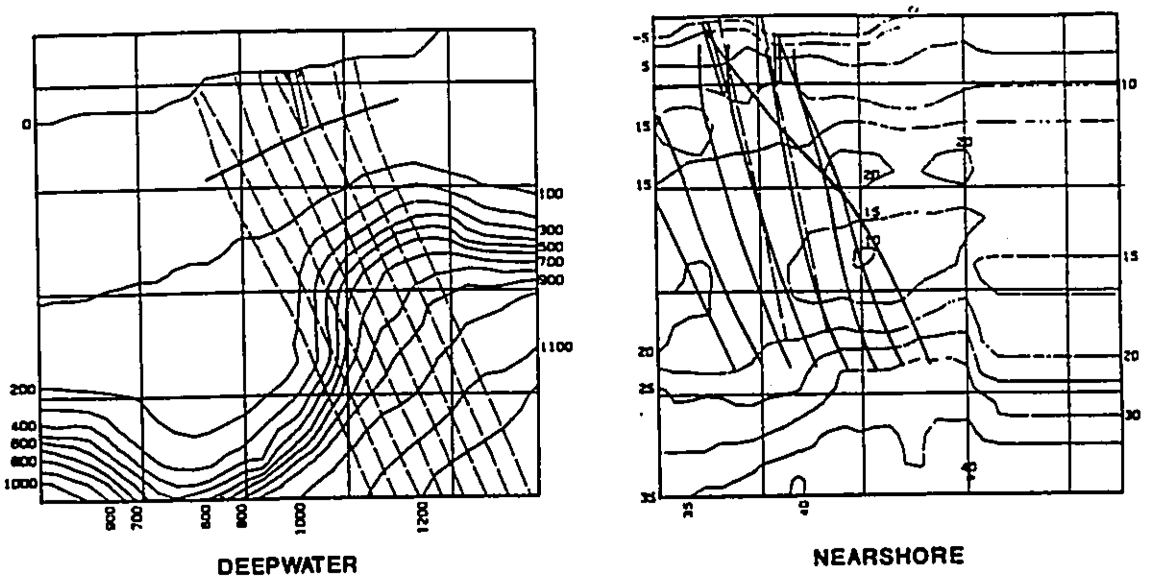
DEEPWATER AZIMUTH 135 DEG.
PERIOD 8 SEC.



DEEPWATER NEARSHORE

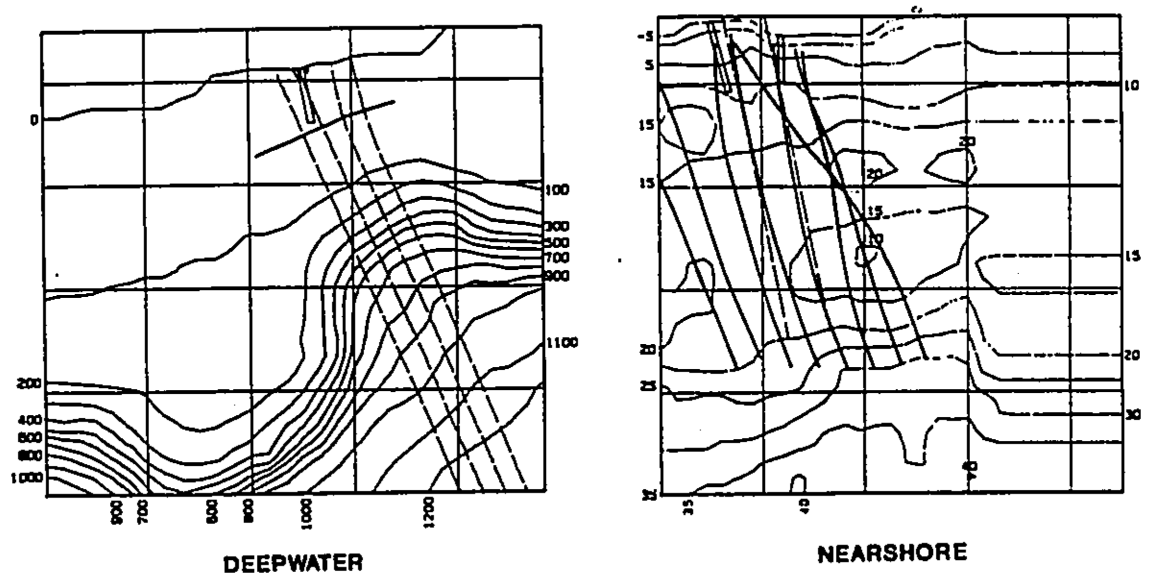
EWA MARINA
WAVE REFRACTION

DEEPWATER AZIMUTH 135 DEG.
PERIOD 6 SEC.



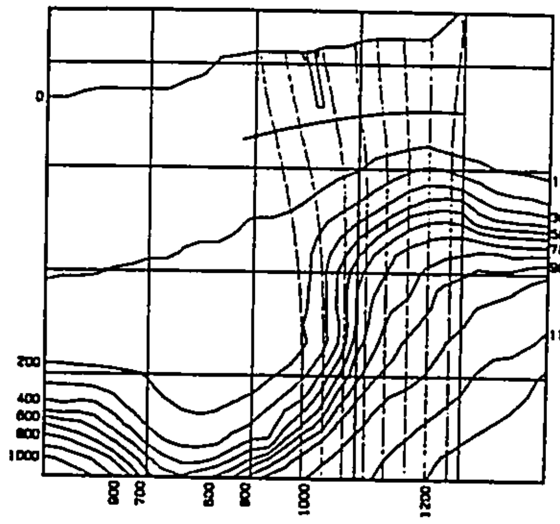
EWA MARINA
WAVE REFRACTION

DEEPWATER AZIMUTH 157 DEG.
PERIOD 10 SEC.

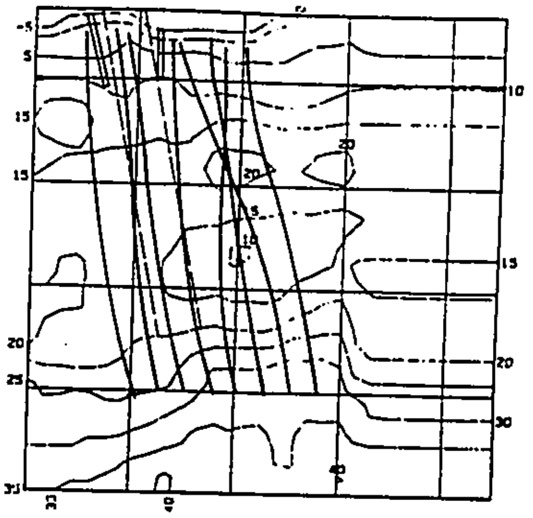


EWA MARINA
WAVE REFRACTION

DEEPWATER AZIMUTH 157 DEG.
PERIOD 8 SEC.



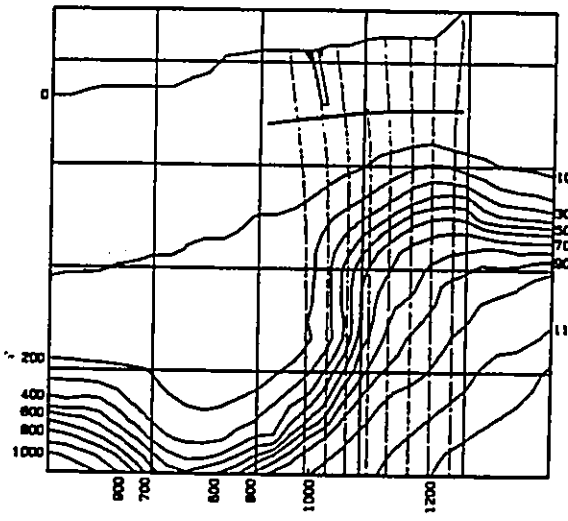
DEEPWATER



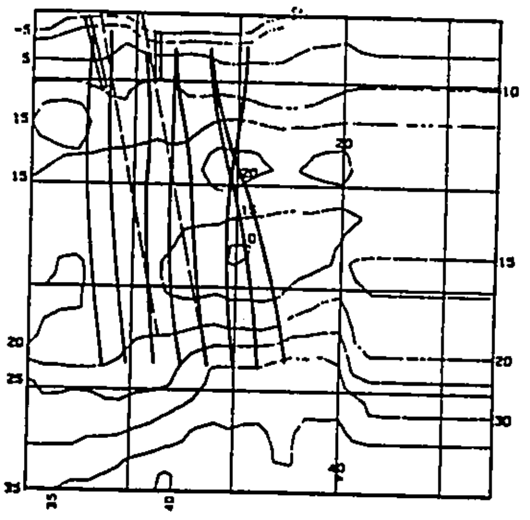
NEARSHORE

EWA MARINA
WAVE REFRACTION

**DEEPWATER AZIMUTH 180 DEG.
PERIOD 10 SEC.**



DEEPWATER



NEARSHORE

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WAVE REFRACTION

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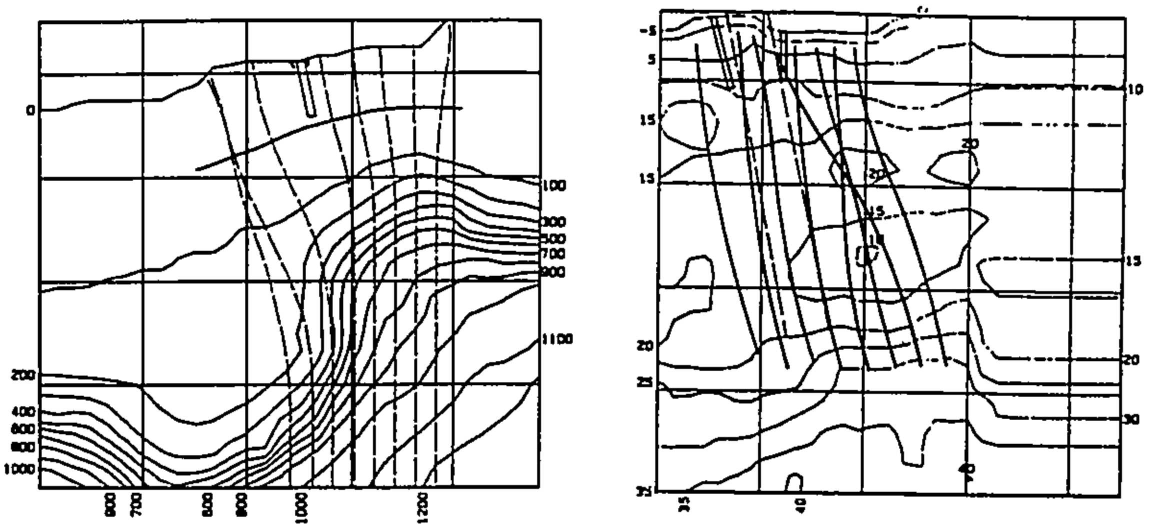
PERIOD 8 SEC.**



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WAVE REFRACTION

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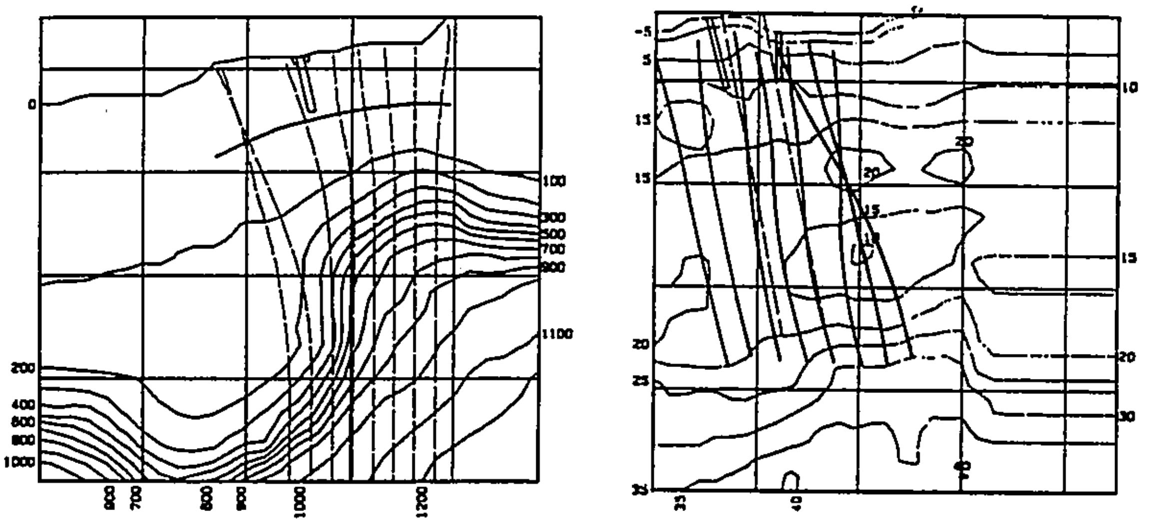

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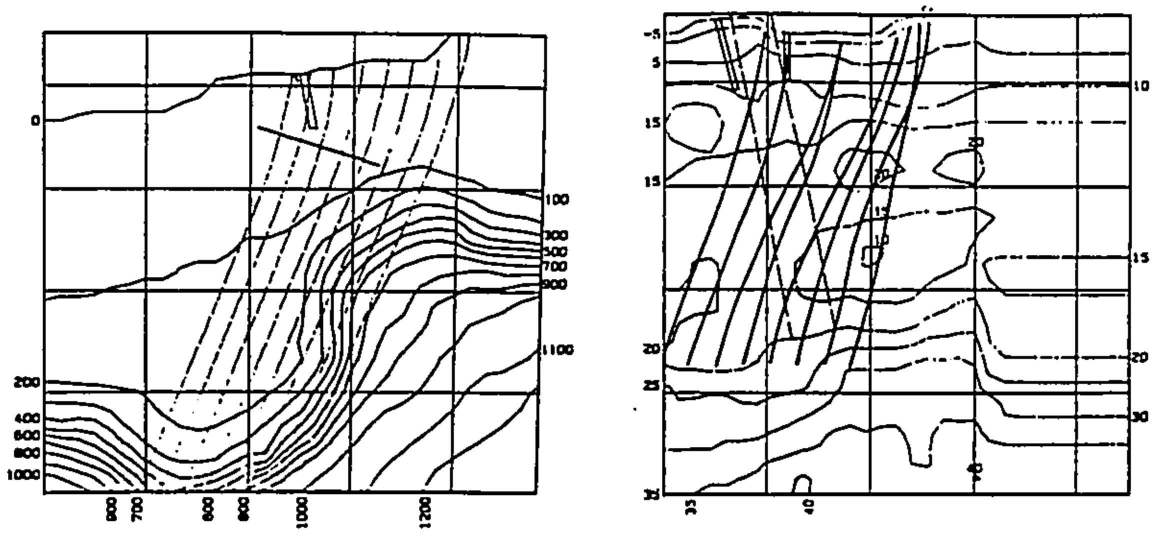

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WAVE REFRACTION

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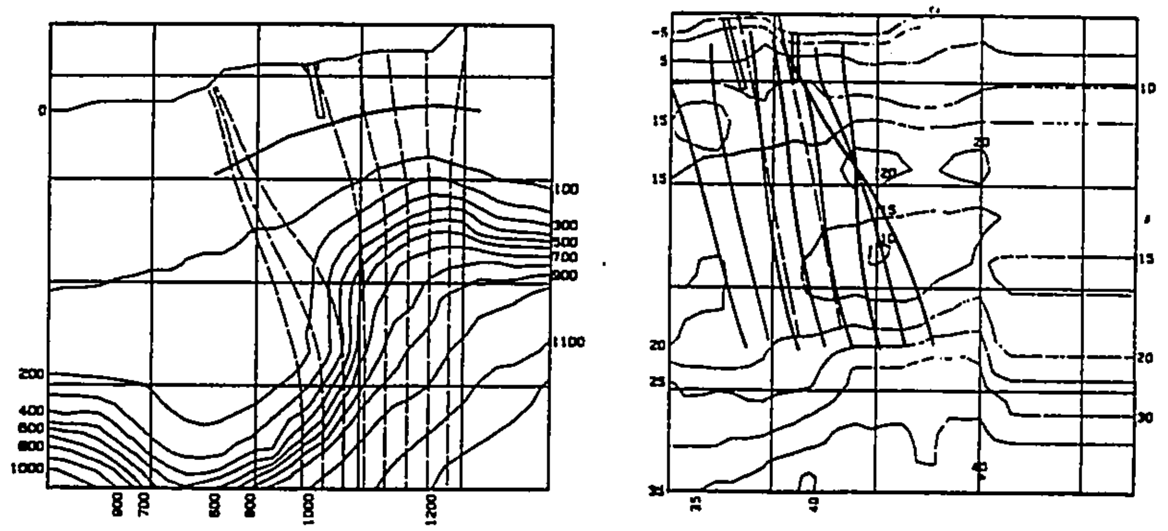
PERIOD 6 SEC.



DEEPWATER NEARSHORE

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WAVE REFRACTION

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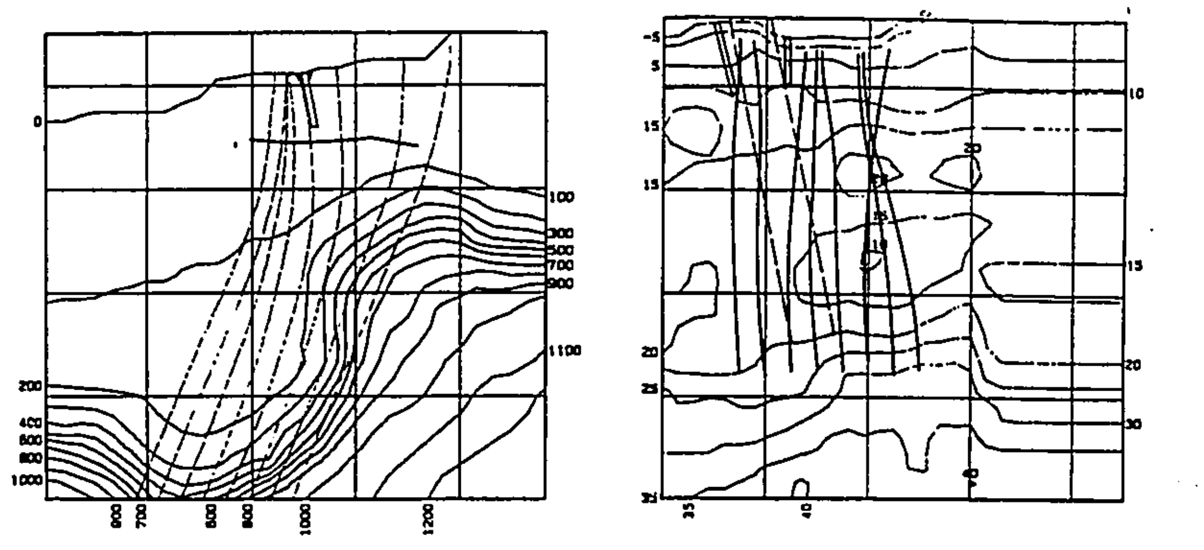

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EWA MARINA
WAVE REFRACTION

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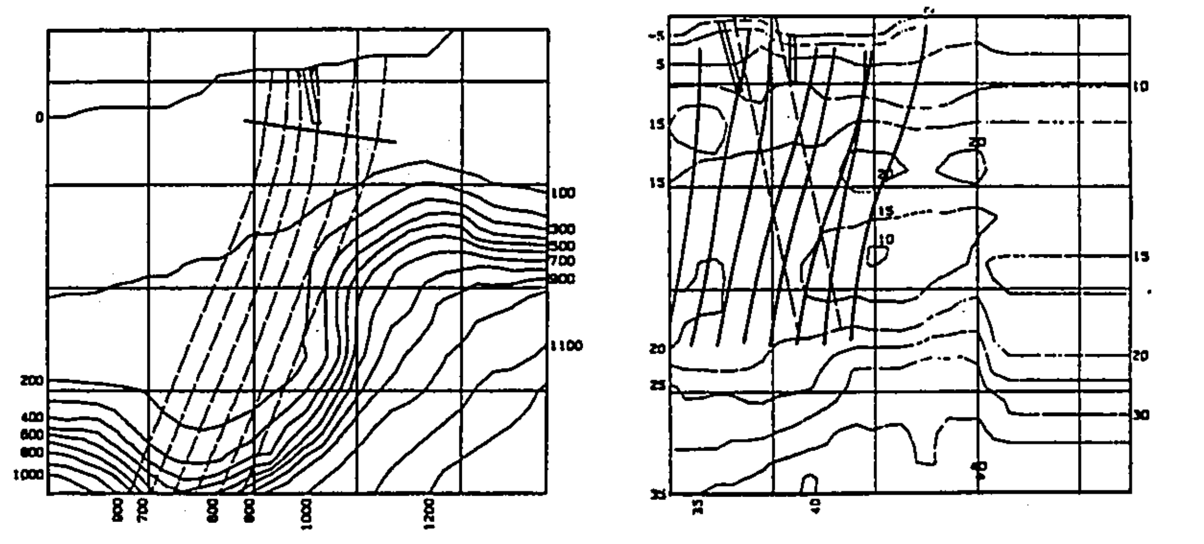

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WAVE REFRACTION

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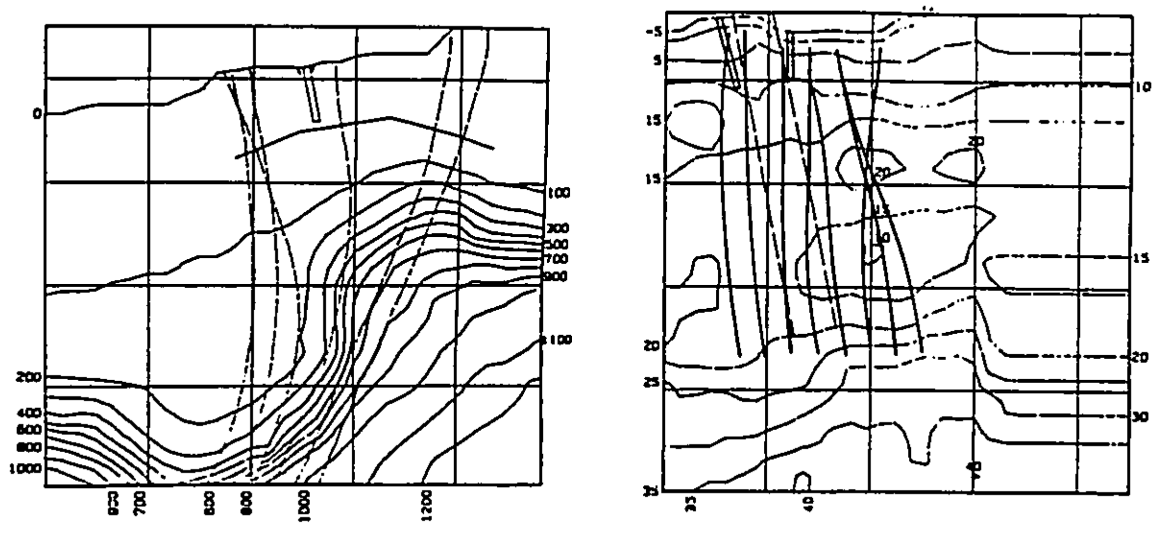
PERIOD 8 SEC.



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WAVE REFRACTION

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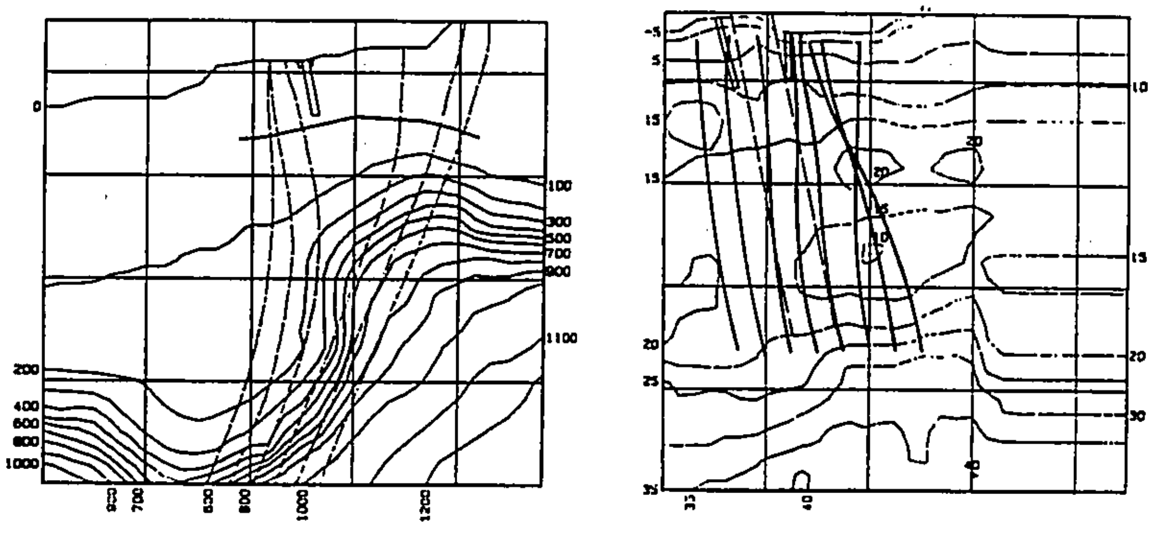

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WAVE REFRACTION

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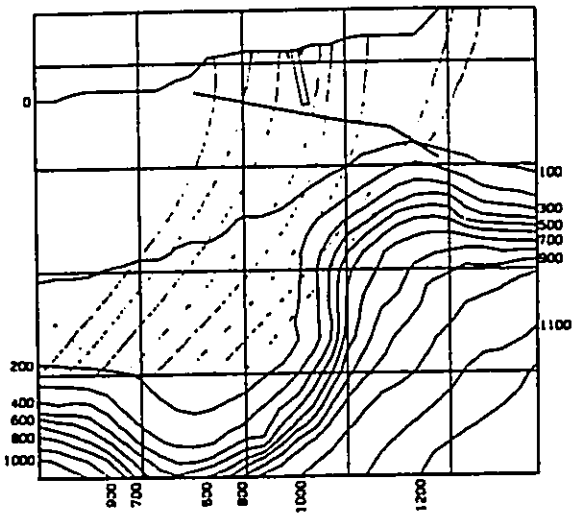

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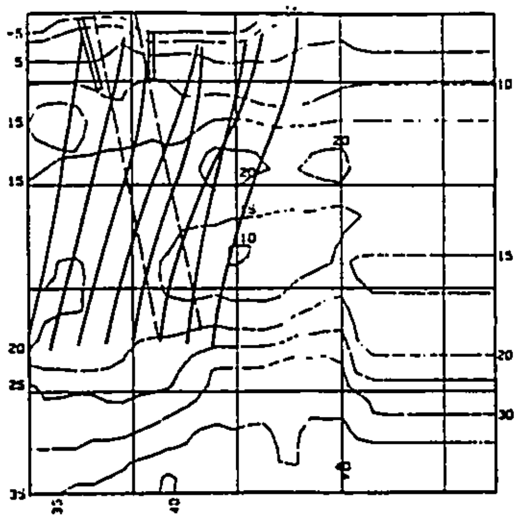

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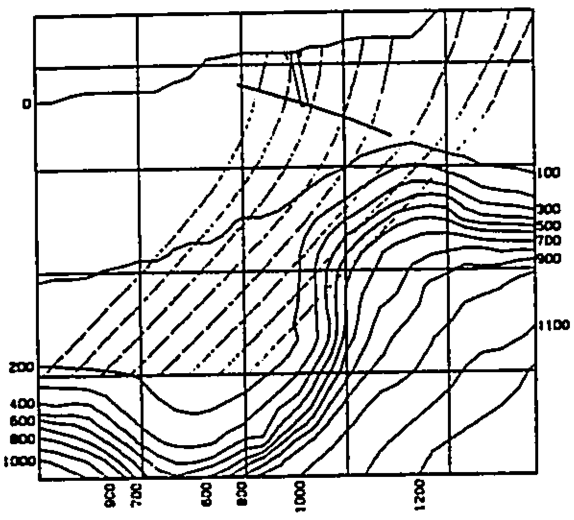

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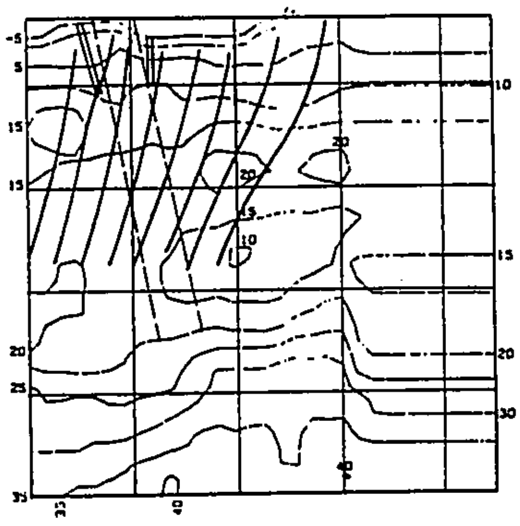

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WAVE REFRACTION

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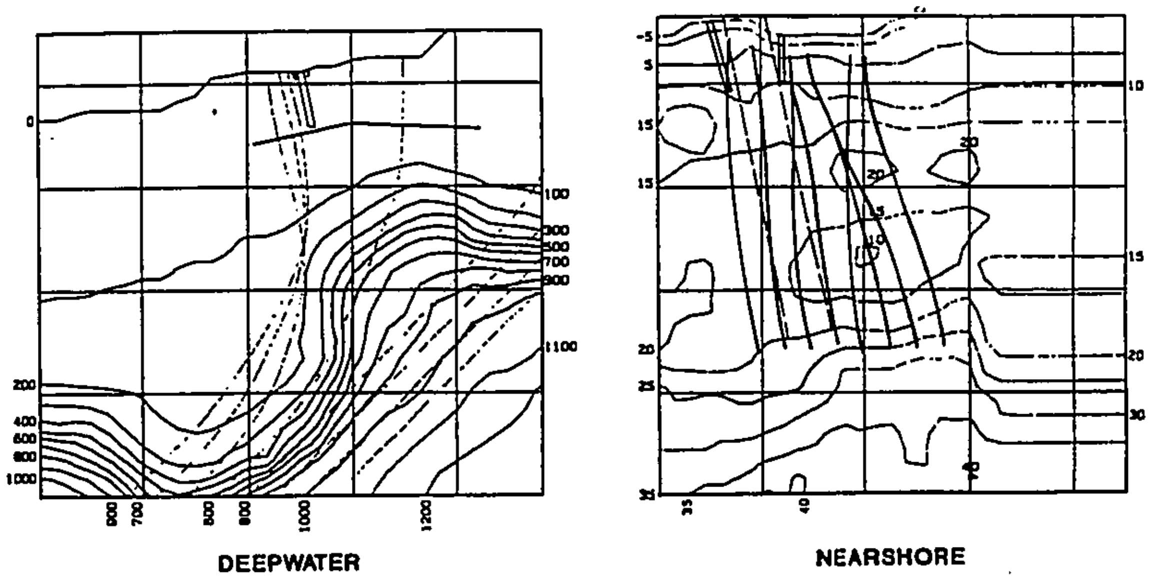

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WAVE REFRACTION

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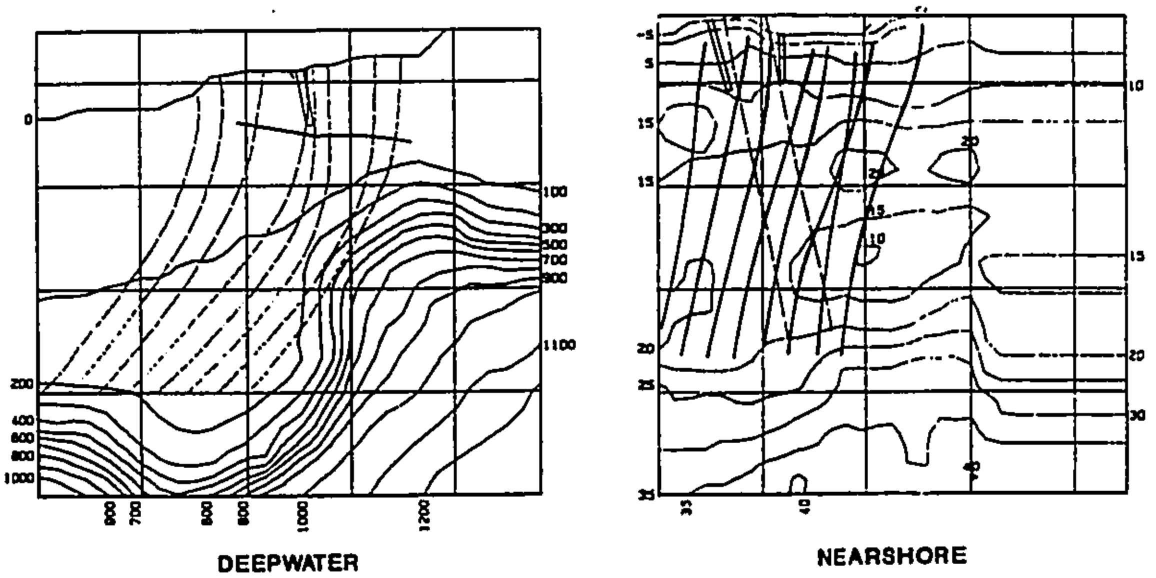
PERIOD 14 SEC.



EWA MARINA
WAVE REFRACTION

DEEPWATER AZIMUTH 225 DEG.
PERIOD 12 SEC.

CORRECTION

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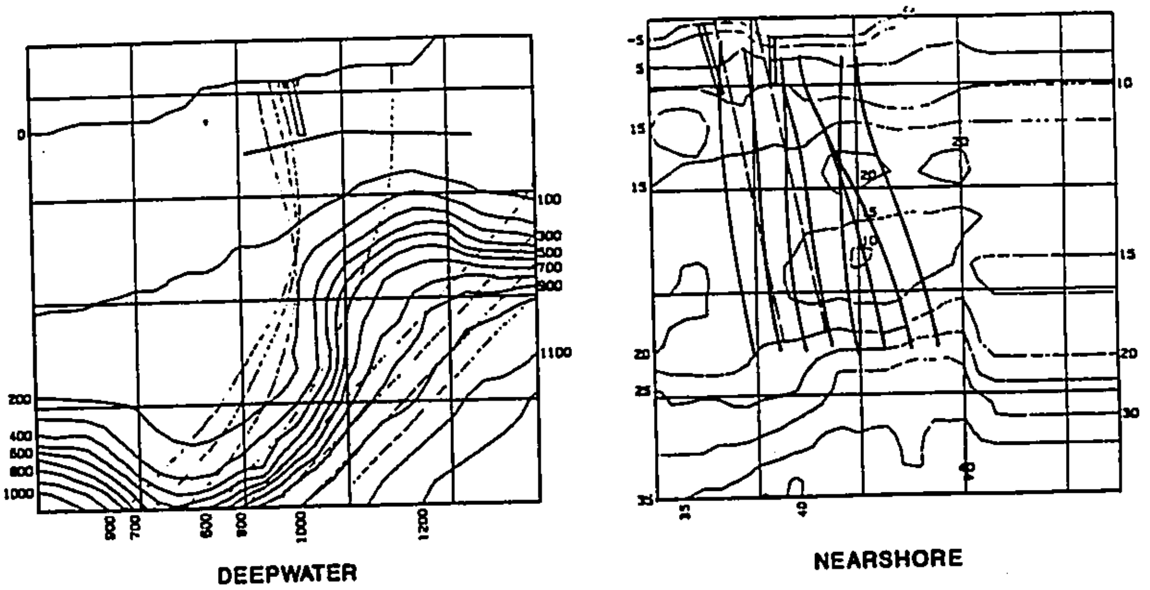

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WAVE REFRACTION

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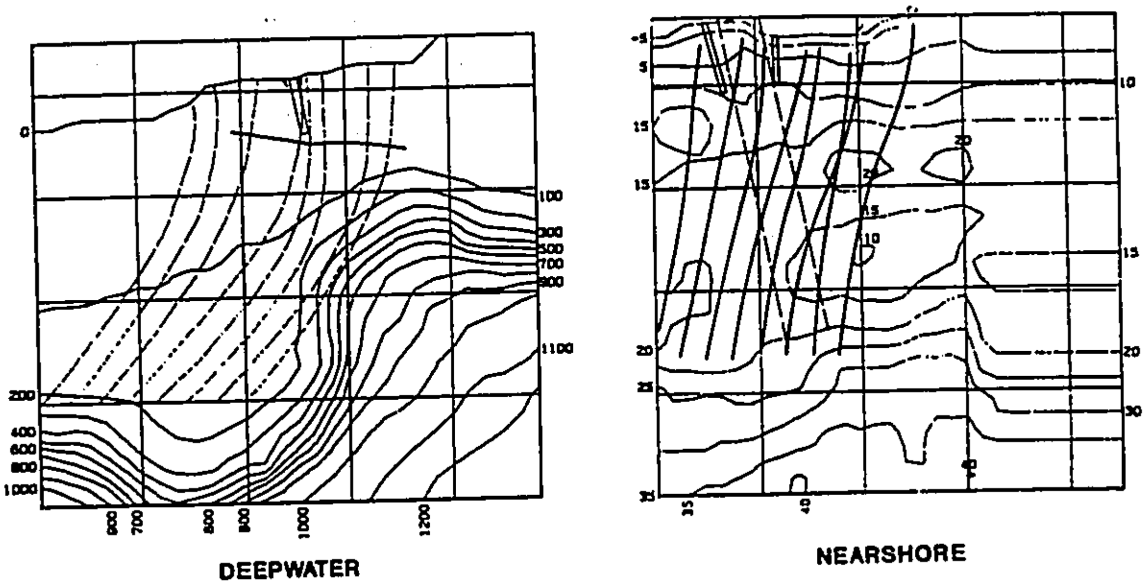

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WAVE REFRACTION

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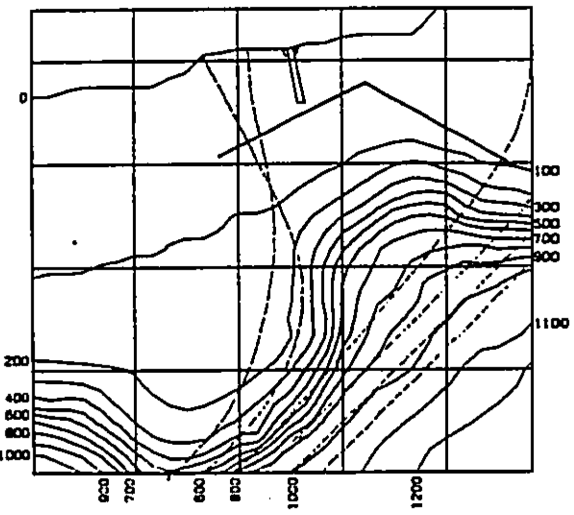

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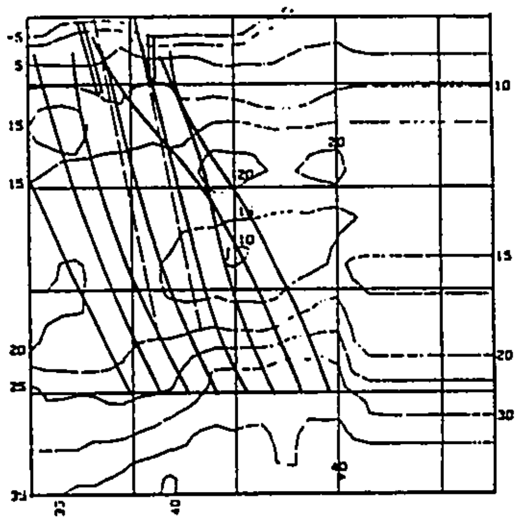

NEARSHORE

EWA MARINA
WAVE REFRACTION

DEEPWATER AZIMUTH 225 DEG.
PERIOD 16 SEC.

APPENDIX B

POTENTIAL LONGSHORE TRANSPORT ANALYSIS

APPENDIX B - POTENTIAL LONGSHORE TRANSPORT ANALYSIS

The potential for waves to transport sediment along a beach can be estimated by applying an empirical factor relating littoral transport to the longshore component of wave energy flux. The longshore component of wave energy flux is primarily a function of the angle of wave approach relative to the depth contours and of the square of the wave height. The Marine Advisers (1964) wave hindcast data set was used to represent typical annual wave statistics. The wave refraction analysis described in Section 3.5 was used, in addition to shoaling estimates to approximate breaking wave conditions associated with each component of the average annual wave climate. Refraction effects for wave azimuths and periods not included in the wave refraction diagrams were interpolated.

Shorelines typical of Hawaiian beaches require special consideration using wave energy flux methods to quantify potential longshore sediment transport. Typically, large waves have the greatest potential to drive longshore transport. However, as a result of the presence of offshore reefs and the existence of perched beach configurations in Hawaii, many of the larger waves that comprise the Hawaiian wave climate break offshore on reefs that have little or no sand. It is not until these waves reform and penetrate inside the reef that beach sediments are set into motion. For purposes of this study, waves breaking in water depths of greater than 4 feet were assumed to be reef break and to not contribute directly to longshore transport. These waves were considered to reform and break in 4 feet of water in the nearshore zone. The associated depth-limited breaking wave height is about 3 feet.

The wave energy flux for each wave component in the average annual wave climate was multiplied by the percent of occurrence for that wave condition to account for duration. The energy flux associated with each wave component was then summed to determine the total monthly and annual wave energy flux.

The longshore transport rate may be estimated by applying an empirical factor to the longshore component of energy flux. The Shore Protection Manual (U.S. Army Corps of Engineers, 1984) recommends the equation:

$$Q = 7{,}500 \, P_{ls};$$

where Q = longshore transport rate (cubic yards per year); and

P_{ls} = longshore component of wave energy flux (foot-pounds per seconds per foot of beach).

The coefficient 7,500 is an empirical factor. The data points used to determine this factor displayed a large scatter (U.S. Army Corps of Engineers, 1984). In a previous publication, Shore Protection, Planning and Design, TR-4 (1966), the factor was 3,750, or one-half of the above value. The increase in the empirical factor doubles littoral transport rates compared to those determined by previous investigations. Table B-1 summarizes the potential longshore transport rates determined in the present study by month; empirical factors of 3,750 and 7,500 were used to establish lower and upper bounds for the rates. Positive values imply east-to-west transport; negative values imply west-to-east transport.

TABLE B-1

POTENTIAL MONTHLY TRANSPORT RATES

	Monthly Potential Transport Rate (cubic yards per month)	
Month	Lower Bound	Upper Bound
January	-1,500	-3,000
February	3,500	7,000
March	5,300	10,600
April	29,000	58,000
May	16,000	32,000
June	20,000	40,000
July	34,000	68,000
August	23,000	46,000
September	-3,000	-6,000
October	12,000	24,000
November	9,000	18,000
December	-500	-1,000
Total potential net annual transport	146,800	293,600

In summary, the potential net annual longshore transport rate at the project site ranges from about 150,000 to 300,000 cubic yards per year.

Appendix H

Ewa Marina Ocean/Marina Monitoring Program
Reef Community Structure
Report No.1

EWA MARINA
OCEAN/MARINA MONITORING PROGRAM

REEF COMMUNITY STRUCTURE

REPORT No. 1

Prepared by

Marine Research Consultants
217 Prospect St., F-2
Honolulu, HI 96813

January 15, 1991

1. INTRODUCTION AND PURPOSE

1.1 Overview of the Project

The Ewa Marina project is located on approximately 1,100 acres of land situated between Barbers Point Naval Air Station and the Ewa Beach community on Oahu's southern shore (see Figure 1) The project includes a 140-acre marina that will eventually be home for approximately 1,600 boats. The marina will be excavated from fast land behind the shoreline and will be connected to the open ocean by an entrance channel that will cross a broad fringing reef.

The marina will have an area of approximately 140 acres, and water depths will range from about 2.5 to 3.7 meters. Over 5 million cubic yards of material will be excavated during its construction and used as fill on the adjoining land. The planned entrance channel is approximately 125 meters wide and 900 meters long; it will be about 6 meters deep, shoaling to about 4 meters after it crosses the existing shoreline. Preliminary calculations indicate that construction of the proposed entrance channel will involve the removal of approximately 300,000 cubic meters of bottom material and the alteration of approximately 115,000 square meters of marine habitat The proposed jetties will occupy only a small fraction of this, with the remainder consisting of channel area

1.2 Monitoring Program Objectives and Frequency

Construction of the proposed project will physically alter the existing marine habitat at the shoreline and in the area of the excavated channel. It will also alter the manner in which groundwater and stormwater runoff is discharged into the ocean. Finally, it will involve activities, such as boating, that have the potential to produce physical and chemical changes in water quality, and hence perhaps biological community structure. In order to evaluate the potential for such changes to the nearshore marine environment, a monitoring program designed to evaluate the effects on marine biological community structure over the course of the project's construction and initial operation has been instituted.

1.3 Monitoring Frequency

The monitoring program will cover pre-, during-, and post-construction periods. Preconstruction monitoring will take place twice, once in the winter and once in the summer prior to the initiation of any marina-related activity. This report presents the results of the initial preconstruction increment of the biological community monitoring program, and was conducted in October of 1990. Reef structure and biota monitoring surveys will be carried out every six months during excavation of the marina basin and entrance channel. Approximately two months after all excavation of the entrance channel, marina basin, and breakthrough connection is completed, another reef community monitoring survey will be conducted. Three additional post-construction benthic surveys will be performed at intervals of six months following completion of the first post-construction survey.

1.4 Reef Structure and Marine Biota Parameters

The physical and biotic structure of the reef environment will be evaluated by establishing a descriptive and quantitative baseline of benthic reef communities in the vicinity of the proposed marina Key components of reef communities include hermatypic and soft corals, benthic algae, motile macroinvertebrates, reef fish, and physical substratum type. Reef community data will also serve as a baseline for evaluating the significance of changes that occur during and after construction.

2. METHODS

2.1 Qualitative Survey Methods

Qualitative reconnaissance surveys covering the entire area fronting the marina from the shoreline out to the limits of coral reef formation (approximately the 20 meter depth contour) were conducted by divers towed behind a boat. 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.

The intertidal areas near the shoreline are subjected to substantial enough wave action to prevent the utilization of the transect methods described below. Thus, qualitative surveys by divers in the intertidal areas were conducted to gather estimates of species abundance. Particular attention was given to characterizing benthic algal abundance in the intertidal areas, since this constituent of the biota is relevant to the assessment of the potential impacts to the green sea turtle.

2.2 Quantitative Survey Methods

2.2.1 Benthos

Following the qualitative survey, three quantitative survey sites were selected. One survey site was located at the approximate western edge of the property boundary (Transect Station 1), one was located at the approximate site of the marina channel (Transect Station 2), and one was located near the eastern edge of the property (Transect Station 3) (see Figure 1). Each survey site can be envisioned as a line running perpendicular to depth contours through the entire nearshore area from the intertidal out to a depth of approximately 60 feet. At each survey site, transects were established in each representative zone of the reef environment. These zones corresponded to depths of approximately 15, 30 and 60 feet. In the area of the proposed channel alignment, an additional transect was conducted at the 20 foot depth.

Quantitative benthic transects were 50 meters (160 feet) long, and were oriented parallel to the shoreline. Survey transects were conducted by stretching a surveying tape over the reef surface between marker floats. An aluminum quadrat frame, 1.0 by 0.66 meter in dimension, was then 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 was taken of 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 substratum type within the quadrat frame. For the present monitoring survey, no attempt was made to disturb substrata to observe organisms, or to identify and enumerate cryptic species dwelling within the reef framework. Only macrofaunal species greater than approximately 1 centimeter were noted

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 recorded. Results of the photo-quadrat analysis were combined with the *in-situ* cover estimates, and community structure parameters (percent cover, species diversity) were calculated. The photo-quadrat transect method is a modification of the technique described in Kinzie and Snider (1978); it has been employed in numerous field studies of Hawaiian reef communities (e.g., Dollar 1979, Grigg and Maragos 1974). The technique has proven to be particularly useful for quantifying coverage of attached benthos such as corals, macrothalloid algae, and large epifauna (holothurians, echinoderms).

2.2.2 Reef Fish

A 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 2 meter wide along the transect path were identified by species name 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)

3. RESULTS AND DISCUSSION

3.1 Physical Structure

The shoreline and intertidal area of the subject property are relatively homogeneous in composition. The entire shoreline frontage of the property, including the area for the proposed channel alignment, consists of a beachrock (calcium carbonate) scarp 1-2 meters in height. At the bottom of the scarp small patches of white beach sand occur in pockets; the remainder of the intertidal area is a solid, flat platform. Sandy areas on the shoreline are most prominent at the western end of the property. In the vicinity of "Officers Beach" at Barbers Point Naval Air Station

From the area immediately off of the beachfront scarp out to the limit of the monitoring survey (60 foot depth contour), the ocean bottom is composed of a wide, predominantly flat calcium carbonate (limestone) platform. This underwater plain is an erosional remnant of the extensive, geologically ancient emergent reef that forms the Ewa Plain, which comprises much of central Oahu. The distance from the shoreline to the 60 foot depth contour is approximately 2 kilometers (1.2 miles). Bottom topography slopes very gradually from the shoreline out to well beyond the 300 foot depth contour. Such a geomorphological structure is somewhat anomalous for the south shore of Oahu, where there are generally several relatively sharp dropoffs within the nearshore region owing to erosional features from submerged ancient shorelines

The surface of the reef platform is predominantly barren of most macrobiota. A short algal turf covers most of the flat reef platform. Bound within the algal turf is a layer of sediment composed of sand grains of marine origin. In some areas, shallow sand-filled channels and depressions intersect the reef platform, resulting in a limited groove and ridge system. In deeper areas of the reef platform (40-60 feet) some areas of extensive sand deposits were encountered.

Quantitative estimates of bottom cover (non-coral substrata) from transects are shown in Table 1. Solid limestone bottom averaged about 35%, while sand and rubble covered bottom comprised an average of 62% of the transected area.

3.2 Biotic Community Structure

3 2 1 Benthic Invertebrate Communities

Table 2 shows abundance estimates of macroinvertebrates observed throughout the region of study. Macroinvertebrates abundance off the entire Ewa Marina site is considered deficient compared to many other areas of the south coast of Oahu. The depauperate nature of the area appears to be a result of the lack of suitable substratum complexity to afford shelter, near constant abrasion from shifting sand, and concusssive force of breaking waves that frequently impact the broad nearshore platform

While a relatively small component of bottom cover, the most abundant taxon of benthic invertebrates throughout the reef zones off the Ewa Marina property were Scleractinian (reef-building) corals. Other dominant macroinvertebrates were the colonial "soft corals" *Palythoa tuberculosa* and *Anthelia edmondsoni*. The other major group of attached benthos that were ubiquitous throughout the reef zones were encrusting sponges of a variety of species. Taxonomy of Hawaiian sponges is not well documented, and most of the observed species were not identifiable to the species level. One species, *Iotrocha protea*, which occurs in a distinct conical growth form was noted throughout the region of study

Motile macrobenthos were generally considered rare in occurrence throughout the region of monitoring Several species of sea cucumbers (*Actinopyga mauritiana, Holothuria atra* and *H.

nobilis*) were seen scattered over the limestone reef platform, generally in the deeper zones where wave action is least intense. Sea urchins were also generally scarce throughout the area The most common urchins were the species that inhabit interstitial spaces within the carbonate reef framework (*Echinometra mathaei, E. oblonga*, and *E. aciculatus*). Larger species that inhabit the surface of the reef included *Tripneustes gratilla, Echinothrix spp.*, and *Heterocentrotus mammillatus*. Other forms of benthic macroinvertebrates listed in Table 1 were extremely rare in occurrence

The design of the reef survey was such that no cryptic organisms or species living within interstitial spaces of the reef surface were enumerated. Since this is the habitat of the majority of mollusks and crustacea, detailed species counts were not included in the transecting scheme. No dominant communities of these classes of biota were observed during the reef surveys at any of the study stations.

3.2.1.1 Coral Community Structure

Descriptively, the entire Ewa region surveyed can be considered a sub-optimal environment for coral colonization and growth, resulting in the low coverage estimates Most of the colonies observed in the region were small, flat encrustations growing either on the flat reef pavement, or the tops of the shallow ridges of the ridge and groove structures In areas where there was vertical relief, especially on transect 2-60, larger and more abundant coral colonies were observed occupying substratum that was raised off the bottom.

Results of quantitative line transects provide a data base characterizing reef coral community structure. Table 2 shows the quantitative summary of coral community structure, while Appendix A is comprised of individual transect results In total, seven species of corals were encountered on transects, while the number of coral species on a single transect ranged from zero to seven. Four species of corals (*Leptastrea purpurea, Cyphastrea ocellina, Pavona varians* and *Pavona duerdeni*) were observed in the study area, but did not occur on any transects (see Table 1) The dominant species on all of the Ewa transects was *Porites lobata*, which accounted for about 64% of total coral cover. The second most abundant species, *Pocillopora meandrina*, accounted for about 27% of coral cover. Thus, bottom cover of the five remaining species encountered on transects totaled about 9%.

Total coral cover on transects ranged from 0 to 41%. No corals were observed at any of the stations in the shallow intertidal areas. Considering transects between the 15 and 30 foot depths, coral cover averaged 4.6% of bottom cover. Results of another benthic survey limited to the specific regions of the proposed channel alignment indicated an average coral cover of 3.7% on nine transects located at depths of 6 to 20 feet (Dames and Moore 1986). Because transect locations are selected to characterize areas of hard bottom, extrapolation of coral cover to the entire offshore area will tend to produce an overestimate, as sandy areas with no coral are not taken into account Thus, a liberal estimate of coral cover for the region that will experience environmental change owing to channel excavation is about 4% of bottom cover.

3.2.2 Algal Community Structure

Table 3 shows results of qualitative assessments of marine algal abundance in each of the transect areas. In general, algal abundance was highest in the nearshore intertidal regions and decreased with distance from the shoreline, as well as depth. However, many of the same species were observed across the entire depth regime. While the biomass of algae was high, especially in the intertidal areas, the species diversity was relatively low. A total of thirty species were identified, with a high of 23 species in a single area (1-INT). By comparison, the maximum number of species encountered on a transect in the previous survey of the channel area was 18 (Dames and Moore 1986).

In the present monitoring survey, several dominant species occurred in the intertidal area. *Chaetomorpha antennina*, occurred ubiquitously throughout the area growing on the shoreline limestone scarp above the low tide mark. In the shallow offshore areas, the dominant algae was *Hypnea spp.*, which essentially carpeted the bottom in thick mats in many areas. Other common species in the shallow intertidal region were *Acanthophora specifera*, *Caulerpa racemosa*, *C. sertularoides*, and *Halimeda discoidea*.

Dominant algal species on the 15 and 30 foot deep transects were *Caulerpa spp.*, *Halimeda spp.*, *Asparagopsis taxiformis*. *Acanthophora specifera*, and *Lyngbya majuscula*. On the deep 60 foot transects algal occurrence was relatively low compared to the shallower regions. *Asparagopsis taxiformis* and *Lyngbya majuscula* were the dominant frondose forms, while a variety of encrusting red algal species were ubiquitous on much of the reef platform.

An important concern with respect to environmental impacts of the proposed Ewa Marina is the potential effects on populations of green sea turtles (*Chelonia mydas*) that inhabit the area. Turtles are known to feed on fleshy algae in intertidal regions. In the main Hawaiian Islands, the dominant turtle forage species are *Pterocladia spp.* and *Amansia spp.* Besides these species, the predominant algal genera that have been documented as preferred by green turtles are *Codium*, *Ulva*, *Caulerpa*, *Turbinaria*, and *Spyridia* (Balazs 1980).

Neither the present monitoring survey, nor the assessment of biota in the channel alignments (Dames and Moore 1986) report the presence of the two algae (*Pterocladia* and *Amansia*) that comprise the major turtle forage species. Three of the other species listed as food sources (*Codium*, *Ulva*, and *Caulerpa*) were common in occurrence in the Ewa region during both reef assessments, but did not comprise a substantial portion of algal biomass. *Hypnea*, the predominant algal species observed at the Ewa sites, has been cited as a minor component of turtle grazing (Balazs 1980).

3.2.3 Reef Fish Community Structure

Results of reef fish community transects are presented in Table 5. On individual transects where fish were encountered, the number of fish species ranged from 8 to 36, the number of individuals ranged

from 23 to 372, and species diversity ranged from 1.55-3.01. A total of 1,326 individuals representing 63 species were noted. The most abundant fish was the blackfin chromis (*Chromis vanderbilti*), a small planktivorous damselfish that forms feeding schools of up to hundreds of individuals. Over four hundred (466) individuals of this species were counted in the course of the present monitoring survey.

As is typical of most reef fish communities in Hawaii, the assemblages off of Ewa appear to be dependent upon the physical structure of the bottom. Areas with little structural relief and coral cover were poor habitats for reef fish. In such areas, few fish were noted and most of these were species such as triggerfishes (humuhumu, Balistidae) and hawkfish (Cirrhitidae). Individuals from these families often inhabit barren areas, and take shelter in small crevices in the reef platform or in isolated coral colonies.

In contrast, areas with low rock ledges or considerable coral growth harbored substantial numbers of fish from several different species. The fish in such areas can be grouped into four general categories: juveniles, planktivores, herbivores, and rubble-dwelling fish.

Juvenile fish belonged mostly to the family Acanthuridae (surgeon fish), with representatives from the families Labridae (wrasses), Mullidae (goat fish) and Chaetodontidae (butterfly fish). The predominant planktivorous fish were the blackfin chromis (*C. vanderbilti*), the sergeant-major damselfish (mamo, *Abudefduf abdominalis*), and the milletseed butterflyfish (lau-wiliwili, *Chaetodon miliaris*). The primary herbivores were the convict tang (manini, *Acanthurus triostegus*), the brown surgeonfish (ma'i'i, *A. nigrofuscus*), the bluelined surgeonfish (maiko, *Acanthurus nigroris*), the orangeband surgeonfish (na'ena'e, *A. olivaceus*), and the orangespine unicornfish (umaumalei, *Naso lituratus*). The primary rubble dwelling fish were the saddle wrasse (hinalea lau wili, *Thalasoma duperrey*), the manybar goatfish (moano, *Parupeneus multifasciatus*), and angelfish (*Centropyge spp.*)

Only a few "food fish" (taken by commercial and/or recreational fishermen) were observed during the survey. A school of approximately 50 blue-lined snapper (taape, *Lutjanus kasmira*) were observed at one site. A large bluespotted grouper (roi, *Cephalopholis argus*) was also seen. Rocky ledges and large coral heads sheltered occasional squirrelfish (u'u, *Myripristes berndti*). Other food fish included goatfish (moana kea and malu, *Parupaneus cyclostomus* and *P. bifasciatus*) and surgeonfish (palani and kala, *Acanthurus dussumieri* and *Naso unicornus*). Overall, however, such fish were quite rare, tended to be small, and avoided divers. It was noted during the course of the monitoring survey that this area is subject to substantial fishing pressure which has noticeably impacted the abundance, size and behavior of sought-after species.

4. SUMMARY

1. The initial phase of benthic and reef fish community structure monitoring off the proposed Ewa Marina development was conducted in October of 1990. Ten transects were quantitatively investigated at three stations located offshore of the property. In addition, qualitative investigations were conducted in the shallow intertidal region along the length of the project site.

2. Physical structure of the nearshore region consists predominantly of fossil limestone shorelines that form the land-sea interface. The offshore region is characterized by a broad, flat platform that is the seaward extension of the Ewa Plain. The major physiographic attribute of the area shallower than about 30 feet is a weakly developed ridge and groove pattern, with low flat ridges separated by sandy channels. At depths greater than about 30 feet the bottom is composed of either flat limestone areas, or expanses of sand.

3. Reef biota is limited throughout the region owing to a lack of complexity of substratum, scour by moving sediments, and concussive force of breaking waves. Motile invertebrates are scarce, with the most dominant forms being sea urchins that reside in interstitial grooves bored in the limestone reef platform.

4. Coral cover is limited throughout the region except at some of the deeper areas where ridge and grooves are more prominent. In the shallow intertidal area, corals are essentially absent; in the 15 to 30 foot depth zones, a liberal estimate of overall coral cover is 4%. Most of the individual colonies comprising coral cover are small, flat encrusting species on areas of the reef platform that are somewhat elevated above the areas where sand movement predominates.

5. Marine algae were abundant off the Ewa sites, and probable composed the highest component of reef biomass throughout the region of study. Algal abundance was highest in the nearshore regions and decreased moving seaward and into deeper water. The most dominant species in the intertidal areas was *Hypnea*, which carpeted the bottom in dense clustered aggregations. While marine algae were very common in the nearshore regions, the most abundant species have not been documented as preferred food sources for green sea turtles.

6. As is typical of most reef fish communities in Hawaii, the assemblages off of Ewa appear to be dependent upon the physical structure of the bottom. Areas with little structural relief and coral cover were poor habitats for reef fish. In such areas, few fish were noted. In contrast, areas with low rock ledges or considerable coral growth harbored substantial numbers of fish from several different species. The fish in such areas can be grouped into four general categories: juveniles, planktivores, herbivores, and rubble-dwelling fish. Substantial fishing pressure in the area is reflected in reduced populations of certain target species.

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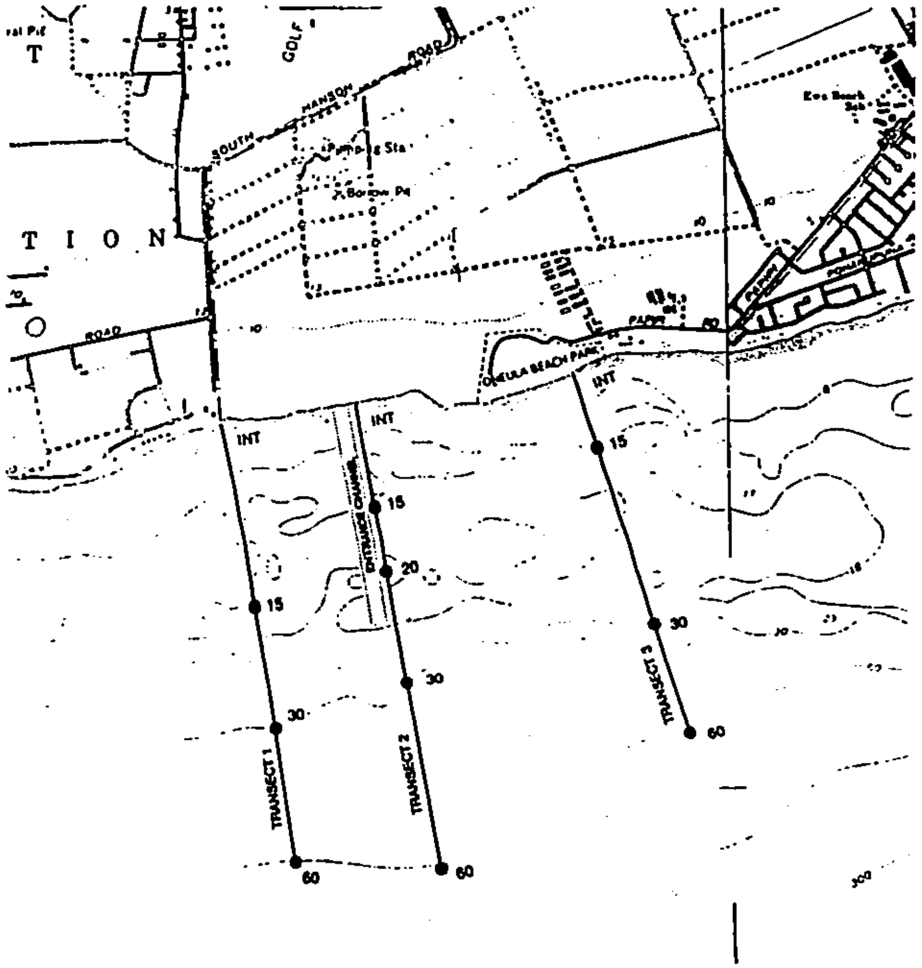

FIGURE 1. Map showing location of proposed Ewa Marina channel, and positions of three biological monitoring transects. Quantitative line transects were conducted at depths shown. "INT" indicates intertidal areas where quantitative surveys were conducted.

TABLE 1. Coral species percent cover, non-coral substrata cover, and coral community statistics for transects off the proposed Ewa Marina. For transect locations, see Figure 1.

CORAL SPECIES	TRANSECT									
	T-1 15'	T-1 30'	T-1 60'	T-2 15'	T-2 20'	T-2 30'	T-2 60'	T-3 15'	T-3 30'	T-3 60'
Porites lobata	3.0	6.7	1.3		3.9	5.9	26.6		1.6	1.3
Porites compressa							1.4			
Porites brighami							0.3			
Pocillopora meandrina		5.5				2.2	7.5	4.6	1.6	
Pocillopora eydouxi							1.6			
Montipora patula						0.3	1.2			
Montipora verrucosa			1.3				2.4			1.3
TOTAL CORAL COVER	0.3	12.2	2.6	0.0	3.9	8.4	41.0	4.6	3.2	2.6
NUMBER OF SPECIES	1	2	2	0	1	3	7	1	2	2
CORAL COVER DIVERSITY	0	0.69	0.69	0	0	0.72	1.14	0.00	0.69	0.69
NON-CORAL SUBSTRATA										
Limestone	36.7	25.6	57.4	18.6	36.7	46.7	37.5	27.5	24.3	36.2
Sand/Rubble	63.0	62.2	42.3	81.4	59.4	49.4	62.5	67.9	72.5	61.2

TABLE 2. Marine invertebrate occurrence at survey stations off the proposed Ewa Marina.
For station locations, see Figure 1.
Abundance code: "R" = rare (0 – 5 individuals or colonies sited on station)
"O" = occasional (5 – 20 individuals or colonies sited on station)
"C" = common (more than 20 individuals or colonies sited on station)

	TRANSECT									
	T-1 15'	T-1 30'	T-1 60'	T-2 15'	T-2 20'	T-2 30'	T-2 60'	T-3 15'	T-3 30'	T-3 60'
SCLERACTINIA										
(Reef-Building Corals)										
Porites lobata	C	C	C	R	C	C	C	C	C	C
Porites compressa			C				C			C
Porites brighami							R			
Pocillopora meandrina	R	O	C		C	C	C	C	C	C
Pocillopora eydouxi							R			
Montipora verrucosa	R	R	R		O	C	O	R	R	R
Montipora patula	R	R	R		O	O	O	R	R	R
Leptastrea purpurea	R	R	R					R		R
Cyphastra ocellina									R	
Pavona varians							R			
Pavona duerdeni										R
ZOANTHINIARIA										
(Colonial "soft" corals)										
Palythoa tuberculosa	R	R	R		R	R	R	R	R	R
ALCYONACEA										
(Colonial "soft" corals)										
Anthelia edmondsoni		R	R	R	R	R	R		R	R
HOLOTHUROIDEA										
(Sea Cucumbers)										
Actiopyga obesa										
Holothuria atra	R	R	R	R	R	R	R	R	R	R
Holothuria nobilis	R	R	R		R		R	R		R
ECHINOIDEA										
(Sea Urchins)										
Echinothrix diadema		R			R	R		R	R	
Echinothrix calamaris								R		
Tripneustes gratilla	R	R		R	C	C	R	C	O	
Echinometra mathaei	R	O	R	R	C	C	O	C	C	R
Echinometra oblonga	R			R						
Echinostrephus aciculatus	R	O						R		
Heterocentrotus mammillatus	R	R	R		R	R		R	R	R
ASTEROIDEA										
(Starfish)										
Linckia diplax					R	R				
MOLLUSCS										
Spondylus tenebrosus				R						
CRUSTACEA										
Panulirus penicillatus										R
PORIFERA										
Iotrochota protea		R	C	C	C	C	C	C	C	C
misc. sponges	C	C	C	C	C	C	C	C	C	C

TABLE 3. Marine algae occurrence at Survey stations in the vicinity of the Ewa Marina.
For station locations, see Figure 1.
Abundance code:
"R" = rare (0 – 5 individuals or colonies sited on station)
"O" = occasional (5 – 20 individuals or colonies sited on station)
"C" = common (more than 20 individuals or colonies sited on station)

	TRANSECT									
	T-1 15'	T-1 30'	T-1 60'	T-2 15'	T-2 20'	T-2 30'	T-2 60'	T-3 15'	T-3 30'	T-3 60'
CHLOROPHYTA										
(Green algae)										
Caulerpa racemosa	C	C		C	C	C		C		
Caulerpa sertularoides	C	C		C	C	C		C		
Chaetomorpha antennina	C			C				C		
Codium spp.	R	R	R	O	O	R		O	O	
Dictyosphaeria spp.	R	R		R	R			R		
Enteromorpha sp.	C	C	C	C	C	C	C	C	C	C
Halimeda spp.	C	C	C	C	C	C	C	C	C	C
Neomeris annulata		O	O	O	O	O	O		O	O
Ulva spp.	O	O		C	O	O		C	O	
Valonia spp.			R			R	R			R
CYANOPHYTA										
(Blue-green algae)										
Lyngbya majuscula			C			C				C
PHAEOPHYTA										
(Brown algae)										
Dictopteris app.	C	C	O	C	C	C	R	O	O	R
Dictyota spp.	O	O	R	O	O	O	R	O	O	R
Padina spp.						O				
Ralfsia sp.			O				O		O	O
RHODOPHYTA										
(Red Algae)										
Acanthophora specifera	C	C	O	C	R	C	O	C	O	O
Amphiroa fragilissima	C	C		C	C	C	R	C	C	R
Asparagopsis taxiformis	R		C				C			C
Corallina spp.	O	O	O	O	O	O	O	O	O	O
Desmia hornemanii	O	R	R	R	O	R	R	R	R	R
Galaxaura spp.	O	O		O	O		O			
Hydrolithon spp.	C	C	C	C	C	C	C	C	C	C
Hypnea spp.	C	C		C	C			C	C	
Jania spp.	C	C		C	C	R	C	C	C	R
Martensia fragilisimis	O	O	O		R	R		R	O	
Neogoniolithon sp.	C	C	C	C	C	C	C	C	C	C
Peysonellia rubra sp.	C	C	C	C	C	C	C	C	C	C
Porolithon spp.	C	C	C	C	C	C	C	C	C	C

TABLE 4. Reef fish community statistics for transects off the proposed Ewa Marina. For transect locations, see Figure 1.

FAMILY / Species	T-1 15'	T-1 30'	T-1 60'	T-2 15'	T-2 20'	T-2 30'	T-2 60'	T-3 15'	T-3 30'	T-3 60'
SYNODONTIDAE										
Synodus sp.										2
MURAENIDAE										
Gymnothorax meleagris										
G. flavimarginatus			1							
AULOSTOMIDAE										
Aulostomus chinensis			1				1			
CIRRHITIDAE										
Cirrhitops fasciatus		1					2			
Paracirrhites arcatus		2	4		1		13		1	3
MULLIDAE										
Parupeneus multifasciatus		7			5	25	8	25	19	9
P. pleurostigma	1					4				7
P. bifasciatus						1				
P. cyclostomus						3				
SERRANIDAE										
Cephalopholis argus						1				
LUTJANIDAE										
Lutjanus kasmira						50				
CHAETODONTIDAE										
Chaetodon lunula	2									
C. quadrimaculatus		2					1			
C. miliaris		2				50	5			3
C. multicinctus		2				7	7			4
C. fremblii						2	3			2
C. kleinii							4			3
Forcipiger flavissimus		3				3				1
POMACANTHIDAE										
Centropyge potteri							4			4
C. fisheri							12			

TABLE 4. continued

FAMILY / Species	T-1 15'	T-1 30'	T-1 60'	T-2 15'	T-2 20'	T-2 30'	T-2 60'	T-3 15'	T-3 30'	T-3 60'
POMACENTRIDAE										
Abudefduf abdominalis		2				50				
Plectro. johnstonianus						1	1			
P. imparipennis		2			3			1	1	
Stegastes fasciolatus		1				6				
Dascyllus albisella		3				2				3
Chromis agilis		1				20	1			
C. vanderbilti		6			60	50	220	10	20	100
LABRIDAE										
Cheilinus bimaculatus			1						1	
Bodianus bilunulatus										1
Coris gaimard						1		1		2
C. venusta		2				3				
Anampses chrysocephalus										1
A. cuvier						1				
Thalassoma duperrey	6	8			7	20	15	9	13	9
T. trilobatum	1									
Labroides phthirophagus						1				
Macropharyngodon geoffroy						3	2			1
Stethojulis balteata	2	4			3	5		6		
Halichoeres						4				
ACANTHURIDAE										
Zebrasoma flavescens							1			1
A. triostegus	4	5			13	10		10	1	
A. olivaceus		7			3	9	4	3	2	1
A. dussumieri	2				3					
A. blochii	1	2			7	2				
A. nigrofuscus		2			6	6	9			8
A. nigrorus		16				15		1		
Ctenochaetus strigosus							7			
Naso lituratus		3	20		2	6				2
N. unicornis										3
ZANCLIDAE										
Zanclus cornutus						1				
BLENNIIDAE										
Exallias brevis							1			
Plagiotremus ewaensis							2		1	

TABLE 4. continued

FAMILY Species	T-1 15'	T-1 30'	T-1 60'	T-2 15'	T-2 20'	T-2 30'	T-2 60'	T-3 15'	T-3 30'	T-3 60'
					TRANSECT					
MONOCANTHIDAE										
Pervagor spilosoma								1		
BALISTIDAE										
Rhinecanthus rectangulus	2	4			5	2			1	3
R. aculeatus		1				1				
Sufflamen bursa		8							5	
S. fraenatus		2	5		2	3		1	1	2
Melichthys vidula		1								
M. niger						1				
Xanthichthys auromarginatus							12			9
TETRADONTIDAE										
Canthigaster jactator	2	2	4		2	3	5	1		3
C. coronata			3				2			5
NUMBER SPECIES	10	28	8	No	15	36	25	12	12	27
NUMBER INDIVIDUALS	23	101	39	Fish	122	372	342	69	66	192
SPECIES DIVERSITY	2.125	3.031	1.552		1.931	2.810	1.666	1.910	1.786	2.136

APPENDIX A.

REEF CORAL TRANSECT DATA SHEET
(PERCENT COVER)

TRANSECT SITE:	EWA	MEAN CORAL COVER	0.3 %
TRANSECT ID #:	I-15'	STD. DEV.	0.6
DATE:	08/25/90	SPECIES COUNT	1
		SPECIES DIVERSITY	0

SPECIES	QUADRAT 1	2	3	4	5	6	7	8	9	10	SPECIES TOTAL
Porites lobata					1					2	3.0
QUADRAT TOTAL	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	2.0	3.0

REEF CORAL TRANSECT DATA SHEET
(PERCENT COVER)

TRANSECT SITE:	EWA	MEAN CORAL COVER	12.2 %
TRANSECT ID #:	I-30'	STD. DEV.	11.4
DATE:	08/25/90	SPECIES COUNT	2
		SPECIES DIVERSITY	0.688

SPECIES	QUADRAT 1	2	3	4	5	6	7	8	9	10	SPECIES TOTAL
Porites lobata		3.0			21	18		21	1	3	67.0
Pocillopora meandrina	11.0	5.0			13	7	2	5	10	2	55.0
QUADRAT TOTAL	11.0	8.0	0.0	0.0	34.0	25.0	2.0	26.0	11.0	5.0	122.0

REEF CORAL TRANSECT DATA SHEET
(PERCENT COVER)

TRANSECT SITE:	EWA	MEAN CORAL COVER	2.6 %
TRANSECT ID #:	I-60	STD. DEV.	2.4
DATE:	08/25/90	SPECIES COUNT	2
		SPECIES DIVERSITY	0.693

SPECIES	QUADRAT 1	2	3	4	5	6	7	8	9	10	SPECIES TOTAL
Porites lobata		1	2		1	1	4	1	1	2	13.0
Montipora verrucosa	1					1	3	1		5	13.0
QUADRAT TOTAL	1.0	1.0	2.0	0.0	1.0	2.0	7.0	4.0	1.0	7.0	26.0

REEF CORAL TRANSECT DATA SHEET
(PERCENT COVER)

TRANSECT SITE:	EWA	MEAN CORAL COVER	3.9 %
TRANSECT ID #:	II-20'	STD. DEV.	6.3
DATE:	08/25/90	SPECIES COUNT	1
		SPECIES DIVERSITY	0

SPECIES	QUADRAT 1	2	3	4	5	6	7	8	9	10	SPECIES TOTAL
Porites lobata	1	5	14	18						1	39.0
QUADRAT TOTAL	1.0	5.0	14.0	18.0	0.0	0.0	0.0	0.0	0.0	1.0	39.0

REEF CORAL TRANSECT DATA SHEET
(PERCENT COVER)

TRANSECT SITE:	EWA	MEAN CORAL COVER	8.4 %
TRANSECT ID #:	II-30'	STD. DEV.	7.2
DATE:	08/25/90	SPECIES COUNT	3
		SPECIES DIVERSITY	0.718

SPECIES	QUADRAT 1	2	3	4	5	6	7	8	9	10	SPECIES TOTAL
Porites lobata	13	6		5		1	16	6		12	59.0
Pocillopora meandrina		9						11	2		22.0
Montipora patula								3			3.0
QUADRAT TOTAL	13.0	15.0	0.0	5.0	0.0	1.0	16.0	20.0	2.0	12.0	84.0

REEF CORAL TRANSECT DATA SHEET
(PERCENT COVER)

TRANSECT SITE:	EWA	MEAN CORAL COVER	41 %
TRANSECT ID #:	II-60'	STD. DEV.	14.3
DATE:	08/25/90	SPECIES COUNT	7
		SPECIES DIVERSITY	1.138

SPECIES	QUADRAT 1	2	3	4	5	6	7	8	9	10	SPECIES TOTAL
Porites lobata	29	21	24	24	46	15	34	26	26	21	266.0
Porites compressa	8			2			3			1	14.0
Porites brighami							3				3.0
Pocillopora meandrina	5	9	3	6	2	16	23		3	8	75.0
Pocillopora eydouxi						16					16.0
Montipora verrucosa	24										24.0
Montipora patula					6			3	3		12.0
QUADRAT TOTAL	66.0	30.0	27.0	32.0	54.0	47.0	63.0	29.0	32.0	30.0	410.0

REEF CORAL TRANSECT DATA SHEET
(PERCENT COVER)

TRANSECT SITE:	EWA	MEAN CORAL COVER	4.6 %
TRANSECT ID #:	III-20'	STD. DEV.	6.8
DATE:	08/25/90	SPECIES COUNT	1
		SPECIES DIVERSITY	0

SPECIES	QUADRAT 1	2	3	4	5	6	7	8	9	10	SPECIES TOTAL
Pocillopora meandrina	12	8				21	5				46.0
QUADRAT TOTAL	12.0	8.0	0.0	0.0	0.0	21.0	5.0	0.0	0.0	0.0	46.0

REEF CORAL TRANSECT DATA SHEET
(PERCENT COVER)

TRANSECT SITE:	EWA	MEAN CORAL COVER	3.2 %
TRANSECT ID #:	III-30'	STD. DEV.	3.5
DATE:	08/25/90	SPECIES COUNT	2
		SPECIES DIVERSITY	0.693

SPECIES	QUADRAT 1	2	3	4	5	6	7	8	9	10	SPECIES TOTAL
Porites lobata		1		1		1	5	4		4	16.0
Pocillopora meandrina			3	1			4	3		5	16.0
QUADRAT TOTAL	0.0	1.0	3.0	2.0	0.0	1.0	9.0	7.0	0.0	9.0	32.0

REEF CORAL TRANSECT DATA SHEET
(PERCENT COVER)

TRANSECT SITE:	EWA	MEAN CORAL COVER	2.6 %
TRANSECT ID #:	III-60	STD. DEV.	2.4
DATE:	08/26/90	SPECIES COUNT	2
		SPECIES DIVERSITY	0.693

SPECIES	QUADRAT 1	2	3	4	5	6	7	8	9	10	SPECIES TOTAL
Porites lobata		1	2		1	1	4	1	1	2	13.0
Montipora verrucosa	1					1	3	3		5	13.0
QUADRAT TOTAL	1.0	1.0	2.0	0.0	1.0	2.0	7.0	4.0	1.0	7.0	26.0

Appendix I

Marine Algae Surveys for the Ewa Marina Coastline

AECOS No. 643

MARINE ALGAE SURVEYS FOR THE EWA MARINA COASTLINE

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INTRODUCTION

Relative to development of the Ewa Marina Project at Ewa Beach on Oahu, AECOS Inc. conducted algal surveys along and off the shoreline. Proposed is the development of a 140 acre marina. The marina will be excavated from land behind the shoreline, and subtidal areas will be disturbed only by the dredging of the entrance channel some 125 meters wide by 900 meters long and 6 meters deep. However, concern about the effect of the marina construction on the habitat and food supplies of a threatened species of sea turtle (Chelonia midas) prompted a year long, bimonthly monitoring survey of sea turtles off the Ewa Marina site. Information available from three surveys (Marine Research Consultants, 1991) has shown most sightings to occur east of One'ula Beach Park and off White Plains Beach of the Barbers Point Naval Air Station (Figure 1) in 20 to 40 meters depth. Up to 14 turtles have been sighted on a given survey, suggesting an abundant population utilizing locally available food sources.

The present survey was conducted in May 1991 to characterize the species and abundances of marine macroalgae along the shore and in nearshore areas that could be affected by the proposed Ewa Marina Project. This information will be of use for evaluating the impact of this development on potential food sources of the sea turtle population.

METHODS

Surveys along four transects off the Ewa Marina site were conducted on May 8 and 9, 1991. Transect locations are shown on Figure 1. The western and eastern most transects (Transects "W" and "E") coincided approximately with the area where most turtles have been sighted further offshore (Marine Research Consultants, 1991). Transects "L" and "R" were located off the Ewa Marina Project coastline in areas considered typical of the shore and nearshore environments between White Plains Beach and Keku Point. Each transect extended about 50 m offshore to about 1.5 m depth. Points 5 meters apart along the transect were used as location markers for the placement of a 20 cm square frame (area = 0.04 m^2). Because of generally unfavorable conditions close to shore, biomass samples from the segment of Transect "L" crossing the marine bench could not be obtained.

All algae that could be removed by hand from within the quadrat frame were collected and transferred into plastic ziplock bags. Samples were returned to the laboratory where they were held under refrigeration until sorted within 48 hours. Algae species from each sample were sorted under a dissecting microscope, identified, and then weighed after towel drying to the nearest 0.01 g on a top loading electronic balance.

The site was again visited during a low tide on May 30. At this time, observations and collections were made along the shore and marine bench between Barbers Point Naval Air Station (BPNAS) and Pupu Place in 'Ewa Beach. The purpose of this survey was to obtain a qualitative description of the algae growing in the intertidal area. This environment is one which can not be surveyed easily at high tides or under high surf conditions, but one which generally differs in composition of species from the subtidal area surveyed earlier. Because the marine bench has a more "typical" form off the town of 'Ewa Beach than off the Ewa Marina property, the shoreline off Pupu Place was visited for comparative purposes.

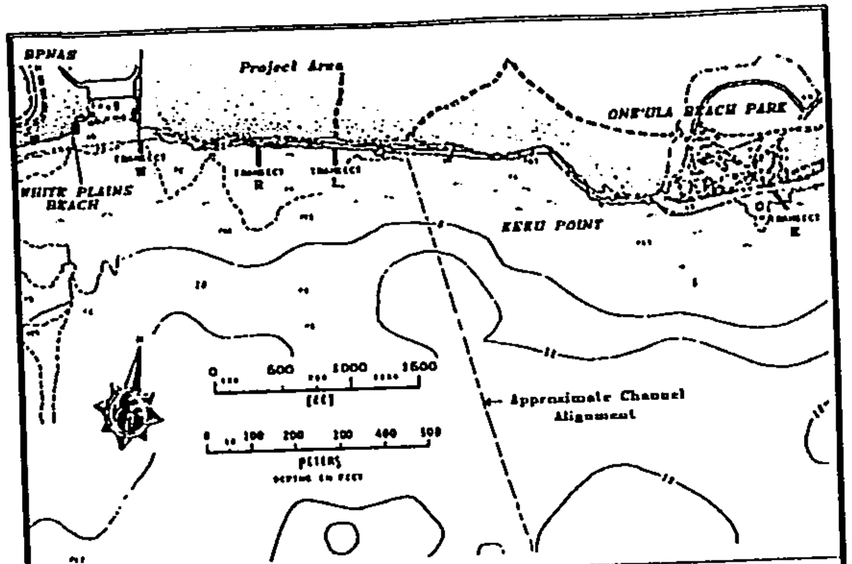

Figure 1. Locations of Nearshore Algal Sampling Transects for the Ewa Marina Project.

SITE DESCRIPTION

The Ewa Marina area is highly exposed to wave and wind turbulence. Despite its location on the leeward side of Oahu, sufficient fetch across Mamala Bay exists for substantial wind waves to be generated by tradewinds. In addition, the area is seasonally exposed to deep ocean swells from the south during summer months and to waves generated by Kona storms primarily during the winter. Consequently the water along the shoreline is frequently turbulent and turbid, and the marine substrata and communities are characteristic of high energy environments such as normally occur on windward reefs. During the time of our survey the surf was moderately high and the water was quite turbid with suspended sediments, making working conditions characteristically difficult.

The shoreline at One'ula Beach Park and at the east end of Barbers Point Naval Air Station (White Plains Beach) is sand beach. Between these areas, which includes nearly all of the Ewa Marina coastline, the shore is an emergent reef limestone some 2 meters high. The erosion of this limestone formation shows some characteristics of a marine bench (Wentworth, 1939), but on the whole is atypical. The "bench" portion is submerged at all but the lowest tides, and has a broken, uneven surface that merges with the offshore sand and limestone bottom without a distinct foreslope. Behind this "bench", the surface rises vertically (or is undercut) one or two meters, then extends as a rock ledge inland for one to several meters with a typical pitted "makatea" surface along the seaward portion of the ledge.

Although this "bench" is generally different in form from that observed along the west shore of Barbers Point (AECOS, 1991b) and elsewhere, the submerged and wave-washed surface of the limestone does support a dense growth of macroalgae as is characteristic of the sublittoral fringe environment in Hawaii.

Descriptions of the Shore and Marine Bench

At the west end of the Ewa Marina Project, White Plains Beach extends about 40 to 50 meters eastward along the shore

from the BPNAS fence. From this point eastward around Keku Point, the shoreline is a continuous limestone feature which rises between 2 and 2.5 meters above sea level. Directly east of White Plains beach, the steep-faced limestone is fronted by a sand deposit that uncovers at low tide. This sand covers most of the marine bench, which has an irregular surface of narrow grooves and ridges. Sand fills the grooves near White Plains Beach, but diminishes eastward. The bench width is between 10 and 20 meters, with the outer edge consisting of fingers of limestone that merge with the sand and limestone bottom offshore. A dense cover of red-tinged macroalgae makes these limestone ridges stand out.

In general, the algal flora on the limestone at and just below the shore is dominated by the same species all along the coast surveyed, with some conspicuous changes in abundances and or dominances as noted below. Generally common to abundant at all sites were *Chaetomorpha antennina*, *Dictyosphaeria versluysii*, and *Acanthophora spicifera* highest on the shore; *Hypnea musciformis*, *Acanthophora spicifera*, *Porolithon onkodes*, *Laurencia* spp., *Ulva fasciata*, and *Pterocladia capillacea* lowest on the bench. In the area just east of White Plains Beach, *Asparagopsis taxiformis* and *Caulerpa taxifolia* are common on the bench, whereas *Pterocladia capillacea* appears not very plentiful.

Eastward from White Plains Beach, the sand deposit at the back of the bench disappears and the surface slopes downward along the shore. At the location our Transect "L", the bench surface is covered by about a meter of water at low tide. In this area, which is typical of much of the shore at the project site, coverage by *Chaetomorpha antennina*, *Dicytyosphaeria versluysii*, *Hypnea chordacea*, *Pterocladia caerulescens*, and *Laurencia crustiformans* (McDermid, 1989) is high on the vertical face and smaller scale shelves of the limestone behind the bench. The bench remnants and low parts of the escarpment are covered by *Pterocladia capillacea*, *Amansia glomerata*, and *Porolithon onkodes*.

East from Transect "L" and the location of the proposed channel alignment, the bench surface rises in elevation. Sand along the shore also increases, presenting again the situation in some places of a narrow sand beach deposited at the base of the low limestone cliff, and with a grooved limestone surface extending seaward of the narrow beach.

The situation at Keku Point is unique for this area. The rock shore includes a shelf or ledge positioned about midway in elevation between the low water mark and the barren, upper surface of the limestone. Although somewhat poorly defined because of erosion cuts perpendicular to shore and an irregular surface, the shelf is seen to slope down to the east where it is continuous with the mostly submerged bench off the west end of One'ula Beach Park. Thus in terms of elevational relationship with sea level and form, the erosion feature at Keku Point is more typical of a marine bench. The bench here supports a dense growth of all the species listed above as typical, with *Gelidiella acerosa*, *Sargassum echinocarpum*, *Pterocladia caerulescens*, *Boodlea composita*, and *Caulerpa racemosa* also common to abundant. *Pterocladia capillacea* is abundant on the frontal slope portion of this feature.

Along the One'ula Beach Park shoreline and east beyond 'Ewa Plantation Beach, the shoreline is sand with scattered outcrops of limestone. Where a "bench" is present, it is ramped (slopes downward into the sea), grooved, and in the shoreward direction either disappears under the beach or connects to low limestone outcrops on the beach. *Ulva fasciata* is the most prominent species of alga here. In addition, *Hypnea musciformis*, *Padina japonica*, *Sargassum echinocarpum*, *Acanthophora spicifera*, *Cladophora* sp., *Centroceras* sp., and *Caulerpa taxifolia* are all common on the bench at the west end of the park.

At the east end of 'Ewa Plantation Beach, a limestone reef-rock shore with a vertical escarpment around 2 meters high is again found, and extends for about 1.5 km east as a continuous and prominent feature of the 'Ewa Beach coastline. A marine bench is found seaward of the escarpment, and was surveyed for this report at the end of Pupu Place in 'Ewa Beach. The form of the bench is generally similar to that observed in the project area, although the bench surface may be slightly higher in elevation, is generally no more than 10 meters across, and appears fairly distinct from the offshore bottom. The surface is irregular, pocked by large holes and grooves. Rounded boulders covered by *Porolithon onkodes* are scattered over much of the surface at this location, although this appears not to be

typical situation. The boulders originated from a nearby massive retaining wall of mostly loose, rounded stones.

Algal growth on the bench includes all of the typical species listed above, although *Chaetomorpha antennina* is not abundant along the back of the bench or on the escarpment at the location surveyed. *Pterocladia capillacea* is abundant along the frontal slope. Other species common on the bench here are *Grateloupia hawaiiana*, *Caulerpa racemosa*, *Dictyota* sp., *Hypnea chordacea*, *Laurencia nidifica*, and *Sargassum echinocarpum*.

Descriptions of the Nearshore Reef

Transect "H" was located seaward from the fence line separating the Ewa Marina property from the Naval Air Station and Transect "E" ran seaward of a coastal defense bunker near the center of One'ula Beach Park (Figure 1). Both areas were primarily beach and offshore sand deposits over a limestone substratum which provided a surface for macroalgal growth. Transect "R" was located about 100 m west of several pipes set into the coastal limestone marking geological survey work relative to the proposed marina channel. Transect "L" was about 20 m west of the pipes. Both of these transects extended from shoreline limestone benches which emerge 1 to 2.5 m above the MLLW mark and have an abundant intertidal algal coverage. The consolidated limestone substratum extends into the subtidal zone beyond the 50 m surveyed, and macroalgae are ubiquitous and abundant along the transect alignments. Also although suspended sediment was less concentrated in the water than at Transects "H" and "E", visibility was obscured by an abundance of detached macroalgae which were drifting freely in the water, having been torn from the bottom by heavy wave turbulence.

RESULTS AND DISCUSSION

The species and wet weight biomasses of macroalgae found at each quadrat on the four transects are shown in Table 1. The results show that both diversity and abundance were substantially greater on the two central transects, which are over a consolidated limestone substratum, than at the west and east transects where the bottom was mostly sand. The highest biomass and greatest number of species occurred at Transect "L", near the center of the Ewa Marina Project coastline. Here 28 species totaled 367 g of macroalgae for nine quadrats (the 5 m quadrat could not be sampled because of dangerous conditions) for a mean of 40.8 g per quadrat, or about 1.02 kg algae per m^2. Transect "R" ranked a close second, with 24 species and a mean of 34.6 g/quadrat, or about 0.85 kg/m^2. Transect "W" had 19 species with a mean of 31.6 g/quadrat or 0.79 kg/m^2, whereas Transect "E" off One'ula Beach Park had only 12 species and 8.6 g/quadrat or only about 0.215 kg/m^2.

The algal communities of the two central transects were dominated by the red alga *Hypnea musciformis*, which, due to its abundance in this area, made up over 40% of the total algal biomass measured for all four transects. This species was so abundant that its detached thalli in the water continually entangled divers and sampling equipment during the survey. The second most abundant species was *Caulerpa taxifolia*, which was the dominant form on the east and west transects over sand substratum. It made up over 22% of the total algal biomass on all four transects. Other abundant species were *Acanthophora spicifera*, *Ulva fasciata* and *Pterocladia capillacea*. Together these five species accounted for nearly 77% of the total biomass of all algae sampled during the survey with 33 species comprising the remaining 23% of the total biomass.

Two previous benthic surveys have been conducted by AECOS off the Ewa Marina site: one in September 1980 and a second in February-March 1986. These were diving surveys and reported either presence-absence or abundance as determined by an in situ point intercept method. The species found on these surveys are shown with the results of the recent survey in Table 2. Only 22 species were reported from the 1980 survey, and 27 from the 1986

Table 1. Algae Species and wet weights (g) on TRANSECT W (Shore to 50 meters) on May 8, 1991

	Quadrat Number										
	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	SUM
Chlorophyta											
Caulerpa racemosa			0.11								0.11
Caulerpa taxifolia	S			2.37	S	103.15		3.53			109.05
Cladophora fascicularis									0.20	0.74	0.94
Cladophoropsis sp.	A	0.02	0.20	26.26*	A		2.75*	3.98		19.95*	53.16
Microdictyon sp.										0.15	0.15
Ulva fasciata	N				N					0.86	0.86
Phaeophyta	D				D						
Dictyota acutiloba				0.02				2.13		4.40	6.55
Dictyota bartayresii							0.04	0.02		0.09	0.15
Padina japonica		0.03								1.21	1.24
Rhodophyta											
Acanthophora spicifera							5.89	39.97		7.16	53.02
Centroceras sp.			3.70				2.51	2.32			8.53
Gracilaria coronopifolia		0.52	0.97								1.49
Hypnea chordacea								2.40			2.40
Hypnea musciformis				0.37		6.38	0.80	12.46	0.63	2.41	23.05
Laurencia nidifica										4.01	4.10
Polysiphonia sp.			0.24								0.24
Peyssonnelia rubra				5.58			0.01	0.69		0.17	6.45
Pterocladia capillacea		0.27									0.27
Spyridia filamentosa								3.08		10.01	13.09
QUADRAT TOTALS	0	0.84	5.22	34.60	0	109.53	12.00	70.58	0.83	51.16	
TRANSECT TOTAL	284.71										
QUADRAT MEAN	31.60										
TOTAL NO. SPECIES	19										

* Sandy

Table 1 (Cont.) TRANSECT R (5 to 50 meters) on May 9, 1991

	Quadrat Number										
	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	SUM
Chlorophyta											
Bryopsis sp.			Tr	Tr	Tr						Tr
Caulerpa racemosa	35.82*				0.18					0.92	36.92
Caulerpa taxifolia		0.11									0.11
Cladophora fascicularis									Tr		Tr
Cladophora luxurians			Tr	Tr	Tr	Tr	1.60*	1.20*	Tr		2.80
Microdictyon sp.				1.31*							1.31
Ulva fasciata	Tr	1.55	1.19	0.18			0.20	1.47	2.97		7.56
Phaeophyta											
Dictyota acutiloba	0.12										0.12
Dictyota bartayresii			Tr							0.14	0.14
Rhodophyta											
Acanthophora spicifera			7.04	0.58	4.65				2.32		14.59
Amphiroa sp.	1.17		0.30					Tr		5.55	7.02
Centroceras sp.					Tr				Tr	0.19	0.19
Coelothrix irregularis						Tr					Tr
Gelidiopsis scoparia	0.10										0.10
Grateloupia sp.	0.70		1.16	0.78							2.64
Hypnea musciformis	7.54	30.96	38.54	28.17	10.54	35.42	5.12	37.61	6.67	5.69	206.26
Jania sp.			Tr	Tr				1.20*	0.33	0.52	2.05
Laurencia nidifica	1.11	1.36	1.11	1.04	0.23	1.23		0.60	2.39		9.07
Martensia fragilis				1.00				2.83	3.02*	7.10	13.95
Plocamium sandvicense	3.88	0.93	0.21							0.80	5.82
Pterocladia capillacea		19.57									19.57
Pterocladia sp.										2.44	2.44
Scinaia hormoides	Tr			0.42	0.78*				Tr		1.20
Spyridia filamentosa		0.45	0.14							0.57	1.16
Unknown	0.92	3.12	0.64*	1.90		2.17		Tr			8.75
QUADRAT TOTALS	53.85	38.05	50.33	35.38	16.38	38.82	6.90	44.91	17.70	23.92	
TRANSECT TOTAL	346.24										
QUADRAT MEAN	34.62										
TOTAL NO. SPECIES	24										

Tr = Trace
* Sandy

Table 1 (cont.) TRANSECT L (5 to 50 meters) on May 9, 1991

	Quadrat Number										
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	SUM
Chlorophyta											
Caulerpa racemosa				0.28			32.08*		0.69		33.05
Caulerpa taxifolia						21.72		Tr	Tr		21.72
Cladophora luxurians			Tr			Tr			Tr		Tr
Codium edule				0.44		5.65			5.02		11.11
Ulva fasciata				0.09	0.19					2.01	2.29
Phaeophyta											
Dictyota acutiloba				Tr		Tr					Tr
Dictyota bartayresii					2.25*			0.57		Tr	2.82
Dictyota sp.									3.66*		3.66
Rhodophyta											
Acanthophora spicifera			0.10	0.28	0.32	8.01		1.63	2.22	1.49	14.05
Amphiroa sp.		15.80	1.43	2.96	8.16	1.76	4.69	Tr	0.37		35.17
Centroceras sp.				Tr			Tr	0.94	Tr	1.80*	2.74
Coelothrix irregularis										1.18	1.18
Dasyopsis sp.									0.09		0.09
Gelidiopsis scoparia											
Gracilaria bursapastoris #										1.01	1.01
Grateloupia sp.		0.08	6.96	9.68	1.60		0.86*	0.62			19.80
Hypnea musciformis		37.22	26.04	20.82	17.17	32.48	30.30	20.99	1.41	6.14	192.57
Jania sp.				Tr		4.71		11.67	Tr	Tr	16.38
Laurencia nidifica						Tr					Tr
Laurencia sp.								0.50			0.50
Martensia fragilis				1.00	0.50			2.83	3.02*	7.10	14.45
Plocamium sandvicense		Tr		Tr	1.06	Tr	Tr	Tr	Tr	0.09	1.15
Polysiphonia sp.											
Pterocladia capillacea			Tr	Tr			1.02*				1.02
Pterocladia sp.			5.13					5.13			10.26
Scinaia hormoides					0.94		0.40	5.43	Tr		6.77
Unknown				0.95	2.00*	Tr		2.27	Tr	Tr	5.22
QUADRAT TOTALS		53.10	39.66	36.50	32.34	44.33	52.58	69.35	18.73	20.82	
TRANSECT TOTAL		367.41									
QUADRAT MEAN		40.82									
TOTAL NO. SPECIES		28									

Tr = Trace
* Sandy

Table 1 (Cont.) TRANSECT E (5 to 50 meters) on May 9, 1991

	Quadrat Number										
	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	SUM
Chlorophyta											
Caulerpa taxifolia			S	1.42		1.99	56.59	S	S	4.69	64.69
Cladophora fascicularis	2.07	Tr	A		0.82	0.37		A	A		3.26
Cladophora sp.	0.90		N					N	N		0.90
Ulva fasciata	12.15	26.68	D		0.35	1.18		D	D		40.36
Phaeophyta											
Dictyota sandvicensis						0.18					0.18
Rhodophyta											
Acanthophora spicifera										0.13	
Coelothrix irregularis						Tr					Tr
Hypnea musciformis				0.06		7.92	6.62			Tr	14.60
Jania sp.						Tr					Tr
Laurencia nidifica						3.03	Tr				3.03
Pterocladia capillacea						0.44					0.44
QUADRAT TOTALS	15.20	26.68	0	1.48	1.17	15.11	63.21	0	0	4.92	
TRANSECT TOTAL	85.89										
QUADRAT MEAN	8.59										
TOTAL NO. SPECIES	11										

Tr = Trace

survey, compared to 38 species in the present transect survey and 49 species including the marine bench area. Many of the species reported from the previous surveys were not found in the present study, and only 19 of the 49 species of macroalgae from the present study were reported in one or the other of the earlier surveys. These different results may be due to a combination of factors such as differences in sampling locations, differences in sampling methods, different investigators, or uncertain taxonomic identifications. One other source of variation could be seasonal changes in the algal assemblages as related to surf parameters. Most significant, however, are probably the environment sampled and the degree of effort expended to identify less conspicuous components of the assemblages.

Table 2. Algal Species Reported for Ewa Marina Nearshore Area For Present and Previous Surveys

Taxon	AECOS 1980	AECOS 1986	Present Surveys[3]
Chlorophyta			
Boodlea composita			MB
Bryopsis sp.			NS
Caulerpa racemosa[2]			NS,MB
Caulerpa taxifolia[2]			NS,MB
Chaetomorpha antennina			MB
Cladophora fascicularis	X		NS,MB
Cladophora luxurians			NS
Cladophora sp.			NS,MB
Cladophoropsis sp.			NS
Codium arabicum[1,2]		X	
Codium edule[1,2]	X	X	NS
Codium reediae		X	
Dictyosphaeria versluysii			MB
Enteromorpha sp.		X	
Halimeda discoidea		X	
Halimeda opuntia	X	X	
Microdictyon sp.			NS
Ulva fasciata[1,2]	X	X	NS,MB
Ulva lactuca[1,2]	X		
Phaeophyta			
Dictyopteris australis		X	
Dictyota acutiloba		X	NS
Dictyota bartayresii	X		NS
Dictyota friabilis	X	X	
Dictyota sandvicensis		X	NS
Dictyota sp.			NS,MB
Padina japonica		X	NS,MB
Sargassum echinocarpum	X		MB
Sargassum obtusifolium		X	
Rhodophyta			
Acanthophora spicifera[1]	X	X	NS,MB
Amansia glomerata[1]	X		MB
Amphiroa fragilissima		X	
Amphiroa sp.			NS
Asparagopsis taxiformis	X	X	MB
Centroceras sp.			NS,MB
Ceramium sp.	X		
Coelothrix irregularis	X		NS
Corallina sp.		X	

Table 2 (Cont.)

Taxon	AECOS 1980	AECOS 1986	Present Surveys[3]
Rhodophyta (continued)			
Dasyopsis sp.			NS
Desmia hornemanni	X	X	
Gelidiella acerosa			MB
Gelidiopsis scoparia			NS
Galaxaura fastigata		X	
Galaxaura filamentosa		X	
Galaxaura sp.	X		
Gracilaria bursapastoris	X	X	NS
Gracilaria coronopifolia			NS
Grateloupia filicina	X		
Grateloupia hawaiiana			MB
Grateloupia sp.			NS
Griffithsia sp.	X		
Hypnea cervicornis	X	X	
Hypnea chordacea			NS,MB
Hypnea musciformis[1]			NS,MB
Jania sp.	X	X	NS
Laurencia nidifica		X	NS,MB
Laurencia crustiformans			MB
Laurencia sp.			NS
Martensia fragilis			NS
Peysionella rubra		X	NS
Plocamium sandvicense			NS
Polysiphonia sp.			NS
Porolithon onkodes	X		MB
Pterocladia caerulescens			MB
*Pterocladia capillacea*1			NS,MB
Pterocladia sp.			NS
Scinaia hormoides	X		NS
Spyridia filamentosa[2]		X	NS
Tolypiocladia glomerulata		X	
Unknown			NS
TOTAL NO. SPECIES	22	27	49

[1] Preferred food by turtles sampled in main Hawaiian lands (Balazs, 1980).
[2] Preferred food by turtles sampled in Leeward Hawaiian Islands (Balazs, 1980).
[3] Present survey; NS - near shore quadrats; MB - marine bench collections.

The concentration of effort during the present survey within the shoreline and nearshore environments clearly contributed to the greater number of species recorded from the area. Not surprisingly, a number of species were not seen in 1991 that may be mostly distributed further offshore on the reef flat. These species were recorded in the earlier studies. Experience has shown that repeated visits to an area will continue to add algal species to the listing as the rarer species are discovered. Such lists provide the reader with a general sense of the algal diversity (i.e., species number). However, species lists provide less ecological information than quadrat data such as that presented in Table 1, even though quadrats often miss a majority of the species present. The value of the quadrat data lies in the indications of abundance of the dominant species; information that can be used for comparison with other areas or with results from the same area taken at a different time.

The collection of biomass samples in May 1991 contributed to the greater number of species by providing many smaller forms that would be overlooked by a diving survey. On the other hand, many more species of low to intermediate abundances probably occur in the area. For example, Doty (1969) reported some 80 species from the shallow reef flat at Waikiki. Smith (1988) found 105 species on the marine bench environment alone at West Beach, and AECOS (1991a) found 54 species on a smaller section of the same marine bench. McDermid (1988) lists 30 species from a relatively small area of marine bench at Lualualei Beach Park, although no more than 18 species were present within her study quadrats at any one time.

The dominant and abundant species determined for the Ewa Marina nearshore area may be compared with known preferences as food for the dominant marine turtle in Hawaii, *Chelonia mydas*. Balazs (1980) has examined stomachs of this species throughout the Hawaiian Islands and determined nine genera or species of macroalgae to comprise most of the turtles' food source. Eight of these species have been reported for the Ewa Marina site and these are indicated in Table 2. Six of these eight algal taxa are reported by Balazs to be a food source for turtles in the main Hawaiian chain, while two were utilized only by turtles sampled in the Leeward chain. Five of these eight taxa, *Hypnea musciformis*, *Caulerpa taxifolia*, *Acanthophora spicifera*, *Ulva* fasciata and Pterocladia capillacea are the five most abundant macroalgae which occur at the Ewa Marina site and make up nearly 77% of the algal community. It is therefore likely that the algae of the Ewa Marina nearshore area provide a significant food source for the turtles that have been sighted offshore.

Sea turtles are usually sighted off the east and west transects of the present algal survey, rather than in areas directly seaward of the Ewa Marina Project (Marine Research Consultants, 1991). However, turtle surveys are usually conducted during the daylight hours when turtles are resting offshore. Presumably these turtles move to inshore areas after dark for foraging. One favored food of the green sea turtle, Pterocladia capillacea, occurs in greatest abundance along the frontal slope of the marine bench, an area not well represented in our samples because of the constantly rough sea conditions where this species occurs and because of the unusual structure of the marine bench in the area surveyed by the transects. Visual observations made along the shore between White Plains Beach and Pupu Place in 'Ewa Beach indicate that this alga is most abundant off Keku Point and off 'Ewa Beach, locations where the marine bench has a distinct frontal slope.

The proposed channel will directly alter a 500 foot-wide segment of a nearly 4000-foot rocky shoreline. This channel will probably come to resemble existing sand-channel or large sand-patch environments. That is, the bottom will be sand covered and support only a few species of algae (such as Halimeda). The channel margins, on the other hand may attract turtles, providing both abundant algal growth and some shelter. The channel could become a route for turtles moving between offshore resting sites and nearshore areas of favored algal growth.

The nearshore reef environment and the sublittoral fringe environments are characterized by an abundance and variety of macrophytes nearly everywhere surveyed for this report. The abundance of macroalgae for food would seem to be secondary in importance to other factors in the selection by turtles of habitat. Indeed, drifting algal thalli, especially of Hypnea musciformis, are so abundant in the water that the distribution of foraging turtles need not be much affected by the actual sites of algal growth.

The distribution of algae on the reef flat as suggested by our transect results appears partly related to the distribution of sand shoreline: generally thinner deposits of sand occur on the bottom off the rocky sections of shoreline than off the sandy sections of shoreline and the abundance and diversity of algae are inverse functions of sand thickness. However, with increasing distance from shore, the differences in the occurrence of macroalgae between the transected areas decreases. On the offshore reef flat, the abundance of macroalgae will be related to the distributions of limestone outcrops, sand patches, and sand channels. The occurrence of these bottom types may not correspond in any particular way with the shoreline types. Except for the shoreline and immediate nearshore areas where algal growth is suppressed by sand deposits, macroalgae are very abundant all along the coastline from Barbers Point Naval Air Station to Ewa Beach.

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Appendix J

Potential for Impact of Proposed Ewa Marina, Ewa, Oahu on Seasonally-Resident Humpback Whales

Potential for Impact of Proposed Ewa Marina, Ewa, Oahu

on Seasonally-Resident Humpback Whales

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Purpose

HASEKO (Hawaii), Inc. proposes the development of a new, 1,600-slip marina between Naval Air Station, Barbers Point and the existing Ewa Beach community. This report evaluates the project's potential effects on seasonally-present humpback whales (Megaptera novaeangliae). It is divided into seven sections. Sections 1 and 2 provide background information concerning the animals' range, abundance, and applicable regulatory controls, including their status as an endangered species. Section 3 provides an overview of the kinds of effects that human activity is believed to have on the behavior of humpback whales. Sections 4, 5 and 6 describe the results of aerial surveys of whale abundance in Hawaiian waters, including a summary of sightings for the waters off the southern shore of Oahu where boating activity generated by the Ewa Marina is likely to have the greatest effect. Finally, Section 7 discusses the effect that the proposed Ewa Marina project is likely to have on the humpback whales, including a projection of the additional boat traffic which the proposed marina could potentially produce (boat data summarized in Appendix).

Background

Humpback whales (Megaptera novaeangliae) are a cosmopolitan species, inhabiting the North Pacific, North Atlantic and southern oceans. Whales in these three oceanic regions are reproductively isolated from one another due to continental barriers and the opposing seasonality of the northern and southern oceans. Within each oceanic population, whales migrate during winter months towards the equator to coastal or island breeding grounds in tropical or subtropical waters. In summer months, the whales return to the colder, higher-latitude areas where food resources exist in greater abundance.

In the North Pacific, whales feed in nearshore waters along the northern rim of the ocean. These areas extend eastward from the Sea of Okhotsk to the Kamchatka Peninsula and the Aleutian Island chain, and across the Gulf of Alaska to the Alexander Archipelago (Perry, Mobley, Baker and Herman, 1988). Strong currents offshore of the North American west coast cause upwelling of nutrient-rich deep water, resulting in rich feeding areas off central California as well. North Pacific whales travel in winter to warm-water breeding grounds off the Mariana, Ryukyu, and Bonin Islands in the western Pacific, to islands off western Mexico, and to the main Hawaiian Islands.

It has been estimated that as many as 15,000 to 25,000 humpback whales (Megaptera novaeangliae) inhabited the North Pacific prior to their 20th-century exploitation by the whaling industry (Rice, 1977; Wolman, 1978). Despite international protection since 1966, all current estimates indicate only a fraction remaining. As a result of this decimation, humpback whales have been classified as an endangered species and are protected under the

Endangered Species Act of 1973 as well as under the Marine Mammal Protection Act of 1972. The National Marine Fisheries Service (NMFS) of the National Oceanic and Atmospheric Administration (NOAA) is the federal agency charged with interpreting and enforcing this legislation. The most recently enacted "anti-harassment" regulations affecting humpback whales in Hawaii were passed in 1987 (Federal Register, 1987), and require all surface vessels to respect a minimum approach distance of 300 yards in designated "preferred habitat" areas (portions of Lanai coast and Maalaea Bay area of Maui) and 100 yards in all other regions of the Hawaiian Island chain. Additionally, the State of Hawaii has further extended this protection through requiring the cessation of certain classes of "thrillcraft" (e.g., jet skis) during the winter breeding season (Dec. 15 to May 15) in preferred habitat areas adjoining the island of Maui. A recent lawsuit brought against the state by one thrillcraft company operating in Maui waters resulted in a court ruling in favor of the State of Hawaii. It is likely that further efforts to control such "nonessential" boat traffic will continue with primary focus on waters surrounding the Four Island Region (Maui, Kahoolawe, Lanai, and Molokai).

Abundance

Of the three known breeding areas in the North Pacific, Hawaii is generally believed to be the largest numerically (Rice 1977; Wolman, 1978). Estimates of current abundance of the "Hawaiian" population range from those derived from aerial or shipboard survey data, of less than 1,000 (Wolman, 1978; Herman & Antinoja, 1977; Herman et al., 1980) to more liberal estimates based on photographic identification data, using mark and recapture formulas. Using the latter approach, Darling and Morowitz (1986) estimated that 2,100 individuals visited Hawaii across a five-year period, with a peak year estimate of 1,000 individuals (i.e., the greatest number of animals believed to be present during one breeding season), based on photographic data obtained during the 1977-1981 seasons. Baker and Herman (1987), however, noted inconsistencies with the methods used to project the latter estimate and offered a more conservative estimate of 635 to 1536 individuals across the same five-year period. Darling and Morowitz further compared their estimate to those derived earlier from aerial surveys and suggested the difference could be construed as evidence for population recovery. However, as Bauer (1986) noted, more than likely the differences in abundance estimates reflect differences in methodology and not necessarily "real" differences in population size.

Recent aerial surveys, however, using methods consistent with earlier surveys performed by the University of Hawaii during the 1977-80 breeding seasons offer data suggestive of increasing abundance in the Hawaiian wintering grounds (Mobley & Bauer, 1990; Mobley, Bauer & Herman, in prep). Owing to departures from more conventional transect methodology, absolute abundance estimates are not derivable from these data, though relative abundance comparisons are tenable (see 1990 Aerial Survey Results).

Impact of Human Activities

Recent empirical evidence has raised specific concern that wintering humpbacks are being displaced from an increasing number of heavily-trafficked areas, particularly noted in the waters surrounding the island of Maui (e.g., Herman et al., 1980; Glockner-Ferrari & Ferrari, 1987; Forestell, 1989). Maui adjoins waters of dense utilization by wintering whales, and like several of the "outer islands" has undergone a sudden surge in development over the past decade. Maui County (Maui, Molokai, and Lanai) showed the largest increase in population from 1970 to 1989—a net increase of 111%, followed by Hawaii and

Kauai counties (increases of 93% and 71%, respectively) (Dept. of Business, Economic Development and Tourism, 1990). This substantial increase in population has coincided with an increased utilization of the waterways by residents and tourists, as indicated by a substantial increase in the number of boat registrations over a ten-year period from 1970-80 (Markrich, 1984). Beyond the sheer increase in vessel traffic, an additional factor of concern has been the increasing interest directed at the presence of the whales themselves (e.g., Federal Register, 1987). Herman et al. (1980) noted that the majority of charter vessels for which advertising brochures were available specifically advertised "whale-watching" among their activities. Since this earlier report, attention to their seasonal presence has noticeably increased. Though the approach of all non-research vessels has been restricted to no less than 100 yards in most Hawaiian waters since 1979 (Federal Register, 1987), Bauer (1986) reported correlational evidence of behavioral change occurring (e.g., faster respiration rates, longer dive times) at distances up to and exceeding 1,000 m.

The earlier report of Herman et al. (1980), based on aerial survey data, showed regions of relative high-densities of sighted whales immediately bordering areas of extremely low densities. In all cases, the latter corresponded to regions of high utilization by vessels. The two areas showing the strongest density gradients corresponded to the waters adjoining the Lahaina Roadstead as well as Maalaea Bay Harbor. More recent data suggests this also to be true for the waters adjoining the recently constructed Keawakapu boat ramp (Kihei coast of Maui) and the Kaanapali coast along northwest Maui (Forestell, 1989; Glockner-Ferrari & Ferrari, 1985).

The concern, as described in the 1987 "Rules and Regulations" published by NMFS (Federal Register, 1987) is that if such regional displacement is occurring, it would suggest that the animals are not habituating to the increasing traffic, as has been reported for other regions (e.g., Watkins, 1986, reporting on humpback whales off Cape Cod). This concern was further substantiated by an apparent case of regional displacement of humpback whales from feeding grounds in Glacier Bay, Alaska (Marine Mammal Commission, 1980). The latter report showed a decreasing utilization trend leading to complete abandonment of the region by 1978. Similar to the case for waters surrounding Maui, this negative distribution effect correlated with a substantial increase of charter/pleasure craft of 120% from 1976 to 1978 in Glacier Bay. Jurasz and Jurasz (1980) and Jurasz and Palmer (1981), also reporting on the departure of whales from that region, further noted a hierarchy of stress behaviors observed in the presence of vessels, as indicated by changes in respiration rates and the display of characteristic behavior patterns.

Based on 148 hours of shore-based observation in the waters surrounding west Maui, Bauer (1985, 1986) showed that the presence of vessels in the vicinity of whales correlated with increased respiration rates, higher swimming speeds, higher rates of pod membership changes and certain surface behaviors. Additionally, Bauer's results indicated the numbers of vessels present exerted a significant behavioral impact at distances as great as 1000 m. In general, smaller pods and pods with calves were more affected than larger pods.

An overall review of the studies cited above reveals several important common findings: a) there is correlative evidence to suggest that whales may be displaced from established subregions within overall feeding or breeding waters as a result of increased vessel traffic; and b) the presence of vessels correlates with short-term behavioral change—most notably increased swimming speed and respiration rates--thus showing that at least the more proximate

indicators of stress are present. Judgements of the possible long-term deleterious effects of such stressors have tended to err on the side of enhanced protection, owing to the status of humpback whales as an endangered species.

Past Aerial Surveys

The Kewalo Basin Marine Mammal Laboratory (KBMML) of the University of Hawaii conducted regular aerial surveys throughout all the major Hawaiian Islands from 1976 to 1980. These were funded in large part by NSF as awarded to Louis M. Herman (NSF grant BNS-77-24934 for years 1978-80). The results of this five-year study have been reported in a variety of sources: 1976 results in Herman and Antinoja (1977); 1977-78 results in Herman, Forestell and Antinoja (1980); 1977-79 results in Baker and Herman (1981); and 1977-80 results by Bauer (1986). The data from these four years have been consolidated into one database which serves as the basis for the determination of regional utilization trends and relative abundance changes described below.

1990 Aerial Survey Results

As noted, the flight paths and procedures for the 1990 aerial survey were identical to those used earlier (1977-80 seasons) to permit direct comparisons of findings. The survey involved aerial assessment across a total of seven flight dates spaced an average of two weeks apart, covering a four-month period from January 27 to April 28, 1990. As shown in Figure 1, all of the flight paths fell within 2-mi of shore of each of the major Hawaiian islands, well within the 100-fathom limit where past surveys have shown the vast majority of wintering humpback whales to reside.

Density changes--1977-80 to 1990. In order to correct for differences in level of effort spent surveying different regions, frequencies of whale sightings for each major region and subregion were converted to sighting rates by dividing these by the amount of total survey time spent in each area (based on flight path distance (nm)/100 km airspeed x no. flights). Since all whales within 2 mi on either side of the aircraft were counted (as per the earlier 1977-80 effort), the resultant whales/hr metric can be easily converted to whales/100 sq mi.[1] Both of these derived sighting rates afford a standardized metric for comparison of whale densities.

A total of 1671 whales were sighted during the 1977-80 season across 196.5 hrs of survey time, yielding an overall sighting rate of 8.5 whales/hr or 1.8 whales/100 sq mi. During the 1990 season 843 whales were confirmed across a total survey time of 58.1 hrs, yielding a sighting rate of 14.5 whales/hr., or 3.2 whales/100 sq mi, representing a 71% increase.[2] Since these survey results were derived using equivalent methods, and since subsequent analyses revealed

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[1] One nautical mile (nm) is equivalent to 1.15 statute miles (mi), thus each hour of flight covered a theoretical area of 460 sq mi.

[2] It is assumed that the total number of whales sighted in a given year reflects an undeterminable percentage of "resights"--i.e., the same animals being counted more than once. Therefore, the fact that 843 whales were sighted during 1990 does not necessarily reflect 843 different individuals. It is assumed, however, that the percentage of resights is more or less uniform across seasons; therefore--assuming equivalent methodology--increases in sighting rates should arguably represent increases in numbers of whales.

comparable sighting conditions (e.g., weather and seastate conditions) across both sets of data, it is reasonable to assume that these increases in sighting rates from the 1977-80 to the 1990 data stem primarily from increased abundance of whales visiting these waters.

Regional Distribution Changes. Figure 2 shows the distributional results for the 1990 breeding season. In contrast to the earlier 1977-80 results which showed a clear modal "center" to the population in the Penguin Bank (shallow shoal extending from southwestern coast of Molokai) and Four Island regions, the 1990 results indicated considerable diffusion of the wintering population into other aggregation areas. Table 1 below summarizes these regional changes:

Table 1

Mean Sighting Rates by Major Region

Region	Whales/100 Sq Mi: 1977-80	1990	% Increase	Calves/100 Sq Mi: 1977-80	1990	% Increase*
Big Island	1.0	1.8	80%	.05	.15	200%
Four Island	1.9	2.6	37%	.15	.31	107%
Penguin Bank	5.5	6.7	22%	.42	.74	76%
Oahu	1.2	2.5	108%	.03	.19	447%
Kauai/Niihau	1.5	5.0	232%	.12	.16	33%
Weighted Means:	1.8	3.2	71%	.13	.27	107%

*Note: The sighting rates for calves are often based on relatively small numbers of sightings, therefore the "percent increase" statistics should be viewed with caution. For example, only three calves were observed around Oahu during 1977-80 seasons, and seven during 1990, which produced the 447% increase in sighting rate as shown.

The 1990 data indicates increases in sighting rate for all five major regions. For all years studied, Penguin Bank showed the greatest density of whales, whereas the Big Island showed the least density. The greatest change from the earlier data occurred for the Kauai/Niihau region, which displayed a more than threefold increase in sighting rate, followed by Oahu which showed a twofold increase.

Figure 3 shows the level of change in overall sighting rates for each of the 60 subregions from the earlier (1977-80) to 1990 data. Increases in sighting rate are indicated by increasing darkness of the shaded areas. The white and cross-hatched areas indicate decreases in sighting rates. Forty-four of the 60 subregions (73%) registered some degree of increase. Only two subregions (one on Penguin Bank and one adjoining northeastern Lanai) showed substantial decreases in whale densities. There is currently no apparent reason for these decreases.

Relationship Between Whales and Vessels. The evidence concerning possible displacement of whales by vessels is mixed. The fact that 73% of all subregions showed increases in whale density--including those subregions previously characterized as distributional "holes," presumably due to heavy vessel traffic (e.g., Lahaina Roadstead area, as reported by Herman et al., 1980; Forestell, 1989)--does not suggest a mass egress of whales away from these areas. In fact, of the 19 subregions which adjoin commercial barge and major recreational boat harbors, only five (26%) showed decreases in density

from the 1977-80 to 1990 data. On the other hand, the six subregions showing greatest increases in density (i.e., darkest shaded subregions in Figure 3) across the 10-to 14-year period may all be characterized as leeward areas relatively low in vessel traffic—all are away from commercial boat routes and adjoin land areas which are relatively uninhabited and where little development is currently taking place (e.g., three of these six areas adjoin Niihau). One plausible interpretation of this pattern is that wintering whales are "spilling-over" into these low trafficked areas from previously preferred habitat—a pattern which could be construed as indirect evidence of vessel traffic on their distribution. However, in the absence of more direct evidence, this interpretation rests as conjecture.

Calf pods. Figure 4 shows the distribution of pods containing calves across the 60 subregions adjoining the major Hawaiian Islands as observed during the 1990 season. Pods of whales containing calves were of particular concern in this census since their incidence offers some indication of the status of recovery of this endangered population. A total of 118 pods with calf were sighted during the 1977-80 breeding seasons, for a rate of .13 calves/100 sq mi. For the 1990 season, the total of 72 calves translates to a sighting rate of .27 calves/100 sq mi, representing a two-fold increase in sighting rate. The proportions of calf pods did not change substantially, however--17% of all pods seen during the 1977-80 surveys contained a calf, as compared with 20% of those seen during the 1990 season.

Several earlier authors have commented on the low percentage of calves and have noted that it is likely below the minimum recruitment rate to produce an increase in population size (e.g., Herman, Forestell and Antinoja, 1976; Herman et al., 1980). How can the apparent increase in the wintering population be reconciled with the lack of change in the relatively low percentage of calves? There are at least two possibilities: a) the 17 to 20% calf ratio may actually be sufficient to produce a net increase in population recruitment despite earlier claims to the contrary; or b) the North Pacific population of humpback whales itself may not be increasing--instead an increasing percentage of the total population may be wintering in Hawaii, rather than other possible wintering sites (e.g., Gulf of California region).

Table 1 also shows changes in regional distribution of calf pods from the earlier to more recent data. As shown, the preference of calf pods for the Four Island and Penguin Bank regions has become increasingly apparent. Based on the 1990 data these regions clearly represent "preferred habitat" for cows with calves, with sighting rates from 1.6 to nearly four times greater than those of the third ranked region, Oahu. The differences among the calf pod sighting rates for the Big Island, Oahu and Kauai/Niihau areas, however, are best regarded as roughly equivalent. Thus, it is clear that none of the former three areas, including Oahu, can be construed as vital habitat for cows with calf.

Densities of whales off Oahu's south shore. The subregions of relevance to the proposed Ewa Marina occur along Oahu's south shore, and are labeled "A" and "B" in Figures 2, 3 and 4. Subregion A extends from Koko Head to Barbers Pt., and includes the area containing the proposed Ewa Marina. Subregion B extends further northwestward from Barbers Pt to Kaena Pt. Table 2 below summarizes in more detail the 1990 data for these two subregions:

Table 2

Densities of Humpback Whales Sighted Off Oahu's South Shore—1990 Results

Subregion	Shore Area Covered	1990 Sighting Densities: Whales/100 Sq Mi	Calves/100 Sq Mi
A	Koko Head to Barbers Pt.	.7	0.0
B	Barbers Pt. to Kaena Pt.	1.6	.3

Subregion A—which includes waters adjoining the proposed Ewa Marina—produced the lowest sighting rate for adult whales and calves for the island of Oahu. The weighted average sighting rates across both subregions were 1.3 whales/100 sq mi and .13 calves/100 sq mi—both of which are below the Oahu averages of 2.5 whales/100 sq mi and .19 calves/100 sq mi, and well below the overall 1990 state average of 3.2 whales/100 sq mi and .27 calves/100 sq mi. Thus we may conclude that neither of these subregions currently represent preferred habitat for adult whales or for pods with calf.

As shown in Figure 3, there has been little change in sighting rates for subregions A and B from the 1977-80 to 1990 data, as indicated by the fact that both subregions showed the lowest level of positive change. Thus, the low level of activity in these areas has been relatively stable across the fourteen year period from 1977 to 1990. The low incidence of whales observed along Oahu's south shore has been attributed to the high rate of vessel traffic in these waters (e.g., Herman et al., 1980).

Potentially Impactful Activities

The activities associated with the development of the proposed Ewa Marina which could potentially impact whales include: dredging, run-off from land development, blasting, use of pile drivers in pier construction, and general engine noise. The first two represent a potential for proximate impact—i.e., impacting only the coastal waters within several miles of the construction site. The latter three, however, represent the potential for more long-range acoustic impact as summarized by other reports (e.g., Malme et al., 1983; Acoustical Society of America, 1980). However, the potential acoustic impact of these activities will be attenuated considerably by the presence of protective features, such as breakwaters and surrounding land formations.

Once construction on the proposed Ewa Marina is completed, however, the potential for impact is limited primarily to the increased vessel traffic produced for this region.

Potential Impact on Seasonally-Resident Humpback Whales

The proposed Ewa Marina is predicted to increase current levels of vessel density along Oahu's south shore (from Koko Head to Kaena Pt) by as much as 39% (see Appendix). However, several factors suggest that the potential for impact from construction and operation of the proposed Ewa Marina on the seasonally resident humpback whales will be minimal. First, the 1990 survey data indicate that densities of whales in waters adjoining the proposed site are among the lowest observed for the entire State of Hawaii. Secondly, comparisons with the earlier (1977-80) data suggest that this pattern of low utilization by whales has been a stable trend. Thirdly, the incidence of whale pods with calf—a

focus of concern for recovery efforts—are similarly very low, suggesting that cow-calf pods avoid these waters.

The only area of significant utilization by humpback whales in the waters surrounding Oahu is the subregion adjoining the northwest coast (from Kaena Pt. to Kahuku). This area is shielded geographically from any significant by-product of construction (including acoustic pollution) and is of a sufficient distance from the Ewa Marina site such that any change in levels of vessel traffic for that region, resulting from the marina's operation, will likely be minimal.

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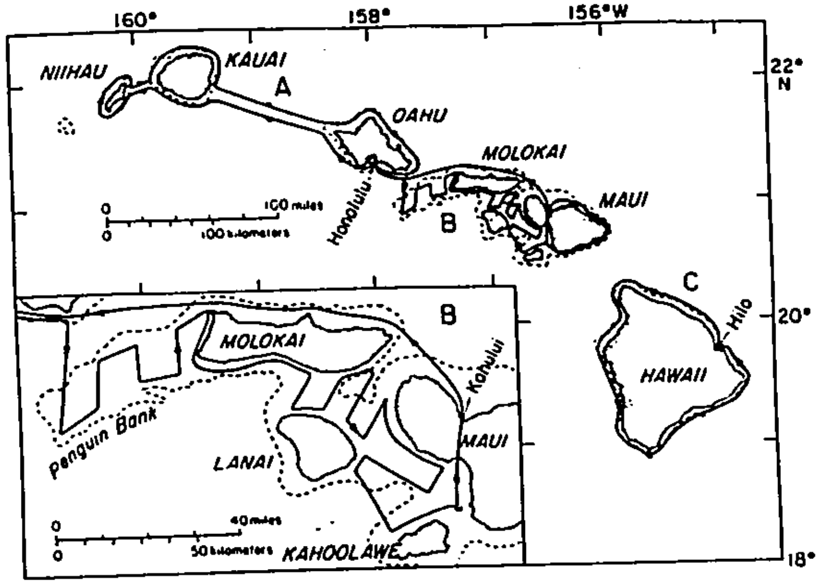

Figure 1. Map of Major Hawaiian Islands Showing Flight Paths. Flight paths shown correspond to those performed during earlier 1976-80 aerial surveys. Flight paths are as follows: (A) Oahu/Kauai/Niihau portion; (B) Penguin Bank/Four Island Region portion; (C) Big Island portion.

1990 SURVEY RESULTS

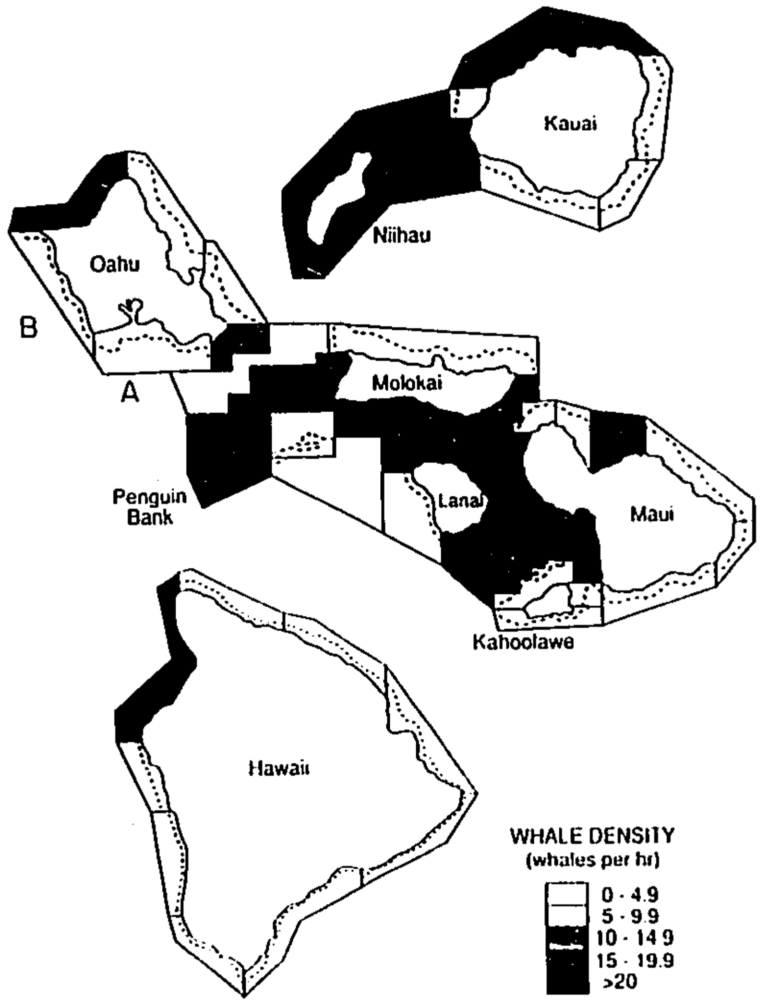

FIGURE 2

CHANGE IN WHALE DENSITY
(1990 Rate minus 1977-80 Rate)

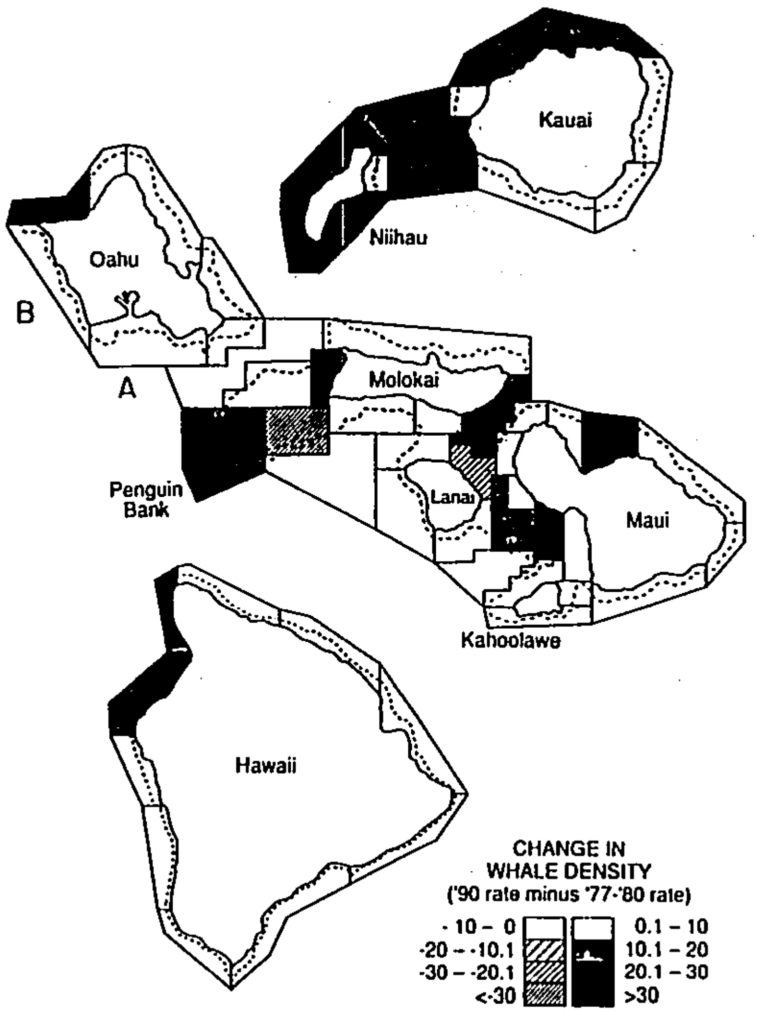

FIGURE 3

1990 SURVEY RESULTS
(Calf Pods Only)

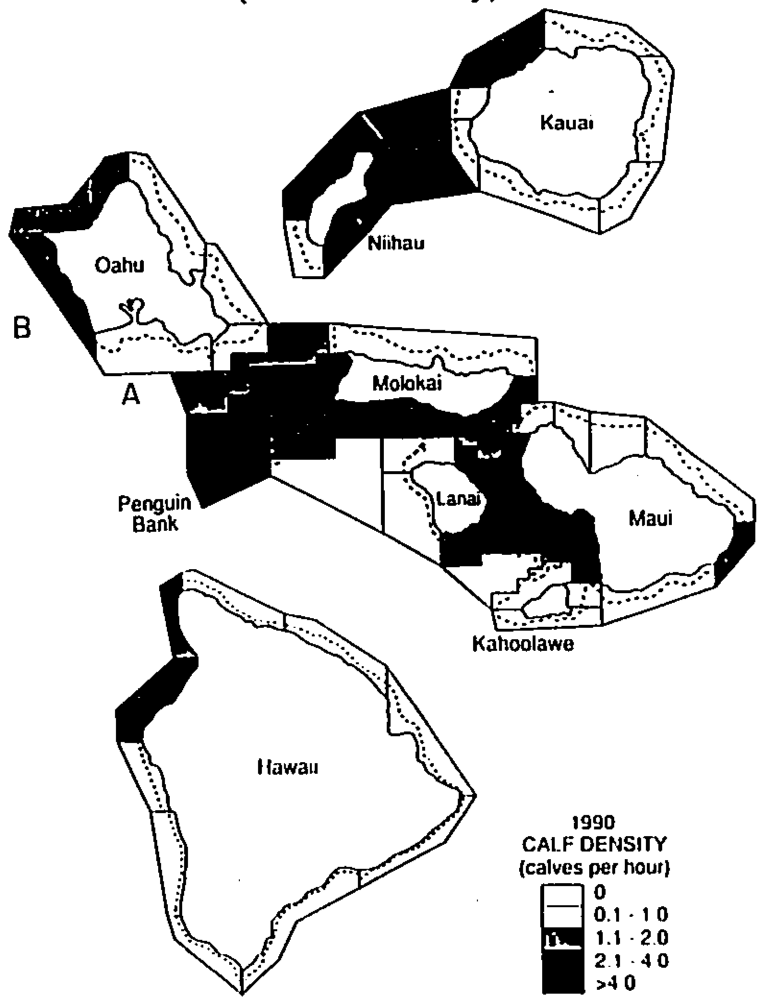

FIGURE 4

APPENDIX

Projected Effects of Proposed Ewa Marina on

Vessel Traffic for Southshore Oahu Coastal Waters

Prepared by:

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Kailua, HI 96734

Purpose

This section presents 1991 data on vessel activity for coastal waters along Oahu's south shore. Also presented are the number of moorings and berths currently available for commercial and recreational boats in this region. Together, these data permit calculation of a "no. vessels per berth" measure which is used to project the additional vessel activity which may likely result from the completion of the Ewa Marina, as currently proposed by HASEKO (Hawaii), Inc.

The following data were gathered as part of a contract awarded by National Marine Fisheries Service (NMFS) of the federal National Oceanic and Atmospheric Agency (NOAA), as awarded to Joseph R. Mobley, Jr. and Paul H. Forestell for the period January through May, 1991. The purpose of this contract is to census humpback whales throughout the major Hawaiian Islands. Additionally, data concerning the incidence of vessel traffic in these waters is being gathered to determine relationships, if any, between the incidences of boats and whales in regional Hawaiian waters. The vessel data presented here represent a portion of the 1991 data, specific to the south-shore areas of the island of Oahu, as gathered on the first four flights.

Aerial Survey Method

These aerial survey data were gathered from four survey flights performed on Jan. 12, 26, Feb. 9 and 23, 1991. Figure 5 shows the flight path for the Oahu portion of the survey (Note: For the Feb. 23 flight, the flight path shown in Figure 5 was reversed to help control for diurnal variations in utilization). All survey flights were performed from Cessna 172 aircraft flying at an average altitude of 800 ft at an average airspeed of 100 kn and flying approximately 1.5 miles from shore. All vessels and whales spotted within 1.5 mi on either side of the aircraft were included in the survey. Reference marks attached to the strut of the overwing aircraft were used to estimate distance. The survey personnel consisted of three individuals, in addition to the pilot, one of whom had the primary responsibility of charting vessels on prepared data maps, though all three staff were responsible for spotting both whales and vessels.

Once spotted, vessels were noted as either under sail (if sail was present) or under power (for all other cases) and were assigned to four size classes, based on subjective assessment, as follows:

Size Class	Approx. Size
1	less than 20 ft
2	20 - 60 ft
3	60 - 100 ft
4	greater than 100 ft

Course times were noted relative to visible landmarks along the coast. These times were used to derive rates, based on numbers of vessels sighted per hour. These rates were converted to "vessels/100 sq mi" based on theoretical coverage of 345 sq mi for every hour of survey time (airspeed of 100 kn x 1.15 mi x 3 mi transect distance).

Vessel Survey Results for Oahu's South Shore

The south-shore region of Oahu--previously labeled Regions A and B in the main body of this report--have been further subdivided into four major regions here for more detailed analysis (see Figure 5): Region A1 from Koko Head to Diamond Head; Region A2 from Diamond Head to Pearl Harbor; Region A3 from Pearl Harbor to Barbers Pt; and Region B from Barbers Pt to Kaena Pt. Table 1 below summarizes the 1991 data obtained from the first four flights by major region:

Table 1

Summary of 1991 Aerial Survey Results for Vessels Observed in Coastal Waters Off South-shore Oahu *

Area		Size Class	No. Vessels: Power	Sail	Survey Time	Density: Vessels/100 Sq Mi
A1	Koko Head to Diamond Head	< 20'	25	6	.27 hrs	33.3
		20 - 60'	6	24		32.2
		60 - 100'	2	0		2.1
		> 100'	1	0		1.1
				Overall:		68.7
A2	Diamond Head to Pearl Harbor	< 20'	7	8	.31 hrs	14.0
		20 - 60'	10	30		37.4
		60 - 100'	1	2		2.8
		> 100'	5	0		4.7
				Overall:		58.9
A3	Pearl Harbor to Barbers Point	< 20'	9	1	.44 hrs	6.6
		20 - 60'	5	0		3.3
		60 - 100'	2	0		1.3
		> 100'	4	0		2.6
				Overall:		13.8
B	Barbers Point to Kaena Point	< 20'	74	1	.76 hrs	28.6
		20 - 60'	53	0		20.2
		60 - 100'	3	0		1.1
		> 100'	3	0		1.1
				Overall:		51.0
TOTALS—ALL REGIONS:		< 20'	115	16	1.78 hrs	21.3
		20 - 60'	74	54		20.8
		60 - 100'	8	2		1.6
		> 100'	13	0		2.1
				OVERALL:		45.8

* Totals from four survey flights flown on Jan. 12, 26, Feb. 9, and 23, with areas surveyed between the hours of 7:30 and 14:38.

When interpreting these density estimates, it is important to bear in mind that they refer to the waters within three miles of shore. As shown, vessels up to 60 ft comprised the majority of all sightings, accounting for nearly 92% of all vessels seen. Comparison of regional rates shows that the heavier vessel densities occurred in the East Honolulu area (Regions A1 and A2), which is expected considering its greater population density. One other pattern of interest favoring the East Honolulu area was the number of vessels sighted under sail--50 of the 52 sightings occurred in Regions A1 and A2.

Assumptions of Projection Model

In the ideal case, the above survey results would be separated into berthed (or moored) vs non-berthed vessels (e.g., trailered boats), since it is the former class of vessels that concern us. However, since that is not directly derivable from the present data, we may make a reasonable assumption that the majority of all berthed vessels are those greater than 20 ft, but less than 100 ft in length. This model assumes that the majority of vessels of 20 ft or less are trailered vessels, and not of concern here. We may further assume that the observed 13 power vessels greater than 100 ft in length (e.g., oil tankers, tug-barge ensembles) are those which travel to and from deep-draft harbors, which should be similarly factored out of our model. This leaves us with a total of 138 vessels between 20 and 100 ft in length, observed over a total of 1.78 hours of survey time, for a density of 22.5 vessels/100 sq mi.

A similarly ideal scenario would be to know the home berth of each vessel observed, in order to determine the relative contribution of each marina or harbor to the observed traffic. Since this is not obtainable, we must be content to calculate a total "vessel per berth" ratio based on the total number of "berthable" vessels seen and the total number of berths available along the south shore of Oahu.

Available Accomodations

Table 2 summarizes the numbers of vessels either berthed or moored at the various public and private marinas and commercial harbors located on Oahu's south shore. As shown, there are a total of 2,043 available berths or moorings from the Hawaii Kai Marina westward to Waianae Harbor.

Projected Increase in Vessel Density from Proposed Ewa Marina

The present model assumes that the majority of vessels seen in the 20-100 ft class were derived from the list of marinas and harbors shown in Table 2. If we divide our "berthable vessel" density of 22.5 vessels/100 sq mi by the total of 2,043 available berths, we derive a "vessel density/berth" ratio of .011. If we assume this to be a uniform measure of activity per available berth, we can use it as a basis of prediction. The additional 1,600 slips of the proposed Ewa Marina will increase the total number of available berths to 3,643 (assuming full occupancy of all available slips). If we apply our vessel density/berth ratio to this total we derive a density of 40.07 vessels/100 sq mi—essentially almost doubling the previous "berthable vessel" density. We can then add in the remaining vessel densities for vessels less than 20 ft and greater than 100 ft (from bottom of Table 1), for a total predicted density of 63.47 vessels/100 sq mi. The latter is the predicted average density of vessels along Oahu's south shore with the proposed Ewa Marina in place, representing an increase of 39% over currently observed vessel densities.

Table 2

Numbers of Vessels Berthed or Moored at all Major Marinas and Harbors Along Oahu's South Shore

Facility	Type	Berths	Moorings	TOTAL
Hawaii Kai Marina	Private	94		94
Diamond Head Moorings	Private		32	32
Hawaii Yacht Club	Private	25		25
Waikiki Yacht Club	Private	135		135
Ala Wai Marina	Public	663	39	702
Kewalo Basin Harbor	Commercial	129		129
AmFac Marina	Private	126	100	226
Honolulu Harbor	Commercial *			
Keehi Lagoon	Public	302	62	364
Club LaMariana Sailing	Private	65		65
Rainbow Bay Marina	Private	75		75
Hickam Harbor	Private	25		25
Iriquois Pt Yacht Club	Private	24		24
Barbers Pt Harbor	Commercial *			
Waianae Harbor	Public	146	1	147
	TOTALS:	1809	234	2043

* At Honolulu and Barbers Pt Harbors, there are no individual berth assignments

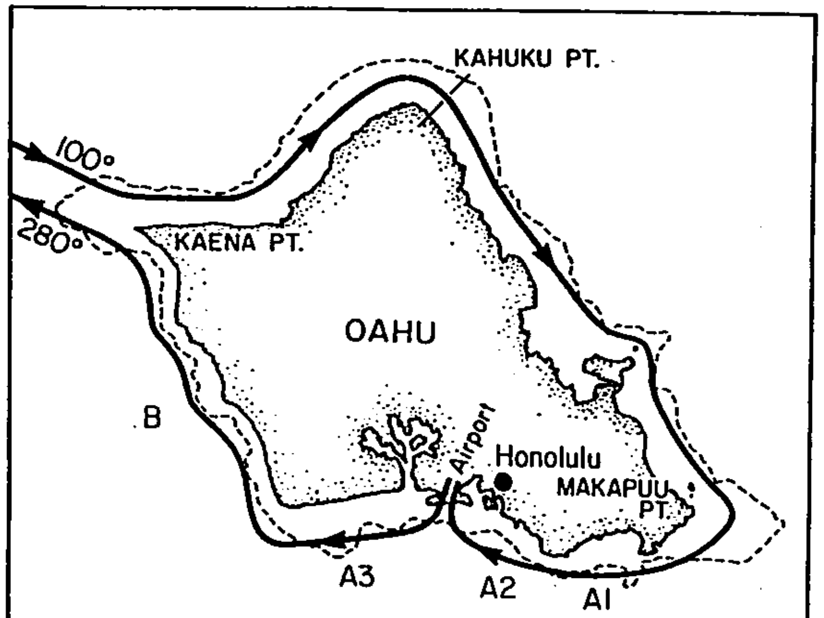
KAHUKU PT.
100°
280°
KAENA PT.
OAHU
B
Airport
Honolulu
MAKAPUU PT.
A3
A2
AI

FIGURE 5

Appendix K

Assessment of Sea Turtle Populations In the Vicinity of the Proposed Ewa Marina, Oahu, Hawaii

Assessment Of Sea Turtle Populations
In the Vicinity of the
Proposed Ewa Marina, Oahu, Hawaii

Cumulative Report No. 9

Prepared by:

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October 28, 1991

INTRODUCTION

Background

The Ewa Marina project is located on approximately 1,100 acres of land situated between Barbers Point Naval Air Station and the Ewa Beach community on Oahu's southern shore. The project includes a 140-acre marina that will eventually be home for approximately 1,600 boats. The marina will be excavated from fast land behind the shoreline and will be connected to the open ocean by an entrance channel that will cross a broad fringing reef. The planned entrance channel is approximately 125 meters wide and 900 meters long; it will be about 6 meters deep, shoaling to about 4 meters after it crosses the existing shoreline. Preliminary calculations indicate that construction of the proposed entrance channel will involve the removal of approximately 300,000 cubic meters of bottom material and the alteration of approximately 115,000 square meters of habitat. The proposed jetties will occupy only a small fraction of this, with the remainder consisting of channel area.

An application for a Department of the Army permit was filed with the Honolulu District of the U.S. Army Corps of Engineers on October 20, 1989, and the Corps issued a Public Notice describing the application on November 30, 1989. Responses to the Public Notice indicated a concern over possible effects on sea turtles, particularly the green sea turtle (*Chelonia mydas*).

In order to evaluate these potential effects, the applicant, HASEKO (Hawaii), Inc., contracted with Marine Research Consultants to develop and implement a one-year-long turtle monitoring program. This cumulative report describes the program's specific objectives, the methodology that is being used, and the findings through the ninth survey.

Overview of the Physical Environment

The bottom topography off the Ewa Marina site is essentially homogeneous at depths of 10 meters and greater. The bottom consists of a relatively flat limestone platform with little structural relief. At depths of less than 8 meters, there is very little coral cover, with most of the bottom consisting of exposed limestone substrate and patches of sand. At depths of between 8 and 10 meters, areas of hard bottom typically have a moderate cover of the coral *Pocillopora meandrina*. Shallow, sand-filled sand surge channels are fairly common features of this area. At depths between 10 and 15 meters, heads of *Porites lobata* scattered over the flat bottom provided the preponderance of vertical relief. Most of these colonies are fairly bioeroded and at least partially overgrown by calcareous algae. At depths greater than about 15 meters, sporadic small ledges and occasional patches of coral (mostly *Porites compressa*), occurred on a bottom composed of limestone flats and sand plains. The ledge that occurs in many areas off Oahu is not apparent in the Ewa region.

There is one atypical region in the vicinity of the planned marina. An area of substantial vertical relief that is located in water depth of about 10 meters directly offshore from the western boundary Ewa Marina property. This area is approximately 500 meters by 100 meters in extent and is characterized by a longitudinal ridge system that rises 1 to 2 meters above the otherwise flat limestone and sand bottom. The long axes of the ridges are aligned parallel to the shoreline and depth contours, and they are undercut, probably by wave action, to form ledges and crevices between 0.25 and 1 m deep. In some areas, the undercut crevices have been smoothed from contact with turtle shells. Some of the excavated pits measure up to 1 m in height, and 2 m in width, suggesting long-term usage as turtle resting sites.

Program Objectives

The turtle monitoring program that was developed for the Ewa Marina project has the following objectives:

- o collect data concerning the number of turtles present during daylight hours in nearshore waters between White Plains Beach (formerly Officers Beach) at the Barbers Point Naval Air Station and the eastern limits of the Ewa Marina site;
- o determine characteristics of the turtles that are sighted (species, size, sex, distinguishing marks, and behavior);
- o correlate sightings with environmental factors that might explain their presence and behavior; and
- o reach preliminary conclusions about the extent to which the turtles sighted might be affected by the proposed Ewa Marina project.

Methodology

The surveys are being conducted by a qualified diver/biologist. In order to provide efficient coverage of the large area that is being surveyed, the biologist works from a steerable sled that is towed behind a small, outboard motor-powered boat. The use of a steerable tow sled allows large areas to be covered much more efficiently than if divers were forced to work in a free-swimming mode or to make "bounce" dives from the dive boat.

The survey pattern that is being used consists of a weaving pattern, with the transects running parallel to the shoreline. The exact routing varies depending upon surf conditions, and is described in the survey results portion of each report. When wave conditions permit, the transects cover the entire area between the 3 and 20 meter depth contours. In calm conditions, the survey methodology provides for a transect length of approximately 2.9 kilometers (1.8 miles) and coverage of approximately 230 hectares (575 acres). As surf size increases, it is necessary to shift the transects farther offshore.

The sled is equipped with an electronic signaling device which allows communication between the diver and the boat operator. With this communication system, the biologist is able to direct the tow boat to shallower or deeper water, and to signal the sightings of turtles. When the boat operator is signaled that a turtle has been sighted, the tow boat is

stopped and its operator notes the position on a chart. In addition to the extensive investigations, intensive investigations of the area of significant limestone relief are conducted by divers swimming the entire area and examining all undercuts and ledges for resting turtles. With all methods of investigation, upon sighting a turtle the diver attempts to observe the following:

- o its species (either green sea turtle or hawksbill turtle);
- o its approximate carapace length (an indicator of size and age);
- o the turtle's sex;
- o the presence of any distinguishing marks (such as tumors or coloration) that would facilitate reidentification of the animal on subsequent surveys; and
- o the activity that the turtle is engaged in at the time of the sighting.

SURVEY 1 = SEPTEMBER 22, 1990

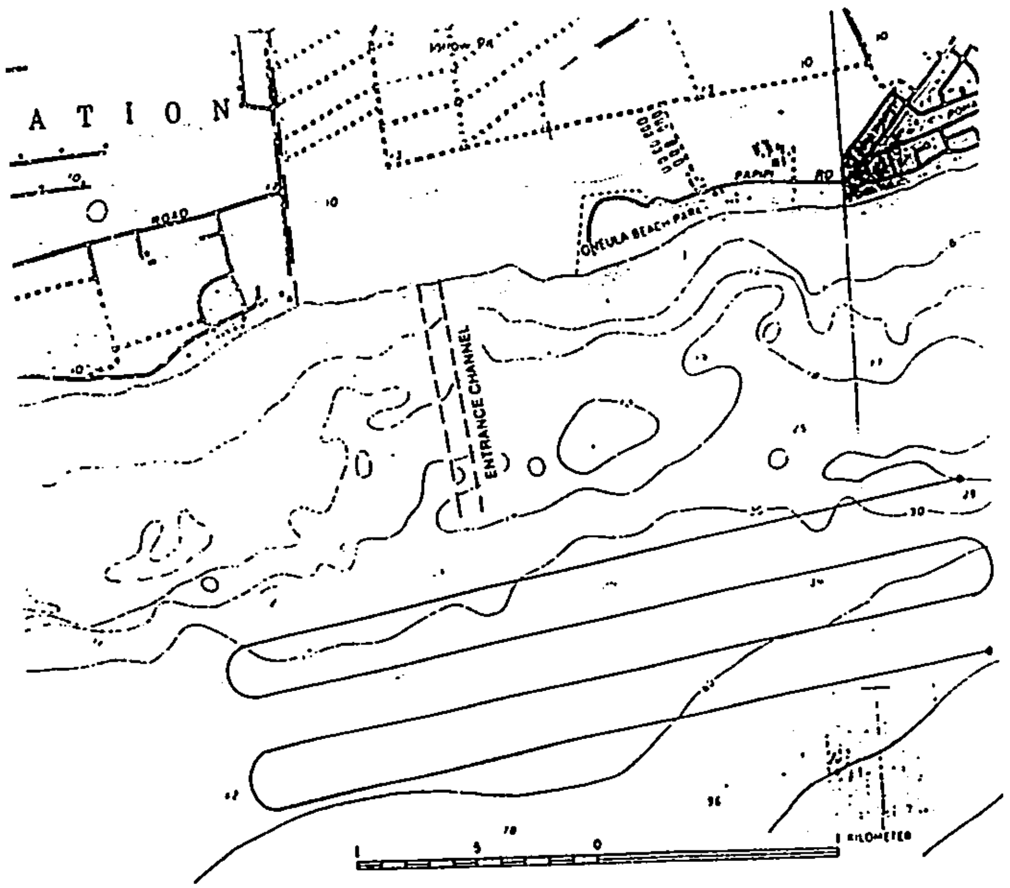
Conditions

The course followed by the survey team on September 22, 1990, is shown on Figure 1. Surveys were not possible in water depths of less than 10 meters due to the surf that was breaking on that day. Despite the substantial wave activity, underwater visibility was adequate for the purposes of the survey.

Findings

No turtles were observed, either on the surface or underwater, during the course of the survey.

FIGURE 1. SEPTEMBER 22, 1990, SURVEY TRANSECTS AND TURTLE SIGHTINGS.



SURVEY 2 -- NOVEMBER 25, 1990

Conditions

The second survey was conducted on November 25, 1990. Surf conditions were extremely calm, which enabled the survey team to investigate much shallower areas than had been accessible during the first survey. The route followed by the survey team is shown on Figure 2.

Findings

A total of 13 turtles were seen during the course of this survey. All sightings were of green sea turtles (*Chelonia mydas*). As indicated by the following tabulation, individuals tended to be adults, and most were seen in resting behaviors. No tags were observed, and large tumors were not prevalent. The site numbers given below correspond to the locations shown on Figure 2.

Site 1:

No.	Sex	Length (cm)	Comments
1	M	100	In midwater near areas of low relief
2	F	100	In midwater near areas of low relief

Site 2:

No.	Sex	Length (cm)	Comments
3	F	80	Resting in crevice; small tumor on right rear flipper
4	F	120	Resting in crevice
5	F	80	Swimming in midwater

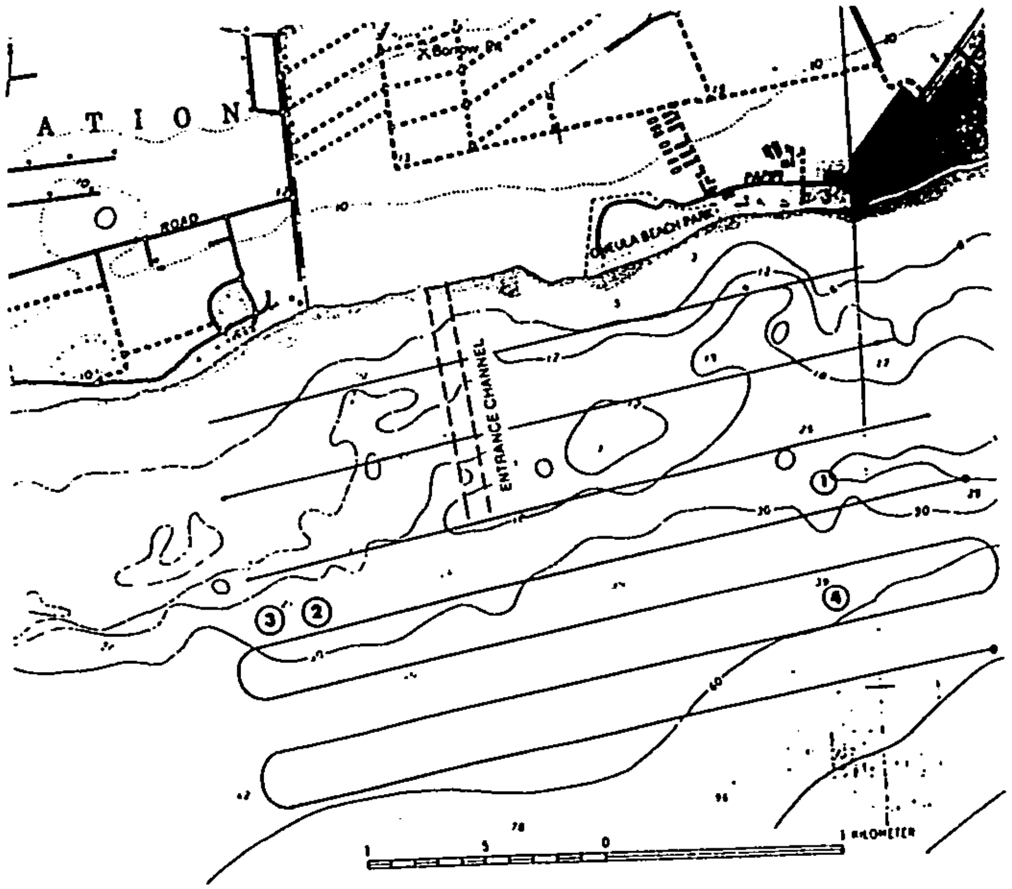
Site 3:

No.	Sex	Length (cm)	Comments
6	F	100	Resting on bottom
7	F	100	Resting on bottom
8	F	100	Resting on bottom; small tumor on rear flipper
9	M	100	Resting on bottom
10	Unknown	100	Resting on bottom
11	F	50	Resting on bottom; small tumor on rear flipper
12	M	50	Resting on bottom

Site 4:

No.	Sex	Length (cm)	Comments
13	F	80	Sleeping in hull of sunken barge

FIGURE 2. NOVEMBER 1990 SURVEY TRANSECTS AND TURTLE SIGHTINGS.



SURVEY 3 -- JANUARY 6 AND 13, 1991

Conditions

The third survey was conducted over two days (January 6 and 13, 1991) owing to the presence of a large-scale netting operation by local fishermen that prevented access to the entire survey area on the initial survey date. While most of the survey was conducted on Jan. 6, the area where the concentration of turtles were observed in Survey 2 was not accessible. On January 6, surf conditions were extremely calm, which enabled the survey team access to shallow reef areas. On January 13, moderate tradewinds and a small south swell caused water conditions to be rough and turbid. However, the area that was missed in the initial survey was accessible on January 13. The composite route followed for Survey 3 are shown on Figure 2.

Findings

A total of 14 turtles were seen during the course of this survey. All sightings were of green sea turtles (*Chelonia mydas*). As indicated by the following tabulation, individuals tended to be adults, and most were seen either in resting behaviors, or on the surface. One tagged turtle was observed, as were small tumors on several individuals. The site numbers given below correspond to the locations shown on Figure 2.

Site 2:

No.	Sex	Length (cm)	Comments
1	?	>100	Swimming on surface: attempt to locate underwater unsuccessful.
2	?	>100	Swimming on surface; attempt to locate underwater unsuccessful.

Site 3:

No.	Sex	Length (cm)	Comments
3	M	100	Resting on bottom
4	F	100	Resting on bottom
5	?	100	Resting on bottom
6	?	100	Resting on bottom
7	?	80	Resting on bottom
8	F	>100	Sleeping in shelter hole; small tumor on front right flipper
9	F	100	Sleeping in shelter hole; tag on right rear flipper.
10	M	100	Sleeping in shelter hole
11	F	>100	Sleeping in shelter hole
12	M	60	Free swimming in water column

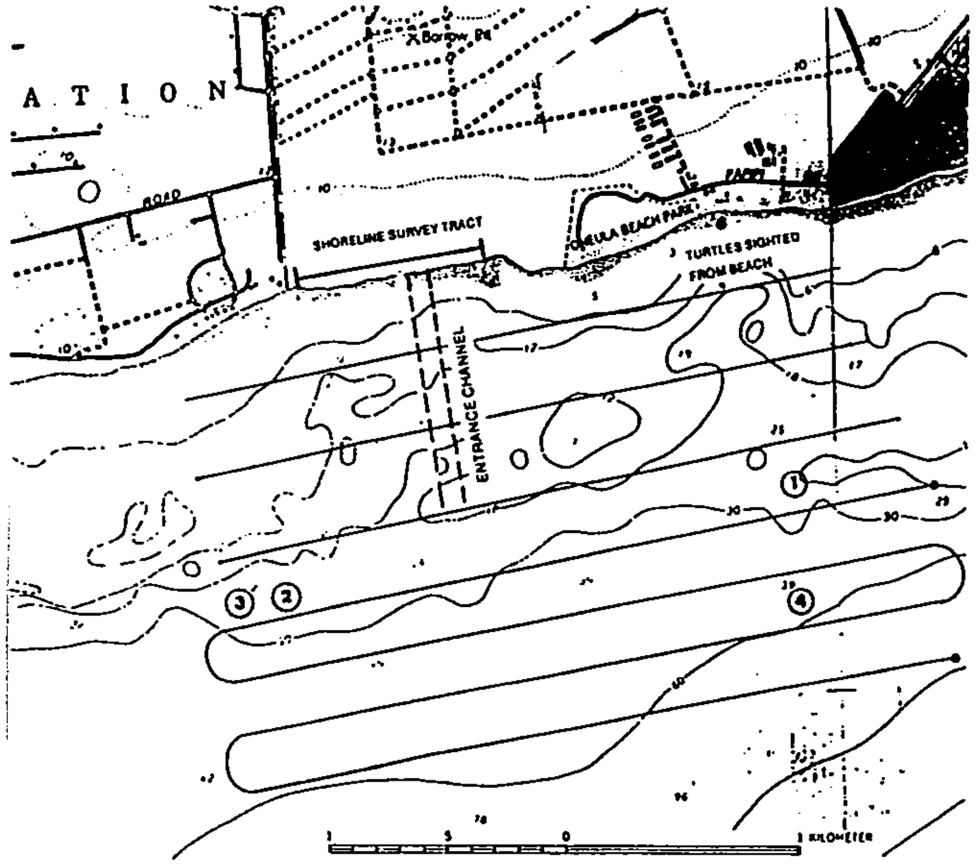
Site 4:

No.	Sex	Length (cm)	Comments
13	F	130	Sleeping in hull of sunken barge; two small tumors, one on each of front flippers.

Shoreline Surveys

Shoreline surveys were conducted on the mornings of November 26, 29, December 5, 7, 10, 13, 18 21, 24, 28, 31, 1990 and January 7, 1991. No turtles were sighted by the observer during any of the morning shoreline surveys. However, the observer, who resides in a house located on Ewa Beach has reported numerous sightings of turtles in the nearshore region fronting his residence (see Figure 3). A major difference in the physical setting between the Ewa Marina site and the Ewa Beach site, is that the latter area is characterized by dense aggregations of frondose benthic algae growing on a shallow intertidal platform. Neither such an intertidal platform, nor abundant frondose algal growth is evident in the area of the proposed marina.

FIGURE 3. JANUARY 1991. SURVEY TRANSECTS AND TURTLE SIGHTINGS.



SURVEY 4 -- May 5, 1991

Conditions

The fourth survey was conducted during a period of moderate northeast tradewinds, and nearly calm surf conditions. Water clarity was only moderate, limiting underwater visibility. Extensive tows were not conducted. Rather, very extensive survey coverage was conducted in the regions of topographic relief where aggregations of turtles were observed in previous surveys.

Findings

A total of 12 turtles were seen during the course of this survey. All sightings were of green sea turtles (*Chelonia mydas*). As indicated by the following tabulation, individuals tended to be adults, and were seen either in resting behaviors, free swimming in the water column, or on the surface. No tags were observed. Several of the larger individuals were observed to have small tumors, mainly on the front flippers. The site numbers given below correspond to the locations shown on Figure 4.

Site 1:

No.	Sex	Length (cm)	Comments
1	?	50-70	Swimming on surface: attempt to locate underwater unsuccessful
2	?	50-70	Swimming on surface: attempt to locate underwater unsuccessful
3	?	>100	Swimming near bottom; unable to identify sex or identifying characteristics.
4	?	>100	Swimming near bottom; unable to identify sex or identifying characteristics.
5	F	100	Resting on bottom.
6	F	70	Resting on bottom.
7	M	>100	Resting in excavated burrow; tumor on left front flipper.
8	F	30	Resting in excavated burrow.
9	F	70	Resting on bottom

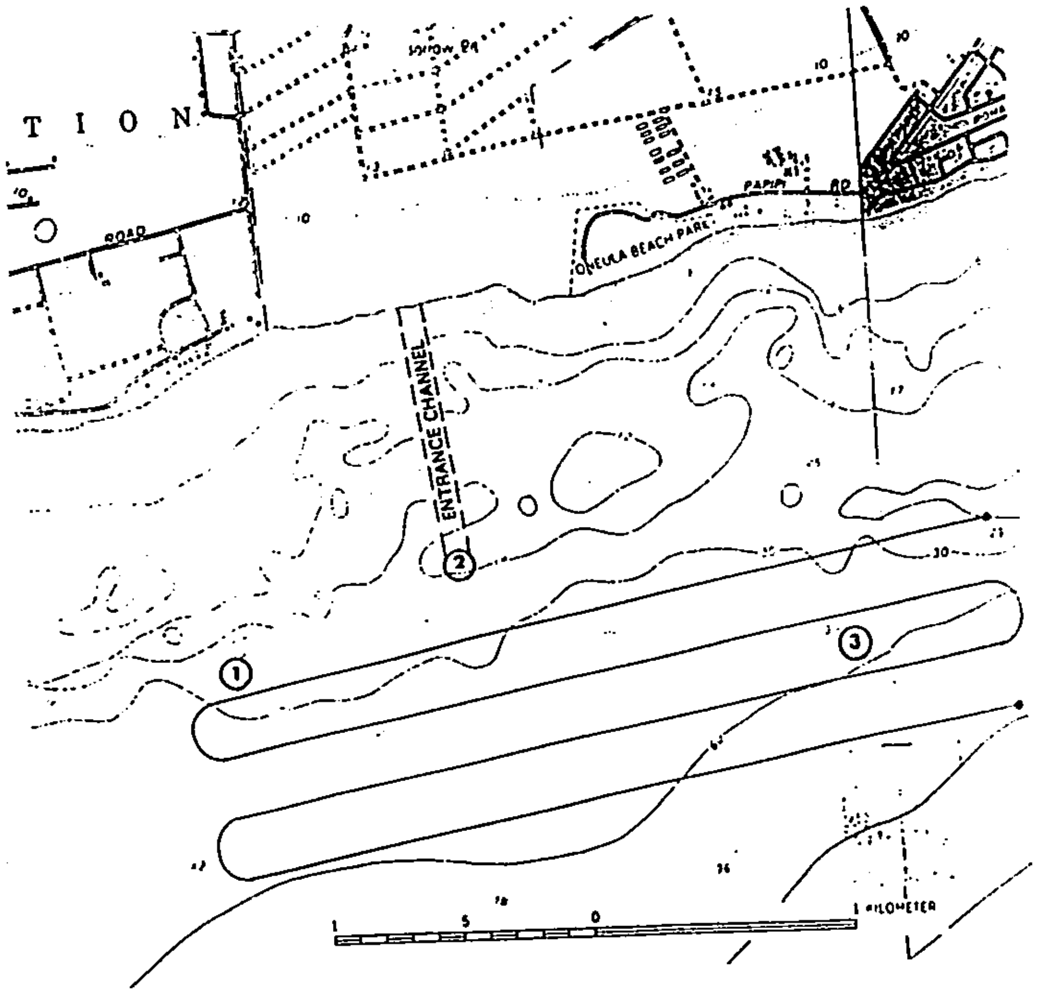
Site 2:

No.	Sex	Length (cm)	Comments
10	M	50	Swimming in water column in entrance channel location.

Site 3:

No.	Sex	Length (cm)	Comments
11	F	90	Sleeping in hull of sunken barge; small tumor on left front flipper.
12	F	80	Resting in hull of sunken barge.

FIGURE 4. MAY 5, 1991, SURVEY TRANSECTS AND TURTLE SIGHTINGS.



SURVEY 5 -- June 17, 1991

Conditions

The fifth survey was conducted during a period of low tradewinds (10-20 kt) and nearly calm surf conditions. While sea conditions were calm, water clarity was considered poor in the survey area owing to an apparent plume of turbid water that flowed west from the mouth of Pearl Harbor. Owing to the substantial turbidity, underwater visibility was limited, and the bottom was not visible from the surface in water depths greater than approximately 20 feet. Tows over the flat plain along the course shown in Figure 5 resulted in no turtle sightings; all individuals were observed during very extensive survey coverage of the two areas of topographic relief called the "turtle house" (Site 1) and the "barge" (Site 2) shown in Figure 5.

Findings

A total of 12 turtles were seen during the course of this survey. All sightings were of green sea turtles (*Chelonia mydas*). As indicated by the following tabulation, individuals tended to be adults with only one sighting of an individual less than approximately 70 cm in carapace length. All turtles were seen either in resting behaviors, free swimming in the water column, or on the surface of the ocean. No tags were observed. Only one turtle exhibited prominent tumors on the front flippers. The site numbers given below correspond to the locations shown on Figure 5.

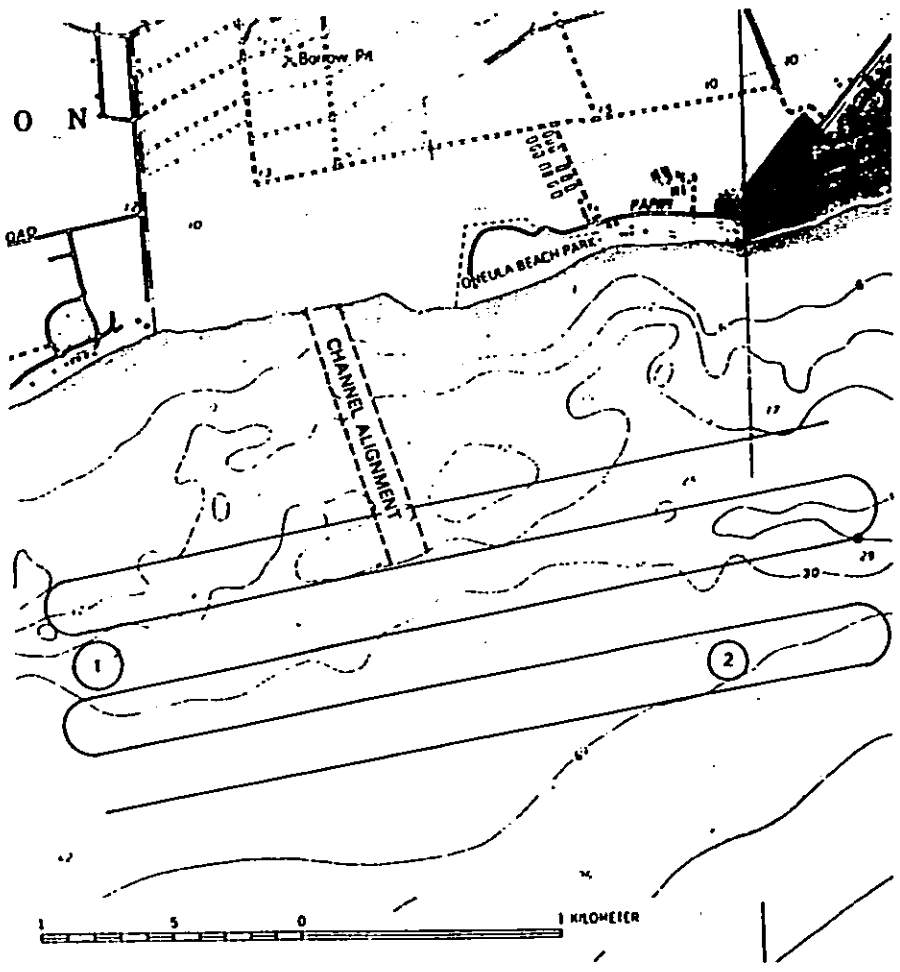
Site 1: "Turtle House"

No.	Sex	Length (cm)	Comments
1	?	50-70	Swimming on surface.
2	?	50-70	Swimming on surface.
3	♀	70	Swimming near bottom; numerous small tumors on both front flippers.
4	♂	90	Resting in excavated cave
5	♀	70	Resting on bottom.
6	♀	30	Resting on bottom.
7	♂	80	Resting in excavated cave.
8	♂	80	Swimming near bottom.
9	♀	40	Swimming near bottom.
10	♀	80	Swimming near bottom.
11	♀	90	Swimming near bottom.

Site 2: "Barge"

No.	Sex	Length (cm)	Comments
12	♀	70	Resting in hull of sunken barge.

FIGURE 5. JUNE 17, 1991, SURVEY TRANSECTS AND TURTLE SIGHTINGS.



SURVEY 6 – July 7, 1991

Conditions

The sixth survey was conducted during a period of low tradewinds (10-15 kt) and nearly calm surf conditions. This survey was relatively unique in that water clarity was distinctly improved over previous investigations. The turbid plume that consists of water flowing out of Pearl Harbor was not present in the Ewa study site during the July survey. As a result of the improved clarity, the underwater environment was more easily assessed with respect to turtle occurrence. Even with the increased range of visibility tows over the flat plain along the course shown in Figure 6 resulted in no turtle sightings; all individuals were observed during very extensive survey coverage of the areas of topographic relief called the "turtle house" (Site 1). For the first time in the last 5 surveys, no turtles were observed taking shelter in the "barge" (Site 2) shown in Figure 5.

Findings

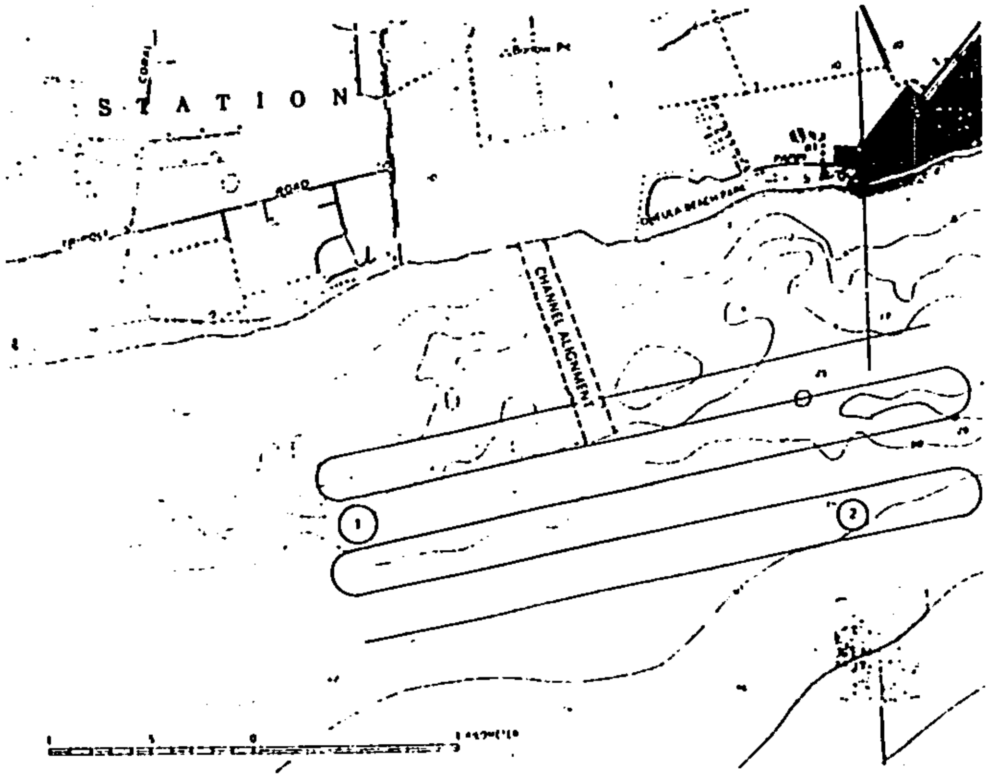
A total of 22 turtles were seen during the course of this survey. Because many of the sightings were of turtles swimming near the bottom, it is probable that some of the recorded encounters represents multiple observations of the same individuals. All sightings were of green sea turtles (*Chelonia mydas*). As indicated by the following tabulation, individuals tended to be adults with only one sighting of an individual less than approximately 60 cm in carapace length. All turtles were seen either resting in depressions on the bottom, free swimming in the water column, or on the surface of the ocean. No tags were observed. Only one turtle exhibited prominent tumors on the front flippers; this individual appears to be the same turtle sighted in previous surveys. The site numbers given below correspond to the locations shown on Figure 6.

Site 1: "Turtle House"

No.	Sex	Length (cm)	Comments
1	?	50-70	Swimming on surface.
2	?	50-70	Swimming on surface.
3	?	70-100	Swimming on surface.
4	♀	30	Swimming near bottom.
5	?	90	Resting in excavated cave.
6	♂	60	Swimming in midwater.
7	♀	30	Swimming near bottom.
8	♀	60	Swimming near bottom.
9	♂	90	Resting in excavated cave.
10	♂	80	Swimming in midwater.
11	♀	70	Swimming near bottom.
12	♀	60	Swimming near bottom.

13	♀	60	Swimming in midwater.
14	♂	60	Swimming near bottom.
15	♂	70	Resting under ledge.
16	♀	100	Swimming near bottom.
17	♀	70	Resting in excavated cave.
18	♂	60	Swimming near bottom.
19	♀	80	Resting on bottom.
20	♀	80	Swimming in midwater.
21	♀	70	Resting under ledge, tumors on front flippers.
22	♀	80	Resting under ledge.

FIGURE 6. JULY 7, AUGUST 17, SEPT. 21, AND OCT. 14 1991, SURVEY TRANSECTS AND TURTLE SIGHTINGS.



SURVEY 7 – August 17, 1991

Conditions

The seventh survey was conducted during a period of strong trade winds (15-25 kt) and moderate south swell (3-5 ft). In strong contrast to the July survey when water clarity was exceptional, turbidity of the water column in August was extreme. Resuspension of fine particulate material from wave action resulted in underwater visibility of only 15-20 ft. The extreme turbidity did not appear to be a result of a distinct plume emanating from outflow from Pearl Harbor as has been noted in previous surveys, but was rather a ubiquitous condition along most of the south shore. Because of the turbid conditions, sighting of turtles underwater was limited to a relatively small radius of visibility. As a result, tow surveys were virtually useless, and were aborted after a short trial run. Similarly, locating the sunken barge was not possible with the limited visibility. Therefore, the basis of the seventh turtle survey was restricted to intensive investigation of the area of topographic relief off the western border of the Ewa Marina property called the "turtle house" (Site 1 in Figure 6).

Findings

A total of 10 turtles were seen during the course of this survey. Half of this number were seen resting on the surface in a very confined area directly over the area of vertical relief at Site 1 in Figure 6. It is probable that some of the recorded encounters from the underwater investigations represents multiple observations of the same individuals when they were on the surface. All sightings appeared to be of green sea turtles (*Chelonia mydas*). As indicated by the following tabulation, individuals tended to be adults at least 70 cm in carapace length. All turtles were seen either resting in depressions on the bottom, free swimming in the water column, or on the surface of the ocean. No observations were made of either tags or prominent tumors. The site number given below corresponds to the location shown on Figure 6.

Site 1: "Turtle House"

No.	Sex	Length (cm)	Comments
1	?	70-90	Swimming on surface.
2	?	70-90	Swimming on surface.
3	?	90-100	Swimming on surface.
4	?	70-90	Swimming on surface.
5	?	70-90	Swimming on surface.
6	♂	80	Resting in excavated hole.
7	♀	70	Swimming in midwater.
8	♂	90	Swimming in midwater.
9	♂	90	Swimming near bottom.
10	♀	80	Swimming near bottom.

SURVEY 8 -- September 21, 1991

Conditions

The eighth seventh survey was conducted during a period of exceptionally calm winds (0-5 kt) and nominal swell (0-2 ft). These conditions were in sharp contrast to the August survey which was conducted during heavy tradewinds and moderate south swell. As a result of heavy seas, resuspension of fine particulate material resulted in underwater visibility of only 15-20 ft in August. Water clarity in September was substantially greater (estimated at 40 ft), but appeared to be affected by a distinct plume emanating from outflow from Pearl Harbor. The eighth survey included tows over the same pattern as shown in Figure 6, and intensive investigations by divers swimming throughout the area marked as Site 1 ("Turtle house"), and Site 2 ("barge") on Figure 6.

Findings

A total of 6 turtles were seen during the course of this survey. Two were seen resting on the surface directly over the area of vertical relief at Site 1 in Figure 6. It is probable that some of the recorded encounters from the underwater investigations represents multiple observations of the same individuals when they were on the surface. The number of turtles sighted on the surface was noticeably fewer than in previous surveys. The lower number of surface sightings was especially evident owing to the glassy surface conditions which enhances the ability to detect turtles.

All underwater sightings appeared to be of green sea turtles (*Chelonia mydas*). No turtles were sighted on the tow transects; all were observed by divers swimming near the bottom at Site 1. As indicated by the following tabulation, with one exception individuals were at least 70 cm in carapace length. All turtles were seen swimming slowly along the bottom; no sightings were made of individuals resting in depressions on the bottom or in caves. No observations were made of either tags or prominent tumors. The site number given below corresponds to the location shown on Figure 6.

Site 1: "Turtle House"

No.	Sex	Length (cm)	Comments
1	?	70-90	Resting on surface.
2	?	70-90	Resting on surface.
3	♂	80	Swimming near bottom.
4	♀	90	Swimming near bottom.
5	?	30	Swimming near bottom.
6	♂	70	Swimming near bottom.

SURVEY 9 -- October 14, 1991

Conditions

The ninth survey was conducted during a period of southwest winds of 10-15 kts, causing very choppy sea conditions, and nominal swell (0-2 ft). These conditions were in contrast to the September survey which was conducted during a period of no wind and very calm seas. During the October survey, even though substantial amounts of gelatinous plankton were observed in the water column, water clarity was moderate to good with visibility up to 60 ft. Neither wave-generated resuspension, nor the turbid plume that has often been noted in the survey area were prominant during the survey. The ninth survey included tows over the same pattern as shown in Figure 6, and intensive investigations by divers swimming throughout the area marked as Site 1 ("Turtle house"), and Site 2 ("barge") on Figure 6.

Findings

At least 6 turtles were seen during the course of this survey. No turtles were observed resting on the surface; all sightings were underwater. The lack of sightings on the surface was unusual in that several individuals have been consistently observed over the area of vertical relief in previous surveys. The absence of surface sightings may have been a result of choppy sea conditions, which greatly decreases the ability to detect turtles.

All underwater sightings appeared to be of green sea turtles (*Chelonia mydas*). No turtles were sighted on the tow transects; all were observed by divers swimming near the bottom at Site 1. As indicated by the following tabulation, with one exception individuals were at least 70 cm in carapace length. All turtles were seen swimming slowly along the bottom or resting in depressions on the bottom or in caves. No observations were made of either tags; a tumor was evident on the right front flipper of one individual. The site number given below corresponds to the location shown on Figure 6. No turtles were observed in the sunken barge. However, a large shark was observed in the area.

Site 1: "Turtle House"

No.	Sex	Length (cm)	Comments
1	?	40	Swimming slowly near bottom.
2	♀	70	Swimming slowly near bottom.
3	♂	80	Resting in hole.
4	♀	80	Resting in hole.
5	♀	90	Resting on bottom.
6	♀	80	Resting on bottom; tumors on rt. front flipper.

CUMULATIVE FINDINGS AND CONCLUSIONS

After extensive and repetitive towing over the entire area fronting the marina site, the only identified region of substantial natural physical complexity is off of the Barbers Point Naval Air Station. This region is approximately 1 kilometer west of the proposed entrance channel to the marina. The extensive excavation of the soft limestone substratum in the ridge system suggests that turtles have used the area for millennia.

Survey results to date show two distinct levels of abundance. The results of surveys 2 through 6 (November - July 1991) were very similar, with green sea turtles present in relatively large aggregations (~10-20 individuals) in the region having the vertical relief sufficient for providing shelter space for protection during daylight resting behavior. Over this time interval, the relative consistency of turtle sightings, as well as the similar size distribution, did not suggest that a significant portion of the resident population has left the area for breeding migration. Repetitive sightings of identifiable individuals also suggested that the same turtles had been inhabiting the area during the course of the survey program.

Results of surveys 7 through 9 (August - October 1991) were similar to each other, but differed rather substantially from previous surveys in that only 4-6 turtles were observed in the area of high relief. The reduction of underwater sightings in August was attributed in part to decreased visibility owing to turbid conditions associated with wave turbulence. During the September and October surveys, however, visibility was not limited by resuspended material, and the number of sightings was consistently low. At this point in time, it is not clear if the reduced sightings are a result of a seasonal migration to breeding grounds in the Northwest Hawaiian Islands, or of a pattern of "local" activity of changing resting habitat by the resident population. Results of repetitive surveys of turtle abundance in the vicinity of West Beach suggest similar patterns of movement of "resident" populations that do not appear to be breeding migrations (R. Brock, personal communication).

While the number of sightings was substantially reduced in the three most recent surveys, characteristics of the individuals observed in all surveys to date have been similar. Most have been mature individuals with carapace lengths greater than about 60 cm; few small adults or juveniles have been observed. None of the turtles sighted to date have exhibited extensive or large tumors on their heads or appendages. Small tumors have been noted on only a small number of individuals.

Another consistent finding of the surveys is that few turtles have been sighted in the areas characterized by the kind of flat "hardpan" bottom characteristic of the proposed channel alignment. The single individual observed in this region in the fourth survey was actively swimming through the water column, and did not appear to be resting or feeding. Such bottom type does not provide vertical relief suitable for daytime resting behaviors that have been observed in the ridge and crevice area off the Barbers Point Naval Air Station. The current survey completes the first full year of monitoring at the Ewa Marina site. Until the commencement of construction, turtle monitoring will be carried out on a quarterly basis. The next survey will be conducted in January 1992.

Appendix L

Ewa Marina Evaluation of Project Impacts on Surf Sites

EWA MARINA
EVALUATION OF PROJECT IMPACTS ON SURF SITES

TECHNICAL STUDY

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File 2612-04

November 7, 1990

CONTENTS

1.0 INTRODUCTION

1.1 Background

Surfing is recognized as an important and desirable element of the Ewa Marina development. Several surf sites have been identified in the vicinity of the projection through the shoreline of the proposed marina entrance channel. An important consideration in siting the entrance channel is to minimize the potential impacts of the project features on surf sites.

Identification of a surf site requires the definition of the characteristics and boundaries of surfing activity at the site under a range of expected wave, wind and tidal conditions. The identification process comprises both technical evaluation and interviews with experts and local surfers. Technical evaluation, which consists of analysis of bathymetry and wave conditions, coupled with field observations during site visits, provides the most effective means of identifying characteristics and boundaries of the surf sites. This report addresses these technical aspects of surf site identification. Interviews with experts and local surfers, also used in surf site identification, are essential in gaining insight concerning the usage and range of surfable waves. Such interviews are currently ongoing.

1.2 Purpose

The purpose of this study was to identify and describe the existing surfing activities in the project site vicinity, discuss the technical aspects of recreational surf breaks, and evaluate the potential impacts of the project on existing surf sites such that they can be minimized.

1.3 Scope

Project impacts on surfing have been addressed in prior project planning studies; the results of these studies are discussed herein. This report expands upon prior investigations with detailed analyses of aerial

photographs, evaluation of site bathymetry and wave conditions, and additional site observations.

The following summarizes the scope of work conducted for this study:

1. Describe the proposed entrance channel location and configuration.

2. Make site observations.

3. Identify the existing surf sites in the vicinity of the entrance channel.

4. Investigate physical aspects of surf sites in general, including wave climate and bathymetry, and correlate these with identified sites in the project vicinity.

5. Correlate identified surf sites with historic and recent aerial photographs.

6. Assess potential impacts of proposed marina entrance and structures on surf sites.

2.0 PROJECT DESCRIPTION

The proposed Ewa Marina project is shown in Figure 2-1. Since the project site is not afforded the protection provided by the shallow reefs typically found at other Hawaiian marinas, special consideration in this study was given to navigation safety and mitigating wave conditions within the harbor. The proposed marina entrance channel would be 400 feet wide and approximately 2,900 feet long. The channel width, as well as the need for protective jetties as discussed below, was determined based upon considerations of navigational safety and vessel traffic. The seaward limit of the entrance channel extends to the 20-foot depth contour to reduce the probability of waves breaking in the channel and to allow passage of boats during periods of large swell.

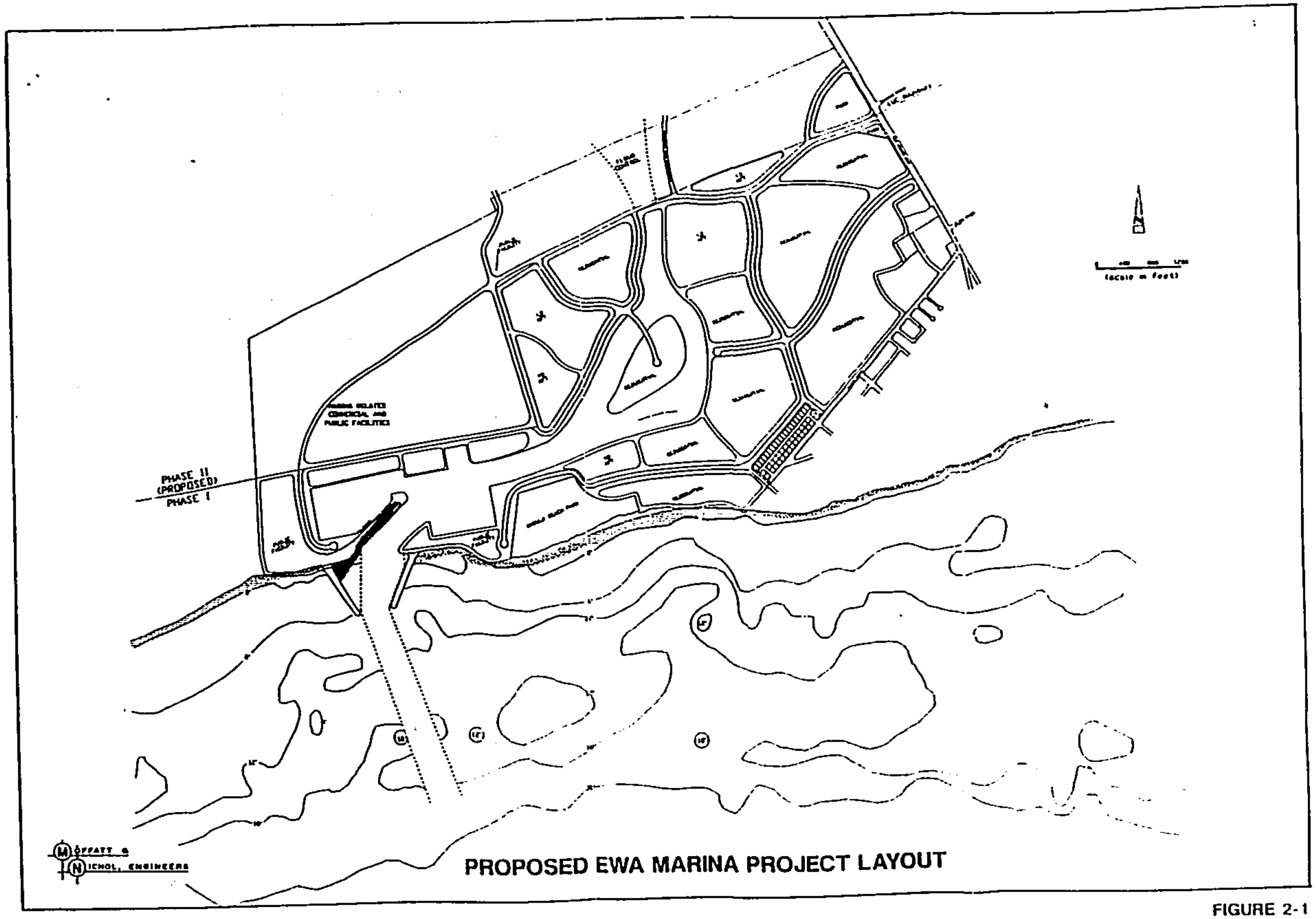
The rock jetties constructed along the entrance channel would serve three main purposes:

1. To protect the marina basin from waves: The jetties act as breakwaters to attenuate waves to acceptable levels before they reach the interior marina basins.

2. To prevent wave-induced longshore currents from creating a navigation hazard: The jetties provide a barrier to cross-channel rip currents that may be created by waves breaking over adjacent reefs.

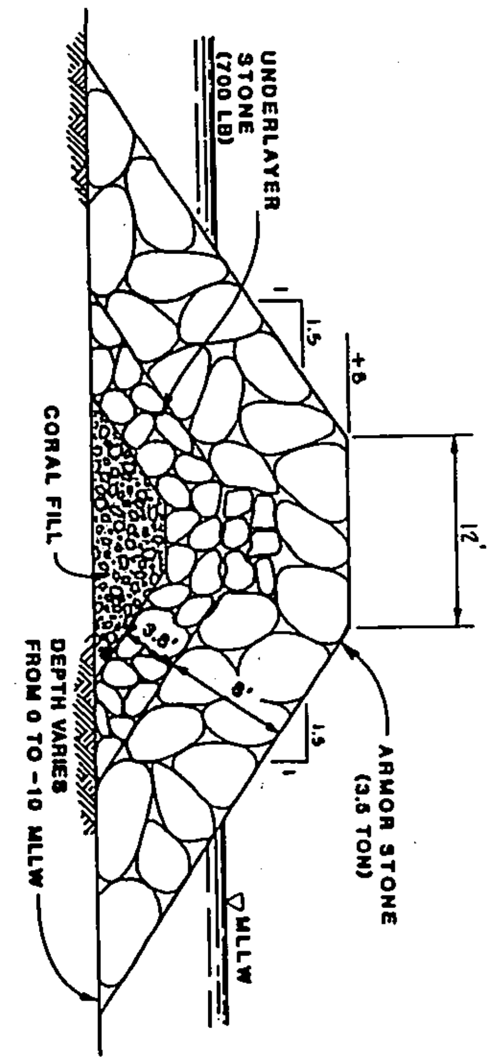
3. To prevent littoral drift from shoaling the channel: The jetties act as barriers to littoral drift that would otherwise be deposited in the navigation channel thereby causing a navigational hazard and temporary lose of beach sand.

The jetties would be approximately 700 feet long, extending offshore to the 10 foot depth contour. The proposed jetty cross section is shown in Figure 2-2. Detailed wave analyses will be used to determine the final jetty design and configuration. The jetty section was designed using procedures described in the Shore Protection Manual (U.S. Army Corps of Engineers, 1984). The side slope and armor-stone size were designed so that the structure will resist the expected wave action. The porous side slopes tend to absorb, rather than reflect, wave energy. A concrete cap may be added to the jetty design in order to provide surf site access from the jetties.



PROPOSED EWA MARINA PROJECT LAYOUT

FIGURE 2-1



TYPICAL JETTY SECTION

FIGURE 2-2

3.0 IDENTIFIED SURF SITES

3.1 Surf Site Surveys

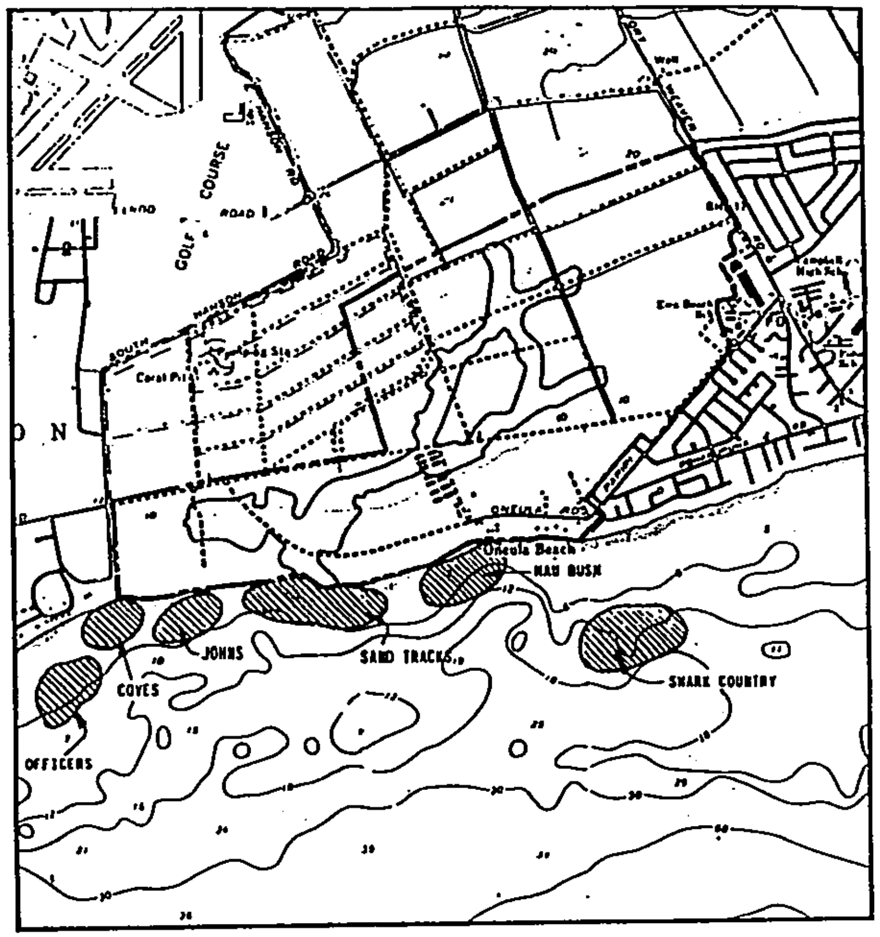
Six surf sites have been identified in the vicinity of the project site by Department of Planning and Economic Development (1971) SCORP Studies. The Division of State Parks, Outdoor Recreation and Historic Sites, Department of Land and Natural Resources, updated this study in an unpublished report, "The Board Surfing Sites Survey" (circa 1976). In this report, the six sites identified in the vicinity of the project site, are Officers, Coves, Johns, Sand Tracks, Hau Bush, and Shark Country (see Figure 3-1). In order to verify the locations of the six surf sites, a number of local surfers were asked earlier this year (1990) to locate these surf sites on a map (see Figure 3-2). The locations determined from this 1990 survey were plotted together with the 1976 survey locations; the results are shown in Figure 3-3. The figure shows that Officers and Hau Bush were the only sites showing good correlation between the two surveys. Shark Country was located farther inshore in the recent survey. The Coves, Johns, and Sand Tracks sites varied significantly between surveys. The new survey also indicated a seventh site called Tree Stumps.

3.2 Site Observations

Several site observations have been performed over the past 10 years. The most recent was carried out during June 25 to 27, 1990. Light-to-moderate tradewinds prevailed during the site visit, with a 2 foot surf from the southeast. Site observations, as well as discussions with local surfers and surfing experts, are summarized as follows:

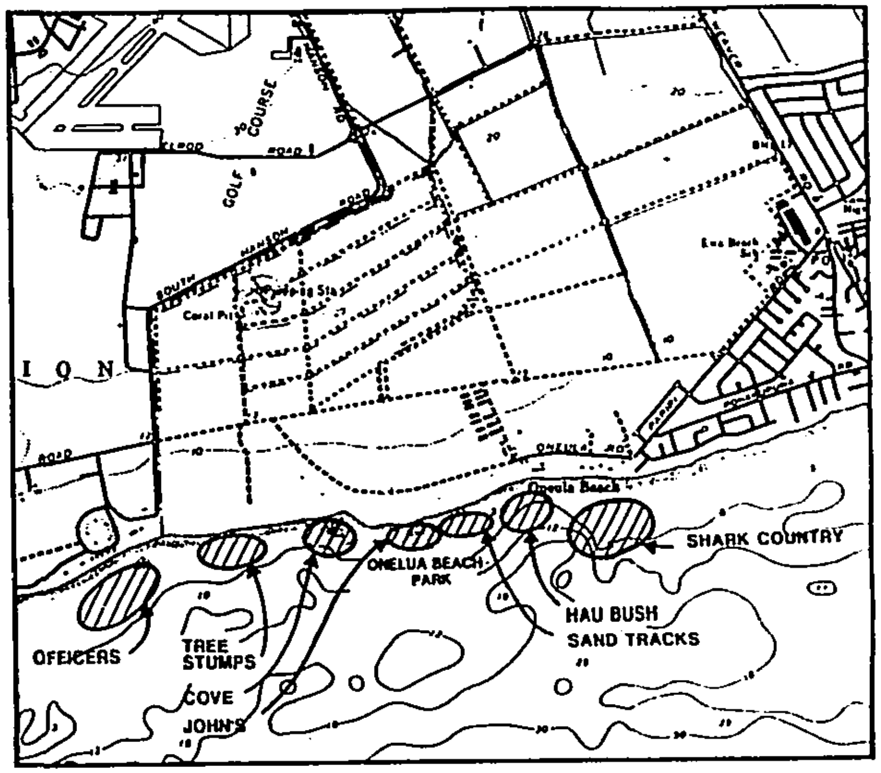
1. There was general concurrence with the results of the 1990 local surfer surf site survey.

2. Coves was described as a reef break, breaking both ways but primarily left (west), away from the adjacent headland. The lefts are ridden



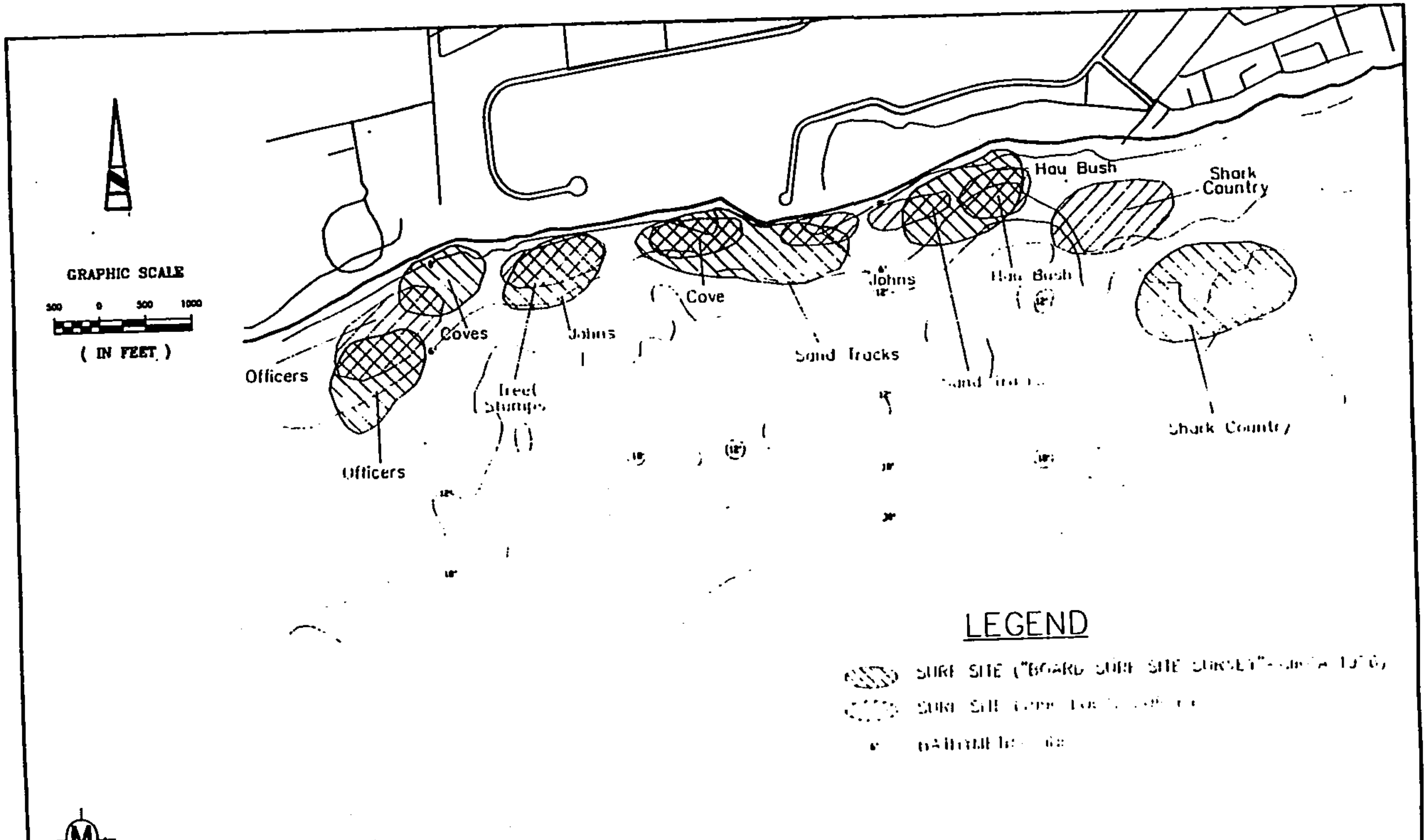
BOARD SURFING SITES SURVEY
(CIRCA 1976)

FIGURE 3-1



LOCAL SURFER SURF SITE SURVEY
(1990)

FIGURE 3-2



COMPARISON OF 1976 AND 1990 SURF SITE SURVEYS

FIGURE 3-3

until the water becomes too shallow. The site typically breaks at 2 to 3 feet, is at its best at 3 to 4 feet, can hold waves from 6 to 8 feet, and then either the wave closes out or the break moves farther offshore.

3. Shark Country was described as the best and most popular of the seven sites identified in the 1990 surf site survey. The site was described as accommodating up to 40 surfers at one time.

4. Tree Stumps was described as one of the least surfed of the seven identified sites, because of short rides. This site was described as breaking to the right (east) only; waves close out when they exceed 4 feet.

5. The proposed marina entrance channel site, described in Section 2.0, was considered to be "the best spot for the channel", with regard to mitigating project impacts on surf sites in the vicinity.

4.0 TECHNICAL ASPECTS OF A SURF SITE

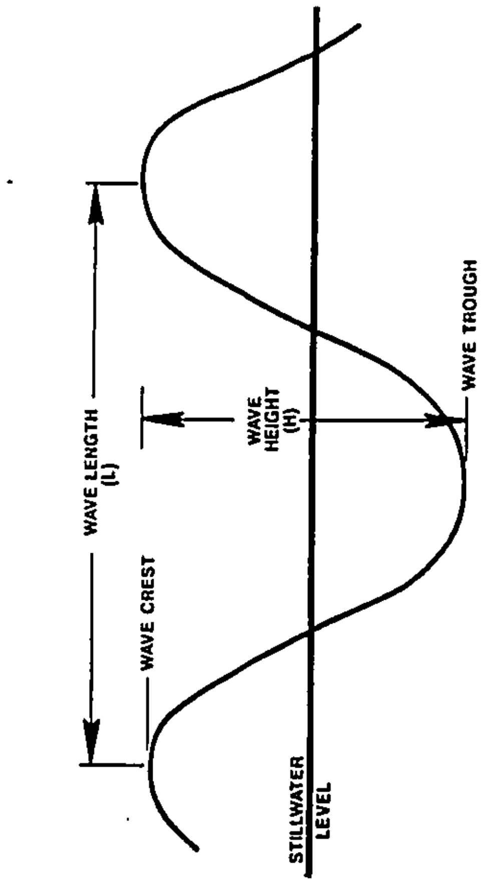
It is important to understand that the surf sites discussed in the preceding section were not identified by measurements nor were they observed over a wide range of conditions. Variations in location should be expected when are drawn locations on a map. It is very difficult to stand on the shoreline and accurately identify the lateral and offshore extents of an individual surf site. More reliable methods of identification are required in order to make an accurate assessment of the potential impacts of the proposed project on surf sites. Detailed analyses of aerial photographs, site bathymetry, and wave transformations can provide a more reliable basis for surf site identification.

This section describes the technical aspects of a surf site (i.e., the physical characteristics that create a desirable surf site.) Section 5.0 then applies the understanding of these physical to the project site in order to better define the characteristics and boundaries of the surf sites in the project vicinity.

4.1 Technical Description of Surfing Waves

Figure 4-1 illustrates a surfing wave and presents the terminology used in this report. A glossary of surfing terms is included as Appendix A. Surfing waves result from the interaction of waves with the bottom, wind with the waves, and the surfer with the wave. Waves approach from offshore, are transformed by the bottom into breaking conditions and are ridden by surfers. The wind affects surface conditions and breaking qualities of the waves. The interaction of the waves with the bottom is the most important factor in distinguishing one site from another.

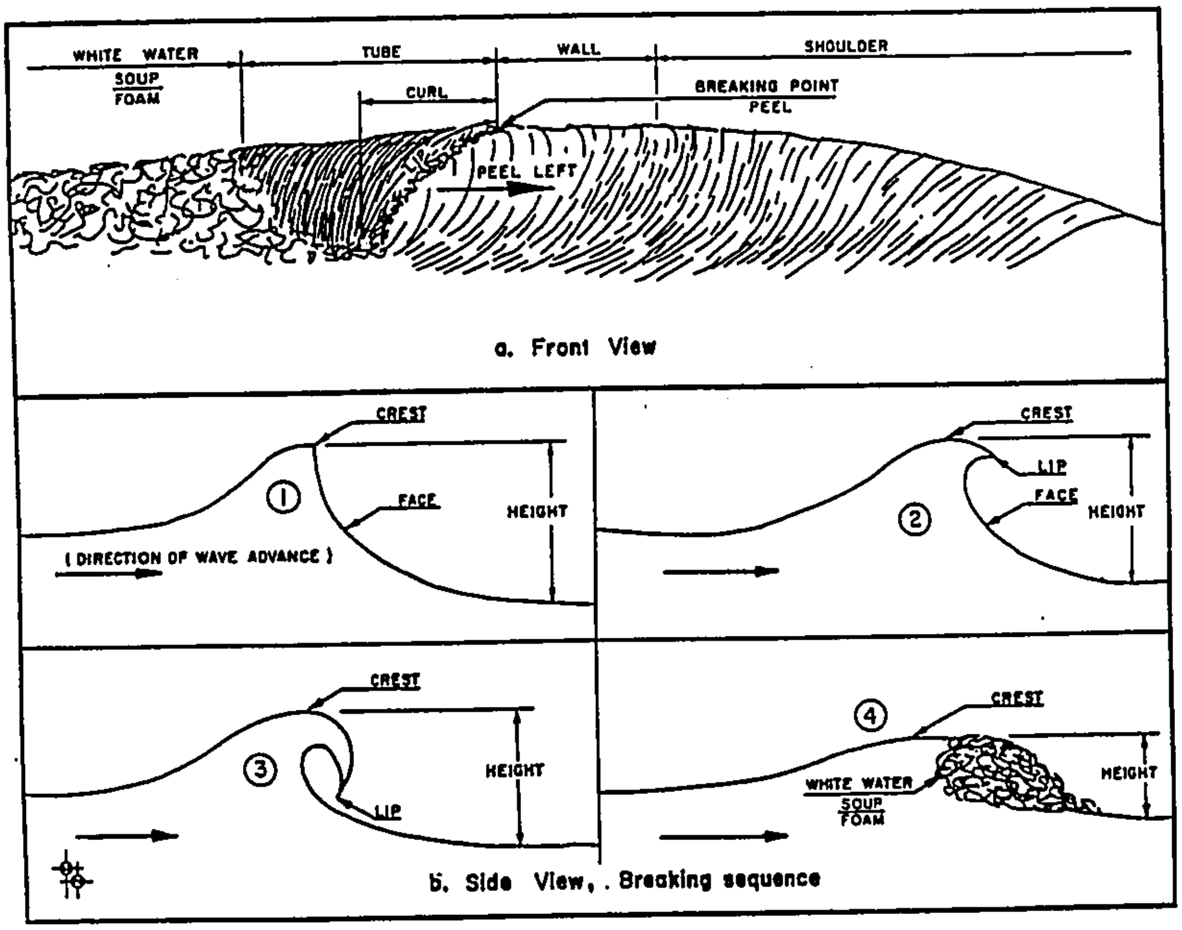
Breaker height, breaker type, and peel angle are all important parameters in the identification of surf site characteristics. The wave height, H, is the most obvious and important parameter. The wave height is the measure of the vertical distance from the trough of the wave to the crest, as defined in Figure 4-2. Another parameter is the wave length, L, which is the horizontal



WAVE PERIOD (T) IS THE TIME REQUIRED FOR SUCCESSIVE WAVE CRESTS TO PASS A GIVEN STATIONARY POINT

WAVE PARAMETERS

FIGURE 4-2



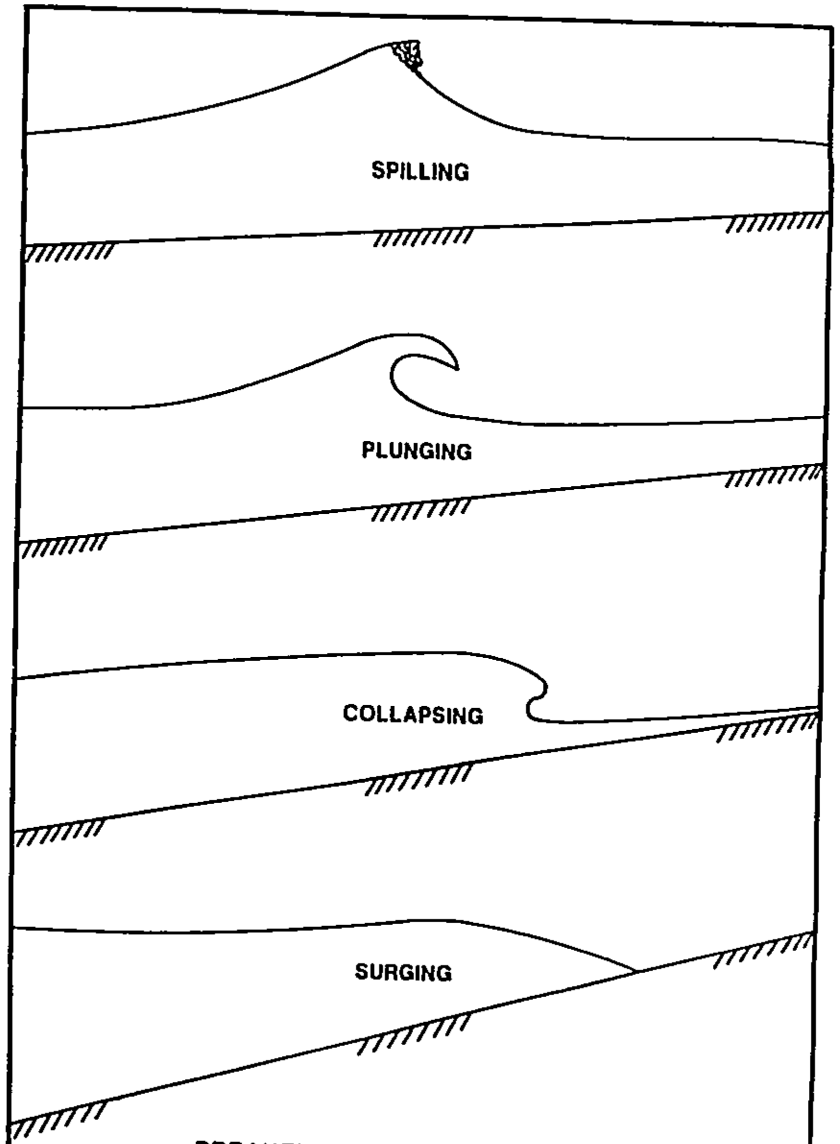
SURFING WAVE TERMINOLOGY

FIGURE 4-1

distance between successive wave crests. The wave period, T, is the time required for successive wave crests to pass a given stationary point.

Breaker type is another important parameter in identifying surf site characteristics. As waves travel toward the beach from deep water into shallower water, they are affected by the bottom conditions. The slope of the bottom, m, in relation to other parameters, such as wave steepness, H/L, and relative depth, d/L, determines the type of breaking conditions that will prevail, thereby determining breaker type. The breaker type may be a gentle spilling, which is characteristic of short-period waves over a gently slope, or plunging which is characteristic of long-period waves over a steep slope. Figure 4-3 graphically illustrates the breaker types as well as collapsing and surging wave types. Figure 4-4 indicates the breaker type expected to occur on a given seaward beach slopes, relative to breaking the wave steepness. Spilling and plunging breakers are the most common surfing waves.

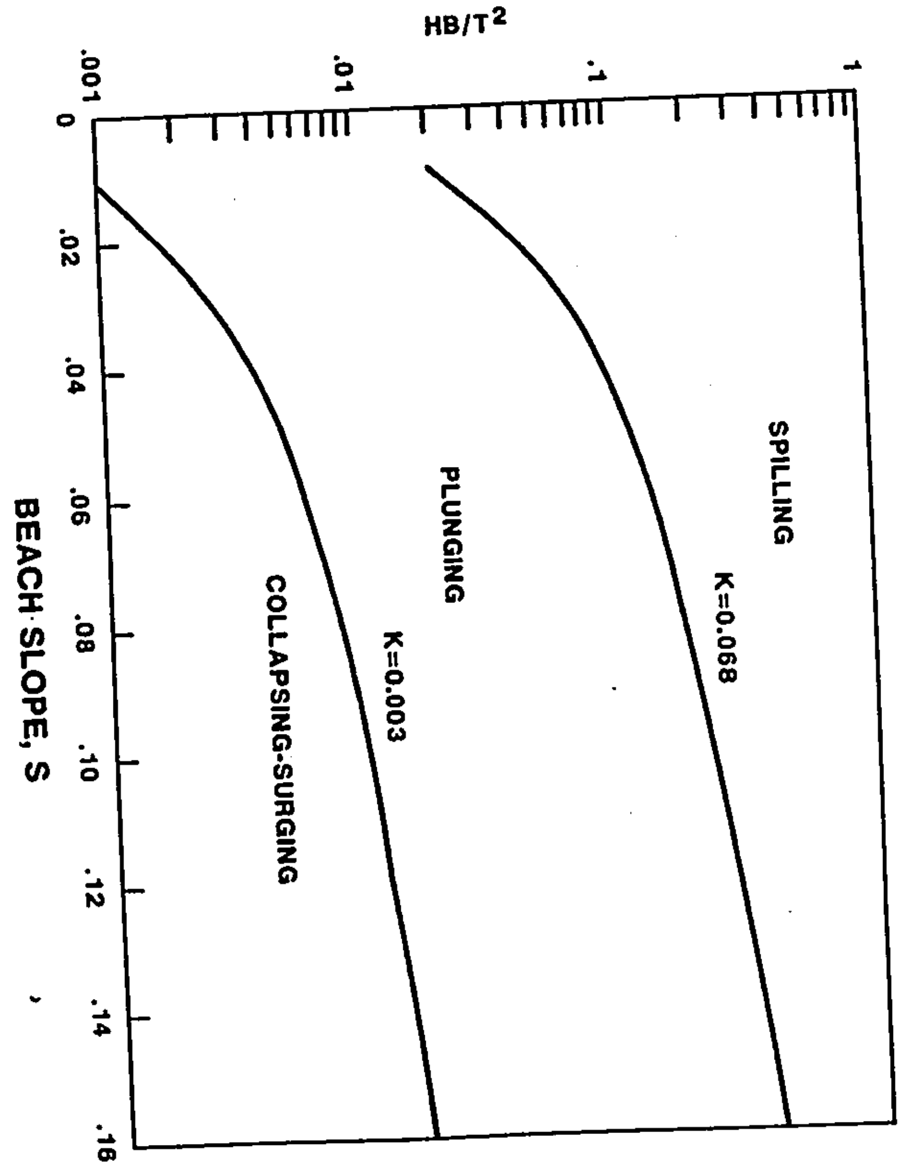
Peel angle is the third important parameter in identifying surf site characteristics. Surfers are not satisfied with a ride straight in toward shore. They prefer to work the face of the breaking portion of the wave (see Figure 4-1). Figure 4-5 shows a plan view of a wave as it breaks laterally along the crest as the wave propagates toward shore. The peel angle, α, is measured from overhead. Walker (1974) documented a relation between the peel angle and the breaker height to develop a description of surfing waves. This relation which is generally applicable is shown in Figure 4-6. The breaker height, H_b, is in part governed by the wave properties and the bottom slope. As the wave propagates toward shore it eventually increases in height to a point where it becomes unstable and breaks. The breaker index H_b/d_b is a ratio of breaker height to water depth. The breaker index of H_b/d_b=0.78 is commonly used as a general guide. For example, a breaker index of 0.78 indicates that a 3-foot wave will break in about 4-feet of water (H_b/d_b = 3 feet/4 feet = 0.75 ≈ 0.78). The peel angle should have a range of 30 to 90 degrees. More acute peel angles are close-out waves; i.e., the wave essentially breaks simultaneously along the crest and is unridable. Waves that progressively break along the crest as they approach shore are highly desirable for surfing and are described as peeling waves. The peel angle is



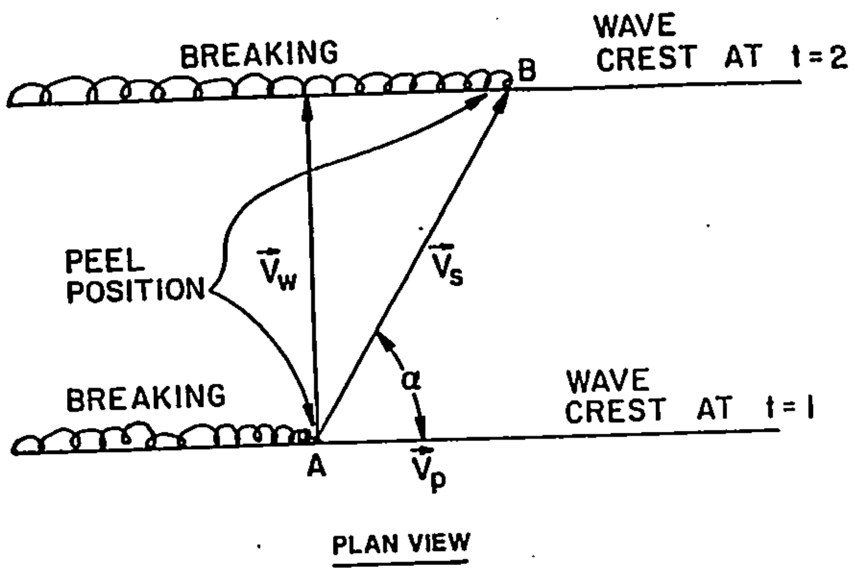
BREAKER TYPE CLASSIFICATIONS

FIGURE 4-3

FIGURE 4-4



BREAKER TYPE INDEX



$\vec{V}_W$ = VELOCITY OF WAVE

$\vec{V}_S$ = SURFER VELOCITY

$\vec{V}_P$ = PEEL VELOCITY

α = PEEL ANGLE

PEEL PARAMETERS

FIGURE 4-5

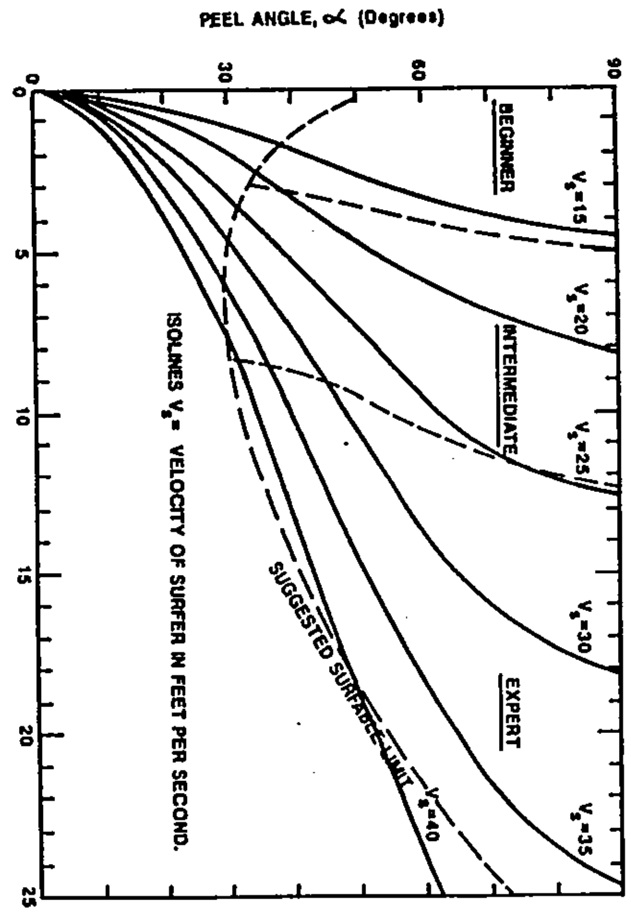
controlled by the angle of the wave crest with the breaker depth. Hence, if the wave propagates directly up a beach slope, it will have a 0-degree peel angle, will close out, and will be unsuitable for surfing unless it is a very gently spilling breaker wherein the white water does not reach the wave trough.

The wind has a profound influence on breaker height and type. Any surfer can attest that a gentle to even strong wind with a component opposing the wave tends to hold the wave up longer and create a smoother surface than a wind with a component in the direction of wave propagation. A component of following wind causes the wave to break prematurely with a lower height consequently, a lower and breaker index, and it spoils the surface conditions. This is one reason why field experiments may yield lower breaker indices than those obtained from laboratory experiments of wave breaking. Wind conditions vary throughout the day. Often the wind is absent or blows offshore during the morning; then, after a few hours of sunlight, the land heats to induce an onshore wind in the afternoon. This is called a sea breeze.

4.2 Surf Site Bathymetry

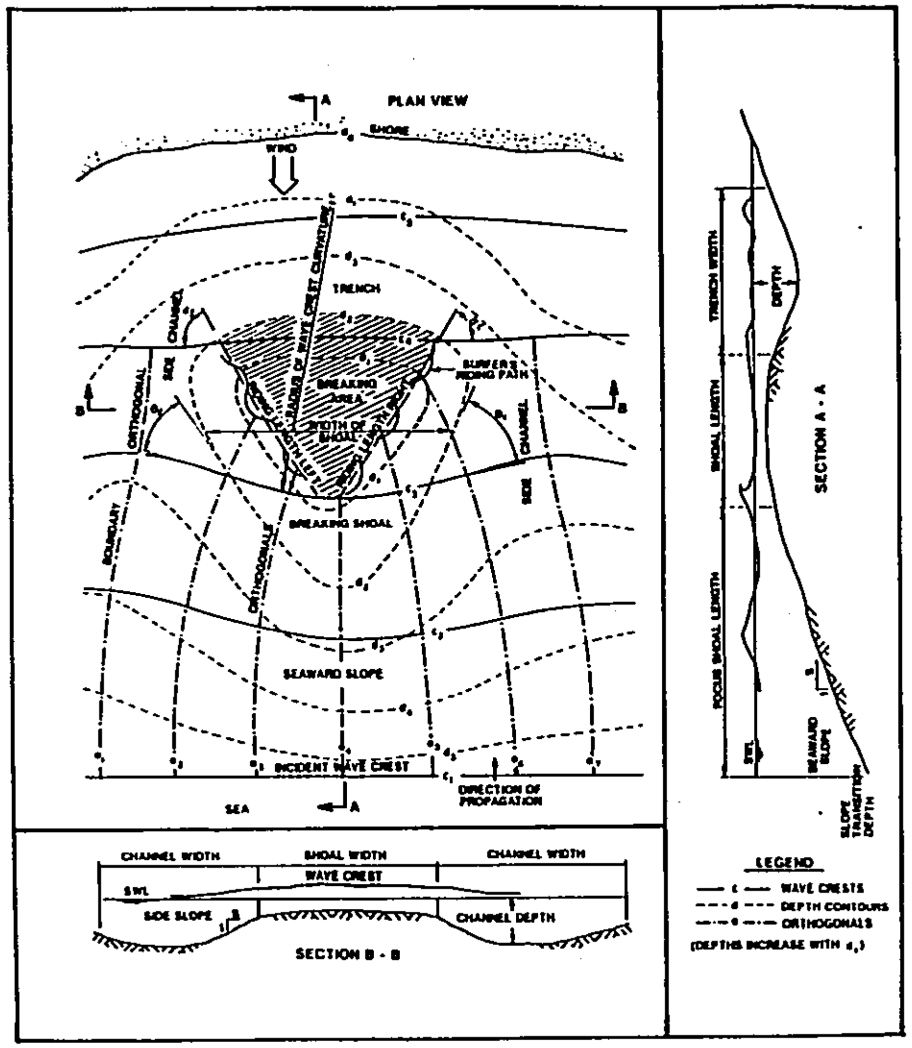
The characteristics of a surf site depend upon wind conditions and upon the bathymetry of the ocean bottom as well as with the wind conditions. The basic requirement for a desirable surfing wave is for the wave to peak gradually into a breaking condition; gradual peaking results from a gradually decreasing water depth. It is desirable for the wave to break at a point and then peel laterally along the crest. The surfer generally rides the wave in the peel region. The ride is terminated at a beach or at a structure, or at a section where the wave stops breaking, or when the surfer desires to get off the wave or wipes out. A desirable surf site requires a place for surfers to enter and return to the surf zone, as well as an access channel to and from the site.

The bottom and boundary configurations that induce surfing waves are different for each site. Prominent bathymetric features that transform incoming waves into desirable surfing waves include a seaward slope, side channels, and a shoal or ridge. These features are discussed in the subsections that follow. Figure 4-7 shows these and other site features.



PEEL ANGLE vs. BREAKER HEIGHT

FIGURE 4-6



GENERAL SURF SITE FEATURES

FIGURE 4-7

4.2.1 Seaward Slope

Wave refraction is defined as the process by which the direction of a wave moving in shallow water at an angle to the depth contours is changed. The part of the wave advancing in shallower water moves more slowly than that part still advancing in deeper water, causing the wave crest line to bend toward alignment with the underwater depth contours. Therefore, a seaward slope in a ridge configuration induces the incoming waves to converge. The primary seaward slope parameters are its steepness and orientation in relation to the incoming waves, as well as the plan configuration.

Seaward slope steepness influences breaker height and type. Steeper slopes result in higher breaking waves. For example, a given incoming wave will break with a 25 percent greater height on a 1:10 slope than on a 1:50 slope. Waves also tend to break in a more plunging form for steeper slopes, as discussed in Section 4.1. Most Hawaiian surf sites break in a plunging or spilling-plunging form.

The orientation of the seaward slope in relation to the incoming waves has a significant influence on a surf site. A shoal oriented directly, or nearly directly, into the direction of approach will cause more convergence, and consequently a greater breaking height, than a shoal oriented at a 45-degree angle to the direction of approach. This influence becomes more pronounced as the shoal extends into deeper water for narrow shoals. Shoals with blunter shapes located in shallow water are not so sensitive to filtering.

The plan configuration of the seaward slope varies considerably from site to site. The seaward slope of most prime Hawaiian surf sites is generally blunt (as opposed to having a sharp point protruding seaward).

4.2.2 Side Channels

Depth variations near the breaker zone contribute toward the creation of desirable surfing waves. A surf shoal commonly has a channel on one or both of its sides. Excellent surfing conditions frequently exist on both sides of a natural channel and sometimes alongside a dredged channel. The important side channel parameters are the depth differential relative to the shoal, the width of the channel, and the alignment of the shoal relative to the incident waves.

Side channels perform several important functions in wave transformations and at surfer-site interfaces. A side channel separates adjacent surf sites from one another, induces a wave-amplitude differential between the non-breaking wave in the channel and the breaking wave over the shoal, and changes wave angle, which subsequently influences peel angle and breaker height. The side channel provides an area for surfers to gain access to and return from the surf site without interfering with others surfing. Rip currents are often found in the side channels.

4.2.3 Shoals or Ridges

A shoal in a ridge configuration is an extension of the seaward slope and the side channel slopes. A shoal fulfills the breaking-depth criterion such that waves are induced to break farther seaward over the shoal than in adjacent channels. The size, shape, depth, and location of the shoal are the important parameters that determine if an incident wave is transformed into a desirable surfing wave. In general, the shape of a shoal at surf sites is blunt, with contours that run obliquely toward shore.

The orientation of shoal side contours controls the peel angle. The peel follows the breaking depths. The wave is highest at the initial break. Subsequent breaking along the crest is usually progressively lower as the wave propagates from the initial break. After the initial break, the instability of the breaking is transferred laterally, and the wave may break at a lower height than the controlling depth. The wave crest at prime surf sites generally subtends a 30- to 90-degree angle with the bottom contours. Waves with crests at more acute angles are generally too fast to ride and those with crests at more obtuse angles are "back-off" waves, which are generally not considered to have a desirable surfing form. A 50-degree wave crest-to-bottom contour angle appears to be a typical angle found at most desirable surf sites. This leaves leeway for wave-direction variability to allow the site to be useful for surfing under a wide range of wave conditions.

4.3 Physical Description of Selected Hawaiian Surf Sites

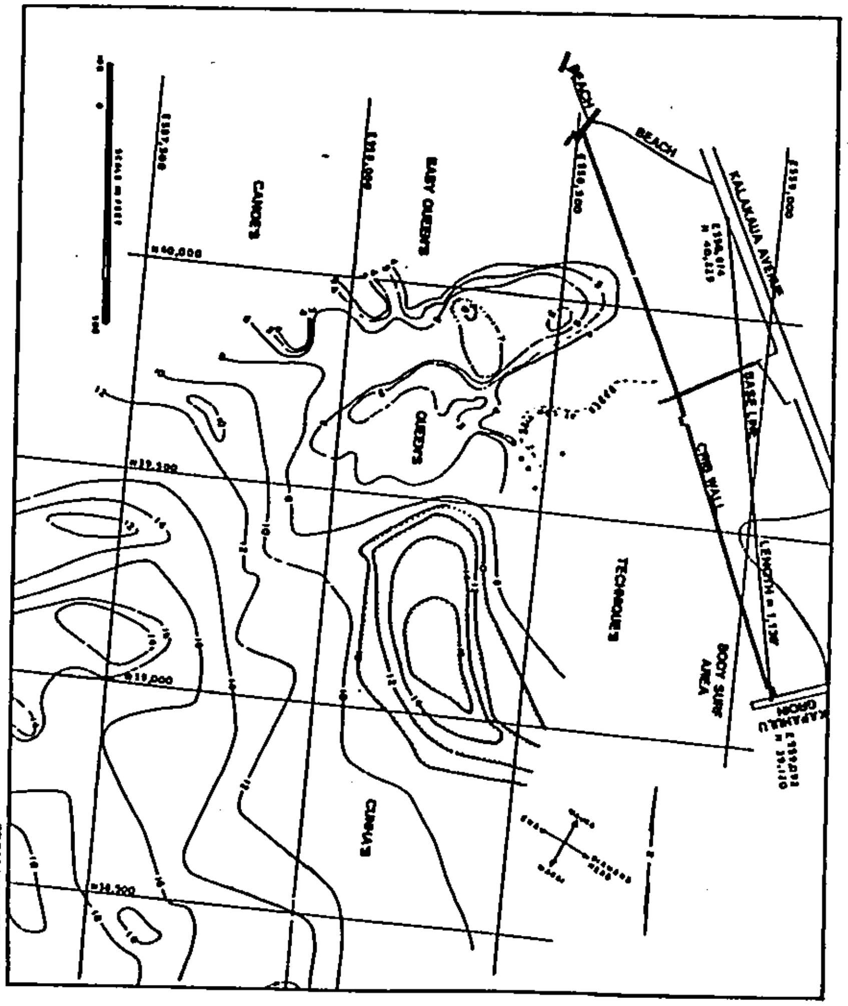
Walker (1974) conducted field observations at prime Hawaiian surf sites to study the interactions between the surfer and the wave and between the wave and the bottom. The cited purposes were to determine the characteristics of recreational surfing over Hawaiian reefs and to determine the major parameters that render a surf site desirable. Of primary interest in his study was the correlation between site bathymetry and desirable surfing waves. An understanding of this correlation and of the parameters that create such desirable waves at prime surf sites can be applied to the project site. The surf sites studied by Walker (1974) were are Queen's and Ala Moana; these sites, as well as the proposed project site, are all located on the south shore of Oahu.

4.3.1 Queen's

The Queen's surf site is located in Waikiki Bay. The Queen's bathymetric chart, presented in Figure 4-8, shows a 300 foot by 600 foot coral reef shoal. It has a 150 foot wide, 7 foot deep sand-filled channel on the left side and a large 16 foot deep hole on the right side. The shoal is located at the head of a bay that has an average 1:120 slope from the 12 to 45 foot depths. The slopes of the shoal steepen to 1:40 from the 12 to 6 foot depths and then become relatively flat. Figure 4-9 shows a cross section through the center of the shoal.

Queen's is a popular south shore surf site that is surfed by intermediate and skilled surfers year round. The best season is in the summer during the southern swell. The site may be surfed on waves ranging in height from 2 to 8 feet. The site is confined to the shoal when breaking wave heights are 6 feet and under. When the breaker heights are over 6 feet, Queen's may connect with Cunhas to the right and Baby Queen's on the inside left. When breaker heights exceed 8 feet, the site loses its isolated identity, and waves close across the side channel.

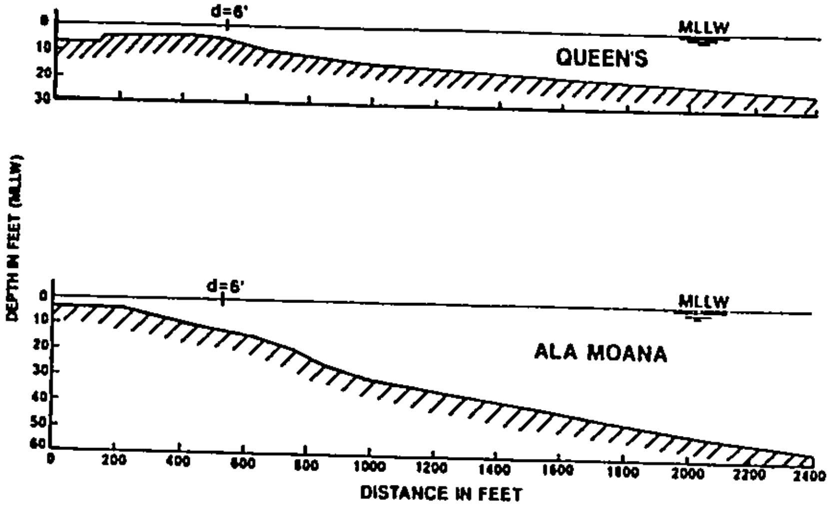
A detailed discussion of typical wave transformations and surfer interactions with the wave is given in the narration that follows, wherein a general



FROM WALKER (1974)

QUEEN'S BATHYMETRIC CHART

FIGURE 4-8



FROM WALKER (1974)

CROSS SECTIONS THROUGH SELECTED SURF SITES

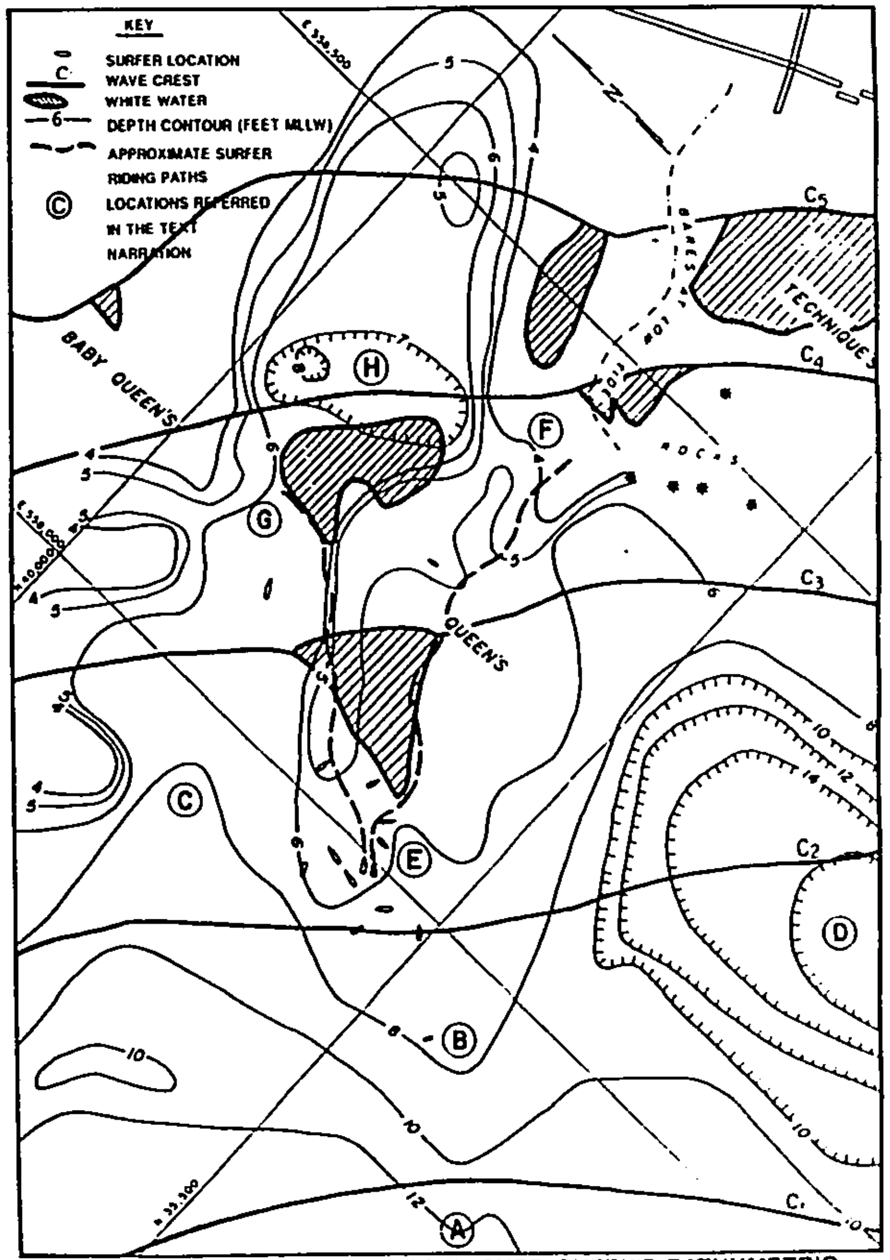
FIGURE 4-9

description of the characteristics of Queen's and surf sites in general is provided. Wave crests and surfer locations on a 4 foot wave, taken from an aerial photograph, were superimposed over a Queen's bathymetric chart, and the results are presented in Figure 4-10. The wave crests are labeled in C_i sequence. The encircled letters pertain to locations in the subsequent narration.

Incoming waves approach the shoal from the southwest. The concave bay shape causes a divergent wave crest, C_1, at the start of the shoal in the 12 foot depth, at position A. At this point, the wave crest is essentially uniform in height. The shallow water depths over the ridge at position B, relative to the depths in side channel C and hole D, concentrate wave energy over the ridge, thereby causing the wave height to increase. The crest line has been transformed to a concave form called a "bowl" by surfers, as shown at crest C_2. The wave is initially picked up by the surfers at the wave peak over ridge E; the locations of several surfers are shown in Figure 4-10 in position E, the take-off area.

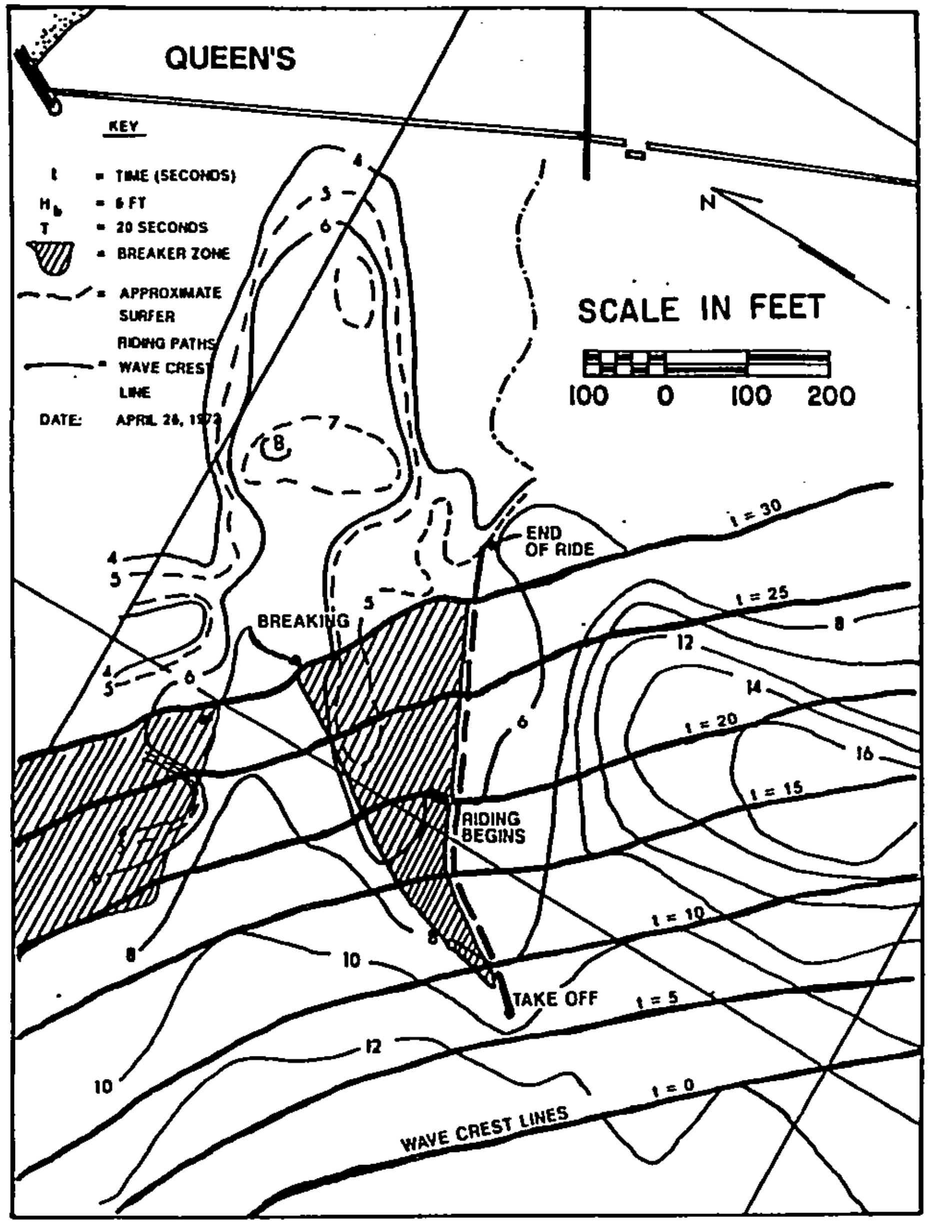
The initial break occurs immediately shoreward of the take-off area, in a plunging-spilling form. The surfer may ride the wave to the right or to the left, depending upon the wave form and his preference. The approximate riding paths are shown in Figure 4-10 by the dashed, wavy lines. The ride to the right generally terminates in front of the rocks, at F. The ride to the left generally terminates in the trench, at H, or in the channel, at G, into the Baby Queen's site.

Figure 4-11 illustrates a sequence of breaking waves over Queen's. The breaking wave height, H_b, was 6 feet, the period, T, was 20 seconds and the direction of approach was from the southwest. Crest-lines showing the wave propagating over the shoal are shown on the figure as crosshatched. The path of a surfer is also plotted. The wave was caught well outside the white water region, which starts at t = 15 seconds. The breaking proceeds laterally along the crest, creating a peel angle of 55 degrees to the right and 80 degrees to the left. The deep hole to the right is apparently partially responsible for refracting the wave more on the right than on the left. Also, the



WAVE PATTERN SUPERIMPOSED OVER QUEEN'S BATHYMETRIC CHART AND SURFER LOCATIONS

FIGURE 4-10



FROM WALKER (1974)

SEQUENCE OF A WAVE OVER QUEENS FIGURE 4-11

orientations of the 5 to 6 foot depth contours relative to the incoming wave direction induces a slightly greater peel angle to the right than to the left.

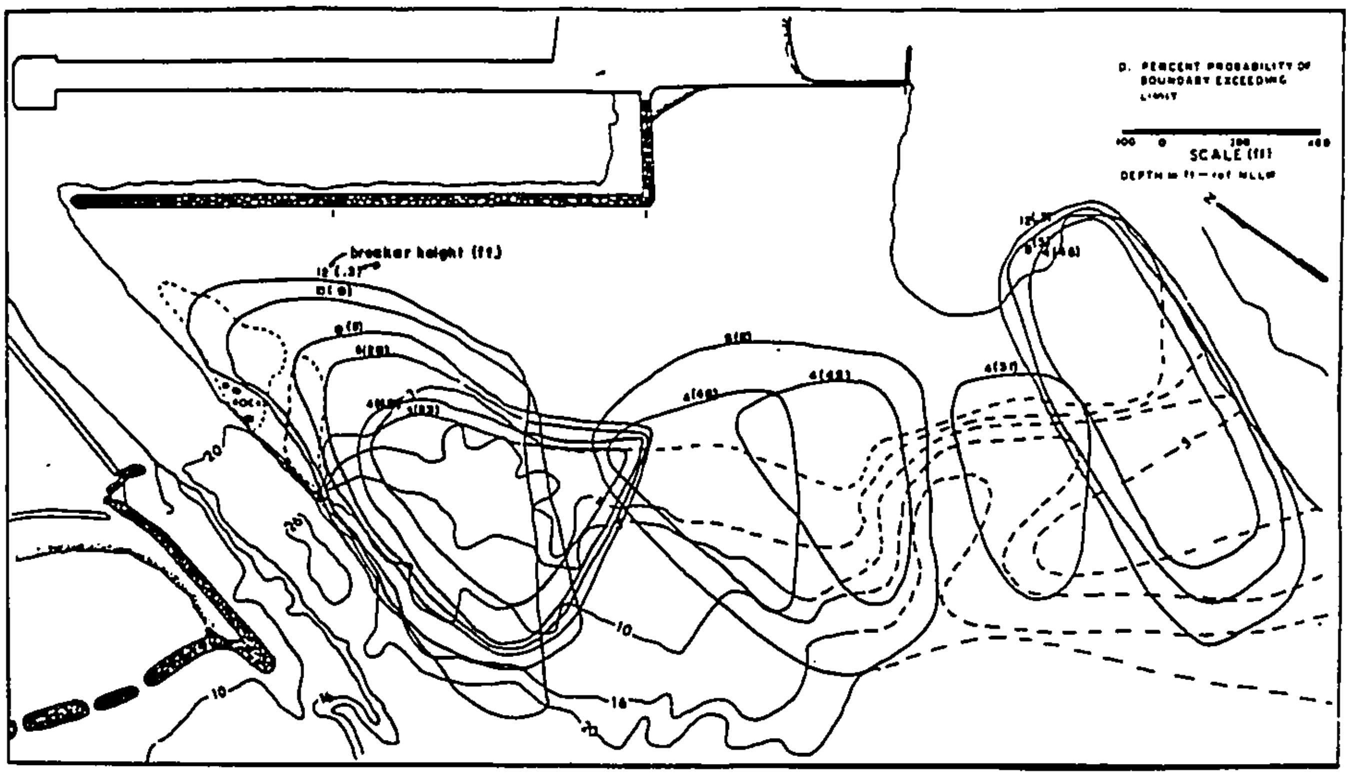
4.3.2 Ala Moana

The Ala Moana surf site is located on the right of the Ala Moana Reef, offshore from the Ala Wai Yacht Harbor. Ala Moana is a very popular south shore surf site because of its challenging wave form and its good accessibility. Surf contests are held at Ala Moana because of the excellent wave form and the spectator vantage point provided by Magic Island. The site is surfed year round but has the best conditions in the summer during the southern swell. Intermediate surfing skill is required to surf this site during most of the year. A few days of the year the site is challenging to the expert surfers on waves with height of 12 feet and greater. Surfers ride both to the left and to the right, but the ride to the left is the more popular. The rides are typically approximately 600 feet long, and the end of a typical ride is approximately 600 feet seaward of the breakwater.

The bottom is composed of an irregular coral reef. The bottom slope is 1:20 between the 20 to 10 foot depth and then it flattens to 1:40 from the 10 to the 5 foot depths. From the 3 foot depth toward shore, the reef becomes flat and 1 to 2 feet deep. A cross section through Ala Moana is shown in Figure 4-9.

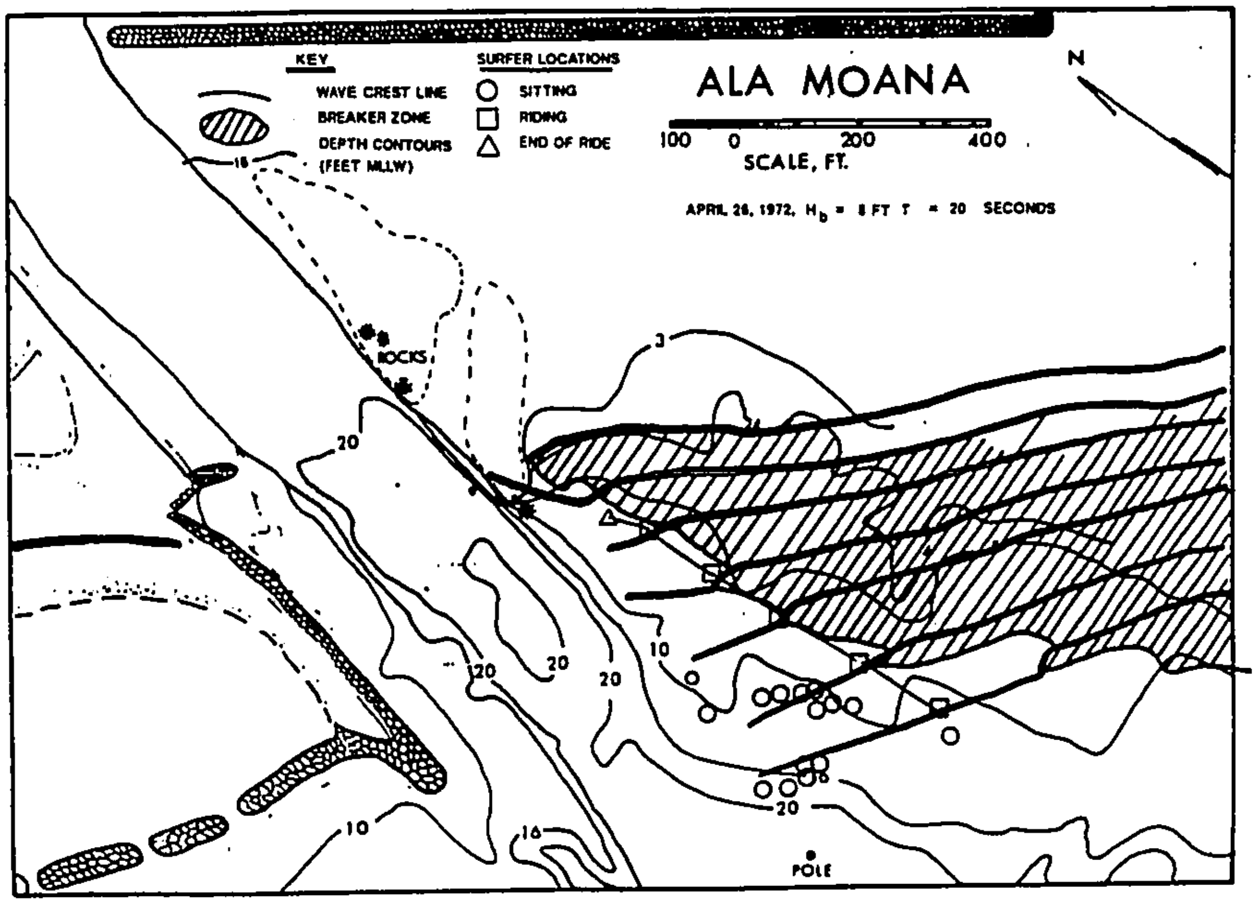
Ala Moana is surfed on waves ranging from 2 to about 20 feet. The largest waves approach from the southwest and are normally incident to the bottom contours. Sequences of aerial photographs were taken to determine wave transformations and surfing characteristics at the site. Figure 4-12 shows a wave sequence superimposed over the site bathymetry. The figure shows the locations of surfers, including those of a surfer riding a wave. The peel angle to the left is about 40 degrees.

Ala Moana has three riding areas. The approximate site boundaries of the riding areas as a function of wave height are shown in Figure 4-13. The figure illustrates how the sites change size and character with change in wave height. Note that the figure, prepared by Walker (1974), shows the areas extending well inshore to include board-recovery area. The current widespread use of board leashes negates this requirement.



FGURE 4-13

ALA MOANA SURF SITE BOUNDARIES



FROM WALKER (1974)

FIGURE 4-12

WAVE SEQUENCE

5.0 DETAILED ANALYSIS OF EWA MARINA SURF SITES

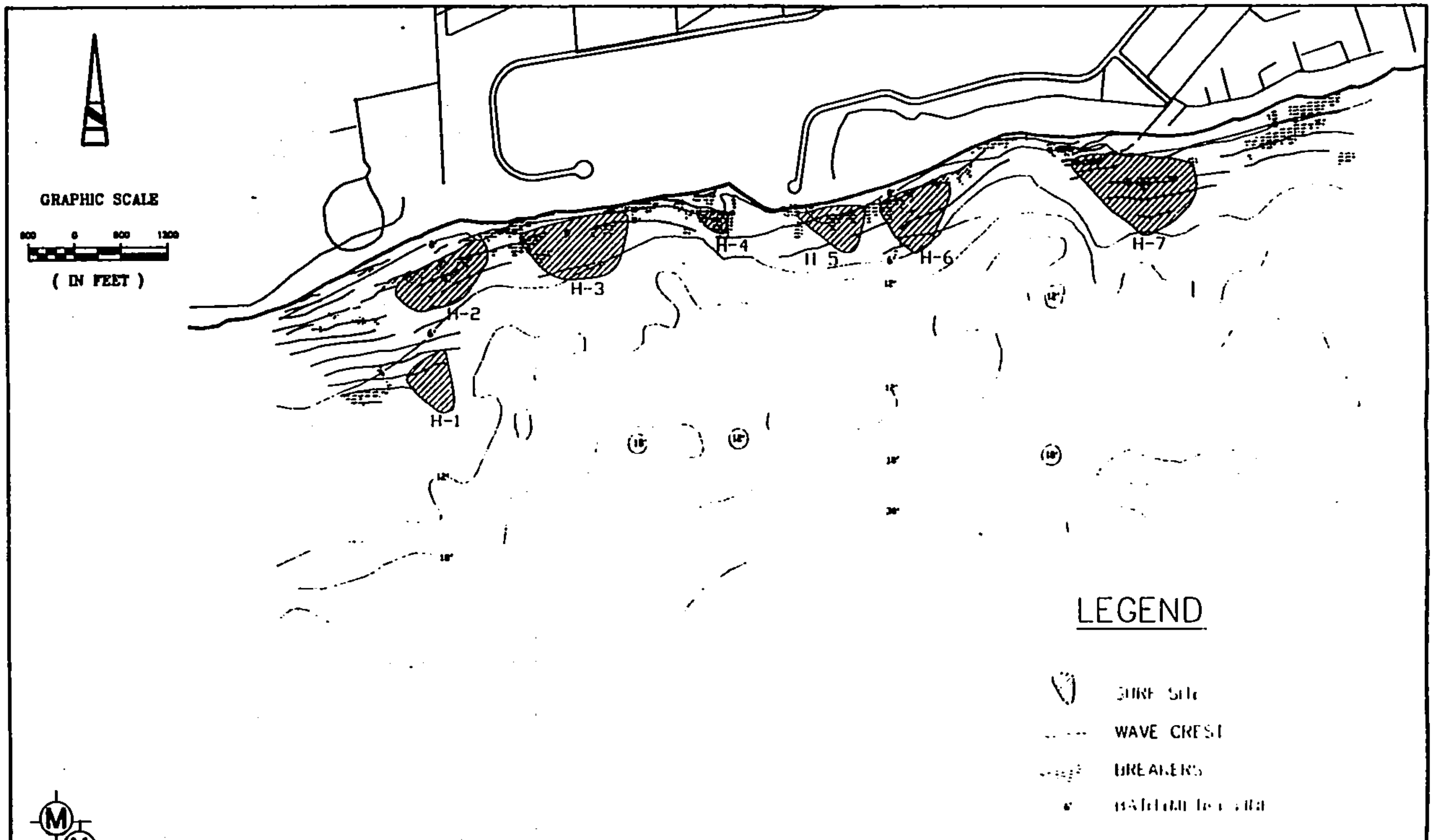
The characteristics and boundaries of surf sites along the proposed project shoreline were defined in detail in order to perform a reliable impact assessment. This section applies the understanding of the surf site parameters described in the preceding section to the detailed identification of these surf sites. Of primary interest are the sites identified in the immediate vicinity of the proposed entrance channel and jetty structures.

The first step in the identification process is the detailed analysis of historic and recent aerial photographs. These provide valuable information particularly in determining site boundaries. The second step is a detailed analysis of the site bathymetry. Site parameters that have been found to create desirable surfing conditions at other prime surfing sites were applied to the sites of interest in the project vicinity.

5.1 Analysis of Aerial Photographs

5.1.1 Historic Aerial Photographs

Sixteen sets of aerial photographs of the site, dating back to 1957, were reviewed for wave patterns and breaking wave locations along the project site shoreline. The crest lines and breaker locations were digitized from the aerial photographs onto a base map. A transfer instrument, called a zoom transfer scope, was used to superimpose the aerial photograph image of fixed reference features found on all aerial photos onto a base map. The base map was constructed to include these features. The wave crests and breakers were then superimposed and recorded onto the base map. The crest and breaker locations are shown in Figure 5-1. The wave patterns represent general locations of surf along the site shoreline. A correlation of photograph date and measured or forecast surf conditions was not performed. The bathymetric contours shown in Figure 5-1 were taken from NOAA Chart No. 19362.



SURF SITES FROM HISTORIC AERIAL PHOTOGRAPHS

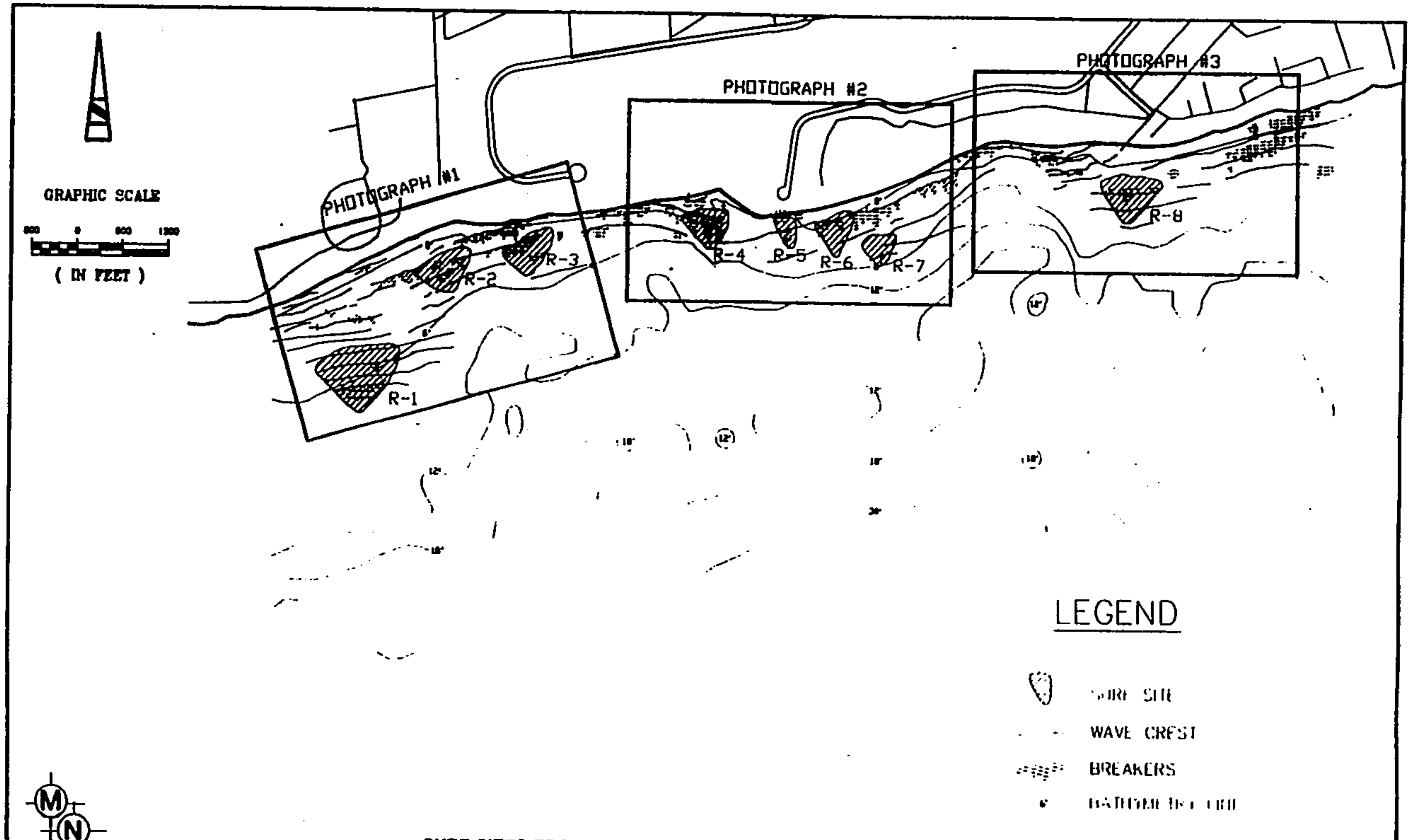
FIGURE 5-1

Seven surf sites were identified as sites H-1 through H-7 in Figure 5-1. The "H" refers to "historic" aerial photographs. Identification was based upon breaker location and configuration only; no correlation with bathymetry was performed. Using the 1990 local surfer surf site survey for reference (Figures 3-2 and 3-3), sites H-1 and H-2 generally correspond to the Officers site, although the H-1 break is farther offshore. H-3 matches relatively well with Tree Stumps. H-4 is smaller than the identified Coves site, discounting the closed-out shorebreak. H-5, H-6 and H-7 correlate relatively well with Johns, Sand Tracks and Shark Country, respectively.

5.1.2 Recent Aerial Photographs

A set of aerial photographs was flown recently (September 7, 1990) during relatively high wave activity in order to obtain a better correlation between breaking wave locations and the identified surf sites. The photographs were taken during a southern swell. The observed surf along the project shoreline was 3 to 6 feet in height. Figure 5-2 shows the digitized wave crest and breaker locations taken from the photographs. Copies of selected aerial photographs used in the analysis are identified on Figure 5-2 and are included as Photographs 1 through 3.

Eight surf sites were identified using the same methodology as that used for the analysis of the historic aerial photographs. The sites, shown in Figure 5-2, are referred to as sites R-1 through R-8. The "R" refers to "recent" aerial photographs. Again, using the 1990 local surfer surf site survey for reference, sites R-1 and R-2 correlate with the Officers site. As for the historic photograph results, the R-1 break was found to be farther offshore than identified in the 1990 surf site survey. R-3 correlates with Tree Stumps, although the break is limited to the western portion of the Tree Stumps site. R-4 correlates with the Coves site. As was found for the historic photographs, the offshore portion of this break is narrower than in the 1990 surf site survey. Three individual breaks, R-5 through R-7, were found in the site covered by Johns and Sand Tracks in the 1990 survey. The R-8 site location matches well with the Shark Country site, although the break during the time of the photograph was farther inshore.



SURF SITES FROM SEPTEMBER 7, 1990 AERIAL PHOTOGRAPH

FIGURE 5-2

RECEIVED AS FOLLOWS

[illegible] #1 [illegible] AND [illegible] STUMPS [illegible]

[illegible] #2 COVES [illegible] AND SAND [illegible]

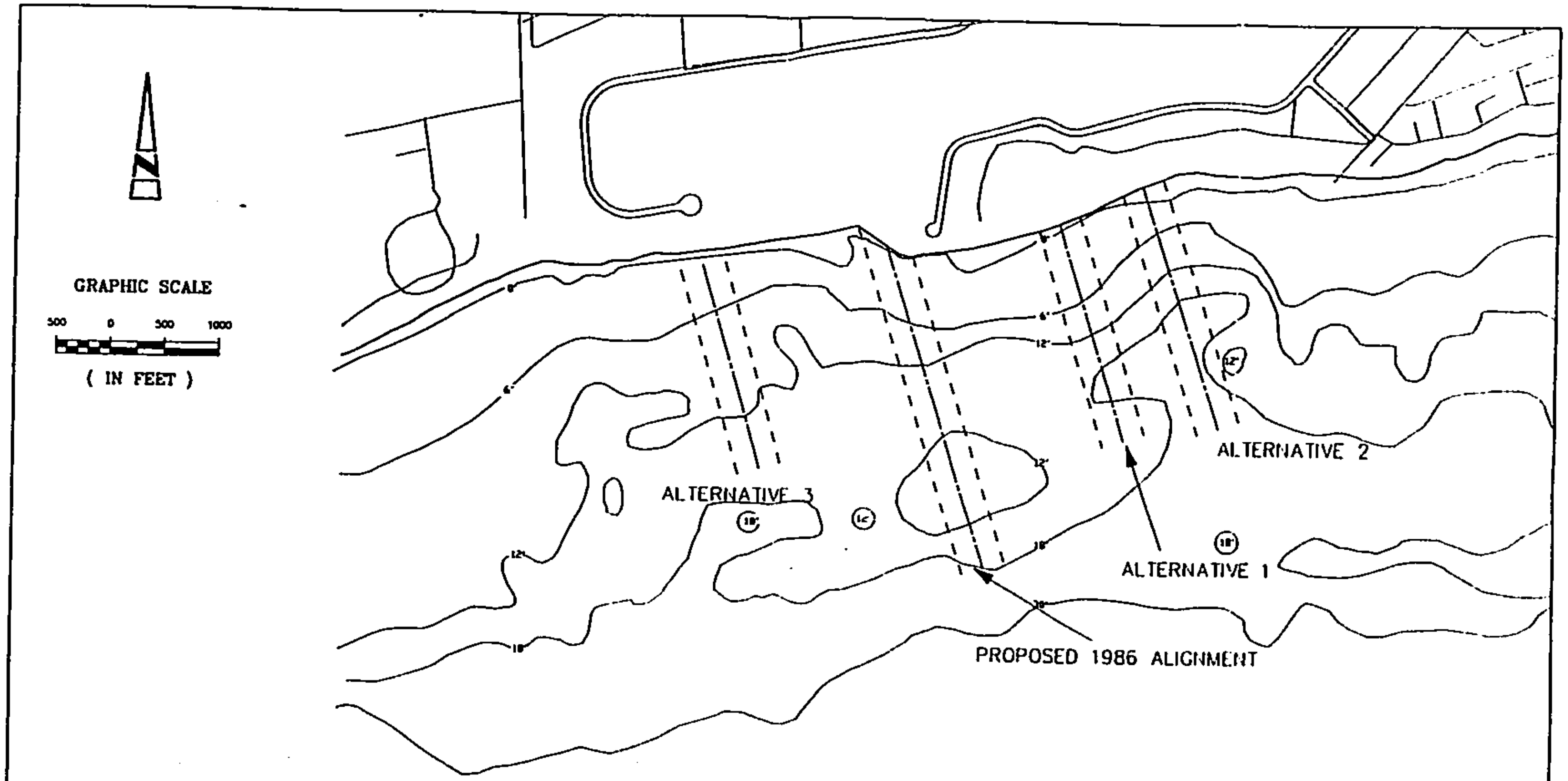
5.2 Analysis of Site Bathymetry

NOAA nautical charts were reviewed for general bathymetric information. These charts provide depth contours at 6 foot intervals only. Inspection of Figure 3-3 indicates that the 6 and 12 foot depth contours run obliquely to the shoreline near the Officers and Shark Country sites, which are at the west and east ends of the project site vicinity, respectively. Shoal-type surf sites require shore-oblique contours to create desirable surfing waves. Thus, the general bathymetry indicates Officers and Shark Country to be representative of classic Hawaiian shoal surf sites. Greater bathymetric detail was required for more detailed analyses of the other inshore surf sites studied. A detailed bathymetric site survey was therefore performed for the project by Noda (1990). The survey was used for the detailed surf site analyses described in Section 5.2.2.

5.2.1 Proposed Entrance Channel Alignment

A number of surf sites have been identified in the project vicinity. The most direct impact on these sites would occur if the entrance channel or structures were constructed directly within an existing surf site. Moffatt & Nichol (1986) described three alternative channel alignments in order to examine mitigating effects on surf sites. These alignment alternatives are shown in Figure 5-3. Alternative 3 was found to have the least adverse impact on surfing. In keeping with the project goal of minimization of adverse impacts on surf sites, this alternative was selected for the presently proposed project.

Figure 5-4 shows the proposed marina entrance channel configuration and its spatial relationship with immediately adjacent surf sites identified herein. Figures 5-4A and 5-4B show the entrance location relative to the surf sites identified in the 1976 and 1990 surf site surveys, respectively. Figures 5-4C and 5-4D show the entrance location relative to the sites identified by historic and recent aerial photographs, respectively. The figures show that the east jetty causes a direct impact only if the 1976 surf site survey results are used. Both of the surveys and both analyses of aerial photographs (i.e., all four figures) indicate a direct impact caused by the west jetty.



ALTERNATIVE ENTRANCE CHANNEL ALIGNMENTS
(MOFFATT & NICHOL, 1986)

FIGURE 5-3

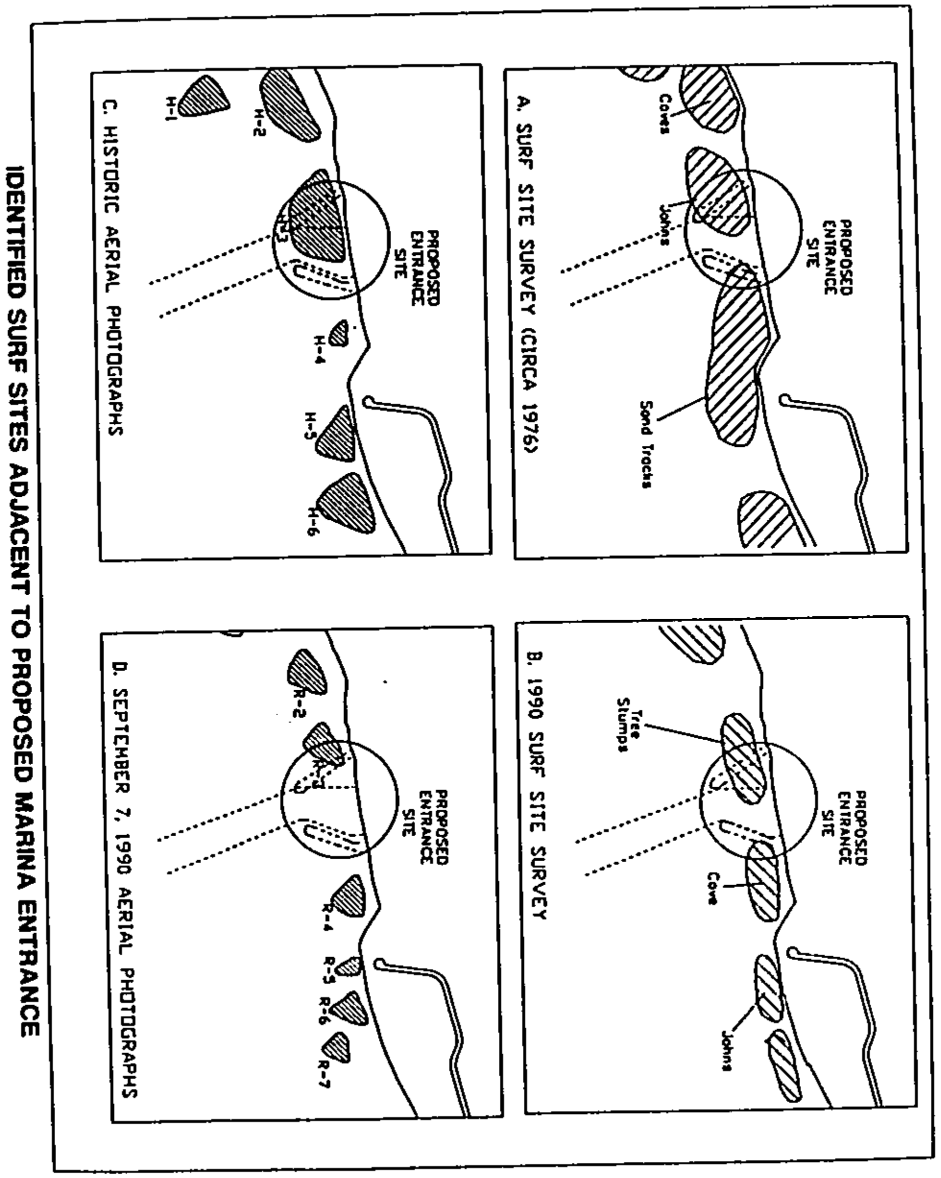


FIGURE 5-4

IDENTIFIED SURF SITES ADJACENT TO PROPOSED MARINA ENTRANCE

Using the 1990 surf site terminology, the Coves site to the east of the entrance and the Tree Stumps site to the west of the entrance were identified as having the most potential of being directly impacted by the jetties. Therefore, these sites have been selected for further detailed study.

5.2.2 Detailed Analyses of Potentially Impacted Surf Sites

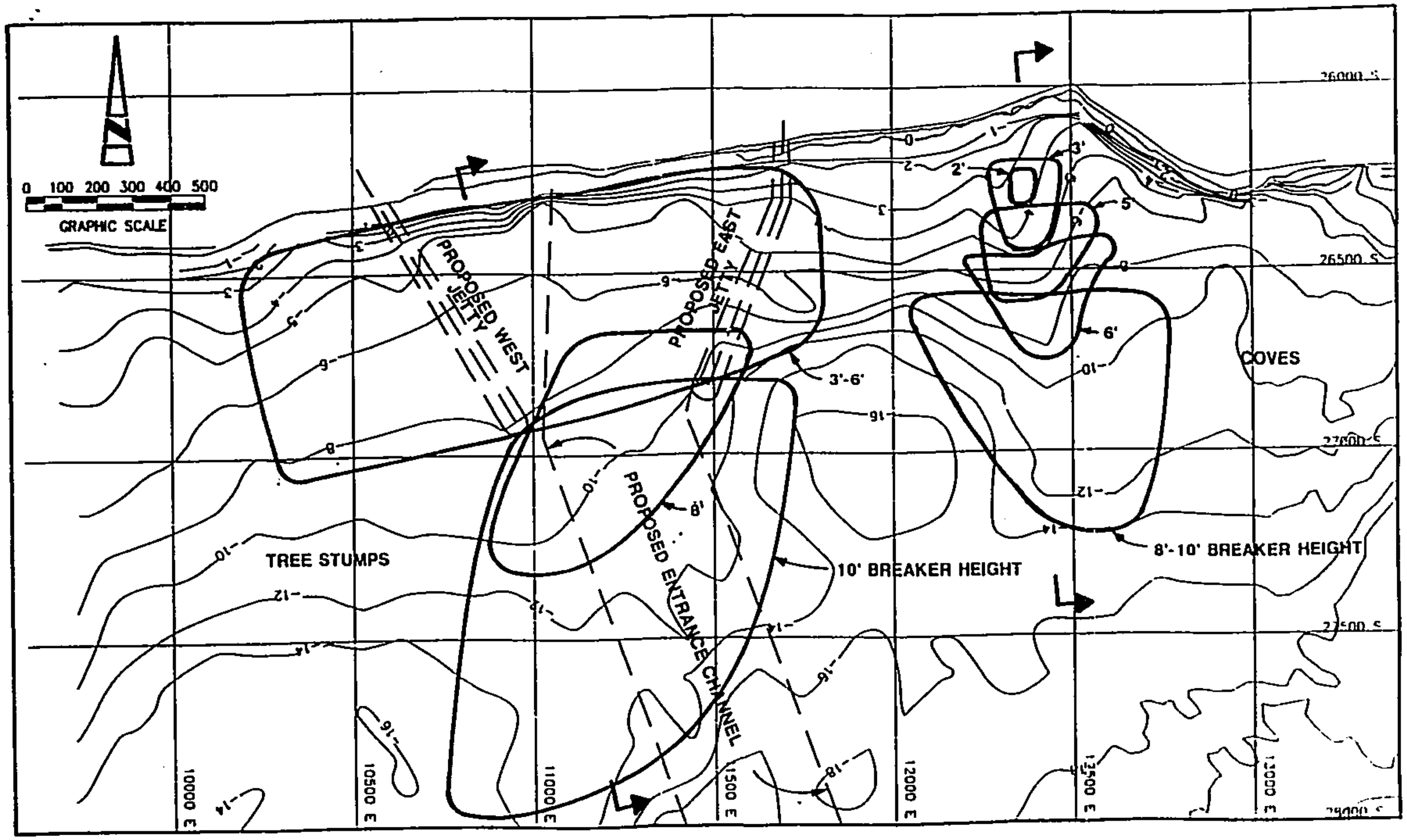
Figure 5-5 identifies the configuration and boundaries of the Coves and Tree Stumps surf sites based upon analyses of the detailed site bathymetry and associated wave transformations. The figure illustrates the configuration and boundaries for a range of breaker heights. The site configurations were determined by identification of blunt shoal contours running obliquely toward shore. The boundaries were determined from the locations at which the depth contours realign with the shoreline, where the waves will close out. As described in Section 4.1, breaker height was approximated using the relationship H_b/d_b=0.78. For example, a 5 foot breaker height is shown to correspond to the 6 foot shoal depth contour.

A. Coves

Figure 5-5 illustrates that both rights and lefts can be surfed at the Coves site, with the lefts exhibiting a more acute peel-angle. This site will hold waves with breaker heights of up to 8 to 10 feet. Larger waves will close out or break farther offshore. These observations are consistent with information obtained during discussions with a long time resident and local surfer.

A cross section through the Coves shoal is shown in Figure 5-6. The shoal has an average slope of 1:75 from the 12 to 4 foot depths and flattens to 1:150 between the 4 foot and 2 foot depths. The breaker types range from plunging to spilling over the 2 foot to 8 foot breaker height range for a typical range of surfing wave periods.

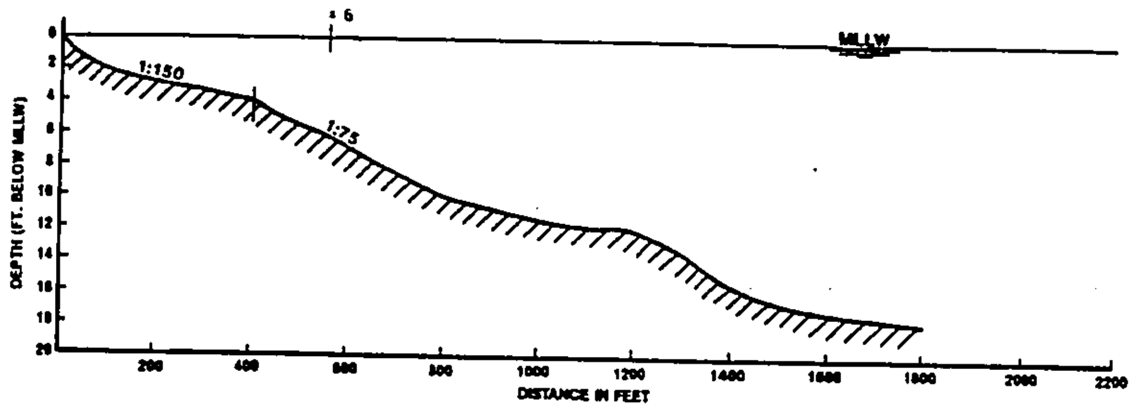
Further detailed analysis of the recent aerial photographs from September 7, 1990 was performed in order to verify the findings of the bathymetric analysis. Figure 5-7 shows crest-lines and breakers that were digitized from Photograph #2 superimposed over the detailed site bathymetry. This figure was



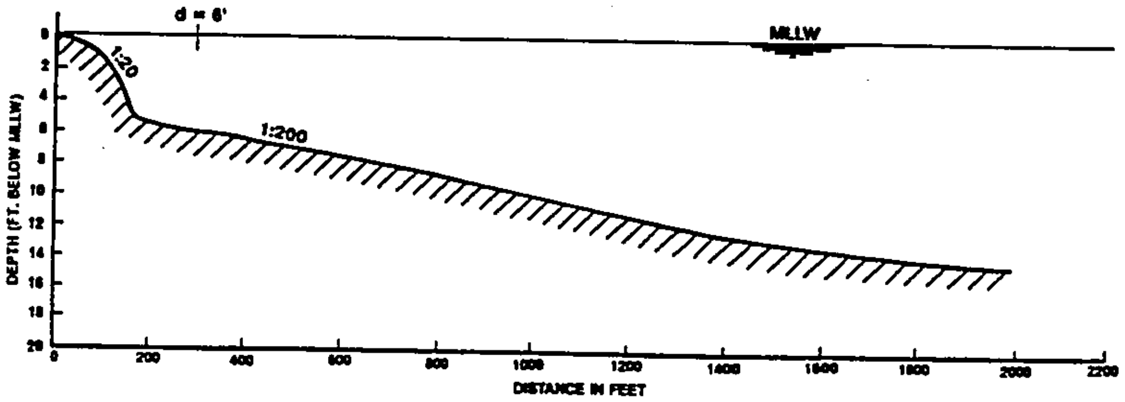
COUNTOURS IN FEET BELOW M.L.L.W.
BATHYMETRY FROM NODA (NOVEMBER 1990)

COVES AND TREE STUMPS SURF BREAK LOCATIONS

FIGURE 5-5



CROSS SECTION THROUGH COVES SITE



CROSS SECTON THROUGH TREE STUMPS SITE

FIGURE 5-6

prepared in a fashion similar to that used for the study of prime Hawaiian surf sites described in Section 4-3.

The observed surf on the day of the photograph was a southern swell with 3 to 6 foot breakers. Figure 5-7 shows breaking on the Coves shoal to initiate at the 6 foot depth contour, which would roughly correspond to a 5 foot breaker. The breaker pattern over the shoal is shown as a crosshatched area; this area corresponds closely with the estimated surf site boundary for 5 foot breakers predicted from the detailed site bathymetry and shown in Figure 5-5.

Figure 5-7 illustrates that both rights and lefts can be surfed at the site, with the lefts exhibiting a more acute peel angle. The left peel-angle is approximately 40 to 50 degrees and the right peel angle is approximately 70 degrees. Discussions with a long time resident and local surfer indicated that surfing the lefts is more popular, which may be partially confirmed by the more acute peel angles. The left ride is assumed to continue until the wave closes out. This occurs where the shoal contours realign with the shoreline, thereby causing the peel angle to approach 0 degrees. Review of Figure 5-7 and Photograph 2 indicate that the 5 foot left closes out near the 3 foot depth contour. Figure 5-8 illustrates the range of peel angles and breaker heights associated with the Coves site.

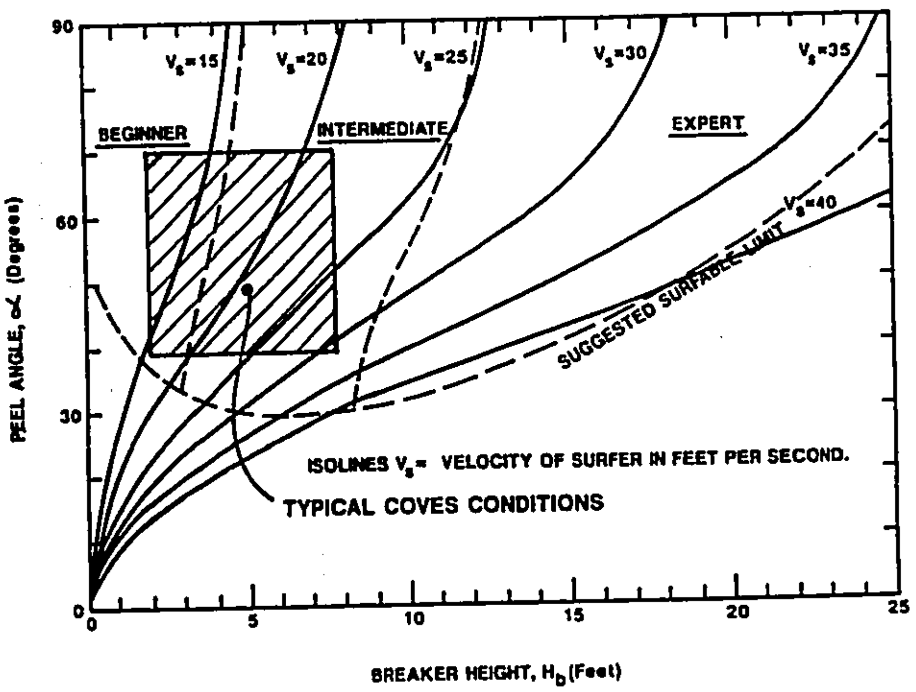
B. Tree Stumps

The bathymetry in the vicinity of the Tree Stumps site is shown in Figure 5-5. Two general wave break areas are also identified on the map for the Tree Stumps site. The outer break is indicated by a large ridge 800 feet wide from the 14 foot depth to the 10 foot depth. This ridge has contours trending toward shore which would induce right rides for waves of about 8 to 10 feet in height. A cross section through this ridge is shown in Figure 5-6. The slope of the ridge is about 1:200. This mild slope would produce spilling waves for short period waves of 6 to 8 seconds and mild plunging waves for longer period surf. The depth contours shoreward of the 10 foot depth become shore parallel and would result in a close-out section. The occurrence of this larger surf would be infrequent, but has the potential for a ride to the right for intermediate skilled surfers. Analysis of wave hindcast data (Marine Advisers, Inc., 1964) indicates waves will break at this depth approximately forty hours per year. Note that half this time will be during night hours.

COUNTOURS IN FEET BELOW M.L.L.W.
BATHYMETRY FROM NODA (NOVEMBER 1990)

BREAKING WAVES OVER SITE BATHYMETRY

FIGURE 5-7



RANGE OF PEEL ANGLES AND BREAKER HEIGHTS AT COVES

FIGURE 5-8

and onshore winds will occasionally reduce the desirability of these waves. Peel angles will range from approximately 40 to 60 degrees, depending upon wave direction.

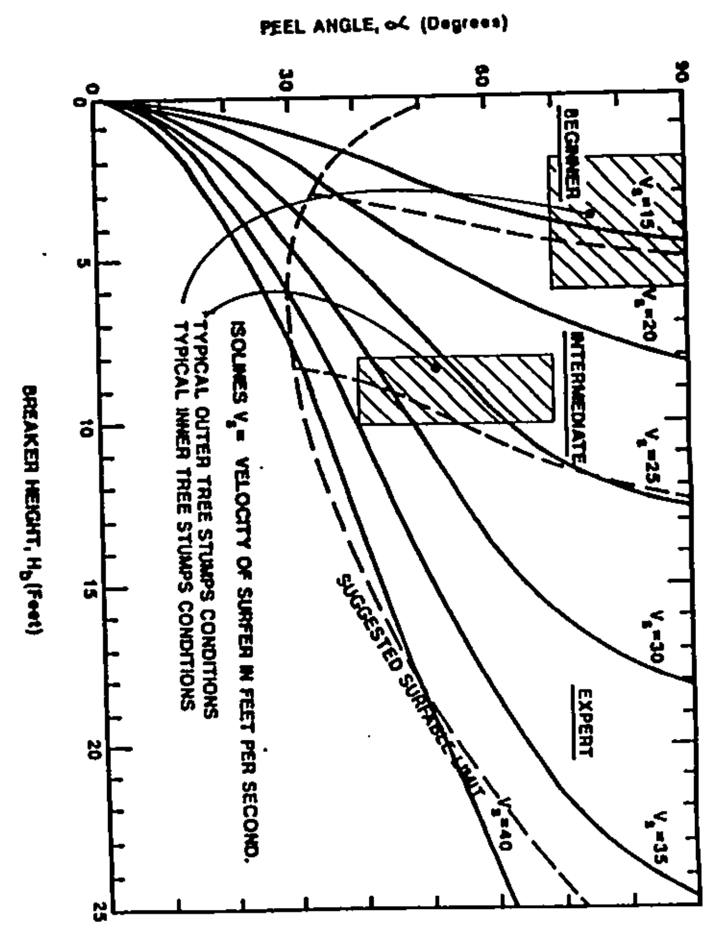
The inner surf break, from the 8 foot depth contour to shore, is very broad with featureless bathymetry and shore-parallel depth contours. The mild bottom slope continues at 1:200 from offshore to the 6 foot depth contour, which would produce ill-defined spilling breakers. The 16 foot depth depression to the east would tend to refract waves toward the center of the area. The side slopes would have a mild tendency toward producing a right shoulder for a short section of the larger 4 to 5 foot breakers. The bottom slope from the 6 to 5 foot contour is 1:20 for a 200 foot section of nearly close-out conditions.

Because of the mild slopes at seaward portion of the inner surf break, the area would create a spilling breaker lacking definitive peel properties. Such characteristics are better suited for beginning surfers. The bottom slope from the 6 foot to 5 foot contour steepens to 1:20 over regular contours. A few minor shoulders may be found for short rides in isolated places.

Figure 5-7 illustrates the crest lines and breakers digitized from the September 7, 1990 aerial photograph. The observed surf on that day was 3 to 6 feet from the south. The figure shows surf breaks at isolated places within the inner Tree Stumps surf break identified in Figure 5-5. The surf breaks are being initiated at approximately the 6 foot depth contour, which would roughly correspond to a 5 foot breaker height. Peel angles and breaker heights associated with the outer and inner Tree Stumps sites are shown in Figure 5-9.

In summary, the Tree Stumps site may support infrequent larger surf from 8 to 10 feet with rides to the right. Under the more predominant smaller wave conditions, the surf would be less defined with spilling breakers suitable for beginners over a broad area.

FIGURE 5-9



RANGE OF PEEL ANGLES AND BREAKER HEIGHTS AT TREE STUMPS

6.0 PRELIMINARY EVALUATION OF PROJECT IMPACTS ON SURF SITES

In general, construction of a marina entrance channel and structures has the potential to affect surf sites in the following ways:

1. Direct surf site encroachment: Direct encroachment of the channel and/or structures into the surf site (including into surfer access channels).

2. Reflected wave impacts: Reflection of waves from jetty structures into the surf site, thus influencing breaking wave characteristics: the ride of the surfer may be bumpy when encountering a reflected wave and reflection may precipitate premature breaking when the incident and reflected waves become in-phase.

3. Boat-wake impacts: Generation of waves from boat traffic that may enter surfing areas, thereby creating a cross-wave that can spoil the face of a surfing wave.

4. Site-access impacts: Change of onshore access to the surf site.

Although wind has been cited as an important parameter affecting the conditions at a surf site, entrance channel jetties typically have negligible impact upon the wind due to their relatively low, sloped profiles.

The sections that follow assess the potential impacts on the identified surf sites from construction of the proposed marina entrance channel.

6.1 Direct Surf Site Encroachment

Two sites identified in the 1976 and 1990 surf site surveys are identified in this study as being potentially impacted by direct encroachment of the proposed entrance channel. The two potentially impacted sites, using the 1990 local surfer surf site survey descriptions, are Coves and Tree Stumps. The proposed entrance channel east jetty shown in Figure 5-5 will not encroach

upon the Coves surf site for the full range of breaker heights at the site. The close-out point for the 8 to 10 foot lefts represents the nearest proximity of the surf site to the jetty. The distance from the jetty to the close-out point is approximately 300 feet, which provides more than ample area for an access channel.

The proposed entrance channel will directly encroach upon both the outer and inner Tree Stumps surf breaks. The outer break, which will produce right rides for large but infrequent 8 to 10 foot surf, will be the most impacted. The western third of the inner break will continue to remain a desirable surf site for beginners.

6.2 Reflected Wave Impacts

Waves may be either partially or totally reflected from both natural and manmade barriers. Reflection of waves implies a reflection of wave energy, as opposed to energy dissipation. The amount of wave reflection is controlled by the barrier slope and roughness and by the angle of incidence of the incoming wave. The angle of incidence is defined here as the relative angle between wave-front orthogonals and the barrier structure centerline. For example, a 90-degree angle of incidence implies that wave crests are parallel to the barrier.

There are basically three types of wave reflection that occur, depending upon the angle of incidence. These three types are illustrated in Figure 6-1.

For an angle of incidence of 45 degrees or greater, a vertical, impermeable wall will reflect nearly all incident wave energy, and reflected wave height will be nearly equal to the height of the incident wave. For an angle of incidence of less than 45 degrees, wave reflection is of the type called "Mach reflection," as described by Wiegel (1964). For an angle of incidence of less than 20 degrees, the wave crest bends so that it becomes perpendicular to the barrier, and no reflected wave appears. When the angle of incidence is greater than 20 degrees but less than 45 degrees, three waves are present: the incident wave, a reflected wave, and a wave approximately perpendicular to the barrier, the width of which grows as the wave travels.

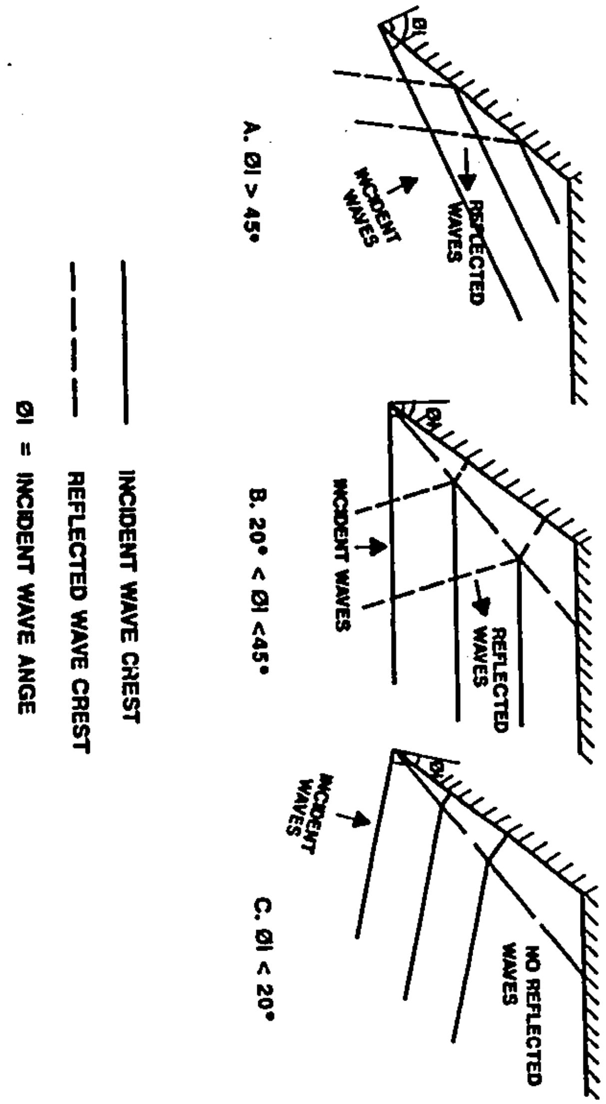
Inspection of crest-lines from aerial photographs shows that waves reaching both the east and west jetty structures would typically have angles of incidence of 20 degrees or less, with 25 degrees being a likely maximum. The resulting reflected wave patterns would be similar to those illustrated in Figure 6-1C (Mach reflection - angle of incidence of less than 20 degrees). Thus, no adverse impact due to reflected cross-waves will occur at the adjacent surf sites.

6.3 Boat Wake Impacts

Boat traffic can generate waves that may enter the two potentially impacted surf sites. However, because of the distance of the sites from the channel, these waves will be dispersed by the time they reach the sites and should not significantly impact them. As a point of reference, Kewalo Basin, Point Panic, and Ala Moana Bowl intermittently experience a cross-wave that spoils the face of some of the surfing waves during the passage of larger, fast-traveling boats. However, these cross-waves are not noticed at sites farther removed from the channel. The Ewa Marina entrance channel will be used only sporadically by large vessels, compared to Kewalo Basin, which berths a significant number of large commercial fishing vessels. Additionally, vessel speeds will be controlled by enforced speed limits within the Ewa Marina entrance channel.

6.4 Site Access Impacts

The development plan includes road access and parking in addition to that already present. The project will thus enhance surf site access and have greater visibility with more people present. This would be a positive impact. Enhanced access will increase the usage of the area. Although the land access to Tree Stumps will be rerouted around the project, surfers will also be allowed to cross the channel from the water. Parking for these surfers on the west side of the entrance channel will be provided. This would be an improvement over existing conditions.



REFLECTED WAVE PATTERNS

FIGURE 6-1

7.0 ALTERNATIVES CONSIDERED FOR IMPACT MITIGATION

Several alternatives have been considered for the mitigation of adverse impacts on surf sites due to construction of the marina entrance channel. These are discussed as follows:

7.1 Relocate the Entrance Channel

The most direct measure to eliminate impacts of the marina entrance channel on surf sites is to relocate the channel at a site where no surf sites will be impacted. As described in Section 5.2.1, there is no potential channel location that is totally free of surf site impacts. The location of the currently proposed entrance was selected specifically for the minimization of impacts on the most popular surf sites within the project area.

7.2 Reduce or Eliminate the Jetties

Much of the direct surf site encroachment by the entrance channel on the Tree Stumps surf site is due to the "arrowhead" jetty configuration. As discussed in Section 2.0, the jetties are designed to protect the marina basin from waves, to prevent wave-induced longshore currents from creating a navigation hazard, and to prevent littoral drift from shoaling the channel. Protection of the marina basin from waves was the controlling condition for the proposed jetty configuration. Since the project site is not protected by shallow reefs typical of other Hawaiian marinas, navigation safety and mild wave conditions within the harbor berthing area suggested that jetties be given special consideration in this study. The jetties protect the entrance and harbor by reducing wave penetration. The arrowhead configuration also dissipates the wave energy by diffraction to reduce the height of waves transmitted into the mooring area.

Reduction in jetty lengths and/or reduction of the jetty construction angles will reduce impacts on adjacent surf sites as well as reduce construction costs. Detailed studies during the design phase will address minimization of jetty size.

7.3 Reduce the Entrance Channel Width

Reducing the entrance channel width would be another direct measure to reduce the amount of direct encroachment of the marina entrance channel on the Tree Stumps site. As in the case for the jetty design, competing design requirements force a compromise to be made in the selection of the final design configuration. A minimum channel width would be 250 to 300 feet. A channel width reduction from the proposed 400 foot wide channel would not result in a significant reduction of the impacts on the Tree Stumps site. This width reduction could, however, create a significant increase in vessel congestion and reduction in navigational safety.

7.4 Relocate the Channel Toward the Coves Surf Site

The study results described herein indicate that the entrance channel and structures encroach a significant amount onto the Tree Stumps site; no encroachment was found on the Coves site. It may be possible to shift the channel eastward up to 100 feet, providing limited reduction of impacts. Any more movement greatly increases the potential for encroachment onto the more popular Coves site.

7.5 Enhance the Existing Surf Sites

Surfing may be enhanced by dredging navigation channels as has been demonstrated at the entrance to Ala Wai Yacht Harbor. Although some improvement of the wave conditions may be attainable through detailed design of the channel contours, the fact that the channel does not cut through an existing offshore shallow reef reduces the likelihood that significant improvement can be achieved unless a major reef sculpturing project is implemented.

8.0 FINDINGS

The following summarizes the assessment of potential impacts on existing surf sites from the proposed marina entrance channel:

1. The proposed channel site was selected to minimize adverse direct and indirect impacts on existing surf sites. Seven surf sites have been identified along the project reach, based upon a 1990 local surfer surf site survey. From west to east, the identified sites are Officers, Tree Stumps, Coves, Johns, Sand Tracks, Hau Bush, and Shark Country. The proposed channel would be located between the Tree Stumps and Coves sites. These two sites have the greatest potential to be impacted by the project.

2. Due to their relatively larger distance from the marina entrance channel, the Officers, Johns, Sand Tracks, Hau Bush, and Shark Country sites will not be impacted by the project, either directly or indirectly.

3. Detailed analyses of the Coves site configuration and boundaries indicate that this site will not be impacted by the entrance channel or jetty structures.

4. The Tree Stumps site has been found to have both a discrete outer and ill-defined inner break. Both will be adversely impacted due to encroachment of the entrance channel into the site. The outer break, which produces right rides for larger, infrequent surf of 8 to 10 feet, will be almost completely eliminated. Approximately two-thirds of the ill-defined inner break will also be impacted by direct encroachment of the entrance channel. However, the Tree Stumps site has been observed to be one the least surfed sites in the project vicinity due to infrequent (less than 20 hours per year) large surf for the outer break and the relatively short rides associated with the inner break. Although this site has been described as one of the less popular sites, further interviews are needed to confirm this. The

inner site may be desirable for beginning surfers, or it may accommodate surfers when other sites are crowded.

5. In general, the proposed marina entrance channel is at the best location along the project reach for the minimization of adverse impacts on surf sites. However, some minor relocation (100 feet or less) of the channel to the east could reduce some of the impacts on the Tree Stumps site without compromising the Coves site. However, the reduction of impacts would be minimal.

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APPENDIX A - GLOSSARY OF SURFING TERMS

Back-off - The termination of the broken wave's white water due to the wave's movement over an inshore trench or deep, diverging orthogonals, or a loss of wave energy caused by wave movement over a long, shallow reef. A breaking wave having an obtuse peel-angle.

Blown-out - A rough, choppy surface condition caused by a wind blowing with sufficient velocity to spoil the waves for surfing. If often implies a surface caused by a component of following wind.

Board surfing - Surfing in which a surfboard is utilized by the surfer.

Body surfing - Surfing in which no extra equipment, except possibly swim fins, are utilized by the surfer.

Bowl - A wave whose crest line is concave in the direction of wave advance due to converging orthogonals.

Break - The surf riding area; the breaking area.

Breaking area - That area outlined by the initial breaking point, the peel-lines, and shoreward limit of advance of the white water.

Channel break - A surf site adjacent to an easily distinguishable natural or man-made channel.

Close-out - A long section of the wave crest that breaks instantly. A section of a wave in which the peel-rate exceed the maximum speed of the surfer. A distinguishable section in which the peel-angle equals zero. Short, fast sections that a surfer is able to ride under would not be considered a "close-out."

Curl - That portion of the breaking wave between the breaking point and the point where the wave lip has touched the wave face. On a plunging wave, this [illegible]gion is very distinct, while on a spilling wave, thi[illegible] is vague and often indistinguishable from [illegible] of the wave.

Face - See "Waveface."

Mat surfing - Surfing in which an inflatable mat is utilized by the surfer.

Mushy - A breaker form similar to that of a spilling wave; often associated with a blown-out condition.

Peak - An easily distinguishable high point along a wave's crest line. It usually occurs just prior to a wave's initial breaking point.

Peel - The wave's breaking point. A peel is said to peel right or left, depending upon the lateral direction the breaking point moves when viewed facing the direction of wave advance.

Peel-angle - The included angle between the peel-line and a line tangent to the crest-line at the breaking point.

Peel-line - The path described by the breaking point along the bottom as the wave proceeds shoreward. The outside boundary of the white water seen in aerial photographs very nearly describes the peel-line.

Peel-off - See "peel."

Peel-rate - The lateral rate of movement along the crest line. The peel-rate is classified as fast or slow based upon its relationship to a surfer's maximum speed.

Point surf - A surf site adjacent to a point of land or promontory.

Riding distance - The distance traveled from the surfer's take-off point to the end of his ride.

Section - A distinguishable portion of a breaking wave where the peel-rate is fairly constant. Sections of breaking waves are classified as fast or slow, depending upon the peel-rate.

Shore-break - A surf site very close to shore. Shore breaks usually have short rides that terminate at or near the beach.

Site line-up - A marker or a series of markers, either natural or artificial used by surfers to position themselves in the proper take-off areas for a particular surf site.

Soup - The turbulent region of the broken wave distinguished by the boiling white water or foam.

Surf site - An area where surfers participate in the sport of surf riding on natural ocean waves. A surf site includes the take-off, riding, board-recovery, rider-return, and access areas.

Surfing - The sport of utilizing a water wave to propel an individual. It can be likened to an individual sliding down a hill as the hill moves forward.

Surf shoal - An area of the ocean bottom contoured so that waves break over it in a favorable surfing form.

Take-off area - The region of a surf site where surfers catch waves. It usually occurs just seaward of the initial breaking point.

Tube - That portion of the breaking wave between the breaking point and the point where the white water defines the fully broken wave. For a plunging breaker, the tube area becomes greater as the peel-angle decreases.

Wall - A nearly vertical wave face. A wave is often said to be "walling up" as its forward face approaches the vertical.

Wave crest - The highest point of a wave.

Wave crest-line - The lateral line described by the wave crest at any instant in time. Wave patterns are distinguished by crest-lines in aerial photographs.

Wave face - The water surface in front of the wave's crest. In most cases for surfing waves, the face is the water surface from the wave crest forward to the point where the water surface is nearly horizontal.

Wave height - The vertical distance from the preceding trough to the following wave crest. In the surf zone, wave height is usually estimated vertically from the point where the water surface is horizontal to the following wave's crest.

Wave line-up - The relationship between the wave's direction of advance and its breaking characteristics at a particular surf site. A good wave line-up implies that the direction of the wave advance corresponds well with the bottom topography at the particular surf site and results in well-formed surfing waves.

Wave lip - The wave's upper leading edge in the curl region.

Wave shoulder - That surfable portion of the wave outside the white water, curl, and wall regions; usually considered the safe riding area for a surfer. On waves with a long "wall" area, the wave shoulder begins after the wall ends.

Wave steepness - In traditional engineering terms it is the ratio of wave height to wave length (H/L). To the surfer, it refers to the attitude or slope of the wave's face. A steep wave would be one with a nearly vertical wave face.

White water - See "soup."

Wipe out - To fall off a surfboard.

Appendix M

Visual Impact Assessment

Visual Impact Assessment

Prepared by:

Wilson Okamoto and Associates Inc.

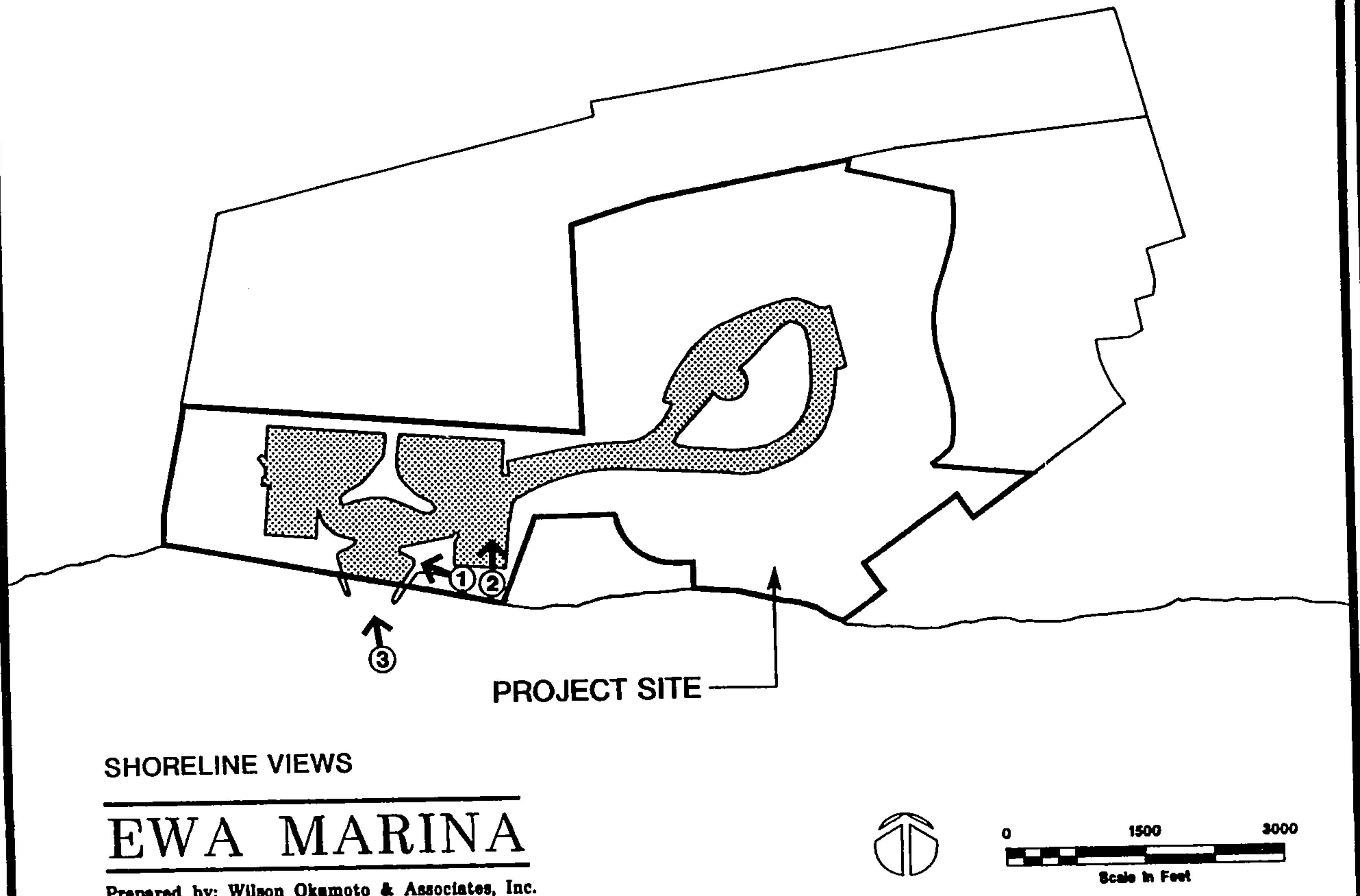
Computer Images by:

Visualizations, Inc.

Prepared for:

Haseko (Ewa), Inc.

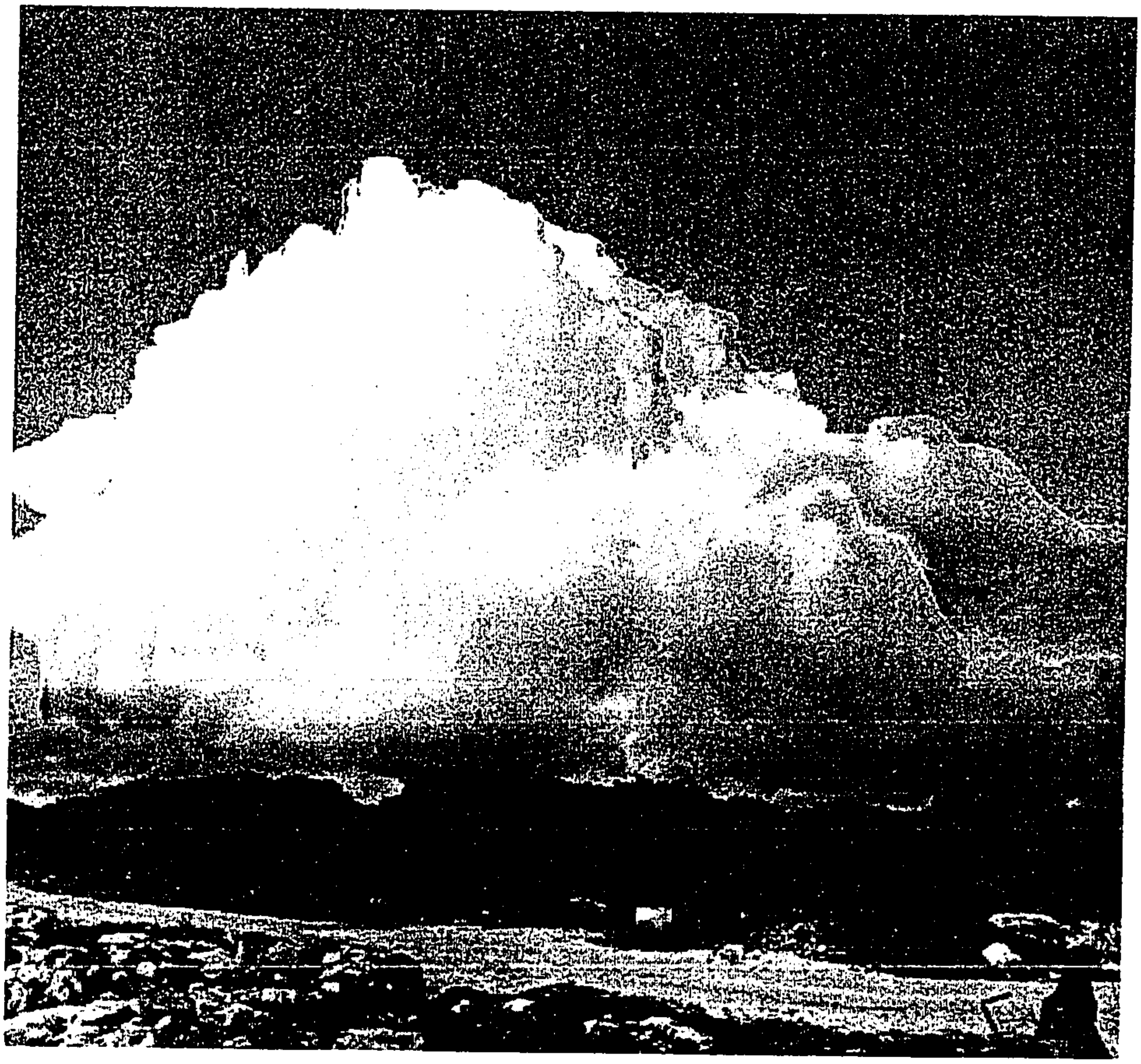
March 20, 1992



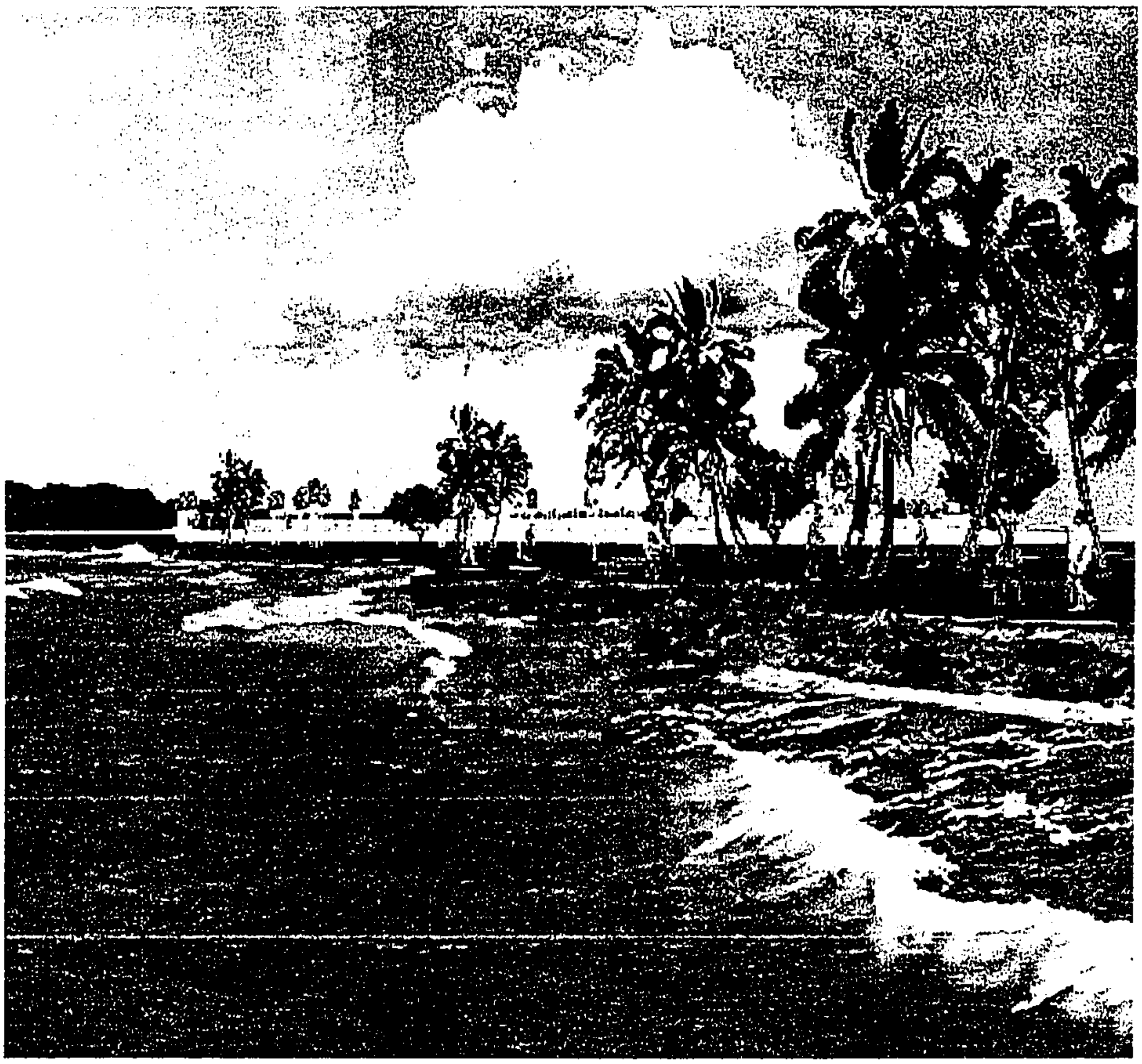
SHORELINE VIEWS

EWA MARINA

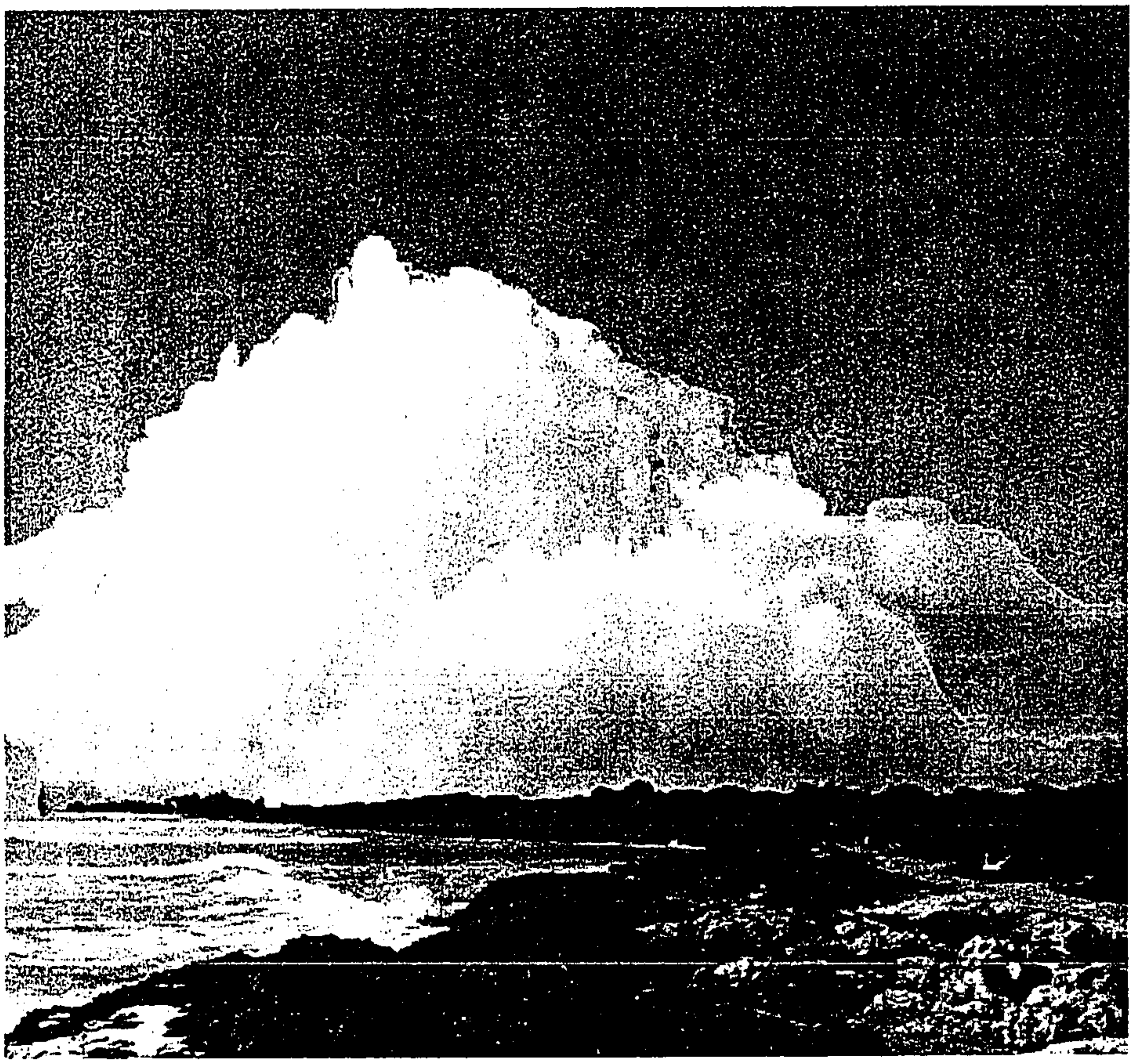
Prepared by: Wilson Okamoto & Associates, Inc.



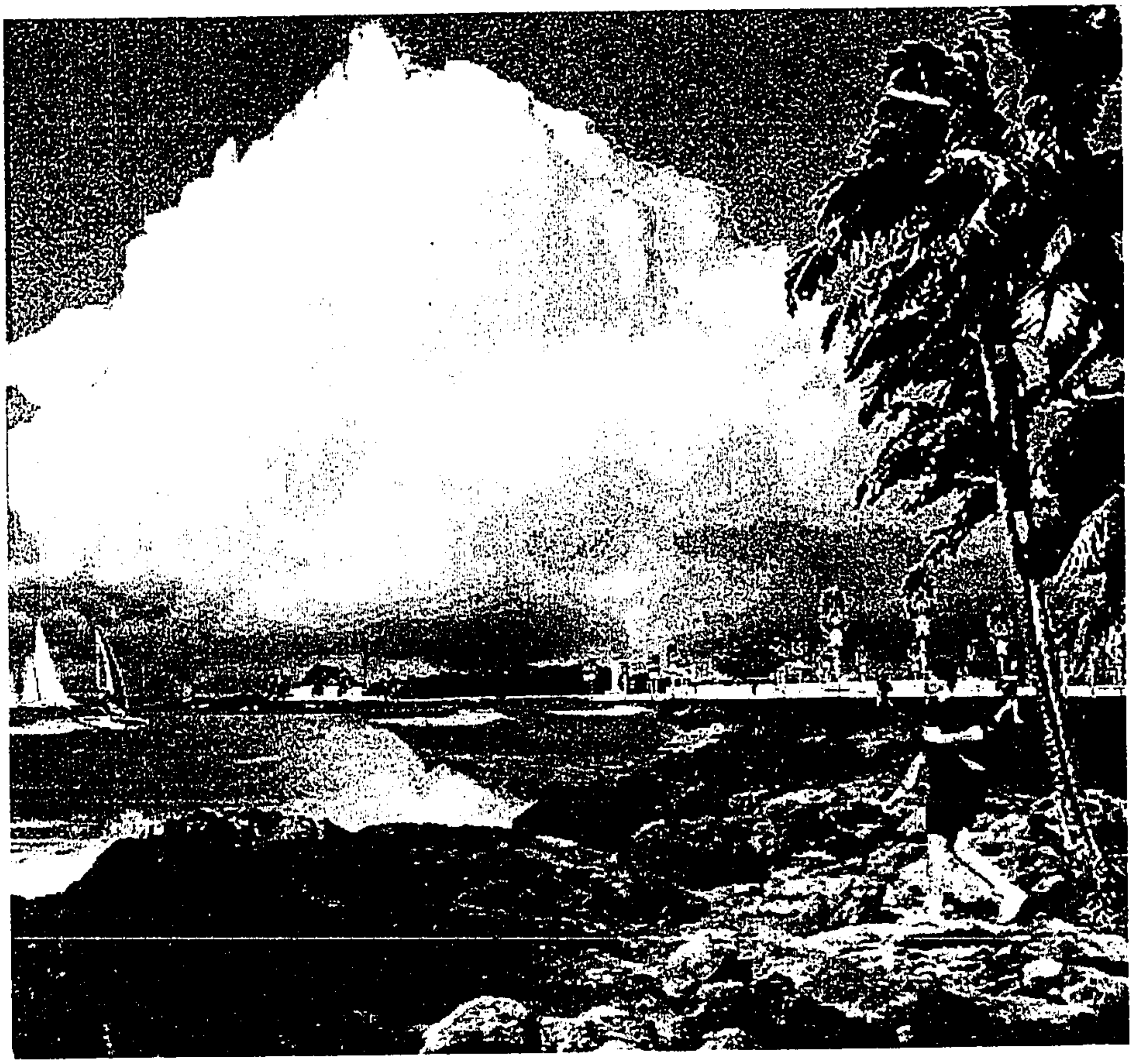
1. View from the western boundary of Oneula Beach Park at the shoreline looking toward the proposed marina.



Same location as facing page but from just offshore and angled to the west. Landscaping removed (except trees) to show marina (blue) and structures (tan with dark roofs).

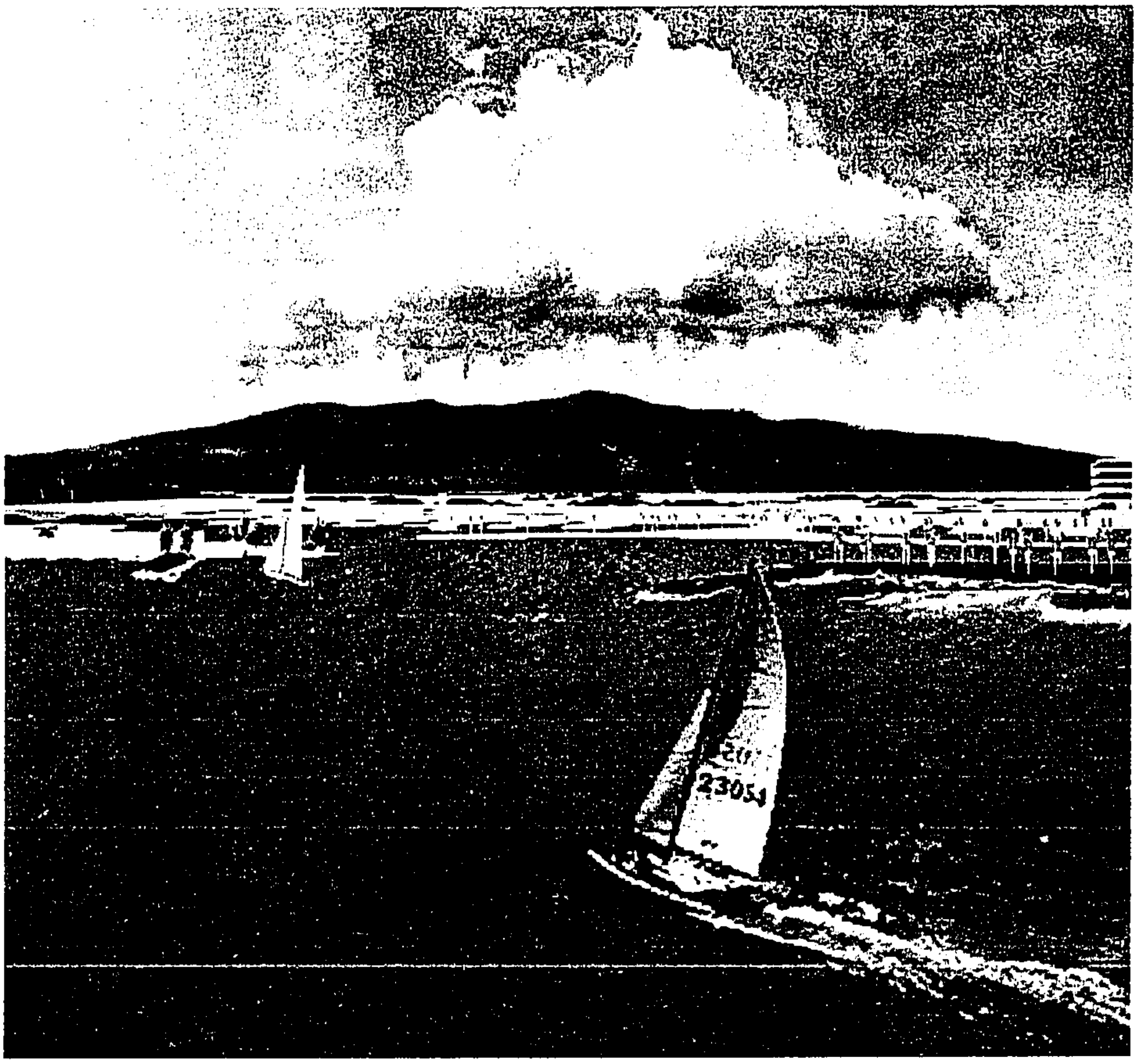


2. View along the shoreline from the western boundary of Oneula Beach Park. The Proposed marina channel entrance would be located approximately where the water extends furthest to the right side of the photo.



Same view as facing page. Structures at left are on the western side of the marina entrance.

The eastern jetty is visible beneath them.



3. Oblique aerial view of marina entrance. Taller structure at right is in Ewa Marina Phase II.

Appendix N

Archaeological Mitigation Plan,
Ewa Marina Community Project - Phase I

Report 763-110890

Archaeological Mitigation Plan
Ewa Marina Community Project - Phase I

Mitigation Plan for Data Recovery,
Interim Site Preservation, and Monitoring

Land of Honouliuli, Ewa District
Island of Oahu

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Report 763-110890

Archaeological Mitigation Plan
Ewa Marina Community Project - Phase I

Mitigation Plan for Data Recovery, Interim Site Preservation, and Monitoring

Land of Honouliuli, Ewa District
Island of Oahu

by

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CONTENTS

ILLUSTRATIONS

TABLES

INTRODUCTION

PROGRAM BACKGROUND

Program Identification

Paul H. Rosendahl, Ph.D. Inc. (PHRI) has prepared this formal archaeological mitigation plan at the request of Mr. Perry J. White of Belt, Collins, & Associates (BCA), for their client, HASEKO (Hawaii), Inc. This plan has been prepared for the Phase I Ewa Marina Community Project site, situated at Honouliuli, Ewa District, Island of Oahu (TMK 9-1-011-001,2,3,4,5,6,7; 9-1-012-008,9,11,12,13,16,17) (*Figure 1*). The plan is designed to satisfy the federal historic preservation review process required under Section 106 of the National Historic Preservation Act of 1966 (as amended), and to be included within the a Memorandum of Agreement (MOA) to be executed among the U.S. Army Corps of Engineers-Honolulu District (COE), the Hawaii State Historic Preservation Officer (SHPO), the Office of Hawaiian Affairs (OHA), and the Advisory Council on Historic Preservation (ACHP), in connection with a Department of the Army (DOA) Permit Application made for the Ewa Marina Project.

Findings of the 1990 PHRI Survey

Between February and June 1990, Paul H. Rosendahl, Ph.D., Inc. conducted a full (100%) archaeological inventory survey (Dunn and Haun 1991) of the Phase I Ewa Marina Community Project site, situated at Honouliuli, Ewa District, Island of Oahu (TMK 9-1-011-001,2,3,4,5,6,7; 9-1-012-008,9, 11,12,13,16,17). The overall objective of the survey was to provide information to satisfy the federal historic preservation review process required under Section 106 of the National Historic Preservation Act of 1966 (as amended), and to provide the basis for preparation of the Mitigation Plan (MP) that would be included within a Memorandum of Agreement (MOA).

A total of 53 sites containing over 321 component features were identified within the project area. The sites are summarized in *Table 1 (at end)*, and their approximate locations are shown on *Figure 2 (at end)*. The coastal portion of the project site constitutes almost the entire Oneula Archaeological district (SIHP Site 50-OA-2873), a district determined to be eligible for inclusion on the National Register of Historic Places. Eighteen of the sites (58 component features) had been previously identified by Davis (1979a,b) and Jourdane (1979). Ranging in physical condition from poor to good, the sites consist of both single and multiple components. Formal feature types in the project area include C-shape, alignment (C-shape, linear, L-shape, rubble, and U-shape), cairn, concrete structure, cupboard, enclosure, midden scatter, modified bedrock, modified sinkhole, mound (circular, linear), platform, rubble concentration, terrace, and wall. These feature types often are combined, forming compound structures (e.g., C-shape wall with adjoining platform, adjoining C-shapes, etc.). Functional types encountered in the project area include a range of agricultural features, military features, an incinerator, a marker, a well, a possible ceremonial feature, and a number of features of indeterminate function.

Of this total of 53 sites, 45 were assessed as significant solely for information content (Dunn and Haun 1991:Table 7). For 32 of the 53 sites, no further work was recommended, because the data recovered during the initial inventory survey was considered to have exhausted the residual scientific and research potential of these sites. For these same 32 sites, preservation was not considered essential, as none represented unique, one-of-a-kind resources or exemplary site types. For the remaining 13 sites considered significant solely for information content, data recovery was recommended.

One site was assessed as significant for information content and potentially for cultural value, if it was found to contain human remains. For this site, further data collection was recommended, and preservation "as is" was provisionally recommended, pending further data collection results.

The remaining seven sites were assessed as significant for information content and as excellent examples of site types. Further data collection followed by preservation with interpretive development of selected features and/or portions of the sites was recommended.

In addition to the sites possessing archaeological significance, several sinkhole clusters include sinkholes that have paleontological significance. This significance is derived from the presence of sub-fossil to fossil osteological remains of extinct avian species. In light of this significance, further data recovery was recommended for sinkholes within Clusters A, B, C, E, F, and G.

Recommendation for a Phased Mitigation Program

Based on the findings of the 1990 PHRI survey, as outlined above, and based on input received from the

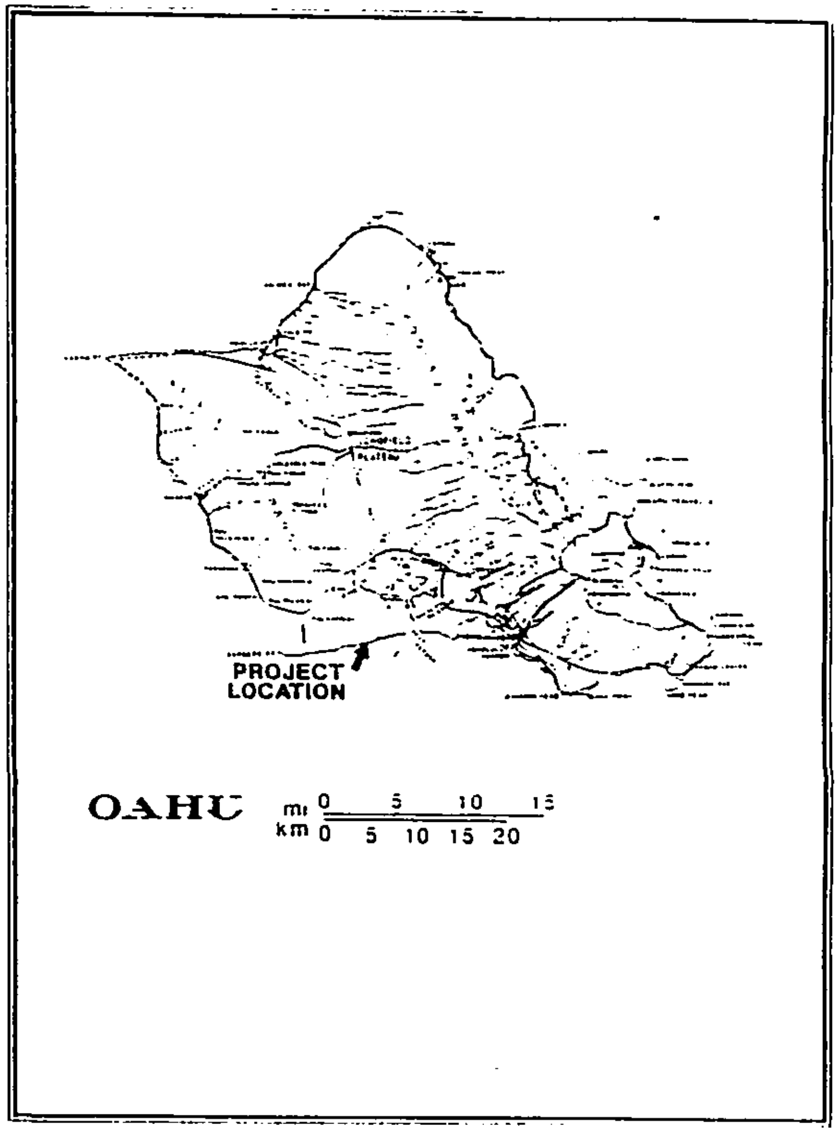

Figure 1. Project Area Location Map

Department of Land and Natural Resources-Historic Preservation Program/State Historic Preservation Office (DLNR-HPP/SHPO), a detailed archaeological mitigation plan involving preservation as well as data collection components was determined to be the most appropriate vehicle for developing site-specific mitigation commitments. The objectives being sought in preparing such a mitigation plan include (a) preservation, and (b) identification of methodological and other approaches to be utilized in conducting additional data collection and data recovery at select sites within the project area.

The present Archaeological Mitigation Plan was thus prepared. A four-phased program was deemed appropriate, in consideration of the various objectives being sought, and in compliance with requirements of the DLNR-HPP/SHPO and the federal historic preservation review process required under Section 106 of the National Historic Preservation Act of 1966 (as amended). The phases of the program are outlined below.

Phase I - Preparation of a formal Archaeological Mitigation Plan, including relevant detail concerning (a) data recovery/collection, (b) interim site preservation, and (c) construction monitoring;

Phase II - Archaeological Data Recovery/Collection work, including mobilization, historical documentary research, field work, data analyses, and preparation of Interim and Final Reports;

Phase III - Preparation of a detailed Site Preservation Plan, upon completion of Phase II data collection work, to provide for interpretive development and long-term site preservation concerns; and

Phase IV - Archaeological Monitoring, as appropriate, of construction activities that might impact significant archaeological remains already identified, or which remain undetected within the project area.

The present document comprises Phase I of the Archaeological Mitigation Program. The overall purpose of the program is to accomplish, to the appropriate standards, all archaeological mitigation work required by the provisions of the DLNR-HPP/SHPO and Section 106 of the National Historic Preservation Act of 1966 (as amended) in connection with project development. Phase II (Archaeological Data Recovery and Collection work) will include implementation of interim site preservation work. DLNR-HPP would verify successful execution of both the interim preservation work and the data collection work. If necessary, verification of Phase II data recovery/collection work could be completed in two steps: (a) upon completion of field work, a check that all field tasks had been implemented, and (b) subsequent review of a draft final report upon completion of data analyses and report preparation. The Phase III (Site Preservation Plan) would be reviewed and approved by DLNR-HPP prior to final preservation plan implementation, and DLNR-HPP would verify subsequent implementation of the final preservation plan.

PROJECT AREA DESCRIPTION

The Ewa Marina project area is located along the coastal portion of the east-central segment of the Ewa Coral Plain. The Ewa Plain is a Pleistocene elevated coralline reef that forms the leeward coastal lowlands of southwestern Oahu, and extends five km south from the Waianae mountains and 8 km south from the adjacent Central Plateau. Pearl Harbor lies at the east end of the plain, while West Beach marks the approximate western end of the feature. The present project area extends inland only a short distance, and the Marina project area consists almost exclusively of coralline lowlands. However, to the north are basaltic uplands also associated with the Ewa Plain geomorphic feature. The marine-terrestrial interface is evident at numerous locations along the Ewa Plain, where the structure of the Pleistocene reef, consisting of coral conglomerate standing 5.0-6.0 m above mean sea level (AMSL), overlies the volcanic strata of the Waianae mountains (Pollock 1928: Plate IV,c). Alluvial encroachment from the volcanic uplands has covered much of the interior of the plain with a mantle of sediment. The coral substrate, however, remains largely exposed at the surface in the coastal zone. Subaerial weathering of this calcareous surface has produced a shallow karstic topography of ridges, hollows, and pinnacles; characteristic components include widespread sinkholes of varying size and depth. Both alluviated and exposed coral areas are present within the Marina project area.

The topography of the Ewa coral plain is quite regular, rising to a maximum elevation of about 30.0 m on an average gradient of less than 1/2 percent from the shore to the uplands. Few features interrupt the monotony of this landscape. Only the low eroded bluffs above West Loch, in Pearl Harbor, and the two volcanic cones of Pu'ukapolei and Pu'upalailai stand out in relief. The ash-cinder cone of Pu'upalailai is of particular interest to any archaeological study of the Ewa coral plain, because this is one of only three known sources of volcanic glass on the Island of Oahu (Manhoff and Uyehara 1976:46). Pu'upalailai lies to the northwest of the Marina project area, at the base of the Waianae range.

The shoreline of the Ewa coral plain is also unremarkable in terms of geomorphological features. It is composed almost entirely of weathered limestone benches that are punctuated periodically with poorly developed calcareous sand beaches. The only significant variations occur at the estuarine outflow of Pearl Harbor, and at the basalt/limestone interface near Kahe Point (west of the Marina project area). In the latter, former seasonal outflows of fresh water once created backwaters that provided estuarine-like conditions both behind the coastal dune and at its breech to the sea. Relics of this can still be found in the area. Extensive coastal sand dunes are not typical of the Ewa coastline, although there are several minimally developed examples along the west shore of the region, south of Kahe Point. The dunes fronting the deep-draft harbor rise 4.0-5.0 m AMSL, and are composed of coarse-grained, light tan to buff-colored carbonate beach sands overlain by finer cream colored carbonate aeolian sands. There is no barrier reef off of either the south or west coasts of the Ewa plain, but there is a well-developed fringing reef along the south coast within the vicinity of the Marina project area. This reef supports an extensive inshore fauna dominated by reef and silt sand bottom species of fish and shellfish. This fringing reef continues intermittently along the west side of the Ewa plain where there is a concomitant shift in the relative distribution between inshore and offshore species.

Due to the porous structure of the coral plain, overland runoff is highly attenuated at the coast. There are few developed surface drainages in the region, with Honouliuli Stream representing the most significant exception. Intermittent streams include Makaiwa and Waimanalo gulches at the western end of the Plain. Additional examples within the central portion of the Ewa Plain (e.g., Makakilo) have been diverted around U.S. Navy and other installations via aquaducts and other modern structures.

The restricted sedimentation and soil development along the coastal margins of the Plain is due in part to the attenuated surface flow. The soils that do exist beyond the alluvial mantle are encountered in sinkholes and depressions among the rock outcrops closest to the coastline, and consist of friable azonal clays and silts weathered from transported alluvial material and from the local substrate. They are loose and well-aerated soils, with poor moisture retention qualities unless frequently replenished with humus.

Ewa in general is a semiarid region of intense sunshine, warm dry tradewinds, and little rainfall. At the western end of the plain these conditions are most accentuated. Except for some coastal marshlands, the vegetation is typically xeric, and, where undisturbed by modern developments, it has become dominated by hardy exotics. There is increasing evidence, however, that prehistoric vegetation in the region was more savannah like, and consisted of a grassland studded with thickets and small groves of trees.

The relatively harsh conditions characterizing the region today, as they did in former times, are primarily determined by geology and the location of the coral plain in the leeward shadow of the Waianae and Koolau mountains, which form the volcanic core of Oahu. Seasonally shifting wind patterns account for the low annual rainfall, which typically ranges from 300-500 mm. Easterly to northeasterly tradewinds of 10-15 knots prevail c. 75-85 percent of the time during an average year. But due to the rain-shadow effect, the retained moisture less frequently reaches the Ewa Plain in the form of significant quantities of rainfall than is true for many other areas of the island. From October through April, the tradewinds decrease in frequency and intensity and are replaced by more variable kona, or leeward, winds. These kona conditions, especially when they originate from the southeast and southwest, bring in the few winter storms, which deposit most of the annual precipitation for this area.

The mean annual temperature in the region is 74-75 degrees F, with a seasonal variation of c. 6-8 degrees F. The winter months are noticeably cooler than the summer months, although the variation is not significant. Diurnal variation is considerably greater than annual temperature variation, ranging from 64 degrees to 84 degrees F in the winter, and from 72 degrees to 93 degrees F in summer. The ocean may have an ameliorating effect on ambient temperatures over the adjacent landmass, but ground temperatures are little affected in this way. Although little information is available on this phenomenon, surface temperatures measured during previous work in the harbor project area revealed a daily variation in ground temperature exceeding 65 degrees F. Nighttime ground temperatures in areas cleared of vegetation averaged 67 degrees F, by mid afternoon, however, the dark humus surfaces which had been exposed directly to the heat of the sun registered temperatures of nearly 135 degrees F.

Despite the relatively low precipitation and the normally restricted surface runoff, coastal Ewa is not without accessible fresh water. Prolonged rains during the winter storm season can exceed the capacity of the coral substrate to accommodate the increased volume, thus producing extensive sheet-wash flooding at the coast. This was especially evident during the winter of 1981-1982. Groundwater is another important factor in flooding at lower elevations. The water table usually stands 0.3-0.6 m AMSL. This is only 1.0-3.0 m below ground level through most of the coastal zone, in some areas it appears at the surface as coastal marshlands

Depending upon the combined affect of runoff from the inland zone and the long-term stability of the water table, some of these marshlands may appear only seasonally while others persist year round.

Groundwater in southwestern Oahu occurs in two reservoirs, or aquifers. Basal fresh water is contained in the Waianae Volcanic Series. This is partly overlain by the adjacent coral rock cap containing largely brackish water. Ordinarily, the basal water would flow into the adjacent coral aquifer due to the pressure created by the higher elevation and greater capacity of the catchment that recharges the basal reservoir. However, the two are separated by an aquaclude, a dense descending stratum of low permeability formed by terrigenous and marine sediments that acts as a barrier, retarding the normal flow of fresh water from the basal aquifer. This restricted movement of groundwater between the two reservoirs means that the recharge of the lowland water table must rely primarily on the direct infiltration of the scant rains over the plain, plus the intermittent stream flow and runoff from the adjacent uplands. Once in the cap rock, the groundwater moves seaward in the southwesterly direction. Because of the porosity of the coral and the many natural conduits within the reef structure, the subterranean flow becomes more rapid as the water approaches the coast. Measurements of the water table through several deeper sinkholes in the previous harbor study area revealed a nearly synchronous response between the water level in widely separated features, and that of the oceanic tides along the shore some 1,000 m distant.

The quality of this groundwater is variable and depends on conditions affecting recharge of the coral aquifer. The bulk of the water is brackish, but fresh water does lens over the saline basement. During the prehistoric period of settlement, the availability and quality of this fresh water was apparently sufficient to have warranted the structural modification of sinkholes for use as "native" wells. During periods of prolonged drought, however, the usual recharge of the lowland water table can be greatly reduced. Under these circumstances the aboriginal modification of sinkholes providing access to ground water sources can be viewed as a Hawaiian response to conditions of environmental stress.

So far this description of the region has emphasized the general aridity of its leeward situation in the island-wide setting, and such factors as geology, soil development, surface runoff, and the relative proximity of groundwater to the surface near the coast. All of these variables contribute to ecological variability within what might otherwise be characterized as a rather monolithic environment. There are several additional factors contributing to the ecological variability of the region, however, and all can be related in potentially important ways to the prehistoric patterns of land use and resource exploitation of the region.

Altitude - At some locations within the Ewa Plain, altitude may represent an important contributor to ecological variability. Variation in altitude throughout portions of the Ewa Plain may be sufficient to have established vertical zonation in terms of environmental resources. On tropical islands generally, altitudinal differences often have greater significance for ecological variation than either windward-leeward or seasonal dichotomies. Most previous studies in the Ewa region have been limited to elevations of 6.0 m and less AMSL, and the present project is no exception. However, at some point in the future, such studies should be supplemented with information from higher elevation zones, and the role of altitudinal zonation in conditioning the exploitation of the shoreline area further evaluated.

Seasonality - Certain aspects of seasonal variation in the region have been discussed in some previous studies. Seasonality is an important heuristic device in attempting to evaluate prehistoric patterns of land use and resource exploitation. The archaeological evidence assembled to date documents use of both the marine and terrestrial zones by the Hawaiian settlers of the Ewa Plain. This included fishing, shellfish gathering, the hunting of birds, and gardening. The recent archaeological research in the deep draft harbor area (Davis 1979a) suggests that the following elements are important to an understanding of seasonal use of the general region:

a. Seasonal Fishery: In the marine zone, the productivity of the Waianae fishery is legendary. It is also generally acknowledged that winter and spring (January to May) are routinely the most productive seasons. The higher productivity of this fishery during this time of the year is apparently correlated with a number of seasonal variations, both oceanographic and biologic. Contributing factors include (a) the prevailing southeasterly surface and near-surface currents and their associated gyrals; (b) the synchrony of peak reproductive activity among Hawaiian reef fish with the occurrence of the southeasterly current; (c) the North Pacific Swell and its effect of upwelling cooler nutrient-rich waters from deeper levels into the upper water column; and (d) the greater aggregation of fish attracted to the increased food levels over the submarine outcrops and escarpments where this upwelling occurs;

b. Seasonal Terrestrial Resources: Seasonal changes in the weather have already been noted. As for effects on terrestrial resources, there is apparently little in the way of conspicuous seasonal variation in the vegetation, other than perhaps flowering and seed-bearing among several species like the wiliwili tree (*Erythrina sandwicensis*). The major floral variation seems largely to be in the output of new greens in response to the increased precipitation from November through April. For the avifauna, some seasonal cycles are indicated below. Note that the potential overlap of stages from one period to another is not indicated. Note also that this is only a partial listing, since no data are available for many of the species identified to date.

(1) For the Hawaiian Goose, breeding adults arrive at nesting sites in lower elevations from October to November and egg laying begins shortly thereafter. Hatching is underway by December and January. The chicks remain in the nest until February or March, by which time the young have fledged and are beginning to fly. Adult birds are also going through their postnuptial molt and are flightless at this time. Finally, from April through September, most, if not all of the geese return to their upland feeding in the interior. A few birds may remain at lower elevations.

(2) For Upland Forest Birds, May to October finds them resident in the uplands, with only occasional excursions to lower areas. These birds frequent lower elevations from November to April, possibly including the coastal plain, avoiding the severe upland winter storms.

(3) For the Petrel (excepting two species), Shearwaters, and Tropic Birds, breeding adults begin arriving at nesting sites in April, and egg laying continues until August. Hatching begins about June, and there may be chicks in the nest through mid-October. Finally, from November to March all the pelagic birds are at sea. The nesting sites are generally abandoned at this time, with the exception of the White-tailed Tropic Bird, which appears to remain in the general vicinity. Markham's Storm Petrel and the Bonin Island Petrel lay eggs in January and February, and chicks begin hatching in March. The young remain in the nest until June. These are also pelagic species and are at sea from July to December.

ARCHAEOLOGICAL CONTEXT

Overview of Hawaii Prehistory

The earliest archaeological evidence for settlement of Oahu and the Hawaiian Islands dates to about AD 300-500 (Kirch and Kelly 1975; Pearson, Kirch, and Pietrusewsky 1971; Schilt 1980). The settlers who came at that time originated from an unspecified island in Eastern Polynesia. Initial settlement is believed to have occurred along the wetter and more fertile windward coasts where "conditions were optimal for marine and terrestrial exploitation along lines followed previously in Eastern Polynesia" (Green 1980:1). This exploitation involved a variety of techniques for obtaining fish and shellfish from the sea, gardening, animal husbandry, and utilization of the natural terrestrial flora and fauna (Kirch and Kelly 1975, Pearson, Kirch, and Pietrusewsky 1971).

The settlement pattern consisted of a series of widely spaced, permanent home settlements that are thought to have gradually given way to a nearly continuous series of settlements along the windward coasts as the population grew. Leeward settlement is believed to have begun only after windward areas were settled. It is currently unclear whether the earliest leeward coastal settlements were permanent or seasonal/temporary. Inland leeward settlement, at least on a permanent basis, is thought to have occurred only after the development of inland dryland agricultural techniques. Evidence currently available indicates that inland leeward settlement did not occur until 600 to 900 years after initial settlement, or between about AD 1100 and 1400 (Green 1980, Hommon 1976).

Hypothetical reconstructions based on data from archaeology, linguistics, and ethnology suggest that early Hawaiians were organized in a typical Polynesian conical clan pattern, in which individual status was based on genealogical ranking (Green 1980:72). Kinship formed a basis for regional and island-wide societal integration, however, the most important social subsistence unit was the localized territorial community-based corporate kin group. Leadership within this group fell to the "highest ranking individual of the locally dominant, socially ranked lineage" (Green 1980:73). This individual acted as the local chief, overseeing the social, political, and economic functioning of the community.

The subsequent development of a uniquely Hawaiian innovation, the *ahupua'a*, resulted in a more complex level of social and political integration (Hommon 1976, Green

1980). The *ahupua'a* is a traditional Hawaiian land division ideally extending from the coast to the mountains, often corresponding with a valley drainage. The chief or manager (*konohiki*) of an *ahupua'a* extracted rents or tribute from the people (commoners or *maka'ainana*) who worked the land. The chief was a member of a non-localized ruling elite (*ali'i*). Thus, the earlier kinship-based relationship between a chief and his local community no longer existed, and this new Hawaiian socio-political organization has thus been classified as a complex chiefdom or primitive state.

Green's (1980) summary of the prehistory of Makaha Valley and the probable pattern of adaptation by Polynesians to the Hawaiian high-island ecosystem is of direct relevance for understanding the prehistory of the Ewa coral plain area in general, and the Marina project area in particular. Makaha prehistory begins with a hypothesized coastal settlement in the late first millennium AD. Although the nature of coastal settlement is unknown, because of land modifications and the lack of archaeological investigations on the coast, it is believed to have consisted of habitation structures associated with nearby garden areas (Green 1980:74). Marine exploitation is thought to have played a prominent role in the subsistence economy, and the presence of a small *heiau* in the area has been interpreted as reflecting a lineage-based system of local chiefly leadership.

Some time between the 12th and 14th centuries, if not before, cultivation of inland areas began. Dryland field systems, marked by stone walls, appear to be associated with small field shelters (C-shapes and other enclosure types) that were used on a temporary basis by people tending the fields, who lived permanently in the coastal settlement (Green 1980). Irrigated terrace systems were in use by the 15th century in the uppermost part of Makaha Valley. Permanent inland settlement is thought to have begun by this time (Green 1980:76). There is abundant evidence for permanent inland habitation during the 17th century, including rectangular dwellings, religious structures (stepped-stone platforms, shrines, and other specialized architecture). Large-scale construction of irrigation works and the rebuilding and expansion of an inland *heiau* at Makaha indicate that, by the mid-1600s, this area had become an *ahupua'a* unit in the "larger scale, complex rank social systems typical of Hawai'i at the time of contact" (Green 1980:76).

While the conditions on the western Ewa coral plain are considerably drier than those at Makaha, many of the archaeological remains reported from the lower valley have also been found in the coastal zone of the Ewa region, and may represent associations generally similar to those suggested above for coastal Makaha. At the west end of the Ewa coral plain, Honouliuli gulch and stream is much closer to Makaha, and it is likely that the Makaha pattern was generally duplicated within this area. Recent research provides some evidence in support of this contention (Jensen et al. 1988), although the extensive agricultural-related and other disturbances to the area have undoubtedly destroyed numerous features dating to the 14-17th centuries, while others have probably been deeply buried by extensive sediments washed down from the Waianae Range to the north.

Native Hawaiian Land Divisions and Settlement Patterns: Existing Models

The Ewa coral plain comprises the seaward portion of Honouliuli, the largest *ahupua'a* on the island of Oahu. At the time of European contact, the *ahupua'a* was the basic aboriginal land division, extending from the central uplands of the island down to the sea, and crosscut the various concentric island ecozones exploited by the Hawaiian people. Each *ahupua'a* thus theoretically incorporated sufficient resources to provide its inhabitants economic self-sufficiency.

The manner in which the *ahupua'a* economic unit was operationalized has long been a topic for discussion, and has led to the formulation of two alternative models for Hawaiian patterns of residence. One position argues for the redistribution of terrestrial and marine resources between permanently resident inland coastal components of the *'ohana*, or the Hawaiian extended family (Handy and Pukui 1972). The other model suggests that the redistributive network may not have involved goods, but rather people, with all or a majority of the productive population moving back and forth between the uplands and the coast (Rosendahl 1972). Population movements and settlement patterns could have followed a predictive seasonal round, or occurred on a more frequent and opportunistic basis, depending upon the degree of seasonal variation expressed in the environment and the logistical problems involved. Alternatively, it should also be considered that these are not necessarily mutually exclusive strategies. Both may have functioned in the same territory, given local or regional conditions, at any point in time.

Previous Archaeological Research

A significant number of archaeological projects have been conducted on the Ewa coral plain, extending from West Loch through Ewa Beach, around Barber's Point, and to the West Beach area near Kahe Point. The most substantial recent projects include those by Lewis (1970), Davis (1980a, 1980b, 1981, 1982), Davis and Griffin (1978), Hammatt and Folk (1981), and Barrera (1975, 1984, 1985, 1986).

The earliest reference to archaeological remains in the area (Thrum 1907:46) mentions the earlier presence of a *heiau* situated on Kapolei hill in Ewa. The site was apparently destroyed for its stones, either for use in constructing fences, or to be crushed for building material (McAllister 1933), and nothing is known concerning its original size or type.

McAllister (1933) listed many sites in Honouliuli; however, most are located at Pearl Harbor or high on the ridges of the Waianae Range. The Barber's Point area and much of the Ewa coral plain are subsumed under his Site 146. Concerning this site area he states:

> Ewa coral plains, throughout which are the remains of many sites. The great extent of old stone walls, particularly near the Puuloa Salt Works, belongs to the ranching period of about 75 years ago. It is probable that the holes and pits in the coral were formerly used by the Hawaiians. Frequently the soil on the floor of the larger pits was used for cultivation and even today one comes upon bananas and Hawaiian sugarcane still growing in them (McAllister 1933:109).

McAllister also identified a rock shelter located on the same hill (Kapolei) as the *heiau* noted by Thrum, where the pig-god, Kamapua'a, is said to have resided with his grandmother (McAllister 1933:108). A well preserved house site and possible *heiau* located on the western part of the Ewa Plain, adjacent to Kalaeloa Boulevard, were examined by Emory (Bishop Museum Site Files [1933]). Both structures had been constructed of stacked limestone slabs and uprights, but Emory found them destroyed by sugarcane planting.

In 1959, William Kikuchi removed 12 to 16 incomplete human burials from a limestone sink (Site 50-Oa-B6-10) prior to the construction of the Standard Oil refinery (Oahu Sites Folder 01.1 and Site Card in Dept. Anthropology, Bishop Museum).

In 1962, Lloyd Soehren recorded a burial at the Naval Air Station (Bishop Museum Files). The burial, a secondary interment, was found in a sinkhole located near house sites and modified pits.

In 1966, Soehren recorded and excavated a possible fishing shrine that was to be destroyed by the construction of a barge harbor (Site 50-OaB6-13, Oahu Sites Folder 01.1 and Site Card in Dept. Anthropology, Bishop Museum). Excavation revealed a pre-construction layer containing large amounts of fish scales. Dog, fish, and shellfish remains, and a one piece rotating fishhook, were recovered from the layer.

A beach midden site (50-Oa-B6-14), located south of the barge harbor in Camp Malakole, was recorded by Roger Green, for the Bishop Museum, in 1969. The site was discovered during construction of a pipeline that cut through the site, and Green collected surface artifacts including a bone awl, a coral file, a one-piece fishhook point fragment, and a piece of cut bone. The site was subsequently tested by Davis (Davis and Griffin 1978), revealing two components both characterized by charcoal-stained sand, charcoal, fire-cracked rocks, burned coral, and artifacts. The upper layer exhibited ash and charcoal pits.

Lewis (1970) has summarized the available historical data for the Ewa coral plain. The data indicates there was a sparse population at European contact, which was further reduced shortly thereafter. Early travelers made few comments about the region, and many native Hawaiians avoided the area, apparently preferring to use trails further inland. In 1969 and 1970, Lewis also conducted the first extensive archaeological survey and excavations in an area inland of Malakole Road. Lewis summarized his archaeological research, as follows:

> For our area we find many kinds of sites: houses and house compounds; cairns mounds, ahus of myriad size and shape, pits that may have had cultural uses; walls of several types. It is obvious that the people at some time adapted themselves to life on this near barren coral expanse. Though much of the land has been put under cane or concrete, there is yet a large area in which we may expect to find many additional sites to the few we have. Thus there is hope that we can define something of the past life of the Hawaiians who lived in such a seemingly un Hawaiian place (Lewis 1970:42).

Lewis considered the area to be so marginal that it would only have been settled after more desirable locations had been occupied, and that one should not ascribe patterns of adaptation, known from other parts of the islands, to west Ewa. The primary food source was thought to be the sea and reef. The possibility of raising fish (mullet) in brackish water ponds, and limited agriculture associated with pits and mounds are also noted, as is trade, as a potential means for obtaining non marine foods and other resources.

The Department of Anthropology of the Bishop Museum conducted a reconnaissance of c. 900 acres at Barber's Point in 1975 (Barrera 1975). Inland areas were examined to relocate sites recorded by Lewis in 1969 and 1970 (Lewis 1970) and to locate additional sites. Seaward areas were examined to determine the extent and density of surface remains. A total of 24 sites was located, and historic sources were researched. Nine of Lewis's sites were relocated within the survey area, three were probably relocated, and one could not be found. At least five of Lewis' sites had been destroyed. Twelve new sites were recorded. Site types included limestone sinks, house sites, walls, cairns, enclosures, shelters, a terrace, a midden deposit, a paved area, a burial cave, and many mounds; the latter are typically constructed of coralline limestone boulders and cobbles. A triangular basalt adze was found on the surface within an enclosure.

Barrera (1975) concluded that prehistoric occupation of the Barber's Point area was demonstrated by the presence of midden and artifacts. Fishing was considered to be the primary prehistoric use of the area, and was evidenced by fish bones and scales, fishhooks, and sinkers. No evidence of agricultural activities were present, but Barrera suggested that some of the mounds may have been used for cultivation of ti (*Cordyline terminalis* [L.] Kunth) and sweet potato (*Ipomoea batatas* [L.] Lam.), and recommended further survey and excavations to document this possibility. The settlement pattern was described as "dispersed clusters of residences, surrounded by a relatively open and little-inhabited area" (Barrera 1975:18). The Barber's Point locality was considered potentially important for archaeological research, because it represented "the prehistoric Hawaiian adaptation to a unique set of ecological circumstances (raised reef, low rainfall, and immediate proximity to deep ocean)" (Barrera 1975:18).

Sinoto (1976) provided a list of sites and features recorded for Barber's Point; the sites/features were in four survey areas designated A through D. A total of 97 sites was identified, including 17 previously recorded by Lewis (1970) and 36 reported by Barrera (1975). All sites were assigned Bishop Museum site numbers (50 Oa-B6-22 through 137; B6-58 through 137 added by A. Sinoto). The most common features recorded were unmodified limestone sinks (80 total), walled sinks (17), rectangular enclosures (18), C-shape enclosures (12), wall segments (14), and *ahu* (15+). Other infrequent sites/features included cairns, complexes of walls and enclosures, an L-shape wall, a ramp associated with a sink, a filled sink, railroad tracks, a cyst, a trail, platforms (2), and culturally modified caves (3). Sinoto (1976) undertook excavation at a total of 27 sites. An important result of the excavations was the discovery of six fossil bird bones in some of the limestone sinks; the bones were assessed as potentially important for paleontological research.

In 1977 an archaeological and paleontological salvage project was conducted by the Department of Anthropology, Bishop Museum, to mitigate the impacts of constructing the deep-draft harbor at Barber's Point (Sinoto 1978). Five archaeological and 13 paleontological sites were excavated. The excavations at the five archaeological sites produced portable artifacts (25), and midden, soil, and land snail samples (Sinoto 1978). In general, the excavations evidence a high degree of disturbance at project area sites. Sinoto noted only a single component, or cultural stratum, among all of the excavated sites. Basaltic glass from one site (Site B6-70) was hydration-rind dated to the 17th century (AD 1612-1650). Artifacts consisted of single specimens of the following artifact categories: adze, adze chip, basalt flake, basalt hammerstone, coral abrader, coral file, fishhook fragment (Type S-IA/B-HT 4 after Emory, Bonk, and Sinoto 1959), modified bird bone, and polished hematite. Ten pieces of basaltic glass and three unmodified basalt flakes were also recovered from the excavations. Midden recovered consisted primarily of molluscs, echinodermata, and crustaceans, which commonly are present in nearby shallow water, near reefs and surge zones. Fish and bird bones were scarce and unidentified, except for tuna (*Scombridae* sp.) Mammal bones were primarily those of rodent, with minor amounts of human bone.

Several trends in prehistoric utilization of the area, as evidenced by the archaeological remains, were discussed by Sinoto (1978). Construction of surface architectural features incorporated natural features such as outcrops surrounding low lying areas. Habitation-related structures were oriented in a manner that offered protection from the prevailing winds (i.e., highest walls along the northeast side of habitation areas). Sinkholes, when sufficiently large, evidenced habitation, and were often modified and incorporated into clusters of surface structures. The prehistoric utilization of the area was interpreted as short term, temporary, or seasonal and/or specialized. This interpretation was based on consistently thin cultural stratigraphic units, the absence of internal features such as fireplaces, and low artifact and midden densities. The stratigraphic consistency and ranges of dates from Sites B6-58 and B6-70 suggested that regional sites represent a "coeval occupation." The artifacts, midden, and the presence of *ahu* considered to be fishing shrines were interpreted as evidence for that fishing was emphasized.

In 1978, Davis and Griffin (1978) discussed previous research in the Barber's Point area. They recognized the tentative nature of some of the earlier hypotheses advanced by Lewis (1970) and Sinoto (1976), particularly the hypotheses suggesting permanent occupation of the area and the comments regarding plant cultivation. Davis and Griffin, on the contrary, suggested another plausible interpretation of the

existing data. Their suggestion was that these sites simply represented use and revisitation over an extended period of time. Furthermore, contrary to Lewis' earlier assertion, Davis and Griffin suggested that techniques for cultivating atoll environments could have been readily applied to the more or less equivalent environmental context at Barber's Point. Intensive labor practices, involving mulching and tapping the subterranean brackish water lens, for example, would have permitted small-scale food production within this area.

Sinoto (1979) conducted survey and test excavations in an 80-acre parcel adjacent to the area which he had previously surveyed in 1976. No new architectural types were present, but Sinoto (1979:32) did note variation in the "intensity in the exploitation of the two areas." Sinoto's research also focused on continued evaluation of paleontological significance. In addition to locating over 500 testable limestone sinks using a systematic quadrant sampling design, 24 sinks were actually evaluated. Sixteen percent of the excavated sinks were found to contain avifaunal remains of extinct species, and Sinoto (1979:34) outlined four categories of significance or potential significance for the avifaunal remains which he had inventoried:

1. Species of birds that are totally extinct in the Hawaiian Islands, with no historic record of extinction;

2. Species of birds that still exist today in the Hawaiian Islands but occupy a totally different type of habitat from that of Barbers Point;

3. Species of birds that are extinct on Oahu Island, and

4. Species of birds that are totally extinct in the Hawaiian Islands today, with a historic record of extinction.

In the mid-1980s, resort, commercial, residential community, and public recreation developments were proposed for a 640-acre parcel situated at the far west end of the Ewa coral plain. Known as West Beach, the area was subjected to intensive inventory survey and test excavation work, which resulted in identifying 181 component features at 48 separate sites (Davis and Haun 1987). Sites included habitation complexes with and without architectural features, gardening areas, and both primary and secondary human burials. Typical features included trash dumps, large cairns and isolated examples, and numerous modified sinkholes, some containing cultural refuse.

Dating results confirmed that most of the occupation likely dated to the latter centuries of the prehistoric sequence. However, samples from some rockshelter sites and cultural deposits identified near an old buried marshland suggested initial use/occupation as early as the period of initial Polynesian settlement of Oahu, and possibly during the period of initial Polynesian settlement of the Hawaiian Islands overall. The West Beach project thus yielded the first clear evidence of early occupation within the leeward zone of Oahu.

Recommendations for additional data collection work and data recovery excavations for the West Beach project area were formalized in the fall of 1986 in a Data Recovery Plan (Davis, Haun, and Rosendahl 1986). The field work portion of this work was completed before the end of 1987, and laboratory and other analyses were undertaken during the subsequent three years. Overall, the findings of the data recovery excavations at West Beach provide a picture of the overall spatial patterning of settlement on the west end of the Ewa coastal plain. It appears that the western Ewa plain had a long initial settlement period and that initial settlement was based on a high degree of marine oriented task specialization. Marine task specialization continued into later settlements, but it seems that in later settlements terrestrially oriented activities increased. This shift in activities suggests a concomitant shift from a very dispersed temporary occupation to a loosely nucleated one involving extended periods of residence. This nucleation apparently depended upon a functionally (task) integrated household where membership was both kin- and task based.

Concurrently with implementation of the West Beach Project, PHRI undertook additional inventory survey work above Pearl Harbor's West Loch (Dicks, Haun, and Rosendahl 1987). The City and County of Honolulu proposed residential community and golf course developments on c. 216 acres located within the lower and upper valley segments of Honouliuli Gulch. Although agriculture and other disturbances to the project area were extensive, seven sites were identified during the field work. These sites include both historic and prehistoric habitation and burial sites situated on Hoaeae Point and on the slopes and uplands surrounding the Honouliuli Stream floodplain. Included among the recorded features were the remnants of a once extensive agricultural system which combined aquiculture in fishponds situated on the shores of West Loch, irrigated pondfield cropping of the floodplain, and dryland cultivation of the surrounding slopes and uplands. Initial findings and radiocarbon dating results from these features suggested that the cultural sequence in the West Loch area spanned the past 1,000 years, and included a variety of agricultural and habitation activities.

Additional data collection was recommended for six of the seven West Loch Estates and Golf Course project area sites. This work was undertaken in 1988 and 1989, but has not been fully reported on. Generally, the findings support initial testing results and indicate that agricultural use of the Honoliuli Stream floodplain for pondfield cultivation of taro may have begun in the lower valley as early as AD 1000 (Davis, Haun, and Rosendahl 1988). Initial dates on the lower valley pondfield systems range from c. AD 1100-1600, with dates from the upper valley pondfields suggesting cultivation of that portion of the project area beginning c. AD 1400-1500. Intensification of agriculture thus appears to coincide temporally with similar events documented at numerous other sites on Oahu and elsewhere in the Hawaiian Island chain. Pondfield cultivation in some areas may have continued into the early twentieth century, with rice crops replacing the earlier taro cultivation in historic times. Modern intensive sugarcane cultivation has since largely obliterated the earlier pondfield system in much of the middle and upper portions of the valley.

The initial testing results also indicate that habitation sites in the West Loch area appear to represent a similarly long time span, with Site 3321, located at the edge of the upper valley segment floodplain, occupied as early as the mid-6th to the mid-9th centuries. Subsequent use of the site is documented for the periods between the 1300s and 1600s, and between the late 1700s and early 1800s. Additionally, Site 3318, located on Hoaeae Point, appears to date to the historic period, while Sites 3319 and 3320, situated on ridges overlooking West Loch and Hoaeae Point, respectively, span late-prehistoric to early-historic times.

SITE SIGNIFICANCE ASSESSMENTS AND RECOMMENDED TREATMENTS

The 1990 PHRI survey findings and conclusions, including general significance evaluations and general recommendations for site treatment, were presented in Dunn and Haun (1991:Table 7), adapted and presented in this document as Table 2 (Table 2 includes only sites Dunn and Haun (1991) recommend for further work). Significance categories used in the site evaluation process are based on the National Register criteria for evaluation, as outlined in the Code of Federal Regulations (36 CFR Part 60). The DLNR-HPP/SHPO use these criteria for evaluating cultural resources. Sites determined to be potentially significant for information content fall under Criterion D, which defines significant resources as ones which "...have yielded, or may be likely to yield, information important in prehistory or history." Sites potentially significant as representative examples of site types are evaluated 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."

Sites with potential cultural significance are evaluated under guidelines prepared by the Advisory Council on Historic Preservation (ACHP) entitled "Guidelines for Consideration of Traditional Cultural Values in Historic Preservation Review" (Draft Report, August 1985). The guidelines define cultural value as "...the contribution made by an historic property to an ongoing society or cultural system. A traditional cultural value is a cultural value that has historical depth." The guidelines further specify that "[a] property need not have been in consistent use since antiquity by a cultural system in order to have traditional cultural value."

Based on the above criteria, of the total 53 sites identified within the Ewa Marina project area, 47 were assessed as significant solely for information content. No further work was recommended for 32 of the 47 sites. For 14 of the 47 sites, further data collection was recommended. For one of the 47 sites, further data collection was recommended, and preservation "as is" was provisionally recommended, pending further data collection results. The remaining six sites were assessed as significant for information content and as excellent examples of site types. The six sites are well preserved representative examples of the more common functional types in the project area. Sites 3201, 3202, and 3205 are all excellent examples of the type of habitation complexes encountered in the western portion of the project area, and date to the initial phase of occupation of the area. Sites 4277 and 4278 are also habitation complexes, but are located on the eastern edge of the project area and are associated with the spread of habitation and agricultural sites to the eastern and central portions of the Ewa plain during the hypothesized second phase of occupation. Site 3209 includes a platform with a probable specialized function, and is located in the midst of the agricultural complexes in the central portion of the project area. Further data collection followed by preservation with interpretive development of the six sites was recommended.

To further facilitate client management decisions regarding the subsequent treatment of resources, the general significance of the archaeological sites identified during the intensive survey was also evaluated in terms of potential scientific research, interpretive, and/or cultural values (PHRI CRM [Cultural Resource Management] value modes). *Research value* refers to the potential of archaeological resources for producing information useful in the understanding

Table 2.

SUMMARY OF GENERAL SIGNIFICANCE ASSESSMENTS AND RECOMMENDED GENERAL TREATMENTS

Site Number	Significance Category				Recommended Treatment			
	A	X	B	C	FDC	NFW	PID	PAI
3203	•	-		-	•			
3206	•	-	-	-	•			
T-2 (4265)	•	-	-	-	•			
T-3 (3210)	•	-	-	-	•			
T-17 (3213)	•	-	-	-	•			
T-19 (3211)	•	-	-	-	•			
T-21 (4275)	•		-	-	•			
T-30 (4280)	•	-	-	-	•			
T-36 (4281)	•		-	-	•			
T-11 (4271)	•			-	•			
T-54 (3216)	•	-		-	•			
T-65 (3215)	•	-	-	-	•			
T-84 (3208)	•	-	-	-	•			
T-96 (4295)	•		-	-	•			
Subtotal:	14	0	0	0	14	0	0	0
3201	•	-	•	•	•	-	•	-
3202	•	-	•	-	•		•	
3205	•		•	-	•		•	
T-25 (4277)	•		•	-	•		•	
T-26 (4278)	•	-	•	-	•		•	
3209	•		•	-	•		•	
Subtotal:	6	0	6	0	6	0	6	0
T-101 (4297)	•	-	-	-	•	-	-	•
Subtotal:	1	0	0	0	1	0	0	1
Total:	21	0	6	[illegible]	21	0	6	1

• Provisional recommendation pending results of further data collection

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, DLNR-HPP=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 (further survey and testing, and possibly subsequent data recovery/mitigation excavations).
- NFW = No further work of any kind necessary, sufficient data collected, archaeological clearance recommended, no preservation potential.
- PID = Preservation with some level of interpretive development recommended (including appropriate related data recovery work).
- PAI = Preservation "as is", with minimal further work (and possible inclusion into a landscaping) or appropriate data recovery/[illegible]

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* refers to the potential of archaeological resources to preserve and promote cultural and ethnic identity and values. CRM value mode assessments for individual sites are presented in Table 1 (at end).

In addition to the sites possessing archaeological significance, several sinkhole clusters encountered included sinkholes with paleontological significance. Present in the sinkholes were sub-fossil to fossil osteological remains of extinct avian species. In light of this significance, further data recovery was recommended for sinkholes within Clusters A, B, C, E, F, and G.

As can be seen from Table 2, the 21 sites requiring further work are separated into categories based on significance assessments and recommendations. Treatment of the sites in each category is described below:

I. Data Recovery - No Preservation (14 sites) - For 14 of the total of 45 sites considered significant solely for information content, data collection is recommended. Subsequent preservation or interpretive development is not recommended for any of the 14 sites. The sites in this category are 3203, 3206, T-2 (4265), T-3 (3210), T-17 (3213), T-19 (3211), T-21 (4275), T-30 (4280), T-36 (4281), T-11 (4271), T-54 (3216), T-65 (3215), T-84 (3208), and T-96 (4295).

II. Further Data Collection - Preservation With Interpretive Development (6 sites) - Six sites have been recommended for interpretive development, following further data collection work. These sites are significant not only for the information value which they retain, but as excellent examples of types of sites currently underrepresented in existing preserves. These sites are a potentially important part of DLNR/HPP-SHPO's regional plan for preserving excellent examples of particular site types for the public's benefit. One of the sites possesses excellent site type qualities and also possesses provisional cultural value. This site is 3209, a well preserved, relatively large and formally stepped platform, which has also been interpreted as a possible ceremonial feature. In addition to Site 3209, Sinkhole Cluster D (Feature K of Site 3202) and Sinkhole Cluster P (Feature N of Site 4275) are assessed as having provisional cultural value, due to the presence of possible burials in the sinkhole deposits.

III. Further Data Collection - Preservation "As Is" or Data Recovery (1 site) - One site, T-101, has been recommended for provisional preservation "as is" pending further data collection work. This site possibly includes a prehistoric burial. If a burial is present, preservation "as is" should be considered. If this is not feasible, relocation or data recovery is recommended.

For the 21 sites requiring further data recovery/collection work (all sites within Categories I-III), the following Data Recovery Plan outlines relevant research questions to be addressed and data collection methods to be employed. The final site preservation and interpretive development plans for the six sites listed in Category II will be presented as one component of the present Mitigation Plan's Phase III Report. Finally, a Monitoring Plan has been included in the Archaeological Mitigation Plan to ensure interim site preservation in accordance with the Interim Preservation Plan element of the Phase I-Mitigation Plan, as well as proper identification, evaluation, and treatment of any potentially significant cultural resources that might be discovered during construction and other work associated with development.

DATA RECOVERY PLAN

As a means of guiding further investigations at the 21 sites requiring further work, general research topics have been developed and incorporated into a general research design, outlined below. Selection of research topics is based in large part on the findings of the inventory survey report (Dunn and Haun 1991), supplemented by findings from previous work at West Beach. The research design, as proposed, serves several functions: (1) it establishes known archaeological and environmental parameters which may have affected the project area, (2) it defines the theoretical orientation of the study and outlines research objectives to be pursued, (3) it discusses strategy and methods by which those objectives are to be realized, and (4) it provides a framework against which the results of field work and laboratory analyses can be evaluated.

RESEARCH OBJECTIVES

The preceding general overview of Hawaiian prehistory and summary of the present state of knowledge about settlement patterns and cultural development on the leeward side of Oahu provide a general framework for developing research questions designed to guide the present data recovery effort. Supplementing this framework are the results of the investigations at West Beach (1986), West Loch (1988) and the Ewa Marina inventory survey (Dunn and Haun 1991), which identify the range of subsistence and industrial resources exploited, and at a general level, the activities engaged in by the occupants of the Ewa Plain during prehistoric and historic times. The proposed research project seeks to build upon these findings by combining a paleo-environmental research approach, coordinated conventional archaeological techniques and, to account for potential ecological variability in the study area, site selection based on stratified sampling theory. This research approach will be supported by ongoing documentary research appropriate to mitigation-level investigation, and will utilize information from artifacts, ecofacts, soils, pollen, and paleontological remains to address and refine the following topics:

1. The nature of the pre human environment, with particular attention to the development of pollen and paleontological sequences;
2. The nature and chronology of environmental changes, where indicated by pollen and paleontological evidence, during the period of human settlement in the project area;
3. The interrelationship between human settlement and environmental change in the project area, with specific focuses on faunal extinctions and human causality;
4. Settlement patterns and subsistence technology, including a focus on response and feedback between adaptative strategies and environmental change at the regional level, and a focus on intra- and inter site variability within the project area;
5. The nature and composition of local residence groups and their relationships to larger social, political or economic networks through time, and
6. The impact of Euro-American influences on traditional Hawaiian settlement and subsistence strategies into the nineteenth century.

Much of the present data recovery/collection effort is focused on habitation and agricultural site complexes in the western and central portions of the Ewa Plain. The 21 sites recommended for further research include sites from several apparent phases of settlement in the project area, and contain a substantial amount of potentially important scientific information. The mitigation investigations offer what could be considered a unique opportunity to make a substantive contribution to our knowledge of Hawaiian prehistory in general, and specifically, add to our understanding of the interrelationships between environmental change, settlement patterns, and subsistence strategies on the Ewa Plain.

In addition to the above research objectives there are questions on cultural and interpretive values that have to be addressed. In terms of evaluating the significance of an archaeological resource, *cultural value* refers to the potential that the resource has for preserving and promoting cultural and ethnic identity and values. *Interpretive value* refers to the potential a resource has for general public education and recreation. The remains found in the project area present an important opportunity to address these two values. In terms of cultural value, the remains reflect a significant aspect of Polynesian/Hawaiian cultural adaptation which enabled Polynesians/Hawaiians to settle the area, apparently in large numbers, under some rather extraordinary conditions. As for interpretive value, the surviving features and their leeward coastal locations—which enhance their accessibility for visitation—offer the opportunity to preserve those structures and material goods (i.e., the artifacts of that adaption) that have survived as examples of the human process. To achieve this preservation it is necessary that the data, as stipulated in the research objectives, be collected from the features. Then, once the analysis of data has been completed, an effort must be made to develop an effective interpretive plan that will present results and conclusions to an interested public. Site-specific levels of interpretive development will be presented in the Phase III - Site Preservation Plan of the Archaeological Mitigation Plan.

HYPOTHESES

The first three research objectives outlined above may be subsumed under three hypotheses concerning ecological change and causality in southwestern Oahu. The principal hypothesis is that of "Prehistoric Anthropogenic Change" (McCoy et al. 1982; Davis, in prep.). This proposition states that over time cultural practices of Hawaiians brought about significant ecological changes in southwestern Oahu including, prior to European contact, the local or universal extinction of a number of endemic bird and land snail species. Other hypotheses posit either that ecological change in the region was anthropogenic, but occurred only in the historic period, or that changes were a natural occurrence due to climatic or other nonhuman causes. All the above hypotheses, however, are not mutually exclusive. As in any ecosystem, natural changes—quite probably changes at a slower pace than wrought by man—would have occurred prior to man's arrival. Moreover, the events of the modern era, as throughout all of Hawaii, have certainly been felt in the region. The problem when studying the prehistoric settlement period is to separate natural effects from hypothesized cultural effects. Findings consistent with the "Prehistoric Anthropogenic Change" hypothesis include the following:

1. Little or no evidence of ecological change prior to human settlement;

2. Evidence of substantial ecological change, including the extinction of most native bird and land snail species, during the prehistoric settlement period;

3. Evidence of few or no now-extinct animal taxa persisting into the modern period;

4. Clear evidence of the co-occurrence of prehistorically introduced adventive animal species (Polynesian rat; gekkonid and scincid lizards; and the land snail species *Lamellaxis gracilis*) and extinct native species, and the absence of co-occurrence of extinct species and modern era adventive species (other rodent species, exotic bird species, and the land snail species *Gastrocopta servilis* and *Psuedopeas tuckeri*);

5. Evidence for the co-occurrence of extinct animals and prehistoric, but not historic, human artifacts; and

6. Archaeological evidence for the prehistoric human exploitation of presently extinct bird species as human food.

The kinds of data that can support the above six findings include:

1. Sedimentary information (stratigraphic profiles, particle size/shape, and soil chemistry) for determining depositional regimes in dry sinkholes, flooded sinkholes, stream beds, marshes, and other alluvial contexts;

2. Zoological materials (the remains of rats, birds, lizards, and land snails) and botanical remains (pollen, opal phytoliths, spores, and preserved vegetal debris) for reconstructing former biotic communities; and

3. Datable material (charcoal, wood, bone, shell, and volcanic glass) to establish chronology of events, particularly human settlement events and their attendant environmental changes.

The remaining three research objectives may be subsumed under a model of native Hawaiian subsistence and settlement patterns. The model is as follows: initial occupation of the region is mainly in the form of temporary encampments utilized by fishermen and bird collectors. Over time some camp sites acquire a quasi-permanent status; particular sites are consistently reoccupied although each occupation remains only temporary. Eventually the frequency and/or duration of occupation increases, with some sites in use year-round, but not necessarily by the same individuals. This type of semi-permanent settlement includes what has been defined as functionally integrated, multi household residence groups (Davis and Griffin 1978, Davis 1980a)—groups which seem to have persisted into the nineteenth century. Dates from recent work in the deep-draft harbor place occupation over a span of nearly 900 years: c. AD 1000-1870 (Davis, in prep.). Recent research in the West Beach and West Loch areas, supplemented by new evidence gathered during the Ewa Marina Inventory Survey Project (see Dunn and Haun

1991), indicate a similar sequence, beginning perhaps as early as c. AD 1000 and continuing until late prehistoric/early historic times in the general project area.

Subsistence during occupation periods involved exploitation of marine strand resources, small scale gardening, and, at least during the initial period of settlement, exploitation of land and sea birds. Evidence of residence groups in the region during a later period, plus evidence of a local horticultural base, suggests settlement in the region may have once included whole families. This, however, still remains to be demonstrated.

Archaeological evidence for such residence groups was defined as being the occurrence of functionally different but presumably contemporaneous habitation features in close spatial association, and thus collectively reflecting a range of activities that serve to identify the residence group (Davis 1981; in prep.). This definition has since been modified to accommodate the importance of ordinary dwellings, or domestic features serving multiple functions, being present.

As a social unit, the residence group was initially inferred (by Davis) to be an extended family, incorporating several households, similar to the family outlined by Handy and Pukui (1972). However, partly because Handy and Pukui's description of the Hawaiian extended family was based on ethnohistorical data gathered during the 1930s, from Ka'u on the island of Hawaii, where residence patterns apparently emphasized the segregation of sexes according to the *kapu* system, the similarity was not complete. Handy and Pukui's residence model included separate cooking and eating houses, sleeping houses, storage facilities, and work areas for men and women, and a menstrual house or other place of seclusion for women (Handy and Pukui 1972:7-11). These proscriptions, however, may not have operated in the same manner throughout the islands, among all levels of society, or during all periods of a cultural sequence. For example, Malo (1951:118-126) described residential organization for what he called "respectable" people as being similar to Handy and Pukui's model, but he also observed that so-called "no accounts" often followed no such proprieties.

The economics within the residence pattern described by Handy and Pukui were essentially static. Residents occupied permanent sites, some along the coast and others inland. Terrestrial and marine resources were then traded between residence groups. Fishermen chiefly remained fishermen and the farmers remained farmers. Again, for the same reasons discussed above, this economic pattern may not have been the pattern followed in the Ewa region or elsewhere in leeward Oahu. Evidence from the Lapakahi area, for instance, indicates that the residence pattern in the earlier portions of the local sequence were considerably more fluid, and focused on the movement of people rather than goods between the coastal fishing and upland garden areas (Rosendahl 1972).

Aside from provisionally applying the architectural aspects of Handy and Pukui's model to Ewa, the model that is being delineated and proposed here clearly makes a number of rather broad, fundamental assumptions which still need substantiation.

1. That the various archaeological sites/features elements of the inferred residence group were in fact occupied at the same time,

2. That the various feature types present in the project area were more-or-less functionally discrete when in use;

3. That the use of any feature type remained functionally consistent through time;

4. That plant cultivation and/or the exploitation of birds was part of the local subsistence base, and

5. That the presence of residence groups, as defined, and the presence of a local horticultural base provides sufficient evidence to (a) support an inference that whole families were part of the local settlement, or (b) support an inference that any part of the settlement was occupied on a more-or-less permanent basis.

DATA REQUIREMENTS

Several classes of data are necessary to resolve the above research questions: (a) data concerning the temporal associations of sites, features, and their constituents, (b) data concerning the definition of pollen and paleontological sequences, and the association of these sequences with cultural occupation of the area, (c) spatial data concerning the horizontal and vertical locations of sites, activity areas, features, artifacts and ecofacts, and (d) data concerning the cultural constituents of sites and of individual features and activity areas. All of these classes of data will be derived from quantified observation and recordation of the spatial relationships of sites, features and their constituents, and the controlled collection and analysis of materials (samples, artifacts, and ecofacts).

Data needed for addressing the research questions outlined above will be derived from detailed recording of cultural and environmental variables; the recording will include mapping and photography, surface collection of portable remains, excavations, and subsequent laboratory analyses. Excavation data may be derived from portable items such as artifacts, ecofactual materials (food/midden remains, soil samples, and vegetal material), and if discovered, human skeletal remains. Non-portable evidence for structures and features may include soil features (pits and depressions), stone alignments and concentrations, and hearths. In order to optimize the potential range of applicable statistical and spatial quantitative analyses, efforts will be made to maximize vertical and horizontal excavation control in order to obtain the most precise provenience information possible. Laboratory data will be derived from various physical, quantitative, qualitative, and statistical analyses of materials recovered during the excavations. These analyses will include, but are not necessarily limited to, artifactual, ecofactual, palynological, and age determination analyses (see Research Methods below).

The research questions necessitate that all sites, features, and isolates will be investigated. This data research plan is focused on site and feature types that are known to exist in the project area or are likely to be found in the project area during excavation. If additional site or feature types are discovered, the mitigation plan will require modification in order to remain responsive to the resultant expanded range of investigations. The nature of the investigation actually undertaken at each site or feature will depend upon the characteristics of the site or feature, its condition, an assessment of its significance, and the nature of the impacts which the site or feature is liable to incur as a result of the proposed construction activities.

SAMPLING STRATEGY

Controlled excavations will be undertaken at all of the 21 sites recommended for further data collection/recovery. The placement of controlled excavation units will be accomplished within a previously superimposed site grid system and will be guided by the need to extract a statistically sufficient and representative sample of the subsurface remains. Additional non-sample excavations will be conducted in selected areas determined to have a high probability of yielding temporally and functionally diagnostic materials or strata. Additional units may also be excavated to expose features (particularly burials and structural features) revealed by the sample units or apparent on the surface, or to supplement the inventory of a particular class of data not well represented in the sample units.

Controlled excavations will involve between 25-50% of structure interiors, and 1-10% of non-feature specific deposit areas to identify subsurface deposits or features. Smaller sample percentages will be taken from sites or features displaying little horizontal and vertical variability. Sites with complex stratigraphy, a wide variety of features, and variability in the distribution of portable remains will be more heavily sampled.

DATA RECOVERY METHODS AND TECHNIQUES

Data for addressing the research topics outlined above are derivable from additional detailed reecording, archaeological surface collections, excavations, and laboratory analyses of recovered artifactual and ecofactual materials. Already available for the project area is inventory-level archaeological survey data, including (a) information on site and feature types and their distributions, (b) amount and types of surface artifactual and ecofactual materials, and (c) general environmental data. Surface collections, excavations, and additional detailed recording could be expected to contribute additional information on artifacts, ecofacts, materials for absolute dating, stratigraphic information, additional specifics concerning site/feature function and construction methods, and intensity of occupation of individual sites and features. Laboratory data could include age determination analyses, artifact and ecofact analyses, paleontological analysis, and palynological analyses, depending on the specific contents of individual sites and features.

Field Methods

As mentioned above, each find will be the subject of a phased data collection/recovery effort. The decision to proceed from one phase to the next will be determined through an evaluation of the adequacy of the work accomplished in light of the research questions. A description of these phases follow:

Phase 1 - Detailed Recording and Surface Collections - variable levels of detailed recording and surface collection will occur at all sites for which additional data recovery/collection work has been recommended. This work will involve re-examination of previously recorded sites, and will include final determination of the extent of each site (in some cases), and detailed documentation on site maps of all site features and components where such documentation has not already been

fully obtained. Surface collection will be undertaken at all sites containing appropriate surface scatters, and will focus on the collection of artifacts, ecofacts, soil samples, and samples for age determination analyses. A collection grid will be superimposed over large sites to facilitate the controlled collection of samples; at smaller sites or at sites with a limited inventory of portable remains, all surface materials will be point-provenienced and collected.

Phase 2 - Controlled Excavations - Controlled excavations will be undertaken at sites that have already been determined to contain intact or otherwise appropriate cultural deposits. The basic controlled excavation unit will be a 2.0 by 2.0 m exposure excavated as four adjacent 1.0 by 1.0 m excavation units. Units will be excavated according to cultural/natural stratigraphic layers. If necessary, excavation by arbitrary 10 cm levels will be employed for thick or stratigraphically complex layers, or where cultural/natural layers cannot be clearly identified during excavation. Any units larger than 2.0 by 2.0 m will be excavated as a series of adjacent 1.0 by 1.0 m units. All excavated materials will be screened through 1/4" and 1/8" screens, with 100% of the artifactual material, and a minimum of 25% of the ecofactual material being returned to the laboratory for sorting and analysis.

Strict horizontal and vertical locational control will be maintained over the excavations. Superimposed excavation grids (and surface collection sample grids) will be tied into the existing project coordinate system. The site grid system will be oriented to conform with the orientation of the project grid system. Locational control will be maintained by the use of 1-minute transit and stadia, or by a system of equal or greater accuracy. A permanent locational datum will be installed at each site or at the nearest point to the site which will not be impacted by project development. The datum will be referenced to both the project coordinate system and to the site specific excavation grid system. The datum will consist of a bronze monument set in concrete and marked with the site number and the datum's site grid coordinates.

The field drawings (plans and sections) will be digitized to allow computerized combination of all drawings into a single three dimensional map of the entire excavation at each site. Excavation will proceed by hand using carefully controlled methods. Trowels, brushes, and various other small instruments will be employed. Both arbitrary 10 cm and stratigraphic levels, whichever are appropriate, will be followed. A precise surveying instrument—transit, theodolite, or total station—will be used to provide horizontal and vertical control of the exposures. Detailed maps of the progress of the excavations and of the locations of all exposed features, activity areas, and collected portable remains and samples will be maintained in the field.

Field documentation of the controlled excavation units will include recording the horizontal and vertical proveniences of recovered portable materials, samples, and the subsurface features and strata encountered. These data will be recorded on standard archaeological excavation grid and feature forms. Plan views and stratigraphic section drawings will be made to scale, as appropriate. Black and-white and color photographs will be taken to document the field work and to support the written and graphic record.

A number of specialized collection methods will also be used to collect samples for palynological, paleontological and age determination analyses. These methods will chiefly involve the collection and analysis of pollen core samples from the wetland area in the western portion of the project area, collection of samples containing datable material from sequential stratigraphic contexts within specific habitation and agricultural complexes, sinkholes, and the wetland area if possible, and collection and detailed recording of faunal materials from sequential stratigraphic contexts in the sinkhole units. Samples will be systematically collected by standard methods which ensure their preservation and relevance. Rationale for the systematic collection of these specialized samples has been outlined in the research design above.

Laboratory Methods and Specialized Analyses

Laboratory analysis of the excavated materials is an integral and highly important aspect of the proposed study. The principal areas of analysis include artifactual analysis, ecofactual analysis, faunal analysis (including paleontological research), and palynological analysis. Descriptions of each analysis are presented below.

Artifactual Analysis - All artifactual material encountered *in situ* from surface or excavation contexts, as well as artifacts encountered during laboratory sorting of ecofactual materials, will be washed, sorted and numbered in the laboratory. Artifacts will be measured, weighed, and classified, with both metric and descriptive attributes being entered into a computer database. Artifact attributes will also be archived on cards printed from the database; drawings of diagnostic artifacts will be included on the appropriate cards. Analysis of portable artifacts will be mainly descriptive, with identifications and functional assessments augmented by Buck (1957), Kirch (1973, 1979), Barrera (1971) and Emory, Bonk and Sinoto (1959). Distributional analysis of functional types will follow, forming an essential element in the overall intrasite and intersite analyses.

Age Determination Analysis - Absolute and relative methods of dating will be used to further refine the temporal framework provided by the earlier inventory survey (Dunn and Haun 1991). Dating samples will be derived from sequential stratigraphic deposits at a representative sample of habitation and agricultural features and site complexes to provide comparative intrasite and intersite temporal frameworks. Dating samples will additionally be selected from the sinkhole deposits and wetland area as a means of relating both the sequence of paleontologically significant and culturally deposited faunal materials, and the paleoenvironmental sequence derived from the pollen cores, to the temporal framework established for cultural development in the project area. The techniques to be used, and the rationale are as follows:

Radiocarbon (C-14) assay provides an estimate of the absolute age of materials analyzed, subject to the limitations of the sample under study. Wood charcoal provides high-quality radiocarbon age ranges, but it is often not found in significant amounts in the region. Where necessary in the case of very small or diffuse samples, extended counter time, and/or an accelerated (AMS) method will be used. The radiocarbon samples will be submitted to Beta Analytic, Inc. of Coral Gables, Florida. Using standard procedures, the samples will be pretreated with an acid, alkali, acid series of soakings to remove carbonates and humic acids. After pretreatment, samples are combusted to form carbon dioxide gas, combined with lithium to separate the carbon, and hydrolized for conversion to liquid form. The liquid is then catalyzed to form benzene and placed in a liquid scintillation counter to determine the amounts of carbon-13 and carbon-12 present. The isotope values obtained during the counting process will then be used to calculate the carbon-13/carbon-12 ratio for each sample, with the final result being determined relative to international standards in order to reduce errors produced by carbon isotope fractionation.

Stratigraphic methods provide a means for estimating the age of a particular sediment layer based on (a) superposition, (b) the presence of historic or prehistoric archaeological artifacts, or (c) the presence of remains of animals or plants known to be have been introduced to the Hawaiian islands by humans, or prehistorically extinct. These artifacts and animal/plant remains can be used as "index fossils" to permit classification of a stratigraphic layer as "prehuman" (no adventive species), as prehistoric (prehistoric artifacts, adventives; no historically adventive species), or as modern (historic period artifacts or adventive species present). Although soil mixing, cultural disturbance, or bioturbation can introduce inaccuracies into such conclusions, careful stratigraphic control during excavation will minimize the hazards of this approach. Information derived from stratigraphic methods will be used to examine relative temporal associations between artifactual and ecofactual material, and will provide the basis for the artifact seriation and cross-dating of site and feature deposits.

Ecofactual Analyses. Midden deposits are archaeologically significant on a number of levels, as the variety and content of food remains contained within a given midden deposit provide useful information concerning prehistoric diet and resource utilization patterns. The analysis of midden remains generally has a number of objectives, including (1) the determination of midden content, in particular the variety and distribution of the remains for each cultural deposit encountered within the project area; (2) to provide an indication of dietary and resource exploitation patterns for each site, and for the project area as a whole, (3) to examine changes in local diet and resource exploitation patterns through time at each site and for the project area in general, and (4) to interpret changes in these patterns, or lack thereof, to cultural and natural processes occuring in the project area over time.

All midden remains recovered from excavation units will undergo detailed analysis in the laboratory. Detailed analysis involves splitting the sample into two size classes by passing each sample through 1/4 in and 1/8-in screens. One hundred percent of

the material retained in the 1/4 in screen is completely sorted at the lowest taxonomic level possible, while the material retained in the 1/8-in screen is inspected for both artifactual material and for taxa not encountered in the larger portion of the sample. Marine shell identifications are verified and augmented using Kay (1979).

The sampling design outlined above is adapted from Kirch (1979), based on a series of experiments measuring the relative distribution of molluscan and bone material retained on each screen. Kirch concluded that use of the screening process increased the speed of the sorting process without decreasing either the accuracy or statistical validity of the overall analysis. The taxonomic distribution and weight of material retained on the 1/4 in screen should thus be considered as representative of the variety and relative percentages of each taxon present in the entire sample.

Faunal Analysis. Faunal remains are archaeologically significant on a number of levels, as the variety and abundance of faunal material contained within a deposit provide useful information concerning prehistoric diet, environment, and resource utilization patterns. The analysis of faunal remains for the current project has three primary objectives: (1) to determine faunal deposit content, in particular the variety and distribution of the remains for each cultural deposit encountered within a particular site or feature, (2) to provide an indication of dietary and resource exploitation patterns at both the intrasite and intersite level, and (3) to document the occurrence and distribution of paleontologically significant fauna present in Sinkhole Clusters A, B, C, E, F, and G, with the goal of determining the sequence of deposition in these units relative to the cultural sequence in the project area; followed by the collection and preservation of specimens of extinct or rare taxa where encountered.

Analysis of the faunal remains from the project area will be completed by Dr. Alan Ziegler, a zoological consultant who currently resides in Kaneohe, Hawaii. Analysis of non-human vertebrate remains will include identifying the range of animal taxa present in each site and feature deposit. All faunal remains will be identified to the lowest taxonomic level possible. Faunal samples will be separated by site, feature, test unit and stratum prior to submission to Dr. Ziegler. Identification information and bone counts will be attached to the separated samples as they are analyzed in order to prevent mixing of contexts during analysis or repacking of the samples when they are returned to the PHRI lab. Quantitative analysis of the faunal material associated with the cultural deposits will consist of summary statistics based on Dr. Ziegler's findings, with specialized analyses such as MNI (minimum number of individuals) and meat/body weight estimations depending on the extent and degree of preservation of the assemblage. Quantitative analysis of remains from the sinkhole deposits will consist of summary statistics for sequential stratigraphic levels, and will be used to seriate the deposits within and between each sinkhole cluster.

Palynological Analysis. Pollen analysis is a valuable tool in reconstructing prehistoric and historic period vegetation and climate in an area. Pollen records, where preserved, can indicate shifts in vegetation which correspond to natural phenomena, such as glaciation or local warming trends, or to cultural activity such as land clearing for agricultural purposes. In cases where pollen is preserved in association with cultural deposits or carbonized material, these shifts can be correlated with the temporal sequences provided by radiometric and stratigraphic means. Preliminary analysis of sediments from the wetlands in the western portion of the project area, collected during the intensive survey project (Dunn and Haun 1991), indicates that pollen is preserved in sufficient quantities to provide a record of plant taxa present in the area over time. While the scope of the preliminary study was limited to determining the presence of pollen in the core samples and the identification of the range of taxa present, the results did suggest that the composition of the wetlands fluctuated over time.

Additional pollen analysis of core samples from the wetlands area will be used as a means of reconstructing paleoenvironmental conditions through time in the project area. Pollen cores collected as part of the proposed project will be submitted for palynological analysis to Dr. Linda Scott Cummings of PaleoResearch Laboratories, Colorado. Samples will be processed and analyzed using standard procedures (Cummings 1987). Quantitative analysis of the results will consist of summary statistics presented in the form of a standard pollen diagram, and if datable material is obtained to link the pollen sequence to the temporal framework in the project area, will provide the basis of paleo-environmental reconstructions for each phase of occupation in the project area.

Historical Documentary Research

Historical documentary research appropriate to mitigation-level data recovery will be undertaken. This research could involve limited work with available local informants, and further examination of relevant historical sources (including published and unpublished reports and records, and historic maps) related to the project area.

Report Preparation

The final report will present findings of the Data Recovery Plan, as outlined in the draft guideline standards for Archaeological Data Recovery Studies and Reports prepared by DLNR-HPP (DLNR 1987). Emphasis will be placed on interpreting individual sites and features, first in terms of function and age, and then in terms of temporal, spatial, and environmental frameworks established for the Ewa Marina project area. The specific research questions outlined above will be addressed.

Treatment of Recovered Materials

All materials recovered during the present project would be handled in compliance with Section 66.3(b) of the National Park Service's "Recovery Standards and Reporting Requirements," which recommends that recovered materials "...should be maintained by a qualified institution or institutions as close as possible to their place of origin, and made available for future research" (CFR). During field work and analysis phases of the proposed project, recovered materials will be stored in the facilities of the PHRI laboratory in Hilo, Hawaii. After completion of the final report, arrangements for permanent curation of archaeological and ecofactual materials will be made in consultation with DLNR-HPP/SHPO and the University of Hawaii-Manoa. Paleontologically significant material from the sinkhole deposits will be curated by Dr. Olsen at the Smithsonian Institution, Washington, D.C., per the recommendation of Dr. Ziegler and the Bishop Museum.

INTERIM SITE PRESERVATION PLAN

Of the total of 53 sites located within the project area, six sites were assessed as valuable for information content, and as excellent examples of site types. For these six sites, further data collection followed by preservation with some level of interpretive development has been recommended. For these six sites the recommended additional data collection has been designed to allow (a) assessment of any additional research which would be necessary and appropriate prior to preservation of the resource(s), and (b) more accurate interpretation of site function so that signs or other interpretive developments are accurate.

Until the data collection research on all sites requiring such work has been completed, interim protection from the potential adverse effects of construction would be necessary. Buffer zones for all sites which may require interim preservation consideration will be approved by DLNR-HPP/SHPO prior to (a) implementation of the interim preservation work, and (b) any land alteration work or construction work. DLNR-HPP/SHPO would also verify implementation of the interim preservation work, which would be conducted as part of the Phase II - Archaeological Data Recovery/Collection work.

Interim preservation will be insured by adopting the following general protective measures:

1. Accurate plotting and locating of all sites on grading plans prior to initiation of grubbing and grading activities, and appropriate notation included on the grading plans,
2. Establishing an appropriate buffer zone around the identified and mapped site perimeters, within which construction activity would not be allowed. The buffer would be staked and construction activity would not be allowed to occur within the buffer zone;
3. Explicit notification of construction supervisors as to the nature and location of the sites, the significance of the buffer zones, and the color and meaning of any site perimeter and buffer zone flagging tape; and
4. On site monitoring of construction grubbing and grading in the immediate vicinity of all sites to be preserved, or sites not to be preserved but at which data collection had not yet been completed at the time construction actually begins.

MONITORING PLAN

A formal written plan to provide guidance for all monitoring work is necessary because it will help to assure (a) interim site preservation in accordance with the Interim Preservation Plan element of the Phase I - Mitigation Plan, as well as (b) proper identification, evaluation, and treatment of any potentially significant cultural resources that might be discovered during construction of the proposed road.

CONSTRUCTION ACTIVITY MONITORING

The basic objectives of the archaeological monitoring of construction activity would be the following:

1. To protect, in accordance with an approved interim site preservation plan, all known sites scheduled for preservation, as well as any sites for which recommended data recovery work may not have been completed prior to the initiation of construction activity;

2. To identify and evaluate the potential significance of any archaeological remains that might be revealed during the course of any construction activities;

3. To immediately notify DLNR-HPP/SHPO upon discovery of any potentially significant archaeological, historical, or cultural properties or objects, in order to (a) establish the significance of such properties or objects and (b) determine the nature and extent of any data recovery and/or preservation measures which might be warranted; and

4. To carry out an appropriate level of data recovery work — consisting of detailed recording (including plan mapping and profiles, written descriptions, and photographs), collection of portable artifacts and appropriate samples of ecofactual remains and dating materials, and any needed mitigation excavations—in order to preserve the significant archaeological information contained within any identified remains.

The archaeological monitoring crew would normally consist of one person who would be present on-site during construction within the vicinity of known sites for which additional data collection has been recommended. In general, the archaeologist would monitor construction adjacent to known sites in order to identify any possible cultural remains that might have been concealed during the initial inventory-level survey work. In the event that archaeological remains are identified during such monitoring, the archaeologist would record and collect the exposed data as expeditiously as possible. If significant remains are revealed and should the scale of work involved in the recording and data recovery be beyond the capacity of a single archaeologist, and/or if construction activities involve multiple pieces of equipment at widely spaced site locations within the project area, additional archaeological field personnel would be provided as appropriate and necessary.

BURIAL TREATMENT PLAN

Of the 21 sites recommended for further data collection/recovery, three (Site 3209, Sinkhole Cluster D/Feature K of Site 3202, and Sinkhole Cluster F/Feature N of Site 4275) contain potential human burial remains. In addition to these potential human remains, the proposed data collection and data recovery excavations could result in the identification of additional, unanticipated burial remains. The evaluation, recording, and reinterment of designated remains will (a) be guided by a specific set of research objectives, (b) be in compliance with various Hawaii State Statutes, and (c) be undertaken in consultation with any identified lineal descendants, affected Native Hawaiian groups and organizations, and appropriate State and County agencies.

Coordination and Compliance

Form of Treatment As indicated earlier, in place preservation (preservation "as is") of known human burials is the preferred form of treatment, with disinterment of burials being an alternative treatment to be considered only in situations where in-place preservation would be difficult or inappropriate for cultural reasons. In any case, treatment of all burials would be conducted in accordance with Chapter 6E, Hawaii Revised Statutes (as amended by Act 306, S.L.H. 1990). Selected treatment of specific burials would be proposed to DLNR-HPP and the Oahu Island Burial Council by means of a formal treatment plan submitted for review and approval.

In-place Preservation - For burials to be preserved in place, various aspects relating to preservation, including approval of appropriate buffer zones, would be determined by DLNR-HPP and the Oahu Island Burial Council. Specific details concerning accomplishment of preservation would be contained within the final Site Preservation Plan (Phase III of the mitigation program).

Disinterment - Prior to any disinterments, a blessing would be conducted at the project area by appropriate representatives of the Hawaiian people. During disinterment, archaeological personnel would adhere to the highest standards of professional conduct, displaying respect and sensitivity during the removal and curation of the remains.

Disinterment would be conducted in a scientific manner by professional archaeologists, using controlled archaeological excavation techniques. Detailed and comprehensive records, including field notes, detailed recording on standard recording forms, maps, and photographs documenting the location, orientation, condition, and other aspects of each burial, would be maintained throughout the disinterment procedures.

Curation, Analysis, and Reporting - Following any disinterment, the remains would be temporarily curated at the PHRI laboratory in Hilo. The temporary curation facility would be appropriate for insuring the physical preservation of the remains, and would be adequate for conducting post field osteological recording and analyses.

Subject to the agreement of any identified lineal descendants or, where no lineal descendants are found, DLNR HPP and the Oahu Island Burial Council, osteological analyses of remains would be carried out in a timely manner, sensitively recording information called for in the disinterment plan. The analysis would consist of recordation of standard metric and non-metric traits and would include assessments of age, sex, and pathology. All aspects of the analysis would be documented by way of written records (including appropriate forms), drawings, and photographs. Reporting would be done in accordance with an approved disinterment plan.

Reinterment - After completion of all laboratory analyses, the remains would be reinterred. For burials that have been claimed by legitimate lineal descendants, the claimants would be consulted with regard to specific reinterment wishes. For all other remains, it is recommended that they be reinterred at a location within the project area that could be preserved and protected. All available associated grave goods recovered during the present project would be reinterred with their respective burials.

Reinterment procedures, including physical treatment of the remains (i.e., type of container), grave preparation and marking, and ceremonies/blessings, would be determined through consultation with DLNR-HPP and the Oahu Island Burial Council, or with lineal descendants, with preference being given to the wishes of the latter. Final disposition of any disinterred remains most likely would involve reinterment at a mutually agreeable and appropriate location within the Ewa Marina project area.

Prior to reinterment, the reinterment site would be mapped to the appropriate archaeological standards. After the remains are reinterred, the exact locations of the remains should be plotted on this map, which could be made available to qualified archaeologists with legitimate reasons for consulting the map.

Subsequent to mapping, the portion of the proposed reinterment site containing the burial remains should be sealed in some fashion, perhaps with a dry masonry rock wall.

EVALUATION OF IDENTIFIED CULTURAL MATERIALS

The significance of any archaeological remains newly identified within the project area would be 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 (ACHP). DLNR HPP/SHPO and HCPD both use these criteria to evaluate eligibility for both the Hawaii State and National Register of Historic Places.

Specifically, the purpose of the National Register is to list properties that are " significant in American history, architecture, archaeology and culture... " (NHPA Sec 101 [a][1]). A property has significance if it satisfies each of two categories comprising the National Register criteria for evaluation (36 CFR Part 60.4): (1) the site must possess integrity of location, design, setting, materials, workmanship, feeling, and association, and (2) it must be characterized by at least one of the following:

(a) It must be associated with events that made significant contributions to broad patterns of history;

(b) It must be associated with the lives of persons significant in the past,

(c) It must embody distinctive characteristics of a type, period, or method of construction, or represent the work of a master, or possess high artistic value, or represent a significant and distinguishable entity whose components may lack individual distinction (representative examples of site types), or

(d) It must have yielded, or may be likely to yield, information important in prehistory or history (information content) (36 CFR Part 60 6).

Sites will also be assessed for potential cultural significance using guidelines prepared by the Advisory Council on Historic Preservation (ACHP) entitled "Guidelines for Consideration of Traditional Cultural Values in Historic Preservation Review" (ACHP 1985). The guidelines define cultural value as "... the contribution made by an historic property to an ongoing society or cultural system. A traditional cultural value is a cultural value that has historical depth" (1985:1). The guidelines further specify that "[a] property need not have been in consistent use since antiquity by a cultural system in order to have traditional cultural value" (1985:7).

To further facilitate client management decisions regarding the subsequent treatment of resources, the general significance of any archaeological remains identified during monitoring would also be evaluated in terms of three PHRI cultural resource management value modes which are derived from the previously mentioned federal evaluation criteria. Sites would be 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 significance evaluation framework used here, refers to the potential of archaeological resources for the preservation and promotion of cultural and ethnic identity and values.

DATA ANALYSIS

Analysis of data recovered during any monitoring field work would be conducted concurrently with the field work and would be reported on in the final report for the project. Data analysis, including, but not necessarily limited to, age determination analyses, and artifactual and ecofactual analyses, will be carried out using standard procedures (refer to the Data Recovery Plan for detailed rationale and methodology).

REPORT PREPARATION

Upon completion of all monitoring field work, a Memorandum Report would be prepared; this report would summarize (a) findings of monitoring field work, (b) appropriate interpretation and evaluation of these findings, and (c) any recommendations for additional work which might be appropriate or justified.

COORDINATION AND CONSULTATION

All on-site monitoring work would be coordinated with the State and designated representatives and/or contractors. The State would be informed of the progress of the monitoring work, and would be notified of any problems encountered as soon as possible. Whenever potentially significant archaeological remains were exposed, the monitoring archaeologist would suspend construction excavation as necessary to permit identification and tentative evaluation of such remains, and to determine and carry out appropriate archaeological data collection and recovery work as deemed necessary. The State would provide adequate and appropriate security to prevent vandals and other unauthorized persons from damaging or disturbing any exposed archaeological remains.

As part of archaeological monitoring work, PHRI would maintain close contact and consult with DLNR HPP/SHPO. Project generated materials—specifically artifacts, midden, and other archaeological samples—would be temporarily curated at PHRI laboratory facilities in Hilo. Upon completion of the project, arrangements for permanent curation would be made in consultation with DLNR HPP/SHPO.

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Table 1.

SUMMARY OF IDENTIFIED SITES AND FEATURES

Site/Feature Number	Formal Site/Feature Type	Tentative Functional Interpretation	*CRM Value Mode Assess R	I	C	+Field Work Tasks DR	SC	EX
3201	Complex (18)#	Habitation	M/H	M/H	L/H			•
A	Enclosure							
B1	Platform							
B2	C-shape alignment							
C	Platform							
E1	Midden scatter							
E2	Mounds (?)							
E3	Mound							
F1	Alignment							
G	C shape							
H	Mound							
I	Mound							
J	Enclosure							
L	C shape							
M1	Alignment							
M2	Alignment							
N	Alignment							
O	L-shape alignment							
P	L shape alignment							
3202	Complex (?)	Habitation	H	M	L			•
A	Platform							
D	Platform							
E	Platform							
F	Platform							
G	Rubble concentration							
H	Modified bedrock							
J	Adjoining C shapes (3)							
K	Sinkhole Cluster D							
3203	Complex (7)	Habitation	L,M	M	L			•
A	Platform							
B	Terrace							
C	Mound							
D	Rubble alignment							
E	Terrace							
F	Platform							
G	Mound							
3204	Complex (5)	Habitation/agriculture	L	L	L			
B	C shape							
E	C shape alignment							
G	Mound							
H	C shape							
I	Rubble concentration							

* Cultural Resource Management Value Mode Assessment—Nature R = scientific research, I = interpretive, C = cultural, —Degree H = high, M = moderate, L = low

+ Recommended further data collection field work tasks DR = detailed recording (scaled drawings, photographs and written descriptions) SC = surface collections EX = limited excavations

Number of component features

Table 1 (cont.)

Site/Feature Number	Formal Site/Feature Type	Tentative Functional Interpretation	*CRM Value Mode Assess R	I	C	+Field Work Tasks DR	SC	EX
3205	Complex (27)	Habitation	H	M/H	L	•	•	•
A1	Enclosure							
A2	C shape							
B	Enclosure with abutting platform							
C	Adjoining C-shapes							
D	Adjoining C shapes							
E	Cairn							
F1	Enclosure							
F2	Platform							
G	Platform							
H1	Platform							
H2	Mound							
I1	C shape							
I2	Mound							
J	Enclosure							
K1	Incomplete structure							
K2	Platform							
L	Platform							
M	Enclosure							
N	Enclosure							
O	C shape							
P	Platform							
Q	Platform							
R	Series of mounds							
S	Platform							
T	Platform							
U	Platform							
V	Rubble concentration							
3206	Enclosure	Habitation	M	L	L		•	•
3208	Platform	Temp. Habit.	M	L	L	•	•	•
3208 (T-7)	Complex (6)	Ceremonial	H	H	L/H	•		•
A	Platform							
C	U shape alignment							
D	Series of alignments							
E	Modified bedrock							
F	Wall segment							
G	C shape							
3210	Complex (9+)	Agriculture	M	L	L			•
A	C-shape							
B	Enclosure							
C	Enclosure							
D	Platform							
E	Sample of agricultural mounds & alignments							
F	Alignment							
G	Alignment							
H	Mound							
I	Alignment							
3211 (T-10)	Complex (4)	Temp. Habitation	M	L	L	•	•	•
A	C shape							
B	C shape							
C	Enclosure							
D	Enclosure with adjoining C shape							

Table 1 (cont.)

Site/Feature Number	Formal Site/Feature Type	Tentative Functional Interpretation	*CRM Value Mode Assess R	I	C	+Field Work Tasks DH	SC	EX
3212	Complex (2)	Indeterminate	L	L	L	•	•	
A	Platform							
B	Rubble concentration							
3213	C shape	Temp. habitation	M	L	L			•
3214	C shape segment (recent)	Indeterminate	L	L	L			
3215	Complex (43+)	Agricultural habitation	M,H	L	L			•
A	Wall							
B	Wall							
C	Modified bedrock							
D	Modified bedrock							
E	Modified bedrock							
F	• •							
G	• •							
H	• •							
I	Linear mound							
J	Linear mound							
K	Modified bedrock							
M	Linear mound							
N	Modified bedrock							
O	Mound							
P	Mound							
Q	Adjoining enclosures (2)							
R	Platform							
S	Alignment							
T	Wall							
U	Cupboard							
V	Modified bedrock							
W	Mound							
X	U shape enclosure							
Y	Modified bedrock							
Z	Adjoining c shape alignments							
AA	Modified bedrock							
BB	Wall segments (2)							
CC	Modified bedrock							
DD	Mound							
EE	Modified bedrock							
FF	• •							
GG	Platform							
HH	Platform							
II	Modified bedrock							
JJ	Terrace							
KK	Modified bedrock							
LL	Enclosure							
MM	Modified bedrock							
NN	• •							
OO	• •							
PP	Enclosure							
QQ	Mounds (3)							

Table 1.(cont.)

Site/Feature Number	Formal Site/Feature Type	Tentative Functional Interpretation	*CRM Value Mode Assess. A	I	C	+Field Work Tasks DR	SC	EX
3216	Complex (21)	Agriculture	M/H	L	L	•	•	•
A	Enclosure							
B	C-shape							
C,D	Wall							
E	Enclosure							
F	Enclosure							
G	Enclosure							
H	Platform							
I	Modified sinkhole							
J	Enclosure							
K	Enclosure							
L	Wall							
M	Alignment							
N	Modified bedrock							
O	Enclosure							
P	Wall							
Q	Mound							
S	Modified bedrock							
T	Modified bedrock							
U	Enclosure							
V	Modified bedrock							
W	Modified bedrock							
3217	Complex (40) Mounds, mod. outcrops cleared areas	Agriculture	L	L	L	•	•	•
3218	Complex (14) Mounds, mod. outcrops	Agriculture	L	L	L	•	•	•
4218	Complex (10+)	Agriculture	L	L	L	•	•	•
A	Mound							
B	Modified bedrock							
4265	Complex (14)	Agriculture	M	L	L	•	•	•
A	Mound							
B	L-shape alignment							
C	Mound							
D	U-shape alignment							
E	Incomplete structure							
F	Modified bedrock							
G	Alignment							
H	Mound							
I	Cairn							
J	Modified bedrock							
K	Alignment							
L	Mound							
M	Mound							
N	Modified bedrock							
4267	Rubble alignment	Possible terrace remnant	L	L	L	•	•	•
4268	Complex (3)	Indeterminate	L	L	L	•	•	•
A	Alignment							
B	Mound							
C	Mound							
4269	Complex (2)	Agriculture	L	L	L	•	•	•
A	Wall segment							
B	Modified bedrock							
4270	Complex (3)	Indeterminate	L	L	L	•	•	•
A	Mound							
B	L-shape alignment							
C	Mound							

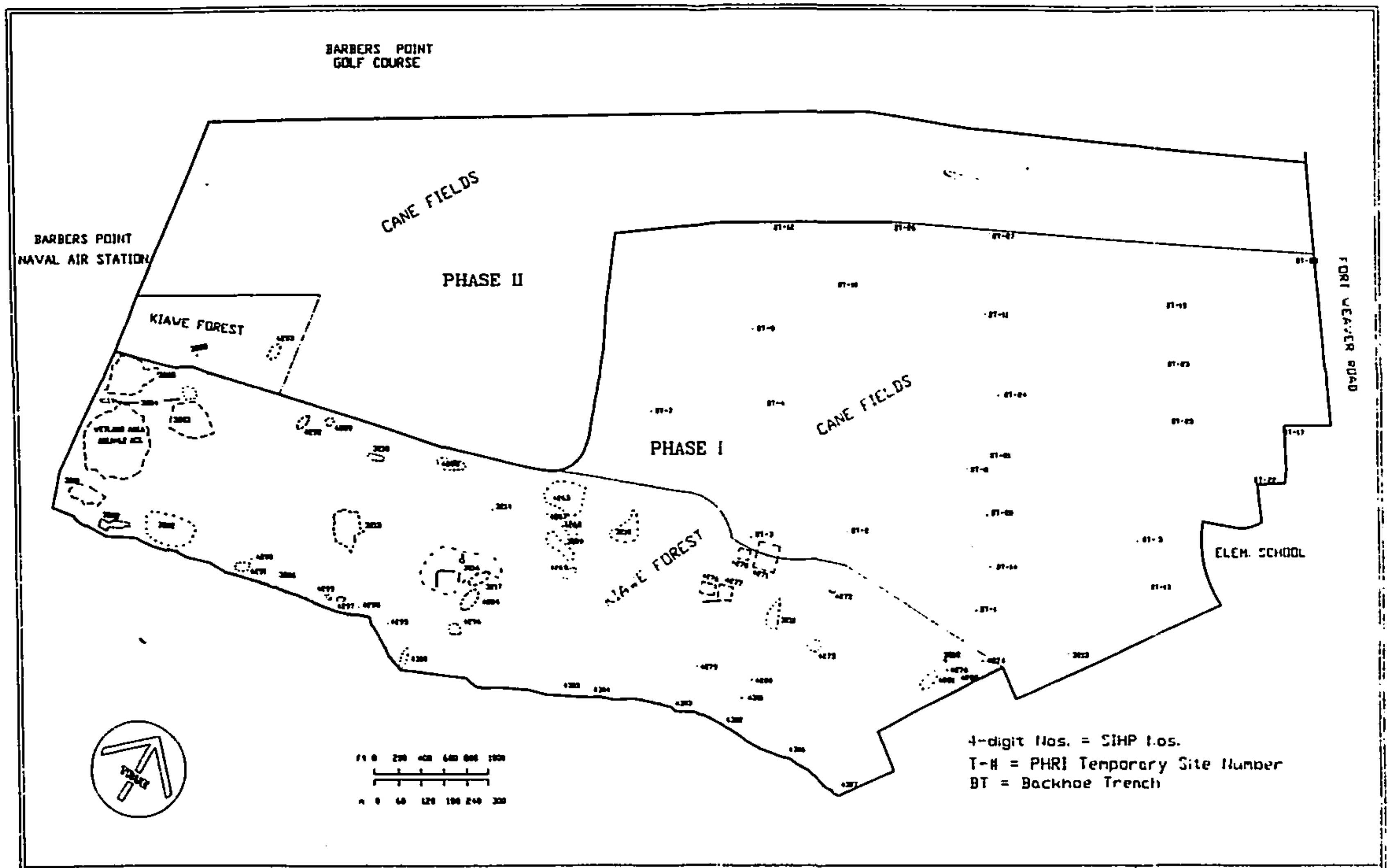
Table 1 (cont.)

Site/Feature Number	Formal Site/Feature Type	Tentative Functional Interpretation	*CRM Value Mode Assess. A	I	C	+Field Work Tasks DR	SC	EX
4271	Complex (4)	Temp. habitation	M	L	L	•	•	•
A	U shape enclosure							
B	Cairn							
C	Incomplete C-shape							
D	Mound							
4272	Concrete foundation	Animal Husbandry	L	L	L			
4274	Cement structure	Incinerator	L	L	L			
4275	Complex (11)	Possible agriculture	M	L	L			•
A	Series of mounds							
D	C shape							
E	Alignment							
F	Possible enclosure with associated mounds							
G	Enclosure							
H	Enclosure							
I	Enclosure with associated mound							
J	Rubble concentration							
K	Rubble alignment							
L	L shape rubble alignment							
M	L shape rubble alignment							
N	Sinkhole Cluster F							
4276	Modified sinkhole	Historic Well	L	L	L			
4277	Complex (5)	Habitation	M/H	M	L			•
A	Enclosure							
B	Enclosure							
C	Modified sinkhole							
D	C shape							
E	Rubble concentration							
4278	Complex (4)	Habitation	M/H	M	L			•
A	Platform							
B	Enclosure							
C	Platform							
D	Enclosure w/adjoining platform							
4279	Platform	Foundation	L	L	L			
4280	Platform	Historic Habit.	M	L	L			•
4281	Complex (5)	Habitation	M	L	L			•
A	Adjoining enclosures							
B	Rubble concentration							
C	Rubble concentration							
D	Rubble concentration							
E	Rubble concentration							
4282	Complex (2)	Foundation/ recent historic	L	L	L			
A	Terrace							
B	Platform w/adjoining alignment							

Table 1.(cont.)

Site/Feature Number	Formal Site/Feature Type	Tentative Functional Interpretation	*CRM Value Mode Assess. R	I	C	+Field Work Tasks DR	SC	EX
4284	Complex (4)	Agriculture	L	L	L	·	·	·
A	Platform w/adjoining alignment							
B	Mound							
C	Mound							
D	Sample of ag. mounds (6)							
4289	Complex (2)	Indeterminate	L	L	L	·	·	·
A	Mound							
B	Alignment							
4290	Concrete structure	Bunker	L	L	L	·	·	·
4291	Complex (2)	Agriculture	L	L	L	·	·	·
A	Wall							
B	Modified bedrock							
4292	Complex (2)	Indeterminate	L	L	L	·	·	·
A	Mound							
B	Adjoining enclosure							
4293	Complex (4)	Habitation/ agriculture	L	L	L	·	·	·
A	Mound							
B	Mound							
C	C-shape							
D	C-shape							
4295	Complex (2)	Marker/Refuse Area	L	L	L	·	·	·
	Cairn							
	Sinkhole Cluster C							
4296	Complex (5+)	Agriculture	L	L	L	·	·	·
A	Modified sinkhole							
B	Modified bedrock							
C	Modified bedrock							
D	Modified bedrock							
E	Modified bedrock							
4297	Complex (2)	Agriculture/poss.	M	L	L/H	·	·	·
A	Rubble alignment burial							
B	Modified sinkhole							
4298	Wall segment	Indeterminate	L	L	L	·	·	·
4299	Complex (2)	Indeterminate	L	L	L	·	·	·
A	Mound							
B	Mound							
4300	Complex (2)	Bunker	L	L	L	·	·	·
A	Concrete structure							
B								
4301	Concrete structure	Bunker	L	L	L	·	·	·
4302	Concrete structure	Bunker	L	L	L	·	·	·
4303	Concrete slab	Footing	L	L	L	·	·	·
4304	Concrete structure	Bunker	L	L	L	·	·	·
4305	Concrete structure	Bunker	L	L	L	·	·	·
4306	Enclosure	Garden plot	L	L	L	·	·	·
4307	Concrete slab	Footing	L	L	L	·	·	·

763-110890



PHRI PAUL H. ROSENDAHL, Ph.D., INC
ARCHAEOLOGICAL · HISTORICAL · CULTURAL
RESOURCE MANAGEMENT STUDIES & SERVICES

Ewa Marina Community Project – Phase I
Intensive Archaelogical Survey and Test Excavations
PHRI Project 89-763

FIGURE 2.
Project Area and Site Location Map

Appendix O

Traffic Impact Assessment Report for Ewa Marina Phase I - Increment II and Phase II

TRAFFIC IMPACT ASSESSMENT REPORT

FOR

EWA MARINA
PHASE I - INCREMENT II AND PHASE II

October 1991

Ewa, Oahu, Hawaii
TMK 9-1-12: Portions 5 & 6 and Parcel 23

Prepared for:
HASEKO (Hawaii) Inc.

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TABLE OF CONTENTS

APPENDIX

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

Pacific Planning & Engineering, Inc. (PPE) was engaged to undertake a traffic impact study to identify and assess future traffic impacts caused by Phase I - Increment II and Phase II of the proposed Ewa Marina Community development. This study identifies and evaluates the probable impacts of traffic generated by the proposed development in the year 2009 when the project is expected to be completed and occupied.

Introduction

The Ewa Marina is a master planned recreation-oriented development in the Ewa region on approximately 1,100 acres of land. The community would include single and multi-family residential units, a 1,600 slip marina, two resort hotels, a resort residential condominium, a championship tennis club, a 27-hole golf course, an office building and other recreational amenities.

Development of the Ewa Marina community is planned in two phases. The first phase of this project is further divided into two increments. During the first increment of Phase I only a portion of the single family and multi-family residential units would be constructed; this part of the project has already received the necessary rezoning. The marina and the remaining portion of the single family and the multi-family residential units would be added in the second increment of Phase I. The commercial areas and the golf course would be developed in Phase II. The developer plans to apply for rezoning and other land use permits for the second increment of Phase I and the entire Phase II in the near future.

Project Description

HASEKO (Hawaii), Inc. is proposing to develop the Ewa Marina Community, a master planned recreation-oriented development in the Ewa region of the island of Oahu. The master plan calls for a community approximately 1,100 acres is size which includes single and multi-family residential units, a 1,600 slip marina, two resort hotels, a resort condominium, a championship tennis club, 27-hole golf course, and a variety of commercial centers to support the residents of the community. The most current land uses are given in Table 1.

Table 1. Land Uses for Ewa Marina Community
Phase I - Increment II and Phase II

Land Use	Quantity
PHASE I - INCREMENT II:	
Single-Family Residential	910 units
Multi-Family Residential	2,650 units
Marina	1,600 slips
PHASE II:	
Visitor Condominium	600 rooms
Marina Hotels	500 rooms
Fitness Promotion Hotel/Center	400 rooms
Retail Shops	40,000 square feet
Restaurant Complex	40,000 square feet
Commercial Offices	70,000 square feet
Tennis Complex	10 courts
Yacht Club	12,000 square feet
Parks	17 acres
27 Hole Golf Course	272 acres

Although Phase II of the project may be completed prior to the first or second increments of Phase I, the full development of the Phase I may extend to year 2009. Hence the completion year of 2009 was utilized for the the entire development.

Methodology

Analysis was conducted for three intersections along Fort Weaver Road to determine the relative impact of the proposed project on the local roadway system. The intersections under study are as follows:

- Fort Weaver Road and Access Road A.
- Fort Weaver Road and Access Road B.
- Fort Weaver Road and Papipi Road.
- Paipipi Road, Hailipo Road and Access Road C.

Since Fort Weaver Road terminates in Ewa Beach, traffic was forecasted at the study intersections using the "build-up" method. This method forecasts traffic by adding traffic generated by the project and other developments in the area.

The study assesses the impact on the study intersections by determining the *level-of-service* (LOS) for the following conditions:

- Existing conditions.
- Year 2009 forecast without the project.
- Year 2009 forecast with the project.

Conclusions and Recommendations

The results of this study confirm the previous 1986 study by Ewa Marina Phase I, Increment I, by Kaku Associates (1986) which indicates that despite the widening of Fort Weaver Road to a four-lane divided highway, a second north-south road parallel to Fort Weaver Road would be required to link Ewa Marina/Ewa Beach area and the H-1 Freeway.

With the currently proposed land uses, no other mitigating actions would be necessary for Fort Weaver Road intersections at the project Access Road A and Access Road B if the following recommendations from 1986 Kaku report are implemented:

- Provide double left-turn lanes on Access Road A and Access Road B, with separate right-turn lanes on Fort Weaver Road for southbound traffic and left-turn lanes for northbound traffic at these two intersections. Fort Weaver Road would need four travel lanes, two in each direction.

- Provide traffic signals at these locations: 1) the intersection of Access Road A with Fort Weaver Road and 2) the intersection of Access Road B with Fort Weaver Road.

For intersection of Papipi Road, Hailipo Street and Access Road C, an unsignalized intersection would be sufficient to serve the forecasted traffic volumes. For the Access C approach, a single lane to serve left, through and right turn movements would be adequate.

Traffic from other proposed projects north of Ewa Marina, such as West Loch Estates and West Loch Fairways, Ewa Villages, Ewa Gentry, and

Laulani/Fairways, would also contribute to the need to provide a second north-south roadway and new interchange with the H-1 Freeway. Because of major developments planned for the Ewa region, the State Director of Transportation imposed a requirement on these projects to participate in the development for an Ewa Region Highway Master Plan to determine future arterial roadways for the area.

The State Department of Transportation has formed a Working Group, which includes the City Department of Transportation Services, the major developers of the Ewa Region (including HASEKO (Hawaii), Inc.), Campbell Estate and other State and City Planning agencies. The purpose of this Working Group is to identify future roadway needs and participate in the fair share costs to implement the required improvements for the Ewa Region.

The joint efforts of the Working Group has resulted in the identification of the North-South Road as one of the major roadways in the Ewa Region. The results of the ongoing Ewa Region Highway Master Plan study will provide the traffic data needed to determine the roadway improvements required for the North-South Road; the roadway improvements within the Ewa Marina project site, especially for the North-South Road, should be adopted and incorporated into the project plans for the Ewa Marina Community.

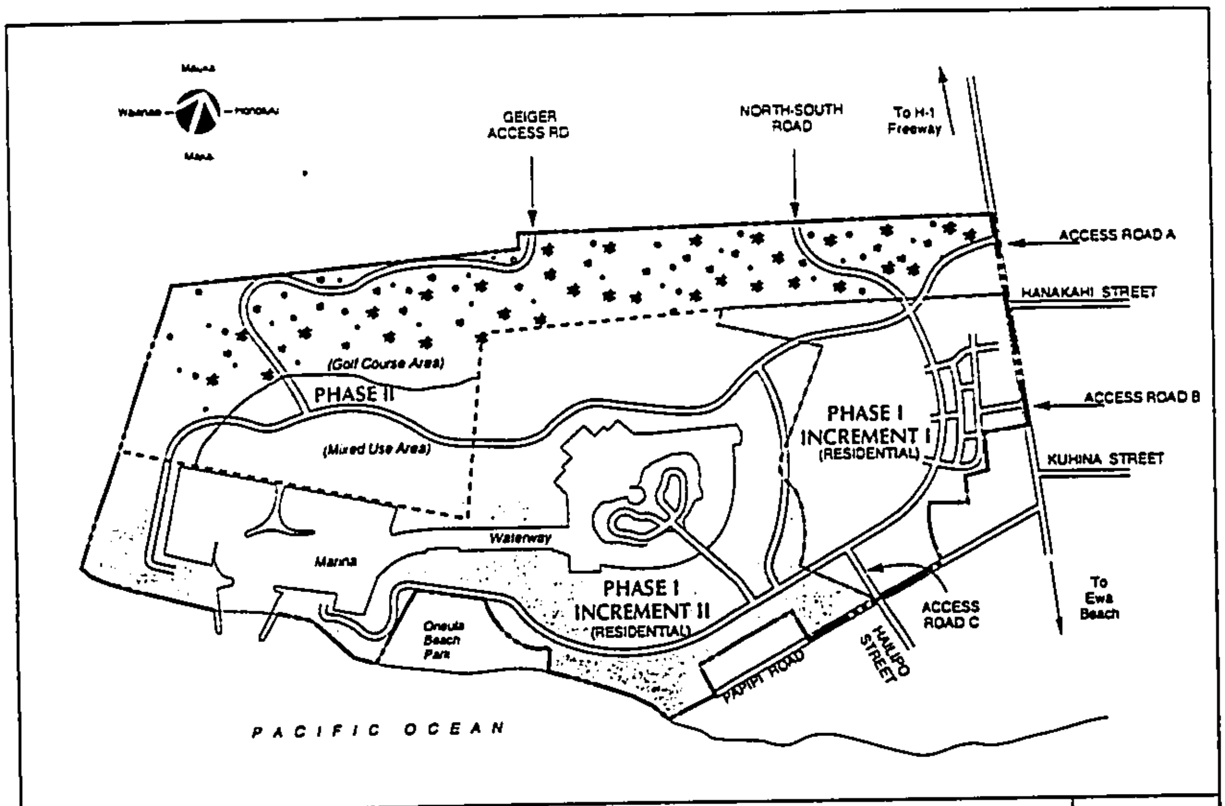
PROJECT DESCRIPTION

HASEKO (Hawaii), Inc. is proposing to develop the Ewa Marina Community as a residential, employment, and commercial center in the Ewa region on the island of Oahu. Figure 1 shows the project location and the roadway network in the vicinity of the project site.

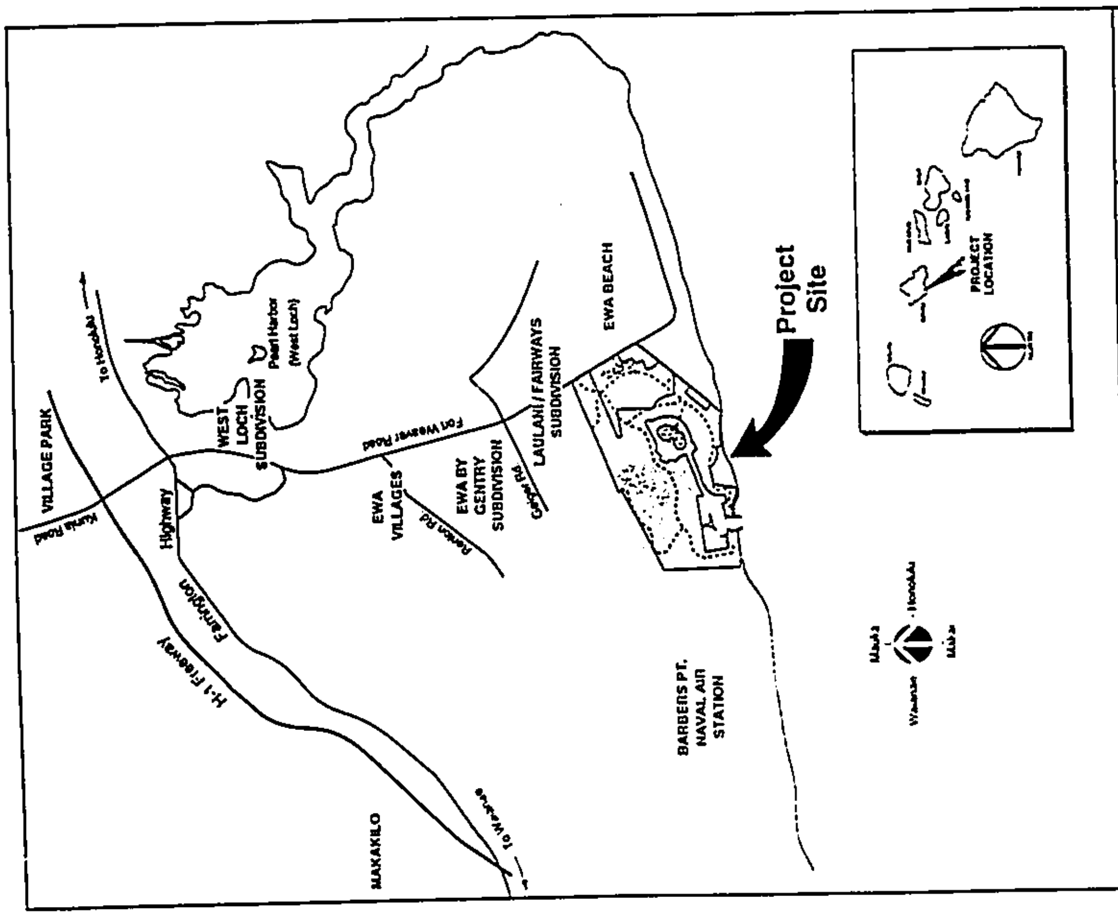
The general site plan and phasing of the Ewa Marina project are given in Figure 2. The most current planned project land uses for Phase I - Increment II and Phase II are shown in Table 2.

Table 2. Land Uses for Ewa Marina Community
Phase I - Increment II and Phase II

Land Use	Quantity
PHASE I - INCREMENT II:	
Single-Family Residential	910 units
Multi-Family Residential	2,650 units
Marina	1,600 slips
PHASE II:	
Visitor Condominium	600 rooms
Marina Hotels	500 rooms
Fitness Promotion Hotel/Center	400 rooms
Retail Shops	40,000 square feet
Restaurant Complex	40,000 square feet
Commercial Offices	70,000 square feet
Tennis Complex	10 courts
Yacht Club	12,000 square feet
Parks	17 acres
27 Hole Golf Course	272 acres



PACIFIC PLANNING | PROJECT SITE PLAN | Figure 2



PACIFIC PLANNING | Project Location Map | Figure 1

The marina will be constructed in Phase I, Increment II. In addition, 910 single family and 2,650 multi-family residential units surrounding the marina will be built.

The Phase II development includes 900 hotel rooms with fitness and conference room facilities, a 600 garden suite hotel, 40,000 square feet of retail shops, 40,000 square feet for restaurants, a yacht club, tennis complex, and a 27-hole golf course. The commercial center will consist of retail shops, professional offices, theme restaurants and marina related establishments including a yacht club located next to the marina.

The Fitness Promotion Center structure will contain 60,000 square feet of floor space and will be a full-featured fitness and conditioning center which will focus on the corporate market. The specific facilities within the center include aerobic and exercise studios, fully equipped weight rooms, racquetball, handball, and other similar courts, swimming pools and a health food restaurant.

The visitor complex will consist of two 250-room marina hotels, 400 Fitness Center rooms and a 600 unit hotel condominium development. The visitor complex will also include an 20,000 square feet exhibition center and related conference facilities and a championship tennis facility comprised of 10 courts and an 18,000 square feet clubhouse.

A major portion of the land area of the project will be used to develop an 27-hole golf course which will cover 272 acres.

EXISTING CONDITIONS

An inventory of existing conditions was conducted to better ascertain the potential traffic impact of the proposed project. The review included the land uses in the area, roadway facilities, and existing traffic conditions.

Land Uses

The project site is presently used for agricultural purposes. Adjacent to the project site at the corner of Fort Weaver Road and Papipi Road is the Ewa Beach Shopping Center. The Ewa Beach community is located southeast of the project site while Barbers Point Naval Air Station is to the west. The Oneula Beach Park, a County park, lies along the south side of the project site.

The majority of the land to the north is currently utilized for sugar cane production. Further north, towards the H-1 Freeway, the residential developments of Ewa Gentry, West Loch Estates and West Loch Fairways are either completed or currently under construction. Directly south of the project site is the Pacific Ocean.

Roadway Facilities

Presently, Fort Weaver Road provides the only link from the H-1 Freeway and the Ewa Beach community. Fort Weaver Road begins at the H-1 Freeway and extends southwards to Ewa Beach. Figure 1 shows the roadway network in the vicinity of the project site.

Fort Weaver Road is the major north-south roadway in the east Ewa region. Fort Weaver Road has been upgraded to a four-lane road from the

Kunia Interchange to Hanakahi Street. The posted speed limit varies from 35 to 45 miles per hour (mph).

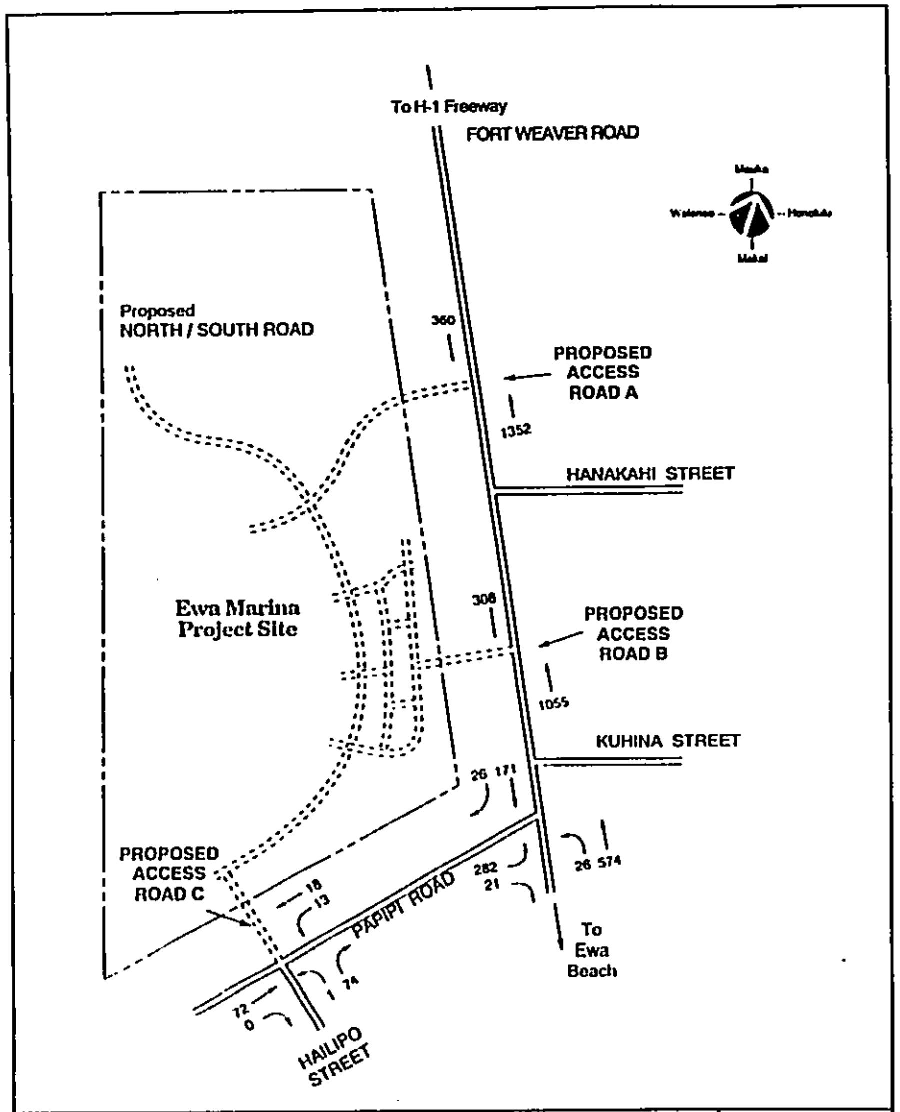
From Hanakahi Street to Ewa Beach, Fort Weaver Road is a two-lane undivided rural collector road which is currently being widened into a four-lane arterial by the State Department of Transportation (DOT). The widening of Fort Weaver Road in expected to be completed by early 1992. The posted speed limit for this portion of the road is 25 mph.

Traffic Conditions

A review of 1989 DOT traffic count data for stations 11-N (Fort Weaver at Kuhina Street), 11-P (Fort Weaver at Hanakahi Street), and 11-R (Fort Weaver at Papipi Road) indicated that the morning peak hour traffic generally occurs between 7:00 and 8:00 a.m. and the afternoon peak hour between 3:00 and 4:45 p.m., respectively.

Manual traffic counts were taken for the intersection of Fort Weaver Road and Papipi Road and at the Papipi Road and Hailipo Street intersection on July 24, 1991 from 3:00 to 5:15 p.m. and July 25, 1991 from 6:00 a.m. to 8:15 a.m. In addition existing Fort Weaver Road traffic volumes in the vicinity of Access Road A and Access Road B were derived from manual traffic counts obtained at the intersection of Fort Weaver Road and Hanakai Street. Manual counts were taken of passenger cars, trucks, buses, motorcycles and pedestrians by turning movements and approaches. The counts were used as a baseline to estimate future traffic volumes. Figures 3 and 4 show the present volumes and movements of traffic at the existing study locations.

When the counts were taken, work was on-going to widen Fort Weaver during the hours of 8:30 a.m. to 3:00 p.m. Left turns out of Hanakai Street were banned, but these motorist could divert and utilize the Kuhina Street intersection to reach Fort Weaver Road. Since the construction work did not require the closing of lanes on Fort Weaver Road and the work hours were generally outside of the peak traffic hours, the effect of the construction work on the traffic volumes were not considered significant. During the field counts, the weather was clear and the pavement was dry.



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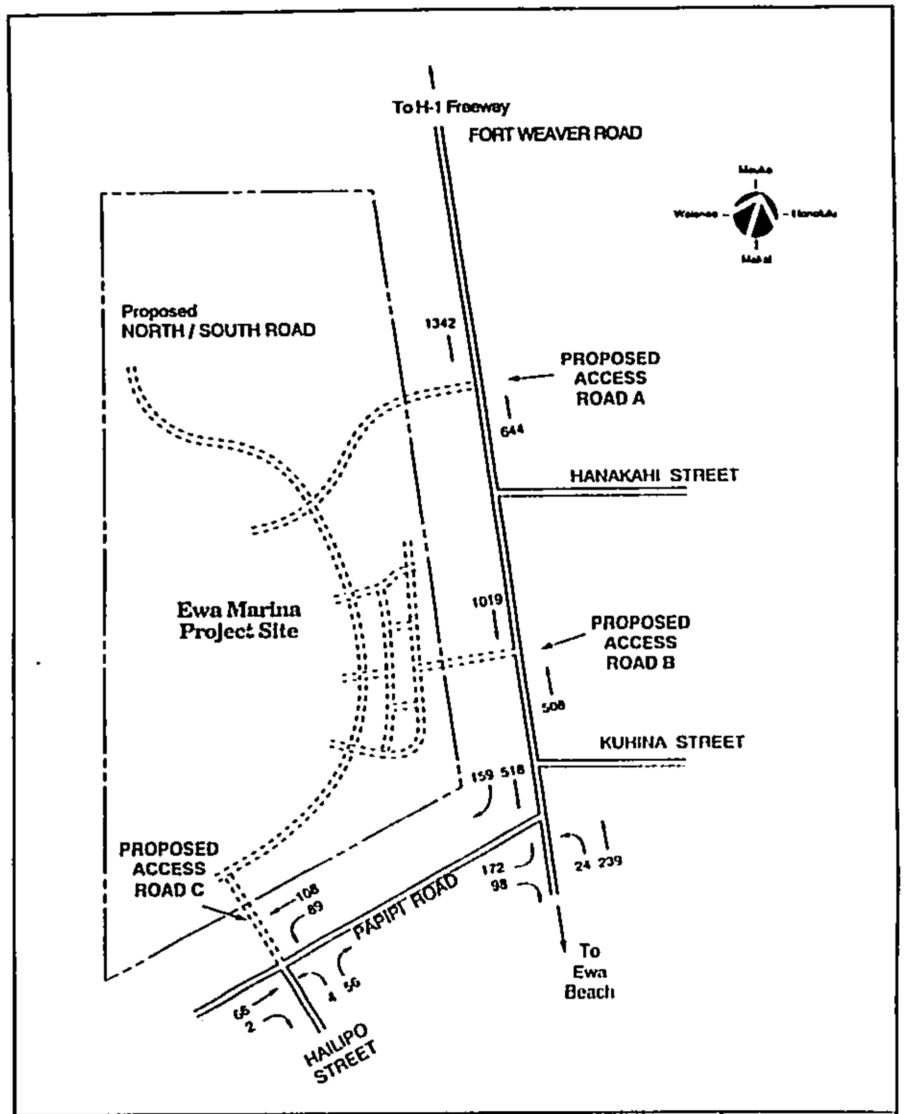
Existing 1991Morning Peak Hour Traffic Volumes

Figure 3



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Existing 1991 Afternoon Peak Hour Traffic Volumes

Figure 4

FUTURE CONDITIONS

A survey of approved planned developments and improvements to transportation facilities was conducted to estimate future traffic conditions at the study intersections.

Land Uses

As described earlier, Fort Weaver Road is the only access from the H-1 Freeway to the Ewa Beach area. Due to this "dead-end" nature of the project location, only developments within the immediate area will impact the study intersections by year 2002. These developments are the planned to occur by year 2009.

- The Ewa Beach Shopping Center would be expanded by 80,000 square feet by year 1992
- The 133-acre Puuloa golf course would be completed by early 1992.
- Phase I, Increment I of the Ewa Marina community will contain 960 single family units 330 multi-family residential units.

Since the full development of Ewa Marina community would be expected to be completed in year 2009, the future traffic forecasts were prepared for study year 2009.

Roadway Facilities

The DOT is in the process of widening Fort Weaver Road in the vicinity of the project to a four-lane divided arterial with turn lanes at the intersections. Between the intersections, the center lane would be designated as two-way left turn lanes. The widening is expected to be completed by early 1992.

Future Intersection Improvements

Improvements to the existing intersection of Fort Weaver Road with Papipi Road are currently under construction and expected to be completed by year 1992. Based upon available information, the DOT plans to provide a northbound left-turn storage lane and a southbound right turn lane on Fort Weaver Road at the Papipi Road intersection. The plans also include widening of the Papipi Road approach at Fort Weaver Road to allow double left turn lanes with optional right turn movements.

Future improvements to the proposed intersections of Fort Weaver Road with Project Access Road A and with Project Access Road B are expected to be completed with the construction of Phase I, Increment I. Based upon a traffic study conducted for Ewa Marina Phase I by Kaku Associates the following improvements were recommended:

1. Provide double left-turn lanes out of the Ewa Marina project site on Access Road A and Access Road B, with separate right-turn lanes on Fort Weaver Road for southbound traffic and left-turn lanes for northbound traffic at these two intersections.

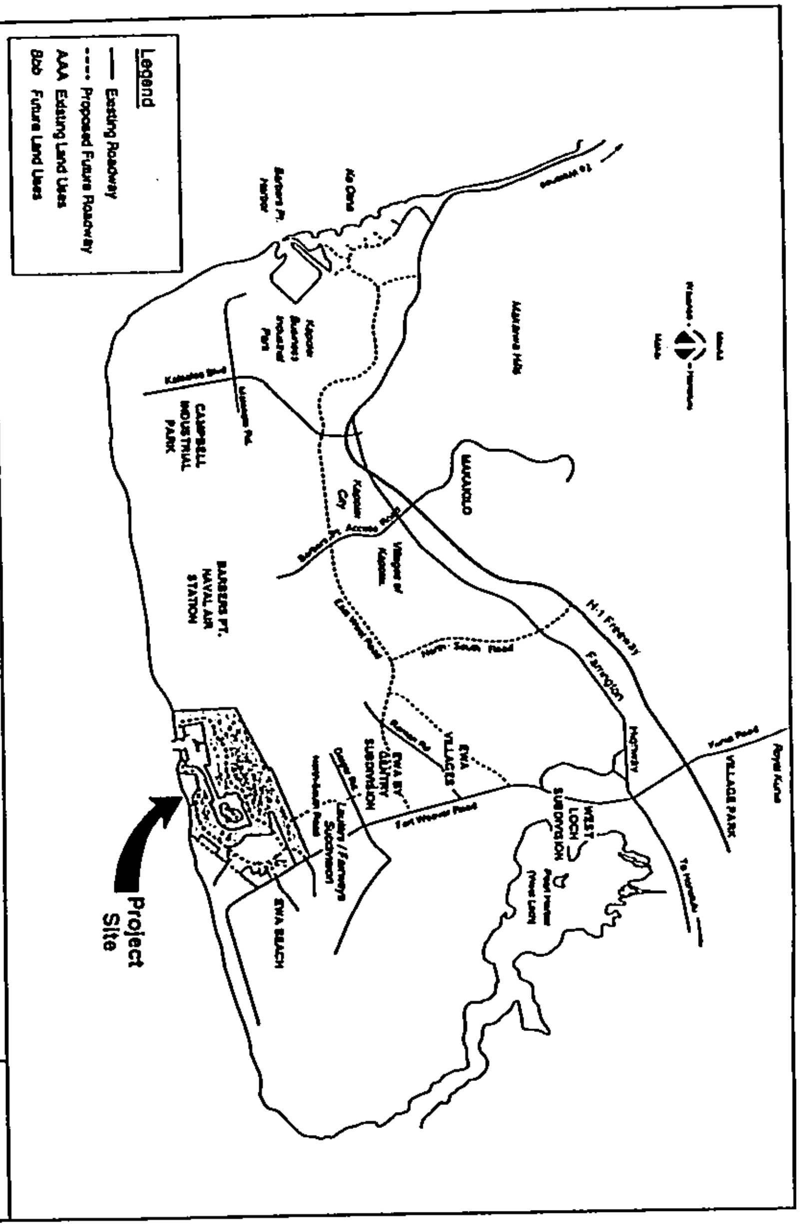
2. Provide traffic signals at the intersections of Access Roads A and B with Fort Weaver Road.

Ewa Region Highway Master Plan

The Ewa Region Highway Master Plan, a regional transportation master plan, is being developed to identify roadway system improvements necessary to accommodate forecasted future traffic and allocate the cost for improvements to the developers in the Ewa region.

Based on current developer plans in the region, highway improvements such as a North-South Road and East-West Road were assumed to be built by the year 2009. Figure 5 shows the proposed roadways that were assumed to be completed by year 2009.

The North-South Road would extend north from Ewa Marina through the Gentry development and connect to Farrington Highway and the H-1 Freeway. North of the Gentry development, the North-South Road will connect to the proposed East-West Road which would take traffic to Kapolei City and Campbell Industrial Park.



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FUTURE ROADWAY NETWORK

Figure 5

PROJECTED TRAFFIC CONDITIONS

Future traffic forecasts without and with the proposed project were estimated for the year 2009. The forecasted traffic was assigned to a proposed 2009 roadway network which includes the proposed North-South Road and East-West Road.

Future Traffic Without Project

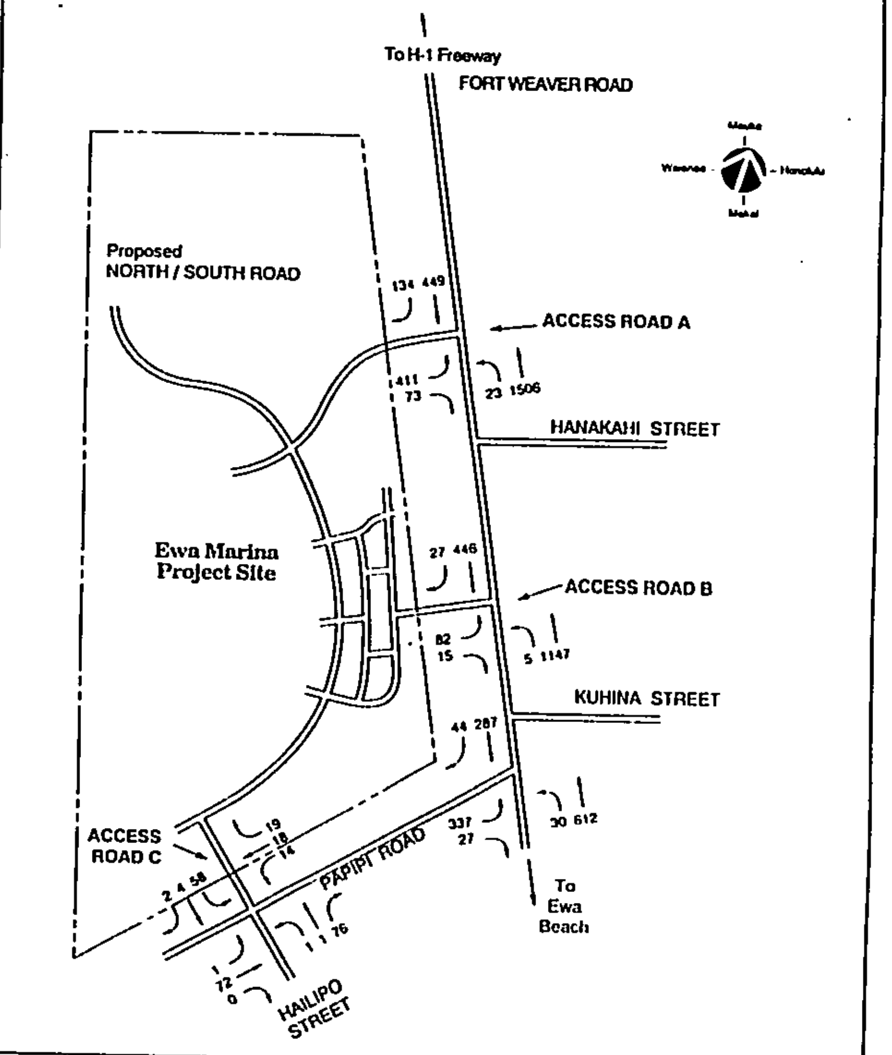
Future traffic without the project was forecasted by adding the following: (1) existing peak hour traffic volumes and (2) traffic generated by nearby projects in the Ewa Beach area. The resultant forecast traffic without the project is shown in Figures 6 and 7 for the morning and afternoon peak hours, respectively.

Traffic Generated from Other Proposed Developments

Since Fort Weaver Road terminates in the Ewa Beach area, only traffic generated by new developments in the immediate area were added onto the roadway. The three step procedure of trip generation, trip distribution, and traffic assignment was used to forecast future peak hour traffic from the other developments in the immediate area.

The trip generation step estimates the number of trips that would be generated during the weekday morning and afternoon peak hours by the project and other developments in the area. The traffic generated by the proposed developments were estimated based on the amount of each development and data from the Trip Generation Report[1]. Table 3 shows the number of trips generated by future developments in the area.

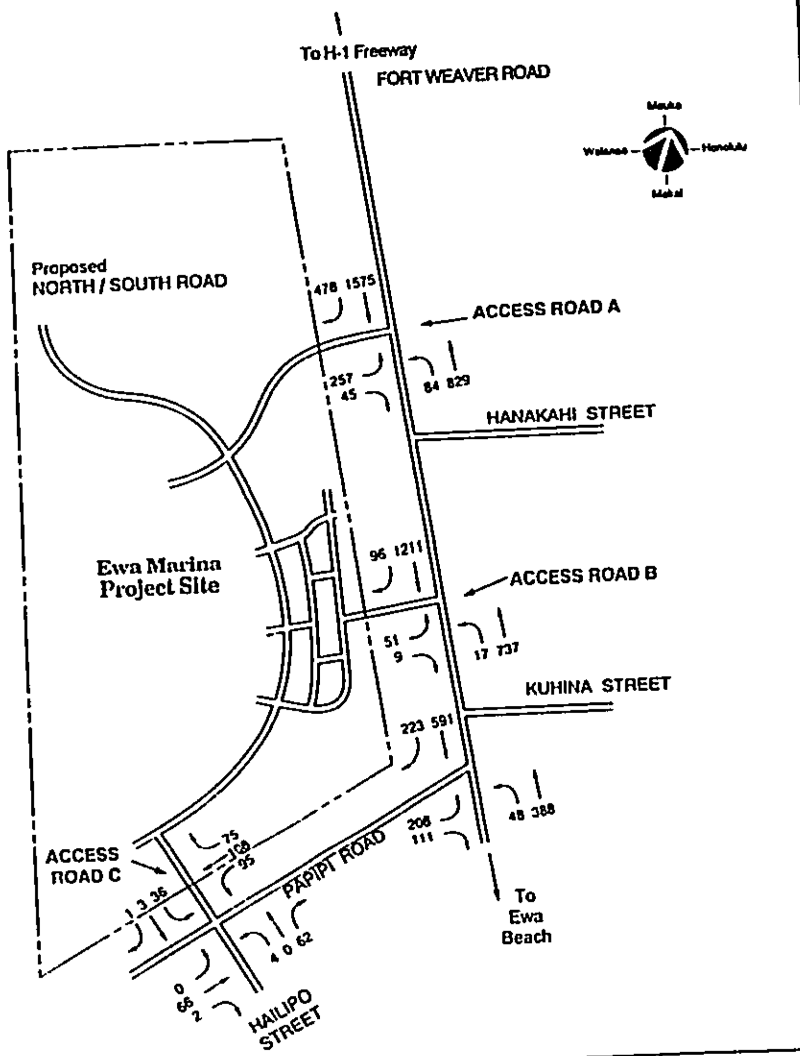
[1] Trip Generation Report, by the Institute of Transportation Engineers, Fifth Edition, 1991 and Fourth Edition, 1987.



PACIFIC PLANNING

Year 2009 Forecast Morning Traffic Without Project

Figure 6



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Year 2009 Forecast Afternoon Traffic Without Project

Figure 7

The trip distribution step assigns trips to their expected origins and destinations. The trips generated by the future developments were distributed based on the distribution of population and employment on Oahu.

The traffic assignment step assign trips to a specific route on the roadway network that will take the driver from origin to destination. Traffic was assigned based on the estimated shortest path of travel time from origins to destinations. Traffic from Phase I - Increment I of the Ewa Marina Community was assigned onto to Fort Weaver Road during the morning peak hour and afternoon peak hour; the connection to the North-South Road would not occur until Phase II of the project. For the Ewa Beach Shopping Center and Puuloa Golf Course, 100% of the traffic from these developments were assigned to Fort Weaver Road. The trip distribution and assignment for these projects are summarized in Table 4.

The three step procedure of trip generation, trip distribution, and traffic assignment was used to estimate peak hour traffic from the proposed project. The number of trips from the Ewa Marina Phase I - Increment II project was based on the project land uses and the Trip and Phase II project was based on the project land uses and the Trip Generation Report. Table 5 shows the number of trips generated by the project land uses.

Table 3. Trip Generation for Future Developments

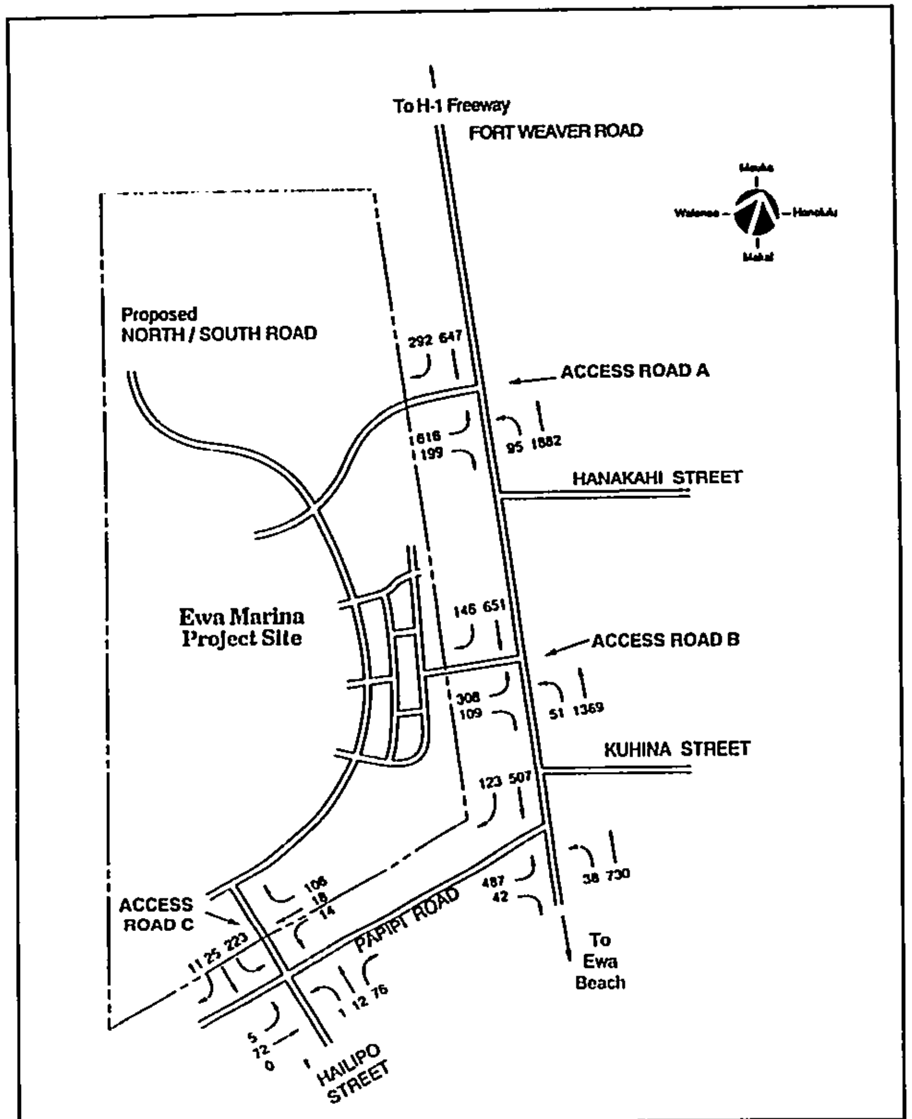
Land Use	Quantity	unit	Morning Peak Hour Enter	Morning Peak Hour Exit	Afternoon Peak Hour Enter	Afternoon Peak Hour Exit
Ewa Beach Shopping Center						
Shopping Center	80	1000 sf	46	26	159	159
Puuloa Golf Course						
Golf Course	133	acres	29	7	10	42
Ewa Marina Community						
Phase I, Increment I						
Single-Family	960	DU	185	525	630	340
Multi-Family	330	DU	25	120	120	62

Table 4. Trip Distribution and Assignment for Future Developments

Peak Hour	DISTRIBUTION North	DISTRIBUTION South	ASSIGNMENT Fort Weaver Road	ASSIGNMENT N/S Road
Ewa Beach Shopping Center				
Morning	50%	50%	100%	0%
Afternoon	50%	50%	100%	0%
Puuloa Golf Course				
Morning	85%	15%	100%	0%
Afternoon	85%	15%	100%	0%
Ewa Marina Community				
Phase I - Increment I				
Morning	85%	15%	100%	0%
Afternoon	85%	15%	100%	0%

Future Traffic With Project

Future traffic with the project was forecasted by adding the without project traffic to the traffic generated by the proposed project. The resultant forecast traffic with the proposed project is shown in Figures 8 and 9 for the morning and afternoon peak hours, respectively.



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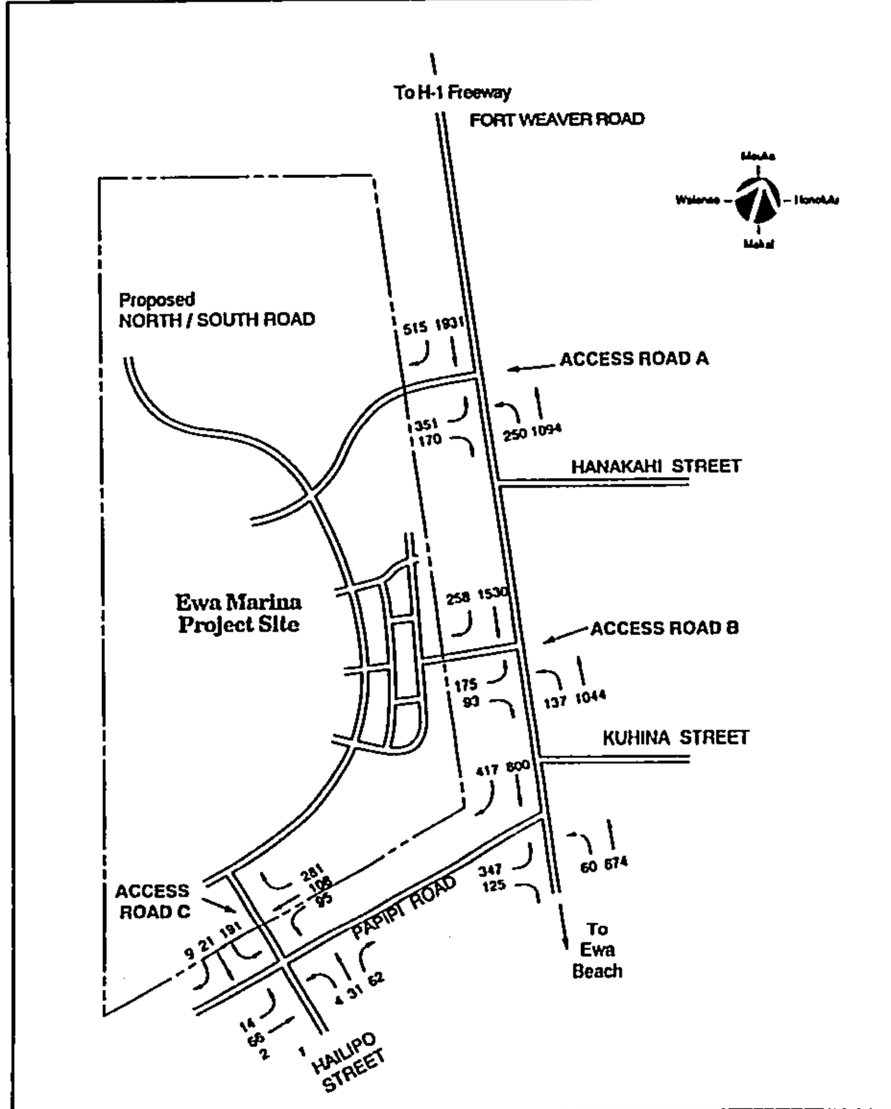
Year 2009 Forecast Morning Traffic With Project

Figure 8



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Year 2009 Forecast Afternoon Traffic With Project

Figure 9

Table 5. Trip Generation for Ewa Marina Community
Phase I - Increment II and Phase II

Land Use	Quantity	unit	Morning Peak Hour Enter	Morning Peak Hour Exit	Afternoon Peak Hour Enter	Afternoon Peak Hour Exit
Ewa Marina Community						
Phase I - Increment II						
Single-Family	910	DU	175	498	597	322
Residential Condominium	2,650	DU	198	968	962	496
Marina	1,600	slips	42	86	182	122
Phase II						
Marina Hotels and Conference Facilities	500	rooms	125	80	105	175
Fitness Hotel/Center	400	rooms	100	64	84	140
Hotel (Condominium)	600	rooms	150	96	126	210
Commercial Offices	70	1,000 sf	129	16	24	119
Retail Shops	40	1,000 sf	24	14	84	89
Restaurants	40	1,000 sf	174	158	282	196
Yacht Club	12	1,000 sf	10	1	64	28
Tennis Complex	10	courts	7	7	19	20
Golf Course	272	acres	58	15	21	85
Park	17	acres	8	33	107	36
Total			1,200	2,036	2,657	2,038

Abbreviations: DU - dwelling unit, sf - square feet.

The trip distribution step assigns trips to their expected origins and destinations. Trips to and from the proposed project are based on the distribution of population and employment on Oahu. The mixed project land uses would provide the project residents with employment opportunities within the site; similarly, the on-site recreational and shopping amenities would encourage the resort guests and residents to remain within the project for these activities. The study estimated that in the morning and afternoon peak hours 76% of the project generated traffic would be travelling north and 13% to the south, while 11% would remain internal within the project.

Traffic was assigned based on the estimated shortest path of travel time from origins to destinations. Traffic from the Ewa Marina development was assigned onto Fort Weaver Road or the North-South Road. In the morning peak hour 62% percent was assigned Fort Weaver Road with 38% utilizing the North-South Road. During the afternoon peak hour about 49% was assigned to Fort Weaver Road and 51% to the North-South Road. The project trip distribution for the external trips are summarized in Table 6.

Table 6. Trip Distribution and Assignment for Ewa Marina

Peak Hour	DISTRIBUTION North	DISTRIBUTION South	DISTRIBUTION Internal	ASSIGNMENT Ft. Weaver Road	ASSIGNMENT N/S Road
Ewa Marina Community					
Morning	76%	13%	11%	62%	38%
Afternoon	76%	13%	11%	49%	51%

TRAFFIC IMPACTS ANALYSIS

Analyses were conducted for the following study intersections:

- Fort Weaver Road with Access Road A.
- Fort Weaver Road with Access Road B.
- Fort Weaver Road with Papipi Road.
- Papipi Road with Hailipo Road and Access Road C.

The study intersections were analyzed for existing conditions and the year 2009 forecast traffic without and with the project. The analysis for forecast traffic conditions were based upon planned improvements to the roadway network.

Analysis Methods

The study intersections were analyzed for morning and afternoon weekday peak hours using the planning analysis for signalized intersections and the unsignalized methodology described in the Highway Capacity Manual (Special Report 209, 1985). Impacts resulting from the project were measured by the change in capacity conditions or level-of-service (LOS) at the study intersections.

Existing and forecasted conditions at the intersection of Fort Weaver Road with Hanakahi Street were analyzed with the planning analysis for signalized intersections. The future conditions at proposed intersections of Fort Weaver Road with Access Road A and Fort Weaver Road with Access Road B were also assessed by the planning analysis since these intersections would be signalized when constructed.

The planning analysis for signalized intersections considers the movements that conflict at an intersection, such as a left turn and the opposing through movement. The sum of the conflicting movements at the study intersection are characterized as under, near or over capacity according to traffic volumes:

- Under capacity: less than or equal to 1,200 vehicles per hour.
- Near capacity: between 1,201 and 1,400 vehicles per hour.
- Over capacity: greater than 1,400 vehicles per hour.

The planning analysis is especially appropriate when detailed information about an intersection, such as the phasing and timing of a traffic signal, are unknown. The planning provides a broad assessment of the geometric conditions of an intersection and serves as a guide to determine the number of lanes on each approach that would be needed to accommodate the forecasted demand volumes.

The existing T-intersection of Papipi Road and Hailipo Street was analyzed with the unsignalized methodology. For the future conditions without or with the project, this intersection would be converted into a cross-intersection with the connection of Access Road C. Papipi Road would remain as the major roadway with stop controls for the traffic on Hailipo Street and Access Road C.

The unsignalized methodology considers the estimated number of vehicle turning movements which could proceed through gaps in a conflicting traffic stream. The LOS is determined by the amount of vehicle reserve capacity available for a particular turning movement. A lower amount of reserve capacity indicates a poorer LOS.

Level-of-Service is divided into six categories ranging from LOS A to LOS F. A detailed description of each LOS category for unsignalized intersections is provided in Appendix A. Capacity conditions for signalized intersections and LOS for unsignalized intersections are not directly comparable since one is based on reserve capacity and the other on the sum of conflicting volumes .

Analysis Results

The results of the analysis for existing conditions at the signalized intersection of Fort Weaver Road with Papipi Road and at the unsignalized intersection of Papipi Road with Hailipo Road are shown on Table 7.

Table 7. Intersection Analysis Results
Existing 1991 Conditions

		Morning Peak Hour	Afternoon Peak Hour
Signalized Intersection			
Fort Weaver Road and Papipi Road			
Capacity condition		Under	Under
Critical volumes		906	988
Unsignalized Intersection			
Papipi Road with Hailipo Road			
Papipi Road	Westbound left turn	A	A
Hailipo Road	Shared left and right turn lane	A	A

The results of the planning analysis for year 2009 forecast conditions at the study intersections are shown on Table 8. The configuration for the intersection of Fort Weaver Road with Papipi Road is based upon intersection design plans by the DOT. The laneage for the intersections of Fort Weaver Road with Access Roads A and B were based upon recommended improvements in the Ewa Marina Phase I traffic study by Kaku Associates.

Table 8. Peak Hour Planning Analysis for Signalized Intersections
Year 2009 Forecast Conditions

	Year 2009 without Project		Year 2009 with Project	
	AM	PM	AM	PM
Signalized Intersection				
Fort Weaver Road and Access Road A				
Capacity condition	Under	Under	Near	Near
Critical volumes	959	1,001	1,249	1,392
Fort Weaver Road and Access Road B				
Capacity condition	Under	Under	Under	Under
Critical volumes	615	649	839	990
Fort Weaver Road and Papipi Road				
Capacity condition	Under	Under	Under	Under
Critical volumes	488	503	630	696

Table 9. Peak Hour Analysis for Unsignalized Intersections
Year 2009 Forecast Conditions

	Year 2009 without Project		Year 2009 with Project	
	AM	PM	AM	PM
Unsignalized Intersection				
Papipi Road with Hailipo Road and Access Road C				
Papipi Road				
Eastbound left turn	A	A	B	D
Westbound left turn	A	A	A	A
Hailipo Road				
Shared left/right turn lane	A	A	A	A
Access Road C				
Shared left/right turn lane	A	A	A	A

Signalized Intersections

Intersection of Fort Weaver Road with Access Road A

- *For future conditions without the project,* the intersection would be under capacity for the morning peak hour and afternoon peak hour.
- *For future conditions with the project,* the intersection would be near capacity during the morning and afternoon peak hours.

Intersection of Fort Weaver Road with Access Road B

- *For future conditions without the project,* the intersection would be under capacity for the morning and afternoon peak hours.

- *For future conditions with the project,* the intersection would remain under capacity in the morning and afternoon peak hours.

Intersection of Fort Weaver Road with Papipi Road

- *For existing conditions,* the intersection would be under capacity for the morning and afternoon peak hours.
- *For future conditions without the project,* the intersection continue to be under capacity during the morning and afternoon peak hours.
- *For future conditions with the project,* the intersection would remain under capacity in the morning and afternoon peak hours.

Unsignalized Intersections

Intersection of Papipi Road with Hailipo Street and Access Road C

- *For existing conditions,* the Papipi Road westbound left turn and the Hailipo Street movements operates with little or no delay at LOS A during the morning and afternoon peak hours.
- *For future conditions without the project,* the Papipi Road east and westbound left turns and the Hailipo Street movements would experience LOS A during the morning and afternoon peak hours. Access Road C shared lane would also operate LOS A during both peak hours.
- *For future conditions with the project,* the Papipi Road east and westbound left turns and the Hailipo Street movements would remain at LOS A during the morning and afternoon peak hours. For Access Road C, the shared lane would experience longer delays with LOS B in the morning peak hour and LOS D in the afternoon peak hour, but the intersection would have sufficient capacity to serve the forecasted traffic volumes.

CONCLUSIONS AND RECOMMENDATIONS

The results of this study confirm the previous 1986 study by Ewa Marina Phase I, Increment I, by Kaku Associates (1986) which indicates that despite the widening of Fort Weaver Road to a four-lane divided highway, a second north-south road parallel to Fort Weaver Road would be required to link Ewa Marina/Ewa Beach area and the H-1 Freeway.

With the currently proposed land uses, no other mitigating actions would be necessary for Fort Weaver Road intersections at the project Access Road A and Access Road B if the following recommendations from 1986 Kaku report are implemented:

- Provide double left-turn lanes on Access Road A and Access Road B, with separate right-turn lanes on Fort Weaver Road for southbound traffic and left-turn lanes for northbound traffic at these two intersections. Fort Weaver Road would need four travel lanes, two in each direction.

- Provide traffic signals at these locations: 1) the intersection of Access Road A with Fort Weaver Road and 2) the intersection of Access Road B with Fort Weaver Road.

For intersection of Papipi Road, Hailipo Street and Access Road C, an unsignalized intersection would be sufficient to serve the forecasted traffic volumes. For the Access C approach, a single lane to serve left, through and right turn movements would be adequate.

Traffic from other proposed projects north of Ewa Marina, such as West Loch Estates and West Loch Fairways, Ewa Villages, Ewa Gentry, and Laulani/Fairways, would also contribute to the need to provide a second north-south roadway and new interchange with the H-1 Freeway. Because of major developments planned for the Ewa region, the State Director of Transportation imposed a requirement on these projects to participate in the development for an Ewa Region Highway Master Plan to determine future arterial roadways for the area.

The State Department of Transportation has formed a Working Group, which includes the City Department of Transportation Services, the major developers of the Ewa Region (including HASEKO (Hawaii), Inc.), Campbell Estate and other State and City Planning agencies. The purpose of this Working Group is to identify future roadway needs and participate in the fair share costs to implement the required improvements for the Ewa Region.

The joint efforts of the Working Group has resulted in the identification of the North-South Road as one of the major roadways in the Ewa Region. The results of the ongoing Ewa Region Highway Master Plan study will provide the traffic data needed to determine the roadway improvements required for the North-South Road; the roadway improvements within the Ewa Marina project site, especially for the North-South Road, should be adopted and incorporated into the project plans for the Ewa Marina Community.

APPENDIX A

LEVEL-OF-SERVICE DEFINITIONS FOR UNSIGNALIZED INTERSECTIONS

DEFINITION OF LEVEL-OF-SERVICE FOR UNSIGNALIZED INTERSECTIONS

For unsignalized intersections, the traffic most impacted will be the minor or cross-street with the stop or yield control. The major roadway will have the right-of-way. The level-of-service is the amount of delay expected for the average vehicle desiring to cross or enter the major road. The following gives a general description of the measure.

The concept of levels of service is defined as a qualitative measure describing operational conditions within a traffic stream, and their perception by motorists and/or passengers. A level of service definition generally describes these conditions in terms of such factors as speed and travel time, freedom to maneuver, traffic interruptions, comfort and convenience, and safety.

Six levels of service are defined for each type of facility for which analysis procedures are available. They are given letter designations, from A to F, with level-of-service A representing the best operating conditions and level-of-service F the worst.

Level-of-Service definitions--In general, the various levels of service are defined as follows for uninterrupted flow facilities:

Level-of-service A represents free flow. Individual users are virtually unaffected by the presence of others in the traffic stream. Freedom to select desired speeds and to maneuver within the traffic stream is extremely high. The general level of comfort and convenience provided to the motorist, passenger, or pedestrian is excellent.

Level-of-service B is in the range of stable flow, but the presence of other users in the traffic stream begins to be noticeable. Freedom to select desired speeds is relatively unaffected, but there is slight decline in the freedom to maneuver within the traffic stream from LOS A. The level of comfort and convenience provided is somewhat less than at LOS A, because the presence of others in the traffic stream begins to affect individual behavior.

Level-of-service C is in the range of stable flow, but marks the beginning of the range of flow in which the operation of individual users becomes significantly affected by interactions with others in the traffic stream. The selection of speed is now affected by the presence of others, and maneuvering within the traffic stream requires substantial vigilance on the part of the user. The general level of comfort and convenience declines noticeably at this level.

Level-of-service D represents high-density, but stable, flow. Speed and freedom to maneuver are severely restricted, and the driver or pedestrian experiences a generally poor level of comfort and convenience. Small increases in traffic flow will generally cause operational problems at this level.

Level-of-service E represents operating conditions at or near the capacity level. All speeds are reduced to a low, but relatively uniform value. Freedom to maneuver within the traffic stream is extremely difficult, and it is generally accomplished by forcing a vehicle or pedestrian to "give way" to accommodate such maneuver. Comfort and convenience levels are extremely poor, and driver or pedestrian frustration is generally high. Operations at this level are usually unstable, because small increases in flow or minor perturbations within the traffic stream will cause breakdowns.

Level-of-service F is used to define forced or breakdown flow. This condition exists wherever the amount of traffic approaching a point exceeds the amount which can traverse the point. Queues form behind such locations. Operations within the queue are characterized by stop-and-go wave, and they are extremely unstable. Vehicles may progress at reasonable speeds for several hundred feet or more, then be required to stop in a cyclic fashion. Level-of-service F is used to describe the operating conditions within the queue, as well as the point of the breakdown. It should be noted, however, that in many cases operating conditions of the vehicles or pedestrians discharged from the queue may be quite good. Nevertheless, it is the point at which arrival flow exceeds discharge flow which causes the queue to form, and level-of-service F is an appropriate designation for such points.

These definitions are general and conceptual in nature, and they apply primarily to uninterrupted flow. Levels of service for interrupted flow facilities vary widely in terms of both the user's perception of service quality and the operational variables used to describe them.

REFERENCE: Highway Capacity Manual (Special Report 209, 1985)

Appendix P

Ewa Marina
Social Impact Assessment

Ewa Marina

Social Impact Assessment

Summary of Social Impact Assessment

1. Introduction And Background

Earthplan has prepared previous social impact studies on specific parts of the Ewa Marina project, namely the "Social Impact Factors" for Increment 2 of Phase 1 (1985); and social impact assessments (1989 and 1991[update]) for Phase 2. In addition Earthplan prepared a 1990 report on community issues and concerns.

The purpose of this report is to compile and update these previous studies. Specifically, this report (1) updates the information base for the study by including new demographic information and updating changes to the 'Ewa region independent of Ewa Marina; (2) revises preliminary community issues by incorporating interviews conducted specifically for this report; and (3) re-examining the impact analysis given changes in the information base and revised community issues.

This report was prepared by Earthplan. Independent contractors Michael P. Mays and John Clark assist in interviewing and the analysis of ocean recreation impacts, respectively.

2. Profile Of The Existing Community

The study area for this report is the 'Ewa Development Plan area. Three sources of information were used to describe 'Ewa. First, 1985 estimates of in-area employment, population and housing were compiled by the Planning Information Branch of the City Department of General Planning. Second, the 1980 Census was used for selected population statistics such as ethnicity, education and family information; 1990 Census statistics at this level of detail has not been released at the time of this writing. Third, the preliminary findings of the 1990 Census include (1) estimates of number of residents and housing number, types, vacancy and sizes by census tract and (2) slightly more detailed information by Census Designated Places, or CDPs.

The 'Ewa region's primary employment generator in 1985 was military activity, as shown in *Figure 1*. Military jobs were the largest category, with about 39 percent of the total 11,121 region jobs held in 'Ewa. Service jobs were the next largest category; 16 percent of the total jobs were service-related. *Figure 2* shows that about half of the jobs in the 'Ewa region were located at the NASBP, which is adjacent to Ewa Marina.

The 'Ewa region experienced population growth double the O'ahu rates over the past twenty years. 'Ewa's population has grown from 24,087 persons in 1970, to 38,324 in 1980 to 42,983 in 1990, as illustrated in *Figure 3*. This means that the area grew 4.2 percent a year in the 1970s, and 1.7 a year in the 1980s. These rates are about double the islandwide rates. From 1970 to 1980, O'ahu's population grew at an average rate of 1.9 percent, and the islandwide rate dropped to slightly less than one percent from 1980 to 1990. *Table 2* contains the average annual growth rates for 'Ewa and O'ahu.

In 1990, 'Ewa had 11,734 housing units, as shown on *Table 3*. Unlike the islandwide steady increase of multi-family units, 'Ewa's housing supply continues to be dominated by single-family units which accounted for 82 percent of the total housing stock.

Tables 4,5 and 6 contain demographic, household and housing information for certain communities in 'Ewa. The highest proportion of single-family units is found in 'Ewa Villages where 95 percent are in that category. 'Ewa Beach, the community adjacent to the eastern portion of the project, also contains a high proportion, with 85 percent of its housing stock being single-family units.

Though the 1990 median values of owner-occupied homes were lower in 'Ewa when compared to islandwide statistics, median rent exceeded the O'ahu median. Median values ranged from a low of $116,500 in 'Ewa Villages to a high of $277,600 in 'Ewa Gentry; these communities are adjacent to each other. The O'ahu median home value was $283,600.

The highest rents were found in the relatively newer communities of Makakilo and 'Ewa Gentry, where respective monthly rents of $960 and $901 exceeded the islandwide median by about $300.

In spite of these high rents, however, 'Ewa region homes were sought after, as indicated by very low vacancy rates. Whereas O'ahu has a total vacancy rate of 5.8 percent, 'Ewa Beach and Makakilo had rates at less half the islandwide figure, with 2.1 and 2.4 percent, respectively. The military communities had especially low vacancies with 1.4 percent for NASBP and 0.5 percent for IPP Military Family Housing.

Demographic and household characteristics are summarized as follows:

1. **Ethnicity and Age.**

   The older communities in 'Ewa retains a few distinctions from the O'ahu averages when it comes to ethnicity. 'Ewa Villages and 'Ewa Beach are well-represented in Asians and Pacific Islanders with 89 and 73 percent, respectively, are in this category. NASBP and IPP Military Family Housing have significantly high proportions of Caucasians (76 and 80 percent, respectively). 'Ewa Gentry, the area's newest community, has ethnic proportions similar to O'ahu.

   'Ewa region communities tend to be slightly younger than the O'ahu-wide community. The military communities are the youngest. NASBP has a median age of 24.7 years; IPP, 25.6 years. With a median age of 32.4 years, 'Ewa Village is the only community which exceeds the islandwide median age (32.2 years).

2. **Family Households.**

   In 1990, 74 percent of O'ahu's total households were family households. Most of 'Ewa's communities exceeded this proportion. The highest proportion of family households was found in IPP Military Family Housing (98.1 percent), followed by 'Ewa Villages (88.8 percent) and 'Ewa Beach (88.6 percent). 'Ewa Gentry was the only community with a proportion lower than that of the island, with only 71 percent of its households being family households.

3. **Household Size.**

   'Ewa has traditionally had larger-than-average households, and the 1990 Census reveals a continuation of this trend in the region's older communities. The largest households were found in 'Ewa Beach (4.26 persons) and 'Ewa Villages (4.19 persons). The households in both communities contained 1+ more person than the average islandwide household of 3.02 persons. The only community with households smaller than the islandwide average was 'Ewa Gentry, with an average household size of 2.81 persons.

3. No-project Scenario

The 'Ewa Development Plan area is targeted for major growth and numerous projects are paving the way to achieve the objectives for a secondary urban center. Without Ewa Marina, the following scenario is likely to occur:

1. **Significant increase in residential population.**

   The target population for 'Ewa is between 119,940 to 132,934 persons in 2010. As *Table 8* indicates, this population projection implies an increase of between 77,000 and 90,000 people over the next twenty years, or between 79 and 109 percent. On the average, the annual growth rate would be between three and 3.8 percent.

2. **Significant increase and diversity in employment.**

   Market study projections estimate that job opportunities within the planning region are projected to increase about 600 percent over a twenty year period (Leventhal, 1986). Whereas the major job-generators in 'Ewa are military and service in nature, the future employment sources will likely resemble a cross-section of the islandwide proportions.

3. **Establishment of city-related mixed uses and secondary urban center in "western" 'Ewa.**

   Kapolei City, Ko Olina and the James Campbell Industrial Park, all situated in the western half of the 'Ewa region, are major employment generators -- which essentially create the city-like environment in the "secondary urban center," as defined by the City and County of Honolulu General Plan. The nearby residential communities include the Kapolei Villages, Makakilo, Honokai Hale/Nanakai Gardens and Maka'iwa Hills.

4. **Intensification of residential uses in eastern 'Ewa.**

   The City and County of Honolulu General Plan designates the eastern half of 'Ewa, generally the area along Fort Weaver Road, as 'Ewa's urban-fringe and this area is intended primarily for residences. If this policy is maintained, all other uses in eastern 'Ewa will be primarily to serve the nearby residents.

5. **Retention of military uses.**

   The NASBP and the IPP Military Family Housing will likely continue their operations.

6. **Land banking in eastern 'Ewa.**

   The State is reserving over 2,000 acres in eastern 'Ewa for future uses.

4. Potential Social Impacts Of Ewa Marina

4.1 Population Impacts

4.1.1 Resident Population

Based on a household size of 2.8 persons per household, the project would directly add an estimated population of 13,580 persons at full build-out in 2010. The General Plan population projection for 'Ewa in 2010 range from 119,940 to 132,934. This means that the future Ewa Marina residents would account for eleven to twelve percent of the 'Ewa region population in 2010.

4.1.2 Visitor Population

Decisions Analysts estimated that, at 80 percent occupancy, the hotel units would generate a visitor population of 1,300 persons. The hotel garden suites would generate 900 visitors based on 75 percent occupancy. In total, the daily average visitor census would be 2,200 visitors.

The average statewide visitor census is estimated at 264,000 for 2010. O'ahu's share is projected at 113,000 daily visitors. Ewa Marina's visitors would account for 0.8 percent of the statewide daily census, and 1.9 percent of the O'ahu total.

4.2 Employment

4.2.1 Employment

Construction of Ewa Marina will annually generate 900 construction jobs over a period of 15 years. Marina construction would be the initial activity, and this may occur between late 1992 and 1994.

In terms of long-term operational employment, Ewa Marina's Mixed Use Commercial Complex in Phase 2 will be a major source of jobs. Decisions Analysis estimated that approximately 2,230 jobs will be generated by Phase 2. On-site visitor accommodations will be the largest employment generator, with 1,500 jobs. The other jobs will be generated

by the commercial complex (510 jobs), the International Fitness Promotion Center (60 jobs), the yacht club (40 jobs), the golf course and clubhouse (70 jobs) and the tennis complex (50 jobs).

The marina and housing components of Phase 1 will generate far fewer jobs, but will nevertheless create jobs in harbor support, park maintenance, landscaping, security and maintenance. Hence, the total project would generate over 2,300 long-term and permanent jobs.

4.2.2 Implications Of Visitor Industry Employment

This study analyzed visitor industry employment issues found in four visitor destinations, including (1) Mauna Kea Resort and its providing first-time employment opportunities for many women; (2) Mauna Lani and its initial use of in-migrants for management positions; (3) Kuilima and ethnicity-based competition for jobs; and (4) the rapid exposure to in-migrants in the workplace in Lana'i.

The common thread of difference between the proposed project and these other resort developments is that 'Ewa is programmed to be a secondary urban center, with major employment centers to alleviate pressures on primary urban center. Hence, cultural and population diversification, in-migration of non-'Ewa residents and the loss of rural qualities will occur without Ewa Marina. The proposed project therefore will not be the major source of change, nor will it dictate the pace of change for the region.

4.3 Change In Land Use Pattern In 'Ewa

The eastern half of the 'Ewa region, generally the area along both sides of Fort Weaver Road, is intended primarily for residences. West Loch and 'Ewa Gentry are already contributing to the residential character, and the recently-proposed Laulani/Fairways project will further add to the suburban character.

Although Phase 1 of Ewa Marina is in keeping with this residential ambiance, the Mixed Use Commercial Complex of Phase 2 would essentially change this land use pattern by creating an urban center in the midst of predominantly residential uses. Although Phase 2 would be at a much smaller scale than the City of Kapolei, the proposed project would essentially serve as an urban center for the eastern half of the 'Ewa region. The effects of this change in land use pattern are as follows:

1. *The project would be the major employment generator of the eastern half of the 'Ewa region* -- Phase 2 would create approximately 2,030 full-time-equivalent (FTE) jobs in this area. No other projects in the eastern half of 'Ewa are expected to achieve this magnitude of employment.

2. *Existing 'Ewa Beach and 'Ewa Village residents will have a major job site in proximity to their residences* -- The proposed project will provide jobs near the existing communities, thus adding convenience and decreased commuting time for existing residents who choose to work at Ewa Marina Phase 2.

3. *The Mixed-Use Commercial Complex of Ewa Marina Phase 2 will provide additional shopping and service convenience to existing residents* -- The proposed project will increase the area's commercial amenities and therefore decrease dependency on facilities in the western half of 'Ewa.

4. *By creating another urban center, the project will help nearby residents in justifying increased public services and facilities* -- Currently, the public facilities being planned for the eastern portion of 'Ewa will be designed to serve residential uses, which imply a smaller scale than the urban-oriented facilities in the City of Kapolei. Ewa Marina will likely result in a greater need for public services and facilities. Such increased requirements could potentially strain the public service system and compete with residential needs. On the other hand, the proposed project will also help nearby residents in justifying higher levels of public services and facilities. The rest of the 'Ewa community will, in turn, have direct access to these upgraded public services and facilities.

5. *The proposed project will be consistent with recently-approved policies of the City and County of Honolulu General Plan* -- The Ewa Marina project site is in the Urban-fringe area, but separate General Plan policies guide the development of the project site. In December 1991, the Honolulu City Council passed a General Plan resolution "to encourage the development of a major marina and associated maritime commercial center including visitor units as part of the Ewa Marina community."

6. *Ewa Marina will result in two visitor destinations in the 'Ewa region* -- The proposed project will result in two visitor destinations at opposite ends of the 'Ewa region. Although both will be operate separately and cater to different market segments, a potential effect of these non-contiguous and distant visitor destinations is the independent creation of visitor-related facilities linking the two destinations. Major planning effort has been made to achieve orderly and manageable development in the 'Ewa region. To avoid this type of arbitrary hotel development, public officials will need to establish and uphold planning policies prohibiting such development. Note that, with the presence of Ko Olina, the possibility of independent hotel development still exists and, thus, this situation could occur with or without Ewa Marina.

4.4 Regional Impacts Of Specific Project Components

4.4.1 Probable Non-project Changes

By 2010, the 'Ewa region could accommodate a population two to three times that of the current 'Ewa population. As Ewa Marina is being built, the existing community will already be undergoing a gradual adaptation to this major influx of new people. Some of the changes which may have occurred prior to project implementation are as follows:

1. *Population and cultural diversification* -- Before the onset of Ewa Marina, the residential profile of the 'Ewa area, including the eastern half, will have begun to reflect more of a cross-section of the islandwide community, given the housing mix of various residential projects. With these changes will come cultural diversity.

Adaptation will begin with competition for jobs at the new clubhouses and commercial centers, shared use of new shopping centers, altered make-up of schools and community organizations and shared new recreation areas.

2. *Disruption of the slow-paced lifestyle* -- The initial impact of impending change is a change in the current slow-paced lifestyle which characterizes the 'Ewa Beach and 'Ewa Villages communities. A 1989 poll found that the majority of 'Ewa Beach residents favored development; if this is still a prevalent sentiment, then 'Ewa Beach residents are willing to alter the current lifestyle.

   Nevertheless, the existing communities may experience difficulty in adjusting to the changes which are likely to develop, such as an increase in traffic and crime; disturbance of community cohesion due to economic disparities; crowding at recreational and commercial facilities; and transitional effects of new schools.

3. *Competition for public, particularly recreational, facilities* -- As the other developments in the 'Ewa region are implemented, 'Ewa will be frequented by visitors and islandwide residents. In the immediate vicinity, new people will visit the area's recreational facilities, including beach parks, public marina and the new Ko Olina beaches.

4. *Shift in employment patterns and increased job competition* -- By the time Ewa Marina is implemented, the 'Ewa region will already have experienced an increased diversity in types of employment, particularly at the City of Kapolei, nearby clubhouses at golf courses, day care centers, schools and new hotels. The new residents of Ewa Marina, Gentry, West Loch and other developments will also be competing for the same jobs.

5. *Introduction of visitor industry to the 'Ewa region* -- 'Ewa residents will have begun to adapt to having a resort community at Ko Olina in their region. Many residents, including those in nearby 'Ewa Beach, will have visited the restaurants and shops and some will be employees at these facilities.

4.4.2 Residential Component

Possible changes in the population composition of the 'Ewa area to which Ewa Marina will contribute include (1) a higher percentage of residents participating in the labor force; (2) an increase in the overall family income level; (3) diversification of the region's labor force; and (4) a change in age, ethnicity and educational characteristics to resemble islandwide characteristics. Ewa Marina will contribute to a diversity in the makeup of an already changing community. To some, this change may be an opportunity for increased social exchange and interaction. To others, this change may threaten a seemingly homogeneous community.

4.4.3 Marina And Support Facilities

The proposed marina will benefits the island-wide community by providing both much-needed berthing and marine support facilities. Further, the marina and its support facilities are envisioned as a major catalyst for the expansion of O'ahu's boating industry.

The 'Ewa region will experience the same islandwide benefits of the marina, with the additional positive impacts of proximity, local use and diversification of employment.

1. *Proximity to boating facilities* -- 'Ewa boat owners will be in proximity to public boat launching facilities at Ewa Marina; they would have the advantage of minimal transport time.

2. *Local use of marina facilities* -- 'Ewa Beach residents also have the advantage of easy access to the marina for non-boating activities. Some have indicated interest in using the marina for canoe paddling activities, with related facilities at the nearby One'ula Beach Park. As the project progresses, HASEKO will be examining the various possibilities for this type of use.

3. *Diversification in job types* -- As the region develops, 'Ewa residents will have a wide variety of jobs in proximity to their homes. Whereas there is currently a predominance of military and service jobs in 'Ewa, the future will bring more industrial, professional, managerial and retail jobs to 'Ewa. The project's marina support facilities will add another dimension to the job supply by introducing marine-related employment.

4.4.4 Mixed-use Commercial Complex

The proposed Mixed-Use Commercial Complex will be a major feature of Ewa Marina. Its potential effects on the community will depend to a large extent on how the then-existing 'Ewa community will have adapted to likely non-project changes identified in the previous section. This section presents some considerations on how this project component may change, affect and enhance the existing community.

1. *The Mixed-Use Commercial Complex will increase the de facto population in 'Ewa -- Although the Mixed Use Commercial Complex will not directly increase the residential population, it will contribute to the influx of new people by accommodating visitors and attracting non-Ewa residents.* Approximately 2,200 visitors will be on-site daily, and over 2,200 people will work at the this commercial complex. Further, Oahu-wide residents will likely be attracted to the proposed facilities, such as restaurants and shopping area, as well as the improved One'ula Beach Park.

2. *The proposed visitor complex is symbolic of positive and negative aspects of tourism* -- Regardless of the specialty nature of the proposed visitor accommodations, it is highly likely that 'Ewa residents will apply their own stereotypes and expectations to the Mixed-Use Commercial Complex.

In the 1989 statewide tourism impact study, Hawai'i and 'Ewa respondents felt very positive about the benefits of tourism; they believe that tourism benefits outweigh its problems. They appreciated contributions to Hawai'i's employment base, as well as amenities which can be shared by residents. Hawai'i and 'Ewa respondents also believed, however, that tourism had negative impacts on existing major community problems. They felt that tourism made the cost of housing and traffic worse, and this sentiment was especially strong in areas where there was a high density of visitor units.

It is very likely that the proposed visitor complex may be viewed as both a community asset, as well as the cause of problems. Problems which may be particularly associated with the visitor complex are (1) traffic and (2) changes in outdoor resources.

3. *Visitors will tend to remain at self-contained area* -- Regardless of the type of development at the project site, there will be an increase in traffic. The estimated visitor contribution to this situation is the subject of the traffic impact study, but it is helpful to examine trends for visitors to travel in cars or busses to off-site locations and thus generate traffic. Tourists tend to remain on-site at the larger resorts, except for occasional side trips around the island or into Honolulu or Waikiki. Compared to Waikiki tourists who rent cars and visit off-site recreation areas, rural resort visitors leave their destination area at about 15 percent total per day. It is expected that with the hotels and commercial complex, a similar pattern would prevail, particularly in light of the targeted niche markets.

4. *Nearby outdoor recreation areas may be frequented by project visitors* -- At Kuilima, a non-Waikiki visitor destination, it was found that visitors from the resort complex do not frequent public recreation areas near the resort site but prefer going some distance, such as Waikiki when they do travel off-site. At Ewa Marina, however, the project's water and marina orientation will attract visitors who would be interested in using the nearby One'ula Beach Park and other shoreline resources.

   The effects of the influx of new people will likely be felt by adolescents and young adults who will find their recreation areas, surfing spots and beaches infringed upon by those wanting these areas for alternate activities. Loitering at beach parks, partying after hours, loud music and cars, and military-local interface invite confrontations which will lead to resident complaints.

5. *Existing residents will experience increased interaction with visitors -- this can be both positive and negative* -- According to the statewide tourism impact study, 'Ewa residents experience low levels of interaction with tourists now. Whenever there was interaction, the experience tended to be pleasant even in the high density visitor areas.

   On a personal level, the diversity of visitors, mainland and foreign born, can be a culturally enriching experience for workers and nearby residents. There is also a tendency for Hawai'i residents to view visitors as a class, however. There is a sense of competition, particularly in high-density visitor areas, of whether the area is "our place" or "their place." This type of impersonal class distinction become increasingly problematic when communication barriers increase.

6. *There is a potential for economic disparity as long as residents view a tourist as a symbol of something* -- The presence of affluent and corporate executives could create a us-them perception in the minds of some residents. This perception might become a focal aggravation to the extent that Hawai'i-born residents are committed to employment within the visitor industry or are excluded from employment because of lack of skills or training. Research has shown that, as the economic dependency on tourism increases, there is not necessarily a corresponding increase "Aloha Spirit" toward the industry. As people feel that they are losing political and economic control over their fate to absentee power-brokers in the industry, residents are more likely to direct their animosity toward the visible tourist, who becomes a *symbol* of the power structure.

7. *The Mixed-Use Commercial Complex will expand the area's recreational resources* -- The visitor complex will include a tennis complex and fitness center. These facilities can be welcomed assets to the community, providing there is sufficient means for the average resident to access these facilities. At the tennis complex, the developer should consider community-oriented programs such low membership or use rates for residents and junior or school-based tennis education programs. At the fitness center, there should be programs to encourage local companies to use the center.

4.4.5 Golf Course

The golf course component will improve the recreational resources in the area. Nearby residents will be able to choose among a number of golf courses proposed for the 'Ewa region. To ensure community access to the Ewa Marina golf course, programs such as junior golf lessons, kama'aina rates and group discounts should be evaluated.

4.5 Impacts On Ocean Recreation

Ocean recreation consultant John Clark has been retained to study the project's impacts on ocean recreation in the area. He based his findings on previously researched activities and characteristics of ocean recreation in this area and interviews with members of the ocean recreation community. This section summarizes Clark's findings relative to possible project impacts or changes to the ocean recreation environment. Non-recreation issues raised by those interviewed, such as lifestyle and value issues, are discussed in Section 5.

4.5.1 Shoreline Activities

Fishing and Crabbing -- The shoreline from One'ula Beach Park to the NASBP fence is a low coral bench, and the primary activity along this reach is pole fishing, either shore casting or whipping. The fishers often spend the day or camp with their families on weekends. They fish for papio, ulua, and moi. This rocky shoreline is also a good area for catching a'ama crabs, the common black rock crabs which are a popular raw dish at luaus.

Development of the area and convenient public access will attract more fishers. Other than increasing competition for the preferred fishing sites, the impact on the fish populations caught by pole will probably be minimal. The jetties bordering the boat channel would provide additional fishing sites, and the safety of pedestrian traffic should be considered in planning the jetties' width.

More crabbers will also be attracted to the area, and this will have a direct impact on the crabbing by possibly reducing the crab population. Although the jetties will provide additional crab habitat, the overall impact may be negative. Crabbers noted that, in other harbor areas, such as the Ala Wai Boat Harbor, the increased pedestrian traffic makes the crabs skittish and harder to catch.

The boat channel will cut off lateral access along the shoreline for anyone traversing the area between the park and NASBP fence. Some public access to both the west and east sides of the channel should be provided.

Seaweed Gathering -- A variety of seaweeds grow on the shallow ocean bottom offshore the beach. These seaweeds are dislodged by water movement, transported onshore, and deposited on the sand. The beach provides an important seaweed gathering site for residents of 'Ewa Beach and other surrounding communities. Seaweed is gathered by waders from "limu piles" or concentrations of seaweed floating nearshore, and by skin divers who harvest the seaweed directly from the ocean bottom.

All of the seaweeds commonly gathered at the beach are used for home consumption, but the limu wawae'iole is also sold commercially to stores and at the local farmers' market. Commercial seaweed gathering is illegal without a permit, but many informants indicate that this occurs anyway.

Those interviewed did not feel that Ewa Marina will have an impact on the present seaweed or seaweed gathering activities. During the construction phase, it was felt that some siltation would occur, and that the prevailing currents would probably carry the plume in a westerly direction, away from the beach and seaweed grounds.

Swimming -- The eastern portion of the beach fronting the plantation camping sites, popularly known as Hau Bush for the large stands of hau in the backshore, is used by campers for traditional beach activities, such as swimming and sunbathing. The nearshore bottom, however, is shallow and rocky, offering only a marginal swimming sites appealing mostly to children. Although the western portion of the site is primarily rocky, there are several small pockets of sand in the rocks that are used by children as swimming holes.

Ewa Marina would probably not impact the present swimming and sunbathing activities. Some problems may result, however, if non-authorized people trespass onto White Plains Beach, an attractive white sand beach separated from the project site by a chain link fence.

4.5.2 Nearshore Activities

Surfing -- Although the islandwide surfing community does not regard 'Ewa Beach as one of the best places for surfing, it does recognize that the area has several excellent primary surfing sites and a number of good secondary sites. The majority of these sites are found offshore of the project site. These sites include Seawalls, Shark Country, Hau Bush, Chicken Creek, Sand Tracks, Johns, Coves and Tree Stumps. Of all of these sites, Coves is generally recognized as having the best waves on a good south swell. Resident area surfers felt that its left side is comparable or as valuable as that at Ala Moana Bowls in Waikiki, one of the best surfing sites in the state. Surfing contests are held annually offshore One'ula Beach Park at Sand Tracks or Johns. Bodyboarding is another important wave riding sport practiced at all of the 'Ewa Beach breaks.

Informants were very concerned about Ewa Marina's potential impact on surfing. To preserve Coves, one of the best surfing sites in this area, project engineers have realigned the boat channel.

It was pointed out that all of the 'Ewa Beach surfing sites are important, in light of the residential growth planned for the 'Ewa Plain; the regional surfing population is expected to grow substantially. Further, surfing sites are ocean parks which many feel cannot be replaced or duplicated. In spite of scientific claims that new surf sites can be created, many surfers feel that the hundreds of years of coral reef formation -- which creates a surfing site -- cannot be duplicated. The jetties lining the boat channel may exert a negative influence on the surfing sites by altering normal wave patterns. Although some informants acknowledged the possibility of creating new sites, most anticipated a negative impact.

Diving -- Some skin diving for reef fish, octopus and lobster occurs along the rocks. From all accounts, however, visibility is poor for most of the year. Hence, most of the in-water fishing consists of laying nets. Some scuba diving and spear fishing occur from boats.

Diving is also limited by the fear of sharks. There is both a community and islandwide belief that the 'Ewa Beach waters are shark-infested. This belief has some accuracy and is a perpetuated by numerous shark sightings by surfers and divers. The surfing site "Shark Country" has been so named for at least 30 years. Fishers commonly find large holes in their nets caused by sharks, and over the years, many large sharks, primarily tigers and hammerheads, have been caught in this area.

Development of the area and convenient public access will attract more divers, thus reducing fish, lobster and octopus populations. The potential increase in divers may lead to conflicts between the pole fishers and the divers.

Based on their personal experiences and knowledge of existing marinas and harbors, informants believed that the boat channel and the marina will likely attract more sharks. Sharks are scavengers and commonly frequent bays and harbors. With the apparent proliferation of sharks in the area now, the new channel and marina may be a natural focal point for sharks.

Boating -- At present, little boating activity occurs near the project area. The water is normally too murky to attract skin or scuba divers and too far from existing boat ramps to attract other boaters. The area is also subject to surf at all times of the year, particularly

during the summer. The boats that do visit the area are usually smaller motor boats, 17 feet in length or less, or inflatable boats, such as Zodiacs or Avons. These boaters tend to be local divers familiar with the area who know when visibility would be good enough for diving. Little or no sailing or windsurfing occurs in this area.

Ewa Marina will improve the supply of recreational boating facilities. Public boat ramps on Oahu are few and far between; a new public boat ramp would meet a major need in the boating community. Boat owners also need more support facilities and the project will provide marina support facilities such as a service station for gas, a store or ice and supplies, and parking for trucks and trailers.

It is anticipated that the marina will offer a refuge for boats in distress which are caught offshore in rough seas, or which experience engine or other problems. More boating traffic offshore will likely lead to more boating accidents, such as boats going aground on the reef, boats overturning in high surf, and boat fires.

More boaters may mean user conflict incidents between boaters and other user groups, such as surfers, nearshore skin divers and shoreline fishers.

Outrigger Canoe Paddling and Kayaking -- Outrigger canoe paddling is not presently practiced in 'Ewa Beach. The former 'Ewa Beach Canoe Club, now known as the Kuakini Canoe Club, has been inactive for approximately four years. Canoe paddling season is usually during the summer months, and summer surf made nearshore training difficult.

Ewa Marina may help revive canoe paddling in 'Ewa Beach. The marina and the boat channel would (1) provide the sheltered waters that canoe paddlers prefer for training and (2) still give them access to the open ocean.

A floating dock area would offer them a place to launch, land, and secure their canoes, and could be used by kayakers as well. These floating docks should be located away from the boat launching ramp to avoid potential hazards to canoe paddlers and kayakers by motor-powered crafts.

4.6 Impacts On Public Services And Facilities

4.6.1 Police Protection

'Ewa is in District III, which extends from Red Hill to Ka'ena Point and Kipapa Ridge and is handled by the Pearl City Police Station. Currently 18 beat officers operate in the 'Ewa Development Plan area daily.

Long-term plans include adding a new full-service station in Kapolei, with the establishment of 'Ewa and the Wai'anae Coast as a new district. The Kapolei station would be the headquarters for five beats in 'Ewa and eight beats along the Wai'anae Coast. In addition, two substations are proposed by the Police Department. One would be located in Ko Olina; the other in Ewa Marina. Both are long-term in nature.

Ewa Marina will impact police protection services because it will increase the resident and de facto population. The increased demand could be met, however, if current plans for police protection services are implemented. In anticipation of growth in 'Ewa, public officials are planning major improvements and additions to police services and facilities.

Ewa Marina could help mitigate the impact on police protection services. First, public officials and HASEKO have been discussing the possibility of establishing a new police sub-station in Ewa Marina. Locating this facility within the project will benefit both the proposed and existing communities. Second, at full build-out, Ewa Marina will comprise several distinct neighborhoods. These neighborhoods can minimize the need for police protection by providing on-site security measures and/or personnel who will monitor suspicious activities and handle minor problems.

4.6.2 Fire Protection

First Alarm at the project site is handled by the 'Ewa Beach and Waipahu Fire Stations. The Makakilo Fire Station provides backup. Currently, there are 15 firefighters per shift at the 'Ewa Beach Fire Station.

To accommodate anticipated growth in 'Ewa, four new fire protection facilities are being planned. First, planning and design funds have been received for a new fire station at the James Campbell Industrial Park. This is envisioned as an engine-and-ladder company and will have a battalion chief. Second, the Ko Olina Phase 1 fire station would also be an engine and ladder company, with twelve firefighters per shift. Third, there have been tentative plans for the relocation of the existing 'Ewa Beach Fire Station to the Gateway Park of Ewa Marina. Finally, another fire station is planned at 'Ewa Villages, but no time frame has been determined.

Ewa Marina will increase the demand for fire protection services by increasing the resident and de facto population and introducing more urban uses. Mitigation measures include working with public officials to locate a fire station on-site or making an otherwise appropriate contribution to regional fire protection services.

4.6.3 Recreational Facilities

The 'Ewa Development Plan area contains four beach parks, four community parks and four neighborhood parks. In addition, there is also Kapolei Park, which is a 28-acre undeveloped regional park.

Ewa Marina is expected will have two types of effects on these existing parks. First, the added population will increase the demand for these resources and cause crowding. This impact will be offset, however, by a corresponding increase of project and non-project recreational resources. All of the residential projects proposed for 'Ewa contain recreational resources and a 73-acre regional park will eventually be located in Kapolei.

The second project effect is a positive one. Ewa Marina is envisioned as a recreation-oriented community and will provide land- and ocean-based recreational amenities for Ewa Marina and existing residents. HASEKO has been actively seeking

ideas and input from the community about the proposed on-site parks, and Section 5 contains more information regarding this public input process. The following outlines predominant ideas about the proposed parks at this time. Note that these ideas will likely evolve and be modified as community discussions continue.

Gateway Park -- The proposed Ewa Marina Gateway Park was generally seen as a facility which would be used by 'Ewa Beach residents as well as by the new Ewa Marina community. This park can be used as a gathering place, a central place to socialize, meet and just gather. Further, the facilities can contain service facilities which could serve 'Ewa Beach and Ewa Marina residents.

One'ula Beach -- Shoreline parks are scarce in this area, and the need for beach parks will greatly increase as 'Ewa develops. Thus, the improvement and development of One'ula Beach Park is seen as a big plus by community leaders. One'ula Beach Park is seen as a place for fishers, surfers, divers, boaters, wind surfers, sunbathers and general recreation. Community leaders want to see these activities accommodated as much as possible, and it was felt that an ocean recreation center was appropriate for this site.

In addition to these larger parks, Ewa Marina will contain numerous small community and neighborhood parks to meet the needs of on-site residents.

4.6.4 Public Education

Ewa Marina is in the Campbell High Education Complex (hereby called Campbell Complex) of the State Department of Education. The elementary schools in this complex include Barbers Point, 'Ewa, 'Ewa Beach, Iroquois, Kaimiloa, Makakilo, Mauka Lani, and Pohakea Elementary Schools. These schools all feed into Ilima Intermediate and Campbell High Schools.

The existing schools which would be affected by Ewa Marina are 'Ewa Beach, and Pohakea Elementary Schools, and Ilima and Campbell High Schools. *Table 9* contains enrollment information for these schools. The elementary schools have experience slight decreases in enrollment, while the upper schools have been increasing in students.

In anticipation of residential growth, State public education officials have been planning school facility additions and administrative changes. Four new schools are being planned for the 'Ewa region including two elementary, one intermediate and one high school. With these schools, the 'Ewa region public schools will have a design enrollment of 13,700. It is anticipated that, eventually, the western schools in the Campbell Complex, including those in Kapolei and Makakilo, will feed into a new Kapolei High School Complex.

Ewa Marina is projected to house 800 elementary school aged children, 190 intermediate school students, and 360 high school students, as contained in *Table 11*. The current plan is that half of the elementary students will attend 'Ewa Beach and Pohakea Elementary Schools; Ilima Intermediate and Campbell High will serve the older students.

If current plans are implemented, Ewa Marina should be adequately served by the public education facilities. State Department of Education officials will continue to monitor the need for and timing of additional facilities and improvements.

4.6.5 Child Care

The project may require child care services because of the increase in residential population and on-site employees. The extent of this requirement depends on, first, the availability of other child care facilities which can serve employees of the proposed project and, second, the actual employee requirements and preferences expressed when the facility is in operation.

Currently three sites have been committed for child care facilities: West Loch and Royal Kunia both have a 5.3 acre site for a park-and-ride facility with a 30,000 square foot child care center. Ko Olina has one acre for child care and other public facilities. In addition, three potential child care centers are being explored in Kapolei.

At present, there is no rule of thumb in projecting child care needs and requirements for specific development proposals have been determined on a case-by-case basis. Options to address child care needs at Ewa Marina Phase 2 include (1) providing a site for a child care facility and (2) employer-based options. The latter includes major employer subsidy of on-site care, pre-tax contributions to qualified employees, and a direct voucher provided by employers to employees who demonstrate their use of qualified child care facilities.

4.6.6 Medical And Emergency Services

The St. Francis-West Hospital is located approximately 4.5 miles north of Ewa Marina and is accessible via Fort Weaver Road. The general community hospital contains 136 acute care beds and has 130 resident physicians. The hospital offers X-ray, Laboratory, obstetrics and emergency services. Two other hospitals are also within reasonable travelling distance of the project site -- the Kaiser Foundation Health Plan in Moanalua and the Pali Momi Medical Center near the Pearl Ridge Shopping Center. In addition, the area contains numerous medical clinics and doctors' offices.

As Kapolei City progresses, additional medical facilities will be required to serve the increased population. The proposed project is expected to be adequately served by the existing and additional medical facilities.

Emergency services are provided by City ambulances located in Aiea. Further, the Waipahu Fire Station contains an ambulance unit which serves Pearl City, Waipahu, 'Ewa Beach, Makakilo and parts of Wai'anae. Also eight-hour service is provided to the Makakilo Fire Station by the Waipahu unit. Twenty-four hour ambulance service at the Makakilo Fire Station is currently in the planning stage.

5. Preliminary Community Issues On Ewa Marina

Whereas social impacts are social changes which are likely to occur, social issues are reactions to community events, changes and problems. Issues change over time, as people's priorities and values change. Earthplan has been monitoring 'Ewa issues over the past few years and has analyzed issues specific to Ewa Marina.

Six sources of information were used in this analysis.

1. *Neighborhood Board minutes* -- To understand the values, concerns and issues of study area residents, this study examined the minutes of the 'Ewa Neighborhood Board No. 23 over a four-year period, from July 1987 through July 1991.

2. *Omnitrak Survey* -- In early 1989, Omnitrak conducted a telephone survey of 403 persons in the 'Ewa Beach area. For percentages based on the entire sample of 403 responses, the maximum estimate of the sampling error is ± 5 percent. The findings of the Omnitrak survey were intended to serve as a benchmark for understanding the current community environment. Section 5.2.2 summarizes the survey results.

3. *State Tourism Survey* -- The findings of the 1989 State-sponsored survey is helpful in identifying 'Ewa residents' attitudes towards tourism, and, indirectly, in indicating possible reaction to the Mixed-Use Commercial Complex of Ewa Marina. This was a statewide telephone survey of 3,904 households.

4. *Previous Earthplan Study on Ewa Marina Issues and Concerns* -- In April 1990, HASEKO (Hawaii), Inc. retained Earthplan to study community issues and concerns about Ewa Marina. Earthplan interviewed 42 people for that study. Two groups were targeted: (1) a "general community" group, and (2) a recreation group.

5. *First Forum on Community Benefits Package* -- In March of this year, HASEKO sponsored a forum to begin group discussions on the community benefits package. HASEKO invited 77 people who represented youth organizations, school representatives, job training organizations, senior citizens, community residential and business organizations, the 'Ewa Neighborhood Board No. 23, church leaders, ocean recreation users, and providers of public services. Participants responded to a questionnaire and took part in small group sessions.

6. *Interviews Conducted for This Study* -- Earthplan supplemented this information with interviews specifically for this study. It was expected that these interviews would provide updated community reactions and would reveal any trends or changes. Earthplan conducted 28 interviews with people who (1) live, conduct business or own land near the project site, (2) have a regional interest in the proposed project, or (3) would be able to provide specific information on how the site might affect the neighboring community. A major attempt was made to network and reach people who were not previously contacted in previous Earthplan studies on Ewa Marina.

The following summarizes and analyzes community issues to date based on these sources:

1. *Increasing apprehension towards development and its changes*

   As 'Ewa is developed, the realities of development temper the community's earlier enthusiasm. New communities are coming up, and roads are being improved. Compared to just a few years ago, there is more traffic, new children are attending local schools, and new faces are seen at the shopping centers.

Whereas the 'Ewa Neighborhood Board has previously endorsed most changes in 'Ewa, Board members are increasingly scrutinizing new projects and placing conditions on their positions. Likewise, during our interviews, there is more of tendency to mention traffic, water and sewerage as major concerns.

2. *Acceptance of and support for Ewa Marina continues*

Ewa Marina has been discussed for over a decade and community leaders in 'Ewa Beach have consistently supported the project. The most recent endorsement was in April 1991, when the 'Ewa Neighborhood Board No. 23 voted to support Phase 2 of Ewa Marina with conditions.

3. *Recent opposition to the project*

Until 1990, testimony at public hearings was generally in favor of Ewa Marina. In June 1990, however, at the State Land Use Commission hearing for Urban designation for Phase 2, a spokesperson for the Save Ewa Beach Ohana cited a petition with over 2,400 signatures. It appears that no signatures have been added to the petition in the following year as a 2,400-signature petition was submitted to the City and County of Honolulu Planning Commission in September of this year. The extent of opposition to Ewa Marina is unclear at this time and the only way to realistically gauge the extent of opposition is to conduct a statistical poll under controlled conditions.

4. *Direct correlation between one's attitude towards community change and one's view of Ewa Marina*

Based on our analysis of community reactions on this project, one's support or opposition to the overall Ewa Marina can be directly correlated to one's attitude towards change. There are those who are optimistic about community changes already occurring or being planned for 'Ewa. These people generally see changes, including Ewa Marina, as the *solution* to current problems such as the housing shortage, crime, and lack of recreation and youth activities. They believe that the project will bring social diversity, more facilities, and generally a better quality of life for 'Ewa residents.

Those who are generally apprehensive or pessimistic about community changes tend to see development as the *root* of problems. To them, development will bring a greater shortage of affordable housing, more crime, and newcomers who will change the community. This latter group is already concerned about changes which are occurring, such as 'Ewa Gentry and West Loch. Ewa Marina is an even bigger threat because it would be the closest to 'Ewa Beach.

5. *Attitude towards tourism and tourists*

The statewide tourism survey indicates two important tendencies with 'Ewa residents. First, the majority of respondents liked tourists; they had pleasant experiences on a one-to-one basis. Further, 'Ewa respondents felt very positive about the benefits of tourism; they believed that tourism benefits outweigh its problems.

The second tendency appeared contradictory. 'Ewa respondents also believed that tourism had negative impacts on existing major community problems. They felt that tourism made the cost of housing and traffic worse. Most people didn't want any more hotels because of these apprehensions.

The basic difference is that the first tendency is based on one's actual experience, whereas the second tendency emerges when a person looks at tourism symbolically.

The interviews for this report indicated similar tendencies. Those interviewed did not object to having tourists in their area, but some had very strong feelings against the hotels. They feared that tourism will negatively affect the residential character of the area, and essentially produce another Waikiki. The have/have-not syndrome was a problem also, especially if affluent tourists were attracted to the area. To these people, the negative connotations of tourism could be realized if Ewa Marina contains hotels.

6. *Shift in interest in employment*

When Ewa Marina was first introduced to 'Ewa, the sheer increase in the number of jobs was a major plus to 'Ewa residents. As unemployment decreases and as the employment prospects for Kapolei and Ko Olina become more evident, "jobs" is no longer development's big plus. Rather, 'Ewa residents are now looking at the types of jobs. They want to see a diversity of jobs, and, more importantly, opportunities for local residents for upward mobility in the job market.

7. *More specific questions and concerns about ecological and environmental impacts*

The community's awareness of potential environmental issues has grown in the last few years. People who read newspapers and attend public meetings are becoming knowledgeable about groundwater, shoreline habitats and air quality. Whereas people were formerly concerned about Ewa Marina's impact on "the environment," they are now more informed and direct their questions to more specific issues. Hence, HASEKO needs to continue to share project information as much as possible to assist the community in making an informed decision about the project.

8. *Community input and integration -- a key ingredient*

Ewa Marina needs to be a good neighbor and the existing community needs to feel comfortable with the types of changes proposed by HASEKO. 'Ewa Beach residents need to feel that they will be an important part of the future community, and that they will not be over-shadowed by the newer residents.

Community organizations in Ewa Marina or at the Gateway Park should be easily accessible for residents and there should be no apparent exclusionary groups, facilities or areas. People feel comfortable with socio-economic diversity if they believe they have physical, legal and some economic access to most facilities. Further, 'Ewa Beach residents need to believe that they have -- or can attain -- the same ability as others to compete for jobs and public services.

Though it is difficult to predict how 'Ewa Beach and Ewa Marina will integrate and interact, HASEKO can help prepare existing residents for future changes by including 'Ewa Beach in the planning process. Further, project aspects which could directly impact 'Ewa Beach should be made clear, so as to help existing residents form realistic expectations.

HASEKO has begun this process by initiating an extensive program of dialogue with the community. This program has several facets. One portion deals with the community benefits package, whereby Ewa Marina will directly contribute to the adjacent 'Ewa Beach. Discussions on the types of benefits and the mechanism for handling benefits are currently underway, and are expected to continue over the next few months. Eventually HASEKO hopes to have a Community Benefits Advisory Committee which will work out the details.

Another facet of the dialogue process is asking community experts to review report findings, as in the case with ocean recreation. HASEKO has also opened an office in 'Ewa Beach, so that residents have direct access to project personnel. Further, the company gives presentations whenever asked, and initiates different types of meetings to provide project information and gather input.

Ewa Marina

Social Impact Assessment

Prepared for HASEKO (Hawaii), Inc.
by Earthplan

September 1991
(Revised January 1991)

Contents

Tables and Figures

Tables

Figures

1. Introduction And Background

1.1 Description Of This Report

1.1.1 Purpose Of This Report

HASEKO (Hawaii), Inc. proposes to develop Ewa Marina in 'Ewa, Oahu. To encompass a total of 1,100 acres, Ewa Marina is envisioned as a recreation-oriented community with 4,850 residential units, 1,600 boat slips to be accommodated in marina basins and waterway systems, golf courses, and a variety of commercial centers and visitor accommodations related to the residential and recreational activities.

The project is to be implemented in two phases. Phase 1 includes the marina and residential components. Major land use approvals have been secured and HASEKO (Hawaii), Inc. is currently seeking Federal, State and City permits for the marina configuration, location and construction. Planning and design for the first housing increment are also in process. The second housing increment needs a Special Management Area Permit.

Phase 2 includes the remaining uses, including the golf courses and mixed-used commercial complex. Phase 2 received Urban designation in 1990. HASEKO (Hawaii), Inc. is currently seeking amendments to the 'Ewa Development Plan Common and Special Provisions and Land Use Map.

Earthplan has prepared previous social impact studies on specific parts of the Ewa Marina project, namely the "Social Impact Factors" for Increment 2 of Phase 1 (1985); and social impact assessments (1989 and 1991[update]) for Phase 2. In addition Earthplan prepared a 1990 report on community issues and concerns.

The purpose of this report is to compile and update these previous studies. Specifically, this report

- updates the information base for the study by including new demographic information and updating changes to the 'Ewa region independent of Ewa Marina;
- revises preliminary community issues by incorporating interviews conducted specifically for this report; and
- re-examining the impact analysis given changes in the information base and revised community issues.

This report was prepared by Earthplan whose office is located at 81 South Hotel Street, Suite 211. Berna Cabacungan, principal of Earthplan, was the project manager, and principal researcher and writer. Michael P. Mays, an independent contractor, was principal interviewer. John Clark, an ocean recreation consultant, prepared the analysis of ocean recreation impacts.

1.1.2 Report Organization

This report contains five major sections. The remaining portions of Section 1 describes Ewa Marina.

Section 2 provides a profile of the existing community to establish the social context in which project impacts may occur. Information is provided for the entire 'Ewa region, as well as for specific nearby communities.

Section 3 explores the Study Area's future without the proposed project. This information extends the baseline data by identifying the possible future scenarios for the community independent of the proposed project. Public policies and major public and private developments are included in this analysis.

Section 4 identifies potential social impacts of Ewa Marina. This section identifies population and employment impacts, and analyzes the change in land use pattern. This section also examines regional impacts of the specific project components and discusses impacts on ocean recreation activities. Impacts on police and fire protection, schools, child care, hospitals and recreational facilities are also discussed.

Section 5 identifies potential community issues and concerns on this project based on historical trends to date and interviews conducted specifically for this project.

1.2 Project Description

1.2.1 Site Description

The project site encompasses 1,100 acres in 'Ewa Beach on O'ahu, Hawai'i. When traveling north to south on Fort Weaver Road, one would see the project site as being located at the entrance of 'Ewa Beach, which is primarily a residential community with support commercial and public facilities.

Fort Weaver Road forms most of the eastern boundary of the Ewa Marina project site. Further east, across Fort Weaver Road, is a residential subdivision.

The southeast corner of project site abuts the Ewa Beach Shopping Center and 'Ewa Beach Elementary School. Residential uses dominate Papipi Road which runs along the southeastern portion of the project site. The 30-acre One'ula Beach Park and the ocean fronts the site's makai portion.

To the north are cane fields and the Naval Air Station, Barbers Point is located to the west of the project site.

1.2.2 Project Description

Ewa Marina is envisioned as a recreation-oriented development with residential, recreational, and commercial components linked by an extensive greenbelt system. The main ingredients for this new community are outlined as follows:

- **Recreational.**

  The recreational component offers a variety of facilities and areas for leisure time and community enjoyment. The project's centerpiece is the 140-acre marina. Currently planned are 1,600 boat slips, boat launching ramps and trailer parking, and marina support operations. The marina will be privately-owned and open to the public.

  Other recreational features include a 20-acre district park, smaller neighborhood parks and playgrounds, pedestrian paths, bikeways. A 27-hole golf course will be located along the northern and western boundaries of the project site, and a 19-court tennis facility and clubhouse will be included.

- **Residential.**

  A major component, the residential portion of Ewa Marina includes 4,850 homes. The single-family units, town houses and low-rise multi-story structures will be located in the eastern half of the project.

- **Mixed Use Commercial Complex.**

  The Mixed-Use Commercial Complex will be located on approximately 87 acres in the western half of the project site. This part of Ewa Marina is envisioned as an important complementary feature of the marina. It will contain establishments providing goods and services related to boating and water sports activities. Other facilities being proposed for this complex are intended as enhancements which would focus around the transportation and recreational qualities of the marina.

  Specific facilities to be included in this complex are a commercial center, an International Fitness Promotion Center (IFPC), 1,500 units in hotels and garden suites, and an exhibition center and conference facilities.

2. Profile Of The Existing Community

This section provides information on the existing community to establish a baseline of information, upon which potential social impacts can be identified and examined.

Section 2.1 defines the study area used in this report. In Section 2.2, population and housing trends are discussed. Section 2.3 presents demographic and housing for the NASBP, 'Ewa Beach, 'Ewa Gentry, 'Ewa Villages, Iroquois Point Pu'uloa Military Housing and Makakilo.

2.1 Study Area Description

The project site is located in the 'Ewa region, or Development Plan area. From north to south, the 'Ewa region extends from the lower slopes of the Wai'anae mountain range to the coastline. From west to east, 'Ewa extends from Kahe Point to the West Loch of Pearl Harbor.

The Study Area for this report is the 'Ewa Development Plan area and the following describes the different areas and uses in this region:

- **'Ewa Beach** is in the southeastern section of the 'Ewa region, and is directly east and southeast of the project site. This is an older residential community, with a small commercial center along Fort Weaver Road.
- **The Iroquois Point Puuloa (IPP) Military Family Housing** is located at the southeastern portion of the 'Ewa region. This community houses Navy, Army and Marine personnel.
- **'Ewa Villages** is in the east central portion of 'Ewa and is located north of the project site. This community comprises former plantation villages, and newer City-initiated residential development.
- Also north of the project site is the new community of **'Ewa Gentry**. By 1990, 752 housing units were completed in this development.
- **Honouliuli** is in the northeastern portion of 'Ewa. This older community includes a mixture of residential uses, few support commercial establishments, and small-scale agricultural operations.
- **West Loch** is located in the northeastern portion of the 'Ewa region. This is a City-initiated project and Phase I was completed in late 1990.
- Located in the south-central area of 'Ewa, the **Naval Air Station Barbers Point (NASBP)** covers 3,672 acres and abuts the western boundary of Ewa Marina. The station's mission is to support aviation activities and units of

the Navy. Aircraft operations are conducted on a 24-hour basis and consist primarily of fixed-winged propeller aircraft with most flights conducted during the daylight hours. The station has three major runways.[1]

- **James Campbell Industrial Park** is located in the western and southwestern area of the 'Ewa region. Approximately 1,360 acres of this 2,400-acre industrial park are currently in use. Major park tenants include two oil refineries, a concrete manufacturing plant, a cattle feed lot operation, large building material supply yards, and a motor vehicle raceway park.
- Located on the lower slopes of the Wai'anae Range, **Makakilo** is a 23-year old residential community offering mid-priced, single family and multi-family housing, and support public and commercial facilities.
- **Honokai Hale and Nanakai Gardens** are two contiguous and older residential communities located in the western portion of 'Ewa.
- **Barbers Point Harbor** is a new state-owned harbor located on the west coast of the 'Ewa region. In May 1990, 1,600 feet of pier and 30 acres of concrete-paved backup area was dedicated. These facilities are currently being utilized and heavy general cargo and bulk commodities are forecasted.[2]
- **Ko Olina Phase 1** is under construction and is located between Farrington Highway, Honokai Hale/Nanakai Gardens and the ocean. The development program includes 5,200 residential units and 4,000 visitor units. Already completed is a visitor center, an 18-hole golf course and four sandy beach lagoons. Under construction are a 400-slip marina and the Ihilani, a new 400-room hotel.[2]
- **Paradise Cove** is located adjacent to the Ko Olina Resort and is Hawai'i's largest luau operator. Between 600 and 1,200 visitors and residents are entertained nightly.
- Oahu's largest sugar producer, **Oahu Sugar Company (OSCO)** cultivates approximately 8,000 acres in the 'Ewa region. Nearly all of the 'Ewa lands under cultivation are leased from the Estate of James Campbell with a lease expiration date of 1995.

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1 *U. S. Navy, 1985*
2 *The Estate of James Campbell, 1991.*

2.2 Information Sources

For the purposes of describing 'Ewa, two sources of information were used. First, estimates of in-area employment, population and housing are compiled by the Planning Information Branch of the City Department of General Planning. These are in the form of "Traffic Zones," and the zones generally are conterminous with Census Tract boundaries used in 1980.

The second source of information is the 1980 and 1990 Census. The 1980 census is used for determining trends. At the time of this writing, 1990 census information is available for Census Designated Places, or CDPs. CDPs are basically distinct communities or urban places.[3]

In anticipation of major increases in population in the 'Ewa region, the U. S. Bureau of the Census, in conjunction with the State Department of Business and Economic Development, created new census tracts. *Table 1* relates the boundaries of these different groupings.

2.3 Employment Profile

For roadway and transportation system planning purposes, the City Department of General Planning estimates employment in traffic zone. This information is gathered every ten years, with the most recent being from 1985. The Traffic Zones are hereby described:

> Traffic Zone (TZ) 138 includes the portion of 'Ewa Beach west of Fort Weaver Road, and is referred to as *West 'Ewa Beach.*
>
> TZ 137 is referred to as *East 'Ewa Beach*, and covers the communities to the east of Fort Weaver Road, and includes the IPP Military Family Housing, and the portion of 'Ewa Beach generally east of Fort Weaver Road.
>
> TZ 142, is referred to as *'Ewa to Honokai Hale* and includes the 'Ewa Villages, Honokai Hale / Nanakai Gardens, Honouliuli and the James Campbell Industrial Park.
>
> TZ 139 is the *Naval Air Station Barbers Point*, or *NASBP.*
>
> TZ 140 is *Makakilo.*

Figures 1 and 2 present estimates of jobs in the 'Ewa region in 1985. *Figure 1* shows that the region's primary employment generator is military activity. Military jobs were the largest category, with about 39 percent of the total 11,121 'Ewa region jobs. Service jobs were the next largest category; 16 percent of the total jobs were service-related.

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3 *At the time of this writing, there is limited information by census tract information, and the census tract boundaries have not been published by the State Department of Business and Economic Development. Thus, CDP information provides the most comprehensive information which can be used for analysis purposes*

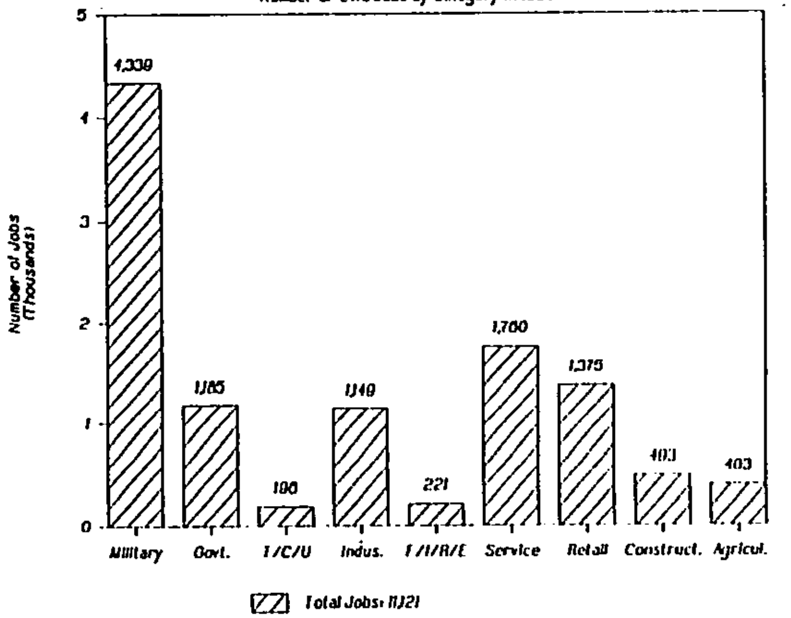
Table 1

Boundary Comparisons for the 'Ewa Region

City Traffic Zone Boundaries	Census Tract Boundaries	
	1980	1990
137	83	83.01 83.02 87.98
138	84	84
139	85	85
142	86.02	86.98
140	86.01	86.03 86.04

Figure 1

Number of 'Ewa Jobs by Category in 1985



T/C/U: Transport, Communications and Utilities
F/I/R/E: Finance, Insurance, Real Estate

Source: City and County of Honolulu Department of General Planning, Planning Information Branch. 1985 Adjusted Employment (Jobs) by DGP Sector by TAZ. October 1987.

Figure 2 indicates how the area's 11,121 jobs are allocated by area. Highlights are as follows:

1. About half of the jobs in the 'Ewa region were located at the NASBP. As expected, this area accounted for virtually all of the area's military jobs.
2. The area from 'Ewa Villages to Honokai Hale contained over one-fifth of 'Ewa's total jobs. Almost half of 'Ewa's industrial jobs are in this area, with the presence of the Campbell Industrial Park.
3. Makakilo, a predominantly residential community, contained only three percent of 'Ewa's total jobs.
4. West 'Ewa Beach contained 17 percent of 'Ewa's total jobs and East 'Ewa Beach contained eight percent.

2.4 Population And Housing Trends

O'ahu's 1990 residential population is estimated at 836,231 persons, which represents a 9.6 percent increase over the 1980 population of 762,564. The average annual growth rate for this ten-year period is slightly less than one percent. This growth rate is lower than the average 1.9 percent between 1970 and 1980, as indicated in *Table 2*.

The islandwide housing count for 1990 was 281,683 units. There has been an increasing number of multi-family units, and in 1990 over half of the housing stock were in this category. Forty-five percent were single-family units. The average household size was 3.02 persons.[4]

The 'Ewa region experienced population growth higher rates than O'ahu over the past twenty years. *Figure 3* illustrates that 'Ewa's population has grown from 24,087 persons in 1970, to 38,324 in 1980 to 42,983 in 1990. This means that the area grew 4.2 percent a year in the 1970s, and 1.7 a year in the 1980s. These rates are about double the islandwide rates.

Two major sources account for the population increase in the 1970s. 'Ewa Beach became home to almost 8,000 more people between 1970 and 1980. Residential development also continued in Makakilo and its population doubled between 1970 and 1980.

Growth in the 1980s occurred during the latter half of the decade. As new projects are being developed, the population has increased at an average annual rate of 1.8 percent between 1985 and 1989.[5]

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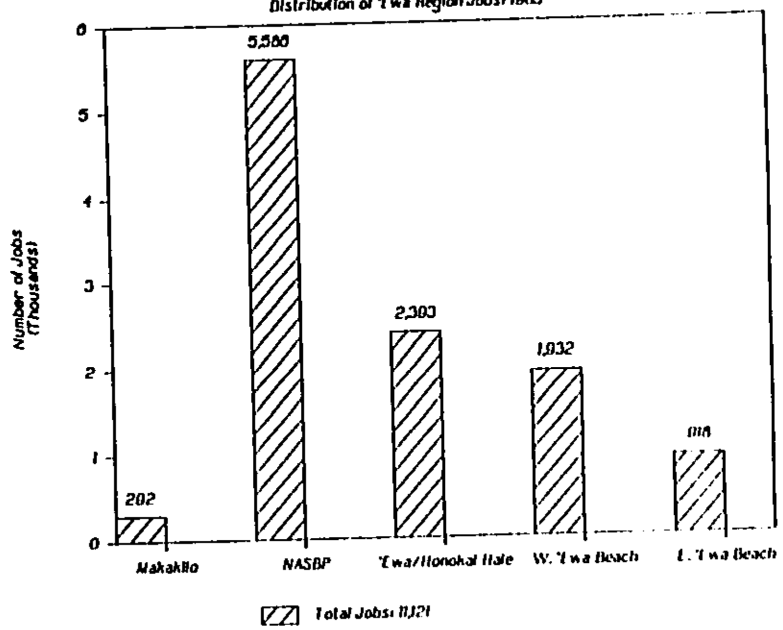
[4] *U. S. Department of Commerce, Bureau of the Census, 1983 and 1991.*
[5] *Earthplan, 1991.*

Figure 2



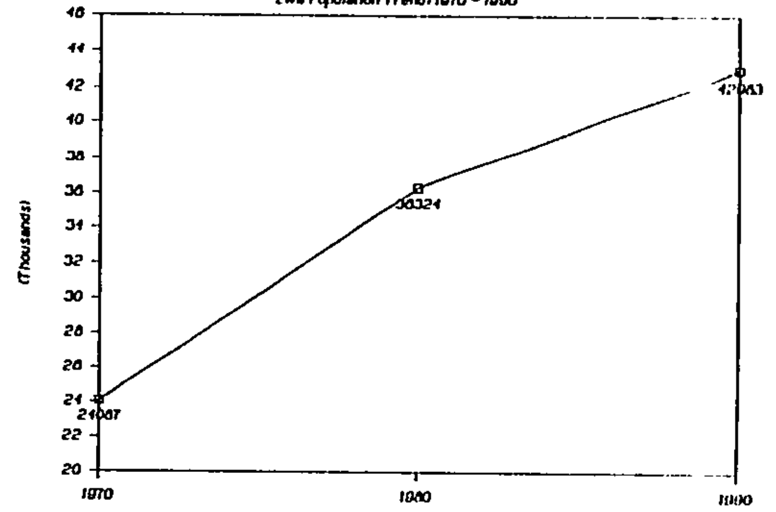
Source: City and County of Honolulu Department of General Planning, Planning Information Branch. Traffic Assessment Zones. October 1987.

Table 2

Average Annual Growth Rate
for the 'Ewa Development Plan Area: 1970 - 1990

	1970 - 1980	1980 - 1990	1970 - 1990
City and County of Honolulu	1.9%	0.9%	1.4%
'Ewa Development Plan Area	4.2%	1.7%	2.9%

Figure 3
'Ewa Population Trend: 1970 - 1990



Source: U.S. Department of Commerce, Bureau of the Census, 1983 and 1991.

Table 3 contains housing information for the study area. In 1990, 'Ewa had 11,734 housing units. The housing supply continues to be dominated by single-family units which accounted for 82 percent of the total housing stock.

2.5 1990 Profile Of 'Ewa Communities

Preliminary results of the 1990 Census include demographic, household and housing information for Census Designated Places, or CDPs. In the 'Ewa region, this information describes the major 'Ewa communities of 'Ewa Beach, the Naval Air Station at Barbers Point, 'Ewa Gentry, 'Ewa Villages, Iroquois Point Military Family Housing and Makakilo City. A discussion of each community is provided in the following sections, and *Tables 4, 5* and *6* provide additional detail. [6]

2.5.1 'Ewa Beach

'Ewa Beach is the community nearest to Ewa Marina and the largest in the study area. An estimated 14,315 persons lived in 'Ewa Beach. In terms of ethnic distribution, 'Ewa Beach differs from O'ahu proportions by containing more Asians and Pacific Islanders. Almost 73 percent of the residents identified themselves as part of this category, whereas only 63 percent responded similarly islandwide. Caucasians and Blacks were relatively under-represented.

'Ewa Beach has a young population. Its median age of 28.6 years was lower than the islandwide 32.2 years. Proportionally this area has more children and fewer elderly people when compared to O'ahu.

In 1990, there were 3,355 households in 'Ewa Beach, and most of these (88.6 percent) were family households, indicating a higher family orientation than the overall island.

The community's 3,426 housing units are predominantly single-family units, with 85.6 percent in this category. 'Ewa Beach's critical housing problem is evident in its housing vacancy rate which is especially low at 2.1 percent. Further, many of the occupied units are considered crowded, with 32 percent having one or more persons per room. When compared to O'ahu and the other 'Ewa communities, 'Ewa Beach has the largest households with an average of 4.26 persons per household.

Over 69 percent of the housing units are occupied by its owners, which is high compared to O'ahu's 52 percent. Rent is relatively high at $701 a month, although the median value of owner-occupied homes, at $216,900 is lower than O'ahu's $283,600.

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[6] *All information in these tables is from preliminary 1990 Census reports as contained in* *1990 Census of Population and Housing: Summary Population and Housing Characteristics* (April 1991).

Table 3

Demographic and Housing Information for the 'Ewa Development Plan Area, 1990

Resident Population	42,983
Persons Living in Group Quarters	2.7%
Total Households	11,434
1-person	9.5%
2-person	21.7%
Over 2-person	68.8%
Average Household Size	3.66 persons
Total Housing Units	11,734
Types of Units	
Single-family	82.1%
Multi-family	16.4%
Mobile/other	1.5%
Total Vacant Units	300
Market units	46.3%
Usual home elsewhere	5.7%

SOURCE: U.S. Bureau of the Census, 1991, as compiled by the City Department of General Planning, Planning Information Branch

Table 4
Demographic Characteristics of O'ahu and
CDPs in the 'Ewa Development Plan Area, 1990

	O'ahu	Barbers Point	'Ewa Beach	'Ewa Gentry	'Ewa Villages	Iroquois Point	Makakilo City
Total Population	836,231	2,218	14,315	1,992	3,780	4,188	9,828
% Male	50.9%	52.8%	50.9%	51.4%	50.5%	50.9%	51.8%
% Female	49.1%	47.2%	49.1%	48.6%	49.5%	49.1%	48.2%
Ethnicity							
Caucasian	31.6%	75.6%	23.0%	31.3%	8.4%	79.6%	47.1%
Asian/Pacific Islander	63.0%	10.8%	72.6%	64.3%	89.4%	9.6%	46.9%
Black	3.1%	9.6%	1.4%	2.2%	0.2%	7.3%	3.3%
American Indian/Eskimo	0.4%	0.7%	0.3%	0.7%	0.4%	0.9%	0.5%
Other	1.9%	3.3%	2.7%	1.6%	1.6%	2.7%	2.2%
Age							
Less than 5 years	7.4%	19.3%	7.4%	10.0%	6.6%	17.8%	8.3%
5 to 17 years	17.1%	9.6%	23.1%	15.0%	21.2%	24.9%	19.0%
18 to 64 years	64.5%	70.9%	62.9%	72.3%	56.9%	57.0%	69.6%
65 or more years	11.0%	0.2%	6.7%	2.7%	15.2%	0.3%	3.2%
Median Age	32.2	24.7	28.6	28.4	32.4	25.6	29.8

Source: U.S. Bureau of the Census, 1991.

Table 5
Household Characteristics of O'ahu and
CDPs in the 'Ewa Development Plan Area, 1990

	O'ahu	Barbers Point	'Ewa Beach	'Ewa Gentry	'Ewa Villages	Iroquois Point	Makakilo City
Total Population	836,231	2,218	14,315	1,992	3,780	4,188	9,828
Persons Living in Group Quarters	4.1%	3.0%	0.1%	0.0%	0.0%	0.0%	0.0%
Total Households	265,304	854	3,355	708	902	1,174	2,978
Non-Family Households	68,010	171	381	207	101	22	601
Family Households	197,294	683	2,974	501	801	1,152	2,377
As % of total households	74.4%	80.0%	88.6%	70.8%	88.8%	98.1%	79.8%
Married couples	80.3%	90.5%	80.7%	90.6%	79.0%	96.3%	87.5%
Other family householders	14.1%	9.5%	19.3%	9.4%	21.0%	3.7%	12.5%
Persons per Household	3.02	2.52	4.26	2.81	4.19	3.57	3.30

Source: U.S. Bureau of the Census, 1991.

CORRECTION

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

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Total Population	836,231	2,218	14,315	1,992	3,780	4,188	9,828
% Male	50.9%	52.8%	50.9%	51.4%	50.5%	50.9%	51.8%
% Female	49.1%	47.2%	49.1%	48.6%	49.5%	49.1%	48.2%
Ethnicity							
Caucasian	31.6%	75.6%	23.0%	31.3%	8.4%	79.6%	47.1%
Asian/Pacific Islander	63.0%	10.8%	72.6%	64.3%	89.4%	9.6%	46.9%
Black	3.1%	9.6%	1.4%	2.2%	0.2%	7.3%	3.3%
American Indian/Eskimo	0.4%	0.7%	0.3%	0.7%	0.4%	0.9%	0.5%
Other	1.9%	3.3%	2.7%	1.6%	1.6%	2.7%	2.2%
Age							
Less than 5 years	7.4%	19.3%	7.4%	10.0%	6.6%	17.8%	8.3%
5 to 17 years	17.1%	9.6%	23.1%	15.0%	21.2%	24.9%	19.0%
18 to 64 years	64.5%	70.9%	62.9%	72.3%	56.9%	57.0%	69.6%
65 or more years	11.0%	0.2%	6.7%	2.7%	15.2%	0.3%	3.2%
Median Age	32.2	24.7	28.6	28.4	32.4	25.6	29.8

Source: U.S. Bureau of the Census, 1991.

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	O'ahu	Barbers Point	'Ewa Beach	'Ewa Gentry	'Ewa Villages	Iroquois Point	Makakilo City
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Persons Living in Group Quarters	4.1%	3.0%	0.1%	0.0%	0.0%	0.0%	0.0%
Total Households	265,304	854	3,355	708	902	1,174	2,978
Non-Family Households	68,010	171	381	207	101	22	601
Family Households	197,294	683	2,974	501	801	1,152	2,377
As % of total households	74.4%	80.0%	88.6%	70.8%	88.8%	98.1%	79.8%
Married couples	80.3%	90.5%	80.7%	90.6%	79.0%	96.3%	87.5%
Other family householders	14.1%	9.5%	19.3%	9.4%	21.0%	3.7%	12.5%
Persons per Household	3.02	2.52	4.26	2.81	4.19	3.57	3.30

Source: U.S. Bureau of the Census, 1991.

Table 6
Housing Unit Characteristics of O'ahu and CDPs in the 'Ewa Development Plan Area, 1990

	O'ahu	Barbers Point	'Ewa Beach	'Ewa Gentry	'Ewa Villages	Iroquois Point	Makakilo City
Total Housing Units	281,683	866	3,426	752	939	1,180	3,050
Single family	44.9%	49.3%	85.6%	49.7%	94.6%	96.3%	79.1%
Multi-family	53.6%	48.4%	13.0%	48.9%	2.9%	2.6%	19.9%
Mobile/other	1.5%	0.3%	1.4%	1.3%	2.6%	1.1%	1.0%
Total vacant units	5.8%	1.4%	2.1%	5.9%	3.9%	0.5%	2.4%
Total occupied units	265,304	854	3,355	708	902	1,174	2,978
With 1+ persons per room	16.4%	4.8%	31.6%	16.7%	41.8%	4.3%	11.9%
Owner-occupied	52.0%	0.4%	69.1%	79.8%	65.5%	0.6%	73.6%
Renter-occupied	48.0%	99.6%	30.9%	20.2%	34.5%	99.4%	26.4%
Median cash rent	$615	$644	$701	$907	$100	$758	$960
Median value of owner-occupied units (*)	$283,600	$275,000	$216,900	$277,600	$116,500	$125,000	$246,600

** Median values are for non-condominium housing units.*
Source: U.S. Bureau of the Census, 1991.

2.5.2 The Naval Air Station At Barbers Point (NASBP)

'Ewa Marina is bounded on the western side by the Naval Air Station at Barbers Point (NASBP). An estimated 2,218 persons live on this military installation and almost 53 percent are male. Three-fourths of the population is Caucasian which is significantly high compared to O'ahu and the other 'Ewa communities.

This is the youngest of all the 'Ewa communities, with a median age 24.7 years. Predominant age groups are children under five years of age and those in the labor force age category of 18 to 64 years. This is a characteristic consistent with an armed forces community comprising mostly young married couples. Three percent of NASBP residents live in barracks.

Reflecting high family-orientation, 80 percent of the total households are family households, and a significantly high 90 percent of these families have married couples. NASBP has the smallest households in 'Ewa with an average of 2.52 persons.

In 1990, NASBP had 866 housing units and 1.4 percent of these were vacant. Crowding in individual housing units is not an issue. As may be expected, virtually all of the units are rented, and the median cash rent is $644 per month.

2.5.3 'Ewa Gentry

Located north of the project site, 'Ewa Gentry is the newest community for which CDP information is available. This community was the smallest in 1990, with a population of 1,992, though it is one that is continuously growing as more new houses are completed.

Of all of the 'Ewa communities, 'Ewa Gentry most resembles the islandwide ethnic distribution with 64 percent Asian/Pacific Islanders and 31 percent Caucasian.

'Ewa Gentry's age characteristics are consistent with the development's market. The housing mix and price range in this project give young couples an opportunity to own their first home, as well as provides choices for more mature families wishing to move up in the housing market. The proportion of children under five (ten percent) is higher than the islandwide and 'Ewa non-military communities, and the working force age group is over-represented at 72 percent. Further, the elderly population is significantly low at only 2.7 percent. The median age is 28.4 years.

Of the 708 households, 71 percent are family households and most of these contain married couples. The household size of 2.81 persons is among the lowest of the 'Ewa communities, and lower than the islandwide average.

The housing stock is roughly divided between single-family (49.7 percent) and multi-family (48.9 percent) units. About six percent of the total units were vacant at the time of the 1990 Census.

'Ewa Gentry has the highest proportion of owner-occupied units, with almost 80 percent in this category. The median value of owner-occupied units was the highest of the 'Ewa communities at $277,600, but still lower than the islandwide median.

2.5.4 'Ewa Villages

'Ewa Villages is also located north of the Ewa Marina project site. An estimated 3,780 people lived in this community in 1990.

'Ewa Villages is a community in transition. It comprises a number of former plantation villages, and the City has initiated redevelopment efforts. Many of the residents have ties with the former sugar operations and this is reflected in the significantly high proportion of Asians and Pacific Islanders (89 percent). Also, this community is the oldest in this region, with a median age of 32.4 years. 'Ewa Villages has the highest proportion of elderly people (15.2 percent), and the lowest proportions of children under five years of age (6.6 percent) and those aged 18 to 64 years of age (57 percent).

Like 'Ewa Beach, 'Ewa Villages has a high family-orientation. Almost 89 percent of the 902 households are family households, and 79 percent of these contain married couples. This community has a significantly large average household size at 4.19 persons.

The housing stock is predominantly single-family units (95 percent). 'Ewa Villages' housing vacancy rate of 3.9 percent is among the highest in the region, but still lower than the O'ahu-wide rate. Of the occupied units, there is a high crowding rate with 41.8 percent of the units having one or more persons per room.

This community has the least expensive housing. The median cash rent is around $100 per month, and the median value of owner-occupied units is $116,500.

2.5.5 Iroquois Point Puuloa Military Family Housing

The Iroquois Point Puuloa (IPP) Military Family Housing is located to the east of 'Ewa Beach. The military community was home to 4,188 persons in 1990.

The IPP Military Family Housing has age characteristics similar to NASBP. Its predominant ethnic group was Caucasian (80 percent), and its residents are young with a median age of 25.6 years.

This community is the most family-oriented in 'Ewa. Over 98 percent of its 1,174 households are family households, and 96 percent have married couples. Its average household size of 3.57 persons is among the highest in 'Ewa.

Most of the houses are single-family units (96 percent), and this community boasts the lowest vacancy rate of 0.5 percent. This community also has the least amount of crowding.

Rent averages at $758 a month, and the median value of owner-occupied units is low by 'Ewa and O'ahu standards at $125,000.

2.5.6 Makakilo City

Makakilo, located northwest of the project site , is the only 'Ewa community mauka of the H-1 Freeway. It is also the second largest community in 'Ewa with an estimated population of 9,828 persons in 1990. There is roughly the same number of Caucasians as Asians and Pacific Islanders (both 47 percent). In terms of age characteristics, Makakilo's proportions generally match islandwide proportions except for a much smaller elderly population (3.2 percent) . Hence, the community has a median age (32.2 years) which is lower than that of O'ahu.

Almost 80 percent of the total 2,978 households in Makakilo are family households, 87 percent of which contain married couples. The average household size of 3.3 persons.

Single-family units are the predominant form of housing in Makakilo; 79 percent of the total 3,050 units are single-family units. There was a vacancy rate of 2.4 percent in 1990.

Almost three-fourths of the homes are occupied by their owners, and the median value of these homes is relatively high at $246,600. At $960, the median monthly rent is the highest of all of the 'Ewa communities and exceeds the islandwide median by $345.

2.6 Summary Of Study Area Characteristics

The 'Ewa region's primary employment generator in 1985 was military activity. Military jobs were the largest category, with about 39 percent of the total 11,121 region jobs held in 'Ewa. Service jobs were the next largest category; 16 percent of the total jobs were service-related. About half of the jobs in the 'Ewa region were located at the NASBP, which is adjacent to Ewa Marina.

The 'Ewa region experienced population growth double the O'ahu rates over the past twenty years. 'Ewa's population has grown from 24,087 persons in 1970, to 38,324 in 1980 to 42,983 in 1990. This means that the area grew 4.2 percent a year in the 1970s, and 1.7 a year in the 1980s. These rates are about double the islandwide rates. From 1970 to 1980, O'ahu's population grew at an average rate of 1.9 percent, and the islandwide rate dropped to slightly less than one percent from 1980 to 1990.

In 1990, 'Ewa had 11,734 housing units. Unlike the islandwide steady increase of multi-family units, 'Ewa's housing supply continues to be dominated by single-family units which accounted for 82 percent of the total housing stock. The highest proportion of single-family units is found in 'Ewa Villages where 95 percent are in that category. 'Ewa Beach, the community adjacent to the eastern portion of the project, also contains a high proportion, with 85 percent of its housing stock being single-family units.

Though the 1990 median values of owner-occupied homes were lower in 'Ewa when compared to islandwide statistics, median rent exceeded the O'ahu median. Median values ranged from a low of $116,500 in 'Ewa Villages to a high of $277,600 in 'Ewa Gentry; these communities are adjacent to each other. The O'ahu median home value was $283,600.

The highest rents were found in the relatively newer communities of Makakilo and 'Ewa Gentry, where respective monthly rents of $960 and $901 exceeded the islandwide median by about $300.

In spite of these high rents, however, 'Ewa region homes were sought after, as indicated by very low vacancy rates. Whereas O'ahu has a total vacancy rate of 5.8 percent, 'Ewa Beach and Makakilo had rates at less half the islandwide figure, with 2.1 and 2.4 percent, respectively. The military communities had especially low vacancies with 1.4 percent for NASBP and 0.5 percent for IPP Military Family Housing.

Demographic and household characteristics are summarized as follows:

1. **Ethnicity and Age.**

   The older communities in 'Ewa retains a few distinctions from the O'ahu averages when it comes to ethnicity. 'Ewa Villages and 'Ewa Beach are well-represented in Asians and Pacific Islanders with 89 and 73 percent, respectively, are in this category. NASBP and IPP Military Family Housing have significantly high proportions of Caucasians (76 and 80 percent, respectively). 'Ewa Gentry, the area's newest community, has ethnic proportions similar to O'ahu.

   'Ewa region communities tend to be slightly younger than the O'ahu-wide community. The military communities are the youngest. NASBP has a median age of 24.7 years; IPP, 25.6 years. With a median age of 32.4 years, 'Ewa Village is the only community which exceeds the islandwide median age (32.2 years).

2. **Family Households.**

   In 1990, 74 percent of O'ahu's total households were family households. Most of 'Ewa's communities exceeded this proportion. The highest proportion of family households was found in IPP Military Family Housing (98.1 percent), followed by 'Ewa Villages (88.8 percent) and 'Ewa Beach (88.6 percent). 'Ewa Gentry was the only community with a proportion lower than that of the island, with only 71 percent of its households being family households.

3. **Household Size.**

   'Ewa has traditionally had larger-than-average households, and the 1990 Census reveals a continuation of this trend in the region's older communities. The largest households were found in 'Ewa Beach (4.26 persons) and 'Ewa Villages (4.19 persons). The households in both communities contained 1+ more person than the average islandwide household of 3.02 persons. The only community with households smaller than the islandwide average was 'Ewa Gentry, with an average household size of 2.81 persons.

3. No-project Scenario

Ewa Marina is being proposed as part of region in transition. Public policies to create a secondary urban center is the major impetus for shaping the future of 'Ewa. This section examines both public policies and proposed changes to understand what is anticipated to occur in 'Ewa independent of the proposed project.

Section 3.1 describes public policies for 'Ewa, and identifies proposed amendments to the 'Ewa Development Plan. Section 3.2 provides an overview of the projects which will help shape the secondary urban center. In Section 3.3, a description of a likely scenario *without* Ewa Marina is provided.

3.1 Direction Outlined In General And Development Plan Policies

The City and County of Honolulu General Plan encourages the development within the secondary urban center at Kapolei and the 'Ewa and Central Oahu urban-fringe areas to relieve developmental pressures in the remaining urban-fringe and rural areas and to meet housing needs not readily provided in the primary urban center.

Consistent with this policy is the General Plan's residential population distribution for the year 2010. As shown in *Table 7*, 'Ewa is targeted to accommodate 12 to 13.3 percent of the total islandwide population. These proportions translate to a range of 119,940 to 132,934 persons in 'Ewa.

The project site lies within 'Ewa's urban-fringe area. The City and County of Honolulu General Plan targets such urban-fringe areas as "desirable places to live," and the following objective and associated policies[7] are intended to meet this intent:

> *Physical Development and Urban Design Objective D* -- To maintain those development characteristics in the urban-fringe and rural areas which make them desirable places to live.
>
> > *Policy 1* -- Develop and maintain urban-fringe areas as predominantly residential areas characterized by generally low rise, low-density development which may include significant levels of retail and service commercial uses as well as satellite institutional and public uses geared to serving the needs of the households.
> >
> > *Policy 2* -- Coordinate plans for developments within the 'Ewa and Central O'ahu urban-fringe areas with the State and Federal governments and with the sugar, pineapple, and other emerging agricultural industries.

[7] *From Resolution No. 88-404, CD-1, FD-1, January 19, 1989, amending the General Plan.*

Table 7
Population Projections by Development Plan Area, 2010

	General Plan Distribution of Residential Population (1)	2010 Population Range Based on Series M-K Projections (2)
Primary Urban Center	45.1% - 49.8%	450,774 - 497,751
Ewa	12.0% - 13.3%	119,940 - 132,934
Central Oahu	14.9% - 16.5%	148,926 - 164,917
East Honolulu	5.3% - 5.8%	52,974 - 57,971
Koolaupoko	11.0% - 12.2%	109,945 - 121,939
Koolauloa	1.3% - 1.4%	12,994 - 13,993
North Shore	1.6% - 1.8%	15,992 - 17,991
Waianae	3.8% - 4.2%	37,981 - 41,979
Total Oahu	95.0% - 105.0%	949,525 - 1,049,475

Notes:

(1) City Council, "Resolution Relating to Amending the General Plan of the City and County of Honolulu, No. 88-404, Cd-1, FD-1"

(2) DBED M-K Population Projections estimate a population of 999,500 persons for the City and County of Honolulu in 2010

Policy 3 – Establish a green belt in the 'Ewa and Central O'ahu areas of Oahu in the Development Plans.

In December 1991, the Honolulu City Council passed a General Plan resolution to "encourage the development of a major marina and associated maritime commercial center, including visitor units as part of the Ewa Marina community." [8]

The current 'Ewa Development Plan designates Ewa Marina Phase 1 as the *Ewa Marina Special Area*. This area excludes Phase 2, and is to contain "a mixture of Residential, Low Density Apartment, Medium Density Apartment, Commercial, Public Facility (including a marina), park and Preservation (waterway and flood control areas)." [9]

Recently three proposed amendments to the 'Ewa Development Plan Land Use Map were approved by the City Council, but were vetoed by the City administration. These projects include (1) Ewa Marina Commercial-Industrial Mixed Use Area; (2) Ewa Marina Golf Course; and (3) a portion of the Kapolei Industrial Park. A bill to amend the Special Provisions for the 'Ewa Development Plan to include Ewa Marina Phase 2 was also vetoed. As of this writing, it is possible that the City Council may re-initiate these projects.

3.2 Major Development Proposals In The Study Area

As the major landowner in 'Ewa, the Estate of James Campbell has taken the lead in preparing the master plan for this region. The first 'Ewa Master Plan was prepared in 1955 and revised in the early 1960s. In a 1974 update of this plan, the concept of a self-contained city began to evolve. The planning firm of Helber, Hastert & Kimura, Planners prepared an update of this plan in 1984, and identified a major "City Center" located between Makakilo, Campbell Industrial Park and NASBP.

In 1986, the Honolulu City Council subsequently amended the 'Ewa Development Plan to adopt the Estate's Master Plan land use pattern in the "City Center" area. After the Estate commissioned a detailed implementation plan for the 890-acre City Center, then re-named Kapolei, the State Land Use Commission granted incremental approval of a 135-acres "First Increment" in mid-1988. [10] The most recent master plan for this region was prepared in March, 1991. Note that, as with all long-range plans, the plan represents a process which is in constant flux in that it anticipates and reacts to economic, social, environmental and political forces. The following summarizes the development projects recently completed and anticipated for the 'Ewa region, beginning with the projects closest to Ewa Marina. [11]

8 *Honolulu City Council, 1991.*
9 *Development Plan Special Provisions for 'Ewa, Ordinance No. 81-90, as amended by Ord. Nos. 83-26, 84-57, 85-61, 87-123, 89-16.*
10 *Helber, Hastert and Kimura, Planners, 1989.*
11 *Except where otherwise indicated, information is from the "Kapolei/Ewa Project Update: Third Quarter 1991," as prepared by the Estate of James Campbell.*

- **Laulani/Fairways.** The City and County of Honolulu proposes to develop this residential community near the northern boundary of Ewa Marina. The 301-acre project site is located on both sides of Fort Weaver Road. Approximately 1,825 dwellings are proposed in residential and apartment settings; 60 percent will be priced in the affordable range. [12]

- **Ewa by Gentry.** Gentry Development Co., has planned 7,500 homes for an area north of the project site. About half of the homes will be single-family dwellings and half multi-family dwellings, all ranging from low to moderate in price. Three neighborhoods have been completed, including Soda Creek, with 450 units, and two multi-family projects, Palm Court and Palm Villas, with 562 units. Approximately 600 units are scheduled for delivery in 1991, with 1,000+ in 1992. By the end of 1992, 2,600 of the 7,500 homes are expected to be completed. The newest neighborhood under construction is The Arbors, a low-rise condominium development which includes a recreation center, pool, cabana, and a meeting room.

- **Ewa Villages.** The City and County of Honolulu has prepared a master plan to revitalize the 'Ewa Villages (Renton, Tenny, and Varona Villages), provide new housing, and create economic development opportunities. The total area of the project encompasses 606 acres. According to the plan, 273 existing housing units will be rehabilitated and 957 new housing units will be constructed. A commercial mixed-use area will also be developed. [13]

- **West Loch Estates.** The City and County of Honolulu has planned a development of 1,500 homes on 520 acres at West Loch on Pearl Harbor. The project includes 60 percent affordable homes and 40 percent market-priced homes. Delivery of the first phase of 593 homes was completed at the end of December, 1990. The second phase includes 718 single-family homes, 136 affordable multi-family homes, 150 elderly and three special needs units, with first delivery scheduled for December, 1991. A golf course was completed in mid-1990.

- **Honouliuli Redevelopment.** The City and County of Honolulu also proposes to redevelop a 46-acre site west of West Loch golf course. This project includes between 431 and 676 townhouse units, 60 percent of which will be affordably priced. [14]

- **The City of Kapolei, the Kapolei Shopping Center, and Campbell Square.** Located northeast of the project site and encompassing approximately 890 acres, the City of Kapolei is the nucleus of the master-planned community. It will evolve over time to include several million square feet of office and

12 *City Department of Housing and Community Development, 1991.*
13 *City Department of Housing and Community Development, 1991.*
14 *From Attachment A of 'Ewa Neighborhood Board minutes of March 14, 1991 meeting*

retail space and several thousand residential housing units. In addition, the State and the City and County of Honolulu are committed to locating offices and services in Kapolei.

Phase I will include zoning for 135 acres, and several buildings are expected to be under construction in 1991, with completion scheduled for 1993. A focal point of the City will be the 73-acre Kapolei Regional Park.

Kapolei Shopping Center is currently under construction. The 140,000 square-foot first phase is 98 percent pre-leased. A second phase, including another 100,000 square feet of retail space, is also planned.

Campbell Square, Kapolei's first office complex, will include two buildings totalling 125,000 square feet of office space.

- **Ko Olina Resort.** This resort along two miles of beachfront encompasses 1,000 acres, or twice the land area of Waikiki, and is anticipated to be one-third its density. Now under construction on 640 acres, the first phase includes 4,000 hotel rooms, 5,200 residences, a golf course, and a shopping center. A second phase may include another 3,500 residences and another golf course.

- **Kapolei Business Park.** Situated on 800 acres, this new business park is located between James Campbell Industrial Park and the City of Kapolei. Lots are scheduled to become available in 1992. It is anticipated that the park will be developed for light industrial and maritime-related uses.

- **Makakilo Expansion.** The development of Makakilo is more than half completed, with more than 10,000 residents living in 3,000 homes ranging in price throughout the market price spectrum. Approximately 2,800 additional homes are planned. Recently, the developer received zoning and land use approval for 2,800 additional units, and a new bridge over Palailai Gulch was completed. Groundbreaking for a golf course scheduled for completion in late 1992.

- **Villages of Kapolei.** In partnership with private developers, the State of Hawaii will develop 5,000 homes in this master planned residential community. Upon completion, the Villages of Kapolei will include a full range of schools, churches, and commercial services. In addition, plans include a public golf course, parks, and swimming pools. Under agreement with the State Housing Finance and Development Corporation, 60 percent of the homes must be sold at affordable rates, while 40 percent may sell at market prices set by the developer.

  Kumu Iki, the initial 71-acre phase, is under construction; model homes are open, and some units are occupied. Groundbreaking for the 296-unit Village III, Malanai, was held in 1990, with delivery of the first homes targeted for March, 1992.

- **Kapolei Knolls.** Approximately 500 three- and four-bedroom homes are planned for this residential development. The project has received State Land Use and City and County Development Plan urban designation. An application for a zoning change was submitted in early 1990.

- **East Kapolei.** The State Board of Land and Natural Resources proposes to acquire 2,284 acres, located in the eastern portion of the 'Ewa Plain, from the Estate of James Campbell. The State intends to reserve this land for future uses and no changes will be made to the existing land uses at this time. The land is currently in sugar cane cultivation; the State will lease the land to Oahu Sugar Company to allow continued agriculture.[15]

  Consistent with this proposal, the State has negotiated a $110 million agreement to acquire 1,283 acres in 'Ewa for future housing development. This includes 1,100 acres of land east of the Villages of Kapolei currently under sugar cane cultivation, 124 acres along the shoreline at Campbell Industrial Park currently being used as a cattle feedlot, and 59 acres that constitute Hawaii Raceway Park.

3.3 Likely Scenario Without Ewa Marina

As indicated in Sections 3.1 and 3.2, the 'Ewa Development Plan area is targeted for major growth and numerous projects are paving the way to achieve the objectives for a secondary urban center.

Without Ewa Marina, the following scenario is likely to occur:

1. **Significant increase in residential population.**

   The target population for 'Ewa is between 119,940 to 132,934 persons in 2010. As *Table 8* indicates, this population projection implies an increase of between 77,000 and 90,000 people over the next twenty years, or between 79 and 109 percent. On the average, the annual growth rate would be between three and 3.8 percent.

2. **Significant increase and diversity in employment.**

   Market study projections estimate that job opportunities within the planning region are projected to increase about 600 percent over a twenty year period (Leventhal, 1986). Whereas the major job-generators in 'Ewa are military and service in nature, the future employment sources will likely resemble a cross-section of the islandwide proportions.

[15] *R. M. Towill Corporation, 1990.*

Table 8

Population Changes Anticipated in 'Ewa: 2010

	Actual	High	Low
1990 Population (1)	42,983		
Population Range Targeted in the General Plan		132,934	119,940
Increase Over 1990		89,951	76,957
Percent Increase		109%	79%
Average Annual Increase		3.8%	3.0%

Notes:

(1) U.S. Department of Commerce, Bureau of the Census, 1991.

3. **Establishment of city-related mixed uses and secondary urban center in "western" 'Ewa.**

   Kapolei City, Ko Olina and the James Campbell Industrial Park, all situated in the western half of the 'Ewa region, are major employment generators -- which essentially create the city-like environment in the "secondary urban center," as defined by the City and County of Honolulu General Plan. The nearby residential communities include the Kapolei Villages, Makakilo, Honokai Hale/Nanakai Gardens and Maka'iwa Hills.

4. **Intensification of residential uses in eastern 'Ewa.**

   The City and County of Honolulu General Plan designates the eastern half of 'Ewa, generally the area along Fort Weaver Road, as 'Ewa's urban-fringe and this area is intended primarily for residences. As discussed in Section 3.1, the major exception to this policy is the Ewa Marina Community.

5. **Retention of military uses.**

   The NASBP and the IPP Military Family Housing will likely continue their operations.

6. **Land banking in eastern 'Ewa.**

   The State is reserving over 2,000 acres in eastern 'Ewa for future uses.

4. POTENTIAL SOCIAL IMPACTS OF EWA MARINA

This section identifies potential social impacts related to the Ewa Marina. Section 5.1 identifies resident and visitor population impacts. Section 5.2 presents employment impacts and includes a discussion about visitor industry related employment. Section 5.3 describes the project effects of changing the land use pattern in 'Ewa.

In Section 5.4, impacts of specific project components, including the residential component, the marina and its support facilities, the Mixed-Use Commercial Complex, and the golf course, are discussed. Section 5.5 explores impacts on nearshore and shoreline ocean recreation activities.

Public facilities and services are discussed in Section 5.6. Included in this sub-section are police and fire protection, recreational facilities, public educational facilities, child care and hospitals and emergency facilities.

4.1 Population Impacts

4.1.1 Resident Population

Ewa Marina will contain 4,850 homes. Based on a household size of 2.8 persons per household, the project would directly add an estimated population of 13,580 persons at full build-out in 2010.[16]

The General Plan population projection for 'Ewa in 2010 range from 119,940 to 132,934. This means that the future Ewa Marina residents would account for eleven to twelve percent of the 'Ewa region population in 2010.

Ewa Marina is not expected cause any indirect population increase. In some instances, a project would indirectly increase an area's population by requiring in-migration to fill jobs. Areas such as Kona and Maui are good examples whereby out-of-area people are needed to fill jobs because of an extremely low unemployment rate. In 'Ewa, however, it is expected that the labor force will be sufficient to satisfy employment needs. Public policy actually encourages job-generating uses in 'Ewa, and it is anticipated that the planned residential units will attract people to live in 'Ewa and thus increase the labor force.

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16 A household size of 2.8 persons reflects the trend towards smaller households. Even though 'Ewa currently has larger-than-average households, it is expected that this trend will change as development continues. Further, the Ewa Marina housing mix will be predominantly zero-lot-line single-family units to mid-rise apartments, which implies smaller households.

4.1.2 Visitor Population

Two types of visitor accommodations will support the marina activities. Hotel units will provide visitors with typical hotel services, such as room service and a concierge; 900 hotel units are planned for Ewa Marina. Hotel garden suites would be an alternative for visitors who prefer a more home-like atmosphere and 600 such suites will be available at Ewa Marina.

It has been estimated that, at 80 percent occupancy, the hotel units would generate a visitor population of 1,300 persons. The hotel garden suites would generate 900 visitors based on 75 percent occupancy.[17] In total, the daily average visitor census would be 2,200 visitors.

The average statewide visitor census is estimated at 264,000 for 2010. O'ahu's share is projected at 113,000 daily visitors.[18] Ewa Marina's visitors would account for 0.8 percent of the statewide daily census, and 1.9 percent of the O'ahu total.

4.2 Employment

4.2.1 Employment

Construction of Ewa Marina is expected to occur over a period of 15 years. Marina construction would be the initial activity, and this may occur between late 1992 and 1994. Upon completion of the marina, construction of the residential component will begin; a 15-year construction period is expected. Concurrently the maritime commercial center will be constructed, and this is expected to take twelve years. It is expected that these construction activities will annually generate 900 construction jobs.

In terms of long-term operational employment, Ewa Marina's Mixed Use Commercial Complex in Phase 2 will be a major source of jobs. A total of 2,230 jobs are expected to be generated by Phase 2. On-site visitor accommodations will be the largest employment generator, with 1,500 jobs. The other jobs will be generated by the commercial complex (510 jobs), the International Fitness Promotion Center (60 jobs), the yacht club (40 jobs), the golf course and clubhouse (70 jobs) and the tennis complex (50 jobs).[19]

The marina and housing components of Phase 1 will generate far fewer jobs, but will nevertheless create jobs in harbor support, park maintenance, landscaping, security and maintenance. Hence, the total project would generate over 2,300 long-term and permanent jobs.

17 *Based on 1.8 visitors per hotel room and two visitors per garden suite; provided by Decisions Analysts (1989).*
18 *Hawai'i State Department of Business and Economic Development, Population and Economic Projections for the State of Hawaii to 2010 (Series M-K), November 1988.*
19 *Decisions Analysts Hawaii, Inc., 1989.*

4.2.2 Implications of Visitor Industry Employment

Although the nearby slow-paced communities will likely to have evolved into a more active, diverse and urban environment as Ewa Marina is built, the *existing context* for this project is this relatively rural neighborhood. Because of this current situation, and the introduction of visitor accommodations, this social impact assessment discusses employment-related issues common to recent developments of large luxury hotel/resorts in non-urban or urban fringe areas. This discussion is intended to stimulate awareness of potential community issues related to the urban uses of Ewa Marina.

This study looks at community issues found in four visitor areas, as follows:

First-time Employment Opportunities For Many Women: Mauna Kea -- The opening of the Mauna Kea in 1965 created first-time employment opportunities for many women living in North Kohala. The entry of women into the provider role within their families and their enhanced self-esteem threatened some marriages.[20]

> *Implications for 'Ewa Marina* -- In 1980, the 'Ewa region had a high potential female participation rate in the labor force and a high unemployment rate for females.[21] With or without the proposed project, and considering the major employment targeted for the 'Ewa area, the 'Ewa communities may experience social problems similar to that of South Kohala in the 1970s.
>
> Two factors offset this possibility, however. First, the Mauna Kea hotel was the only major alternative employment in 1960 to the area's faltering sugar industry. That is not the case with 'Ewa, where residents have access to islandwide employment and women who choose to work may easily commute to other parts of the island. Second, the census data is dated, and women have increasingly entered the labor force in the 1980s. Hence, 1990 Census information will be a more accurate portrayal of the current proportion of women in the work force.[22]

Hawaii-born Versus In-migrants For Management Positions: Mauna Lani -- Although management personnel at Mauna Lani were initially mostly in-migrants from the mainland or off-island, the hotel has found that Hawaii-born employees (65 percent of total) are stable workers adding Hawaiian ambience and more inclined to be career oriented (55 percent in management positions).[23]

> *Implications for Ewa Marina* -- Job opportunities proposed by 'Ewa Marina will likely be welcomed. This support may be tempered, however, if 'Ewa residents observe that out-of-area residents are being hired for the higher-paying positions. The current low unemployment rate and labor shortage may contribute to pressures

20 *Cottington, 1969.*
21 *U.S. Department of Commerce, Bureau of the Census, 1983.*
22 *As of this writing, this information is unavailable.*
23 *Community Resources, 1987.*

to hire non-residents. Although the developer cannot guarantee jobs to a specific geographic community, developer-sponsored or participation in job training programs would help nearby residents qualify for these jobs.

Ethnicity-based Competition for Jobs: Kuilima -- When the Kuilima Resort was expanding, positions were sought by many Pacific Islanders, immigrants, part-Hawaiians and Filipinos in the area as well as other immigrant groups outside the area. Disputes over perceived favoritism along ethnic lines emerged, and recently unemployed Kahuku Sugar Plantation workers were concerned about non-local residents getting jobs.[24]

Implications for Ewa Marina -- Both the Ko'olauloa and 'Ewa regions share similarities with relatively few and large ethnic groups. It is expected, however, that by the time the proposed project is implemented, 'Ewa will have begun to reflect more of a cross-section of the islandwide community. Residents of 'Ewa Beach will already have experienced a diversity of new residents from nearby residential developments. The preliminary 1990 Census already indicates that the nearby 'Ewa Gentry community has brought people with characteristics similar to the islandwide community. It is therefore highly unlikely that the proposed project will cause ethnic-based job competition similar to Kuilima.

Rapid Exposure To In-migrants In The Workplace: Lana'i -- Lana'i residents undergoing a transition from a homogenous pineapple plantation to a more cosmopolitan resort community are showing signs of stress from such a rapid adaptation. Though developers expressed concern that local residents become part of the work-force, the rapid exposure to in-migrants during the construction phase manifested negative reactions by residents through family problems, excessive drinking and drug use. Castle and Cooke commissioned a study by the University of Hawai'i School of Social Work to address such social problems. Findings show that, although there is general support for resort development on the island, the perceived costs are increased crime, decreased family values and cohesion, decreased community values and cohesions, and increased financial problems.[25]

Implications for Ewa Marina -- Ewa Marina differs from the Lana'i resort in terms of source of change and isolation. Whereas the Lana'i Development Company is the major source of change for Lana'i, Ewa Marina is only one of the many proposed developments in the 'Ewa region. Further, the 'Ewa region already has access to employment and social activities in other parts of O'ahu and is not geographically or socially isolated.

The common thread of difference between the proposed project and these other resort developments is that 'Ewa is programmed to be a secondary urban center, with major employment centers to alleviate pressures on primary urban center. Hence, cultural and population diversification, in-migration of non-'Ewa residents and the loss of rural qualities

24 *Community Resources, 1984.*
25 *University of Hawai'i School of Social Work, 1990.*

will occur without Ewa Marina. Ewa Marina therefore will not be the major source of change, nor will it dictate the pace of change for the region.

4.3 Change In Land Use Pattern In 'Ewa

The eastern half of 'Ewa, generally the area along both sides of Fort Weaver Road, is intended primarily for residences. West Loch, 'Ewa Gentry and Laulani/Fairways would result in a strong suburban character, with all other uses established to serve the nearby residents. These other uses include three commercial areas (existing at 'Ewa Beach, and planned at 'Ewa Gentry and West Loch), public facilities and golf courses.

While the residential component of Ewa Marina would contribute to this suburban character, the other components would essentially change this land use pattern by introducing a commercial center and visitor-related activities to 'Ewa's eastern suburban community. The proposed project would therefore create an urban center in the midst of predominantly residential uses. Although Ewa Marina would be at a much smaller scale than the City of Kapolei, the proposed project would essentially serve as an urban center for the eastern half of the 'Ewa region. The effects of this change in land use pattern are as follows:

1. **The project would be the major employment generator of the eastern half of the 'Ewa region.**

   Ewa Marina would create over 2,300 jobs in this area. No other projects in the eastern half of 'Ewa are expected to achieve this magnitude of employment.

2. **Existing residents will have a major job site in proximity to their residences.**

   Most of the existing residents must commute to other parts of O'ahu to work. The proposed project will introduce employment in the eastern half of 'Ewa, which will add convenience and decreased commuting time for existing residents who choose to work at Ewa Marina.

3. **The Mixed-Use Commercial Complex will provide additional shopping and service convenience to existing residents.**

   The proposed project will increase the area's commercial amenities and therefore decrease dependency on facilities in the western half of 'Ewa. Competition with existing commercial facilities at 'Ewa Beach is also possible, however, and it is recommended that HASEKO (Hawaii), Inc. work with the community to identify desired commercial uses.

4. **By creating another urban center, the project will help nearby residents in justifying increased public services and facilities.**

Currently, major public facilities are being planned for the western half of the 'Ewa region, particularly in the City of Kapolei. While some facilities are being planned for the eastern portion of 'Ewa, these facilities will be designed to serve residential uses, which imply a smaller scale than the urban-oriented facilities in the City of Kapolei.

Ewa Marina will likely result in a greater need for public services and facilities, such as increased police protection, because of the intensification of land uses and people activities. Such increased requirements could potentially strain the public service system and compete with residential needs. On the other hand, the proposed project will also help nearby residents in justifying higher levels of public services and facilities. The rest of the community will, in turn, have direct access to these upgraded public services and facilities.

5. **The proposed project will be consistent with recently-approved policies of the City and County of Honolulu General Plan.**

The City and County of Honolulu General Plan sets forth a policy to develop and maintain urban-fringe areas as predominantly residential areas characterized by generally low rise, low-density development. Allowable development includes significant levels of retail and service commercial uses as well as satellite institutional and public uses geared to serving the needs of the households. For the most part, the eastern half of the 'Ewa Plain is in the Urban-Fringe area.

The Ewa Marina project site is in the Urban-Fringe area, but separate General Plan policies guide the development of the project site. In December 1991, the Honolulu City Council passed a General Plan resolution "to encourage the development of a major maina and associated maritime commercial center including visitor units as part of the Ewa Marina community." 26

6. **Ewa Marina will result in two areas offering visitor accommodations and facilities in the 'Ewa region.**

Current Development Plan policies call for the West Beach Special Area to serve as a water-oriented residential and resort community, which is known as Ko Olina. This area is identified as "a secondary resort destination area containing up to 4,000 visitor units within the areas designated for Resort use."

Ewa Marina will add another self-contained visitor destination to the 'Ewa region.

26 *Honolulu City Council, 1991.*

These two visitor destinations would be located at the westernmost (Ko Olina) and eastern (Ewa Marina) ends of the 'Ewa region. Although both will be operate separately and cater to different market segments, a potential effect of these non-contiguous and distant visitor destinations is the independent creation of visitor-related facilities linking the two destinations. In the future, other developers may propose additional visitor units near Ko Olina and Ewa Marina, the long-term effect of which would be "strip" hotel development along major thoroughfares.

From a land use and planning standpoint, this sprawling effect would be highly undesirable. Major planning effort has been made to achieve orderly and manageable development in the 'Ewa region. To avoid this type of arbitrary resort development, public officials will need to establish and uphold planning policies prohibiting such development.

Note that, with the presence of Ko Olina, the possibility of independent hotel and resort development still exists and, thus, this situation could occur with or without Ewa Marina.

4.4 Regional Impacts Of Specific Project Components

4.4.1 Probable Non-project Changes

Section 3 presents the General Plan target population range of 119,940 to 132,934 persons in 2010. This population increase implies that the current proposals for residential growth could accommodate a population two times that of the 1990 population.

As Ewa Marina is being built, the existing community will already be undergoing a gradual adaptation to this major influx of new people. Some of the changes which may have occurred prior to project implementation are as follows:

1. **Continued creation of distinct, new communities.**

Until very recently, 'Ewa's communities comprised 'Ewa Beach, the 'Ewa Villages, Makakilo, Honokai Hale/Nanakai Gardens, and the military communities of NASBP and Iroquois Point/Pu'uloa Military Housing. With the development of the secondary urban center, three new communities have already emerged: Kapolei, West Loch, and Ewa by Gentry.

2. **Effort to retain identity/characteristics of existing communities.**

The existing communities will likely want to retain some characteristics which distinguishes them from the newer communities. Many residents will most likely want to see established family and social ties, as well as community organizations, continue. While existing residents may welcome new residents and their contributions, 'Ewa residents will be likely to resist having their current social structures dominated by or precluded by newcomers.

3. **Evolution of 'Ewa's regional identity.**

As these new communities emerge, 'Ewa's regional identity will probably change. Formerly, the pockets of communities in the 'Ewa region operated mostly independent of each other; events have been community- and neighborhood-centered, rather than regional in nature. Such a situation occurred because of geographical distances between the communities, as well as different community ties and backgrounds.

Regional interaction between the communities has been facilitated mostly by the Neighborhood Board, and 'Ewa residents further interacted in churches, social events, and in the intermediate and high schools.

While this community-centered pattern will probably continue, there may also be increased efforts to deal with the larger 'Ewa region, as new communities become part of 'Ewa. In a sense, the distance between the communities is "lessening" and interaction between long-time and newer residents is more likely as people shop at stores, attend schools and churches and play at parks. 'Ewa residents may increase efforts to establish and work towards goals and on issues common to all of the communities to effectively solve problems.

4. **Population and cultural diversification.**

When compared to the islandwide community, the existing 'Ewa community tends to be slightly younger, and contain significantly higher proportions of Caucasians and Filipinos, as indicated in the 1990 Census. The 1980 Census indicated that 'Ewa had proportionally (1) fewer people born in Hawai'i, (2) more people born in other parts of the United States, and (3) slightly less foreign-born residents. Residents of 'Ewa tended to be less educated than the islandwide community, and the mean family income was lower.[27]

Without the Ewa Marina project, the residential profile of the 'Ewa area, including the eastern half, will have begun to reflect more of a cross-section of the islandwide community. Residents of 'Ewa Beach will already have experienced a diversity of new residents from nearby residential development. Though many of these developments will offer affordable housing, many of the new residents will be part of the market housing segment and will therefore have incomes above the current median income level for the 'Ewa area.

With these changes will come cultural diversity. Adaptation will begin with competition for jobs at the new clubhouses and commercial centers, shared use of new shopping centers, altered make-up of schools and community organizations and shared new recreation areas.

[27] *Earthplan, 1991.*

5. **Disruption of the slow-paced lifestyle.**

The initial impact of impending change is a change in the current slow-paced lifestyle which characterizes the 'Ewa Beach and 'Ewa Villages communities. Omnitrak (1989) has indicated that the majority of 'Ewa Beach residents favor development; this implies a willingness to alter the current lifestyle.

Nevertheless, the existing communities may experience difficulty in adjusting to the changes which are likely to develop. Some of these changes include (1) the potential increase in crime due to the sheer increase in population; (2) disturbance of community cohesion due to different values of the newer residents; (3) crowding at recreational and commercial facilities; (4) increased traffic; and (5) transitional effects of new schools.

6. **Competition for public, particularly recreational, facilities.**

'Ewa will be visited by visitors and islandwide residents. The improved and expanded One'ula Beach Park and the new Ko Olina beaches will attract visitors from Waikiki seeking recreation areas outside Waikiki; they will visit by rent-a-car, on tour bus, or diving tours.

7. **Shift in employment patterns and increased job competition.**

By the time Ewa Marina is implemented, the 'Ewa region will already have experienced an increased diversity in types of employment. Many current 'Ewa residents who are currently working outside 'Ewa will have jobs closer to home. Many unemployed and currently employed people working in other parts of Oahu will seek jobs in the City of Kapolei, nearby clubhouses at golf courses, day care centers, schools and new Ko Olina hotels.

The new residents of Ewa Marina, Gentry, West Loch and other developments will also be competing for the same jobs. This period of adjustment to a new lifestyle will be difficult for many Hawai'i-born residents who need jobs but lack training. As evidenced in the Kuilima situation, typically those service jobs demanding good verbal skills and cultural savoir faire, e.g. bartenders, waitresses, maitre d'hotel, are taken by foreign or mainland in-migrants.

A potential for further confounding the frustrations of old residents will be working under new management from a different cultural group.

8. **Introduction of visitor industry to the 'Ewa region.**

By the time Ewa Marina is underway, the visitor industry will have been introduced to the 'Ewa region. Cultural diversification will increase as residents interact with non-Hawai'i residents at Ko Olina's restaurants and shopping malls.

4.4.2 Residential Component

Ewa Marina will increase the number and variety of homes in the 'Ewa area and thus will continue the then-already occurring diversification of the overall composition of the population. Possible changes in the population composition of the 'Ewa area to which Ewa Marina will contribute include:

- a higher percentage of residents participating in the labor force;
- an increase in the overall family income level;
- diversification of the region's labor force; and
- a change in age, ethnicity and educational characteristics to resemble islandwide characteristics.

Ewa Marina will contribute to a diversity in the makeup of an already changing community. To some, this change may be an opportunity for increased social exchange and interaction. To others, this change may threaten a seemingly homogeneous community.

Those who have been accustomed to conducting community affairs with fellow residents in a mutually-understood social system may increasingly need to adjust. Many new residents will want to participate and make changes in accordance with the socio-cultural patterns of their previous residence or origin. Some long-term residents may find their low-key participation in community affairs and decision-making by consensus upset by the combination of newcomers who may be more vocal, articulate and assertive. On the other hand, some new residents may be able to make contributions which will enrich the lives of existing residents.

4.4.3 Marina and Support Facilities

The proposed marina will benefits the island-wide community by providing both much-needed berthing and marine support facilities. The marina and its support facilities are envisioned as a major catalyst for the expansion of O'ahu's boating industry. O'ahu has an extreme shortage of berthing, dry storage and maritime-related commercial facilities. Over 1,400 people are waiting for boat slips. The greatest demand is for berths in the 35-foot to 45-foot range; the waiting time for this size berth is four to six years.

In addition to more berths, Ewa Marina will also contain retail facilities and businesses offering marine craft and supplies, businesses specializing in rigging, sail and canvas supplies, repair and maintenance facilities, charter operations for fishing, sailing and diving excursions, restaurants, and water sport shops. [28]

The 'Ewa region will experience the same islandwide benefits of the marina, with the additional positive impacts of proximity, local use and diversification of employment:

[28] *Kiefer, Oshima, Chun, Fong & Chung, 1991.*

1. **Proximity to boating facilities.**

   'Ewa boat owners will be in proximity to public boat launching facilities at Ewa Marina. Although 'Ewa residents would need to compete with other residents for these facilities, especially in light of the current major demand for more launching ramps, they would nevertheless have the advantage of minimal transport time.

2. **Local use of marina facilities.**

   'Ewa Beach residents also have the advantage of easy access to the marina for non-boating activities. Some have indicated interest in using the marina for canoe paddling activities, with related facilities at the nearby One'ula Beach Park. As the project progresses, HASEKO will be examining the various possibilities for this type of use.

3. **Diversification in job types.**

   As the region develops, 'Ewa residents will have a wide variety of jobs in proximity to their homes. Whereas there is currently a predominance of military and service jobs in 'Ewa, the future will bring more industrial, professional, managerial and retail jobs to 'Ewa. The project's marina support facilities will add another dimension to the job supply by introducing marine-related employment.

4.4.4 Mixed-use Commercial Complex

The proposed Mixed-Use Commercial Complex will be a major feature of Ewa Marina. Its potential effects on the community will depend to a large extent on how the then-existing 'Ewa community will have adapted to likely non-project changes identified in the previous section. This section presents some considerations on how this project component may change, affect and enhance the existing community.

1. **The Mixed-Use Commercial Complex will increase the de facto population in 'Ewa.**

   Phase 2 of Ewa Marina will contribute to the influx of new people by accommodating visitors and attracting non-Ewa residents. The 1,500-unit visitor component of Phase 2 could attract an estimated 2,200 overnight visitors. The overall project will also provide over 2,300 on-site jobs. Further, O'ahu-wide residents will likely be attracted to the proposed facilities, such as restaurants and shopping area.

2. **The proposed visitor complex is symbolic of positive and negative aspects of tourism.**

Regardless of the specialty nature of the proposed visitor accommodations, it is highly likely that 'Ewa residents will apply their own stereotypes and expectations to the Mixed-Use Commercial Complex. Based on the 1988 statewide tourism impact study, 'Ewa region respondents were generally consistent with statewide respondents in their opinions about tourism.

Hawai'i and 'Ewa respondents felt very positive about the benefits of tourism; they believed that tourism benefits outweigh its problems. They appreciated contributions to Hawai'i's employment base, as well as amenities which can be shared by residents.

Hawai'i and 'Ewa respondents also believed, however, that tourism had negative impacts on existing major community problems. They felt that tourism made the cost of housing and traffic worse, and this sentiment was especially strong in areas where there was a high density of visitor units. Where there were many visitor units, respondents were most likely to say that tourism made all sorts of things worse. Conversely, quiet rural areas were more likely to say tourism had improved the pace of life or social relationships, while the more urbanized areas said that these same things had been harmed by tourism. [29]

It is very likely that the proposed visitor complex may be viewed as both a community asset, as well as the cause of problems. Problems which may be particularly associated with the visitor complex are (1) traffic and (2) changes in outdoor resources. Both are discussed below.

3. **Visitors will tend to remain at self-contained area.**

Regardless of the type of development at the project site, there will be an increase in traffic. The estimated visitor contribution to this situation is the subject of the traffic impact study, but it is helpful to examine trends for visitors to travel in cars or busses to off-site locations and thus generate traffic.

Tourists tend to remain on-site at the larger visitor destinations, except for occasional side trips around the island or into Honolulu or Waikiki. Compared to Waikiki tourists who rent cars and visit off-site recreation areas, rural resort visitors leave their destination area at about 15 percent total per day. [30] It is expected that with the hotels and commercial complex at Phase 2, a similar pattern would prevail, particularly in light of the targeted niche markets.

[29] *Community Resources, 1989.*
[30] *Community Resources, Inc., and Lyman, 1984.*

4. **Nearby outdoor recreation areas may be frequented by project visitors.**

In the Kuilima experience, visitors from the resort complex do not frequent public recreation areas near the resort site but prefer going some distance, such as Waikiki when they do travel off-site. [31] At Ewa Marina, however, the project's water and marina orientation will attract visitors who would be interested in using the nearby One'ula Beach Park and other shoreline resources.

It is likely that the effects of the influx of new people will be felt by adolescents and young adults who will find their recreation areas, surfing spots and beaches infringed upon by those wanting these area for alternate activities. Adolescents are typically the most vocal and demonstrative toward tourists who infringe on what are considered local recreation areas. Though most young people may welcome the excitement of new faces, visitors, new residents and military will undoubtedly frequent these same areas and compete for recreation space. This could compel youth gangs or other locals to establish their territory either through incidents of confrontation or opportunistic crimes or misdemeanors. Loitering at beach parks, partying after hours, loud music and cars, and military-local interface invite confrontations which will lead to resident complaints.

5. **Existing residents will experience increased interaction with visitors -- this can be both positive and negative.**

According to the aforementioned statewide tourism impact study, 'Ewa residents experience low levels of interaction with tourists now. Whenever there was interaction, the experience tended to be pleasant even in the high density visitor areas.

On a personal level, the diversity of visitors, mainland and foreign born, can be a culturally enriching experience for workers and nearby residents. Opportunities to meet these people at work or in recreation or commercial areas will prove stimulating if mutual respect for the other's differences is demonstrated.

There is also a tendency for Hawai'i residents to view visitors as a class, however. There is a sense of competition, particularly in high-density visitor areas, of whether the area is "our place" or "their place." This type of impersonal class distinction become increasingly problematic when communication barriers increase.

For example, though Japanese visitors are generally perceived to be respectful of local cultural differences, their tendency to move in large groups and to isolate themselves could be misinterpreted. Large bus loads of

[31] *Ibid.*

non-English speakers visiting a golf course, restaurant or beach park might test the patience of many local employees or residents present. These things will take time and understanding as is true elsewhere in Hawai'i.

6. **There is a potential for economic disparity as long as residents view a tourist as a symbol.**

The presence of affluent and corporate executives could create a us-them perception in the minds of some residents. This perception might become a local aggravation to the extent that Hawai'i-born residents are committed to employment within the visitor industry or are excluded from employment because of lack of skills or training. Research has shown that, as the economic dependency on tourism increases, there is not necessarily a corresponding increase "Aloha Spirit" toward the industry. As people feel that they are losing political and economic control over their fate to absentee power-brokers in the industry, residents are more likely to direct their animosity toward the visible tourist, who becomes a *symbol* of the power structure.

7. **The Mixed-Use Commercial Complex will expand the area's recreational resources.**

The visitor complex will include a tennis complex and fitness center. These facilities can be welcomed assets to the community, providing there is sufficient means for the average resident to access these facilities. At the tennis complex, the developer should consider community-oriented programs such low membership or use rates for residents and junior or school-based tennis education programs. At the fitness center, there should be programs to encourage local companies to use the center.

4.4.5 Golf Course

Golf courses have become related to or symbolic of other issues. In a recent study of Hawaii's golf course industry, land use policies and water impacts were the most frequently raised issues. Land use policies which dealt with the compatibility and relationship to land use policies were the most frequent type of issue raised at Honolulu public hearings. In a review of 20 EISs on golf courses, impacts on water quality and supply were raised the most.

Community issues and concerns were the second most frequent category of golf course concerns in both testimony and EISs. Concerns included land competition with affordable housing, increased property values and taxes and impacts on a rural lifestyle. Another growing concern is foreign investment; cultural differences are exacerbated by potential exclusion and/or "pricing-out," as well as related displacement. [32]

32 *Ordway, 1990.*

The golf course component of Ewa Marina will improve the recreational resources in the area. Nearby residents will be able to choose among a number of golf courses proposed for the 'Ewa region. To ensure community access to the Phase 2 golf course, programs such as junior golf lessons, kama'aina rates and group discounts should be evaluated.

4.5 Impacts on Ocean Recreation

The shoreline of the project site begins where Papipi Road meets the ocean and extends west to the boundary fence of the NASBP. It is fronted from one end to the other by a low coral bench, the seaward edge of a prehistoric coral reef. In the eastern half of the project site, a narrow white sand beach covers the seaward edge of the coral bench, while in the western half, the seaward edge of the coral bench comprises a low sea cliff.

The sand beach begins where Papipi Road meets the ocean and ends near the western boundary of the One'ula Beach Park, which is formerly the 'Ewa Beach Hau Bush Beach Park. This 30-acre City and County park is reached by means of a secondary dirt road and has one comfort station. [33]

Ocean recreation consultant John Clark has been retained to study the project's impacts on ocean recreation in the area. As author of The Beaches of O'ahu, he had previously researched activities and characteristics of ocean recreation in this area. He supplemented his findings with interviews conducted in two separate efforts. First, he conducted a general ocean recreation analysis in 1990. Second, the 1991 engineering study on marina entrance design [34] was distributed to members of the ocean recreation community. Clark provided his input in that study and interviewed members of the ocean recreation community for their input as well. *Appendix A* lists the people he interviewed in this effort.

This section summarizes Clark's findings relative to possible project impacts or changes to the ocean recreation environment. Non-recreation issues raised by those interviewed, such as lifestyle and value issues, are discussed in Section 5. [35]

4.5.1 Shoreline Activities

Fishing and Crabbing

The shoreline from One'ula Beach Park to the NASBP fence is a low coral bench, and the primary activity along this reach is pole fishing, either shore casting or whipping. The fishers often spend the day or camp with their families on weekends. They fish for papio, ulua, and moi. This rocky shoreline is also a good area for catching a'ama crabs, the common black rock crabs which are popular raw dish at luaus.

33 *Clark, 1977.*
34 *Moffatt & Nichol, Engineers, 1991.*
35 *This report examines ocean recreation impacts from a social perspective. Physical impacts, such as impact on wave patterns and sand deposits, have been studied by project engineers.*

Potential project impacts on these activities include:

- *Lateral access* -- The boat channel will cut off lateral access along the shoreline for anyone traversing the area between the park and NASBP fence. Some public access to both the west and east sides of the channel should be provided.

- *Increase of fishers and crabbers* -- Development of the area and convenient public access will attract more fishers. Other than increasing competition for the preferred fishing sites, the impact on the fish populations caught by pole will probably be minimal. The jetties bordering the boat channel would provide additional fishing sites, and the safety of pedestrian traffic should be considered in planning the jetties' width. During periods of high surf, waves may pose a hazard for those walking on the jetties.

  More crabbers will likely be attracted to the area, and this will have a direct impact on the crabbing by possibly reducing the crab population. Although the jetties will provide additional crab habitat, the overall impact may be negative. Crabbers noted that, in other harbor areas, such as the Ala Wai Boat Harbor, the increased pedestrian traffic makes the crabs skittish and harder to catch.

Seaweed Gathering

A variety of seaweeds grow on the shallow ocean bottom offshore the beach. These seaweeds are dislodged by water movement, transported onshore, and deposited on the sand. The beach provides an important seaweed gathering site for residents of 'Ewa Beach and other surrounding communities.

The most commonly gathered seaweed in limu wawae'iole (*Codium edule*). While limu manauea (*Gracilaria coronoplfolia*), often called by its Japanese name ogo, is also gathered, it is not as abundant as in former times. Limu palahalha (*Ulva fasclata*) grows on the rocks at the water's edge, but is rarely harvested.

Seaweed is gathered by waders from "limu piles" or concentrations of seaweed floating nearshore, and by skin divers who harvest the seaweed directly from the ocean bottom. Direct harvesting from the ocean bottom is a source of resentment because plants are usually ripped out by their roots, instead of above the roots, which would allow regeneration.

All of the seaweeds commonly gathered at the beach are used for home consumption, but the limu wawae'iole is also sold commercially to stores and at the local farmers' market. Commercial seaweed gathering is illegal without a permit, but many informants indicate that this occurs anyway. Apparently there is no monitoring of this activity. Reportedly, illegal commercial gatherers are immigrants, and there was strong resentment against them by local gatherers.

Those interviewed did not feel that Ewa Marina will have an impact on the present seaweed or seaweed gathering activities. During the construction phase, it was felt that some siltation would occur, and that the prevailing currents would probably carry the plume in a westerly direction, away from the beach and seaweed grounds.

Swimming

The eastern portion of the beach fronting the plantation camping sites, popularly known as Hau Bush for the large stands of hau in the backshore, is used by campers for traditional beach activities, such as swimming and sunbathing. The nearshore bottom, however, is shallow and rocky, offering only a marginal swimming sites appealing mostly to children.

Although the western portion of the site is primarily rocky, there are several small pockets of sand in the rocks that are used by children as swimming holes.

Those interviewed felt that Ewa Marina would probably not impact the present swimming and sunbathing activities. Some problems may result, however, if non-authorized people trespass onto White Plains Beach, an attractive white sand beach separated from the project site by a chain link fence.

4.5.2 Nearshore Activities

Surfing

Although the islandwide surfing community does not regard 'Ewa Beach as one of the best places for surfing, it does recognize that the area has several excellent primary surfing sites and a number of good secondary sites. The majority of these sites are found offshore of the project site.

These sites include Seawalls, Shark Country, Hau Bush, Chicken Creek, Sand Tracks, Johns, Coves and Tree Stumps. Of all of these sites, Coves is generally recognized as having the best waves on a good south swell. Resident area surfers felt that its left side is is comparable or as valuable as that at Ala Moana Bowls in Waikiki, one of the best surfing sites in the state.

Surfing contests are held annually offshore One'ula Beach Park at Sand Tracks or Johns.

Bodyboarding is another important wave riding sport practiced at all of the Ewa Beach breaks. On a good surfing day, the bodyboards often number as high as the surfboards.

On a normal day at most of the 'Ewa Beach breaks, the waves are small, from one to three feet, spilling-type waves without much power to them. These are ideal waves for beginners, and good waves for long boards. Long board riders are commonly seen in this area, especially offshore the beach park, where the most consistent waves are found.

On occasion, surf ski riders also frequent the waves offshore the park.

Informants were very concerned about Ewa Marina's potential impact on surfing, as follows:

- *Cores* -- The boat channel could destroy one of the best surfing sites in this area.[36]

- *Importance of these sites relative to increased population* -- All of the 'Ewa Beach surfing sites are important because these are the only ones near 'Ewa and Waipahu. With the residential growth planned for the 'Ewa Plain, the regional surfing population is expected to grow substantially. Hence, the surfing community feels that it cannot afford to loose any sites.

- *"Ocean parks" concept* -- Surfing sites are ocean parks, and some informants pointed out the surfers are as familiar with their surfing sites as baseball players are with their diamonds and golfers are with their golf courses.

  A major distinction between these recreational facilities and a surfing site is that the latter cannot be replaced or duplicated. In spite of scientific claims that new surf sites can be created, many surfers feel that the hundreds of years of coral reef formation -- which creates a surfing site -- cannot be duplicated.

- *Effect of the jetties* -- The jetties lining the boat channel may exert a negative influence on the surfing sites by altering normal wave patterns. Although some informants acknowledged the possibility of creating new sites, most anticipated a negative impact.

Diving

Some skin diving for reef fish, octopus and lobster occurs along the rocks. From all accounts, however, visibility is poor for most of the year. Hence, most of the in-water fishing consists of laying nets. Some scuba diving and spear fishing occur from boats.

Diving is also limited by the fear of sharks. There is both a community and islandwide belief that the 'Ewa Beach waters are shark-infested. This belief has some accuracy and is a perpetuated by numerous shark sightings by surfers and divers. The surfing site "Shark Country" has been so named for at least 30 years. Fishers commonly find large holes in their nets caused by sharks, and over the years, many large sharks, primarily tigers and hammerheads, have been caught in this area.

Ewa Marina may impact present diving activities as follows:

- *Increase in divers* -- Development of the area and convenient public access will attract more divers, thus reducing fish, lobster and octopus populations.

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[36] *To minimize project impacts on surf sites, modifications have been made to the marina channel entrance by the engineers, based on information provided by Clark and those interviewed.*

- *User conflicts* -- The potential increase in divers may lead to conflicts between the pole fishers and the divers.

- *More sharks* -- Those interviewed felt that, based on their personal experiences and their knowledge of other marinas and harbors, the boat channel and the marina will likely attract more sharks. Sharks are scavengers and commonly frequent bays and harbors. With the apparent proliferation of sharks in the area now, the new channel and marina may be a natural focal point for sharks.

Boating

At present, little boating activity occurs near the project area. The water is normally too murky to attract skin or scuba divers and too far from existing boat ramps to attract other boaters. The area is also subject to surf at all times of the year, particularly during the summer.

The boats that do visit the area are usually smaller motor boats, 17 feet in length or less, or inflatable boats, such as Zodiacs or Avons. These boaters tend to be local divers familiar with the area who know when visibility would be good enough for diving. Little or no sailing or windsurfing occurs in this area.

Most of the boating activity occurs offshore where fishers bottom fish and commercially net akule. Sailors also traverse the area, rarely coming nearshore.

Informants had the following reactions to Ewa Marina from a boating standpoint:

- *Need for more boating facilities* -- Public boat ramps on Oahu are few and far between; a new public boat ramp would meet a major need in the boating community. To reach the 'Ewa Beach and Barbers Point areas now, boaters have to launch from Ke'ehi Lagoon or Wai'anae Boat Harbors.

- *Support facilities* -- Boat owners need more support facilities and the project will provide marina support facilities such as a service station for gas, a store or ice and supplies, and parking for trucks and trailers.

- *Need for additional mooring slips* -- The need for more mooring space has been demonstrated, and the project will meet this need.

- *Refuge* -- It is anticipated that the marina will offer a refuge for boats in distress which are caught offshore in rough seas, or which experience engine or other problems. Some of the boaters in the marina are expected to be members of the Coast Guard Auxiliary, an organization that assists boats in distress.

- *Additional boat-related traffic* -- The marina and boat ramp will bring many boaters into the area, which means additional truck and trailer traffic for the nearby communities.

- *Increased potential for boating accidents* -- More boating traffic offshore will likely lead to more boating accidents, such as boats going aground on the reef, boats overturning in high surf, and boat fires.
- *User conflicts* -- More boaters may mean user conflict incidents between boaters and other user groups, such as surfers, nearshore skin divers and shoreline fishers.
- *Puuloa Firing Range* -- Located between 'Ewa Beach Park and Iroquois Point, this facility is still operational. All boaters will have to avoid the waters offshore the range when it is in use.

Outrigger Canoe Paddling and Kayaking

Outrigger canoe paddling is not presently practiced in 'Ewa Beach. The former Ewa Beach Canoe Club, now known as the Kuakini Canoe Club, has been inactive for approximately four years. The club originally trained in the Iroquois Point Boat Harbor, a military facility, but was unable to remain there. The club then moved to 'Ewa Beach Park, and, subsequently, to One'ula Beach Park, but neither site was suitable. Canoe paddling season is usually during the summer months, and summer surf made nearshore training difficult.

Ewa Marina may help revive canoe paddling in 'Ewa Beach. The marina and the boat channel would (1) provide the sheltered waters that canoe paddlers prefer for training and (2) still give them access to the open ocean.

A suitable launching and landing area could be designated within the marina, since the beach fronting the beach park would be suitable for launching and landing kayaks and canoes only during periods of calm seas. The launching/landing site could be floating wooden docks similar to those on the Ala Wai Canal. These docks should be backed by a grassy area that can be used to rig and stage the canoes and kayaks and a parking lot.

The floating docks should be located away from the boat launching ramp to avoid potential hazards to canoe paddlers and kayakers by motor-powered crafts.

4.6 Impacts On Public Services And Facilities

4.6.1 Police Protection

Overall Community

'Ewa is in District III, which extends from Red Hill to Ka'ena Point and Kipapa Ridge and is handled by the Pearl City Police Station. As part of District III, the 'Ewa region is in Beats 325 (Honokai Hale/Nanakai Gardens and Makakilo), 326 (Ewa Villages, Honouliuli and NASBP) and 327 (James Campbell Industrial Park, 'Ewa Beach and IPP Military Family Housing). Beats 326A and 327A were recently included.

Currently, two officers per beat are dispatched to the Makakilo beat and the other beats are covered by one officer per beat. There are three shifts within a 24-hour period; hence, 18 beat officers operate in the 'Ewa Development Plan area daily.

In 'Ewa Beach, all categories of crime are currently low in incidences compared to other areas. This is particularly so of property and serious crime. In terms of youth-related crime, school vandalism and graffiti are reported. Gang activities in 'Ewa Beach have not been major problems, though gang members may reside in this community. [37]

In terms of short-term plans, the Police Department is requesting funds for two officers per shift. Long-term plans include adding a new full-service station in Kapolei, with the establishment of 'Ewa and the Wai'anae Coast as a new district. This means that the District III would cover the area from Red Hill to Kunia Road, and the new district would extend from Kunia Road to Ka'ena Point. If this occurs, the Kapolei station would be the headquarters for five beats in 'Ewa and eight beats along the Wai'anae Coast. [38]

In addition, two substations are proposed by the Police Department. One would be located in Ko Olina, near a proposed fire station. The other would be located near the proposed relocation site of the 'Ewa Beach Fire Station at 'Ewa Marina. Both are long-term in nature. [36]

Ewa Marina will impact police protection services because it will increase the resident and de facto population. The increased demand could be met, however, if current plans for police protection services are implemented. In anticipation of growth in 'Ewa, public officials are planning major improvements and additions to police services and facilities. Ewa Marina has been part of the 'Ewa development efforts for over a decade and the project is incorporated in expansion plans.

Ewa Marina could help mitigate the impact on police protection services in two ways:

- *On-site facilities* -- Public officials and HASEKO have been discussing the possibility of establishing a new police sub-station in Ewa Marina. Locating this facility within the project will benefit both the proposed and existing communities.
- *On-site security* -- At full build-out, Ewa Marina will comprise several distinct neighborhoods. These neighborhoods can minimize the need for police protection by providing on-site security measures and/or personnel who will monitor suspicious activities and handle minor problems.

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[37] *Personal communication with Sergeant Vernon Kilborn, Pearl City Station, Honolulu Police Department, September 11, 1991.*
[38] *Earthplan, 1991.*

Tourist-Related Crime

A correlation exists between increased growth of tourism and increases in certain categories of crime against tourists. These categories include property crimes, robbery, rape and aggravated assault.[39] A report of the relationship between crime and tourism in Honolulu over a 23-year period found that the number of tourist present was significantly related to all major crimes except murder and auto theft. Tourism proved a significant predictor of crime in Honolulu. Research also strongly suggested, however, that a distinction be drawn between tourism-generated criminal activity and the easy assertion of the lucrative tourist as an easy victim.[40]

The study showed tourists were more likely victims of property crimes and robbery. The crime - tourist relationship was significantly high for non-violent crimes of larceny, robbery and burglary. Tourists in Honolulu were slightly (11 percent) more likely rape victims than residents. A significant relationship was also found between tourism and assault.

Some of the reasons for tourism-related crime are as follows:

1. Many property crimes result from taking advantage of tourists' carelessness. Tourists are generally less careful with their belongings when on vacation.
2. Tourists frequently engage in risk-taking they would otherwise not have taken. Behavior displaying their vulnerability to victimization include drinking too much too late, night strolls on beaches and visits to parts of the community considered dangerous by residents. Fujii and Mak (1979) found such risk-taking partially accounted for high rate of rape among tourists.
3. When the victim is a tourist, there is less tendency to follow through with prosecution. This is particularly true in cases of rape, where 62.7 percent of the arrests involved visitor victims, but 57.9 percent of the those arrested were released without charge.[41]
4. The individual tourist can become a symbol and target of resident animosity felt toward the visitor industry.

The increase in the tourist population is inevitable, given public policy to support the visitor industry. The increase in tourists due to Ewa Marina will therefore not alter the current trend in visitor-related crime.

Tourist-related crime is more prevalent in areas frequented by the general public, as in Waikiki. The specialty nature of proposed facilities are not expected to be conducive to large numbers of the general public.

39 *Pizam, 1982.*
40 *Chesney-Lind, etal., 1983.*
41 *Criminal Justice Data Center, 1983.*

The proposed project can further assist in mitigating visitor-related crime as follows:

1. *Creation of a safe physical environment* -- The on-site facilities should be designed to minimize visitor-related crime by featuring effective security devices and to avoid secluded, dark spaces.
2. *On-site security* -- The size and complexity of the proposed complex warrants security personnel to monitor the different areas.
3. *Tourist education* -- The visitor industry is already informing tourists on crime prevention. The project developer could participate in these programs.

4.6.2 Fire Protection

First Alarm at the project site is handled by the 'Ewa Beach and Waipahu Fire Stations. The Makakilo Fire Station provides backup.

Currently, there are 15 firefighters per shift at the 'Ewa Beach Fire Station, which has one fire truck-pumper. An engine-and-ladder company, the Waipahu Fire Station has, per shift, five firefighters assigned to the engine and six to the ladder. Makakilo Fire Station has five firefighters per shift as an engine company.[42]

To accommodate anticipated growth in 'Ewa, four new fire protection facilities are being planned:

- Planning and design funds have been received for a new fire station at the James Campbell Industrial Park. This is envisioned as an engine-and-ladder company and will have a battalion chief. Per shift, twelve firefighters will be assigned to this station. The fire department expects to apply for construction funds in Fiscal Year 1992-1993.
- The Ko Olina Phase I fire station would also be an engine and ladder company, with twelve firefighters per shift.
- There have been tentative plans for the relocation of the existing 'Ewa Beach Fire Station to the Gateway Park of Ewa Marina. These plans are very preliminary, however. If this relocation occurs, the relocated Ewa Beach Fire Station will be an engine company, with five firefighters working in a 24-hour period.
- Another fire station is planned at 'Ewa Villages, but no time frame has been determined.[43]

42 *Personal communication with Battalion Chief Attilio Leonardy, Honolulu Fire Department, September 11, 1991.*
43 *Earthplan, 1991, and personal communication with Battalion Chief Leonardy.*

Ewa Marina will increase the demand for fire protection services by increasing the resident and de facto population and introducing more urban uses. Mitigation measures include working with public officials to locate a fire station on-site or making an otherwise appropriate contribution to regional fire protection services.

4.6.3 Recreational Facilities

The 'Ewa Development Plan area contains four beach parks, four community parks and four neighborhood parks. In addition, there is also Kapolei Park, which is a 28-acre undeveloped regional park.

Ewa Marina is expected will have two types of effects on these existing parks. First, the added population will increase the demand for these resources and cause crowding. This impact will be offset, however, by a corresponding increase of project and non-project recreational resources. All of the residential projects proposed for 'Ewa contain recreational resources and a 73-acre regional park will eventually be located in Kapolei.

The second project effect is a positive one. Ewa Marina is envisioned as a recreation-oriented community and will provide land- and ocean-based recreational amenities for Ewa Marina and existing residents. HASEKO has been actively seeking ideas and input from the community about the proposed on-site parks, and Section 5 contains more information regarding this public input process. The following outlines predominant ideas about the proposed parks at this time. Note that these ideas will likely evolve and be modified as community discussions continue.

- **Gateway Park.**

  The proposed Ewa Marina Gateway Park was generally seen as a facility which would be used by 'Ewa Beach residents as well as by the new Ewa Marina community. Two concepts of the use of this park emerged.

  First, 'Ewa Beach residents saw this park as a gathering place, a central place to socialize, meet and just gather. Suggested facilities such as meeting rooms, a community center, a youth center and a senior citizens center all reiterated this concept of creating a gathering place.

  Second, they also saw a possibility for having the Gateway Park contain service facilities which could serve 'Ewa Beach and Ewa Marina residents. It was suggested that the community center could operate in conjunction with a job training center or a "one-stop center" for government services. Family support services could be housed here, and residents could take adult education courses in the facilities' meeting rooms.

- **One'ula Beach.**

  Shoreline parks are scarce in this area, and the need for beach parks will greatly increase as 'Ewa develops. Thus, the improvement and development of One'ula Beach Park is seen as a big plus by community leaders.

  One'ula Beach Park is seen as a place for fishers, surfers, divers, boaters, wind surfers, sunbathers and general recreation. Community leaders want to see these activities accommodated as much as possible, and it was felt that an ocean recreation center was appropriate for this site. This ocean recreation center would be an asset for the entire 'Ewa community. Beach park facilities would support public users of the adjacent marina. Participants wanted the marina to have a boat ramp and areas for fishing and canoe paddling.

  Community leaders have also expressed a desire for a small cultural center, which would operate in conjunction with the ocean recreation center and would provide information about Hawaiian traditions in ocean food gathering and recreation.

In addition to these larger parks, Ewa Marina will contain numerous small community and neighborhood parks to meet the needs of on-site residents.

4.6.4 Public Education

Ewa Marina is in the Campbell High Education Complex (hereby called Campbell Complex) of the State Department of Education. The elementary schools in this complex include Barbers Point, 'Ewa, 'Ewa Beach, Iroquois, Kaimiloa, Makakilo, Mauka Lani, and Pohakea Elementary Schools. These schools all feed into Ilima Intermediate and Campbell High Schools.

The existing schools which would be affected by Ewa Marina are 'Ewa Beach, and Pohakea Elementary Schools, and Ilima and Campbell High Schools. Planning considerations for these schools are as follows:

- **'Ewa Beach Elementary.**

  This school is located at the southwestern boundary of the project site. Between 1985 and 1989, enrollment decreased from 515 to 400 students. This trend is expected to reverse as the various projects are developed. Students from the Soda Creek portion of 'Ewa Gentry are currently attending this school. This school is expected to accommodate half of 'Ewa Marina's elementary-school aged children.

- **Pohakea Elementary.**

  Pohakea is located in 'Ewa Beach, at the corner of Fort Weaver and North Roads. Enrollment has remained stable. Half of 'Ewa Marina's elementary-school aged children will attend Pohakea.

- **Ilima Intermediate.**

  Ilima Intermediate is located on Fort Weaver Road, across the Papipi Road junction. Between 1985 and 1989, enrollment remained stable at around 900 students. By 1991, enrollment increased to over 1,000 students. The design enrollment, which is what the facility is currently designed to handle, is 1,300 students.

- **Campbell High School.**

  Located adjacent to Pohakea Elementary and Ilima Intermediate Schools, Campbell High School experienced a decline in enrollment from 1,918 in 1985 to 1,652 in 1991. The design enrollment is 2,200.[44]

Table 9 contains enrollment information for these schools. The elementary schools have experience slight decreases in enrollment, while the upper schools have been increasing in students. Ilima Intermediate School in particular had an increase of about 100 students between 1989 and 1991.

In anticipation of residential growth, State public education officials have been planning school facility additions and administrative changes, as follows:

- **New Schools.**

  Four new schools are being planned for the 'Ewa region. These include a second 'Ewa Elementary School, a Kapolei Elementary School and Kapolei Intermediate and High Schools. With these schools, the 'Ewa region public schools will have a design enrollment of 13,700.

- **Restructuring of Complex.**

  Eventually, the western schools in the Campbell Complex, including those in Kapolei and Makakilo, will feed into a new Kapolei High School Complex.[43]

Ewa Marina is projected to house 800 elementary school aged children, 190 intermediate school students, and 360 high school students, as contained in *Table 11*. The current plan is that half of the elementary students will attend 'Ewa Beach and Pohakea Elementary Schools; Ilima Intermediate and Campbell High will serve the older students.

If current plans are implemented, Ewa Marina should be adequately served by the public education facilities. The timing of improvements depends on actual occupancy of new housing units, and as *Table 10* indicates, the region has generally grown slower than originally expected. State Department of Education officials will continue to monitor the need for and timing of additional facilities and improvements.

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[44] *Hawai'i State Department of Education, 1990.*

Table 9

**School Enrollment Trends
for Certain Campbell Complex Schools**

School	1989 (*)	Projected 1991 (*)	Actual 1991 (**)	Difference Between Projected and Actual 1991	Difference Between Actual 1989 and Actual 1991
'Ewa Beach Elementary	403	523	399	-23.7%	-1.0%
Pohakea Elementary	558	525	550	4.8%	-1.4%
Ilima Intermediate	969	1,067	1,013	-5.1%	4.5%
Campbell High	1,634	1,865	1,652	-11.4%	1.1%

Notes:

(*) From State Department of Education, 1990.
(**) Personal communication with Tom Saka, Demographics Specialist, State Department of Education, September 11, 1991.

Table 10

School Enrollment Projections for Certain Campbell Complex Schools

School	Actual 1991	Projected 1996	Difference Between 1991 and Projected 1996	Average Annual Growth Rate
'Ewa Beach Elementary	399	600	50.4%	8.5%
Pohakea Elementary	550	700	27.3%	4.9%
Ilima Intermediate	1,013	1,300	28.3%	5.1%
Campbell High (*)	1,652	1,900	15.0%	2.8%

(*) Based on assumption that the Kapolei High School will be built.

Source: Personal communication with Tom Sala, Demographics Specialist, State Department of Education, September 11, 1991.

Table 11

Ewa Marina Projected School Enrollment

Level	Projected Enrollment
Elementary	800
Intermediate	190
High School	360
Total	6,750

Note: Projection is very conservative. DOE used a base residential unit count of 5,000.

Source: Hawai'i State Department of Education, 1990.

4.6.5 Child Care

As Kapolei develops, the need for child care services within the region will increase as more and more people live and work in the Second City. Three sites in the area already have been committed for child care purposes. First, West Loch has a 5.3 acre site for a park-and-ride facility with a 30,000 square foot child care center. This is scheduled for implementation in Phase 2. Second, Ko Olina has one acre for child care and other public facilities. Third, Royal Kunia, which is just outside 'Ewa in Central Oahu, has similar provisions included in its master plan.

In addition, three potential child care centers are being explored in Kapolei. One site is located in the City of Kapolei, with the other two in Kapolei Villages. [45]

Ewa Marina will increase the regional demand for child care services because of the increase in residents and employment generated by the proposed regional shopping center. Currently, there is no rule of thumb in projecting child care needs and requirements for specific development proposals have been determined on a case-by-case basis.

The extent of the increase in demand for child care services generated by Ewa Marina is unknown at this time. Also undetermined is the degree to which proposed child care centers may meet this requirement.

Options to address child care needs include (1) providing a site for a child care facility and (2) employer-based options. The latter includes major employer subsidy of on-site care, pre-tax contributions to qualified employees, and a direct voucher provided by employers to employees who demonstrate their use of qualified child care facilities.

4.6.6 Medical And Emergency Services

The St. Francis-West Hospital is located approximately 4.5 miles north of Ewa Marina and is accessible via Fort Weaver Road. The general community hospital contains 136 acute care beds and has 130 resident physicians. The hospital offers X-ray, Laboratory, obstetrics and emergency services. Expansion plans call for up to 300 acute care beds; timing will depend on the pace of growth in the 'Ewa region. [46]

Two other hospitals are also within reasonable travelling distance of the project site -- the Kaiser Foundation Health Plan in Moanalua and the Pali Momi Medical Center near the Pearl Ridge Shopping Center. In addition, the area contains numerous medical clinics and doctors' offices.

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45 *Earthplan, 1991.*
46 *Personal communication with David Leong, Vice President of Physical Services at St. Francis West Hospital, September 11, 1991.*

As Kapolei City progresses, additional medical facilities will be required to serve the increased population. The proposed project is expected to be adequately served by the existing and additional medical facilities.

Emergency services are provided by City ambulances located in Aiea. Further, the Waipahu Fire Station contains an ambulance unit which serves Pearl City, Waipahu, 'Ewa Beach, Makakilo and parts of Wai'anae. Also eight-hour service is provided to the Makakilo Fire Station by the Waipahu unit. Twenty-four hour ambulance service at the Makakilo Fire Station is currently in the planning stage.

5. Preliminary Community Issues On Ewa Marina

Whereas social impacts are social changes which are likely to occur, social issues are reactions to community events, changes and problems. Issues change over time, as people's priorities and values change. Earthplan has been monitoring 'Ewa issues over the past few years and has analyzed issues specific to Ewa Marina. This section presents an overview and analysis of issues related to Ewa Marina as of September 1991.

Section 5.1 identifies the sources of information used in this analysis. Section 5.2 summarizes issues and concerns independent of the proposed project, and Section 5.3 examines issues specific to tourism. Section 5.4 identifies previously-identified issues on Ewa Marina, and this is followed by information gathered in recent interviews (Section 5.5). Section 5.6 analyzes community issues on Ewa Marina to date.

5.1 Sources of Information

Six sources of information were used in this analysis:

1. **Neighborhood Board minutes.**

   The Neighborhood Board system is a formal mechanism for citizen input to public entities regarding islandwide City policies, specific community problems and other matters, and proposed changes. The types of issues addressed by a Neighborhood Board and subsequent actions often reflect values and concerns of the constituent population.

   To understand the values, concerns and issues of study area residents, this study examined the minutes of the 'Ewa Neighborhood Board No. 23 over a four-year period, from July 1987 through September 1991. Section 3.2.1 discusses issues addressed by this Board.

2. **Omnitrak Survey.**

   In early 1989, HASEKO (Hawaii), Inc. commissioned Hill and Knowlton / Communications Pacific, Inc. to identify general community issues and concerns and gauge community reaction to the overall Ewa Marina. The company retained Omnitrak Research and Marketing to do the actual survey.

   Omnitrak conducted a telephone survey of 403 persons in the 'Ewa Beach area. For percentages based on the entire sample of 403 responses, the maximum estimate of the sampling error is ± 5 percent.

   The findings of the Omnitrak survey were intended to serve as a benchmark for understanding the current community environment. Section 5.2.2 summarizes the survey results.

3. **State Tourism Survey.**

In 1985, the State Legislature directed the State Department of Business and Economic Development (DBED) to initiate a Tourism Impact Management System (TIMS). Coopers and Lybrand was contracted to (1) review and analyze the costs and benefits of tourism; (2) develop and establish a system to monitor the continued growth of tourism; and (3) to make recommendations to assure that tourism development and activities enhance the quality of life for Hawaii's residents.

Coopers and Lybrand (1986) developed a framework to measuring and monitoring the industry's impacts through the Tourism Impact Management System (TIMS). This framework included (1) DBED Tourism Data Book, a collection of relevant data; (2) Community Journal, including an analysis of major tourism-related issues; (3) professionally conducted surveys, including a CORE survey and special surveys; and (4)intermittent studies.[47]

Of particular relevance to Ewa Marina is the CORE survey, the function of which is to facilitate ongoing monitoring of the attitudes of Hawaii's residents towards tourism. The findings of the 1989 survey is helpful in identifying 'Ewa residents' attitudes towards tourism, and, indirectly, in indicating possible reaction to the Mixed-Use Commercial Complex of Ewa Marina.

This was a statewide telephone survey of 3,904 households. The survey contains 60 questions designed to measure resident attitudes and opinions regarding tourism and development in general. The survey was conducted in 23 sub-areas, six of which are on O'ahu. One of these areas is "*West Beach*," which included 'Ewa, 'Ewa Beach, Makakilo and Waipahu. At the time of the survey, the 'Ewa region was considered a "low-density" area in that there was a 0-ratio of visitor units to resident population.

Section 5.3 summarizes information relevant the 'Ewa region.

4. **Previous Earthplan Study on Ewa Marina Issues and Concerns.**

In April 1990, HASEKO (Hawaii), Inc. retained Earthplan to further study community issues and concerns about Ewa Marina. This study expanded the information base on community issues and included field interviews specifically dealing with the currently proposed Ewa Marina. Earthplan interviewed 42 people for that study. Two groups were targeted: (1) a "general community" group, and (2) a recreation group. These groups were considered distinct for the purpose of this report because of the different networks. Section 5.4.1 presents findings of this 1990 study.

47 *Coopers and Lybrand, 1986.*

5. **First Forum on Community Benefits Package.**

In March of this year, HASEKO sponsored a forum to begin group discussions on the community benefits package. HASEKO invited 77 people to participate in the initial forum. Collectively, these people represented youth organizations, school representatives, job training organizations, senior citizens, community residential and business organizations, the 'Ewa Neighborhood Board No. 23, church leaders, ocean recreation users, and providers of public services.

Prior to the forum, HASEKO asked participants to fill out a questionnaire. This questionnaire was designed to find out what participants felt were appropriate means for community benefits. It was intended to stimulate ideas and prepare for the forum and was not designed to be a statistical survey. The questionnaire was to have been submitted to HASEKO a few days prior to the forum.

The forum was held on March 23, 1991 in the Band Room of Ilima Intermediate School. There were three basic parts to the forum: (1) introductory remarks and preparation for small group work sessions; (2) small group sessions and a (3) summary of small group sessions and next step.

Section 5.4.2 summarizes the questionnaire results and forum information.

6. **Interviews Conducted for This Study.**

Although previous efforts have been made to gauge community issues regarding Ewa Marina, Earthplan decided to supplement this information with interviews specifically for this study. It was expected that these interviews would provide updated community reactions and would reveal any trends or changes.

Earthplan conducted 28 interviews with people who (1) live, conduct business or own land near the project site, (2) have a regional interest in the proposed project, or (3) would be able to provide specific information on how the site might affect the neighboring community. A major attempt was made to network and reach people who were not previously contacted in previous Earthplan studies on Ewa Marina.

The interviews were conducted by telephone. The purpose of the interviews was to isolate issues and identify personal and community concerns about the project. No attempt was made to quantify responses since only a survey utilizing rigid sampling procedures could produce meaningful results. This was not within the scope of Earthplan's work in conducting a social impact assessment. The only time we make reference to the quantity of opinion is where there was a significant difference in numbers, such as "only one respondent," or "all of those interviewed."

Twenty-eight people were interviewed during this study and the list is presented in *Appendix B*. Each person was informed that input would be summarized in the Social Impact Assessment and that individual opinions would remain confidential.

Interviewees were first asked about the 'Ewa or 'Ewa Beach area and their own neighborhood. They were asked to share their likes and problems/concerns about the region.

Next, they were asked about the project, beginning with their prior knowledge of the project. Almost all of those interviewed knew about the major components of the project. After being given a brief summary of the proposed project, informants were then asked to provide their perspectives on how the proposed project might affect them personally, and affect nearby uses and the regional community; the question varied depending on appropriateness.

Those interviewed were not asked to represent the views of their organizations, although if the organization has taken a formal position, they were asked to discuss these positions.

Section 5.5 presents the findings of the interviews.

5.2 Issues And Concerns Independent Of The Project

5.2.1 Neighborhood Board Issues

Over the past four years, the 'Ewa Neighborhood Board No. 23 addressed the following types of problems:

1. **Problems typically associated with stable, active and predominantly residential communities.** These included:

   - controlling and minimizing crime,
   - improving the quality and facilities in the public education system,
   - improving roadway infrastructure and circulation,
   - monitoring and improving recreational facilities, and
   - improving the delivery of ambulance, police and fire protection services.

   The 'Ewa Neighborhood Board appeared to be very active in and aware of community affairs. As a whole, the Board maintained an ongoing working relationship with the 'Ewa Beach, Makakilo and Honokai Hale Community Associations. In fact, many of the Board members were active participants in these neighborhood groups.

   This Neighborhood Board also worked closely with public officials in advocating community improvements.

2. **Potential effects of proposed developments.** This Neighborhood Board is unique among the other neighborhood boards in that 'Ewa is a community in constant transition. New communities and development proposals were discussed at virtually every meeting during this four-year period. Construction activities on previously vacant or agricultural land are evidence that the existing physical, social and economic environments will evolve into the secondary urban center. Hence, the awareness of, and expectations for, change exist among the Neighborhood Board members.

   Generally, this Neighborhood Board tended to support these developments, providing that (1) the proposal is consistent with the Kapolei Master Plan of The Estate of James Campbell and (2) the proposal addresses the necessary infrastructure and public service requirements. Within this four-year period, the Board supported or had no objections to the following projects:

   - Urban designation of 130 acres in Kapolei;
   - The 27-hole Golf Course by The Myers Company;
   - Kapolei Knolls;
   - Ewa Gentry;
   - 64-acre expansion of the James Campbell Industrial Park;
   - Puuloa Golf Course;
   - City's proposal to remove the vehicle shredder facility from the 'Ewa Development Plan Public Facilities Map;
   - Kapolei Town Center (with request to see overall plan);
   - Rezoning of 96 acres in Kapolei City to B-2;
   - Ko Olina Phase 2 (with stipulations regarding Kamokila Park relocation);
   - Preservation designation for Midden Beach; and
   - Continuing the use of Hawai'i Raceway Park at the James Campbell Industrial Park until lease termination.

Issues and concerns within the last year are as follows:

<u>*Gang Violence*</u> -- The Board was very concerned about increased gang violence and drug abuse in schools and parks and at the shopping center.

<u>*Transportation and Traffic*</u> -- The Board was instrumental in new bus stops and more busses serving the 'Ewa area. Members monitored current needs for improved roadway facilities and continued to urge good planning measures in preparing for 'Ewa's growth.

<u>*Review of Development Proposals*</u> -- The Board reviewed the Sky-walker project, a proposed dirigible operation in Maka'iwa, and recommended non-support. Support of the relocation of Kamokila Park was rescinded, when the adjacent neighborhood opposed the move. Even though the Board supported the existing and temporary Hawai'i Raceway Park, members encouraged the eventual relocation of that facility to the Lagoon Drive area.

The Board reviewed a proposed home for retarded persons, but deferred action until more information was provided.

Four major development efforts came before the Board between during this time. First, the Board reviewed the City's proposal for 'Ewa Villages, though no formal position has been taken. Second, action on the draft Honouliuli Development Plan has been deferred until there is more community input and until the final plan is presented.

The third major development project reviewed by the 'Ewa Neighborhood Board over the last year is Ewa Marina Phase 2. The Board recommended approval of the project with the following conditions:

- reduce the allowable height limit to 60 to 90 feet,
- assure public play times and kama'aina rates at the golf course, and
- require HASEKO to provide funds for social and community benefits.

Fourth, the 'Ewa Neighborhood Board supported the concept of the proposed Maka'iwa Hills, subject to further review of community concerns. Board members preferred that Kapolei be developed first.

Golf Course legislation -- In response to proposed interim development control measures for golf courses on O'ahu, the 'Ewa Neighborhood Board unanimously felt that, until actual future population needs determine otherwise, the 'Ewa Development Plan should not go beyond the five planned. These five include Ko Olina Phase 1, Makakilo, West Loch, the Myers/Seibu course and Pu'uloa.

5.2.2 HASEKO-sponsored Survey And Study

The Omnitrak survey revealed that most 'Ewa Beach residents were satisfied with life in 'Ewa, and they were optimistic about the future. The most important problem in the community was crime and drugs, and water quality was the most important environmental issue. Respondents were generally favorable towards development, and most liked the idea of "a marina in Ewa." They tended to favor development more if the project provided basic community needs. 'Ewa Beach residents tended to like playgrounds, parks, boat ramps and marinas, but most did not want to see more private golf courses. The following provides detail on the survey findings.

1. **Satisfaction with life in Hawai'i.**

Overall, 'Ewa Beach residents appear satisfied with life in Hawaii, and this level of satisfaction corresponds with O'ahu as a whole. More than half, or 55 percent, of the respondents are "very satisfied," as compared to O'ahu's 57 percent. Three percent were "very dissatisfied."[48]

[48] *Omnitrak, 1989, Table 1.*

Almost 60 percent of the respondents also felt that life today is better than it was five years ago.[49]

2. **Outlook on future quality of life.**

The future outlook on the quality of life in five years was positive among 'Ewa Beach residents, despite a major concern about the infiltration of crime and drugs in their community. Two-thirds of the respondents anticipate life will be better in five years.[50]

3. **Most important community problem.**

Almost half cite crime and drugs as the most important problems facing their community. This was followed by traffic and education. O'ahu-wide residents had different priorities, however, and their problems ranked traffic first, housing second and education third.[51]

4. **Priority for government.**

Although affordable housing was not a top problem for respondents, they appeared to recognize this as a major problem facing the islandwide community. Twenty-seven percent felt that "reduc[ing] housing costs" was a priority for government, followed by 22 percent citing "creat[ing] more jobs."[52]

5. **Environmental priority.**

Water quality was the most important environmental priority for 84 percent of the respondents. The distant second most important environmental priority was water and beach access.[53]

6. **Attitude towards development.**

'Ewa Beach residents had a favorable attitude towards development, with 61 percent tending to favor more development.[54] This overall favorable attitude extends to support for specific 'Ewa developments, such as a marina in 'Ewa (71 percent) and the second city (70 percent). Ko Olina is also supported, with two-thirds of all respondents in favor of development.

[49] *Ibid., Table 2.*
[50] *Ibid., Table 3.*
[51] *Ibid., Table 4.*
[52] *Ibid., Table 7.*
[53] *Ibid, Table 10.*
[54] *Ibid., Table 5.*

Respondents tended to be more favorable towards a development if the project provided basic community needs, including job opportunities (90 percent), medical facilities (90 percent) and a school or college (80 percent).

For those who opposed development, 38 percent cited "overpopulated/too many people" as the reason to stop development.[55]

7. **Growth trade-offs.**

Slightly more people (45 percent) favored growth to create jobs, rather than saving the environment (40 percent).[56]

8. **Preference for types of recreational facilities.**

Respondents tended to favor the development of more playgrounds (79 percent) and parks (78 percent). Almost half favored more boat ramps and marinas and 17 percent favored more golf courses.[57]

Further, over two-thirds of the respondents "strongly opposed" the development of more private golf courses in Hawai'i.[58] The possibility of public play at private golf courses did not sway two-thirds of the respondents.[59]

9. **Attitudes and perceptions toward foreign investment.**

Almost half of 'Ewa Beach residents, or 45 percent, felt "very unfavorable" towards Japanese companies investing in Hawai'i. Overall, Hawaii-owned companies scored higher than Japanese-owned companies on specific attributes relating to image. Specifically, these attributes included balancing self-interest with community interest, honesty, responsiveness, and environmental concerns.[60]

5.3 Issues Specific To Tourism

The 1989 statewide survey on tourism indicate that 'Ewa region residents have had a fairly positive attitude towards the visitor industry. On a personal level, they tended to have pleasant experiences with tourists and enjoyed meeting tourists in both indoor and outdoor situations. Tourists do not interfere with the lives of most 'Ewa Beach residents, although one-fifth of the respondents felt stopped going to an outdoor area because it was taken over by tourists.

55 *Ibid., Table 6.*
56 *Ibid., Table 8.*
57 *Ibid., Table 11.*
58 *Ibid., Table 12.*
59 *Ibid., Table 13.*
60 *Ibid., Tables 15 and 17.*

On a community-wide level, most of the 'Ewa respondents felt that tourism was good for the island and that tourism brought more positive benefits than problems. They also felt, however, that tourism was detrimental to parks, the cost of housing and crime. Most 'Ewa respondents did not want to see more hotels, even though there was an acknowledged need for more tourist jobs.

The following further describes the survey findings.

1. **Travel and Use of Tourist Facilities.**

Compared to the statewide proportions, there was less tendency among 'Ewa region residents to have gone to a restaurant in a tourism area in the past 30 days. There was also a lesser tendency to stay in a Hawai'i resort and to take vacations outside Hawai'i.

2. **Perception About Tourism Jobs.**

In the 'Ewa region, there was a greater tendency for respondents to feel that (1) most visitor industry jobs pay pretty well, though (2) most tourism jobs don't have much chance for advancement. Though many felt there was a wide variety of jobs in Hawai'i's visitor industry, it was also felt that tourism jobs have poor work hours.

There was also a greater tendency for 'Ewa respondents to feel that "most visitor industry managers are people from Hawai'i these days," and that good tourism management training is available in Hawai'i.

3. **Contact With Visitors and Nature of Visitor Relationship.**

As expected, unlike the "High Density" tourism area, there was less tendency for one's job to have "much contact with visitors." 'Ewa Beach residents saw tourists outside their job with much less frequency than statewide residents. When 'Ewa respondents did see tourists, most (88 percent) felt that the experience was "usually pleasant." They enjoyed seeing visitors they haven't met before in mostly commercial/indoor situations (37 percent) and outdoor recreation (30 percent).

4. **Impact of Tourism on Personal Lives.**

When asked if there have been any recent situations when tourists interfered with their lives, 96 percent of the 'Ewa region residents responded "no." Over half of the 'Ewa region respondents felt that the smaller tourist activities in their area made their lives either a "lot more pleasant" or "somewhat more pleasant;" eleven percent felt that there was some degree of unpleasantness associated with these tourist activities. Thirty percent felt there was no effect, which is slightly high compared to the statewide 23 percent.

Respondents were asked "in the past five years, have you ever just stopped going to some favorite place because you felt it had been taken over by tourists?" Statewide, 72 percent replied "no." In the 'Ewa region, 80 percent replied in the negative. The type of place no longer frequented by the remaining 20 percent tended to be an "outdoor place."

On a statewide level, 60 percent of the respondents felt that tourism was good for the respondent and the family; 30 percent felt there was not effect. In the 'Ewa region, 56 percent felt that tourism was good, with 33 percent feeling that tourism had no effect. The key way in which tourism was good for the 'Ewa region respondent and family was jobs and economic issues, which is consistent with state-wide responses.

5. **Impact of Tourism on the Community.**

In 'Ewa, 77 percent of the respondents agreed with the statement that "Overall, tourism has brought more benefits than problems to this island." Eighty-four percent felt that tourism make the availability of jobs better, and 54 percent felt that tourism helped in the preservation of native Hawaiian culture. On the other hand, 'Ewa region residents tended to feel that tourism made both the quality of beach parks and the cost of housing worse; the majority also felt that tourism exacerbated the traffic and crime problems.

Thirty-seven percent of 'Ewa region respondents felt that tourism had no effect on the number of people living in "your part of the island, with the remaining responded split between whether tourism made it better (27 percent) or worse (29 percent).

Thirty-five percent felt that tourism made the beauty of the area better, while 45 percent felt that tourism had no effect. The majority felt that tourism made the overall standard of living better and that it made shopping, restaurants and entertainment better.

6. **Community's "Big Problem."**

Respondents were asked if certain elements were a problem in their part of the island. In the 'Ewa region, over half of those interviewed considered the cost of housing and traffic as "big problems." Crime and population growth were also considered big problems by over 40 percent of those interviewed.

It is noted that 46 percent felt that development's destruction of the beauty of the area was "not a problem," and neither was the pollution of ocean or natural areas.

7. **The Future of Tourism.**

'Ewa region respondents (73 percent) tended to want to keep all future resorts close to existing hotels. Fifty-nine percent felt that taxes generated by tourism should go for public improvements in visitor areas. Over 60 percent believed that "in my part of the island it is more important to keep things the way they are than have more tourism jobs."

Further, 68 percent felt that "it is time to stop building new hotels on this island," even though 55 percent felt "We need more tourism jobs on this island."

5.4 Previously-Identified Issues on 'Ewa Marina

5.4.1 1990 Study on Community Issues and Concerns on Ewa Marina

When the 1990 Earthplan study of issues and concerns related to Ewa Marina was conducted, the Ewa Marina project had just been modified. The residential component was greatly reduced, and the Phase 2 residential units were replaced with a golf course and the Mixed Use Commercial Component, including 1,500 hotel units. The following summarizes input provided by the community informants.

1. **Support for or acceptance of development in 'Ewa.**

Collectively, those interviewed either strongly supported major development in the 'Ewa region, or accepted it as inevitable. Three reasons formed the bases for this support/acceptance: (1) the need to improve the social image of 'Ewa Beach; (2) the need to increase the sheer number of jobs in this area; and (3) public policy consensus for such growth.

2. **Traffic, infrastructure and public services.**

When it came to development, traffic was *the problem* for both the general community and recreation groups. Impacts on the water and sewerage systems were also cited by the general community group as problems, but not as frequently as the traffic problem, and mostly by Neighborhood Board members and 'Ewa region residents. Some people also warned that public services would be strained; most seemed confident that government would plan for these changes, however.

3. **Knowledge and acceptance of Ewa Marina.**

All those interviewed knew about Ewa Marina, and only a couple of non-Ewa recreation group interviewees did not know the exact location of the project site. Even though some people did not like specific project components, or were concerned about project-related impacts, there was nevertheless acceptance that Ewa Marina will happen. Project supporters -- who were mostly in the general community group -- expressed frustration at the slow pace of implementation.

4. **Desire for shoreline and beach improvements.**

Most of those interviewed associated Ewa Marina with beach park improvements, and they welcomed these changes. These improvements were of higher priority for 'Ewa Beach residents and Neighborhood Board members, than for 'Ewa region residents. Almost all of the recreation group interviewees appreciated beach park improvements.

The only concern which qualified support for such improvements was project-generated impacts on surfing and ocean food-gathering activities. These concerns were expressed mostly by recreation group interviewees, and less so by the general community group.

In addition to beach park improvements, on-site urban recreational uses and public access to these uses and facilities were desired mostly by 'Ewa Beach residents of both interview groups.

5. **Addressing the youth-related problems in Ewa Marina and other future developments.**

   Next to traffic, youth-related problems was a prevalent community concern. Ewa Marina represented at least a partial solution to many of those interviewed. Also raised was the potential for Ewa Marina to exacerbate the youth problem because of economic disparity.

   The youth problem was more of a priority for the general community group, particularly 'Ewa Beach residents and Ewa Neighborhood Board members.

6. **Social interface and economic disparity.**

   There was consensus that Ewa Marina would be an upscale project, attracting affluent people of different social backgrounds. On one hand, many welcomed the economic revitalization afforded by the project, in terms of jobs and business opportunities. They also liked the diversification of uses proposed for the project and were looking forward to new shopping areas and leisure facilities. At the same time, there was apprehension about how the current 'Ewa Beach residents and social structure would evolve with this new project.

   Social-related impacts tended to be a greater concern of 'Ewa region residents and 'Ewa Neighborhood Board members, rather than of 'Ewa Beach residents. This may be because the 'Ewa Beach residents had a greater tendency to view Ewa Marina as part of the solution, rather than as the problem.

7. **Effect on property values.**

   While most of the interviewees felt that increases in property values were good, many also feared that Ewa Marina would indirectly displace renters and elderly people with fixed incomes. 'Ewa Neighborhood Board tended to express this concern more frequently than others.

8. **Impact on surfing and ocean food-gathering activities.**

   Almost all of those interviewed were familiar with the makai end of the project site because they have picnicked, surfed, fished or gathered seaweed at the Oneula Beach Park. Many no longer frequented the site because they feel the area is dirty and dangerous. Ewa Marina is seen as a way to clean the area up and deter alleged crime at the site. Also of importance is the project's potential for altering the ecosystem and negatively affecting these recreational activities.

   Concerns about these types of impacts were expressed by all in the recreation group, and occasionally by those in the general community group.

9. **Specific project components.**

   Interviewees seemed to like Ewa Marina as a whole, and few recommended changes to project components. Boat slips and public boat ramps were appreciated, as were the shopping center and recreational facilities. Recommended changes targeted two components. First, the marina channel alignment was a concern because it might eliminate a surfing site. Second, a few simply did not like the visitor-oriented component and suggested its elimination. Both types of changes were suggested by recreation group interviewees.

10. **Agriculture.**

    A couple of Neighborhood Board members indicated that they have second thoughts about eliminating the agricultural industry because of the then-controversial O'ahu Sugar Company vs. Mayor Frank Fasi conflict.

5.4.2 'Ewa Beach Forum Conducted by HASEKO

HASEKO (Hawaii), Inc. asked community leaders to participate in the first forum on community benefits in two ways. First, they were asked to fill out a questionnaire and return it to HASEKO before the forum. Second, they were asked to interact with each other at the March 1991 forum.

Forty-five pre-forum questionnaires were returned; the response rate was 57 percent. The questionnaire contained six questions, and the following summarizes responses:

1. **Which [community] problems do you think HASEKO (Hawaii) should help solve?**

   Respondents wanted HASEKO to help mostly with things related to young people, including programs and crime problems. Recreation and job training were also important, as were pollution (general and ocean) and maintaining a clean environment.

2. **What are the two most important ways do you think HASEKO (Hawaii) can help 'Ewa Beach?**

   The two most frequent responses were (1) to provide community facilities within Ewa Marina and (2) to participate in community efforts in some way. Choices which were less popular included contributing funds to government-sponsored projects in 'Ewa Beach and contributing funds to community fundraising efforts in 'Ewa Beach.

3. **What types of government-sponsored programs in 'Ewa Beach, if any, do you think HASEKO (Hawaii) should contribute to?**

   Choices included (1) transportation and roadways; (2) water system, supply and quality; (3) affordable housing; and (4) education. All of the choices received almost an equal number of responses.

4. **If HASEKO (Hawaii) contributes funds to community fundraising efforts in 'Ewa Beach, what kind of efforts or programs do you think we should consider?**

   Responses fell into four categories: social, economic, cultural and environmental. Further discussion on the types of ideas is provided in the forum summary.

5. **Ewa Marina can provide community-oriented facilities within the Gateway Park. What kind of facilities or programs do you think should be provided there?**

   Section 4.6.3 discusses how respondents envision the Gateway Park.

6. **HASEKO (Hawaii) will help improve the One'ula Beach Park. What kinds of improvements or programs should be provided there?**

   Section 4.6.3 discusses how respondents feel the beach park should be improved.

The small group portion of the forum discussed three topics, corresponding to the latter three questions of the questionnaire. Participants were provided summaries of responses to these questions and were asked to discuss, expand upon and modify comments related to (1) community-wide benefits, (2) the Gateway Park and (3) One'ula Beach Park. The comments on the Gateway Park and One'ula Beach Park are provided in Section 4.6.3.

There were no major deviations between questionnaire responses and forum comments. The major difference was that forum participants were able to hear each other's opinions and comments. The discussions tended to evolve based on group dynamics, and participants often built upon comments of others to emphasize and clarify.

In all three groups, participants tended to focus on how HASEKO could provide benefits for the overall 'Ewa Beach community. Participants saw the company's participation in community-wide efforts -- regardless of whether the efforts occurred within project boundaries -- as essential to the success of the Ewa Marina.

Basic themes which recurred among the three groups are:

- **Youth-orientation**

  Whether it was a sports program, a facility for youth gatherings, or specific organizational efforts, participants often discussed the possibilities of how HASEKO could provide for young people. Many pointed out that 'Ewa Beach residents are very concerned about the young people. Youth crime and gangs are a problem, and it was felt that contributing factors include boredom and a breakdown of traditional family values.

  Thus, a key solution was to *provide something for the young people to do* and participants saw HASEKO has part of this solution. They saw possibilities for HASEKO somehow participating in or contributing to:

  - *programs*, such as PAL activities and the Boys and Girls Club;
  - *facilities* for meetings and recreation; and
  - *activities*, such as ocean sports competitions and athletic events.

- **Social Service Needs.**

  Participants often cited the community's need for certain social services and suggested that HASEKO play a part in these services. In addition to youth-oriented service needs, social service areas identified by participants included:

  - *education and job training*, including academic, vocational and management courses, in preparation jobs at Ewa Marina and for the general benefit of the community;
  - *family support programs*, which would help 'Ewa Beach residents address current social problems; and
  - *community organizing*, including establishing a community newsletter and an "umbrella" organization comprising interests present at the forum.

  Regarding community organizing, participants often noted that this forum is unprecedented in 'Ewa Beach in that there was a very wide representation of 'Ewa Beach interests. They wanted to see this type of gathering and sharing of ideas continued and saw Ewa Marina as a catalyst for community organization.

It was stressed that HASEKO should support, rather than duplicate existing services and programs.

- **Integration between Ewa Marina and 'Ewa Beach.**

  Participants did not want to see existing 'Ewa Beach residents alienated from the new Ewa Marina residents. They encouraged facilities and programs which integrated and involved residents of these communities. They discouraged perpetuating the have/have-not economic disparities.

5.5 Issues Raised In Community Interviews for This Study

The results of the interviews are summarized in two parts. The first presents interviewees' feelings about the existing 'Ewa community. The second outlines reactions to the Ewa Marina.

5.5.1 Feeling About Today's 'Ewa

'Ewa's strengths are her people and slow-paced lifestyle. The beach was another important ingredient in 'Ewa's strengths. People felt that the community still retains qualities considered rural. Another favorable aspect that was cited was the community's "progress," in terms of improvements to infrastructure and new development. Those who looked forward to change anticipated social diversity and improved public services.

Not everyone agreed that progress is good, however. Progress was also considered a problem, especially if it brought higher rents and more traffic. More people in general was also seen as a problem, mostly because it was feared that the new people would change 'Ewa.

Those who look forward to progress cited 'Ewa's geographical isolation as a problem. It was felt that there were too few commercial opportunities, and that young people do not have enough activities and programs close to home.

Affordable housing was a major problem, although it was also felt that one of 'Ewa's strengths was inexpensive housing. A related problem to some was the increase of families with low incomes. It was felt that government-sponsored housing attracted these families and that, in time, this could create an overall social composition which is undesirable.

Changes to the ecosystem are problems, particularly of one frequented the beach and ocean. People were afraid that increasing siltation and the eradication of seaweed and fish populations may be irreversible at this point.

5.5.2 Reactions to Ewa Marina

Almost all of those interviewed tolerated or supported 'Ewa's growth and were likely to accept Ewa Marina. It was felt that Ewa Marina was part of the overall scheme to establish the Second City. This does not mean, however, that these people accepted the total project. They had concerns about specific aspects of Ewa Marina and these are discussed below. Where specific concerns about certain components, such as the marina or hotel, were strongly negative, acceptance of the overall project was low.

For those who were opposed to any large development project, and Ewa Marina was a major problem. These people wanted to keep 'Ewa Beach the way it is today, and did not want to see the lifestyle or ambience change. They did not accept change as a good or inevitable occurrence, but rather as a cause for problems, such as increased rents and loss of rural lifestyle. The following summarizes specific comments raised by those interviewed.

1. **New residents.**

   There were two distinct feelings about the new residents in Ewa Marina. On one hand, the new residents were welcomed. Ewa Marina was expected to change the overall social and economic composition of the area by bringing in people with higher incomes and various types of employment. This was seen as a positive aspect, particularly by those involved in public or social-related institutions. To them, different people meant new role models for young people, new resources in community organizations, and more business for 'Ewa Beach stores.

   On the other hand, there was apprehension about the new residents. The biggest concern was related to social problems related to economic disparity. It was feared that new residents would be conspicuously wealthier than existing residents, and the latter would feel inferior. The new residents would compete with existing residents, some felt, to the point where current residents may be overruled.

2. **Infrastructure.**

   The project's impact on roadways and traffic was a big and frequent concern. People are already experiencing longer waiting times in traffic because of new development, and yet they see no real progress in solving the traffic problems. It was felt that more roads are not enough to solve the problem; they only allow 'Ewa motorists to reach the H-1 Freeway bottleneck sooner.

   Water availability and the sewerage system were other major concerns. It was felt that the Honouliuli Wastewater Treatment Plant would not be able to handle future growth, and yet projects continue to be approved.

3. **Reactions to specific project components.**

   The two components which generated the most comments were the marina and Mixed Use Commercial Complex. People wanted to make sure that the dredging for the marina did not damage the fresh water aquifer. They felt that any damage would be irreparable and were afraid of the possible permanence of impact. The marina's impact on the ecosystem was also a big concern. Impacts on fish habitats and population and seaweed were raised. Especially important was any impact on surfing; it was pointed out that surf sites cannot be replaced.

In the Mixed Use Commercial Complex, the hotels raised the most comment. The hotels meant more jobs, restaurants, opportunities to meet new people and a place for relatives to stay when visiting Hawai'i. On the other hand, the hotels were also undesirable because it meant tourism in 'Ewa Beach. Tourism would detract from the residential character, and, in the worst case scenario, would bring another Waikiki to this area.

The building height of hotels was a problem. If the hotels are to be tall, informants did not approve of them because they were too much like Waikiki. When height itself was an issue, the acceptable height was around four or five stories.

Informants were ambivalent about the proposed golf course. They were either neutral about the golf courses, or criticized the addition of golf course to 'Ewa. It was felt that there was little or no market for the five golf courses already approved, much less the five others that are being proposed in 'Ewa.

People generally liked the other recreational aspects of the project, particularly the Gateway Park and improvements to One'ula Beach Park. They saw these as opportunities for existing residents.

4. **Public access and employment.**

Informants wanted to make sure that existing residents will be able to use Ewa Marina's parks and golf course and visit the facilities. They also wanted to see local residents have an opportunity to obtain the better-paying jobs at Ewa Marina, and not just the lower-paying service jobs.

5. **Ecological and archaeological impacts.**

Those interviewed wanted assurances that the marina construction and operational activities do not adversely affect the ocean. Also of concern were the archeological resources; people wanted to see the valuable resources studied and retained.

6. **Attitude towards HASEKO (Hawaii), Inc.**

Almost all of those interviewed felt that HASEKO has been trying to be a good neighbor. They believed that the company is responsive to input, is open with information, and is accessible to the community.

Those who disliked the company distrusted developers in general. They cited the company's foreign ownership as a negative aspect, and believed that profit-oriented efforts will negatively impact the 'Ewa community.

7. **Different perceptions about extent of project opposition.**

Those who were unequivocally opposed to Ewa Marina felt that they represented the majority of 'Ewa Beach residents. They distrusted company-sponsored polls and studies which may indicate otherwise, believing that these are skewed in favor of the developer.

Those who were neutral or supportive of Ewa Marina believed otherwise. They felt the many residents are generally accepting of change and Ewa Marina. It was pointed out that, when there was a community concern, HASEKO would address it in a timely fashion, and this encourages a favorable reaction. These people also felt that those who oppose the project has been disseminating wrong or misleading information about Ewa Marina in order to obtain petition signatures.

5.6 Analysis of Issues Related to Ewa Marina

Earthplan has been monitoring 'Ewa and Ewa Marina issues since 1985 and issues have evolved as new homes are built, problems and priorities change, and the community takes on a different look. This section analyzes these issues and attitudes over time.

1. **Increasing apprehension towards development and its changes.**

As 'Ewa is developed, the realities of development temper the community's earlier enthusiasm. New communities are coming up, and roads are being improved. Compared to just a few years ago, there is more traffic, new children are attending local schools, and new faces are seen at the shopping centers.

Whereas the 'Ewa Neighborhood Board has previously endorsed most changes in 'Ewa, Board members are increasingly scrutinizing new projects and placing conditions on their positions. Likewise, during our interviews, there is more of tendency to mention traffic, water and sewerage as major concerns.

2. **Acceptance of and support for Ewa Marina continues.**

Ewa Marina has been discussed for over a decade and community leaders in 'Ewa Beach have consistently supported the project. The most recent endorsement was in April 1991, when the 'Ewa Neighborhood Board No. 23 voted to support Phase 2 of Ewa Marina with conditions.

3. **Recent opposition to the project.**

Until 1990, testimony at public hearings was generally in favor of Ewa Marina. In June 1990, however, at the State Land Use Commission hearing for Urban designation for Phase 2, a spokesperson for the Save Ewa Beach Ohana cited a petition with over 2,400 signatures. It appears that no signatures have been added to the petition in the following year as a 2,400-signature petition was submitted to the City and County of Honolulu Planning Commission in September of this year.

The extent of opposition to Ewa Marina is unclear at this time and the only way to realistically gauge the extent of opposition is to conduct a statistical poll.

4. **Direct correlation between one's attitude towards community change and one's view of Ewa Marina.**

Based on our analysis of community reactions on this project, one's support or opposition to the overall Ewa Marina can be directly correlated to one's attitude towards change.

There are those who are optimistic about community changes already occurring or being planned for 'Ewa. These people generally see changes, including Ewa Marina, as the *solution* to current problems such as the housing shortage, crime, and lack of recreation and youth activities. They believe that the project will bring social diversity, more facilities, and generally a better quality of life for 'Ewa residents.

Those who are generally apprehensive or pessimistic about community changes tend to see development as the *root* of problems. To them, development will bring a greater shortage of affordable housing, more crime, and newcomers who will change the community.

This latter group is already concerned about changes which are occurring, such as 'Ewa Gentry and West Loch. Ewa Marina is an even bigger threat because it would be the closest to 'Ewa Beach.

5. **Attitude towards tourism and tourists.**

The statewide tourism survey indicates two important tendencies with 'Ewa residents. First, the majority of respondents liked tourists; they had pleasant experiences on a one-to-one basis. Further, 'Ewa respondents felt very positive about the benefits of tourism; they believed that tourism benefits outweigh its problems.

The second tendency appeared contradictory. 'Ewa respondents also believed that tourism had negative impacts on existing major community problems. They felt that tourism made the cost of housing and traffic worse. Most people didn't want any more hotels because of these apprehensions.

The basic difference is that the first tendency is based on one's actual experience, whereas the second tendency emerges when a person looks at tourism symbolically.

The interviews for this report indicated similar tendencies. Those interviewed did not object to having tourists in their area, but some had very strong feelings against the hotels. They feared that tourism will negatively affect the residential character of the area, and essentially produce another Waikiki. The have/have-not syndrome was a problem also, especially if affluent tourists were attracted to the area. To these people, the negative connotations of tourism could be realized if Ewa Marina contains hotels.

6. **Shift in interest in employment.**

When Ewa Marina was first introduced to 'Ewa, the sheer increase in the number of jobs was a major plus to 'Ewa residents. As unemployment decreases and as the employment prospects for Kapolei and Ko Olina become more evident, "jobs" is no longer development's big plus. Rather, 'Ewa residents are now looking at the types of jobs. They want to see a diversity of jobs, and, more importantly, opportunities for local residents for upward mobility in the job market.

7. **More specific questions and concerns about ecological and environmental impacts.**

The community's awareness of potential environmental issues has grown in the last few years. People who read newspapers and attend public meetings are becoming knowledgeable about groundwater, shoreline habitats and air quality. Whereas people were formerly concerned about Ewa Marina's impact on "the environment," they are now more informed and direct their questions to more specific issues. Hence, HASEKO needs to continue to share project information as much as possible to assist the community in making an informed decision about the project.

8. **Community input and integration -- a key ingredient.**

Ewa Marina needs to be a good neighbor and the existing community needs to feel comfortable with the types of changes proposed by HASEKO. 'Ewa Beach residents need to feel that they will be an important part of the future community, and that they will not be over-shadowed by the newer residents.

Community organizations in Ewa Marina or at the Gateway Park should be easily accessible for residents and there should be no apparent exclusionary groups, facilities or areas. People feel comfortable with socio-economic diversity if they believe they have physical, legal and some economic access to most facilities. Further, 'Ewa Beach residents need to believe that they have -- or can attain -- the same ability as others to compete for jobs and public services.

Though it is difficult to predict how 'Ewa Beach and Ewa Marina will integrate and interact, HASEKO can help prepare existing residents for future changes by including 'Ewa Beach in the planning process. Further, project aspects which could directly impact 'Ewa Beach should be made clear, so as to help existing residents form realistic expectations.

HASEKO has begun this process by initiating an extensive program of dialogue with the community. This program has several facets. One portion deals with the community benefits package, whereby Ewa Marina will directly contribute to the adjacent 'Ewa Beach. Discussions on the types of benefits and the mechanism for handling benefits are currently underway, and are expected to continue over the next few months. Eventually HASEKO hopes to have a Community Benefits Advisory Committee which will work out the details.

Another facet of the dialogue process is asking community experts to review report findings, as in the case with ocean recreation. HASEKO has also opened an office in 'Ewa Beach, so that residents have direct access to project personnel. Further, the company gives presentations whenever asked, and initiates different types of meetings to provide project information and gather input.

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Appendix A

List of People Contacted by John Clark for Ocean Recreation Purposes in 1990 and 1991

These people were contacted in two different efforts. First, ocean recreation consultant John Clark conducted a general ocean recreation analysis in 1990. Second, he distributed the 1991 engineering study on marina entrance design to members of the ocean recreation community.

Those interviewed were asked to share their knowledge and were not asked to take a position on Ewa Marina. If their organization had taken a position, they were asked to discuss the formal position.

Name	Organization/Affiliation
Don Akiyama	Ewa Complex Supervisor, City Department of Parks and Recreation
Robert Burns	President, Save Waves
Edward Cashman	Captain, Ewa Beach Fire Station Past President, Ewa Beach T-Ball League Former coach for various youth sports
Robert Cho	Recreational user of nearby shoreline Fire Fighter, Waipahu Fire Station
Sonny Dela Cruz	Former coach, Ewa Beach (Kuakini) Canoe Club Coach, Haleakala Canoe Club at Hickam Harbor
Albert Fernandez	Recreational user of nearby shoreline Lifeguard, White Plains Beach, NASBP Fire Fighter, Nanakuli Fire Station
Anthony Ferreira	Recreational user of nearby shoreline Fire Fighter, Ewa Beach Fire Station

Appendix B

List of People Interviewed for This Study

Those interviewed were asked to share their knowledge and opinion about 'Ewa and Ewa Marina. They were not asked to take a position or to "represent" their organization. If their organization had taken a position, they were asked to discuss the formal position.

Name	Organization/Affiliation
Jeff Alexander	Acting Chair of Save Ewa Beach Ohana Member of Barbers Point Navy League
Benson Araki	'Ewa Beach resident
Dick Beamer	President of the 'Ewa Beach Community Association Member of the 'Ewa Neighborhood Board
Tony Bise	Fernandez Village resident Member of various committees in 'Ewa Villages
Ed Cashman	Captain of 'Ewa Beach Fire Station 'Ewa Beach resident
Harry Ching	Charter member of Lions Club in 'Ewa Charter member of 'Ewa Beach Community Association
Willy Espero	Member of 'Ewa Gentry Community Association Member of the Board of Directors of the 'Ewa Beach Community Association
Sue Flynn	Member of 'Ewa Beach Community Association
Cynthia Foo	President of the 'Ewa Merchants Association

Name	Organization/Affiliation
Steve Gifford	Recreational user of nearby shoreline Caretaker at one of the plantation recreation areas east of the project site Fire Fighter, Waipahu Fire Station
John Goody	President, American Canoe Association
Fred Hemmings, Jr.	Sports Consultant
Reid Inouye	Recreational user of nearby shoreline Holds amateur surfing contests at Oneula Beach Park Director, Hawaii Surfing Federation
Bobby Kekoanui	President, Hawai'i Longboard Surfing Association
John Kelly	Spokesperson, Save Our Surf
Lee Kravitz	Director, Hale'iwa Community and Surf Center
David McFaull	Commodore, Hawaii Hobie Cat Racing Association
Jo Mogle	Member, Hawaii Yacht Racing Association Member of various yacht clubs Sailing instructor
David Phillips	Sailor and Member, Iroquois Point Yacht Club
Randy Rarick	President, Triple Crown of Surfing
Robert Thomas	President, Honolulu Bodysurfing Club
Debbie Bowers Wayman	Former Ewa Beach resident Former professional surfer and lifeguard

Name	Organization/Affiliation
Mike Freitas	Vice President of Honokai Hale/Nanakai Gardens Community Association
William Godwin	Pastor of the First Baptist Church of 'Ewa Beach Member of the 'Ewa Ministerial Association
John Hamilton	Former 'Ewa Beach resident (spoke in behalf of his father who is current resident)
Darrin Katayama	Member of 'Ewa by Gentry Community Association
Susan King	Reverend in the Ewa Community Church
Peggy Kirby	Kapolei resident Member of Committee on Homeless
Ernest T.W. Lau	Member of 'Ewa Neigbhorhood Board No. 23 West Loch resident
Glenn Oamilda	Vice Chair of the 'Ewa Neighborhood Board No. 23 Chair of the West O'ahu Employment Corporation
Emogene Martin	President of Friends for 'Ewa Member of 'Ewa Neigbhorhood Board No. 23 Member of the Leeward Schools Community Council
Clifford Oliveira	Member of 'Ewa Neigbhorhood Board No. 23 Member of Save Ewa Beach Ohana
Carole Paulsen	Principal of James Campbell High School
Alan Ramos	Principal of 'Ewa Beach Elementary School
Annette St. Pierre	'Ewa Beach resident
Paul Sherman	'Ewa Beach resident

Name	Organization/Affiliation
Oscar Silva	Director of Police Athletic League (PAL) Ewa Police officer
Rene Stevens	'Ewa Beach resident
David Parsons	Member of the Board of Directors of the 'Ewa Beach Community Association
Jane Ross	Chair of the 'Ewa Neighborhood Board No. 23 Corresponding Secretary of the Honokai Hale/ Nanakai Gardens Community Association
Fred Toopes	Executive Board Secretary of Friends for 'Ewa Renton Village resident
Andy Yamada	Recreation Director III, 'Ewa Beach Community Park