HILO AREA COMPREHENSIVE STUDY

Draft Navigation Report

151

US Army Corps
of Engineers
Honolulu District

AUGUST 1981

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NAVIGATION REPORT

Hilo Area Comprehensive Study

US Army Engineer District
Honolulu
June 1981

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SUMMARY

As early as 1973, suggestions received by the Honolulu Engineer District (Hawaii Chamber of Commerce report, Need for a Hilo Bay Study, September 1973; Hawaii County Council Resolution #144, November 1973) suggested a desire for a complete study of problems and needs of the Hilo area, in particular, Hilo Bay. In addition, Hawaii County Council Resolution #480, November 1975, indicated a desire of the council for preparation of a "...comprehensive plan for Hilo Bay..." and further indicated the council's support for such a study by the Corps of Engineers. The District began the Hilo Area Comprehensive Study (HACS) in 1976, completing the HACS Plan of Study (POS) in December that year. One of the broad objectives identified for the study was an examination of the navigation problems in the Hilo area.

Because the majority of all goods entering the State of Hawaii arrive by water, efficient harbors are essential to the well-being of the State. Hilo is the buisness and industrial center of Hawaii County, and Hilo Harbor handles the bulk of the water-borne traffic to and from the island. Also, small-craft boating is important to the community, both as a vocation and as recreation. Navigation deficiencies were noted in the Chamber of Commerce report and in both resolutions of the County Council, and the issue of navigation problems was prominent in the discussions during the early public meetings of HACS. Due to the pressing need, it became apparent that a report on this subject, separate from the overall comprehensive study, would be beneficial to the residents of Hilo and to the boating community at large.

This report documents the investigations relating to both small craft and deep draft navigation in the Hilo area. Preliminary investigations determined the principal small craft probelm to be an acute shortage of facilities for small boat users, especially fishermen. Potential sites for establishing new facilities were examined along the north and south coasts of East Hawaii, both inside and outside the Hilo breakwater. Problems facing deep draft navigation include a turning basin too narrow and too shallow, unpredictable surge conditions in the commercial port, and a shortage in dock-side space. Deep draft measures examined included both structural and nonstructural, ranging from a large construction scheme on Blonde Reef to removal of the outer 7,000 feet of the existing breakwater for improvement of water circulation.

While neither directly related to navigation nor directly addressed in this report, the memories of devasting tsunamis and the fears of future tsunamis are very much present in the minds of Hilo residents. Removal of the existing breakwater (or allowing it to deteriorate), a measure discussed as a possibility to improve the bay's water quality, was an object of great concern. The existing rubble-mound breakwater, while not constructed to modern standards, is considered by residents to be a deterrent to incoming tsunami waves and it is clear the community would resist any alteration of the breakwater unless convincing evidence were shown that future tsunamis would be no worse without the breakwater in place.

Recommendations for both small craft and deep draft navigation are summarized below.

The recommendation for small craft is the construction of a small boat harbor at King's Landing on the coast south of Hilo at a total cost of $15.0 million. Of this amount, the Federal share is $10.7 million and the local share is $4.3 million. The average annual cost is approximately $1.2 million and the average annual benefits are $2.14 million, for a benefit-cost ratio of 1.8.

The harbor would accommodate 170 vessels and serve both commercial fishing interests and other small craft users over the next 50 years. The navigation improvement has the potential for expansion into a major commercial harbor with associated landside facilities such as fish processing, boat building, and marine stores.

The deep draft recommendation includes improvements to the existing harbor project at a total cost of $5.7 million. The plan contains nonstructural features (improvements to the existing fender system and replacing the existing mooring buoy with a submersible buoy) to remedy the residual problem of delays and damages caused by surge conditions in the harbor. This problem has existed in the harbor since the breakwater was completed in 1929. The plan also includes deepening of the turning basin and entrance channel from 35 to 40 feet, with deep ocean disposal of the dredged materials recommended as the least costly alternative.

SECTION I

INTRODUCTION

PURPOSE

The purposes of this study were to evaluate the feasibility of navigation improvements in the Hilo area on the island of Hawaii and to determine the extent to which the Federal Government can participate in the recommended solutions. The County of Hawaii, indicated sponsorship of the overall comprehensive study in December 1976.

The Plan of Study (POS) for the Hilo Area Comprehensive Study (HACS) was completed by the U.S. Army Corps of Engineers, Honolulu District in December 1976. The POS identified six categories of water resources for investigation: Regional Harbors, Bay Protection and Restoration, Water Supply, Flood Plain Management, Fish & Wildlife Enhancement, and Water Related Recreation. Regional harbor improvements were given high priority at the 1976 public meeting and at subsequent public workshops. As a consequence, study resources were focused on navigation problems and their possible solutions. A Stage 2 report completed in September 1980, the predecessor to this report, discussed the problems and needs of deep-draft and small-craft harbors in the Hilo area and recommended continuation of the navigation study. Figure 1 is a vicinity map of the State and the study area. Other stage 2 reports will address the non-navigation components of the Comprehensive Study.

STUDY AUTHORITY

Section 144 of the Water Resources Development Act of 1976, (Public Law 94-587), quoted verbatim in Appendix A, Problem Identification, authorized a comprehensive study of the Hilo Bay Area. The overall Hilo Area Comprehensive Study, as well as this navigation report, is being conducted under that authority.

STUDY AREA

The study area is located on the eastern side of Hawaii (Figure 2) and includes over 1000 square miles of land (about one fourth of the island's area). Hilo, economic and political center of Hawaii County and the main

port, Hilo Harbor, are the focal points of the study. The small-craft portion of the study has been concerned mainly with the coastal area and off-shore waters between Laupahoehoe and South Point, where the fishing grounds are located and where harbors are most urgently needed.

Economically, Hilo's unemployment rate has remained somewhat higher than the overall unemployment rate in the State over the past few years. The area has one of the lower hotel occupancy rates in the state, which lists tourism as the major industry. Significant growth has occurred in commercial fishing, but the main industry (sugar) is stable. Local interests indentified Hilo Bay's water quality and inadequate harbor facilities as problems of special interest for this study.

The water quality of Hilo Bay and the quality of beaches around the bay are less attractive to vacationing visitors than those in other locations in the State. Hilo Bay is recovering from a 75-year period of pollution stress, heavy metals, including the discharge of pollutants, pesticides, and organic wastes, into the bay. The sources of this pollution no longer exist. Except for contaminants which reside in bay sediments, only Hilo's breakwater remains as a significant factor in water quality. The breakwater reduces circulation in the bay, exchange of water with the ocean, and traps significant quantities of fresh flowing water from underground springs along most of the shoreline.

The poor circulation and relatively unmixed fresh and salt waters created a two-layered water body. The resultant heavy sedimentation forms a poor habitat for some benthic organisms, such as coral. Recreational fishing is still popular, but commercial fishing for bait have declined inside the breakwater.

The coastal areas in the southeastern sector of the study area outside Hilo are largely undeveloped and pristine with long stretches of open space and several small parks. The area has a multitude of archaeological sites, many of which are not fully researched.

The coastal area north of Hilo is steep and mountainous with an abrupt shoreline. Sugar cane cultivation above the shoreline causes erosion and streams carrying the silt into the coastal waters. During the rainy season, these waters are highly turbid due to the silt-laden water.

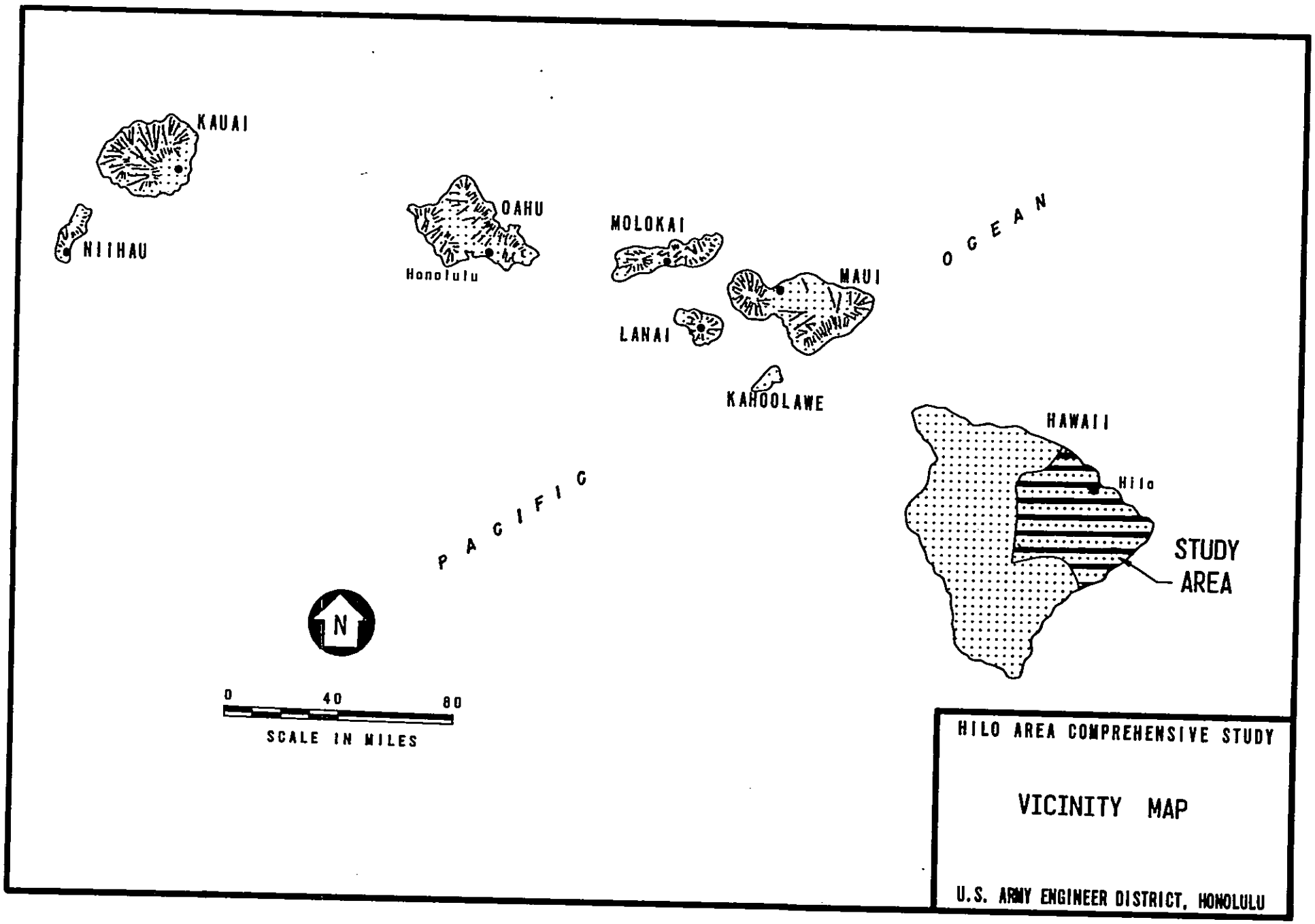
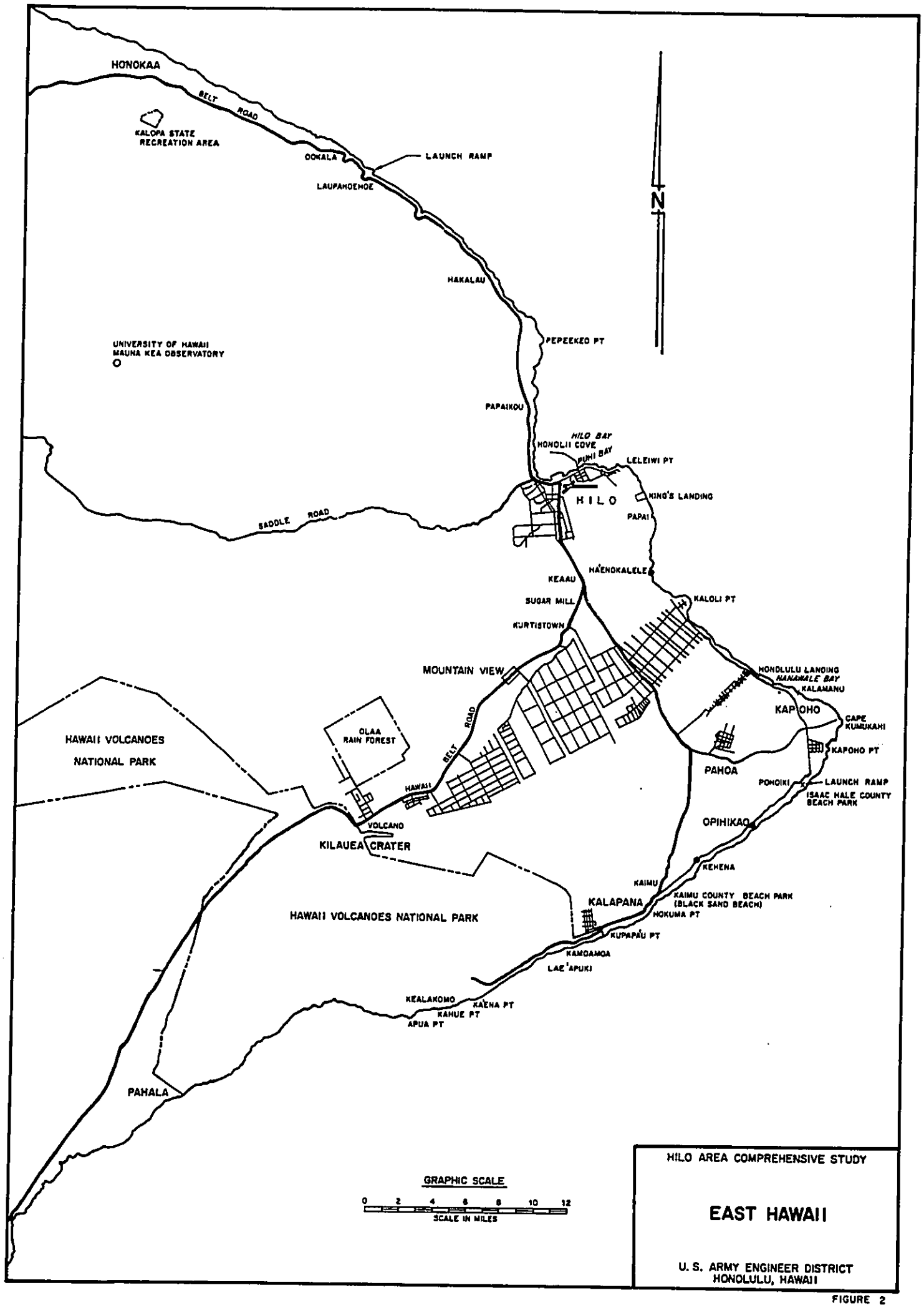

KAUAI
NIIHAU
OAHU
Honolulu
MOLOKAI
MAUI
LANAI
KAHOOLAWE
PACIFIC
OCEAN
HAWAII
Hilo
STUDY AREA
N
0
40
80
SCALE IN MILES
HILO AREA COMPREHENSIVE STUDY
VICINITY MAP
U.S. ARMY ENGINEER DISTRICT, HONOLULU

FIGURE 1



HILO AREA COMPREHENSIVE STUDY

EAST HAWAII

U. S. ARMY ENGINEER DISTRICT
HONOLULU, HAWAII

FIGURE 2

SCOPE OF STUDY

The principal concern has been an investigation of Hilo's deep-draft harbor and of small-craft navigation needs in the Hilo area.

Specific studies conducted included site investigations, archaeological-cultural studies, hydrographic and topograhic surveys, geologic, foundations and materials investigations, fish and wildlife studies, engineering designs, economic evaluations, and environmental assessments. Emphasis was placed on the conduct of the public involvement program, which attempted to reach all concerned publics in the Hilo area. The input from the attendees to the meetings comprising this program was a key element in identifying the problems, needs and concerns relating to navigation during this study.

For both deep-draft and small-craft planning, the scope of work included:

a. Identification of problems and needs

b. Consideration of the present and future situations

c. Preparation of a variety of plans to solve both present and future problems

d. Studies of the adverse and beneficial effects of the various sites and plans

e. Selection of the most appropriate plans for more detailed study to determine which plan should be recommended for implementation

STUDY PARTICIPANTS AND COORDINATION

The U.S. Army Corps of Engineers, Honolulu District, conducted and coordinated the overall study and prepared the report. Studies and investigations were performed with the assistance of the County of Hawaii and the State of Hawaii.

As part of the public involvement program, governmental agencies (Federal, State and County), community groups, environmental groups, boaters, the general public and private interests were contacted during the study and encouraged to participate in ten public workshops and public meetings. This public involvement program helped to identify study concerns, to obtain pertinent study information, and to develop and evaluate alternative plans. Public views and responses voiced at the various workshops and meetings and a summary of the public involvement program are discussed in Appendix C, Public Views and Responses.

STUDIES OF OTHERS

The planning documented in this report conformed to objectives set out in all local planning documents, including the County of Hawaii General Plan, the Keaukaha Shoreline Plan (a plan for trails and shoreline access along Hilo Bay), the State Comprehensive Outdoor Recreation Plan, the State Coastal Zone Management Plan, the State and County Water Quality Management Plans (208 plans) and the State's Hilo Harbor Development Master Plan.

PRIOR CORPS STUDIES

The Honolulu Engineer District has performed studies in Hilo Harbor over the years since 1905. Of particular note are studies for a Tsunami Barrier (1967), the Hilo Harbor Modification Wave Gaging (1972), and Hilo Breakwater Repair (1980).

The Tsunami Barrier Study recommended a $60 million improvement consisting of barriers and levees to protect Hilo. With a local cost of $10 million, the local government rejected the tsunami barrier plan and the project was deauthorized in 1977. The plan was based on results of physical modeling conducted in Honolulu at the James K. Look Laboratory of the University of Hawaii, the model results are not applicable to studying the harbor's present navigation problems because the distorted scale was only correct for the long period tsunami waves. The planning assumption at that time was that the tsunami barriers would also protect the harbor from seasonal North Pacific storm waves, the apparent cause of the ship motion problem at the docks.

The Hilo Harbor Modification Study was started after the tsunami barrier study to determine the nature of waves causing ship motion. The results were not fully conclusive but suggest that the surge problem may be caused by short period storm waves generated by distant North Pacific winter storm.

An authorized small-craft harbor project exists for Reeds Bay, inside Hilo Harbor. This harbor was recommended in the 8 March 1963 report Coasts of the Hawaiian Islands: Harbors for Light Draft Vessels. This harbor is anticipated to meet the immediate and future needs of the recreational boating community in the Hilo area.

THE STUDY PROCESS AND THE REPORT

The study documented in this report followed the planning requirements of the Water Resources Council (WRC) and the guidelines of the US Army Corps of Engineers (Corps) for conducting feasibility studies for water and water-related land resources. The WRC planning requirements are presented in "Principles and Standards for Water and Related Land Resources Planning" (18 CFR Part 711, 29 September 1980), most frequently known as the "Principles and Standards" or simply "P&S". The guidelines of the Corps are contained in the various planning regulations, circulars and pamphlets that address this subject.

These guidelines specify that feasibility studies be conducted in a three-phase process:

Stage 1 - Reconnaissance
Stage 2 - Intermediate Plan Development
Stage 3 - Detailed Plan Development

The four interative tasks of problem identification, formulation of alternatives, impact assessment, and evaluation are performed at each stage, but with different emphasis for each stage. Separation of plan development into stages allows the development of more reliable and more precise plans throughout the study.

In the initial stage, the four tasks were performed at a limited level sufficient only to define the scope and character of the study. The purposes were to determine the need for additional study and to establish a tentative schedule for performing the additional studies, if needed. The product of this stage was the HACS POS.

The emphasis in Stage 2 was on identifying and analyzing a range of alternative measures for solving the small craft and deep draft navigation problems of East Hawaii. The measures were not detailed in depth, but only of detail sufficient to make a preliminary choice of options for the detailed studies that characterized the final stage of planning.

In the final stage - Detailed Plan Development - the emphasis has been on impact assessment and evaluation of the detailed alternatives. This draft report is the product of the final stage of planning.

The report is divided into two components: the Main Report, which includes the Draft Environmental Impact Statement (DEIS), and the technical appendices. The main report is essentially a summary of the study process, highlighting the planning logic and the conclusions reached during the study. The main report is structured generally around the four basic planning tasks: problem identification, formulation of alternatives, impact assessment and evaluation, each task covered in a separate section. Because this report addresses two separate problems, each section of the main report is divided into two sub-sections with very similiar titles, each sub-section discussing either small craft or deep draft navigation. The main report does not contain detailed or technical information; this material is included in the technical appendices. Most of these appendices are also divided into small craft and deep draft sections. The appendices attached to this report are briefly described below.

NATIONAL OBJECTIVES

The Principles and Standards (P&S) for planning water and related land resources define the national objectives of national economic development (NED) and environmental quality (EQ). These objectives are one means of measuring the effectiveness of possible solutions examined. Alternative plans were formulated to satisfy the NED and EQ objectives, stated below.

NED OBJECTIVE

Contribute to national economic development by increasing the value of the national output of goods and services.

EQ OBJECTIVE

Contribute to environmental quality by providing for favorable changes in the ecological, cultural, and aesthetic attributes of natural and cultural resources that sustain and enrich human life.

The NED and EQ contributions of a measure are evaluated during the formulation of alternative plans. For any plan to be considered for implementation, the total beneficial contributions accruing must exceed the total adverse impacts. The P&S also require that the impacts of the proposed action be measured in terms of contributions to Regional Development (RD) and Social Well Being (SWB). The RD impacts are determined by establishing a proposal's effects on a region's income, employment, population, economic base, environment, and social development; and SWB contributions are determined by establishing a proposal's effects on real recreational opportunities and emergency preparedness.

SECTION II

PROBLEM IDENTIFICATION

Problem Identification is the first step in the Corps planning process. During this step, meetings are held with the various agencies, groups, and the general public, with the goal of obtaining as broad a spectrum of public comment as possible. Information gathered from these meetings and data obtained during studies performed during this task produce a range of concerns, needs, and opportunities to be addressed. Based on these, the proper area of the study is established as are based conditions within this study area. Culminating the problem identification task is the development of planning objectives, positive restatements of the expressed needs that can be addressed by one or more management measures. Once formulated, the planning objectives guide the remaining tasks of the planning process.

From input received in meetings held throughout the study area during the problem identification task of this navigtion study, and from other data collected, a list of needs was generated for both the small craft and deep draft components of navigation. (See Appendix C for details on the meetings.) The planning objectives developed to address these needs are listed at the end of each of the next two sub-sections of this section. Appendix A discusses in greater detail the activities performed during the problem identification task.

The remainder of this section of the main report is divided into two parts -- one each for small craft navigation and deep draft navigation. Each of these parts begins with a discussion of the existing conditions and concludes with a listing of the planning objectives developed for that component (small craft-deep draft) of the study.

SMALL CRAFT NAVIGATION

The paragraphs that follow describe segments of the study completed during the problem identification task that pertain to small craft navigation. Existing Conditions discusses the situation (relating to small craft navigation) in the Hilo area at the present time, Without Conditions discusses the most likely situation foreseen if no Federal small craft navigation improvements are completed, Problems and Needs discusses the public involvement

program conducted during the study and lists the problems and needs expressed during that program, and the Planning Objectives segment lists the study's planning objectives applicable to small craft navigation.

EXISTING CONDITIONS

The State and County governments have constructed a variety of navigation facilities in the Hilo area for both commercial fishing and recreation small craft users. The locations of the facilities in the Hilo Bay vicinity are shown on Figure 3 and described below (numbers refer to location numbers on Figure 3).

Bay Front Beach (1). This beach on Hilo's bayfront is heavily used for Hawaiian canoe launching, which is extremely popular and a recreational as well as a cultural resource. No facilities exist for launching or landing any other type craft.

Wailoa River (2). This State facility has two launch ramps and berths for 37 boats. The high flow of fresh springwater through the basin reduces bottom fouling, and boaters have requested an increase in the number of berths. Vessels using these facilities are limited to those with a height of less than 8 feet by the low clearance of the Kamahameha Avenue Bridge across the Wailoa River. Limited parking and other uses of the State park in which it is located also restrict these facilities.

Suisan Basin (3). This State facility for larger commercial fishing boats has eight berths located at the mouth of the Wailoa River. The fish auction and cold storage facilities are adjacent to the basin.

Waiakea Marine Railway (4). The main haulout facility on the island of Hawaii, it has the capacity to handle a 70-foot-long boat and is owned by the State. Work space is an open, unprotected, and unsecured area and is sufficient for only three boats at a time. Boaters using the railway have requested improved haulout and work areas.

Reeds Bay (5). This State-designated mooring area can accommodate up to 50 small sailcrafts. This location has no ramps or any other facilities for launching/landing.

Radio Bay (6). The State maintains these 11 berths for transient small craft. A US Coast Guard vessel is also berthed here. Possible long-term State plans include filling most of Radio Bay for additional container storge space for the commercial port.

The two locations outside the breakwater with facilities for small craft are Laupahoehoe and Pohoiki Bay, north and south of Hilo, respectively (locations shown on Figure 4). Neither location has a sheltered area for berthing, only a launch ramp and parking. The ramp at Laupahoehoe was constructed by the county; and the ramp at Pohoiki, protected by a Federal breakwater, was constructed by the State. The primary ramp users at both locations are commercial fishermen.

WITHOUT CONDITION

Even without additional small craft improvements, the number of small craft and the demand for wet storage will continue to grow with increased trailering compensating for lack of berths. The commercial fish catch and associated incomes will increase, but the rate of growth will be depressed with the shortage of berths constraining boat sizes in the fishing fleet. Rising fuel costs will increase the costs of trailering, further constraining the fleet.

PROBLEMS AND NEEDS

In east Hawaii, access to the ocean for boaters is especially difficult due to trade wind exposure and a rugged coastline. The needs expressed by the boating public indicate a need for more small-craft berths, harbors of refuge, protected mooring areas for fish offloading and vessel resupplying, and launch ramps for trailered boats. The significant increase in commercial fishing is making the need for facilities to serve those boaters particulary acute.

Hilo Bay is the only all weather harbor in east Hawaii, but it is far from the best fishing grounds and has only limited small craft facilities. Recent studies indicate that significant benefits may be realized from providing for commercial fishing harbor improvements. In this study, sites for small-boat harbors were investigated on the north coast of Hilo to Lapahoehoe, to Cape

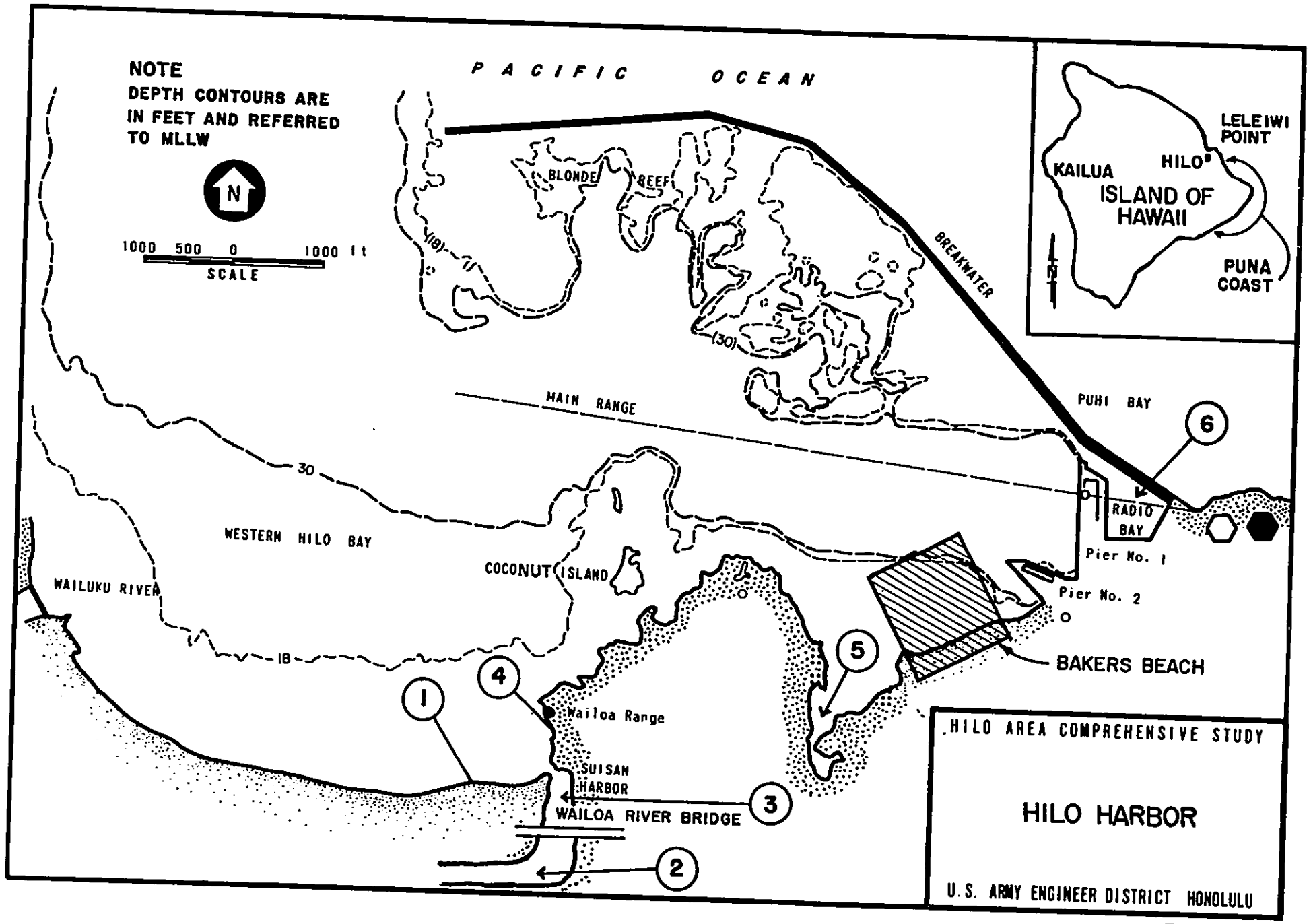

NOTE
DEPTH CONTOURS ARE IN FEET AND REFERRED TO MLLW
N
1000 500 0 1000 ft
SCALE
PACIFIC OCEAN
BLONDE REEF
(18)
(30)
BREAKWATER
MAIN RANGE
PUHI BAY
6
RADIO BAY
Pier No. 1
Pier No. 2
BAKERS BEACH
30
WESTERN HILO BAY
COCONUT ISLAND
WAILUKU RIVER
18
1
4
5
Wailoa Range
SUISAN HARBOR
WAILOA RIVER BRIDGE
3
2
LELEIWI POINT
HILO
KAILUA
ISLAND OF HAWAII
PUNA COAST
N
HILO AREA COMPREHENSIVE STUDY
HILO HARBOR
U.S. ARMY ENGINEER DISTRICT HONOLULU

FIGURE 3

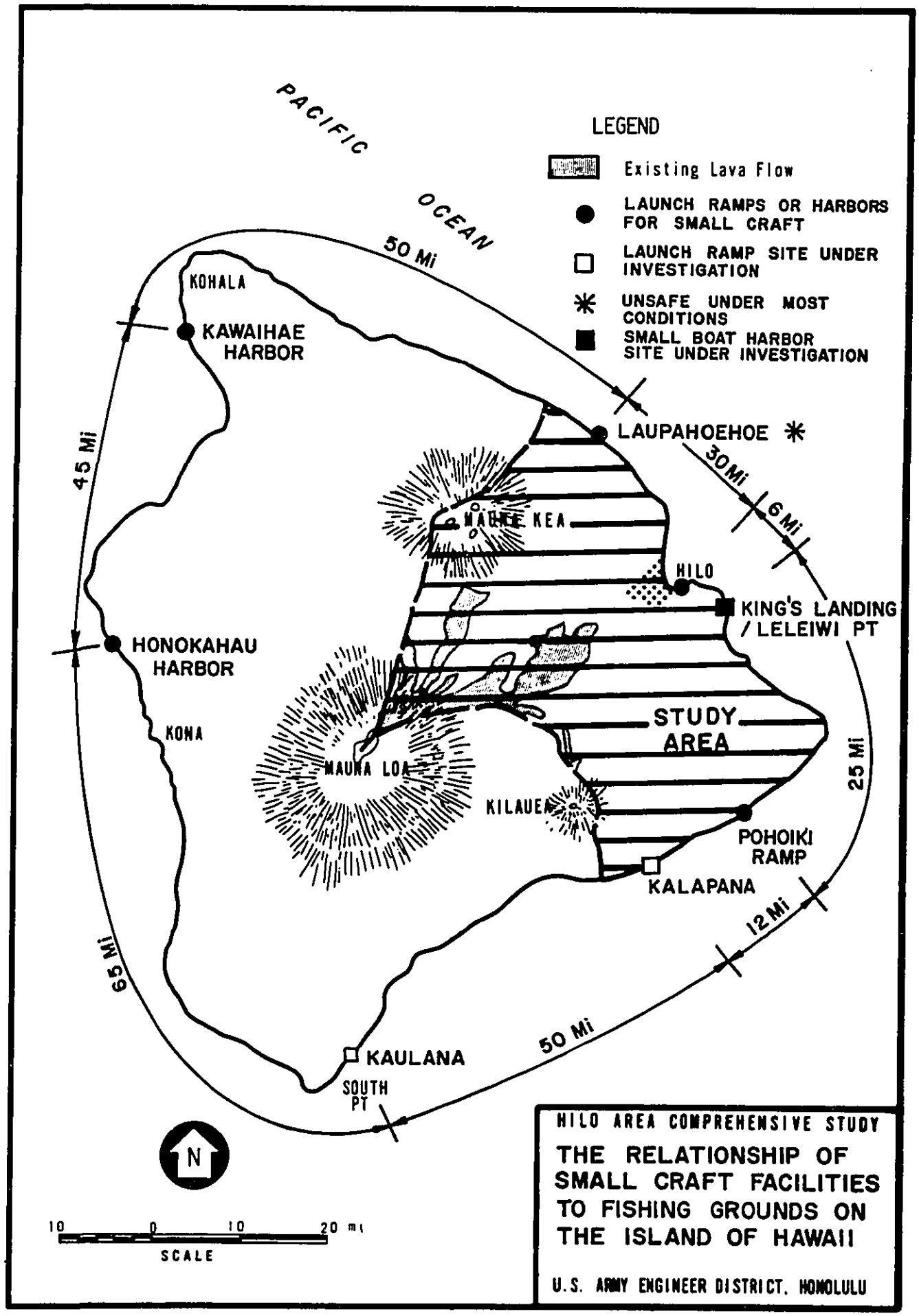

PACIFIC
OCEAN
LEGEND
Existing Lava Flow
LAUNCH RAMPS OR HARBORS FOR SMALL CRAFT
LAUNCH RAMP SITE UNDER INVESTIGATION
UNSAFE UNDER MOST CONDITIONS
SMALL BOAT HARBOR SITE UNDER INVESTIGATION
50 Mi
KOHALA
KAWAIHAE HARBOR
LAUPAHOEHOE
30 Mi
6 Mi
45 Mi
MAUNA KEA
HILO
KING'S LANDING / LELEIWI PT
HONOKAHAU HARBOR
KONA
STUDY AREA
MAUNA LOA
KILAUEA
25 Mi
POHOIKI RAMP
KALAPANA
12 Mi
65 Mi
50 Mi
KAULANA
SOUTH PT
N
10 0 10 20 mi
SCALE
HILO AREA COMPREHENSIVE STUDY
THE RELATIONSHIP OF SMALL CRAFT FACILITIES TO FISHING GROUNDS ON THE ISLAND OF HAWAII
U.S. ARMY ENGINEER DISTRICT, HONOLULU

FIGURE 4

Kumukahi south of Hilo, and on the South Puna coast from Cape Kumukahi to South Point.

The distance between safe entrances to protected waters poses a serious problem for small craft boaters. Small craft with engine trouble or caught by sudden squalls often cannot return to their port of departure. Table 1 lists the existing ports along the east Hawaii coastline and the distances between them. Figure 4 shows the location of the existing and proposed small craft facilities and the corresponding mileages.

The small craft navigation problem has been reduced to two issues: one, which site is feasible and publicly acceptable for a new small craft harbor with sufficient backup space to support commercial fishing; two, meeting the needs for systemic planning for small craft facilities be met by a combined application of small improvements, construction of the authorized Reed's Bay improvement (primarily recreation boating), and construction of a new small-craft harbor (primarily intended for commercial fishermen).

Table 1. DISTANCES BETWEEN PORTS ON THE ISLAND OF HAWAII

Ports	Miles
Hilo to Pohoiki	30
Pohoiki to South Point	60
Pohoiki to Honokahau via South Point	125
Honokahau to Kawaihae	45
Kawaihae to Laupahoe	50
Laupahoehoe to Hilo	30
Kawaihae to Hilo	80

PLANNING OBJECTIVES

a. Contribute to safe commercial and sport fishing and recreational boating along the coastal zone of East Hawaii during the 1985-2035 period of analysis.

b. Contribute to coastal water quality and opportunities for fishing and water-based recreation in the waters of East Hawaii.

c. Promote the understanding of Hawaiian culture (reflected in the historic and archaeological resources) and preserve or enhance the environmental resources in the East Hawaii coastal area.

DEEP DRAFT

The following paragraphs describe segments of the problem identification task pertaining to deep draft navigation. Existing Conditions describes the existing situation in the Hilo area, Without Condition discusses the situation that is most likely to exist if no modifications are made to the deep draft project of Hilo Harbor, Problem and Needs lists those problems and needs expressed during the public involvement program conducted during the problem identification task, and the Planning Objectives segment lists the deep draft planning objectives.

EXISTING CONDITIONS

The cargo volume at the commercial port has averaged about one million tons annually for several years. An upward trend continues, but major increases in cargo throughput are not predicted unless significant changes to the existing economic situation develop, for example, establishment of a new industry. A passenger vessel recently began visiting Hilo, and continued growth may be possible. Hilo Harbor has a 35-foot project depth, which does not permit the largest capacity ships to enter Hilo Harbor fully loaded. North Pacific winter storms have annually caused surge conditions in the commercial port that prevented ships from loading or unloading at the docks and has resulted in pier damage and personal injury. A shortage of docking space at times causes delays to shippers.

The Corps of Engineers is responsible for the maintenance of the Federal project. About 50,000 cubic yards of sediment were deredged in 1977 from the turning basin. Repairs began on the breakwater in FY81, and a 900-foot section directly seaward of Pier 1 is being reinforced with tribars and covered with reinforced concrete ribs at a cost of less than $2 million. Additional work is expected to be done over the next few years to repair the entire 10,000 feet of breakwater, which is over 50 years old and was not constructed using currently recommended design criteria.

WITHOUT CONDITION

Longer vessels with deeper drafts (and larger cargo capacities) replace some vessels in the existing fleet. In the absence of dredging to deepen the

entrance channel and turning basin, some vessels will not be able to operate fully loaded, and vessels will continue to have problems turning because of the less than optimum basin width. Without a solution for the surge problem, ship motion at the docks will continue to delay vessels and cause damages to lines, fenders, piers, and vessels, as well as present potential threats of personal injury. With no increase in docking space, ship delays may continue.

The quality of the Hilo Bay waters will not improve greatly over the existing condition. Recreational fishing and boating in Hilo will remain popular activities, but commercial fishing (for tuna bait) inside the breakwater is not likely to improve markedly.

PROBLEMS AND NEEDS

The concerns relating to deep-draft navigation were all centered on Hilo Harbor, the primary commercial port of the island of Hawaii. Some of the vessels in the existing fleet and many of the projected future fleet cannot operate fully loaded with the existing depths in the entrance channel and turning basin. All but one of the vessels which regularly call at Hilo continue to have the problem of turning because the basin's width is less than the safe design criteria of two times the vessel length. The situation is exacerbated because a vital mooring buoy, necessary for mooring during conditions of heavy surge is located in the middle of the turning basin. This causes delays in turning, the maneuver requires extra tugs on longer vessels, and the risk of an accident is increased.

The problem of ship motion caused by surge conditions at Hilo is a major concern to vessel operators, port officials, and local businesses. Although the problem occurs for only a few days each year, it is unpredictable, normally occurring between October and May.

Other needs of deep-draft shipping include additional container storage space because of the increasing volume of containerized general cargo and a deeper and wider entrance channel and turning basin to accommodate larger vessels.

Coincidental to the need to improve deep-draft shipping conditions is the problem of Hilo Bay's water quality. The long history of effluent discharge into the bay has contaminated the bay sediments. Improved circulation is a major need for a net enhancement of environmental quality in the bay.

PLANNING OBJECTIVES

a. As a contribution to deep draft navigation, encourage the efficient development and utilization of Hilo Harbor to accommodate all waterborne commerce and associated traffic during the 1985-2035 period of analysis.

b. Contribute to the reduction of ship delays and damages caused by ship motion or natural wave action at the Hilo docks.

c. Maximize the effectiveness of the Hilo breakwater for public safety and preserve historic values associated with the breakwater.

d. Enhance the water quality and fish habitats of Hilo Bay.

SECTION III

FORMULATION OF PRELIMINARY PLANS

This task of the planning process begins with the Planning Objectives whose formulation concluded the Problem Identification task. An array of management measures were identified to address each of these objectives. These measures, both structural and non-structural, were combined in various combinations to create a series of possible solutions. These solutions were then evaluated to determine which were technologically feasible and had sufficient public and agency support to warrant being carried into the detailed planning stage.

This section is divided into two major sub-sections: SMALL CRAFT NAVIGATION and DEEP DRAFT NAVIGATION. Each of these is further divided into segments describing portions of the Preliminary Plan Formulation task. While the planning process for each was essentially the same, the format presenting the material in this report differs in the two sub-sections because of the different types of problems examined.

SMALL CRAFT NAVIGATION

MANAGEMENT MEASURES

Non-structural measures examined for small craft navigation include increased stacked storage to accommodate increased boating and additional launch ramps to encourage more trailered boating, lessening the congetion in wet storage areas. Launch ramps were examined as non-structural measures because of the minor construction required when compared to a harbor. The primary structural measure was the construction of a small boat harbor to accommodate the growing number of vessels in the Hilo area. Other measures were included to satisfy the remaining objectives, including those of cultural, social, and environmental importance. Table 2 contains a full listing of the management measures considered during the small craft portion of this study, matching the measures with the appropriate planning objectives addressed.

TABLE 2. SMALL-CRAFT MANAGEMENT MEASURES

Planning Objective	Management Alternatives
Contribute to safe commercial and recreational boating and sport fishing along the coastal zone of East Hawaii during the 1985-2035 period of analysis.	Build new launch ramps to encourage more trailer boating.
	Build areas to accommodate stacked dry storage of boats near launch sites.
	Construct a new small boat harbor on the Puna coastline in the study area.
	Construct a network of launch ramps and emergency mooring areas between Laupahoehoe Harbor and South Point.
	Create new opportunities for industries and employment by locating a small boat harbor where there is ample room for backup facilities and to serve as a basis for increased development of a commercial fishing industry.
Contribute to coastal water quality and opportunities for fishing and water based recreation in the waters of East Hawaii.	Select small boat harbor sites outside of wetlands.
	Include practicable measures to minimize harm to the wetland if construction cannot be avoided.
	Construct in area with minimum dredge requirements.
	Design harbor to have minimum water resident time.
	Excavate inland harbors to create a new marine habitat.
	Excavate harbor basin prior to making connection to the sea.
	Require support facilities in the harbor.
	Construct boat ramp facilities in lieu of a harbor.
	Construct pier and crane type launch facilities.
	Build areas to accommodate stacked dry storage of boats near launch sites.

TABLE 2. SMALL-CRAFT MANAGEMENT MEASURES (Cont)

Planning Objective	Management Alternatives
Promote the understanding of Hawaiian culture (reflected in the historic and archaeological resources and preserve or enhance the environmental resources in the East Hawaii coastal area.	Select construction sites in areas with minimal or no significant sites. Salvage any items of archaeologiccal value that would be destroyed by construction.

PLAN FORMULATION RATIONALE

Ultimately, the choice in small craft plan formulation was between non-structural (construction of additional launch ramps and stacked storage) and structural (construction of an entire harbor facility). As no available location for launch ramps offered both the protected waters needed for launching small boats and the land necessary for back-up facilities, this solution was determined to be infeasible, leaving construction of a small boat harbor as the only viable solution for the small craft navigation problem.

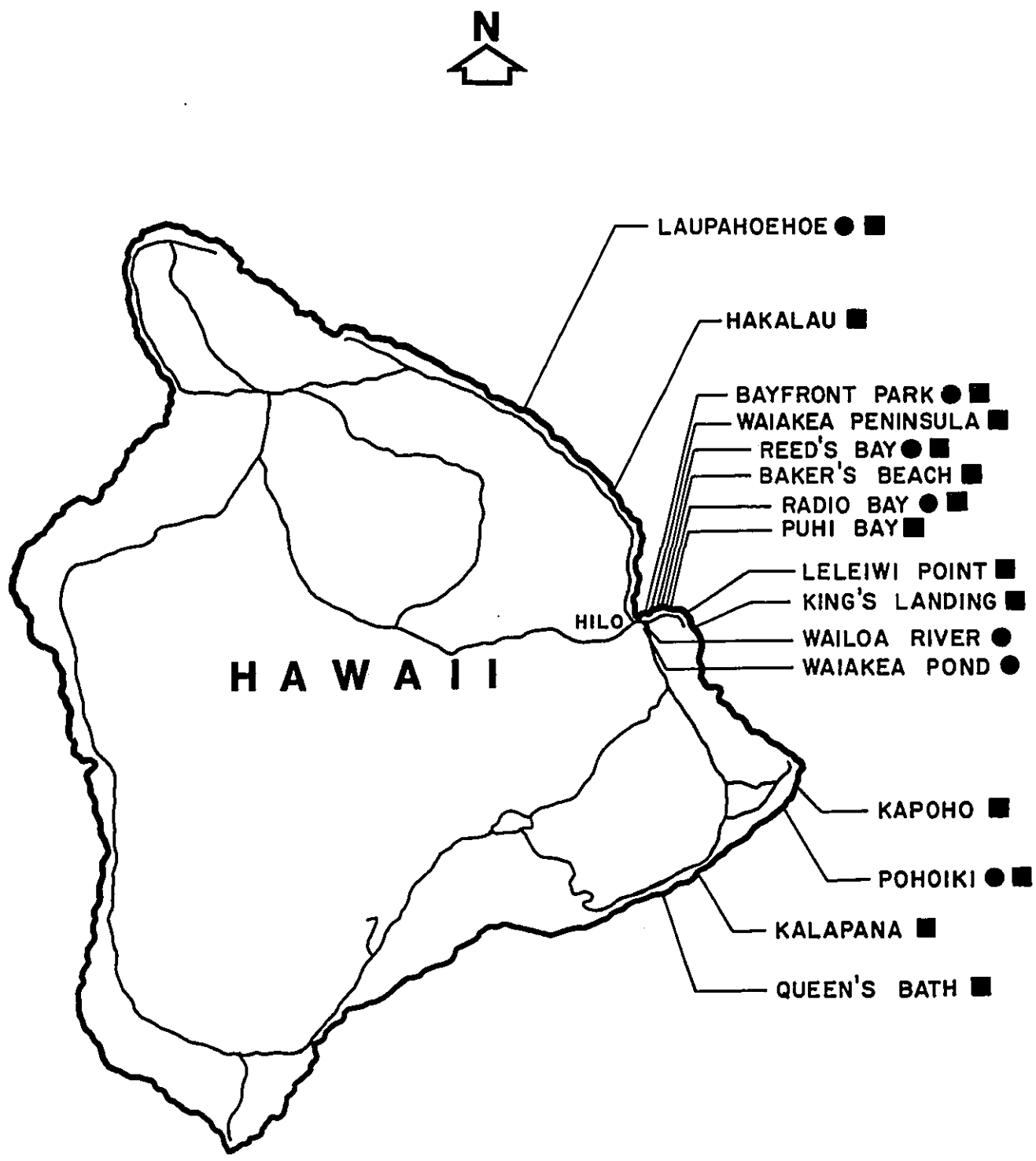
Sixteen sites were identified as having potential for development of a small boat harbor. Of these, 12 were discussed in the 1977 report Preliminary Planning for Small Craft Facilities in East Hawaii summarizing the results that stage of this study. Four others (King's Landing, Leleiwi Point, Queen's Bath and Kalapana), all south of Hilo, were suggested through input as part of the public involvement program. The location of the sixteen sites are shown on figure 5. The sites are described individually in Appendix B in the section titled Description and Evaluation of Potential Sites.

ANALYSIS OF SITES CONSIDERED IN PRELIMINARY PLANNING

Table 3 summarizes the sixteen sites examined. Thirteen of these were dropped during preliminary evaluation because of public opposition, environmental or archaeological impacts, and other reasons. This left only the King's Landing, Leleiwi Point, and Kalapana sites as viable alternatives for detailed planning and analysis. The Leleiwi Point site is located within a county park, the King's Landing site is on private land, and the Kalapana site is on State land. Figure 6 shows the area in which both King's Landing and Leleiwi Point are located, and Figure 7 shows the Kalapana area. The plans developed for each of these sites are described in Section IV, Assessment and Evaluation of Detailed Plans, which follows the discussion of deep draft preliminary plan formulation, which is next.

TABLE 3. SUMMARY OF NAVIGATION IMPROVEMENT ALTERNATIVES

SITE	EXISTING FACILITY	PROPOSED IMPROVEMENT	STATUS
Laupahoehoe	1-lane ramp, loading dock.	Protective breakwater, improved launch ramp.	Begin Reconnaissance/Detailed Project Report studies under Small Project Authority in Fiscal Year 1982.
Hakalau	None.	Launching facilities, refuge harbor.	Proposed by State-wide Boat Launching Facilities Master Plan as alternative to Laupahoehoe. No further plans being developed.
Bayfront Park	50-foot wharf at mouth of Wailoa River.	150 berths, 2-lane launch ramp, protective breakwater.	Hawaii County plans to develop a Bayfront Park. Plans for small craft facilities not continuing.
Waiakea Peninsula	None.	Launching facilities.	The State has constructed a senior citizens park. Plans for launch ramp not continuing.
Reed's Bay	26 sailboat anchor moorings.	Launch ramp, increase berthing spaces to 100, protective breakwater.	Authorized Federal project. Begin Detailed Project Report studies in Fiscal Year 1982.
Baker's Beach	None.	Small boat harbor.	Dropped from HACS plans. Insufficient backup space.
Radio Bay	11 berths with mooring by anchor in the middle of the bay for 10 crafts.	Launch ramp and more berthing.	Insufficient backup space. State has plan to fill in Radio Bay to provide for more container storage.
Puhi Bay	None.	Launch ramp.	State DOT has dropped plans for construction.
Leleiwi Point	None.	Small boat harbor, launching facilities.	One of three alternatives presented in this report.
King's Landing	None.	Small boat harbor, launching facilities.	One of three alternatives presented in this report.
Wailoa River	36 berthing spaces, 2-lane launch ramp, loading ramp.	Increased car and trailer parking, dredge mouth, raise Wailoa Bridge to accommodate vessels with high profiles.	District has recommended emergency dredging of the mouth. State DOT plans to replace existing bridge with one with same vertical clearance leaving little potential for expansion. No further Corps planning.
Waiakea Pond	1-lane launch ramp, catwalk for loading.	Lengthen loading dock.	Project needs based on State-wide Boat Launching Facilities Master Plan would not require construction until 1990. This is used only for row boats.
Kapoho	None.	Launch ramp, small boat harbor.	Local residents oppose any development, alternative has been dropped from HACS plans.
Pohoiki	Federal breakwater, 1-lane launch ramp.	Small boat harbor.	Potentially severe impacts on archaeological sites. Dropped from further study.
Kalapana	None.	Small boat harbor.	One of three alternatives presented in this report.
Queens' Bath	None.	Small boat harbor.	Located adjacent to National Park. Potentially severe impacts on historical sites. Dropped from HACS plans. Harbor of Refuge may be suitable and planning may proceed under Small Project Authority.



LEGEND:

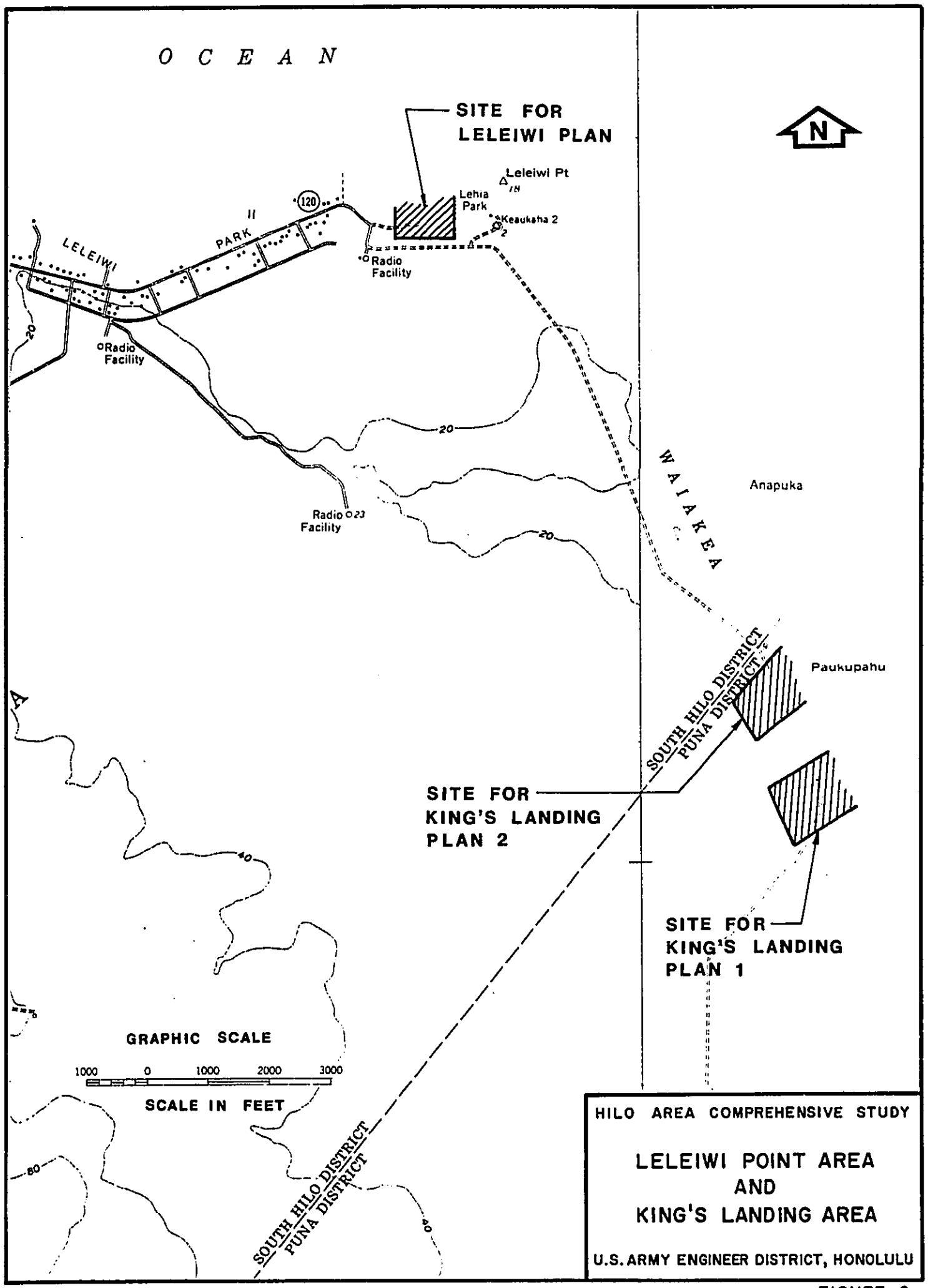
- ● EXISTING FACILITIES
- ■ PROPOSED FACILITIES

HILO AREA COMPREHENSIVE STUDY

POTENTIAL
SMALL BOAT HARBOR
SITES

U.S. ARMY ENGINEER DISTRICT, HONOLULU

FIGURE 5


OCEAN
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Leleiwi Pt
Lehia Park
Keaukaha 2
Radio Facility
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SOUTH HILO DISTRICT
PUNA DISTRICT
SITE FOR KING'S LANDING PLAN 2
SITE FOR KING'S LANDING PLAN 1
40
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GRAPHIC SCALE
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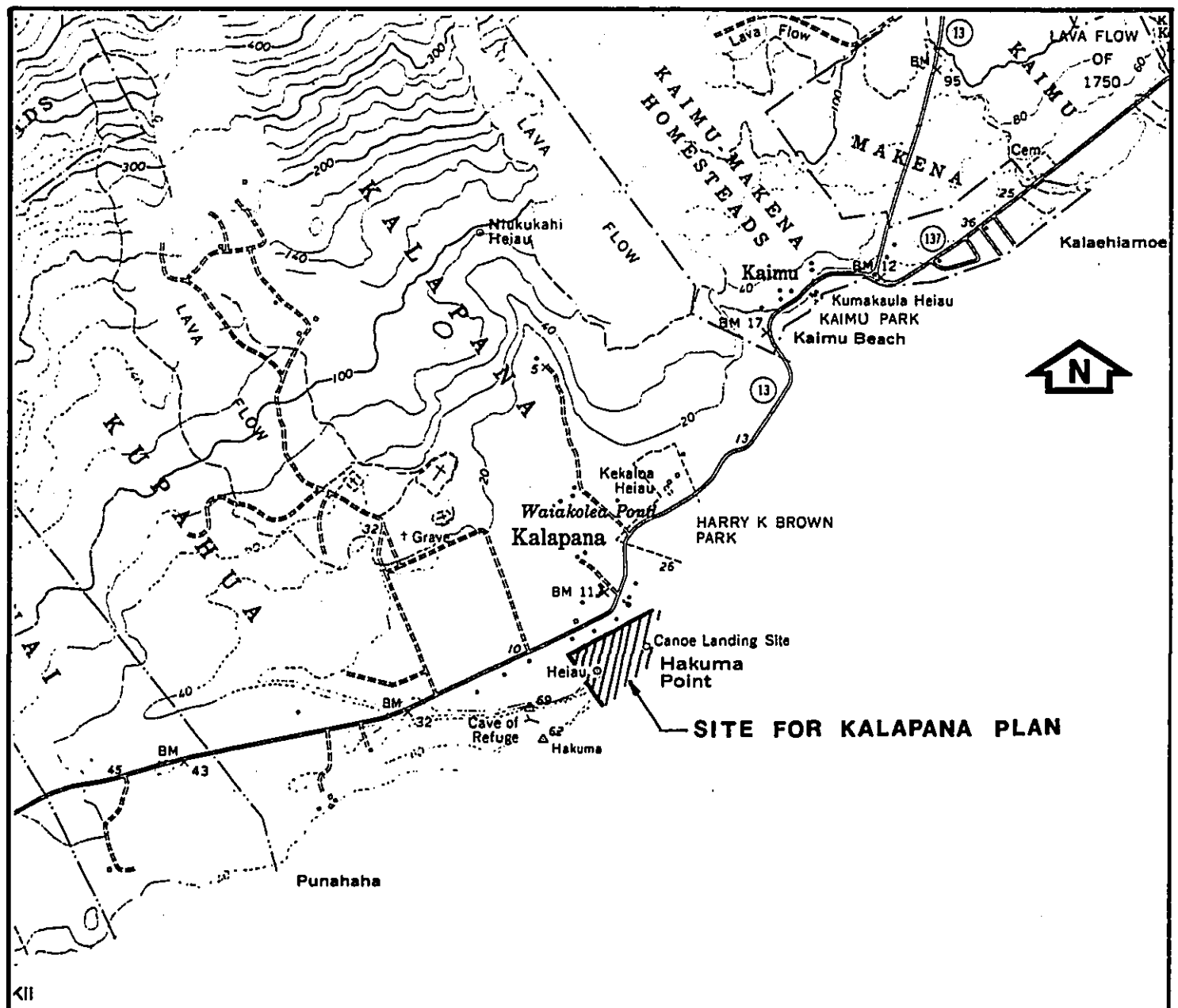
SCALE IN FEET
SOUTH HILO DISTRICT
PUNA DISTRICT
HILO AREA COMPREHENSIVE STUDY
LELEIWI POINT AREA
AND
KING'S LANDING AREA
U.S. ARMY ENGINEER DISTRICT, HONOLULU

FIGURE 6



GRAPHIC SCALE

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SCALE IN FEET

HILO AREA COMPREHENSIVE STUDY

KALAPANA AREA

U.S. ARMY ENGINEER DISTRICT, HONOLULU

FIGURE 7

DEEP DRAFT NAVIGATION

The paragraphs that follow discuss the preliminary plan development task for deep draft navigation, beginning with the selection of a range of management measures, both structural and non-structural, to address the planning objectives formulated at the conclusion of the problem identification task. Table 4 is a listing of the deep draft navigation planning objectives, matched with the management measures that address each objective. The second sub-section of this section, Analysis of Plans Considered in Preliminary Planning, discusses the formulation of plans from combinations of the management measures examined.

MANAGEMENT MEASURES

The measures considered under the deep draft portion of this study included dredging, improvement of the fender systems at the piers, construction of a revetted fill area, removal of the existing breakwater, installation of a submersible mooring buoy and other structural and non-structural components.

Non-Structural Measures. The non-structural measures included replacement of the existing mooring buoy with a submersible buoy, removal of the existing breakwater, and fender systems' improvement. All of these were used in combination to formulate alternative deep draft plans.

Structural Measures. The structural measures were those concerned with dredging and construction of new facilities. Of these, dredging to provide a wider turning basin and construction of a revetted fill area for additional container storage were infeasible for Federal implementation. Construction of the fill area is being considered by local agencies. Deepening the entrance channel and turning basin and non-structural measures were also used in formulating plans.

PLANS OF OTHERS

The Hilo County Chamber of Commerce prepared a development plan to solve the problems of surge, inadequate storage and docking space, and the narrow and shallow channel and basin. The plan requires significant changes in the

harbor configuration through realignment of the breakwater and filling on Blonde Reef. While the impacts of this plan are substantial and the costs excessive for Federal development, the plan is carried forward for comparison purposes.

TABLE 4. DEEP DRAFT MANAGEMENT MEASURES

Planning Objective	Management Measures
Encourage the efficient development and utilization of Hilo Harbor to accommodate all waterborne commerce and associated traffic during the 1985-2035 period of analysis.	Dredge a deeper entrance channel and turning basin.
	Dredge a wider turning basin.
	Remove existing mooring buoy.
	Construct a revetted fill area to store additional containers.
	Stack containers on existing storage area.
Contribute to the reduction of ship delays, and damages caused by ship motion or natural wave action at the Hilo docks.	Improve fender systems on the piers.
	Manage vessel schedules more efficiently.
	Dredge a deeper turning basin to provide a greater underkeel clearance.
	Install pretension winches.
	Construct an inner breakwater to provide greater protection to the port.
	Realign piers, construct new piers.
Maximize the effectiveness of the Hilo breakwater for public safety and preserve historic values associated with the breakwater.	Continue maintaining the Hilo breakwater.
	Document the history of the breakwater and the Hilo area.
Enhance the water quality and fish habitats of Hilo Bay.	Remove existing breakwater in Hilo Bay.
	Reduce sediments/pollution entering the Bay.

ANALYSIS OF PLANS CONSIDERED IN PRELIMINARY PLANNING

Four preliminary deep draft plans were formulated using various combinations of the management measures just described. Deepening the entrance channel and the turning basin were components of each, as is ocean disposal of the dredged materials. Plan A includes inner protective breakwaters. The Chamber of Commerce Plan is designated Plan B, Plan C includes changes to the existing breakwater and replacing the existing mooring buoy with a submersible mooring buoy, and Plan D includes this buoy and other non-structural measures.

Description of Plans. Plan A includes the construction of two rubblemound breakwaters and deepening of the entrance channel and turning basin. Plan B is the Chamber of Commerce Plan, requiring extensive breakwater modifications, construction, dredging, and filling to provide new land and piers. It would also include the harbor deepening. Under Plan C, the outer 7,000 feet of the existing breakwater would be removed or allowed to deteriorate and a realigned 2,000-foot breakwater would be constructed in its place. The plan also includes the harbor deepening, the submersible mooring buoy, and an improved fender system at the piers. Plan D includes only the deepening, the submersible mooring buoy, and the fender system.

Comparative Assessment and Evaluation of Plans. Harbor deepening is a component of each of the four plans, incorporating accommodation of larger vessels than presently into the benefits of each of the plans developed for the deep draft harbor. Implementation of Plan A would decrease circulation in the bay and would result in lessened water and habitat quality in the commercial port area. The plan would effectively reduce surge, but would worsen the overall environmental condition of the bay. Construction of the facilities included in Plan B would involve considerable dredging and filling on Blode reef, causing a significant negative impact to the reef and requiring mitigation for that impact. The plan would effectively alleviate the surge problem. Removal of the breakwater under Plan C would improve circulation in the bay, contributing to an improvement of water quality over the existing water quality. If the existing breakwater in the past has reduced the height of incoming tsunami waves, then removal of the breakwater could significantly increase the level of damages incurred in any future tsunami. Physical modeling of Hilo Harbor would be necessary before implementation of this plan

to fully determine all effects of removing the existing structure. Surge would be reduced through non-structural measures under this plan. The benefits of Plan D would include accommodation of larger vessels and reduction of surge through non-structural measures. The only adverse impacts of this plan would be those temporary impacts incurred during dredging. All four plans were carried into detailed plan formulation for comparison and evaluation, and a figure showing each plan is part of that section of this report.

SECTION IV

ASSESSMENT AND EVALUATION OF DETAILED PLANS

This section of the report covers the final portion of the plan formulation task of the planning process. In detailed plan formulation, those plans surviving the screening conducted at the conclusion of preliminary planning are examined thoroughly, with detailed analyses made of each plan, culminating in the tentative selection of a plan, if one appears feasible a that point.

This section is divided into Small Craft Navigation and Deep Draft Navigation, each sub-section describing the process outlined above for a single area of concern. Preliminary planning for small craft navigation ended with three potential sites remaining for development of a small boat harbor, all three located south of Hilo. Deep draft preliminary planning concluded with four deep draft plans being carried forward for analysis. Discussion of those four plans follows discussion of the small craft detailed plans.

SMALL CRAFT NAVIGATION

Of the sixteen sites identified, three merited further consideration as a potential small boat harbor after preliminary screening. Investigations were continued at King's Landing, Leleiwi Point, and Kalapana for preparation of detailed impact assessment and design. The following investigations were conducted for this final planning.

1. Hydrographic surveys at King's Landing, Leleiwi Point, and Kalapana.

2. Topographic surveys at King's Landing and Kalapana. (A 1973 County survey of Leleiwi Point was used to determine the topography at that site.)

3. An Archaeological/cultural reconnaissance survey to determine the presence of culturally significant artifacts at Kalapana and Leleiwi Point was completed in June 1981 by Chiniago, Inc., for the corps of Engineers. An archaeological survey completed in 1978 of the King's Landing site by the Archaeological Research Center of Hawaii for Hawaiian Paradise Park Corporation was used to determine the presence of culturally significant artifacts.

Two harbor plans were developed for the King's Landing site; one plan was developed for each of the other sites. All four plans are for an inland harbor, requiring blasting and excavation for the entrance channel and the basin. The paragraphs that follow discuss each plan individually, including impacts and costs for each.

KING'S LANDING PLAN 1

The King's Landing area is situated on 2,138 acres of privately-owned land about 7 road miles southeast of Hilo. This area is adjacent to the South Hilo-Puna boundary on the northeast coast of the island, but within the Puna Judicial District. The coastline at King's Landing is characterized by rough waters and high cliffs near the water's edge. There are few points of access to the shoreline. Surge is heavy throughout the year.

A new community is to be developed in this area as part of the King's Landing master plan. Preliminary plans call for a residential subdivision of one-acre lots. Proposed future developments include schools, churches and resort/recreational facilities.

The navigation improvement has a potential for expansion into a major commercial harbor with associated landside facilities such as fish processing, boat building, and marine stores, as well as accommodate recreational boaters. At the present time, the only access to the undeveloped area is by an unimproved gravel road. There are no paved roads in the area; however, new roads are to be constructed as part of the initial phase of the private development plan.

Plan Description

Plan 1 at King's Landing (Figure 8) consists of constructing a 1,420-foot long wave absorber and dredging entrance and access channels totalling 1,430 feet in length and a 38,000-square foot turning basin. The costs for this plan are shown in Table 5.

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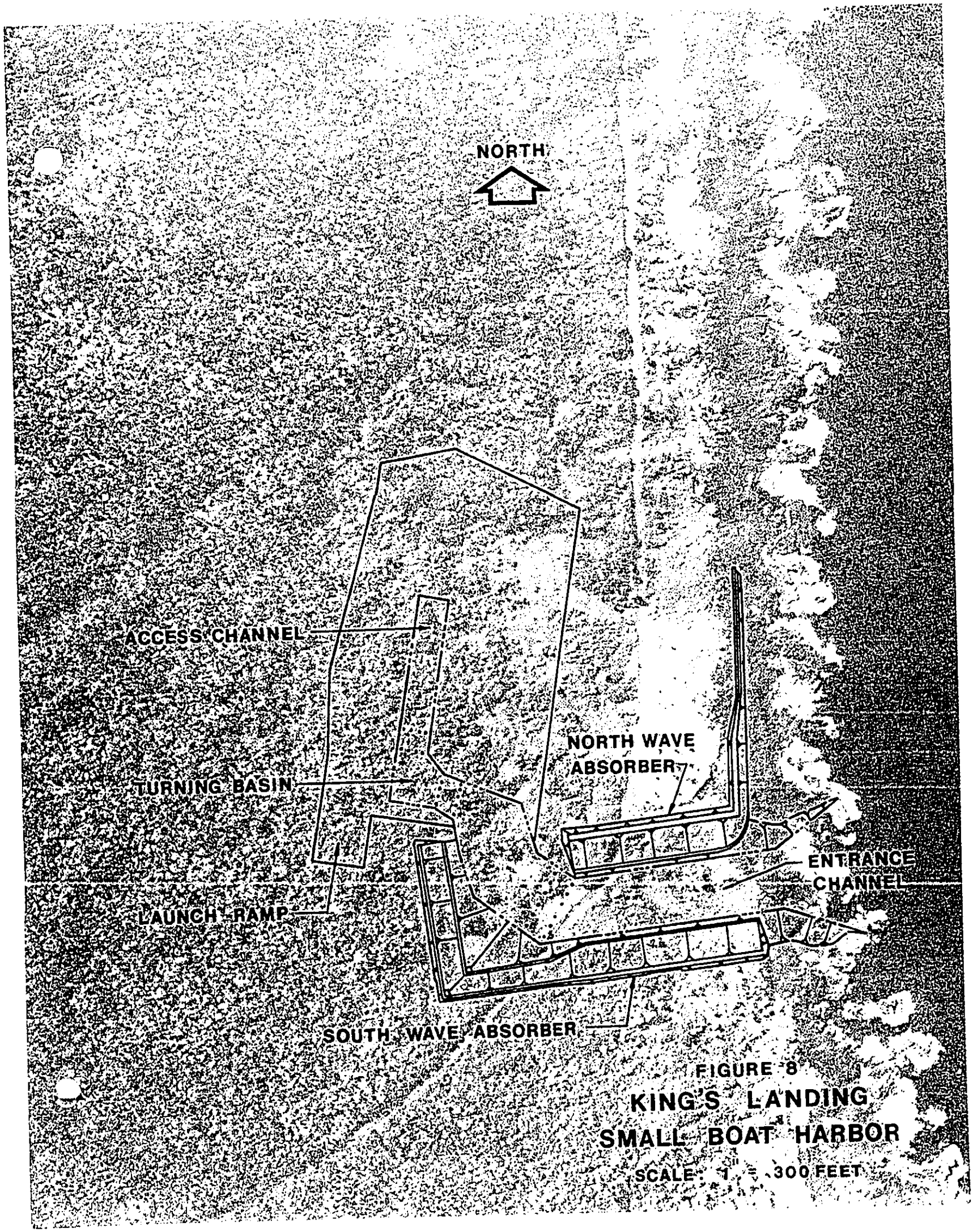

FIGURE 8
KING'S LANDING
SMALL BOAT HARBOR
SCALE: 1" = 300 FEET

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Photograph No. 1 King's Landing

Photograph No. 2 Leleiwi Point

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Photograph No. 3 Kalapana

Photograph No. 4 Laupahoehoe

Table 5. KING'S LANDING PLAN 1 COSTS

Project First Cost	$15,000,000
Interest and Amortization (.07591)	1,139,000
Average Annual Operation & Maintenance Cost	23,000
Total Average Annual Cost	1,162,000
Average Annual Benefits	2,138,000
Benefit-Cost Ratio	1.8

Impact Assessment. The site is located in a tsunami inundation hazard area and an area of high volcanic hazard risks. Plan 1 will eliminate upon a 12-acre wetland area by excavation. No important beneficial wetland values have been attributed to the wetland. Because the King's Landing area is remote and undeveloped, a project in this location would have no direct social impacts, although the harbor would probably enhance the community development plans for the surrounding land area. No unique terrestrial habitats or threatened and endangered species will be affected, but the harbor will clear 150 acres (including the 12-acre wetland) of open, ohia scrub forest which provides general wildlife habitat. The harbor will destroy an unknown number of anchialine pools, which form unique aquatic environments in harsh volcanic environments, and will bury a midden site and excavate a cultural artifact, both of which have potential for inclusion to the National Register of Historic Places. The harbor will create about 10 acres of marine habitat at the loss of 10 acres of terrestrial habitat.

Mitigation Requirements. To reduce water turbidity, the harbor basin and channel would be fully excavated inland before opening the harbor to the ocean. Intensive archaeological surveys and salvage and relocation will be performed, if necessary, prior to project implementation.

Implementation Responsibilities. The Federal government would design and prepare the plans and provide overall management for implementation. The State would be responsible to furnish all lands, easements, and rights-Of-way required by the plan and the non-Federal share of the total cost.

Cost Apportionment

	Non-Federal	Federal	Total
Project First Cost	$4,349,000	$10,661,000	$15,000,000

Average Annual Maintenance Cost: $23,000[1/]

[1/]Includes $2,500 for Aids to Navigation

Public Views.

Federal Agencies: No objections.

Non-Federal Agencies. The State of Hawaii is in favor of this plan if land and cost agreements can be reached with the local landowner.

KING'S LANDING PLAN 2

Plan Description. This plan involves construction of a 1,755-foot wide wave absorber and dredging entrnce and access channels totalling 1,430 feet in length and a 14,000-square foot turning basin. Table 6 shows costs of construction.

Table 6. KING'S LANDING PLAN 2 COSTS

Project First Cost	$16,000,000
Interest and Amortization (.07591)	1,215,000
Average Annual Operation & Maintenance Cost	23,000
Total Average Annual Cost	1,238,000
Average Annual Benefits	2,138,000
Benefit-Cost Ratio	1.7

Impact Assessment: This plan creates 11-acres of marine habitat at the loss of 11-acres of open, ohia scrub forest, general habitat. An unknown number of anchialine ponds will be filled and destroyed. The harbor would destroy several archaeological sites including a heiau and midden site which have potential for inclusion to the National Register of Historic Places, and could

enhance community development plans in the surrounding areas. No direct effect on human residences is anticipated with construction due to the undeveloped nature of the location. No endangered or threatened species will be affected. The project site is located within a tsunami inundation hazard area and an area of high volcanic hazard risks.

Mitigation Requirements: The channel and basin will be excavated inland before opening the harbor to the ocean. Intensive archaeological surveys and salvage will be performed, if necessary, before project implementation.

Implementation Responsibilities: The Federal government would design and prepare the plans and provide overall management for implementation. The State would be responsible to furnish all lands, easements, and rights-of-way required by the plan and the non-Federal share of the total cost.

Cost Allocation. None.

Cost Apportionment.

	Non-Federal	Federal	Total
Project First Cost	$5,770,000	$10,230,000	$16,000,000

Average Annual Maintenance Cost: $23,000[1/]

1/ Includes $2,500 for Aids to Navigation

Public Views.

Federal Agencies: No objections.

Non-Federal Agencies. No objections.

LELEIWI POINT

Plan Description. The Leleiwi Point site (Lehia Park) is within the South Hilo Judicial District about 5 road miles east of Hilo. The park has a total land area of 43 acres and is presently owned, operated, and maintained by the State of Hawaii. The property is mainly classified as conservation with some commercial land. The County has prepared a master plan for the development of the entire Lehia Park area. The proposed development plan includes improvements and additions to park facilities, but does not provide for recreational harbor facilities.

The construction of a small boat harbor at Leleiwi Point would consist of a 1,310-foot wave absorber and dredging entrance and access channels totalling 1,565 feet in length and a 14,000 square foot turning basin. Figure 9 shows a preliminary layout of the harbor. Table 7 shows construction costs.

Table 7. LELEIWI POINT COSTS

Project First Cost	$12,328,000
Interest and Amortization (.07591)	936,000
Average Annual Operation & Maintenance Cost	23,000
Total Average Annual Cost	959,000
Average Annual Benefits	2,138,000
Benefit-Cost Ratio	2.2

Impact Assessment. The project eliminates 43-acres of land designated for park use and fills several tidepools which provide protected swimming areas within park lands. The tidepools provide unique local aquatic habitats. A condominium is adjacent to the site and construction noise and traffic will create a significant social nuisance. Harbor operations will induce a traffic increase on Kalanianaole Avenue. The harbor site is located in a tsunami hazard inundation zone, and a high volcanic hazard risk area. No endangered or threatened species will be affected.

Mitigation Requirements. The harbor channel and basin will be excavated inland prior to opening the harbor to the sea. Intensive archaeological surveys could be performed prior to project implementation, if necessary.

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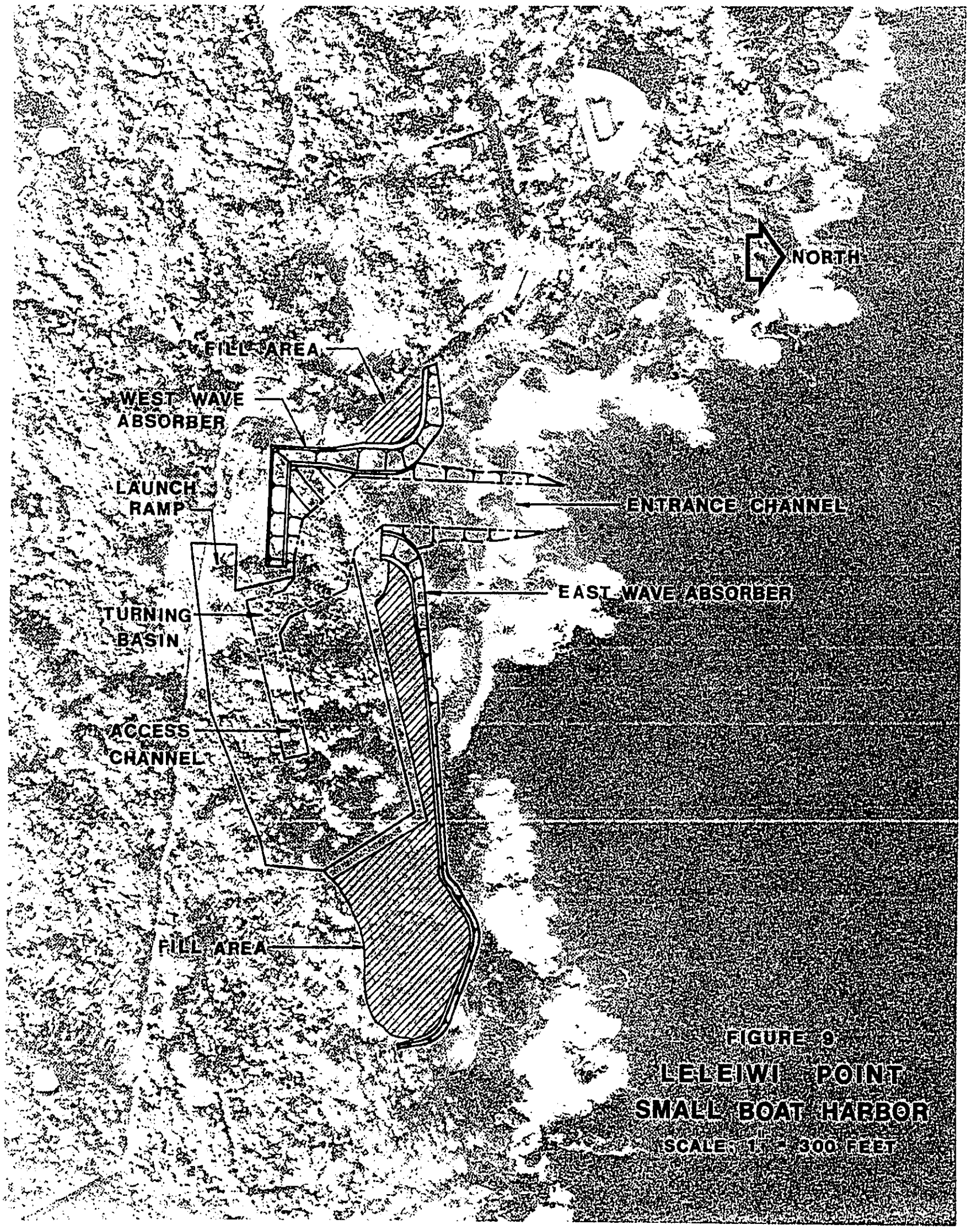

FIGURE 9
LELEIWI POINT
SMALL BOAT HARBOR
SCALE: 1" = 300 FEET

Implementation Responsibilities. The Federal government would design and prepare the plans and provide overall management for implementation. The State would be responsible to furnish all lands, easements, and rights-of-way required by the plan and the non-Federal share of the total cost.

Cost Allocation. None.

Cost Apportionment

	Non-Federal	Federal	Total
Project First Cost	$4,326,000	$8,002,000	$12,328,000

Average Annual Maintenance Cost: $23,000[1/]

[1/] Includes $2,500 for Aids to Navigation

Public Views.

Federal Agencies: The US Fish and Wildlife Service recommended preservation of some of the tidepools because they serve a valuable recretional resource and provide habitat for juvenile reef fish.

Non-Federal Agencies. Local residents have objected to any significant increase in vehicular traffic along Kalanianaole Avenue that the harbor may induce.

KALAPANA

Plan Description. The Kalapana area is located in the Puna District about 30 road miles south of Hilo. The land area at the site is owned by the State of Hawaii and is zoned for conservation use. Approximately 200 persons live in

the Kalapana area. The coast highway is the only overland access to the community and provides access to County and State parks popular with residents and tourists. Kaimu Beach Park, located one mile from the Kalapana community, is a 2.6 acre County park and includes the Kaimu Black Sand Beach. At the eastern edge of Kalapana, one-half mile from Kaimu Beach, is the 22.8-acre Harry K. Brown County Park. A proposed Kalapana-Kaimu Park, connecting and extending the two existing parks, has been a consistent feature of recent community development community planning for this area. This park development plan for Kalapana-Kaimu was recommended for implementation in the County of Hawaii General Plan, as revised and approved in 1971.

The Kalapana community is threatened by natural disasters from both the land and the sea because the active Kilauea volcano periodically threatens the Kalapana coastline and the community is located within a tsunami inundation hazard area. In 1975, a local earthquake and subsidence resulted in a local tsunami and areas in Kalapana settling about 4 feet.

Kalapana was chosen as a potential site because of its proximity to the preferred fishing grounds, its mid-point location in relation to the existing harbors on the Puna Coastline, its comparitively moderate offshore conditions, and its engineering feasibility.

The construction of a small boat harbor at Kalapana would consist of a 920-foot wave absorber and dredging entrance and access channels totalling 1,280 feet in length and a 13,000 square foot turning basin. Figure 10 shows a preliminary layout of the harbor. Table 8 shows construction costs.

TABLE 8. Kalapana Costs

Project First Cost	$10,694,000
Interest and Amortization (.07951)	812,000
Average Annual Operation & Maintenance Cost	23,000
Total Average Annual cost	835,000
Average Annual Benefits	2,138,000
Benefit - Cost Ratio	2.6

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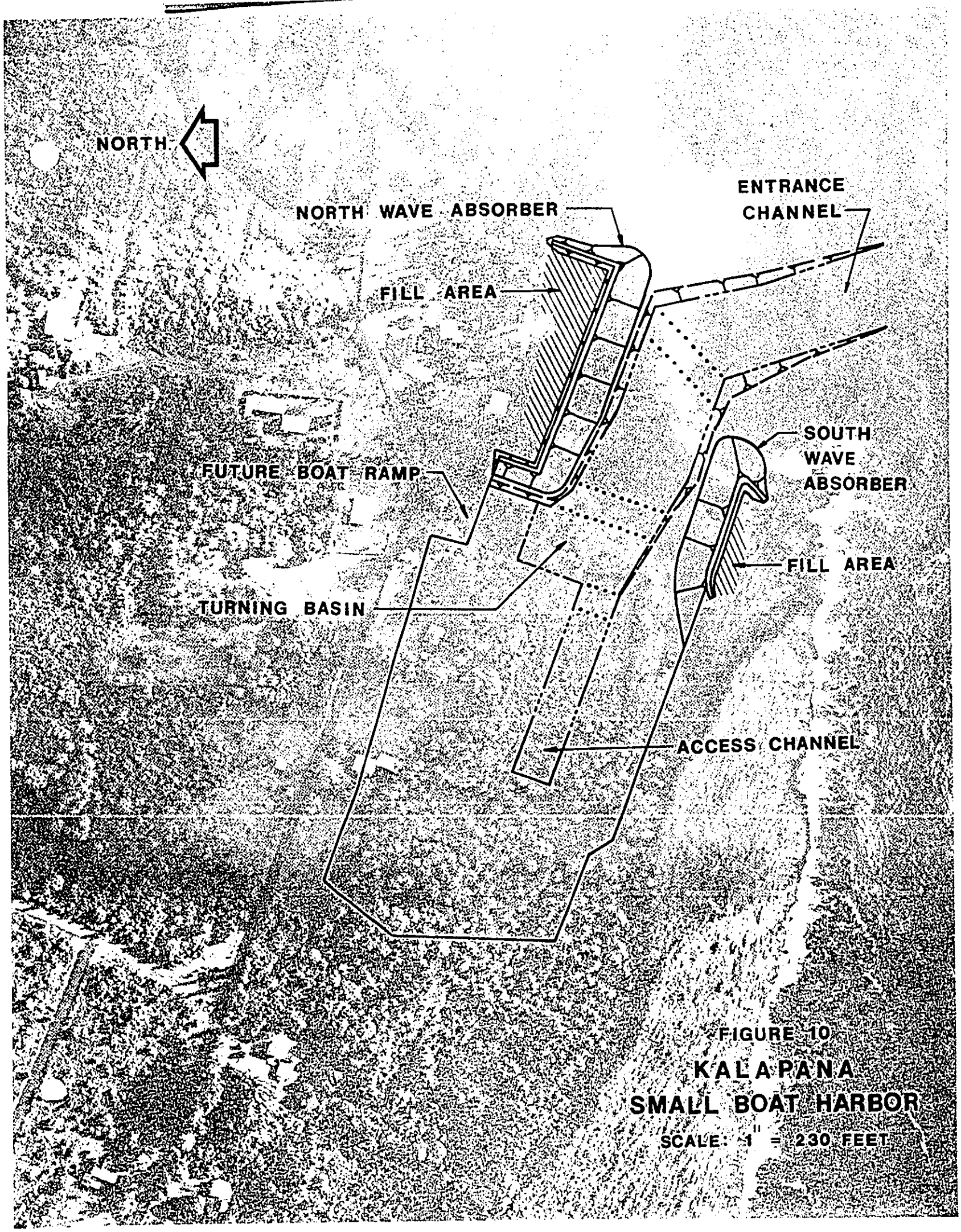


FIGURE 10

KALAPANA SMALL BOAT HARBOR

SCALE: 1" = 230 FEET

Impact Assessment. Kalapana is presently a small, rural community in a quiet setting. Harbor development in this area would have a great impact on the community. At present, no boating facilities are located along the shoreline and traffic is limited to beach users and tourists.

The Kalapana site has 13 acres of public land, adequate for the boat harbor, but not for backup facilities. The site has been designated as a state historic park; the construction of a boat harbor here would be incompatible with present land use plans.

The waters off the area have some surfing value, and the development of a boat harbor could effect surfing.

There are numerous archaeological and historical sites in the Kalapana area. The development of a small craft harbor would destroy Kikoa heiau and fishpond, two sites which have potential for inclusion on the National Register and two locally significant historic resources. The harbor would also create new visual elements which would alter the area around the historic cave of refuge, and the Star-of-the-Sea Painted Church. There would be a loss of about 11 acres of terrestrial habitat and the cretion of about 11 acres of marine habitat.

Mitigation Requirements. The channel and basin will be excavated inland before opening the harbor to the ocean. Intensive archaeological surveys and salvage could be used to offset lost or alteration of historic properties eligible for inclusion on the National Register of Historic Places.

Implementation Responsibilities. The Federal Government would design and prepare the plans and provide overall management for implementation. The State would be responsible to furnish all lands, easements, and rights-of-way required by the plan and the non-Federal share of the total cost.

Cost Allocation. None

Cost Apportionment.

	Non-Federal	Federal	Total
Project First Cost	$ 5,050,000	$5,644,000	10,694,000

Average Annual Maintenance Cost: $23,000 1/

1/ Includes $2,500 for Aids to Navigation.

Public Views.

Federal Agencies: No views received until a plan has been formalized.

Non-Federal Agencies. The State is less favorable to this site than others and has requested that a small facility such as a launch ramp or harbor of refuge be considered for this site.

DEEP DRAFT NAVIGATION

The four plans formulated in preliminary planning were carried forward for comparison and evaluation. The plans vary considerably in their costs, structural and non-structural features, and environmental impacts. The plans are identified as follows:

Plan A - Inner Harbor Protective Breakwater and Deepening

Plan B - Chamber of Commerce Plan

Plan C - Existing Breakwater Changes

Plan D - Harbor Deepening and Non-Structural Measures

PLAN A - INNER HARBOR PROTECTIVE BREAKWATERS AND DEEPENING

Description. This Plan (Plate D-11) requires construction of two rubblemound breakwaters to minimize wave energy entering the berthing areas. Deepening of the entrance channel and turning basin to -40 feet are also included in this plan. This plan provides the most effective surge reduction. Table 9 shows the construction costs of this plan.

Table 9. PLAN A COSTS

Project First Cost	$19,800,000
E & D, S & A	1,600,000
Interest & Amortization (.07591)	1,500,000
Average Annual Operation & Maintenance Cost	57,000
Total Average Annual Cost	1,557,000
Average Annual Benefits	495,000
Benefit-Cost Ratio	0.3

Impact Assessment. Enclosing the inner harbor will reduce wave energy and mixing of the water layers and reduce water exchange with the outer harbor. Deepening will have temporarily increase water turbidity. The alternative will add on to the historic Hilo breakwater.

Mitigation Requirements. None.

Implementation Responsibilities. The Corps would provide overall management for implementation and the State would be responsible for all local requirements.

Cost Allocation. None.

Cost Apportionment.

	($ Millions) Non-Federal	Federal
Breakwaters	-	14.9
Pier 1 Modifications	-	0.4
Dredging	0.4	4.1
E & D, S & A	-	1.6
	0.4	21.0
Total (Non-Federal + Federal)	21.4 million	
Average Annual Maintenance:		
Pier 1 Modifications		1,000
Breakwater		43,000
Dredging		13,000
		57,000

Public Views.

Federal Agencies. The USF&WS would prefer to improve not decrease circulation in the harbor.

Non-Federal Agencies. No objections.

PLAN B - CHAMBER OF COMMERCE PLAN

Description. This Plan (Plate D-12) requires extensive breakwater modifications, construction, and dredging and filling. It would provide new land for harbor opertions and additional piers. Table 10 displays construction and maintenance costs.

Table 10. PLAN B COSTS

Project First Cost	$108,274,000
E & D, S&A	7,115,000
Interest & Amortization (.07591)	8,219,000
Average Annual Operation & Maintenance Cost	73,000
Total Average Annual Cost	8,292,000
Average Annual Benefits	332,000
Benefit-Cost Ratio	0.4

Impact Assessment. This plan would eliminte much of Blonde Reef, the most extensive coral habitat in Hilo Bay due to filling and dredging. Temporary impacts on water turbidity and sedimentation are anticipated. The alternative would realign the historic Hilo breakwater.

Mitigation Requirements. Mitigation could be required due to the loss of Blonde Reef.

Implementation Responsibilities. The Corps would provide overall management for implementation and the State would be responsible for all local requirements.

Cost Allocation. None.

Cost Apportionment.

	($ Millions) Non-Federal	Federal
Project First Cost	68.0	40.3
E&D, S&A	-	7.1
Total (Non-Federal + Federal)	115.4 million	
Average Annual Maintenance:		
Dredging		$13,000
Breakwaters		60,000
		73,000

Public Views.

Federal Agencies: The USF&WS opposes this plan.

Non-Federal Agencies. The Hilo Chamber of Commerce suggested and supports this plan.

PLAN C - EXISTING BREAKWATER CHANGES

Description. This Plan (Plate D-13) requires abandoning or removing armor stone from the outer 7,000 feet of the existing breakwater and constructing a new 2,000-foot section with a different alignment. The new shorter breakwater would be as effective as the exising breakwater, but would give a substantial savings in repairs and maintenance. The outer 7,000 feet would be removed or allowed to deteriorate, using that stone suitable in construction of the new breakwater. The plan includes harbor deepening to -40 feet, a submersible mooring buoy, and fender improvements to Pier 1. Table 11 shows construction and maintenance costs.

Table 11. PLAN C COSTS

Project First Cost	$17,400,000
E&D, S&A	1,500,000
Interest & Amortization (.07591)	1,320,000
Average Annual Operation & Maintenance Cost	61,000
Total Average Annual Cost	1,381,000
Average Annual Benefits	2,003,000
Benefit-Cost Ratio	1.4

Impact Assessment. This plan would have a significant positive enhancement to Hilo Bay's water quality by improving mixing of the two layered water body and flushing Blonde Reef. Temporary turbidity would occur during construction. If the existing breakwater has in the past significantly reduced tsunami heights, any decrease in length could result in tsunami increased damages. A full investigation of this possibility would be required before implementation. The alternative will shorten the historic Hilo breakwater.

Mitigation Requirements. None.

Implementation Responsibilities. The Corps would provide overall management for implementation and the State would be responsible for all local requirements.

Cost Allocation. None.

Cost Apportionment.

	($ Millions) Non-Federal	Federal
Breakwater	-	12.4
Submersible Mooring Buoy	-	0.2
Pier 1 Modifications	-	0.4
Dredging	0.4	4.0
E&D, S&A	-	1.5
	0.4	18.5

Total (Federal + Non-Federal) 18.9 million

Average Annual Maintenance:	
Breakwaters	44,000
Dredging	13,000
Submersible Buoy	3,000
Pier 1 Modification	1,000
	61,000

Public Views.

Federal Agencies: The USF&WS prefers the increased circulation of the bay's water provided by this plan.

Non-Federal Agencies. This plan was opposed during public meetings because of fear of the tsunami impacts on Hilo if the outer 7,000 feet of breakwater were no longer maintained.

PLAN D - HARBOR DEEPENING AND NON-STRUCTURAL MEASURES

Description. This Plan (Plate D-14) reduces surge damages through the non-structural measures of a submersible mooring buoy and an improved fender system. The plan includes harbor deepening to -40 feet. Table 12 displays the construction and maintenance costs for Plan D.

Table 12. PLAN D COSTS

Project First Cost	$5,000,000
E&D, S&A	700,000
Interest & Amortization (.07591)	380,000
Average Annual Operation & Maintenance Cost	17,000
Total Average Annual Cost	397,000
Average Annual Benefits	495,000
Benefit-Cost Ratio	1.2

Impact Assessment. There would be temporary impacts on water quality in the bay associated with dredging. No significant impacts due to construction of the mooring buoy or the fender system are anticipated. No effect on the historic Hilo breakwater is anticipated.

Mitigation Requirements. None.

Implementation Responsibilities. The Corps would provide overall management for implementation and the State would be responsible for all local requirements. The mooring buoy and fender system will be part of the Federal project because they function to reduce surge, not fully accomplished by the existing breakwater.

Cost Allocation. None.

Cost Apportionment.

	($ Millions) Non-Federal	Federal
Dredging	0.4	4.0
Submersible Mooring Buoy	-	0.2
Pier 1 Modifications	-	0.4
E&D, S&A	0.7	-
	1.1	4.6

Total (Federal + Non-Federal) 5.7 million

Average Annual Maintenance:	
Dredging	13,000
Submersible Buoy	3,000
Pier 1 Modification	1,000
	17,000

Public Views.

Federal Agencies: This plan is acceptable to the USF&WS.

Non-Federal Agencies. This plan is acceptable to local agencies.

SECTION V

COMPARISON OF DETAILED PLANS

SMALL CRAFT NAVIGATION

COMPARISON OF DETAILED PLANS

From a technical standpoint, both King's Landing and Leleiwi Point are poor candidates for a small boat harbor. The offshore wave conditions are very rough and the bottom slope drops off steeply to very deep water. An inland harbor is the only alternative to provide for safe navigation at either site because of the dangerous sea conditions. Extensive blasting of hard basalt rock would be required to construct the long entrance channel and turning basin. Some offshore dredging is also necessary to provide adequate entrance depths. Table 13 provides a summary of the three sites.

Four archaeological sites with potential for inclusion in the National Register of Historic Places are present at King's Landing. At Kalapana, Kikoa Fishpond, Kikoa heiau, the Star-of-the-Sea Painted Church and the cave of refuge have potential for inclusion on the National Register of Historic Places. A possible midden site was found at Leleiwi, but there was insufficient data to determine eligibility for inclusion on the National Register of Historic Places.

There are no environmental advantages to any sites under consideration. Plan 1 at King's Landing would eliminate 12-acres of wetland. Both King's Landing Plan 1 and Plan 2 will eliminate an undeterminable number of anchialine pools and affect significant historical resources. At Leleiwi and Kalapana, a harbor would eliminate park uses. Tidepools at Leleiwi would be filled reducing recreational swimming resources. A harbor at Kalapana appears to affect more historical resources than at the other sites. All the sites lie in high volcanic and tsunami risk areas subject to subsidence and water inundation but the threat of lava inundation, subsidence and tsunami inundation is more significant at Kalapana due to its close location to Kilauea Volcano. Table 14 summarizes the potential environmental impacts associated with the alternative sites.

TABLE 13. COMPARISON OF SMALL CRAFT HARBOR SITES

	KING'S LANDING	LELEIWI POINT	KALAPANA
Land Available	All private lands. Up to 150 acres to be donated by private landowner which would also be sufficient for extensive backup facilities.	43 acres of State land available. Sufficient for minimal backup facilities. Site designated as County park.	13 acres of State land available. Requires purchase of private lands for backup facilities. Site designated as historic County park.
Offshore Conditions	Hazardous. Open coast entrance channel.	Hazardous. Open coast entrance channel.	Moderate. Semi-protected entrance channel.
Natural Hazards			
Volcanic	High.	High.	Very high.
Tsunami	High.	High.	Very high.
Land Subsidence	None.	None.	Moderate.
Wave Exposure	Direct tradewind exposure.	Indirect tradewind exposure.	Direct tradewind exposure.
Design Wave	12.5 feet.	10.0 feet.	10.0 feet.
Offshore Bottom Slope	10 percent.	7 percent.	9 percent.
Offshore Water Depth	Very deep.	Moderate.	Moderate.
Wave Absorber Length	Plan 1: 1,755 feet Plan 2: 1,420 feet	1,370 feet.	920 feet.
Wave Absorber Armor Rock Weight	0.5 tons.	0.5 tons.	05. - 3 tons.
Length Entrance and Access Channels	Plan 1: 1,800 feet Plan 2: 1,430 feet	1,565 feet.	1,280 feet.
Area of Turning Basin	Plan 1: 14,000 square feet Plan 2: 38,000 square feet	14,000 square feet.	13,000 square feet.
Historic Sites	Impacts on two sites proposed for National Register at each site.	Unknown.	Impacts on one site on National Register; two sites on State Register; three proposed for National Register.
Endangered Species	No effect.	No effect.	No effect.
Wetland Evaluation	Plan 1: Required Plan 2: None	None.	None.
Surfing Value	No.	No.	Yes.
Utilities and Access	Presently none.	Mostly in place.	In place, no electricity, no sewer.
Local Residents	No impact.	Significant impact.	Significant impact.

	KING'S LANDING	LELEIWI POINT	KALAPANA
Driving Distance to Hilo	6 miles.	5 miles.	31 miles.
Planning Objectives Met	Yes	Yes	Yes
Estimated First Cost	Plan 1: $15,000,000 Plan 2: $16,000,000	$12,328,000	$10,694,000
Local First Cost	Plan 1: $ 4,349,000 Plan 2: $ 5,770,000	$ 4,326,000	$5,050,000
Average Annual Cost	Plan 1: $ 1,162,000 Plan 2: $ 1,238.000	$ 959,000	$ 835,000
Average Annual Benefit	$2,138,100	$ 2,138,100	$2,138,000
Benefit-to-Cost Ratio	Plan 1: 1.8 Plan 2: 1.7	2.2	2.6

● Major Concern
◒ Moderate Concern
○ Minimal or No Concern

TABLE 14. SUMMARY OF POTENTIAL IMPACTS AND MAJOR CONCERNS

CRITERIA	KING'S LANDING	LELEIWI POINT	KALAPANA
1. Physical Criteria			
a. Access of site by the design vessel.	● Major dredging required.	● Major dredging required.	◒ Moderate dredging required.
b. Offshore sea conditions.	● Hazardous.	◒ Fair.	◒ Fair.
c. Area to accommodate approximately 12 acres for harbor.	○ To be donated by prive landowner.	○ Public land available.	○ Public land available.
d. Public land area to accommodate approximately 50 acres of fishing complex facilities.	○ Up to 138 acres offerred free by a private landowner.	◒ 31 acres of public land available; some private land may have to be purchased.	● 1 acre of public land available; requires purchase of some private lands.
2. Land Use Policy			
a. Compatible with local land-use planning.	○ Site designated as possible marina.	● Site designated as County park.	● Site designated as County park.
b. Possible community impacts.	○ No impacts expected; area is remote with no residents.	◒ Commercial/residential mix may be incompatible (traffic, noise, air quality).	◒ Commercial/residential mix may be incompatible (traffic, noise, air quality).
3. Environmental/Significant Adverse Affects on:			
a. Aquatic. Plan 1:	● Major negative impact on 12 acres of wetland.	◒ Marine loss partially offset by marine habitat creation.	◒ Marine loss partially offset by marine habitat creation.
Plan 2:	● Marine loss partially offset by marine habitat creation.		
b. Terrestrial.	● Major loss of terrestrial habitat.	● Major loss of terrestrial habitat.	● Major loss of terrestrial habitat.
4. Archaeological/Historical Resources	● Effect on 2 sites considered eligible for inclusion to the National Register of Historic Places.	○ No effect on known resources.	● Potential major impact on Kikoa Heiau and fish-pond; setting changes.

The benefits derived from a new small craft harbor consist of navigation benefits to fishing craft that would be moored without the project, increased fish catch; and a reduction in damages to vessels otherwise moored outside the project. The computations are based on a 7-3/8 percent interest rate and a 50-year project life. The project base year, 1985, is when benefits are expected to begin accruing to the proposed harbor plans. Benefits are based on December 1980 price levels. Appendix I presents the methodology used to determine the projected fleet which would use the harbor and estimated increase in fish catch attributed to the new facility. Table I-18 in Appendix I is a summary of project average annual benefits derived from a new small boat harbor in the Hilo Tributary Area.

Costs for construction were estimated at September 1981 price levels, and assume that construction would start in September 1981 for a period of 2 years. The cost growth for the 16-month time period between May 1981 and September 1982 is assumed to be 1%/month for a total of 16%. (Appendix D, Section 3, presents a breakdown of cost items.) Table 15 shows a summary of costs and benefits for the four alternative plans.

Table 15. SUMMARY OF SMALL BOAT HARBOR COSTS AND BENEFITS
($1,000)

	King's Landing Plan 1	King's Landing Plan 2	Leleiwi Pt.	Kalapana
Total 1st Cost	15,000,000	16,000,000	12,328,000	10,694,000
Federal 1st Cost	10,661,000	10,230,000	8,002,000	5,644,000
Non-Federal 1st Cost	4,349,000	5,770,000	4,326,000	5,050,000
Average Annual Costs	1,162,000	1,238,000	959,000	835,000
Average Annual Benefits	2,138,000	2,138,000	2,138,000	2,138,000
Net Annual Benefits	976,000	900,000	1,179,000	1,303,000
Benefit-Cost Ratio	1.8	1.7	2.2	2.6

RATIONALE FOR DESIGNATION OF NED PLAN

Kalapana is designated as the NED Plan because it has the greatest net benefits and the highest benefit-to-cost ratio.

RATIONALE FOR DESIGNATION OF EQ PLAN

None of the sites proposed for a small craft harbor would provide a net beneficial contribution to the environment. King's Landing Plan 2 preserves park lands at Leleiwi Point and the 12-acre wetland at King's Landing Plan 1

site from disturbance related to harbor instruction. While the plan appears to be the least environmentally damaging plan, the plan will modify 11 acres of general wildlife habitat, will enhance community development of the King's Landing area and will generate traffic along Kalanianaole Avenue. The harbor also increases energy and water demands, and will destroy some anchialine pools and historic resources.

RATIONALE FOR TENTATIVELY SELECTED PLAN

King's Landing was selected as the site best suited for development of a commercial fishing harbor. It was chosen over the other sites based on availability of land, economics, and social and environmental considerations.

Two plans were formulated at the King's Landing area. Plan 1 (Figure 8) would have a major impact on 12 acres of wetland. Dredging and excavation costs are minimum because the site is located in a low area. Plan 2 is located on higher ground, completely avoiding the wetland. However, costs of excavation are significantly higher, increasing the total project cost by $1 million. It was determined tht there are no beneficial values associated with the wetland, and the US Fish and Wildlife Service did not attribute any unique wildlife values with the wetland. Therefore, Plan 1 was chosen as the tentatively recommended plan. Table 16 summarizes the final alternative small craft plans.

DEEP DRAFT NAVIGATION

COMPARISON OF DETAILED PLANS

PLAN A - Inner Harbor Protection. This plan has a benefit to cost ratio less than unity (BCR = 0.3). It would be an effective structural plan to reduce surge. It would worsen the environmental conditions in inner Hilo Harbor. Deepening is included so that deeper draft vessels could be accommodated.

PLAN B - Chamber of Commerce Plan. This plan has a benefit to cost ratio which less than unity (BCR = 0.04). An effective structural plan to reduce surge, the plan would have significant negative impacts on the natural marine environment. Deeper draft vessels would be accommodated. The plan would provide benefits to local interests because of the opportunities for growth.

TABLE 16. SUMMARY OF FINAL ALTERNATIVE PLANS

		WITH CONDITION			
A. PLAN DESCRIPTION	WITHOUT CONDITION	PLAN A KING'S LANDING: PLAN 1	PLAN A KING'S LANDING: PLAN 2	PLAN B LELEIWI POINT	PLAN C KALAPANA
1. Structural Features	No small boat harbor between Hilo and South Point.	Offshore 170 berth harbor with entrance channel just off King's Landing.		Construction of a 170-berth small boat harbor.	Construction of a 170-berth small boat harbor.
2. Land Requirements	None	18 Acres	20 Acres	24 Acres	12 Acres
B. IMPACT ASSESSMENT					
1. Social Well-Being					
a. Health, Safety and Community Well-Being	King's Landing rural, no community; Leleiwi Point, suburb of Hilo, condominium and private homes located nearby.	Light industrial activities to be added at each location. No change to public health, police or fire facilities anticipated with harbor development. (2, 5, 10)			
b. Traffic	King's Landing no public roadway. Leleiwi Point located next to Avenue.	New road to be provided. Commercial traffic volume to increase. (2, 6, 10)		Road present. Commercial traffic volume to increase. (2, 6, 10)	Commercial traffic volume to increase.
c. Residents	King's Landing none. Leleiwi Point, condominium, houses, population unknown.	No human displacement.	No human displacement.	No human displacement.	No human displacement. Homes abandoned.
d. Water	King's Landing - no system. Leleiwi Point 6-inch line.	Provide new source or extend lines. (2, 6, 10)		Extend existing line. (2, 6, 10)	Extend existing line.
e. Power	King's Landing none. Leleiwi Point - Hilo grid.	Provide facilities or power generation. (2, 6, 10)		Extend existing lines to site. (2, 6, 10)	Individual power generation.
f. Community Well-Being	All areas subject to tsunami inundation. Recreation: King's Landing - recreational fishing. Leleiwi Point - Lehia Park, tide pools.	Increased public access to shoreline areas. (1, 6, 9)		Loss of general park potential and tide pools. (1, 6, 9)	Loss of historic park, potential loss of surf site.
		Potential damages and losses due to volcanic hazards and tsunami inundation. (3, 4, 10)			

(CONT'D) B. IMPACT ASSESSMENT	WITHOUT CONDITION	WITH CONDITION: PLAN A KING'S LANDING: PLAN 1	PLAN A KING'S LANDING: PLAN 2	PLAN B LELEIWI POINT	PLAN C KALAPANA
b. Terrestrial Environment					
Total Area Altered	N/A	18 acres. (2, 6, 10)	20 acres. (2, 6, 10)	24 acres. (2, 6, 10)	acres
Wetland Area Affected	King's Landing's - 12 acres.	Destroyed.	No effect.	No effect.	No effect.
c. Water Quality Degraded	Short-term.	Temporary construction turbidity: (1, 6, 9) ____ days	____ days.	____ days.	____ days.
	Long-term.	Fishery activities will generate wastes which can enter the water. (2, 5, 10)			
d. Changes in Air Quality	Pristine.	Fishery processing activities can possibly create new pollution sources. Traffic will increase automotive emissions over the long-term. (2, 5, 10)			
e. Endangered and threatened species.	Humpback whales, hawkbill turtles, green sea turtles.	No jeopardy.	No jeopardy.	No jeopardy.	No jeopardy.
C. PLAN EVALUATION					
1. Contributions to Planning Objectives					
a. Provide Additional Facilities for Commercial Fishing Opportunities and Related Recreational Boating Activities	No change.	Provides a safe harbor for 170 (40-ft) boats, contributes to the development of a centralized fishing complex; increases efficiency and opportunities for existing fishing operations; provides a social and economic commitment on the importance of fishing.		Same as Plan A.	Same as Plan A.
b. Minimize Alteration to Environment	No change.	10 acres modified.	11 acres modified.	10 acres modified.	10 acres modified.
c. Improve the Socio-Economic Opportunities for the People of Guam	Does not contribute to socio-economic opportunities.	Provides employment opportunities, provides diversity to Hilo's tax revenue base from commercial boating and boating related business activities. Provides stability of fish supply and prices.		Same as Plan A.	Same as Plan A.
2. Response to Formulation Criteria					
a. Technical					
1. Provide a harbor that can accommodate a typical fishing vessel of 40-ft length, ft. draft, and ft. bean.	No	Yes	Yes	Yes	Yes

(CONT'D) C. PLAN EVALUATION	WITHOUT CONDITION	WITH CONDITION: PLAN A KING'S LANDING: PLAN 1	PLAN A KING'S LANDING: PLAN 2	PLAN B LELEIWI POINT	PLAN C KALAPANA
2. Provide a harbor that can provide berthing slips for approximately 170 boats.	No	Yes	Yes	Yes	Yes
3. Provide a place of refuge and base for rescue.	No	Yes, however, location is just outside Hilo.		Yes, however, location is just outside Hilo.	Yes, mid-way between Hilo Harbor and South Point.
4. Provide an Ancillary Land Area that can accommodate a planned fishing complex.	No	Yes	Yes	Yes	Yes
b. Economics					
1. Provide a project with a benefit-to-cost ratio ≥ 1.	N/A	Yes	Yes	Yes	
2. Provide a plan where the local share of the harbor would be within financial capability.	N/A	Yes	Yes. However, this plan has the highest first cost to the local government.	Yes	
c. Environmental					
1. Enhance, preserve or minimize effects on marine and terrestrial resources.	N/A	No	Yes	No	No
2. Minimize conflicts with local land use policy and physical community disruption.	N/A	Yes	Yes	No	No
3. Relationship to National Accounts					
a. National Economic Development (NED)					
Average Annual Benefits	N/A	$2,138,000	$2,138,000	$2,138,000	2,138,000
Average Annual Costs	N/A	$1,162,000	$1,238,000	$ 959,000	835,000
Net Annual Benefits	N/A	976,000	900,000	1,179,000	1,303,000
Benefit to Cost Ratio	N/A	1.8	1.7	2.2	2.6

(CONT'D) C. PLAN EVALUATION	WITHOUT CONDITION	WITH CONDITION: PLAN A KING'S LANDING: PLAN 1	PLAN A KING'S LANDING: PLAN 2	PLAN B LELEIWI POINT	PLAN C KALAPANA
b. Environmental Quality	SEE ITEM B.3 ON THIS TABLE.				
c. Social Well Being	SEE ITEM B.1 ON THIS TABLE.				
d. Regional Development	SEE ITEM B.2 ON THIS TABLE.				
4. Response to Associated Evaluation Criteria					
a. Acceptability	N/A	Acceptable	Acceptable	May not be acceptable to local residents.	May not be acceptable to local residents.
b. Completeness	N/A	Complete	Complete	Incomplete - requires additional private land.	Incomplete - requires additional private land.
c. Effectiveness	N/A	Most effective.	Effective	Effective	Effective
d. Efficiency	N/A	Most efficient.	Somewhat inefficient.	Efficient	Efficient
D. IMPLEMENTATION RESPONSIBILITIES					
1. Corps of Engineers		Provide estimated project first cost of $10.7 million; design and construction of the breakwater, entrance and access channels; and turning basin.	Provide estimated project first cost of $10.2 million; design and construction of the breakwater, entrance and access channels, and turning basin.	Provide estimaed project first cost of $8.0 million; design and construction of the breakwater, entrance and access channels, and turning basin.	Provide estimated project first cost of $5.6 million; design & construction of the breakwater, entrance, and access channels, and turning basin.
2. State of Hawaii		Provide estimated project first cost of $4.3 million; design and construction of berthing area, docks, launch ramp and backup facilities.	Provide estimated project first cost of $5.6 million; design and construction of berthing area, docks, launch ramp and back-up facilities.	Provide estimated project first cost of $4.3 million; design and construction of berthing area, docks, launch ramp and backup facilities.	Provide estimated project first cost of $5.1 million; design and construction of berthing area, docks, launch ramp and back-up facilities.
3. US Coast Guard		Provide navigation aids and maintenance.		Same as Plan A.	Same as Plan A.

INDEX OF FOOTNOTES:

TIMING

1. Impact is expected to occur prior to or during implementation of the plan.
2. Impact is expected within 15 years following plan implementation.
3. Impact is expected in a longer time frame (15 or more years following implementation).

INDEX OF FOOTNOTES: (CONT'D)

UNCERTAINTY
4. The uncertainty associated with impact is 50% or more.
5. The uncertainty is between 10% and 50%.
6. The uncertainty is less than 10%.

EXCLUSIVITY
7. Overlapping entry: Fully monetized in NED account.
8. Overlapping entry: Not fully monetized in NED account.

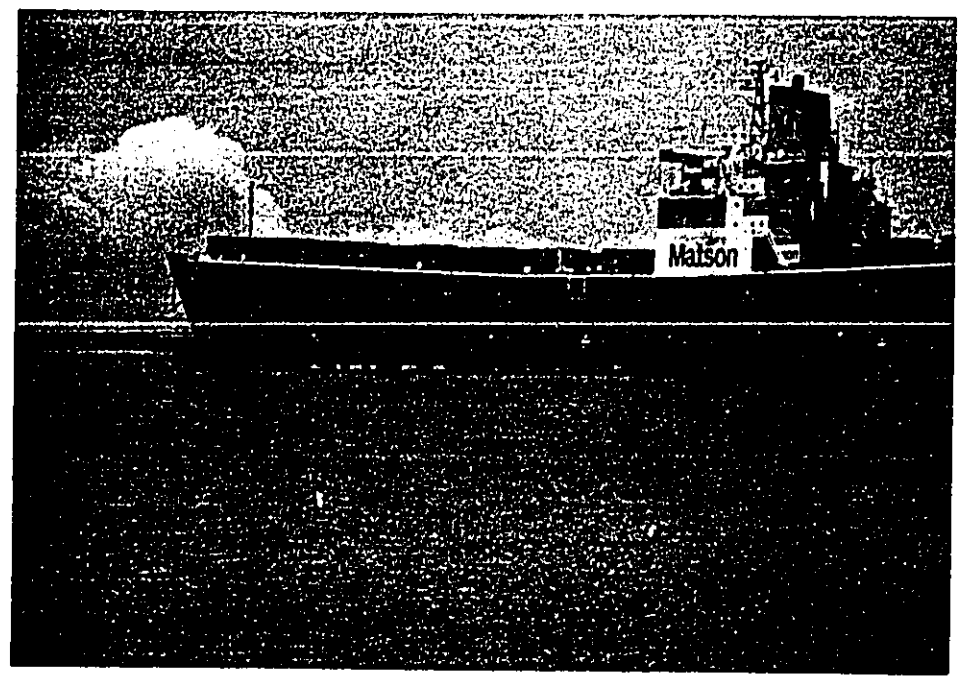
ACTUALITY
9. Impact will occur with implementation.
10. Impact will occur only when specific additional actions are carried out during implementation.
11. Impact will not occur because necessary additional actions are lacking.

(*) Item specifically required in Section 122, Public Law 91-611 and ER 1195-2-240.

(CONT'D) B. IMPACT ASSESSMENT	WITHOUT CONDITION	WITH CONDITION: PLAN A KING'S LANDING: PLAN 1	WITH CONDITION: PLAN A KING'S LANDING: PLAN 2	WITH CONDITION: PLAN B LELEIWI POINT	WITH CONDITION: PLAN C KALAPANA
g. Noise Nuisance	All potential sites quiet areas.	Construction noise - temporary, ____ day nuisance. (1, 6) Traffic and harbor activity to be long-term noise severe at each site (2,5,10).	Traffic and harbor activity to be long-term noise severe at each site. (2,5,10)	Construction noise - temporary, ____ day nuisance. (1, 6, 9)	Construction noise- temporary, ____ day nuisance.
h. Odor Nuisance	None	Long-term effect possible dependent upon type of facilities constructed to support commercial harbor. 2		Long-term nuisance to present residences.	Long-term nuisance to present residences.
i. Residential Displacement	N/A	None	None	None	None, but private properties purchased.
j. Cultural and Historical Properties		Midden deposits in sand dunes, Heiau, house sites, fetal stone. Potentially damaged. (1,6,9)		No effect.	Heiau, canoe landing beach, lost. Painted Church aesthetic modification.
k. Land-Use Conformance	King's Landing open space, urban and resort, and Leleiwi Point (43 acres) park use.	150 acres, private land zoned resort/urban converted to harbor use. Urban (150+ acres). (1, 6, 10)		43 acres of park land converted to harbor use. (1, 6, 10)	13 acres park land, and ____ acres private land zoned resort/urban, converted to harbor use.
2. Economic					
a. Property Values	No change.	Increases nearby property values.		Same as Plan A.	Same as Plan A.
b. Tax Revenues	No change.	Increases commercial fishing and recreation.1		Same as Plan A.	Same as Plan C.
c. Public Facilities/Services	No change.	Encourages commercial fishing, develops recreational potential, enhances community development.		Same as Plan A.	Same as Plan A.
d. Desired Regional Growth	No effect.	Enhances base due to increased business.		Same as Plan A.	Same as Plan A.
e. Employment/Labor Force	No change.	Enhances business and light industrial activities.		Same as Plan A.	Same as Plan A.
f. Business/Industrial Activities	No change.	No impact.	No impact.	No impact.	No impact.
g. Farm Displacement	No change.				
3. Environmental					
a. Marine Environment					
Area of Marine Habitat Altered		1.5 acres. (1, 6, 9)	1.6 acres. (1, 6, 9)	2.4 acres. (1, 6, 9)	acres.
Total Area of Marine Environment Created	N/A	10 acres. (2, 6, 10)	11 acres. (2, 6, 10)	10 acres. (2, 6, 10)	10 acres.

DOCUMENT CAPTURED AS RECEIVED

Photograph No. 5 Commercial Fishing in Hilo
Suisan Market Place



Photograph No. 6 Roll On/Roll Off Containership
At Pier 1, Hilo Harbor

PLAN C - Existing Breakwater Changes. This plan has a benefit to cost ratio greater than unity (BCR = 1.4). It includes nonstructural measures to reduce surge damages and delays. Deeper draft vessels are provided for through dredging. Lower maintenance and repair costs are projected for the Federal project at Hilo Harbor with abandonment of outer 7,000 feet of the existing breakwater. This plan provides net enhancement to the natural environment of Hilo Bay. The possibility exists of increased tsunami runup after deterioration of the outer 7,000 feet of breakwater. Without physically modeling the problem, it is not now possible to determine the net change in runup. If this plan were selected, physical modeling of Hilo Harbor would be required as part of the project authorization.

PLAN D - Harbor Deepening and Nonstructural Measures. This plan has a benefit to cost ratio greater than unity (BCR = 1.2). It provides for reduction of damage and delay caused by surge through the use of nonstructural measures. Deeper draft vessels would be accommodated through dredging. These are some temporary adverse impacts on water quality during dredging, but the long term impact on benthic quality are beneficial because poor quality sediments would be removed.

Table 17 shows a breakdown of the benefits attributed to each of the four plans. The computations are based on a 7-3/8 percent interest rate and a 50-year project life. The project base year 1985, is when benefits are expected to begin accruing Appendix H presents the methodology used to determine the benefits.

Table 17. COMPARISON OF AVERAGE ANNUAL BENEFITS (DEEP DRAFT)

Benefit	Plan A	Plan B	Plan C	Plan D
Surge Reduction1/				
Submersible Mooring Buoy	$65,000	0	65,000	65,000
Improved Fender System	98,000	0	98,000	98,000
Harbor Deepening2/	332,000	332,000	332,000	332,000
Maintenance & Repair3/	0	0	1,508,000	0
Savings of Outer 7000' Breakwater				
TOTAL	495,000	332,000	2,003,000	495,000

1/ See p. H-34 - Mooring buoy takes 40%, fenders take 60% of the total average annual benefits ($162,500) for savings in delays and damages.

2/ See p. H-34 - Savings from incremental depth increases.

3/ See p. H-34 - Savings in breakwater maintenance.

Costs for construction were estimated at September 1981 price levels. Appendix D, Section 4 presents a breakdown of major cost items and lsits the assumption used for the estimates. Table 18 shows summary of costs and benefits for the four alternative plans.

Table 18. DEEP DRAFT NAVIGATION SUMMARY OF COSTS AND BENEFITS
($1,000)

	Plan A	Plan B	Plan C	Plan D
Total 1st Cost	21,400,000	115,400,000	18,900,000	5,700,000
Federal 1st Cost	21,000,000	47,400,000	18,500,000	4,600,000
Non-Federal 1st Cost	400,000	68,000,000	400,000	1,100,000
Average Annual Project Costs + Avg Ann O&M	1,557,000	8,292,000	1,381,000	397,000
Average Annual Benefits	495,000	332,000	2,003,000	495,000
Net Annual Benefits	-	-	622,000	98,000
Benefit-Cost Ratio	0.3	0.04	1.4	1.2

RATIONALE FOR DESIGNATION OF NED PLAN

Plan D has a lower first cost than Plan C ($5.7 million vs. $18.9 million) although its benefit-cost ratio is somewhat lower (1.2 vs. 1.4). Plan D is publicly acceptable. Plans AS and B have benefit cost ratio significantly less than one. Based on these factors. Plan D is the NED plan.

RATIONALE FOR DESIGNATION OF EQ PLAN

Plan C is designated the Environmental Quality Plan (EQ Plan). Plan C makes a positive contribution to the environment with an improvement to circulation in Hilo Bay. Increased wave energy over Blonde Reef could flush silt from the reef and improve water exchange which could enhance revitalization of the reef. Increased wave energy in the harbor could improve water mixing and exchange, possibly reducing erosion along the Bayfront Beach and restoring surf sites in the bay.

RATIONALE FOR TENTATIVELY SELECTED PLAN

Plan D, harbor deepening and nonstructural improvements, was selected as the tentatively recommended plan. It was chosen because of its low cost, public acceptability and minimal adverse impact on the marine environment. Table 19 summarizes the final altenative deep draft plans.

TABLE 19. SYSTEMS OF ACCOUNTS
DEEP-DRAFT NAVIGATION

		WITH CONDITION			
		PLAN A	PLAN B	PLAN C	PLAN D
A. PLAN DESCRIPTION	WITHOUT CONDITION	INNER HARBOR PROTECTION	CHAMBER OF COMMERCE PLAN	CHANGES IN EXISTING BREAKWATER	HARBOR DEEPENING AND NON-STRUCTURAL MEASURES
	Repair and maintain: 10,080-foot breakwater. 35-foot project depth.	Dredge to 40 feet.	Dredge to 40 feet.	Dredge to 40 feet.	Dredge to 40 feet.
		Maintain existing 10,080-foot breakwater.	Major modification of existing 10,080-foot breakwater to include bridge, access road to new harbor areas.	Cease maintenance on outer 7,000 feet of existing breakwater.	Maintain existing 10,080-foot breakwater.
		Construct 2 inner breakwaters 900 feet and 2,100 feet.	Construct revetted fills.	Construct an inner 2,000-foot breakwater.	Install submersible mooring buoy and new Pier 1 fenders.
				Install submersible mooring buoy and new Pier 1 fenders.	
B. IMPACT ASSESSMENT					
1. Social Well-Being					
	Hilo Breakwater historic site.	Adds 2 breakwaters to the view. No adverse effect. (1, 6, 9)	Breakwater realigned as part of the project. No adverse effect. (1, 6, 9)	Breakwater deterioration results in partial loss of property. Length modified, purpose unchanged. No adverse effect. (2, 6, 9)	No effect.
2. Environmental					
a. Marine Environment	Silt stressed Blonde Reef, silty harbor bottom.	80 acres of silty bottom disturbed. (1,6,9)	80 acres of silty bottom habitat disturbed. (1,6,9)	80 acres of silty bottom habitat disturbed. (1,6,9)	80 acres of silty bottom habitat disturbed. (1, 6, 9)
		Maintenance dredging cycle increased from 10 to 15 years.		Maintenance dredging cycle increased from 10 to 15 years.	Maintenance dredging cycle increased from 10 to 15 years.
		6 acres reef habitat covered. (1, 6, 9)	240 acres of marine habitat destroyed by fill and dredging. (1,6,9)	6 acres reef habitat covered. (1,6,9)	
		4 acres of rocky intertidal habitat created. (1,6,9)	7 acres of rocky intertidal habitat created. (1,6,9)	2 acres of rocky intertidal habitat created. (1,6,9)	
b. Terrestrial Environment	Developed park, commercial, industrial area.	No effect.	Increased land for industrial; commercial development; 100 acres. (1,6,9)	No effect.	No effect.
c. Water Quality Degraded	Reduced flushing, circulation, water exchange. Low mixing, riverine discharges, high turbidity and siltation.	Temporary turbidity; ___ days. (1,6,9)	Temporary turbidity; ___ days. (1,6,9)	Temporary turbidity; ___ days. (1,6,9)	Temporary turbidity; ___ days. (1,6,9)

	WITHOUT CONDITION	WITH CONDITION: PLAN A INNER HARBOR PROTECTION	WITH CONDITION: PLAN B CHAMBER OF COMMERCE PLAN	WITH CONDITION: PLAN C CHANGES IN EXISTING BREAKWATER	WITH CONDITION: PLAN D HARBOR DEEPENING AND NON-STRUCTURAL MEASURES
B. IMPACT ASSESSMENT	Existing ocean disposal site, previously used.	551,000 CY ocean disposal. (1,4,9) No long-term water quality change.	0 C.Y. ocean disposal. (1,4,9). No long-term water quality change, although greater potential for trash pollutants.	551,000 CY ocean disposal. (1,4,9). Water quality improved-breakwater deterioration improve mixing, flushing and exchange.	551,000 CY ocean disposal. (1,4,9). No long-term water quality change.
C. PLAN EVALUATION					
1. Contributions to Planning Objectives					
a. Provide for deeper draft and larger vessels of the existing and future fleets.	No	Yes	Yes	Yes	Yes
b. Reduce delays and damages caused by ship motion or "surge" at the Hilo docks.	No	Yes	Yes	Yes	Yes
2. Response to Formulation Criteria					
a. Provide a project with a benefit-to-cost ratio of 1.		No	No	Yes	Yes
b. Enhance, preserve or minimize effects on marine and terrestrial resources.		No	No	Yes	Yes
3. Relationship to National Accounts					
a. National economic development (NED)					
Average annual benefits	N/A	$ 495,000	$ 332,000	$2,003,000	$ 495,000
Average annual cost	N/A	$1,557,000	$8,292,000	$1,381,000	$ 397,000
Net annual benefits	N/A	–	–	$ 622,000	$ 98,000
Benefit to cost ratio	N/A	0.3	0.04	1.4	1.2
b. Environmental quality (EQ)		No	No, maximum loss of marine enviroment.	Yes, most improvement to water quality and most potential benefit to marine environment.	Yes, least amount of environmental change.
c. Regional Development (RD)					

C. PLAN EVALUATION	WITHOUT CONDITION	WITH CONDITION: PLAN A INNER HARBOR PROTECTION	PLAN B CHAMBER OF COMMERCE PLAN	PLAN C CHANGES IN EXISTING BREAKWATER	PLAN D HARBOR DEEPENING AND NON-STRUCTURAL MEASURES
d. Other Social Effects (OSE)	Economic urban growth same as projected by state and county.	No effect.	No effect.	No effect.	No effect.
4. Response to Associated Evaluation Criteria					
a. Acceptability	N/A	Acceptable	Unacceptable to USF&WS	May not be acceptable to some Hilo Publics.	Acceptable
b. Completeness	N/A	Incomplete	Incomplete	Most complete.	Complete
c. Effectiveness	N/A	Ineffective	Ineffective	Effective	Effective
d. Efficiency	N/A	Inefficient	Inefficient	Very efficient.	Very efficient.
D. IMPLEMENTATION RESPONSIBILITIES					
1. Corps of Engineers	N/A	Construct breakwater and dredge.	Construct breakwater and dredge; construct revetted fills.	Construct breakwater and dredge; construct submersible mooring buoy and dredge. Maintain submersible mooring buoy.	Construct submersible mooring buoy and fenders.
2. State of Hawaii	N/A	No new requirements.	Construct new piers, roads, bridge and new O&M requirements.	Maintain new fenders; operate submersible mooring buoy.	Maintain new fenders; operate submersible mooring buoy.
3. U.S. Coast Guard	N/A	Additional navigational aids are required.	Additional navigational aids are required	Additional navigational aids are required.	Relocation of channel and basin buoys required.

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TIMING
1. Impact is expected to occur prior to or during implementation of the plan.
2. Impact is expected within 15 years following plan implementation.
3. Impact is expected in a longer time frame (15 or more years following implementation).

UNCERTAINTY
4. The uncertainty associated with impact is 50% or more.
5. The uncertainty is between 10% and 50%.
6. The uncertainty is less than 10%.

EXCLUSIVITY
7. Overlapping entry: Fully monetized in NED account.
8. Overlapping entry: Not fully monetized in NED account.

ACTUALITY
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(*) Item specifically required in Section 122, Public Law 91-611 and ER 1195-2-240.

DRAFT

ENVIRONMENTAL IMPACT STATEMENT

PROPOSED PLAN FOR SMALL CRAFT NAVIGATION IMPROVEMENTS
HILO AREA COMPREHENSIVE STUDY, HILO, HAWAII

The responsible local cooperating agency is the State of Hawaii, Department of Transportation.

The responsible lead federal agency is the US Army Engineer District, Honolulu.

The responsible cooperating federal agency is the US Fish and Wildlife Service.

Information, displays and figures referred to in the Main Report and Appendices are incorporated into the Environmental Statement by reference (see the Index).

Abstract: The study to provide a small boat harbor to serve commercial fishing interests in the Puna District, Island of Hawaii, focused on siting the harbor at one of four locations, Kalapana, two sites at King's Landing and Leleiwi Point. The Kalapana site was zoned for park use and planned for development as a historic park. The King's Landing sites were located on private, undeveloped land. Both King's Landing sites encompassed anchialine pools and archaeological sites. The King's Landing Plan 1 site involves construction in a wetland. The Leleiwi Point site is planned for park use and the tide pools at the site provided a unique recreational resource. King's Landing Plan 1 was designated the tentatively selected plan and designated the National Economic Development Plan due to its reduced construction first costs. No Environmental Quality plan is available. King's Landing Plan 2 was designated as the least damaging environmental quality plan because it preserved the wetland area at King's Landing, and park uses at Kalapana and Leleiwi Point. However, archaeological artifacts and sites, which have potential for inclusion to the National Register of Historic Places, and some anchialine pools would be destroyed at King's Landing.

SEND YOUR COMMENTS TO THE DISTRICT ENGINEER BY:

If you would like further information on this environmental impact statement, please contact:

Dr. James Maragos, Chief
Environmental Resources Section
U.S. Army Engineer District, Honolulu
Building 230
Fort Shafter, HI 96858
Phone: (808) 438-2263

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1. Summary:

1.1 Major Conclusions and Findings: The Small Craft Navigation Improvements Study found that four potential sites could be developed to provide a 170-boat harbor in the Puna District of Hawaii. The tentatively recommended plan is the selection of the King's Landing, Site 1, which will eliminate a 12-acre wetland and some anchialine pools. The wetland does not provide important beneficial values in the King's Landing area. The discharge of rock in wave absorber and breakwater construction is specified under Section 404(b)(1) guideline evaluation (Appendix J). The plan is the National Economic Development Plan because of its reduced cost to the local government. The King's Landing Site 2 is the least damaging environmental plan because it preserves the wetland area at Site 1, park use at Kalapana and Leleiwi Point, and the tide pools at Leleiwi Point. Construction at both King's Landing sites and Kalapana will affect historic resources that have potential for inclusion to the National Register of Historic Places. All the feasible alternative sites are located in tsunami and volcanic hazard areas. The Fish and Wildlife Service has no preferred location indicating that no significant fish and wildlife values exist at any of the alternative sites. Construction of the harbor at any of the sites does not jeopardize the continue existence of endangered humpback whales and hawksbill turtles and the threatened green sea turtle. No ocean dumping or prime agricultural lands are involved.

1.2 Areas of Controversy: None.

1.3 Unresolved Issues: None.

1.4 Relationship to Environmental Requirements: See Table 1.

1.5 Adoption of an EIS: Not applicable.

Table 1. Relationship to Environmental Requirements.

Federal Statutes	Kapalana	King's Landing Site 1	King's Landing Site 2	Leleiwi Point
Archaeological and Historic Preservation Act (see Section 6)	Partial	Partial	Partial	Partial
Clean Air Act	Full	Full	Full	Full
Clean Water Act (see Section 6)	Partial	Partial	Partial	Partial
Coastal Zone Management Act (see Section 6)	Partial	Partial	Partial	Partial
Endangered Species Act (see Section 6)	Partial	Partial	Partial	Partial
Estuaries Protection Act	N/A	N/A	N/A	N/A
Federal Water Project Recreation Act (see Section 6)	Partial	Partial	Partial	Partial
Fish and Wildlife Coordination Act (see Section 6)	Partial	Partial	Partial	Partial
Land and Water Conservation Fund Act	N/A	N/A	N/A	N/A
Marine Protection, Research and Sanctuaries Act	N/A	N/A	N/A	N/A
National Historic Preservation Act (see Section 6)	Partial	Partial	Partial	Partial
National Environment Policy Act (see Section 6)	Partial	Partial	Partial	Partial
Rivers and Harbors Act	N/A	N/A	N/A	N/A
Watershed Protection and Flood Prevention Act	N/A	N/A	N/A	N/A
Wild and Scenic Rivers Act	N/A	N/A	N/A	N/A
Executive Orders, Memoranda, Etc.				
Floodplain Management (E.O. 11988)	N/A	N/A	N/A	N/A
Protection of Wetlands (E.O. 11990)	N/A	Full	N/A	N/A

Table 1. Relationship to Enmvironmental Requirements (Cont)

Executive Orders, Memoranda, Etc. (Cont)	Kapalana	King's Landing Site 1	King's Landing Site 2	Leleiwi Point
Environmental Effects Abroad of Major Federal Actions (E.O. 12114)	N/A	N/A	N/A	N/A
Analysis of Impacts on Prime and Unique Farmlands (CEQ Memorandum)	Full	Full	Full	Full
State and Local Policies.				
State Land Use Plan	Full	Full	Full	Full
County General Plan (see Section 5.3)	Partial	Partial	Partial	Partial
State Environmental Policy Act (see Section 6)	Partial	Partial	Partial	Partial
Special Management Area Permit	NC	NC	NC	NC
Coastal Zone Management Program (see Section 6)	Partial	Partial	Partial	Partial
Conservation District Use Area Permit	NC	NC	NC	NC
Federal Coastal Zone Consistency Determination (see Section 6)	Partial	Partial	Partial	Partial

Notes:

Full - Full compliance, having met all requirements of the statute, E.O. or other environmental requirements for the current stage of planning (either pre- or post-authorization).

Partial - Partial compliance, not having met some of the requirements that normally are met in the current stage of planning.

NC - Non-Compliance, Violation of a requirement of the statute, E.O. or other environmental requirement.

N/A - Not-Applicable, no requirements for the statute, E.O. or other environmental requirement for the current stage of planning.

2. Need for and Objectives of the Action:

2.1 Study Authority: The study of small craft navigation needs in the Hilo Area was performed under Section 144 of the Water Resources Development Act of 1976, which authorized the Corps of Engineers in cooperation with the State of Hawaii and County of Hawaii to study methods to develop, utilize and conserve water and land resources in the Hilo Bay area including the consideration of the need for navigation facilities, enhancement and conservation of water quality, enhancement and conservation of fish and wildlife, and other measures for environmental enhancement and economic and human resources development. The Corps of Engineers has studied the need for small craft navigation at the request of and in cooperation with the State of Hawaii, Department of Transportation, Harbors Division.

2.2 Public Concerns: The public has expressed the need for: (a) small craft facilities, (b) launch ramps and harbors to increase navigation safety along the Puna Coast, (c) boat haul-out and maintenance facilities, (d) fish processing and marine stores and other support facilities, (e) reducing reduce travel time from Hilo to the Puna fishing grounds, by locating the facility near the fishing grounds. The only opposition to these needs was at a public meeting in Pahoa, where residents of Kapoho objected to the siting of a harbor in their community. Subsequently, the site was dropped due principally to the lack of support from the landowner.

2.3 Planning Objectives: The following objectives for small craft navigation improvements were derived from the consideration of public concerns, and management needs expressed during public and agency coordination of the project.

a. Provide appropriate facilities to meet the needs of commercial fishermen and recreational boaters who use 30- to 40-foot power or sailing craft.

b. Locate new facilities so that small craft have less distance to travel to launch or to take refuge in case of emergency.

c. Improve commercial fishing opportunities.

d. Minimize environmental modifications to terrestrial and marine environments.

e. Protect or enhance beneficial values of wetlands.

f. Minimize potential natural hazard damages or losses.

g. Protect significant archaeological and historic sites.

h. Improve socio-economic opportunities for the people of East Hawaii.

i. Increase or maintain recreational diversity.

3. Alternatives, Including the Proposed Action:

3.1 Plans Eliminated from Further Study:

(1) The study included the districts of South Hilo and Puna within the Hilo Area Comprehensive Study. The search for possible harbor sites covered the entire coastline from Hilo to Kalapana. Sites selected for closer inspection were chosen based upon geological features that offered natural protection along the shoreline, the availability of land at low costs, i.e., public lands or lands where landowners expressed interest in supporting a harbor, and a preliminary estimate on construction costs. Based on this evaluation Kapoho and Pohoiki sites were eliminated from further study. Kapoho was a sheltered embayment which had a relatively large community along the shoreline. At a public meeting residents and the principal landowner objected to the construction of the harbor at the site. Since the land was privately owned, further investigations of the site were terminated due to lack of landowner support. Pohoiki, the site of the Pohoiki launch ramp, was considered because the area appeared to offer the opportunity of constructing the harbor using breakwaters with a minimum of inland excavation. However, the water depth forced the siting of a breakwater near shore with extensive inland excavation. Since the harbor would also destroy a surfing site, a plan to construct the harbor entirely by excavation from the shoreline was evaluated. Due to the topography, the harbor would have had to be excavated

from lava rock raising to a height of 20-35 feet above sea level. The large amount of rock that would have to be removed in order to build the harbor would have resulted in extremely high construction costs. Thus, the site was eliminated from further consideration.

(2) Launching Ramps: The construction of boat launching ramps in the Puna and South and North Hilo Districts is being studied under small project authorities, and is not a part of this draft environmental impact statement. Boat launching ramps are incorporated into the harbor design. However, boat launching ramps as an alternative to the harbor did not meet the projected need for wet storage of 30- to 40-foot craft, for protected anchorage and for the growth of recreational boating and commercial fishing in the project area. The launch ramp would satisfy only part of the project objectives and does not provide for larger vessels which cannot be trailered.

(3) Dry Storage: This alternative consisted of providing a large land area to store boats and a shoreside dock crane or launch ramp to place the boats in the water. Operation of dry storage could not handle the 30- to 40-foot design fishing vessels, but could more appropriately accommodate smaller recreational craft.

3.2 Without Conditions:

(1) Presently, only the launch ramps and harbor in Wailoa River, Hilo Bay and the Pohoiki launch ramp are available to serve commercial fishing interests within the study area. The State of Hawaii has no plans to provide any other launch ramp or harbor facility within the region outside of Hilo Harbor. The public ramp at Kaulana, South Point, is being studied by the Corps of Engineers and the State of Hawaii for possible improvements, and a private ramp is located at Punaluu in the Kau District. Both ramps are located outside the study area, but are available for use to fishermen in the South Hilo and Puna Districts willing to drive the distance. Navigational safety along the Puna coast will continue to be treacherous due to weather conditions and to the lack of harbors of refuge or other harbor facilities which could offer haven for boats operating in Puna waters.

(2) The potential harbor sites are located within rural areas dependent upon agriculture and employment in Hilo. Agriculture is expected to remain the mainstay of the Puna economy supplemented by various employment opportunities in Hilo. Resort development is nonexistent at present, but areas around Kaimu-Kalapana, Pohoiki and King's Landing are zoned for urban and resort development, which could occur depending upon economic conditions which would favor investment. Lehia Park at Leleiwi Point and the Kalapana Canoe Landing Park will probably be developed in the future along with other recreational facilities in the region. In spite of the anticipated growth in agriculture and increase in population due to recreational, urban and resort expansion, economic and population growth is expected to be slow in comparison with the rest of the County (Hawaii Water Resources Regional Study, 1975). However, population growth between 1970 and 1980 increased 128% (5,154 to 11,751), the second highest in the county.

Water, power and other utility demands and traffic flow between Hilo and Leleiwi Point and Kalapana will increase with population growth. The Puna Coast Highway connecting Hilo to Kapoho may be constructed in the future, speeding the flow of traffic in the area and possibly inducing agricultural and urban development in the region. Water resources are sufficient to support increased demands, and development in geothermal power will be able to satisfy future demands. Tsunami and volcanic hazards in the region will continue to be significant factors influencing land use and the coastal environment in the region. Shoreline development in the region will contribute to an increase in potential tsunami and volcanic hazard losses and damages. While natural hazards may be the most significant factors affecting future environmental conditions, urban and agricultural development will also be factors affecting the coastal environment. Urbanization can contribute to increased exploitation of natural resources by improving access to areas previously inaccessible and by increasing the number of persons in the area that can exploit the resources. Hawaii's resources are sensitive to heavy exploitation; however, if the rugged nature of the coastal area remains the same, hazardous shoreline and water conditions may probably discourage many from utilizing the coastal areas.

3.3 Plans Considered in Detail:

(1) Leleiwi Point: A small boat harbor at Leleiwi Point would consist of 1,310-foot wave absorber, dredging an entrance and access channel totalling 1,565 feet in length and a 14,000 square foot turning basin (see Figure D-3). The construction first cost is estimated at $10,477,300 with the federal cost being $6,924,900 and the State share being 3,546,400. The State will also be responsible for excavating the berthing basin and providing the shoreside facilities, lands, easements and rights-of-way. Construction of the harbor at this location would require the use of 43 acres of land zoned for park development and will eliminate the use of the tide pools in the park. Water, power, sewer and road utilities are in place. The site is located outside Hilo Harbor and will reduce travel time around the Hilo Breakwater, but the site is the farthest site from the Puna fishing grounds. The site is adjacent to a residential area and the construction noise and dust impacts would create a nuisance. The operation of the harbor in support of commercial fishing activities would create a conflict with adajcent residential land uses. Construction dust and noise controls would have to be implemented to reduce public inconveniences, and the alignment of the harbor and discharge of excavated material will have to be altered to protect the tide pools. An intensive archaeological survey of the Leleiwi Point area may be necessary to determine the significance of the midden site.

(2) King's Landing Plan 2: A harbor at this site would consist of a 1,755-foot wide breakwater, an entrance and access channel totalling 1,430 feet in length and a 14,000 square foot turning basin (see Figure D-5 in the report). The construction first cost is estimated at $13,154,600 with the federal share being $9,405,300 and the State share being $3,749,300. The State would also be responsible for excavating the berthing basin and providing the shoreside facilities, lands, easements and rights-of-way. About 150 acres of private land, donated to public use, would be available for construction of the harbor and shoreside facilities. The landowner would also provide road access and utilities in conjunction with his plans to develop the area. The construction of the harbor would destroy some archaeological sites, which have potential for inclusion to the National Register of Historic Places, and would eliminate some anchialine pools. Construction at this site would

require action to salvage any archaeological data from the affected archaeological sites. This site is also far from the Puna fishing grounds.

(3) King's Landing Plan 1: A small boat harbor at this site would consist of a 1,420-foot wave absorber, an entrance and access channel totalling 1,430 feet in length and a 38,000 square foot turning basin (see Figure D-6 in the report). The construction first costs is estimated at $14,152,700 with the federal share being $8,922,600 and the State share being $5,230,100. The State would also be responsible for excavating the berthing basin and providing the shoreside facilities, and lands, easements and rights-of-way. The same amount of private land in Plan 2 is available as in Plan 1. This plan is sited in a wetland and will essentially destroy the 12-acre wetland; the wetland does not provide important beneficial values and is part of the general wildlife habitat in the area. The construction would possibly destroy two archaeological sites which have potential for inclusion to the National Register of Historic Places and would possibly eliminate some anchialine pools in the area. Construction would require action to salvage any archaeological data. This site is also far from the Puna fishing grounds.

(4) Kalapana: A small boat harbor at Kalapana would consist of a 920 -foot wave absorber, entrance and access channels totalling 1280 feet in length and a 13000 square foot turning basin (see Figure 10 in the report). The construction first cost is estimated at $ 10,694,000 with the federal share being$5,644,000and the State share being $5,050,000. The State would also be responsible for excavating the berthing basin and providing the shoreside facilities, lands, easements and rights-of-way. Construction of the harbor at this location would require the use of 13 acres of land designated for historic park development and the purchase of about 15 acres of private land. Excavation would destroy two archaeological sites and a historic site which have potential for inclusion to the National Register of Historic Places. No residential displacement is anticipated because the State has been acquiring the land for park development. Water and road facilities are in place, but power and wastewater treatment would have to be provided. The harbor is also located in an area of highest volcanic hazard

subject to subsidence, earthquakes and lava flow. The site is in the middle of the Puna fishing grounds. Construction at this location would require action to salvage any archaeological data from damaged archaeological sites. Dust and noise control measures would have to be implemented to reduce public inconveniences.

(5) None of the plans are expected to jeopardize the continued existence of the endangered humpback whale, the endangered hawksbill turtle or the threatened green sea turtle. The excavated material will be used for on-site construction and the excess will be sold or given away for other construction purposes. The development of a harbor servicing commercial fishing interests will increase power and water demands in the region.

(6) Environmental Quality Plan: None of the plans enhance or improve the environment. The least environmental damaging plan is the King's Landing Plan 2. This plan will preserve the wetland at King's Landing, Site 1, will not affect adjacent residences during construction, and allows the continued use of Leleiwi Point and Kalapana as parks. However, Plan 2 causes the loss of archaeological data, which will be salvaged, and some anchialine pools.

(7) National Economic Development Plan: The King's Landing Plan 1 is designated the National Economic Development Plan because public benefits would accrue at low public costs. Even though the Leleiwi Point site has a lower first cost than the King's Landing Plan 1, the local cost of construction will be reduced because the utilities and access will be paid for by the landowner, who may provide part of the local cost for dredging, thus substantially lowering the local share of the first cost of construction. The site also provides the State with more land than presently available at Leleiwi Point for development of the harbor.

(8) Tentatively Recommended Plan: The King's Landing Plan 1 is the tentatively recommended plan.

(9) Nonstructural Plan: No nonstructural plan is available to provide the project purpose and needs.

3.4 Comparative Impacts of Alternatives: A comparison of alternative impacts is provided on Table 2.

TABLE 2. COMPARISON OF IMPACTS OF THE ALTERNATIVES

	Leleiwi Point	King's Landing Plan 1	King's Landing Plan 2	Kalapana
Significant Resources				
Construction first cost	$10,477,300	$13,154,600	$14,152,700	
Federal Cost	6,924,900	9,405,300	8,922,600	
Local Cost	3,546,400	3,749,300	5,230,100	
Amount of rock excavated	447,200 c.y.	532,200	636,400	
Population				
Base Condition	No residents on-site. Condominium adjoining property; area suburb of Hilo. Quiet rural area. No commercial or industrial activities.	No residents present. Quiet rural area. No commercial, residential or industrial activities.	No residents on-site. 3 homes adjoining property abandoned. Church and resident being used. Quiet rural area, limited commercial activities. No industrial activities.	
	No displacement anticipated for any of the alternative harbor sites.			
Effect				
Noise, dust	Construction noise and dust nuisance, judged significant. Length of construction 2 years.	No effect anticipated. Length of construction, 2 years.	Construction noise and dust nuisance judged significant. Length of construction, 2 years.	
Traffic	Traffic along Kalanianaole Ave increased, but will increase with Lehia Park development.	Same as Leleiwi Point, unless traffic routing or point of access changed.	Traffic along Kalapana-Kaimu road increased.	
Odors	Nuisance fish odors possible.	No effect.	Nuisance fish odors possible.	

TABLE 2. COMPARISON OF IMPACTS OF THE ALTERNATIVES (Contd)

Significant Resources	Leleiwi Point	King's Landing Plan 1	King's Landing Plan 2	Kalapana
Land Ownership Base Condition	Public lands, unrestricted access.	Private lands, restricted access.		13 acres public lands, unrestricted access. Private lands also present in upland areas.
Effect	No change.	150 acres, private lands donated to public; public access improved and less restricted.		Purchase 14 acres of private land for public use. No change to access.
Land Use Base Condition	43 acres to be developed as Lehia Park. Zoned conservation; open space.	2000+ acres of private land. Urban and resort zoning. Shoreline zoned for open space.		13 acres of public land to be developed as Kalapana Canoe Landing Park. Private lands zoned for urban and resort uses.
Effect	No zoning change. 43 acres of park land to be dedicated to harbor use.	No zoning change. 150 acres of urban, conservation and resort land converted to harbor use.		No zoning change. 13 acres of public land and 14 acres of urban/resort, private land dedicated to harbor use.

TABLE 2. COMPARISON OF IMPACTS OF THE ALTERNATIVES (Contd)

Significant Resources	Leleiwi Point	King's Landing Plan 1	King's Landing Plan 2	Kalapana
Recreation Base Condition	All areas represent relatively pristine coastal environments, offering fishing, picnicking, hiking sunbathing and sightseeing diversions.			
	Tide pools, swimming, 43-acre Lehia Park	No public recreation.		Canoeing, surfing, swimming, 13-acre Kalapana Canoe Landing Park
Effect	Harbor becomes a visual element in a relatively open, undeveloped shoreline.			
	Tide pools destroyed. 43-acre park converted to harbor.	Increased public recreational opportunities.		13 acres of park area converted to harbor. Canoe area lost. Surfing, probably lost. 14 acres of private land converted to public use.
Utilities Water Base Condition	6-inch waterline at end of Kalanianaole Ave.	No system present.		8-inch waterline along Kalapana-Kaimu Highway.
Effect	Increased water demands anticipated for all sites, quantity unknown. Resources adequate to meet demands, but will have to be developed.			
	Extension of line to harbor site.	Extension of public line to harbor site or development of on-site source.		Extension of public line to harbor site.

TABLE 2. COMPARISON OF IMPACTS OF THE ALTERNATIVES (Contd)

Significant Resources		Leleiwi Point	King's Landing Plan 1	King's Landing Plan 2	Kalapana
Power	Base Condition	Transmission line at end of Kalanianaole Highway.	No system present.		No system present. Power provided for residences on individual generator basis.
	Effect	Increased power demands anticipated for all sites; quantity unknown.			
		Extend lines to harbor site.	Extend line to harbor site, or develop individual power producing capability.		Provide individual power production capability.
Sewer	Base Condition	Sewerline at end of Kalanianaole Highway.	No system present.		Cesspools for individual homes and other properties.
	Effect	Wastewater generation will increase for all sites.			
		Extend sewerline to harbor site.	Extend Kalanianiole line to harbor site or provide other wastewater treatment facilities.		Provide other wastewater treatment facilities, including cesspools.
Roads	Base Condition	Kalanianaole Ave.	Private, gravel road.		Kalapana-Kaimu Highway.
	Effect	Access/Egress provided.	New public road to be constructed.		Access/Egress provided.

TABLE 2. COMPARISON OF IMPACTS OF THE ALTERNATIVES (Contd)

Significant Resources	Leleiwi Point	King's Landing Plan 1	King's Landing Plan 2	Kalapana
Historic Resources				
Base Condition	Possible midden site.	Midden site, Piko stone both potentially eligible to National Register of Historic Places.	Midden site, heiau, and house site present. Midden site and heiau potentially eligible to Natl Register of Historic Places.	Heiau, filled fishpond, canoe landing site, and painted church present. Heiau and painted church potentially eligible for inclusion to the National Register of Historic Places.
Effect	Potential midden site excavated.	Midden site buried. Piko stone relocated.	Midden site, heiau destroyed.	Filled fishpond and canoe landing site destroyed. Heiau and painted church undisturbed, but visual setting disturbed and altered.
Natural Hazards				
Tsunami				
Base Condition	Harbor site within 100 year Tsunami Inundation Zone.	Harbor site within 100 year Tsunami Inundation Zone.		Harbor site within 100 year Tsunami Inundation Zone.
Effect	The presence of the harbor increases potential tsunami damages and losses. The harbor is not expected to increase flood elevations inland.			
Volcanic Hazards				
Base Condition	Hazard Zone E, high risks from lava flows; subject to earthquakes possible subsidence.			Hazard Zone F. Very high risk from lava flow, earthquakes and subsidence.
Effect	Presence of harbor increases potential volcanic hazard damages and losses.			

TABLE 2. COMPARISON OF IMPACTS OF THE ALTERNATIVES (Contd)

Significant Resources	Leleiwi Point	King's Landing Plan 1	King's Landing Plan 2	Kalapana
Natural Hazards (Contd)				
Water Quality				
Base Condition	No riverine systems located at any of the project sites. Groundwater leakage probably influences nearshore salinity at all locations.			
	No wastewater discharges.	No wastewater discharges.		Cesspool leakage probably affects nearshore water quality.
Effect				
Temporary	Water turbidity increases approximately ____ days when dredging channel opening.	Same as Leleiwi Point, except ____ days		Same as Leleiwi Point, except ___ days.
Long-term	Boating operations and handling of fish at all sites will introduce petrochemical, organic and other pollutants into the harbor waters. Groundwater leakage creates estuarine environment in harbor and increases nutrient levels in harbor..			
Groundwater Impacts				
Base Condition	Groundwater fed by rainwater percolating through the volcanic rock. Chlorinity high in all locations, no drinking water sources present. Leakage occurs along the shoreline.			
Effect	No effect on drinking water sources at any of the sites. Groundwater leakage into harbor basin will create an estuary and carry nutrients into the harbor.			
Air Quality				
Base Condition	No industrial or commercial pollution sources at sites. Volcano, agriculture fires and automotive emissions.			
Effect	Increase in automotive emissions at harbor location. Potential fish odor and other pollutants with harbor development.			

TABLE 2. COMPARISON OF IMPACTS OF THE ALTERNATIVES (Contd)

Significant Resources	Leleiwi Point	King's Landing Plan 1	King's Landing Plan 2	Kalapana
Fish and Wildlife Habitat				
Base Condition	43 acres Ironwood and Kamani trees.	2000+ acres naupaka coastal strand and ohia scrub forest.		14 acres coconut grove.
	No coral reef, but 10% coral cover.	No coral reef, but 10% coral cover.		No coral reef, but 10% coral cover.
	No wetlands present.	12-acre; wetland present. No important beneficial values.	No wetland present.	No wetland present.
	Tide pools	Anchialine pools.	Anchialine pools.	
Effect	43 acres of ironwood, hau and kamani trees converted to marine habitat.	150 acres naupaka and ohia scrub forest and 12-acre wetland converted to marine habitat.	150 acres ohia scrub forest and naupaka converted to marine habitat.	14 acres of coconut grove coverted to marine habitat.
	Tide pools destroyed.	Some anchialine pools filled.		
Marine habitat created:	Marine habitat created: 10 acres	10 acres	11 acres	___ acres
Existing marine habitat altered:	2.4 acres	1.5 acres	1.6 acres	3.5 acres

TABLE 2. COMPARISON OF IMPACTS OF THE ALTERNATIVES (Contd)

Significant Resources	Leleiwi Point	King's Landing Plan 1	King's Landing Plan 2	Kalapana
Wetland Values Base Condition	None.	12 acres, general wildlife habitat.	None.	None.
Effect	None.	Lost 12 acres of general wildlife habitat.	None.	None.
Endangered Species Base Condition	Humpback whales seasonally migrate through waters around Hawaii. None of the sites were identified as calving, nursing or breeding grounds.			
	Whales counted in this area.	No data available for this area.	No data available for this area.	
	Endangered Hawksbill turtle and threatened green sea turtles forage along the coastline.			
			One hawksbill turtle nest reported in Harry K. Brown Park.	
Effect	Harbors are not expected to jeopardize the continued existence of the endangered and threatened species.			

4. Affected Environment:

4.1 Environmental Conditions:

(1) Kalapana: Kalapana community is located about 30 miles south of Hilo and is composed of about 80 households concentrated within the town area. The community is rural in nature with its residents relying upon employment in agriculture and government with some residents commuting to jobs in Hilo. The ethnic composition in the region is evenly mixed between Japanese, Hawaiians and Caucasians. However, most of the residents in Kalapana have resided in the area for a long period of time.

(2) The project site is located in the undeveloped, State Kalapana Canoe Landing Beach Park. The park abuts private property located along Highway 130 out of Hilo forming the northern boundary of the project site. The private property is zoned for mixed urban and resort development. Two abandoned homes and a church are located on the property adjacent to the park. Hakuma Point, a fault scarp, which rises 70 feet above sea level, forms the southern boundary of the project site. A gravel bar forms a protected pool and separates the park from the ocean on the east. The dominant vegetation in the park are coconut trees which extend westward into private lands forming a large grove. The park together with other parks in the region, Kalapana Beach Park, Kaimu Beach Park and Harry K. Brown Beach Park, attract a multitude of island residents and visitors and are heavily utilized during weekends and holidays.

(3) Natural hazards in the Kalapana region present a high risk to life and property, and continues to be a major factor influencing topography and the environment. Located on the southern flank of the Kilauea eastern rift zone, Kalapana has been threatened by lava flows, which have forced the occasional evacuation of the community, and by earthquakes and sudden subsidence. In 1975 a subsidence together with an earthquake of a magnitude of 7.2 on the Richter scale, occurred and generated a local tsunami with wave heights ranging from 26-48 feet along the coast of Hawaii. As a result, the Kalapana area subsided 3 feet, and the road fronting Harry K. Brown Park had to be realigned and raised to prevent inundation during high tide. An area southwest of Kalapana, Halape sank 11.5 feet and moved seaward 20 feet as a result of the event.

(4) King's Landing: King's Landing is located about 8 miles east of Hilo and one must pass through the Leileiwi Point site to get to King's Landing. The project site is located on private land, and public access is restricted. The shoreline area is zoned for open space, but the upland area is zoned for mixed urban and resort development. The area is undeveloped except for single lane access road and three beach parks constructed by the landowner. The land consists of pahoehoe lava flows heavily vegetated by scrub ohia, ohelo berry, aalii, ferns and pandanus, and is moderately sloped (0-6% slope) although the ground is very irregular due to collapsed lava tubes and lava ridges and depressions. The old flows create a cliff shoreline and the wave and spray swept rocks are unvegetated. Large wave-tossed boulders form boulder tracts, and isolated pockets of sand and sand dunes are present. The backshore is heavily vegetated by naupaka and pandanus which grade into the scrub ohia uplands.

(5) No people live in the area. Occasional campers and fishermen with permission to use the land, and the park ground keepers are usually present in the area. No utilities service the area. The area is subject to tsunami and high wave flooding, but to a smaller degree than Kalapana and Leleiwi Point. Volcanic hazards are greatly reduced in comparison to Kalapana, but still significant in comparison with the island as a whole. The landowner has conceptual plans to develop the area for urban and resort uses, but no plans have been approved or reviewed by the local government agencies. The landowner has ideas of developing hotels around Papai Bay, a golf course along the shoreline and residential areas further inland.

(6) Leleiwi Point: Leleiwi Point is located 6 miles east of Hilo at the end of Kalanianaole Highway within the undeveloped Lehia Park. The area is considered a suburb of Hilo in this report. The project site is located in a low-lying section of the coast fronted by a large, boulder tract and sand pockets vegetated by ironwood trees, kamani trees, hau and beach grass. While no persons live in the park, a condominium is located on private lands adjacent to the park. The park attracts island residents and visitors. The upland areas are also comprised of old pahoehoe flows vegetated by scrub ohia. Utility services along Kalanianaole Avenue are available to service the area when the park is developed. The park area is subject to tsunami and high wave inundation due to its depressed topographic relief. The volcanic hazards in the Leleiwi Point area are similar to those in the King's Landing area.

4.2 Significant Resources:

(1) Population: No people reside on the properties being considered as potential harbor sites. At Kalapana, private homes and a church adjoin the potential harbor site, and a condominium is adjacent to Leleiwi Point. King's Landing is undeveloped. Unless there is a change in economic conditions that make resort or urban development feasible at the locations, no change in population is anticipated, although district populations will continue to grow.

(2) Landownership: The State owns 13 acres of land along the shoreline at Kalapana and the area further inland is in private ownership. At Leleiwi Point the State owns 43 acres, and the upland area is owned by State Department of Hawaiian Home Lands. Two thousand acres at King's Landing are privately owned. Landownership patterns are not expected to change significantly in the near future.

(3) Land Use: At Kalapana the shoreline area is zoned for open space and the State of Hawaii is planning to develop the 13 acres as a historic park. The upland areas behind the park are zoned for resort and urban uses and are being acquired by the State for park uses. At King's Landing the lands are zoned for resort and urban use with the coastal area zoned for open space. At Leleiwi Point, the State's 43 acres are zoned for open space to be developed as Lehia Park. Land use patterns are not expected to change significantly in the near future. The King's Landing landowner wants to develop urban and resort activities at King's Landing, but plans to develop the area are not available.

(4) Recreation: Sites under consideration are pristine coastal areas offering a variety of recreational opportunities. Since King's Landing is privately owned, public access and use of the area is restricted and controlled by the landowner. Kalapana and Leleiwi Point are public parks with unrestricted public access. All the sites offer recreational fishing opportunities, principally pole fishing and possibly opihi picking. At King's Landing one opihi picker was swept to his death by the rough waters. Due to rough water conditions and the rugged coastline, King's Landing offers no swimming opportunities. Swimming at Kalapana is also limited due to periodic

rough water conditions. Waters are also rough at Leleiwi Point, but swimming conditions are judged better than the other two sites. Tide pools at Leleiwi provide protected swimming areas and are located in quiet pleasant surroundings. None of the sites provide boat launch facilities. Kalapana and Leleiwi Point are undeveloped park areas. The Keaukaha Shoreline Plan (County of Hawaii, undated) indicates that Leleiwi Point would be developed as Lehia general park providing swimming, camping and hiking opportunities. The draft Puna Development Plan (County of Hawaii) suggests that the Kalapana canoe landing beach will be developed as a historic park. The park will be one of several beach parks located in the Puna district extending from Kaimu Black Sand Beach south to Kalapana canoe landing beach. A surfing site off Harry K. Brown Beach Park, which is adjacent to Kalapana canoe landing beach, was identified in a 1977 surfing site survey by the Surfing Education Association. No surfing sites at Leleiwi Point or King's Landing were identified during the survey.

(5) Natural Hazards: All the sites lie within volcanic and tsunami hazard zones. Kalapana lies within a volcanic hazard area rated as a very high risk area exposed to lava flows, earthquakes, subsidence and local tsunamis. In comparison the King's Landing and Leleiwi Point sites are located in areas of high risk, but still subject to threat of lava flows. The degree of risk decreases with distance from the summit of the volcanoes and rift zones (see Table G-6 and Figure G-1 in Appendix G). In 1975, the Kalapana area subsided 3 feet and the road fronting Harry K. Brown beach park was underwater during high tide. Kalapana is situated in a shallow fault trench. All sites lie within the 100-year tsunami flood inundation zone outlined in Federal Flood Insurance Rate Maps for the area. Water elevations at distances 500 to 2,000 feet inland range from 18-34 feet based on the maps.

(6) Utilities:

(a) Water: Kalapana is serviced by a 6-inch water line connected to two upland wells. The Leleiwi Point area is serviced by a 8-inch water line extending out from Hilo City. No water system is available at King's Landing. Water production in the district is adequate for existing and near future needs and the potential source capability is more than adequate to meet long-term demands (see Appendix G).

(b) Power. At Kalapana homeowners provide their own power with individual generators since power transmission lines have not been extended to the area. No power system exists at King's Landing. Power transmission lines from Shipman power plant in Hilo service the Leleiwi Point area.

(c) Sewer: Homeowners at Kalapana must provide their own sewer treatment facilities and most presently use cesspools. No sewer system is present at King's Landing. The Hilo wastewater treatment system services the Leleiwi Point area.

(d) Roads: Kalapana and Leleiwi Point are easily accessible over improved roads. King's Landing is accessible via a private gravel road. Traffic on roads servicing Kalapana and Leleiwi Point will increase with park development. King's Landing will not be improved unless the landowner develops the area.

(7) Water Quality: No riverine or wastewater discharges occur at any of the potential harbor sites. Groundwater leakage from the aquifer possibly creates low salinity conditions nearshore at all sites, but no measurements are available to determine the effect. Cesspool leakage from homes and parks around Kalapana may affect water quality, but again no measurements are available to determine the effect. No long-term changes are anticipated.

(8) Groundwater: The groundwater system in the region is dependent upon rainfall in the high elevations. Water near shore is too saline for drinking purposes, containing 700-900 mg/l and chloride. The rate of groundwater leakage into the ocean was estimated at 100 mgd in the South Hilo-Kumakahi area and 4 mgd from Kapoho to Punaluu (Hawaii Water Resources Regional Study, 1975).

(9) Air Quality: None of the sites have sources of air pollutants. King's Landing is the most pristine with only occasional camping and ground keeping fires. Leleiwi Point is located within easy driving distance from Hilo, thus automotive emissions are the only source of air pollution at the site. Kalapana is a tourist destination with pristine air quality except for automotive emissions and agricultural fires. Volcanic emissions are the significant factor affecting air quality in the region.

(10) Historic Properties:

(a) Kalapana: The historic canoe landing site is located at Kalapana and is the theme of a park to be developed there. The historic cave of refuge is located on top of Hakuma Point ridge to the west of the harbor site. The historic Star-of-the-Sea painted church is located adjacent to the Kalapana park lands outside of the project limits. Kikoa heiau and the previously filled Waikikoa fishpond are located adjacent to Hakuma Point in the coconut grove. The heiau, fishpond, and church have potential for inclusion to the National Register of Historic Places (see Appendix F).

(b) King's Landing Plan 1. The project encompasses a heiau, a sand dune midden site which contains archaeological data, a lava sinkhole enclosure, and possibly a house platform. The heiau and midden site have potential for inclusion to the National Register of Historic Places.

(c) King's Landing Plan 2. The project encompasses a culturally significant stone artifact and a sand dune which contains archaeological data. Both the artifact and site have potential for inclusion to the National Register of Historic Places.

(d) Leleiwi Point. No sites are present. A midden site may possibly exist in the area. The area was devastated by a tsunami which could have destroyed sites in the area covering them with sand and other debris.

(11) Fish and Wildlife:

(a) Anchialine Ponds: At King's Landing many small anchialine ponds formed by lava tubes or depression may be present under the heavy undergrowth. The U.S. Fish and Wildlife Service suggests that the presence of mosquito fish in the ponds surveyed precludes the presence of any unique aquatic species. The geological youthfulness of the area provides an opportunity of finding many more similar habitats along the coast from Hilo to Kalapana. Vegetative litter will eventually fill the ponds removing them from aquatic productivity.

(b) Vegetation: No unique vegetation was found by the US Fish and Wildlife Service in any of the potential harbor sites. The Kalapana area is highly disturbed due to recent geological land shifts, cultivation of coconuts and use of the area for pasture. The King's Landing area consists of scrub ohia and alaa berries colonizing recent lava flows. Naupaka and pandanus are common along the shoreline. Leleiwi Point is a continuation of the King's Landing vegetative cover, except that the ironwood, hau and kamani trees form a dense cover in the park with the ironwood and beach grass forming the predominate cover around the tide pools.

(c) Habitat Values: No unique or special habitat values were found by the US Fish and Wildlife Service. The vegetative cover provided general habitat for a variety of common upland species found in the area.

(d) Marine Environment: No coral reefs are present at the sites. Basalt beds and boulders dominate the substrate and corals are judged to cover about 10 percent of the substrate. The varied bathymetric relief and rocky interstices probably provide habitat for a variety of common reef fish and invertebrates. No silty environments are found at any of the project sites.

(e) Tide Pools: The tide pools at Leleiwi Point contained common, juvenile, reef fish and an algal turf. The tide pools are unique aquatic habitats subject to severe salinity and temperature variations, and possibly serve as nursery areas of unknown value.

(12) Wetland Resource: A wetland is located at the King's Landing site as shown in Figure G-4 of Appendix G, and is formed by a depression in the lava field separated from the ocean by 300-400 feet of lava rock. A park is built on a sand dune which lies on top of the lava rock separating the wetland from the ocean. The wetland has no visible connection to the ocean and is densely overgrown with vegetation (see Appendix G). No open water bodies exist in the wetland. The water level in the wetland rises and falls with the tide. During spring high tides the water in the wetland covers the road through the wetland.

(a) Existing Wetland Values:

1 Natural Biological Functions:

a Food Chain Production: The wetland provides food for insects and some avian species, but no important wetland specific organisms are known to occur in the wetland.

b General Habitat: The wetland together with the surrounding ohia scrub habitat provide general habitat for wildlife.

c Nesting, Spawning, Rearing and Resting Areas. None.

2 Refuge or Sanctuary: None. The wetland is not set aside as a refuge, sanctuary or other area for special aquatic studies.

3 Natural Drainage, Sedimentation, Salinity, Flushing, Current Pattern Benefits: None. The wetland is not tributary to any riverine or flood plain system, where the wetland would influence natural drainage, sedimentation, salinity, flushing or current of the water body.

4 Erosion Barrier: None. The wetland is not associated with any barrier beach, island, reef or bars that protect other areas from wave action, erosion or storm damage.

5 Storage Area for Storm and Floodwaters: None. The wetland is not tributary to a riverine or other water body which periodically floods so that the wetland serves as a storage area for storm and floodwaters. The wetland does lie within a tsunami inundation zone and is periodically flooded by storm waves, but the area does not store or protect the surrounding lands from those flood events.

6 Prime Natural Recharge Area: None. The prime groundwater recharge areas in the region lie further upland in areas of high rainfall.

7 Natural Water Filtration: None. The wetland is not tributary to any riverine or other water body such that the water passes through the wetland and the wetland can filter out sediments and other nutrients prior to discharge into the ocean.

(b) Potential Wetland Values: The wetland resembles an anchialine or tide pool which has filled in and become overgrown with wetland vegetation. As time progresses, natural processes will permit the invasion and establishment of upland species. Without intervention from man the wetland will eventually disappear, but will still provide general habitat for wildlife in the area. The wetland could be cleared, possibly restoring the anchialine pool characteristics and allowing the natural colonization by anchialine pool organisms. Periodic infilling by storm wave, will necessitate continued clearing of sediment from any recreated pool. The open pool would probably attract water birds and shorebirds as would other open water bodies in the region. The pool might be converted to raising wetland crops, such as taro, if hydrologic conditions are suitable for taro cultivation.

(13) Endangered and Threatened Species: Humpback whales seasonally migrate through the waters of the island of Hwaii. The National Marine Fisheries Service indicated that the number of whales seen in the Leleiwi Point area have decreased from 12 in 1976 to 9 in 1979. The whales are not known to calve, mate or nurse their young in waters off the proposed harbor sites. The humpback whales appear to concentrate north of Hilo at Upolu Point during the peak of the season, which begins in November and ends in June. The endangered hawksbill turtle and threatened green sea turtle are said to forage along the coast from Hilo to Kapoho, but are not known to concentrate at any particular site including the Leleiwi Point and King's Landing areas. A turtle was reported to have nested at Harry K. Brown Beach in 1978, but no further nesting reports were made in subsequent years.

5. Environmental Consequences:

5.1 Population: Construction of the harbor at either Kalapana, King's Landing or Leleiwi Point, does not result in the displacement of any residences because no people are living in the construction areas. Construction noise, including blasting and heavy equipment operation, dust and increased vehicular traffic will be a significant nuisance to condominimum dwellers at Leleiwi Point and the homes and churches at Kalapana. The length of construction was used as a measure of the magnitude of the impact in Table 2. With the development of the commercial fishing industry odors, human traffic and light

industrial activities will be continuous long-term nuisances to residents used to relative quiet, rural locations. While park development will increase traffic and noise problems in the Kalapana and Leleiwi Point areas, the effects are judged to be less annoying in relation to industrial activities associated with a commercial fishing harbor.

5.2 Landownership: Public access to the shoreline at Kalapana and Leleiwi Point sites will not be changed with the development of a harbor at either location since the lands are public lands. Public access and use of private lands at Kalapana will be somewhat increased since 14 acres would have to be purchased from private landowners to complete the harbor. Public access and use of the shoreline at King's Landing will be increased with the donation of 150 acres of private lands for public use by the landowner.

5.3 Land Use: The development of a commercial fishing and recreational boat berths harbor conflicts with some aspects of residential/resort/park land-use zoning. The harbor may require land rezoning or land use planning to reduce residential exposure to light industrial activities associated with the harbor. Adjacent land areas zoned for urban and resort uses may be incompatible with long-term light industrial activities.

5.4 At Kalapana, the development of the harbor would eliminate 13 acres of open space for park development and eliminate 14 acres of private land from urban and resort use. At Leleiwi Point, the harbor would eliminate about 43 acres of open space for park use. Since there is no urban development at the King's Landing harbor site, construction and development can proceed without any direct impact on land uses. However, subsequent urban and resort development would have to be planned to reduce industrial nuisances to future urban and resort users. The harbor would enhance the developer's plans to develop King's Landing and possibly induce the developer to start his project in conjunction with harbor construction.

5.5 Recreation: The construction of a commercial fishing harbor at Kalapana and Leleiwi Point may eliminate any future park development in those areas. Recreational fishing will still be available, although opihi picking may decline. Swimming, sunbathing, hiking and camping opportunities will be reduced, if not partially eliminated, since the harbor will concentrate on

light industrial, fishing activities and will create an unpleasant environment for passive recreational pursuits. Harbor activities would tend to attract sightseers, but the relatively pristine, quiet atmosphere will be lost. The surfing site at Harry K. Brown Beach Park may be affected and possibly destroyed by the channel construction at the canoe landing beach. At Leleiwi Point, the harbor development will destroy the tide pools. At King's Landing the harbor will increase public use of the private land. Since public access to and use of King's Landing is restricted, the public would enjoy open use of the area, if the harbor was constructed. However, rough waters offshore will prevent swimming and other water contact activities, but fishing will benefit. Recreational craft will be allowed in the harbor, enhancing boating recreation at the selected harbor site.

5.6 Natural Hazards: The construction and development of the harbor at any of the proposed locations will increase potential damages and losses since the harbor will be located within tsunami and volcanic hazard zones. Volcanism is more active in the Kalapana area than near Leleiwi Point and King's Landing; thus, the hazards at Kalapana are greater. The problem of long-term subsidence is island-wide; however, rapid subsidence related to local earthquakes is greater at Kalapana which subsided 3 feet in 1975. Tsunami runup elevations at Kalapana are higher than at Leleiwi Point or King's Landing (see Appendix G).

5.7 Water Quality: Construction will temporarily increase water turbidity during the excavation of the harbor entrance channel. The severity of the increase cannot be predicted since the excavation will involve use of explosives and the excavation of solid basalt. The duration of the water turbidity impact is qualitatively estimated in Table 2 by the number of days required to complete the excavation of the entrance channel. Excavating the harbor access and berthing in the inland areas prior to opening the harbor to the ocean reduces the amount of work performed in the water providing some measure of turbidity control and reduction in sedimentation stress.

5.8 Groundwater leakage into the harbor basin is anticipated based upon surveys of Honokohau Harbor, Kailua-Kona, Hawaii, which was constructed in 1970. The groundwater discharge in the proposed harbor should be brackish, may create a two-layered water body in the harbor, may induce a continuous

outflow on the surface and may be a source of nutrients in the harbor. The rate of discharge should vary directly with the amount of rainfall in the upland areas. The surface water should be cooler than the bottom water, should contain a higher level of nutrients and should be less saline than the bottom water. Turbidity may probably range from less than 0.5 FTU to less than 1.50 FTU due to phytoplankton growth. At Honokohau phytoplankton was the principal factor affecting water turbidity, and phytoplankton density was controlled by a combination of high nutrient concentration and water residence time.

TABLE 3. PROBABLE WATER QUALITY IN THE HARBOR BASIN (RANGE OF MEAN CONCENTRATIONS OVER THREE-YEAR PERIOD) (Based on experience at Honokohau Harbor)

	Surface	Bottom
Salinity	12-35°/00-	35°/00
Temperature	22-24°C	24-26°C
Nitrate-Nitrogen (g-at N/l)	10.74 - 43.9	0.15 - 1.050
Reactive Phosphate (μg-at P/l)	0.45 - 3.375	0.15 - 1.050
Ammonia (μg-at N/l)	0 - 1.41	0.14 - 9.60
Amino nitrogen (μg-at N/l)	0.133 - 0.566	0.290 - 1.720

5.9 Development in support of commercial fishing activities in the harbor has the potential for introducing trash, fish offal and petroleum and other chemical pollutants into the water in greater amounts than a recreational harbor. While sewage pumpout facilities, and the restriction of live aboards in the harbor will help to reduce pollution sources, marine dry dock facilites and day-to-day fishing operations can be a major source of pollution.

5.10 Groundwater: No groundwater drinking sources will be affected.

5.11 Air Quality: During construction, temporary dust nuisances will be created for workers and adjacent residences at Kalapana and Leleiwi Point. The problem will be significant at Leleiwi Point, where the site is adjacent to the condominium. At Kalapana relatively few residences will be exposed to the dust and noise. At King's Landing, only the workers will be exposed to the dust and noise. Automotive emissions will increase with the operational use of the harbor due to boat and automotive engines. Air pollution sources could be present with the development of shoreside facilities, since the harbor will be servicing commercial fishing operations. Odors could occur if

fish processing activities, such as smoking and drying facilities, are allowed. The odor problems could be great in areas with adjoining residences, such as Leleiwi Point and Kalapana. King's Landing is undeveloped and uses of the land could be planned to avoid impact.

5.12 Historic Properties:

(a) Kalapana: The excavation of the harbor would destroy the canoe landing site, and Kikoa heiau and filled fishpond. The harbor and harbor activities would alter visual elements around the Star-of-the-Sea painted church and the cave of refuge.

(b) King's Landing Plan 2: The harbor would destroy the heiau, the walled enclosure and the sand dune. Archaeological data recovery prior to their destruction would preserve some data for the scientific community.

(c) King's Landing Plan 1: The harbor would destroy the stone artifact and the sand dune which contains archaeological data. The stone could be relocated. Archaeological data recovery would preserve some data for the scientific community. The unaffected portion of the sand dune would be covered during construction of the harbor preserving any remaining information in the dune for an eternity.

(d) Leleiwi Point: No effect anticipated.

5.13 Utilities: The construction of the harbor by excavating the entrance channel and berthing basin from the basalt shoreline does not require an increase in utilities demands. However, the development of ancillary backup facilities to support commercial fishing activities will increase demands on water, power and wastewater systems, and will require road improvements. The utility demands created by development of the harbor cannot be predicted at this time due to the uncertainty of the nature of the harbor development and the lack of plans on the types of services to be provided. At Kalapana the water line can be easily extended to the harbor site. If new water sources are required, the Hawaii Water Resources Regional Study indicates that potential water source capability can be increased by about 80 MGD. If power cannot be transmitted to the area, local power generation with individual

units would have to be provided. Road access to the site is easily provided due to the closeness of the site to the Kalapana-Kaimu Highway. Wastewater treatment should be sufficient to meet State health requirements. Solid waste processing and treatment would have to be improved. At Leleiwi Point, water, power, sewer and roads can easily be extended to the harbor site, but may have to be increased to handle the demands created by light industrial activities. The expense of providing utilities at King's Landing would be the greatest since the site is isolated and no systems are presently available. Road access to the site would be a major construction item. Power can be brought in or generated using individual generator. Water can probably be developed on site or brought in from Hilo. Sewer systems could be provided in a similar fashion. At the present time, the State of Hawaii and the landowner are discussing the sharing of costs to provide the utilities if King's Landing is selected.

5.14 Fish and Wildlife:

The major effect of harbor construction at any of the potential harbor sites is the conversion of general terrestrial habitat into marine habitat. Based on a five-year survey of Honokohau Harbor, which was constructed by excavating the harbor basin from a recent basaltic laval flow, a stratified estuary should be created in the new har bor and colonization by mollusks, sea urchins, algae, coral and fish from adjacent marine areas should proceed rapidly. Within one year of construction both brackish water and marine organisms should colonize the walls and bottom of the new harbor. Investigators hyphothesized that biological succession in Honokahau would probably take 10 years before biological communities approach a climax state within the harbor.

TABLE 4. BIOLOGICAL SUCCESSION PATTERN IN HONOKOHAU HARBOR

	1971	1972	1973	1976
Molluscs (# species)	43	48	61	--
Sea Urchins (# species)	8	8	9	--
Coral				
Density (# per M^2)	0.05	1.43	2.66	--
Growth (Mean diameter of coral)	4 cm.	8.5 cm	12.5 cm	--
Fish (# species)	19-28	33-46	25-41	35-55
(# individuals)	93-225	244-381	142-337	355-629

At Honokohau, diversity, abundance and density variations varied with distance from the ocean, with depth of water and with bottom relief. Sea urchin density doubled during the survey period while the number of species remained relatively stable. Coral recruitment rate was estimated at 1.23 colonies per square meter per year. Most fish observed were juvenile and sub-adults; and the data suggest that the number of fish species was generally increasing from year to year. Eight species of fish were counted during each of the surveys over 5-year period.

5.15 The rate and nature of succession and colonization in the proposed harbor would be dependent upon man's use of the harbor and the ability of aquatic organisms to withstand stresses and conditions in the harbor. Petro-chemical spills, trash, organic debris and maintenance activities may alter the community health and species composition particularly within the inner harbor reaches. For example, higher nutrient inputs may induce a higher phytoplankton and zooplankton growth that would increase water turbidity reducing light penetration in the harbor stressing photosynthetic organisms. The piers, wharves and boat bottoms will provide habitat for fouling organisms which will contribute to an increase in benthic species diversity, but hull maintenance will periodically affect the community abundance. Hull cleaning and the plankton population may contribute to sedimentation in the harbor.

5.16 Wetland Resources: Plan 1 at King's Landing will destroy the wetland by excavation and filling. Development of a harbor at either Leleiwi Point, King's Landing Plan 2 or Kalapana avoids the wetland site. The Plan 1, King's Landing will eliminate the wetland as general wildlife habitat, preventing any potential uses of the wetland. No measures to minimize unavoidable adverse impacts are available since the plan destroys the wetland. Realignment of the harbor would still require excavation in the wetland and would drain the wetland. The only other form of mitigation available is the replacement of 12 acres of general habitat.

5.17 Anchialine Ponds: Construction at King's Landing has the potential for destroying an undeterminable number of pools in the lava substrate. At the present time, no unique organisms are known to occur in pools surveyed by the Fish and Wildlife Service in the King's Landing area.

5.18 Tide Pools: The tide pools at Leleiwi Point would be filled, if the site is selected, destroying the organisms presently inhabitating the pools and eliminating any future use of the pools by man or aquatic organisms.

5.19 Vegetation: The loss of vegetation at any of the potential harbor sites will result in a localized loss of general habitat. While the loss is not significant in comparison with the remaining vegetated areas surrounding the sites, the loss represents a long-term reduction in vegetation and modification of the island coastal environment.

TABLE 5. VEGETATIVE LOSS AT POTENTIAL HARBOR SITES

Kalapana	14 acres of Coconut trees
King's Landing	150 acres of naupaka and ohia scrub forest
Leleiwi Point	43 acres of ironwood and kamani trees

5.20 Endangered and Threatened Species:

(1) Humpback Whales: The endangered whales migrate through the waters off the three potential harbor sites. The harbors do not interfere with their migratory movement. Studies at Glacier Bay, Alaska, seem to indicate that fishing boats under the 100-ton class do not bother the whales, unless the boats buzz the whales. The potential harbor sites are not known calving, nursing or mating grounds. Since the whales are usually seen migrating through the area, harbor operations during the migration are not expected to jeopardize the continued existence of the whale.

(2) Sea Turtles: The endangered hawksbill and threatened green sea turtles are reported to forage along the coastal areas from Hilo to Kalapana. The relative isolation of the areas and rough waters protect the turtles from man. Since no concentrated turtle feeding or nursing grounds are known to occur at any of the potential harbor sites, the construction of the harbor is not expected to jeopardize the continued existence of the sea turtles. Continued recreational use of Harry K. Brown Beach Park presently jeopardizes the reported nesting site of one hawksbill turtle, and construction of the harbor at Kalapana neither improves nor degrades conditions affecting the hawkbill turtle nest at Harry K. Brown Beach Park. With an increase in boating activity along the coast, the human contact with turtles will probably

increase and some fishermen may attempt to illegally catch them. Accidental boat collisions with turtles are also probable, but these collisons with individuals are not expected to jeopardize the continued existence of the species.

6. Public Involvement:

6.1 Public Involvement Program: No meetings were held in the preparation of the environmental impact statement during the scoping process. The public involvement program has consisted of a series of nine public workshops held on the island of Hawaii. The problems of small craft navigation needs have centered primarily on identifying sites for small craft facilities and safe anchorages to assist local commercial fishermen. However, the need for recreational craft was also stressed by the State of Hawaii. The need for facilities at Laupahoehoe, in Hilo, at Pohoiki and in the Puna area to support fishing interests were defined early in the study. The Pohoiki launch ramp was improved in 1979 as a result of the study. Small craft facilities at Laupahoehoe and in Hilo will be studied under separate project authorities, while the study for a small craft facility in the Puna area continues under the Hilo Area Comprehensive Study. Sites at Leleiwi Point and King's Landing were initially discussed with the public. Sites at Kapoho and Kalapana were later added based on fishermen desire to have a harbor closer to the Puna fishing grounds. Kapoho was later dropped as a result of a March 1981 public workshop in which resident and landowner objection to the site was great. Leleiwi area residents opposed the Leleiwi Point site, and fishermen indicated that the Leleiwi Point and King's Landing sites were too treacherous for their boats. Most workship attendees appeared to favor use of the Kalapana site, despite the presence of archaeological and recreational resources.

6.2 Required Coordination:

(1) Prime and Unique Agricultural Lands: No prime or unique agricultural lands are located at any of the potential harbor sites. However, the comments from the US Soil Conservation Service and the State of Hawaii, Department of Agriculture concernings the project effects on agricultural lands will be solicited by the circulation of the draft report and environmental impact statement.

(2) Section 404 - Evaluation: The evaluation of the discharge of dredged or fill material is contained in Appendix J, and will be coordinated with the US Congress during the authorization process. This constitutes compliance with the requirements of the Clean Water Act.

(3) Wetland Evaluation: The wetland evaluation in accordance with Executive Order 11990 is contained in the draft environmental impact statement for agency and public review and comment.

(4) Endangered Species: A biological assessment concerning project impacts on the endangered humpback whale, endangered hawksbill turtle and the threatened green sea turtle, and the determination that the project will not jeopardize the continued existence of the species is being coordinated with the US Fish and Wildlife Service and the US National Marine Fisheries Service in accordance with the Endangered Species Act.

(5) Fish and Wildlife Coordination: Comments concerning project effects from the US Fish and Wildlife Service, National Marine Fisheries Service and the State Division of Fish and Game required under the Fish and Wildlife Coordination Act will be solicited using the draft report and environmental impact statement. The US Fish and Wildlife Service will also provide an independent report under Section 2(b) of the Act for consideration and inclusion in the final report and environmental impact statement.

(6) Coastal Zone Management (CZM) Consistency Determination: A CZM consistency evaluation is being coordinated with the State CZM Office in order to obtain a federal CZM consistency determination.

(7) Historic Coordination: Consultation on determinations of eligibility for inclusion to the National Register of Historic Places will be completed with the State Historic Preservation Officer and the National Park Service before final determinations of effect under the National Historic Preservation Act.

(8) Recreation: The opinions of the County of Hawaii, Department of Parks and Recreation, and the State of Hawaii Department of Land and Natural Resources are required for project implementation at Kalapana and Leleiwi

Point, since both agencies control the land use at the sites. The National Park Service will be contacted for its views concerning project impacts on recreation. The coordination will be done under the Federal Water Project Recreation Act.

(9) Water Quality, Air Quality, and Noise Control: The US Environmental Protection Agency will have an opportunity of commenting on project impacts discussed in the environmental impact statement under the Clean Water Act, Clean Air Act and Noise Control Act.

(10) State and Local Policies: The State of Hawaii, Departament of Transportation is responsible for obtaining all necessary State and local permits or authorizations for the construction of a harbor at the selected location.

6.3 Statement Recipients: A list of agencies, special interest groups and individuals who received the draft environmental statement is provided in the deep draft section of the environmental impact statement.

6.4 Public Views and Responses (To be completed after review of the draft environmental impact statement)

List of Preparers:

The following people were primarily responsible for preparing this Environmental Impact Statement.

Mr. Michael T. Lee	Biology	BA, Biology; 1 year Biologist, US Navy; 9 years EIS studies, Corps of Engineers.	Preparer, overall impact assessment.
Mr. William B. Lennan	Zoology	BA, Zoology; 2 years postgraduate studies, University of Hawaii; 2 years fishery biologist, US Fish and Wildlife Service.	Fish and Wildlife assessment.
Dr. James E. Maragos	Marine Ecology	BS, Zoology; PhD, Oceanography; 2 years postdoctoral research; 8 years environmental consultant; 5 years EIS studies, Corps of Engineers.	Review, overall impact assessment.
Mr. David G. Sox	History and Culture	BA, MA Geography; 6 years research; 4 years EIS studies; Corps of Engineers	Cultural and historical impact assessment.

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ENVIRONMENTAL IMPACT STATEMENT
DEEP DRAFT NAVIGATION IMPROVEMENTS IN HILO HARBOR
HILO AREA COMPREHENSIVE STUDY

The responsible State lead agency is the State of Hawaii, Department of Transportation, Harbors Division.

The responsible Federal lead agency is the US Army Corps of Engineers, and the cooperating Federal agency is the US Fish and Wildlife Service.

Abstract. Deep draft vessels operating in Hilo Harbor are hampered by surge (ship motion) insufficient water depth and lack of berthing and container space. The Corps has considered four plans to resolve problems and operational inefficiency in the harbor. Plan D, which involves deepening the harbor channel and basin, removing the existing buoy in the turning basin, and improving the mooring system, was found to resolve the problems with the least construction cost and the least modification of the existing harbor. Thus, the plan was designated the National Economic Development Plan and the nonstructural plan. Plan C which incorporated the features of Plan D, but shortened the existing breakwater, was designated the Environmental Quality Plan because it afforded an opportunity to improve water quality in the bay, to enhance recolonization and revitalization of Blonde Reef, to possibly reduce erosion along Bayfront Beach and to increase surfing opportunities in the bay. However, Plan C could possibly increase tsunami hazards along the shoreline, and requires further tsunami hazard evaluation. Hilo breakwater is eligible for inclusion to the National Register of Historic Places, and a determination of no adverse effect is being coordinated with the State Historic Preservation Officer.
Bioassay and bioaccumulation tests and approval from the US Environmental Protection Agency are required before ocean dumping of the contaminated dredged material from Hilo Harbor can be implemented. If ocean disposal of dredged material is disapproved, other methods of dredged material disposal will have to be reevaluated.

SEND YOUR COMMENTS TO THE DISTRICT ENGINEER BY 5 October 1981.

If you would like further information on this statement, contact:

James E. Maragos, PhD
Chief, Environmental Resources Section
US Army Corps of Engineers
Building 230
Fort Shafter, HI 96858
Phone: (808) 438-2263

NOTE 1: The information, displays, etc., in the main report or appendices are incorporated by reference into the EIS.

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Fish	DD-EIS-28
Water Quality	DD-EIS-31
Sediment Quality	DD-EIS-31
Ocean Dumping	DD-EIS-33
Upland Disposal	DD-EIS-33
Air Quality	DD-EIS-34
Noise Quality	DD-EIS-34
Historic Resources	DD-EIS-36
PUBLIC INVOLVEMENT	DD-EIS-37
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INDEX, REFERENCES, AND APPENDIX	

1. SUMMARY

1.1 MAJOR CONCLUSIONS AND FINDINGS. Four plans are considered for implementation in the Hilo Area Comprehensive Study, Deep Draft Navigation Improvements Study. These plans included Plan A--Improving the Inner Harbor, Plan B--Chamber of Commerce Plan, Plan C--Modification of the Breakwater and Plan D--Harbor Deepening and Dock Improvements.

TABLE 1. PLAN FEATURES

Plan A	Deepen the harbor from -35 feet to -40 feet MLLW; ocean disposal of dredged material. Construct two new breakwaters.
Plan B	Realign existing breakwater. Enlarge channel and turning basin; use dredged material for fill. Create fill areas behind breakwater .
Plan C	Deepen harbor from -35 feet to -40 feet MLLW; ocean disposal of dredged material. Construct new breakwater. Remove or allow 7000 feet of breakwater to deteriorate. Replace existing buoy in the turning basin with submersible buoy. Improve the dock mooring system.
Plan D	Deepen the harbor from -35 feet to -40 feet MLLW; ocean disposal of dredged material. Improve the dock mooring system.

Plan D is designated the nonstructural plan since the plan will not involve major structural improvements and will cause the least change to the existing harbor configuration. Plan D is also the National Economic Development Plan since it costs the least to implement, and resolves navigational problems in the harbor. Plan C is the Environmental Quality Plan since modification of

the breakwater could enhance recolonization of Blonde Reef, improve water quality while possibly reducing erosion along Bayfront Beach, and increase the number of surfing sites in the bay.

No wetlands or flood plains are involved. Bioassay and bioaccumulation tests and approval from the US Environmental Protection Agency are required before ocean disposal can be implemented. The effects of the discharge of dredged and fill material were evaluated under Section 404(b)(1) and the discharge sites for Plan A and C are specified under the evaluation. Hilo breakwater is eligible for inclusion to the National Register of Historic Places. A determination of no adverse effect is being coordinated with the State Historic Preservation Officer. No prime agricultural lands are located within the project area.

1.2 AREAS OF CONTROVERSY. None.

1.3 UNRESOLVED ISSUES.

a. Ocean Dumping. The requirements for bioassay and bioaccumulation testing and US Environmental Protection Agency approval need to be completed prior to discharge of the dredged material at the ocean dump site. If the Environmental Protection Agency disapproves the ocean disposal of the dredged material, other methods of disposal will have to be evaluated.

b. Historic Resources. The modification of the breakwater affects a site eligible for inclusion on the National Register of Historic Places. A determination of no adverse effect is being coordinated with the State Historic Preservation Officer.

c. Coastal Zone Management (CZM) Determination. Hawaii CZM program consistency certification has been requested from the State of Hawaii, Department of Planning and Economic Development.

d. US Fish and Wildlife. The final report of the US Fish and Wildlife Service will be completed for the final report by September 1981.

1.4 RELATIONSHIP TO ENVIRONMENT REQUIREMENTS: (See Table 2).

1.5 ADOPTION OF AN EIS. The probable environmental impacts of ocean disposal of the dredged material at the disposal site are discussed in the US Army Corps of Engineers, "Final Environmental Impact Statement for Maintenance Dredging in the State of Hawaii," 1975, and the US Environmental Protection Agency, "Final Environmental Impact Statement for Hawaii Dredged Material Disposal Sites Designation," 1980, and are adopted for the purposes of this report. The results of the bioassay and bioaccumulation tests will be documented in supplements to this environmental impact statement.

TABLE 2. RELATIONSHIP OF THE PLANS TO ENVIRONMENT PROTECTION STATUTES AND OTHER ENVIRONMENTAL REQUIREMENTS

Federal Statutes	Plan A	Plan B	Plan C	Plan D
Archaeological and Historic Preservation Act (See Section 6.2)	N/A	Partial	Partial	N/A
Clean Air Act	Full	Full	Full	Full
Clean Water Act (See Section 6.2)	Partial	partial	Partial	N/A
Coastal Zone Management Act (See Section 6.2)	Partial	Partial	Partial	Partial
Endangered Species Act (See Section 6.2)	Partial	Partial	Partial	Partial
Estuaries Protection Act	N/A	N/A	N/A	N/A
Federal Water Project Recreation Act	Full	Full	Full	Full
Fish and Wildlife Coordination Act (See Section 6.2)	Partial	Partial	Partial	Partial
Land and Water Conservation Act	N/A	N/A	N/A	N/A
Marine Protection, Research and Sanctuaries Act (See Section 6.2)	Partial	N/A	Partial	Partial
National Historic Preservation Act (See Section 6.2)	N/A	Partial	Partial	N/A
National Environmental Policy Act (See Section 6.2)	Partial	Partial	Partial	Partial
Rivers and Harbors Act	N/A	N/A	N/A	N/A
Watershed Protection and Flood Prevention Act	N/A	N/A	N/A	N/A
Wild and Scenic Rivers Act	N/A	N/A	N/A	N/A
Executive Orders and Memorandum				
Flood Plain Management	N/A	N/A	N/A	N/A
Protection of Wetlands	N/A	N/A	N/A	N/A

TABLE 2. RELATIONSHIP OF THE PLANS TO ENVIRONMENT PROTECTION STATUTES AND OTHER ENVIRONMENTAL REQUIREMENTS (Cont'd

Executive Orders and Memorandum (Cont'd)				
Environmental Effects Abroad of Major Federal Actions	N/A	N/A	N/A	N/A
Analysis of Impacts on Prime and Unique Farmlands	N/A	N/A	N/A	N/A
State and Local Policies				
State NEPA (See Section 6.2)	Partial	Partial	Partial	Partial
State Coastal Zone Management Program (See Section 6.2)	Partial	Partial	Partial	Partial
County Special Management Area Permit (See Section 6.2)	Non-compliance	Non-compliance	Non-compliance	Non-compliance
State Conservation District Use Application Permit (See Section 6.2)	Non-compliance	Non-compliance	Non-compliance	Non-compliance
County General Plan	Full	Full	Full	Full
State Land Use Plan	Full	Full	Full	Full
Required Federal Entitlements (Permits)				
None required				

NOTES:

a. Full (Full Compliance). Having met all requirements of the statute, Executive Order or other environmental requirements for the current stage of planning (either pre- or post-authorization).

b. Partial (Partial Compliance). Not having met some of the requirements that normally are met in the current stage of planning. Partial compliance entries should be explained in appropriate places in the report and/or EIS and referenced in the table.

c. Non-Compliance. Violation of a requirement of the statute, Executive Order, or other environmental requirement. Non-compliance entries should be explained in appropriate places in the report and/or EIS and referenced in the table.

d. N/A (Not applicable). No requirements for the statute, Executive Order or other environmental requirement for the current stage of planning.

2. NEED FOR AND OBJECTIVES OF THE ACTION.

2.1 STUDY AUTHORITY. The study of Deep Draft Harbor Navigation Improvements in Hilo Harbor is conducted under Section 144 of the Water Resources Development Act of 1976. The Act authorizes a study of methods to develop, utilize and conserve water and land resources in the Hilo Bay area, including the consideration of the need for navigation facilities, for enhancement and conservation of water quality and, fish and wildlife, for environmental enhancement and for economic and human resources development. The recommendations shall be compatible with other local comprehensive development plans and plans of other interested Federal agencies.

2.2 PUBLIC CONCERNS.

(1) The State of Hawaii, Department of Transportation, requested the assistance of the Honolulu District, US Army Corps of Engineers, to find methods of improving vessel operating efficiency in Hilo Harbor and of reducing damages due to ship motion. Some of the vessels presently using Hilo Harbor and of many of the projected future vessels cannot operate fully loaded in the existing harbor due to limiting water depths in the channel and turning basin. One of the vessels which regularly calls at Hilo has trouble turning in the basin because of the basin's limiting size. The turning basin is further restricted by a mooring buoy located in the middle of the turning basin. The buoy is used to safely berth vessels when ship motion (surge) alongside the dock becomes severe. The turning basin is also restricted when berthing space is overcrowded and vessels have to moor in the turning basin. The restriction in the turning basin delays ship or barge turnaround time, increases the chances for accidents, and requires the use of extra tugs. Ship motion is a major concern to vessel operators, port officials, and local businesses since the problem prevents vessels from unloading in Hilo, and causes damages to both vessels and wharves. The lack of container storage space also contributes to shipping delays by lengthening the time it takes to unload vessels and to make space for new arrivals.

(2) Local residences and agencies have expressed a need to improve water quality in Hilo Bay. The turbid waters and accumulated vegetative trash on the bayfront beach reduce recreational aesthetics and discourages water contact recreation. Fishermen complain of low recreational catches, and

commercial fishing in the bay has declined. The bay is presently recovering from 75 years of sewage and industrial discharges, but contaminants are still present in the harbor sediments. Hilo Harbor breakwater reduces water exchange and circulation in the bay, induces heavy sedimentation which eliminates hard bottom habitat, and creates a two-layered water body by trapping freshwater discharged into the bay by springs and rivers. Local residents do not wish to see tsunami hazards aggravated and believe that the breakwater provided some protection during past tsunamis.

2.3 PLANNING OBJECTIVES.

a. Provide adequate improvements in the harbor and facilities to accommodate deeper draft and longer vessels of the existing and future fleets.

b. Provide for an increasing number of containers being handled at Hilo.

c. Reduce delays and damages caused by ship motion at the Hilo docks.

d. Provide for an increased number of vessels using Hilo Harbor.

e. Improve water quality, fish habitat, and water-contact recreation in Hilo Bay through modifications of the breakwater.

f. Prevent any aggravation of tsunami hazards in Hilo Bay.

3. ALTERNATIVES, INCLUDING THE PROPOSED ACTION.

3.1 PLANS ELIMINATED FROM FURTHER STUDY.

a. Widening the turning basin. Plans to widen the basin by dredging were eliminated since the plans considered in detail provided solutions to problems in Hilo Bay without dredging a wider turning basin.

b. Scheduling vessel arrivals. This alternative is a management action implemented by the local government to reduce delays related to surge and to efficiently utilize existing berthing and container storage space. The

alternative was not considered in detail because scheduling control could not be effectively implemented by local port authorities, surge conditions cannot be accurately predicted nor can vessel arrivals be accurately forecast to the nearest day.

3.2 WITHOUT CONDITION (NO ACTION). Radical changes in cargo composition and tonnage traffic are not anticipated, but tonnage is expected to increase in relation to demands resulting from the continued growth of Hawaii County's population (see Appendix H). The limitations in harbor depth (-30 feet) and the lack of berthing and cargo storage space will continue the harbor inefficiency. Barge traffic volume is expected to remain unchanged, but a deeper draft barge (33 feet draft) is expected to be put into service. Two petroleum tankers with 36 feet design draft presently most underload to operate in Hilo Harbor and will continue to do so in the near future. Existing and future bulk carrier vessels have design drafts greater than 30 feet and will continue operating in Hilo Harbor. The continued use of roll-on and roll-off vessels for container shipments will aggravate the shortage of container storage space, and surge problems will continue to affect the unloading of the container vessels. The State plans to expand the berthing area in Hilo Harbor along Baker's Beach, which will provide more container storage space, and to align the berthing area, to minimize present surge problems. No change in existing water quality parameters or water-contact recreation problems is anticipated.

3.3 PLANS CONSIDERED IN DETAIL. Four plans were considered in detail for improvements to Hilo Harbor. Plan D, Harbor Deepening and Dock Improvements, is designated the nonstructural plan because the plan does not involve major structural elements for its implementation. The plan is also considered the National Economic Development Plan because it has the least construction cost for implementation in comparison to the other plans. Plan D also involves the least amount of energy to implement due to its low construction cost and lack of major structural elements. Only Plan B requires an increase in potable water demand since more extensive landside facilities are provided in comparison to other plans. Plan C is considered the Environmental Quality Plan because it provides an opportunity to improve water quality, fishery habitat, and recreation.

3.3 ~~3.4~~ PLANS CONSIDERED IN DETAIL.

a. Inner Harbor Improvements (Plan A). This plan consists of deepening the existing entrance channel and turning basin from -35 feet MLLW to -40 feet MLLW, and constructing two new breakwaters, one 900 feet in length and the other 2100 feet in length (see Plate D-11). The plan has a benefit-cost ratio of 0.31 and has a total first cost of $20.3 million with the Federal share being $19.4 million and the State share being $0.9 million. Baker's Beach is left open for harbor expansion as planned by the State. The plan effectively reduces surge problems and improves operating depths and turning within the harbor. Water circulation within the inner harbor is further reduced, but areas outside the inner harbor are unaffected. Water turbidity will temporarily increase due to dredging. The maintenance dredging frequency may be decreased from once every 10 years to once every 15 years reducing the frequency of benthic community disturbance and associated ocean disposal impacts.

The breakwaters will provide rocky interstitial habitat while eliminating silt covered coralline habitat. Approximately 551,400 cubic yards of silty-clay, contaminated dredged material will be disposed of in the ocean, depending upon the outcome of bioassay and bioaccumulation tests and approval of the action by the US Environmental Protection Agency. If the Environmental Protection Agency does not approve of the action, other alternatives for disposal of the material will have to be reconsidered, including land disposal, containerization or encryptment on land or in the ocean, and varying the rate of dilution and discharge into the ocean. Land disposal costs are less than ocean disposal costs within 4.5 miles of the harbor, but no land disposal sites are available within 6 miles of the harbor and land purchases will increase disposal costs. Suitability for uncontained land disposal will depend upon the results of leachate testing and U.S. Environmental Protection Agency leachate standards for land disposal of hazardous materials. Potential tsunami damage and losses will be increased by locating 2 new breakwaters within the tsunami hazard area.

b. Chamber of Commerce Plan (Plan B). This plan consists of a major realignment of the breakwater, expansion of the turning basin by dredging, and creating fill areas along the harbor side of the breakwater for container

storage space, a small boat harbor, and a recreational park using the dredged material (see Plate D-12). This plan has a cost-benefit ratio of 0.04 and a total first cost of $108.3 million with the Federal share being $40.3 million and the State share being $68.0 million. This plan creates the greatest environmental change in the bay in comparison with the other plans. If implemented, approximately 119 acres of Blonde Reef will be dredged and 85 acres filled. The discharge of dredged or fill material will have to conform with the US Environmental Protection Agency Section 404(b)(1), Clean Water Act, guidelines and possibly undergo sediment and elutriate analysis due to the presence of contaminants. The dredging and discharge of dredged material will temporarily increase water turbidity within the harbor, and eliminate 200 acres of fishery habitat on Blonde Reef. The landfill does not enhance water-contact recreation activities along the Bayfront area, but does provide for an improved small boat harbor and provide a new recreational facility within the bay. Potential tsunami damages and losses will be increased by locating damageable properties in the tsunami hazard area, particularly along the breakwater. The plan also realigns a portion of the historic Hilo breakwater and increases the land area adjoining the breakwater modifying the visual elements in the bay.

c. Changes to the main Existing Breakwater (Plan C). This plan consists of the deepening element of Plan A, and replacement of the existing buoy in the turning basin, improving the dock fender system, and construction of a new 2000 feet breakwater (see Plate D-13). The plan has a cost benefit ratio of 1.3 and a total first cost of $17,900,000 with the Federal share being $17 million and the State share being $900,000. About 7000 feet of the outermost portion of the existing breakwater will be removed down to -8 feet MLLW, or will be allowed to deteriorate naturally, or will be breached with the stones salvaged for use in constructing the new breakwater. The existing surface buoy in the turning basin would be replaced with a submersible buoy, which can be raised and lowered from the harbor bottom when needed. The improved fender system will consist of providing pretensioning winches to handle the mooring lines to damp surge, and the replacement of the wooden fenders with cylindrical rubber fenders.

The improvements will reduce surge damages, improve navigation within harbor, and reduce costs of maintaining the breakwater. The partial removal, natural deterioration, or breaching of the breakwater is expected to improve water quality in Hilo Bay by increasing wave energy in the bay that would flush silt from Blonde Reef and reduce the salinity differences in the outer harbor. Water column mixing within the inner harbor is not improved. The modification of the outer portion of the breakwater may reduce erosion along the Bayfront Beach and and possibly improve surfing conditions in the bay. The dredged material will be disposed of by ocean dumping, as discussed in Plan A. The reduction of 7000 feet of breakwater could possibly result in an increase in tsunami wave height at the shoreline, and further tsunami hazard evaluation is necessary. The plan reduces the length of the historic breakwater modifying visual elements, but does not alter the historical significance of the breakwater.

d. Harbor Deepening and Dock Improvements (Plan D). This plan consists of deepening the existing harbor as described and discussed in Plan A, and the submersible buoy and improved fender elements of Plan C. This plan has a cost-benefit ratio of 1.19 and a total first cost of $5.5 million with the Federal share being $4.6 million and the State share being $0.9 million. This plan causes the least amount of environmental change in comparison with the other plans. A temporary increase in water turbidity is anticipated with dredging and ocean disposal. The Environmental Protection Agency requirements, as discussed in Plan A, will have to be fulfilled. The maintenance dreding frequency for Hilo Harbor may decrease from once every 10 to once every 15 years with the deeper water depths.

3.4 COMPARISON OF ALTERNATIVE IMPACTS. (See Table 3.)

TABLE 3. COMPARISON OF ALTERNATIVE IMPACTS

Resource	Base Condition	Plan A	Plan B	Plan C	Plan D
Recreation Beach Parks	Mooheau Park eroding	No effect	No effect on existing parks.	No effect.	No effect
	Bayfront Park eroding canoeing	"	Adds new park.	Possible erosion reduction along Bayfront beach.	"
	Wailoa River Park	"	No effect	No effect	"
	Liliuokalani Gardens and adjacent areas	"	"	"	"
	Coconut Island	"	"	"	"
	Banyan Drive shoreline	"	"	"	"
	Reed's Bay swimming	"	"	"	"
	Baker's Beach	"	"	"	"
	Radio Bay	"	"	"	"
	Radio Bay Park	"	"	"	"
	Hilo Breakwater fishing	Adds 2 new breakwaters	Improved access, reduced hazards, adds 3 new breakwaters.	Net Reduction of 5000 feet	No effect
Surfing	Coconut Island area (1)	No effect	No effect	No effect	No effect
	Wailuku River Mouth (3)	"	"	"	"
	Tip of Hilo Breakwater (1)	"	"	Possible increase in surfing sites, on Blonde Reef.	"

TABLE 3. COMPARISON OF ALTERNATIVE IMPACTS (Contd)

Resource	Base Condition	Plan A	Plan B	Plan C	Plan D
Fishing	Hilo Breakwater	Adds 2 new breakwaters	Improved access, adds 3 new breakwaters, eliminates about 200 acres of reef.	Possible improvement, reduction of 5000 feet of breakwater	No effect
	Shoreline areas	No effect	No effect	Possible reduction of erosion along Bayfront beach	No effect
Boating	Wailoa River shoaling	No effect	No effect	No effect	No effect
	Radio Bay	"	"	"	"
	Reed's Bay	"	"	"	"
			Add new boat harbor		
Natural Hazards Volcanic	High risk	No effect	No effect	No effect	No effect
Tsunami	Very high risk	Increase potential damages.	Increased potential damages.	Potential wave height increase, & increased inundation elevations.	No effect
Endangered Species Humpback Whale (endangered)	No critical habitat in harbor, seasonal migration offshore.	No jeopardy	No jeopardy	No jeopardy	No jeopardy
Hawksbill Turtle (endangered)	No critical habitat seen in harbor possibly foraging.	No jeopardy	No jeopardy	No jeopardy	No jeopardy
Green Sea Turtle (threatened)	No critical habitat seen in harbor possibly foraging.	No jeopardy	No jeopardy	No jeopardy	No jeopardy

TABLE 3. COMPARISON OF ALTERNATIVE IMPACTS (Contd)

Resource	Base Condition	Plan A	Plan B	Plan C	Plan D
Hawaiian Coot (endangered)	Two nests in Waiakea Pond	No jeopardy	No jeopardy	No jeopardy	No jeopardy
Migratory Waterbirds Ducks	Winter population in Waiakea Pond.	No effect	No effect	No effect	No effect
Estuaries					
Waiakea Pond		No effect	No effect	No effect	No effect
Wailoa River		No effect	No effect	No effect	No effect
Wailuku River		No effect	No effect	No effect	No effect
Terrestrial Area	None	None created	85 acres created	None created	None created
Marine Resources Blonde Reef	16% coral cover, 220 acres.	6 acres covered 4 acres rocky intertidal habitat created.	120 acres dredged, 85 acres covered. 7 acres rocky intertidal habitat created.	Increased revitalization. 6.2 acres covered. 2 acres rocky intertidal habitat created.	No effect
Coconut Island Reef	10% coral cover 40 acres.	No effect	No effect	No effect	No effect
Fishery Resources	Recreational value high. Number of fish species high.	No effect	Possible decrease in resource abundance.	Possible increase in abundance.	No effect
Water Quality	Data incomplete to compare with State Water Quality Standards. High salinity gradient.	Increased gradient inner harbor.	No effect	Decreased gradient in bay. Increase in inner harbor.	No effect

TABLE 3. COMPARISON OF ALTERNATIVE IMPACTS (Contd)

Resource	Base Condition	Plan A	Plan B	Plan C	Plan D
Water Quality (Cont'd)	High turbidity, high nutrient concentration. High sedimentation.	Temporary turbidity stress; 190 days. No effect or sedimentation rate, make reduce sedimentation rate in inner harbor.	Temporary turbidity stress; 2 years. No effect or sedimentation rate.	Temporary turbidity stress; 190 days. No effect on sedimentation rate in harbor.	Temporary turbidity stress; 190 days. No effect Lower sedimentation on reef.
	Pollution discharges terminated.	No pollution discharges	No pollution discharges increased stormwater runoff from commercial wharf areas.	Increased dissolved oxygen concentration on reef and in bay.	No effect
Sediment Quality	Silt-day contaminated with Arsenic, PCB and Pesticides.	No change	No change	No change	No change
Ocean Dumping	EPA approved site available.	551,400 cy	No dumping required.	551,400 cy	551,400 cy
Historic Properties Hilo Breakwater	Hilo Breakwater eligible for inclusion to National Register of Historic Places.	No effect, adds two new breakwaters.	Effect not adverse. Realignment, add 3 new breakwaters.	Effect not adverse shorten breakwater.	No effect
Discharge of Fill or Dredged Material	Not applicable.	200,700 cy of stone for the breakwaters.	5,242,500 cy of dredged coralline material 603,300 cy of rock for the breakwaters & revetments.	22,700 cy of stone the breakwater; 5500 dolos (concrete armor units).	None required.

4. Affected Environment.

4.1 Environmental Conditions.

(1) Hilo is the capital and business center of the County of Hawaii. The 1980 population of Hilo was 42,320 (State of Hawaii, 1980), and continues to grow at a slow rate in comparison to the Kona side (western side) of the island. Hilo is considered a mildly depressed area with disproportionately higher unemployment than the State and has one of the lowest visitor counts in a State in which tourism is a major industry. Hilo's principal industry is sugar production, which is stable but not growing. The principal employers in Hilo are government, services and trades. The city of Hilo is situated along the shoreline of Hilo Bay and is a fully developed urban area. A University of Hawaii extension campus is located in the city together with the main county hospital, modern shopping centers and a variety of other commercial establishments. Hilo Harbor is the principal port-of-call and handles the most of cargo, agricultural and petroleum shipments in the County.

(2) Hilo Bay shoreline is essentially developed park open space as a result of local land use zoning in the tsunami hazard area. Residences are located along Baker's Beach and on Waiakea Peninsula along Banyan Drive. The developed nature of the shoreline and the high urbanized nature of the area precludes significant vegetation and wildlife habitats, except in Waiakea Pond and Wailuku River. The breakwater, Wailoa and Wailuku Rivers, and groundwater seepage into Hilo Bay are the principal factors influencing water quality in the bay. The breakwater traps freshwater discharged into the bay and reduces water circulation and exchange creating a significant salinity gradient in the bay. Sediment, cane and vegetation trash carried into the harbor by the tributaries discourage water contact recreation in the bay. Boating, recreational fishing, canoeing, and surfing are the as significant water contact recreational activities in the bay. Commercial fishing in the bay has declined although the principal commercial fishing facility in the region is located at Suisan Harbor, in the mouth of the Wailoa River.

4.2 Significant Resources.

(1) Recreation occurs all along the bay shoreline. Mooheau and Bayfront beach parks extend along the bay shoreline from the Wailuku River to the Wailoa River. There is both boat berthing and open space recreation in Wailoa River Park. Liliuokalani Gardens and Coconut Islands provide open space along the Waiakea Peninsula. Reed's Bay and Baker's Beach are swimming areas relatively free of trash from the Wailuku and Wailoa Rivers. Radio Bay is used for berthing of recreational craft and the Radio Bay Park provides additional open space within the harbor area. Hilo Breakwater is a frequently used fishing site, despite signs warning fishermen of the hazardous conditions on the breakwater. The breakwater is frequently overtopped during high surf conditions, and waves can sweep fishermen from the breakwater. Recreational fishing is the most significant recreational activity in the bay. Fishermen use every location in the bay as a fishing site, including the harbor facilities. Boating and canoeing are also important recreational activities together with wading. Swimming is not a major recreational activity, possibly due to the highly turbid waters in the bay and the trash in the water and on the shoreline. Five surf sites in the bay were identified by Kelly, 1981 (See Appendix G for details).

(2) Natural Hazards.

(a) Volcanic Hazards. Hilo is located in a high risk volcanic area exposed to lava flow threats, earthquakes and subsidence (See Appendix G). The risk generally decreases with distance from the northeast rift zone of Mauna Loa volcano. During the past 15 years the island of Hawaii has experienced 11 earthquakes with Richter magnitude ratings of 6 or more. The most recent in 1975 resulted in an estimated $4 million dollars of damage island wide. Most lava flows from Mauna Loa have stopped short of the Hilo suburbs. Public fears of volcanic damages and losses are still significant. At the present time, the Corps of Engineers is seeking Congressional authorization at the request of the State of Hawaii to react to threatening lava flows under emergency conditions.

(b) Riverine Flood and Tsunami Hazards. Hilo is subject to riverine flooding principally due to high intensity rainfall and surface runoff in undefined drainage ways. The flood prone areas are located within the Alenaio Stream floodplain, which is a tributary to the Wailoa River. Hilo is also subject to tsunami flood hazards. The tsunamis of 1946 and 1960 were particularly destructive resulting in the loss of 234 lives and about $52 million in property damage. After the 1960 Tsunami, vulnerable waterfront areas were rezoned to open space, such as the Bayfront and Wailoa River Parks, and structural design were required to reduce tsunami damages. The harbor area is located within the tsunami flood hazard area.

(3) Endangered Species. The endangered humpback whale seasonal migrates through waters outside of Hilo Harbor. The whales begin to appear in November and leave the islands by the end of June. The greatest number of whales in the islands appear during February and March. The National Marine Fisheries Service indicates that no whales have been sighted inside Hilo Harbor. Data indicate that the whales concentrate at Upolu Point in northern Hawaii, and suggest that the Hilo Harbor area is not a calving, nursing and breeding area in the Hawaiian Islands. The endangered hawksbill turtle and the threatened green sea turtles have been observed in Hilo Harbor possibly foraging for food. No nesting grounds exist in the harbor and no seasonal aggregations in the harbor have been reported. The turtles are also reported by the US National Marine Fisheries to forage along the entire coastline from Hilo to Kalapana.

(4) Endangered and Migratory Waterbirds. The endangered Hawaiian coot was reported nesting in Mouholi Pond within Waiakea Pond. The pond has not been declared a wildlife refuge or critical habitat for the coot by the US Fish and Wildlife Service. During the winter season, migratory ducks are frequently seen in Waiakea Pond.

(5) Estuaries. Reed's Bay, Waiakea Pond, Wailoa River and Wailuku River are estuaries within the Hilo Bay and Harbor area. Approximately 1000 mgd of freshwater is discharged into the harbor from the tributaries and springs. The estuaries are important recreational fishing areas within the bay and are planned for open space. Reed's Bay, Wailoa River and Waiakea Pond are planned by the local government for park use, and Wailuku River is planned for a natural wilderness area.

(6) Marine Resources. The two important marine areas within the bay are the areas with the greatest coral cover, Blonde Reef (16% coral cover) and Coconut Island (10% coral cover). Both the live and dead coral mass on Blonde Reef and at Coconut Island provide habitat for a variety of reef fish important to recreational fishing in the bay. Commercial fishing in the bay has declined, but the sale of the catch occurs at Suisan Harbor and fish market at the mouth of the Wailoa River. Fishermen suggest that fish stocks are declining due to over-exploitation, sedimentation and chemical pollution. Although exact factors affecting fish abundance have not been determined, high water turbidity does reduce spear fishing success and sedimentation can bury fish shelter and food resources reducing the amount of nearshore fish habitat.

(7) Water Quality.

(a) The data are insufficient to compare existing conditions with new State of Hawaii Water Quality Standards which were revised in September 1979. Based on previous standards, water quality in Hilo Bay was poor due to high nutrient concentrations, high water turbidity, high suspended solids concentration and high chlorophyll-a concentration. However, water quality is significantly improved from the past when sugar mills, the Canec Plant and the City of Hilo discharged their wastewaters directly into the bay.

(b) In general, water inside and outside the breakwater is vertically stratified due to the discharge of ground and riverine water into the ocean, and the salinity gradient inside the harbor is greater than that outside due to the reduced mixing behind the breakwater. The depth of the freshwater layer in the bay reaches 20 feet indicating that mixing is occurring between surface and bottom layers, but not sufficient to reduce the salinity gradient. The depth of freshwater on Blonde Reef reaches 10 feet inside the breakwater. The primary water column mixing forces are wind and occassional ship traffic. Nutrient concentrations and suspended solids and turbidity vary with the volume of surface runoff and groundwater discharge entering. Fecal strep bacteria tend to survive longer in the bay due to the freshwater layer in the bay than other areas in the State. Chlorophyll-a concentration vary with water turbidity increasing during periods of low riverine flow and decreasing during periods of high flow. Water temperature in the surface

layer is warmer than the bottom layer due to solar heating, but is colder near the source of groundwater discharge. During periods of low freshwater discharge, solar heating can warm the bottom layer because the depth of the freshwater layer is reduced.

(c) Sedimentation and Sediment Quality. The sediment in the harbor entrance channel and turning basin consists of silty-clays. The low wave energy environment behind the breakwater allows much of the water-borne sediment to settle out in the harbor and on Blonde Reef where the sediment smothering and destroying the reef ecosystem. The rate of sedimentation may be slow based upon the frequency of maintenance dredging in Hilo Harbor -- once every ten years. In 1977, about 54,000 cubic yards of material was removed from the harbor during the maintenance cycle and the material was disposed of by ocean dumping at the EPA approved Hilo ocean disposal site. However, about 35,000 tons of silt per year are deposited in the bay from the Wailuku River, the quantity may be less than in the past, because a 1881 lava flow covered up erodible soils within the Wailuku River drainage basin and the termination of the discharge of 20,000 tons of sediment a year from the Wainaku Sugar Mill which closed in 1976. Based upon sediment analysis by the State Department of Health, Hilo Bay sediments are contaminated with arsenic, PCB and chlordane. Arsenic trioxide was discharged into Waiakea Pond by the Canec Plant, and the PCB's probably originated from the Shipman Power Plant near the Wailoa River. Chlordane probably occurs due to agricultural activities and use as a termicide in home construction in Hilo.

TABLE 4

Contaminant Concenteration in Hilo Harbor Sediments.

Total Arsenic concentration: Range from 33-104 ppm

PCB concentration: A mean value of 200 ppb

Chlordane concentration: a mean value of 2-84 ppb

Source: State of Hawaii, 1978

Tests of crab and fish tissue indicate that arsenic and PCB are not bioconcentrating in the tissue. Fish viscera contained chlordane residue in concentrations 3-4 times higher than the flesh, where concentrations ranged from 80-160 ppb.

(9) Ocean disposal Site for Dredged Material. In 1981, the US Environmental Protection Agency designated a permanent ocean disposal site for dredged material of Hilo Harbor. The site is located 8 miles northeast of Hilo Harbor in ocean depths ranging from 330 to 340 meters. The surface currents in the area ranged in velocity from 15 to 36 cm/sec in a predominantly northwesterly direction. The bottom sediment was silty clay, and the site is also located outside of the major commercial fishing grounds. The dump site is not a site of up-welling. In 1977, about 54,000 cubic yards of dredged material from Hilo Harbor were discharged at the dump site. In 1962, approximately 85,000 cubic yards of dredged material were removed from Hilo Harbor and disposed of in the ocean offshore from Hilo.

TABLE 5

EPA Dredged Material Disposal Site for Hilo Harbor

Location: Center Point Latitude 49° 48" 30" N
Longitude 154° 50' 30" W

Size: Circular with radius of approximately 920 meters

Primary Use: Dredged Material

Period of Use: Continuing use

Restriction: Disposal shall be limited to dredged material

Source: Federal Register, (46)115: June 16, 1981 (31412).

(10) Air Quality. Air quality in Hilo is good, lacking major industrial emissions. The sulfur dioxide concentration in 1980 was less than 5 micograms per cubic meter. Volcanic gases, agricultural fires, sugar mills, both aircraft and automotive engines and the power plant are the only major sources of air pollution in the Hilo area.

(11) Noise. Hilo is a quiet urban area with the exception of aircraft landing and taking off from Hilo Airport, the aircraft landing pattern takes aircraft over the bayfront area.

(12) Historic Resources. The Hilo Breakwater was determined to be eligible for inclusion to the National Register of Historic Places by the Keeper of the Register in 1980. The Keeper of the Register indicated that the breakwater was significant in the areas of commerce, and transportation for the vital role that it played in the development of the port of Hilo, the historic main port of entry for the island of Hawaii, and that the breakwater has retained its essential physical integrity despite alterations to its original design, function and visual appearance. The State Historic Preservation Officer had indicated that the breakwater was associated with events that facilitated railroad and port expansion in Hilo, the reestablishment of Hilo as the hub of transportation on the island of Hawaii and the growth of Hilo. The 2-mile long breakwater is also the longest breakwater in the state and continues to be a visible entity in the bay. For 50 years the breakwater has stood 1 mile offshore in Hilo Bay; and has been damaged by past tsunamis. The design changes necessary to maintain navigation safety in the bay and to allow continued use of the port by Hawaii's industries.

5. Environmental Effects.

5.1 Social. The improvements will not alter Hilo's population growth or influence its existing economic trend. No humans will be displaced. The harbor will remain in industrial and commercial use, and management will remain with the State of Hawaii.

5.2 Recreation. None of the plans will have a direct impact on existing park areas in Hilo Bay. The construction of two new breakwaters in Plan A will attract fishermen and increase the amount of fishing sites in Hilo Bay, despite warnings that the fishing locations on the breakwaters are hazardous. Plan B provides the largest increase of recreational fishing area by creating 85 acres of land area from Blonde Reef for use as park, small boat harbor and container storage. Plan C provides 2000 feet of breakwater fishing sites in replacement of the 7000 feet of existing breakwater which will be removed or allowed to deterioate. However, the modification of the existing breakwater may improve surfing in the bay due to increased wave action on Blonde Reef and around Wailuku River and Coconut Island. The modification may also reduce erosion along Hilo Bayfront Beach by reestablishing the westward littoral transport along the beach. Plan D makes no contribution to recreation in Hilo Bay and will not degrade existing recreation.

5.3 Natural Hazards.

(a) Volcanic Hazards. None of the plans increase volcanic hazard risks.

(b) Tsunami and Riverine Flood Hazards. None of the plans affect riverine flooding along the Alenaio Stream floodplain. Plan C, which reduces the breakwater length by 7000 feet, may possibly allow a higher tsunami wave to reach the shore, since the breakwater may presently reduce the tsunami wave energy. Model or other engineering studies will have to be performed to determine the effect of breakwater removal or deterioration on the tsunami hazard. Plan B increases the amount of damageable property, i.e., container storage, small boat harbor, located within the tsunami hazard zones. Plan A located two new breakwaters in the tsunami hazard area also increasing potential tsunami damages.

5.4 Endangered Species.

(a) Endangered humpback whale. None of the plans will affect the migratory route of the humpback whale, or any critical whale calving, nursing or breeding areas in Hawaii. Ocean disposal of dredged material under Plans A, D and C would occur in offshore waters used by the whales. If the dumping was conducted during the migratory season, the dumping would not hinder whale movement through the area. The operation of the conveyance vessel would create underwater sounds which the whales may find unpleasant, but should not affect their migration. In Glacier Bay, Alaska, the operation of tour boats averaging about 100 tons displacement appeared to interfere with whale feeding and possibly their use of the area. However, during their migration through Hawaiian waters, the whales are not known to feed and are not confined in an embayment.

(b) Endangered hawksbill turtle and threatened green sea turtle. Plan D involves the least modification to the existing harbor and does not alter available foraging in Hilo Harbor. Plan C probably increases foraging habitat in Hilo Harbor if the breakwater is lowered below sea level. Slow deterioation of the breakwater or segmented breaching of the breakwater will not provide as much foraging area in short period of time as compared to lowering the breakwater. Plan B involves the greatest change to the existing harbor and eliminates 200 acres of Blonde Reef, which may be used for foraging by the turtles. None of the plans would affect turtle nesting areas or areas of turtle aggregations in Hawaii. The plans would not eliminate foraging area along the coast outside of Hilo Harbor.

(c) Endangered Hawaiian Coot. None of the plans involve modification of Waiakea Pond where the endangered Hawaiian Coot was reported nesting.

5.5 Migratory Waterbirds. None of the plans involve modification of Waiakea Pond where migratory ducks have been observed.

5.6 Estuaries. None of the plans involve work in the Wailuku River, Wailoa River, Reed's Bay estuaries.

5.7 Marine Resources.

(a) Dredging in Hilo Bay will involve removing material from Blonde Reef and the silty areas in the commercial port. The activity will eliminate resident benthic infauna within the dredged areas and will temporarily increase siltation and turbidity stress in adjacent areas. Recolonization of dredged and stressed areas is anticipated, but species diversity on Blonde Reef will be lowered by decreasing the available hard substrate and creating more silty habitat. Recolonization of the silty mud environment will occur more quickly and by different species compared to damaged coral areas because of the homogenity of the habitat and the relatively high mobility and tolerance of the fauna to sediment compared to reef organisms attached on the solid substrate. However, the benthic faunal assemblage will be less diverse than the reef.

(b) During dredging, an artificial feeding situation will develop as predatory fish will exploit food resources displaced, exposed, or stirred up by the dredging activities. This fish concentrating effect will attract fishermen to the area. The loss of a portion of Blonde Reef is not expected to eliminate the presence of any fish resource in the bay, but it may influence the abundance of some species by reducing available reef habitat.

(c) Plans A, C and D involve removing silt from 80 acres muddy, silt bottom habitat within the existing harbor entrance channel and turning basin. The loss of any benthic infaunal organisms would be typical of the impact associated with present periodic maintenance dredging activities. The dredging activities would temporarily increase water turbidity adding to the sedimentation and turbidity stress already experienced in the harbor and on Blonde Reef. The extent of turbidity and sedimentation stress cannot be accurately predicted in light of the heavy siltation and turbidity present in the harbor due to the Wailuku River. However, the extent of stress maybe grossly estimated based upon the number of days it takes to complete the dredging action. Plan B involves dredging and filling 200 acres of Blonde Reef reducing the available coral and fishery habitat in Hilo Bay and temporarily increasing sedimentation stress. The Plan will create 120 acres of silt habitat which would have a lower diversity of organisms and a lower abundance of recreationally important fish.

Plan C may possibly benefit the environment. Increased wave energy over Blonde Reef may flush silt from the reef reopening habitat for fishery resources and possibly allowing the recolonization of coral on the reef. If wave energy along the Hilo shoreline is increased, other silt covered areas may also be cleared and recolonization given a chance to succeed.

5.8 Water Quality.

(a). All plans involve dredging and a temporary increase in water turbidity as a result of dredging. The impact is a cumulative impact which adds to the stress already created by the influx of sediment from the tributaries entering Hilo Bay. Usually the color of the water returns to normal within a day, but transmissiometer and visual underwater observations indicate that fine sediments remain in suspension longer obscuring underwater visibility. The duration of dredging is used as a gross indicator of the extent of turbidity change anticipated. None of the plans affect the amount of sediment carried into the harbors, but the changes to the current patterns in the bay will alter the sedimentation patterns.

(b). Hilo Harbor has a silty-clay bottom and deepening the channel and turning basin from -35 feet MLLW to -40 feet MLLW could probably be performed using a hopper dredge (ship type dredge with suction booms and dredge material storage bins (hoppers)) during a normal maintenance dredging cycle. However, hydraulic suctions dredges and mechanical clamshell dredges could also be used. The hydraulic dredge could pump fluid mud from the harbor bottom into a barge which would be towed to the dump site. Overflow water usually contains fine silt and creates a highly turbid plume. Clamshells or draglines without containment buckets also cause turbid plumes, but the cohesive clays stay within the bucket. While material falling from the bucket and water draining from the bucket contribute to water turbidity, a fluid mud condition, where the sediment is entrained in a large volume of water is not created. In dredging the harbor under Plan B, where the dredged material is used for construction material, a hydraulic cutter head dredge would probably be used and the material pumped to the contained fill site. Turbidity plumes would also be expected, but the containment area confines the discharged dredged material slurry, allowing time for the material to settle out from the water. Water returning to the harbor could be less turbid than the harbor water, if sufficient settling time is allowed within the containment area.

(d) Sedimentation and turbidity stress related to dredging is dependent upon the characteristics of the material being dredged, the type of dredge used, and the direction and strength of water currents in the dredge area. The material dredged from Hilo Harbor is expected to consist of silty clays from the existing harbor channel and basin, and coralline rubble and rock aggregate from Blonde Reef. Blasting may be required. A suction dredge with barge and a mechanical dredge, clam shell or dragline, have the potential of increasing suspended sediment load, turbidity conditions, and siltation stress because water turbulence and water draining from the bucket and barge can wash dredged material into the bay. Hydraulic suction dredges combined with land disposal of dredged spoils create the least amount of water turbidity since material and water are drawn from the bottom and pumped to a retention pond where sediment is allowed to settle out of the water. Leaks from the pipelines and physical disturbance of the bottom are primarily responsible for turbid plumes associated with hydraulic dredging. The material previously dredged from Hilo Harbor during the 1977 maintenance dredging consisted entirely of silty clay; 50% of the material had a grain size smaller then 0.010 millimeters. While most of the material dredged may be plastic and cohesive, some loose fine material can be washed into the water where the material can remain in suspension for a considerable length of time. For example, a particle with a grain size of 0.10 can take about 33 minutes to settle 1-foot in the absence of strong currents. Dredging on hard coral and rock can create fine silt particles, but most of the material will probably be coarse to medium size material with large grain sizes that can settle out quickly. For example, particles with grain size in the range of 5 to 1 mm can settle 1-foot in 0.3 to 3 seconds. Much of the fine material suspended by dredging on hard substrates is usually material which has settled out from the water column. Drogue studies (Reference M & Pacific, 1980) indicate that water currents will carry turbid water from the commercial harbor out to the harbor mouth. However, the closer dredging is located to Blonde Reef, the greater the possibility of suspended silt carried over the reef.

(e) Rough calculations indicate that current velocities in the commercial harbor range from 0.03 to 0.19 knots and can convey non-cohesive fine silt particle (size 0.10 mm) a long distance (9,200 feet based on a particle settling velocity of 0.0005 feet/second, current speed of 0.3 knots, and water

depth of 16 feet) from the dredge site. Coarse material (size 5mm) can settle out within 14 feet of the dredge site (based on particle settling velocity of 0.33 feet/second, water depth of 16 feet and current speed of 0.3 knots). Medium grained material will probably have a more detrimental effect on reef life than fine coarse material. The medium material is expected to have a settling rate which may exceed tolerance of some benthic species. The material will settle out within moderate distances from the dredge, where it can bury or smother cone benthic organisms, and cannot easily wash from the surface under reduced wave conditions experienced in Hilo Bay. While turbidity can induce stress to photosynthetic organisms, the effect is temporary as water clarity will return to ambient levels after termination of dredging. The period of stress may be long, depending upon the length of time required to complete the dredging, and can be aggravated by rainfall induced turbidity. The period of stress may be long depending upon the length of time required to complete the dredging. Periodic rainstorms impart similar sediment stresses in Hilo Bay because large amounts of sediments can be discharged from rivers and streams entering the bay.

(c) The breakwaters in Plan A further restrict mixing within the inner harbor and will possibly increase the salinity gradient within the harbor due in part to the groundwater dishcarge in the inner harbor. The groundwater discharge will probably create a net surface outflow from the harbor and may tend to keep sediment laden water from the tributaries out of the harbor basin possibly reducing the rate of sedimentation in the harbor turning basin.

(d) Plan B reduces the water surface area in the harbor by 85 acres and deepens 200 acres of the harbor. The shallow areas in the harbor have a good rate of water exchange due to tide and movement of the top layer of water in comparison to the deep areas in the harbor where tidal movement is the principal factor affecting water movement and exchange. The increased land surface area along the breakwater increases surface runoff from the commercial and industrial area which will contribute roadway pollutants into the bay.

(e) Plan C will probably improve water quality in the bay. While the new breakwater may tend to restrict mixing within the inner harbor, mixing will be improved in the outer harbor due to increased wave energy. As in Plan A, the inner harbor will probably have an increased salinity gradient with a net

surface outflow. In the outer harbor wave energy over Blonde Reef will increase as the breakwater deteriorates or due to other breakwater modifications, such as breaching or lowering to -8 feet MLLW. Wave turbulence will increase the amount of dissolved oxygen in the water over the reef. Water currents will carry the oxygen laden water into the bay possibly improving dissolved oxygen concentrations in the deeper areas. Wave turbulence will also decrease the salinity gradient over the reef. The less saline top layer presently extends to a depth of 10 feet over the reef. Presently wind, ship traffic and shear forces between the layers are factors influencing mixing in the bay. Wave energy will add another factor influencing mixing and the water pushed into the bay by wave action will be a force influencing the rate of water exchange.

(f) Plan D does not affect water quality in the bay because it involves the least modification to the existing bay environment. The anticipated increase in ship traffic in the bay may also help to improve water column mixing, as the ship propellors create forces which mix the two water layers in the bay.

(g) Sediment Quality. None of the plans will improve or further degrade sediment quality. The removal of 551,400 cubic yards of contaminated sediment in Plans A, C and D may temporarily improve conditions in the bottom for infaunal organisms, but the continued movement of contaminants for inland and upland sources into the bay and the movement of contaminated sediment in the bay into uncontaminated areas essentially maintains existing conditions in the bay sediment quality.

5.9 Ocean Dumping.

(a) The probable impacts of ocean dumping are discussed in the Corps of Engineers, "Final Environmental Impact Statement Harbor Maintenance Dredging in the State of Hawaii," 1975, and the US Enviromental Protection Agency, "Final Environmental Impact Statement for Dredged Material Disposal Site Designation", 1980. In summary, the dump site has a silty-clay substrate and is dominated by a polychaete infauna. The level of biological activity is lower than at shallower coastal waters. The site is not a significant

commercial fishing ground. The water depth and coastal currents provide significant dilution and dispersion of the dredged material. Agitation of the dredged material in the water column may create a temporary nutrient increase and a temporary depression in dissolved oxygen concentrations. Short-term biostimulation may occur, together with mounding and faunal shifts on the bottom. Suspended sediment load and water turbidity will temporarily increase. Some plankton may be entrapped in the sediment falling through the water column. The material deposited on the ocean bottom will smother some organisms, but repopulation is anticipated. Toxic effects and pollutant accumulation are possible, and bioassay and bioaccumulation tests performed prior to disposal will be used to assess the effects of the material on test animals representing the population of both the dump and dredging sites. In accordance with US Environmental Protection Agency regulations, bioassay and bioaccumulation tests on the dredged material will be performed and the results submitted to EPA for their review and approval of the ocean dumping activity. The tests are designed to predict toxic effects of the dredged material on organisms representative of the dump site and any bioaccumulation which might occur. However, the use of representative organisms does not accurately predict conditions and consequences which may occur in the actual deep ocean environment where organisms and environmental conditions are poorly studied and not well documented or researched.

(b) State Department of Health analysis of sediment samples from Hilo Bay suggest that dredged material from the silty environment contain high concentrations of arsenic, PCB and chlordane. The presence of bioassay and bioaccumulation analysis may find the material unsuitable for ocean dnumping in accordance with EPA criteria. However, the presence of the pollutants may also make it unsuitable for land disposal. If so, the material may have to be either mixed with non-toxic material to dilute its toxicity, packaged prior to disposal, incinerated, biologically or chemically treated, or discharged into the ocean at a low rate to allow adequate dilution. In the aquatic environment, the pollutants, especially heavy metals, are in a stable physiochemical environment not subject to wide variations in pH or reduction-oxidation (redox) potential. Thus, the pollutants tend to be bound to the sediments and not readily available for biological uptake. When sediments are stirred up either by wave energy or dredging, the concentrations of pollutants initially increases, but rapidly decrease as the materials are oxidized.

5.10 Upland Disposal. In upland disposal sites, the dredged material undergoes a wide variation in pH and redox potential, and pollutants are readily released from the material. The presence of the pollutants can toxify the soil, preventing the growth of plants or limit the availability of other nutrients needed for plant growth. The pollutants can also be leached from the soil into the groundwater where they can possibly be conveyed into coastal waters by spring water or into subsurface drinking water souces. The plants may be able to bioconcentrate some of the pollutants, possibly removing the pollutants from the soil and limiting their availability in the environment.

Initially soil salinity of the dredged spoil will prevent the growth of plants, except for those with a high salt tolerance. The salt will be leached from the material by rainfall, eventually permitting the growth of some vegetation. Because of the potential adverse environmental effects, a suitable land disposal site should not be adjacent to potable groundwater sources and should not be in agricultural use if the material is to be disposed of in potentially toxic concentrations. Erosion control methods will have to be employed to keep the material within the disposal site. If the dredged material is found to have significant amounts of toxic material that could form leachates, disposal may require use of an approved hazardous waste disposal site. No such sites are in Hawaii. Leachate tests will have to be performed on the contaminated dredged material to determine the potential of toxic materials leaching from the material. In Hawaii, leachates can percolate through the porous volcanic material and enter the groundwater, possibly contaminating drinking water sources or municipal water supplies. Encryptment, impervious linings and locating the disposal site close to the shore where the groundwater is unsuitable for drinking may be alternatives used in land disposal. The dredged material in Plans A, C and D consists of silty-clays, which are unsuitable as construction material, but may be used as sanitary landfill cover. The dredged materail in Plan B consists of coralline material suitable for fill, which would be used to create the land areas along the breakwater.

5.11 Air Quality. Only Plan D has the potential for affecting air quality, since the dredged material will be used to create land. The dredged material will be a source of dust until the areas are improved, or paved. The only habitated areas that will be affected are the homes at Baker's Beach and the hotels along Banyan Drive.

5.12 Noise Quality. None of the plans will result in a long-term increase in noise. The operation of equipment in the construction of the breakwaters and dredging and filling in Plan B will be temporary noise sources. The duration of construction is a gross measure to the extent of the noise pollution. The only habitated area which will be affected are the homes along Baker's Beach and the hotels along Banyan Drive.

5.13 Historic Resources. Extensive modification of the breakwater may adversely affect the breakwater as a historic site. While the breakwater will continue to exist, its length will be shorter and its configuration will be altered. The port area will continue to exist and its operational capability improved. The history of the Hilo Area and breakwater is recorded in a historical report prepared by the Bishiop Museum for the Honolulu District and the remaining portions of the breakwater will continue to serve its historic function.

6. Public Involvement

6.1 Public Involvement Program. The public involvement program has consisted of meetings and workshops with the public at large, meetings and workshops with members of the Federal, State, and County agencies, and the distribution of various reports and documents resulting from studies conducted under the Hilo Area Comprehensive Study to the public and agencies concerned with the progress of the study. In total, 10 public meetings were held including the initial public meeting in 1976, and eight technical studies have been released to the public. Tsunami hazards were the most frequent concern expressed by the public and the agencies. Needs for small craft berths, ramps, and other facilities were also expessed. Surge (ship motion) in Hilo Harbor was the most frequent problem mentioned for deep-draft navigation, and beach restoration of the Bayfront beach was the most frequent recreational need. See Appendix C of the main report for further details.

6.2 Required Coordination. The following coordination must be completed with the following agencies:

a. Clean Water Act, Section 404 Evaluation. The EIS contains an evaluation of the effects of the discharge in accordance with US Environmental Protection Agency requirements for review by Congress prior to authorization of the project. The U.S. Environmental Protection Agency has an opportunity to review and comment on the EIS and the evaluation.

b. CZM Consistency. A Hawaii Coastal Zone Management Program evaluation to determine project consistency with the program must be coordinated with the State Department of Planning and Economic Development.

c. Endangered Species Act Consultation. A determination of no jeopardy to the humpback whale, hawksbill turtle and green sea turtle on the Federal List of endangered and threatened species was forwarded to the National Marine Fisheries Service on 1 July 1981.

d. US Fish and Wildlife Coordination. The US Fish and Wildlife Service has provided a preliminary opinion of project impact on fish and wildlife resources, and an official report is expected in September 1981 prior to preparation of the final project report and environmental impact statement.

e. Marine Protecton, Research and Sanctuaries Act, Ocean Dumping. Bioassay and bioaccumulation test procedures need to be developed and approved by US Environmental Protection Agency, and the tests performed prior to ocean disposal of dredged material in Plans A, C and D. The results of the test must be coordinated with the US Environmental Protection Agency, which will decide whether or not to permit the ocean dumping of the dredged material. A public notice of intent to dispose of the dredged material in the ocean will be released following the completion of the tests.

f. Historical and Cultural Coordination. Plans B and C require coordination with the State Historic Preservation Officer and the US Advisory Council on Historic Preservation since the plans involve the modification of the historic Hilo breakwater. A determination of effect was requested from the State Historic Preservation Officer on 23 July 1981.

g. *Flood Plain Evaluation.* Not required since the project is not located in a flood plain.

h. Wetland Evaluation. Not required due to the absence of the resource.

i. National Environmental Policy Act. Following public renew of the draft EIS, the final EIS must be filed with the U.S. Environmental Protection Agency.

j. State and County Approvals. The State of Hawaii, Department of Transportation, is responsible for obtaining all necessary local permits and approvals and satisfying the State NEPA requirements. The Federal EIS and CZM discuss the construction impacts and compatibility of the action to local policies, but does not address actions to be planned by the State.

6.3 Statement Recipients. The following agencies and public-at-large were sent copies of the draft environmental statement and survey report.

6.4 Public Views and Responses (To be completed after review of the draft environmental impact statement.)

Administrator, SW Region, Western
Pacific Prog Ofc, Nat Marine
Fisheries Svc, US Dept of Com
P.O. Box 3830
Honolulu, HI 96812

Director of State Clearinghouse
Dept of Planning & Economic Devel
P. O. Box 2359
Honolulu, HI 96804

Director, International Tsunami
Information Center
P.O. Box 50027
Honolulu, HI 96850

Director, Pacific Region
National Weather Service, NOAA
US Department of Commerce
300 Ala Moana, Box 50027
Honolulu, HI 96850

Manager, Pacific Islands Office
US Environmental Protection Agcy
300 Ala Moana Blvd, Room 1302
Honolulu, HI 96850

Endangered Species Coordinator
Div of Endangered Species, FWS
US Dept of the Interior
300 Ala Moana Blvd, Box 50167
Honolulu, HI 96850

Hawaii Administrator
Fish & Wildlife Service
US Dept of the Interior
300 Ala Moana Blvd, Box 50167
Honolulu, HI 96850

Director, National Park Service
Hawaii State Office
US Dept of the Interior
300 Ala Moana Blvd, Rm 6305
Honolulu, HI 96850

Director
Ofc of Environmental Quality
Control, State of Hawaii
550 Halekauwila St
Honolulu, HI 96813

Director
Department of Health
State of Hawaii
1250 Punchbowl St
Honolulu, HI 96813

Administrator
Division of State Parks
State Dept of Land & Nat Resrs
P. O. Box 621
Honolulu, HI 96809

Director
Division of Fish and Game
State Dept of Land & Nat Resrs
1151 Punchbowl St
Honolulu, HI 96813

State Forester
Forestry & Wildlife Div
State Dept of Land & Nat Resrs
1151 Punchbowl St
Honolulu, HI 96813

Administrator
Land Management Div
State Dept of Land & Nat Resrs
P. O. Box 621
Honolulu, HI 96809

State Historic Preservation Officer
State Dept of Land & Nat Resrs
P. O. Box 621
Honolulu, HI 96809

Chairman
Board of Land & Nat Resrs
State of Hawaii
P. O. Box 621
Honolulu, HI 96809

Manager-Chief Engineer
Water & Land Development Division
State Dept of Land & Nat Resrs
P. O. Box 373
Honolulu, HI 96809

Marine Affairs Coordinator
State of Hawaii
P. O. Box 2359
Honolulu, HI 96813

Director
Dept of Planning & Economic Devel
State of Hawaii
P.O. Box 2359
Honolulu, HI 96804

Chief
Conserv & Resrs Enf Div
State Dept of Land & Nat Resrs
1151 Punchbowl St
Honolulu, HI 96813

Director
Inst of Pac Isls Forestry
Forest Svc, US Dept of Agrcltr
1151 Punchbowl St, Rm 323
Honolulu, HI 96813

State Conservationist
Soil Conservation Service
US Dept of Agriculture
300 Ala Moana Blvd, Box 50004
Honolulu, HI 96850

Director
US Department of Energy
300 Ala Moana Blvd, Box 50168
Honolulu, HI 96850

Administrator, Hawaii Division
Federal Highway Administration
300 Ala Moana Blvd, Box 50206
Honolulu, HI 96850

Manager, Honolulu Area Office
US Dept of Housing & Urban Devel
300 Ala Moana Blvd, Box 50007
Honolulu, HI 96850

District Chief
Geological Survey
US Dept of the Interior
300 Ala Moana Blvd, Rm 6110
Honolulu, HI 96850

Director
Department of Transportation
State of Hawaii
869 Punchbowl St
Honolulu, HI 96813

Commander
Fourteenth Coast Guard District
ATTN: Planning Officer
300 Ala Moana Blvd
Honolulu, HI 96850

Director
Water Resources Center
University of Hawaii
2444 Dole St
Honolulu, HI 96822

Chief, Public Works Division
Dept of Acctg & Gen Svcs,
State of Hawaii
1151 Punchbowl St
Honolulu, HI 96813

Attorney General
State of Hawaii
Honolulu, HI 96813

Chairman
Board of Agriculture
State of Hawaii
1428 South King St
Honolulu, HI 96814

Director, Environmental Ctr
University of Hawaii
2550 Campus Rd, Crawford 317
Honolulu, HI 96822

Chairman
Public Utilities Commission
Dept of Budget & Finance
1164 Bishop St, Suite 911
Honolulu, HI 96813

Director
Dept of Budget & Finance
P. O. Box 150
Honolulu, HI 96813

Hawaii Institute of Marine Biology
University of Hawaii
P. O. Box 1346
Kaneohe, HI 96744

Hawaii Public Library
Hawaii Mediamobile
300 Waianuenue Ave
Hilo, HI 96720

Harbormaster
Dept of Transportation
State of Hawaii
P. O. Box 397
Honolulu, HI 96809

Chief
Highways Div, DOT,
State of Hawaii
869 Punchbowl St
Honolulu, HI 96813

Director
Dept of Hawaiian Home Lands
State of Hawaii
P.O. Box 1879
Honolulu, HI 96805

Association of Hawaiian Civic
Clubs
Hawaii Council
P. O. Box 1560
Hilo, HI 96720

Big Island Fish & Game Assn
c/o Dept of Land & Natural Resr
75 Aupuni St
Hilo, HI 96720

Hawaii Leeward Planning Conf
c/o Mr. W. Y. Thompson
P. O. Box 635
Kailua-Kona, HI 96740

President
Hawaii Society of Professional
Engineers, Big Island Chapter
P. O. Box 942
Hilo, HI 96720

Hilo Downtown Improvement Assn
P. O. Box 1502
Hilo, HI 96720

Hilo Sailing Club
P. O. Box 1774
Hilo, HI 96720

Conservation Council for Hawaii
Hawaii Island Chapter
Hawaii National Park, HI 96718

Japanese Chamber of Commerce &
Industry of Hawaii
Hata Building, Room 5
318 Kamehameha Ave
Hilo, HI 96720

Kailua Trolling Club
30 Palani St
Hilo, HI 96720

Kawaihae Trolling Club
P. O. Box 33
Kamuela, HI 96743

Kona Mauka Trollers, Inc.
P. O. Box 1455
Kealakekua, HI 96750

Kona Yacht Club
P. O. Box 546
Kailua-Kona, HI 96740

Hawaii Audubon Society
c/o Ms. Mae E. Mull
P. O. Box 275
Volcano, HI 96785

Hawaii Civic Club
c/o Mr. Herbert A. Kai
301 Makani Circle
Hilo, HI 96720

Hawaiian Civic Club
c/o Mr. Samuel Hooke
P. O. Box 461
Kamuela, HI 96743

Manager
Hawaii Electric Light Company
1200 Kilauea Ave
Hilo, HI 96720

Hawaii Island Board of Realtors
100 Pauahi St, Room 212C
Hilo, HI 96720

Hawaii Island Chamber of Commerce
180 Kinoole St
Hilo, HI 96720

Hawaii Island Chamber of Commerce
ATTN: Transportation Committee
180 Kinoole St
Hilo, HI 96720

League of Women Voters
c/o Mrs. John Zelko
205 Kaiulani St
Hilo, HI 96720

Hawaii District Land Agent
Land Management Division
DLNR, State of Hawaii
Hilo, HI 96720

District Administrator
Division of State Parks
DLNR, State of Hawaii
75 Aupuni St
Hilo, HI 96720

District Administrator
Div of Water & Land Devel
DLNR, State of Hawaii
75 Aupuni St
Hilo, HI 96720

Hawaii District Manager
Harbors Division
DOT, State of Hawaii
Port of Hilo
Hilo, HI 96720

Sea Grant/Marine Advisory Program
University of Hawaii Kona Office
P. O. Box 559
Kealakekua, HI 96750

Hawaii District Engineer
Highways Division
DOT, State of Hawaii
50 Makaala St
Hilo, HI 96720

Sea Grant/Marine Advisory Program
University of Hawaii at Hilo
Richardson Ocean Center
2349 Kalanianaole St
Hilo, HI 96720

Dept of Land & Natural Resources
Div of State Parks
Historic Sites Section
P. O. Box 621
Honolulu, HI 96809

Soil and Water Conservation
District
P. O. Box 1361
Hilo, HI 96720

Mr. Richard Thoren, President
Hilo Trolling Club
Route 1, Box 154-A
Papaikou, HI 96781

Director
Department of Parks & Recreation
County of Hawaii
25 Aupuni St
Hilo, HI 96720

Director
Dept of Planning
County of Hawaii
25 Aupuni St
Hilo, HI 96720

Chairman
Planning Commission
County of Hawaii
25 Aupuni St
Hilo, HI 96720

Chief Engineer
Dept of Public Works
County of Hawaii
25 Aupuni St
Hilo, HI 96720

Keaukaha School
Desha Ave
Hilo, HI 96720

Director
Dept of Research & Development
County of Hawaii
25 Aupuni St
Hilo, HI 96720

Managing Engineer
Dept of Water Supply
County of Hawaii
25 Aupuni St
Hilo, HI 96720

Mr. Herbert Mann
P. O. Box 28
Volcano, HI 96785

Mr. Edward Bumatay
HFD
44 Elm Dr
Hilo, HI 96720

Mr. Dave Soderlund
Hilo Sailing Club
P. O. Box 1774
Hilo, HI 96720

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List of Preparers:

The following people were primarily responsible for preparing this Environmental Impact Statement.

Mr. Michael T. Lee	Biology	BA, Biology; 1 year Biologist, US Navy; 9 years EIS studies, Corps of Engineers.	Preparer, overall impact assessment.
Mr. William B. Lennan	Zoology	BA, Zoology; 2 years postgraduate studies, University of Hawaii; 2 years fishery biologist, US Fish and Wildlife Service.	Fish and Wildlife assessment.
Dr. James E. Maragos	Marine Ecology	BS, Zoology; PhD, Oceanography; 2 years postdoctoral research; 8 years environmental consultant; 5 years EIS studies, Corps of Engineers.	Review, overall impact assessment.
Mr. David G. Sox	History and Culture	BA, MA Geography; 6 years research; 4 years EIS studies; Corps of Engineers	Cultural and historical impact assessment.

HILE00351XXXXD01F01

HONORABLE VIRGINIA ISBELL
HAWAII HOUSE OF REPRESENTATIVE
HONOLULU, HI 96813

HILE00362XXXXD01F01

HONORABLE RICHARD MATSUURA
HAWAII HOUSE OF REPRESENTATIVE
HONOLULU, HI 96813

HILE00377XXXXD01F01

HONORABLE YOSHITO TAKAMINE
HAWAII HOUSE OF REPRESENTATIVE
HONOLULU, HI 96813

HILE00301XXXXD01F01

HONORABLE DANIEL K. INOUYE
UNITED STATES SENATOR
300 ALA MOANA BLVD, ROOM 6104
HONOLULU, HI 96850

HILE00303XXXXD01F01

HONORABLE SPARK M. MATSUNAGA
UNITED STATES SENATOR
P.O. BOX 50124
HONOLULU, HI 96850

HILE00305XXXXD01F01

HONORABLE DANIEL K. AKAKA
REPRESENTATIVE IN CONGRESS
300 ALA MOANA BLVD, ROOM 5104
HONOLULU, HI 96850

HILE00307XXXXD01F01

HONORABLE CEC HEFTEL
REPRESENTATIVE IN CONGRESS
300 ALA MOANA BLVD, ROOM 4104
HONOLULU, HI 96850

HILE00300XXXXD01F01

HONORABLE DANIEL K. INOUYE
UNITED STATES SENATE
105 RUSSELL SENATE OFFICE BLDG
WASHINGTON, DC 20510

HILE00302XXXXD01F01

HONORABLE SPARK M. MATSUNAGA
UNITED STATES SENATE
362 RUSSELL SENATE OFFICE BLDG
WASHINGTON, DC 20510

HILE00304XXXXD01F01

HONORABLE DANIEL K. AKAKA
HOUSE OF REPRESENTATIVES
1510 LONGWORTH HOUSE OFC BLDG
WASHINGTON, DC 20515

HILE00306XXXXD01F01

HONORABLE CEC HEFTEL
HOUSE OF REPRESENTATIVES
1030 LONGWORTH HOUSE OFC BLDG
WASHINGTON, DC 20515

HILE00313XXXXD01F01

HONORABLE DANTE K. CARPENTER
HAWAII SENATE
HONOLULU, HI 96813

HILE00328XXXXD01F01

HONORABLE JOHN T. USHIJIMA
HAWAII SENATE
HONOLULU, HI 96813

HILE00359XXXXD01F01

HONORABLE ANDY LEVIN
HAWAII HOUSE OF REPRESENTATIVE
HONOLULU, HI 96813

HILE00374XXXXD01F01

HONORABLE HERBERT A. SEGAWA
HAWAII HOUSE OF REPRESENTATIVE
HONOLULU, HI 96813

HILE00308XXXXD01F01

HONORABLE GEORGE R. ARIYOSHI
GOVERNOR OF HAWAII
HONOLULU, HI 96813

HILE00317XXXXD01F01

HONORABLE RICHARD HENDERSON
HAWAII SENATE, ROOM 217
HONOLULU, HI 96813

HILG00200XXXXD01F01
EXECUTIVE DIRECTOR
ADVISORY COUNCIL ON HISTORIC
PRESERVATION
1522 K ST, NW
WASHINGTON, DC 20005

HILG00201XXXXD06F06

DEPUTY ASSISTANT SECRETARY FOR
ENVIRONMENTAL AFFAIRS
US DEPT OF COMMERCE
WASHINGTON, DC 20230

HILG00202XXXXD01F01
PACIFIC REGIONAL MANAGER
NOAA, OFC OF COASTAL ZONE MGT
US DEPT OF COMMERCE
3300 WHITEHAVEN ST, NW
WASHINGTON, DC 20235

HILG00203XXXXD20F05
ASST SECRETARY, PROGRAM POLICY
OFC OF ENVIRONMENTAL PROJECT
REVIEW
US DEPARTMENT OF THE INTERIOR
WASHINGTON, DC 20240

HILG00205XXXXD05F05
CHIEF, OFC OF ARCHEOLOGICAL &
HISTORIC PRESERVATION
NATL PARK SERVICE
US DEPT OF THE INTERIOR
WASHINGTON, DC 20240

HILG00204XXXXD05F05
DIRECTOR
OFC OF ENVIRON REVIEW (A-104)
US ENVIRON PROTECTION AGENCY
401 M ST, SW
WASHINGTON, DC 20460

HILG00225XXXXD01F01

OFC OF ENVIRONMENTAL ANALYSIS
FEDERAL MARITIME COMMISSION
1100 L ST, NW, RM 9102
WASHINGTON, DC 20573

HILG00229XXXXD01F01

DIRECTOR
COASTAL ENGRG RESEARCH CTR
KINGMAN BLDG
FT BELVOIR, VA 22060

HILG00207XXXXD01F01
INSTITUTE OF ECOLOGY
HOLCOMB RESEARCH BLDG
BUTLER UNIVERSITY
ATTN: H. PAUL FRIESEMA
INDIANAPOLIS, IND 46208

HILG00206XXXXD01F01
CHIEF, WESTERN PROJECT REVIEW
ADV COUNCIL ON HIST PRESERV
LAKE PLAZA-SOUTH, SUITE 616
44 UNION BLVD
LAKEWOOD, CO 80228

HILG00216XXXXD01F01
CHIEF, NATIONAL PARK SERVICE
ARIZONA ARCHEOLOGICAL CENTER
US DEPT OF THE INTERIOR
P.O. BOX 49008
TUCSON, AZ 85717

HILG00212XXXXD01F01
CHIEF
INTERAGENCY ARCHEOL SERVICE
NATIONAL PARK SERVICE
450 GOLDEN GATE AVE, BOX 36065
SAN FRANCISCO, CA 94102

HILG00209XXXXD01F01
REGIONAL DIRECTOR, SW REGION
NAT MARINE FISHERIES SVC, NOAA
US DEPARTMENT OF COMMERCE
300 SOUTH FERRY STREET
TERMINAL ISLAND, CA 90731

HILG00214XXXXD01F01

ADMINISTRATOR, REGION IX
US DEPT OF HOUSING & URBAN DEV
450 GOLDEN GATE AVE, BOX 36003
SAN FRANCISCO, CA 94102

HILG00211XXXXD01F01
REGIONAL ADMINISTRATOR
US DEPT OF HEALTH, EDUCATION
& WELFARE, REGION IX
50 FULTON ST
SAN FRANCISCO, CA 94102

HILG00210XXXXD05F05

ADMINISTRATOR, REGION IX
US ENVIRON PROTECTION AGENCY
215 FREMONT ST
SAN FRANCISCO, CA 94105

HILG00217XXXXD01F01
SECRETARY'S FIELD REP
PACIFIC SOUTHWEST REGION
US DEPT OF THE INTERIOR
450 GOLDEN GATE AVE, BOX 36098
SAN FRANCISCO, CA 94102

HILG00213XXXXD01F01
REGIONAL DIRECTOR, REGION IX
US FISH & WILDLIFE SERVICE
LLOYD 500 BLDG, SUITE 1692
500 NE MULTNOMAH STREET
PORTLAND, OR 97232

HILG00215XXXXD01F01
DIRECTOR, PAC SW REGION
NATL PARK SERVICE
US DEPT OF THE INTERIOR
P.O. BOX 36063
SAN FRANCISCO, CA 94102

Mr. Rex Matsuno
Suisan Co.
[illegible]65 Kamehameha Ave
[illegible]lo, HI 96720

Mr. Alika Cooper
163 Kaulani St
Hilo, HI 96720

North Hilo Community Council
P. O. Box 161
Laupahoehoe, HI 96764

Life of the Land
Rt #1, Box 125
Captain Cook, HI 96704

Honorable Herbert T. Matayoshi
Mayor of the County of Hawaii
25 Aupuni St
Hilo, HI 96720

Mr. Stephen K. Yamashiro
Chairman
Hawaii County Council
25 Aupuni St
Hilo, HI 96720

Councilman James Dahlberg
Hawaii County Council
25 Aupuni St
Hilo, HI 96720

Councilman Frank De Luz, III
Hawaii County Council
25 Aupuni St
Hilo, HI 96720

Councilman Takashi Domingo
Hawaii County Council
25 Aupuni St
Hilo, HI 96720

Councilman Tomio Fujii
Hawaii County Council
25 Aupuni St
Hilo, HI 96720

Mr. Spencer Kalani Schutte
Vice-Chairman
Hawaii County Council
25 Aupuni St
Hilo, HI 96720

Councilman William S. Kawahara
Hawaii County Council
25 Aupuni St
Hilo, HI 96720

Councilwoman Merle K. Lai
Hawaii County Council
25 Aupuni St
Hilo, HI 96720

Councilwoman Helene H. Hale
Hawaii County Council
25 Aupuni St
Hilo, HI 96720

Ms. June Gutmanis
85-1373-B5 Waianae Valley Rd
Waianae, HI 96792

Hilo Yacht Club
Kahaoi St
Hilo, HI 96720

Young Brothers, Inc.
ATTN: Mr. G. Matsuno
Pier 2, Hilo
Hilo, HI 96720

Hilo Transportation &
Terminal Co., Inc.
ATTN: Mr. B. Thibadeau
Pier 1
Hilo, HI 96720

Conservation Council
for Hawaii
P.O. Box 1222
Hilo, HI 96720

Matson Navigation Company
ATTN: Mr. Alex Bolton
P.O. Box 899
Honolulu, HI 96808

Department of Health
State of Hawaii
P. O. Box 916
Hilo, HI 96720

Ms. Lei Keliipio
66 Pilipaa St
Hilo, HI 96720

Mr. David Higa, Chief
Harbors Division, State of Hawaii
79 S. Nimitz Highway
Honolulu, HI 96813

Mr. Daniel Tanaka
Harbors Division, State of Hawaii
79 S. Nimitz Highway
Honolulu, HI 96813

Fire Department
County of Hawaii
25 Aupuni St
Hilo, HI 96720

Library
University of Hawaii
52 Halaulani Pl
Hilo, HI 96720

Mr. Glenn Miyao
Dept of Parks & Recreation
County of Hawaii
25 Aupuni St
Hilo, HI 96720

Mr. Ronald Okamura
Dept of Parks & Recreation
County of Hawaii
25 Aupuni St
Hilo, HI 96720

Ms Virginia Goldstein
Dept of Planning
County of Hawaii
25 Aupuni St
Hilo, HI 96720

Mr. Rodney Nakano
Dept of Planning
County of Hawaii
25 Aupuni St
Hilo, HI 96720

Mr. Duane Kanuha, Deputy Director
Department of Planning
County of Hawaii
25 Aupuni St
Hilo, HI 96720

Hale Consultants, Inc.
38 Kalakaua St
Hilo, HI 96720

Puna Community Council
Pahoa, HI 96778

Mr. Richard Kihara, President
Big Island Casting Club
SR Box 48
Pahoa, HI 96778

Moku Loa Sierra Club Group
P. O. Box 1137
Hilo, HI 96720

Mr. William Kaawaloa
Kalapana Community Association
P. O. Box 844
Pahoa, HI 96778

Mr. Dan Pakele
117 Alapaki Pl
Hilo, HI 96720

Western Div Proj Rev-Lake-
Plaza-South
44 Union Blvd, Suite 616
Lakewood, Colorado 80228

Advisory Council on Historic
Preservation
1522 K St, NW
Washington, DC 20005

USCG Cape Small
P.O. Box 4819
Hilo, HI 96720

Mark's Boat Works
P. O. Box 525
Pahoa, HI 96778

Save our Surf
P. O. Box 477
Kamuela, HI 96743

Mr. George E. Goss
District Manager
Matson Navigation Co
Pier One
Hilo, HI 96720

Mr. David Watumull, President
Hawaiian Paradise Park Corp.
2051 Young St
Honolulu, HI 96826

Mr. Jim Road
Hawaii Tribune Herald
355 Kinoole St
Hilo, HI 96720

Manager
State Energy Office
Dept of Plng & Economic Dev
P.O. Box 2359
Honolulu, HI 96804

Library
Dept of Planning & Economic
Development, State of Hawaii
250 S King St
Honolulu, HI 96813

University of Hawaii Library
Serial Records
2550 The Mall
Honolulu, HI 96822

Library
Kawaii Community College
1175 Manono St
Hilo, HI 96720

Hawaii Public Library
ATTN: Hawaiian Room
300 Waianuenue Ave
Hilo, HI 96720

Hawaii Public Library
Holualoa, HI 96725

Hawaii Public Library
Honokaa, HI 96727

Hawaii Public Library
77-140 Hualalai Road
Kailua, HI 96740

Hawaii Public Library
Kamuela, HI 96743

Hawaii Public Library
Keaau, HI 96749

Hawaii Public Library
Kealakekua, HI 96750

Hawaii Public Library
Kohala, HI 96755

Hawaii Public Library
Laupahoehoe, HI 96764

Hawaii Public Library
Mt View, HI 96771

Hawaii Public Library
Pahala, HI 96777

Hawaii Public Library
Pahoa, HI 96778

Director
Dept of Civil Defense
County of Hawaii
25 Aupuni St
Hilo, HI 96720

Chairman
Big Island Resource Conservation
and Development Council
P. O. Box 915
Hilo, HI 96720

District Conservationist
US Dept of Agriculture
Soil Conservation Service
P. O. Box 1361
Hilo, HI 96720

Scientist in Charge
US Geological Survey
Volcano Observatory
Hawaii Volcano National Park
Hawaii 96718

Mike Lee

PODED-PV

0 1 JUL 1981

Mr. Doyle E. Gates
Administrator
National Marine Fisheries Service
Western Pacific Program Office
P. O. Box 3830
Honolulu, HI 96812

Dear Mr. Gates:

On 2 and 29 April 1981, you provided us with information concerning the presence of the endangered humpback whale, endangered hawksbill turtle, and the threatened green sea turtle at five sites being considered for the construction of a small boat harbor under the Hilo Area Comprehensive Study, Small Craft Navigation Improvements Project. The presence of the threatened green sea turtle in the Hilo Bay area and the endangered whale outside the bay was noted in our studies of the Hilo Area Comprehensive Study, Deep Draft Navigation Improvements Project, in Hilo Harbor, based on your letter of 14 April 1981 concerning the Hilo Breakwater Report.

At the present stage of the study, three sites are presently being considered in the Small Craft Navigation Improvements Project. These include Kalapana, King's Landing and Leleiwi Point. Four plans for deep draft navigation improvements in Hilo Harbor are also being considered. The plan details are provided on attached blueprints.

Based on the information you provided to us, we have found that none of the alternatives will jeopardize the continued existence of threatened and endangered species mentioned by your agency. Our biological assessment is provided in Inclosure 1 for your information and review.

Sincerely,

1 Incl
As stated

KENNETH E. SPRAGUE
LTC, Corps of Engineers
Deputy Commander and
Deputy District Engineer

BIOLOGICAL ASSESSMENT

Hilo Area Comprehensive Study,
Small Craft and Deep Draft Navigation Improvements

1. Project Status.

a. Small Craft Navigation Improvements. The project consists of constructing a small boat harbor to accommodate 170 40-foot vessels at either Kalapana, King's Landing and Leleiwi Point. Two sites at King's Landing are being considered and are designated Plan 1 and Plan 2; Plan 1 involves construction in a wetland. Blueprints of the harbor plans are provided as attachments. Harbor construction would involve excavating the harbor channel and basin out of the basalt shoreline similar to the construction of Honokohau Harbor, Kailua-Kona. Blasting techniques will probably be used, and excavation is expected to occur in the inland portions before the harbor is opened to the sea. The harbor is expected to serve recreational and commercial fishing craft, but will be principally a commercial fishing harbor. No detailed development plans have been prepared by the State of Hawaii, Harbors Division, but such activities as fish processing, boat haul out and maintenance, fueling and icing could be available. The King's Landing Plan 1 is the tentatively selected plan, but the plan is still subject to public review and comment and the remaining plans still have favorable cost-benefit ratios.

b. Deep Draft Navigational Improvements. Four plans of improvement in Hilo Harbor are being evaluated as shown on the attached blueprints. Plan B involves dredging Blonde Reef and using the dredged material to fill behind the Hilo Breakwater. Plans A, C and D involve the disposal of dredged material at the Environmental Protection Agency ocean disposal site for dredged material located about 8 miles outside of Hilo Bay (Latitude 19d 48' 80" N; Longitude 154d 58' 30" W). At the present time Plans A and B have cost-benefit ratios that are unfavorable for federal participation, but could be implemented by the local government. Plan C is tentatively designated the Environmental Quality Plan since the plan has the potential of improving water mixing and circulation in Hilo Bay possibly revitalizing Blonde Reef, improving surfing in the bay, and reducing erosion along the Bayfront Park. Plan D involves no alteration of the breakwater or harbor configuration and is designated the non-structural plan.

2. Endangered Species, Existing Conditions. The information in this section was based upon data provided by the National Marine Fisheries Service and the US Fish and Wildlife Service.

a. Humpback Whale (*Megaptera novaeangliae*). The humpback whale seasonally migrates through Hawaiian waters and can be found around all the major islands from Hawaii to Kaula Rock during the seasonal migration. The whales begin to appear during November and leave the islands for their northern feeding grounds by June with the greatest number occurring during February and March. The National Marine Fisheries Service indicated that 500-700 whales annually migrate through Hawaiian waters to mate, calve and nurse their young. The whales prefer relatively shallow water, usually waters less than 100 fathoms deep, and are particularly numerous on Penquin Banks, in the area between Maui, Lanai, Molokai and Kahoolawe, around the northwest tip of Hawaii and between Niihau and Kauai. However, they are consistently seen

in small numbers in other areas of the Hawaiian Islands during the season. Herman (1981) suggests that the whales first arrive in Hawaii around the island of Hawaii and travel northward toward the islands of Maui County before continuing toward Niihau and Kauai, where they leave on their return to the northern summer feeding grounds. The relative concentrations of whales in the Hawaiian Islands is illustrated in Figure G-6 based upon information provided in 1976 and 1977 censuses (Wolman and Jurasz 1976, and Rice and Wolman, 1977). The National Marine Fisheries Service provided the following whale census for the Hilo-Leleiwi Point area of Hawaii. The whales have been seen outside Hilo Bay and are not known to enter the bay. The EPA disposal site is located within the area in which National Marine Fisheries Service has counted the whales. The whales are not known to feed during their stay in Hawaiian waters, and the prime calving, nursing and possibly breeding areas in Hawaii appear to be in waters off Maui, between Niihau and Kauai and the northwest tip of Hawaii.

Table G-12. WHALE SIGHTINGS - HILO TO LELEIWI POINT

Year	#Whales Sighted
1976	12
1977	7
1978	5
1979	9

b. Sea Turtle. The National Marine Fisheries Service indicated that the endangered hawksbill sea turtle (*Eretmochelys imbricata*) and the threatened green sea turtle (*Chelonia mydas*) can be found in waters around Hawaii, that the waters in Hilo Bay and around Leleiwi Point and King's Landing are reported to be foraging areas for the turtles, and that a hawksbill turtle nest was recently reported at the Harry K. Brown Beach Park near the Kalapana site. Takata (referred to by the National Marine Fisheries Service; personal communication, 1981) indicated that some youngsters in 1978 brought to his Sea Grant Office in Hilo some small turtles which had hatched from a nest located on a sand bar at Harry K. Brown Park. The sand bar separates a park wading pool from the ocean and is heavily used by park visitors on weekends. No surveillance or investigations of the nest site were performed by Takata, or the National Marine Fisheries Service in subsequent years since the initial report to determine if the hawksbill turtle has returned to the site. Takata indicated that human use of the sand bar probably obliterates any traces of turtle tracks produced during the night. The US Fish and Wildlife Service, Endangered Species Office indicated that the sighting was significant because it involved an endangered species, it was the first report of its kind in that area of Hawaii, and the turtle might return to the site due to turtle fidelity to particular nesting sites. Continued human presence and use of the park probably jeopardizes the continued use of the site for nesting, and the sighting appears to be a rare occurrence. The US Fish and Wildlife Service did see one green turtle at the Leleiwi Point site, during site surveys in May 1981. The National Marine Fisheries Service suggested that the green sea turtles observed in Hilo Harbor are probably foraging for food. No nesting grounds or other areas of turtle concentration are found in the harbor or along the coast for Leleiwi Point to Kalapana.

3. Effect Analysis.

a. Small Craft Navigation Improvements.

(1) Endangered and Threatened Sea Turtles. The small craft harbor construction will disturb small areas of the existing marine area, which are not known to be either nesting areas or areas of concentration for either the endangered hawksbill turtle or the threatened green sea turtle.

Table 1

Area of Existing Marine Environment Modified by Harbor Construction

	Acres
Kalapana	Unavailable
King's Landing Plan 1	1.5
King's Landing Plan 2	1.6
Leleiwi Point	2.4

Operation of vessels from the harbor may discourage turtles from entering the harbor or using the disturbed marine areas. Both turtles are protected under Hawaii Fish and Game Regulations which should discourage fishing for or catching the turtles. Collisions between individual turtles and boats are possible.

(2) Endangered Humpback Whales. The construction of the harbor will not interfere with the whale migratory routes and does not affect any areas of known whale concentration. An increase in boating activities in the Puna waters is not expected to affect the whales, as experienced in the Glacier Bay area where 100 ton displacement vessel operations appeared to annoy the whales and interfere or interrupt their feeding behavior. No areas of whale concentrations will be affected.

b. Deep Draft Navigation Improvements.

(1) Endangered and Threatened Turtles. The implementation of any of the plans should not affect any areas of known turtle concentration or nesting. Plans A, C and D, which involve dredging, deepen the existing harbor by removing silty material from the harbor bottom. Plan B involves the elimination of acres of reef reducing available foraging area.

(2) Endangered Humpback Whales. Ocean disposal of dredged material could occur during the annual whale migration. The disposal site is located in the National Marine Fisheries Service Hilo-Leleiwi Point whale census area. Although the action would create a turbid plume that would discolor the water at the dump site, the whales will avoid the site since the site is located in open water 8 miles from the bay and not in an embayment. Similarly, vessel traffic related to the dump should not interfere with whale feeding or calving activites, which do not occur in the disposal site waters.

4. Determination of Jeopardy.

a. Small Craft Navigation Improvements.

(1) Endangered and Threatened Sea Turtles. The construction and operation of a small boat harbor are not expected to jeopardize the continued existence of the threatened green sea turtle and the endangered hawksbill turtle. The harbor would not affect any turtle nesting areas or other areas of turtle concentration. The harbor would eliminate small areas of marine habitat that may periodically provide foraging resources for the turtles, but there are no data which shows that the potential harbor sites are critical to the survival of the turtles. The Kalapana site should not affect the turtle nesting site at the Harry K. Brown Beach Park, but the extent of human activities in the area contributes to the long-term degradation of the single turtle nest.

(2) Endangered Humpback Whales. The construction and operation of the small boat harbor are not expected to jeopardize the continued existence of the endangered humpback whales. The harbor will not affect the whale northern feeding grounds, will not interfere or interrupt their migration through waters off the project areas, and should not affect any known areas of whale concentrations.

b. Deep Draft Navigation Improvements.

(1) Endangered and Threatened Sea Turtles. The plans of improvement in Hilo Harbor are not expected to jeopardize the continued existence of the threatened green sea turtle or the endangered hawksbill turtle. The plans should not affect any turtle nesting areas or areas of known turtle concentration. Dredging and filling Blonde Reef reduces potential foraging areas for the few turtles seen in Hilo Bay but the reef is not known as a critical habitat or feeding area for the turtles. Breakwater deterioration or lowering the breakwater to below sea level could increase potential foraging resources for the turtles.

(2) Endangered Humpback Whales. The ocean dumping of dredged material from Hilo Harbor in conjunction with the implementation of Plans A, C and D is not expected to jeopardize the continued existence of the endangered humpback whales. The discharge of dredged material will occur only during brief periods and will not obstruct the migration of whales through the open ocean waters offshore from Hilo Bay. The activity will not exclude whale use of the dump site waters. The whales may avoid the turbid plume at the dump site, but are capable of avoiding the plume in the open water around the dump site. The dump site is not located in a critical habitat area for the whales and is located in an area where the National Marine Fisheries Service counted 5-12 whales out of a population of about 500 whales. The disposal site is not a prime calving, nursing or breeding area for the whales, and the discharge of dredged materials would not disturb those activities.

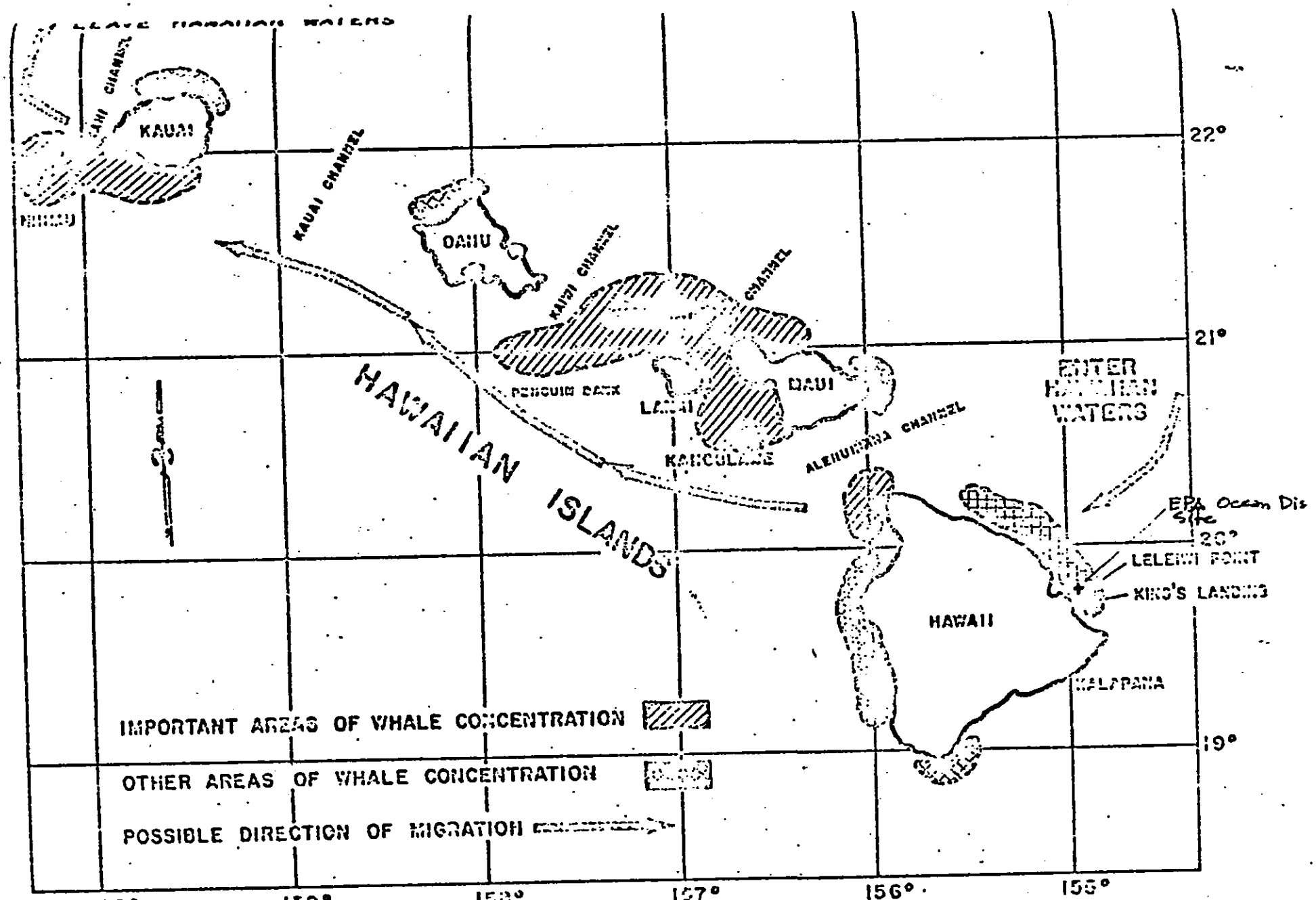

FIGURE G-6 DISTRIBUTION OF HUMPBACK WHALES IN HAWAII

ADAPTED FROM: WOLMAN AND [illegible], 1970 AND RICE AND WOLMAN, 1977. [illegible] IN WHITTEN, 1981.

M Lee
jmd/2263

12 August 1981

Maragos
PODED-PV

PODED-PV

12 August 1981

Clark
PODED-P

Mr. Susumo Ono
State Historic Preservation Officer
Department of Land and Natural Resources
State of Hawaii
PO Box 621
Honolulu, HI 96809

Maj Thai
PODED

Fujii
PODED

Cheung
PODED

Dear Mr. Ono:

PODED-P
file

In March 1981 we informed you of our Small Craft Navigation Improvement Project being studied under the Hilo Area Comprehensive Study, and of our consideration of several harbor sites in the Puna District of Hawaii. At the present stage of study we are considering the construction of a small boat harbor (170-boat berthing capacity) at one of three sites: Kalapana, King's Landing, and Leleiwi Point. Two harbor plans are being studied in the King's Landing area. We have completed one reconnaissance level archaeological/historical survey for Kalapana and Leleiwi Point, and we were provided a report for another survey at King's Landing. Inclosed are the reports for your information and use (Incl 1 and 2). We have also inclosed a summary and copies of our determinations of eligibility (Incl 3) for archaeological/historical sites found in the project areas and determinations of effect (Incl 4) for your review and comment in accordance with the US Advisory Council on Historic Preservation regulations (36 CFR 800). We would appreciate your comments on our determinations of eligibility and effect by 7 September 1981.

Sincerely,

4 Incl
As stated

KISUK CHEUNG
Chief, Engineering Division

SUMMARY
FOR
HILO AREA COMPREHENSIVE STUDY
SMALL CRAFT NAVIGATION IMPROVEMENT PROJECT
12 August 1981

Sites Present Within the Project Limits	Sites Determined to be Eligible for Inclusion on the National Register of Historic Places	Effect	Adverse Effect	Proposed Mitigation
Kalapana				
Kikoa Heiau	Yes	Yes	Yes	Survey and salvage of scientific data.
Kikoa Fishpond	Yes	Yes	Yes	Same as above.
Star-of-the-Sea Painted Church	Yes	Yes	None	None
Canoe Landing	No	------No longer present-------		
King's Landing Plan 1				
Cultural Deposit	Yes	None	None	None
Pohaku Pike	Yes	Yes	None	None
ing's Landing Plan 2				
Stone Platform	Yes	Yes	No	None
Cultural Deposit	Yes	Yes	No	None
Historic House Platform	No	None	None	None
Stone Wall	No	None	None	None
Leleiwi Point				
Puu Maile Hospital Site	No	None	None	None

P. 3

DETERMINATION OF ELIGIBILITY
FOR
HILO AREA COMPREHENSIVE STUDY
SMALL CRAFT NAVIGATION IMPROVEMENT PROJECT
12 August 1981

1. Bibliography. The determination of eligibility is based on information contained in the following reports:

a. Leleiwi Point and Kalapana, Hawaii: Archaeological Reconnaissance by Chiniago, Inc., for the US Army Engineer District, Honolulu, 1981.

b. Archaeological Reconnaissance of the Proposed King's Landing Subdivision, Kea'au Puna, Island of Hawaii, by Archaeological Research Center Hawaii, Inc., for Hawaiian Paradise Park Corporation, 1978. The report was provided to the Corps of Engineers by Mr. David Watumull, President of Hawaiian Paradise Park Corporation.

2. Results of Survey.

Project Site	Historical/Archaeological Site	Remarks Ownership	Comments
Kalapana	Kikoa Heiau	State of Hawaii	Overgrown and collapsing.
	Kikoa Fishpond	Private	Filled or silted in and overgrown.
	Star-of-the-Sea Painted Church	Private	Good condition.
	Canoe Landing Site	State of Hawaii	No longer in existence.
King's Landing Plan 1	Cultural Deposit (Site 6466)	Private	Developed as a park.
	Pohaku Pike (Site 6467)	Private	Good condition; stone artifact preserved by landowner.
King's Landing Plan 2	Stone Platform (Site 6462)	Private	
	Cultural Deposit (Site 6464)	Private	Developed as a park.
	Historic House Foundation (Site 6465)	Private	
	Stone Wall (Site 16)	Private	
Leleiwi Point	No surface remains.	State of Hawaii	Possible subsurface remains.
	Puu Maile Home Foundation	State of Hawaii	Tuberculosis facility destroyed by high seas in 1947.

Incl 1 to Inc 3

3. Historic Significance and Eligibility.

Project Site	Historic/ Archaeological Site	Significance Description	Listed on the State Register	Eligible for Inclusion on the National Register
Kalapana	Kikoa Heiau*	Associated with events that have made a significant contribution to the broad patterns of our history. Religious site for prehistoric native Hawaiians. Distinctive type, period, and method of construction. Potential for yielding information, important to an understanding of prehistory Hawaiian settlement and culture in the area.	No	Yes

*Note: A 1932 description of the heiau indicated that residents in the area had formerly remembered drums and chanting on certain nights at the heiau. A 1952 description suggested that ceremonies at the heiau were used to replenish fish in the area, and fish runs were signaled by flying kites from the heiau. A 1981 informant doubted that the flying kites from the heiau occurred because it would have signaled a coming of a famine. The heiau is not known to be used any longer in modern times for religious ceremonies.

Kalapana (cont'd)	Kikoa Fishpond	Unique rectangular type and method of construction. The fishpond was completely surrounded by stone walls, an unusual feature for an ocean fishpond.	No	Yes
	Canoe Landing	Physical remnants no longer present.	No	No
	Star-of-the-Sea Painted Church	Embodies distinctive construction and interior design characteristics of a type, period, and method of construction. The church was constructed in 1929. In 1932, Father Evarist Gielen painted murals in the church that possess high artistic values.	No	Yes

Project Site	Historic/ Archaeological Site	Significance Description	Listed on the State Register	Eligible for Inclusion on the National Register
King's Landing Plan 1	Cultural Deposit (Site 6466)	Potential to yield information important to an understanding of prehistory Hawaiian settlement and culture in the area.	No	Yes
	Pohaku Pike (Site 6467)	Associated with events that made a significant contribution to broad patterns of Hawaiian culture. The site is a stone artifact in which umbilical cords of infants were placed in indentations in the stone and the indentations covered with coral pebbles.	No	Yes
King's Landing Plan 2	Cultural Deposit (Site 6464)	Potential to yield information important to an understanding of prehistory Hawaiian settlement and culture in the area.	No	Yes
	Stone Platform (Site 6462)	Same as above.	No	Yes
	Historic House Platform (Site 6465)	None.	No	No
	Stone Wall (Site 16)	None.	No	No
Leleiwi Point	Puu Maile Home Foundation	None.	No	No

DETERMINATION OF EFFECT
FOR
HILO AREA COMPREHENSIVE STUDY
SMALL CRAFT NAVIGATION IMPROVEMENT PROJECT
12 August 1981

1. Harbor plans at Kalapana (Incl 1), King's Landing (Plans 1 and 2) (Incl 2), and Leleiwi (Incl 3) best illustrate potential effects of the harbor on historic and archaeological resources found eligible for inclusion on the National Register of Historic Places. The table below provides a determination of effect, adverse effect and potential mitigation proposed by the US Army Corps of Engineers in the event that a harbor is selected for construction at the listed sites.

Project Site	Historic/ Archaeological Site	Determination of Effect	Determination of Adverse Effect	Proposed Mitigation
Kalapana	Kikoa Heiau	Yes	Yes, excavation will destroy the heiau.	Intensive archaeological survey and salvage of scientific data prior to its destruction.
	Kikoa Fishpond	Yes	Yes, the excavation will destroy the fishpond.	Intensive archaeological survey and salvage of scientific data prior to its destruction.
	Star-of-the-Sea Painted Church	Yes	Not adverse.	None proposed.
King's Landing Plan 1	Cultural Deposit	Yes	No, area to be filled and not excavated. Fill preserves the area permanently.	None proposed.
	Pohaku Pike	Yes	No, the stone will be relocated.	None proposed.
King's Landing Plan 2	Cultural Deposit	Yes	No, intensive archaeological surveys will be performed prior to construction to recover and preserve the scientific data.	None.
	Stone Platform	Yes	Same as above.	None.
Leleiwi Point	None	None	None	None proposed.

Incl 4

2. Provisions in the construction plans and specifications provide for the notification of proper authorities in the event that previously unknown and undetermined archaeological or historic sites are discovered during construction.

3. Kikoa Heiau is in a state of disrepair and is deteriorating due to geological alterations to the land, and is not now used for Hawaiian religious activities. The information provided in the Chiniago report indicates that modern residents do not know for what the heiau was used and are confused about the types of activities which may have occurred there.

3 Incl
As stated

EXECUTIVE CORRESPONDENCE

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
FT. SHAFTER, HAWAII 96858

PODED-PV

13 August 1981

Keeper of the Register
National Park Service
US Department of the Interior
Washington, DC 20240

Dear Sir:

We are requesting a determination of eligibility in accordance with the provisions of the National Historic Preservation Act for historic and archaeological resources found at the alternative harbor sites being studied under the Hilo Area Comprehensive Study, Small Craft Navigation Improvements project. At the present stage of study, we are considering the construction of a small boat harbor at one of four locations: Kalapana, two sites at King's Landing, and Leleiwi Point (Incl 1). We completed an archaeological reconnaissance survey of the Kalapana and Leleiwi Point area and were provided a copy of the reconnaissance survey of the King's Landing area by Mr. David Watumull, President, Hawaiian Paradise Park Corporation (Incl 2 and 3). Based upon the reconnaissance reports, we have made a determination of eligibility for the historic and archaeological resources found within the project area, and provide the determination (Incl 4) to you for your review and comments. We forwarded the same information to the State Historic Preservation Officer on 11 August 1981. We anticipate a reply and opinion from your office by 12 September 1981.

Sincerely,

4 Incl
As stated

KISUK CHEUNG
Chief, Engineering Division

CF: w/o incl
Mr. Susumo Ono
State Historic Preservation Officer
Department of Land and Natural Resources
State of Hawaii
1151 Punchbowl Street
Honolulu, HI 96813

DO NOT WRITE ON THIS COVER AS IT IS INTENDED FOR RE-USE
RETURN IT WITH THE FILE COPIES TO ORIGINATING OFFICE

DETERMINATION OF ELIGIBILITY
FOR
HILO AREA COMPREHENSIVE STUDY
SMALL CRAFT NAVIGATION IMPROVEMENT PROJECT
12 August 1981

1. Bibliography. The determination of eligibility is based on information contained in the following reports:

a. Leleiwi Point and Kalapana, Hawaii: Archaeological Reconnaissance by Chiniago, Inc., for the US Army Engineer District, Honolulu, 1981.

b. Archaeological Reconnaissance of the Proposed King's Landing Subdivision, Kea'au Puna, Island of Hawaii, by Archaeological Research Center Hawaii, Inc., for Hawaiian Paradise Park Corporation, 1978. The report was provided to the Corps of Engineers by Mr. David Watumull, President of Hawaiian Paradise Park Corporation.

2. Results of Survey.

Project Site	Historical/Archaeological Site	Remarks Ownership	Comments
Kalapana	Kikoa Heiau	State of Hawaii	Overgrown and collapsing.
	Kikoa Fishpond	Private	Filled or silted in and overgrown.
	Star-of-the-Sea Painted Church	Private	Good condition.
	Canoe Landing Site	State of Hawaii	No longer in existence.
King's Landing Plan 1	Cultural Deposit (Site 6466)	Private	Developed as a park.
	Pohaku Pike (Site 6467)	Private	Good condition; stone artifact preserved by landowner.
King's Landing Plan 2	Stone Platform (Site 6462)	Private	
	Cultural Deposit (Site 6464)	Private	Developed as a park.
	Historic House Foundation (Site 6465)	Private	
	Stone Wall (Site 16)	Private	
Leleiwi Point	No surface remains.	State of Hawaii	Possible subsurface remains
	Puu Maile Home Foundation	State of Hawaii	Tuberculosis facility destroyed by high seas in 1947.

Incl 1 to Incl 3

3. Historic Significance and Eligibility.

Project Site	Historic/ Archaeological Site	Significance Description	Listed on the State Register	Eligible for Inclusion on the National Register
Kalapana	Kikoa Heaiu*	Associated with events that have made a significant contribution to the broad patterns of our history. Religious site for prehistoric native Hawaiians. Distinctive type, period, and method of construction. Potential for yielding information, important to an understanding of prehistory Hawaiian settlement and culture in the area.	No	Yes

*Note: A 1932 description of the heiau indicated that residents in the area had formerly remembered drums and chanting on certain nights at the heiau. A 1952 description suggested that ceremonies at the heiau were used to replenish fish in the area, and fish runs were signaled by flying kites from the heiau. A 1981 informant doubted that the flying kites from the heiau occurred because it would have signaled a coming of a famine. The heiau is not known to be used any longer in modern times for religious ceremonies.

Kalapana (cont'd)	Kikoa Fishpond	Unique rectangular type and method of construction. The fishpond was completely surrounded by stone walls, an unusual feature for an ocean fishpond.	No	Yes
	Canoe Landing	Physical remnants no longer present.	No	No
	Star-of-the-Sea Painted Church	Embodies distinctive construction and interior design characteristics of a type, period, and method of construction. The church was constructed in 1929. In 1932, Father Evarist Gielen painted murals in the church that possess high artistic values.	No	Yes

Project Site	Historic/ Archaeological Site	Significance Description	Listed on the State Register	Eligible for Inclusion on the National Register
King's Landing Plan 1	Cultural Deposit (Site 6466)	Potential to yield information important to an understanding of prehistory Hawaiian settlement and culture in the area.	No	Yes
	Pohaku Pike (Site 6467)	Associated with events that made a significant contribution to broad patterns of Hawaiian culture. The site is a stone artifact in which umbilical cords of infants were placed in indentations in the stone and the indentations covered with coral pebbles.	No	Yes
King's Landing Plan 2	Cultural Deposit (Site 6464)	Potential to yield information important to an understanding of prehistory Hawaiian settlement and culture in the area.	No	Yes
	Stone Platform (Site 6462)	Same as above.	No	Yes
	Historic House Platform (Site 6465)	None.	No	No
	Stone Wall (Site 16)	None.	No	No
Leleiwi Point	Puu Maile Home Foundation	None.	No	No

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southwest Region
Western Pacific Program Office
P. O. Box 3830
Honolulu, Hawaii 96812

Mike
PJ

April 29, 1981 F/SWR1:ETN

Mr. Kisuk Cheung
Chief, Engineering Division
Department of the Army
U. S. Army Engineer District,
Honolulu
Fort Shafter, Hawaii 96858

Dear Mr. Cheung:

In response to your letter of April 10, 1981, we are providing the following information.

Humpback whales (Megaptera novaeangliae) have been observed in small numbers around the Puna coast of the island of Hawaii during National Marine Fisheries Service (NMFS) winter surveys conducted between 1976 and 1979.

The occurrence of green (Chelonia mydas) or hawksbill (Eretmochelys imbricata) turtles in or around the Pohoiki Bay Project area is not known; however, NMFS is planning to conduct site surveys in May 1981 for sea turtles at the areas proposed for the small boat harbor on the east coast of Hawaii. The results will be forwarded to the Corps as soon as they are available.

The report of the hawksbill turtle nesting at Harry K. Brown Park was provided by Howard Takata, Sea Grant, Hilo through George Balazs. Details should be available from Mr. Takata, who can be reached at 808-935-3830.

Because of their low numbers and site fidelity in nesting behavior we must consider the record of hawksbill turtle nesting at Harry K. Brown Park as probably significant for the continued existence of the species, particularly in Hawaii.

As before, should you require further information we would be pleased to provide it upon request.

Sincerely yours,

Doyle E. Gates
Administrator

cc: E. Kosaka, FWS

APR 2 2 1981

United States Department of the Interior

FISH AND WILDLIFE SERVICE
300 ALA MOANA BOULEVARD
P.O. BOX 50167
HONOLULU, HAWAII 96850

IN REPLY REFER TO:
ES
Room 6307
1-2-81-SP-212

APR 22 1981

Mr. Kisuk Cheung
Chief, Engineering Division
U. S. Army Engineer District, Honolulu
Ft. Shafter, Hawaii 96858

Dear Mr. Cheung:

This replies to your request of April 13, 1981 (PODED-PV) for information on endangered and threatened species, listed, proposed, or candidates for listing which may be present at the site of the proposed Hilo Area Comprehensive Study, Small Craft Navigation Improvements Project at Pohoiki Bay.

To the best of our knowledge there are no endangered or threatened species listed, proposed, or candidates for listing present in the proposed project area.

Thank you for your concern for conserving listed species.

Sincerely yours,

Pacific Islands Administrator

CONSERVE AMERICA'S ENERGY

Save Energy and You Serve America!

United States Department of the Interior

FISH AND WILDLIFE SERVICE
300 ALA MOANA BOULEVARD
P.O. BOX 50167
HONOLULU, HAWAII 96850

APR 22 1981

IN REPLY REFER TO:
ES
Room 6307
1-2-81-SP-209

APR 16 1981

Mr. Kisuk Cheung
Chief, Engineering Division
U.S. Army Engineering District, Honolulu
Fort Shafter, Hawaii 96850

Dear Mr. Cheung:

On February 26, 1981, you requested a list of endangered and threatened species listed, proposed to be listed, or candidates for listing relative to the four potential small craft harbor sites on the Island of Hawaii: Leleiwi Point, Kings Landing, Kapoho, and Kalapana (PODED-PV). We responded on March 16, 1981, to your request.

Since our response, we have received information that a hawksbill sea turtle (Eretmochelys imbricata) has nested on the beach at Harry K. Brown Park, an area near the Kalapana site. We learned of this siting through a National Marine Fisheries Service, Western Pacific Program Office Administrator's letter to Mr. Clarence S. Fujii of April 2, 1981 (F/SWR1:ETN).

In view of this additional information and due to the fact that listed marine turtles are under the protection of the Fish and Wildlife Service while on land, we amend our March 16, 1981 letter to you to indicate that the hawksbill sea turtle may occur at the Kalapana site. This information should be considered in addressing your Section 7, Endangered Species Act of 1973, as amended, obligations.

Sincerely yours,

Ernest Kozaka
for Pacific Islands Administrator

CONSERVE AMERICA'S ENERGY

Save Energy and You Serve America!

Humpback whale surveys in Hilo Bay (Pepeekeo Point to Leleiwi Point) conducted by the National Marine Fisheries Service (NMFS) yielded counts of 12 in 1976, 7 in 1977, 5 in 1978, and 9 in 1979.

Green turtles have been observed around the Leleiwi Point and King's Landings areas which have been reported as likely foraging areas for these turtles. Near the Kalapana site there is a recent record of hawksbill nesting at Harry K. Brown Park. The occurrence of sea turtles at the Kapoho site is unknown at this time.

We recommend that you contact the U. S. Fish & Wildlife Service, Endangered Species Coordinator, P. O. Box 50167, Honolulu, HI 96850, for information regarding any endangered or threatened species under their jurisdiction which might be found in the proposed project sites.

Should you require any further information or clarification of Corps' responsibilities under Section 7 of the Endangered Species Act, as amended, please do not hesitate to contact our office.

Sincerely yours,

Doyle E. Gates

Doyle E. Gates
Administrator

cc: E. Kosaka, FWS
FWS Ecological Services

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southwest Region
Western Pacific Program Office
P. O. Box 3830
Honolulu, Hawaii 96812

April 2, 1981 F/SWR1:ETN

Mr. Clarence S. Fujii
Acting Chief, Engineering Division
U. S. Army Engineer District, Honolulu
Building 230
Fort Shafter, Hawaii 96858

Dear Mr. Fujii:

In response to your letter of March 9, 1981 the following is provided for your information concerning the four potential small craft harbor sites on the east coast of the island of Hawaii.

Presently, there are no formally designated marine sanctuaries within the State of Hawaii. A proposal for a humpback whale sanctuary in Hawaiian waters is under review by the Office of Coastal Zone Management, National Oceanic & Atmospheric Administration, and an issue paper regarding that proposal should be available for public review within the next few months.

An estuarine sanctuary has been designated for the Waimanu Stream system and Waimanu Bay on the Kohala coast of the island of Hawaii. Construction at any of the four proposed sites will have no adverse impact on the Waimanu Estuarine Sanctuary.

At the present time there has been no designation of critical habitat (as defined in the Endangered Species Act of 1973, as amended) in marine or estuarine waters of the State of Hawaii for the protection of fish, reptiles, or marine mammals under the jurisdiction of the NMFS. There are, however, endangered and threatened species inhabiting these waters for which critical habitat may be designated at some future date.

Endangered species found in and around the proposed project areas include humpback whales (*Megaptera novaeangliae*) and hawksbill turtles (*Eretmochelys imbricata*). Green turtles (*Chelonia mydas*) are also found in these areas and are listed as threatened.

During the months of November through May an estimated 500 to 700 humpback whales inhabit waters of the main Hawaiian Islands, with peak numbers seen in February and March. While in Hawaiian waters these whales are primarily found in relatively shallow water, usually less than 100 fathoms in depth, and are particularly attracted to broad submerged bank areas such as Penguin Bank and the channel waters between Maui, Molokai, Lanai and Kahoolawe. They are consistently found, although in smaller numbers, in numerous other areas throughout the main Hawaiian Islands.

MAR 27 1981

East Coast of Hawaii
Puna District
Small Boat Hbrs.
Teresa (PJ)

United States Department of the Interior

NATIONAL PARK SERVICE
PACIFIC AREA OFFICE
300 Ala Moana Blvd., Box 50165
Room 6305
Honolulu, Hawaii 96850

IN REPLY REFER TO:

L76

March 20, 1981

Mr. Clarence S. Fujii
Acting Chief, Engineering Division
U. S. Army Engineer District, Honolulu
Fort Shafter, Hawaii 96858

Dear Mr. Fujii:

None of the proposed sites are listed as a National Trail, Park, or Landmark. This does not mean that one of the areas may be near or include a listing on the National Register of Historic Places. We suggest you contact the State Historic Preservation Officer, Susumu Ono, on this matter.

Sincerely yours,

Bryan Harry
Director, Pacific Area

MAR 19 1981

United States Department of the Interior

FISH AND WILDLIFE SERVICE
300 ALA MOANA BOULEVARD
P.O. BOX 50167
HONOLULU, HAWAII 96850

IN REPLY REFER TO:
ES
Room 6307
1-2-81-SP-209

MAR 16 1981

Mr. Kisuk Cheung
Chief, Engineering Division
U.S. Army Engineer District, Honolulu
Ft. Shafter, Hawaii 96850

Dear Mr. Cheung:

This replies to your letter of February 26, 1981 (PODED-PV) for information on endangered or threatened species, listed, proposed, or candidate which may be present at the four potential small craft harbor sites on the Island of Hawaii; Leleiwi Point, Kings Landing, Kapoho, and Kalapana.

There are no endangered or threatened species listed, proposed, or candidates for listing present in the proposed project areas.

Thank you for your concern for conserving listed species.

Sincerely yours,

Pacific Islands Administrator

CONSERVE AMERICA'S ENERGY

Save Energy and You Serve America!

GEORGE R. ARIYOSHI
GOVERNOR OF HAWAII

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

SUSUMU ONO, CHAIRMAN
BOARD OF LAND & NATURAL RESOURCES

EDGAR A. HAMASU
DEPUTY TO THE CHAIRMAN

DIVISIONS:
- CONSERVATION AND RESOURCES ENFORCEMENT
- CONVEYANCES
- FISH AND GAME
- FORESTRY
- LAND MANAGEMENT
- STATE PARKS
- WATER AND LAND DEVELOPMENT

AUG 13 1981

AUG 10 1981

Mr. Kisuk Cheung, Chief
Engineering Division
Department of the Army
U.S. Army Engineer District,
Honolulu
Fort Shafter, Hawaii 96858

Dear Mr. Cheung:

Thank you for your letter of July 23, 1981, requesting our office's review and comments on four plans for the improvement of Hilo Harbor. With regards to the effect these proposed plans will have upon the Hilo Breakwater, we concur with your agency's determination of no adverse effect with regards to Plan B, and no effect with regards to Plans A and D. However, we cannot agree with your agency's determination that Plan C, which calls for the abandonment of 7000 feet of the outer end of the breakwater, and its eventual demolition to provide materials for the construction of other harbor improvements, to be a no adverse effect. Such an undertaking would entail the destruction or alteration of a part of the property and also would introduce a visual element that is out of character with the property. ?

If you should have any further questions concerning our viewpoint, please call Ralston Nagata or Don Hibbard of my staff at 548-7460.

Sincerely yours,

Susumu Ono
Chairman of the Board and
State Historic Preservation
Officer

GEORGE R. ARIYOSHI
GOVERNOR OF HAWAII

MAR 25 1981

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

DIVISIONS:
CONSERVATION AND ENFORCEMENT
CONVEYANCES
FISH AND GAME
FORESTRY
LAND MANAGEMENT
STATE PARKS
WATER AND LAND DEVELOPMENT

March 16, 1981

Mr. Clarence S. Fujii
Acting Chief, Engineering Division
U. S. Army Engineer District, Honolulu
Building 230
Ft. Shafter, Hawaii 96858

Dear Mr. Fujii:

Thank you for your letter of March 9, 1981 regarding the feasibility study of your small craft harbor sites in the Puna area, island of Hawaii.

Only one site, Kalapana, is within an area being managed by the State Parks Division. Initial funds for Kalapana Canoe Landing were appropriated by the 1969 Legislature and three parcels of private land were subsequently purchased for park purposes. No park development has occurred and none is planned in the present budget. Some planning has been done as part of the Kalapana-Kaimu...Hookena...Palemano Point...Kiholo Bay Park Development Plans prepared for the County of Hawaii in 1969. Subsequent volcanic/earthquake activity has reduced private and public development priorities for this area.

The primary State Park value of the site is the cultural/archaeological value of the canoe landing and the surrounding undeveloped shoreline areas which protect the integrity of this site. The historic sites office of our department will prepare separate comments on archaeological values.

Very truly yours,

Susumu Ono
Chairman of the Board

recommend an archaeological reconnaissance survey on any of the four proposed sites. Further archaeological work, which might include intensive survey and excavation, can only be evaluated after the reconnaissance.

If we can be of further assistance in the selection of a site or the archaeological recommendations after a site has been selected, please contact this office. The references mentioned here are in the Historic Sites reference library and are available for use but they must remain within the office during use.

Sincerely yours,

Susumu Ono
Chairman of the Board and
State Historic Preservation
Officer

Kapoho, Puna, Hawaii (TMK: 1-4-02)

The two sites in Kapoho have not been surveyed and there are no known recorded sites. However, maps indicate a fishpond in the southern proposed site which would need to be checked archaeologically. We would not recommend this site based on the presence of the fishpond. The other site should also be surveyed for cultural resources. There are several references for the mauka area of Kapoho.

Bevacqua, Robert and Thomas Dye
1972 Archaeological Reconnaissance of Proposed Kapoho-Kalapana Highway, District of Puna, Island of Hawaii. Bishop Museum.

Cordy, Ross
n.d. Cultural Reconnaissance Report for Pohoiki Bay Navigation Improvements, Pohoiki Bay, Hawaii.

Bonk, William
1980 An Archaeological Survey in Keahialaka and Pohoiki, Puna, Hawaii.

Hakuma Point, Kalapana, Puna, Hawaii (TMK: 1-2-03)

The Hakuma Point site area is surrounded by several historic sites that have been recorded in the state inventory and during several archaeological surveys in the area. We would recommend an archaeological reconnaissance of this area prior to any development. The references for this area include those under Kapoho as well as:

Barrera, William and Dorothy Barrere
1971 Archaeological and Historical Survey: Ahupua'a of Kupahua, District of Puna, Island of Hawaii. Bishop Museum.

Barrera, William
1975 Archaeological Survey of a Portion of the Ahupua'a of Kupahua, District of Puna, Island of Hawaii. Bishop Museum.

The above statements are very general and cover a fairly large area based on the scale of the proposed site on the USGS map. At this time, it appears that the Leleiwi and King's Landing sites would have the least impact on any cultural, historical, and/or archaeological features known at present. We would, however,

GEORGE R. ARIYOSHI
GOVERNOR OF HAWAII

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

SUSUMU ONO, CHAIRMAN
BOARD OF LAND & NATURAL RESOURCES
EDGAR A. HAMASU
DEPUTY TO THE CHAIRMAN

DIVISIONS:
CONSERVATION AND ENFORCEMENT
CONVEYANCES
FISH AND GAME
FORESTRY
LAND MANAGEMENT
STATE PARKS
WATER AND LAND DEVELOPMENT

MAR 16 1981

MAR 16 1981

Mr. Kisuk Cheung
Chief, Engineering Division
Department of the Army
U.S. Army Engineer District, Honolulu
Fort Shafter, Hawaii 96858

Dear Mr. Cheung:

SUBJECT: Four Proposed Sites for the Construction of a Small Craft Harbor on the Island of Hawaii

The four proposed sites for a small craft harbor on the Island of Hawaii are at Leleiwi Point, King's Landing, Kapoho, and Kalapana. Each of these proposed sites was reviewed for known historic resources. Based on the materials available, recommendations are presented for each site relative to further archaeological work.

Lelewai Point, South Hilo, Hawaii (TMK: 2-1-19)

The Lelewai Point site appears to be between Lehia Park and Leleiwi Beach Park. There are no recorded archaeological or historical sites in this area but this does not confirm the absence of subsurface archaeological deposits. The coastal vicinity suggests the possibility of subsurface deposits. The only archaeological report for this area, but mauka of the proposed site, is:

Ching, F. K. W. and Catherine Stauder
1974 The Archaeology of South Hilo, Hawaii (Between Keaukaha and the South Hilo-Puna Boundary).

Several archaeological sites were noted during this survey, including walls, platforms, and enclosures.

King's Landing, Puna, Hawaii (TMK: 1-6-01)

There is one recorded archaeological site in this vicinity (TMK: 1-6-01:25). The site (#10-36-1845) is a walled enclosure. It is uncertain from the map you enclosed if this site would be affected by any plans for the small craft harbor. The aforementioned archaeological report also can be referenced for this locality.

State of Hawaii. Department of Planning and Economic Development. 1980. The State of Hawaii Data Book, 1980, Statistical Abstract.

State of Hawaii, Department of Land and Natural Resources. 1980. State Recreation Plan, Technical Reference Document.

Shallenberger, Edward W. 1977. Humpback Whales in Hawaii, Population and Distribution, in Oceans 1977.

Sunn, Low, Tom and Hara, Inc. (now M&E Pacific). 1977. Hilo Harbor, First Spring Season Environmental Studies.

Stearns, H. T. and G. A. Macdonald. 1946. Geology and Groundwater Resources of the Island of Hawaii. Bulletin 9, Hawaii Division of Hydrography, Territory of Hawaii.

Takata, Howard. 1981 personal communication on turtle nesting at Harry K. Brown Beach Park. Hilo Seagrant Office.

US Army Corps of Engineers, Honolulu District. 1978. Final Detailed Project Report and Environmental Impact Statement, Pohoiki Bay Navigation Improvements, Pohoiki Bay Hawaii.

_____. 1976. Plan of Study, Hilo Area Comprehensive Study.

US Department of Housing and Urban Development. 1979. Flood Insurance Rate Map.

US Fish and Wildlife Service. 1977. The Biological Resources of the Hilo Study Area, Hawaii, An Overview.

US Geological Survey. 1975. Natural Hazards on the Island of Hawaii. Geological Survey Report USGS: INF-75-18.

US National Park Service. 1980. Glacier Bay National Monument, Protection of Humpback Whales, Final Rule, Federal Register 45(96):32228 (15 May 1980.

US Soil Conservation Service. 1973. Soil Survey of Island of Hawaii, State of Hawaii.

Wolman, Allen A. and Charles M. Jurasz. Undated. Humpback Whales in Hawaii, Vessel Census, 1976.

APPENDIX A

PROBLEM IDENTIFICATION

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INTRODUCTION

STUDY AUTHORITY

The Plan of Study (POS) was prepared under the Harbors and Rivers of Hawaii Survey Study authority, (Public Law 87-874; Section 209) which directs the consideration of problems and remedies related to navigation, flood control, hydroelectric power, water supply, and other beneficial uses.

Congress passed the Water Resources Development Act of 1976 (Public Law 94-587) in October of that year. Section 144 of the Act quoted below, authorizes a comprehensive study of the Hilo Bay Area.

> The Secretary of the Army, acting through the Chief of Engineers, in cooperation with the State of Hawaii and appropriate units of local government, shall make a study of methods to develop, utilize, and conserve water and land resources in the Hilo Bay Area, Hawaii, and Kailua-Kona, Hawaii. Such study shall include, but not be limited to, consideration of the need for flood protection, appropriate use of flood plain lands, navigation facilities, hydroelectric power generation, regional water supply and wastewater management facilities systems, recreational facilities, enhancement and conservation of water quality, enhancement and conservation of fish and wildlife, other measures for environmental enhancement, and economic and human resources development. Based upon the findings of such study, the Secretary of the Army, acting through the Chief of Engineers, shall prepare a plan for the implementation of such findings which shall be compatible with other comprehensive development plans prepared by local planning agencies and other interested Federal agencies.

CONTENTS OF THE APPENDIX

The purpose of the Problem Identification Appendix is to document the first stage of the multi-objective planning process utilized by the Corps of Engineers in the conduct of feasibility studies. This appendix contains the detailed information and data that define the boundaries of the area examined and the problems and needs of that area's water and water-related resources. The problem identification stage concludes with the formulation of the planning objectives that guide the remainder of the study and planning process. These objectives are listed in Planning Objectives, the final section of this appendix.

IDENTIFICATION OF PUBLIC CONCERNS

PUBLIC INVOLVEMENT

The public involvement program of HACS was an ongoing activity from the initial public meeting in April 1976 announcing the beginning of the study to the last meeting at which the final results were announced. All the various publics were encouraged to express their opinions and suggestions, either in the meetings or by submitting their comments by mail, phone, or in person. Appendix C, Public Involvement, details the public involvement program and the results and products of the program.

PUBLIC CONCERNS, NEEDS, AND OPPORTUNITIES

The concerns expressed by the public throughout the course of the study can be broken into six categories: deep draft navigation, small craft navigation, recreation, Hilo Bay water quality, other environmental/cultural concerns, and other concerns not fitting into any other category. Table A-1 displays an aggregate compilation of the problems and needs as defined and delineated in Appendix C.

DEEP DRAFT NAVIGATION

The concerns relating to deep draft navigation were all centered on Hilo Harbor, the primary commercial port of the island of Hawaii. Of the needs shown in the table, rehabilitation of the existing breakwater and dredging and disposal of dredged materials would normally be addressed in a routine manner through the existing operation and maintenance procedures of the Corps of Engineers. The others were considered in the study, even though the needs of additional facilities and more land would normally be the concern of a local agency. The need for providing for new and potential uses can be addressed only abstractly until that use becomes a reality, for example, establishment of the manganese nodule industry or establishment of an interisland ferry service.

TABLE A-1. PROBLEMS AND NEEDS

DEEP DRAFT NAVIGATION
Surge and docking problems during periods of surge
Rehabilitation of existing breakwater
New and potentially new users
Deeper/wider project for larger vessels
Additional facilities, more land for container handling

SMALL CRAFT NAVIGATION
Shortage of ramps, dock space and other facilities
Shortage of berths for commercial fishing vessels and supporting facilities
Congestion at existing facilities
Increasing number of fish landings
No safe anchorage north of Hilo; none from Hilo to Ka Lae
Harbor of Refuge at Laupahoehoe
Drydock and supporting facilities
Joint recreational/commercial fishing facilities
Statewide priorities, coordination, and leadership in planning
Harbor(s) close to fishing grounds
Harbor or ramp outside Hilo Harbor, aiding HFD rescue operations
Silting at mouth of Wailoa River

RECREATION
Restoration of beach; access to beach
Impact of new facilities on family recreation and shore fishing
Improving bay water quality to make beach fully usable
Artificial surfing shoals

HILO BAY WATER QUALITY
Polluted sediments, wastewater, and underground discharges to bay
Breakwater traps pollution
Sewage discharge from moored boats
Longshore currents contribute to harbor pollution
Arsenic and other metals in sediments

OTHER ENVIRONMENTAL/CULTURAL
Changing land use patterns
Impact on Hawaiian way of life
Impacts on filling/dredging Blonde Reef
Historical sites at Bakers Beach, in Puna, and at other sites

OTHER CONCERNS
Tsunami hazard
Sharks in bay
Hilo tourism
Unemployment
Sand mining

SMALL CRAFT NAVIGATION

The most urgent small craft navigation need is the shortage of berths and other facilities. Sites for small boat harbors were proposed on the coast north of Hilo from Laupahoehoe to Cape Kumukahi, south of Hilo and on the South Puna coast from Cape Kumukahi to a site seaward of Queen's Bath, south of Kalapana. The silting at the mouth of the Wailoa River is being investigated under another Corps of Engineers authority. The other needs expressed seem to indicate an overall lack of planning for small craft, while at the same time indicating a growth in the use of small craft, particularly in the area of commercial fishing.

RECREATION

These concerns primarily center on Hilo Bay and the recreational uses of the bay. Restoration of the beach and improving the quality of the bay's waters are tied together, as it is unlikely that any beach would be used to any great extent if the waters facing it were foul. The other main concern is the impact of a new small craft harbor on the area where it is constructed. Any new facilities should not be located in an area now used for shore-based recreation if new facilities would degrade those activities.

TSUNAMI HAZARD

Expressions of concern about tsunamis and Hilo's tsunami hazard occurred more frequently than for any other single concern. Studies performed after the disastrous tsunamis of 1946 and 1960 led to the authorization of a tsunami protection project for Hilo. The height of the barrier required to provide total protection and the local cost share eventually led to rejection of the project by local officials. Nonetheless, the concern over tsunamis is still very evident in the minds of the residents of Hilo.

OTHERS

This navigation portion of the HACS included those concerns that are related to navigation, addressing the environmental/cultural concerns in the Environmental Impact Statement and related appendices. Concerns outside the range of this report will be covered in other portions of the overall comprehensive study.

STUDY AREA

The study authority authorizes a study "...in the Hilo Bay area." The HACS Plan of Study (December 1976), prepared under the broad Harbors and Rivers in Hawaii authority, identified the study area as 1300 square miles of the eastern side of the island. The area is roughly triangular, consisting of all land downslope from lines connecting the summits of Mauna Kea, Mauna Loa, and Kilauea and of land east of lines extending from the summits of Mauna Kea and Kilauea to the ocean. The shoreline of this area extends from Ookala to Cape Kumukahi on the northeast coast and from Cape Kumukahi to Apua Point on the southeast coast. Figure A-1 displays the study area as identified in the Plan of Study (POS).

Concerns and problems relating to navigation and potential sites for small craft harbors were mentioned from Laupahoehoe, north of Hilo, to a location south of Kalapana on the southeast coast. All of these locations are within the study area established in the POS, but publication of that document might well have discouraged any expression of need outside the study area.

EXISTING CONDITION

DESCRIPTION OF THE AREA

The island of Hawaii is the youngest and largest of the Hawaiian chain. The island has a total land area of over 4,000 square miles, almost twice that of the other islands combined. The island is composed of the remnants of five volcanos, including two, Mauna Loa and Kilauea, that are still active. The County of Hawaii is comprised of only the island of Hawaii, with Hilo, the largest populated area on the island, the center of government and industry for the island. The Hilo area contains the only international airport on the island, General Lyman Field, and the largest commercial port, Hilo Harbor. The other deep draft commercial port, Kawaihae, is located on the western side of the island. The study area, described above, comprises about one-third the total land area of the county. The resident population of the island of Hawaii in 1979 was about 84,000, with approximately 50 percent of that located in the Hilo area. The total population of the study area is not quite two-thirds of the total island resident population. The island's de facto population, as tourism is a major industry of the county, is probably 10 percent higher than the resident population.

NAVIGATION

DEEP-DRAFT FACILITIES

Hilo Harbor has three piers used for mooring large commercial ships and barges. Pier 1 has a length of 1,255 feet, 66,000 square feet of covered storage, and 5.8 acres of open storage that can hold approximately 550 standard containers stacked two high. Pier 2 has two sections with lengths of 549 feet and 173 feet, 26,000 square feet of covered storage, and no open storage. Pier 3 has a length of 636 feet, 11,000 square feet of covered storage, and 2 acres of open storage. All large mechanical aids for unloading are located on Pier 1, which has 2 bulk loading towers for bulk sugar, 1 straddle carrier and 6 yard hustlers for containers, and 2 truck-loading hoppers for bulk fertilizer. The other piers have stevedore equipment available as necessary.

DEEP DRAFT TRAFFIC

Barge-carried goods make up about 54% of all incoming traffic to Hilo Harbor. Tankers and container ships account for the remainder. Outgoing cargo is carried on these three types of vessels and on bulk carriers. Passenger vessels also call at Hilo, but at present, only the Oceanic Independence, an interisland cruise ship, makes regularly-scheduled visits.

Tonnage through Hilo amounts to over 1 million short tons annually. While this tonnage is projected to increase, the changes to types of vessels is minimal. The only expected change is the introduction of an Integrated Tug and Barge (ITB) by Brewer Chemical that will have a maximum draft of 36 feet. This vessel will assume some of the transshipment loads now carried by Matson's fleet.

SURGE CONDITIONS

Even with the existing breakwater, surge action creates serious problems for navigation in the bay. At times when a heavy swell, unaccompanied by storms, is running from the north or northeast direction, waves or swells enter the

harbor and are resolved into a marked surge at the three piers. This surge action causes berthed ships to pitch and roll, causing difficulty in holding the ships to the piers. This problem has delayed sailing, hampered efficient working of vessels, prevented complete discharge of cargo, and caused rerouting of vessels to other ports.

The most recent occurrence of the surge problem was in early December 1979. The harbormaster closed the port for over two days. As a result, loading was delayed for a fertilizer barge, lumber and general cargo barges from Oregon moored in the turning basin waiting for a vacant and quiet berth, and a fuel tanker barge was diverted to another port which caused an increase in operating time. The Lurline, a large, roll-on/roll-off vessel, arrived one day after the harbor was reopened. If the condition had continued, the Lurline would have by-passed her normal trip to Hilo and called at Honolulu directly. This would have caused a one- or two-week delay in delivery and there would have been added costs of transshipments from Honolulu.

In December 1977, Hilo's merchants were quite disappointed because a passenger liner with 1,000 visitors on board by-passed Hilo on the last leg of a Hawaii excursion. The "surge" condition came up suddenly. In this case, economic benefits for transportation savings (or losses) are almost nonexistent, yet the loss as perceived by the business community was large. Apprehension is strong among businessmen and vessel operators that similar losses will occur again now that interisland passenger traffic has been resumed.

SMALL CRAFT FACILITIES

The small craft facilities in the study area include launch ramps at Laupahoehoe (1), Wailoa River and Waiakea Pond State Park (2), and Pohoiki (1). The launch ramp at Laupahoehoe is hazardous during rough weather, a frequent condition at that location, while the Pohoiki ramp, which formerly had similar problems, is now protected by a recently-completed federal breakwater. Boats launched at the Wailoa River/Waiakea Pond ramps must have an over-the-water height of less than eight feet to pass under the fixed Kamehameha Avenue bridge over the Wailoa River. There are only 106 official mooring spaces and berths in the study area (and an additional four spaces allotted to transient boats), all within the Hilo Harbor breakwater (Reed's Bay, Radio Bay, and Wailoa River/Waiakea Pond).

Part of the pressure on berths is caused by the growing commercial fishing industry. After falling to a post war low in 1965, the number of people employed in this industry is now steadily growing. The number of commercial fishing boats registered in Hawaii is now at an all-time high, but the shortage of berths probably has a dampening effect on this growth.

TSUNAMI HAZARD

Since 1819, more than 40 damaging tsunamis have struck Hilo. The orientation of the triangular-shaped bay makes Hilo susceptible to tsunamis originating in an arc from the Aleutian Islands to the coast of South America. Physical features peculiar to Hilo Bay seem to intensify and concentrate the waves, on several occasions creating devastating bores of water. The tsunamis of 1946 and 1960 combined caused 234 deaths and damages in excess of $52 million. The tsunami of 1946 severely damaged the breakwater, but little damage to the breakwater resulted from that of 1960. In 1975, an earthquake three miles offshore of Kalapana generated a tsunami in that area. The tsunami caused two deaths, and the damages from the earthquake and tsunami amounted to more than $4 million.

FUTURE CONDITIONS

PROJECTED TRENDS

POPULATION

Assuming a continuation of the existing 10.1 percent portion of the State's population, Hawaii County will have a population of 123,000 by the year 2000. Hilo's existing 63 percent share of the county total is expected to decline as expansion takes place in North Kona, the area that is now the major destination for visitors, and in South Kohala, where much of the new visitor-related construction is expected to take place. Growth in other areas of the island will take place as diversified agriculture increases in importance.

INDUSTRY

The tourism industry should continue to grow in relation to other more established industries, and the service industries supporting tourism should also continue to grow. The demand for Hawaii's fish products is expected to exceed the supply, and the outlook for the fishing industry will continue to be that of growth. The economic impact of manganese nodule mining is potentially significant. Because of the proximity of the State to the belt of high grade nodules, development of a manganese nodule industry appears attractive for Hawaii County.

NAVIGATION

Deep Draft. Radical changes in cargo composition and Hilo's tonnage proportion are not anticipated, and the overall tonnage is expected to increase in relation to Hawaii County's population. With the existing federal project at Hilo, allowable draft based on Corps criteria is 30 feet. Appendix H, Deep-Draft Economic Benefits, discusses the existing and future fleets, each with vessels that exceed this draft. Deepening the project depth would allow these vessels to enter and depart the harbor fully loaded, which would decrease the unit costs for each vessel.

Small Craft. The ratio of small boats to population in the Hilo tributary area is slowly increasing, but at a decreasing rate. This ratio is estimated to reach a plateau of 19/1000 population by the year 2000, growing from 7.1/1000 in 1970. An estimated 678 boats existed in the Hilo area in 1970. With the existing 106 berths and mooring spaces full, 572 vessels were dry-stored, but the estimated demand for wet berths was 163. Table A-2 shows the existing and projected craft in the Hilo area, assuming that additional berths become necessary for those vessels needing wet berths. Without development of additional facilities, the number of wet berths will remain at 106. Table A-3 shows the projected fleet distribution from 1979 to 2000, both with and without improvements for small craft berthing.

TSUNAMI HAZARDS

Following the tsunami of 1960, the US Congress, in the River and Harbor Act of 1960, took the unusual step of authorizing both a study of the tsunami problem at Hilo and authorizing the project that would result from that study as well. As part of the study, the Look Laboratory, named for James K. K. Look, an employee of the Honolulu Engineer District killed in the 1960 tsunami, was dedicated in 1964. The laboratory contained a model of Hilo and Hilo Bay that was used to evaluate various plans for protecting Hilo from tsunamis. The plan that came from these studies was eventually rejected by the local officials on the bases of size and cost. While it is probable that a plan to protect Hilo is feasible from an engineering aspect, it is still unlikely that any conceivable solution would be acceptable, due to the extreme height and costs required to provide adequate protection. After the destruction in 1960, the damaged areas were not rebuilt, but became open areas along the bayfront. The State and county governments are continuing to pursue this path and of support: floodproofing ordinances in providing tsunami protection.

PLANNING OBJECTIVES

From the preceding problems, needs, and concerns, the following planning objectives were developed to guide the course of this study throughout the remainder of its conduct.

DEEP DRAFT

a. Provide improvements in Hilo Harbor to accommodate deeper draft and larger vessels of the existing and future fleets during the 1985-2035 period of analysis.

b. Provide for an increasing number of containers being handled at Hilo Harbor during the 1985-2035 period of analysis.

c. Reduce delays and damages caused by ship motion or "surge" at the Hilo docks during the 1985-2035 period of analysis.

d. Provide for an increasing number of vessels anticipated to be using Hilo Harbor during the 1985-2035 period of analysis.

e. Improve water quality in Hilo Bay (reflected by State Water Quality Standards) for fishing and recreation enjoyment during the 1985-2035 period of analysis.

f. Manage the historic Hilo Breakwater for public and historic appreciation in Hilo Bay during the 1985-2035 period of analysis.

g. Improve the quality of fish habitat in Hilo Bay for fishing during the 1985-2035 period of analysis.

SMALL CRAFT

a. Contribute to commercial and sport fishing benefits through providing appropriate facilities on the coastline of the East Hawaii area during the 1985-2035 period of analysis.

b. Contribute to safe and efficient boating by providing for harbors of refuge on the East Hawaii coastline during the 1985-2035 period of analysis.

c. Contribute to commercial and recreational boating benefits by improving boating opportunities in the East Hawaii area during the 1985-2035 period of analysis.

d. Contribute to coastal water quality for fishing and recreation in the East Hawaii area during the 1985-2035 period of analysis by adhering to State Water Quality Standards.

e. Contribute to the understanding of Hawaii culture (reflected in the historic and archaeological resources) in the East Hawaii area during the 1985-2035 period of analysis.

f. Contribute to land and water-based recreational diversity in the East Hawaii area by improving recreational opportunities during the 1985-2035 period of analysis.

APPENDIX B

PLAN FORMULATION, ASSESSMENT AND EVALUATION

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APPENDIX B

PLAN FORMULATION, ASSESSMENT AND EVALUATION

SECTION I
INTRODUCTION

This appendix is directed towards the development and evaluation of alternative measures to resolve the identified problems and needs of the study area and to fulfill the planning objectives defined in the previous section. Possible measures do not necessarily have to be within the Corps of Engineers' authority or capabilities. If favorable or superior measures are available outside the Corps of Engineers' authorities, the final recommendations will also indicate these alternatives. The initial step in the formulation process is the identification of broad management measures (nonstructural or structural) available to resolve the problems. If the structural measures are considered to be the best solution to meet the planning objectives, the second step is to identify and evaluate potential sites where structural solutions can be constructed with minimal adverse impacts. After the selection of a suitable project site or sites, specific design layouts can be formulated and evaluated. Those plans that meet the planning objectives and local desires can then be identified.

SECTION II
SMALL CRAFT NAVIGATION

1. MANAGEMENT MEASURES

Table B-1 lists the management measures examined and the small craft navigation planning objectives addressed by each measure.

TABLE B-1. SMALL-CRAFT MANAGEMENT MEASURES

Planning Objective	Management Alternatives
Contribute to safe commercial and recreational boating and sport fishing along the coastal zone of East Hawaii during the 1985-2035 period of analysis.	Build new launch ramps to encourage more trailer boating.
	Build areas to accommodate stacked dry storage of boats near launch sites.
	Construct a new small boat harbor on the Puna coastline in the study area.
	Construct a network of launch ramps and emergency mooring areas between Laupahoehoe Harbor and South Point.
Contribute to coastal water quality and opportunities for fishing and water based recreation in the waters of East Hawaii.	Select small boat harbor sites outside of wetlands.
	Include practicable measures to minimize harm to the wetland if construction cannot be avoided.
	Construct in area with minimum dredge requirements.
	Design harbor to have minimum water resident time.
	Excavate inland harbors to create a new marine habitat.
	Excavate harbor basin prior to making connection to the sea.
	Require support facilities in the harbor.
	Construct boat ramp facilities in lieu of a harbor.
	Construct pier and crane type launch facilities.
	Build areas to accommodate stacked dry storage of boats near launch sites.
Promote the understanding of Hawaiian culture (reflected in the historic and archaeological resources and preserve or enhance the environmental resources in the East Hawaii coastal area.	Select construction sites in areas with minimal or no significant sites.
	Salvage any items of archaeologiccal value that would be destroyed by construction.
	Create new opportunities for industries and employment by locating a small boat harbor where there is ample room for backup facilities and to serve as a basis for increased development of a commercial fishing industry.

2. PRELIMINARY SCREENING OF ALTERNATE MEASURES

NONSTRUCTURAL ALTERNATIVES. Trailer boating is considered a nonstructural solution because a launch ramp is not a major construction. There are no locations in the study area or East Hawaii where a new ramp could be built and boats safely launched without protective structures. This can be resolved by placing ramps in protected harbors.

Stacked dry storage appears to have potential for use in Hawaii with the same limitation applying as for trailer boats--a protected body of water is required within which the boat can be launched. The King's Landing site could accommodate stacked dry storage because of the extensive land area available.

STRUCTURAL ALTERNATIVES. The basic problem for small craft in Hawaii is access to the ocean. In East Hawaii, access is especially difficult due to tradewind exposure and the rugged coastline. Any type of structural navigation facility plan, whether it is a launch ramp or commercial small boat harbor, will have to be technically and economically feasible and publicly acceptable. One possibility is to locate a small-craft harbor adjoining the deep-draft port and share some of the costs involved. Hilo Bay is a good location for small craft because it is the only all-weather harbor entrance in East Hawaii. However, it is far from the best fishing grounds and our recent studies show that significant benefits may be realized from providing for commercial fishing harbor improvements. Locating the harbor at Hilo would not fulfill the planning objective to decrease the distances between safe entrances to protected waters. Small craft which have engine trouble or are caught by sudden squalls often cannot return to their port of departure. Fishermen who would operate out of Hilo with the existing fleet, but prefer to fish in the southern waters, would sustain a loss of fish quality and price, a reduction in fish-catch volume because of reduced fishing time, and an increase in fuel consumption per pound of fish caught. Based on the foregoing reasons, it is not considered safe or practical for these fishermen to use navigation facilities at Hilo. In order to fulfill the planning objectives, alternate sites along the coast south of Hilo were proposed.

3. IDENTIFICATION OF POTENTIAL SITES

A total of sixteen potential sites were identified during the course of the planning process. Twelve of these were described in the 1977 Report "Preliminary Planning for Small Craft Facilities in East Hawaii" prepared for the Corps by Aotani & Associates. Four others, King's Landing, Leleiwi Point, Queen's Bath, and Kalapana were added based on public comments and suggestions. Table B-2 lists the sites investigated, the existing facilities, the proposed improvements, and the status of planning. Figure 5 (MR) is a map showing the location of the potential sites. The 16 sites are discussed in the paragraphs that follow.

4. DESCRIPTION AND EVALUATION OF POTENTIAL SITES

LAUPAHOEHOE

The Laupahoehoe site is located on a low peninsula on the coast about 20 miles northwest of Hilo. The existing facilities include a launch ramp, limited parking, freshwater, and restrooms. The launch ramp is used by both commercial fishermen and recreational boaters. One of the original 13 sites identified for examination in 1977, Laupahoehoe was also suggested as a site for a harbor of refuge in subsequent meetings and workshops. The site appears feasible for Federal involvement and will be the subject of a small navigation project study under the Corps of Engineers Continuing Authorities Program, which should result in a final determination sooner than if carried forward under the Comprehensive Study Authority.

HAKALAU

The Hakalau site is on the coast about halfway between Laupahoehoe and Hilo. The site was proposed for development in the State's Statewide Boat Launching Facilities Master Plan as an alternative to development at Laupahoehoe. The site is in Hakalau Bay, which is directly exposed to incoming waves, but which has calmer waters than Laupahoehoe. No facilities have been constructed at Hakalau, and access is very poor and difficult. This site was determined to be inferior to Laupahoehoe and was dropped from further consideration.

TABLE B-2 SUMMARY OF NAVIGATION IMPROVEMENT ALTERNATIVES

SITE	EXISTING FACILITY	PROPOSED IMPROVEMENT	STATUS
Laupahoehoe	1-lane ramp, loading dock.	Protective breakwater, improved launch ramp.	Begin Reconnaissance/Detailed Project Report studies under Small Project Authority in Fiscal Year 1982.
Hakalau	None.	Launching facilities, refuge harbor.	Proposed by State-wide Boat Launching Facilities Master Plan as alternative to Laupahoehoe. No further plans being developed.
Bayfront Park	50-foot wharf at mouth of Wailoa River.	150 berths, 2-lane launch ramp, protective breakwater.	Hawaii County plans to develop a Bayfront Park. Plans for small craft facilities not continuing.
Waiakea Peninsula	None.	Launching facilities.	The State has constructed a senior citizens park. Plans for launch ramp not continuing.
Reed's Bay	26 sailboat anchor moorings.	Launch ramp, increase berthing spaces to 100, protective breakwater.	Authorized Federal project. Begin Detailed Project Report studies in Fiscal Year 1982.
Baker's Beach	None.	Small boat harbor.	Dropped from HACS plans. Insufficient backup space.
Radio Bay	11 berths with mooring by anchor in the middle of the bay for 10 crafts.	Launch ramp and more berthing.	Insufficient backup space. State has plan to fill in Radio Bay to provide for more container storage.
Puhi Bay	None.	Launch ramp.	State DOT has dropped plans for construction.
Leleiwi Point	None.	Small boat harbor, launching facilities.	One of three alternatives presented in this report.
King's Landing	None.	Small boat harbor, launching facilities.	One of three alternatives presented in this report.
Wailoa River	36 berthing spaces, 2-lane launch ramp, loading ramp.	Increased car and trailer parking, dredge mouth, raise Wailoa Bridge to accommodate vessels with high profiles.	District has recommended emergency dredging of the mouth. State DOT plans to replace existing bridge with one with same vertical clearance leaving little potential for expansion. No further Corps planning.
Waiakea Pond	1-lane launch ramp, catwalk for loading.	Lengthen loading dock.	Project needs based on State-wide Boat Launching Facilities Master Plan would not require construction until 1990. This is used only for row boats.
Kapoho	None.	Launch ramp, small boat harbor.	Local residents oppose any development, alternative has been dropped from HACS plans.
Pohoiki	Federal breakwater, 1-lane launch ramp.	Small boat harbor.	Potentially severe impacts on archaeological sites. Dropped from further study.
Kalapana	None.	Small boat harbor.	One of three alternatives presented in this report.
Queens' Bath	None.	Small boat harbor.	Located adjacent to National Park. Potentially severe impacts on historical sites. Dropped from HACS plans. Harbor of Refuge may be suitable and planning may proceed under Small Project Authority.

BAYFRONT PARK

This location is adjacent to the mouth of the Wailoa River at the east end of the black sand beach fronting Hilo Bay. This portion of the beach and the water alongside are used for canoe racing and related activities, and insufficient land exists for both a small boat harbor and existing uses unless the bayfront highway is closed. Recommendation of this site originated in a 1969 report by the State Foundation on Culture and the Arts, which included the highway closing. The irreconcilable conflicts with canoe racing and other existing public uses of the beach precluded continued consideration of this site.

WAIAKEA PENINSULA

This site is located on the western shore of the peninsula on State property. The site of an abandoned dock, it is currently used as a gathering area and for offshore fishing. Waiakea Peninsula was proposed in the Statewide Boat Launching Facilities Master Plan as an alternative to the Reeds Bay site. Plans by the State to construct a senior citizen's park at the site terminated any consideration of this site.

WAILOA RIVER AND WAIAKEA POND

The Wailoa River site is on the Wailoa River upstream of the Kamehameha Avenue bridge, which has a restrictive clearance. The existing facilities part of the Wailoa State Park, include a 2-lane ramp, 36 berths, and facilities for parking and picnicking. These facilities serve the entire Hilo area and are congested. As the State plans to replace the bridge with no increase in clearance, development at this site would not satisfy the small craft needs. The Waiakea Pond site is upstream of the Wailoa River site and is also part of the State park. Existing and projected uses and regulations governing use of this area do not allow for mooring or for use of powered craft. A small boat harbor clearly could not be developed within these guidelines.

REEDS BAY

Reeds Bay is just east of Waiakea Peninsula and is the site of an authorized Corps of Engineers small boat harbor project. While concepts were prepared for discussion early in this study at workshops, development of this site will be pursued under the existing SBH authorization.

BAKERS BEACH

Bakers Beach is west of and adjacent to the commercial port facilities. The land behind the beach area is private residential, constricting the area available for habor development. The owners of these residences oppose any development of this site, and it was dropped from consideration.

RADIO BAY

Presently used for transient mooring, the Radio Bay location was mentioned in the 1972 Statewide Boat Launching Facilities Master Plan and was one of the 13 sites originally identified as having potential for development. In early meetings during the study, the Water Transportation Division of the State Department of Transportation (DOT) indicated they have plans for filling Radio Bay as an expansion for commercial container storage. The location inside the commercial port area would create conflicts with mixed commercial and recreational boating. Consequently, this site was dropped from the study.

PUHI BAY

Puhi Bay is located just outside the Hilo Breakwater adjacent to Kalanianaole Highway. The bay has relatively calm and deep waters and has been mentioned frequently by the State DOT as a potential site. No facilities now exist in this area, but it is popular for swimming, snorkeling, wading and canoe racing practice. The land is administered by the Department of Hawaiian Home Lands, which will not permit any development at this site, eliminating Puhi Bay from consideration.

LELEIWI POINT AND KING'S LANDING

These two sites are located 5 to 10 miles south of Hilo. Both were carried forward into the detailed planning stage and detailed descriptions are given of the two sites in later sections.

KAPOHO

The Kapoho site identified in the Statewide Boat Launching Facilities Master Plan was immediately south of Cape Kumukahi in a small bay surrounded by residential development. The residents in this area strongly oppose any development in the bay, removing this site from detailed consideration.

POHOIKI

The Pohoiki site is now regularly used for boat launching and recovery, and the launch ramp is protected by a Federal breakwater constructed in 1979. This site was suggested for consideration as an offshore harbor project during a public workshop late in preliminary planning. Investigations showed that development could severely impact on archaeological sites, and this location was dropped from additional consideration.

KALAPANA

This location is one of three carried forward into detailed planning. Detailed descriptions are in a later section.

QUEEN'S BATH

This location was also suggested for consideration during a public workshop late in preliminary planning. The site is south of Kalapana, seaward of the historic Queen's Bath pool. The area is adjacent to the Volcano National Park and is in an area rich in archaeological sites. Development could produce severe adverse impacts on these historical sites, and this location was not carried into detailed planning.

5. DEVELOPMENT OF DETAILED PLANS

Of the initial 16 sites identified, three were deemed worthy of further consideration as a potential small boat harbor. Investigations were continued at King's Landing, Leleiwi Point, and Kalapana in order to prepare a more detailed impact assessment and design. The following investigations were conducted during the final stage of planning.

a. Hydrographic surveys at King's Landing, Leleiwi Point, and Kalapana.

b. Topographic surveys at King's Landing and Kalapana. (A 1973 County survey of Leleiwi Point was used to determine the topography at that site.)

c. Archaeological/cultural reconnaissance survey to determine the presence of culturally significant artifacts at Kalapana and Leleiwi Point. An archaeological study was completed in 1978 at the King's Landing site by the Archaeological Research Center of Hawaii. This report was used to assess the impacts at King's Landing.

6. DESCRIPTION AND EVALUATION OF DETAILED PLANS

LELEIWI POINT

The Leleiwi Point site (Figure 6 in the Main Report) also called Lehia Park, is within the South Hilo Judicial District on the northeast coast of the island, about 5 road miles east of Hilo. The park has a total land area of 41 acres and is presently owned, operated, and maintained by the State of Hawaii. The property is classified as mainly conservation with some commercial land. A master plan for the development of the entire Lehia Park area has been prepared by the County. The proposed development plan includes improvements and additions to park facilities, but does not provide for recreational harbor facilities.

The construction of a small boat harbor at Leleiwi Point would consist of a 1,310-foot wave absorber, dredging of entrance and access channels totalling 1,565 feet in length and a 14,000-square-foot turning basin. Figure B-3 shows a preliminary layout of the harbor.

KING'S LANDING

The area known as "King's Landing" (Figure 6) is situated on 2,138 acres of privately-owned land about 7 road miles southeast of Hilo. King's Landing is within the Puna Judicial District, adjacent to the South Hilo-Puna District boundary, on the northeast coast of the island. The coastline at King's Landing is characterized by rough waters and high cliffs near the water's edge. There are few points of access to the shoreline. Surge is heavy throughout the year. The improvement of the harbor basin and much of the entrance channel would be constructed inland from shore. The proper design and engineering of a safe entrance channel and adequate harbor will pose the biggest problem at King's Landing.

King's Landing appears to be socially and environmentally suitable site for a commercial fishing harbor.

A new community is to be developed in this area as part of the King's Landing master plan. Preliminary plans call for a residential subdivision of one-acre lots. Proposed future developments include schools, churches and resort/recreational facilities.

The navigation improvement has a potential for expansion into a major commercial, shallow-draft harbor with associated landside facilities such as fish processing, boat building, and marine stores. It could also accommodate recreational boaters. A private landowner has offered to give the local government sufficient acreage for the harbor and backup facilities.

At the present time, the only access to the undeveloped area is by an unimproved gravel road. There are no paved roads in the area; however, new roads are to be constructed as part of the initial phase of the private development plan.

Two alternative harbor layouts were developed for the King's Landing area (Figure 8 in the Main Report). The first plan which would avoid the wetland consists of construction of a 1,755-foot long wave absorber, dredging of entrance and access channels totalling 1,800 feet in length and a 14,000-square

foot turning basin. The second plan would impact upon a 12-acre wetland, involves construction of a 1,420-foot-long wave absorber, dredging of entrance and access channels totalling 1,430 feet in length and a 38,000-square-foot turning basin.

KALAPANA

The Kalapana area is located in the Puna District about 30 road miles south of Hilo, as shown on Figure 7 (in the Main Report). The land area is owned by the State of Hawaii and is zoned for conservation use. Approximately 200 persons live in the Kalapana area. The coast highway is the only overland access to the community. In addition, the highway provides access to County and State parks popular with residents and tourists. Kaimu Beach Park, located one mile from the Kalapana community is a 2.6 acre County park and includes the Kaimu Black Sand Beach. At the eastern edge of Kalapana, one-half mile from Kaimu Beach Park is the 22.8 acre Harry K. Brown Park (a County park). A proposed Kalapana-Kaimu Park, connecting and extending the two existing parks, has been a consistent feature of recent community development community planning for this area. This Park Development Plan for Kalapana-Kaimu has been recommended for implementation in the County of Hawaii General Plan, as revised and approved in 1971.

The Kalapana community is threatened by natural disasters from both the land and the sea. The active Kilauea volcano periodically threatens the Kalapana coastline.

The construction of a small boat harbor at Kalapana would consist of a 920-foot wave absorber and dredging entrance and access channels totalling 1,280 feet in length and a 13,000 square foot turning basin.

7. COMPARISON OF DETAILED PLANS

The benefits derived from a new small craft harbor consist of navigation benefits to fishing craft that would be moored without the project, increased fish catch; and damage prevention. The computations are based on a 7-3/8

percent interest rate and a 50-year project life. The project base year, 1985, is when benefits are expected to begin accruing to the proposed harbor plans. Benefits are based on December 1980 price levels. Appendix I presents the methodology used to determine the projected fleet which would use the harbor and estimated increase in fish catch attributed to the new facility. Table B-3 is a summary of project average annual benefits derived from a new small boat harbor in the Hilo Tributary Area.

TABLE B-3. SUMMARY AND ALLOCATION OF PROJECT AVERAGE ANNUAL BENEFIT HILO TRIBUTARY AREA (7-3/8%) ($1,000's)

Benefit Category	High Projection1/	Medium Projection1/	Low Projection1/
Full-Time Commercial	$2,622.9	$1,965.6	$1,111.8
Part-Time Commercial	159.1	125.0	75.1
Transient	2.1	2.1	2.1
Damage Prevention	45.4	45.4	45.4
Total	$2,829.5	$2,138.1	$1,234.4

1/ High projection annual benefits are based on a boat harbor of 203 berths, medium projection benefits 169 berths, and low projection benefits 119 berths.

Costs for construction were estimated at September 1981 price levels, and assume that construction would start in September 1981 for a period of 2 years. The cost growth for the 16-month time period between May 1981 and September 1982 is assumed to be 1%/month for a total of 16%. Table B-4 shows a breakdown of federal vs. nonfederal costs and average annual costs of 4 alternative plans. Appendix D presents a breakdown of cost items.

TABLE B-4. SMALL BOAT HARBOR SUMMARY OF COSTS AND BENEFITS

	King's Landing Plan 1	King's Landing Plan 2	Leleiwi Pt.	Kalapana
Total 1st Cost	15,000,000	16,000,000	12,328,000	10,694,000
Federal 1st Cost	10,661,000	10,230,000	8,002,000	5,644,000
Non-Federal 1st Cost	4,349,000	5,770,000	4,326,000	5,050,000
Average Annual Costs	1,162,000	1,238,000	959,000	835,000
Average Annual Benefits	2,138,000	2,138,000	2,138,000	2,138,000
Benefit to Cost Ratio	1.8	1.7	2.2	2.6

Table B-5 summarizes the major items of consideration used in selecting the recommended plan from the three alternative sites.

Kalapana was chosen as a potential site because of its proximity to the preferred fishing grounds, its mid-point location in relation to the existing harbors on the Puna Coastline, its comparitively moderate offshore conditions, and its engineering feasibility.

The Kalapana site has 13 acres of public land which is adequate for the boat harbor but not for backup facilities. Site has been designated as a county park; the construction of a boat harbor here would be incompatible with present land use plans. There are numerous archaeological and historical sites in the Kalapana area. The development of a small craft harbor could affect the historic canoe landing site, one prehistoric heiau (a Hawaiian temple) and one historic church, both of which appear to be eligible for inclusion on the National Register of Historic Places. Potentially severe impacts and public opposition are likely to be strong.

The waters off Kalapana have some surfing value. The development of a boat harbor would most likely eliminate some of the surfing.

Kalapana is presently a small, rural community in a quiet setting. The impact on the Kalapana Community would be great.

Kalapana is in a geologically active zone and the coastline has been sinking over the past few decades. The active Kilauea volcano periodically threatens the community. A small boat harbor would be subject to these hazards which make Kalapana a less than ideal location for a harbor.

Marine or terrestial/ecological impacts are not thought to be significant. The harbor basin would be excavated from the shoreline, creating new marine habitat and eliminating much of the coconut grove. No wetlands are located at the site. Canoeing activities in the existing pond would be eliminated. No effect on the endangered humpback whale, endangered hawksbill turtle and threatened green sea turtle is anticipated.

TABLE B-5 COMPARISON OF SMALL CRAFT HARBOR SITES

	KING'S LANDING	LELEIWI POINT	KALAPANA
Land Available	All private lands. Up to 150 acres to be donated by private landowner which would also be sufficient for extensive backup facilities.	43 acres of State land available. Sufficient for minimal backup facilities. Site designated as County park.	13 acres of State land available. Requires purchase of private lands for backup facilities. Site designated as historic County park.
Offshore Conditions	Hazardous. Open coast entrance channel.	Hazardous. Open coast entrance channel.	Moderate. Semi-protected entrance channel.
Natural Hazards			
Volcanic	High.	High.	Very high.
Tsunami	High.	High.	Very high.
Land Subsidence	None.	None.	Moderate.
Wave Exposure	Direct tradewind exposure.	Indirect tradewind exposure.	Direct tradewind exposure.
Design Wave	12.5 feet.	10.0 feet.	10.0 feet.
Offshore Bottom Slope	10 percent.	7 percent.	9 percent.
Offshore Water Depth	Very deep.	Moderate.	Moderate.
Wave Absorber Length	Plan 1: 1,755 feet Plan 2: 1,420 feet	1,370 feet.	920 feet.
Wave Absorber Armor Rock Weight	0.5 tons.	0.5 tons.	05. - 3 tons.
Length Entrance and Access Channels	Plan 1: 1,800 feet Plan 2: 1,430 feet	1,565 feet,	1,280 feet.
Area of Turning Basin	Plan 1: 14,000 square feet Plan 2: 38,000 square feet	14,000 square feet.	13,000 square feet.
Historic Sites	Impacts on two sites proposed for National Register at each site.	Unknown.	Impacts on one site on National Register; two sites on State Register; three proposed for National Register.
Endangered Species	No effect.	No effect.	No effect.
Wetland Evaluation	Plan 1: Required Plan 2: None	None.	None.
Surfing Value	No.	No.	Yes.
Utilities and Access	Presently none.	Mostly in place.	In place, no electricity, no sewer.
Local Residents	No impact.	Significant impact.	Significant impact.

	KING'S LANDING	LELEIWI POINT	KALAPANA
Driving Distance to Hilo	6 miles.	5 miles.	31 miles.
Planning Objectives Met	Yes	Yes	Yes
Estimated First Cost	Plan 1: $15,000,000 Plan 2: $16,000,000	$12,328,000	$10,694,000
Local First Cost	Plan 1: $ 4,349,000 Plan 2: $ 5,770,000	$ 4,326,000	$5,050,000
Average Annual Cost	Plan 1: $ 1,162,000 Plan 2: $ 1,238,000	$ 959,000	$ 835,000
Average Annual Benefit	$2,138,100	$ 2,138,100	$2,138,000
Benefit-to-Cost Ratio	Plan 1: 1.8 Plan 2: 1.7	2.2	2.6

Based on the land concerns, and severe historical, archeological, and social, impacts associated with the development of a small boat harbor at Kalapana, this site was not selected as the recommended plan.

It is still felt that some type of navigation facility is needed in this stretch of the coastline for craft to put in in rough weather. Therefore, we recommend that a navigation facility be constructed at Kalapana consisting of an offshore protective breakwater, launch ramp and small mooring area.

Leleiwi Point was included as an alternative plan because it was a site located just outside Hilo breakwater and is situated on public (State) land. The 43 acres of public land available is adequate for a small craft harbor and minimal back-up facilities. However, the land is zoned for conservation use and a park is planned for the area. The development of a boat harbor conflicts with the park plans, but would also eliminate the park, and the park tide pools, which provide a swimming resource.

The King's Landing area is located approximately 2 miles down the coastline from Leleiwi Point. The two sites possess similar topography, geology and offshore conditions.

King's landing was included because a private landowner offered to give 150 acres to the State to develop a small craft harbor.

From a technical standpoint, both King's Landing and Leleiwi Point are poor candidates for a small boat harbor. The offshore wave conditions are very rough and the bottom slope drops off steeply to very deep water. An inland harbor is the only alternative to provide for safe navigation at either site because of the dangerous sea conditions. Extensive blasting of hard basalt rock would be required to construct the long entrance channel and turning basin. Some offshore dredging is also necessary to provide adequate entrance depths.

Determinations of eligibility for possible inclusion in the National Register will be sought for two archaeological sites present at King's Landing. A reconnaissance study to determine the number and significance of historic sites at Leleiwi Point is presently under contract. At this time, no sites of significance are known.

There are no overriding environmental problems or constraints at King's Landing Plan 2. Plan 1 at King's Landing would eliminate 12 acres of wetland.

King's Landing was chosen as the tentative recommended plan over Leleiwi Point because of the following reasons:

a. Although the local first cost of construction at both King's Landing sites is shown to be greater than at Leleiwi Point, it will in fact be less because the land owner at King's Landing has agreed to provide the land with some of the excavation already completed. This would substantially reduce or eliminate the local costs associated with excavation and dredging.

b. The landowner at King's Landing has also offered to provide all necessary access roads and facilities. The local government would be responsible for the access and utilities at Leleiwi Popint which is not already in place. The local cost share would be further reduced by selecting King's Landing over Leleiwi Point.

c. The State would receive revenues from the leasing of newly acquired land for back up facilities at King's Landing. Leleiwi Point is already public land and the State would not gain any revenues from leasing.

d. There is more land available at King's Landing to develop support facilities to create a complete marina setting.

e. The development of a small boat harbor at Leleiwi Point would conflict with county plans to develop the area into a park.

SECTION III
DEEP DRAFT NAVIGATION

1. MANAGEMENT MEASURES

Table B-6 provides a listing of possible management measures examined for deep draft navigation with the planning objective each measure addresses.

TABLE B-6. DEEP DRAFT MANAGEMENT MEASURES

Planning Objective	Management Measures
As a contribution to deep draft navigation, encourage the efficient development and utilization of Hilo Harbor to accommodate all waterborne commerce and associated traffic during the 1985-2035 period of analysis.	Dredge a deeper entrance channel and turning basin.
	Dredge a wider turning basin.
	Remove existing mooring buoy.
	Construct a revetted fill area to store additional containers.
	Stack containers on existing storage area.
Contribute to the reduction of ship delays, and damages caused ship motion or natural wave action at the Hilo docks.	Improve fender systems on the piers.
	Manage vessel schedules more efficiently.
	Dredge a deeper turning basin to provide a greater underkeel clearance.
	Install pretension winches.
	Construct an inner breakwater to provide greater protection to the port.
	Realign piers, construct new piers.
Preserve and maximize the effectiveness of the historic Hilo breakwater for public safety and historic values.	Continue maintaining the Hilo breakwater.
Enhance the water quality and fish habitats of Hilo Bay.	Remove existing breakwater in Hilo Bay.
	Reduce sediments/pollution entering the Bay.

2. PRELIMINARY SCREENING OF ALTERNATE MEASURES

NONSTRUCTURAL ALTERNATIVES. Table B-7 lists the various management measures corresponding to the planning objectives and the planning status of each. Nonstructural components of the deep draft navigation plans include replacing the existing mooring buoy with a submersible mooring buoy, improving the existing dock fender system, installing pretensioning devices, managing vessel schedules more efficiently and developing new systems to meet the increased container storage needs.

Submersible Mooring Buoy. Persons knowledgeable of navigation and shipping conditions in Hilo Harbor agree that the buoy is invaluable during the winter months to settle ships, but at its present location, the existing mooring buoy presents an obstuction limiting the available maneuvering area in the turning basin. Without the buoy, ships would have to clear berth and anchor somewhere in the bay or adjust shipping schedules.

A possible means by which the obstruction posed by the buoy might be removed is to develop a submersible buoy. This plan (Appendix D) utilizes the existing anchors, ground chains, and ground ring. A buoyant tube, somewhat longer than the depth of water in the vicinity of the anchors, would be attached at one end to the ground ring. The other end of the tube would be fitted with buoyancy cells and provision for attaching ship lines. The tube serves as a tension rod link between the ship lines and existing anchors, as well as a boom which can be raised to expose the tip to which ship lines are attached. The tube and cells would be constructed with low profile so as to minimize reduction of harbor clear depth.

When anchorage is needed during surge conditions, high pressure air would be introduced into the air sacs in the cell and tube, displacing and thereby expelling water, such that the attachment tip of the tube is buoyed to the surface, much like a submarine surfaces upon blowing its tanks. The ship lines would then be secured to the top of the tube.

When no longer needed, the ship lines would be disconnected and the tube laid on the harbor bottom by releasing the air pressure, thereby collapsing the air sacs and flooding the tube. It should be noted that as a precautionary measure, hazard buoys should be placed about the tube location prior to raising the tube.

The submersible buoy is estimated to cost about $300,000. The costs do not include engineering, design and supervision during contruction. The buoy is a component of Plans C and D.

Improvements to Existing Fender System. In theory, it is possible to moor a ship with little ship movement. Ship motions, as well as mooring downtime, can be reduced significantly if breast lines of the ships are pretensioned. The steady force created by the cable pretension can hold the hull in contact with the fender system. Because of this effect, ship motions can be damped out by the friction force on the contact surface and the bumping force against the fender can partially be cancelled by the steady slide force.

Monitoring the mooring lines tension and relative movement of the loading equipment is considered an acceptable alternative. With appropriate instrumentation, the force in each mooring cable could, together with the instantaneous motion of the loading equipment, can be measured and displayed in a console located in a control room. Under the surveillance of a berth attendant, the instantaneous status of the mooring system can be adjusted. During the operations, the communication between the operators can be implemented by using portable radio equipment. Pretension devices should be used in conjunction with a good marine dock fender system.

If pretension devices (constant tension mooring winches) are used, the assumption is that two are installed at the bow and two installed at the aft of the design vessel. It is estimated that each devise would cost about $150,000 (installation cost not included). Replacement of the existing fender system with a cylindrical rubber fender would cost about $225 a linear foot. Pier 1 would be top priority for fender improvement. About 1,300 lineal feet are requested. Both the pretension devices and the improved dock fender system are locally implementable. Many of the vessels using Hilo Harbor have the winches but they are not used because of the existing fender design. An improved fender system at Pier 1 is a component of Plans C and D.

Other Measures. As a measure to reduce surge, one of the simplest methods is management of vessel schedules. The harbor master manages schedules, but the randomness of surge events inevitably disrupts traffic. There is no early warning of surge and some vessels schedules vary. Particularly the double tow tug and barges from the west coast. Their arrival time is not predictable to the nearest day as in the case of the container ships. Therefore, management of vessel schedules would provide a further improvement to the surge problem. This, also, would not be locally implementable.

New systems which could be developed to meet cargo and increased container storage needs include stacking of containers and better utilization of the open space on the piers. This plan could be studied further by the local government.

STRUCTURAL MEASURES

Structural measures applicable to deep draft navigation (Table B-7) are dredging of a deeper entrance channel and turning basin, dredging of a wider turning basin, constructing new piers and supporting facilities to accommodate the increasing number of vessels using Hilo Harbor, constructing a revetted fill area to store additional containers, and partially removing the existing breakwater and replacing it with a new inner breakwater.

Entrance Channel and Turning Basin. The entrance channel and turning basin were designed to provide safe navigation of vessels to a length of 700 feet, a beam of 92 feet, and a draft of 34 to 36 feet. In order to accommodate the larger vessels using and projected to use Hilo Harbor, the entrance channel and turning basin would have to be dredged to -40.0 feet from -35.0 feet. The one-way entrance channel width of 450 feet and depth of -40.0 feet were computed to insure safe and economic navigation. Deepening of the entrance channel and turning basin is a component of all four deep draft plans.

The width of the turning basin is, related to ship motion at Hilo docks. Minimization of ship motion would permit removal of a buoy which is now required for ships moored during severe conditions. This buoy is an obstacle to navigation. Removing this buoy directly affects the amount of widening

that must be done to the basin to make it adequate from an operational viewpoint. With the buoy, the harbor should be widened by 400 feet, but without the buoy the widening would not be required. The cost of widening the basin by 400 feet is $2.6 million. Since construction of a submersible mooring buoy is estimated to cost less than $0.3 million the buoy is a component of Plans C and D as an alternative to widening the basin.

Minimum Basin Size	Depth
width (feet)	1450
length (feet)	1800
depth (feet)	40
cost	$4,150,000
Maximum Basin Size	
width (feet)	1800
length (feet)	1800
depth (feet)	40
cost	$6,725,000
Average annual maintenance cost	$ 13,000

TABLE B-7. STATUS OF DEEP DRAFT MEASURES

Planning Objective	Management Measure	Planning Status
As a contribution to deep draft navigation, encourage the efficient development & utilization of Hilo Harbor to accommodate all waterborne commerce and associated traffic during the 1985-2035 period of analysis.	Dredge a deeper entrance channel and turning basin.	Included in Plans A, B, C & D.
	Dredge a wider turning basin.	Submersible mooring buoy is more favorable.
	Remove existing mooring buoy and replace with submersible mooring buoy.	Included in Plans C & D.
	Construct a revetted fill area to store additional containers.	Economically infeasible for Federal project. May be locally implementable.
	Stack containers on existing storage area.	Locally implementable.
	Adjust vessel schedules.	Locally implemeneeable.
	Reduce time to tie-up and turn.	Locally implementable.
	Build new piers and supporting facilities.	Locally implementable.

TABLE B-7. STATUS OF DEEP DRAFT MEASURES CONT'D

Planning Objective	Management Measure	Planning Status
Contribute to the reduction of ship delays and damages caused by ship motion or natural wave action at the Hilo docks.	Improve ship fender system.	Included in Plans C & D.
	Manage vessel schedules more efficiently.	Currently implemented.
	Install pretension winches.	Partially implemented by local interests.
	Construct an inner breakwater to provide greater protection to the port.	Included in Plan C.
Enhance the water quality and fish habitats of Hilo Bay.	Remove existing breakwater in Hilo Bay and replace with new inner breakwater.	Included in Plan C.
	Reduce sediments/pollution entering the bay.	Partially implemented by local interests

All material to be dredged is clay and silt, and deep ocean disposal is less costly and is the preferred alternative of spoiling. Based on a strict comparison of transport costs, land disposal is least expensive where the land disposal site is less than 4.5 miles from the dredge site, and no sites exist within 6 miles of the harbor. Ocean disposal is cheaper beyond that point. Bioassay and bioaccumulation testing of the dredged material will be required prior to obtaining U.S. Environmental Protection Agency approval to ocean disposal.

Additional Storage Area. Construction of a revetted fill area for additional storage would require a quarry stone revetment to retain dredged material. The revetment would require quarry stones placed on a 1.5 horizontal to vertical slope, a slope sufficiently flat to adequately dissipate wave energy. In addition, voids between stones would also provide dumpening capacity to absorb wave energy, which if reflected back into the harbor, would adversely affect navigation.

Revetted Fill Area

Area (acres)	11
Elevation (feet)	+8.0
Cost	$2,300,000

As a Federal project, construction of a revetted fill area is economically infeasible, but such a project could be implemented locally. It is not a component of any detailed plan.

Existing Breakwater Modification. To improve circulation to the extent required for enhancement of the water quality in Hilo Bay, modification of the existing Hilo breakwater is a major environmental quality plan component.

Implementation of this would require structural alteration of the breakwater. The plan which would best improve water quality is the removal of the break-
water. The plan which would best improve water quality is the removal of the breakwater stone to an elevation of -8.0 feet on the outer 7,000 feet of breakwater. Variations of this plan include breaching the outer 7,000 feet of breakwater at regular intervals or removing stone to an elevation higher than -8.0 feet. Methods of breaching include the following:

a. Allow the breakwater to deteriorate naturally.

b. Remove the breakwater rock and using and the rock to construct other features in the harbor.

c. Remove the breakwater rock and storing the rock for future construction such as the small boat harbor.

d. Remove rock from the breakwater on an as-needed-basis to repair the remainder of the breakwater.

e. Breech the breakwater at specified intervals.

f. Improve the navigability of the harbor basin installing a submersible mooring buoy.

g. Deepen Hilo Harbor to reduce the frequency of maintenance dredgings and to remove toxic sediments from the harbor and bay area.

This component (breakwater modification) is included in Plan C.

Inner Harbor Protective Breakwater. This concept consists of two rubble mound breakwater placed to reduce surge in the berthing area and would be a major structural addition to Hilo Harbor. This concept is included as a component of Plan A for comparative purposes. (See Figure D-11.)

Chamber of Commerce Plan. The proposal requiring the greatest amount of reef modification was made by the Hilo Chamber of Commerce. It is a significant alteration from the existing harbor design. The benefit to cost ratio is much less than unity. (See Figure D-12.)

3. ASSESSMENT AND EVALUATION OF DETAILED PLANS

PLAN A: Inner Harbor Protection. This plan has a benefit to cost ratio less than unity (BCR = 0.3). It would be an effective structural plan to reduce surge. It would worsen the environmental conditions in inner Hilo Harbor. Deepening is included so that deeper draft vessels could be accommodated.

PLAN B: Chamber of Commerce Plan. This plan has a benefit to cost ratio much less than unity (BCR = 0.1). An effective structural plan to reduce surge, the plan would have significant negative impacts on the natural marine environment. Deeper draft vessels would be accommodated. The plan could provide benefits to local interests because of the opportunities for growth.

PLAN C: Existing Breakwater Changes. This plan has a benefit to cost ratio greater than unity (BCR = 1.4). It includes nonstructural measures to reduce surge damages and delays. Deeper draft vessels are provided for by dredging. Lower maintenance and repair costs are projected for the Federal project at Hilo Harbor if the outer 7,000 feet of the existing breakwater were abandoned. This plan provides net enhancement to the natural environment of Hilo Bay. There would be increased tsunami runup after deterioration of the outer 7,000 feet of breakwater. Without physically modeling the problem, it is not now possible to determine the net change in runup. If this plan were selected, physical modeling of Hilo Harbor would be required, as part of the project authorization.

PLAN D: Harbor Deepening and Nonstructural Measures. This plan has a benefit to cost ratio greater than unity (BCR = 1.2). It provides for damage and delay reduction caused by surge through the use of nonstructural measures. Deeper draft vessels would be accommodated through dredging. These are some temporary adverse impacts on water quality during dredging, but the long term impact on benthic quality are beneficial because poor quality sediments would be removed. Bioassay and bioaccumulation testing of the dredged material prior to ocean disposal will be required.

TABLE B-8. DEEP DRAFT BENEFIT - COST ANALYSIS

Plan	Total Cost ($ Millions)	Average Annual ($ Millions) Benefits	Costs	B C Ratio
A Inner Harbor	21.4	0.495	1.557	0.3
B Chamber of Commerce	115.4	0.332	8.292	0.1
C Existing Breakwater Changes	18.9	2.00	1.381	1.4
D Harbor Deepening and Nonstructural Measures	5.7	0.495	0.397	1.2

APPENDIX C

PUBLIC INVOLVEMENT

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INTRODUCTION

The public involvement program of the navigation portion of the Hilo Area Comprehensive Study (HACS) consisted of three interwoven elements:

meetings and workshops with the public at large

meetings and workshops with members of federal, state, and local agencies

the various reports and documents distributed to keep the concerned publics informed of the progress being made in the study

Beginning with the initial HACS public meeting in April 1976, ten public meetings and workshops were part of this public involvement program. The next section discusses these meetings and workshops, including a summary of each. The section following that is a summary of the concerns expressed during these various meetings and workshops. The fourth section contains a discussion of each of the reports and other documents thus far produced in the study relating to navigation. The final section contains the correspondence pertinent to this aspect of HACS.

MEETINGS AND WORKSHOPS

INITIAL HACS PUBLIC MEETING (27 APRIL 1976)

SUMMARY OF MEETING

Staff members of the Pacific Ocean Division (POD) discussed aspects of the proposed comprehensive study. The general tone of comments received was support for the study. The attendees, about 80 total, included representatives of Hawaii's Congressional delegation, officials of federal, state and local agencies, members of community groups, and individuals. A representative of the State of Hawaii presented a statement noting the State expected the study to be the basis for fulfilling the requirements of Section 208 of PL 92-500.

CONCERNS EXPRESSED FOLLOWING THE MEETING

In the weeks following the 27 April meeting, POD received the concerns listed below, primarily in correspondence addressing the meeting and the documents distributed to that time in the study: the draft and final plan of study, the 1972 Environmental Studies, and two information sheets.

NAVIGATION

Surge in commercial harbor

Small craft needs

Additional land for commercial harbor

Effect of pollutants on maintenance dredging and disposal

Shortage of small craft dock space

Launch ramps east and south of harbor

RECREATION

Restoration of Hilo Black Sand Beach

Surfing in bay

HILO BAY WATER QUALITY

Study of water quality

Determination of water quality standards

Sediment, wastewater, and underground water discharge into bay

Effectiveness of existing breakwater as opposed to probable trapping of pollution.

Sewage disposal from moored boats

OTHER ENVIRONMENTAL/CULTURAL

Historic Hawaiian lifestyle

Land use patterns

Endangered water bird habitat

OTHER CONCERNS

Coordinate CZM with HACS and with 208 planning

Overlap of HACS with Hawaii Water Resources Regional Study (State conducted)

Negative impact of products on Hilo tourist industry

Overlap or conflict with 1971 County General Plan

Tsunami hazard

SMALL CRAFT NAVIGATION WORKSHOP (23 MAY 1977)

SUMMARY OF WORKSHOP

This workshop and the workshop following in June were used to obtain community input on an array of potential Small Boat Harbor (SBH) sites. The attendees at this meeting discussed the merits of all sites, selecting those most favorable from the user's point of view. Following presentation of videotapes of the sites, no objection was raised to any site except Kapoho. Shore fishermen expressed concerns about possible adverse effects of new boating facilities on shore casting, particularly at Kapoho, but also at Pohoiki, to a lesser extent. Boaters expressed the need for more facilities at Laupahoehoe, Hilo, and in Puna. With no safe harbors north of Hilo in rough weather, Laupahoehoe was asked to be considered for development as a harbor of refuge. The needs existing at the Wailoa basin were mentioned: more berths, more parking, and the bridge that restricts entry to the basin. It was stated that a launch ramp could be located adjacent to the Hilo Iron Works. If the Pohoiki ramp were to be protected, boaters in Hilo indicated they would use Pohoiki more frequently.

SMALL CRAFT NAVIGATION WORKSHOP (13 JUNE 1977)

SUMMARY OF WORKSHOP

The videotape shown at the previous meeting was used as an introduction, then the status of the sites was given: seven had been deleted from further consideration for a variety of reasons. One site deleted, Pohoiki - the site of another Corps study, specifically received a good deal of attention. The boaters were concerned that deletion from HACS consideration would be harmful to the project. (The Pohoiki breakwater project was completed in 1979.) As compared to the first meeting, people representing a broader range of interests attended: state and county officials, an environmental representative, as well as many of the boaters and fishermen that attended the meeting in May.

Laupahoehoe received much support. Supporters from there presented a film showing the difficulties in launching at Laupahoehoe with a north wind and again requested consideration of Laupahoehoe as a harbor of refuge. The problems of Waiakea Peninsula were discussed: tremendous tsunami force, encroachment on view, interference with fishing, and possibility of further reducing the black sand beach by changing the littoral drift. The bayfront harbor site has the same tsunami problems, would interfere with canoe racing, and would directly remove some of the black sand beach. Expressed concerns for Wailoa River were the highway bridge is too low, a fuel dock is needed, and there are potential adverse environmental effects. Reed's Bay, a site of an approved Corps SBH, was the group's choice for the Hilo area. Of the conceptual alternatives presented for Reed's Bay, number two has better access for sailboats. One person in attendance expressed concern that the Corps apparently was neglecting the Chamber of Commerce plan for developing Hilo Harbor.

CONCERNS EXPRESSED OUTSIDE THE MEETING

As the 23 May workshop and the 13 June workshop were close together in time, all comments were received after the second meeting. As no comment expressly addressed either meeting, all are treated together.

Navigation

Wailoa River Plan preferred with expansion to Radio Bay and/or Baker's Beach, if needed

Both Radio Bay and Baker's Beach are backup land for commercial port -- King's Landing suggested for examination

Request from State DOT to conduct studies of King's Landing, Lehia Park, and Laupahoehoe under small navigation authority

Surge in Hilo Harbor

Hilo Bay Water Quality

-none-

Other Environmental/Cultural

Environmental consequences of filling and/or dredging Blonde Reef

Recreational

State DLNR prefers to restrict entry to Wailoa Basin, encouraging more canoeing type activities

Other

Coordination with Master Plan for Hilo Harbor

SMALL CRAFT FACILITIES WORKSHOP (26 APRIL 1978)

SUMMARY OF WORKSHOP

This workshop was combined with a workshop for the POD mooring study, which was also in progress at that time. The results of the reconnaissance studies for navigation at Laupahoehoe, King's Landing and Lehia Park were

given, and all were found to be infeasible for federal participation. A summary of past small craft facility planning was given, followed by a discussion centering on the Hilo area.

Comments on the Wailoa site included the feeling that this site is more protected, would be less expensive to develop, fresh water in river is advantageous for boat maintenance, and that it would be cheaper to upgrade the restrictive highway bridge than to construct breakwaters at other sites. Reed's Bay received several comments: lands for access to Reed's Bay would be expensive, surge is a problem at Reed's Bay (as well as Hilo Harbor), and Reed's Bay should be preserved as a beach for visitors. A general comment was that more centralized facilities are needed as a deterrent to the increasing vandalism.

CONCERNS/COMMENTS OTHER THAN AT MEETINGS

Navigation

Filling of Radio Bay, which will be necessary to provide more back-up space for commercial port, will displace transient boats allowed to moor there since Wailoa River is full

Need exists for joint recreational/fishing facilities

An increase in fish landings is anticipated

A lack of drydock and supporting facilities exists on the outer islands

There is a lack of overall statewide coordination and leadership in small craft planning; need for a state wide list of small craft priorities

Unmet need for commercial fishing berths and other port facilities

Wider turning basin needed for Hilo Harbor, based on Matson's plans for replacing 600-650' vessels with 840' vessels

Dredging needed to accommodate vessels with 36' draft

Initiation of interisland ferry service would create new needs

Potential manganese nodule industry would create several new needs

Major problems at Hilo Harbor are depth and surge conditions

Hilo Bay Water Quality

-none-

Other Environmental/Cultural

-none-

Recreational

Closing bayfront highway and restoring backbeach on which highway is built would help restore Black Sand Beach

New beach along bayfront highway would protect highway from erosion and overtopping, but public access would be limited

Other

Hawaii County resolution asking for status of tsunami control planning

Two documents printed by the State of Hawaii in 1979 contain sections that impact on navigational needs in the Hilo area. Hawaii Water Resources Plan, Hawaii Water Resources Regional Study, January 1979:

> Projected demand for small boat berths in Hawaii in the year 2000 is 440; existing number of berths is 241. Existing facilities have a potential of additional 495 berths: 243 more at Reed's Bay, existing is 27; and 252 additional berths at Kawaihae, existing is 48 (p. 81).
>
> Projected demand for launch ramps in the year 2000 in Hawaii County is 28; existing ramps number 12 (p. 81). Expansion at existing facilities could provide 8 more ramps; 2 at Keahou Bay and 6 at Honokohau (p. 83). As traffic continues to grow, additional harbor will be needed on each major island (p. 104).

Recommendations to accomplish these needs:

Rec. 13-7: Provide facilities for recreational boating, provide additional boat ramps and dry storage facilities, and provide additional small boat harbors (p. 84).

Rec. 18-1: Improve harbor facilities for transocean shipping, improve navigability of existing harbors, increase cargo storage and handling facilities, and provide additional deep-draft harbors as needed (p. 105).

In addition, the report recommends an "Inter-island Marine Highway" to unite the islands socially and economically. This would require improving the facilities now serving interisland transportation (pp. 105-6).

Hawaii Fisheries Development Plan, Hawaii DLNR, 1979:

Recommends construction of a total of 3000 dock feet on the east coast of Hawaii to serve 200 small craft, and recommends the state DOT and the Corps of Engineers be the agencies with responsibility for this construction.

DEEP DRAFT AND SMALL CRAFT NAVIGATION WORKSHOP (28 FEBRUARY 1980)

SUMMARY OF WORKSHOP

The purpose of the workshop was to discuss the status of the comprehensive study as a whole; to discuss the various alternatives possible at Baker's Beach, as opposed to some other site farther south; and to discuss the possible changes to the deep draft harbor. Attendees at the workshop represented a good cross section of public agencies and the general public; fishermen were not as well represented.

The general reaction to the Baker's Beach proposals was favorable, but commercial fishermen stated preference for any site farther south, closer to the best fishing grounds. The Hawaii FD rescue squad wants at least a ramp outside the breakwater to facilitate rescue operations at sea. Their feeling is that the wave conditions are better at King's Landing than at Puhi Bay,

just outside the breakwater. There were total opposition to creating a channel through the breakwater near Radio Bay. Such a channel would be extremely hazardous in high waves, and could present a dangerous attraction to boaters trying to get inside the harbor in bad weather. The consensus was that an alternative on the Puna Coast should be carried into stage 3 for further consideration.

COMMENTS/CONCERNS EXPRESSED OTHER THAN AT MEETING

Navigation

Mouth of Wailoa River is silting in and sand bar forming; larger commercial fishing boats having difficulty entering river, especially at night or in rough weather

Hilo Bay Water Quality

-none-

Other Environmental/Cultural

Sediments in Hilo Harbor may be polluted, creating problems for dredging and dredge material disposal

Recreation

Bayfront beach restoration is consistent with Hilo downtown improvement plan

Other

Interest exhibited in tsunamis and Corps protection plan

Protection wanted for bayfront highway to include tsunami and storm waves

PUBLIC MEETING - DEEP DRAFT AND SMALL CRAFT NAVIGATION (20 AUGUST 1980)

SUMMARY OF PUBLIC MEETING

Attendance at this meeting was the largest of any meeting since the 1976 meeting initiating the study. The purpose of the meeting was to discuss deep draft/small craft navigation plans and the status of the comprehensive study. The Corps presentation, because of concern expressed about tsunami hazard and tsunami protection, included the history of the POD tsunami protection barrier for Hilo and its deauthorization in 1977; status of the bay front beach restoration; water quality of Hilo Bay; deep draft plans and small craft plans, including an overview of all sites examined earlier and a presentation of the concepts of the two plans considered feasible. It was emphasized that all plans were tentative.

COMMENTS/CONCERNS EXPRESSED DURING THE MEETING

Navigation

No safe anchorage from Hilo to South Point

Coast Guard station should be at entrance to bay

Wind direction at Hilo is very steady; vessels should be moored at finger piers parallel to wind

Sand buildup at mouth of Wailoa caused by big drainage ditch built by the State that changed the current patterns

Effectiveness of tethered floating breakwall

Not enough traffic in Hilo Harbor to warrant C of C Plan

Design of Bakers Beach Harbor is bad, first bad northerly storm will put all the boats against the breakwater; harbor should be designed so that northerly storms won't affect boats

King's Landing is roughest place between Hilo and Kumukahi, there is a treacherous cross current; small boat harbor should be put at Puna - Nat'l Park Service has 180,000 acres there

Need a groin on Puna side of river to wash sand out

Importance of Hilo Harbor has been minimized

Would be a traffic conflict problem with a SBH at Baker's Beach

Put a rock barrier at mouth of Wailoa River, used to be a pile barrier there, would decrease dredging costs

Need a crane at the harbor for unloading containers so that goods won't have to be barged from Honolulu - decrease costs at the supermarket

Break in breakwater would be dangerous for small boats

Chamber of Commerce plan would not be any good in bad weather

Puna area more feasible for harbor than King's Landing

Need a harbor between Hilo and South Point because it's a rough long trip

Very expensive to build a breakwater where the new one is indicated - about 78 feet of silt to bedrock there

Consideration of building new harbor on south side is subsidence there

Hilo Bay Water Quality

Bay water quality is problem caused by long shore currents outside breakwater

Coastal currents are the big currents

Other Environmental/Cultural

Arsenic in sediments in bay is from penite used on plantations, not canec factory

Some historical sites are in the Bakers Beach area - a heiau and burials.

A harbor in Puna would destroy the warm springs.

Recreation

Good beach with decent facilities would encourage tourist visitors

Breaching breakwater would cause erosion of the beaches

Artificial surfing shoal is a good idea

Corps built sand bag shoal in 1960's in California - lasted about 2 weeks

One of the most important things to consider is cleansing the bay waters; good beach would not be used if the water is filthy - breaching breakwater might help by bringing in fresh water

Sailboats nice to look at, contribute aesthetically to shoreline view

Should not take a beach or park area for a harbor; we need those areas for family recreation

Need to look at both commercial and recreational uses in determining harbors

Sailboat owners need a ramp for getting boats in and out of water and a place to work on their boats out of the water. A simple set up in Reed's Bay would be best. Baker's Beach design wrong for sailboats; have to tack against strong wind and building a harbor in Reed's Bay would take away from the beauty of sailing there

Other

Breaching breakwater would bring in sharks and increase tsunami damage

Should build futuristically, not on basis of benefit/costs

Disappointed at abandonment of tsunami protection project

Building a big breakwater to stop tsunamis won't help; a bigger tsunami will come along and destroy the wall

Existing breakwater provides tremendous tsunami protection; don't put holes in it

If you build a 30' breakwater, a 50' wave would come along and knock it down

Should do something that will help unemployment - locate SBH at Leleiwi Point so a cannery could be built to provide employment

Evidence at King's Landing that water has washed sand 3000' inland

We need tsunami protection, has caused almost 60 deaths, can't put a dollar value on a life

Need more research on prevention of tsunamis - bay tends to funnel and make wave higher

Need breakwater on Hamakua Coast because tsunami glances off it into bay.

COMMENTS/CONCERNS EXPRESSED OUTSIDE MEETING

Navigation

Rehabilitation of breakwater

Shoaling at mouth of Wailoa River caused by completion (1975) of Kaneoelehua Avenue storm drain, emptying into river just south of bridge, altering previous current patterns

Dredging of Wailoa River shoal

Sampling and analysis of Wailoa River sediments

Hilo Water Quality

-none-

Other Environmental/Cultural

-none-

Recreation

Sand mining (for sand to restore bayfront beach) in less than 30' depths

Improvement of highway: planning should include access to beach and increasing height of Wailoa River bridge

SMALL CRAFT FACILITIES WORKSHOP (11 FEBRUARY 1981)

SUMMARY OF WORKSHOP

The purpose of this workshop was to discuss small craft facilities and potential sites for new small boat harbors for Hilo and East Hawaii specifically:

Laupahoehoe - construction of stub breakwater

Baker's Beach - construction of recreation SBH

Leleiwi, King's Landing, Kapoho, and Kalapana - construction of SBH at one of these sites, principally commercial fishing

The workshop was extremely well attended, rivaling the attendance of the two public meetings (1976 & 1980) held in conjunction with the main comprehensive study. Because no residents from the Kalapana/Kapoho areas attended, consideration was given to conducting a subsequent workshop in one of those areas.

In response to earlier comments that a SBH was needed nearer South Point, the sites at Kalapana and Kapoho were added to the array of possible sites under examination as part of the comp study. Leleiwi Point, added as an alternative to King's Landing, was also discussed.

The sites at Kalapana and Kapoho were generally favored (keeping in mind that no residents of those areas attended) because of the calmer offshore conditions. The conditions at King's Landing/Leleiwi Point were thought to be too rough to be safe for small boats. Because the best fishing grounds are

more south from King's Landing/Leleiwi Point, some fishermen preferred the other sites. Other fishermen, because they fish both north and south from Hilo, thought a SBH in the King's Landing/Leleiwi Point area would be ideal.

Other comments:

Dredging needed at mouth of Wailoa River

Earlier alignment of breakwater at Reed's Bay preferred to that presented

Baker's Beach should not be used as back-up for SBH inside Hilo Harbor - homeowner leases had just been renewed in Baker's Beach area

Radio Bay could not be used for small craft berthing as the State is still planning to fill Radio Bay for more container storage

Better navigation aids needed at Pohoiki - approach and entrance are hazardous for those unfamiliar with Pohoiki

COMMENTS/CONCERNS EXPRESSED OTHER THAN AT MEETING

Progress on SBH site selection

Shoaling at mouth of Wailoa River suspected to be part of entire Hilo Bay littoral transport system - any shore protection or beach restoration should be based on evaluation of that system

SMALL CRAFT FACILITIES WORKSHOP (18 MARCH 1981)

SUMMARY OF WORKSHOP

The potential for siting a small boat harbor at King's Landing, Leleiwi Point, Kapoho, and Kalapana was discussed. Those attending were unanimous against any development at Kapoho. There was general agreement that Kalapana would make a good site for a small craft harbor. The feelings about a harbor in the King's Landing/Leleiwi area were mixed.

COMMENTS RECEIVED DURING THE MEETING

Most of the comments were specific statements against locating the harbor at Kapoho, however, it was suggested that the Corps examine new sites at Pohoiki, which would be an off-shore harbor, and on the coast next to Queen's Bath, just south of Kalapana, which would be an inland site very similiar to the other sites under consideration.

PROBLEMS AND NEEDS

SUMMARY OF STATED CONCERNS

The comments, concerns, and questions received during the course of the study, which varied greatly in content, were condensed into the list of problems and needs. In preparing this list, summarization and interpretation were necessary to reduce the large number of statements. For example, all mention of tsunamis, including the provision of a breakwall on the Hamakua coast and providing tsunami protection for the bayfront highway were taken as an expression of concern about tsunami hazard. Likewise, any mention of concern about wind or water conditions (including tsunamis) was taken as an expression of concern that the design of any facility should fit the conditions existing at the site chosen. Other concerns were similiarly combined. For clarity, the concerns listed earlier under the single heading navigation have been divided into deep draft navigation and small craft navigation.

LIST OF PROBLEMS AND NEEDS

DEEP DRAFT NAVIGATION

Surge and docking problems

Rehabilitation of existing breakwater

New and potential users

Deeper/wider project for larger vessels

Dredging and dredged materials disposal

Additional facilities, more land for container handling

SMALL CRAFT NAVIGATION

Shortage of ramps, dock space, and other facilities

Shortage of commercial fishing berths and supporting facilities

Congestion at existing facilities

Increasing number of fish landings

No safe anchorage north of Hilo; None from Hilo to Ka Lae

Harbor of refuge at Laupahoehoe

Drydock and supporting facilities

Joint recreational/commercial fishing facilities

Statewide priorities, coordination, and leadership in planning

Harbor(s) close to fishing grounds

Harbor or ramp outside Hilo breakwater for HFD rescue operations

Silting at mouth of Wailoa River

RECREATION

Restoration of beach; access to beach

Impact of new facilities on family recreation and shore casting

Improving water quality to make beach fully usable

Artificial surfing shoals

HILO BAY WATER QUALITY

Polluted sediments, wastewater, and underground discharges

Breakwater traps pollutants

Sewage discharge from moored boats

Longshore currents contribute to harbor pollution

Arsenic, metals in sediments

OTHER ENVIRONMENTAL/CULTURAL

Changing land use patterns

Impact on Hawaiian way of life

Impacts of filling/dredging Blonde Reef

Historical Sites at Baker's Beach, Puna, other sites

OTHER CONCERNS

Tsunami hazard
Sharks in bay
Hilo tourism
Unemployment
Sand mining

SUMMARY

Tsunami hazard was the single most frequent concern stated, although expressions of shortages of berths, ramps, and other facilities for small craft was by far most frequently mentioned in the aggregate. Surge was the most frequent problem expressed for deep draft navigation and beach restoration was most frequent under recreational needs.

DOCUMENTS PRODUCED DURING STUDY

Baseline Environmental Investigation of Hilo Harbor, Summer 1972

This report contains a summary and an analysis of selected physical, chemical, and biological conditions characterizing the waters of Hilo Harbor during July and August 1972. An attempt was made to compare the data collected during this investigation to available historic data, but the comparisons have limited value because previous studies were limited in scope and of short duration. The report provides a summary and analysis of agency development plans that could directly impact on the environment of the harbor. Recommendations are included for future evaluation of the physical, chemical, and biological conditions of the harbor.

The study that produced the results presented in this report was funded by POD's broad Harbors and Rivers in Hawaii authority (Public Law 84-874, Section 209). The report was reproduced and distributed using funds from the Hilo Area Comprehensive Study authority, and, because of this, the report is included as a document produced during the comprehensive study.

Plan of Study, Hilo Area Comprehensive Study, December 1976

This report, while funded under the Harbors and Rivers authority, was the first formal report of the comprehensive study. The Plan of Study presented a preliminary identification of the problems of the water and water-related land resources in the Hilo area and addressed the need for a comprehensive study. The report presented activities that should be performed in the study and a schedule for accomplishing those activities. The problems of the Hilo Bay area as listed in this report included both deep-draft and shallow-draft (small boat) navigation needs.

Hilo Harbor First Spring Season Environmental Studies, August 1977

The purpose of this study was to describe existing ambient conditions of Hilo Bay -- water quality, beach and biological conditions, prevailing weather conditions, and freshwater inflows. Included in the study were examination of circulation and stratification of the waters, measurements of water quality parameters inside and outside the harbor, marine biology surveys, a fish catch inventory, observation of littoral sand transport, and collection of meteorological and hydrological data. The information gathered in this study was evaluated and compared to data collected earlier, particularly that data collected in the 1972 Baseline Environmental Investigation.

Preliminary Planning for Small Craft Facilities in East Hawaii, March 1978

This report discusses 23 potential small craft harbor locations in the three districts around Hilo: Puna, Hilo, and North Hilo. The 13 sites shown in the report formed the basis for the preliminary stage of plan formulation outlined in Appendix B and Section III of the Main Report. The Small Craft Facilities report gives the needs, as seen at that time, of the three areas. (Since reproduction of the report, the navigation improvements recommended for Pohoiki have been constructed.) The report contains projections of future boating needs and design standards applicable for small boat harbors.

The results of two public workshops held in May and June 1977 to discuss the potential sites and to discuss the navigation problems of the area in general are presented. The sites were assembled prior to the workshops from

community input, agency recommendations, and field observations. The concepts and conclusions presented are based on the opinions and comments received at the workshops. No firm recommendations are presented, only conclusions about the navigation needs of the three areas.

Biological Resources, Hilo Area Comprehensive Study, March 1979

This report was prepared by the US Fish and Wildlife Service for the Corps of Engineers as a baseline description of fish, wildlife, and environmental values to be considered in the HACS. The report has descriptions of the study area and the terrestrial and aquatic ecosystems found in the study area, including characteristics and unique resources of those ecosystems. The report concludes that there are considerable opportunities to conserve and protect the native fish and wildlife within the study area. The needs of the study area are listed as the need for continued study and research, the need to assess the impacts and incorporate mitigation measures for those impacts into water resource development projects, and the need to institute management programs. Recommendations are given to satisfy these needs within the study area in general and in the individual ecosystems and other unique areas found within the study area.

Navigation: Deep Draft and Small Craft Stage 2 Report, Hilo Area Comprehensive Study, September 1980

This report presents the findings of the stage 2 planning portion of the study. A stage 2 report is a decision-making document, the contents used to determine if the study should be terminated or carried into stage 3, the detailed Plan Formulation stage of a study. The report contains alternative solutions developed to satisfy the problems and needs related to navigation as they were ascertained at that time. The report is the basis for the present report, which is the stage 3 report, and contains most of the types of information contained in the stage 3 report, but at a lower level of detail.

Geological, Biological and Water Quality Investigations of Hilo Bay, October 1980

The purpose of these investigations was to expand the data base collected in earlier investigations performed for HACS (Hilo Harbor First Spring Season Environmental Studies 1977, August 1977), providing a basis for impact

evaluation of potential projects in the Hilo Bay area. Measurements were taken of geological and biological characteristics, circulation, and water quality and an evaluation made of existing information. While the results of this series of studies did not seem to contradict earlier data, there were indications that the water quality of the bay is improving and that the amount of live coral in the bay may be slowly decreasing.

Hilo Bay: A Chronological History -- Land and Water Use in the Hilo Bay Area, Island of Hawaii, March 1981

This report presents a chronological history of Hilo and the areas around Hilo Bay, beginning in the early time of the Hawaiian chiefs and ending in 1980. The document discusses in detail the important industries of the area, the rise and demise of the railroad in Hilo, the importance of the bay and later the harbor, the calamities that strike Hilo, the man-made changes to the bay and the inland areas, and the changing patterns of lifestyles and inhabitants. It includes many old maps and pictures that greatly enhance the text.

PERTINENT CORRESPONDENCE

(To be added in final report)

(will include comments to this draft report)

APPENDIX D

DESIGN AND COST ANALYSIS

APPENDIX D

DESIGN AND COST ANALYSIS

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APPENDIX D

DESIGN ANALYSIS SECTION

1. GENERAL CRITERIA

a. FORMULATION AND ANALYSIS. The formulation and analysis of the alternative plans were based on the Waters Resources Council's Principles and Standards, and applicable Corps regulations and guidelines on planning process.

b. TECHNICAL CRITERIA. The following technical criteria were adopted for use in developing alternative plans:

(1) The design of the protective works will allow for minor overtopping by a design wave which could be expected from a theoretical 50-year hurricane and hydrological conditions;

(2) The entrance channel is to be of adequate depth and width to safely accommodate two-way traffic by the design vessel and the turning basin is to provide a safe maneuvering area. The prevailing wind and wave approach directions are to be evaluated to determine safe channel alignments for navigation. To insure navigational safety, the severity of turns (dog legs) of the entrance channel should be minimized and the widening (flaring) of the channel at the turns are to be provided. The protected basin is to have a maximum wave amplitude of 2 feet to insure minimal damage to vessels.

(3) Navigation improvements shall be designed to accommodate a design vessel, whose length is 40 feet, beam is 15 feet, and draft is 7.5 feet, during all weather and sea conditions except severe storms.

(4) The protective harbor basin shall provide a safe maneuvering area for the design vessel, to be compatible with berthing and shoreside facilities.

(5) Provision for adequate land area for shoreside facilities and adequate access.

c. FEDERAL DESIGN FEATURE. Federal design features include an entrance channel, turning basin, access channel, and channel wave absorbers. All berthing and shoreside features necessary for a complete harbor facility would be provided by the State of Hawaii.

d. LEVEL OF DESIGN ANALYSIS. The appendix contains engineering data and analysis to support the Stage 3 formulation and the plan selection process. Each harbor site is situated in an area directly exposed to severe wave attacks. The alignment and location of the selected entrance channel is based on theoretical wave analysis and appears to be the most feasible of several possibilities. Considering the hydrographic factors influencing actual wave conditions in the project area and comments by local boaters, a physical model study is necessary as part of the advance engineering and design stage for the selected harbor site in order to develop the most suitable harbor entrance channel alignment and wave absorber plan to insure navigational safety.

2. SITE LOCATION

a. Leleiwi Point (Figure 6 in main report) is located on the northeast coast of the island of Hawaii, about 2.5 road miles east of Hilo Harbor at about 19°44' north latitude and 155°2' west longitude.

b. King's Landing (Figure 6 in main report) is located on the northeast coast of the island of Hawaii, about 5.5 road miles east of Hilo Harbor at about 19°44' north latitude and 155°00' west longitude.

c. Kalapana (Figure 7 in main report) is located on the southeast coast of the island of Hawaii, about 28.5 road miles south of Hilo Harbor at about 19°21' north latitude and 154°59' west longitude.

Maps of sites and vicinities are shown on the listed publications:

Description	Prepared By	Chart No.
Island of Hawaii	U.S. Dept of Commerce National Oceanic & Atmospheric Administration	19320
Island of Hawaii	Army Map Service Corps of Engineers	W532XNE515
Hilo, Hawaii	U.S. Geological Survey	N1937.5 - W15500/7.5
Keaau Ranch, Hawaii	U.S. Geological Survey	N1937.5 - W15452.2/7.5
Kalapana, Hawaii	U.S. Geological Survey	N1916.5 - W1547.5/6X10

3. WIND CONDITIONS

a. PREDOMINANT WIND.

Leleiwi Point and King's Landing. The wind velocity and direction records show that winds approach each site primarily from the southwest (SW) and west-southwest (WSW) directions, rather than the typical northeasterly trades that predominate for most of the islands. Winds are predominantly from the SW and WSW during the night and early morning hours, with winds generally shifting to the typical trade direction by midday. A wind diagram for the years 1965-1974 from the gage located at General Lyman Field, Hilo, is shown on Plate D-1.

Kalapana. There are no wind gages in the immediate vicinity of Kalapana. Information on wind conditions at this location is extrapolated from statistical data on offshore winds contained in the U.S. Naval Weather Service Command publication, "Summary of Synoptic Meteorological Observation," June 1971. The wind information is for the position 20.9° north latitude and 156.0° west longitude. This information is considered to be representative of conditions at the project site. Plate D-2 is a diagram which shows wind direction, speed, and frequency.

b. TROPICAL STORMS AND HURRICANES. Although extremely rare in the Hawaiian Islands, tropical storms and hurricanes have, from time-to-time, affected the islands. Tropical storms are defined as having sustained wind speeds between 34 and 63 knots, while hurricanes are defined as storms with sustained wind speeds equal to or greater than 64 knots. Based on information

from the U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), National Weather Service, from 1950 to 1980, at least 14 tropical storms or hurricanes have intruded within 500 miles of the State. So far, most of the threatening storms have weakened before reaching the islands and their effects have been minimal in most cases. Hurricanes effects in the Hawaiian waters generally occur during the summer months.

4. WAVE CONDITIONS

a. WAVE CLIMATE.

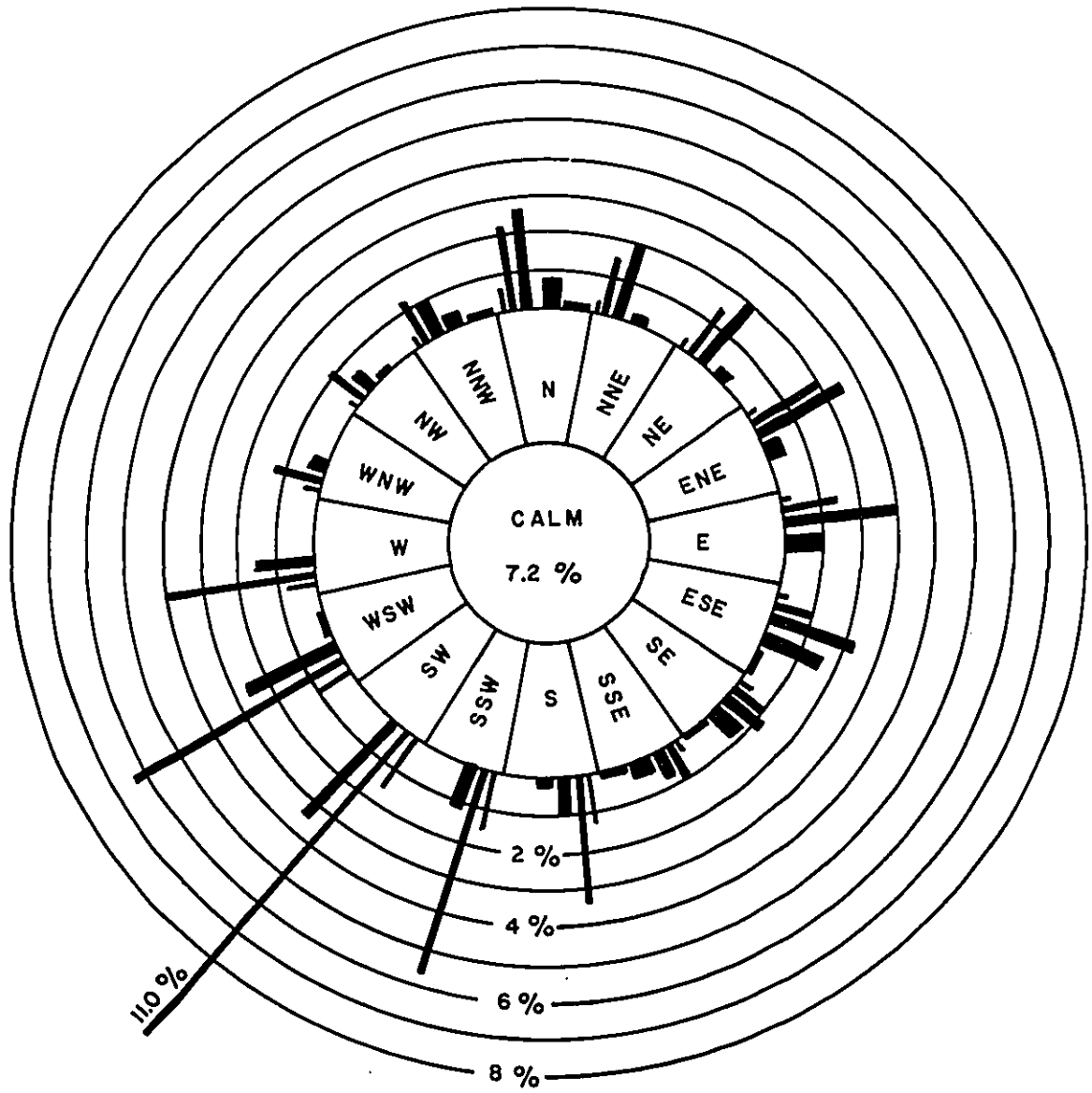
Waves arriving at Leleiwi Point, King's Landing and Kalapana originate from various areas in the Pacific Ocean. These waves have a variety of periods and heights depending on their origin and other factors related to wave building and decay. At each site, several distinct wave types may be acting simultaneously. This produces a very complex wave climate.

Waves arriving at Leleiwi Point and King's Landing are generated in the northeastern sector of the Pacific Ocean, ranging from the Aleutian Islands in the north to South America. Two primary types affect these sites: (1) the local wind waves and (2) the northern swell. Kalapana face roughly southeast and generally are subject to a wave spectrum from the northeast clockwise to the southwest. Three primary wave types affect Kalapana: (1) the local wind waves, (2) the southern swell, and (3) the "Kona" storm waves.

LOCAL WIND WAVES. There are no wave gage stations in the area. Information on wave conditions is based on statistical data on offshore waves in the "Summary of Synoptic Meteorological Observations" (SSMO), Hawaii and Selected North Pacific Island Coastal Marine Areas, Volume 1, Area 1, Hawaiian Windward, prepared by the National Climatic Center for the U.S. Weather Service Command, June 1971. The wave information is for the position 20.9° north latitude and 156.0° west longitude.

This data was obtained through direct synoptic observation by shipboard personnel in the island of Hawaii area and represent data recorded during the 8-year period from 1963 to 1970. These statistics represent average conditions during the period of record. The data also shows that the majority of waves

GENERAL LYMAN FIELD
HILO, HAWAII



NOTE: THE PERCENTAGES AND THE DIRECTIONS ARE AVERAGES DURING THE 10 YEAR PERIOD, 1965 TO 1974 INCLUSIVE.

LEGEND:

- 0-3 KNOTS
- 4-6 KNOTS
- 7-10 KNOTS
- 11-16 KNOTS
- OVER 16 KNOTS
- —8%— TOTAL % OF YEAR

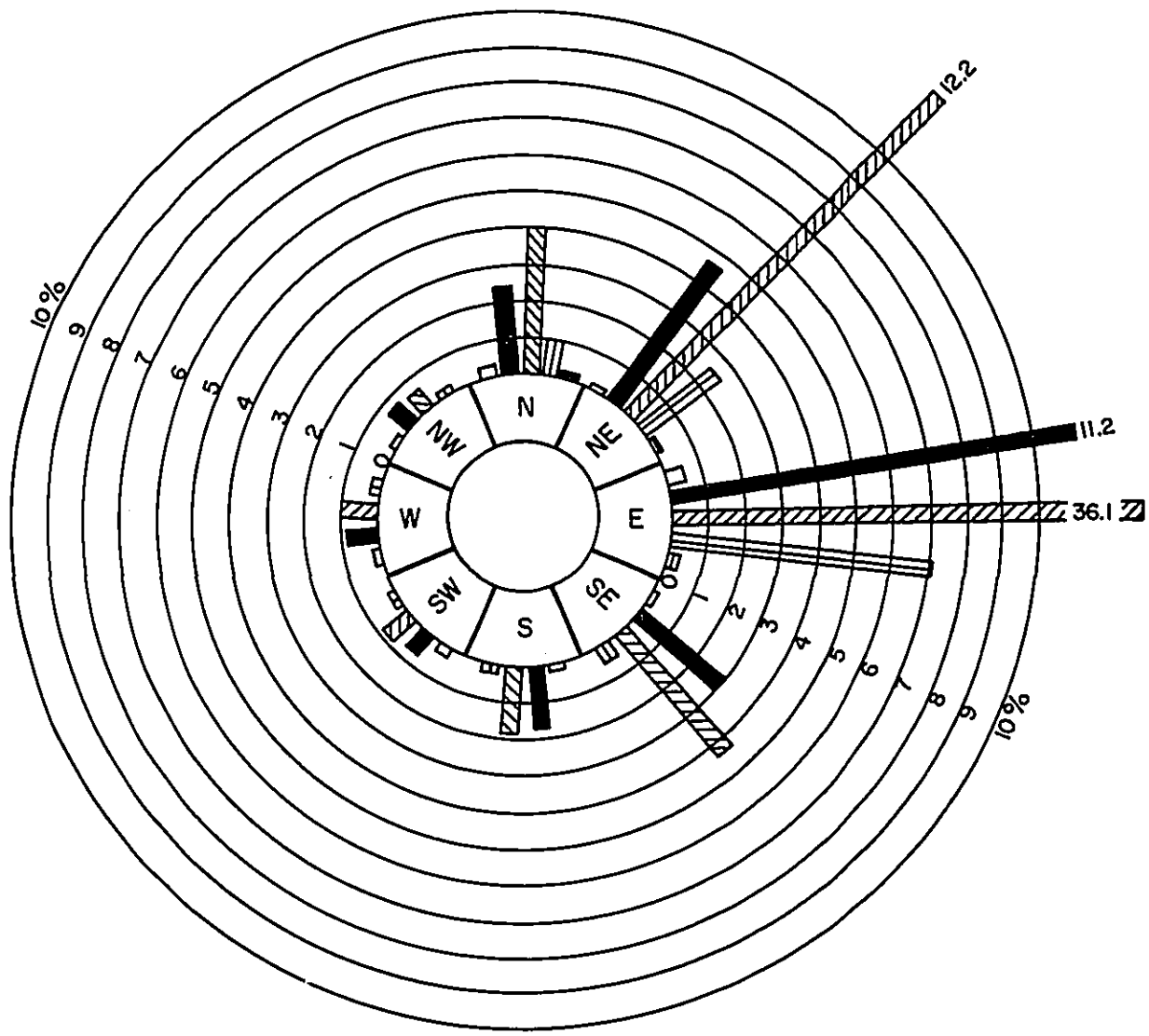
SOURCE – HONOLULU DLNR, DOWALD

HILO AREA COMPREHENSIVE STUDY

WIND DIAGRAM

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE D-1



TOTAL % OF THE YEAR
10 %

PERIOD OF RECORD
1963 TO 1970

STATION LOCATION
209 NORTH LATITUDE
156 WEST LONGITUDE

SOURCE
U.S. NAVAL WEATHER SERVICE COMMAND

LEGEND:

- 1 - 3 KTS
- 4 - 10 KTS
- 11 - 21 KTS
- 22 - 33 KTS
- 34 - 37 KTS

HILO AREA COMPREHENSIVE STUDY

OFFSHORE WIND DIAGRAM

US ARMY ENGINEER DISTRICT, HONOLULU

PLATE D-2

affecting Hawaii are easterly tradewind-generated waves. The tables show that deepwater wind wave heights are generally 2 to 10 feet with periods of 6 to 12 seconds (Table D-1 and D-2).

TABLE D-1

ANNUAL PERCENT OF OCCURRENCE OF WAVE HEIGHTS VERSUS DIRECTION

Wave Ht (Feet)	NW	N	NE	E	SE	S	TOTAL
< 1	0.1	0.7	0.8	1.4	0.4	0.4	3.8
1-2	0.5	1.8	4.1	10.0	2.1	1.2	19.7
3-4	0.5	2.6	7.0	19.1	3.2	1.3	33.7
5-6	0.2	1.5	4.5	13.9	1.5	0.7	22.3
7	0.1	0.7	2.1	6.2	0.6	0.1	9.8
8-9	0.1	0.3	0.9	3.0	0.1	0.1	4.5
10-11	0.1	0.1	0.2	0.9	0.1	-	1.4
12	-	0.1	0.1	0.4	0.1	-	0.7
13-16	-	-	-	0.2	-	-	0.2
17-19	-	-	-	0.1	-	-	0.1
TOTAL	1.6	7.8	19.7	55.2	8.1	3.8	96.2

TABLE D-2

PERCENT FREQUENCY OF WAVE HEIGHT VERSUS WAVE PERIOD

Period	Wave Height (Feet)									
(Sec)	< 1	1-2	3-4	5-6	7	8-9	10-11	12	13-16	TOTAL
< 6	1.0	8.7	17.9	9.4	3.3	1.3	0.3	0.1	0.1	42.1
6-7	-	1.3	6.9	10.8	6.0	2.6	1.1	0.6	0.2	29.5
8-9	-	0.3	1.6	3.8	4.5	2.3	1.1	0.5	0.4	14.5
10-11	0.0	0.1	0.4	0.9	1.5	1.1	0.7	0.4	0.4	5.5
12-13	0.0	-	0.1	0.3	0.4	0.4	0.3	0.2	0.1	1.8
> 13	0.0	-	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.6
Indet	2.5	0.8	0.8	0.7	0.3	0.2	0.1	-	-	5.4
TOTAL	3.5	11.3	27.6	26.0	16.2	8.1	3.6	1.8	1.3	99.4

NORTHERN SWELL. Northern swell is generated in the north Pacific Ocean by winter storms. Waves may typically have periods of 10 to 15 seconds, and heights of 5 to 15 feet. Some of the largest waves reaching the Hawaiian Islands are of this type. Northern swell usually occur during the winter season from October to April.

SOUTHERN SWELL. Southern swell is generated during the Antarctic winter months by strong winds blowing over long fetches of the southern Pacific and Indian Oceans. After traveling over thousands of miles of open ocean, these waves arrive at the southern shores of the Hawaiian Islands as long period swell. Periods typically range between 14 and 22 seconds with heights generally 1 to 4 feet. In an average year, southern swell arrives at Kalapana Bay about 10 percent of the time; usually during the summer months from April to October.

"KONA" STORM WAVES. "Kona" storm waves are generated by local storms and fronts which generally cause winds and waves from the south through the west. These storms are neither frequent nor consistent, however, they can generate large destructive waves which can directly affect Kalapana. Commonly, periods range from 8 to 10 seconds, with heights of 10 to 15 feet. In any given year, Kona storms may occur several times or not at all. They occur most often in the winter months.

TROPICAL STORM WAVES. In addition to the primary wave types discussed above, there are others which are less frequent, but which are significant. One of these is the large swell generated by tropical storms in the equatorial regions. Wave heights can reach 8 to 15 feet with periods of 10 to 15 seconds. These waves generally approach the Hawaiian Islands from the southeast through the southwest and are most likely to occur in August and September.

HURRICANES. Another infrequent source of large destructive waves is associated with hurricanes. In the last 25 years hurricanes passed through the Hawaiian chain in December 1957, August 1959, and again in July 1978. Theoretical calculations by Dr. C. L. Bretschneider indicate that a significant deep-water wave height of 27 feet can be expected for a typical 50-year hurricane having the following parameters: (a) central pressure reduction of 1 inch of mercury, (b) radius of maximum winds of 20 nautical miles, (c) forward speed of

12 knots. This results in a maximum sustained wind speed of 62 knots (tropical storm speed) and a corresponding maximum deepwater wave height of 46 feet.

b. REFRACTION ANALYSIS. A computer-aided refraction analysis was performed to locate zones of high-energy concentration in the vicinity of proposed harbor entrance channels, and to determine the probable approach alignment of the primary wave types affecting each site. Wave refraction diagrams were drawn for deepwater waves approaching each site. These directions were selected after evaluating the storm exposure regime at each site. The deepwater wave height from the SSMO data for the directions affecting each site were analytically transformed considering refraction and shoaling to shallow wave heights at each harbor entrance. Based on Table D-2, percent frequency of wave height versus wave period, 8- and 10-second waves were considered for refraction purposes as being representative of the local wind-wave period. Wave period of 15 seconds were considered characteristic of deep-water swells contributed by a 50-year hurricane.

Preliminary refraction analysis shows that each site is subjected to critical wave attack. Critical wave attack is that which is most likely to produce the largest and most damaging waves. A theoretical 50-year deepwater wave height of 27 feet, refracted towards the shoreline provided greater wave heights than a breaking wave height at the 20-foot depth contour, depth-controlled design wave criteria was used for selection of design wave height. The proposed entrance channel location is unlikely to be a zone of wave energy convergence. Critical wave direction and wave period at the harbor entrance at each site, to be used in the wave diffraction analysis, is as follows:

	Direction	Period (Sec)
Leleiwi Point --	North	15
King's Landing --	East	15
Kalapana --	East	15

5. TSUNAMI

All harbors are subject to potential tsunami or seismic sea-wave inundation as are most low-lying coastal areas in the Hawaiian Islands. The nature of tsunami is not fully understood. An occurrence may be nearly imperceptible or

may cause catastrophic destruction of coastal areas. A severe tsunami may cause abnormal rising and falling of the sea level, resulting in flooding of low-lying areas, and grounding of boats in the harbor. The 100-year tsunami inundation elevation at Leleiwi Point, King's Landing, and Kalapana are estimated to be about 18, 17, and 36 feet respectively above the mean lower low water (MLLW) datum. Adverse impacts resulting from locating in the tsunami flood zone include the risks of destruction of property and loss of life. The proposed action will require development in the inundation zone such as harbor backup facilities. There is no alternative location for these facilities, however, utilizing construction practices which meet requirements of the National Flood Insurance Program will minimize tsunami damages. Adverse impacts resulting from increased use of the tsunami flood zone can be minimized by adequate tsunami warning. A State-wide tsunami warning system is presently in existence. The harbor can be evacuated in the event of a tsunami warning. Boats would not reenter the harbor until the tsunami warning has been cancelled.

6. WATER LEVEL AND CURRENTS

a. TIDES. The nearest tidal benchmark to Leleiwi Point and King's Landing is at Hilo Harbor, approximately 2.5 miles from Leleiwi Point and 5.5 miles from King's Landing. The nearest tidal benchmark to Kalapana is at Honuapo on the south coast of the island, approximately 43 miles from Kalapana. The tidal data shown were obtained from the U.S. Coast and Geodetic Survey and are referenced to Mean Lower Low Water (MLLW). All elevations in this appendix are in feet referenced to MLLW datum.

	Leleiwi Point/ King's Landing (Feet)	Kalapana (Feet)
Highest tide (observed)	3.80	*4.0
Mean higher high water	2.40	2.50
Mean high water	1.90	2.00
Half tide level	1.10	1.15
Mean low water	0.30	0.30
Mean lower low water	0.00	0.00
Lowest tide (observed)	-1.60	*-1.50

* Estimated.

b. ASTRONOMICAL TIDE (S_a).

The astronomical tide is estimated to be about equivalent to the mean higher high water of 2.6 feet.

c. ATMOSPHERIC PRESSURE DROP (S_p).

The water level rise due to atmospheric pressure is calculated by:

$S_{\Delta p} = 1.14\ (P_n - P_o)\ (1 - e^{-R/r})$ EQ. 3-85, SPM [1/]

P_n = 29.92 inches

P_o = 28.92 inches

R = 20 nautical miles

r = 40 nautical miles

$S_{\Delta p}$ = 0.4 feet

[1/] U.S. Army Coastal Research Center, Shore Protection Manual, 3d Edition, 1977.

d. STORM SURGE (S_s).

The water level rise due to storm surge is calculated by:

Storm surge = ΔS_i, which is the incremental rise in water level due to wind stress perpendicular to the bottom contour.

$$S = \frac{540K\ U_R^2\ \Delta X}{\bar{d}} \qquad \text{(TR-4, 1-64)}^{2/}$$

X = total distance in N.M.

K = 3.0×10^{-6}

U_R = 62 knots

ΔX = incremental distance in N.M.

$\bar{d}$ = mean depth over increment (FT)

d_i = initial depth

Storm surge in the study area is estimated to be in the neighborhood of 0.5 feet.

e. WAVE SETUP, S_w: Wave setup is estimated from calculated theoretical values, considering that the location of the primary protective structure is not in the zone of maximum wave setup. Under certain wave conditions, the structure may be in a zone of wave setdown, resulting in a relatively lower water level. For engineering calculations, a value of 0.5 feet is selected for S_w.

f. DESIGN STILLWATER LEVEL. The design stillwater level (SWL) is defined as the level of water above the elevation datum plane, when no waves are present. Components of the SWL are astronomical tide level (S_a), atmospheric pressure drop (S_p), storm surge (S_s), and wave setup (S_w). Stillwater level components are calculated as follows; assuming the components are additive functions.

2/ U.S. Army Coastal Research Research Center, Technical Report No. 4, 3d Edition, 1966.

SWL = Design stillwater level

$SWL = S_a + S_p + S_s + S_w$

$SWL = 2.6' + 0.4' + 0.5' + 0.5'$

SWL = 4.0 feet

g. CURRENTS.

Reports indicate that surface currents in the study area generally follow the northeast trade wind, but occasionally set against it. One current follows the coast northwestward from Cape Kumukahi, the eastern extremity of Hawaii and around the northern extremity. Another current follows the coast southwestward from Cape Kumukahi around the southern extremity of the island. The observations of surface current conditions during the time of the hydrographic surveys were as follows:

Wind and Sea Conditions. Very light northeast tradewinds, 0-5 mph. Moderate north swell, approximately 5-foot wave heights in deepwater with occasional larger sets. Tide ebbing from about 0.8 feet to 0.1 feet and then flooding to about 1.2 feet during the course of the day. At Leleiwi Point, there was a strong seaward setting surface current shoreward of the breaker zone all along the coastline between wave sets. No site specific rip currents were observed, although it is reasonable to presume they exist, particularly during the occurrence of severe north swell. Seaward of the breaker zone a slow easterly setting (toward Leleiwi Point) surface current was present. This current set easterly regardless of the tide stage but was more pronounced during the flooding tide. At King's Landing, the surface current outside the breaker zone was observed to set northwest regardless of the tide stage. Coastal surface currents at both sites were observed to set toward Leleiwi Point, which is in agreement with other surface current information for this area which describes a northwest setting coastal surface current from Cape Kumukahi north to Upolu Point and a possible counterclockwise eddy in Hilo Bay3/.

3/ U.S. Coast Pilot; Laevastu et al, "Coastal Currents and Sewage Disposal in the Hawaiian Islands", HIG Report 64-1.

7. SHORELINE CHANGES

No erosion or sand accretion in the entrance channel is expected as a result of the construction of the harbor. The shoreline in the vicinity of each site is volcanic rock, and there is no evidence of appreciable littoral drift in the area.

8. DESIGN VESSEL

The entrance channel, turning basin, and main access channel are designed to accommodate vessels up to a length of 40 feet, a beam of 15 feet, and a draft of 7.5 feet. These criteria represent the draft of a loaded tuna boat or a large charter fishing boat, which are the largest vessels anticipated to use the harbor. Vessel characteristics are listed in the following tabulation:

VESSEL CHARACTERISTICS

Vessel	Length (Feet)	Beam (Feet)	Draft (Feet)
Tuna boat	40	15	7.5
Charter fishing boat	40	15	7.5
Trailer fishing boat	27	7	2.5

9. ALTERNATIVE HARBOR PLANS

Preliminary analysis indicated that a basin to provide for the projected boat population could not be economically developed through an offshore scheme because of the high cost of required breakwater construction. The inshore harbor concept was determined as being the only reasonable concept based on economics, engineering and environmental standpoint. Plans for all three sites can have the same basic navigation features, including an entrance channel turning basin, access channel and channel wave absorbers (Plates D-3, D-5, D-6, and D-8).

10. CHANNEL AND TURNING BASIN DESIGN

a. ENTRANCE CHANNEL.

Minimum Width. Required channel width is based on concurrent, 2-way passage of the design vessel. Total channel width is the sum of (1) the maneuvering lane, (2) the ship clearance lane, and (3) the bank clearance lane widths all based on the design vessel. Width factors are calculated assuming good vessel operators, presence of strong and gusty winds, and rough sea conditions. Lane widths and total channel width are:

Lane	Beam Factor X (Feet)	Width (Feet)
Bank clearance	2.0 X 15	30.0
Vessel maneuvering lane	2.5 X 15	37.5
Vessel clearance	1.0 X 15	15.0
Vessel maneuvering lane	2.5 X 15	37.5
Bank clearance	2.0 X 15	30.0
Total Channel Width	10.0 X 15	150.0

Channel width is increased to 180 feet at the turn into the harbor basin.

Minimum Depth. Required depth for safe navigation of the design vessel is computed as the sum of the following items at the calculated and estimated values shown:

	Depth (Feet)
Loaded draft of the design vessel	7.5
Vessel squat and trim	1.0
Pitch and roll due to wave action	4.0
Bottom clearance	2.0
Total Channel Depth	14.5 Say 15 feet

b. TURNING BASIN.

Minimum Length and Width. Turning basin dimensions were kept to a minimum to allow for as much berthing space as possible. The length and width of the turning basin is 2.5 times the length of the design vessel.

Minimum Length and Width = 2.5 x design vessel length
= 2.5 x 40 feet
= 100 feet

Minimum Depth. Required depth for safe navigation is computed as the sum of the following items at the values shown:

	Depth (Feet)
Loaded draft of the design vessel	7.5
Vessel trim	0.5
Pitch and roll due to wave action	2.0
Bottom clearance	2.0
Total Basin Depth	12.0

c. ACCESS CHANNEL

Minimum Width. Access channel dimensions were kept to a minimum to allow for as much berthing space as possible. The width of the access channel is 5 times the beam of the design vessel.

Minimum width = 5 x design vessel beam
= 5 x 15 feet
= 75 feet

Minimum Depth. Required depth for safe navigation is computed as the sum of the following items at the values shown:

	Depth (Feet)
Loaded draft of the design vessel	7.5
Vessel trim	0.5
Pitch and roll due to wave action	1.0
Bottom clearance	1.0
Total Channel Depth	10.0

11. CHANNEL WAVE ABSORBER DESIGN

a. WAVE HEIGHTS. During severe tropical storms, waves as high as 20 feet can be expected. Because of depth limitation, 20-feet waves would break offshore. The theoretical wave incident (Hi) to the opening at the channel mouth is assumed to be a broken wave of 17.2 feet, based on an average depth of 22.0 feet and slope of M = 0.00.

b. WAVE ENERGY LOSSES. Based on hydraulic model studies conducted by WES[4/] and existing information[5/] for harbors of similar design in similar physical environments, it is estimated that as much as 70 percent of the incident wave at the harbor entrance will be dissipated by refraction, diffraction, and bottom friction, as the wave propagates up the entrance channel to the location 2 at Leleiwi Point and King's Landing harbors. The rubble sides of the wave absorbers and bottom friction should further reduce the wave height of the wave passing through location 2 at Kalapana harbor. Based on model test of wave absorbers and wave reducing characteristics of rubble structures, it is estimated that a reduction of about 20 percent would occur.

c. DIFFRACTION ANALYSIS. Theoretical wave diffraction analysis were conducted for each plan. The diffraction analysis was performed in accordance with procedures, techniques, and diagrams described in the CERC Shore Protection Manual. Diffraction coefficients were used to compute the theoretical maximum wave height in each plan shown in Plate D-11 to D-14. The diagram is drawn for an 15-second incident wave period. Lines of equal energy and diffraction coefficients are shown for energy entering the harbor basin, incident at location 2 shown on Plates D-11 to D-14.

The theoretical wave incident to the harbor entrance is assumed to be a broken wave (Hi) of 17.2 feet. Based on results from hydraulic model test for harbors of similar design design wave height (H) at 1 and 2 is determined by multiplying the model test coefficient by the incident wave height, Hi. Wave heights in the harbor basin area is computed by multiplying the wave height (H) at 2 , by the diffraction coefficient, K.

4/ U.S. Army Engineer Waterways Experiment Station:
Technical Report No. 2-740, Investigation of In-Shore Harbor, Site X, 1966.
Contract Report No. 2-122, Wave Absorbers in Harbors 1965.
Technical Report H-74-16, Design of An Interisland Barge Harbor For The Island of Tau, American Samoa, 1974.
Technical Report H-75-15, Wave and Current Conditions For Various Modifications of Kewalo Basin, Honolulu, Oahu, Hawaii, 1975.

5/ U.S. Army Corps of Engineers Honolulu District:
Report of Model Tests, Scheme 9 and 9a, Honokahau Boat Harbor, Hawaii, February 1964.
Technical Report No. 8, Study of Proposed Barbers Point Harbor, Hawaii, April 1970.

Table D-3 shows the design wave heights obtained for the applicable areas at specified locations along the entrance channels.

TABLE D-3. DESIGN WAVE HEIGHTS

Wave Absorber (Station of Entrance Channel	Design Wave Height (Feet) Leleiwi Point	King's Landing	Kalapana
1	10.0	12.5	-
2	6.5	5.5	10.0

d. STRUCTURES. The Coastal Engineering Research Center's Shore Protection Manual (SPM) design formulas were used to determine the weight of the stones and the thickness of the stone layers. The following factors were used in the armor layer design computations:

Unit weight of armor stone: W_r (lb/ft^3)	160-162		
Specific gravity of armor stone: S_r	2.6		
Stability coefficient: K_D			
structure trunk	3.5	3.9	3.9
structure head	2.9	3.7	3.7
Side slope: Cot θ	1.5	3	4
Layer thickness: n	2	3	3
Layer coefficient: K_Δ	1.15	1.10	1.10
Design wave height: H	See Table D-3		
Armor stone size: $W = \frac{W_r H^3}{K_D (S_r - 1)^3} \cot\theta$	EQ. 7-11, SPM		

Thickness of armor layers and underlayers:

$$r = nk_\Delta \left(\frac{W}{W_r}\right)^{\frac{1}{3}}$$ EQ. 7-113, SPM

The resulting computed armor stone size were increased 50 percent in area 1 and 100 percent in area 2 to increase absorption of wave energy. Where cut material is erodable an underlayer of stones is required beneath the armor layer. The underlayer stones were

initially computed using a 1/10 factor of the armor stones, adjusted to provide a wide enough range in size to facilitate construction without loss of underlayer material through the armor layers.

Wave Runup and Crest Elevation. Wave runup (Ru) and resulting crest elevation (CE) for the head 1, and trunk sections 2, of the wave absorber were based on criteria contained in the SPM, from existing information[6/] and discussions with personnel at the Waterways Experimental Station (WES). The runup computations were based on a 15-second wave period; 4.0-foot stillwater level; and the structure effective side slopes. The runup and resulting crest elevations for areas 1 and 2 are listed in the following tabulations:

	AREA 1				AREA 2			
	Ru (Feet)	SWL (Feet)	CE (Feet)	CE Set at (Feet)	Ru (Feet)	SWL (Feet)	CE (Feet)	CE Set at (Feet)
Leleiwi Point	6.5	4.0	10.5	10.0	2.6	4.0	6.6	7.0
King's Landing	9.8	4.0	13.8	14.0	3.6	4.0	7.6	8.0
Kalapana	-	-	-	-	10.0	4.0	14.0	12.0

The incident wave approaches the wave absorbers at Leleiwi Point and King's Landing at an angle of 90 degrees, angle between wave crest and wave absorber. The striking wave runs along the structure, increasing the effective surface area for wave energy dissipation and decreasing the wave runup. Computed wave runup results for Kalapana is similar to Leleiwi and King's Landing harbors. Although the wave runup was computed to be 10.0 feet, with a crest elevation of 14.0 feet, crest elevations for the two wave absorbers were set at 12.0 feet, allowing for minor overtopping. For aesthetic reasons the crest elevations is kept at a minimum.

6/ CETA Report No. 79-1, Wave Runup on Rough Slopes, July 1979.

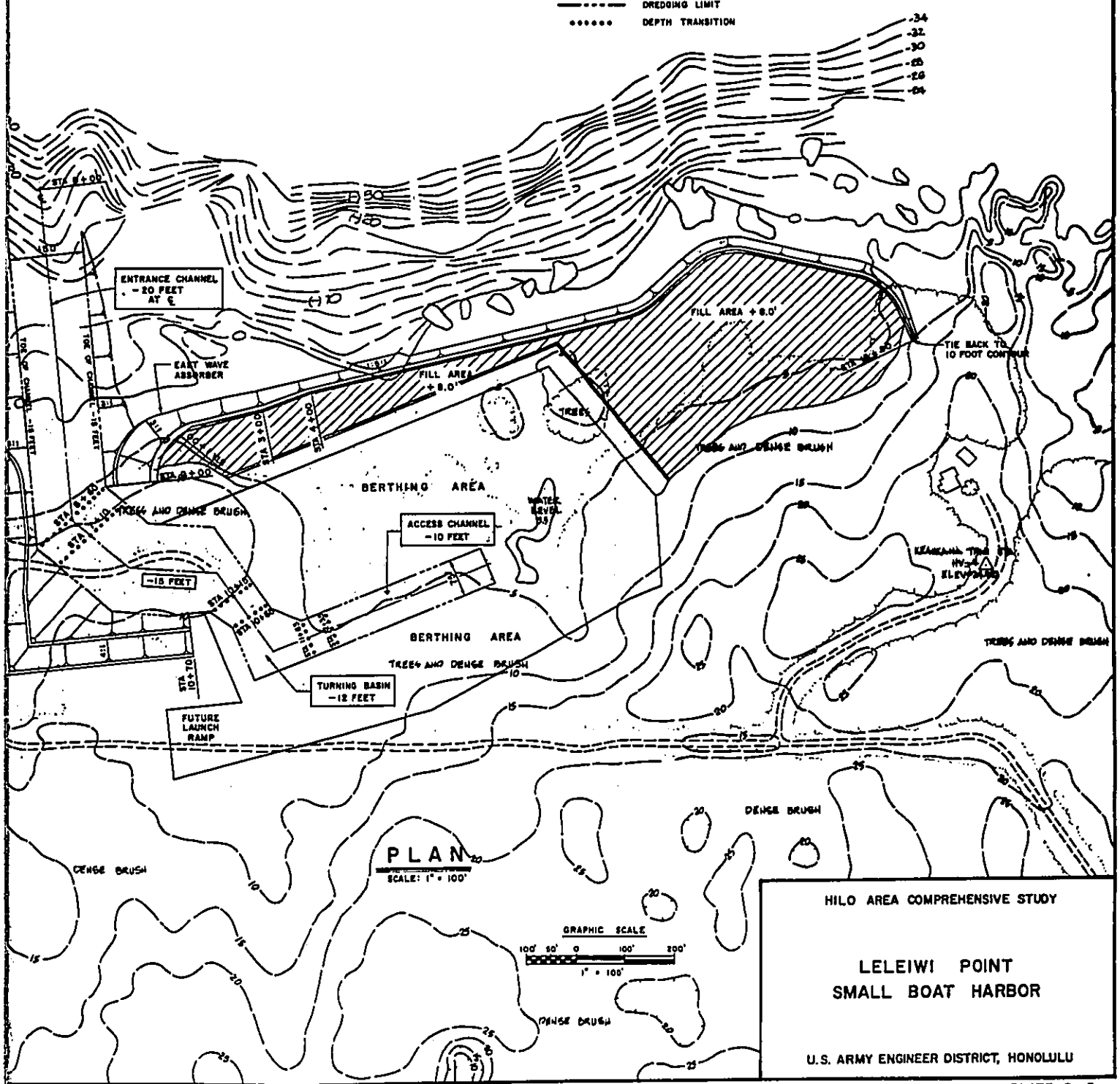
TP Report No. 78-2, Reanalysis of Wave Runup on Structures and Beaches, March 1978.

NOTES:

1. ALL ELEVATIONS AND DEPTHS REFERENCED TO MEAN LOWER LOW WATER DATUM (MLLW).
2. CONTOUR INTERVAL:
   TOPOGRAPHIC SURVEY - 5 FEET
   BATHYMETRIC SURVEY - 2 FEET
3. DATE OF SURVEY:
   TOPOGRAPHIC SURVEY MARCH 1973
   BATHYMETRIC SURVEY APRIL 1981
4. ORIGIN OF COORDINATES: HAWAII PLANE COORDINATE SYSTEM, ZONE 1.

LEGEND

1. EXISTING CONDITION
   - UNIMPROVED ROAD
   - PAVED ROAD
   - HOUSES / BUILDINGS
   - DEPRESSION
2. RECOMMENDED
   - HARBOR STRUCTURES (FEDERAL)
   - TOE OF STRUCTURES
   - DREDGING LIMIT
   - DEPTH TRANSITION



HILO AREA COMPREHENSIVE STUDY

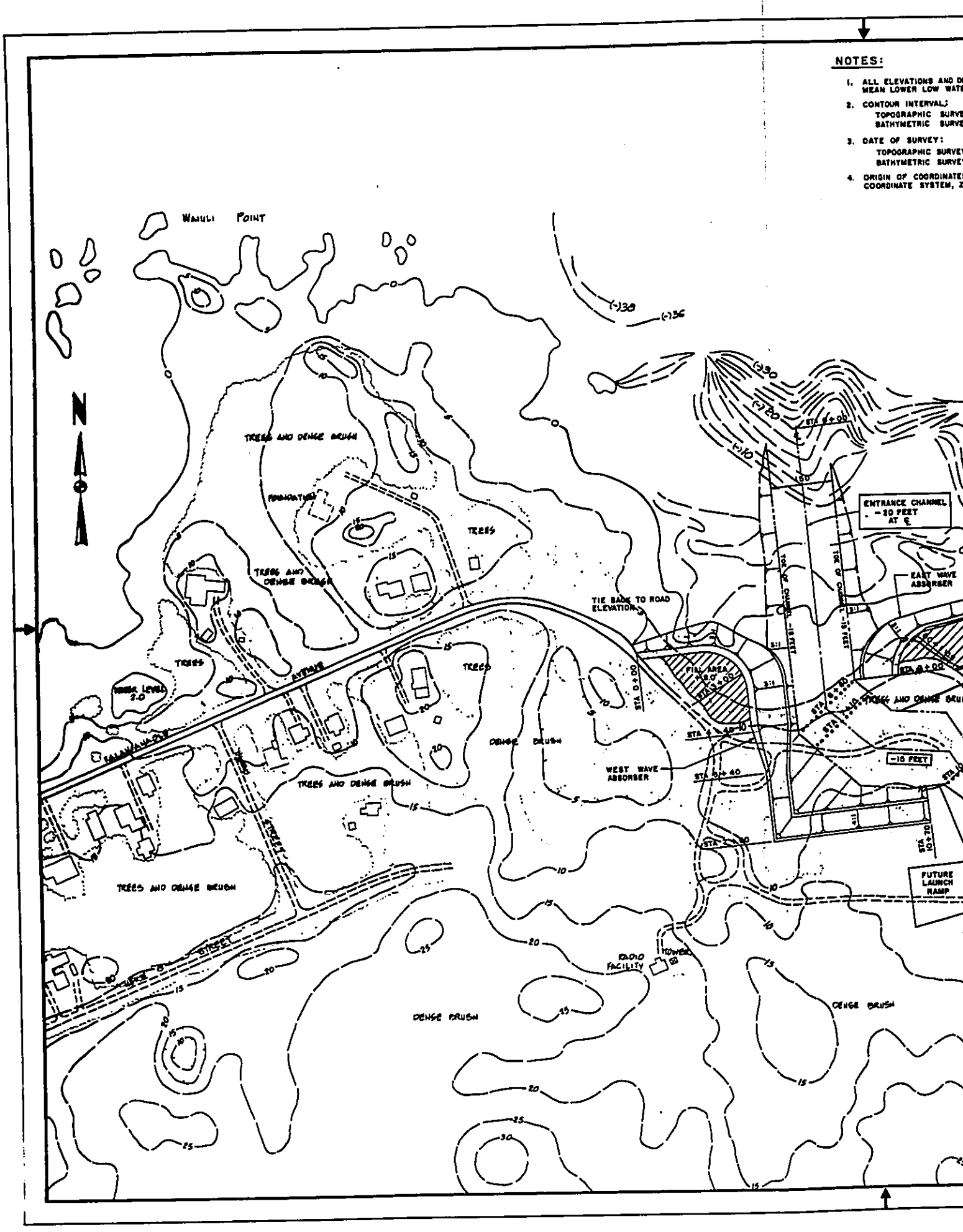
LELEIWI POINT
SMALL BOAT HARBOR

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE D-3

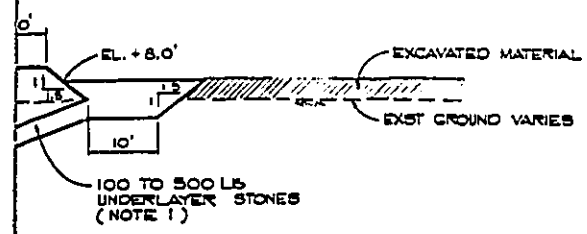
NOTES:

1. ALL ELEVATIONS AND D
   MEAN LOWER LOW WATE
2. CONTOUR INTERVAL:
   TOPOGRAPHIC SURVE
   BATHYMETRIC SURVE
3. DATE OF SURVEY:
   TOPOGRAPHIC SURVE
   BATHYMETRIC SURVE
4. ORIGIN OF COORDINATE
   COORDINATE SYSTEM, Z



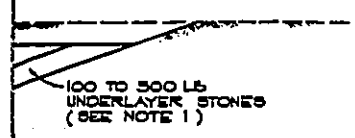
NOTES:

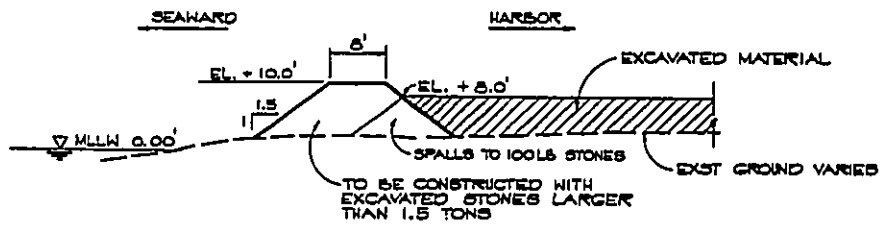
1. UNDERLAYER NOT REQUIRED WHEN ARMOR LAYER REST ON SOLID ROCK. IF EXISTING MATERIAL IS SAND OR SILT A 2 FOOT THICK BEDDING LAYER COMPOSED OF 1 LB (MIN) TO 50 LB STONES IS REQUIRED.
2. WHEN EXISTING GRADE AT TOE OF WAVE ABSORBER IS OTHER THAN SOLID ROCK, EXTEND TOE OF STRUCTURE 3 FEET BELOW GRADE OR TO SOLID ROCK, WHICHEVER IS LESS.



SECTION

TO STA 1 + 00
TO STA 4 + 40
STA 5 + 40





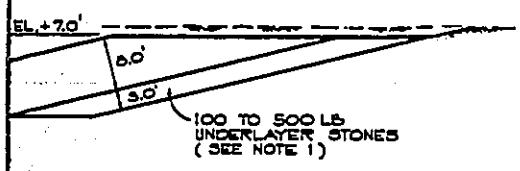
TYPICAL FILL AREA

SCALE: 1" = 10'

STA 4+00 TO STA 15+80

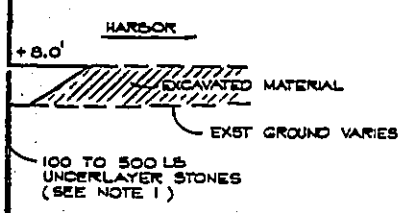
SECTION

TO STA 7+00



SECTION

TO STA 10 + 70



ER SECTION

TO STA 3 + 00
STA 4 + 00
TO STA 3 + 00

GRAPHIC SCALE

10' 5' 0 10' 20'

1" = 10'

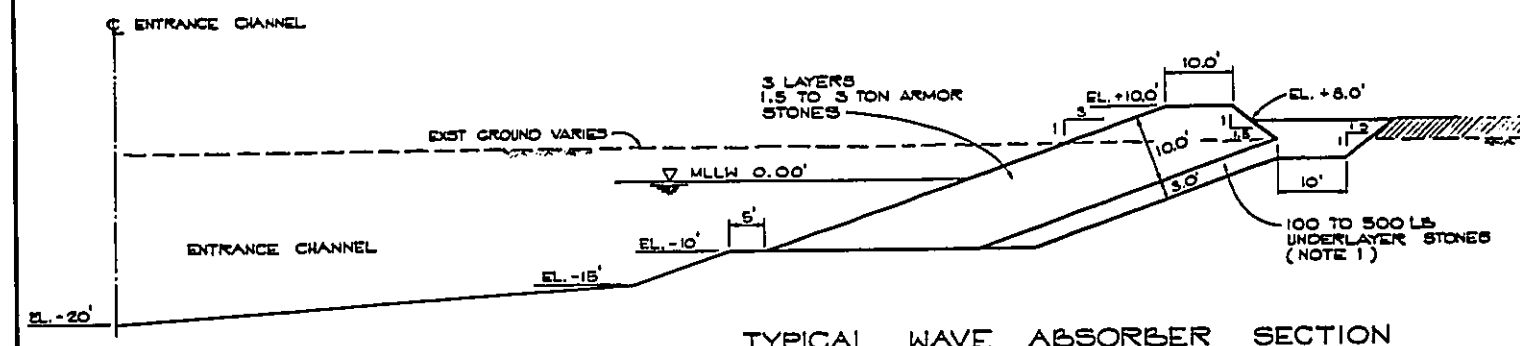
HILO AREA COMPREHENSIVE STUDY

LELEIWI POINT
SMALL BOAT HARBOR

TYPICAL SECTIONS

U.S. ARMY ENGINEER DISTRICT, HONOLULU

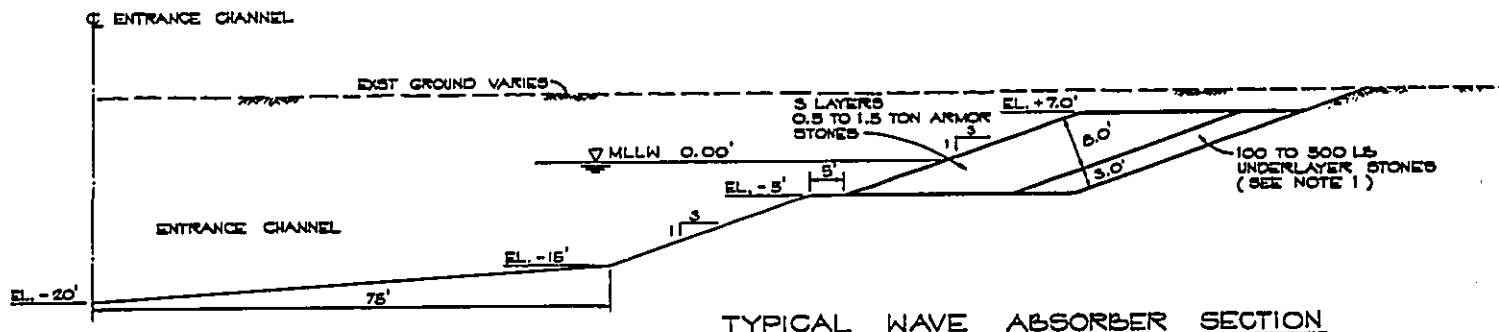
PLATE D-4



TYPICAL WAVE ABSORBER SECTION

SCALE: 1" = 10'

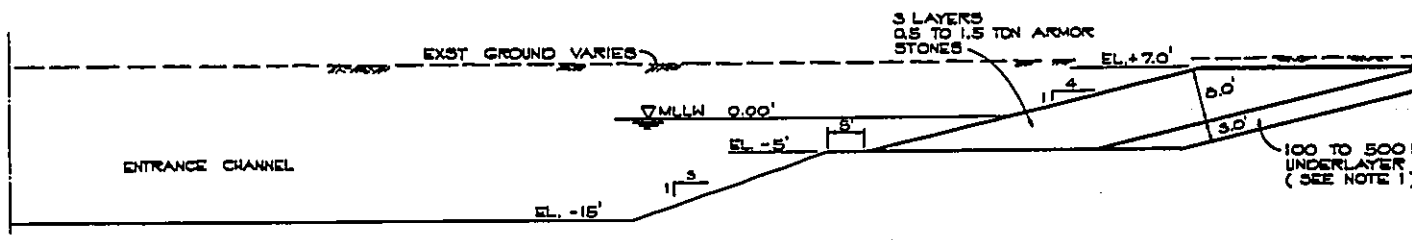
EAST WAVE ABSORBER STA 0+00 TO STA 1+00
WEST WAVE ABSORBER STA 3+00 TO STA 4+40
TRANSITION SECTION STA 4+40 TO STA 5+40



TYPICAL WAVE ABSORBER SECTION

SCALE: 1" = 10'

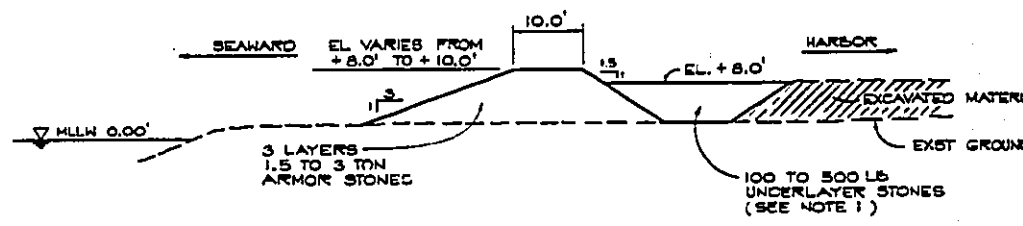
WEST WAVE ABSORBER STA 5+40 TO STA 7+00



TYPICAL WAVE ABSORBER SECTION

SCALE: 1" = 10'

WEST WAVE ABSORBER STA 7+00 TO STA 10+70



TYPICAL WAVE ABSORBER SECTION

SCALE: 1" = 10'

EAST WAVE ABSORBER STA 1+00 TO STA 3+00
TRANSITION SECTION STA 3+00 TO STA 4+00
WEST WAVE ABSORBER STA 0+00 TO STA 3+00
(SEE NOTE 2)

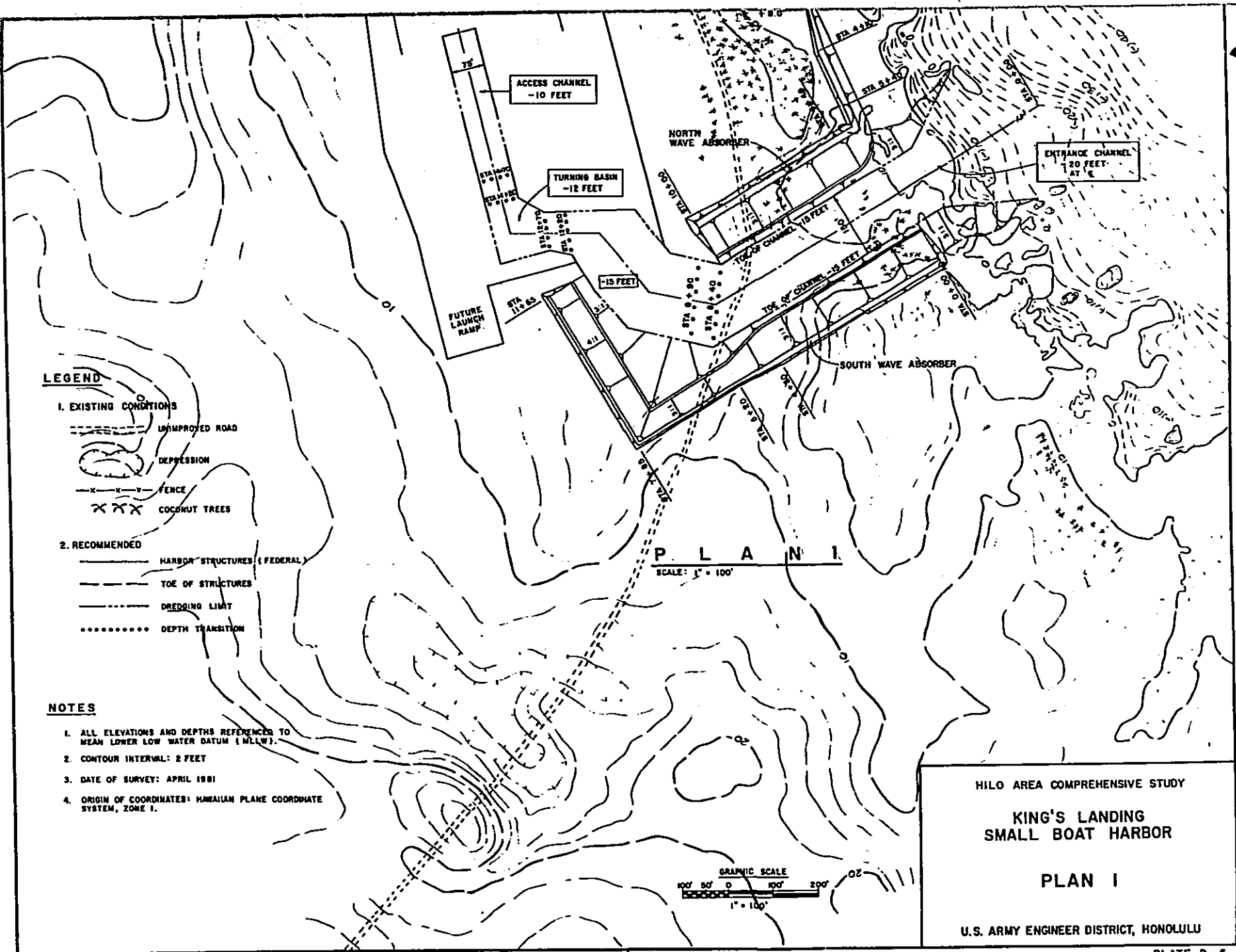
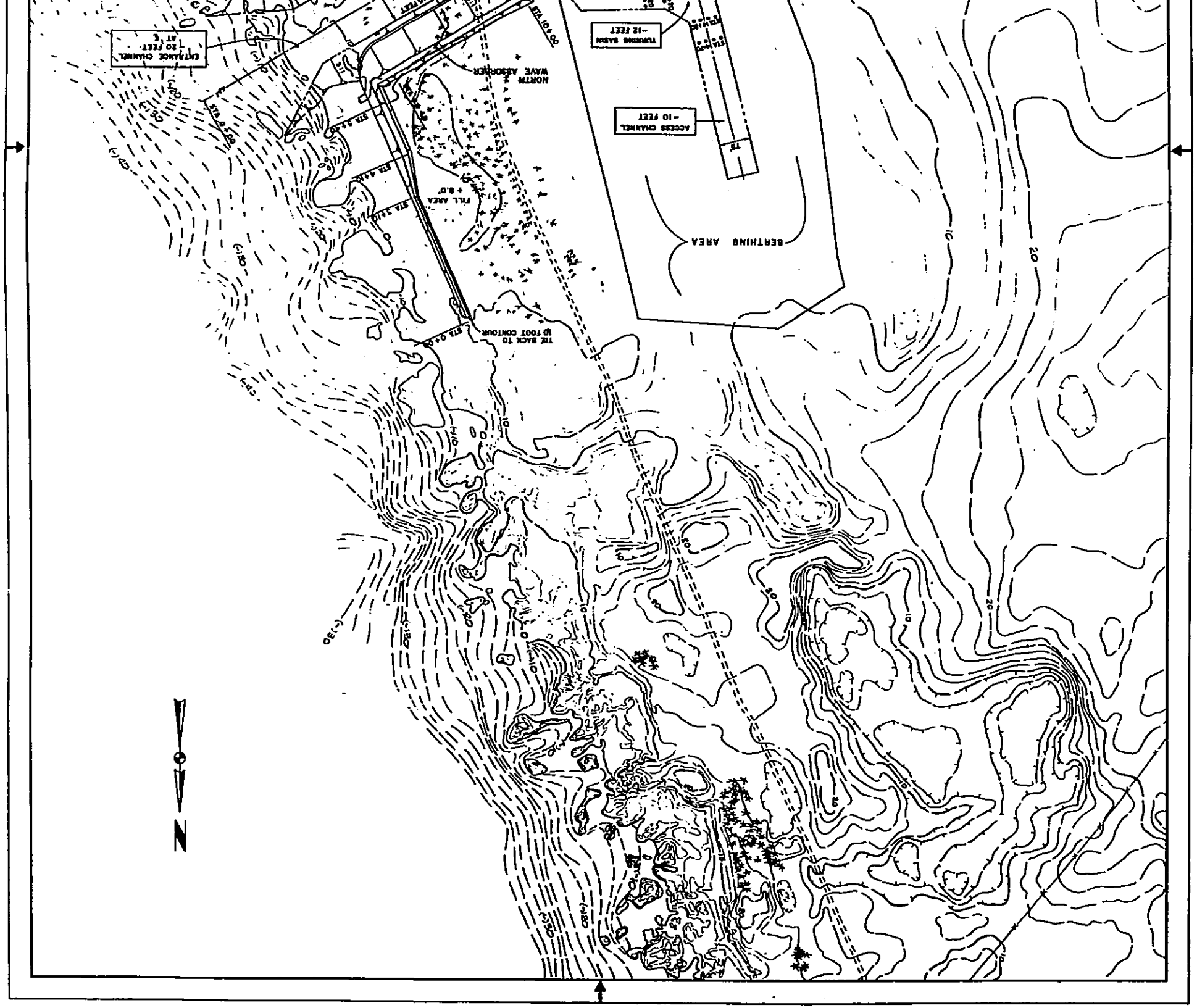

ACCESS CHANNEL
-10 FEET
TURNING BASIN
-12 FEET
-15 FEET
FUTURE LAUNCH RAMP
NORTH WAVE ABSORBER
SOUTH WAVE ABSORBER
ENTRANCE CHANNEL
-20 FEET
AT ℄
TOE OF CHANNEL -10 FEET
TOE OF CHANNEL -15 FEET
LEGEND
1. EXISTING CONDITIONS
UNIMPROVED ROAD
DEPRESSION
FENCE
COCONUT TREES
2. RECOMMENDED
HARBOR STRUCTURES (FEDERAL)
TOE OF STRUCTURES
DREDGING LIMIT
DEPTH TRANSITION
NOTES
1. ALL ELEVATIONS AND DEPTHS REFERENCED TO MEAN LOWER LOW WATER DATUM (MLLW).
2. CONTOUR INTERVAL: 2 FEET
3. DATE OF SURVEY: APRIL 1981
4. ORIGIN OF COORDINATES: HAWAIIAN PLANE COORDINATE SYSTEM, ZONE 1.
P L A N I
SCALE: 1" = 100'
GRAPHIC SCALE
100' 50' 0 100' 200'
1" = 100'
HILO AREA COMPREHENSIVE STUDY
KING'S LANDING
SMALL BOAT HARBOR
PLAN I
U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE D-5


ENTRANCE CHANNEL
20 FEET
AT ℄
NORTH
WAVE ABSORBER
TURNING BASIN
-12 FEET
ACCESS CHANNEL
-10 FEET
BERTHING AREA
FILL AREA
+ 8.0'
TIE BACK TO
10 FOOT CONTOUR
N

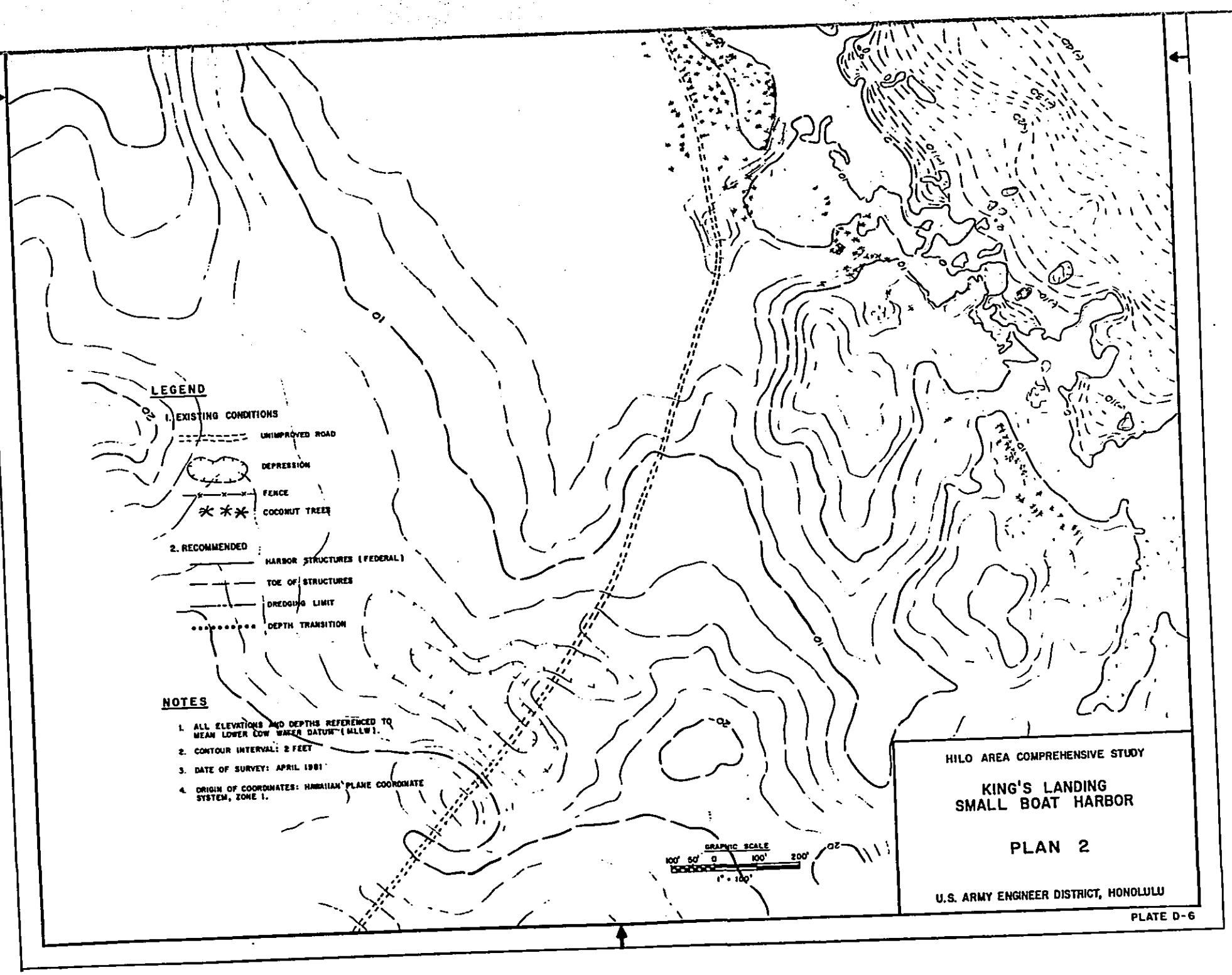
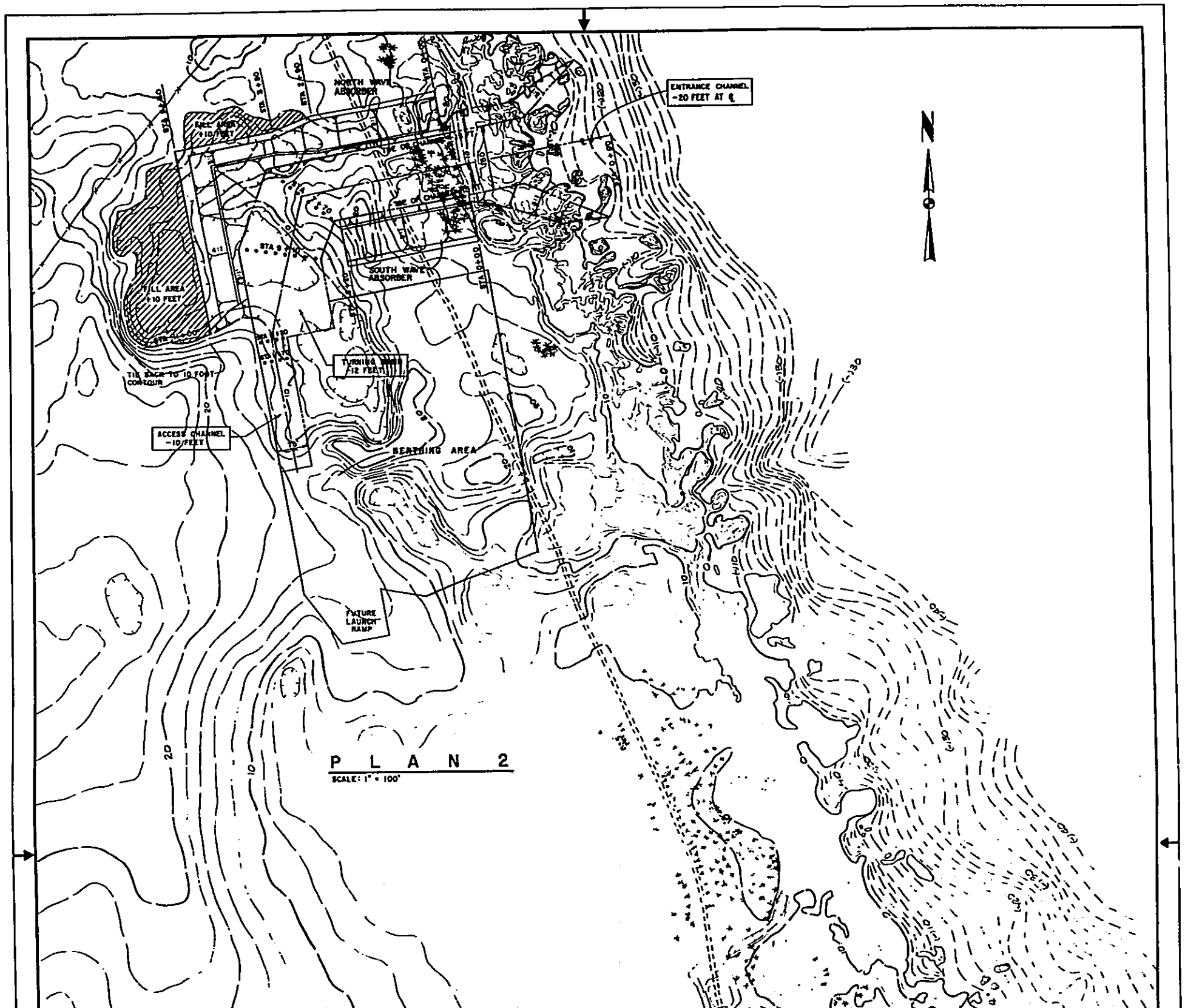
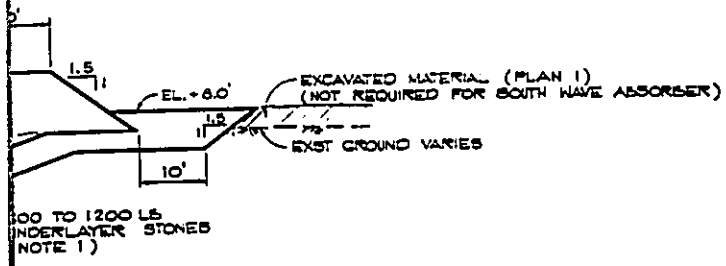

LEGEND
1. EXISTING CONDITIONS
UNIMPROVED ROAD
DEPRESSION
FENCE
COCONUT TREES
2. RECOMMENDED
HARBOR STRUCTURES (FEDERAL)
TOE OF STRUCTURES
DREDGING LIMIT
DEPTH TRANSITION
NOTES
1. ALL ELEVATIONS AND DEPTHS REFERENCED TO MEAN LOWER LOW WATER DATUM (MLLW).
2. CONTOUR INTERVAL: 2 FEET
3. DATE OF SURVEY: APRIL 1981
4. ORIGIN OF COORDINATES: HAWAIIAN PLANE COORDINATE SYSTEM, ZONE 1.
GRAPHIC SCALE
100' 50' 0 100' 200'
1" = 100'
HILO AREA COMPREHENSIVE STUDY
KING'S LANDING
SMALL BOAT HARBOR
PLAN 2
U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE D-6


ENTRANCE CHANNEL
-20 FEET AT ℄
NORTH WAVE ABSORBER
SOUTH WAVE ABSORBER
FILL AREA
+10 FEET
TIE BACK TO 10 FOOT CONTOUR
TURNING BASIN
-12 FEET
ACCESS CHANNEL
-10 FEET
BERTHING AREA
FUTURE LAUNCH RAMP
N
P L A N 2
SCALE: 1" = 100'

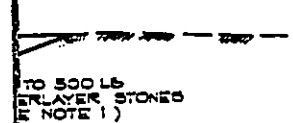
NOTES:

1. UNDERLAYER NOT REQUIRED WHEN ARMOR LAYER REST ON SOLID ROCK. IF EXISTING MATERIAL IS SAND OR SILT A 2 FOOT THICK BEDDING LAYER COMPOSED OF 1 LB (MIN) SPALLS TO 50 LB STONES IS REQUIRED.

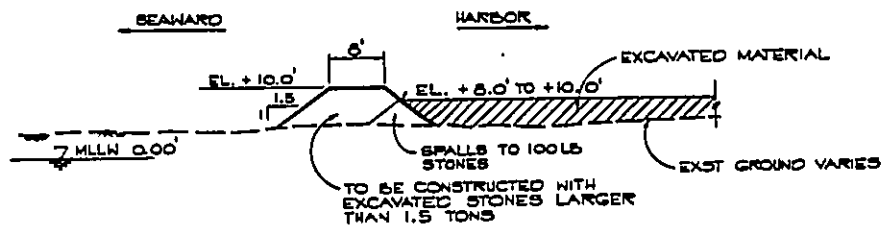


CTION

+00
+30
20
2+00
00
3+20



TO 500 LB
ERLAYER STONES
E NOTE 1)



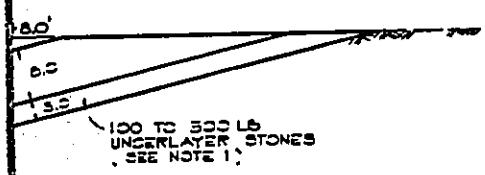
TYPICAL FILL AREA

SCALE: 1" = 10'

PLAN 1 - STA 0+00 TO STA 3+10
TRANSITION SECTION STA 3+10 TO STA 4+10

ION

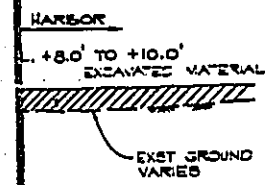
+85
+60



TION

+85
+00

HARBOR



SECTION

5 + 40
40

GRAPHIC SCALE

10' 5' 0 10' 20'

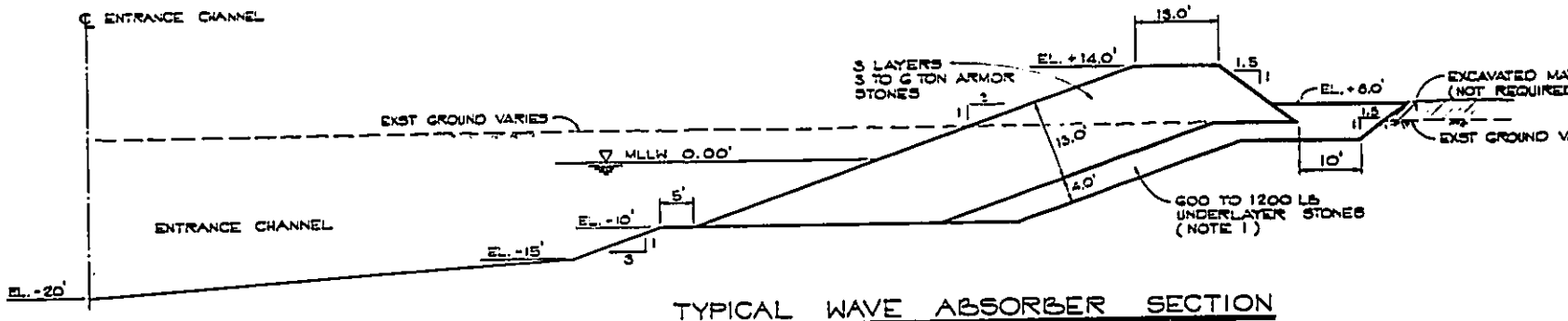
1" = 10'

HILO AREA COMPREHENSIVE STUDY

KING'S LANDING
SMALL BOAT HARBOR

TYPICAL SECTIONS
PLAN 1 AND PLAN 2

U.S. ARMY ENGINEER DISTRICT, HONOLULU

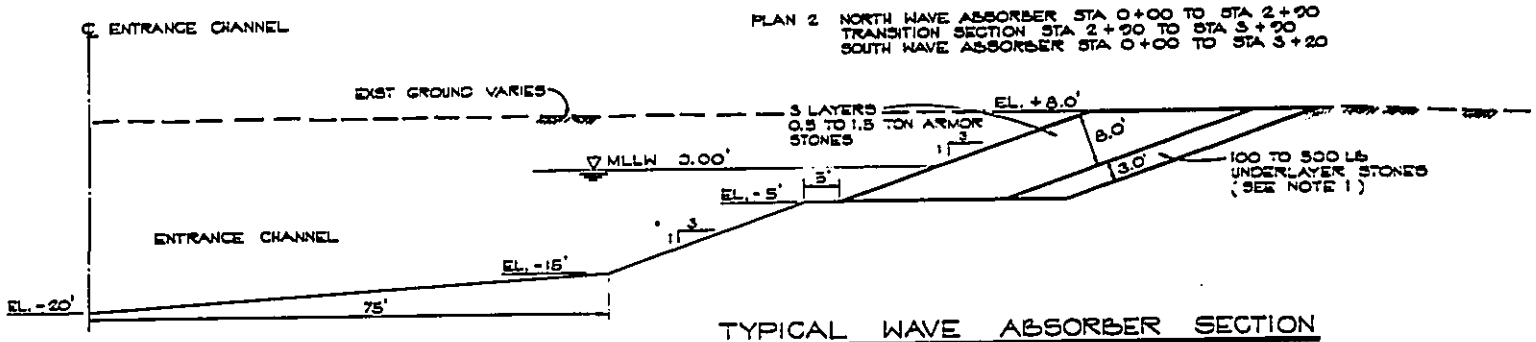


TYPICAL WAVE ABSORBER SECTION

SCALE: 1" = 10'

PLAN 1 - NORTH WAVE ABSORBER STA 6+40 TO STA 10+00
SOUTH WAVE ABSORBER STA 0+00 TO STA 4+30
TRANSITION SECTION STA 4+20 TO STA 5+20

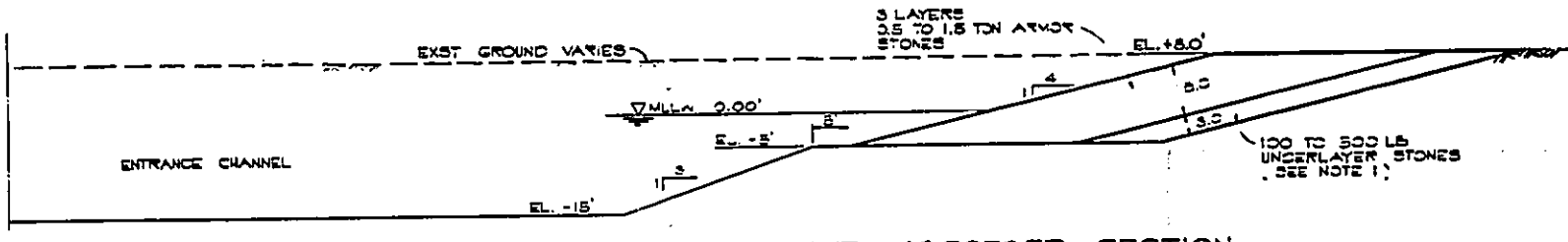
PLAN 2 NORTH WAVE ABSORBER STA 0+00 TO STA 2+90
TRANSITION SECTION STA 2+90 TO STA 3+90
SOUTH WAVE ABSORBER STA 0+00 TO STA 3+20



TYPICAL WAVE ABSORBER SECTION

SCALE: 1" = 10'

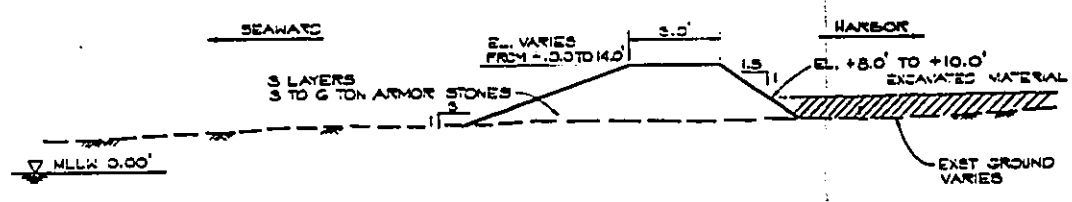
PLAN 1 - SOUTH WAVE ABSORBER STA 5+20 TO STA 7+85
PLAN 2 - NORTH WAVE ABSORBER STA 3+90 TO STA 6+60



TYPICAL WAVE ABSORBER SECTION

SCALE: 1" = 10'

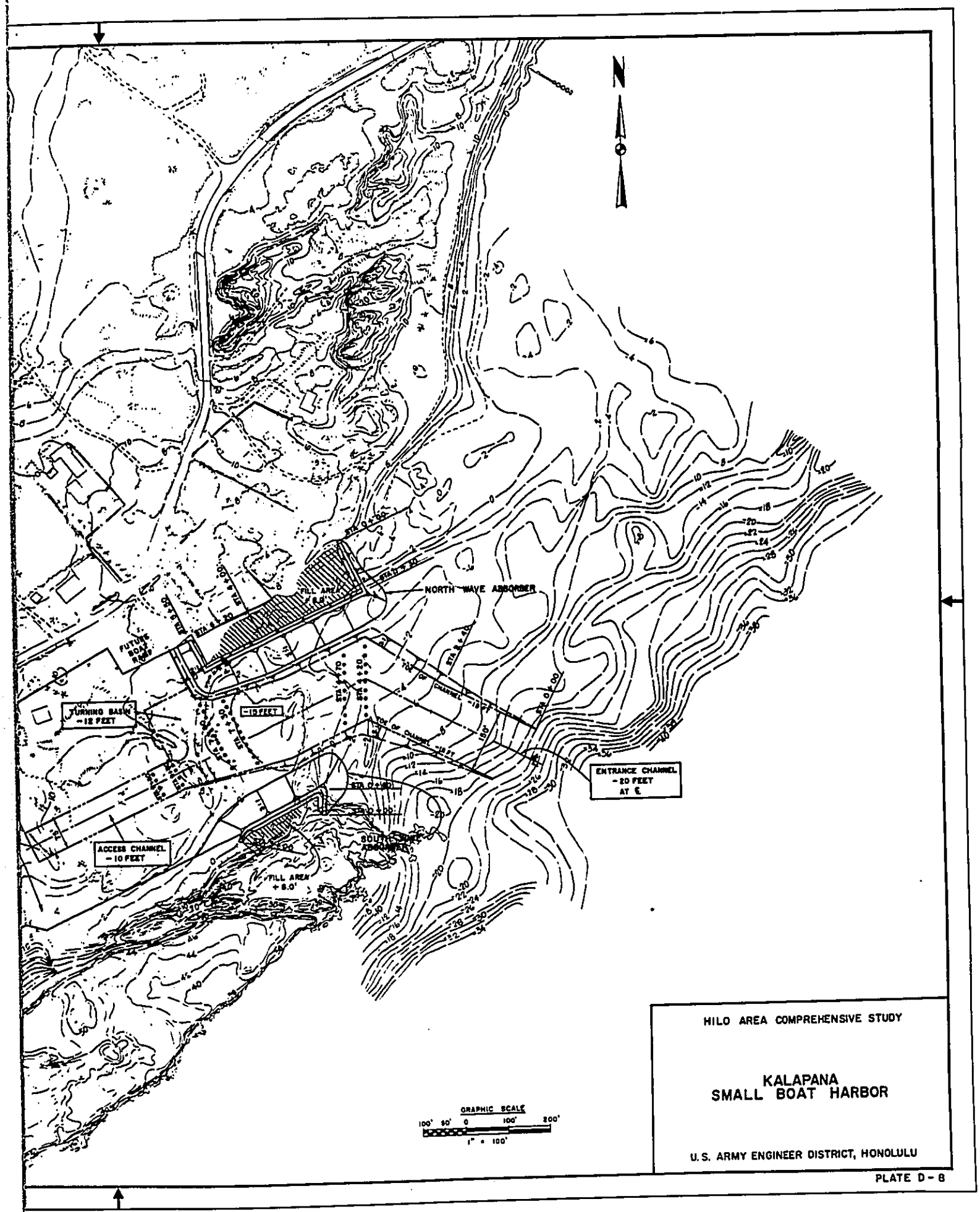
PLAN 1 - SOUTH WAVE ABSORBER STA 7+85 TO STA 11+85
PLAN 2 - NORTH WAVE ABSORBER STA 6+60 TO STA 11+00



TYPICAL WAVE ABSORBER SECTION

SCALE: 1" = 10'

PLAN 1 - NORTH WAVE ABSORBER STA 4+10 TO STA 5+40
TRANSITION SECTION STA 5+40 TO STA 6+40



HILO AREA COMPREHENSIVE STUDY

KALAPANA
SMALL BOAT HARBOR

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE D-8

TURNING BASIN
-12 FEET
ACCESS CHANNEL
-10 FEET
BERTHING AREA

NOTE:

1. UNDERLAYER NOT REQUIRED WHEN ARMOR LAYER REST ON SOLID ROCK. IF EXISTING MATERIAL IS SAND OR SILT A 2 FOOT THICK BEDDING LAYER COMPOSED OF 1 LB (MIN) SPALLS TO 50 LB STONES IS REQUIRED.

BOR

EL +8.0'

EXST GROUND VARIES

+8.0'

EXCAVATED MATERIAL

EXST GROUND VARIES

NES

D VARIES

500 LB
LAYER STONES

EXCAVATED MATERIAL

EXST GROUND VARIES

N

GRAPHIC SCALE

10' 5' 0 10' 20'

1" = 10'

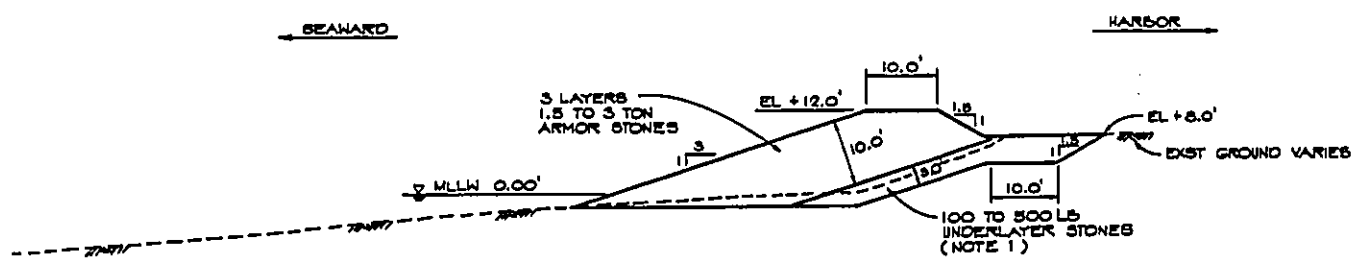
HILO AREA COMPREHENSIVE STUDY

KALAPANA
SMALL BOAT HARBOR

TYPICAL SECTIONS

U.S. ARMY ENGINEER DISTRICT, HONOLULU

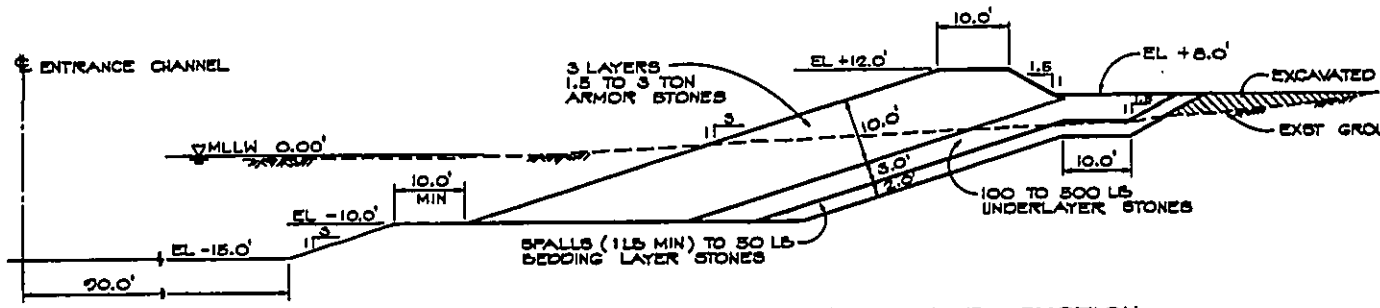
PLATE D-9



TYPICAL WAVE ABSORBER SECTION

SCALE: 1" = 10.0'

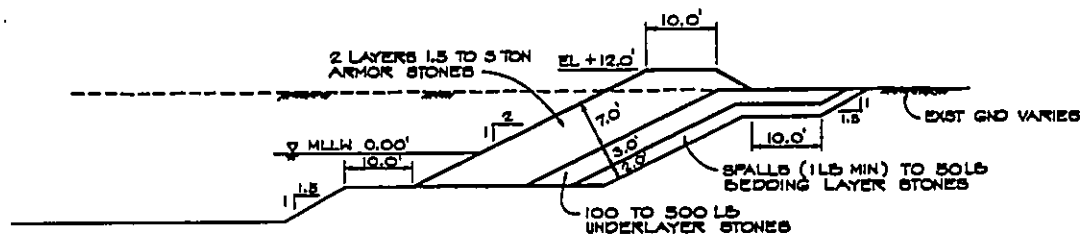
SOUTH WAVE ABSORBER STA 0+00 TO STA 0+60



TYPICAL WAVE ABSORBER SECTION

SCALE: 1" = 10.0'

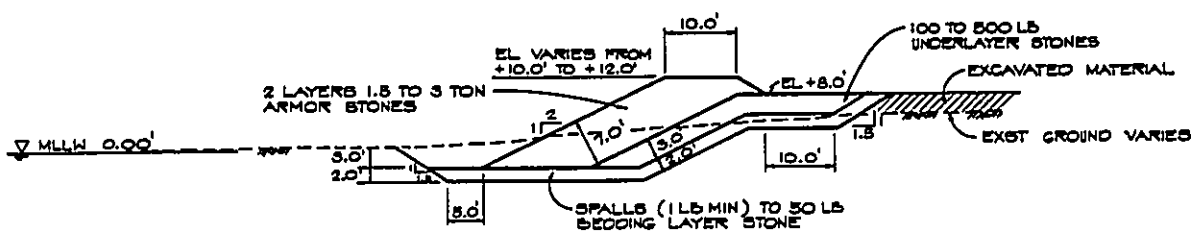
SOUTH WAVE ABSORBER STA 0+60 TO STA 3+00
NORTH WAVE ABSORBER STA 1+30 TO STA 4+00
TRANSITION SECTION STA 4+00 TO STA 5+50



TYPICAL WAVE ABSORBER SECTION

SCALE: 1" = 10.0'

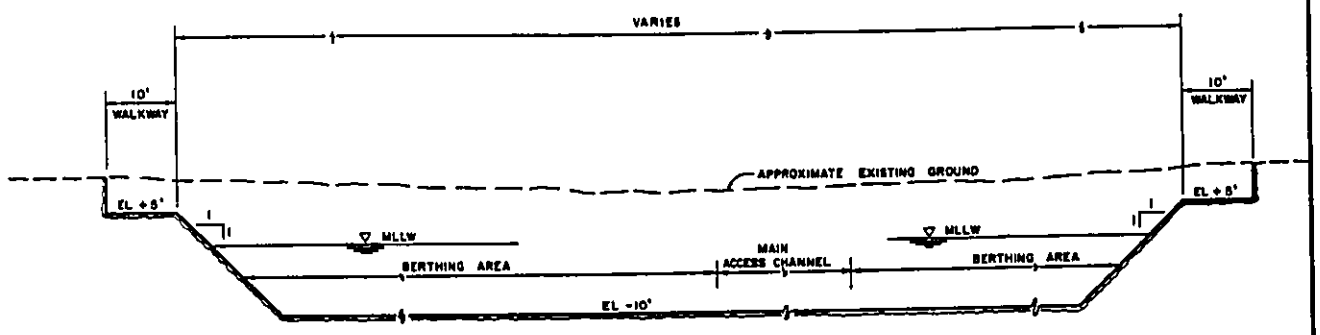
NORTH WAVE ABSORBER STA 5+50 TO STA 6+20



TYPICAL WAVE ABSORBER SECTION

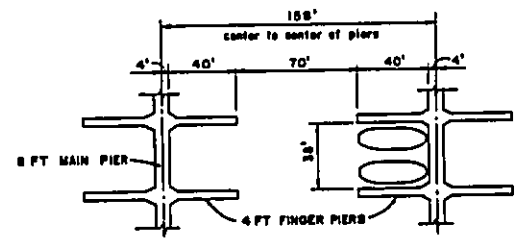
SCALE: 1" = 10.0'

NORTH WAVE ABSORBER STA 0+00 TO STA 1+30



SECTION B-B

SCALE: 1" = 10'

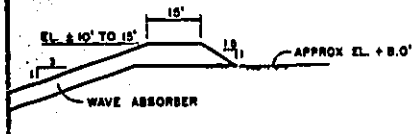


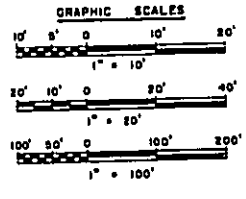
TYPICAL BERTHING ARRANGEMENT

NOT TO SCALE

NOTE:

ELEVATIONS BASED ON MEAN LOWER LOW WATER DATUM.



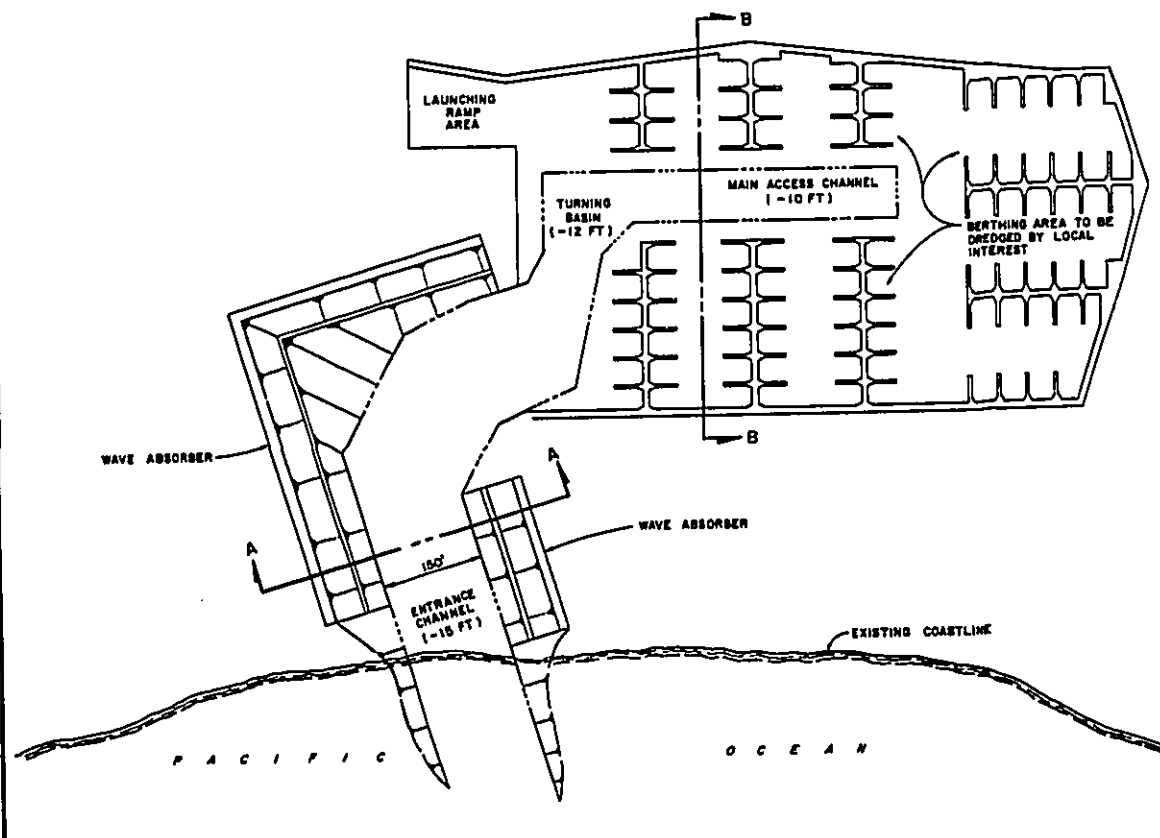


HILO AREA COMPREHENSIVE STUDY

PROTOTYPE SMALL BOAT HARBOR
WITH
POSSIBLE BERTHING LAYOUT

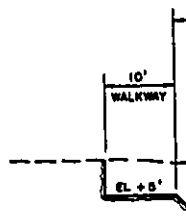
U.S. ARMY ENGINEER DISTRICT, HONOLULU

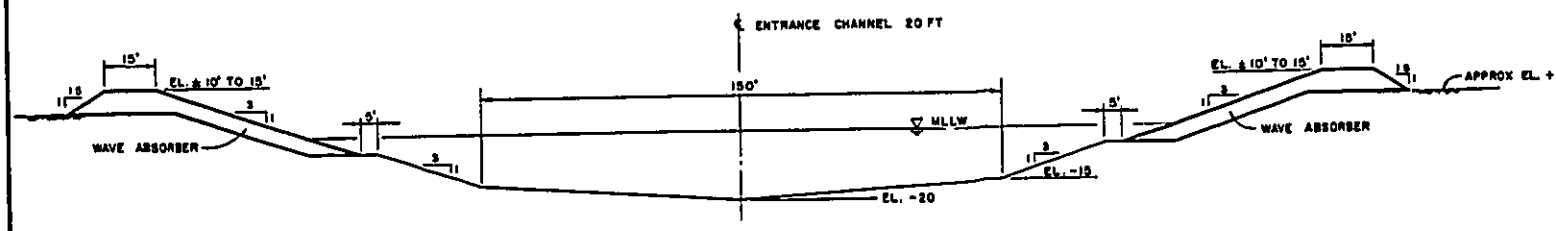
PLATE D-10



PLAN

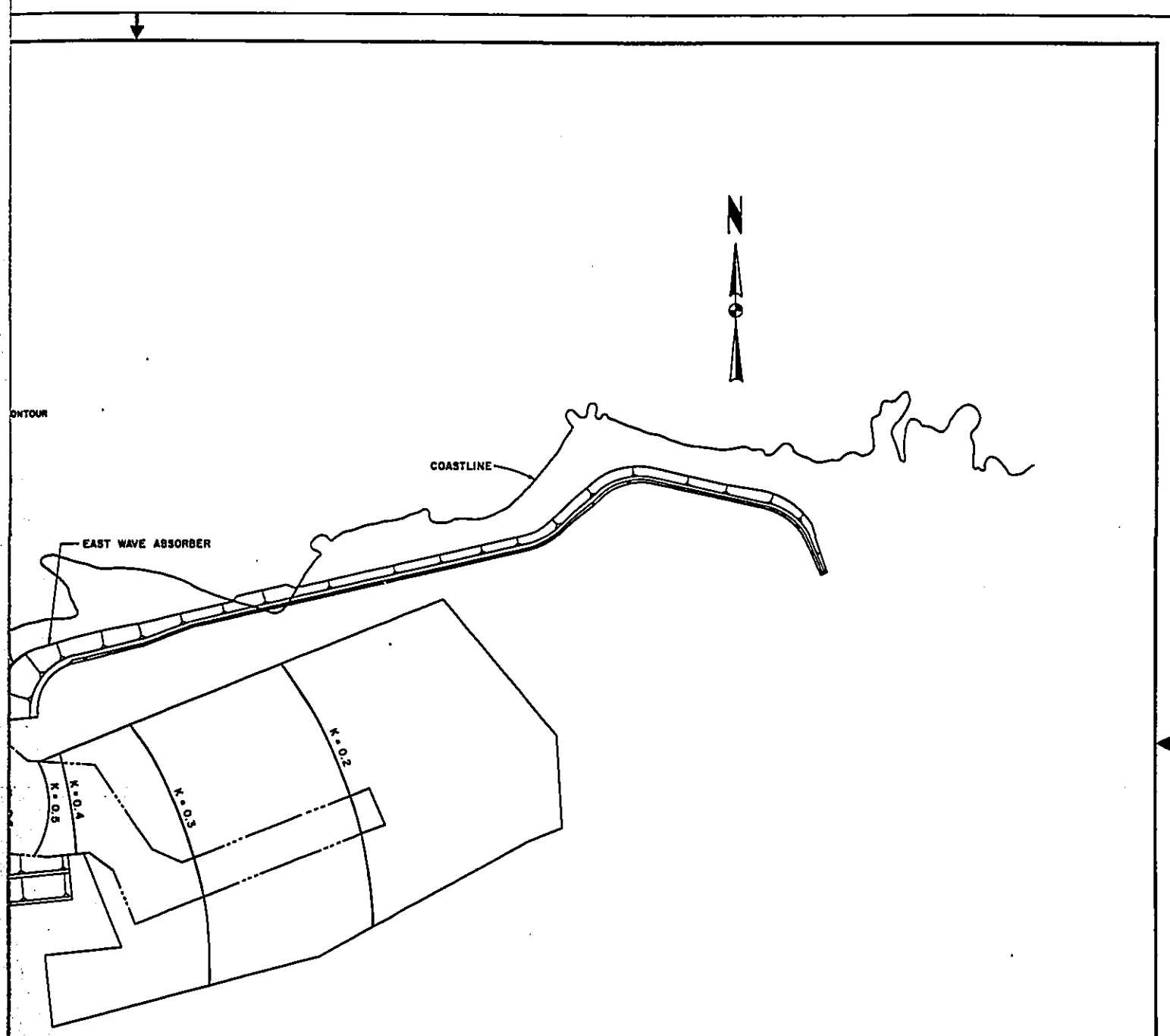
SCALE: 1" = 100'





SECTION A-A

SCALE: 1" = 20'



P L A N

SCALE: 1" = 100'

GRAPHIC SCALE

100' 50' 0 100' 200'

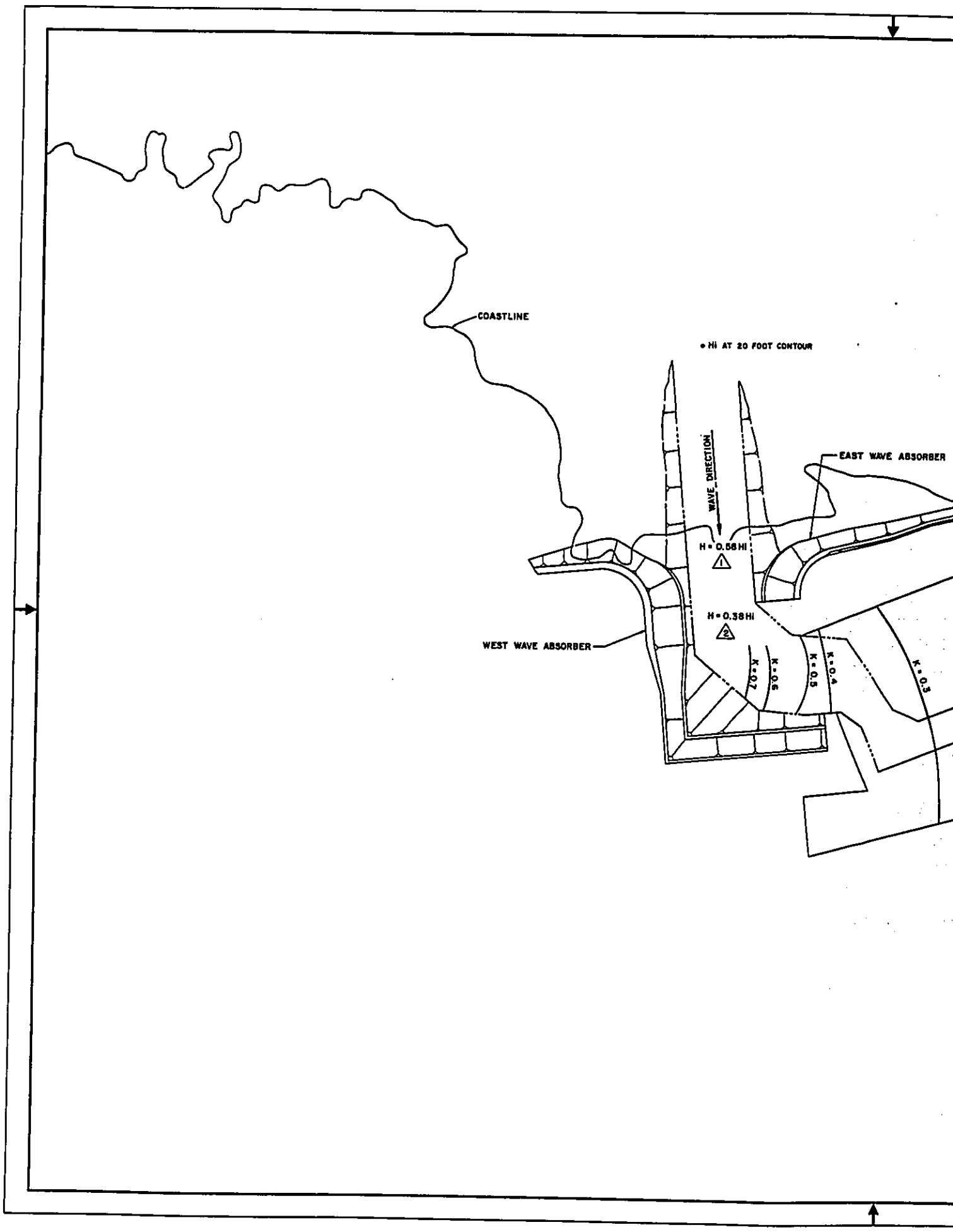
1" = 100'

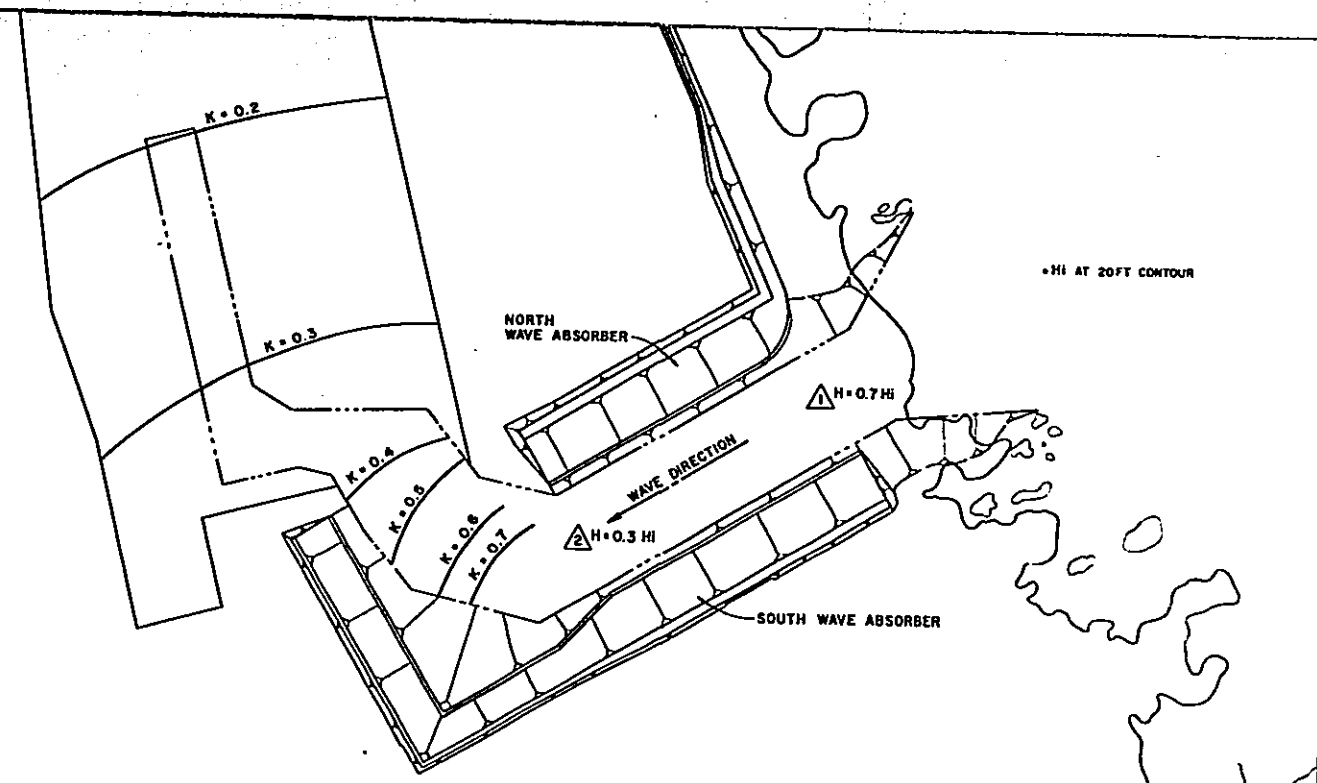
HILO AREA COMPREHENSIVE STUDY

LELEIWI POINT
SMALL BOAT HARBOR

WAVE DIFFRACTION DIAGRAM

U.S. ARMY ENGINEER DISTRICT, HONOLULU


COASTLINE
• Hi AT 20 FOOT CONTOUR
WAVE DIRECTION
EAST WAVE ABSORBER
H = 0.58 Hi
1
H = 0.38 Hi
2
WEST WAVE ABSORBER
K = 0.7
K = 0.6
K = 0.5
K = 0.4
K = 0.3



P L A N 1

SCALE: 1" = 100'

GRAPHIC SCALE

100' 50' 0 100' 200'

1" = 100'

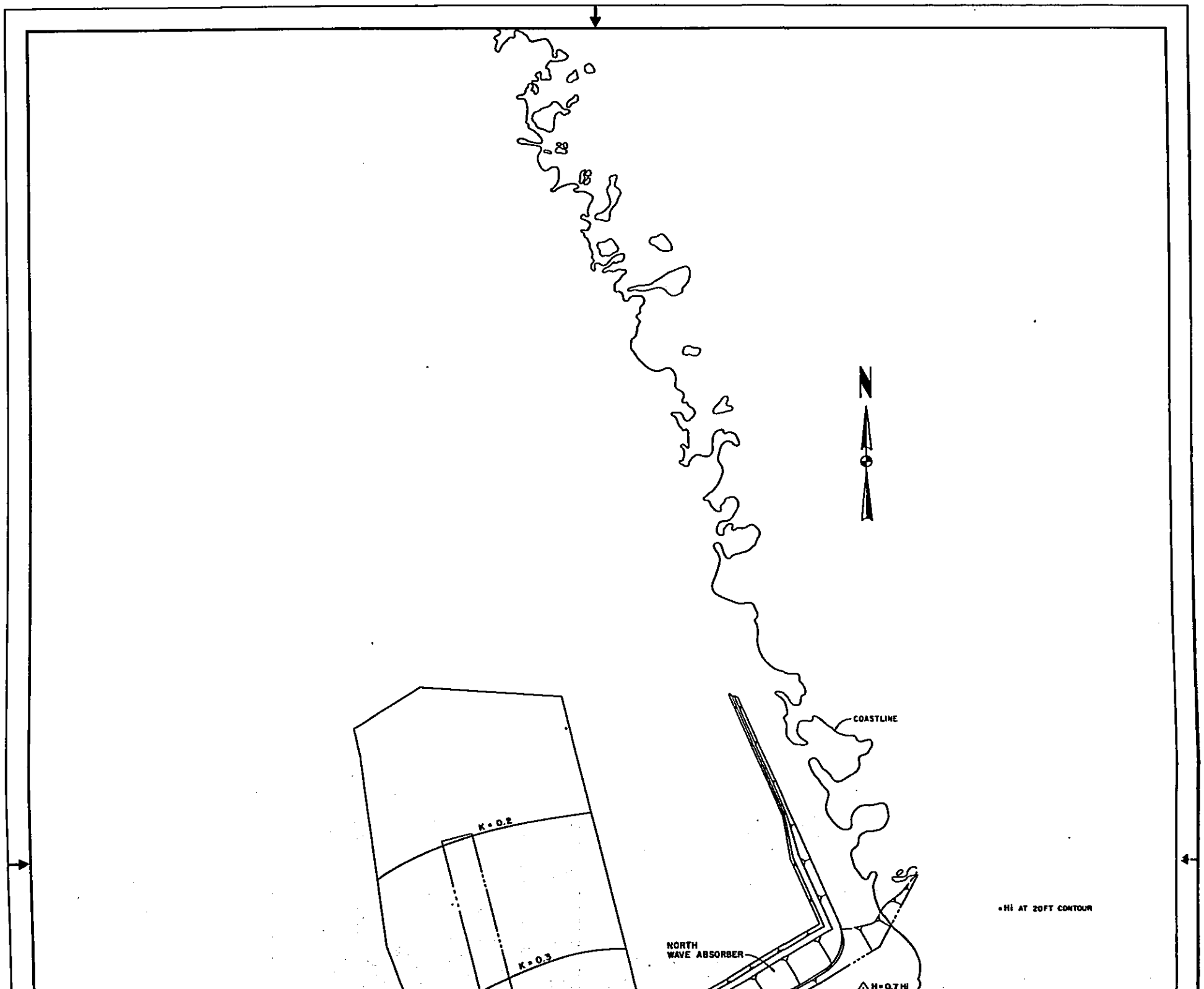
HILO AREA COMPREHENSIVE STUDY

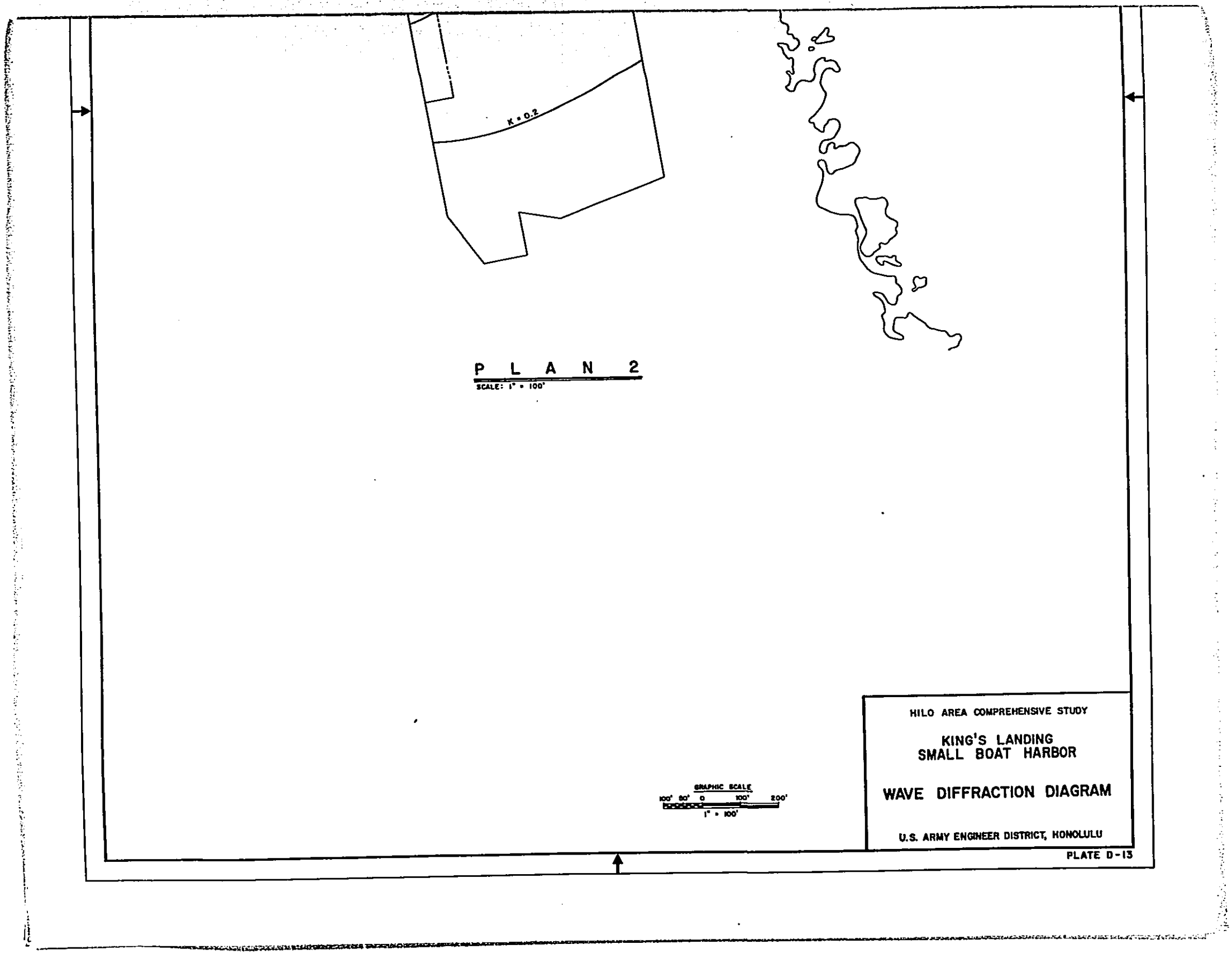
KING'S LANDING
SMALL BOAT HARBOR

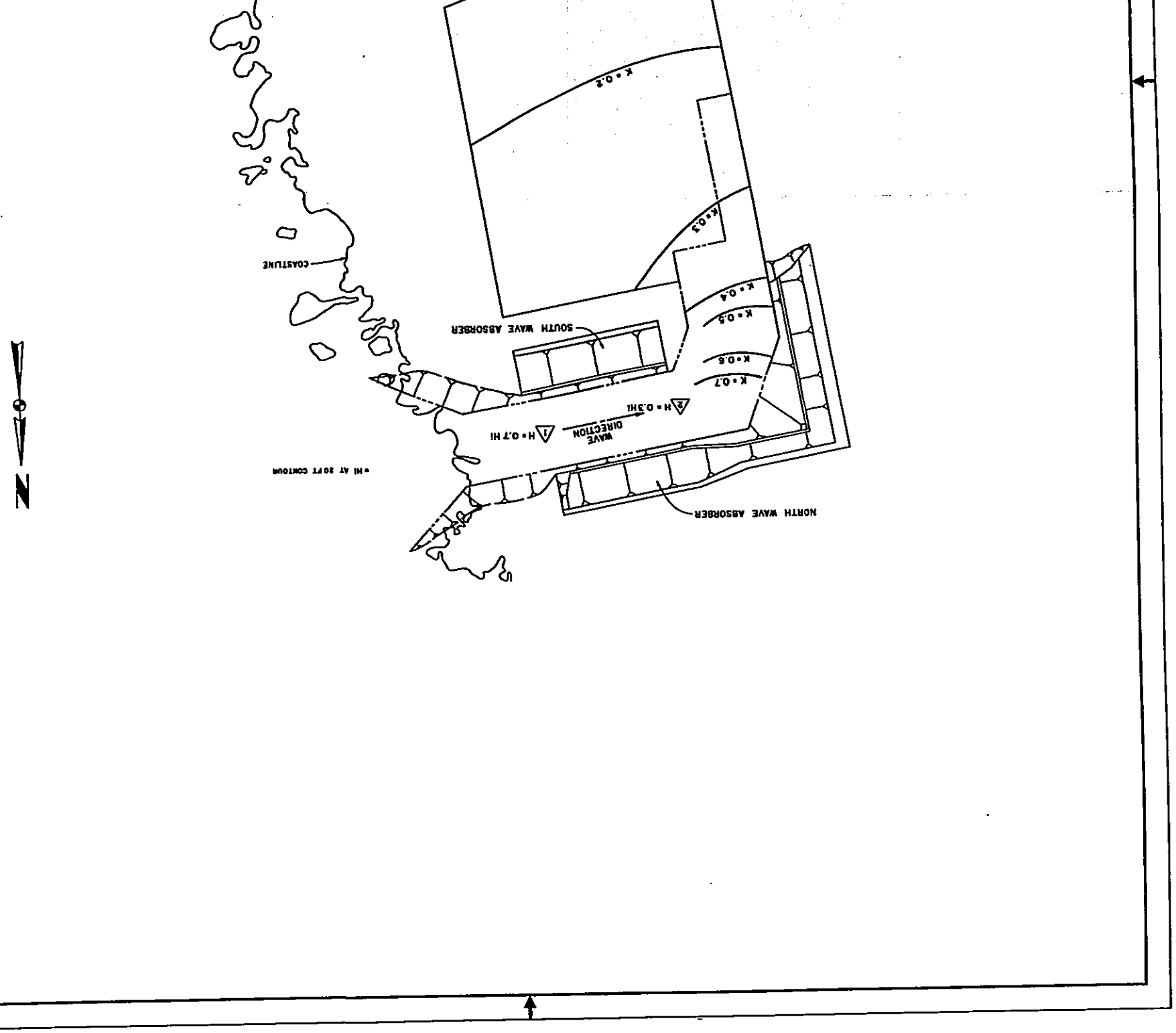
WAVE DIFFRACTION DIAGRAM

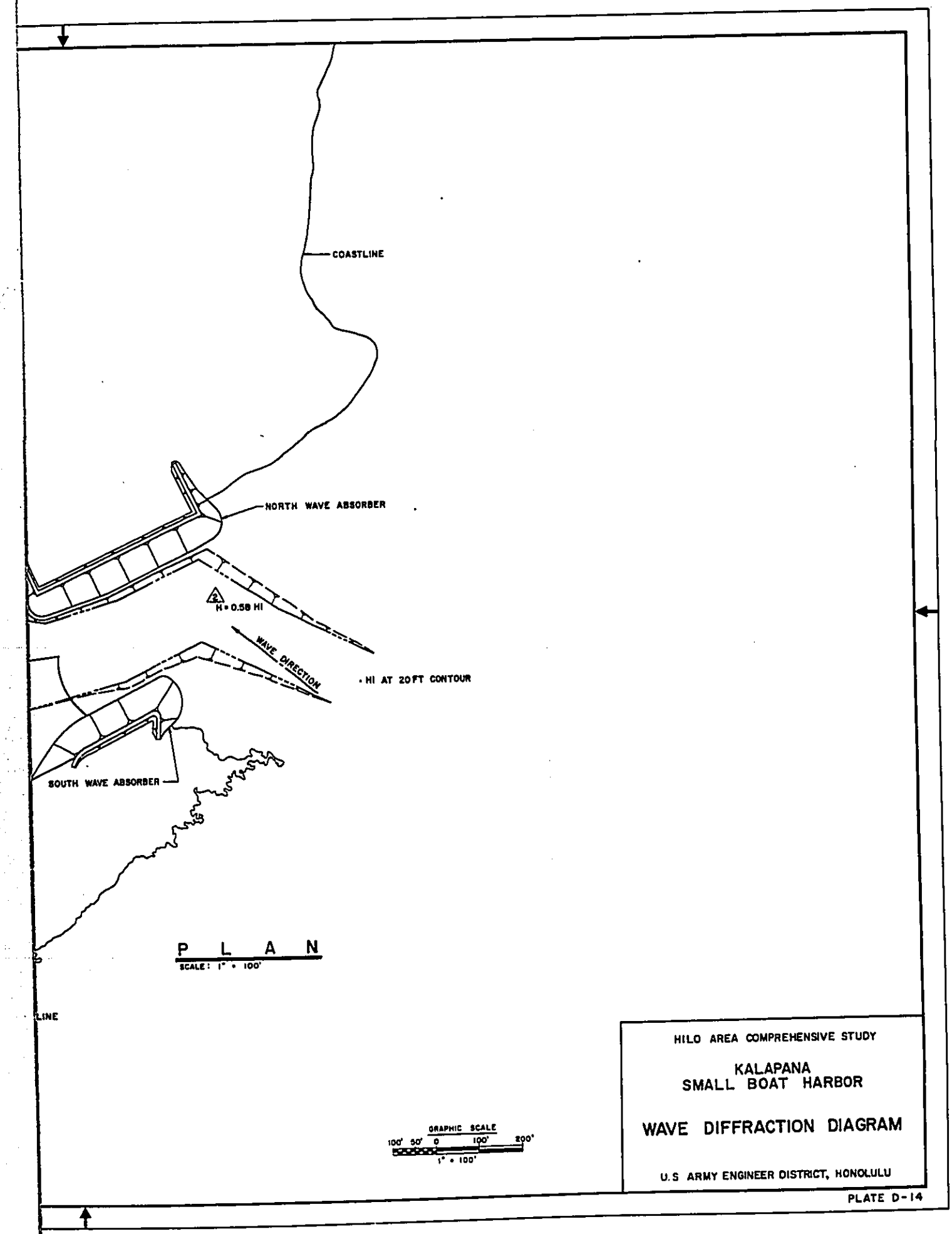
U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE D-12


N
COASTLINE
K = 0.2
K = 0.3
NORTH
WAVE ABSORBER
H = 0.7 Hi
•Hi AT 20FT CONTOUR


K = 0.2
PLAN 2
SCALE: 1" = 100'
GRAPHIC SCALE
100' 50' 0 100' 200'
1" = 100'
HILO AREA COMPREHENSIVE STUDY
KING'S LANDING
SMALL BOAT HARBOR
WAVE DIFFRACTION DIAGRAM
U.S. ARMY ENGINEER DISTRICT, HONOLULU
PLATE D-13


NORTH WAVE ABSORBER
WAVE DIRECTION
H = 0.7 HI
H = 0.3HI
K = 0.7
K = 0.6
K = 0.5
K = 0.4
K = 0.3
K = 0.2
SOUTH WAVE ABSORBER
COASTLINE
= HI AT 20 FT CONTOUR
N

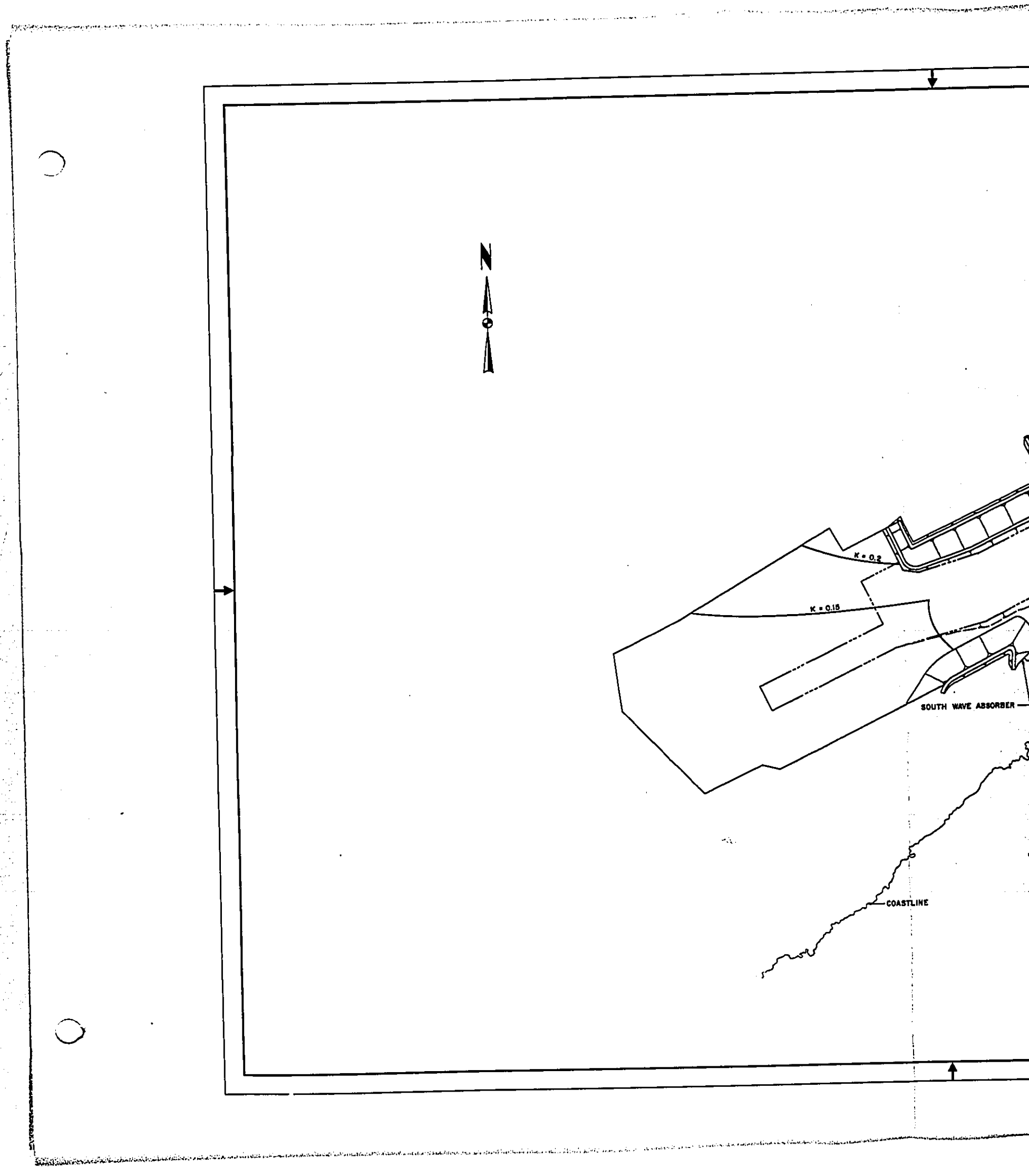


HILO AREA COMPREHENSIVE STUDY

KALAPANA
SMALL BOAT HARBOR

WAVE DIFFRACTION DIAGRAM

U.S ARMY ENGINEER DISTRICT, HONOLULU


N
K = 0.2
K = 0.15
SOUTH WAVE ABSORBER
COASTLINE

SECTION 2. DESIGN ANALYSIS SECTION: DEEP DRAFT HARBOR

Section	Title	Page
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	b. Technical Criteria	D-1
	c. Federal Design Feature	D-1
	d. Level of Design Analysis	D-1
2.	Site Location	D-1
	a. Hilo Bay	D-1
	b. Port of Hilo	D-2
3.	Climatology	D-2
	a. Local Climatology	D-2
	b. Tropical Storms and Hurricanes	D-4
4.	Water Level and Currents	D-4
	a. Tides	D-4
	b. Astronomical Tide	D-6
	c. Atmospheric Pressure Drop	D-6
	d. Storm Surge	D-6
	e. Design Stillwater Level	D-7
	f. Currents	D-7
5.	Wave Conditions	D-8
	a. Wave Climate	D-8
	b. Refraction Analysis	D-10
	c. Breaking Wave Condition	D-10
6.	Wave Conditions in Hilo Bay	D-11
	a. Forecasting for Shallow Water Waves	D-11
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7.	Selected Design Conditions	D-14
	a. Water Levels (MLLW)	D-14
	b. Design Wave Heights	D-14
8.	Plan Components	D-15
	a. Harbor Deepening	D-15
	b. Breakwaters	D-17
	c. Submersible Mooring Buoy	D-19
	d. Pretension Devices and Improve Existing Pier 1 Fender System	D-21
	e. Circulation Improvement	D-22
	f. Commercial Port Expansion	D-23

LIST OF PLATES

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D-4	Design Wave Height for Applicable Areas	D-14
D-5	Typical Stone Breakwater and Revetment Section	D-18
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D-7	Submersible Buoy	D-22
D-8	Pier 1 Fender Modification	D-22
D-9	Pier 1 Fender Modification	D-22
D-10	Typical Dolo Breakwater Section	D-24
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D-14	Plan D	D-24

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D-3	List of Significant Tsunamis Since 1946	D-9
D-4	Diffraction - Refraction Analysis	D-13
D-5	Design Wave Heights	D-15
D-6	Crest Elevation, Stone Weight and Layer Thickness for Rubble-Mound Breakwaters	D-18
D-7	Crest Elevation, Layer Weight and Layer Thickness for Circulation Improvement Breakwater	D-22
D-8	Crest Elevation, Layer Weight and Layer Thickness for the Commercial Port Expansion Breakwater	D-23
D-9	Crest Elevation, Layer Weight and Layer Thickness for the Commercial Port Expansion Fill Areas	D-24

APPENDIX D

DESIGN ANALYSIS SECTION

1. GENERAL CRITERIA

a. FORMULATION AND ANALYSIS. The formulation and analysis of the alternative plans were based on the Waters Resources Council's Principles and Standards, and applicable Corps regulations and guidelines on planning process.

b. TECHNICAL CRITERIA. The following technical criteria were adopted for use in developing alternative plans:

(1) Navigation improvements should be designed to accommodate a design vessel, whose length is 700 feet, beam is 92 feet and draft from 35 to 36 feet, during all reasonable expected weather and sea conditions.

(2) The entrance channel should be of adequate depth and width to safely accommodate one-way traffic by the design vessel.

(3) The protective harbor basin should provide a safe maneuvering area for the design vessel, with provisions for berthing.

(4) Local plans for land use and port expansions area will be considered.

c. FEDERAL DESIGN FEATURE. Federal design features include an entrance channel, turning basin and protective works such as breakwaters and stub breakwaters. All berthing and shoreside features necessary for a complete harbor facility would be provided by the State of Hawaii.

d. LEVEL OF DESIGN. The appendix contains supporting engineering data and analysis to support the Stage 3 formulation and the plan selection process.

2. SITE LOCATION

a. HILO BAY. The study area was limited to the triangular shaped Hilo Bay at approximately 19.7° north latitude and 155.1° west longitude (Plate D-1) on

the northeast coast of the island of Hawaii. The south and east shores are relatively flat and at low elevations, while the west shore is rocky, nearly vertical cliffs. The entrance to the bay separates the cliffs and a coral reef, known as Blonde Reef, is about 1 mile wide with a maximum depth of 60 feet.[1/] Blonde Reef extends about 2 miles northwesterly from the southeast side of the bay, with depths varying from 6 to 18 feet. The reef and the existing 10,080-foot long rubble mound breakwater affords storm wave protection to the inner bays. The inner bay includes Kuhio, Radio and Reeds Bays (Plate D-2). Kuhio Bay serves as the deep draft harbor turning basin which is 1,400 feet wide, 2,300 feet long and 35 to 40 feet deep. The port area is located in the southeast end of the bay at the root of the 10,080-foot long breakwater. Two small rivers enter Hilo Bay: The Wailuku River adjoining the bluffs on the west, and the Wailoa River on the south. Published maps of the study area and vicinity are listed in the following tabulation:

Description	Prepared by	Chart No.
Hawaiian Islands	National Oceanic and Atmospheric Administration National Ocean Survey (N.O.A.A.)	19004
Island of Hawaii	N.O.A.A.	19320
Hilo Bay	N.O.A.A.	19324

b. PORT OF HILO. The port facilities at Hilo is on state-own land under the jurisdiction of the Department of Transportation, Harbors Division. The facilities at Kuhio Bay are used for handling general and bulk cargo, and the one at Radio Bay is used for mooring small transit vessels. Table D-1[2/] is a tabulation of the physical characteristics of the state's facilities at the Port of Hilo.

3. CLIMATOLOGY

a. LOCAL CLIMATOLOGY. The average annual temperature at Hilo is 73°F. The highest average monthly temperature is 76°F in August and September and

1/ All elevations referenced to mean lower low water datum (MLLW), unless stated otherwise.

2/ Development Plans, Port of Hilo and Port of Kawaihae, Island of Hawaii, Tudor Engineering Company, August 1972.

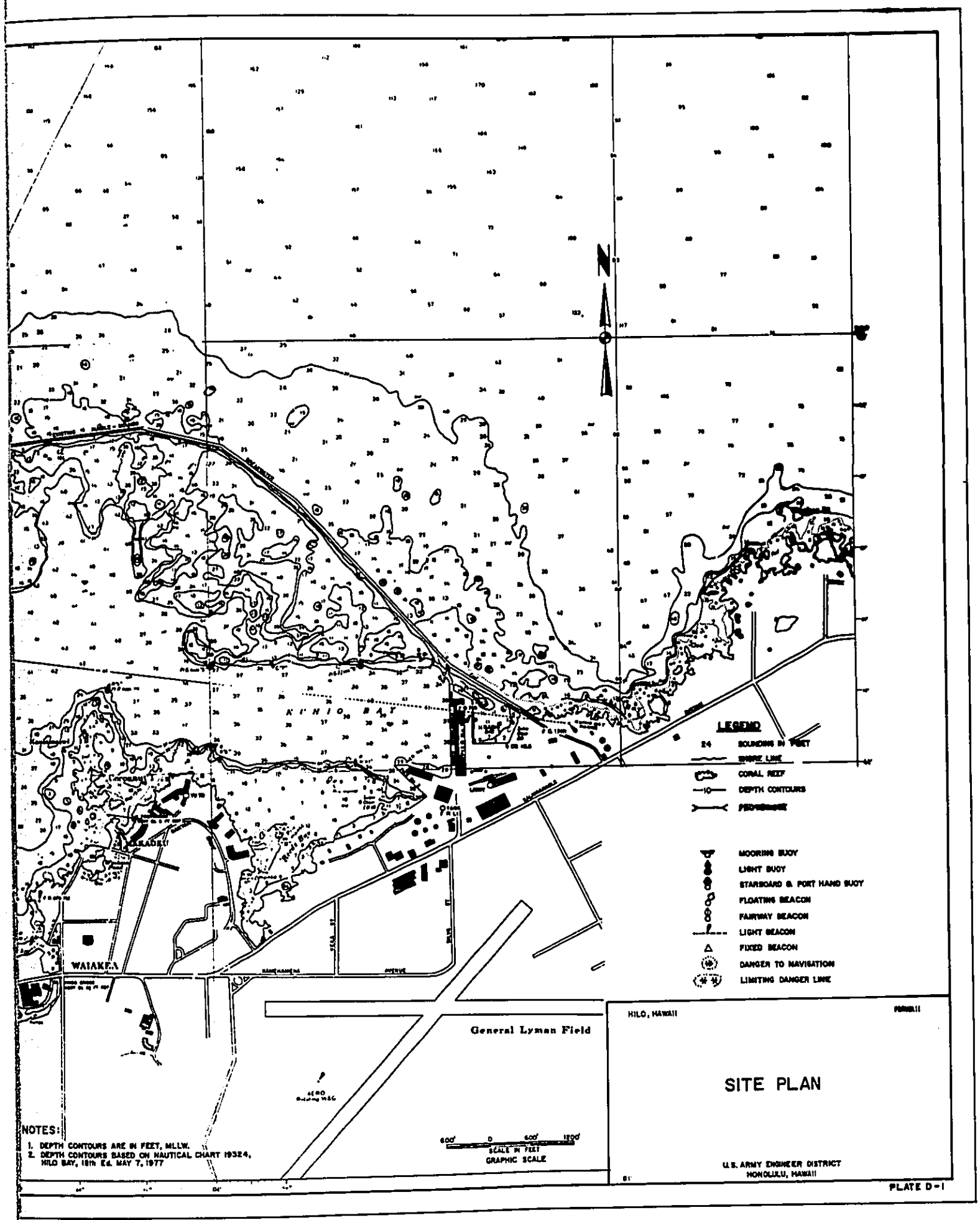
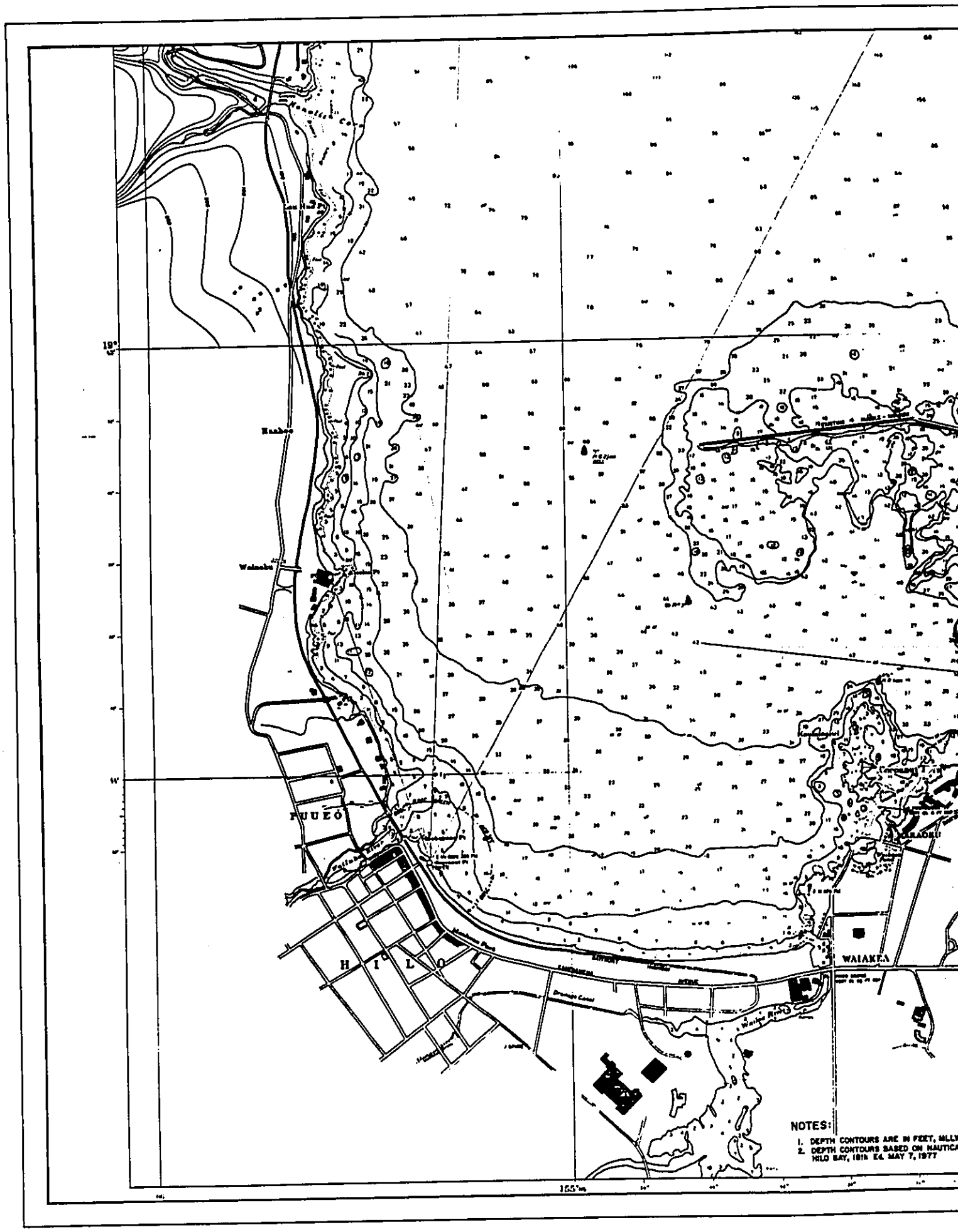
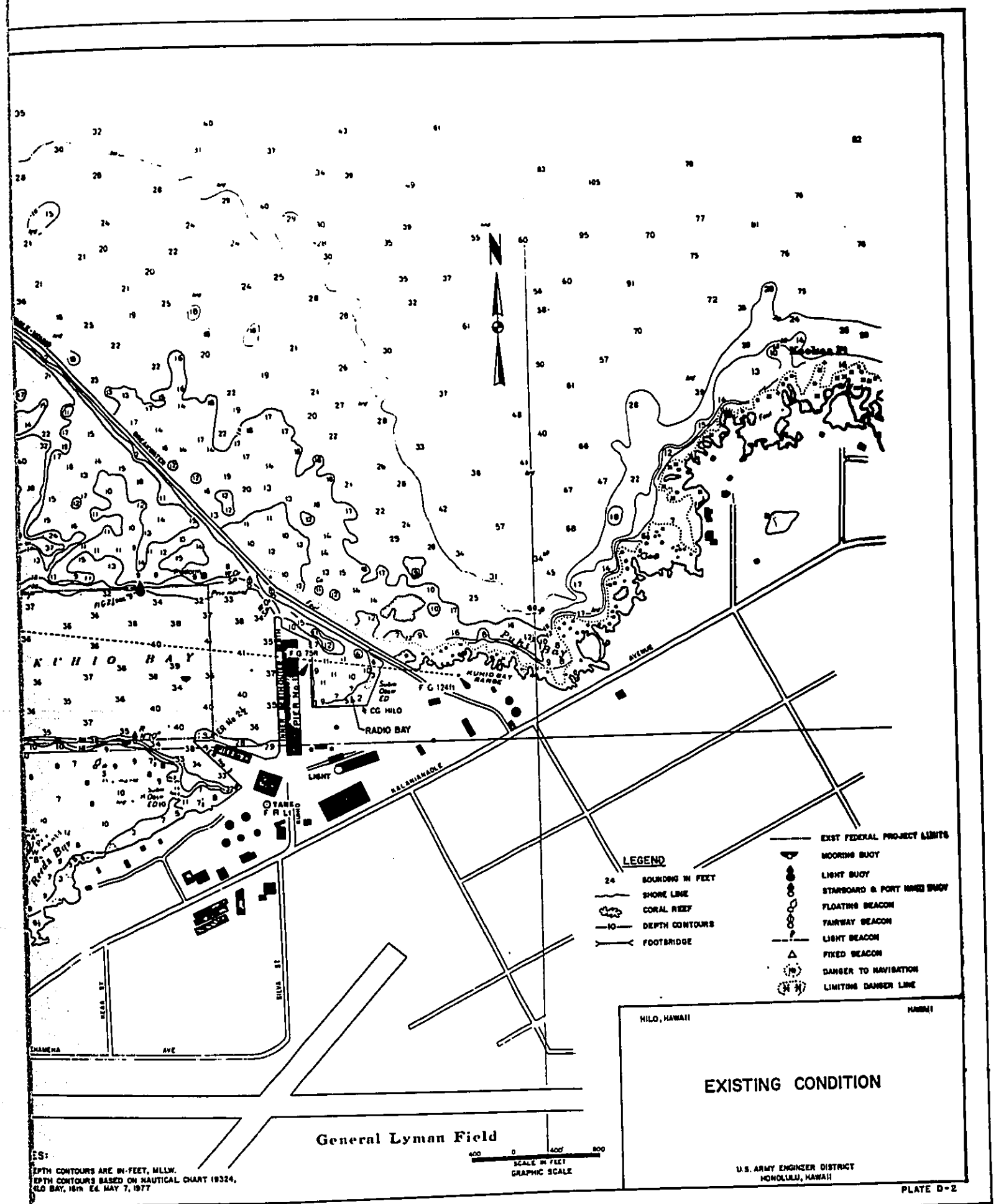

N
LEGEND
24 SOUNDING IN FEET
SHORE LINE
CORAL REEF
DEPTH CONTOURS
PIER
MOORING BUOY
LIGHT BUOY
STARBOARD & PORT HAND BUOY
FLOATING BEACON
FAIRWAY BEACON
LIGHT BEACON
FIXED BEACON
DANGER TO NAVIGATION
LIMITING DANGER LINE
WAIAKEA
General Lyman Field
600' 0 600' 1200'
SCALE IN FEET
GRAPHIC SCALE
HILO, HAWAII
HAWAII
SITE PLAN
U.S. ARMY ENGINEER DISTRICT
HONOLULU, HAWAII
NOTES:
1. DEPTH CONTOURS ARE IN FEET, MLLW.
2. DEPTH CONTOURS BASED ON NAUTICAL CHART 19324, HILO BAY, 18th Ed. MAY 7, 1977

PLATE D-1



19°
Waiakea
PUUEO
H I L O
WAIAKEA
NOTES:
1. DEPTH CONTOURS ARE IN FEET, MLLW
2. DEPTH CONTOURS BASED ON NAUTICA
HILO BAY, 18th Ed. MAY 7, 1977



HILO, HAWAII

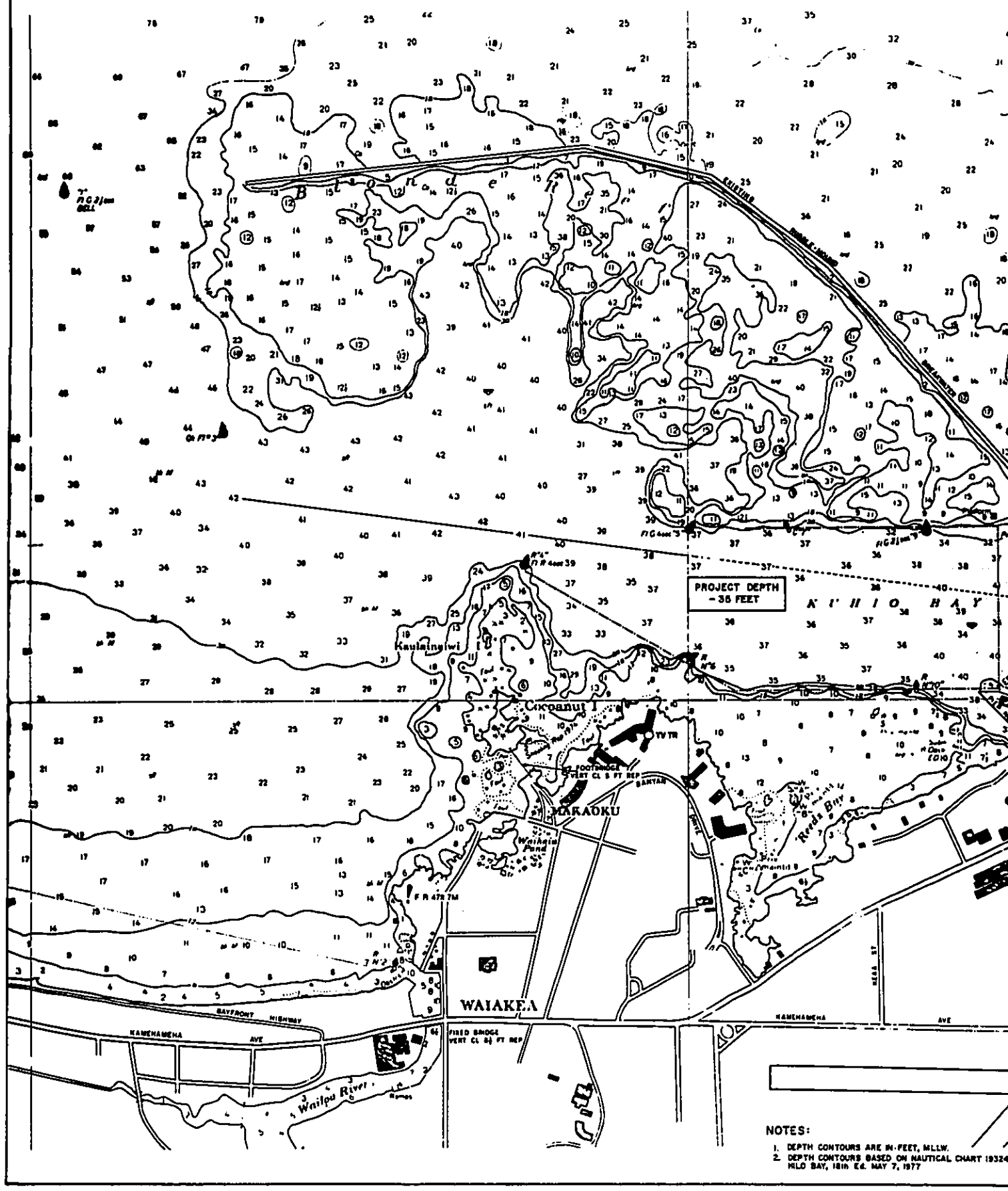
HAWAII

EXISTING CONDITION

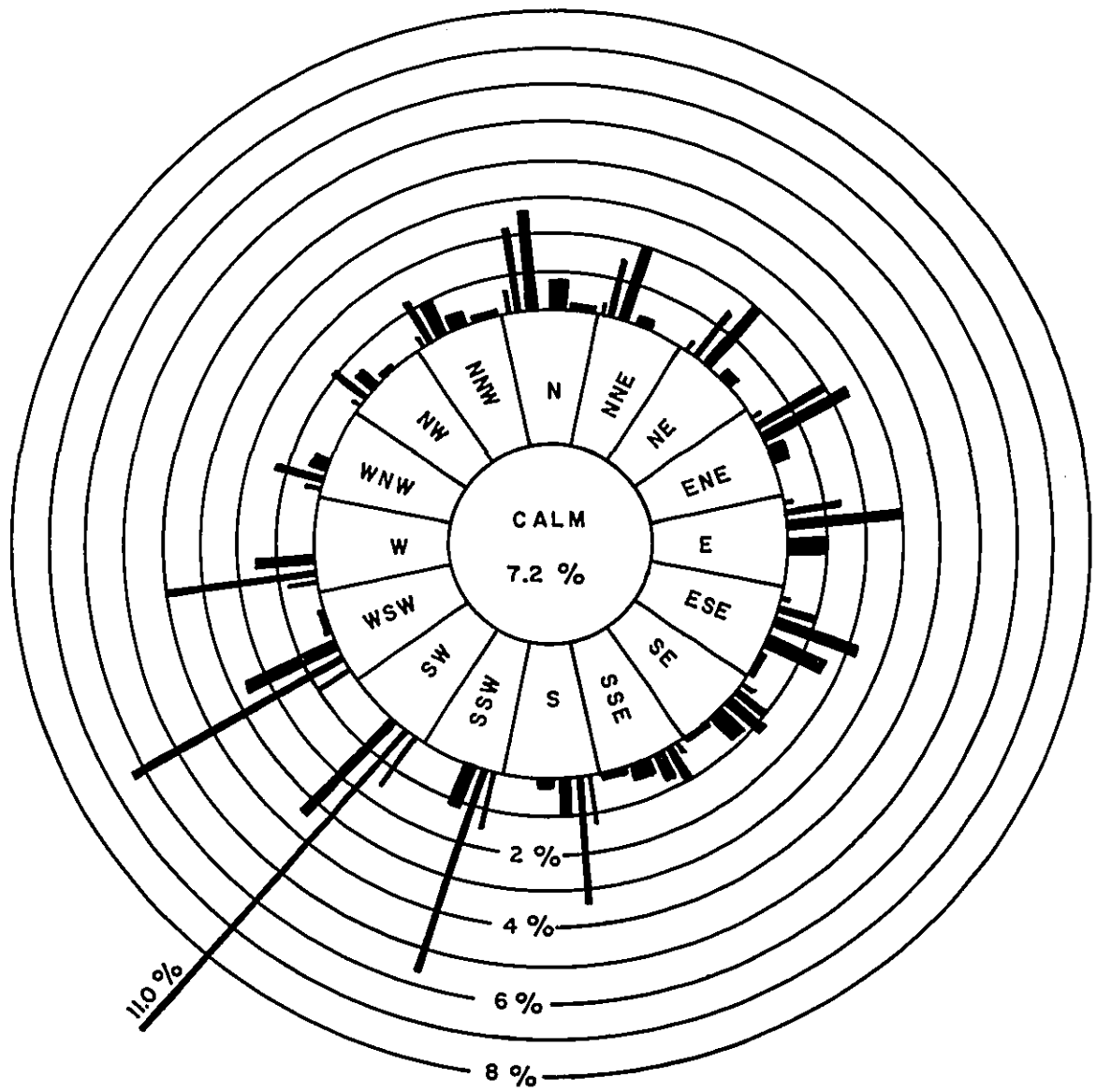
U.S. ARMY ENGINEER DISTRICT
HONOLULU, HAWAII

PLATE D-2

ES:
EPTH CONTOURS ARE IN FEET, MLLW.
EPTH CONTOURS BASED ON NAUTICAL CHART 19324,
ILO BAY, 16th Ed. MAY 7, 1977


PROJECT DEPTH
- 35 FEET
KUHIO BAY
Kaulainaiwi
Cocoanut I
MAKAOKU
WAIAKEA
Reeds Bay
Wailpa River
KAMEHAMEHA AVE
BAYFRONT HIGHWAY
FIXED BRIDGE
VERT CL 8½ FT REP
FOOTBRIDGE
VERT CL 5 FT REP
EXISTING
NOTES:
1. DEPTH CONTOURS ARE IN FEET, MLLW.
2. DEPTH CONTOURS BASED ON NAUTICAL CHART 19324
HILO BAY, 18th Ed. MAY 7, 1977

GENERAL LYMAN FIELD
HILO, HAWAII



NOTE: THE PERCENTAGES AND THE DIRECTIONS ARE AVERAGES DURING THE 10 YEAR PERIOD, 1965 TO 1974 INCLUSIVE.

LEGEND:

- 0-3 KNOTS
- 4-6 KNOTS
- 7-10 KNOTS
- 11-16 KNOTS
- OVER 16 KNOTS
- —8%— TOTAL % OF YEAR

SOURCE – HONOLULU DLNR, DOWALD

HILO, HAWAII — HAWAII

WIND DIAGRAM

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE D-3

TABLE D-1. STATE FACILITIES, PORT OF HILO

Facility	Wharf or Berthing Description	Transit Shed	Paved Open Storage	Bulk Transfer Facilities
Pier 1	1275-foot concrete deck on concrete piles. Pier apron west of shed is 42' feet wide. Berthing depth is 35 feet.	150,800 square feet of steel frame shed with corrugated metal siding and roofing.	5.0 Acres	Sugar Molasses Fuel Oil Diesel Oil Bitumuls Water
Pier 2 & 2-1/2	Concrete deck on concrete piles. Usable berthing length is approximately 500 feet at Pier 2 and 170 feet at Pier 2-1/2. Berthing depth is 35 feet. Pier apron is 33 feet wide at Pier 2.	37,900 square feet of steel frame shed with corrugated metal siding. 9200-square-foot addition has corrugated metal roofing; remainder has built-up roofing.	3.2 Acres	Molasses Fuel Oil Water Cement
Pier 3	Concrete deck on concrete piles. Berthing length is 540 feet; berthing depth is 35 feet. Pier apron varies in width from 40 feet to over 100 feet.	None, but there is access to Pier 2 shed.	None, but there is access to Pier 2 & 2-1/2 open area.	Petroleum Products Molasses Water Aqua Ammonia
Radio Bay	450-foot concrete-capped sheet pile bulkhead. Fingers support boathouse for pilot boat and provide moorage for Coast Guard vessel.	None.	Minimum, but there is limited access to Pier 1 open.	None

the lowest average monthly temperature is 71°F for January to March. Owing to the moderating influence of the bay and the ocean, extreme temperatures are of short duration and range from a record low of 53°F to a high of 94°F. Within the city of Hilo itself, average rainfall varies from about 130 inches a year near the shore to as much as 200 inches in mountain sections. The wettest part of the island, with a mean annual rainfall exceeding 300 inches, lies about 6 miles upslope from the city limits. Rain falls on about 280 days a year in the Hilo area. Temperature and precipitation data compiled by the Department of the Naval Oceanography Command Detachment, Barbers Point, Hawaii for the period 1946 to 1979 are shown on Table D-2. The wind velocity and direction table shows that winds approach Hilo Bay primarily from the southwest (SW) and west southwest (WSW) directions, rather than the typical northeasterly trade direction for the islands. Winds are predominantly from the SW and WSW during the night and early morning hours, with winds generally shifting to the typical trade direction by late morning. A wind diagram for the years 1965-1974 from the gage located at General Lyman Field is shown on Plate D-3.

b. TROPICAL STORMS AND HURRICANES. Although extremely rare in the Hawaiian Islands, tropical storms and hurricanes have and do, from time to time, affected the islands. Tropical storms are defined as having sustained wind speeds between 34 and 63 knots, while hurricanes are defined as storms with sustained wind speeds equal to or greater than 64 knots. Based on information from the U.S. Department of Commerce, Natural Oceanic and Atmospheric Administration (NOAA) National Weather Service, from 1950 to 1978 at least fourteen tropical storms or hurricanes have intruded within 500 miles of the state. So far, most of the threatening storms have weakened before reaching the islands and their effects have been minimal in most cases. Hurricanes effects in the Hawaiian waters generally occur during the summer months.

4. WATER LEVEL AND CURRENTS

a. TIDES. The tidal data shown below were obtained from the U.S. Coast and Geodetic Survey and are referenced to Mean Lower Low Water (MLLW). All elevations in this appendix is referenced to MLLW datum.

TABLE D-2. HILO, HAWAII CLIMATOLOGY

	TEMPERATURE DEGS F							PRECIPITATION IN INCHES						
MON	AVG MAX	AVG MIN	AVG	EX MX	YEAR	EX MN	YEAR	AVG	MAX	YEAR	MIN	YEAR	24 HR MAX	YEAR
JAN	79	63	71	90	1977	54	1969	09.07	29.11	1949	00.36	1953	09.94	1949
FEB	79	63	71	92	1968	53	1962	12.90	43.66	1969	01.70	1963	15.70	1969
MAR	78	63	71	93	1972	54	1971	13.69	31.91	1948	00.88	1972	09.18	1953
APR	80	65	72	89	1978	56	1949	12.88	31.94	1963	02.93	1962	11.07	1971
MAY	81	65	74	94	1966	58	1947	10.07	25.01	1964	01.18	1945	10.26	1965
JUN	83	67	75	90	1969	60	1946	06.61	15.50	1943	02.46	1977	04.21	1978
JUL	83	68	75	89	1977	62	1970	09.54	14.89	1958	03.83	1975	05.42	1951
AUG	84	68	76	93	1950	63	1955	10.88	26.42	1957	02.66	1971	09.65	1970
SEP	84	68	76	92	1970	61	1970	07.44	13.63	1947	01.59	1974	06.02	1960
OCT	83	67	75	91	1976	62	1970	10.96	26.10	1951	02.40	1962	08.88	1951
NOV	81	66	74	88	1978	58	1948	13.77	27.03	1959	03.74	1943	15.59	1959
DEC	79	64	72	91	1977	55	1977	15.76	50.82	1954	00.77	1963	10.50	1946
					MAY		FEB			DEC		JAN		FEB
ANN	81	65	73	94	1966	53	1962	133.57	50.82	1954	00.36	1953	15.70	1969

	Feet
Highest Tide Observed	3.8
Mean Higher High Water	2.4
Mean High Water	1.9
Mean Tide Level	1.1
Mean Low Water	0.3
Mean Lower Low Water	0.0
Lowest Tide Observed	-1.6

b. ASTRONOMICAL TIDE.

The astronomical tide is estimated to be about equivalent to the mean higher high water or 2.6 feet.

c. ATMOSPHERIC PRESSURE DROP.

The water level rise due to atmospheric pressure is calculated by,

$$S_{\Delta p} = 1.14\ (P_n - P_o)\ (1 - e^{-R/r}) \qquad \text{EQ. 3-85, SPM}^{3/}$$

Assuming parameters of hurricane Fico, 1978

P_n = 29.92 inches
P_o = 28.20 inches
R = 25 nautical miles
r = 100 nautical miles

$S_{\Delta p}$ = 0.4 feet

d. STORM SURGE.

The water level rise due to storm surge is calculated by:

Storm surge = ΔS_i, where ΔS_i is the incremental rise in water level due to wind stress perpendicular to the bottom contour

$$S_i = \frac{540K\ U_R^2\ \Delta X}{\bar{d}} \qquad \text{(TR-4, 1-64) } 4/$$

3/ U.S. Army Coastal Research Center, Shore Protection Manual, 3rd Edition, 1977.

4/ U.S. Army Coastal Research Center, Technical Report No. 4, 3rd Edition, 1966.

X = total distance in N.M.

$K = 3.0 \times 10^{-6}$

U_R = 62 knots

ΔX = incremental distance in N.M.

$\bar{d}$ = mean depth over increment (FT)

d_i = initial depth

Storm surge in the study area is estimated to be in the neighborhood of 0.5 feet for the July 1978 hurricane Fico.

e. DESIGN STILLWATER LEVEL. The design stillwater level (SWL) during hurricane conditions consists of (1) astronomical tide, (2) the rise due to atmospheric pressure drop, and (3) the rise due to storm surge.

(1)	Astronomical Tide	+2.6 ft.
(2)	Atmospheric Pressure Drop	+0.4 ft.
(3)	Storm Surge	+0.5 ft.
	SWL =	+3.5 ft.

f. CURRENTS. The "Geological, Biological and Water Quality Investigations of Hilo Bay," prepared by M and E Pacific, Inc., Environmental Engineers for the Honolulu District Corps of Engineers in September 1980, provides a general understanding of the circulation pattern in Hilo Harbor. The following findings are presented:

(1) The freshwater discharge into Hilo Harbor have a profound influence in the circulation pattern by the creation of a vertical stratification of the water column.

(2) Wind stresses have significant influences on the surface layer.

(3) A net seaward flow occurs in the surface layer of the water column, while the bottom layer responds primarily to the tide.

(4) Subsurface flows at the harbor mouth are primarily influenced by tide. During periods of flood tide, subsurface flow is generally inshore (southerly) across the entire mouth of the harbor.

During periods of ebb tide, the subsurface flow is generally outward (northerly) across the entire mouth of the harbor.

Surface flows in the harbor are influenced primarily by the wind stresses and by the general outward gradient of the surface layer.

(5) Surface flows at the entrance to Kuhio Bay (turning basin) are influenced by wind stresses. The surface flow is generally in the direction of the wind and a counterflow easts at the 5-foot depth.

During flood tide, current speeds averaged 0.08 knots. During ebb tide, current speeds averaged 0.07 knots.

(6) Inner harbor (pier-Baker's Beach). The current speed in the subsurface layer averaged 0.05 knots during ebb and 0.02 knots during flood tide.

5. WAVE CONDITIONS.

a. WAVE CLIMATE.

Waves arriving at Hilo Bay are generated in the northeastern sector of the Pacific Ocean, ranging from the Aleutian Islands in the north to South America. Three primary wave types affect the study area. These three types are (a) the east-northeast trade waves, (b) the northern swell, and (c) the tsunami.

LOCAL WIND WAVES. East-northeast trade waves may be present throughout most of the year, but are most frequent between May and September, the summer season, when they usually dominate the local wave spectrum. They result from the strong trade winds blowing out of the northeast quadrant over long fetches of open ocean. Typically, these deepwater waves have periods ranging from 6 to 10 seconds and heights of 4 to 12 feet. Generally, east-northeast trade waves are present from 80 to 90 percent of the time during the summer season, and from 60 to 70 percent of the time during the remainder of the year.

NORTHERN SWELL. Northern swell is generated in the north Pacific Ocean by winter storms. Waves may typically have periods of 10 to 15 seconds, and heights of 5 to 15 feet. Some of the largest waves reaching the Hawaiian Islands are of this type. Northern swell usually occurs during the winter season of October through April.

TSUNAMI. Tsunami are impulse-generated water waves caused by catastrophic geological occurrences within an ocean basin. The orientation of the triangular-shaped bay at Hilo makes this port city very susceptible to tsunami attacks from the eastern half-circle of the seismic belt extending from the Aleutian Islands down to the west coast of South America. In several tsunami occurrences (Table D-3) at Hilo, the waves were transformed into bores which devastated large areas of the city and harbor.

TABLE D-3. LIST OF SIGNIFICANT TSUNAMIS SINCE 1946 5/

Date	Origin of Tsunami	Distance and Direction from Hawaii	Time of Arrival and Travel Time	Largest Wave Reported (Feet)
1 Apr 46	Aleutian	2000 nautical miles due north	Hilo 0645 4 hrs 55 min	30
4 Nov 52	Kamchatka	2600 nautical miles northeast	Hilo 1335 6 hrs 37 min	12
9 Mar 57	Aleutian	2000 nautical miles northwest	Hilo 0911 4 hrs 49 min	14
22 May 60	Chile	6600 nautical miles southeast	Hilo 1024 14 hrs 47 min	35
28 Mar 64	Alaska	2350 nautical miles north-northeast	Hilo 2300 5 hrs 24 min	10
29 Nov 75	Local	--	Hilo 0512 24 min	8.5

The most recent tsunami, which occurred on 29 November 1975, was unique because it was generated locally by a large scale land subsidence which occurred during an earthquake centered off the southeast coast of the island of Hawaii. This earthquake measured 7.2 on the Richter scale. The tsunami caused runups of about 10 feet along much of the Hilo District. In Hilo, the water level dropped with the recession of the first tsunami. The USS Cape Small, a Coast Guard cutter moored in Radio Bay, settled to the muddy bottom and began to list to one side. A series of waves surged in and out of the bay at approximately 15-minute intervals, smashing some small boats and washing others into docks; four boats were sunk and three damaged.6/

5/ Loomis, H. G. 1976 Tsunami Wave Runup Heights in Hawaii, HIG-76-5, Hawaii Institute of Geophysics, University of Hawaii, Honolulu.

6/ Cox, D.C. and J. Morgan, 1977 Local Tsunamis and Possible Local Tsunami in Hawaii, HIG-77-14, Hawaii Institute of Geophysics, University of Hawaii, Honolulu.

b. REFRACTION ANALYSIS.

Analyzed previous wave refraction studies for deepwater waves approaching from the North, N.22.5°E., and N.45°E. directions. These directions were selected after evaluating the wave exposure regime for the study area. Deepwater storm waves were analytically transformed considering refraction and shoaling to shallow water wave heights at the entrance to Hilo Bay. Refraction analyses for the various wave approach directions studied indicated that the critical direction for storm waves at Hilo Harbor is north northeast. The computed wave heights for a storm approaching from N.22.5°E were higher than any other direction. Based on a deepwater wave height of 27 feet[7/] and a wave period of 17 seconds, the maximum theoretical storm wave height incident to the entrance of Hilo Bay was computed according to SPM equation 2-77:

$$\frac{H}{H_0} = K_R K_S$$

$$H = H_0 K_R K_S$$

where H = wave height in any depth
H_0 = wave height in deep water = 27 feet
K_R = refraction coefficient = 0.81
K_S = shoaling coefficient = 1.30

H = 28.4 feet

c. BREAKING WAVE CONDITION.

Assuming a wave period of 17 seconds to be characteristic of the largest storm wave, seaward bottom to have a slope m = 0.00 and H_b = 28.4 feet.

7/ U.S. Army Engineer District, Honolulu, Corps of Engineers, Technical Report No. 1, 1977.

Breaker depth (d_b) from SPM figure 7-2 is:

$$\frac{H_b}{gT^2} = \frac{28.4}{32.2(17)^2} = 0.0031$$

$d_b(max) = \alpha H_b = 1.5\ (28.4) = 43$ feet

$d_b(min) = \beta H_b = 1.28\ (28.4) = 36$ feet

Breaker travel distance (x_p) from SPM EQ 7-3

$x_p = \gamma_p H_b = [4.0-9.25m]H_b = 114$ feet

Based on the foregoing calculations, the design storm wave of 28.4 feet will be fully broken seaward of the 30-foot contour. Thus, the design wave for the harbor structures in the bay must be based on the largest wave generated by either wave forecasting for shallow water or diffraction-refraction analysis performed in accordance with procedures, techniques and diagrams described in the SPM.

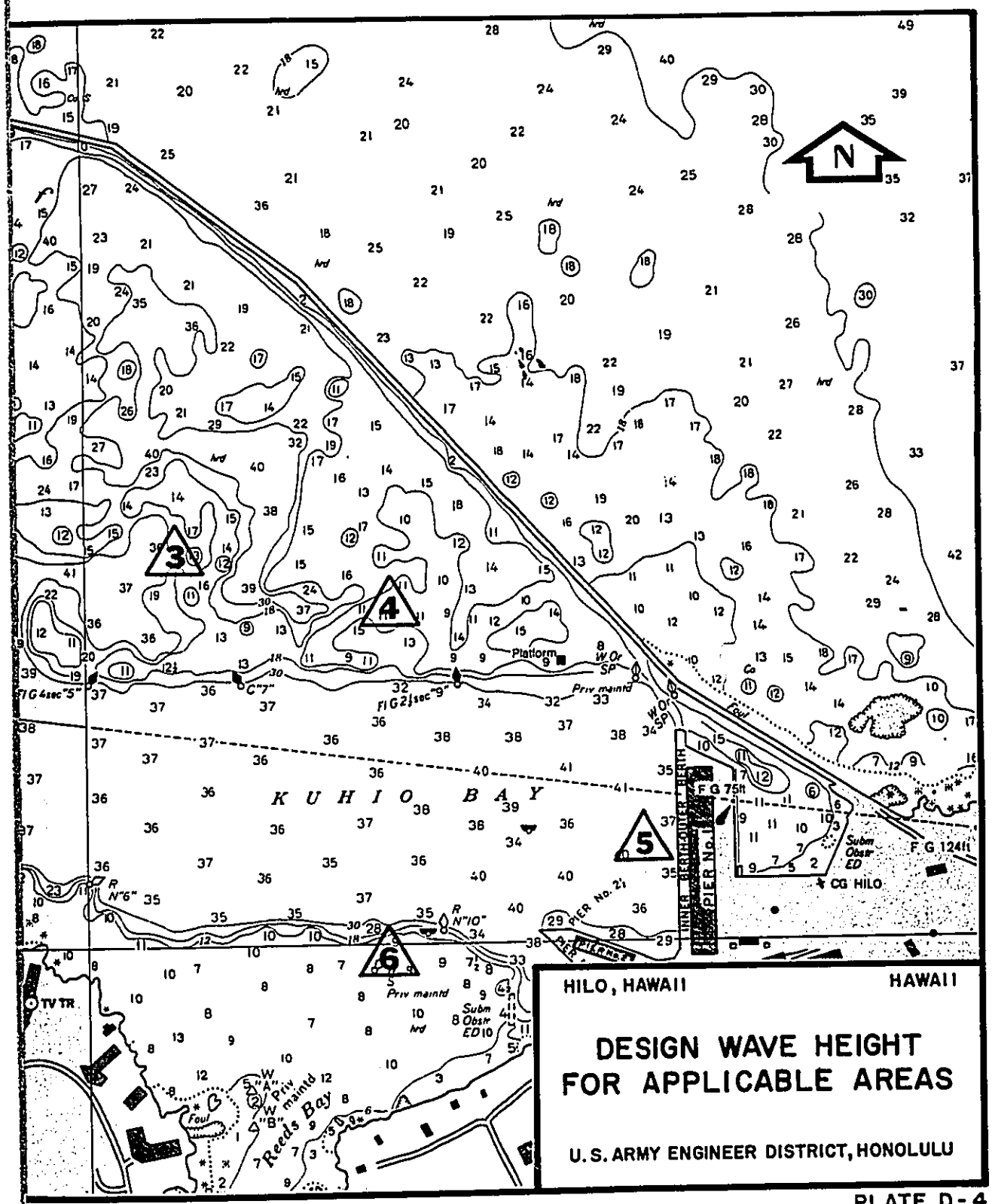
6. WAVE CONDITIONS IN HILO BAY

a. FORECASTING FOR SHALLOW WATER WAVES. The wave heights and periods for various wind directions, fetch lengths and average constant depths are tabulated from SPM Figures 3-25, 3-26, 3-27, 3-28, and 3-29.

Location of Improvements (Plate D-4)	Wind Direction	Fetch (Feet)	Average[8/] Constant Depth (Feet)	U (MPH)	H_f (Feet)	T_f Second
1	East	4300	20	75	3.2	4
	Southeast	6700	20	75	3.8	4
	South	5200	20	75	3.5	4
	Southwest	5400	20	75	3.5	4
	West	5400	20	75	3.5	4
2	East	5000	20	75	3.5	4
	Southeast	4600	20	75	3.3	4
	South	2500	35	75	3.0	4
	Southwest	6300	30	75	4.0	4
	West	6700	30	75	4.1	4
3	East	1700	15	75	2.3	3
	Southeast	2900	20	75	2.8	3
	South	2100	20	75	2.5	3
	Southwest	7500	30	75	4.2	4
	West	8800	35	75	4.5	4
4	East	800	15	75	1.8	2
	Southeast	1700	20	75	2.5	3
	South	1700	20	75	2.5	3
	Southwest	3300	20	75	3.0	3
	West	8300	30	75	4.0	4
5	West	4200	35	75	3.5	4
	Northwest	10000	35	75	4.8	4
6	North	3300	20	75	3.0	3
	Northeast	2100	25	75	2.5	3
	Northwest	5000	35	75	3.8	4

b. DIFFRACTION-REFRACTION ANALYSIS. The previous theoretical wave diffraction-refraction studies were also analyzed, the incident wave perpendicular to the tip of the existing Hilo breakwater is assumed to be the maximum nonbreaking wave of 16.8 feet based on controlling depth of 21.5 (18 feet plus SWL) feet, m = 0.00. The results of the diffraction-refraction analysis are tabulated in the following Table D-4.

8/ Includes design SWL (3.5 feet).



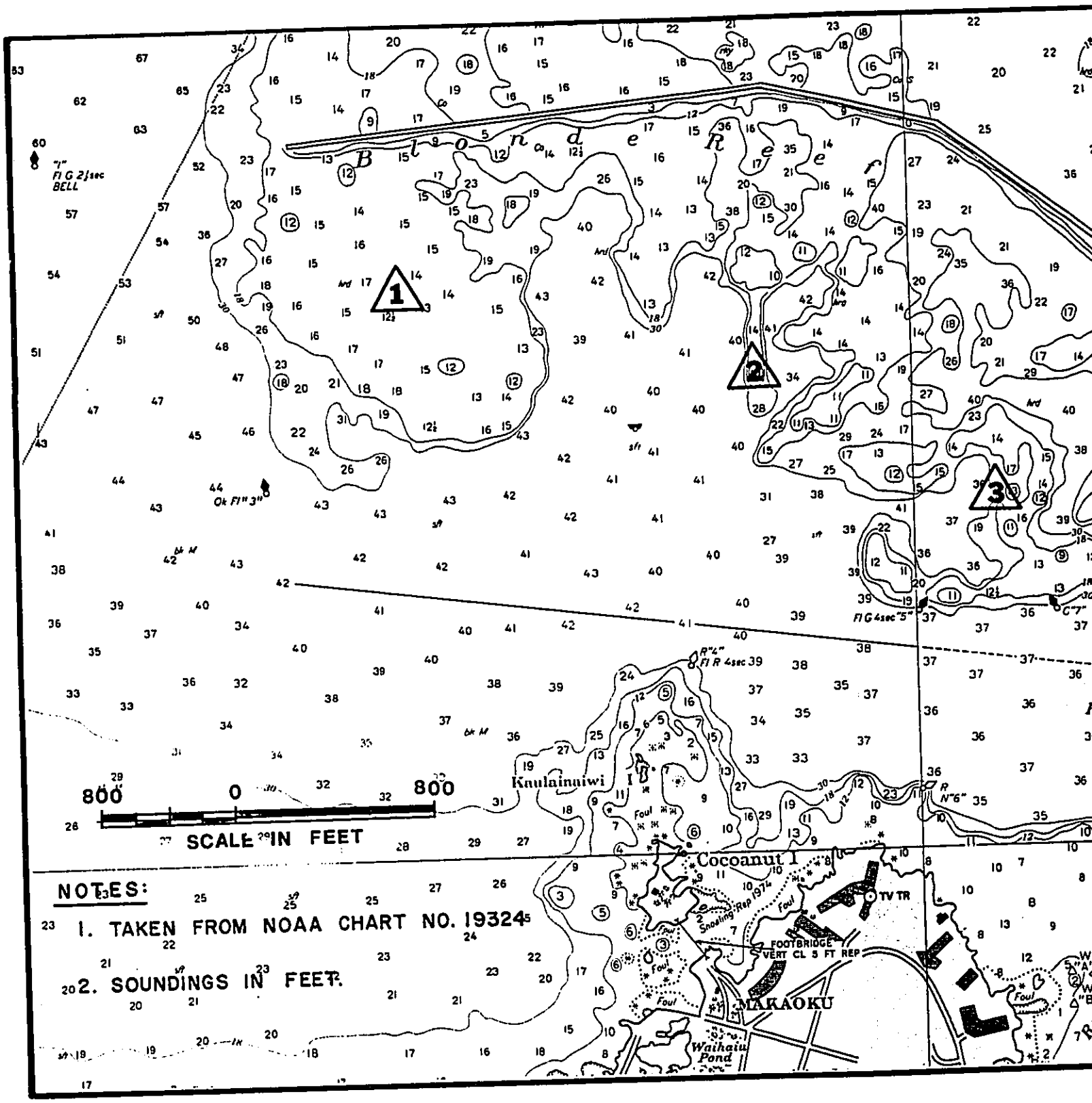
HILO, HAWAII

HAWAII

DESIGN WAVE HEIGHT FOR APPLICABLE AREAS

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE D-4



NOTES:

1. TAKEN FROM NOAA CHART NO. 19324
2. SOUNDINGS IN FEET.

TABLE D-4. DIFFRACTION - REFRACTION ANALYSIS

Approaching Deepwater Wave Direction	Wave Period (sec)	Azimuth of Approaching Wave 9/ (degrees)	Incident Wave 10/ Height, H_i (feet)	1		2				3				4				5				6			
				K'	H 11/ (feet)	K'	K_R	K_S	H 12/ (feet)	K'	K_R	K_S	H 12/ (feet)	K'	K_R	K_S	H 12/ (feet)	K'	K_R	K_S	H 12/ (feet)	K'	K_R	K_S	H 12/ (feet)
North	17	139	16.8	0.5	8.4	0.25	0.50	1.21	2.5	0.30	0.55	1.14	3.2	0.30	0.55	1.36	3.8	0.35	0.31	1.16	2.1	0.40	0.31	1.47	3.1
N 22.5°E	17	141	16.8	0.5	8.4	0.25	0.49	1.21	2.5	0.30	0.58	1.14	3.3	0.30	0.58	1.36	4.0	0.35	0.29	1.16	2.0	0.40	0.41	1.47	4.1
N 45°E	17	134	16.8	0.5	8.4	0.25	0.41	1.21	2.1	0.35	0.37	1.14	2.5	0.35	0.37	1.36	3.0	0.35	0.30	1.16	2.0	0.40	0.41	1.47	4.1
North	14	141	16.8	0.6	10.1	0.15	0.53	1.05	1.4	0.18	0.43	1.06	1.4	0.18	0.43	1.24	1.6	0.18	0.21	1.07	0.7	0.25	0.38	1.34	2.1
N 22.5°E	14	152	16.8	0.6	10.1	0.17	0.76	1.05	2.3	0.20	0.45	1.06	1.6	0.20	0.45	1.24	1.9	0.25	0.39	1.07	1.8	0.25	0.39	1.34	2.2
N 45°E	14	139	16.8	0.6	10.1	0.25	0.43	1.05	1.9	0.30	0.51	1.06	2.7	0.30	0.51	1.24	3.2	0.40	0.20	1.07	1.3	0.45	0.38	1.34	3.8
North	10	147	16.8	0.3	5.0	0.20	0.54	0.95	1.7	0.30	0.37	0.97	1.8	1.30	0.37	1.094	2.0	0.35	0.13	0.96	0.7	0.35	0.23	1.15	1.6
N 22.5°E	10	139	16.8	0.3	5.0	0.20	0.41	0.95	1.3	0.20	0.45	0.97	1.5	0.20	0.45	1.09	1.6	0.25	0.32	0.96	1.3	0.35	0.32	1.15	1.5
N 45°E	10	151	16.8	0.3	5.0	0.12	0.58	0.95	1.0	0.12	0.46	0.97	0.9	0.12	0.46	1.09	1.0	0.13	0.35	0.96	0.7	0.14	0.35	1.15	0.9

9/ Azimuth is measured with south as zero.

10/ Assumed to be a broken and reformed wave of 16.8 feet, based on a controlling depth of 21.5 feet and a slope m = 0.00.

11/ $H = H_i K'$.

12/ $H = H_i K' K_R K_S$.

7. SELECTED DESIGN CONDITIONS

a. WATER LEVELS (MLLW).

(1) Astronomical tide
Use +2.6 feet

(2) Storm surge
Use +0.5 feet

(3) Atmospheric pressure drop
Use +0.4 feet

(4) The design stillwater level (d_{swl}) during design conditions is:

$$d_{swl} = 2.6 \text{ feet} + 0.5 \text{ feet} + 0.4 \text{ feet} = 3.5 \text{ feet}$$

b. DESIGN WAVE HEIGHTS. Design wave heights are based on the largest wave generated by either wave forecasting for shallow water or diffraction-refraction analysis. Table D-5 shows the design wave heights and wave periods obtained at areas of improvements in Hilo Bay.

TABLE D-5. DESIGN WAVE HEIGHTS

Area of Improvement (see Plate D-4)	Wave Height, H (feet)	Wave Period (seconds)	Depth of Structure, ds (feet)	
1	10.1	14	18.5	nonbreaking wave
2	4.1	4	18.5	" "
3	4.5	4	18.5	" "
4	4.0	17	15.5	" "
5	4.8	4	38.5	" "
6	4.1	14	11.5	" "

8. PLAN COMPONENTS

a. HARBOR DEEPENING

(1) Entrance Channel.

Minimum Width. Required channel width is based on one-way passage of the design vessel. Total channel width is the sum of (1) bank clearance lane and (2) the maneuvering lane widths all based on the design vessel. Width factors are calculated assuming poor vessel handling qualities, presence of strong and gusty winds, and rough sea conditions. Lane widths and total channel width are:

Lane	Factor x Beam (feet)	Width (feet)
Bank clearance	1.5 x 92	138
Vessel maneuvering lane	1.8 x 92	166
Bank clearance	1.5 x 92	138
TOTAL	4.8 x 92	442
		USE: 440 FEET

NOTE: The navigable width is wider than required for one-way traffic. The establishment of a minimum channel width was considered for maintenance dredging.

Minimum Depth. Required depth for safe navigation of the design vessel is computed as the sum of the following items at the calculated and estimated values shown:

	Depth (feet)
Vessel draft	35.0
Squat and trim	1.0
Scend	2.0
Bottom clearance	2.0
Design Depth	40.0

(2) Harbor Basin Design.

Minimum Basin Length and Width. A turning basin is provided so that the design vessel can turn around under tug assistance. Based on observation of vessel movement, it has been the practice to provide a basin at the head of, or adjacent to and utilizing, the harbor channel so that the turning diameter is 1.5 to 2.0 times the vessel's length. The variance in diameter will depend on weather conditions and congestion in the area of the turning maneuver. The minimum basin length and width of 1,400 feet to allow for maneuverability of the design vessel were computed as follows:

minimum length and width = 2 x length of design vessel
= 2 x 700'
= 1400'

		Depth (Feet)
minimum depth:	vessel draft	35.0
	squat and trim	1.0
	scend	2.0
	bottom clearance	2.0
	Design depth	40.0

b. BREAKWATERS

(1) Rubble-Mound Breakwaters.

Procedures and formulas contained in the SPM were used to determine the various structure design. The following factors and coefficients are selected based on information available on materials and on the evaluations presented earlier.

The following factors were used in armor layer computations:

	Area of Improvement (See Plate D-4)				
	1	2	3	4	6
Unit weight of armor: W_r (lb/ft^3)			160-162		
Specific gravity of armor stone: S_r			2.6		
Stability coefficient: Head section: K_D	3.2	2.9	2.9	3.2	3.2
Trunk section: K_D	4.0	3.5	3.5	4.0	4.0
Side slope: Cot θ 14/			1.5		
Layer coefficient: K_Δ			1.15		
Design wave height: H (feet)	10.1 15/	4.1 16/	4.5 16/	4.0 15/	4.1 15/

Armor stone size: $W = \frac{W_r H^3}{K_D (S_r - 1)^3 \cot \theta}$ EQ. 7-11, SPM

Thickness of armor layers and underlayers:

$$r = nK_\Delta \left(\frac{W}{W_r}\right)^{\frac{1}{3}}$$ EQ. 7-113, SPM

Maximum Runup and Crest Elevation. The runup and resulting crest elevation were based on criteria contained in the SPM and from existing information. 17/, 18/ Assume the maximum runup occurs when the incident waves approach parallel to the structure. The runup diminishes where the incident waves begin to approach at an angle of 90° (angle between the crest and structure). Typical rubble-mound cross section is shown on Plate D-5.

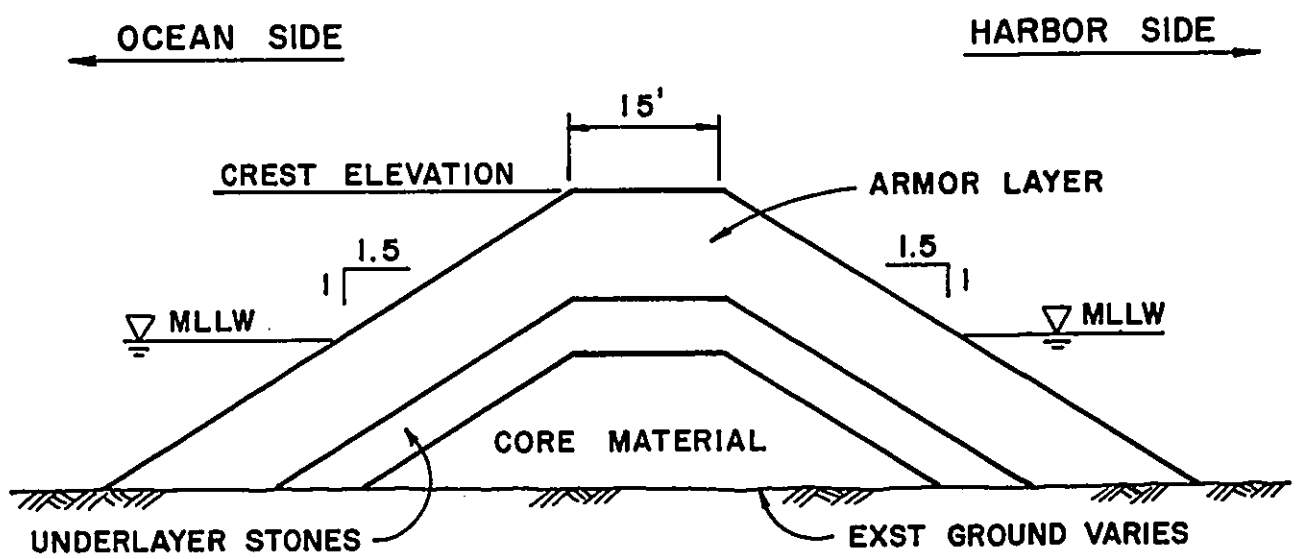
14/ Slope perpendicular to wave front
15/ nonbreaking wave
16/ breaking wave
17/ CETA Report No. 79-1, Wave Runup on Rough Slopes, July 1979.
18/ TP Report No. 78-2, Reanalysis of Wave Runup on Structures and Beaches, March 1978.

The crest elevation, weight and thickness of the stone layers for the breakwaters are shown on Table D-6. Typical breakwater sections is shown on Plate D-5. Rubble-mound breakwater plan is shown on Plate D-11.

TABLE D-6. CREST ELEVATION, STONE WEIGHT AND LAYER THICKNESS FOR RUBBLE-MOUND BREAKWATERS

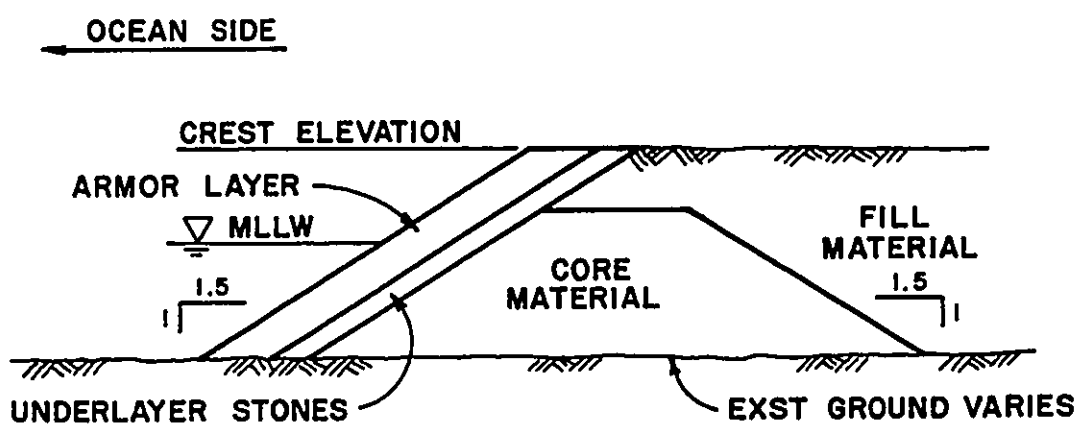
Location	Crest Elevation (feet)	Armor Layer Design Stone Weight	Armor Layer Layer Thickness (feet)	Underlayer Design Stone Weight (pounds)	Underlayer Layer Thickness (feet)	Core Material Design Stone Weight (pounds)
4	+10.0	500 to 1000 lb	3.8	50 to 200	2.0	spalls to 50
6	+10.0	500 to 1000 lb	3.8	50 to 200	2.0	spalls to 50

(2) Floating Breakwater. A floating breakwater is a structure designed to protect an area exposed to short-period, wind-generated waves. These structures are being used in sheltered areas such as inland waterways, lakes and ponds. They are being used for shore erosion control, as combination breakwater and docks for marinas, temporary protection for dredging operation and other protected bodies of water. Floating breakwaters are low profile structures designed to prevent wave energy transmission by reflection and dissipation through interaction with the breakwater structure. They may be constructed in a module arrangement of varying size, shape and components. Floating breakwaters were eliminated from further consideration because no floating breakwater has yet been developed that will economically and sufficiently attenuate ocean waves except for rare occasions (i.e., the formations of a portable harbor for military use), the use of floating breakwaters of any type is not very practical unless the wave environment consists of short period waves (less than seven seconds) and water depths that are deep relative to wave length. In the harbor the breakwater will only "ride" the wave rather than dampen it.



TYPICAL STONE BREAKWATER SECTION

NOT TO SCALE



TYPICAL STONE REVETMENT SECTION

NOT TO SCALE

c. SUBMERSIBLE MOORING BUOY

(1) Existing Condition.

The existing mooring buoy at Hilo Harbor consists of two 15,000 pound ship's anchors joined at a common ground ring via two 45' long 3" ground chains. A 60' long, 3" riser chain connects the ground ring to a riser buoy with tension bar. There is a 3-1/2" shackle at the buoy to which ship's lines are secured.

The mooring buoy system is used to secure the berthed ship away from the pier during heavy surge conditions to protect both ship and pier from damage.

At its present location, the buoy presents an obstruction which considerably limits the available maneuvering area in the harbor turning basin.

The proposed submersible buoy was developed as a possible means by which the obstruction posed by the buoy might be removed, while maintaining the present surge anchorage capability at Hilo Harbor.

(2) Description of Proposed Scheme.

The submersible buoy employs (Plates D-6 and D-7) the existing anchor and ground chains to provide anchorage against surge. Anchorage working capacity therefore remains unchanged. All components and fittings which make up the new system are sized to provide at least the capacity of the existing system.

The system consists of a shore compressor and controls, 1,000 LF of rigid pneumatic submarine pipeline, submersible tube-buoy, connecting linkage fittings, anchor sinker weight, and the existing anchor and ground chains.

The buoy is an 18" diameter steel tube fitted with a fabric-reinforced rubber air sac which, when inflated, snugly fits the inner space of the buoy tube. The air sac is connected to the compressor via the submarine pneumatic line and valve controls. The pneumatic line terminates with a perforated

section of plastic pipe within the air sac to distribute air pressure during inflating and to insure that localized bubbles do not form during flooding of the tube. The tube is perforated at intervals along its entire length, with a rubber valve fitted to each perforation. The valves will pass water in either direction when differential pressures occur. The valves will minimize entry of debris and/or marine life into the inner space of the tube. One end of the tube buoy is attached by a linkage arrangement to the sinker weight and anchor ground chains. The other end is fitted with a shackle to which the using ship's lines can be attached. The tube serves as a tension rod link between the ship's lines, as well as a boom which can be raised, by buoyancy means, to surface the tip to which the ship's lines are attached. The linkage connection between the buoy, sinker weight and ground chains is arranged to permit the buoy two degrees of angular freedom: 45° vertical and about 180° horizontal. The vertical freedom is required for the normal operation of the system. The horizontal freedom is necessary to free the buoy to move (point) in the direction of the thrust of the propellors of a ship operating in the vicinity of the buoy resting on the bottom.

The sinker weight is sized to prevent vertical displacement of the lower and of the buoy during normal use of the anchorage system. This reduces the length requirement of the flexible pneumatic lines at the connection between the buoy and the rigid submarine pneumatic line.

(3) Operation.

When anchorage is required during surge conditions, pressurized air will be introduced into the air sac in the tube-buoy, displacing and thereby expelling water. The tip of the buoy would then surface, enabling ship's lines to be secured to the buoy. The ship can then be held just clear of the wharf, preventing impact damage thereto.

When no longer needed, the ship's lines would be disconnected and the tube laid on the harbor bottom by releasing the air pressure, thereby flooding the tube and collapsing the air sac.

(4) Other Considerations.

To insure proper operation, a model test of the system should be accomplished, and design changes dictated by the results of the test made, prior to construction and installation of the prototype.

If employed, the proposed system operating procedures should include a hazard warning plan such as the use of hazard marker buoys in the vicinity of the rising buoy, in addition to alarm warning or audio devices during activation of the system.

Periodic visual inspection of the submerged portions of the system should be made as well as operational tests. These tests should preferably be made concurrently.

d. PRETENSION DEVICES AND IMPROVE EXISTING PIER 1 FENDER SYSTEM.

In theory, it is possible to moor a ship with little ship movement. Ship motions, as well as mooring downtime, can be reduced significantly if breast lines of the ships are pretensioned. The steady force created by the cable pretension can hold the hull in contact with the fender system. Because of this effect, ship motions can be damped out by the friction force on the contact surface and the bumping force against the fender can partially be cancelled by the steady slide force.

Monitoring of the mooring line tension and relative movement of the loading equipment is considered an acceptable alternative. With appropriate instrumentation, the force in each mooring cable could, together with the instantaneous motion of the loading equipment, be measured and displayed in a console located in a control room. Under the surveillance of a berth attendant, the instantaneous status of the mooring system can be adjusted. During the operations, the communication between the operators can be implemented by using portable radio equipment. Pretension devices should be used in conjunction with a good marine dock fender system. Preliminary plans to improve existing Pier 1 fender system are shown on Plates D-8, and D-9.

e. CIRCULATION IMPROVEMENT.

In order to improve circulation over Blonde Reef and in Hilo Bay a design analysis was made to evaluate the feasibility of reducing the effectiveness of the outer 2,000-feet of the existing breakwater. This required consideration of a new, shorter breakwater to protect the inner harbor (Plate D-13).

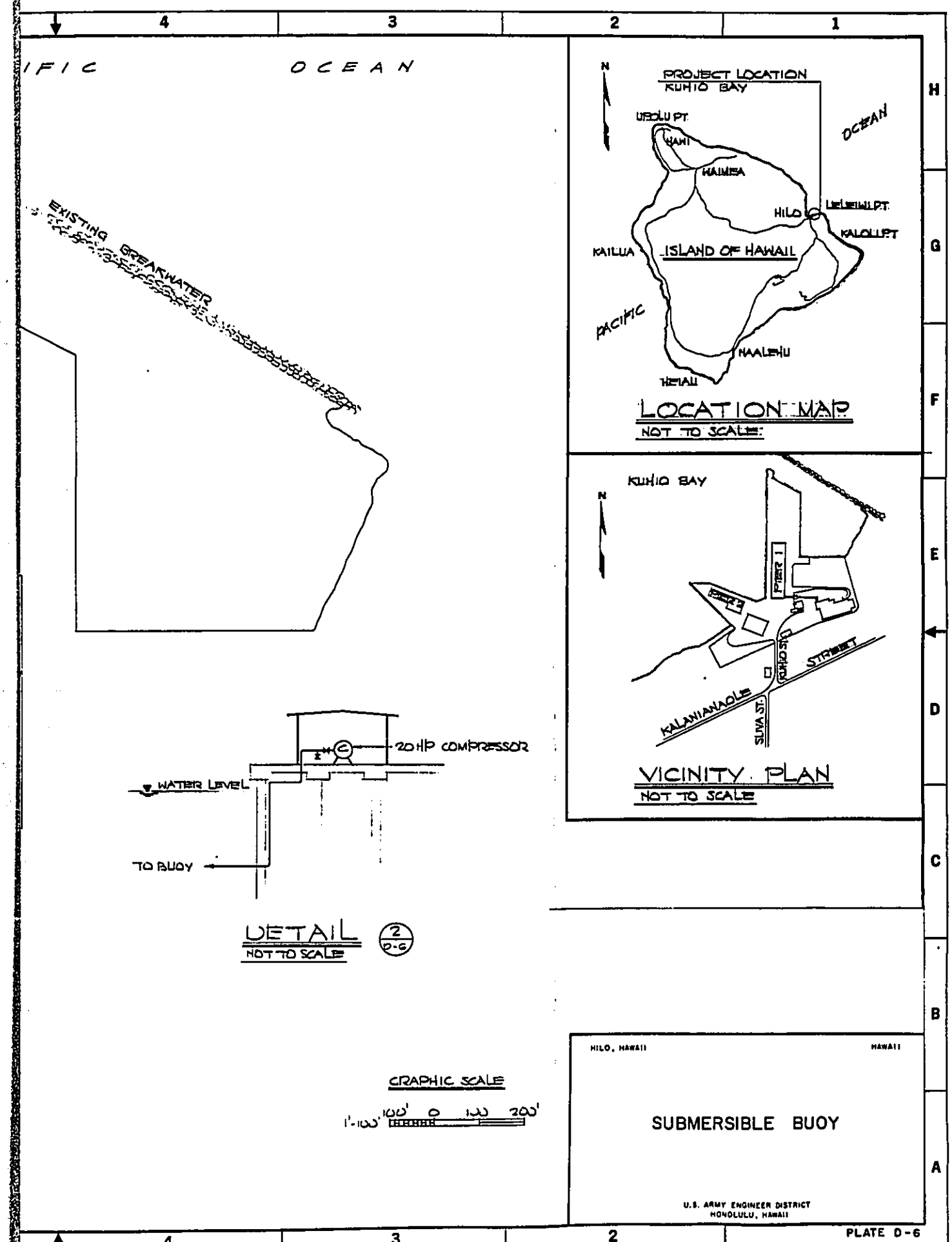
(1) DESIGN WAVE HEIGHT. Calculation of the design wave height was based on the controlling depth criteria. Based on this criteria and the fact that the reef flat fronting the structure has a 0.00 nearshore slope, the design wave height is equal to 0.78 times the depth of water. Using a SWL of 3.5 feet and depth at toe of structure of -14 feet, a controlling depth of 17.5 feet was obtained. The design wave was computed to be 13.7 feet.

(2) DIFFRACTION ANALYSIS. Wave diffraction analyses were analyzed to aid in determining the length of the breakwater and in estimation of wave height reduction in the vicinity of Hilo dock. A wave crest orientation of 90° was selected assuming the existing breakwater seaward of the circulation improvement plan is allowed to deteriorate naturally. Based on the diffraction analysis, the estimated wave height at Hilo docks will be about 10 percent of the incident wave height at the breakwater head.

(3) BREAKWATER. The crest elevation, weight and thickness of the dolosses and stone layers for the breakwater are shown on Table D-7. Typical breakwater sections is shown on Plate D-10.

TABLE D-7. CREST ELEVATION, LAYER WEIGHT WEIGHT AND LAYER THICKNESS FOR THE CIRCULATION IMPROVEMENT BREAKWATERS

		Armor Layer		Underlayer		Core Material
Location	Crest Elevation (Feet)	Design Dolosse Weight	Layer Thickness (Feet)	Design Stone Weight (Pounds)	Layer Thickness (Feet)	Design Stone Weight (Pounds)
3	+15.0	4 ton	7.6	600 to 1000	3.9	Spalls to 100



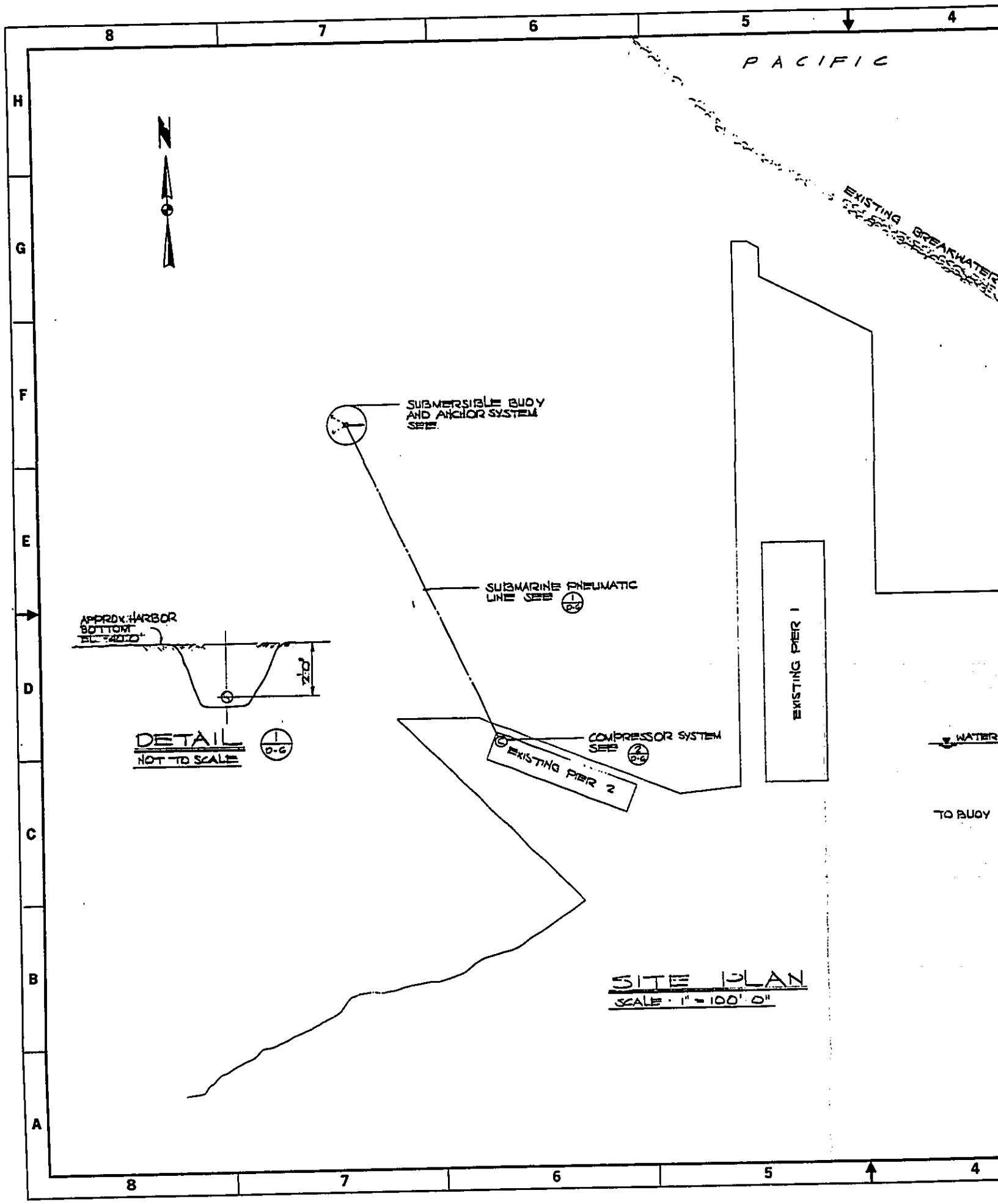
HILO, HAWAII

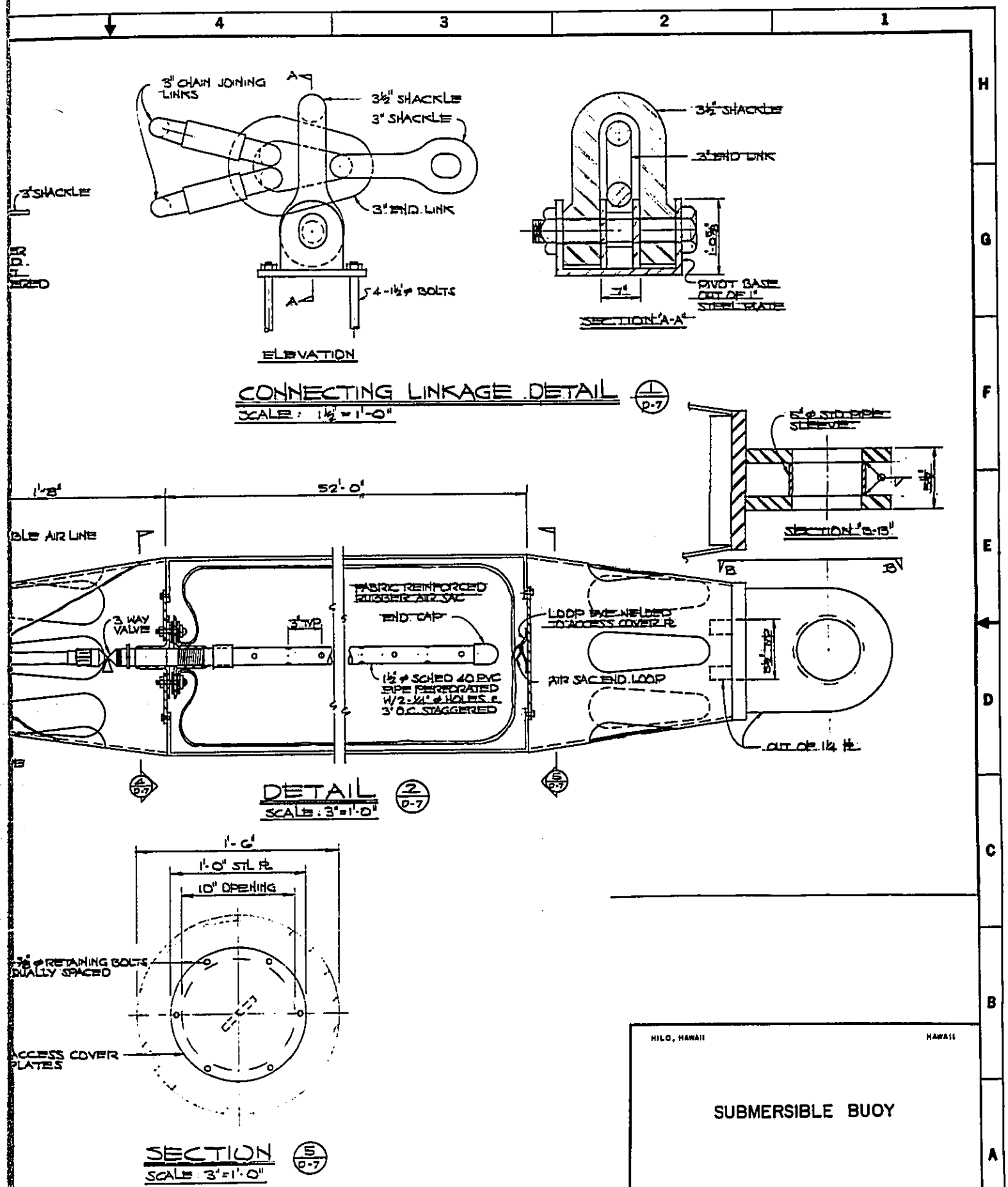
HAWAII

SUBMERSIBLE BUOY

U.S. ARMY ENGINEER DISTRICT
HONOLULU, HAWAII

PLATE D-6


8
7
6
5
4
H
G
F
E
D
C
B
A
PACIFIC
N
EXISTING BREAKWATER
SUBMERSIBLE BUOY AND ANCHOR SYSTEM SEE
SUBMARINE PNEUMATIC LINE SEE 1/D-6
APPROX. HARBOR BOTTOM EL. -40.0'
2'-0"
DETAIL 1/D-6
NOT TO SCALE
COMPRESSOR SYSTEM SEE 2/D-6
EXISTING PIER 2
EXISTING PIER 1
WATER
TO BUOY
SITE PLAN
SCALE · 1" = 100' 0"



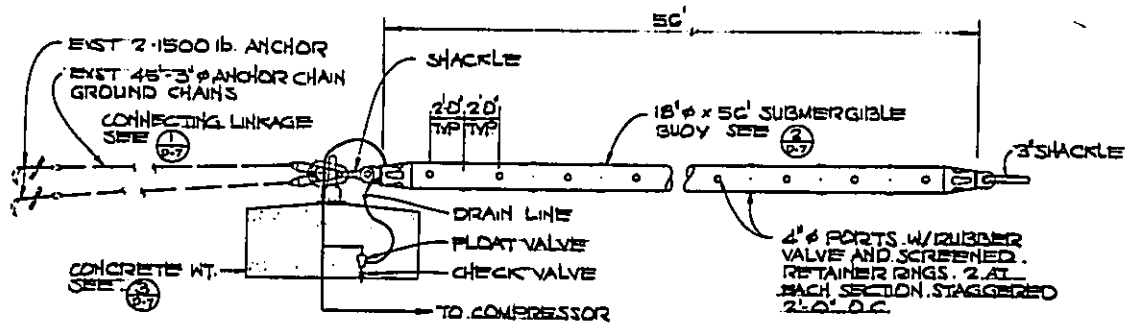
HILO, HAWAII

HAWAII

SUBMERSIBLE BUOY

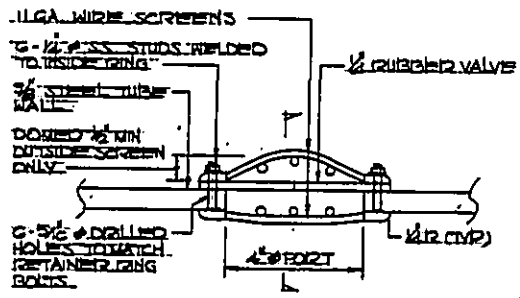
U.S. ARMY ENGINEER DISTRICT
HONOLULU, HAWAII

PLATE D-7

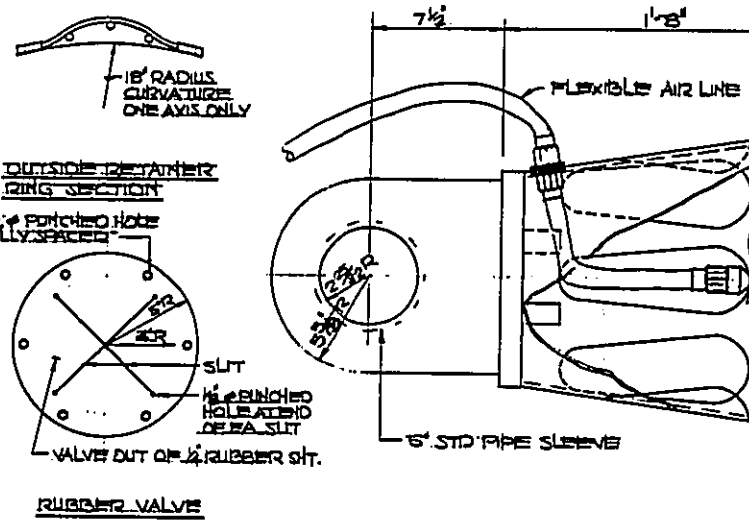


SUBMERSIBLE BUOY AND ANCHOR SYSTEM

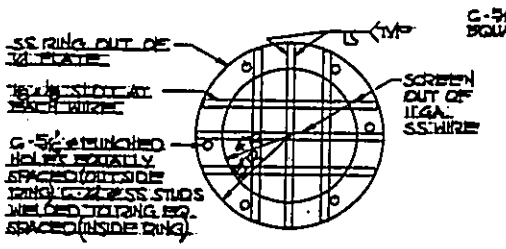
SCALE: 1/4" = 1'-0"



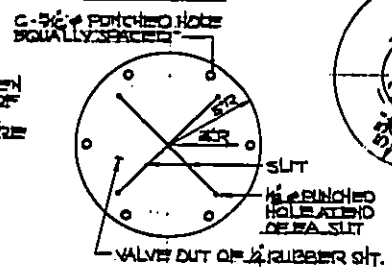
TYPICAL SECTION AT PORT



OUTSIDE RETAINER RING SECTION



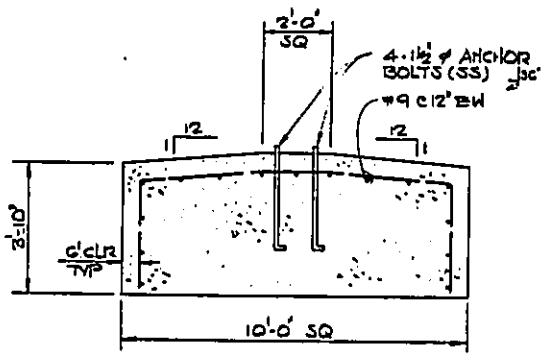
VALVE RETAINER RING W/SCREEN



RUBBER VALVE

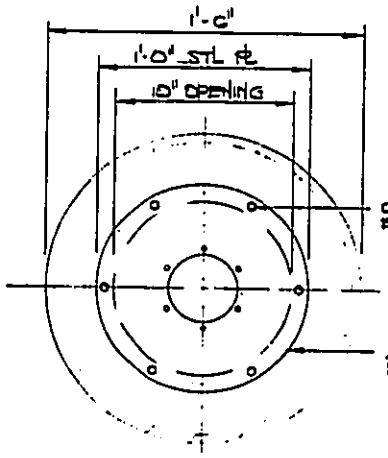
TYPICAL PORT DETAIL

NOT TO SCALE



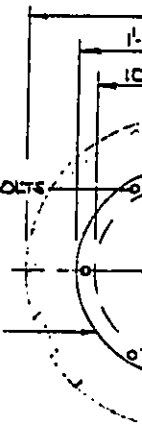
CONCRETE WEIGHT DET. 3 D-7

SCALE: 1 1/2" = 1'-0"



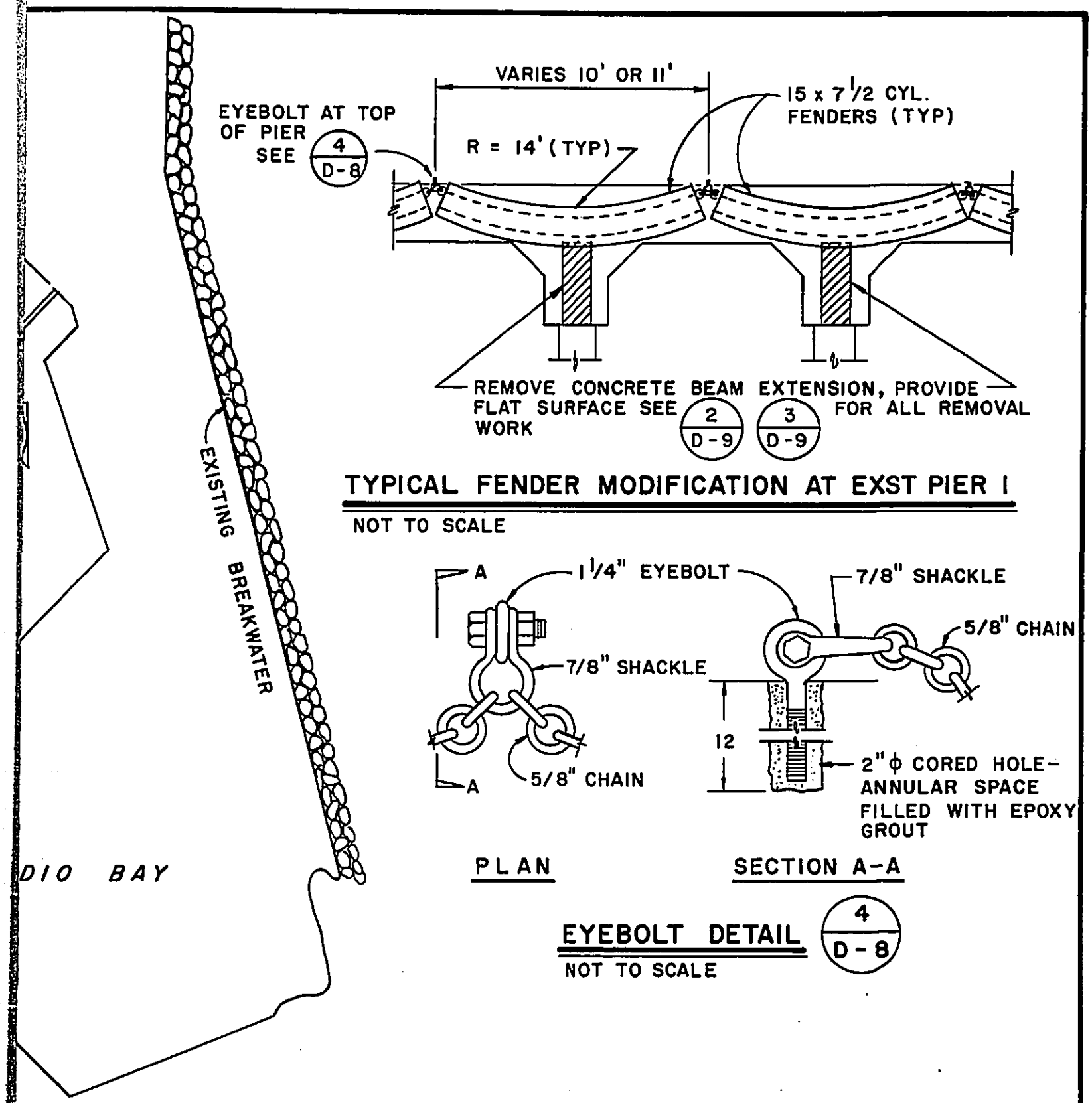
SECTION 4 D-7

SCALE: 3" = 1'-0"



SECT

SCALE: 3

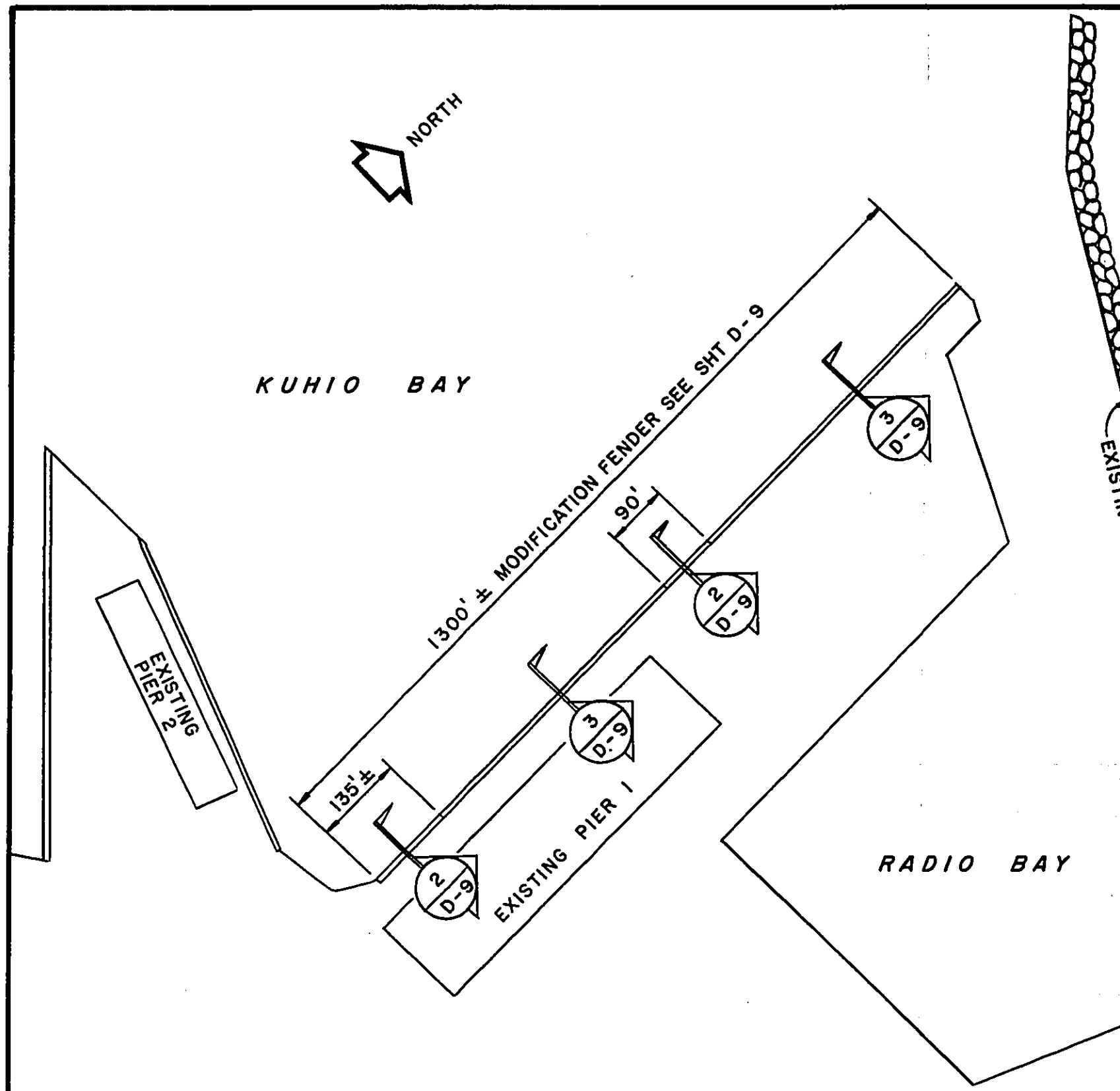


HILO, HAWAII HAWAII

PIER I
FENDER MODIFICATION

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE D-8

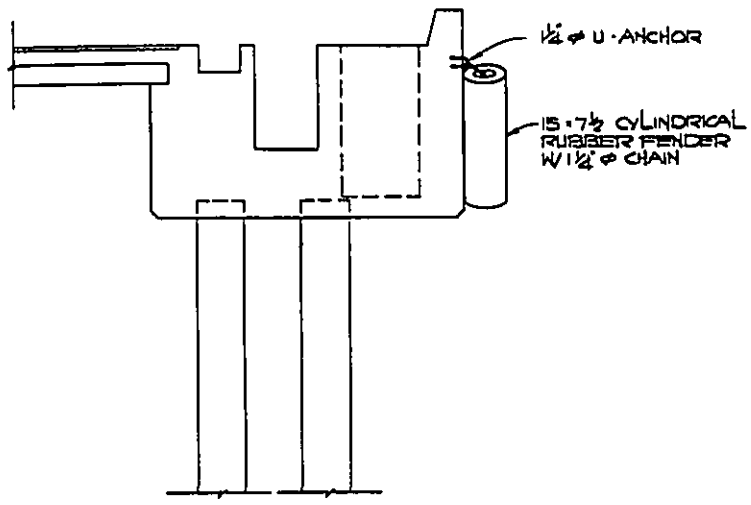


S I T E P L A N

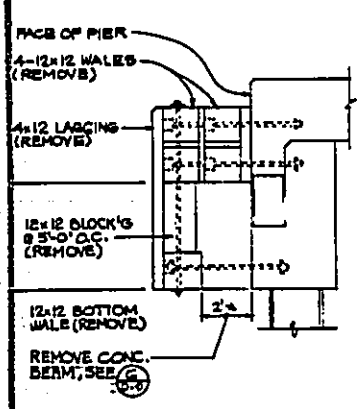
SCALE: 1" = 200'

NOTES

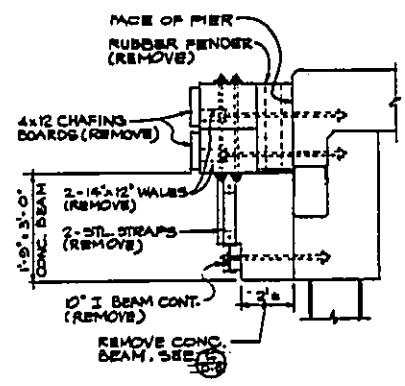
1. CYLINDRICAL RUBBER FENDER SHALL BE EPMD TYPE AS MANUFACTURED BY THE GOODYEAR TIRE AND RUBBER COMPANY. AKRON, OHIO 44316 OR APPROVED EQUAL.
2. CHAIN AND SHACKLES SHALL BE GALVANIZED WITH TWO COATS OF COAL TAR COATING COMPOUND.
3. U-ANCHOR SHALL BE STAINLESS STEEL.



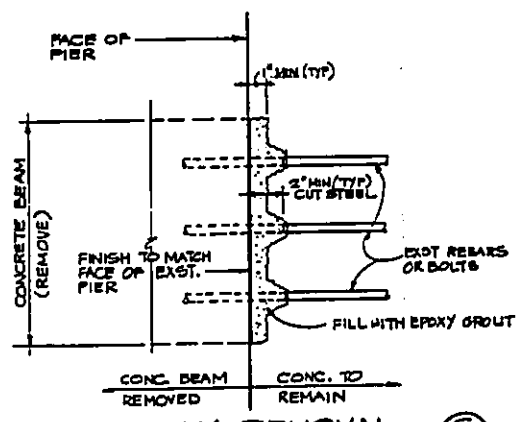
TYPICAL SECTION (1/D-9)
SCALE: ½" = 1'-0"



MOVAL WORK @ PIER 1 (2/D-9)



REMOVAL WORK @ PIER 1 (3/D-9)
SCALE: ½" = 1'-0"



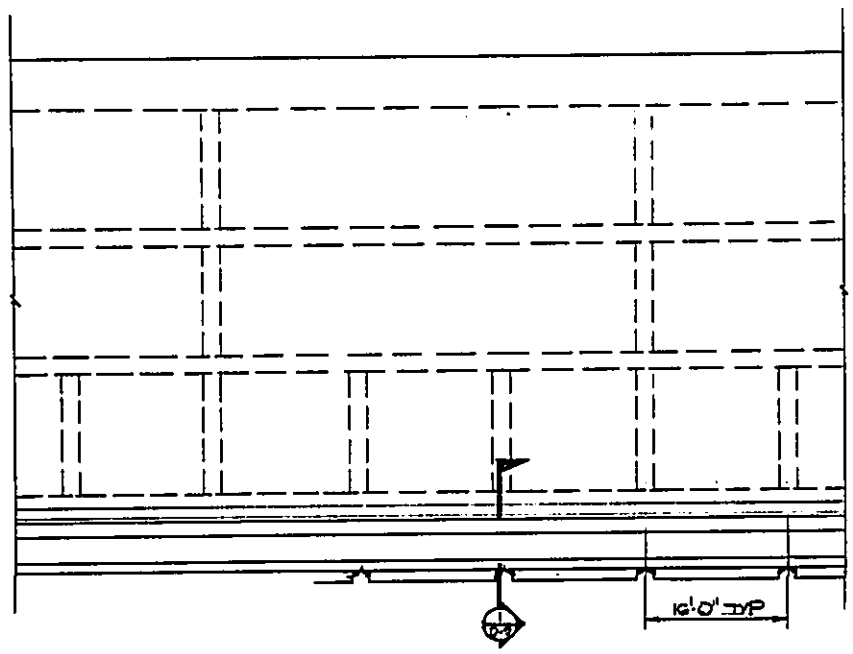
CONC. BEAM REMOVAL (6/D-9)
NOT TO SCALE

HILO, HAWAII — HAWAII

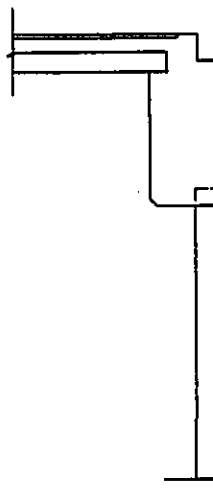
PIER 1 FENDER MODIFICATION

U.S. ARMY ENGINEER DISTRICT
HONOLULU, HAWAII

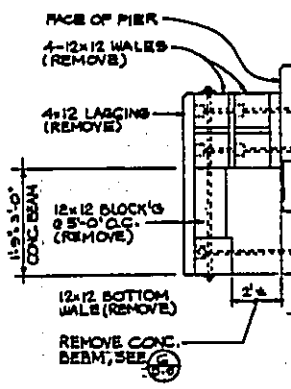
PLATE D-9



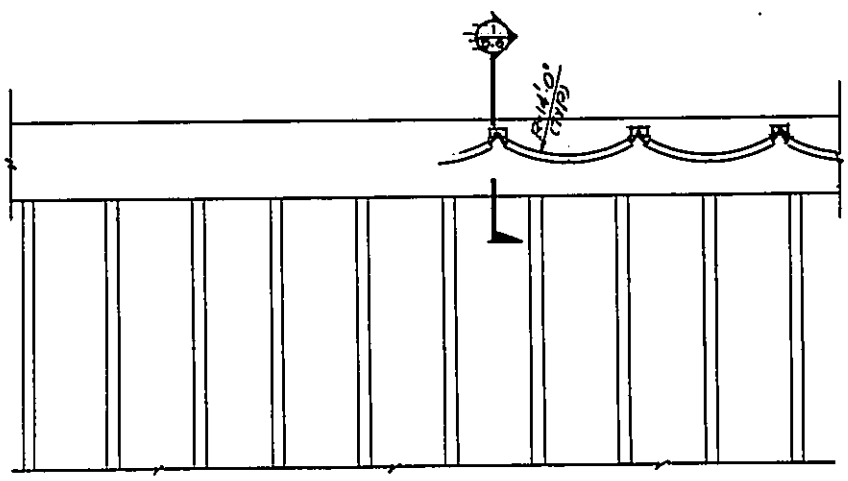
PLAN
SCALE 1/8" = 1'-0"



TYPIC
SCALE : W



REMOVAL WORK @ PIER
SCALE 1/8" = 1'-0"



ELEVATION
SCALE 1/8" = 1'-0"

f. COMMERCIAL PORT EXPANSION

(1) STRUCTURES. Procedures and formulas contained in the SPM were used to determine the various structure design. The design factors and coefficients are based on information available on materials and on the evaluations presented earlier.

(2) BREAKWATERS. The crest elevation, weight and thickness of layers for the breakwater are shown on Table D-8. Typical breakwater section is shown on Plates D-5 and D-10.

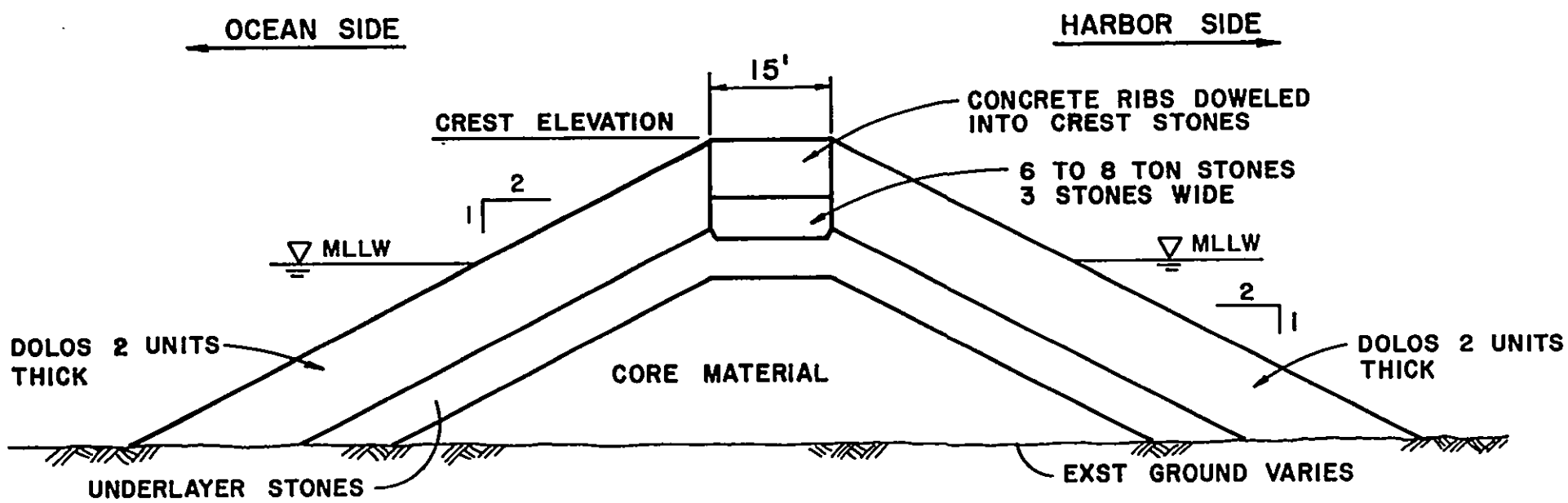
TABLE D-8. CREST ELEVATION, STONE WEIGHT AND LAYER THICKNESS FOR THE COMMERCIAL PORT EXPANSION BREAKWATER

		Armor Layer		Underlayer		Core Material
Location	Crest Elevation (Feet)	Design Stone Weight	Layer Thickness (Feet)	Design Stone Weight (Pounds)	Layer Thickness (Feet)	Design Stone Weight (Pounds)
1	+8.0	4 to 7 ton	9.5	800 to 1400	4.5	spalls to 100
2	+8.5	700 to 1200	4.0	100 to 500	2.8	spalls to 50

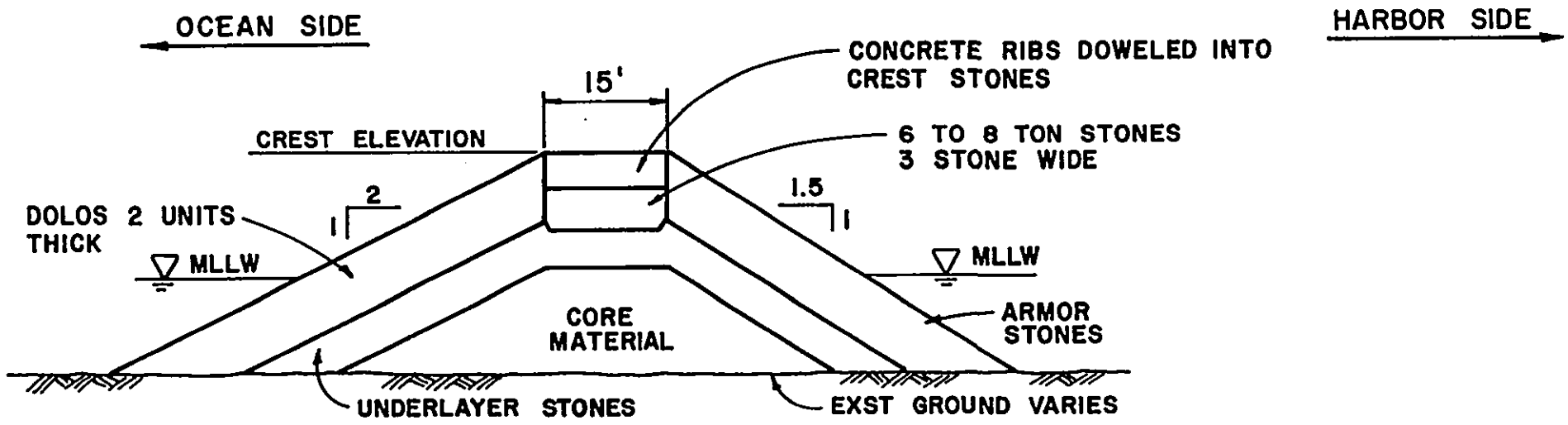
(3) REVETTED FILL AREAS. The plan require construction of a quarry stone revetment to retain dredge material. The revetment would require quarry stones placed on a 1.5 horizontal to 1 vertical slope. This slope is sufficiently flat to adequately dissipate wave energy. In addition, voids between stones would also provide dampening capacity to absorb wave energy, which if reflected back into the harbor could adversely affect navigation. The crest elevation, weight and thickness of the stone layers of the revetted fill area are shown on Table D-9. Typical section of the revetted fill area is shown on Plate D-5. The commercial Port Expansion Plan is shown on Plate D-12.

TABLE D-9. CREST ELEVATION, STONE WEIGHT AND LAYER THICKNESS FOR THE COMMERCIAL PORT EXPANSION FILL AREAS

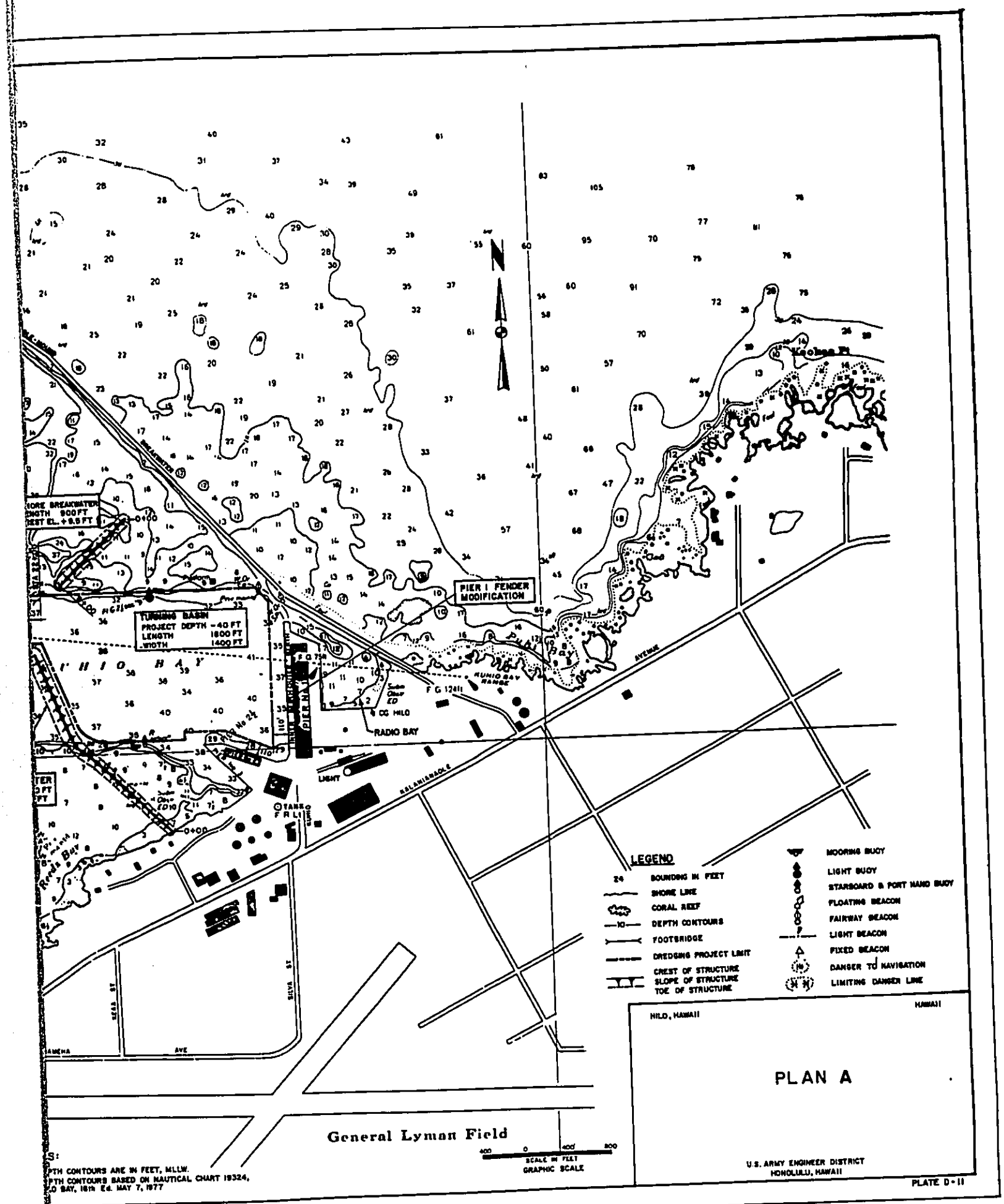
Location	Crest Elevation (Feet)	Armor Layer		Underlayer		Core Material
		Design Stone Weight	Layer Thickness (Feet)	Design Stone Weight (Pounds)	Layer Thickness (Feet)	Design Stone Weight (Pounds)
2 and 3	+8.5	700 to 1200 lb	4.0	100 to 500	2.8	spalls to 50
4	+10.0	500 to 1000 lb	3.8	50 to 200	2.0	spalls to 50



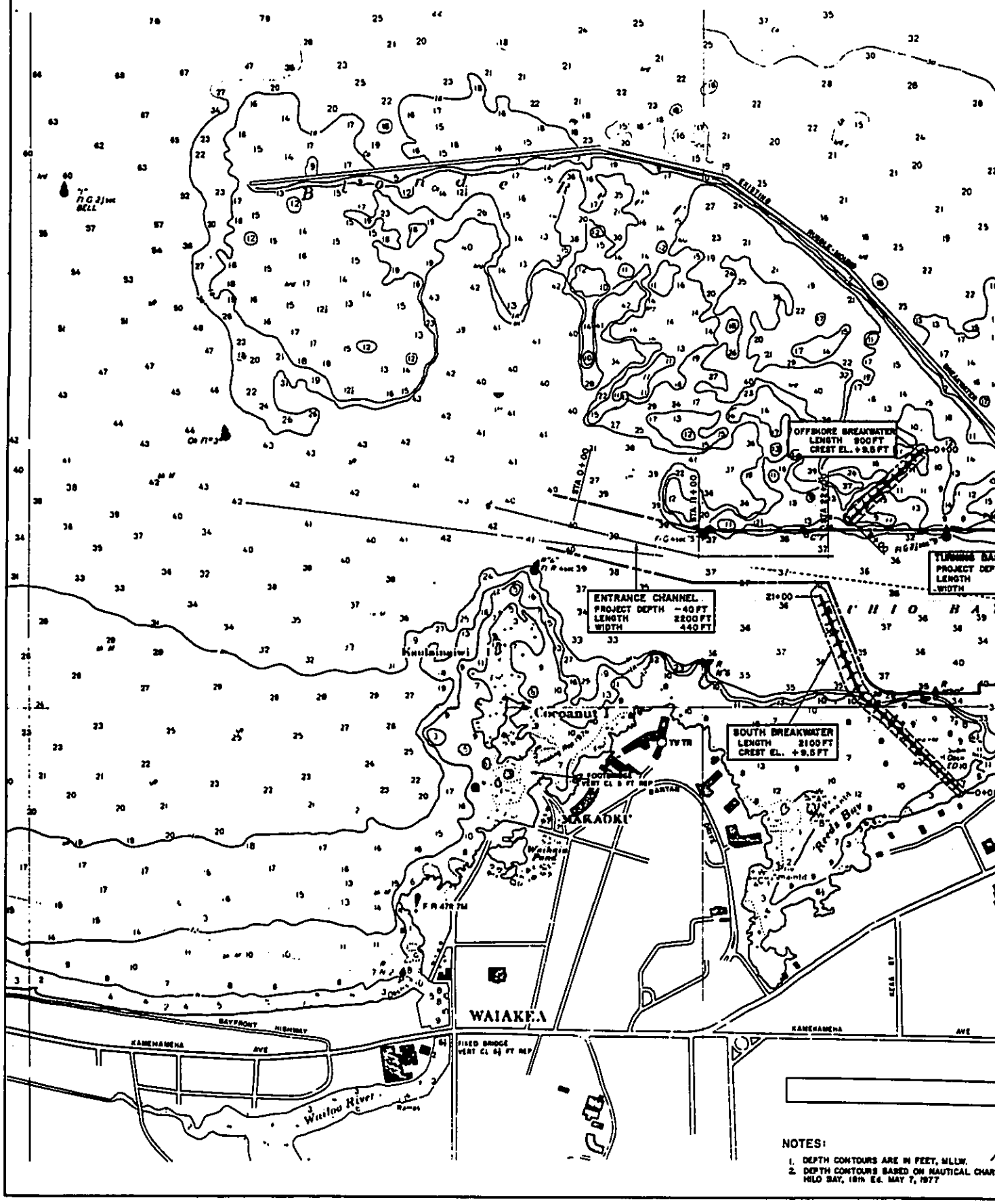
TYPICAL DOLO BREAKWATER SECTION
(OVERTOPPING CONDITION)

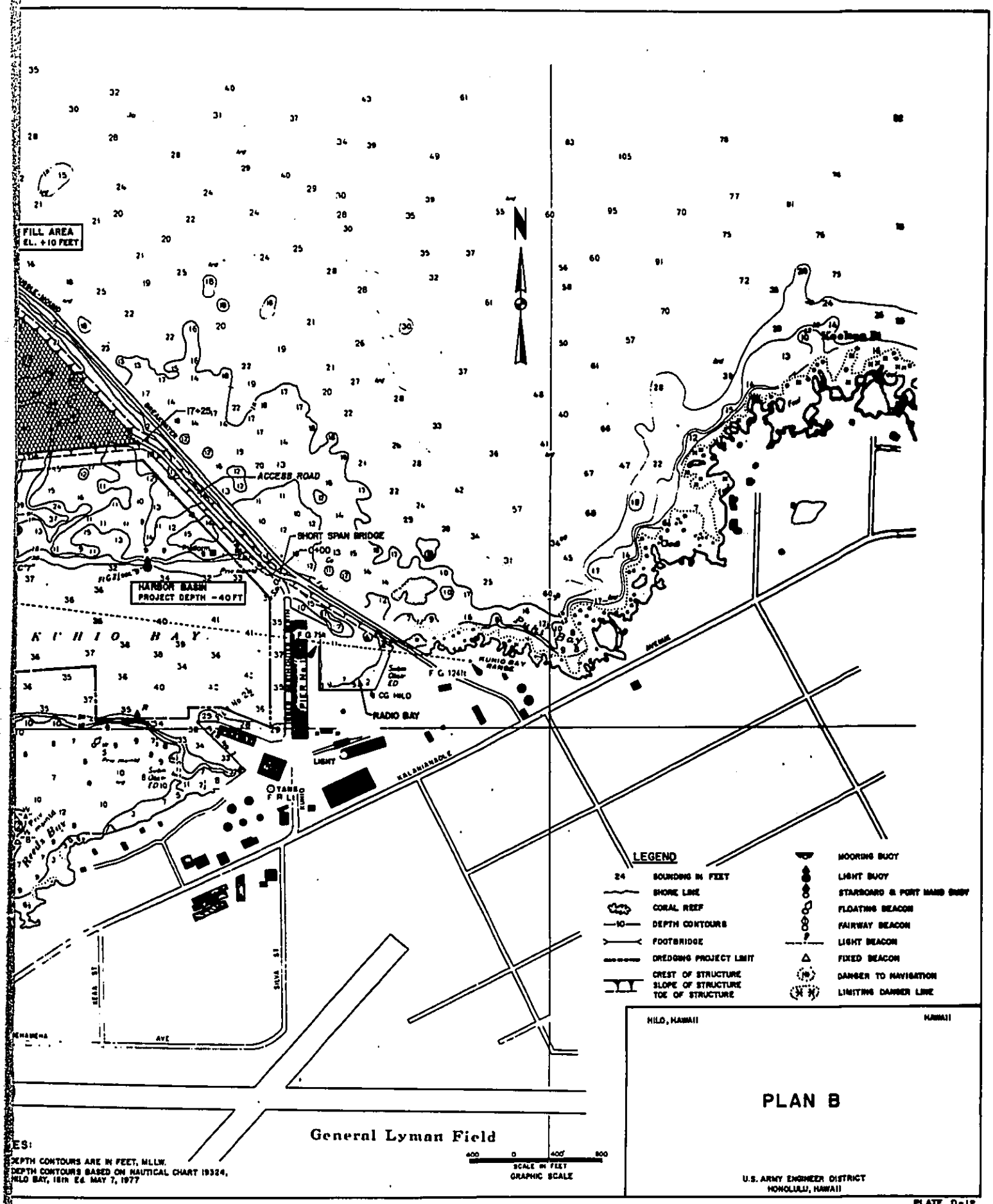


TYPICAL DOLO BREAKWATER SECTION
(MINOR OVERTOPPING)



PIER I FENDER MODIFICATION
TURNING BASIN
PROJECT DEPTH -40 FT
LENGTH 1800 FT
WIDTH 1400 FT
RADIO BAY
LIGHT
KALANIANAOLE
AVENUE
General Lyman Field
LEGEND
BOUNDING IN FEET
SHORE LINE
CORAL REEF
DEPTH CONTOURS
FOOTBRIDGE
DREDGING PROJECT LIMIT
CREST OF STRUCTURE
SLOPE OF STRUCTURE
TOE OF STRUCTURE
MOORING BUOY
LIGHT BUOY
STARBOARD & PORT HAND BUOY
FLOATING BEACON
FAIRWAY BEACON
LIGHT BEACON
FIXED BEACON
DANGER TO NAVIGATION
LIMITING DANGER LINE
SCALE IN FEET
GRAPHIC SCALE
HILO, HAWAII
HAWAII
PLAN A
U.S. ARMY ENGINEER DISTRICT
HONOLULU, HAWAII
PLATE D-11


OFFSHORE BREAKWATER
LENGTH 900 FT
CREST EL. +9.5 FT
ENTRANCE CHANNEL
PROJECT DEPTH -40 FT
LENGTH 2200 FT
WIDTH 440 FT
SOUTH BREAKWATER
LENGTH 2100 FT
CREST EL. +9.5 FT
Cocoanut I
MAKAOKU
WAIAKEA
Reeds Bay
Wailoo River
KAMEHAMEHA AVE
BAYFRONT HIGHWAY
EXISTING RUBBLE-MOUND BREAKWATER
NOTES:
1. DEPTH CONTOURS ARE IN FEET, MLLW.
2. DEPTH CONTOURS BASED ON NAUTICAL CHAR
HILO BAY, 18th Ed. MAY 7, 1977



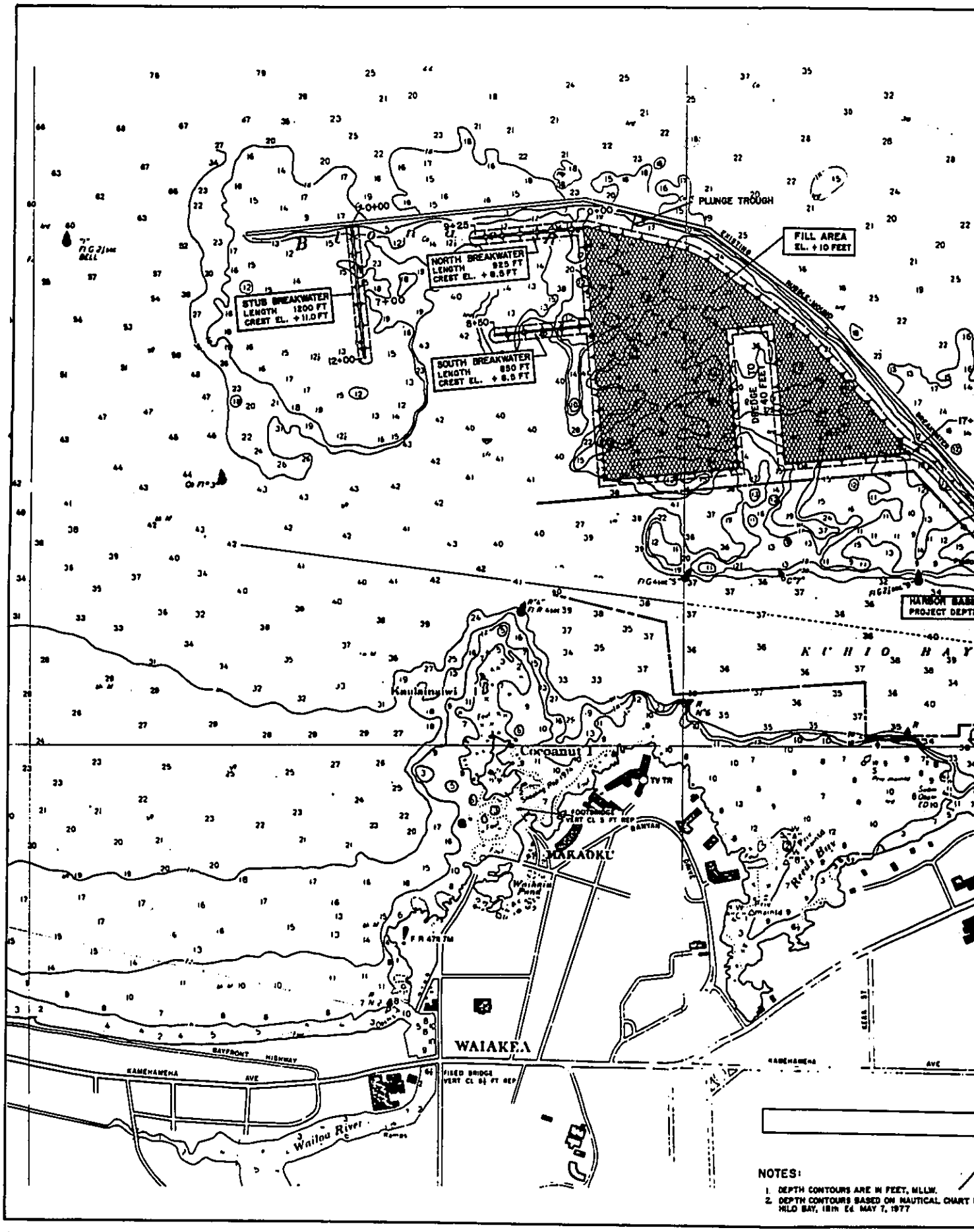
ES:
DEPTH CONTOURS ARE IN FEET, MLLW.
DEPTH CONTOURS BASED ON NAUTICAL CHART 19324,
HILO BAY, 18th Ed. MAY 7, 1977

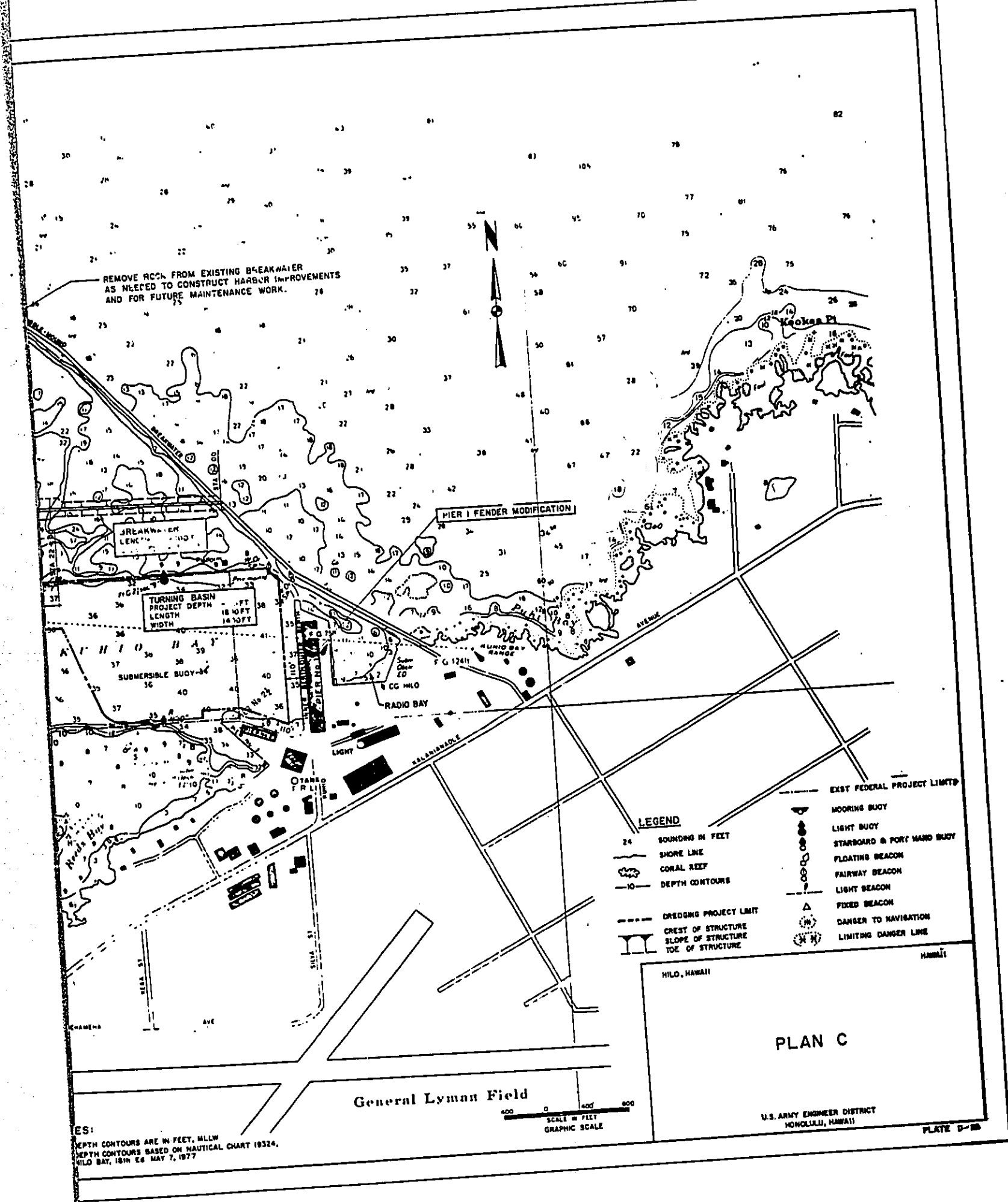
HILO, HAWAII HAWAII

PLAN B

U.S. ARMY ENGINEER DISTRICT
HONOLULU, HAWAII

PLATE D-12


PLUNGE TROUGH
FILL AREA
EL. + 10 FEET
NORTH BREAKWATER
LENGTH 925 FT
CREST EL. + 8.5 FT
STUB BREAKWATER
LENGTH 1200 FT
CREST EL. + 11.0 FT
SOUTH BREAKWATER
LENGTH 850 FT
CREST EL. + 6.5 FT
DREDGE TO 40 FEET
HARBOR BASIN
PROJECT DEPTH
KUHIO BAY
Kaulainaiwi
Cocoanut I
MAKAOKU
Waihaia Pond
Reeds Bay
WAIAKEA
BAYFRONT HIGHWAY
KAMEHAMEHA AVE
Wailoa River
FIXED BRIDGE
VERT CL 5½ FT REP
NOTES:
1. DEPTH CONTOURS ARE IN FEET, MLLW.
2. DEPTH CONTOURS BASED ON NAUTICAL CHART
HILO BAY, 18th Ed. MAY 7, 1977



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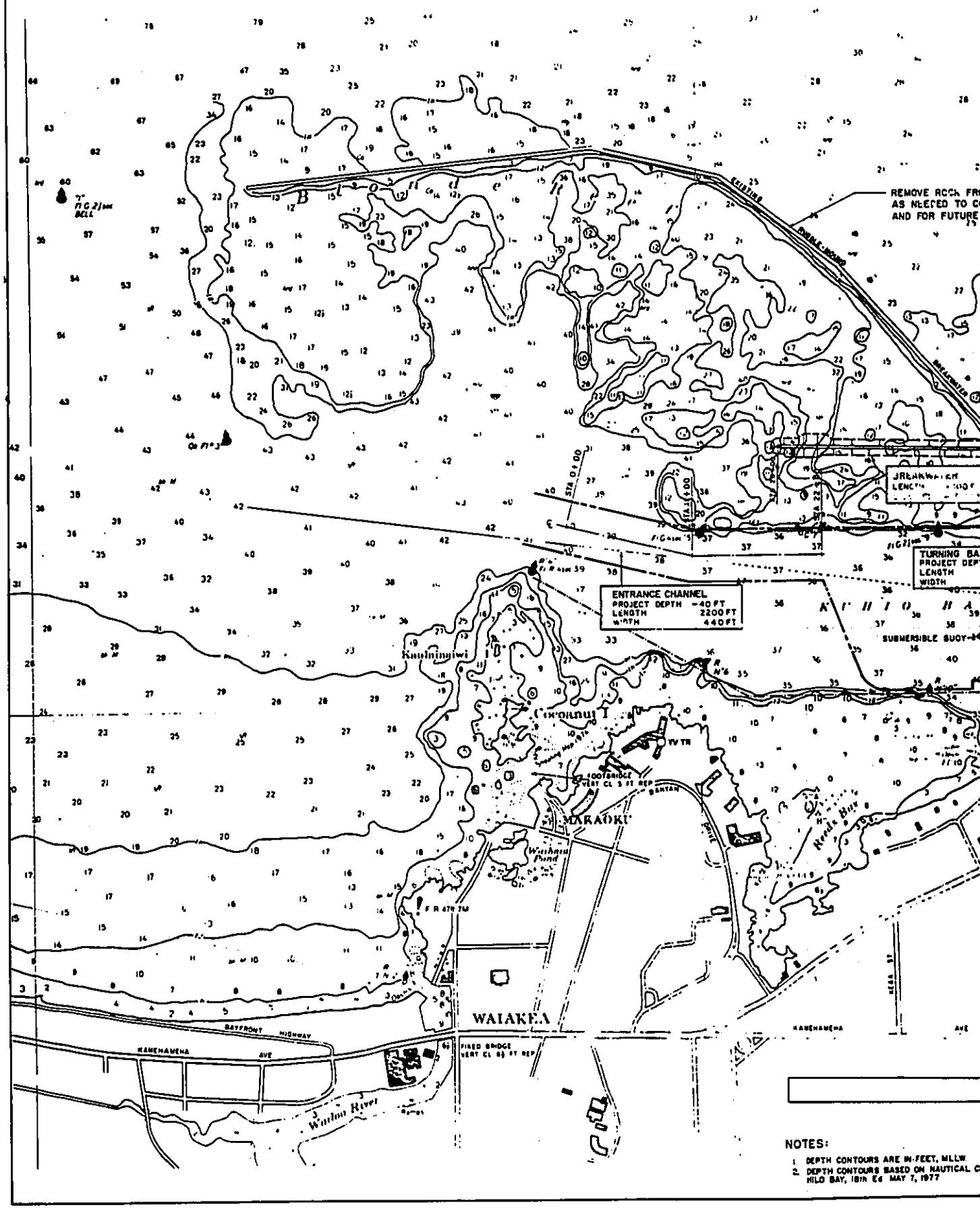
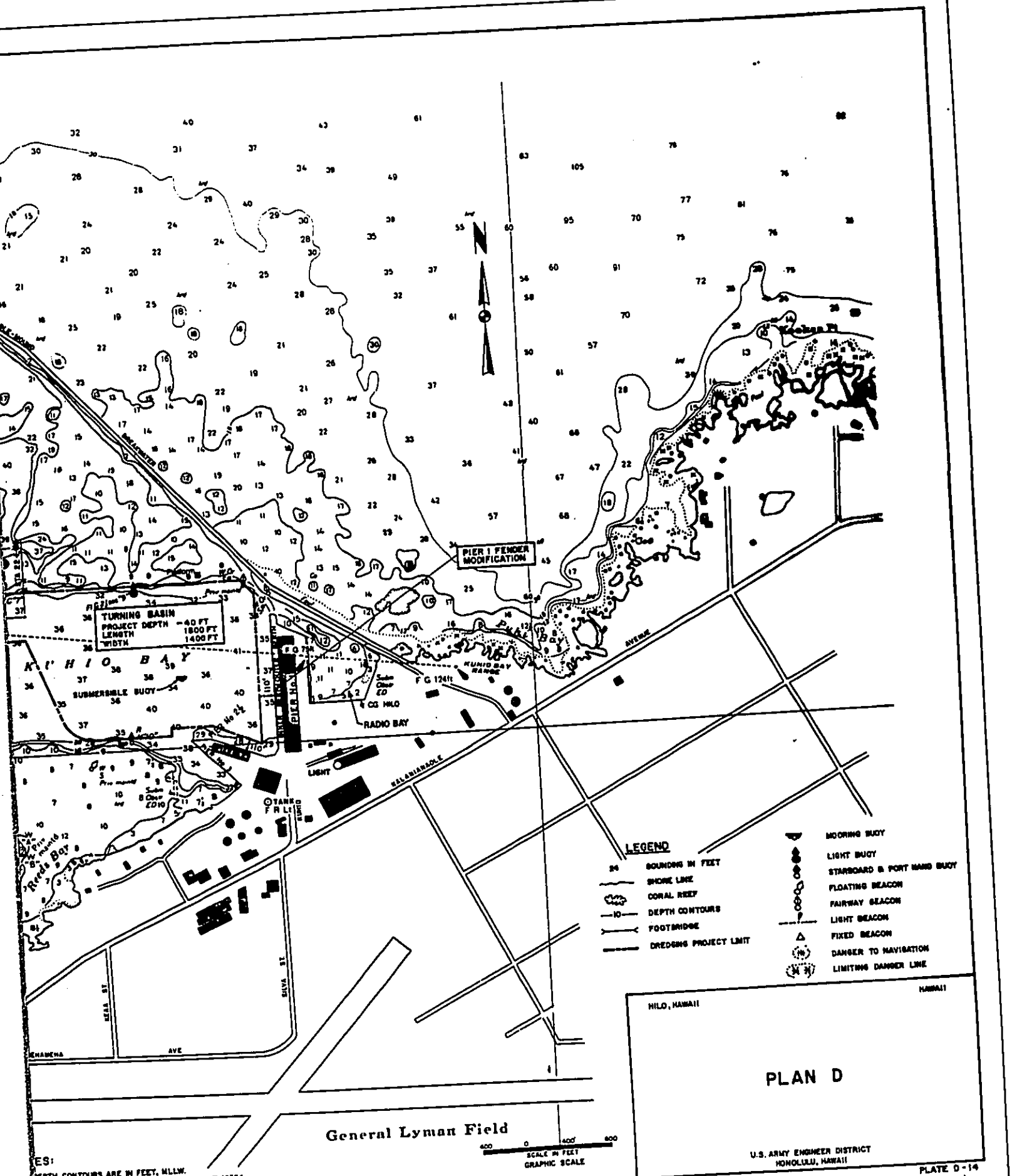
ILO BAY, 18th Ed MAY 7, 1977



NOTES:

1. DEPTH CONTOURS ARE IN FEET, MLLW.
2. DEPTH CONTOURS BASED ON NAUTICAL C
HILO BAY, 18th Ed MAY 7, 1977



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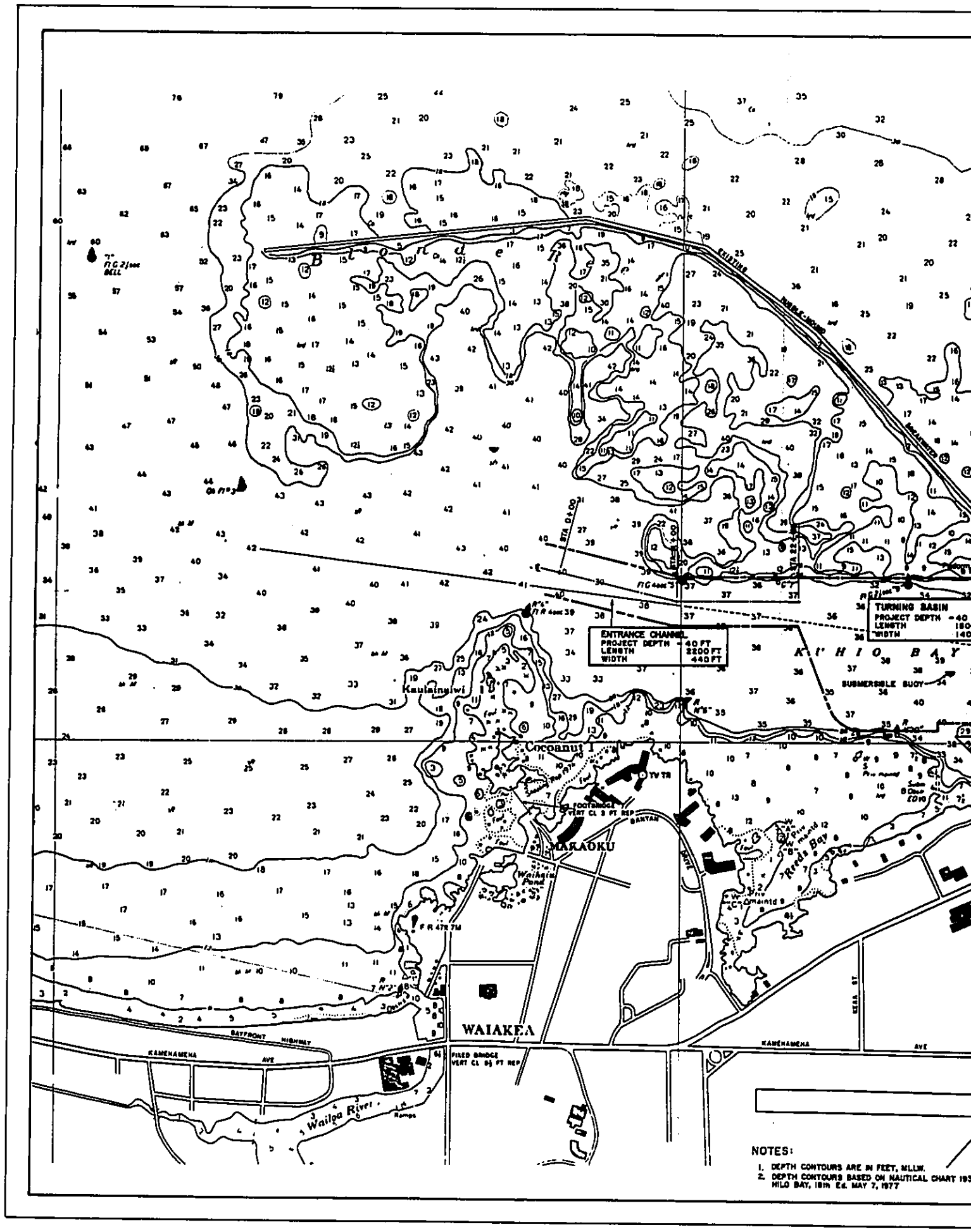
HILO BAY, 18th Ed. MAY 7, 1977



NOTES:

1. DEPTH CONTOURS ARE IN FEET, MLLW.
2. DEPTH CONTOURS BASED ON NAUTICAL CHART 193
HILO BAY, 18th Ed. MAY 7, 1977

APPENDIX D

SECTION 3. COST ESTIMATION SECTION: SMALL BOAT HARBOR

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	b. King's Landing	
	Plan 1	D-3
	Plan 2	D-4
	c. Kalapana	D-4

1. BASIS FOR ESTIMATE

a. Estimated quantities were based on existing topograhic and hydrographic maps and surveys and typical plans and section.

b. Materials to be dredged and excavated are assumed to be hard basalt rock.

c. The disposal site will be designated within two (2) miles from the site.

d. Armor stones and underlayer stones will be obtained from the government quarry at Hilo.

e. Estimated construction period is two (2) years and 12% of cost growth is included in the unit cost.

f. Oahu Contractor will do the construction.

g. September 1981 price levels.

h. Engineering and design cost.

i. Supervision and administration cost during construction.

j. A 25% contingency cost allowance.

k. All unit prices includes factors for waste.

b. King's Landing - Plan 1

Item	Quantity	Unit Cost ($)	Subtotal Cost ($)	Total Cost ($)
FEDERAL COST				
Mob & Demob	LS	-	420,000	
Clearing	8 AC	2,200.00	17,600	
Blast the Hard Material	307,200 CY	5.75	1,766,400	
Exc. & Disposal - Above Water	112,950 CY	6.25	705,900	
Exc. & Disposal - Below Water	194,250 CY	8.10	1,573,400	
Armor - 3-6 Ton	32,120 CY	56.50	1,814,800	
Armor - 0.5 to 1.5 Ton	8,430 CY	65.40	551,300	
Underlayer 600# - 1200#	6,560 CY	53.40	350,300	
Underlayer 100# - 500#	3,170 CY	53.40	169,300	
Armor from Exc. 1.5 Ton	1,500 CY	50.80	76,000	
Build A Causeway	LS	-	79,000	
				7,524,000
CONTINGENCY 25%				1,881,000
TOTAL FEDERAL COST				9,405,000
NON-FEDERAL COST				
Clearing	10 AC	2,200.00	22,000	
Blast Hard Material	225,000 CY	5.75	1,293,800	
Exc. & Disposal - Above Water	75,100 CY	6.25	469,000	
Exc. & Disposal - Below Water	149,900 CY	8.10	1,284,200	
				2,999,000
CONTINGENCY 25%				749,000
TOTAL NON-FEDERAL COST				3,748,000
TOTAL FIRST COST				13,153,000

CORRECTION

THE PRECEDING DOCUMENT(S) HAS BEEN REPHOTOGRAPHED TO ASSURE LEGIBILITY

SEE FRAME(S) IMMEDIATELY FOLLOWING

1. BASIS FOR ESTIMATE

a. Estimated quantities were based on existing topograhic and hydrographic maps and surveys and typical plans and section.

b. Materials to be dredged and excavated are assumed to be hard basalt rock.

c. The disposal site will be designated within two (2) miles from the site.

d. Armor stones and underlayer stones will be obtained from the government quarry at Hilo.

e. Estimated construction period is two (2) years and 12% of cost growth is included in the unit cost.

f. Oahu Contractor will do the construction.

g. September 1981 price levels.

h. Engineering and design cost.

i. Supervision and administration cost during construction.

j. A 25% contingency cost allowance.

k. All unit prices includes factors for waste.

2. PROJECT FIRST COST

a. Leleiwi Point

Item	Quantity	Unit Cost ($)	Subtotal Cost ($)	Total Cost ($)
FEDERAL COST				
Mob & Demob	LS	-	420,000	
Clearing	13 AC	2,200.00	28,600	
Blast Hard Material	235,300 CY	5.75	1,353,000	
Exc. & Disposal - Above Water	86,000 CY	6.25	537,500	
Exc. & Disposal - Below Water	149,300 CY	8.10	1,209,300	
Armor - 1.5 to 3 Ton	10,600 CY	65.40	693,200	
Armor - 0.5 to 15 Ton	7,620 CY	65.40	498,400	
Underlayer 100# - 500#	7,020 CY	53.40	374,900	
Armor from Exc. 1.5 Ton	6,810 CY	50.80	345,000	
Build A Causeway	LS	-	79,000	
				5,539,900
CONTINGENCY 25%				1,385,100
TOTAL FEDERAL COST				6,925,000
NON-FEDERAL COST				
Clearing	11 AC	2,200.00	24,100	
Blast Hard Material	211,900 CY	5.75	1,218,400	
Exc. & Disposal - Above Water	65,900 CY	6.25	411,900	
Exc. & Disposal - Below Water	146,000 CY	8.10	1,182,600	
				2,837,000
CONTINGENCY 25%				709,000
TOTAL NON-FEDERAL COST				3,546,000
TOTAL FIRST COST				10,471,000

b. King's Landing - Plan 1

b. King's Landing - Plan 1

Item	Quantity	Unit Cost ($)	Subtotal Cost ($)	Total Cost ($)
FEDERAL COST				
Mob & Demob	LS	-	420,000	
Clearing	8 AC	2,200.00	17,600	
Blast the Hard Material	307,200 CY	5.75	1,766,400	
Exc. & Disposal - Above Water	112,950 CY	6.25	705,900	
Exc. & Disposal - Below Water	194,250 CY	8.10	1,573,400	
Armor - 3-6 Ton	32,120 CY	56.50	1,814,800	
Armor - 0.5 to 1.5 Ton	8,430 CY	65.40	551,300	
Underlayer 600# - 1200#	6,560 CY	53.40	350,300	
Underlayer 100# - 500#	3,170 CY	53.40	169,300	
Armor from Exc. 1.5 Ton	1,500 CY	50.80	76,000	
Build A Causeway	LS	-	79,000	
				7,524,000
CONTINGENCY 25%				1,881,000
TOTAL FEDERAL COST				9,405,000
NON-FEDERAL COST				
Clearing	10 AC	2,200.00	22,000	
Blast Hard Material	225,000 CY	5.75	1,293,800	
Exc. & Disposal - Above Water	75,100 CY	6.25	469,000	
Exc. & Disposal - Below Water	149,900 CY	8.10	1,284,200	
				2,999,000
CONTINGENCY 25%				749,000
TOTAL NON-FEDERAL COST				3,748,000
TOTAL FIRST COST				13,153,000

King's Landing - Plan 2

Item	Quantity	Unit Cost ($)	Subtotal Cost ($)	Total Cost ($)
FEDERAL COST				
Mob & Demob	LS	-	420,000	
Clearing	11 AC	2,200.00	24,200	
Blast Hard Material	311,700 CY	5.75	1,792,300	
Exc. & Disposal - Above Water	145,100 CY	6.25	906,900	
Exc. & Disposal - Below Water	166,600 CY	8.10	1,349,500	
Armor - 3-6 Ton	24,730 CY	56.50	1,397,300	
Armor - 0.5 to 1.5 Ton	8,850 CY	65.40	578,800	
Underlayer 600# - 1200#	7,730 CY	53.40	412,800	
Underlayer 100# - 500#	3,320 CY	53.40	177,200	
Build A Causeway	LS	-	79,000	
				7,138,000
CONTINGENCY 25%				1,784,000
TOTAL FEDERAL COST				8,922,000
NON-FEDERAL COST				
Clearing	9 AC	2,200.00	19,800	
Blast Hard Material	324,700 CY	5.75	1,867,000	
Exc. & Disposal - Above Water	179,900 CY	6.25	1,124,400	
Exc. & Disposal - Below Water	144,800 CY	8.10	1,172,080	
				4,184,000
CONTINGENCY 25%				1,046,000
TOTAL NON-FEDERAL COST				5,230,000
TOTAL FIRST COST				14,152,000

c. Kalapana

Item	Quantity	Unit Cost ($)	Subtotal Cost ($)	Total Cost ($)
Federal Cost				
Mob & Demob	1 Job	-	450,000	
Clearing	9 Acre	2,200	19,800	
Blast Hard Material	140,080 cy	5.75	805,000	
Exc & Disposal - Above Water	18,350 cy	6.25	114,700	
Exc & Disposal - Below Water	121,730 cy	8.10	986,000	
Armor 1.5 - 3 Ton	11,320 cy	74.30	841,100	
U'layer 100# - 500#	4,350 cy	62.20	270,600	
Bedding 1# - 50#	3,860 cy	37.50	144,800	
Build Causeway	1 Job	-	79,000	
				3,711,000
		Contingency 25%		928,000
				4,639,000
Non-Federal Cost				
Clearing	13 Acre	2,200	28,000	
Blast Hard Material	261,410 cy	5.75	1,503,000	
Exc & Disposal - Above Water	126,150 cy	6.25	788,400	
Exc & Disposal - Below Water	135,260 cy	8.10	1,095,600	
				3,415,000
		Contingency 25%		854,000
				4,269,000
TOTAL NON-FEDERAL COST				8,908,000
TOTAL FIRST COST				

APPENDIX D

SECTION 4. COST ESTIMATION SECTION: DEEP DRAFT HARBOR

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	c. Submersible Mooring Buoy	
	d. Pretension Devices and Improve Existing Dock Fender System	D-5
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	f. Commercial Port Expansion	D-6
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	c. Plan C	D-7
	d. Plan D	D-7

1. BASIS FOR ESTIMATE

General

a. Estimated quantities were based on existing topograhic and hydrographic maps and surveys and typical plans and section.

b. Estimated construction period and 12% of cost growth is included in the unit cost.

c. Oahu based contractor will do the construction.

d. A 20% contingency cost allowance.

e. All unit prices includes factor for waste.

f. September 1981 price levels.

g. The harbor will operate during construction period.

Dredging

a. Material to be dredged is loose rock, sand and silt.

b. Dredging by floating clam shell.

c. Ocean disposal of dredged material.

d. All equipment from Oahu except for two dump scows from west const.

e. No blasting required.

f. 24-hour operation 6 days per week.

g. Estimated construction period is 6 to 8 months.

Breakwaters

a. Armor stones and underlayer stones will be obtained from the Government quarry at Hilo.

b. Equipment working on barge.

c. Estimated construction period is 2-1/2 years.

Pier 1 Fender Modification

a. Pier will operate during construction period.

b. Estimated construction period is 6 months.

Submersible Buoy

a. Existing buoy to be removed by others.

b. Cost is for setting anchors, block, buoy, copper pipe (1,000') and placing compressor.

c. Copper pipe laying to be done by floating crane and barge.

d. Copper to be welded in 100 foot lengths on the barge, each length to be lowered into trench from barge and joined under water.

e. Estimated construction period one month.

Circulation Improvement

a. Equipment working on breakwater with steel angle running inside of crane tracks for stability.

b. A 100' x 200' staging area will be built at sta 0+00 of new breakwater. Equipment will be parked in staging area at night.

c. Estimated construction period two years.

Commercial Port Expansion

See dredging and breakwaters above.

2. PLAN COMPONENT FIRST COST

a. Harbor Deepening

Item	Quantity	Unit Cost ($)	Subtotal Cost ($)	Total Cost ($)
FEDERAL COST				
Mob & Demob	LS	-	880,000	
Dredge				
Project Depth	370,000 CY	5.60	2,072,000	
Overdepth 1.0'	115,000 CY	3.75	432,000	
				3,384,000
CONTINGENCY 20%				677,000
TOTAL FEDERAL COST				4,061,000
NON-FEDERAL COST				
Dredge				
Project Depth	58,000 CY	5.60	327,600	
Overdepth 1.0'	8,400 CY	3.75	31,500	
				359,200
CONTINGENCY 20%				72,800
TOTAL NON-FEDERAL COST				432,000
TOTAL FIRST COST				4,493,000

b. Breakwaters

Item	Quantity	Unit Cost ($)	Subtotal Cost ($)	Total Cost ($)
FEDERAL COST				
Mob & Demob	LS	-	600,000	
Offshore Breakwater				
500-800 lb stones	11,700 CY	94.50	1,105,700	
50-100 lb stones	4,800 CY	66.00	316,800	
Spalls to 20 lb stones	23,500 CY	50.70	1,191,200	
				2,613,700
South Breakwater				
500-800 lb stones	33,700 CY	94.50	3,184,700	
50-100 lb stones	14,400 CY	66.00	950,400	
Spalls to 20 lb stones	112,600 CY	50.70	5,707,700	
				9,842,800
				12,456,500
CONTINGENCY 20%				2,491,500
TOTAL FEDERAL COST				14,948,000
NON-FEDERAL COST				0
TOTAL FIRST COST				14,948,000

c. Submersible Mooring Buoy

Item	Quantity	Unit Cost ($)	Subtotal Cost ($)	Total Cost ($)
FEDERAL COST	Job	-	140,000	140,000
CONTINGENCY 20%				28,000
TOTAL FEDERAL COST				168,000
NON-FEDERAL COST				0
TOTAL FIRST COST				168,000

d. Pretension Devices and Improve Existing Dock Fender System

Item	Quantity	Unit Cost ($)	Subtotal Cost ($)	Total Cost ($)
FEDERAL COST				
Replace existing wooden fender system to cylindrical rubber fender				
Mob & Demob	LS	-	13,000	
Clear & remove debris	LS	-	2,900	
Remove Existing Wood Fender	1,300 Ft	24.00	31,200	
Remove 1.75'x3'x2" Conc Beam	125 Ea	121.00	15,100	
Fill with Expoxy Grout on Chipped Surfaces & Misc.	1,300 Ft	8.55	11,100	
Install 15'x7-1/2" Cylindrical Rubber Fender	130 Ea	1,695.00	220,400	
				293,700
CONTINGENCY 20%				58,300
TOTAL FEDERAL COST				352,000
NON-FEDERAL COST				
Pretension Devices	4/Ship	100,000	400,000	400,000
CONTINGENCY 20%				80,000
				480,000
TOTAL FIRST COST				832,000

e. Circulation Improvement

Item	Quantity	Unit Cost ($)	Subtotal Cost ($)	Total Cost ($)
FEDERAL COST				
Mob and Demob	LS		600,000	
Breakwater				
Develop Quarry	LS		262,700	
Workload & Staging Area	LS		228,800	
Armor 7-Ton Cap	5,600 CY	70.35	394,000	
4-Ton Dolos	5,500 Ea	315.00	1,734,000	
3-5 Ton Stones	33,400 CY	81.00	2,705,400	
500-lb Stones	24,400 CY	63.00	1,537,200	
116-150 lb Stones	59,300 CY	49.20	2,918,600	
				10,380,700
CONTINGENCY 20%				2,076,300
TOTAL FEDERAL COST				12,457,000
NON-FEDERAL COST				
TOTAL FIRST COST				12,457,000

f. Commercial Port Expansion

Item	Quantity	Unit Cost ($)	Subtotal Cost ($)	Total Cost ($)
FEDERAL COST				
Mob & Demob	LS	-	1,190,000	1,190,000
Dredging	2,139,300 CY	5.60	11,980,000	11,980,000
Stub Breakwater				
500-800 lb stones	33,400 CY	94.50	3,156,000	
50-100 lb stones	15,800 CY	66.00	1,043,000	
Spalls - 20 lb stones	157,400 CY	50.70	7,980,000	12,179,000
North Breakwater				
500-800 lb stones	14,300 CY	94.50	1,351,000	
50-100 lb stones	6,000 CY	66.00	396,000	
Spalls - 20 lb stones	36,100 CY	50.70	1,830,000	3,577,000
South Breakwater				
500-800 lb stones	16,100 CY	94.50	1,521,000	
50-100 lb stones	6,900 CY	66.00	455,000	
Spalls to 20 lb stones	52,200 CY	50.70	2,647,000	4,623,000
CONTINGENCY 20%				33,549,000
TOTAL FEDERAL COST				6,710,000
				40,259,000
NON-FEDERAL COST				
Dredging	311,700 CY	5.60	1,746,000	1,746,000
Fill Area				
500-800 lb stones	105,400 CY	94.50	9,960,000	
50-100 lb stones	56,200 CY	66.00	3,709,000	
Spalls to 20 lb stones	41,700 CY	50.70	2,114,000	
Dredged Coral Fill	5,142,400 CY	6.50	33,426,000	49,208,000
Access Road				
500-800 lb stones	26,400 CY	94.50	2,495,000	
50-100 lb stones	13,100 CY	66.00	865,000	
Spalls to 20 lb stones	14,900 CY	50.70	755,000	
Dredged Coral Fill	100,100 CY	6.50	650,000	4,765,000
Subbase (Select Material)	6,900 CY	27.50	190,000	
Base Course 4"	1,300 CY	30.10	40,000	
AC Pavement 2"	1,000 T.	45.80	46,000	
Metal Guard Rail	6,200 LF	22.30	138,000	414,000
Remove & Reuse Armor Stone from Existing Breakwater				
8 Ton & Larger	5,800 CY	27.90	162,000	
3 Ton & Larger	1,600 CY	27.90	45,000	207,000
Short Span Bridge	100 LF	3,400.00	340,000	340,000
CONTINGENCY 20%				56,680,000
TOTAL NON-FEDERAL COST				11,336,000
TOTAL FIRST COST				68,016,000
				108,275,000

3. PROJECT FIRST COST

a. Plan A

Federal Cost	
Dredging	$4,061,000
Breakwaters	14,948,000
Pier 1 Modification	352,000
	$19,361,000
Non-Federal Cost	
Dredging	$432,000
Pretension Devices	480,000
	$912,000
TOTAL PROJECT FIRST COST	$20,273,000

b. Plan B

Federal Cost	$40,259,000
Non-Federal Cost	68,016,000
TOTAL PROJECT FIRST COST	$108,275,000

c. Plan C

Federal Cost	
Dredging	$4,061,000
Breakwater	12,457,000
Submersible Buoy	168,000
Pier 1 Modification	352,000
	$17,038,000
Non-Federal Cost	
Dredging	$432,000
Pretension Devices	480,000
	$912,000
TOTAL PROJECT FIRST COST	$17,950,000

d. Plan D

Federal Cost	
Dredging	$4,061,000
Submersible Buoy	168,000
Pier 1 Modification	352,000
	$4,581,000
Non-Federal Cost	
Dredging	$432,000
Pretension Devices	480,000
	$912,000
TOTAL PROJECT FIRST COST	$5,493,000

APPENDIX E:

GEOLOGICAL ENGINEERING CONSIDERATIONS

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SECTION 1: SMALL CRAFT NAVIGATION

REGIONAL GEOLOGY.

The Island of Hawaii was formed during the last 800,000 years by the gradual emergence and subsequent coalescence of five volcanoes, two of which, Mauna Loa and Kilauea, are still active. The King's Landing and Leleiwi Point sites are located on the northeast edge of Mauna Loa. The proposed Kalapana harbor will be on the south central flank of Kilauea volcano. Mauna Loa is 75 miles (120 km) long and 64 miles (103 km), rising from a base 15,000 feet (4570 meters) below sea level to 13,680 feet (4170 meters) above sea level. It is the largest active volcano and the biggest single mountain on earth.

Kilauea volcano is on the southeast slope of Mauna Loa and merges so imperceptibly with its giant neighbor that significant dimensions cannot be assigned. Lava flows from Mauna Loa pass over the slopes of Kilauea. The caldera, Halemaumau, is three miles (5 km) and two miles (3 km) wide. The notable features of Kilauea are the high echelon fault escarpments on the south coast.1/

Mauna Loa has a broad, smooth, dome-shape which gives rise to the name of "shield" volcano. The average slope above the two sites is six degrees, about 1V to 10H, at the sites the slope decreases to 1V to 100H. The slopes are formed by the cooling of lava flows and accompanying change in lava gradient.

TERRAIN CONDITIONS

Leleiwi Point and King's Landing are in areas of aa flow similar to terrain south of Hilo in the Waiakea district. The comprehensive quarry investigations made for the Tsunami Protection & Navigation Improvement Project, DM #2 found "the upper part of the aa flows consists of porous, sponge-like rock (volcanic slag)" known as scoria or clinkers. The porous

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1/ Bathmetric, Topographic and Structural Map of the South-Central Flank of Kilauea Volcano, J. G. Moore and D. L. Peck, U.S. Geol Survey, Map I-456, Mic Map Invest, 1965.

structure is caused by the escape of gases and water vapor resulting from internal mechanical stirring of the lava which leaves voids or vesicles. The upper surface of aa flows are indescribably rough and almost impossible to traverse especially if covered by thick vegetation and the surface is hidden by moss, lichen and ferns. The clinker surface layers normally range from five feet to ten feet and overlies dense, hard basalt. The basalt layer in turn varies from two or three feet to ten feet or more. The near surface layer(s) of basalt where less than ten feet thick can be excavated and exposed by ripping. The excavation on the Kaimu-Chain of Craters Road by Yamada and Sons (see PODED-GE report 710 dated 11 Jun 79) was done using D-9 bulldozers. The rock has a specific gravity of 2.86 S.S.D. and an average unconfined compression strength of 22,500 psi. Pieces are pulled from their interlocked position by the dozers getting their rippers under the layers and using their blades to work pieces loose. Rock below water level will require drilling and blasting or similar other excavation effort to remove.

LAVA FLOWS - ROCK CLASSES.

Both pahoehoe and aa[2/] are common on the slopes of Mauna Loa and Kilauea with a preponderance of aa usually found at lower elevations. Because all flows are erupted first in the pahoehoe form the upland parts near the fissure or crater exhibit a larger preponderance of pahoehoe. The level of the ocean at the time the lava flows were deposited controlled to a large extent the quality of the rock that solidified.

The contact of lava flows, one on another is marked by great irregularity occasioned by the broken character of the pre-existing surface and by the chilling and increase in viscosity of the advancing lava. Pahoehoe flows are distinguished by relatively smooth, billowy, ropy or entrail like surfaces. When the viscosity of the molten lava increase and the slope of the terrain decreases, tumuli or pressure domes develop. Transition of pahoehoe to aa goes through a stage called slabby pahoehoe, a rock form commonly found in the slopes above Kalapana and evidenced in the ridge of rock outcropping in the middle of Kaimu beach.

2/ The terms pahoehoe and aa are Hawaiian and are used to classify the surface appearances and structure of lava flow.

The upper part of aa consists of clinker and loose scoriaceous basalt pieces which are generally weathered and produce a soil-rock mixture when excavated. The loose clastic surface layer of aa is open and porous and hence decay has created a residual sediment suitable for embankment and level construction. Dense, hard basalt underlies the clinker-scoriaceous, strippable layer in aa flows which requires ripping to excavate. The hard layer varies in thickness and strength, from closely jointed easily excavatable to thick (up to 15 feet) wide joint spacing (five feet or more) hard rock requiring drilling and blasting. The rock at the three proposed sites is expected to be similar to that found at the Honokahau Small Boat Harbor and the construction experiences will be similar.

EARTHQUAKE HISTORY - SEISMIC STABILITY.

Hawaii has a higher density of earthquakes (occurrence rate of magnitude two and greater earthquakes per unit area) than any other state in the United States. During the past 18 years about 48,000 earthquakes in Hawaii have been located and their magnitude determined. Of these 48,000 earthquakes, more than 3,400 events were of magnitude 3.0 to 7.2; magnitude 3.0 is generally the threshold of felt earthquakes in Hawaii.

The strongest earthquake in historic time in the islands occurred April 2, 1868 and was centered along the south coast of the island of Hawaii. This earthquake had a Richter magnitude of about 7.5 on the island of Hawaii and caused serious damage across the entire island even stopping clocks as far away as Honolulu. The last eruption and lava flows affecting the Puna coastline was in September 1977. During the past 15 years, the island of Hawaii has experienced 11 earthquakes with Richter magnitude ratings of 6 or more. The most recent occurred on 19 November 1975. Earthquakes and volcanic activity can be expected to continue in the Puna district. Practically all earthquakes on the island of Hawaii are associated with intermittent volcanic activity.

The Koae and Hilina block fault systems on the south central flank of Kilauea are closely related to intrusion of magma into two rifts, east and southwest. The faults extend the entire south flank and are characterized by gaping cracks and long, sinuous normal fault zones with north-facing scarps.

Most fractures are 200 meters or longer and arranged in echelon. Fractures dip vertically, strike N.75°E and have dilated in a N.15°W. Average dilation across the entire fault system is about 25 meters and generally increase eastward. The faults are tear-away zone as the south flank is pushed southward by dike injection into the rifts.

The Uniform Building Code and Corps of Engineers Manual 1110-2-1902 assign a zone three seismic risk rating for the Island of Hawaii for design consideration.

SUBSIDENCE

Depression of the shoreline of the island of Hawaii relative to sea level has been observed in the last 200 years through archeological and historical investigations. The rise of the sea level has been documented in a paper titled "The Rise of Sea Level in Contemporary Times at Honaunau, Kona, Hawaii" in Pacific Science, Vol XX, No. 1, January 1966 by Russel A. Apple and Gordon A. MacDonald. Increased depth of water over past land routes, comparisons of old and new photographs, increasing storm damage to structures, and newspaper accounts all indicate a relative sinking of the shore. The rate of change of relative level of land and sea over many parts of the island of Hawaii is much greater than that of worldwide change of sea level, and must be the result of actual sinking of the island. The actual sinking indicated by the shoreline evidence is most likely the result of isostatic adjustment resulting from loading of the earth's crust by the great added mass of the volcanoes. The southern part of the island of Hawaii appears to be sinking isostatically at a rate of about 8 or 9 inches a century.

EXCAVATION - CONSTRUCTION PROBLEMS

Lava basalt in the three proposed harbor sites is variable and unpredictable in physical and chemical properties. Even with detailed investigation which projects of this magnitude cannot justify or support economically, there will be major sources for claimed changes conditions. Investigations to map intraflow and clinker layers and lava tubes are necessary. Ragged and irregular surfaces result from drilling and blasting

lava basalt even with line drilling and controlled blasting methods, both difficult to control and obtain. The history in constructing Honokahau Small Boat Harbor will be repeated if any of the three sites reach the construction stage. A first phase for design consideration will be a thorough review of the records for Honokahau.

SECTION 2: DEEP DRAFT NAVIGATION

There is a dearth of data regarding the geological conditions in and around Hilo Harbor. The majority of geological data is based on findings gathered during the investigations for the construction of the breakwater expansion on Blonde Reef and periodic dredging of the navigation channel of Hilo Harbor.

GEOLOGICAL DESCRIPTION OF HILO AREA

Regional Geology

The island of Hawaii, the largest of the Hawaiian Archipelago, covers an area of over 4,000 square miles. The island was formed during the last 800,000 years by the gradual emergence and subsequent coalescence of five volcanoes; Mauna Loa and Kilauea, which are still active, Hualalai, which last erupted in 1801, Mauna Kea, which has been inactive in recent geologic time, and Kohala, which has been extinct for eons.

The volcanic mountains are generally oval and dome-shaped. Mauna Loa is 75 miles long and 64 miles wide, rising from a base 15,000 feet below sea level to 13,680 feet above sea level. It is the largest active volcano and is considered the biggest single mountain on earth. Its volume is about 10,000 cubic miles. Mauna Kea is 50 miles long and 25 miles wide. Its volume is about 7500 cubic miles. These huge mountains have been formed almost entirely by the accumulation of thousands of thin flows of lava, each separate flow averaging less than ten feet in thickness. The broad, smooth, dome shapes have given rise to the name of "shield" volcanoes. Nowhere are the lower slopes of the mountains steeper than twelve degrees with the average slope around six degrees. Gentle, flat slopes extend outward beneath the water to the sea floor.

Site Geology

The city of Hilo and the breakwater are located where the lower slopes of Mauna Loa and Mauna Kea merge. The surface of the ground in

Hilo, Waiakea District, has a gentle, flat slope northward toward an of one foot in 400 feet, or less than one degree.

Hilo Bay is a broad indentation in the northeastern coastline of the island, created by the Hamakua volcanic series of Mauna Kea and the Ka'u volcanic series of Mauna Loa. Recent scoriaceous, black lava flows from Mauna Loa have formed the entire central and southern half of the Bay. Older flows from Mauna Kea have made vertical, high, wave-cut cliffs along the north side of the Bay. The existing breakwater structure is built on a coral-limestone reef over lava. Marine sediments consisting of fine and medium grained sand and silt from volcanic sources interspersed with fragments of coral limestone, cover the narrow beach and form the ocean floor in shallow water.

The area north of Wailuku River consists of Mauna Kea's Hamakua volcanic series. This series is a permeable basalt, enveloped by an overlying Pahala ash layer (up to 25 feet thick) and its derivative soil, resulting in a surface far less permeable than normal for exposed basalts. As a result, surface runoff from this area is substantial and flow in the Wailuku River, which originates on the ash-covered surface, averages several hundred million gallons per day. Slopes on the Mauna Kea surface are moderately steep, averaging 0.05 to 0.10, and are incised by numerous small streams.

East of Wailuku River, the surface rocks consist of the Kau volcanic series of Mauna Loa, an extremely permeable basalt that is too recent in origin to have had formed a deep soil and saprolite top layer. Patches of Pahala ash lie on some older Mauna Loa lavas near the Wailuku River but are insignificant in contrast to the wide extent of bare Kau lava over the remainder of the study area.

The Ka'u series, which erupted from Mauna Loa following the main deposition of Pahala ash, is relatively thin in section, perhaps 25 feet thick in the Hilo region. Beneath the ash is the initial Mauna Loa basalt formation--the Kahuku series--also extraordinarily permeable. The result of permeable surface and subsurface formations, even though a discontinuous strata of ash lies between them, is a lack of appreciable surface runoff

South Hilo, Waiakea District, has a gentle, flat slope northward toward the ocean of one foot in 400 feet, or less than one degree.

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and the occurrence of high infiltration and subsurface flow rates. Also contributing to the large infiltration rates are low slopes of Kau volcanics over much of the region, varying from 0.005 to 0.05.

The island of Hawaii is too young to have drowned valleys and a coastal plain formed of land and marine sediments (cap rock), as is typical of the older islands of the Hawaiian chain. Streams cut in fresh rock and the coasts consist of bare lava, sometimes bordered by small banks of coral offshore.

HISTORICAL DATA

The following is a summary of past geological investigations in the area of Hilo Bay (Harbor):

1. U.S. Corps of Engineers: Wash Borings, Kuhio Bay, May 1923; A.H. Hobart (see Figure E-1).

   The borings, taken in 1923 in the Kuhio Bay area indicates that Blonde Reef is composed of coraline matter to a depth of at least 36 feet. (See Boring Log Number 14 and 15.)

   Basaltic outcrop (pahoehoe) was found beneath 5 to 15 feet of coraline material, just offshore of the Waiakea Peninsula. (See Boring Log Number 8 and 10.)

   Coraline material was found in the area of what is now the navigation channel within Hilo Harbor. (See Boring Log Number 1, 5, 6, and 7.)

2. U.S. Corps of Engineers: Geology and Explorations, Hilo Tsunami Protection Project, Hawaii. (See Figures E-2 and E-3).

   Boring made in 1967 for the Puhi Land Dike indicated Blonde Reef to be generally composed of corraline matter lying on top of a mixture of silt, sand and gravel. (See Boring Log Number B-11, B-12 and B-13.)

   Closer to shore near Cocoanut Island, fractured basalt was found at elevation of -30 feet. (See Boring Log Number B-14.)

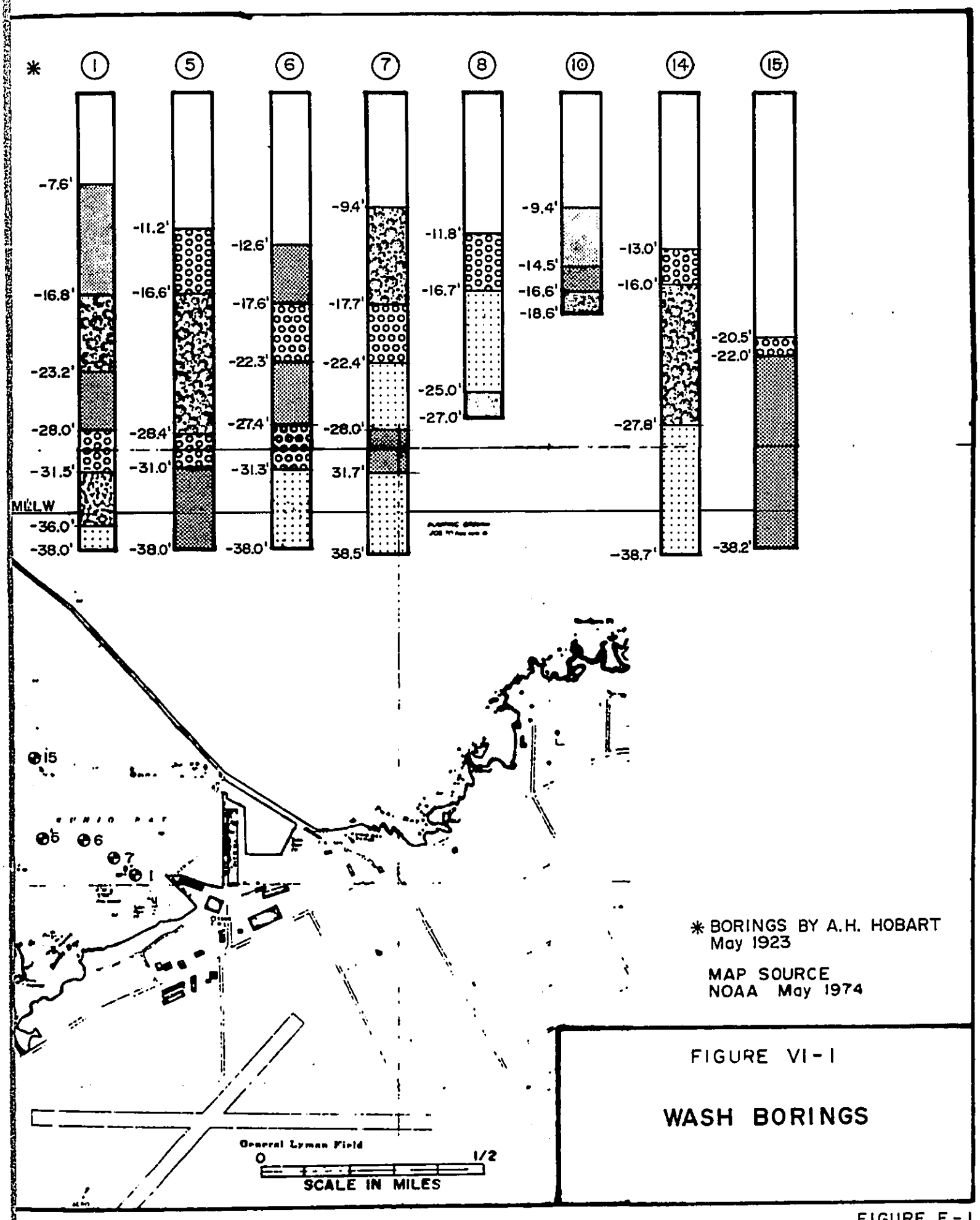
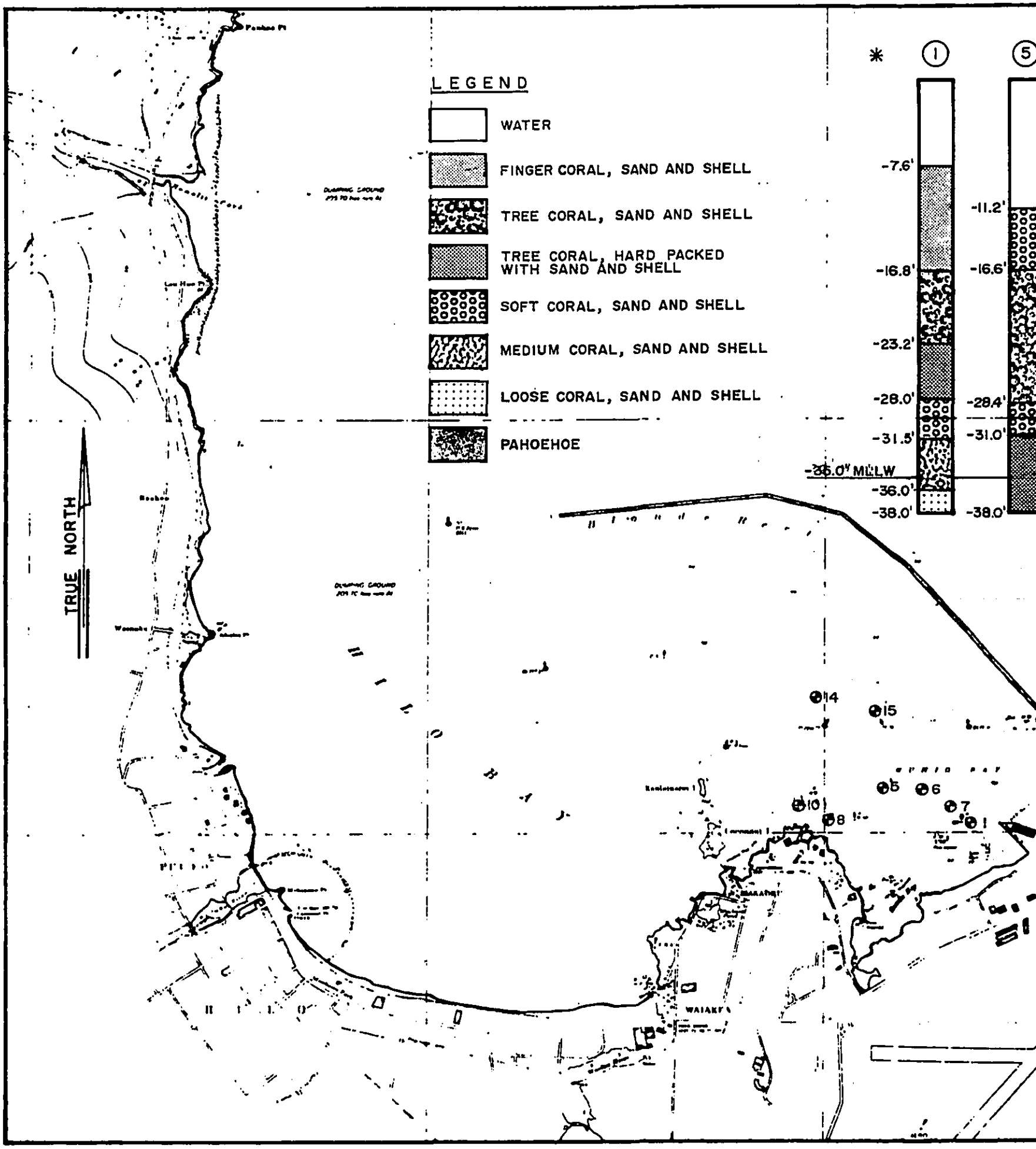


FIGURE VI-1

WASH BORINGS

FIGURE E-1


LEGEND
WATER
FINGER CORAL, SAND AND SHELL
TREE CORAL, SAND AND SHELL
TREE CORAL, HARD PACKED WITH SAND AND SHELL
SOFT CORAL, SAND AND SHELL
MEDIUM CORAL, SAND AND SHELL
LOOSE CORAL, SAND AND SHELL
PAHOEHOE
TRUE NORTH
-7.6'
-16.8'
-23.2'
-28.0'
-31.5'
-36.0' MLLW
-36.0'
-38.0'
-11.2'
-16.6'
-28.4'
-31.0'
-38.0'
14
15
5
6
7
10
8
1
WAIAKEA

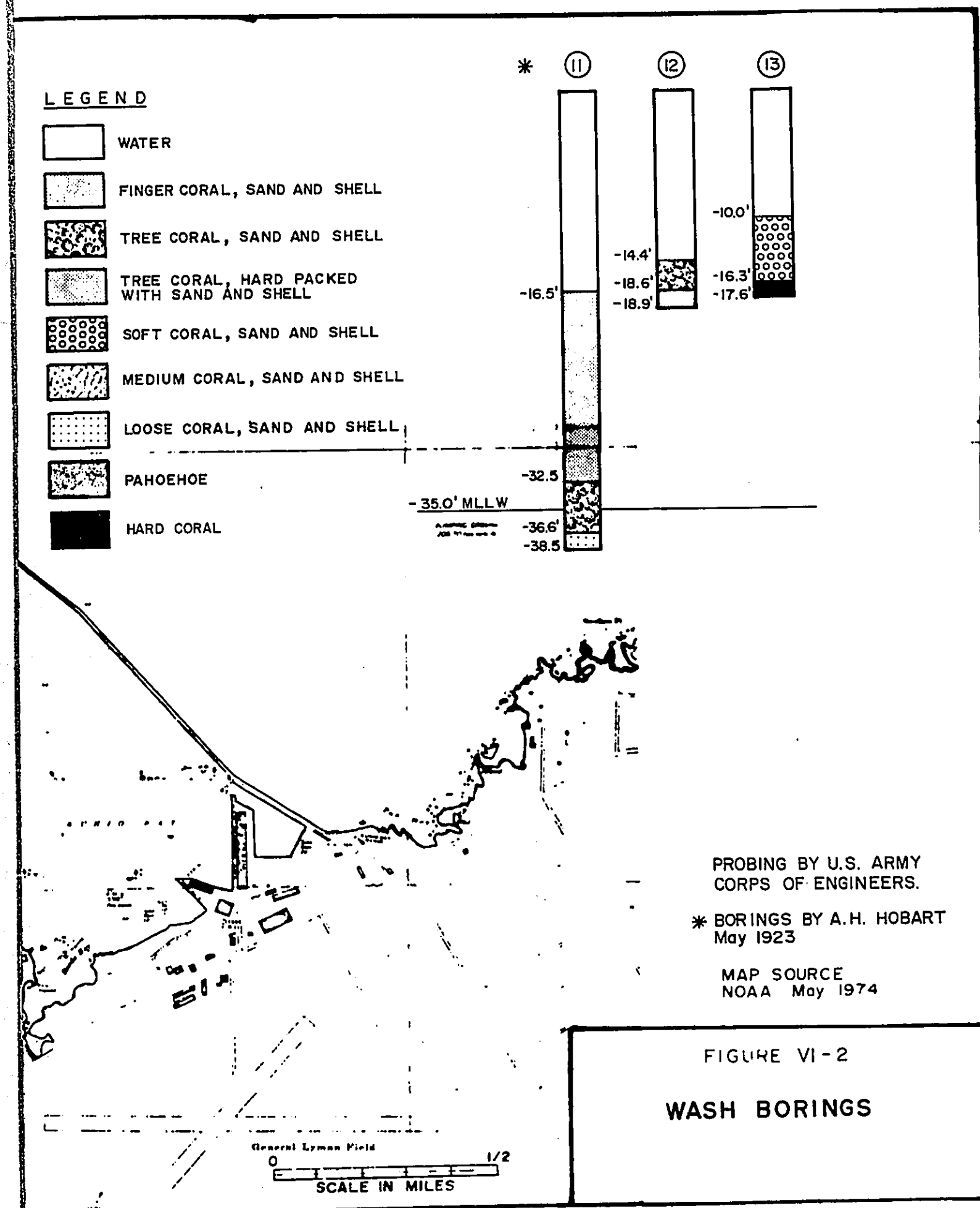
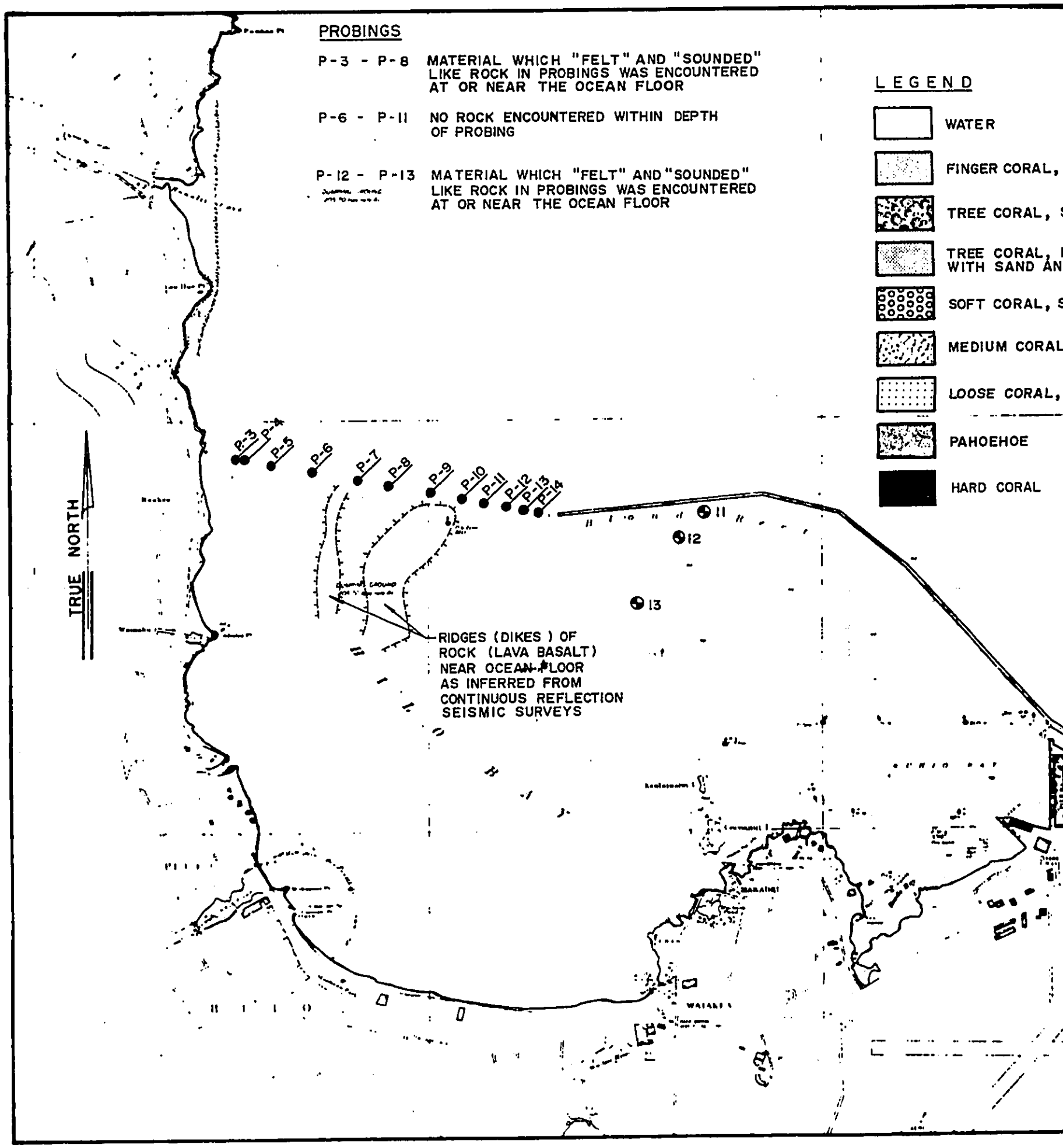
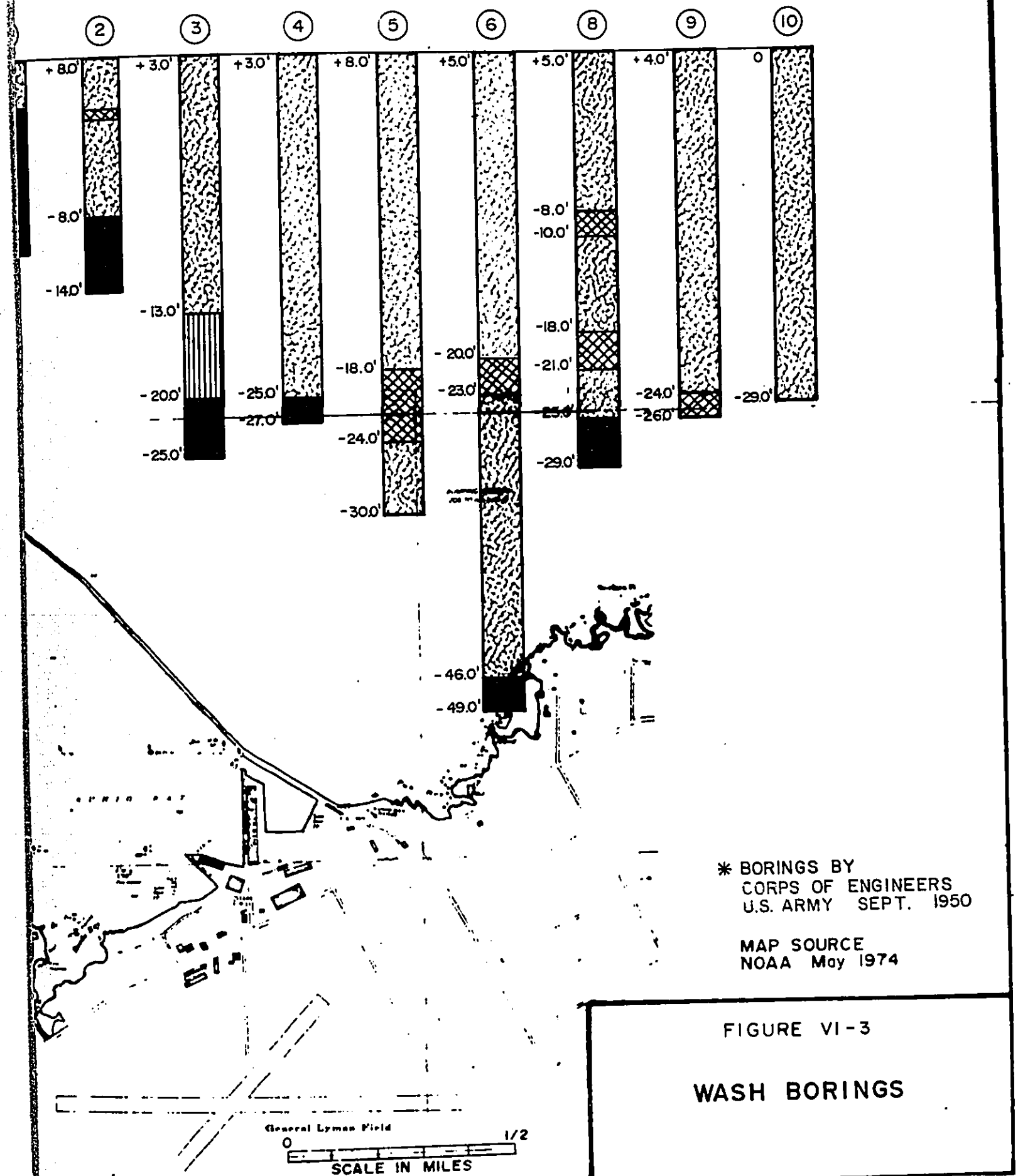


FIGURE VI-2

WASH BORINGS

FIGURE E-2


PROBINGS
P-3 - P-8 MATERIAL WHICH "FELT" AND "SOUNDED" LIKE ROCK IN PROBINGS WAS ENCOUNTERED AT OR NEAR THE OCEAN FLOOR
P-6 - P-11 NO ROCK ENCOUNTERED WITHIN DEPTH OF PROBING
P-12 - P-13 MATERIAL WHICH "FELT" AND "SOUNDED" LIKE ROCK IN PROBINGS WAS ENCOUNTERED AT OR NEAR THE OCEAN FLOOR
LEGEND
WATER
FINGER CORAL,
TREE CORAL,
TREE CORAL,
WITH SAND AN
SOFT CORAL,
MEDIUM CORAL
LOOSE CORAL,
PAHOEHOE
HARD CORAL
TRUE NORTH
P-3
P-4
P-5
P-6
P-7
P-8
P-9
P-10
P-11
P-12
P-13
P-14
11
12
13
RIDGES (DIKES) OF ROCK (LAVA BASALT) NEAR OCEAN FLOOR AS INFERRED FROM CONTINUOUS REFLECTION SEISMIC SURVEYS



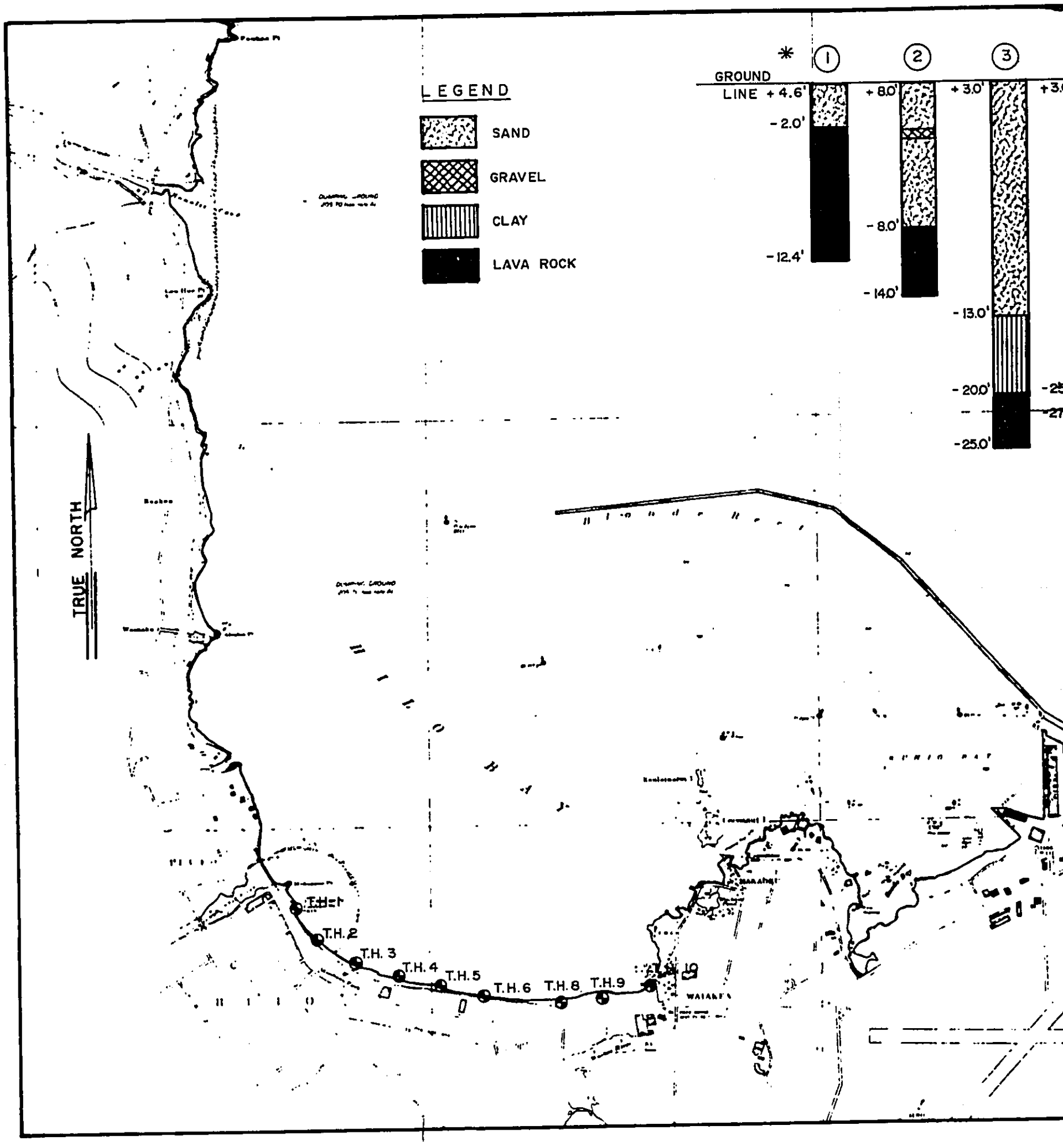
* BORINGS BY
CORPS OF ENGINEERS
U.S. ARMY SEPT. 1950

MAP SOURCE
NOAA May 1974

FIGURE VI-3

WASH BORINGS

FIGURE E-3


LEGEND
SAND
GRAVEL
CLAY
LAVA ROCK
TRUE NORTH
GROUND LINE
+4.6'
-2.0'
-12.4'
+8.0'
-8.0'
-14.0'
+3.0'
-13.0'
-20.0'
-25.0'
T.H. 1
T.H. 2
T.H. 3
T.H. 4
T.H. 5
T.H. 6
T.H. 8
T.H. 9
T.H. 10

Probing of the harbor entrance was made in 1965 using a 2-inch diameter open-end pipe. The eastern half of the harbor entrance was found to be composed of at least 5 feet of "soft" material while the bottom of the western portion was found to be "rock". Ridges of lava, positioned in a north-south direction were also found near the entrance of the harbor.

Boring along the Bay front (between the Wailuku and Wailoa Rivers) were taken in 1950. Sand deposits were found to a depth ranging from elevation (-)40 feet. Basalt rock was found beneath the deposits.

3. Ocean Innovators: Hilo Sand Survey, December 1979.

This investigation was conducted with the intent of locating a source of black sand for beach replenishment. The investigator's findings are noted:

a) The sediment located between the Wailoa and Wailuku Rivers to a depth of 20 to 25 feet was black mud and very fine sand.

b) The ocean floor of an area extending radially out to about 1400 feet from the mouth of the Wailuku River was found to be composed of lava boulders, rocks, pebbles, gravel and black sand varying from very coarse to fine. The thickness of the sand layer varied from 0.5 feet to 5 feet.

Just beyond the above mentioned area in 20 to 25 feet depth of water, a sand deposit, about 100 yards wide, 25 feet thick, was found. It was estimated that about 450,000 cubic yards of black sand were available as source of beach nourishment.

The region beyond this sand deposit was found to contain black mud.

(c) Sand deposits were also found off Alealea Point in 17 to 30 feet depth of water.

4. Historical Point Source Discharges:

Point source discharges into Hilo Harbor have influenced the geological character of the bay. Process wastewater from sugar mills have discharged tons of silt and organic solids (debris) into the harbor. Industrial plants (canec, gas petroleum) which discharged waste flows into the harbor have to some extent altered the geological structure.

FIELD INVESTIGATION

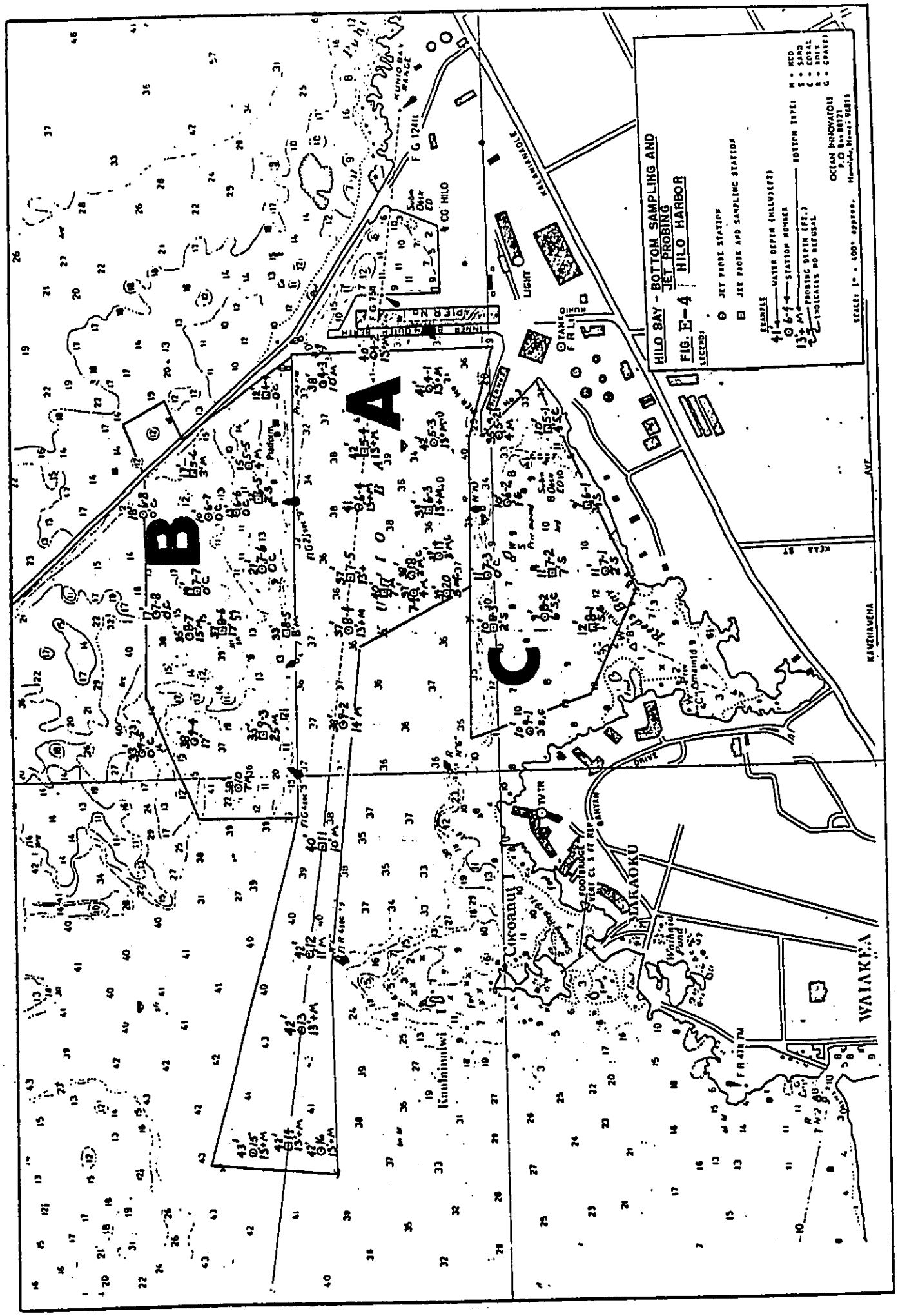
Field investigations to document the geological character of the substrata of Hilo Harbor were conducted as part of a study conducted in October 1980 by M&E Pacific for the Corps. The results of the field studies will be used, not only for purposes of describing the geological character of the substrata of Hilo Harbor, but also, among others, for purposes of assessing possible impacts of future construction projects within the harbor.

Station Locations

The areas of interest within the harbor are segmented into subareas roughly corresponding with the proposed construction activities. These subareas are identified as areas A, B, C and D.

1. Inner Harbor

In order to determine the nature and quality of the bottom in Hilo Harbor, probing and sampling stations were located about 500 feet apart in the specified sampling areas. (See Figure E-4). These stations were assigned a hyphenated number corresponding to the transect number and the successive station along that transects, which runs in a northly direction; i.e., station number 6-4 refers to the fourth station along transect #6 starting from the south. The results of the transect probes indicated that additional stations (10 through


HILO BAY - BOTTOM SAMPLING AND JET PROBING
FIG. E-4 HILO HARBOR
LEGEND:
JET PROBE STATION
JET PROBE AND SAMPLING STATION
OCEAN INNOVATORS
A
B
C
Cocoanut I
MAKAOKU
WAIAKEA
KAMEHAMEHA
KEAA ST
DRIVE
KALANIANAOLE
LIGHT
CG HILO
Kaulainaiwi

20) need to be established in order to assess the outer reaches of area A.

2. Outer Harbor

For the Outer Harbor sand deposit investigations, which were to define the quality and extent of a submarine black sand deposit, two transects (#1 and #2) were layed out along Alealea Point (see Figure E-5). Transect #3 was set down in a northerly direction after the results of the jet probes and samples from transects #1 and #2 were analyzed.

Results of the Bottom Sampling Investigations

The results and conclusions are stated according to area. Table E-1 lists each jet probing station showing the area in which the station is located, depth of water, and general description of what was found at the bottom.

Area A. The majority of stations in this area revealed that the bottom consists mainly of mud (sediments in the silt clay range) in thicknesses greater than 13 feet. Relatively thin sediment in Area A was found at station 7-4; here only 4 feet of mud was found to exist over a probable coral gravel bottom. Several additional probes were later completed in the vicinity of station 7-4, stations 17 through 20, all revealing 3 to 7 feet of mud overlying a crunchy but solid bottom.

Area B. This area is essentially the southeast portion of Blonde Reef inside the breakwater.

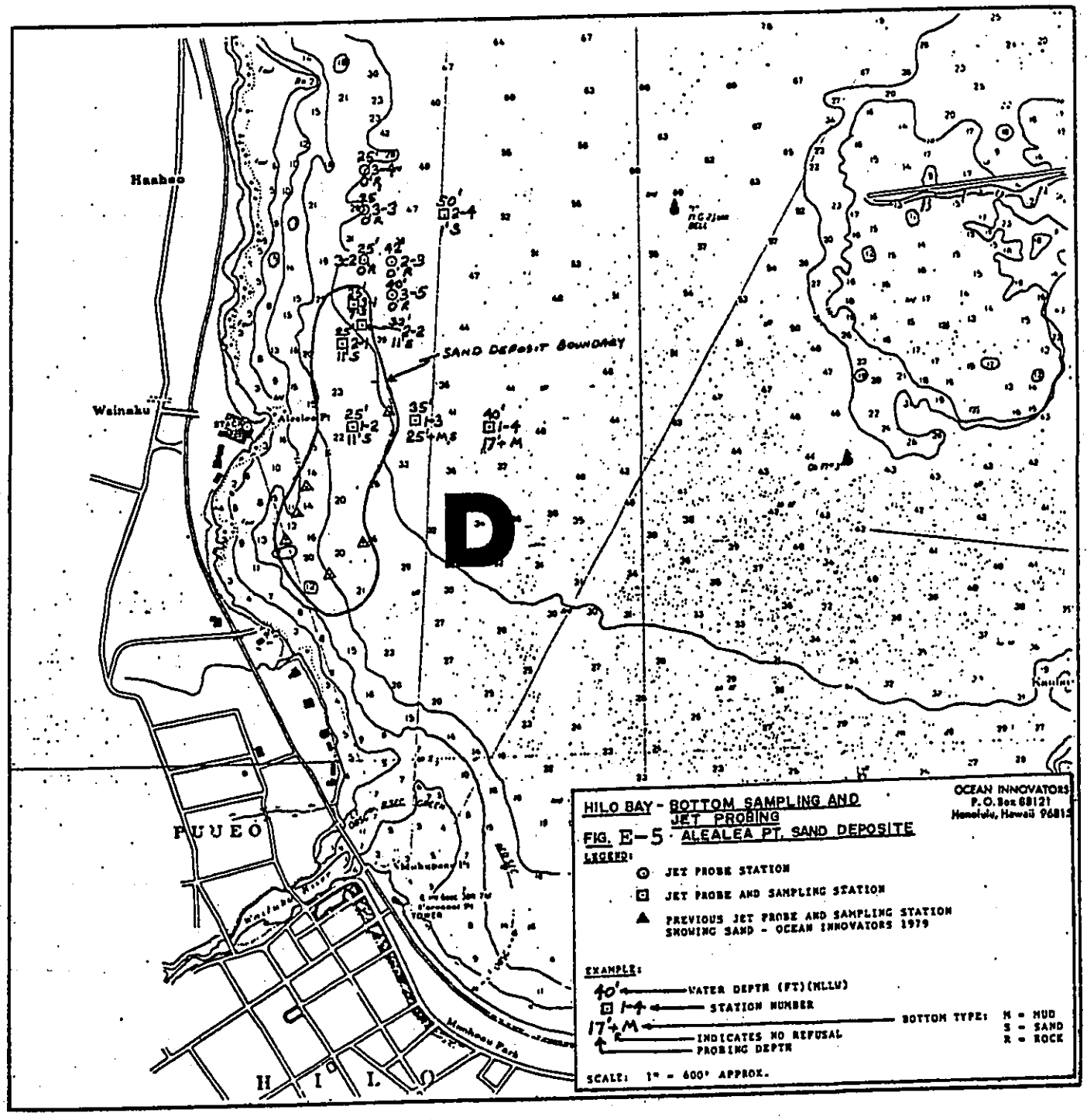

Haaheo
Wainaku
Alealea Pt
SAND DEPOSIT BOUNDARY
D
PUUEO
H I L O
Munhoau Park
OCEAN INNOVATORS
P.O. Box 88121
Honolulu, Hawaii 96815
HILO BAY - BOTTOM SAMPLING AND JET PROBING
FIG. E-5 · ALEALEA PT. SAND DEPOSITE
LEGEND:
JET PROBE STATION
JET PROBE AND SAMPLING STATION
PREVIOUS JET PROBE AND SAMPLING STATION SHOWING SAND - OCEAN INNOVATORS 1979
EXAMPLE:
40' WATER DEPTH (FT)(MLLW)
1-4 STATION NUMBER
17'+M INDICATES NO REFUSAL
PROBING DEPTH
BOTTOM TYPE: M = MUD S = SAND R = ROCK
SCALE: 1" = 600' APPROX.

TABLE E-1

JET PROBING LOG - HILO HARBOR

STATION NUMBER	AREA	WATER DEPTH (FEET)	PROBING DEPTH (FEET)	TYPE OF REFUSAL	COMMENTS	SAMPLE NUMBER
4-1	A	41	13	None	Slight crunchy layer at 10 feet	None
4-2	A	40	13	Seizing	Close to wharf	None
4-3	A	38	10	Crunchy	Crunchy layer at 7', coral fragments in wash	None
4-4	B	12	0	Hard	Scattered coral rubble, lava boulders, some sand	4-4-S
5-1	C	10	4	Hard	Surface is 50% lava cobbles, 50% sand and gravel	5-1-S
5-2	C	35	4	Crunchy	2 probes	None
5-3	A	43	13	None	black mud	None
5-4	A	42	13	None	Black mud, composit sample from first 3 feet	5-4-C
5-5	B	15	4	Crunchy	Mud overlying coral rubble	None
5-6	B	17	3	Crunchy	Mud overlying coral rubble	5-6-S, 5-6-W wash from 4' down
6-1	C	9	4	Crunchy	Fine white sand	6-1-S
6-2	C	10	1.5	Crunchy	Coral gravel over rubble, 3 probes	None
6-3	A	39	13	None	Brown/black mud	6-3-S
6-4	A	41	13	None	Mud	None
6-5	B	12	2	Crunchy	Fine sand overlying coral rubble Some coral heads on surface	6-5-S
6-6	B	13	0	Hard	Coral reef	6-6-S
6-7	B	10	0	Hard	Dead coral and coral rubble	None
6-8	B	18	0	Hard	Coral rubble, live coral heads	6-8-S
7-1	C	11	2	Hard	White sand	None
7-2	C	11	7	Hard	Fine brown sand	7-2-S
7-3	C	11	0	Hard	Coral rubble	None
7-4	A	37	4	Crunchy	Mud with coral head or rock protruding	None
7-5	A	37	13	None	Brown/black mud	7-5-S
7-6	B	21	0	Hard	Coral heads on coral rubble	None
7-7	B	19	0	Hard	Live coral, abundant	7-7-S
7-8	B	17	0	Hard	Live coral on coral rubble	None

TABLE E-1 (cont.)

JET PROBING LOG - HILO HARBOR

STATION NUMBER	AREA	WATER DEPTH (FEET)	PROBING DEPTH (FEET)	TYPE OF REFUSAL	COMMENTS	SAMPLE NUMBER
8-1	C	12	1	Hard	Sand, gravel	8-1-S
8-2	C	9	6	Hard	Coral rubble over sand and gravel	None
8-3	C	9	2	Hard	Sand, gravel	8-3-S
8-4	A	37	13	None	Mud	None
8-5	B	33	8	Hard	Mud, probe 10' from coral reef	8-5-S
8-6	B	37	17	Seizing	Mud	8-6-S, 8-6-W
8-7	B	35	15	Seizing	Mud	None
9-1	C	10	3	Crunchy	Sand and gravel over rubble	None
9-2	A	38	14	Hard	Mud	None
9-3	B	35	25	Crunchy	Brown mud	9-3-W
9-4	B	38	17	Hard	Mud	None
9-5	B	33	0	Hard	Very thin layer of silt over coral reef	None
10	B	38	7	Crunchy	Rocks protruding from rocks	None
11	A	40	10	Hard	Brown Mud	11-S
12	A	42	11	Hard	Mud	None
13	A	42	13	None	Mud	None
14	A	42	13	None	Black Mud	14-S
15	A	43	13	None	Mud	None
16	A	42	13	None	Mud	None
17	A	40	7	Crunchy	2 feet of mud over gravel	17-W
18	A	38	3	Crunchy	Mud with scattered coral formations on surface	None
19	A	13	3	Crunchy	same as above	
20	A	39	5	Crunchy	same as above	

TABLE E-1 (cont.)

JET PROBING LOG - HILO HARBOR

STATION NUMBER	AREA	WATER DEPTH (FEET)	PROBING DEPTH (FEET)	TYPE OF REFUSAL	COMMENTS	SAMPLE NUMBER
1-2	D	25	18	Hard	Medium to fine black sand	1-2-S, 1-2-W
1-3	D	35	25	None	Very fine black sand and mud	1-3-S
1-4	D	40	17	None	Black mud	1-4-S
2-1	D	25	11	Hard	Medium black sand and mud layered	2-1-S, 2-1-W
2-2	D	32	11	Hard	Medium to fine black sand	2-2-S, 2-2-W
2-3	D	42	0	Hard	Basalt rock	None
2-4	D	50	1	Hard	Coarse black sand with some calcareous content	2-4-S
3-1	D	25	7	Hard	Coarse to medium black sand	3-1-S, 3-1-W
3-2	D	25	0	Hard	Basalt rock	None
3-3	D	25	0	Hard	Basalt rock	None
3-4	D	25	0	Hard	Basalt rock	None
3-5	D	40	0	Hard	Basalt rock	None

This area is shown to be a coral reef covered partially by thin sediment (2 to 4 feet) over a gravel or coral rubble bottom. Results of stations 4-4, 5-5, 6-5, 6-6 and 7-6 show the reef flat is exposed in some portions and is covered by scattered lava boulders, live coral heads and coral rubble.

Area C. This zone includes the area west of Pier 2 adjacent to Bakers Beach and outside of Reeds Bay at the south end of the harbor. There is up to 7 feet of sand,silt,and gravel covering an apparent coral reef.

Area D. Rough sea conditions are common in this area. This survey showed little or no usable sand existing seaward of the boundary of the sand deposit as defined in the 1979 Ocean Innovators report. Thick sediments of mud mixed with fine sand occur at the 35 feet level with the mud content increasing toward the 40 foot depth where pure mud is encountered. The transects north from Alealea Point showed that the sand deposit stretches for about 1200 feet north of the point with sand thicknesses diminishing from 11 to 7 feet. A revised sketch of the estimated boundaries of the sand deposit is shown on Figure E-5. Since no data points could be collected inshore of the 25 foot contour due to heavy wave action, the inner boundary of the deposit is not certain. Based on this new outline of the deposit it is estimated that about 775,000 cubic yards of black sand exists in this area

which has a quality (similar in size distribution and organic content) that appears suitable for beach replenishment purposes. However, only a very small portion of the sand deposit exists in water depths of 30 feet or more and beyond 1000 feet from shore, thus making its recovery questionable from a legal standpoint.

RESULTS OF ANALYSIS OF SEDIMENT SAMPLES

Sediment samples of Hilo Harbor were analyzed with results shown in Table E-2. The sampling stations are shown on Figure E-6.

Chemical Analyses

Generally, negative values of oxidation-reduction potential (ORP) were measured in the deep, mud/silt layer of Hilo Harbor, while positive values of ORP were noted in areas of sand substratum. There was one instance where a positive ORP reading in the mud sediment (Station A-11) was recorded. This deviation may be an artifact due to analytical error.

Negative ORP values in the mud-laden areas of Hilo Bay are indicative of anaerobic conditions within the mud sediment layer and that sulfide production could be occurring. This is considered to be typical. For example, investigations of the dredging of the Ala Wai Canal showed not only negative ORP readings but also an exertion of an oxygen demand.

Higher values of total Kjeldahl nitrogen were found in the sediment sample containing mud compared to sediment samples of sand and coralline matter. This is expected and attributable to a higher organic content in the mud sediment.

Correspondingly, higher values of phosphorus were found in sediments containing mud. An average value of 0.088 mg/gm phosphorus was found compared to 0.052 mg/gm phosphorus in the sand.

The values of nitrogen and phosphorus shown in Table E-2 provide an indication of the potential for release of nutrients to the water column.

Sediment analysis for other coastal waters were evaluated. A comparison is shown in Table E-3.

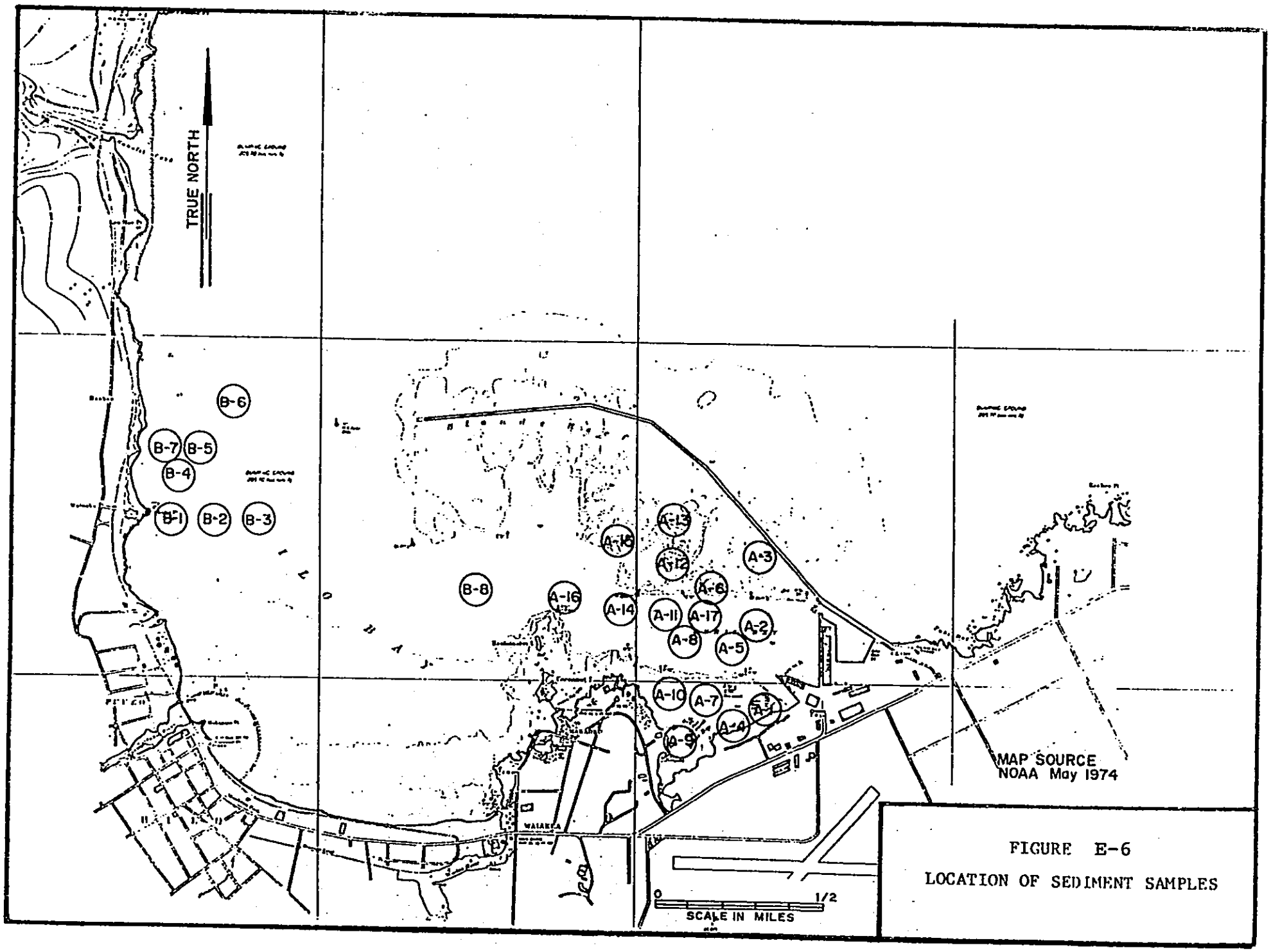


FIGURE E-6

LOCATION OF SEDIMENT SAMPLES

TABLE E-2

ANALYSIS OF SEDIMENT SAMPLES

March 17 - 22, 1980

Station	Depth of Water in feet	Type of Sediment	Oxidation-Reduction Potential (millivolts)	Total Kjeldahl Nitrogen (mg/gm)	Total Phosphorus (mg/gm)
Inner Harbor					
A-1-S	10	Lava cobbles, sand, and gravel		0.56	0.054
A-2-S	42	Mud		1.64	0.087
A-3-S	17	Mud/coral		2.69	0.112
A-4-S	9	White sand		0.19	0.032
A-5-S	39	Mud		2.23	0.095
A-6-S	12	Sand		2.64	0.093
A-7	11	Sand		0.55	0.073
A-8-S	37	Mud		2.75	0.101
A-9-S	12	Sand/gravel		0.63	0.083
A-10-S	9	Sand/gravel		0.32	0.035
A-11	37	Mud	+25		
A-12-S	33	Mud		2.09	0.087
A-13-S	37	Mud	-50	1.38	0.083
A-13-W		Mud		1.56	0.096
A-14	38	Mud	-200		
A-15	35	Mud	-200		
A-16-S	40	Mud	-200	2.12	0.074
A-17	40	Mud overlying gravel	-250		
Outer Harbor					
B-1	25	Black sand	+50		
B-2-S	35	Fine sand and mud	-200	1.42	0.045
B-3-S		Mud		1.64	0.061
B-4-S	25	Black sand and mud layered	-225	2.03	0.054
B-5-S	32	Sand	-100	1.04	0.037
B-6-S		Black sand with some calcareous content		0.27	0.021
B-7	25	Black sand	+25		
B-8	42	Mud	-225		

TABLE E-3

NUTRIENT ANALYSES OF SEDIMENT
FOR SELECTED HAWAIIAN COASTAL AREAS

Concentrations in mg/gm dry

Location	Land Use	Total Nitrogen	Total Phosphorus
Kahana Bay[a)]	Undeveloped	0.299	0.434
Maunalua Bay[a)]	Urban	0.712	0.607
Waikiki[a)]	Urban	0.324	0.515
Kilauea[a)] (Kauai)	Agriculture	0.235	0.414
Hilo Harbor[b)]	Urban-Agriculture	1.46	0.070
Inner Harbor[b)]	Urban-Agriculture	1.52	0.079
Outer Harbor[b)]	Urban-Agriculture	1.28	0.044

a) Source: Water Resources Research Center, The Quality of Coastal Waters: Second Annual Progress Report, Technical Report No. 77, September 1973.

b) This Study, 1980.

Nitrogen values were notably higher in Hilo Harbor than the other four locations, even those measured in the sediment fronting the agricultural lands of the Kilauea (Kauai) Plantation which have had nitrogen application as fertilizer.

In contrast, the total phosphorus concentrations found in the Hilo Bay sample were substantially lower in comparison to the other locations by an order of 10. It should also be noted that the total phosphorus concentrations in the outer harbor were lower than the inner harbor.

Particle Size of Sediment

For purposes of discussion, particle size of sediment can be separated into two classifications: coarse sand and fine sand. Coarse sand is defined as sediment greater than 0.063 mm, while particle sizes equal to and less than 0.063 mm are considered fine (silt-clay) sediments. See Table E-4 for sediment size distribution for Hilo Harbor.

Majority of the samples taken in the inner harbor are composed predominantly of fine particles, with about 75 percent of the sediment composed of silt-clay. According to the results of the jet probings (see Table E-1), the sediment layer is mostly mud over gravel with scattered coral formations. Majority of samples exhibiting high percentage of silt-clay were taken in the navigation channel where quiescent conditions generally exist. The source of sediment is the river discharge.

Particle sizes of sediment taken on Blonde Reef vary considerably. Some samples contain over 70 percent silt-clay, while other samples exhibit a more even distribution between coarse and fine. Since Blonde Reef is characterized by sparse coral, gravel, and mud overlying gravel.

In the area off Baker's Beach, turbulent conditions from wave action appears to erode the sand into the Reeds Bay. Most of the sediment samples taken in this area was found to contain a high percentage of coarse particles (50 percent of their particle sizes larger than 2.00 mm). Only one sample, located just offshore of the beach, was predominantly fine white sand, resulting in an 80 percent of "fines."

TABLE E-4

HILO BAY SEDIMENTS SIZE DISTRIBUTION

Station	Percent by Weight							
	Coarse Size (mm)							Fine
	> 4.00	2.00-4.00	1.00-2.00	.500-1.00	.250-.500	1.25-.250	.063-.125	≤0.063
Inner Harbor								
A-1-S	29.8	17.4	14.5	11.2	7.1	5.5	3.6	10.9
A-2-S	0.3	0.4	0.7	1.4	2.1	7.9	10.1	77.2
A-3-S	-	0.1	0.2	0.6	0.6	10.0	6.2	82.3
A-4-S	0.1	0.1	0.3	1.1	1.4	16.6	74.0	6.4
A-5-S	0.2	0.3	0.5	0.8	1.9	5.7	6.4	84.3
A-6-S	0.1	0.1	0.2	0.3	2.5	14.3	11.6	70.9
A-7	8.1	13.2	14.9	10.2	3.4	5.1	17.8	27.3
A-8-S	-	0.1	0.2	3.8	3.0	5.2	6.2	81.5
A-9-S	19.8	19.1	16.7	12.8	7.3	5.3	3.2	15.8
A-10-S	50.9	12.3	17.0	13.2	2.5	1.5	0.8	1.8
A-12-S	12.3	4.8	3.5	2.9	3.5	11.0	14.8	47.3
A-13-W	0.1	0.1	2.7	3.8	2.5	4.8	3.9	82.0
A-16-S	7.2	3.8	5.0	4.1	2.3	4.0	4.7	69.0
Outer Harbor								
B-2-S	0.1	0.1	0.1	0.2	0.5	14.3	43.1	41.8
B-3-S	0.2	0.4	0.6	1.4	4.0	16.0	36.0	41.4
B-4-S	0.2	0.4	6.8	20.5	20.7	17.7	15.0	18.6
B-5-S	0.1	0.1	13.0	29.1	26.8	26.8	0.6	3.6
B-6-S	1.1	2.5	7.5	33.6	47.6	6.9	0.3	0.5
B-8	0.3	0.8	3.1	3.4	3.9	7.0	8.9	72.6

Refer to Figure VI-6 for station locations

The area off Alealea Point (outer harbor) was sampled to determine the location and expanse of a black sand deposit for the proposed Black Sand Beach restoration project. Of the five samples taken, two samples contained a high percentage of coarse particles, in the 0.250 mm to 1.00 mm range. The remaining three samples were comprised mostly of fine sediment ranging from less than 0.63 mm to 0.125 mm. At one station located within the sand deposit boundary (see Figure E-5), 45.1 percent was fine particles and 54.9 percent were larger than 0.125 mm. This sample could be representative of the type of sand located for the Black Sand Beach restoration project.

DISCUSSION ON GEOLOGICAL INVESTIGATIONS

The Probable Impact of Dredging and Filling in the Harbor Basin Area

The dredging activity of the mud sediment in Hilo Harbor by suction dredge should create excessive turbidity of the waters. However, the method selected in conveying the spoils would also determine the degree resultant of turbidity in the water column. For example, use of the "overflow" method, where the sediment is collected into a holding tank (barge) and the supernatant is discharged back into the water, would result in a high degree of localized turbidity of the water column. In contrast, a "closed" method, where the slurry is totally contained, would result in a more effective control of turbidity in the harbor.

Potential for odors during dredging operations are anticipated to be localized and insignificant. Sulfide will be mainly in the ionized state due to the relatively high pH values of sea water.

Usefulness of Dredged Material

The use of silty dredged material from Hilo Harbor as a resource-recovery application has several constraints. The high saline content limits its use for agriculture. Further, based on reports on the dredging of the Ala Wai Canal, the soil texture was not conducive as a soil conditioner.

Also, there is a potential for noxious odors to develop from the dredged materials when applied or stored to the land. Rain water would lower the pH value of the dredged mass, and result in equilibrium shift of the sulfide from the ionized state to the unionized state (hydrogen sulfide) where release of the gaseous sulfide could occur at a rate sufficient to cause odors.

Leaching contaminants (such as heavy metals) could pose problems or limit the use of the dredged material.

Sand Mining Operations

As reported by Ocean Innovators, sand deposit were discovered offshore of Alealea Point. However, legal restrictions and the high wave conditions encountered may limit the full recovery of this deposit.

Another, although small, sand deposit was found offshore from the mouth of the Wailuku River.

Sediment Transport

The major amount of sediment that enters Hilo Harbor comes from the Wailuku River. The sediment load affects the surface layer by impacting turbidity. Much of this sediment would settle out of suspension before it reaches the mouth of the Harbor (except possibly during periods of intense river discharge). In examining the water quality data for March 18, 1980, suspended solids levels in the surface layer tend to decrease with distance from the mouth of the Wailuku River. This suggests that the solids carried in the discharge of the Wailuku River could be settling (perhaps by flocculation) as it flows outward of the Harbor.

The major factor which affects the settling rate of these suspended solids is turbulence, which in turn is affected by wind, tide, and wave action. The peculiarity of Hilo Harbor is the strongly stratified surface layer that exist from the input of large discharges of freshwater into the harbor. The fact that the stratification persists shows that energy input from the natural elements is insufficient to cause verticle mixing against the density gradient of the two layered system. It further means that quiescent conditions exist sufficiently to allow sedimentation to occur in the harbor.

The effect of wind in Hilo Harbor causes the upper one-third of the surface layer to flow generally in the direction of the wind while causing a countercurrent flow in the lower layer.
The direction of sediment transport in this surface layer would be transported by the wind influences. Also, the wind can have the effect of impeding the flow of the surface layer, pushing it further into the harbor eventually displacing the bottom layer. This will cause a wave in the thermocline (density gradient) causing the bottom layer to rise in another section of the harbor. This effect is similar to spring turnover in lakes. This can cause the disposition of sediment further into the harbor than would normally occur. Moreover, the deposited sediments of the clay faction remain in the fluid state, free to flow toward the inner harbor on its own density gradient.

The tidal effect on sediment transport is much less than that exerted by the wind. The tidal velocities (predominantly in the subsurface layer) are generally too low to resuspend sediments, but sediments in the subsurface layer of the water column are transported toward the inner harbor during periods of flood tide and towards the outer harbor during periods of ebb tide.

The overall effect is a distribution of sediments over the entire harbor. Sediment transport from the Wailuku River disperses suspended solids concentrations as high as 160 mg/l throughout the outer harbor, with much settling within the harbor.

While sediment pockets were observed, portions of Blonde Reef appear to be one of the areas protected from heavy sediment deposits due to the existing circulation patterns and shallow depth (which is more susceptible to mixing of the water column) from waves overtopping the breakwater. Only in the deep crevices of Blonde Reef are heavy deposits of sediment observed. The remaining portions were covered by only a thin layer.

Arsenic Levels in Sediment of Hilo Harbor

Arsenic is found in nature mostly in the form of arsenites of true metals. Elemental arsenic is insoluble in water but other forms such as arsenic trioxide is sparingly and slowly soluble in cold water.

Arsenic is used in metallurgy as hardening agent, in dye manufacturing and in the tanning and chemical industries. Its major use is in the manufacture of pesticides and herbicides.

Arsenic is found in seawater at an average concentration of about 0.003 mg/l. Marine plants have been known to accumulate arsenic concentrations up to 30 mg/l, with the highest concentrations in brown algae.

Exceptionally high levels of arsenic in sediments of Hilo Harbor and Waiakea Mill Pond were found in a survey conducted by the State Department of Health. As shown in Table E-5 and Figure E-7 the levels of arsenic concentration in the sediment varied within the harbor area, with a general trend of decreasing concentration with distance from the mouth of the Wailoa River. Levels of total arsenic in sediment samples taken in Waiakea Mill Pond were reported as high as 6370 ug/g by the State Department of Health. These high levels of arsenic were found in sediment up to 35 cm in depth.

In conjunction with sediment sampling, analyses for arsenic in crabs and mullets of Hilo Harbor and Waiakea Mill Pond were conducted. The findings of the State Department of Health indicate:

1. Non-detectable to trace amount of arsenic were measured in tissue of white crab (P. sanguinolentus). As shown in Table E-6, there is no correlation between arsenic levels in tissue of crabs and the sediment environs. Arsenic levels found in crab tissue in Hilo Harbor averaged 0.17 ug/g, while higher concentrations of arsenic were found in crabs where there were significantly lower levels of arsenic in the sediment (Kaneohe, Kaiaka Bay, Ala Wai Canal).

2. No detectable levels of arsenic were found in the flesh of Samoan Crab (Scylla serrata) which were caught in Waiakea Mill Pond.

3. No arsenic accumulation were found in mullet tissue.

4. Arsenic levels in the viscera of mullet in Waiakea Mill Pond range from 1.67 to 5.65 ug/g which is a tenfold greater than

TABLE E-5

ARSENIC CONCENTRATION IN THE SEDIMENT

Station	Description	Arsenic Concentration in ug/g Dry Solid Average	Range
1	Wailoa River	136	65 - 246
2	Mouth of Wailoa River	135	96.7 - 179.0
3	Inner Harbor (Navigational Channel)	110	32.9 - 213.0
4	Outer Harbor (offshore of mouth of Wailuku River)	21.9	-
5	Outer Harbor (mouth of Hilo Harbor, offshore of Alealea Pt.)	96	91.0 - 103.8

Source: Eugene Akazawa, Investigation and Enforcement Branch, State Department of Health.

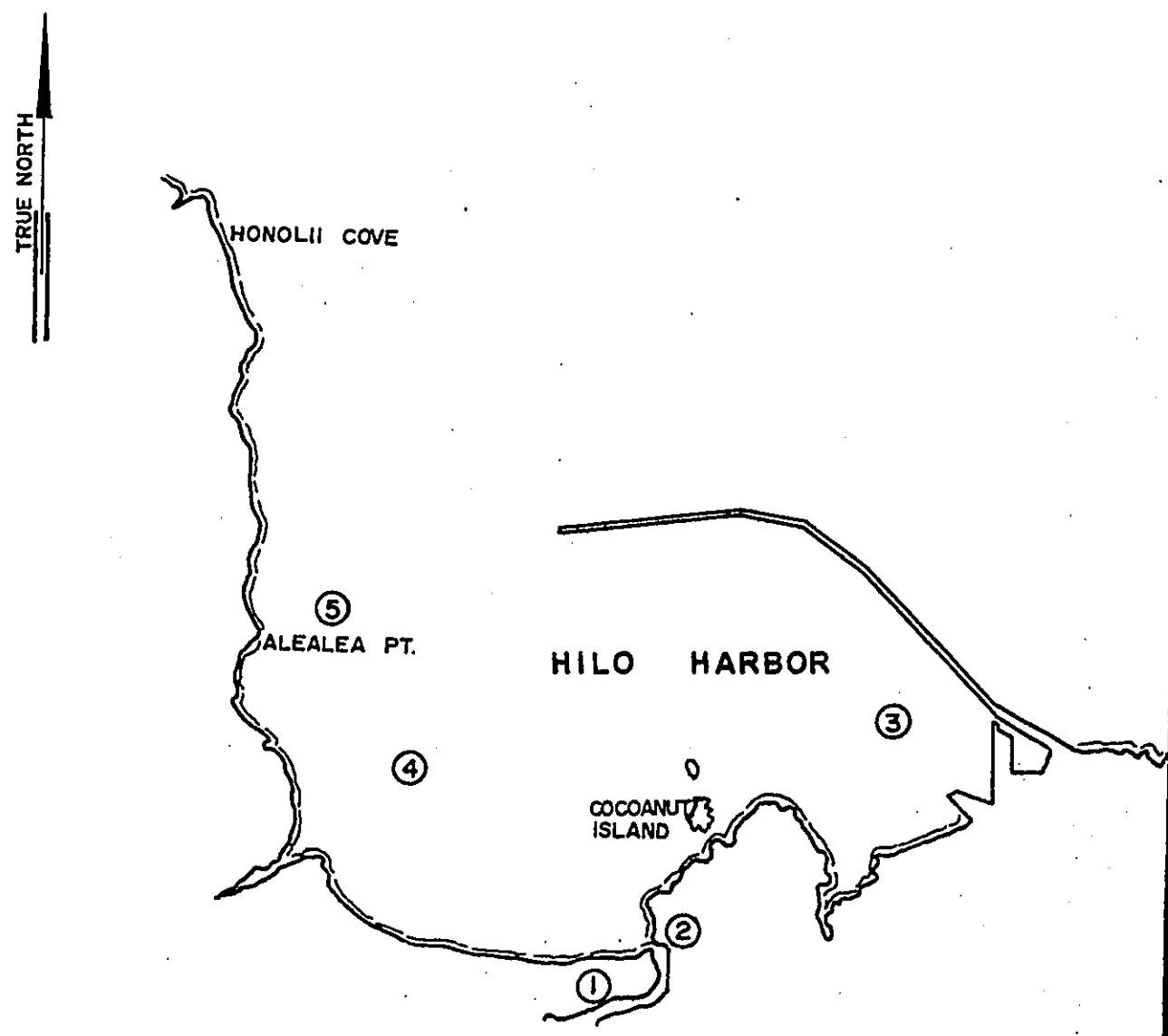


FIGURE E-7

STATION LOCATION
FOR ARSENIC SAMPLING

TABLE E-6

COMPARISON OF RESIDUE IN WHITE CRAB TISSUES (P. SANGUINOLENTUS) AND ARSENIC CONCENTRATIONS

Location	Concentration in ug/g Sediment	Whole Crab
Kaneohe Bay, STP Outfall	20.8	0.34
Kaneohe Bay, Kahaluu	32.5	0.10
Pearl Harbor, West Loch	4.0	0.10
Ala Wai Canal	13.5	0.25
Kapalama Canal	18.8	0.05
Kaiaka Bay	17.3	0.29
Nawiliwili Harbor	8.3	0.10
Hilo	82.2	0.17

Source: Department of Health, December 1978.

that observed in mullet collected from Molokai or Nawiliwili (Kauai). The State Department of Health also found high amounts of arsenic in the filamentous algae in Waiakea Mill Pond which serves as the predominant food source of the mullet.

Discussion of Arsenic in Hilo Harbor-Waiakea Mill Pond

It is suspected by the State Department of Health that the former canec manufacturing plant is responsible for the high levels of arsenic in the sediment of Waiakea Mill Pond and Hilo Harbor. Arsenic trioxide (As_2O_3) was used as a termite treatment agent in the process of canec manufacturing.

The canec plant operated from 1932 until 1963. The process waste flows were formerly discharged into Waiakea Mill Pond.

In a survey of estuaries in the State of Hawaii, (see Table E-7) elevated levels of arsenic in sediments were found only in Hilo Harbor. Baseline values for all areas are about 20 ug/g as compared to Hilo Harbor of 675 ug/g. It is also noted that arsenic levels in sediment do not vary significantly for ocean waters fronting urban or non-urban setting.

Based on the distribution pattern of arsenic in various portions of the harbor, it suggests that Waiakea Mill Pond serves as the source of arsenic-laden sediment. The sediment is transported during periods of high flows, into estuarine environs of Hilo Harbor through the Wailoa River. Upon discharging from the Wailoa River into the outer harbor, sediment in the subsurface layer is carried into the inner harbor, where most of it settles and remain in the deep navigational channel.

Sediment from the Wailoa River in the surface layer is generally carried towards the mouth of the harbor. Concentration in the sediment taken at the mouth averaged 96 ug/g. Note that arsenic levels of sediment taken in the outer harbor just offshore of the mouth of the Wailuku River were near background levels. This suggests that most of the sediment settling in this area originates from the Wailuku River.

TABLE E-7

DISTRIBUTION OF ARSENIC

IN HAWAIIAN ESTUARINE SEDIMENTS

Location	Concentration in ug/g dry weight
Kaneohe Bay	19.8
Pearl Harbor, West Loch	4.5
Ala Wai Canal	13.6
Kapalama Canal	16.7
Kaiaka Bay	12.3
Kahana Bay	18.5
Nawiliwili Bay	13.5
Hanapepe Bay	19.3
Manele/Hulopoe	4.0
Hilo Harbor	675.4

= Values are minimum detectable limit for the samples analyzed.

Source: Department of Health, December 1978.

The periodic maintenance dredging of the navigational channel will tend to remove the arsenic-laden sediment from Hilo Harbor. Benthic organisms would be exposed to this sediment which results in an accumulation of arsenic in the viscera as reported in the study of crabs and mullets but not much in the tissues of the animals.

A mitigating factor would be that water column organims would not be grossly affected since arsenic is relatively insoluble. This is corroborated by water quality data taken by the State Department of Health.[1] Arsenic levels at all sampling stations taken in Hilo Harbor indicated non-detectable levels (less than 0.001 mg/1).[1] While no tests were performed to determine the arsenic compound, it is highly probably that the arsenic is tied up with the sulfide, resulting in a relative insoluble precipitate.

In summary, elevated levels of arsenic in the sediment of both the inner and outer harbors will continue to be observed because of the continuous flushing of sediment out of Waiakea Mill Pond.

Regulations Pertaining to Arsenic in Marine Environment

There are several agencies which control the levels of arsenic in the marine environment. The following summary is a status of the various laws pertaining to arsenic levels in the environment:

1. The State of Hawaii has no specific standards for arsenic in marine waters at this time.

2. Preliminary water quality standards promulgated by the U.S. Environmental Protection Agency for saltwater aquatic life restrict arsenic concentrations to 29 ug/1 (24 hour average) with a maximum instantaneous value of 67 ug/1. No values of arsenic in sediment are available.

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[1] Personal communications with Eugene Akazawa, State Department of Health, Pollution Investigation and Enforcement Branch.

Health Considerations

Trace amounts of arsenic compounds are constantly ingested into the human body through normal consumption of food products. There is no evidence that arsenic is an essential element of human nutrition. The arsenic levels in the human tissues vary from 0.2 to 1.0 mg/l.

Arsenic can be toxic to humans. Ingestion of as little as 130 mg has proven fatal. Also ingestion of small doses of arsenic over a long period of time may become fatal if the rate of ingestion is sufficiently high to result in a net accumulation in human tissues.

According to Price and Knight (1978) in the study of clams, no food chain relationships exist between sediment, plankton and clams. Furgusen and Gavis (1972) has stated that arsenic is not progressively concentrated in the food chain and that arsenic consumed as an organically-bound species in flesh appears to have low toxicity.

In a report (1978) by the State Department of Health, it stated that "since uptake of arsenic appears to be concentrated primarily in the viscera of the organisms studied, the consumption of crab innards posing as a potential health hazard is questionable, however."

APPENDIX F

SOCIAL AND CULTURAL RESOURCES

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SECTION I: SMALL CRAFT NAVIGATION

A. Social Well-Being

1. Population Characteristics. Both the South Hilo and Puna Districts of the island of Hawaii have experienced rapid population growth in the last decade (1970-1980) due principally to the influx of new residents. Growth in the study area has occurred principally in the Hilo City region of South Hilo and the Mountain View - Keaau region of Puna. Kalapana is located in rural areas of Puna, while the Leleiwi Point and King's Landing are located close to Hilo. The Leleiwi Point area is essentially a suburb of Hilo, and King's Landing is an undeveloped private property outside of the Hilo suburbs. Kalapana Village is a small close-knit community with long-time family relations and residences, and a sharing of common history, problems and needs. While population growth within the South Hilo and Puna Districts is expected to continue, population growth at the three potential harbor sites is expected to be slow. The continuing influx of new residents may change the ethnic composition of the rural communities and influence community social structure and lifestyle.

Table F-1. POPULATION CHARACTERISTICS

	Hawaii County	Hilo City (South Hilo District)	Leleiwi Point	King's Landing	Puna District	Kalapana-Pahoa
Population						
1960	61,332 1/	31,553 1/	No persons living at project site.		5,030 1/	Data not available
1970	63,468 1/	33,915 1/			5,154 1/	1,352 1/
1980	92,206 1/	42,320 1/			11,175 1/	Data not available
1990	105,100 2/	46,665 2/			12,800 2/	Data not available
2000	123,300 2/	Data not available			Data not available	
% Ethnic Composition 1970		(Hilo City) 4/				
Japanese	37.5	43.4	Not applicable		40.7 2/	38 2/
Caucasion	28.8	28.0			24 2/	17
Hawaiian	12.3	11.5			9 2/	18
Others	21.4	17.1			26.3 2/	27
Length of Residence						
# Households (1976)	27,943 2/	12,751 2/			3,060 2/	80 3/

Data adapted from:

1/ State of Hawaii, Department of Planning and Economic Development, 1980
2/ State of Hawaii, Department of Planning and Economic Development, 1978
3/ County of Hawaii, Planning Department, 1979
4/ County of Hawaii, Planning Department, 1975
5/ Corps of Engineers, 1977

2. Employment. Agriculture and Government are the major employers in the Puna District, and retail and construction activities are secondary employers. A substantial number of Puna residents commute to jobs in Hilo, the commercial and government center of the island, but Puna also provides jobs for a portion of the Hilo residents. Puna's location close to Hilo airport and harbor allows quick transport of produce to markets outside of Hilo. Sugar, papaya, macadamia nuts and fresh flowers are the major agricultural products grown in Puna. Agriculture is expected to remain a major economic force. While tourism is a strong economic force in the County, Puna does not provide a tourist destination, other than sightseeing. No resort developments exist in the Puna district although resort areas are zoned in the district. None of the potential harbor sites support business or industrial activity or labor forces.

Table F-2. EMPLOYMENT CHARACTERISTICS

	Hawaii County	Hilo	Puna	Kalapana-Pahoa
Income Distribution 1/				
# Families	14,692	6,131	1,222	281
Median Income	$ 9,750	$7,778-12,616	$8,371-7,603	$ 7,603
# Families below Poverty	1,430	524	121	34
# Families Under $10,000	7,588	2,654	783	182

County Employment Distribution 2/	Total Labor Force	Japanese	Caucasian	Hawaiian	Others
Employed	26095	10228	4019	5079	6769
Unemployed	2668	675	610	670	713

Sources: 1/ State of Hawaii, Department of Planning and Economic Development, 1978

2/ State of Hawaii, Department of Planning and Economic Development, 1979

3. Intrastructure.

Traffic and Road Access. Kalapana and Leleiwi Point are accessible from main arterials servicing the areas. Traffic volume between Hilo and Leleiwi Point is not known at this time, but will increase if Lehia Park is developed. The Puna Development Plan indicates that 1990 estimated traffic flow through Kalapana was estimated at 1,470 vehicles per day with 1,140 of those vehicles headed for the Volcano National Park. King's Landing is accessible by private gravel road. No improvements to the road system are anticipated in the near future. A Puna coast road, which would connect Leleiwi Point to Kapoho, is in the planning stages by the County and State of Hawaii.

Table F-3. TRANSPORTATION

Site	Approximate Distance From Hilo (Miles)	Arterial Servicing Area
Kalapana	30	Kalapana-Pahoa Road
King's Landing	8	Private Gravel Road
Leleiwi Point	3	Kalanianaole Hwy

4. Water Supply. Neither Kalapana, Leleiwi Point nor King's Landing are presently serviced by a centralized water supply. An 8-inch waterline, which can be extended to the Kalapana site, is located along Kalapana-Kaimu Road, and a 6-inch waterline at the end of Kalanianaole Avenue can be extended into the Leleiwi Point site. No water supply system exists at King's Landing. Water supply sources are expected to more than adequately meet future water demands in both the Hilo and Puna Districts. In areas of Puna that rely upon rain catchment for water, periods of drought create severe water shortages, such as period in 1973 when Puna was declared a disaster area.

Table F-4. WATER SUPPLY

District	Production at Existing Sources	Future Demands Year 2000	Potential Source Capability
Hilo	100 MGD	65	2200
Puna-Kau	12	12	98

Source: Hawaii Water Resources Regional Study, 1975.

5. Power. Power in the Kalapana area is generated by small, individual gas generators. No power generation capability or transmission lines are present at King's Landing. Leleiwi Point, within the suburbs of Hilo, has access to the Shipman Power Plant power lines. There are no immediate plans to extend power transmission lines into the rural areas.

6. Sewer. All of the potential harbor sites lack sewer systems. Leleiwi Point is close to the existing sewer system extending out from Hilo. Residences in Kalapana utilize cesspools. King's Landing has no wastewater treatment system. There are no immediate plans to provide centralized sewer systems in the rual areas.

7. Fire, Medical, Police and Sanitation Services. Fire, medical and police services in the area are provided at neighboring towns. Homeowners must haul their trash to the County dumps or transfer stations. The dump in the Puna area is located at Kulani Road, Glenwood.

Table F-5. PUBLIC SERVICES

Site	Location of Police Station	Location of Fire Station	Location of Medical Svcs	Sanitation Service
Kalapana	Keaau	Pahoa	Pahoa	Owner haul to transfer station
King's Landing	Downtown Hilo	Waiakea	Downtown Hilo	None
Leleiwi Point	Downton Hilo	Waiakea	Downtown Hilo	Owner haul to dump in Hilo

8. Landownership, Land Use and Zoning. The lands in the King's Landing site are privately owned. The Leleiwi Point site is situated on public lands. The Kalapana site encroaches on both public and private lands (Figure E-1). Landownership is not expected to change in near future.

All the shoreline areas at the three potential harbor sites lie within areas classified conservation by the State of Hawaii. The upland areas behind the Leleiwi Point are classified agricultural lands, while the lands behind the Kalapana and King's Landing sites are classified Urban. In the County General Plan, all the conservation lands are planned for open space and the agricultural lands upland from the coast planned for orchards. At Kalapana and King's Landing, the urban lands are zoned for residential and resort uses.

B. Cultural Resource Reconnaissance Report and Coordination

Information on cultural resources at Kalapana, Leleiwi Point and King's Landing is provided in Section III of this Appendix. The King's Landing area was surveyed by the Archaeological Research Center Hawaii, Inc. in 1978 for the Hawaiian Paradise Park Corporation, and the report was provided by David Watumull, President, Hawaiian Paradise Park Corp. to the Corps of Engineers. The survey of the Kalapana and Leleiwi Point areas was performed by Chiniago, Inc. in 1981 for the US Army Corps of Engineers. Much of the Kalapana information was obtained from surveys by Archaeological Research Center Hawaii, Inc., in 1974 and the Bishop Museum in 1979. The resources present in the areas of the potential harbor sites and their significance and potential for inclusion to the National Register of Historic Places are presented below:

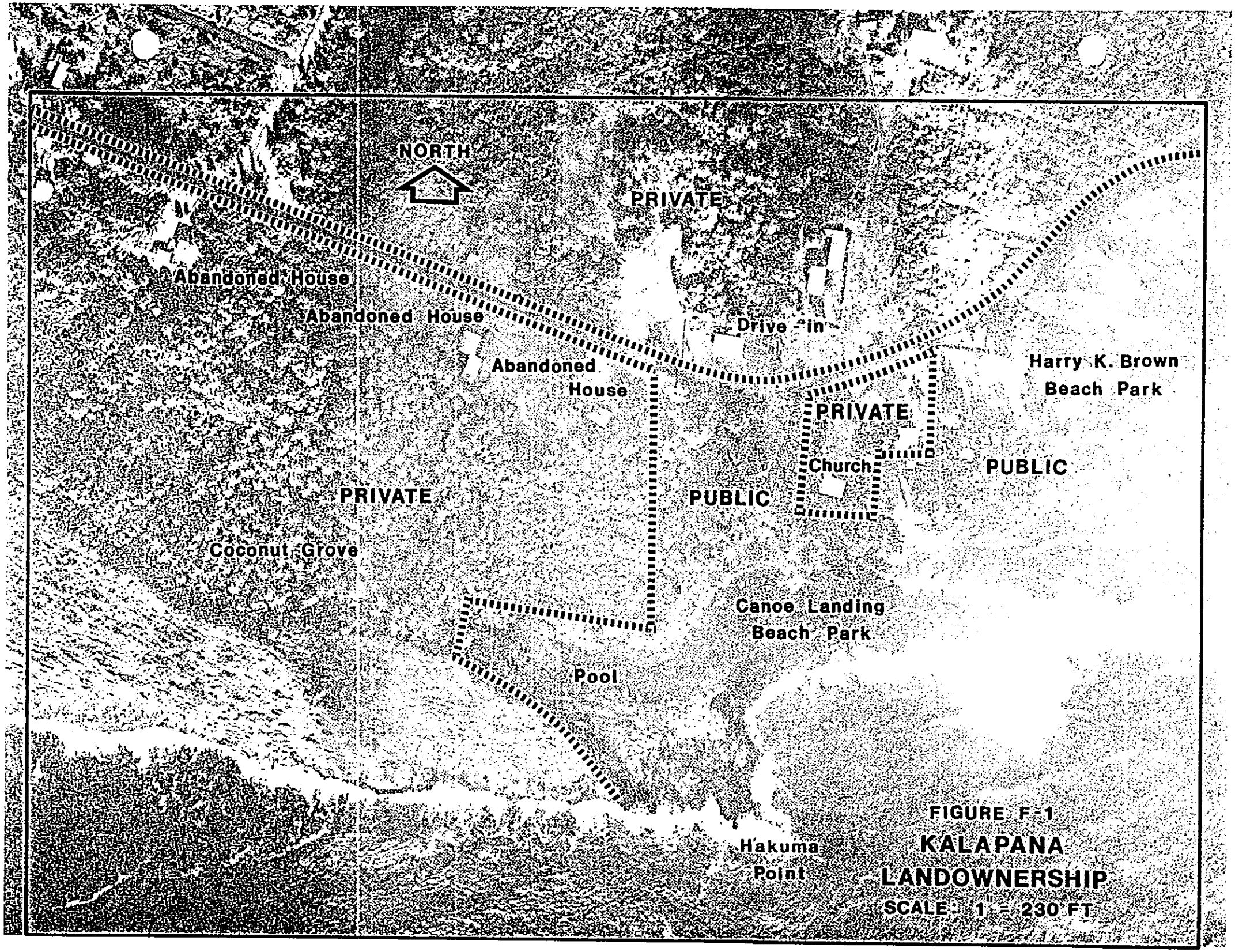

FIGURE F-1
KALAPANA LANDOWNERSHIP
SCALE: 1" = 230' FT

Table F-6. CULTURAL RESOURCES

Project Location	Cultural Resource	Significance	Listed on the Hawaii Register of Historic Places	Potential for listing on the National Register of Historic Places
Kalapana	Canoe Landing Site	Histoic site	No	High
	Kikoa Heiau, Hokuma	Religious temple	No	High
	Cave of Refuge	Historic site	No	High
	Painted Church	Historic site, architecture	No	High
	Fishpond	Archaelogical Data	No	Low
King's Landing	Pohaku Piko -	traditional navel stone	No	High
	Four cultural deposits in the sand dunes.	Potential for yielding scientific data	No	High
	Keana Moi	Traveler's cave	No	Low
	Burials	Potential for scientific data	Location lost, could not be found.	
	Moku Nui Heiau	Religious temple	No	High
	Walled enclosure with lava sinkhole	Unknown	No	Low
Leleiwi Point	Puu Maile Hospital Site	Historic site	No	Low

Coordination. Letters requesting information on cultural resources and their development at Kalapana, Leleiwi Point and King's Landing were sent to the State Historic Preservation Officer, Director of the State Department of Land and Natural Resources, the County of Hawaii Departments of Planning, Parks and Recreation and the National Park Service. The National Park did not have any projects in the area. The State Historic Preservation Officer provided information on sites of interest near the project sites and recommendations for reconnaissance level surveys at Kalapana and Leleiwi Point. No information on the coastal trail system on Hawaii was provided.

Upon the completion of the reconnaissance survey for Kalapana and Leleiwi Point and an evaluation of existing information on King's Landing, a determination of eligibility of the sites for inclusion to the National Register of Historic Sites was coordinated with the State Historic Preservation Officer. (See Appendix .)

This report has been edited to delete reference to specific resource locations to preclude vandalism. Information regarding the site specific location of resources can be obtained from the Honolulu District, US Army Corps of Engineers, based on a need-to-know. Specifically, Figure 3 of the report has been deleted.

ARCHAEOLOGICAL RECONNAISSANCE OF THE PROPOSED KINGS LANDING SUBDIVISION, KEA'AU, PUNA, ISLAND OF HAWAI'I

by Hallett H. Hammatt

Prepared by

ARCHAEOLOGICAL RESEARCH CENTER HAWAII, INC.

for

HAWAIIAN PARADISE PARK CORPORATION

November, 1978

Lawa'i

ARCH 14-141

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ACKNOWLEDGEMENTS

We would like to thank Mr. David Watumull, President, Hawaiian Paradise Park Corporation for providing us with useful information and support. The assistance of Imata and Associates in providing warm greetings, transportation, and box lunches is greatly appreciated. Mr. Louis Akiona was our guide on the first day of the survey and background information from him as well as Mrs. Kua was extremely useful. John Malina assisted in the field and Myra J. Tomanari Tuggle drafted the maps.

INTRODUCTION

At the request of Mr. David Watumull, President, Hawaiian Paradise Park Corporation, Honolulu, Hawaii, an archaeological reconnaissance was carried out in a coastal segment of North Puna, in October, 1978. The study area (Figure 1 and 2) includes approximately 2,138 acres along the coast from the south Hilo - Puna boundary to approximately 5,000 feet south of Papa'i Bay in the *Ahupua'a* of Kea'au and is designated as the Kings Landing Subdivision. The study area has been divided into three (3) separate parcels, (Figure 3). Area I includes the coastal strip 1,300 feet or less inland. Area II includes a triangular shaped inland parcel of approximately 250 acres. The remaining part of the study area is designated Area III.

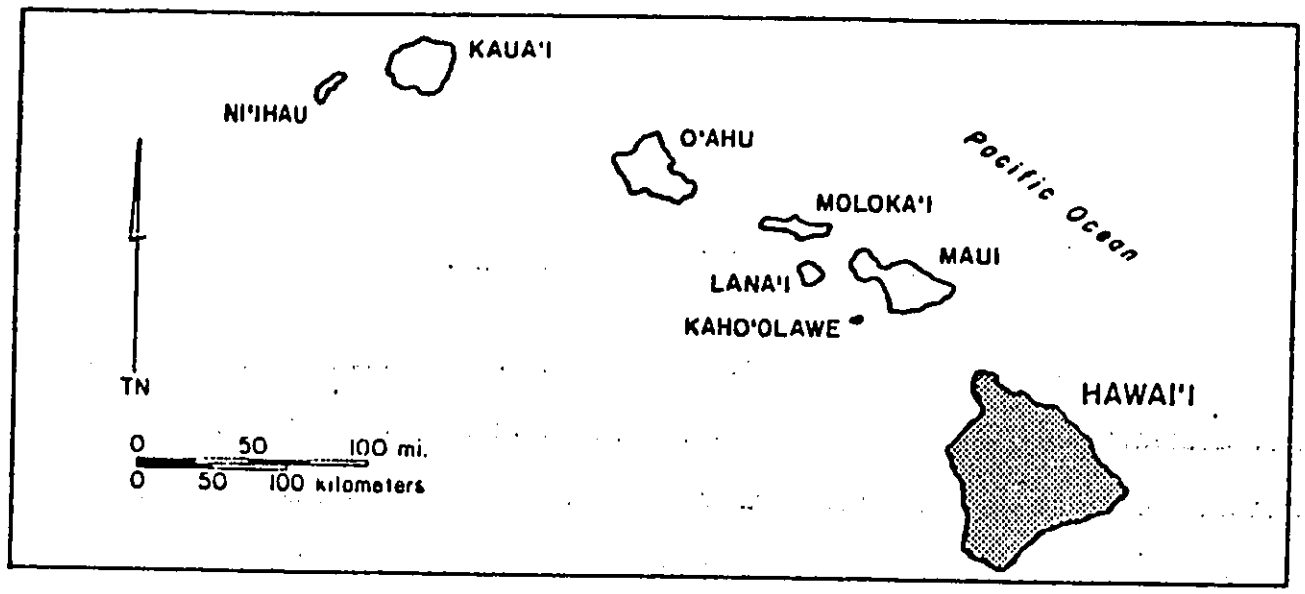

Figure 1

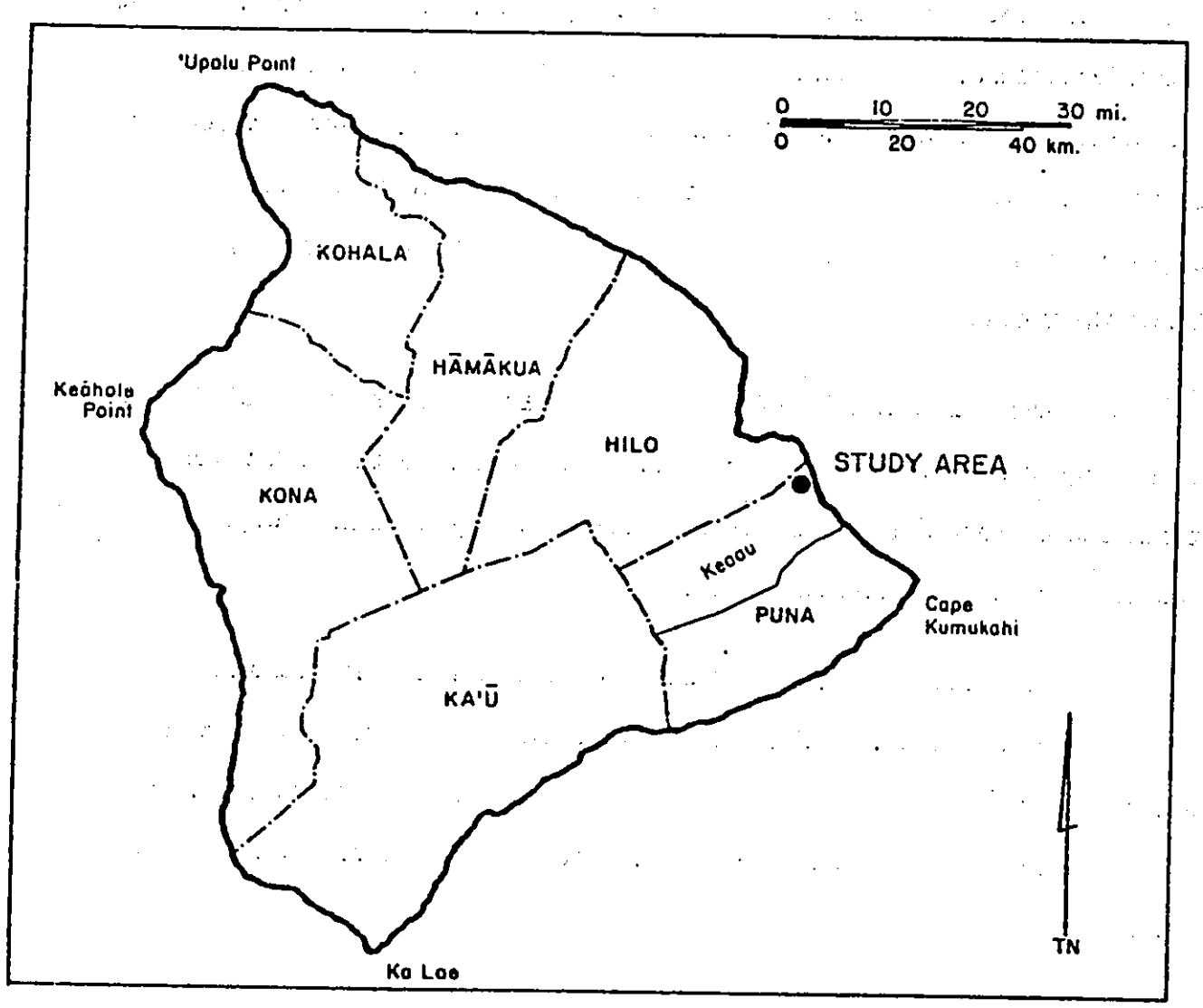

Figure 2

PHYSIOGRAPHIC AND HISTORICAL SUMMARY

The project area is located in the *Ahupua'a* ancient land division of Kea'au in eastern Hawai'i. The landscape is relatively flat and undissected by major erosion or drainage networks. It consists of rough *a a* and *pahoehoe* lava of the *Ka'u* series from Moana Loa (Macdonald 1949). These flows are relatively recent geologically and date to the late Pleistocene and early recent periods and post date the wide spread mid and late Pleistocene *pahala* ash. The present surface is marked by minor crevasses, collapsed, swampy lava tubes and low knolls. Soil development on the lava has been minimal and unconsolidated sediments are peaty organic deposits in marshy depressions and coarse basaltic beach sand along the coast.

Average annual rainfall for a 10 year period recorded at Ka'a'a is 156 inches. This plentiful rainfall contributes to the high water table and dense vegetation which consists of *naupaka, hala,* and guava in addition to many grasses and vines.

Kea'au is one of the larger *Ahupua'a* in the district of Puna. According to Hardy and Hardy, (1972), taro was grown here in low areas and in numerous shallow crevasses. The taro plants if mulched properly, frequently grew to great size, sweet potatoes, bread fruit and sugarcane were also grown.

In the 19th century this portion of the coast of Hawai'i was almost entirely abandoned and little is left of the historical traditions. The Reverend William Ellis travelled through the area in 1823 but makes no specific observations on this particular portion of Kea'au except to describe the Kea'au settlement to the south.

PREVIOUS WORK

Thomas Thrum (1909) travelled along the Puna coast in the early part of this century and provides some general historic information for this area. He lists no *heiau* along the coast line between Hilo and Kapoho. Hudson (1932) performed an archaeological survey of the whole coastal region and lists 16 sites between Popa'i and the north Puna boundary. However, the sites were never mapped or located except in the most general terms. Most are assumed to be near the coastal trail and a number of them may be the same as those located in the present reconnaissance, others may have been destroyed. The Bishop Museum surveyed the corridor for the Kapoho Keaukaha Highway (Ewart and Luscomb, 1974), in which seven sites were recorded in the northern portion of the project area. All but one (site 33) were relocated in the present reconnaissance. All of these sites are concentrated along the coast and no archaeological remains were located in the inland segment of the present project area covered by the highway corridor.

SUMMARY AND RECOMMENDATIONS

Twenty-seven (27) archaeological and or historical sites were located during the present reconnaissance (Table I). Some of these sites had been previously located and the others were located for the first time on this reconnaissance. In all cases the sites are distributed along the coastal strip (Area I). They include three (3) types of sites.

1. Stone structures including walls, platforms, enclosures, *heiau* and small shelters.
2. Cultural deposits which consists of the remains of human habitation under the surface of the ground.
3. Historic places which may or may not have actual structures or human modification marking their position.

With the exception of 6475 and 6476 (Figure 3) all of the stone structures (type 1) located are in poor condition and have been badly disturbed by encroaching vegetation particulary *hala* trees. They are considered to be of marginal value for archaeological excavation and research potential. Preservation is not recommended from an archaeological-scientific point of view. However, to the extent possible selective features might be preserved for aesthetic and or interprative reasons as part of the development plan. Sites 6475, and 6476 are judged, on the basis of size and construction features, to be *heiau* and should be preserved. Site 6475 has already been cleared of vegetation and made into a visible, accessable attraction. If deemed appropriate, nearby site 6476 should be

treated in a similar manner. Some of the stone structures may contain human burials. If these burials are disinterred during the development of the area, they should be reburied in an appropriate place safe from future disturbance. Site 33 is an unusual igloo shaped corbelled structure located and described by Ewart and Luscomb (1974). This structure which probably served as a burial vault would certainly be worthy of preservation. In spite of a systematic effort, this structure could not be located and is assumed to have collapsed. A similar structure was reported by Hudson (1932). It too has probably been destroyed.

Type 2 sites which include 6461, 6464, 6466, 6468 and 6470 consist of buried cultural deposits containing charcoal, basaltic glass and flaked basalt.

These sites are of high potential archaeological-scientific interest and should be preserved. The surface of these deposits are presently planted in grass and coconut trees. It is recommended that subsurface disturbance of these areas be kept to a minimum. If such disturbance is proposed than archaeological test excavation should be carried out before hand. Although no subsurface archaeological remains were observed in the Popa'i Bay Park, the potential for such remains is high. Therefore this recommendation should apply to this area as well.

Type 3 sites which classify as historic places include the *pōhaku piko* (6467) and 6477 the place of the incident of *Kalaleiki*. The use of "navel stones" were apparently a common tradition in ancient Hawai'i, and

similar stones have been reported from other islands. The incident of *Kaleleiki* which eventually led to the law of the splintered paddle or *Mamala hoa* was an event of great significance for Hawaiian culture, and might be commemorated with a plaque or other appropriate marker at Papa'i Bay.

The recommendations made above apply generally only to the coastal strip or Area I. Area II was inspected and archaeological clearance is recommended with no further survey. The remainder of the project area was traversed partly by vehicle and partly on foot and no archaeological remains were discovered and none have been reported in previous surveys. (Ewart and Luscomb, 1974). All of the archaeological remains observed by Hudson (1932) were along the coastal trail. It is thought both unneccessary and unrealistic to recommend intensive survey for Area III. Unneccessary because the proability of locating archaeological remains is slight and unrealistic because of the thickness of the vegetation cover and nature of the topography would necessitate a lengthy and there fore expensive effort with negative or minimal return.

It is recommended, however, that when the thick, vegetated inland portion of Area I is cleared for development that the cleared areas be briefly inspected by an archaeologist to evaluate the possible occurence of as yet undiscovered archaeological remains under present dense vegetation.

To summarize, the recommendations are as follows:

1. No further archaeological work in Areas II and III.

2. Archaeological testing of type 2 sites (6461, 6464, 6466, 6468, 6470) and the flat, low, area of Papa'i Bay Park should preceed significant subsurface disturbance.

3. A breif inspection by an archaeologist of the inland thickly vegetated portion of Area I, following clearing. Otherwise, no further archaeological work is recommended.

4. Preservation of sites 6475 and 6476, because of their cultural as well as archaeological significance.

TABLE I - ARCHAEOLOGICAL SITES LOCATED IN KINGS LANDING SUBDIVISION AREA

NUMBER	PREVIOUS NUMBER	REFERENCES	PRESENT STATUS	DESCRIPTION
	36	Ewart & Luscomb 1974	Relocated	Historic wall and partial enclosure formed of 2 walls extending from a lava bluff.
50 - 10 36 - 1845	19 50 - 10 36 - 1845	Ewart & Luscomb 1974 Hawaii Register of Historic Places - 1971	Relocated	2 stacked boulder walls extending from lava bluff forming enclosures.
	14 - 15 63	Ewart & Luscomb 1974 Hudson - 1932	Relocated	Several short, low walls, Probalby historic
50 - 10 36 - 1846	32 50 - 10 36 - 1846	Ewart & Luscomb - 1974 Hawaiian Register of Historic Places - 1973	Relocated (Reserve Status) (Local Significance)	Short walls, facing walls built around a natural sink and lava bluff. A filled lava crack is a possible burial site.
	33	Ewart & Luscomb 1974	Not Located. Probably collapsed.	Small igloo like structure built against the side of a lava bluff, the roof is corbelled. Interior dimensions are 1 meter deep and 1 meter high. The opening faces almost directly north.
	16	Ewart & Luscomb	Relocated	Wall lining the edge of a lava sink.

NUMBER	PREVIOUS NUMBER	REFERENCES	PRESENT STATUS	DESCRIPTION
50 - 10 36 - 6461			Discovered during present reconnaissance	Cultural deposit extending 20 to 30 meters parallel to beach and an undertermined distance inland. A cut bank in the cultural deposit along the beach shows coarse sand beach deposit containing charcoal and basaltic glass.
	64	Hudson - 1932	Not Located Probably destroyed	Triangular shaped rough platform about 7.5 meters on a side and roughly paved with beach boulders.
	65	Hudson - 1965	Not Located. Probably destroyed	Square rock alignment with two upright stones making a probable historic grave site.
50 - 10 36 - 6462		Mrs. Kua Louis Akiona	Located by Mrs. Kua described is present reconnaissance.	Platform 6 meters wide, 10 meters long, one meter high, built along lava bluff. Facing wall on makai side. Platform consists of water worn cobbles and boulders. The platform is on the north end of a tidal swamp. Termed *Moku Nui heiau*. Either a small*heiau* or habitation platform. Partially constructed channel on south side.
50 - 10 36 - 6463		Mrs. Kua	Located by Mrs. Kua described in present reconnaissance.	Lava sink 8 meters wide, 10 meters long, 3 meters deep, with overhang on side, 8 meters by 4 meters, 2 meters high. The floor is gravel with plentiful *'opihi* and cowrie shell. In high surf zone. Excavation potential, slight. *Keana Moi*.

NUMBER	PREVIOUS NUMBER	REFERENCES	RESENT STATUS	DESCRIPTION
50 - 10 36 - 6464			Discovered during present reconnaissance	Cultural deposit showing on cut bank extending 40 to 50 meters paralled to beach. Deposit consists of fine gravel and very course sand beach sediments containing charcoal chunks. Burials have been reported here. All cultural material observed was reworked in the deposits.
50 - 10 36 - 6465			Discovered during present reconnaissance	Rectangular foundation of historic house, 6 meters square. Walls 1 meter thich, core filled. Entrance on southside of structure Protected on north, east and west sides by lava outcrops.
50 - 10 36 - 6466			Discovered during present reconnaissance	Cultural deposit, showing on cut bank extending 150 meters parallel to beach and 60 meters inland from cut bank. Area is grassed and planted with coconut trees. Undisturbed cultural deposit occurs in the top 20 to 30 centimeters with some lenses of charcoal deeper. Matrix is medium to coarse sand and fine gravel. Charcoal and basaltic glass and polished flakes observed in place. Excavation potential is good.
50 - 10 36 - 6467		Mrs. Kua	Located by Mrs. Kua described during present survey	*Pohaku Pike* - water rounded boulder one meter in diameter. Small circular indententations are filled with pebbles hammered into place. According to Mrs. Kua umbilical cords of infants were placed in the indentations and covered with pebbles.

NUMBER	PREVIOUS NUMBER	REFERENCES	PRESENT STATUS	DESCRIPTION
50 - 10 36 - 6468			Located during present reconnaisance	Cultural deposit extending 50 meters parallel to beach and 30 meters inland. Cut bank along beach front shows medium to very coarse sand beds containging charcoal and basaltic glass. Most cultural material along beach front appears reworked.
50 - 10 36 - 6469			Located during present reconnaisance	Stone platform 1.8 meters high 4.5 meters square, extending from lava outcrop overlooking a drackish water pool. Access to the coast is through a high sided corridor between 2 lava outcrops Possible house platform.
50 - 10 36 - 6470			Located during present reconnaissance	Cultural deposit extending 200 meters from south edge of *Kipuloko* Pond along beach edge and a maximum of 100 meters inland. Cut bank along beach shows charcoal and isolated basaltic glass flakes. Directly inland are short wall segments and 1 small shelter around lava bluff.
50 - 10 36 - 6471			Located during present reconnaissance	Wall 1 meter or less high extending from the beach inland at least 100 meters at an angle of 245°. This wall of stacked boulders is probably a historic boundry wall or cattle wall.
50 - 10 36 - 6472			Located during present reconnaissance	Wall at base of lava bluff directly inland and slightly north of Papa'i Bay. Wall extends 10 meters parallel to beach and may be the retaining wall of former platform. Considerably disturbed.

NUMBER	PREVIOUS NUMBER	REFERENCES	PRESENT STATUS	DESCRIPTION
50 - 10 36 - 6473			Located during present reconnaissance	Rock mound 2.5 meters long, 2 meters wide and 40 centimeters high on top of lava bluff behind Papa'i Bay. Possible historic burial mound.
50 - 10 36 - 6474	75 (?)	Hudson 1932 (?)	Located during present reconnaissance	Platform built onto lava bluff 8 meters square. In poor condition, possible house platform. Possibly Hudson's site 75.
50 - 10 36 - 6475		Mrs. Kua	Located by Mrs. Kua, termed *Pikinae heiau*	Large platform 22 meters long, parallel to beach and 15 meters wide. Height of platform on makai side .5 meter and on mauka side 2 meters. Well constructed retaining walls have uprights on the lower course. The platform fill consists of angular medium sized boulders. A lower and smaller stone platform adjoins the main one on the southeast side, measures 5 by 3 meters. On the top of the main platform are 2 oval shaped rock mounds containing stone lined chambers and large flat cap stones on the top. The southern most mound contains portions of a human cranium. Both of these are burial mounds and were probably added on to the top of the platform possibly in historic times. The massive size and construction of the platform indicates its function as a *heiau*.
50 - 10 36 - 6476			Located during present reconniassance.	Large platform incorporating a flat lava bluff. The platforms adjoins the bluff on the north side. North retaining wall is partially collapsed. Platform paving extends onto the surface of

NUMBER	PREVIOUS NUMBER	REFERENCES	PRESENT STATUS	DESCRIPTION
Cont.				The bluss forming a roughly circular paved area 1.2 meters above the surrounding landscape 38 meters in diameter. This structure is either a large habitation platform or a *heiau*.
50 - 10		Mrs. Kua	Located by Mrs. Kua	Historic place. As determined by Mrs. Kua and numerous written accounts the incident of *Ka lele iki* which eventually led to the law known as *Mamalahoe* or the "splintered paddle" took place at Papa'i Bay. No exact posistion for the event was located although an *ahu* is reputed to mark the point where the struggle took place.

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LELEIWI POINT AND KALAPANA, HAWAII: ARCHAEOLOGICAL RECONNAISSANCES

Prepared for:

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Prepared by:

William Barrera, Jr.

CHINIAGO INC.
76 North King Street
Honolulu, Hawaii 96717

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I. INTRODUCTION

Archaeological reconnaissance surveys, historical literature searches and informant interviews to determine the nature of archaeological and historical remains that might be impacted by proposed small boat harbor construction were conducted at Kalapana and Leleiwi Point, Hawaii Island [Figure 1]. The results of these invesigations are to be used in the planning and designing of the intended facilities, as well as in the environmental and cultural impact analyses being prepared by the Corps of Engineers. This report is therefore intended to comply with the Reservoir Salvage Act of 1960, as amended, the National Historic Preservation Act of 1980, the Advisory Council on Historic Preservation's 36 CFR Part 800 and the U.S. Army Corps of Engineers 33 CFR Part 305.

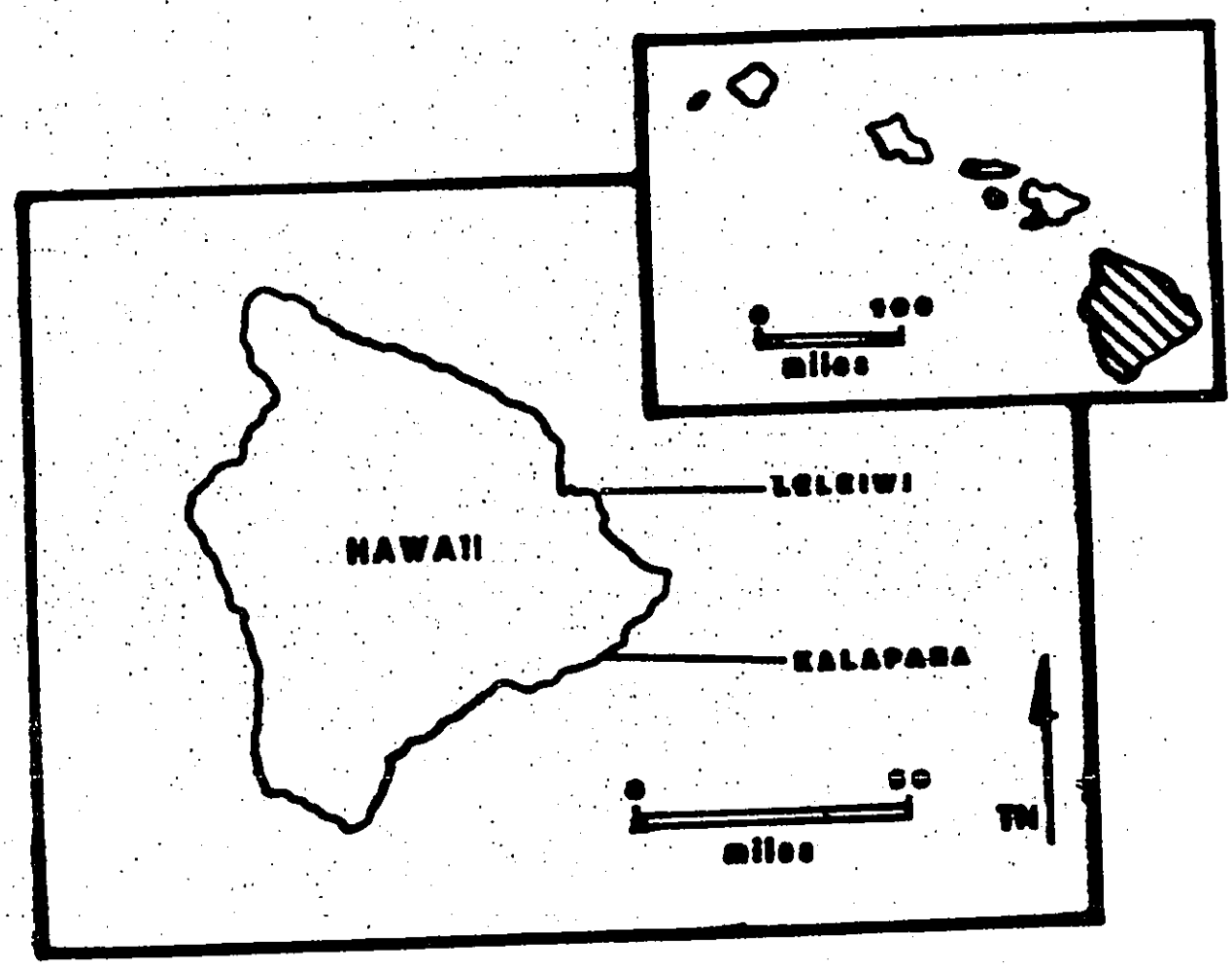

Figure 1. Map of Hawaii, Showing Locations of Survey Areas.

II. CULTURAL BACKGROUND

A. KALAPANA

Alfred Hudson in his unpublished 1932 manuscript on the archaeology of east Hawaii describes a heiau known as Kikoa at Kalapana:

> "Although the site is small it is of interest because it consists of two distinct platforms connected by a wall and terrace across their seaward ends. In this duplex nature it resembles Waiaka heiau at Kupaahu.
>
> "In their present condition both platforms are roughly triangular in ground plan but it is possible that the missing corners may have been built up because much of the original stone work has been removed for walls. Both are built of large lava blocks from the bluff.
>
> "The west platform is the better preserved and today is the larger. Its west side is 66 feet long and the south side 45 feet. The north and east sides form a curved wall 85 feet long.
>
> "Of the east platform 52 feet of the west wall and 20 feet of the south can be measured. Undoubtedly they were once longer but it is impossible to say how much. Nothing remains of the other side or sides.
>
> "Apparently a continuous terrace at one time extended across the seaward front of both platforms thus forming a unified but duplex structure. In addition to this terrace a wall 30 feet long joins the tops of the two platforms. It is sufficiently wide to walk on and may have been paved to form a runway between the two units.
>
> "At the best preserved points the tops of the platforms are 8 feet above the surrounding ground level. Two small pools of brackish water adjoin the site.
>
> "This place is noted among the people of Kalapana for the sound of drums and chanting

which they say can be heard from it on certain nights" [Hudson n.d.: 420-421].

Hudson also indicates the presence of traces of platforms a few feet inland of Kikoa heiau, which he states were:

> "...apparently of hard-packed earth surrounded by a border of smooth sea boulders sunk flush with the level of the ground. Only a few lines of boulders, imbedded in the ground, can still be traced" [Ibid: 422].

Theodore Kelsey and Henry E. P. Kekahuna visited Kikoa heiau in 1952 and reported on their visit in the Honolulu Advertiser of March 2 of that year. Their description of the site differs from that of Hudson:

> "This temple, slightly elevated by a base of pahoehoe lava, is 70 feet long by 68 wide. Its main walls, or those of the central structure, are 6 feet high, more or less, on three sides, but on the north the rear part of the heiau slopes down and outward to a height of but about 2 feet. From here a short walkway leads to a shallow spring 12 feet in diameter, lined with heavy stones. The main floor, largely occupied by a low rock platform, was originally paved with large rocks, and is level with the tops of the principal walls. On the east and west sides lie flanking paved areas 3 feet lower than the central portion...Kikoa's principal function is said to have been the replenishment of the shores with fish through prayers and ceremonies (hooulu i'a, cause increase of fish). The visits of schools of certain kinds of fish that remained in the vicinity for some time (i'a ku) were made known to fishermen and the people by the flying of various kinds of signal-kites" [Kekahuna and Kelsey 1952].

Kelsey and Kekahuna also mention the former presence, immediately adjacent to the heiau, of a fishpond which also went by the name of Kikoa. By the time of their visit, siltation and tidal wave debris had filled it in and converted it into a marshy pasture. They make reference to an old canoe landing to the southeast of the fishpond, as well as to a large rock in the water:

> "In the sea to the right of the channel entered by canoes may be seen the large rock of Pohakau, known to old-timers as a kupua, or demi-god, turned to stone by vengeful Pele, terrible goddess of Volcano Fires" [Ibid].

Ching, Stauder and Palama [1974] conducted an archaeological surface survey of the proposed Kalapana-Kaimu Beach Park approximately three-fourths of a mile to the east of our survey area. They recorded three habitation structures, five agricultural areas, four trails, two religious structures, six walls, two cisterns, one platform, and two enclosures.

Barrera [1975] and Barrera and Barrère [1971] conducted archaeological and ethnohistorical investigations in the seaward portion of the ahupua'a of Kupahua, to the west of the Kalapana survey area. Nearly 1,000 mounds, numerous house sites and a heiau were recorded.

A list of historical sites compiled by Violet Hansen in 1967 includes Kikoa Heiau and the canoe landing. She reports that at that time the latter site was gradually being destroyed by high seas.

The State of Hawaii Tax Map for the Third Division, Zone 1, Section 2, Plat 03 indicates almost the entire western portion of Kalapana Bay as an ancient canoe landing site.

B. Leleiwi Point

Hudson's 1932 manuscript, while not indicating the presence of sites within the present project area itself, does mention remains in the vicinity:

> "...in the region east of Hilo toward Leleiwi Point there are numerous sites still sufficiently well preserved to be measured and described" [Hudson n.d.: 226].

> "Indistinct traces of old stone work in and around the pandanus grove on the tip of Leleiwi Point. The site probably covered an area about 50 feet square. No stones now remain in place except one line 11 feet long of large beach boulders embedded in sand. This course of stones presumably marked part of one side of a terrace or platform. Many other heavy boulders are scattered about

without giving any indication of their original position. The whole area is thickly strewn with opihi shells. Stokes, in a brief note added to a photograph on file in the Bishop Museum, mentions the existence of an alleged former heiau at this site" [Ibid: 272].

III. RESEARCH METHODOLOGY

A. Kalapana

The primary archaeological objective was to locate Kikoa Heiau and determine the impact of recent coastal subsidence on the integrity of the structure. Our attempt to follow the directions of Kekahuna and Kelsey [1952] was impeded by thick vegetation and by the fact that subsidence had so altered the coastline that their directions could not be readily followed. Kikoa Fishpond and the canoe landing site were also inspected, and a brief search for additional archaeological remains was conducted. The Painted Church was investigated both through a literature search and informant interviews. Long-time residents of the area were also interviewed for whatever information they might have concerning the history of the area in general. The interviews and literature searches were conducted by Ms. Terrilee Kekoolani.

B. Leleiwi

The project area was searched for surface indications of archaeological or historical sites, and informant interviews were again conducted by Ms. Kekoolani.

IV. SURVEY RESULTS

A. KALAPANA

[Figure 2]

Kikoa Heiau [Figures 3 and 4] is completely overgrown with dense vegetation and appears to have suffered somewhat from seismic activity, both factors making observations difficult. The walls are collapsing, and a shallow pool resulting from the recent subsidence approaches to within five feet of the structure. The description provided by Kekahuna and Kelsey is more accurate than that of Hudson, and the discrepancy between the two is so great as to suggest that Hudson was describing another site altogether.

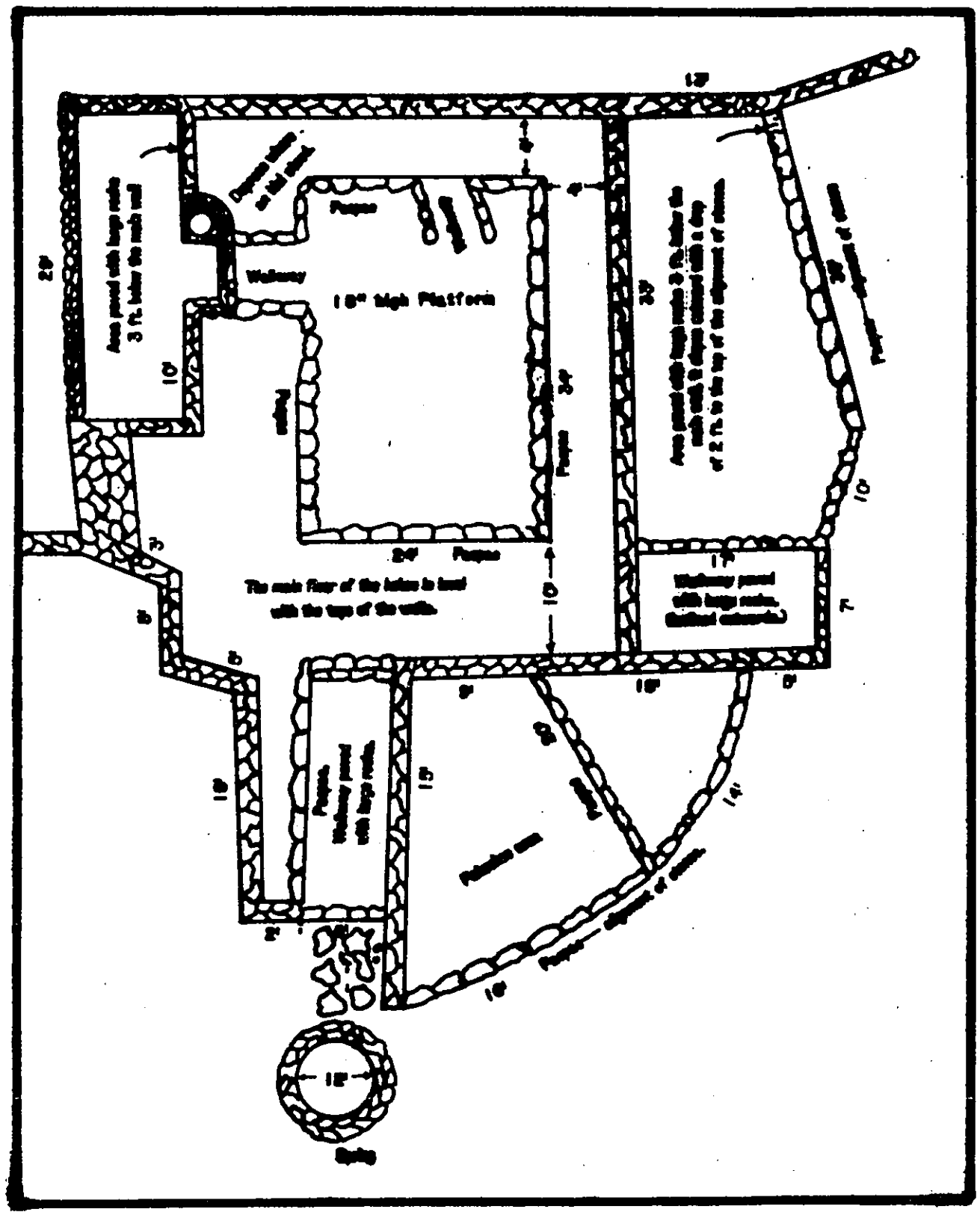

Figure 3. Plan of Kikoa Heiau.
[after Kekahuna and Kelsey (1952)]

Figure 4. Location of Kikoa Heiau, looking West. [behind palm grove at center of picture]

The vague platforms which Hudson mentioned as being inland of the heiau could not be located.

Kikoa Fishpond is a rectangular structure clearly visible in aerial photographs. It is completely silted in and covered with a thick growth of low guava [Psidium guajava] trees and an unidentified grass, and is bordered on three sides by a grove of palm (Cocos nucifera] trees. It originally measured about 75 by 106 meters [250 by 350 feet], but the subsidence of November 1975 has submerged a portion of the southeast corner. This feature is unusual in that it is an ocean pond completely enclosed by stone walls, a type which was not included in the typology devised by Apple and Kikuchi [1975].

The canoe landing site appears to have completely disappeared since Hansen's 1967 report of its continuing deterioration from the effects of high seas. Although no documentation could be found concerning the site, an informational sign near the site describes how the Hawaiians had constructed a ramp and ladder arrangement of poles over which canoes were carried during launching and landing.

The Star of the Sea Church, which is also referred to as Kalapana Painted Church and Puna Painted Church [Figure 5] was constructed in 1929 by Father Evarist Gielen, who in 1931 and

Figure 5. The Painted Church at Kalapana.
[Nancy Bannick photo]

1932 painted the murals. Father Evarist subsequently moved on to other churches in which he also executed paintings, but Kalapana was apparently his best effort:

> "The masterpiece of Father Evarist...is his first effort, the church called Star of the Sea at Kalapana. This is as notable an achievement as Father John's Church at Honaunau, and it is difficult to understand why it has been totally ignored.
>
> "At Kalapana, as at Honaunau, one is deeply impressed with the totality of the structure, its telling relationship of painting and architecture, and the clarity of the entire concept" [Frankenstein 1961: 27-8].

Mrs. Mary Kahilihiwa, a Kalapana resident and kupuna in her late seventies, provided information concerning a pohaku [rock] situated somewhere offshore near the curve of the canoe landing [this is not the kupua mentioned by Kekahuna and Kelsey]. She states that it was used by paddlers to mark a proper entry into the landing, but Mrs. Kahilihiwa's feelings about this feature suggest that it has considerably more significance, for as she says, "If the pohaku goes, Kalapana goes." Mrs.

Kahilihiwa also takes exception to a reference in the Kekahuna and Kelsey newspaper article that the flying of kites took place at Kikoa Heiau, for today it is held among Hawaiians that kite flying of any form "...is a sign that starvation will come to the land."

B. Leleiwi

[Figure 6]

The entire project area is surrounded by a thick grove of hau (Hibiscus tiliaceus], which is virtually absent in the survey area itself. This strongly suggests that the area has been cleared, and the chewed-up appearance of the ground indicates that this was probably done with heavy equipment. A large boulder beach is testimony to the power of the surf, as is the presence of thick deposits of mixed coral and lava sand. Thus high seas and ground clearing could have obliterated any surface evidence of former structures. The presence of a few shells of types of mollusks commonly eaten by prehistoric Hawaiians [Cypraea caputserpentis and Nerita picea] constitute one of two tenuous suggestions that the area may have been utilized in aboriginal times. The second suggestion is the fact that immediately outside of the survey area on the southwest there is a collapsed lava bubble shelter, a favorite type of Hawaiian habitation location. It is almost entirely filled up with sand, and there is therefore a possibility that completely buried features of the same type [which may contain midden materials] are located within the survey area.

Interviews with Hawaii residents familiar with Leleiwi Point produced valuable information. Mr. and Mrs. Robert Napeahi, both in their early seventies, are Keaukaha homesteaders who were born and raised in the area. They stated that the fishing grounds to the east and west of Leleiwi Point [the name translates as "flying bones"] are sacred and kapu to the Hawaiians. The kapu states that fish can be taken, but only in quantities sufficient for immediate needs; none must be taken for sale. They told of some Hawaiians who commercially harvested opihi on the east side of the point, one of whom subsequently drowned.

The Napeahis remember when non-resident Hawaiians set up fishing shacks and grew watermelons, sweet potatoes and other vegetables in the sand near the point. Present-day uses of the area are primarily net and spear fishing and the picking of opihi and seaweed. They also say that Hawaiians consider the large boulders along the Lehia Park coastline to have been brought in by high seas in order to protect the area.

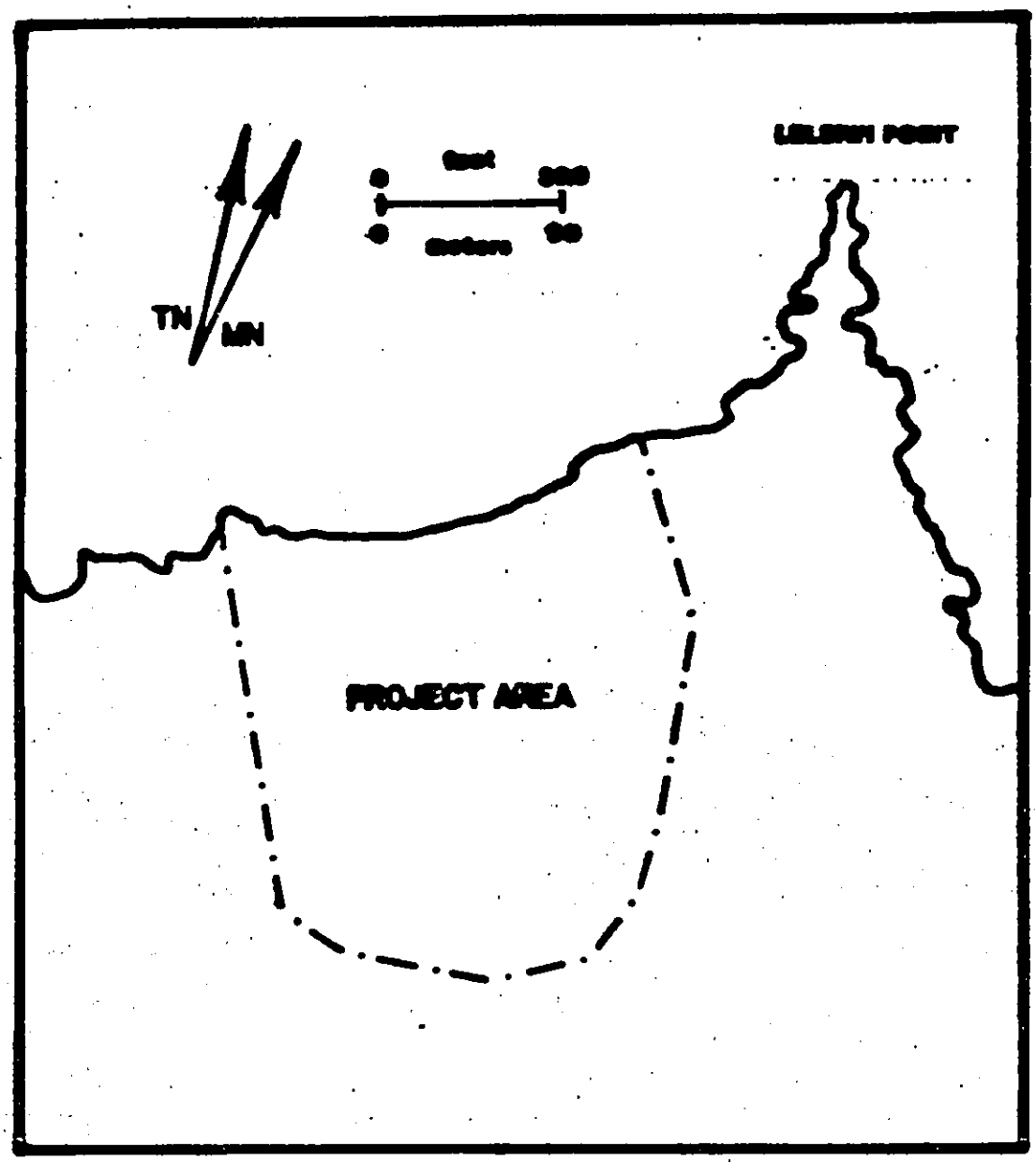

Figure 6. Map of the Leleiwi Point Survey Area.

Puumaile Home, a tuberculosis facility, was constructed in the vicinity in 1939, but was destroyed by high seas in 1947 and never rebuilt. Mrs. Napeahi states that a concrete seawall was broken by high surf and carried into the hospital.

Mr. Napeahi remembers a stone wall near Leleiwi Point that was part of a heiau, and that it was situated adjacent to a military pillbox. This may be the heiau mentioned by Stokes and Hudson.

V. CONCLUSIONS AND RECOMMENDATIONS

A. KALAPANA

Kikoa Heiau, Kikoa Fishpond and Star of the Sea Painted Church are all eligible to the National Register of Historic Places. The heiau and the fishpond are eligible on the basis of the potential they have for providing information concerning the prehistory of Puna District. According to historical architect Spencer Leineweber of Spencer Ltd. [personal communication], the church is eligible primarily because of its combination of architectural and artistic values. It is somewhat tenuously eligible because it has a link with Father Damien as the successor to his church at Kupaahu.

It is therefore strongly recommended that Kalapana be removed from consideration as an alternative location for a small boat harbor.

B. Leleiwi

The fact that there is a lack of surface remains is insufficient grounds for a determination of no effect at this site. The possibility of the presence of both lava bubbles and sub-surface midden materials buried beneath the sand makes it imperitive that either a sub-surface test pit survey of the property be conducted prior to construction or that a qualified archaeologist be retained to monitor activities during construction. If the latter alternative were chosen, it would have to be with the understanding that such construction activities must cease should sub-surface archaeological materials be uncovered.

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SECTION II: DEEP DRAFT NAVIGATION

This section provides information specific to the Hilo area not previously discussed in Section I.

A. Social Well-Being

1. Community Cohesion. Hilo's population growth has been attributed to a migration of people from the rural to the urban area and an influx of people from out of the County. Persons of Japanese ancestry form the dominant ethnic group in the area, but the Caucasian population has increased about 50% from 1950 to 1970, forming the second dominant ethnic group in Hilo. The number of persons of other ethnic groups have declined. The diversity of interests, education backgrounds and ethnic ancestry diffuse community cohesion, which is based principally on common community history and interests, ethnic backgrounds, and length of residences in the County. Most persons feel a strong tie to the County in which they live because of their preference for the geographical location.

2. Economics, Education, and Cultural Opportunities. Hilo is the center of business, government and education in the County. The University of Hawaii was established at Hilo campus which is the center of higher education and cultural activities in the city. Government, trade and services are principal employers in the city with construction and manufacturing important secondary employers. Tourism is a powerful economic force, but inflation has been a principal factor affecting a decline in hotel occupancy rate and the number of visitors entering the County. Hilo Harbor is the principal deep draft port in the County handling the majority of petroleum, general cargo and agricultural products being shipped into the County.

3. Protective Services.

Fire. Hilo has four fire stations with three providing 24-hour service. Principal problems identified in the Hilo Community Development Plan, 1975, related to lack of parking at two stations, need for equipment to fight high rise fires and a new fire station in the airport and industrial port area.

Police. Hilo had a 90 member police force and an old building, which the 1975 plan indicated needed replacement.

Health. The main general hospital for the County is located in Hilo.

Solid Waste. Municipal home collection service was not provided by the County in 1975, and one sanitary landfill located in Hilo was operated by the County.

Utilities:

Water. Hilo's water distribution system consists of a number of reservoirs and a network of water mains. In 1975, the average daily consumption in Hilo was 3.7 mgd. The 1975 planning projections estimated an increase from 4.5 mgd in 1972 to about 5.7 mgd in 1980-1985. The Hawaii Water Resources Regional Study projected water demand by the year 2000 will be 65 mgd. Existing sources have the capability to produce 100 mgd and a potential capability of 2,300 mgd is available in the region.

Sewer. In 1975, the Community Development Plan indicated that Hilo had a primary treatment plan plant with an ocean discharge located outside the harbor in 50 feet of water. At the time Hilo generated about 7 mgd of effluent, but some homes were still using septic tanks and cesspools. The 1975 plan envisioned extending the discharge about 5,000 feet offshore and constructing a secondary treatment plant at Puhi Bay.

Power. Two power plants located in Hilo are basically fossil fuel plants and two others utilize hydropower. Improvements were needed to replace old facilities and lines, and to expand other facilities to replace loss generation. Geothermal power generation appears to be the most important alternate energy source besides other alternative energy sources such as bagasse and biomass conversion.

Landownership and Land Use. Hilo Harbor is dedicated to industrial and recreational use. The waters and major port facilities are owned and operated by the State of Hawaii.

B. Cultural Resources.

Hilo Breakwater: In 1980, the State Historic Preservation Officer and National Park Service informed the Honolulu District that the Hilo Breakwater was eligible for inclusion on the National Register of Historic Places. The breakwater is significant for its contribution to railroad and port expansion in the Hilo region, to the re-establishment of Hilo as the transportation hub of the island of Hawaii and to the growth of Hilo.

APPENDIX G

RECREATION AND NATURAL RESOURCES

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SECTION I: SMALL CRAFT NAVIGATION

A. Regional Recreation and Natural Resource Problems and Needs

1. Throughout the Hilo Area Comprehensive Study, public and government participants continued to stress the need for a system of small craft facilities along the coast north and south of Hilo that would improve navigational safety by providing protected moorings and launch areas for use during periods of high winds and waves. Except for the Pohoiki and Kaulana launch ramps, no other public facility is available south of Hilo during foul weather. A small private ramp is located at Punaluu. Recreational boaters and commercial fishermen continually emphasized a need for haul out and repair facilities within the Hilo region. In discussing siting alternatives, shoreside residents have opposed various sites, especially sites close to their homes, citing adverse effects to scenic and open space values, loss of or interference with other shoreline activities, such as fishing and recreational values, and adverse effects on life-style.

2. The State Recreational Plan (DLNR, 1980) indicates that swimming and sunbathing are high priority recreational needs, with surfing, fishing, picnicking, camping and launch ramps as medium priority needs. The need for boat mooring and slips is recognized as a long-term need. The State Recreational Plan, the Hilo Community Development (Belt, Collins and Associates, 1975) and the draft Puna Community Development Plans (County of Hawaii, 1979) stress the protection and conservation of native endangered species, natural ecosystems of endemic plants, fish and wildlife, and coastal recreational resources. The plans emphasized the need for balancing the installation of public improvements with recreational, educational and other public needs.

B. Recreational and Natural Resource Management Aspects of the Potential Harbor Sites.

1. Recreational Resources.

a. Scenic and Wild Rivers. None present.

b. National Trails. None present, However, a regionally important historic trail around the coast of Hawaii does exist and passes through all the potential sites under consideration.

c. Natural Landmarks. No Nationally recognized natural landmarks are present at any of the potential sites. However, the low cliff south of Kalapana is a small horst block elevated between two faults forming a fault scarp (Stearns and MacDonald, 1946). The Puna Community Development Plan identifies the scarp as a natural beauty and scenic viewpoint.

d. National Shoreline Parks or Beaches. No shoreline parks or beaches listed on the National inventory of parks and beaches are found at Kalapana, King's Landing or Leleiwi Point. The Kalapana site includes the undeveloped Kalapana historic canoe landing site. The Puna Community Development Plan indicates that 13 acres of the site would be developed as a historic park by the State of Hawaii possibly by 1983. The site is also adjacent to the Harry K. Brown County Beach Park. The Leleiwi Point site is located on lands set aside for the Lehia County Beach Park. Forty-three acres of park are designated in the Hilo Community Development Plan for camping, water recreation and hiking uses. The King's Landing site is located on private land and is not designated for any local park development.

TABLE G-1. RECREATIONAL RESOURCES

Site	Recreational Site	Acres	Ownership	Designated Park Use
Kalapana	Kalapana canoe landing	13	State	historic park
King's Landing	None	-	Private	none
Leleiwi Point	Lehia Park	43	State	general park uses

e. Water Contact Recreation. Based upon information provided from the public, water contact recreation at the various sites include swimming, surfing, fishing, and sunbathing. Water conditions at King's Landing are particularly dangerous due to the precipitous, rocky shoreline and exposed open water conditions. A surfing site at Harry K. Brown Park was identified in a 1971 survey by Surfing Education Association. At Leleiwi Point, tidepools surrounded by ironwoods provide a quiet, aesthetically pleasing and protected swimming area in contrast to the rough ocean wates along the shoreline.

TABLE G-2. WATER CONTACT RECREATION RESOURCES

	Recreation					
Site	Swimming	Fishing	Boating	Surfing	Picnicking Sunbathing Sightseeing	Hiking
Kalapana	X	X	-	X	X	X
King's Landing	-	X	-	-	Public access limited	
Leleiwi Point	X	X	-	-	X	X

TABLE G-3. RECREATIONAL FACILITIES

Recreational Area	Pavilion	Rest-rooms	Showers	Drinking Water	Picnic Areas	Camping Areas	Electri-city	Small Boat Landing
Kalapana Canoe Landing Site	UNDEVELOPED							
Harry K. Brown Beach Park	X	X	X	X	X	X	X	-
Lehia Park (Leleiwi Point)	UNDEVELOPED							

Source: State of Hawaii, Department of Planning and Economic Development, 1978, County of Hawaii, Data Book, 1978.

2. Natural Resources.

a. Land Resources. All the potential harbor sites under consideration involve land derived from volcanic flows having moderate slopes varying from 0-6%. Soil erosion hazards are slight due to the high soil permeability, and rocky and hard soil surface (Soil Conservation Service, 1975).

TABLE G-4. SOIL CLASSIFICATION

Site	Soil Type	Agricultural Capability
Kalapana	Volcanic glass beach and Punaluu extremely stony peat.	Moderately limited due to stony conditions. Rocky outcrops cover 40-50% of the land surface. Peat layer about 4-inches thick.
King's Landing	Pahoehoe Lava Flow	Severely limited. No soil cover present. Very stony.
Leleiwi Point	Pahoehoe Lava Flow	Severely limited. No soil cover present. Very stony.

b. Prime and Unique Agricultural Lands. Neither Kalapana, King's Landing nor Leleiwi Point are located on prime or unique agricultural lands (State of Hawaii, Department of Agriculture, 1972).

c. Natural Hazards.

(1) Volcanism. The summit and major rift zones of Mauna Loa and Kilauea volcanoes on the island of Hawaii have been very active during historic times, and volcanic activity is expected to continue through the foreseeable future.

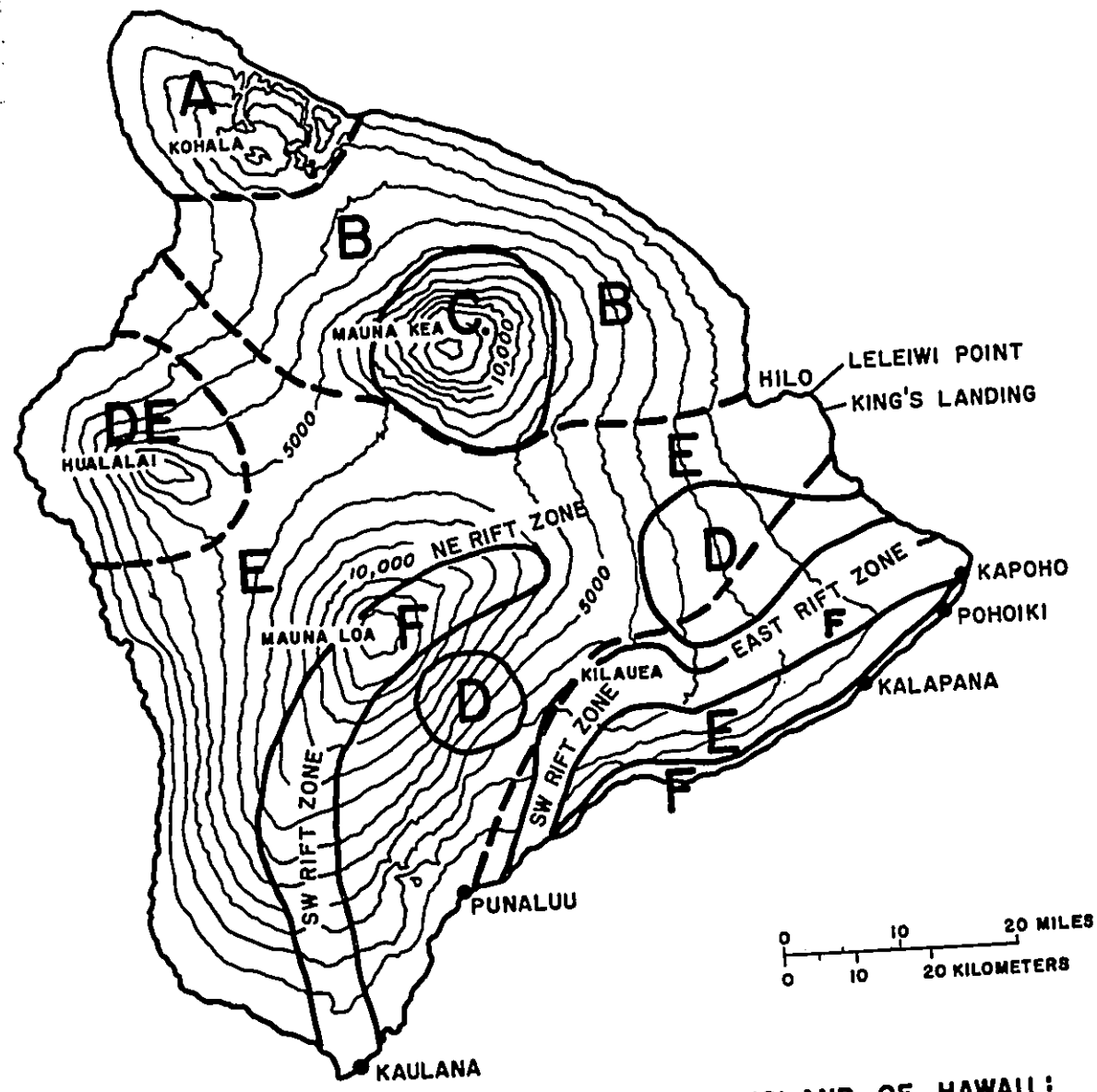
TABLE G-5. RECORDED OR ESTIMATED NUMBER OF VOLCANIC ERUPTIONS ON THE ISLAND OF HAWAII DURING HISTORIC TIMES (1800-Present)

Volcano	Total Eruptions	Eruptions Outside the Caldera
Mauna Loa	30-40	About 15
Kilauea	40-50	About 25
Mauna Kea	0	-
Hualalai	2	-
Kohala	0	-

Adapted from US Geological Survey, 1974.

Kalapana, King's Landing and Leleiwi Point all lie within volcanic hazard zones. However, Kalapana lies within the area of highest volcanic hazard (see Figure G-1). Volcanic hazards include burial by lava flow, falling ejecta, volcanic gases, particle-gas clouds, ground subsidence and cracking, earthquakes, and localized tsunamis. In particular, the Kalapana coastal area is an areal of active and frequent faulting, where the land is subject to cracking and sudden subsidence. Block slumping along the southern flank of Kilauea can cause a rise in sea level along the coast that can result in localized tsunamis, inundation of previously dry areas, or sea level rises that result in wave and storm wave damage. Kalapana village is situated in a shallow fault trench, the floor of which subsided several feet in 1868. In November 1975, a local massive subsidence triggered an earthquake of a magnitude of 7.2 on the Richter scale and a local tsunami. The land mass at Halape sank 11.5 feet and moved seaward 20 feet. The coastal areas at Kalapana and Kaimu subsided 3 feet and the road fronting Harry K. Brown Park subsided to a level which placed it underwater during normal high tide. The localized tsunami wave heights ranged from 26 to 48 feet above sea level along the coast.

The island of Hawaii is settling at an average island-wide rate of about 4mm per year (County of Hawaii, 1979). However, settling is not uniform for all parts of the island, but is particularly active along the southern flank of the Kilauea Volcano (South Puna) and the west flank of Mauna Loa (South Kona). The volcanic activity associated with the hazards areas is presented in Table G-7 as an indication of the danger associated with the hazard ratings.



THE FIVE VOLCANOES THAT FORM THE ISLAND OF HAWAII: KOHALA, MAUNA KEA, HUALALAI, MAUNA LOA AND KILAUEA. CONTOUR INTERVAL 1,000 FEET. DASH LINES SEPARATE NAMED VOLCANOES. (USGS, 1974)

EXPLANATION

HAZARD DESIGNATION	
F	AREA OF HIGHEST RISK WITH HISTORIC AND RECENT PREHISTORIC RECORD OF ACTIVE VOLCANISM, FAULTING AND SUBSIDENCE.
E	AREA SUSCEPTIBLE TO BURIAL BY LAVA FLOWS ORIGINATING FROM AREA F. DEGREE OF RISK GENERALLY DECREASES WITH DISTANCE FROM SUMMITS AND MAJOR RIFT ZONES.
DE	HUALALAI VOLCANO ONLY. LAVA BURIAL MORE FREQUENT THAN AREA D, BUT LESS THAN AREA F.
D	MODERATE RISK. NO HISTORIC OR RECENT PREHISTORIC LAVA FLOWS.
C	MAUNA KEA VOLCANO SUMMIT. SMALL RISK. ERUPTION FREQUENCY LOW, LAST ERUPTION 3000 - 5000 YEARS AGO.
B	NO ERUPTIONS DURING LAST 10,000 YEARS.
A	NO VOLCANIC ACTIVITY IN LAST 60,000 YEARS.

SOURCE: USGS, 1975

FIGURE G-1

TABLE G-6. EVALUATION OF VOLCANIC HAZARD POTENTIAL

Area	Volcanic Hazard Rating	Lava Flow	Hazard Rating Eject and Gas	Particle-Gas Cloud	Subsidence	Ground Cracking	*Earthquake	Tsunamis
Leleiwi Point	E	E	Moderate	Unknown	Moderate	Low	Moderate	High
King's Landing	E	E	Moderate	Unknown	Moderate	Low	Moderate	High
Kalapana	F	E	Moderate	Unknown	High	Moderate	High	High

Source: US Geological Survey, 1974.

*Assumed to be similar to subsidence due to the interrelationship between earthquakes and faulting.

TABLE G-6. EVALUATION OF VOLCANIC HAZARD POTENTIAL

Area	Volcanic Hazard Rating	Lava Flow	Hazard Rating Eject and Gas	Particle-Gas Cloud	Subsidence	Ground Cracking	*Earthquake	Tsunamis
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King's Landing	E	E	Moderate	Unknown	Moderate	Low	Moderate	High
Kalapana	F	E	Moderate	Unknown	High	Moderate	High	High

Source: US Geological Survey, 1974.

*Assumed to be similar to subsidence due to the interrelationship between earthquakes and faulting.

TABLE G-7. NUMBER OF ERUPTIONS ORIGINATING WITHIN HAZARD AREAS AND NUMBER OF TIMES LAVA FLOW COVERED LAND WITHIN HAZARD AREAS DURING HISTORIC TIMES (SINCE 1800) ON THE ISLAND OF HAWAII

Hazard Area	# of Eruptions	# of Lava Flows	% Land Covered by Lava
A	0	0	0
B	0	0	0
C	0	0	0
D	0	0	0
DE	1	2	6
E	1	35	15
F	80	more than 80	50

Source: US Geological Survey, 1974.

(2) Tsunami and flood inundation. Based on the Flood Insurance Rate Maps (US Department of Housing and Urban Development, 1979), Kalapana, King's Landing and Leleiwi Point lie within the 100-year tsunami inundation and coastal high hazard areas. At Leleiwi Point a tsunami water elevation of 18 feet is calculated at the shoreline and an 11-foot water elevation approximately 2000 feet inland. A comparison of inundation information is presented in Table G-8.

TABLE G-8. TSUNAMI AND COASTAL FLOODWATER ELEVATIONS

Site	Water Elevation at the Shoreline	Water Elevation in Land	
	Height	Height	Distance Inland
Leleiwi Point	18	11	2000 feet
King's Landing	17	19	500 feet
Kalapana	34	38	2000 feet

d. Vegetation. The vegetation at Kalapana, King's Landing and Leleiwi Point is illustrated in Figures G-2 to G-4. The vegetation consists principally of coastal strand vegetation, except in areas inhabited or modified by man. The coconut grove at the Harry K. Brown Park was identified as an area of natural beauty, but the coconut grove at the Kalapana Canoe Landing site, which is larger than the Harry K. Brown grove, was not identified for its natural beauty. No significant or important trees are found at the project sites.

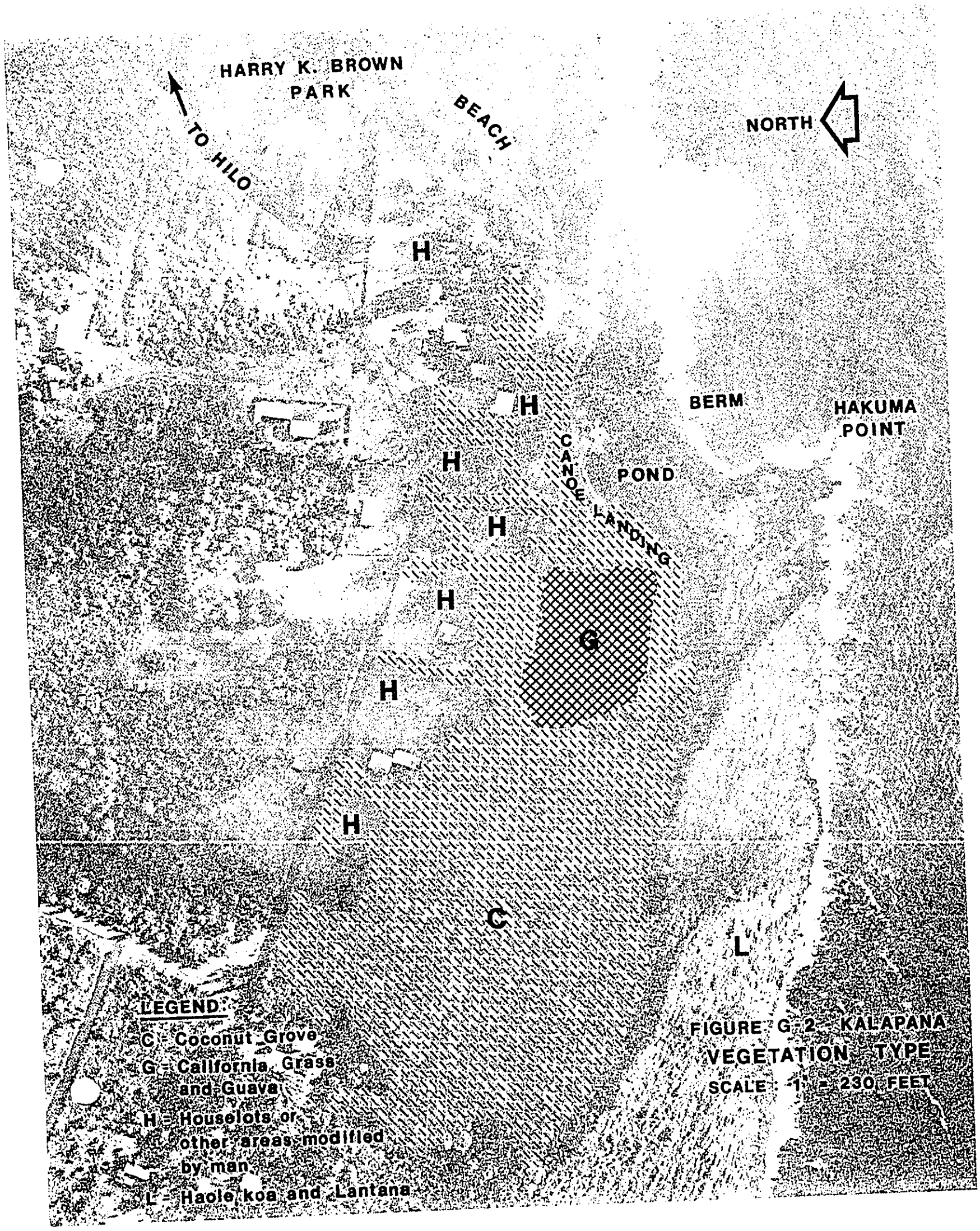

FIGURE G-2 - KALAPANA VEGETATION TYPE

SCALE: 1" = 230 FEET

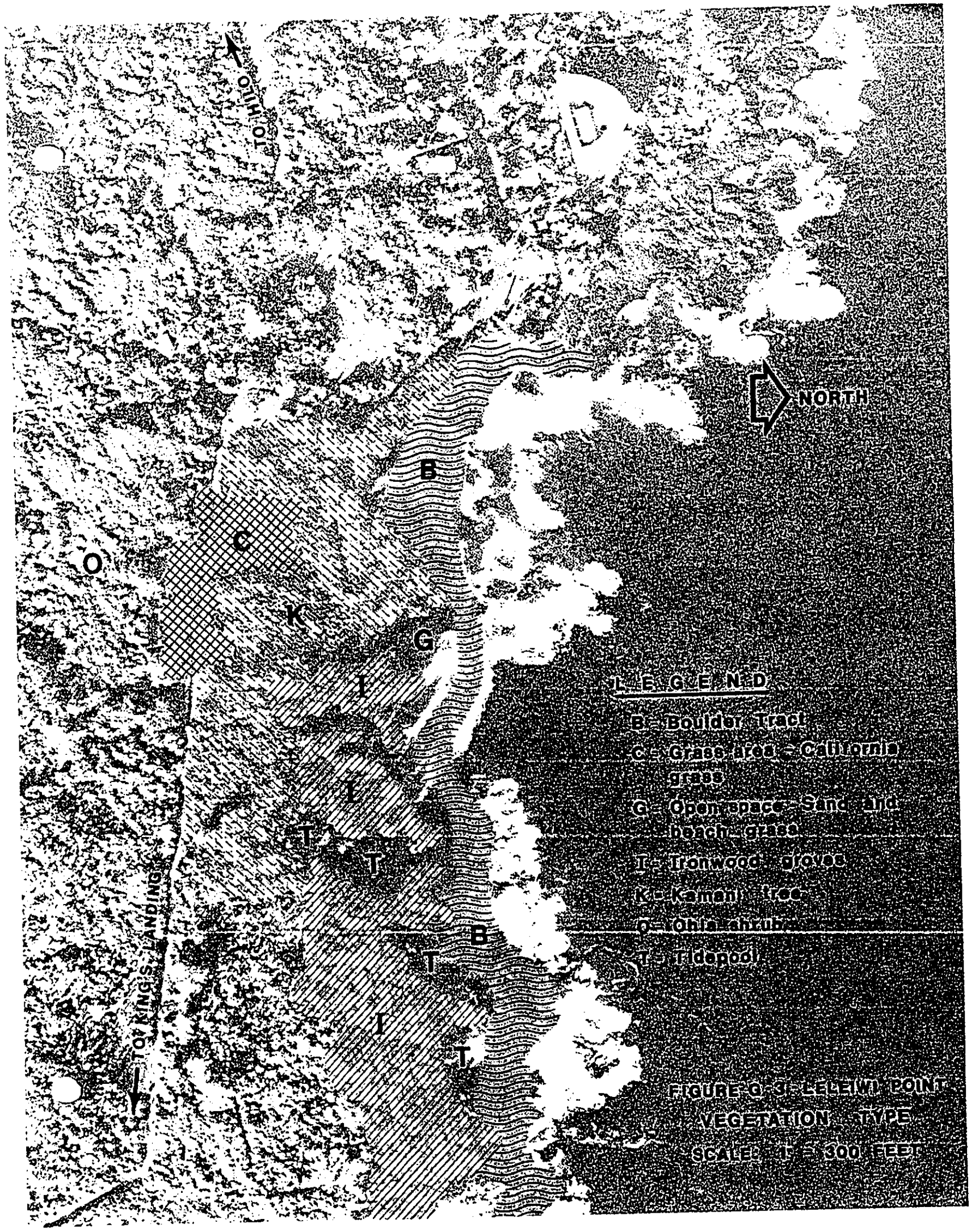

FIGURE G-3 LELEIWI POINT VEGETATION TYPE

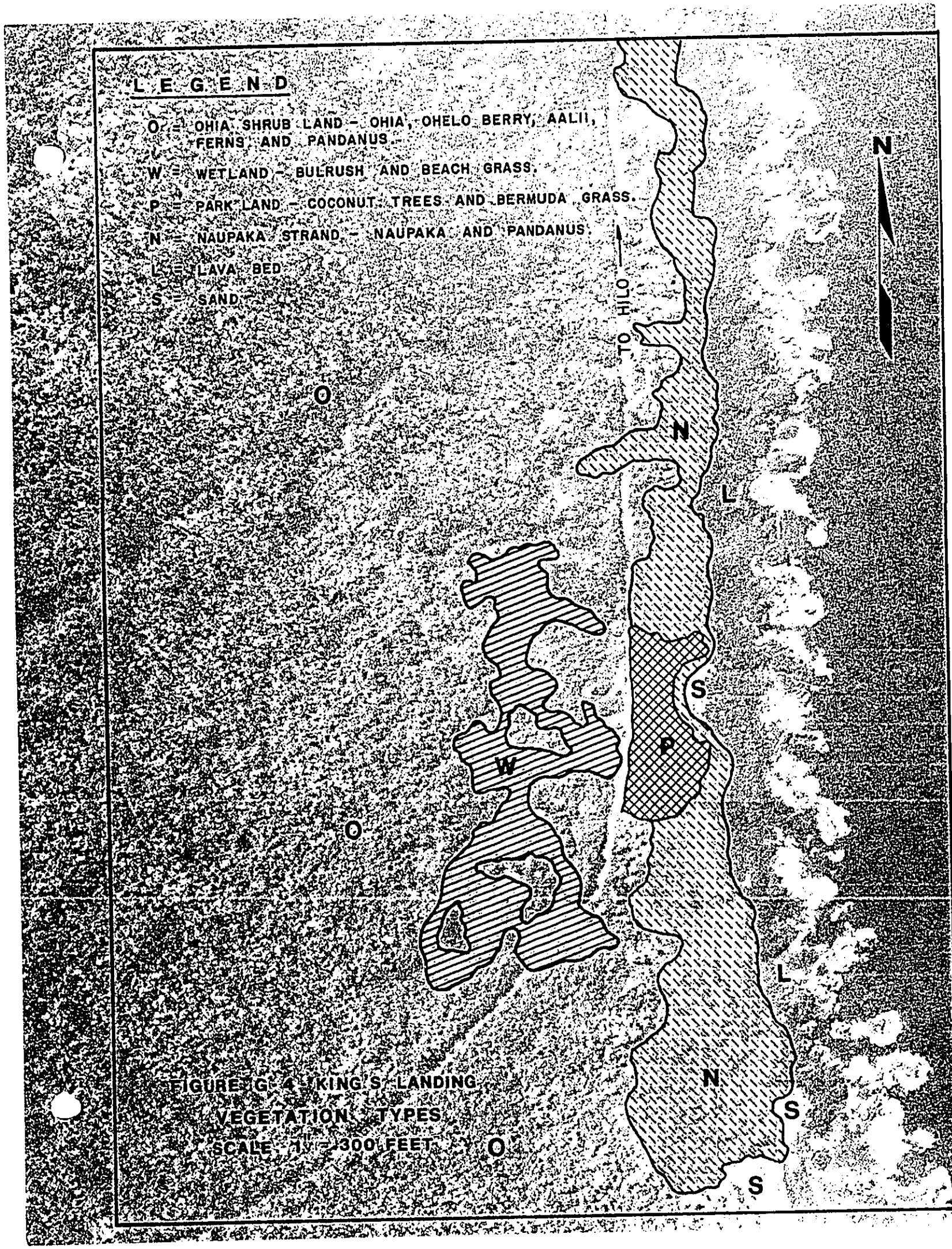

FIGURE G 4 KING'S LANDING
VEGETATION TYPES
SCALE 1" = 300 FEET

e. Wildlife Refuges. No wildlife refuges are present at either Kalapana, King's Landing or Leleiwi Point.

f. Wetlands. A 12-acre wetland is found at the King's Landing Site 1 (Figure G-4). The wetland is comprised of beach grass (Sporobolus virginicus) and bulrush (Scirpus validus). No open water areas exist and the dense vegetation growth restricts wildlife habitat usefulness. No important wetland values are attributed to the site, but the wetland provides general wildlife habitat. The wetland may have been formed by the natural filling of a collapsed lava tube or brackish water pool by sand washed in from the ocean and the growth of vegetation.

g. Marine Resources. Kalapana, King's Landing and Leleiwi Point are located on open and exposed basalt shorelines which drop quickly into deep water. No coral reefs are located at the project sites although coral can be found growing on the basalt substrate. See U.S. Fish and Wildlife Planning Aid Letter for small boat navigation improvement project. None of the sites provide commercial fishing resources, however, all the sites provide recreational fishing opportunities. The tide pools at Leleiwi Point provide a localized attraction and nursery area for juvenile reef fish.

TABLE G-9. RECREATIONAL FISHING

Site	Fishing Activities			
	Opihi Gathering	Polefishing	Boat Fishing Facilities	Diving
Leleiwi Point	-	X	-	X
King's Landing	X	X	-	-
Kalapana	X	X	-	X

No significant fish nursery, breeding or spawning values are associated with the sites. No commercially harvestable shellfish beds are found at any of the sites, but opihi gathering does occur in some areas.

h. Estuaries. Neither Kalapana, King's Landing nor Leleiwi Point are estuaries listed in the National Inventory.

i. Streams. No streams are found at any of the potential harbor sites. The land mass is geologically young for the development of defined stream and river drainageways and the high soil permeability reduces the amount of rainfall runoff.

j. Anchialine Pools. At King's Landing, the U.S. Fish and Wildlife Service found some holes and fissures which contained water possibly forming anchialine pools. The number of pools present are unknown due to the dense vegetation and rugged terrain which makes an accurate survey time consuming and difficult. The pools examined contained fish of the family Poecilliidae whose presence precludes the likelihood of finding small endemic crustaceans. The pools are unique in that they contain freshwater which fluctuate with the tide, and provide a freshwater aquatic system in a harsh, youthful geologic area where streams have not yet developed.

k. Groundwater. The highly porosity of lava allows rainfall to contribute significantly to the basal groundwater. Rainfall quickly infiltrates the ground resulting in a small amount of runoff, except during extremely heavy periods of rainfall. Dense lava flows or areas of highly weathered rock, trap water in dikes or at high elevation creating perched groundwater sources. Seepage from these high sources form the basis of streams in older portions of the island. In the newer portions of the island groundwater discharges along the shoreline as springs.

TABLE G-10. GROUNDWATER RESOURCES

(Units in Million Gallons per Day)

Water Resource Region	Rainfall	Runoff	Evapotranspiration	Surplus to Basal Water	Groundwater Flow Per Mile Shoreline
South Hilo to Kumakahi (Leleiwi Point and King's Landing)	4200	630	1260	2310	100
Kapoho to Punaluu	1040	104	728	208	4

Source: Hawaii Water Resources Regional Study, 1975.

In the Kilauea area, which includes Kalapana, the rift zone is believed to be a barrier to basal groundwater. While groundwater is believed available, extraction by wells is judged to be costly and relatively unproductive since the wells may have to be 1000-2000 feet deep or deeper and the basal water may exist as a thin lens. The groundwater elevation generally rises from sea level at the shoreline to 2-4 feet above sea level per mile inland. Five to six miles inland the groundwater reaches an elevation of 12-18 feet above sea level. Diked and perched water provide most of water supply sources in the study area.

Groundwater chloride content along the coast makes the water unsuitable for drinking purposes. However, springs and old wells along the coast (Stearns and MacDonald, 1946) did produce drinkable brackish water. Some of the old wells identified by Stearns and MacDonald were located at the Kalapana Cave of Refuge and Leleiwi Point. These wells produced water having a chloride content of about 700-900 mg/l. By comparison, safe potable water should have a chloride content of 250 mg or less.

TABLE G-11. COASTAL GROUNDWATER CHLORIDE CONTENT

Site	Chlorinity
Leleiwi Point	1000 mg/l
King's Landing	500-1000 mg/l
Kalapana	1000 mg/l

Source: Hawaii Water Resources Regional Study, 1975.

l. Aquatic Plants. No aquatic plant control problems are known to exist either Kalapana, King's Landing and Leleiwi Point.

m. Water Quality. Coastal waters at Kalapana, King's Landing and Leleiwi Point are judged pristine, except for areas along the shoreline permanently inhabited by man. Since sewer facilities are not available in the Kalapana area, residences use cesspools to dispose of their wastewater. Effluent from the cesspools probably leaches into the water along the shoreline. No residents reside at King's Landing or Leleiwi Point. Since no restroom facilities are provided at Lehia Park at Leleiwi Point human use of the park may contribute to coastal water pollution.

n. Ocean Disposal. No ocean disposal sites are located near Kalapana, King's Landing or Leleiwi Point. The nearest ocean disposal site is located several miles north of outer Hilo Bay in water depths of approximately 190 fathoms.

o. Pesticides. Pesticides are not produced or stockpiled at either Kalapana, King's Landing or Leleiwi Point. Pesticide application on a major scale is performed on agricultural lands in the Puna and South Hilo areas. Pesticide residues are not detected in the groundwater (Hawaii Water Resources Regional Study, 1975).

p. Air Pollution. Volcanic gases are the most significant air pollutant in the study area, particularly in the Kalapana area. Sugar fires in the Puna, South Hilo and North Hilo areas are the most significant man-made pollution sources. Automotive emissions are considered a minor pollution source compared to volcanic gases and agricultural fires, but may be a locally important factor at Kalapana which is heavily visited by island visitors and residents. Leleiwi Point is within easily commuting distance from Hilo and may be influenced by resident and park user vehicle emissions. Access to King's Landing requires a special permit; thus there are few man-made pollution sources.

q. Noise. Significant noise pollution sources are man-made related to vehicular traffic and recreation activities. Leleiwi Point is influenced by aircraft operations at Hilo Airport.

C. Fish and Wildlife Coordination

1. Endangered Species

1.1 The National Marine Fisheries Service (Appendix (__) indicated that the endangered humpback whale (Megaptera novaeangliae), the endangered hawksbill sea turtle (Eretmochelys imbricata) and the threatened green sea turtle (Chelonia mydas) can be found in waters around Hawaii. They further indicated that the waters around Leleiwi Point and King's Landing are reported to be foraging areas for the turtles, and that a hawksbill turtle nest was recently reported at the Harry K. Brown Beach Park near the Kalapana site. Takata (personal communication, 1981) indicated that some youngsters in 1978 brought to his Sea Grant Office in Hilo some small turtles which had hatched from a nest located on a sand bar at Harry K. Brown Park. The sand bar separates a park wading pool from the ocean and is heavily used by park visitors on weekends. No surveillance or investigations of the nest site were performed by either Takata, the National Marine Fisheries Service or the U.S. Fish and Wildlife Service in subsequent years since the initial report to determine if the hawksbill turtle has returned to the site. Takata indicated that human use of the sand bar probably obliterates any traces of turtle tracks produced during the night. The US Fish and Wildlife Service, Endangered Species Office

(Appendix ___) indicated that the sighting was significant because it involved an endangered species, it was the first report of its kind in that area of Hawaii, and the turtle might return to the site due to turtle fidelity to particular nesting sites. However, continued human presence and use of park and nesting site probably jeopardizes the continued use of the site for nesting, and the sighting is a rare occurrence. No other turtle nesting areas known to exist along the Puna coast.

1.2 The humpback whale seasonally migrates through Hawaiian waters and can be found around all the major islands from Hawaii to Kaula Rock during the seasonal migration. The whales begin to appear during November and leave the islands by June with the greatest number occurring during February and March.

The National Marine Fisheries Service indicated that 500-700 whales annually migrate through Hawaiian waters to mate, calve and nurse their young. The whales prefer relatively shallow water, usually waters less than 100 fathoms deep, and are particularly numerous on Penquin Banks, in the area between Maui, Lanai, Molokai and Kahoolawe, around the northwest tip of Hawaii and between Niihau and Kauai. However, they are consistently seen in small numbers in other areas of the Hawaiian Islands during the season. Herman (1981) suggests that the whales first arrive in Hawaii around the island of Hawaii and travel northward toward the islands in Maui County and continuing toward Niihau and Kauai, where they leave on their return to the northern summer feeding grounds. The relative concentrations of whales in the Hawaiian Islands is illustrated in Figure G-5 based upon information provided in 1976 and 1977 censuses (Wolman and Jurasz 1976, and Rice and Wolman, 1977). The National Marine Fisheries Service provided the following whale census in the Leleiwi Point area of Hawaii.

TABLE G-12. WHALE SIGHTINGS OFF LELEIWI POINT

Year	# Whales Sighted
1976	12
1977	7
1978	5
1979	9

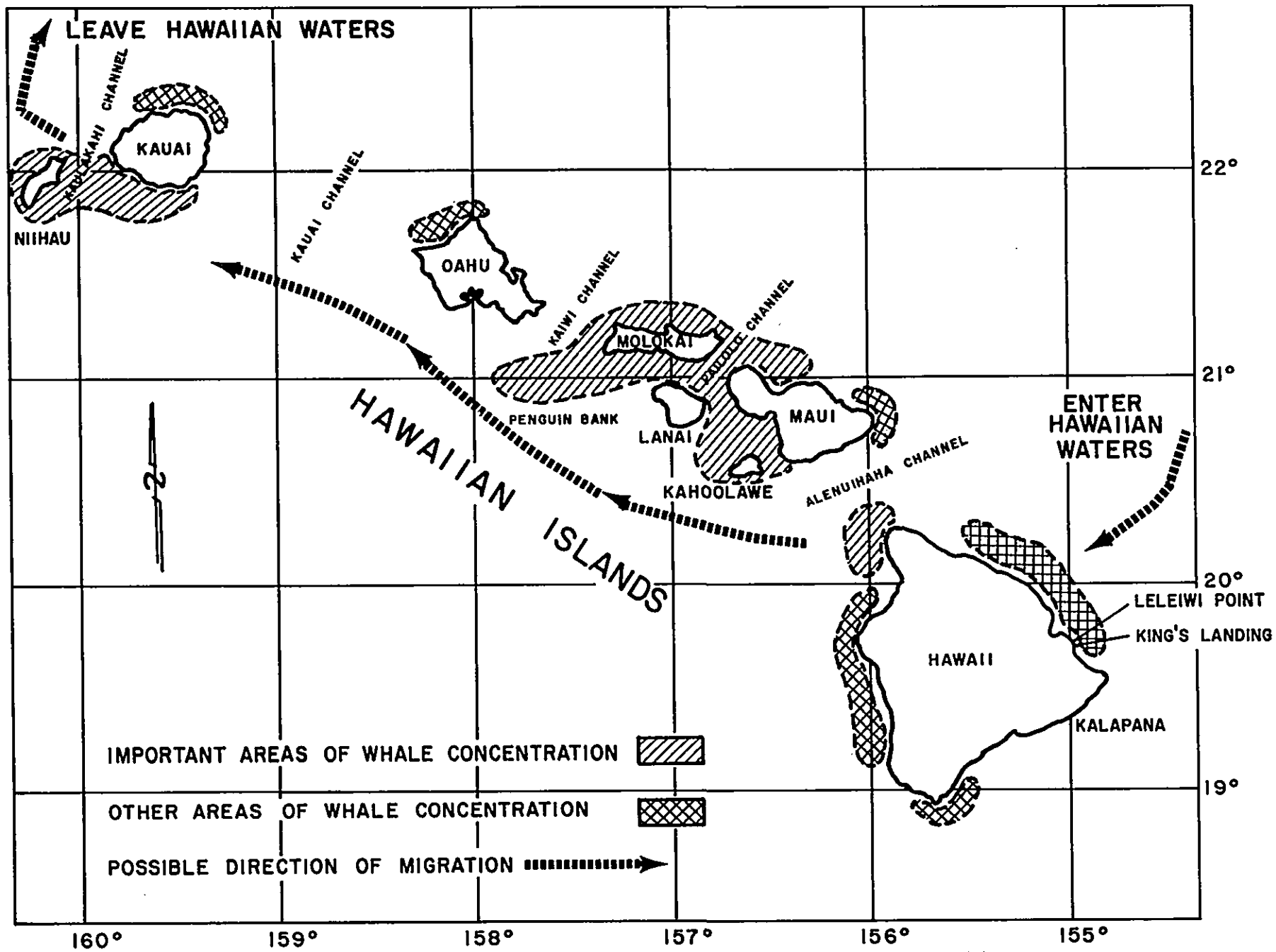

FIGURE G-5 DISTRIBUTION OF HUMPBACK WHALES IN HAWAII

ADAPTED FROM: WOLMAN AND JURASZ, 1976 AND RICE AND WOLMAN, 1977. HERMAN IN WHITTEN, 1981.

United States Department of the Interior

FISH AND WILDLIFE SERVICE
300 ALA MOANA BOULEVARD
P.O. BOX 50167
HONOLULU, HAWAII 96850

IN REPLY REFER TO
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Room 63

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SEA

Colonel Alfred J. Thiede
U.S. Army Engineer District, Honolulu
Building 230
Fort Shafter, Hawaii 96858

Re: PAL Hilo Area
Navigation Improvements
County of Hawaii, HI

Dear Colonel Thiede:

This is the U.S. Fish and Wildlife Service's Reconnaissance Planning Aid Letter regarding plans by the Honolulu District of the U.S. Army Corps of Engineers to construct a small boat harbor in the vicinity of Hilo, County of Hawaii, Hawaii. These comments are preliminary in nature and do not constitute the report of the Secretary of the Interior on the project within the meaning of Section 2(b) of the Fish and Wildlife Coordination Act. When the harbor site is selected, the Service will provide a more detailed Planning Aid Letter for that site, and subsequently a Section 2(b) Report.

This document has been prepared using various reports provided by the Corps, on site investigations by Service biologists during the period May 20-22, 1981, and engineering drawings provided by the Corps on May 19, 1981.

Description of the Planning Area

The Island of Hawaii is the largest of the Hawaiian Islands, encompassing 4,038 square miles of land area. The island has two main population centers, Kailua-Kona on the west coast and Hilo on the East coast. Hilo is the economic center of the island (figure 1).

The Corps has identified three possible alternative harbor sites; Leleiwi Point, King's Landing and Kalapana (figure 2).

Leleiwi Point

The Leleiwi Point site is located approximately 4 miles east of Hilo (figure 2). The coast in that area is very rocky, having been formed by lava flows. The harbor site is accessible by a well-paved road except for the last several hundred yards. Several hundred yards inland from the coast is a wetland area, largely covered with waist-deep grass. Although it had rained the day before, there was no standing water in the grass area; however, scattered throughout were very small patches of bullrush in which there was standing water. The higher elelvation around the wetland consisted mostly of ironwoods, kamani, pandanus, hau, some 'ohi'a, guava and coconut.

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No birds or other macrofauna were observed in the wetland area. On the higher ground, we observed the Common Mynah, Japanese White-Eye and Cardinal. In the eastern portion of the project area there is an extensive network of tidepools and channels which are brackish, and in the northeast corner another large tidepool complex. These two areas are covered with grass and scattered ironwoods. The tidepool complex contained a large number of juvenile fish and many juvenile sea hares (family Aplysiidae).

A snorkel survey was made off-shore from the proposed entrance channel south to Leleiwi Point and north approximately 100 meters. The bottom slopes rapidly seaward from the rocky shore. Our survey was generally between 75 and 150 meters from shore, and in water depths of 10 to 20 meters. The visibility was good, probably on the order of 25 to 35 meters. The bottom immediately seaward of the proposed entrance channel was composed of large boulders from one to several meters in diameter. North and south of that area, the bottom was strewn with boulders less than one meter in diameter. Close to Leleiwi Point the large boulders occurred again. Coral growth was extensive, with a cover estimated to vary from approximately 10 per cent to 50 per cent. Species identified from the surface were Pocillapora meandrina, Porites lobata, Porites compressa, Montipora verrucosa, Montipora flabellata, and Palythoa tuberculosa. Also seen were the sea urchins Colobocentrotus stratus, Echinometra mathaei, Echinothrux diadema, and Tripneustes gratilla. Vertebrates observed included the green sea turtle Chelonia mydas agassizi, and 24 species of fish.

King's Landing

The two King's Landing sites are located approximately 7 miles east of Hilo. The coast is very rocky, and although similar to Leleiwi Point, it appears to be a higher energy wave environment. The area is accessible by a crushed rock road from the vicinity of Leleiwi Point. Portions of the two sites have been cleared of heavy growth seaward of the road and are used for picnicing. The areas are grassed, with numerous coconut trees. The landward side of the road is thickly vegetated with ironwood, pandanus, kamani, hau, californiagrass and patches of bullrush. The bullrush were around small pools which were scattered throughout the area. The pools which we examined closely appeared to contain small fish of the family Poeciliidae, therefore it is unlikely any of the small endemic crustaceans sometimes found in anchaline pools are present. We observed mongoose and a feral domestic cat as well as the Cardinal, Barred Dove, Spotted Dove, Japanese White-Eye, Common Mynah and Black-Crowned Heron.

Due to heavy wave action, we did not make an aquatic survey; however, due to the similarity of the shore to that at Leleiwi, we anticipate similar habitat and organisms.

Kalapana

The Kalapana site is located approximately 35 miles south of Hilo on Highway 13. Like Leleiwi and King's Landing the shore is lava rock and the waves are high energy.

Much of the project area is an old coconut plantation, and another sizable portion is californiagrass mixed with guava. There are also scattered kamani and ironwood trees. The area is a disturbed, essentially abandoned agricultural area, and includes several abandoned houses. The only wildlife observed was one mongoose, however other common exotic species of birds and mammals undoubtedly frequent the area.

A large tidepool was located on the seaward (eastern) edge of the project area. This pool was being used for swimming, fishing, and canoeing during our survey. Because of the congestion in the pool we did not enter the water, but did observe some juvenile fish from the shore. Due to heavy wave action, no off-shore aquatic survey was attempted, however the shore is similar to that at Leleiwi and King's Landing and we anticipate similar habitat and organisms.

Discussion

The terrestrial wildlife resources in the three alternative project areas are very similar, and consist of common exotic species. Although habitat would be destroyed, at each site there is nearby similar habitat so there would be little significant impact on most of the organisms.

The tidepools at the Leleiwi Point and Kalapana sites provide valuable habitat for juvenile fish, protecting them from larger predators. The off-shore portions of the three project sites are probably similar, with similar species of fish and invertabrates. Since the substrate is largely rock, no significant siltation effects from dredging the entrance channel are anticipated at any of the three sites, and recolonization by the benthic organisms should be rapid. Recolonization by corals should also be rapid, especially for fast-growing species such as Poecillapora spp.

Recommendations

The Service believes construction of the project at either of the King's Landing sites will have less adverse impact on fishery resources because of the absence of extensive tide pools in the area. We therefore recommend that location be chosen.

If the Leleiwi Point or Kalapana sites are selected, we recommend that the harbor plans be altered slightly to avoid impacting the tidepools.

Sincerely yours,

ACTING Pacific Islands Administrator

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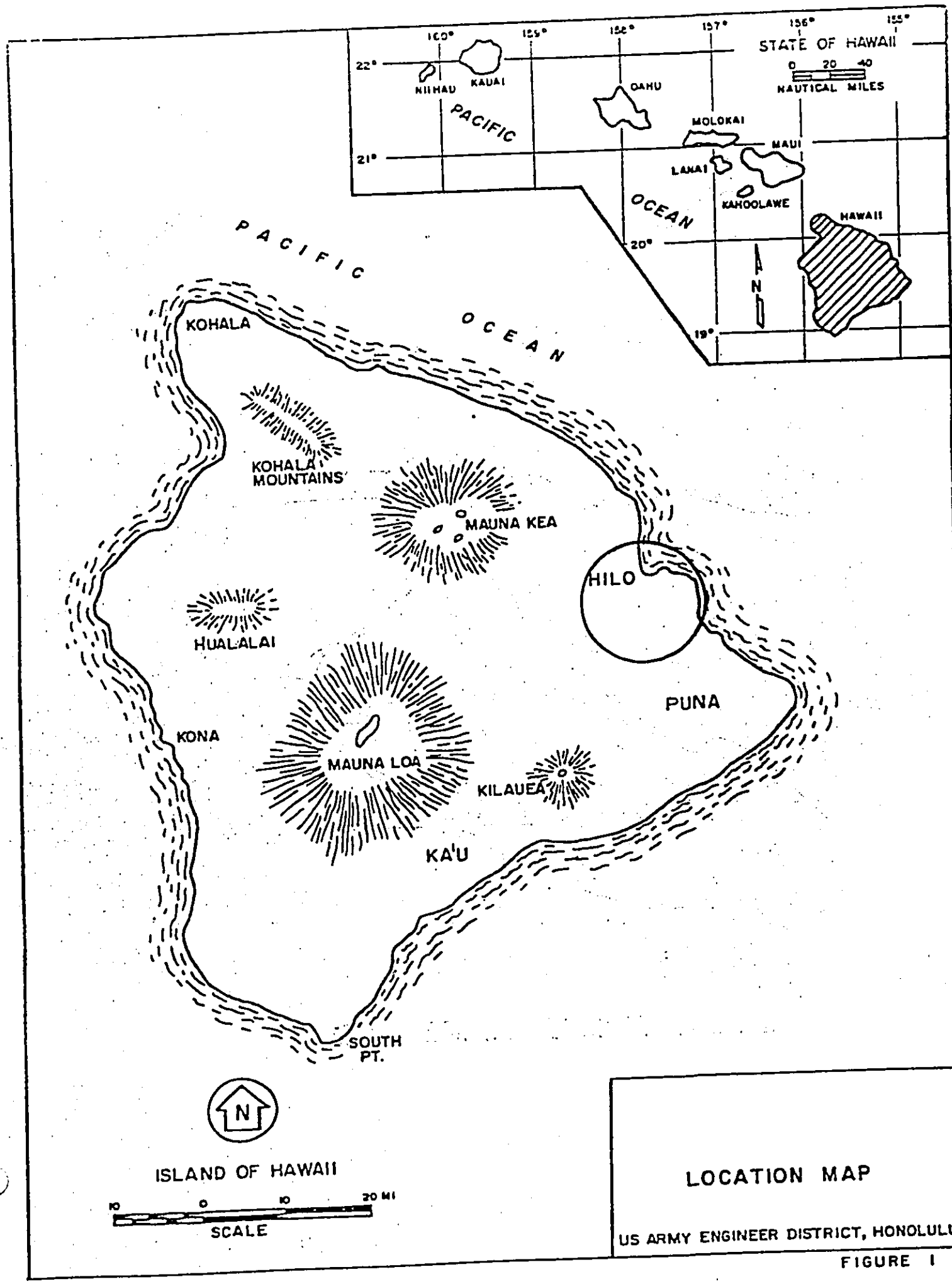
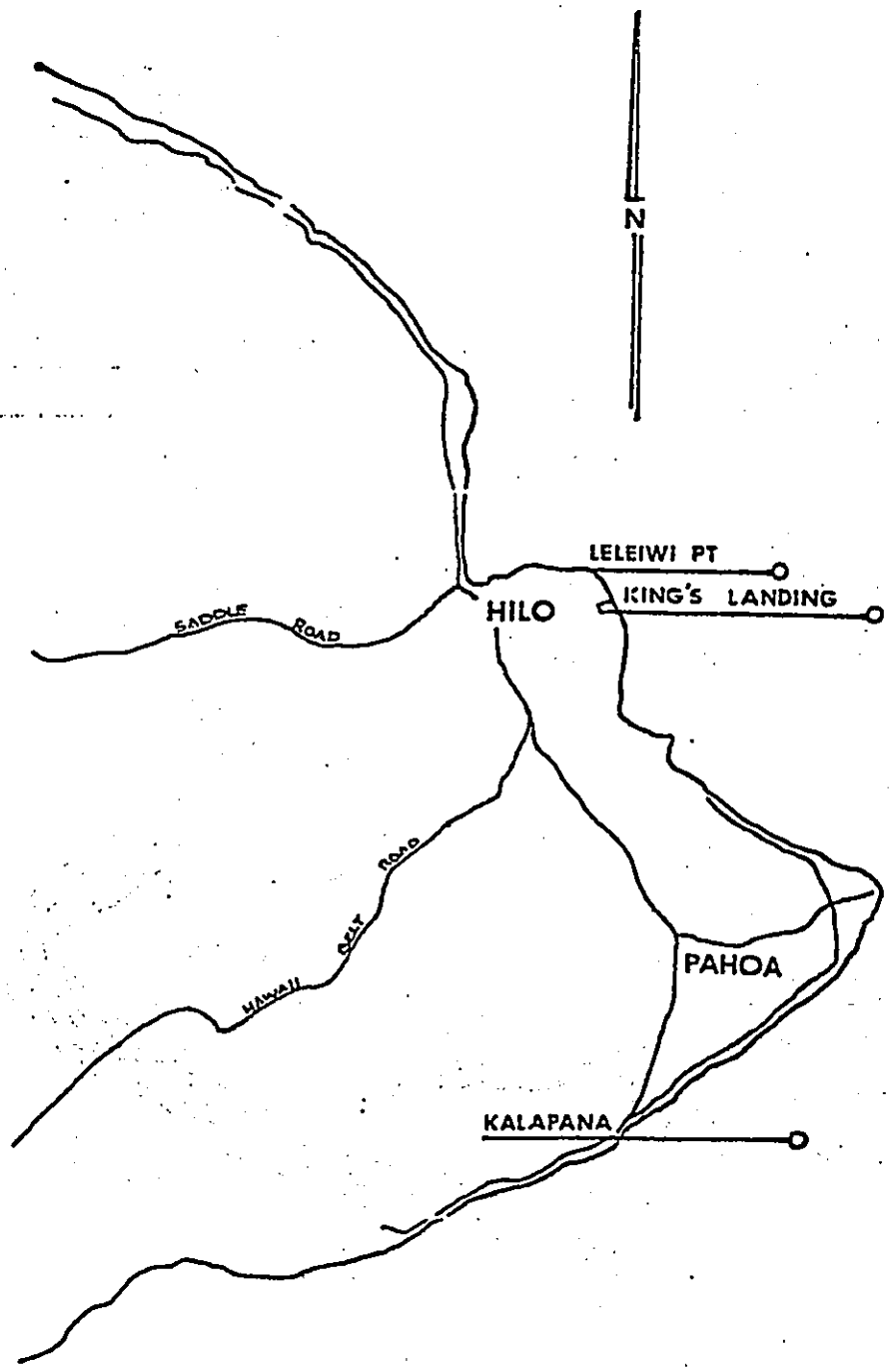


LOCATION MAP

US ARMY ENGINEER DISTRICT, HONOLULU

FIGURE 1



ALTERNATIVE BOAT HARBOR SITES

FIGURE 2

SECTION II: DEEP DRAFT NAVIGATION

A. Regional Recreation and Natural Resource Problems, Needs and Opportunities.

1. Hilo Bay is a developed urban, commercial and industrial area. Recreation and natural resource opportunities are restricted to the use of the open bay, the Wailuku and Wailoa Rivers and the open areas set aside for recreational uses. Public and government study participants have indicated the need to protect, maintain and improve existing recreational opportunities, to improve water quality and fishing, and for better recreational and commercial fishing boat facilities including berthing, drydock and other support facilities. The State Recreation Plan, 1980, stressed the need to maintain surfing and fishing activities in the Hilo Bay area, to improve and maintain regional attractions within the City of Hilo, to improve local activities within existing parks and open space areas and to maintain and enhance Hilo Bay Bayfront, Wailoa River and Wailuku River open space. The plan proposed the improvement of 45 acres of the existing Bayfront Beach for field games, camping, sunbathing and surfing. The Hilo Community Development Plan, 1975, envisioned the development of a natural wilderness area within the Wailuku River Tributary, improvement to the Bayfront and Mooheau beaches, Wailoa River Park, Reed's Bay beach park, and Radio Bay park. Suisan open fish market in the Wailoa River, Liliuokalani Gardens, Coconut Island and Banyan Drive would remain as aesthetic and cultural elements. Wailoa River and Radio Bay are the sites of the existing recreational and commercial fishing boat berths. Portions of Baker's Beach was planned for inclusion in the expansion of the existing deep draft harbor. The Keaukaha Shoreline Plan, undated, envisioned the development of an improved small boat harbor at the mouth of the Wailoa River and the development of Baker's Beach as a beach park. The Corps of Engineers had considered the development of an improved small craft harbor at the Bayfront beach, Wailoa River, Reed's Bay, Baker's Beach and Radio Bay. A federal small craft harbor project in Reed's Bay was authorized for construction, but has not been constructed.

2. The breakwater has reduced wave energy on Blonde Reef and in Hilo Bay, reducing water column mixing, water oxygenation and water exchange and increasing sedimentation. The low energy environment behind the

breakwater has allowed the expansion of the two-layered water circulation system inside the bay and allowed freshwater influence to extend over a large area behind the breakwater. Freshwater stress has limited marine organism development on reef areas behind the breakwater. Silt, which is carried further out into the bay by freshwater discharges, settles on the reef smothering benthic organisms and limiting regrowth. The sedimentation and salinity stress, has apparently reduced the amount of viable coral reef habitat behind the breakwater. This in turn has contributed to the low diversity of marine resources in Hilo Bay, possibly influencing the availability of fishery resources in the bay. The breakwater is apparently a factor which has enhanced erosion of Hilo Bayfront Beach by altering the currents and wave regime acting on the beach. The breakwater structure and lower wave activity has probably reduced the number of surfing sites on Blonde Reef. Modification of the breakwater related to improvement of Hilo Harbor affords an opportunity to improve water quality in the bay with the possibilities of improving recreational opportunities and marine resource diversity in the bay.

B. Recreational and Natural Resource Management Aspects of the Hilo Harbor Area.

1. Recreational Resources.

a. National Scenic and Wild Rivers. None present. Local land use planning documents propose the development of Wailuku River as a natural wilderness area and the development of Wailoa River and Waiakea Pond as park, open space.

b. National Trails. None present.

c. Natural Landmarks. None present.

d. National Shoreline Parks or Beaches. None present. Several State and County parks are present along the shoreline. While public access and use of the Hilo Breakwater is discouraged due to hazardous conditions, fishermen use the breakwater as a fishing site.

TABLE G-13. RECREATIONAL RESOURCES

Recreation Site	Acres	Ownership	Park Use
Wailuku River Mouth	-		Surfing
Mooheau Park	18.9		Beach (eroding)
Bayfront Park	6.8		Beach (eroding), canoeing, fishing
Wailoa River Park	146.0	State	General, boating, shoaling, river mouth
Liliuokalani Gardens and adjacent areas	20.5		General
Coconut Island	3.1		General, surfing
Banyan Drive Shoreline	-		Scenic
Reed's Bay	15.5		Beach (man-made) swimming
Baker's Beach		State	Beach (man-made)
Radio Bay		State	Boating
Radio Bay Park		State	General
Hilo Breakwater		Federal	Fishing

e. Water Contract Recreation. Principal water contact recreation activities in Hilo Bay include shoreline fishing, boating, wading and canoeing. Swimming is seldom observed possibly due to the highly turbid nearshore waters and concentrated mats of vegetative debris carried into the bay from the tributary systems. Six surfing sites were identified in Hilo Bay in the "Hilo Bay - a Chronological Study" in 1981. According to the Hawaii Chamber of Commerce, 1973, surfing demands have grown sufficiently to warrant investigations for increasing the number of surfing sites on the island. Fishing and boating are judged the most significant recreational activities. Canoeing is centered on use of the Bayfront beach and Wailoa River. Swimming is most prevalent in Reed's Bay.

(1) Fishing. Recreation areas and resources in Hilo Bay are limited, popular, and need to be protected. Leisure time, recreational fishing is more important in Hilo Bay than commercial fishing as a source of sea food for local residents. Commercial fishing interests are principally interested in the offshore fishing grounds. The number of recreational fishermen is about 2,100 persons; 60% are shore fishermen, 5% are net fishermen, and the remainder utilize other fishing methods (Cheney, 1977). Favorite fishing sites, list of recreational fish species and general locations where the fish are caught are provided in Cheney, 1977. Fishermen believe that too many

fishermen and poor enforcement of fishing regulations are partially responsible for over-exploitation. Fishermen are also competing for water use with canoe paddlers, surfers and boaters. Increasing the number of fishing sites and enforcing existing fishing regulations were believed to be beneficial to recreational fishing in Hilo Bay.

(2) Surfing. Five surfing sites are located in Hilo Bay (Kelly, 1981). One is located at Coconut Island, 2 at the Wailuku River mouth, one at Wainaku, and one at the tip of the breakwater. Kelly indicated that more surfing sites existed in the bay in the 1800's prior to construction of the breakwater.

(3) Beach Parks. The principal beach parks in Hilo Bay are Baker's Beach, Reed's Bay, Hilo Black Sand Beach, and Liliuokalani Gardens. Both Hilo Black Sand Beach and Baker's Beach are man-made. Also, portions of Reed's Bay was created from material dredged from Hilo Harbor turning basin during the period from 1925-1930. Hilo Black Sand Beach was formed by the natural accretion of eroded basalt material from the 1881 lava flow in the Wailuku River drainage basin. Black sand was mined from the beach in the 1900's. Both beaches are eroding. The creation of Baker's Beach appeared to have altered the dynamic equilibrium of the shoreline area and erosion is believed to be a natural process which reestablishes equilibrium. Erosion at Hilo Black Sand Beach appears to be related to the Hilo Breakwater (Reference M & E Pacific, 1980). The breakwater protects a portion of the beach which has remained stable. However, the exposed portion has eroded and beach sand is transported in an easterly direction. The breakwater appears to have eliminated the westerly component of the littoral transport which moved black sand into Wailoa River in the 1930's.

(4) Boating. Wailoa River provides berthing for recreational and fishing craft. A State launch ramp is located in the river. Radio Bay and Reed's Bay are also used for berthing principally for sail craft and vessels with high superstructures which prevent use of the Wailoa River area. Boats using the Wailoa river must have an over-the-water height of less than 8 feet to pass under the Kamehameha Highway bridge over the Wailoa River. The existing facilities provide berthing for only 106 vessels. Only 4 transient berths are available.

2. Natural Resources.

a. Land Resources. The Hilo Bay shoreline is classified as Keaukaha Extremely Rocky Much with 6-20% slope. The bay shoreline specifically consists of rocky headlands at Wailuku River, rock revetment and black sand along the Mooheau Beach Park, black sand at the Bayfront Beach park, rock headlands around Waiakea Penninsula, dredged coral fill at Baker's Beach and Reed's Bay and the developed port area. The harbor bottom consists of silty clays carried into the bay from upland areas by the Wailuku and Wailoa Rivers. Blonde Reef is principally a coralline reef area.

b. Prime and Unique Agricultural Lands. None present.

c. Natural Hazards.

(1) Volcanic Hazards.

Hilo is located in a high risk volcanic area (designated risk area E in U.S. Geological Survey, 1974). While the greatest danger to Hilo from volcanic activity is associated with eruptions within the northeast rift zone of Mauna Loa, the risk of potential damages and losses from lava flow and other hazards (ejecta, gases, subsidence and surface rupture) generally decreases down the volcanic slopes toward Hilo. Most lava flows from Mauna Loa have stopped short of the Hilo suburbs. Subsidence and surface rupture risks are considered low in Hilo, although property damage has occurred due to earthquakes. The earthquake in 1975 caused about $4 million in property damage throughout the island. Since major structural damage risks are high, earthquake resistant structural design regulations are enforced.

(2) Tsunami and Riverine Flood Hazards

Hilo Bay is susceptible to tsunami and riverine flooding. Forty destructive tsunamis have reached Hilo since 1819, seven of which inflicted loss of life and property. The tsunamis of 1946 and 1960, resulted in the combined loss of 234 lives and damages in excess $52 million. Actions taken to lessen the impact of tsunamis included rezoning of vulnerable waterfront areas to open space and the adoptions of structural design codes to reduce future losses and damages. The highest tsunami runup elevation recorded was 35 feet in 1960. Riverine flood hazards are related to high intensity rainfall, overland sheetflow and undefined drainageways, the last of which is the consequence of the geological youthfulness of the region. The Alenaio Stream flood plain is the principal flood hazard area in Hilo.

d. Vegetation. No significant vegetation communities or species are found around the Hilo Bay shoreline, although the Wailuku River is planned as a natural wilderness area by local planners.

e. Wildlife.

(1) Endangered Species. The endangered Hawaiian coot was observed nesting in Mohouli Pond in Waiakea Pond by Shallenberger, 1977. The endangered humpback whale seasonally migrates through the waters off Hilo Bay, but have not been seen in the bay (See Appendix G, Section 1D). The endangered hawksbill turtle and the threatened green sea turtle forage along the coastal areas and have been observed near the breakwater. The National Marine Fisheries Service (1981) indicated that Hilo Harbor is not a habitat on which the turtles depend for their continued existence, but that they may enter the harbor while foraging for food..

(2) Wildlife Refuges. No wildlife refuges are established in the area.

(3) Marine Sanctuaties. No marine sanctuaries are established in the area.

(4) Migratory Waterbirds. The Hilo Bay area is not a major area of concentration for migratory shorebirds or waterbirds. However, migratory and domestic ducks have been observed in Waiakea Pond during the winter seasons. The most common waterbird in the Waiakea Pond is the domestic mallard.

(5) Wetlands. No wetlands are located along the Hilo Bay shoreline.

(6) Estuaries. Reed's Bay, Waiakea Pond, Wailoa River and the Wailuku River form small localized estuaries. These estuaries are not listed on the National Inventory of Estuaries.

f. Marine Resources.

(1) Hilo Bay is biologically depauperate, possibly the consequence of freshwater, siltation and turbidity stresses. The breakwater reduces the wave energy and water transport into the harbor, possibly allowing increases siltation in coral areas and reduce the mixing of marine and freshwaters masses. Freshwater stress prevents the establishment and growth of benthic marine communities on the reefs, and poor light penetration in water limits photos/nthetic activity. The silt areas lack a developed infauna (Reference M & E Pacific, 1981). No live organisms were found in benthic samples taken from the silt areas probably as a result of recent maintenance dredging in the harbor. Six samples containing live organisms were obtained from rocky coralline areas in the bay. Scour and freshwater stress may be factors limiting benthic development inthe Wailuku River mouth area.

(2) Blonde Reef: Live coral cover based on a survey of 5 sites in Hilo Bay ranged from 1-16% attaining the highest cover on Blond Reef (16%). The areas around Coconut Island had a live coral cover raning from about 1-10% (M&E Pacific, 1980a). The surveyed detected a decline in coral cover between 1977 and 1980 possibly attributed to large floods in March 1980. Coralline algae, Porolithon, was more abundant than coral increasing its substrate coverage between 1977 and 1980. Porolithon is responsible for the consolidation of loose reef material and encrusting coral skeletons. Large dead coral heads on the reefs inside the breakwater suggest that the reef was once a viable ecosystem. Wave energy on the reef would have created a high energy environment that flushed silt from the reef and reduced salinity stress by rapidly dissipating freshwater concentrations before the freshwater could affect the reef area. The wave action would have also created a high dissolved oxygen environment, and surge and wave currents would have promoted excellent water circulation over the reef, creating favorable conditions for

coral growth. Areas within the breakwater exposed to waves refracted around the end of the breakwater have flourishing coral communities. The dead coral mass does provide habitat for fish and invertebrates and are areas of richness within the bay. The number of fish observed on the hard substrate habitat ranged from 4-365 fishes representing 3-29 species. For comparative purposes, areas seaward and to the east of the breakwater had coral cover ranging from 40-70% and fish numbers ranging from 172-543 fish representing 36-39 species (M&E Pacific, 1980b). Plankton densities in Hilo Bay, based upon 300 measurements, were not considered significantly different from other areas in the State, but were similar to ocean areas.

g. Fisheries.

(1) Fishermen believe fish stocks in Hilo Bay are declining (Reference Cheney, 1977) and attribute this reduction to a variety of factors including over-exploitation, removal of juveniles by bait fishermen, mechanical sugarcane harvesting and chemical pollutants. Whether or not a decline has acutally occurred is unknown and the exact factors affecting fish abundance have not been determined. The inshore fish catch presently accounts for less than 10% of the total fish landings in Hilo Bay, and are represented by fewer species than offshore fish. This contrasts to earlier trends at the turn of the century, when inshore reef fish accounted for 50% of the total pounds of fish landed in Hilo Bay and represented more species caught than offshore fish. Nehu catches have declined and are presently insufficient to support a fishing fleet. The decline in nehu resources is attributed by fishermen to overfishing, nutrient and sediment loading and an overall decline of the tuna fishery. The Hawaii Island Chamber of Commerce, 1973, would like to see nehu of other bait resources improved in hopes of revitalizing the commercial fishing industry in Hilo. The principal nehu catch areas are located within the commercial port. Former baiting areas were along the Bayfront shoreline to Hoolii.

(2) The development of the bay as a commercial port, dredging and filling shoreline areas, and disposal of industrial and domestic wastes have affected the aquatic habitat and may have affected fishery resources. However, the long-term trend in fishing stocks and composition is unclear. Fishermen

opinions concerning cause and effect relationships on local fishery stocks suggest that certain natural or man-related factors influence fish abundance and species, and the fishing methods used. For example, siltation probably fills habitat required by moi, aweoweo amd menpachi. Low stream flow and dry winters appear correlated to increased catch rates, but high streamflows usually correlate with increased papio catches. Murky water tended to increase ulua and moi catch rates, but reduced reef fish and nehu catches.

High waves are thought to clear out the mud and improve fishing. The 30 years of canec plant discharge into Waiakea Pond were thought to inprove fishing. Good crabbing along the bay front was associated with abundant Enteromorpha and Ulva growth. Chlorine from the sewage plant discharge was believed to be the cause of decline in piha (Spratelloides delicatulus) abundance. Shutting down and cleaning the sugar mills have resulted in a decrease in papio, ulua and moi catch and in an increase in menpachi, aweoweo, aku and other reef fish catch. Trawlers no longer foul their lines on rafts of bagasse. Turbid waters reduced spearfishing success and probably accounted for reduced reef fish catches.

h. Harvestable Shellfish Beds. None present.

i. Water Quality.

(1) Water quality in Hilo Bay has improved over the long-term with the removal and treatment of agricultural, industrial and domestic wastewater discharges. The pollutant sources have included wastewater from sugarcane and canec processing operations, raw sewage discharges, periodic shipboard waste disposal, cesspool overflow and leachates, surface runoff from agricultural lands, a thermal discharge, fish wastes, and petroleum wastes. At present, the major point source discharges in Hilo Bay are the municipal sewage treatment plant discharging outside of the breakwater into Puhi Bay, and the Hilo Electric Company's Shipman power plant thermal discharge (28 mgd) into Wailoa River. The only sugar mill discharge in the area is located 8 miles north of Hilo Harbor entrance at Pepeekeo. The principal nonpoint pollution sources in Hilo Bay are the surface runoff from agricultural lands and leachates from cesspools. Groundwater seepage and riverine discharge into Hilo Bay has a significant influence on bay water quality.

(2) Hilo Bay is a two-layered water body (M & E Pacific, 1980a) due to the discharge of 300 mgd of freshwater from Wailuku River and 700 mgd of groundwater into the harbor. The freshwater forms a distinct surface layer over the more saline bottom water. The surface layer persists throughout the year and is thicker in the wet season than in the dry season reflecting hydrologic conditions in the watershed. Salinity gradients are higher near the shore where groundwater discharges into the harbor and persist next to the breakwater, suggesting that the breakwater forms a barrier that inhibits mixing of marine and freshwaters.

(3) The predominant surface current direction is seaward out of the harbor. A continuous outflow occurs along the breakwater possibly as a result of groundwater outflow from Radio Bay. The surface current is dependent upon the influx of freshwater and the predominant wind direction. The influence of freshwater is measurable to a depth of 10 feet on Blonde Reef inside the breakwater and outside of the harbor mouth. In some areas the freshwater influence extends down to 20 feet. The depth of the freshwater influence generally reflects the low degree of mixing between the surface and bottom waters in the bay. The primary mixing force is provided by the wind with some mixing at the interface due to the shear force between the freshwater layer and the saline bottom water. Turbulence from ship traffic periodically mixes the two water layers. During certain periods (20% of the time) the prevailing wind direction is onshore retarding the outward flow of water on the surface. A two-cell circulation pattern was measured in 1973 (Reference Neighbor Island Consultants, 1973), but this condition may be the exception rather than the norm. Subsurface currents are influenced by the predominant westerly offshore coastal current off Blonde Reef (M & E Pacific, 1980a). Subsurface waters flow into Hilo Bay at a depth of 20-40 feet along the western side of the harbor mouth. Water continuously flows out of the harbor along the eastern side of the harbor mouth.

(4) Water quality baseline data are incomplete to compare annual variations with the State Water Quality Standards. The problem is due to water quality monitoring patterned after standards which were later revised in September 1979. The existing data are not reported in the same units of

measurements contained in the new standards, and were not collected at a frequency sufficient to determine compliance with the new standards. In some instances the constituents analyzed are not the same as those required by the standards. The new standards classify Hilo Bay (inside the breakwater) as an embayment with marine water standards for a wet and dry season. Other types of water qaulity standards are further provided for artificial basins, reef communities and soft bottom areas within Hilo Bay. Data collected between March and June 1980 in comparison with the State Water Qaulity Standards indicate that turbidity, nitrate plus nitrite and total phosphorus exceed the geometric mean standard, and values for suspended solids, total kjeldahl nitrogen and chlorophyll-a exceeded standard maximum values (M & E Pacific, 1980). In general, Hilo Bay is vertically stratified due to freahwater discharges from surface and groundwater sources. Nutrients concentrations do not limit phytoplankton growth and do reflect seasonal fluctuations related to surface runoff and groundwater influx. Water temperatures are warmer in the surface waters than in subsurface waters, but solar heating can warm subsurface waters when the surface outflow is retarded. Suspended solids and turbidity fluctuate with seasonal water runoff and do not appear related to phytoplankton density. Subsurface seawater pH values are normal for seawater conditions and are higher than the freshwater surface layer. Generally, pH values are high when photosynthetic activity increases. Chlorophyll-a concentrations also fluctuate seasonally, being lower in the wet season when light water-penetration is reduced and when water turbidity is higher due to increased suspended solids. Dissolved oxygen levels are near saturation on the surface and attain super-saturated conditions in areas of high photosynthetic activity. Dissolved oxygen levels were lowest near the silty bottoms of the inner harbor and in Wailoa River probably due to reduced mixing with surface waters, to organic loading from terrestrial sources, and to organic material in the harbor that settles out of the water column. Fecal strep and fecal coliform bacteria concentrations have decreased over the past years with the removal of the sewage discharges, and are presently influenced by riverine and groundwater discharges. Fecal strep bacterial tend to survive longer in Hilo Bay than other areas in the State due to the freshwater layer in the harbor.

(5) Sedimentation. Water qualtiy data indicate that sedimentation is a significant factor influencing water quality in Hilo Bay. The low wave energy environment created by the breakwater allows silt to settle out onto the coral reef environments smothering and destroying the reef ecosystem. The rate of sedimentation may be slow based on maintenance dredging records for Hilo Bay Harbor; approximately 54,000 cubic yards of material was removed from the harbor in 1977 reflecting the amount of material accumulated in the harbor since 1962. The estimated maintenance dredging cycle for Hilo Harbor is once every ten years based on past records. Silt is derived primarily from upland erosion within the Wailuku River drainage basin. Based on Table G-14, the principal sources of silt are the agricultural areas and the areas around the summit of Mauna Loa. However, about 35,000 tons of silt per year are deposited into Hilo Bay from Wailuku River (Corps of Engineers, 1976). Based on average annual rainfall in the region, significant soil losses are related to severe storm or intense rainfall events which affect severe erosion areas rather than smaller daily rainfall events. The rates of sedimentation in the harbor may be lower than in the past due to volcanism depositing new lava over erodible soils and to the termination of the sugar mill processing wastewater discharge into the harbor. The lava flow of 1881 covered some of the erodible soil in the Wailuku River drainage basin, and Wainaku Mill discharged 20,000 tons of suspended solids a year into the bay until it closed in 1976.

TABLE G-14. LAND-USES AND EROSION HAZARD OF THE WAILUKU RIVER DRAINAGE BASIN

Land-Use	Acres	%Total Area	Estimated Erosion Damage (Tons/Acres/Year)
Urban	1,800	1.0	4
Sugarcane and Diversified Crops	3,900	2.5	7-11
Forest	77,500	46.5	0.2
Pasture	33,800	20.2	2-3
High Mountains Conservation	50,000	29.8	1-15

Source of Data: Hilo Comprehensive Study, Plan of Study, December 1976, Honolulu District, U.S. Army Corps of Engineers

(6) Sediment Quality. Pollutant discharge into Hilo Bay have left arsenic PCB (Polychlorinated biphenyls) and pesticide contaminants in the bay sediments. A State Department of Health survey in 1978 indicated that arsenic, PCB and chlordance concentrations were found in significantly high amounts in Hilo Bay (State of Hawaii, 1978) in comparison with other sites surveyed in the state. The contaminants in dredged material may make the material unsuitable either for land or ocean disposal, and may require special handling or treatment of the material prior to disposal. Sediments from a shoal in the mouth of Wailoa river were found suitable for upland disposal following Environmental Protection Agency EP testing which indicated that pollutants did not leach from the sediment.

(a) Arsenic.

Based on the State survey, sediment samples from the Hilo Bay area contained total arsenic residues in concentrations ranging from about 22 ppm to 6370 ppm. A Canec plant, which manufactured canec boards from bagasse, discharged wastewater containing arsenic trioxide, a termicide, into Waiakea Pond. Sediments form the pond contain total arsenic residues in concentrations of about 6370 ppm. Sediments from the mouth of Wailoa River contained 131 ppm total arsenic, and sediments from Hilo Harbor contained total arsenic concentrations ranging from about 33 to 104 ppm. Total arsenic concentrations from sediments obtained from the outer part of the harbor ranged from about 22 to 33 ppm. The analysis indicated that arsenic migrated from Waiakea Pond into the bay environment. Arsenic concentrations in other Hawaiian estuarine sediments ranged from less than 4 ppm at Manele/Hulopoe, Lanai to about 20 ppm in Kaneohe Bay, and may reflect natural levels in Hawaiian soils. Analysis of fish and crab tissue indicate that arsenic is not bioconcentrating in the species tested.

(b) PCB.

Out of ten sites sampled in the State of Hawaii only two, Hilo Bay, Hawaii and Ala Wai Canal, Oahu, had measurable concentrations of PCB. Concentrations of PCB in Ala Wai Canal sediment ranged from 200 to 740 ppb with a mean of 372.6 ppb. The mean PCB concentration in Hilo Bay sediments was 200 ppm. The mean PCB concentration for other sample sites was less than 200 ppb. Under the test procedure the detectable limit was 200 ppb. No concentration of PCB was found in 27 biota samples analyzed.

(c) Chlordane.

Hilo Bay sediments also contained measurable quantities of chlordane. The sum of the mean values of three deriatives of chlordane was 84.2 ppb and was one of four sites in Hawaii found to have chlordane present in the sediments. Sediment from six other sites contained no chlordane residues above the detectable limit of 10 ppb. The levels of chlordane residue in mullet flesh from Waiakea Pond ranged from 80-160 ppb. No mullet from Hilo Bay was analyzed. The mullet viscera contained a chlordane residue 3 to 4 times higher than the flesh. The mean concentration of chlordane residue in Hilo sediment were considerable lower than the range of mean concentrations of chlordane residue (about 296 to 567 ppb) found in the Ala Wai and Kapalama canals.

j. Air Quality.

Air quality in Hilo is judged good because of the lack of industrial emission sources. Volcanic gases and agricultural fires are the major emissions sources influencing air quality in Hilo. Automotive and aircraft emissions are the second major emission source in the area. M & E Pacific (1980) indicated that particulate matter concentration in the air averaged 34 micrograms per cubic meter and concentrations of sulfur dioxide is less than 5 micrograms per cubic meter based on State Department of Health sources.

k. Noise.

Hilo is a quiet rural city except for aircraft landing at Hilo Airport which pass over the bay and automotive traffic along Kamehameha Highway.

United States Department of the Interior

FISH AND WILDLIFE SERVICE
300 ALA MOANA BOULEVARD
P.O. BOX 50167
HONOLULU, HAWAII 96850

IN REPLY REFER TO:

ES
Room 6307

July 1, 1980

Colonel B. R. Schlapak
U.S. Army Engineer District Honolulu
Building 230
Fort Shafter, Hawaii 96858

Dear Colonel Schlapak:

This is a preliminary report of the U.S. Fish and Wildlife Service for several navigation improvements proposed by the U.S. Army Corps of Engineers in Hilo Harbor, Hawaii. This letter is intended to assist you in project planning and does not satisfy the requirements for the report of the Secretary of the Interior within the meaning of Section 2(b) of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.).

This environmental assessment has been prepared using materials provided by the Corps of Engineers, a previous project site inspection by the Service, and other pertinent information.

We regret that the reporting date of this letter did not allow our review of Dr. Chaney's 1980 biological report (due to be published in July 1980), nor have we been able to schedule a field inspection trip, specifically for this project, to date. Therefore, when this information is available for our review, we may choose to supplement our letter with additional comments.

Project Area Description

Hilo Bay is on the northeast coast of the island of Hawaii. Hilo Harbor was constructed through placement of a 10,080 ft. rubblemound breakwater; by dredging of a 35 ft. deep entrance channel, and a 35 ft. deep harbor basin, measuring 1,400 ft. by 2,300 ft. The entrance to the port is in deep water from the north between a coral reef (Blonde Reef) on the east and the west shores of Hilo Bay, then eastward through the bay and following the inside of the reef to Kuhio Bay. The bay shoreline varies from steep cliffs on the west to relatively flat terrain on the south. The north and east sides of the bay are delineated by Blonde Reef, which forms an arc originating on the south shore. A small point of land, Waiakea Peninsula, lies immediately east of the mouth of the

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Wailua River. Kuhio Bay and Reeds Bay are on the east of the peninsula and Hilo Bay on the west side of the peninsula (Shallenberger, 1980). The proposed harbor improvements all lie within the "inner harbor" which can be defined as the area east of an imaginary north-south line drawn from the breakwater tip to the Wailoa River.

Project Description

A number of alternative plans are proposed for the Hilo Harbor area and are briefly described in this section. Detailed plans for these projects are not yet available, hence it is only possible to present a general analysis of environmental impacts.

Ten project concepts (including an Environmental Quality plan) were considered in our review. They are:

1. Plan A (Figure 1). Dredging will deepen the entrance channel from -35 to -40 ft. (MLLW), and deepen the turning basin from -35 to -38 ft. (MLLW). The estimated volume of dredged material is 350,000 cu. yd., consisting mostly of fine silt and clay. This material is not considered to be suitable for load-bearing fill because of high shrink-swell properties.

2. Plan B (Figure 1). Dredging will widen the turning basin from 1200 ft. up to 1600 ft. The estimated volume of dredged material is 430,000 cu. yd. consisting mostly of coral rubble, rock and minor overburden quantities of fine silty clay. The coral/rock material is suitable for load-bearing. Final design will detail the extent of the basin enlargement and other harbor improvements.

3. Plan C (Figure 1). This plan is for a detached short breakwater near the tip of the existing breakwater. Materials to be used will consist of armor stone and concrete dolosses. This component would dissipate storm waves that refract around the existing breakwater and impact the deep draft berthing area, particularly Pier 1.

4. Plan D (Figure 2). This alternative is considered by the Corps to be the environmental quality plan. It is comprised of several components. The existing breakwater from about 2800 ft. to the seaward tip will be: removed to a depth of about -8 ft. (MLLW); breached in several locations; or allowed to deteriorate naturally. A new 200 ft.-long breakwater section will replace the former structure to provide commercial harbor protection. An additional feature of this proposal is to place culverts in two locations through the breakwater (trunk section) to the inner harbor. Materials from the old breakwater can be used to construct the new structure. These measures are proposed to improve water circulation in Hilo Harbor and reduce surge problems at the commercial port.

5. Plan E (Figure 3). The construction plan proposed by the Hilo Chamber of Commerce would create new deep draft berths, marine storage areas, and a small boat harbor on Blonde Reef. Plan components also include the construction of an access road inside the existing breakwater. This plan will require significant dredging and large quantities of fill materials.

6. Plan F (Figure 4). A construction plan to build a solid fill pier in conjunction with the construction of the Baker's Beach Small Boat Harbor. Fill materials would originiate from turning basin widening as discussed in Plan B.

7. Plan G (Figure 4). A non-structural alternative which includes the placing of a submersible mooring bouy in the turning basin and an improved fender system on the piers. These measures should reduce dock and vessel damages during high surge conditions and allow larger vessels to use the port without widening the turning basin.

8. Plan H (Figure 4). A construction plan to build a new small boat harbor at Baker's Beach which will accommodate 150-200 boats. Construction would require a stone fill for the harbor walls and some minor dredging.

9. Plan I (no figure). A construction concept to build a new small boat harbor on the Puna Coast, as an alternative to the Baker's Beach site. Such construction will require excavation into coastal fastland.

10. Plan J (no figure). A non-structural plan to provide a boat launching facility in protected waters, and a dry storage area for small craft.

The Marine Environment

Plysical Oceanography

Hilo Bay has circulation patterns based on tides, waves, wind and freshwater influences. A study by Neighbor Island Consultants (1972) described a two-cell circulation pattern in the harbor, with a net movement of water seaward. Water movement through the breakwater is believed to contribute to this flow and also cause surging within the deep draft harbor (Shallenberger, 1980). Replenishment of harbor waters is believed to occur by movement through the breakwater and by currents from the western half of the bay. Replenishment with Reeds Bay and Radio Bay is believed to be primarily through extensive freshwater input from rivers and underground springs. The two primary freshwater drainages into the Bay are the Wailuku River and Wailoa River. The tidal range in the bay is 2.4 ft.

The natural condition of Hilo Bay has been subjected to more than 150 years of direct and indirect modification resulting from human use of the bay and surrounding environment. Cultivation of peripheral lands increased the rate of siltation in the bay from several drainages. Wastewater and bagasse first entered the bay from nearby sugar mills in the late 19th century. Wastewater pollution from industry and untreated sewage began in the early part of the present century. In the last 20 years, direct dumping into the bay of sewage, industrial wastewater, sugar mill effluent and bagasse has ceased. Although water quality studies in the bay during this period have documented improved conditions for several parameters, localized problem areas still exist.

Low dissolved oxygen measurements indicate that organic loading is still too high to be compensated by slow water turnover of the bottom layer (Sunn, Low, Tom and Hara, 1977).

Highest levels of fecal coliform and fecal strep are in areas influenced by discharges from the Wailuku River, Wailoa River, and Reeds Bay. However, decreased coliform levels in recent years result from discontinuing point discharges into the bay (Sunn, Low, Tom and Hara, Inc. 1977).

Turbidity continues to be a periodically serious problem, particularly during high rainfall periods, when river-borne sediment extends throughout the bay. Nutrient levels exhibit a similar periodicity and are attributed to storm drains, cesspool seepage and other sources. Studies in 1977 (Sunn, Low, Tom and Hara, Inc. 1977) indicated that nutrient levels generally exceeded the State Water Quality Standards for total phosphorus and total nitrogen in Class A as well as Class B waters. Under new State WQ Standards, adopted September 1979, the Hilo embayment is placed into a new Class A, "underwater areas to be protected".

Salinity measurements throughout the bay show the extensive year-round groundwater inflow, creating a stratified system inside the breakwater and throughout most of the bay. It is believed that the tradewind stress on the surface retards the seaward movement of surface water, thereby increasing the residence time of this layer, resulting in higher concentrations of freshwater derived nutrients, and allowing time for growth of high levels of photoplankton (Neighbor Island Consultants, 1978).

Marine Biology

Marine biological conditions in Hilo Bay generally range from poor to fair in terms of diversity and biomass of organisms relative to nearby coastal areas. Generally, macrofaunal distribution is determined by substrate type, freshwater influx, wave action, and light availability. On the basis of substrate types, Hilo Harbor can be divided into four major areas (Figure 5): silt and mud environment in deeper portions; silt, fine sand, and coarse sand along the western and southern shorelines between the Wailuku and Wailoa Rivers; the area seaward of the Wailuku River mouth which is influenced by freshwater, mud, silt, and basalt river stones; and areas of past and present coral growth, including Blonde Reef, the shallow areas around Kaulainaiwi Island and Coconut Island, and the shallow areas seaward of Reeds Bay.

The first three substrate types are relatively depauperate from a biological standpoint. Shallow silt and sand bottoms provide a uniform habitat to which only a few organisms are suited. In contrast, the deeper silt and mud portions should provide habitat for various crabs and shrimps. However, these organisms were not present, possibly as a result of dredging and anaerobic conditions caused by heavy organic loading. The hard substrate near the Wailuku River mouth also supports a sparse biological community, consisting only of a few serpulid worms. This condition is probably related to freshwater exposure and heavy siltation.

In contrast, the living and dead coral formations provide a varied and relatively stable habitat, supporting a richer and more diverse biological community. The inner portion of Hilo Bay, encompassing the area east of the Wailoa River and within the breakwater, contains the major portion of these coral formations. The presence of corals which appear to have died recently is significant and may indicate that water conditions are deteriorating. Nevertheless, dead coral blocks continue to provide habitat for fish and spiny lobsters (Sunn, Low, Tom and Hara, Inc., 1977).

Biological surveys in 1977 included zooplankton sampling, and invertebrate and fish counts. In general, the plankton samples recovered from the inner portions of Hilo Bay contained greater numbers of zooplankton types compared to samples from the outer portion of the bay.

Macroscopic invertebrates at sampling sites along the breakwater in the commercial port, and at Baker's Beach included 6 species of coral and a variety of other animals (Appendix A). The estimated percent coverage of the substrate by coral ranged from 4 to 44 percent, with the highest percent coverage in the vicinity of Blonde Reef (U.S. Fish and Wildlife, 1979).

The general biology of the inner harbor is described in an analysis by Neighbor Island Consultants (1973) as follows:

> "Low salinity areas, i.e. shoreline areas, are characterized by fresh water tolerant algal species such as Ahnfeltia, Cladophora, Ulva, and Enteromorpha, and sparse epifauna growth on the substrate. Rocks are typically encrusted with polychaetes, a few barnacles, the gastropod Nerita picea and Ostrea sandvichensis, as well as a few encrusting sponges. Corals are completely absent from these areas. However, fishes are surprisingly abundant. The bulk of fishes are juvenile manini and palani which appear to be well-adjusted to decreased salinities. A number of pomacentrids and young goat fishes are also present in these areas.
>
> In areas of fluctuating salinity and crushed coral substrate, such as at Baker's Beach, the algal and faunal community is particularly sparse. The most obvious biotic community in these areas is generally limited to the few rocks scattered amongst the coral rubble. Even along the rocks of the harbor side of the breakwater, the algal and faunal community appears sparse compared to that at slightly greater depths. Within the intertidal zone, rocks are never heavily encrusted, but instead bear a few barnacles, tubeworms, and sponges. The poor diversity of animals in these intertidal areas is probably affected by the low surface salinities encountered in these areas during periods of considerable fresh-water runoff and spring activity.
>
> The diversity of animals in the deep water silt substrate is very low, and limited to forms which are able to tolerate the harsh conditions. The only large animals endemic to this area were the portunid crabs, Portunus sandguinolentus and Podopthalmus vigil, and other small invertebrates such as polychaete tubeworms and nemertin worms. The larger gastropods, bivalves, sponges, bryzoa and corals, which are so characteristic of other subtidal areas, are completely absent from the deep silt substrate. Transitory species are occasionally found here.
>
> Shallower waters with silt bottoms have a paucity of plant and animal life. The area west and north of Coconut Island (to buoy 6) and the northwest portion of Reed's Bay are typical of this situation.

The shallow waters with sandy bottoms, composed of crushed coral and mollusk shells, are typified by much of Reed's Bay and Baker's Beach. The algae and fauna community is not particularly rich in these areas. Algal growth is concentrated on the few scattered rocks, while fragments of algae are scattered throughout the bottom. Fishes are found in low numbers and are comprised by juvenile manini (Acanthurus sandvicensis). The portunid crab, P. sanguinolentus, small gastropods, and the bivalve mollusk, Ostrea sp., are also common to this area.

The substratum of the Blonde Reef areas is composed primarily of dead coral, interspersed with silt pockets. Viable corals, mainly species of Montipora, Porites, and Pocillopora, are found scattered throughout the area. The viable coral heads are small and occupy less than 5 percent of the bottom area. Worn fragments of coral heads indicate that a far richer coral community existed at Blonde Reef in the past. Whether its decline is due to the presence of the breakwater, siltation from river runoff, or a combination of these and other factors, is unknown.

Blonde Reef is the area of the harbor which is richest in algae, invertebrates and fishes. Compared to outer reef areas and other enclosed bodies of water, such as Honaunau and Kealakekua Bays, Hilo Harbor is not particularly rich."

Based on previous studies, (Neighbor Island Consultants, 1973; Sunn, Low, Tom and Hara, Inc. 1977), relative environmental values are presented for Hilo Harbor in Figure 6.

The distribution of sportfish within Hilo Bay was correlated with habitat availability shown in substrate analyses (Chaney 1977). Reef fish, including palani, kipipu, manini and puhi, were found in association with areas of past and present coral growth. Similarly, papio, ulua, akule, bottom fish (demersal) such as kumu, moano, oama, weke, toau, and taape, aholehole, moi, mullet, and oio, and shellfish were found in this vicinity and appeared to frequent the nearshore areas around the bay (Appendix B). Based on reported recreational fishing catches, the silt/mud substrate, presently comprising nearly half the bay's marine habitat, appears to support little, if any, fishery resources (Chaney, 1977). This was substantiated by diver observations during the marine survey performed by Bowers (in Sunn, Low, Tom and Hara, Inc., 1977).

Species of marine fishes caught by shore fishermen in the project area are presented in Appendix C.

Project Impacts

Benthic Fauna: Dredging in Hilo Bay (Plans A and B) would result in localized impacts on benthic fauna by excavation and by smothering with resuspended sediments. This would most adversely affect filter-feeding organisms such as bivalve mollusks, tunicates, and sponges. Coral in the Blonde Reef area would also be adversely affected by prolonged sedimentation. Expansion of

the basin to the north (Plan B) would destroy coral rubble areas not previously dredged, and would adversely impact corals on the fringe of Blonde Reef. Plan E would have the most devastating impact on this reef. Small boat harbor construction and placement of fill along Baker's Beach would have localized impacts on an area of bottom characterized by scattered dead corals and silt. However, much of the affected area would be recolonized by crustaceans and annelids. Areas of the bottom now covered with silty clay may support a more diverse benthic fauna after dredging if harder substrate is exposed. Breakwaters and other structures added to the water would provide a suitable site for colonization by benthic organisms.

Zooplankton: The Zooplankton community within Hilo Bay is composed mostly of copepods, with a few dominating species. Adverse impact on zooplankton community as a result of increased turbidity during dredging should be temporary.

Algae: The Hilo Bay shoreline is typically luxuriant in algae growth. Localized high concentrations of Ulva sp. and Enteromorpha sp. are believed to reflect comparatively high nutrient levels. Further increase in nutrient levels in the inner bay, resulting from resuspension of sediments, additional shipboard wastes and restricted flushing may result in increased algal growth.

Fishes: Biological surveys of Hilo Bay show the presence of large and diverse populations of fishes only on comparatively undisturbed coral reef communities, particularly on Blonde Reef adjacent to the existing breakwater. Plan E would have major adverse impacts on fish in this area. The Baker's Beach site supports several fish species which are low in abundance. Impacts of breakwater placement or limited dredging in these areas should be compensated by the recolonization of biota on the rocky substrate after construction. Breakwaters in all identified plans would create suitable substrate for colonization by assemblages which in turn would supply food for fishes. However, Blonde Reef has an existing diversity and abundance of fishes that probably would not be matched by post-construction conditions. Migratory fishes may be able to escape increased turbidity related to dredging. Resuspension of organic detritus and nutrients may even result in localized attraction of some fishes to the dredging site. Sedimentation would adversely impact reef fish habitat on Blonde Reef and lead to reduced populations.

Endangered Species/Critical Habitats. No sanctuaries, refuges or critical habitats will be affected by any of the proposed alternative harbor plans. Two listed turtle species (Hawksbill Turtle - Endangered: Green Sea Turtle - Threatened) may enter the bay occasionally, but it is not likely that the condition of the bay waters is of long term significance to the survival of these species.

The endangered humpback whale is seen occasionally off Hilo Harbor but would not be adversely affected by proposed harbor modifications. The same is true for the endangered Hawaiian bats are often observed feeding over bay waters.

Plans under consideration for Hilo Harbor would have varied impacts on the commercial and recreational fishery. Although there has been no documented long range adverse impact of maintenance dredging on nehu catch statistics,

it seems likely that the fishery in the immediate vicinity of the dredging would be adversely impacted during the operation. This may have long range impacts as this inner harbor is the only suitable nehu fishing area when turbid Wailuku River waters enter the western part of the bay (Chaney, 1977).

Placement of breakwaters will provide additional sites to accommodate recreational fishing demand. Popular fishing sites in the commercial port and along Baker's Beach shoreline would be altered by Plans G and H, but harbor and pier construction would provide new habitat and convenient sites from which to fish.

Summary

Living marine resources are found throughout most of the project area, but (with the exception of Blonde Reef) have low diversities and abundances. The alternative plans will have the following anticipated impacts.

1. Plan A. Entrance channel and turning basin dredging: Localize displacement of neritic fishes during dredging operations; removal or smothering of sessile organisms; significant silting of reef areas along the breakwater resulting in coral die-back and elimination of reef fishes. Mitigation might include suction dredging and operation scheduling to coincide with favorable current conditions.

2. Plan B. Expansion of Turning Basin: Will eliminate low quality benthic habitat. Turbidity problems as in Plan A but more localized to the commercial port.

3. Plan C. Stub Breakwater Construction: Will reduce coral reef habitat in high diversity area. May be partially compensated by habitat creation from the rocky substrate of the breakwater.

4. Plan D. Environmental Quality Plan: Breaching or removal of the breakwater as described will significantly improve circulation (and water quality) in the harbor. Culverts in the trunk section will have the same effect. Natural deterioration will not make a significant water quality change in the near future, and will not impact the area by structure removal. Water quality outside the existing breakwater (along Blonde Reef) may be impacted by poor quality waters coming from the harbor if the structure is removed. The construction of a new stub breakwater will eliminate about 1000 sq. meters of moderately good harbor habitat. This will be mitigated somewhat by the creation of new rock habitat and improved water quality. Recolonization of low diversity areas in the harbor may be rapid due to "seed stocks" presently outside the breakwater.

5. Plan E. Chamber of Commerce Plan: The most environmentally damaging option. Breakwater, roadway and commercial fill construction will eliminate most of the better marine habitat within the harbor. Dredging and pollution will account for additional loss. Fishing opportunities will be reduced due to habitat loss and elimination of reef fish stocks.

6. Plan F. Non-structural: Insignificant short-term and localized impacts during fender and bouy installation.

7. Plan G. Construction of Pier 4: Will result in the elimination of marginal habitat. Mitigation from the creation of rocky substrate may increase local fauna. Turbidity from local dredging will have localized impacts as described in Plans A and B.

8. Plan H. Construction of Small Boat Harbor: Impacts of construction should be similar to those in Plan G. Harbor operations may result in increased but localized water pollution.

9. Plan I. Small Boat Harbor outside of Hilo Harbor: Not addressed at this time.

10. Plan J. Boat launching and Dry storage: Will have little impact on marine resouces. Impact on terrestrial resources is not addressed at this time.

In view of the variety of impacts described above, the U.S. Fish and Wildlife Service recommends that the Corps proceed with the Environmental Quality Plan (Plan D) because of its obvious benefit to the harbor environment. The Service opposes the Chamber of Commerce Plan (Plan E) because of its total destruction of habitat on inner Blonde Reef.

We recommend that if Plan D is to be implemented along with other options that it be done first. Improving circulation within the harbor basin will significantly reduce the impacts of additional dredging and structure placement.

We appreciate this opportunity to assist you in project planning.

Sincerely yours,

Nevin D. Holmberg

Nevin D. Holmberg
Deputy Project Leader
for Ecological Services

cc: ARD-E
HDF&G
NMFS
EPA-San Francisco

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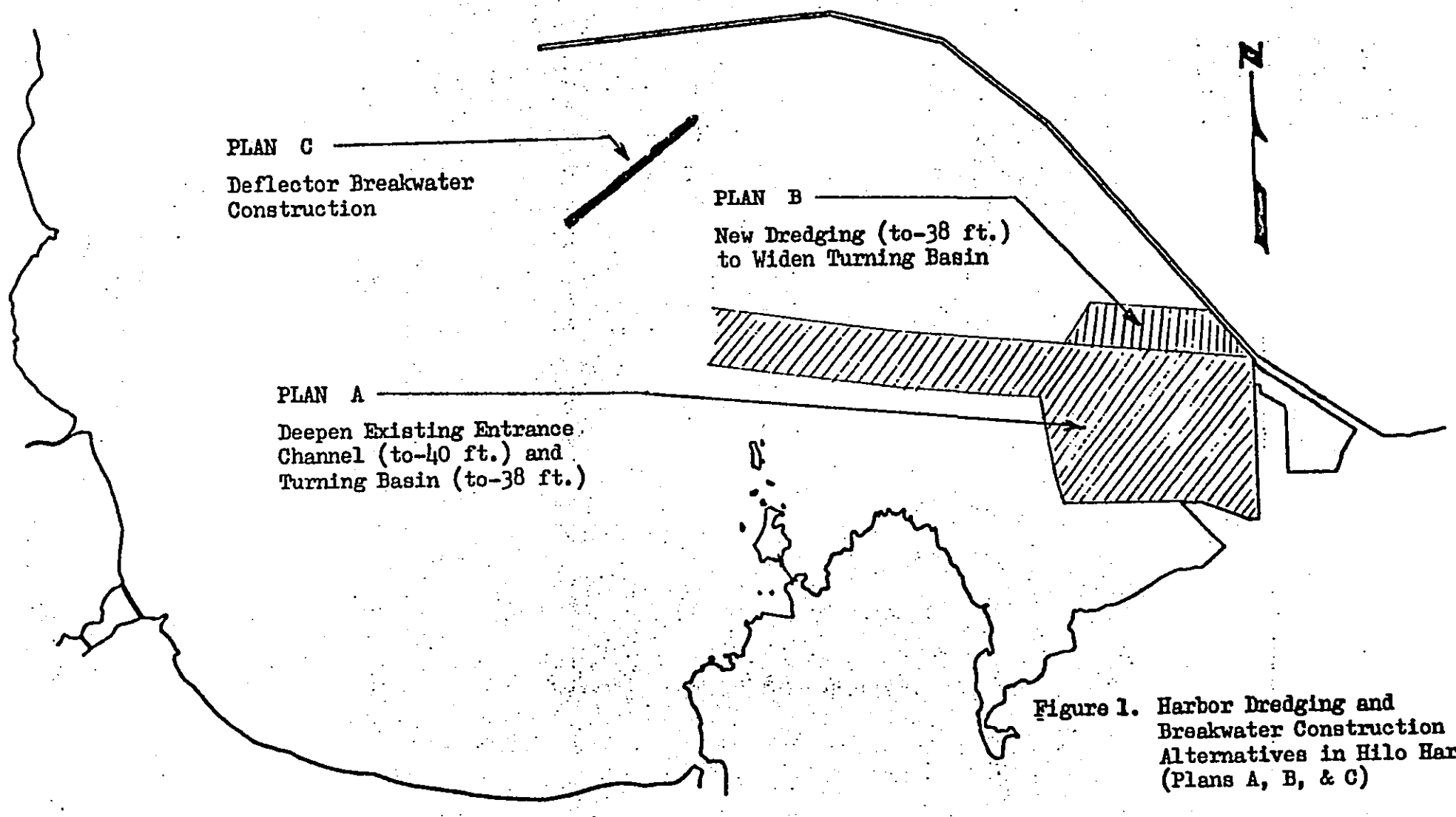

Figure 1. Harbor Dredging and Breakwater Construction Alternatives in Hilo Harbor (Plans A, B, & C)

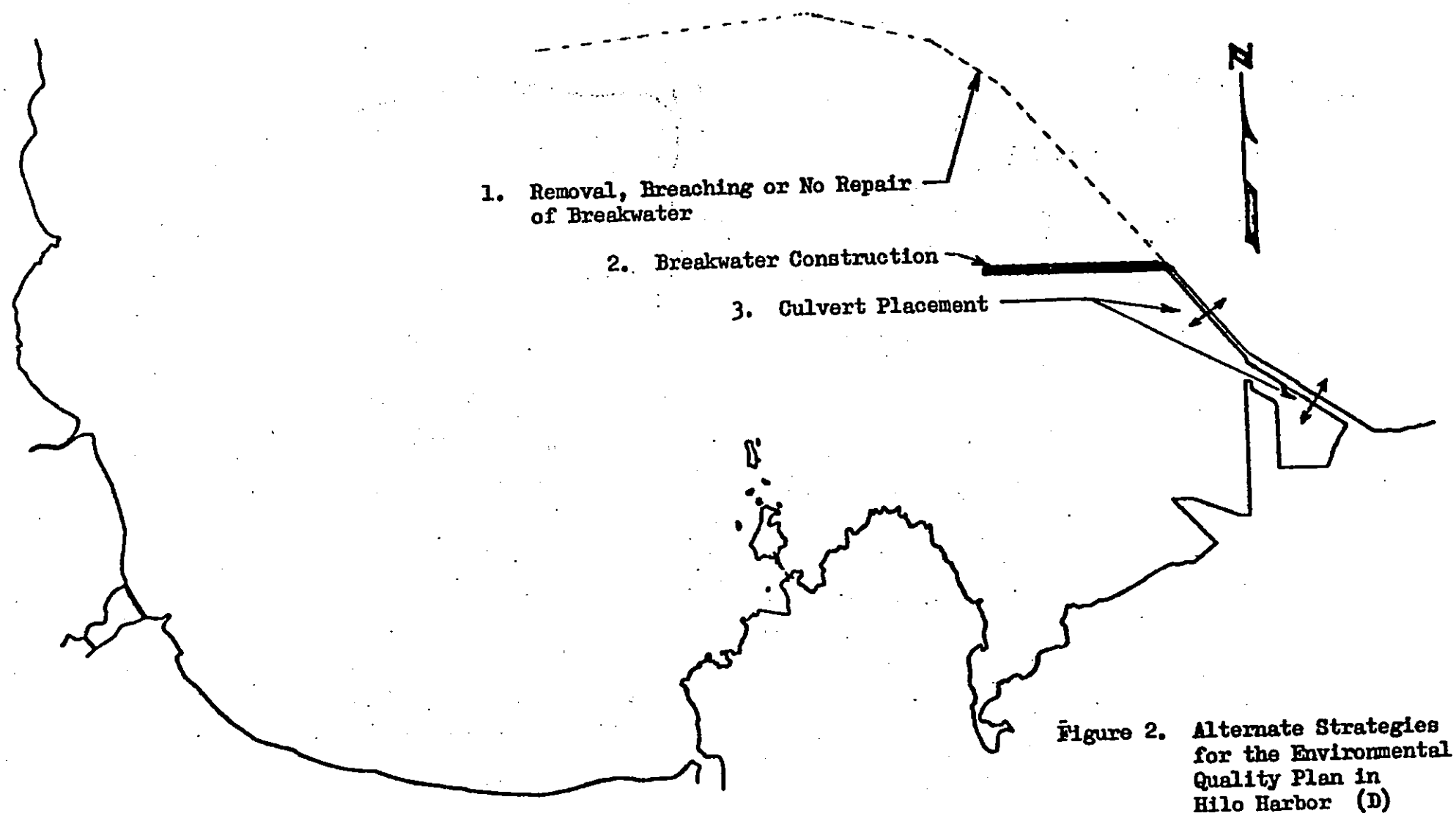

Figure 2. Alternate Strategies for the Environmental Quality Plan in Hilo Harbor (D)

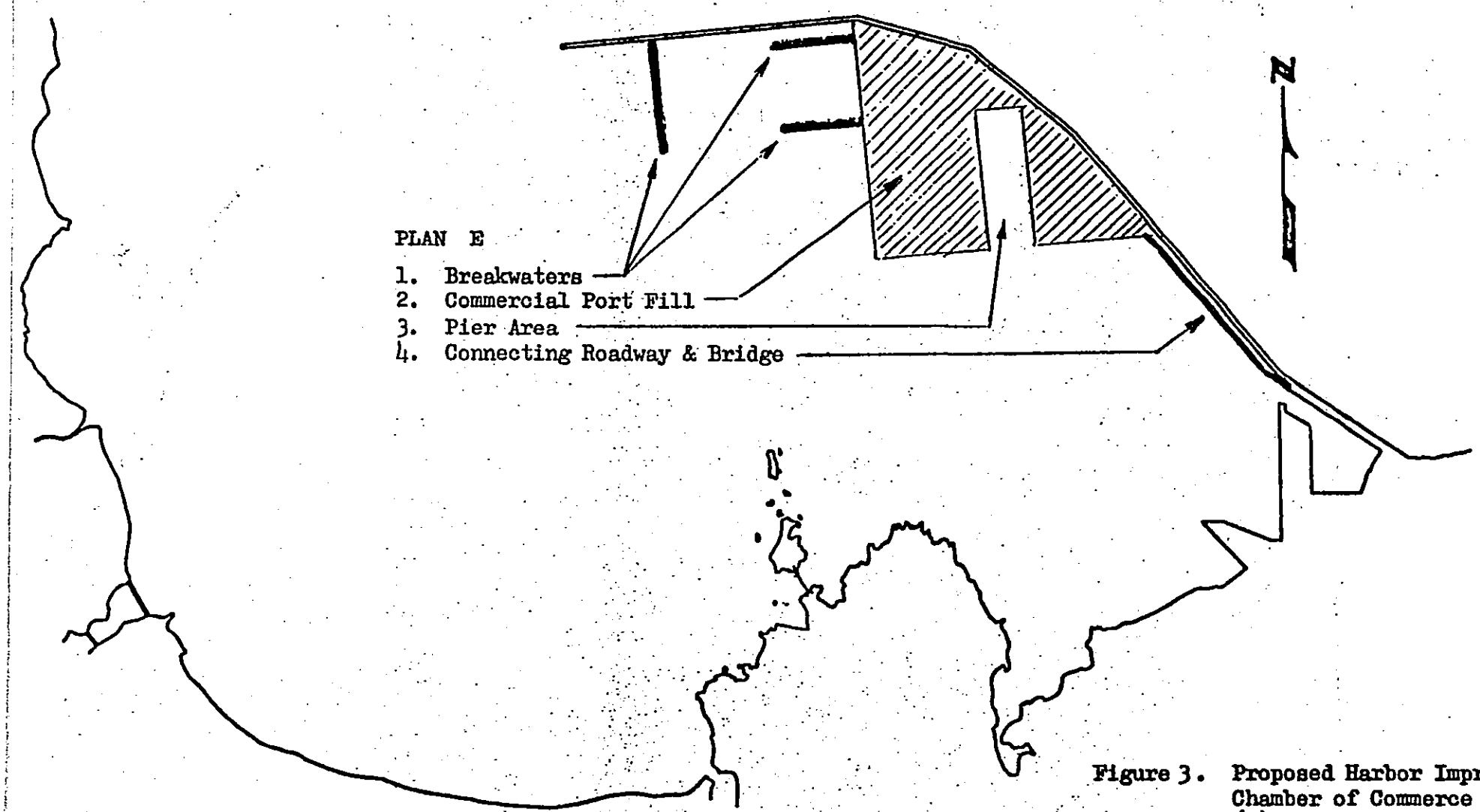

Figure 3. Proposed Harbor Improvement Chamber of Commerce Plans (E)

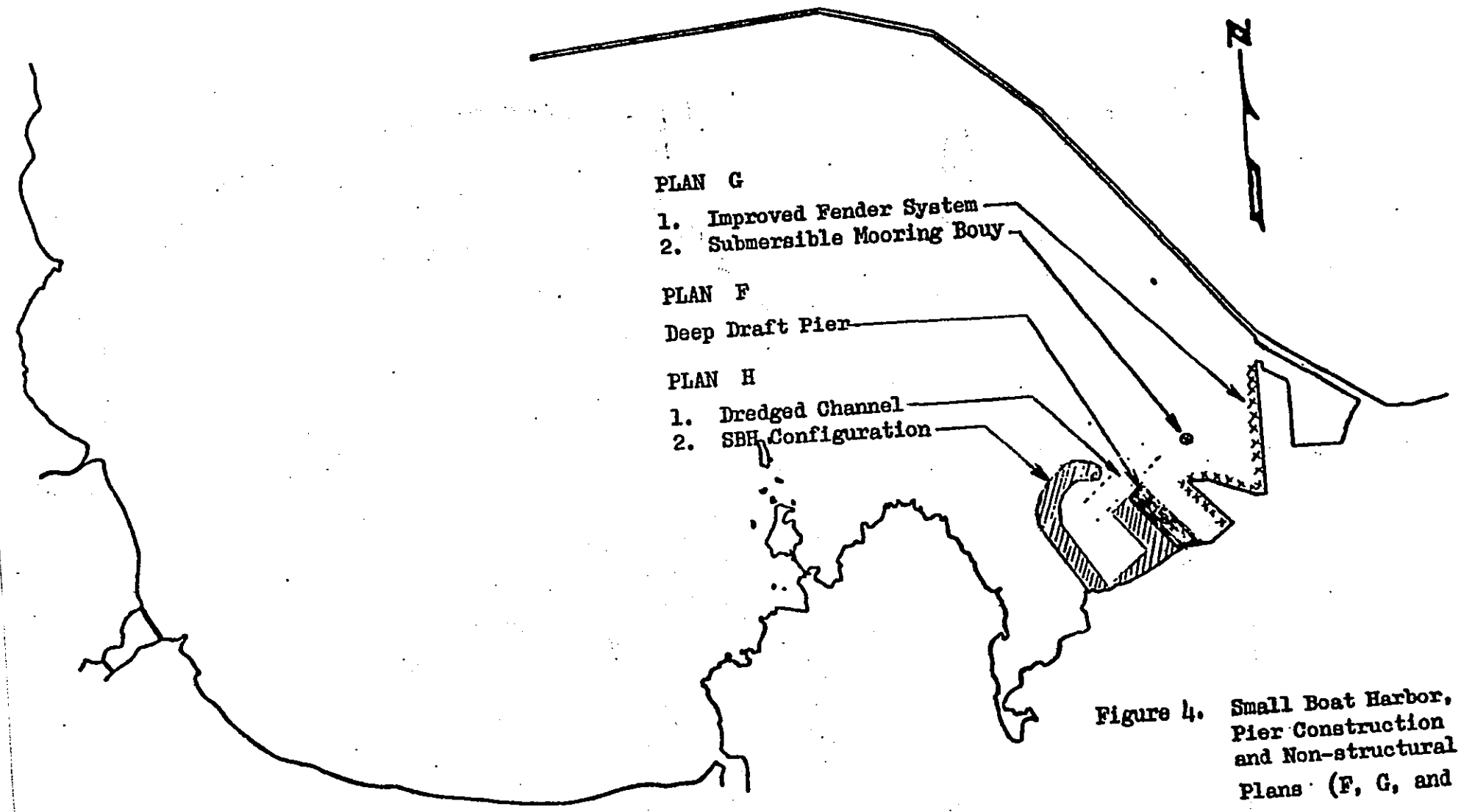

Figure 4. Small Boat Harbor, Pier Construction and Non-structural Plans (F, G, and H)

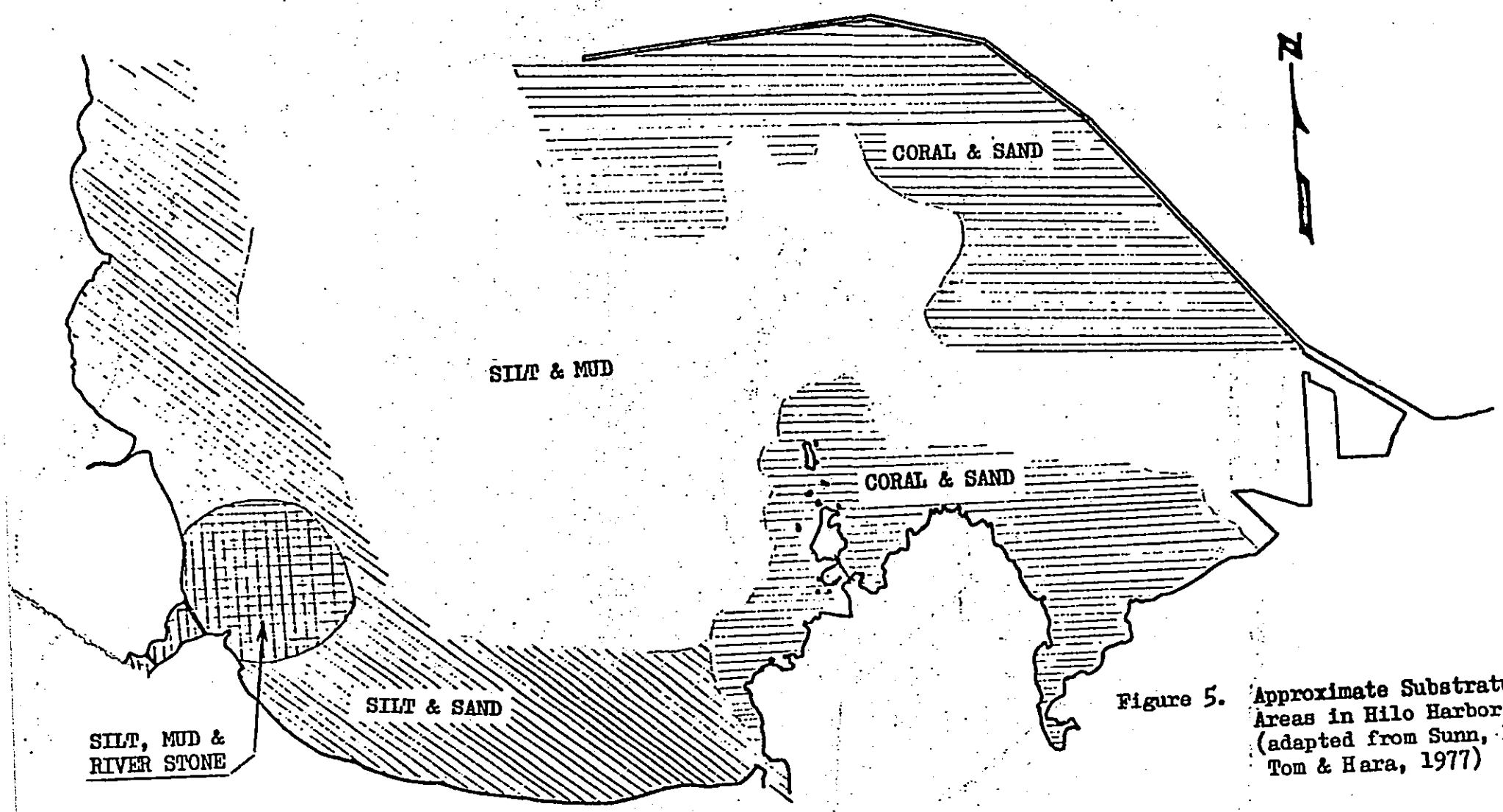

Figure 5. Approximate Substratum Areas in Hilo Harbor (adapted from Sunn, Low Tom & Hara, 1977)

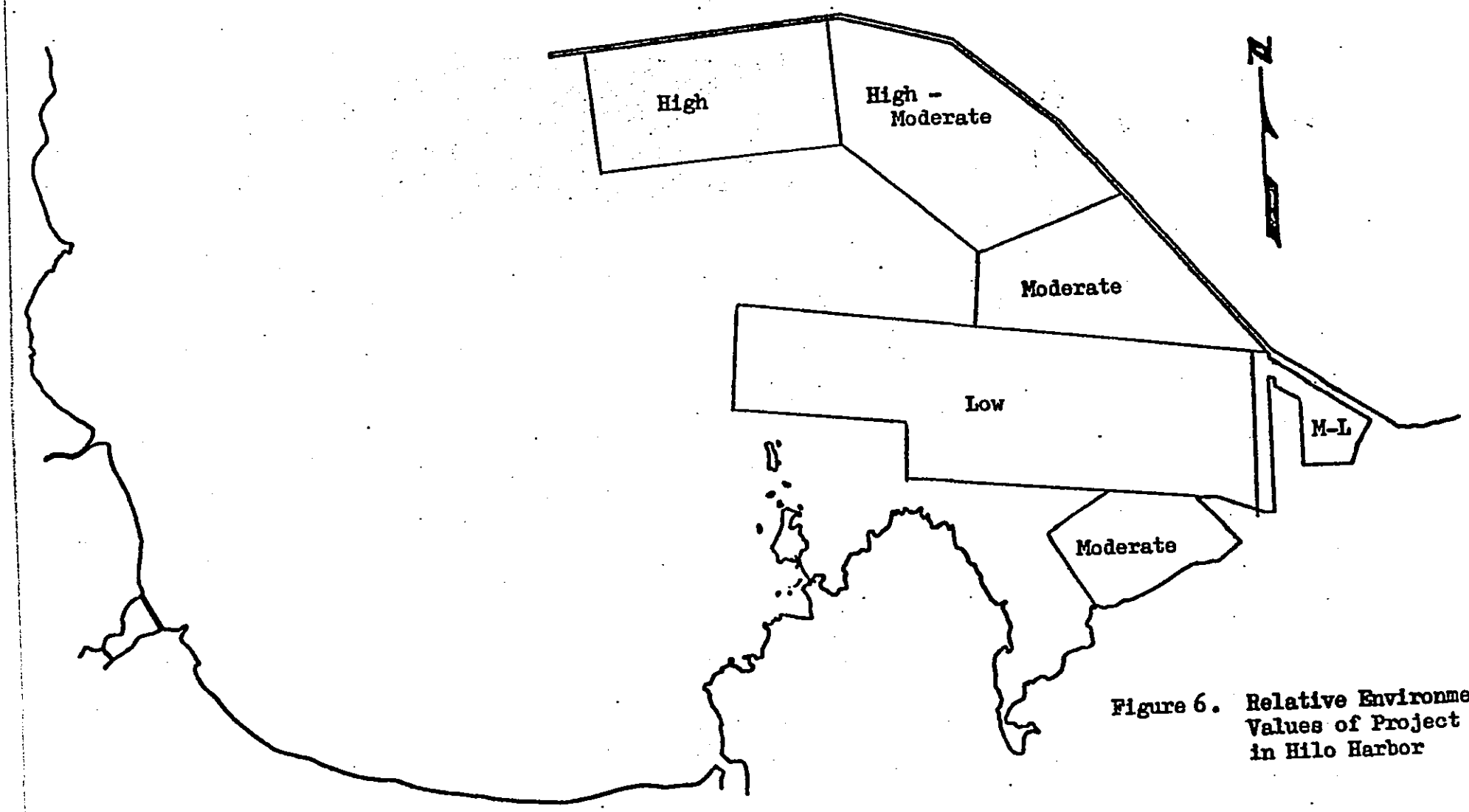

Figure 6. Relative Environmental Values of Project Areas in Hilo Harbor

Appendix A. Fish counts by diver observations in Hilo Harbor, June 1977. (adapted from Sunn, Low, Tom and Hara, 1977).

Scientific Name	Common Name	BB	MB	BT
Acanthurus leucopareius	Surgeon Fish			X
A. nigrofuscus	Surgeon Fish	X		X
A. dussumieri	Surgeon Fish	X		X
A. mata	Surgeon Fish	X		X
Ctenochaetus strigosus	Surgeon Fish	X		X
Chaetodon fremblii	Butterfly Fish			X
C. corallicola	Butterfly Fish			X
C. auriga	Butterfly Fish			X
C. unimaculatus	Butterfly Fish	X		X
C. lunula	Butterfly Fish	X		X
C. ornatissimus	Butterfly Fish		X	
C. multicintus	Butterfly Fish			X
C. miliaris	Butterfly Fish	X		X
Centropyge potteri	Damselfish			X
Dascyllus albisella	Damselfish			X
Pomacentrus jenkinsi	Damselfish	X		
Chromis ovalis	Wrasse			X
Bodianus bilunulatus	Wrasse			X
Labroides phthirophagus	Wrasse			X
Thalassoma duperreyi	Wrasse	X	X	X
Pseudojuloides cerasinus	Wrasse	X		
Stethoiulis axularis	Wrasse	X		
Halichoeres ornatissimus	Hawkfish			X
Paracirrhites arcatus	Hawkfish			X
Cirrhitops fasciatus	Goat Fish			X
Mulloidichthys aamoensis	Goat Fish			X
Parupeneus porphyreus	Goat Fish	X		X
P. multifasciatus	Parrot Fish	X		X
Scarus sordidus	Parrot Fish	X		
Immature scarids	Moorish Idol			X
Zanclus canescens	Blenny	X		
Runula ewaensis	Trigger Fish			X
Rhinecanthus rectangulus	Boxfish			X
Ostracion meleagris	Puffer			X
Arothron hispidus	Sharpbacked Puffer			X
Canthigaster jactator	Surgeon Fish			X
Acanthrus sandvicensis	Snapper	X		
Lutjanus kasmira			X	

BB - Baker's Beach
MB - Harborside Mid-Breakwater
BT - Harborside Breakwater Tip

Appendix B. (continued)

Group	Description
Coral	Pocillopora damicornis Pavona varians Montipora patula M. verrucosa Porites compressa
Polychaeta	Serpulidae Vermiliopsis hawaiiensis Spirorbis sp.
Bryozoa	Black encrusting form Massive sheets of clear encrusting species
Mollusca	Ostrea sandvicensis Hipponix sp. Mytilus sp.
Crustacea	Balanus sp. Hapalocarcinus marsupialis (gall crab) Trapezia intermedia Orange Xanthid with brown chelae Portunus sanguinolentus Podopthalmus vigil
Echinodermata	Tripneustes gratilla Centrechinus paucispinus Lytechinus verruculatus Holothuria atra Ophiocoma sp.
Tunicata	Didemnum candidum Styela sp.

Station: Breakwater (1/3 length from trunk)

Hydrozoa	Colonia hydroid
Corals	Pocillopora damicornis Montipora verrucosa
Polychaeta	Salmacina dysteri Spirorbis Dead serpulids
Arthropoda	F. Caprellidae
Mollusca	Ostrea sandvicensis (dead)
Echinodermata	Tripneustes gratilla
Bryozoa	V. rigid and purplish/black in color V. abundant

Appendix B. (continued)

Group	Description
Station: Commerical Port Basin	
Porifera	*Dysidea herbacea*
Polychaeta	Serpulidae - specie not determined Terebellidae - specie not determined Cirratulidae - specie not determined Glyceridae - specie not determined Eunicidae - specie not determined
Bryozoa	Tubular, branched form
Mollusca	*Ostrea sandvicensis*
Crustacea	*Balanus* sp. Xanthid crabs (2 species) *Portunus sanguinolentus*
Tunicata	*Ascidia* sp. *Microcosmus* sp. Grey colonial form (Didemnidae)
Station: Baker's Beach	
Porifera	Orange encrusting form (Demospongiae)
Hydrozoa	Encrusting colonial hydroids
Anthozoa	*Epiphellia humilis*
Coral	*Pocillopora damicornis*
Polychaeta	*Protula atypha* *Spirorbis* sp. Eunicids - errant forms
Mollusca	*Acanthochiton* sp. *Ostrea sandvicensis*
Crustacea	*Balanus* sp. *Portunus sanguilentus* Small shrimp (Caridae)
Tunicata	Grey, colonial form (Didemidae)
Station: Radio Bay Entrance	
Coral	*Pocillopora damicornis*

Appendix B. (continued)

Group	Description
Polychaeta	One tiny errant *Hydroides norvegica* *Spirorbis* (dextral and sinistral) Other small serpulids
Crustacea	*Trapezia intermedia* *Trapezia digitalis*

Appendix C. Check List of fish and shellfish taken by fishermen within the Hilo Bay Survey Area (adapted from Resource Planning, Inc., 1977).

Local/Common Name	Scientific Name	BB	CP	RB
Aholehole	Kuhlia sandvicensis		X	
Akule (Aji)/Hahalalu	Trachurops crumenophthalmus		X	
Amaama (mullet)	Mugil cephalus	X		X
Hihimanu (ray)	Dasyatidae		X	
Kawakawa	Euthynnus yaito		X	
Kumu	Parupeneus porphyreus		X	X
Manini	Acanthurus sandvicensis		X	
Mano kihikihi (hammerhead shark)	Sphyrna lewini		X	
Maomao	Abudefduf abdominalis			X
Moano	Parupeneus multifasciatus		X	
Moi/moi-lii	Polydactylus sexfilis		X	
Nehu	Stolephorus purpureus		X	
Nenue	Kyphosus cinerascens		X	
Pakii (flatfish)	Bothus spp.			X
Palani	Acanthurus dussumieri	X		
Puhi (moray eel)	Muraenidae		X	
Puhi (tohe--conger eel)	Conger marginatus		X	
Ulua/Papio	Carangidae		X	X
Upapalu (cardinal fish)	Apogon synderi			X
Weke/Oama	Mulloidichthys samoensis	X		X
Crab - Kuahono	Portunus sanguinolentus			X
Opae (glass shrimp)	Palaemon debilis			X

BB - Baker's Beach
CP - Commercial Port
RB - Radio Bay

APPENDIX H

BENEFIT ANALYSIS:

DEEP-DRAFT NAVIGATION

ECONOMIC APPENDIX

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CARGO TRENDS AND PROJECTIONS

The island of Hawaii is served by two major commercial deep-draft ports: Hilo Harbor, located on the northeast coast and Kawaihae Harbor on the west coast of the island. Hilo Harbor, which fronts the city of Hilo, was constructed in 1930 and is the second largest deep-draft port in the State. Hilo is also the second largest city in the State of Hawaii and is the center of economic activity on the island. Within the last decade, an average annual cargo of more than 1,000,000 short tons passed through Hilo Harbor. Principal imports at Hilo include general cargo and petroleum products. Principal exports include sugar and molasses. Kawaihae Deep-Draft Harbor, constructed in 1957, is approximately 85 nautical miles northeast of Hilo. The harbor provides major services to sugar plantations on the western half of the island. In 1978, the harbor handled over 500,000 short tons of cargo of which over one-third was sugar and molasses. General cargo shipments received at Kawaihae Harbor cover a broad, even spectrum with no one import dominating the statistics. Sugar, molasses, and wood chips are the principal export items from Kawaihae. Bulk sugar and molasses are transshipped to the mainland for processing while large quantities of woodchips are exported to Japan. Table H-1 gives a breakdown of the total cargo traffic through both harbors from 1966 to 1978.

TABLE H-1. TOTAL CARGO TRAFFIC TO HILO AND KAWAIHAE HARBOR 1/
HAWAII COUNTY (1966-1978), SHORT TONS

Year	Hilo	Kawaihae
1966	835,029	266,894
1967	882,535	265,625
1968	991,111	342,614
1969	990,476	317,415
1970	1,141,163	329,425
1971	1,064,384	355,546
1972	1,108,067	303,116
1973	1,041,647	385,850
1974	928,619	291,036
1975	1,053,879	279,687
1976	995,544	263,562
1977	1,013,430	318,197
1978	1,272,734	502,451

1/ Waterborne Commerce of the United States, Department of the Army, Corps of Engineers.

PETROLEUM

Total energy consumption in the State of Hawaii increased at an average annual rate of 9 percent from 1934 to 1974, compared with a 2 percent annual growth rate in population. From 1975 to 1978, conservation in energy consumption resulted in a somewhat slower increase of about 3 percent a year compared with a 2.4 percent growth rate in population. Petroleum imports on the Big Island of Hawaii increased from 136,100 short tons in 1965 to 225,174 short tons in 1978, representing a 4.0 percent annual rate of growth. The bulk of the petroleum imported to the Big Island is transshipped by barge from Honolulu. During this 13-year period, the population of Hawaii County grew at an annual rate of 2.1 percent for a 31 percent increase. The growth rate of per capita energy consumption for this period was 2.3 percent. Total petroleum shipments to Hawaii County were projected (Table H-2), based on the future per capita consumption growth rate used in the petroleum demand study conducted by Tudor Engineering Co. and II-F population projections available from the Department of Planning and Economic Development (DPED).

TABLE H-2. PETROLEUM CONSUMPTION PROJECTIONS FOR HAWAII COUNTY

Year	Total Projected Shipments to Hawaii County (Short Tons)	Population 2/	Tons Per Capita 4/
1978	225,174 1/	80,900 3/	2.78 5/
1980	263,709	92,053 6/	2.86
1985	292,600	95,000	3.08
1990	347,600	105,000	3.31
1995			3.57
2000	461,300	123,000	3.75
2010	571,300	138,000	4.14
2020	674,300	155,000	4.35
2025			4.46
2030	776,000	174,000	4.46
2035	820,100	184,000	4.46

1/ Actual - from Waterborne Commerce of the U.S.
2/ From II-F projections, DPED (modified to include 1980 census estimate)
3/ Actual - Hawaii Data Book (1979)
4/ Based on Tudor Engineering Study, per capita energy consumption will increase at the following rates:

1975-1995	1.5% per year
1995-2010	1.0% per year
2010-2025	0.5% per year
2025-2035	No increase

5/ Actual - 225,174 - 80,900 = 2.78
6/ 1980 census

Future petroleum imports to Hilo Harbor are based on this projection of total petroleum shipments to Hawaii County, historical records, and population estimates. Historical trends indicate that over a 13-year period from 1966-1978 (Table H-3), an average of 92 percent of the total shipments to Hawaii County were handled at Hilo Harbor. Therefore, taking 92 percent of the projected total shipments to Hawaii County gives us an estimate of the total shipments to Hilo Harbor (Table H-4).

TABLE H-3. PETROLEUM INSHIPMENTS TO HAWAII COUNTY (1965-1978)

Year	Total Inshipments To Hilo (Short Tons)	% of Total	Total Inshipments To Kawaihae (Short Tons)	% of Total	Total Inshipments To Hawaii County (Short Tons)
1965	145,400	100			145,400
1966	174,847	94	11,433	6	186,280
1967	157,074	90	16,698	10	173,772
1968	209,245	90	23,204	10	232,449
1969	280,085	92	23,162	8	303,247
1970	337,166	90	38,879	10	376,045
1971	285,996	88	38,541	12	324,537
1972	308,398	89	38,511	11	346,909
1973	240,226	92	19,756	8	259,982
1974	235,625	93	18,735	7	254,360
1975	243,042	94	14,331	6	257,373
1976	234,305	95	12,071	5	246,376
1977	236,115	95	11,521	5	247,636
1978	209,623	93	15,551	7	225,174
		92%		8%	

TABLE H-4. FUTURE PETROLEUM INSHIPMENTS TO HILO HARBOR (SHORT TONS)

Year	Total Inshipments 1/ To Hawaii County	Total Inshipments 2/ To Hilo Harbor
1980	263,709	242,600
1985	292,600	269,200
1990	347,600	319,800
2000	461,300	424,400
2010	571,300	525,600
2020	674,300	620,400
2030	776,000	713,900
2035	820,100	754,400

1/ From Table H-2.
2/ Based on 92% of total inshipments to Hawaii County.

The County of Hawaii is making efforts to reduce its reliance on imported energy which is currently 62 percent of the total island energy consumption. Studies and experiments on alternative energy sources, including biomass, geothermal, and oceanthermal, are being conducted to determine their feasibility. It is conceivable that the majority or possibly all of the future electric power could be generated from these alternate energy sources. The reduction in petroleum consumption could be significant since electrical power generation consumes approximately 33 percent of the island's petroleum demand. The remaining petroleum is used for land, water, and air transportation.

GENERAL CARGO

Major import items handled through Hilo Harbor include fabricated metal products, general commodities, and construction materials. Cargo inshipments to the Big Island increased from 246,582 short tons in 1966 to 720,359 short tons in 1978. During this same period, cargo in-shipments to Hilo increased from 212,538 short tons to 579,230 short tons, representing roughly 85% of all general cargo traffic to Hawaii County. In 1978, outshipments at Hilo Harbor remained relatively unchanged from 1966, with sugar and molasses accounting for about 78% of all export items.

Projections of inshipments of general cargo for consumption on the Big Island have been constructed by analyzing historical trends and relationships. Multiple regression analysis was performed on 24 years of data for the Hawaii State ports in order to relate the dependent variable of cargo inshipments to an array of independent variables. Among the dozens of models developed, the following model works equally well for each of the major islands in the state and is considered to be the most reasonable and reliable, meeting the criteria of (1) good statistical fit with historical data, (2) incorporation of independent variables that have a logical relationship to the dependent variable and (3) independent variables that can be reasonably projected for the next 50 years.

$$C = 28.6\ (PURPWR)^{0.5} + 1382(TOUR)^{0.5} - 116188$$

Where C = inshipment tonnage of general cargo to Hawaii County
PURPWR = resident population x per capita income at 1967 price levels
TOUR = hotel rooms x occupancy rate

Table H-5 shows the estimated general cargo inshipment tonnages using this model and the input data, including projections of population, per capita income and tourism.

TABLE H-5. PROJECTIONS OF WATERBORNE GENERAL CARGO INSHIPMENT, HAWAII COUNTY

Year	Population	Per Capita Income ($)	Purchasing Power (10^3)$	Tourism	Inshipment Tonnage (10^3)
1985	95,000	4,321	410,000	7,067	579
1990	105,000	4,824	507,000	9,778	664
2000	123,000	5,655	696,000	14,125	802
2010	138,000	6,611	912,000	14,125	912
2020	155,000	7,819	1,212,000	14,125	1,044
2030	174,000	9,253	1,610,000	14,125	1,196
2035	184,000	10,064	1,852,000	14,125	1,279

Future inshipments of general cargo to Hilo Harbor were based on historical trends and a projection of total general cargo inshipments to Hawaii County. During the 13-year period from 1966 to 1978, an average of 85 percent of the total inshipments to the Big Island were handled at Hilo Harbor (see Table H-6). Therefore, taking 85 percent of the projected total shipments to Hawaii County will give us the projected shipments to Hilo Harbor (Table H-7).

TABLE H-6. GENERAL CARGO INSHIPMENTS TO HAWAII COUNTY (1965-1978)

Year	Total Inshipments To Hilo (Short Tons)	% of Total	Total Inshipments Kawaihae (Short Tons)	% of Total	Total Inshipments To Hawaii County (Short Tons)
1965	209,293	100	-	-	209,293
1966	212,538	86	34,044	14	246,582
1967	193,664	79	36,254	21	229,918
1968	204,905	83	42,112	17	247,017
1969	247,873	84	48,995	16	296,868
1970	324,655	83	64,664	17	389,319
1971	324,687	87	48,241	13	372,928
1972	375,996	85	64,315	15	440,311
1973	328,850	86	55,460	14	384,310
1974	264,116	85	47,136	15	311,252
1975	362,607	89	45,697	11	408,304
1976	336,816	89	42,069	11	378,885
1977	335,365	85	57,272	15	392,637
1978	579,230	80	141,129 1/	20	720,359
		85%		15%	

1/ The significant jump in total inshipments to Kawaihae in 1978 is almost entirely the result of the increase in shipments of motor vehicles, parts, and equipment. In 1977, the port received 9,203 short tons of these commodities. In 1978, total receipts were 87,038 short tons for an increase of 77,835 short tons. In Hilo Harbor, the increase in inshipments was relatively evenly distributed among all commodities.

TABLE H-7. FUTURE GENERAL CARGO INSHIPMENTS TO HILO HARBOR (SHORT TONS)

Year	Tons
1985	492,500
1990	564,500
2000	682,000
2010	775,100
2020	887,200
2030	1,016,300
2035	1,087,000

SUGAR AND MOLASSES

Agriculture plays a major role in the overall economy on the Big Island. Sugar production is the leading agricultural commodity, representing 82 percent of the value of agricultural production. Most of the island's 91,136 acres of sugarcane are located along the Hamakua Coast and in the Puna and Ka'u districts. Over the past few years, acreage development for sugarcane and the production of raw sugar and molasses have begun to stabilize, but the sugar industry continues to experience high equipment and labor costs and depressed sugar prices.

In 1979, the value of raw sugar and molasses production in Hawaii County was $126.4 million, an 18 percent increase from the 1978 registered value of $107.0 million. Sugarcane harvested in 1979 was 4.0 million tons, which represented 41.7 percent of the total State production. The value of sugarcane, based on a farm price of $19.70 per ton, was $79.5 million or 15.9 percent greater than the 1978 value.

Since local plantations do not expect any significant increase in acreage development for sugar production, the export of sugar and molasses from Hilo Harbor is expected to remain stable throughout the projection period. During a 14-year period from 1965 to 1978, the export of sugar and molasses ranged from a high of 416,657 short tons in 1968 to a low of 295,234 short tons in 1976 (Table H-8). In 1978, shipments of sugar and molasses from Hilo totaled 220,636 and 80,506 short tons, respectively. Hawaii County totals, which include shipments from Kawaihae, were 347,310 short tons and 109,056 short tons for sugar and molasses, respectively. Production figures marked the first upturn in tonnage in the previous three years for these commodities. Recent shipments of molasses and sugar have stabilized over the last few years (1974-1978). Future shipments from Hilo Harbor were assumed to be equal to the average tonnage exported during the last 5 years of record.

TABLE H-8. OUTSHIPMENTS FROM HILO HARBOR (SHORT TONS) 1/

Year	Sugar	Molasses	Sugar & Molasses	Total Outshipments 3/
1965	246,815	54,777	301,592	385,212
1966	253,473	45,570	299,043	400,011
1967	278,721	98,158	376,879	463,035
1968	288,893	127,764	416,657	511,336
1969	246,184	87,688	333,872	399,569
1970	218,048	115,366	333,414	415,114
1971	197,605	80,993	278,598	395,246
1972	205,142	71,405	276,547	355,833
1973	270,751	78,142	348,893	416,958
1974	224,008	65,504	289,512	374,464
1975	219,162	80,679	299,841	402,932
1976	222,925	72,309	295,234	366,876
1977	202,505	93,383	295,888	398,324
1978	220,636	80,506	301,142	434,513
1985	217,850 2/	78,150	296,000 2/	-
2035	217,850	78,150	296,000	-

1/ U.S. Waterborne Commerce
2/ Projection based on average export for last five years of record
3/ Domestic and Foreign

MANGANESE NODULES

The economic impact of potential manganese nodule mining operations could be significant for the State. Because of the proximity of the State to the belt of high-grade nodules, development of a manganese nodule industry appears attractive for Hawaii. If tests currently underway prove successful, mining of deep-sea manganese nodules southeast of Hawaii could begin within a few years. Initial construction of a processing plant and associated infrastructure would require a capital investment of $521 million. An additional $20 to $24 million would be needed for construction of a power-generating plant. It has been estimated that during the three-year construction phase, the Gross State Product would increase by about $202 million annually and an additional 6,000 new jobs would be created. About 5,000 of these jobs would be available in Hawaii County with 3,000 in the construction industry.

Preliminary feasibility studies have investigated the Puna District on the Big Island as a potential site for the manganese processing facilites. A major requirement for the processing plant will be the availability of energy resources. Scientists have estimated that the Puna area has enough geothermal resources to produce from 400 to 500 megawatts of power.

Approximately 3 million wet (2.25 million dry) metric tons of nodules are expected to be mined and processed annually. This new industry would increase the Gross State Product by $335 million and add an additional 2,400 jobs to the State labor force.

The impact of the manganese nodule industry on Hilo Harbor will be significant. Transport of nodules from the primary mining areas would be by a tug and barge system because of the relatively short distance involved. Based on existing harbor and channel depths of 35 feet at Hilo Harbor, draft restrictions limit the maximum size of a bulk carrier (barge) to about 35,000 DWT. At the Port of Hilo, special storage facilities requiring about 10 acres will be needed to receive nodule shipments. The ocean transportation system will consist of a fleet of four barges with individual capacities of 35,000 DWT. In order to transport the projected 3 million metric tons of manganese nodules, each barge will be required to make 24 trips a year.

FLEET COMPOSITION TRENDS AND PROJECTIONS

EXISTING FLEET CHARACTERISTICS

The growth of waterborne commerce within the State of Hawaii has been in an uptrend over the past few years. With a growing population, increased demands for food, fuel, and other major commodities resulted in an upturn in interisland transportation. Barges, containerships, and tankers provide the major modes of travel for cargo destined for Hilo Harbor.

Barge-General Cargo. Barge traffic through Hilo Harbor during 1978 represented approximately 60 percent of all incoming vessel traffic. The names of individual shipping companies and vessels will not be used in this appendix to avoid any possible disclosure of confidential information.

Company and vessel or barge names have been replaced when necessary with a number and letter. There are seven companies that operate barges; the largest currently brings in general cargo to Hilo Port. Recent trends in shipping have tended towards containerized cargo, and in 1979, 59,141 revenue tons or 26 percent of all general cargo brought in by this company was containerized. The predominant size container used is 20 feet with each container weighing an average of 32 tons based on 1978-1979 data. The barges used have a rated capacity ranging from 2,000 to 3,700 tons and a maximum draft between 6 and 7 feet. Existing service to Hilo is provided three times a week.

A second company, with main headquarters in the Pacific Northwest, imports lumber and wood products to the State. Their existing operation at Hilo port consists of movement by tug and tandem barge. These barges, which call on Hilo Harbor once a month, have rated capacities from 3,600 - 5,400 tons and a fully loaded draft of 14 feet.

A third company provides most of the fertilizer and chemical products consumed in Hawaii County. Tug and barge operations are being utilized to deliver dry bulk shipments of fertilizer as well as other chemical products. Existing service to Hilo is provided 6 times a year by a 15,500 ton capacity barge.

A fourth company, with its own barge operation, calls on Hilo Harbor approximately 18 times a year with a full load of cement for the local construction industry. Total in-port time spent by barges for unloading and loading cargo was available from the Department of Transportation (DOT), Harbors Division. Based on these data, the average in-port time for barges can be computed.

Barge-Petroleum. Petroleum and petroleum products are supplied by three major producers. Transshipment of these products is done principally by tug and barge operations. The largest supplier of petroleum brought in approximately 958,000 barrels in 1979, accounting for over 50 percent of the total imports to Hilo. The barge used had a rated capacity of 60,000 barrels and a fully loaded draft of 21 feet. During the past year, this barge made a total of 24 trips or an average of 1 trip about every 2 weeks.

Two other barges are also used to transport petroleum to Hilo Harbor. One of the barges, with a rated capacity of 30,000 barrels, averaged 10,000 barrels per trip in 1979. The barge made a total of 24 trips to Hilo Harbor last year.

The average time spent at berth by petroleum barges was available from DOT records. Since the barges have different capacities, turnaround times will vary given the identical discharge rate at port.

Petroleum Tankers. Sister ships owned and operated by another major oil company are currently the only petroleum tankers calling at Hilo Harbor. Both vessels are 661 feet in length, 90 feet in breadth and have an international summer draft of 36 feet. Although the tankers have a maximum draft of 36 feet, company officials indicated the tankers have not encountered any major navigational problems at Hilo. Since most of the shipment to Hawaii from the mainland is jet fuel, major deliveries are unloaded at Honolulu Harbor before the remaining load is delivered at Kahului Harbor on Maui and Hilo Harbor. The maximum draft of these tankers are never reached because of sharply reduced loads when entering Hilo Harbor. During the past year, the capacity of these ships did not exceed half of its maximum 35,000 DWT.

Dry Bulk Carriers. Dry bulk carriers have played an active role in Hawaii's interisland transportation system. During the past year these ships have been used to export bulk sugar as well as servicing Hilo port with general cargo shipments. The existing fleet, used for exporting sugar and molasses, consists of three vessels, the largest with a rated capacity of 31,000 DWT. This vessel is the largest bulk sugar carrier in the fleet. Industry officials indicated that another vessel has recently been purchased and will be used regularly for exporting bulk sugar.

Containerships. Major container port operations at Pier 1 involve the loading and unloading of roll-on/roll-off (RO/RO) and load-on/load-off (LO/LO) vessels. The existing fleet calling at Hilo Harbor consists of two vessels. One vessel (LO/LO) has a capacity of 187 24-foot containers and calls on Hilo Harbor once a week. The other vessel (RO/RO) has a capacity of 293 40-foot containers and an additional 160 autos and calls on Hilo about every other week. The RO/RO vessel is capable of unloading 26 containers and 40 autos per hour. The LO/LO vessel, on the other hand, unloads 20 containers per hour. Based on the above data and the fact that empty containers must be reloaded on

the containership, the average turnaround times for the RO/RO and LO/LO vessels are 27 and 19 hours, respectively. A third vessel (RO/RO) is currently being lengthened to handle lift-on, lift-off containers. The ship will get an additional 126-1/2-foot midbody section, increasing its total length to 826-1/2 feet. The work is scheduled to be completed by the end of 1981. The increased length enables the vessel to handle 1,046 24-foot equivalents of trailer and container units compared with its previous capacity of 434 equivalents. The ship is not yet scheduled to serve Hilo Harbor, but could possibly be used to complement the existing fleet in the future.

Interisland Cruise Ships. Congressional authority was recently granted for a passenger cruise ship to serve Hawaii, and interisland cruises began on June 21, 1980. The 750-passenger, 20,300-ton vessel sails from Honolulu, Oahu, and makes full day calls at Hilo and Kona on the Big Island, Kahului on Maui, and Nawiliwili, Kauai. The ship is 682 feet long and draws a maximum loaded draft of 23 feet.

A summary of the existing vessel fleet is shown in Table H-9.

TABLE H-9. EXISTING VESSEL FLEET 1/2/

Company Vessel	Type	Cargo Capacity (DWT)	Loaded Draft (Feet)	Length (Feet)
Company No 1				
Vessels A	Containership	4,400	18' 4"	338'
B	Containership	14,000	28' 1"	700'
C	Bulk Carrier	16,100	32'	630'
D	Bulk Carrier	16,100	32'	630'
Company No 2				
Vessels E	Tanker	35,000	35' 8"	661'
F	Tanker	35,000	35' 8"	661'
Company No 3				
Vessel G	Tanker	12,110	29' 5"	492'
Company No 4				
Vessel H	Passenger Ship	750 Passengers	23'	682'

1/ Companies and vessel names have been replaced with a number and letter to avoid disclosure of confidential information. This policy will be followed where necessary throughout the remainder of this section of the report.

2/ Does not include barge traffic. There are seven companies using barges to Hilo.

FUTURE FLEET CHARACTERISTICS

Future fleet characteristics have been surmised from discussions with various shipping agents, industry representatives and the Hilo Harbormaster. Existing vessel fleet size is not expected to grow appreciably over the period of projection.

Barge. Future barge traffic through Hilo Harbor will essentially remain unchanged, and no appreciable increase in vessel fleet or vessel size is anticipated. The only foreseeable change in the barge vessel fleet is the conversion of a conventional barge to a new Integrated Tug and Barge (ITB) vessel in 1982 and the proposed use of a 60,000 barrel barge.

With the ITB vessel, the capacity for fertilizer shipments will increase by 21,500 tons over the present barge capacity of 15,500 tons. The new vessel, with a capacity of 37,000 DW tons and a design draft of 33 feet, will be making 6 rounds trips a year to the State. The initial stopover for each trip will alternate between Hilo Harbor on the Big Island and Port Allen on Kauai. The ITB vessel will bring in fertilizer from the mainlaind and depart the islands with bulk sugar from either Nawiliwili Harbor on Kauai or the Big Island. Since fertilizer shipments are expected to remain relatively stable, no increase in the number of trips is anticipated.

Tankers. Continued use of the existing ships for transporting oil is anticipated according to oil company representatives. Because of the limited demand and through-put capacity at Hilo Harbor, a trend towards the usage of super tankers is not a viable alternative.

Dry Bulk Carriers. With the introduction of the ITB vessel, the existing sugar fleet will no longer play an active role in the transshipment of bulk sugar and molasses from the Big Island. The ITB vessel and two other bulk carriers will handle future shipments of sugar beginning in the next two years. Since the production of sugar during the period of projection is expected to remain relatively unchanged, the required number of trips needed to transport this commodity will also remain constant. No decision has been made concerning the handling of future molasses shipments.

Containerships. Continued use of the two existing containership vessels are anticipated over the period of projection, and an alternate vessel could possibly be used when additional trips are required for extra cargo. Containership vessels have been converting to the relatively new RO/RO type vessel because of more efficient operational capabilities with containerized cargo. Containerization of general cargo is becoming increasingly popular among local shipping companies.

Interisland Cruise Ships. There is only one interisland cruise ship presently in operation. Four other ships have been granted permission to serve Hawaii. Two of these vessels, however, have had to postpone their scheduled start because of financial tie-ups and delays. The other two vessels are scheduled for operation within a year.

A summary of the future vessel fleet serving Hilo Harbor is shown on Table H-10.

TABLE H-10. FUTURE VESSEL FLEET 1/2/

Company Vessel	Type	Cargo Capacity (DWT)	Loaded Draft (Feet)	Length (Feet)
Company No 1				
Vessels A	Containership	4,400	18' 4"	338'
B	Containership	14,000	28' 1"	700'
Company No 2				
Vessels C	Bulk Carrier	40,700	36' 0"	688'
D	Bulk Carrier	31,900	33' 10"	641'
E	Bulk Carrier	24,000	33' 8"	595'
Company No 3				
Vessels F	Tanker	35,000	35' 8"	661'
G	Tanker	35,000	35' 8"	661'
Company No 4				
Vessel H	Tanker	12,110	29' 5"	492'
Company No 5				
Vessel I	Passenger Ship	750 Passengers	23'	682'

1/ Company and vessel name has been replaced with a number and letter to avoid disclosure of confidential information.
2/ Does not include barge traffic. There are seven companies using barges to Hilo.

PROJECTION OF VESSEL TRAFFIC.

A projection of ships by user for Piers 1, 2 and 3 at Hilo Harbor (Table H-11) was based on future incoming and outgoing tonnage through Hilo Harbor and on a two-year record of shipping trends available from the Department of Transportation, Harbors Division. A projection of vessels to each pier was made possible by obtaining the percentage split of cargo among users for that particular pier. A summary of all projected vessel and barge traffic through Hilo Harbor is shown on Table H-12. Based on conversations with various local shipping agencies, the existing scheduled trips by each company was assumed to remain constant as long as the capacity of the vessel was not exceeded. For example, in the year 1985, it is anticipated that Company No 10's barge will handle approximately 52,292 short tons through Hilo Harbor. Based on its existing schedule of 24 trips per year and the capacity of this vessel, future shipments can be handled through the year 2010. In 2030, however, 120,717 short tons are estimated for the barge. With a barge capacity of only 30,000 barrels or 4,200 short tons, four additional trips will be needed to accommodate the anticipated petroleum shipments.

TABLE H-11 - PROJECTION OF SHIPS TO PIERS IN HILO HARBOR BY USER

PIER 1

Year	Total Cargo to Pier (short tons)	Company No 1 1/ Vessel A 2/ Total Cargo (short tons)	Trips	Vessel B 3/ Total Cargo (short tons)	Trips	Company No 2 Total Cargo (short tons)	Trips	Company No 3 Total Cargo (short tons)	Trips
1985	315,500	117,262	26	117,262	52	30,975	20	50,000	3
1990	358,700	136,343	26	136,343	52	36,015	20	50,000	3
2000	429,200	167,480	26	167,480	52	44,240	20	50,000	3
2010	485,060	192,152	27 4/	192,152	52	50,757	20	50,000	3
2020	552,320	221,858	29 4/	221,858	52	58,604	20	50,000	3
2030	629,780	253,340	33 4/	228,800	52	67,641	20	50,000	3
2035	672,200	320,810	36 4/	228,800	52	72,590	20	50,000	3

PIER 2

Year	Total Cargo to Pier (short tons)	Company No 4 Total Cargo (short tons)	Trips	Company No 5 Total Cargo (short tons)	Trips
1985	177,000	13,275	12	163,725	156
1990	205,800	15,435	14	190,365	156
2000	252,800	18,960	17	233,840	156
2010	290,040	21,753	20	268,287	156
2020	334,880	25,116	23	309,764	156
2030	386,520	28,989	26	357,531	156
2035	414,800	31,110	28	383,690	156

TABLE H-11 (contd). PROJECTION OF SHIPS TO PIERS IN HILO HARBOR BY USER

PIER 3

Year	Total Cargo to Pier (short tons)	Comapny No 6 1/ Total Cargo (short tons)	Trips	Company No 7 Total Cargo (short tons)	Trips	Company No 8 Total Cargo (short tons)	Trips	Company No 9 Total Cargo (short tons)	Trips	Company No 10 Total Cargo (short tons)	Trips
1980	255,800	158,596	24	10,232	9	20,464	6	23,022	3	43,486	24
1985	307,600	190,712	24	12,304	10	24,608	8	27,684	3	52,292	24
1990	366,200	227,044	27	14,648	12	29,296	9	32,958	4	62,254	24
2000	485,500	301,010	35	19,420	16	38,840	12	43,695	5	82,535	24
2010	601,800	373,116	44	24,072	19	48,144	15	54,162	6	102,306	24
2020	710,100	440,262	51	28,404	23	56,808	17	63,909	7	120,717	28
2030	818,000	507,160	59	32,720	26	65,440	20	73,620	8	139,060	33
2035	865,000	536,300	63	34,600	28	69,200	21	77,850	9	147,050	35

1/ Company and vessel name has been replaced with a number and letter to avoid disclosure of confidential information.

2/ Vessel A will be making only 26 trips per year to Hilo. Any additional trips required for extra cargo will be handled by its sister ship. Vessel A currently carries 50% of its cargo to Kahului and the remaining 50% to Hilo.

3/ Vessel B will be making 52 trips per year to Hilo. Any residual cargo will be handled by an alternate vessel.

4/ Ship projections include the estimated number of trips to be made by the sister ship.

TABLE H-12. SUMMARY OF FUTURE VESSEL AND BARGE TRIPS TO HILO HARBOR

Year	Number of Vessels Per Pier Pier 1	Pier 2	Pier 3	Total Vessel and Barge Trips to Hilo Harbor
1985	101	168	69	338
1990	101	170	76	347
2000	101	173	92	366
2010	102	176	108	386
2020	104	179	126	409
2030	108	182	146	436
2035	111	184	156	451

SAVINGS FROM INCREMENTAL DEPTH INCREASES

There are only three vessels, with fully loaded drafts of 36' (37,000 DWT), 33'10" (31,000 DWT), and 33'8" (24,000 DWT), that will approach the project depths at Hilo Harbor. Beginning in late 1981 all three of these vessels will be carrying exports from the Big Island to the mainland. The 36' draft vessel will be calling at Hilo Harbor six times a year, but will only transport commodities to the mainland three times a year from Hilo. On the other three occasions, the vessel will be loading in Nawiliwili Harbor on Kauai. The other two vessels will alternate in transporting commodities from Hilo Harbor to the mainland.

Controlling depth within the existing Federal project is 35 feet for both the entrance channel and turning basin in Hilo Harbor. This limits vessel drafts to about 30 feet, although the Harbormaster has at times allowed ships to navigate at 32'6 under high tide conditions. Tables H-13, H-14 and H-15 provide estimates of vessel transportation costs fully loaded and at various shut-out drafts for the three vessels with maximum drafts over 30 feet. The advantage of traveling fully loaded is evident in the cost per ton for these vessels.

Navigation benefits for a deeper draft harbor were computed on the transportation savings that would be realized by allowing the three vessels to navigate with drafts greater than 30 feet. The benefits for a 36', 37', 39', and 40' channel are shown in Table H-16. The 40,700 DWT vessel is projected to transport 108,000 tons annually; the other two vessels 109,850 tons annually.

TABLE H-13. 37,000 DWT VESSEL TRANSPORTATION COSTS, FULL LOAD AND SHUT-OUT DRAFT

	30' Draft	31' Draft	32' Draft	33'10" Full Load
Port Costs, Hilo				
Wharfage 1/	$ 16,500	$ 16,800	$ 17,600	$ 20,350
Dockage 2/	1,241	1,241	1,241	1,861
Tug 3/	9,140	9,140	9,140	9,140
Pilot 4/	1,190	1,190	1,190	1,190
Linemen 5/	2,050	2,050	2,050	2,050
Port Entry	95	95	95	95
Ship Costs				
Hawaii Loading 6/	53,100	54,100	56,650	65,500
West Coast Discharging 7/	31,500	32,000	33,600	38,800
Travel Loaded 8/	258,080	258,080	258,080	258,080
Estimated Port Cost, U.S. West Coast				
Wharfage 9/	7,425	7,560	7,920	9,158
Dockage	1,241	1,241	1,241	1,241
Tug	2,755	2,755	2,755	2,755
Miscellaneous	1,241	1,241	1,241	1,241
Cost	385,558	387,493	392,803	411,461
Payload (short tons)	33,000	33,600	35,200	40,700
Cost Per Ton	11.68	11.53	11.19	10.11

NOTE: Footnotes follow Table H-15.

TABLE H-14. 31,000 DWT VESSEL TRANSPORTATION COSTS, FULL LOAD AND SHUT-OUT DRAFT

	30' Draft	31' Draft	32' Draft	33'10" Full Load
Port Costs, Hilo				
Wharfage 1/	$ 14,000	$ 14,550	$ 15,250	$ 15,950
Dockage 2/	968	968	968	968
Tug 3/	9,140	9,140	9,140	9,140
Pilot 4/	862	862	862	862
Linemen 5/	2,050	2,050	2,050	2,050
Port Entry	95	95	95	95
Snip Costs				
Hawaii Loading 6/	25,200	26,100	27,400	28,700
West Coast Discharging 7/	14,900	15,500	16,200	17,000
Travel Loaded 8/	134,400	134,400	134,400	134,400
Backhaul 8/	134,400	134,400	134,400	134,400
Estimated Port Cost, U.S. West Coast				
Wharfage 9/	6,300	6,548	6,863	7,178
Dockage	484	484	484	484
Tug	2,755	2,755	2,755	2,755
Miscellaneous	484	484	484	484
Cost	346,038	348,336	351,351	354,466
Payload (Short Tons)	28,000	29,100	30,500	31,900
Cost Per Ton	12.36	11.97	11.52	11.11

NOTE: Footnotes follow Table H-15

TABLE H-15. 24,000 DWT VESSEL TRANSPORTATION COSTS, FULL LOAD AND SHUT-OUT DRAFT

	30' Draft	31' Draft	32' Draft	33'10" Full Load
Port Costs, Hilo				
Wharfage 1/	$ 10,500	$ 10,950	$ 11,450	$ 12,000
Dockage 2/	968	968	968	968
Tug 3/	9,140	9,140	9,140	9,140
Pilot 4/	706	706	706	706
Linemen 5/	2,050	2,050	2,050	2,050
Port Entry	95	95	95	95
Ship Costs				
Hawaii Loading 6/	18,900	19,700	20,600	21,600
West Coast Discharging 7/	11,200	11,700	12,200	12,800
Travel Loaded 8/	134,400	134,400	134,400	134,400
Back Haul 8/	134,400	134,400	134,400	134,400
Estimated Port Cost, U.S. West Coast				
Wharfage 9/	4,725	4,928	5,153	5,400
Dockage	484	484	484	484
Tug	2,755	2,755	2,755	2,755
Miscellaneous	484	484	484	484
Cost	330,807	332,760	334,885	337,282
Payload (short tons)	21,000	21,900	22,900	24,000
Cost Per Ton	15.75	15.20	14.62	14.05

Footnotes for Tables H-13, H-14 and H-15.

1/ Wharfage fee based on $.50/ton for overseas shipment of bulk sugar ($.44/ton for interisland).
2/ Dockage fee based on $484 per day.
3/ When vessel enters port, one tug is needed for assistance. When vessel departs fully loaded two tugs are normally used. Since HT&T, which does the towing has only one tug, another tug from Maui is usually called. Cost for assist by HT&T tug is $1378 and $6384 for tug from Maui.
4/ Cost for one movement for 595' vessel, 641' vessel, and 688' vessel is $353, $431 and $487.
5/ Cost for one crew (6 men) working a minimum of 4 hours is approximately ($42.73 x 6 x 4) = $1025.
6/ Based on a loading rate of 800 tons per hour at Hilo Harbor and a vessel operating cost in port of $30,900 per day for the 36' draft and $17,250 per day for the 33'10" and 33'8" vessels.
7/ Based on discharge rate of 1350 tons per hour at Crockett, California.
8/ Based on a ship operating cost at sea of $22,400 and $32,260 per day for the 33'8", 33'10" draft and 36' draft vessels, respectively. The trip from Hilo to the West Coast will take approximately 6 days, 6 days, and 8 days, respectively.
9/ Based on Honolulu Harbor Study. U.S. West Coast wharfage costs assumed to be 45% of Hilo wharfage cost.

NOTE: All benefits have been updated by appropriate indexes to be comparable with project cost estimates.

TABLE H-16. INCREMENTAL BENEFITS FOR HARBOR DEPTHS OF 36, 37, 39 AND 40 FEET

Vessel DWT	Harbor Depot 36'	37'	39'	40'
37,000	$16,200	$ 52,920	$130,000	$169,560
31,000 1/	21,421	46,137	68,656	68,656
24,000 1/	30,209	62,065	93,373	93,373
TOTAL	$67,830	$161,122	$291,938	$331,589

1/ It was assumed each vessel (31,000 DWT and 24,000 DWT) would transport one-half of the 109,850 tons projected to be carried by both vessels.

DAMAGE AND DELAY ANALYSIS

PROBLEMS ASSOCIATED WITH SURGE CONDITIONS

Introduction. Although Hilo Harbor is presently protected by a breakwater, under certain weather conditions surge action creates a serious problem to navigation. At times when a heavy swell, unaccompanied by storms, is running from the north or northeast direction, waves or swells enter the harbor and are resolved into a marked surge within the bay at Piers 1, 2, and 3, causing ships to roll and pitch. It has been extremely difficult to hold rolling ships to the piers, which has delayed sailing, hampered efficient working of vessels and in several instances, prevented complete discharge of cargo.

Frequency of Surge Conditions. To establish the total monetary losses resulting from the above conditions and to determine the prospective benefits which may be expected to accrue from improvements to Hilo Harbor, it was first necessary to compile from available sources the record of past surge conditions and the number of vessels adversely affected. From data obtained from past reports and from the files and daily log reports of the Hilo Harbormaster, the following record of surge conditions was compiled.

TABLE H-17. RECORD OF SURGE CONDITION

Year or Period	Heavy Surge Conditions Reported (Number of Days)	Total Number of Vessels Adversely Affected
1934-1938 (inclusive)	36	32
1940	5	5
1946	4	4
1947	6	9
1950-1960 (inclusive)	25	32
1961-1969	190	70
1977-1979	9	7
Total for 31 Years	275	159
Annual Average	8.9	5.1

It has been estimated that approximately 9 days of heavy surge action may be expected each year with over 87 per cent occurring from October to March. Earlier estimates (1930-1970) computed from the above record covered only surge conditions when vessels were adversely affected. The remaining estimates of surge conditions (only 1977-1979) were counted for heavy surge regardless of whether there were any vessels in the harbor or whether a vessel was subject to surge action. The relatively high incidence of reported surge conditions prior to the period beginning with 1950 reflects to a major extent interisland steamer vessels adversely affected. Since 1952, interisland steamer operations have been discontinued. Waterborne interisland commerce is now handled exclusively by tugs and barges, containerships and a few tankers. Historical records on surge conditions have been very erratic. There is no distinct trend from which to approximate future conditions. An inspection of the available data indicates that the occurrence of heavy surge may be a cyclical condition. Between 1960 and 1970, an extremely high number of heavy surge occurrences was experienced; however, after 1970, a significant drop in surge was noted.

Record of Past Damages and Delays. For the determination of average annual damages associated with surge conditions at Hilo Harbor over the past years of record, the period from 1934 to 1980 was selected for detailed study. Although several years of records are missing, an appraisal of the entire record revealed that the coverage of surge conditions and vessels affected during the 31 years recorded was fairly complete. Further, the information relative to

vessel action during surge disclosed in the record for this period provided a reliable basis for the estimation of monetary damages and losses. A detailed analysis of total monetary damages and losses was completed for the period between 1934-1980. The types of damages or losses associated with vessels affected by surge generally fall into three categories. First, there are the delay costs for a vessel required to remain in the harbor for extended periods over and above the normal period of time required to work a given vessel. A detailed delay analysis was conducted using historical data and a 31-year record of surge at Hilo Harbor. Secondly, there are associated stevedoring delay costs. These costs take the form of stevedore standby time and efficiency losses incurred in working vessels subject to surge action. In those cases where delays were incurred after a vessel had discharged and loaded cargo, no stevedore delay costs were taken. A third category of monetary losses includes the cost of emergency measures such as anchoring, moving the vessel within the harbor, and the cost of running additional mooring lines to hold vessels. There are also the costs associated with the loss of lines and hawsers, as well as actual damages to the affected vessels and to the port facilities. Typical damages to port facilities over the years has been damages to the pier fender system. Because of the differences in the techniques of reporting for this period, monetary losses for certain years have been estimated as a lump sum at the end of the detailed tabulation. In both cases the detailed damage estimates were increased 10 percent as a conservative estimate of monetary losses to vessels not covered in the reports of surge conditions. All monetary losses are expressed in terms of current price levels.

BENEFITS FROM REDUCTION OF SURGE

The plan of improvement would reduce surge conditions within the bay and at the piers to non-damaging proportions. The estimate of benefits presented herein assumes that existing and future annual delays and damages would be entirely eliminated with the plan of improvement. To determine the average annual benefits which may be expected to accrue from improvements to Hilo Harbor over the 50-year economic life of the project, it was necessary to first establish the preventable delays and damages under existing harbor conditions and utilization. Secondly, the accrual of future delays and damages were estimated that would occur without the improvements.

Vessel Delays under Existing Conditions. The estimate of total delay costs of $568,745 for the recorded 29-year period for which delay costs could be computed, or $20,000 annually was used as a comparison for future delay cost projections. Future delay costs are directly related to the number of vessel trips through Hilo Harbor. Between 1948 and 1958, the average number of vessels through Hilo Harbor was 240. From 1985-2035 it is anticipated that vessel traffic will grow from 338 to 451 vessels annually.

Projection of Vessel Delays. Based on historical records, the probability of heavy surge occurrences at Hilo Harbor was calculated. Combining this information with the projected number of vessel trips to Hilo Harbor and the average surge delay time for each vessel type gives the annual delay time encountered in port by a vessel during heavy surge conditions. To arrive at the total annual delay cost, the hourly delays due to surge conditions was multiplied by the vessel operating cost. Table H-18 gives a breakdown of the various vessels anticipated to experience delay costs. Based on an interest rate of 7-3/8% and a 50-year period of analysis, the equivalent average annual benefits associated with the plan of improvement to reduce delays was computed to be $128,900.

Stevedore Delays. Because of surge conditions in Hilo Harbor, stevedore delays are also occasionally encountered. When surge conditions are severe, vessels are unable to enter or unload at the docks. Most companies charge a minimum of 5 hours for an idle stevedore crew, but a company with its own stevedores charges a minimum of 4 hours. No stevedore costs are incurred with vessels transporting petroleum or petroleum products to Hilo. Workmen aboard these vessels are paid their regular hourly wages regardless of whether any delays are encountered. These delay costs have been included in the vessel delay costs computations. The stevedore delay costs is computed by taking the number of vessel trips affected by surge each year and multiplying this number by the minimum standby cost for various stevedore crews. It was assumed that no delays would be experienced after unloading operations. A summary breakdown of the stevedoring delay costs at Hilo Harbor is shown for each major vessel in Table H-19.

Damages Under Existing Conditions. The estimate of total damages of $733,900 (in 1981 prices) for the years examined (1934-1938, 1952-1969, 1977-1979) was considered as representative of past and existing surge and damage conditions at Hilo Harbor. To establish a realistic annual damage estimate under existing conditions as a base for future damage projections, it was necessary to modify the total damage estimate for a segment of past traffic not expected to continue in the future. The damage estimate includes estimated monetary losses to interisland steamer traffic for the period 1934 through 1938. As these steamers are no longer in use nor are expected to be in use to any great extent in the future, the total damage estimate was modified by eliminating a portion of damages associated with these vessels from the total estimated damages. About half of the vessels affected by surge conditions during the 1934-1938 period were interisland steamers with total accrued damages of about $36,700. The adjusted total damage estimate, excluding interisland steamer traffic, is then $697,200, or $26,815 annually.

TABLE H-18. PROJECTED AVERAGE ANNUAL VESSEL DELAY COST FOR HILO HARBOR 1/2/

Vessel	1980	1985	1990	2000	2010	2020	2030	2035	Surge Delay (Hrs) 3/
A--# yearly trips		52	52	52	52	52	52	52	21
$ loss due to surge @ $442/hr		11901	11901	11901	11901	11901	11901	11901	
B--# yearly trips		26	26	26	27	29	33	36	21
$ loss due to surge @ $1445/hr		19454	19454	19454	20202	21699	24692	26936	
C--# yearly trips		156	156	156	156	156	156	156	21
$ loss due to surge @ $1124/4 hrs		22699	22699	22699	22699	22699	22699	22699	
D--# yearly trips		20	20	20	20	20	20	20	21
$ loss due to surge @ $1124/4 hrs		2910	2910	2910	2910	2910	2910	2910	
E--# yearly trips	3	3	4	5	6	7	8	9	21
$ loss due to surge @ $2208/hr	3430	3430	4573	5717	6860	8003	9147	10290	
F--# yearly trips	24	24	27	35	44	51	59	63	21
$ loss due to surge @ $1124/4 hrs	3492	3492	3929	5093	6402	7421	8585	9167	
G--# yearly trips	24	24	24	24	24	28	33	35	21
$ loss due to surge @ $370/hr	4598	4598	4598	4598	4598	5364	6322	6706	
H--# yearly trips	6	6	6	6	6	6	6	6	21
$ loss due to surge @ $1148/hr	3567	3567	3567	3567	3567	3567	3567	3567	
I--# yearly trips	4	4	4	4	4	4	4	4	21
$ loss due to surge @ $1305/hr	2703	2703	2703	2703	2703	2703	2703	2703	
J--# yearly trips	52	52	52	52	52	52	52	52	21
$ loss due to surge @ $1410/hr	37966	37966	37966	37966	37966	37966	37966	37966	
K--# yearly trips	9	10	12	16	19	20	26	28	21
$ loss due to surge @ $509/hr	2372	2636	3163	4217	5008	5271	6853	7380	

TABLE H-18 (contd). PROJECTED AVERAGE ANNUAL VESSEL DELAY COST FOR HILO HARBOR 1/2/

Vessel	1980	1985	1990	2000	2010	2020	2030	2035	Surge Delay (Hrs) 3/
L--# yearly trips	6	8	9	12	15	17	20	21	21
$ loss due to surge @ $370/hr	1149	1533	1724	2299	2874	3257	3832	4023	
M--# yearly trips		3	3	3	3	3	3	3	21
$ loss due to surge @ $1148/hr		1783	1783	1783	1783	1783	1783	1783	
N--# yearly trips		12	14	17	20	23	26	28	21
$ loss due to surge @ $268/hr		1665	1943	3090	2775	3192	3608	3886	
O--# yearly trips		3	3	3	3	3	3	3	21
$ loss due to surge @ $1148/hr		1783	1783	1783	1783	1783	1783	1783	
YEARLY TOTALS		122120	124691	129780	134031	141519	148351	153700	

AVERAGE ANNUAL = $128,928

1/ Vessel name has been replaced with a letter to avoid disclosure of confidential information.

2/ Vessel delay cost computed using following equations:

$$\text{Delay Cost} = \frac{\text{ave. \# days of heavy surge}}{\text{days in a year}} \times \left(\frac{\text{\#trips}}{\text{yr}}\right) \times \left(\frac{\text{surge delay time}}{\text{trip}}\right) \times \left(\frac{\text{operating cost}}{\text{hr}}\right)$$

3 Based on historical record of severe surge conditions encountered in Hilo Harbor.

TABLE H-19. PROJECTED AVERAGE ANNUAL STEVEDORE DELAY COST FOR HILO HARBOR 1/2/

Vessel 1/	1985	1990	2000	2010	2020	2030	2035	Delay Avg (Hr) 3/
A--# trips/yr	52	52	52	52	52	52	52	5
$ loss due to stevedoring delay @ 225/hr	1442	1442	1442	1442	1442	1442	1442	
B--# trips/yr	26	26	26	27	29	33	36	5
$ loss @ 1000/hr	3205	3205	3205	3329	3575	4068	4438	
C--# trips/yr	6	6	6	6	6	6	6	5
$ loss @ 400/hr	296	296	296	296	296	296	296	
D--# trips/yr	4	4	4	4	4	4	4	5
$ loss @ 400/hr	197	197	197	197	197	197	197	
E--# trips/yr	156	156	156	156	156	156	156	4
$ loss @ 150/hr	2308	2308	2308	2308	2308	2308	2308	
F--# trips/yr	20	20	20	20	20	20	20	5
$ loss @ 250/hr	616	616	616	616	616	616	616	
G--# trips/yr	52	52	52	52	52	52	52	5
$ loss @ 180/hr	1154	1154	1154	1154	1154	1154	1154	
Yearly Totals	9218	9218	9218	9342	9588	10081	10451	

Equiv. Ave Annual Cost - $9,290

1/ Vessel name has been replaced with a letter to avoid disclosure of confidential information.

2/ Stevedore delay cost computed using following equation:

$$\text{Delay Cost} = \frac{\text{(ave. \# days of heavy surge)}}{\text{days in a year}} \times \frac{\text{(trips)}}{\text{(year)}} \times \frac{\text{(hrs delay)}}{\text{(trip)}} \frac{\text{(crew cost)}}{\text{(hour)}}$$

3/ Minimum time charged for stevedore delay.

Projection of Damages. The annual estimate of $26,815 represents the average annual preventable damages for the period from 1952-1979 and serves as a basis for the projection of future benefits over the economic life of the proposed improvements. Future benefits associated with the elimination of adverse surge conditions were based on the number of transpacific and interisland vessels expected to call on Hilo Harbor over the next 50 years. Projections of vessel traffic were presented earlier and are summarized below.

TABLE H-20. CALCULATIONS FOR PROJECTED TOTAL DAMAGE COSTS

Year	Number of Transpacific & Interisland Vessels Through Hilo Harbor	Percent Increase Over Previous Period
1962-1977 (annual average)	395	
1985	338	-14.4
1990	347	2.7
2000	366	5.5
2010	386	5.5
2020	409	6.0
2030	436	6.6
2035	451	3.4

Assuming that future benefits will accrue in direct proportion to the expected increases in vessel traffic, future levels of benefit accrual were established as follows.

TABLE H-21. DAMAGE BENEFITS

Year	Estimated Annual Damage Benefits 1/
1979 (existing condition)	26,815
1985	22,954
1990	23,574
2000	24,870
2010	26,238
2020	27,812
2030	29,648
2035	30,656

Equivalent Average Annual = $24,332 1/

1/ Based on 1985 base year

As noted earlier, the basic damage estimate includes not only vessel damage associated with transpacific vessel traffic, but also damage allowances for interisland barge traffic as well. In estimating future benefits, it was assumed that the rate of increase in transpacific traffic used as a basis for projection was of sufficient magnitude to account for benefits to interisland vessels. Based on the projection of future average annual benefits, the equivalent average annual benefit associated with the elimination of adverse surge conditions at Hilo Harbor was computed to be $24,300 at an amortization rate of 7-3/8%.

Summary of Surge Reduction Benefits. Total average annual benefits associated with the plan of improvement to reduce surge conditions at Hilo Harbor consist of benefits from reduction in vessel and stevedore delays and vessel and pier facility damages. A summary of these benefits is shown below.

TABLE H-22. SUMMARY OF SURGE REDUCTION BENEFITS

Benefit Category	Savings/Benefit
Reduction in Vessel Delays	$128,900
Reduction in Stevedore Delays	9,300
Reduction in Vessel and Pier Facility Damages	24,300
	$162,500

BENEFITS FROM BREAKWATER MAINTENANCE REDUCTION

Potential benefits resulting from construction of a new inner breakwater would accrue from maintenance reduction savings. A new inner breakwater is being proposed under the EQ plan for Hilo Harbor. Since the main breakwater will no longer be maintained under the EQ plan, benefits can be anticipated from tsunami and storm repair savings and savings from expected new works.

TSUNAMI REPAIR SAVINGS

Five major tsunamis (1946, 1952, 1957, 1960, 1964) have occurred in Hilo since the original breakwater was completed in 1930. The 1946 tsunami, with a wave height of 27 feet at the breakwater, was the most destructive in terms of monetary losses. The Hilo breakwater was severely damaged with repair costs totalling $12,760,000 (April 1981 price level).

To arrive at the expected average annual benefits accrued from tsunami repair savings, a frequency-damage curve was plotted using historical tsunami damages (1930 to present) and the annual expected frequency for the 5 major tsunamis. The following table illustrates the expected frequency for the given wave height and associated breakwater damages for the 1946, 1952, 1957, 1960, and 1964 tsunamis.

TABLE H-23. RECORD OF DAMAGES TO BREAKWATER DUE TO TSUNAMI

Year (Tsunami)	Wave Height (Feet)	Expected Annual Frequency	Breakwater 1/ Damages ($)
1946	27	.00558	12,760,000
1952	11	.03251	464,000
1957	10	.03629	469,000
1960	13	.02608	132,000
1964	--	--	356,000

1/ 1981 price levels (based on Construction Cost Index)

This data was used to plot the frequency-damage curve to yield $139,000 of average annual damages on the main breakwater. Based on the estimated annual damages for the 10,000-foot existing breakwater the unit cost per foot for tsunami maintenance repairs will be $13.90.

STORM REPAIR SAVINGS

Additional benefits resulting from an inner breakwater construction would accrue from storm repair savings. The average annual maintenance cost for the existing 10,000 foot breakwater due to periodic storm damages from 1930 to 1980 was approximately $18,000 per year or $1.80 per foot. Under the EQ plan only 2,500 feet of the existing breakwater will be maintained, resulting in significant storm repair savings.

COST OF NEW WORK

Existing Breakwater (Without Project Condition). The existing Hilo breakwater, completed in 1930, is currently being upgraded to improve structural stability. Initial work has begun on an 900-foot portion of the main breakwater at a cost of about $2,400 per foot. Future improvements for Hilo Harbor include the eventual repair of the entire existing Hilo breakwater. Since construction costs tend to increase with the greater harbor depths, a slightly higher unit cost of $2,800 per foot was used in cost evaluations for the remaining breakwater repairs. It was assumed that these repairs would be completed incrementally at a rate of 2,300 feet per year beginning in 1983. With a 10,000-foot existing breakwater, repair works would be completed within 4 years. Based on a discount rate of 7-3/8% and a 50-year period of analysis, the average annual cost for major repair work on the existing Hilo breakwater is estimated at $1.76 million.

New and Existing Breakwater (With Project Condition). Under the with project condition, a new 2,000-foot inner breakwater will be constructed and merged with 2,500 feet of the old existing Hilo breakwater. Since 900 feet of the existing breakwater will already have been completed by 1983, the average annual repair costs for the existing breakwater was taken for only 1,700 feet. Based on a unit cost of $2,800 per foot, the average annual repair cost for this portion will be $361,300. The estimated average annual construction cost for the proposed inner breakwater will be $1,005,700. The combined annual repair and construction cost for both the new inner breakwater and the 1700 foot section of the existing breakwater is estimated at $1.37 million. Average annual costs are based on a discount rate of 7-3/8% and a 50-year period of analysis.

SUMMARY

Maintenance reduction savings have been evaluated for storm and tsunami damages for both with and without project conditions. Based on the unit damage costs from tsunamis and storms and the cost of new work for both with and without project conditions, a summary table (Table H-24) was constructed illustrating the net average annual benefits and the average annual benefits accrued from implementation of the EQ plan.

TABLE H-24. SUMMARY OF BENEFITS ASSOCIATED WITH EQ PLAN

Average Annual Cost Incurred Under Without Project Conditions		Averate Annual Cost Incurred Under With Project Conditions		
Storm Repair		Storm Repair		
$1.80/ft. 10,000 ft	= $18,000	$1.80/ft.	2500 ft	= $4,500
			2000 ft1/	= 940
Tsunami Repair:		Tsunami Repair:		
$13.90/ft. 10,000 ft	= 139,000	$13.90/ft.	2500 ft	= 34,750
			2000 ft1/	= 7,250
New Work:		New Work:		
Major Repairs	1,760,000	Major Repairs		361,300
		Subtotal		408,740
		New Breakwater		1,005,700
Total	$1,917,000			$1,414,440

Net Average Annual Benefits = $1,917,000 - 1,414,440 = $502,560
Average Annual Benefits = $1,917,000 - 408,740 = $1,508,260

1/ Storm and tsunami damage repair applicable to the new 2000-foot inner breakwater after an estimated 20 years when substantial deterioration of the main breakwater occurs.

LAND ENHANCEMENT BENEFITS

Alternate Plan 2, discussed in Appendix G of this report, includes a revetted mole structure adjacent to the small boat harbor at Radio Bay. An area of about 11 acres would be created by placement of about 310,000 cubic yards of dredged material, resulting in land enhancement value. Excess dredged material composed of mixed limestone reef material and terrigenous sediment would be disposed at a land site with no expected market value on the Big Island. The recent market value of commercial land near the harbor area is approximately $196,000 per acre. The created 11-acre parcel would therefore have a minimum value of about $2.16 million. The cost of equivalent fill material is about $15 per cubic yard (in place) for a total cost of $4.65 million for the required volume of 310,000 cubic yards. Using the parcel value of $2.16 million and deducting the cost of $1.265 million incurred by placing the fill material in the revetted area instead of disposing on land, the equivalent average annual benefit of $67,900 is generated at the current interest rate of 7-3/8%. The cost of only half of the revetment was deducted since the other half is an integral part of the small boat harbor.

TABLE H-25. BENEFIT SUMMARY FOR HILO HARBOR IMPROVEMENTS

Benefit Type	Amount
1. Savings from Incremental Depth Increases	
a. 31,000 & 24,000 DWT Vessels	$ 169,560
b. 40,700 DWT Vessel	162,029
2. Savings in Delays and Damages	
a. Vessel Delays	128,900
b. Stevedore Delays	9,300
c. Vessel Damages	24,300
3. Savings in Breakwater Maintenance	
a. Tsunami Repair	12,560
b. Storm Repair	97,000
c. New Work	1,398,700
4. Land Enhancement	67,900
TOTAL AVERAGE ANNUAL BENEFITS	$2,070,249
ROUNDED	$2,070,000

APPENDIX I

BENEFIT ANALYSIS:

SMALL-CRAFT NAVIGATION

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OBJECTIVE

The objective of this study is to analyze the benefits for a light draft harbor serving the Hilo area commercial fishing needs. The recreational boating needs for the Hilo area are anticipated to be met by implementation of a Federally authorized project for a small recreational boat harbor in Reed's Bay, Hilo. The project was authorized under Section 107 of the 1965 River and Harbors Act, as amended and provides for an entrance channel 880 feet long, 120 feet wide and 12 feet deep; a breakwater 870 feet long and a berthing basin 9 acres in area.

GENERAL

Three alternative size harbors were analyzed -- an additional small boat harbor of 203 berths (high projection), 169 berths (medium projection), and 119 berths (low projection). The benefits derived from each size harbor consist of navigation benefits to fishing craft that would be moored without the project; increased fish catch; and damage prevention. The computations are based on a 7-3/8 percent interest rate and a 50-year project life. The project base year, 1985, is when benefits are expected to begin accruing to the proposed harbor plans. Benefits are based on December 1980 price levels.

METHOD OF ANALYSIS

The Hilo Tributary Area (consisting of Puna, South Hilo and North Hilo districts) was designated as the study are. Without the project, the moored craft capacity of the Hilo Tributary Area will remain at its current level of 110 spaces, including 106 (52 commercial and 54 recreational) spaces for officially moored craft (Hilo Harbor) and four spaces for transients. With the proposed small boat harbor the spaces for officially moored craft would increase to 261, 227 and 177 for the high, medium, and low projections, respectively. Under any of these conditions it is estimated that eight spaces will be generally available for transient craft.

BERTHING SPACE DEMAND

Requirements for berthing spaces are based on an analysis of historical trends, population, growth in vessel registration, latent demand and other factors. Table 1 shows historical and projected demand determinants for the Hilo Tributary Area.

Population. The Hawaii State Department of Planning and Economic Development (DPED) is the source for historical and projected population for the State and Hilo tributary area. The OBERS-E projections for the non-SMSA portion of OBERS Economic Region 173 (Hawaii) would ordinarily be applicable to the growth of Hawaii's islands other than Oahu. However, the OBERS projection, made in 1972, forecasts a declining population for this part of the State. In view of the rapid growth that these islands have experienced since 1972, and which seem to have every reason for continuing growth, the OBERS-E projections are not used in this analysis. The projections for the Hilo tributary area, based on DPED County growth rate forecasts, follow from historical trends and econometric projections for Series II-F the state and its island components.

Existing and Projected Fleet. The State Department of Transportation (DOT), Harbors Division, maintains records of small craft registration by island (registered craft). Larger vessels, not required to register with the State, are documented with the U.S. Coast Guard (assumed to be 100% wet-stored). The DOT's Small Boat Harbor Utilization Report periodically lists the capacity, moorings and waiting lists for each harbor. This information is shown in Table 1.

The number of registered commercial craft statewide has been increasing steadily in recent years growing from 380 in 1970 to 1,155 in 1980, representing an average growth of 11.8 percent per year. Plotting this growth indicates a general trend of growth but at a declining rate. A reasonable extension of this trend indicates that growth should reach a plateau of about 2,200 crafts by year 2000 as shown in Figure 1, medium projection, and Table 1. This equates to an annual growth rate of 3.3 percent for this 20 year period.

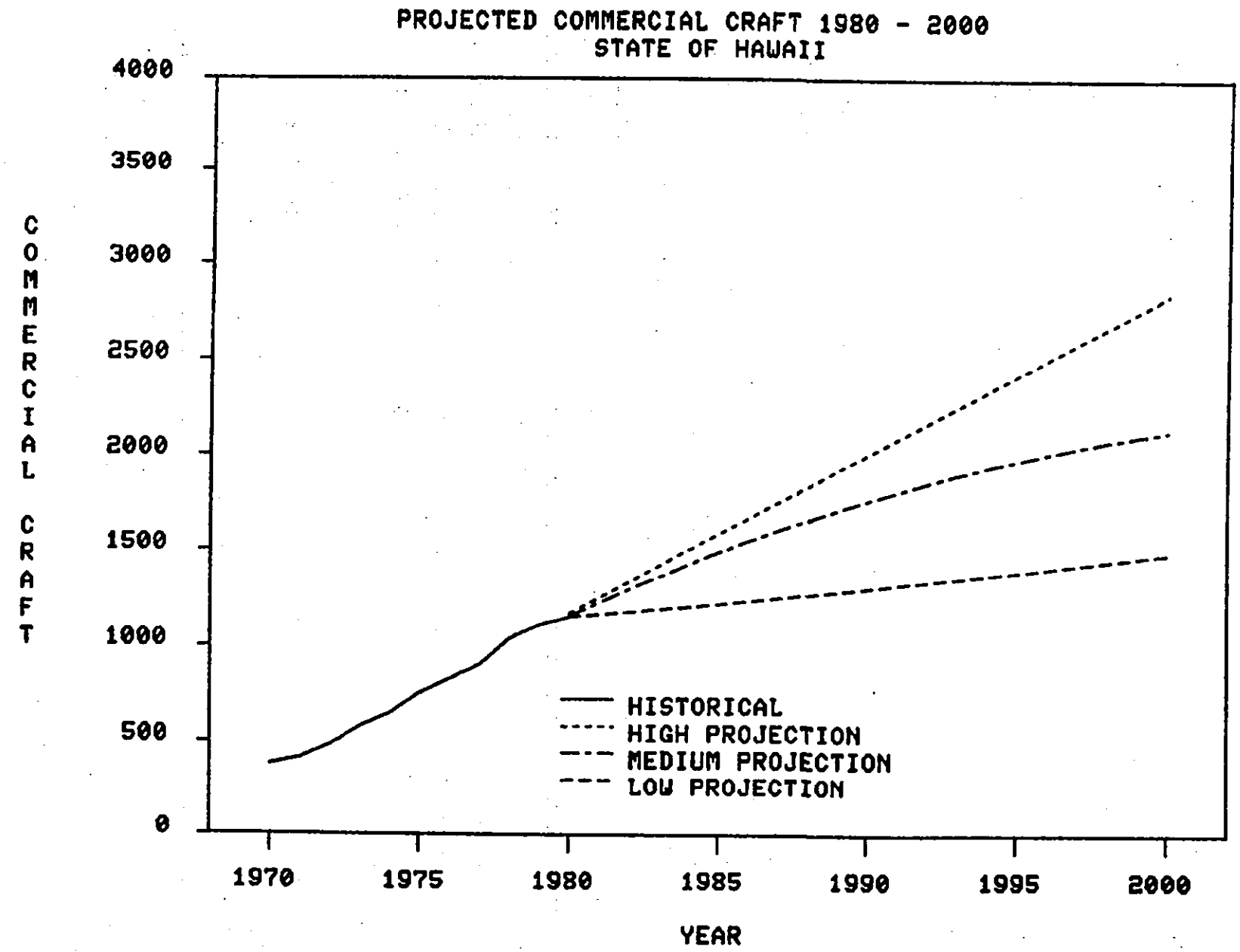
PROJECTED COMMERCIAL CRAFT 1980 - 2000
STATE OF HAWAII
COMMERCIAL CRAFT
4000
3500
3000
2500
2000
1500
1000
500
0
1970
1975
1980
1985
1990
1995
2000
YEAR
HISTORICAL
HIGH PROJECTION
MEDIUM PROJECTION
LOW PROJECTION

Figure 1

The County of Hawaii is the second leading producer of seafood in the State. As a result, commercial waterborne activity on the "Big Island" has been in many instances indicative of overall statewide trends. Three sets of projections (Figure 2) were generated for the commercial fleet in the Hilo Tributary Area based on this analogy. The first projection (high projection, see Table 1) forecasts an increase in the size of the fleet over the next 20 years, based on a linear projection of historical data. The medium projection (Table 2) indicates a growth in total craft but at a decreasing rate and the low projection (Table 3) takes the 1980 ratio of commercial craft to 1000 population and holds it constant throughout the projection period.

Although only one growth projection was chosen for determining the recommended size of a small boat harbor, the range of alternative growth scenarios presented show the sensitivity of such projections in determining total future boating needs. For this analysis the medium projection was selected as being representative of expected future growth in commercial craft in the study area. The high projection, although very plausible, was discounted because the slow down in growth in total commercial craft over the past years is not adequately reflected in the projection. The low projection, as well, was discounted because the relationship assumed as a basis for making the projection is contrary to the historical growth in the ratio. The medium projection, however, represents a meaningful trendline that takes into consideration events that have occured in recent years. The projection makes a conservative statement about growth in the Hilo Tributary Area while remaining competitive with expected future expansion of the commercial fleet statewide.

The number of berthing space applications for Hilo Tributary Area's harbors is a poor indication of demand. In recent years less than ten applications have been on file. Harbor construction and development in and around Hilo has been of such a small scale, and harbor berths are so few, that the overwhelming majority of Hawaii's boaters have been oriented to trailer-mounted vessels over the years. The demand for harbor space for wet storage is evident, however, waiting lists exist only where there are prospects for new capacity. Waiting lists at other harbors are usually small. There is little turnover, and Hawaii's boaters are accustomed to trailering, despite the problems associated with trailering the larger vessels required for boating in the island's rough waters.

PROJECTED COMMERCIAL CRAFT 1980 - 2000
HILO TRIBUTARY AREA

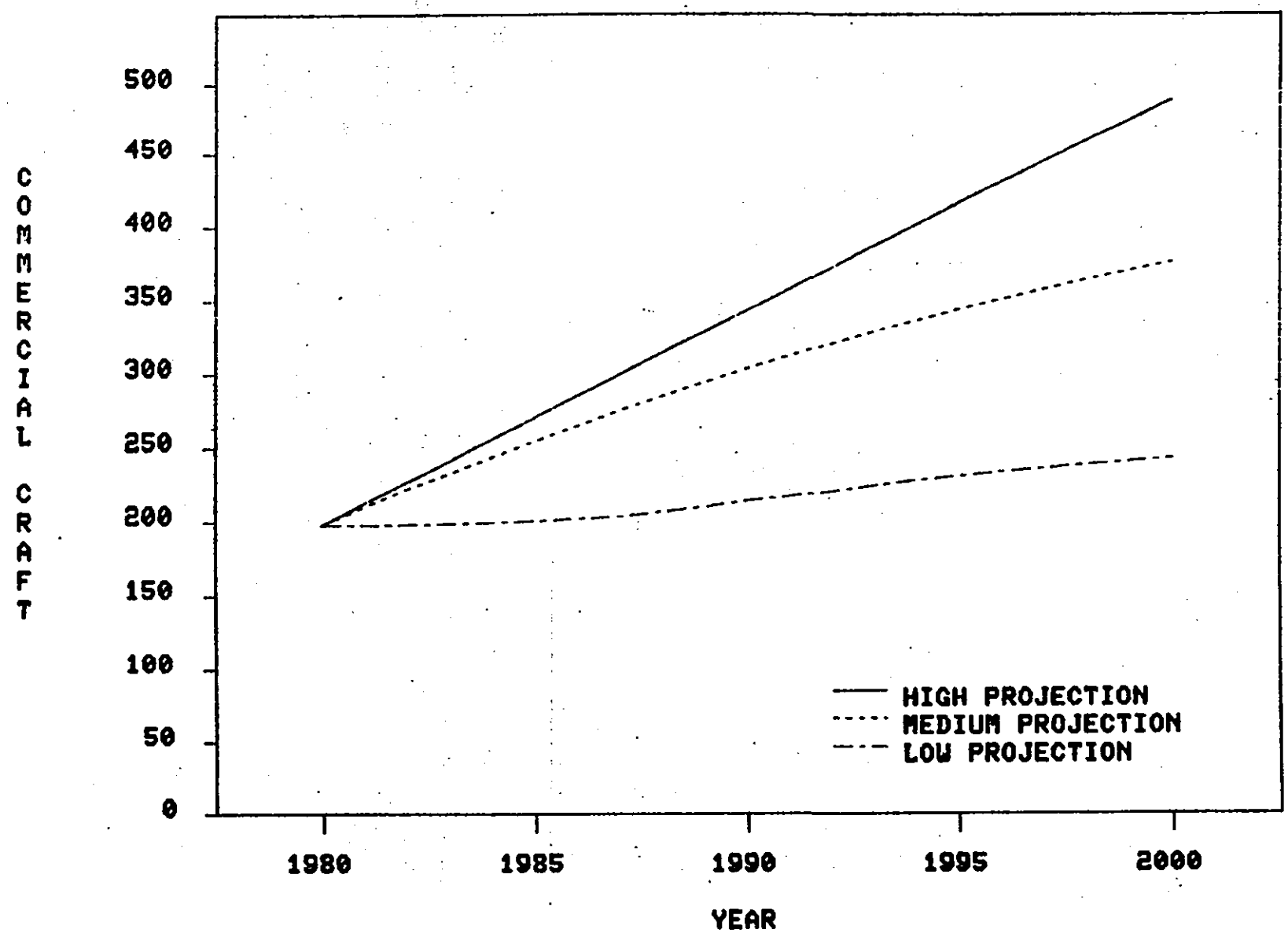

Figure 2

During recent Corps of Engineers surveys of commercial boat owners (Hawaii State-Wide Boating Survey & Survey of Parameters -- Hilo 1980), respondents were asked to indicate their preferred storage (under ideal conditions). Those owners of dry-stored craft indicating a preference for harbor berths represent effective demand for mooring berths. The following percentages of owners of dry-stored craft indicated preference for harbor space:

Full-Time Commercial Fishing: 50.0%
Part-Time Commercial Fishing: 23.3%

Existing capacity coupled with existing and projected fleet sizes, produces a measure of excess demand for berthing spaces. Under the alternative conditions analyzed, this excess demand is assumed to be absorbed in 1985 (base year) and the fleet to then grow proportionately up to the planned harbor capacity constraint. Graphic extrapoliation of the series indicates that the total demand for berthing spaces in the project base year is 198 (plus the 4 transient spaces). By 2000 a proposed Hilo area capacity of 488 (high projection), 377 (medium projection), and 243 (low projection) spaces would be fully utilized.

DISTRIBUTION OF CRAFT TYPES

The distribution of the present fleet and average value of vessels and net returns to charter and fishing operations was determined from the boater surveys. Responses also yielded a prospective distribution under ideal conditions. For projection purposes, the percentage distribution between type of storage and values is kept constant. With harbor improvement, the "ideal" distribution would occur in 1985. The distribution of type of storage and values of craft is probably a conservative estimate for the remainder of the project life since there is a continuing statewide trend for an upgrading of the fleet to larger, more expensive craft.

TRANSIENT CRAFT

Hilo is often a destination for craft from other Hawaiian Islands ports. The demand for transient slips is substantial with over 160 transient craft

registering with the Coast Guard in Hilo in 1979. Presently four slips are available for transient use in Radio Bay. It is anticipated that four additional transient slips in the proposed harbor would be fully utilized. The value of craft expected to use the transient slips was compiled as a weighted average of values of craft large enough to negotiate the seas between the islands. The average depreciated value per transient craft was determined to be $39,444.

ANNUAL RETURNS

The annual return that accrues to commercial fishing craft (Tables 14, 15 & 16) was derived from information provided by operators of these types of craft within the Hilo Tributary Area. Without a new small boat harbor, the average annual returns for a particular type of commercial fishing craft are expected to be the same as with a harbor. These craft are operated by professional seamen and will probably not be significantly affected by the proposed navigation improvements. However, based on owner responses, the distribution of the commercial fishing fleet would be expected to change -- with a shift toward more moored commercial fishing vessels.

CHARTER CRAFT RETURNS

During the statewide boating survey no responses were received from operators of charter sport fishing craft in the Hilo tributary area. It was assumed, therefore, that no charter craft operate in the study area. At one time, however, such a vessel, did operate out of Hilo but has since relocated to the Island of Maui.

COMMERCIAL FISHING CRAFT RETURNS

1. Full-Time Fishing Craft

The surveys of fishing craft operators of seven full-time moored craft indicated that each craft averages 285 trips per year. Each craft catches an average of 380 lbs. of seafood per trip with an average selling price of $1.46 per pound. Expenses included wages, depreciation, fuel, gear, supplies,

maintenance and repair, and other came to $30,697 per craft. A salary of $31,200 per year based on returns to occupations requiring comparable skill and training was imputed to the owner/operator to yield total expenses of $61,897 per craft. Thus, the average full-time moored commercal fishing craft yielded a net catch value of $96,221.

Analysis of seven full-time trailered fishing craft returns indicated that the average number of trips per year for this group is 235, with a catch of 258 lbs. per trip selling at an average of $1.46 per lb. Expenses of $11,648 were determined. A salary of $31,200 per year was imputed to the owner/operator to yield total expenses of $42,848 per craft. Thus, the average full-time trailered commercial fishing craft yielded a net catch value of $45,672.

2. Part-Time Fishing Craft

The State-Wide Boating Survey of part-time fishing craft operators included four part-time moored craft and thirty part-time trailer-mounted craft. Analysis of moored part-time fishing craft returns indicated that the average number of trips is 130 with a catch of 109 lbs. per trip selling at an average of $1.40 per lb. Expenses totaled $3,536. A salary of $12,480 was imputed to the operator (130 trips x 8 hrs x $12/hr.). Thus, the average part-time moored commercial fishing craft yielded a net catch value of $3,822.

Analysis of trailered part-time fishing craft returns indicated that the average number of trips per year for this group is 105, with a catch of 89 lbs. per trip selling at an average of $1.40 per lb. Expenses totalled $1,410. A salary of $10,080 was imputed to the operator (105 trips x 8 hrs. x 12/hr.). Thus, the average part-time trailered commercial fishing craft yielded a net catch value of $1,593.

DAMAGE PREVENTION BENEFITS

The damage prevention benefits are shown in Table 17. The size of the moored fleet without the harbor is expected to remain constant, while the size of the trailered fleet will increase to the year 2000 and then remain constant. Conservatively, the average annual damages were calculated using the 1985 prospective (without improvements) fleet (base year).

TABLE 1. EXISTING AND PROJECTED COMMERCIAL FISHING FLEET - STATE OF HAWAII AND HILO TRIBUTARY AREA-HIGH PROJECTION

YEAR	STATE POPULATION (1000)	STATE REGISTERED COMMERCIAL CRAFT	STATE COMMERCIAL CRAFT PROJECTED	STATE CRAFT/1,000 POPULATION	HILO TRIBUTARY AREA POPULATION (1000)	HILO TRIBUTARY AREA COMMERCIAL CRAFT PROJECTED	HILO TRIBUTARY AREA TOTAL MOORED CRAFT CAPACITY 7/	HILO TRIBUTARY AREA EXCESS DEMAND FOR MOORED SPACE	HILO TRIBUTARY AREA CRAFT/1,000 POPULATION
1970	775.1	380		0.5	41.0		43		
1971	797.4	410		0.5	42.9		43		
1972	820.7	482		0.6	43.6		67		
1973	840.5	582		0.7	45.2		99		
1974	853.5	648		0.8	46.9		100		
1975	868.0	756		0.9	48.4		100		
1976	882.4	832		0.9	49.4		100		
1977	892.8	906		1.0	50.7		100		
1978	902.4	1041		1.2	51.3		106 8/		
1979	914.7	1113		1.2	53.2		106		
1980	964.7 1/	1155		1.2	57.8 1/	198 5/	106	(42) 9/	3.4
1985	1,020.9 2/		1,500 3/	1.5	59.0 4/	272 6/		(65)	4.6
1990	1,091.5		1,780	1.6	63.0	344		(97)	5.5
1995	1,163.8		2,000	1.7	67.9	416		(127)	6.1
2000	1,225.9		2,200	1.8	71.5	488		(147)	6.8

NOTES:

( ) Projected or extrapolated

1/ Census (preliminary).
2/ Projections for 1985-2000 based on II-F projections by County, State Department of Planning and Economic Development, 1979 preliminary.
3/ Projected historical data per Report of Undocumented Vessel Registration, State of Hawaii, Department of Transportation 1970-1980 which indicates a decreasing rate of increase that will maximize at 2200 craft by year 2000.
4/ Puna, South Hilo, and North Hilo Districts, II-F projections, Hawaii Water Resources Regional Study, Social Base - Study Element Report, Page 36.
5/ Existing commercial craft.
6/ Projected based on a linear regression technique, see Figure 2 (High Projection).
7/ Includes recreational and commercial craft.
8/ Commercial craft occupy 52 of the mooring spaces.
9/ Determined from boater responses to Hawaii State-Wide Survey (1980), Commercial Craft.

TABLE 2. EXISTING AND PROJECTED COMMERCIAL FISHING FLEET
HILO TRIBUTARY AREA - MEDIUM PROJECTION

YEAR	HILO TRIBUTARY AREA POPULATION (1000)	TOTAL COMMERCIAL CRAFT PROJECTED	HILO TRIBUTARY AREA TOTAL MOORED CRAFT CAPACITY 5/	EXCESS COMMERCIAL DEMAND FOR MOORED SPACE	HILO TRIBUTARY AREA CRAFT/1,000 POPULATION
1970	41.0		43		
1971	42.9		43		
1972	43.6		67		
1973	45.2		99		
1974	46.9		100		
1975	48.4		100		
1976	49.4		100		
1977	50.7		100		
1978	51.3		106		
1979	53.2		106 6/		
1980	57.8 1/	198 3/		(42) 7/	3.4
1985	59.0 2/	257 4/		(61)	4.6
1990	63.0	305		(82)	5.5
1995	67.9	343		(98)	6.1
2000	71.5	377		(113)	6.8

NOTES:
( ) Projected or extrapolated.

1/ Census (preliminary).
2/ Puna, South Hilo, and North Hilo Districts, II-F Projections, Hawaii Water Resources Regional Study, Social Base-Study Element Report, Page 36.
3/ Existing commercial craft.
4/ Projected growth but at a decreasing rate, see Figure 2 (Medium Projection).
5/ Includes recreational and commercial craft.
6/ Commercial craft occupy 52 of the mooring spaces.
7/ Determined from boater responses to Hawaii State-Wide Survey (1980), commercial craft.

TABLE 3. EXISTING AND PROJECTED COMMERCIAL FISHING FLEET
HILO TRIBUTARY AREA - LOW PROJECTION

YEAR	HILO TRIBUTARY AREA POPULATION (1000)	TOTAL COMMERCIAL CRAFT PROJECTED	HILO TRIBUTARY AREA TOTAL MOORED CRAFT CAPACITY 5/	EXCESS COMMERCIAL DEMAND FOR MOORED SPACE	HILO TRIBUTARY AREA CRAFT/1,000 POPULATION
1970	41.0		43		
1971	42.9		43		
1972	43.6		67		
1973	45.2		99		
1974	46.9		100		
1975	48.4		100		
1976	49.4		100		
1977	50.7		100		
1978	51.3		106		
1979	53.2		106 6/		
1980	57.8 1/	198 3/		(42) 7/	3.4
1985	59.0 2/	201 4/		(43)	3.4
1990	63.0	214		(49)	3.4
1995	67.9	231		(58)	3.4
2000	71.5	243		(63)	3.4

NOTES:

( ) Projected or extrapolated.

1/ Census (preliminary).
2/ Puna, South Hilo, and North Hilo Districts, II-F Projections, Hawaii Water Resources Regional Study, Social Base-Study Element Report, Page 36.
3/ Existing commercial craft.
4/ Projected by holding the 1980 ratio of commercial craft to 1000 population (3.4) constant throughout the projection period, see Figure 2 (Low Projection).
5/ Includes recreational and commercial craft.
6/ Commercial craft occupy 52 of the mooring spaces.
7/ Determined from boater responses to Hawaii State-Wide Survey (1980), commercial craft.

TABLE 4. COMMERCIAL FISHING FLEET DISTRIBUTION-HILO TRIBUTARY AREA – HIGH PROJECTION

PARAMETERS				DISTRIBUTION					
				FULL-TIME FISHING		PART-TIME FISHING			
YEAR	NO. BOATS	WET STORED	DRY STORED	WET	DRY	WET	DRY	TOTAL	TRANSIENT
WITHOUT PROJECT									
1980	198	52	146	26	30	26	116	198	4
1985	272	52	220	26	51	26	169	272	4
1990	344	52	292	26	71	26	221	344	4
1995	416	52	364	26	92	26	272	416	4
2000	488	52	436	26	112	26	324	488	4
WITH PROJECT 1/									
1980	198	52	146	26	30	26	116	198	4
1985	272	117	155	52	25	65	130	272	8
1990	344	149	195	66	31	83	164	344	8
1995	416	179	237	80	38	99	199	416	8
2000	488	199	289	93	45	116	234	488	8

1/ Unconstrained after 1985.

TABLE 5. COMMERCIAL FISHING FLEET DISTRIBUTION-HILO TRIBUTARY AREA - MEDIUM PROJECTION

PARAMETERS				DISTRIBUTION					
				FULL-TIME FISHING		PART-TIME FISHING			
YEAR	NO. BOATS	WET STORED	DRY STORED	WET	DRY	WET	DRY	TOTAL	TRANSIENT
WITHOUT PROJECT									
1980	198	52	146	26	30	26	116	198	4
1985	257	52	205	26	47	26	158	257	4
1990	305	52	253	26	60	26	193	305	4
1995	343	52	291	26	71	26	220	343	4
2000	377	52	325	26	81	26	244	377	4
WITH PROJECT 1/									
1980	198	52	146	26	30	26	116	198	4
1985	257	113	144	50	23	63	121	257	8
1990	305	134	171	59	27	75	144	305	8
1995	343	150	193	66	31	84	162	343	8
2000	377	165	212	73	34	92	178	377	8

1/ Unconstrained after 1985.

TABLE 6. COMMERCIAL FISHING FLEET DISTRIBUTION-HILO TRIBUTARY AREA - LOW PROJECTION

PARAMETERS				DISTRIBUTION					
				FULL-TIME FISHING		PART-TIME FISHING			
YEAR	NO. BOATS	WET STORED	DRY STORED	WET	DRY	WET	DRY	TOTAL	TRANSIENT
WITHOUT PROJECT									
1980	198	52	146	26	30	26	116	198	4
1985	201	52	149	26	31	26	118	201	4
1990	214	52	162	26	35	26	127	214	4
1995	231	52	179	26	39	26	140	231	4
2000	243	52	191	26	43	26	148	243	4
WITH PROJECT 1/									
1980	198	52	146	26	30	26	116	198	4
1985	201	95	106	42	15	53	91	201	8
1990	214	101	113	45	16	56	97	214	8
1995	231	110	121	49	17	61	104	231	8
2000	243	115	128	51	18	64	110	243	8

1/ Unconstrained after 1985.

TABLE 7. ESTIMATED AVERAGE ANNUAL OPERATING COST OF COMMERCIAL FISHING CRAFT 1/

	FULL-TIME FISHING		PART-TIME FISHING	
	WET	DRY	WET	DRY
Crew Wages	$ 8,918	$ 1,329	-	-
Operator Wages	31,200 2/	31,200 2/	12,480 2/	10,080 2/
Expenses	10,446 3/	8,559 3/	3,536 3/ 4/	1,410 3/ 4/
Depreciation	11,333	1,760	-	-
Total Cost	$61,897	$42,848	$16,016	$11,490
Average No. of Trips/ Year	285	235	130	105
Cost/Trip	$ 217	$ 182	$ 123	$ 109

1/ Tabulation and analysis of questionnaire data, State of Hawaii Boat Owner Survey, March 1980; "A Survey of Small Craft Fleet Parameters and Use Patterns Hilo, Hawaii Tributary Area," Environmental Capital Managers Inc, Dec 1979; "Geological, Biological and Water Quality Investigations Hilo Bay, Hawaii, Fishery Resource Survey," Daniel P. Cheney, Services in Environmental Sciences.

2/ Based on returns to occupations requiring comparable skills and training.

3/ Updated from date of survey to reflect increases in operation and maintenance costs.

4/ Includes crew wages and depreciation.

TABLE 8. PROSPECTIVE INCREASE IN FISH CATCH - HILO TRIBUTARY AREA - HIGH PROJECTION

YEAR	FULL-TIME FISHING WET	FULL-TIME FISHING DRY	PART-TIME FISHING WET	PART-TIME FISHING DRY	TOTAL
PROSPECTIVE FISH CATCH (w/o Project) (1,000 pounds)					
1985	2,816	3,092	368	1,579	7,855
1990	2,816	4,305	368	2,065	9,554
1995	2,816	5,578	368	2,542	11,304
2000	2,816	6,791	368	3,028	13,003
2035	2,816	6,791	368	3,028	13,003
PROSPECTIVE FISH CATCH (w/ Project) (1,000 pounds)					
1985	5,632	1,516	921	1,215	9,284
1990	7,148	1,880	1,176	1,533	11,737
1995	8,664	2,304	1,403	1,860	14,231
2000	10,072	2,728	1,644	2,187	16,631
2035	10,072	2,728	1,644	2,187	16,631
NET INCREASE IN FISH CATCH (1,000 pounds)					
1985	2,816	(1,576)	553	(364)	1,429
1990	4,332	(2,425)	808	(532)	2,183
1995	5,848	(3,274)	1,035	(682)	2,927
2000	7,256	(4,063)	1,276	(841)	3,628
2035	7,256	(4,063)	1,276	(841)	3,628

TABLE 9. PROSPECTIVE INCREASE IN FISH CATCH - HILO TRIBUTARY AREA - MEDIUM PROJECTION

YEAR	FULL-TIME FISHING WET	FULL-TIME FISHING DRY	PART-TIME FISHING WET	PART-TIME FISHING DRY	TOTAL
PROSPECTIVE FISH CATCH (w/o Project) (1,000 pounds)					
1985	2,816	2,850	368	1,477	7,511
1990	2,816	3,638	368	1,804	8,626
1995	2,816	4,305	368	2,056	9,545
2000	2,816	4,911	368	2,280	10,375
2035	2,816	4,911	368	2,280	10,375
PROSPECTIVE FISH CATCH (w/ Project) (1,000 pounds)					
1985	5,415	1,394	893	1,131	8,833
1990	6,390	1,637	1,063	1,346	10,436
1995	7,148	1,880	1,190	1,514	11,732
2000	7,906	2,061	1,304	1,663	12,934
2035	7,906	2,061	1,304	1,663	12,934
NET INCREASE IN FISH CATCH (1,000 pounds)					
1985	2,599	(1,456)	525	(346)	1,322
1990	3,574	(2,001)	695	(458)	1,810
1995	4,332	(2,425)	822	(542)	2,187
2000	5,090	(2,850)	936	(617)	2,559
2035	5,090	(2,850)	936	(617)	2,559

TABLE 10. PROSPECTIVE INCREASE IN FISH CATCH - HILO TRIBUTARY AREA - LOW PROJECTION

YEAR	FULL-TIME FISHING WET	FULL-TIME FISHING DRY	PART-TIME FISHING WET	PART-TIME FISHING DRY	TOTAL
PROSPECTIVE FISH CATCH (w/o Project) (1,000 pounds)					
1985	2,816	1,880	368	1,103	6,167
1990	2,816	2,122	368	1,187	6,493
1995	2,816	2,365	368	1,308	6,857
2000	2,816	2,607	368	1,383	7,174
2035	2,816	2,607	368	1,383	7,174
PROSPECTIVE FISH CATCH (w/ Project) (1,000 pounds)					
1985	4,549	909	751	850	7,059
1990	4,874	970	794	906	7,544
1995	5,307	1,031	864	972	8,174
2000	5,523	1,091	907	1,028	8,549
2035	5,523	1,091	907	1,028	8,549
NET INCREASE IN FISH CATCH (1,000 pounds)					
1985	1,733	(971)	383	(253)	892
1990	2,058	(1,152)	426	(281)	1,051
1995	2,491	(1,334)	496	(336)	1,317
2000	2,707	(1,516)	539	(355)	1,375
2035	2,707	(1,516)	539	(355)	1,375

TABLE 11. PROSPECTIVE REVENUE FROM FISH CATCH-HILO TRIBUTARY AREA - HIGH PROJECTION

YEAR	FULL-TIME FISHING WET	FULL-TIME FISHING DRY	PART-TIME FISHING WET	PART-TIME FISHING DRY	TOTAL
PROSPECTIVE REVENUE (w/o Project) ($1,000)					
1985	4,111	4,515	516	2,211	11,353
1990	4,111	6,285	516	2,891	13,803
1995	4,111	8,144	516	3,559	16,330
2000	4,111	9,914	516	4,239	18,780
2035	4,111	9,914	516	4,239	18,780
PROSPECTIVE REVENUE (w/ Project) ($1,000)					
1985	8,222	2,213	1,289	1,701	13,425
1990	10,436	2,744	1,647	2,146	16,973
1995	12,649	3,364	1,964	2,604	20,581
2000	14,705	3,983	2,301	3,061	24,050
2035	14,705	3,983	2,301	3,061	24,050
INCREASED REVENUE ($1,000)					
1985	4,111	(2,302)	773	(510)	2,072
1990	6,325	(3,541)	1,131	(745)	3,170
1995	8,538	(4,780)	1,448	(955)	4,251
2000	10,594	(5,931)	1,785	(1,178)	5,270
2035	10,594	(5,931)	1,785	(1,178)	5,270

TABLE 12. PROSPECTIVE REVENUE FROM FISH CATCH - HILO TRIBUTARY AREA - MEDIUM PROJECTION

YEAR	FULL-TIME FISHING WET	FULL-TIME FISHING DRY	PART-TIME FISHING WET	PART-TIME FISHING DRY	TOTAL
PROSPECTIVE REVENUE (w/o Project) ($1,000)					
1985	4,111	4,160	516	2,067	10,854
1990	4,111	5,311	516	2,525	12,463
1995	4,111	6,285	516	2,878	13,790
2000	4,111	7,170	516	3,192	14,989
2035	4,111	7,170	516	3,192	14,989
PROSPECTIVE REVENUE (w/ Project) ($1,000)					
1985	7,906	2,036	1,250	1,583	12,775
1990	9,329	2,390	1,488	1,884	15,091
1995	10,436	2,744	1,666	2,119	16,965
2000	11,543	3,010	1,825	2,329	18,707
2035	11,543	3,010	1,825	2,329	18,707
INCREASED REVENUE ($1,000)					
1985	3,795	(2,124)	734	(484)	1,921
1990	5,218	(2,921)	972	(641)	2,628
1995	6,325	(3,541)	1,150	(759)	3,175
2000	7,432	(4,160)	1,309	(863)	3,718
2035	7,432	(4,160)	1,309	(863)	3,718

TABLE 13. PROSPECTIVE REVENUE FROM FISH CATCH - HILO TRIBUTARY AREA - LOW PROJECTION

YEAR	FULL-TIME FISHING WET	FULL-TIME FISHING DRY	PART-TIME FISHING WET	PART-TIME FISHING DRY	TOTAL
PROSPECTIVE REVENUE (w/o Project) ($1,000)					
1985	4,111	2,744	516	1,544	8,915
1990	4,111	3,098	516	1,662	9,387
1995	4,111	3,452	516	1,832	9,911
2000	4,111	3,806	516	1,936	10,369
2035	4,111	3,806	516	1,936	10,369
PROSPECTIVE REVENUE (w/ Project) ($1,000)					
1985	6,641	1,328	1,051	1,191	10,211
1990	7,115	1,416	1,111	1,269	10,911
1995	7,748	1,505	1,210	1,361	11,824
2000	8,064	1,593	1,270	1,439	12,366
2035	8,064	1,593	1,270	1,439	12,366
INCREASED REVENUE ($1,000)					
1985	2,530	(1,416)	535	(353)	1,295
1990	3,004	(1,682)	595	(393)	1,524
1995	3,637	(1,947)	694	(471)	1,913
2000	3,953	(2,213)	754	(497)	1,997
2035	3,953	(2,213)	754	(497)	1,997

TABLE 14. COMMERCIAL FISHING BENEFITS - HILO TRIBUTARY AREA - HIGH PROJECTION

YEAR	NO. BOATS	WET STORED	DRY STORED	FULL-TIME FISHING WET	FULL-TIME FISHING DRY	PART-TIME FISHING WET	PART-TIME FISHING DRY	TOTAL	TRANSIENT
PROSPECTIVE FLEET (w/o Project)									
1980	198	52	146	26	30	26	116	198	4
1985	272	52	220	26	51	26	169	272	4
1990	344	52	292	26	71	26	221	344	4
1995	416	52	364	26	92	26	272	416	4
2000	488	52	436	26	112	26	324	488	4
2035	488	52	436	26	112	26	324	488	4
PROSPECTIVE FLEET (w/ Project)									
1980	198	52	146	26	30	26	116	198	4
1985	272	117	155	52	25	65	130	272	8
1990	344	149	195	66	31	83	164	344	8
1995	416	179	237	80	38	99	199	416	8
2000	488	199	289	93	45	116	234	488	8
2035	488	199	289	93	45	116	234	488	8
RETURN/CRAFT ($)									
AVERAGE DEPRECIATED VALUE 1/				33,380	14,500	13,100	11,313		39,444 3/
% ANNUAL RETURN (Ideal Conditions)				2/	2/	2/	2/		9%
NET ANNUAL RETURN (w/ Project)				96,221	45,672	3,822	1,593		3,549
NET ANNUAL RETURN (w/o Project)				96,221	45,672	3,822	1,593		3,017
PERCENT NET ANNUAL RETURNS (w/o Project)									85%
ANNUAL RETURNS (w/o Project) ($)									
1985				2,501,746	2,329,272	99,372	269,217		26,264 4/
1990				2,501,746	3,242,712	99,372	352,053		26,264
1995				2,501,746	4,201,824	99,372	433,296		26,264
2000				2,501,746	5,115,264	99,372	516,132		26,264
2035				2,501,746	5,115,264	99,372	516,132		26,264
ANNUAL RETURNS (w/ Project) ($)									
1985				5,003,492	1,141,800	248,430	207,090		28,392
1990				6,350,586	1,415,832	317,226	261,252		28,392
1995				7,697,680	1,735,536	378,378	317,009		28,392
2000				8,948,553	2,055,240	443,352	372,762		28,392
2035				8,948,553	2,055,240	443,352	372,762		28,392
TOTAL BENEFIT GAIN ($)									
1985				2,501,746	(1,187,472)	149,058	(62,127)		2,128
1990				3,848,840	(1,826,880)	217,854	(90,801)		2,128
1995				5,195,934	(2,466,288)	279,006	(116,287)		2,128
2000				6,446,807	(3,060,024)	343,980	(142,370)		2,128
2035				6,446,807	(3,060,024)	343,980	(142,370)		2,128

SUMMARY OF COMMERCIAL BENEFITS ($)

YEAR	FULL-TIME	PART-TIME	TOTAL
1985	1,314,274	86,931	1,401,205
1990	2,021,960	127,053	2,149,013
1995	2,729,646	162,719	2,892,365
2000	3,386,783	201,610	3,588,393
2035	3,386,783	201,610	3,588,393

EQUIVALENT AVERAGE ANNUAL BENEFIT ($)

FULL-TIME	PART-TIME	TRANSIENT	TOTAL
2,622,854	159,122	2,128	2,784,104

NOTES:

1/ Derived from surveys of boat owners in Hawaii.

2/ Estimated returns for commercial fishing craft were derived from information provided by operators of these types of craft in the Hilo Tributary Area; the returns for with and without project conditions are expected to remain the same as these professional operators are probably not significantly affected by the channel conditions.

3/ Weighted average of the types of craft expected to stop as transients.

4/ Computed based on the full ideal net return on investment being realized by four boat operators and 85% of the ideal net return on investment of four other boat operators who would take advantage of available transient space, but are not able to.

TABLE 15. COMMERCIAL FISHING BENEFITS - HILO TRIBUTARY AREA - MEDIUM PROJECTION

YEAR	NO. BOATS	WET STORED	DRY STORED	FULL-TIME FISHING WET	FULL-TIME FISHING DRY	PART-TIME FISHING WET	PART-TIME FISHING DRY	TOTAL	TRANSIENT
PROSPECTIVE FLEET (w/o Project)									
1980	198	52	146	26	30	26	116	198	4
1985	257	52	205	26	47	26	158	257	4
1990	305	52	253	26	60	26	193	305	4
1995	343	52	291	26	71	26	220	343	4
2000	377	52	325	26	81	26	244	377	4
2035	377	52	325	26	81	26	244	377	4
PROSPECTIVE FLEET (w/ Project)									
1980	198	52	146	26	30	26	116	198	4
1985	257	113	144	50	23	63	121	257	8
1990	305	134	171	59	27	75	144	305	8
1995	343	150	193	66	31	84	162	343	8
2000	377	165	212	73	34	92	178	377	8
2035	377	165	212	73	34	92	178	377	8
RETURN/CRAFT ($)									
AVERAGE DEPRECIATED VALUE 1/				33,380	14,500	13,100	11,313		39,444 3/
% ANNUAL RETURN (Ideal Conditions)				2/	2/	2/	2/		9%
NET ANNUAL RETURN (w/ Project)				96,221	45,672	3,822	1,593		3,549
NET ANNUAL RETURN (w/o Project)				96,221	45,672	3,822	1,593		3,017
PERCENT NET ANNUAL RETURN (w/o Project)									85%
ANNUAL RETURNS (w/o Project) ($)									
1985				2,501,746	2,146,584	99,372	251,694		26,264 4/
1990				2,501,746	2,740,320	99,372	307,449		26,264
1995				2,501,746	3,242,712	99,372	350,460		26,264
2000				2,501,746	3,699,432	99,372	388,692		26,264
2035				2,501,746	3,699,432	99,372	388,692		26,264
ANNUAL RETURNS (w/ Project) ($)									
1985				4,811,050	1,050,456	240,786	192,753		28,392
1990				5,677,039	1,233,144	286,650	229,392		28,392
1995				6,350,586	1,415,832	321,048	258,066		28,392
2000				7,024,133	1,552,848	351,624	283,554		28,392
2035				7,024,133	1,552,848	351,624	283,554		28,392
TOTAL BENEFIT GAIN ($)									
1985				2,309,304	(1,096,128)	141,414	(58,941)		2,128
1990				3,175,293	(1,507,176)	187,278	(78,057)		2,128
1995				3,848,840	(1,826,880)	221,676	(92,394)		2,128
2000				4,522,387	(2,146,584)	252,252	(105,138)		2,128
2035				4,522,387	(2,146,584)	252,252	(105,138)		2,128

SUMMARY OF COMMERCIAL BENEFITS ($)

YEAR	FULL-TIME	PART-TIME	TOTAL
1985	1,213,176	82,473	1,295,649
1990	1,668,117	109,221	1,777,338
1995	2,021,960	129,282	2,151,242
2000	2,375,803	147,114	2,522,917
2035	2,375,803	147,114	2,522,917

EQUIVALENT AVERAGE ANNUAL BENEFIT ($)

FULL-TIME	PART-TIME	TRANSIENT	TOTAL
1,965,609	125,045	2,128	2,092,782

NOTES:

1/ Derived from surveys of boat owners in Hawaii.

2/ Estimated returns for commercial fishing craft were derived from information provided by operators of these types of craft in the Hilo Tributary Area; the returns for with and without project conditions are expected to remain the same as these professional operators are probably not significantly affected by the channel conditions.

3/ Weighted average of the types of craft expected to stop as transients.

4/ Computed based on the full ideal net return on investment being realized by four boat operators and 85% of the ideal net on investment of four other boat operators who would take advantage of available transient space, but are not able to.

TABLE 16. COMMERCIAL FISHING BENEFITS - HILO TRIBUTARY AREA - LOW PROJECTION

YEAR	NO. BOATS	WET STORED	DRY STORED	FULL-TIME FISHING WET	FULL-TIME FISHING DRY	PART-TIME FISHING WET	PART-TIME FISHING DRY	TOTAL	TRANSIENT
PROSPECTIVE FLEET (w/o Project)									
1980	198	52	146	26	30	26	116	198	4
1985	201	52	149	26	31	26	118	201	4
1990	214	52	162	26	35	26	127	214	4
1995	231	52	179	26	39	26	140	231	4
2000	243	52	191	26	43	26	148	243	4
2035	243	52	191	26	43	26	148	243	4
PROSPECTIVE FLEET (w/ Project)									
1980	198	52	146	26	30	26	116	198	4
1985	201	95	106	42	15	53	91	201	8
1990	214	101	113	45	16	56	97	214	8
1995	231	110	121	49	17	61	104	231	8
2000	243	115	128	51	18	64	110	243	8
2035	243	115	128	51	18	64	110	243	8
RETURN/CRAFT ($)									
AVERAGE DEPRECIATED VALUE ($)				33,380	14,500	13,100	11,313		39,444 3/
% ANNUAL RETURN (Ideal Condition)				2/	2/	2/	2/		9%
NET ANNUAL RETURN (w/ Project)				96,221	45,672	3,822	1,593		3,549
NET ANNUAL RETURN (w/o Project)				96,221	45,672	3,822	1,593		3,017
PERCENT NET ANNUAL RETURN (w/o Project)									85%
ANNUAL RETURNS (w/o Project) ($)									
1985				2,501,746	1,415,832	99,372	187,974		26,264 4/
1990				2,501,746	1,598,520	99,372	202,311		26,264
1995				2,501,746	1,781,208	99,372	223,020		26,264
2000				2,501,746	1,963,896	99,372	235,764		26,264
2035				2,501,746	1,963,896	99,372	235,764		26,264
ANNUAL RETURNS (w/ Project) ($)									
1985				4,041,282	685,080	202,566	114,963		28,392
1990				4,329,945	730,352	214,032	154,521		28,392
1995				4,714,829	776,424	233,140	165,672		28,392
2000				4,907,271	822,096	244,608	175,230		28,392
2035				4,907,271	822,096	244,608	175,230		28,392
TOTAL BENEFIT GAIN ($)									
1985				1,539,536	(730,752)	103,194	(43,011)		2,128
1990				1,828,199	(867,768)	114,660	(47,790)		2,128
1995				2,213,083	(1,004,784)	133,770	(57,348)		2,128
2000				2,405,525	(1,141,800)	145,236	(60,534)		2,128
2035				2,405,525	(1,141,800)	145,236	(60,534)		2,128

SUMMARY OF COMMERCIAL BENEFITS ($)

YEAR	FULL-TIME	PART-TIME	TOTAL
1985	808,784	60,183	868,967
1990	960,431	66,870	1,027,301
1995	1,208,299	76,422	1,284,721
2000	1,263,725	84,702	1,348,427
2035	1,263,725	84,702	1,348,427

EQUIVALENT AVERAGE ANNUAL BENEFIT ($)

FULL-TIME	PART-TIME	TRANSIENT	TOTAL
1,111,758	75,116	2,128	1,189,002

NOTES:

1/ Derived from surveys of boat owners in Hawaii.

2/ Estimated returns for commercial fishing craft were derived from information provided by operators of these types of craft in the Hilo Tributary Area; the returns for with and without project conditions are expected to remain the same as these professional operators are probably not significantly affected by the channel conditions.

3/ Weighted average of the types of craft expected to stop as transients.

4/ Computed based on the full ideal net return on investment being realized by four boat operators and 85% of the ideal net return on investment of four other boat operators who would take advantage of available transient space, but are not able to.

It is expected that the proposed improvements will prevent 80 percent of the reported damages. These include grounding, hitting bottom, collisions and other hazards often involved with the harbor or channel conditions.

TABLE 17

ANNUAL DAMAGE PREVENTION BENEFITS 1/

HILO TRIBUTARY AREA

	Number of Boats	Average Annual Damage Per Boat	Total Annual Damage	Annual Damages Prevented (80%)
Transient	4	$171	$684	$547
Full-Time Commercial Fishing				
- Moored	26	$171	$4,446	$3,557
- Trailered	47	$68	$3,196	$2,557
Part-Time Commercial Fishing				
- Moored	26	$986	$25,036	$20,509
- Trailered	158	$144	$22,752	$18,202

Source: "BENEFIT ANALYSIS OF HILO LIGHT DRAFT HARBOR," Environment Capital Managers, Inc., August 1980.

1/ Tabulation and analysis of questionnaire data, State of Hawaii Boat Owner Survey, March 1980

NED EMPLOYMENT BENEFITS

The computation of EDA benefits is governed by Part IX of the Water Resource Council final rule, 14 December 1979. No such benefits were computed nor claimed for this project.

SUMMARY AND APPORTIONMENT OF BENEFITS

The average annual benefits anticipated for the three projected future conditions are summarized in Table 18.

TABLE 18 SUMMARY AND ALLOCATION OF PROJECT AVERAGE ANNUAL BENEFIT HILO TRIBUTARY AREA (7-3/8%) ($1,000's)

Benefit Category	High Projection 1/	Medium Projection 1/	Low Projection 1/
Full-Time Commercial	$2,622.9	$1,965.6	$ 1111.8
Part-Time Commercial	159.1	125.0	75.1
Transient	2.1	2.1	2.1
Damage Prevention	45.4	45.4	45.4
Total	$2,829.5	$2,138.1	$1,234.4

1/ *High projection annual beneits are based on a boat harbor of 203 berths, medium projection benefits 169 berths, and low projection benefits 119 berths.*

APPENDIX J

SECTION 404(b)(1) EVALUATION

DISCHARGE OF DREDGED OR FILL MATERIAL
FOR
SMALL CRAFT NAVIGATION IMPROVEMENTS
AND
DEEP DRAFT NAVIGATION IMPROVEMENTS

SECTION I. SMALL CRAFT NAVIGATION IMPROVEMENTS

A. DISCHARGE OF DREDGED OR FILL MATERIAL, SMALL CRAFT NAVIGATION IMPROVEMENTS SECTION 404(b)(1) FACTUAL DETERMINATION:

1. Special Aquatic Areas.

Sanctuaries and Refuges: None.

Wetland: A 12-acre, wetland occurs at King's Landing Plan 1 Site. The area is choked with bulrush, California grass and beach grass. Wetland is isolated, not connected with river or flood plain system and is not openly connected with ocean. The wetland does not provide infiltration, aquifer recharge, recreation, buffer zone, floodwater storage or fisheries values. Effect: The wetlands provides general wildlife habitat, the same as the surrounding ohia scrub forest. The discharge of basalt armor units will occur in the harbor created by excavating the wetland. Excavation in the wetland will essentially drain and destroy the wetland.

Mudflat. None.

Vegetation Shallows: None.

Coral Reefs: None.

Riffle and Pool Complex: None.

Other: Anchialine Pools. Several small depressions and holes in the lava substrate in the King's Landing area contained water and mosquito fish. The pools are referred to as "anchialine pools" which are close to the ocean with no direct connection, and the water levels fluctuate with the tide, but the water remains brackish or fresh. The US Fish and Wildlife Service did not ascertain whether the pools were actually anchialine, but for the purposes of this evaluation they are considered anchialine pools. The number of pools in the area are not known, but the recent geologic age of the area suggests that the pools are common throughout the region. Since no rivers have formed in the recent lava, the underground water surfacing in the lava tubes or depressions allows freshwater organism, usually found in streams and rivers in Hawaii, to establish themselves in the inhospitable environment creating aquatic ecosystems and unique aquatic organisms.

The US Fish and Wildlife Service indicated that the presence of large, introduced carnivorous fish species in the pools reduces the possibility of finding unique anchialine pool organisms. Effect: During the grading of the surrounding land area for the development of the harbor, material will fill the pools and eliminate them from further biological usefulness. The number of pools both large and small that would be destroyed are not determinable based upon the information provided by the US Fish and Wildlife Service.

2. Human Use Characterization:

Municipal Water Supply: None.

Recreation Fishing: Recreational pole fishing present along entire coastline between Hilo and Kalapana. Opihi picking confined to infrequently used areas. Public access to King's Landing restricted by rugged coastline and private landowner control of access. Kalapana and Leleiwi Point are public park lands. Effect: Recreational fishing values improved with the placement of armor units in the water. The wave absorbers and breakwater will provide habitat for common reef fish, possibly providing new fishing sites.

Commercial Fishing: None.

Water-Related Recreation: King's Landing access and public use is restricted. Hiking, camping, sunbathing and swimming available at Kalapana and Leleiwi Point. Tide pools at Leleiwi Point provide unique recreational resource. Surfing present at Kalapana. Effect: The discharge of excavated material will destroy the tide pools at Leleiwi Point.

Aesthetics: Pristine, open coastal area. Effect: Discharge will form a breakwater structure in the open coastal area.

Parks: Kalapana canoe landing park and Leleiwi Point Lehia Park. Effect: The discharge of fill does not affect the park use; however, harbor construction will eliminate park lands.

National Monuments: None.

National Park: None.

National Seashore: None.

National Wilderness Areas: None.

Research Sites: None.

National Historic Sites: Present. Effect: Discharge of fill does not affect the sites. Harbor construction excavation will affect the sites, before the discharge occurs.

3. Physical Substrate Determination.

Harbors: The harbor discharge sites will have substrates consisting of recently excavated, solid basalt, which would not be subject to erosion or movement. Effect: The placement of basalt armor units to form the wave absorbers and the breakwaters will not alter the physical substrate in the harbor.

Tide Pools, Leleiwi Point: The tide pools are formed by depressions in the lava flow and sand has been deposited in the pools by natural wave action. Effect: The discharge of excavated material into the tide pools will cover the sandy substrate. The fill will be protected and not easily erodible.

Anchialine Pools, King's Landing: The pools have basalt bottoms probably covered with organic debris. Effect: The discharge of basalt material into the pools will cover the organic layer on the bottom of the pool. Since the pools are located inland the fill will not be erodible by wave or reverine action.

4. Water Quality, Circulation, Fluctuation and Salinity Determination:

Harbor: The discharge will occur within a man-made body of water, since the harbor will be excavated out of a volcanic basalt shoreline. Effect: The placement of the basalt armor units to form the wave absorbers and breakwaters will not interfere with water circulation or fluctuation in the harbor. The structures will reduce wave energy in the harbor, thereby reducing mixing

energy, allowing the brackish groundwater to form a layer over the more saline ocean water. The structures will not affect water current direction or pattern, normal water fluctuations, potability, color, odor, taste, water chemistry or physical properties, pathogen or biological content, or eutrophication.

Tide Pools, Leleiwi Point: The tide pools are formed by ocean water passing over the lava shore into the pool and by tidal waters seeping through the rock into the pools. Groundwater leakage may also provide water to the pools. Effect: The fill will cover the pools eliminating them as aquatic systems. The fill will not affect the leakage of the groundwater or coastal water quality, circulation, fluctuation or salinity.

Anchialine Pools, King's Landing: The pools are not directly connected to the ocean and are located inland outside of the water. The lava tubes or depressions extend below the groundwater level allowing the formation of pools. The groundwater floats on the saline ocean water and the water level in the pool fluctuates with tide and rainfall intensity. Effect: The fill will cover the pools eliminating them as aquatic systems. The fill will not affect the normal fluctuation of groundwater levels or coastal water quality.

5. Suspended Particulate/Turbidity Determination: The placement of armor units into the harbor waters is not expected to affect water turbidity or suspended particulate concentration, or to create a significant turbidity plume. The filling of the anchialine pools will not affect coastal water turbidity since they are located out of the water. The fill in the tide pool will form part of a revetted landfill, and will be contained and protected by a revetment.

6. Contaminant Determination: The armor units and fill material are not contaminated, and the material is classified as Category 5. The initial evaluation does not indicate the presence of contaminants above background levels (see Item B, page J-5).

7. Aquatic Ecosystem and Organism Determination:

Harbor: The placement of armor units will occur within a recently excavated harbor basin in which no organisms will be present. Effect: The armor units will form rocky intertidal and submerged interstitial habitat for a variety of common marine and brackish water organisms

Tide Pools: The tide pools are colonized by common algae and juvenile reef fish. While the tide pool provides some nursery habitat, no major food chain productivity is associated with the tide pool. Effect: The fill will eliminate the tide pools within the project limits.

Anchialine Pools: The pools form unique aquatic habitats (see item 1), but are not major food chain contributors. Effect: The fill will eliminate anchialine pools within the project limits.

B. DISCHARGE OF DREDGED OR FILL MATERIAL, SMALL CRAFT NAVIGATION IMPROVEMENTS SECTION 404(b)(1) INITIAL EVALUATION:

The material to be discharged is fill material consisting of basalt rock excavated from the selected project site. Estimated quantities of basalt to be discharged are provided below:

Leleiwi Point	King's Landing Site 1	King's Landing Site 2	Kalapana
32,000 C.Y.	51,800 C.Y.	44,600 C.Y.	15,700 C.Y.

Contaminants cannot flow into the project area because no riverine systems pass through or into the areas. The areas consist of recent lava fields which are too geologically young for the development of streams. Rainwater quickly percolates through the rock into the groundwater table.

The material proposed for discharge has not been previously tested under the Section 404(b)(1) test requirements.

Pesticide runoff cannot enter the extraction site by surface flow.

Spills or disposal of contaminants have not been documented at or near the extraction sites. All the sites remain rural without major agricultural, industrial or commercial development. King's Landing has no human residences. Kalapana is park and coconut grove land. Leleiwi Point is also park land.

No natural deposits of minerals or other substances harmful to man are present at the extraction site.

Findings:

a. The material is not contaminated.

b. The fill material is classified as Category 5.

c. Further testing is not required.

C. DETERMINATION:

a. The discharge of armor units into the harbor does not significantly degrade water quality in the harbor since it does not destroy special aquatic areas, degrade human uses of the water, alter the physical substrate or water quality and water fluctuation in the harbor, cause prolonged water turbidity; contain contaminants, or significantly degrade the aquatic ecosystem.

b. The discharge of fill material into the tide pools eliminates any recreational use of the pools at Leleiwi Point. The fill eliminates the tide pools, but does not significantly degrade coastal water quality, does not affect coastal water turbidity, and does not contain contaminants that can cause a long-term environmental stress or affect human health. The tide pools are a localized recreational and biological resource.

c. The discharge of fill into the anchialine pools destroys the pools eliminating further use as a unique aquatic habitat. The fill does not significantly degrade water quality since the fill destroys only those pools within the project limits, does not affect human uses of water in the area, does not alter physical substrates in coastal areas, does not affect

groundwater movement, fluctuation and quality, does not affect water turbidity in coastal waters and does not result in a release or introduction of contaminants into the water. The lost of the pools is localized and does not affect pools outside the harbor area.

d. Contaminants: The initial evaluation of the material indicated that the material has a low likelihood of being contaminated. The extraction site is adjacent to the discharge site and the materials are similar, thus, are not likely to degrade the disposal site. The material placed in the habor is not likely to be eroded and carried to less contaminated areas. The fill used at the tide pools will be revetted and protected from wave erosion. The fill in the anchialine pools are located outside the influence of the ocean and will not be eroded into the water to contaminate other areas.

SECTION II. DEEP DRAFT HARBOR NAVIGATION IMPROVEMENTS

A. DISCHARGE OF DREDGED OR FILL MATERIAL, DEEP DRAFT HARBOR IMPROVEMENTS, SECTION 404(b)(1), FACTUAL DETERMINATION.

1. Special Aquatic Areas.

Sanctuaries and Refuges: None.

Wetlands: None.

Mudflat: None.

Coral Reefs: Portions of the discharge will occur on Blonde Reef, the major reef in Hilo Bay. Coral cover on the reef varies from 0-16% reflecting a decline in coral growth probably caused by the breakwater reducing wave energy and flushing on the reef, and increasing freshwater and sedimentation stress. Surveys suggest that the breakwater reduces water column mixing in the bay resulting in the development of a two-layered water body, where freshwater reduces water salinity to a depth of 10-20 feet in the bay. Reduced wave energy permits silt, carried into the bay by tributaries, to settle out on the reef, smothering benthic organisms, particularly coral. By contrast, portions of the reef outside of the breakwater have coral cover ranging from 40-70%. Effect: The discharge of dredged and fill material in Plan B results in the loss of reef habitat that could be revitalized if the breakwater were removed as proposed under Plan C.

Base Condition	Plan A	Plan B	Plan C	Plan D
220 acres available inside the breakwater	6 acres covered. 4 acres rocky intertidal habitat created.	85 acres filled; 130 acres dredged. 7 acres of intertidal habitat created.	6.2 acres covered. 2 acres of rocky intertidal habitat created. Area under existing breakwater reclaimed as marine habitat.	No effect

Riffle and Pool Complex: None.

2. Human Use Characterization.

Municipal Water Supply: Not applicable.

Recreational and Commercial Fisheries: Hilo Bay supports a large recreational shoreline fishery, and fishing sites are located all along the bay shoreline. Fishing within the discharge area occurs from Hilo breakwater and from the Baker's Beach shoreline. Recreational boaters possibly troll in the discharge areas. Common reef and nearshore coastal (neritic) fish are caught in the bay (see Attachment 1 for fish species list). The productivity of the fishery has not been measured, however, the fishery resource supports an estimated 2,100 local recreational shoreline fishermen, based on a 1972 survey (Hoffman and Yamauchi in Cheney, 1977). The State Division of Fish and Game indicated that 456 two-year permits for night fishing in the bay were issued between May 1975 and May 1976. Commercial fishing in Hilo Bay is no longer a significant industry. Effect: While the discharges will eliminate water area in the bay, the breakwater and fill structures will also provide new recreational fishing sites in the bay. The effect of the discharge of the rock used in constructing the breakwaters will probably provide fish and intertidal habitat partially offsetting loss of fish habitat. The discharge of fill in Plan B eliminates 85 acres of Blonde Reef, which may possibly reduce the available fishery resources in the bay.

Water-Related Recreation: Surfing, wading, swimming, canoeing and boating are significant recreational activities in Hilo Bay. Blonde reef is used by boaters and the Baker's Beach area provides open space, and wading and swimming opportunities. One surfing site in the bay is located at the tip of the breakwater. Effect:

Base Condition	Plan A	Plan B	Plan C	Plan D
Boating	Breakwaters remove 6 acres of open water from boating use, and create new navigation feature in the bay.	Breakwaters and fill remove 85 acres of open water from boating use. The fill creates a new recreational boat harbor.	Breakwater removes 6.2 acres of water from boating use, & creates new navigational feature.	No effect

Base Condition	Plan A	Plan B	Plan C	Plan D
Wading, swimming and open space at Baker's Beach.	South breakwater may eliminate wading, swimming and open space by enhancing expansion of Hilo port at Baker's Beach.	No effect	No effect	No effect
Surfing at breakwater tip.	No effect	Potential interference with surfing.	Discharge results in shortening or lowering the existing breakwater, possibly improving surfing conditions, if breakwater crest elevation is lowered to -8 feet MLLW, or breached.	No effect

Aesthetics: Hilo Bay's vista is dominated by the breakweater. Effect: The discharge will create new visual elements in Hilo Bay, except Plan D, which does not involve the construction of new structures in the bay.

Plan A - Adds two new breakwaters in the bay.

Plan B - Adds three new breakwaters and an 85-acre fill area in the bay.

Plan C - Shortens the existing breakwater.

Plan D - No effect.

National Monuments: None.

National Seashores: None.

National Wilderness Areas: None.

Research Sites: None.

National Historic Sites: Hilo Breakwater is eligible for inclusion on the National Register of Historic Places, based on its role in the development of Hilo port. The breakwater is also associated with events that facilitated the expansion of the railroad and port facilities in the Hilo area, the reestablishment of Hilo as the hub of transportation on the island of Hawaii, and the growth of Hilo. The breakwater is also the longest in the State of Hawaii, and has essentially maintained its physical integrity despite alterations to its original design, function and visual appearance. Effect:

Base Condition	Plan A	Plan B	Plan C	Plan D
Historial significance.	No effect	No effect	No effect	No effect
Visual & physical appearance.	No effect	Trunk realigned. 85-acre landfill covers one side of breakwater. 3 new breakwaters adjoin existing breakwater.	Shortened by 5,000 feet.	No effect

3. Physical Substrate Determination.

Size Gradation and Coarseness: The Blonde Reef discharge site substrate consists of mud overlying coralline rubble and pavement. The Baker's Beach discharge site consists of sand and lava and coral cobbles and gravel. Effect: The discharges are associated with the construction of structures which will cover the substrate and raise the bottom elevations from below mean lower low water (MLLW) to about +10 feet above MLLW. Plan D involves no change to the existing condition.

Compaction: Not applicable. The discharge involves the construction of breakwaters and the fill area to be protected and confined by a rock revetment.

Bottom Elevation/Contour: See table below:

Base Condition	Plan A	Plan B	Plan C	Plan D
Water depths at the discharge site.	0 to -36' below MLLW at Baker's Beach. -11 to -16' MLLW on Blonde Reef.	-11 to -42' on Blonde's Reef.	-11 to -15' MLLW.	No effect
Condition after the discharge. Breakwater crest elevation.	+9.5' MLLW.	+10' MLLW.	+15' MLLW.	

Material Movement: Baker's Beach and Bayfront Beach are presently eroding. Effect: The construction of the south breakwater at Baker's Beach may reduce the rate of erosion along the beach. Shortening the existing breakwater associated with the discharge in Plan C may reduce the erosion along the Bayfront Beach. If the existing breakwater crest elevation in Plan C is lowered or the breakwater is breached, wave energy should increase and possibly restore the westward current component to counteract the eastward erosion on Bayfront Beach.

Deposition: Not applicable.

4. Water Quality, Circulation, Fluctuation and Salinity Determination.

Current Velocity, Direction and Pattern: Presently a predominant surface outflow occurs in the harbor along the breakwater due to the discharge of groundwater and riverine water into the bay. Drogue studies indicate that current velocities vary from 0.03 to 0.19 knots. The ocean water lies beneath the surface, freshwater layer, and its movement is tidal dependent with no set current direction. Effect:

Plan A - Plan A will tend to isolate the inner harbor from the outer harbor with the construction of two breakwaters. The breakwaters may tend to further reduce mixing in the inner harbor and create a greater salinity gradient in the inner harbor. The outflow of freshwater from the inner harbor may keep silt-laden riverine water out of the inner harbor and slow sedimentation in the inner harbor.

Plan B - No change to the existing condition is anticipated.

Plan C - If the existing breakwater crest elevation is lowered or the breakwater is breached, increased wave energy on the reef and in the bay may tend to reduce the salinity gradient. In the inner harbor, the predominant outflow will continue, but in the outer harbor mixing may reduce the current velocity. Increased wave energy over the reef may create a shoreward current component flushing silt from the reef and possibly restoring surfing conditions in the bay. The increased wave energy may also impart a westward current component along Bayfront Beach that will counteract the eastward current which appears to be responsible for the erosion along the beach.

Plan D - No effect.

Downstream Flow: Not applicable.

Normal Water Fluctuations: No estuarine tidal lags are evident in Hilo Bay and the discharges are not expected to interfere with normal tidal fluctuations.

Salinity Gradient/Stratification: A salinity gradient is measurable in Hilo Harbor to a depth of 20 feet at the mouth of the harbor and 10 feet over Blonde Reef. The gradient is related to the amount of groundwater and riverine water discharged into the bay and the percent of freshwater in the surface layer can vary between 25% in the dry season to 75% following a storm event. Salinity measurements in the bay vary from 32-34 parts per thousand in the bottom layer and 11-30 parts per thousand in the surface layer. The formation of the salinity gradient is partially attributable to the breakwater which reduces wave energy as a water-column mixing force in the bay. Mixing is dependent upon wind and tidal forces, and ship traffic in the bay. Effect:

Plan A - The construction of the inner breakwaters may increase the salinity gradient and the depth of freshwater influence in the inner harbor.

Plan B - No effect.

Plan C - Possible reduction of the salinity gradient, in the outer bay, if the breakwater is lowered below Mean Lower Low Water or breached.

Plan D - No effect.

Potability: Not applicable.

Water Physical Characteristics: Water chemical and physical characteristics in Hilo Bay are dependent upon riverine and groundwater discharges into the bay. Wastewater discharges into the bay were removed. Effect: See Table J-1.

TABLE J-1. DISHCARGE EFFECTS ON WATER CHARACTERISTICS

Base Conditions (Mean Values)	Surface	Bottom	Plan A	Plan B	Plan C	Plan D
pH	7.60-8.32	8.04-8.36	Possible increase of temperature difference in tne inner harbor.	Possible nutrient increase with runoff from landfill.	Possible increase in dissolved oxygen concentration & reduction of difference between surface and bottom waters.	No effect.
Temp (°C)	19.7-24.9	23.4-25.2				
Dissolved oxygen (mg/l)	7.59-9.71	4.64-8.00				
Total nitrogen (ug/l)	172-403	28.4-90.4				
Total phosphorus (ug/l)	13.9-53.5	17.8-60.2				

Source: M&E Pacific, 1980.

Pathogens/Biological Content: Fecal coliform mean concentrations (number per 100 ml) ranged from 10 to 239 and fecal strep mean concentrations ranged from 62 to 1480. The source of the fecal bacteria was the riverine and storm drainage discharges into Hilo Bay. Effect: Only Plan B involves an increase in the amount of storm drainage water entering the bay due to the creation of the 85-acre landfill.

Eutrophication: Not applicable.

5. Suspended Particulate and Turbidity Determination.

Turbidity: The waters in Hilo Bay are highly turbid due to the discharge of suspended material from Wailoa River and other drainage ways into the bay. Turbidity usually increases with the volume of water discharged into the bay. Ship traffic and periodic maintenance dredging (once every 10 years) also contribute to normal turbidity levels in the bay. During the dry season, turbidity is considerably lower than the wet season. High chlorophyll-a and zooplankton concentrations are principal turbidity causing material during the dry season compared with inorganic sediment during the wet season.

	Storm	Wet Season	Dry Season
Turbidity (NTU, mean values)			
Surface	7.82-22.3	2.92-7.52	0.56-1.67
Bottom	4.9-7.65	3.65-9.15	0.69-2.20
Total Suspended Molds (mg/l, mean values)			
Surface	9.30-75.4	6.43-17.3	no data available
Bottom	16.1-44.5	7.40-28.6	

Source: M&E Pacific, 1980.

Effect: The discharge of rock to construct the breakwaters in Plans A, B and C is not expected to result in a significant increase in turbidity. The discharge of fill related to Plan C has the potential for increasing water turbidity, however, the use of containment and settling basins will probably result in the discharge of effluent with suspended material concentrations below existing conditions.

6. Contaminant Determination.

Initial Evaluation:	Plan A	Plan B	Plan C	Plan D
a. The material proposed for discharge:	Basalt rock.	Basalt rock and coralline material.	Basalt rock.	No discharge.
b. Source site:	Quarry.	Quarry and dredging Blonde Reef.	Existing breakwater.	N/A.
c. Contaminants can flow into extraction site:	No.	Yes.	No.	N/A.
d. The material proposed for discharge was previously tested.	No.	Yes--chemical constituents only.	No.	N/A.
e. Can pesticides enter the extraction site.	No.	Yes.	No.	N/A.
f. Spills or disposal of contaminants have been documented in the past.	No.	Yes.	No.	N/A.
g. Natural deposits of minerals or other substances harmful to man are present at the extraction site.	No.	No.	No.	N/A.

The sediments in Hilo Harbor are contaminated with chlordane, PCB and arsenic based on analysis by the State Department of Health. The coral on Blonde Reef is not expected to be contaminated, but the sediment in the harbor is contaminated and will be impossible to separate from the coralline material.

Findings:

a. The material proposed for discharge in Plans A and C is not contaminated consisting of basalt stone. The material proposed for discharge in Plan B consists of uncontaminated basalt stone and contaminated dredged material. The dredged material is suspected of being contaminated with arsenic, PCB and chlordane.

b. The material classification for the basalt stone is Category 5, Discharge without potential for environmental contamination. The material classification for the dredged material is Category 2, Open water discharge with level of contamination similar to the discharge site.

c. Further testing of the dredged material is required under Category 2. Test protocol requires a sediment analysis and water column elutriate analysis.

List of Contaminants to be Further Evaluated: The discharge of dredged material under Plan B for the landfill requires testing for arsenic, PCB and chlordane.

Results of testing will be provided, if Plan B is selected for implementation.

Zone of Mixing: Not applicable. The dredged material will be used for construction purposes and will be confined to the fill site by a rock revetment.

7. Aquatic Ecosystem and Organisms Determination.

Fishery resources which support a recreational shoreline fishery are identified in Attachment 1. Corals are major reef organisms, but do not dominate Blonde Reef. Coralline algae presently dominates the reef cementing coralline rubble and dead coral forming the reef foundation.

Rare/Threatened and Endangered Species: None.

Aquatic Ecosystem Dependency: Fishery resource dependency on Blonde Reef is unknown, however, fish surveys indicate that the most fish species and the greatest number of fish were found on Blonde Reef in comparison to other areas in Hilo Bay. Effect:

Base Condition	Plan A	Plan B	Plan C	Plan D
Blonde Reef discharge site:				
52-133 fish counted, 18-21 species represented. 220 acres available behind breakwater.	6 acres of reef covered; 4 acres rocky habitat formed.	85 acres covered; 130 acres dredged; 7 acres rocky habitat formed.	6.2 acres covered; 2 acres rocky habitat formed.	No effect.

The effect of reef loss on fishery opportunities and success is unknown, but loss of reef habitat could result in a reduced fish abundance in the bay. Plan B results in the largest loss of reef habitat in comparison to the other plans and could reduce recreational fishing success in the bay.

Determination: The discharge of armor units into the harbor under Plans A and C do not significantly degrade water quality or human uses of the water. The basalt rock is not expected to contain contaminants, cause prolonged water turbidity problems will significantly degrade the aquatic ecosystem even though a lost of reef area is anticipated. Plan does significantly degrade the aquatic ecosystem with the loss of fishery habitat and could lower recreational fishing success. Water turbidity associated with the discharge of the fill material can be controlled with the use of settling basins and the returning water will probably contain less suspended material than the existing bay waters. In Plan B, the dredged material will probably be contaminated with arsenic, PCB and chlordane and should undergo elutirate and sediment analysis prior to discharge. The contaminants are found throughout Hilo Bay within the bay sediments and probably not within the dredged corraline material.

Material Proposed for Discharge:

	Plan A	Plan B	Plan C	Plan D
Basalt rock	200,700 C.Y.	588,500 C.Y.	117,100 C.Y.	0
Dredged corralline fill	0	5,242,500 C.Y.	0	0
Dolos armor units			5,500 units	

TABLE VI

CHECK LIST OF FISH AND SHELLFISH TAKEN BY FISHERMEN WITHIN THE HILO BAY SURVEY AREA

LOCAL/COMMEN NAME	SCIENTIFIC NAME	LOCATION BY REGION
Aholehole	*Kuhlia sandvicensis*	5,6,7,9,11,12,14,16,17
Aku	*Katsuwonus pelamis*	3
Akule (Aji)/Hahalalu	*Trachurops crumenophthalmus*	1,6,9,11,14
Amaama (mullet)	*Mugil cephalus*	5,6,7,8,9,13,15
Awa (milkfish)	*Chanos chanos*	1,7
Aweoweo	*PRIACANTHIDAE*	16
Ehu (red snapper)	*Etelis marshi*	4
Hihimanu (ray)	*DASYATIDAE*	11,14
Hinalea (wrasse)	*LABRIDAE*	9,16
Humuhumu	*BALISTIDAE*	16,17
Kaku (barracuda)	*Sphyraena barracuda*	1
Kawakawa	*Euthynnus yaito*	14
Kumu	*Parupeneus porphyreus*	1,4,11,14,15,16
Kupipi	*Abudefduf sordidus*	9,11,16,17
Lae	*Scomberoides sancti-petri*	9
Maiko	*Acanthurus nigroris*	16,17
Manini	*Acanthurus sandvicensis*	11,14,16,17
Mano (tiger shark)	*Galeocerdo cuvieri*	1
Mano kihikihi (hammerhead shark)	*Sphyrna lewini*	1,2,11,14,16,17
Maomao	*Abudefduf abdominalis*	15,17
Menpachi	*Myripristis spp.*	16
Moano	*Parupeneus multifasciatus*	1,14,16,17
Moi/moi-lii	*Polydactylus sexfilis*	3,4,5,6,7,14

TABLE VI (cont.)

LOCAL/COMMEN NAME	SCIENTIFIC NAME	LOCATION BY REGION
Nehu	*Stolephorus purpureus*	1,2,11,13,14
Nenue	*Kyphosus cinerascens*	14
Oio	*Albula vulpes*	1,5,6,9
Omaka	*Caranx mate*	1
Oopuhue (balloon fish)	*Arothron hispidus*	4
Opakapaka	*Pristipomoides microlepis*	4
Opelu	*Decapterus pinnulatus*	9
Pakii(flatfish)	*Bothus spp.*	15
Palani	*Acanthurus dussumieri*	9,12,13,16,17
Piha	*Spratelloides delicatulus*	16
Pualu	*Acanthurus xanthopterus*	1
Puhi (moray eel)	*MURAENIDAE*	14
Puhi (tohe--conger eel)	*Conger marginatus*	14
Taape	*Lutjanus kasmira*	1,2
Toau	*Lutjanus vaigiensis*	11
Ulua/Papio	*CARANGIDAE*	1,3,4,5,6,7,9,11,14,15, 16,17
Upapalu (cardinal fish)	*Apogon snyderi*	15
Weke/Oama	*Mulloidichthys samoensis*	1,11,12,13,15
Tilapia	*Tilapia spp.*	10
Oopu (goby)	*GOBIDAE*	5
Crab - Kuahono	*Portunus sanguinolentus*	3,4,6,7,15
Crab - Samoan	*Scylla serrata*	3,4
Opae (glass shrimp)	*Palaemon debilis*	7,8,10,15
Ula	*Panulirus spp.*	3,4,16,17
Taco (octopus)	*OCTOPODA*	4,16,17
Opihi	*Cellana spp.*	4,16,17

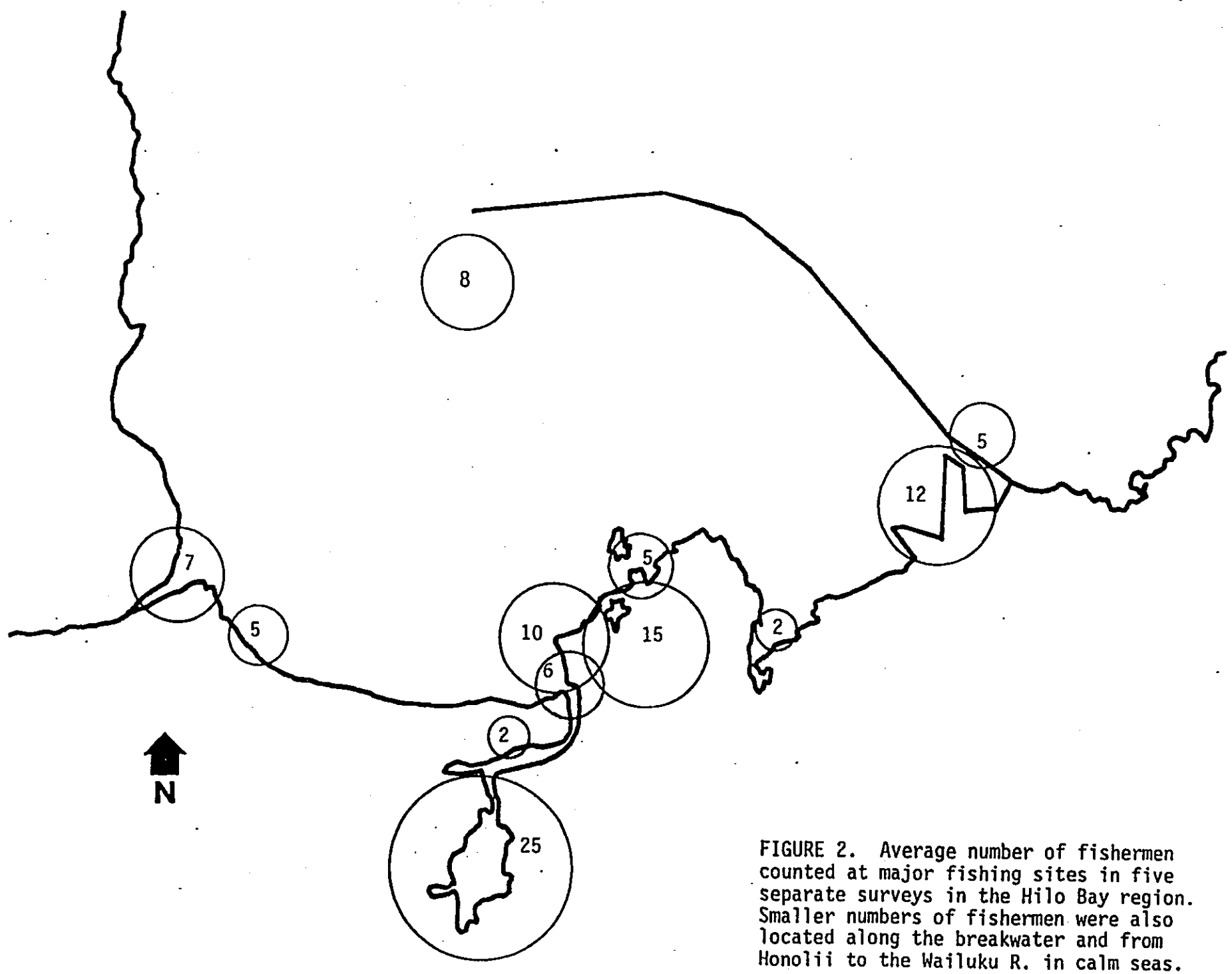

FIGURE 2. Average number of fishermen counted at major fishing sites in five separate surveys in the Hilo Bay region. Smaller numbers of fishermen were also located along the breakwater and from Honolii to the Wailuku R. in calm seas.