Kaupulehu Resort Beach 34121
Safety Imp.

JOHN WAIHEE
GOVERNOR OF HAWAII

KEITH W. AHUE, CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES

DEPUTIES
JOHN P. KEPFELER, II
DONA L. HANAIKE

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OFC. ... QUALIT...

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
P. O. BOX 621
HONOLULU, HAWAII 96809

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

OCT 27 1994

File No.: HA-2719

MEMORANDUM

TO: Honorable Bruce S. Anderson, PhD., Interim Director
Office of Environmental Quality Control

FROM: Keith W. Ahue, Chairperson
Board of Land and Natural Resources

SUBJECT: Negative Declaration for Kaupulehu Resort Shoreline Modification, Kaupulehu, North Kona, Hawaii, TMK 7-2-3: 4, 5, & 6

The Department of Land and Natural Resources has reviewed the comments received during the 30-day public comment period which began on August 8, 1994. The Department has determined that this project will not have significant environmental effect and has issued a negative declaration. Please publish this notice in the November 8, 1994 OEQC Bulletin.

We have enclosed a completed OEQC Bulletin Publication Form and four copies of the final EA.

Please contact Don Horiuchi at 587-0381 if you have any questions.

Encl.

1994-11-08-HI-FEA-Kaupulehu Resort NOV - 8 1994
Beach Safety Improvements

February 1983

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
P. O. BOX 621
HONOLULU, HAWAII 96809

DEPARTMENT MASTER APPLICATION FORM

(Print or Type)

FOR DLNR USE ONLY
Reviewed by ______
Date ______
Accepted by ______
Date ______
Docket/File No. ______
180-Day Exp. ______
EIS Required ______
PH Required ______
Board Approved ______
Disapproved ______
Well No. ______

I. LANDOWNER/WATER SOURCE OWNER
(If State land, to be filled in by Government Agency in control of property)

Name State of Hawaii
Address ______
Telephone No. ______
SIGNATURE ______
Date ______

II. APPLICANT (Water Use, omit if applicant is landowner)

Name Kaupulehu Land Company
Address P.O. Box 1119
Kailua-Kona, HI 96745
Telephone No. 325-0808
Interest in Property Developer of adjacent fast land
(Indicate interest in property; submit written evidence of this interest)
*SIGNATURE [signature]
Date ______

*If for a Corporation, Partnership, Agency or Organization, must be signed by an authorized officer.

III. TYPE OF PERMIT(S) APPLYING FOR

(X) A. State Lands
(X) B. Conservation District Use
( ) C. Withdraw Water From A Ground Water Control Area
( ) D. Supply Water From A Ground Water Control Area
( ) E. Well Drilling/Modification

IV. WELL OR LAND PARCEL LOCATION REQUESTED

District North Kona
Island Hawaii (offshore)
County Hawaii (offshore)
Tax Map Key 7-2-03:4, 5 & 6, 3rd Division (Offshore area)
Area of Parcel Approximately 2 acres
(Indicate in acres or sq. ft.)
Term (if lease) N/A

V. ENVIRONMENTAL REQUIREMENTS

Pursuant to Chapter 343, Hawaii Revised Statutes, and in accordance with Title 11; Chapter 200, Environmental Impact Statement Rules for applicant actions, an Environmental assessment of the proposed use must be attached. The Environmental assessment shall include, but not be limited to the following:

(1) Identification of applicant or proposing agency;

(2) Identification of approving agency, if applicable;

(3) Identification of agencies consulted in making assessment;

(4) General description of the action's technical, economic, social, and environmental characteristics;

(5) Summary description of the affected environment, including suitable and adequate location and site maps;

(6) Identification and summary of major impacts and alternatives considered, if any;

(7) Proposed mitigation measures, if any;

(8) Determination;

(9) Findings and reasons supporting determination; and

(10) Agencies to be consulted in the preparation of the EIS, if applicable.

An Environmental Assessment is attached.

VI. SUMMARY OF PROPOSED USE (what is proposed)

Condition 14 of the Kaupulehu Resort SMA Permit Nos. 271 and 272 (approved in 1988), relating to requirement for public shoreline access, states: "Best efforts shall be used to secure the necessary governmental permits for the development of a swimming beach at a location between the two hotel sites on the subject property." This current application seeks to implement Condition 14 of County SMA approval.

The applicant proposes to improve the shoreline and offshore region adjacent to its Kaupulehu Resort by enhancing the safety, accessibility, and recreational potential of the area. The sites of the proposed excavations are currently too shallow for most types of water recreation, and safety is compromised by the presence of nearshore rock ledges and sharp a'a lava outcrops.

The applicant proposes to improve accessibility into the water and provide protected areas that are safe for swimming and other water-related activities. Excavation of the shoreline and nearshore area will result in four-foot-deep pools with smooth bottoms and easy access from the beach. Access to the one deep tidepool in the nearshore area will be improved by removal of an emergent nearshore rock ledge. All construction activities will be confined to the nearshore zone and adjacent beach. The offshore sill will not be breached. No blasting will occur and all excavation will be completed with standard earth-moving equipment.

INFORMATION REQUIRED FOR ALL USES

I. DESCRIPTION OF PARCEL (See attached description.)

A. Existing structures/Use. (Attach description or map).

B. Existing utilities. (If available, indicate size and location on map. Include electricity, water, telephone, drainage, and sewerage).

C. Existing access. (Provide map showing roadways, trails, if any. Give street name. Indicate width, type of paving and ownership).

D. Vegetation. (Describe or provide map showing location and types of vegetation. Indicate if rare native plants are present).

E. Topography; if ocean area, give depths. (Submit contour maps for ocean areas and areas where slopes are 40% or more. Contour maps will also be required for uses involving tall structures, gravity flow and other special cases).

F. If shoreline area, describe shoreline. (Indicate if shoreline is sandy, muddy, rocky, etc. Indicate cliffs, reefs, or other features such as access to shoreline)..

G. Existing covenants, easements, restrictions. (If State lands, indicate present encumbrances.)

H. Historic sites affected. (If applicable, attach map and descriptions).

II. DESCRIPTION: Describe the activity proposed, its purpose and all operations to be conducted. (Use additional sheets as necessary).

Please see Sections 2.2 and 2.3 of the attached Environmental Assessment for a detailed description of the project.

III. COMMENCEMENT DATE: Early summer 1995

COMPLETION DATE: Late summer 1995

IV. TYPE OF USE REQUESTED (Mark where appropriate) (Please refer to Title 13, Chapter 2)

A. Permitted Use (exception occasional use):
DLNR Title 13, Chapter 2, Section 13 ; Subzone Resource .

B. Accessory Use (accessory to a permitted use):
DLNR Title 13, Chapter 2, Section ____; Subzone ____.

C. Occasional Use: Subzone ____.

D. Temporary Variance: Subzone ____.

E. Conditional Use: Subzone ______.

Area of Proposed Use: approximately 2 acres
(Indicate in acres or sq. ft.)

Name & Distance of Nearest Town or Landmark 6 miles North of Keahole Airport
Boundary Interpretation (If the area is within 40 feet of the boundary of the Conservation District, include map showing interpretation of the boundary by the State Land Use Commission).

Conservation District Subzone Resource

County General Plan Designation Offshore of Intermediate Resort

V. FILING FEE

A. Enclose $50.00. All fees shall be in the form of cash, certified or cashier's check, and payable to the State of Hawaii.

B. If use is commercial, as defined, submit additional public hearing fee of $50.00.

INFORMATION REQUIRED FOR CONDITIONAL USE ONLY

I. PLANS: (All plans should include north arrow and graphic scale).

A. Area Plan: Area plan should include but not be limited to relationship of proposed uses to existing and future uses in abutting parcels; identification of major existing facilities; names and addresses of adjacent property owners.

B. Site Plan: Site plan (maps) should include, but not be limited to, dimensions and shape of lot; metes and bounds, including easements and their use; existing features, including vegetation, water area, roads, and utilities.

C. Construction Plan: Construction plans should include, but not be limited to, existing and proposed changes in contours; all buildings and structures with indicated use and critical dimensions (including floor plans); open space and recreation areas; landscaping, including buffers; roadways, including widths; off-street parking area; existing and proposed drainage; proposed utilities and other improvements; revegetation plans; drainage plans including erosion sedimentation controls; and grading, trenching, filling, dredging or soil disposal.

D. Maintenance Plans: For all uses involving power transmission, fuel lines, drainage systems, unmanned communication facilities and roadways not maintained by a public agency, plans for maintenance shall be included.

E. Management Plans: For any appropriate use of animal, plant, or mineral resources, management plans are required.

F. Historic or Archaeological Site Plan: Where there exists historic or archaeological sites on the State or Federal Register, a plan must be submitted including a survey of the site(s); significant features; protection, salvage, or restoration plans.

II. SUBZONE OBJECTIVE: Demonstrate that the intended use is consistent with the objective of the subject Conservation District Subzone (as stated in Title 13, Chapter 2).

Permitted uses in the Resource subzone include "Research, recreational, and educational use which require no physical facilities."

The proposed project will be used exclusively for recreational purposes and will incorporate no physical facilities. Therefore, it is a permitted use.

DESCRIPTION OF PARCEL

A. With the exception of temporary stockpiling, the proposed project is confined to offshore submerged land and the adjacent beachface. No structures exist offshore or on the beach and none are proposed (see Figures 2 and 3 of the Environmental Assessment).

B. No utilities exist in the offshore or beach areas.

C. Access to the adjacent parcel and the shoreline area is via Queen Kaahamanu Highway and a private roadway that accesses the existing Kona Village Resort. A public right-of-way runs from a parking area on the Kona Village property to the beach. The land-based Kaupulehu Resort development includes two additional mauka-makai rights of way (see Figure 2 of the Environmental Assessment).

D. Vegetation on the adjacent property is sparse. Strand vegetation, including beach naupaka, Bermuda grass, and 'aki 'aki characterizes the adjacent beach area, covering approxiately 50 to 70 percent of the beach crest and landward side.

E. Depths in the nearshore area range from approximately three to four feet below sea level to one to two feet above sea level (see Figure 4 of the Environmental Assessment).

F. The shoreline is characterized by a calcareous sand beach, approximately 50 to 130 feet in width and a shallow offshore area. The beach slopes from a crest seven to ten feet in elevation to the waterline at a slope of about 20 to 27 percent (Figure 4 of the Environmental Assessment). The seaward portion of the beach is strewn with basalt and coral gravel and cobbles. An a'a lava flow marks the southern boundary of the beach and extends offshore to Kumukehu Point. The tidal range in the area is less than three feet.

G. The area of the proposed project is owned by the State; the adjacent fast land is owned by Bishop Estate.

H. No significant offshore historic or archaeological sites are known to exist. The only feature found in the vicinity of the proposed project is desribed as a natural lava formation that may have been used as a fishtrap. This feature was rated of low cultural, scientific, and interpretive significance.

Final Environmental Assessment

BEACH SAFETY IMPROVEMENTS AT KAUPULEHU RESORT
Kaupulehu, North Kona, Hawaii

Applicant:
Kaupulehu Land Company
P.O. Box 5440
Kailua-Kona, Hawaii 96745

Applicant's Agent:
Belt Collins Hawaii

October 21, 1994

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1.0 INTRODUCTION AND SUMMARY

The applicant is Kaupulehu Land Company, P.O. Box 5440, Kailua-Kona, HI 96745. The accepting agency is the State Department of Land & Natural Resources (DLNR).

1.1 PURPOSE OF THIS DOCUMENT

The proposed project includes excavation of submerged land makai of the certified shoreline. This land is owned by the State, is under the jurisdiction of DLNR, and is within the State Conservation District. This environmental assessment (EA) was prepared in accordance with Chapter 343, Hawaii Revised Statutes as part of the applicant's request for use of State land and to support the Conservation District Use Application (CDUA) for the project.

This document is also intended to support applications for other permits required by the proposed project: a U.S. Army Corps of Engineers Section 10 Permit for Activities in Waterways, and a State of Hawaii Coastal Zone Management federal consistency determination. Subject to a determination by the Hawaii County Planning Department, a Shoreline Setback Variance and a Special Management Area (SMA) Minor Permit may also be required.

1.2 CONSULTED PARTIES

Chapter 343 HRS requires early consultation with parties which have jurisdiction, expertise, or are otherwise interested in a proposed project. This consultation is intended to ensure that all pertinent issues are addressed. The following agencies and groups were consulted prior to the completion of this EA; identified concerns generated additional study which is incorporated into the document.

- U.S. Army Corps of Engineers, Operations Division
- State of Hawaii Department of Land and Natural Resources, Office of Conservation and Environmental Affairs
- DLNR, Aquatic Resources Division
- DLNR, Land Management Division
- State of Hawaii Department of Health
- State of Hawaii, Office of Hawaiian Affairs
- County of Hawaii Planning Department
- The Ocean Recreation Council of Hawaii (TORCH)
- Kona Conservation Group
- Surfrider Foundation
- Public Access Shoreline Hawaii (PASH)
- West Hawaii Sierra Club
- Kona Village Resort General Manager

1.3 PROJECT BACKGROUND AND OBJECTIVES

The proposed project has been designed to comply with Condition #14 of Special Management Area (SMA) Use Permits # 271 and 272 for Kaupulehu Resort, which were approved in 1988. Condition #14 states that "Best efforts shall be used to secure the necessary governmental permits for the development of a swimming beach at a location between the two hotel sites on the subject property". The project is intended to accomplish this goal.

1.4 SUMMARY OF THE PROPOSED ACTIVITY AND THE AFFECTED ENVIRONMENT

The applicant proposes to improve the shoreline and offshore region adjacent to its Kaupulehu Resort in North Kona, on the island of Hawaii (Figures 1 and 2). The proposed action involves excavating four recreational areas in the nearshore area (Figure 3). (Public access to the improved beach area will be facilitated by development and maintenance of two new mauka-makai access trails, public comfort stations and showers, and a pedestrian shoreline trail. Public parking areas will also be provided. However, these public access improvements are not part of the proposed activity since they occur on Urban land and were previously permitted pursuant to conditions of zoning and SMA use approvals granted in 1988.)

The proposed project site consists of a sandy beach which slopes to a shallow offshore region that is characterized by two major bio-geomorphological zones, a nearshore partially emergent basalt and cemented sand (beachrock) bench and a broad submerged offshore platform. The two zones are separated by an offshore sill composed of basalt and beachrock. The broad offshore platform and offshore sill protect the nearshore area from the force of breaking waves, and the waters of the nearshore zone are calm. This area would be ideal for swimming and snorkeling, but access and safety are compromised by the presence of nearshore rock ledges, sharp a'a lava outcrops, and shallow water depths.

The applicant proposes to improve accessibility into the water and provide four protected recreational areas (Sites A through D) that are safe for swimming and other water-related activities. Excavation of the nearshore area will result in four-foot deep pools with smooth bottoms and easy access from the beach. All construction activities will be confined to the nearshore zone and adjacent beach, seaward of the certified shoreline. The offshore sill will not be breached. Standard earthmoving equipment will be used and no blasting will occur.

Existing offshore water quality in the area is generally in compliance with Department of Health (DOH) criteria. Exceedances of DOH nutrient standards in some areas are caused by input of groundwater which is high in nutrients, at the coast. Rapid mixing with oceanic water, however, produces nearly homogenous

233.7400/002

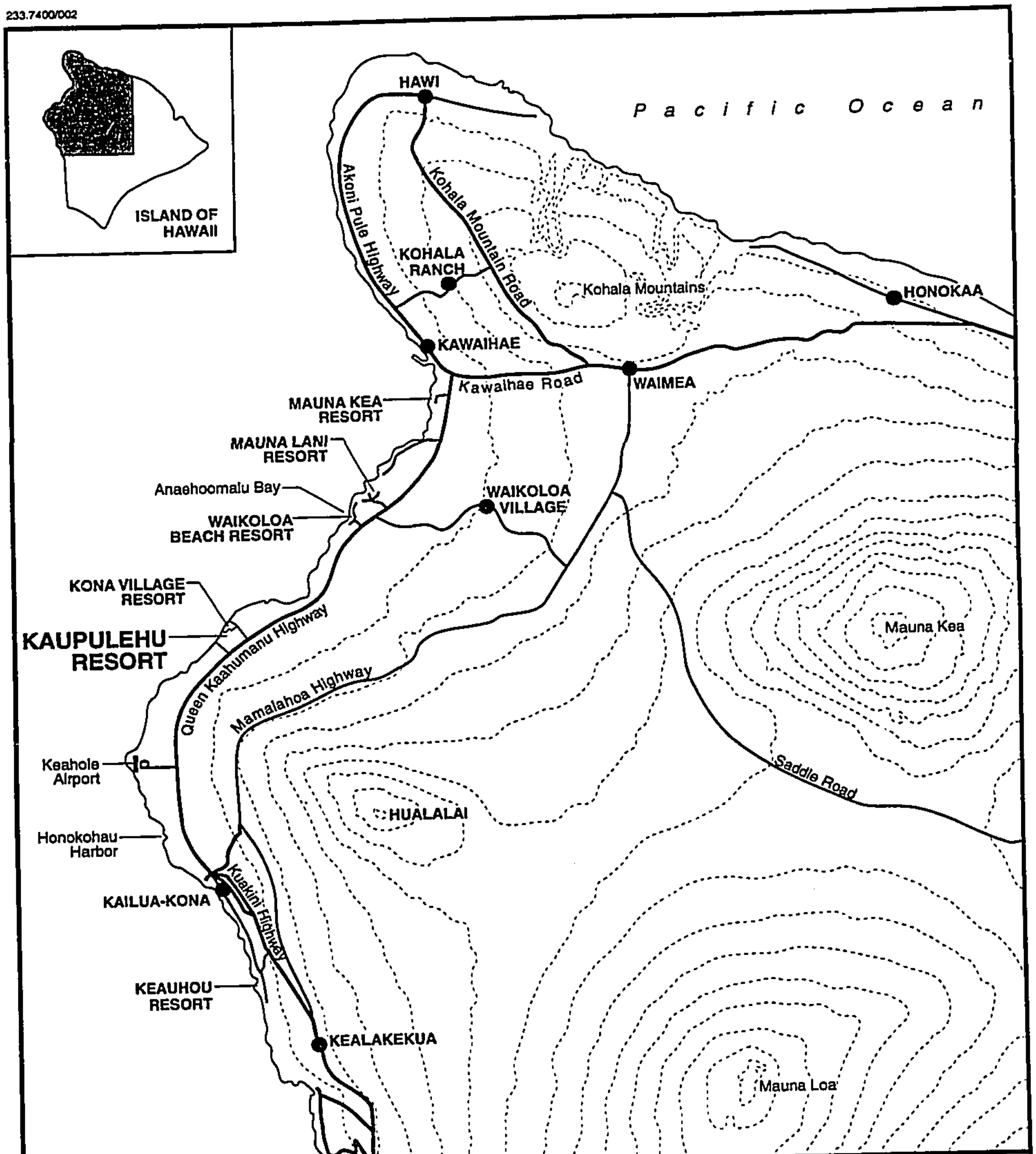
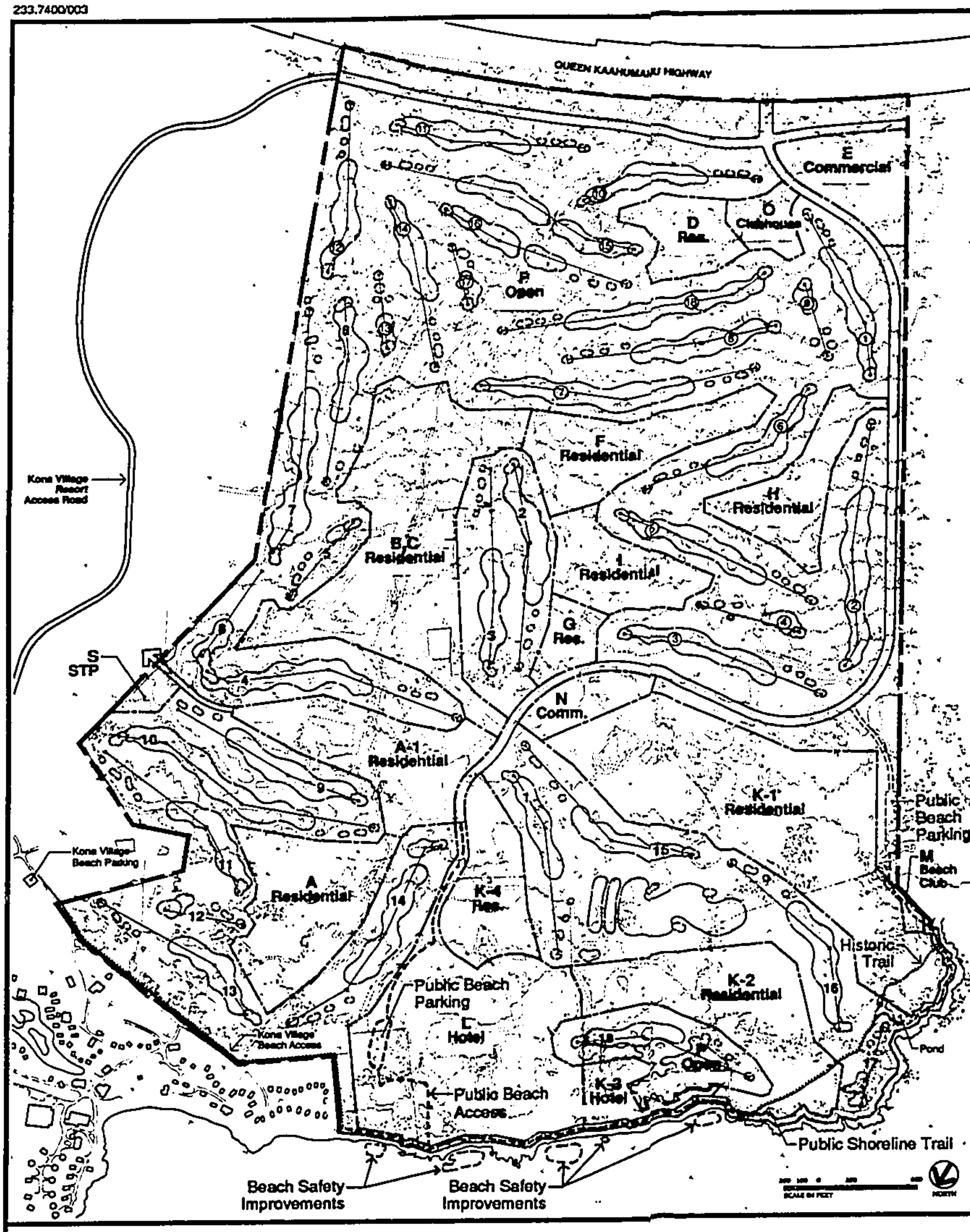


Figure 1
REGIONAL MAP

KAUPULEHU RESORT
Prepared By: Belt Collins Hawaii
October 1994

233.7400/003



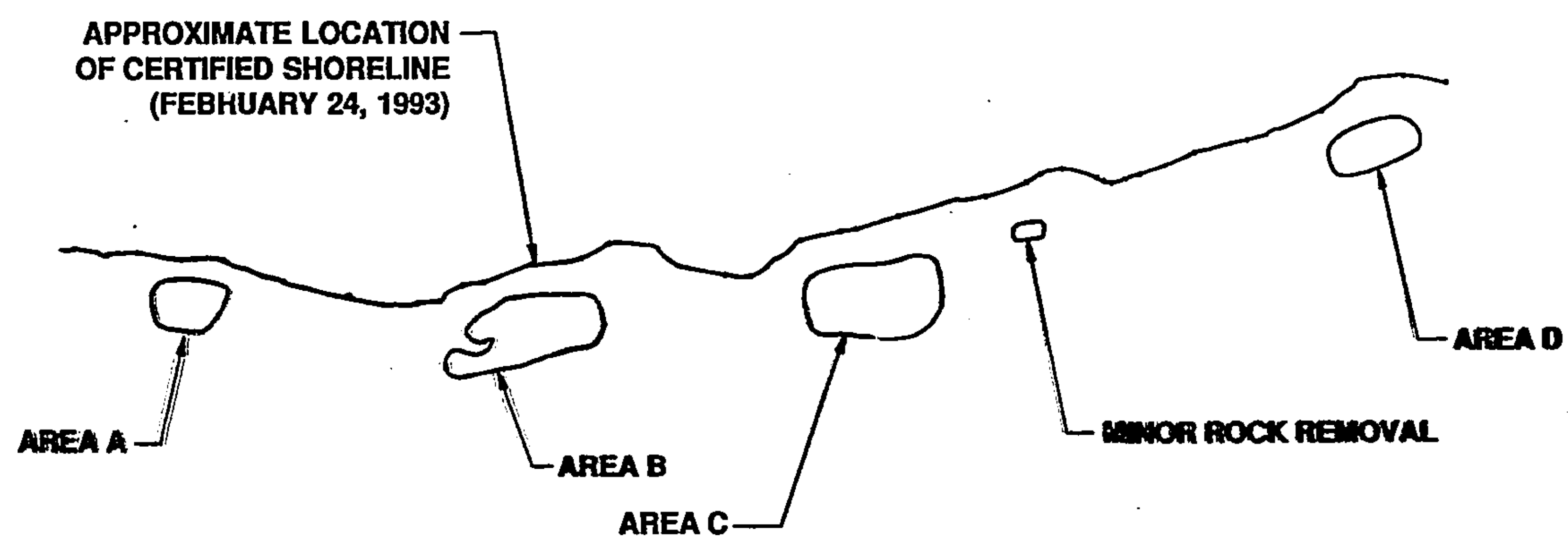
Note: Plan is preliminary and subject to change.

NORTH

0 400 800
SCALE IN FEET

Figure 2
LAND-BASED DEVELOPMENT AND PUBLIC ACCESS

KAUPULEHU RESORT
Prepared By: Belt Collins Hawaii
October 1994



PROPOSED PUBLIC BEACH IMPROVEMENTS

233.7400/002

NORTH

0 140 280 560

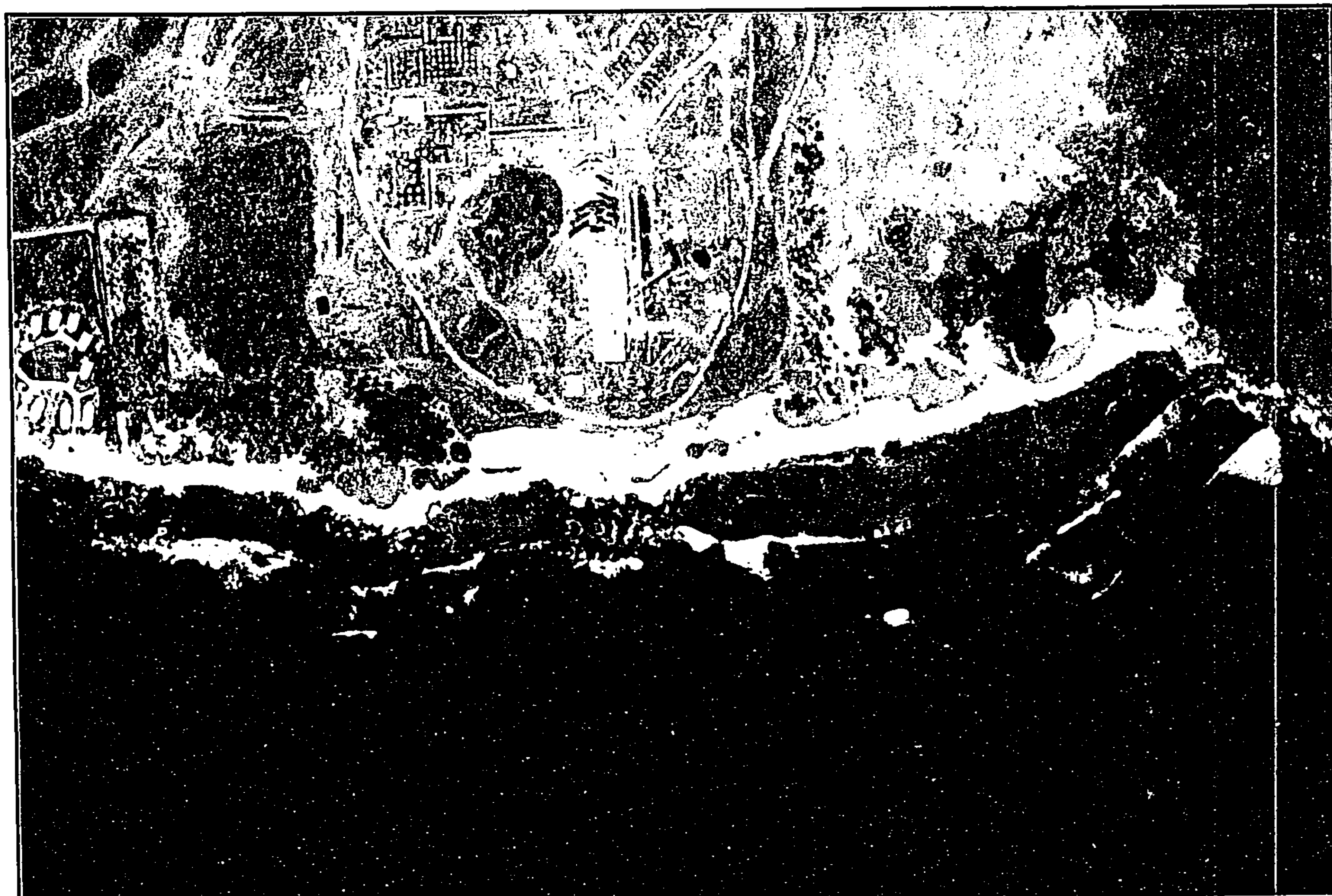
SCALE IN FEET

Source of overlay: Tom Nance Water Resource Engineering (April 1993; Revised May 1993 and April 1994). R.M. Towill photo dated May 4, 1992.

Figure 3
AERIAL PHOTOGRAPH OF PROJECT SITE
PROPOSED PUBLIC BEACH IMPROVEMENTS
KAUPULEHU RESORT

Prepared By: Belt Collins Hawaii
October 1994

233.7400/002



NORTH

0 140 280 560

SCALE IN FEET

Source of overlay: Tom Nance Water Resource Engineering (April 1993; Revised May 1993 and April 1994). R.M. Towill photo dated May 4, 1992.

Figure 3
AERIAL PHOTOGRAPH OF PROJECT SITE

KAUPULEHU RESORT
Prepared By: Belt Collins Hawaii
October 1994

water masses, both vertically and horizontally a short distance from the shoreline.

Surveys completed in the vicinity of the proposed improvements indicate that common marine organisms in the area include reef corals, sea urchins, algae, and reef fish. Biological density and diversity in the nearshore zone appear to be strongly controlled by water depth. Water depths of approximately three feet appear to be required to prevent the extremes in temperature and salinity that limit settlement and growth of organisms, particularly corals. Most of the nearshore is shallower than three feet and thus is characterized by low abundances and diversity. Coral concentrations at Sites A, B, and D, for example, are two percent or less. In comparison, coral cover at a deep (approximately three to four feet deep) tidepool near Site C is about 10 percent.

1.5 SUMMARY OF POTENTIAL IMPACTS

The proposed project will include excavating State-owned submerged lands, composed of basalt lava and beachrock, and removing the material on shore. The existing nearshore area is too shallow and inaccessible for most recreational or other uses. Removal of this material is not expected to result in a significant loss of any public benefit. The proposed project is intended to provide several public benefits through improvements to the safety and recreational potential of the shoreline and offshore area.

No significant adverse impacts to offshore water quality are expected to result from the proposed project. Excavation of the improvement sites may result in localized alterations to the flow of groundwater into the nearshore area; however, rapid mixing of waters in this area will minimize any potential effects. In addition, excavation will necessarily remove some marine organisms. Deepening of the improvement sites, however, is expected to provide a more favorable environment for growth of coral and other biota. The net long-term result will be an increase in the diversity and abundance of marine organisms in the nearshore area. Numerical modeling of wave conditions indicates that excavation of the proposed improvement areas will not have a significant effect on wave heights in the nearshore area. As a result, the improvements are not expected to affect wave run-up on the beach, or beach stability.

Construction activities will generate temporary impacts, but these will be short-lived and will be mitigated to the greatest extent possible. Noise levels will increase as a result of the use of earthmoving equipment. These will be minimal, however, especially in comparison with those resulting from the land-based construction activities that will occur concurrently. Short-term offshore turbidity increases during construction are unavoidable. All silt, sand and cobble sized material created during excavation and subsequent smoothing of the pool bottoms but not removed by bulldozer and/or a front-end loader will be removed by suction pumping. This material will be pumped onshore, dewatered, and buried at an appropriate location.

2.0 DESCRIPTION OF THE PROPOSED ACTIVITY

2.1 EXISTING AND PLANNED DEVELOPMENT

The site of the proposed project is within the North Kona District which encompasses the coastal and inland area between Keauhou Resort and Anaehoomalu Bay (Figure 1). The major population and commercial center of the region is the town of Kailua. Most of the urbanized area of North Kona occupies a strip from Kailua along the southern one-third of the North Kona District coastline. Occasional subdivisions and urbanized areas also exist along the Mamalahoa and Kuakini Highways.

Historically, North Kona and South Kohala have been a center of resort activity on the island of Hawaii. This trend continues today with a number of planned and proposed developments. North of the Kaupulehu Resort site is the Kona Village Resort; the site of the proposed Kukio Beach Resort is south of the applicant's property.

Because the region has long been designated as a resort area by both the State and the County, substantial investments have been made in the infrastructure, including construction of the Queen Kaahumanu Highway and Keahole Airport. The Airport is currently expanding with a runway extension that is expected to be completed in 1994.

The existing land-based Kaupulehu development plan consists of a self-contained resort/residential community. This plan includes two 18-hole golf courses, the Kaupulehu Resort (which incorporates tennis courts, a fitness center, and other facilities), a beach club, and residential and commercial areas (Figure 2). Vehicular access to the resort will be via a new entry road off Queen Kaahumanu Highway. Public parking and access to the shoreline will be provided via two new mauka-makai rights of way and a pedestrian shoreline trail. A State Land Use change, zoning changes, Special Management Area Use Permits and other County permits, as well as Conservation District Use Permits have been obtained for activities related to the shore-based development.

2.2 NEED FOR THE PROPOSED PROJECT

The offshore region of the Kaupulehu Resort is considered unusual for West Hawaii. Most of the West Hawaii coast is characterized by a narrow nearshore reef terrace open directly to the ocean. At Kaupulehu, however, the offshore area is divided into two distinct regimes, a nearshore partially emergent intertidal bench and an offshore submerged platform (Figures 4 and 5). The nearshore bench is separated and protected from the open ocean by the wide offshore platform and an emergent offshore beachrock sill that divides the two zones. Any waves that are not

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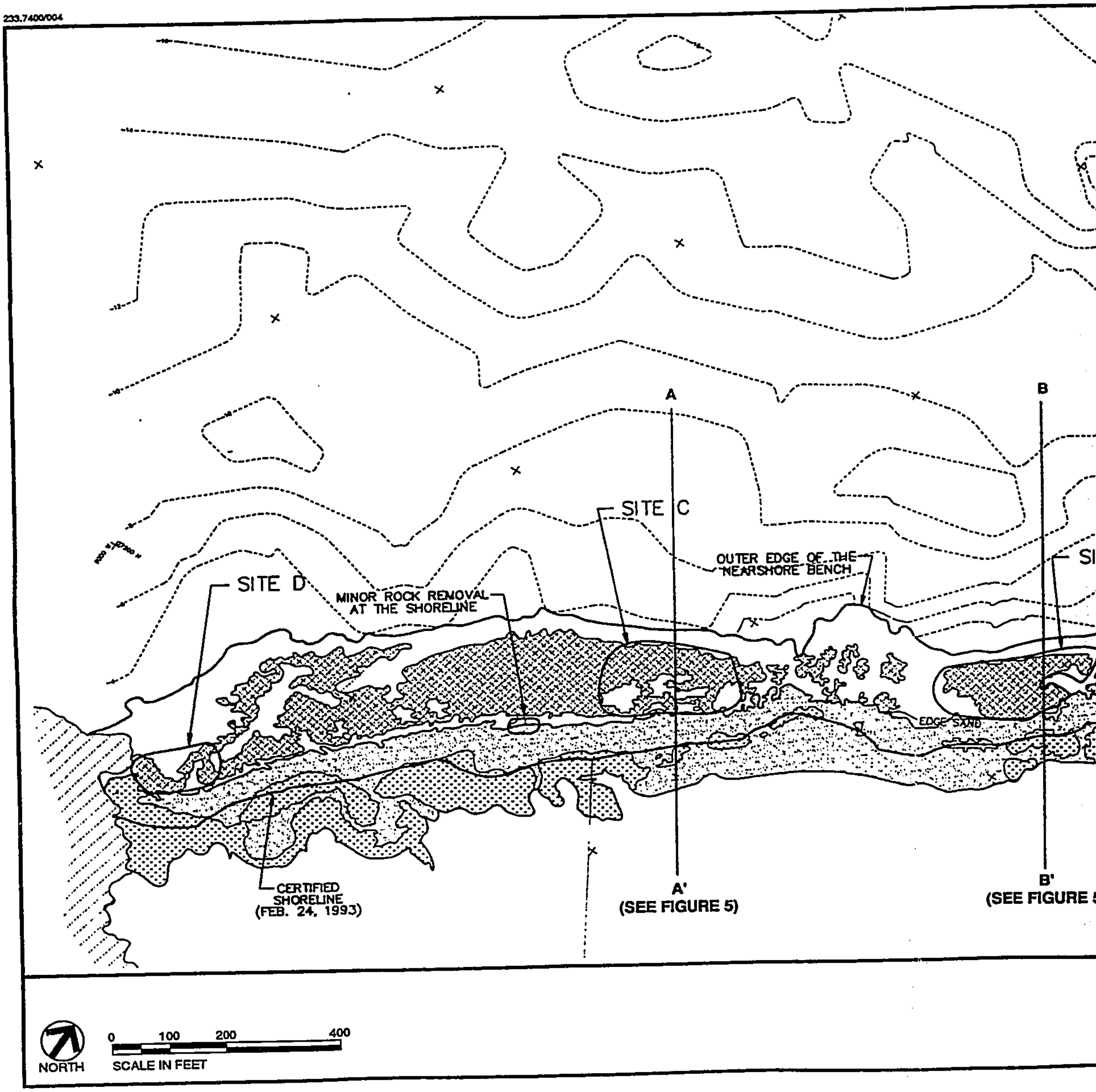
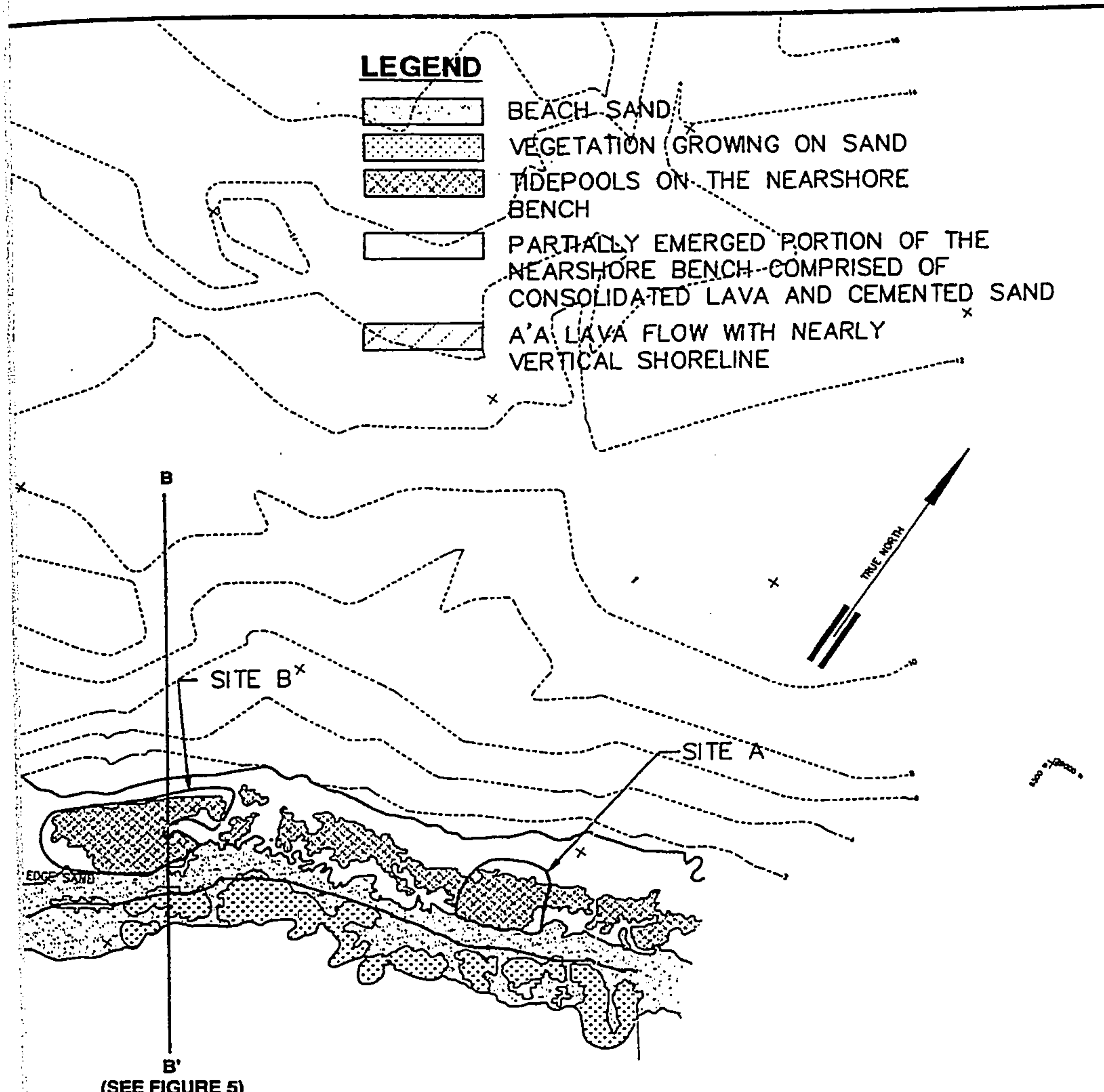


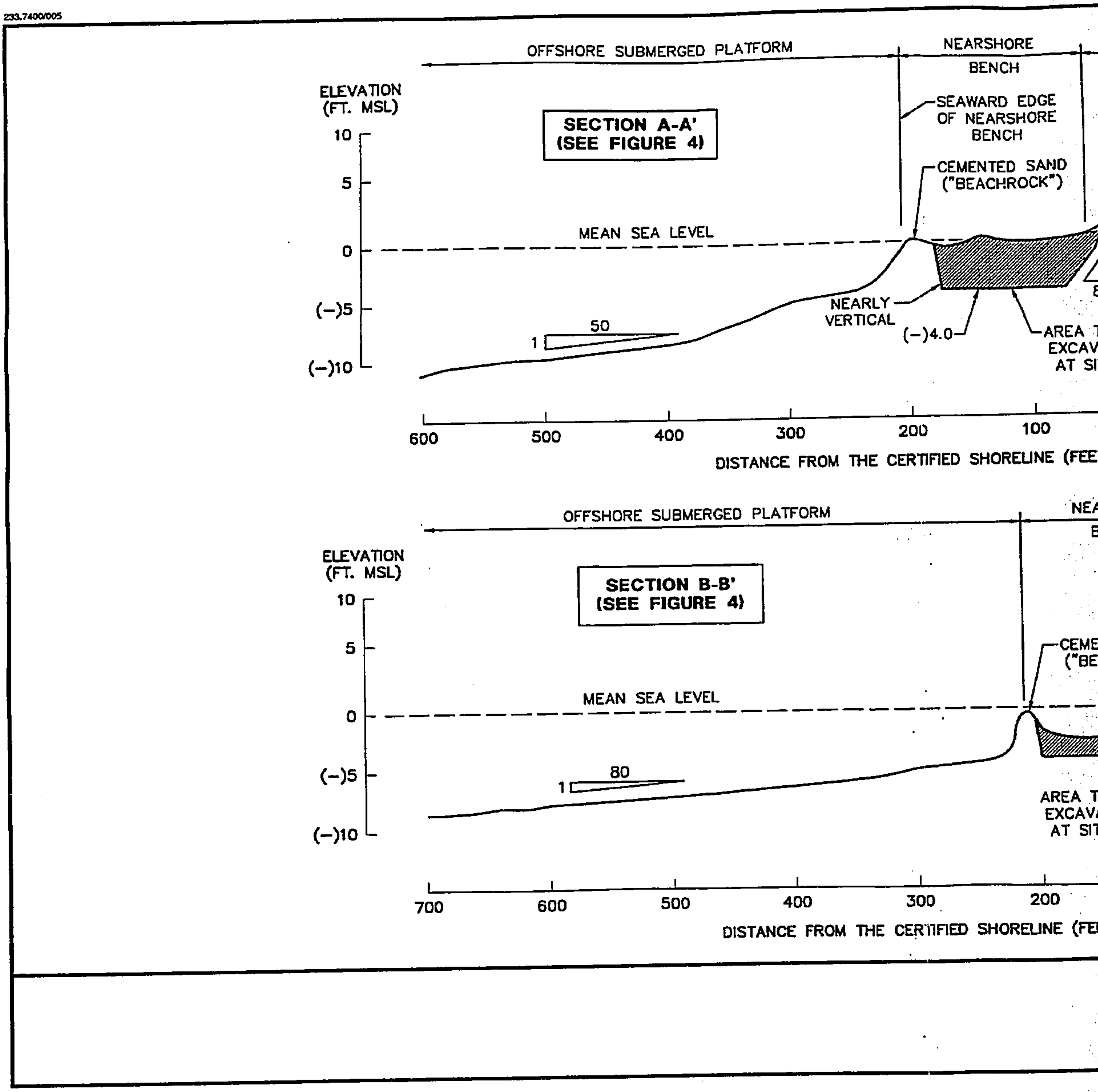
SITE D
MINOR ROCK REMOVAL AT THE SHORELINE
SITE C
OUTER EDGE OF THE NEARSHORE BENCH
EDGE SAND
A
B
CERTIFIED SHORELINE (FEB. 24, 1993)
A'
(SEE FIGURE 5)
B'
(SEE FIGURE 5
NORTH
0
100
200
400
SCALE IN FEET



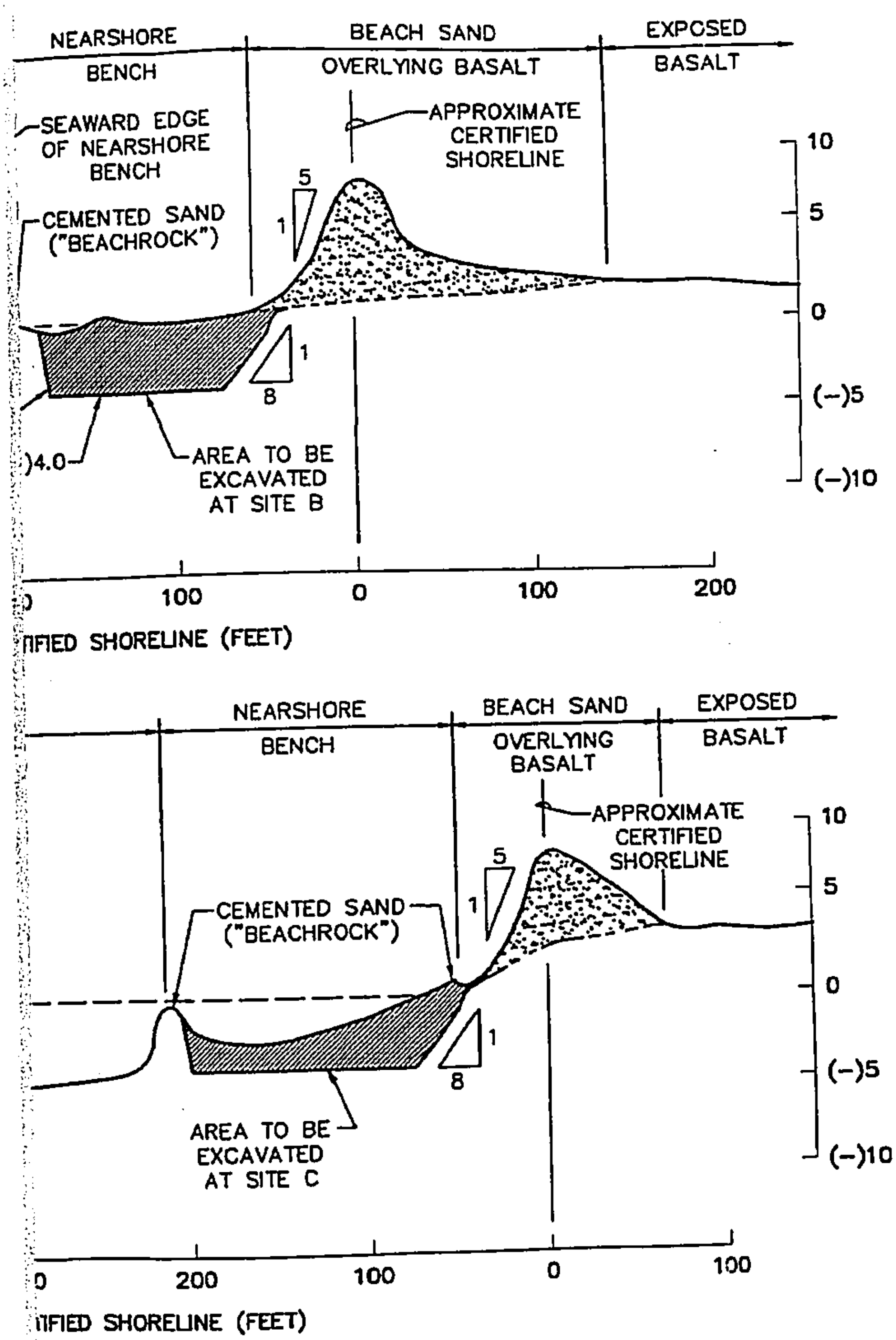
Source: Tom Nance Water Resource Engineering (April 1993; Revised May 1993 and April 1994)

Figure 4
LOCATIONS OF PROPOSED SHORELINE IMPROVEMENTS
KAUPULEHU RESORT
Prepared By: Belt Collins Hawaii
October 1994

233.7400/005



OFFSHORE SUBMERGED PLATFORM
NEARSHORE
BENCH
ELEVATION
(FT. MSL)
SECTION A-A'
(SEE FIGURE 4)
SEAWARD EDGE
OF NEARSHORE
BENCH
CEMENTED SAND
("BEACHROCK")
10
5
0
(−)5
(−)10
MEAN SEA LEVEL
NEARLY
VERTICAL
(−)4.0
1
50
AREA T
EXCAV
AT SI
600
500
400
300
200
100
DISTANCE FROM THE CERTIFIED SHORELINE (FEE
OFFSHORE SUBMERGED PLATFORM
NEA
ELEVATION
(FT. MSL)
SECTION B-B'
(SEE FIGURE 4)
10
5
0
(−)5
(−)10
MEAN SEA LEVEL
CEME
("BE
1
80
AREA T
EXCAVA
AT SIT
700
600
500
400
300
200
DISTANCE FROM THE CERTIFIED SHORELINE (FE



Source: Tom Nance Water Resource Engineering
(April 1993; Revised May 1993 and April 1994)

Figure 5
EXISTING & PROPOSED PROFILES ACROSS THE KAUPULEHU RESORT SHORELINE
KAUPULEHU RESORT
Prepared By: Belt Collins Hawaii
October 1994

dissipated by traversing the offshore platform break on this sill. Consequently, the wave energy reaching the shoreline is minimal. Numerous tidepools are present on the bench, their boundaries delineated by emergent basalt ledges. The calm waters of these tidepools would be ideal for swimming and snorkeling, but access and safety are compromised by the presence of nearshore rock ledges, sharp lava outcrops, and shallow water depths.

The purpose of the proposed project is to provide the safest possible environment for swimming, snorkeling, and other water-related activities. To this end, the applicant proposes to improve four areas along the shoreline, each with safe, direct access from the beach into the water (Figures 4 and 5). Access to an existing three-foot deep tidepool will be improved by removal of a small portion of a nearshore rock ledge. The result will be safe offshore recreation areas, readily accessed from the beach and sheltered from breaking waves, that are available to the public, resort guests, and residents for a variety of water-related activities.

2.3 DESCRIPTION OF THE PROPOSED PROJECT

Tom Nance Water Resource Engineering (April 1993; revised May 1993 and April 1994; Appendix A) describes the proposed construction activities in detail; this section is summarized from that report.

2.3.1 Excavation

Operations will entail excavation of approximately three to four feet of basalt from the seafloor of the nearshore area; an approximate profile of the improvement areas following excavation is shown in Section A-A on Figure 5. The general areal dimensions and extent of the excavations will be determined largely by the nearshore bathymetry. Three of the four improvement areas currently are shallow tidepools, delineated by emergent intertidal ledges. These ledges will remain intact and form the boundaries of improvement Sites A, B, and D.

Site A will be nearly square. The average dimension parallel to the shoreline will be about 105 feet, the offshore dimension, about 110 feet (Figure 4). The area will be deepened to approximately four feet below mean sea level (msl). The north and south sides and the seaward edge of the excavation will be cut as nearly vertical as practical, to reduce the risk of foot and leg injury to shoreline users. The landward slope will be relatively flat, about 12.5 percent to permit safe easy access from the beach to the offshore area. This slope was chosen as one on which the medium- to coarse-grained sand that is common in the area would be stable. The improved area will cover approximately 0.29 acres. An estimated 1400 cubic yards of material will be excavated.

Site B will have an average long axis length of 280 feet, oriented approximately parallel to the shoreline, and an offshore width of about 80 to 115 feet. It will encompass approximately 0.59 acres (Figure 4). Site B will also have nearly vertical north, south, and offshore sides, a four foot deep floor, and a 12.5 percent slope leading to the beach into the water (see Section A-A in Figure 5). Total excavated volume will be about 2,850 cubic yards.

In contrast to Sites A and B, Site C is not as clearly delineated by emergent rock ledges, but is separated and protected from the open ocean by the emergent offshore sill. The excavated area will be nearly oval, with a long axis approximately 230 feet in length, parallel to the shoreline. The offshore dimension will vary from 110 to 135 feet. The area will be approximately 0.67 acres and will be excavated to a depth of about four feet; the sides and offshore edge will be nearly vertical and the nearshore boundary will have a 12.5 percent slope. The volume of material to be excavated is about 2,650 cubic yards.

Site D is delineated by the a'a lava flow to the south and an emergent basalt ledge to the north. The offshore sill that marks the edge of the nearshore bench along the remainder of the project area is absent at this location. Consequently, the seaward extent of the proposed excavation is farther from the edge of the offshore platform than at the other sites and provides additional protection from wave energy. The excavated area will be about 0.24 acres, 160 feet long and 80 feet across (Figure 4). Approximately 950 cubic yards of material will be excavated. This excavation will also have nearly vertical outer edges and a 12.5 percent slope from the beach.

In addition, a natural break in the nearshore rock ledge that marks the seaward edge of the beach near Site C will be enlarged, permitting safe access from the beach into the largest and deepest natural tidepool in the area. This tidepool is approximately 380 feet by 150 feet, and is about three to four feet deep. It is inhabited by extensive and diverse coral and reef fish communities (see Section 3.3.1.3).

All excavations will be completed with standard earthmoving equipment. Most work is expected to be done with a bulldozer equipped with a ripper and/or a backhoe. If the ripper proves inadequate, a hydraulic ram will be used to fracture the rock and enable removal by the bulldozer or backhoe. No blasting will be done. A rough estimate of the total volume of material to be excavated is 8,000 cubic yards. The general sequence of construction is described below.

Beach sand will be moved further on shore, beyond the reach of waves and outside the construction area, but seaward of the certified shoreline. Loose cobbles in the improvement areas will be removed and stockpiled (see below) for possible use on the property.

Earthmoving equipment will be used to excavate the improvement areas. The excavated material will be removed to land and stockpiled temporarily. Any debris generated during construction that is not removed by the bulldozer or backhoe will be suction pumped on shore to a location inland of the 40-foot shoreline setback after completion of construction activities. This material will be dewatered before being buried in place. The temporary stockpile area for excavated material (as opposed to suction pumped material) is anticipated to be located on the hotel parking area, a site which will have already been altered by grading and subject to other construction activities when it is used for the stockpiles.

The bottoms of the excavated areas and the slopes leading into the water will be smoothed so that they are safe to walk on, and provide safe access from the beach into the water. This will be accomplished by multiple passes of a bulldozer.

The sand that had been moved prior to construction will be pushed back to approximately its original configuration. Natural tidal processes are expected to adjust the beach to a final stable shape (see Section 3.3.2.1). The new beach at each improvement site will extend into the water and will be slightly flatter than at present.

Construction activities at each site are expected to require one month or less. As discussed in the Inman and Masters report (Appendix F), there may be some movement inland of the crest of the beach. The applicant will monitor any such movement and evaluate the situation after approximately one year. If it is deemed desirable to supplement sand inland of the beach crest, the applicant will apply for the necessary permits to do this.

It is anticipated that if this course of action is desired or necessary, the replenishment will only take place in the inland area, more than 40 feet landward of the certified shoreline and the crest of the beach. Sand utilized for replenishment would be calcareous and obtained from legally permissible sand source within the State of Hawaii. Based on this, the current applications are not requesting permission to place any sand landward or seaward of the certified shoreline.

2.3.2 Removal and Disposal

If desired by DLNR, the applicant will make arrangements to purchase the excavated material. Some of this material may be suitable for use in the land-based development. The unusable fine-grained debris generated by excavation will be dewatered and buried after temporary stockpiling. The remaining excavated material will be transported to a suitable disposal site. The applicant will comply with all applicable government regulations.

3.0 DESCRIPTION OF AFFECTED ENVIRONMENT AND POTENTIAL ENVIRONMENTAL IMPACTS

Information in this chapter has been summarized from several sources, including the Kaupulehu Resort Final Environmental Impact Statement (June 1986) and references and appendices therein, as well as reports completed by Tom Nance Water Resource Engineering (April 1993; revised May 1993 and April 1994), Marine Research Consultants (May 1990, December 1992, and January 1993), and Edward K. Noda & Associates (September 1993). The latter are attached as Appendices A, B, C, D, and E, respectively.

3.1 REGIONAL SETTING

3.1.1 Location, Geology, and Climate

The proposed project site is located offshore of the applicant's Kaupulehu Resort in the ahupua'a of Kaupulehu in North Kona, Hawaii (Figure 1). It is within the region between Honokohau and Anaehoomalu called Kekaha, which means "dry, sunbaked land." Annual rainfall in the coastal area averages only seven to eight inches. Mean annual temperature is about 78° F, with minimal daily or seasonal fluctuations.

The area is on the northwest flank of the Hualalai Volcano, one of five volcanoes that make up the island of Hawaii. Hualalai is one of the three historically active volcanoes on the island. Geologically, Hualalai is characterized by alkali-basaltic lavas that erupt somewhat explosively. A few flows may be Pleistocene in age, but the majority are believed to be Recent. Most of the site, on shore and offshore, consists of a'a and pahoehoe lavas generated by eruptions of Hualalai. The last eruption, in 1800-1801, generated flows that reached the ocean north of Kona Village Resort and south at Mahaiula. The southern boundary of the proposed project site is marked by a prominent a'a flow.

The land slopes gently seaward at approximately five percent and topographic relief is primarily the result of layering and buckling of lava flows. Much of the property is characterized by thin or non-existent soil cover. Vegetation is also sparse.

3.2 NEARSHORE CONDITIONS

3.2.1 Existing Conditions

3.2.1.1 Physical Conditions

The nearshore area consists of a white calcareous sand beach, approximately 50 to 130 feet in width (Figures 3 and 4). The beach slopes from a crest, with an elevation that varies from seven to ten feet above sea level, to the waterline. This foreshore area is relatively steep, with a slope of about 20 to 27 percent (Figure 5). Vegetation covers approximately 50 to 70 percent of the beach crest and landward side. The seaward portion of the beach is strewn with basalt and coral gravel and cobbles. The a'a lava flow that marks the southern boundary of the beach forms Kumukehu Point off-shore. The average tidal range is less than three feet. The beach was surveyed and the shoreline was certified on February 24, 1993 (approximate location of certified shore-line is shown on Figures 3 and 4).

The offshore area along much of the property consists of a basalt and beachrock bench characterized by shallow tidepools separated by basalt ledges that are exposed at low tide. Seaward of this nearshore bench is a wide, gently sloping offshore platform that extends out to a distance of approximately 2,000 to 2,700 feet (Tom Nance Water Resource Engineering, April 1993; revised May 1993 and April 1994).

3.2.1.2 Land-based Flora and Fauna

Much of the applicant's property is sparsely vegetated because of lack of soil and water. The beach area is characterized by strand vegetation, particularly beach naupaka (*Scaevola taccada*), and low growing Bermuda grass (*Cynodon dactylon*) and 'aki 'aki (*Sparobolus virginicus*). Hardy scrub species such as kiawe, pluchea (*Pluchea odorata*), and 'ilima (*Sida cordifolia*) were also observed on the property (Char & Associates, 1985).

Land-based mammals are limited to mongoose, dogs, cats, mice, goats, and donkeys. Indigenous and migratory birds are also present. No threatened or endangered species have been observed, or are expected on the property (Bruner, 1985).

3.2.1.3 Wetland and Coastal Pond Areas

Part of the applicant's property is considered wetland habitat (Char & Associates, 1985). This area is delineated by water-logged, often organic soils and water-loving plants, including 'ohelo kai (*Lycium sandwicense*) and water hyssop (*Bacopa monnieria*).

Eight coastal ponds have been identified. Of these, three are considered typically anchialine in nature, and support populations of anchialine species, including *Holocaridina rubra* and *Metabetaus lohena*. The other five are older and in different stages of transition to wetlands (OI Consultants, 1986).

3.2.1.4 Historical and Archaeological Resources

Numerous archaeological surveys in the Kaupulehu area have documented the existence of both prehistoric and historic-period sites and features mauka of the shoreline. The most recent intensive survey recommended nine sites for preservation, including six foot trails (Walker and Rosendahl, 1986). The applicant has incorporated preservation of these sites into the design plan and has established archaeological preserves to maintain the sites in their undisturbed state.

No significant offshore historic or archaeological resources were found. The only feature found in the vicinity of the proposed shoreline improvements is described as a natural lava formation, possibly used as a fishtrap, located between Sites C and D. The archaeologists rated it of low cultural, scientific, and interpretive significance.

3.2.2 Potential Impacts

Most of the potential impacts to land-based flora and fauna associated with the proposed improvements will occur only during construction. These impacts include possible trampling of vegetation by construction equipment or personnel and temporary displacement of some animals. Any effects will be temporary, however, and no long-term changes are expected as a result of the proposed improvements.

The proposed project is expected to have no effect on the hydrology or biology of the coastal ponds. The single archaeological feature near the project site will be avoided during construction and will not be impacted by the project. Greater detail regarding potential impacts and proposed mitigation measures associated with the land-based development can be found in the Final Environmental Impact Statement for Kaupulehu Resort (June 1986).

3.3 MARINE ENVIRONMENT

This section was based on observations and data presented in reports completed by Marine Research Consultants (May 1990, December 1992, and January 1993), Tom Nance Water Resource Engineering (April 1993; revised May 1993 and April 1994), and Edward K. Noda & Associates (September 1993). These reports are included as Appendices A through E.

3.3.1 Existing Conditions

3.3.1.1 Physical Conditions

As mentioned above, the offshore area is divided into two major bio-geomorphological zones: a nearshore, partially emergent bench and an offshore submerged platform. An offshore sill of beachrock forms the boundary between the two zones. The nearshore bench and offshore platform are theorized to have formed by drowning of a prehistoric lava flow.

Water depths over the outer platform rarely exceed 15 feet and slopes are less than two percent. The outer edge of the platform is marked by a sharp cliff approximately 10 to 15 feet high. Undercut caves and crevices are common along the cliff wall and large basaltic boulders lie near the cliff base.

The inner zone is characterized by a shallow intertidal basalt and beachrock bench between 80 and 220 feet wide and averages 140 feet. Elevations range from one to two feet above sea level to three to four feet below sea level. About one third or less of the bench consists of encrusting coralline algae and cemented sand ("beachrock") attached to submerged basalt. Another one quarter to one third is composed of emergent (intertidal) basalt ledges. The remainder of the bench consists of shallow tidepools, delineated in areal extent by the emergent ledges. The floors of these pools are covered, to a greater or lesser extent, with water-rounded rocks, coarse-grained sand, and encrusting algae. Significant live coral only occurs in one deep tidepool (see below).

Most large storm waves break at the edge of the offshore platform. Waves also break as they traverse this broad area, or on the offshore sill that marks the boundary between the offshore platform and the nearshore bench. As a result, with the exception of times when large waves occur during high tides, the wave energy reaching the beach is very low and the waters of the nearshore bench are calm.

The specific characteristics of the four areas chosen for the improvement sites (see Figures 4 and 5) differ somewhat. Site A, the northern-most, is the smallest in areal extent. It is located near the northern boundary of the property, adjacent to an existing mauka-makai public shoreline access. A shallow natural tidepool, it is bounded on three sides by intertidal basalt ledges which are exposed at low tide (Figures 4 and 6). The offshore sill forms the seaward extent of this area. Figures 1 and 6 show the curved, crescent shape of the beach at Site A; the calm waters landward of the offshore sill are evident in Figure 6. The seafloor at Site A consists primarily of solid basalt or a layer of cobbles. The present water depth averages less than about one quarter foot.

Site B, approximately 400 feet southwest of Site A, is about twice as large in area. In other aspects, the two sites are similar. Site B is also delineated by intertidal basalt ledges and is protected from wave action by the offshore sill (Figure 7). Water depths in the vicinity of Site B do not exceed two and a half feet, even at highest tide (Figures 4 and 5). The beach at Site B is also crescent shaped (Figure 7); the offshore seafloor is composed mostly of cobbles over the basaltic bench.

Site C is located near the center of the Kaupulehu Resort beach about 350 feet southwest of Site B. It is also separated from the open ocean by the offshore sill. The primary difference between Site C and Sites A and B, however, is that it is not as clearly delineated by basalt ledges (Figure 8). Instead, it is part of a larger region that is morphologically considered a tidepool (Figure 4). Parts of the area planned for excavation are relatively shallow; depths over the area chosen for Site C range from less than one foot to about 2.5 feet.

Site C is adjacent to an existing relatively deep tidepool in which water depths range from three to four feet (Figure 4). The tidepool is clearly delineated by basalt ledges and is protected from the open ocean by the offshore sill. The nearshore bench in this area is wide (approximately 250 feet) and the tidepool is relatively large (about 220 feet wide by nearly 800 feet long). Access to this tidepool is hindered by the presence of a nearshore rock ledge that is emergent at low tide.

Site D is located at the southern end of the beach, adjacent to an a'a lava flow. In contrast to the other three sites, the offshore sill is absent at Site D; consequently, this area receives more wave energy than most of the rest of the shoreline in the project area. The wide outer platform affords protection from wave action, as does the seaward extension of the a'a lava flow, creating a semi-enclosed area suitable for improvement. The planned improvement area will be excavated from the solid rocky bottom to approximately the seaward extent of the lava flow. Present water depths are less than two feet. The seafloor in this area is composed primarily of basalt. An extensive system of grooves, cut by burrowing sea urchins, is the dominant bottom feature. Figure 9 presents a photograph of Site D showing the offshore a'a flow and the emergent basalt ledge that forms the north boundary of the site. The slightly higher wave energy in this area is evident by the small waves breaking on the beach and the proximity of the waves offshore.

3.3.1.2 Water Quality

An ongoing water quality monitoring program has been conducted offshore of the Kaupulehu property since late 1989. Figure 10 shows the approximate locations of the surveys. Surface samples (within six inches of the surface) and bottom samples (within one foot of the bottom) are taken along three offshore transects. Measured parameters include total nitrogen, nitrate + nitrite, ammonium, total phosphorus, chlorophyll a, and turbidity. These represent the criteria specified by the State

233.7400/006

Figure 6
IMPROVEMENT SITE A

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233.7400/007

Figure 7
IMPROVEMENT SITE B

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233.7400/008

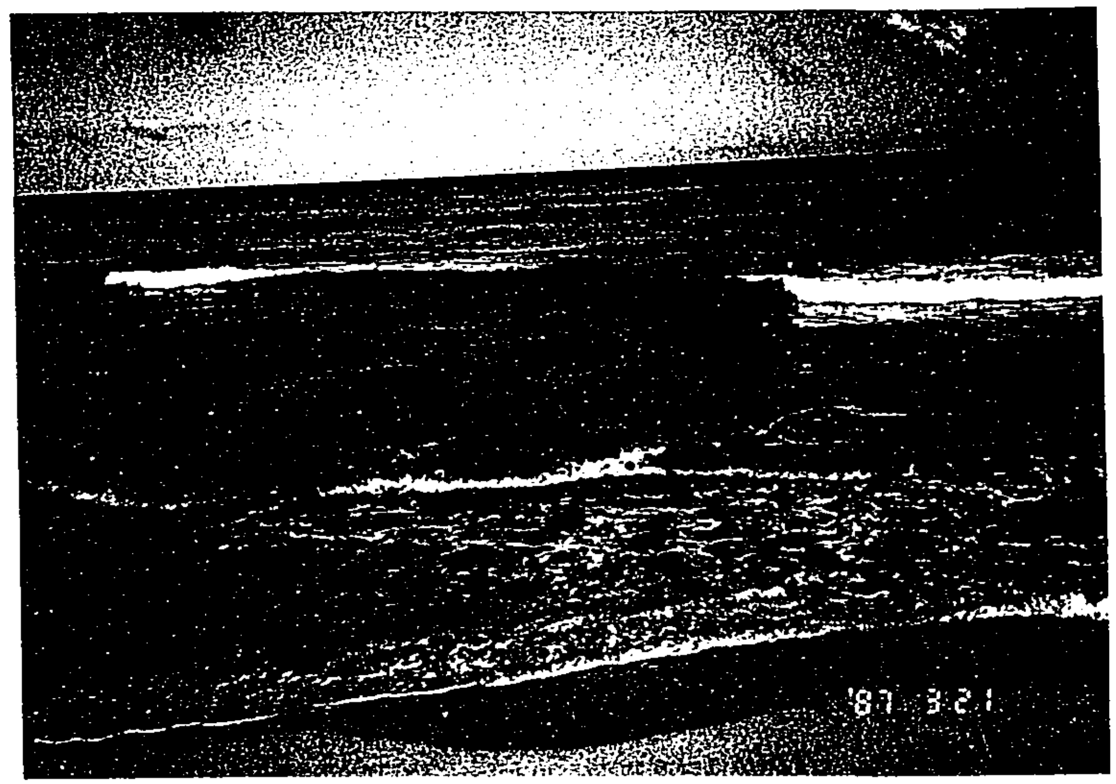

Figure 8
IMPROVEMENT SITE C

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233.7400/009

Figure 9
IMPROVEMENT SITE D

KAUPULEHU RESORT
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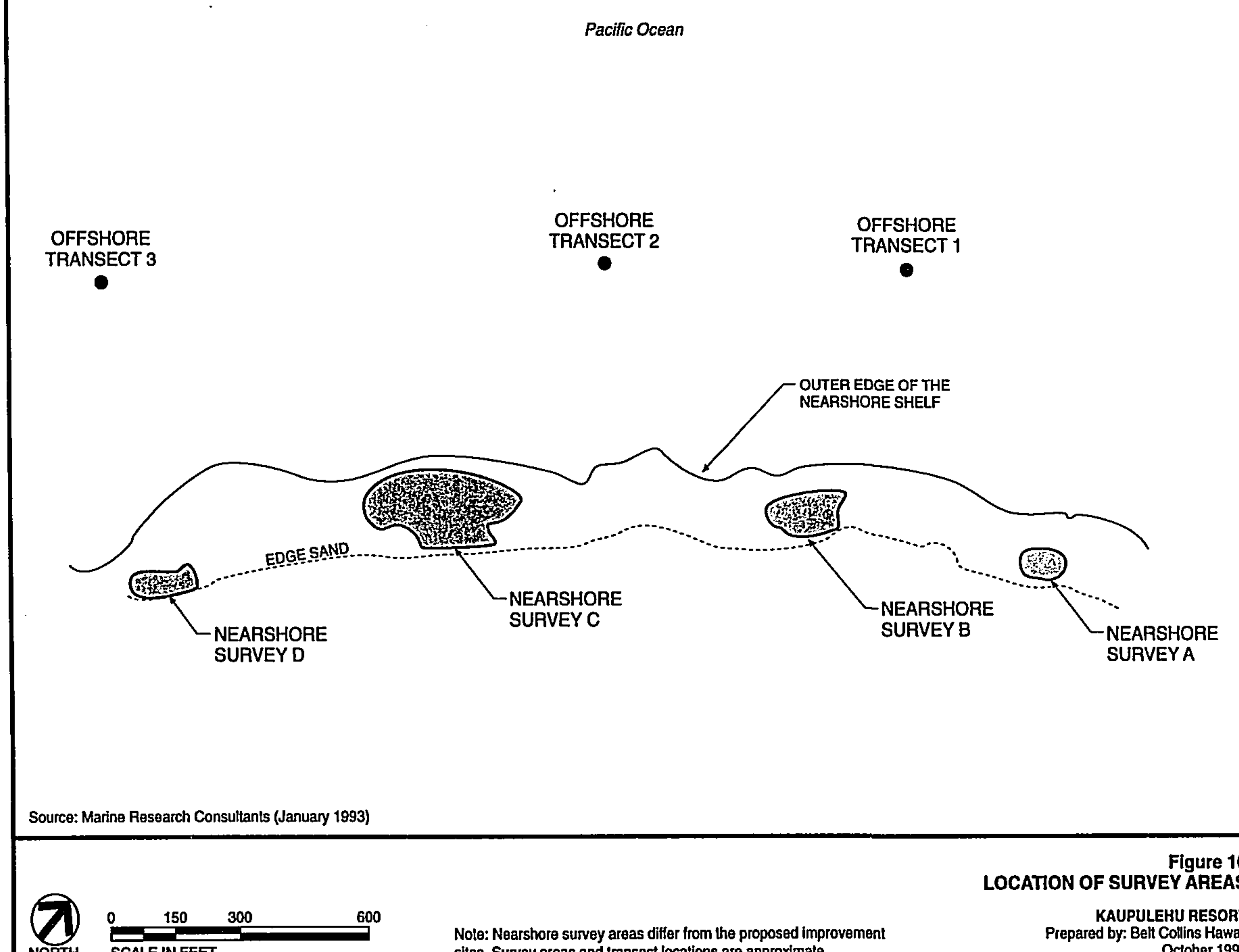
October 1994

233.7400/011



Source: Marine Research Consultants (January 1993)

Note: Nearshore survey areas differ from the proposed improvement sites. Survey areas and transect locations are approximate.

Figure 10
LOCATION OF SURVEY AREAS

KAUPULEHU RESORT
Prepared by: Belt Collins Hawaii
October 1994

Department of Health's (DOH) water quality standards for open coastal waters (Title 11, Chapter 54). "Wet" criteria apply because the area receives more than three million gallons per day of fresh water (i.e., groundwater) input per shoreline mile.

Measurements indicate that substantial discharges of low salinity, high nutrient groundwater occur at the coastline, although the signal varies with time and location. Input of this high nutrient groundwater resulted in several exceedances of the DOH's water quality standards between 1989 and 1993, particularly nitrate + nitrite, ammonium, and total nitrogen (Figure 11). Groundwater input is particularly significant near Site D.

Nutrients occur in naturally high concentrations in groundwater in the region (see Table 1). Thus, areas receiving a substantial groundwater input generally exhibit a zone of mixing near the coast in which some nutrient concentrations exceed DOH standards as a result of natural processes. Such exceedances are typical in West Hawaii and have been reported in numerous locations (Table 1) from Kahuku, Ka'u (Dollar, 1987) to Mahuku (Brock, 1990). In addition, data indicate that mixing is effective in dissipating the high nutrient groundwater signal within a short distance from the coastline (Figure 11).

In general, the high concentrations measured near the coast do not persist beyond 30 feet from the shoreline and a very homogenous water mass, both vertically and horizontally, exists offshore.

3.3.1.3 Marine Biota

Semi-quantitative surveys of fish and benthic organisms were completed at Sites B and D, and in the deep tidepool near Site C during 1990 and 1992 (nearshore survey C in Figure 10). A survey was conducted at Site A during 1992. The outer platform area was surveyed in 1990 (Marine Research Consultants, 1990, 1993). The single most important factor determining the density and diversity of marine organisms in the project area appears to be water depth. Shallow depths at the four improvement sites lead to elevated water temperatures and salinities due to higher rates of heating and evaporation. These extreme conditions impose a significant amount of stress on organisms and result in low abundances.

Sites A and B, both of which are presently very shallow, are characterized by low coral cover (approximately one percent) and low diversity (three to six species). Multi-species turfs of filamentous algae cover the seafloor at these two sites. The sea urchin *Colobocentrotus atratus* is abundant along the inner wall of the offshore sill at Site B.

TABLE 1
SELECTED WEST HAWAII WATER QUALITY DATA

LOCATION	DEPTH (m)	$NO_3 + NO_2$ µg/l	NH_4 µg/l	TOTAL P µg/l
DOH STANDARDS[1]		5.00	3.5	20.00
Humuhumu Point, Kahuku, Ka'u (1987)[a]	0.5	15.8	3.1	7.4
Honokohau Harbor (1983)[b]	0.5	1.7	12.6	7.4
Keahole Point (1982-1986 avg.)[c]	13.7	2.8	5.1	5.0
Makaiwa Bay (1987)[d]	0.5	59.0	8.0	11.0
Mauna Lani Cove (1989)[e]	0.5	38.9	4.1	6.2
Pauoa Bay (1986)[d]	0.5	222.0	7.0	9.0
Hapuna Bay (1987)[f]	0.5	129.2	2.4	9.9
Kawaihae (1978)[g]	0.5	22.0	N/A	21.4
Mahukona (1990)[h]	0.5	79.1*	2.4	3.69
Kaupulehu (1990)[i]	0.3	13.9	4.2	10.8
Well Water[i]	N/A	196.5	2.94	43.7

Notes:

1 State DOH Standards are specified in terms of "Geometric mean not to exceed the given value", Wet Criteria.

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

b Data from Corps of Engineers, 1983.

c Data from Hawaii Natural Energy Laboratory warm water intake pipe weekly samples. Pipe is 13.7 meters below surface, 92.4 meters offshore.

d Data from Dollar, 1987. Effects to Water Quality and Marine Community Structure from Beach Reconstruction at Makaiwa Bay, Mauna Lani Resort, South Kohala, Hawaii, Phase III. Prepared for Mauna Lani Resort, Inc.

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

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

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

h Data from Brock, 1990. In Draft EIS, Mahukona. Prepared for Chalon International of Hawaii, Inc. *Data represents total N.

i Data from Marine Research Consultants, 1992. Marine and anchialine pond monitoring program, Kaupulehu Makai Venture, North Kona, Hawaii. Nutrient values are geometric means of nine surveys from December 1989 through November 1992.

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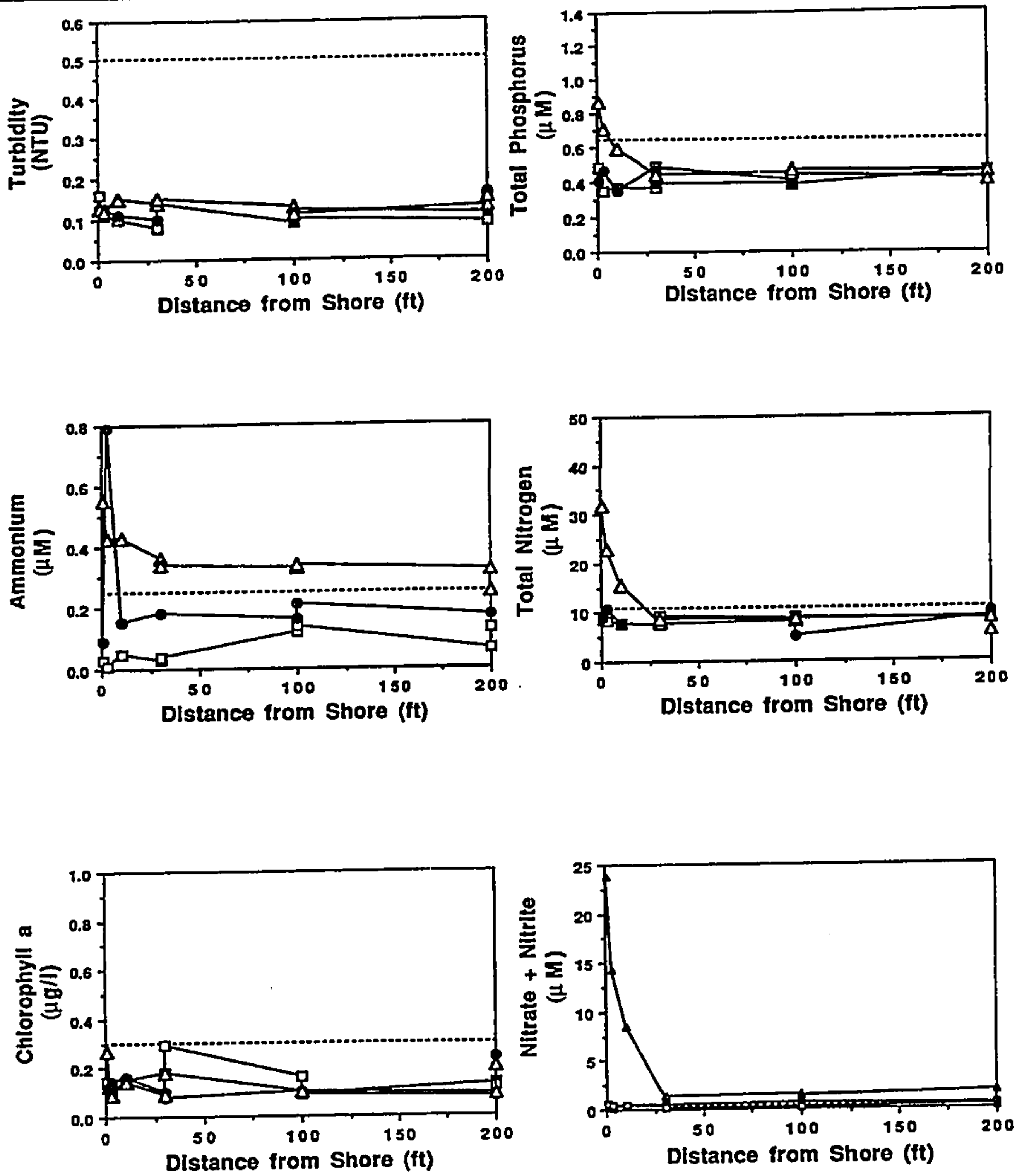

Source: Marine Research Consultants (1990)

LEGEND
- Site B
- Site C
- Site D
- Standard

Figure 11
OFFSHORE WATER QUALITY MEASUREMENTS

KAUPULEHU RESORT
Prepared by: Belt Collins Hawaii
October 1994

At Site D, the higher intensity wave activity has resulted in greater physical stress and even lower coral abundances - less than one percent. Only four or five (1990 versus 1992) species of coral are present. Boring sea urchins (*Echinometra mathaei* and *E. oblonga*) are the only abundant biota, reaching densities of 50 per square meter. In some areas of Site D, numerous grooves cut by these urchins give the seafloor a honeycomb appearance.

Site C was not subject to the same rigorous quantitative surveys completed at the other three sites. A qualitative examination of the area indicated that coral cover is relatively low, less than approximately two percent (S. Dollar, personal communication, 1993). This is consistent with its shallow depth and extreme physical conditions.

The natural tidepool near Site C (identified as nearshore survey C in Figure 10) was also surveyed and is the deepest of the four nearshore surveys. It hosts the densest and most diverse population of benthic organisms. It is likely that the greater depth (three to four feet) at this site prevents the extremes in temperature and salinity found elsewhere in the project area. Coral cover averages 8.5 percent to 10 percent and includes nine to ten different species. Coral colonies are larger here than at any other transect; species include *Porites lobata* and *P. rus*. Other biota include sea cucumbers (*Holothuria spp.* and *Actinopyga spp.*) and algae (e.g., *Turbinaria ornata* and *Padina spp.*).

Coral cover on the outer platform seaward of the offshore sill is uniformly low, resulting from the high physical stresses caused by breaking waves. Colonies are generally small in size and dominated by *Porites lobata* and *Pocillopora meandrina*. Sea urchins have also been observed. Fishes in the platform area consist primarily of algal-feeding acanthurids.

Virtually no fish were observed during the one survey of Site A. Fish observed at nearshore survey areas B, C, and D include a mix of juvenile reef fish, schooling mullet, and species adapted to environments of extreme temperature and salinity. The latter consist primarily of the blackspot sergeant (kupini, *Abudefduf sordidus*) and the Christmas wrasse (awela, *Thalasoma trilobatus*). A comparison of fish populations observed during surveys in 1990 and 1992 indicates a high degree of variability that is typical of reef fish communities. While the number of species varied, the overall character of the fish communities observed during the different surveys was similar.

At the request of the Kona Hawaiian Civic Club, an additional survey was conducted in October 1994 to confirm the presence of Kupe'e (narita polita), a common snail that is prized by Hawaiians for its colorful shell and as a food source. The results of Dr. Dollar's survey are included as an addendum to his 1993 report (see Appendix D).

3.3.1.4 Endangered or Threatened Species

Three species of marine animals that have been declared threatened or endangered by the U.S. Fish and Wildlife Service (Department of the Interior, 1985) occur in Hawaiian waters. The threatened green sea turtle (*Chelonia mydas*) is common offshore of the major Hawaiian Islands, including along the West Hawaii coast. Its usual resting habitat is deeper reef areas characterized by undercut ledges and other topographic relief; its diet consists primarily of selected species of macroalgae. Green sea turtles have been frequently observed near the project area; their occurrence near the outer edge of the outer platform is consistent with their known habits (Balazs et al., 1987).

The hawksbill turtle (*Eretomochelys imbricata*), a Federally listed endangered species, is encountered infrequently in the waters of Hawaii. In general, observations of this species in West Hawaii have been restricted to the southeastern coast in the Ka'u District; it has not been reported offshore of Kaupulehu (e.g., PBR Hawaii, 1990). Endangered humpback whales (*Megaptera novaengliae*) spend winter months in the Hawaiian Islands and are occasionally seen in the vicinity of the project site (e.g., Bauer and Herman, 1986). Although the behavior patterns of this species are poorly understood, data indicate that they generally prefer water depths of approximately 60 to 600 feet.

3.3.2 <u>Potential Impacts</u>

3.3.2.1 Physical Impacts and Water Quality

Impacts to the physical environment will include changes in the offshore bathymetry as a result of deepening, smoothing, and improving access to the four offshore areas, and a short-term increase in turbidity resulting from construction activities. Because the protective offshore sill will not be breached, neither the offshore current pattern nor wave regime will be altered.

A numerical model was used to evaluate possible changes to the nearshore wave environment as a result of the proposed excavation of the four improvement areas (Edward K. Noda & Associates, 1993). The model results indicate that the depth of the offshore sill limits the maximum wave height that can propagate over the nearshore bench and that wave energy decreases shoreward. Comparison of the existing condition and that proposed shows no significant difference in wave energy levels reaching the shoreline. Even with the four proposed excavations, wave heights reaching the beach are typically less than half a foot. Consequently, the proposed project is expected to have no significant adverse effect on beach stability.

Any potential changes to the input of groundwater during or after construction are expected to be well within the natural range of variability along the coast of West

Hawaii (see Table 1). In addition, mixing in the nearshore area is so effective that if groundwater input does increase, it would be readily dissipated (Marine Research Consultants, 1990, 1993). In fact, deepening the four sites may actually promote more vigorous circulation and mixing. No detrimental effects to water quality are expected as a result of the proposed improvements.

With regard to increased turbidity, as discussed above the existing sill provides better protection from ocean waves for Sites A and B than for Sites C and D. As a consequence, suspended particulate matter resulting from construction could settle at the bottom of these two sites. In an effort to mitigate turbidity impacts at the four sites, all silt, sand, and cobble sized material created during excavation and subsequent smoothing but not removed by bulldozer and/or a front-end loader will be removed by suction pumping. This material will be pumped onshore to a location inland of the 40-foot shoreline setback, dewatered, and buried in place.

3.3.2.2 Marine Biota

The proposed excavations and removal of substrate from the improvement areas will unavoidably result in an initial net loss of sessile organisms (mainly corals) at these sites. Existing coral abundances are extremely low however; therefore, this loss will be minor.

Surveys of Honokohau Harbor and Kawaihae Harbor reported that coral rapidly colonized new substrate created by excavation. The resulting coral communities are reported to be healthy and diverse, and in the case of Honokohau Harbor, exhibit higher coral densities than neighboring communities (U.S. Army Corps of Engineers, 1983; ORCA, 1978). Similarly, investigations of other projects in the Hawaiian Islands indicate that increased siltation caused by excavation is unlikely to have any long-term detrimental effect on coral or fish (e.g., Dollar, 1985; Grigg and Dollar, 1980).

Currently, the abundance and diversity of marine organisms in the region is greatest in the natural tidepool near Site C, which is significantly deeper than other portions of the project area. As a result of the deeper water depths, this area does not experience the extremes in temperature or salinity that occur elsewhere in the nearshore region, and consequently, is more conducive to settlement and growth of biota than other, shallower parts of the nearshore region. It is probable that increasing water depths at the improvement sites will result in corresponding increases in biological abundance and diversity, similar to those now observed in this tidepool. As discussed in Dr. Dollar's kupe'e survey, the proposed project will not result in a significant adverse impact to the existing kupe'e population.

3.3.2.3 Endangered or Threatened Species

The proposed shoreline improvements are not expected to have any detrimental effects on any of the three threatened or endangered species occasionally present in the general vicinity. In general, these animals inhabit deeper offshore areas distant from the coast and should not be impacted by construction activities, or the use of the improved areas. Any potential effects would be mitigated by the presence of the offshore sill which will act as a physical barrier to siltation and turbidity, and dampen any temporary changes in water elevations or coastal processes that may occur during construction.

3.4 RECREATIONAL ACTIVITIES

3.4.1 Existing Conditions

Much of the North Kona shoreline, including the area encompassing the site of the proposed project, is used for water-related recreational activities such as fishing, SCUBA diving and occasionally surfing (e.g., Clark, 1985). Other recreational activities, such as swimming and snorkeling, occur elsewhere along the coast, but are very limited in the Kaupulehu Resort region, because of safety concerns resulting from the existence of sharp a'a outcrops and shallow water depths near the shoreline. Current use of the beach and offshore area adjacent to the Kaupulehu property is minimal. Both the 1985 and 1990 State Comprehensive Ocean Recreation Plan (SCORP; Department of Land and Natural Resources, 1985, 1990) identify a high need for beach activities in the Kona planning district, of which Kaupulehu is a part.

3.4.2 Potential Impacts

Completion of the proposed project would greatly enhance the recreational resources of the area by improving safety and accessibility, and by increasing the potential uses of the region. Swimming and snorkeling would be made viable activities for both guests and residents. Enjoyment of the beach and offshore areas would be encouraged through separate construction of public parking facilities and maintenance of the mauka-makai public rights of way to the shoreline, public comfort stations and beach showers, as well as a lateral pedestrian shoreline trail (see Figure 2). However, public access improvements are not included as part of the proposed project.

The proposed improvements may also stimulate more fishing, diving, and gathering activities as the public becomes more aware of the area. As noted in other areas along the West Hawaii coast that have been made more accessible, the number of popular food fish may decline as a result of increased recreational fishing. Although the magnitude and extent of these changes are impossible to quantify, it is likely, from strictly a recreational point-of-view, any potential decline in the number of fish in the area will be more than balanced by the public benefits of improved safety, access, and increased recreational opportunities. However, to offset the potential impacts of increased public access, a marine resource management plan will be implemented. This will help to ensure that resource gathering is conducted in a manner that preserves a sustainable yield.

3.5 NATURAL HAZARDS

The coastal areas adjacent to the proposed improvement sites are subject to tsunami flood hazards. These areas, designated as Zones A4 and V15 on the Flood Insurance Rate Map, are within the 100-year flood boundary. Flooding of the improvement sites would likely cause a temporary increase in suspended sediment and turbidity, but no permanent changes. The proposed improvements will not have any effect on the size or location of the flood zone boundaries.

The last eruption of the Hualalai Volcano occurred in 1800-1801. Geological evidence suggests that although the average time between eruptions is approximately 50 years, the general pattern is one of groups of eruptions separated by several centuries of no activity. Recent volcanic-related seismic activity suggests that magma still exists beneath the surface and scientists speculate that an eruption may occur within the next several decades. Seismic activity related to either magma or tectonic movements appears likely in the near future. The Kona Regional Plan (1982) cites historical data that indicates that earthquakes on the order of 6.4 Richter Scale magnitude occur on average every 62 years in the Kona area, although several magnitude 4 earthquakes occur on Hualalai each year. Data indicate that large tsunamis are only generated by magnitude 6 earthquakes or larger. Tsunami waves might damage corals, benthic organisms, or fish but are unlikely to result in any permanent changes.

It is unlikely that earthquakes would cause any damage to the improvement sites. The only natural hazard that could potentially affect the proposed sites is inundation by a lava flow.

The project area is situated in Lava Flow Hazard Zone 4 (1 being most severe on a scale of 1-9). The flanks of the Hualalai do not have a distinctly lower hazard than its rift zones because the distance from the vents to the coast is short and the slopes are steep. The potential threat from lava flows can be mitigated to some extent by providing adequate warning to area residents through the provision of a Civil Defense emergency warning system and the implementation of a Emergency Evacuation Plan. As part of previous development approvals, the applicant has committed to the implementation of both these measures.

3.6 SOCIOECONOMIC CONSIDERATIONS

State-owned (public) property, in the form of basalt and beachrock, will be excavated and removed from the nearshore area as a result of the proposed excavation of the improvement areas and removal of material on shore. No permanent changes will be made to the extent of the offshore area, or to the beach. Public access to the improved shoreline area will be ensured through maintenance of two new public parking areas, two new mauka-makai trails, two new comfort stations and beach showers, and a lateral pedestrian shoreline trail. In addition, the material to be removed currently provides no public benefit. Increases in safety and recreational opportunities resulting from the proposed improvements represent a significant net benefit to the public. Such improvements also enhance the competitive position of the resort in the visitor industry. In addition, the proposed project will provide at least four to six temporary construction jobs.

3.7 NOISE ISSUES

Existing noise levels in the vicinity of the applicant's property are minimal, consisting primarily of vehicular traffic and wind and wave noise. Analyses completed by Y. Ebisu (1986) indicated that the only significant long-term source of noise generated by the land-based development would result from increased traffic.

Large increases in noise levels are expected during construction. Because excavation of the proposed improvement sites is to proceed simultaneously with land-based construction, however, the noise generated by the proposed project will not have a significant effect on overall noise levels. In addition, these increases will be temporary.

3.8 VISUAL IMPACTS

The only visual impact expected as a result of the improvements is a change in the appearance of the shoreline area at low tide. The existing water's edge bottom consists of a ledge of basalt and beachrock. It will be removed and the bottom covered with sand as a result of the proposed project.

3.9 CUMULATIVE IMPACTS

The proposed project is part of the overall Kaupulehu Resort development. Impacts of the land-based development have been fully addressed by the Final Environmental Impact Statement (1986) for the project, as well as numerous State and County permit applications. All land-based development is in compliance with necessary government regulations.

4.0 ALTERNATIVES TO PROPOSED ACTIVITY

The State of Hawaii Revised Statutes, Chapter 343 indicate that alternatives to the proposed action which could "feasibly attain the objectives of the action" must be considered and discussed, even if they are more costly than the proposed action. Of particular importance is discussion of alternative actions that reduce or eliminate environmental costs or risks. Three alternatives were considered: 1) the "no action" alternative, in which no improvements are made, 2) reduction of offshore excavation, and 3) other improvement sites.

4.1 NO IMPROVEMENTS

The "no action" alternative would require no changes to the existing bathymetry of the offshore area and no excavation. The only environmental effects to the offshore region would be those associated with land-based development. This alternative would provide no benefits to the applicant, general public, or resort guests. Further, it would not improve the unsafe conditions that currently exist, and in fact, would increase the potential for injury, as access to the shoreline is improved and more people use the area. Moreover, this alternative does not fulfill the conditions of the Special Management Area permit approved for the land-based development. Therefore, it is not considered a reasonable alternative.

4.2 LESS EXCAVATION

4.2.1 Fewer Improvement Sites

The proposed action could be altered by reducing the number of areas planned for improvement. Sites B and C are the largest and are closest to the center of the applicant's property. An alternative involving fewer improvement sites would likely retain these sites, and make no changes at Sites A and D. This alternative would reduce the use and enjoyment of the offshore area. The planned excavations are not expected to result in any significant detrimental effects to either the nearshore land or offshore areas. Therefore, the only difference between this alternative and the proposed action is a reduction in the amount of excavated material and a shorter construction period. The minor benefits of a slightly shorter construction period and smaller volume of excavation are outweighed by the costs of reduced public use and enjoyment.

4.2.2 Smaller Volume Removed

This alternative would reduce either the size or depth of one or more of the four proposed improvement sites. The existing bathymetry essentially dictates the areal extent of the sites. Therefore, a reduction in the volume of excavation is limited to decreases in the depth of excavation. Excavation to the planned three to four feet, however, is specifically designed to enhance the use and recreational potential of these areas. Any reduction in the depth of the sites will necessarily reduce their potential for use. Furthermore, shallower water depths are expected to provide less favorable habitats for marine organisms. Therefore, this alternative is also considered inferior to that proposed.

4.2.3 Other Improvement Sites and Schemes

Other areas along the shoreline were examined as potential improvement sites. The natural tidepool near Site C was considered for expansion, but was not chosen because of the potentially adverse effects that construction activity might have on the well-developed marine community that is present there. Consequently, the only change proposed for this area is improving access into the tidepool by expanding an opening in the nearshore rock ledge that separates the tidepool from the beach.

Construction of a channel from the nearshore bench to the open ocean, breaching the offshore sill, was also considered. This project was rejected because of its potential to significantly change the nearshore wave climate and possibly to adversely affect the calmness of the nearshore waters and the stability of the beach.

5.0 RELATIONSHIP OF THE PROPOSED ACTION TO LAND USE PLANS, POLICIES, AND CONTROLS

5.1 STATE LAND USE PLANS, POLICIES, AND LAWS

5.1.1 State Land Use Districts

All lands in the State have been placed in one of four land use districts, Urban, Agriculture, Conservation, and Rural, by the State Land Use Commission (SLUC). The proposed improvements involve submerged lands which are designated Conservation. The Conservation District is divided further into five subzones. The offshore area adjacent to the applicant's property is within the Resource Subzone. The objective of the Resource Subzone is to "develop, with proper management, areas to ensure sustained use of the natural resources of those areas." A permitted use in the Conservation District is "research, recreational, and educational uses which require no physical facilities." The proposed project will involve no permanent physical facilities. Therefore, the proposed improvements are permitted uses.

5.1.2 Hawaii State Plan

The Hawaii State Plan consists of a series of broad goals, objectives, and policies that are designed to act as long-range guidelines for growth and development of the State. Specific objectives of the State Plan and the proposed project's relevance to them are discussed below.

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

Discussion: Various policies that support this objective address maintenance and improvements to visitor destinations and attractions. Increased safety and accessibility resulting from the proposed improvements will improve the quality of the Kaupulehu Resort as well as the surrounding area.

Objective: Prudent use of Hawaii's land-based, shoreline, and marine resources.

Objective: Effective protection of Hawaii's unique and fragile environmental resources.

Discussion: The applicant understands the unique environmental character of the West Hawaii shoreline and offshore area. The high quality coastal waters will be maintained, while the density and diversity of marine biota will be increased in the nearshore areas as a result of the planned project. The locations and boundaries of the planned improvement areas were chosen to enhance the safety, accessibility, and use of the protected nearshore zone to the greatest extent possible with a minimum of physical change. Beach stability will not be affected by the proposed project.

Objective: 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 resources.

Discussion: The proposed improvements are designed to enhance both the use of Hawaii's natural resources, and the resources themselves. The recreational potential of the area will be expanded and the density and diversity of marine organisms will be increased.

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

Discussion: The applicant intends to improve the safety and the recreational potential of the area and to enhance the natural resources. Public access to these improvements will be ensured by construction of two public parking areas, two new pedestrian mauka-makai trails, and a pedestrian shoreline trail.

5.1.3 State Functional Plans

State Functional Plans are intended to provide more detail to the Hawaii State Plan in 12 specific areas. As defined in the State Plan, a functional plan sets forth "the policies, programs, and projects designed to implement the objectives of a specific field of activity when such activity or program is proposed, administered, or funded by an agency of the State." The relevant State Functional Plans and the relationship of the proposed improvement project to each are discussed below.

5.1.3.1 State Conservation Lands Functional Plan

Two policies presented in the State Conservation Lands Functional Plan (Department of Land and Natural Resources, 1991) are relevant to the proposed improvements.

Policy: Expand and enhance outdoor recreation opportunities and other resource uses.

Policy: Develop and expand resources to protect natural shorelines and wilderness recreation areas.

Discussion: The proposed improvements will increase and enhance the outdoor recreational opportunities for both resort guests and the general public. In addition, marine biological resources will be increased as a result of the project, with no adverse effects to water or land resources expected.

5.1.3.2 State Recreation Functional Plan

Several objectives of the State Recreational Functional Plan (Department of Land and Natural Resources, 1991) have relevance to the proposed shoreline improvements.

Objective: Reduce the incidence of ocean recreation accidents.

Discussion: The primary goal of the proposed project is to improve the safety of the shoreline and offshore areas.

Objective: Prevent the loss of access to shoreline and upland recreation areas due to new developments.

Discussion: Public parking, two new public mauka-makai access trails, two new shoreline comfort stations, and a pedestrian shoreline trail will be provided by the applicant.

Objective: Prevent degradation of the marine environment.

Discussion: The proposed project is not only expected to generate no detrimental effects to the marine environment, but will actually provide an enhanced environment expected to result in increased density and diversity of the marine life in the area.

5.1.3.3 State Tourism Functional Plan

The State Tourism Functional Plan (Department of Business, Economic Development, and Tourism, 1991) presents objectives and policies designed to promote economic growth while preserving and managing the State's rich and diverse resources. The policies most relevant to the proposed improvement project are those concerning physical development.

Policy: Maintain high standards of overall quality of existing visitor destination and attraction areas.

Policy: Improve the quality of existing parks and recreational areas, and ensure that sufficient recreational areas...are available for the future.

Policy: Encourage the development of hotels and related facilities within designated visitor destination areas with adequate infrastructure and support services before development of other possible visitor destinations.

Discussion: The proposed project site is within the South Kohala/North Kona region, a designated visitor destination area. The improvements will increase visitor use and enjoyment, therefore enhancing the overall quality of the area.

5.1.4 Hawaii Coastal Zone Management Program

The Hawaii Coastal Zone Management Act, which became Chapter 205A, Hawaii Revised Statutes, establishes State objectives regarding protection of seven broad categories of resources. This section discusses the relationship of the proposed improvements to these objectives and related policies.

Recreation: Provide coastal recreational opportunities accessible to the public.

Discussion: Coastal recreational resources will be improved and public access to them provided. Safe use of these resources will be promoted and an increase in water-related activities is expected.

Scenic and Open Space: Protect, preserve, and where desirable, restore or improve the quality of coastal scenic and open space resources.

Discussion: The appearance and purpose of the proposed improvements are consistent with the use and appearance of the adjacent beach area. Underwater resources will be enhanced by the proposed improvements as a result of increased density and diversity of marine biota that is expected as a result of deepening the improvement sites.

Coastal Ecosystems: Protect valuable coastal ecosystems from disruption and minimize adverse impacts on all coastal ecosystems.

Discussion: The proposed improvements will not require any blasting. The offshore sill that protects the nearshore zone from the effects of wave impacts will not be breached and the existing offshore wave and current pattern will be maintained. In addition, the applicant will take any other precautions necessary to minimize disruption to the offshore and on shore areas.

5.2 COUNTY PLANS, POLICIES, AND ZONING

5.2.1 Hawaii County General Plan

The Hawaii County General Plan includes both a set of general objectives and policies and land use maps showing the locations of existing and desired land uses for the entire county. The area of the applicant's property is currently designated as "Urban Expansion" on these land use maps.

5.2.2 County Zoning

County zoning designations of the applicant's property include Open, Resort-Hotel, and Multiple-Family Residential. These designations are appropriate for the planned development.

5.2.3 County Special Management Area

None of the four improvement sites are in the County Special Management Area (SMA) which is defined as mauka of the certified shoreline (see Figure 4). The only impact on the SMA from the proposed project will be movement through the SMA by the excavation equipment and temporary stockpiling of dewatered excavated material there.

The intent of the SMA guidelines impacts the proposed improvement project, and has been considered in the project design. Guidelines A.1 through A.5 seek to minimize alterations to water bodies and associated water, scenic, and wildlife resources. Guidelines A.2 and A.3 seek to maintain public access to beach and shoreline areas. The proposed project is intended to improve water-related resources and safety, with as little change as possible. Public access to the shoreline will be provided according to a public access plan approved by the County of Hawaii Planning Department.

Guidelines B.1, B.2, and B.3 state that development will be approved only if it is shown to have no significant adverse environmental effects. Information presented elsewhere in this document provides ample evidence of the fact that minimal adverse effects will result from the proposed project.

Guidelines C.1, C.2, and C.5 are designed to ensure that adequate recreation resources are maintained, and that adverse environmental impacts are minimized. As stated above, the project is designed to improve safety and recreational potential with minimal adverse effects.

Furthermore, the proposed project has been designed specifically to comply with Condition #14 of Special Management Area Use Permits # 271 and 272 for Kaupulehu Resort, which were approved in 1988. Condition #14 states that "Best efforts shall be used to secure the necessary governmental permits for the development of a swimming beach at a location between the two hotel sites on the subject property".

5.2.4 West Hawaii Regional Plan

The West Hawaii Regional Plan was prepared with the goal of formulating and implementing a plan that would address areas of State concern in the region. The plan presents critical topical issues that require State attention to most effectively meet the region's present and future needs. The West Hawaii Regional Plan is meant to complement the County General Plan and Community Development Plans.

The proposed project site is within the Kaupulehu-Kukio "Resort Destination Node" one of four areas in which the State wishes to "cluster" resorts. The Plan recognizes the need for a quality visitor industry climate, as well as increased public access to and along the shoreline. Completion of the proposed project will improve the quality of the water-related resources for both residents and visitors.

6.0 DETERMINATION OF NO SIGNIFICANT ENVIRONMENTAL IMPACT

Based on the significance criteria contained in Title 11 Chapter 200-12 of the Hawaii Administrative Rules, the proposed project will have no significant adverse environmental impact. The proposed project:

- involves an irrevocable commitment to the loss of public-owned submerged lands, but does not involve destruction of any natural or cultural resource. The benefits of the project will significantly outweigh any losses. In addition, the applicant will make arrangements with DLNR to purchase the excavated material, if desired. Moreover, the completion of the proposed project is required by Condition #14 of Special Management Area (SMA) permits # 271 and 272 for Kaupulehu Resort, which were approved in 1988;

- will not curtail, but rather will significantly improve, the range of beneficial uses of the environment in the area;

- does not conflict with the state's long-term environmental policies or goals and guidelines, as expressed in Chapter 344 Hawaii Revised Statutes;

- will not substantially affect the economic or social welfare of the community or State; its effects will be benefits to both the community and the State;

- will not substantially affect public health;

- does not involve any substantial degradation of environmental quality over the long-term or short-term;

- will not result in any effects that will cumulatively have a considerable effect on environment; it does not involve a commitment for larger or more extensive actions;

- does not substantially affect any rare, threatened, or endangered species, or any habitat;

- will have no permanent detrimental effects on air or water quality, or ambient noise levels;

- affects coastal waters, but no adverse impacts will result.

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8. PUBLIC AND AGENCY REVIEW OF DRAFT ENVIRONMENTAL ASSESSMENT

A notification of availability of the Draft EA was published on August 8, 1994 in the Bulletin of the Office of Environmental Quality Control. During the 30-day review and comment period, the Department of Land and Natural Resources, accepting agency for the EA, received eight comment letters. These letters are included below together with responses prepared by the applicant's agent, Belt Collins Hawaii.

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September 7, 1994
EA: 00085

Mr. Don Horiuchi
Department of Land and Natural Resources
1151 Punchbowl Street, Room 103
Honolulu, Hawaii 96813

Dear Mr. Horiuchi:

Draft Environmental Assessment (EA)
Kaupulehu Resort Beach Safety Improvements
North Kona, Hawaii

The applicant, Kaupulehu Land Company, proposes to excavate four shallow sites in the nearshore area adjacent to Kaupulehu Resort in order to ensure greater accessibility and safety for beach users. The applicant also wishes to develop two new mauka-makai access trails, a pedestrian shoreline trail, parking lots, comfort stations and showers.

We have reviewed the Draft EA with the assistance of Charles Fletcher, Geology and Geophysics; Jacquelin Miller and Malia Akutagawa of the Environmental Center.

<u>Project Segmentation</u>

With the recent submission of the Kaupulehu Resort Expansion Draft EIS and the Kaupulehu Resort Golf Maintenance Facility and Plant Nursery Draft EA, it appears that the referenced document proposing various beach improvement developments is part of an effort to segment a project that should be "treated as a single action" under Section 11-200-7 of the Hawaii Administrative Rules (H.A.R.). Under this rule,

> *A group of actions proposed by an agency or an applicant shall be treated as a single action when:*
> *(1) The component actions are phases or increments of a larger total undertaking.*
> *(2) An individual project is a necessary precedent for*

a larger total undertaking.

(3) *An individual project represents a commitment to a larger project.*

(4) *The actions in question are essentially identical and a single statement will adequately address the impacts of each individual action and those of the group of actions as a whole.*

On page 31 of the referenced document, it is stated,

The proposed project is part of the overall Kaupulehu Resort development. Impacts of the land-based development have been fully addressed by the Final Environmental Impact Statement (1986) for the project ...

The Draft EA makes a thorough assessment of the environmental impacts of the excavation work, but lacks information on the development of access trails, parking lots, comfort stations, and showers, as well as the environmental implications of these actions. None of these latter improvements were addressed in the referenced 1986 FEIS in any detail beyond the following statement in Section 7.2 on page 10-57: "New public access ways to the shoreline would be provided by Kaupulehu Developments, giving residents and visitors additional shoreline access." Given that these developments were not assessed elsewhere, the present Draft EA is inadequate due to the omission of consideration of the full range of environmental effects of the proposed action. Since this project could be considered as a *phase or increment of a larger total undertaking*, a *necessary precedent for a larger total undertaking*, and a *commitment to a larger project*, then it should have been a part of the 1986 Kaupulehu Resort Final EIS or the 1994 Kaupulehu Resort Expansion Draft EIS.

The Draft EA mentions that the excavation sites are submerged lands zoned Conservation. However, there is no discussion of the land use classification applicable to other planned improvements. On page 34, it is stated,

A permitted use in the Conservation District is "research, recreational, and educational uses which require no physical facilities." The proposed project will involve no permanent physical facilities. Therefore, the proposed improvements are permitted uses.

Again, since the proposed beach facilities, parking lots, and access trails were not assessed in previous EISs, then this is an issue of segmentation. If any portion of the trails, parking or beach facilities are located in land zoned Conservation, such development would not be allowed unless the necessary permits are obtained or the land use classification is redesignated.

In response to our query, the applicant's environmental consultant, Belt Collins Hawaii, stated that separate documents were submitted because they were requested by separate applicants. The applicant for the Kaupulehu Resort Expansion Draft EIS was Kaupulehu Developments, and Kaupulehu Land Company was the applicant for the two EAs on the Golf Course Maintenance Facility & Plant Nursery and Beach Safety Improvements.

Section 11-200-7, H.A.R. does not account for situations in which separate applicants submit different EISs or EAs of simultaneous projects that are mutually interrelated. However, it is the explicit intent of the EIS rules to prohibit piecemeal consideration of proposed actions. Under Section 11-200-12(b), H.A.R. it is imperative that *every phase of a proposed action, the expected consequences, both primary and secondary, and the cumulative as well as the short and long-term effects of the action* be assessed. When analyzing only certain particulars of a given project, the environmental impacts may not be deemed significant; but an entirely different conclusion may be reached when all aspects of a project are viewed synergistically. It is noteworthy that the same consultant (Belt Collins Hawaii) prepared documentation for the present Draft EA and the Kaupulehu Resort Expansion Draft EIS. That the opportunity for a more synergistic consideration of effects of the proposed actions was apparently disregarded is indeed unfortunate.

<u>Significance Criteria</u>

On page 40, the Draft EA states that

> *[T]he proposed project will have no significant adverse environmental impact ... [It] will not result in any effects that will cumulatively have a considerable effect on [the] environment; it does not involve a commitment for larger or more extensive actions.*

Our reviewers have discerned two issues raised by this statement. First, as mentioned above, the excavation activities are most appropriately viewed within the context of the entire project: the resort itself, the expansion activities, the proposed beach facilities and access trails.

Second, it can be inferred that the above statement argues for a Negative Declaration, implying that there will be no significant impacts which require the drafting of an EIS. However, Section 11-200-12, H.A.R. does not define significance criteria in terms of "adverse" or "beneficial". These terms are in the "eye of the beholder". What is adverse to one may well be beneficial to another. Consider the following example: It was predicted that there would be an increase in biodiversity and marine abundance due to the artificial deepening of selected intertidal areas. Such a result was deemed beneficial by the consultant. However, excavation activities will likely alter species composition; dominant species adapted to present environmental conditions may be outcompeted by other organisms as these conditions change. Residents who harvest presently dominant species may view the change in species composition an adverse impact. It is for this reason that the drafters of Hawaii's EIS and EA statutes and rules have been careful to avoid defining criteria in terms of adverse or beneficial.

As such, Section 11-200-12(b) states,

> *In most instances, an action shall be determined to have a significant effect on the environment if it:*
> *(1) Involves an irrevocable commitment to loss or destruction of any natural or cultural resource*
> *(8) Is individually limited but cumulative has considerable effect upon the environment or involves a commitment for larger actions*
> *(9) Substantially affects a rare, endangered and threatened species and their habitats*
> *(10) Detrimentally affects air or water quality or ambient noise levels*
> *(11) Affects an environmentally sensitive area such as a flood plain, tsunami zone, erosion-prone area, geologically hazardous land, estuary, fresh water, or coastal waters*

Given the nature of the action in relation to the significance criteria, we strongly suggest that an EIS is required. Revision of the present Draft EA as a Draft EIS would offer the ancillary benefit of an opportunity to comprehensively assess the synergistic and cumulative effects of all the actions proposed within this relatively confined region.

<u>State Land Use Plans, Policies, and Laws</u>

The Draft EA summarizes some of the objectives of the Hawaii State Plan. In addition to promoting tourism, the State's goals also include the "prudent use of Hawaii's land-based, shoreline, and marine resources," and the "effective protection of Hawaii's unique and fragile environmental resources". (p. 34) Clearly, the excavation of submerged lands to provide swimming opportunities is antithetical to the goals of protecting shoreline and marine resources. Increased access to the beach will likely increase ocean harvesting. It was stated in the Draft EA that "any potential decline in the number of fish in the area will be more than balanced by the public benefits of improved safety, access, and increased recreational opportunities". (p. 29) While the State Plan contains conflicting goals, and value judgments must be made, our reviewers expressed the concern that the prevailing assumption in this Draft EA is that any perceived human benefit outweighs potential detrimental effects on the environment.

<u>Concerns of the Public and Ocean Gatherers</u>

The document makes no mention of how the general public and traditional ocean gatherers feel about this project. Under Hawaii law, no beach can be privately owned, and all people have access to the ocean. Under the significance criteria of Section 11-200-12(b)(1), an action shall be deemed significant if it "involves an irrevocable commitment to loss or destruction of any natural or cultural resource." The Kaupulehu beach area may be used a cultural and natural resource for gathering of marine resources. Thus, interests of local residents are just as important as those of hotel patrons. While hotel guests may be primarily concerned about having a "swimmable" beach, local residents may be more appreciative of the existing physical conditions of the beach which may facilitate the gathering of seaweed, wana (sea urchin), and other species associated with this shallow water and rocky environment. The latter group may argue that hotel guests have ample opportunity to find other natural, "swimmable" beaches in the vicinity of the resort or to utilize swimming pool facilities.

Archaeological Concerns

The Draft EA does not mention potential archaeological impacts. An archaeological survey should be conducted to determine whether excavations for parking lots and pathways pose a threat to ancient structures such as heiau (Hawaiian temples), ko'a (fishing shrines), or ancient burials.

Safety Issues

The Draft EA mentions that various sea urchin species are found in the pools, particularly the deeper pool at Site C. Will the increased depth of the pools encourage the proliferation of sea urchins, and will these,in turn, pose a hazard to users of the pools? Conversely, will increased use of the pools prevent the settlement of many types of marine fauna and flora, thereby negating the consultant's predictions that excavation will enhance biodiversity?

Physical Impacts

Our reviewers differ in their evaluation of potential physical impacts arising from excavation activities. Generally, we harbor concerns about projects that alter the shoreline, because, more often than not, past anthropogenic activities have proven detrimental to physical and biological characteristics of the nearshore marine environment.

In the present case, one reviewer feels that this project will be relatively benign. The reviewer agrees with the consultant that excavation will result in initial erosion, but that this problem will not be ongoing since the project involves the digging of pits, not coves exposed to the open ocean. Some caution is recommended when handling a'a lava formations common at the site, since it has a high erosion potential as compared to pahoehoe lava. As long as the natural bench remains unbreached by excavation and coherent rock is used to maintain the seaward edge, there should be no severe impacts to the shoreline.

Another reviewer feels that although an outer platform and seaward extension of a'a lava flow which exists at Site D may serve to dissipate wave energy, there may be a greater problem of sand erosion on the shoreline since this site lacks the protection of an offshore sill. Wave energy is higher here than at the other three sites which are sheltered by the sill. In addition, the a'a lava at Site D may be more susceptible to collapse once excavation work takes place.

Another reviewer questions whether the horizontal distance between the excavated area and the sand is as close as illustrated. From a perusal of Figures 4 and 5, this reviewer predicts that beach sand would be lost to the excavated areas. The aerial photo reveals sand running mauka of the beach into the upland area where coastal development has occurred. This may be indicative of sand depositions during heavy storm events. Would future storm activity also cause sand deposition into excavated pits? The response of the reconfigured shoreline to storm surge should be analyzed to evaluate hazards to lower elevations. FEMA elevation requirements must be followed.

Threatened or Endangered Sea Turtles

It was mentioned that sea turtles have frequented the Kaupulehu beach area. Do the turtles use the beach as a nesting ground? If so, how will the proposed excavation which may cause sand loss, as well as the building of beach facilities, access trails, and parking lots affect nesting activity?

Water Circulation

Will the existing currents and wave action be sufficient to maintain "swimmable" water quality in the excavated pits?

Anchialine Ponds

Rare fauna are usually associated with anchialine ponds. Will excavation work affect water levels in anchialine ponds located on the applicant's property? Will the construction of parking lots, comfort stations, showers, and access trails directly or indirectly affect these ponds? How close are these ponds to the proposed sites?

Ciguatera Poisoning

There is some evidence that dredging and excavation activities may contribute to blooms of the dinoflagellate, *Gambierdiscus toxicus*, which causes ciguatera poisoning. A study done by Hokama, et al. (1993) also attributed the ciguatera outbreaks at Puako in the South Kohala District of Hawaii to low salinity from fresh groundwater intrusion.

Water quality analysis of the Kaupulehu beach area revealed low salinity measurements and nutrient enrichment from freshwater input up to the point where the offshore sill is located. There were no exceedances of DOH water quality requirements in waters located beyond the sill where more mixing occurs. Since the project site is located inshore of the sill where there is low water circulation, will excavation activities add to the risk of *G. toxicus* blooms?

Summary

We have serious concerns with the Draft EA because of possible segmentation issues. Given the overall scope of resort development at Kaupulehu, this project should have been integrated substantially into the regional development concept as developed in the 1986 Kaupulehu Resort Final EIS and the 1994 Kaupulehu Resort Expansion Draft EIS. In order to be fully acceptable, the final document should assess the potential cumulative impacts of the construction of parking lots, access trails, comfort stations, and showers in the context of the beach excavation work covered in this Draft EA, the existing structures of Kaupulehu Resort, and the proposed resort expansion project summarized in the 1994 Draft EIS. We suggest that the scope of potential significance of all of these proposed actions warrants preparation of a full Environmental Impact Statement.

An archaeological study should also be submitted. Issues of safety, the threat of ciguatera poisoning, effect on nearby anchialine ponds, water circulation, and the concerns of local residents who fish and gather ocean resources should also be addressed in the final document.

Thank you for the opportunity to review this Draft EA.

Sincerely,

John T. Harrison
Environmental Coordinator

cc: OEQC
Kaupulehu Land Company
Belt Collins Hawaii
Roger Fujioka
Charles Fletcher
Jacquelin Miller
Malia Akutagawa

References

Hokama, Y, Asahina, AY, Titus, E, Shirai, JLR, Hon, TWP, Chun, S, Miyahara, JT, Takata, D, Muranaka, A, Pang, E, Abbott, IE, Ichninotsubo, D: A survey of Ciguatera: assessment ofPuako, Hawaii, associated with Ciguatera toxin epidemics in humans. *J Clin Lab Anal* 7:147-154, 1993.

BELT COLLINS
HAWAII

October 12, 1994
233.7400/94(P)-555

Mr. John T. Harrison, Environmental Coordinator
Environmental Center
University of Hawaii at Manoa
Crawford 217
2550 Campus Road
Honolulu, Hawaii 96822

Dear Mr. Harrison:

Response to Comments
Draft Environmental Assessment (EA)
Kaupulehu Resort Beach Safety Improvements
North Kona, Hawaii

Thank you for your letter of September 7, 1994 concerning the Draft Environmental Assessment for the above project. Following are responses to your comments in the order they were presented in your letter.

Project Components

The proposed project which is the subject of a Conservation District Use Permit application and Draft EA is limited to improvements on the shoreline and in the offshore region of the Kaupulehu Resort. The public access improvements discussed on page 2 of the Draft EA are not part of the currently proposed project. The provision of public access improvements were conditions of the original 1988 County zoning and Special Management Area Use Permit approvals for the Kaupulehu Resort; they are located within the Urban portion of the resort property, as discussed in Section 2.1 of the Draft EA. Hence, they are not situated on Conservation lands and require no further environmental assessment. We will add a sentence to the first paragraph under section 1.4 and the first paragraph under Section 1.5 to clarify this distinction.

Project Segmentation

We respectfully disagree with your interpretation of Section 11-200-7 of the Hawaii Administrative Rules. The proposed beach safety improvements and the proposed golf maintenance facility are not efforts to segment a larger project. Rather, they are ancillary elements of the Kaupulehu Resort, a 624-acre project that is part of the Kaupulehu area designated in approved State and County plans for development as a resort destination node in North Kona. The Draft EIS prepared for Kaupulehu Resort Expansion was for a separate project which addresses a separate developer's proposal to reclassify Conservation District lands for residential and recreational uses.

We agree that Section 11-200-7, H.A.R., does not specifically account for situations

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in which separate applicants submit different EISs or EAs for simultaneous projects. In the absence of clarifying language, we must rely upon previous experience and precedent established by other projects. For example, the State's Kealakehe affordable housing project and the Liliuokalani Trust's regional commercial center occupy adjoining parcels in North Kona. Both projects sought reclassification of Conservation and Agriculture land to Urban and both projects submitted EISs for public review between September and October of 1990. Although both projects proposed to share common infrastructure, no concerns were raised during the review and approval process that they should have been reviewed as a single action. As a point of fact, the Environmental Center commented on both Draft EISs but did not express the concerns it now raises about segmentation. We fail to see a substantive difference between this example and the two development areas at Kaupulehu.

With regard to your concerns about primary, secondary, and cumulative impacts as outlined in Section 11-200-12, H.A.R., we must again disagree with your interpretation. The proposed beach safety improvements are quite limited in scope. No other beach improvements are currently proposed at Kaupulehu Resort or the adjacent Kaupulehu Resort Expansion project. Thus, the only cumulative impacts that could result from the beach safety improvements as proposed would involve the combined impacts of land based development open coastal waters. These potential impacts have been fully addressed in the respective environmental impact statements for the projects. Because no significant impacts on coastal waters were identified for any of the land-based development projects, the proposed shoreline safety improvements are not likely to generate adverse cumulative impacts. We feel that the Draft EA adequately addresses short- and long-term effects of the project and primary and secondary impacts (Section 1.5), as well as cumulative impacts (Section 3.9).

We are confused about your stated concern that an "...opportunity for a more synergistic consideration of the effects of the proposed actions was apparently disregarded..." This comment seems to contradict the statement on page 2 of your letter that the Draft EA makes a "...thorough assessment of the environmental impacts of the excavation work..." We can only respond that as a consultant to two separate but adjacent developments, we are particularly mindful of the need to ensure that both projects are mutually compatible.

Significance Criteria

With regard to your comment about the contextual view of excavation activities, we believe that the above discussion adequately addresses your concern. We respectfully disagree with your interpretation of Section 11-200-12 and your assertion that the proposed project warrants an EIS because of its relation to this section. We note that the definition of "significant effect" in Section 11-200-2 states,

> *"Significant effect or significant impact means the sum of effects on the quality of the environment, including actions that irrevocably commit a natural resource, curtail the range*

of beneficial uses of the environment, are contrary to the state's environmental policies or long-term environmental goals and guidelines as established by law, or adversely effect the economic or social welfare, or are otherwise enumerated in section 11-200-9 of this chapter." (emphasis added)

While Section 11-200-12 does not, as you suggest, define significance criteria in terms of adverse or beneficial uses, Section 11-200-2 clearly does. The tone of Section 11-200-2 demonstrates a particular concern about negative impacts. Thus, we believe that our use of the term "significant adverse impact" is consistent with the intent of Department of Health Environmental Impact Statement Rules (Title 11, Chapter 200). However, to alleviate any additional concerns you may have, we have carefully examined each of the subsections noted in your letter. Section 11-200-12(b) states:

In most instances, an action shall be determined to have a significant effect on the environment if it:

(1) *Involves an irrevocable commitment to loss or destruction of any natural or cultural resource;*

As discussed in Section 3.3.1.1 of the Draft EA, the proposed project areas consist of submerged basalt and cemented sand (beach rock). We do not believe that either of these substances can be interpreted to be a natural or cultural resource. The proposed action will alter a portion of this submerged beachrock and basalt but by and large the general physical environment will retain most of its current character, i.e., the area will remain a mixed rocky/sandy coastal strip.

(8) *Is individually limited but cumulatively has considerable effect upon the environment or involves a commitment for larger actions;*

As discussed earlier in this letter, the cumulative effects of the proposed project have been addressed in the Draft EA and have not been found to be significant. The project is clearly limited in scope and does not represent a commitment to a larger action. It does not irrevocably commit a valued natural resource or curtail the range of beneficial uses of the environment. Further, it is not contrary to the state's environmental policies or long-term environmental goals and guidelines as established by law, nor does it adversely affect the economic or social welfare.

(9) *Substantially affects a rare, endangered and threatened species or its habitat;*

Potential impacts upon rare, endangered and threatened species or their habitat are fully addressed in Section 3.3.2.3 of the Draft EA. No substantive effect has been identified.

(10) *Detrimentally affects air or water quality or ambient noise levels;*

As discussed in Section 1.5 of the Draft EA, no significant adverse impacts to offshore water quality resulting from the proposed project are anticipated. Section 1.5 also discusses the short-term impacts of construction activity. These impacts are not considered to be significant.

(11) *Affects an environmentally sensitive area such as a flood plain, tsunami zone, erosion-prone area, geologically hazardous land, estuary, fresh water, or coastal waters;*

As discussed in Appendix D of the Draft EA, "All indications are that the proposed plan, if carried out with environmental considerations as an integral part of the process, will not result in any permanent or detrimental changes to the marine environment." (page 15, Marine Research Consultants, 1993). Therefore, based upon observations of many similar projects in Hawaii that have resulted in no short- or long-term adverse impacts, we believe that the proposed project will not have a significant effect upon coastal waters

State Land Use Plans, Policies, and Laws

We do not agree with your comment that the provision of swimming opportunities is antithetical to the goals of protecting shoreline and marine resources. We have attempted to demonstrate in the Draft EA that the provision of new recreational opportunities can be accomplished without substantial adverse impacts to the environment. As discussed in Section 4.0 of the Draft EA, the provision of swimming opportunities could be accomplished through a variety of alternative engineering designs. However, these alternative designs were rejected because they generally resulted in adverse impacts to the coastal resources. Our analysis of State Plan goals and objectives in Section 5.1.2 specifically discusses how the resultant increase in the density and diversity of marine biota fulfills the State's objectives of coastal resource protection and the economic health of the visitor industry.

Your comment concerning the statement in the Draft EA about the potential decline in the number of fish in the area being offset by public benefits doesn't seem to take into account the context in which the statement was made. Chapter 343 requires full disclosure of potential impacts. The statement appears in Section 3.4.2, which identifies potential impacts of recreational activities. It was not meant as a summary conclusion or evaluation of the project's benefits and should not be used as such. Rather, it was intended to address the single issue of recreation: the benefits of increased access to fishermen results in greater pressures upon food fish. It would be inappropriate to interpret the comment as being a value judgement.

With regard to your concerns about the prevailing assumption of the Draft EA being that human benefits outweigh environmental impacts, we wish to assure you that this is not the case. As has been discussed throughout the Draft EA, as well as in this letter, the proposed project has been assessed to not have any potentially significant detrimental impacts to coastal resources. The proposed excavations are limited to the removal of basalt, beachrock, and rubble. The improvement sites do not appear to provide significant habits for marine biota. These sites are not considered to be either unique or fragile. We believe that adequate mitigation measures have been proposed in the Draft EA to minimize potential adverse impacts on water quality during construction. As discussed in the Draft EA, we feel that the proposed project will benefit the environment by providing new habitats for a variety of marine biota. The project design illustrates that human benefits can be attained through development that is compatible with the goals of resource preservation and enhancement.

Concerns of the Public and Ocean Gatherers

You state that the Draft EA makes no mention of how ocean gatherers feel about the proposed project. The EA review process has been established to allow the public an opportunity for full disclosure and review of proposed projects. Publication of the Draft EA's Notice of Availability serves as official notice to all those persons interested in participating in the review process.

In addition to the EA review process established by the OEQC, the application for a Conservation District Use Permit to allow commercial use in the Conservation District also requires a public hearing. The Board of Land and Natural Resources held a public hearing for the project on September 8, 1994, the closing date for comments on the Draft EA. During the public hearing, the mollusk *narita polita* (kupe'e snail) was identified by the Kona Hawaiian Civic Club as a valued resource in the area.

In response to the comments of the Civic Club's representative, the project's marine consultant, Dr. Steve Dollar, stated that the proposed shoreline improvements should actually increase the habitat for the kupe'e snail because the snail tends to live in submerged sand in the intertidal zone. Excavation of the swimming areas will increase the area of submerged sand available to the species. Thus, the habitat of the kupe'e will be substantially increased, which will indirectly benefit ocean gatherers.

The matter of public input from ocean gatherers also pertains to the entire Kaupulehu Resort project. The Draft EIS for Kaupulehu Resort (Belt Collins & Associates, 1986) provided an opportunity for review and comment on the matter of resort development adjacent to the coastal area. Although a number of individuals and organizations commented on matters of public access, a review of that document indicates that no comments were received from ocean gatherers specifically, and no comments concerning ocean gathering were raised.

However, comments concerning ocean gathering were raised during the August 1994 comment period for the Draft EIS for the adjacent Kaupulehu Resort Expansion project. That document indicates that the coastal area fronting the proposed resort expansion project is recognized for salt gathering as well as marine biota including limu, crab, and opihi. Studies of the Kaupulehu beach area revealed that it is not a habitat that supports abundant biota which can be gathered. While occasional subsistence food gathering occurs, the beach to the north, fronting the Kaupulehu Resort Expansion project, is more frequently used by salt and opihi gatherers.

We do know that the beach fronting the Kaupulehu Resort and Four Seasons Hotel is used by local fishermen and skin divers. Their activities will not be eliminated by the proposed beach improvements. There will still be plenty of good places to throw net, fish, or dive. However, it may be prudent to institute some management control on cross nets as suggested by the Kona Hawaiian Civic Club.

Archaeological Concerns

As discussed earlier, the public access related improvements mentioned in the Draft EA are not part of the proposed use of Conservation District lands. Thus, construction activity is limited to submerged or partially submerged areas. An archaeological reconnaissance was not conducted for these areas because several previous studies conducted for the Kaupulehu Resort project identified no significant sites in the area of the proposed improvements.

As part of the review and comment process, we have received a comment letter from the State Historic Preservation Division of the DLNR which states in its entirety, "The proposed action, to excavate submerged and shorefront land adjacent to the Kaupulehu Resort for swimming beaches, will have "no effect" on significant historic sites." That letter will be presented in the Final EA for the beach improvement project.

Safety Issues

We have queried the project's marine consultant with regard to your comment about a possible proliferation of sea urchins resulting from the proposed excavations. Dr. Dollar responds that there is no reason to expect sea urchin abundance to increase. He also noted that the sea urchins presently found in the area are not spiny *wana*, but rather the short spined Echinometra spp., and therefore, do not appear to be a potential hazard to human safety.

Concerning your comment that increased use of the pools may negate Dr. Dollar's predictions of increased biodiversity, Dr. Dollar took the increased use of the pools into account when making his assessment. Despite increased use by humans, biodiversity is expected to increase. Simply stated, in an area that is relatively barren of marine biota due to the shallow waters and high water temperatures, any improvements that would increase the water depth and indirectly lower water temperature would probably result in a corresponding increase in biodiversity. Usage by swimming or snorkeling should have no adverse effect on biota composition.

Physical Impacts

We agree with your reviewer who commented that the physical impacts of the project will be relatively benign. Regarding the note concerning the erosional potential of a'a lava, we agree with the recommendation that if any a'a lava formations are encountered they should be handled cautiously.

Concerning the wave energy regime at excavation site D, we agree that wave energy at that site is higher than the other three sites, due in part to the absence of the sill on the outer edge of the submerged platform. However, the proposed excavation will be on the inland side of a partially emerged pahoehoe lava outcrop. The excavation will be done in a way which will not alter the angle of waves approaching the beach. The prominent a'a flow immediately south of the excavated area forms a "pocket" for the beach, preventing the lateral or potential offshore movement of beach sand. The a'a flow itself will not be touched by excavation activities. In short, none of the natural physiographic features which presently provide beach stability will be altered in any way. The existing dynamics of beach stability will continue with or without the proposed improvements. Deepening the area may increase sand retention and eventually result in a larger beach.

Threatened or Endangered Sea Turtles

There was no evidence during field surveys of the proposed improvement areas that sea turtles use the beach fronting them as a nesting ground. While it is possible, it cannot be confirmed. If sea turtles use the beach, the proposed beach improvements will not constrain their nesting.

Due to the substantial amount of sand in the coastal area, the natural processes of sand movement into the excavated areas will not substantively impact the volume of sand remaining on the beach above mean sea level. Because the protective sill will not be breached by the proposed project, little if any sand will be lost as a result of excavation.

Water Circulation

In response to your concern about maintaining "swimmable" water quality in the excavated pools, we believe that normal tidal flushing of the excavated areas will continue to occur twice a day. There will be adequate water exchange as the result of tidal flushing to maintain good water quality in the excavated areas. Evidence supporting this opinion comes from observations of other swimming areas, such as Makaiwa Bay, Kawaihae Harbor, and Kahalu'u beach at Keauhou. Kahalu'u beach, in particular, is an excellent example because of its similarity to the project site in terms of a protective outer barrier, the so-called Menehune Wall.

Anchialine Ponds

Excavation work at the proposed sites will not affect water levels in the anchialine ponds on the resort property. The ponds have all been preserved pursuant to conditions of zoning and SMA permit approval (in accordance with a pond management plan approved by county agencies) and will not be impacted by any construction on the property, including the public access facilities to be developed as part of the already approved Kaupulehu Resort. The anchialine pond nearest the proposed improvements is Pond #3, which is over 75 feet inland of improvement area B.

Ciguatera Poisoning

We disagree with your assertion that there is some evidence that dredging and excavation activities may contribute to blooms of the dinoflagellate, *Gambierdiscus toxicus*. It is a popular but unproven hypothesis and there is no evidence of ciguartera being causally linked to dredging. The theory to which you are referring is unproven, as is Hokama's theory about low-salinity water. If these unproven theories were true, there would be an abundance of ciguartera everywhere on the Kona coast because fresh water discharge is higher in many locations than it is at Kaupulehu. There is no evidence that excavation activities will add to the risk of G. *toxis* blooms.

Summary

We do not agree that the proposed project warrants the preparation of a Draft EIS. The proposed project is a stand-alone element of the overall Kaupulehu Resort project. There is no relationship between the proposed project and the Kaupulehu Resort Expansion project on the adjacent property. In addition, because the proposed improvements are not anticipated to have a significant adverse impact upon the coastal resources of the area, we believe that the project is consistent with the intent of Section 11-200-12, H.A.R. Finally, as discussed above, the public access facilities mentioned in the Draft EA are not specific components of the proposed project and have been addressed as part of previous permit approvals and conditions of approval.

Very truly yours,
BELT COLLINS HAWAII

Anne L. Mapes

ALM:lws

cc: Roger Harris
Steve Dollar

Kona Hawaiian Civic Club
P.O. Box 4098
Kailua-Kona, HI 96745

September 9, 194

Ann Mapes
Belt Collins Hawaii
680 Ala Moana Blvd, #100
Honolulu, HI 96813

Dear Ms. Mapes:

On behalf of the Kona Hawaiian Civic Club, I would like to request that the following letter be included with community comments in regards to the Ka'upulehu Resort Beach Safety Improvements CDUA.

We do realize that according to the OEQC, the deadline to submit was on September 7, however, we did not receive the Draft Environmental Assessment and the Application for Department of the Army Permit until September 7. We hope our comment letter will still be included as this reflects the consensus of a large cross section of the Hawaiian community.

We will understand if your deadlines are rigid but hope that if that is the case, you will still forward our comments to the developer as input from the community.

Please feel free to contact me at (808)329-7368 at any time should you have any questions or concerns. Again, we apologize for the delay in getting this to you.

Very truly yours,

Leimana DaMate

Leimana DaMate, President
Kona Hawaiian Civic Club

CORRECTION

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

Kona Hawaiian Civic Club
P.O. Box 4098
Kailua-Kona, HI 96745

September 9, 194

Ann Mapes
Belt Collins Hawaii
680 Ala Moana Blvd, #100
Honolulu, HI 96813

Dear Ms. Mapes:

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Very truly yours,

Leimana DaMate

Leimana DaMate, President
Kona Hawaiian Civic Club

Kona Hawaiian Civic Club
P.O. Box 4098
Kailua-Kona, HI 96745

September 8, 1994

Belt Collins Hawaii
680 Ala Moana Boulevard
Honolulu, HI 96813

RE: REVIEW OF THE DRAFT ENVIRONMENTAL ASSESSMENT FOR THE PROPOS.:: BI :CH SAFETY IMPROVEMENTS FOR KA'UPULEHU RESORT

Aloha mai,

The Kona Hawaiian Civic Club welcomes the opportunity to c:mme :c upon the proposed beach safety "improvements" at Ka'upulehu, North Kon.. H :ai'i TMK: 7-2-03: 4,5, & 6, 3rd Division (Offshore area). We have the foll.win: concerns:

1) (1.2) The list of consulted parties includes various gove:nme : agencies and community environmental and recreational organizations h:t : Hawaiian agencies or organizations. Since the activity proposed would :ccu upon 5(f) Trust Lands, we would expect the Office of Hawaiian Affairs, at :he ery least, to have been consulted.

2) (1.4) The nearshore beachrock bench and the area shorewa:d f:om it are important to those of us who have used the area in our and our eld:.s' times. It is unique in composition and character in this region of ba:slt :oastline. We use it for fishing, gathering, and swimming according to the :id: and swell conditions. Is the number of types of shoreline recreation goi:g t: increase, or will there merely be an increase in one form of use?

We ask for greater consideration and development of the e:luca:ional and attitudinal aspects of shoreline safety. Consider that with g::d e:ucational and marketing programs , tabi and reefwalkers might be brisk se..lers at resort shops. For those unable to master safe practices, the shorel:.:e :.y be for walking on and the resort swimming pool(s) for swimming in. Data :n t:e safety, and injury from Kahalu'u Beach Park, which as a minimally alte::ed :horeline, might be useful to this discussion.

3) (2.3.1) We are concerned with the removal for silt, sand, a:.d cc:bles from submerged state lands. The Office of Hawaiian Affairs as well a:: th: Dept. of Land and Natural Resources should be consulted.

With regard to future "replenishment" of the beach, we :que:tion the desirability of ever mechanically moving sand from one ecosystem t: an:ther.

4) We find no discussion of kupe'e (Narita polita), a highly reg.:ded food source who's shell is valued as an adornment, and which in known :ro proposed "improvement" area D.

5) While the marine conditions for schooling and juvenile reef f:.sh a:y actually improve, how will an increase in recreational activity affect 'ish:ry/nursery activity?

6) (3.3.2.2) Dollar's and Grigg's works cited are 9 to 14 ,ear: old - are they still current? Expanding the discussion to include any da.a c.lected at Mauna Lani Resort at Kalahuipua'a would be useful.

7) (3.4.2) Regarding the stimulation of recreational fishing act:.vi', many of us fish as part of our families' nutritional budget. Sugges.ing that "any potential decline in the number of fish in an area will be more t:an ..lanced by the public benefits of improved safety, access, and increase: r:creational opportunities", seems to diminish the value and desirability of ma:taining a sustainable population of species and fails to present any manage:ent :chemes to maintain sustainable populations for either fishing or viewing.

We look forward to your response.

'O makou no me ka 'oia'i'o,

Leimana DaMate

Leimana DaMate, President
Kona Hawaiian Civic Club

cc: Keith Ahue, Department of Land & Natural Resources
Dante Carpenter, Administrator, Office of Hawaiian Affairs
Mike Lee, U.S. Army Corps of Engineers
Dept. of Health
Virginia Goldstein, Hawai'i County Planning Director
Kona Conservation Group
Surfrider Foundation
Roger Harris, Kaupulehu Land Company
Gabriel Makuakane, Royal Order of Kamehameha
Fanny Au Hoy, Hulihe'e Palace
Charles Young, Ka Lahui Hawai'i
Michael Matsukawa, Attorney-At-Law
C. J. Villas, West Hawai'i Sierra Club

BELT COLLINS
HAWAII

October 12, 1994
233.7400/94(P)-556

Ms. Leimana DaMate, President
Kona Hawaiian Civic Club
P.O.Box 4098
Kailua-Kona, Hawaii 96745

Dear Ms. DaMate:

Response to Comments
Draft Environmental Assessment (EA)
Kaupulehu Resort Beach Safety Improvements
North Kona, Hawaii

Thank you for your letter of September 8, 1994 concerning the Draft Environmental Assessment for the above project. Following are responses to your comments in the order they were presented in your letter.

1) We recognize the importance of including Hawaiian agencies and organizations in project consultation and regret not having done so early in the process. A representative of the applicant, Kaupulehu Land Company, contacted Ms. Lynn Lee at the Office of Hawaiian Affairs (OHA) on September 7, 1994, as soon as the concern was brought to his attention. We were able to confirm that OHA had previously received a copy of the Draft EA as part of the formal distribution process.

2) As discussed in the Draft EA, the proposed improvements are intended to create safe swimming areas. Thus, the number of swimmers and snorklers in the area will likely increase as a direct result of the improvements. We also anticipate a corresponding increase in the number of sunbathers utilizing the beach area fronting the improved swimming areas.

The proposed project, in and of itself, is not anticipated to increase other recreational uses or activities in the nearshore area. Increased recreational use of the nearshore areas is directly linked to the provision of public access to those areas. The provision of public access is a requirement of both the state and the county and was addressed as part of the original 1988 approvals of the Kaupulehu Resort project.

With regard to your concerns about educational and attitudinal aspects of shoreline safety, the safety of resort guests is an important consideration for any resort operator. We expect that Kaupulehu Resort will strive to ensure that its guests are sufficiently educated about the potential perils of unsafe reef-walking. However, as you are well aware, the coastal areas of the islands fall under the jurisdiction of the state and public access to them is unrestricted. Consequently, the ability of the resort to educate all users of the Kaupulehu coastline is virtually impossible. The

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ultimate responsibility for safety among people who utilize public accesses lies with the people themselves. To assist them, the Kaupulehu Resort can work to ensure that information about safety is readily available.

In response to your request, we contacted the Hawaii County Parks Department concerning the availability of data for injuries at Kahalu'u Beach Park. The department does not keep detailed records or statistics of injuries reported. While the staff can estimate the number of times first aid assistance was provided at the park, they do not record the source of injuries reported: whether a person cut their foot on broken glass in the parking area or while reef-walking. According to the department's records, during the period from February through September of this year, a total of eight incidents requiring first aid have occurred at Kahalu'u Beach Park. They include one bee sting, five lacerations, and 2 avulsions (deep lacerations). During fiscal year 1993-94, 17 similar incidents occurred at the park, but no breakdown on injury type is available. This was equal to one incident for every 23,600 people who used the park. During the 1992-93 fiscal year, 16 incidents occurred (one incident for every 26,000 park users). For comparison purposes, the highest number of incidents requiring first aid recorded for Hawaii County parks during FY 1993-94 was 20, at Richardson Beach Park in East Hawaii (one incident for every 8,200 park users).

3) Both OHA and the Department of Land and Natural Resources have been and will continue to be consulted concerning the beach improvements.

Although the possibility of beach replenishment is discussed in the Draft EA, this is to ensure that all possible actions and associated impacts are disclosed and evaluated. However, no beach replenishment is now contemplated for the project.

4) We appreciate this matter being brought to our attention and acknowledge that the marine consultant's work did not specifically include a survey of kupe'e in the vicinity of the project. We have asked Dr. Dollar to amend his report to include an evaluation of potential impacts upon the kupe'e. His addendum has been included in the Final EA.

5) We do not believe that an increase in the number of swimmers and snorklers will result in a significant adverse impact upon the spawning habits of the various species present in the Kaupulehu coastal area. In fact, because the proposed modifications to the nearshore area will improve the habitat by increasing water depth, we anticipate a beneficial impact upon biodiversity.

6) With regard to your concern about the use of more current marine studies, please note that the reference section of the Draft EA cites ten separate marine-related studies conducted between 1985 and 1993, including baseline and monitoring programs at the Mauna Lani Resort in 1987 and 1989.

7) Kaupulehu Resort agrees that maintaining the sustainable population of food species in the coastal area is a desirable objective and supports the Civic Club and DLNR in any effort to study and implement a management plan aimed at maintaining these populations in or near the project area. The applicant is ready and willing to work with the Civic Club and interested government agencies in creating and implementing such a plan.

Thank you for your comments. We hope to continue this dialogue as the project progresses.

Very truly yours,
BELT COLLINS HAWAII

Anne L. Mapes

ALM:lws
cc: J. Mongan
R. Harris

JOHN WAIHEE
GOVERNOR

BRUCE S. ANDERSON, Ph.D.
INTERIM DIRECTOR

RECEIVED
'94 AUG 11 AM 10:53
DLNR
OCEA

STATE OF HAWAII
OFFICE OF ENVIRONMENTAL QUALITY CONTROL
220 SOUTH KING STREET
FOURTH FLOOR
HONOLULU, HAWAII 96813
TELEPHONE (808) 586-4185
FACSIMILE (808) 586-2452

RECEIVED
94 AUG 11 A10:36
DEPT. OF LAND & NATURAL RESOURCES
STATE OF HAWAII

August 9, 1994

To: Keith Ahue, Chairperson
Board of Land and Natural Resources

From: for Bruce S. Anderson, Ph.D.
Interim Director

Subject: REQUEST FOR COMMENTS
Conservation District Use Application

APPLICANT:	Kaupulehu Land Company
FILE NO.:	HA-2719
REQUEST:	Shoreline Excavations
LOCATION:	Kaupulehu, North Kona, Hawaii
TMK(s):	7-2-3: 4, 5, & 6

Thank you for allowing us to review the request for shoreline improvements at Kaupulehu, North Kona, Hawaii.

We do not have any comments to offer on the proposed improvements.

BSA:kk

Attachment

145

BELT COLLINS
HAWAII

October 12, 1994
233.7400/94(P)-557

Dr. Bruce Anderson,
Interim Director
Office of Environmental Quality Control
State of Hawaii
220 South King Street, 4th Floor
Honolulu, Hawaii 96813

Dear Dr. Anderson:

Response to Comments
Draft Environmental Assessment (EA)
Kaupulehu Resort Beach Safety Improvements
North Kona, Hawaii

Thank you for your letter of August 9, 1994 concerning the Draft Environmental Assessment for the above project. We appreciate your participation in the review process.

Very truly yours,
BELT COLLINS HAWAII

Anne L. Mapes

ALM:lws

cc: J. Mongan
R. Harris

680 ALA MOANA BOULEVARD, FIRST FLOOR, HONOLULU, HAWAII 96813-5406 U.S.A., TEL: 808 521-5361 FAX: 808 538-7819
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Gray • Hong • Bills & Associates, Inc.
CONSULTING ENGINEERS

Brian L. Gray, P.E.
Daniel S.C. Hong, P.E.
David B. Bills, P.E.
Roy T. Aoki, P.E.
Beverly G. Ing, P.E.
Michael H. Nojima, P.E.
Raymond M. Santo, P.E.

119 Merchant Street, Suite 607
Honolulu, Hawaii 96813
Telephone: (808) 521 0306
Fax: (808) 531 8018

August 22, 1994

Mr. Donald Y. Horiuchi
Planner
Conservation & Environmental Affairs
Department of Land & Natural Resources
State of Hawaii
1151 Punchbowl Street, Room 131
Honolulu, Hawaii 96813

RECEIVED
'94 AUG 23 A 11:00

SUBJECT: Kaupulehu Resort Beach Safety Improvements
Draft Environmental Assessment
TMK: 7-2-03: por. 4, 5, and 6 (Offshore)

Dear Mr. Horiuchi:

We have been asked by Kona Village Resort to review the subject assessment. The assessment has been reviewed by our office as well as Sea Engineering Inc. We both believe the impact of the subject project will be minimal. However, work is proposed in close proximity to the Kona Village Resort boundaries. As your are aware, this is an exclusive isolated retreat and construction nuisances such as noise and dust are detrimental to Village operation. It is important that all care be provided to minimize the construction related impacts to Kona Village Resort.

We are assure that you are aware that various stages of construction had been incurring on property directly adjacent to Kona Village for the last 4 to 5 years. Due to situations beyond Kaupulehu Land Development's control, the construction period has stretched far beyond that originally intended. These construction related impacts have had a direct bearing on visitors to Kona Village Resort and all precautions to minimize the impact would be appreciated by the Village.

Should you have any questions, please contact our office.

Very truly yours,
GRAY, HONG, BILLS & ASSOCIATES, INC.

David B. Bills

DB:am
1882-2

cc: Kona Village Resorts - Fred Duerr
McCorriston, Miho & Miller - Sharon Nishi, Esq.
Belt Collins - Anne Mapes

BELT COLLINS
HAWAII

October 12, 1994
233.7400/94(P)-558

Mr. David B. Bills
Gray Hong Bills & Associates, Inc.
119 Merchant Street, Suite 607
Honolulu, Hawaii 96813

Dear Mr. Bills:

Response to Comments
Draft Environmental Assessment (EA)
Kaupulehu Resort Beach Safety Improvements
North Kona, Hawaii

Thank you for your letter of August 22, 1994 concerning the Draft Environmental Assessment for the above project. We appreciate your concerns about construction nuisances. The applicant will make every effort to minimize construction noise and dust impacts. The applicant is also willing to arrange a construction schedule with the Kona Village Resort that does not conflict with the Village's high-occupancy season.

Very truly yours,
BELT COLLINS HAWAII

Anne L. Mapes

Anne L. Mapes

ALM:lws

cc: J. Mongan
R. Harris

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JOHN WAIHEE
GOVERNOR

ESTHER UEDA
EXECUTIVE OFFICER

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

August 16, 1994

SUBJECT: Director's Referral No. 94-264-N
Conservation District Use Application - Kaupulehu Land Company Shoreline Excavations; File No.: HA-2719

We have reviewed the subject Conservation District Use Application (CDUA) and accompanying Draft Environmental Assessment (Draft EA) and have the following comments to offer:

1) We confirm that the areas intended for shoreline excavations for beach safety improvements, as depicted on Figure 3/overlay of the Draft EA, are within the State Land Use Conservation District.

2) We wish to note that the land-based development site adjacent to the sites for shoreline excavation are within the State Land Use Urban District, with the exception of a pond named Waiakuhi which is within the Conservation District.

The land-based development site with proposed uses of hotel, golf course, and resort-condominiums, was also the subject of LUC Docket No. A85-597/Kaupulehu Developments, which reclassified approximately 575 acres from the Conservation District to the Urban District and approximately 123 acres from the Urban District to the Conservation District on October 24, 1986.

3) Kaupulehu Developments has filed a petition for reclassification of approximately 1,000 acres from the Conservation District to the Urban District, situated north of Kaupulehu Resort and Kona Village Resort, for expansion of the Kaupulehu Resort (LUC Docket No. A93-701).

The petitioner is currently preparing an Environmental Impact Statement for acceptance by the LUC.

We have no further comments to offer at this time.

EU:LA:th

BELT COLLINS
HAWAII

October 12, 1994
233.7400/94(P)-559

Ms. Esther Ueda, Executive Director
State Land Use Commission
State of Hawaii
Department of Business, Economic Development & Tourism
Old Federal Building, Room 104
335 Merchant Street
Honolulu, Hawaii 96813

Dear Ms. Ueda:

Response to Comments
Draft Environmental Assessment (EA)
Kaupulehu Resort Beach Safety Improvements
North Kona, Hawaii

Thank you for your letter of August 16, 1994 concerning the Draft Environmental Assessment for the above project. We appreciate your participation in the review process.

Very truly yours,
BELT COLLINS HAWAII

Anne L. Mapes

ALM:lws

cc: J. Mongan
R. Harris

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'94 AUG 25 PM 12:42

DLNR
OCEA

August 24, 1994

LOG NO: 12460
DOC NO: 9408PM19

MEMORANDUM

TO: Roger Evans, Administrator
Office of Conservation and Environmental Affairs

FROM: Don Hibbard, Administrator
State Historic Preservation Division

SUBJECT: **FILE NO. HA-2719. Conservation District Use Application**
Shoreline Improvements (Kaupulehu Land Company)
Kaupulehu, North Kona, Island of Hawaii
TMK: 7-2-3: 4, 5, 6

The proposed action, to excavate submerged and shorefront land adjacent to the Kaupulehu Resort for swimming beaches, will have "no effect" on significant historic sites.

PM:amk

BELT COLLINS
H A W A I I

October 12, 1994
233.7400/94(P)-560

Mr. Don Hibbard, Administrator
State Historic Preservation Division
Department of Land and Natural Resources
1151 Punchbowl Street
Honolulu, Hawaii 96813

Dear Mr. Hibbard:

Response to Comments
Draft Environmental Assessment (EA)
Kaupulehu Resort Beach Safety Improvements
North Kona, Hawaii

Thank you for your August 24, 1994 memorandum concerning the Draft Environmental Assessment for the above project. We appreciate your participation in the review process.

Very truly yours,
BELT COLLINS HAWAII

Anne L. Mapes

ALM:lws

cc: J. Mongan
R. Harris

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SENT BY: ... ...

State of Hawaii
Department of Land and Natural Resources
DIVISION OF AQUATIC RESOURCES

Date: August 29, 1994

TO: Paul Kawamoto, Aquatic Biology Program Manager
FROM: RS Richard Sixberry, Aquatic Biologist
SUBJECT: Comments on Conservation District Use Application HA-2719

Comment Requested by: Roger Evans, Office of Conservation and Environmental Affairs — Date of Request 08/01/94 — Date Rec'd. 08/08/94

Summary of Proposed Project

Title: Shoreline Excavations

Project by: Kaupulehu Developments

Location: N. Kona, Hawaii

Brief Description:

The developer is planning to improve the shoreline and offshore region next to its proposed resort by enhancing the safety, accessibility and recreational potential of the area. The four sites selected, ranging from a quarter to a half acre, are too shallow for swimming and potentially hazardous because of nearshore rock ledges and a'a lava outcropping. The offshore sill will not be breached.

All construction will be carried out with standard earth-moving equipment which would build four-foot-deep pools with smooth bottoms and easy access from the shoreline. A rock ledge will also be removed in order to provide access to a tide pool. All silt, sand and cobble created during excavation would be removed by bulldozer and/or front-end loader. Residual material would be removed by suction pumping. The spoils would be placed onshore, dewatered and disposed of on fast land. The final step would be to push the beach sand back to the shoreline where the tides would define the final configuration.

Public access to the improved beach area will be facilitated by development and maintenance of two new mauka-makai access trails, public comfort stations and showers, and a pedestrian shoreline trail. Public parking areas will also be provided.

Comments:

Some temporary turbidity, siltation and other disturbance is expected to affect aquatic resources during the activities proposed. The area does not appear to be an overly rich marine environment, however, it is not devoid of aquatic communities which are necessary for the well being of the other marine organisms within the various stages of the food chain. Endangered and threatened species should not be affected by this project since the excavation areas are in shallow water and buffered by the offshore sill.

Removal of spoils in nearshore waters during high tides, offshore wind and high surf would probably reduce the effectiveness of a silt curtain. Therefore, we suggest, since the use of silt curtains are not planned, that all activities in the water be restricted to low tides and calm sea conditions to limit excessive transport and associated scouring by rubble and sediment before it is removed.

Re: Comments on CDUA HA-2719

Mitigation measures, including monitoring is being established by the applicant which should identify and prevent any permanent or detrimental changes to the marine environment. Also, precautions should be taken to prevent debris, petroleum products and other potential contaminants from entering coastal waters.

In summary, we believe that the disposal of sediments on land would provide the most environmentally safe procedure for the excavation proposed on State submerged land, and would be enhanced by restricting excavation to periods of low tides and surf.

BELT COLLINS
HAWAII

October 12, 1994
233.7400/94(P)-561

Mr. Paul Kawamoto, Aquatic Biologist
Division of Aquatic Resources
Department of Land and Natural Resources
1151 Punchbowl Street, Room 330
Honolulu, Hawaii 96813

Dear Mr. Kawamoto:

Response to Comments
Draft Environmental Assessment (EA)
Kaupulehu Resort Beach Safety Improvements, North Kona, Hawaii

We are responding to Aquatic Biologist Richard Sixberry's August 29, 1994 memorandum concerning the above project. Please be advised that the proposed project is limited to the beach safety improvements discussed in the Draft EA. The provision of public access improvements is not part of the proposed project since these improvements will occur within the Urban District subject to conditions of permit approvals granted in 1988.

Although we understand the intent of Mr. Sixberry's comments concerning the advisability of restricting construction activity to periods of low tides and calm sea conditions to limit excessive transport, we are concerned that his suggestion may result in increased turbidity within the area protected by the offshore sill. Our engineers have evaluated the same concern and conclude that excavation may be more advisable during periods of high tides because fines can be more easily flushed from the excavated basins, which will minimize adverse impacts on existing marine invertebrates. We do not feel that the volume of material subject to potential transport will pose a significant adverse impact to the waters outside the protective sill, given the existing wave regime and the extent of rapid mixing that occurs in the area. Nevertheless, we will take his comment under advisement.

We agree with Mr. Sixberry's concern that all precautions should be taken to prevent debris, petroleum products and other potential contaminants from entering coastal waters. We believe that this can be accomplished with daily inspection of all equipment utilized for nearshore construction activities.

Very truly yours,
BELT COLLINS HAWAII

Anne L. Mapes

ALM:lws
cc: J. Mongan
R. Harris

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August 29, 1994

MEMORANDUM:

TO: Wayne Ching, Resource Management Forester

FROM: Rodney Oshiro, Na Ala Hele

SUBJECT: HA-2719, Shoreline Excavations
Kaupulehu, North Kona, Hawaii
TMK: 7-2-3: 4, 5, & 6

The lateral access along the shoreline will be temporarily affected if the proposed shoreline excavations are approved. However, no major adverse impact to the program is expected, except for the loss of some fishing grounds.

The Na Ala Hele Advisory Council meeting is scheduled on September 21, 1994 and some members are expected to attend the public hearing on September 8, 1994. Should any significant issue arise, a formal response will be made following the advisory council meeting.

Sept. 1, 1994

I concur with Hawaii Branch's comments and concerns.

Michael G. Buck
Administrator

RECEIVED
'94 SEP 6 AM 10:26
DLNR
OCEA

BELT COLLINS
H A W A I I

October 12, 1994
233.7400/94(P)-562

Mr. Rodney Oshiro
Na Ala Hele
Department of Land and Natural Resources
1151 Punchbowl Street
Honolulu, Hawaii 96813

Dear Mr. Oshiro:

Response to Comments
Draft Environmental Assessment (EA)
Kaupulehu Resort Beach Safety Improvements
North Kona, Hawaii

Thank you for your August 24, 1994 memorandum concerning the Draft Environmental Assessment for the above project. We appreciate your participation in the review process.

Very truly yours,
BELT COLLINS HAWAII

Anne L. Mapes

ALM:lws

cc: J. Mongan
R. Harris

680 ALA MOANA BOULEVARD, FIRST FLOOR, HONOLULU, HAWAII 96813-5406 U.S.A., TEL: 808 521-5361 FAX: 808 538-7819
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STATE OF HAWAI'I
OFFICE OF HAWAIIAN AFFAIRS
711 KAPI'OLANI BOULEVARD, SUITE 500
HONOLULU, HAWAI'I 96813-5249
PHONE (8.:1) 594-1888
FAX (808) 594-1865

September 12, 1994

Mr. Keith W. Ahue, Chairperson
Board of Land and Natural Resources
P.O. Box 621
Honolulu, Hawai'i 96809

Re: CDUA, Kaupulehu Land Company, HA-2719, Shoreline Excavations, Kaupulehu, North Kona, Hawai'i, TMK:7-2-3:4,5, & 6

Dear Mr. Ahue:

Thank you for the opportunity to review the above-referenced Conservation District Use Application.

Although this project involves the excavation of submerged lands within the ceded lands trust we believe that this project, with some small modification, is acceptable for two reasons.

First, this CDUA has been prepared in response to a SMA condition imposed on the developer by the County of Hawai'i. That condition required the developer to seek governmental approval to improve public access and safety for the beach area fronting the proposed resort. The developer is attempting to comply with this condition by proposing to excavate four small areas for safer swimming, building public parking, marked access paths and public comfort stations.

Second, the anticipated shoreline excavation is not a commercial use of ceded lands. Although improved beach access may benefit the resort it is not the main focus of the resort and the resort could continue even if the proposed beach excavation did not take place. There will be no charge to individuals, whether resort guests or the public, for use of the improved beach.

Thus, the Office of Hawaiian Affairs' (OHA) continued concern for the uncompensated or non-public use of submerged lands is not affected in this instance.

Finally, the modifications we believe necessary are first that parking areas for the general public be within reasonable walking distance for the very young and the elderly. The Environmental Assessment indicates the general location of parking areas and access paths. However, it does not provide information on distance. It appears that most of the parking areas are quite a distance from the beach. We urge the Board of Land and Natural Resources (BLNR) to require the developer to provide most public parking within a reasonable walking distance to the first beach pool areas.

Second, we urge the BLNR to impose a condition requiring the developer provide public access and parking in perpetuity, at no cost. Too often resorts have made preliminary arrangements for public access and parking which ultimately result in user fees to the public.

If you have any questions concerning our comments, please contact Linda K. Delaney, or Lynn J. Lee, in our Land and Natural Resources Division at 594-1934.

Me ka 'oia'io

Dante K. Carpenter
Administrator

cc: Clayton H.W. Hee, Chairperson
Board of Trustees

BELT COLLINS
HAWAII

October 12, 1994
233.7400/94(P)-563

Mr. Dante K. Carpenter, Administrator
Office of Hawaiian Affairs, State of Hawaii
711 Kapiolani Boulevard, Suite 800
Honolulu, Hawaii 96813

Dear Mr. Carpenter:

Response to Comments
Draft Environmental Assessment (EA)
Kaupulehu Resort Beach Safety Improvements
North Kona, Hawaii

Thank you for your letter of September 12, 1994 concerning the Draft Environmental Assessment for the above project. We appreciate your comments and assessment of the project's general acceptability to your organization.

Please be assured that shoreline access and parking will be provided in accordance with the approved comprehensive public access plan and will be as close as possible to the shoreline and readily usable for the young and elderly. The applicant does not intend to impose user fees upon the general public, now or in the future. For your information, construction has begun on elements of the plan, and completed amenities will be in place with the opening of the Four Seasons Hotel.

Very truly yours,
BELT COLLINS HAWAII

Anne L. Mapes

cc: J. Mongan
R. Harris

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APPENDIX A

Recommended Shoreline Improvements Along the Kaupulehu Resort Shoreline in North Kona, Hawaii

Prepared for

Kaupulehu Land Company
P. O. Box 1119
Kailua-Kona, Hawaii 96745

Prepared by

Tom Nance
Water Resource Engineering
680 Ala Moana Boulevard - Suite 406
Honolulu, Hawaii 96813

April 1993
Revised May 1993
Revised April 1994

Table of Contents

List of Figures

Introduction

The 600-acre Kaupulehu Resort is being developed along the North Kona shoreline between Kuhio and Kahuwai Bays (Figure 1). The initial stage of development will include a 250-room hotel, 250 condominium units, an 18-hole golf course, and related amenities and infrastructure. The current land use plan for the 600-acre site, including the initial development stage, is shown on Figure 2.

The Resort has approximately 4200 linear feet of shoreline frontage. About 55 percent or 2350 feet of this is a sand beach which is fronted by a partially emerged and partially submerged, basalt platform which varies from 80 to 220 feet wide. The form of the rocky shelf creates numerous shallow tidepools which are a recreational attraction. However, the rocks are slippery and sharp and pose a hazard to users of the beach. Modifications to this shelf, consisting of deepening tidepools and removing several rock outcrops along the shoreline, are proposed in this report to provide safe access to the water and enhance the recreational potential of the shoreline.

Description of the Nearshore Physical Environment

The southernmost 1850 feet of the Kaupulehu Resort shoreline is a prominent a'a lava flow, the seaward end of which is a nearly vertical, 10- to 15-foot high escarpment. This portion of the shoreline has no beach. Because the shoreline form makes it impossible for sand to accumulate at the toe of the escarpment or further offshore, this portion of the shoreline has no beach. The northern 2350 feet of Kaupulehu's shoreline is comprised of a substantial sand deposit lying on an older pahoehoe lava flow. The sand has the form of a small sand dune about 80 to 130 feet wide at its base. Its crest elevation varies from seven to 10 feet above mean sea level. On the landward side of the sand deposit, vegetation covers about 50 to 70 percent of its surface area. The seaward slope of the sand is a typical foreshore beach with a relatively steep, 1 (vertical):5 (horizontal) slope.

The low lying, pahoehoe lava flow on which the beach sand rests extends offshore as a partially submerged, partially emerged shelf with a clearly delineated seaward edge along most of its length. Its bench-like cross section is 80 to 220 feet across and averages about 140 feet. Elevations vary from one to two feet above sea level to 3 to 4 feet below sea level in the deepest tidepools. About one-quarter to one-third of its surface area is exposed basalt. Another portion, also less than one-third of the area, is comprised of encrusting coralline algae and cemented sand ("beachrock") attached to submerged basalt. The cemented sand occurs mostly at the foot of the sand beach at the waters edge and at the outer edge of the basalt platform. At the outer edge, the beachrock is in the form of an

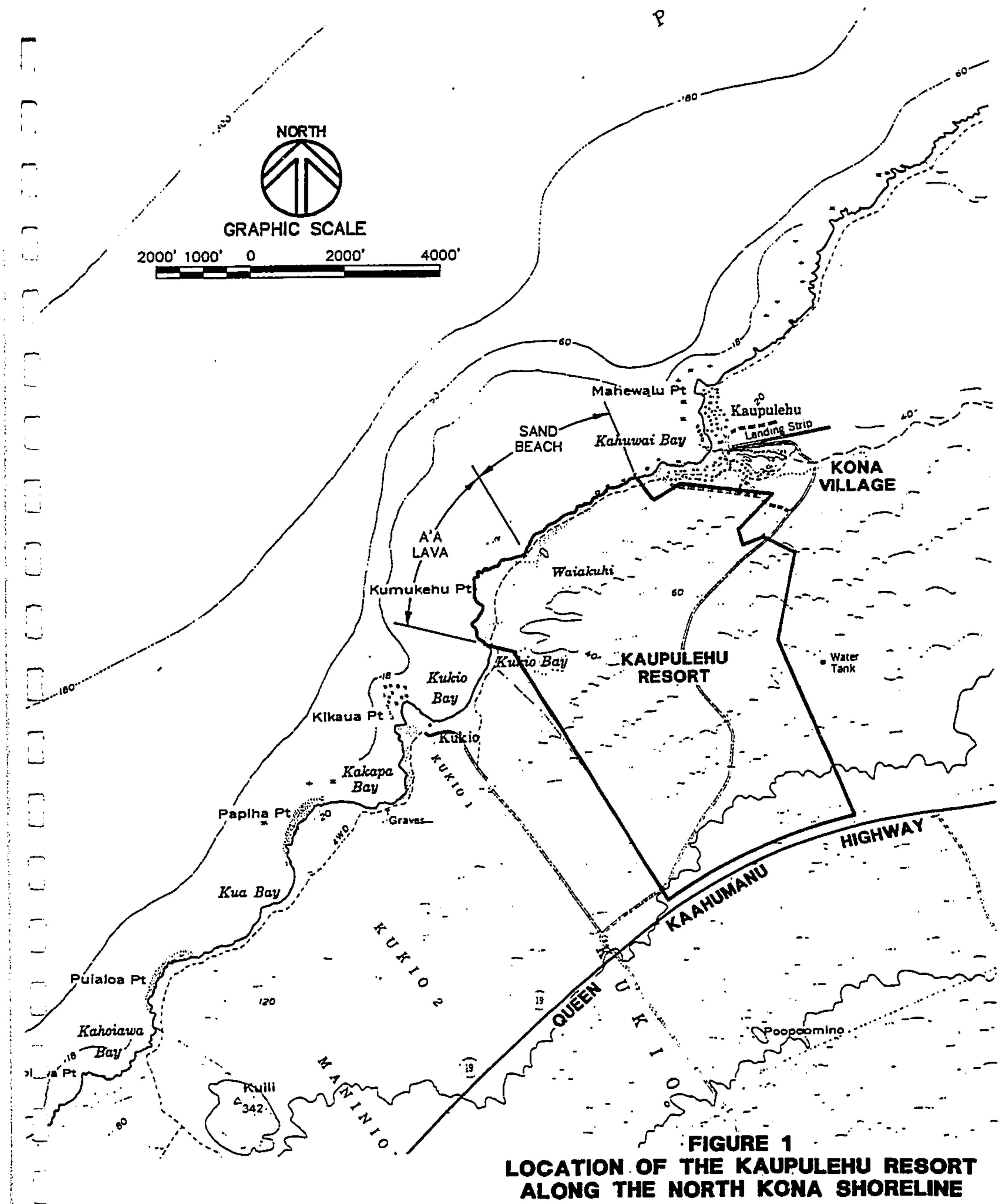


FIGURE 1
LOCATION OF THE KAUPULEHU RESORT ALONG THE NORTH KONA SHORELINE

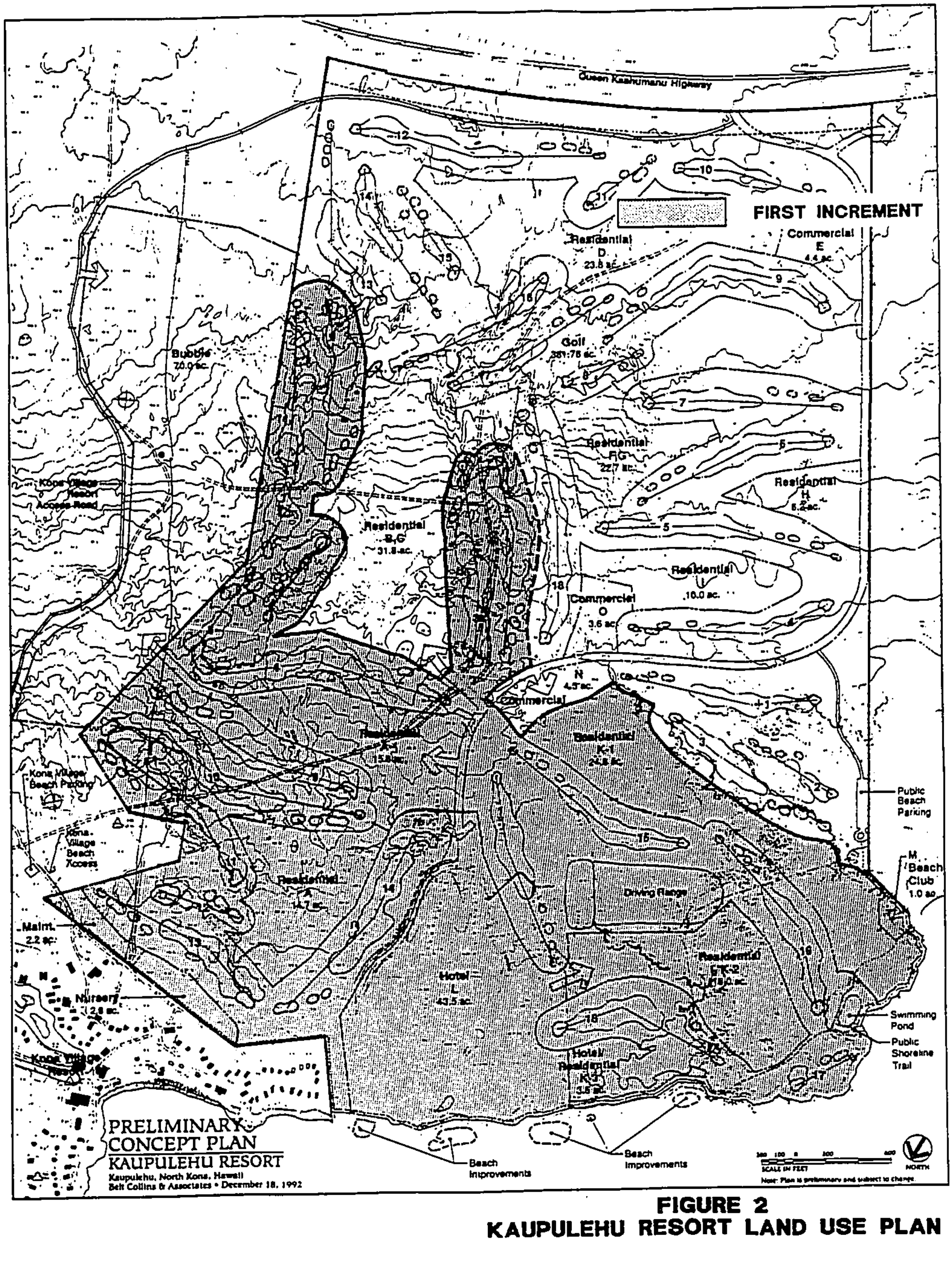


FIGURE 2
KAUPULEHU RESORT LAND USE PLAN

emerged sill which clearly demarcates the seaward extent of the platform. The remaining area of the nearshore platform consists of indentations and pockets in the basalt comprising numerous tidepools. The floors of these pools are covered with water-rounded coral and basalt rocks, coarse beach sand, and encrusting algae. Coral growth occurs in only one tidepool, the largest and deepest along the shoreline.

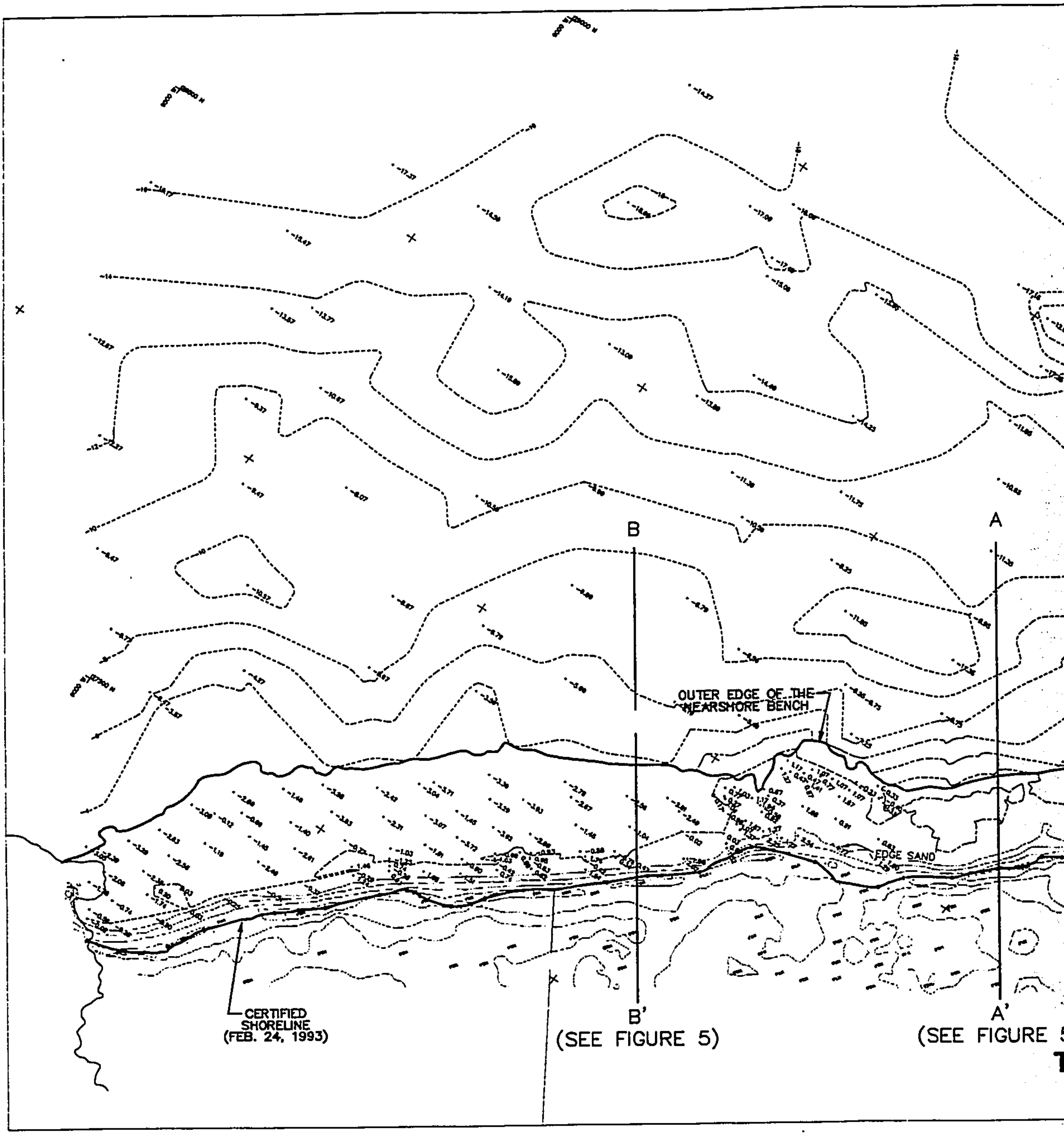
Seaward of the nearshore bench lies a deeper and broader submerged platform. Its aerial extent is approximated by the 18-foot depth contour on Figure 1 and is also clearly delineated as the lighter colored water on Photo 1. This larger submerged platform encompasses the entire shoreline between Kuhio and Kahuwai Bays and extends 2000 to 2700 feet offshore in front of the Kaupulehu Resort shoreline. Depths over this shelf vary from 10 to 18 feet and its overall slope is very flat, typically between 1:50 and 1:80. The broad offshore platform, together with the partially emerged nearshore bench, provide excellent protection from waves for the Resort's beach. The deeper, offshore platform causes large storm waves to break far offshore. Smaller waves which move across this platform without breaking then encounter the partially emerged, nearshore platform and its beachrock sill. All waves break on its outer edge, even during the highest tides when the water level is approximately as high as the sill.

Figure 3 is a reproduction of R.M. Towill's bathymetric survey for the northernmost 2350 feet of the Resort's shoreline. Although the survey does not have sufficient data points to depict small-scale features, it does provide a general picture of the elevations of the offshore submerged platform and the nearshore, partially emerged bench. On the nearshore bench, basalt outcrops dominate the northern end while tidepools of various sizes and with depths of 3 to 4 feet are more common toward the south end. On Figure 4, these nearshore features are shown at the same scale as R.M. Towill's survey. This drawing was made using a vertical color photograph taken on May 4, 1992 (No. 8811-23 by R.M. Towill Corporation), the Towill topographic survey, and field inspection. The cross sections shown on Figure 5 are based primarily on Towill's survey but annotations based on field work have been added. The cemented sand which forms an emerged sill along most of the outer edge of the nearshore bench gives it distinctive topographic definition.

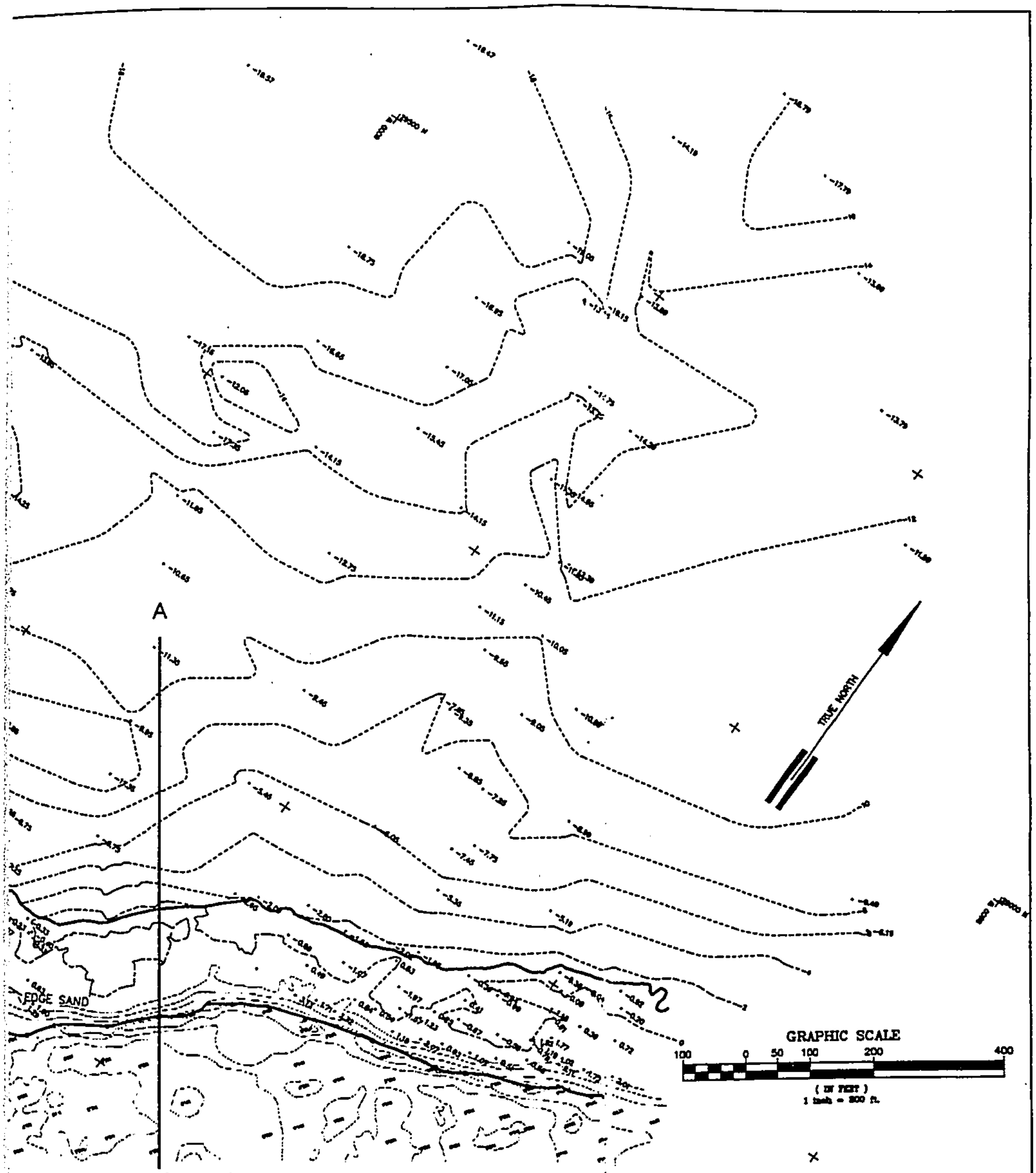
Proposed Shoreline Improvements

Deepening existing tidepools on the nearshore bench and removing several rock outcrops within these tidepools are proposed at four locations (see Figures 6 and 7). Each site was chosen for the natural opportunity provided by the form and bathymetry of the nearshore bench so as to minimize the

Photo 1. This oblique aerial photo shows the broad offshore shelf and partially emerged nearshore platform which provide wave protection for Kaupulehu Resort's beach. The hotel's foundation and grading for the golf course are partially completed.



B
A
OUTER EDGE OF THE NEARSHORE BENCH
EDGE SAND
CERTIFIED SHORELINE (FEB. 24, 1993)
B'
(SEE FIGURE 5)
A'
(SEE FIGURE 5



(SEE FIGURE 5)

FIGURE 3
TOPOGRAPHIC AND BATHYMETRIC SURVEY
BY R.M. TOWILL CORPORATION


OUTER EDGE OF THE NEARSHORE BENCH
EDGE SAND
CERTIFIED SHORELINE (FEB. 24, 1993)

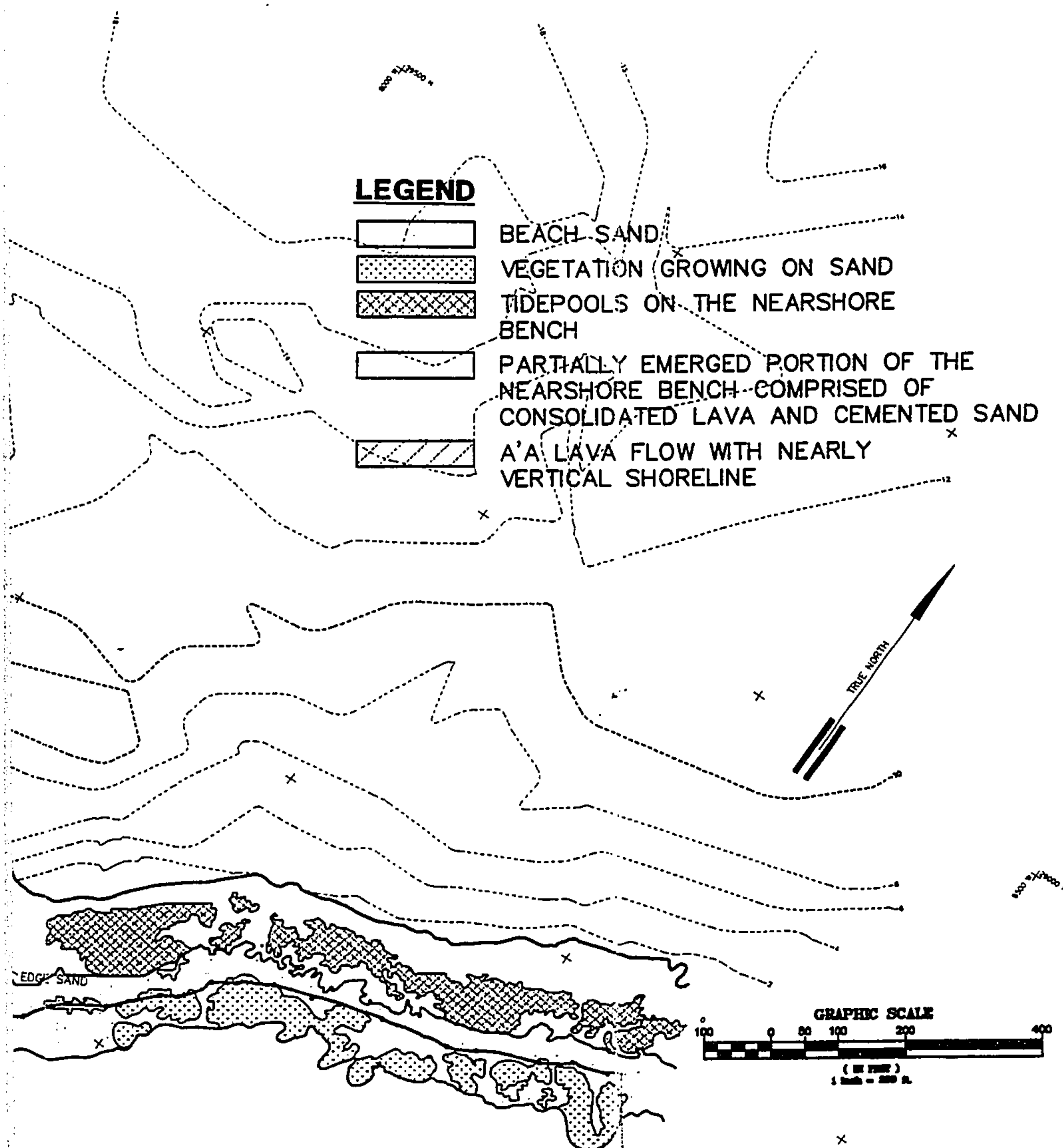
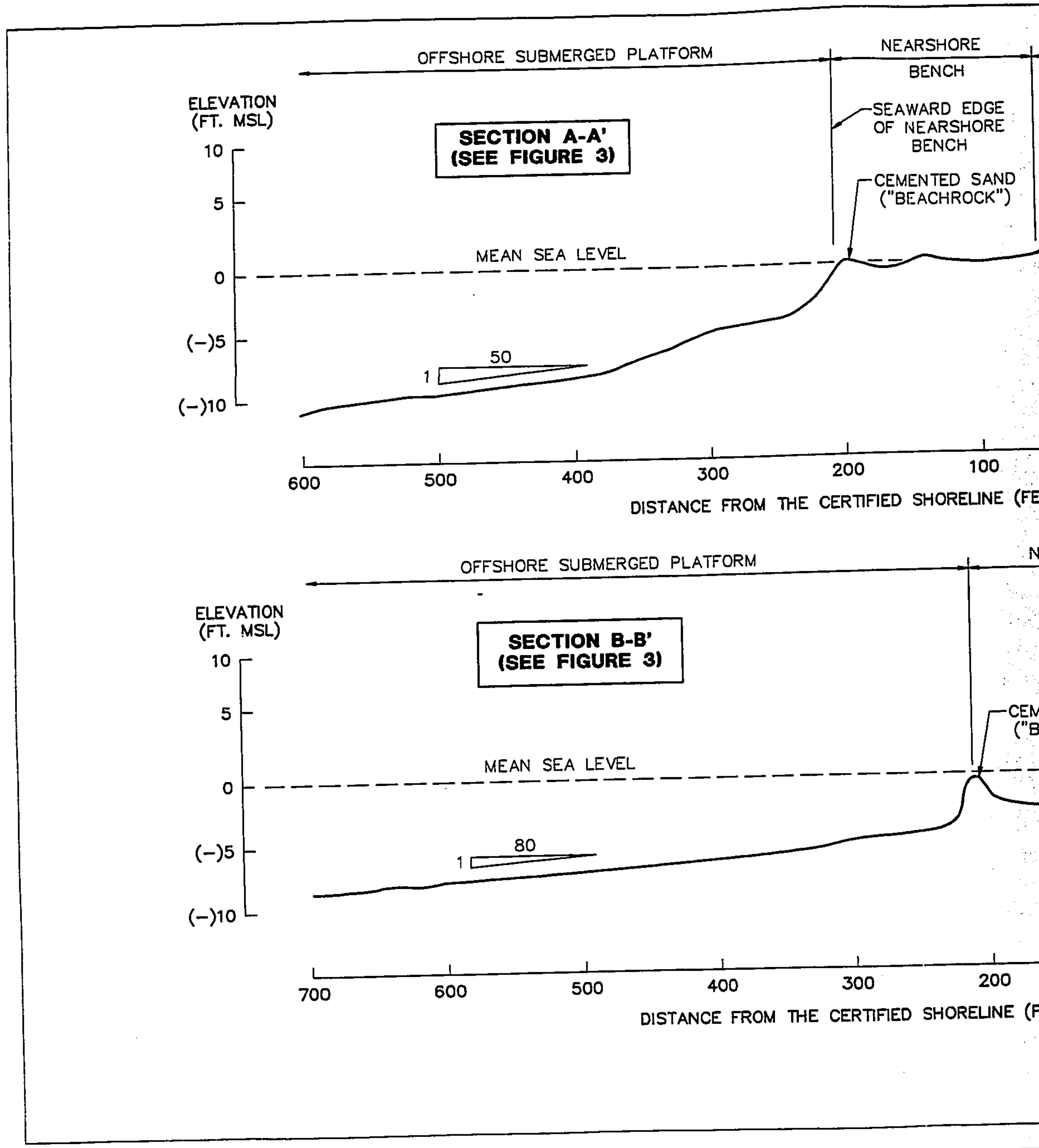


FIGURE 4
FEATURES ALONG THE KAUPULEHU RESORT SHORELINE



OFFSHORE SUBMERGED PLATFORM
NEARSHORE
BENCH
ELEVATION
(FT. MSL)
SECTION A-A'
(SEE FIGURE 3)
SEAWARD EDGE
OF NEARSHORE
BENCH
CEMENTED SAND
("BEACHROCK")
MEAN SEA LEVEL
10
5
0
(−)5
(−)10
50
1
600
500
400
300
200
100
DISTANCE FROM THE CERTIFIED SHORELINE (FE
OFFSHORE SUBMERGED PLATFORM
ELEVATION
(FT. MSL)
SECTION B-B'
(SEE FIGURE 3)
MEAN SEA LEVEL
10
5
0
(−)5
(−)10
80
1
700
600
500
400
300
200
DISTANCE FROM THE CERTIFIED SHORELINE (F

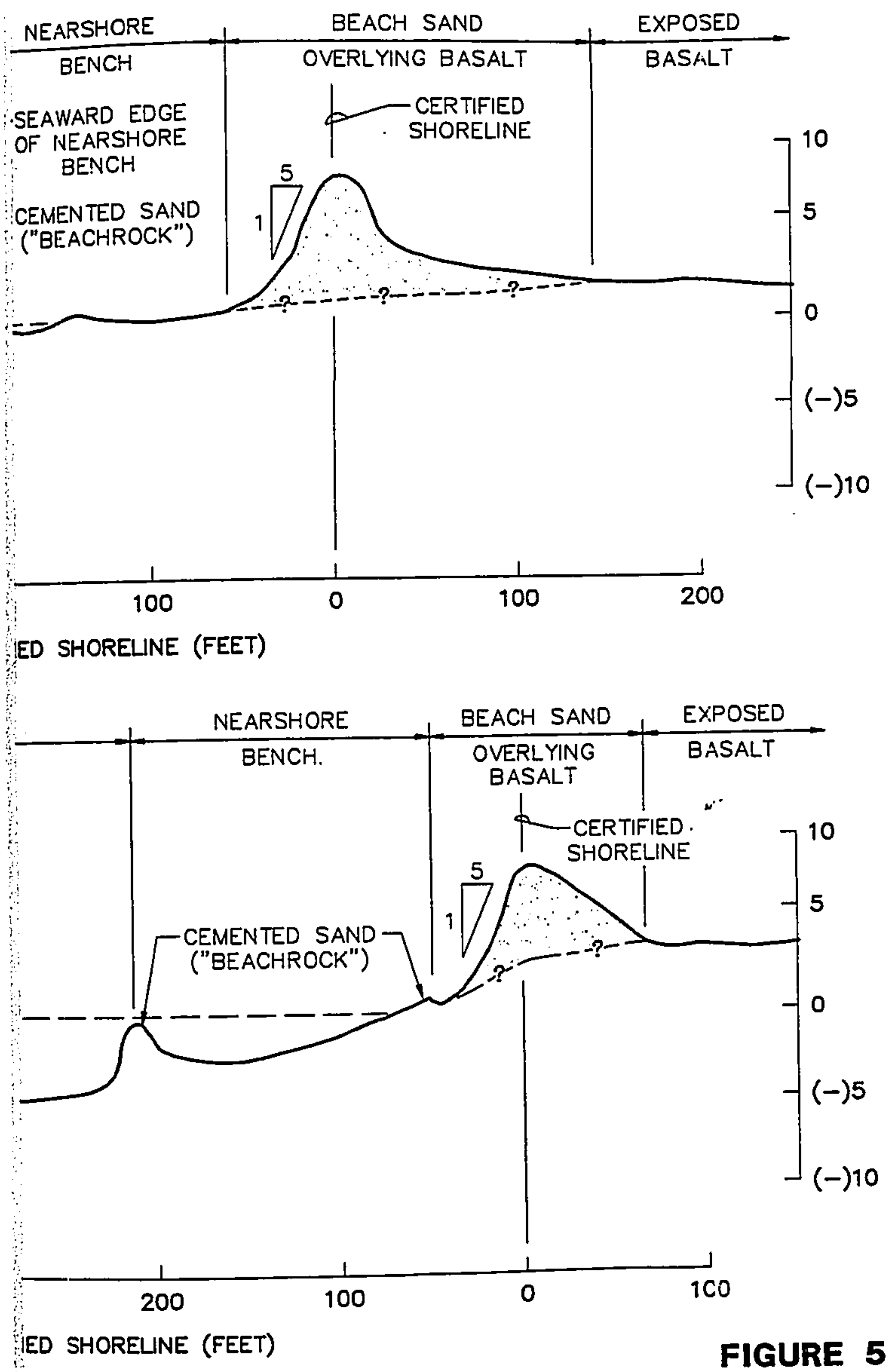
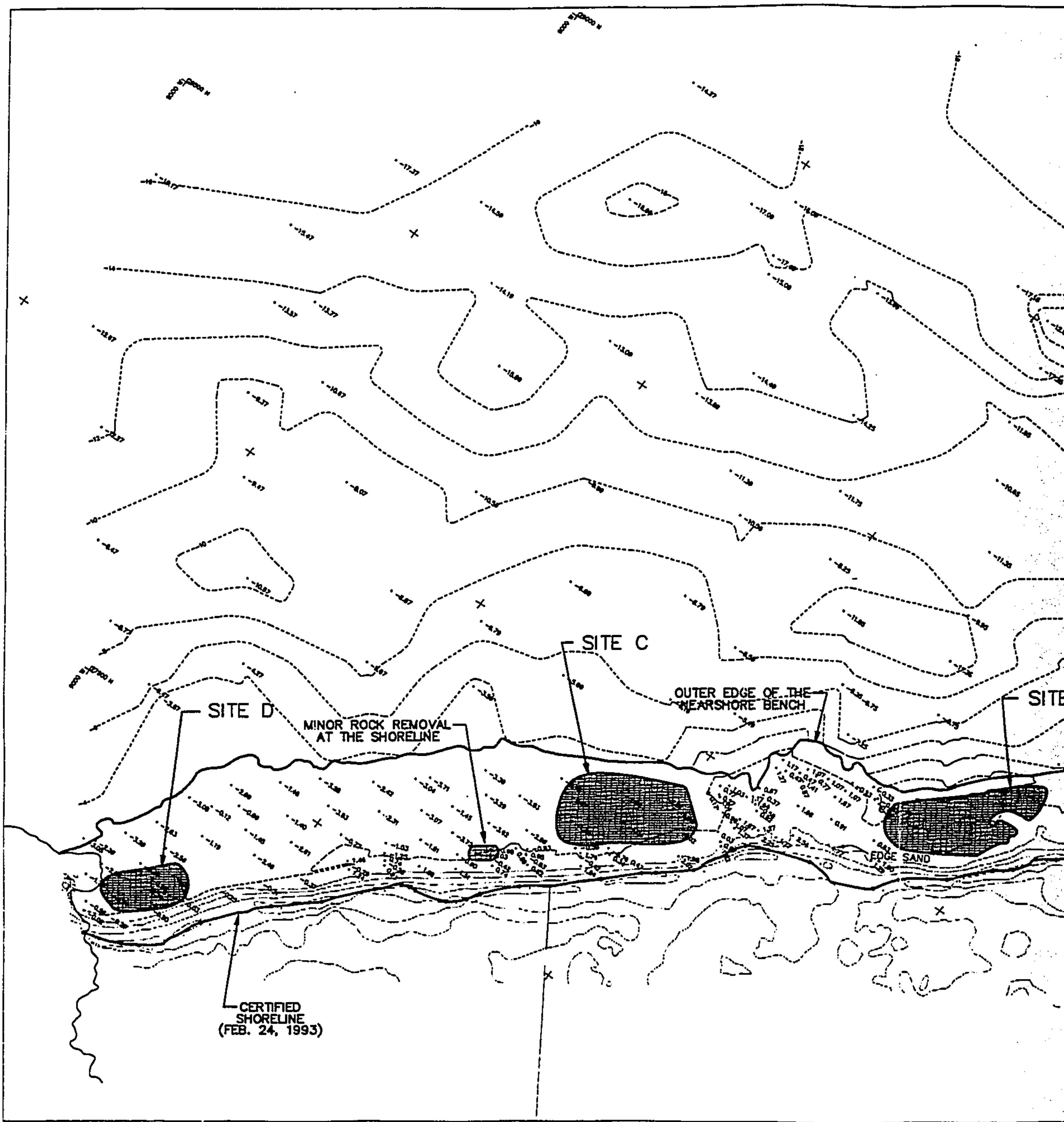


FIGURE 5
PROFILES ACROSS THE KAUPULEHU RESORT SHORELINE


SITE C
SITE D
MINOR ROCK REMOVAL AT THE SHORELINE
OUTER EDGE OF THE NEARSHORE BENCH
EDGE SAND
CERTIFIED SHORELINE (FEB. 24, 1993)

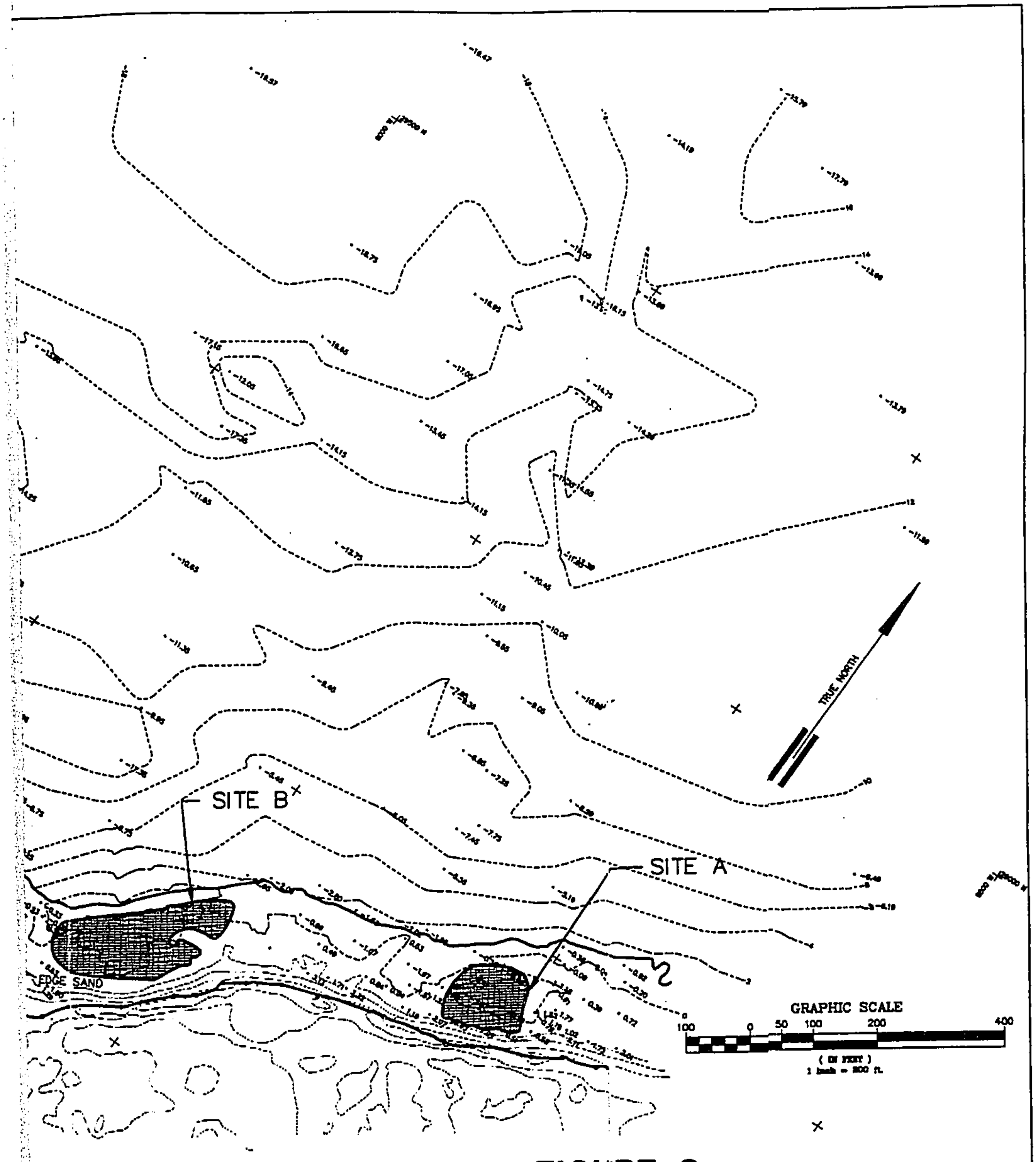
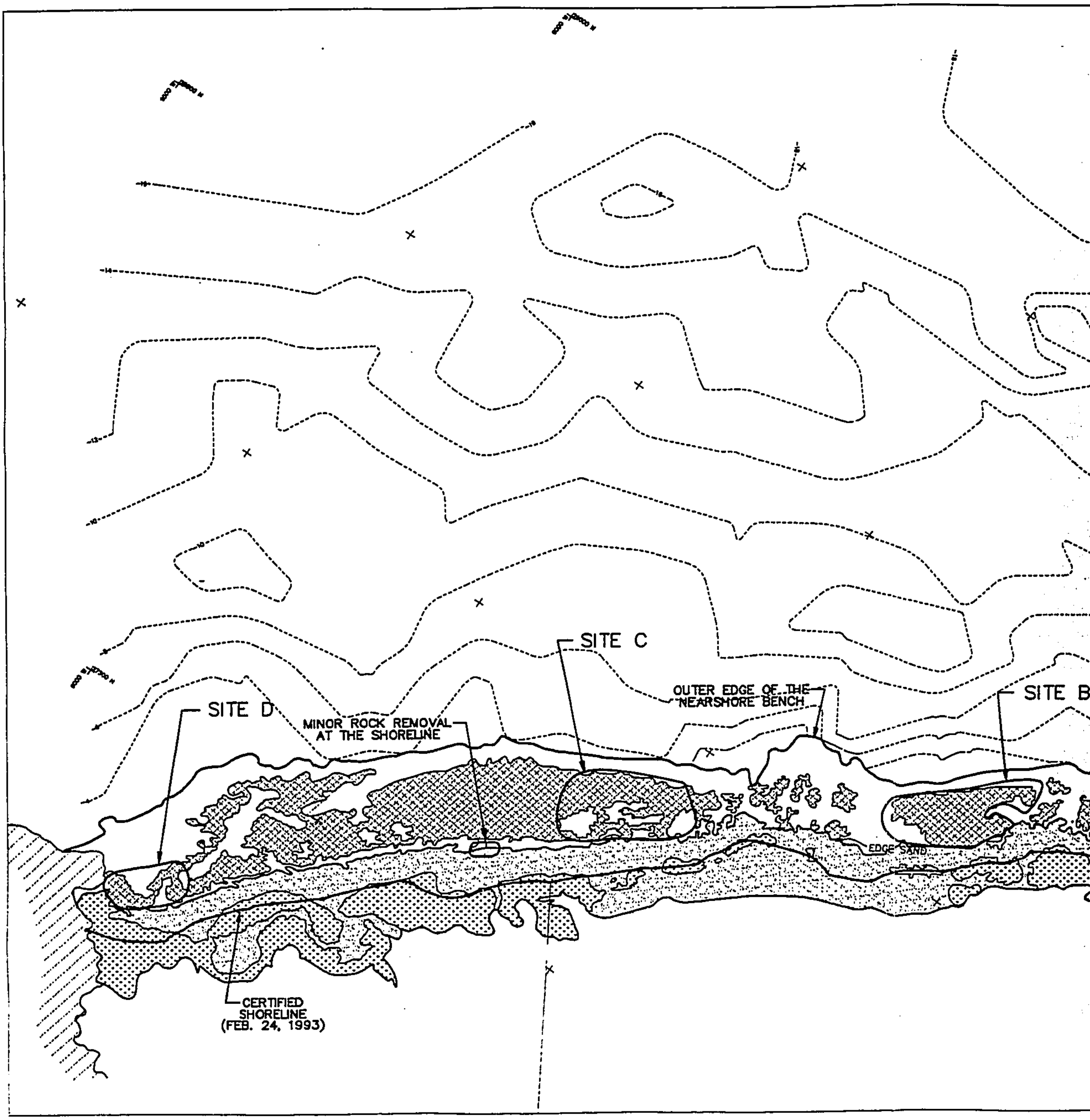


FIGURE 6
LOCATIONS OF PROPOSED SHORELINE IMPROVEMENTS


SITE C
SITE D
SITE B
MINOR ROCK REMOVAL AT THE SHORELINE
OUTER EDGE OF THE NEARSHORE BENCH
EDGE SAND
CERTIFIED SHORELINE (FEB. 24, 1993)

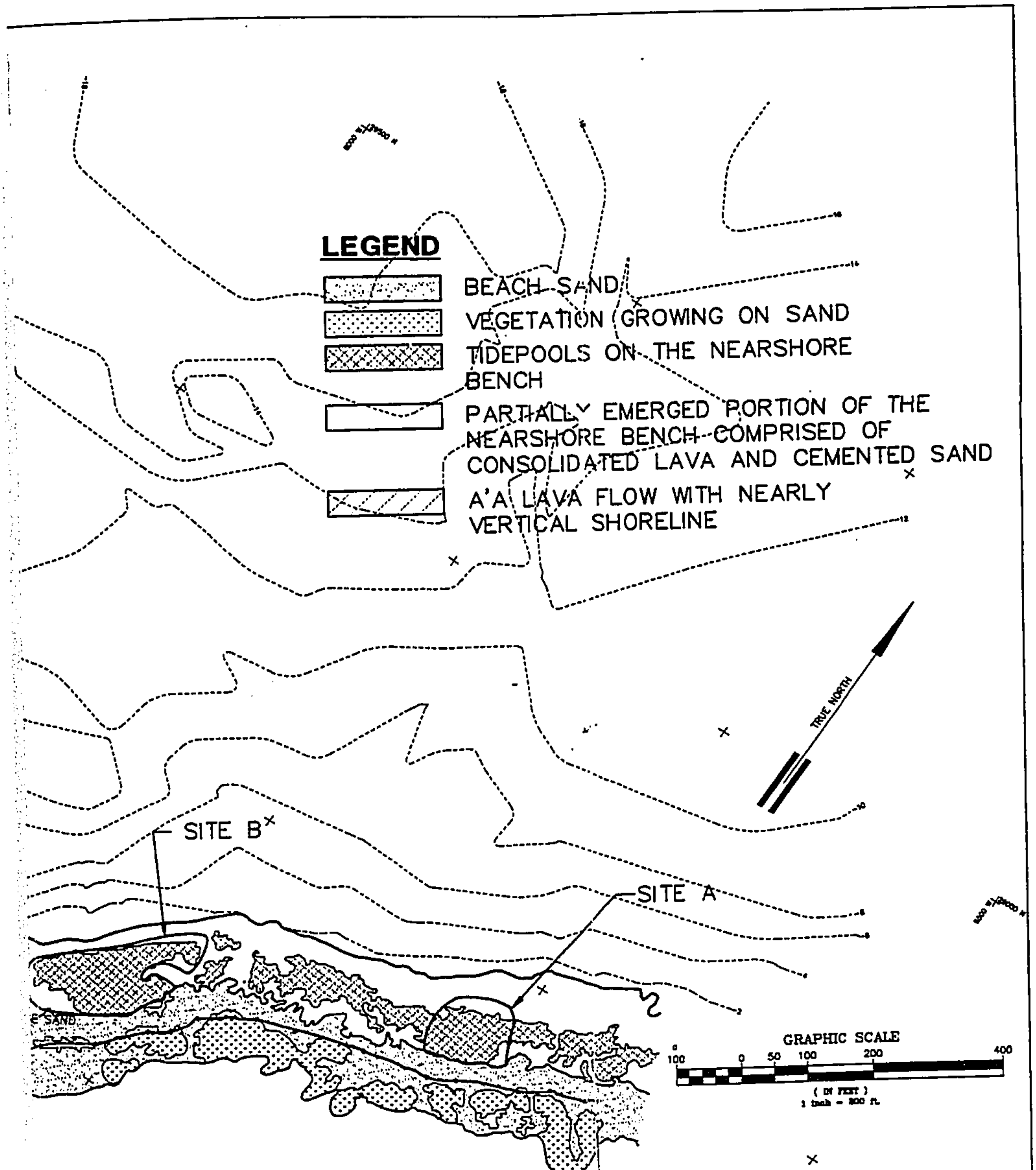


FIGURE 7
SHORELINE IMPROVEMENT AREAS

amount of excavation and disturbance of the sand beach. Details of the work proposed for each area are described below.

Site A. Excavation at this site would encompass 0.29 acres of area, nominally about 125 feet long and 110 feet across (see Figure 8). The area is a small, natural tidepool bounded by basalt rock outcrops on both sides, a crescent-shaped sand beach on the landward side, and the emerged beachrock sill on the seaward side (Photos 2 and 3). The tidepool is very shallow, varying from 0.25 feet above mean sea level to 0.67 feet below mean sea level. The area outlined on Figure 8 would be deepened to an average of 4 feet below sea level. The sides and seaward end of the excavation would be cut as nearly vertical as practical, but the slope excavated along the beach would be relatively flat, about 1 (vertical):8 (horizontal). An estimated 1400 cubic yards of material would be removed.

Site B. This site is another natural tidepool defined by rock outcrops at either end, a crescent-shaped sand beach, and the offshore, beachrock sill (Photos 4 and 5). The seaward end of excavation would be 10 to 15 feet inside the projecting, beachrock sill. The area is about 280 feet long, 80 to 115 feet across, and encompasses 0.59 acres (Figure 9). The tidepool is slightly deeper than at Site A, varying between 0.4 feet above sea level to about two feet below sea level. The shape and depth of the excavated area would be similar to Site A: a flat bottom approximately 4 feet below sea level; nearly vertical sides and seaward end; and a 1:8 shoreside slope. Total excavation is estimated to be 2850 cubic yards.

Site C. Site C is a portion of the submerged basalt bench. In contrast to Sites A and B, rock outcrops do not define the lateral extent of the proposed excavation. Also, the existing beach is linear rather than crescent shaped (Photos 6 and 7). This linearity is denoted by an emerged ledge of cemented sand which separates the toe of the beach and the edge of the water. Photo 8 is a close-up of this beachrock and Section B on Figure 5 shows its position at the toe of the beach.

Proposed excavation and clearing at Site C is about 230 feet long, 110 to 135 feet across, and covers 0.67 acres Figure 10). Depth of the submerged basalt bench in this area varies from 0.5 to 2.5 feet below mean sea level. At the beach, excavation would create a 1:8 slope down to a flat bottom at (-)4 feet. Sides and offshore edge of the excavation would be cut nearly vertical. Total excavation is estimated to be 2650 cubic yards.

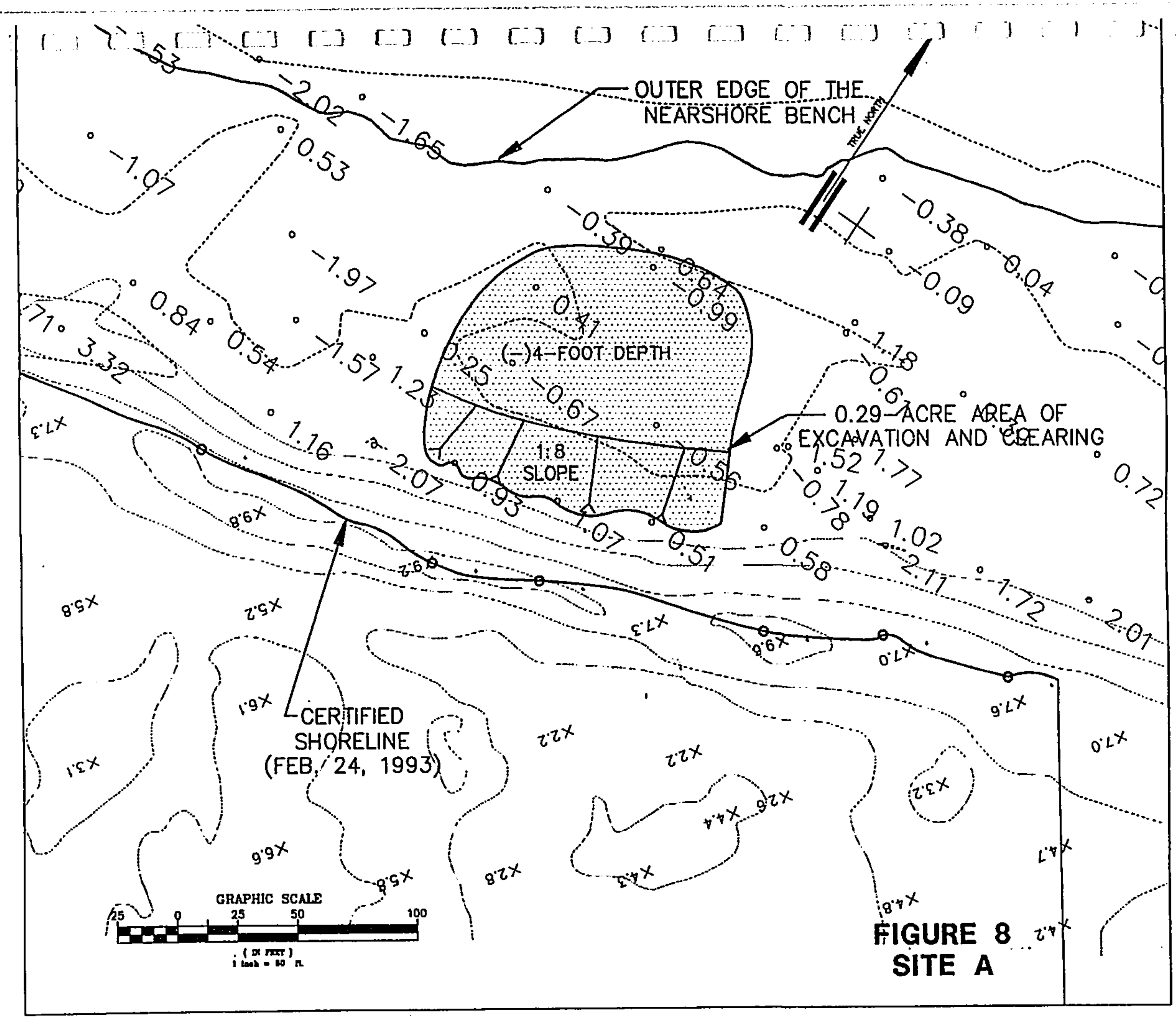


FIGURE 8
SITE A

Photo 2. Excavation to deepen the natural tidepool at Site A would include removing the rock outcrops in the middle of the photo and at the beach to the right. Excavation would extend from the rock outcrop in the background to the rock outcrop from which the photo was taken.

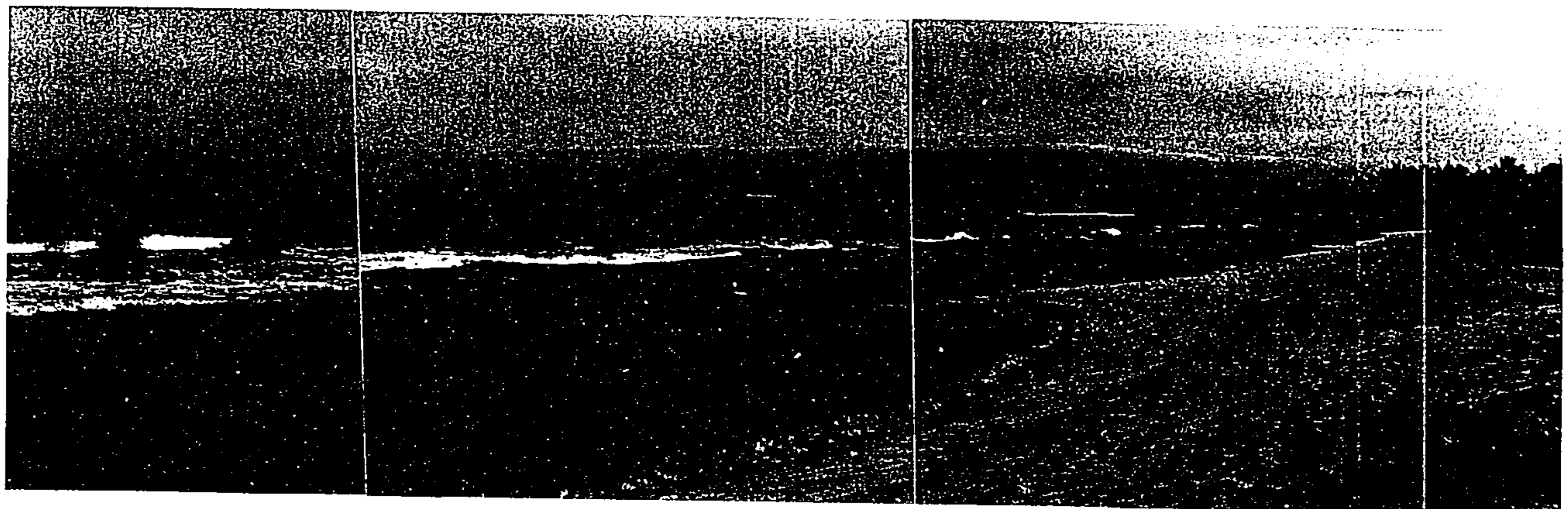


Photo 3. This view of Site A, taken from the beach crest at a midpoint along the proposed excavation and clearing, shows waves breaking on the beachrock sill at the outer edge of the nearshore platform. The basalt outcrop extending from the beach in the middle right of the photo would be left in place. It delineates the northeast end of the proposed excavation and clearing.

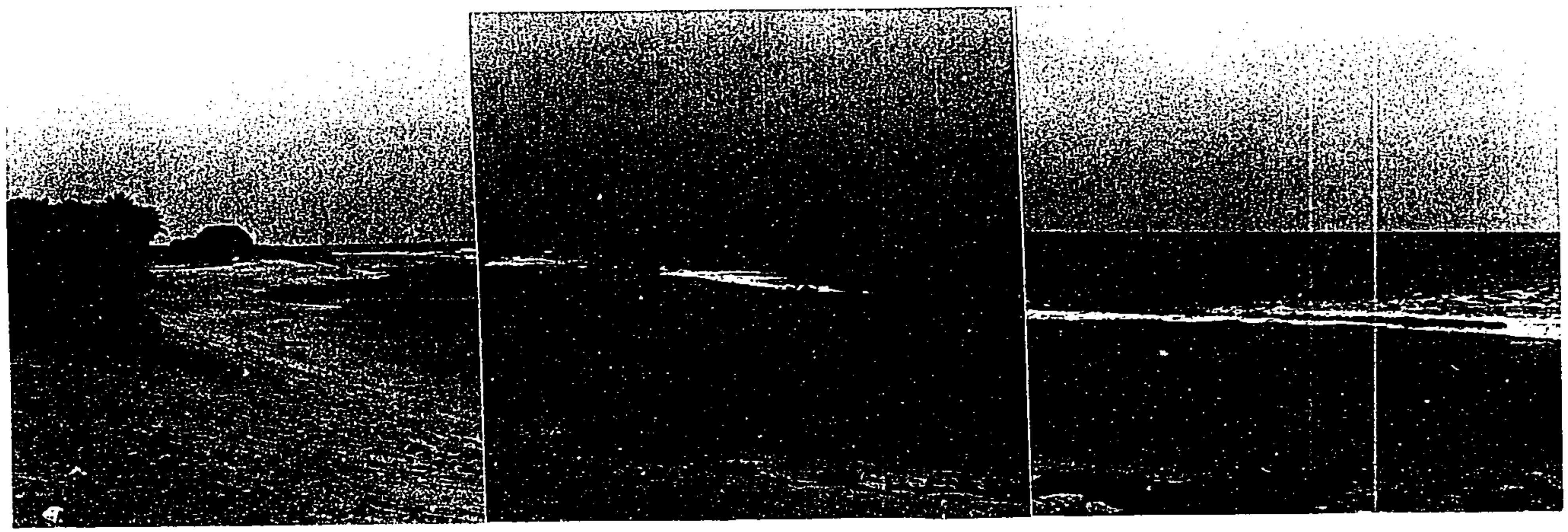


Photo 4. This photo was taken from the beach crest at the northeast end of Site B. It clearly illustrates the beachrock sill at the outer edge of the nearshore platform. Excavation to deepen the tidepool would be between the basalt outcrops at each end of the photo.

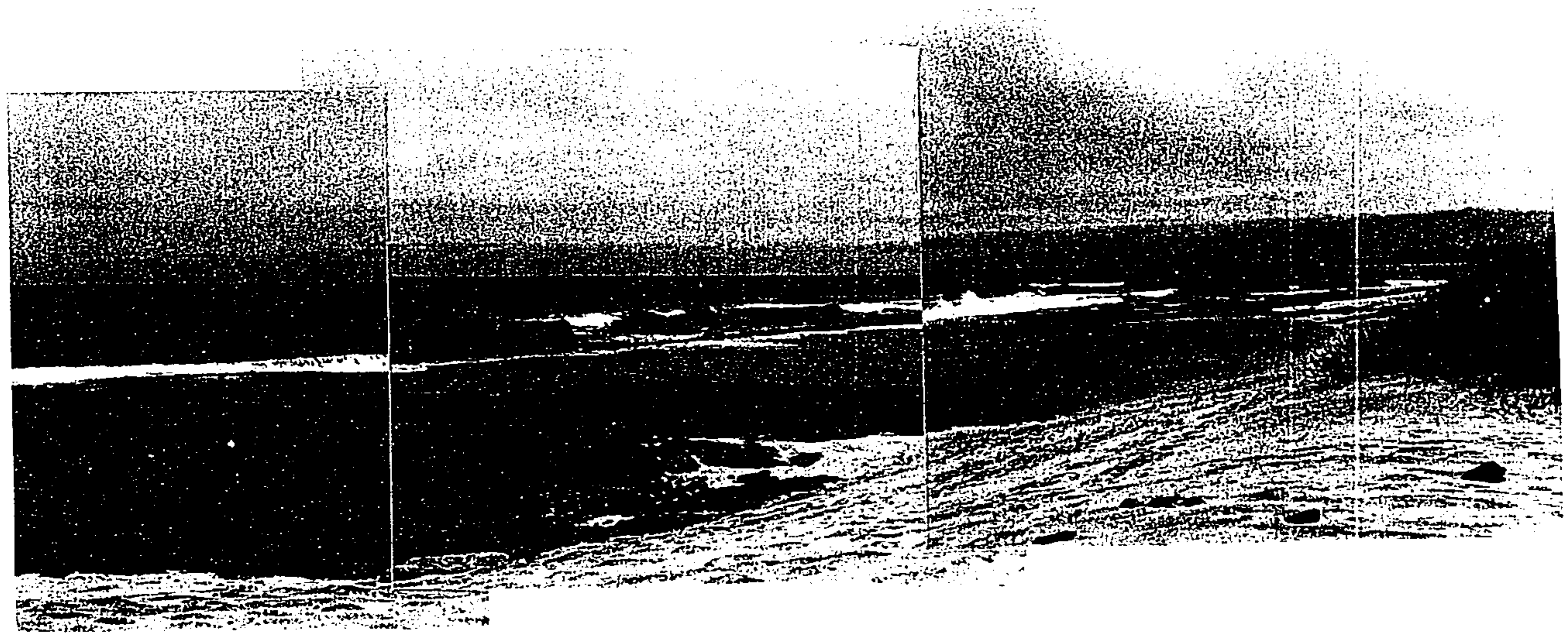


Photo 5. This photo of Site B from its southwest end shows waves breaking on the beachrock sill at the outer edge of the nearshore platform. The basalt outcrop in the foreground would be removed during the proposed excavation and clearing.

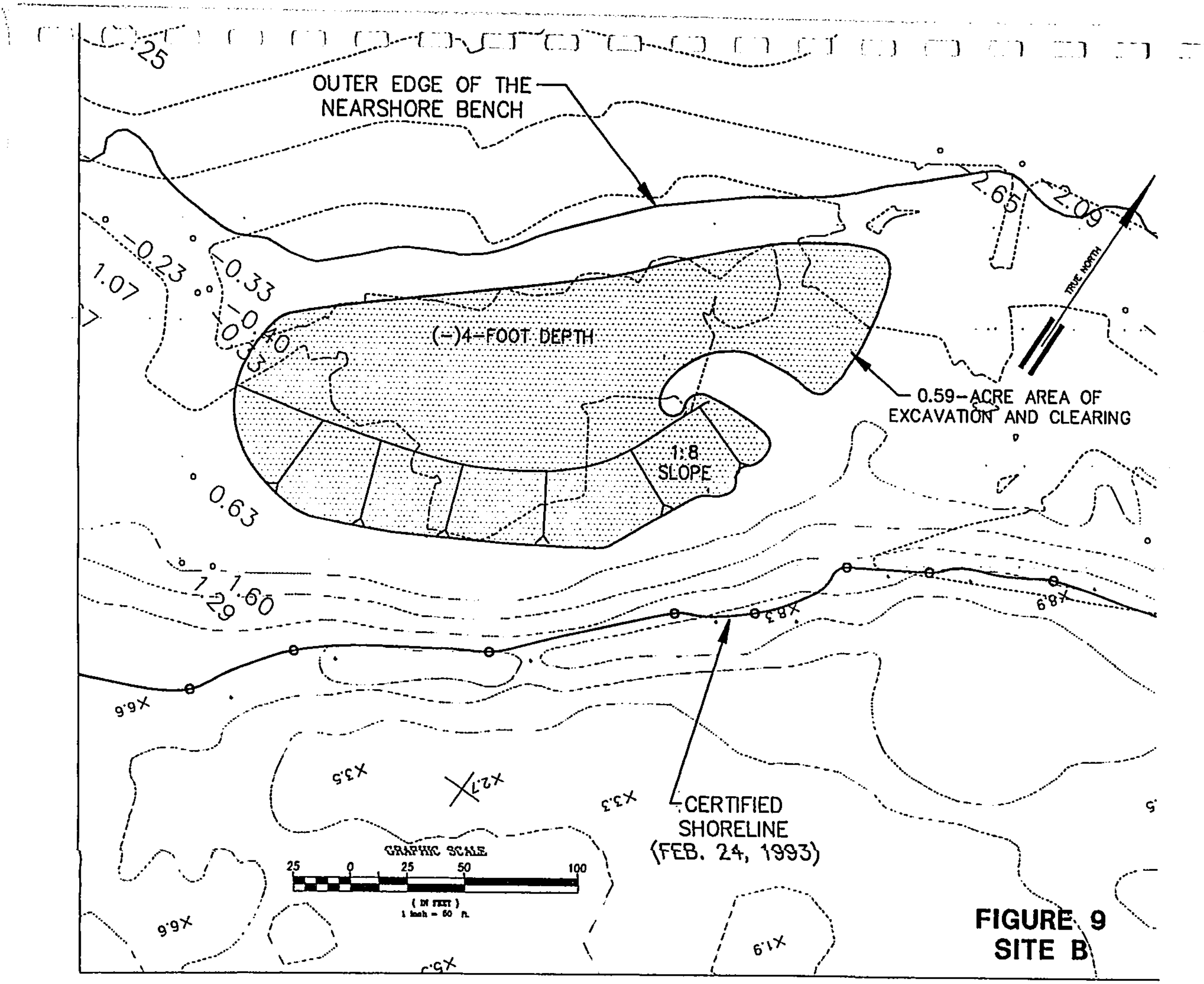
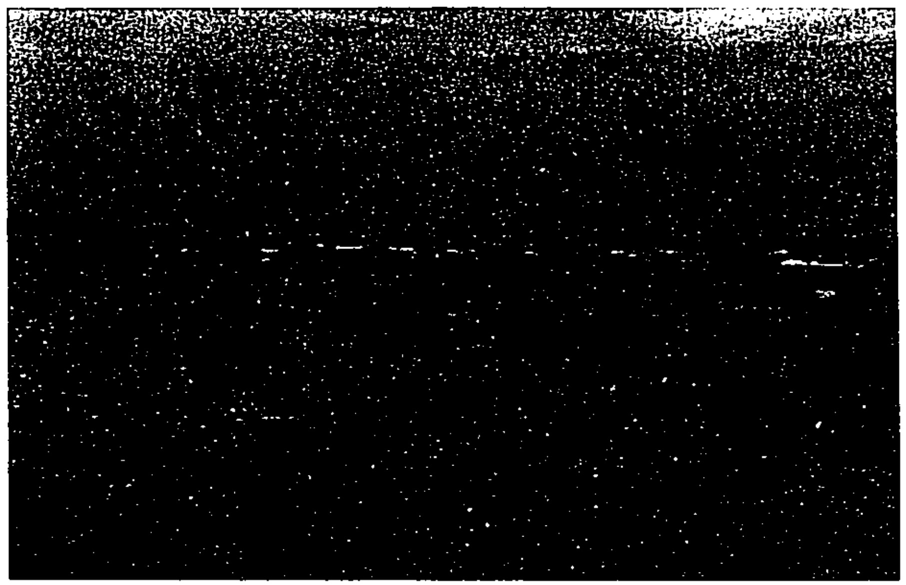
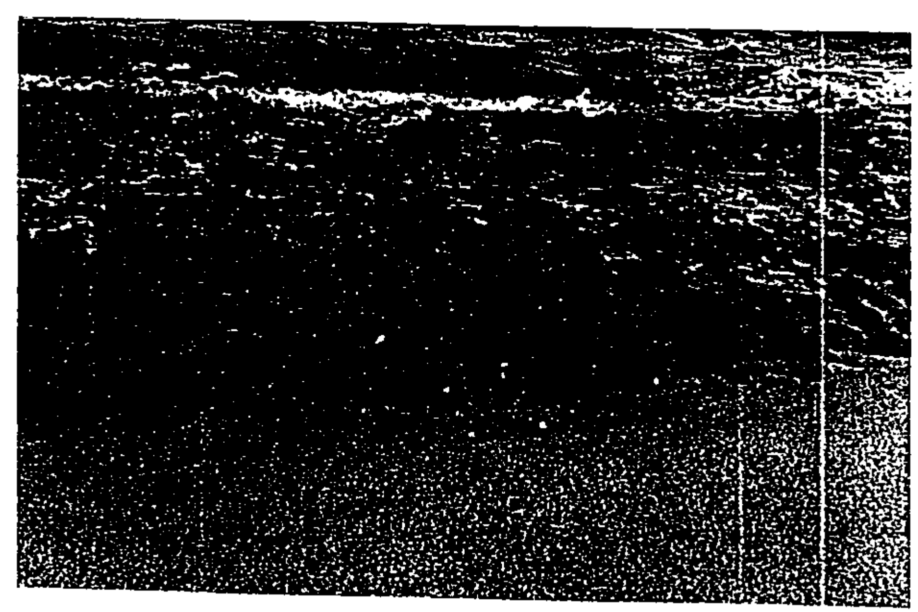


FIGURE 9
SITE B

Photo 6. This view of Site C from its northeast end shows the linearity of the beach. Excavation would begin just beyond the black, basalt outcrop in the foreground of the photo.





Photos 7 and 8. The beachrock at Site C occurs in a narrow band which can easily be removed with conventional equipment.

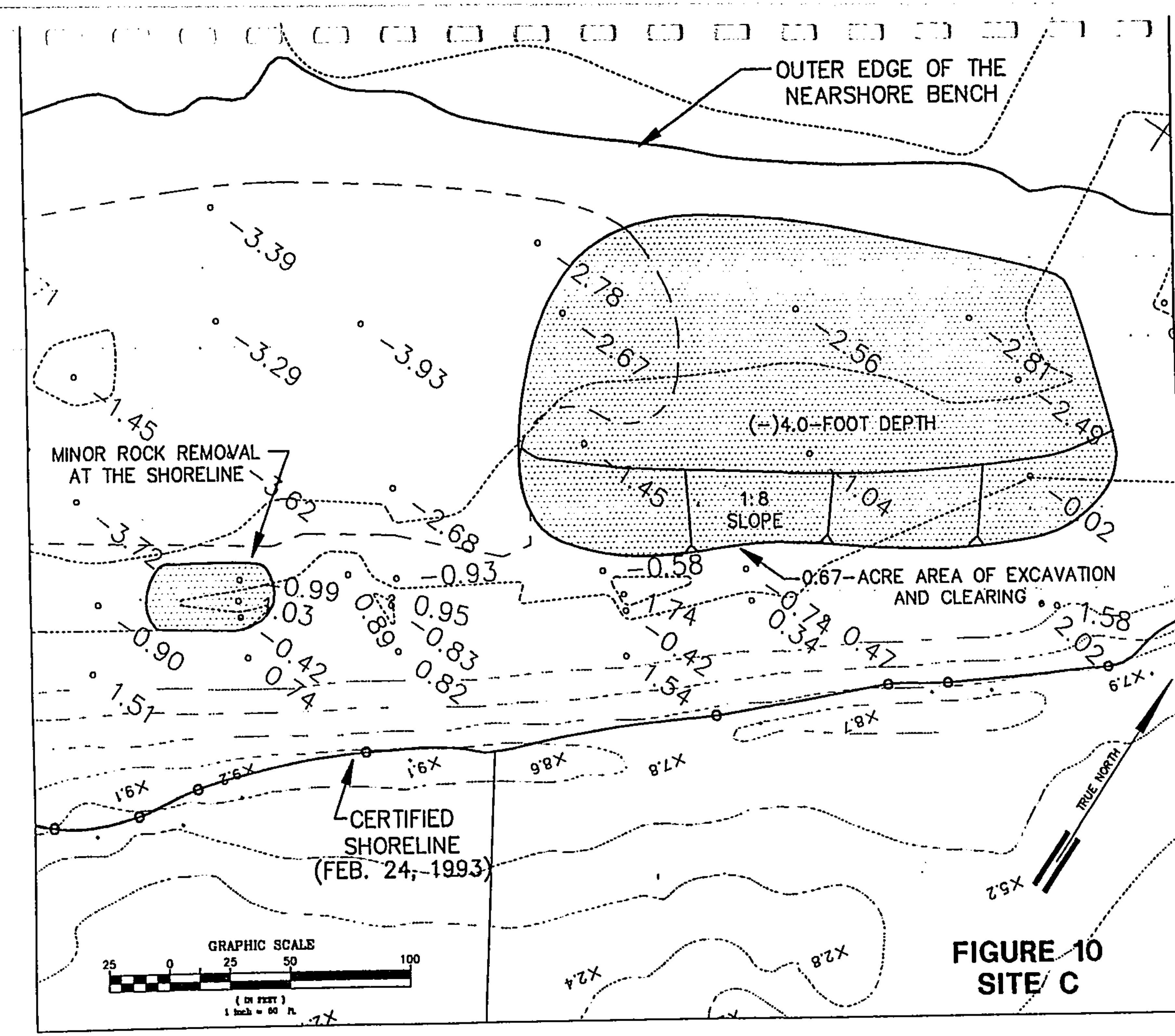


FIGURE 10
SITE C

Site D. Site D is at the southwest end of Kaupulehu's shoreline beach. Immediately to the south is the prominent a'a flow with its abrupt shoreline escarpment (Photo 9). At this end of the beach, the beachrock sill which delineates the outer edge of the nearshore platform is absent. Instead, the outer edge is a broad, shoal delineated by the location breaking waves (Photos 9 and 10). The area proposed for clearing and excavation is 160 feet long, 80 feet across, and covers 0.24 acres (Figure 11). Its configuration would be similar to Sites A, B and C: a 4.0-foot deep bottom; 1:8 shoreside slope; and nearly vertical sides around the other edges of the excavation. An estimated 950 cubic yards of material would be removed. Although the outer beachrock sill is not as prominent in this location, the offshore submerged platform and partially emerged nearshore bench provide good wave protection for the existing, crescent-shaped beach (Photo 11).

Construction Methods and Sequence

The submerged portion of the nearshore bench at the four sites typically consists of consolidated basalt covered with water-rounded rocks or by encrusting algae. Most excavation would be done with a bulldozer equipped with a ripper. A hydraulic ram would be employed if some of the rock could not be ripped. No blasting would be done. The sequence of construction would be as follows:

1. Beach sand would be pushed further onshore, beyond the reach of waves and the area to be excavated.

2. Excavation in each of the areas to the depths and extent described previously would be carried out. Excavated material would be stockpiled onshore.

3. The surface of the excavated area would be smoothed out so that it is safe to walk on. This would be accomplished with multiple passes of the bulldozer's tracks.

4. All silt, sand, and cobble sized material created during excavation and subsequent smoothing but not removed by the bulldozer and/or a front-end loader would be removed by suction pumping. This material would be pumped onshore, dewatered, and buried.

5. The final step would be to push the beach sand back into the general configuration of a crescent-shaped beach. Waves during successive high tides would redistribute the beach sand to its final configuration.

Photo 9. Proposed excavation and clearing at Site D is within the small pocket delineated by the a'a lava flow and a small, crescent-shaped beach which is behind this photo to the left. The nearshore platform at this location is a broad shoal which does not have a beachrock sill on its outer edge.

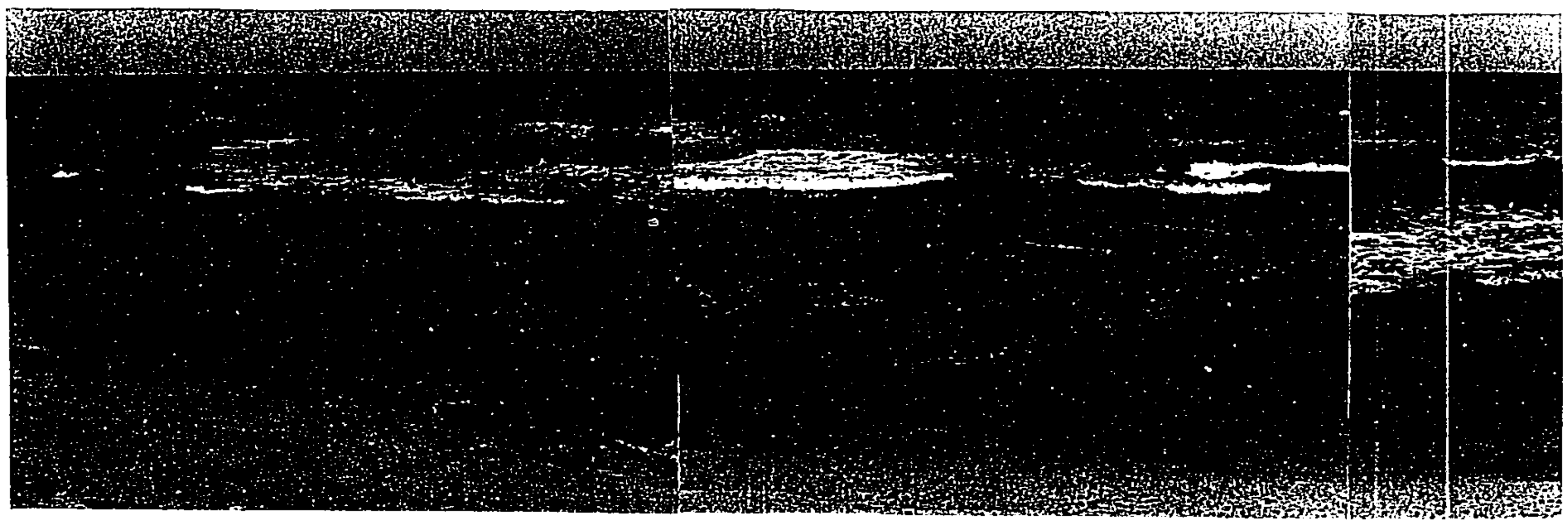


Photo 10. The northeast end of excavation at Site D would be mid-way across this photo. The outer edge of excavation would be approximately at the location of the innermost wave crest at the left side of the photo.

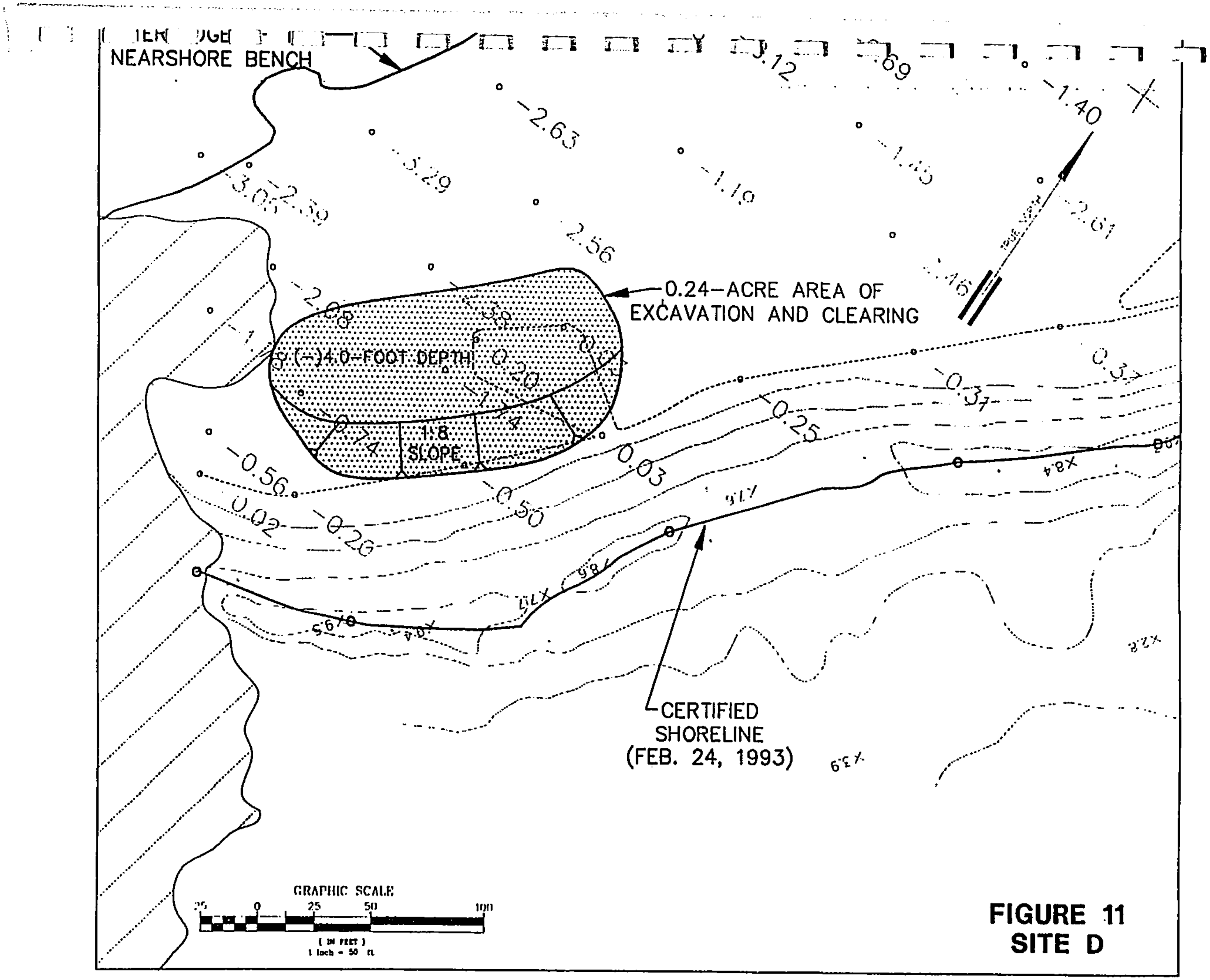


FIGURE 11
SITE D

Photo 11. These rocks in front of the cresent-shaped beach at Site D would be removed and replaced by a smooth, 1:8 slope down to a depth of four feet.

At each site, excavation and subsequent smoothing by passes with the bulldozer would be completed in several days to about one week. The pumping to clean the excavated area of fines created during construction is a labor intensive task. Based on experience with similar projects elsewhere in West Hawaii, this work will take two to three weeks in each area. Once the pump cleaning is completed, the beach sand would be pushed in place by a bulldozer in one day or less. With the action of consecutive high tides and waves, the beach sand would be redistributed to its ultimate configuration over the following days or weeks.

Anticipated Effects of the Proposed Excavation on Beach Stability

As discussed earlier, the natural offshore bathymetry provides excellent protection for the beach from wave attack. The offshore submerged platform and the nearshore, partially emerged bench control the size, direction, and amount of wave energy reaching the beach. At low tide, more than half of the nearshore bench is exposed and very little wave energy reaches the beach, even during periods of high waves. At high tide, most of the nearshore bench is submerged. However, incoming waves still break on the offshore platform or nearshore bench. Residual wave energy in broken waves moves across the nearshore bench to the beach as translating white water or as small, reformed waves several inches to one foot high. The wave energy which actually strikes the beach is very low, even during periods when high waves occur during high tide.

The proposed excavation has been carefully chosen to avoid altering the natural protection provided by the two basalt platforms. All work would be well inside the outer edge of the nearshore bench. The entire outer edge of the bench, including its emerged beachrock sill, would be left intact. The prominent basalt outcrops, which define and isolate the bench's numerous tidepools, would be left in place to define the lateral limits of excavation and clearing.

In terms of sand movement and beach stability, the changes brought about by the proposed excavation to consider are the deepening of the natural tidepools and the creation of the 1:8 slope along the shoreline of each excavated area. At present, the seaward extent of beach sand in each of these areas ends at the water's edge; virtually no sand extends onto the basalt bench in any of the sites proposed for excavation. After the excavation at each site is completed, the beach sand will cover the excavated slope, extending down to the bottom and a short distance out onto the floor of each deepened tidepool. The choice of the excavated slope was made to provide a surface on which the medium to coarse grained beach sand would be stable. Also, the location of these excavated slopes will enable the crest of the new beach to match the existing beaches on both sides of the construction area.

Conclusions

Proposed excavation at the four sites could be accomplished over several months if the sites are done in sequence. Conventional equipment, including a bulldozer and possibly a hydraulic ram, would do all the excavation. No blasting would be required. Since the bathymetric features which provide protection for the beach -- the offshore submerged platform and the emerged beach rock sill of the nearshore bench -- will not be altered, the stability of the beach at each site would not be changed. Natural tidepools at three of the sites would be deepened and the excavated slope along all four sites will be sufficiently flat to enable the sand beach to extend down to the bottom of the tidepool. With these changes, the recreational potential of the shoreline would be significantly enhanced and safe access to the water would be provided.

APPENDIX B

MARINE ENVIRONMENTAL SURVEY TO ASSESS POTENTIAL IMPACTS FROM THE PROPOSED PUBLIC BEACH SAFETY IMPROVEMENTS AT KAUPULEHU RESORT, NORTH KONA, HAWAII

Prepared for

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by

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May 9, 1990

INTRODUCTION AND PURPOSE

In order to provide the public with the safest possible environment for swimming, snorkeling and other water related activities, investigations are under way to determine the best methods to improve the beach at the site of the Kaupulehu Resort. One possible scenario for such improvements involves modifying the nearshore area by removing basalt features located at the shoreline and in shallow intertidal areas. Such actions will provide easy access, and enhance the recreational potential for swimming and snorkeling in the offshore region, compared to the situation at present. The sites for the proposed improvements appear to be ideal locations for such action, as existing beachrock dikes form natural "lagoons" between the shoreline and the open ocean that diminish much of the wave action that impinges on the coastline.

There is no reason to suspect that excavation activities necessary to complete the proposed beach improvements will result in any permanent detrimental changes to the marine environment. Yet, a potential concern, as expressed by regulatory agencies, regarding alteration of the shoreline may focus on the potential for environmental degradation of the ocean resulting from the project.

In the interest of addressing these concerns and assuring maintenance of environmental quality, it has been deemed appropriate to conduct a baseline marine survey and potential impact analysis. The purpose of this report is to present the results of the survey, which was designed to evaluate the potential effects of beach safety improvements on water quality and marine biological composition of the nearshore environment.

Based on these data, along with information from past studies of the effects of other beach modification projects, evaluations are presented regarding the potential for impacts from the proposed project. The survey results can also serve as a baseline preliminary phase for any monitoring programs that may be required as a contingency for permit approval by government agencies, including the Corps of Engineers, the State of Hawaii, and the County of Hawaii.

OBJECTIVES

1) To establish a quantitative baseline set of water chemistry parameters that delineate the present environmental conditions of the nearshore ocean offshore of the sites planned for beach improvements. Chemical composition of the environment will be evaluated by analysis of all parameters specified by State of Hawaii, Department of Health water quality

standards (Chapter 11-54 S11-54-06 (3)), as well as several other parameters that are not listed by DOH, but provide important information. Particular attention will be given to evaluating the influence of groundwater entering the marine environment.

2) To establish a descriptive and quantitative baseline of biotic communities at the sites where beach improvements may take place. Such a characterization of biotic assemblages will provide a basis of estimating alteration of community structure as a result of modifying the shoreline. This baseline will also serve to select specific sites for beach improvements that will minimize impacts to the biotic communities.

3) To evaluate the degree of natural stresses (sedimentation, wave scour, freshwater input, etc.) that influence the nearshore marine environment in the area that could be potentially influenced by the proposed project. Typically, water quality and the composition of nearshore marine communities is intimately associated with the magnitude and frequency of these stresses, and any impacts caused by the proposed project may either be mitigated in large part, or amplified by natural environmental factors. Therefore, evaluating the range of natural stress is a prerequisite for assessing the potential for additional change to the marine environment owing to shoreline modification.

4) To utilize existing comparative sets of water chemistry parameters and biotic community structure that delineate the presently occurring environmental conditions of similar beach modification projects. While minor site-specific differences will undoubtedly occur between the environments, comparing water quality and community structure data will allow the best possible assessment of potential effects from the proposed activity.

5) to offer recommendations on scheduling and construction procedures to minimize impacts, based on the characteristics of the environment determined by the baseline.

ANALYTICAL METHODS

Water Chemistry

Three areas along the shoreline of the KHV property have been identified as potential sites for beach improvements. Site 1 lies closest to the Kona Village Resort at the northern end of the KHV property, Site 2 lies at the approximate center of the property, and Site 3 lies at the northern edge of the 1801 lava flow (see Figure 1). Water quality was evaluated along 3 transects, each of which bisected one of the proposed sites. Each transect was oriented perpendicular to the shoreline, and extended from the highest wash of waves across the intertidal and nearshore reef platform out to the open ocean, a distance of approximately 200 feet. Water samples were collected at 6 locations along each transect. Sampling was concentrated within the areas close to the shoreline as this is the region which is most sensitive to inputs from land, and where actual construction activities will take place. With the exception of the stations located 1, 3 and 10 feet from the shoreline, samples were collected at two depths; a surface sample was collected within approximately 6 inches of the surface, and a bottom sample was collected within 1 foot of the sea floor. In addition, a water sample was collected from a potable water source at the Kona Village Resort.

Water quality parameters evaluated included the 10 specific criteria designated for open coastal waters in Chapter 11-54, Section 06 (Open Coastal waters) of the State of Hawaii, Department of Health (DOH) Water Quality Standards. These criteria include: total nitrogen (TN), nitrate + nitrite nitrogen (NO_3^- + NO_2^-), ammonium (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.

Water samples were collected by divers opening 1-liter polyethylene bottles at the desired depth. Subsamples for nutrient analyses were immediately placed in 125-milliliter (ml) acid-washed, triple rinsed, polyethylene bottles and stored on ice until returned to Honolulu. Analyses for NH_4^+, PO_4^{3-}, and NO_3^- + NO_2^- were performed using manual spectrophotometric techniques on a Brinkman fiber-optic colorimeter. Total nitrogen (TN) and total phosphorus (TP) were analyzed in a similar fashion following digestion. Dissolved organic nitrogen (DON) and dissolved organic phosphorus (DOP) were calculated as the difference between TN and dissolved inorganic N, and TP and dissolved inorganic P, respectively. 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, and the 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 Cole-Parmer Digisense millivolt meter with a readability of 0.001 pH units.

Marine Biota

Physical and benthic biotic structure of the reef environment was evaluated by establishing a descriptive and quantitative baseline of benthic reef communities in the vicinity of the proposed beach improvements. Key components of reef communities that were evaluated include hermatypic and soft corals, benthic algae, motile macroinvertebrates, reef fish, and substratum type.

Qualitative reconnaissance surveys extending from the shoreline to approximately 250 feet offshore were conducted throughout the area fronting the KHV property. 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. At each of the survey sites, qualitative macrobenthic species checklists were compiled. Each species encountered was placed in one of three abundance categories. Categories were defined as "Abundant" (greater than 100 individuals), "Common" (10-100 individuals, and "Rare" (less than 10 individuals).

Following the qualitative survey, the 3 selected sites described above were evaluated in detail. At 2 of the sites, a line transect method was employed for quantitative evaluation of marine biota. Conducting transect surveys at Site 3 was not possible owing to extremely shallow water depth and vigorous water motion created by breaking surf. Transect were oriented parallel to the shoreline across the area of most abundant biota. At each area a 160-foot long surveying tape was stretched over the reef surface between weighted floats. An aluminum quadrat frame, with dimensions of 1 m by 0.66 m, was sequentially placed over 10 random marks on the transect tape so that the tape bisected the long axis of the frame. At each quadrat location a color photograph recorded the segment of reef area enclosed by the quadrat frame. In addition, a diver knowledgeable in the taxonomy of resident species visually estimates the percent cover and occurrence of organisms and substratum type within the quadrat frame. No attempt was made to disturb substrata to observe organisms, and no attempt was made to identify and enumerate cryptic species dwelling within the reef framework. Only macrofaunal species greater than approximately 2 cm 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-quadrats 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 l974, Grigg 1983), and has proven to be particularly useful for quantifying coverage of attached benthos such as corals and macrothalloid algae, and large epifauna (holothurians, echinoderms).

Qualitative 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 m wide along the transect path were identified by species name, and enumerated. At Site 3, reef fish abundance was evaluated by qualitative assignment of species into *three abundance categories*. 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).

RESULTS

Physical Setting

The overall physical setting of the nearshore area off of the KHV Resort is fairly homogeneous. The shoreline is composed of a white calcareous sand beach approximately 30 feet wide that slopes down from the vegetation line to the waterline at an angle of approximately 15 degrees. The actual shoreline along most of the property is composed of a basalt and beachrock ledge that forms an intertidal platform with numerous tidepools. The beachrock component of the shoreline appears to have formed from chemical precipitation processes associated with contact of calcareous sediments with low saline water. The southern boundary of the KHV beach is demarcated by the 1801 Kaupulehu a'a lava flow that enters the ocean and forms Kumukehu Point. The shoreline off the lava flow is a sea cliff of jagged lava boulders.

The offshore area can be catagorized into two major regions, inner lagoons and an outer reef bench. Along much of the KHV property, there are natural lagoons formed as a result of an offshore dike of emergent beachrock. This dike serves to absorb much of the energy of breaking waves, resulting in relatively calm waters within the lagoons. This lagoonal structure provides much of the infrastructure for the proposed swimming areas, as the planned work will primarily be to improve shoreline access and increase depth of the naturally occurring features. Three sites within the natural lagoonal habitat have tentatively been selected for evaluation as areas for modification to improve access for swimming. These sites are designated as KHV-1, 2 and 3. Detailed descriptions of each area are presented below.

The second offshore region occurs seaward of the beachrock dike. This area is composed of a very broad (up to 0.5 mile), flat, bench-like structure that extends offshore from Kahuwai Bay to Kukio Bay. This flat bench appears to be a result of a prehistoric lava flow that has since been drowned. Water depth over the bench rarely exceeds 15 feet; the shallow depth exposes the area to high levels of concussive force of breaking waves, and as a result coral cover and benthic biota is low in abundance. The outer edge of the lava bench is marked by a sharp ledge and cliff 10 to 15 feet high. The walls of the cliff are frequently undercut with caves and crevices and the base of the cliff is marked by an area of large basaltic boulders. Quantitative benthic transects were conducted across the bench at three sites offshore of the lagoon sites (see Figure 1).

Each of the three sites selected for possible modification are differentiated by unique characteristics. The northernmost area, designated as Site 1, is presently a natural lagoon bordered at the seaward edge by a protruding solid dike of beachrock that effectively absorbs much of the force of breaking waves. As a result, water motion inside the lagoon is relatively quiet. The lagoon is bounded on the northern and southern edges by expanses of exposed basalt that form intertidal benches. The entire floor of the lagoon is presently composed of either a layer of cobbles or a solid rock platform. The present depth of the natural lagoon at the highest tidal stand does not exceed 2.5 feet, suggesting that excavation of the area from the shoreline out to the beachrock dike will be required in order to establish a viable and safe swimming area.

Site 2, located in the approximate center of the KHV Beach, also is separated from the open ocean by a beachrock dike that creates a lagoon. The dike is situated farther from the shoreline than at site 1, resulting in a lagoonal width of approximately 100 feet. The shoreline at this site is also composed of beachrock; however, there are several breaks in the rock formation resulting in sandy channels that extend from the beach into the lagoon. Depth of the lagoon is also greater than at Site 1, ranging from 3-5 feet near the seaward beachrock dike. Bottom structure of the lagoon is composed of a solid rocky surface with interspersed channels of coarse white sand.

Site 3 is located at the southern end of the KHV beach (see Figure 1). This area differs from those described above in that there is no offshore beachrock dike to create an inner lagoon. As a result the nearshore area is not protected from the force of surge and breaking waves. The shoreline is composed of a shallow basaltic platform that is bounded to the south by the 1801 lava flow which extends into the ocean. The extension of the lava flow creates a semi-enclosed area that constitutes a configuration with the potential for creation of a swimming area. The basaltic bench forming the seafloor extends seaward with a gradual slope; at a distance of approximately 300 feet from shore water depth is about 10 feet. Bottom topography is generally without substantial relief, and major sand channels are absent. The dominant structural relief is an extensive excavation of grooves cut by the burrowing activity of sea urchins.

Water Chemistry

Table 1 shows results of water chemistry analyses for samples collected on March 29, 1990, at stations shown in Figure 1. On transects 1 and 2, samples within 30 feet of the shoreline were collected in the natural lagoons landward of the beachrock dike; samples 100 and 200 feet from shore were collected seaward of the dike. Also shown in Table 1 are DOH water quality standards for open coastal waters under "wet" conditions. The criteria for wet conditions are applied to the KHV property because this area receives at least 3 million gallons of groundwater input per mile per day (T. Nance, personal communication). Comparing water chemistry results from the KHV samples to DOH standards reveals that nine measurements of $NO_3^- + NO_2^-$ and one measurement of TN exceed the "not to exceed more than 10% of the time" specified criteria . $NO_3^- + NO_2^-$ is normally found in high concentrations in uncontaminated groundwater (note concentration of 14.8 μM in well water).

Figure 2 shows plots of twelve water chemistry parameters as functions of distance from the shoreline at each of the potential swimming areas. It can be seen that for the parameters that occur in abundance in groundwater (Si, NO_3^-, PO_4^{3-}, TN, TP and salinity), there is a distinct input from the shoreline at transect 3. It can be seen, however, that the groundwater input is rapidly mixed to background oceanic levels within 10 feet of the shoreline. While groundwater input at Sites 1 and 2 is less pronounced than at Site 3, there is no indication of retention of input from land within the natural lagoons, and mixing effectively homogenizes the water mass very close to the shoreline. Nutrient constituents that are not present in groundwater (DON and DOP) show no pattern of increased concentrations at the nearshore sites. With one exception, Chl. a, turbidity, and temperature are essentially uniform across the sampling array. The single exception at the 1-foot from shore sample at transect 1 reflects warmer, more turbid conditions in a semi-enclosed shoreline tidepool.

With the exception of temperature, none of the water chemistry parameters exhibited patterns of distinct vertical stratification. The lack of such stratification, especially at transect 3 where there is a considerable input of groundwater, suggests that the water column throughout the region is well mixed by physical processes.

Marine Biota

Corals and Other Macroinvertebrates

Table 2 shows macroinvertebrate species that were observed in the three areas of potential modification, along with ranks of abundance. Table 3 shows results of quantitative coral transects at lagoon Sites 1 and 2, as well as on the offshore reef bench. Owing to the shallow depth which likely results in elevated temperatures during periods of high insolation and low circulation, biota is limited in distribution at Site 1. Only 6 species of coral were observed in the shallow lagoon, and all of these species were ranked as rare in abundance. Transect results reveal that average coral coverage at Site 1 is about 1%; species diversity of 1.27 indicates that coral cover is relatively even in distribution among the species encountered. Sea urchins, especially Echinometra mathaei and E. oblonga were present on the lagoon floor in abundance. One characteristic of this area that was not found at the other 2 sites was an abundance of the sea urchin Colobocentrotus atratus clinging to the inner wall of the beachrock dike. The entire floor of the lagoon was covered with a multi-species turf of filamentous algae. The major distinctive alga other than the turf were tufts of Giffordia breviarticulata.

Of the three potential swimming areas, Site 2 contained the most diverse assemblages of benthic organisms as well as the highest percent bottom cover of corals. Qualitative reconnaissance of the area revealed 15 species of corals (Table 2), while total coral cover on the transect was approximately 10%, and included 9 species (Table 3). Other macroinvertebrates that were particularly abundant were the sea cucumbers, Holothuria spp. and Actinopyga spp.. Dominant algal species were Turbinaria ornata, Padina spp., Galaxaura filamentosa, and various forms of encrusting calcareous algae.

The primary difference between Sites 1 and 2 is the greater water depth of the latter. The increased depth (3-5 feet) of the area between the beach and the beachrock dike at Site 2 appears to be sufficient to prevent extremes in physical factors (temperature and salinity) from limiting coral settlement and growth, yet the outer dike affords protection from the destructive force of breaking waves. As a result, the area is inhabited by a diverse assemblage of corals. Depth of the natural lagoon is also sufficient to not require any excavation other than at the shoreline in order to create a safe swimming area.

Site 3, located on the northern border of the 1801 lava flow is not bounded by the beachrock structure that characterizes Sites 1 and 2. Rather, the basaltic bench that stretches offshore beyond the beachrock dike at the other sites, extends to the beach at Site 3. As a result, breaking waves reach the shoreline area unimpeded by the protective dike. Owing to the elevated physical stress, corals are extremely rare in the nearshore (within 100 feet from shore) regions of Site 3; only 4 species were observed and total cover was less than 1%. The only prominent biota in the area were the boring sea urchins Echinometra mathaei and E. oblonga. In some areas, the reef bench has a honeycombed appearance owing to the pattern of grooves gouged out by these urchins. In the areas of densest aggregations, abundance of urchins is on the order of 50 per square meter. Fleshy macroalgae was not observed at any locations in the zones of dense sea urchin abundance.

On the broad reef bench seaward of the lagoonal areas, coral cover is uniformly low. At the three 10-foot transect stations located on the bench, total coral cover averaged 6% (see Table 3). In general, the colonies that occurred were small in size, and predominantly of two species, Porites lobata and Pocillopora meandrina. Such low coral cover is indicative of the high degree of physical stress, predominantly from breaking waves. The only other predominant macrobenthos throughout the reef bench were the sea urchins Echinometra mathaei and E. oblonga.

At the seaward edge of the reef bench, increasing water depth results in decreased water motion and increased coral cover. At the 20 foot transects, coral cover ranged from 11% to 50%, predominantly in the form of large colonies of P. lobata growing at the base of the cliff that marks the edge of the reef bench. In deeper water beyond the cliff, coral cover is the highest through the reef system, with live coral comprising 50-60% of bottom cover (see Table 3). These zones of abundant coral cover occur from 0.25 to 0.5 miles from the shoreline in the areas of planned swimming area modification.

Reef Fish Community Structure

Results of reef fish community transect assessments in the areas of the proposed swimming lagoons are shown in Table 4. The lagoons at Sites 2 and 3 harbored a mix of juvenile reef fish, schooling mullet, and species specifically adapted to a shallow water environment with extremes in temperature and salinity. The most abundant juveniles were convict tang (manini, Acnthurus triostegus) and saddleback wrasse (hinalea, Thalassoma duperry). The main schooling fishes were flagtails (aholehole, Kuhlia sandvicensis) and mullet (ama'ama, Mugil cephalus). In particular, Site 1 hosted a very large school of small mullet. Species adapted to tidepool environments were also present. These were the blackspot sergeant (kupipi, Abudefduf sordidus) and the Christmas wrasse (awela, Thalasoma trilobatus).

Outside of the beachrock barrier, fishes tended to be clustered near areas of structural relief. Algal-feeding acanthurids were the most numerous group of fishes observed. Brown surgeonfish (ma'i'i'i, Acanthurus nigrofuscus), and convict tang (manini, A. triostegus) were the most abundant fishes at the shallow water sites. Also common were eye-stripe surgeonfish (palani, A. dussumieri), ringtail surgeonfish (pualu, A. blochi) and orangespine unicornfish (umaumalei, Naso lituratus).

Planktivorous damselfishes of the genera Chromis and Abudefduf were common. Also quite prominent in the water column was the black durgon (humuhumu-'ele'ele, Melichthys niger). Other common fishes included the manybar goatfish (moano, Parupeneus multifasciatus) and the saddleback wrasse (Thalassoma duperrey).

Several species of "food fishes" were observed during the survey. These included parrotfishes (Scarus spp.), goatfishes (Parupaneus and Mulloidichthys spp.), jacks (Caranx melamphygus), emperorfish (Mu, Monotaxis grandoculis), sugeonfishes (Acanthurus and Naso spp.) and the introduced grouper (Cephalophilis argus). These fishes were not abundant and tended to avoid divers.

CONCLUSIONS

The purpose of the proposed project is to remove solid rock portions of the shoreline and nearshore area in order to create environments that are safer, and provide more potential for recreational utilization by the public. While this action will unavoidably involve removing a section of the existing reef and associated biota, results of this survey indicate that the same factors that cause the selected sites to require deepening are also the factors that naturally limit biota settlement and growth. It can be seen that at the shallowest sites (1 and 3), coral cover and fish abundance are very low. At Site 2, which is naturally deeper, relatively rich biotic assemblages are presently occupying the area. In order to carry out the proposed plan, no activity other than creating easier access at the shoreline will be required at Site 2. While the sparse aggregations of organisms at Sites 1 and 3 will be eliminated during the deepening process, a long-term result of the project may likely be an increase of living coral and associated biota following completion of the project. As reported in a 10-year monitoring survey of Honokohau Harbor, located to the south of the KHV property (U.S. Army Corps of Engineers 1983), corals rapidly recolonized the outer harbor and channel walls following construction. Surveys of the coral communities outside the existing harbor entrance indicate that coral abundance near the entrance is greater than in neighboring communities farther away. Similarly, healthy and diverse coral communities have been observed inside of Kawaihae Harbor (ORCA 1978). A similar situation is likely to occur at Kaupulehu. Owing to the greater depths of the proposed lagoons relative to presently existing conditions, it is likely that the newly created substrata will be a more suitable settling area than the natural setting, and coral cover will increase above the present 1% level. There is no reason to suspect that sea urchins, reef fish and other reef biota will not also recolonize the newly created surfaces.

Other than direct effects of substrata removal by excavation, potential alteration to water quality and biotic structure could potentially occur by increased sedimentation and turbidity. These parameters will increase during the construction process, and the length of time of decreased water quality will depend on the length of the construction period.

The major group of reef organisms that may be sensitive to increased sedimentation caused by the construction process are reef corals. The effects of sediment stress to corals have been extensively reviewed by Johannes (1975), Dodge and Vaisnys (1977), Bak (1978), Brown and Howard (1985) and Grigg and Dollar (1989). In summary, while it is clear that increased sedimentation can have a deleterious effect on corals, especially when buried, sedimentation can also result in no negative impacts. Because sediments are suspended by natural processes in many reef environments, most corals can withstand a certain level of sediment supply to the living surface. Many species have the ability to remove sediment from their tissues by distension of the coenosarc with water, or ciliary action which can nullify lethal effects of sedimentation (Yonge 1931).

In case studies of the effects of sedimentation, the range of environmental effects varies through the entire spectrum of stress. Cases where effects of dredging have caused mortality have been generally limited to areas of confined circulation such as Castle Harbor, Bermuda (Dodge and Vaisnys 1977), and Kaneohe Bay, Hawaii (Banner, 1974). In areas of unrestricted circulation, however, there have been instances of increased sedimentation reported that do not appear to cause any substantial effects to reefs. Sheppard (1980) reported that following dredging and blasting for a military Harbor in Diego Garcia Lagoon, coral cover appeared to show no effects from increased siltation. In addition to the discussion concerning lack of impacts from Honokohau Harbor, a survey of the Kawaihae Deep Draft Harbor located in South Kohala, Hawaii, also showed that coral communities located just outside the harbor breakwater, as well as inside the harbor are flourishing (ORCA 1978).

Results of another shoreline modification project in West Hawaii can be used to illustrate the likely effects should sedimentation increase during modification of the shoreline at Kaupulehu. Monitoring of beach construction at Makaiwa Bay (Dollar 1987), showed that while substantial sediment plumes in the water column were created by excavation of the shoreline, there were no temporary or permanent negative effects to benthos and fish communities. Rapid flushing of the bay by normal current exchange, and the ability of live corals to exercise sediment removal behavior appeared to prevent measureable changes in community structure parameters. The monitoring survey also showed that water quality parameters were not permanently affected by temporary sediment loads, and quickly returned to preconstruction levels after the new beach was completed.

Several other scenarios around the Hawaiian Islands can also be drawn upon to substantiate that impacts from sedimentation do not always result in substantial, irreversible damage to neighboring marine environments. Studies conducted at Princeville, Kauai (Grigg and Dollar 1980), French Frigate Shoals (Dollar and Grigg 1981), and Hilo Bay (Dollar 1985), all investigated the impacts to reef coral communities subjected to high levels of sediment stress. Results of these studies indicate that Hawaiian reef communities possess the adaptive ability to maintain community integrity under conditions of substantial, but temporary, sediment stress.

The common factor in all of these case studies is that as long as sediment generating activities occur in environments with unrestricted circulation, and that the sediment stress is episodic, rather than chronic in nature, there is no negative impact (either temporary or permanent) to coral reef communities. At the Kaupulehu site, it is expected that sediment suspension and removal by current action will prevent buildup of material on the sea floor, and allow organisms to maintain functional cleaning mechanisms.

An additional factor at Kaupulehu that appears to further preclude the potential for detrimental changes to coral community structure owing to shoreline modification is the physical structure of the offshore region. As described above, the offshore area is characterized by a broad, flat bench that is devoid of high concentrations of coral cover owing to stress from breaking waves. These natural stresses are likely more severe, and continual than the temporary alteration that may accompany shoreline modification. Thus, any material emanating from shoreline activities would have to travel upwards of 0.25 miles before it would be exposed to substantial coral communities that are not routinely exposed to limiting conditions.

Water chemistry measurements revealed inputs of groundwater at the shoreline, especially at Site 3. Mixing of the groundwater input, however, appeared to be rapid and the transition zone between water with oceanic properties and groundwater was restricted to a narrow band on the order of 10 feet in width. Even with the restricted circulation in the natural lagoons, there is little indication of alteration of water quality owing to inputs from land. Altering the shoreline in terms of deepening the lagoons may alter localized groundwater flow patterns somewhat, but there is no indication that such alterations would result in any detrimental influence to water chemistry. If anything, it is likely that deepening of the shoreline areas would promote even more rapid circulation and mixing. As the entire coast of West Hawaii experiences groundwater flow of varying magnitudes, slight changes in these factors brought about by the proposed project would not likely exceed the natural level of variability to which receiving environments are adapted.

SUMMARY AND RECOMMENDATIONS

1) The marine environment offshore of the KHV Kaupulehu Resort is characterized by two major bio-geomorphological zones. An inner lagoonal area extends from the white sand beach offshore to a beachrock dike that effectively absorbs much of the force of breaking waves. Seaward of the beachrock dike, bottom topography is characterized by a wide, shallow reef bench that is formed from a submerged lava flow. The seaward edge of the reef bench is defined by a shallow drop-off, and a sloping reef platform extends to depths of 60 feet. All construction activities associated with the beach and swimming area improvements will take place within the nearshore lagoon area.

2) Three potential sites for beach improvement were evaluated for various parameters of water chemistry. Water quality off the entire development site can be considered in compliance with open coastal criteria as most measured parameters are within DOH water quality standards. The parameters that exceed DOH standards ($NO_3^- + NO_2^-$, TN) occur in high concentration as a result of input of groundwater at the shoreline. Dissolved material entering the ocean from groundwater extrusion is rapidly mixed with oceanic water near the shoreline resulting in nearly homogeneous water masses on both horizontal (distance from shore), and vertical scales. Construction activity to create the desired depth for the swimming areas will not exceed the present depth of Site 2. As there is presently no indication of variance of water quality parameters at this area compared to the other sites, it does not appear that the proposed activity will cause significant alteration in patterns of water chemistry.

3) Reef corals and associated biotic community distribution are restricted at Sites 1 and 3 owing to limiting physical conditions (temperature, wave stress) associated with shallow depth. At Site 2, where water depth is suitable for settlement and growth, coral communities are abundant and diverse. Beyond the beachrock dike, the offshore bench is sparsely populated owing to the force of breaking waves.

4) In order to create the desired beach and swimming environments at Sites 1 and 3, it will be necessary to remove solid rock from the shoreline and nearshore areas. At Site 2, only minor alteration of the shoreline will be required to promote safe entry into the ocean. The construction techniques to remove the shoreline material may result in temporary increases in turbidity. Biotic communities are preadapted to such temporary stresses and it is not likely that there will be any alteration to the existing communities in the area. At Sites 1 and 3, it will be necessary to remove material from the shoreline out to the limit of the desired swimming area. It is probable that a richer assemblage of organisms will colonize the excavated areas compared to the present situation. While this activity will eliminate much of the existing biota, it is likely that the long-term results of the action will be increased biotic community abundance as a result of increased depth. Reef corals will probably colonize the walls and floor of the excavated lagoons. Because corals are "keystone"

species, other forms of marine flora and fauna should also colonize the channel. Reef fish will undoubtedly inhabit the area in proportion to the amount of suitable shelter created. It is highly unlikely that any activity related to altering the shoreline will have effects on the offshore coral reef communities located beyond the edge of the reef bench.

5) Even though any shoreline modification activities will take place only in regions that are essentially devoid of macrobiota, all planning efforts should focus on minimizing impacts associated with suspended sediments created by construction. Planning of construction should minimize the duration of excavation phases, in order to keep the period of suspended sediment plume generation to the shortest possible time. If these conditions are met there does not appear to be the potential for substantial or permanent negative alteration of the marine environment. Similar projects in areas of unrestricted circulation have illustrated that suspended material generated by excavation can be dispersed by normal circulation before substantial settlement on the bottom. Marine communities appear to be able to withstand sediment stress utilizing natural adaptations such as cleaning mechanisms.

6) None of the biotic assemblages observed in and near the area to be excavated constitute rare, endangered or commercially valuable resources. Because the excavated area constitutes a very small percentage of the total reef platform fronting the KHV Kaupulehu property, the overall integrity of the area will not likely be altered by the project.

7) As all activities will be conducted within 100 feet from shore and in water depths less than 4 feet, and there appears to be no need for blasting, there is no potential for impacts to protected and endangered marine species.

8) All indications are that the proposed plan, if carried out with environmental considerations as an integral part of the process, will not result in any permanent or detrimental changes to the marine environment. However, in order to identify any unforseen factors that may cause such undesireable changes, it is recommended that a monitoring program be conducted during each stage of the development process. The present survey can serve as a baseline for any such monitoring program that might be required to meet county, state and/or federal permit requirements.

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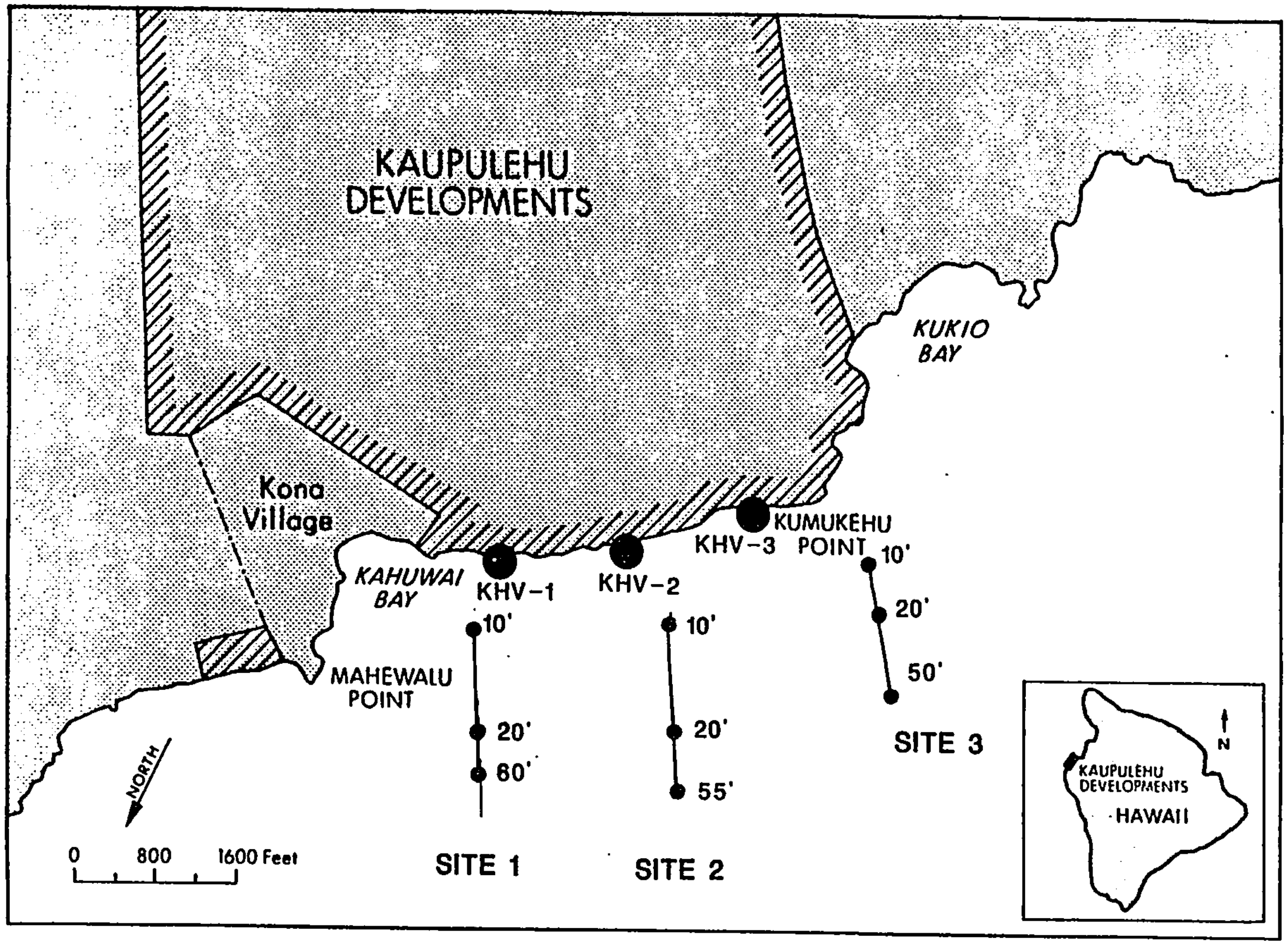

FIGURE 1. Map showing location of KHV Kaupulehu Developments on the West Coast of the Island of Hawaii. Proposed beach and swimming lagoon improvement sites are labeled as KHV-1, KHV-2, KHV-3. Offshore reef survey sites are indicated as 1-, 2- and 3- along with the water depth at each location.

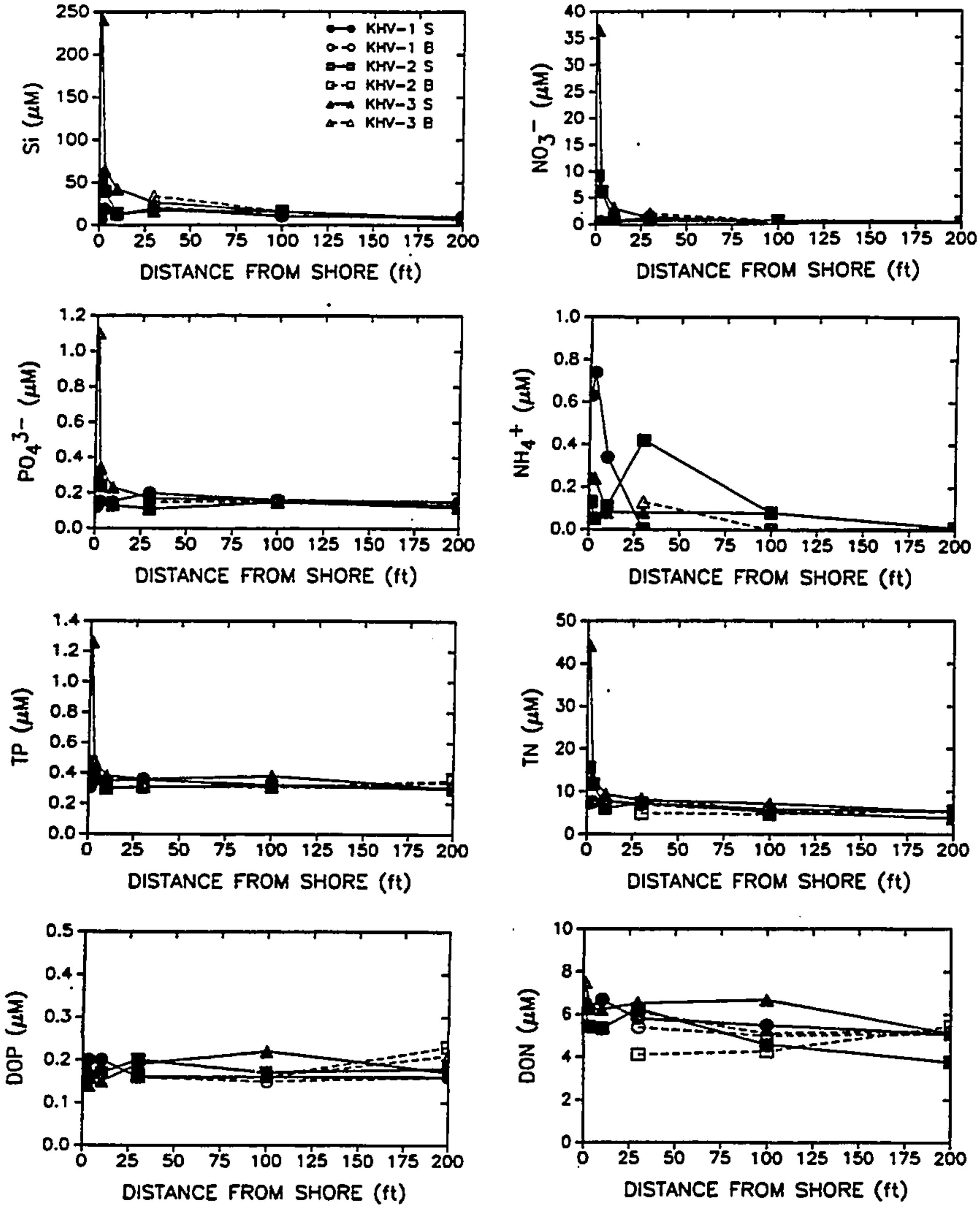

FIGURE 2. Plots of water chemistry parameters as functions of distance from the shoreline at the three proposed beach and swimming lagoon improvement sites at the KHV Kaupulehu Development. "S" refers to surface water sample; "B" refers to bottom water sample. For station locations, see Figure 1.

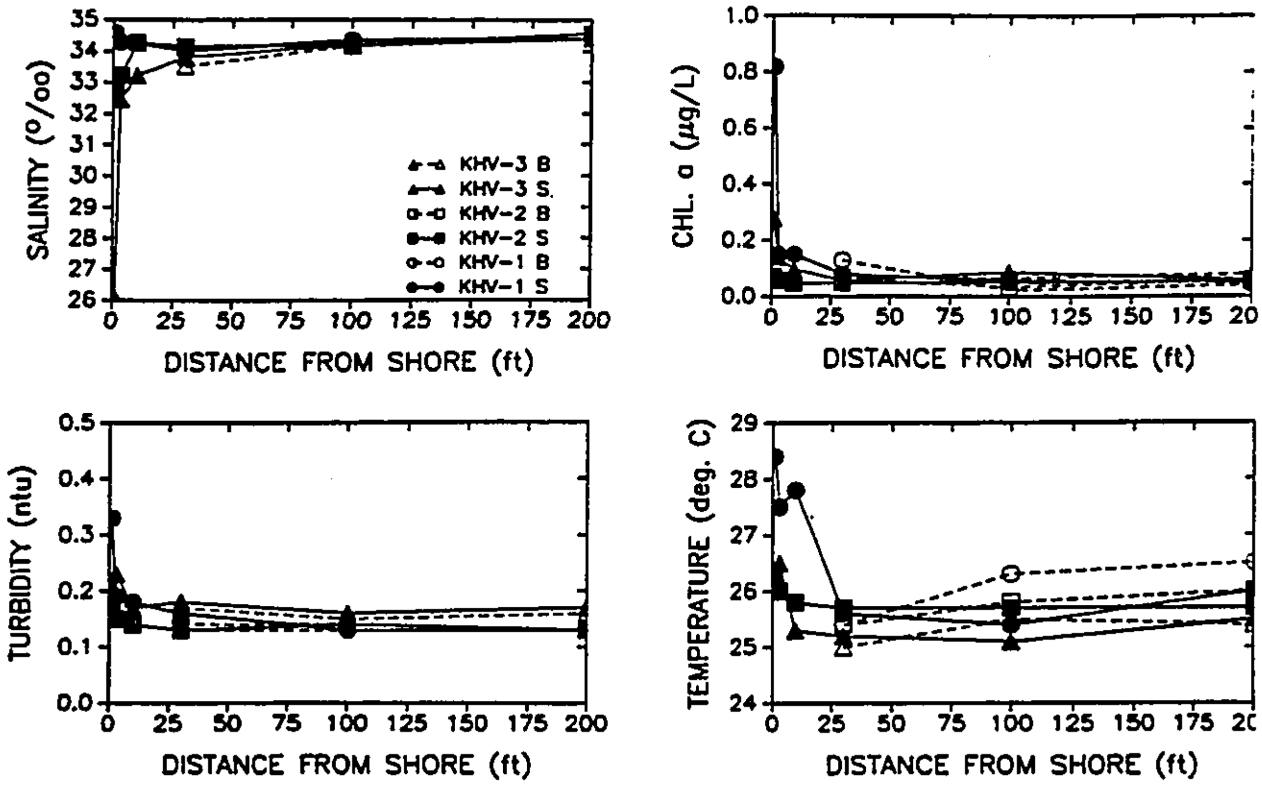

FIGURE 2. continued.

TABLE 1. *Water chemistry measurements from sampling locations in proposed swimming areas off the KHV Resort. "S" indicates surface sample; "B" indicates bottom sample. For sampling locations, see Figure 1.*

STATION NO.		DISTANCE OFFSHORE (ft)	PO4 (µM)	NO3 (µM)	NH4 (µM)	SI (µM)	DOP (µM)	DON (µM)	TP (µM)	TN (µM)	TURB (ntu)	CHL. a (µg/L)	SALINITY (o/oo)	O2 (mg/L)	TEMP. (deg. C)	pH
KHV-1-	1-S	1	0.12	0.11	0.63	6.44	0.19	6.48	0.31	7.22	0.33	0.818	34.5833	7.2	28.4	8.38
	2-S	3	0.15	0.49	0.74	18.52	0.20	6.26	0.35	7.49	0.19	0.149	34.2923	6.8	27.5	8.35
	3-S	10	0.15	0.60	0.34	11.88	0.20	6.68	0.35	7.62	0.18	0.149	34.2482	6.4	27.8	8.36
	4-S	30	0.20	1.41	<0.03	19.32	0.16	5.81	0.36	7.22	0.16	0.078	34.0039	6.2	25.6	8.36
	4-B	30	0.20	1.49	<0.03	21.14	0.16	5.40	0.36	6.89	0.13	0.128	33.9681	6.4	25.4	8.27
	5-S	100	0.18	0.38	<0.03	10.47	0.16	5.48	0.32	5.86	0.13	0.055	34.3592	6.3	25.4	8.18
	5-B	100	0.18	0.46	<0.03	11.07	0.15	4.99	0.31	5.45	0.13	0.022	34.3334	6.4	26.3	8.16
	6-S	200	0.15	0.24	<0.03	9.66	0.18	5.08	0.31	5.32	0.13	0.051	34.4040	6.5	26.0	8.27
	6-B	200	0.15	0.22	<0.03	9.26	0.18	5.10	0.31	5.32	0.13	0.041	34.4079	6.4	26.5	8.24
KHV-2-	1-S	1	0.30	9.20	0.13	51.94	0.17	6.30	0.47	15.63	0.17	0.072	32.8004	7.6	26.2	8.16
	2-S	3	0.24	6.21	0.05	39.86	0.16	5.43	0.40	11.69	0.15	0.058	33.2255	8.0	26.0	8.20
	3-S	10	0.13	0.62	0.11	13.49	0.17	5.35	0.30	6.08	0.14	0.044	34.2661	7.4	25.8	8.21
	4-S	30	0.11	0.68	0.42	18.91	0.20	6.25	0.31	7.35	0.13	0.048	34.1362	6.9	25.7	8.21
	4-B	30	0.15	0.79	<0.03	17.71	0.16	4.12	0.31	4.91	0.14	0.061	34.1201	6.8	25.4	8.23
	5-S	100	0.15	0.52	0.08	15.90	0.17	4.58	0.32	5.18	0.14	0.051	34.1960	6.8	25.7	8.23
	5-B	100	0.15	0.46	<0.03	15.50	0.16	4.26	0.31	4.72	0.14	0.034	34.2015	7.0	25.8	8.25
	6-S	200	0.12	<0.03	<0.03	6.44	0.18	3.77	0.30	3.77	0.13	0.055	34.5604	6.7	25.7	8.23
	6-B	200	0.12	<0.03	<0.03	6.44	0.23	5.45	0.35	5.45	0.13	0.058	34.5594	6.7	26.0	8.23
KHV-3-	1-S	1	1.10	38.52	0.24	241.18	0.16	7.49	1.26	44.25	0.21	0.277	26.0995	7.5	26.3	8.23
	2-S	3	0.34	6.54	0.24	64.62	0.14	6.27	0.48	13.05	0.23	0.139	32.4463	7.4	26.5	8.20
	3-S	10	0.23	3.09	0.08	42.47	0.15	6.22	0.38	9.39	0.17	0.096	33.2089	7.4	25.3	8.20
	4-S	30	0.17	1.28	0.08	26.37	0.19	6.53	0.36	7.89	0.18	0.055	33.8047	7.2	25.2	8.15
	4-B	30	0.20	2.06	0.13	34.02	0.16	6.11	0.36	8.30	0.17	0.068	33.5138	7.1	25.0	8.18
	5-S	100	0.16	0.41	0.06	15.30	0.22	6.67	0.38	7.16	0.16	0.065	34.2042	7.4	25.1	8.11
	5-B	100	0.15	0.49	<0.03	15.70	0.16	5.10	0.31	5.59	0.15	0.065	34.1719	7.5	25.5	8.11
	6-S	200	0.13	0.08	<0.03	8.25	0.17	5.10	0.30	5.18	0.17	0.059	34.4069	7.5	25.5	8.11
	6-B	200	0.13	0.08	<0.03	7.65	0.21	5.24	0.34	5.32	0.18	0.078	34.4106	7.4	25.4	8.11
WELL			1.40	14.76	0.05	983.95	0.00	0.90	1.40	15.71			0.2692			
DOH WATER QUAL. STDS.																
GEOMETRIC MEAN				0.35	0.25				0.64	10.71	0.50	0.30				
NOT TO EXCEED 10%				1.00	0.61				1.29	17.85	1.25	0.90				
NOT TO EXCEED 2%				1.78	1.10				1.93	25.00	2.00	1.75				

TABLE 2. Invertebrate species abundance at sites of KHV swimming lagoons.
"A" = Abundant; "C" = common; "R" = rare.

SPECIES	TRANSECT		
	KHV-1	KHV-2	KHV-3
ECHINOIDEA			
(Sea Urchins)			
Echinometra mathaei	A	A	A
Echinometra oblonga	A	A	A
Colobocentrotus atratus	A	R	
Echinostrephus aciculatus	A	A	C
Heterocentrotus mammillatus	R	R	R
Tripnestes gratilla		C	C
Echinothrix diadema	C	R	
HOLOTHURIA			
(Sea Cucumbers)			
Holothuria atra		C	R
Holothuria nobilis	R	C	
Actinopyga obesa		C	
Actinopyga mauritiana		C	
SCLERACTINIA			
(Stony corals)			
Porites lobata	R	A	R
Porites compressa		R	
Porites brighami		R	
Porites evermanni		C	R
Pocillopora meandrina	R	A	C
Pocillopora damicornis	R	C	
Montipora verrucosa	R	A	
Montipora patula	R	C	
Montipora flabellata		R	
Pavona varians		R	
Leptastra purpurea	R	C	
Leptastrea bottae		R	
Cyphastrea ocellina		R	
Palythoa tuberculosa		R	
Anthelia edmondsoni		R	R
MOLLUSKS			
Octopus spp.		R	
Conus spp.		R	

TABLE 3. Coral community structure on Lagoon and offshore transects in the vicinity of the KHV Resort. For transect locations, see Figure 1.

SPECIES	TRANSECT										
	KHV-1	KHV-2	1-10'	1-20'	1-60'	2-10'	2-20'	2-55'	3-10'	3-20'	3-50'
Porites lobata	0.4	2.9	3.3	45.5	23.6	4.0	6.7	19.5	4.0	26.1	18.1
Porites compressa				1.0	37.2	1.0	0.2	30.0		0.4	30.3
Porites evermanni	0.2	0.9									
Pocillopora meandrina	0.1	1.5	2.7	2.0		1.6	3.2	0.2	0.6	1.8	
Pocillopora damicornis	0.2	2.2									
Montipora verrucosa		1.4		1.7			0.5		0.3	0.4	
Montipora patula		0.1		0.2						0.1	
Leptastra purpurea		0.4									
Leptastrea bottae		0.1									
Cyphastrea ocellina		0.1									
TRANSECT TOTAL COVER	0.9	9.6	6.0	50.4	60.8	6.6	10.6	49.7	4.9	28.8	48.4
CORAL SPECIES COUNT	4	9	2	5	2	3	4	3	3	5	2
CORAL SPECIES DIVERSITY	1.27	1.77	0.69	0.43	0.67	0.67	0.87	0.69	0.59	0.45	0.66

TABLE 4. Reef fish community structure at sites of swimming lagoons off the KHV Resort. For transect locations, see Figure 1.

FAMILY SPECIES	TRANSECT		
	KHV-1	KHV-2	KHV-3
KUHLIIDAE			
Kuhlia sandvicensis	30		
AULOSTOMIDAE			
Aulostomus chinensis		2	
MULLIDAE			
Mulloides flavolineatus	8	22	C
P. multifasciatus	2		C
CARANGIDAE			
Caranx melamphygus			R
LUTJANIDAE			
Lutjanus kasmira			C
CHAETODONTIDAE			
C. quadrimaculatus			R
C. ornatissimus			R
C. unimaculatus			R
POMACENTRIDAE			
Abudefduf abdominalis		15	C
A. sordidus	2	3	
Plectro. johnstonianus			R
P. imparipennis	5	3	
Stegastes fasciolatus	6	7	
LABRIDAE			
Thalassoma duperrey	16	15	A
T. trilobatum		2	C
T. ballieui			R
Stethojulis balteata	3	6	R
Halichoeres ornatissimus			R
SCARIDAE			
Scarus sordidus			C
S. rubroviolaceus			C
ACANTHURIDAE			
Zebrasoma flavescens			C
Acanthurus achilles			A
A. triostegus	20		
A. dussumieri			C
A. blochii			C
A. nigrofuscus			A
Ctenochaetus strigosus			C
Naso lituratus			C
N. unicornis			R

TABLE 4. continued

FAMILY SPECIES	TRANSECT		
	KHV-1	KHV-2	KHV-3
ZANCLIDAE			
Zanclus cornutus	2		R
BALISTIDAE			
Rhinecanthus rectangulus			C
M. niger			C
OSTRACIONTIDAE			
Ostracion meleagris		1	
TETRADONTIDAE			
Arothron hispidus	1		R
NUMBER SPECIES	11	10	
NUMBER INDIVIDUALS	95	76	
SPECIES DIVERSITY	1.93	1.92	

APPENDIX C

MARINE AND ANCHIALINE POND MONITORING PROGRAM, KAUPULEHU MAKAI VENTURE, NORTH KONA, HAWAII

WATER CHEMISTRY

REPORT 3-92

Prepared for

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INTRODUCTION AND PURPOSE

The Kaupulehu Land Company (KLC) Kaupulehu Makai Ventures project is a planned self-contained resort-residential community situated on approximately 600 acres of land in the North Kona District of the Island of Hawaii. The project, which is adjacent to the existing Kona Village Resort, will encompass approximately one mile of shoreline between Kukio Bay north to Mahuewalu Point. In addition to the proximity to the marine environment, the property contains eight anchialine (brackish) ponds.

Both the marine environment and the ponds have been assessed in Baseline Surveys (Marine Research Consultants, 1989). These evaluations indicated that the proposed construction and development activities should cause little or no irreversible alterations to the aquatic environments as long as proper construction and management practices are followed. However, because of the concern for maintaining the present level of environmental quality in all of the aquatic systems, and as a means of ensuring that proper procedures are set forth, a condition of permitting was the inclusion of a marine and pond management program. The functions of the management program include delineating conditions that must be met during construction and operation of the project, as well as devising a monitoring plan to take place before, during and after construction for the purpose of identifying and mitigating any potential environmental problems.

The monitoring program includes time-course evaluation of water quality and biological community structure of the nearshore reef and anchialine pond environments. The program is also designed to meet all requirements for permit approval by government agencies, including County, State, and the U.S. Army Corps of Engineers. This document constitutes the seventh report describing the results of the water chemistry monitoring program, and contains data from sampling conducted in November 1992. The sampling was conducted after grading and initial construction on the resort complex, but during a period where construction activity was on hold.

METHODS

Three locations fronting the Kaupulehu property have been selected as sampling sites for the monitoring program. Site 1 lies closest to the Kona Village Resort at the northern end of the property; Site 2 lies at the approximate center of the property; and Site 3 lies at the northern edge of the 1801 lava flow (see Figure 1). Water quality was evaluated along sampling transects at each site. Each transect was oriented perpendicular to the shoreline, and extended from the highest wash of waves across the intertidal and nearshore reef platform out to the open ocean, a distance of approximately 100 meters (m). Water samples were collected at six stations (seven at Site 2) along each transect. Such sampling spanned the greatest range of salinity with respect to freshwater efflux at the shoreline. Sampling was more concentrated in the nearshore zone as this area is most likely to show the effects of shoreline modification. With the exception of the stations located 0.1, 1, 3 and 5 m from the shoreline, samples were collected at two depths; a surface sample was collected within approximately 10 centimeters (cm) of the surface, and a bottom sample was collected within 1 m of the sea floor.

Water quality constituents that were measured included the 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 (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.

Water samples were collected by divers opening 1-liter polyethylene bottles at the desired depth. Subsamples for nutrient analyses were immediately placed in 125-milliliter (ml) acid-washed, triple rinsed, polyethylene bottles and stored on ice until returned to Honolulu. Analyses for NH_4^+, PO_4^{3-}, and NO_3^- + NO_2^- were performed with a Technicon autoanalyzer using standard methods for seawater analysis (Strickland and Parsons 1968, Grasshoff 1983). Total nitrogen (TN) and total phosphorus (TP) were analyzed in a similar fashion following digestion. Dissolved organic nitrogen (DON) and dissolved organic phosphorus (DOP) were calculated as the difference between TN and dissolved inorganic N, and TP and dissolved inorganic P, respectively.

Water for other analyses was subsampled from 1-liter polyethylene bottles and kept chilled until analysis. Turbidity was determined on 60-ml subsamples fixed with $HgCl_2$ to terminate biological activity. Fixed samples were kept refrigerated until turbidity was measured on a Monitek Model 21 nephelometer, and reported in nephelometric turbidity units (NTU). Chl a was measured by filtering 300 ml of water through glass fiber filters; pigments on filters were extracted in 90% acetone in the dark at -5° C for 12-24 hours, and the 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 readability of 0.1° C., and pH using a millivolt field meter with a readability of 0.01 pH units.

Nutrient, turbidity and salinity analyses were conducted by Marine Analytical Specialists (Honolulu, HI) and Chl a analyses were conducted by OI Consultants, Inc. (Waimanalo, HI).

RESULTS OF WATER CHEMISTRY ANALYSIS

Environmental Conditions

The nearshore marine environment fronting the Kaupulehu Resort can be considered somewhat unique for the coastline of West Hawaii. Most of the West Hawaii coastline is characterized by a narrow nearshore reef terrace that is not separated from the open ocean by any constructional features. Off the Kaupulehu property, however, the nearshore area is partially separated from the outer offshore region by a lithified beachrock barrier that has formed approximately 25 m from the existing beach. At low tides the beachrock dike is exposed to the atmosphere, forming a physical barrier to water exchange between the open ocean and the inner regions. As a result, the nearshore area can be considered as partial lagoons with somewhat restricted exchange with the open ocean. At high tidal stands, water level exceeds the top of the beachrock barrier and exchange with the inner lagoons and open ocean is essentially unrestricted. Formation of the lagoons is most prominent at Site 1, and is least prominent at Site 3.

The ninth monitoring survey was conducted on November 7, 1992. Environmental conditions were sunny with light onshore wind. No rainfall occurred during the sampling, nor had considerable rainfall occurred during the weeks preceding the survey. Ocean conditions consisted of calm seas with a 2 to 3 foot swell; sampling was conducted at a low tidal stage that exposed the beachrock rampart separating the offshore area from the nearshore lagoon. Sampling was started at low tide (approximately -0.6 feet) and proceeded during a rising tide.

Horizontal and Vertical Gradients

Tables 1 and 2 show the results of all water chemistry analyses for samples collected off the Kaupulehu on November 7, 1992. Table 1 shows dissolved nutrient concentrations in micromolar (μM) units, while Table 2 shows concentrations in units of micrograms per liter (μg/L). The concentrations of eight dissolved nutrient constituents in surface and deep samples are plotted as functions of distance from the shoreline in Figure 2. Values of salinity, turbidity, Chl a and temperature as functions of distance from shore are shown in Figure 3.

At Site 3 *the concentrations of several nutrients (Si,* NO_3^-*, and* PO_4^{3-}*, TP and TN)* are elevated in samples collected from the nearshore stations (Table 1, Figure 2). Salinity exhibits the reverse trend of increasing salinity with increasing distance offshore with the lowest salinity value of 29.69°/oo recorded from the shoreline station (Table 1, Figure 3). This pattern of decreasing nutrient concentration and increasing salinity is evident through the whole sampling transect at Site 3, although the concentration gradients are steepest within 10 m of the shoreline.

At Site 2, these patterns are also evident to a small extent; concentrations of Si, NO_3^-, and TN are elevated in the nearshore stations but the magnitude of change is not as great as occurs at Site 3. At Site 2, concentrations of PO_4^{3-}, TP and salinity do not show any gradients with respect to distance offshore. At Site 1, dissolved nutrients and salinity do not exhibit any gradients with distance from the shoreline (Figures 2 and 3).

The peak values of Si, NO_3^-, PO_4^{3-}, TN and TP in combination with low salinity in the nearshore zone at Site 3 indicates a concentrated input of groundwater at the shoreline. Groundwater normally contains high concentrations of these nutrients and low salinity (see values for well water in Tables 1 and 2). It is also apparent in Figures 2 and 3 that the groundwater input is rapidly mixed to near background oceanic levels within 10 m of the shoreline; mixing of ocean water and groundwater effectively homogenizes the water column very close to the shoreline.

While not present in high concentrations in groundwater relative to ocean water, NH_4^+ concentrations are also elevated at the samples within 10 m of the shoreline at Site 3. With the exception of one sample at Site 2, concentrations of NH_4^+ within 10 m of the shoreline at Sites 1 and 2 are lower than concentrations farther offshore (Figure 2).

Concentrations of DOP and DON show no clear pattern of decrease with distance from shore, and are of approximately the same magnitude at all three sites.

Turbidity measurements show a slight decreasing trend with distance offshore for samples collected at the surface at all three sites (Figure 3). Beyond 10 m from the shoreline, turbidity levels are relatively constant across each transect. Chl a data show no trend with distance offshore at any of the sites. The magnitude of both turbidity and Chl a measurements is nearly the same among the three sites (Tables 1 and 2 and Figure 3). Temperature measurements in the nearshore stations were highest at Site 2 compared to the other two sites (Figure 3). Temperature tended to decrease with increasing distance offshore within 10 m of the shoreline at sites 1 and 2; beyond this distance, temperature measurements remained comparatively constant. Temperature at Site 3 was fairly constant (26.6°C) across the transect (Figure 3).

As a result of lower density groundwater entering the ocean, a surface layer characterized by high nutrient concentrations and low salinity, often forms in areas of relatively calm nearshore water in west Hawaii. This surface lens extends seaward until mixed to background oceanic levels by physical processes, primarily wave action. With the exception of turbidity, deep water samples collected beyond the nearshore lagoons showed no discernible pattern in chemical concentration when compared to surface samples during the November 1992 survey at any of the three sites (Figures 2 and 3, Tables 1 and 2). Although there were differences in concentrations between deep and surface sample at a given station there was no consistent overall pattern with respect to depth in the water column. The lack of vertical stratification suggests that the water column throughout the region is well mixed by physical processes.

Temporal Comparison of Monitoring Results

Figures 4-9 show concentrations of the various chemical constituents in surface water samples as functions of distance from the shoreline for each of the nine monitoring surveys over the period from December 1989 to November 1992. The December 1989 and March 1990 surveys were conducted prior to any construction activities and serve as preconstruction baselines. The remaining surveys followed initial construction activities of hotel and golf course grading, excavation (including blasting), and the laying of resort building foundations.

At Site 1 groundwater input was most evident during July 1990, March and August 1991 (Figures 4 and 5). The magnitude of the concentrations for Si, NO_3^- and PO_4^{3-} are higher from samples collected within 10 m of the shoreline during these surveys compared to other sampling periods. At a distance of 100 m offshore, however, the concentrations are approximately the same for all surveys. Salinity was correspondingly lowest during the same three samplings with measured values of 17.1, 29.4 and 28.3 °/oo, respectively, in the nearshore samples. In contrast, salinity values measured for the nearshore stations during the other surveys is approximately 34.6°/oo.

Site 3 shows a similar pattern in groundwater input, in terms of Si, NO_3^- and PO_4^{3-} concentrations and salinity values (Figures 8 and 9). However, the time of greatest groundwater input was greatest during March 1990, August 1991 and April 1992. At Site 2 groundwater efflux were greatest during March and July 1990. The magnitude of the groundwater input, however, was much less at this site compared to the other two sites (Figures 6 and 7).

Examination of Figures 4, 6 and 8 reveal that NH_4^+ concentrations show no distinct temporal pattern. The highest NH_4^+ concentrations measured at Sites 1 and 2 occurred during October 1990; in the 100 m from shore station at Site 1 and in the 3 m from shore station at Site 2 (Figures 4 and 6). At Site 3, the highest concentration of NH_4^+ was measured during April 1992 in the 3 m from shore station (Figure 8). Concentrations of DON and DOP generally do not vary over time, although DOP measured at Site 1 was lower during April 1992 and slightly higher in November 1992 compared to the other seven survey dates (Figure 4). These results indicate that, in general, changes in these constituents are independent of seasonal effects.

Temperature measurements show a seasonal pattern at all three sites, with the months of December, March and April displaying coolest temperatures and July, August and October the warmest temperatures (Figures 5, 7 and 9). The seasonal pattern was most evident in samples collected from stations located beyond 10 m from the shoraline where influences from groundwater efflux were minimized. Three temperature ranges are evident: a low range (24-25°C), a mid range (25-27°C) and a warm range (27-29 °C). These ranges are most clearly defined at Sites 2 and 3 where groundwater efflux is most prominent, indicating that although groundwater effects are minimized beyond 10 m from shore they are not completely dissipated.

Chl a concentrations showed maximum values during different times of the year at each site. At Site 1, Chl a peaked during August 1991, at Site 2, the maximum was measured during April 1992. At Site 3, results from the March 1991 survey had the highest measurement of Chl a (Figures 5, 7 and 9). Likewise, Figures 5, 7 and 9 show that little, if any temporal patterns exist for turbidity. While turbidity was lowest during March 1991 at all sites, the difference was small compared to the other survey dates. Excluding the December 1991 survey at Site 1, the overall range of turbidity values was no greater nor less in those samples measured during construction (after March 1990) as compared to those measured before the initiation of construction (December 1989 and March 1990). Such similarities indicate that construction practices did not appear to be influencing water clarity as measured by turbidity.

Conservative Mixing Analysis

A useful treatment of water chemistry data for interpreting the extent of material inputs from land is application of a hydrographic mixing model. In the simplest form, such a model consists of plotting the concentration of a dissolved chemical species 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 10 shows plots of concentrations of four constituents (Si, NO_3^-, NH_4^+, PO_4^{3-}) as functions of salinity for the samples collected at the Kaupulehu ocean stations in November 1992. Figure 11 shows a similar plot for all nine monitoring surveys grouped into year classes from 1989 to 1992. Each graph also shows conservative mixing lines that are constructed by connecting the endmember concentrations of open ocean water and groundwater from a well located upslope of the Kaupulehu property that is used as a water source for the Kona Village Resort (see Table 1 for well water nutrient concentrations and salinity).

If the nutrient constituent in question displays purely conservative behavior (no input or removal resulting 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 through processes such as leaching of fertilizer nutrients to groundwater, 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 the model as this material is present in high concentration in groundwater, but is not a major component of fertilizer, and is not utilized rapidly within the nearshore environment by biological processes. It can be seen in Figure

10 that when Si concentrations are plotted versus salinity, data points for all three sites fall in a straight line very near the conservative mixing line. Examination of Figure 11 also reveals that most of the Si data points fall on or near the conservative mixing line. The good linear relationship indicates that the mixing model provides a valid representation of the system under investigation.

The plots of NO_3^- versus salinity for the latest survey in November 1992 show patterns similar to that for dissolved Si (Figure 10). Data points from all three sites fall very close to the conservative mixing line indicating that there appears to be no input of NO_3^- to the nearshore ocean environment owing to activities on land. During 1990 and 1991 some of the NO_3^- vs salinity data points fall considerably above the conservative mixing line causing the slope of NO_3^- vs salinity to be greater than the slope of the conservative mixing line (Figure 11).

These results for the 1990 and 1991 surveys suggest some external input of the material to the system. NO_3^- is the form of nitrogen most common in fertilizer mixes, and subsidies of this material in the nearshore ocean are usually a result of leaching of fertilizer material to groundwater. At the Kaupulehu site, however, no fertilization has taken place to date. Rather it is suggested that the observed subsidy was a consequence of blasting activities that were used to excavate for the hotel foundations. Blasting material was composed of ammonium nitrate. It is likely that blasting introduced this compound into the basal rock near the water table. A relatively small fraction of residual ammonium nitrate could have leached to groundwater in the aquifer near the shoreline. Such leachate could have provided the substantial augmentation to natural occurring NO_3^- in groundwater entering the nearshore ocean that was detected in monitoring survey results.

Most of the high NO_3^- values were observed in July 1990, soon after completion of blasting activity. Virtually all of the samples collected within 50 m of the shoreline contained concentrations of NO_3^- well above the conservative mixing line. In October 1990, no samples concentrations were above the mixing line, in March 1991 only one sample was substantially above the mixing line, in August 1991 three data points fell slightly above the line while in the past two surveys all data points fall on or slightly below the line. Such a temporal pattern suggests that the high levels of NO_3^- in July 1990 were most likely a result of blasting residue. While there still appeared to be a slight detectable input of NO_3^- after the August 1991 survey, it appears that there is no longer any recognizable subsidy to the area.

The distribution of the other form of dissolved inorganic nitrogen, NH_4^+, shows no overall inverse relationship with respect to concentration and salinity for both the November 1992 survey (Figure 10) and the combined surveys (Figure 11). Many of the highest concentrations are from samples with high salinity values. In addition, the conservative mixing line is essentially "flat" with similar concentrations in groundwater and open ocean water. These factors indicate that this material is not added to the ocean off the Kaupulehu site via input from land. As many of the measured NH_4^+ concentrations fall above the mixing line, it appears that there is a natural input of this form of nitrogen from biological processes within the shallow nearshore lagoons.

PO_4^{3-} is also a major component of fertilizer but is usually not found to leach to groundwater to the extent of NO_3^-, owing to a high absorptive affinity of phosphorus in soils. It can be seen in Figure 10 that data points for PO_4^{3-} fall predominantly on or near the mixing line. For the cumulative data set, most PO_4^{3-} concentrations below salinities of 34°/oo fall on or below the mixing lines (Figure 11). Such results indicate that there is either some process actively removing PO_4^{3-} from the nearshore ocean, or that the groundwater from the upslope wells has a different PO_4^{3-} concentration as the water in the aquifer under the development parcel. As the wells which were sampled were nearly directly upslope from the project site, it is unlikely that the groundwaters could have differed to the extent detectable in the mixing models shown in Figure 11. In any event, it is clear that there is no subsidy of PO_4^{3-} to the nearshore ocean as a result of construction activity.

Compliance with DOH Standards

Tables 1 and 2 lists samples that exceed DOH water quality standards for open coastal waters under "wet" conditions. The criteria for wet conditions are applied to the Kaupulehu property because this area receives at least 3 million gallons of groundwater input per mile per day (T. Nance, personal communication). Comparing water chemistry results from the Kaupulehu samples to DOH criteria reveals that in November 1992, eight measurements of NO_3^-, one measurement of NH_4^+, and two measurements of TN exceeded the 10% standards.

It can be seen from Tables 1 and 2 that all of the samples for NO_3^-, NH_4^+ and TN that exceeded the DOH criteria were from Site 3 at the nearshore stations where groundwater input was most evident. It should be noted that data from preconstruction surveys exceeded the DOH limits, particularly in the samples collected within 10 m of the shoreline.

As described in the sections above, NO_3^- is a natural component of groundwater. In areas that receive substantial input of groundwater there is typically a zone of mixing near the shoreline where NO_3^- concentrations may consistently exceed DOH criteria as long as salinity remains low. Thus it appears that natural processes can result in water quality that exceeds specified DOH limits.

Tables 3 and 4 shows geometric mean data calculated from water chemistry samples collected over the period from December 1981-November 1992. Also shown in Tables 3 and 4 are the samples from each sampling site that exceed DOH geometric mean criteria. Nearly all of the NO_3^- measurements at all three sites exceed the DOH geometric mean limits. In addition, fourteen NH_4^+ measurements, one measurement of TP, seven measurements of TN and three measurements of Chl a exceeded DOH criteria. In no case did turbidity values exceed DOH limits. As discussed above, natural groundwater efflux into the nearshore ocean can result in water quality measurements that exceed specified DOH limits.

ANCHIALINE PONDS

Sampling Methodology

A preliminary survey of the anchialine ponds at Kaupulehu (OI Consultants 1986) identified eight ponds within the property boundaries. Three of the ponds were considered to be typically anchialine in nature, one pond was almost completely filled with leaf litter, and one pond was only wet at high tide, while the remaining three ponds were more properly considered wetlands, being typified by complete coverage of dense growths of sedges and grasses. At the time of the preliminary survey, no evidence of negative impacts owing to the activities of man were noted.

For the Kaupulehu monitoring program, it was deemed appropriate to monitor chemical constituents in the three ponds that contained water throughout the tidal cycle (#1, 5 and 7 in the OI report) (see Figure 1). Ponds 1 and 5 are similar in physical nature, as both are composed of depressions in basaltic structures with sediment-covered bottoms, clear water columns, and little emergent plant growth. Pond 7 is located in a marshy area, with substantial plant growth throughout.

Physical/chemical parameters that were measured in ponds include salinity, Chl a, and turbidity. Dissolved chemical species that were sampled in the ponds include ammonium (NH_4^+, nitrate + nitrite (NO_3^- + NO_2^-), orthophosphate (PO_4^{3-}), total nitrogen (TN), total phosphorus (TP) and silica (Si). Measurements were taken at low and high tides to determine the relationship between tidal cycle and physical structure of the water columns in the ponds. Analytical methods for pond water analyses are identical to those described above for marine waters.

Results of Anchialine Pond Water Chemistry

Table 5 shows results of water chemistry measurements in the three monitoring ponds during high and low tides for each monitoring survey. During the November 1992 monitoring survey the change in tidal level was 0.6 feet between the low and high tide samples. During the November sampling, concentrations of the dissolved nutrients PO_4^{3-}, NO_3^-, Si, TP, and TN, and measurements of salinity, turbidity, Chl a and pH showed either no changes or only relatively minor differences between samples collected during low tide compared to high tide samples at Ponds 5 and 7 (Table 5). Results from Pond 1 samples show an decrease in the dissolved nutrients PO_4^{3-}, NO_3^-, TP and TN in the low tide samples relative to the high tide samples and no changes in the concentration of Si or salinity during the tidal cycle. Turbidity, Chl a, and pH increased during the tidal cycle from low to high tide at Pond 1.

In general, the magnitude of chemical concentrations were the same among the three ponds, with the exception of Pond 7 which had a distinctly higher DON concentration. (12.03 μM) during high tide. Pond 1 showed the greatest change in concentration between low and high tide, a result which is similar to the April 1992 survey. During surveys conducted prior to April 1992 Pond 7 exhibited the greatest fluctuations with respect to tidal exchange.

Table 5 shows that variations between high and low tide in all ponds has been generally very small; less than would be expected if the volume of the ponds was exchanging freely with the tide. The relatively small tidal variation in salinity and nutrients that occur in pond water suggests that the ponds are somewhat contained. As a result, low saline water in the ponds appears to "float" on a basal tidal layer, with less variation in salinity than would occur with complete tidal mixing.

It is also evident that nutrient concentrations in the ponds are relatively constant over the nine sampling intervals (with the exception of July 1990). During July 1990, NO_3^- concentrations in Pond 1 were also elevated compared to preconstruction conditions.

These results indicate that construction activities, including blasting, may have caused increases in NO_3^- concentrations in some of the anchialine ponds. However, it appears that such subsidies have now dissipated as concentrations in the most recent survey are similar to preconstruction values. In any event, it has been suggested that the ponds are not nutrient limited systems under any conditions. Without nutrient limitation, addition of more nutrients is not expected to have any effect on pond biota.

SUMMARY

1. The ninth phase of water chemistry monitoring of the nearshore ocean and anchialine ponds was carried out on November 7, 1992. Twenty-eight water samples were collected along three transects running from the shoreline, through lagoon-like areas behind a beach rock berm, out to the open ocean. Samples were analyzed for chemical criteria specified by DOH water quality standards. In addition, six water samples were collected from three representative ponds at high and low tides.

2. Groundwater entering the nearshore ocean was apparent during the November 1992 survey at Site 3. Water chemistry constituents that are found in high concentration in groundwater (Si, NO_3^-, PO_4^{3-}, freshwater) were substantially elevated within 10 m of the shoreline. Groundwater efflux was only slightly evident at Site 2 and not at all evident at Site 1. Beyond the nearshore area in the lagoons, mixing of groundwater and ocean water is complete; materials originating from groundwater input are not retained within the natural lagoons near the shoreline.

3. Vertical stratification was not apparent within the sampling regime, apparently as a result of substantial physical mixing processes that homogenize groundwater and ocean water constituents.

4. Most water chemistry constituents that do not occur in high concentrations in groundwater did not display any recognizable trend with distance from shore. Turbidity was elevated in the samples closest to shore, and essentially constant over the remainder of the ocean transects. Chl a showed no trends with distance offshore or among sites.

5. Comparative results of the nine monitoring surveys to date indicate that there is some natural variability in the input and mixing characteristics of groundwater efflux, especially at Sites 1 and 3. With the exception of temperature, there are no apparent seasonal trends with respect to most water chemistry constituents off the Kaupulehu site. Variations in

chemical constituency appears to be more a result of short-term processes (tidal stage and turbulent mixing) rather than time of year.

6. Scaling nutrient concentrations to salinity indicates that there was an external source of NO_3^- to the nearshore ocean during the 1990 and 1991 samplings. Residual ammonium nitrate used for blasting appeared to have been the origin of the extraneous NO_3^-. Continuous monitoring over the past two years, however, has shown that the majority of the NO_3^- subsidy has been leached from the system. During the most recent survey (November 1992) there is no indication of a subsidy of NO_3^- to nearshore marine waters. High levels of NH_4^+ do not appear to be a result of activities on land, but rather from biological activity within the marine environment. Mixing analyses indicate that PO_4^{3-} is not being added to nearshore waters from activities on land.

7. Comparing measurements of water chemistry parameters to DOH standards reveals that NO_3^- exceeded specified criteria during November 1992. It is evident that natural inputs of groundwater can result in concentrations exceeding DOH limits since most of the concentrations above specific criteria occurred at Site 3, the only site to show substantial groundwater input.

8. Water quality characteristics in the three monitoring anchialine ponds suggest that the ponds are not flushing completely with tidal exchange; rather pond water appears to be somewhat confined and floats over the underlying water table. Water quality within the ponds did not vary substantially between pre- and during- construction monitoring surveys. There is an indication of increased NO_3^- only during July 1990, presumably as a result of leaching of blasting material. Such nutrient subsidies are not a likely cause of alteration of biotic structure of the ponds.

9. The next phase of the Kaupulehu water chemistry monitoring will be carried out in January-May quarter of 1993.

REFERENCES CITED

Grasshoff, K. 1983. Methods of seawater analysis. Vera Cheyenne, Weiner. 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 measurements off the KLC project area collected November 7, 1992. Abbreviations as follows: DFS = distance from shore; S = surface; D = deep. Shaded values exceed DOH criteria for open coastal waters under "wet" conditions. For sampling site locations, see Figure 1.

SITE	NO.	DFS (m)	PO4 (μM)	NO3 (μM)	NH4 (μM)	Si (μM)	DOP (μM)	DON (μM)	TP (μM)	TN (μM)	TURB (NTU)	SALINITY (o/oo)	CHL a (μg/L)	TEMP (deg.C)	pH
KLC-1-	1-S	0.1	0.11	0.23	0.03	7.32	0.37	8.37	0.48	8.63	0.16	34.449	0.14	26.5	8.25
	2-S	3	0.13	0.21	0.01	7.41	0.22	8.18	0.35	8.40	0.11	34.444	0.10	26.5	8.24
	3-S	5	0.13	0.39	0.05	8.84	0.24	7.31	0.37	7.75	0.10	34.416	0.15	26.5	8.22
	4-S	10	0.13	0.43	0.03	8.86	0.24	6.87	0.37	7.33	0.08	34.419	0.18	26.3	8.20
	4-D	10	0.13	0.44	0.04	8.92	0.35	8.75	0.48	9.23	0.14	34.420	0.29	26.4	8.20
	5-S	50	0.13	0.60	0.12	9.69	0.28	7.91	0.41	8.63	0.09	34.408	0.16	26.2	8.18
	5-D	50	0.14	0.59	0.14	9.43	0.24	8.31	0.38	9.04	0.10	34.406	0.09	26.3	8.19
	6-S	100	0.13	0.38	0.06	5.85	0.33	7.75	0.46	8.19	0.09	34.533	0.13	26.2	8.17
	6-D	100	0.12	0.37	0.13	6.34	0.32	8.27	0.44	8.77	0.15	34.516	0.12	26.4	8.16
KLC-2-	1-S	0.1	0.11	0.58	0.09	11.02	0.30	8.21	0.41	8.88	0.13	34.298	0.12	26.9	8.23
	2-S	1	0.11	0.40	0.14	10.31	0.29	7.46	0.40	8.00	0.12	34.322	0.10	27.0	8.23
	3-S	3	0.10	0.46	0.79	35.66	0.37	9.33	0.47	10.58	0.13	34.317	0.14	27.0	8.23
	4-S	5	0.11	0.41	0.15	10.07	0.24	7.25	0.35	7.81	0.11	34.348	0.16	26.9	8.21
	5-S	10	0.13	0.25	0.18	7.69	0.35	6.98	0.48	7.41	0.10	34.440	0.10	26.5	8.18
	5-D	10	0.11	0.22	0.18	7.57	0.28	7.46	0.39	7.86	0.14	34.437	0.08	26.6	8.18
	6-S	50	0.12	0.19	0.16	7.41	0.27	7.66	0.39	8.01	0.09	34.446	0.10	26.8	8.17
	6-D	50	0.10	0.19	0.21	7.43	0.34	4.64	0.44	5.04	0.12	34.439	0.09	26.6	8.17
	7-S	100	0.11	0.23	0.17	7.64	0.31	8.44	0.42	8.84	0.11	34.439	0.08	26.6	8.19
	7-D	100	0.10	0.21	0.17	7.88	0.31	9.58	0.41	9.96	0.16	34.439	0.24	26.6	8.19
KLC-3-	1-S	0.1	0.66	23.81	0.55	160.79	0.21	7.46	0.87	31.82	0.13	29.697	0.27	26.6	8.19
	2-S	3	0.50	14.24	0.43	119.04	0.21	8.14	0.71	22.81	0.12	31.119	0.09	26.7	8.17
	3-S	5	0.39	8.50	0.43	79.26	0.20	6.46	0.59	15.39	0.15	32.343	0.14	26.6	8.24
	4-S	10	0.15	1.24	0.36	19.39	0.29	6.37	0.44	7.97	0.14	34.074	0.09	26.7	8.25
	4-D	10	0.16	1.29	0.34	21.71	0.28	6.89	0.44	8.52	0.15	34.004	0.18	26.8	8.26
	5-S	50	0.16	1.54	0.33	26.00	0.29	6.49	0.45	8.36	0.13	33.897	0.10	26.6	8.23
	5-D	50	0.17	1.36	0.34	24.94	0.30	6.84	0.47	8.54	0.11	33.921	0.10	26.6	8.24
	6-S	100	0.18	1.83	0.32	26.84	0.28	6.36	0.46	8.51	0.13	33.882	0.09	26.5	8.20
	6-D	100	0.13	0.51	0.25	12.78	0.28	5.31	0.41	6.07	0.15	34.292	0.20	26.5	8.17
WELL			5.26	140.4	0.21	1014.0						1.467	0.09		
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 2. Water chemistry measurements (in µg/L) off the KLC project area collected November 7, 1992. Abbreviations as follows: DFS = distance from shore; S = surface; D = deep. Shaded values exceed DOH criteria for open coastal waters under "wet" conditions. For sampling site locations, see Figure 1.

SITE	NO.	DFS (m)	PO4 (µg/L)	NO3 (µg/L)	NH4 (µg/L)	Si (µg/L)	DOP (µg/L)	DON (µg/L)	TP (µg/L)	TN (µg/L)	TURB (NTU)	SALINITY (o/oo)	CHL a (µg/L)	TEMP (deg.C)	pH
KLC-1-	1-S	0.1	3.41	3.22	0.42	206	11.47	117.18	14.88	120.82	0.16	34.449	0.14	26.5	8.25
	2-S	3	4.03	2.94	0.14	208	6.82	114.52	10.85	117.60	0.11	34.444	0.10	26.5	8.24
	3-S	5	4.03	5.46	0.70	248	7.44	102.34	11.47	108.50	0.10	34.416	0.15	26.5	8.22
	4-S	10	4.03	6.02	0.42	249	7.44	96.18	11.47	102.62	0.08	34.419	0.18	26.3	8.20
	4-D	10	4.03	6.16	0.56	251	10.85	122.50	14.88	129.22	0.14	34.420	0.29	26.4	8.20
	5-S	50	4.03	8.40	1.68	272	8.68	110.74	12.71	120.82	0.09	34.408	0.16	26.2	8.18
	5-D	50	4.34	8.26	1.96	265	7.44	116.34	11.78	126.56	0.10	34.406	0.09	26.3	8.19
	6-S	100	4.03	5.32	0.84	164	10.23	108.50	14.26	114.66	0.09	34.533	0.13	26.2	8.17
	6-D	100	3.72	5.18	1.82	178	9.92	115.78	13.64	122.78	0.15	34.516	0.12	26.4	8.16
KLC-2-	1-S	0.1	3.41	8.12	1.26	310	9.30	114.94	12.71	124.32	0.13	34.298	0.12	26.9	8.23
	2-S	1	3.41	5.60	1.96	290	8.99	104.44	12.40	112.00	0.12	34.322	0.10	27.0	8.23
	3-S	3	3.10	6.44	11.06	1002	11.47	130.62	14.57	148.12	0.13	34.317	-0.14	27.0	8.23
	4-S	5	3.41	5.74	2.10	283	7.44	101.50	10.85	109.34	0.11	34.348	0.16	26.9	8.21
	5-S	10	4.03	3.50	2.52	216	10.85	97.72	14.88	103.74	0.10	34.440	0.10	26.5	8.18
	5-D	10	3.41	3.08	2.52	213	8.68	104.44	12.09	110.04	0.14	34.437	0.08	26.6	8.18
	6-S	50	3.72	2.66	2.24	208	8.37	107.24	12.09	112.14	0.09	34.446	0.10	26.8	8.17
	6-D	50	3.10	2.66	2.94	209	10.54	64.96	13.64	70.56	0.12	34.439	0.09	26.6	8.17
	7-S	100	3.41	3.22	2.38	215	9.61	118.16	13.02	123.76	0.11	34.439	0.08	26.6	8.19
	7-D	100	3.10	2.94	2.38	221	9.61	134.12	12.71	139.44	0.16	34.439	0.24	26.6	8.19
KLC-3-	1-S	0.1	20.46	333.34	7.70	4518	6.51	104.44	26.97	445.48	0.13	29.697	0.27	26.6	8.19
	2-S	3	15.50	199.36	6.02	3345	6.51	113.96	22.01	319.34	0.12	31.119	0.09	26.7	8.17
	3-S	5	12.09	119.00	6.02	2227	6.20	90.44	18.29	215.46	0.15	32.343	0.14	26.6	8.24
	4-S	10	4.65	17.36	5.04	545	8.99	89.18	13.64	111.58	0.14	34.074	0.09	26.7	8.25
	4-D	10	4.96	18.06	4.76	610	8.68	96.46	13.64	119.28	0.15	34.004	0.18	26.8	8.26
	5-S	50	4.96	21.56	4.62	731	8.99	90.86	13.95	117.04	0.13	33.897	0.10	26.6	8.23
	5-D	50	5.27	19.04	4.76	701	9.30	95.76	14.57	119.56	0.11	33.921	0.10	26.6	8.24
	6-S	100	5.58	25.62	4.48	754	8.68	89.04	14.26	119.14	0.13	33.882	0.09	26.5	8.20
	6-D	100	4.03	7.14	3.50	359	8.68	74.34	12.71	84.98	0.15	34.292	0.20	26.5	8.17
WELL			163	1965	2.94	28392						1.467	0.09		
DOH WATER QUAL. STDS.															
NOT TO EXCEED 10%				14.00	8.50				40.00	250.00	1.25		0.90		
NOT TO EXCEED 2%				25.00	15.00				60.00	350.00	2.00		1.75		

TABLE 3. Geometric mean data from water chemistry measurements off the KLC project area collected during nine monitoring surveys over the period from December 1989 - November 1992. Abbreviations as follows: DFS = distance from shore; S = surface; D = deep. Measurements below detection limit were not included in mean calculations. Shaded values exceed DOH geometric mean criteria for open coastal waters under "wet" conditions. For sampling site locations, see Figure 1.

SITE	NO.	DFS (m)	PO4 (µM)	NO3 (µM)	NH4 (µM)	Si (µM)	DOP (µM)	DON (µM)	TP (µM)	TN (µM)	TURB (NTU)	SALINITY (o/oo)	CHL a (µg/L)	TEMP (deg.C)
KLC-1	1-S	0.1	0.16	1.83	0.44	21.41	0.20	6.75	0.40	18.60	0.22	30.705	0.54	26.3
	2-S	3	0.15	1.12	0.21	18.06	0.21	7.17	0.38	13.99	0.18	32.578	0.30	26.2
	3-S	5	0.13	1.10	0.23	13.99	0.22	7.13	0.35	11.30	0.19	33.201	0.24	26.1
	4-S	10	0.12	0.97	0.22	12.90	0.17	6.37	0.30	9.17	0.18	33.999	0.23	25.7
	4-D	10	0.13	1.00	0.17	13.08	0.19	6.46	0.34	9.13	0.17	34.020	0.22	25.7
	5-S	50	0.12	0.72	0.24	10.49	0.17	6.46	0.30	8.18	0.15	34.213	0.19	25.7
	5-D	50	0.12	0.62	0.23	10.09	0.17	6.22	0.29	7.44	0.16	34.295	0.16	25.9
	6-S	100	0.09	0.35	0.21	6.52	0.20	6.21	0.29	6.89	0.13	34.514	0.16	25.9
	6-D	100	0.09	0.27	0.21	5.89	0.20	6.19	0.30	6.67	0.14	34.526	0.15	26.0
KLC-2	1-S	0.1	0.10	1.76	0.27	17.16	0.20	7.84	0.33	11.24	0.22	33.989	0.38	26.5
	2-S	1	0.10	1.49	0.24	14.62	0.20	6.53	0.32	9.38	0.19	34.058	0.18	26.2
	3-S	3	0.08	0.69	0.34	11.61	0.20	6.46	0.29	7.81	0.20	34.348	0.18	26.1
	4-S	5	0.08	0.55	0.30	9.49	0.20	6.29	0.29	7.38	0.18	34.369	0.18	26.1
	5-S	10	0.10	0.46	0.24	9.06	0.19	5.97	0.30	6.92	0.16	34.402	0.18	25.9
	5-D	10	0.09	0.46	0.24	8.72	0.19	5.55	0.29	6.44	0.15	34.399	0.13	26.0
	6-S	50	0.08	0.51	0.32	8.34	0.20	5.73	0.29	6.67	0.16	34.432	0.15	26.0
	6-D	50	0.08	0.46	0.29	7.91	0.20	5.35	0.28	6.19	0.15	34.455	0.15	26.1
	7-S	100	0.10	0.14	0.29	4.60	0.19	5.29	0.31	5.78	0.11	34.610	0.10	26.1
	7-D	100	0.08	0.17	0.16	4.19	0.23	6.34	0.31	6.70	0.12	34.609	0.11	26.0
KLC-3	1-S	0.1	0.44	9.82	0.65	75.89	0.18	7.07	0.72	23.27	0.18	29.244	0.47	26.4
	2-S	3	0.24	4.51	0.60	43.67	0.21	7.90	0.54	17.60	0.20	31.606	0.28	26.3
	3-S	5	0.20	2.91	0.39	28.66	0.20	6.56	0.42	11.50	0.18	33.311	0.23	26.1
	4-S	10	0.13	1.51	0.33	18.33	0.23	7.33	0.37	9.91	0.16	33.874	0.17	26.1
	4-D	10	0.12	1.37	0.32	17.36	0.22	6.70	0.35	8.98	0.16	33.961	0.24	26.0
	5-S	50	0.13	1.00	0.32	14.29	0.21	6.90	0.35	9.02	0.15	34.025	0.17	26.0
	5-D	50	0.11	0.75	0.29	11.84	0.20	6.26	0.31	7.47	0.15	34.258	0.17	26.0
	6-S	100	0.10	0.25	0.20	5.56	0.20	6.10	0.31	6.70	0.13	34.490	0.13	26.1
	6-D	100	0.08	0.15	0.18	4.55	0.22	6.06	0.30	6.41	0.13	34.563	0.14	26.1
DOH WATER QUAL. STDS.				0.36	0.25				0.64	10.71	0.50		0.30	

TABLE 4. Geometric mean data (in μg/L) from water chemistry measurements off the KLC project area collected during nine monitoring surveys over the period from December 1989 - November 1992. Abbreviations as follows: DFS = distance from shore; S = surface; D = deep. Measurements below detection limit were not included in mean calculations. Shaded values exceed DOH geometric mean criteria for open coastal waters under "wet" conditions. For sampling site locations, see Figure 1.

SITE	NO.	DFS (m)	PO4 (μg/L)	NO3 (μg/L)	NH4 (μg/L)	Si (μg/L)	DOP (μg/L)	DON (μg/L)	TP (μg/L)	TN (μg/L)	TURB (NTU)	SALINITY (o/oo)	CHL a (μg/L)	TEMP (deg.C)
KLC-1-	1-S	0.1	4.93	25.58	6.21	600	6.28	94.50	12.54	260.37	0.22	30.705	0.54	26.3
	2-S	3	4.59	15.62	2.98	506	6.37	100.41	11.80	195.84	0.18	32.578	0.30	26.2
	3-S	5	3.95	15.36	3.28	392	6.74	99.77	10.94	158.23	0.19	33.201	0.24	26.1
	4-S	10	3.73	13.52	3.08	361	5.31	89.23	9.32	128.37	0.18	33.999	0.23	25.7
	4-D	10	4.14	14.05	2.42	366	6.00	90.45	10.60	127.81	0.17	34.020	0.22	25.7
	5-S	50	3.77	10.12	3.37	294	5.23	90.43	9.25	114.55	0.15	34.213	0.19	25.7
	5-D	50	3.61	8.73	3.24	283	5.34	87.14	9.13	104.17	0.16	34.295	0.16	25.9
	6-S	100	2.75	4.86	2.93	182	6.15	86.96	9.08	96.40	0.13	34.514	0.16	25.9
	6-D	100	2.78	3.74	3.00	165	6.30	86.69	9.21	93.45	0.14	34.526	0.15	26.0
KLC-2-	1-S	0.1	3.19	24.70	3.76	480	6.29	109.72	10.16	157.39	0.22	33.989	0.38	26.5
	2-S	1	3.13	20.86	3.37	409	6.29	91.44	9.83	131.36	0.19	34.058	0.18	26.2
	3-S	3	2.59	9.64	4.76	325	6.15	90.50	8.96	109.40	0.20	34.348	0.18	26.1
	4-S	5	2.51	7.75	4.17	266	6.25	88.10	8.86	103.26	0.18	34.369	0.18	26.1
	5-S	10	2.99	6.44	3.29	254	5.99	83.59	9.31	96.86	0.16	34.402	0.18	25.9
	5-D	10	2.82	6.46	3.36	244	5.79	77.63	8.86	90.11	0.15	34.399	0.13	26.0
	6-S	50	2.60	7.18	4.53	234	6.08	80.25	8.91	93.36	0.16	34.432	0.15	26.0
	6-D	50	2.49	6.44	4.12	222	6.26	74.87	8.83	86.69	0.15	34.455	0.15	26.1
	7-S	100	3.15	2.03	4.12	129	5.79	74.13	9.61	80.92	0.11	34.610	0.10	26.1
	7-D	100	2.51	2.35	2.31	117	7.01	88.76	9.73	93.74	0.12	34.609	0.11	26.0
KLC-3-	1-S	0.1	13.64	137.41	9.07	2125	5.51	99.00	22.29	325.76	0.18	29.244	0.47	26.4
	2-S	3	7.59	63.08	8.38	1223	6.37	110.55	16.72	246.45	0.20	31.606	0.28	26.3
	3-S	5	6.08	40.80	5.49	802	6.29	91.90	13.02	160.98	0.18	33.311	0.23	26.1
	4-S	10	4.17	21.15	4.67	513	7.04	102.66	11.50	138.71	0.16	33.874	0.17	26.1
	4-D	10	3.57	19.21	4.54	486	6.67	93.82	10.77	125.77	0.16	33.961	0.24	26.0
	5-S	50	4.06	14.05	4.47	400	6.36	96.57	10.71	126.33	0.15	34.025	0.17	26.0
	5-D	50	3.42	10.52	4.11	332	6.22	87.57	9.76	104.58	0.15	34.258	0.17	26.0
	6-S	100	3.16	3.44	2.85	156	6.30	85.41	9.62	93.84	0.13	34.490	0.13	26.1
	6-D	100	2.35	2.07	2.57	127	6.79	84.77	9.29	89.78	0.13	34.563	0.14	26.1
DOH WATER QUAL. STDS.				5.00	3.50				20.00	150.00	0.50		0.30	

TABLE 5. Water chemistry measurements from monitoring ponds on the KHV property collected on nine monitoring surveys over the period from December 1989 - November 1992 during high (HI) and low (LO) tides. For chemical abbreviations, see "methods" section. "BDL" = below detection limit; "NA" = not available. For pond locations, see Figure 1.

DATE	POND NO.	TIDE	PO4 (µM)	NO3 (µM)	NH4 (µM)	SI (µM)	DOP (µM)	DON (µM)	TP (µM)	TN (µM)	TURB (ntu)	SALINITY (o/oo)	CHL. a (µg/L)	pH
DEC 1989	1	HI	4.12	112.80	2.14	872.54	0.06	1.44	4.18	116.38	0.87	2.854	0.40	8.26
		LO	5.85	164.40	4.39	874.82	0.14	2.21	5.99	171.00	0.96	2.930	0.48	8.04
	5	HI	4.99	132.70	0.89	881.56	0.24	5.22	5.23	138.81	0.74	3.013	0.88	8.14
		LO	5.09	146.40	1.50	894.88	0.14	2.00	5.23	149.90	0.85	3.426	0.92	8.08
	7	HI	4.84	94.70	0.45	835.65	0.01	10.01	4.85	105.16	1.02	3.759	1.40	8.01
		LO	5.02	135.50	1.30	857.36	0.11	1.10	5.13	137.90	1.28	5.637	1.45	7.75
MAR 1990	1	HI	3.82	106.20	1.56	863.17	0.01	5.22	3.83	113.00	0.70	2.744	0.21	8.52
		LO	5.72	145.60	3.04	853.11	0.60	12.56	6.32	161.20	1.01	2.738	0.32	8.13
	5	HI	5.11	147.60	0.77	898.40	BDL	3.66	5.11	152.00	0.88	3.017	0.12	8.20
		LO	5.55	165.30	0.37	903.43	0.02	5.73	5.57	171.40	0.94	3.032	0.16	7.80
	7	HI	3.36	46.91	0.11	873.24	0.5	20.56	3.9	67.58	1.15	3.547	1.24	8.08
		LO	5.82	161.20	0.69	883.30	0.03	3.38	5.85	165.30	1.34	3.886	1.11	7.57
JUL 1990	1	HI	5.93	254.00	6.00	910.90	BDL	1.09	5.93	261.10	0.43	2.763	0.21	8.54
		LO	5.44	255.30	4.88	910.90	0.12	1.57	5.56	261.70	1.00	2.791	0.34	8.21
	5	HI	5.51	159.80	1.29	930.54	0.14	6.54	5.65	167.50	0.75	3.142	0.44	8.19
		LO	4.96	67.52	1.67	930.54	0.95	26.07	5.91	95.26	0.95	3.203	0.17	7.99
	7	HI	5.72	161.10	0.19	908.55	BDL	5.62	5.72	166.90	1.02	3.860	0.05	8.10
		LO	3.42	0.41	15.35	930.54	2.79	62.73	6.21	78.49	1.42	4.438	10.03	7.87
OCT 1990	1	HI	7.28	183.97	0.25	894.61	BDL	0.35	7.28	184.57	0.21	2.789	0.04	8.15
		LO	3.68	128.95	0.12	901.84	0.66	8.85	4.34	137.92	1.02	2.952	0.28	8.75
	5	HI	5.44	156.46	2.14	916.50	0.12	1.45	5.56	160.05	0.32	3.006	0.09	8.02
		LO	4.56	132.54	2.14	923.93	0.59	9.22	5.15	143.90	0.81	3.041	0.70	7.99
	7	HI	5.81	168.42	0.19	906.73	0.03	1.01	5.84	169.62	0.17	3.395	0.01	8.06
		LO	2.94	88.29	1.15	867.63	1.00	19.18	3.94	108.62	1.13	3.138	1.34	8.67
MAR 1991	1	HI	5.93	237.14	0.51	861.63	0.29	9.14	6.22	246.79	0.13	2.669	0.04	8.15
		LO	5.50	217.82	1.71	864.07	0.57	17.61	6.07	237.14	0.26	2.681	0.28	8.18
	5	HI	5.50	165.40	0.66	873.46	0.22	9.00	5.72	175.06	0.11	3.066	0.09	8.45
		LO	5.07	151.61	1.05	878.15	0.25	9.98	5.32	162.64	0.30	2.981	0.70	8.33
	7	HI	5.79	176.44	0.19	873.83	0.21	9.46	6.00	186.09	0.14	3.345	0.01	8.18
		LO	4.57	150.92	0.51	856.93	0.36	12.59	4.93	164.02	0.25	3.640	1.34	8.26
AUG 1991	1	HI	5.60	183.12	0.03	865.45	0.05	2.15	5.65	185.30	0.11	2.729	0.11	8.32
		LO	3.19	121.23	2.44	851.46	0.03	2.41	3.22	126.08	0.25	2.759	0.99	8.35
	5	HI	4.61	140.64	1.75	888.78	0.04	1.90	4.65	144.29	0.21	3.055	0.20	8.34
		LO	4.26	115.16	4.95	888.78	0.02	1.12	4.28	121.23	0.28	3.059	0.24	8.32
	7	HI	4.89	149.14	BDL	874.78	0.05	1.21	4.94	150.35	0.19	3.552	0.18	8.33
		LO	5.18	149.14	1.12	874.78	0.03	1.31	5.21	151.57	0.18	3.392	0.12	8.08
DEC 1991	1	HI	5.58	178.70	1.29	911.25	0.02	1.05	5.60	181.04	0.50	2.682	0.26	8.01
		LO	5.50	182.00	0.35	906.85	0.03	0.29	5.53	182.64	0.28	2.709	0.09	8.06
	5	HI	4.86	143.30	3.45	928.67	0.04	1.11	4.90	147.86	0.96	3.012	0.41	7.77
		LO	4.88	142.77	2.75	928.43	0.04	0.29	4.92	145.81	0.70	3.010	0.34	7.76
	7	HI	5.13	151.87	0.23	914.64	0.03	0.53	5.16	152.63	0.30	3.456	0.05	NA
		LO	5.16	151.23	0.03	918.62	0.02	0.92	5.18	152.18	0.37	3.401	0.05	7.88
APR 1992	1	HI	2.95	107.01	2.78	791.94	0.22	5.51	3.17	115.30	0.49	2.717	2.94	8.59
		LO	4.84	153.83	1.71	888.00	0.04	3.39	4.88	158.93	0.34	3.120	0.26	7.85
	5	HI	4.12	146.40	3.07	852.76	0.07	2.22	4.19	151.69	0.31	2.715	1.05	8.21
		LO	3.65	111.65	1.93	829.45	0.27	12.37	3.92	125.95	0.47	3.387	1.53	8.45
	7	HI	4.71	146.73	3.23	887.48	BDL	3.22	4.71	153.18	0.33	3.111	0.37	7.96
		LO	4.20	131.33	3.30	856.37	0.22	5.98	4.42	140.61	0.42	3.398	0.90	8.20
NOV 1992	1	HI	4.52	159.63	0.31	758.24	0.09	4.78	4.61	164.72	0.35	2.768	1.02	8.48
		LO	5.29	182.00	0.32	768.69	0.15	2.50	5.44	184.82	0.26	2.732	0.13	8.14
	5	HI	4.58	150.47	0.45	775.94	0.14	6.38	4.72	157.30	0.39	3.089	0.14	7.95
		LO	4.57	149.63	0.80	777.65	0.14	6.54	4.71	156.97	0.32	3.068	0.15	7.82
	7	HI	4.43	137.97	3.04	776.20	0.08	12.03	4.51	153.04	0.79	3.442	1.34	8.16
		LO	4.39	143.95	5.44	774.44	0.28	8.91	4.67	158.30	0.78	3.451	1.15	7.84

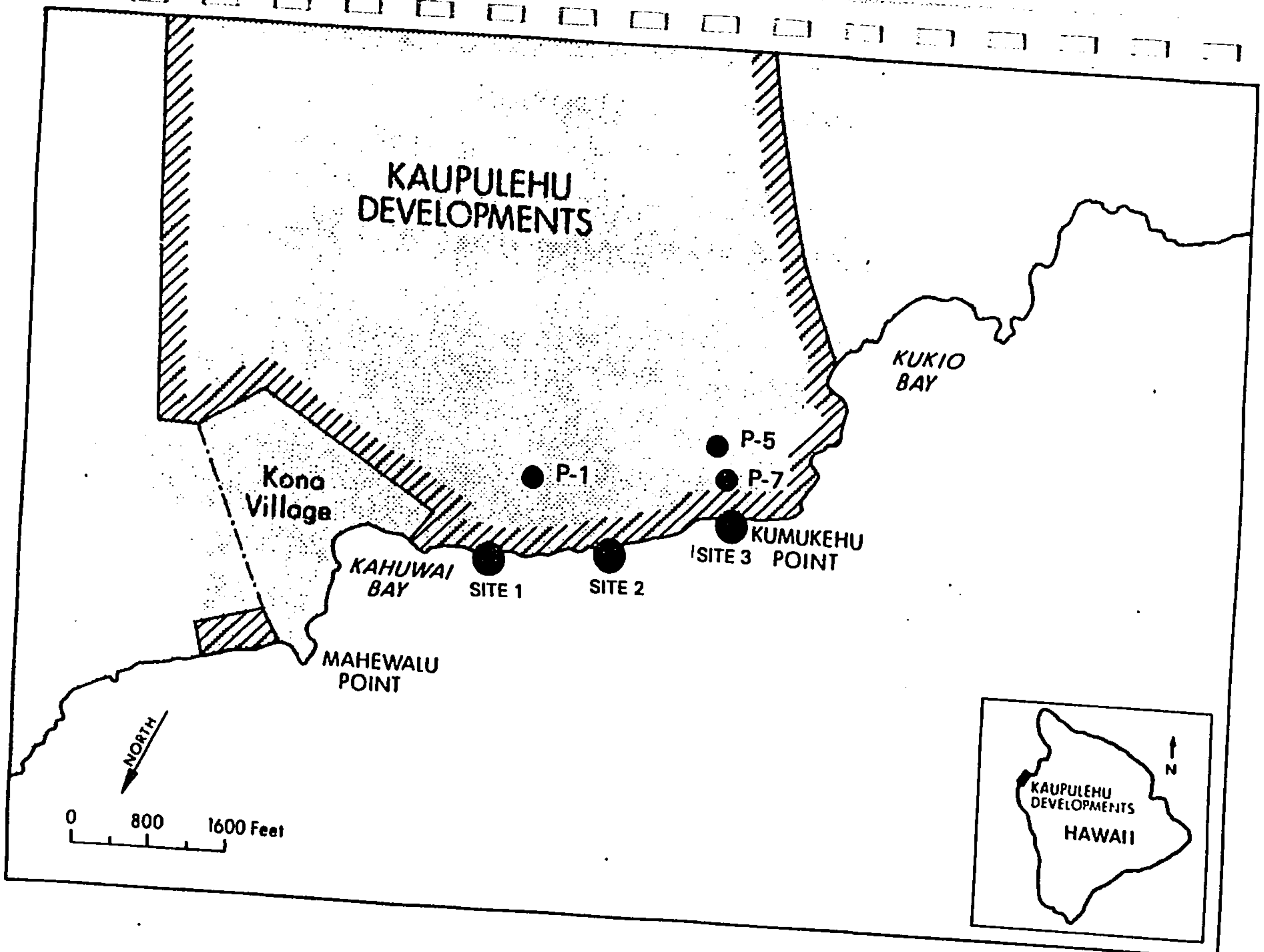

FIGURE 1. Map showing location of Kaupulehu Land Company development on the west coast of the Island of Hawaii. Water chemistry transect site 1-3 locations, and anchialine ponds P-1, P-5 and P-7 are also shown.

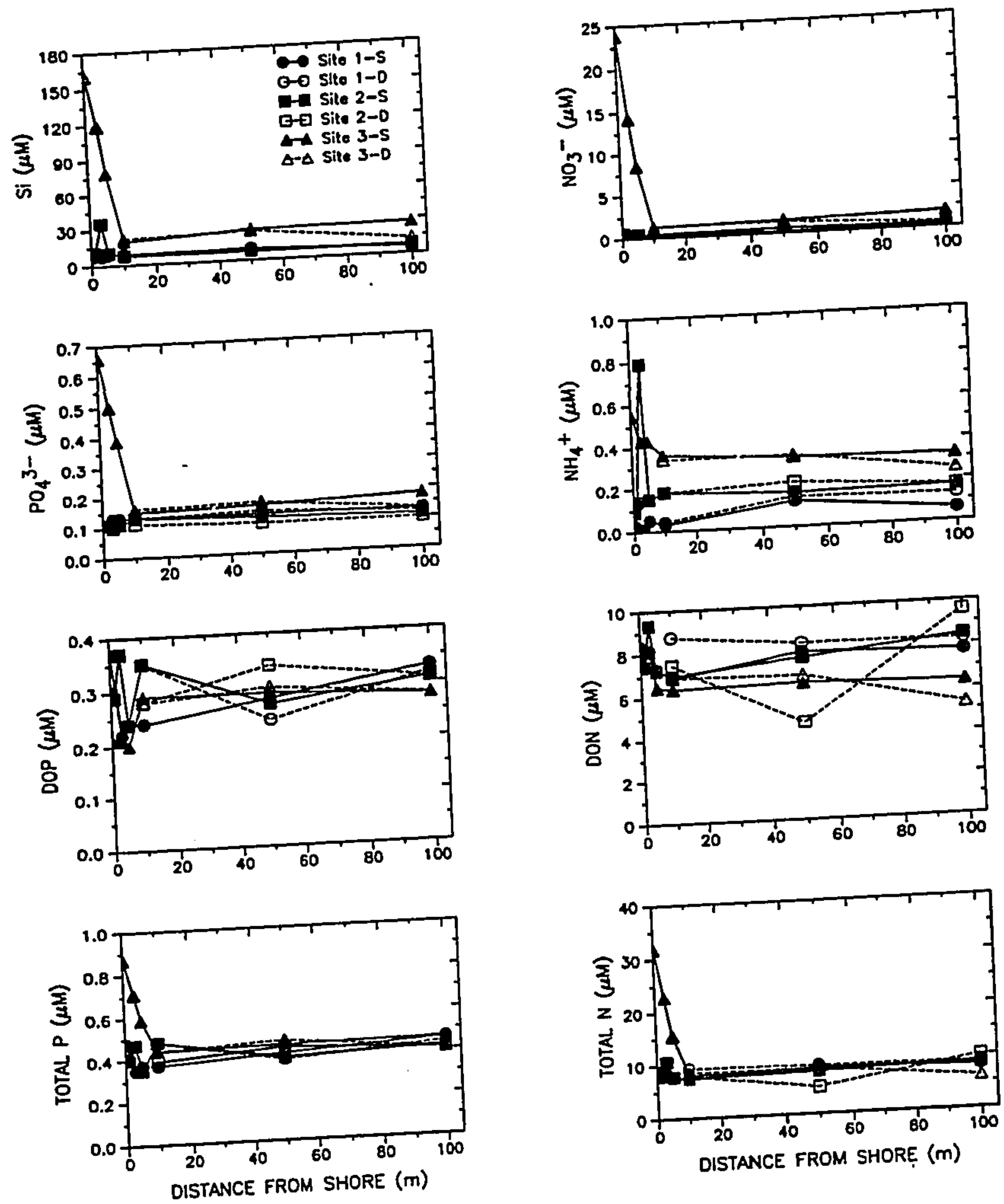

FIGURE 2. Plots of dissolved nutrients as functions of distance from the shoreline at three sites off the KLC project area collected in November 1992. "S" indicates surface sample; "D" indicates deep sample. For site locations, see Figure 1.

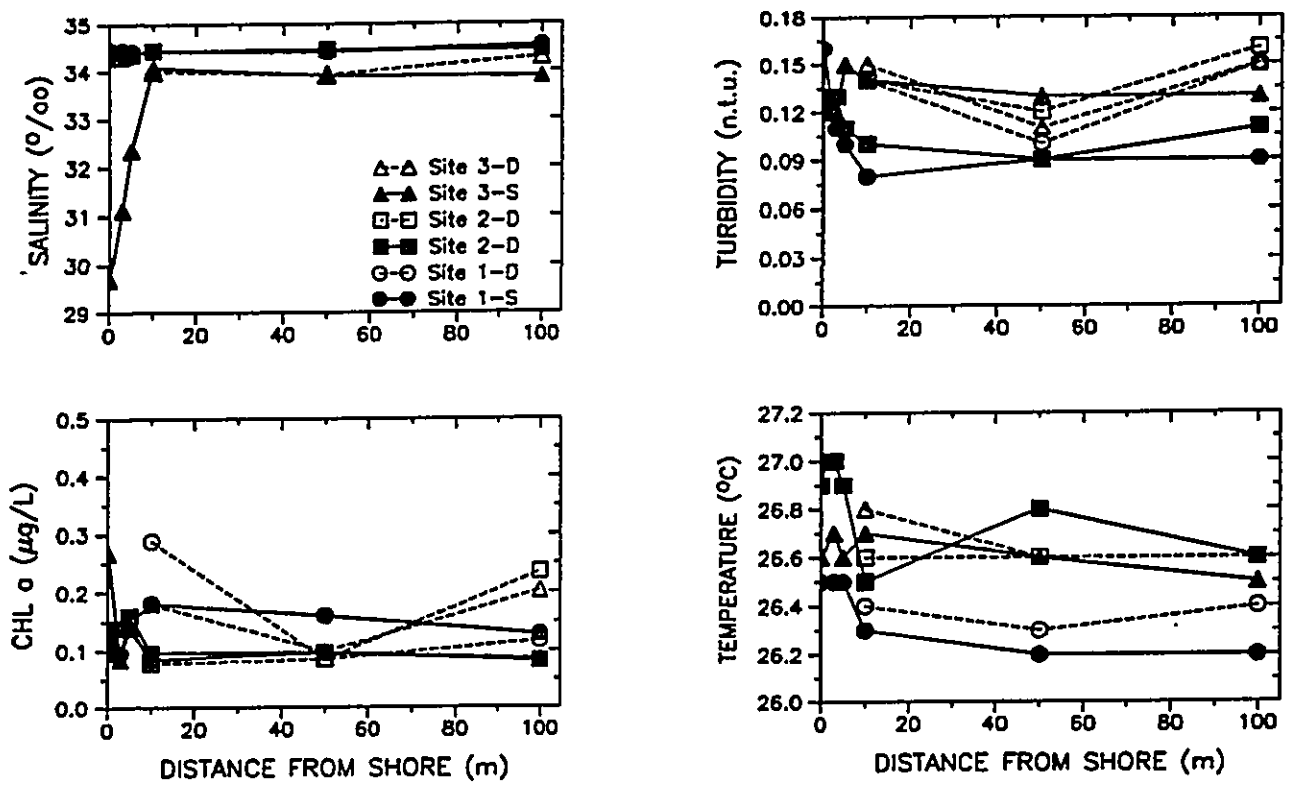

FIGURE 3. Plots of water chemistry constituents as functions of distance from the shoreline at three sites off the KLC project area collected in November 1992. "S" indicates surface sample; "D" indicates deep sample. For site locations, see Figure 1.

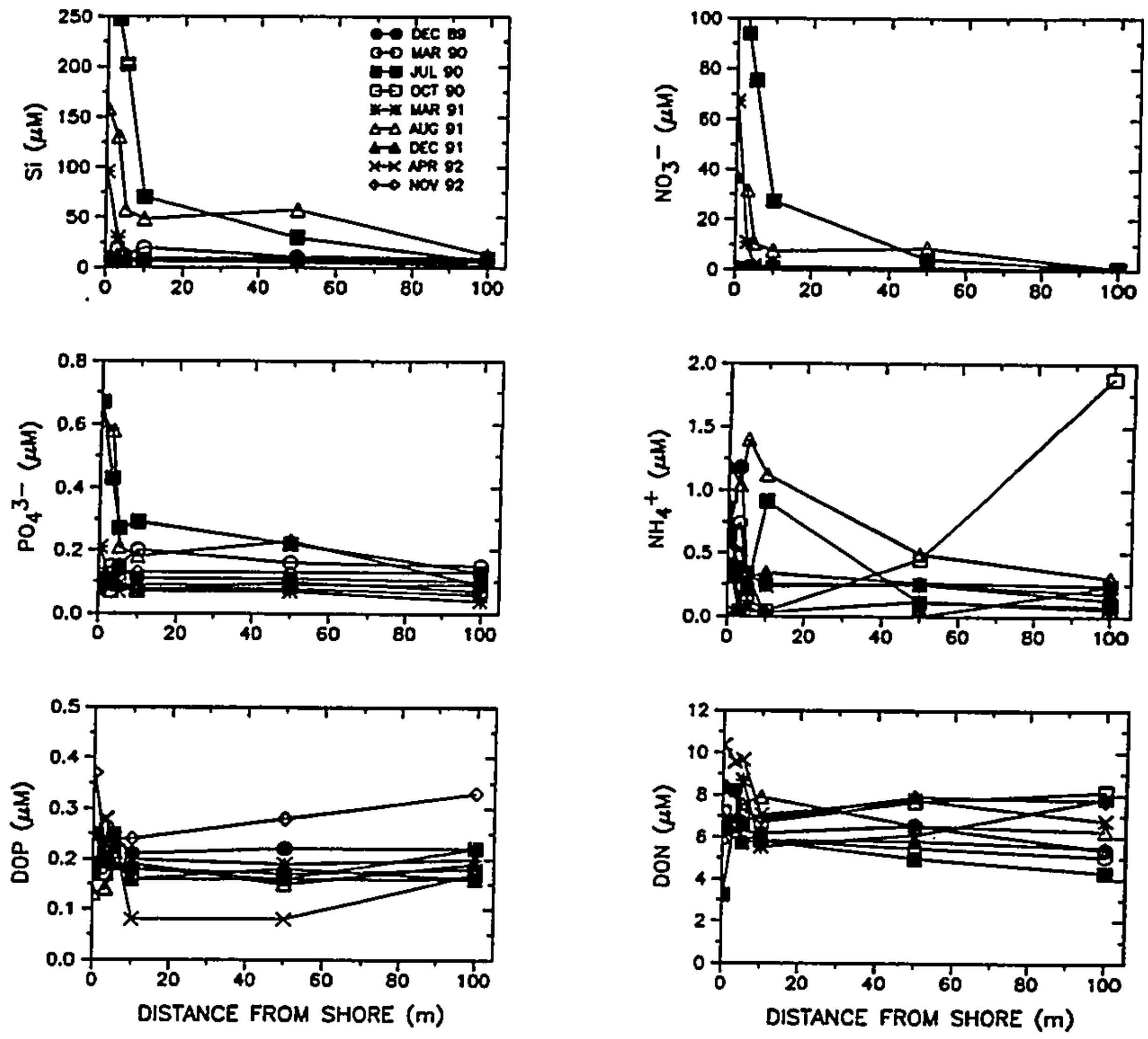

FIGURE 4. Plots of surface water dissolved nutrients as functions of distance from the shoreline at Site 1 collected during nine monitoring surveys over the period from December 1989 - November 1992 off the KLC project area. For location of Site 1, see Figure 1.

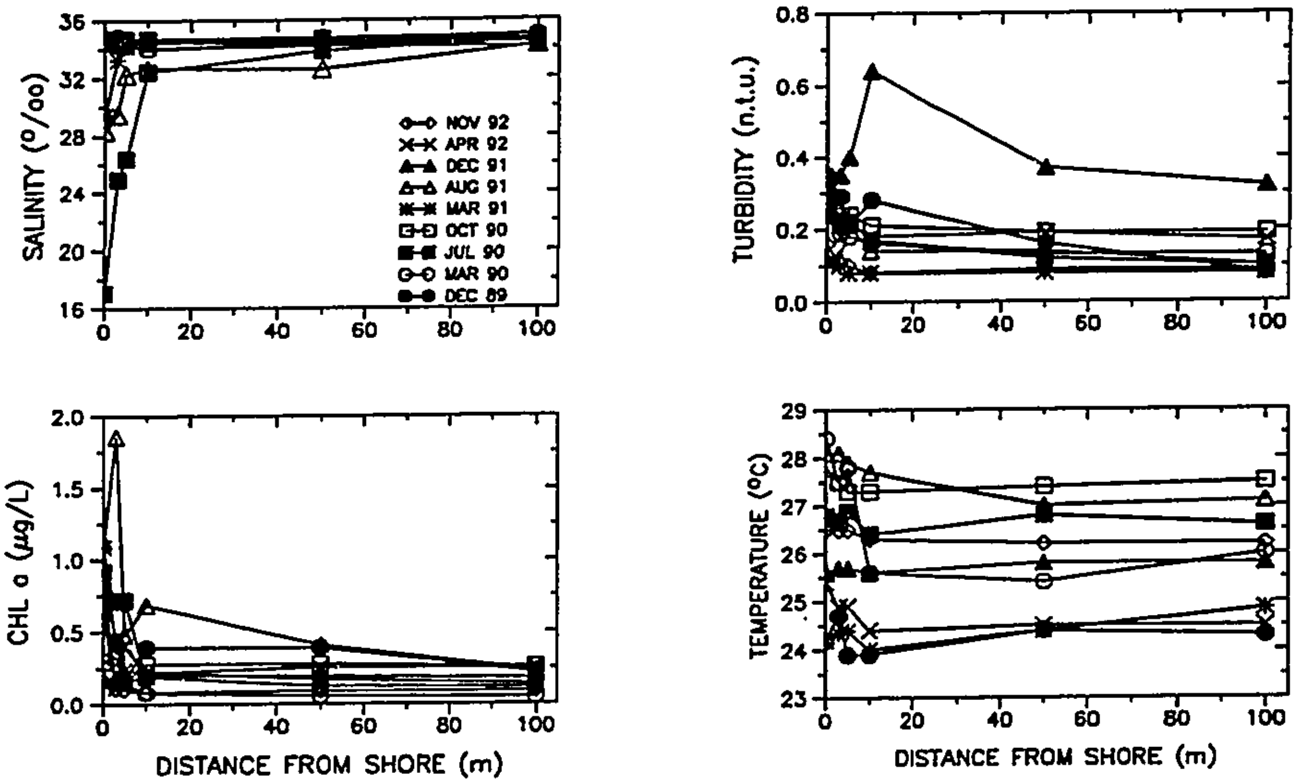

FIGURE 5. Plots of surface water chemistry constituents as functions of distance from the shoreline at Site 1 collected during nine monitoring surveys from December 1989 - November 1992 off the KLC project area. For location of Site 1, see Figure 1.

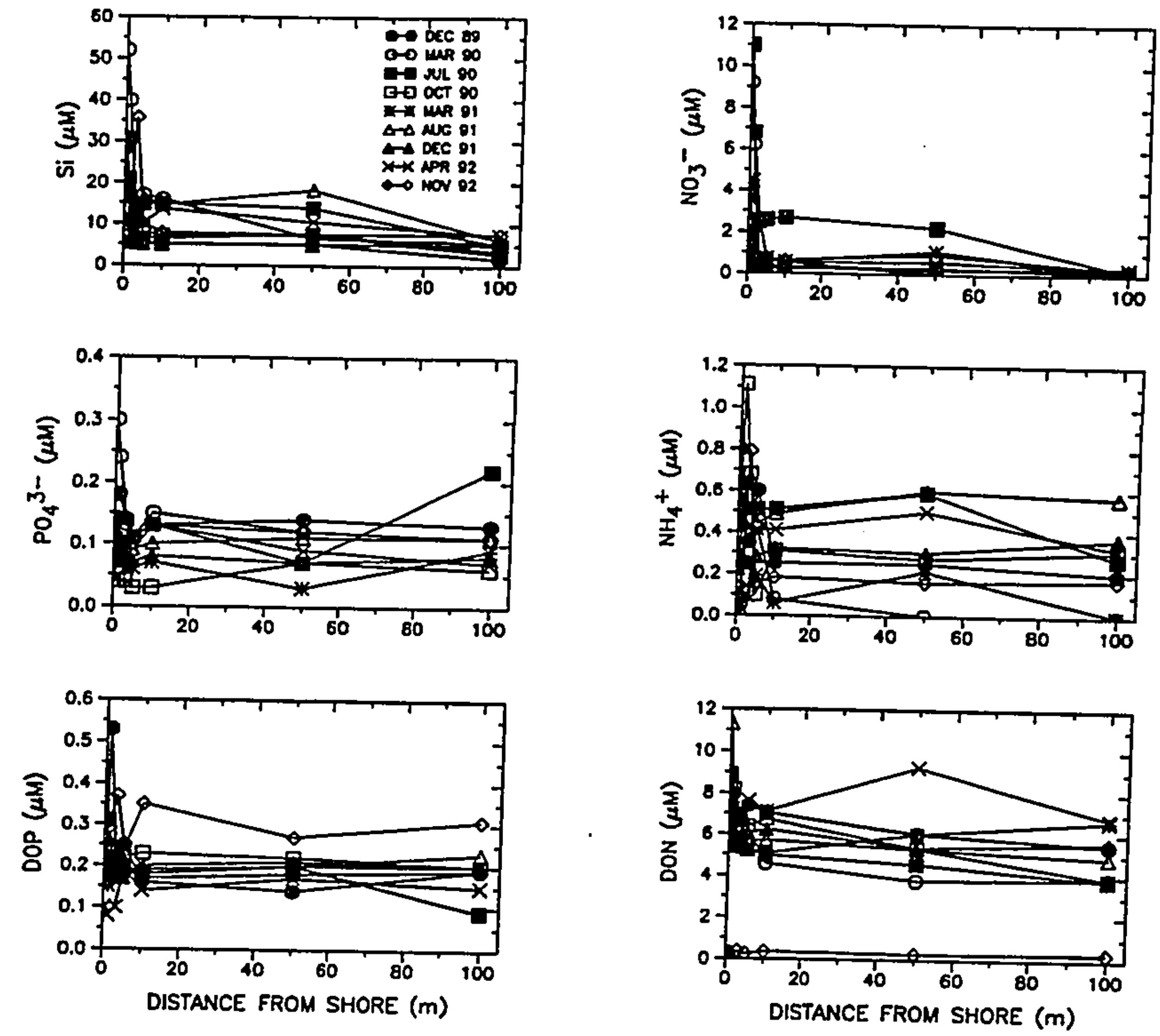

FIGURE 6. Plots of surface water dissolved nutrients as functions of distance from the shoreline at Site 2 collected during nine monitoring surveys over the period from December 1989 - November 1992 off the KLC project area. For location of Site 2, see Figure 1.

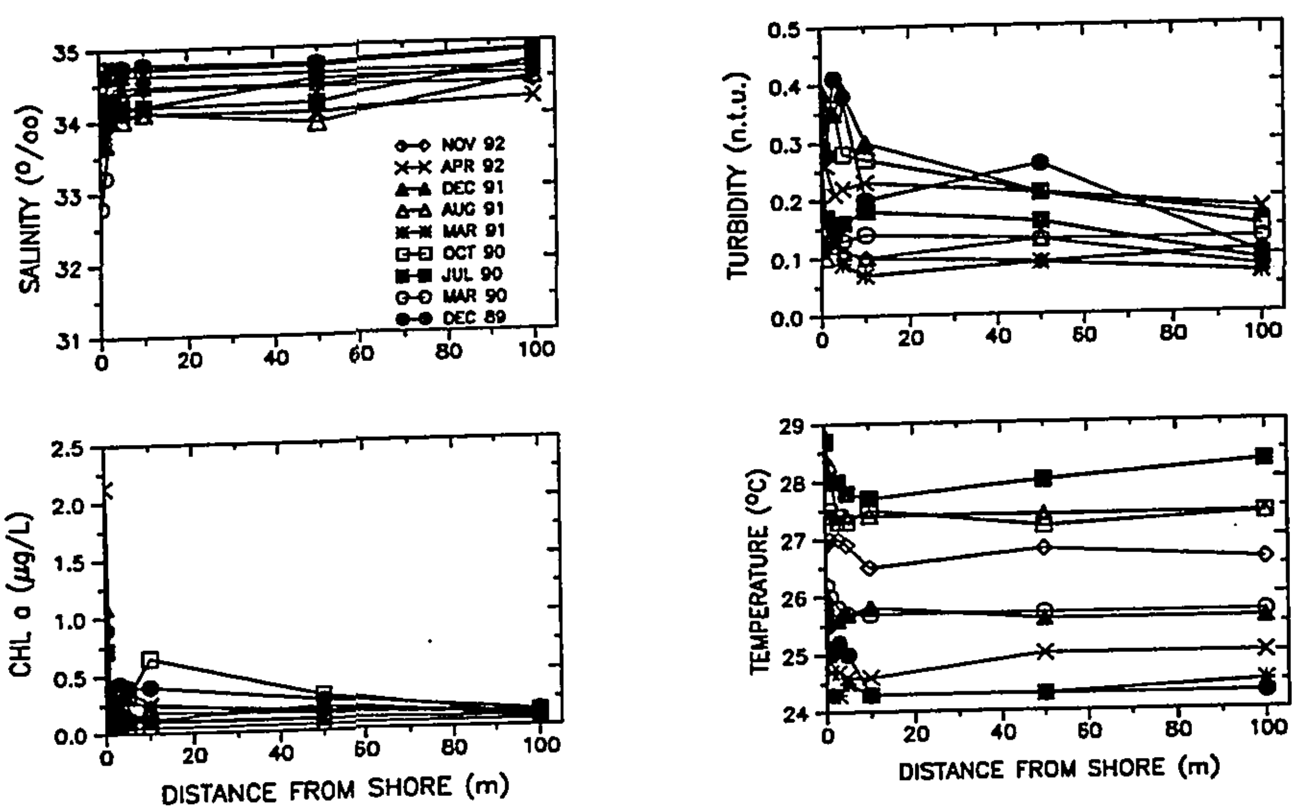

FIGURE 7. Plots of surface water chemistry constituents as functions of distance from the shoreline at Site 2 collected during nine monitoring surveys over the period from December 1989 - November 1992 off the KLC project area. For location of Site 2, see Figure 1.

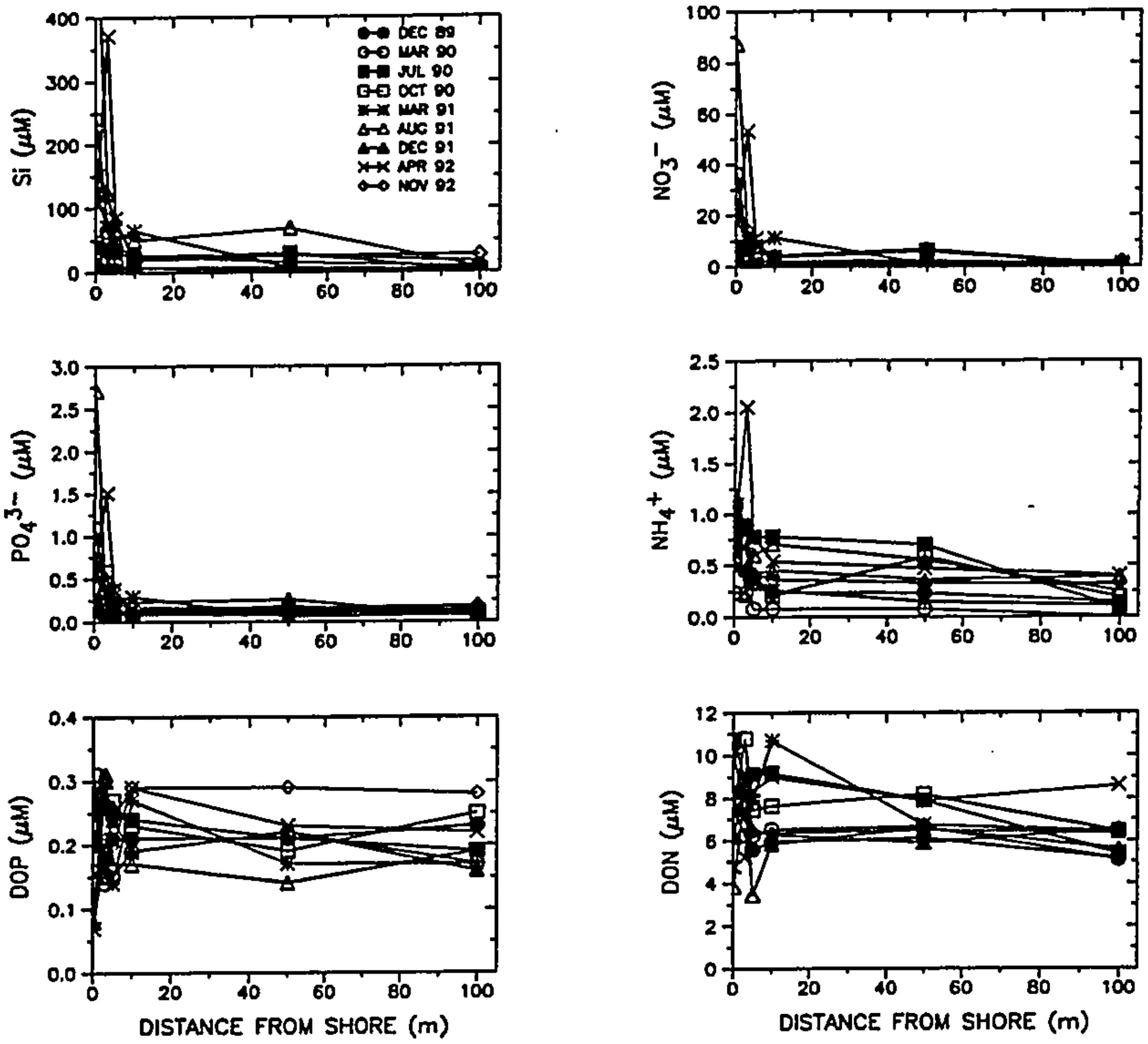

FIGURE 8. Plots of surface water dissolved nutrients as functions of distance from the shoreline at Site 3 collected during nine monitoring surveys over the period from December 1989 - November 1992 off the KLC project area. For location of Site 3, see Figure 1.

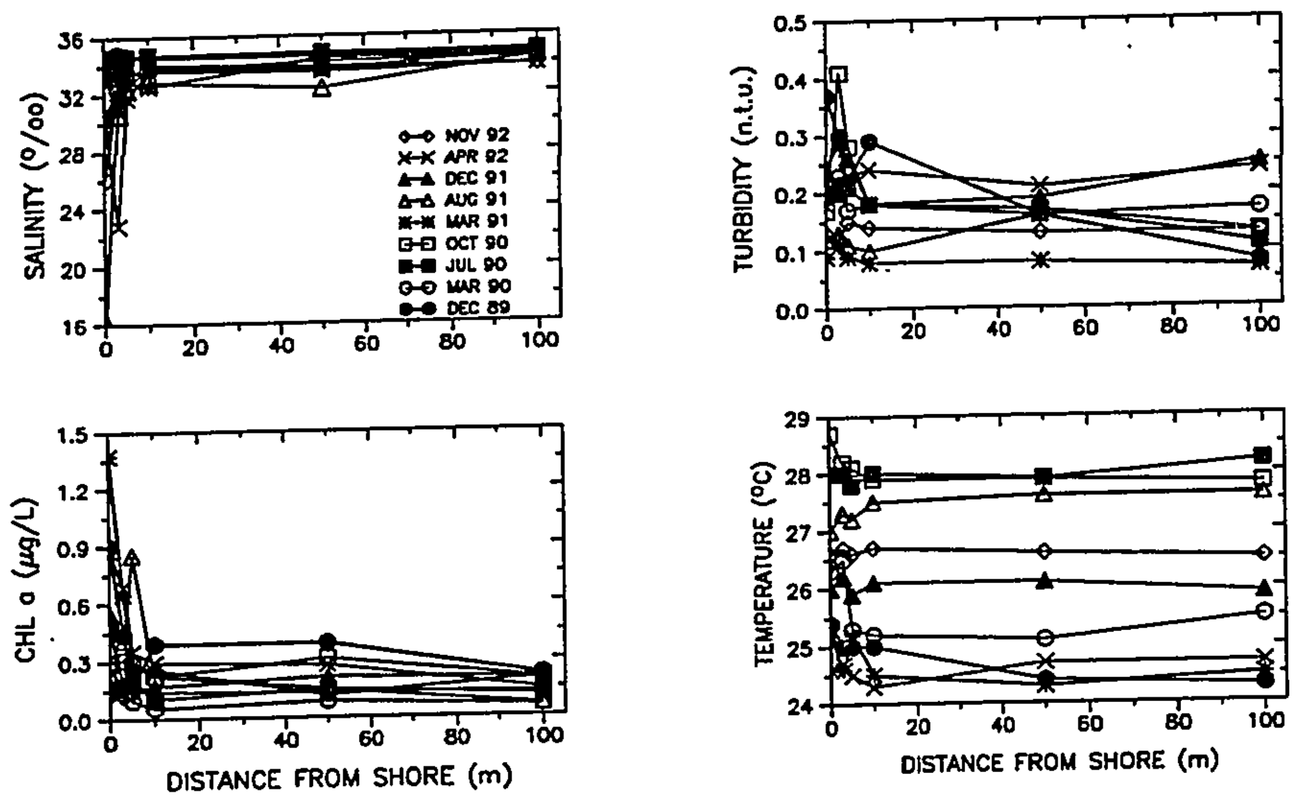

FIGURE 9. Plots of surface water chemistry constituents as functions of distance from the shoreline at Site 3 collected during nine monitoring surveys over the period from December 1989 - November 1992 off the KLC project area. For location of Site 3, see Figure 1.

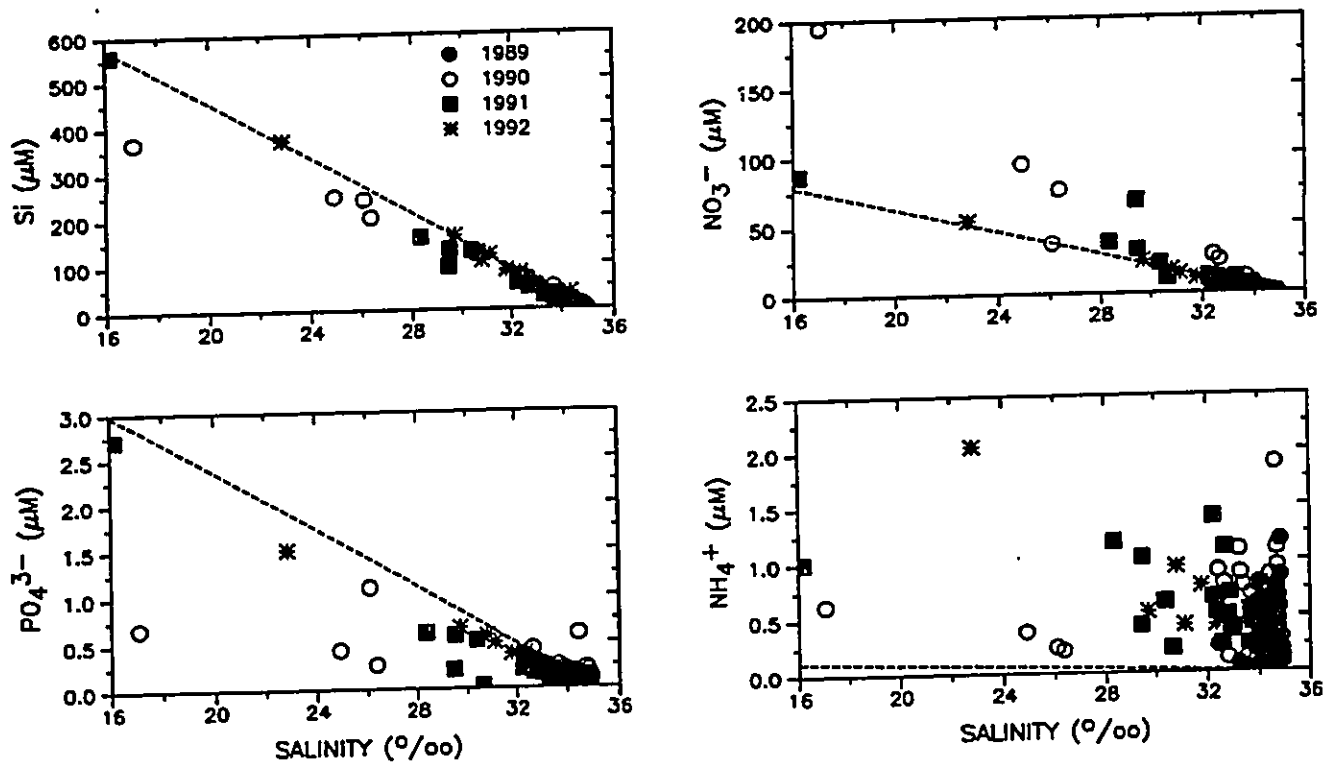

FIGURE 11. Mixing diagram showing concentration of dissolved nutrients as functions of salinity for samples collected between 1989 and 1992 off the KLC project area. During the period, nine monitoring surveys were conducted; one in 1989, three in 1990, three in 1991 and two in 1992. Dashed line is conservative mixing line constructed by connecting endmember concentrations of well water and open coastal water.

APPENDIX D

MARINE ENVIRONMENTAL SURVEY TO ASSESS POTENTIAL IMPACTS FROM THE PROPOSED PUBLIC BEACH SAFETY IMPROVEMENTS AT KAUPULEHU RESORT, NORTH KONA, HAWAII

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January 6, 1993

INTRODUCTION AND PURPOSE

In order to provide the public with the safest possible environment for swimming, snorkeling and other water-related activities, plans are being developed to improve the beach at the site of the Kaupulehu Resort. The present scenario for such improvements involves modifying the nearshore area by removing basalt rock features located at the shoreline, and deepening several areas of the existing nearshore region. Such actions will facilitate safer and easier access to the nearshore marine areas than exist presently, and enhance the recreational potential for swimming and snorkeling in the offshore region. Most of the sites for the proposed improvements appear to be ideal locations for such action, as existing beachrock dikes form natural "lagoons" between the shoreline and the open ocean that diminish much of the wave action that impinges on the coastline.

It is recognized by the developers that all measures will be implemented to insure that excavation activities necessary to complete the proposed beach improvements will not result in any permanent detrimental changes to the marine environment. One of these measures is to address all potential concerns regarding alteration of the shoreline. In the interest of addressing these concerns and assuring maintenance of environmental quality, it has been deemed appropriate to conduct a baseline marine survey and potential impact analysis. The purpose of this report is to present the results of the survey, which was designed to evaluate the potential effects of beach safety improvements on water quality and marine biological composition of the nearshore environment.

Based on these data, along with information from past studies of the effects of other beach modification projects, evaluations are presented regarding the potential for impacts from the proposed project. The survey results can also serve as a baseline preliminary phase for any monitoring programs that may be required as a contingency for permit approval by government agencies, including the Corps of Engineers, the State of Hawaii, and the County of Hawaii.

An initial baseline survey to assess the impact potential of the beach safety improvements was conducted in 1990. The second phase of the survey was conducted in November of 1992. Presented below are the objectives, methods and results of both phases of the baseline assessment surveys.

Qualitative reconnaissance surveys extending from the shoreline to approximately 250 feet offshore were conducted throughout the area fronting the Kaupulehu Resort property. 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. At each of the survey sites, qualitative macrobenthic species checklists were compiled. Each species encountered was placed in one of three abundance categories. Categories were defined as "Abundant" (greater than 100 individuals), "Common" (10-100 individuals, and "Rare" (less than 10 individuals).

Following the qualitative survey, the four selected sites described above were evaluated in detail. At two of the sites, a line transect method was employed for quantitative evaluation of marine biota. Conducting transect surveys at Site A was not possible owing to extremely shallow water depth and small area of planned improvements, while at Site D extremely vigorous water motion created by breaking surf precluded transecting.

At Sites B and C, transects were oriented parallel to the shoreline across the area of most abundant biota. Transects consisted of a 160-foot long surveying tape that was stretched over the reef surface between weighted floats. An aluminum quadrat frame, with dimensions of 1 m by 0.66 m, was sequentially placed over 10 random marks on the transect tape so that the tape bisected the long axis of the frame. At each quadrat location a color photograph recorded the segment of reef area enclosed by the quadrat frame. In addition, a diver knowledgeable in the taxonomy of resident species visually estimates the percent cover and occurrence of organisms and substratum type within the quadrat frame. No attempt was made to disturb substrata to observe organisms, and no attempt was made to identify and enumerate cryptic species dwelling within the reef framework. Only macrofaunal species greater than approximately 2 cm 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-quadrats 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 l974, Grigg 1983), and has proven to be particularly useful for quantifying coverage of attached benthos such as corals and macrothalloid algae, and large epifauna (holothurians, echinoderms).

Qualitative 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 m wide along the transect path were identified by species name, and evaluated by qualitative assignment of species into three abundance categories (Abundant, Common or Rare). 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).

RESULTS

Physical Setting

The overall physical setting of the nearshore area off of the Kaupulehu Resort is fairly homogeneous. The shoreline is composed of a white calcareous sand beach approximately 30 feet wide that slopes down from the vegetation line to the waterline at an angle of approximately 15 degrees. The actual shoreline along most of the property is composed of a basalt and beachrock ledge that forms an intertidal platform with numerous tidepools. The beachrock component of the shoreline appears to have formed from chemical precipitation processes associated with contact of calcareous sediments with low saline water. The southern boundary of the Kaupulehu Resort is demarcated by the 1801 Kaupulehu a'a lava flow that enters the ocean and forms Kumukehu Point. The shoreline off the lava flow is a sea cliff of jagged lava boulders.

The offshore area can be categorized into two major regions, inner lagoons and an outer reef bench. Along much of the Kaupulehu Resort property, there are natural lagoons formed as a result of an offshore dike of emergent beachrock. This dike serves to absorb much of the energy of breaking waves, resulting in relatively calm waters within the lagoons. The lagoonal structure provides much of the infrastructure for the proposed swimming areas, as the planned work will primarily be to improve shoreline access and increase depth of the naturally occurring features. Sites A, B and C within the natural lagoonal habitat have tentatively been selected for evaluation as areas for modification to improve access for swimming. At the location of Site D, the dike structure does not occur, and the inner nearshore area is not protected from incoming wave energy as is the case at the other three sites. Detailed descriptions of each area are presented below.

The second offshore region occurs seaward of the beachrock dike. This area is composed of a very broad (up to 0.5 mile), flat, bench-like structure that extends offshore from Kahuwai Bay to Kukio Bay. This flat bench appears to be a result of a prehistoric lava flow that has since been drowned. Water depth over the bench rarely exceeds 15 feet; the shallow depth exposes the area to high levels of concussive force of breaking waves, and as a result coral cover and benthic biota is low in abundance. The outer edge of the lava bench is marked by a sharp ledge and cliff 10 to 15 feet high. The walls of the cliff are frequently undercut with caves and crevices and the base of the cliff is marked by an area of large basaltic boulders. Quantitative benthic transects were conducted across the bench at three sites offshore of the lagoon sites (see Figure 1).

Each of the four sites selected for possible modification are differentiated by unique characteristics. The northernmost area, designated as Site A, is presently a small natural lagoon bordered at the seaward edge by a protruding solid dike of beachrock that effectively absorbs much of the force of breaking waves. As a result, water motion inside the small lagoon is relatively quiet. The lagoon is bounded on the northern and southern edges by expanses of exposed basalt that form intertidal benches. The entire floor of the lagoon is presently composed of either a layer of cobbles or a solid rock platform. The present depth of the natural lagoon at the highest tidal stand does not exceed 2.5 feet, suggesting that excavation of the area from the shoreline will be required in order to establish a viable and safe swimming area. The planned area of modification of Site A is oval in shape with a long axis of approximately 100 feet.

The area designated as Site B is similar to Site A in that it also is a natural lagoon bordered at the seaward edge by a protruding solid dike of beachrock that effectively absorbs much of the force of breaking waves. As a result, water motion inside the lagoon is relatively quiet, especially at low tidal stages. The major difference between Sites A and B is size. The proposed excavated area of Site B is roughly elliptical in shape with a long axis of about 200 feet that is parallel to the shoreline, and a short axis of approximately 100 feet. The natural lagoon at Site B is bounded on the northern and southern edges by expanses of exposed basalt that form intertidal benches. The entire floor of the lagoon is presently composed of either a layer of cobbles or a solid rock platform. The present depth of the natural lagoon at the highest tidal stand does not exceed 2.5 feet, suggesting that excavation of the area from the shoreline out to the beachrock dike will be required in order to establish a viable and safe swimming area.

Site C, located to the south of the center of the Kaupulehu Resort property, also is separated from the open ocean by a beachrock dike that creates a lagoon. The dike is situated farther from the shoreline than at Sites A and B, resulting in a lagoonal width of approximately 150 feet. The shoreline at this site is also composed of beachrock; however, there are several breaks in the rock formation resulting in sandy channels that extend from the beach into the lagoon. Depth of the lagoon is also greater than at Sites A and B, ranging from 3-5 feet near the seaward beachrock dike. Bottom structure of the lagoon is composed of a solid rocky surface with interspersed channels of coarse white sand. An important feature of Site C that distinguishes it from Sites A and B is that the lagoon floor is populated with living coral colonies of several species. As described above, the lagoon floors at Sites A and B are primarily rock with little living coral cover.

Site D is located at the southern end of the Kaupulehu Resort beach (see Figure 1). This area differs from those described above in that there is no offshore beachrock dike to create an inner lagoon. As a result the nearshore area is not protected from the force of surge and breaking waves. The shoreline is composed of a shallow basaltic platform that is bounded to the south by the 1801 lava flow which extends into the ocean. The extension of the lava flow creates a semi-enclosed area that constitutes a configuration with the potential for creation of a swimming area. The basaltic bench forming the seafloor extends seaward with a gradual slope; at a distance of approximately 300 feet from shore water depth is about 10 feet. Bottom topography is generally without substantial relief, and major sand channels are absent. The dominant structural relief is an extensive excavation of grooves cut by the burrowing activity of sea urchins.

Water Chemistry

Beginning in December of 1989, a water quality monitoring program has been conducted at the site of the Kaupulehu Resort. To date, nine such surveys have been conducted, in which water chemistry has been evaluated along three transects, that bisect Sites B, C, and D which are described above. The most recent summary of results of these water quality monitoring surveys are presented in a report entitled "Marine and Anchialine Pond Monitoring Program, Kaupulehu Makai Venture, North Kona Hawaii, Water Chemistry, Report 3-92" (Marine Research Consultants 1992).

Each transect was oriented perpendicular to the shoreline, and extended from the highest wash of waves across the intertidal and nearshore reef platform out to the open ocean, a distance of approximately 200 feet. Water samples were collected at 6 locations along each transect. Sampling was concentrated within the areas close to the shoreline as this is the region which is most sensitive to inputs from land, and where actual construction activities will take place. With the exception of the stations located 1, 3 and 10 feet from the shoreline, samples were collected at two depths; a surface sample was collected within approximately 6 inches of the surface, and a bottom sample was collected within 1 foot of the sea floor.

Water quality parameters evaluated included the 10 specific criteria designated for open coastal waters in Chapter 11-54, Section 06 (Open Coastal waters) of the State of Hawaii, Department of Health (DOH) Water Quality Standards. These criteria include: total nitrogen (TN), nitrate + nitrite nitrogen (NO_3^- + NO_2^-), ammonium (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.

In brief, results of the water chemistry monitoring program indicate that there is substantial flow of high nutrient-low salinity groundwater at the shoreline along the entire development property. Such groundwater discharge is typical for the entire coastline of West Hawaii, and the subject property does not appear to display any unique characteristics of groundwater discharge. Even during periods of calm weather, however, the input of groundwater is rapidly mixed with oceanic water resulting in only a very narrow region near the shoreline where water does not display oceanic qualities.

The only unique characteristic of the area was the temporary increases in groundwater discharge of NO_3^- that occurred shortly after blasting activities to excavate for the hotel foundations. While the increases in dissolved NO_3^- were substantial in the nearshore region immediately after blasting, within several months of the cessation of excavation the subsidy had dissipated. Presently, there is no indication of residual NO_3^- in groundwater entering the ocean, and the entire area proposed for modification can be considered to have no anomalous features with respect to water chemistry.

Marine Biota

Corals and Other Macroinvertebrates

Results of baseline surveys conducted in 1990 and 1992 are summarized in Tables 1 through 3. It should be noted that in 1990 Site A was not included in the survey, hence data for this area are only provided for the most recent investigation. Table 1 shows macroinvertebrate species that were observed in the four areas of potential modification, along with ranks of abundance. Table 2 shows results of quantitative coral transects at lagoon Sites B and C. Results of quantitative surveys from the offshore reef bench that were acquired in 1990 are also included in Table 2 (see Figure 1 for locations of transects).

Owing to the shallow depth which likely results in elevated temperatures during periods of high insolation and low circulation, biota is limited in distribution at Site A and B. At Site A, only 3 species of coral were observed, and all of these observations consisted of small (less than 5 cm in diameter) colonies. At Site B, only 6 and 8 species of coral were observed in the shallow lagoon in 1990 and 1992, respectively, and all of these species were ranked as rare in abundance. Transect results from Site B reveal that average coral coverage at Site B was about 1% during both surveys; species diversity of 1.27 and 1.42 indicates that coral cover is relatively even in distribution among the species encountered (Table 2).

Sea urchins, especially *Echinometra mathaei* and *E. oblonga* were present on the lagoon floor in abundance at Site B. One characteristic of this area that was not found at the other three sites was an abundance of the sea urchin *Colobocentrotus atratus* clinging to the inner wall of the beachrock dike. The entire floor of the lagoon was covered with a multi-species turf of filamentous algae. The major distinctive alga other than the turf were tufts of *Giffordia breviarticulata*.

Of the four potential swimming areas, Site C contained the most diverse assemblages of benthic organisms as well as the highest percent bottom cover of corals. Qualitative reconnaissance of the area revealed 16 species of corals during both the 1990 and 1992 surveys (Table 1). Quantitative transects results indicated that total coral cover on the transect was approximately 10% comprised of 10 species in 1990, and 8.5% comprised of 9 species in 1992 (Table 2). Of particular note were large flat-topped lobate colonies of *Porites lobata* and *P. rus* growing throughout the lagoon. Other macroinvertebrates that were particularly abundant were the sea cucumbers, *Holothuria spp.* and *Actinopyga spp.*. Dominant algal species were *Turbinaria ornata*, *Padina spp.*, *Galaxaura filamentosa*, and various forms of encrusting calcareous algae.

The primary factor that differentiates Site C from the other three areas is water depth. The increased depth (3-5 feet) of the area between the beach and the beachrock dike at Site C appears to be sufficient to prevent extremes in physical factors (temperature and salinity) from limiting coral settlement and growth, yet the outer dike affords protection from the destructive force of breaking waves. As a result, the area is inhabited by a diverse assemblage of corals. Depth of parts of the natural lagoon is also sufficient to minimize excavation, and maintain the present bottom configuration and benthic communities.

Site D, located on the northern border of the 1801 lava flow is not bounded in the seaward direction by the beachrock structure that characterizes Sites A-C. Rather, the basaltic bench that stretches offshore beyond the beachrock dike at the other sites, extends to the beach at Site D. As a result, breaking waves reach the shoreline area unimpeded by the protective dike. Owing to the elevated physical stress, corals are extremely rare in the nearshore (within 100 feet from shore) regions of Site D; 4 and 5 species were observed in 1990 and 1992, respectively, with a total bottom cover of less than 1%.

The only prominent biota in the area were the boring sea urchins *Echinometra mathaei* and *E. oblonga*. In some areas, the reef bench has a honeycombed appearance owing to the pattern of grooves gouged out by these urchins. In the areas of densest aggregations, abundance of urchins is on the order of 50 per square meter. Fleshy macroalgae was not observed at any locations in the zones of dense sea urchin abundance.

On the broad reef bench seaward of the lagoonal areas, coral cover is uniformly low. At the three 10-foot transect stations located on the bench, total coral cover averaged 6% (see Table 2). In general, the colonies that occurred were small in size, and predominantly of two species, *Porites lobata* and *Pocillopora meandrina*. Such low coral cover is indicative of the high degree of physical stress, predominantly from breaking waves. The only other predominant macrobenthos throughout the reef bench were the sea urchins *Echinometra mathaei* and *E. oblonga*.

At the seaward edge of the reef bench, increasing water depth results in decreased water motion and increased coral cover. At the 20 foot transects, coral cover ranged from 11% to 50%, predominantly in the form of large colonies of *P. lobata* growing at the base of the cliff that marks the edge of the reef bench. In deeper water beyond the cliff, coral cover is the highest through the reef system, with live coral comprising 50-60% of bottom cover (see Table 2). These zones of abundant coral cover occur from 0.25 to 0.5 miles from the shoreline in the areas of planned swimming area modification.

Reef Fish Community Structure

Results of reef fish community transect assessments in the areas of the proposed swimming lagoons are shown in Table 3. Virtually no fish were observed at Site A in 1992. During the 1990 survey, the lagoons at Sites B, C and D harbored a mix of juvenile reef fish, schooling mullet, and species specifically adapted to a shallow water environment with extremes in temperature and salinity. The most abundant juveniles were convict tang (manini, *Acanthurus triostegus*) and saddleback wrasse (hinalea, *Thalassoma duperry*). The main schooling fishes were flagtails (aholehole, *Kuhlia sandvicensis*) and mullet (ama'ama, *Mugil cephalus*). In particular, Site B hosted a very large school of small mullet. Species adapted to tidepool environments were also present. These were the blackspot sergeant (kupipi, *Abudefduf sordidus*) and the Christmas wrasse (awela, *Thalasoma trilobatus*).

Outside of the beachrock barrier, fishes tended to be clustered near areas of structural relief. Algal-feeding acanthurids were the most numerous group of fishes observed. Brown surgeonfish (ma'i'i'i, *Acanthurus nigrofuscus*), and convict tang (manini, *A. triostegus*) were the most abundant fishes at the shallow water sites. Also common were eye-stripe surgeonfish (palani, *A. dussumieri*), ringtail surgeonfish (pualu, *A. blochi*) and orangespine unicornfish (umaumalei, *Naso lituratus*).

Planktivorous damselfishes of the genera *Chromis* and *Abudefduf* were common. Also quite prominent in the water column was the black durgon (humuhumu-'ele'ele, *Melichthys niger*). Other common fishes included the manybar goatfish (moano, *Parupeneus multifasciatus*) and the saddleback wrasse (*Thalassoma duperrey*).

Several species of "food fishes" were observed during the survey. These included parrotfishes (*Scarus spp.*), goatfishes (*Parupaneus* and *Mulloidichthys spp.*), jacks (*Caranx melamphygus*), emperorfish (Mu, *Monotaxis grandoculis*), sugeonfishes (*Acanthurus* and *Naso spp.*) and the introduced grouper (*Cephalophilis argus*). These fishes were not abundant and tended to avoid divers.

Comparisons of fish populations between the two surveys indicates that number of species varied considerably at each site. Nearly double the number of species were observed at Sites B and C in 1992, while ten fewer species were observed at Site D in 1992 than 1990. Such variability in fish community structure is typical. While the numbers of species of reef fish varied, however, the overall character of the fish communities was similar during the two surveys.

CONCLUSIONS

The purpose of the proposed project is to remove solid rock portions of the shoreline and nearshore area in order to create environments that are safer, and provide more potential for recreational utilization by the public. While this action will unavoidably involve removing a section of the existing reef and associated biota, results of this survey indicate that the same factors that cause the selected sites to require deepening are also the factors that naturally limit biota settlement and growth. It can be seen that at the shallowest sites (A, B and D), invertebrate cover are low. At Site C, which is naturally deeper, relatively rich biotic assemblages are presently occupying the area.

While the relatively sparse aggregations of organisms at Sites A, B and D will be eliminated during the deepening process, a long-term result of the project may likely be an increase of living coral and associated biota following completion of the project. As reported in a long-term monitoring survey of Honokohau Harbor, located to the south of the Kaupulehu property (U.S. Army Corps of Engineers 1983, OI Consultants 1991), corals rapidly recolonized the outer harbor and channel walls following construction. Surveys of the coral communities outside the existing harbor entrance indicate that coral abundance near the entrance is greater than in neighboring communities farther away. Similarly, healthy and diverse coral communities have been observed inside of Kawaihae Harbor (ORCA 1978).

A similar situation is likely to occur at Kaupulehu. Owing to the greater depths of the proposed lagoons relative to presently existing conditions, it is likely that the newly created substrata will be a more suitable settling area than the natural setting, and coral cover will increase above the present 1% level. There is no reason to suspect that sea urchins, reef fish and other reef biota will not also recolonize the newly created surfaces.

Other than direct effects of substrata removal by excavation, potential alteration to water quality and biotic structure could potentially occur by increased sedimentation and turbidity. These parameters will increase during the construction process, and the length of time of decreased water quality will depend on the length of the construction period.

The major group of reef organisms that may be sensitive to increased sedimentation caused by the construction process are reef corals. The effects of sediment stress to corals have been extensively reviewed by Johannes (1975), Dodge and Vaisnys (1977), Bak (1978), Brown and Howard (l985) and Grigg and Dollar (1989). In summary, while it is clear that increased sedimentation can have a deleterious effect on corals, especially when buried, sedimentation can also result in no negative impacts. Because sediments are suspended by natural processes in many reef environments, most corals can withstand a certain level of sediment supply to the living surface. Many species have the ability to remove sediment from their tissues by distension of the coenosarc with water, or ciliary action which can nullify lethal effects of sedimentation (Yonge 1931).

In case studies of the effects of sedimentation, the range of environmental effects varies through the entire spectrum of stress. Cases where effects of dredging have caused mortality have been generally limited to areas of confined circulation such as Castle Harbor, Bermuda (Dodge and Vaisnys 1977), and Kaneohe Bay, Hawaii (Banner, 1974). In areas of unrestricted circulation, however, there have been instances of increased sedimentation reported that do not appear to cause any substantial effects to reefs. Sheppard (1980) reported that following dredging and blasting for a military Harbor in Diego Garcia Lagoon, coral cover appeared to show no effects from increased siltation. In addition to the discussion concerning lack of impacts from Honokohau Harbor, a survey of the Kawaihae Deep Draft Harbor located in South Kohala, Hawaii, also showed that coral communities located just outside the harbor breakwater, as well as inside the harbor are flourishing (ORCA 1978).

Results of another shoreline modification project in West Hawaii can be used to illustrate the likely effects should sedimentation increase during modification of the shoreline at Kaupulehu. Monitoring of beach construction at Makaiwa Bay (Dollar 1987), showed that while substantial sediment plumes in the water column were created by excavation of the shoreline, there were no temporary or permanent negative effects to benthos and fish communities. Rapid flushing of the bay by normal current exchange, and the ability of live corals to exercise sediment removal behavior appeared to prevent measurable changes in community structure parameters. The monitoring survey also showed that water quality parameters were not permanently affected by temporary sediment loads, and quickly returned to preconstruction levels after the new beach was completed.

Several other scenarios around the Hawaiian Islands can also be drawn upon to substantiate that impacts from sedimentation do not always result in substantial, irreversible damage to neighboring marine environments. Studies conducted at Princeville, Kauai (Grigg and Dollar 1980), French Frigate Shoals (Dollar and Grigg 1981), and Hilo Bay (Dollar 1985), all investigated the impacts to reef coral communities subjected to high levels of sediment stress. Results of these studies indicate that Hawaiian reef communities possess the adaptive ability to maintain community integrity under conditions of substantial, but temporary, sediment stress.

The common factor in all of these case studies is that as long as sediment generating activities occur in environments with unrestricted circulation, and that the sediment stress is episodic, rather than chronic in nature, there is no negative impact (either temporary or permanent) to coral reef communities. At the Kaupulehu site, it is expected that sediment suspension and removal by current action will prevent buildup of material on the sea floor, and allow organisms to maintain functional cleaning mechanisms.

An additional factor at Kaupulehu that appears to further preclude the potential for detrimental changes to coral community structure owing to shoreline modification is the physical structure of the offshore region. As described above, the offshore area is characterized by a broad, flat bench that is devoid of high concentrations of coral cover owing to stress from breaking waves. These natural stresses are likely more severe, and continual compared to the temporary alteration that may accompany shoreline modification. Thus, any material emanating from shoreline activities would have to travel at least 0.25 miles before it would be exposed to substantial coral communities that are not routinely exposed to limiting conditions.

Water chemistry measurements collected during the ongoing monitoring program reveal inputs of groundwater at the shoreline, throughout the project area. Mixing of the groundwater input, however, appeared to be rapid and the transition zone between water with oceanic properties and groundwater was restricted to a narrow band within the natural lagoons. Even with the restricted circulation in the natural lagoons, there is little indication of alteration of water quality owing to inputs from land. Altering the shoreline in terms of deepening the lagoons may alter localized groundwater flow patterns somewhat, but there is no indication that such alterations would result in any detrimental influence to water chemistry. If anything, it is likely that deepening of the shoreline areas would promote even more rapid circulation and mixing. As the entire coast of West Hawaii experiences groundwater flow of varying magnitudes, slight changes in these factors brought about by the proposed project would not likely exceed the natural level of variability to which receiving environments are adapted.

SUMMARY AND RECOMMENDATIONS

1) The marine environment offshore of the Kaupulehu Resort is characterized by two major bio-geomorphological zones. An inner lagoonal area extends from the white sand beach offshore to a beachrock dike that effectively absorbs much of the force of breaking waves. Seaward of the beachrock dike, bottom topography is characterized by a wide, shallow reef bench that is formed from a submerged lava flow. The seaward edge of the reef bench is defined by a shallow drop-off, and a sloping reef platform extends to depths of 60 feet. All construction activities associated with the beach and swimming area improvements will take place within the nearshore lagoon area.

2) Results of an ongoing time-course water chemistry monitoring program indicate that water quality off the entire development site can be considered in compliance with open coastal criteria as most measured parameters are within DOH water quality standards. The parameters that exceed DOH standards (NO_3^- + NO_2^-, TN) occur in high concentration as a result of input of groundwater at the shoreline. Dissolved material entering the ocean from groundwater extrusion is rapidly mixed with oceanic water near the shoreline resulting in nearly homogeneous water masses on both horizontal (distance from shore), and vertical scales. It does not appear that the proposed activity will cause significant alteration in patterns of water chemistry.

3) Four potential sites for beach improvement were evaluated for biotic community structure. Reef corals and associated biotic community distribution are restricted at Sites A, B and D owing to limiting physical conditions (temperature, wave stress) associated with shallow depth. At Site C, where water depth is suitable for settlement and growth, coral communities are abundant and diverse. Beyond the beachrock dike, the offshore bench is sparsely populated by corals owing to the force of breaking waves. Repetitive surveys of the inner lagoon areas that are proposed for deepening in 1990 and 1992 did not reveal any substantial changes in community structure in the two year interval.

4) In order to create the desired beach and swimming environments at the four proposed sites, it will be necessary to remove solid rock from the shoreline and nearshore areas. The construction techniques to remove the shoreline material may result in temporary increases in turbidity. Biotic communities in the area that will not be physically removed are preadapted to such temporary stresses and it is not likely that there will be any alteration to the existing communities in the area. At Sites A, B and D, it will be necessary to remove material from the shoreline out to the limit of the desired swimming area; at Site C, some of existing lagoon is presently deep enough to omit further excavation to reach a safe swimming depth. It is probable that a richer assemblage of organisms will colonize the excavated areas compared to the present situation. While this activity will eliminate much of the existing biota, it is likely that the long-term results of the action will be increased biotic community abundance as a result of increased depth. Reef corals will probably colonize the walls and floor of the excavated lagoons. Because corals are "keystone" species, other forms of marine flora and fauna should also colonize the channel. Reef fish will undoubtedly inhabit the area in proportion to the amount of suitable shelter created. It is highly unlikely that any activity related to altering the shoreline will have effects on the offshore coral reef communities located beyond the edge of the reef bench.

5) Even though any shoreline modification activities will mainly take place primarily in regions that contain restricted communities of macrobiota, all planning efforts should focus on minimizing impacts associated with suspended sediments created by construction. Planning of construction should minimize the duration of excavation phases, in order to keep the period of suspended sediment plume generation to the shortest possible time. If these conditions are met there does not appear to be the potential for substantial or permanent negative alteration of the marine environment. Similar projects in areas of unrestricted circulation have illustrated that suspended material generated by excavation can be dispersed by normal circulation before substantial settlement on the bottom. Marine communities appear to be able to withstand sediment stress utilizing natural adaptations such as cleaning mechanisms.

6) None of the biotic assemblages observed in and near the area to be excavated constitute rare, endangered or unique commercially valuable resources. Because the excavated area constitutes a very small percentage of the total reef platform fronting the Kaupulehu Resort property, the overall integrity of the area will not likely be altered by the project.

7) As all activities will be conducted within 100 feet from shore and in water depths less than 4 feet, and there appears to be no need for blasting, there is no potential for impacts to protected and endangered marine species.

8) All indications are that the proposed plan, if carried out with environmental considerations as an integral part of the process, will not result in any permanent or detrimental changes to the marine environment. However, in order to identify any unforeseen factors that may cause such undesirable changes, it is recommended that a monitoring program be conducted during each stage of the development process. The present survey can serve as a baseline for any such monitoring program that might be required to meet county, state and/or federal permit requirements.

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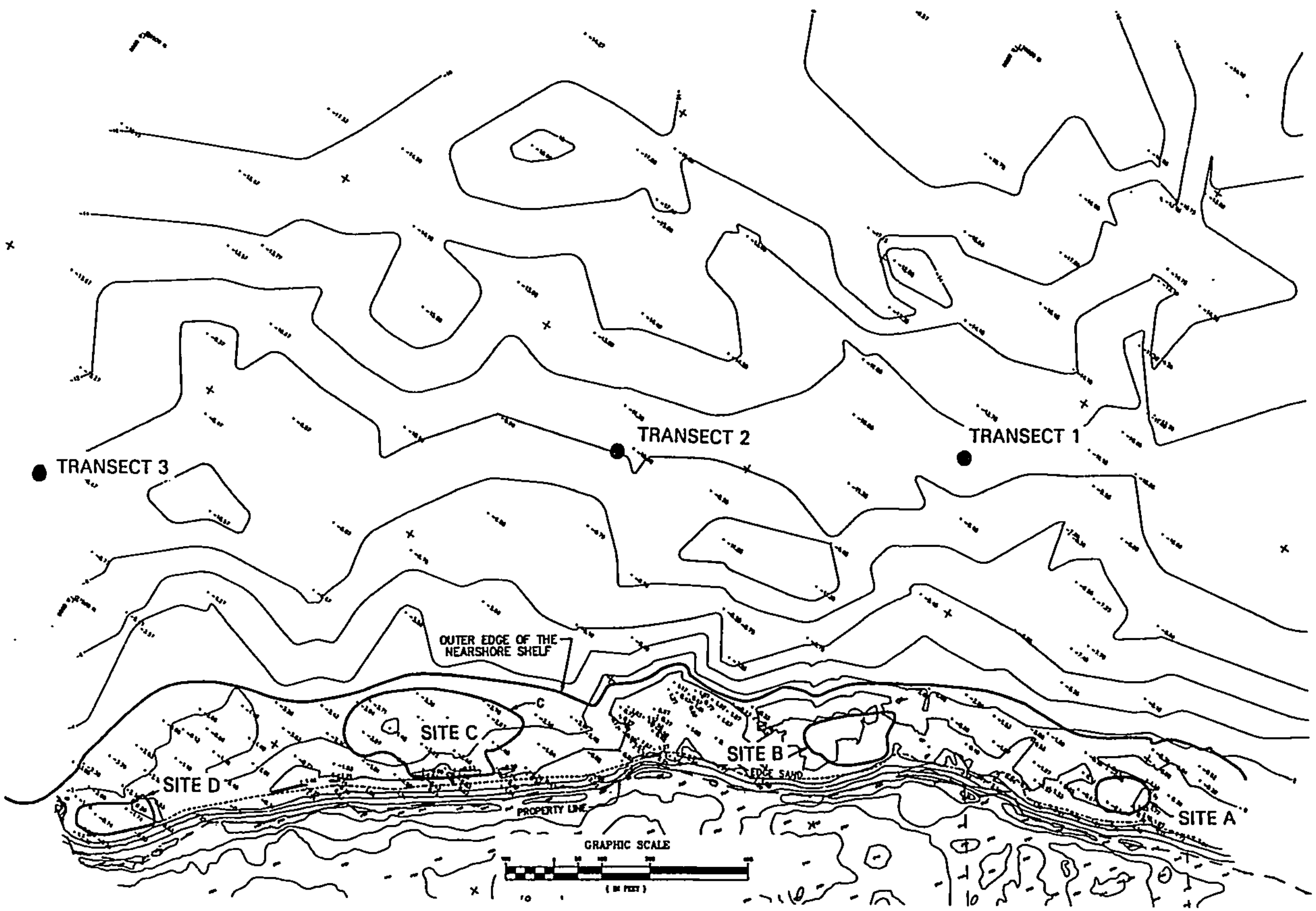

FIGURE 1. Contour map of shoreline of Kaupulehu Resort showing seaward property line, edge of sand, and outer edge of the nearshore shelf that is separated from the open ocean by a beachrock ledge. Also shown are the the four sites within the nearshore lagoons proposed for safety improvements. Locations of offshore transects that were surveyed in 1990 are also shown.

TABLE 1. Invertebrate species abundance at sites of proposed Kaupulehu Resort beach safety improvements.
For location of sites, see Figure 1. Abbreviations are: "A" = Abundant; "C" = common; "R" = rare.

SPECIES	SITE A (1992)	SITE B (1990)	SITE B (1992)	SITE C (1990)	SITE C (1992)	SITE D (1990)	SITE D (1992)
ECHINOIDEA (Sea Urchins)							
Echinometra mathaei	R	A	A	A	A	A	A
Echinometra oblonga	R	A	C	A	A	A	A
Colobocentrotus atratus		A	A	R			
Echinostrephus aciculatus	R	A	A	A	A	C	C
Heterocentrotus mammillatus		R	R	R	R	R	R
Tripnestes gratilla	R		R	C	C	C	A
Echinothrix diadema		C	C	R	R		R
HOLOTHURIA (Sea Cucumbers)							
Holothuria atra				C	C	R	
Holothuria nobilis		R	R	C	C		
Actinopyga obesa				C	C		
Actinopyga mauritiana				C	C		
SCLERACTINIA (Stony corals)							
Porites lobata	R	R	R	A	A	R	R
Porites compressa				R	R		
Porites brighami				R	R		
Porites evermanni				C	C	R	R
Porites rus			R	A	A		
Pocillopora meandrina	R	R	R	A	A	C	C
Pocillopora damicornis		R	R	C	C		
Montipora verrucosa	R	R	R	A	A		
Montipora patula		R	R	C	C		
Montipora flabellata				R	R		
Pavona varians			R	R	R		
Leptastra purpurea		R	R	C	C		
Leptastrea bottae				R	R		
Cyphastrea ocellina				R	R		
Palythoa tuberculosa				R	R		R
Anthelia edmondsoni				R	R	R	R
MOLLUSKS							
Octopus spp.				R			
Conus spp.				R			

TABLE 2. Coral community structure on monitoring transects in the vicinity of the Kaupulehu Resort. Inshore transects are located within the areas proposed for safety improvements.
For transect locations, see Figure 1.

SPECIES	INSHORE TRANSECTS SITE B (1990)	SITE B (1992)	SITE C (1990)	SITE C (1992)
Porites lobata	0.4	0.6	2.9	3.2
Porites evermanni	0.2	0.1	0.9	0.2
Porites rus		0.1	1.0	2.5
Pocillopora meandrina	0.1	0.1	1.5	0.6
Pocillopora damicornis	0.2	0.1	2.2	1.0
Montipora verrucosa		0.1	0.4	0.6
Montipora patula			0.1	0.2
Leptastra purpurea			0.4	0.1
Leptastrea bottae			0.1	
Cyphastrea ocellina			0.1	0.1
TRANSECT TOTAL COVER	0.9	1.1	9.6	8.5
CORAL SPECIES COUNT	4	6	10	9
CORAL SPECIES DIVERSITY	1.27	1.42	1.77	1.63

SPECIES	OFFSHORE TRANSECTS 1–10'	1–20'	1–60'	2–10'	2–20'	2–55'	3–10'	3–20'	3–50'
Porites lobata	3.3	45.5	23.6	4.0	6.7	19.5	4.0	26.1	18.1
Porites compressa		1.0	37.2	1.0	0.2	30.0		0.4	30.3
Porites evermanni									
Pocillopora meandrina	2.7	2.0		1.6	3.2	0.2	0.6	1.8	
Pocillopora damicornis									
Montipora verrucosa		1.7			0.5		0.3	0.4	
Montipora patula		0.2						0.1	
Leptastra purpurea									
Leptastrea bottae									
Cyphastrea ocellina									
TRANSECT TOTAL COVER	6.0	50.4	60.8	6.6	10.6	49.7	4.9	28.8	48.4
CORAL SPECIES COUNT	2	5	2	3	4	3	3	5	2
CORAL SPECIES DIVERSITY	0.69	0.43	0.67	0.67	0.87	0.69	0.59	0.45	0.66

TABLE 3. Reef fish community structure on monitoring transects off the Kaupulehu Resort collected in 1990 and 1992. For transect sites, see Figure 1.

FAMILY SPECIES	SITE B		SITE C		SITE D	
	1990	1992	1990	1992	1990	1992
ENGRAULIDAE		A				
KUHLIIDAE						
Kuhlia sandvicensis	A	C				
AULOSTOMIDAE						
Aulostomus chinensis			R			
HEMIRAMPHIDAE				A		C
FISTULARIDAE						
Fistularia petimba		R				
KYPHOSIDAE						
Kyphosus bigibbus						A
MULLIDAE						
Mulloides flavolineatus	C	C	A	A	C	A
Parupeneus bifasciatus		C		R		
P. multifasciatus	R			A	C	
P. porphyreus		R				
CARANGIDAE						
Caranx melamphygus					R	
LUTJANIDAE				R		
Lutjanus kasmira					C	
CHAETODONTIDAE						
Chaetodon lunula		R		R		
C. quadrimaculatus				R	R	
C. ornatissimus					R	
C. unimaculatus					R	
C. lineolatus				R		
POMACENTRIDAE						
Abudefduf abdominalis		C	A	C	C	
A. sordidus	R	R	R	R		
Plectro. johnstonianus					R	R
P. imparipennis	C	C	R	C		R
Stegastes fasciolatus	C	A	A	A		A
Dascyllus albisella						R
LABRIDAE						
Coris flavovittata		C				
Thalassoma duperrey	A	A	A		A	A
T. trilobatum		C	R	A	C	C
T. ballieui					R	R
Stethojulis balteata	R	C	A	C	R	
Halichoeres ornatissimus					R	
Gomphosus varius		R				
SCARIDAE						
Scarus sordidus					C	
S. rubroviolaceus					C	
Juvenile scarid						C

TABLE 3. continued

FAMILY SPECIES	SITE B		SITE C		SITE D	
	1990	1992	1990	1992	1990	1992
ACANTHURIDAE						
Zebrasoma flavescens					C	
Acanthurus achilles		C		C	A	A
A. triostegus	A	A		A		R
A. dussumieri					C	
A. blochii					C	
A. nigrofuscus		C		C	A	A
Ctenochaetus strigosus					C	
Naso lituratus					C	
N. unicornis					R	
ZANCLIDAE						
Zanclus cornutus	R	R			R	R
BALISTIDAE						
Rhinecanthus rectangulus					C	C
M. niger					C	
OSTRACIONTIDAE						
Ostracion meleagris		R	R	R		
TETRADONTIDAE						
Arothron hispidus	R			R	R	
Canthigastor jactator				C		
TOTAL NUMBER OF SPECIES	11	21	10	20	28	18
ABUNDANT	3	4	5	6	3	6
COMMON	3	10	0	6	14	6
RARE	5	7	5	8	11	6

POPULATION SURVEYS OF THE MARINE GASTROPOD *Nerita polita* (Kupe'e) AT THE SITES OF PLANNED IMPROVEMENTS OF THE NEARSHORE MARINE ENVIRONMENT AT KAUPULEHU RESORT, SOUTH KONA, HAWAII

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INTRODUCTION

Condition 14 of the Kaupulehu Resort SMA Permit Nos. 271 and 272 (approved in 1988), relating to the requirement for public shoreline access states: "Best efforts shall be used to secure the necessary governmental permits for the development of a swimming beach at a location between the two hotel sites on the subject property." In order to meet this condition, Kaupulehu Land Company is proposing to improve the shoreline and offshore region adjacent to the Kaupulehu Resort by enhancing the safety, accessibility, and recreational potential of the area. The sites where the enhancements are proposed are currently too shallow for most types of marine recreation, and safety is compromised by the presence of rocky outcrops in the intertidal area which must be traversed for entry into the ocean, as well as rough rocky bottoms of the existing marine lagoons.

Improved accessibility and safety is planned by excavating the shoreline and nearshore area to create four-foot deep pools with smooth bottoms that are easily accessible from the beach. In addition, access to the one existing area that is presently about four feet deep will be improved by removal of an emergent nearshore rock ledge. All construction activities will be confined to the nearshore zone and adjacent beach. No blasting will occur and all excavation will be completed using standard earth-moving equipment.

As part of the planning for the proposed nearshore marine environmental improvements, several surveys were conducted of existing conditions of water chemistry and marine biological community structure. The results and conclusions of these surveys generally found that the proposed activity would not be detrimental to existing marine communities or water quality, and in fact will probably enhance biotic composition in the long term. These conclusions were reached primarily because the areas to be deepened are presently so shallow that environmental conditions (primarily solar warming and wave action) are suboptimal for settlement. As a result, the shallow areas are relatively barren of normal community components that are common at the deeper areas of the nearshore zone.

However, one component of the biotic community that inhabits the nearshore area at Kaupulehu that was not addressed by the existing surveys was the gastropod mollusk *Nerita polita*, known locally as *kupe'e*. The snails are approximately one inch in length, and are generally mottled gray and white in color. However, some individuals are banded, or with flamelike markings of darker gray or red. Kupe'e live beneath the surface of the sand among boulders in the intertidal zone. They are seldom seen during the day, but emerge at night, plowing though the sand and crawling up the algal covered rocks on which they feed (Kay 1979). In the Hawaiian culture kupe'e shells are prized as items of adornment (made into necklaces and bracelets), while the animals are used as food.

Because of the potential importance of these gastropods as a cultural and natural resource, it was deemed important to gain an understanding of the existing populations at the sites planned for beach improvement. Presented below are the results of surveys conducted in October 1994 to describe the habitat, population numbers, and projected effect of the planned modifications on kupe'e at Kaupulehu.

METHODS

Three nocturnal surveys were carried out on October 1, 5, and 8, 1994. Sampling areas were located along the shoreline at each of the sites planned for improvement (designated as A, B, C, and D) (see Figure 1). In addition, following the initial survey on October 1, two control sites were established adjacent to the improvement sites. One control site was located between improvement areas A and B (Con A-B). The other control site was located immediately to the south of Site D, at the base of the a'a lava flow that defines the southern end of the Kaupulehu beach (see Figure 1). The purpose of the control sites was twofold: 1) to enable comparison of the relative abundance of Kupe'e at the improvement sites compared to adjacent areas that are not planned for modification, and 2) to provide a population census in areas that will not be modified that can serve as a baseline to measure changes as part of any monitoring program that might be required to take place during and after construction.

Sampling was conducted by measuring a distance of 30 m (100 feet) along the shoreline (parallel to the sand/water interface) at each survey site. Stakes pushed into the beach sand marked the ends of the sampling transect. During each transect survey, two investigators slowly walked along the intertidal zone between the two stakes illuminating the shoreline with flashlights. One investigator counted all kupe'e within a belt 1 m (3 feet) wide that extended landward of the waterline (mauka), while one investigator counted all individuals within a belt extending 1 m seaward of the waterline (makai). It was found that the 2 m belt width encompassed virtually all of the individuals that were observed. Thus, the resultant counts are representative of the entire visible population, and not just a subset within the transect belt. Movement of the snails was very slow, and almost imperceptible during the period of illumination. Behavior of the snails did not appear to be modified by the illumination of the flashlights.

Sampling was conducted during various stages of the tide during each survey. During the initial survey, sampling was conducted during low, mid, and high tidal stages. However, it was found that during high tidal stands, very few snails were present. As a result, high tide counts were not conducted during the final two surveys. There was no visible moon during the first two sampling periods, and a quarter moon was visible during the third sampling.

RESULTS

Description of Survey Sites

Because the occurrence of kupe'e appear tp be dependent on habitat characteristics, it is important to describe the habitat of each of the survey sites:

SITE A - Predominantly loose rock material over sand with fixed basalt regolith on southern edge of transect. Moderate wave and wash impact area.

SITE B - Mixed basalt and loose rock material with approximately 20% of sample area consisting of exposed sand. Some fixed sedimentary rock in northern area of transect. Low wave impact on northern area, and moderate impact on southern section.

SITE C - Predominantly fixed sedimentary rock adjacent to sand. Moderate to high wave impact area.

SITE D - Approximately 70% of northern transect section composed of exposed sand and loose rock material. Remainder of transect consisting of fixed basalt regolith and large basalt rocks interspersed with sand. High wave impact in northern area. Low impact in southern section.

CONTROL A-B - Approximately 70% elevated basalt regolith with sand and rubble in deep (≈20 cm) cracks. Remainder of site consists of sand and loose rock. Low wave energy.

CONTROL D - Entire area consists of small to medium basaltic rocks and boulders partially submerged in sand. Low wave energy.

Survey Results

Several important points were apparent as a result of the kupe'e surveys. Almost immediately after darkness, snails were observed emerging from the sand in the intertidal zone, and moved to the solid surfaces of basalt and limestone where they could be observed feeding on epilithic algal films. Emergence of the snails appeared to be completed within 1-2 hours of darkness; there was no indication that individuals remained submerged under the sand past this period to emerge later in the night.

It was observed that the numerous kupe'e at Kaupulehu occupy a very restricted marine habitat. Snails were only found in wetted areas with low wave energy and exposed, but fixed rocky surfaces. No individuals were observed in areas with high water motion, in completely sandy areas, or in areas with loose rocks that rolled easily. These habitat restrictions are apparently a response to the rather weak adhesive ability of the snails to cling to rocks in areas of high wave wash, as well as avoidance behavior to crushing from rocks being rolled by wave energy. In addition, few snails were observed on dry rocks or sand, or submerged in more than several inches of water. As a result of this limitation, the distribution of kupe'e was extremely patchy. Areas of suitable habitat containing many snails were adjacent to unsuitable areas with virtually no snails.

Tables 1 and 2 summarize the results of the kupe'e population counts at Kaupulehu. Table 1 shows all counts at each site during each tidal phase during each of the three surveys; Table 2 summarizes counts at each site by tidal stage (combined counts for all three surveys). Several points are apparent from Tables 1 and 2. First, kupe'e were observed at all sites during all surveys. However, counts varied considerably depending on tidal stage, and were substantially higher during low and mid tides than high tides. As described above, the snails are very restricted in the habitat that they occupy. The ideal habitat consisted of wetted low energy areas with fixed rock. During high tide, virtually all of the rocky surfaces at the shoreline were submerged. In addition, at high tide the outer beachrock dike is fully submerged resulting in substantially more wave action at the shoreline. Both of these factors resulted in restriction of the emergent populations to low or mid tidal stages.

It can be seen in Table 2 that for the pooled counts, Site C had the lowest counts, while both control stations had higher counts than any of the proposed sites for improvements. These results do not appear to be random, but rather are related to habitat suitability. The intertidal area of Site C consisted mainly of an emergent beachrock (lithified limestone) with substantial wave surge, even at low tide. As a result, this area appears to be the least suitable for kupe'e of all survey sites.

Control area A-B consisted primarily of a raised basaltic bench that separated the lagoonal features of sites A and B. Owing to the physical structure, the area was highly sheltered from incoming wave action. Control D consisted of what appeared to be the "perfect" habitat for kupe'e as exhibited by the very high densities of individuals at low and mid tides. At this locale it was estimated that as many as 50 snails occurred per square meter.

CONCLUSIONS

The most important conclusion resulting from the study is that the Kaupulehu beach area is a habitat populated by relatively large numbers of *Nerita polita* (kupe'e). However, when viewed in the context of the planned nearshore improvements in the area, it appears that several factors can result in little or no short or long-term negative effects to the kupe'e population.

Results of the census surveys indicate that the snails occupy a very restricted area within the intertidal zone; abundance in this zone is dictated by the condition of the substratum (rock or sand) and the physical rigor imposed by water motion. While kupe'e occurred in the areas scheduled for modification by removing solid material in the intertidal zone, these areas did not appear to be the preferred habitats of the snails. Rather, adjacent areas which consisted of higher percentages of solid rock, and lower wave energy appeared to be far more suitable habitats. As only a relatively small percentage of the intertidal area of the Kaupulehu property is proposed for modification (estimated at 20%), the majority of the area that is presently inhabited by the largest proportion of the snail population will not be altered.

Another important conclusion from the census surveys is that the populations appear to be relatively fixed and localized. These factors indicate that a very effective mitigative measure could be transplantation. In the nights prior to, and during the course of construction activities, it would be relatively simple to collect all of the emergent snails and relocate them to adjacent areas where no excavation will occur. Such a simple mitigative action could ensure virtually no elimination of the resource. As survey results indicate that the sites where construction is to take place are not the areas of highest population abundance, it is probable that there would be little mortality resulting from transplantation. While the results of the present surveys were not designed to determine the mobility of individuals over time, it would not appear that return of individuals to the area where shoreline modification takes place after the completion of construction would not result in any net loss. In addition to kupe'e, all other invertebrates occupying the intertidal zone could be transplanted to neighboring areas, to ensure minimal loss of biotic resources.

As mentioned above, the areas planned for modification are not the major centers of kupe'e density. Survey results indicate that the rock-sand area adjacent to the lava flow south of Site D is the most populous region with respect to this species. This area is not part of the area proposed for modification. As this is the area of apparently ideal habitat, this region should not be altered.

Based on the results of the survey, the high population numbers suggest that the kupe'e at Kaupulehu have not sustained substantial overharvesting. Because of the relatively fixed and localized populations, it appears that it would be relatively easy to substantially reduce the population by overharvesting (at least temporarily). Little has been published in the scientific literature about the life history of kupe'e. In addition, the purpose and scope of the present study did not include investigation of such factors as time scales of population recovery following removal of a significant component of the population. Thus, it is difficult to estimate the time required for regeneration of populations following overharvesting. As access to the area is likely to increase with the completion of the Kaupulehu Resort, consideration should be given to preserving the resource. It is suggested that some management programs (even voluntary programs) are put into place to protect the resource from overharvesting.

This report provides a preliminary perspective on the populations of kupe'e at Kaupulehu, as well as suggested mitigative measures to ensure preservation of the resource in conjunction with the nearshore and beach improvement program that is presently under consideration. With simple mitigation measures, it appears that the kupe'e resource can be preserved. The current survey also provides a baseline of pre-construction conditions which can serve as a useful indicator of actual changes that might take place during the course of the improvement project. Continuation of the population census surveys during and after construction will indicate the degree of success of mitigative measures in terms of actual effects to the populations.

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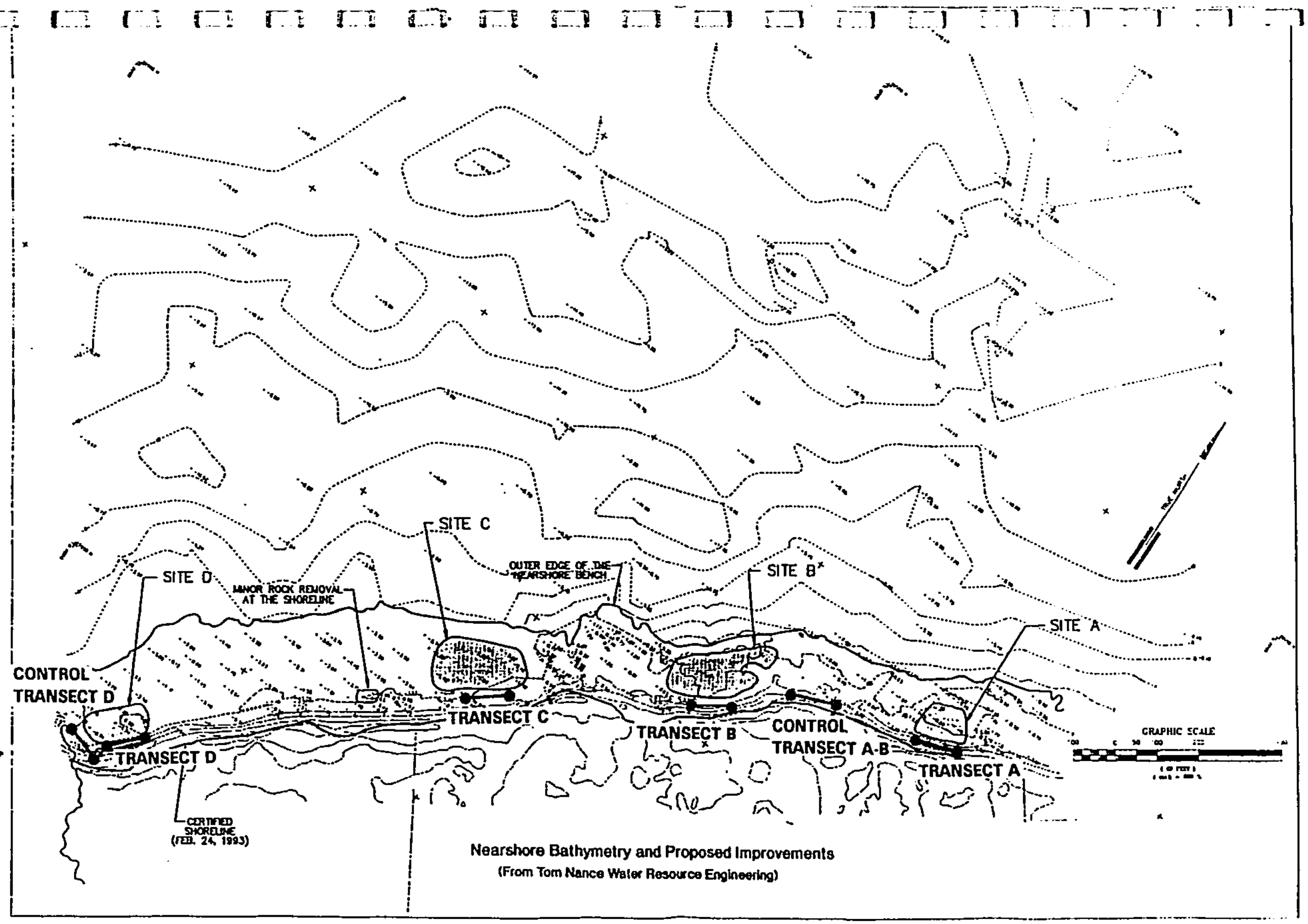

FIGURE 1. Map of Kaupulehu Resort beach area showing locations of five areas proposed for safety improvements. Also shown are locations of belt transects used to estimate populations of the kupe'e (*Nerita polita*). Transects were 30 m long and 2 m wide, with the central line defined as the waterline. Kupe'e observed 1 m shoreward of the center line were considered the "mauka" counts, while snails observed 1 m seaward of the waterline were considered "makai" in Table 1.

TABLE 1. Population census of Nerita polita at Kaupulehu Resort For location of survey sites, see Figure 1. TNTC = too numerous to count

10/1/94	TIME (p.m.)	TIDAL STAGE	NUMBER N. polita MAUKA	MAKAI
SITE A	7:30	LOW	9	33
	9:30	MID	16	8
	11:00	HIGH	0	0
SITE B	7:45	LOW	8	6
	9:45	MID	18	10
	11:15	HIGH	2	0
SITE C	8:00	LOW	3	5
	9:50	MID	1	4
	11:30	HIGH	0	0
SITE D	8:15	LOW	14	17
	10:00	MID	0	1
	11:45	HIGH	0	0
CONTROL D	8:45	LOW	TNTC	26
	10:15	MID	TNTC	45
	11:45	HIGH	0	0

10/5/94	TIME (p.m.)	TIDAL STAGE	NUMBER N. polita MAUKA	MAKAI
SITE A	7:30	MID	0	0
	9:30	LOW	19	4
SITE B	7:55	MID	4	14
	9:55	LOW	1	3
SITE C	8:00	MID	0	0
	10:00	LOW	1	4
SITE D	8:10	MID	4	0
	10:15	LOW	10	18
CON. A–B	7:40	MID	56	59
	9:50	LOW	14	35
CONTROL D	8:30	MID	TNTC	24
	10:40	LOW	TNTC	16

10/8/94	TIME (p.m.)	TIDAL STAGE	NUMBER N. polita MAUKA	MAKAI
SITE A	8:30	MID	3	1
	10:30	LOW	14	12
SITE B	8:50	MID	1	3
	10:40	LOW	4	8
SITE C	9:00	MID	0	2
	11:00	LOW	10	3
SITE D	9:15	MID	8	3
	11:15	LOW	19	29
CON. A–B	8:40	MID	10	8
	10:40	LOW	18	47
CONTROL D	9:30	MID	TNTC	11
	11:30	LOW	TNTC	24

TABLE 2. Summary of Nerita polita counts by survey site.

SITE	TIDAL STAGE		
	LOW	MID	HIGH
A	91	28	0
B	30	50	2
C	26	7	0
D	157	16	0
CON A-B	114	133	NO DATA
CON D	TNTC	TNTC	0

APPENDIX E

COASTAL IMPACT EVALUATION OF PROPOSED SHORELINE IMPROVEMENTS ALONG THE KAUPULEHU RESORT SHORELINE NORTH KONA, HAWAII

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September 1993

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1.0 INTRODUCTION

The 600-acre Kaupulehu Resort property is located on the North Kona shoreline (Figure 1). Situated on a northwesterly facing coastline north of Keahole Point, this shoreline reach is sheltered by the island mass from the prevailing northeasterly tradewind waves and summer swell.

Approximately 2350 feet of the property shoreline is fronted by a shallow rocky subtidal bench that is partly emergent, with a sandy beach along the backshore. A prior report[1] describes the shoreline and nearshore physical environment in detail. Figure 2, extracted from that study, depicts the nearshore bathymetry and the proposed improvements on the shallow nearshore bench. The proposed improvements consist of deepening the tidepools at four locations on the shallow nearshore bench to provide enhanced recreational opportunities. The four deepened tidepools will have a depth of 4 feet below mean sea level (MSL), with a gentle landside slope of 1V:8H to the beach. The improvements also include minor rock removal at the shoreline to improve access to the water. The minor rock removal will not result in deepening of the water depth on the nearshore bench.

While it is anticipated that the proposed excavation will not have significant impact on the existing coastal processes or on beach stability, this study was performed to demonstrate its possible effects. The study included numerical modeling of wave transformation over the shallow nearshore bench and an assessment of the changes to the wave characteristics as it affects the beach. This report describes the numerical model study and the results.

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[1]"Recommended Shoreline Improvements Along the Kaupulehu Resort Shoreline in North Kona, Hawaii", prepared by Tom Nance Water Resource Engineering, for Kaupulehu Land Company, May 1993.

2.0 DESCRIPTION OF COASTAL PROCESSES

Littoral processes affecting the beach along the Kaupulehu Resort shoreline are fairly benign because of the sheltered wave environment. The 80 to 220-foot wide partially emergent nearshore bench stabilizes the beach by dissipating much of the predominant wave energy affecting this coastal reach. This shallow bench effectively "anchors" the beach toe, resulting in the creation of a form of "perched" beach[2]. Seaward of the nearshore bench, a gently-sloping broad platform extends approximately 2000 to 2700 feet offshore to a water depth of about 18 feet. Beyond the seaward edge of this broad platform, the bottom drops off at about 1V:10H to water depths exceeding 180 feet.

Over a gently-sloping bottom, deepwater waves break in water depths approximately equivalent to their wave height. Therefore, large waves will break over the broad submerged platform. Remaining energy is reformed as secondary waves which propagate towards shore, ultimately breaking at the seaward edge of the nearshore bench where most of the remaining energy is spent. The partly emergent nearshore bench subsequently dissipates nearly all of the remaining wave energy due to its shallowness.

The maximum wave height that can reach the beach is dependent on the water depth over the shallow nearshore bench. Over a relatively flat bottom, the maximum wave height is approximately 0.8 times the water depth. The seaward edge of the narrow nearshore bench is at about 0 feet MSL across much of the shoreline reach, with 1-3 foot deep tidepools scattered throughout the partially emergent bench area. Therefore, at high

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[2]A perched beach is a beach or fillet of sand retained above the otherwise normal profile level by a submerged dike. (Shore Protection Manual)

tide (MHHW is about 1 foot above MSL), the maximum wave heights reaching the beach are typically less than 1 foot.

During large storm wave conditions, waves breaking on the broad submerged offshore platform can cause a rise in water level known as wave setup. The phenomenon of wave setup is related to the conversion of kinetic energy of wave motion to a quasi-steady potential energy. Near the point of breaking, the mean water level decreases, reaching a minimum at the breaking point. Shoreward of the breaking point, the mean water level increases. The wave setup is the difference in elevation between the mean water level at the shoreline and the offshore stillwater level. With higher mean water levels near shore during storm wave conditions, increased water levels over the shallow bench allow more wave energy to propagate across the bench. Waves breaking at the edge of the bench will also contribute to higher water levels at the beach. In addition to higher wave energy levels reaching the beach, the increased water levels allow waves to reach the shoreline at higher elevations on the beach, causing greater runup. These higher wave energy and water levels can transport sand over and across the shallow bench and deposit these sediments on shore. The existing beach foreshore and high dune backshore were thus created by storm wave activity, since the typical waves affecting this coastline are not capable of causing any appreciable setup and very little wave energy normally reaches the beach.

Minor deepening of tidepools on the shallow bench area will not change or influence the storm wave processes. The small depth variations over the nearshore bench have insignificant effect on the storm wave energy levels reaching the beach. Therefore, the numerical modeling effort was performed to address the potential impacts during typical wave conditions where the relative scale of the improvements could possibly change the normal wave conditions at the beach.

3.0 TYPICAL WAVE CLIMATE

The Kaupulehu Resort shoreline is sheltered by the island mass from the prevailing northeasterly tradewind waves and summer swell. These waves diffract around the island and further refract prior to reaching the site with much lower wave heights. The project site faces the northwesterly direction, and is exposed to winter North Pacific swell as well as westerly waves generated by infrequent Kona storms or hurricanes passing to the southwest of the islands. The island chain to the northwest provides substantial shielding from the direct approach of northwesterly swell. While North Pacific swell from the northwesterly direction is greatly attenuated prior to reaching the site, swell from a northerly direction can approach the site more directly. Figure 3 depicts the sectors of wave exposure at the site.

There is no long-term record of measured wave data for the project shoreline. However, wave data obtained as part of the OTEC CWP At-Sea Test Phase III project can be used to describe the typical wave climate affecting this site. Wave data were acquired over a one-year period from June 1984 to May 1985 offshore the north side of Keahole Point by a Waverider buoy moored in about 130-foot water depth. Wave records were obtained at various sampling intervals ranging from about 1 hour to 12 hours. Significant wave heights from each record were used to develop monthly and annual percent frequency of occurrence statistics. Table 1 provides the data for the months of January (representing typical winter wave conditions) and July (representing typical summer wave conditions), and for the entire 12-month period. While the one year data period is too short to provide a true statistical representation of a "typical" year (because large wave heights which can occur on a yearly basis may be under-represented), it does provide a reasonable representation of the wave types which occur at the project site.

TABLE 1
MEASURED WAVE DATA OFFSHORE KEAHOLE POINT
% Frequency Occurrence of Significant Wave Height vs. Period

Month	Hs/Ts	4-6	6-8	8-10	10-12	12-14	14-16	16-18	TOT%
January 1985	1-2′		1.5	4.5	6.1				12.1
	2-3′		4.5	6.1	22.7	3.0			36.4
	3-4′			1.5	6.1	10.6			18.2
	4-5′			6.1	4.5	6.1	1.5		18.2
	5-6′			1.5					1.5
	6-7′			3.0					3.0
	7-8′		3.0	4.5					7.6
	8-9′			3.0					3.0
	9-10′								0.0
	TOT%	0.0	9.1	30.3	39.4	19.7	1.5	0.0	100
July 1984	1-2′	9.2	20.0	6.2			1.5		36.9
	2-3′	3.1	12.3	15.4	12.3				43.1
	3-4′		4.6	4.6	1.5	1.5			12.3
	4-5′			1.5	4.6		1.5		7.7
	5-6′								0.0
	6-7′								0.0
	7-8′								0.0
	8-9′								0.0
	9-10′								0.0
	TOT%	12.3	36.9	27.7	18.5	1.5	3.1	0.0	100
Annual Jun 84- May 85	1-2′	4.5	23.9	14.3	4.3	0.1	0.1		47.3
	2-3′	3.6	16.5	9.7	7.9	1.9			39.6
	3-4′	0.4	2.2	1.2	0.9	2.0			6.7
	4-5′		0.4	1.0	1.1	1.5	0.5		4.5
	5-6′			0.1		0.5	0.1		0.7
	6-7′			0.2					0.2
	7-8′		0.2	0.4					0.6
	8-9′			0.2					0.2
	9-10′								0.0
	TOT%	8.6	43.3	27.2	14.3	6.0	0.7	0.0	100

Hs = significant wave height
Ts = significant wave period

For the month of January, North Pacific Swell is expected to dominate during this "winter" month, as is reflected in the frequency of occurrence of wave periods in the 10-14 second range. High waves up to 9 feet with period of 8-10 seconds were also recorded, reflecting occurrence of strong "Kona" wind conditions. For the month of July, which is a typical "summer" month, the data show a majority percentage of wave heights less than 3 feet, with periods generally less than 10 seconds. This reflects the sheltering from southern swell and the influence of local wind waves and possibly tradewind generated waves propagating through the Alenuihaha Channel and diffracting towards the site. On an annual basis, the data are indicative of the relatively mild wave climate, with offshore wave heights less than 4 feet about 94% of the time on an annual basis.

For the numerical modeling effort, three deepwater wave conditions were modelled representing the range of typical wave types affecting the site:

- 8 sec, 2 ft, from 5° true north
  (typical tradewind energy through the Alenuihaha Channel)

- 14 sec, 4 ft, from 5° true north
  (typical winter North Pacific swell)

- 10 sec, 8 ft, from 247.5° true north
  (winter Kona waves)

4.0 WAVE TRANSFORMATION ANALYSIS

Wave refraction and shoaling effects modify the deepwater waves as they approach shore. A numerical model called REF/DIF[3] was used to propagate the deepwater waves to shore. REF/DIF solves the propagation of water waves over irregular bottom bathymetry including the processes of shoaling, refraction, energy dissipation and diffraction. The overall bathymetry grid for the REF/DIF model was represented by 150 grid cells in the offshore direction and 200 grid cells in the alongshore direction, each cell with a 150 feet x 150 feet size. A smaller subgrid was used to define the bathymetry in the nearshore region to obtain the necessary resolution of small-scale features over the shallow nearshore bench. This subgrid was represented by 110 grid cells in the offshore direction and 120 grid cells in the alongshore direction, each cell with a 15 feet x 15 feet size. At each of the nodes or intersections of the cells, water depth, wave height, and wave direction are specified. Figure 4 shows the overall grid area and bathymetry contours for the model, and Figure 5 shows the nearshore subgrid area. The offshore bathymetry contours were obtained from USGS maps of the area, and the nearshore bathymetry was obtained from the prior report by Tom Nance Water Resource Engineering (TNWRE). For the purposes of this analysis, 1-foot contours over the shallow nearshore bench were interpreted from the information contained in TNWRE's report. The dashed lines represent the proposed improvement areas.

Figures 6 through 11 are 3-dimensional graphical representations of the nearshore wave field results from the REF/DIF model for

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[3]Dalrymple, R.A. and J.T. Kirby (1991), "Documentation Manual, Combined Refraction/Diffraction Model, REF/DIF 1, Version 2.3", Center for Applied Coastal Research, Department of Civil Engineering, University of Delaware, CACR Report No. 91-2, January.

the three wave conditions, for the existing bathymetry, and after completion of the proposed improvements. Because of the shallowness of the nearshore bench, a +1-foot tide level was imposed to provide conservative results for wave energy propagation over the bench during high tide.

Because the waves break at the edge of the shallow nearshore bench and the resulting waves over the bench area are small, it is difficult to see the wave patterns near the shoreline and to compare the differences, if any, between the existing condition and with the proposed improvements. Therefore, a different method was developed to graphically show the model results. Figures 12 through 17 depict wave height contours corresponding to the wave fields in Figures 6-11. Each contour line represents waves of a given height. From these graphical presentations, the following can be noted:

- The shallow depth at the seaward edge of the nearshore bench controls the maximum wave height that can propagate across the bench area. In other words, the maximum wave heights at the seaward edge of the nearshore bench are depth-limited, and wave heights cannot increase shoreward of the edge of the nearshore bench even though there are deeper pockets there.

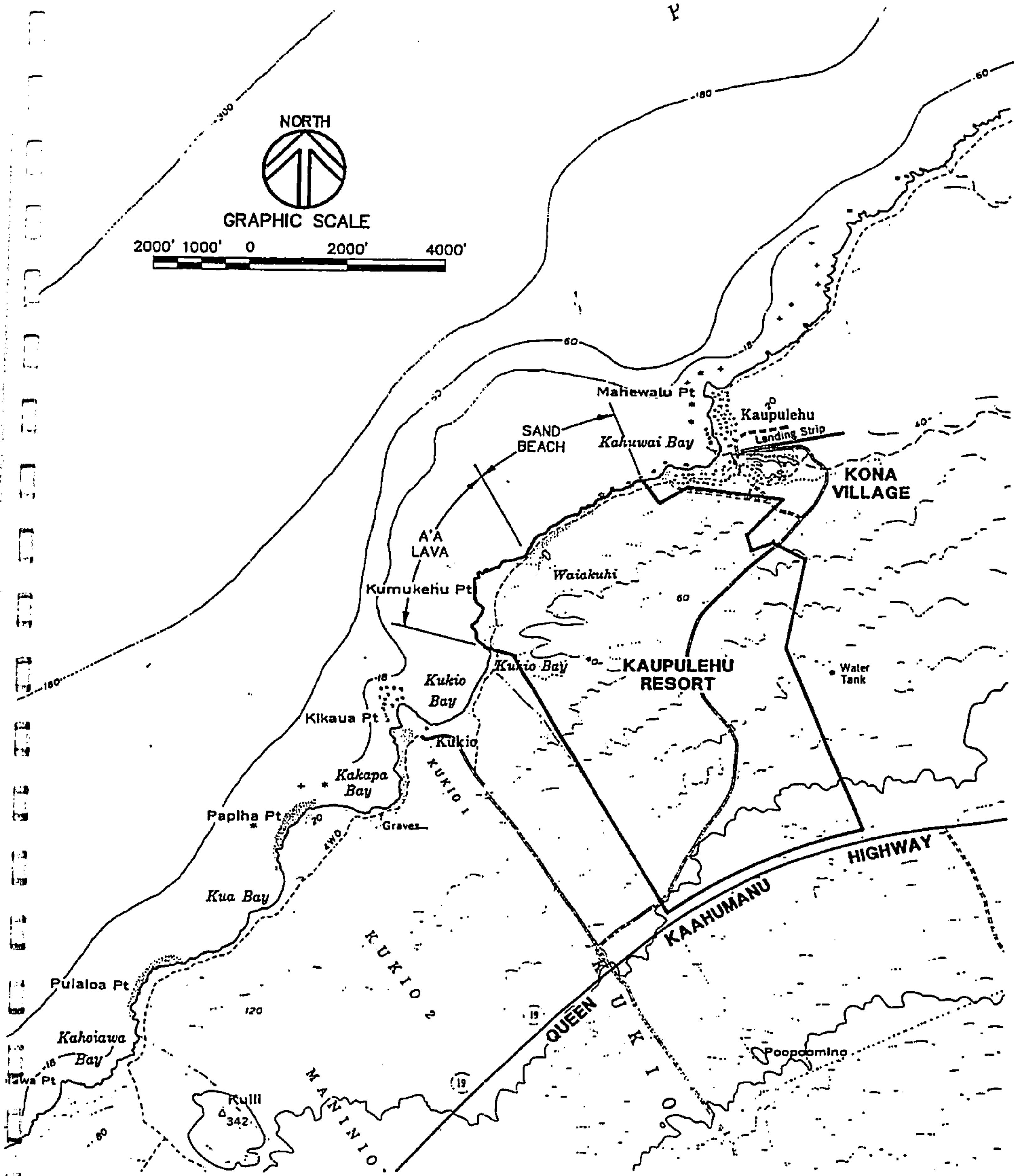
- Wave heights at the shoreline are less than 0.5 feet, regardless of the deepwater wave parameters. There is no significant difference in wave heights at the shoreline for the existing condition and after improvements are completed.

5.0 SUMMARY AND CONCLUSIONS

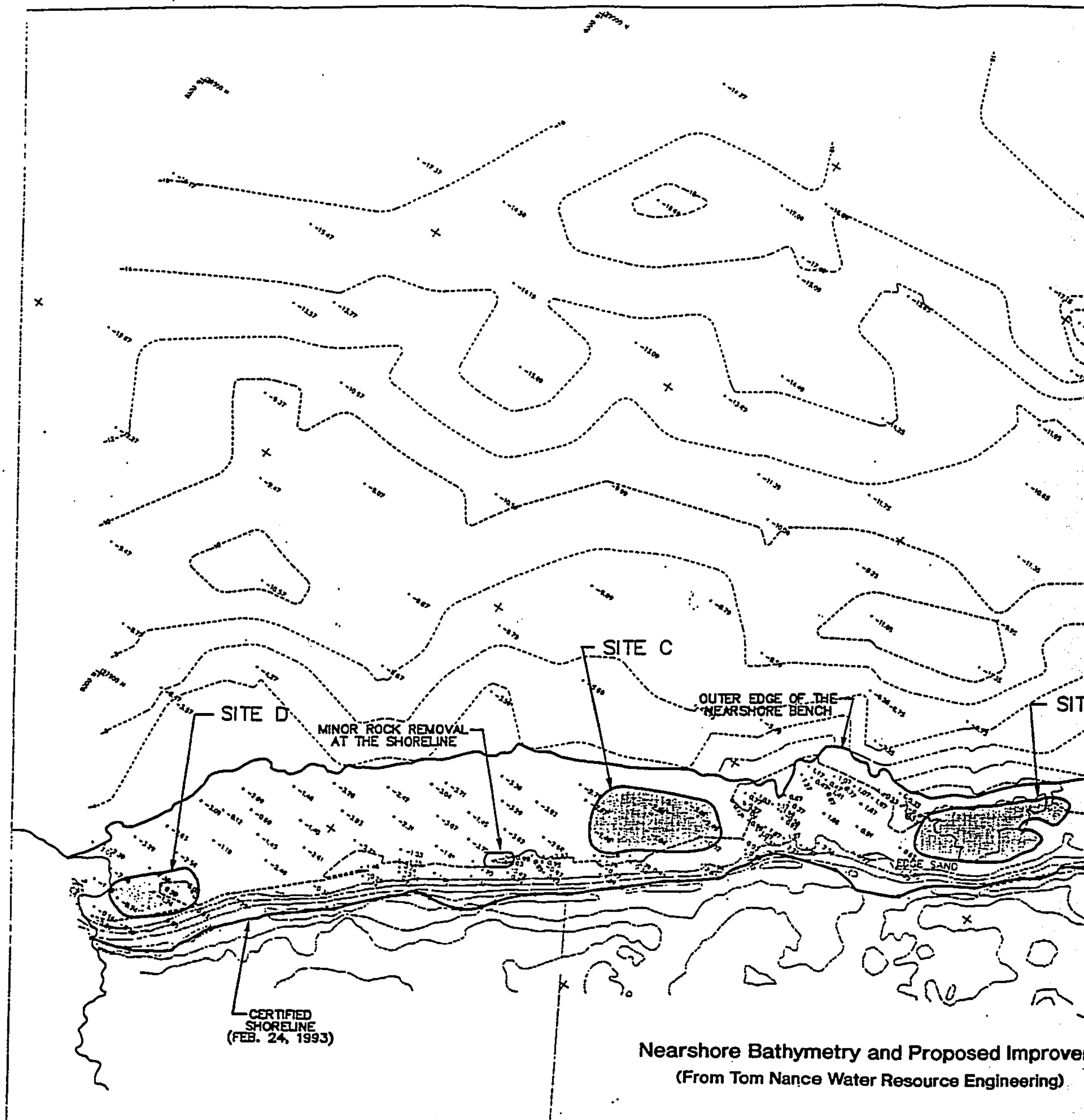
A numerical model called REF/DIF was used to evaluate wave transformation characteristics over the shallow nearshore bench fronting the Kaupulehu Resort property. The purpose of this study was to demonstrate the possible changes to the wave heights at the shoreline due to deepening of four sites on the nearshore bench. Three deepwater wave conditions were modeled, representing the typical range of wave types affecting the site.

The study confirms the benign wave climate at the site and the small wave heights that reach the shoreline. The results from the wave transformation modeling indicate that the waves at the seaward edge of the narrow nearshore bench are depth-limited, and that wave energy decreases shoreward. Comparison of the results between the existing condition and with the proposed improvements indicate no significant difference in the wave energy levels reaching the shoreline. Even with the proposed deepening of the tidepools, wave heights reaching the shore are typically less than 0.5 feet.

From the results of this study, it can be concluded that there would be no significant impact on the existing coastal processes or on beach stability as a result of the proposed improvements.



Location of the Kaupulehu Resort Along the North Kona Shoreline **FIGURE 1**



Nearshore Bathymetry and Proposed Improve

(From Tom Nance Water Resource Engineering)

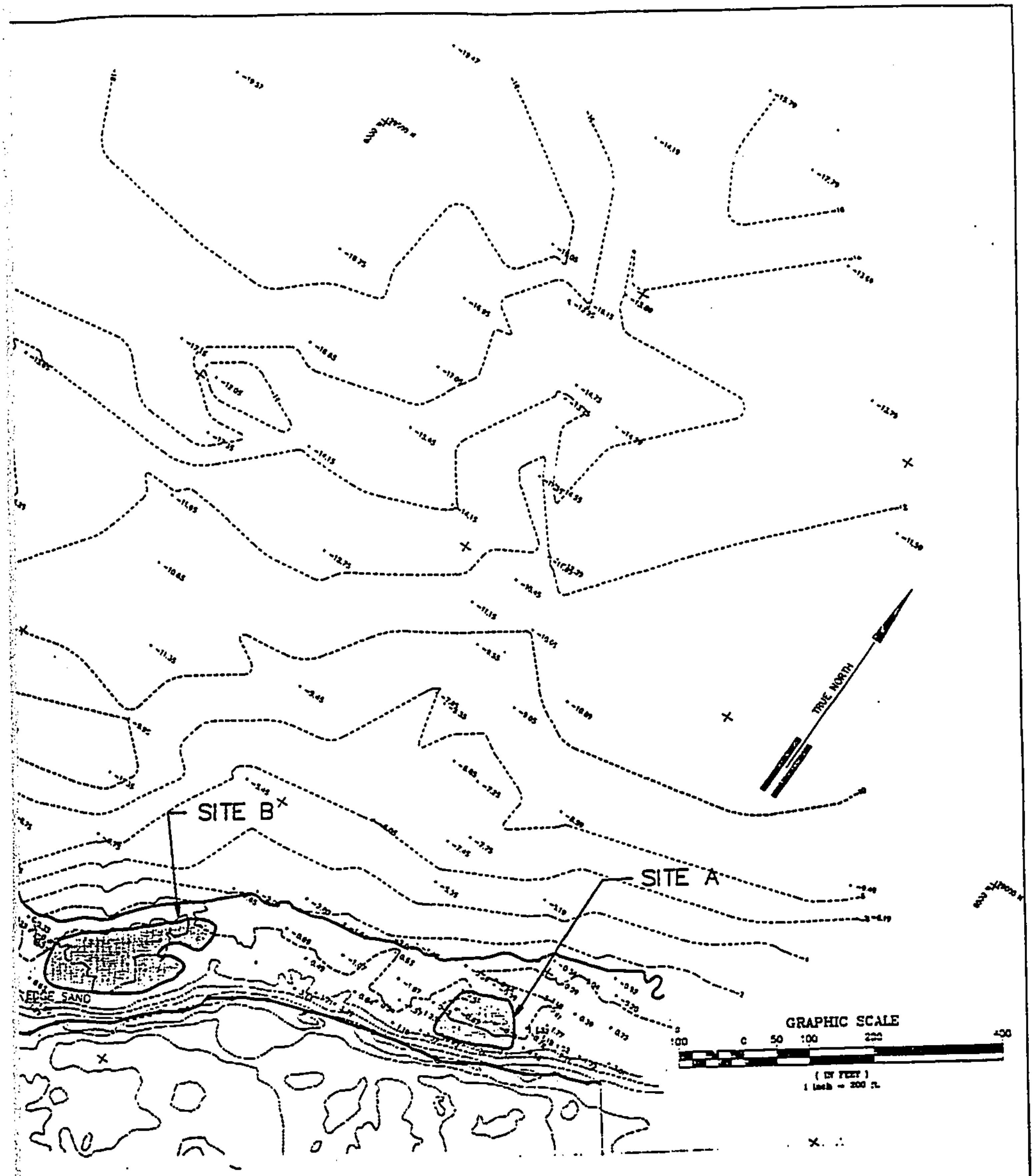
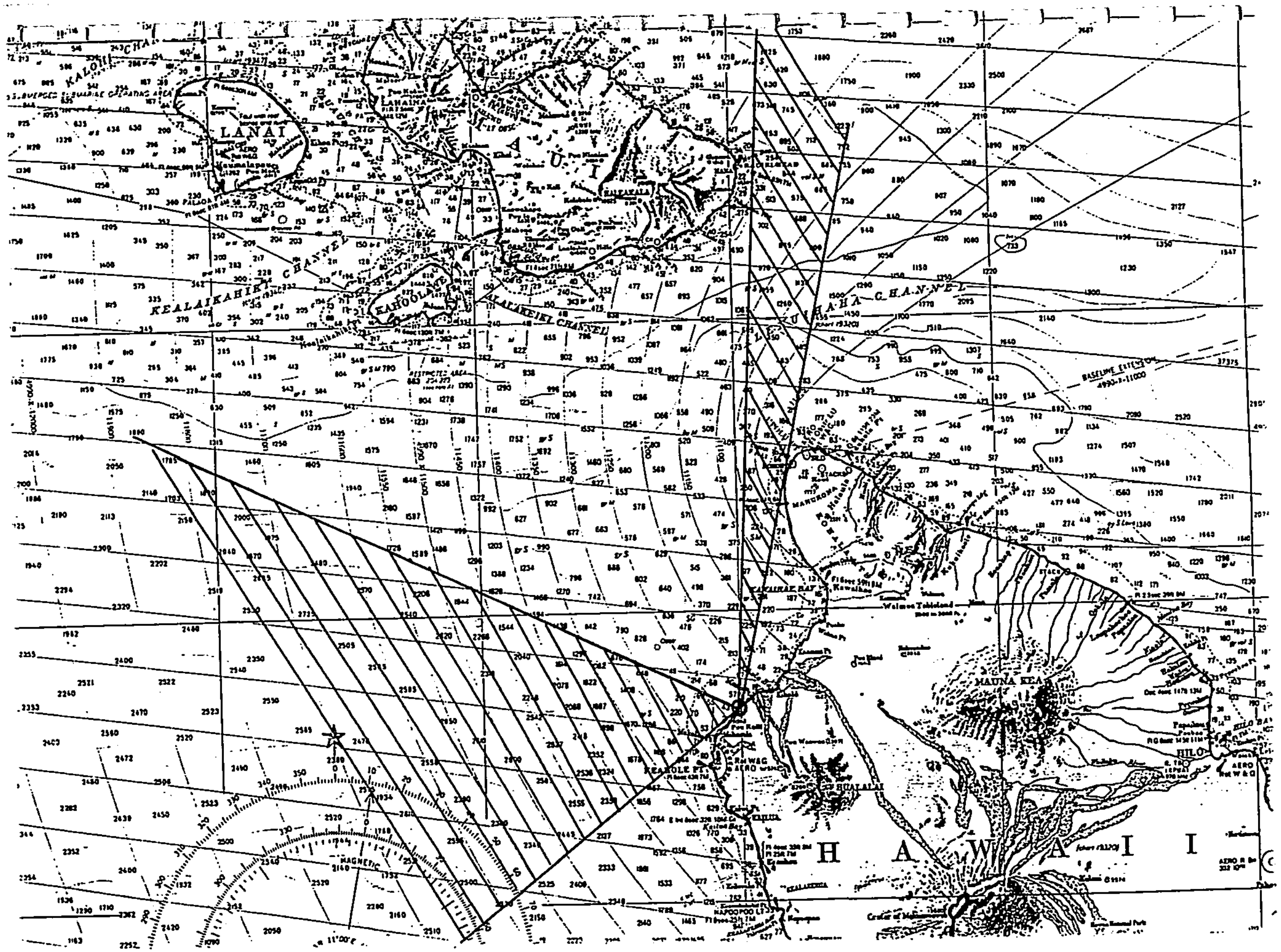


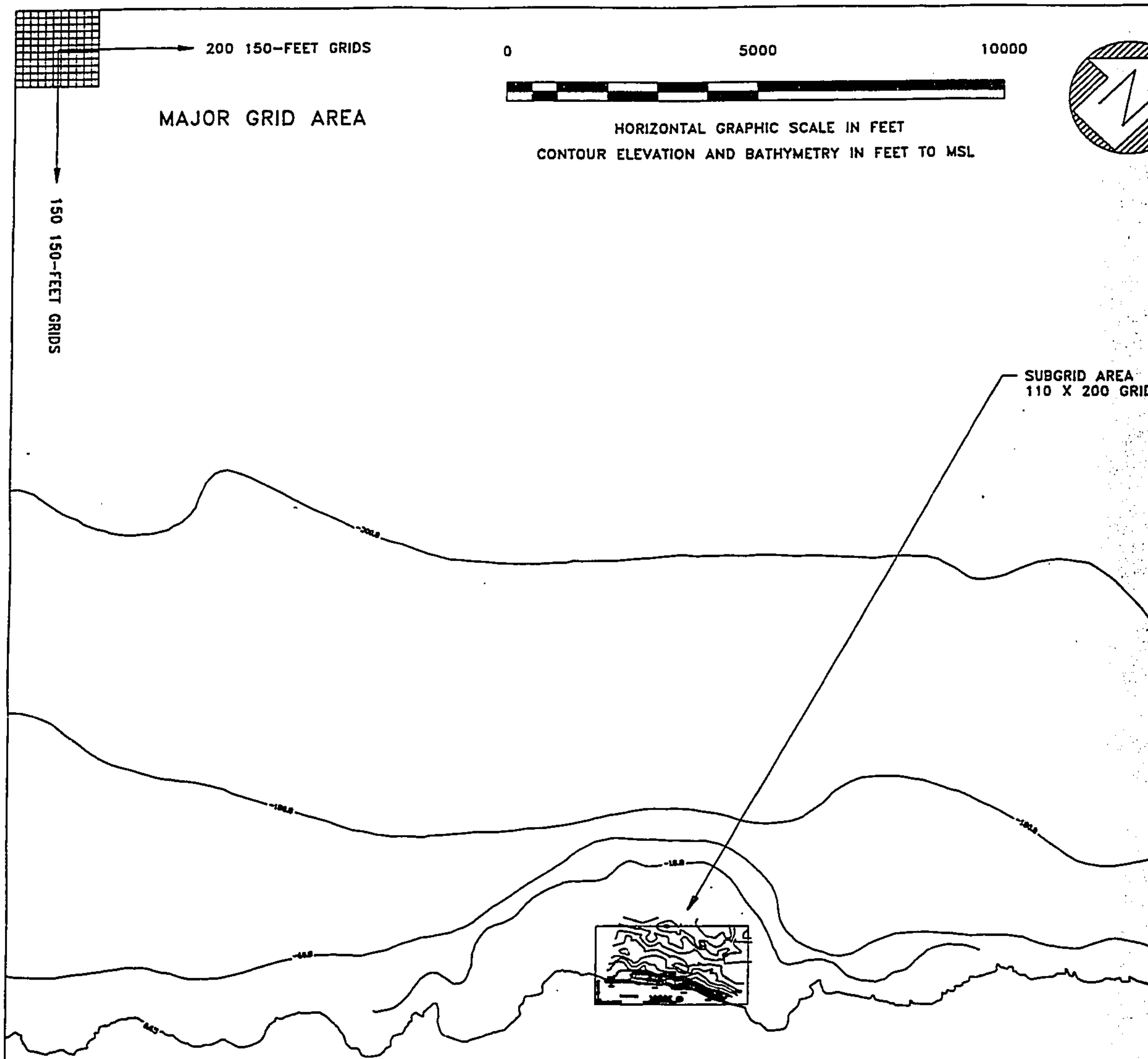
FIGURE 2

...d Proposed Improvements
...Resource Engineering)

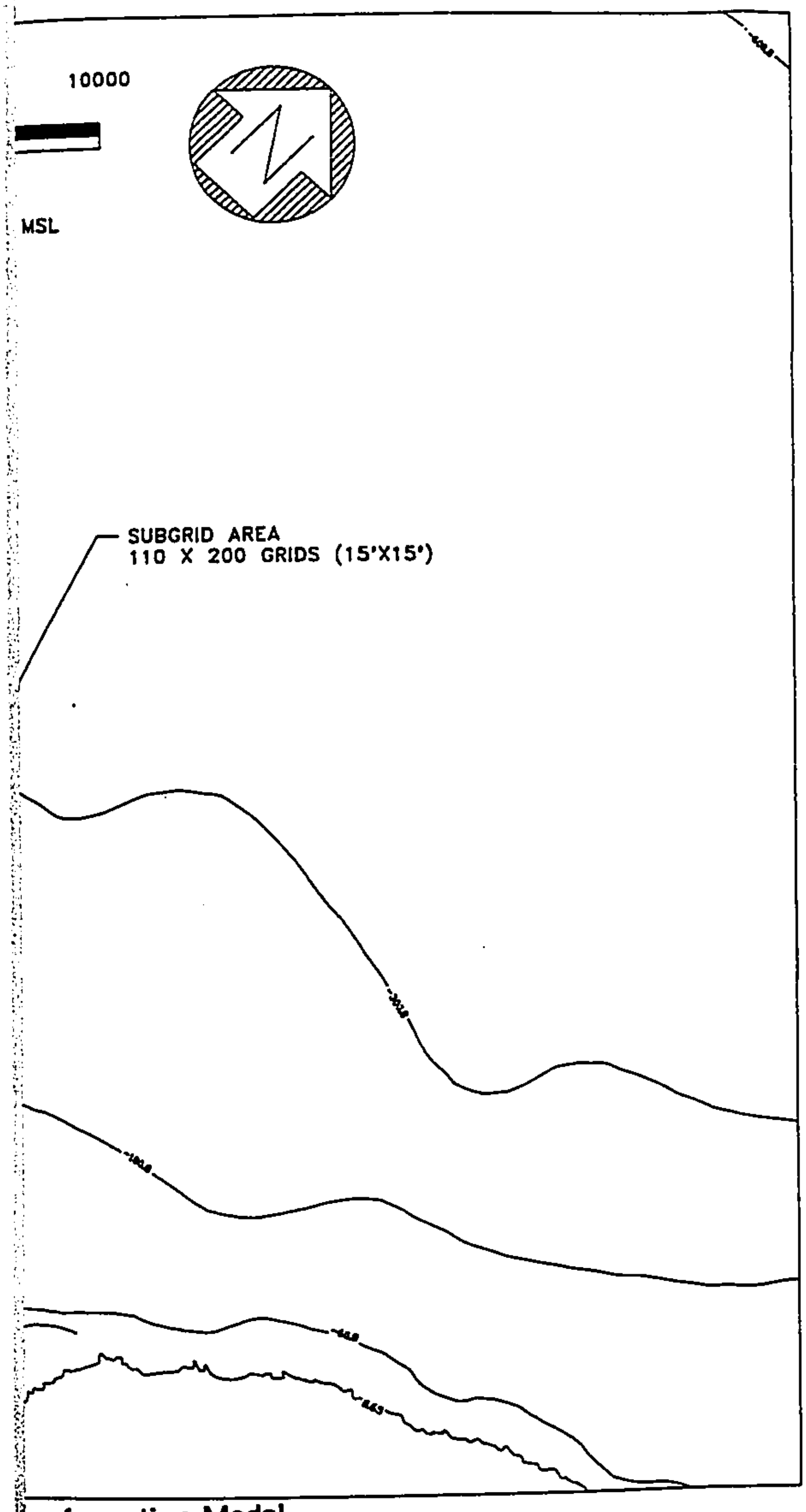


Wave Approach Sectors Affecting the Project Site

FIGURE 3

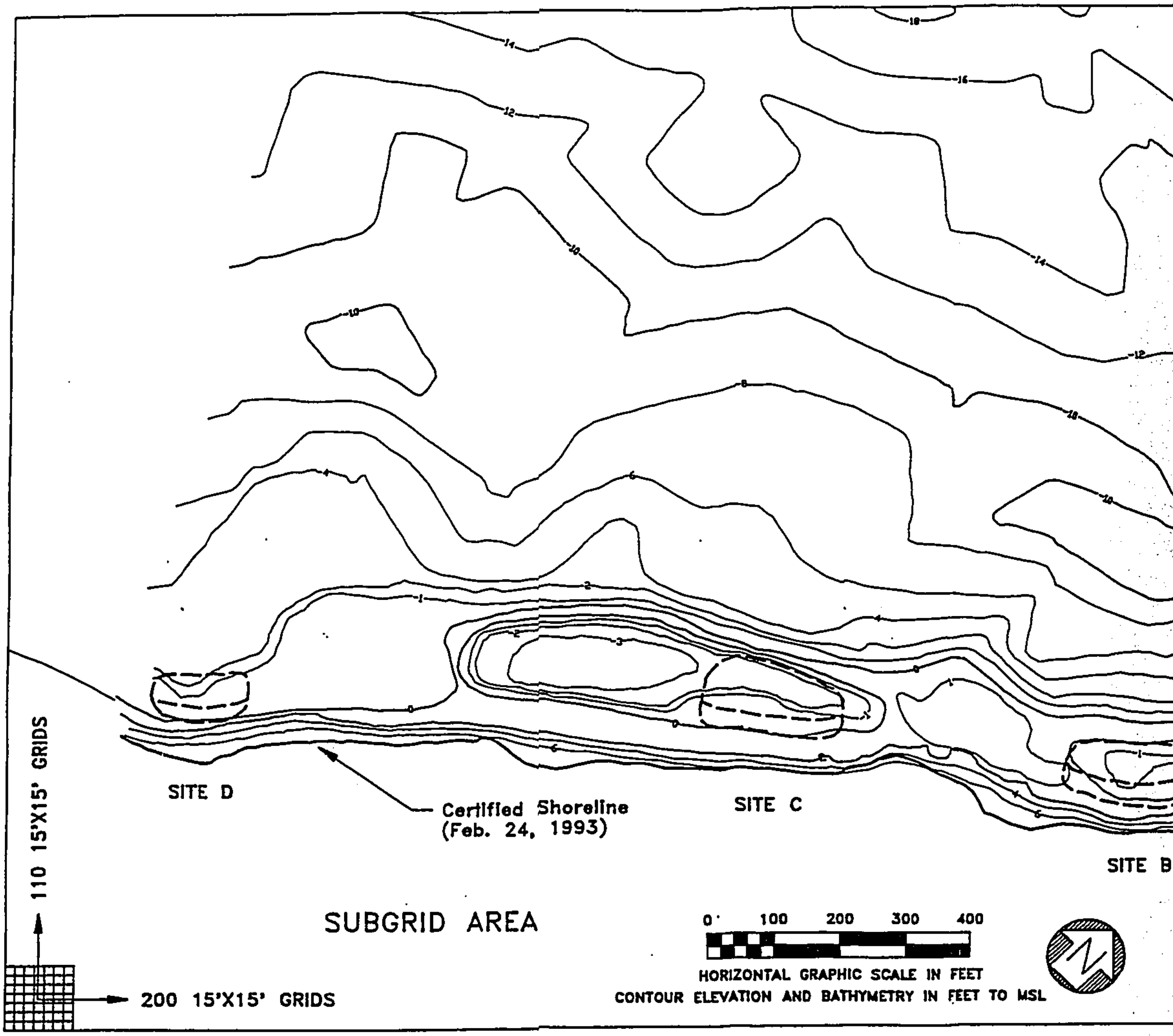


Overall Grid Area and Bathymetry Contours for the Wave Transformation Model

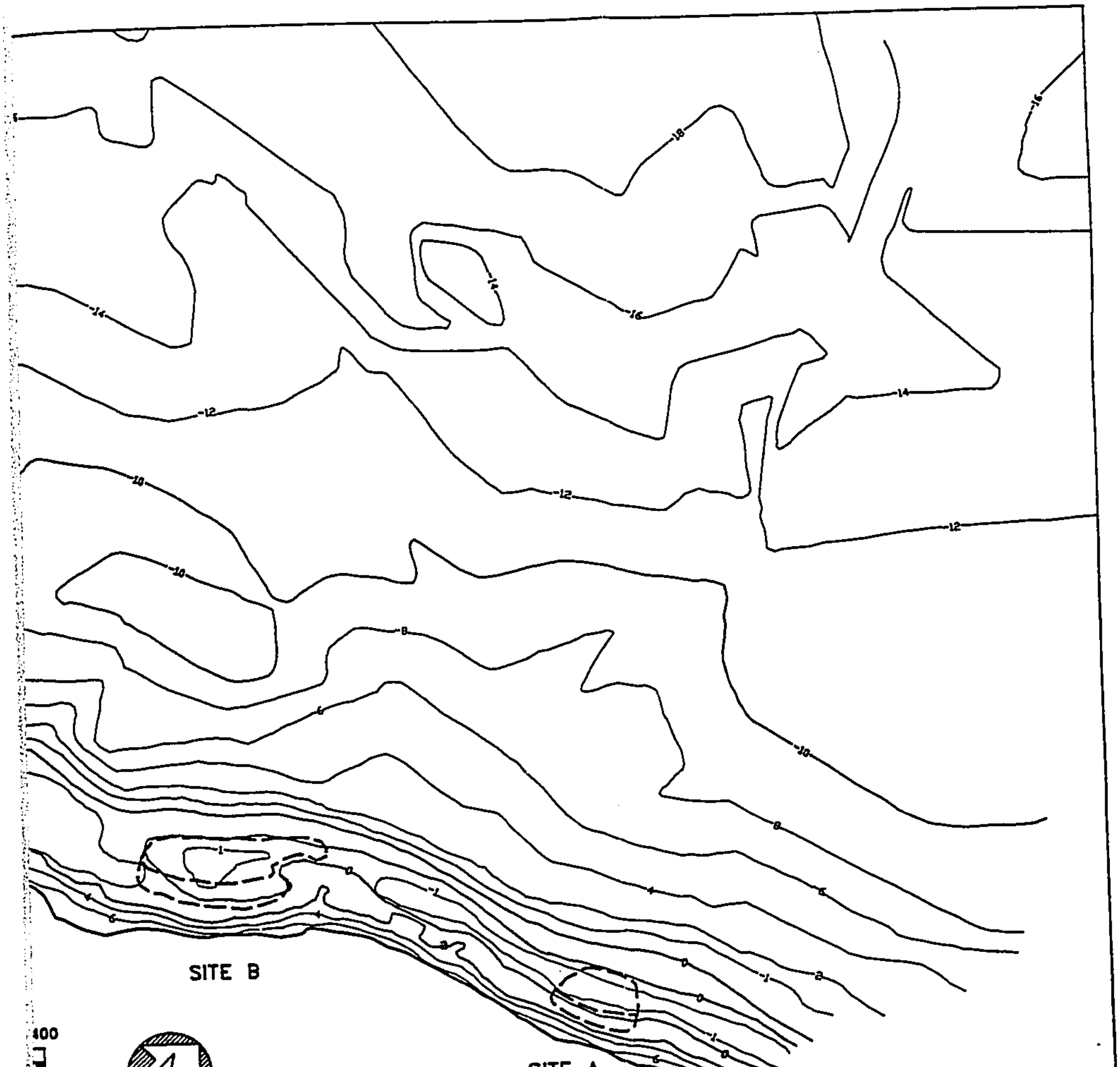


nsformation Model

FIGURE 4

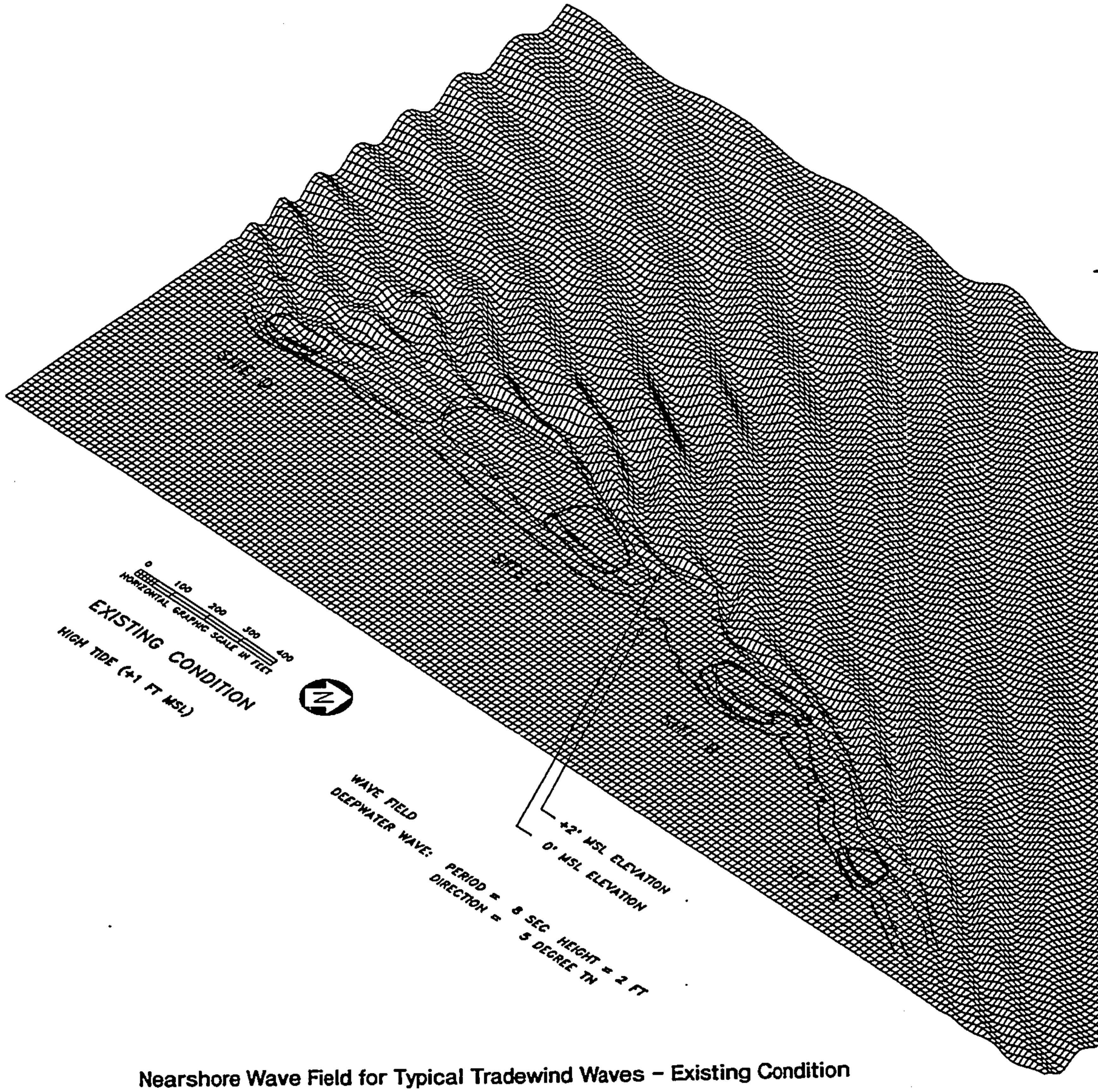


Nearshore Subgrid Area and Bathymetry Contours for the Wave Trans



's for the Wave Transformation Model

FIGURE 5



Nearshore Wave Field for Typical Tradewind Waves – Existing Condition

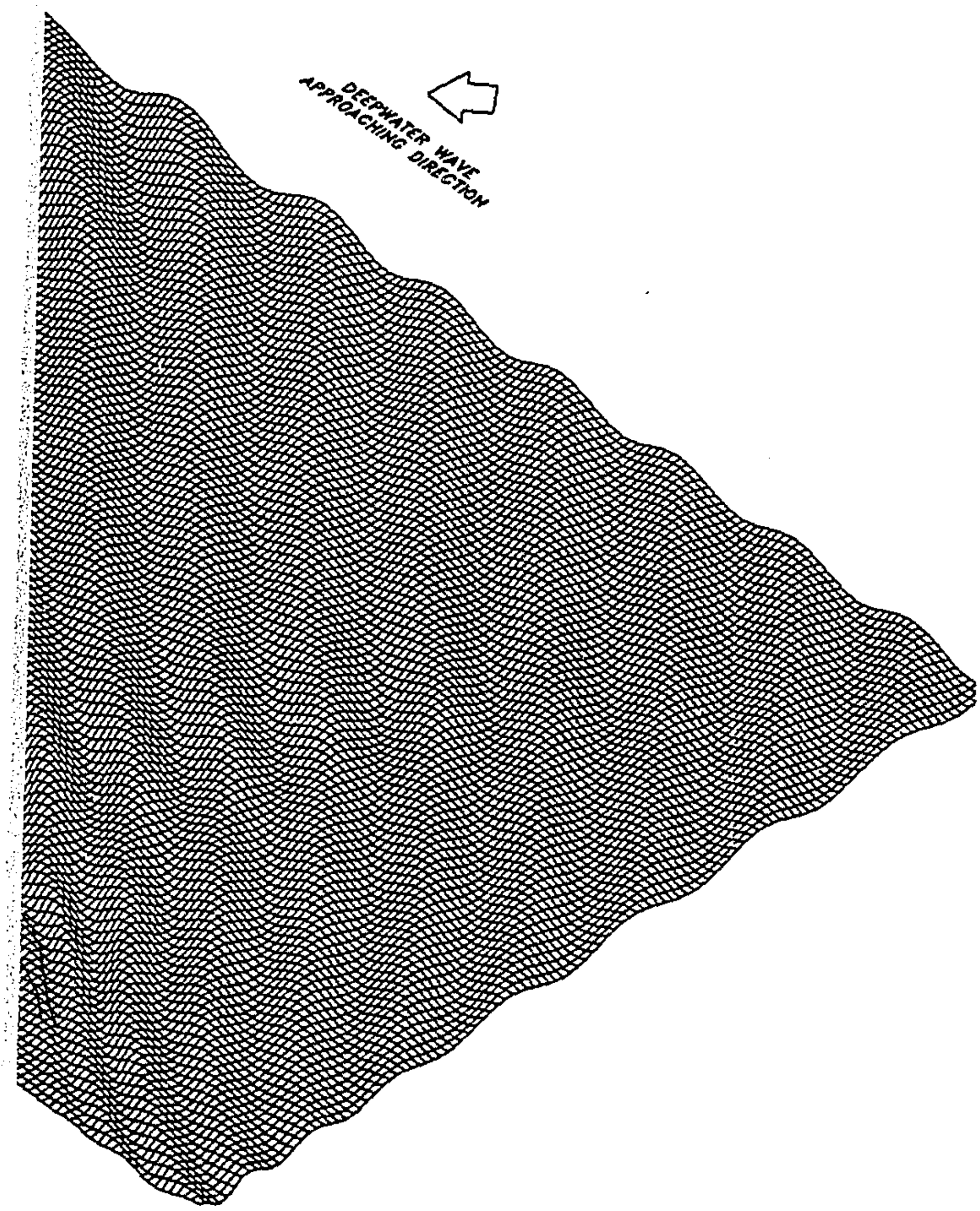
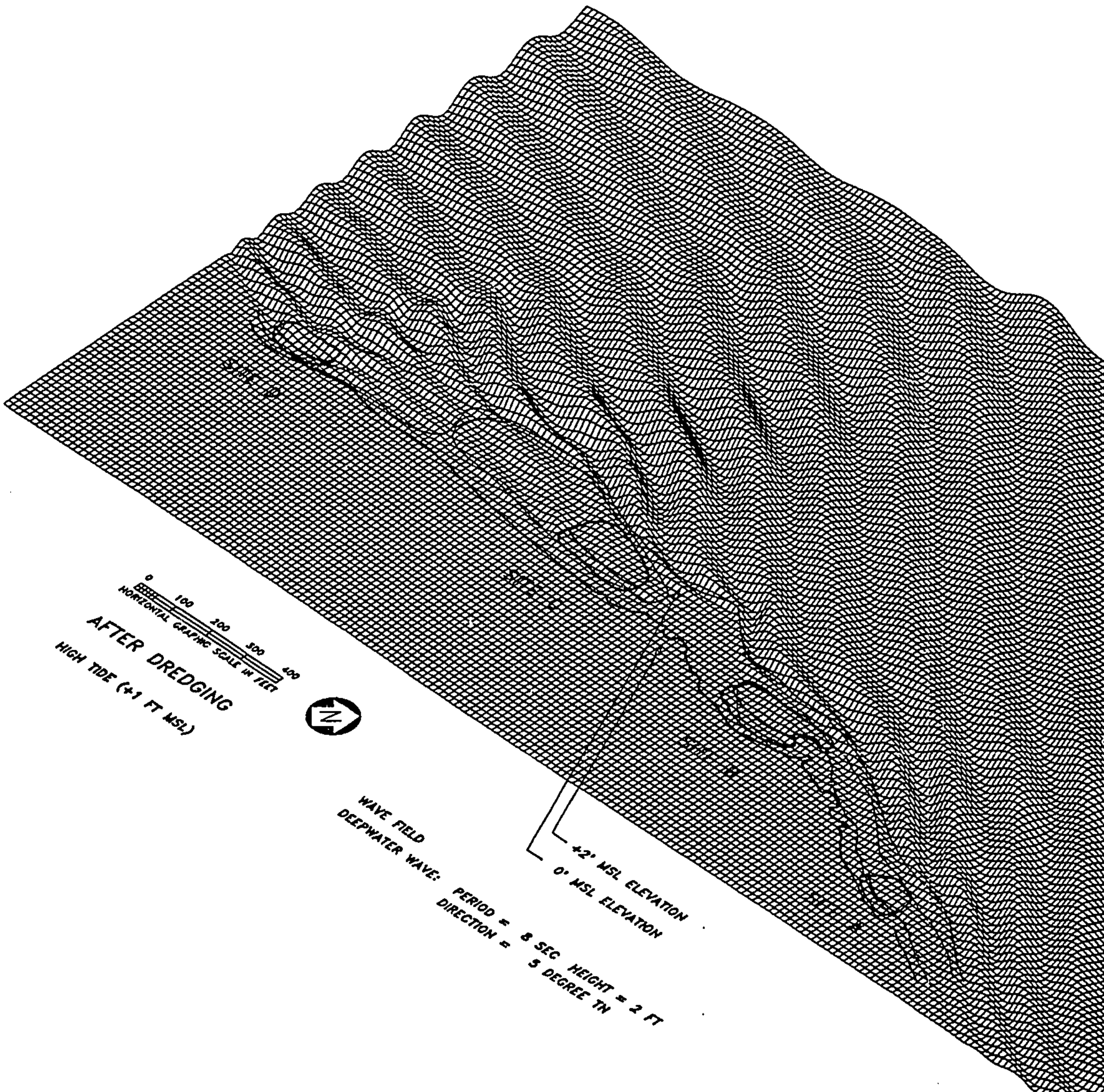


FIGURE 6



Nearshore Wave Field for Typical Tradewind Waves – With Proposed Improvements

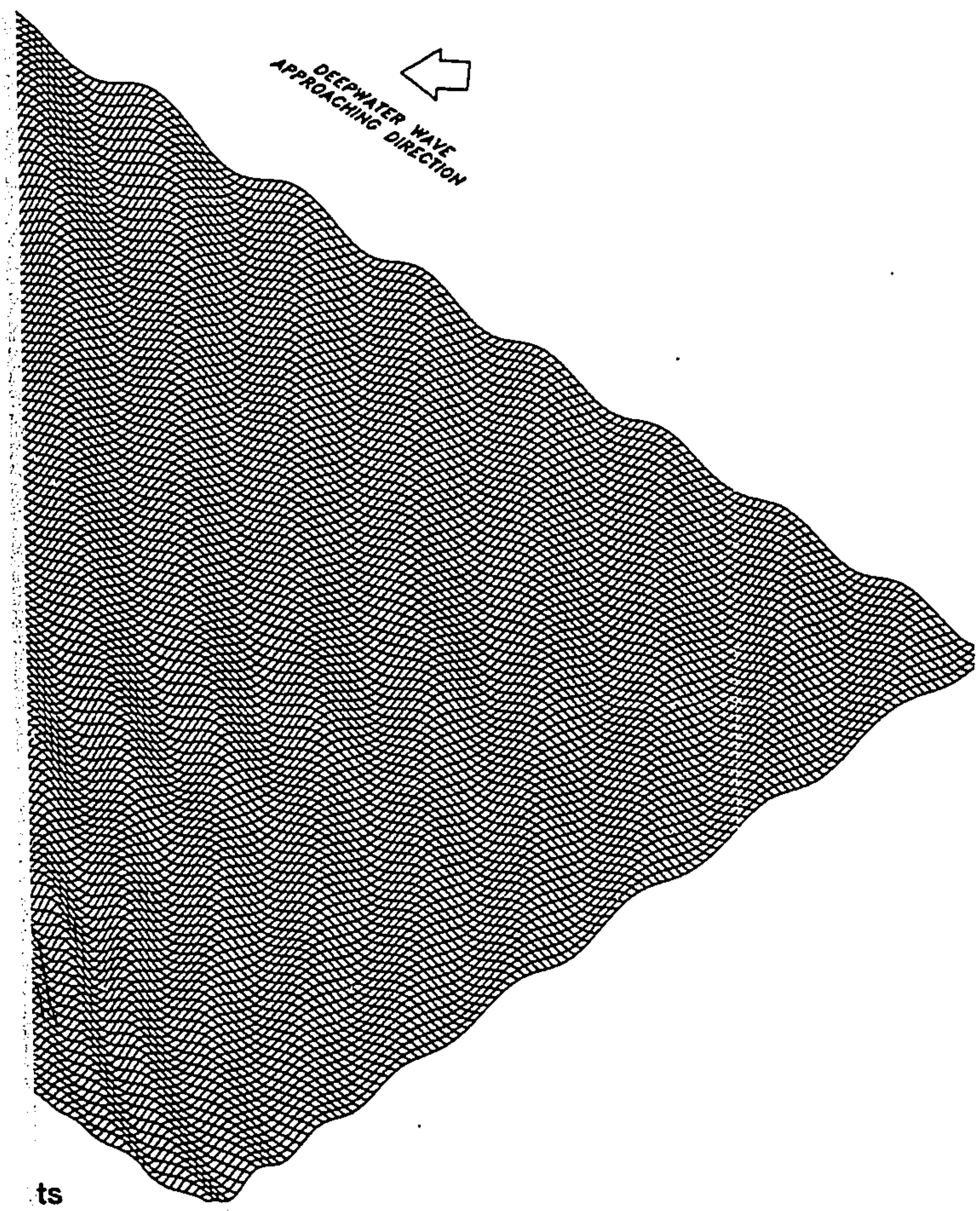


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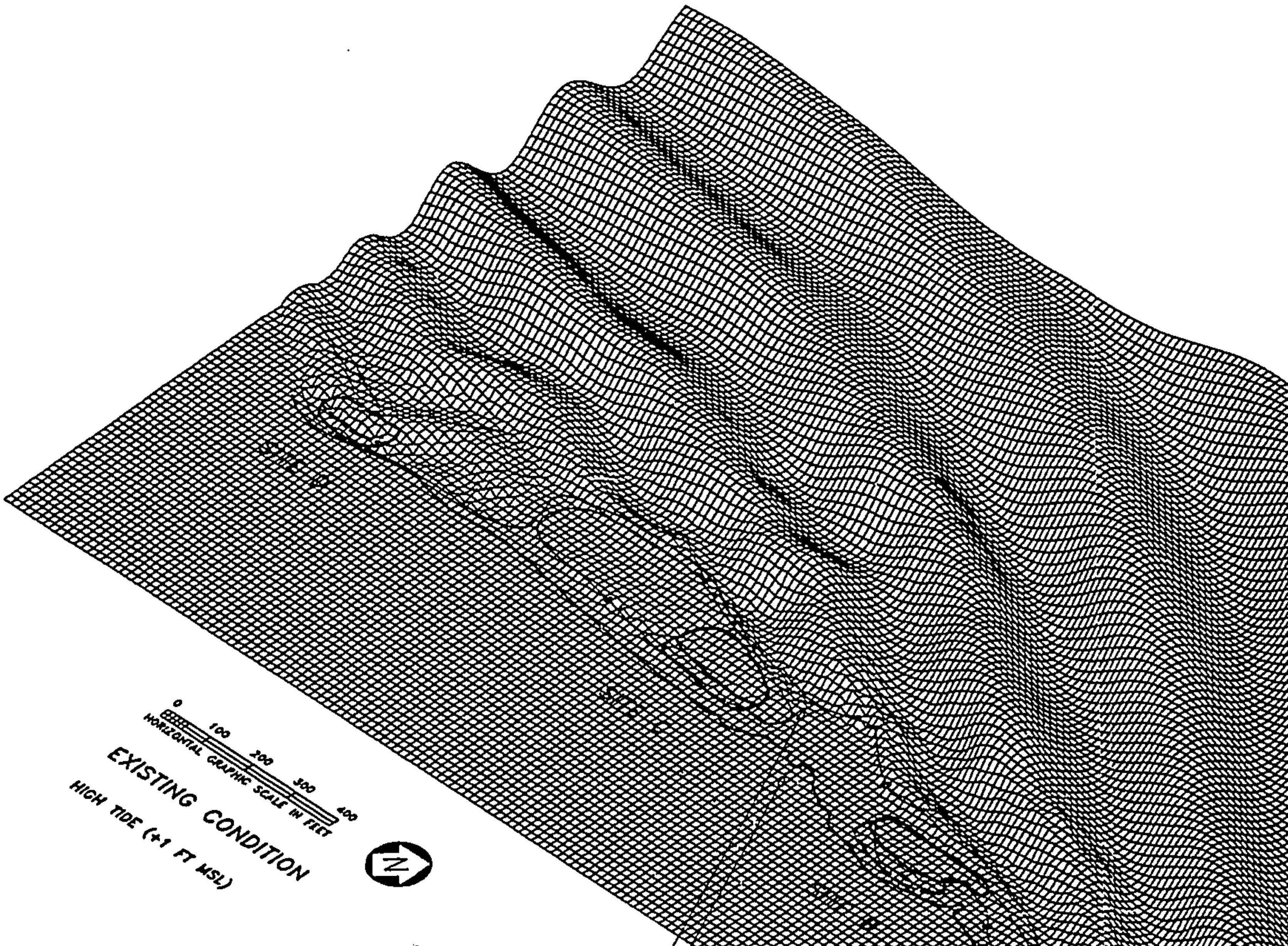
FIGURE 7



Nearshore Wave Field for Typical North Pacific Swell – Existing Condition

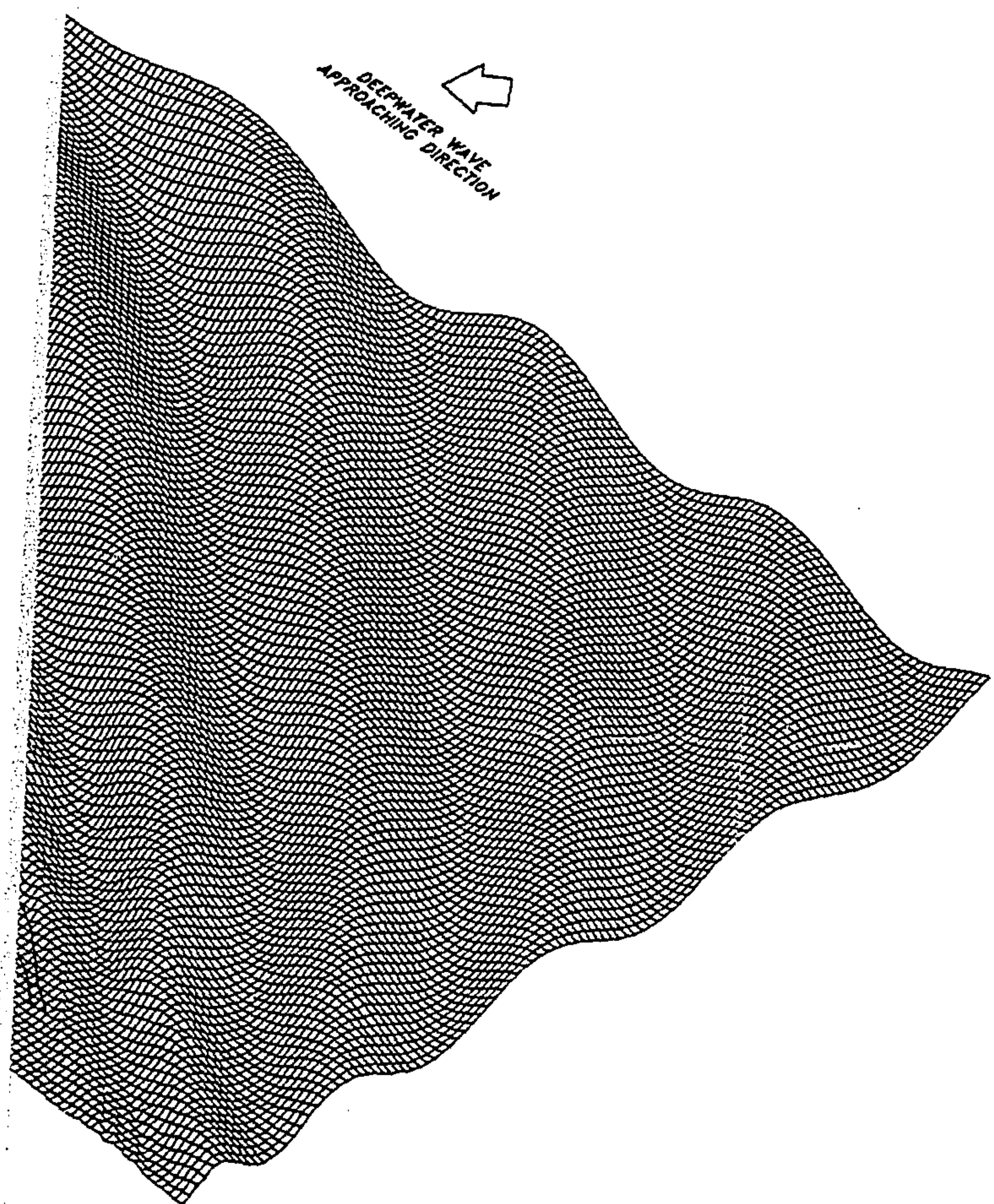
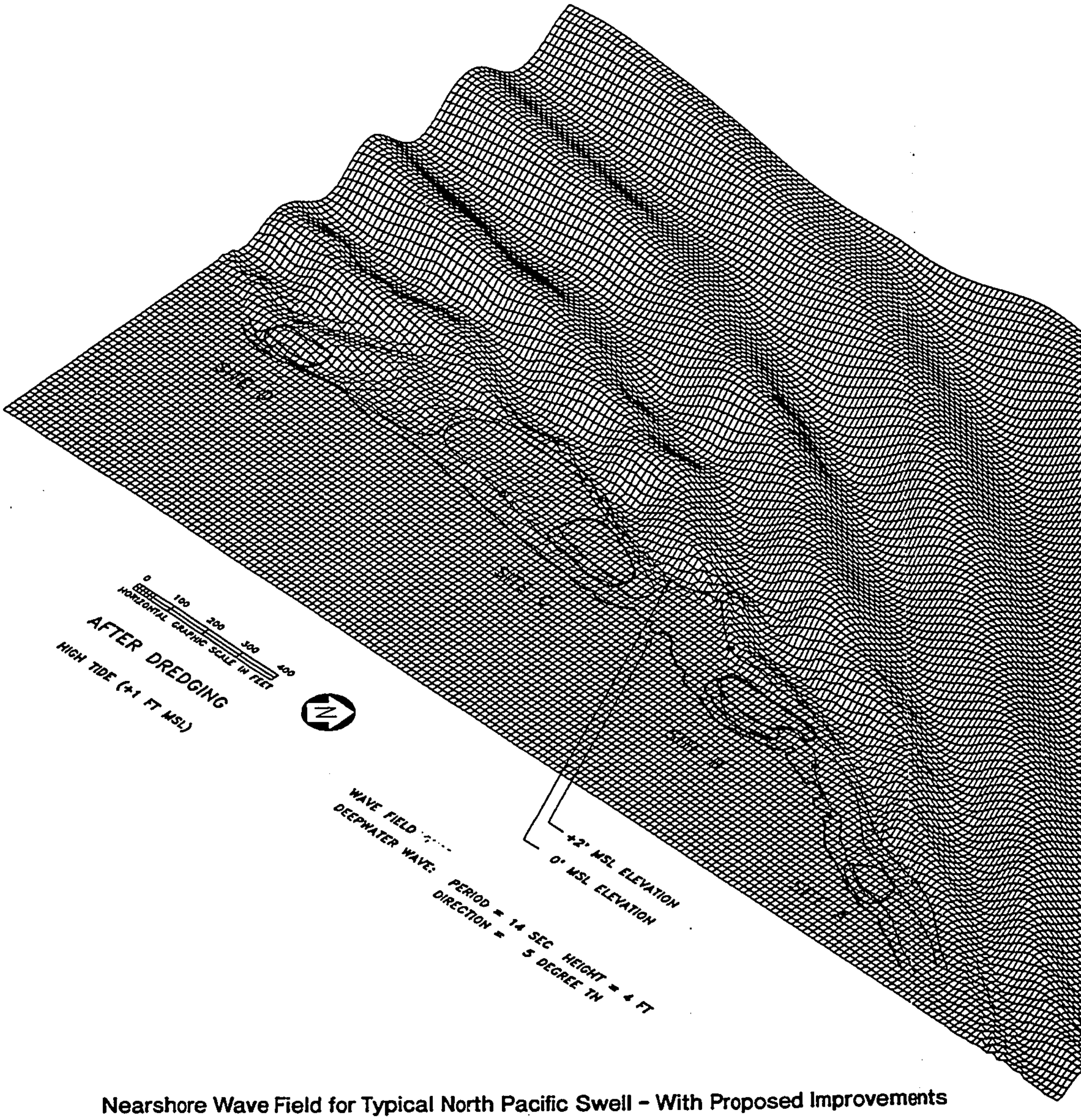


FIGURE 8



Nearshore Wave Field for Typical North Pacific Swell - With Proposed Improvements

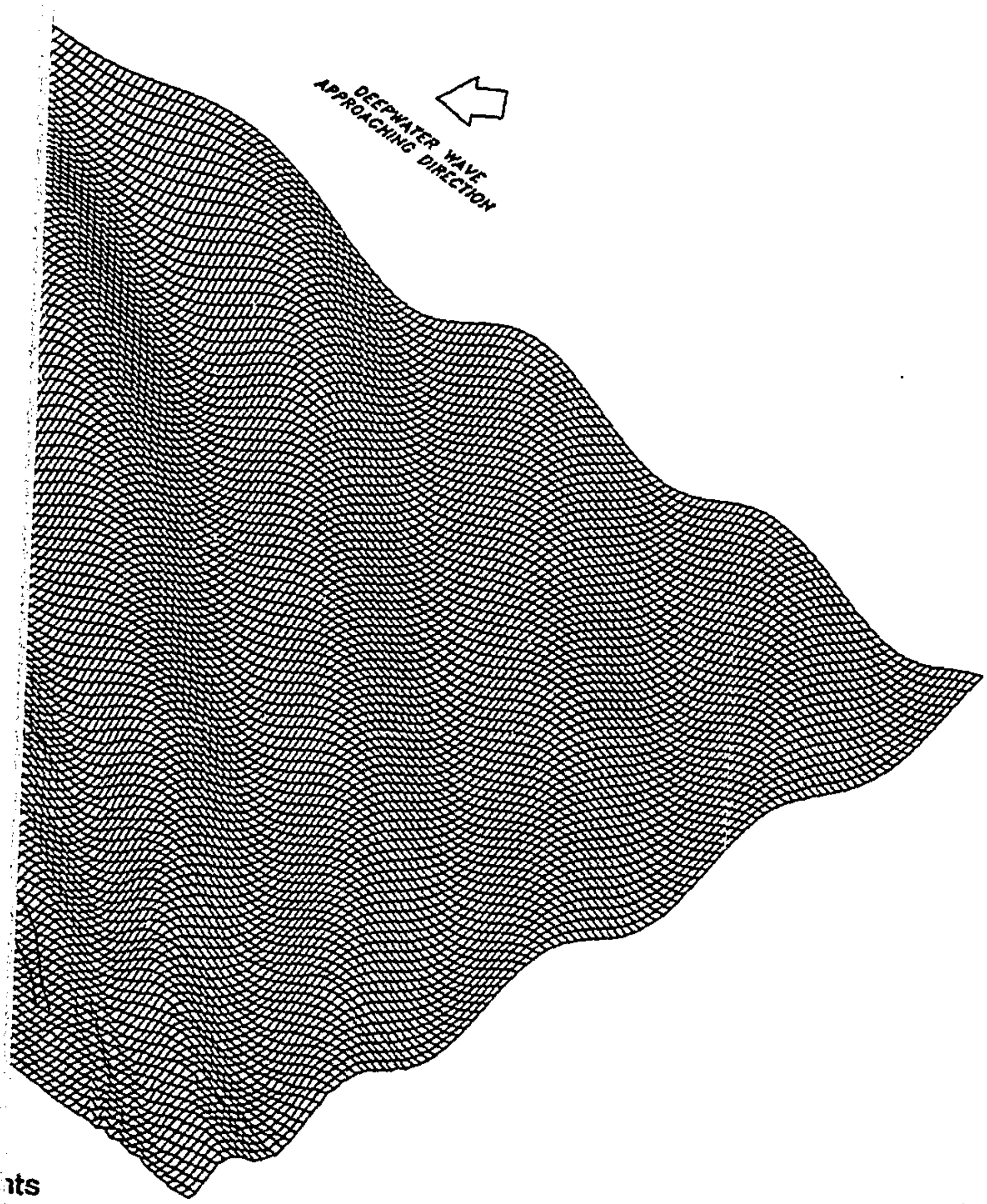


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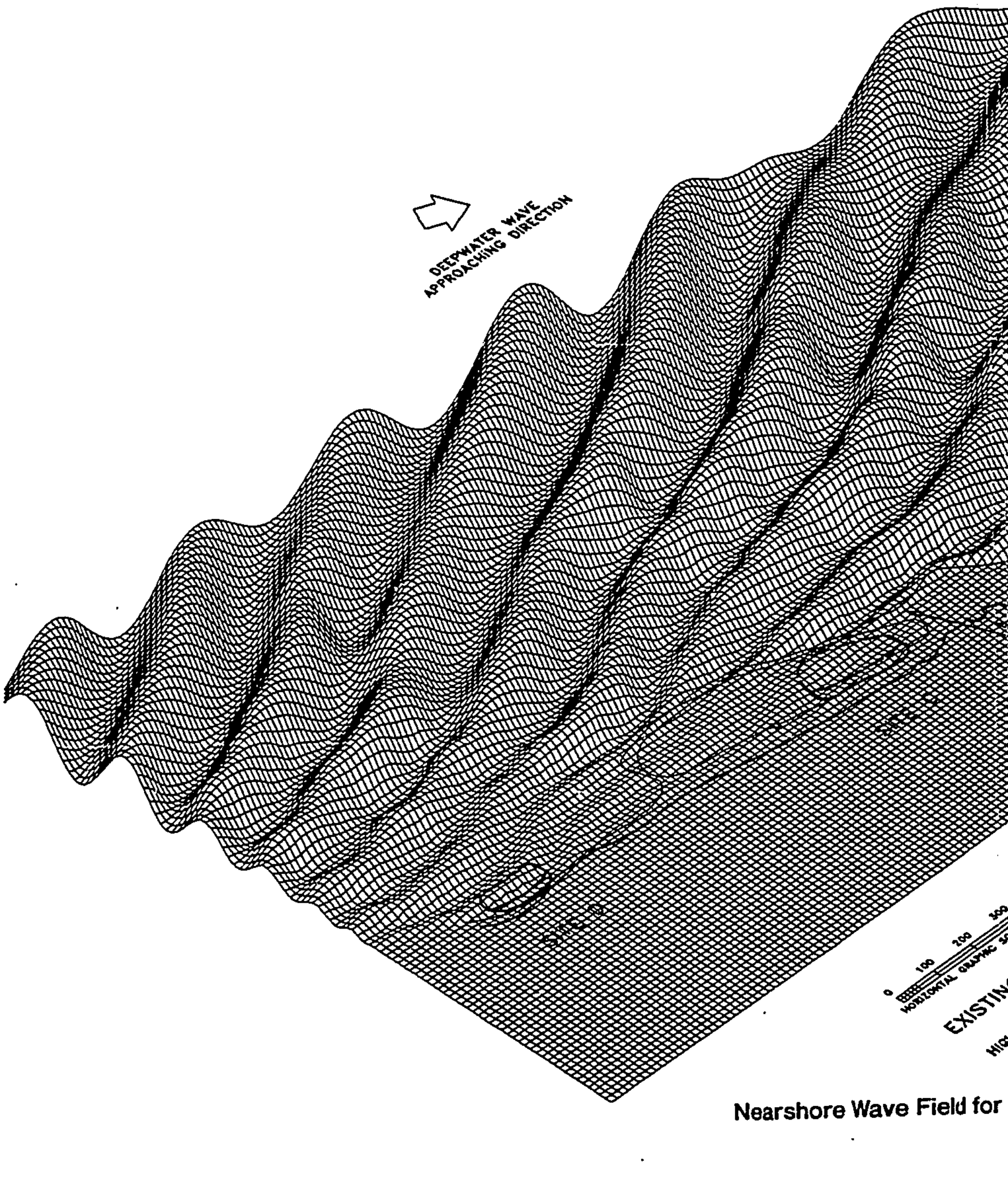
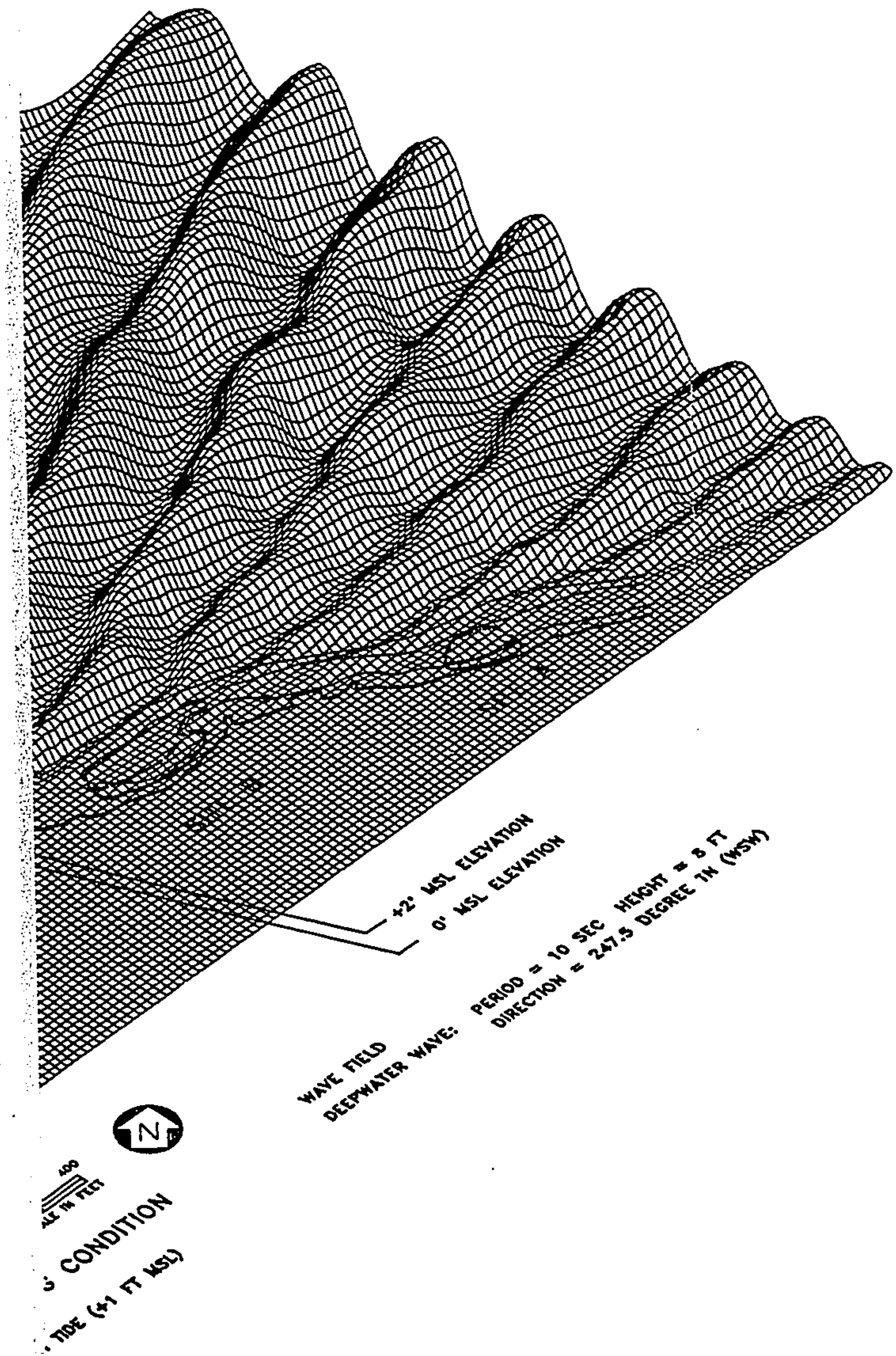
FIGURE 9

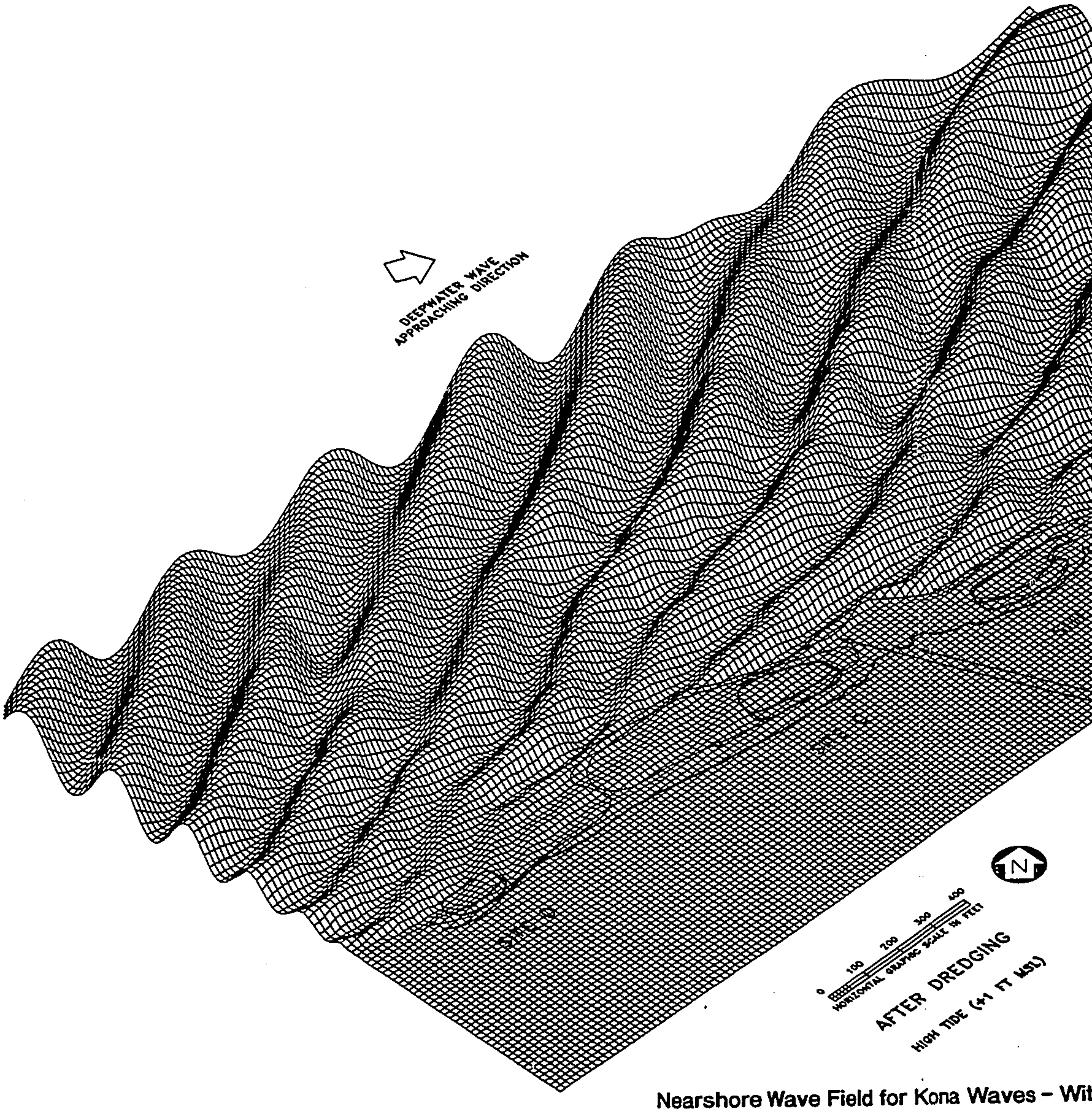


Nearshore Wave Field for

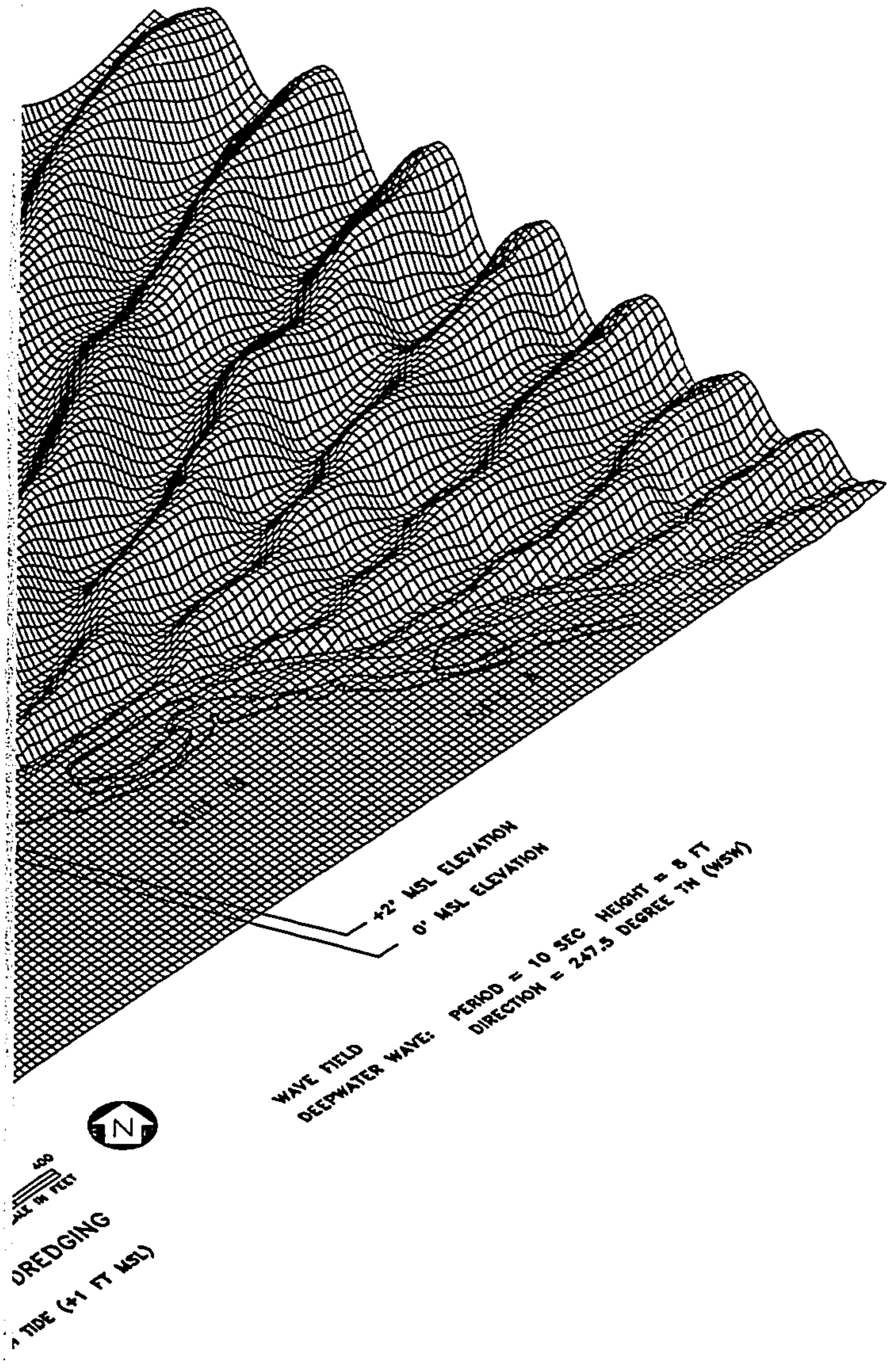


Kona Waves - Existing Condition

FIGURE 10

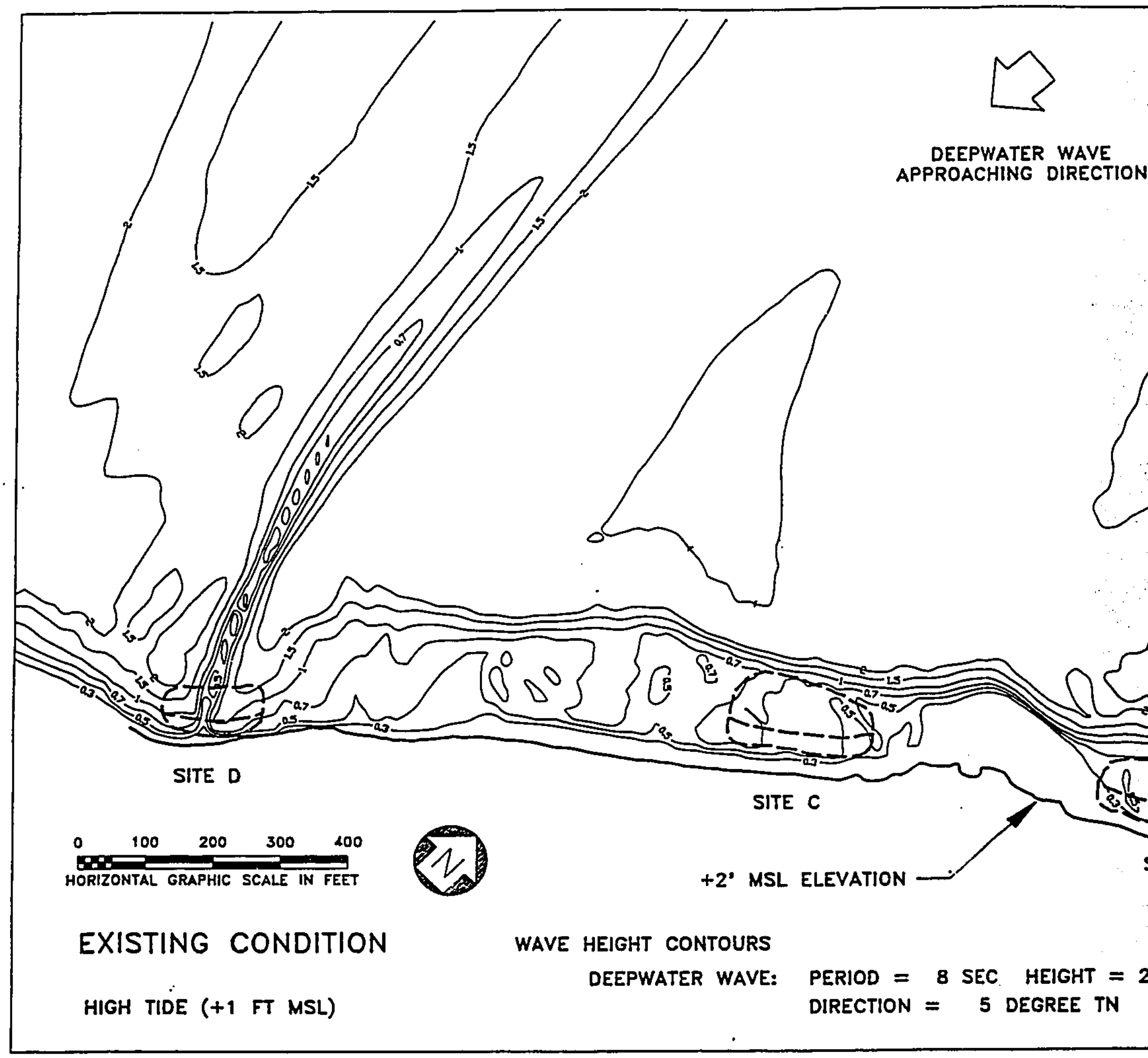


Nearshore Wave Field for Kona Waves - Wit

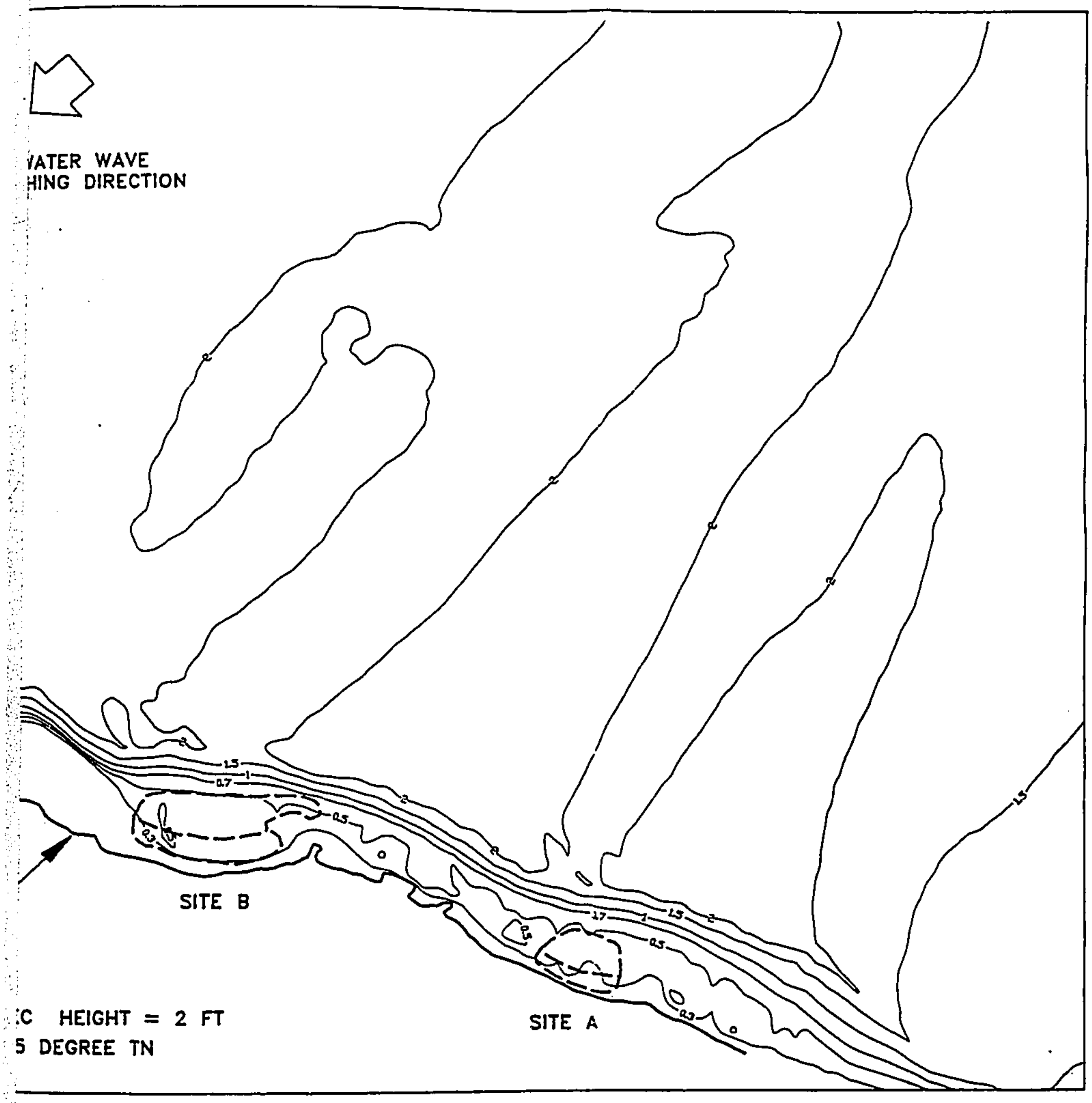


na Waves - With Proposed Improvements

FIGURE 11

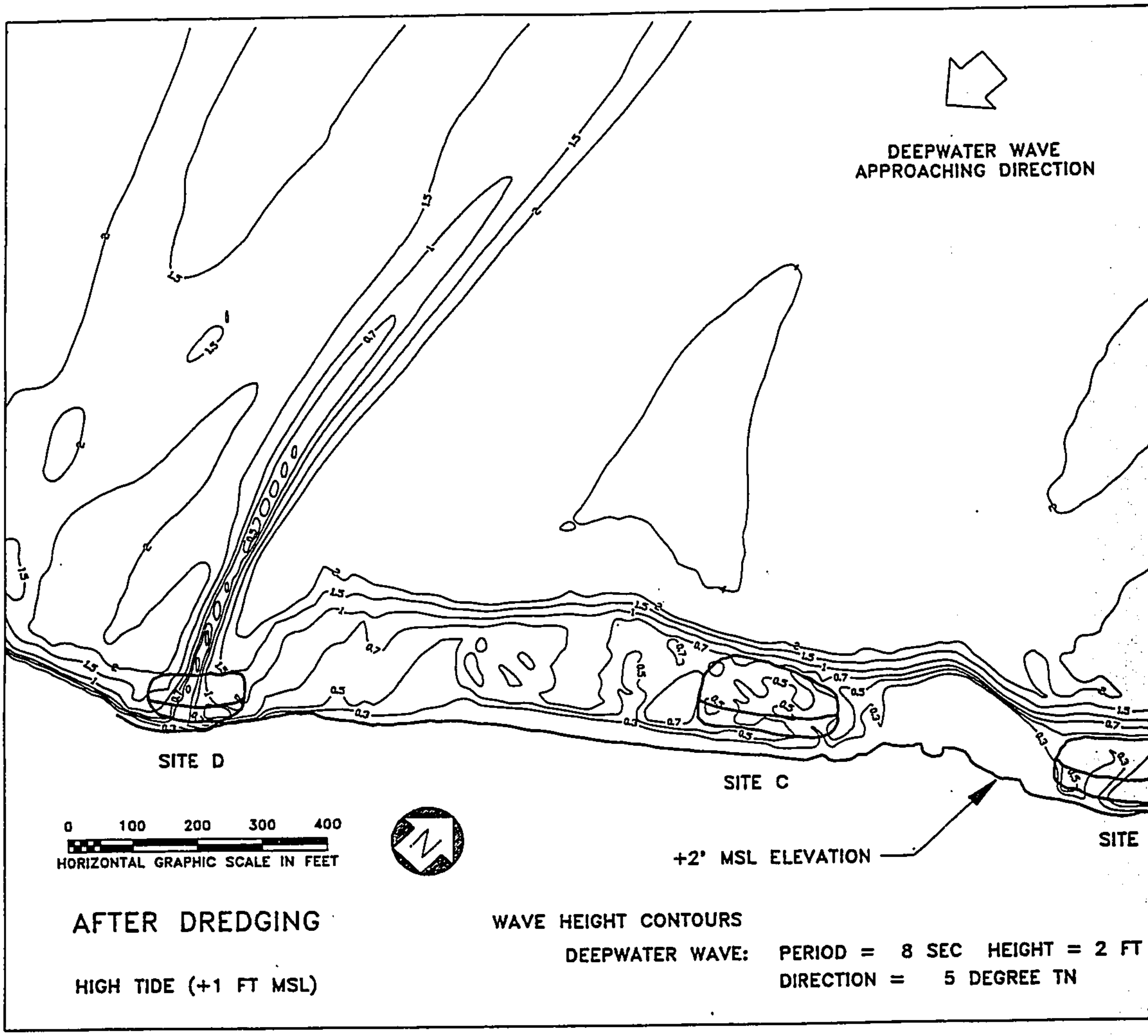


Wave Height Contours for Typical Tradewind Waves – Exis

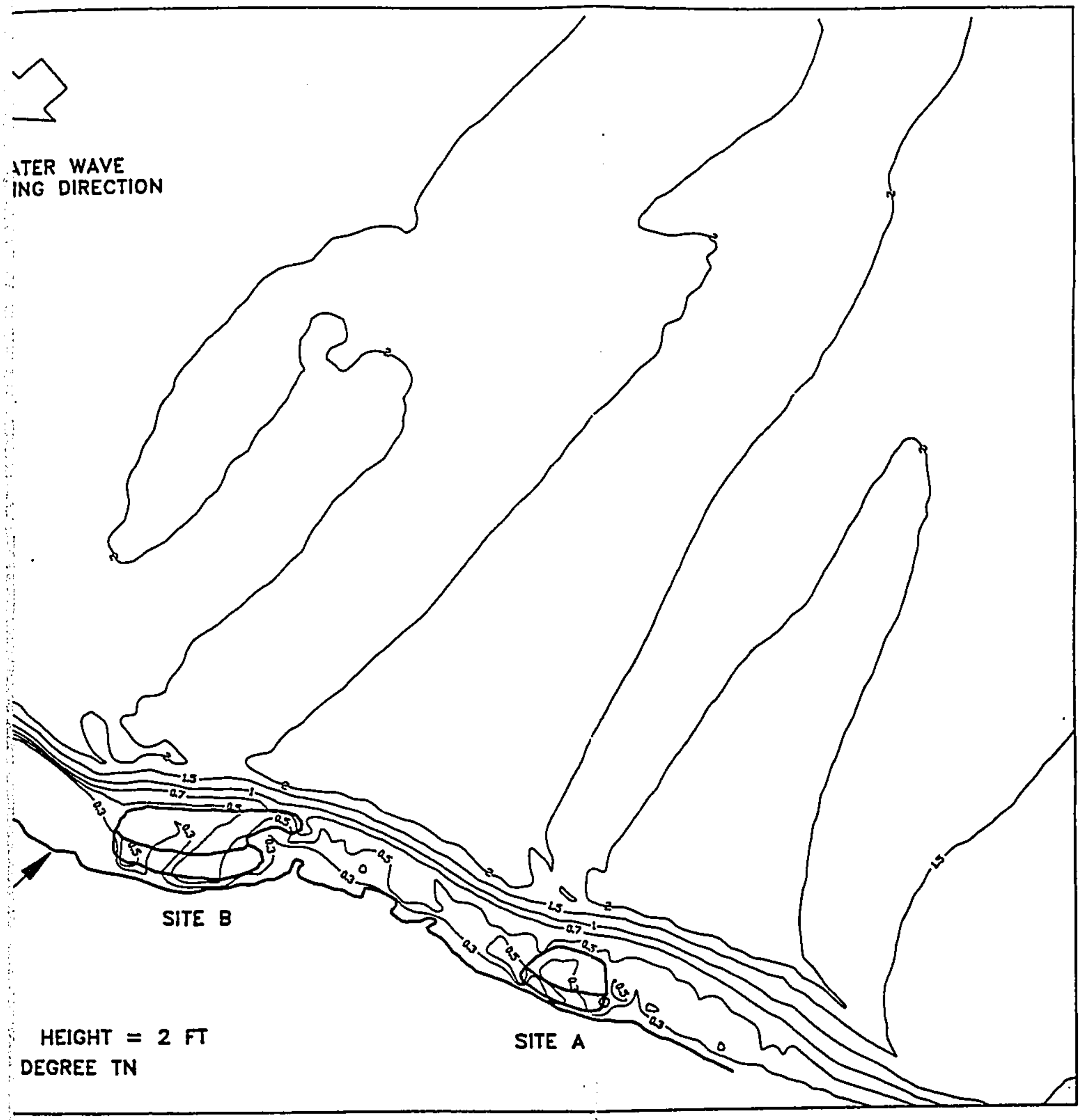


nd Waves – Existing Condition

FIGURE 12

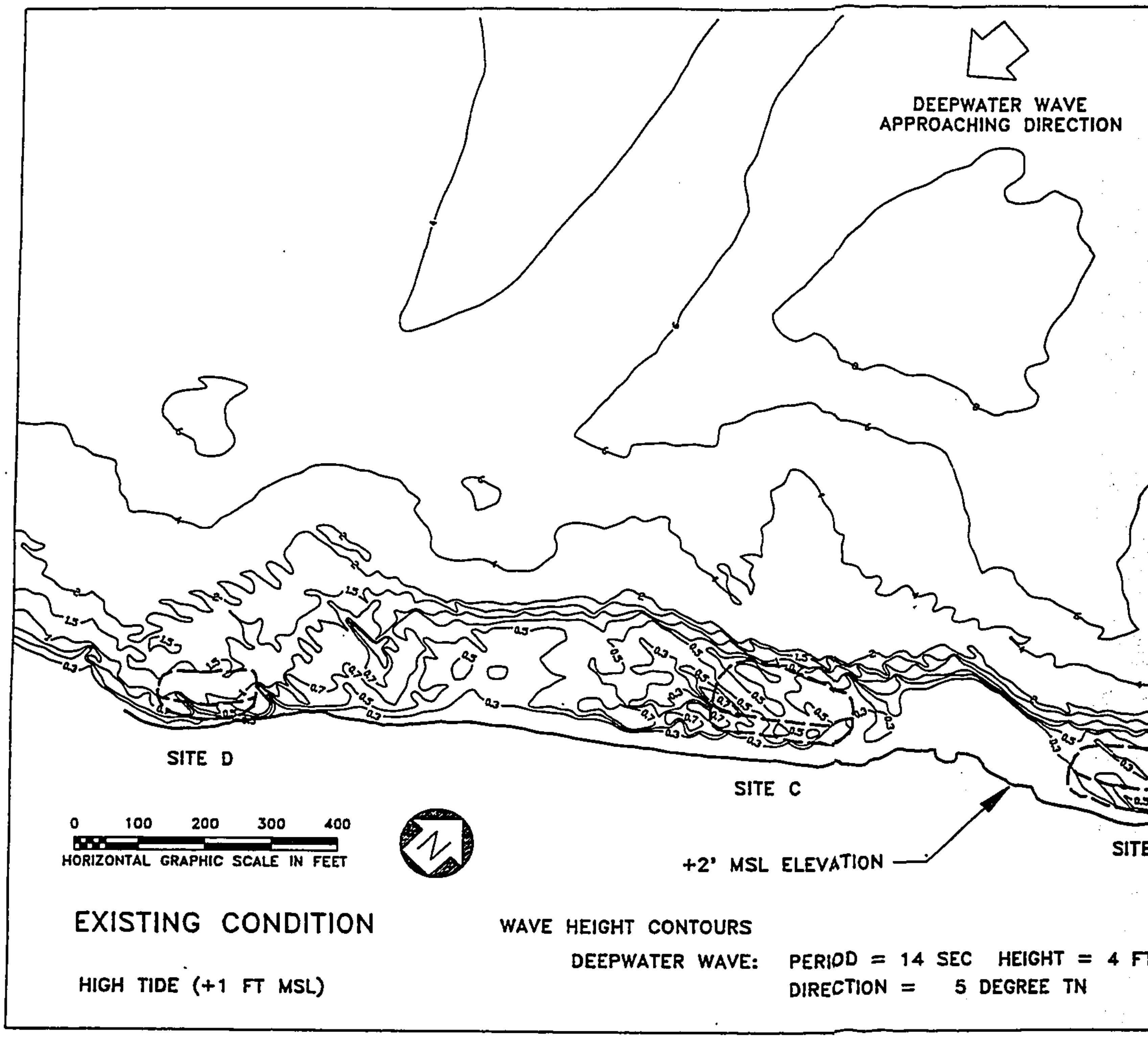


Wave Height Contours for Typical Tradewind Waves - With Proposed

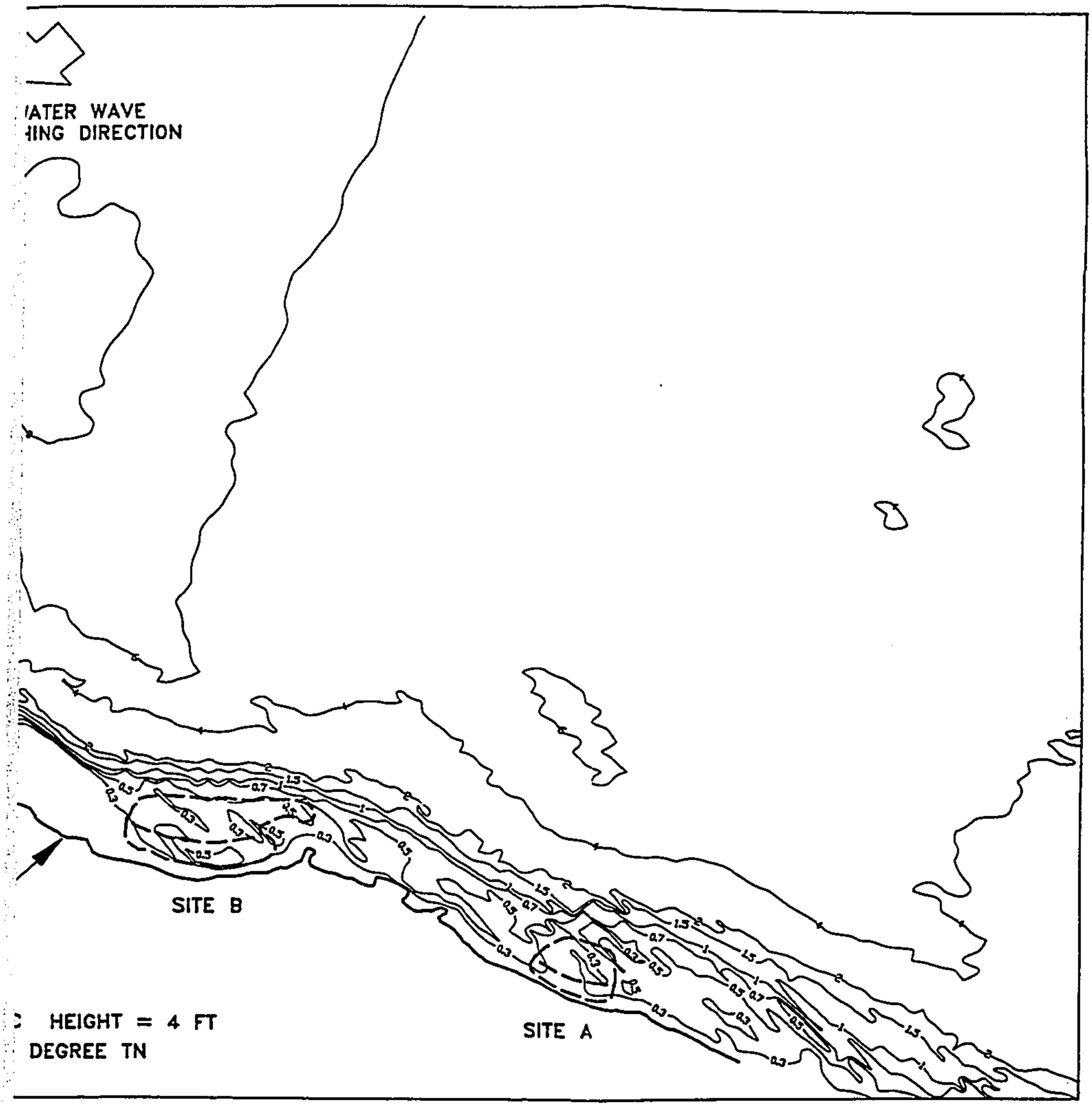


ıs - With Proposed Improvements

FIGURE 13

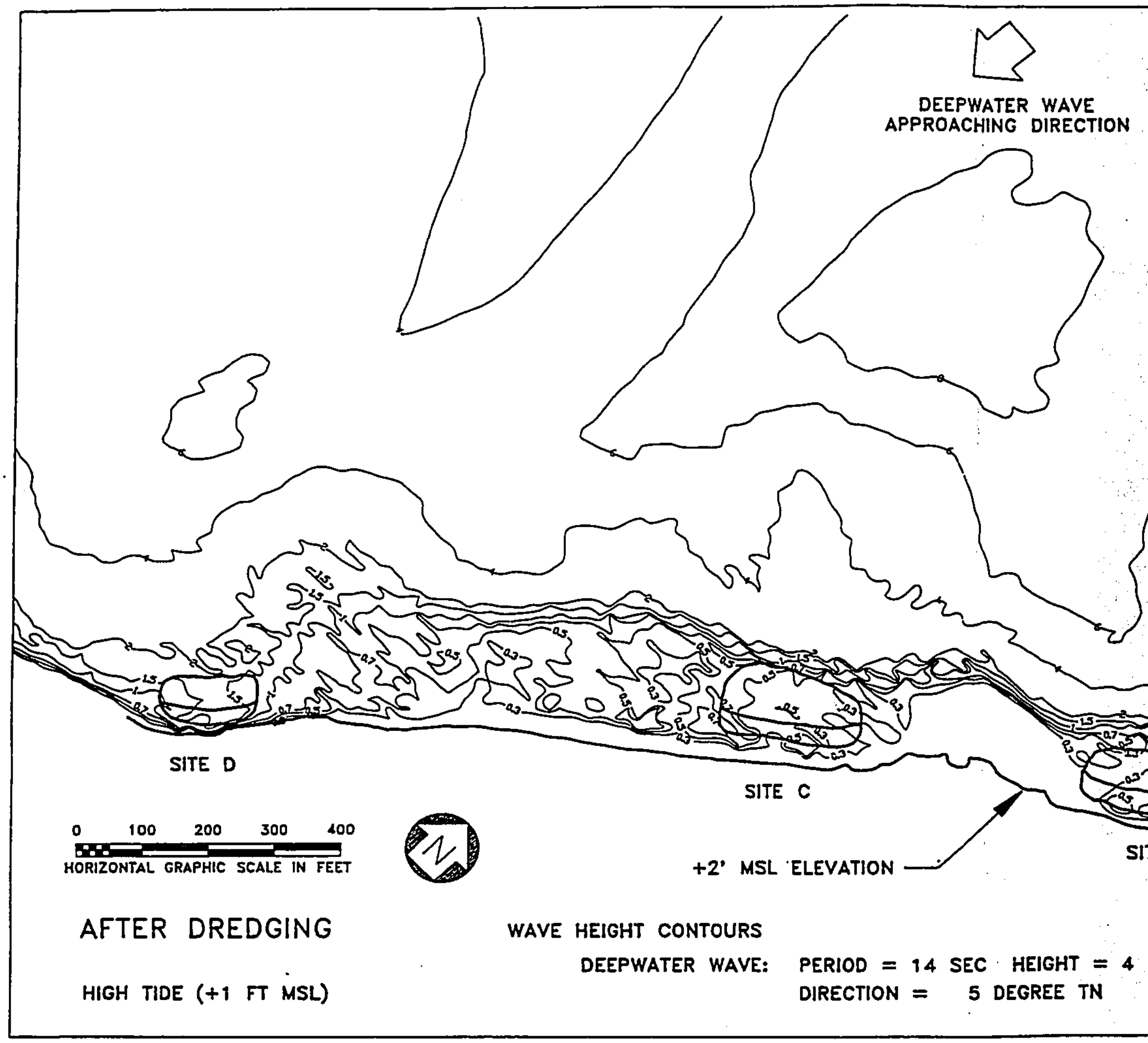


Wave Height Contours for Typical North Pacific Swell – Existing

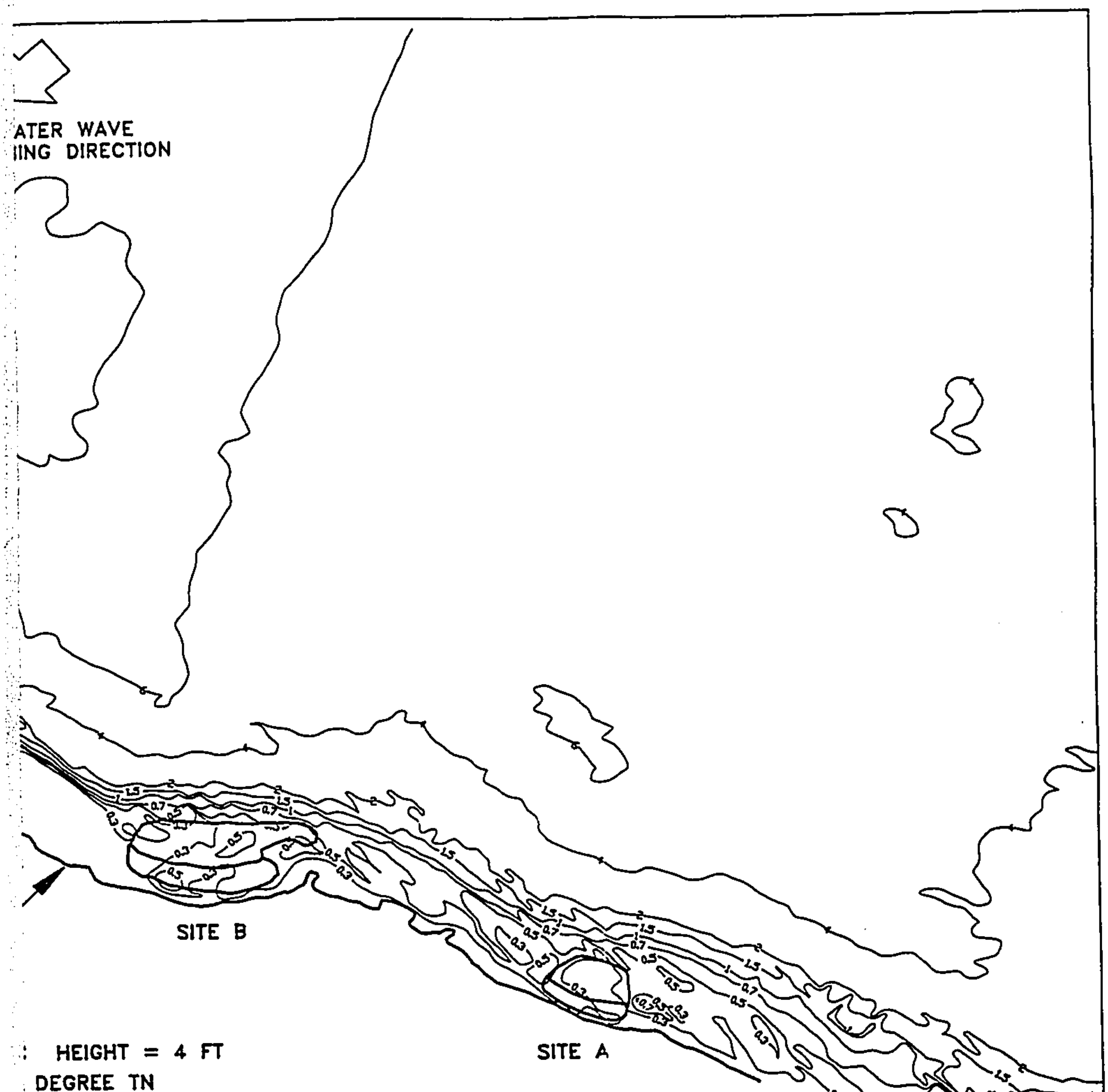


c Swell – Existing Condition

FIGURE 14

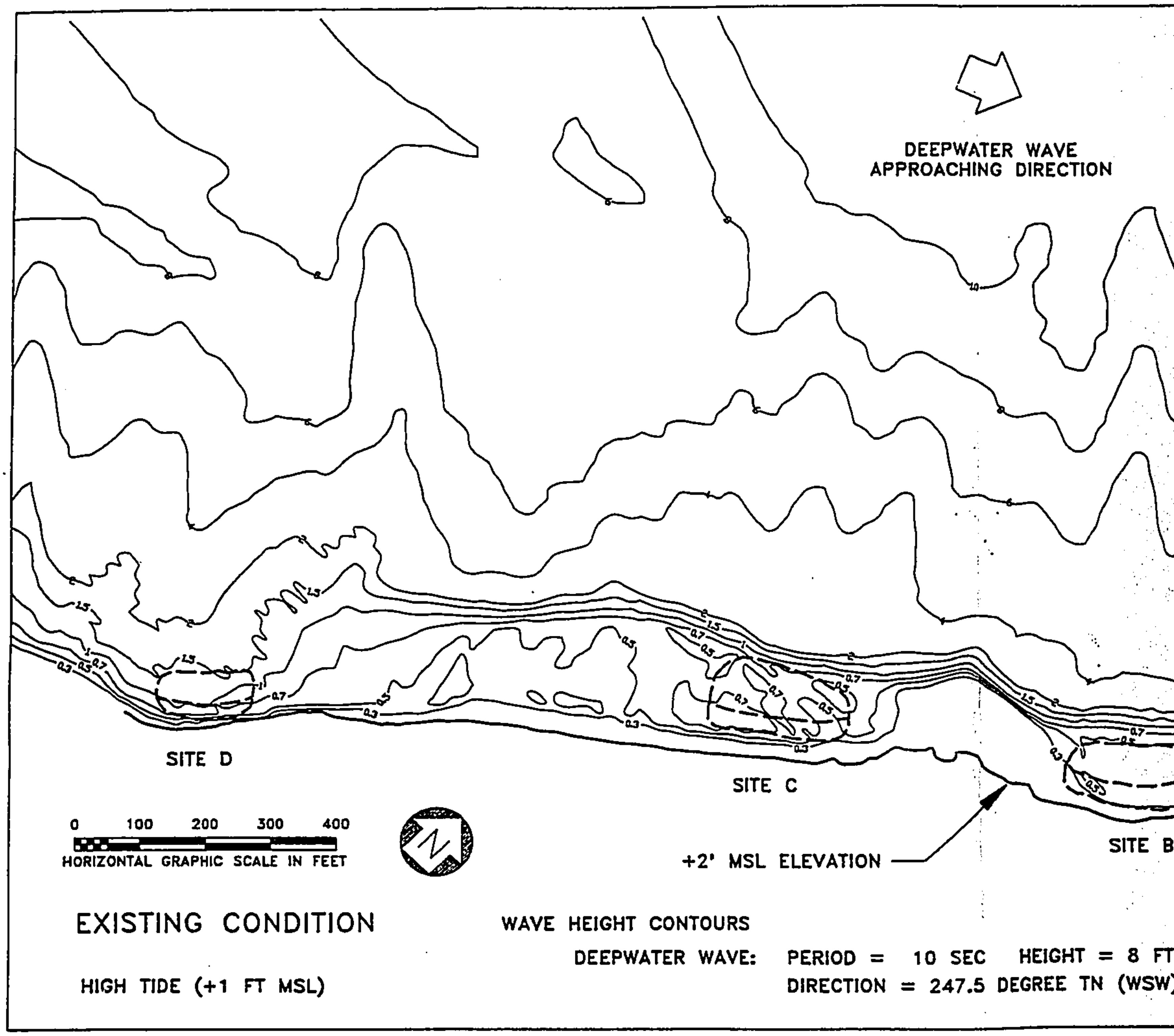


Wave Height Contours for Typical North Pacific Swell – With Propose

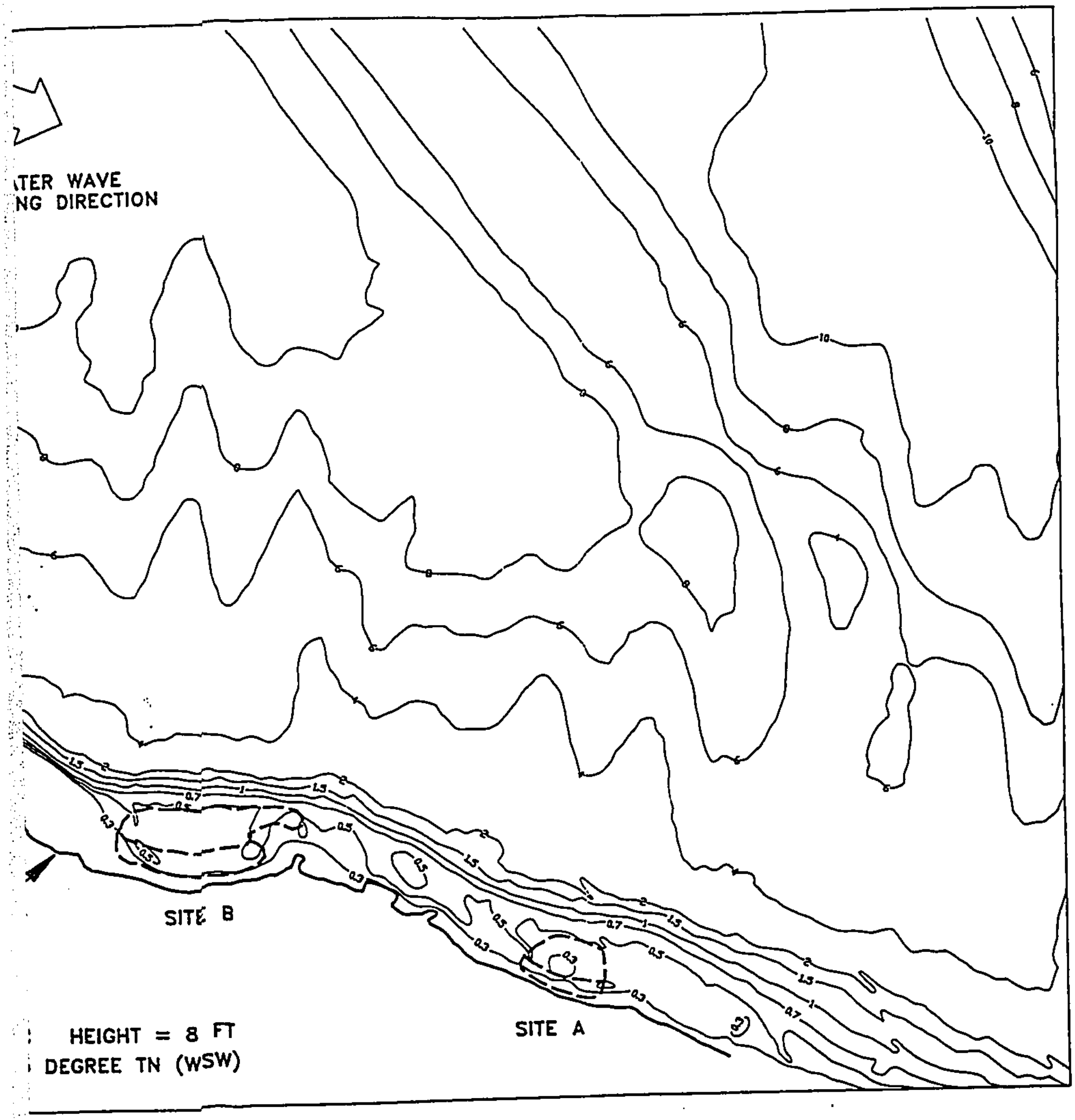


| – With Proposed Improvements

FIGURE 15

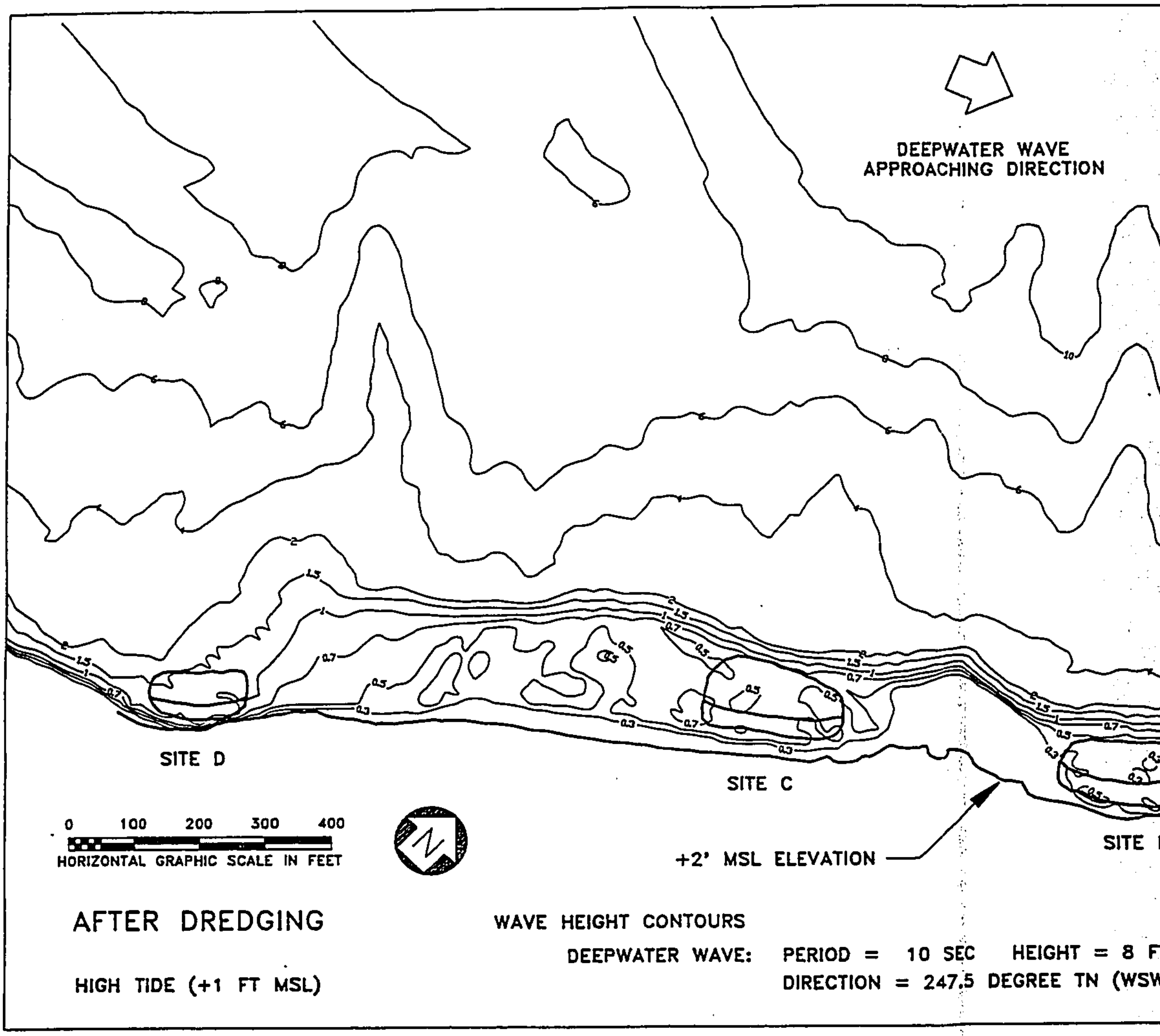


Wave Height Contours for Kona Waves – Existing Condition

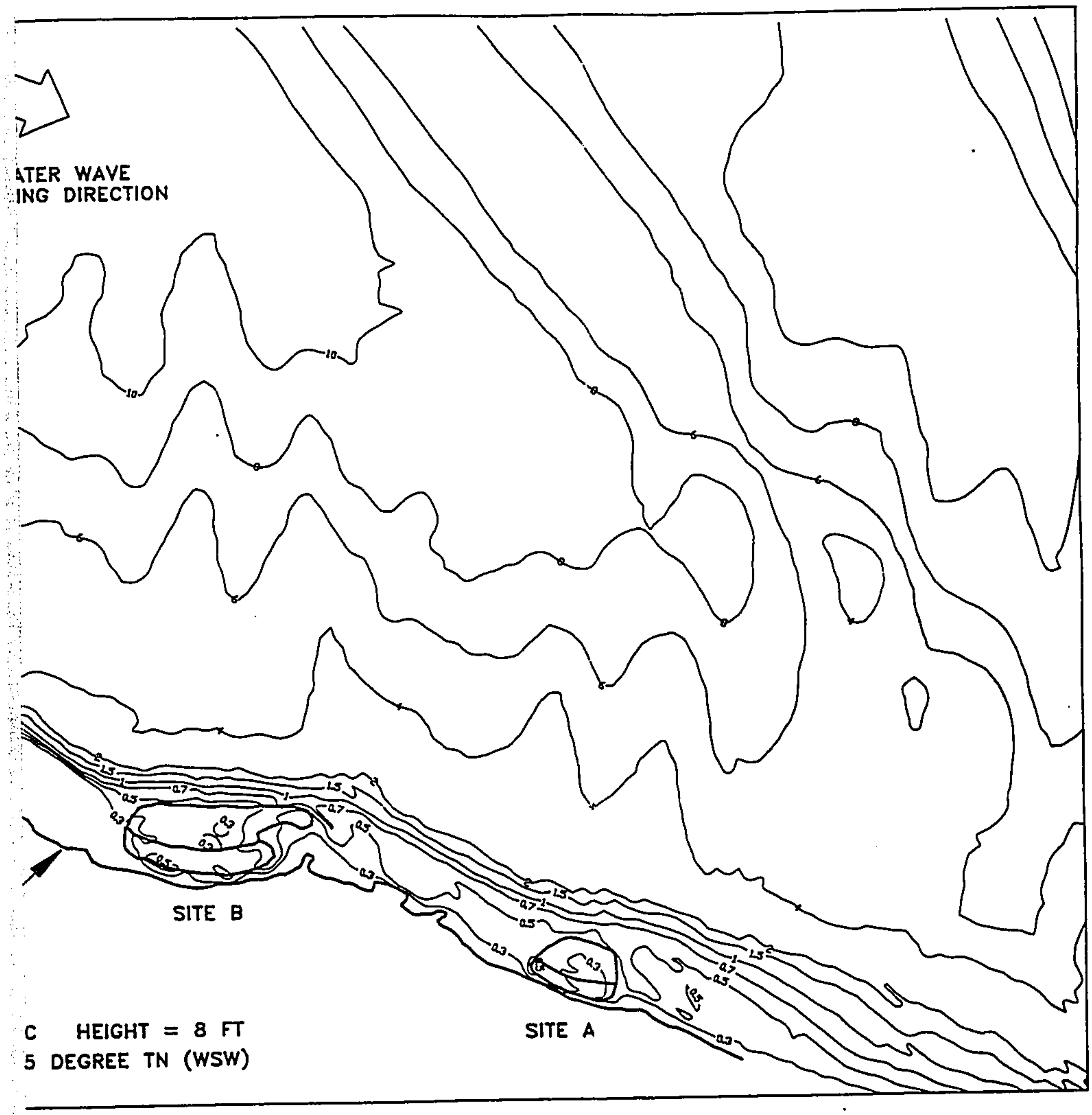


isting Condition

FIGURE 16



Wave Height Contours for Kona Waves – With Proposed Improveme



oposed Improvements

FIGURE 17

APPENDIX F

Beach Reconnaissance and Critique of the Proposed Shorezone Modifications, Kaupulehu, Hawaii

Prepared for

Kaupulehu Land Company
P.O. Box 1119
Kailua-Kona, Hawaii 96745-1119

Prepared by

Inman and Masters Consultants
2604 Ellentown Road
La Jolla, California 92037

25 May 1994

INMAN AND MASTERS CONSULTANTS
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(619) 453-1445

25 May 1994

Mr. Jeff Mongan
Vice President
Kaupulehu Land Company
P.O. Box 1119
Kailua-Kona, Hawaii 96745
FAX (808) 325-1400

Re: Kaupulehu Resort, North Kona, Hawaii
Proposed Beach Modifications

Dear Jeff:

I have concluded my evaluation of Kaupulehu Land Company's proposed modifications to the beach at Kaupulehu as outlined in the DEA (April 1994) prepared by Belt Collins Hawaii. Transmitted herewith is my report entitled "Beach Reconnaissance and Critique of the Proposed Shorezone Modifications, Kaupulehu, Hawaii."

I have conducted an on-site review of the proposed modifications as well as reviewing the pertinent design information for the project. Based on my review and the information presented in my report, I have concluded that the project could be compatible with an expanded public use of the beach environment provided that the principles expressed in my report be carefully addressed during the modification process. These principles include (1) that the integrity of the beachrock reef be preserved, (2) that the shape of the beach/excavation profile be decreased to follow a best-fit parabolic form, (3) that the beach will respond to increased wave exposure associated with deepening behind the beachrock reef, and (4) that there be provisions for nourishing the beach to accommodate the anticipated minor beach adjustments.

If you have any questions or require further information during the permit process, please let me know.

Sincerely,

Douglas L. Inman

Purpose

The purpose of this report is to evaluate and advise on beach modifications planned for Kaupulehu Resort, Kaupulehu, North Kona, Hawaii. The proposed changes are described in DEA (1994) and include shorezone modifications in four areas to permit:

Area A. Wading pool and tide pool ("kakeka"), Figures 1 and 3.

Area B. Swimming and snorkeling inside a protecting reef ("kohola"), Figures 4 and 5.

Area C. Swimming ("au") with extended natural snorkeling area to south inside the reef, Figures 6 and 7.

Area D. Swimming and seasonal canoe launching through an "awa" channel, Figures 8 and 9.

It is to be noted that this report includes information essential to good design but does not constitute an engineering design.

Reconnaissance

This report is based on reconnaissance during 14-15 April 1994 of the project area at Kaupulehu Resort, Kaupulehu, North Kona, Hawaii. The reconnaissance included visiting the site, inspecting the beach, snorkeling portions of the beach and reef, an overflight of the project area, and sand sampling from the beach. Two representative beach profiles were surveyed by R.M. Towill Corporation on 4 May 1994 (refer to Figures 10-12 of this report).

Physiography

The submerged portion of Kaupulehu consists of a juvenile fringing reef overlying the lava flow platform that extends from the shoreline and under water a maximum of 0.5 mile offshore as indicated by the 18 and 60 foot bathymetric contours. The project area extends along the coast for about 1.1 miles from Mahewalu Point (just north of the Kona Village Resort), south to Kikaua Point (at the south end of Kukio Bay). The southern 0.3 mile is the "a'a" lava cliff of

Kumukehu Point. The northern 0.6 mile of reef shoreline is backed by a beach-dune ridge, a continuation of the beaches of the Kona Village Resort. Paralleling this shoreline about 150 feet offshore is a reef composed of beachrock that is exposed at mean sea level (MSL). The northern portions of the reef are closer to the shoreline as shown in Figure 2. Beachrock is commonly formed on the beach face by the evaporation of calcium carbonate-rich waters percolating through the beach-dune ridge from ponded fresh water (Inman et al. 1963). It is probably a remnant of the earlier shoreline now submerged by a combination of eustatic sea level rise and sinking of the island of Hawaii due to the weight of extruded lava on the Earth's crust.

Principle Factors Concerning Beach Modification

When considering modifications in the shorezone, it is important to bear in mind two basic principles. The first is the conservation of mass. For beaches, this principle is usually called the "budget of sand" (e.g., Inman 1994). The second principle is the nearshore equivalent of Newton's Third Law: Sediment in nearshore waters and on beaches responds to forcing by waves and currents such that the beach tends toward an equilibrium with the intensity of the forcing. For every change in forcing, there will be a change in the beach. However, it is possible to modify nearshore features in a manner that will minimize the beach change. In particular, modifications that simulate the equilibrium form of natural beaches will in general have a minimum and quasi-predictable effect on the beach.

Consideration of these basic principles in relation to sea level rise and regional geology leads to the following points:

1. The source of sediment is from the reef. Although the reef is predominantly a lava platform, coral and calcareous algae are well established. Inspection of sand sampled from the beach showed that 90-92% of the grains are calcareous, and 8-10% are lava. The calcareous portion consists of fragments of coral, molluscs, algae, and foraminifera. The sand grains are rounded, indicating a long transport path from the outer reef to the beach. Therefore, the juvenile coral reef portions of the platform are the source of sediment for the beach. The sand that forms the beach-dune ridge system was transported over the beachrock reef by breaking waves and across the tide pool areas, including those that are to be deepened. Any modifications must be

carried out in a manner that is conducive to occasional sand transport across the tide pool areas.

2. Under the weight of the extruded lava flows, the shoreline is subsiding. In addition, eustatic sea level is rising. The beachrock, which borders and protects the inner beach, represents extensive beach formation at a relatively lower sea level (or higher elevation of the island). It must be emphasized that the beachrock reef is <u>unique</u> and <u>essential</u> to the preservation of protected, interior swimming and snorkeling areas.

3. The beach is generally straight except where there are depressions in the beachrock reef. These gaps admit more wave energy to the beach. The increased wave energy at each gap produces a series of small coves backed by beach sand.

- Opening up the gaps by deepening or widening them admits more wave energy which will cause beach recession.

- Extensive excavation of the floors inside the beachrock reef also will direct more wave energy on to the beach and promote beach recession.

- Removing large rocks from the floors also will permit more wave energy to reach the beach, causing beach recession.

4. There is a balance of the budget of sediment corresponding to the availability of sediment from the reef and to the intensity of wave action breaking over the reef or coming through it. Clearly, there is a limited amount of sand. The supply has not kept up with the rate of subsidence or the beach would not have migrated back to its present position. It would be prudent to consider an initial importation of small amounts of beach sand of similar size to nourish the areas that are to be modified until the areas attain an equilibrium relation with the modifications.

5. In view of the limits on sand supply, the excavated pools at Site B and Site C (DEA 1994, Figure 4) should have a profile configuration in keeping with natural profiles resulting from wave action. If the excavations are carried out as proposed in DEA (1994, Figure 5), the profiles will tend to adjust to the

natural form resulting in the redeposition of portions of the existing beach into the area of excavation.

6. The conjoined shorerise and bar-berm profile model of Inman et al. (1993) has direct application to this project as described below.

The Equilibrium Beach Profile on Reefed Beaches

The equilibrium beach profile and the concept of the budget of sediment within a littoral cell constitute the two most important concepts in the field of nearshore processes. The concept of the equilibrium beach profile maintains that beaches respond to wave forcing by adjusting their form to an equilibrium or constant shape attributable to a given type of incident wave. The well-known seasonal changes in beach profile in response to the high waves of winter and the lower waves of summer are expressions of the beach form tending toward a seasonal equilibrium with the changing character of the prevailing waves. However, the concept of equilibria also provides a basis for understanding transition and disequilibrium conditions, a far more common beach condition (Inman et al. 1993).

Unfortunately, there are no studies of the equilibrium profiles from fringing reef beaches. However, the bar-berm portion of the equilibrium profile for beaches should apply in principle to back-reef beaches. The obvious advantage at Kaupulehu is that an excavation adjusted to the prevailing equilibrium conditions could be self-maintaining and would permit sand to travel across the excavated area.

As pointed out by Inman et al. (1963, p. 124) and more recently by Wiegel (1990), waves passing over a reef are transformed into a multi-crested system of shorter waves. Waves break on the reef and produce a surge of white water (bore) that disperses into a train of smaller waves of height 15 to 30 cm (0.5 to 1 ft) and lengths of about 6 m (20 ft). Otherwise the equilibrium processes appear similar on the bar-berm portion of all beaches.

The equilibrium bar-berm profile has been shown to be parabolic in shape with an origin about 0.5 to 1 m (1.5 to 3 ft) above the beach berm. In the equilibrium profile, the bar-berm forcing begins at the breakpoint (over the beachrock reef), continues shoreward, seeking the origin as a limit, but reaches a maximum at the crest of the berm where all of the remaining water from the swash percolates into the beach face. When the origin of the coordinate system coincides with that of the equilibrium curve, the relation is

$$h = Ax^m \tag{1}$$

where h is positive downward from the origin and x is positive in a seaward direction from the origin. The slope β of the profile becomes

$$\tan\beta = dh/dx = Amx^{m-1} \tag{2}$$

where $\tan\beta(x)$ is the slope at any point x measured from the origin of the curve, the exponent m is a dimensionless number, and the factor A has dimensions of unit distance raised to the exponent (m-1).

From relation (2), it is apparent that the equilibrium beach slope is steeper along the beach face (where the swash action occurs) than in its underwater portions that decrease parabolically with depth. If the slope of the beach face, which commonly for this size sand (0.5 to 1 mm diameter) may be about 1:8, is continued underwater, the beach will erode until the proper parabolic equilibrium slope given by equation (2) is attained. The basic problem here is to determine the values of A and m for a back-reef beach.

Curve Fitting

In principle, these values can be approximated by curve-fitting of profiles from the Kaupulehu beaches that have the most pronounced embayments and the deeper adjacent tide pools. Accordingly, profiles K (Area B) and W (Area D) were surveyed normal to the cove beaches with details noted of the sand/rock contact and the wave runup level on the beaches (Figures 10-12). On profile K (Figure 11), the runup line was at +5 ft MSL and the beach toe/rock contact was at MSL. For profile W (Figure 12), these points were at +5 ft MSL and -1.7 ft MSL, respectively. The best-fit parabolic curve for these minimal portions of the bar-berm beach were found to have the form

$$h = 2.04x^{0.4} \tag{3}$$

where h and x are in feet and the factor 2.04 has units of feet raised to the 0.6 power. Note that with h and x in meters, the factor has a value of 1.0 meter raised to the 0.6 power. For both profiles, the best-fit origin was found to be +8.2 ft (+2.5 meters) MSL. When it is assumed that the wave runup elevation approximates the beach berm, then the origin is 3.2 ft (1.0 m) above the berm, in agreement with data from other beaches (Inman et al. 1993). Coordinates relative to the origin of the best-fit curve and to MSL are given in Table 1.

Summary and Conclusions

1. Some beach adjustment will always occur whenever the wetted portions of the shorezone are modified. However, these adjustments can be minimized when they are minor and the resulting bathymetry follows that for natural beaches. Unfortunately, there are no definitive studies to guide us for back-reef beaches.

2. We have determined the best-fit parabolic curves for two surveyed beach profiles (Figures 10-12). Although the curves are based on limited data, their form, given by equation (3), is consistant with that for previous studies of bar-berm portions of beaches (Inman et al. 1993). This indicates that modifications of the shorezone following this form will result in minimal beach change. The appropriate dimensions are given in Table 1.

3. Best-fit two-dimensional beach profiles give no information about the configuration of the beach shoreline. However, if the modifications are linear in their longshore aspects, then it is to be expected that the shoreline will respond accordingly. If the modifications are such as to intensify the wave exposure at one point along the beach, then that portion will recede more or less in proprtion to the increased wave intensity. A case in point is the proposed canoe channel in Area D, which, if deepened, will allow some unbroken waves into the swimming cove. This would result in shoreline recession at the point opposite the channel, causing the area to become more cove-like or crescentic in shape. The resulting shoreline configuration could be estimated by formulating a "gap in the reef" type refraction-diffraction model with circulation.

4. Since some beach readjustment is to be expected, it is recommended that some other source of sand be available to nourish the beach until it reaches its new equilibrium condition. It is important that the sand be similar in size distribution and density to that already on the beach.

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Table 1. Best-Fit Curves for Profiles

Origin

Profile K x_o = 5.0 ft seaward of certified shoreline
h_o = +8.2 ft MSL

Profile W x_o = 14.0 ft seaward of certified shoreline
h_o = +8.2 ft MSL

Coordinates Relative to Origin

Horizontal Distance Seaward (ft)	Vertical		Slope	
	Below Origin (ft)	Relative to MSL (ft)	tan β	*h* : *x*
0	0	+8.2	∞	vertical
5	3.9	+4.3	0.311	1 : 3.2
10	5.1	+3.1	0.205	1 : 5
15	6.0	+2.2	0.161	1 : 6
20	6.8	+1.4	0.135	1 : 7.5
30	8.0	+0.2	0.106	1 : 9.5
40	8.9	-0.7	0.089	1 : 12
50	9.8	-1.6	0.078	1 : 13
60	10.5	-2.3	0.070	1 : 14.5
75	11.5	-3.3	0.161	1 : 16.5
85	12.1	-3.9	0.057	1 : 18

Figure 1. Kaupulehu with Kona Village Resort and Mahewalu Point in foreground and Kumukehu Point in background. Looking southeast. (DLI #94.3-24)

Figure 2. Details of beachrock reef fronting Kona Village Resort, just south of the anchorage. (DLI #94.3-1)

Figure 3. Cove-like pocket beach at Area A, north Kaupulehu Beach. (DLI #94.3-2)

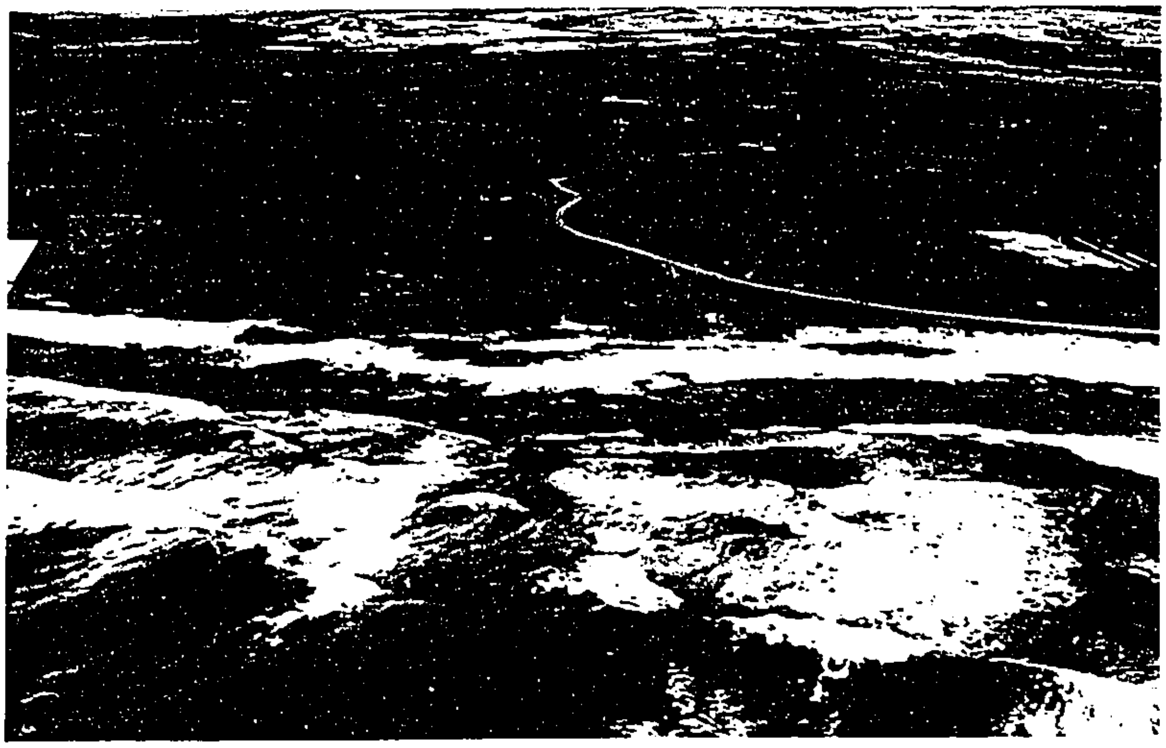

Figure 4. Air photograph of Area B looking east. Note the beachrock reef protecting the cove (right half of photograph). (DLI #94.3-32)

Figure 5. Details of cove beach of Area B shown in Figure 4. Profile K crosses center of cove. Note beachrock reef right center of photograph. (DLI #94.3-4)

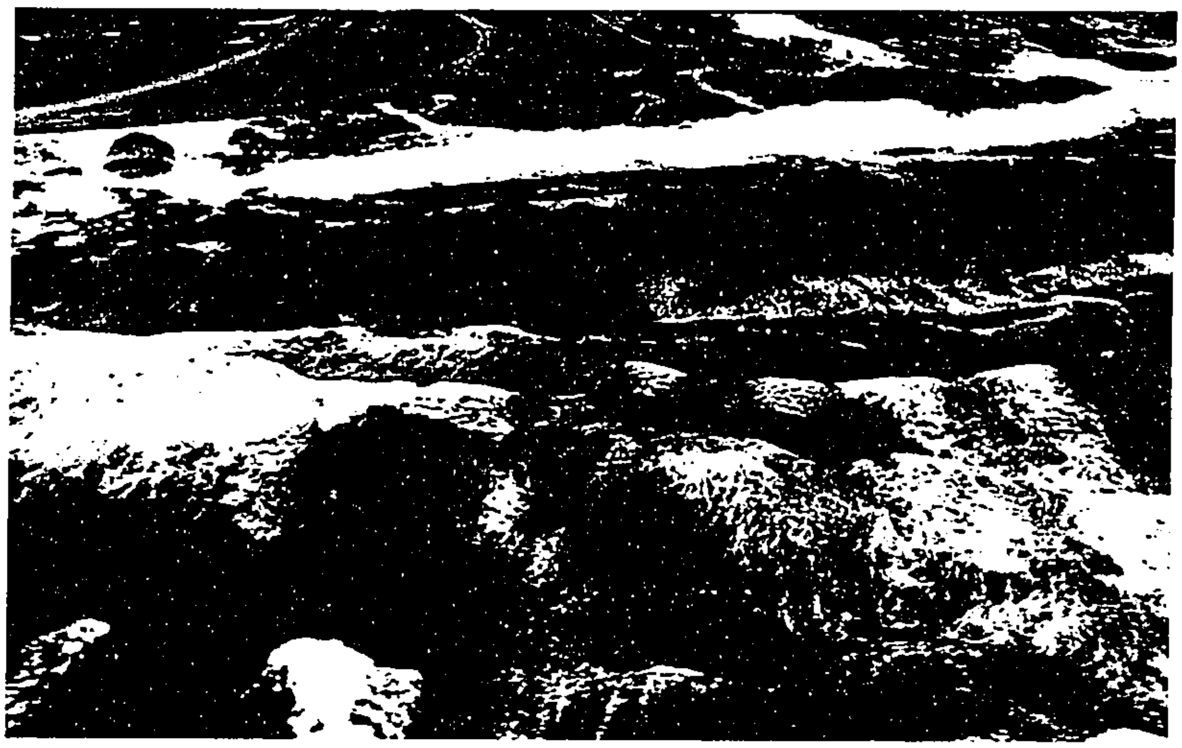

Figure 6. Aerial photograph of Area C. Note beachrock reef paralleling beach. (DLI #94.3-27)

Figure 7. Details of beach and snorkeling pool at Area C. (DLI #94.3-6)

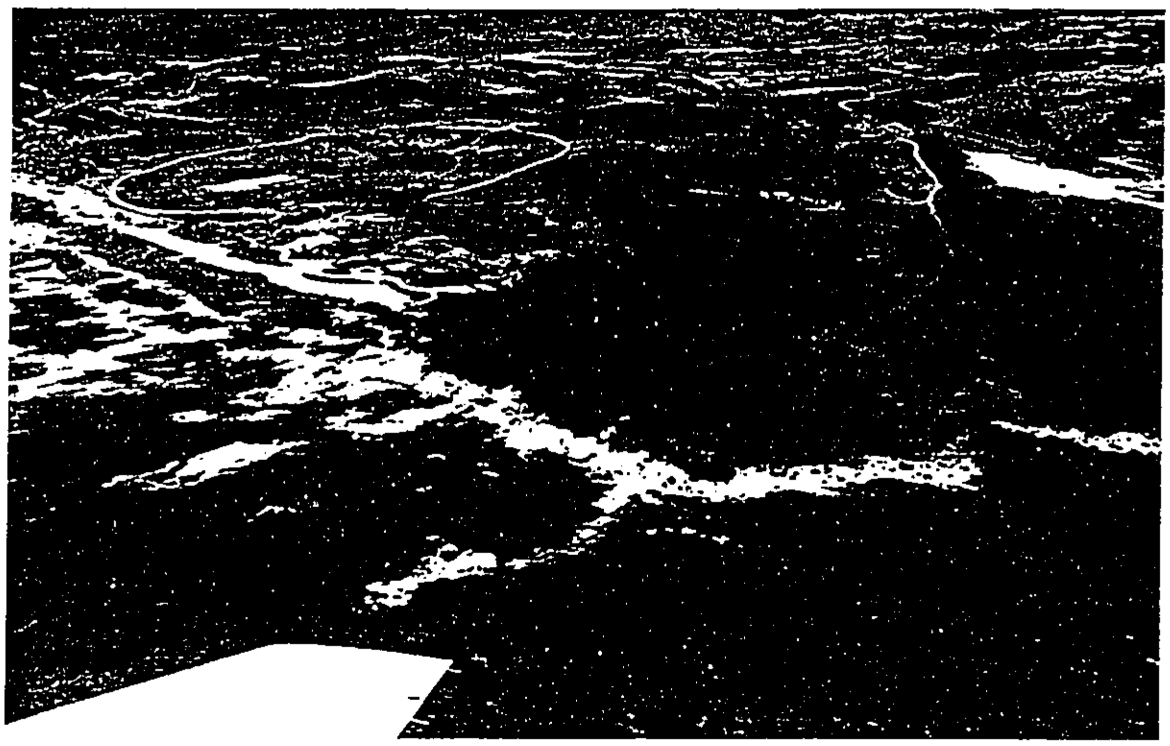

Figure 8. Aerial photograph of Kumukehu Point with beaches of Areas C and D in left center of photograph. (DLI 94.3-21)

Figure 9. Details of cove at Area D adjacent to Kumukehu Point. (DLI #94.3-9)

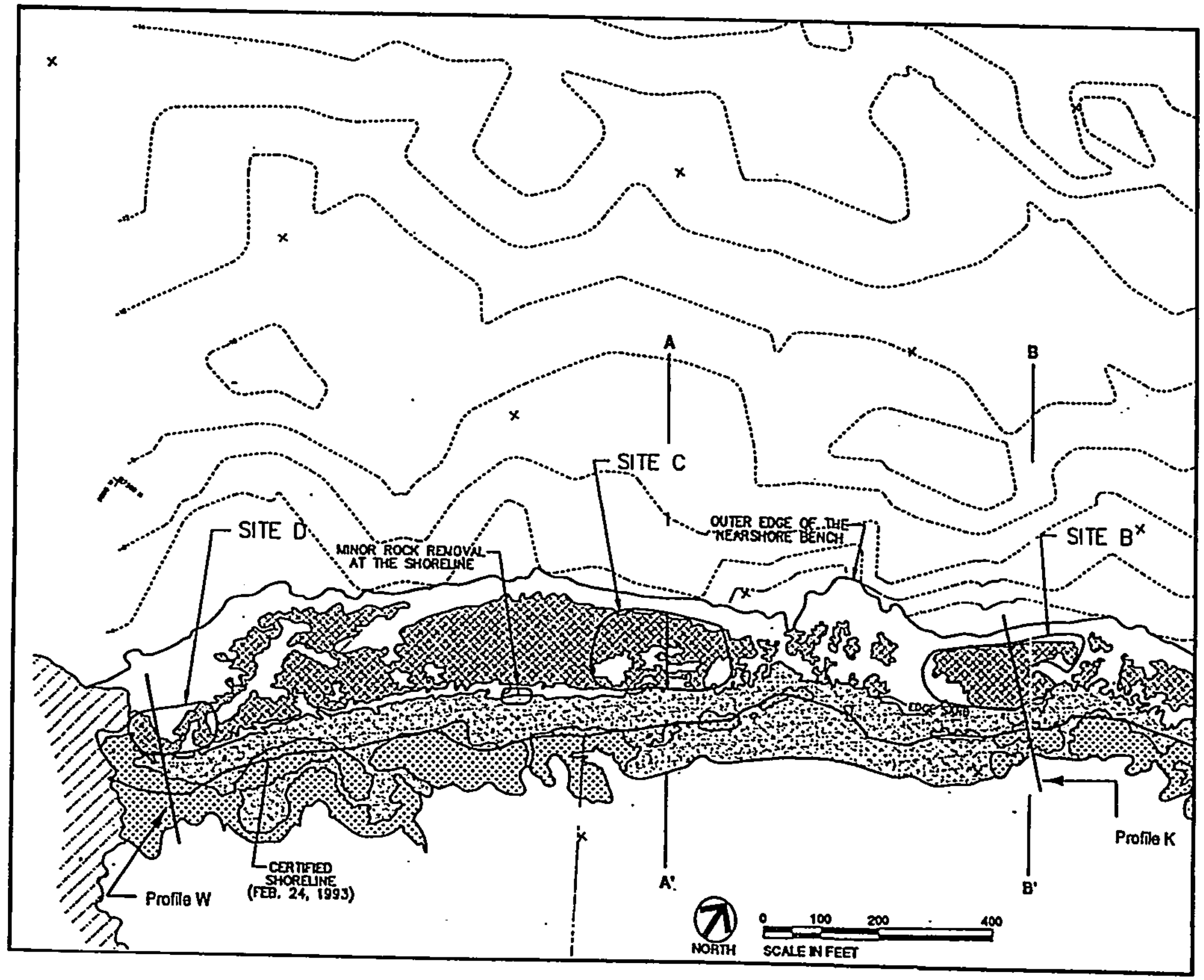

Figure 10. Location map for sites B-D and Profiles K and W. Bathymetry from DEA (1994, Figure 4).

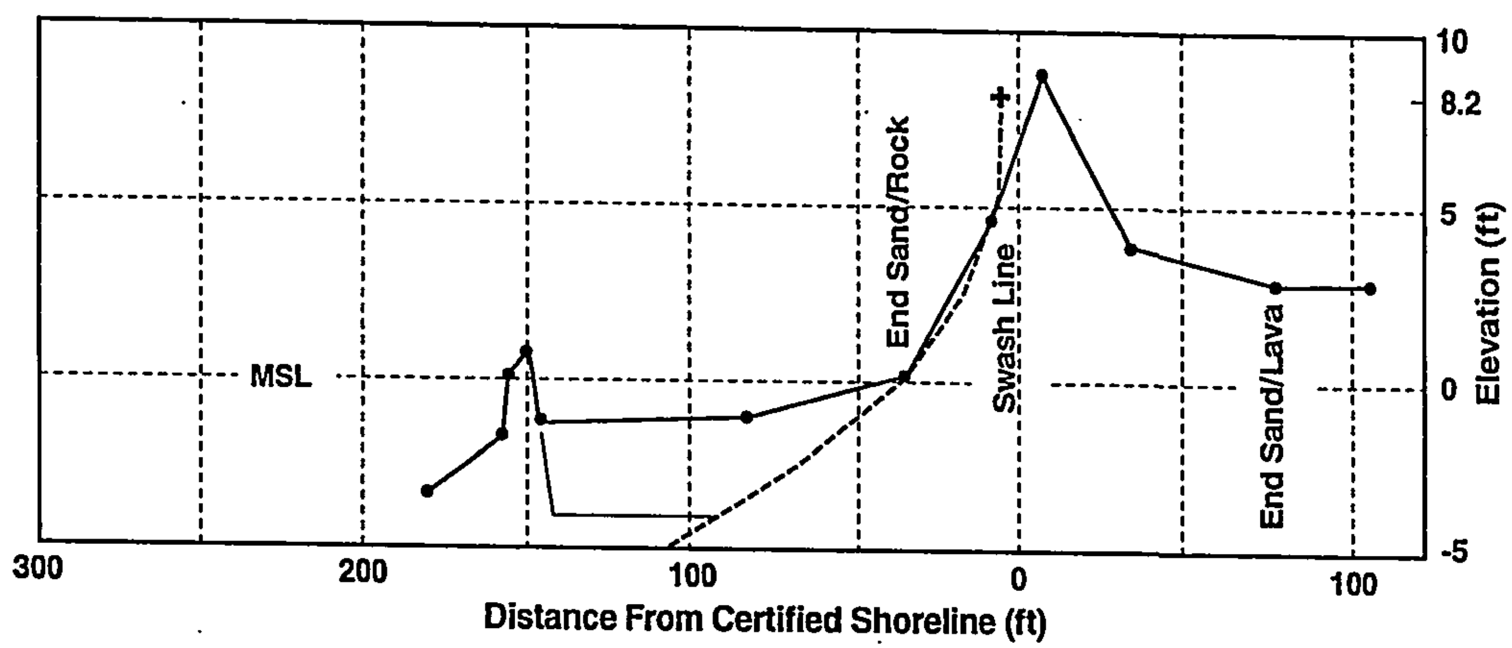

Figure 11. Beach Profile K (solid line) with fitted parabolic curve (dashed line). The origin of the curve (cross) is at +8.2 ft MSL.

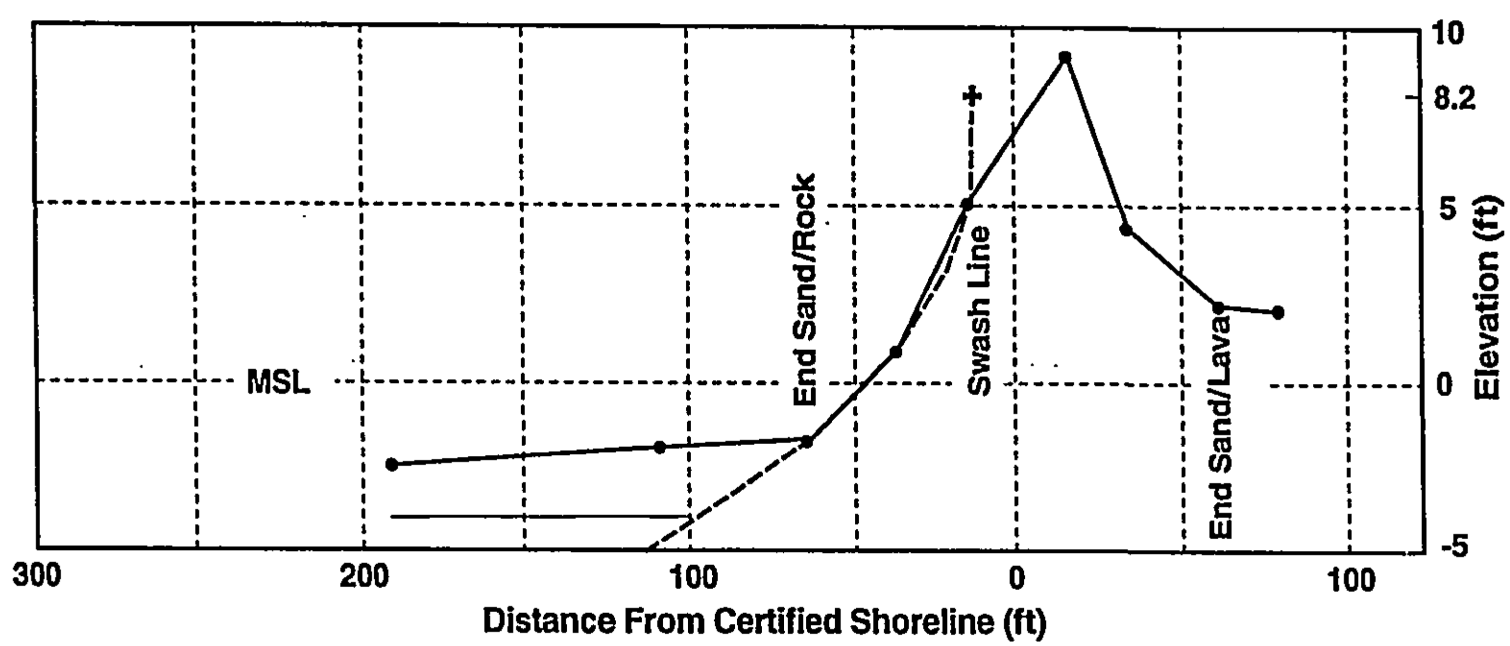

Figure 12. Beach Profile W (solid line) with fitted parabolic curve (dashed line). The origin of the curve (cross) is at +8.2 ft MSL.