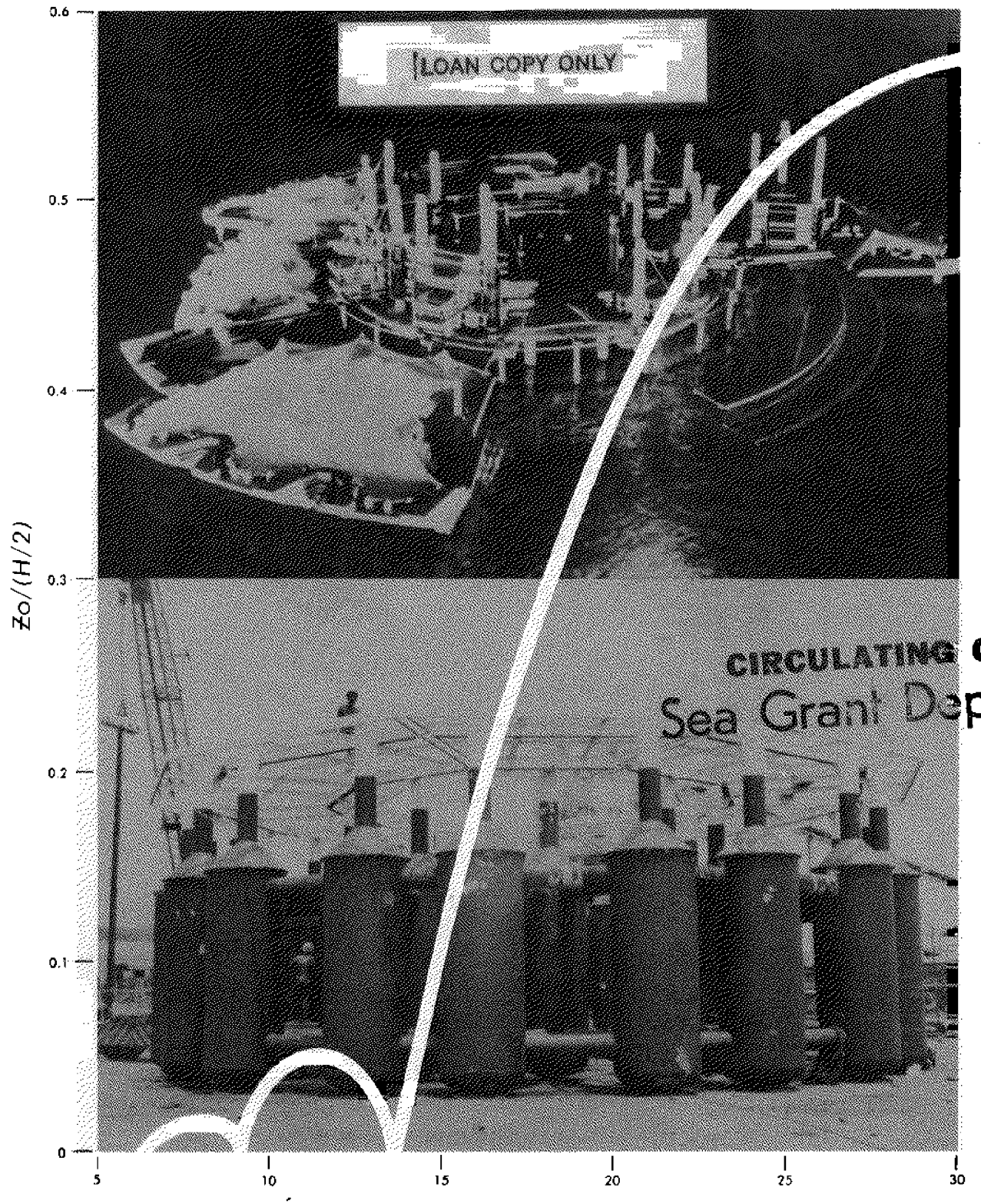
HAWAII'S FLOATING CITY

DEVELOPMENT PROGRAM

CONSTRUCTION SITE SELECTION



HAWAII'S FLOATING CITY DEVELOPMENT PROGRAM

Technical Report No. 6

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Construction Site Selection

by

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PROGRAM MANAGER'S NOTE

While the main emphasis of the program of which this study is a part is the engineering analysis of very large, "superstable" floating platforms, concepts of true floating cities lie behind that emphasis. When floating cities or very large platforms for any purpose are to be built, construction site selection becomes an important concern. This study employed the State of Hawaii as a sample environment and proceeded to compare construction site requirements imposed by the nature of the problem with potential construction site characteristics. The investigation was not limited to physical requirements and characteristics. Rather, it extended into economic, sociological and ecological questions as well. Though this work was focused on the State of Hawaii, we believe the methods employed and the basic scope of this work are largely transferable to other regions.

The majority of this investigation was conducted by Rosine M. Koningsberger, a graduate student at the University of Hawaii, and Stephen B. Ribakoff, staff engineer at the Oceanic Foundation. They were supervised by Guy N. Rothwell, Chief Engineer of the System Sciences and Engineering Division of the Oceanic Foundation. Bonnie M. Rhodes edited the manuscript, and Diane Henderson was responsible for final manuscript preparation. We owe a debt of gratitude to a number of individuals in the Hawaiian community for their help in the form of information and advice. These people are cited in the references.

Joe A. Hanson
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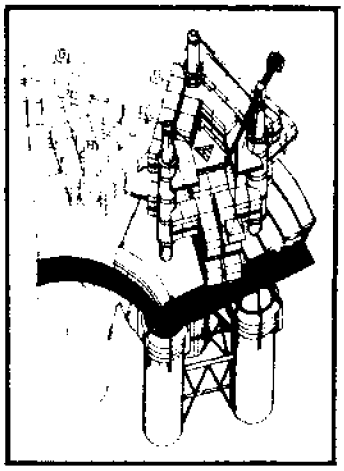
I. INTRODUCTION

Hawaii's Floating City Project had its formal inception in 1970, with the award of a grant by the State of Hawaii to the Department of Architecture, University of Hawaii, for a project to investigate the possibilities and opportunities that might lie in the construction of an urban center aboard a very large, deep-sea, floating platform. This work resulted in the conceptual design of a ring-shaped floating city with inner and outer rings consisting of up to thirty independently stable modules, all rigidly connected to form the final city, but separately removable for repair or renovation. The typical module would be supported from three or four vertically oriented, fully submerged buoyancy chambers, each topped by a structural column which would pass through the elevated main deck structure to form the core of a moderately high-rise superstructure building.



Typical module

The city was envisaged as housing a broad range of domestic, commercial, recreational, industrial and public activities, all served and supported by a complete suite of on-board public utilities, and linked with Honolulu and the world by a variety of transportation and communications services. In general, the industrial, utility and commercial services would utilize available space in the submerged buoyancy chambers. At the lowest levels would be found fuel and water storage, as well as sewage treatment facilities and variable ballast tanks. Above these would be power generation, air conditioning and desalination plants, as well as other machinery spaces. Also included would be warehousing and cold storage, maintenance and repair shops, and some commercial spaces, such as stores and offices. At the top of the buoyancy chambers, where windows on the sea could be provided, would be restaurants, apartments and places of public assembly.

The main deck structure, located above the highest waves, would contain commercial and recreational facilities and transportation terminals. The weather surface of the main deck structure would be landscaped as a park. Finally, the superstructure would contain mainly living spaces, either apartments or hotel rooms.

Superstructure model

Principal structural material was to be concrete. The city site was chosen as five miles south of Honolulu in the open ocean, where water depth is 600 meters.

In subsequent years, with support from NOAA's Sea Grant Program, engineering studies of various aspects of this concept have been made, including environmental conditions at the site, hydrostatics and hydrodynamics of the city's form, and feasibility of the modular approach. Studies for the current year include an analysis of concrete as a suitable structural material, a structural design investigation, a review of applicable transportation methods, an analysis of internal environmental control problems, and the study contained in this report.

A. Objectives, Scope and Limitations of the Present Study

The purpose of this study is to establish the outlines of a feasible method for building very large floating platforms of the type envisaged, and to locate and classify potential building sites in the Hawaiian Islands.

Two basic limitations of the present report must be pointed out. The first is that no detailed construction schedule was prepared. The second limitation stems from the fact that no agency or corporation has been identified as the builder. Hence the recommendations for construction method and construction site take no cognizance of special technology, land, or capital assets that might be in the possession of such a builder. Should a builder be chosen, his special abilities and limitations in these categories will naturally operate to modify the recommendations contained in this report.

B. Statement of the Construction Problem

The gross displacement of the 10-module Floating City is a million tons, exclusive of peripheral modules. No seagoing structure of this magnitude has ever been attempted. In addition, the design requirement for

superstability, that is, exceptionally small motion response, is so far unique. A major consequence of superstability is extreme draft, of the order of 240 to 280 feet. Furthermore, the use of concrete as the basic hull material is unusual. For these reasons, the method selected for building the Floating City will lie outside the boundaries of conventional shipyard practice, indicating that an entirely new approach is required. It will be helpful in developing this new approach if a transfer of technology from landside concrete construction practice can be effected.

We assume that the Floating City will be built in Hawaii. From this it follows that the construction method must fit the physical, geographical, and human resources of the Islands.

Ideally, the bulk of the construction should be done ashore rather than at sea, where weather and logistical problems would multiply costs. However, there are practical limits on the size of floatable elements of the city that could be successfully launched.

A project of this size will take several years to complete, and will strongly affect the area surrounding the construction site, both economically and physically.

There may be a need to preserve at least a part of the construction facility during the life of the Floating City, to accommodate major maintenance and repair, or to modify and expand the city's structure.

C. A Proposed Approach

Perhaps the simplest solution would be to make a graving dock of appropriate size and depth to build the entire city in the dry. Unfortunately, Hawaii has no natural site such as a fjord that could be dammed for this purpose. However, extensive shoal area is available in the open ocean at depths of 250 to 300 feet. It is possible to contemplate a cofferdam more than a mile in circumference, able to withstand heavy wave action and large hydrostatic head for several years, only to be substantially dismantled to allow passage of the city, but the cost of such a structure might equal that of the city itself, and any appreciable failure of the cofferdam could cause the loss of the entire project. Accordingly, building the entire city at once in the dry can be rejected.

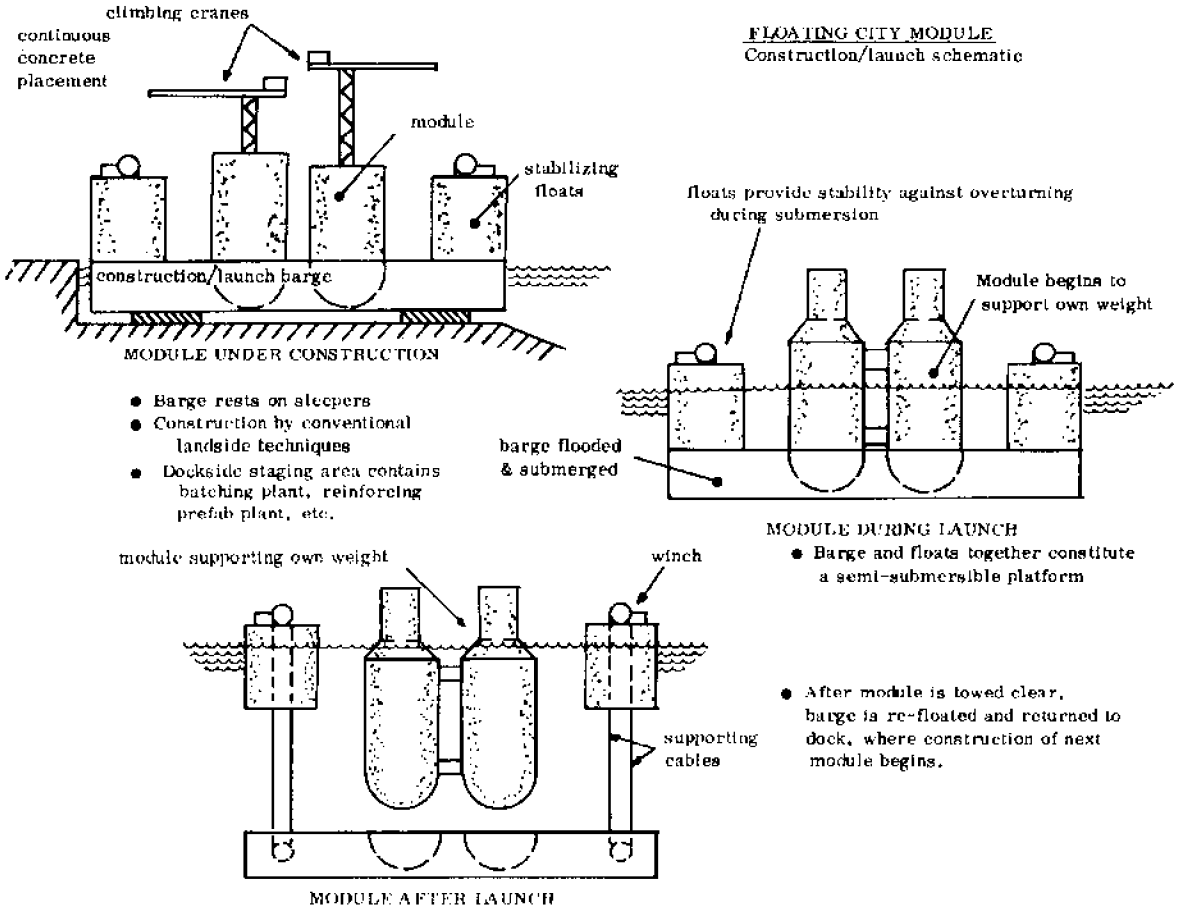
At the opposite extreme, a large number of minimum-size floatable elements could be built in a conventional shipyard, launched, and joined

together while afloat. Whereas this approach would make minimum demands on shipyard facilities, it suffers from two very serious disadvantages. First, the bulk of construction, finishing, and fitting out would have to be done at sea, giving rise to high costs and logistic difficulties. Second, the requirements for individual floatable sections would result in decreased structural efficiency in the assembled platform, hence smaller payload. A number of solutions of this type were examined, and all were rejected.

The solution which appears to be optimum occupies a middle ground between the notion of small floatable elements and construction of the entire city at one time. A complete module, consisting of three flotation chambers, interconnecting struts, main deck structure, and superstructure framing can be built complete and outfitted at dockside, on a large, specially designed floating drydock (Figure 1). The drydock can then be towed to sea to launch the module. When afloat, the module is a functioning stable platform in its own right, which can be occupied immediately, while the floating drydock is returned to dockside for construction of the next module. Advantages of this scheme appear to be:

- Virtually all construction is at dockside, providing for reduced construction cost and direct use of conventional building construction techniques.
- Weather hazard is minimized, being important only during module launching.
- Occupancy of the Floating City can commence long before the entire project is complete.
- The floating drydock, while moderately expensive, provides for continuing service and expansion of the Floating City, and can be used as a drydocking facility for conventional ships. Because it is portable, it can be stored away from premium dock frontage when not in use.

The work presented in this report is based on the use of a floating drydock big enough to handle a module displacing 100,000 tons, constructed of high-strength concrete. Concrete is assumed to be locally batched, with reinforcing prefabricated at the site. In addition, supporting shops, warehousing and yard areas will be required, along with docking space for ships and large barges.



- Barge rests on sleepers
- Construction by conventional landside techniques
- Dockside staging area contains batching plant, reinforcing prefab plant, etc.

- Barge and floats together constitute a semi-submersible platform

- After module is towed clear, barge is re-floated and returned to dock, where construction of next module begins.

Figure 1 -- Floating City module and drydock.

D. Site Selection Criteria

Basic criteria for selecting a construction site are:

- Adequate area of sheltered water with at least 30 feet of depth.
- A channel negotiable by the construction barge.
- Adequate back-up area on land adjacent to the site.
- Access to skilled labor force, transportation and utilities, and capital resources.
- Minimum environmental consequences; for example, conflict should be avoided with existing public or resort use of adjacent land and water areas.

Several potential construction sites exist within the Islands, at least with regard to geography. The body of this report examines these sites in some detail, and by comparison evaluates them.

II. SELECTION OF CONSTRUCTION SITE

As planned, the gross displacement of the Floating City will be at least a million tons. Its design draft will be at least 240 feet. The city will be under construction for a period of no less than five years, including preparation of the site. Furthermore, the site must include a sizeable, protected, deep draft harbor, extensive staging and storage areas, excellent transportation to the site, and a broad range of industrial and technical support in the vicinity. In short, building the city will be a project of the first magnitude. It follows that wherever the construction site is located, the project will have a strong and long-lasting effect on the surrounding area. But site selection is by no means a simple matter, for several reasons:

1. The people of Hawaii have long recognized that the scenic beauty of their islands has enormous economic value. This recognition has resulted in steadily increasing private investments in the resort industry, accompanied by a rising awareness, both in government and among the citizens, that the Islands' beauty is worth protecting through legislation and regulation of land use. Today, each county has effective zoning ordinances, and the State Land Use Commission has a mandate to monitor and regulate the inevitable movement of land into urban and industrial use.

2. All the Outer Islands still retain their essentially rural character while Oahu races toward complete urbanization. Many people on the Outer Islands prefer it this way.

3. On the other hand, the Honolulu waterfront is already overcrowded with industrial activities. Locating the construction site there can only increase land costs, further overload transportation facilities, and contribute additional environmental damage.

4. The State of Hawaii has few natural harbors. In general, its coastlines are extremely rugged. Shelter is scarce, and access to the shore is often barred by reefs or cliffs. All the spots most suitable for harbors have long since been occupied.

5. Virtually all the remaining coastal locations with easy access, beaches, and sheltering bays are either earmarked for resorts, are actually under resort development, or have been designated as public parks.

It is assumed that the Outer Islands at present do not have the technical and industrial base to support a project of this magnitude. However, to identify all geographically and economically promising sites, all counties (Kauai, Oahu, Maui, and Hawaii) were considered in the initial pass of the selection process.

This initial selection was based on the geographic suitability of coastal areas such as bays, harbors, and sheltered coastline, unless factors at each site other than geography proved inhibitive. These sites were:

County	Island	Site Location
Hawaii	Hawaii	Hilo Harbor Kawaihae
Kauai	Kauai	Port Allen Nawiliwili Ahukini Landing
Honolulu	Oahu	Barber's Point Keehi Lagoon Pearl Harbor Honolulu Harbor
Maui	Lanai Kahoolawe Maui	Kaumalapau Kamohio Kahului Maalaea Bay

Of these thirteen site locations, six were rejected for one or more reasons, as listed below.

- o Prohibitive military ownership or land use

  Pearl Harbor
  Kamohio (see discussion of Kahoolawe on page 33)

- o Direct interference with present/projected commercial activity

  Honolulu Harbor
  Hilo Harbor
  Nawiliwili
  Kahului Harbor

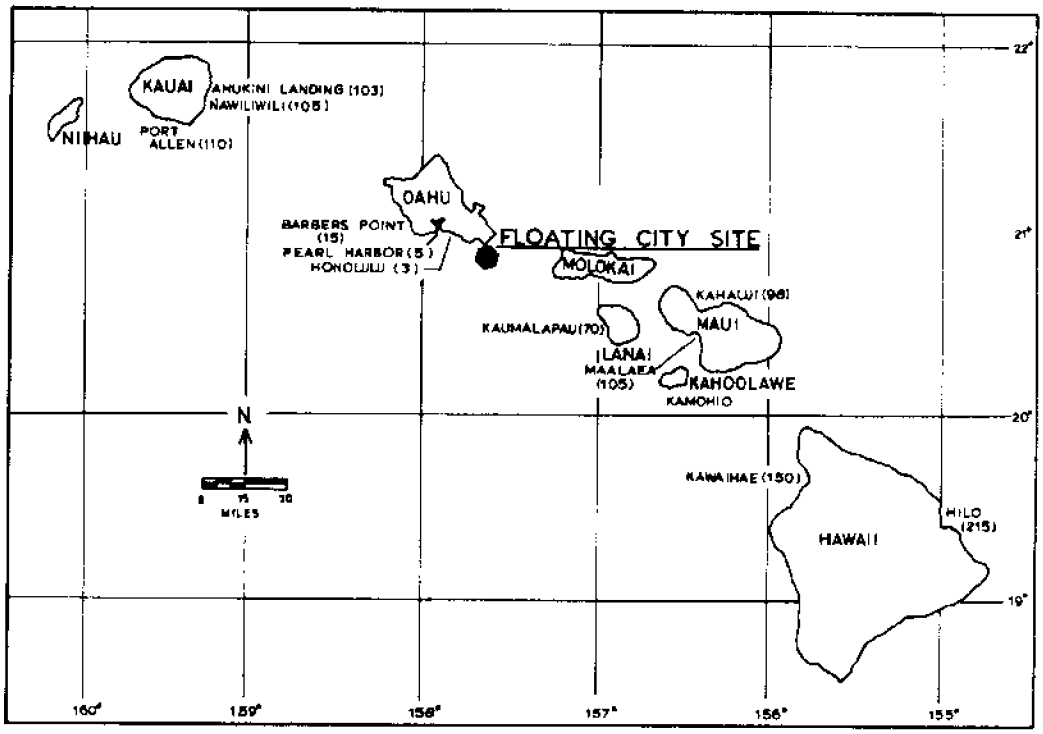


Figure 2 -- Map of the Hawaiian Islands with locations of the sites examined.

o Extreme vulnerability to bad weather

Hilo Harbor
Kahului Harbor

The second pass of the selection process comprised a testing of each site against the following major requirements for construction of the Floating City:

1. Physical site properties: harbor and channel size and depth, shelter, harbor facilities, land area and land use, environment.

2. Transportation facilities: roads, waterways and airports.

3. Capital and human resources: availability of concrete materials, construction and other heavy industries, skilled labor, service industries, housing, power, etc.

The present site parameters based on the above categories are summarized in tables entitled "Physical Site Dimensions" (which include land use) and "Capital and Human Resources" (including transportation facilities) following discussion of each individual site. The tables showing physical site dimensions also list the modifications necessary to accommodate the construction barge and the construction activity.

The following sites were considered in the second pass:

County	Island	Site Location
Hawaii	Hawaii	Kawaihae Harbor
Kauai	Kauai	Port Allen Ahukini Landing
Maui	Lanai Maui	Kaumalapau Maalaea Bay
Honolulu	Oahu	Barber's Point Keehi Lagoon

In the remainder of this section, general descriptions of each county are given, followed by discussions of the individual sites under consideration. Conclusions are presented in Section III.

A. Hawaii County

The only island encompassed within the county is Hawaii. Commonly termed the Big Island, the land area of Hawaii is nearly twice that of all the other islands in the State combined. Hawaii is the southernmost island of the Hawaiian Archipelago and is approximately 180 miles from the city of Honolulu. It contains two of the State's seven deep water ports: one located on the east coast at Hilo and the other on the west coast at Kawaihae.

Throughout the island's history, agriculture has played a dominant economic role. Since its early years, sugar cane and cattle ranching have provided its agricultural base. In recent years, other agricultural products such as papaya, macadamia nuts and coffee have come into prominence. In the past ten years a new industry, tourism, has emerged. From 1960 to 1972 the number of hotel units on the island of Hawaii increased

from 580 to 4,500, with another 5,000 units planned for the next five years (1). This tremendous boom has had a widespread effect on the economic growth of the Island.

Figure 3 shows the annual increase in visitor expenditures in Hawaii County since 1960 (2) compared with the increase in crop sales (3). The plantations, although losing some significance due to the tourist industry, still exert a large influence on the social and economic lives of the island's inhabitants.

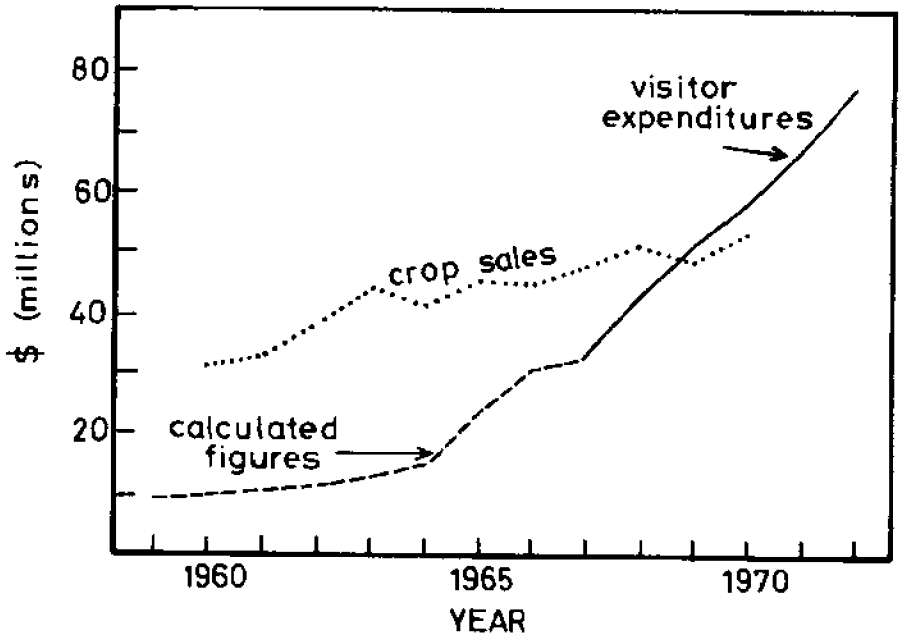


Figure 3 -- Visitor expenditures and crop sales for Hawaii County (2, 3).

The county's population based on the 1970 census was 63,468. This was the first census since 1930 to show an increase in population, as shown in Figure 4 (4).

Two geographic locations on the island of Hawaii were investigated to determine their potential as construction sites for a large floating platform. These sites were Hilo Harbor and Kawaihae Harbor, both of which are deep water, commercial ports.

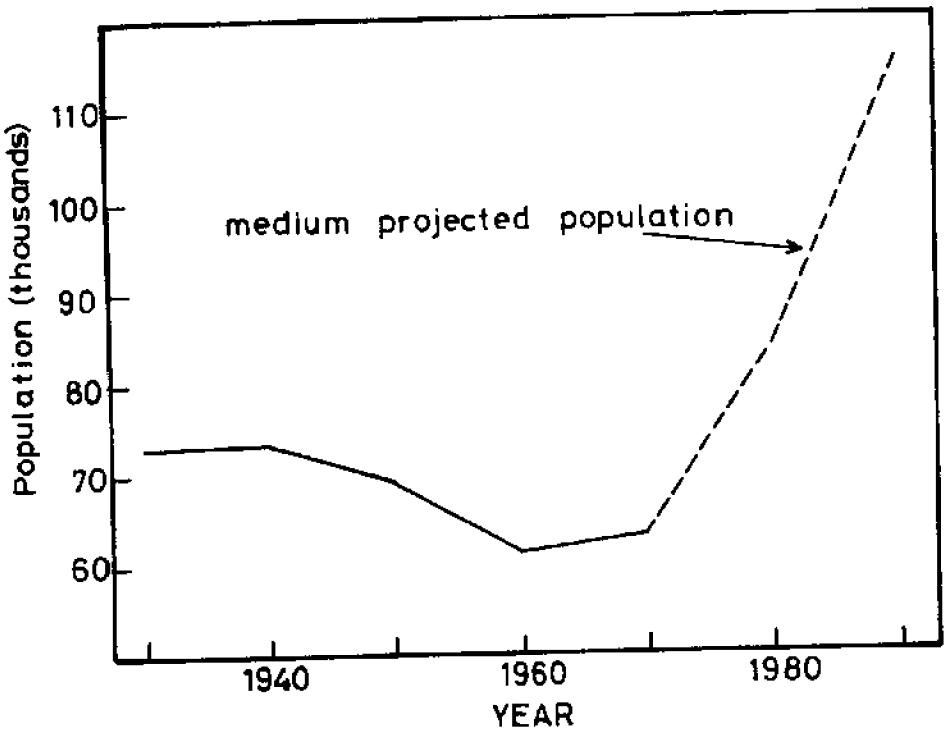


Figure 4 -- Population vs years for Hawaii County (4).

1. Hilo Harbor

Hilo Bay, located on the northeast coast of the island of Hawaii, is 215 miles from Honolulu. Hilo is the State's fourth largest city and had a 1970 population of 26,353. The harbor area is protected from heavy north and northeast swells by a 10,000-foot long breakwater. Since 1946, five tsunamis have hit the Hilo Bay area causing $55 million damage to the breakwater, the harbor area and the town itself (1). The geography of the bay makes the harbor vulnerable to tsunamis originating from both Alaska and South America. The unpredictability of tsunamis is unfortunate: by the time warning is received, very little protection other than evacuation of the area can be afforded. Past experience with breakwaters has failed to produce a design that is resistant to the impact of a 56-foot wave (1).

The Hilo area is also susceptible to earthquakes. Since 1838 there have been 23 earthquakes in the Hilo area which registered over 6.0 on the Richter scale. One such quake (April 2, 1868), centered over Kilauea crater, measured 7.5 on the Richter scale and produced a 66-foot tsunami in the Hilo area (1).

Based on Hilo's vulnerability to these catastrophic environmental events, it is ruled out as a potential site.

2. Kawaihae Harbor

Kawaihae harbor on the northwest coast of Hawaii serves as the transportation hub for the northern and western portions of the island, encompassing the districts of Hamakua, North and South Kohala, and North and South Kona. This tributary area (Figure 5), with a 1970 population of about 19,000, is presently in a critical stage of development.

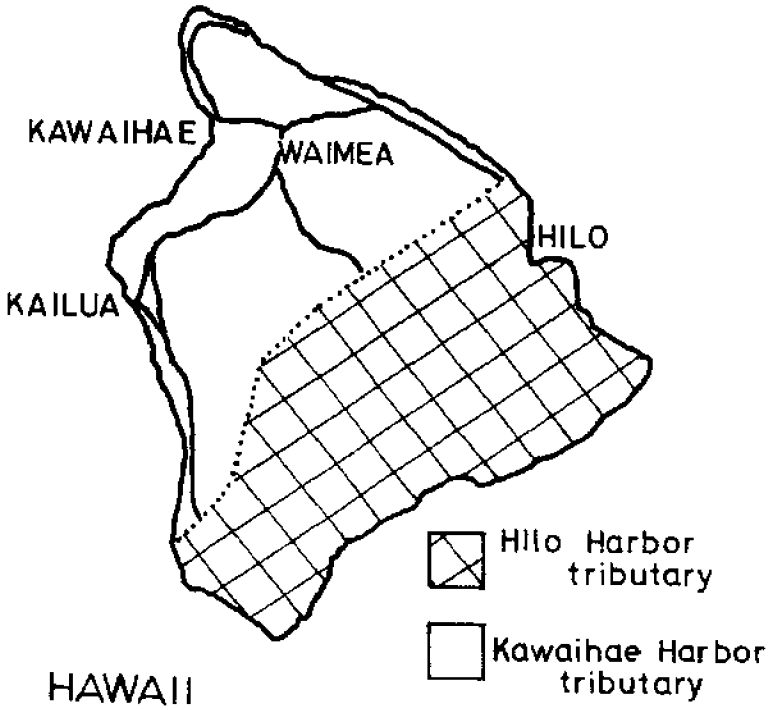


Figure 5 -- Kawaihae tributary area (5).

Large-scale land development projects, for residential or tourist use are being proposed or have already entered the first stages of implementation. After more than 100 years of operation, the Kohala Sugar Company, once the major source of income and employment for North Kohala, will cease production in 1974. South Kohala experienced the largest percentage (50.2%) population increase for any district in Hawaii County during the 1960's, which can be attributed to tourism and the development of truck farming (6). The Kohala area houses one of the largest privately owned cattle ranches in

the world, covering 227,000 acres (4). The cattle ranches of the area produce almost all of the county's cattle sales, which in 1968 amounted to about 60 percent of the State's total (6). Kona's coffee industry, once the major industry of the Kona area, is struggling for survival. West Hawaii produces a fair share of the State's diversified agricultural products*, but access to markets is difficult and the area's enterprises suffer from the inefficiencies of small-scale family operations (6).

The port of Kawaihae, a man-made harbor, was improved in 1959 by a joint Federal and State effort which made it into a deep draft harbor (35-foot depth)(7). Its fair-weather entrance channel is 40 feet deep and 500 feet wide. A breakwater protects the harbor from waves, but not from surge or tsunami run-up. The breakwater extends northward from the point of a coral landfill south of the harbor parallel to the shore, for a length of 27,000 feet (Figure 6). In 1970 the combined traffic for the port of Kawaihae was 330,000 short tons (1). The State of Hawaii and the Army Corps of Engineers are cooperating to relocate the existing small boat facilities (a small craft basin north of the barge pier and a berthing area in the southwest corner of the harbor) outside the limits of the deep draft harbor complex (7). This will provide space for future expansion of the commercial operations of Kawaihae including terminal space for the envisaged interisland ferry system.

At present, facilities include 1500 feet of pier frontage for barge and general freighter traffic, with fuel tanks, molasses storage, bulk sugar storage and a loading plant located shoreside of the pier. These facilities border on Kawaihae road, 700 feet inland. Immediately to the south is an area of vacant land 1400 feet long and 700 feet wide. The land directly adjacent to the harbor is State-owned and zoned for commercial-industrial use. Other land within a mile of the site is classified for urban land use (4, 6, 8).

In light of its present physical characteristics, Kawaihae harbor qualifies as a potential construction site for Hawaii's Floating City. Compared to the other sites, this harbor would require only minor modifications which are generally in line with future development plans and projected use of the harbor by the State of Hawaii and the Corps of Engineers. The modifications would include removal of the small craft facilities from the south end of the harbor to make room for the construction barge. The barge could be

* As reported for Hawaii County, diversified agriculture excludes sugar, pineapple, ranching and macadamia nuts.

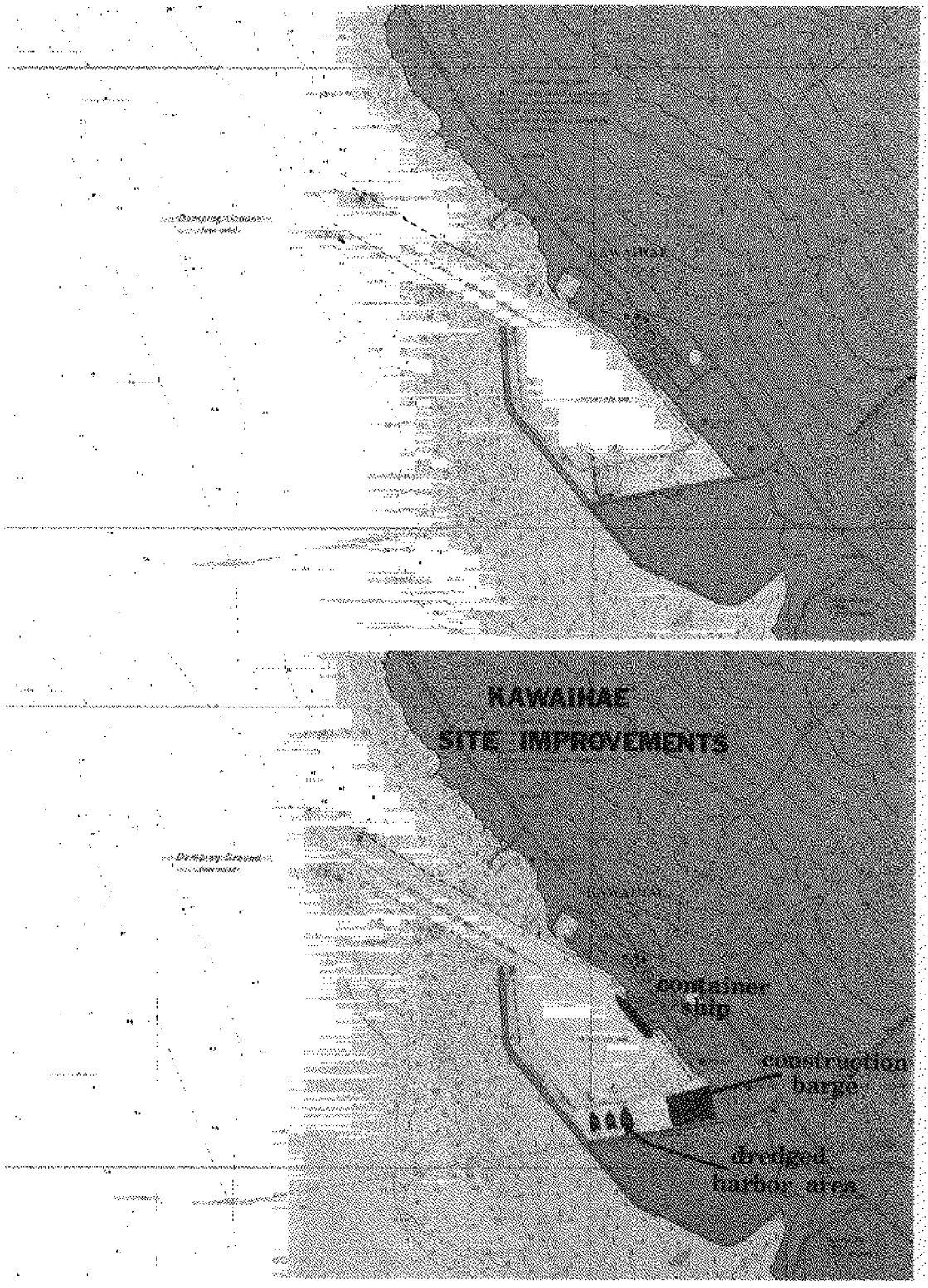


Figure 6 -- Kawaihae Harbor before and after modifications.

located in the southeast corner of the harbor, tied lengthwise to the coral landfill (see Figure 6). The southern part of this landfill is required for shoreside facilities for the planned small craft harbor, with the remainder available for other use. This choice of barge location requires minimum dredging to increase the harbor depth from its present 4.5 feet to 35 feet.

An alternative would be to locate the barge at the south end of the breakwater. This, however, would involve widening a large portion of the breakwater to at least 120 feet to facilitate access to the barge. Dredging of approximately 750,000 cubic yards of material would be required also. Table 1 shows the present physical site dimensions of Kawaihae and the modifications that would be required as discussed above.

The capital and human resources, including transportation facilities, available to the construction project are listed in Table 2.

Table 1 -- Physical site dimensions of Kawaihae Harbor.

LAND USE	present	industrial (4)
	projected	industrial (4)
	ownership	State (4)
HARBOR SIZE	present	harbor: 2.8 million ft^2 (7) channel: 2400 ft long, 500 ft wide (7)
	required	no modifications required
DEPTH	present	harbor: 35 ft (7) channel: 40 ft (7)
	dredging required	minimal amount
	bottom material	coral (7)
	estimated cost of dredging	minimal
SHELTER	breakwater size:	
	present	27,000 ft long and 75 ft wide
	required	(27,000 ft long, 120 ft wide; required fill 540,000 yd^3)
	availability of material	nearby quarry (see Table 2)
	cost of construction	\$14 - \$21/yd^3 for stone fill; \$1/yd^3 for coral fill (9)
LAND AREA	present	sufficient to accommodate all construction requirements
PIER FACILITIES	present	1500 ft pier space, barge and general freighter cargo, storage, fuel
	required	no additional pier space required

Table 2 -- Capital and human resources of Hawaii County (Kawaihae Harbor).

TRANSPORTATION	ROADS	2-lane paved to / from: Hilo Harbor and Hilo airport - 68 miles Waimea-Kamuela airport - 12 miles Kailua-Kona airport - 60 miles (25 miles upon completion of new highway) (6) Kailua-Kona town & marina - 52 miles
	DEEP-DRAFT HARBOR	at Hilo: wharf, piers, barge, general freighter and container cargo, storage, fuel (3) 1.14 million short tons in 1970 (1)
	AIRPORTS	Waimea-Kamuela: passenger, cargo, mail; 2.7 million lbs in 1972 (3, 10) Kailua-Kona: passenger, cargo, mail; 5.5 million lbs in 1972 (3, 10) Hilo (interisland and overseas traffic): passenger, cargo, mail. 43.6 million lbs in 1972 (3, 10)
CAPITAL RESOURCES	POWER	electricity: substation at Kawaihae, powerplant at Waimea with existing capability of 11,250 kW; lines to Kawaihae 69 kV. (Hawaiian Electric Co. is investigating feasibility of powerplant at Kawaihae)(11)
	WATER	not abundantly available (4, 6)
	AGGREGATE	quarry stones available at Queen's Hospital Quarry in Makeahua Gulch, about 1/2 mile from site (7) Also at: Haina (Hamakua) @ 28 miles Hawi (Kohala) @ 19 miles Paauhau (Hamakua) @ 28 miles and several others (12)
	CEMENT	no cement plant on island; available from Oahu (Barber's Point and Nanakuli) (12)

(continued)

(Table 2 - continued)

CAPITAL RESOURCES	SAND & GRAVEL	not available (12)
	WAREHOUSING & TRUCKING	1 firm, over 100 employees (13)
	TRUCKING	20 firms, all less than 20 employees (13)
	CONCRETE PLANT	not available (13)
	DREDGING	not available & not required on a major scale (13)
	CONSTRUCTION	11 heavy construction contractors (N. E. C.) with a total of 75 employees, less than 50 employees/ firm; 61 general building contractors with a total of 573 employees, and 59 firms less than 50 employees; 60 special trade contractors with a total of 461 employees, all firms less than 50 employees (13)
	STEEL MILL	not available
HUMAN RESOURCES	LABOR FORCE	1970-1971 figures: total employed in Hawaii County 1971: 30,050 (1) laborers and farm workers: 3,357 (14) managerial & administrative: 1,829 (14) professional & technical: 2,864 (14) contract construction: 1,820 (1)
	LOCAL SUPPORT & SERVICES	employment by industry, 1971 figures: transportation, commun., utilities: 1,390 (1) services, other than hotel: 2,120 (1) medical: 528 hospital beds, 61 physicians (1) education: 30 public schools, 9 private schools, 1 community college, 1 four-year college at Hilo (3) housing: total units island: 18,972 (14) total units Kohala/Kona: 3,721 (14)

B. Kauai County

Kauai County encompasses the islands of Kauai and Niihau (Figure 7). It is the smallest and least populated of all the counties.

The island of Niihau (the Forbidden Island) consists of 70 square miles and supports a pureblood Hawaiian population of about 275 (15). Access to the privately owned island is restricted. The island has no transportation links to the other islands of the chain, and is entirely self-supporting.

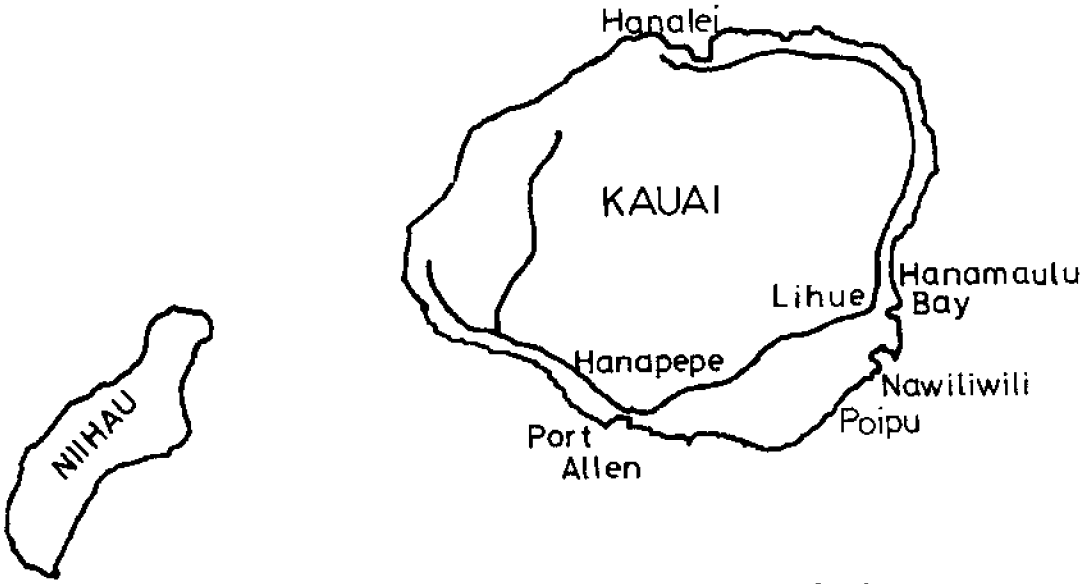


Figure 7 -- Kauai County with Niihau and Kauai Islands.

Like the other islands in the State, Kauai's economy is primarily based on sugar and pineapple production. Because of the island's compactness and scenic splendors, tourism is rapidly becoming its major source of income. In 1968, Kauai had 1,538 hotel rooms, only 540 fewer than Maui. By February 1972, that figure had almost doubled (1). Figure 8 shows the rapid rise in visitor expenditures since 1960, compared with crop sales (2, 16). The tourist industry of Kauai has centered about three major areas, the largest being along the coastline from Nawiliwili to Kapaa. The second most attractive area is the south coast between Poipu and Port Allen. The third is on the north coast at Hanalei.

The history of Kauai's population is similar to that of the other Outer Islands. The peak population of 35,942 occurred in 1930 (15). Since that time, the closing of many pineapple and sugar plantations resulted in a

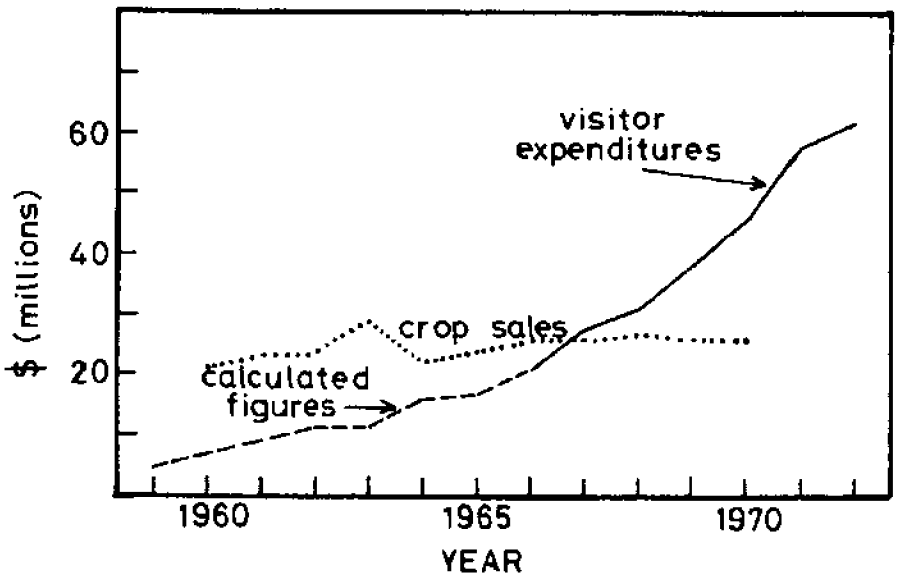


Figure 8 -- Visitor expenditures and crop sales for Kauai County.

steady downward trend until the 1960's, when the population once again started to rise, as shown in Figure 9 (1, 15).

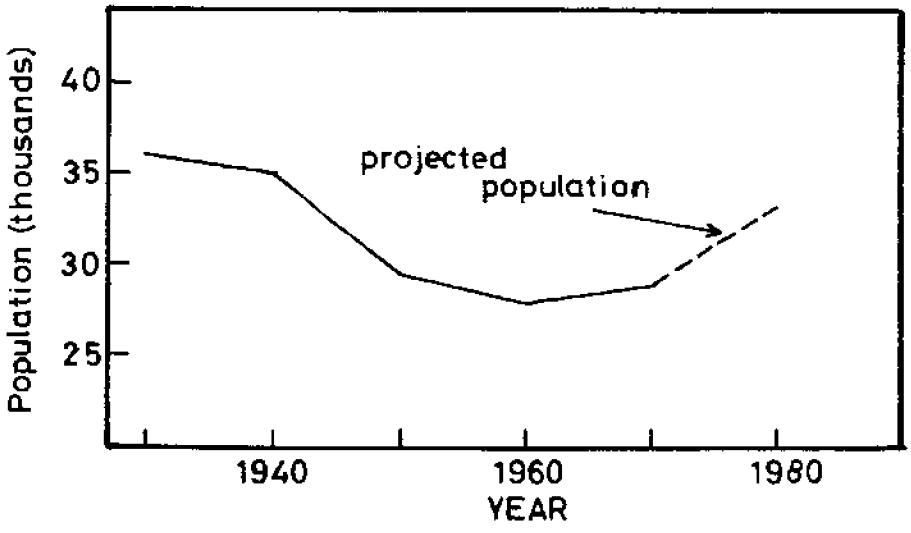


Figure 9 -- Population vs years for Kauai County.

Kauai is presently served by two major interisland air carriers which fly to Lihue on the southeast coast of the island. In addition, the island has three deep water ports, two of which are currently used for commercial traffic (Nawiliwili and Port Allen). The other, non-active, deep water port is located at Ahukini Landing in Hanamaulu Bay. These facilities were abandoned with the closing of the sugar plantations in the area.

1. Nawiliwili Harbor

Nawiliwili is Kauai's largest deep water port (Figure 10). In 1970 over 500,000 short tons of cargo were handled at its facilities (1). The port has the capability for handling bulk cargo (sugar, molasses, fuel, etc.), general cargo, and containerized cargo. Existing facilities include a belt conveyor, warehouse and bulk storage facilities. Berthing areas are protecte from heavy seas by a 2,000-foot long breakwater. Adjacent land areas are already overcrowded with commercial facilities supporting the shipping industry of the island; thus no space to support the construction of the

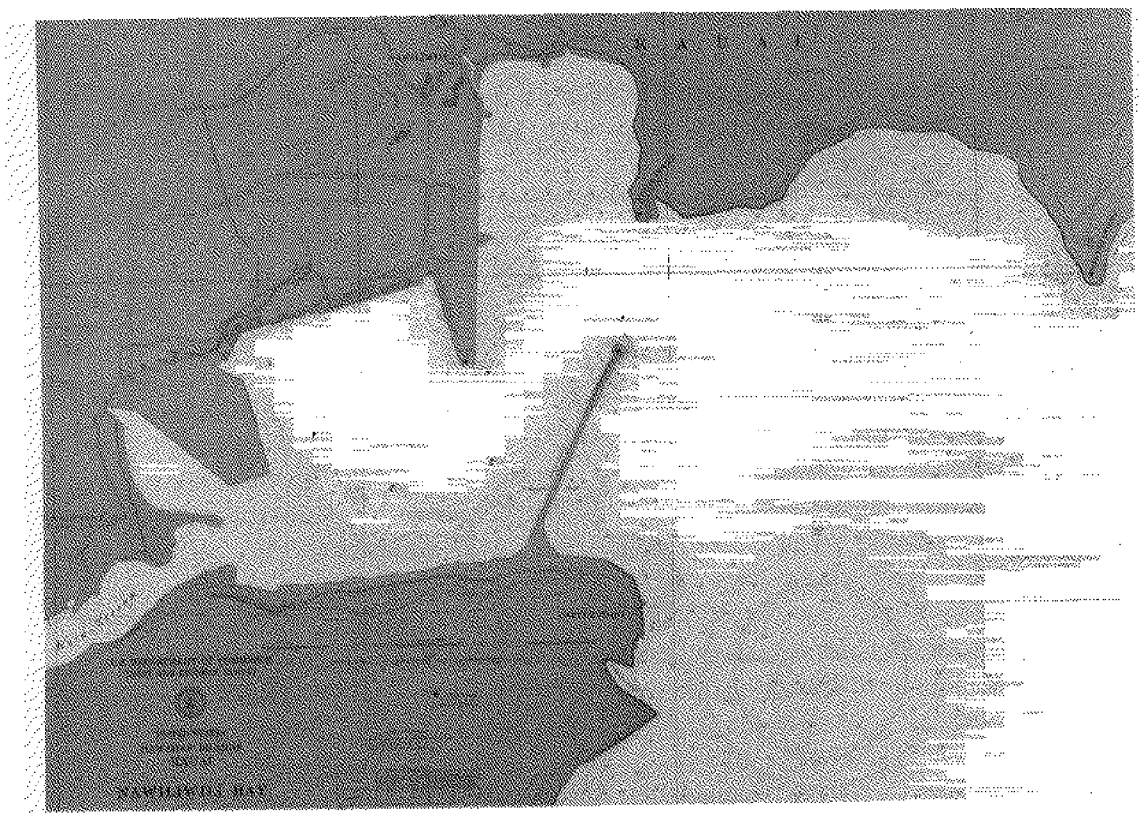


Figure 10 -- Nawiliwili Harbor as it exists.

city would be available immediately surrounding the deep water basin. To the east of the harbor, the land is zoned for residential use and for an existing hotel complex. Consequently, there are no suitable construction sites in the Nawiliwili area.

2. Ahukini Landing

Ahukini Landing, at the mouth of Hanamaulu Bay on the east coast of Kauai, is approximately two miles north of Lihue. Until the early 1960's, Ahukini Landing served as the east coast's major barge harbor for the sugar industry, with a mill and storage facilities adjacent to the wharf. As many of the surrounding plantations closed, however, the wharf was abandoned. Today only the concrete pilings remain, and most of the port installations are in ruins. The wharf area is protected from heavy swells by a 300-foot long breakwater which projects from the south point of the bay's entrance. Periods of heavy outside swell produce considerable surge in the harbor. To the south of the landing, there are extensive fields of sugar cane.

Since this landing is abandoned, there would be no conflict of interest in acquiring the land and wharf area for a construction site. The land surrounding the pier facilities is presently zoned for urban/agricultural use, and is partially vacant. Very little of this land would be needed to support the construction effort. Extensive dredging (on the order of 850,000 cubic yards) of the northwest portion of the bay would be required to provide adequate clearance for barge maneuvering. Modifications and expansion of the existing breakwater would also be required (see Figure 11 and Table 3).

Upon first inspection, Ahukini Landing seems suitable as a construction site. The disadvantages of this site stem from the fact that the bay is too small to support both construction of the platform and offloading of the cargo required to support the construction operation. Arriving cargo would have to be brought in through the port of Nawiliwili and trucked four miles to the site on presently inadequate roads.

Based on the cost of dredging, estimated at over $3.5 million, and the lack of space for general cargo delivery, Ahukini Landing has been classified as a secondary site. It should not be eliminated from the list of potential construction sites, however. Physically, the site can be used; it is economics that will determine its practicality.

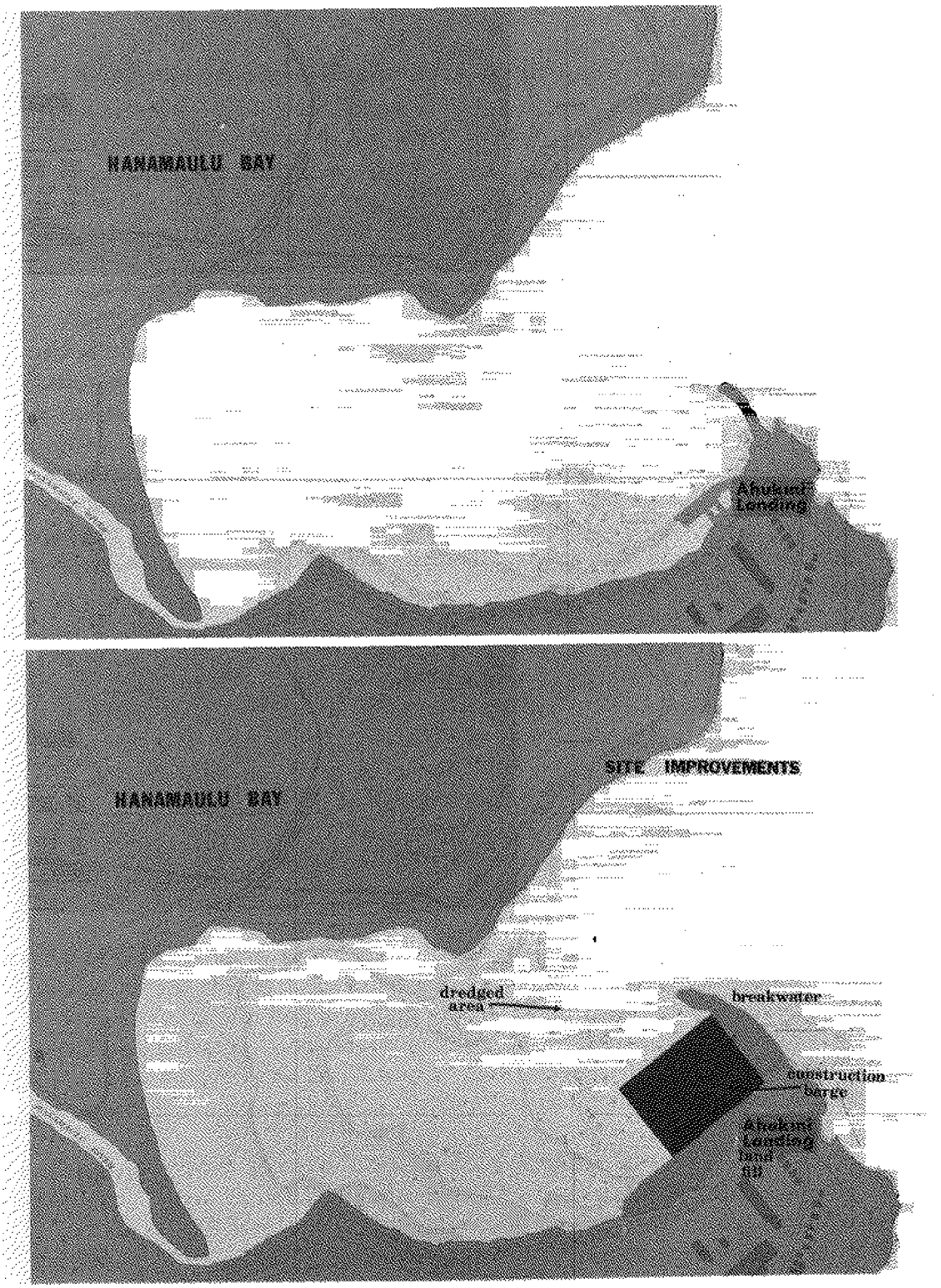


Figure 11 - Ahukini Landing before and after modifications.

Table 3 -- Physical site dimensions of Ahukini Landing (Hanamaulu Bay).

LAND USE	present	urban/agricultural (17)
	projected	urban/agricultural (17)
	ownership	private (17)
HARBOR SIZE	present	580,000 ft^2 >30 ft depth
	required	1.2 million ft^2 ≥ 35 ft depth
DEPTH	present	> 30 ft
	dredging required	850,000 yd^3
	bottom material	mud, sand, coral
	estimated cost of dredging	at \$4/yd^3; \$3.5 million
SHELTER	breakwater size:	
	present	335 ft long and 50 ft wide
	required	650 ft long and 165 ft wide, tapering to 75 ft at point
	availability of material	nearby quarries (See Table 5)
	cost of construction	\$14-\$21/yd^3 for stone fill, \$1/yd^3 for coral fill (9)
LAND AREA	present	at < 20 ft elevation: 140,000 ft^2
	required	220,000 ft^2
	availability of material	dredged fill available from dredging and nearby quarries (see Table 5)
	estimated cost of filling	\$14-\$21/yd^3 for stone fill, \$1/yd^3 for coral fill, \$1/yd^3 for dredged fill
PIER FACILITIES	present	for barge traffic, 285 ft long and 50 ft wide
	required	700 ft long, 165 ft wide (up to 20 ft elevation mark); additional pier facilities

3. Port Allen

Port Allen is located at Hanapepe Bay on Kauai's south shore. It is a small, deep draft commercial harbor, not extensively used and serving mainly the Kaumakani and Hanapepe area. In 1970, combined traffic for Port Allen was 146,000 short tons (1).

The Hanapepe area is primarily an agricultural community with commercial and industrial centers around the bay. Port Allen is located at the east end of the bay, with a small craft basin due north of the port facilities (Figure 12). Residential settlements are found north of the port. The main highway for the island runs east-west about one-fourth mile north of the bay. Along the north shore of the bay, land use is mixed (residential, commercial, and recrational) with intermittent vacant spaces. The land bordering the bay's west shore is vacant except for a small air-strip.

Hanapepe Bay offers a natural shelter from heavy seas. The deep draft area of the bay encompasses over two million square feet at depths greater than 35 feet. A loading/unloading pier extends 600 feet into the bay. The harbor has an all-weather channel and basin and is protected from waves (but not from surge and tsunami run-up) by a breakwater 1,200 feet long. The pier offers 75,000 square feet of space for barge and freighter cargo handling and fueling. Additional facilities for storage, bulk sugar handling and a wharf are located shoreside of the pier.

Four factors point to Port Allen as a prime construction site:

1. Land within 500 yards of the harbor is zoned for commercial/industrial use. Kauai's General Plan calls for development of the north and west shore of Hanapepe Bay into a water-oriented, recreational facility (17). However, utilization of the harbor facilities for construction activities would not greatly interfere with these projections.

2. Port Allen is not extensively used and hence construction operations would not greatly interfere with regular commercial operations. Moreover, the commercial freight handling role of Port Allen is expected to decline (17).

3. Modifications of the present port facilities to accommodate the construction barge and construction activities would be relatively minor.

4. Sufficient waterfront space, which is presently unused, is available for the barge between the south side of the pier and the existing breakwater.

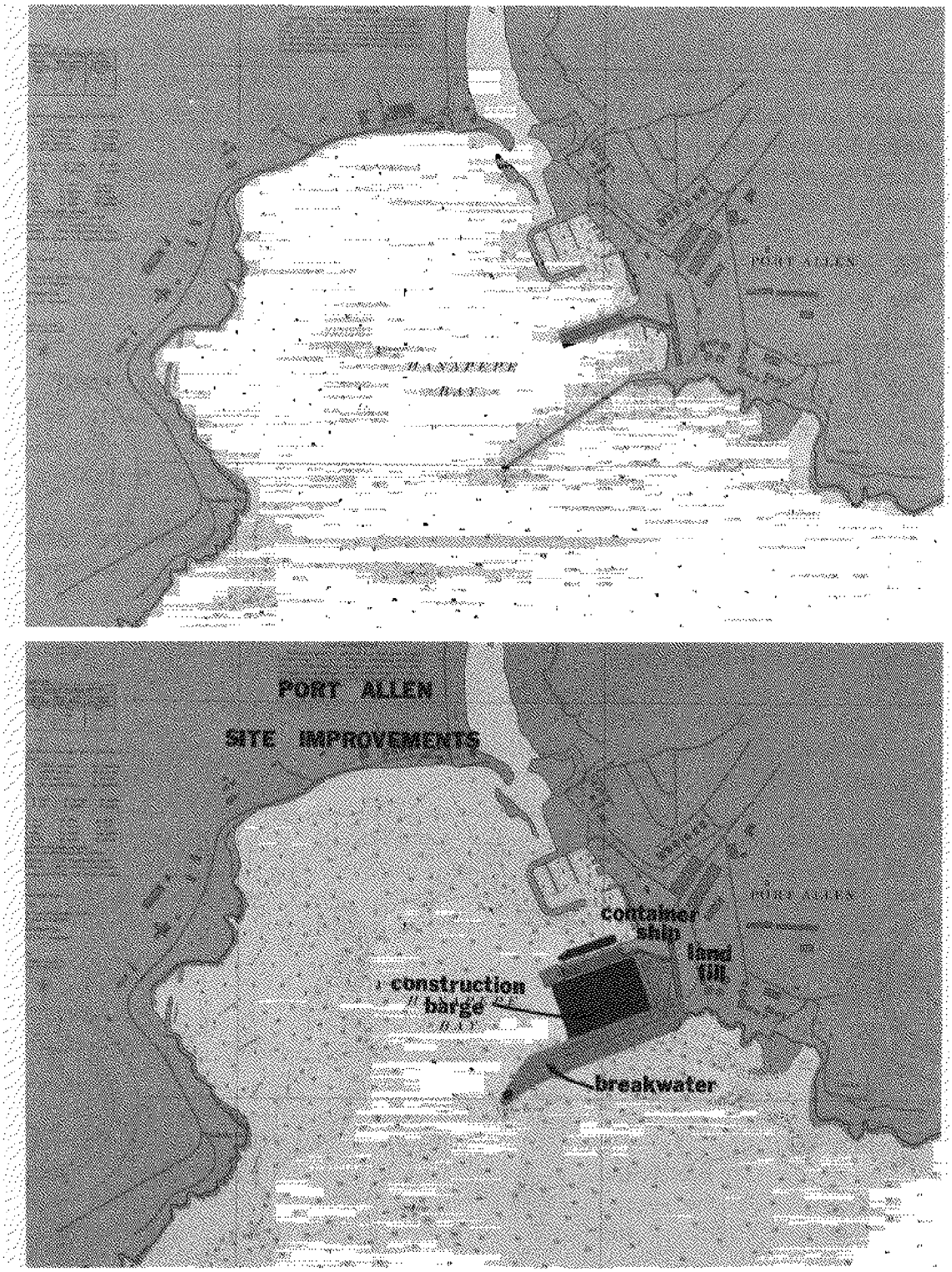


Figure 12 -- Port Allen before and after modifications.

Figure 12 shows the construction barge in the sheltered harbor space between pier and breakwater. For easy access to the barge, the breakwater would have to be expanded to a uniform width of 250 feet. As the present depth between pier and breakwater is not sufficient to accommodate the barge's construction draft, dredging of 400,000 cubic yards of material would be required. The present harbor pier would have to be extended to 800 feet for additional pier space, and to allow container freight handling. A landfill of about 84,000 cubic yards would be required for this operation.

In short, modifications would be limited to dredging operations of 400,000 cubic yards and landfill for a total of 140,000 cubic yards. The dredged material, mainly coral, could be used for part of the landfill.

The physical site dimensions of Port Allen are summarized in Table 4.

A breakdown of the capital and human resources available on Kauai for the envisaged construction project is given in Table 5.

Table 4 -- Physical site dimensions of Port Allen (Hanapepe Bay).

LAND USE	present	urban/industrial (17)
	projected	urban/industrial (17)
	ownership	state/private (17)
HARBOR SIZE	present	2 million ft^2
	required	no modifications
DEPTH	present	> 35 ft
	dredging required	400,000 yd^3 at proposed barge location
	bottom material	coral
	estimated cost of	at \$4/yd^3: \$1.6 million
SHELTER	breakwater size:	
	present	1200 ft long and 20 ft wide
	required	1400 ft long and 250 ft wide, tapering to 100 ft at point
	availability of material	nearby quarries (See Table 5)
	cost of construction	\$14-\$21/yd^3 for stone fill, \$1/yd^3 for coral fill (9)
LAND AREA	present	sufficient to accommodate all construction activities, with minor additions
	required	landfill of 57,000 yd^3 at proposed barge location
	availability of material	nearby quarries (See Table 5)
	estimated cost of filling	see above under SHELTER
PIER FACILITIES	present	600 ft long and 125 ft wide; barge and general freighter cargo, wharf, storage, loading, fuel
	required	extention of pier to 800 ft length, additional facilities to handle containerized cargo

Table 5 -- Capital and human resources of Kauai County (Port Allen and Ahukini Landing).

TRANSPORTATION	ROADS	Ahukini Landing: 1 mile of secondary access road to 2-lane paved highway, Lihue airport - 1 mile (secondary road) Lihue - 2.5 miles Nawiliwili harbor - 4 miles Port Allen - 20 miles Port Allen: 2-lane paved to/from: Lihue - 15 miles Lihue airport - 17 miles Nawiliwili harbor - 16 miles (1 mile secondary road) Ahukini Landing - 20 miles
	DEEP-DRAFT HARBOR	Nawiliwili harbor: piers, docks, parking, warehouses, utilities; barge, general freighter and container cargo (9) Port Allen: see text Ahukini Landing: see text
	AIRPORTS	Lihue airport: passenger, cargo, mail; 10 million lbs in 1972 (10, 16) Airstrip on land tongue to east of Hanapepe Bay (17)
CAPITAL RESOURCES	POWER	electricity - Port Allen: power plant at Port Allen, present maximum capacity lines 57 kV. (short line extensions may be needed to site). - Ahukini Landing: power plant at Lihue (owned by Lihue Plantation Co.), substation at Hanamaulu, present maximum capacity lines 12.5 kV. Kauai Electric is planning added generation at Lihue plant (18).
	CEMENT	no cement plant on island; available from Oahu (Barber's Point and Nanakuli) (12)
	WATER	abundantly available at both sites (17)

(continued)

(Table 5 - continued)

CAPITAL RESOURCES	AGGREGATE	open quarry at: Puhi @ 4.5 miles from Ahukini and 16 miles from Port Allen Lihue @ 2.5 miles from Ahukini and 15 miles from Port Allen (12)
	SAND & GRAVEL	open pit mine at: Nawiliwili @ 4 miles from Ahukini and 16 miles from Port Allen Kekaha @ 10 miles from Port Allen and 30 miles from Ahukini Lihue @ 2.5 miles from Ahukini and 15 miles from Port Allen Eleele @ 1.5 miles from Port Allen and 19.5 miles from Ahukini (12)
	WAREHOUSING & TRUCKING	not available (13)
	CONCRETE PLANT	not available (13)
	DREDGING	not available (13)
	CONSTRUCTION	20 general building contractors with a total of 233 employees, less than 50 employees/firm. Twenty special trade contractors, less than 20 employees/firm (13).
HUMAN RESOURCES	LABOR FORCE	1970-1971 figures: total employed on Kauai 1971: 13,320 (1) laborers and farm workers: 1,846 (14) managerial and administrative: 862 (14) professional and technical: 1,347 (14)
	LOCAL SUPPORT & SERVICES	employment by industry, 1971 figures: transportation, commun., utilities: 1,070 (1) contract construction: 440 (1) services other than hotel: 1,400 (1) medical: 251 hospital beds, 24 physicians (1) education: 13 public schools, 7 private schools, 1 community college (16) housing: total units island: 8,980 (14) total units Puhi-Hanamaulu-Lihue: 1,967 (14) total units Kaumakani-Hanapepe: 908 (14)

C. Maui County

Maui County includes the islands of Molokai, Maui, Lanai and Kahoolawe (Figure 13). The 1970 population for the county was 46,156, an increase of less than 4,000 over tje previous 1960 census. The distribution of population is as follows(1):

Island	1970 Population
Molokai	5,089
Maui	38,863
Lanai	2,204
Kahoolawe	0

The island of Maui is not only the population center for the county, but also the economic center, in that it has the only deep water port in the county.

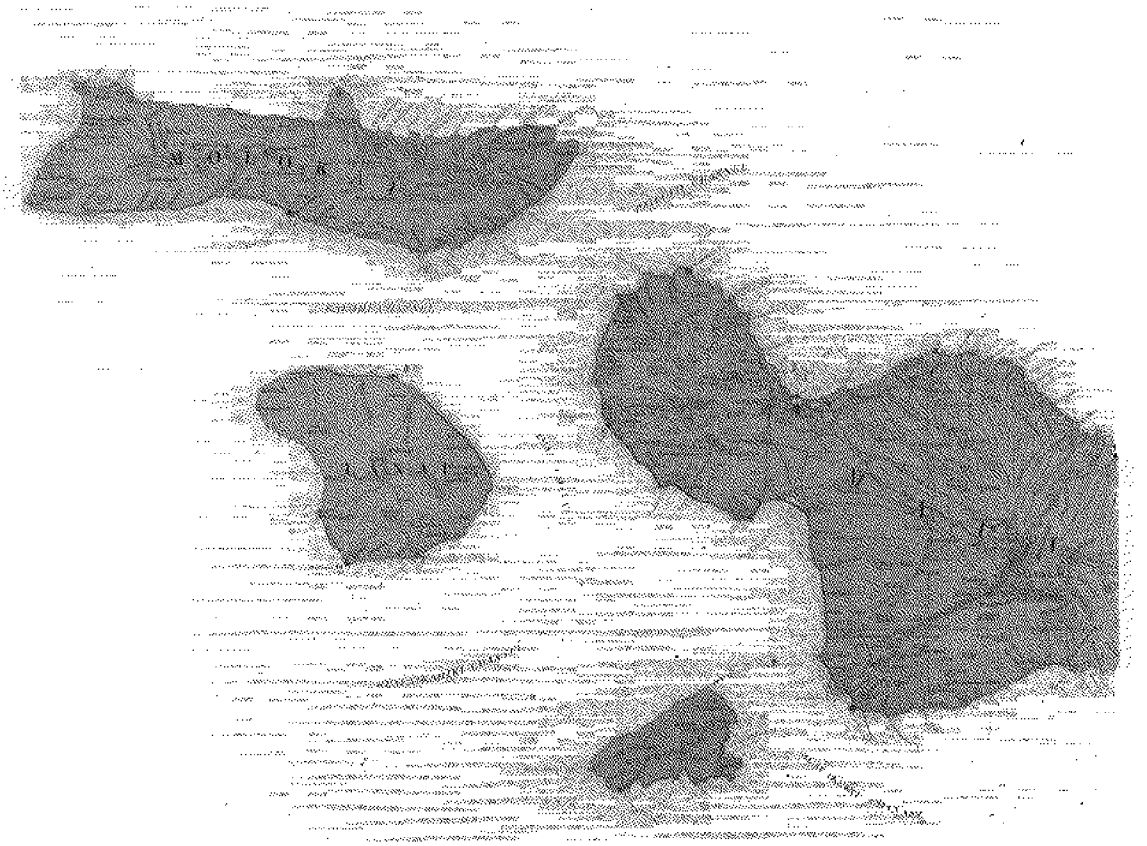


Figure 13 -- Maui County.

The primary sources of employment in Maui County are the sugar, pineapple, cattle and tourist industries. Because of the high cost of labor in Hawaii, which ranks among the highest in the world, the sugar and pineapple industries of the State are declining. Many plantations in Maui County have closed or will do so within a very few years. On the other hand, tourism may be expected to increase significantly and add to the potential employment opportunities in the county (19).

1. Molokai

Molokai, the Friendly Isle, is 261 square miles in area (1) and its chief industries are pineapple farming and cattle raising. The only harbor on the island capable of handling barges is located at Kaunakakai on the south central coast. A small harbor 15 miles west of Kaunakakai, constructed by private interests, is used in conjunction with a sand mining operation. Due to the lack of a suitable geographic location for construction, no sites were selected on Molokai.

2. Kahoolawe

The island of Kahoolawe, 45 square miles in area, is leased by the Navy and Marine Corps for use as a bombing practice range for military aircraft. No sites were investigated on this island. However, if it is ever returned to the State and developed as an industrial site (e.g., to locate a nuclear power plant), geographic features indicate several areas that may be quite suitable as a construction site for a floating platform. One of these is Kamohio, located on the south side of the island, which was considered in the initial selection process.

3. Lanai

Lanai, the Pineapple Island, is the sixth largest island in the State, with 141 square miles of privately owned land mainly devoted to the production of pineapple (1). Of the 90,240 acres on Lanai, approximately 16,000 are used for pineapple cultivation. Lanai City and Kaumalapau Harbor, occupying 600 acres, are the only urbanized areas (20). The remainder of the land is used as a forest and game preserve.

Water on Lanai is limited. Annual rainfall ranges from 10 inches on the leeward coast to 35 inches at the highest peak in central Lanai. The climate is similar to that of the other islands in the chain and is affected by the surrounding ocean and the tradewinds. The northern end of the island is exposed to heavy tradewinds and is actively eroding.

Approximately 2,700 persons live on the island, nearly all relying on the Dole Plantation for economic support. Castle & Cook, Inc., Dole's parent company, owns nearly 98 percent of the acreage in fee, with the remainder of the land distributed among the State, the County and private homeowners (20).

Lanai is situated 74 miles from Oahu and 154 miles from Hilo. There is a highly developed commercial barge harbor at Kaumalapau, which was one of the sites investigated in our study.

Kaumalapau Harbor. Kaumalapau, located on the west coast of Lanai, is the island's only deep water commercial port, providing adequate protection for interisland barges and local fishing boats in all but westerly and Kona weather. The crescent-shaped harbor lies at the mouth of the most prominent gulch in the vicinity (Figure 14). The extremely small size of the basin makes maneuvering in and out of the harbor difficult and dangerous. During periods of heavy Kona weather, surge in the harbor may exceed four feet.

The commercial barge landing at the north end of the harbor supports the island's pineapple industry. It has facilities for offloading and onloading of general cargo as well as fuel and warehouse storage. The private wharf provides cargo sheds and about 400 feet of berthing space. A 250-foot long breakwater on the north side of the harbor entrance protects the berthing area from heavy seas. There is no entrance channel, but a 600-foot opening leads to a turning basin which is 30 to 50 feet deep.

The land surrounding the harbor area (excluding the gulch area) consists of precipitous cliffs towering as high as 100 feet along the water's edge. On the northern end of the harbor these cliffs have been excavated to provide space for the terminal and wharf facilities. In its present configuration, Kaumalapau is far too small to support the construction of a floating platform. Extensive excavation of the cliffs on the margins of the harbor would be required to provide sufficient level ground for support activities. In addition dredging of the south portion of the harbor would be required to provide adequate draft for the construction barge. It is estimated that over 1.9 million cubic yards of material would have to be removed. An operation of this size would undoubtedly upset the natural beauty of the area. The coral reefs bordering the southern cliffs of the harbor are claimed to be the most well-developed in the Islands. The necessary dredging would destroy these reefs and threaten the ecological balance of those outside the immediate area. Even in its modified condition, surge in the basin would be significant,

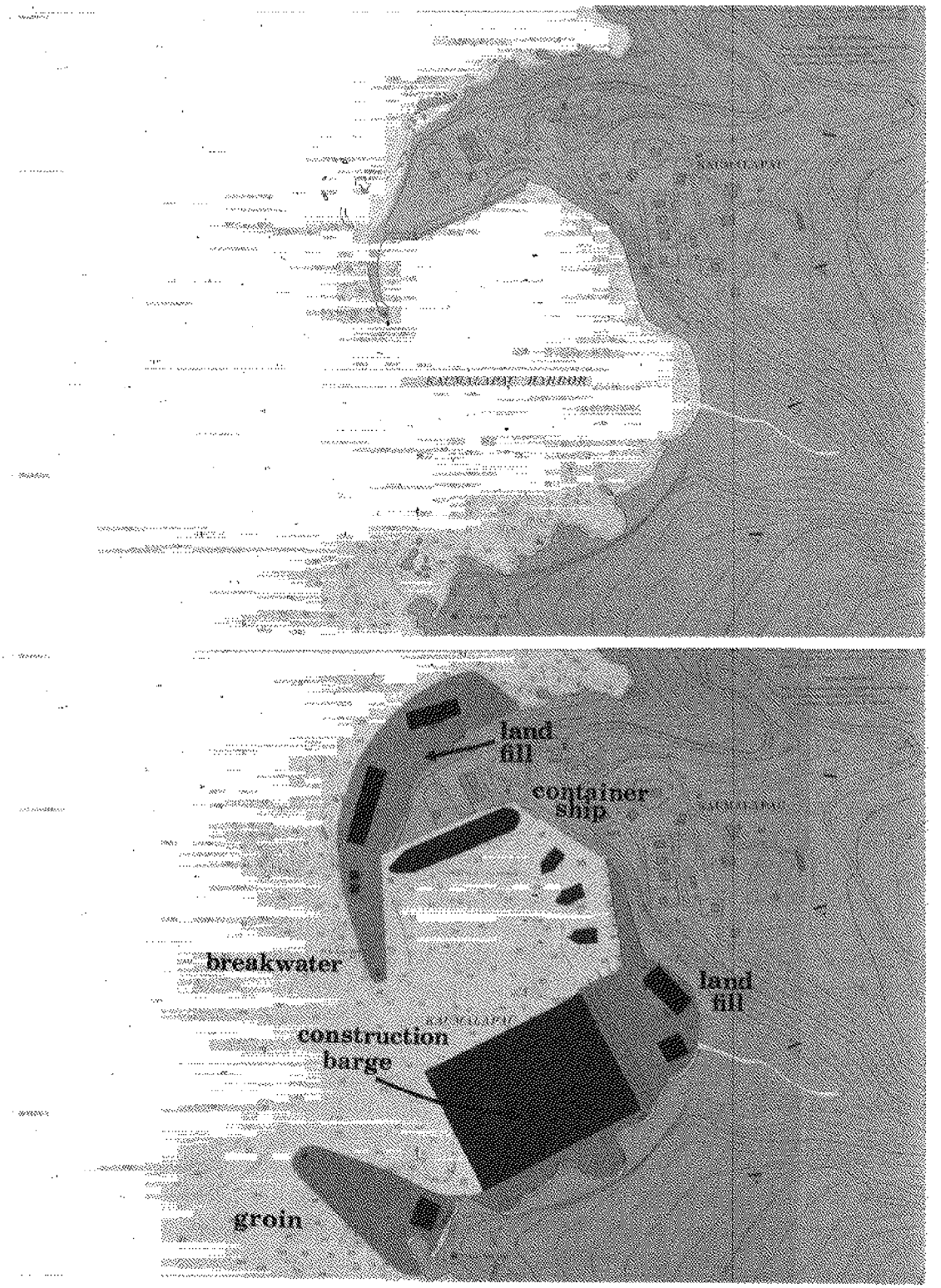


Figure 14 -- Kaumalapau Harbor before and after modifications.

Table 6 -- Physical site dimensions of Kaumalapau Harbor.

LAND USE	present	industrial (2)
	projected	urban/industrial (2)
	ownership	Dole Company (2)
HARBOR SIZE	present	320,000 ft^2, 35 ft depth
	required	770,000 ft^2, 35 ft depth
DEPTH	present	30 to 50 ft
	dredging required	960,000 yd^3
	bottom material	mud/rocks
	estimated cost of dredging	at \$4/yd^3: \$3.84 million
SHELTER	breakwater size:	
	present	at north harbor harbor entrance: 250 ft long and 25 ft wide
	required	expand present breakwater to 400 ft long and 120 ft wide, tapering to 40 ft at point; and, build breakwater at south harbor entrance to protect proposed barge location, 550 ft long and 260 ft wide, tapering to 70 ft at point. (total fill required: 2 million yd^3)
	availability of material	from dredging at quarry at Lanai City (Dole Co.) (12)
	estimated cost of construction	\$14-\$21/yd^3 for stone fill, \$1/yd^3 coral fill (9)
LAND AREA	present	minimal
	required	325,000 ft^2, required fill 830,000 yd^3
	availability of material	from dredging and quarry at Lanai City (Dole Co.) (12)
	estimated cost of filling	see above under SHELTER
PIER FACILITIES	present	400 ft long; barge traffic, fuel and cargo sheds
	required	expand pier & facilities to handle general and containerized cargo

and commerce into and out of the harbor would be risky. Under these conditions, deployment of the barge would require deep sea moorings to guide it through the harbor entrance without running aground.

Aside from these physical limitations, Lanai lacks the capital and human resources to support such a large construction project. The majority of its present population is employed in some phase of the pineapple industry and has no technical or construction skills. Unlike the other islands, Lanai has very few natural water reservoirs, and the addition of construction project personnel would place a great strain on existing reserves. Housing, schools, hospital, retail stores and an assortment of other supporting services would have to be provided, thus restructuring both the economy and the development of the entire island.

Based on the foregoing considerations, Kaumalapau was eliminated from the list of potential construction sites.

4. Maui

Maui, called the Valley Isle, is made up of two volcanic mountains separated by a low-lying isthmus, giving Maui a total land area of 729 square miles (1). The Island's most prominent feature is Haleakala, a 10,023-foot volcano. The seven-mile-wide crater is the heart of Haleakala National Park. On the summit of Haleakala rests the tracking and observatory facilities for the complex known as "Science City." The core of Science City is a $5 million tracking station and astrophysical observatory constructed for the Department of Defense. It houses a 60-inch reflector telescope and two 48-inch infrared telescopes, which are operated by the University of Hawaii and the University of Michigan, and several other facilities operated by the Air Force and the Federal Aviation Administration.

The presence of Haleakala governs the climatic conditions for east and central Maui as well as providing a unique tourist attraction. The east and southeast coasts of the island are characterized by lush tropical rain forests in deeply eroded valleys. Most of the valleys are so densely covered with vegetation that access to the interior is extremely difficult if not impossible. Haleakala's southern slopes differ greatly from the eastern shore and are more reminiscent of desert country.

West Maui, with its leeward shores, is rapidly becoming the largest neighbor island tourist destination. The ideal climatic conditions and the fine white sand beaches associated with the Kaanapali area have spurred tremendous resort development since 1962.

The growth of the Kaanapali area has enabled Maui to reverse the population drain that started in the late 1940's (Figure 15).

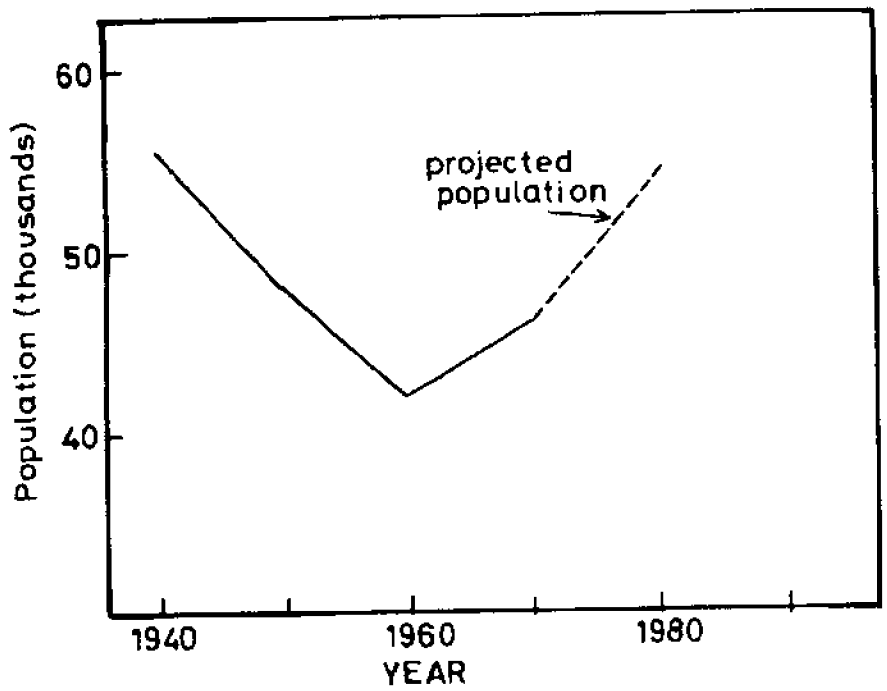


Figure 15 -- Population vs years for Maui County (1, 15).

The economy of Maui is similar to that of the other islands in the county, with sugar and pineapple being the leading industries over the past few years. The recent surge of tourism, coupled with rising agricultural labor costs, has had a tremendous impact on the economy, as seen in Figure 16. From present indications, revenues from the tourist industry should overtake the agricultural market by 1980.

Transportation to the island is provided by two commercial air carriers and several smaller air taxi services. Maui has commercial airports at Kahului and at Kaanapali. Plans are underway to expand the Kahului airport to handle overseas flights. In addition, several sites on Maui have been selected as terminals for a planned interisland high speed ferry service.

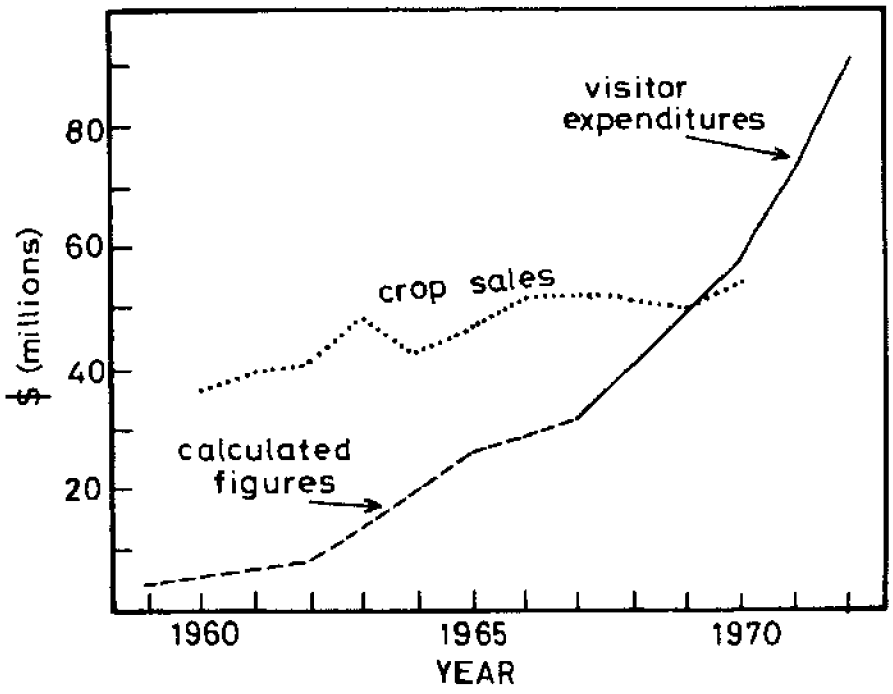


Figure 16 -- Visitor expenditures and crop sales for Maui County.

Kahului Harbor. Maui's only commercial deep water port is Kahului Harbor, located on the north coast of the island. General cargo and containerized goods can be handled at this facility. In 1970 over 1 million short tons of cargo passed through Kahului (1). The harbor is protected from heavy seas by breakwaters which extend outward from the west and east shores. The berthing area is on the southeast side of the harbor.

In recent years, the breakwater at the harbor has suffered considerable damage from severe storms. There is no adequate space within the harbor to support the construction project. In light of these adverse factors, Kahului was eliminated as a potential construction site.

Maalaea Bay. Maalaea Bay lies on the southern coast of the isthmus between Haleakala and West Maui. This six-mile isthmus is a low-lying land area which supports the majority of the sugar production for the island. During Kona storms (low pressure storms associated with the winter months) the area is highly susceptible to flooding. It acts as a funnel between the two mountain ranges, causing winds of very high velocities during heavy tradewind weather.

Two possible site locations were considered at Maalaea Bay: the small boat harbor at the northeast shore of the bay and a site at Kihei. The small boat harbor, which serves the needs of the local fishermen, is the proposed site for an interisland ferry terminal. The harbor is 500 yards long and 200 yards wide with a mean depth of 7 feet. In recent years, the Army Corps of Engineers has proposed to modify the existing facilities to incorporate more berthing areas and to realign the entrance to the harbor, with the goal of improving the marina for recreational activities.

On the east coast of Maalaea Bay lies the community of Kihei, a possible construction site. However, a quick overview of the site parameters reveals that Kihei fails to meet a critical combination of requirements, as does the small boat harbor. A complete harbor facility would have to be built especially for the project. The land surrounding the Kihei site is projected for urban, resort and recreational development by the State, and numerous hotels and resorts have already been built or are in the planning stages.

Aside from this restrictive zoning and the economics involved at both site locations, the environmental impact of dredging and construction on the marine life of the bay would be prohibitive. It appears then that there are no suitable sites in the Maalaea Bay area.

D. Honolulu County

Honolulu County comprises for all practical purposes the island of Oahu (Figure 17). Since the mid 1850's, Oahu's population has led all the other islands and today it has a population of over 650,000 people, or 83 percent of the State's total (1). It is not by accident that Oahu has become the center for political and economic activity of the State. Its growth was dictated by the presence of a protected natural harbor deep enough to accommodate the sailing ships of the 19th century. Today, the Honolulu area plays a special role in the State. It is still the principal transportation terminal for people and goods, the major warehouse and distribution facility, the center of commerce, the seat of government, the principal military base, the industrial center, and the primary tourist destination area.

In 1970, over 8 million short tons of cargo passed through the port of Honolulu (1). Facilities at the port include several dock-mounted gantry cranes, bulk storage for sugar, molasses, and petroleum products, container yards, general cargo handling equipment and a floating dry dock.

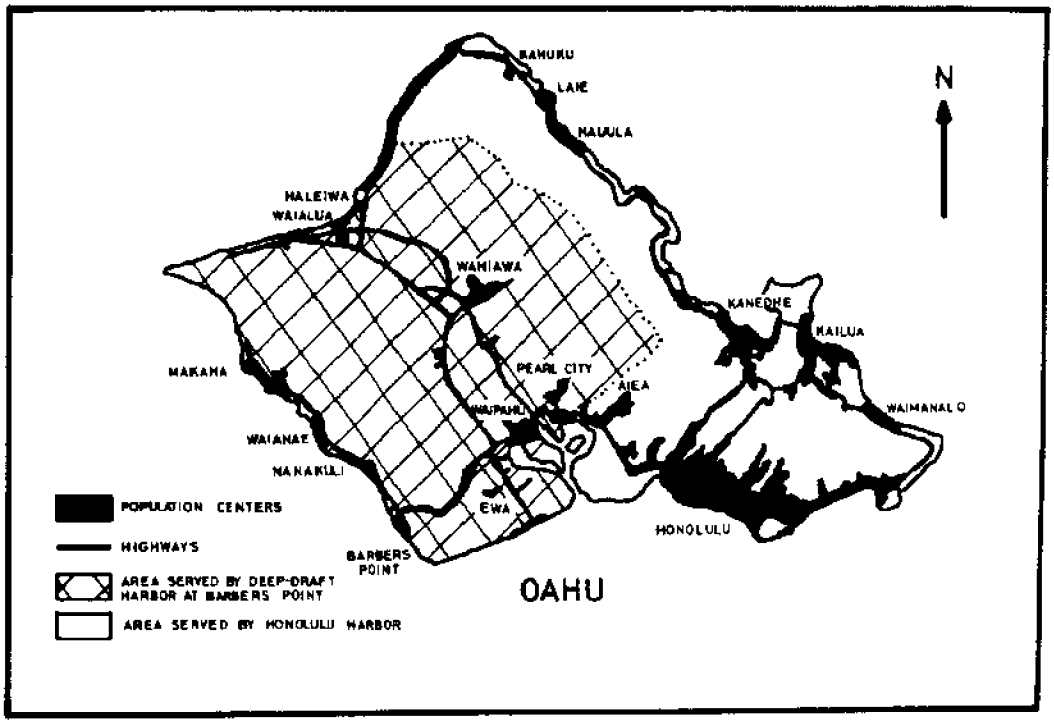


Figure 17 -- Oahu, with population densities and harbor tributaries.

The industrial base on Oahu provides most of the State with its products. For instance, the State's two cement plants are located on Oahu, along with the State's only steel mill. Dillingham Corporation, one of the world's largest marine construction firms, operates a shipyard and an interisland barge company.

Oahu also leads all the other counties in actual construction of new dwellings and commercial buildings. In 1971, $326 million worth of building permits were issued in the State and of that total, $231 million, or 70 percent, were issued for the island of Oahu (1). In 1958, with the opening of Campbell Industrial Park on the island's west coast, another industrial district came into being on Oahu. Today this area is one of the fastest growing in the islands. Plans to expand the existing barge harbor at Barber's Point will provide west Oahu with a commercial deep draft port, and will help to alleviate the overcrowded conditions in Honolulu harbor.

The one generalization that can be made about the Honolulu waterfront is that it is overcrowded. Other than the Sand Island area, there is no available waterfront footage.

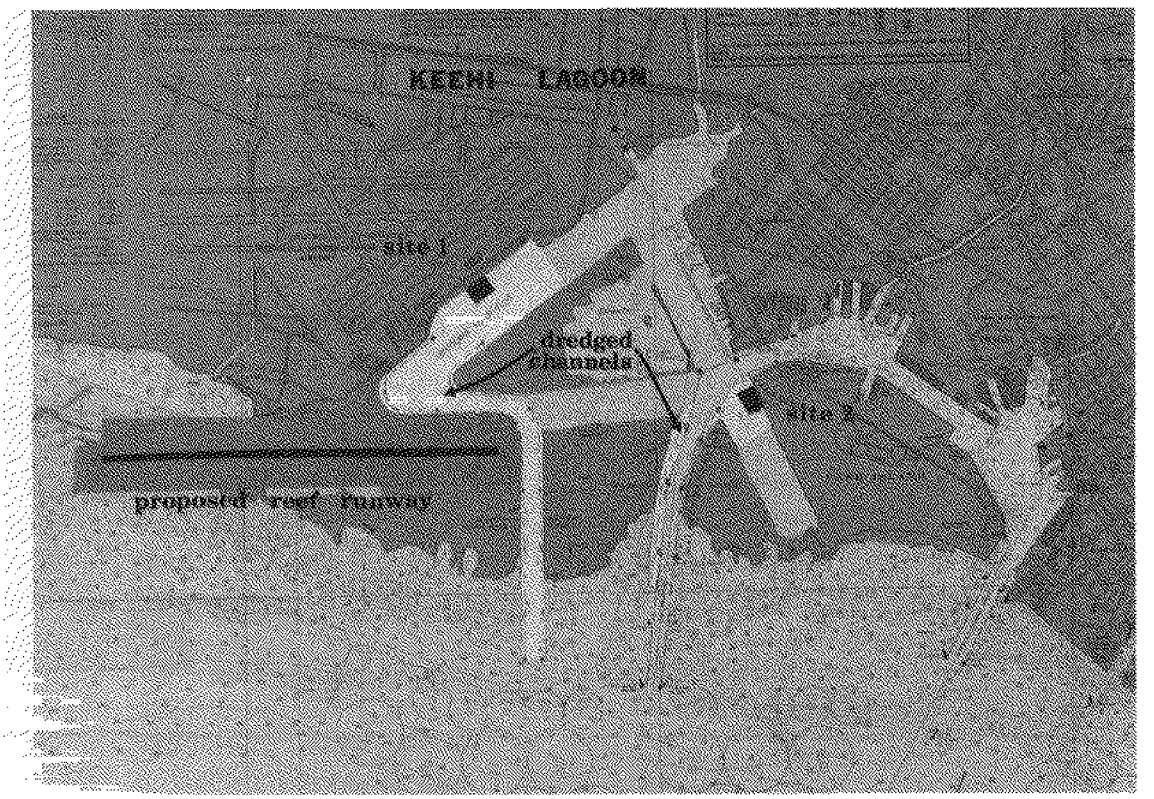


Figure 18 -- Keehi Lagoon and Sand Island area.

1. Keehi Lagoon Area (Sand Island)

Two sites were considered in the Keehi Lagoon area (Figure 18). Site #1 at the west side of the lagoon is impractical because plans exist for a new interisland air terminal adjacent to the site (23). Moreover, a very limited amount of land for staging and back-up facilities would be available. Site #2 is located on the east side of Keehi Lagoon at Sand Island adjacent to Kapalama channel. That section of Sand Island is either vacant or used for refuse storage, so land would be available. However, plans exist for general development of that section of Sand Island for jet fuel storage (23). In addition, the proposed new jet runway south of Honolulu International Airport would directly interfere with the construction activities at both sites: its critical clearances extend over the sites and their access channels, limiting height of all structures to less than 150 feet.

2. Barber's Point

The Barber's Point area is located on the leeward coast of Oahu, about 16 miles west of Honolulu (22). The area is largely occupied by Campbell Industrial Park, managed and operated by the James Campbell Estate, which also owns the land. This park was Hawaii's first planned industrial district and since its inception 1958 has rapidly grown to compete for first place as Oahu's industrial center. To date, over 50 firms have bought or leased nearly 1,100 acres of land. Facilities at the park include two major oil refineries, a steel mill, a cement plant, a factory for manufacture of building materials, and chemical, fuel and construction industries (24,25).

Barber's Point barge harbor is located about two miles up the coast from the point's lighthouse on Campbell Estate land. In its present configuration the harbor is too small (520 by 700 feet) to be useful as a construction site. The only developed terminal facility at the harbor is a wharf 250 feet long where barge traffic is handled (22). In 1970, over 2.5 million short tons of cargo were handled at Barber's Point, but the majority of this tonnage was crude oil which was discharged and loaded through two offshore pipelines associated with the oil refineries at Campbell Park (1). This indicates the inadequacy of the present port facilities.

However, State and Federal agencies, in cooperation with the Campbell Estate, are jointly planning the construction of a deep draft commercial harbor at the site of the present barge harbor, and a portion of the necessary dredging has already been done. How urgently this port is needed to serve the Industrial Park and west Oahu is perhaps best expressed by the following quote from the Army Corps of Engineers study on Honolulu and Barber's Point harbor:

> "The planning, zoning and initial development of a new industrial area at Barber's Point prompted local interests to request Congres in 1958 for study authority to determine the feasibility of providing a Federal deep draft harbor to directly serve the new industries in the area, as well as the expanding economy of the western portions of Oahu. Subsequent investments of over $82 million in industrial plants and land development at the Barber's Point Industrial Park alone, not to mention considerable population and economic growth in surrounding areas, has strengthened the claim that such a harbor is needed. Further expansion of the industrial park and of

Figure 19 -- Barber's Point and Campbell Industrial Park.

the general economy of western Oahu is expected in conjunction with the anticipated economic and population growth of Oahu and the State. The preponderant portion of the testimony received at the public hearing held on 12 September 1961 favored the establishment of an appropriate deep-draft harbor at Barber's Point. No opposition to the proposed project was voiced at the hearing." (22)

The Army Corps of Engineers study calls for a harbor area of 1.68 million square feet at 38-foot depth, with an entrance channel of 3,100 feet over a width of 450 feet at 42-foot depth. The harbor would be protected by a breakwater extending 900 feet from the shore north of the harbor entrance, and wave absorbers along portions of the inner harbor shoreline. Total dredging required, including excavation, is estimated at 4 million cubic yards, primarily coral material. The harbor would comprise a flared maneuvering area and two arms extending inland to access berthing and pier facilities. The south end of the present barge harbor would be kept at a depth of 21 feet to handle barge traffic at the existing barge pier. The projected size of the harbor would accommodate present transpacific cargo ships, short of deep draft tankers which would continue to use the offshore pipeline terminal. Facilities envisaged are general cargo handling, container yard, fueling, pier space and storage areas (24).

At the site, tidal and coastal currents are weak, with coastal currents generally in a westerly direction. The present harbor is not protected from surge or tsunami run-up, and light surge is caused even by normal wave action due to the absence of reefs along the shoreline (22). The University of Hawaii Look Laboratory Harbor Model investigation, carried out at the request of the U.S. Army Corps of Engineers (26), and the Army Corps of Engineers study diverge on a specific harbor configuration and on how the surge problem should be handled. It can be emphasized that this is a point in favor of selecting Barber's Point harbor as a potential construction site: if the plans for Hawaii's Floating City go ahead, then the use of Barber's Point harbor as a construction site can be incorporated into the final plans for a harbor configuration.

For these reasons, it is assumed that space would be available for the construction barge inside the harbor basin, but no specific barge location can be determined at this time. Even if surge control in the harbor's final configuration should be insufficient for project purposes, an additional floating breakwater could be applied to protect the barge. Land around the projected harbor is presently vacant and will be kept available for the project harbor back-up facilities (24). Hence land space and staging area for the construction project would be no problem.

The present zoning at Barber's Point, the close proximity of the industrial park with its services, and the plans for a deep draft commercial harbor are all favorable points for the selection of Barber's Point as a potential construction site. Moreover, all of Oahu's immense resources would be at the disposal of the construction project.

III. CONCLUSIONS

1. There are three adequate sites in Hawaii for construction of the Floating City. They are Kawaihae on the island of Hawaii, Port Allen on Kauai, and Barber's Point on Oahu.

2. The preferred site is Barber's Point, for the following reasons:

   - o A need for a deep draft harbor at Barber's Point has already been identified, and plans have been made for its construction.

   - o The district is zoned for heavy industry, and much of the required industrial capacity is already present.

   - o No serious conflicts appear to exist with incompatible land use.

   - o The site is on Oahu, where most of the State's capital and human resources are located.

3. Other considerations should be mentioned, which would argue for another site.

   - o At present no harbor exists at Barber's Point. If financing for a deep draft harbor cannot be obtained independently of the Floating City project, Kawaihae or Port Allen might be less expensive alternates, since both possess suitable harbors.

   - o Choice of either of these sites would help to achieve two goals of the State government: decentralization of Hawaii's economy and population, and direct stimulation for an economically depressed area. Selection of Barber's Point would continue an already lopsided trend toward high density and overdevelopment on Oahu.

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