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Honolulu District

WAIMEA RIVER

KAUAI, HAWAII

FLOOD CONTROL STUDY

DETAILED PROJECT REPORT
AND
FINAL
ENVIRONMENTAL STATEMENT

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

DETAILED PROJECT REPORT
AND
ENVIRONMENTAL STATEMENT
WAIMEA RIVER, KAUAI, HAWAII

A STUDY TO DETERMINE THE FEASIBILITY
OF PROVIDING FLOOD CONTROL IMPROVEMENTS
FOR THE TOWN OF WAIMEA,
ISLAND OF KAUAI, STATE OF HAWAII

JUNE 1980

Rev. 30 Jun 81
Rev. 16 Nov 81
Rev. 26 Feb 82

WAIMEA RIVER FLOOD CONTROL

WAIMEA, KAUAI

MAIN REPORT

SYLLABUS

The purpose of this report is to document the feasibility, the impacts, and technical features of potential flood damage reduction improvements for the Waimea River, island of Kauai, Hawaii. The final Environmental Statement which describes the impacts of the final alternative plans is included. This report will serve as the authorizing document for construction upon approval by the Chief of Engineers.

The scope of the report included identification of the flood problem, examination of various alternative plans, and evaluation of plans in terms of technical, economic, environmental, and social acceptability. The evaluation and plan selection process was guided by the dual national objectives of National Economic Development (NED) and Environmental Quality (EQ) in accordance to the US Water Resources Council (WRC) regulations for Federal Water and Related Land Development projects. The flood problem in the Waimea area was attributed to backwater river effects, potential overbank floodflows, and inadequate interior drainage and ponding in the urbanized, low-lying west bank area.

The recommended plan of improvement consists of a structural levee and floodwall system providing a level of protection up to the Standard Project Flood. As discussed within the text of this document, the District Engineer in June 1980 initially recommended a similar plan which would provide a level of protection up to a one percent exceedance frequency flood (100-year flood). However, based upon further evaluation by the Office of the Chief of Engineers, exceedance of the 100-year flood would result in catastrophic conditions. In view of this concern, the Chief of Engineers considers the Standard Project Flood plan appropriate.

The plan of improvement includes a levee extension downstream of Kealii Ditch, rock toe protection and a new reinforced concrete I-wall constructed on the existing levee, two new flood gates and regulated flood-plain areas. The plan is substantially in compliance with all applicable environmental statutes. The estimated first cost of the recommended plan is $5,763,000, of which $3,853,000 is the Federal share and $1,910,000 is the non-Federal share. This project would be authorized under Section 205 of the 1948 Flood Control Act, as amended. The statutory limit for Federal expenditures is currently $4 million for a project at any single locality regardless of any disaster declaration.

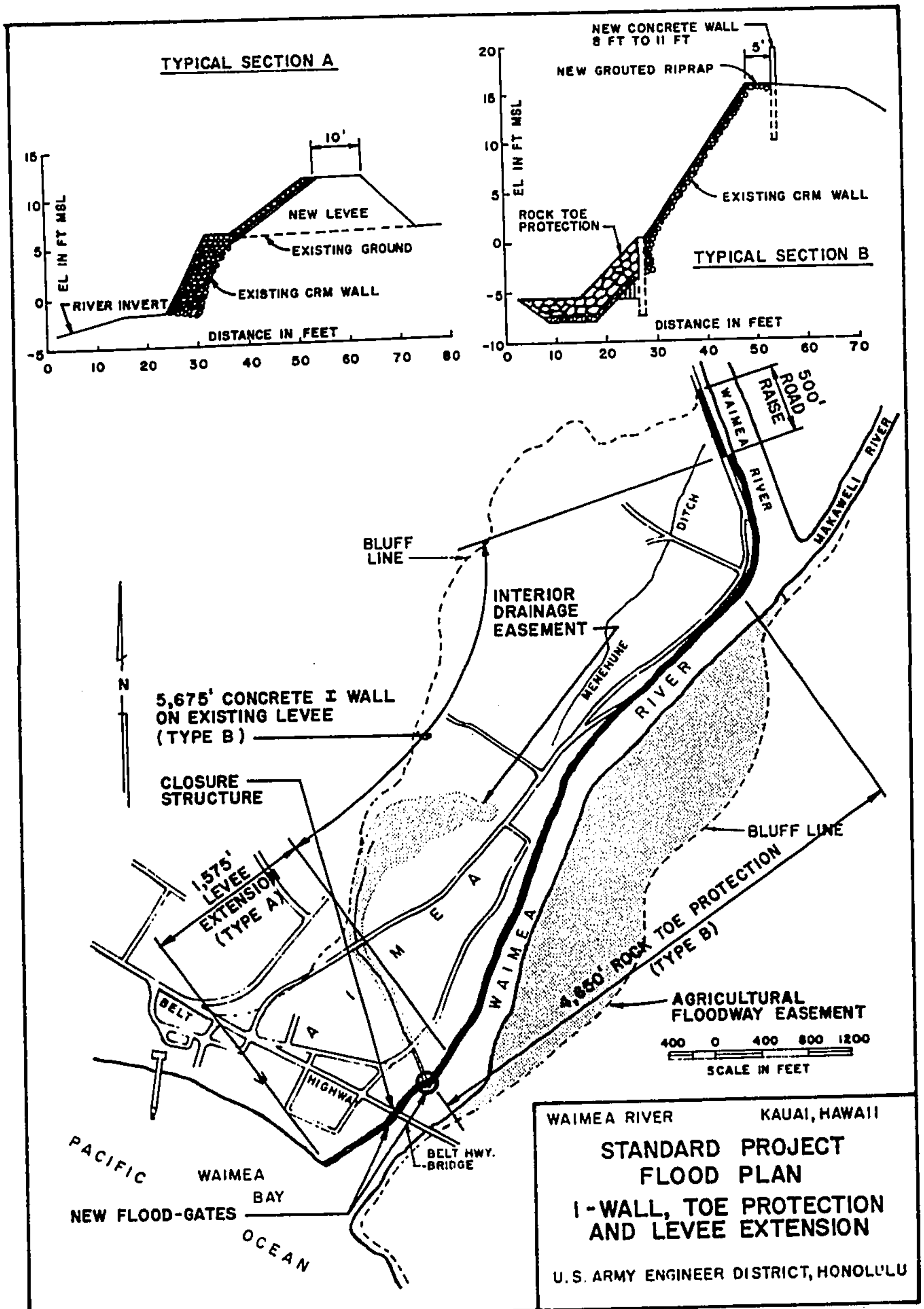
Pertinent data are shown on the following sheet. The District Engineer recommends the plan be approved and constructed provided local interests furnish necessary assurances satisfactory to the Secretary of the Army prior to initiation of construction.

WAIMEA RIVER FLOOD CONTROL
WAIMEA, KAUAI, HAWAII

PERTINENT DATA

HYDROLOGIC AND HYDRAULIC DATA		
Drainage Area at Mouth		85.5 Sq. mi.
Flood Discharges at Mouth		
Standard Project Flood		100,000 cfs
0.2 Percent Flood (500-year)		90,000 cfs
1.0 Percent Flood (100-year)		64,000 cfs
Design Data		
Discharge Along Improvements		100,000 cfs
Velocities		7 to 14 fps
PROPOSED IMPROVEMENTS		
Levee Extension		
Length		1,575 feet
Height		7 to 13 feet
Floodwall		
Length		5,675 feet
Height		8 to 11 feet
Rock Toe Protection, Length		4,650 feet
Road Raising, Length		500 feet
Flood Outlets and Gates		1-24 inch and 5-60 inch
Regulated Floodplain		
Internal Drainage Ponding Area		11 acres
Agricultural Floodway		52 acres
PROJECT FIRST COSTS 1/		
Total Federal First Costs		$3,853,000
Total Non-Federal First Costs		1,910,000
Rights of Way & Indirect	$ 130,000	
Cash Contribution	1,780,000	
Total Project First Costs		$5,763,000
AVERAGE ANNUAL BENEFITS AND COSTS 1/ 2/		
Total Average Annual Benefits		$ 461,000
Total Average Annual Costs		460,000
Federal	$ 294,000	
Non-Federal	166,000	
ECONOMIC FEASIBILITY MEASURES		
Average Annual Net NED Benefits		$ 1,000
Benefit-To-Cost Ratio		1.00+

1/ Excludes pre-authorization costs. Price level: Apr 1982. Based on 7-5/8 percent rate and 100-year economic life.
2/ Includes annual operations and maintenance estimate.



TYPICAL SECTION A
10'
NEW LEVEE
EXISTING GROUND
EXISTING CRM WALL
RIVER INVERT
EL IN FT MSL
DISTANCE IN FEET
NEW CONCRETE WALL
8 FT TO 11 FT
5'
NEW GROUTED RIPRAP
EXISTING CRM WALL
ROCK TOE PROTECTION
TYPICAL SECTION B
DISTANCE IN FEET
500' ROAD RAISE
WAIMEA RIVER
MAKAWELI RIVER
DITCH
BLUFF LINE
INTERIOR DRAINAGE EASEMENT
MENEHUNE
RIVER
N
5,675' CONCRETE I WALL ON EXISTING LEVEE (TYPE B)
CLOSURE STRUCTURE
1,575' LEVEE EXTENSION (TYPE A)
BLUFF LINE
WAIMEA
4,850' ROCK TOE PROTECTION (TYPE B)
AGRICULTURAL FLOODWAY EASEMENT
400 0 400 800 1200
SCALE IN FEET
BELT
HIGHWAY
BELT HWY. BRIDGE
PACIFIC
WAIMEA BAY
NEW FLOOD-GATES
OCEAN
WAIMEA RIVER
KAUAI, HAWAII
STANDARD PROJECT FLOOD PLAN
I-WALL, TOE PROTECTION AND LEVEE EXTENSION
U.S. ARMY ENGINEER DISTRICT, HONOLULU

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INTRODUCTION

STUDY AUTHORITY

By letter dated 31 March 1978, the Mayor of the Kauai County requested assistance for flood control improvements within the Waimea River drainage basin. The purpose of this report is to evaluate the extent of the flood problem and to determine the feasibility and justification of Federal participation in providing flood mitigation measures in the Waimea River drainage basin.

The study and report were accomplished under the authority of Section 205 of the 1948 Flood Control Act, as amended:

> "The Secretary of the Army is authorized to allot from any appropriations heretofore or hereafter made for flood control, not to exceed $30,000,000 for any one fiscal year, for the construction of small projects for flood control and related purposes not specifically authorized by Congress, which come within the provisions of Section 1 of the Flood Control Act of June 22, 1936, when in the opinion of the Chief of Engineers such work is advisable. The amount allotted for a project shall be sufficient to complete Federal participation, in the project. Not more than $2,000,000 shall be allotted under this section for a project at any single locality, except that not more than $3,000,000 shall be allotted under this section for a project at a single locality if such project protects an area which has been declared to be a major disaster area pursuant to the Disaster Relief Act of 1966 or the Disaster Relief Act of 1970 in the five-year period immediately preceding the date the Chief of Engineers deems such work advisable. The provisions of local cooperation specified in Section 3 of the Flood Control Act of June 22, 1936, as amended, shall apply. The work shall be complete in itself and not commit the United States to any additional improvement to insure its successful operation, except as may result from the normal procedure applying to projects authorized after submission of preliminary examination and survey reports."

SCOPE OF THE STUDY

The study area (Figure 1) includes the lower Waimea River drainage basin which is located in the west-central portion of the island of Kauai. This study focuses on the evaluation of the flood and related water resource problems; identification of the causes of these problems and their relationship to the overall environmental and socioeconomic needs and desires of the people in the study area; development of alternative solutions for preventing flood damages; determination of the costs, benefits, and environmental impacts associated with implementing these measures; and selection of a recommended plan.

Studies conducted included site investigations, archeological surveys, topographic surveys, geologic and material investigations, fish and wildlife studies, engineering designs, economic evaluations, and environmental assessments.

STUDY PARTICIPANTS AND COORDINATION

The U.S. Army Corps of Engineers, Honolulu Engineer District, was responsible for conducting and coordinating the study and preparing the report. The County of Kauai Department of Public Works is the local sponsoring agency, coordinating Corps activities on the island of Kauai throughout this study. Corps personnel have worked closely with the Kauai Departments of Public Works and Planning who provided information on future plans for the study area, utility maps, and pertinent County of Kauai reports and drawings. Assistance was also provided by the Hawaii State Department of Transportation and the U.S. Fish and Wildlife Service. The Department of Transportation furnished data and construction information on the bridge at the Belt Highway. Baseline information and an analysis of effects on fish and wildlife within the Waimea drainage basin were provided by the U.S. Fish and Wildlife Service.

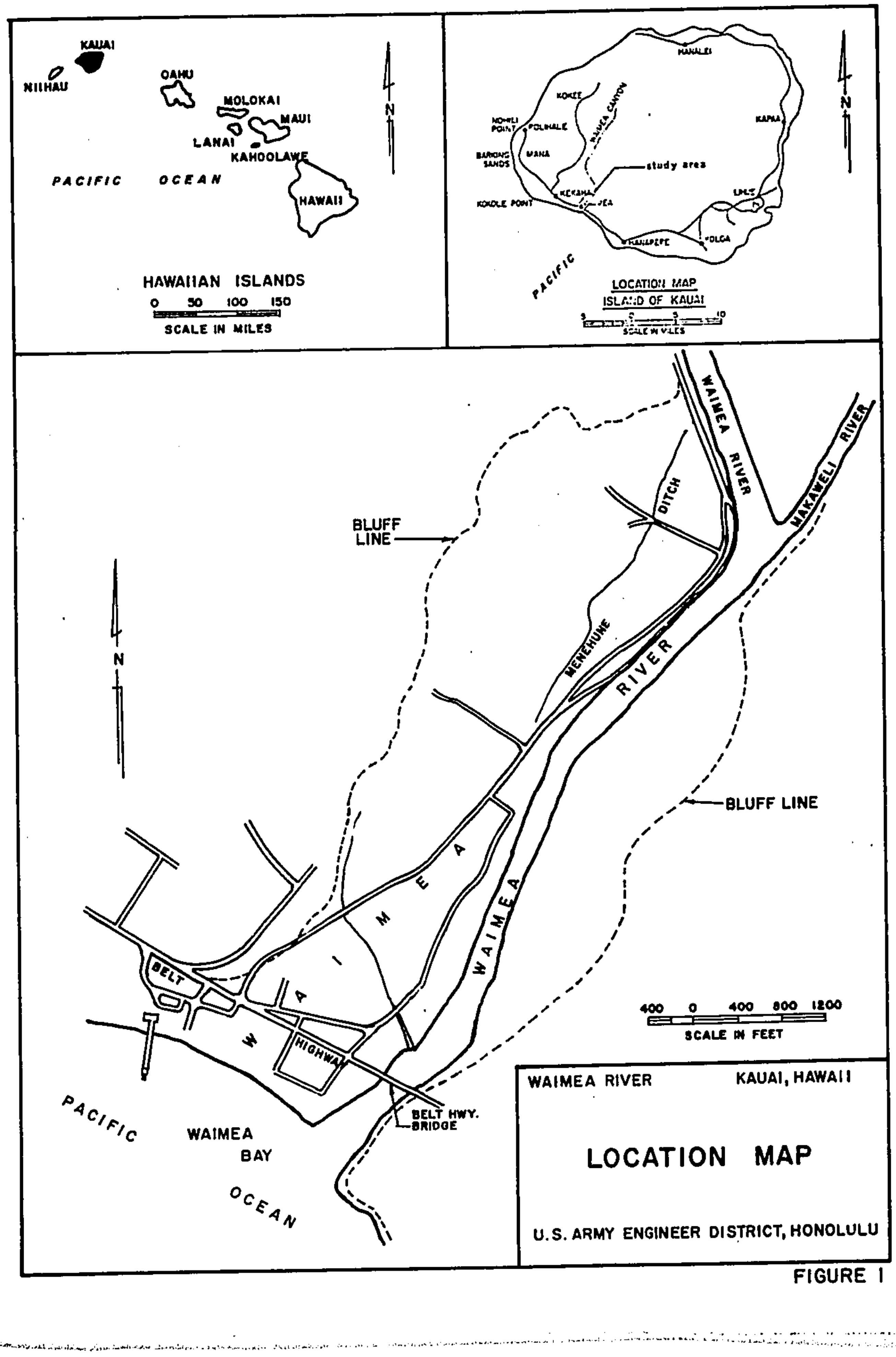
The study was also coordinated with other appropriate federal and nonfederal agencies, and with interested groups or individuals. A workshop was conducted in Waimea, Kauai, on 25 January 1979 at the Waimea Neighborhood Center. In addition to the workshop, two public meetings were held at the same location on 8 November 1979 and 28 February 1980. Details on coordination and public views are summarized in Appendix F, Public Involvement.

PRIOR STUDIES

In March 1959, authority to prepare a Detailed Project Report under Section 205 of the Flood Control Act of 1948, as amended was granted to the Honolulu District by the Office of the Chief of Engineers. The report concluded that the levee constructed in 1950 by local interests provided adequate protection for the major portion of Waimea town. The lower portion of the town remained unprotected, but protection for this area could not be economically justified.

In September 1978, a reconnaissance report on the Waimea River recommended that detailed studies be undertaken to determine the feasibility of providing additional flood control improvements for Waimea town. As a result, this detailed study was authorized.

In June 1973, the U.S. Army Corps of Engineers, Pacific Ocean Division, and the State of Hawaii, Department of Land and Natural Resources prepared a flood hazard information report for the island of Kauai. This report defines the flood problem on the island of Kauai and provides information on the hydrology.



KAUAI
NIIHAU
OAHU
MOLOKAI
MAUI
LANAI
KAHOOLAWE
HAWAII
PACIFIC OCEAN
HAWAIIAN ISLANDS
0 50 100 150
SCALE IN MILES
N
study area
PACIFIC
LOCATION MAP
ISLAND OF KAUAI
SCALE IN MILES
N
BLUFF LINE
DITCH
WAIMEA RIVER
MAKAWELI RIVER
MENEHUNE
RIVER
BLUFF LINE
W A I M E A
WAIMEA
BELT
HIGHWAY
BELT HWY. BRIDGE
PACIFIC
WAIMEA BAY
OCEAN
400 0 400 800 1200
SCALE IN FEET
WAIMEA RIVER
KAUAI, HAWAII
LOCATION MAP
U.S. ARMY ENGINEER DISTRICT, HONOLULU

FIGURE 1

THE REPORT

This document consists of a main report, which includes the environmental statement, and attached technical appendices. The main report is essentially a summary of the planning process and conclusions. The appendices contain technical detail information and backup data to support the information contained in the main report:

Appendix	Title
A	Hydrology
B	Geology and Soils
C	Engineering Investigations, Design and Cost Estimates
D	Economics
E	Social & Cultural
F	Public Involvement
G	Natural Resources

PROBLEM IDENTIFICATION

Problem identification is the first task in the planning process. Although it is the major task early in the study, the identification task continued, with revisions and refinements throughout the study. The activities performed as part of the Problem Identification task are outlined below:

1. Identify public concerns
2. Analyze resource management problems
3. Define the study area
4. Describe the existing conditions
5. Establish planning objectives

NATIONAL OBJECTIVES

The Water Resources Council's Principles and Standards (P&S) require that planning for development of water and water-related land resources must be directed toward achieving two equal national objectives: National Economic Development (NED) and Environmental Quality (EQ). The NED objective is achieved by a plan that increases the nation's output of goods and services and improves the national economic efficiency. The EQ objective is achieved by the management, conservation, preservation, creation, restoration, or improvement of the quality of certain natural and cultural resources and ecological systems.

As an aid to decision making and plan selection, the P&S require that an NED plan (the plan that maximizes benefits to the economy) and an EQ plan (the plan with the maximum contribution to the environment) be designated. If no plan can be formulated that is economically justified, the investigation is ended. If no plan can be formulated with net environmental benefits, the plan least damaging to the environment must be noted.

EXISTING CONDITIONS

Kauai, the northernmost of the eight major Hawaiian islands, is 103 statute miles west and slightly north of Honolulu. The roughly circular island is fourth largest in land area with 549 square miles. The study area (Figure 1) is located in the town of Waimea, a community of 1,600 residents near the mouth of Waimea River along the southwestern coast of Kauai. Land along the western and eastern banks of the Waimea River is in urban and agricultural uses. The historical Captain Cook Landing Site and the Russian Fort Site are located on the western and eastern banks of the Waimea River, respectively. Taro fields are located just above the confluence of the Waimea and Makaweli Rivers, approximately 1.25 miles upstream of the river mouth. Kekaha is the district's principal residential area, located about 2 miles to the west of Waimea.

ENVIRONMENTAL SETTING

The island of Kauai is the summit of one of the principal volcanic mountains of the partially submerged Hawaiian range. This range extends for a distance of 1,500 miles across the Pacific Ocean floor. Kauai has a complex geologic structure as a result of volcanic activities, separated by intervals of erosion and decomposition combined with faulting. The soils in the basin are mainly residual. The soils in the lower floodplains are alluvial and marine deposits of silts, sand and gravelly sands, and plastic clay and silt. A thin layer of red-brown soil covers the area along the confluence of the Waimea and Makaweli Rivers and lower slopes of the ridges.

The upper and central regions of the Waimea River basin are characterized by deep canyons and steep hills. The upper western portion of the basin contains Waimea Canyon, one of the popular tourist attractions of Kauai. The Alakai Swamp, located in the higher regions of the 85 square mile drainage area, measures 1/2 to 2 miles wide and 10 miles long. The ridges that bound the drainage basin on the west and east rise from sea level to elevations of 4,000 and 5,000 feet, respectively.

The climate of the Waimea River basin ranges from subtropical in the lower regions to temperate in the upper and central regions. Mean monthly temperatures in the coastal area range from 70°F to 78°F, and temperatures in the higher areas range from 67°F to 75°F. Trade winds predominate the air flow patterns in Waimea, blowing from 80 to 90 percent of the time during the summer months and 50 to 80 percent during the winter months.

Located on the leeward side of Kauai, Waimea receives the smallest amount of rainfall on the island. The average annual rainfall rate is about 22 inches per year in the coastal plain. In the upper regions, rainfall averages 100 inches per year. Rainfall on Kauai is produced chiefly by orographic lifting of the trade winds which originate from the east or northeast. The rainfall is seldom intense and is usually not responsible for the large floods in the Waimea Valley. The "kona" (southerly) storms, associated with fronts of extratropical cyclonic disturbances, are responsible for most of the floods in the area. During a kona storm, the dry leeward and coastal areas may receive enough rain within a single day to nearly equal their average annual total. The study area is not located within any designated wildlife refuge, marine sanctuary, or natural area reserve, nor are there any threatened or endangered species or their habitats within the study area.

The taro fields above the confluence of the Waimea and Makaweli rivers provide marginal habitat for endangered Hawaiian ducks and Hawaiian coot. The terminal reach of the river, from the confluence to the sea, is of negligible value to endemic waterbirds. Due to the extensive recreational use of the river and past modifications to riparian habitat, no endangered waterbirds have been observed in the river below the taro fields. The shorelands adjacent to the river mouth do provide feeding areas for migratory shorebirds. Vegetation along the shoreline areas has been highly altered and consists mainly of various grasses and shrubs.

The lower, estuarine portion of the Waimea River is habitat for migratory freshwater species and itinerant marine fishes. Crabs and opae are found along the river banks and under bridges. The few endemic species which exist in the Waimea and Makaweli rivers are particularly abundant in the Makaweli River.

At one time, prehistoric Waimea was a populous Hawaiian village with intensive irrigated and terraced cultivation and numerous house sites and heiau reflecting a prosperous native community. Waimea was the site of the first anchorage of Captain James Cook, the first recorded contact between Hawaiians and Europeans, and the opening of a world sea trade route. Until the 1840's, Waimea was the port of entry for Kauai and in 1817, a Russian trader built Fort Elizabeth on the southern bank of the river at its mouth. Both the Fort and a single stone memorial commemorating Cook's landing site, located across the river from the Fort, are listed on the National Register of Historic Places and are also designated National Historic Landmarks. Within Waimea town there are two buildings, Gulick-Rowell House and Bishop National Bank of Hawaii, dating from the sugar plantation era of the district, which are both listed on the National Register. Remains from the prehistoric era are still found back in the valley, notably a unique irrigation ditch, known as Peekauai (Menehune) Ditch, with fitted, faced basalt slabs. This linear feature is in the process of being determined eligible for the National Register. Part of the ditch flows under a portion of the recommended project alignment. Other sites in the region include Waimea Valley (Prehistoric) Complex, the Keakuamele Heiau, and a series of prehistoric taro terraces and inter-field irrigation auwai (ditches). The latter are located partially within the floodplain and may also be eligible for the National Register.

HUMAN RESOURCES

The population of the island of Kauai declined between 1930 and 1960. However, Kauai's population increased from 27,900 in 1960 to 31,800 in 1975 representing an increase of about 1 percent per year. During this period, the population of Waimea town is estimated to have increased from 1300 to 1600, representing an annual increase of 1.5 percent.

According to the 1970 census, the median age in the Waimea-Kekaha area is 29.5, with about nine percent of the people over age 65 compared with only six percent for the State of Hawaii. In 1974, the median income per family for Waimea-Kekaha was $10,100 as compared with $15,800 for the entire state.

DEVELOPMENT AND ECONOMY

Hawaii is a prosperous state with a growing population and economy. Between 1950 and 1975, the total resident population increased over 73 percent from 498,000 to 865,000. During the same period, the gross State product more than quadrupled, from $900 million to $6.49 billion. The three largest contributors to the State economy are tourism, defense expenditures, and agriculture, the bulk of the last activity being in the production of sugar and pineapple. The most rapid growth during the last several years has been in the tourist industry. Tourist arrivals totaled 687,000 in 1965 and 2,830,000 in 1975. Tourist expenditures were $225 million in 1965 and $1.4 billion in 1975, an increase of 524 percent. This is compared to an increase of 125 percent for defense spending.1/

In the Waimea-Kekaha area, an economy dominated by the sugar industry is giving way to one dominated by federally-supported defense and scientific activities. Nearly all the land on Mana Plain west of Waimea is the property of the State of Hawaii and the federal government. Almost all of the State-owned land is under long-term lease to the Kekaha Sugar Company. Kekaha Sugar Company, owned by AmFac Inc., produces sugarcane on 7,947 acres and in 1976 employed approximately 440 workers. Employment at the sugar company has been declining for several decades but is now expected to remain stable or decline only gradually with continuing technological improvements. The chief economic mainstay of the Waimea-Kekaha region is the defense/scientific complex at Barking Sands and Kokee. The major operations at Pacific Missile Range (PMR) involve the US Navy's missile testing and development and Anti-Submarine Warfare training, the National Bureau of Standards, the National Weather Service, and the Energy Research and Development Agency (ERDA). At the beginning of 1976, a total of 560 persons were employed at PMR, including 105 Navy personnel and about 250 dependents who lived on base. At Kokee in the mountains, 253 full-time workers were employed by the NASA Tracking Station, the Hawaii Air National Guard, and the National Weather Service.

1/ Statistical information extracted or computed from the data published in Bank of Hawaii's Annual Economic Review Reports.

Unlike most of Kauai, tourism has not played a significant role in the economy of Waimea, principally because there are no hotels or large restaurants in the area. An estimated 500,000 tourists passed through Waimea in 1975 to visit the Waimea Canyon area. According to County planning officials, tourists usually follow the Belt Highway along the coast to view Niihau Island then turn inland toward the mountains. Polihale State Park, beyond Barking Sands, is another favorite tourist destination.

Other revenue for Waimea includes retail business activities and diversifed agriculture. In 1976, fifty-six retail or commercial establishments were located in Waimea employing approximately 170 people. Crops such as corn, taro, and alfalfa are grown in the rich, fertile lands of the Waimea Valley.

The Belt Highway is the major transportation route serving the defense/ scientific complex at Barking Sands and the tourist destination areas of Waimea Canyon and Polihale State Park. Although Barking Sands installation has its own airfield, most of its food and logistical needs are supplied by land transportation. According to State Department of Transportation sources, in September 1975, a one-day count of 1,519 vehicles passed in both directions on the Belt Highway west of Waimea.

FUTURE CONDITIONS WITHOUT FEDERAL ACTION

POPULATION PROJECTION

The 1975 population for the Waimea-Kekaha region is approximately 4,700 and represents a 12 percent increase over the 1970 census. By the year 2000, the population should increase to 8,400 (Table 1). Population growth will continue to be dependent upon increased employment opportunities with federally-supported activities, relocation of federal employees to new housing in the nearby area, and immigration of new sugar plantation workers to replace retiring workers.

TABLE 1. WAIMEA-KEKAHA REGION POPULATION PROJECTION

YEAR	POPULATION
1960	3967
1970	4159
1980	5300
1990	7100
2000	8400
2010	10100
2020	12100
2030	14500

Source: Hawaii Water Resource Regional Study, Social Base Study Element Report, 1975.

ECONOMY AND LAND USE

The defense/scientific complex at Barking Sands and Kokee and the Olokele Sugar Company will remain as the chief economic mainstays of the Waimea-Kekaha region. Tourism is not expected to play a large role in the economy of Waimea-Kekaha area for at least 10 to 15 years. Kauai County's Regional Development Plan provides for a 180-acre parcel of privately-owned coastal land between Waimea and Kekaha for possible residential, commercial, industrial, resort, open or other uses. It appears that the residents favor controlled growth and want to maintain Waimea as a plantation and residential community and the regional center of socioeconomic and governmental activities. Recommended zoning under the Regional Development Plan is shown on Figure 2.

PROBLEMS AND NEEDS

FLOOD PROBLEM

Prior to the flood control improvements constructed by local interests in the early 1950's, frequent and damaging floods occurred in Waimea. Photographs of the lower Waimea River basin are shown on Figures 3 through 5. At the 1950 public meeting, local residents indicated that floods in 1916, 1921, 1927, 1942, and 1949 caused damages in excess of $1.0 million. The flood of January 1949 claimed two lives and destroyed five houses. Although the existing levee along the west bank performed satisfactorily in containing intermediate flood flows, it is inadequate for major flood events. The existing levee provides a flow capacity of approximately 60,000 cubic feet per second (cfs), which is approximately a 100-year event or less than 60 percent of the estimated standard project flood peak. Downstream of the levee the river capacity is about 48,000 cfs, which is equivalent to a 25-year runoff.

Approximately 480 acres could be inundated by the standard project flood. Of the 480 acres, 250 acres are located in the Waimea town area below the confluence of Waimea and Makaweli Rivers. Major improvements in the 250-acre floodplain include residential development, small business and commercial buildings, highways, streets, and utility facilities. Developments and improvements will continue in the future in the urban section of Waimea. In addition to new structures being constructed on previously vacant lands, older structures are being replaced with new ones. The floodplain on the left bank and above the river confluence has been developed primarily for agricultural uses.

The critical problem area is the gap along the west bank between the existing levee and the Belt Highway (State Route 50). Because of the lower basin's topography, overbank flow at this location would inundate much of the area protected by the levee. Flooding is a major problem because of man's activities and development of damageable structures within the floodplain. Inadequate interior drainage within the basin also contributes to the overall flood problem in Waimea. Although levee overtopping has never occurred, widespread property damage could occur should a major flood overtop the existing levee.

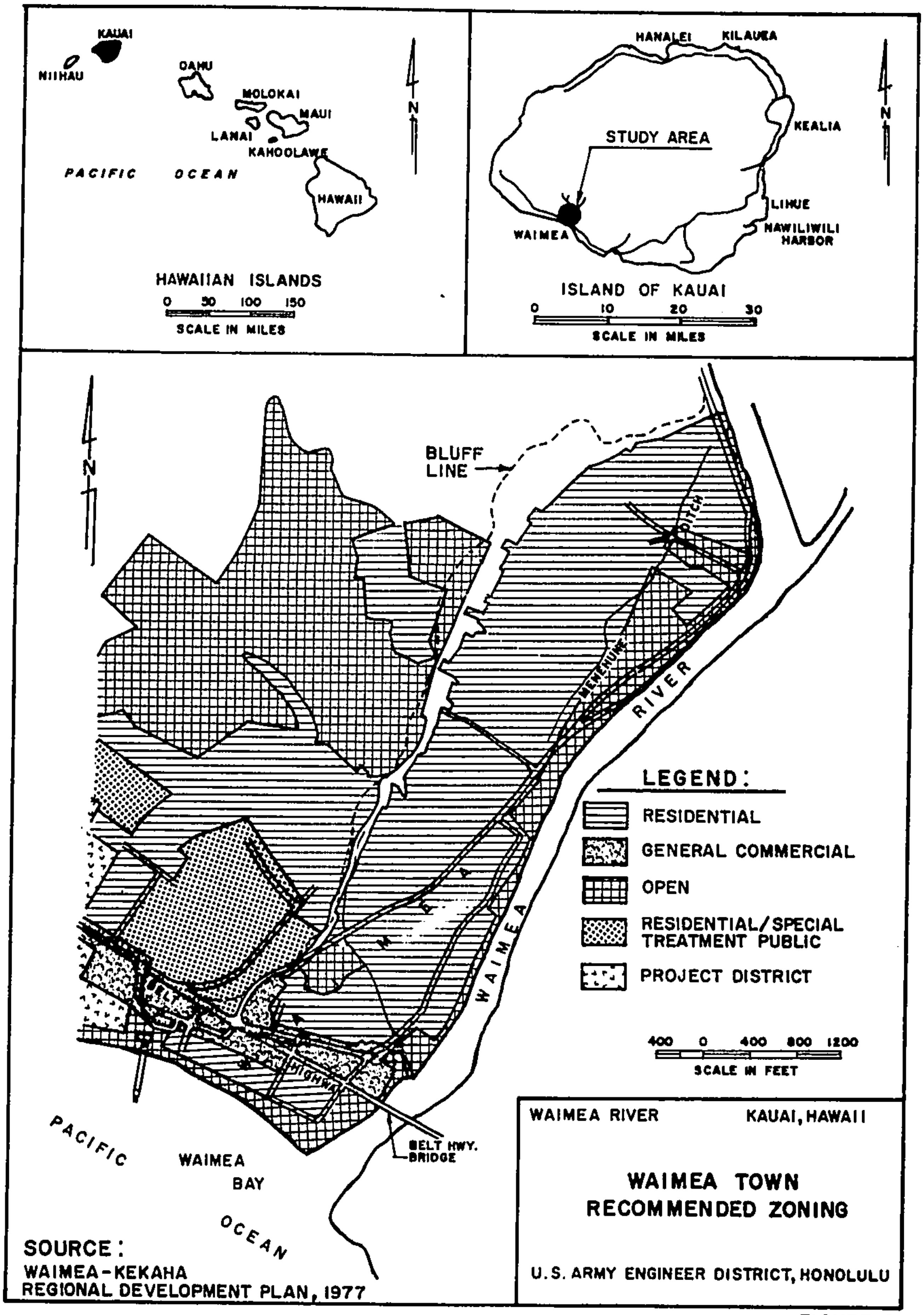
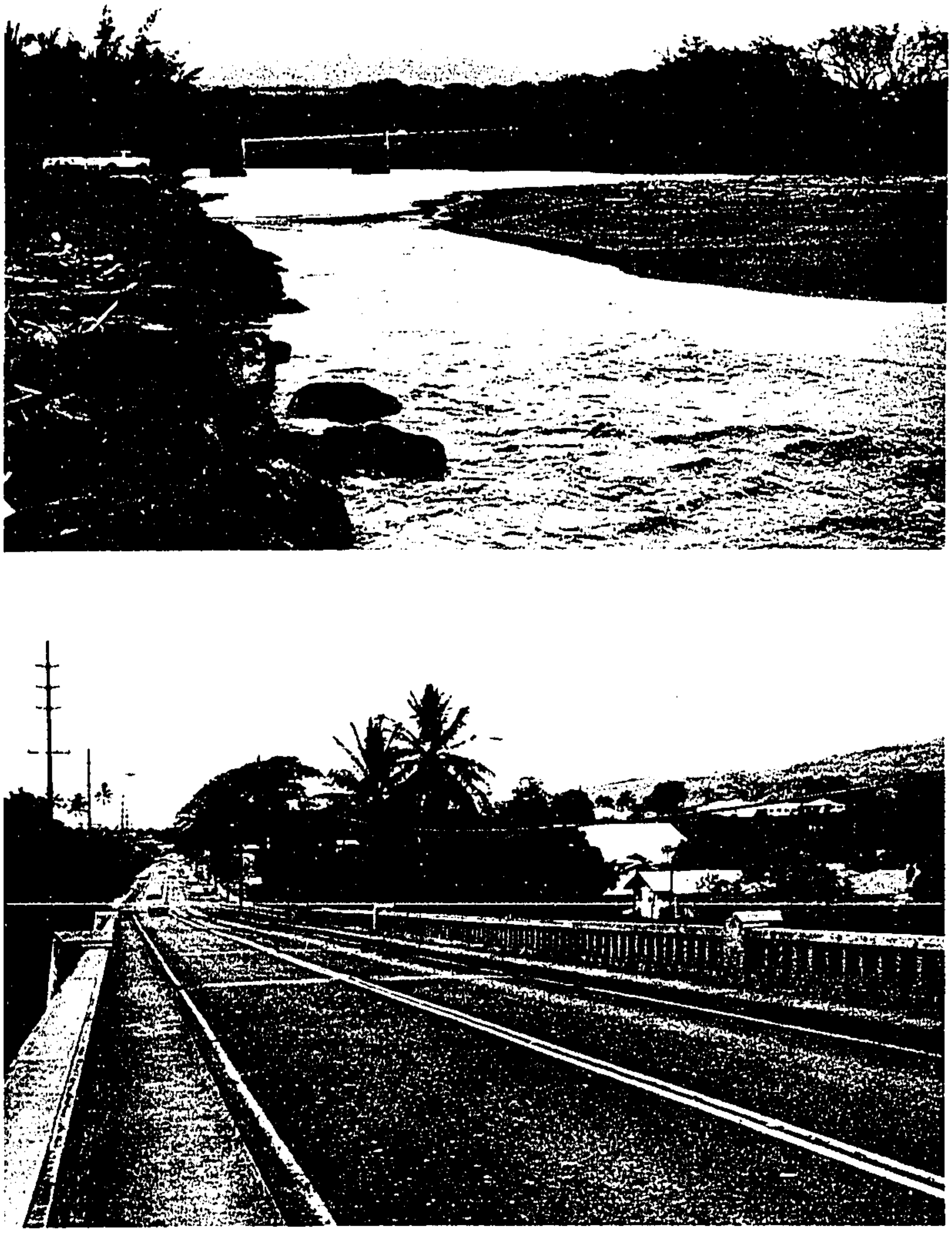

KAUAI
NIIHAU
OAHU
MOLOKAI
MAUI
LANAI
KAHOOLAWE
HAWAII
PACIFIC OCEAN
HAWAIIAN ISLANDS
0 50 100 150
SCALE IN MILES
HANALEI
KILAUEA
KEALIA
STUDY AREA
WAIMEA
LIHUE
NAWILIWILI HARBOR
ISLAND OF KAUAI
0 10 20 30
SCALE IN MILES
BLUFF LINE
DITCH
MENEHUNE
RIVER
WAIMEA
LEGEND:
RESIDENTIAL
GENERAL COMMERCIAL
OPEN
RESIDENTIAL/SPECIAL TREATMENT PUBLIC
PROJECT DISTRICT
400 0 400 800 1200
SCALE IN FEET
BELT HWY. BRIDGE
PACIFIC OCEAN
WAIMEA BAY
SOURCE:
WAIMEA-KEKAHA REGIONAL DEVELOPMENT PLAN, 1977
WAIMEA RIVER
KAUAI, HAWAII
WAIMEA TOWN RECOMMENDED ZONING
U.S. ARMY ENGINEER DISTRICT, HONOLULU

FIGURE 2

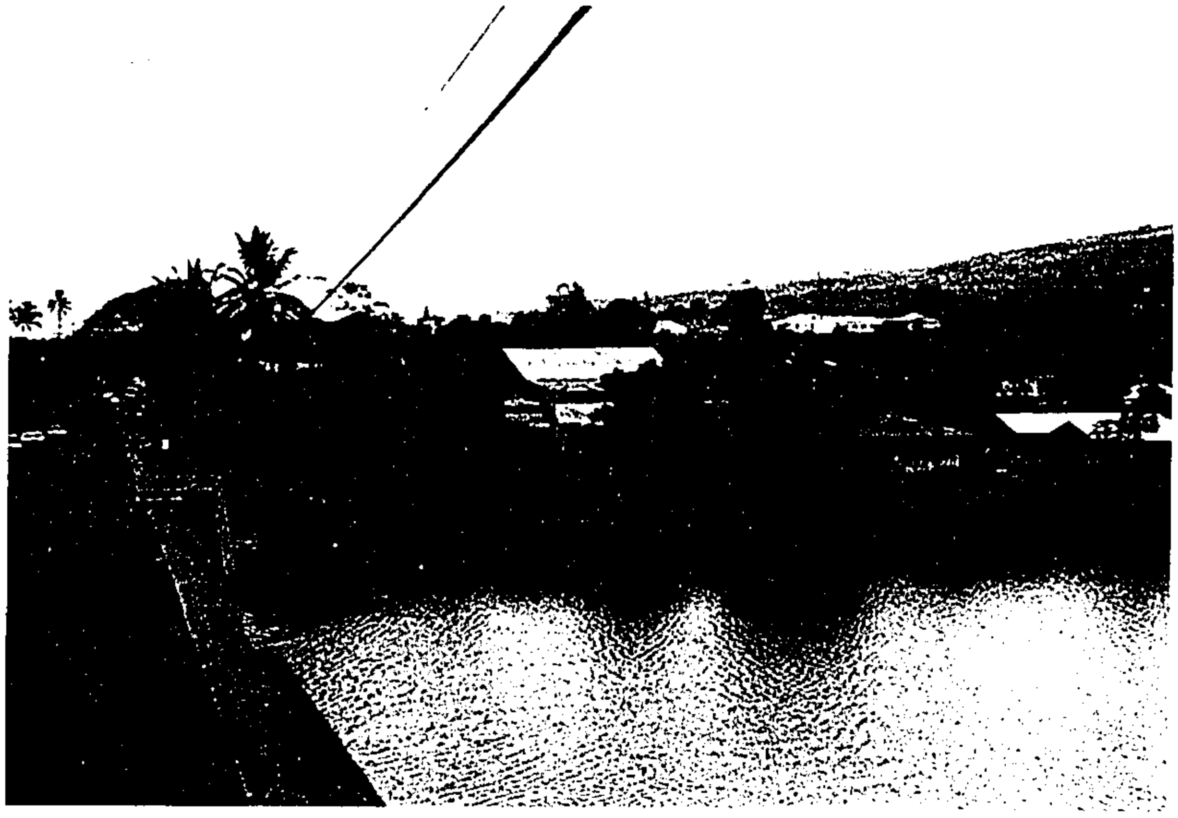
UPPER-SAND BAR AT MOUTH OF WAIMEA RIVER, WAIMEA BAY IN BACKGROUND.
LOWER- LUCY WRIGHT PARK ALONG WEST BANK OF WAIMEA RIVER DOWNSTREAM FROM BELT HIGHWAY BRIDGE.

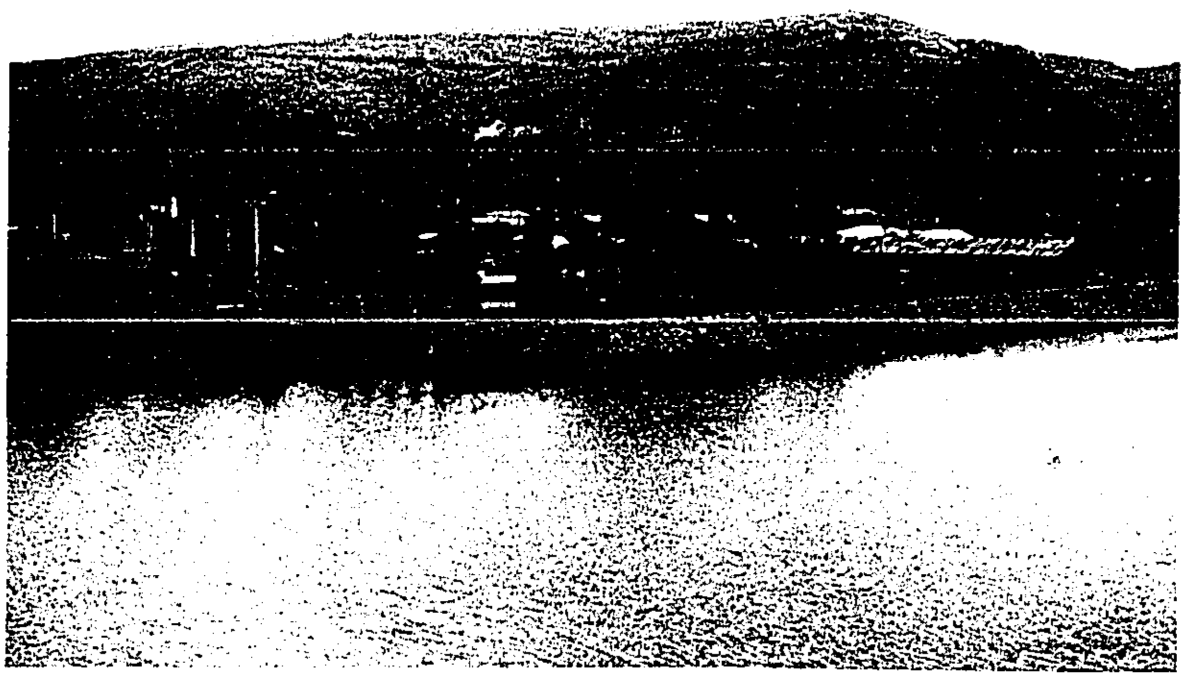
FIGURE 3



UPPER-BELT HIGHWAY BRIDGE FROM NEAR MOUTH OF WAIMEA RIVER.
LOWER-LOOKING WEST FROM BELT HIGHWAY BRIDGE ALONG BELT HIGHWAY IN WAIMEA TOWN.

FIGURE 4





UPPER-UNIMPROVED WEST BANK OF WAIMEA RIVER.
LOWER-EXISTING FLOODGATE AND GROUTED RIPRAP LINING ON WEST BANK OF WAIMEA RIVER.

FIGURE 5

The Flood Disaster Protection Act of 1973 stipulates that future federal financial assistance to a community would be contingent upon the community's implementation of an effective floodplain management program, participation in the National Flood Insurance Program (NFIP) or implementation of improvements to alleviate future flood losses. The NFIP is an ongoing program; however, insurance alone merely indemnifies property owners for flood losses, but does not reduce physical damages from flooding as requested by local interests and as defined by the study objectives.

The flood of 7 February 1949 was the most destructive to Waimea and to the surrounding floodplain and beach areas. During this flood, the entire town of Waimea was inundated. The highest gage reading ever recorded for the Waimea River, 11.40 feet above MSL (45,500 cfs), occurred during this flood. Rampaging waters swept through the town. Buildings and commercial establishments were tilted off their foundation by the flood currents and the town business center was flooded to depths of 3 to 8 feet. Waimea sustained estimated damages in excess of $870,000 at 1949 price levels; the total effect was devastating to the welfare of the community.

Severe flooding also occurred during the hurricane-associated flood of 16-17 August 1950. The Waimea River overflowed twice, causing flooding in the streets to depths greater than 4 feet, and resulting in the evacuation of more than 200 residents from the valley. A flood stage of 7.50 feet above MSL (32,000 cfs), the fourth highest level ever, was recorded by the Waimea River crest gage. In addition, high surf generated by the storm caused severe erosion and some flooding along the shore.

There are no federal flood control improvements along the Waimea River. The existing drainage improvements and levee works were constructed by local interests (Figure 6). Early improvements consisted of an earth and rubble wall along the right bank of the river. After the flood of 7 February 1949, the Territory of Hawaii relocated the wall at the river mouth in an outlet widening project. In 1950, the Waimea River was widened upstream and downstream of the confluence with Makaweli River, and the excavated material was used to construct an earthfill levee. The levee extends from about 300 feet upstream of the Belt Highway bridge to about 1,340 feet upstream of the Makaweli River confluence for a total distance of 6,650 feet. The levee was constructed 5 to 14 feet higher than the existing ground. The levee side slopes are 1 on 1-1/2 on the riverward side and 1 on 2 on the landward side. The riverward face of the levee is revetted with derrick-size stone which are chinked and mortared. The crest width varies from 15 feet at the lower end to 25 feet at the upper end.

In 1952, the County of Kauai with funds provided by the Territorial Government, completed the existing project for Waimea River. The improvements included channel excavation and widening, levee construction and grouted riprap lining, a 300-foot reinforced concrete retaining wall and related interior drainage facilities. The project was completed in 1954.

Since the completion of the levee project, increased urbanization in the Waimea floodplain has overtaxed the interior drainage system such that problems of ponding and inundation of lowlying residential and agricultural areas during heavy rains are a common occurrence. Runoff from higher ground deposits silt, mud, and gravel along Belt Highway and side streets. Mud and debris are found in the existing drains and ditches which hamper discharges to Waimea River. Storms of 1 December 1973 and 31 January 1975 document some of these problems.

During the 1 December 1973 storm, an old auwai (ditch) in lower Waimea Valley overflowed and was the principal cause of flooding to adjoining properties. Water blockage in existing drains and ponding problems were reported.

The 31 January 1975 storm produced the second highest gage reading of 8.77 feet above MSL (37,000 cfs) at the Waimea River crest gage. Since the river stage was higher than the water level in the auwai, the floodgate (the outlet terminus of the interior drainage system) was kept closed. Overflow from the auwai flooded the lowlying areas of Waimea.

RELATED PROBLEMS

In addition to the flood problems, two other related water resources problems are water quality and the presence of a substantial sand berm at the river mouth. The sampling program conducted by the State Department of Health from January 1974 to December 1978 indicated that the mean total coliform value and maximum values for total nitrogen and total phosphorus at the river mouth exceeded that State water quality standards. Samples taken near the confluence of Waimea and Makaweli Rivers showed that the maximum pH values, mean coliform and fecal coliform bacterial concentrations also exceeded the State water quality standards. Stock grazing upstream probably contributed to the high concentrations. There are no known local programs specifically designed to improve water quality in the Waimea basin.

The second related concern is the sand berm at the river mouth. The sand berm has resulted in a high water table within the developed area. This in turn contributes to the poor interior drainage and the improper functioning of cesspools. Although the County Department of Public Works maintains an opening to minimize the backwater effects, the natural rebuilding process makes the sand berm a recurring problem. The cesspool problem can be eliminated when sewer facilities are installed in Waimea; however, these improvements are not anticipated to be completed in the near future.

PLANNING CONSTRAINTS

Various planning constraints were considered throughout the planning effort. Planning constraints generally specify limitations that are used to guide plan formulation and restrict impacts. As limitations, they affect a broad range of concerns, including legal, social, economic, and environmental factors, and are discussed below.

a. The Corps may participate in the construction of flood control measures, when in the opinion of the Chief of Engineers such work is advisable. Any project recommended must be justified under established federal planning criteria, must be complete in itself, and must not obligate the federal government to future work. Local interests must agree to assume responsibility for designated items of local cooperation and for all project costs in excess of the specified Corps cost limitation. In the case of Waimea

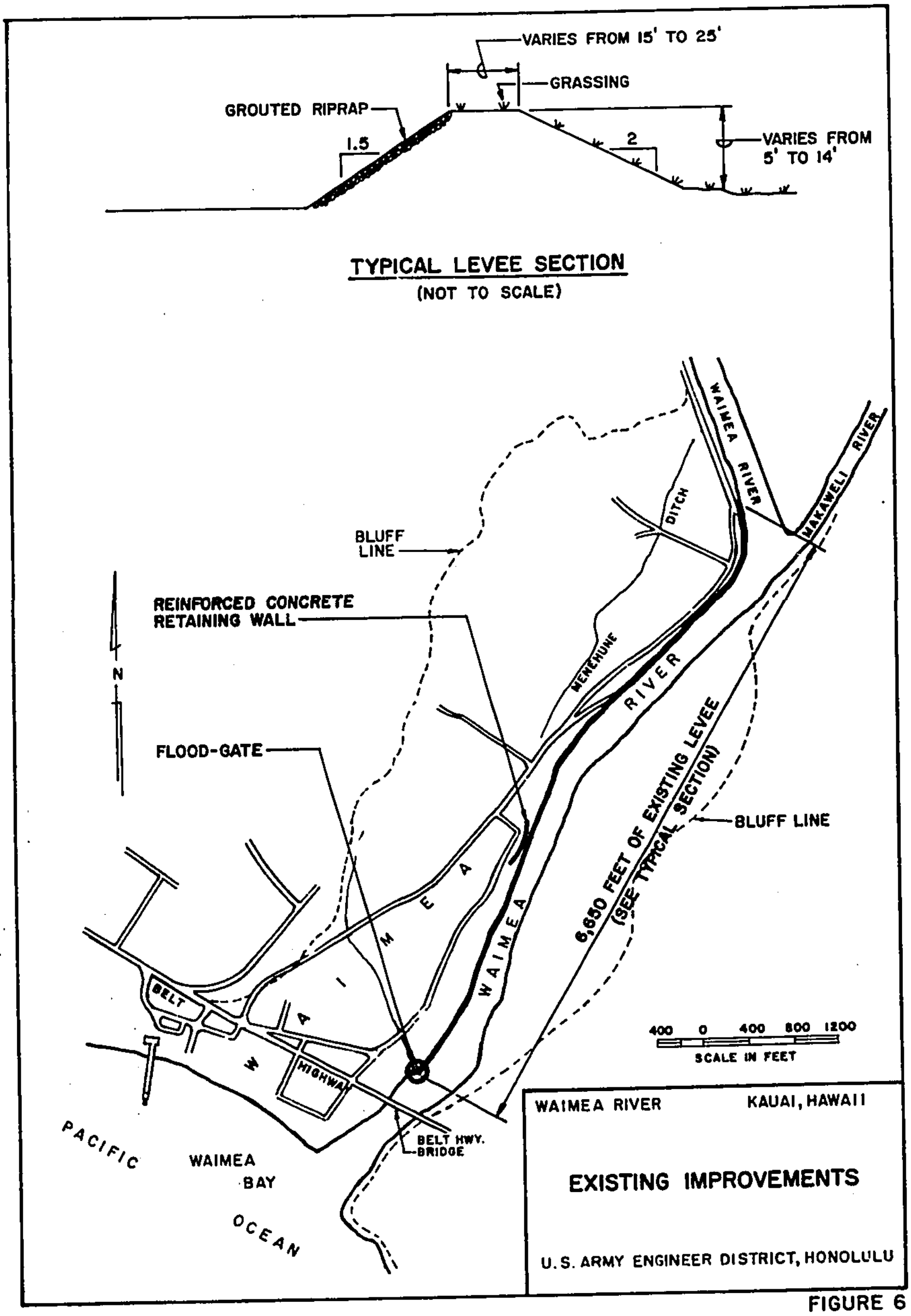

VARIES FROM 15' TO 25'
GRASSING
GROUTED RIPRAP
1.5
2
VARIES FROM 5' TO 14'
TYPICAL LEVEE SECTION
(NOT TO SCALE)
BLUFF LINE
REINFORCED CONCRETE RETAINING WALL
N
FLOOD-GATE
WAIMEA RIVER
MAKAWELI RIVER
DITCH
MENEHUNE
RIVER
WAIMEA
6,650 FEET OF EXISTING LEVEE (SEE TYPICAL SECTION)
BLUFF LINE
BELT
HIGHWAY
BELT HWY. BRIDGE
PACIFIC
WAIMEA BAY
OCEAN
400 0 400 800 1200
SCALE IN FEET
WAIMEA RIVER KAUAI, HAWAII
EXISTING IMPROVEMENTS
U.S. ARMY ENGINEER DISTRICT, HONOLULU

FIGURE 6

River, the Corps will participate up to a limit of $2.0 million, subject to project authorization by the Chief of Engineers.

b. Consistent with the Kauai County floodplain and tsunami ordinance, the 100-year level of protection was considered the minimum design protection level.

c. The Waimea River and existing flood control improvements are within public rights-of-way. Possible improvements within the Lucy Wright County Park, located on the west bank of Waimea River and downstream of the Belt Highway, would require a request for conversion and approval from the Secretary of Interior. The Park was developed with matching State and Federal Land and Water Conservation Fund Act monies.

d. Federal statutory and regulatory requirements guided the analysis of environmental resources and impacts. The required coordination was primarily related to evaluation and assessment of potential project implementation effects.

PLANNING OBJECTIVES

Based on the analysis of social, economic and environmental aspects of the study area, and the identification of problems and needs, the following planning objectives have been developed to guide the formulation and evaluation of alternative plans for improvement:

1. Contribute to the reduction of floodwater danger in the lower Waimea River drainage basin during the 1985-2085 period of analysis.
2. When possible, preserve or enhance the existing environmental resources within the lower Waimea River drainage basin.

FORMULATION OF PRELIMINARY PLANS

MANAGEMENT MEASURES

Possible management measures for flood mitigation in the Waimea area can be separated into two broad categories, nonstructural measures and structural measures. The effectiveness of these measures in alleviating the flood problem and their economic feasibility and compatibility with existing and desired socioeconomic and environmental conditions in Waimea are discussed in the following paragraphs. The alternative of "No Development" would result in continued damages from flooding and restriction of land use in the flood plain. This action would not be responsive to the study area's needs and was therefore eliminated as an alternative.

NONSTRUCTURAL MEASURES

Nonstructural measures would not reduce or eliminate the occurrence of floods. They are intended to minimize loss of life and damages when floods occur through implementation of various programs. These include flood warning and evacuation, floodproofing, relocation, and regulation of future development in flood plain areas through zoning ordinances and building codes.

Flood Warning and Temporary Evacuation. Flood forecasting can be considered useful in two ways: the preparation of temporary protection to minimize damage from an impending flood and the evacuation of flood plains anticipated to be inundated. Reliable and timely forecasts of potential flooding and flood stages are necessary to provide adequate warning for effective implementation of this measure.

Flood Proofing. This measure consists of adjustments to structures and building contents which are designed or adapted primarily to reduce flood damages. Flood proofing includes, but is not limited to: (a) raising existing buildings, (b) providing flood walls to protect structures and content, (c) providing flood shields for all openings, and (d) providing waterproof coatings to reduce seepage.

Permanent Evacuation and Relocation. This measure for reducing potential damages in flood-prone areas is the physical removal of all damageable structures located in the floodplain and converting the land to a use that is compatible with the degree of flood risk.

Flood Plain Regulation. Flood plain regulation and management programs are designed to control development of flood-prone areas to lessen the damaging effects of floods. Flood plain regulation relies on local government's adoption and use of legal tools to control the extent and type of development which would be permitted in these areas. The Federal Flood Insurance Program gives residents the opportunity to purchase flood insurance to cover losses from flooding.

STRUCTURAL MEASURES

A variety of structural measures exists for managing resources, reducing flood damages, and minimizing or preventing the occurrence of floods. These measures which confine and channel harmful floodwaters include reservoirs, levees, channel improvements, and combinations of these measures. The various structural measures were examined with respect to the Waimea area.

Reservoirs. The function of a reservoir is to store a portion of the floodflow in such a way as to reduce the flood peak in the areas to be protected. Reservoirs offer the possibility of serving several purposes including water supply, irrigation, recreation, fish and wildlife conservation, as well as flood mitigation.

Levees. Levees are the oldest structural form of flood control. Levees confine floodwaters to a designated floodway, or divert waters away from developed areas and into a designated channel or floodway.

Channel Improvements. The occurrences of floods and their damaging effects can be controlled by the construction of channel improvements which are designed to contain normal streamflows as well as floodflows. Channel improvements include realigning the channel to eliminate restrictive bends, enlarging the channel capacity, lining the channel to prevent bank erosion, and constructing structures to control the velocity of water flowing through the channel.

PRELIMINARY SCREENING

APPLICABLE NONSTRUCTURAL MEASURES

Because the existing use and recommended zoning (Figure 2) of the Waimea floodplain are primarily residential and general commercial, preliminary analysis indicated that an essentially nonstructural plan is possible and would partially meet the planning objectives. A nonstructural plan consisting of flood proofing all existing and future structures together with a program for comprehensive floodplain management has been carried out in the analysis. This plan is discussed further in subsequent sections. Analyses of other nonstructural measures showed that application of these measures on a basin-wide basis would not provide a practical or economical solution to the Waimea problems and needs (Table 2).

Flood prediction, warnings, preparation of temporary flood protection measures and temporary evacuation would help to decrease both the loss of human lives and flood damages. Because of the uncertainty of predicting hydrologic variables over a relatively small drainage area and the flashy nature of stream flows typical of most island streams, these methods of damage reduction for Waimea are generally not considered reliable, accurate nor timely. However, the Waimea River drainage basin (85 sq mi) is approximately one-sixth the island of Kauai. Considering the size and length of Waimea River and Makaweli River, a system of rain and stream gaging stations could be developed to provide timely forecasts of flooding and flood stages. The concept of permanent evacuation and relocation has been assessed on the basis of moving practically the entire town of Waimea to another site on Kauai. On the basis of total investment committed in the basin and its rich historical and cultural values, complete evacuation would have a tremendous adverse effect from both the economic and social viewpoints. Mass relocation would mean development of alternative sites on Kauai for residential and commercial facilities. Although floodplain regulation would control future development and thereby eliminate or reduce damages, this approach will not alleviate the existing flood problems in the developed areas.

APPLICABLE STRUCTURAL MEASURES

Various structural methods for alleviating the flood threat and preventing flood damages in Waimea were considered. These included detention of floodwater in reservoirs; increasing channel capacities by channel deepening, levee height increase or floodwalls; and various combinations of the above. Preliminary assessments indicated that reservoirs on Waimea and Makaweli River or Waimea River only could not provide protection as economically as could be provided by channel or levee improvements. The main reason for the low feasibility of plans which include reservoirs is that such facilities would cost substantially more than other structural measures available for the protection of Waimea. Consequently, alternative flood protection plans for

Waimea consisting of increasing channel capacities by channel deepening and levee modifications and extension were developed for further consideration.

APPLICABLE NONSTRUCTURAL AND STRUCTURAL COMBINATIONS

Various combinations of channel and levee improvements with nonstructural measures such as flood warning, flood proofing and/or relocation were also evaluated. Since a substantial portion of the existing flood damages are located upstream of the Belt Highway, the basic combination plan considered was flood proofing or permant relocation of structures seaward of the highway, and structural measures to protect the upstream remaining areas. An early flood warning system was also included in the combination plan evaluation. However, since structural improvements could be extended to the river mouth at a more cost-effective basis without community disruption, the combination measure was eliminated from further consideration. From the community well-being and cohesion standpoint, the combination of structural and flood proofing/relocation measures was viewed as less favorable than either structural or nonstructural possibilities. An early flood warning system is however, considered important to any basin protection planning in view of the relatively large drainage basin of Waimea River.

TABLE 2 - SCREENING OF POSSIBLE MEASURES

Measures	Preliminary Findings
Flood Warning/Temporary Evacuation	Predictions untimely and unreliable for small,flashy drainage areas. For larger basins like Waimea River however, warning system should be considered as a component of the overall plan.
Flood Proofing	Has merit, should consider further.
Permanent Evacuation and Relocation	High cost and tremendous adverse social impact.
Floodplain Regulation	Does not alleviate the existing flood problems in developed areas.
Reservoirs	Less favorable economically and environmentally than other structural measures.
Channel-Levee Improvements	Has merit, should consider further.
Combination Nonstructural and Structural	Except for a flood warning system, other nonstructural measures combined with structural improvements are less desirable than either all nonstructural or all structural measures.

PLAN FORMULATION RATIONALE

As defined earlier, flood mitigation is the primary objective of this study and the principal benefit values are considered generally basin-wide. Possible measures evaluated include nonstructural, structural and likely combinations of the two. Certain measures were subjected to preliminary investigations only because they were obviously less favorable than other measures in solving the flood problems. Some measures which have implementation possibilities were subjected to more studies to define their technical and economical feasibility, environmental impacts, and social acceptability. These factors are discussed in the following paragraphs.

TECHNICAL CRITERIA

Technical criteria established for plan formulation include consideration of alternative plans that can effectively reduce the flood problem or flood damage potential in the Waimea floodplain. The alternative plans should have dimensions adequate to provide a level of protection consistent with design and safety requirements.

ECONOMIC FEASIBILITY

The alternative plans must be examined for economic feasibility. First, the quantifiable benefits should exceed project economic costs. Second, the project scope and scale should be formulated so that each alternative would maximize its net benefit effects. The economic analysis should be based on current prices, the adopted 100-year period of analysis, and at an interest rate of 7-1/8 percent.

ENVIRONMENTAL AND SOCIAL ACCEPTABILITY

Environmental and social acceptability involved the identification, assessment, and evaluation of environmental resources and social effects which might be affected by a plan's implementation. Emphasis should be placed on avoidance of plans with severe natural resources, social, and health impacts. The views of the general public, particularly those of the Waimea residents, should be given careful consideration. Support from both the public and the sponsoring local agency is a necessary item for plan implementation.

PRELIMINARY PLANS

In view of the type and extent of existing flood control improvements, and as a result of the preliminary screening of applicable measures, three preliminary alternative plans that could fulfill the planning objectives were developed. One is a nonstructural plan consisting of flood proofing by raising structures or provisions for floodwalls. The other two are levee-channel alternatives. One structural plan considered primarily dredging the riverbed as the major improvement component, while the other considered increasing the conveyance capacity by providing additional wall height.

LEVEL OF PROTECTION

In considering the desired level of protection for both structural and non-structural alternative plans, the following procedure was used in the determination of various appropriate levels of protection:

a. Formulate plans and determine the level of protection afforded by maximizing net economic benefits.

b. Formulate plans for the standard project flood (SPF).

c. Formulate other plans for higher or lower degrees of protection based on the planning objectives established for the study and other factors, such as desires of local interests, environmental or social considerations, or design considerations.

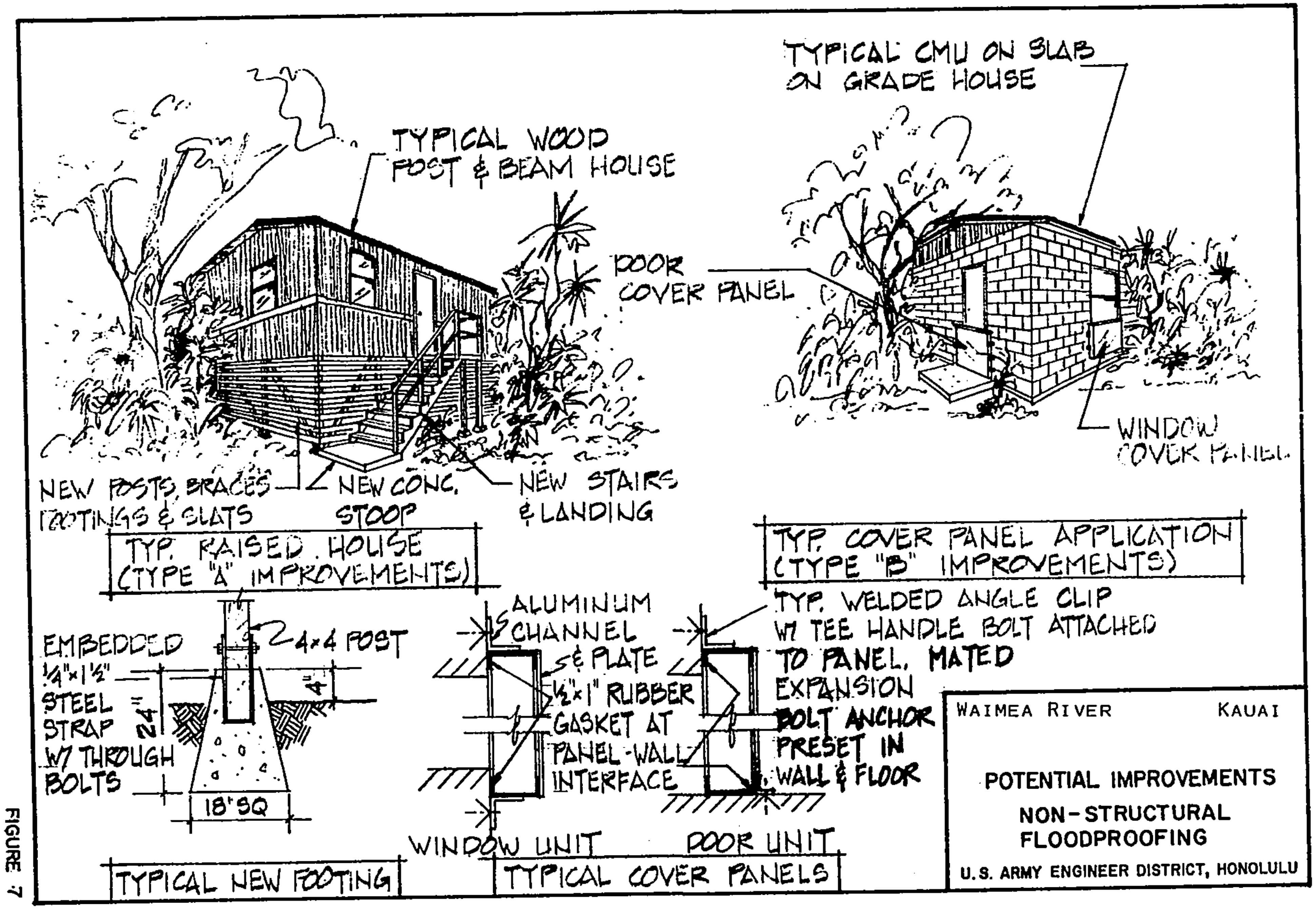
d. Consider the chance and risk of exceeding various floods and the consequences of exceeding those floods.

The concept of risk is useful in advising the community of the potential hazards remaining following completion of the project. Risk is defined as the probability that one or more events will exceed a given magnitude within a specified period of years. Flood frequency curves are used to estimate the probability of an event being exceeded in any single year. In contrast, risk defines the probability of an event being exceeded during the lifetime of the structure. For example, although a project designed for a 100-year flood may provide protection for a flood up to a flood which has a one percent chance in any year, during a 100 year period there is a risk of 63 percent that the flood will be exceeded one or more times. Similarly, during a 30 year period, a 100 year level of protection may have a risk of 26 percent. This indicates that although a 100-year flood design is significant, there exists a fair risk of the design being exceeded. The relationship at the period of time and design frequency on the determination of risk is shown in the following tabulation:

Period of Time (In Years)	Risk of One or More Overtopping Events (in %) for selected Exceedance Frequencies 1/				
	2%	1%	0.5%	0.2%	0.1%
30	45	26	14	6	3
50	64	39	22	10	5
70	76	51	30	13	7
100	87	63	39	18	10

1/ U.S. Water Resources Council, Guidelines for Determining Flood Flow Frequency, Bulletin 17A, June 1977.

Based on preliminary benefit maximization studies, net benefits are maximized approximately at the 50-year level of protection. The 2 percent or 50-year flood corresponds to a 87 percent risk that will be exceeded one or more times in a 100-year period. Because of the nature of the flood hazard that exists



TYPICAL WOOD POST & BEAM HOUSE
DOOR COVER PANEL
TYPICAL CMU ON SLAB ON GRADE HOUSE
WINDOW COVER PANEL
NEW POSTS, BRACES FOOTINGS & SLATS
NEW CONC. STOOP
NEW STAIRS & LANDING
TYP. RAISED HOUSE (TYPE "A" IMPROVEMENTS)
TYP. COVER PANEL APPLICATION (TYPE "B" IMPROVEMENTS)
EMBEDDED 1/4"x1 1/2" STEEL STRAP W/ THROUGH BOLTS
4x4 POST
4"
24"
18" SQ
TYPICAL NEW FOOTING
ALUMINUM CHANNEL & PLATE
1/2"x1" RUBBER GASKET AT PANEL-WALL INTERFACE
TYP. WELDED ANGLE CLIP W/ TEE HANDLE BOLT ATTACHED TO PANEL, MATED EXPANSION BOLT ANCHOR PRESET IN WALL & FLOOR
WINDOW UNIT
DOOR UNIT
TYPICAL COVER PANELS
WAIMEA RIVER
KAUAI
POTENTIAL IMPROVEMENTS
NON-STRUCTURAL FLOODPROOFING
U.S. ARMY ENGINEER DISTRICT, HONOLULU

FIGURE 7

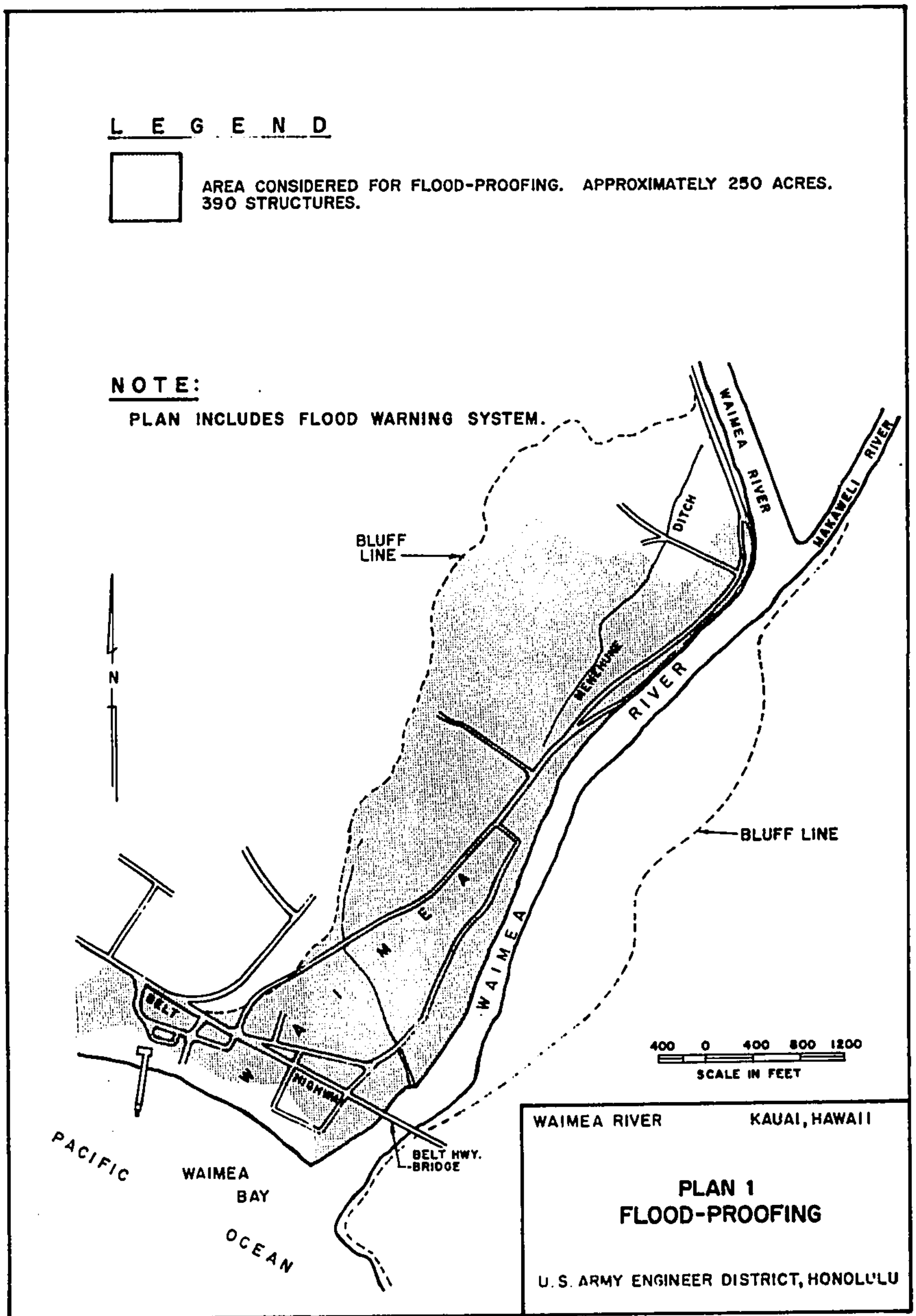

LEGEND
AREA CONSIDERED FOR FLOOD-PROOFING. APPROXIMATELY 250 ACRES. 390 STRUCTURES.
NOTE:
PLAN INCLUDES FLOOD WARNING SYSTEM.
BLUFF LINE
N
WAIMEA RIVER
DITCH
MENEHUNE
RIVER
HANAWELI RIVER
BLUFF LINE
WAIMEA
WAIMEA
BELT HIGHWAY
BELT HWY. BRIDGE
PACIFIC
WAIMEA BAY
OCEAN
400 0 400 800 1200
SCALE IN FEET
WAIMEA RIVER
KAUAI, HAWAII
PLAN 1
FLOOD-PROOFING
U.S. ARMY ENGINEER DISTRICT, HONOLULU

FIGURE 8

in the Waimea basin and the high risk of exceeding the 50-year flood, the 100-year protection level was adopted as an appropriate level of protection for all three alternative plans. It was recognized that alternative structural and nonstructural plans need not afford the same level of protection; however, in view of the benefit maximization studies and with the consideration given to Kauai County ordinances, the 100-year level is considered the minimum acceptance level.

ANALYSIS OF PRELIMINARY PLANS

DESCRIPTION OF PLANS

Flood Proofing (Plan 1). Flood proofing was found to be the only practical nonstructural flood control measure. Within the Waimea River flood plain, there are approximately 48 commercial-type buildings and 351 residential homes. The homes are mostly single wall, wood siding structures posted on footings. Large lateral forces produced by flooding would structurally damage these frame homes by rupturing walls and floors. On this basis, the most practical flood proofing measure for residential homes would be raising the floors to flood-free levels. For commercial buildings flood walls could be provided since most are masonry structures and are subjected to relatively shallow depths of flooding (Figures 7 and 8).

Levee and Channel Improvements (Plan 2 and 3). Two levee and channel plans which would provide structural protection for Waimea were investigated. Under these plans, channel and levee modifications and improvements would be provided from the mouth of Waimea River to the vicinity of Waimea and Makaweli river confluence area, a distance of approximately 7,200 feet. Plan 2 is a levee extension and channel deepening alternative (Figure 9). Plan 3 is a levee extension and floodwall plan (Figure 10). Major improvements common to both plans are a gravity floodgate for interior drainage, and 4,650 feet of toe protection along a major portion of the existing levee. The main components of Plans 2 and 3 are summarized as follows.

Feature	Plan 2	Plan 3
Dredging	278,000 C.Y.	9,100 C.Y.
Levee extension	1,050 ft.	1,575 ft.
Floodwall construction	165 ft.	3,175 ft.
Toe protection	4,650 ft.	4,650 ft.
Interior drainage	Floodgate	Floodgate
Road raise	None	500 ft.

IMPACT ASSESSMENT OF PRELIMINARY PLANS

Flood Proofing (Plan 1). Flood proofing would have the least impact on existing stream habitat. The large number of home owners, along with temporary evacuation during construction and reoccupation would present social as well as economic problems. This would have an adverse visual impact on the aesthetic-architectural characteristics of affected homes and historic buildings, both registered and unregistered. Consistent with the requirements of the Principles and Standards, explicit formulation and consideration of a primarily nonstructural plan as one alternative must be carried through all stages of the planning process. Accordingly, the floodproofing plan was carried into the detailed analysis stage.

Levee and Channel Improvements (Plans 2 and 3). The plans differ with respect to the method of improvement and their impact on factors such as construction costs and area of construction. Plan 2 provides for a lower and shorter levee

ASSESSMENT AND EVALUATION OF DETAILED PLANS

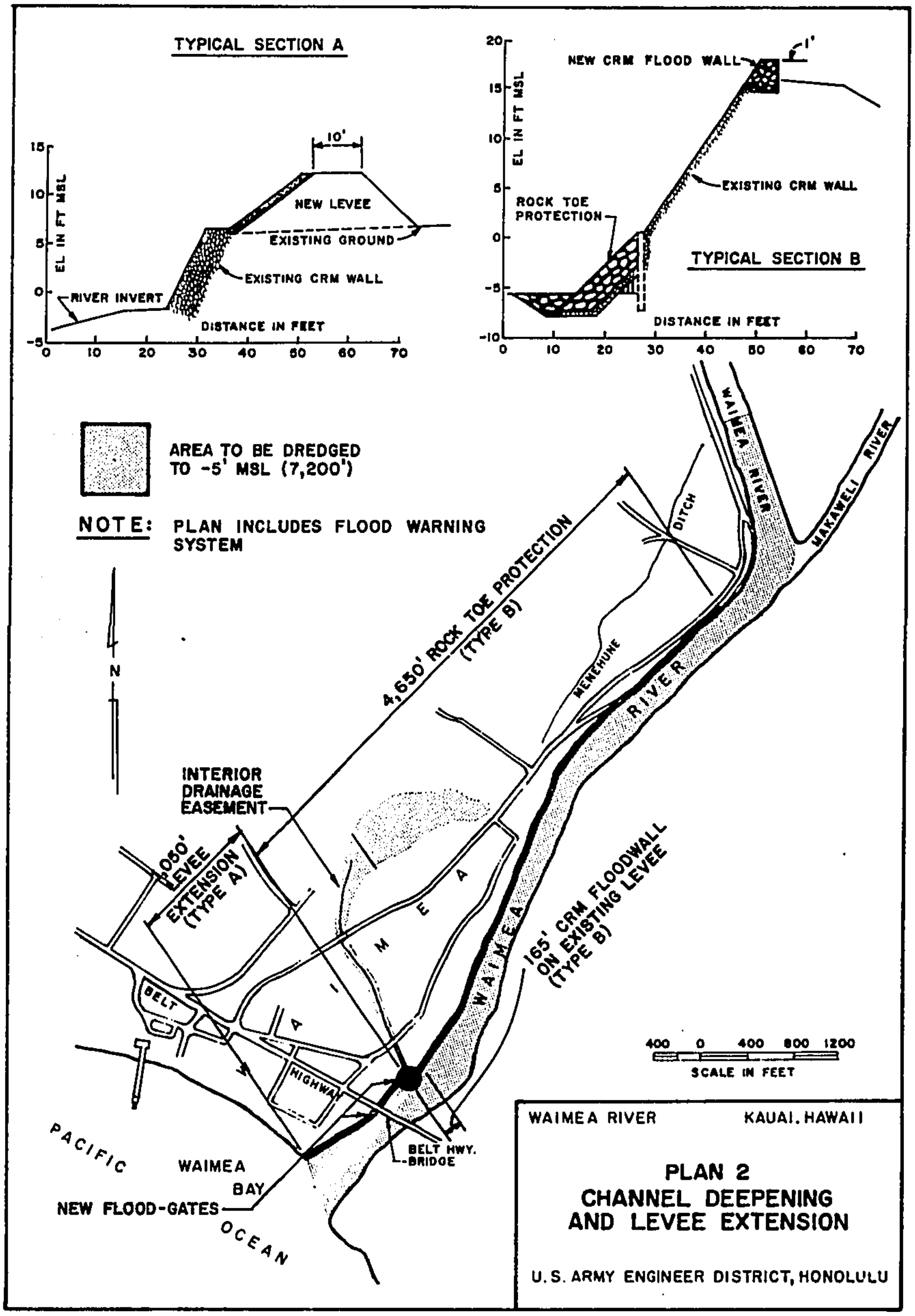
ALTERNATIVES CONSIDERED FURTHER

As a result of the impact assessment and analysis of the preliminary plans, the three plans that could fulfill the need of flood reduction were developed further and analyzed in detail. When compared to the "without project condition," each plan offers an improvement with respect to flood damage mitigation. To provide a basis for choosing the most desirable alternative, studies were conducted to identify, measure, and compare the likely economic, social, and environmental effects of the alternatives. These effects were analyzed and formed the basis for evaluating the beneficial and adverse contributions of each alternative plan.

PLAN 1 - FLOOD PROOFING

The beneficial effects that will result from this plan are reduction of existing flood damages and area redevelopment benefits. Flood proofing of structures would produce flood damage reduction benefits for approximately 250 acres of existing and open lands downstream of the Waimea River confluence. The primary adverse effect associated with various flood proofing measures is the "added on" visual impact on existing structures. Required functional measures and additions could detract from the existing stuctural and architectural appearance. Another beneficial effect would be the preservation of the stream environment since flood control structures or modifications of the existing facilities would not be needed.

Field inspection during the study indicated that a number of the older residential homes are structurally inadequate for flood proofing. Of the homes located within the Waimea floodplain, 51 structures or 22 percent are considered unsound for elevating purposes unless substantial improvements are made prior to or during the flood proofing process. Investigative results for the commercial buildings indicated 26 of the 48 structures are substandard for flood proofing and a more reasonable approach would be to rebuild with flood or waterproofing measures incorporated into the rebuilding process. Increased structure height and related flood proofing measures would create a change from the low profile and quiet atmosphere of Waimea. A summary of the cost-sharing and economics of this alternative is as follows:



WAIMEA RIVER KAUAI, HAWAII

PLAN 2
CHANNEL DEEPENING AND LEVEE EXTENSION

U.S. ARMY ENGINEER DISTRICT, HONOLULU

FIGURE 9

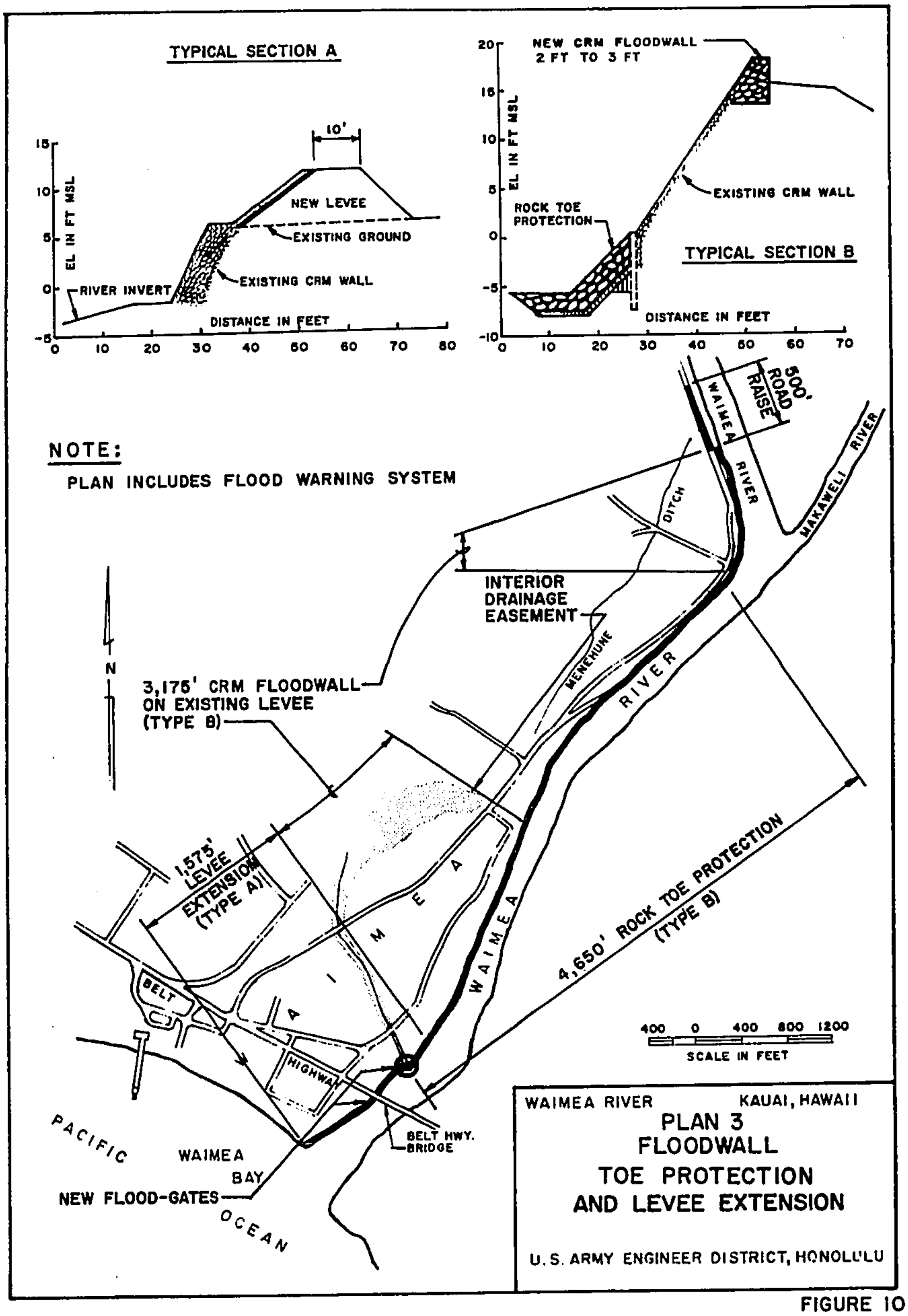

TYPICAL SECTION A
10'
NEW LEVEE
EXISTING GROUND
EXISTING CRM WALL
RIVER INVERT
DISTANCE IN FEET
EL IN FT MSL
NEW CRM FLOODWALL
2 FT TO 3 FT
EXISTING CRM WALL
ROCK TOE
PROTECTION
TYPICAL SECTION B
DISTANCE IN FEET
NOTE:
PLAN INCLUDES FLOOD WARNING SYSTEM
500' ROAD RAISE
WAIMEA RIVER
MAKAWELI RIVER
DITCH
INTERIOR
DRAINAGE
EASEMENT
MENEHUNE
3,175' CRM FLOODWALL
ON EXISTING LEVEE
(TYPE B)
1,575' LEVEE EXTENSION (TYPE A)
WAIMEA
4,650' ROCK TOE PROTECTION
(TYPE B)
BELT HIGHWAY
BELT HWY. BRIDGE
PACIFIC OCEAN
WAIMEA BAY
NEW FLOOD-GATES
400 0 400 800 1200
SCALE IN FEET
WAIMEA RIVER KAUAI, HAWAII
PLAN 3
FLOODWALL
TOE PROTECTION
AND LEVEE EXTENSION
U.S. ARMY ENGINEER DISTRICT, HONOLULU

FIGURE 10

Federal First Cost	$1,853,000 1/
Non-Federal First Cost	$5,147,000
Total Project First Cost	$7,000,000
Average Annual Charges	$ 500,000 2/
Average Annual Benefits	274,000
Benefit to Cost Ratio	0.6

1/ $2 million federal limitation, less $147,000 preauthorization costs.
2/ Includes $1,000 O&M charges for flood warning system.

PLAN 2 - CHANNEL DEEPENING, FLOODWALL AND LEVEE EXTENSION

Nearly all of the 250 acres of floodplain land in Waimea would be flood free due to this plan of improvement. Although the seven acres of ponding area are part of this acreage, the depth of ponding would be less than without the project in that area. Under this plan, only about an acre of river bank land would be required for levee construction. River deepening would destroy or displace some aquatic and estuarine biota. Some riparian vegetation would be destroyed or damaged. However, it is expected that aquatic and estuarine biota will gradually repopulate after the deepening work is completed. Dredging work would also generate water turbidity temporarily during construction, although suitable turbidity control measures would minimize the adverse impacts. The cost-sharing and economic data for Plan 2 are:

Federal First Cost	$1,853,000
Non-Federal First Cost	$3,377,000
Total Project First Cost	$5,230,000
Average Annual Charges	
Interest & Amortization	$ 373,000
Operation, Maintenance & Replacement	28,000
Total Annual Charges	$ 401,000
Average Annual Benefits	$ 278,000
Benefit to Cost Ratio	0.7

PLAN 3 - FLOODWALL AND LEVEE EXTENSION

Except for the dredging work and the floodwall construction, Plans 2 and 3 are very similar. Compared with Plan 2, this plan is environmentally more desirable because, other than excavation or dredging work for the toe protection, dredging of the river would not be required. Because of the lower riverbed created by dredging, the estimated water surface and therefore levee height requirements for Plan 2 would be slightly lower than for Plan 3. However, since wall height increase is accomplished much more economically than dredging, Plan 3 could be implemented at a lower cost. The potential implementation of the CRM floodwall is compatible and would blend in favorably with the existing, grouted riprap levee. The estimated costs, benefits, and benefit to cost ratio are shown as follows:

Federal First Cost	$1,853,000
Non-Federal First Cost	750,000
Total Project First Cost	$2,603,000
Average Annual Charges	
Interest and Amortization	186,000
Operation, Maintenance & Replacement	16,000
Total Annual Charges	$ 202,000
Average Annual Benefits	$ 254,000
Benefit to Cost Ratio	1.3

TRADEOFF ANALYSIS

The economic factors of the three alternative plans were presented in the previous paragraph. Major environmental, social, and economic effects of each alternative plan are summarized in Table 3. The table displays significant contributions, beneficial and adverse, of each plan to aid the tradeoff analysis, which was used to provide a basis for selecting a plan.

As summarized in Table 3, the major monetary beneficial effect that will result from the alternative plans is the reduction of flood damages in the Waimea River drainage basin. With respect to the adverse economic effects, the greatest difference between the plans is the higher project cost for the floodproofing alternative. While the flood proofing alternative requires no land for plan implementation or changes to the existing and future land use, belongings outside of the homes would still be subject to flood damages. The levee and channel alternatives would result in a loss of about one acre of riverbank land along the lower Waimea River. However, the commitment of land for levee construction is viewed as a direct economic enhancement to local interests because it would protect and enhance existing and future facilities.

COMPARISON OF DETAILED PLANS

PLAN COMPARISON

Alternative Plan 1 (Flood proofing) does not alter the existing ecology of Waimea River and correspondingly is least damaging to the environment. The existing natural condition will be retained except homes in the floodplain will be raised above the 100-year flood level. The structural plans (levee and channel) involve temporary degradation of the existing riverine resources and would have adverse visual impacts along the lower west riverbank with the imposition of the new levee. As shown in the referenced table, the plan which contributes most to the objectives of National Economic Development (NED) is Plan 3. Because of their high costs, Plans 1 and 2 do not have net benefits and are economically infeasible.

TABLE 3. SUMMARY COMPARISON AND SYSTEM OF ACCOUNTS

	WITHOUT CONDITION	WITH CONDITI[ONS] PLAN 1 (LED PLAN) FLOODPROOFING	PLAN 2 - CHANNEL DEEPENING, FLOODWALL, TOE PROTECTION, NEW LEVEE	PLAN 3 PROTECT
A. PLAN DESCRIPTION	NO PROJECT.	RAISING STRUCTURES ABOVE THE 100-YEAR FLOOD LEVEL, FLOOD WARNING.	DREDGING 7,200' OF RIVERBED TO A DEPTH OF -5' MSL (278,000 CY). 165' OF FLOODWALL; 4,650' OF TOE PROTECTION. LEVEE EXTENSION. 100-YEAR PROTECTION, FLOOD WARNING.	3,175' TOE PRO LEVEE E PROTECT
B. SIGNIFICANT IMPACTS AND PLAN RELATIONSHIPS TO NATIONAL ACCOUNTS				
1. ECONOMIC (NED)				
a. PROPERTY VALUES	INCREASING AT PREVAILING REAL ESTATE MARKET RATE.	SAME AS WITHOUT CONDITION. (2, 6, 8, 9)	SAME AS PLAN 1.	SAME AS
b. PUBLIC FACILITIES AND SERVICES	DAMAGES TO FACILITIES AND INTERRUPTION OF SERVICES DURING FLOODING.	INTERRUPTION OF SERVICES DURING FLOODING. (2, 5, 8, 9)	SAME AS PLAN 1.	SAME AS
c. DESIRED REGIONAL GROWTH	ADVERSE EFFECT IN FLOODPLAIN.	BENEFICIAL IMPACT IN FLOODPLAIN. (2, 6, 8, 9)	GREATER IMPACT THAN PLAN 1. (2, 6, 8, 9)	SAME AS
d. BUSINESS/INDUSTRIAL ACTIVITIES	DISRUPTION DURING FLOODING.	DISRUPTION DURING FLOODING DUE TO FLOODED ROAD ACCESS. (2, 6, 7, 9)	MINIMAL DISRUPTION DURING FLOODING. (2, 6, 7, 9)	SAME AS
e. FARM ACTIVITY	DISRUPTION DURING FLOODING.	DISRUPTION DURING FLOODING. (2, 6, 7, 9)	SAME AS WITHOUT.	SAME AS
f. QUANTITATIVE ANALYSIS				
(1) BENEFICIAL IMPACTS ($000)				
(a) REDUCTION IN FLOOD DAMAGES	0	221	261	
(b) EDA BENEFITS	0	53	17	
(c) TOTAL NED BENEFITS	0	274	278	
(2) ADVERSE IMPACTS ($000)				
(a) LOCAL - FIRST COST		5,147	3,377	
(b) REST OF THE NATION - FIRST COST		1,853	1,853	1
(c) ANNUAL O&M (LOCAL)		1	28	
(d) TOTAL ANNUAL COSTS (7-1/8%, 100-YEAR LIFE)		499	401	
(3) NET NED BENEFITS ($000)				
(a) LOCAL (ASSUME ALL BENEFITS ACCRUE TO LOCAL)		-94	9	
(b) NATION		-132	-132	
(c) NET NED BENEFITS		-226	-123	
(4) B/C RATIO		0.6	0.7	
2. ENVIRONMENTAL (EQ)				
a. TERRESTRIAL ENVIRONMENT	INSIGNIFICANT CHANGE.	SOME DAMAGE TO SOME COMMON FLORA. (1, 6, 9)	SAME AS PLAN 1.	SAME A
*b. AQUATIC	INSIGNIFICANT CHANGE.	NO SIGNIFICANT IMPACT.	DESTRUCTION OF ANY BENTHIC BIOTA WITHIN THE 6-ACRE PROJECT AREA FROM DREDGING. DESTRUCTION OF 1.3 ACRES OF BENTHIC HABITAT BY EXCAVATION FOR TOE PROTECTION; PROVISION OF 1.3 ACRES OF NEW ROCKYHABITAT FROM CONSTRUCTION OF TOE PROTECTION. (1, 6, 9)	DESTRU HABITA PROTEC BIOTA SION O HABITA PROTEC
*c. MARINE ENVIRONMENT	INSIGNIFICANT CHANGE.	NO SIGNIFICANT IMPACT.	DEGRADATION DUE TO TURBID WATER DISCHARGE. (1, 6, 9)	SAME A
d. ENDANGERED SPECIES	INSIGNIFICANT CHANGE.	NO SIGNIFICANT IMPACT.	SAME AS PLAN 1.	SAME A
*e. AIR AND WATER QUALITY	INSIGNIFICANT CHANGE.	NO SIGNIFICANT IMPACT.	TEMPORARY TURBIDITY AND SUSPENDED SEDIMENTS DURING CONSTRUCTION. (1, 6, 9)	SAME A
f. HISTORIC	NO IMPACT.	NO IMPACT.	NO ADVERSE EFFECT ON CAPT COOK MONUMENT (2, 6, 9) BOULDER MONUMENT TEMPORARILY MOVED DURING CONSTRUCTION (1, 6, 9). NO EFFECT ON PEEKAUAI (MENEHUNE) DITCH.	SAME A
*g. RECREATION	INSIGNIFICANT CHANGE.	NO SIGNIFICANT IMPACT.	SOME INTERRUPTION IN RECREATIONAL FISHING DURING CONSTRUCTION. DECREASE OF PARK LAND & FACILITIES. (1, 6, 9)	SAME A ADVER

W I T H   C O N D I T I O N

PLAN 2 - CHANNEL DEEPENING, FLOODWALL, TOE PROTECTION, NEW LEVEE	PLAN 3 - (NED) FLOODWALL, TOE PROTECTION, NEW LEVEE	500-YR PLAN - FLOODWALL, TOE PROTECTION, NEW LEVEE	SPF PLAN - FLOODWALL, TOE PROTECTION NEW LEVEE
DREDGING 7,200' OF RIVERBED TO A DEPTH OF -5' MSL (278,000 CY). 165' OF FLOODWALL; 4,650' OF TOE PROTECTION. LEVEE EXTENSION. 100-YEAR PROTECTION, FLOOD WARNING.	3,175' OF FLOODWALL; 4,650' OF TOE PROTECTION, RAISING ROAD, LEVEE EXTENSION. 100-YEAR PROTECTION, FLOOD WARNING.	5,679' NEW FLOODWALL; 4,650' OF TOE PROTECTION, RAISING ROAD, LEVEE EXTENSION. 500-YEAR PROTECTION, FLOOD WARNING.	5,675' NEW FLOODWALL; 4,650' OF TOE PROTECTION, RAISING ROAD, LEVEE EXTENSION, SPF PROTECTION, FLOOD WARNING.
SAME AS PLAN 1.	SAME AS PLAN 1.	SAME AS PLAN 1.	SAME AS PLAN 1.
SAME AS PLAN 1.	SAME AS PLAN 1.	SAME AS PLAN 1.	SAME AS PLAN 1.
GREATER IMPACT THAN PLAN 1. (2, 6, 8, 9)	SAME AS PLAN 2.	SAME AS PLAN 2.	SAME AS PLAN 2.
MINIMAL DISRUPTION DURING FLOODING. (2, 6, 7, 9)	SAME AS PLAN 2.	SAME AS PLAN 2.	SAME AS PLAN 2.
SAME AS WITHOUT.	SAME AS WITHOUT.	SAME AS WITHOUT.	SAME AS WITHOUT.
261	239	314	325
17	15	26	33½
278	254	340	358
3,377	750	2,247	2,747
1,853	1,853	1,853	1,853
28	16	22	23
401	202	314	351
9	184	158	139
-132	-132	-132	-132
-123	52	26	7
0.7	1.3	1.08	1.02
SAME AS PLAN 1.	SAME AS PLAN 1.	SAME AS PLAN 1.	SAME AS PLAN 1.
DESTRUCTION OF ANY BENTHIC BIOTA WITHIN THE 6-ACRE PROJECT AREA FROM DREDGING. DESTRUCTION OF 1.3 ACRES OF BENTHIC HABITAT BY EXCAVATION FOR TOE PROTECTION; PROVISION OF 1.3 ACRES OF NEW ROCKY HABITAT FROM CONSTRUCTION OF TOE PROTECTION. (1, 6, 9)	DESTRUCTION OF 1.3 ACRES OF BENTHIC HABITAT BY EXCAVATION FOR TOE PROTECTION; DESTRUCTION OF ANY BENTHIC BIOTA WITHIN THE ABOVE AREA; PROVISION OF 1.3 ACRES OF NEW ROCKY HABITAT FROM CONSTRUCTION OF TOE PROTECTION. (1, 6, 9)	SAME AS PLAN 3.	SAME AS PLAN 3.
DEGRADATION DUE TO TURBID WATER DISCHARGE. (1, 6, 9)	SAME AS PLAN 2.	SAME AS PLAN 2.	SAME AS PLAN 2.
SAME AS PLAN 1.	SAME AS PLAN 1.	SAME AS PLAN 1.	SAME AS PLAN 1.
TEMPORARY TURBIDITY AND SUSPENDED SEDIMENTS DURING CONSTRUCTION. (1, 6, 9)	SAME AS PLAN 2.	SAME AS PLAN 2.	SAME AS PLAN 2.
NO ADVERSE EFFECT ON CAPT COOK MONUMENT (2, 6, 9) BOULDER MONUMENT TEMPORARILY MOVED DURING CONSTRUCTION (1, 6, 9). NO EFFECT ON PEEKAUAI (MENEHUNE) DITCH.	SAME AS PLAN 2.	SAME AS PLAN 2.	SAME AS PLAN 2.
SOME INTERRUPTION IN RECREATIONAL FISHING DURING CONSTRUCTION. DECREASE OF PARK LAND & FACILITIES. (1, 6, 9)	SAME AS PLAN 2. GREATER ADVERSE EFFECT ON PARK.	SAME AS PLAN 3.	SAME AS PLAN 3.

TABLE 8
SUMMARY COMPARISON
AND
SYSTEM OF ACCOUNTS

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TABLE 3. SUMMARY COMPARISON AND SYSTEM OF ACCOUNTS (CONT'D)

	WITHOUT CONDITION	WITH CONDI[TION]		
		PLAN 1 (LED) PLAN FLOODPROOFING	PLAN 2 - CHANNEL DEEPENING, FLOODWALL, TOE PROTECTION, NEW LEVEE	PLAN 3 - (NED) PROTECTION, N[...]
3. SOCIAL (SWB)				
*a. HEALTH, SAFETY, & COMMUNITY WELL-BEING	DEGRADED DURING AND AFTER FLOODING.	FLOOD-RELATED HEALTH AND SAFETY PROBLEMS WOULD CONTINUE. (2, 6, 8, 9)	HEALTH, SAFETY, AND COMMUNITY WELL-BEING ENHANCED. (2, 6, 9)	SAME AS PL[...]
*b. AESTHETIC VALUES	DEGRADATION OF LAND AND WATER QUALITY DURING AND AFTER FLOODING.	NEW VISUAL ELEMENTS ADDED CHANGING AESTHETIC CHARACTER OF AREA. (2, 6, 9)	IMPOSITION OF NEW LEVEE ON EXISTING VISTAS. (2, 6, 9)	OF GREATER [...] PLAN 2.
*c. AIR AND NOISE POLLUTION.	INSIGNIFICANT CHANGE.	TEMPORARY DURING CONSTRUCTION. (1, 6, 9)	SAME AS PLAN 1.	SAME AS PL[...]
*d. DISPLACEMENT	DISPLACEMENT OF FAMILIES IN FLOODPLAIN DURING FLOOD.	TEMPORARY DISPLACEMENT OF RESIDENTS. (1, 5, 10)	ONE HOUSE DISPLACED. (1, 6, 9)	SAME AS PL[...]
*e. COMMUNITY COHESION	DEGRADED DUE TO FLOODING.	NO SIGNIFICANT EFFECT. (2, 6, 9)	SAME AS PLAN 1.	SAME AS PL[...]
4. REGIONAL DEVELOPMENT (COMMUNITY GROWTH)	ADVERSE EFFECT ON DEVELOPMENT WITHIN FLOODPLAIN.	IN CONFORMANCE WITH REGIONAL DEVELOPMENT PLAN. (2, 5, 8, 9)	SAME AS PLAN 1.	SAME AS PL[...]
C. PLAN EVALUATION				
1. CONTRIBUTION TO PLANNING OBJECTIVES				
a. CONTRIBUTE TO THE LOWER WAIMEA RIVER DRAINAGE BASIN FOR FLOOD MITIGATION DURING THE 1985-2085 PERIOD OF ANALYSIS.	CONTINUED FLOODING AND FLOOD DAMAGES.	REDUCTION IN FLOOD DAMAGES TO RESIDENTIAL, COMMERCIAL STRUCTURES.	SAME AS PLAN 1. EXCEPT DAMAGES TO UTILITIES AND LOW LYING PROPERTY REDUCED.	SAME AS PL[...]
b. WHEN POSSIBLE, PRESERVE OR ENHANCE THE EXISTING ENVIRONMENTAL RESOURCES WITHIN THE LOWER WAIMEA DRAINAGE BASIN	*NO CONTRIBUTION*	*MOST ENVIRONMENTAL RESOURCES WOULD BE PRESERVED.*	LESS ENVIRONMENTAL RESOUCES WOULD BE PRESERVED THAN PLAN 3. CAPT COOK MONUMENT WOULD BE PROTECTED BUT WOULD REQUIRE MOVING DURING CONSTRUCTION.	LESS ENVIRON[...] BE PRESERVED [...] REGARDING CA[...]
2. RESPONSE TO ASSOCIATED EVALUATION CRITERIA				
a. ACCEPTABILITY	N/A	UNACCEPTABLE.	ACCEPTABLE.	ACCEPTABLE.
b. COMPLETENESS	N/A	COMPLETE	COMPLETE	CCOMPLETE
c. EFFECTIVENESS	N/A	MODERATELY HIGH	HIGH	HIGH
d. EFFICIENCY	N/A	MODERATE	HIGH	HIGH
e. CERTAINTY	N/A	MODERATE	HIGH	HIGH
f. NED B/C RATIO	N/A	0.6	0.7	1.3
g. REVERSIBILITY	N/A	MODERATE	LOW	LOW
h. STABILITY	N/A	LOW	MODERATE	MODERATE
3. RANKING OF PLAN CONTRIBUTIONS				
a. NED		5	4	1
b. EQ		1	3	2
c. SWB		5	3	4
d. RD		ALL FIVE ALTERNATIVES ARE IN CONFORMANCE WITH LOCAL REGIONAL DEVELOPMENT PLAN.		
D. IMPLEMENTATION RESPONSIBILITY	N/A	CORPS OF ENGINEERS/COUNTY OF KAUAI	SAME AS PLAN 1.	SAME AS PLAN [...]

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)

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.

ACUTALITY
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.

W I T H C O N D I T I O N			
- CHANNEL DEEPENING, FLOODWALL, OTECTION, NEW LEVEE	PLAN 3 - (NED) FLOODWALL, TOE PROTECTION, NEW LEVEE	500-YR PLAN - FLOODWALL, TOE PROTECTION, NEW LEVEE	SPF PLAN - FLOODWALL, TOE PROTECTION, NEW LEVEE
ALTH, SAFETY, AND COMMUNITY WELL-ING ENHANCED. (2, 6, 9)	SAME AS PLAN 2.	ENHANCED SAFETY UP TO 500-YEAR LEVEL OF PROTECTION.	ENHANCED SAFETY UP TO SPF LEVEL OF PROTECTION.
POSITION OF NEW LEVEE ON EXISTING STAS. (2, 6, 9)	OF GREATER ADVERSE DEGREE THAN PLAN 2.	SIMILAR TO PLAN 2 EXCEPT ADDITIONAL ADVERSE VISUAL IMPACT OF CONCRETE "I" WALL.	SIMILAR TO PLAN 2 EXCEPT ADDITIONAL ADVERSE VISUAL IMPACT OF CONCRETE "I" WALL.
ME AS PLAN 1.	SAME AS PLAN 1.	SAME AS PLAN 1.	SAME AS PLAN 1.
E HOUSE DISPLACED. (1, 6, 9)	SAME AS PLAN 1.	SAME AS PLAN 1.	SAME AS PLAN 1.
ME AS PLAN 1.	SAME AS PLAN 1.	SAME AS PLAN 1.	SAME AS PLAN 1.
ME AS PLAN 1.	SAME AS PLAN 1.	SAME AS PLAN 1.	SAME AS PLAN 1.
ME AS PLAN 1. EXCEPT DAMAGES TO ILITIES AND LOW LYING PROPERTY DUCED.	SAME AS PLAN 2.	SAME AS PLAN 2.	SAME AS PLAN 2.
ENVIRONMENTAL RESOUCES WOULD BE RVED THAN PLAN 3. CAPT COOK MONU- WOULD BE PROTECTED BUT WOULD IRE MOVING DURING CONSTRUC-	LESS ENVIRONMENTAL RESOURCES WOULD BE PRESERVED THAN PLAN 1. SAME REGARDING CAPT COOK MONUMENT.	SAME AS PLAN 3.	SAME AS PLAN 3.
TABLE.	ACCEPTABLE.	UNACCEPTABLE.	UNACCEPTABLE.
LETE	CCOMPLETE	COMPLETE	COMPLETE
	HIGH	HIGH	HIGH
	HIGH	HIGH	HIGH
	HIGH	HIGH	HIGH
	1.3	1.08	1.02
	LOW	LOW	LOW
ATE	MODERATE	MODERATE	MODERATE
	1	2	3
	2	4	5
	4	2	1
ANCE WITH LOCAL REGIONAL DEVELOPMENT PLAN.			
AS PLAN 1.	SAME AS PLAN 1.	SAME AS PLAN 1.	SAME AS PLAN 1.

TABLE 3 (CONT'D)
SUMMARY COMPARISON
AND
SYSTEM OF ACCOUNTS

The contribution to the Social Well-Being (SWB) account would be highest for Plan 2. Plan 2 would eliminate much of the flood-related health and safety problems of Plan 1, while maintaining a lower levee and floodwall profile than Plan 3. From the Regional Development (RD) point of view, all three plans are in conformance with local plans.

DESIGNATION OF NED PLAN

A National Economic Development (NED) plan addresses the planning objectives in the way which maximizes net economic benefits. Plan 3 has the lowest construction cost along with net benefits of $52,000. Based on this, alternative Plan 3 is designated the NED plan.

DESIGNATION OF EQ PLAN

None of the plans resulted in a net positive environmental contribution. Consequently, it is not possible to designate an EQ plan. However, Plan 1 is considered to best meet the environmental quality aspects by preserving open space and causing least damages to the natural environment. Therefore, Plan 1 is designated the Least Environmentally Damaging (LED) Plan.

THE SELECTED PLAN

The selection of the most desirable plan of improvement involved comparison and tradeoffs among the alternative plans. Ranking of the alternative plans was performed on the basis of (1) beneficial and adverse effects of each alternative; (2) relative contribution to the planning objectives; and (3) response to associated evaluation criteria as listed in Table 3. A key criterion pertinent to the analysis was that Plan 3 is the only economically justified plan among the three alternatives analyzed, in that total beneficial contributions exceeded total adverse contributions. There are no overriding environmental contributions to make up or overcome the deficiency of NED benefits for Plans 1 and 2. Based on the comments received during coordination of the alternative plans with federal, State, and county agencies, and during the public meeting on 8 November 1979, Plan 3 appeared to be the plan which was most desirable and responsive to the planning objectives. Plan 3 was also discussed as the tentatively selected plan during the late stage public meeting which was held in Waimea on 28 February 1980. In view of its cost-effectiveness, comments received during coordination, and opinions expressed during the 28 February 1980 public meeting, Plan 3 was selected for implementation.

FUNCTIONAL ELEMENTS

The recommended plan consists of levee and channel improvements as shown on Plates 1 and 2. The proposed levee would extend downstream from the existing levee to the coastline area, a distance of about 1,600 feet. Channel improvements would consist of about 3,200 feet of CRM floodwall on the existing levee in two segments, and toe protection of 4,650 feet for the existing levee. For interior drainage improvements, two new flood gates and a 7-acre drainage easement would be provided. At the upstream limit, a 500-foot roadway reach would be modified to be compatible with the CRM floodwall construction and meet hydraulic requirements. The design discharge is 64,000 cubic feet per second, which is the estimated peak discharge under the 100-year flood flow conditions.

In addition to the structural improvements shown on the General Plan, Plate 1, an early flood warning system would be provided as part of the overall plan. The warning system will basically consist of three stream gaging and three rain gaging stations, and a receiving and monitoring station to be located in Honolulu. The gaging stations are shown on Plate C-20. To provide advance warning of high rainfall, the rain gages will be located in the upper drainage tributaries to triangulate the Waimea and Makaweli watersheds, with the lower rain gage to be placed near the divide between the Waimea and Makaweli basins.

The stream gages are considered the primary flood warning stations; however, correlation between the river stages and rainfall intensities during operation could provide the basis for river flow projections with rainfall data. It is estimated that for a 100-year runoff, the flood travel time to cover the 2.6 miles from the stream gages to the confluence would take approximately 20 minutes. Actual warning time would increase by setting the system to warn at a lower river stage such as the 50-year flow elevation. The rainfall and streamflow gages, accompanying data collection platforms (DCP) and Kauai island systems will be operated and maintained by local interests. The telecommunications system would include the satellite, transmission stations, receiving station, and data storage which will be operated by the U.S. Geological Survey and the National Oceanic and Atmospheric Administration.

Finally, the selected plan requires a regulated floodplain areas by local interests. The two areas are the internal drainage ponding area and the riverine floodway opposite Waimea town. The ponding area, totaling approximately 11 acres, will include lands upstream of the gate structure up to elevation +5 (msl). In addition, the use of lands on the opposite side of the levee improvements will remain consistent with the flood hazards. These agricultural lands, consist of approximately 52 acres and lie between the existing river banks and elevation +20 (msl).

PLAN ACCOMPLISHMENTS

The recommended plan would provide protection from floods up to the one percent flood (100-year). As an added protective measure, the warning system would further minimize the threat to life associated with floods. The Waimea floodplain without flood control improvements is shown on Figure 8. Based on current development trends, future development of vacant flood-prone lands is likely to take place with or without flood protection. The realization of inundation reduction benefits from implementation of the recommended plan, estimated at $239,000 annually, is broad in terms of interests and beneficiaries. There are no large individual beneficiaries.

POLICY ON STANDARD PROJECT FLOOD PROTECTION (SPF) AND 500-YEAR PROTECTION

With the early flood warning system and on the assumption that exceedance of the design flow would not endanger human lives, no consideration was given to the standard project flood protection level. However, in compliance with engineering regulations, a detailed plan with protection against the SPF is presented in Figure 11. The dominating features of the SPF plan would be the 8 to 11-foot concrete "I" wall to be constructed on top of the existing levee. This plan costs an estimated $4.6 million. The average annual benefits and costs are $358,000 and $351,000, respectively. The benefit to cost ratio is 1.02.

Similarly, in accordance to the U.S. Water Resources Council's rules and regulation regarding urban flood damage reduction measures, the 500-year plan was evaluated. The features would be similar to the SPF Plan except the concrete "I" wall would vary in height from 4 to 7 feet. The project first cost is an estimated $4.1 million. The average annual benefits and costs are $340,000 and $314,000, respectively. The benefit-to-cost ratio is 1.08.

Potential Damage Resulting from 500-Year Flood and SPF Events. In accordance with WRC and Corps guidelines, analyses of 500-year flood and SPF events under "with project" conditions are required. The detailed technical analyses are contained in Appendices A (Hydrology), B (Geology and Soils), C (Engineering Investigations and Design), and D (Economics). In both extreme flood events, the levee would be overtopped and waters would inundate Waimea town as well as flood the unprotected left bank agricultural area. The floodwaters originating from the river are expected to gradually pond in the lowest lying areas and flow with the natural ground gradient. The expected duration of overtopping would be approximately 2.5 hours and the actual flooding condition is expected to last approximately 8 hours. The drawdown and depletion of flooding will depend on the natural infiltration/evaporation processes and the capacity of internal drainageways.

On the unprotected left bank area, the depths would vary between 11 to 13 feet for both major floods depending on location. The existing sugar crops would not suffer any flood damages except following harvest when the bare ground would be subject to erosion.

The inundation in upper Waimea town would vary between 10 to 13 feet under the 500-Year and SPF events. Depending upon the actual location and height of the structure, the damaging depths would generally vary between 8 to 11 feet. Due to the flat gradient of the land, the average velocities would be low, on the order of 1 to 2-1/2 feet per second. The average annual residual damages would total $21,200 and $9,900, respectively, for the 500-Year and SPF events.

The physical effect of the extreme 500-Year and SPF events on the levee would be progressive erosion on the town side of the levee and floodwall. The most susceptible location would be the 2- to 3-foot high CRM floodwall between Stations 61+00 to 72+00. The cascading floodwaters would tend to gradually undermine the floodwall base. Similar, although less severe erosion would occur at other levee locations. Embankment repairs would be necessary following major floods.

EFFECTS OF THE PLAN ON THE ENVIRONMENT

Historic Resources. The Captain Cook Landing Site marker will require temporary relocation; however, in coordination with the State Historic Preservation Officer, this action has been determined not to have an adverse effect on this National Landmark. The recommended plan will require the raising of a local road in the vicinity of Peekauai (Menehune) Ditch. The raising of the road will not have any effect on known or possible original portions of the ditch. Documentation of Effect and documentation relating to a request for a determination of National Register eligibility for the linear prehistoric and historic ditch are being coordinated with the appropriate state and Federal agencies.

Wildlife Resources. The benthic biota within the area dredged for the toe protection foundation will be destroyed. The rock toe will provide habitat suitable for colonization by some demersal species. Some common riparian plants will be destroyed during construction and will probably recover rapidly after completion of the project. Between the Kaumualii (Belt) Highway Bridge and Lucy Wright Park, eight common ornamental trees will be removed in the area of the new levee and transplanted in the same general area. None of the project alternatives would affect any Federal or state designated wildlife refuge, marine sanctuary, wetland or natural area reserve, nor would it affect any Federal or state designated, threatened or endangered species or their habitats.

Visual Concerns. During construction some turbidity would be generated during dredging activities and may temporarily degrade the appearance of river waters. The floodwall would impose a new visual element atop the existing levee; however, views from nearby residences are already obstructed by the existing levee. The new levee would superimpose a larger element atop the existing revetment and would partially obstruct views of the landscape, and Russian Fort across the river.

Recreational Resources. During construction of the project certain areas normally used by recreational fishermen may be temporarily precluded from use. Fishermen may be forced to temporarily seek other publicly accessible fishing areas during construction. The completed new levee will provide a permanent platform for use by recreational and subsistence fishermen. Portions of Lucy Wright Park will be displaced by the new levee.

Water Quality. Dredging for the toe wall foundation would generate localized water turbidity temporarily exceeding state water quality standards. Construction-generated turbidity will probably be significantly less than natural turbidity caused by large storm runoff in the Waimea River.

Socio-Economic and Land-Use Effects. The plan would protect life and property and enhance the well-being of residents living within the river floodplain. One residence, one-half of a duplex, located just upstream of the bridge, would be demolished and the residents would have to be permanently relocated. Property values, especially those near the river, could increase. Greater community/regional growth within the floodplain could occur due to the added level of protection. As a result of a decrease in frequency and depth of ponding, there should be significantly less structural damage, a decrease in safety hazards and in nuisance levels. The flowage easement may have a restrictive effect on future development within the ponding area since no fill would be allowed in this area.

PLAN IMPLEMENTATION AND PUBLIC VIEWS

IMPLEMENTATION RESPONSIBILITIES

The responsibilities of Federal and non-Federal interests for the recommended plan include the design, construction, financing, and operation and maintenance.

FEDERAL

The Federal government would design, prepare detailed plans for and construct the levee, channel improvements, and the flood warning system. Construction of the project would be contingent on approval by the Chief of Engineers, appropriation of funds, and on the receipt of a formal agreement on local cooperation and non-Federal cost-sharing. The presently estimated Federal share of the total project first cost is $1,853,000, excluding pre-authorization study costs.

NON-FEDERAL

Federal participation in the construction of the proposed project will be subject to conditions that local interests would:

a. Provide without cost to the United States all lands, easements, rights-of-way necessary for the construction and subsequent maintenance of the project;

b. Hold and save the United States free from damages due to the construction and maintenance of the project, excluding damages due to the fault or negligence of the United States or its contractors;

c. Maintain and operate all the work including flood warning systems on Kauai after completion in accordance with regulations prescribed by the Secretary of the Army;

d. Provide without cost to the United States all relocations or alterations of buildings, utilities, highway bridges, sewers, and other structures and improvements;

e. Prescribe and enforce regulations to prevent obstruction on the channels, the interior ponding area up to elevation 5 feet MSL, and the lands opposite the levee on the eastern overbank between the river and elevation 20 feet MSL, which would reduce their flood carrying capacity or hinder maintenance and operations.

f. At least annually inform affected interests regarding the limitations of the protection afforded by the project.

g. Provide contributions for the flood warning system equal to 20 percent of the first cost allocated to these measures; and

h. Assume all costs in excess of the $2 million Federal limitation for the channel improvements and related work.

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i. Fulfill such requirements of non-Federal cooperation as may be required by the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (PL 91-646).

The County of Kauai has assured that they will comply with the local cooperation requirements for the project, and pertinent correspondence is included in Appendix F. Formal assurances required by Section 221 of the 1970 Flood Control Act will be obtained prior to advertising for construction.

PUBLIC VIEWS

Public meetings, informal discussions with government agencies, and a workshop were conducted during the study to maintain coordination and obtain views and input from Federal and non-Federal interests. Prior to the 8 November 1979 public meeting on plan formulation, the draft report document was circulated to the following Federal, State and County agencies for formal review and comments:

a. U.S. Government Agencies
   - Members of Congress, Hawaii
   - Advisory Council on Historic Preservation
   - Department of Agriculture
   - Department of Commerce
   - Department of Defense
   - Environmental Protection Agency
   - Department of Health, Education and Welfare
   - Department of Housing and Urban Development
   - Department of Transportation
   - Department of the Interior

b. State of Hawaii
   - Governor of Hawaii
   - Department of Social Services & Housing
   - Department of Education
   - Department of Accounting and General Services
   - Department of Defense
   - Department of Transportation
   - Department of Health
   - Department of Land and Natural Resources
   - Department of Planning and Economic Development
   - Department of Agriculture
   - Environmental Center, University of Hawaii
   - Water Resources Research Center, University of Hawaii
   - State Historic Preservation Officer
   - Office of Environmental Quality Control

c. County of Kauai
   - Mayor of Kauai
   - Kauai County Council
   - Department of Water Supply
   - Department of Public Works

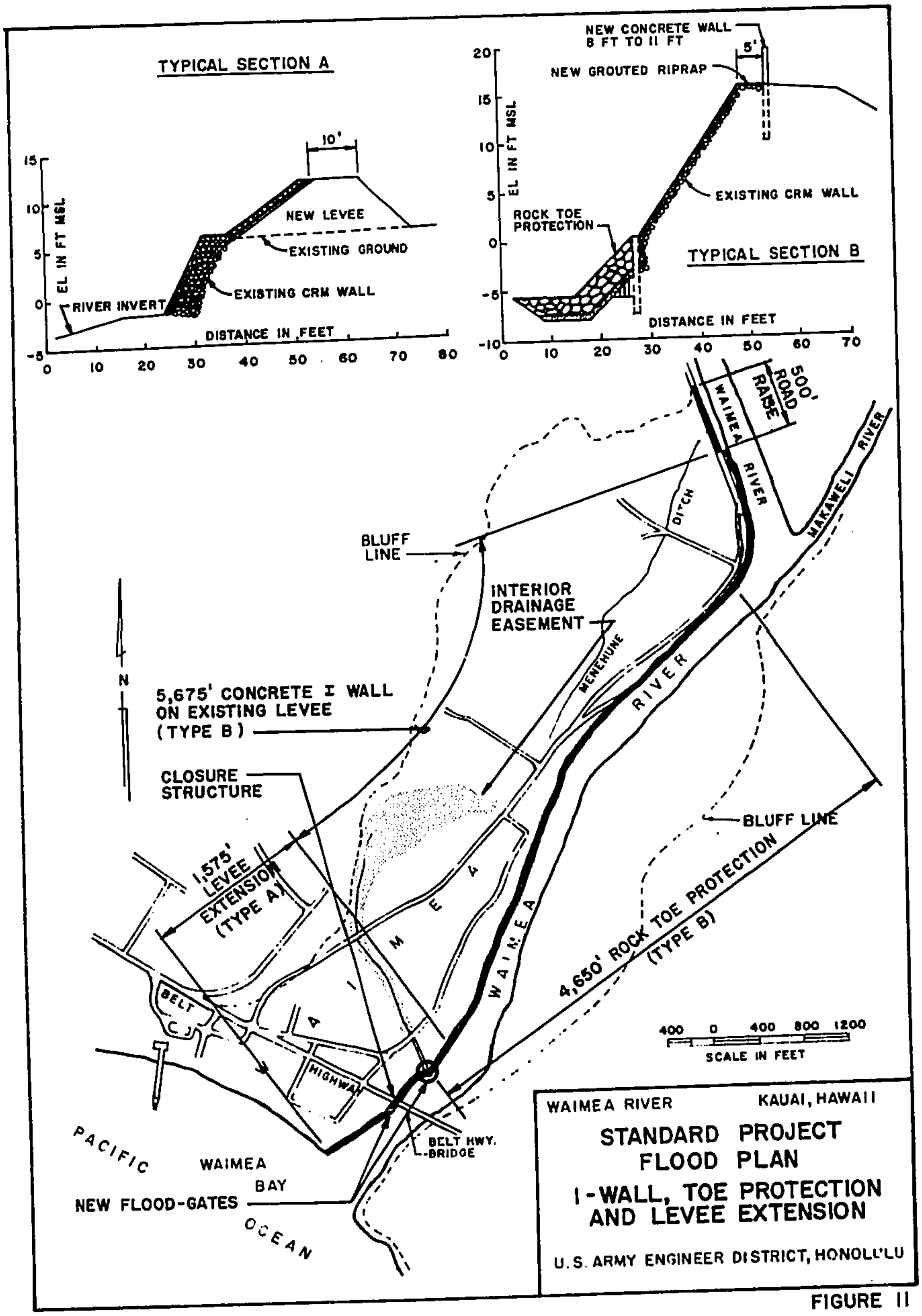

TYPICAL SECTION A
10'
NEW LEVEE
EXISTING GROUND
EXISTING CRM WALL
RIVER INVERT
EL IN FT MSL
DISTANCE IN FEET
NEW CONCRETE WALL
8 FT TO 11 FT
5'
NEW GROUTED RIPRAP
EXISTING CRM WALL
ROCK TOE PROTECTION
TYPICAL SECTION B
DISTANCE IN FEET
500' ROAD RAISE
WAIMEA RIVER
HAKAWELI RIVER
DITCH
BLUFF LINE
INTERIOR DRAINAGE EASEMENT
MENEHUNE
RIVER
N
5,675' CONCRETE I WALL ON EXISTING LEVEE (TYPE B)
CLOSURE STRUCTURE
BLUFF LINE
1,575' LEVEE EXTENSION (TYPE A)
WAIMEA
4,650' ROCK TOE PROTECTION (TYPE B)
WAIMEA
BELT HIGHWAY
SCALE IN FEET
PACIFIC OCEAN
WAIMEA BAY
NEW FLOOD-GATES
BELT HWY. BRIDGE
WAIMEA RIVER KAUAI, HAWAII
STANDARD PROJECT FLOOD PLAN
I-WALL, TOE PROTECTION AND LEVEE EXTENSION
U.S. ARMY ENGINEER DISTRICT, HONOLULU

FIGURE 11

Department of Parks and Recreation
Department of Planning
Office of Economic Development
Public Information Officer
Kauai Community College

Public views expressed at the workshop and public meetings, correspondence received during report coordination, and pertinent Corps of Engineers responses are presented in Appendix F - Public Involvement.

The draft report coordination with government agencies surfaced information, concerns and desires related to the respective agencies' jurisdiction and expertise. The comments received included a statement from the Advisory Council on Historic Preservation that determinations of effect on historic and cultural properties are to be done in consultation with the State Historic Preservation Officer (SHPO). The Environmental Protection Agency recommended implementation of the flood-proofing alternative since it is the least environmentally damaging plan; however, they further noted that if a structural alternative is necessary due to other considerations, Plan 3 would be more desirable than Plan 2. Support for Plan 3 was also received from the National Marine Fisheries Service, Department of Commerce. The Department of the Interior noted that the study should address the potential impact of dredged, spoil disposal, and that considerations be given to the sandbar removal to reduce flooding hazards and to minimization of damages to aquatic habitat from sedimentation. The Department of the Interior further commented that levee construction in the Lucy Wright Park will necessitate a request for possible land use conversion, which requires approval from the Director, Heritage Conservation and Recreation Service.

The SHPO agreed that none of the Advisory Council's "Criteria of Adverse Effect" apply to the project necessity of relocating the Cook Landing Site Memorial. On the Peekauai "Menehune" Ditch, the SHPO feels that the ditch may be eligible for the National Register and appropriate Federal regulations should be followed. The Division of Fish and Game, Department of Land and Natural Resources, expressed preference for Plan 3. Similar comments and support for Plan 3 were also received from the State Division of Forestry and the Department of Planning and Economic Development. Another comment by the Department of Planning and Economic Development was related to the presently diverted streamflows of Waimea River. They suggested that if a portion of the diverted flow is restored, it may aid in keeping the channel open and reduce buildup of the sandbar. Comments by the Environmental Center, University of Hawaii, related primarily to further clarification or discussion on combinations of nonstructural and structural measures, versus pure nonstructural or pure structural alternatives; relationship of the National Flood Insurance Program to the proposed plans; more detailed information on the Menehune Ditch which may be affected by project implementation; and a relevant summary of agency reports on the probable social/historical impacts of the alternative plans.

The County Department of Public Works recommended that the study be based on a level of protection of 100-year recurrence interval, since existing County ordinances and the Federal Insurance Administration call for this level of analysis. They also requested additional interior drainage information which the study may have included but did not present in detail in the draft document.

CONCLUSION

STATEMENT OF FINDING

In light of the overall public interest, the District Engineer has evaluated the pertinent information and the stated views of other government agencies and the concerned public on the various practical alternatives for alleviating the flood problems on the Waimea River, Island of Kauai, Hawaii. The alternatives considered and consequences of each were examined for economic, environmental, and social effects and for engineering feasiblility. Other factors considered were the specifically stated desires of local government officials and citizens.

During the course of study, on-site investigations were made independently and in cooperation with others, and discussions were held with County of Kauai officials and interested citizens. The possible consequences of alternative plans, which included both nonstructural and structural measures, were studied and analyzed in the decision-making process. Initial consideration was given to the possibility of using nonstructural measures to solve the flood and related water resources problems. These measures included flood warning and temporary evacuation, flood-proofing, relocation, and floodplain regulation. Based on the initial evaluation, flood-proofing, flood warning and evacuation were found to be applicable nonstructural measures. Floodplain regulation would help to minimize damages to future developments but would not reduce damages to existing developments. Relocation would have tremendous adverse social impact.

Structural measures which were also considered included reservoirs, channel improvements, and levees. Because of the existing flood control levee and related improvements, which were constructed by local interests in the Waimea floodplain, structural measures were considered to be important elements of a flood control plan for the basin. Accordingly, alternative plans incorporating various combinations of applicable nonstructural and structural measures were developed and evaluated. The flood warning system was considered only partially effective in that timely warning would minimize damage from an impending flood due to advance preparation of temporary protection and evacuation. However, in combination with other protective measures, an early flood warning system would be an effective component of an overall plan in view of the large size of the Waimea drainage basin, approximately 85 square miles.

The detailed plans examined consisted of a plan for flood-proofing, existing structures, and four plans consisting of levee and channel improvements. Each of the plans would include a flood warning system. In the course of the study, the alternatives and their physical, socio-economic, and environmental impacts were coordinated with other Federal, State, and County agencies, and the concerned public. The development and analyses of plans were discussed at several informal meetings with County of Kauai agencies and at two formal public meetings (8 November 1979 and 8 February 1980).

Based on evaluation of feasibility and acceptability, and comments received during coordination of the alternative plans, the levee extension and floodwall plan (Plan 3) was selected to be the recommended plan for implementation.

Plan 3 includes 3,175 feet of floodwall, 4,650 feet of toe protection, 500 feet of roadway raising, 1,575 feet of levee extension, new floodgates, a flood warning system, and floodplain management of 11 acres in the internal ponding area and 52 acres in agricultural lands opposite the levee improvements. This plan is also the NED plan, while Plans 1 and 2 were determined to be economically infeasible. The 500-year and SPF plans were similar to Plan 3 and although economically feasible, were not consistent with local flood control ordinance and local acceptability. In addition to being economically infeasible, Plan 2 would have the most adverse impact on the environment, particularly with respect to river dredging. None of the plans would result in a net positive contribution environmentally. However, the flood-proofing (Plan 1) alternative was designated the Least Environmentally Damaging (LED) plan because it emphasizes preservation of open space and minimized adverse impacts to the natural environment. The adverse impacts associated with the recommended plan are primarily related to the floodwall and levee extension which would add a new visual element, the loss of river bank land due to the levee extension, and its temporary construction impact on water quality and the aquatic biota. The impacts are not considered to be sufficiently detrimental to preclude proceeding with the recommended plan at this time.

The District Engineer believes that all necessary investigations commensurate with the scope of the detailed project study of flood and related water resources problems in the Waimea River have been made, and sufficient information on engineering, economic, and environmental aspects of the alteratives considered have been reviewed to facilitate making a sound decision. Based on his evaluation, the District Engineer finds that no alternative plan considered would fulfill the study objctives and the needs of the Waimea residents as effectively as the recommended plan. He concludes that the public interest would be served best by construction of the proposed flood control improvements.

COMPLIANCE WITH FEDERAL ENVIRONMENTAL REQUIREMENTS

GENERAL

The relationship of the recommended plan to applicable environmental requirements is summarized in Table 4 of the environmental statement. With the exception of continuing coordination on the matter of historic preservation and impacts upon National Register Sites, the recommended plan is in full compliance with all applicable Federal policies. The report of the U.S. Fish and Wildlife Service and the water quality certifications, pursuant to Sections 401 and 404 of the Clean Water Act of 1977, are reproduced in Appendix G, Natural Resources.

SECTION 404, P.L. 92-500

In accordance with Section 404 of the Federal Clean Water Act of 1977, the discharge or disposal of fill material into the nation's waters is administered by the Corps of Engineers in compliance with guidelines of the Environmental Protection Agency. The placement of materials for the toe protection and backfill is included within the definition of "discharge of fill material" within the navigable waters of the United States.

Consequently, the effects of rock and backfill placement have been considered within the context of Secion 404 considerations. Based on the detailed evaluation which is contained in Appendix G, it is concluded that feasible alternatives to the proposed revetment have been considered, and none that are practicable will have less adverse impact on the aquatic and semi-aquatic ecosystem. In addition, unacceptable environmental impacts as a result of the discharge are not expected. Finally, the discharge of fill material will be accomplished under conditions which will minimize, to the extent practicable, adverse environmental effects.

The public was provided an opportunity to comment on Section 404 evaluation matters at two public meetings. As discussed earlier, no testimony opposing the recommended plan was offered, and no serious concerns relating to Section 404 matters were expressed.

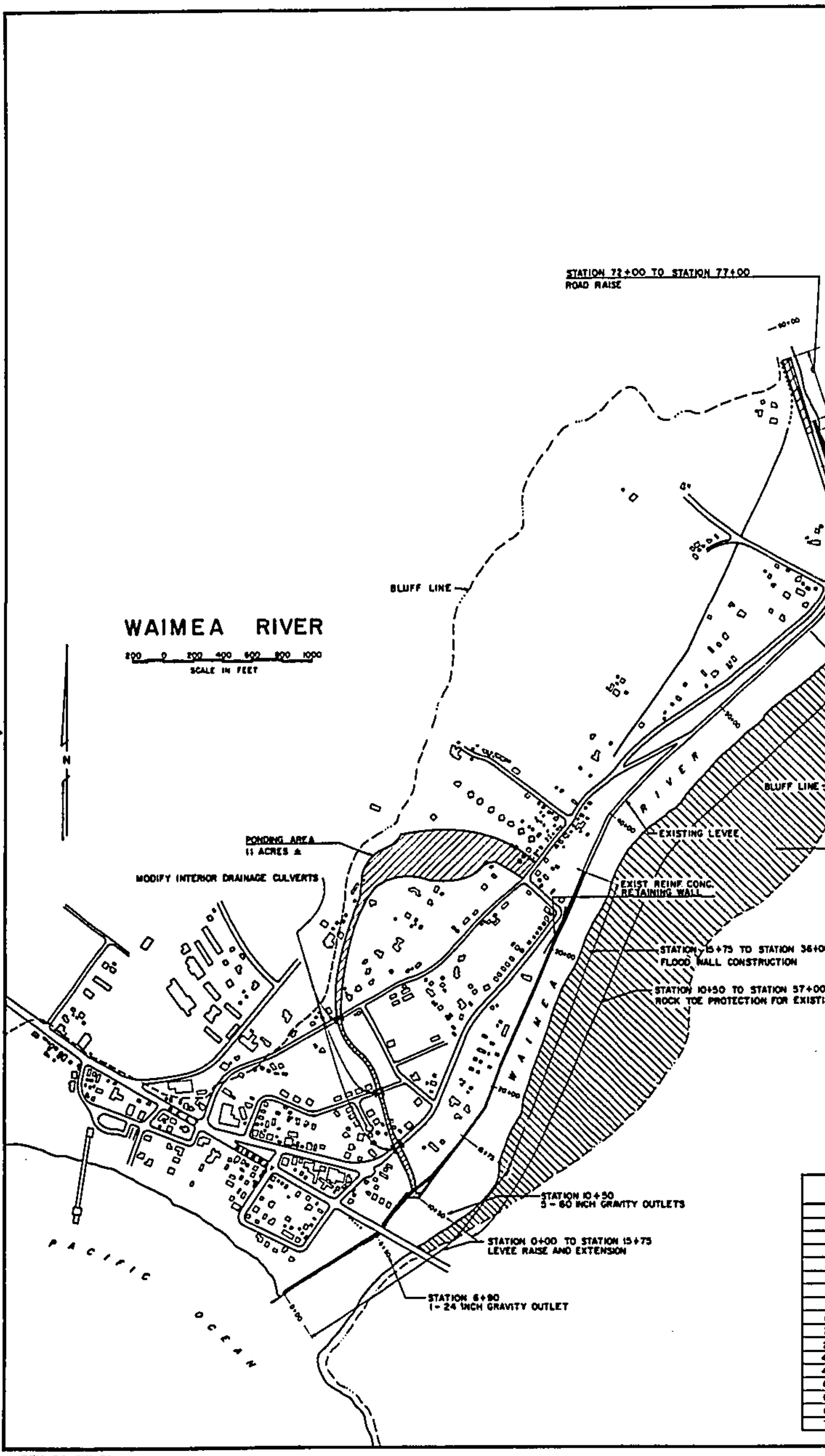
E.O. 11988, FLOOD PLAIN MANAGEMENT

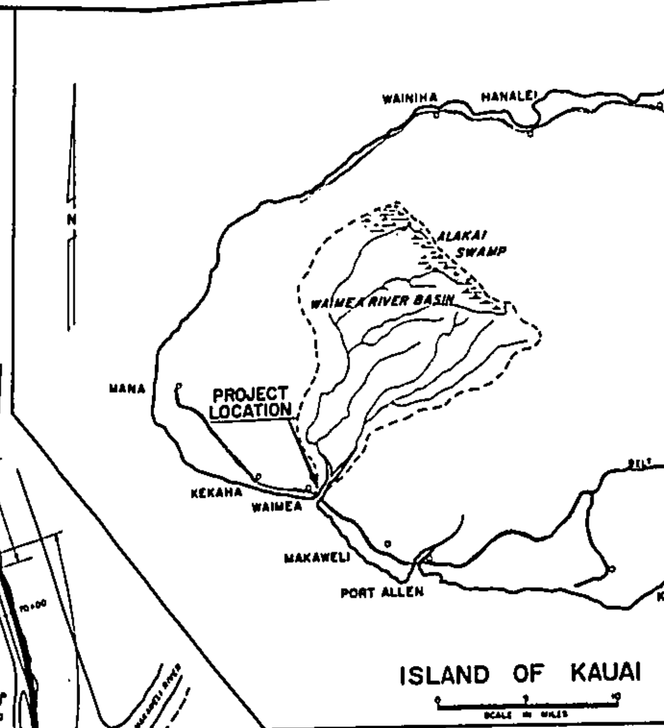
This Executive Order, signed on 24 May 1977, required federal agencies to avoid adverse impacts associated with the use of floodplains and avoid inducing development in the one percent change or 100-year floodplain as a result of their proposed actions. The recommended action is located within the base floodplain described by the executive order, and a detailed evaluation report is contained in Appendix G, Natural Resources. The evaluation concludes that the recommended plan must be constructed with the base floodplain and is the only practicable alternative. The plan satisfies the goals of the executive order and may slightly improve the existing beneficial floodplain values.

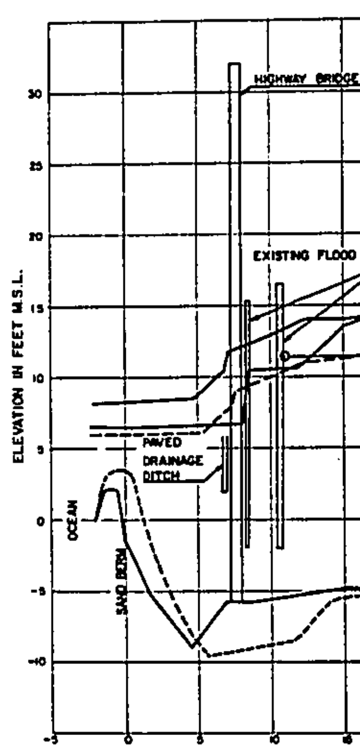
RECOMMENDATIONS

The District Engineer recommends that the selected plan for flood control improvements at Waimea be approved and constructed, provided that the County of Kauai furnishes the assurances satisfactory to the Secretary of the Army that they will comply with the local cooperation requirements outlined previously. The estimated first cost of the recommended plan is $2,603,000, of which $1,853,000 would be Federal cost and $750,000 would be non-Federal.

ALFRED J. THIEDE
Colonel, Corps of Engineers
Commander and District Engineer







HYDRAULIC ELEMENTS

STA	VELOCITY (FT/SEC)	W. S. (FT.-M.S.L.)
0+00	13.8	8.2
1+40	13.8	8.3
4+70	13.6	8.4
7+00	13.2	10.5
7+50	12.8	11.8
7+90	13.6	12.0
8+00	12.2	12.4
8+50	13.5	12.4
12+50	10.8	14.0
21+00	12.4	14.8
27+00	12.6	15.6
42+00	12.7	16.6
48+00	13.3	17.0
60+30	12.5	19.5
65+00	8.2	21.2
68+00	7.0	21.7
75+20	9.4	22.5

FLOODPLAIN MGT. AREAS

NOTE: NONSTRUCTURAL FLOOD WARNING ON PLATES C-20 AND C-21.

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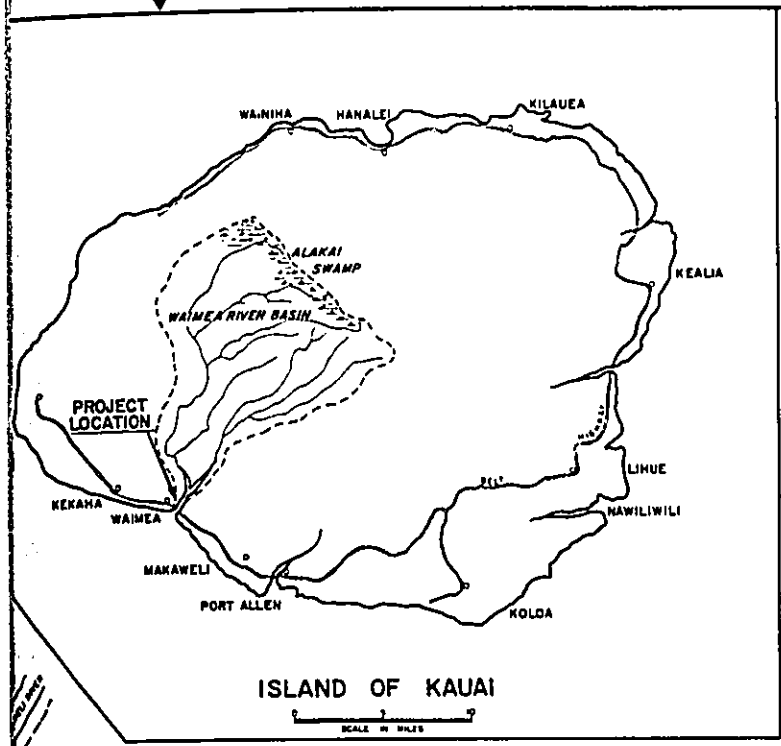
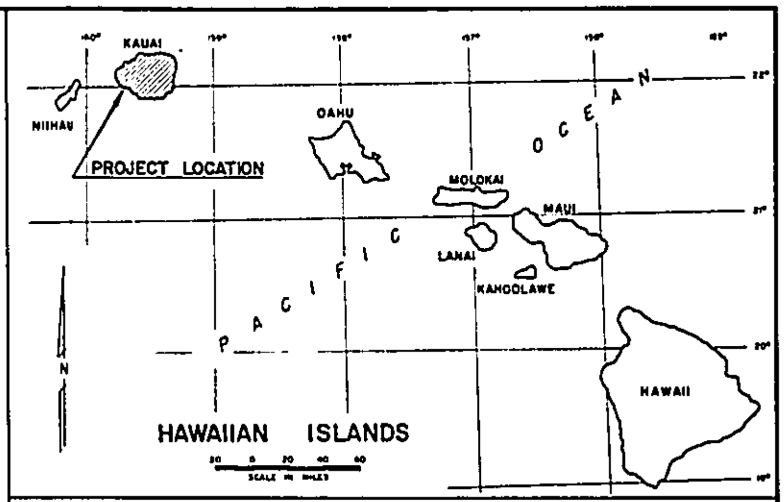
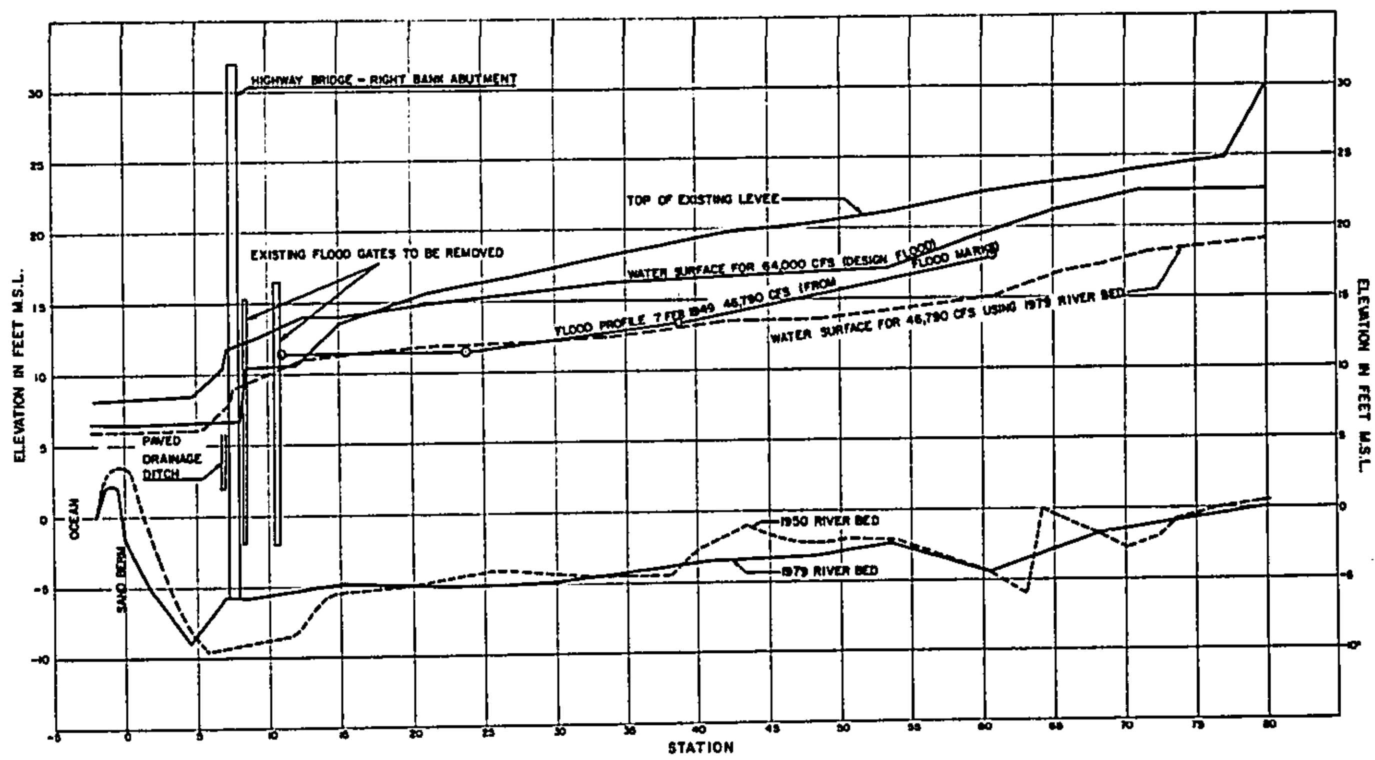




STATION 61+00 TO STATION 72+50
FLOOD WALL CONSTRUCTION

FLOODWAY



PROFILE OF WAIMEA RIVER

MENTS

	W. S. (FT-M.S.L.)
	8.2
	8.3
	8.4
	10.6
	11.8
	12.0
	12.6
	12.4
	14.0
	14.8
	15.6
	16.6
	17.0
	19.5
	21.2
	21.7
	22.5

▨ FLOODPLAIN MGT. AREAS

NOTE: NONSTRUCTURAL FLOOD WARNING SYSTEM SHOWN ON PLATES C-20 AND C-21.

DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI

GENERAL PLAN

U.S. ARMY ENGINEER DISTRICT, HONOLULU

ENVIRONMENTAL IMPACT STATEMENT
WAIMEA RIVER FLOOD CONTROL STUDY
WAIMEA, ISLAND OF KAUAI, HAWAII

Responsible lead agency: U.S. Army Engineer District, Honolulu

Responsible cooperating agencies: U.S. Fish and Wildlife Service, Hawaii Region

Department of Public Works, County of Kauai

Abstract: In March 1978, the Mayor of Kauai County requested the U.S. Army Corps of Engineers to study the feasibility of protecting the town of Waimea, Kauai from flooding as a result of overbank flow from the Waimea River. Detailed alternative plans considered were:

Plan 1. Floodproofing (nonstructural)

Plan 2. River channel deepening, raising of the existing levee with a flood wall, toe protection, and construction of a new levee, designation of a ponding area, and elevation of a portion of the existing road (structural).

Plan 3. Raising of the existing levee with a flood wall 2 to 4 feet high, toe protection, and construction of a new levee, designation of floodplain areas, elevation of a portion of the existing road and flood warning system (predominantly structural).

500-Yr Plan. Similar to Plan 3 except 4 to 7-foot high concrete flood wall.

SPF Plan. Similar to Plan 3 except 8 to 11-foot high concrete flood wall.

Further information may be obtained from:

Dr. James E. Maragos
U.S. Army Engineer District, Honolulu
Building 230
Fort Shafter, HI 96858

Telephone: (808) 438-2263/2264

ENVIRONMENTAL STATEMENT

LIST OF PREPARERS

The following people were responsible for the preparation of this Environmental Impact Statement:

Name	Expertise	Experience	Professional Discipline
Mr. Arthur G. Cropper	Geology	BA, MS in Geology; 10 years in marine geology; 4 years EIS studies, Honolulu District	Physical Environmental Specialist
Mr. David G. Sox	Geography	BA, MA in Geography; 4 years EIS studies; Honolulu District	Social Environmental Specialist. Historical and Cultural Resources Management
Dr. James E. Maragos	Oceanography	BS Zoology; PhD in coral reef ecology; 10 years Environmental Consultant; 6 years EIS studies; Honolulu District	Supervisory Environmental Biologist
Mr. Carl L. Couret	Limnology	BA, MS in Zoology; 6 years freshwater ecology; 2 years FWL studies; USFWS, Honolulu	Fishery Biologist
Mr. Harvey H.B. Young	Engineering	BS, in Civil Engrg, 5 years Civil Engrg, 14 years planning and hydraulic engineering	Project Manager

SUMMARY

MAJOR CONCLUSIONS AND FINDINGS

1.01 Non-Structural. Although the floodproofing alternative, Plan 1, would protect life and property and enhance the well-being of residents of the floodplain, it would not prevent flooding. Some temporary dislocation and interruption of lifestyle of residents within the floodplain would occur during the floodproofing construction period and during flooding. Raised buildings and floodwalls would add new visual elements within the floodplain. The alternative could adversely affect federal and state registered historic buildings and some unregistered historic buildings, unless exemptions were sought to reduce protection for these buildings.

1.02 Structural. Effects of structural alternatives on the general physical setting of the Waimea River would consist of new visual elements created by the floodwall and the new levee and by partial obstruction of the park vista by the new levee. None of the structural alternatives would affect any federal or state designated wildlife refuge, marine sanctuary, wetland, or natural area reserve, nor would any federal or state designated threatened or endangered species or their habitats be affected. Some common aquatic and terrestrial species of animals and plants would be destroyed, damaged, or displaced; however, these same species would probably recolonize the project area after completion of construction. The degree of perturbation to the biota of the project area would depend upon the alternative finally selected as the Plan of Improvement. Because there is little dredging work, Plan 3 would have considerably less impact upon the river biota than Plan 2. The 500-Year Plan and the Standard Project Flood (SPF) plan are, essentially, the same design as Plan 3, except the floodwalls are 4 to 7 feet high for the 500-year plan and 8 to 11 feet high for the Standard Project Floodplain. The environmental impact for the 500-year and the SPF plans would be the same as for Plan 3 except, the higher floodwalls would be somewhat less aesthetically pleasing. Both the 500-year and the SPF plans would provide enhanced flood protection over Plan 3 flood protection. Use of some recreational facilities at Lucy Wright Park and some informal recreational fishing along the western bank of the river would be temporarily disrupted during construction but use would resume after completion of the project. The park's restroom and shower and five trees would require removal. Both structural plans would not adversely affect the Captain Cook Landing Monument, which is a National Historic Landmark listed in the National Register of Historic Places. The small boulder monument would only have to be temporarily moved from its present location during construction. Consultation with the Advisory Council on Historic Preservation is underway. A determination of National Register eligibility for Peekau'ai Ditch is being sought. Coordination with the appropriate agencies will be conducted under the presumption that the recommended plan can be constructed without affect this historic site. Both structural alternatives would entail the demolition of one residence and permanent relocation of one family. Either of the structural alternatives would benefit those utilizing the existing ponding area within the town of Waimea by enhancing health, safety, and property values.

1.03 The least environmentally damaging plan (LED) is the floodproofing alternative (Plan 1) since it does not alter the existing ecology of the Waimea River. Plan 3 is designated the National Economic Development (NED) alternative since it has the lowest construction cost and potentially the greatest flood damage prevention for Waimea. The recommended alternative is Plan 3.

AREAS OF CONTROVERSY AND ISSUES TO BE RESOLVED

1.04 The State Historic Preservation Officer has concurred with the Corps' finding that implementation of a structural alternative would not adversely affect the Captain Cook Site. The finding has been forwarded to the Advisory Council on Historic Preservation for their review. A determination of eligibility for Peekau'ai (Menehune Ditch) has been sought and coordination with the above agencies is underway.

RELATIONSHIP TO ENVIRONMENTAL REQUIREMENTS

1.05 A brief outline of the relationship of the five alternative plans to environmental laws and regulations affecting this study is presented in Table 4. Detailed descriptions of the environmental setting, detailed discussions of problems and needs, development of planning objectives, engineering solutions, and economic costs and benefits are provided in the main report and appendices. The environmental statement focuses principally on those elements most significant in evaluating the benefits and costs to the affected environment.

PROBLEMS AND OBJECTIVES

2.01 The authority for this study and report is Section 205 of the 1948 Flood Control Act, as amended. A public workshop was held in Waimea on 25 January 1979. Concerns expressed at the meeting included the possibility of widespread damage because of decreasing river flow capacity due to sediment deposits, the restriction of outlet flows caused by the sandbar, and the problem of interior drainage.

2.02 The planning objectives were developed to guide the formulation and evaluation of alternative plans; contribute to the reduction of flood water danger in the lower Waimea River drainage basin during the 1985-2035 period of analysis; when possible, preserve or enhance the existing environmental resources within the lower Waimea River drainage basin.

2.03 Additional information on the study authority, public concerns, and planning objectives may be found in the main report and the Public Involvement Appendix.

ALTERNATIVES

3.01 Measures which were eliminated from further study include permanent evacuation and relocation, floodplain regulation and management, and reservoirs. Plans considered in detail include floodproofing, levees, channel improvements, floodwalls, excavation, flood warning, and temporary excavation. Plans 1 and 2 were not economically feasible and were eliminated as alternatives. The 500-Year and Standard Project Flood plans were not institutionally acceptable and were eliminated as alternatives.

3.02 Detailed information on these measures and plans may be found in the main report and the Engineering Design Appendix C.

TABLE 4
RELATIONSHIP OF PLANS TO ENVIRONMENTAL REQUIREMENTS

Federal Policies	Plan 1	Plan 2	Plan 3	500-Year Plan	SPF Plan
	Floodproofing	Channel Deepening, Floodwall, Toe Protection, and New Levee	Floodwall, Toe Protection, and New Levee	Similar to Plan 3 except new concrete floodwall 4' to 7' high.	Similar to Plan 3 and 500-year plan except concrete floodwall 8' to 11' high.
Archaeological and Historic Preservation Act	All plans in full compliance.				
Fish and Wildlife Coordination Act	All plans in full compliance.				
Federal Water Project Recreation Act	All plans in full compliance.				
Water Resources Development Act 1977	All plans in full compliance.				
National Environmental Policy Act	All plans in full compliance.				
National Historic Preservation Act	All plans in partial compliance. Coordination in progress.	Resource identification completed.			
Wild and Scenic Rivers Act	All plans in full compliance.				
Endangered Species Act of 1973	All plans in full compliance.				
Clean Air Act	All plans in full compliance.				
Clean Water Act - Section 401	All plans in full compliance.				
- Section 402	No NPDES permit required.				
- Section 404	All plans in full compliance.				
Marine Protection Research and Sanctuaries Act	Not applicable.				

TABLE 4 (Cont)
RELATIONSHIP OF PLANS TO ENVIRONMENTAL REQUIREMENTS

Federal Policies	Plan 1	Plan 2	Plan 3	500-Year Plan	SPF Plan
Watershed Protection and Flood Prevention Act	Not applicable.				
Estuary Protection Act	All plans in full compliance.				
Land and Water Conservation Act	All plans in full compliance.				
River and Harbor Act of 1899	All plans in full compliance.				
Flood Plain Management (EO 11988)	All plans in full compliance.				
Protection of Wetlands (EO 11988)	All plans in full compliance.				
State and Local Policies					
State CZM Consistency Certification	All plans in full compliance.				
Federal CZM Consistency Certification from DPED	All plans in full compliance.				
Land Use Plans					
Waimea-Kekaha Regional Development Plan	All plans in full compliance.				

TERRESTRIAL ENVIRONMENT

4.01 The US Fish and Wildlife Service (FWS) performed a terrestrial and aquatic biological survey of the project area in 1979 (Ref 1) and provided a 2(b) report. Data from the 2(b) report are summarized in the following sections.

4.02 Vegetation in the project area is characteristic of highly altered shoreline areas in Hawaii. Paragrass and guinea grass extend from the levee bank out about 30 meters in the shallow upper portion of the river below the confluence. Various grasses, ferns and shrubs are found on the top and landward embankment of the levee. The levee and its upstream bank are used for grazing. Ornamental trees such as monkeypod, coconut, ironwood, banyan, and royal palm are found in the proposed new levee area within Lucy Wright Park.

4.03 The Waimea mouth and estuary provide feeding habitat for a variety of migratory shorebirds, including the American golden plover (*Pluvialis dominica fulva*), sanderling (*Calidris alba*), wandering tattler (*Heteroscelus incanus*), and ruddy turnstone (*Arenaria interpres*).

Resident avian species reported or observed by the Fish and Wildlife Service survey were the white-tailed tropic bird (*Phaethon lepturus dorotheae*). pueo (*Asio flammeus sandwichensis*), and black-crowned night heron (*Nycticorax nycticorax hoactli*). Due to the extent of human development and activity, the stream, taro patches and abandoned rice fields near and above the confluence provide only marginal habitat for the endangered Hawaiian duck (koloa) (*Anas wyvilliana*), Hawaiian stilt (a'eo) (*Himantopus mexicanus knudseni*), Hawaiian gallinule (alae 'ula) (*Gallinula chloroptus sandvicensis*), and the Hawaiian coot ('alae ke'oke'o) (*Fulica americana alai*). One Hawaiian coot was observed during the FWS survey period along the eastern bank of the Waimea River estuary. None of these species have been sighted recently within this area by either the State Division of Fish and Game or by the Audubon Society. The overhanging hau, koa haole, and various grasses and shrubs provide substantially more cover on the east side of the estuary opposite the project area. A variety of urban birds were also observed in the project area.

4.04 Other common terrestrial fauna that are found in the project area include the Norway rat, Polynesian rats, house mouse, marine toad, feral/domestic cat and dog and some domestic livestock.

AQUATIC ENVIRONMENT

4.05 The lower 1.6 km of the Waimea River estuary is heavily silted with alluvial deposits and in mid-river below the bridge is less than four feet deep at several points. The river bed changes to boulder and gravel interspersed with silt about 300 meters below the Waimea-Makaweli River confluence. The main stem, however, continues to show evidence of siltation below the USGS gaging station No. 310. During the FWS field investigation, small schools of juvenile mullet (*Mugil cephalus* L.) and in-migrating hinana or juvenile gobies (*Sicidium stimpsoni*), as well as two species of adult gobies (*Awaous genivitatus* and *Eleotris sandwicensis*), papio (*Caranyx* sp.) and tilapia (*Sarotheradon* sp.) were observed along the estuary's shoreline. For two hours during low tide, variable mesh 60-foot gill net was set perpendicular to shore next to Lucy Wright Park. Although only four Samoan mullet (Chelon engli) (Bleeker) and aholehole (Kuhlia sandvicensis) were caught, yields are expected to be greater and more diverse during strong flood and ebb tides and at night.

4.06 Intertidal species observed at the project site include Littorina pintado, mytilids, and an occasional small opihi or limpet on the riprap groin at the mouth. Inside the river mouth along the riprap bank, grapsid crabs (about one crab per linear meter of shoreline) were observed for about 200 meters upstream. The neritid snail (Theodoxus vespertinus) was abundant (about 30 individuals/m^2) throughout the estuary as was the prawn, Macrobrachium grandimanus. Barnacles were observed in clumped distributions on loose stones in a riffle area about 300 meters below the Waimea-Makaweli River confluence.

4.07 Above the estuary, four goby species, neritid, thiarid, and ancillid molluscs (only the egg cases of Neritina granosa were observed), palaemonid and atyid shrimp and a variety of benthic insect nymphs and larvae (e. g., diptera, trichoptera and odonata) were observed. Macrofaunal populations were particularly abundant in the Makaweli River. The ubiquitous tilapia, swordtail and guppy were relatively common to abundant in all areas examined above the estuary. On December 15, 1979, a team of whale experts, approved by the NOAA CZM Office, recommended that all Hawaiian coastal waters within the 100-fathom depth contour be designated as a marine sanctuary for the Humpback whale.

WATER QUALITY

4.08 The waters of the Waimea and Makaweli Rivers are designated Class 2 by the State of Hawaii Water Quality Standards (Ref 2). The uses to be protected are bathing, swimming, the support and propagation of aquatic life, compatible recreation, and agricultural and industrial water supply. The receiving marine waters off the mouth of the Waimea River are Class "A" designated by the State Water Quality Standards. The uses to be protected are recreational, aesthetic enjoyment, and the support and propagation of aquatic life. The receiving waters off the Waimea River have also been designated as Effluent Limitation Segment 1 (EL 1) (Ref 3). EL 1 segments are those coastal water areas where water quality standards are not being met, but are expected to be met after application of the required effluent limitations.

4.09 Some physiochemical measurements were taken along the Waimea and Makaweli Rivers by the U.S. Fish and Wildlife Service between 24 and 26 January 1979. These measurements indicate that temperature, salinity, and conductivity in the project area vary considerably, as is usually the case in an estuary, with regard to time of day, tidal phase and range, stream discharge, and depth.

4.10 From January 1974 to December 1978, water quality sampling was performed by the State Department of Health in the upper Waimea River and at the landing at Waimea Bay Beach (see Natural Resources Appendix G). The samples taken at the landing showed that mean total coliform value and maximum values for total nitrogen and total phosphorus exceeded the State water quality standards for Class "A" waters. Samples taken at the swinging bridge, immediately above the estuary, showed that maximum pH values exceed the State water quality standards for Class 2 waters. Mean coliform and fecal coliform bacterial concentrations also exceeded the water quality standards for Class 2 waters. Stock grazing upstream is probably the source of coliform contributions to the stream.

RECREATION AND AESTHETIC RESOURCES

4.11 The Lucy Wright County Park, located at the mouth of the Waimea River, is within the study area. Lucy Wright Park is a 2.25-acre beach park with about 650 feet of beach-frontage, parking, picnicking, and restroom facilities within a pleasant tree-covered setting. Within the park is a three-foot diameter boulder upon which is affixed a plaque commemorating the landing of Captain Cook in 1778. The park is also a favorite place from which tourists view the Russian Fort Elizabeth across the river. Both these sites are listed on the National Register of Historic Places. The FWS survey report (Ref 1) states that surf casters commonly fish near the river mouth and that crabbing is conducted from the highway bridge. The catch reported from the estuary include Samoan crab, prawn, goby, grey mullet, Samoan mullet, moi, aholehole, papio, and tilapia. Occasionally large ulua and yellow perch (ta'ape) are caught within the estuary, particularly during the o'opu (goby) spawning runs around September and October. O'opu nakea, the main goby species taken in this popular part-time fishery, may reach up to 14 inches in length. Some commercial fishing activity occurs off the mouth of the Waimea River. A commercial seiner using three outboard motor boats to deploy a net was observed in January 1979 catching akule/halalu (Trachurops crumenophthalmus). These fish are sold throughout the island.

4.12 The National Register of Historic Places lists two sites in the study area: Russian Fort Elizabeth and Cook Landing Site (Ref 4), both National Historic Landmarks. The Russian Fort Elizabeth is on a bluff directly above and southeast of the mouth of Waimea River and Cook Landing Site is along the northwest bank of the Waimea River about 400 feet from the mouth. These two sites are of national-level significance and are designated National Historic Landmarks. There is an additional historic site, Peekau'ai (or Menehune) Irrigation Ditch, which runs close to the west bank of the Waimea River about 1,000 feet above its confluence with the Makaweli River. This site is the highest "High Value" category on the Hawaii State Register of Historic Places (Ref 5). A determination of eligibility for inclusion on the National Register is currently being sought for this linear feature. A cultural resources reconnaissance survey indicates that no additional significant archaeological sites appear to be located in the study area (Ref 6). There are however, remnant taro terraces of possible prehistoric origin located within the 100-year floodplain both within the area of proposed flood protection and outside of it.

4.13 The Cook Landing Site as marked by the boulder-plaque monument is not believed to be an accurate location of the actual landing site of Captain James Cook, who in 1778 made an Hawaiian village near Waimea River, the first known point of Western (European-American) contact in the Hawaiian Islands. Russian Fort Elizabeth was constructed of earth and stone in 1816 and 1817 by an agent of the Russian-American Company based at Sitka, Alaska (Ref 7). The Fort was erected to protect Kauai's independent King Kaumualii against Kamehameha I as well as Russian and Aleut settlers who cultivated the banks of the Waimea River. The Hawaiian islands were eventually united under Kamehameha I. The origin of the "Menehune" Ditch is lost in antiquity, but the existence of early 18th-century documents suggests strongly that it was originally constructed prior to Western contact. Since then, however, nearly every reach of the ditch has undergone considerable modification and its prehistoric segments are not clearly delineated, particularly within the study area (Ref 12).

4.14 There are scattered other historic buildings in Waimea village, two of which are listed on the National Register: Gulick-Rowell House and Bishop National Bank of Hawaii (Fig 12). The latter is in part of the area which the proposed project is designed to provide supplementary protection. There is also a second small monument commemorating the landing of Captain Cook located adjacent to the Bishop National Bank of Hawaii (Fig 12). Many residents of Waimea believe that the actual landing of Cook may have occurred nearer this spot than the National Register site and circumstantial historic evidence supports this hypothesis (Ref 6). Up until the late Nineteenth Century, the coast of Waimea was considerably inland of its present alignment.

SOCIOECONOMIC AND LAND-USE CHARACTERISTICS

4.15 The proposed project is located within the area of the Waimea-Kekaha Regional Development Plan (Ref 8). This plan was formulated on the basis of planning research and public input reflecting the needs and desires of the district. The plan provides for growth at a moderate level including land-use measures and public improvement recommendations that would improve and enhance the quality of life in the region rather than stimulate rapid community development.

4.16 The "Community Profile" (Ref 9) indicates that more than one-third of the population in the Waimea-Kekaha district is of Japanese ancestry, almost one-third is Filipino, and about one-fifth Caucasian. There is great stability in the population of this region, more so than any other part of the island. The main influx of newcomers is from Filipino immigrants.

4.17 In other areas of Kauai, agriculture has declined in recent years, and tourism has replaced it as a major employment generator. Waimea-Kekaha, however, differs from the rest of the island in that respect, since major employers in the area are the defense/scientific complex at Barking Sands to the northwest, and Kokee and the sugar industry. Although Waimea is the second largest town in the district, it is the center of the area's social, economic, and institutional activities. Sugar employment has declined somewhat over the past decade but is now relatively stable and should remain stable in the future. Moreover, Waimea-Kekaha differs from other areas in Kauai in that there are no hotels in the region. The economic benefits from tourism are indirectly felt from the passage of tourists to the historic Russian Fort, Cook Landing Monument, and Menehune Ditch in Waimea town, and Polihale Park, Kokee and Waimea Canyon.

4.18 The town of Waimea is an urban area. The area east of the Waimea River is in agricultural use as well as those areas north and west of town. An area northwest of the town is utilized as open space and pasture. A large portion of the floodplain in the valley and behind the "old town" is in diversified agriculture. Rice, once grown as a staple, has given way to newer crops. The most popular are seed corn, taro, alfalfa, and other truck crops, which are marketed islandwide (Fig 13).

4.19 Immediately behind the old town within the floodplain is a new residential development called Waimea Valley Estates comprising about 10.4 acres. To date, 23 houses have been built or are in construction out of a total of 43 available lots.

4.20 A primary ponding area of approximately 7 acres is located on 9 land parcels within Waimea town. Approximately two percent of this area is owned by Kauai County, 36 percent by Kikiaola Land Company, Ltd., and 62 percent by private owners. This area periodically ponds with water during large storm runoff. Only 14 structures have been constructed in this area and most of the area is heavily wooded. The ponding area lies within two groups of parcels which were zoned in 1977 from R-2 to R-6 (6 units per acre). This area has not been formally designated as a ponding area by any government agency. Water from the pond exits through Kealii Drain and a floodgate into the Waimea River. Adverse effects generally associated with the use of ponding areas (Ref 10) consist of inundation damages, land-use constraints, business and transportation losses, health hazards and sanitary problems and decreased property values. These effects may now exist to varying degrees during flooding within the ponding area in Waimea town.

ENVIRONMENTAL EFFECTS

PHYSICAL IMPACTS

5.01 Plan 1 - Floodproofing. The floodproofing alternative would not change the general physical character of Waimea town. Raised homes, walls around structures, and waterproof panels and sealing around structure openings would add new visual elements within the floodplain of the town.

5.02 Plan 2 - Channel Deepening, Floodwall, Toe Protection, and New Levee. The topographic relief in the project area would be changed by deepening of the riverbed and by the placement of toe protection and the new levee atop the existing revetment. There would be no change in substrate material in the riverbed area; however, the completed toe protection structure area would be changed from soft riverbed sediment to hard rock.

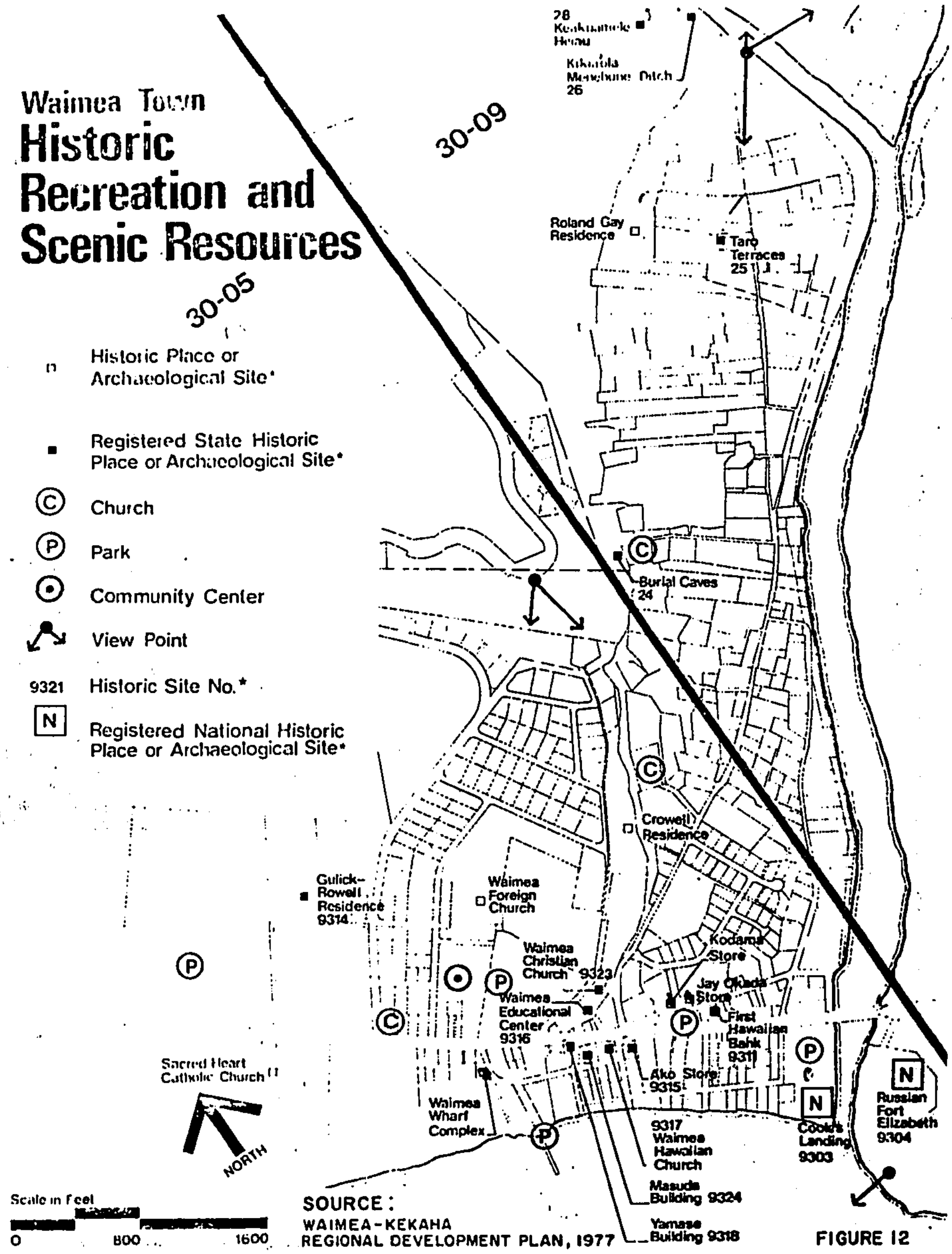
5.03 Plan 3 - Floodwall, Toe Protection, and New Levee. Topographic relief in the project area would be changed by excavation for and placement of the toe protection structure and by the placement of the new levee atop the existing revetment. The substrate in the toe protection structure area would be changed from soft riverbed sediment to hard rock. The floodwall would be 2 to 4 feet high.

5.03.1 500-Year Plan - Floodwall, Toe Protection, and New Levee. This plan is the same as Plan 3 except the floodwall would be 4' to 7' high and thus would be visually more adverse than Plan 3.

5.03.2 Standard Project Flood Plan - Floodwall, Toe Protection, and New Levee. This plan is also the same as Plan 3 except the floodwall would be 8' to 11' high and would be visually more adverse than Plans 3 and 4.

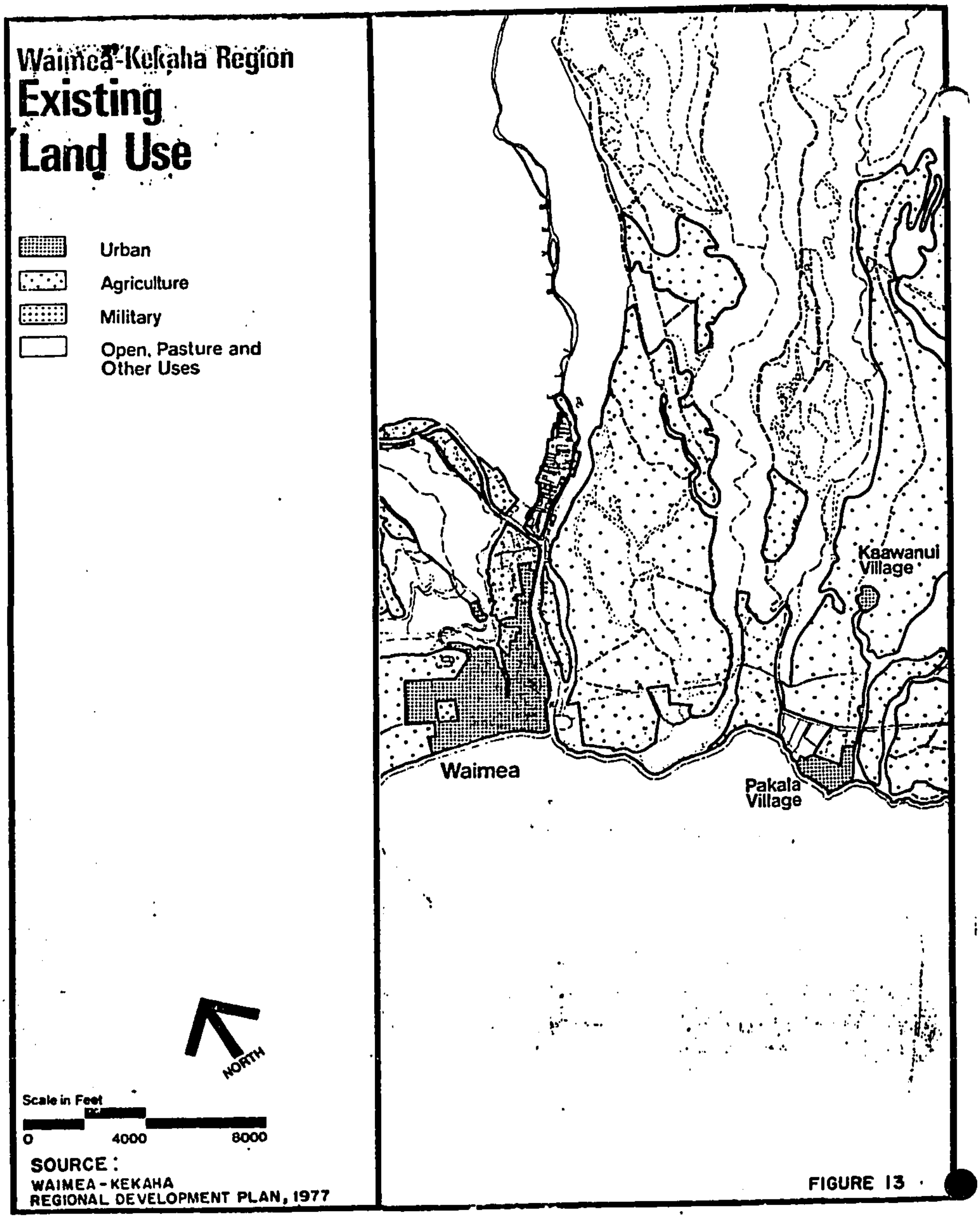
BIOLOGICAL

5.04 None of the protection alternatives would affect any federal or state designated wildlife refuge, marine sanctuary, wetland or natural area reserve, nor would any federal or state designated threatened or endangered species or their habitats be affected. Since the project area is located in a shallow estuary, none of the project alternative plans would affect the recommended Humpback whale sanctuary.



SOURCE: WAIMEA-KEKAHA REGIONAL DEVELOPMENT PLAN, 1977

FIGURE 12



Waimea-Kekaha Region
Existing
Land Use
Urban
Agriculture
Military
Open, Pasture and Other Uses
Kaawanui Village
Waimea
Pakala Village
NORTH
Scale in Feet
0
4000
8000
SOURCE:
WAIMEA-KEKAHA REGIONAL DEVELOPMENT PLAN, 1977

FIGURE 13

5.05 Plan 1 - Floodproofing. The floodproofing alternative would be performed on structures within the town of Waimea, with minor destruction or damage to some common ornamental plants in the vicinity of the construction. This vegetation would recover or be replaced after floodproofing is completed. This alternative would not affect any biota within the Waimea River waters.

5.06 Plan 2 - Channel Deepening, Floodwall, Toe Protection, and New Levee. Deepening of the river channel by excavation would destroy or displace some aquatic and estuarine biota. Some riparian vegetation would be destroyed or damaged. It is expected that aquatic and estuarine biota would gradually repopulate the channel after completion of the deepening. The dredging should be accomplished during the dry season. Construction of a raised floodwall along the existing levee would have minimal effects upon any terrestrial or aquatic biota within the river channel. Some common grasses covering the outer banks of the levee would be destroyed or damaged by construction activities; however, it is expected to recover rapidly after completion of construction. Rock and toe protection along the existing levee would provide a new environment consisting of shelter and hard surfaces for the possible colonization of aquatic biota. The aquatic biota utilizing the existing revetment for habitat would be destroyed or displaced by the construction of the new levee. The completed new levee and rock toe protection would provide a new habitat for possible colonization by the same species that were destroyed or displaced. The streambank area between the two floodgates is now covered by a common variety of grass. This grassy area would be covered and permanently destroyed by the new levee. Between the Kaumualii (Belt) Highway Bridge and Lucy Wright Park, eight common ornamental trees would be removed in the area of the new levee and transplanted in the general area.

5.07 Plan 3 - Floodwall, Toe Protection, and New Levee. This plan is essentially the same as Plan 2, except that there is no river channel deepening, and the length of the floodwall and toe protection is greater. Construction of a raised floodwall along the existing levee would have minimal effects upon any terrestrial or aquatic biota. Some common grasses covering the outer bank of the levee would be destroyed or damaged by construction activities; however, it is anticipated that it would recover rapidly after completion of construction. The benthic biota within the area dredged for the toe protection foundation would be destroyed and the placement of the rock toe would permanently preclude recolonization by benthic biota. The new levee would be constructed between the river mouth and the upper floodgate. The aquatic biota utilizing the existing revetment for habitat would be destroyed or displaced by the construction of the new levee. The completed new levee and rock toe protection would provide a habitat for possible colonization by the same species that were destroyed or displaced. The streambank area between the two floodgates is covered by a common variety of grass. This grassy area would be covered and permanently destroyed by the new levee. Between the Kaumualii (Belt) Highway Bridge and Lucy Wright Park, eight common ornamental trees would be removed in the area of the new levee and transplanted in the general area.

5.07.1 The 500-Year Plan and the Standard Project Flood Plan impacts on biological resources would be the same as Plan 3.

5.08 The degree of disturbance to the biota in the project area would depend on the alternative selected for the Plan of Improvement. The existing conditions and aquatic resources within the Waimea River probably would change little over the project life, provided water demands, as well as floodplain and upland development (residential and agriculture) do not increase significantly.

WATER QUALITY

5.09 The recommended Plan of Improvement has been evaluated by application of the U.S. Environmental Protection Agency guidelines under the authority of Section 404(b) of the Clean Water Act of 1977 (40 CFR, Part 230).

5.10 Plan 1 - Floodproofing. Some debris and particulates from floodproofing construction may enter the river and nearshore waters during storm runoff; however, the effects are expected to be minimal.

5.11 Plan 2 - Channel Deepening, Floodwall, Toe Protection, and New Levee. Excavation for deepening of the river channel and for the toe wall foundation would generate water turbidity temporarily exceeding State water quality standards. Additional turbidity could also be generated by construction materials falling into or deliberately placed (riprap and backfill) into river waters. Temporarily adverse impacts of turbidity during construction may be mitigated through employment of suitable turbidity control techniques and proper scheduling of work to avoid periods of excessive rainfall runoff. Any unmitigated turbidity plumes exiting the mouth of the Waimea River into the ocean would be carried along the shore in the direction of the prevailing nearshore current. The length of the turbidity plume would vary in relation to the period of generation and the quantity of suspended sediments introduced into the waters. Construction-generated turbidity would probably be significantly less than natural turbidity caused by large storm runoff in the Waimea River. Excess suspended solids levels in the river could cause adverse impacts to the survival of aquatic life as a result of their effect on growth rates, egg and larvae development, availability of food, and other factors. The project would have no effect upon the quality of waters entering the project area from upstream.

5.12 Plan 3 - Floodwall, Toe Protection, and New Levee. Dredging for toe wall foundations would generate water turbidity temporarily exceeding State water quality standards. Additional turbidity could also be generated by construction materials falling or deliberately placed (riprap and backfill) into river waters. Temporarily adverse impacts of turbidity during construction may be mitigated through employment of suitable turbidity control techniques and proper scheduling of work to avoid periods of excessive rainfall runoff. Any unmitigated turbidity plumes exiting the mouth of the Waimea River into the ocean would be carried alongshore in the direction of the prevailing nearshore current. The length of the turbidity plume would vary in relation to the period of generation and the quantity of suspended sediments introduced into the waters. Construction-generated turbidity would probably be significantly less than natural turbidity caused by large storm runoff in the Waimea River. Excess suspended solids levels in the river could cause adverse impacts to the survival of aquatic life as a result of their effect on growth rates, egg and larvae development, availability of food, and other factors. The project would have no effect upon the quality of waters entering the project area from upstream.

5.12.1 The 500-Year Plan and the Standard Project Flood Plain impacts on water quality would be the same as Plan 3.

RECREATIONAL AND AESTHETIC RESOURCES

5.13 Plan 1 Floodproofing. Floodproofing should not have a significant effect on either recreational or aesthetic resources, except possibly for some of the aesthetic-architectural characteristics of the older homes and buildings in Waimea village, including those on the National Register of Historic Places, if these were floodproofed. However, aesthetic views from raised floodproofed houses should be maintained or improved.

5.14 Plan 2 - Channel Deepening, Floodwall, Toe Protection, and New Levee. During the construction period, this alternative would temporarily generate some turbidity in river waters which may be influential in decreasing the size or species composition of the catches of recreational and commercial fishermen within the river, the estuary, and outside the river mouth. In addition, construction equipment and activities would occupy areas in the river and on the banks normally used by recreational fishermen and these areas would be temporarily precluded from use. Construction activities relating to toe protection may, in some cases, require removal of existing private floating docks along the river bank. Recreational fishermen may be temporarily forced to seek other publically accessible fishing areas during construction. Informal access across the levee into the river may be inconvenienced by the presence of the floodwall, which would vary in height up to three feet. New levee construction would temporarily obstruct access to the river for fishing and other activities, although the entire stretch from the floodgates to the mouth of the river would probably be restricted at one time. During weekends, access to the river through the construction site may be inevitable. The completed new levee would provide a permanent platform for use by recreational fishermen and crabbers. Consideration may be given to providing steps or grouting at strategic points for fishing access. Upon completion of the project, normal recreational fishing activities should resume. The deepened channel and toe protection would be below water level; and, therefore, no aesthetic changes or new visual elements will be visible in relation to these features. The floodwall would impose a new visual element atop the existing levee; however, it would not obstruct any views from the residences nearby since the vistas are already obstructed by the existing levee. The new levee constructed between the river mouth and the upper floodgate would superimpose a new and larger visual element atop the existing revetment. The new levee would partially obstruct views of the landscape across the river (Russian Fort) when viewed from the existing grade on the western bank of the river. The vista from atop the new levee would be obstructed. Levee construction within Lucy Wright County Park would require the transplanting of three monkeypod trees, one ironwood tree, and one banyan tree. Consideration would be given to transplanting these trees within the general area. Two additional monkeypod trees may possibly be saved in place at the landward base of the new levee toe. Another monkeypod tree on the edge of the County Maintenance Yard and a lychee and coconut palm on private property would also require removal and possible destruction. Within the park, the levee at the point of the Captain Cook Landing Site boulder and plaque would be about 2.5 feet high and should not obstruct anyone's view of the historic Russian Fort across the river. In any case, the levee could serve as a readily accessible viewing platform; however, the seaward end of the levee would remove about 1,500 square feet of paved parking area and block access to a much larger area adjacent to the beach. Construction of the levee would not require relocation of the park's restroom and shower facility.

5.15 Plan 3 - Floodwall, Toe Protection, and New Levee. During the construction period, this alternative would temporarily generate some turbidity in river waters which may be influential in decreasing the size or species composition of the catches of recreational and commercial fishermen within the river, the estuary, and outside of the rivermouth. Because this plan has less dredged area than Plan 2, the effects of turbidity are anticipated to be less. Construction equipment and activities would occupy areas on the river bank normally used by recreational fishermen and these areas would be temporarily precluded from use. Construction activities relating to toe protection may, in some cases, require removal of existing private floating docks along the levee bank. Recreational fishermen may be temporarily forced to seek other publicly accessible fishing areas during construction. Informal access across the existing levee into the river may be inconvenienced by the presence of the floodwall which would vary in height up to three feet. New levee construction would temporarily obstruct access to the river for fishing and other activities, although the entire stretch from the floodgates to the mouth of the river would probably not be restricted at one time. During weekends, access to the river through the construction site may be inevitable. The completed new levee would provide a permanent platform for use by recreational fishermen and crabbers. Consideration may be given to providing steps or grouting at strategic points for fishing access. The toe protection would be below water level and, therefore, there would be no visible aesthetic changes. The floodwall would impose a new visual element atop the existing levee; however, it would not obstruct any views from the residences nearby since the vistas are already obstructed by the existing levee. The new levee constructed between the river mouth and the upper floodgate would superimpose a new and larger element atop the existing revetment. The new levee would partially obstruct views of the landscape across the river (Russian Fort) when viewed from the existing grade on the western bank of the river including the site of the Captain Cook monument. The vista from atop the new levee would be unobstructed.

5.15.1 The 500-Year Plan and the Standard Project Flood Plan recreational impacts would be the same as Plan 3. The aesthetic impacts of the 500-Year Plan and the Standard Project Flood Plan would each be more negative than Plan 3.

5.16 Levee construction within Lucy Wright County Park would require the removal of three monkeypod trees, one ironwood tree and one banyan tree. Consideration will be given to transplanting these trees within the general area. Two additional monkeypod trees may possibly be saved in place at the base of the new levee toe. Another monkeypod tree on the edge of the County Maintenance Yard and a lychee and coconut tree on private property would also require removal and possible destruction. The seaward end of the levee would remove about 1,500 square feet of paved parking and block access to a much larger area adjacent to the beach. Construction of the levee would also require relocation of the park's restroom and shower facility. Relocation and, if necessary, construction of a new facility within the park would be the responsibility of the local sponsor.

CULTURAL RESOURCES

5.17 Plan 1 - Floodproofing. This alternative could require structural modifications to one site listed on the National Register of Historic Places, the Bishop National Bank of Hawaii. The work would consist of an outside protective wall or waterproofing of the structure, windows, ceilings, blocking of doorways, etc. Four (formerly) State-registered historic buildings and three unregistered historic buildings could also be affected. There would be no effect on the National Register-listed Cook Landing Site. If this alternative had been selected, further studies would have been conducted to determine how floodproofing could be best achieved with the least possible or no adverse effect on the National Register sites.

5.18 Plan 2 - Channel Deepening, Floodwall, Toe Protection, and New Levee. The Captain Cook Landing Site marker would require temporary relocation under this alternative, but in coordination with the State Historic Preservation Officer, this action has been determined to not have an adverse effect on the National Landmark and National Register site. Since road raising was eliminated from this alternative after further study, the Peekau'ai (Menehune) Ditch would not be affected by this plan. In addition, further analysis has shown that improving the level of protection by providing a floodwall will not change the upstream characteristics of inundation, thus historic or prehistoric taro fields and irrigation canals (auwai) outside the protected floodplain would not be affected by the changes in the flood control system implemented under this alternative. The level of protection for the same resources within the protected floodplain would be increased. No known archaeological sites or historic structures are known to exist on the downstream portion of the low east bank river terrace of Waimea River where dredged material would have been dumped as a result of channel deepening. Neither channel deepening nor any other element of this alternative would have affected the Russian Fort Elizabeth, an historic site also designated a National Landmark and listed on the National Register of Historic Places.

5.19 Plan 3 - Floodwall, Toe Protection, New Levee and Road Raising. The effects of the recommended plan on the Captain Cook Landing Site marker and on historic or prehistoric taro terraces and irrigation canals will be the same as under Plan 2. The Russian Fort Elizabeth will not be affected by this alternative, except as mentioned above in regards to the view of it from Lucy Wright Park. This plan will, however, require the raising of a local road in the vicinity of Peekau'ai (Menehune) Ditch by about 1.5 feet above the road's present grade. As noted in the Cultural Appendix, the prehistoric ditch's original course and physical integrity were destroyed in the 1920's when the road was constructed. The ditch water now passes through a modern concrete culvert about three to four feet below road grade. About three to four feet of road separates the road surface from the downstream outlet of the culvert and about two feet further begins a dry-stacked basalt-stone retaining wall which may or may not be of prehistoric origin. It is not similar to the upstream dressed-stone facing outside the project area which is believed to be of prehistoric origin. The raising of the road will not have any effect on known or possible original portions of Peekau'ai (Menehune) Ditch, as defined by the "Criteria of Effect" in 36 CFR Part 800.3(a). Documentation of this Determination of Effect and documentation relating to requesting a determination of National Register eligibility for the linear prehistoric and historic ditch are being coordinated with the appropriate State and Federal agencies.

5.19.1 The 500-Year and the Standard Project Flood Plan impacts on cultural resources would be the same as Plan 3.

SOCIO-ECONOMIC AND LAND-USE EFFECTS

5.20 Plan 2 - Floodproofing. The floodproofing alternative would protect life and property and enhance the well-being of those residents living within the river floodplain, but it would necessitate the temporary relocation of some residents within the river floodplain during some phases of construction. Flood-related health and safety problems related to stagnating water, possible disruption of emergency services and utilities such as water, sewage, electricity, and telephone service would remain. If houses are raised, living and storage areas may be increased and scenic views enhanced. The only resident to comment on the floodproofing alternative at any of the public meetings on the project was opposed to it. The flood-warning system now a part of this alternative should enable residents and businessmen to save some property not otherwise protected and would enhance the emergency preparedness of the community and perhaps enhance the community well-being, in an unobtrusive way.

5.21 Plan 2 - Channel Deepening, Floodwall, Toe Protection, and New Levee. This alternative would protect life and property and enhance the well-being of residents living within the river floodplain. There would be no moving of residents from their homes during construction nor any change of lifestyle during or after construction of this project alernative. Property values, especially those near the river, could increase. The beneficial effects of flood-warning system would be similar to those for Plan 1, but the feeling of well-being will probably be more pervasive. This plan would probably not alter the existing socio-economic characteristics of residents and business within or outside of the project area, except greater community/regional growth within the floodplain could occur due to the added level of protection. Some land owners could be encouraged to transform land from agriculture into residential or apartment use, despite the constraints offered in local land use plans and zoning regulations. Except for the ponding easements property values of flood-protected lands should increase in value. Within the ponding area, the new frequency and depth of ponding should decrease and as a result of the new floodgates, there should be significantly less structural damages, a decrease in safety and health hazards, and in nuisance levels. The flowage easement would still have a restrictive effect on future development within the ponding area since no fill would be allowed in the area. One residence, one-half of a duplex, located just upstream of the bridge, would be demolished and the residents would have to be permanently relocated. During construction, minor traffic congestion would also occur along portions of the construction alignment.

5.22 Plan 3 - Floodwall, Toe Protection, New Levee, and Road Raising. The socioeconomic effects of the recommended plan are similar to those of Plan 2.

5.22.1 The 500-Year Plan and the Standard Project Flood Plan impacts on socioeconomic and land use resources would be the same as Plan 3 except additional flood protection would be provided.

PUBLIC INVOLVEMENT

PUBLIC INVOLVEMENT PROGRAM

6.01 A public workshop was held on 25 January 1979 at the Waimea Neighborhood Center to obtain input on the problems and needs concerning flood damages within the Waimea River area. Total attendance was approximately 45 persons. Concerns expressed at this meeting are addressed in Section 6.04 and Appendix F. A public meeting to present the alternative plans for flood control at the Waimea River area was held on 24 October 1979. A late stage public meeting was held on 28 February 1980 to present the recommended plan.

REQUIRED COORDINATION

6.02 A determination of eligibility is underway for Peekau'ai (Menehune) Ditch. Formal coordination with the Historic preservation Officer for Hawaii and with the Advisory Council on Historic Preservation for this site and for the Captain Cook Monument will continue and appropriate mitigation actions will be evaluated and recommended. The US Fish and Wildlife Service Division of Ecological Services has provided the Corps with a 2(b) report in which project impacts and measures for compensation and enhancement of fish and wildlife are discussed. A Section 404(b) Water Quality Evaluation has been prepared for the recommended plan. The public has had the opportunity to respond to the notice issued with this evaluation and there have been no responses.

STATEMENT RECIPIENTS

6.03 A list of agencies, groups and individuals that received a copy of the draft EIS for review is contained in the Public Involvement Appendix.

PUBLIC VIEWS AND RESPONSES

6.04 The overall reaction of the study and possible improvements was favorable. Although the existing levee does provide some degree of protection, it was emphasized by a number of people that widespread inundation damage could result because of decreasing flow capacity of the river due to sediment deposition, coupled with continuous sandbar blockage at the mouth and interior drainage problems. No new or controversial issues were raised by the public during the 24 October 1979 or the 28 February 1980 public meetings.

LIST OF REFERENCES

1. U.S. Department of the Interior, Fish and Wildlife Service (21 March 1979) "Planning Aid Letter for Waimea River Food Control Project, Kauai, Hawaii."

2. State of Hawaii, Public Health Regulations, Chapter 37-A, "Water Quality Standards" as amended, 5 September 1979.

3. Hawaii Water Resources Regional Study (1975), "Study Element Report-Water Quality."

4. U.S. National Register of Historic Places, 44 Federal Register 7416 (February 1979).

5. State of Hawaii, "Register of Historic Places."

6. Joerger, Pauline King and Streck, Charles F, Jr. (Hawaii Marine Research, Inc.) (1979) "Cultural Reconnaissance Survey of the Waimea River Flood Control Study Area, Waimea, Kauai, Hawaii, Sections I and II," prepared for the Corps of Engineers, Pacific Ocean Division, Department of the Army.

7. State of Hawaii, Department of Land and Natural Resources, Division of State Parks (1975) "Outdoor Recreation and Historic Sites, 1975, Final Environmental Impact Statement for Russian Fort State Park."

8. County of Kauai, State of Hawaii (1977) "Waimea-Kekaha Regional Development Plan Supplement," prepared by Belt, Collins & Associates, Ltd., Honolulu, Hawaii.

9. State of Hawaii, Department of Planning and Economic Development (1973) "Community Profiles for Hawaii."

10. Department of the Army, Office of the Chief of Engineers (3 May 1965) "Engineering Design, Internal Drainage of Leveed Urban Areas: Hydrology, Em 1110-2-1410."

11. U.S. Department of the Interior, Fish and Wildlife Service, 2(b) Report for Waimea River Flood Control Project.

12. Mr. Francis Ching (Archaeological Research Center Hawaii, Inc.). Personal Communication, 13 March 1980.

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Waimea River Flood Control
Waimea, Kauai

HYDROLOGY

Appendix A

HYDROLOGY APPENDIX

LIST OF TABLES

HYDROLOGY APPENDIX

LIST OF PLATES

* All plates follow page A-14.

HYDROLOGY APPENDIX

DISCHARGE - FREQUENCY ANALYSIS

METHODOLOGY

1. Discharge-frequency curves were developed at the confluence of Waimea River and Makaweli River, and at the mouth of Waimea River by routing and combining the recorded flood hydrographs from two streamgages (Waimea River, Sta 310 and Makaweli River, Sta 360). The contribution from the areas below the streamgages were determined by applying the recorded rainfall, less infiltration losses, to the unit hydrograph developed for the areas.

ANALYSIS

2. The sources for flood hydrographs and rainfall data, the development of the unit hydrograph, and the flood routing procedures are described in the SPF and PMF paragraphs.

3. A complete search was made to locate the maximum annual peak discharges. The maximum annual stage recorded at Station 380, a crest-stage gage located 150 feet above the Highway Bridge at Waimea, did not represent the maximum annual peak discharge for several water years (1944, 1948, 1951, 1952, 1954, 1961, 1962, 1965, 1967, 1972, 1973, 1974, and 1976).

4. Table A-1 shows the summary of the peak discharges. Flood hydrographs were not available for several events. For these instances, an estimation of the peak discharge at the confluence was made using published estimated peak discharges at the streamgages (Sta 310 and Sta 360) and the recorded stages at Station 380.

5. Runoff originating from the area between the streamgages (Sta 310 and Sta 360) and the confluence did not contribute significantly to the routed peak discharges. In about half of the events analyzed, rainfall over the contributory area was not severe enough to produce runoff at the time of peak river discharges. When rainfall did cause runoff, the contributory peak discharge would substantially precede the peak river discharges and would have an insignificant effect on the peak discharges. This occurrence is typically illustrated by the 13 Jan 70 event. On that day the contributory runoff peaked at 260 cfs at 2100 hr, one hour and 45 minutes before the peak discharges at the confluence (the recession limb ended 15 minutes before the peak discharges). These conditions were made in the rainfall-runoff investigation: (1) assuming an infiltration loss rate of 0.18 inch per hour, and (2) restructuring the hourly precipitation data to 10 minute intervals to match the unit hydrograph time interval. Table A-2 shows the recorded rainfall data at Station 944, Kekaha (the nearest recording rainfall station to the contributory areas) which were used in the rainfall-runoff investigation.

TABLE A-1. SUMMARY OF PEAK DISCHARGE ANALYSIS

PEAK DISCHARGES (CFS) AND TIME (24-HR CLOCK)

WATER YEAR	DATE	STA 310 WAIMEA RIVER	STA 360 MAKAWELI RIVER	TOTAL AT CONFLUENCE
1944	9 Mar 44	10,800	No record	11,000 estimated
1945	6 Apr 45	10,300 @2030	4,900 @1630	10,700 @ 2045
1946	6 Dec 45	13,600 @1530	6,420	14,000 estimated
1947	22 Dec 46	14,400 @0430	4,670 @0230	16,900 @0445
1948	17 Dec 47	8,850 @0600	No record	10,800 estimated
1949	7 Feb 49	37,100 @1430	11,900 @1300	45,500 @1430
1950	17 Aug 50	No record	9,200 @0030	32,000 estimated
1951	4 Mar 51	27,900 @0230	12,800	32,000 estimated
1952	16 Dec 51	27,900 @0800	7,640	30,000 estimated
1953	4 Mar 53	6,960 @0330	1,550 @0300	7,900 @0345
1954	28 Feb 54	10,700 @2200	5,850 @2200	15,800 @2215
1955	28 Nov 54	12,100 @1330	4,720 @0900	15,800 @1330
1956	11 Nov 55	26,500 @2330	11,500 @2300	34,800 @2345
1957	23 Oct 56	16,200 @2200	12,100	18,000 estimated
1958	1 Dec 57	23,100 @2300	13,400 @2100	33,500 @2300
1959	6 Aug 59	24,300 @2200	11,600 @2100	32,100 @2145
1960	2 Nov 59	8,080 @0700	800 @0500	8,200 @0715
1961	4 Dec 60	8,110 @1200	4,950 @0900	10,000 @1200
1962	28 Jan 62	17,900 @0400	12,200 @0530	21,600 @0415
1963	15 Apr 63	7,400 @1900	15,900 @1830	21,900 @1845
1964	30 Sep 64	10,600 @2130	5,620	12,000 estimated
1965	9-10 Jan 65	13,300 @0200	12,700 @2400	15,000 @0200
1966	20 Nov 65	9,000 @0700	11,100 @0600	18,000 @0700
1967	13 Jan 67	12,800	No Record	13,000 estimated
1968	26 Nov 67	11,100 @0600	11,500 @0730	18,800 @0745
1969	29 Nov 68	No Record	5,600 @1900	21,000 estimated
1970	13 Jan 70	18,900 @2230	3,910 @2330	20,900 @2245
1971	6-7 Apr 71	11,700 @0030	13,300 @2330	17,800 @0030
1972	2 Mar 72	9,240 @1700	5,210	13,900 estimated
1973	11 Mar 73	2,780	No Record	3,000 estimated
1974	19 Apr 74	No Record	17,900 @0700	29,100 estimated
1975	31 Jan 75	No Record	26,000 @1315	37,000 estimated
1976	6 Feb 76	6,850 @0230	4,440	9,000 estimated
1977	12 May 77	4,740 @0900	4,660	7,000 estimated

TABLE A-2. RAINFALL DATA
STATION 944, KEKAHA

See Table A-1 for date of occurrence for each water year.

Water Year	24-Hour Rainfall (inch)	Peak Discharge For Area Between Streamgages and Confluence (CFS)
1944	No Record	
1945	No Record	
1946	No Record	
1947	No Record	
1948	No Record	
1949	No Record	
1950	No Record	
1951	1.07	60
1952	4.05	740
1953	0.21	0
1954	0.31	0
1955	1.75	280
1956	2.61	450
1957	0.96	50
1958	1.35	170
1959	0.48	0
1960	0.02	0
1961	1.63	260
1962	2.74	470
1963	1.77	280
1964	0.02	0
1965	3.99	730
1966	0.35	0
1967	0.07	0
1968	0.87	0
1969	0.10	0
1970	1.64	260
1971	0.19	0
1972	1.83	280
1973	0.11	0
1974	0.67	0
1975	4.32	1,145
1976	3.32	235
1977	0.87	0

NOTE: Peak discharges from 1951 to 1965 were estimated from the rainfall-discharge relationship for the years 1966 to 1977. Hourly precipitation data for Station 944 were recorded and published since 1966.

6. The maximum annual peak discharges at the confluence were analyzed by the "Flood Flow Frequency Analysis" computer program which incorporates the recommendations of Bulletin No. 17A "Guidelines for Determining Flood Flow Frequency", Water Resources Council. The streamgage locations are shown on Plate A-1 and the peak discharge-frequency curves at the confluence and mouth are shown on Plates A-2 and A-3 respectively. Plate A-4 shows a typical flood routing and combining analysis.

FLOOD HYDROGRAPH DERIVATION, SPF AND PMF

GAGE STATIONS USED IN UNIT HYDROGRAPH DERIVATION

7. Unit hydrographs were developed at Waimea River (Gage Station 310) and at Makaweli River (Gage Station 360) from the river stage data at the stations and from data of rain gages within and adjacent to the watershed. Plate A-5 shows the gage locations.

UNIT HYDROGRAPH DERIVATION

8. Upon examination of the recorded discharge and rain gage data, a 30-minute time interval for the unit hydrograph derivation was selected. The discharge and rain gage data were analyzed by the HEC-1 computer program which yielded the optimum unit hydrograph parameters. Synder's unit hydrograph was used to model the hydrologic response of the watersheds.

STORMS INVESTIGATED

9. The Waimea River, Sta 310 unit hydrograph was derived from the 13 Jan 70 and 31 Jan 71 storms. The Makaweli River, Sta 360 unit hydrograph was derived from the 6 Apr 71 and 19 Apr 74 storms. These storms were chosen due to the availability of recorded data and the relatively high discharges produced. Table A-3 shows the storm data and the optimized unit hydrograph parameters. Plate A-6 shows the adopted peak versus width curve used to construct the unit hydrographs.

SOURCE OF DATA

10. The recorded flood stage hydrographs at Stations 310 and 360 were obtained from the US Geological Survey and were converted to flood discharge hydrographs by applying a stage-discharge relationship developed by the US Geological Survey. Daily precipitation data were obtained from the National Oceanic and Atmospheric Administration (NOAA) monthly publication "Climatological Data", for Hawaii and other Pacific Islands. Hourly precipitation data were obtained from the NOAA monthly publication "Hourly Precipitation Data - Hawaii." Recording raingage charts of the tipping bucket

TABLE A-3.

UNIT HYDROGRAPH DERIVATION

Waimea River at Gaging Station 310
Drainage = 57.8 Square Miles
Greatest Recorded Discharge = 37,100 cfs

Makaweli River at Gaging Station 360
Drainage Area = 26.0 square miles
Greatest Recorded Discharge = 26,000 cfs

				OPTIMIZATION RESULTS			
Gaging Station	Storm Date	Peak Discharge (cfs)	Rank of Discharge	Reconstituted Flood Peak (cfs)	Uniform Infiltration Loss (In/Hr)	Standard Lag (Hr)	Cp
310	13 Jan 70	18,900	11th	17,200	0.16	2.41	0.67
310	31 Jan 71	12,600	19th	10,500	0.18	2.97	0.82
360	6 Apr 71	13,300	6th	9,800	0.47	0.82	0.65
360	19 Apr 74	17,900	2nd	15,000	0.28	1.41	0.75

UNIT HYDROGRAPH PARAMETERS

Gaging Station	Storm Date	L (Miles)	LCA (Miles)	CT	Qpr (cfs)	W_{75} (Hr)	W_{50} (Hr)
310	13 Jan 70	17.0	10.5	0.51	10,270	1.9	3.0
310	31 Jan 71	17.0	10.5	0.63	10,380	2.2	3.3
360	6 Apr 71	13.0	8.3	0.20	11,970	0.8	1.3
360	19 Apr 74	13.0	8.3	0.35	8,480	1.2	1.7

type for 2 stations (Waialeale Trail and Mt. Waialeale) were obtained from the US Geological Survey. The hourly precipitation rates were converted to half-hour amounts by using rainfall proportions of the same hour period with the recording raingage charts. Table A-4 shows the raingage descriptions and rainfall data.

FLOOD RECONSTITUTION

11. To obtain the best reconstitution of the flood hydrographs several methods were employed. One method is incorporated in the HEC-1 computer program and provides the operator with the flexibility of increasing or decreasing discharges at critical points on the flood hydrograph to produce a better fit. Another approach employed in this investigation, used various rainfall distribution weights (total rainfall and rainfall intensity) which were initially selected using the Thiessen Polygon method. The 6 Apr 71 flood hydrograph was also shifted backward a half-hour time increment to better fit the rainfall data and reconstituted flood. The best fit reconstituted floods are shown on Plates A-7 to A- 10.

UNIT HYDROGRAPH TERMINOLOGY (PLATES A-11 and A-12)

12. The averaged unit hydrograph was determined from two storm events. C_t and C_p are Snyder's unit hydrograph parameters. Lag is the time from the center of a one inch rainfall excess for a duration of 30 minutes to the peak discharge of the unit hydrograph. In conformance with EM 1110- 2-1405, 31 August 1959, the peak discharge of the unit hydrograph was increased. Based on the relative rainfall intensities of the analyzed storms and the expected rainfalls of the Standard Project Storm (SPS) and the Probable Maximum Precipitation (PMP), a 50 percent increase was employed.

STANDARD PROJECT STORM (SPS)

13. The SPS rainfall was obtained from the Memorandum for Record, "Standard Project Storm Determinations Hawaiian Islands, OCE, US Army Corps of Engineers, 19 September 1962. A 24-hour average index rainfall of 23 inches was computed for the watershed. Adjusting for the size of the watershed area, a 24-hour design rainfall of 18.4 inches was developed, of which the greatest half-hour rainfall equalled 2.5 inches.

PROBABLE MAXIMUM PRECIPITATION (PMP)

14. The PMP was derived from hydrometeorological Report No. 39, "Probable Maximum Precipitation in the Hawaiian Islands," US Weather Bureau, May 1963. The computed 24-hour average point rainfall for the PMP equalled 46 inches. An analysis made to account for the drainage area size yielded a 24-hour design rainfall of 39.6 inches and the highest half-hour intensity of 4.9 inches.

TABLE A-4. STATIONS USED IN UNIT HYDROGRAPH DERIVATION

RECORDING RAIN GAGES:

Station No.	Station Name	Observer	Elevation (Feet)
1037.1	Kitano	Kekaha Sugar	2150
1045	Waialeale Trail	USGS	4520
1047	Mr. Waialeale	USGS	5075
1075	Kanalohuluhulu	Bd of Agr & Ftry	3600
1083	Upper Mohihi	USGS	3500

NON-RECORDING RAIN GAGES (24 HOURS):

Station No.	Station Name	Observer	Elevation (Feet)	Time Read
945	Hukipo	Kekaha Sugar	800	8 AM
1086	Intake Wainiha	McBryde Sugar	700	Varies

RECORDING RIVERSTAGE GAGES:

Station No.	Station Name	Observer	Elevation (Feet)	Drainage Area (Sq Miles)
310	Waimea River near Waimea	USGS	25	57.8
360	Makaweli River near Waimea	USGS	18.2	26.0

TABLE A-4. STATIONS USED IN UNIT HYDROGRAPH DERIVATION

RECORDING RAIN GAGES:

Station No.	Station Name	Observer	Elevation (Feet)
1037.1	Kitano	Kekaha Sugar	2150
1045	Waialeale Trail	USGS	4520
1047	Mr. Waialeale	USGS	5075
1075	Kanalohuluhulu	Bd of Agr & Ftry	3600
1083	Upper Mohihi	USGS	3500

NON-RECORDING RAIN GAGES (24 HOURS):

Station No.	Station Name	Observer	Elevation (Feet)	Time Read
945	Hukipo	Kekaha Sugar	800	8 AM
1086	Intake Wainiha	McBryde Sugar	700	Varies

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Station No.	Station Name	Observer	Elevation (Feet)	Drainage Area (Sq Miles)
310	Waimea River near Waimea	USGS	25	57.8
360	Makaweli River near Waimea	USGS	18.2	26.0

TABLE A-4. (con't)

RAINFALL DISTRIBUTION

Location & Storm	Raingage Number	Raingage Name	Recording Distribution Weight	Rainfall Distribution Weight	Storm Rainfall (inches)
1. Waimea River, Station 310	945	Hukipo	0	6	1.77
13 Jan 70 Storm	1037.1	Kitano	32	26	2.10
13 Jan (12 noon) to 14 Jan (8 am)	1045	Waialeale Trail	60	21	5.28
	1075	Kanalohuluhulu	20	31	6.92
	1086	Intake Wainiha	0	16	5.11
2. Waimea River, Station 310	945	Hukipo	0	7	1.06
31 Jan 71 Storm	1037.1	Kitano	20	24	1.84
31 Jan (12 noon) to 1 Feb (4 am)	1047	Mt. Waialeale	10	2	7.25
	1075	Kanalohuluhulu	18	18	3.11
	1083	Upper Mohihi	40	44	3.13
	1086	Intake Wainiha	0	5	3.80
3. Makaweli River, Station 360	945	Hukipo	0	10	0.41
6 Apr 71 Storm	1047	Mt. Waialeale	50	53	7.24
6 Apr (6 pm) to 7 Apr (4 am)	1083	Upper Mohihi	45	19	1.62
4. Makaweli River, Station 360	945	Hukipo	0	9	0.80
19 Apr 74 Storm	1037.1	Kitano	10	30	2.53
18 Apr (12 noon) to 19 Apr (3 pm)	1047	Mt. Waialeale	90	61	12.48

INFILTRATION LOSSES

15. Infiltration losses were assumed to be uniform and were determined by the Soil Conservation Service method of relating soil types and land-use to curve numbers from which rainfall losses can be determined. An evaluation of the characteristics produced a curve number of 55 for the watershed and an infiltration loss rate of 0.4 inches per hour for the SPS and PMP.

BASE FLOW

16. At the river gages, the average discharges for Waimea River (Station 310) and Makaweli River (Station 360) are 132 cfs and 89 cfs, respectively. To allow for the contributory area below the gages, a base flow of 225 cfs was used in the study.

UNIT HYDROGRAPHS AND CONTRIBUTARY AREAS

17. 10-minute unit hydrographs for two contributory areas (above the confluence up to the streamgages, DA = 0.9 square miles, and below the confluence down to the mouth, DA = 0.75 square miles) were developed using data from the Makaweli, Sta 360 unit hydrograph and from the "Drainage Standards," City and County of Honolulu. The "Drainage Standards" was primarily used in estimating the lag time of the unit hydrographs. The unit hydrographs are shown on Plates A-13, and A-14. The drainage areas are shown on Plate A-15.

STANDARD PROJECT FLOOD (SPF)

18. The SPF was developed in accordance with the criteria contained in EM 1110-2-1411. The incremental rain fall excess of the SPS was arranged in a manner which produced the greatest peak discharges when applied to the unit hydrographs at Waimea River (Sta 310) and Makaweli River (Sta 360). The SPF hydrographs were routed and combined to produce the SPF hydrographs at the confluence and at the mouth (see Plates A-16 to A-18). The peak discharges equalled 105,000 cfs and 100,000 cfs at the confluence and mouth, respectively. These peak discharges were determined by routing under the existing conditions, therefore, any levee improvement between the confluence and the mouth will affect the peak discharge.

PROBABLE MAXIMUM FLOOD (PMF)

19. The PMF was derived in accordance with the directions and criteria of EM 1110-2-1411. The selected PMP hyetograph pattern will generate the highest peak discharges when applied to the unit hydrographs at Waimea River (Sta 310) and Makaweli River (Sta 360). The PMF hydrographs were routed and combined to produce the PMF hydrographs at the confluence and at the mouth. Plates A-19 to A-21 show the routed and combined hydrographs. A peak discharge of 248,000 cfs was calculated at the confluence and mouth. The attenuation of the routed hydrograph from the confluence to the mouth was very slight due to a short (10 minute) routing period.

FLOOD ROUTING

20. Flood routing was accomplished using the modified Puls method. The outflow discharge-storage relationships were developed from data obtained from HEC-2 water surface profile computer runs. The routing time step was determined using the criteria contained in EM 1110-2-1408, "Routing of Floods Through River Channels". The flood wave celerity method was selected from the EM. The ratio of the wave celerity to the mean velocity (V_W/V) of 1.44 (for a wide parabolic channel) was selected for the routing analysis. The mean velocity was computed from the HEC-2 water surface profile computer runs. For the SPF, routing time steps of 15 minutes for Waimea River (streamgage Sta 310 to confluence and confluence to mouth) and 7.5 minutes for Makaweli River (streamgage Sta 360 to confluence) were used. For the PMF, routing time steps of 10 minutes for Waimea River (streamgage Sta 310 to confluence, and confluence to mouth) and 5 minutes for Makaweli River (streamgage Sta 360 to confluence) were used. The lesser time steps for the PMF were due to increased mean velocities. The initial SPF and PMF hydrographs which were described at 30 minute time intervals were redescribed at the appropriate time interval (equalling the routing time step) for the routing analysis. A summary of the routed peak discharges are shown on Plate A-22.

WATER SURFACE ELEVATIONS

COMPARISON OF WATER SURFACE ELEVATIONS

21. A crest-stage gage (Sta 380) with 33 years of record is located 150 feet above the highway bridge (see Plate A-1). A stage-frequency analysis was made by the graphical method, plotting the data on probability paper using the factors shown on Exhibit 37, Plotting Positions in Percent, published in "Statistical Methods in Hydrology", Leo R. Beard, Jan 1962. The stage data is shown on Table A-5 and the graphical analysis is shown on Plate A-23. A graphical analysis was selected since the lower river stages are influenced by tide levels, wave actions, and by the sandbar at the rivermouth.

22. Water surface elevations at the gage (Sta 380) location were computed by the HEC-2 computer program for the various peak discharges determined in the discharge-frequency analysis. A comparison of the water surface elevations is shown on Table A-6. There are many variables which could affect the simplified water surface comparison made and these include riverbed scour during a flood, changing stream cross-sections during the past years, levee construction on the west bank, debris accumulation on the bridge piers, sandbar elevations prior to the flood, rate of the sandbar removal, high tides and wave action, the timing of the peak discharge with respect to the sandbar removal, and the actual flood hydrograph at the gage location. An exhaustive study would probably be impossible due to the nature of the subject matter and available data.

TABLE A-5.

CREST GAGE NO. 380, WAIMEA RIVER AT WAIMEA

Location: 150 feet above highway bridge at Waimea.

Gage: Crest-stage gage. Datum of gage is mean sea level.

WATER YEAR	DATE	STAGE HEIGHT (FT)
1944	9-17-44	4.11
1945	4-6-45	4.75
1946	12-6-34	5.39
1947	12-22-46	5.62
1948	6-25-48	4.77
1949	2-7-49	11.40
1950	8-17-50	7.50
1951	1-14-51	5.36
1952	1-19-52	7.32
1953	3-4-53	4.92
1954	2-22-54	7.01
1955	11-28-54	5.58
1956	11-11-55	7.70
1957	10-23-56	5.86
1958	12-1-57	6.15
1959	8-6-59	7.58
1960	11-2-59	6.48
1961	4-11-61	4.40
1962	4-25-62	6.12
1963	4-15-63	5.25
1964	9-30-64	6.48
1965	1-5-65	5.05
1966	11-20-65	6.27
1967	11-4-66	5.63
1968	11-26-67	4.74
1969	11-29-68	5.49
1970	1-13-70	5.40
1971	4-7-71	6.40
1972	4-14-72	5.55
1973	7-4-73	4.74
1974	12-1-73	5.97
1975	1-31-75	8.77
1976	10-21-75	6.48

TABLE A-6.

COMPARISON OF WATER SURFACE ELEVATION AT
STA. 380, 150 FEET ABOVE
HIGHWAY BRIDGE

WATER SURFACE ELEVATION (FEET)

Flood Frequency	Stage-Frequency Curve	HEC-2 Computations Using Discharges From Discharge-Frequency Curve
2-YEAR	5.7	3.7
10-YEAR	7.8	7.4
50-YEAR	11.5	11.8
100-YEAR	14.0	13.7

The difference (5.7 feet versus 3.7 feet) for the 2-year flood is believed to be caused by the inability of the actual 2-year flood to remove the sandbar at the river mouth, a condition which was assumed in the water surface profile analyses using the HEC-2 computer program.

WATER SURFACE DETERMINATION

23. Water surface elevations in Waimea River were determined by using the HEC-2 computer program, "Water Surface Profiles." The inundation limits of the various floods for the existing condition were determined (Plate A-24). It was found that subcritical flow governed the flow regime of discharges flowing in Waimea River past Waimea Town. The water surface profiles were started at the mouth. A mean high tide elevation of 1.5 feet was inputted as a starting water surface elevation. However, for the higher discharges, critical depth governed. The sandbar was assumed to have been washed out prior to the occurrence of the peak discharges.

MANNING'S "n"

24. Manning's roughness coefficients, ranging from 0.025 to 0.03 for the river channel and 0.04 to 0.08 for the overbank areas, were used in the evaluation. The roughness coefficients were determined by field inspection of the existing river and overbank areas.

FLOODPLAIN

25. There are two notable floodplain features in the Waimea area which greatly affect the flood inundation pattern, and these are the existing levee on the west bank and the relatively high coastal area with a low swale leading away from Waimea River. The 100-year flood will overtop the downstream section of the west bank and will cause floodwaters to pond and inundate most of the upstream low-lying areas of Waimea. The overtopping flows will then cross the highway and will follow two paths to the ocean. One path will be towards the Waimea River and the other path will be along the low swale leading away from Waimea River.

DRAINAGE AREA

26. For the purposes of documentation, Table A-7 lists the appropriate drainage areas related to the hydrologic analyses.

TABLE A-7. DRAINAGE AREAS

River	Location	Drainage Area, Square Miles
Total area at confluence	at confluence of Waimea and Makaweli River	84.7
Waimea	at confluence	58.4
Makaweli	at confluence	26.3
Waimea	at mouth	85.5
Waimea	at recording streamgage 310	57.8
Makaweli	at recording streamgage 360	26.0
Waimea	at crest gage 380	86.5*

*as determined by USGS.

EXTREME FLOOD DATA

27. In accordance with the U.S. Water Resources Council and Corps of Engineers directives, water surface computations were performed for the 500-Year and Standard Project Floods. Both these extreme events would exceed the project design flood. Under existing conditions the water surface would extend across the entire cross section. As a result, uniform and undivided flow conditions would prevail. The analysis was conducted as described in paragraph 23 of this section. In contrast, under improved conditions, divided flows would exist. The water surface elevations would be higher in the river and left bank area as compared with the right bank or Waimea town area. Specific analytical techniques used in determining the variable flows as a result of overtopping the project design levee are described in paragraphs 45-50 of Section C. Backwater analysis was performed with the HEC-2 computer program utilizing the variable flow input. The completed evaluation of discharges, water surface elevations, flood depths, and velocities for typical locations in the floodplain are shown in tables A-9 and A-10. The specific locations are shown in Plate A-24.

28. The water surface elevations was determined to be lower in Waimea town under project conditions as compared to existing conditions. As shown in tables A-8 and A-9, the water surface elevations are generally one to three feet lower for the project condition as compared to the existing condition under the 500-Year flood event. Similarly for the SPF the relative differences were determined to be one to four feet. The average velocity differences were not significant. For both extreme events and under both existing and project conditions, the velocities were computed to be on the order of one to three feet per second.

TABLE A-8. HYDRAULIC DATA FOR 500-YEAR FLOOD UNDER EXISTING AND PROJECT CONDITIONS

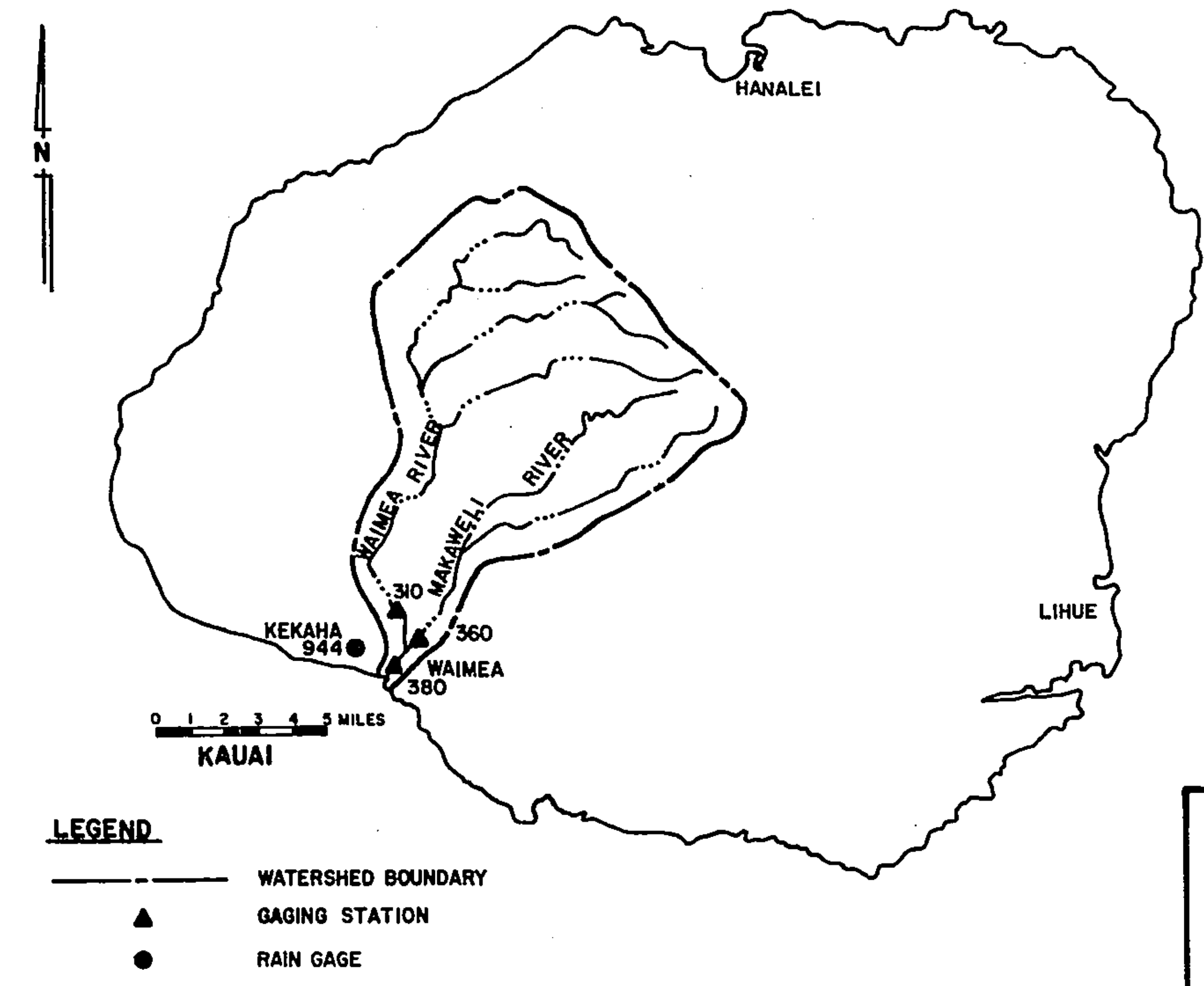
		EXISTING CONDITION				PROJECT CONDITIONS			
River Station	Location Right/Left Bank	Discharge, cfs 1/	Water Surface Elevation ft,MSL	Avg Flood Depth, ft 3/	Avg Velocity ft/sec	Discharge, cfs 2/	Water Surface Elevation ft,MSL	Avg Flood Depth, ft 3/	Avg Velocity ft/sec
1+40	Right	89,000	11.0	2.8	1.0	24,800	9.9	1.7	0.8
7+00	Right	89,000	15.2	5.6	1.8	24,800	14.0	4.6	1.5
12+50	Right	89,000	17.7	10.7	2.0	24,780	16.6	9.5	2.0
21+00	Right	89,000	18.3	12.5	2.5	24,020	16.8	11.0	1.7
	Left		18.3	11.7	1.8	69,980	15.6	12.6	2.8
33+50	Right	89,000	18.6	11.3	2.3	21,690	17.2	9.9	1.9
	Left		18.6	11.8	2.4	72,310	17.0	11.5	3.2
42+00	Right		19.2	10.7	1.8	20,490	17.6	9.3	1.7
	Left	89,000	19.2	10.1	2.5	73,510	18.0	10.7	2.9
53+50	Right	89,000	20.0	7.5	2.9	16,970	17.9	5.7	1.5
60+30	Right	89,000	22.2	7.3	2.3	15,920	18.8	2.8	3.6

1/ Undivided flow; total discharge shown.
2/ Divided flow.
3/ Hydraulic depth.

TABLE A-9. HYDRAULIC DATA FOR STANDARD PROJECT FLOOD UNDER EXISTING AND PROJECT CONDITIONS

River Station	Location Right/Left Bank	EXISTING CONDITION Discharge, cfs 1/	Water Surface Elevation ft, MSL	Avg Flood Depth, ft 3/	Avg Velocity ft/sec	PROJECT CONDITIONS Discharge, cfs 2/	Water Surface Elevation ft, MSL	Avg Flood Depth, ft 3/	Avg Velocity ft/sec
1+40	Right	100,000	13.1	6.5	1.4	34,600	13.5	5.3	1.5
7+00	Right	100,000	16.2	6.6	2.0	34,600	16.5	7.1	1.9
12+50	Right	100,000	18.8	11.8	2.2	34,560	17.7	10.8	2.5
21+00	Right	100,000	19.5	13.7	2.6	33,430	18.0	12.4	2.1
	Left		19.5	12.9	1.9	71,570	15.8	12.8	2.8
33+50	Right	100,000	19.8	12.4	2.5	30,280	18.4	11.1	1.1
	Left		19.8	12.9	2.5	74,720	17.2	11.7	3.2
42+00	Right		20.4	11.8	1.9	28,640	18.6	10.3	2.2
	Left	100,000	20.4	11.9	2.6	76,360	19.2	11.9	3.0
53+50	Right	100,000	21.2	8.2	3.0	24,090	19.1	6.8	2.5
60+30	Right	100,000	23.6	8.0	2.5	22,820	20.0	4.0	3.7

1/ Undivided flow; total discharge shown.
2/ Divided flow.
3/ Hydraulic depth.

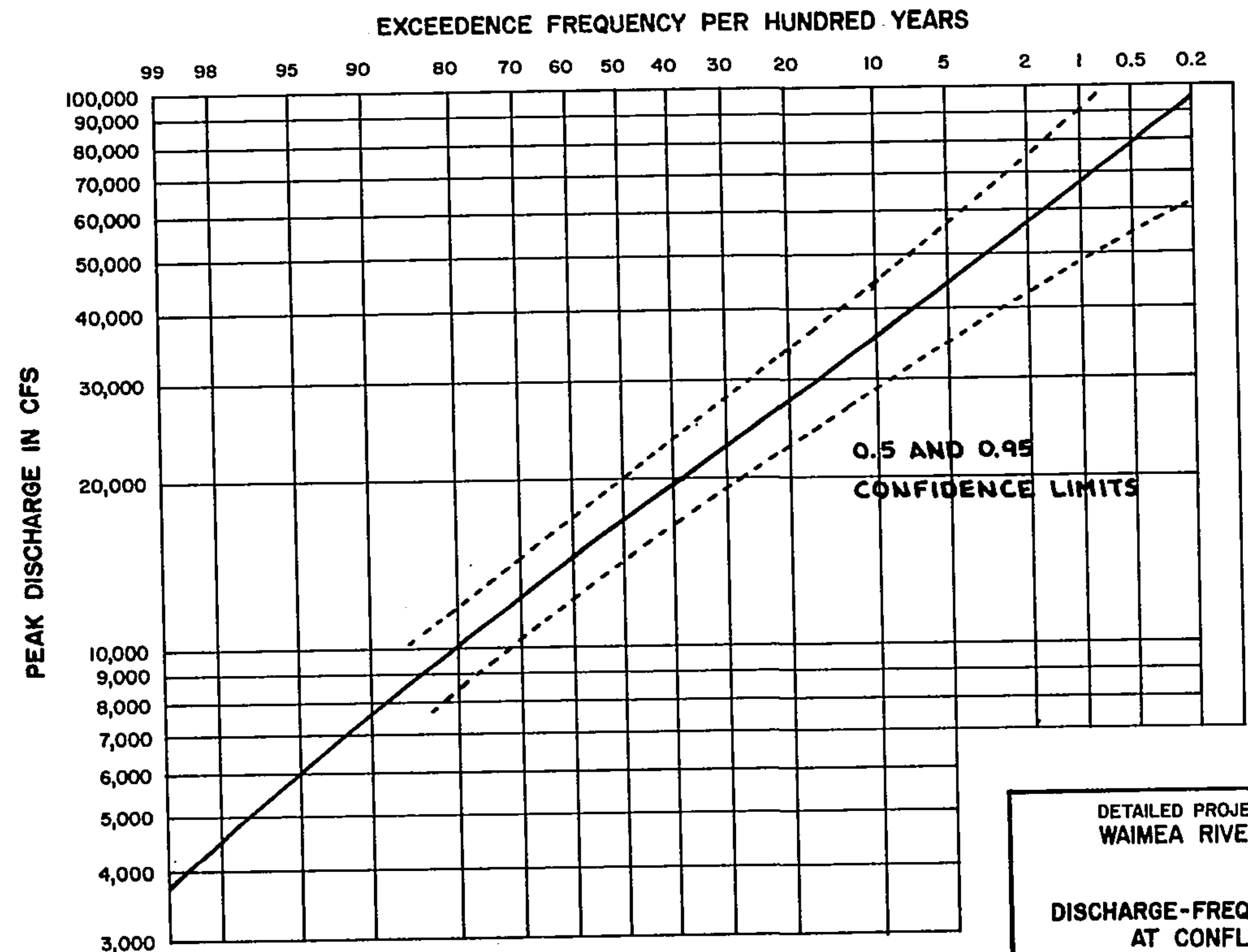


DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI

DRAINAGE AREA AND
STREAM GAGE LOCATIONS

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE A-1

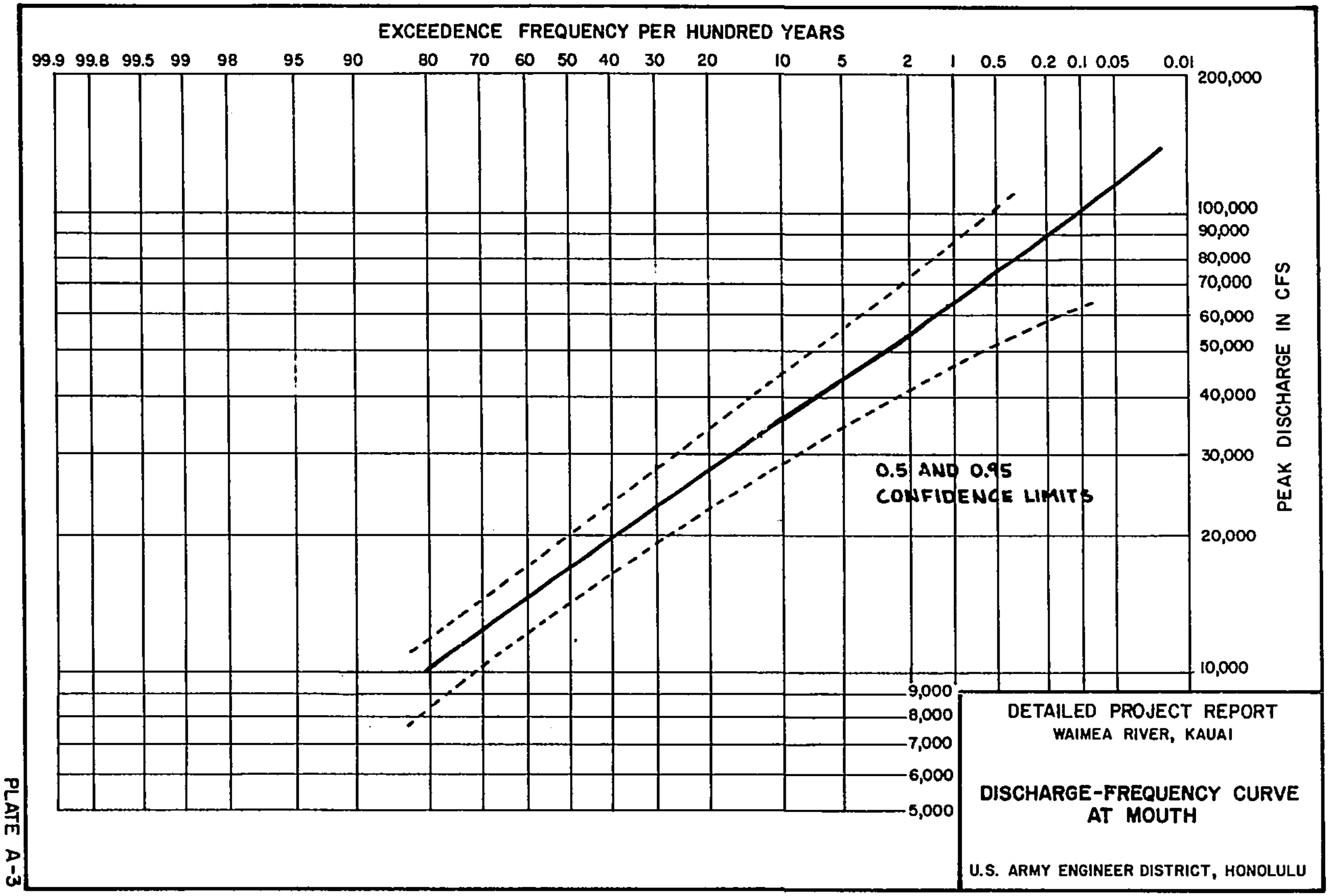


DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI

DISCHARGE-FREQUENCY CURVE
AT CONFLUENCE

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE A-2

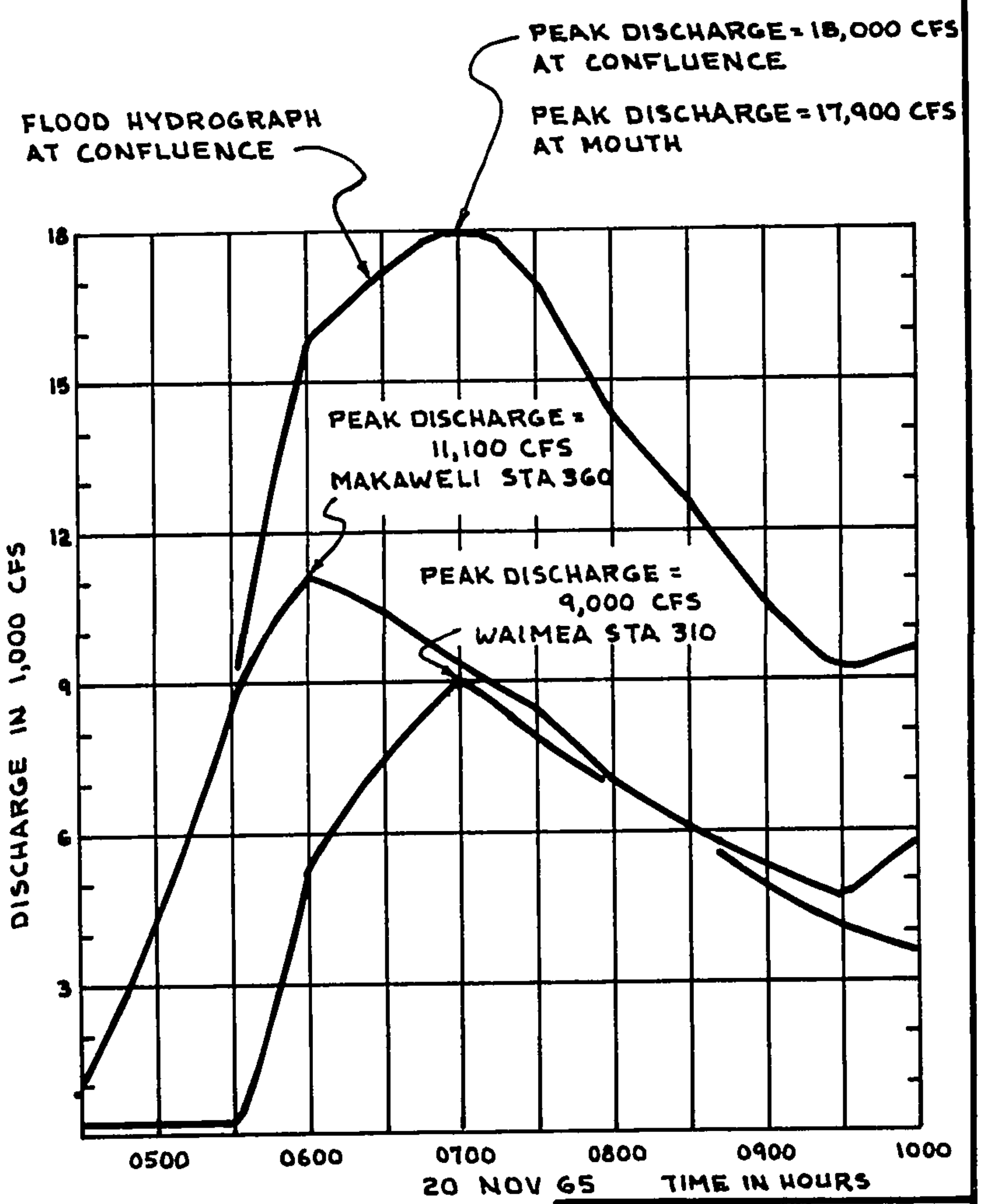


DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI

DISCHARGE-FREQUENCY CURVE AT MOUTH

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE A-3

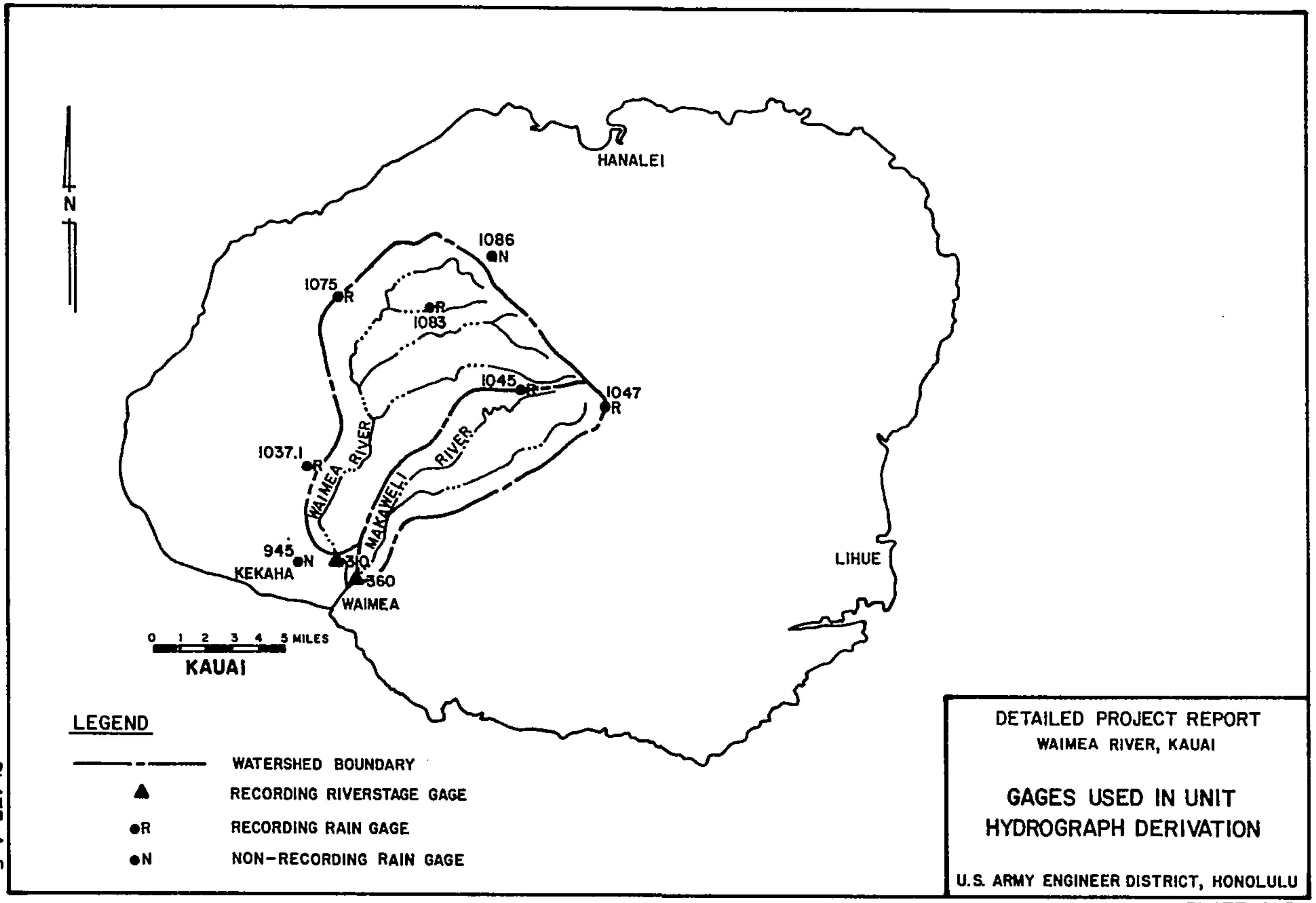


DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI

FLOOD ROUTING AND COMBINING (TYPICAL)

U.S. ARMY ENGINEER DISTRICT, HONOLULU

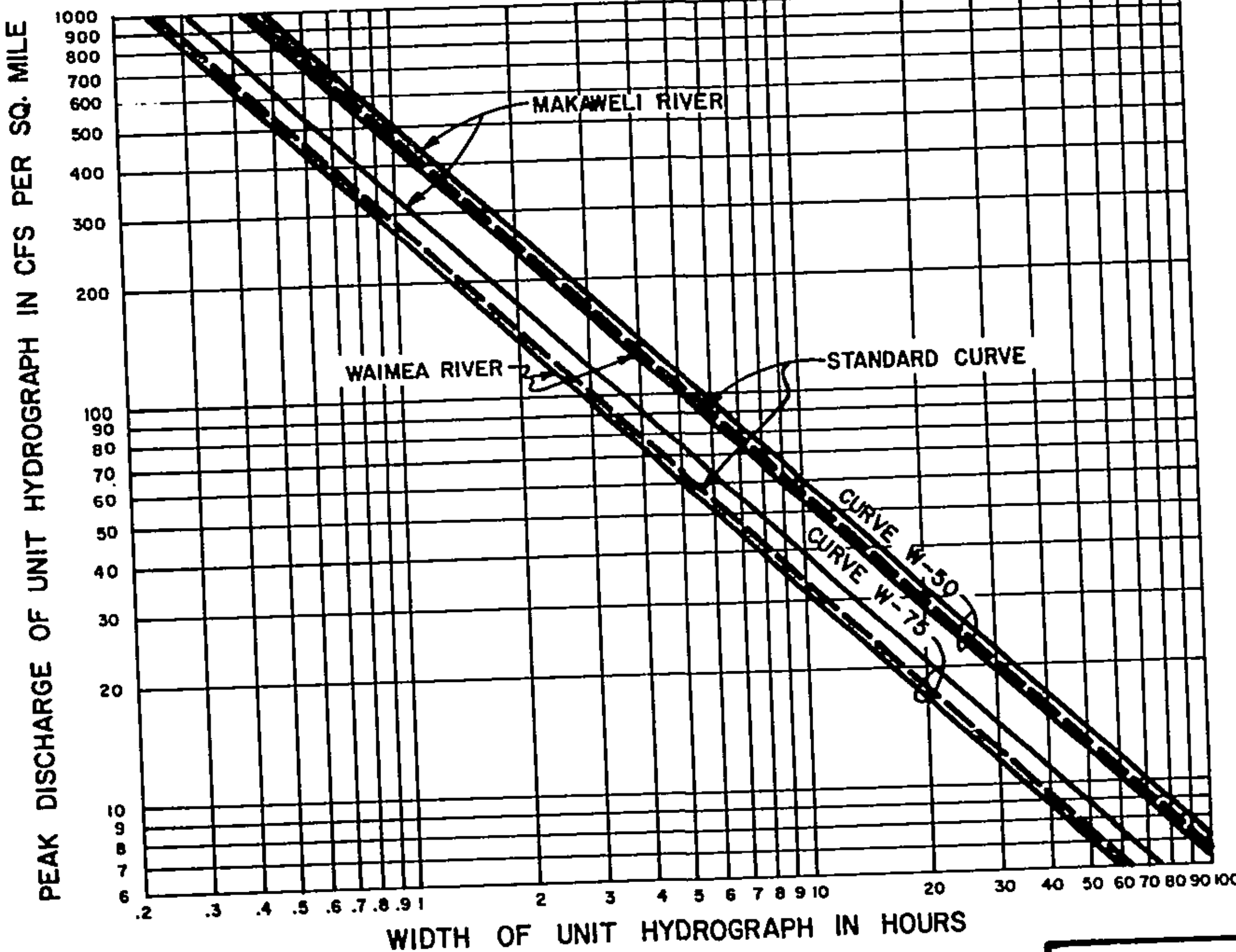
PLATE A-4



DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI

GAGES USED IN UNIT HYDROGRAPH DERIVATION

U.S. ARMY ENGINEER DISTRICT, HONOLULU

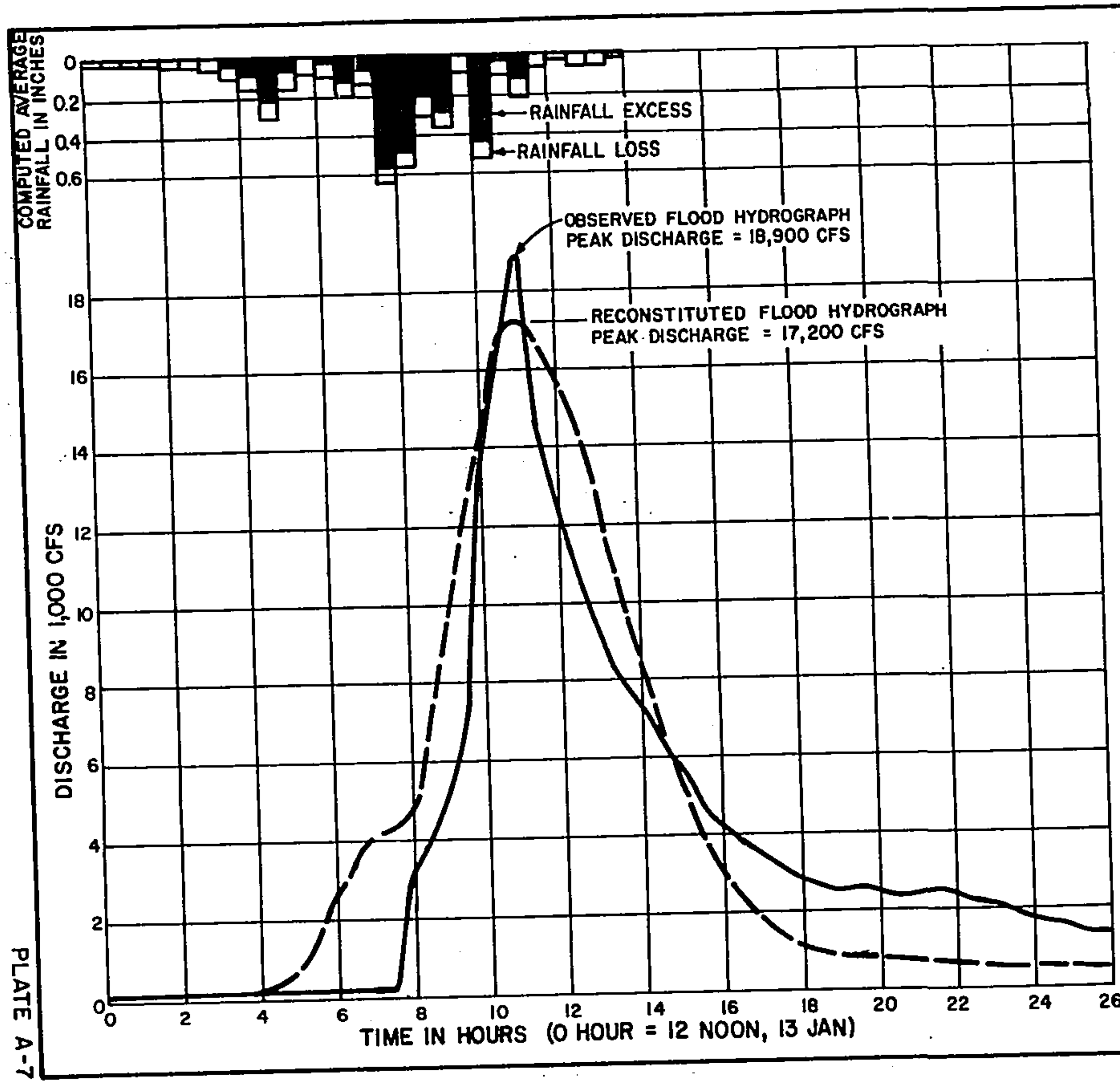


DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI

UNIT HYDROGRAPH
PEAKS VERSUS WIDTHS

U.S. ARMY ENGINEER DISTRICT, HONOLULU

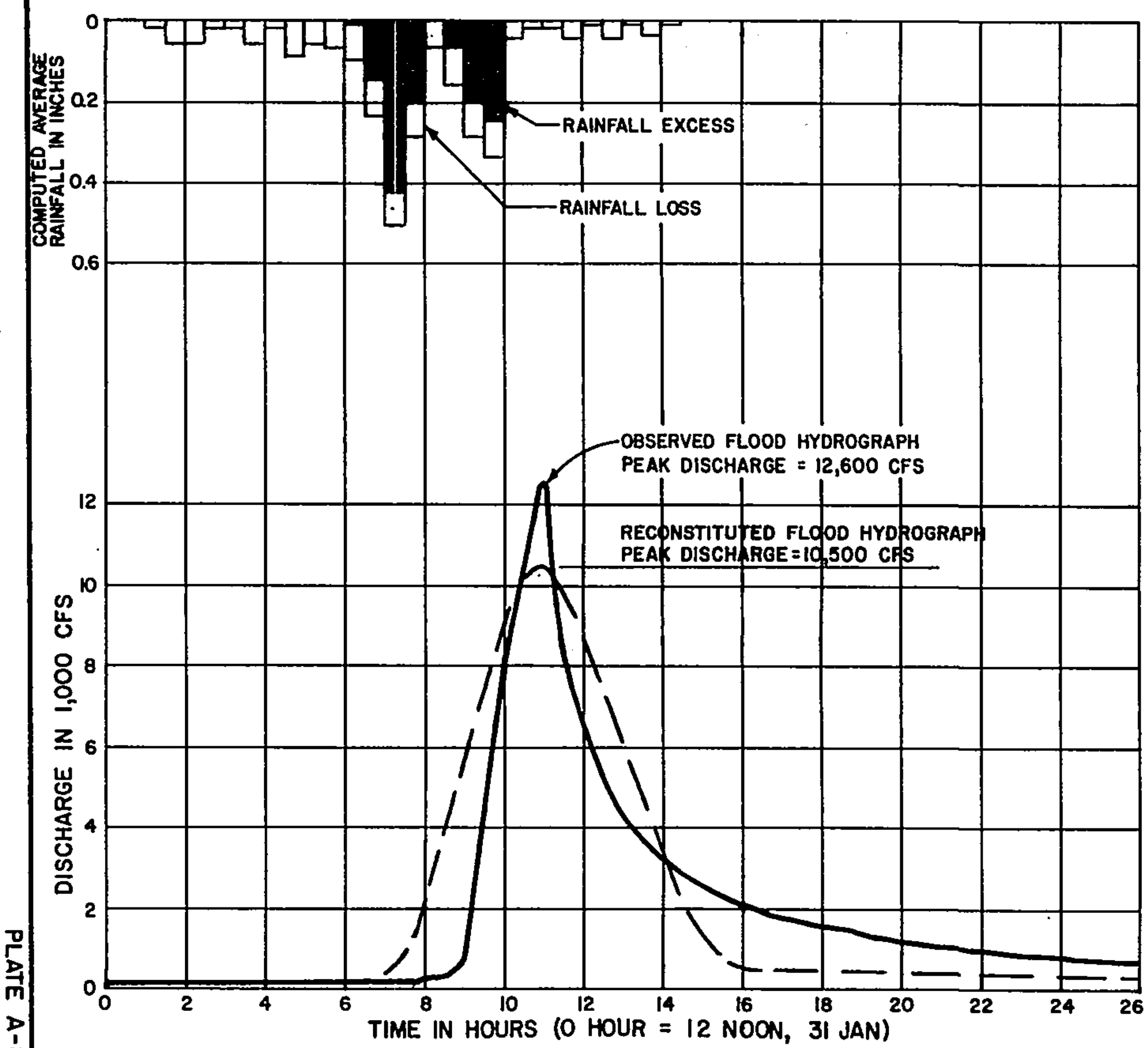
PLATE A-6



DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI

FLOOD RECONSTITUTION
WAIMEA RIVER, STA 310
13 JAN 70 FLOOD

U. S. ARMY ENGINEER DISTRICT, HONOLULU

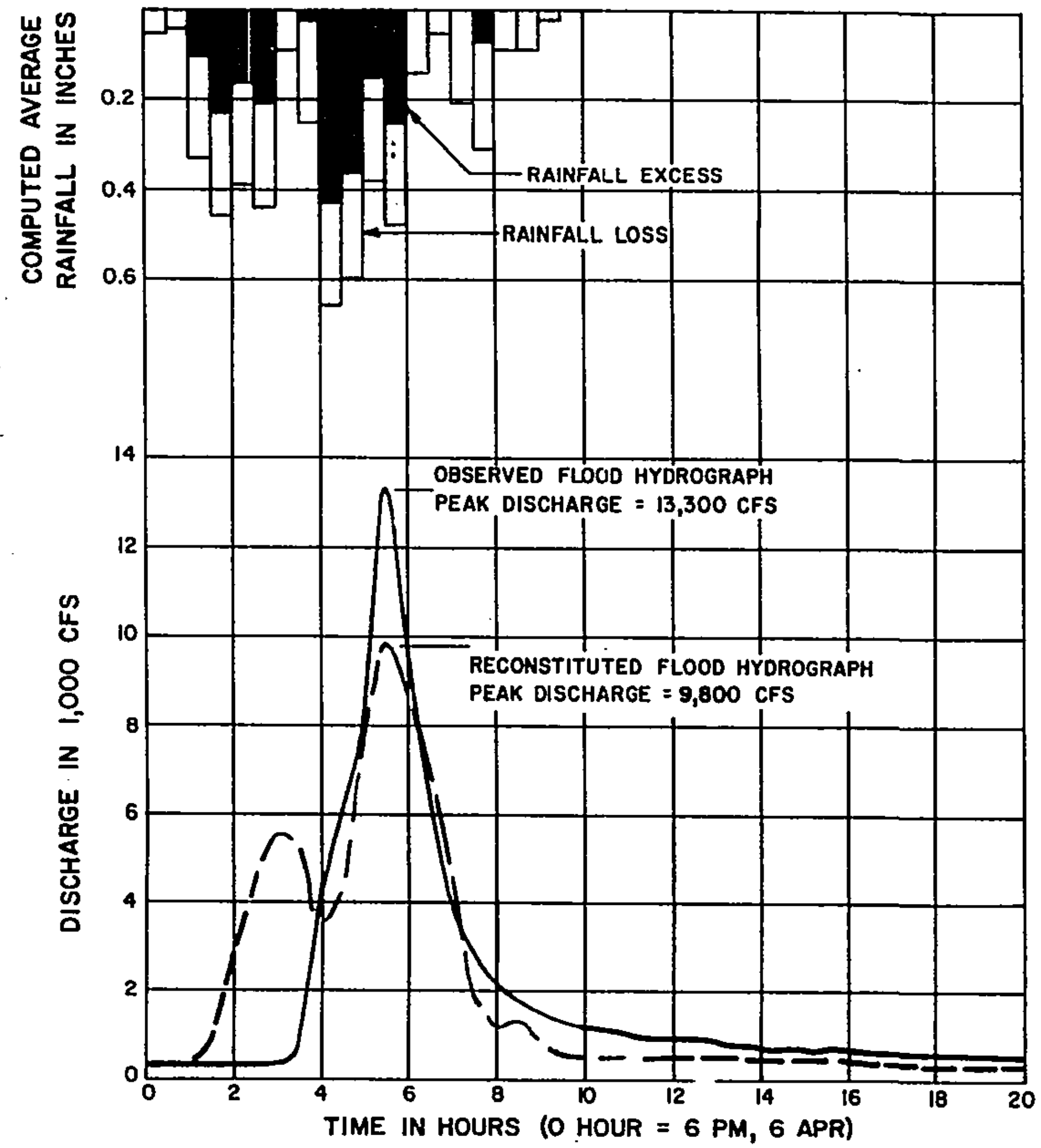


DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI

FLOOD RECONSTITUTION
WAIMEA RIVER, STA 310
31 JAN 71 FLOOD

U. S. ARMY ENGINEER DISTRICT, HONOLULU

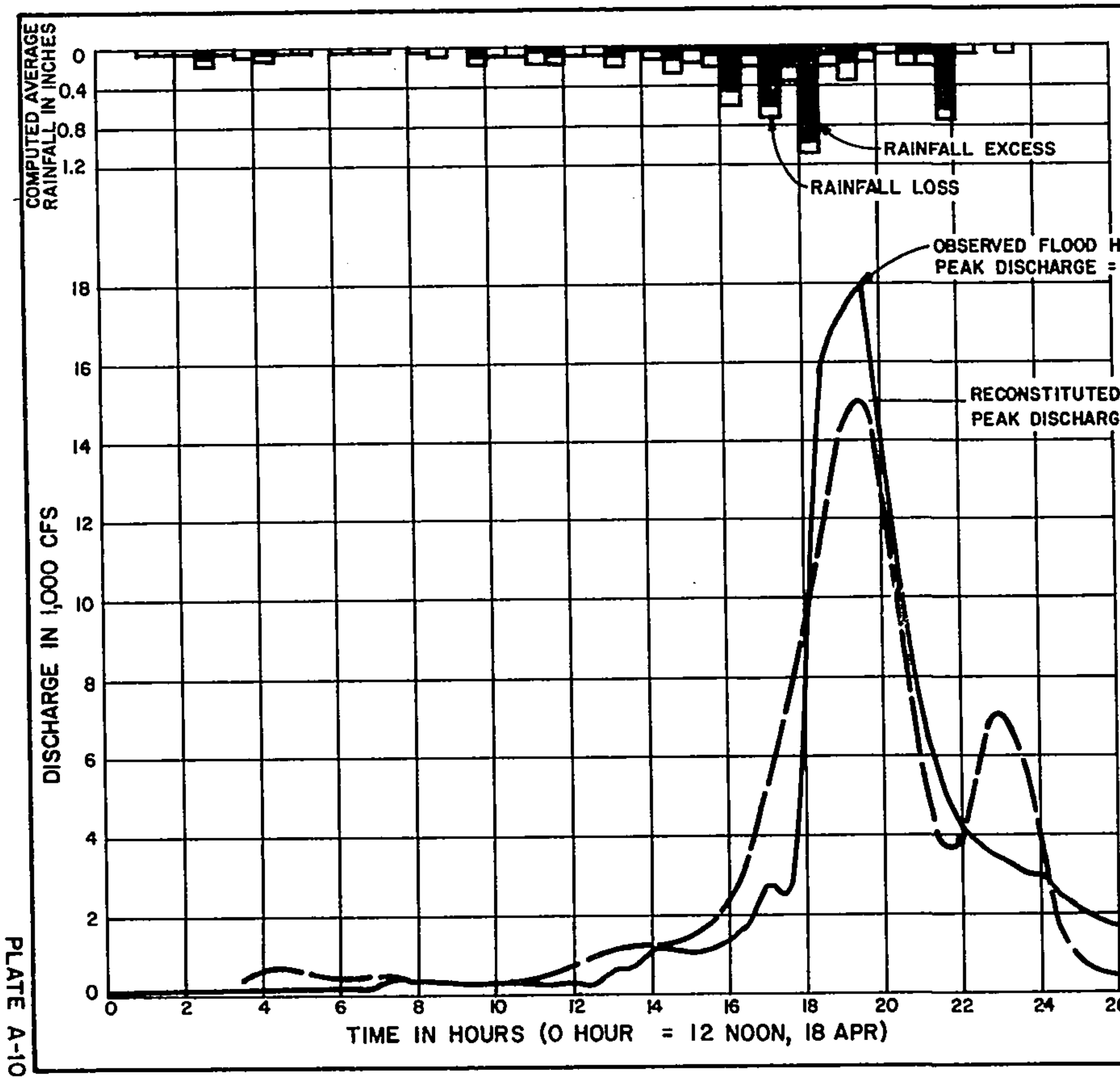
PLATE A-8



DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI

FLOOD RECONSTITUTION
MAKAWELI RIVER, STA 360
6 APR 71 FLOOD

U.S. ARMY ENGINEER DISTRICT, HONOLULU

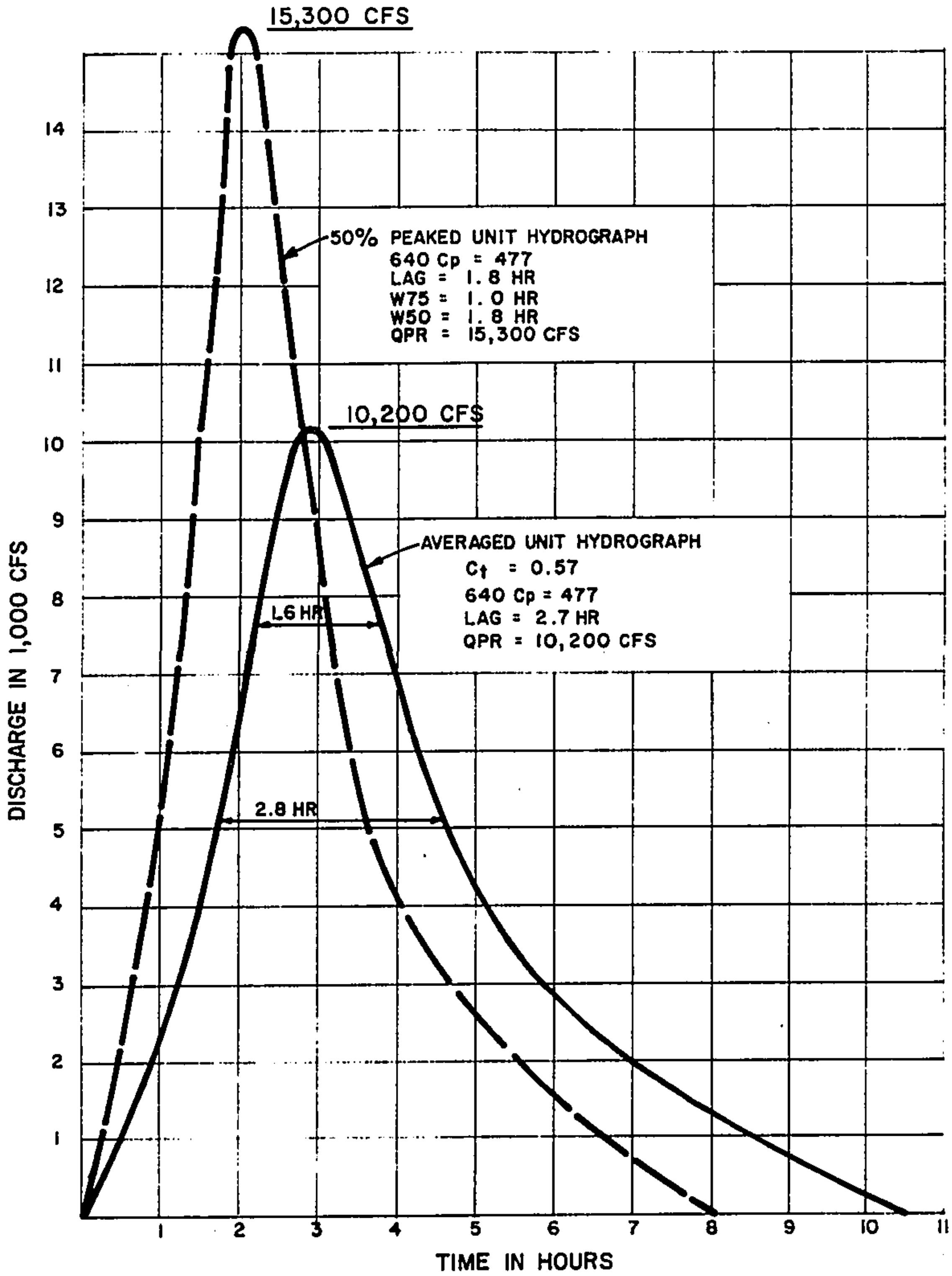


DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI

FLOOD RECONSTITUTION
MAKAWELI RIVER, STA 360
19 APR 74 FLOOD

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE A-10

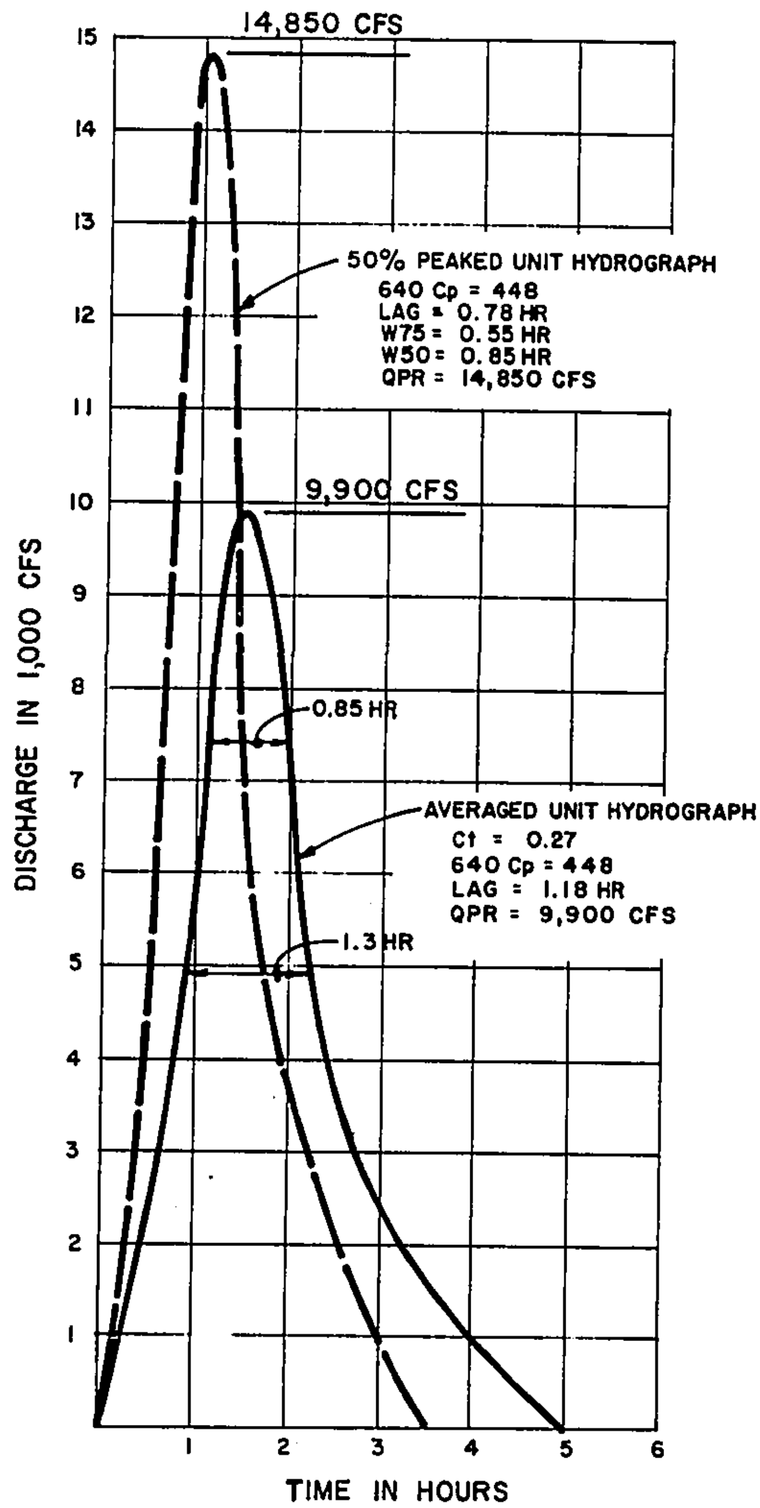


DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI

30 MINUTE UNIT HYDROGRAPH
WAIMEA RIVER, STA 310

U.S. ARMY ENGINEER DISTRICT, HONOLULU

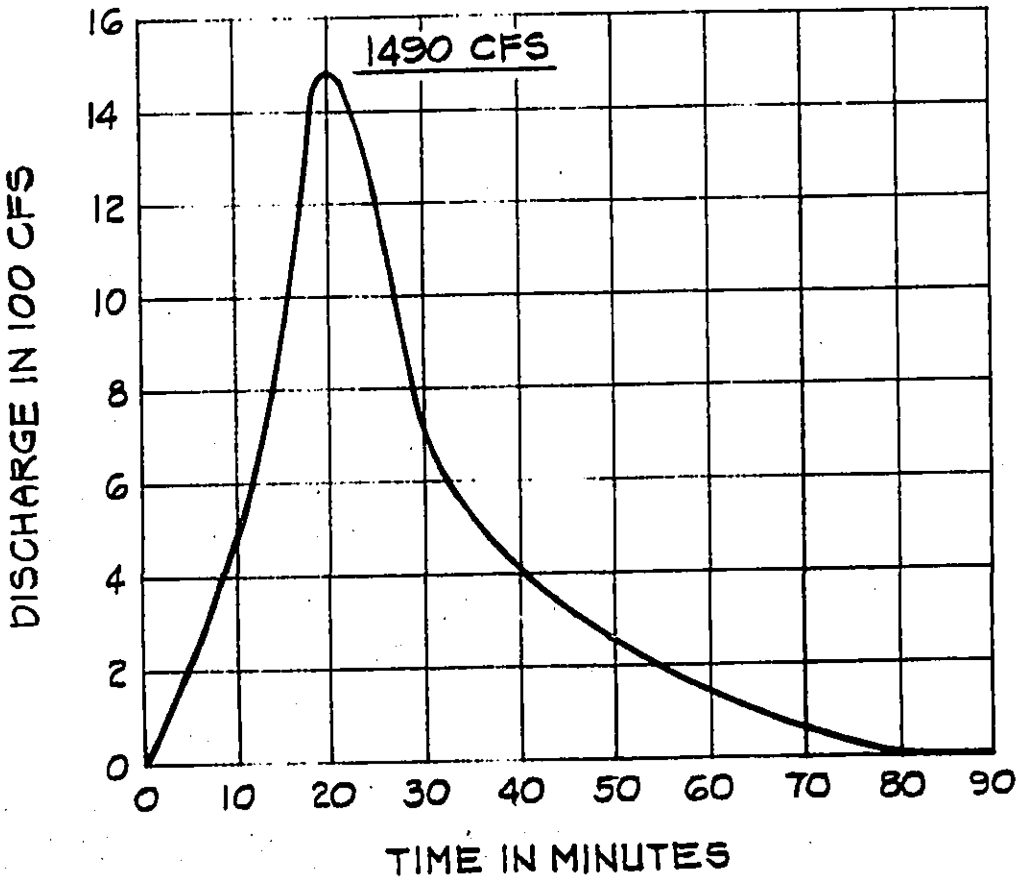
PLATE A-11



DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI

30 MINUTE UNIT HYDROGRAPH
MAKAWELI RIVER, STA 360

U.S. ARMY ENGINEER DISTRICT, HONOLULU



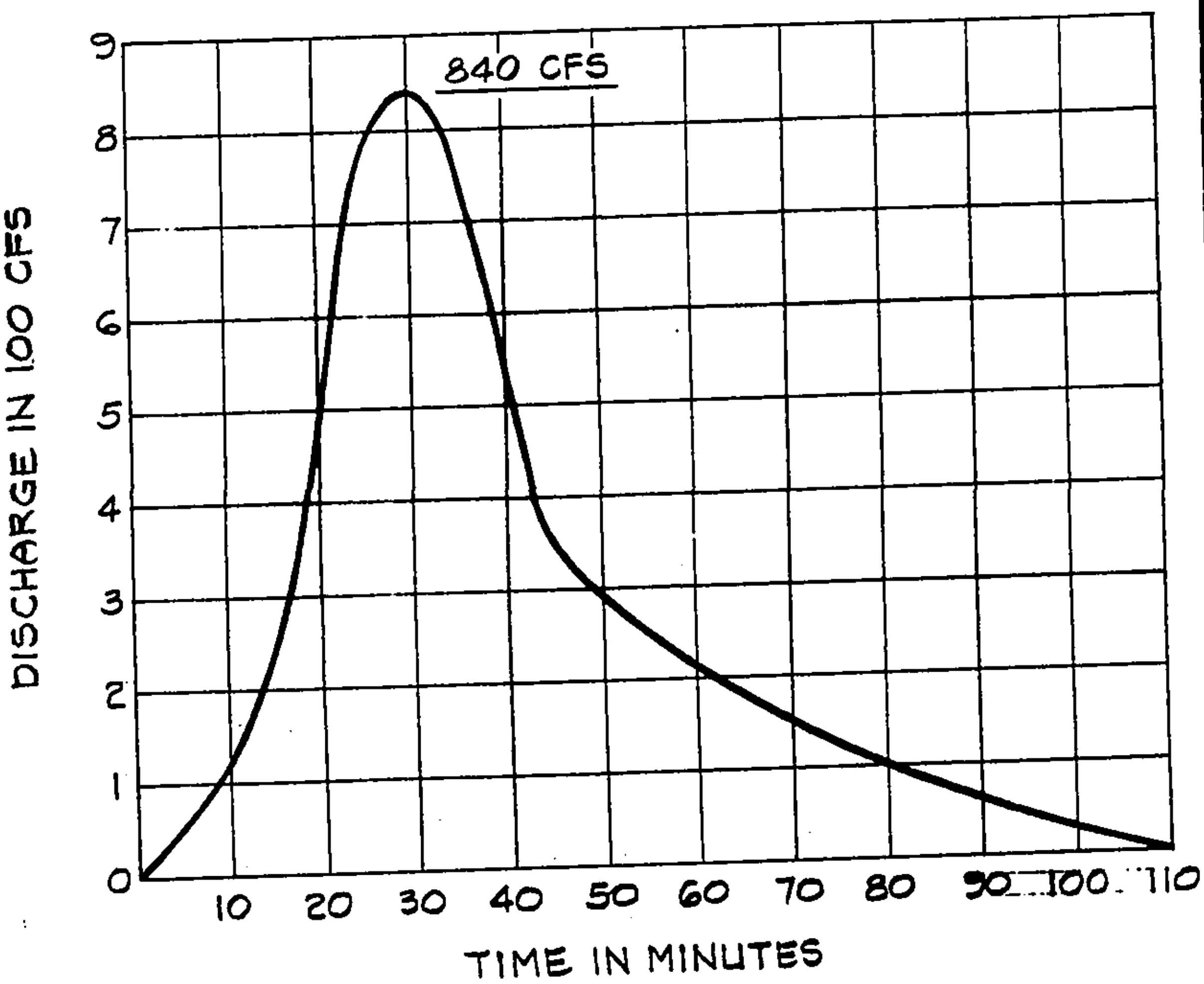
UNIT HYDROGRAPH

Ct	= 0.27
640 Cp	= 448
LAG	= 16 MIN
W75	= 10 MIN
W50	= 16 MIN
QPR	= 1490 CFS

DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI

10 MINUTE UNIT HYDROGRAPH GAGING STATIONS TO CONFLUENCE

U.S. ARMY ENGINEER DISTRICT, HONOLULU



UNIT HYDROGRAPH

Ct = 0.35
640 Cp = 448
LAG = 24 MIN
W75 = 14 MIN
W50 = 23 MIN
QPR = 840 CFS

DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI

10 MINUTE UNIT HYDROGRAPH, CONFLUENCE TO MOUTH

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE A-14

DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI

DRAINAGE AREA BELOW GAGES

U.S. ARMY ENGINEER DISTRICT, HONOLULU

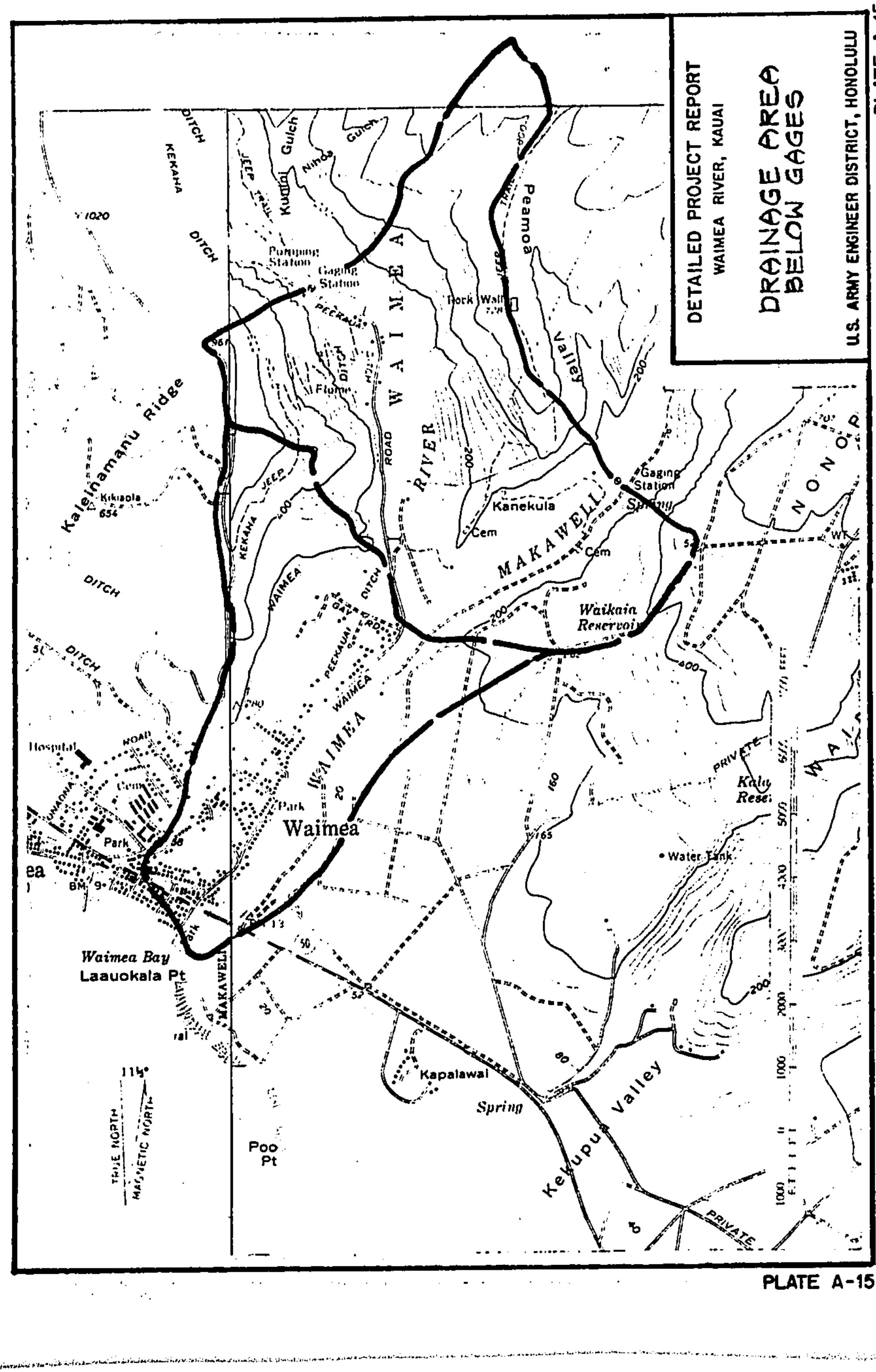
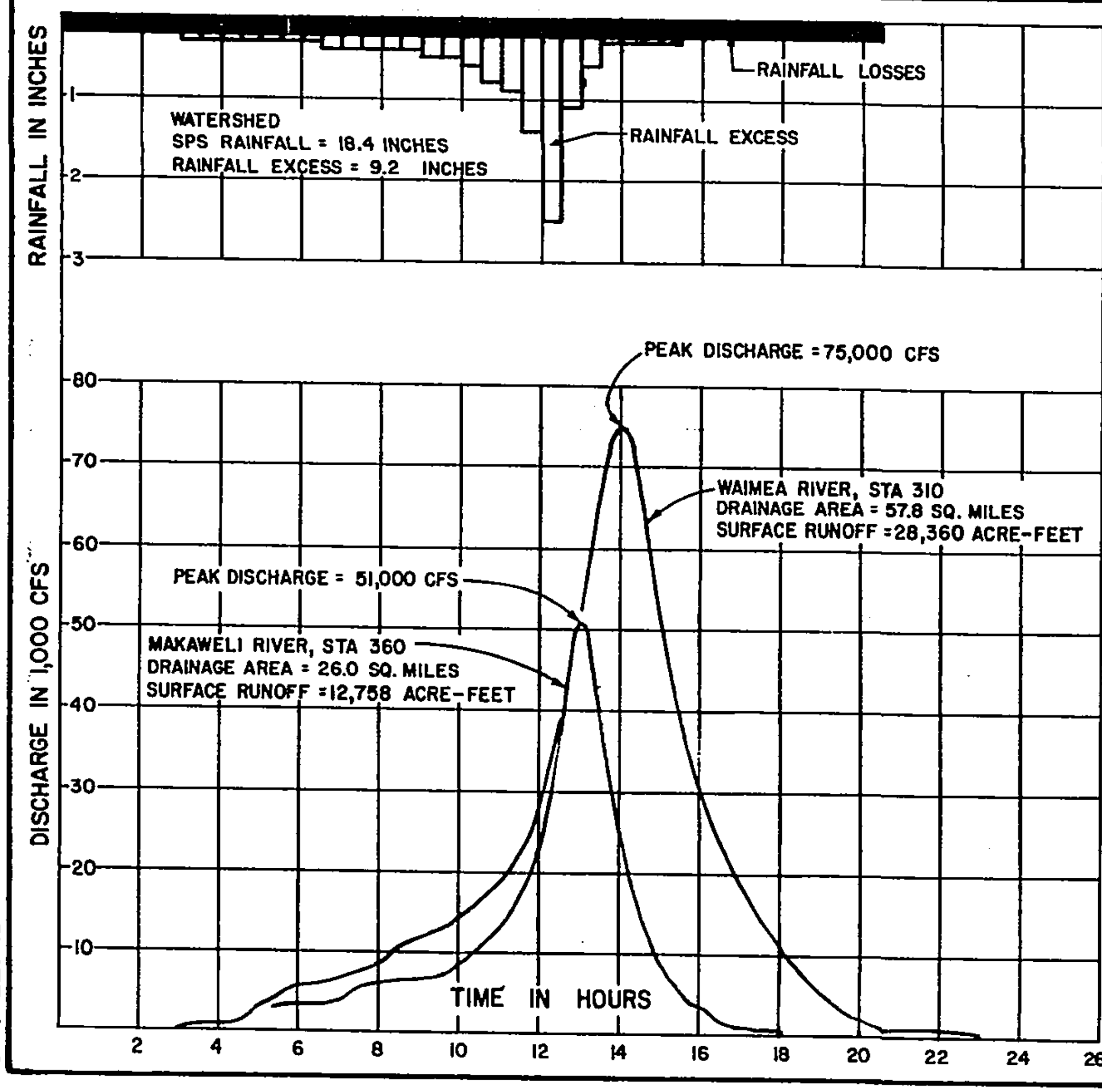


PLATE A-15



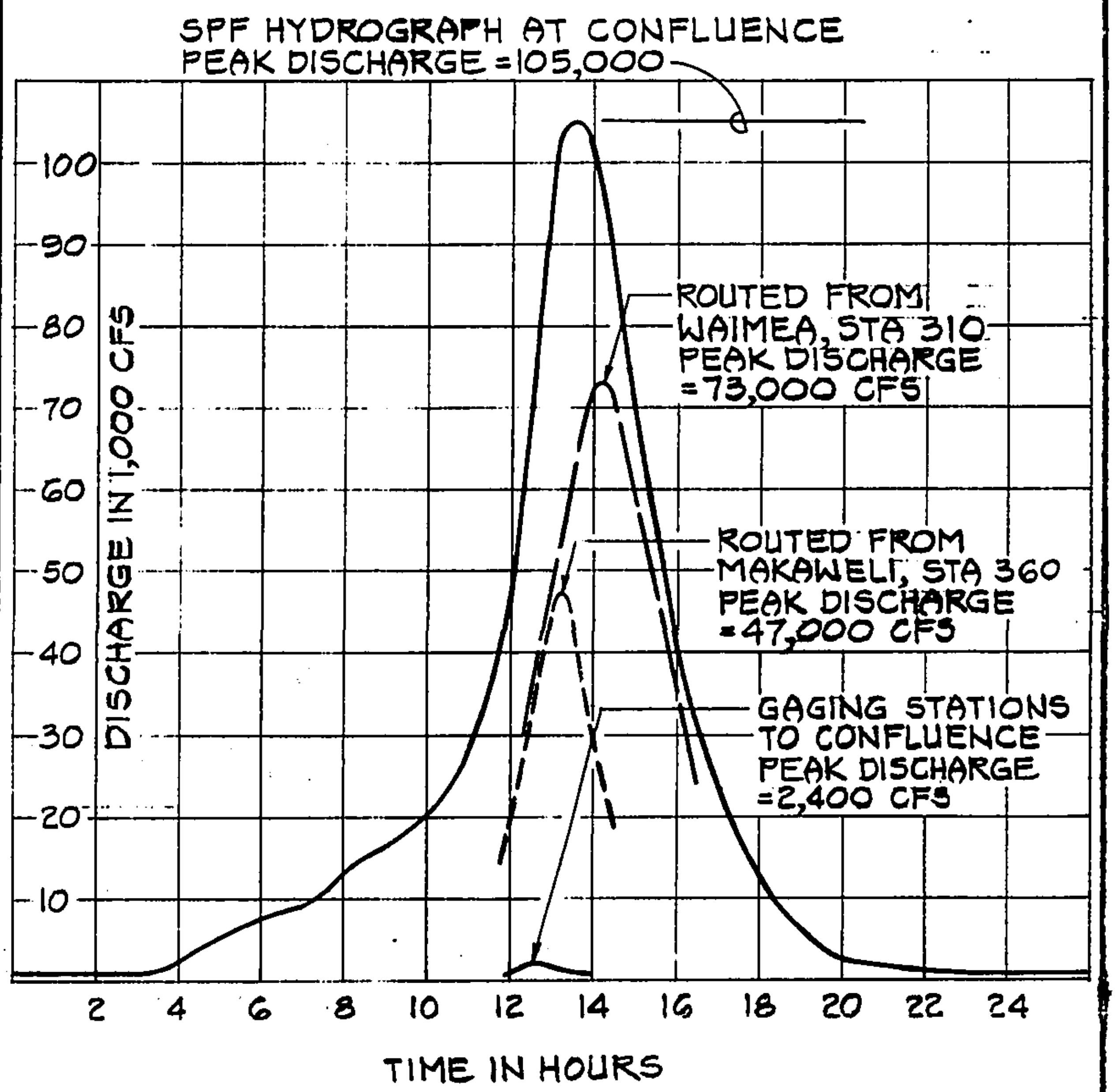
NOTE:
BASE FLOW NOT INCLUDED

DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI

SPF HYDROGRAPH
WAIMEA RIVER, STA 310
MAKAWELI RIVER, STA 360

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE A-16

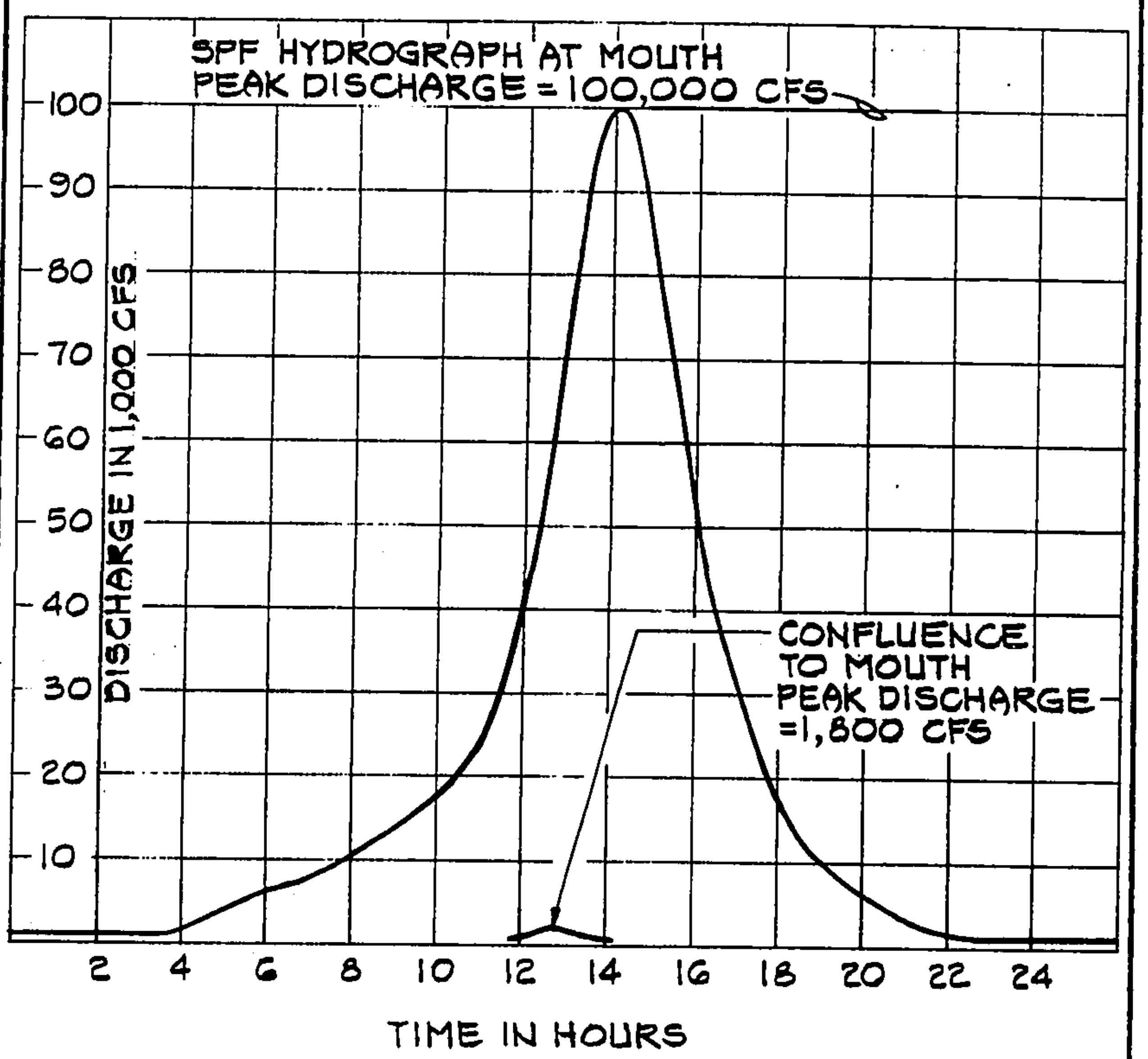


DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI

SPF HYDROGRAPH AT CONFLUENCE

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE A-17



NOTE

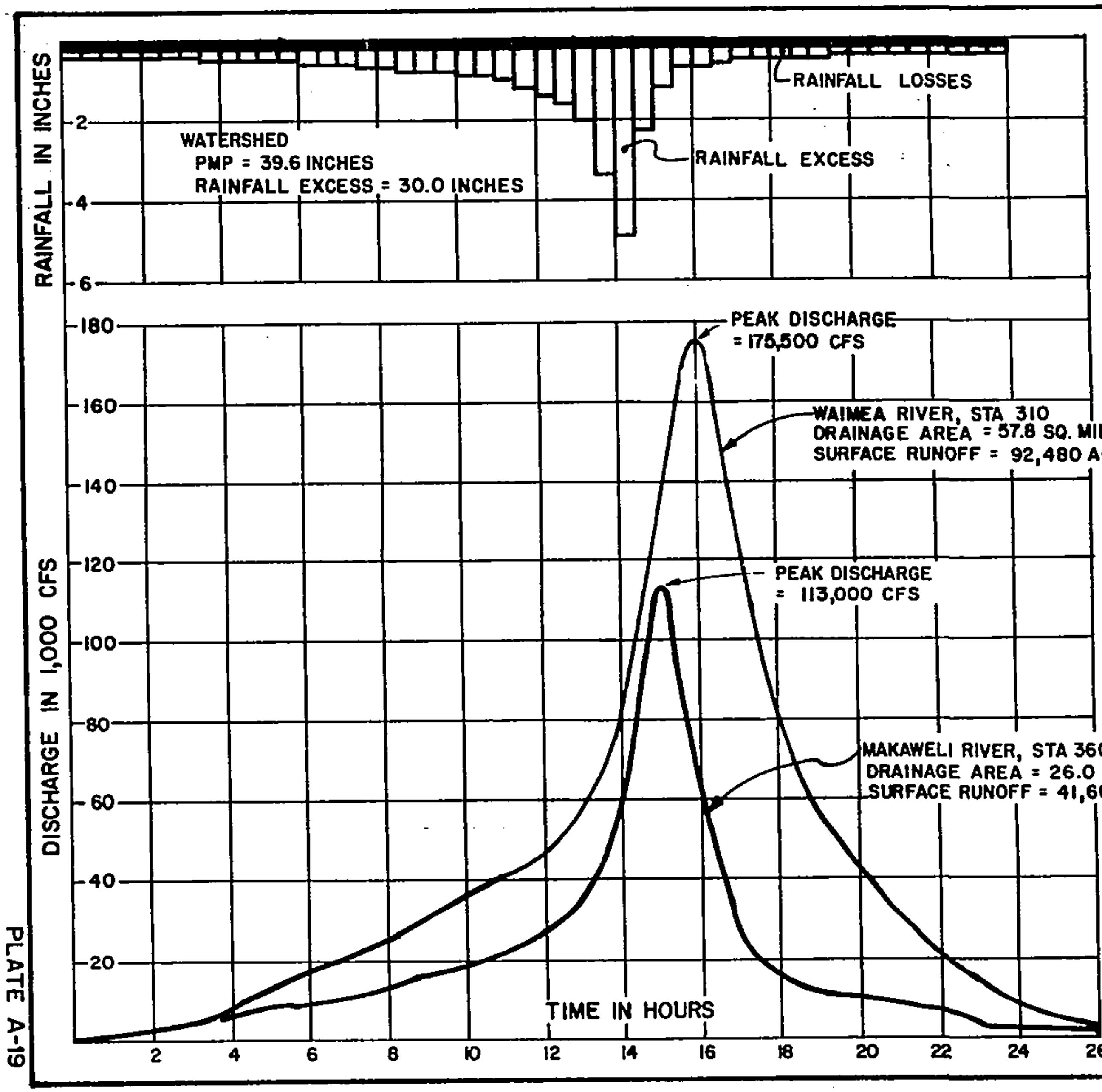
ROUTED SPF HYDROGRAPH FROM CONFLUENCE IS SLIGHTLY BELOW THE SPF HYDROGRAPH AT MOUTH AND IS NOT SHOWN. ROUTED PEAK DISCHARGE = 99,500 CFS

DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI

SPF HYDROGRAPH AT MOUTH

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE A-18



NOTE:

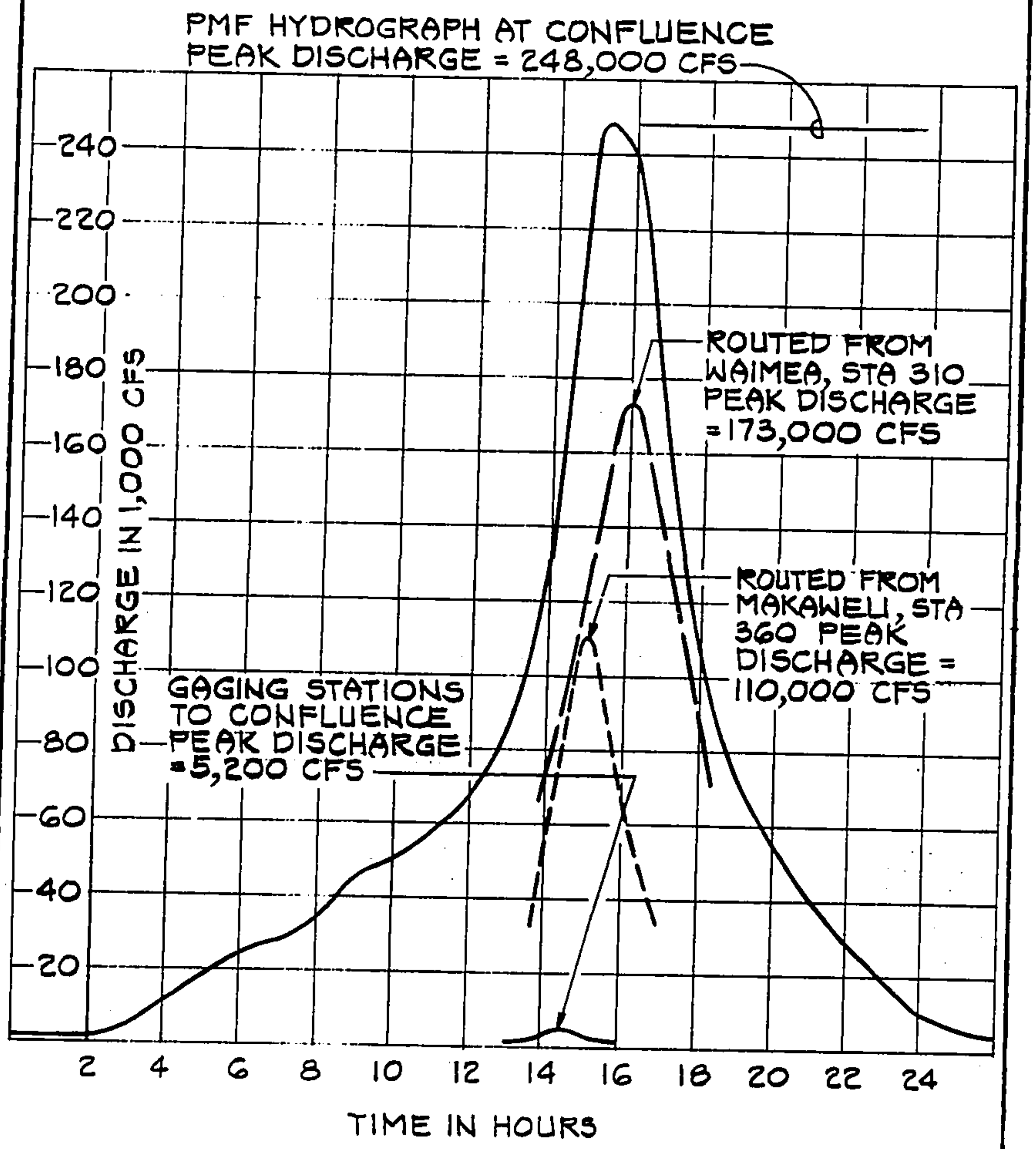
BASE FLOW NOT INCLUDED.

DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI

PMF HYDROGRAPH
WAIMEA RIVER, STA 310
MAKAWELI RIVER, STA 360

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE A-19

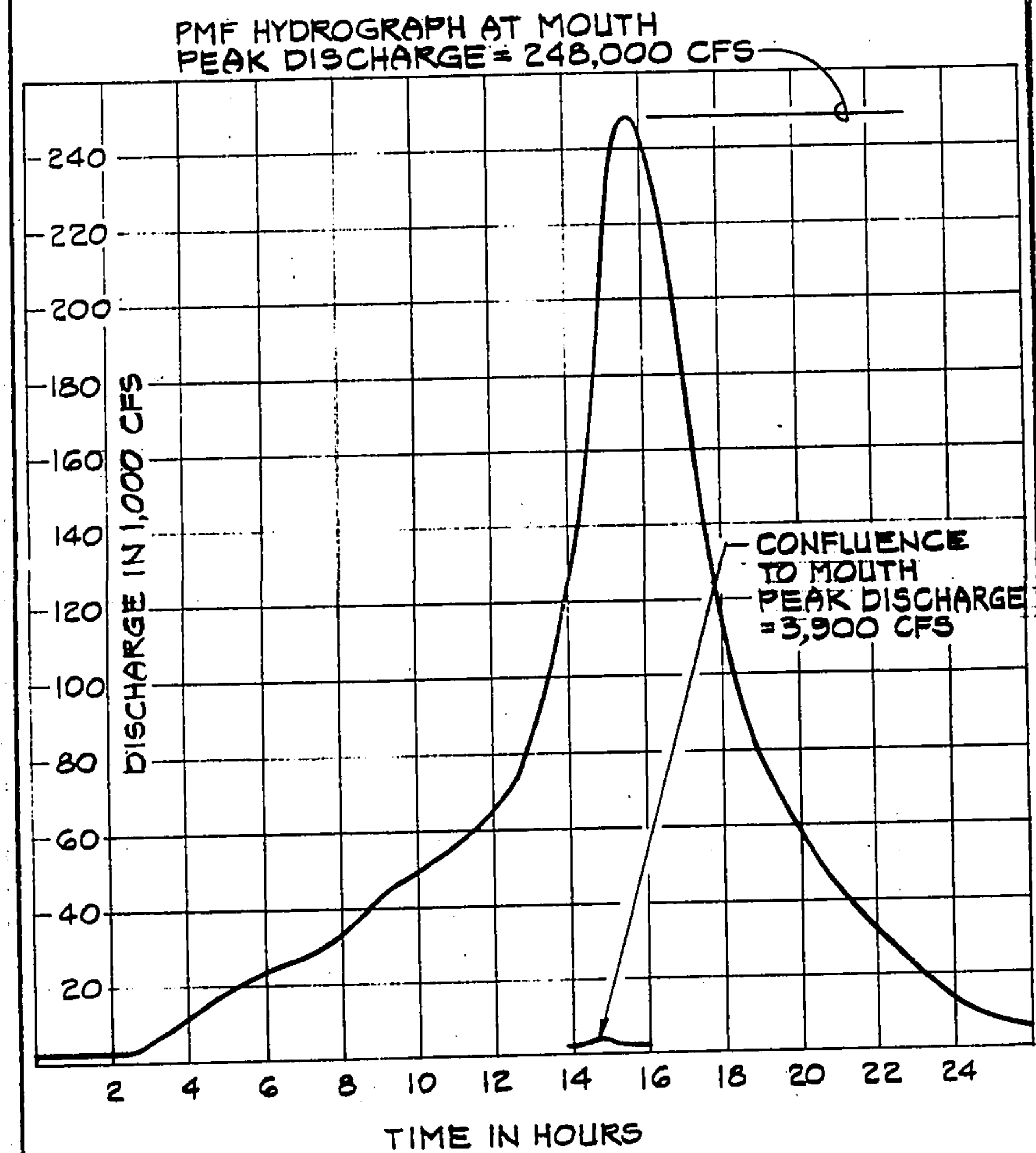


DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI

PMF HYDROGRAPH AT CONFLUENCE

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE A-20



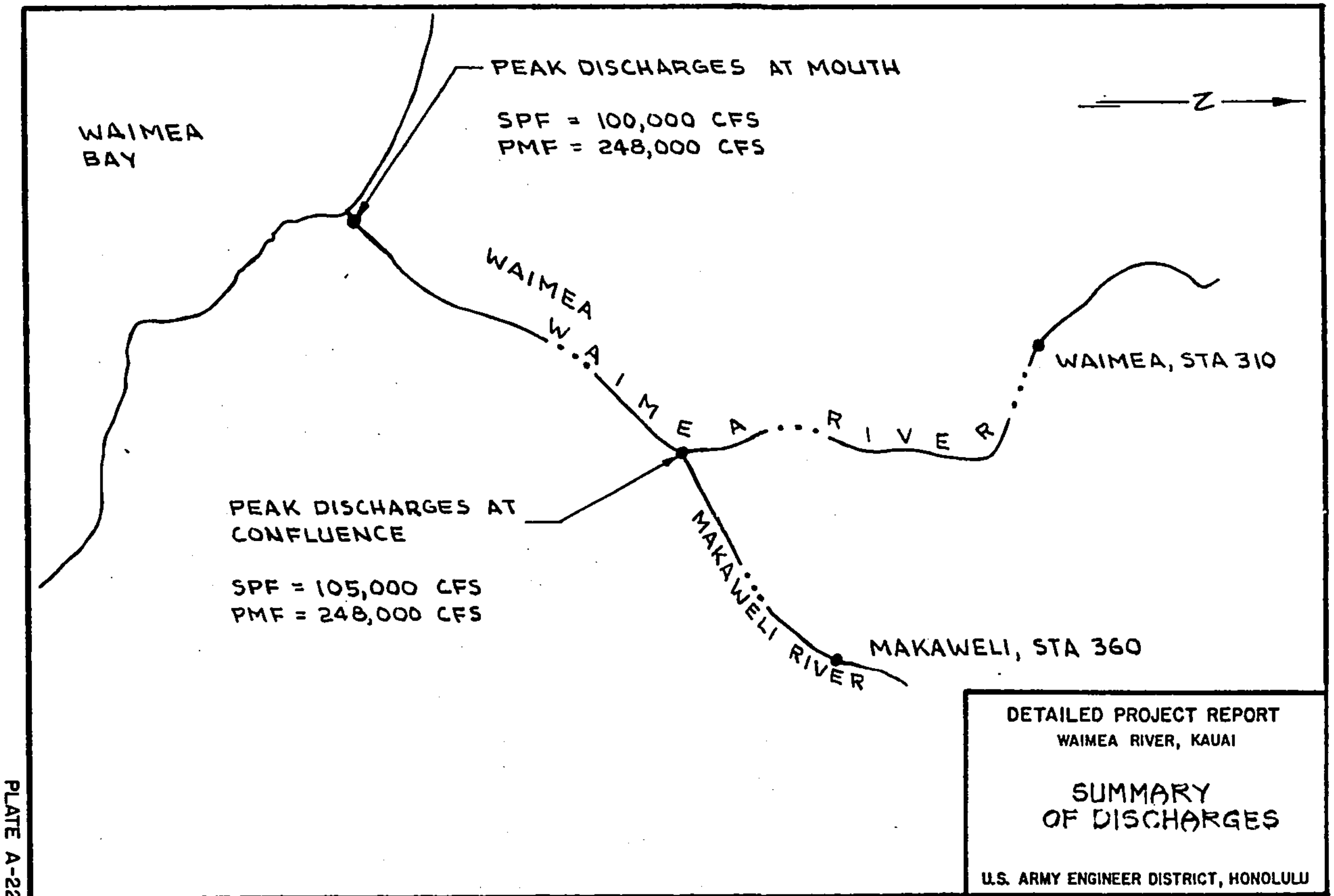
NOTE

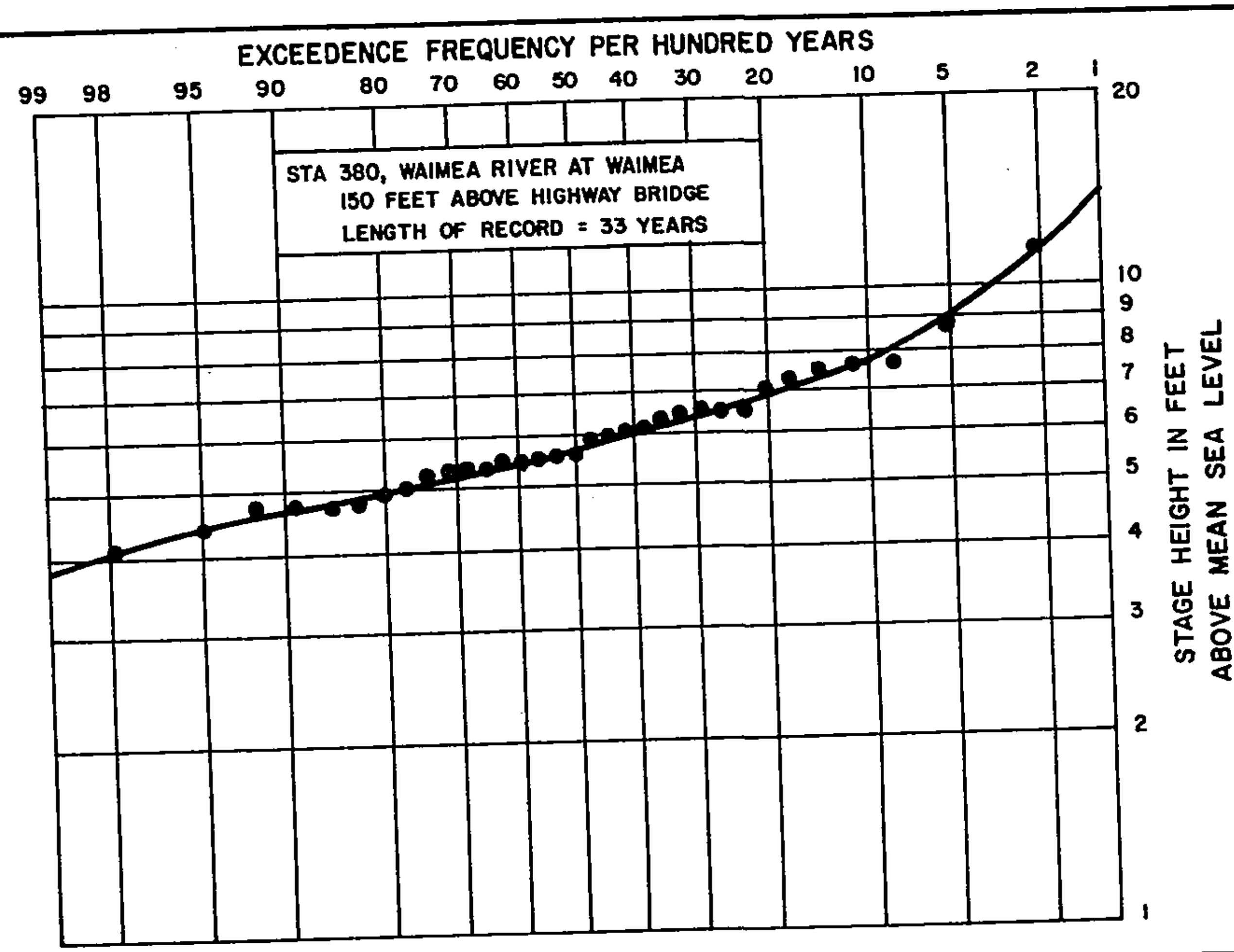
ROUTED PMF HYDROGRAPH FROM CONFLUENCE IS SLIGHTLY BELOW THE PMF HYDROGRAPH AT MOUTH AND IS NOT SHOWN.
ROUTED PEAK DISCHARGE = 246,000 CFS

DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI

PMF HYDROGRAPH
AT MOUTH

U.S. ARMY ENGINEER DISTRICT, HONOLULU


PEAK DISCHARGES AT MOUTH
SPF = 100,000 CFS
PMF = 248,000 CFS
WAIMEA BAY
N
WAIMEA
WAIMEA RIVER
WAIMEA, STA 310
PEAK DISCHARGES AT CONFLUENCE
SPF = 105,000 CFS
PMF = 248,000 CFS
MAKAWELI RIVER
MAKAWELI, STA 360
DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI
SUMMARY OF DISCHARGES
U.S. ARMY ENGINEER DISTRICT, HONOLULU
PLATE A-22

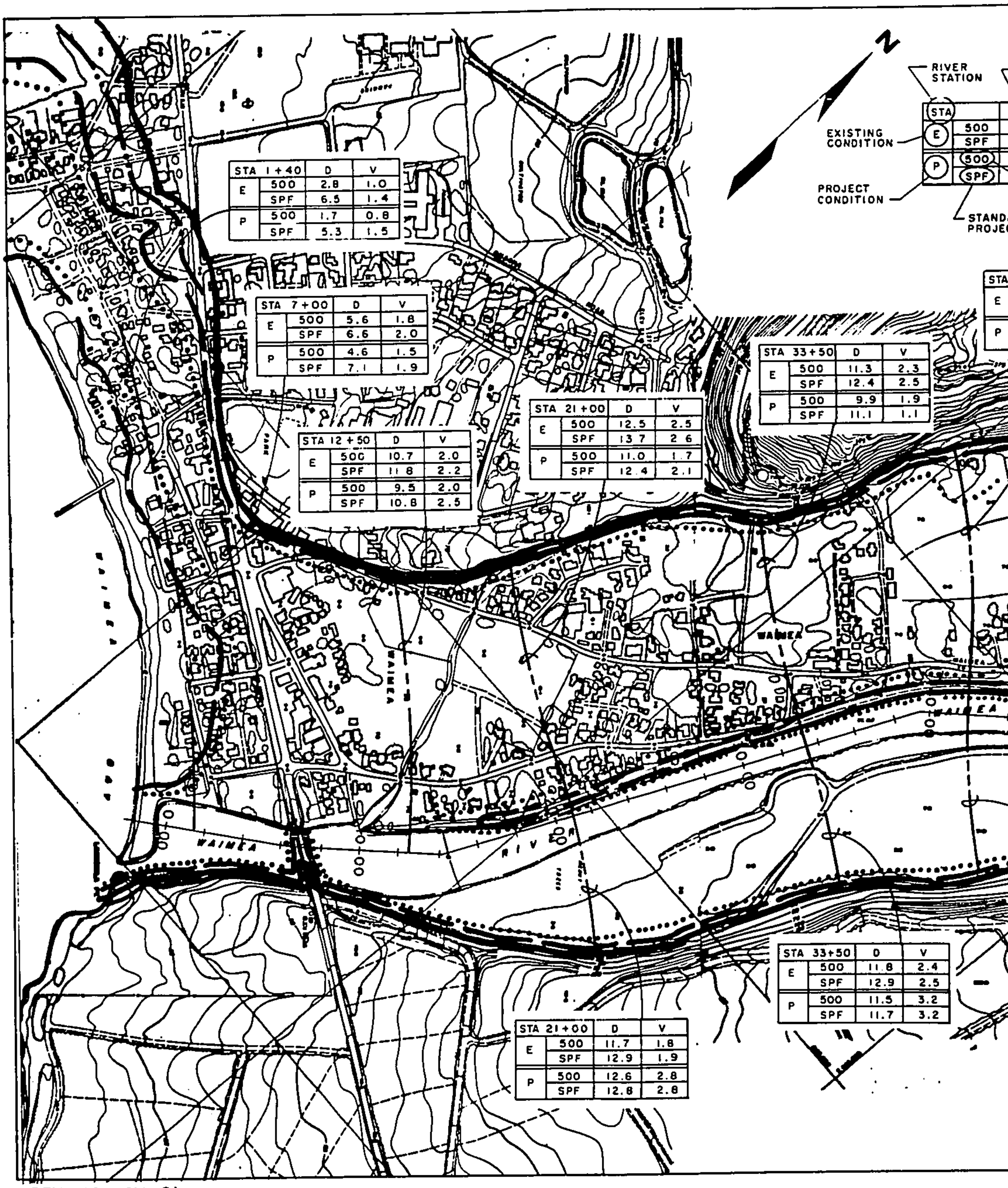


DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI

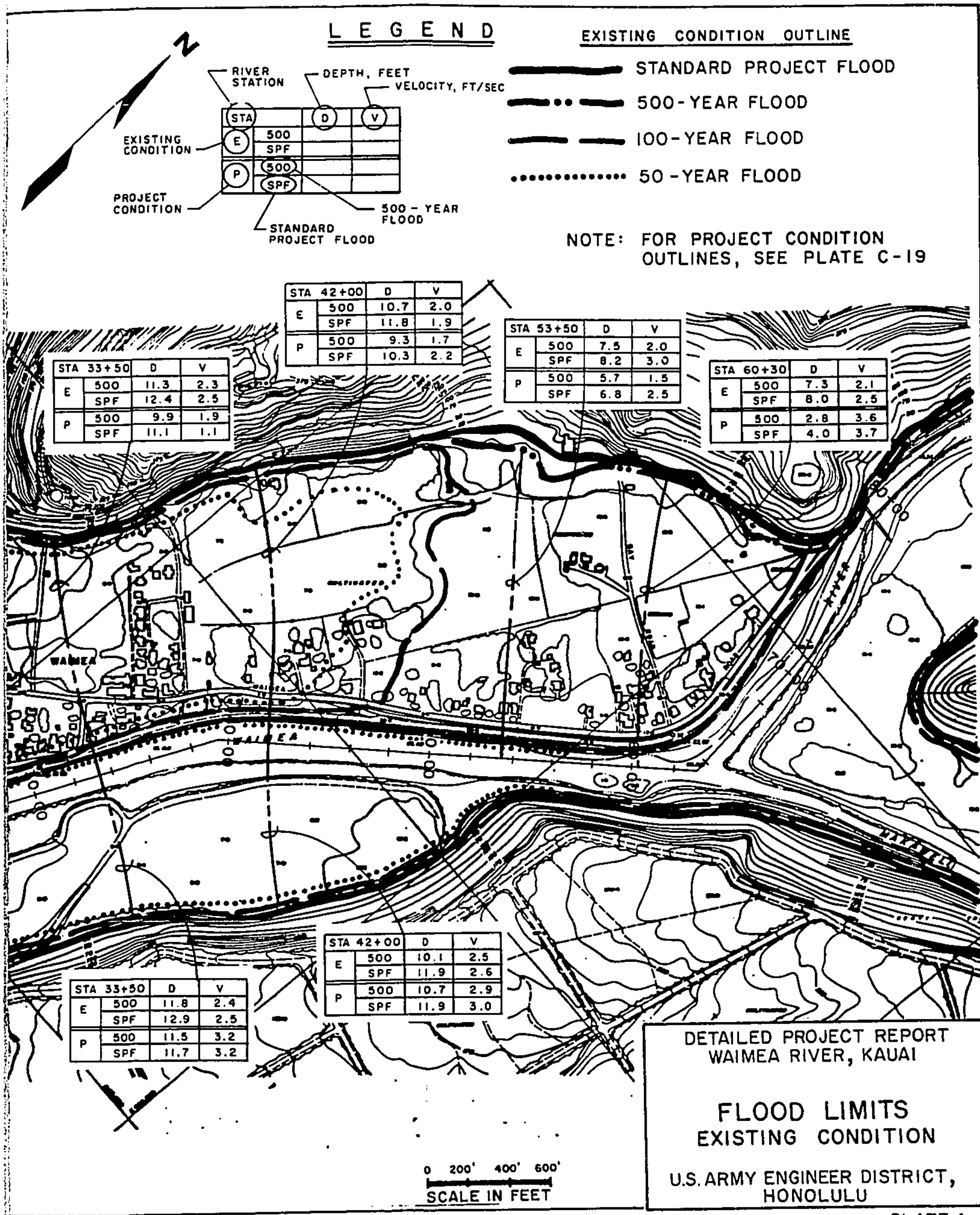
STAGE-FREQUENCY CURVE
WAIMEA RIVER AT WAIMEA
STA 380

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE A-23


N
RIVER STATION
EXISTING CONDITION
PROJECT CONDITION
STA
E 500
SPF
P 500
SPF
STA 1+40 D V
E 500 2.8 1.0
SPF 6.5 1.4
P 500 1.7 0.8
SPF 5.3 1.5
STA 7+00 D V
E 500 5.6 1.8
SPF 6.6 2.0
P 500 4.6 1.5
SPF 7.1 1.9
STA 12+50 D V
E 500 10.7 2.0
SPF 11.8 2.2
P 500 9.5 2.0
SPF 10.8 2.5
STA 21+00 D V
E 500 12.5 2.5
SPF 13.7 2.6
P 500 11.0 1.7
SPF 12.4 2.1
STA 33+50 D V
E 500 11.3 2.3
SPF 12.4 2.5
P 500 9.9 1.9
SPF 11.1 1.1
WAIMEA
WAIMEA
RIVER
STA 33+50 D V
E 500 11.8 2.4
SPF 12.9 2.5
P 500 11.5 3.2
SPF 11.7 3.2
STA 21+00 D V
E 500 11.7 1.8
SPF 12.9 1.9
P 500 12.6 2.8
SPF 12.8 2.8

REV. 16 NOV 81



STA 33+50		D	V
E	500	11.3	2.3
	SPF	12.4	2.5
P	500	9.9	1.9
	SPF	11.1	1.1

STA 42+00		D	V
E	500	10.7	2.0
	SPF	11.8	1.9
P	500	9.3	1.7
	SPF	10.3	2.2

STA 53+50		D	V
E	500	7.5	2.0
	SPF	8.2	3.0
P	500	5.7	1.5
	SPF	6.8	2.5

STA 60+30		D	V
E	500	7.3	2.1
	SPF	8.0	2.5
P	500	2.8	3.6
	SPF	4.0	3.7

STA 42+00		D	V
E	500	10.1	2.5
	SPF	11.9	2.6
P	500	10.7	2.9
	SPF	11.9	3.0

STA 33+50		D	V
E	500	11.8	2.4
	SPF	12.9	2.5
P	500	11.5	3.2
	SPF	11.7	3.2

DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI

FLOOD LIMITS
EXISTING CONDITION

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE A-24

WAIMEA RIVER FLOOD CONTROL
WAIMEA, KAUAI

GEOLOGY AND SOILS

APPENDIX B

GEOLOGY AND SOILS APPENDIX

LIST OF TABLES

LIST OF PLATES

GEOLOGY AND SOILS APPENDIX

1. The purpose of this appendix is to present and discuss the geology, soils and foundation data, design and construction considerations, and sources of construction materials for the Waimea River Flood Control Study.

GEOLOGY

REGIONAL GEOLOGY

2. The island of Kauai is the summit of one of the principal volcanic mountains of the partially submerged Hawaiian range. This range extends for a distance of 1,500 miles across the Pacific Ocean floor.

3. Kauai consists of a single, large, shield volcano built from the sea floor by many thousands of thin flows of basaltic lava.1/ Toward the end of the growth of the shield about five million years ago,2/ the volcano summit collapsed to form a broad, well-defined central depression (caldera). The town of Lihue is located on the southeast edge of this huge depression. The high mountains Kawaikini and Waialeale on the west side are erosional remnants of the crater rim of the original shield volcano. The huge depression was bordered by less depressed fault blocks, some of which merged imperceptibly with the outer slopes of the volcano. Volcanic activity about one million years ago gradually filled the depression, burying piles and ridges of talus along the foot of the boundary cliffs.

ROCK WEATHERING AND CLAY MINERALS

4. Extrusive volcanic rocks range from highly permeable cinders, clinkers, and ash to dikes and dense, thick lava-basalt flow with low permeability. The large variation in permeability consequently results in variations in the rate of weathering and the end products of weathering. The principal factors controlling rock weathering besides water are the difference in ground slope and exposure to leaching action of solutions, and the variation in physical properties of parent extrusive volcanic rocks. In low, poorly drained areas, the depth and intensity of weathering and concentration of clay minerals is noticeably greater than on steep, well-drained areas where fresh, dark-colored basalt is often found in outcrops.

1/ G.A. MacDonald, D.A. Davis & D.C. Cox, Geology and Groundwater Resources of the Island of Kauai, Hawaii, Bulletin 13, Hawaii Division of Hydrography, 1960.

2/ Jan McDougall, Potassium-Argon Ages from Lavas of the Hawaii, Mineral Industries, Penn State University Journals, Vol. 29, No.8, May 1960.

5. In areas where rainfall is moderate to high, where the slope is such that leaching is continuous and effective, and where time has been sufficient, the end products of weathering are a mixture of oxides and hydroxides of aluminum, iron, and titanium; the relative proportions of these elements depend on the composition of the parent rock and the effectiveness and duration of the leaching process. Kaolinite and gibbsite are the main clay minerals formed. The distinctive brick red mineral hematite is the most abundant iron compound present. Weathering of lava basalt and erosion and removal of the softer sedimentary material has left a concentration of cobble to boulder-sized pieces of harder rock as relics in the cane fields. The pieces of rock, known as field stone, are real obstacles and make planting and harvesting costly. The number, size, and distribution of stones per acre in the various fields being worked are indicators of weathering intensity.

6. The soils in the Waimea basin are mainly residual. The soils in the lower flood plains are alluvial and marine deposits of silts, sands and gravelly sands, and plastic clay and silt. A thin layer of red-brown soil covers the area along the confluence of the Waimea and Makaweli Rivers and lower slopes of the ridges.

SEISMICITY

7. The strongest earthquake in historic times in the islands occurred 2 April 1868 and was centered along the south coast of the island of Hawaii. This earthquake had a Richter magnitude of about 7.5 and caused serious damage across the entire island even stopping clocks as far away as Honolulu. Practically all earthquakes on the island of Hawaii and Maui are associated with intermittent volcanic activity. Potential earthquakes on Kauai can be caused by deepseated tectonic forces and not from the indirect action of volcanic activity. Recent explorations by geophysical methods show that faults and rift zones cut through the major islands and that these faults are branches of a gigantic fracture system known as the Molokai Fracture Zone.

8. The magnitude of Hawaiian Earthquakes was not routinely determined locally until 1958. Prior to that, magnitudes of large earthquakes were measured by seismograph stations on continental United States, usually by those at the California Institute of Technology, University of California at Berkeley, and Colombia University, from their own seismograms.3/

9. The Uniform Building Code and the Corps' Engineering Manual EM 1110-2-1902 assigns a Zone Zero seismic risk rating for Kauai for design consideration. Zone Zero is described as no damage resulting from an intensity earthquake on the abridged Modified-Mercalli scale of three. The equivalent Richter scale is a magnitude of 3.5 to 4.2.

3/ A Study of Past Earthquakes, Isoseismic Zones of Intensity and Recommended Zones for Structural Design for Hawaii, Hawaii Institute of Geophysics 73-4, A.S. Furumoto, et al, 1973.

10. The seismic risk for Kauai should be detrmined from the major earthquakes that have occurred close to the Molokai Fracture Zone and not from earthquakes that have their epicenters close to the very seismically active areas close to the island of Hawaii.3/ Kauai should be classified in seismic risk Zone One for non-critical structures and Zone Two for structures where major damage can result and lives are dependent on protection. All structures funded by the Department of Accounting and General Services, State of Hawaii, are designed according to Zone Three, intensity scale of seven, magnitude Richter scale of six, acceleration of 100 cm/sec^2 and gravity of 0.1g.

11. No seismograph stations operate on Kauai, and no records are available on which to base a seismic risk evaluation.

SUBSURFACE EXPLORATIONS

12. Prior to construction of the existing flood control improvements the County of Kauai in 1950 made 20 wash boring s to an average depth of 50 feet along the riverward toe of the then proposed (now existing) levee. Logs of the wash borings (not included in this report) show the subsurface materials as consisting, in general, of alternating layers of boulders, alluvium, silt, sand, and gravel.

13. In connection with an earlier detailed project study, seven borings (DB-1 to DB-7) ranging in depth from 16 feet to 30 feet were made by the Government along the right bank of Waimea River. (Plates B-1, B-2, B-3) Standard 2-inch diameter split barrel samples and 2-3/8 inch diameter undisturbed Shelby tube samples were obtained to determine the type, continuity, density, moisture condition, and strength parameters of the subsurface materials.

LABORATORY TESTS

14. Samples of the subsurface material were tested for gradation, natural moisture content, natural dry density, specific gravity Atterberg Limits, and unconfined compression. A triaxial compression test was made on one remolded sample. Individual test results were performed (Plates B-4 to B-10) and summarized (Plates B-11 and B-12).

3/ A Study of Past Earthquakes, Isoseismic Zones of Intensity and Recommended Zones for Structural Design for Hawaii, Hawaii Institute of Geophysics 73-4, A.S. Furumoto, et al, 1973.

SUBSURFACE CONDITIONS

15. The existing levee is composed of silty sand (SM), gravel (GP), poorly graded sands (SP-SM) and boulders, underlain by silty sand (SM) stratified with layers of silt (ML). Dry densities of the in-place materials vary from 59 to 127 pcf. In one boring, hard basalt was encountered at elevation -15 Mean Sea Level, 27 feet below the top of the existing levee. The foundation material for the proposed levee extension is composed predominantly of silty sand (SM) and poorly graded sand (SP-SM) with a few basalt boulders near the surface. Unconfined compression tests performed on the sandy silt (ML) materials with an average dry weight of 91 pcf showed unconfined compressive strengths varying from 1,043 psf to 1,604 psf. A sample of sandy silt was remolded and an unconsolidated undrained triaxial test performed on this sample indicated 375 psf cohesion and a friction angle of 8°21'.

ADOPTED SOIL VALUES FOR DESIGN

16. Adopted design values of the foundation and fill materials are summarized below (Table B-2).

DESCRIPTION AND CONDITION OF EXISTING IMPROVEMENTS

EXISTING LEVEE

17. The existing levee, located on the right bank of Waimea River between approximate stations 10+50 and 77+00 (Plate B-1), is approximately 10' high measured from the landward toe and has a crest width ranging from 15' to 25' and side slopes of 1V on 1.5H on the riverward face and 1V on 2H on the landward face. The riverward slope of the levee is lined with grouted riprap while the crest and landward slope are grassed.

TABLE B-1. DESIGN VALUES FOR FOUNDATION AND FILL MATERIALS

Type of Material	δm (KCF)	δSUBM (KCF)	ø (Degrees)	C (KSF)
Along Existing Levee				
a. Brown Silty Sand (SP-SM) w/gravel and boulders	0.125	0.062	30[1/]	0
b. Brown sandy silt (ML)	0.113	0.050	--	1.043
c. Brown silty sand (SP-SM)	0.128	0.065	30[1/]	0.147
d. Brown sandy silt (ML)	0.115	0.052	8.35	0.375
e. Brown silty sand (SM)	0.125	0.062	30[1/]	0.428
Along Levee Extension				
a. Brown silty sand (SM)	0.128	0.078	30[1/]	0
b. Brown silty sand (SM)	0.121	0.071	30[1/]	0

1/ Assumed values in accordance with standard practice on sandy soils.

18. Between approximate stations 10+50 and 72+00 a concrete bulkhead was installed along the riverward toe of the levee to serve as a retaining structure and buried cutoff for the levee. The concrete bulkhead consists of three tiers of precast concrete panels retained at 10-foot intervals by 16" square soldier piles driven 30 feet into the riverbed. The concrete panels appear to be wedged between the soldier piles and the adjacent soil with no visible evidence of attachment to the piles. Dimensions of the individual precast concrete panels are 10' long x 3'6" high x 8" thick in the upper two tiers and 10' long x 4' high x 10" thick in the lowest tier. With a top elevation of (+) 0.5 MSL and a total height (depth) of 11 feet, the bottom of the concrete bulkhead is at Elevation (-) 10.5' MSL (Plate B-13).

19. The levee embankment is generally in satisfactory condition except for minor erosion along the top and downstream slope caused by pedestrians and maintenance vehicles. Signs along the levee prohibit unauthorized vehicles from operating on the levee. The GRP lining along the riverward slope is in good condition with no serious cracking, spalling, or other evidence of distress. Grass cover along the crest and landward slope is good except along pedestrian footpaths, vehicle wheel paths, and other random areas where bare soil is exposed. Some irregularity exists in the downstream slope in the vicinity of station 46+00. However, this irregularity is the result of construction of a vehicular on-ramp and interior drainage outlet through the levee at this location.

20. The concrete bulkead appears to be in satisfactory condition with no visible evidence of structural failure in either soldier piles or concrete panels. In plan view the concrete bulkhead deviates from linear alignment by as much as 0.5 foot in a few places. There is no indication of movement or separation between the bulkhead and the abutting grouted riprap lining. The linear deviation appears to be the result of inaccuracy in positioning the soldier piles and precast concrete panels during construction rather than post construction movement. A few of the piles are rotated along their vertical axis such that the concrete panels bear along a corner rather than along a flat face of the pile as intended. Also, inaccuracy in spacing of piles during construction has resulted in gaps up to 5 inches wide between abutting panels. At one location, pile spacing was apparently too close since the ends of adjacent panels are overlapped by a few inches in lieu of being butted.

21. Although crude and primitive in construction based on present day standards, the concrete bulkhead has served its purpose of providing erosion protection and lateral support for the levee over the past 27 years.

22. The riverbed along the toe of the levee is subject to erosion and deposition during periods of heavy river flows. The extent and location of scouring and deposition changes from flood to flood and are not predictable. River bottom profile surveys subsequent to construction of the concrete bulkhead are limited to two observations made in July 1959 and June 1961. These limited observations indicate that scouring to a maximum depth of minus 9 feet Mean Sea level had occurred at random locations along the concrete bulkhead. Lateral extent of scouring normal to the alignment of the concrete bulkhead was not determined. Visual observations during February 1979 revealed 3 to 6 feet oferosion between approximate Stations 19+00 and 51+00 and little or no erosion elsewhere. On the basis of this observation, stability analyses were conducted for a typical levee section with 6 feet of erosion at the riverward toe. The existing levee was analyzed for "partial pool" condition and for "sudden drawdown" condition assuming drawdown from levee crest (El.19.0). Results of the stability analyses are summarized in Plates B-14 and B-15. The "end of construction" condition was not considered applicable for the existing levee in view of the long time lapse since its construction. Minimum safety factors of 1.46 and 1.08 obtained for the "partial pool" and "sudden drawdown" cases, respectively, indicate that the existing levee is stable, with maximum scour depth to -6 MSL elevation in view of the minimum safety factors recommended in EM-1110-2-1913, Design and Construction of Levees.

EXISTING REINFORCED CONCRETE RETAINING WALL

23. A reinforced concrete retaining wall with a maximum height of 16 feet was constructed along the right bank between approximate stations 29+90 and 33+50. Purpose of the wall was to prevent the crest and landward slope of the levee from encroaching over an existing road into adjacent private property. Top width of the levee-wall section at this location is less than 3 feet. The existing concrete retaining wall is in good condition with no evidence of distress.

GROUTED RIPRAP LINING

24. Portions of the grouted riprap slope lining on the right bank immediately upstream of the highway bridge and around the gate structure in the vicinity of station 8+50 have been undermined and lost.

CRM WALLS

25. Existing CRM walls along the right bank downstream of the highway bridge were constructed with very little mortar (only surface grouted). The walls are deteriorating at random locations and need to be repaired.

DESIGN CONSIDERATIONS AND ANALYSIS

EXISTING LEVEE

26. Two conditions could cause failure of the existing levee: overtopping and uncontrolled erosion along the toe. Overtopping could cause erosion along the top and downstream slope causing collapse of the upstream grouted riprap lining due to loss of support and may eventually result in a breach. The in-situ silty sand material is highly susceptible to erosion. Uncontrolled erosion along the levee toe could cause structural failure of the concrete bulkhead by overstressing due to loss of lateral passive resistance and loss of upstream slope stability. Also undermining beneath the lowest tier of the bulkhead would cause loss of levee fill and separation and loss of individual concrete panels.

27. The new cement rubble masonry (CRM) floodwall proposed along the crest of the existing levee would increase the degree of protection. The impervious nature of the existing grouted riprap lining and new CRM floodwall and the short duration of high flows prevents seepage from being a problem. Protection of the levee toe against further erosion and slope stability failure would be accomplished by providing a dumped rock toe along the existing concrete bulkhead between approximate stations 10+50 and 57+00 (Plate 16). The rock toe protection was designed to withstand a flow velocity of 14 feet per second.

LEVEE EXTENSION

28. The levee is 1575 feet long and is to be constructed in the lower reach of Waimea River. The levee has a top width of 10 feet, riverward side slopes of 1V on 3H, and landward side slopes of 1V on 2H. Stability analyses performed in accordance with EM 1110--2-1913 for the levee extension confirms that a 1V on 3H riverward side slope is stable for the levee sections proposed. Results of the stability analyses are summarized on Plates B-17 and B-18. Seepage through and under the new levee will not be a problem due to the short duration of the high flows. Numerous site inspections over the past 20 years have revealed no evidence of settlement in the existing levee. Likewise, settlement of the new levee will be negligible. In view of the cohesionless nature of the foundation materials, any settlement that might occur would take place during construction.

29. Slope protection consisting of 27 inches of riprap over 6 inches of bedding material will be provided along the riverside slope of the levee based on 14 FPS velocity and 156 pcf unit weight for rock. Assuming that riprap and bedding will be placed without dewatering, riprap and bedding thicknesses below elevation plus one foot MSL have been increased by 50 percent (Plate B-19).

ROAD RAISE

30. The road raise section located between stations 72+00 and 77+00 is situated within the freeboard zone. Slope protection consisting of 27 inches of riprap over 6 inches of bedding will be provided on the riverward slope as shown on Plate B-20. A typical pavement section for the road raise is shown on Plate B-21.

POTENTIAL EFFECTS OF OVERTOPPING CONDITIONS

31. The proposed flood control improvements recommended for this project are designed to provide protection up to and including the one percent flood. Floods exceeding the one percent flood have a potential for overtopping the proposed flood control improvements. Based on hydraulic computations (see Section C) the Standard Project Flood (SPF) would overtop different sections of the proposed levee and floodwall by 0.5' to 3.4' during the peak flow. The 500-year flood would similarly, although to a lesser degree, overtop the proposed improvements. Duration of overtopping would be approximately 2.5 hours with overtopping velocities ranging from 1.5 to 4.3 feet per second for the Standard Project Flood.

32. The primary concern imposed by overtopping flows is the potential for erosion. Stability of levee slopes is essentially unaffected by overtopping except as a secondary result of erosion diminishing the levee cross section and oversteepening the slope at landward side of the levee. Given the extended duration of overtopping calculated for the Standard Project Flood, overtopping flows may cause progressive erosion of the levee embankment and eventually result in a breach. The mode of erosion would be a combined process of deep gullying accompanied by collapse of the resulting oversteepened gully walls. Gullying is expected to originate along the steep (1V on 2H) landward fill slope and gradually extend across the levee crest toward the riverward slope. Grass cover proposed for the levee crest and landward slope would provide adequate protection against normal surface runoff but is not expected to provide adequate protection against overtopping flows of the Standard Project Flood.

CONSTRUCTION CONSIDERATIONS

NEW ROCK TOE PROTECTION

33. The new rock toe should be constructed as the work progresses to minimize turbidity and reduce exposure of the open excavation to unexpected flood flows. If environmentally acceptable, the contractor should be allowed to temporarily stockpile excavated materials in the riverbed along the excavation until placement of rock in any increment is complete.

NEW CRM FLOODWALL

34. The new CRM floodwall along the levee crest will be imbedded 18 inches below existing ground and abut the top and rear surfaces of the existing grouted riprap lining. The temporary overhang created by the existing lining will impede excavation and CRM placement. Care should be exercised during construction to prevent damage to the existing grouted riprap and to insure the absence of voids in the overhang region.

SOURCES OF CONSTRUCTION MATERIALS

35. Embankment materials for levee construction will be obtained from offsite sources to be designated by the County of Kauai. The possibility of removing and using materials comprising the sand bar blocking the mouth of Waimea River will be investigated during the Plans and Specifications stage prior to construction. Since the shape and size of the sand bar is subject to seasonal variation and its existence at the time of construction cannot be guaranteed, this source can only be considered as a possibility at present. Removal of material from the sand bar will also be subject to Government approval.

36. Based on materials investigation for armor stone conducted in 1977 for Kekaha Beach Erosion Project, the following sites are possible sources for riprap stone: Hukipo Valley, Kapilimao Valley, Paua Valley, Waipao Valley, Kahoana Valleys (east and west), and Niu Valley.

37. Crushed aggregate for concrete, asphaltic concrete, base course and bedding material is available at the Hale Kauai Ltd. quarry located at Halfway Bridge near Lihue. Ready mixed concrete with jobsite delivery is also available from Hale Kauai Ltd. which has four concrete plants including one located in nearby Kekaha. An asphaltic concrete batch plant operated by Hawaiian Bitumuls and Paving Company is located at Halfway Bridge near the Hale Kauai quarry.

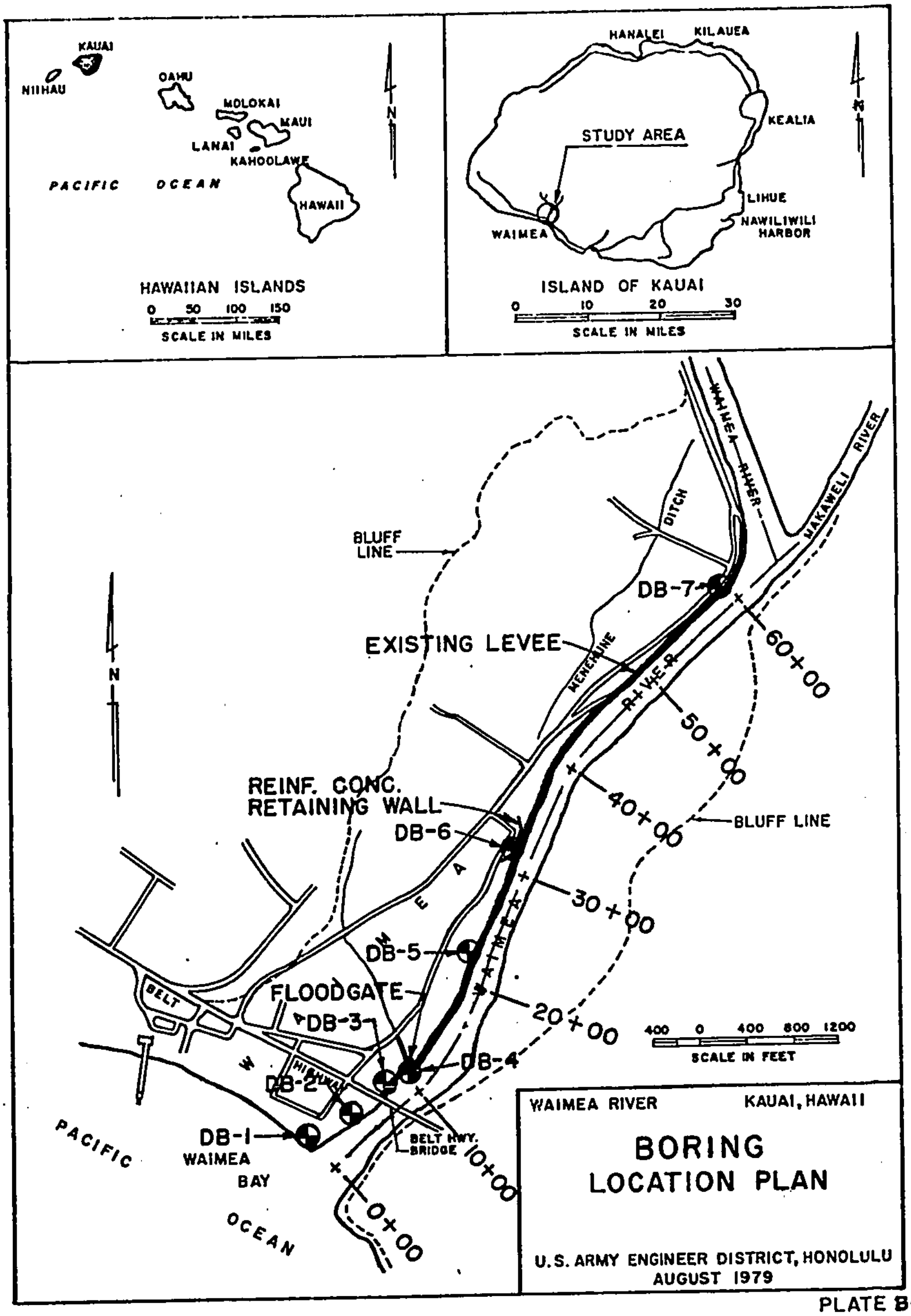
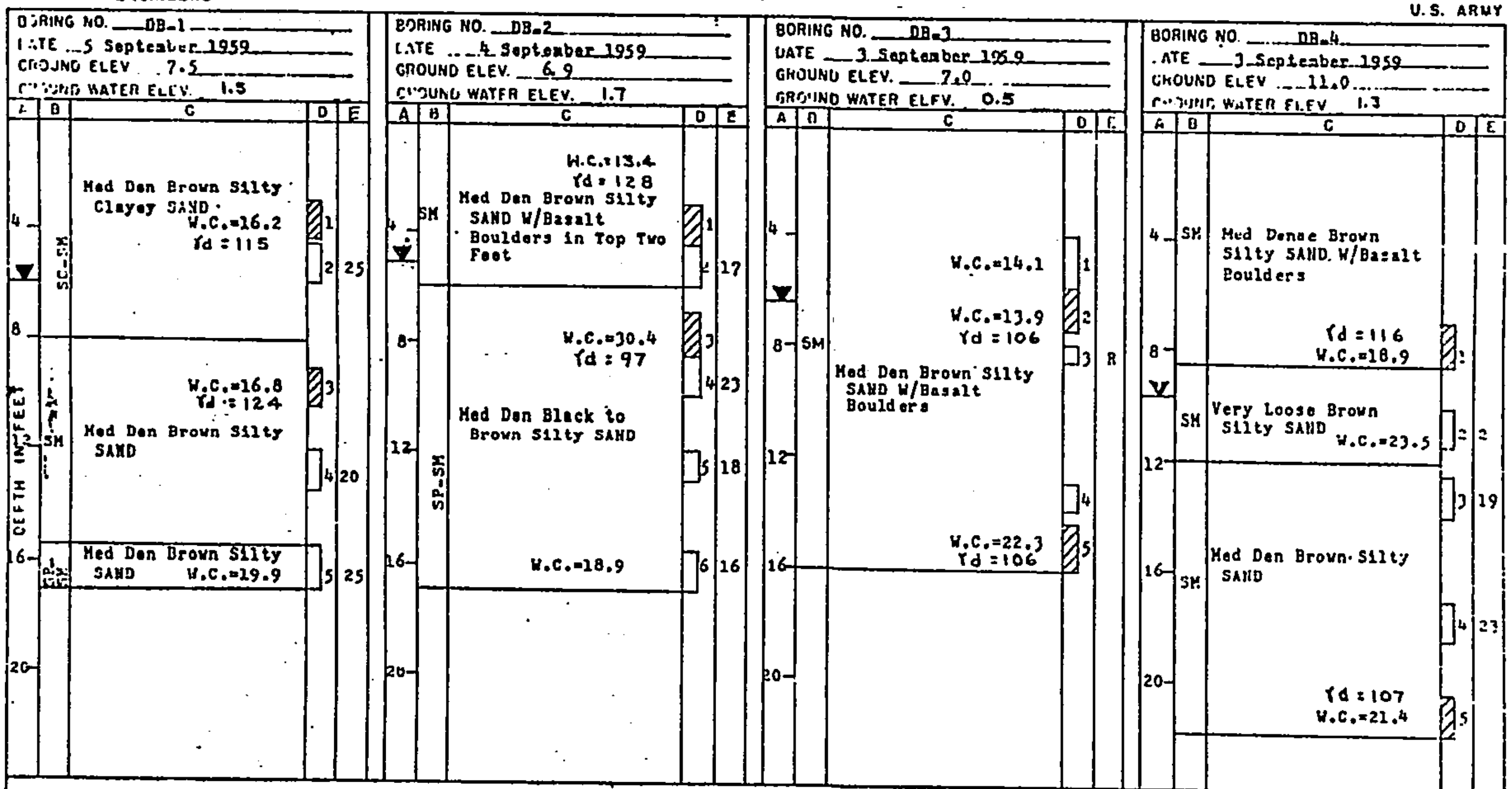

KAUAI
NIIHAU
OAHU
MOLOKAI
MAUI
LANAI
KAHOOLAWE
HAWAII
PACIFIC OCEAN
N
HAWAIIAN ISLANDS
0 50 100 150
SCALE IN MILES
HANALEI
KILAUEA
KEALIA
STUDY AREA
LIHUE
NAWILIWILI HARBOR
WAIMEA
N
ISLAND OF KAUAI
0 10 20 30
SCALE IN MILES
WAIMEA RIVER
DITCH
MAKAWELI RIVER
BLUFF LINE
DB-7
EXISTING LEVEE
MENEHUNE
RIVER
60+00
50+00
N
REINF. CONC. RETAINING WALL
40+00
BLUFF LINE
DB-6
30+00
DB-5
FLOODGATE
DB-3
20+00
DB-4
DB-2
BELT
HIGHWAY
WAIMEA
DB-1
PACIFIC
WAIMEA BAY
OCEAN
BELT HWY. BRIDGE
10+00
0+00
400 0 400 800 1200
SCALE IN FEET
WAIMEA RIVER KAUAI, HAWAII
BORING LOCATION PLAN
U.S. ARMY ENGINEER DISTRICT, HONOLULU
AUGUST 1979

PLATE B-1

CORPS OF ENGINEERS

U.S. ARMY



NOTES:

1. COLUMN "A" DENOTES DEPTH OF BORING IN FEET. WC = Water Content (% Dry Wt.), Yd = NAT. DRY DENSITY (lbs/cf)
2. COLUMN "B" DENOTES SYMBOL PRESENTATION OF SOILS DATA IN ACCORDANCE WITH UNIFIED SOIL CLASSIFICATION SYSTEM.
3. COLUMN "C" DENOTES VISUAL CLASSIFICATION OF MATERIALS ENCOUNTERED.
4. COLUMN "D" DENOTES SAMPLE NUMBER AND TYPE AT APPROPRIATE DEPTH; ☐ - DISTURBED JAR SAMPLE; ▨ - UNDISTURBED TUBE SAMPLE; ■ - CORE SAMPLE.
5. COLUMN "E" DENOTES NUMBER OF BLOWS/Ft. ON 2" SAMPLE SPOON USING 140 LB. HAMMER FALLING 30". R=Refusal=) 50 Blows/0.5 Ft.
6. SYMBOL (▼) INDICATES WATER LEVEL OBSERVED WHEN BORINGS WERE MADE. POROSITY OF SOIL STRATA, VARIATIONS OF RAINFALL, SITE TOPOGRAPHY, AND ETC., MAY CAUSE CHANGES AND FLUCTUATIONS IN GROUND WATER LEVELS. ELEVATIONS BASED ON MSL.
7. Subsurface exploration COMPLETED IN 1961. FOR BORING LOCATIONS SEE PLATES C-1, C-2.

WAIMEA RIVER KAUAI, HAWAII

DETAILED PROJECT REPORT FOR FLOOD CONTROL

BORING LOGS

AUGUST 1979

FCH F 1 . 47 . MAY '55

PLATE B-2

CORPS OF ENGINEERS

BORING NO DB-5
DATE 2 September 1959
GROUND ELEV 12.0
GROUND WATER ELEV NONE OBSERVED

A (Depth, ft)	B	C	D	E
0–3.5	GP	Brown Coarse GRAVEL W/Boulders		
3.5–5		Basalt BOULDERS		
5–17	ML	Med Den Brown Sandy SILT; W.C.=13.5	1 (undisturbed)	
			2 (disturbed)	27
		W.C.=26.7, γd = 96	3 (undisturbed)	
			4 (disturbed)	14
17–27	SM	Med Den Brown Silty SAND; W.C.=27.9, γd = 97	5 (undisturbed)	
			6 (disturbed)	17
		W.C.=16.3, γd = 114	7 (undisturbed)	18
27–30		Hard BASALT		

BORING NO. DB-6
DATE 1-2 September 1959
GROUND ELEV. 19.0
GROUND WATER ELEV. NONE OBSERVED

A (Depth, ft)	B	C	D	E
0–6.5	SM	Med Den Brown Silty SAND; W.C.=15.4	1 (disturbed)	27 R
6.5–8.5		Basalt BOULDERS		
8.5–12.5	ML-CL	Dense Brown Sandy Clayey SILT; W.C.=31.4, γd = 92	2 (undisturbed)	32
12.5–17	ML	Loose Brown Sandy SILT; W.C.=28.5	3 (undisturbed)	
			4 (disturbed)	10
17–19	SM	Loose Brown Silty SAND		
19–30	SM	Med Den Brown Silty SAND; W.C.=24.8	5 (undisturbed)	
			6 (disturbed)	16
			7 (undisturbed)	

BORING NO. DB-7
DATE 1 September 1959
GROUND ELEV. 22.6
GROUND WATER ELEV. NONE OBSERVED

A (Depth, ft)	B	C	D	E
0–7	GP	Very Dense Brown Coarse GRAVEL W/Basalt Boulders	1 (disturbed)	63
7–10		Basalt BOULDERS		
10–14	SP-SM	Very Den Brown Silty SAND W/Gravel; W.C.=15.6	2 (disturbed)	60
14–16	SM	Loose Brown Silty SAND	3 (disturbed)	7
16–21	ML	Loose Brown Sandy SILT; W.C.=29.5, γd = 87	4 (undisturbed)	
21–25.5	SP-SM	Med Den Brown Silty SAND; γd = 99, W.C.=27.6	5 (undisturbed)	
25.5–29	ML	Med Den Brown Sandy SILT; γd = 60, W.C.=67.5	6 (undisturbed)	
29–30	SM	Med Den Black Silty SAND	7	19

BORING NO.
DATE
GROUND ELEV.
GROUND WATER ELEV.

A	B	C	D	E

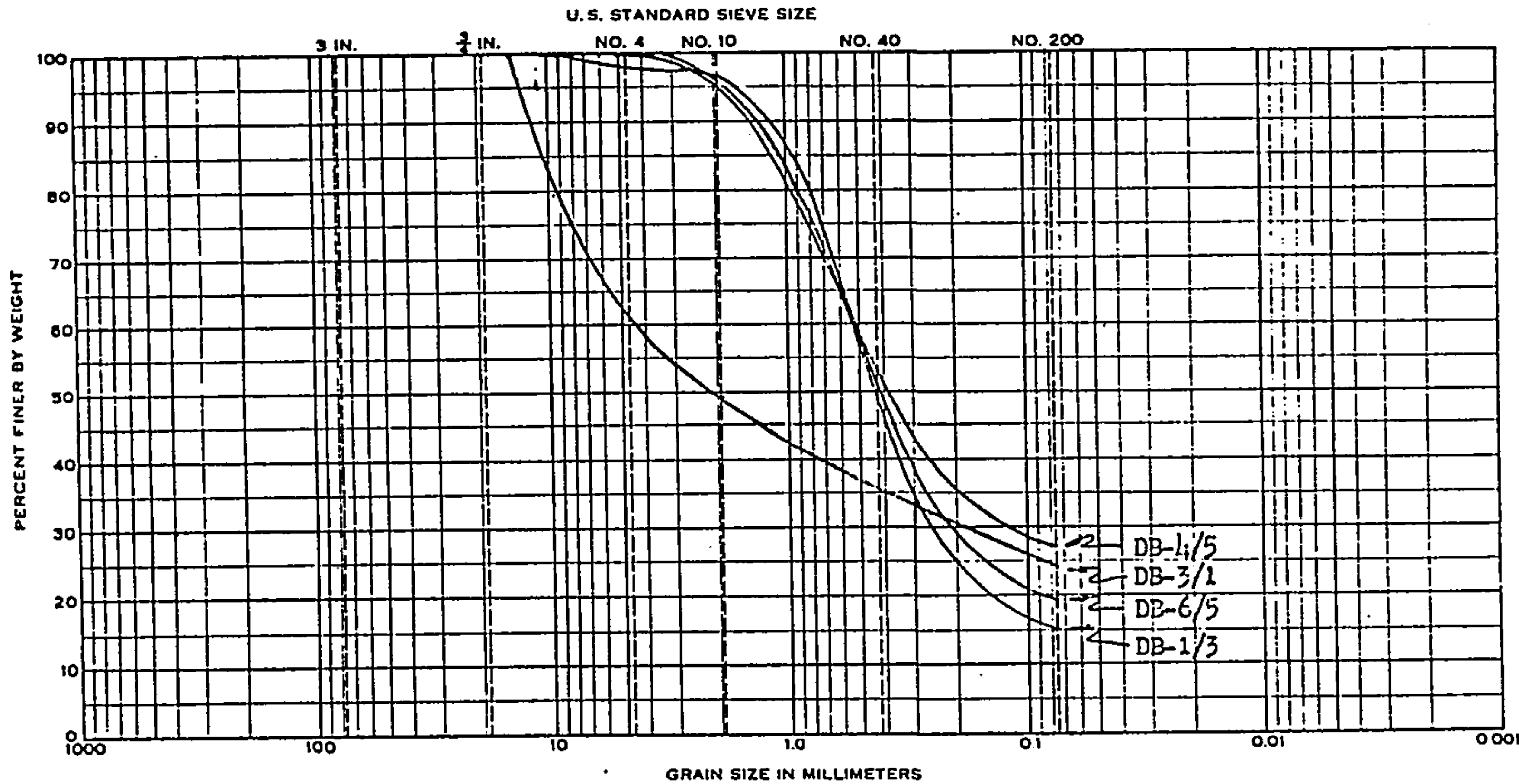
NOTES:
1. COLUMN "A" DENOTES DEPTH OF BORING IN FEET. W.C. = Water Content (% Dry Wt.), γd = NAT. DRY DENSITY (lbs/cf)
2. COLUMN "B" DENOTES SYMBOL PRESENTATION OF SOILS DATA IN ACCORDANCE WITH UNIFIED SOIL CLASSIFICATION SYSTEM.
3. COLUMN "C" DENOTES VISUAL CLASSIFICATION OF MATERIALS ENCOUNTERED.
4. COLUMN "D" DENOTES SAMPLE NUMBER AND TYPE AT APPROPRIATE DEPTH; ☐ - DISTURBED JAR SAMPLE; ▨ - UNDISTURBED TUBE SAMPLE; ■ - CORE SAMPLE.
5. COLUMN "E" DENOTES NUMBER OF BLOWS/ON 2" SAMPLE SPOON USING 140 LB. HAMMER FALLING 30"; R=Refusal=> 50 Blows/0.5 Ft. /Ft.
6. SYMBOL (▼) INDICATES WATER LEVEL OBSERVED WHEN BORINGS WERE MADE. POROSITY OF SOIL STRATA, VARIATIONS OF RAINFALL, SITE TOPOGRAPHY, AND ETC., MAY CAUSE CHANGES AND FLUCTUATIONS IN GROUND WATER LEVELS. ELEVATIONS BASED ON MSL.
7. Subsurface exploration COMPLETED IN 1961. FOR BORING LOCATIONS SEE PLATES C-1, C-2.

POH FORM 47 [illegible] JULY '59

WAIMEA RIVER KAUAI, HAWAII
DETAILED PROJECT REPORT
FOR FLOOD CONTROL

BORING LOGS
AUGUST 1979

PLATE B-3



COBBLES	GRAVEL		SAND			SILT OR CLAY
	Coarse	Fine	Coarse	Medium	Fine	

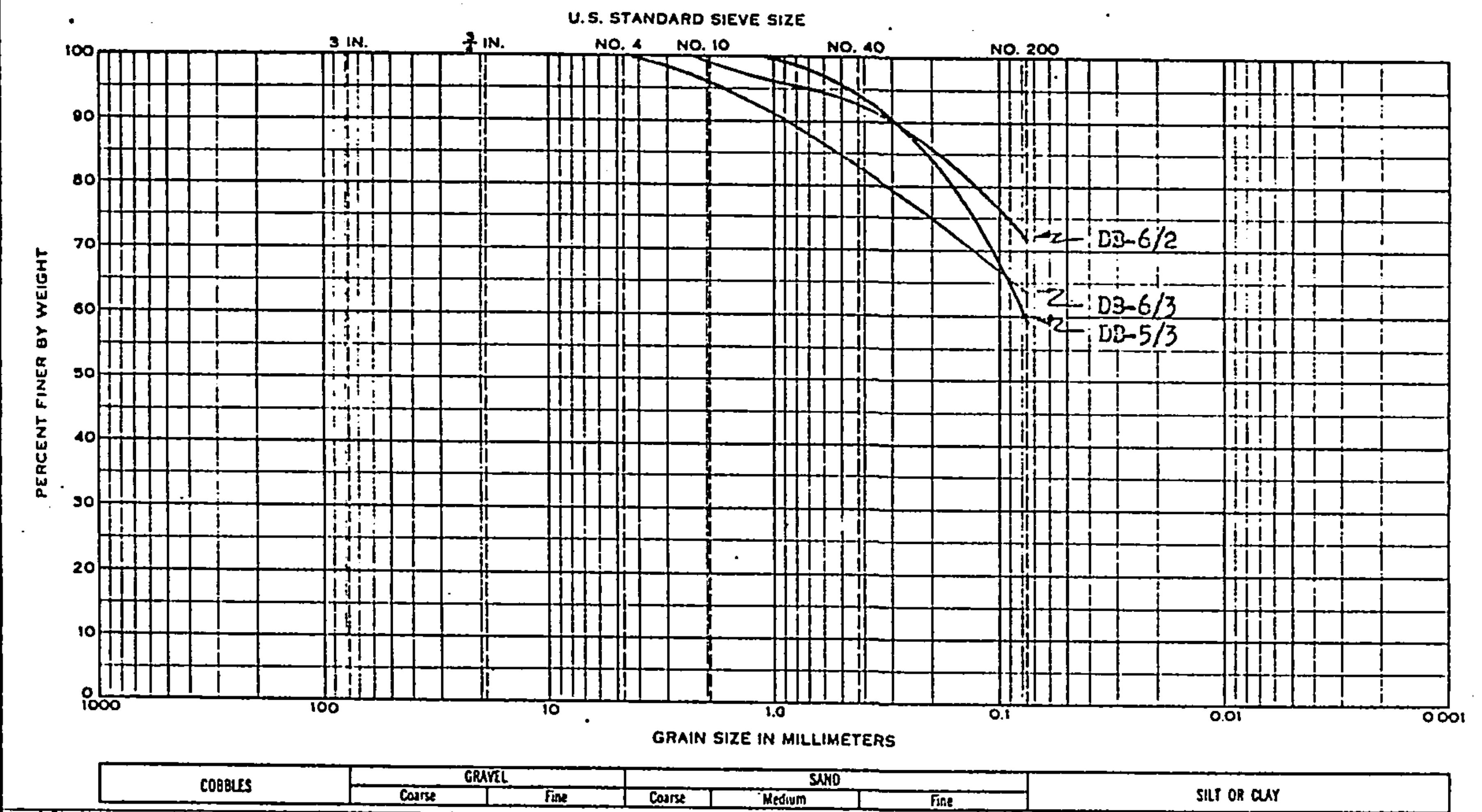
Sample No.	Elev or Depth	Classification	NatWC	LL	PL	PI	
DB-1/3	9.0-10.5	Med Den Br Silty Sand (SM)	16.8				
DB-3/1	4.0-6.0	Med Den Br Silty Sand (SM)	14.1		NP		SM
DB-4/5	20.5-22.0	Med Den Br Silty Sand (SM)	21.4		NP		Materials
DB-6/5	21.0-22.5	Med Den Br Silty Sand (SM)	24.8		NP		

GRADATION CURVES

Project Waimea Flood Control
Kauai
Area Foundation Material
Boring No DB 1, 3, 4, & 6
Date AUGUST 1979

2087

PLATE B-4



Sample No.	Elev or Depth	Classification	NatWC	LL	PL	PI	
DB-5/3	12.0-13.5	Med Den Br Sandy Silt (ML)	26.7	40	27	13	ML
DB-6/2	10.0-11.5	Den Br Sandy Clayey Silt (MLCL)	31.4	43	26	17	Materials
DB-6/3	15.0-16.5	Loose Br Sandy Silt (ML)	28.5	36	27	6	

GRADATION CURVES

Project Waimea Flood Control
Kauai

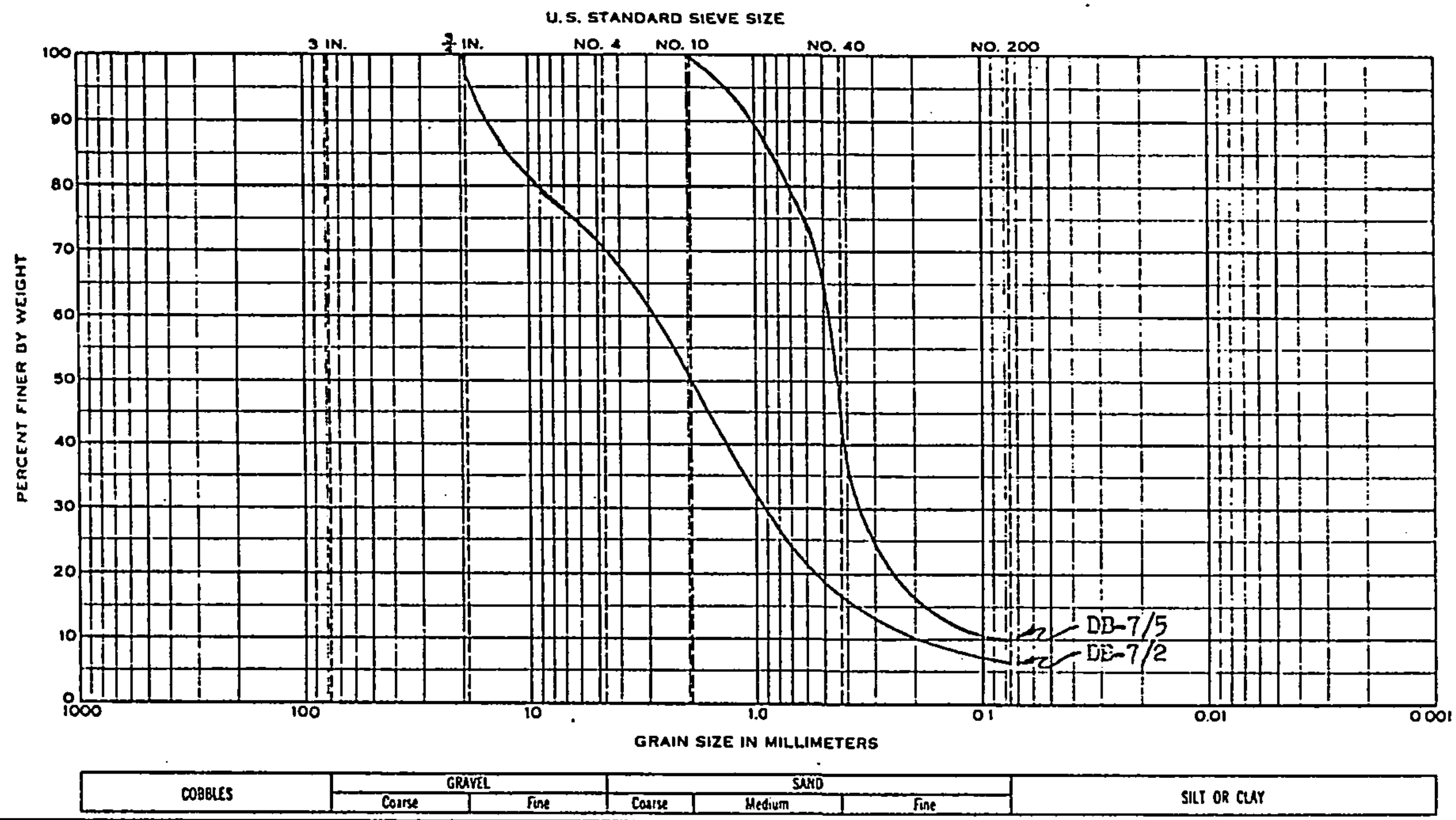
Area Foundation Material

Boring No. DB5 & 6

Date AUGUST 1979

2037

PLATE B-5



Sample No.	Elev or Depth	Classification	NatWC	LL	PL	PI	
DB-7/2	10.5-11.5	Very Den Br Silty SAND (SP-SM)	15.6				SP-SM Materials
DB-7/5	22.0-23.5	Med Den Br Silty SAND (SP-SM)	27.6				

GRADATION CURVES

Project: Waimea Flood Control
Kauai

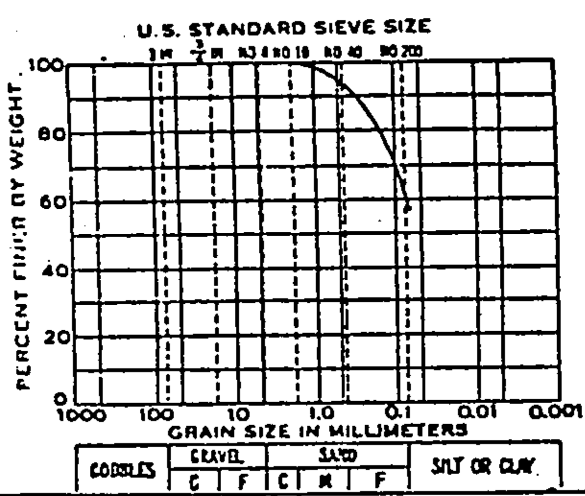
Area: Foundation Material

Boring No. DB 7

Date: AUGUST 1979

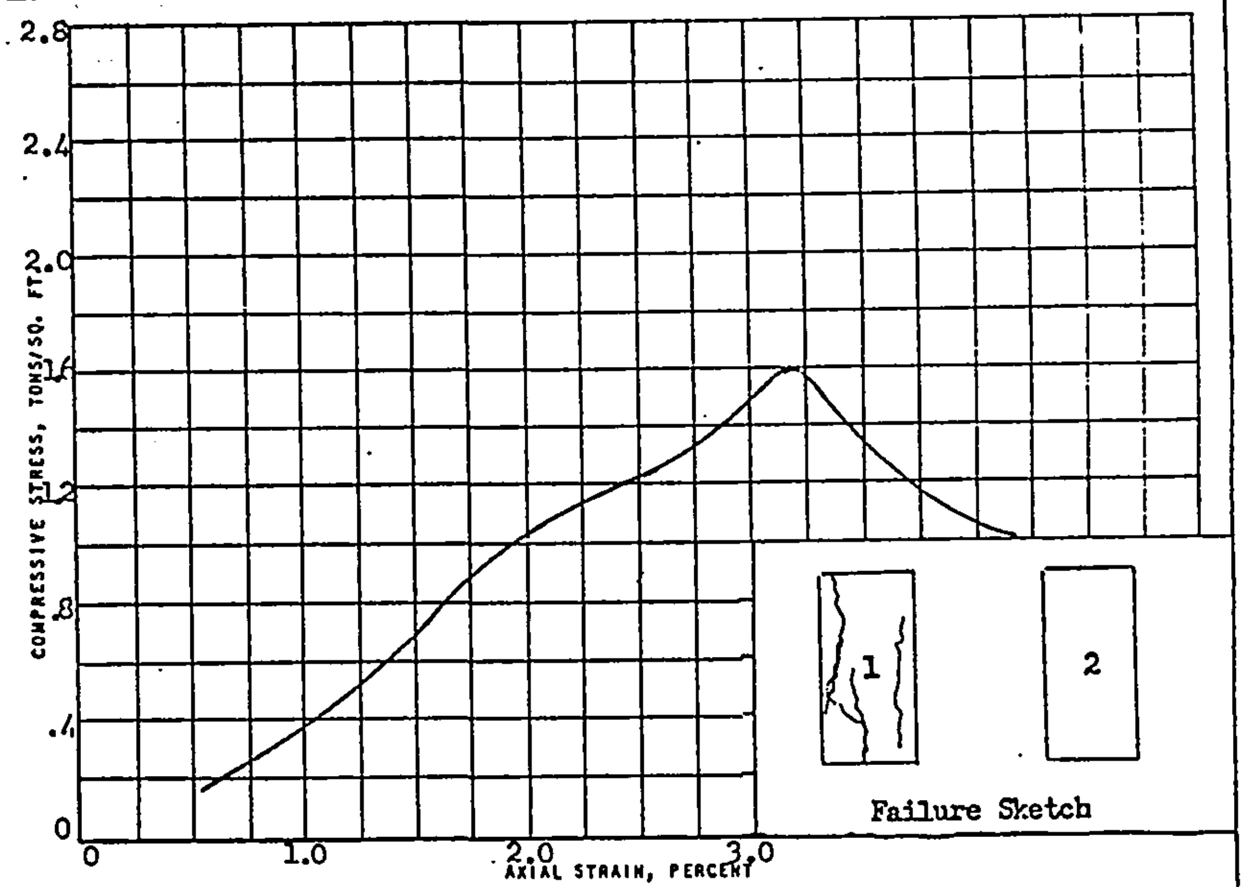
PLATE B-6

POD Form 68
1 Aug 60



LL	40	G	2.933
PL	27	D_{10}	
X UNDISTURBED		REMOLDED	

WATER CONTENT, w_o	%	26.7
DRY DENSITY	LBS./CU.FT.	96.2
VOID RATIO e_o		.90
SATURATION, S_o	%	86.8
UNCONFINED COMP. STRENGTH q_u	TONS/SQ.FT.	1.60
SPECIMEN DIAMETER	INCHES	2.38
SPECIMEN HEIGHT	INCHES	4.75



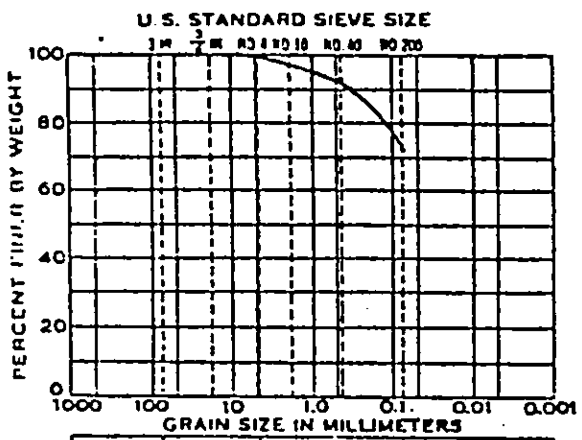
REMARKS: Medium dense brown sandy silt (ML).

PROJECT	Waimea River Flood Control		
AREA	Waimea, Kauai		
BORING NO. B-5	SAMPLE NO. 3	ELEV. OR DEPTH 12.0-13.5	DATE AUG. 1979

UNCONFINED COMPRESSION TEST

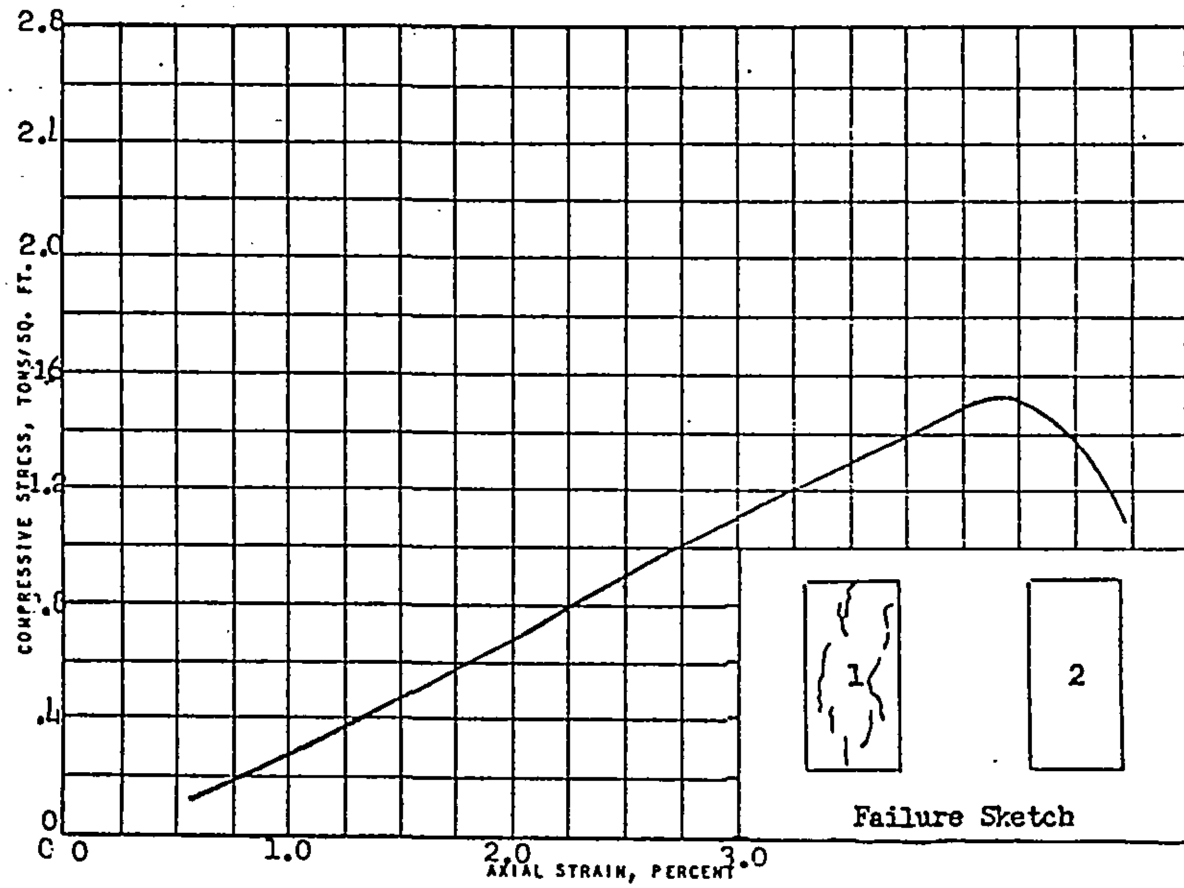
PLATE B-7

POD Form 68
1 Aug 60



LL	43	G	2.855
PL	26	D_{10}	
X	UNDISTURBED		REMOLDED

WATER CONTENT, w_o %	31.4
DRY DENSITY LBS./CU.FT.	91.5
VOID RATIO e_o	.95
SATURATION, S_o %	94.7
UNCONFINED COMP. STRENGTH qu TONS/SQ.FT.	1.543
SPECIMEN DIAMETER INCHES	2.38
SPECIMEN HEIGHT INCHES	4.75



Failure Sketch

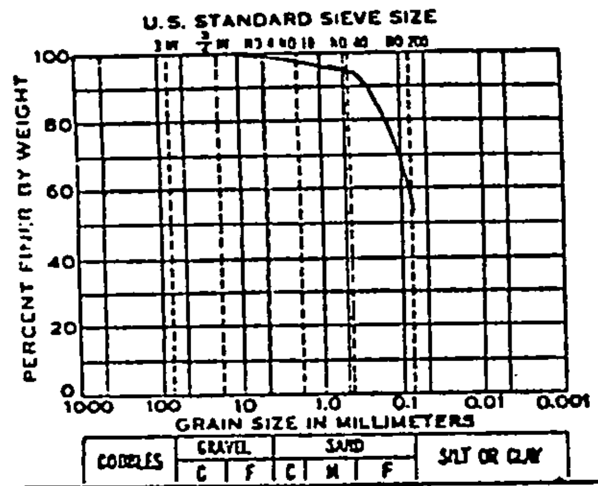
REMARKS: Dense brown sandy clayey silt (ML-CL).

PROJECT	Waimea River Flood Control						
AREA	Waimea, Kauai						
BORING NO.	B-6	SAMPLE NO.	2	ELEV. OR DEPTH	10.0-11.5	DATE	AUG. 1979

UNCONFINED COMPRESSION TEST

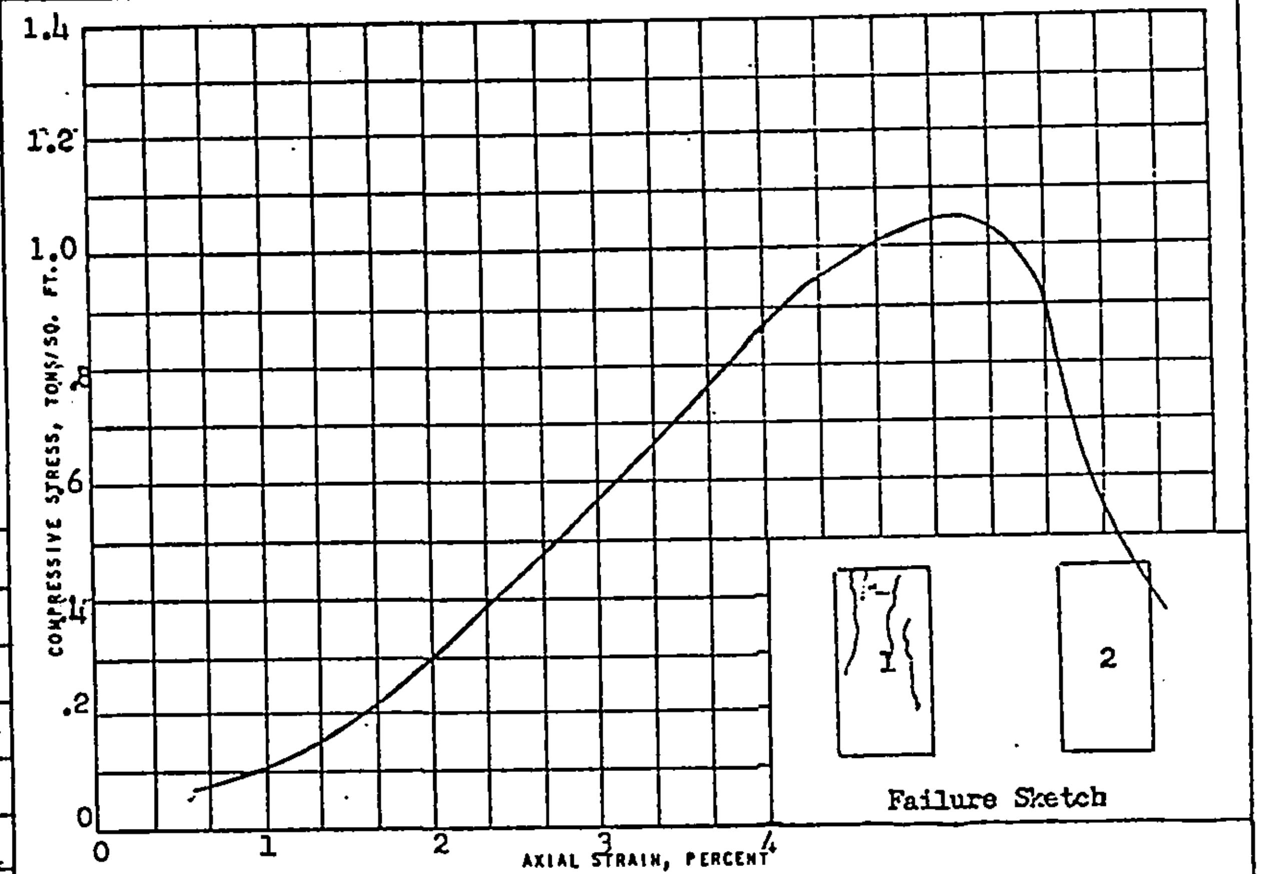
PLATE B-8

POD Form 68
1 Aug 60



LL	37	G	2.855
PL	30	D_{10}	
X UNDISTURBED			REMOLDED

WATER CONTENT, W_o	%	29.5
DRY DENSITY	LBS./CU.FT.	87.3
VOID RATIO e_o		1.04
SATURATION, S_o	%	80.9
UNCONFINED COMP. STRENGTH qu	TONS/SQ.FT.	1.043
SPECIMEN DIAMETER	INCHES	2.38
SPECIMEN HEIGHT	INCHES	4.75



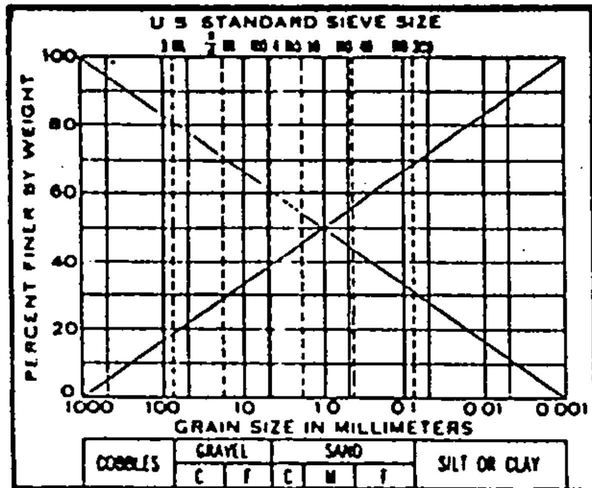
REMARKS: Loose brown sandy silt (ML).

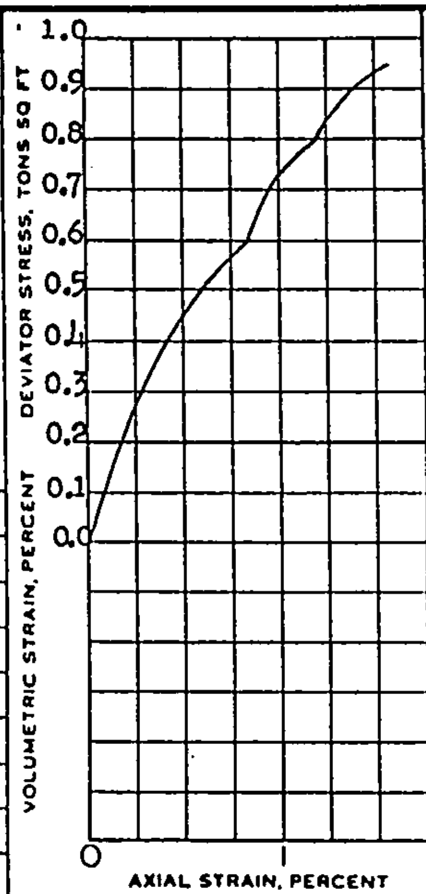
PROJECT	Waimea River Flood Control
AREA	Waimea, Kauai

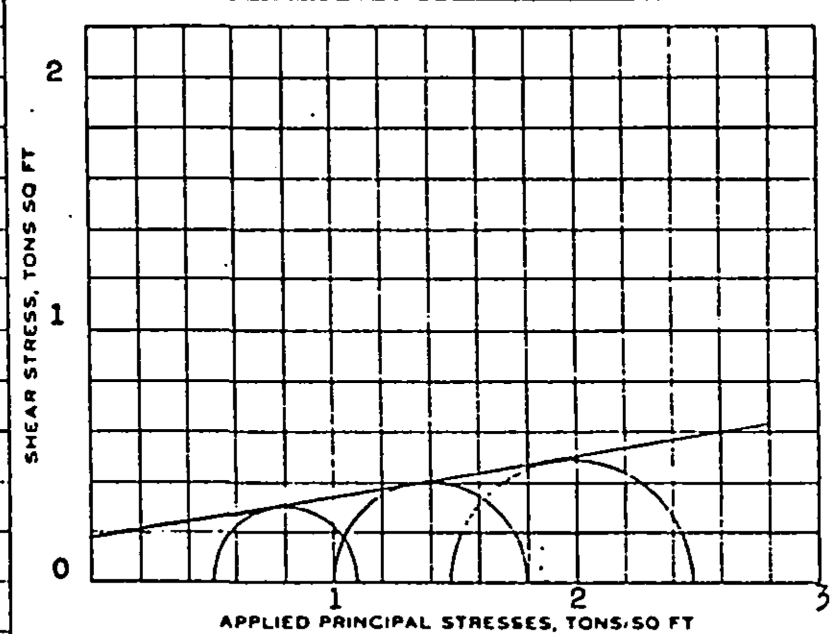
BORING NO. 7	SAMPLE NO. 4	ELEV. OR DEPTH 14.0-17.5	DATE AUG. 1979

UNCONFINED COMPRESSION TEST

PLATE B-9







	Test No			
INITIAL	Water Content, W_o %	27.6	27.6	27.6
	Dry Density Lbs/Cu Ft	102.2	102.2	102.2
	Void Ratio, e_o	0.798	0.798	0.798
	Saturation, S_o %	100	100	100
BEFORE TEST	W.C after Saturation, W_s %	—	—	—
	Saturation, S %	100	100	100
	Consol Pressure T/SqFt	0.50	1.00	1.50
	W C after Consol, W_c %	27.6	27.6	27.6
	Void Ratio after Consol e_c	—	—	—
AT FAILURE	Maj Prin Stress, σ_1 T/Sq Ft	1.10	1.80	2.45
	Min Prin Stress, σ_m T/Sq Ft	0.50	1.00	1.50
	Water Content, W_f %	27.6	27.6	27.6
	Void Ratio, e_f	0.798	0.798	0.798
Specimen Diameter Inches		2.31	2.31	2.31
Initial Height Inr		4.75	4.75	4.75
Test Time to Failure Min		15	11	8

Type of Test Multi-Stage

Constant Control Strain

UNConsolidated, UNDrained

Type of Specimen Remolded

ϕ - 8.35°	Tan ϕ - .147	c = .188 T/Sq Ft
Classification ML		
LL 40	G 2.93	
PL 27	D_{u}	

Remarks:
Test was performed on a composite remolded sample.

Project Waimea Flood Control
Kauai

Area Foundation Material

Boring No. DB 5 Sample No. 2 & 4

Elev or Depth Date AUG. 1979

TRIAXIAL COMPRESSION TEST REPORT

(Translucent)

TEST DATA SUMMARY

(T) Undisturbed Tube Sample
(S) Disturbed Standard Penet. Sample

FEATURE Waimea Flood Control AUGUST 1979

Boring No.	Sam No.	Depth or Elev of Sample	Laboratory Classification	Gravel %	Sand %	Fines %	D10	LL	PL	Specific Gravity G	Nat. Water Cont %	Natural Dry Density lb/cu ft	Remarks
DB-1	1(T)	3.0-4.5	Med Den Brown Silty Clayey SAND(SC-SM)	0	77	23		21	15	3.15	16.2	115.4	Foundation materials along proposed levee extension.
	3(T)	9.0-10.5	Med Den Brown Silty SAND (SM)	0	85	15		-	NP	3.17	16.8	124.[illegible]	
	5(S)	15.5-17.0	Med Den Brown Silty SAND (SP-SM)	6	87	7		-	-	-	19.9	-	
DB-2	1(T)	3.0-4.5	Med Den Brown Silty SAND (SM)	1	85	14		-	NP	3.14	13.4	127.6	
	3(T)	7.0-8.5	Med Den Black Silty SAND (SP-SM)	0	91	9		-	NP	3.18	10.4	97.0	
	6(S)	15.5-17.0	Med Den Brown Silty SAND (SP-SM)	10	80	10		-	-	-	18.9	-	
DB-3	1(S)	4.0-6.0	Med Den Brown Silty SAND (SM)	39	38	23		-	-	-	14.1	-	
	2(T)	6.0-7.5	Med Den Brown Silty SAND (SM)	1	63	16		-	NP	3.07	13.9	105.6	
	5(T)	14.5-16.0	Med Den Brown Silty SAND (SM)	3	84	13		-	NP	-	22.3	105.6	
DB-4	1(T)	7.0-8.5	Med Den Brown Silty SAND (SM)	1	80	19		-	NP	3.07	18.9	115.9	
	2(S)	10.0-11.5	Very Loose Brown Silty SAND (SM)	2	82	16		-	-	-	23.5	-	
	5(T)	20.5-22.0	Med Den Brown Silty SAND (SM)	1	72	27		-	NP	-	21.4	107.2	

TC – Triaxial Compression; UC – Unconfined Compression; DS – Direct Shear; UU – Unconsolidated Undrained; CD – Consolidated Drained; CU – Consolidated Undrained; *Values at Pressure; T/SQ FT

ENG FORM 1 MAR 66 2086 (PREVIOUS EDITIONS MAY BE USED) (TRANSLUCENT)

TEST DATA SUMMARY

FEATURE Waimea Flood Control AUGUST 1979

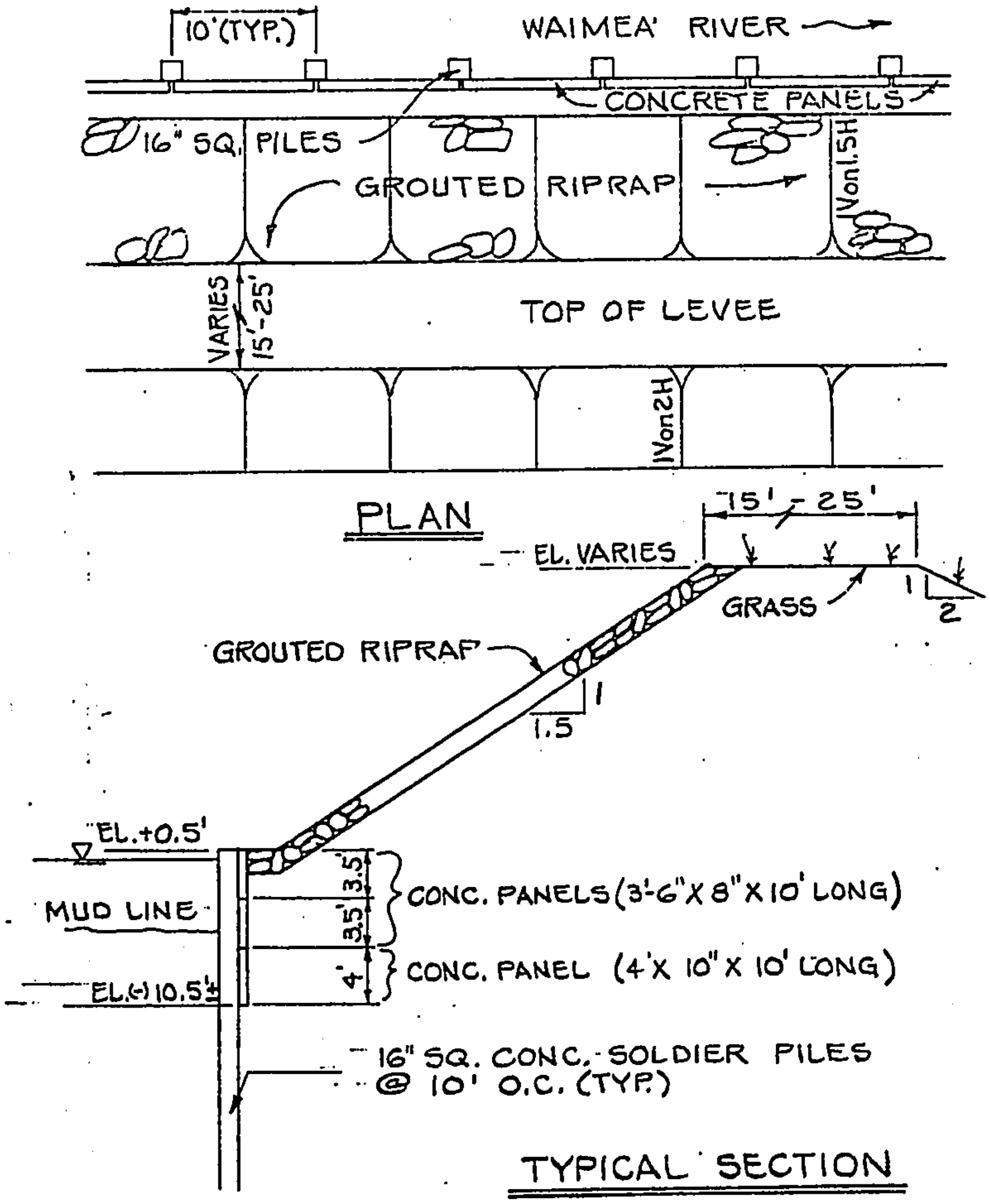
(T) Undisturbed Tube Sample
(S) Disturbed Standard Penet. Sample

Boring No.	Sam. No.	Depth or Elev. of Sample	Laboratory Classification	Gravel %	Sand %	Fines %	D_{10}	LL	PL	Specific Gravity G	Nat. Water Cont. %	Natural Dry Density lb/cu ft	Initial e	Type Test	Specimen Size Inches	Test	σ_3	σ_1	c	$\bar{\phi}$	Remarks
DB-5	1(T)	7.0-8.0	Med Den Brown Sandy SILT (ML)	9	29	62		-	-	-	13.5	-									
	2(T)	12.0-13.5	Med Den Brown Sandy SILT (ML)	0	41	59		40	27	2.93	26.7	96.2		UC	2.38"Dia. 4.75" HT.			3208	1504		Strain=[illegible].2%
	3(T)	18.0-19.5	Med Den Brown Silty SAND (SM)	0	82	18		-	NP	3.[illegible]	27.9	97.4									
	7(T)	24.0-25.5	Med Den Brown Silty SAND(SM)	2	85	13		-	-	3.11	16.3	113.9									
DB-6	1(S)	3.5-4.5	Med Den Brown Silty SAND (SM)	2	83	15		-	-	-	15.4	-									
	2(T)	10.0-11.5	Dense Brown Sandy CLAYEY SILT (ML-CL)	1	27	72		43	26	2.86	31.4	91.5		UC	2.38"Dia. 4.75" HT.			3086	1543		Strain=4.2%
	3(T)	15.0-16.5	Loose Brown Sandy SILT (ML)	1	36	63		36	27	2.86	28.5										
	5(T)	21.0-22.5	Med Den Brown Silty SAND (SM)	0	81	19		-	NP	-	24.8	-									
DB-7	2(S)	10.5-11.5	Very Den Brown Silty SAND (SP-SM)	29	64	7		-	-	-	15.6	-									
	4(T)	16.0-17.5	Loose Brown Sandy SILT (ML)	1	46	53		37	30	28.6	29.5	87.3		UC	2.38"Dia. 4.75" HT.			2086	1043		Strain=5.3%
	5(T)	22.0-23.5	Med Den Brown Silty SAND (SP-SM)	0	90	10		-	-	3.11	27.6	98.7									
	6(T)	27.0-28.5	Med Den Brown Sandy SILT (ML)	0	35	65		-	NP	3.11	67.5	58.9		UC	2.38"Dia. 4.75" HT.			856	428		Strain=4.2%
DB-5	2(S) 3(S)	8.0-9.5 13.5-15.0	Med Den Brown Sandy SILT (ML)					40	27	2.93	27.6	102.2	0.798	CU	2-5/16"Dia. 4-3/4" HT.	1	1000	2200	375	8.3%	Remolded Composite
																2	2000	3600			
																3	3000	4900			

Materials in existing levee. (DB-6 2(T) through DB-5 3(S))

TC – Triaxial Compression
UC – Unconfined Compression
DS – Direct Shear
UU – Unconsolidated Undrained
CD – Consolidated Drained
CU – Consolidated Undrained
* Values at Pressure

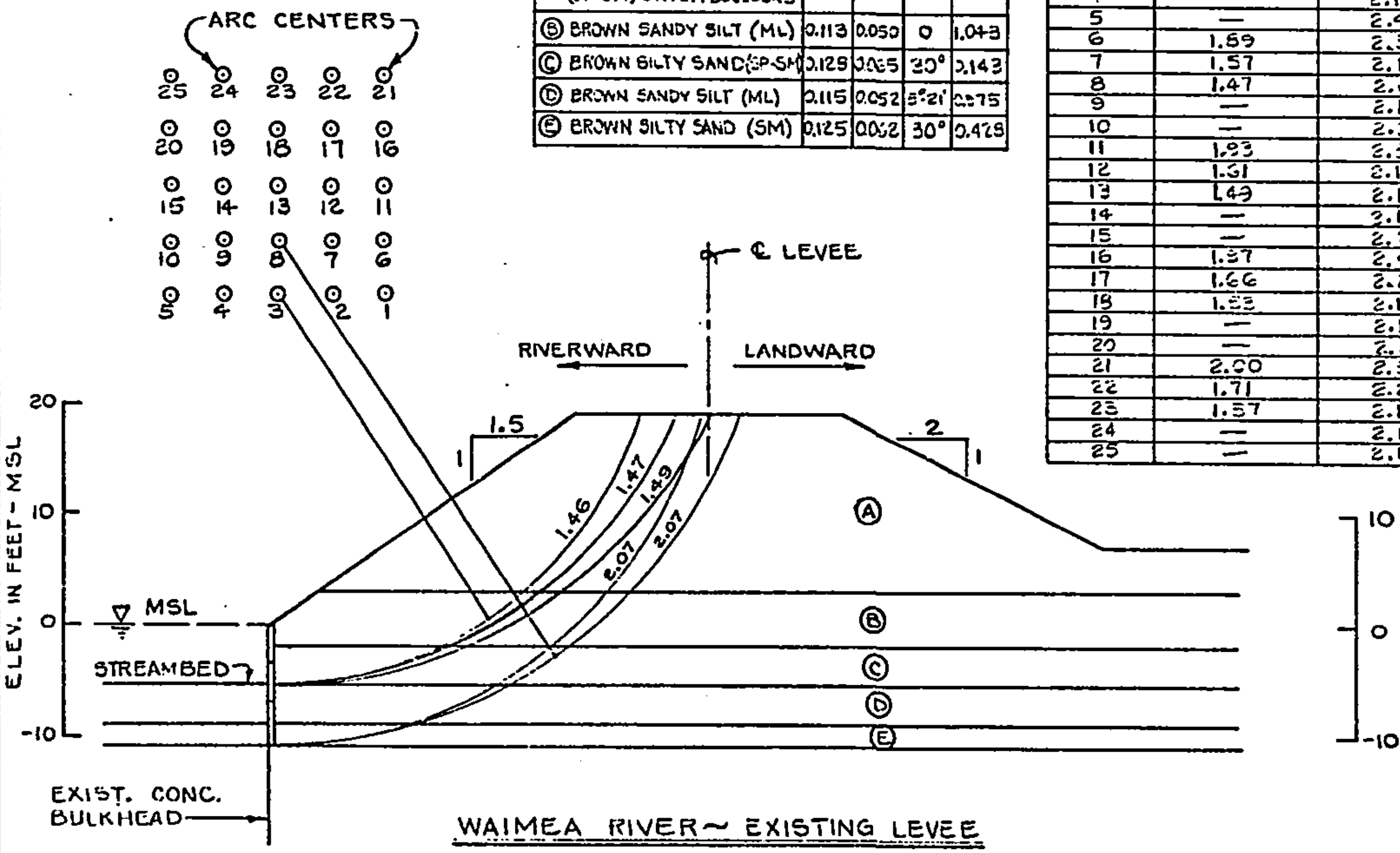
ENG FORM 2086 (PREVIOUS EDITIONS MAY BE USED) (TRANSLUCENT)



WAIMEA LEVEE EXISTING CONDITION

ADOPTED DESIGN DATA				
TYPE MATERIAL	γ_M (KCF)	γ' (KCF)	Ø	C (KSF)
Ⓐ BROWN SILTY SAND (SP-SM) GRVL. & BOULDERS	0.125	0.062	30°	0
Ⓑ BROWN SANDY SILT (ML)	0.113	0.050	0	1.043
Ⓒ BROWN SILTY SAND (SP-SM)	0.128	0.065	30°	0.143
Ⓓ BROWN SANDY SILT (ML)	0.115	0.052	5°21'	0.275
Ⓔ BROWN SILTY SAND (SM)	0.125	0.062	30°	0.429

ARC CENTERS	FACTORS OF SAFETY	
	TANGENT EL.(+)5.5	TANGENT EL.(-)11.0
1	1.55	2.31
2	1.55	2.12
3	1.46	2.07
4	—	2.15
5	—	2.40
6	1.69	2.34
7	1.57	2.13
8	1.47	2.07
9	—	2.11
10	—	[illegible]
11	1.93	2.37
12	1.61	2.16
13	1.49	2.10
14	—	2.10
15	—	2.21
16	1.57	2.47
17	1.66	2.21
18	1.53	2.13
19	—	2.11
20	—	[illegible]
21	2.00	2.31
22	1.71	2.27
23	1.57	2.14
24	—	2.14
25	—	2.10



WAIMEA RIVER ~ EXISTING LEVEE
STABILITY ANALYSIS (PARTIAL POOL)

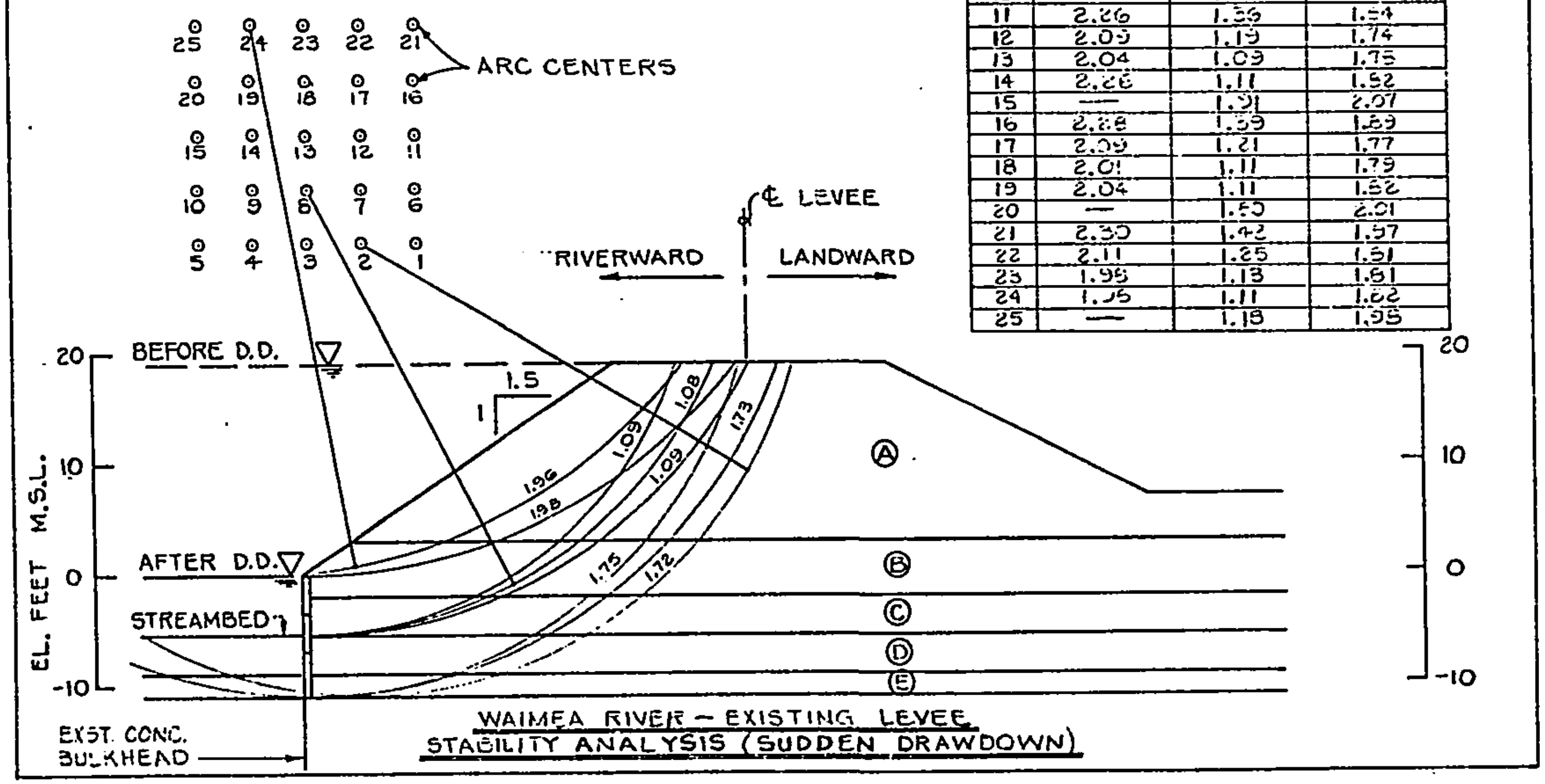
PLATE B-14

ADOPTED DESIGN DATA

TYPE MATERIAL	γ_M (KCF)	γ_S (KCF)	ϕ	C (KSF)
Ⓐ BROWN SILTY SAND (SP-SM) W/ GRAVEL & BOULDERS	0.125	0.062	30°	0
Ⓑ BROWN SANDY SILT (ML)	0.113	0.050	0°	1.043
Ⓒ BROWN SILTY SAND (SP-SM)	0.128	0.065	30°	0.143
Ⓓ BROWN SANDY SILT (ML)	0.115	0.052	8°-21'	0.375
Ⓔ BROWN SILTY SAND (SM)	0.125	0.062	30°	0.428

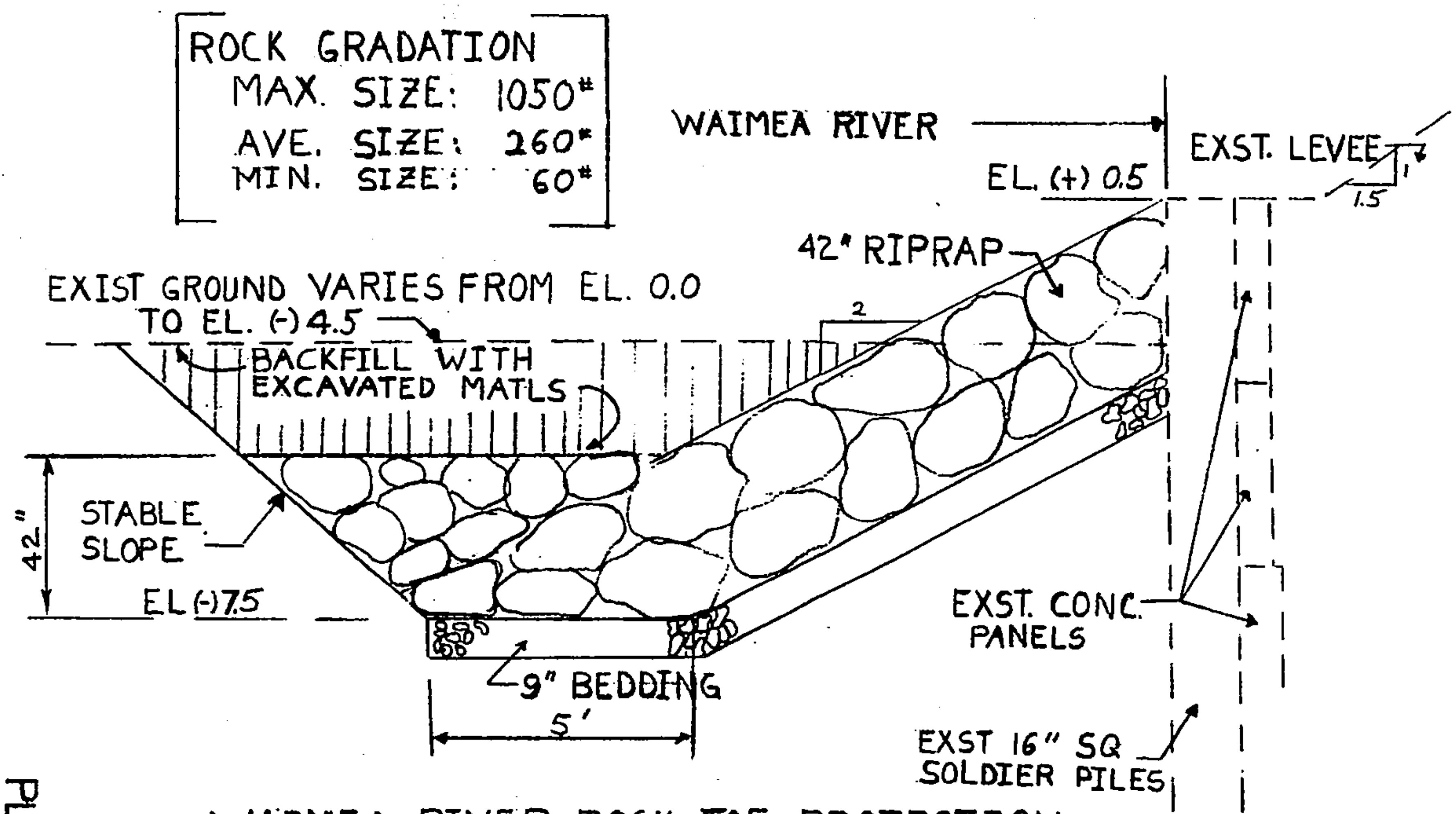
FACTORS OF SAFETY

ARC CENT.	TAN. EL. 0.0	TAN. EL. (-)5.5	TAN. EL. (-)11.0
1	2.29	1.35	1.53
2	2.21	1.16	1.72
3	2.48	1.09	1.75
4	3.00	1.21	1.94
5	—	2.65	2.24
6	2.25	1.35	1.55
7	2.12	1.17	1.76
8	2.16	1.08	1.73
9	2.60	1.13	1.55
10	—	1.45	2.16
11	2.26	1.36	1.54
12	2.09	1.19	1.74
13	2.04	1.09	1.75
14	2.26	1.11	1.52
15	—	1.31	2.07
16	2.28	1.39	1.69
17	2.09	1.21	1.77
18	2.01	1.11	1.79
19	2.04	1.11	1.52
20	—	1.50	2.01
21	2.30	1.42	1.57
22	2.11	1.25	1.51
23	1.99	1.13	1.61
24	1.95	1.11	1.62
25	—	1.18	1.95



WAIMEA RIVER – EXISTING LEVEE
STABILITY ANALYSIS (SUDDEN DRAWDOWN)

PLATE B-15



WAIMEA RIVER ROCK TOE PROTECTION

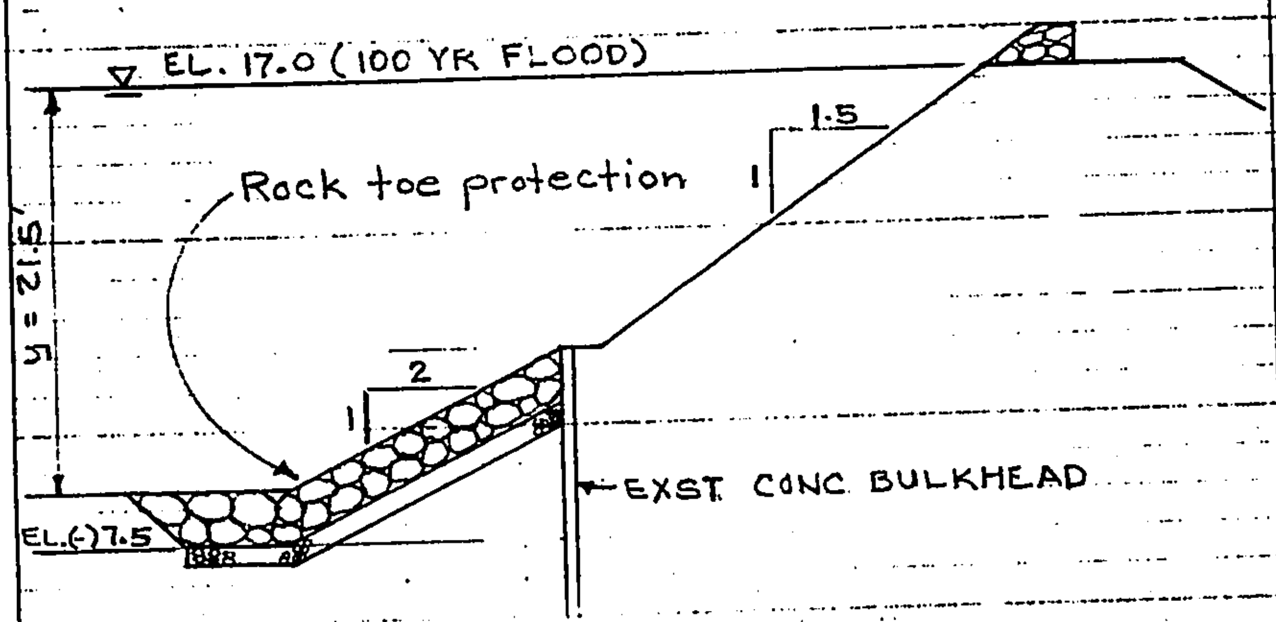
STA. 10+50 TO 57+00

PLATE B-16
(1 OF 4)

U.S. ARMY ENGINEER DIVISION, PACIFIC OCEAN
CORPS OF ENGINEERS

PROJECT TITLE Waimea River F.C. SH NO. 2 OF 4 SHS
LOCATION Kauai, Hawaii SECTION
DRAWING(S) NO. Riprap Design ~ Rock Toe Protection
COMPUTED BY T.H. DATE 2/25/80 CHECKED BY DATE

DESIGN ANALYSIS



STA. 48+00

References:

1. EM 1110-2-1601, Hydraulic Design of Flood Control Channels.
2. ETL 1110-2-120, Additional Guidance for Riprap Channel Protection.

U.S. ARMY ENGINEER DIVISION, PACIFIC OCEAN
CORPS OF ENGINEERS

PROJECT TITLE Waimea River F.C. SH NO. 3 OF 4 SHS
LOCATION Kauai, Hawaii SECTION
DRAWING (S) NO. Riprap Design ~ Rock Toe Protection
COMPUTED BY T. H. DATE 2/25/80 CHECKED BY DATE

DESIGN ANALYSIS

Assumptions:

1. Underwater placement ~ Use Incl. 2 of Ref. 2.
2. Non-uniform flow ~ Use factor of 1.5.
3. $G_{rock} = 2.5$, $\gamma_{rock} = 156$ pcf (basalt)
4. Velocity = 14.0 fps
5. Side slopes = 1V on 2H

Try 36" Thickness

From Incl. 2 of Ref. 2 and Pl. 30 of Ref. 1,

$W_{50\,max} = 192^{\#}$, $D_{50\,max} = 1.35'$

$W_{50\,min} = 130^{\#}$, $D_{50\,min} = 1.18'$

$y/D_{50\,max} = 21.5/1.35 = 15.93$

From Pl. 32 of Ref. 1, $K_2 = 0.0112$

Boundary Shear

$\tau_o = 1.5\,K_2 V^2 = 1.5(0.0112)(14.0)^2 = \underline{3.29}$

Design Shear

From Pl. 35 for $D_{50\,min} = 1.18'$, $\tau = 4.3$

From Pl. 36 for 2:1 slope, $K_1 = 0.72$

$\tau' = K_1 \tau = 0.72(4.3) = \underline{3.10 < 3.29}$ N.G.

POD Form 115
1 Jul 70

U.S. ARMY ENGINEER DIVISION, PACIFIC OCEAN
CORPS OF ENGINEERS

PROJECT TITLE Waimea River F.C. SH NO. 4 OF 4 SHS
LOCATION Kauai, Hawaii SECTION
DRAWING(S) NO. Riprap Design ~ Rock Toe Protection
COMPUTED BY T.H. DATE 2/25/80 CHECKED BY DATE

DESIGN ANALYSIS

Try 42" Thickness

From Incl. 2 of Ref. 2 and Pl. 30 of Ref. 1,

$W_{50max} = 305^{\#}$; $D_{50max} = 1.55'$

$W_{50min} = 206^{\#}$; $D_{50min} = 1.36'$

$y/D_{50max} = 21.5/1.55 = 13.87$

From Pl. 32 of Ref. 1, $K_2 = 0.0119$

Boundary Shear

$\tau_o = 1.5 K_2 V^2 = 1.5(0.0119)(14)^2 = \underline{3.50}$

Design Shear

From Pl. 35 for $D_{50min} = 1.36'$, $\tau = 5.0$

From Pl. 36 for 2:1 slope, $K_1 = 0.72$

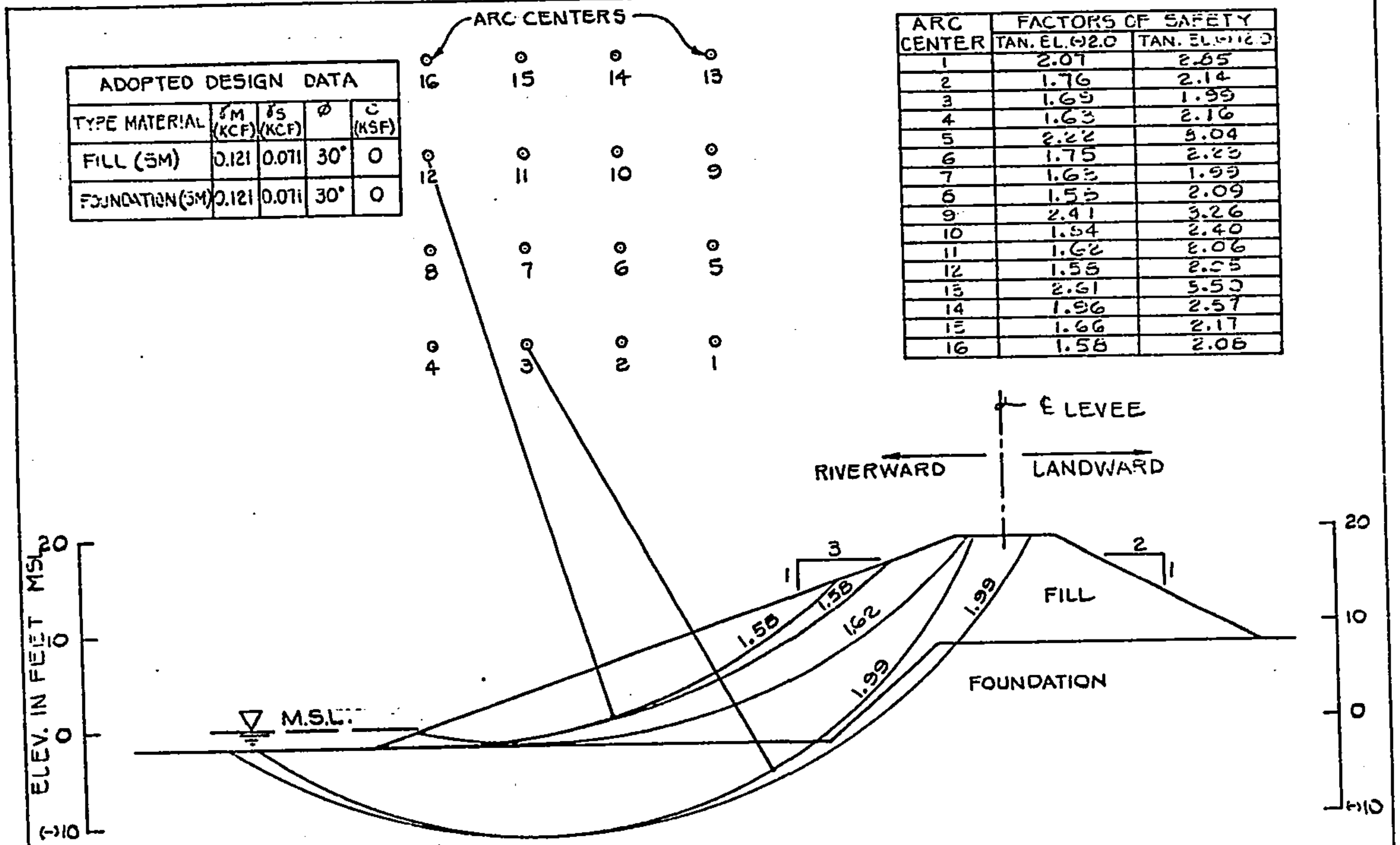
$\tau' = K_1 \tau = 0.72(5.0) = \underline{3.60 > 3.50}$ O.K.

$\therefore$ USE 42" THICKNESS

POD Form 115
1 Jul 70

ADOPTED DESIGN DATA				
TYPE MATERIAL	γ_M (KCF)	γ_S (KCF)	ϕ	C (KSF)
FILL (SM)	0.121	0.071	30°	0
FOUNDATION (SM)	0.121	0.071	30°	0

ARC CENTER	FACTORS OF SAFETY	
	TAN. EL.(+)2.0	TAN. EL.(+)12.0
1	2.07	2.65
2	1.76	2.14
3	1.69	1.99
4	1.63	2.16
5	2.22	3.04
6	1.75	2.23
7	1.65	1.99
8	1.55	2.09
9	2.41	3.26
10	1.54	2.40
11	1.62	2.06
12	1.58	2.05
13	2.61	3.50
14	1.96	2.57
15	1.66	2.17
16	1.58	2.06

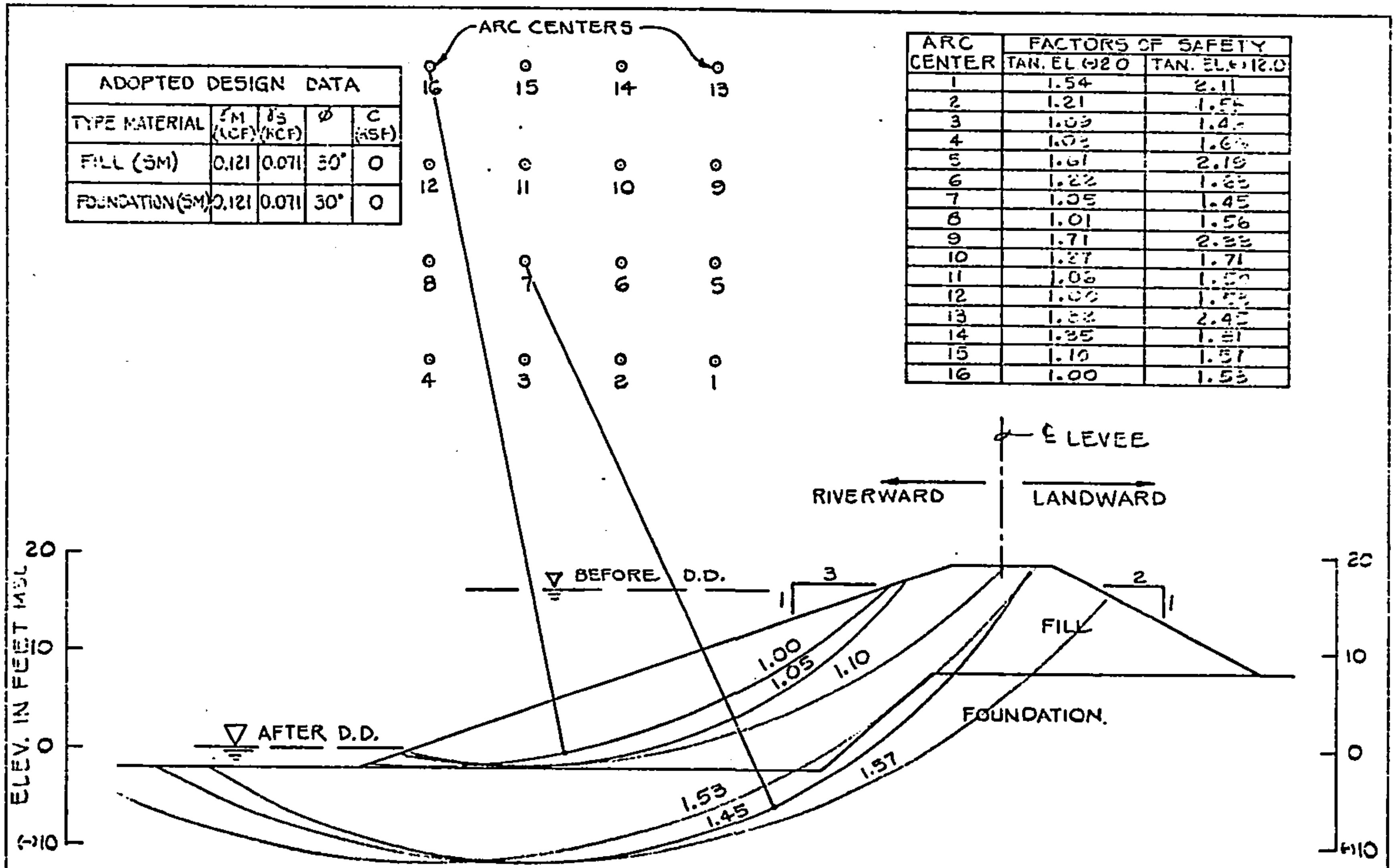


WAIMEA RIVER — LEVEE EXTENSION
STABILITY ANALYSIS (PARTIAL POOL)

PLATE B-17

ADOPTED DESIGN DATA				
TYPE MATERIAL	γ_M (KCF)	γ_S (KCF)	ϕ	C (KSF)
FILL (SM)	0.121	0.071	30°	0
FOUNDATION (SM)	0.121	0.071	30°	0

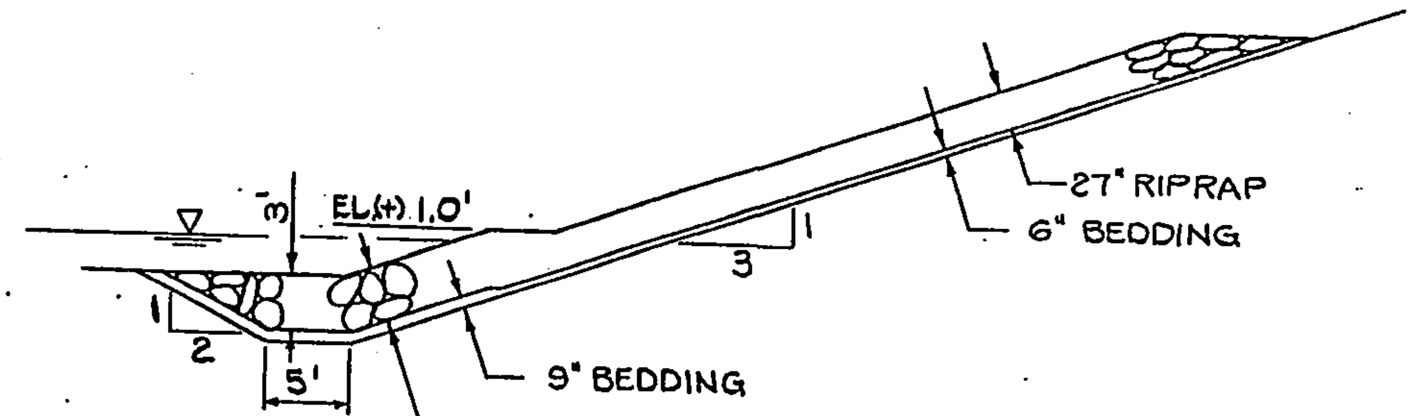
ARC CENTER	FACTORS OF SAFETY	
	TAN. EL (-)2.0	TAN. EL (+)12.0
1	1.54	2.11
2	1.21	1.5[illegible]
3	1.0[illegible]	1.4[illegible]
4	1.0[illegible]	1.6[illegible]
5	1.61	2.19
6	1.22	1.[illegible]
7	1.05	1.45
8	1.01	1.56
9	1.71	2.[illegible]
10	1.27	1.71
11	1.06	1.5[illegible]
12	1.0[illegible]	1.[illegible]
13	1.[illegible]	2.4[illegible]
14	1.35	1.[illegible]
15	1.10	1.57
16	1.00	1.53



WAIMEA RIVER — LEVEE EXTENSION
STABILITY ANALYSIS (SUDDEN DRAWDOWN)

DESIGN ASSUMPTIONS:
γ ROCK = 156 P.C.F. (S.G. = 2.5)
V = 14 F.P.S.

RIPRAP GRADATION	
MAX. SIZE:	1,000#
50% SIZE:	250#
MIN. SIZE:	50#

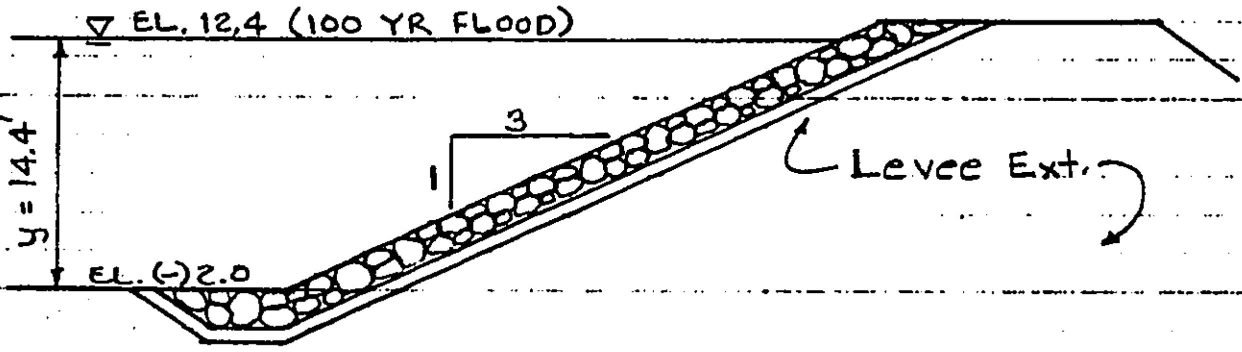


WAIMEA RIVER
TYPICAL RIPRAP SECTION
LEVEE EXTENTION

U.S. ARMY ENGINEER DIVISION, PACIFIC OCEAN
CORPS OF ENGINEERS

PROJECT TITLE Waimea River F.C. SH NO. 2 OF 4 SHS
LOCATION Kauai, Hawaii SECTION
DRAWING (S) NO. Riprap Design ~ Levee Extension
COMPUTED BY T.H. DATE 2/26/80 CHECKED BY DATE

DESIGN ANALYSIS



STA 8+50

References:

1. EM 1110-2-1601, Hydraulic Design of Flood Control Channels.
2. ETL 1110-2-120, Additional Guidance for Riprap Channel Protection.

Assumptions:

1. Riprap design based on Incl. 1 of Ref. 2 and thickness increased by 50 percent for underwater placement, as appropriate.
2. Non-uniform flow ~ Use factor of 1.5.
3. G_{rock} = 2.5, γ_{rock} = 156 pcf (basalt)
4. Velocity = 14.0 fps

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1 Jul 70

U.S. ARMY ENGINEER DIVISION, PACIFIC OCEAN
CORPS OF ENGINEERS

PROJECT TITLE Waimea River F.C. SH NO. 3 OF 4 SHS
LOCATION Kauai, Hawaii SECTION
DRAWING (S) NO. Riprap Design ~ Levee Extension
COMPUTED BY T.H. DATE 2/26/80 CHECKED BY DATE

DESIGN ANALYSIS

5. Side slopes = 1V on 3H

Try 27" Thickness

From Incl. 1 of Ref. 2 and Pl. 30 of Ref. 1,

$W_{50max} = 274^{\#}$, $D_{50max} = 1.5'$

$W_{50min} = 185^{\#}$, $D_{50min} = 1.3'$

$y/D_{50max} = 14.4/1.5 = 9.6$

From Pl. 32 of Ref. 1, $K_2 = 0.0137$

Boundary Shear

$\tau_o = 1.5 K_2 V^2 = 1.5 (0.0137)(14.0)^2 = \underline{4.03}$

Design Shear

From Pl. 35 for $D_{50min} = 1.3'$, $\tau = 4.80$

From Pl. 36 for 3:1 slope, $K_1 = 0.872$

$\tau' = K_1 \tau = 0.872 (4.8) = \underline{4.19 > 4.03}$

O.K., But try thinner section

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1 Jul 70

U.S. ARMY ENGINEER DIVISION, PACIFIC OCEAN
CORPS OF ENGINEERS

PROJECT TITLE Waimea River F.C. SH NO. 4 OF 4 SHS
LOCATION Kauai, Hawaii SECTION
DRAWING (S) NO. Riprap Design ~ Levee Extension
COMPUTED BY T. H. DATE 2/26/80 CHECKED BY DATE

DESIGN ANALYSIS

Try 24" Thickness

From Incl. 1 of Ref. 2 and Pl. 30 of Ref. 1,

$W_{50max} = 192^{\#}$; $D_{50max} = 1.35'$

$W_{50min} = 130^{\#}$; $D_{50min} = 1.18'$

$y/D_{50max} = 14.4/1.35 = 10.67$

From Pl. 32 of Ref. 1, $K_2 = 0.0132$

Boundary Shear

$\tau_o = 1.5 K_2 V^2 = 1.5(0.0132)(14)^2 = \underline{3.88}$

Design Shear

From Pl. 35 for $D_{50min} = 1.18$, $\tau = 4.3$

From Pl. 36 for 3:1 slope, $K_1 = 0.872$

$\tau' = K_1 \tau = 0.872(4.3) = 3.75 < 3.88$ N.G.

∴ USE 27" THICKNESS ABOVE EL. (+) 1.0

AND 40" THICKNESS BELOW EL. (+) 1.0

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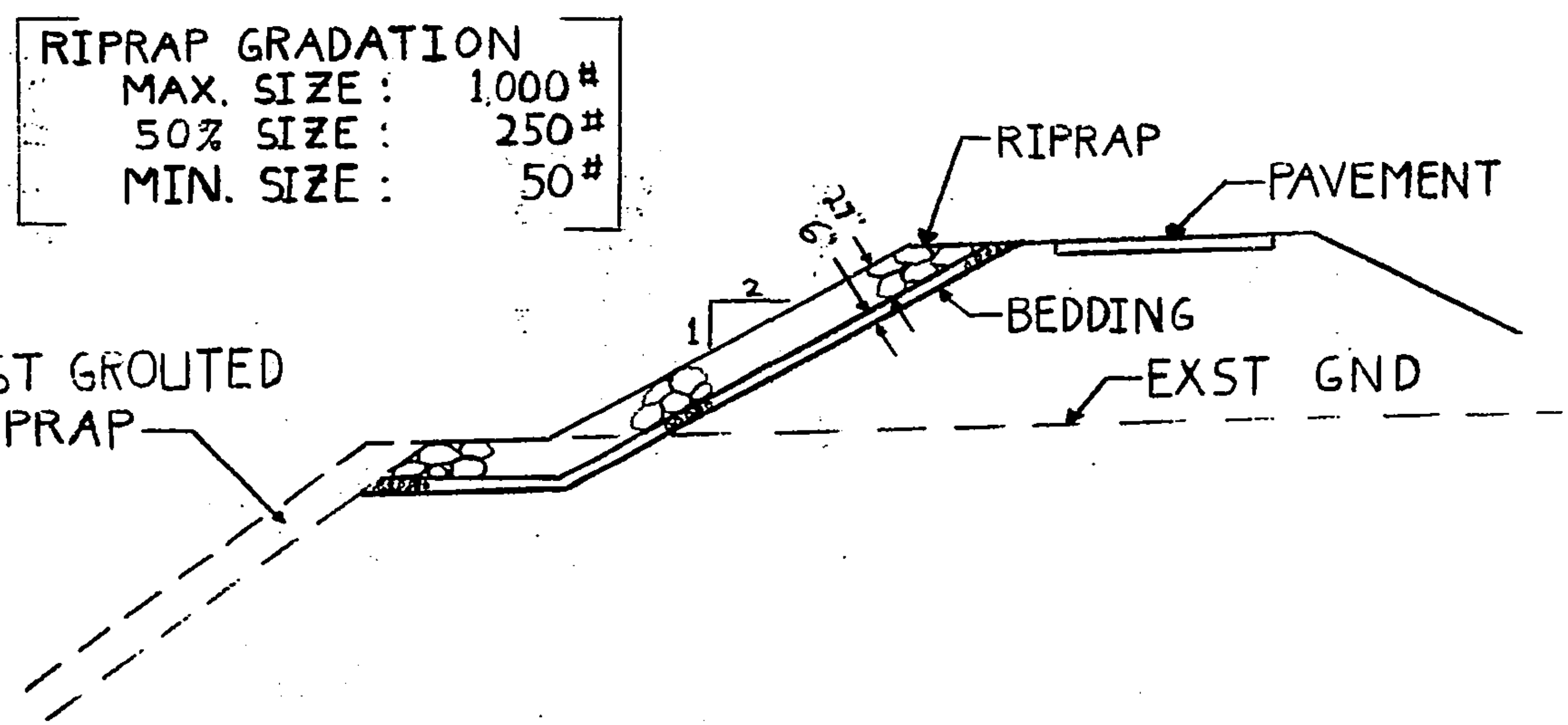
1 Jul 70

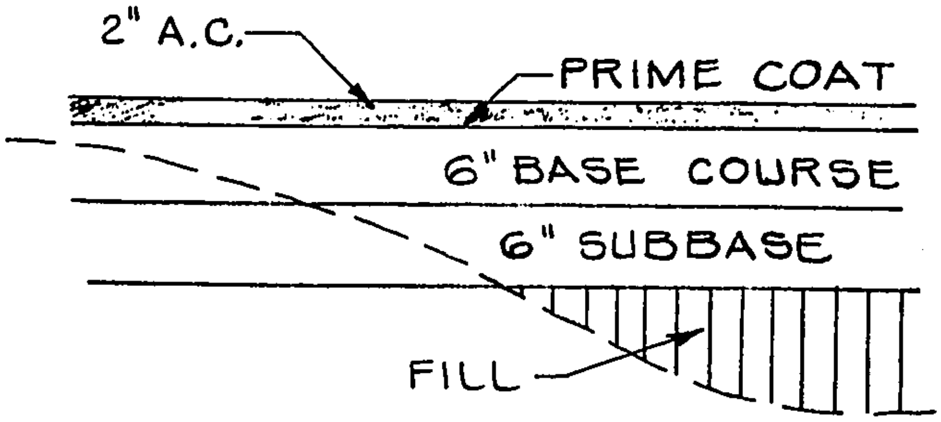


WAIMEA RIVER

TYPICAL RIPRAP SECTION AT ROAD RAISE

STA. 72+00 TO STA. 77+00

PLATE B-20



NOTES:

1. COMPACT BASE COURSE AND SUBBASE TO MIN. 100% OF A.S.T.M. 1557 (D) MAX. DENSITY.
2. COMPACT ALL FILL AND TOP 6" OF SUBGRADE IN CUT OR FILL TO MIN. 95% OF A.S.T.M. 1557 (D) MAX. DENSITY FOR COHESIONLESS MATERIAL AND MIN. 90% MAX. DENSITY FOR COHESIVE MATERIAL.

WAIMEA RIVER

TYPICAL PAVEMENT SECTION
ROAD RAISE

PLATE B-21

WAIMEA RIVER FLOOD CONTROL
WAIMEA, KAUAI

ENGINEERING INVESTIGATIONS AND DESIGN

APPENDIX C

ENGINEERING INVESTIGATIONS,
DESIGN AND COST ESTIMATES
APPENDIX C

ENGINEERING INVESTIGATIONS,
DESIGN AND COST ESTIMATES
APPENDIX C (Cont)

LIST OF TABLES

ENGINEERING INVESTIGATIONS,
DESIGN AND COST ESTIMATES
APPENDIX C (Cont)

LIST OF PLATES

*All plates follows page C-38.

PROJECT DESIGN

1. The design for flood protection at Waimea consists of 1,575 feet of new levee, a 500-foot road raise, 3,175 feet of concrete rubble-masonry flood wall construction, two gravity outlets for interior drainage, and 4,650 feet of rock toe protection for the existing levee. A flood warning system will be installed on the Waimea River upstream of Waimea.

2. The levee design will provide 100-year flood protection for the town of Waimea in contrast to existing protection against the 25-year flood event. The 100-year flood design discharge is 64,000 cfs along the entire levee system.

HYDRAULIC DESIGN

3. To provide a 100-year flood protection for Waimea, the existing levee must be extended and raised. The levee extension is from the mouth at station 0+00 to an existing floodgate at station 10+50. The levee would be continued upstream by building on the existing levee from station 10+50 to 15+75 (Plate C-1). A layer of riprap will be placed on the riverside of the earth levee to prevent erosion. At station 15+75 the earth levee raise would be terminated because of real estate constraints and a concrete-rubble-masonry flood wall will be constructed from station 15+75 to 36+00 and from station 61+00 to 72+50. The existing asphalt road will be raised from station 72+00 to station 77+00 where the road will tie into a bluff. In addition to the levee extension and raise, stone riprap will be placed along the toe of the existing levee from station 10+50 to station 57+00 to prevent erosion of the levee toe (Plate 1 and Figure 10 of Main Report).

FREEBOARD

4. Three feet of freeboard is included along the entire project length to protect the project against overtopping from wind-generated wave action, surges, debris blockage of the Belt Highway Bridge and to insure the specified degree of protection will not be reduced by unaccounted hydrologic and hydraulic factors. Because of the subcritical flow condition, air entrainment is negligible and no adjustments are made for bulking of flow.

WATER SURFACE PROFILES

5. Water Surface Profiles for the 1-year, 2-year, 5-year, 10-year, 50-year, 100-year, 200-year, 500-year, and Standard Project Flood were developed for 9,000 feet of the Waimea River from the mouth to a point approximately 1,250 feet upstream from the end of the existing levee (Plate C-3). The flow profiles for existing and design conditions match at station 90+00. The water surface profiles shown are computed using cross sections taken in January 1979. The HEC-2 Water Surface Profile computer program was used for all of the profile analysis. HEC-2 input for the design improvement conditions is shown on Table C-1. The computed profile closely matches the 7 February 1949 profile

TABLE C-1 (HEC-2 DATA INPUT)

1 T1	DETAILED PROJECT REPORT, WAIMEA RIVER FLOOD CONTROL STUDY									
2 T2	WAIMEA, KAUAI, HAWAII						MARCH 1980			
3 T3	1 YR FLOOD									
4 J1	-1	2						1.5		
5 NC	.08	.07	.025	.1	.3					
6 QT	7	5200	28000	35500	54500	64000	74000	105000		
7 X1	0	17	1832	2240						
8 X3	10							100		
9 GR	20	0	15	20	10.2	35	10.1	390	11.2	1040
10 GR	10.7	1200	10	1680	6.8	1810	6.7	1832	4.7	1839
11 GR	-2.2	1842	-4.8	1862	-4.8	2135	0	2155	2.8	2240
12 GR	16.5	2265	25	2320						
13 X1	1.0				140	140	140			
14 X3	10							100		
15 X1	4.7	15	1544	1804	330	330	330			
16 X3	10							100		
17 GR	20	0	15	15	10	150	10	1000	8	1430
18 GR	6.7	1510	6.6	1544	-3.4	1546	-2.2	1570	-2.7	1625
19 GR	-8.9	1688	-0.4	1748	-0.8	1804	2.2	1804	30.9	1873
20 X1	7	17	1577	1861	230	230	230			
21 X3				1548	100					
22 GR	30		15	35	10	80	10	820	9.6	1270
23 GR	8	1400	6.6	1548	6.6	1577	-0.7	1584	-2	1604
24 GR	-3.2	1630	-5.8	1735	-5.8	1858	3	1861	26	1899
25 GR	30	1910	45	1980						
26 NC	.08	.08	.025	.3	.6					
27 X1	7.5	18	1566	1932	50	50	50			
28 X3	10							100		
29 GR	30		15	35	10	80	9.4	270	9.6	1280
30 GR	17.7	1550	6.6	1566	6.6	1595	-0.7	1602	-2	1622
31 GR	-3.2	1648	-5.8	1753	-5.8	1876	3	1879	6	1907
32 GR	26.2	1932	31.4	1943	45	2030				
33 NC	.04	.04	.025	.3	.6					
34 X1	7.6	36	1572	1932	10	10	10			
35 X3	10							100		
36 BT	34		30	30	35	15	15	80	10	10
37 BT	270	9.4	9.4	1280	9.6	9.6	1550	17.7	17.7	1572
38 BT	18.5	13.6	1595	19.3	14.4	1602	19.5	14.7	1622	20.2
39 BT	14.2	1645	21.1	11	1646	21.1	-3.2	1650	21.1	-3.2
40 BT	1651	21.1	11	1675	22	16	1701	22.9	18.1	1727
41 BT	23.8	17.8	1750	24.8	14.7	1751	24.8	-5.8	1755	24.8
42 BT	-5.8	1756	24.8	14.7	1780	25.7	19.7	1806	26.6	21.8
43 BT	1832	27.5	21.5	1855	28.4	18.3	1856	28.4	-5.8	1860
44 BT	28.4	-5.8	1861	28.4	18.3	1876	29	21.9	1879	29.2
45 BT	22.6	1907	30.1	25.3	1932	31.1	26.2	1943	31.4	31.4
46 BT	2030	45	45							
47 GR	30		15	35	10	80	9.4	270	9.6	1280
48 GR	17.7	1550	18.5	1572	6.6	1572	6.6	1595	-0.7	1602
49 GR	-2	1622	-3.2	1645	-3.2	1646	-3.2	1650	-3.2	1651
50 GR	-3.9	1675	-4.5	1701	-5.2	1727	-5.8	1750	-5.8	1751
51 GR	-5.8	1755	-5.8	1756	-5.8	1780	-5.8	1806	-5.8	1832
52 GR	-5.8	1855	-5.8	1856	-5.8	1860	-5.8	1861	-5.8	1876
53 GR	3	1879	6	1907	26.2	1932	31.1	1932	31.4	1943
54 GR	45	2030								
55 X1	7.9				30	30	30			

TABLE C-1 (continued)

56	X2							1			
57	X3	10							100		
58	X1	8	18	1566	1932	10	10	10			
59	X3	10							100		
60	GR	30		15	35	10	80	9.4	270	9.6	1280
61	GR	17.7	1550	6.6	1566	6.6	1595	-0.7	1602	-2	1622
62	GR	-3.2	1648	-5.8	1753	-5.8	1876	3	1879	6	1907
63	GR	26.2	1932	31.4	1943	45	2030				
64	NC	.08	.09	.025	.3	.6					
65	X1	8.5	18	1394	1746	50	50	50			
66	X3	10							100		
67	GR	20	0	15	5	10	115	7.6	280	7.5	640
68	GR	8.3	1110	8.6	1280	7.8	1375	10.5	1379	10.4	1394
69	GR	-2.3	1410	-1.4	1453	-1.3	1502	-2.2	1562	-5.9	1633
70	GR	-0.9	1707	29	1746	31.7	1782				
71	NC	.07	.08	.025	.1	.3					
72	X1	12.5	20	1289	1656	400	400	400			
73	X3	10							100		
74	GR	20	0	15	10	10	70	6.6	320	6.5	810
75	GR	5.4	1040	5.5	1240	10.6	1270	10.7	1289	-0.9	1309
76	GR	-0.8	1360	-1.9	1446	-0.1	1506	-5.1	1595	2.8	1656
77	GR	3.9	1656	13.8	1710	14.1	1740	30	1785	50	1825
78	NC	.06	.08	.025	.1	.3					
79	X1	15	22	1285	1620	250	250	250			
80	X3	10							100		
81	GR	50	0	10	40	7.9	100	6	330	5	670
82	GR	5	760	5.3	1080	5.7	1225	6.2	1251	13.6	1271
83	GR	13.6	1285	-0.3	1309	-0.8	1335	-2.1	1397	-4.8	1493
84	GR	-4.4	1550	6.4	1620	7.9	1620	5	1648	13.6	1858
85	GR	25	1860	50	1900						
86	X1	21	22	1278	1541	600	600	600			
87	X3	10							100		
88	GR	50	0	10	40	5	80	5	150	6.8	250
89	GR	5.3	450	5	820	5.2	1020	5.9	1200	7.1	1247
90	GR	15.7	1269	15.5	1278	0	1309	-4.7	1357	-4.8	1413
91	GR	-3.5	1469	1.9	1516	3.9	1516	5.1	1541	6	1870
92	GR	10.1	2060	50	2100						
93	NC	.08	.08	.025	.1	.3					
94	X1	27	19	1275	1504	600	600	600			
95	X3	10							100		
96	GR	50	0	5	30	5	500	7.6	720	5.2	940
97	GR	5.4	1160	7.6	1190	7.4	1231	16.2	1261	16.7	1275
98	GR	0.3	1249	-0.9	1340	-0.9	1420	2.3	1494	2.8	1494
99	GR	7.5	1504	6.1	2125	25	2155	50	2190		
100	X1	33.5	22	1145	1350	650	650	650			
101	X3	10							100		
102	GR	50	0	25	20	10	105	6.4	270	5	580
103	GR	8.5	880	7.6	1100	7.6	1139	18.2	1139	17.9	1145
104	GR	0.8	1170	-4.5	1228	-2.7	1289	-1.6	1336	3.1	1350
105	GR	3.6	1350	8.4	1376	6	1620	6	1945	10	1985
106	GR	25	2020	50	2050						
107	NC	.06	.06	.025	.1	.3					
108	X1	42	22	1248	1533	850	850	850			
109	X3	10							100		
110	GR	50	0	25	45	10	90	10	210	7.5	370

TABLE C-1 (continued)

111	GR	6.8	740	9.3	1160	7.1	1185	19.2	1225	19.6	1248
112	GR	-0.6	1281	-3.1	1249	-3.4	1354	-1.6	1435	-1.8	1471
113	GR	2.4	1515	8.9	1533	8.8	1587	7.4	2000	10	2230
114	GR	25	2260	50	2275						
115	NC	.06	.06	.025	.1	.3					
116	X1	48	25	1439	1657	600	600	600			
117	X3	10							100		
118	GR	50	0	25	70	10	140	8.2	320	6.5	620
119	GR	10	880	10.2	1180	9.6	1350	8.5	1371	19.7	1394
120	GR	20.4	1439	2.6	1469	0.7	1475	-3.3	1531	-1.7	1583
121	GR	-1.6	1644	1.8	1657	3.4	1657	10.2	1701	9.6	1741
122	GR	10	1540	10.2	2120	15	2240	25	2260	50	2300
123	X1	53.5	20	1594	1830	550	550	550			
124	X3	10							100		
125	GR	50	0	25	30	20	150	15	370	11.2	580
126	GR	12	910	11	1530	11.4	1530	11.6	1549	21	1573
127	GR	21.2	1594	1.8	1676	-2.4	1679	-1.9	1743	-2.2	1801
128	GR	2	1819	9.6	1830	10.1	1855	15	1935	50	2025
129	NC	.06	.06	.025	.1	.3					
130	X1	60.3	24	1642	1916	680	680	680			
131	X3	10							100		
132	GR	50	0	25	120	20	260	15.4	500	18.2	800
133	GR	16	1110	15	1390	11.6	1580	12	1598	22.4	1621
134	GR	22.1	1642	10.4	1660	9.1	1667	4.1	1679	0.3	1712
135	GR	-0.7	1712	-4.4	1747	-2.1	1780	0.2	1819	-3.8	1851
136	GR	0.8	1898	9.9	1916	17.6	1939	50	1970		
137	X1	65	26	1596	2037	470	470	470			
138	X3	10							100		
139	GR	50	0	25	120	20	210	18.2	740	15	1280
140	GR	12	1542	12.8	1550	23	1573	22.8	1596	8.7	1617
141	GR	6.5	1673	-0.4	1720	-0.8	1754	-1.4	1786	-1.4	1809
142	GR	8.2	1835	8.6	1855	7.3	1900	0.5	1908	-1.5	1935
143	GR	-2.6	1968	-2.2	1989	7.4	2010	9.2	2037	25	2080
144	GR	50	2110								
145	NC	.06	.08	.04	.1	.3					
146	X1	66	33	1337	2021	300	300	300			
147	X3	10							100		
148	GR	50	0	25	70	20	110	16.8	480	15.1	890
149	GR	15	1160	13.5	1290	23.5	1313	23	1337	12	1355
150	GR	11.4	1383	7.6	1387	6.6	1397	-0.2	1417	0.2	1454
151	GR	-0.6	1487	0.3	1520	2.6	1539	9.3	1558	10.3	1593
152	GR	16.5	1604	17	1626	15	1816	13.4	1896	14.1	1910
153	GR	1.1	1921	-1.7	1935	-1.1	1944	-0.2	2016	6.1	2021
154	GR	7.4	2049	10.8	2060	50	2130				
155	X1	71	36	1042	2185	300	300	300			
156	X3	10							100		
157	GR	50	0	25	90	20	150	17.4	640	16.5	980
158	GR	24.1	1020	23.9	1042	21.5	1062	12.9	1076	12.4	1104
159	GR	7.4	1110	4.9	1200	2.1	1208	1.8	1222	0.4	1224
160	GR	-1.2	1254	-1.2	1280	-1.1	1296	11.3	1309	12.9	1321
161	GR	16.5	1335	18.4	1352	13.6	1600	15	1810	15.2	1920
162	GR	15	2030	14.8	2050	16.1	2068	6.2	2089	0.9	2102
163	GR	-0.9	2121	0.9	2175	4.6	2185	8.4	2203	8.4	2215
164	GR	50	2345								
165	NC	.08	.06	.03	.1	.3					

TABLE C-1 (continued)

```
QT       7    3160   22400   28900   45300   53300   62000   89000
X1    75.2      26     240     512     420     420     420
X3      10                                                   100
GR      50       0      25      20      20      90      20     200    24.4     220
GR    24.4     280    22.6     264    18.3     275    17.6     286    12.6     289
GR    11.6     307     7.8     321     5.8     343     0.8     369    -0.6     426
GR    -0.6     460     8.1     477    10.7     512    20.9     533    21.4     543
GR    12.6     565    13.1     588    13.8     870      15    1010      25    1040
GR      50    1060
NC     .06     .07     .03      .1      .3
X1    83.6      15     181     293     840     840     840
GR      50       0      25      80    17.6     110    16.9     125    11.5     138
GR     6.3     181      .1     191     0.6     213     0.7     238     2.1     259
GR     4.9     264     7.5     293     9.5     336    23.4     374      15     590
GR      15     960      25     990      50    1070
X1      90      15     345     510     640     640     640
GR      50       0      25      50      20      80      15     295      10     345
GR       5     370     2.5     380     2.5     475       5     490      10     510
GR      15     540    18.4     710      20    1030      25    1050      50    1100
EJ
T1       DETAILED PROJECT REPORT, WAIMEA RIVER FLOOD CONTROL STUDY
T2      WAIMEA, KAUAI, HAWAII                               MARCH 1980
T3       5 YR FLOOD
J1              5                                                   1.5
J2      2
T1       DETAILED PROJECT REPORT, WAIMEA RIVER FLOOD CONTROL STUDY
T2      WAIMEA, KAUAI, HAWAII                               MARCH 1980
T3       10 YR FLOOD
J1              4                                                   1.5
J2      3
T1       DETAILED PROJECT REPORT, WAIMEA RIVER FLOOD CONTROL STUDY
T2      WAIMEA, KAUAI, HAWAII                               MARCH 1980
T3       50 YR FLOOD
J1              5                                                   1.5
J2      4
T1       DETAILED PROJECT REPORT, WAIMEA RIVER FLOOD CONTROL STUDY
T2      WAIMEA, KAUAI, HAWAII                               MARCH 1980
T3       100 YR FLOOD
J1              6                                                   1.5
J2      5
T1       DETAILED PROJECT REPORT, WAIMEA RIVER FLOOD CONTROL STUDY
T2      WAIMEA, KAUAI, HAWAII                               MARCH 1980
T3        200 YEAR FLOOD
J1              7                                                   1.5
J2      6
T1       DETAILED PROJECT REPORT, WAIMEA RIVER FLOOD CONTROL STUDY
T2      WAIMEA, KAUAI, HAWAII                               MARCH 1980
T3        STANDARD PROJECT FLOOD
J1              6                                                   1.5
J2     15
ER
EOF..
```

for the first 4,200 feet of channel. The divergence upstream of station 42+00 is attributed to a change in channel geometry since the 1949 flood (Plate 1, Main Report). The design water surface profile assumes no scour in the channel because the sediment bedload entering the reach from upstream is assumed to satisfy transport requirements in the design reach. The profiles are all subcritical flow and begin at critical depth near the river mouth where it is assumed that the existing sand bar has been washed out. Observations by local residents confirm that the sand bar washes out during high flows. The low chord of the Belt Highway bridge is 13.6 feet MSL on the Waimea side and 26.2 feet MSL on the east side of the river. Two feet of debris blockage on each side of the bridge pier is assumed (Plate C-3). Average water velocities from the 100-year flood are shown on Plate 1 of the Main Report. Due to the subcritical flow at the Makaweli and Waimea River channel junction, no adverse hydraulic effects are anticipated.

LOSS COEFFICIENTS

6. The design channel roughness coefficient of 0.025 is selected based on the following channel characteristics: a relatively straight channel alignment with a gradual and uniform change in cross-section and shape; lack of significant vegetation within the channel; channel material which tends to uniformly silt and scour; and a smooth concrete-rubble-masonry wall on the right bank of the channel. A sensitivity analysis using channel roughness coefficients from 0.02 to 0.03 is shown on Table C-2. The selected riprap design velocity is 14 feet per second. Contraction and expansion coefficients of 0.1 and 0.3 were used for the main river reaches. Contraction and expansion coefficients of 0.3 and 0.6 were used at the bridge. These coefficients were selected based on channel geometry and suggested coefficients shown in the HEC-2 Water Surface Profiles Users Manual, August 1979, and EM 1110-2-1601, Hydraulic Design of Flood Control Channels. About 20 percent of the design flow is on the low left bank area below the bluff line between stations 15+00 and 59+00. All of the design flow is confined to the channel in the remaining levee length.

EROSION CONTROL

7. The present outlets of interior drainage structures are riprapped or concreted, and additional riprap for erosion is not necessary. The design water velocities at the structures' outlets will dissipate rapidly and are not expected to cause any erosion problems beyond the levee.

STRUCTURAL DESIGN

8. Selected load conditions were evaluated for the two gravity outlets. Load conditions selected are the significant stresses imposed on the structural components by soil and water forces. Adequate structural member sizes and dimensions were established based on the evaluated stresses.

TABLE C-2 SENSITIVITY ANALYSIS FOR ROUGHNESS COEFFICIENTS

MANNINGS ROUGHNESS COEFFICIENTS	0+00	1+40	4+70	7+00	7+50	7+90	8+00	8+50	12+50	21+00	27+00	42+00	48+00	60+30	65+00	68+00	75+20
WSEL (FT-MSL)	7.8	7.9	8.0	10.2	11.5	11.4	12.3	12.1	13.6	13.9	14.4	15.5	16.1	18.5	20.4	20.9	21.6
0.020																	
VEL (FT/SEC)	14.0	14.3	14.0	13.8	13.1	14.0	12.4	13.9	11.1	13.5	14.1	14.6	15.2	13.2	8.7	7.6	10.8
WSEL (FT-MSL)	8.0	8.1	8.2	10.4	11.7	11.7	12.5	12.3	13.8	14.5	15.1	16.4	16.7	19.1	21.0	21.5	21.9
0.023																	
VEL (FT/SEC)	13.9	14.0	13.8	13.6	12.9	13.8	12.3	13.7	11.0	12.9	13.3	13.5	14.0	12.8	8.4	7.3	10.1
WSEL (FT-MSL)	8.2	8.3	8.4	10.5	11.8	12.0	12.6	12.4	14.0	14.8	15.6	16.6	17.0	19.5	21.2	21.7	22.5
0.025																	
VEL (FT/SEC	13.8	13.8	13.6	13.2	12.8	13.6	12.2	13.5	10.8	12.4	12.6	12.7	13.3	12.5	8.2	7.0	9.4
WSEL (FT-MSL)	8.3	8.4	8.5	10.7	11.9	11.9	12.7	12.5	14.2	15.2	15.9	17.4	18.1	20.0	21.8	22.3	22.9
0.027																	
VEL (FT/SEC)	13.6	13.7	13.5	12.9	12.7	13.6	12.1	13.4	10.7	12.2	12.4	12.3	12.8	12.2	8.0	6.8	9.3
WSEL (FT-MSL)	8.5	8.6	8.7	10.9	12.1	12.1	12.9	12.8	14.5	15.6	16.5	18.1	18.9	20.8	22.4	23.0	23.6
0.030																	
VEL (FT/SEC)	13.1	13.4	13.3	12.7	12.6	13.4	11.9	13.2	10.5	11.8	11.9	11.6	12.0	11.7	7.7	6.5	8.7

Q = 64,000 cfs 100-yr profile

9. The design of reinforced concrete structures are in accordance with the Alternate Design Method (working stress) outlined in ACI 317-71 Building Code Requirements for Reinforced Concrete, American Concrete Institute, 1971.

INTERIOR DRAINAGE

HYDROLOGY

10. Unit Hydrograph Derivation. To adequately describe the hydrologic response of the interior drainage areas (Plate C-2), 10-minute unit hydrographs were adopted. The unit hydrographs were developed from the parameters of the Makaweli River (Station 360) averaged unit hydrograph and from the material contained in the City and County of Honolulu, "Storm Drainage Standards," Department of Public Works, March 1969. For the Waimea section above the highway (drainage area = 0.53 square miles), the following parameters described the unit hydrograph: C_t = 0.29, 640 C_p = 403, LAG = 20 minutes, Peak Discharge = 634 CFS, W_{75} = 15 minutes, and W_{50} = 24 minutes. The unit hydrograph for the area below the highway (drainage area = 2.9 acres) consists of the following parameters: C_t = 0.59, 640 C_p = 403, LAG = 12 minutes, Peak Discharge = 8.6 CFS, W_{75} = 7 minutes, and W_{50} = 14 minutes (Plate C-2).

11. Rainfall. Annual rainfall amounts and time distribution were determined from Technical Paper No. 43, Rainfall-Frequency Atlas of the Hawaiian Islands, US Weather Bureau, 1962 (Plate C-4).

12. Coincidental Rainfall. Coincidental rainfall is that dependent rainfall which can be expected to occur when the river flow is equal to or greater than a selected discharge. Coincidental rainfalls used in the interior drainage analysis are the maximum annual 1-hour and 24-hour rainfalls which occurred when the mean daily river discharge equalled or exceeded 1,100 cfs. Twenty-seven years of record from 1951 to 1977 are used to develop the 24-hour coincident rainfall (Table C-3) and thirteen years of record from 1965 to 1977 were used to develop the 1-hour coincident rainfall (Table C-4). Twenty-four-hour rainfall is from the Waimea gage located about 1.3 miles west of the 340-acre interior drainage basin. The gage's 8:00 am reading is converted to a midnight to midnight reading by using one-third of the present day plus two-thirds of the following day's rainfall. The 1-hour rainfalls shown are a combination of rainfalls from the Kekaha and Waimea gages. The Kekeha gage is located 3.5 miles west of the interior drainage basin. The maximum annual coincident 1-hour rainfall at Kekaha is expressed as a percentage of the same day's 24-hour rainfall. The 24-hour rainfall at Waimea is multiplied by this percentage to develop the 1-hour rainfall used in the analysis.

13. Rainfall Probabilities. Rainfall probabilities were developed from the historical events by using the Pearson Type III Frequency Distribution (Tables C-5 and C-6) and the natural derived skew coefficient. Historical

TABLE C-3

MAXIMUM ANNUAL 24-HOUR RAINFALL ON DAYS WHEN WAIMEA RIVER DISCHARGE EXCEEDED 1,100 CFS

DATE	MEAN RIVER DISCHARGE (CFS)	AMOUNT (INCHES)	DATE	MEAN RIVER DISCHARGE (CFS)	AMOUNT (INCHES)
11 Mar 51	3260	3.25	5 Jan 64	2300	1.27
16 Dec 51	7470	5.93	13 Apr 65	3230	2.98
4 Mar 53	2120	0.00	14 Oct 65	1460	2.69
1 Mar 54	3730	1.61	4 Nov 66	2800	2.38
21 Jan 55	4030	1.75	27 Jan 68	1120	1.85
12 Nov 55	8510	3.18	1 Oct 68	2040*	5.38
17 Jan 57	2180	1.75	13 Jan 70	2550	1.21
1 Dec 57	4200	0.94	27 Jan 71	3980	2.07
17 Jan 59	1940	0.99	23 Jan 72	2680	4.34
3 Mar 60	1340	0.68	11 Mar 73	1100	0.11
4 Dec 60	3590	1.01	1 Dec 73	2820*	4.81
6 Jan 62	8740	2.97	31 Jan 75	3040*	4.52
7 Jan 63	2150	2.21	6 Feb 76	5310*	2.75
			10 May 77	1275*	1.74

NOTE: Events are based on water year.
* Makaweli River only.

TABLE C-4

MAXIMUM ANNUAL 1-HOUR RAINFALL ON DAYS WHEN WAIMEA RIVER DISCHARGE EXCEEDED 1,100 CFS

DATE	AMOUNT (INCHES)
13 Apr 65	2.31
6 Feb 66	1.01
5 Nov 66	0.71
27 Jan 68	0.62
1 Dec 68	1.06
13 Jan 70	0.45
15 Jan 71	0.40
15 Apr 72	1.75
11 Mar 73	0.07
1 Dec 73	1.63
31 Jan 74	1.87
24 Nov 75	0.47
13 May 77	1.06

NOTE: Events are based on water year

TABLE C-5

PEARSON TYPE III ANALYSIS (24-HOUR RAINFALL)

P	K	RAINFALL (INCHES)
0.90	-1.11785	0.66
0.50	-0.17151	2.10
0.20	0.75169	3.50
0.10	1.34064	4.40
0.05	1.88505	5.23
0.04	2.05375	5.48
0.02	2.56258	6.26
0.01	3.05330	7.00
0.005	3.53029	7.73
0.001	4,59943	9.35

TABLE C-6

PEARSON TYPE III ANALYSIS (1-HOUR RAINFALL)

PROBABILITY	K	RAINFALL (INCHES)
0.90	-1.21176	0.21
0.50	-0.08759	0.97
0.20	0.80584	1.57
0.10	1.32459	1.92
0.05	1.78060	2.23
0.04	1.91821	2.32
0.02	2.32431	2.60
0.01	2.70502	2.86
0.005	3.06640	3.10
0.001	3.85115	3.63

rainfall events are plotted on Plate C-5. Plotting positions for the historical events use the Weibull plotting formula of:

$$P = \frac{m}{n + 1}$$

where

P = Plotting position

m = Event number

n = Number of events

Coincident rainfalls of 1-, 2-, 5-, 10-, 25-, 50-, 100-, 250-, and 1,000-year frequency (Plate C-6) are replotted from Plate-5 and are used to compute the coincidental runoff hydrographs.

14. Infiltration Losses. Infiltration losses were assumed to be uniform and were calculated by employing the Soil Conservation Service procedure of determining rainfall losses from curve numbers. Curve numbers of 67 and 77 were determined for the areas above and below the highway, respectively. Infiltration loss rates ranged from 0.06 to 0.24 inches per hour.

15. Future Conditions. The unit hydrographs were adjusted to reflect estimated future conditions. Due to the faster runoff response of the improved condition, the lag decreased and the peak discharged increased. The unit hydrograph peak discharges increased to 860 cfs and 10.7 cfs for the areas above and below the highwav, respectively. A curve number of 77 was derived for the future condition of the area above the highway. Since the area below the highway is relatively developed, no change in the infiltration loss rate was made.

16. Interior Flood Hydrographs. Flood hydrographs of the various frequencies were developed by applying the rainfall excess hyetograph to the unit hydrographs. The rainfall excess hyetograph is ordered to produce the highest possible peak discharge.

INTERIOR DRAINAGE PLAN

17. About 340 acres of agricultural, residential, commercial, and conservation lands contribute runoff to the major interior drainage outlet. The interior drainage plan for Waimea includes the construction of two gravity outlets, the demolition of two existing floodgates, and the reconstruction of three culverts by local interests. A major outlet of five 60-inch diameter pipes and a smaller 24-inch outlet will convey interior drainage flows through the levee (Plate C-1). The smaller outlet drains 2.8 acres consisting primarily of residential and park lands. The majority of the interior drainage area is flat except about 25 percent of the area which consists of cliffs up to 800 feet above the floodplain. Most runoff from the area is carried to the river through a ditch system which ends at a floodgate about 250 feet upstream

of the Belt Highway bridge. During dry weather, flow consists of irrigation water from an ancient Hawaiian irrigation system. The water from this system may be diverted to the river at the upstream end of the levee system during high water periods. Numerous concrete outlets which pass through the existing levee (Table C-7) appear to be abandoned. Because of their poorly maintained condition, only three outlets and the main floodgate were considered functional in removing interior drainage flows as noted on Table C-7. Other outlets were not considered effective in evaluating interior drainage outflows as they appear to drain only very small areas immediately adjacent to the levee or are abandoned.

TABLE C-7 EXISTING GRAVITY OUTLETS

Approx. River Station	Inlet Invert (Ft-MSL)	Outlet Invert (Ft-MSL)	Diameter (Inches)	Length (Ft)	Ground Elevation (Ft-MSL)	Notes
8+50	-	-	Abandoned Floodgate			
10+50*	1.7	1.7	Main Floodgate			
29+75*	3.1	2.1	24	65	5.8	Irrigation Return Flow
36+10*	5.3	4.0	24(2)	65	10.0	Irrigation Return Flow
42+00*	6.0	3.9	24	60	8.0	Irrigation Return Flow
46+90	5.9	2.8	24	85	10.0	
50+10	6.6	5.2	24	60	11.7	
59+00	7.1	4.3	24	95	11.7	
62+80	7.5	5.3	24	60	12.0	
65+30	8.8	5.3	24	80	14.0	
69+60	11.1	8.1	24	105	17.0	
72+20	11.1	9.3	24	95	17.0	
75+60	17.0	13.7	24	60	Ditch Overflow Pipe	

*Used in the evaluation of existing condition interior drainage outflows.

18. The existing floodgate on the main ditch system consists of four wooden gates about four feet wide with a cable attached for manual opening and closing, and a concrete slab at elevation 1.7 feet msl. The floodgate is in poor condition and the 36-inch culvert which passes under the floodgate has an inoperable flap gate on the riverside. The abandoned floodgate at Station 8+50 is almost identical to the main floodgate at Station 10+50.

19. Although the basin is only partially urbanized, hydrographs were computed assumming fully developed conditions and were used for all interior drainage analysis.

20. Ponding areas for the main floodgate include all land less than elevation 4.5 feet MSL in the town of Waimea. The area (Plate 1, Main Report), contains seven acres owned by six individual landowners (64%), a land company (34%), and the County of Kauai (2%). The land would not have to be acquired in fee, but a permanent flowage easement is required to prevent filling of the area.

The frequency and depth of ponding in this area will be decreased with construction of the major gravity outlet. This small ponding area provides the equivalent of 1/4-inch of runoff storage over the 340 acres. All temporary ponding for the 24-inch outlet will be on County park land (Station 6+90). The construction of an artificial ponding area was investigated and is discussed later. Waimea interior drainage damage begins around elevation 4.7 feet MSL (Plate C-7). Ponding damages include residential and commercial properties, and transportation delays.

DESIGN PARAMETERS

21. Waimea is considered to be a Class III (damages expected to be comparatively low under anticipated future conditions) urban development as defined in EM 1110-2-1410. The design of the 24-inch gravity outlet is based on all-year rainfall probabilities from "Technical Paper No. 43, Rainfall Frequency Atlas of the Hawaiian Islands." All year rainfall is independent of river discharge and may occur at any time. The main outlet consisting of five 60-inch RCP's (Reinforced Concrete Pipe) considers the all-year rainfall probabilities but the design is not based on the all-year storms. The all-year frequency (Table C-8) shows the expected frequencies of obtaining the pond stages under design conditions. Paragraph 3-03 of EM 1110-2-1410 defines the pond stage designations.

TABLE C-8. POND STAGE - FREQUENCIES WITH FIVE 60-INCH RCP'S

Stage	All Year Frequency	Ponding Elevation 1/	Damage
A (Minor Adverse Effects)	1 year	2.7	$0
B (Intermediate Design Objective)	3 years	3.4	0
C (Normal Design Limit)	25 years	4.5	0
D (Critically Severe Adverse Effects)	Standard Project Storm	6.8	790,000

1/ Elevation reached during nonflood (low tailwater) periods for the 340 acre area.

22. Discharge Duration Curve. An all-year discharge-duration curve for the Waimea River at the mouth is computed by adding the Waimea River gaging stations' mean daily discharge to the Makaweli River gaging station's mean daily discharge. The discharge-duration curve for the Waimea River is based on 24 years of record from 1945 to 1968 (Plate C-8).

23. Hydrographs. The coincidental and all-year theoretical hydrographs are derived from coincident and all-year rainfalls. The 1-, 2-, 5-, 10-, 25-, 50-, 100-, 250-, 500-, and 1,000-year coincidental runoff hydrographs (Table C-9) and the 1-, 5-, 10-, 50-, 100-year, and Standard Project Storm all-year frequency hydrographs (Table C-10) are for fully urbanized watershed conditions and were used for all interior drainage analysis.

TABLE C-9. COINCIDENTAL RUNOFF HYDROGRAPHS

TIME Hr/Min	1 Yr (CFS)	2 Yr (CFS)	5 Yr (CFS)	10 Yr (CFS)	25 Yr (CFS)	50 Yr (CFS)	100 Yr (CFS)	250 Yr (CFS)	500 Yr (CFS)	1000 Yr (CFS)
10	2.	2.	2.	2.	2.	4.	4.	7.	7.	7.
20	13.	11.	11.	11.	11.	22.	22.	32.	32.	35.
30	26.	15	15	15	15.	30.	30.	46.	46.	56.
40	37.	20.	20.	20.	18.	35.	38.	53.	53.	68.
50	52.	32.	30.	30.	21.	38.	49.	58.	60.	77.
1 00	35.	46.	35.	35.	31.	42.	55.	63.	71.	90.
10	20.	58.	38.	40.	36.	52.	61.	75.	79.	97.
20	11.	81.	44.	51.	40.	56.	71.	88.	92.	102.
30	6.	116.	62.	56.	51.	61.	79.	97.	107.	114.
40	3.	205.	74.	59.	56.	73.	92.	114.	115.	128.
50	0.	330.	94.	65.	61.	87.	109.	138.	126.	142.
2 00		415.	129.	83.	93.	97.	215.	150.	154.	172.
10		287.	160.	96.	87.	109.	134.	159.	171.	188.
20		183.	213.	125.	101.	123.	143.	179.	187.	205.
30		114.	342.	167.	131.	152.	166.	211.	207.	247.
40		69.	539.	209.	149.	174.	191.	232.	264.	287.
50		31.	701.	275.	175.	215.	238.	278.	332.	358.
3 00		10.	511.	431.	223.	268.	308.	376.	408.	449.
10		4.	333.	660.	267.	334.	380.	454.	493.	541.
20		1.	216.	897.	332.	419.	459.	537.	586.	661.
30		0.	136.	635.	489.	564.	627.	705.	751.	841.
40			84.	432.	767.	852.	945.	1042.	1102.	1189.
50			53.	304.	1072.	1199.	1323.	1502.	1610.	1709.
4 00			41.	192.	783.	876.	945.	1095.	1161.	1220.
10			31.	122.	529.	598.	656.	755.	801.	860.
20			24.	78.	371.	426.	476.	549.	587.	633.
30			13.	57.	249.	286.	324.	374.	411.	437.
40			7.	46.	168.	188.	224.	257.	293.	316.
50			3.	33.	108.	117.	144.	161.	210.	231.
5 00			1.	27.	82.	86.	110.	128.	161.	184.
10			0.	22.	71.	71.	93.	112.	130.	160.
20				11.	64.	55.	77.	94.	106.	139.
30				6.	50.	48.	67.	78.	92.	119.
40				3.	36.	44.	54.	70.	77.	101.
50				1.	29.	45.	48.	66.	69.	89.
6 00				0.	25.	48.	42.	63.	65.	76.
10					20.	32.	29.	55.	56.	62.
20					10.	18.	16.	29.	30.	32.
30					5.	10.	8.	16.	16.	17.
40					3.	5.	4.	9.	9.	9.
50					1.	2.	2.	4.	4.	4.
7 00					0.	0.	0.	1.	1.	1.
10								0.	0.	0.
Runoff Volume Ac-Ft	2.0	27.9	54.5	72.8	93.9	109.5	124.5	144.5	155.8	171.2
Runoff Volume Inches over the 339.2 acre area	0.10	0.99	1.93	2.58	3.32	3.87	4.40	5.11	5.61	6.06

TABLE C-10. ALL-YEAR RUNOFF HYDROGRAPHS

TIME Hr/Min		1 Yr (CFS)	5 Yr (CFS)	10 Yr (CFS)	50 Yr (CFS)	100 Yr (CFS)	SPF (CFS)
	10	2.	7.	9.	13.	15.	40.
	20	13.	35.	43.	67.	76.	194.
	30	26.	59.	61.	102.	106.	274.
	40	33.	79.	75.	126.	130.	318.
	50	37.	90.	98.	154.	167.	346.
1	00	39.	97.	111.	170.	186.	373.
	10	41.	101.	117.	179	199.	423.
	20	41.	104.	120.	182.	212.	456.
	30	41.	113.	124.	186.	219.	512.
	40	41.	120.	134.	195.	227.	541.
	50	43.	133.	141.	206.	248.	558.
2	00	52.	148.	154.	235.	269.	579.
	10	56.	156.	171.	250.	287.	626.
	20	59.	160.	187.	258.	304.	662.
	30	65.	162.	202.	274.	335.	717.
	40	92.	175.	233.	320.	363.	769.
	50	135.	218.	249.	343.	414.	871.
3	00	158.	240.	269.	366.	441.	947.
	10	193.	274.	328.	428.	478.	1084.
	20	287.	379.	418	519	606.	1298.
	30	357.	482.	550.	664.	806.	1677.
	40	502.	672.	800.	979.	1193.	2245.
	50	625.	966.	1242.	1495.	1831.	2939.
4	00	449.	623.	852.	1083	1209.	2090.
	10	300.	421.	586.	739.	833.	1585.
	20	204.	316.	429.	581.	619.	1249.
	30	138.	243.	326.	438.	475	1009.
	40	94.	185.	248.	346.	365.	781.
	50	60.	138.	185.	279.	268.	645.
5	00	49.	121.	163.	239.	246.	596.
	10	44.	112.	151.	212.	233.	534.
	20	42.	107.	137.	199.	219.	492.
	30	41.	102.	130.	192.	212.	434.
	40	41.	92.	122.	183.	201.	403.
	50	39.	85.	103.	164.	174.	386.
6	00	30.	74.	93.	152.	160.	376.
	10	24.	62.	79.	125.	137.	332.
	20	13.	32.	42.	66.	72.	175.
	30	7.	17.	22.	36.	39.	96.
	40	3.	9.	12.	19.	20.	52.
	50						
7	00						
	10						
Runoff Volume Ac-Ft		62.1	106.0	130.8	175.5	200.7	408.2
Runoff Volume Inches over the 339.2 acre area		2.20	3.75	4.63	6.21	7.10	14.44

24. Total Probability Theorem. A study of historical records indicates that large rainfalls and floods are coincident and occur more frequently during the winter months than the summer months. A river flood equal to 1,100 cfs is selected for the analysis because the corresponding river stage begins to have an effect on interior drainage outflows. The selected coincidental rainfalls occur in conjunction with river discharges of 1,100 cfs or greater (discharge equalled or exceeded 4 percent of the time). A statistical analysis of twenty-two mean daily Waimea River discharges and the corresponding 24-hour coincident rainfalls indicates a correlation coefficient (r) of 0.55 for the 24-hour rainfall events (Table C-3). This means that 30 percent of the variation in 24-hour rainfall is accounted for by its relationship with the mean daily river discharge. The interior hydrograph and river discharges are assumed independent because of the variability of time of concentration between the interior hydrograph and the river hydrograph. The time distribution of rainfall producing the interior hydrograph and the actual river stage at the time of interior drainage outflow also supports independence. The events are mutually exclusive and the "Total Probability Theorem" can be applied for collectively exhaustive events. The theorem is useful for interior drainage analysis because it allows a theoretically infinite number of runoff hydrographs to be routed though a ponding area against all possible river stages. The "Total Probability Theorem" says that:

If A and B are independent events, then

$$P(A \cap B) = P(A) \cdot P(B)$$

Where $P(A \cap B)$ = Total probability of reaching a pond elevation

$P(A)$ = Probability of an interior storm reaching a ponding elevation with an index river elevation

$P(B)$ = Probability of the index river elevation

A detailed study on how this method is used for Waimea is presented later in this report (paragraphs 29 to 32).

GRAVITY FLOW DESIGN

25. The proposed gravity outlet design consists of one major drainage structure and one smaller gravity outlet. The major structure includes five 60-inch gravity outlets with flap gates and electrically-operated sluice gates (Plates C-9 and C-10). The smaller outlet consists of one 24-inch gravity outlet with a manually operated sluice gate and a flap gate (Plate C-11). Three existing culverts within the interior area will be modified to improve interior drainage flows to the major gravity outlet (Stations 10+50). Additional outlet modifications are sealing off of some existing abandoned outlets and flap gate repairs to outlets currently used for return irrigation flows.

26. Hydraulic Design. The hydraulic design of the gravity outlets are based on criteria presented in TM 5-820-4, "Hydraulic Design Criteria" from Waterways Experiment Station, and culvert nomographs from the Bureau of Public Roads, January 1963. Manning's roughness coefficient is assumed to be 0.015, and the entrance, gatewell, and flap gate hydraulic losses are assumed to be one-half of the velocity head. Gravity outlet design information is shown on Table C-11.

TABLE C-11. DESIGN DATA, GRAVITY OUTLETS

Location (Approximate River Station)	Pipe Size Type	Inlet Invert (Ft MSL)	Outlet Invert (Ft MSL)	Gate Closure (Ft MSL)	Pipe Length (Ft)	Pipe Slope	Contributing Drainage Area (Acres)
Main Floodgate Sta 10+50	5 60-inch R.C.P. 1/	-2.0	-2.0	4.5	65	-0-	339.2
Sta 6+90	1 24-inch R.C.P.	2.1	1.7	4.5	55	0.007273	2.89

1/ R.C.P. = Reinforced Concrete Pipe

TABLE C-12. RATING CURVE, 24-INCH R.C.P., INLET CONTROL

Q (CFS)	HEADWATER (Ft MSL)
0	2.1
5	3.3
10	3.8
15	4.4
20	5.1
25	6.0
30	7.0
35	8.3

Rating curves were developed for the main floodgate (Plate C-12) and for the 24-inch gravity outlet assuming inlet control (Table C-12).

27. Other Outlets Considered. An optimization procedure was used to size the main floodgate because of the large cost attributable to the gate and because of the project benefits derived from the interior drainage facilities. Gravity outlets consisting of two 60-inch RCP's, three 60-inch RCP's, and five 60-inch RCP's were evaluated to obtain the optimum gate capacity. The smaller 24-inch gate is designed based on the Class III urban area criteria of a 25-year all-year storm.

EVALUATION OF EXISTING FLOODGATE

28. A rating curve for the existing floodgate (Plate C-13) is developed using "Hydraulic Design Criteria," Sections 010-6 to 010-6/5. Due to the gate geometry, it functions essentially as a bridge pier in open channel flow. The Yarnell equations were used for Class A and Class B flows. For Class A:

$$H_3 = 2K\,(K + 10\omega - 0.6)\,(\alpha + 15\alpha^4)\,\frac{V_3^2}{2g}$$

H_3 = drop in water surface, in feet, from upstream to downstream at the contraction

K = 1.25, pier shape coefficient

$\omega = \frac{V_3^2}{2gy_3}$, velocity head to depth ratio downstream of contraction

α = 0.20, horizontal contraction ratio

V_3 = velocity downstream of contraction (ft/sec)

g = 32.2 ft/sec^2, gravity acceleration

For gate discharges greater than or equal to 40 CFS, Class B flow governs.

$$L_B = C_B \frac{V_1^2}{2g}$$

$$C_B = 0.50 + K_B\,(5.5\,\alpha^3 + 0.0\beta)$$

L_B = pier nose loss (ft)

C_B = pier nose coefficient

V_1 = upstream velocity (ft/sec)

K_B = 5.0, shape coefficient

By successive approximation,

$Y_1 = Y_L + L_B$

Y_1 = upstream depth

Y_L = the higher depth in the unobstructed channel which has flow of equal energy to that required for critical flow within the constricted gated section

PROBABILISTIC-COINCIDENTAL-RAINFALL-STREAMFLOW ANALYSIS

29. River Stage-Duration Distribution. Probabilistic-Coincidental-Rainfall-Streamflow Analysis is a method developed to analyze interior drainage facilities based on a probability analysis. The initial step in performing the analysis is to prepare a stage-duration curve. The all-year discharge-duration curve (Plate C-8) is truncated, therefore making a river discharge of 1,100 cfs a 100 percent duration rather than a 4 percent duration. The partial-stage-duration curve (Plate C-14) is used because river discharges less than 1,100 cfs are not significant to the interior ponding levels. The area beneath the curve is subdivided into five sections with the average river stage shown for each section. The five sections represent durations of 2, 8, 15, 25, and 50 percent with average river stages of 5.5 (I_5), 4.25 (I_4), 3.25 (I_3), 2.50 (I_2), and 2.00 (I_1) feet MSL, respectively.

30. Tide Levels. Tide levels at Waimea have no influence on the river duration at the main floodgate as indicated by Table C-13 and Table C-17.

TABLE C-13. TIDE LEVELS

Mean higher high water	0.9 ft MSL
Mean high water	0.5 ft MSL
Half tide level	0.0 ft MSL
Mean low water	-0.5 ft MSL
Mean lower low water	-1.7 ft MSL

31. Maximum Pond Levels. Maximum pond levels were obtained based on the combination of the above river stages; coincident rainfall events having a frequency of 1-, 2-, 5-, 10-, 25-, 50-, 100-, 250-, 500-, and 1,000-years; and outlets consisting of the existing outlet, two 60-inch RCP's , three 60-inch RCP's, and five 60-inch RCP's (Table C-14). Pond level frequencies for the five selected river stages for the existing floodgate and for five 60-inch RCP's were obtained by plotting (Plates C-15, C-16) the maximum pond levels against the rainfall frequency values (Table C-14). Elevation-storage and elevation-flooded area curves from the area adjacent to the main floodgate are shown on Plate C-17.

TABLE C-14. POND LEVELS PRODUCED BY COINCIDENT RAINFALL EVENTS

RIVER STAGE	RETURN PERIOD IN YEARS									
	1	2	5	10	25	50	100	250	500	1000
	Existing Gate									
1_1	2.80	4.64	5.36	5.66	5.93	6.13	6.30	6.54	6.62	6.71
1_2	2.94	4.76	5.45	5.72	6.00	6.20	6.37	6.57	6.65	6.75
1_3	3.59	5.05	5.61	5.90	6.16	6.37	6.52	6.67	6.76	6.87
1_4	4.42	5.39	5.88	6.16	6.42	6.58	6.68	6.85	6.94	7.04
1_5	4.78	5.83	6.39	6.61	6.80	6.97	7.08	7.28	7.37	7.48
	2 60-Inch R.C.P.'s									
1_1	2.11	3.61	4.78	5.24	5.57	5.81	6.02	6.30	6.47	6.59
1_2	2.60	3.71	4.80	5.25	5.58	5.82	6.03	6.31	6.48	6.60
1_3	3.31	4.24	5.09	5.47	5.75	5.99	6.18	6.46	6.57	6.68
1_4	4.30	4.94	5.52	5.80	6.08	6.30	6.49	6.66	6.76	6.88
1_5	4.78	5.74	6.16	6.45	6.64	6.80	6.92	7.08	7.17	7.28
	3 60-Inch R.C.P.'s									
1_1	2.07	2.99	4.12	4.65	5.07	5.31	5.53	5.78	5.92	6.10
1_2	2.57	3.08	4.15	4.68	5.08	5.32	5.54	5.79	5.93	6.11
1_3	3.29	3.73	4.60	5.03	5.33	5.56	5.72	5.98	6.12	6.29
1_4	4.29	4.63	5.17	5.51	5.73	5.93	6.10	6.35	6.50	6.59
1_5	4.78	5.70	6.05	6.26	6.50	6.62	6.71	6.86	6.94	7.04
	5 60-Inch R.C.P.'s									
1_1	2.04	2.36	3.02	3.43	4.06	4.37	4.64	5.00	5.13	5.26
1_2	2.54	2.85	3.12	3.56	4.10	4.40	4.66	5.02	5.14	5.28
1_3	3.26	3.45	3.80	4.23	4.62	4.85	5.06	5.27	5.40	5.56
1_4	4.27	4.45	4.71	5.03	5.23	5.40	5.56	5.76	5.88	6.02
1_5	4.78	5.66	5.91	6.05	6.19	6.32	6.43	6.56	6.62	6.69

32. The combined pond level exceedance proabilities for various interior pond levels are based on the five selected river stages, the ten selected coincidental rainfall events, and the operation of the existing gate and the three alternative gates (Table C-15). The coincident frequency of occurrence for the various pond levels were obtained by converting the frequencies (Plates C-15 and C-16) in "return period in years" into events per year, multiplying this value times the selected river stage duration, and toaling these values for each of the five selected river stages. These values were then multiplied by 100 to obtain the percent chance of occurrence. The damages (Table C-15) were obtained from the elevation-damage curve (Plate C-7). The lower left corner of Plate C-7 shows the pond elevation frequency curve for the existing gate and the three alternative gates.

ECONOMIC EVALUATION

33. Damage Frequency Curves. Damage frequency curves for the existing gate and the three alternatives gates are shown in the lower right corner of Plate C-7. These curves are based on the elevation-frequency values (Table C-15) and plotted opposite the damage-frequency curves. Average annual benefits are equal to the difference between the existing condition curve and each alternative curve. Average annual damages and benefits are summarized in the table included in Plate C-7.

34. Benefits. The estimated benefits for the alternative floodgates at a gate closure of 4.5 feet MSL were compared with the estimated cost of the gates (Table C-16). A benefit cost curve for the alternative floodgates was also developed (Plate C-18).

35. Costs. The estimated first cost of the sluice gates, flap gates, and pipe are based on manufacturers' prices plus costs of shipping and installation. The structure cost is from a detailed cost breakdown of individual construction components. All costs shown are as of October 1979. The average annual maintenance and repair cost for purposes of comparison in the optimization is assumed to be 5 percent of the average annual cost. All average annual costs were computed based on an interest rate of 7-1/8 percent and 100-year project life.

36. Net Benefits, Gate Closure. The most appropriate floodgate design based on maximization of net benefits consists of five 60-inch RCP's with a gate closure at 4.5 feet MSL. The gate size was selected based on maximum net benefits. The gate closure elevation is based on the length of time that the gravity outlet will have to be closed and the available ponding storage capacity. If the gate closure elevation were lower than 4.5 feet MSL, the gates would be closed more frequently and the chance of having a rainstorm with the gates closed would increase (Table C-17). Since the area for ponding storage is small, the gates should be left open as long as possible to minimize damage which could be caused by a rapid rise on ponding levels. A higher gate closure is not feasible due to the starting damage elevation of 4.7 feet MSL and the rapid increse in damages above the zero damage elevation.

TABLE C-15. POND LEVEL EXCEEDANCE PROBABILITY

Pond Level	INDEX RIVER STAGES I_1 (2.0) 0.50	I_2 (2.5) 0.25	I_3 (3.25) 0.15	I_4 (4.25) 0.08	I_5 (5.50) 0.02	Chance of Exceedance (%)	Return Period (Yrs)	Damage ($1,000)
Existing Floodgate								
3.0	1.00	1.00	1.00	1.00	1.00	100	1.00	-
3.5	0.8929	0.9434	1.00	1.00	1.00	93	1.07	-
4.0	0.7407	0.7937	0.9091	1.00	1.00	81	1.24	-
4.5	0.5556	0.6061	0.7576	0.9709	1.00	64	1.56	-
5.0	0.3448	0.4000	0.5128	0.7576	0.9804	43	2.33	50
5.5	0.1515	0.1754	0.2439	0.4082	0.7353	20	4.91	180
6.0	0.0325	0.0408	0.0781	0.1563	0.3937	6	17.1	410
6.5	0.0043	0.0048	0.0105	0.0299	0.1408	1	98.7	680
7.0	-	-	-	0.0016	0.0172	-	2118	855
2 60-Inch R.C.P.'s								
2.0	1.00	1.00	1.00	1.00	1.00	100	1.00	-
2.5	0.7634	1.00	1.00	1.00	1.00	88	1.13	-
3.0	0.5848	0.6671	1.00	1.00	1.00	71	1.41	-
3.5	0.5025	0.5208	0.8333	1.00	1.00	61	1.65	
4.0	0.4310	0.4310	0.5797	1.00	1.00	51	1.96	-
4.5	0.2857	0.2857	0.4167	0.8264	1.00	36	2.76	-
5.0	0.1493	0.1493	0.2326	0.4587	0.9524	20	4.94	50
5.5	0.0552	0.0552	0.0962	0.2041	0.6667	9	11.70	180
6.0	0.0120	0.0120	0.0233	0.0633	0.3125	2	42	410
6.5	0.0016	0.0016	0.0027	0.0087	0.0870	-	247	680
7.0	-	-	-	-	0.0076	-	6579	855
3 60-Inch R.C.P.'s								
2.0	1.00	1.00	1.00	1.00	1.00	100	1.00	-
2.5	0.7692	1.00	1.00	1.00	1.00	88	1.13	-
3.0	0.5348	0.5556	1.00	1.00	1.00	66	1.52	-
3.5	0.3571	0.3571	0.6579	1.00	1.00	47	2.14	-
4.0	0.2237	0.2237	0.4000	1.00	1.00	33	3.05	-
4.5	0.1220	0.1220	0.2326	0.6250	1.00	20	5.09	-
5.0	0.0500	0.0500	0.1053	0.2924	0.9524	10	10.45	50
5.5	0.0112	0.0112	0.0250	0.1031	0.6667	3	29.7	180
6.0	0.0015	0.0015	0.0036	0.0192	0.2740	1	115.9	410
6.5	-	-	-	0.0017	0.0448	-	969	680
5 60-Inch R.C.P.'s								
2.0	1.00	1.00	1.00	1.00	1.00	100	1.00	-
2.5	0.4831	1.00	1.00	1.00	1.00	74	1.35	-
3.0	0.2188	0.3030	1.00	1.00	1.00	44	2.30	-
3.5	0.0971	0.1124	0.4132	1.00	1.00	24	4.19	-
4.0	0.0403	0.0476	0.1429	1.00	1.00	15	6.52	-
4.5	0.0152	0.0161	0.0529	0.3922	1.00	7	14.1	-
5.0	0.0041	0.0041	0.0133	0.1053	0.9091	3	31.6	50
5.5	-	-	0.0014	0.0125	0.6250	1	73.0	180
6.0	-	-	-	0.0011	0.1333	-	363	410
6.5	-	-	-	-	0.0061	-	8197	680

TABLE C-15. POND LEVEL EXCEEDANCE PROBABILITY

Pond Level	I_1 (2.0) 0.50	I_2 (2.5) 0.25	I_3 (3.25) 0.15	I_4 (4.25) 0.08	I_5 (5.50) 0.02	Chance of Exceedance (%)	Return Period (Yrs)	Damage ($1,000)
	INDEX RIVER STAGES							
Existing Floodgate								
3.0	1.00	1.00	1.00	1.00	1.00	100	1.00	-
3.5	0.8929	0.9434	1.00	1.00	1.00	93	1.07	-
4.0	0.7407	0.7937	0.9091	1.00	1.00	81	1.24	-
4.5	0.5556	0.6061	0.7576	0.9709	1.00	64	1.56	-
5.0	0.3448	0.4000	0.5128	0.7576	0.9804	43	2.33	50
5.5	0.1515	0.1754	0.2439	0.4082	0.7353	20	4.91	180
6.0	0.0325	0.0408	0.0781	0.1563	0.3937	6	17.1	410
6.5	0.0043	0.0048	0.0105	0.0299	0.1408	1	98.7	680
7.0	-	-	-	0.0016	0.0172	-	2118	855
2 60-Inch R.C.P.'s								
2.0	1.00	1.00	1.00	1.00	1.00	100	1.00	-
2.5	0.7634	1.00	1.00	1.00	1.00	88	1.13	-
3.0	0.5848	0.6671	1.00	1.00	1.00	71	1.41	-
3.5	0.5025	0.5208	0.8333	1.00	1.00	61	1.65	
4.0	0.4310	0.4310	0.5797	1.00	1.00	51	1.96	-
4.5	0.2857	0.2857	0.4167	0.8264	1.00	36	2.76	-
5.0	0.1493	0.1493	0.2326	0.4587	0.9524	20	4.94	50
5.5	0.0552	0.0552	0.0962	0.2041	0.6667	9	11.70	180
6.0	0.0120	0.0120	0.0233	0.0633	0.3125	2	42	410
6.5	0.0016	0.0016	0.0027	0.0087	0.0870	-	247	680
7.0	-	-	-	-	0.0076	-	6579	855
3 60-Inch R.C.P.'s								
2.0	1.00	1.00	1.00	1.00	1.00	100	1.00	-
2.5	0.7692	1.00	1.00	1.00	1.00	88	1.13	-
3.0	0.5348	0.5556	1.00	1.00	1.00	66	1.52	-
3.5	0.3571	0.3571	0.6579	1.00	1.00	47	2.14	-
4.0	0.2237	0.2237	0.4000	1.00	1.00	33	3.05	-
4.5	0.1220	0.1220	0.2326	0.6250	1.00	20	5.09	-
5.0	0.0500	0.0500	0.1053	0.2924	0.9524	10	10.45	50
5.5	0.0112	0.0112	0.0250	0.1031	0.6667	3	29.7	180
6.0	0.0015	0.0015	0.0036	0.0192	0.2740	1	115.9	410
6.5	-	-	-	0.0017	0.0448	-	969	680
5 60-Inch R.C.P.'s								
2.0	1.00	1.00	1.00	1.00	1.00	100	1.00	-
2.5	0.4831	1.00	1.00	1.00	1.00	74	1.35	-
3.0	0.2188	0.3030	1.00	1.00	1.00	44	2.30	-
3.5	0.0971	0.1124	0.4132	1.00	1.00	24	4.19	-
4.0	0.0403	0.0476	0.1429	1.00	1.00	15	6.52	-
4.5	0.0152	0.0161	0.0529	0.3922	1.00	7	14.1	-
5.0	0.0041	0.0041	0.0133	0.1053	0.9091	3	31.6	50
5.5	-	-	0.0014	0.0125	0.6250	1	73.0	180
6.0	-	-	-	0.0011	0.1333	-	363	410
6.5	-	-	-	-	0.0061	-	8197	680

TABLE C-16. SUMMARY OF FLOODGATE COSTS AND INTERIOR DRAINAGE BENEFITS

Gate Size	2 60-Inch	3 60-Inch	5 60-Inch 1/
Estimated First Cost			
Sluice Gate & Electric Opener	$ 39,000	$ 58,500	$ 97,500
Flap Gate	17,400	26,100	43,500
Pipe	13,000	19,500	32,500
Structure	83,100	107,600	141,500
Contingencies (20%)	30,500	42,300	63,000
TOTAL FIRST COST	$183,000	$254,000	$378,000
Estimated Average Annual Maintenance & Repair Cost (5%)	700	1,000	1,500
Total Average Annual Cost 2/	$13,800	$19,100	$28,500
Average Annual Benefits	$56,000	$83,600	$97,300
Benefit to Cost Ratio	4.1	4.4	3.4
Net Benefits	$42,200	$64,500	$68,800

NOTES: 1/ Selected Gate

2/ Based on an interest of 7-1/8 percent and a 100-year project life.

TABLE C-16. SUMMARY OF FLOODGATE COSTS AND INTERIOR DRAINAGE BENEFITS

Gate Size	2 60-Inch	3 60-Inch	5 60-Inch 1/
Estimated First Cost			
Sluice Gate & Electric Opener	$ 39,000	$ 58,500	$ 97,500
Flap Gate	17,400	26,100	43,500
Pipe	13,000	19,500	32,500
Structure	83,100	107,600	141,500
Contingencies (20%)	30,500	42,300	63,000
TOTAL FIRST COST	$183,000	$254,000	$378,000
Estimated Average Annual Maintenance & Repair Cost (5%)	700	1,000	1,500
Total Average Annual Cost 2/	$13,800	$19,100	$28,500
Average Annual Benefits	$56,000	$83,600	$97,300
Benefit to Cost Ratio	4.1	4.4	3.4
Net Benefits	$42,200	$64,500	$68,800

NOTES: 1/ Selected Gate

2/ Based on an interest of 7-1/8 percent and a 100-year project life.

TABLE C-17. WAIMEA RIVER FLOOD STAGE-DURATION DATA

River Stage at the Main Flood Gate Sta 10+50	Average Duration at or Above the Selected Stage Level		
	Percent	Days	Hours
1.7 Ft MSL 1/	100.00	365.0	8760.0
2.0	3.00	11.0	262.8
2.5	1.70	6.2	148.9
3.0	1.10	4.0	96.4
3.5	0.70	2.6	61.3
4.0	0.45	1.6	39.4
4.5 2/	0.30	1.1	26.3
5.0	0.20	0.7	17.5

NOTE: 1/ Sand Bar and Estuary Effect

2/ Selected Gate Closure

HISTORICAL ANALYSIS

37. An historical analysis was made for Waimea for 27 years of coincident rainfall and river discharge record from 1951 to 1977. Assumptions made for this analysis were that the 24-hour rainfall occurred while the river remained at its mean daily discharge. Pond elevations were computed by using the 24-hour rainfall frequency and the frequency-elevation curves (Plates C-15, C-16). The pond elevation used was either from the frequency curve or from the assumed rainfall volume whichever was less (Table C-18).

38. The average annual damages from the historical analysis are greater than those damages obtained from the probabilistic analysis although a net benefit computation indicates that the floodgate of five 60-inch RCP's is the optimum selection. The residual damages shown of $33,700 for the selected gate configuration using a historical analysis are not considered excessive when compared to the existing annual damages of $152,400. This historical analysis supports the assumptions made in the probabilistic analysis.

TABLE C-18. HISTORICAL ANALYSIS 1951-1977 (27 YEARS OF RECORD)

Date	River Discharge (CFS)	24-Hour Rain (in)	Frequency (Years)	Storm Volume (Ac-Ft)	River Elev. (Ft)	Maximum Ponding Elev. Existing Gate	Damage $	Maximum Ponding Elev. 5 60" R.C.P.'s	Damage $	Maximum Ponding Elev. 3 60" R.C.P.'s	Damage $	Maximum Ponding Elev. 2 60" R.C.P.'s	Damage $
4 Mar 51	10,500	0.97	1.0	12.4	5.40	5.30	$ 120,000	5.30	$120,000	5.30	$ 120,000	5.30	$ 120,000
16 Dec 51	7,470	5.93	35.0	101.8	4.55	6.50	675,000	5.30	120,000	6.15	510,000	6.45	655,000
28 Nov 54	7,750	1.67	1.6	17.5	4.67	5.30	125,000	4.82	15,000	4.92	32,000	5.17	85,000
12 Nov 55	8,510	3.18	4.0	48.1	4.90	6.15	510,000	5.45	160,000	5.85	320,000	6.00	410,000
1 Dec 56	14,200	0.43	1.1	3.7	5.80	4.90	30,000	4.90	30,000	4.90	30,000	4.90	30,000
6 Jan 62	8,470	2.97	3.6	45.2	4.95	6.20	540,000	5.50	180,000	5.80	310,000	5.95	380,000
16 Mar 63	7,720	0.72	1.1	9.3	4.65	4.90	30,000	4.70	None	4.75	None	4.85	20,000
13 Apr 65	3,230	2.98	3.6	46.6	3.00	5.35	135,000	3.55	None	4.10	None	4.75	None
4 Nov 66	2,800	2.38	2.3	33.3	2.80	5.05	60,000	3.25	None	3.60	None	4.10	None
26 Nov 67	11,100	0.82	1.2	10.7	5.50	5.30	120,000	5.30	120,000	5.30	120,000	5.30	None
1 Oct 68	2,040	5.38	20.0	86.0	2.40	5.92	370,000	4.00	None	5.00	45,000	5.55	200,000
27 Jan 71	3,980	2.07	1.9	27.1	3.30	5.00	45,000	3.45	None	3.70	None	4.15	None
23 Jan 72	2,680	4.34	10.0	72.0	2.70	5.80	300,000	3.70	None	4.65	None	5.25	110,000
1 Dec 73	2,820	4.31	10.0	72.0	2.80	5.90	360,000	3.80	None	4.75	None	5.35	135,000
31 Jan 75	3,040	4.52	11.4	74.0	2.90	5.92	370,000	3.90	None	4.95	40,000	5.45	165,000
6 Feb 76	5,310	2.75	3.0	41.0	4.85	5.85	325,000	5.45	165,000	5.65	230,000	5.85	325,000
TOTAL DAMAGES							$4,115,000		$910,000		$1,757,000		$2,755,000
AVERAGE ANNUAL DAMAGES							$152,400		$33,700		$65,000		$102,000

SUPPLEMENTAL PONDING AREA

39. Construction of a supplemental ponding area immediately adjacent to the main floodgate was investigated. A 1.38 acre parcel of land next to the gate is owned by the County of Kauai and is used as a corporation yard for county maintenance vehicles. Excavation of the area to 1 foot below MSL with 3H to 1V side slopes adds 4.9 acre-feet of additional available storage volume between elevation 1.7 feet MSL and 7.6 feet MSL. The first cost of construction is approximately $64,000 with an average annual cost of $4,960 including maintenance cost and assuming no land cost. A new elevation-storage curve was developed and a coincidental frequency analysis was performed (Table C-19). This supplemental ponding area was eleiminated due to the unfavorable benefit/cost ratio.

TABLE 19. SUPPLEMENTAL PONDING ANALYSIS

Improvement	Average Annual Damages, Existing Ponding Area	Average Annual Damages With Supplemental Ponding Area	Increased Benefit	Ponding B/C 1/
Two 60" RCP's	$47,600	$36,400	$11,200	2.26
Three 60" RCP's	20,000	16,000	4,000	0.81
Five 60" RCP's	6,300	6,300	0	0.00

1/ Based on an average annual ponding cost of $4,960.

40. Additional ponding areas were examined, including temporary storage in the upper reaches of the basin but were found to be uneconomical due to land or development cost.

ALTERNATIVES INVESTIGATED

41. Alternative interior drainage schemes investigated were elimination of the floodgate and construction of a ditch adjacent to the levee to outlet interior drainage flows directly to the ocean. The ditch alternative is not considered feasible due to the large capacity required, a flat slope, and additional land requirements. A second route to the ocean on the west side of Waimea was investigated but dropped due to real estate requirements and large excavations.

42. A 24-inch gravity outlet is planned at approximately river station 6+90. Alternatives to this structure include laying storm sewer to the main floodgate, or construction of a storm sewer or ditch to the ocean. These alternatives were more costly than the 24-inch gravity outlet selected.

SUPPLEMENTAL PUMPING

43. A permanent pumping station is not required at Waimea because the recommended gravity outlet can adequately and economically convey interior drainage flows through the line of protection. Average annual residual damages based on the probabilistic analysis of $6,300 are not large enough to economically justify a pumping station. A sump will be provided on the upstream end of the large gravity outlet so that temporary pumping may be employed by local interests if considered necessary. No benefits or costs are attributed to temporary pumping in this analysis.

POND FREQUENCY ANALYSIS

44. The maximum coincident one percent pond level for the existing condition (Table C-15) and the selected floodgate was obtained by interpolation (Table C-20). Damages are from the elevation-damage curve (Plate C-7).

TABLE C-20. ONE PERCENT POND LEVEL DATA

	Existing Gate	Five 60-Inch RCP's
One Percent Pond Level	6.5 feet MSL	5.7 feet MSL
Estimated Damage	$680,000	$250,000

LEVEE OVERTOPPING ANALYSIS

45. The proposed design levee would provide Waimea with flood protection against a one percent flood discharge of 64,000 cfs. The 0.2 percent flood (500-year) and the Standard Project Flood were analyzed to determine the extent of inundation within Waimea from levee overtopping by floods greater than the design flood. The 0.2 percent and Standard Project Flood discharges at the confluence of Waimea River and Makaweli River are 94,000 cfs and 105,000 cfs, respectively. The approximate extent of flooding from levee overtopping is shown on Plate C-19.

46. Over a period of 2 hours and 40 minutes, the Standard Project Flood would spill 4,900 acre-foot of water over the levee. This volume represents approximately 12 percent of the Standard Project Flood runoff volume. The 500-year flood would spill 3,000 acre-feet of water over the levee during a period of 2 hours and 20 minutes which would constitute 8 percent of the 500-year flood runoff volume.

47. The water surface elevation at sections along the levee for the 500-year flood and the Standard Project Flood are shown on Tables C-21 and C-22. The overflow water surface elevation is computed to be lower than the non-overflow elevation because of the decreased flow in the channel. The peak discharge passing over the levee would be 34,600 cfs and 24,800 cfs for the Standard Project Flood and 500-year floods, respectively. Incremental discharges between sections along the levee are also shown on the tables. Freeboard allowance was not included in the water overflow computations. The levee profile for analytical purposes is reduced by three feet along its length.

48. The river water surface profile was computed using the spatially-varied-flow equation with decreasding discharge as described by Chow.1/

TABLE C-21. LEVEE OVERTOPPING ANALYSIS FOR 500-YEAR FLOOD

River Station	Water Surface Elevation FT, MSL)	River Discharge (CFS)	Coefficient CO_D	HEAD H (FT)	Overflow Velocity (FT/SEC)	Overflow Between Sections (CFS)	Sum of Overflow (CFS)
90+00	29.4	94,000	-	-	-	-	-
83+60	24.6	94,000	-	-	-	-	-
75+20	24.3	94,000	2.36	2.26	3.55	3,450	3,450
71+00	25.2	90,550	2.36	2.62	3.82	3,010	6,460
68+00	24.4	87,540	2.36	2.56	3.78	2,910	9,370
65+00	23.7	84,630	2.36	2.22	3.52	3,660	13,030
60+30	21.4	80,970	2.36	1.45	2.93	2,890	15,920
53+50	19.3	78,080	2.36	0.90	2.12	1,050	16,970
48+00	18.2	77,030	2.36	1.05	2.49	1,570	18,540
42+00	18.0	75,460	2.36	1.00	2.29	1,950	20,490
33+50	17.0	73,510	2.75	0.76	2.41	1,200	21,690
27+00	16.3	72,310	2.75	0.79	2.44	1,150	22,840
21+00	15.6	71,160	2.75	0.80	2.46	1,180	24,020
15+00	14.8	69,980	2.75	0.82	2.14	440	24,460
12+50	14.8	69,540	2.36	0.49	1.65	320	24,780
8+50	13.2	69,220	2.36	0.27	1.23	20	24,800
8+00 (Bridge)	13.4	69,200					

TABLE C-22. LEVEE OVERTOPPING ANALYSIS FOR STANDARD PROJECT FLOOD

River Station	Water Surface Elevation FT, MSL)	River Discharge (CFS)	Coefficient C_D	HEAD H (FT)	Overflow Velocity (FT/SEC)	Overflow Between Sections (CFS)	Sum of Overflow (CFS)
90+00	30.4	105,000					
83+60	25.3	105,000	-	-	-	-	-
75+20	24.9	105,000	-	-	-	-	-
71+00	26.0	99,700	2.36	2.95	4.05	5,300	5,300
68+00	25.1	95,320	2.36	3.37	4.33	4,380	9,680
65+00	24.3	91,170	2.36	3.26	4.26	4,150	13,830
60+30	22.0	85,870	2.36	2.84	3.98	5,300	19,130
53+50	19.3	82,180	2.36	1.75	3.10	3,690	22,820
48+00	18.4	80,910	2.36	1.00	2.31	1,270	24,090
42+00	18.2	78,960	2.36	1.25	2.60	1,950	26,040
33+50	17.2	76,360	2.36	1.20	2.55	2,600	28,640
27+00	16.5	74,720	2.75	0.95	2.67	1,640	30,280
21+00	15.8	73,160	2.75	0.96	2.70	1,560	31,840
15+00	15.0	71,570	2.75	0.98	2.72	1,590	33,430
12+50	15.0	70,970	2.75	1.01	2.37	600	34,030
8+50	13.4	70,440	2.36	0.68	1.95	530	34,560
8+00 (Bridge)	13.6	70,400	2.36	0.47	1.62	40	34,600

$$\Delta y' = \frac{\alpha Q_1 (V_1 + V_2) \Delta V}{g (Q_1 + Q_2)} \left(1 - \frac{\Delta Q}{2 Q_1}\right) + h_e$$

in which:

$\Delta y'$ = Change in water surface
α = Kinetic energy correction factor
Q_1, Q_2 = Discharges at sections 1 and 2
V_1, V_2 = Mean flow velocities at sections 1 and 2
ΔQ = $-(Q_2 - Q_1) = C_D L H^{3/2}$ (see below)
h_e = Total energy head loss
g = Acceleration of gravity

1/ Chow, Ven Te, Open-Channel Hydraulics, 1959.

49. The unknown discharge was computed by a iterative technique using levee overflow discharge losses between sections. The head (H) for use in the weir overflow formula is the average (trial and error) head over the levee between cross sections. Velocity head was assumed negligible. Levee overflow was determined based on the standard weir formula:

$$\Delta Q = C_D L H^{3/2}$$

in which:

ΔQ = overflow discharge between sections

C_D = Coefficient of discharge

L = Length of overflow

H = Head over the levee

The coefficient of discharge was computed for a broad-crested weir using the formula:1

$$C_D = 3.47 \left[\frac{1}{1 + \frac{1}{\frac{L'/P}{L'/H} + 1} + 0.0109\, L'/H} \right]^{1/2}$$

in which:

L' = Weir cross section length
P = Height of weir

1/ Pennaz, James, "Discharge Coefficient for a Broad Crested Weir," Thesis, University of Minnesota, 1972.

50. Based upon the equation, a coefficient value of 2.75 was determined for a narrow concrete-rubble-masonry wall between stations 12+50 and 33+50 and a value of 2.36 was used for the wide levee section along the remainder of the levee.

FLOOD WARNING SYSTEM

COMPONENTS

51. The flood warning system for the Waimea River Flood Control Project would consist of two lines of telecommunications, including necessary operational and real-time manpower. Portions of the equipment and hardware are either existing or have already been programmed for installation. The basic elements of the system are schematically shown on Plate C-21.

52. The primary data line would originate from the rain and stream gage sensors and transmit data to Honolulu via the National Oceanic and Atmospheric Administration's (NOAA) Geostationary Operational Environmental Satellite (GOES) system. The secondary line would redundantly transmit data from the gages to Lihue, Kauai. The processed information from both lines would be received at Lihue and would subsequently warn the citizens of Waimea town.

PRIMARY LINE

53. For the primary data line, the US Geological Survey (USGS) is in a process of implementing a network of approximately 12 hydrologic measurement stations in the Pacific basin. This system would transmit the resultant data via the GOES system to their district headquarters in Honolulu. The USGS has informally indicated that at least one of the data transmission stations would be located in the Waimea River basin and that access to their communications system for the purposes of the planned warning system would be acceptable. A receiving terminal is scheduled to be completed in late 1981; other receiving terminals for their hydrologic data collection system are not planned outside of Honolulu.

54. Six data collection platforms (DCP) with sensors would be installed in the Waimea and Makaweli River Watersheds (see Plate C-20 for locations). Three rainfall seasons, two of which would be at or near existing rainfall gages, would be installed to triangulate the area of the upper watershed. The actual gages would be the tipping-bucket type. In addition, one streamstage-rainfall sensor would be placed on each river, approximately 2.6 miles upstream of the confluence and one placed at the confluence for a total of three streamflow rainfall sensors. The stream-stage sensors would be the "bubble-gage" type. The DCP hardware would be the identical or equivalent proprietary type to those scheduled to be installed by the USGS.

55. The planned USGS receiving station would store the data. By prior arrangements, data would be transmitted to the US Army Corps of Engineers' POD Harris computer system for data processing and interpretation. Minor software and hardware modifications would be necessary to adapt the existing Harris system for real-time conditions. Following processing, the information will be transmitted to the NOAA National Weather Service (NWS) office at Honolulu airport. The NWS office is currently operational 24 hours a day. Additional monitoring equipment at the airport would include a cathode ray tube display,

keyboard, printer and microcomputer. During continuous monitoring, warning conditions would subsequently be transmitted to the Lihue, Kauai NWS station. The NWS personnel at Lihue would signal the Waimea Police Station and activate sirens. Two sirens forming part of the statewide civil defense network primarily designed for impending tsunami or enemy attack conditions already exist in Waimea. The transmitted signals would be activated specifically for the flood warning system and would be independent of other civil defense disaster conditions.

SECONDARY LINE

56. In addition to the data analysis and communication from Honolulu, a direct indication of potential hazards is needed on Kauai. Because of access to a broader range of meteorological data and greater analytical capability for the National Weather Service personnel in Honolulu, it is desirable to implement centralized monitoring in Honolulu. However, since the County of Kauai is responsible for local civil defense actions and to counteract potential system failures, a secondary or redundant communications system would be implemented. The backup system would include modifications to the DCP's to permit simultaneous local data signal transmission, installation of three signal repeating stations, a receiver and monitoring equipment (cathode ray tube display, keyboard, printer, alarm, and microcomputer) at the NWS office at Lihue airport. The microcomputer will be programmed on a simplified basis to monitor and interpret threshold level rainfall intensities and streamflow stages.

OPERATIONAL PHASES

57. The flood warning system would consist of three phases. The first phase would be the existing flood watch phase which is issued by NWS in coordination with the State and County Civil Defense agencies. Weather advisories and public warnings would be made through radio and television broadcasts when storm conditions warrant a flood watch alert. The second phase will be initiated when critical rainfall intensities and for significant rises in river stage are detected. During this phase, the residents of the flood-prone area along Waimea River would be notified to be on alert for possible evacuation. The notification would occur by television and radio announcements over both the Emergency Broadcast System (EBS) and commercial stations and door-to-door contacts by the police and fire department forces. The third phase, signalled by the sirens, would be evacuation.

Evacuation would be determined primarily on the data received from the upstream streamstage sensors on Waimea and Makaweli Rivers. Approximately 20 minutes will elapse from the detection of high discharges at the upstream sensors to levee overflow at Waimea town. Throughout the flood warning phases, rainfall and stream stage data would be monitored and analyzed with the aid of computer programs by NWS personnel in Honolulu. Any warning or information would be sent through the NWS Office at Lihue airport to the Waimea police station via existing communication lines. The Waimea police station would activate the flood evacuation siren.

58. To activate the monitoring alarms in Honolulu, the DCP's would be programmed at low (5- to 10-year events) threshold levels. To activate the second phase, the monitoring system would be programmed at predictive levels of design levee overtopping conditions. This would provide the observer time to

acquaint himself with the equipment and procedures. Once activated on the emergency channel, the DCP's would be programmed to transmit data at the shortest time interval possible (currently at 2 minute intervals).

COST ESTIMATES

BASIS OF COST ESTIMATES

59. Quantity computations for the levee section were made by the average end area method. Existing ground lines were determined from maps prepared from field surveys completed in January 1979. The sources of construction materials are discussed in Appendix B - "Geology and Soils," under "Sources of Construction Materials." Construction was assumed to be performed by an Oahu-based contractor.

UNIT COSTS

60. Unit and lump sum prices, based on June 1980 price levels in Hawaii, were derived on the assumption that construction can be accomplished with standard equipment. Wage rates were based on the contractor working 6-day, 10-hour shifts per week. The detailed estimate is provided in Table C-23.

TABLE C-23. DETAILED COST ESTIMATE

Item	Unit	Quantity	Unit Cost	Total Cost
Federal Work Items				
Mobilization & Demobilization	Job	-	-	$164,000
Levee				
Clear Borrow Site	Job	-	-	15,200
Clear Grub & Strip	AC	2	$4,500	9,000
Insp. Trench Exc & Backfill	CY	3,400	11.80	40,100
Gravel Fill	CY	800	31.50	25,200
Impervious Fill	CY	15,000	13.20	198,000
Excavate for Riprap	CY	520	7.00	3,600
27-Inch Riprap	Ton	7,300	24.80	181,000
6-Inch Bedding	Ton	1,800	28.40	51,100
Topsoil & Grassing	SY	5,000	3.20	16,000
				539,200
Contingency				80,800
				$620,000
CRM Wall Structure				
Trench & Roughen Existing Wall	FT	3,175	7.10	22,500
CRM Wall	CY	700	156	109,200
				131,700
Contingency				19,300
				$151,000

TABLE C-23. DETAILED COST ESTIMATE (Cont)

Item	Unit	Quantity	Unit Cost	Total Cost
Federal Work Items				
Rock Toe Protection				
Excavate	CY	9,100	7.00	$63,700
Riprap	Ton	15,200	24.80	377,000
Bedding	Ton	2,900	28.40	82,400
				523,100
Contingency				78,900
				$602,000
Roadway Modifications				
Subgrade	SY	3,750	2.50	9,300
Fill	CY	1,850	12.50	23,100
6-Inch Subbase	CY	560	25.50	14,300
6-Inch Base Course	CY	560	30.00	16,800
2-Inch AC	SY	3,350	6.00	20,100
27-Inch Riprap	Ton	580	24.80	14,400
6-Inch Bedding	Ton	190	28.40	5,400
				103,400
Contingency				15,600
				$119,000
Grouted Rock Riprap	CY	155	156.00	24,200
Contingency				3,800
				$28,000
Interior Drainage Structures				
24-Inch Gravity Outlet				
Concrete Gatewell	CY	16	495	7,900
Structural Backfill	CY	65	17.70	1,200
24-Inch RCP Class V	FT	55	70	3,900
Concrete Headwall	CY	3	434	1,300
Drainage Fill	CY	35	44.70	1,600
Sluice Gate w/18-foot stem	EA	1	10,800	10,800
Flapgate & Concrete Outlet	EA	1	3,500	3,500
Riprap & Bedding	CY	20	37.70	800
Galv. Iron Rails	FT	10	35.10	400
Steel Ladder	FT	18	20	400
Steel Plate	EA	1	300	300
				$32,100
Contingency				4,900
				$37,000

TABLE C-23. DETAILED COST ESTIMATE (Cont)

Item	Unit	Quantity	Unit Cost	Total Cost
Federal Work Items				
Interior Drainage Structures				
60-Inch Gravity Outlet				
Dewater	Job	-	-	$27,000
Earthwork	CY	140	12.50	1,800
Concrete Structure	CY	257	337	86,600
60-Inch Dia. Sluice Gate	EA	5	26,800	134,000
60-Inch Dia. Flapgate	EA	5	12,000	60,000
Steel Ladder	EA	1	350	400
Aluminum Grating	FT	33	69	2,300
Steel Rails	FT	115	25	2,900
60-Inch RCP	FT	325	144	46,800
				$361,800
Contingency				54,200
				$416,000
Early Flood Warning System (Cost-Shared)				
Raingage and DCP	EA	3	4,500	13,500
Raingage site preparation	EA	1	1,000	1,000
Streamgage and DCP	EA	3	5,000	15,000
Streamgage site preparation	EA	3	12,000	36,000
Repeating station and site preparation	EA	3	6,500	19,500
Lihue monitoring station (CRT Printer, microcomputer)	EA	1	15,000	15,000
Honolulu monitoring station (CRT and Printer)	EA	1	4,500	4,500
Siren modification & electrical connection	EA	2	1,500	3,000
				77,500
Contingency				12,500
				$90,000

Federal Indirect Costs	
Engineering and Design	$120,000
Supervision and Inspection	145,000
Preauthorization Cost	147,000
	$412,000
Non-Federal Costs	
Lands, Easements, Rights-of-Way and Relocations	96,000
Indirect Costs	15,000
	$111,000
TOTAL PROJECT FIRST COST	
Without preauthorization cost	$2,603,000
With preauthorization cost	$2,750,000

TABLE C-23. DETAILED COST ESTIMATE (Cont)

Item	Unit	Quantity	Unit Cost	Total Cost
Federal Work Items				
Interior Drainage Structures				
60-Inch Gravity Outlet				
Dewater	Job	-	-	$27,000
Earthwork	CY	140	12.50	1,800
Concrete Structure	CY	257	337	86,600
60-Inch Dia. Sluice Gate	EA	5	26,800	134,000
60-Inch Dia. Flapgate	EA	5	12,000	60,000
Steel Ladder	EA	1	350	400
Aluminum Grating	FT	33	69	2,300
Steel Rails	FT	115	25	2,900
60-Inch RCP	FT	325	144	46,800
				$361,800
Contingency				54,200
				$416,000
Early Flood Warning System (Cost-Shared)				
Raingage and DCP	EA	3	4,500	13,500
Raingage site preparation	EA	1	1,000	1,000
Streamgage and DCP	EA	3	5,000	15,000
Streamgage site preparation	EA	3	12,000	36,000
Repeating station and site preparation	EA	3	6,500	19,500
Lihue monitoring station (CRT Printer, microcomputer)	EA	1	15,000	15,000
Honolulu monitoring station (CRT and Printer)	EA	1	4,500	4,500
Siren modification & electrical connection	EA	2	1,500	3,000
				77,500
Contingency				12,500
				$90,000

Federal Indirect Costs	
Engineering and Design	$120,000
Supervision and Inspection	145,000
Preauthorization Cost	147,000
	$412,000
Non-Federal Costs	
Lands, Easements, Rights-of-Way and Relocations	96,000
Indirect Costs	15,000
	$111,000
TOTAL PROJECT FIRST COST	
Without preauthorization cost	$2,603,000
With preauthorization cost	$2,750,000

COST APPORTIONMENT

61. The cost apportionment between Federal and non-federal work is determined by various statutory and policy requirements. In accordance with Section 221 of Public Law 51-611, the acquisition of land, easements and rights-of-way, relocations including utilities, structures, and associated engineering and administrative costs are local costs. Policy guidance from the Office of the Chief of Engineers for nonstructural features pursuant to Section 73 of Public Law 93-251 states that the federal share of the first cost of separable flood warning system, when part of the recommended plan, is 80 percent; the local share is 20 percent. The total federal first cost for the project is of course limited by the statutory limit of the basic project authority, Section 205 of the 1948 Flood Control Act (Public Law 80-858), as amended. Costs, including all pre-authorization costs, in excess of $2 million shall be borne by the local interests. Finally all operation, maintenance, and replacement costs for structural and nonstructural features are also a local responsibility.

62. Based upon the prior considerations, Table C-24 summarized the principal items related to cost apportionment.

TABLE C-24. PRELIMINARY COST APPORTIONMENT ANALYSIS

Item	Cost
Federal	
Structural features 100%	$2,137,000
Nonstructural flood warning 80%	72,000
Subtotal	$2,209,000
Indirect Costs (E&D, S&I)	265,000
Preauthorization Cost	147,000
Subtotal	$2,621,000
Non-Federal	
Lands, easements, rights-of-way, relocations, and indirect costs	$111,000
Nonstructural flood warning 20%	18,000
	$129,000

63. The Federal work items is shown above exceed the statutory $2 million. As a result, the final cost-apportionment and summary of major cost items are shown in Table C-25.

PROJECT COST

64. The estimated total project cost is $2,603,000, including a 15 percent contingency allowance for each major feature and excluding preauthorization study costs. Table C-25 summarizes the estimated cost.

TABLE C-25. SUMMARY OF FIRST COSTS

Item	Cost	
Federal		
Mobilization and Demobilization	$164,000	
Levee Fill	620,000	
CRM Wall Structure	151,000	
Rock Toe Protection	602,000	
Roadway Modifications	119,000	
Grouted Rock Riprap	28,000	
Interior Drainage Structures	453,000	
Early Flood Warning System 80%	72,000	
Subtotal		$2,209,000
Engineering and Design3/	120,000	
Supervision and Inspection3/	145,000	
Preauthorization Cost	147,000	
Subtotal		$2,621,000
Less Non-Federal Contribution		621,000
Total Federal First Cost1/		$2,000,000
Total Federal First Cost2/		$1,853,000
Non-Federal		
Lands, Easements, and Rights-of-Way, and Relocations	$96,000	
Early Warning System 20%	18,000	
Indirect Costs	15,000	
Cash Contribution	621,000	
Total Non-Federal First Cost		$750,000
Total Project First Cost1/		$2,750,000
Total Project First Cost2/		$2,603,000

1/ With preauthorization cost
2/ Without preauthorization cost
3/ Includes all overhead

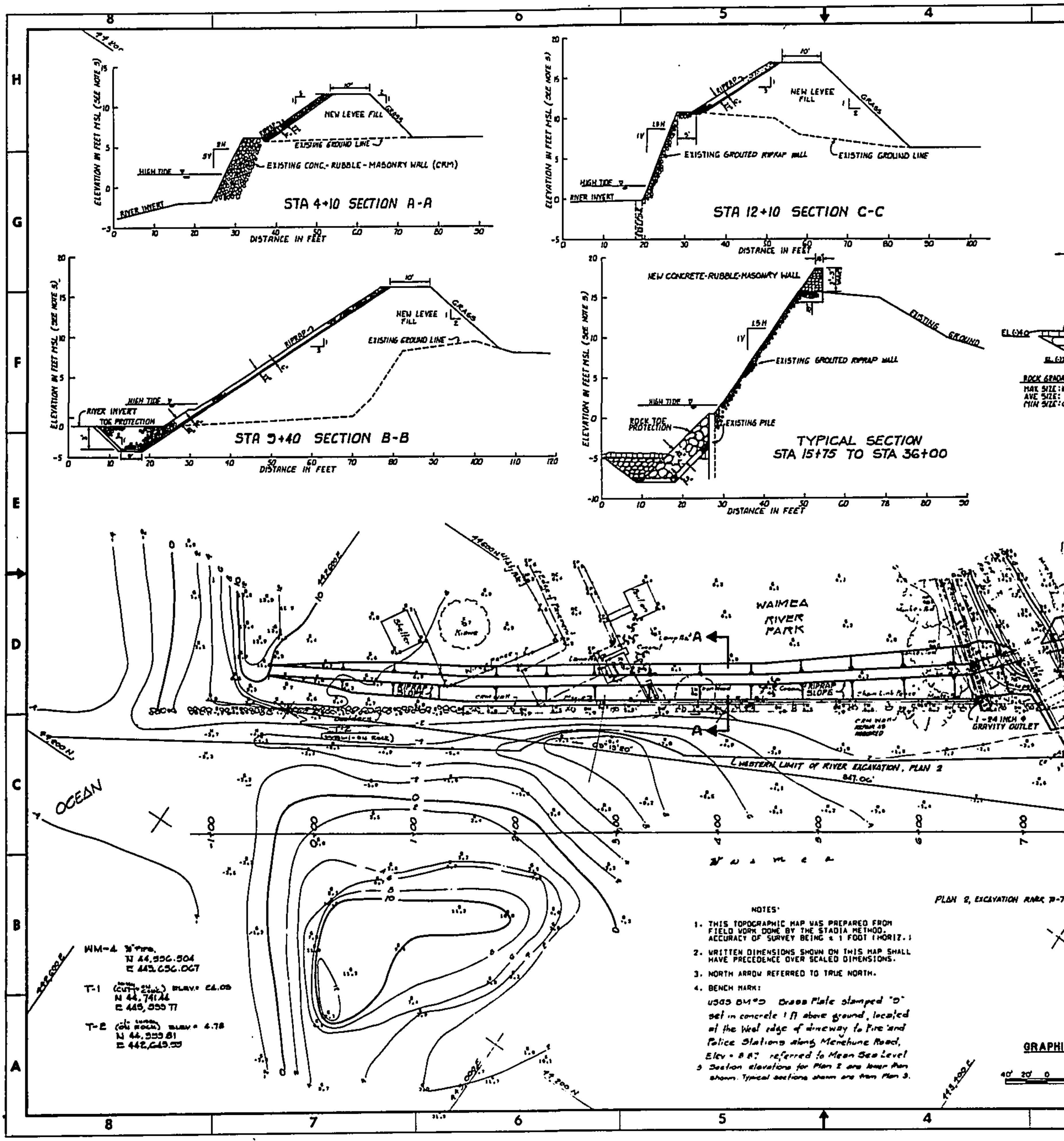
MAINTENANCE

65. Maintenance of the project will be the responsibility of local interests and would be performed in accordance with regulations prescribed by the Secretary of the Army. The average annual maintenance cost for the levee extension, CRM floodwall, rock toe, and the floodgates is estimated at $11,000. Replacement cost for gates and gate valves is estimated at $4,000. Maintenance of the data collection platforms and gages is estimated at $1,000. The total operation, maintenance and replacement cost is estimated at $16,000.

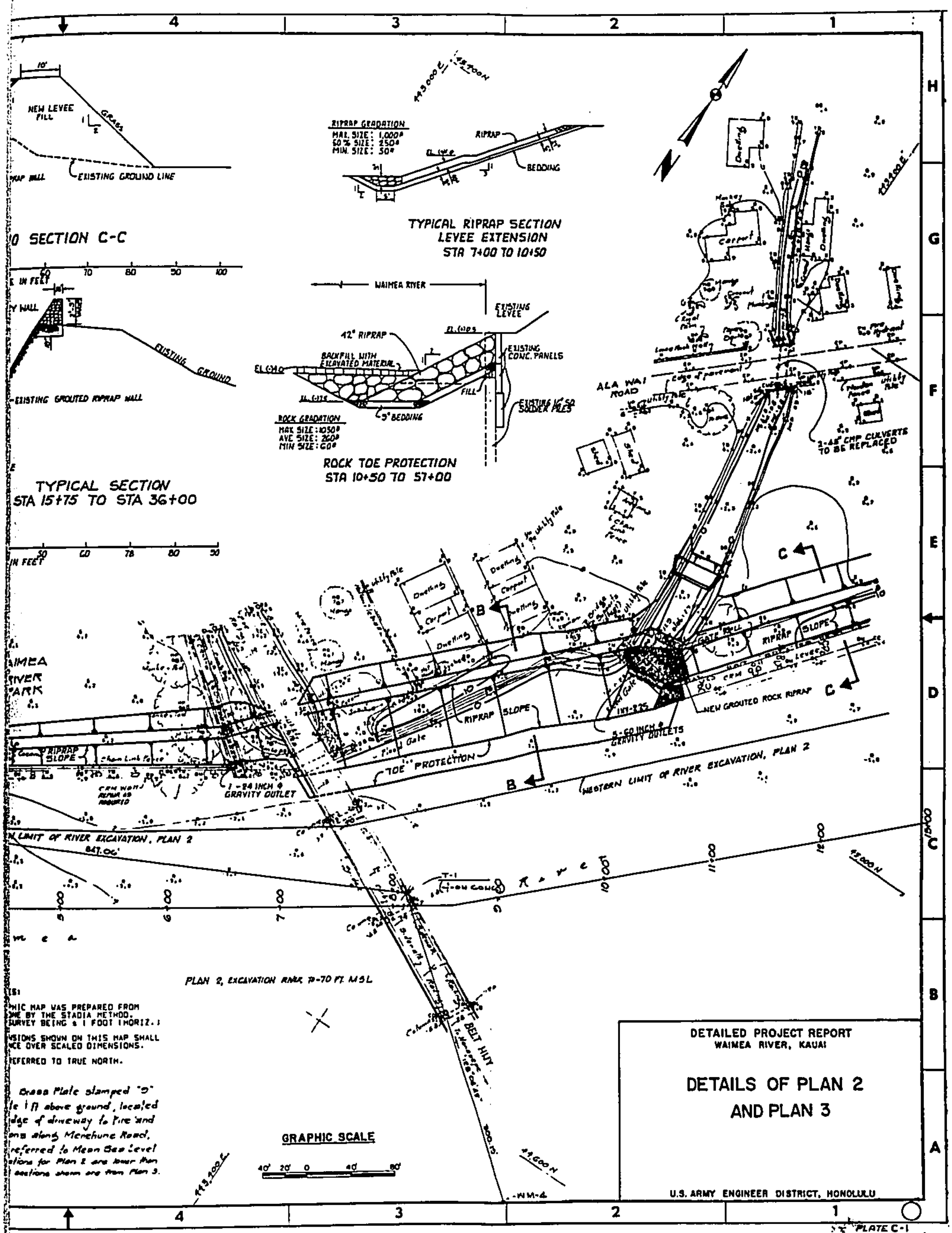
ANNUAL COSTS

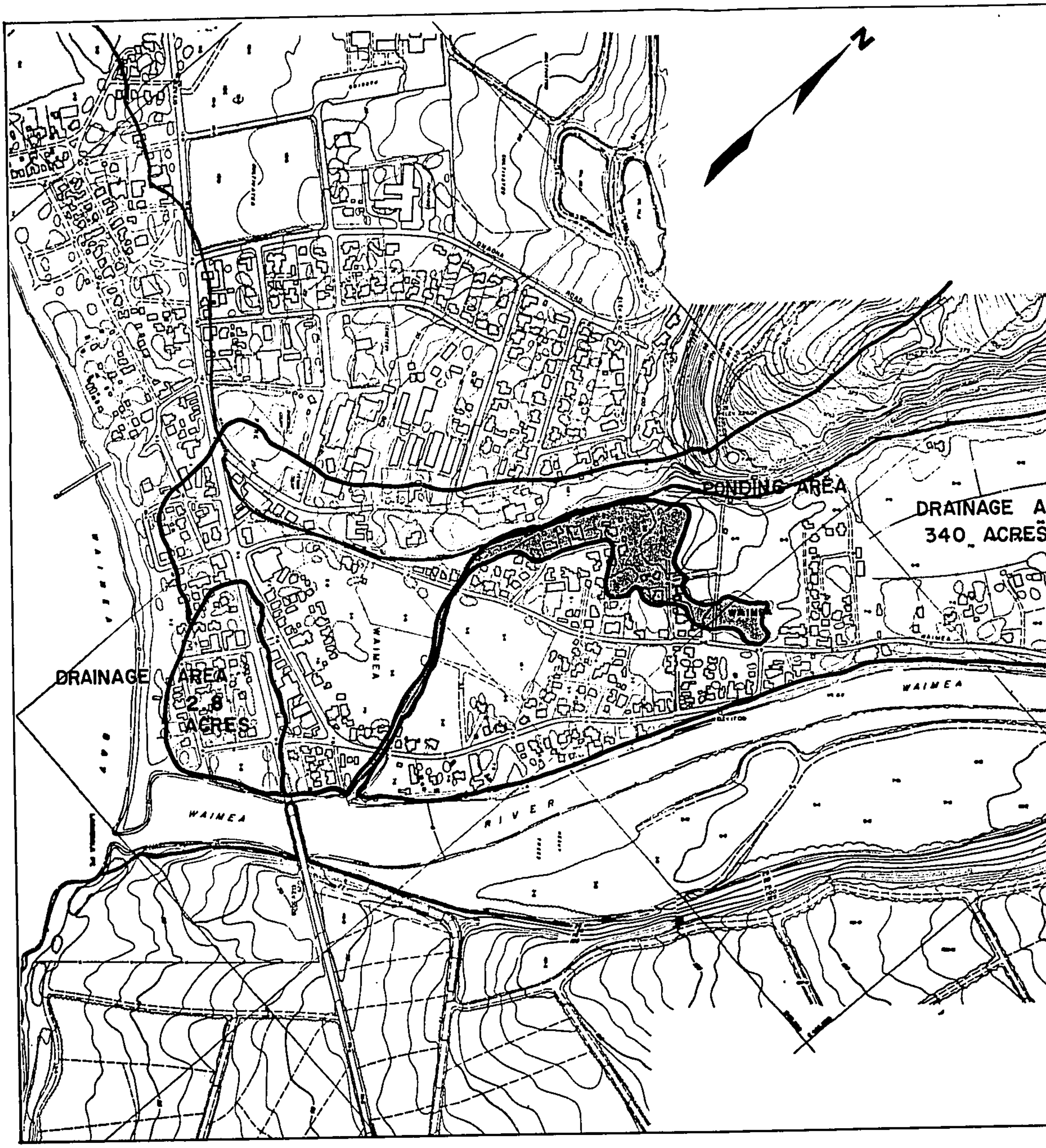
66. Estimates of annual costs summarized below are based on an economic life of 100 years. Interest and amortization charges are based on an interest rate of 7-1/8 percent. The estimated cost of operation, maintenance, and replacement is also included.

<u>Federal</u>		
Interest and Amortization	($1,853,000 x 0.07132)	$132,000
<u>Non-Federal</u>		
Interest and Amortization	($750,000 x 0.07132) = $54,000 Annual operation, maintenance, and replacement = $16,000	70,000
Total Project Annual Cost		$202,000

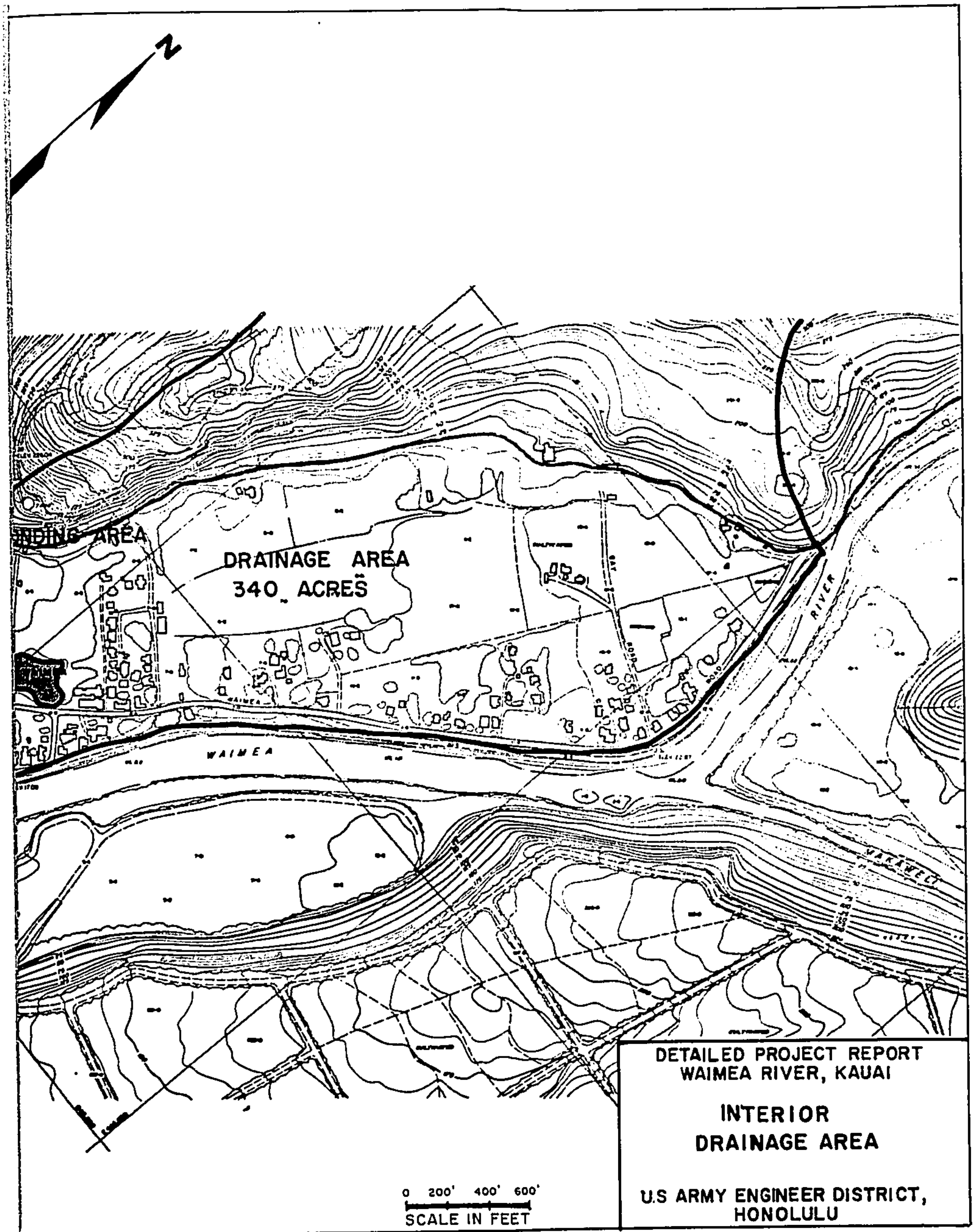


STA 4+10 SECTION A-A
NEW LEVEE FILL
EXISTING GROUND LINE
EXISTING CONC.-RUBBLE-MASONRY WALL (CRM)
HIGH TIDE
RIVER INVERT
ELEVATION IN FEET MSL (SEE NOTE 5)
DISTANCE IN FEET
STA 12+10 SECTION C-C
NEW LEVEE FILL
GRASS
EXISTING GROUTED RIPRAP WALL
EXISTING GROUND LINE
STA 5+40 SECTION B-B
RIVER INVERT
TOE PROTECTION
EXISTING GROUND LINE
NEW CONCRETE-RUBBLE-MASONRY WALL
EXISTING GROUND
EXISTING GROUTED RIPRAP WALL
ROCK TOE PROTECTION
EXISTING PILE
TYPICAL SECTION
STA 15+75 TO STA 36+00
WAIMEA RIVER PARK
OCEAN
RIPRAP SLOPE
WESTERN LIMIT OF RIVER EXCAVATION, PLAN 2
1-24 INCH Φ GRAVITY OUTLET
PLAN 2, EXCAVATION
NOTES:
1. THIS TOPOGRAPHIC MAP WAS PREPARED FROM FIELD WORK DONE BY THE STADIA METHOD. ACCURACY OF SURVEY BEING ± 1 FOOT (HORIZ.)
2. WRITTEN DIMENSIONS SHOWN ON THIS MAP SHALL HAVE PRECEDENCE OVER SCALED DIMENSIONS.
3. NORTH ARROW REFERRED TO TRUE NORTH.
4. BENCH MARK:
USGS BM "D" Brass Plate stamped "D" set in concrete 1 ft above ground, located at the West edge of driveway to Fire and Police Stations along Menehune Road, Elev = 8.87 referred to Mean Sea Level
5 Section elevations for Plan 2 are lower than shown. Typical sections shown are from Plan 3.
GRAPHI


SECTION C-C
NEW LEVEE FILL
GRASS
EXISTING GROUND LINE
TYPICAL SECTION
STA 15+75 TO STA 36+00
EXISTING GROUTED RIPRAP WALL
EXISTING GROUND
RIPRAP GRADATION
MAX. SIZE: 1,000#
50% SIZE: 250#
MIN. SIZE: 50#
RIPRAP
BEDDING
TYPICAL RIPRAP SECTION
LEVEE EXTENSION
STA 7+00 TO 10+50
WAIMEA RIVER
EXISTING LEVEE
42" RIPRAP
BACKFILL WITH EXCAVATED MATERIAL
EXISTING CONC. PANELS
FILL
EXISTING 16" SQ. SOLDIER PILES
3" BEDDING
ROCK GRADATION
MAX SIZE: 1050#
AVE SIZE: 260#
MIN SIZE: 60#
ROCK TOE PROTECTION
STA 10+50 TO 57+00
ALA WAI ROAD
3-48" CMP CULVERTS TO BE REPLACED
RIPRAP
SLOPE
NEW GROUTED ROCK RIPRAP
5-60 INCH Ø GRAVITY OUTLETS
TOE PROTECTION
WESTERN LIMIT OF RIVER EXCAVATION, PLAN 2
1-24 INCH Ø GRAVITY OUTLET
LIMIT OF RIVER EXCAVATION, PLAN 2
WAIMEA RIVER PARK
PLAN 2, EXCAVATION RANK TO -70 FT. MSL
BELT HWY
GRAPHIC SCALE
40' 20' 0 40' 80'
DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI
DETAILS OF PLAN 2
AND PLAN 3
U.S. ARMY ENGINEER DISTRICT, HONOLULU
PLATE C-1



N
PONDING AREA
DRAINAGE
340 ACRES
DRAINAGE AREA
2.8
ACRES
WAIMEA
RIVER

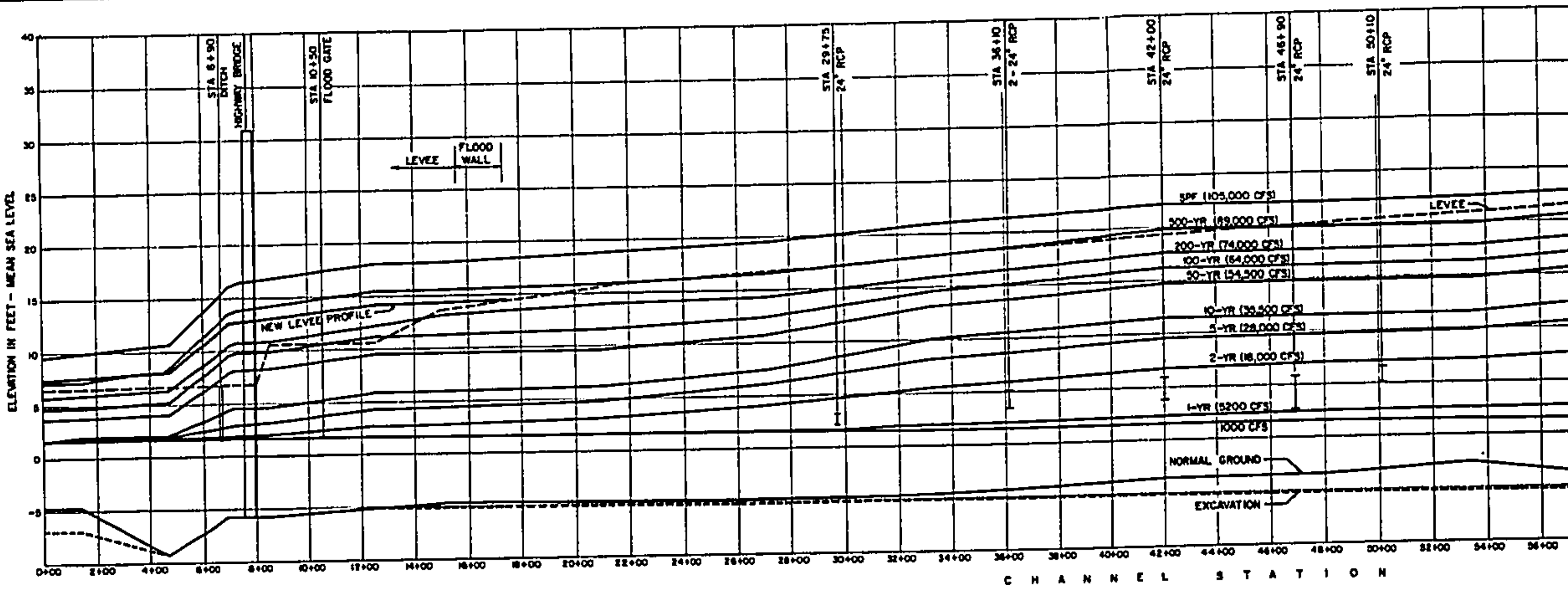


DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI

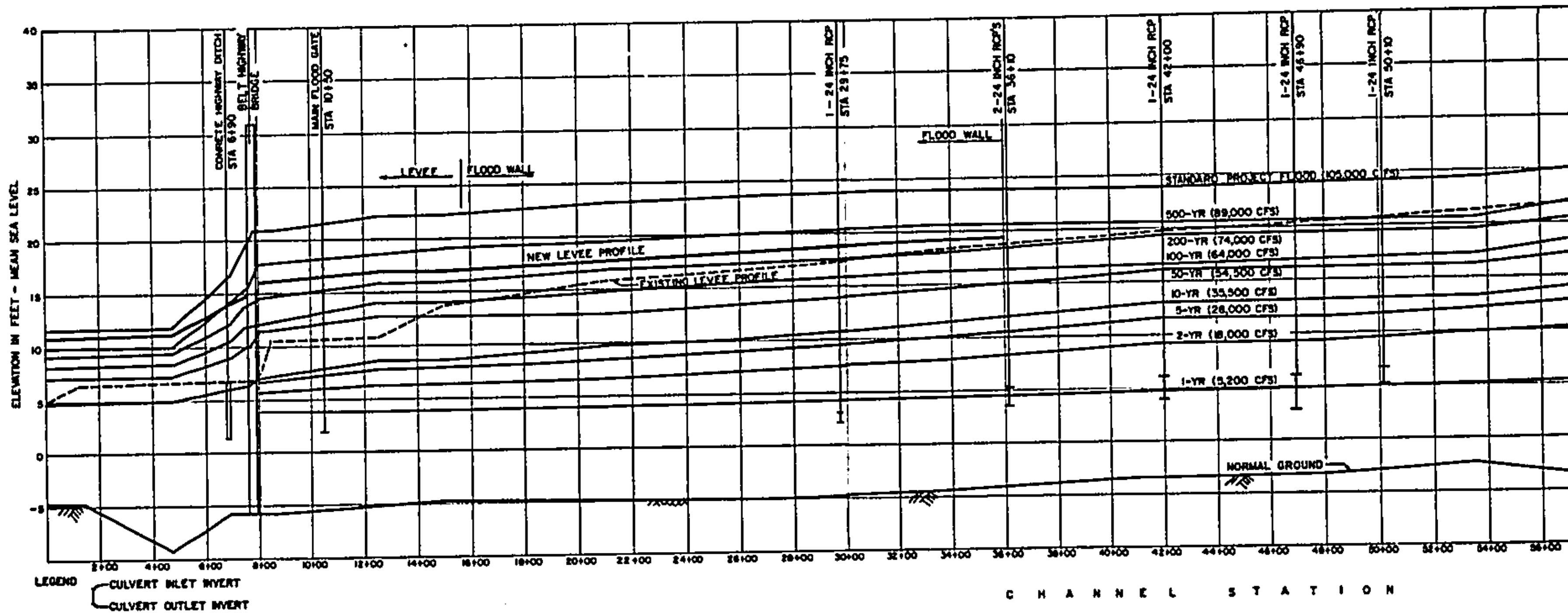
INTERIOR
DRAINAGE AREA

U.S ARMY ENGINEER DISTRICT,
HONOLULU

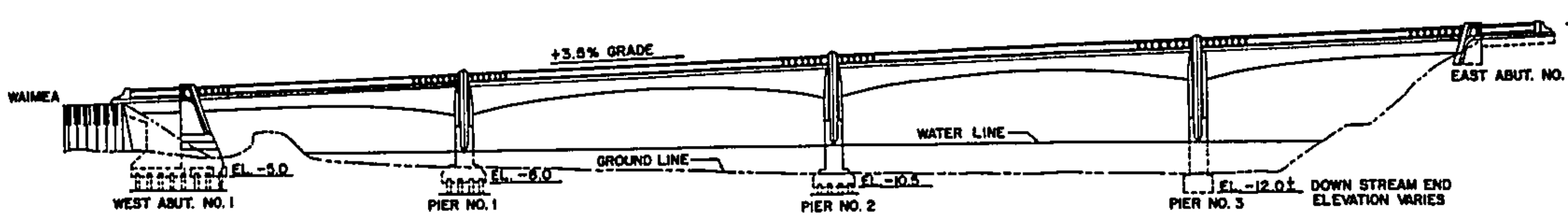
PLATE C-2



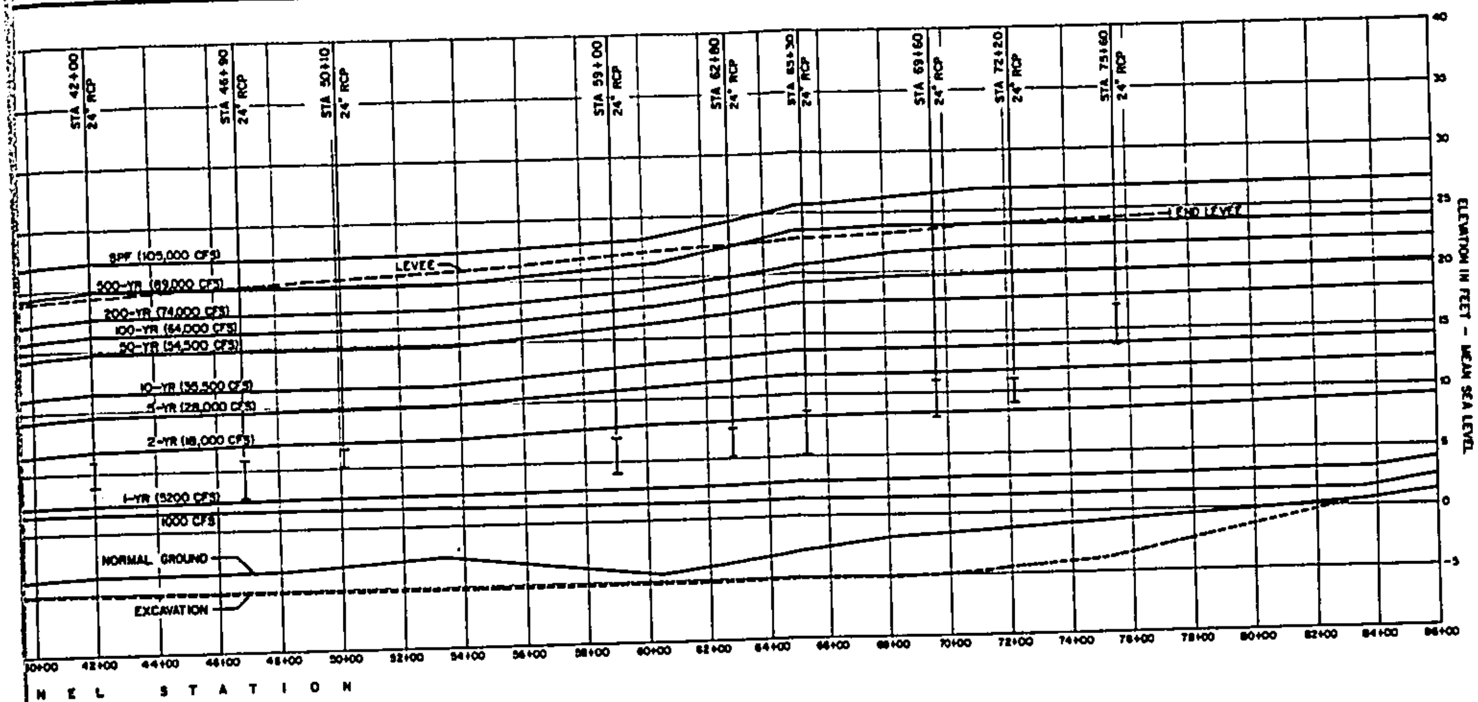
PLAN 2 - CHANNEL DEEPENING AND LEVEE EXTENSION



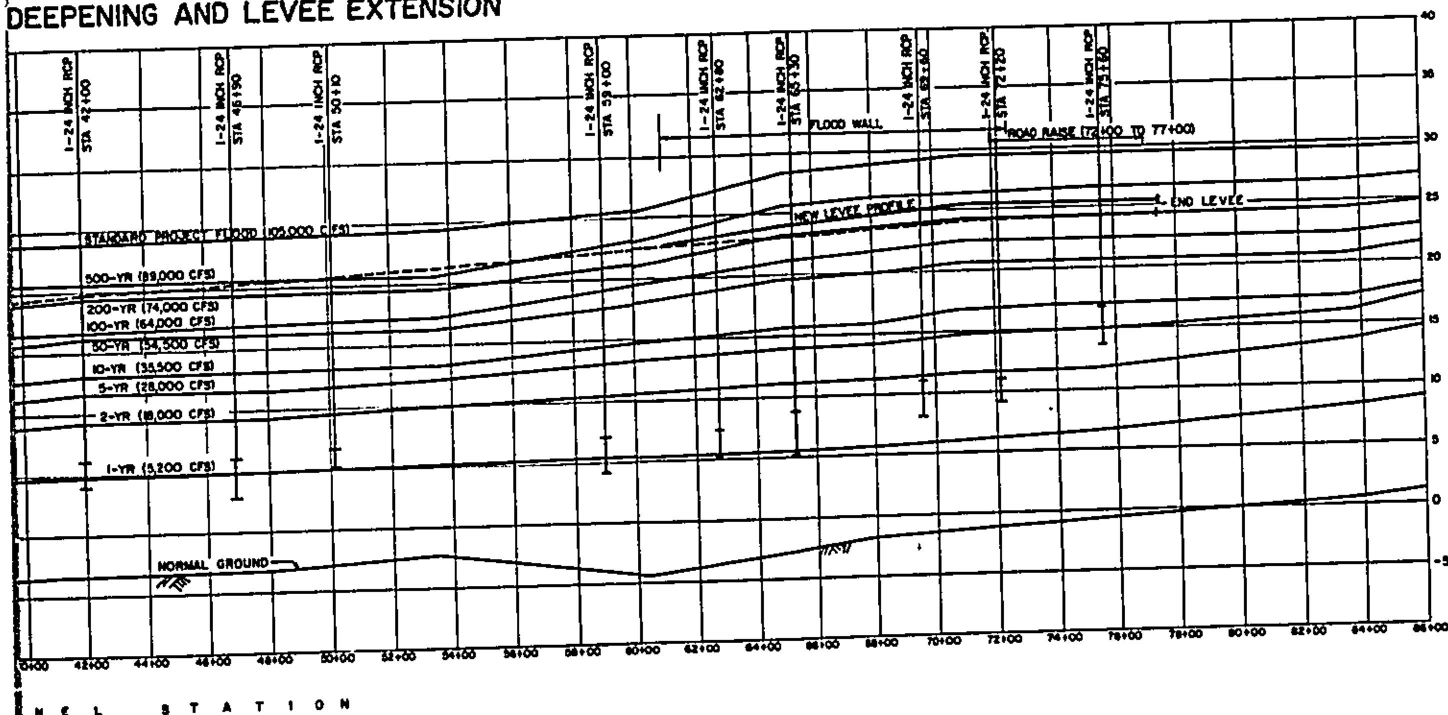
PLAN 3 - FLOOD-WALL, TOE PROTECTION AND LEVEE EXTENSION



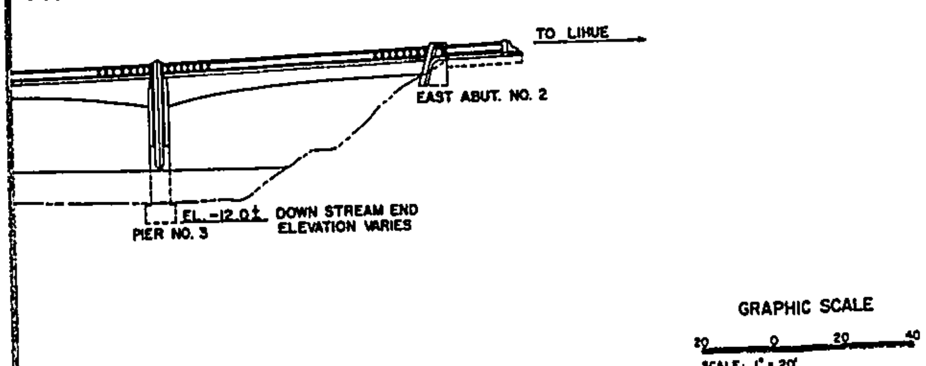
BRIDGE SECTION
SCALE: 1" = 20'



DEEPENING AND LEVEE EXTENSION



PROTECTION AND LEVEE EXTENSION

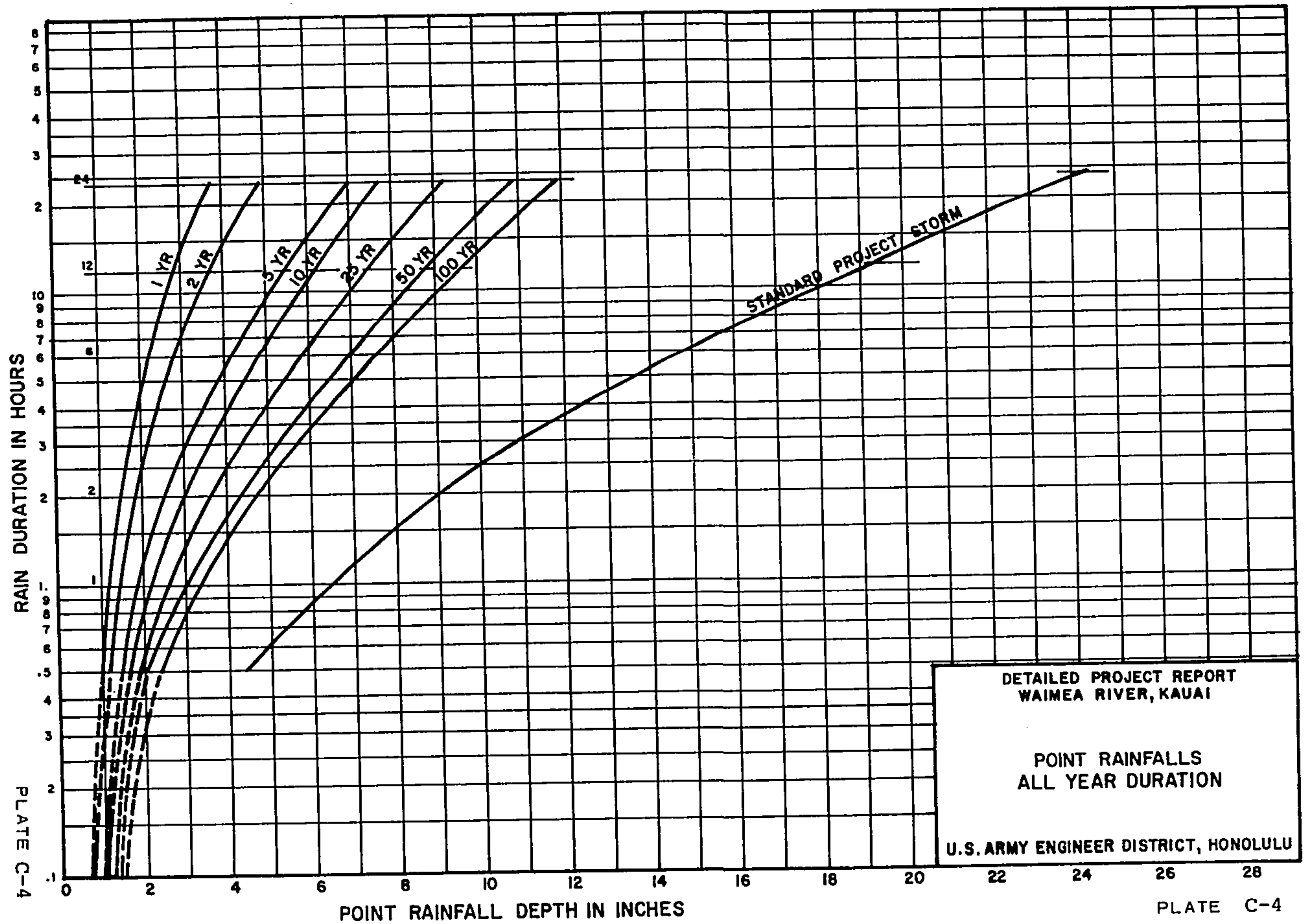


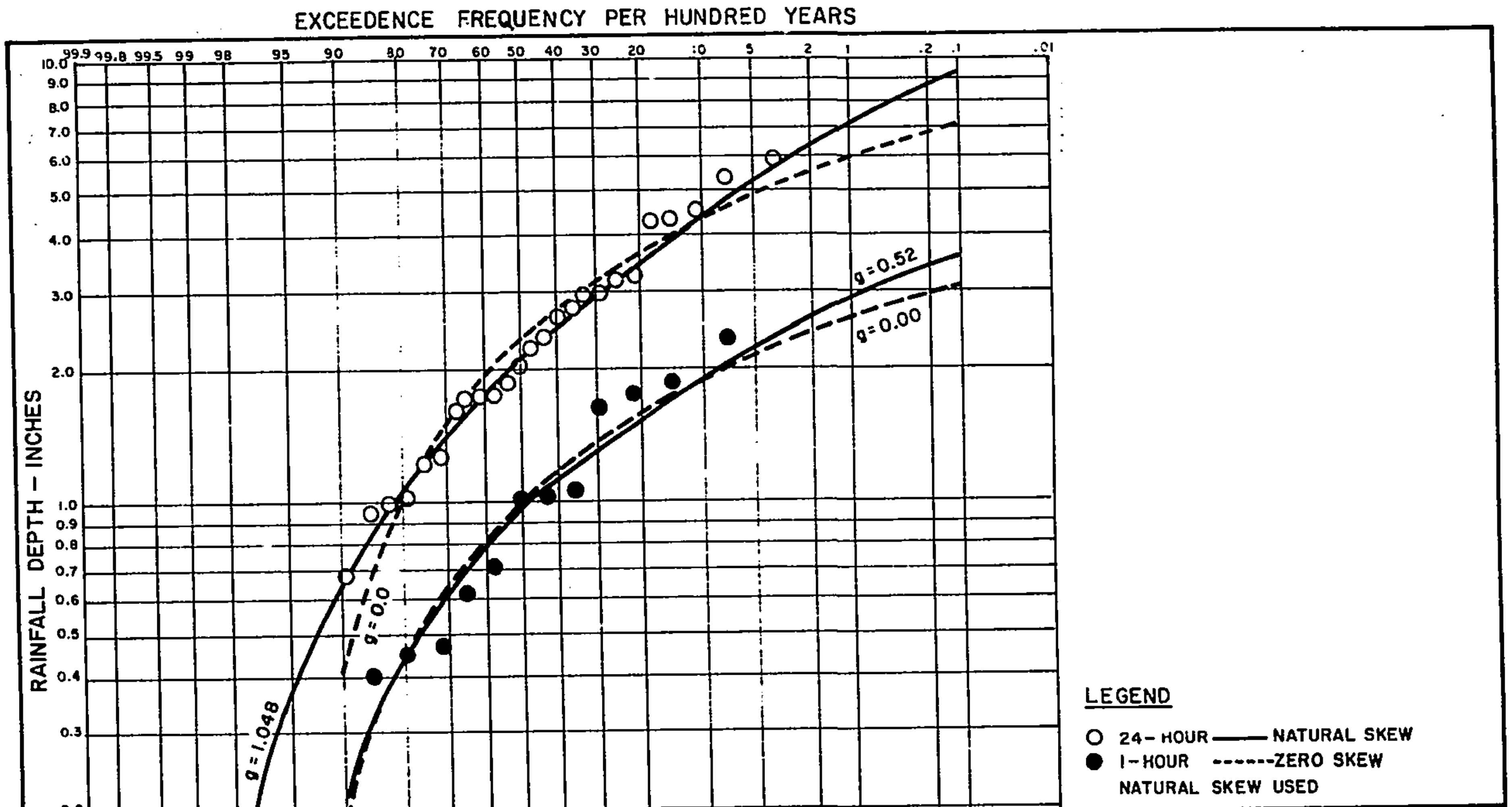
DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI

PLANS 2 & 3 WATER SURFACE PROFILES AND BRIDGE SECTION

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE C-3


1 YR
2 YR
5 YR
10 YR
25 YR
50 YR
100 YR
STANDARD PROJECT STORM
RAIN DURATION IN HOURS
POINT RAINFALL DEPTH IN INCHES
DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI
POINT RAINFALLS
ALL YEAR DURATION
U.S. ARMY ENGINEER DISTRICT, HONOLULU

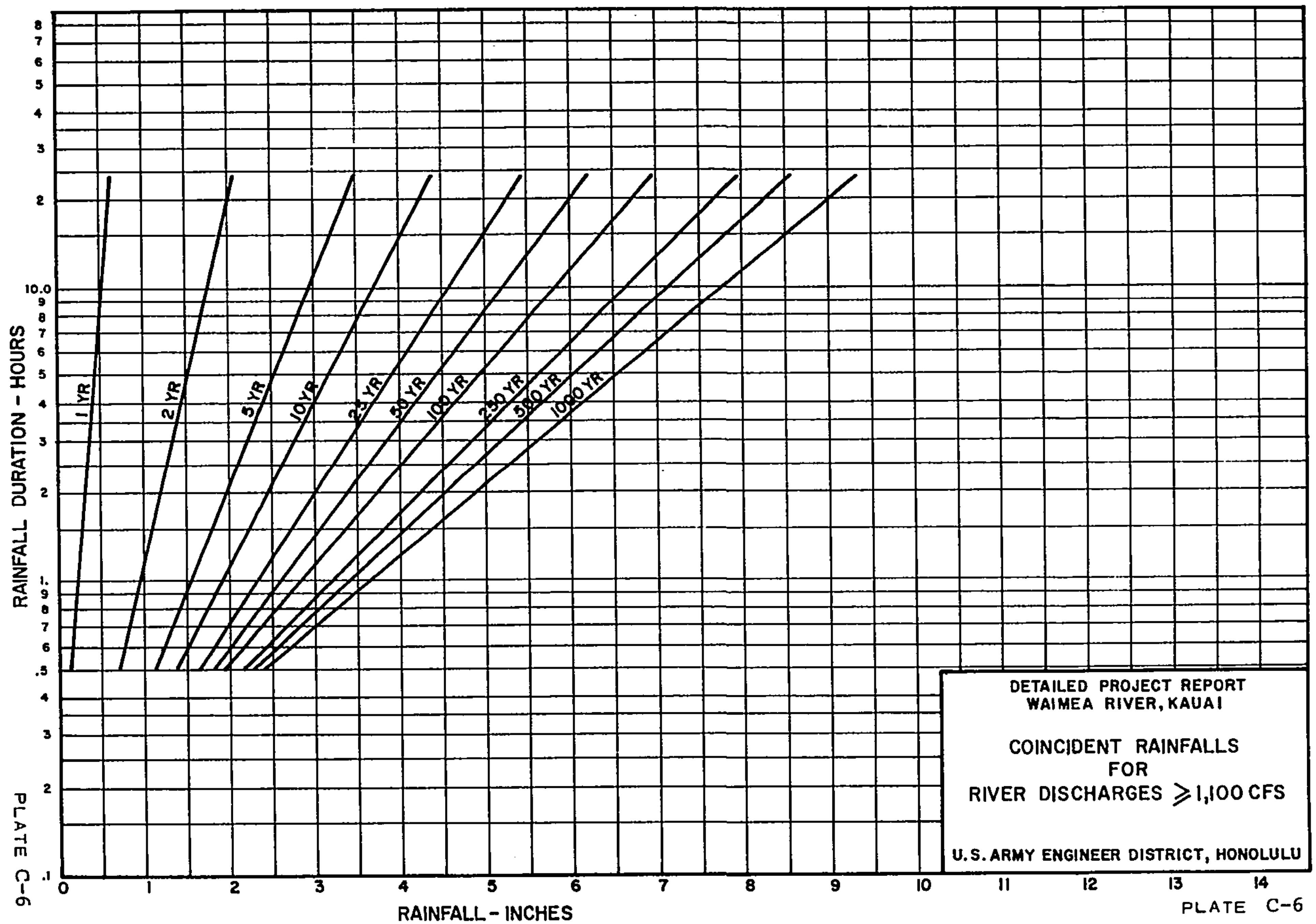


DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI

DEPENDENT
COINCIDENT RAINFALLS

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE C-5



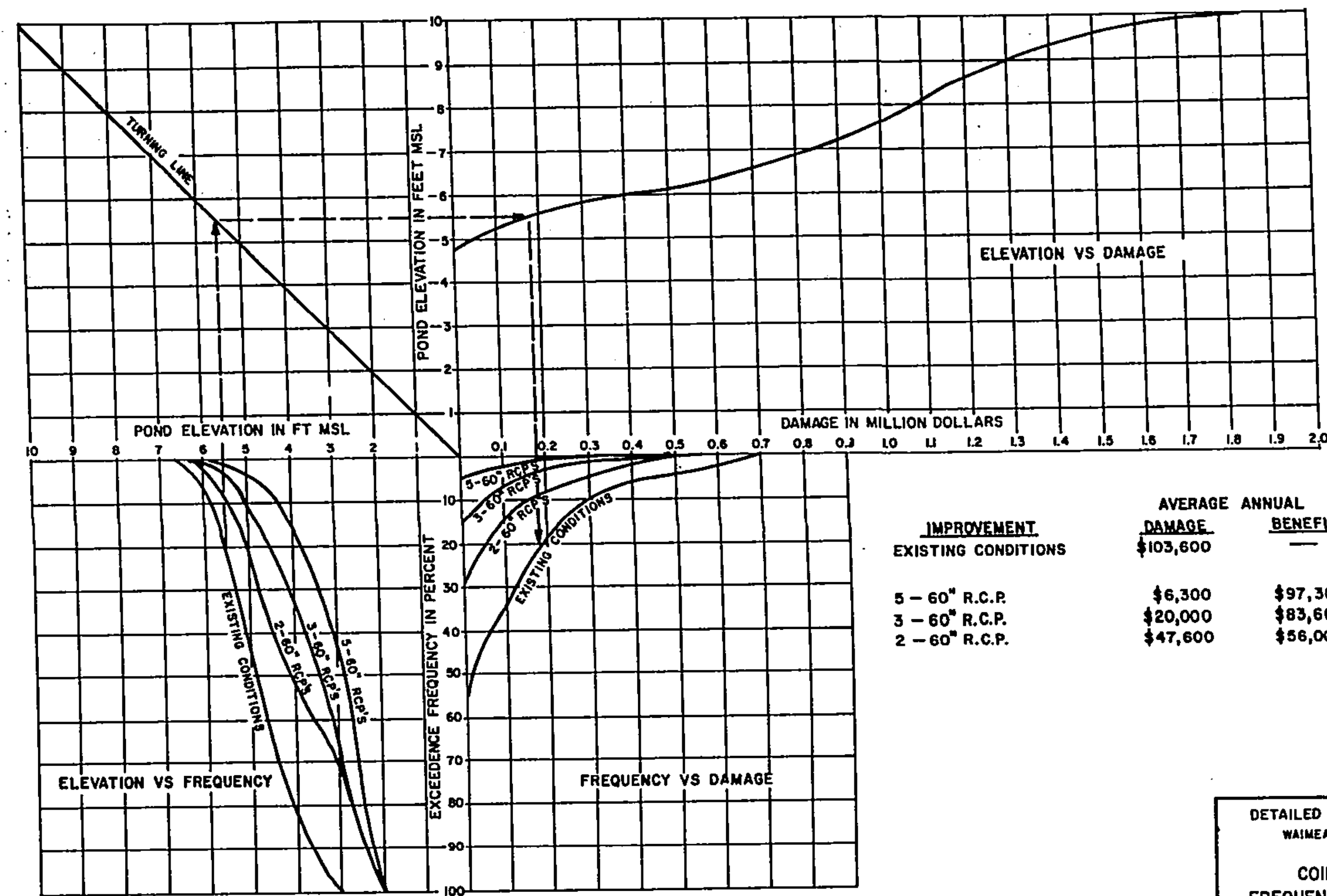
DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI

COINCIDENT RAINFALLS
FOR
RIVER DISCHARGES ≥ 1,100 CFS

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE C-6

PLATE C-6

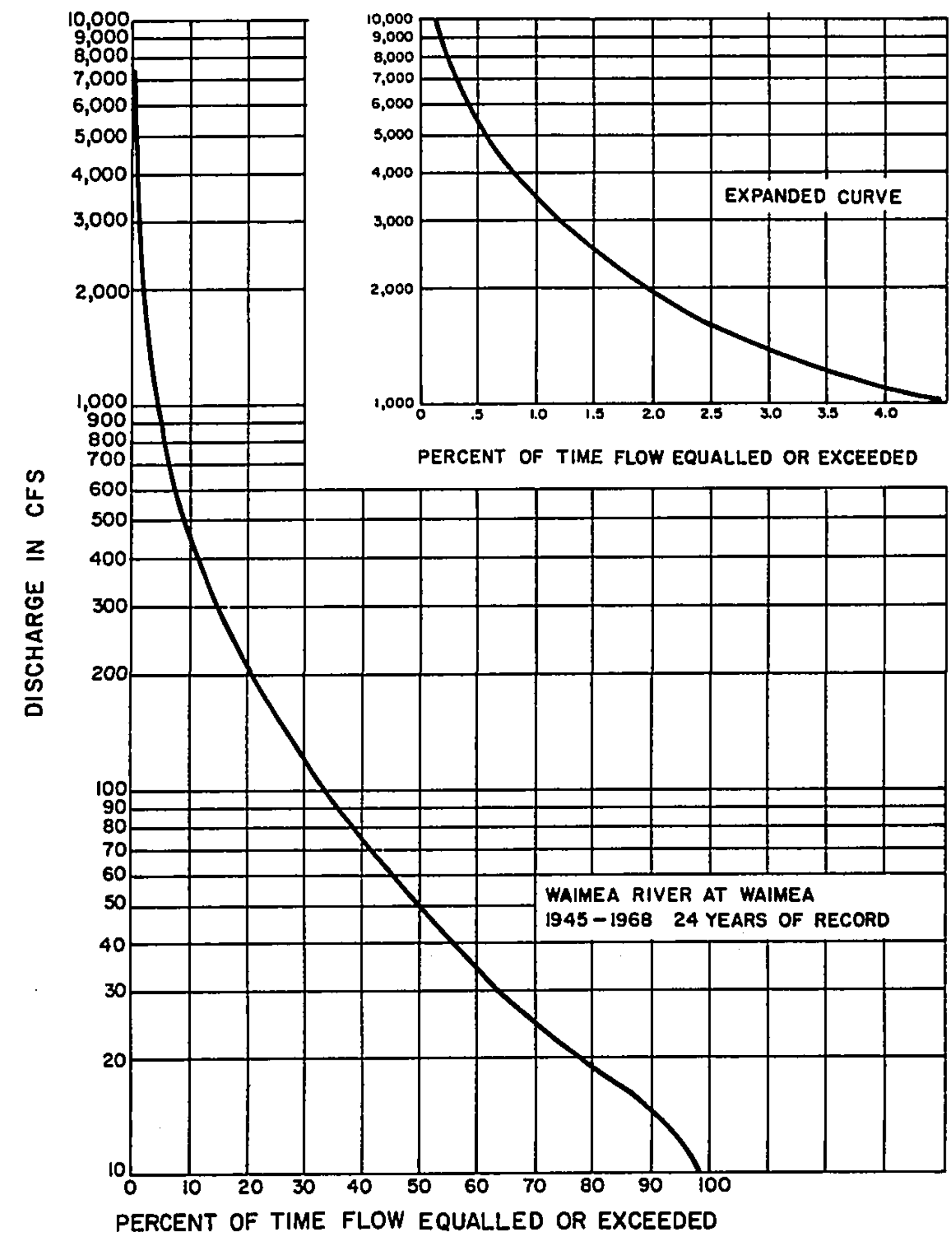


IMPROVEMENT	AVERAGE ANNUAL DAMAGE	AVERAGE ANNUAL BENEFIT
EXISTING CONDITIONS	$103,600	—
5 – 60" R.C.P.	$6,300	$97,300
3 – 60" R.C.P.	$20,000	$83,600
2 – 60" R.C.P.	$47,600	$56,000

DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI

COINCIDENTAL FREQUENCY ANALYSIS

U.S. ARMY ENGINEER DISTRICT, HONOLULU

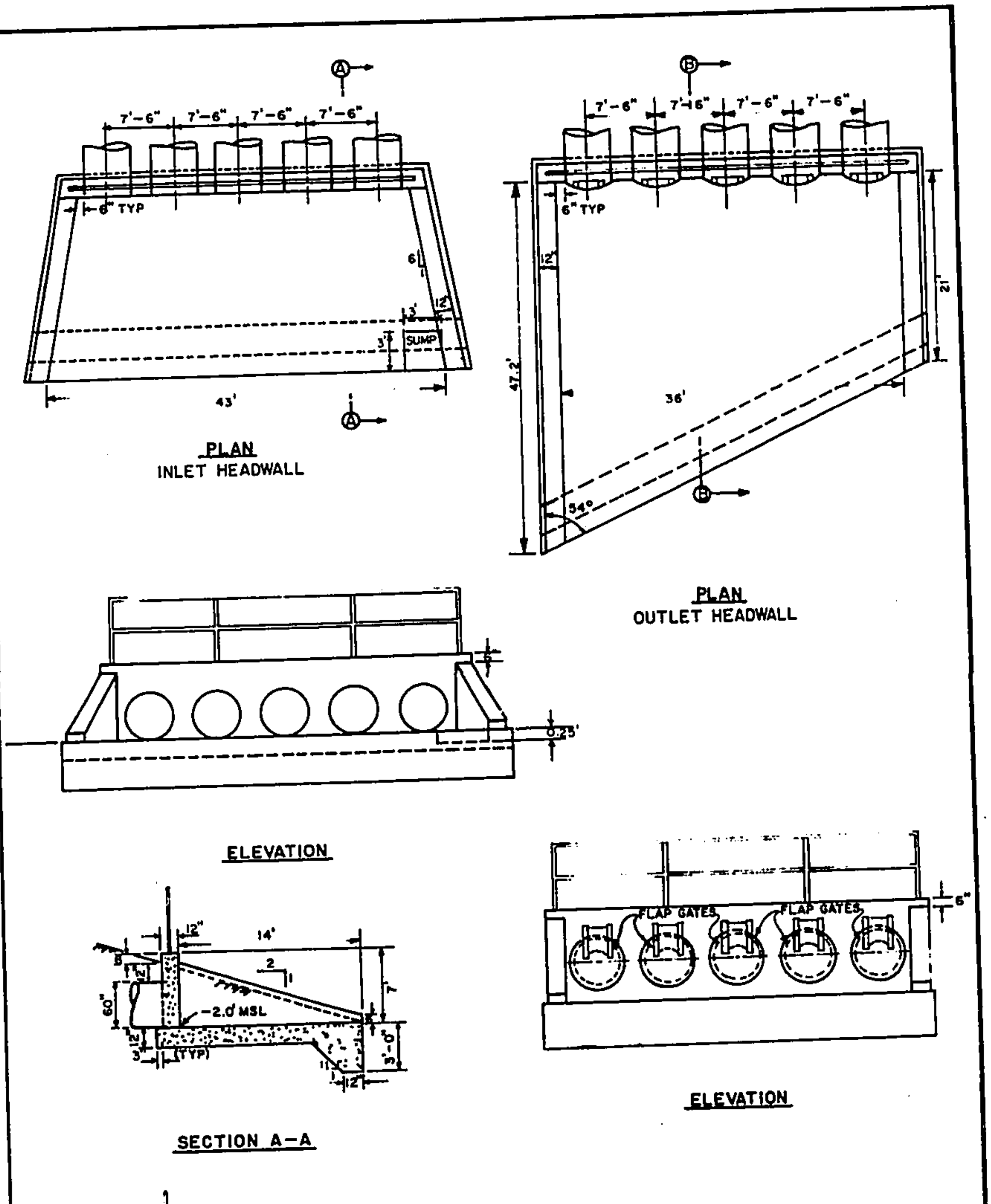


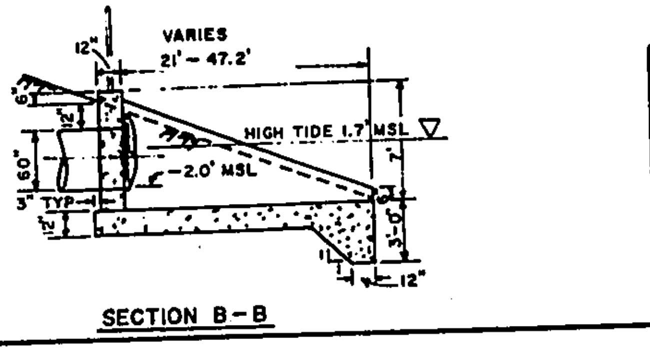
DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI

ALL YEAR
DISCHARGE – DURATION CURVE

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE C-8



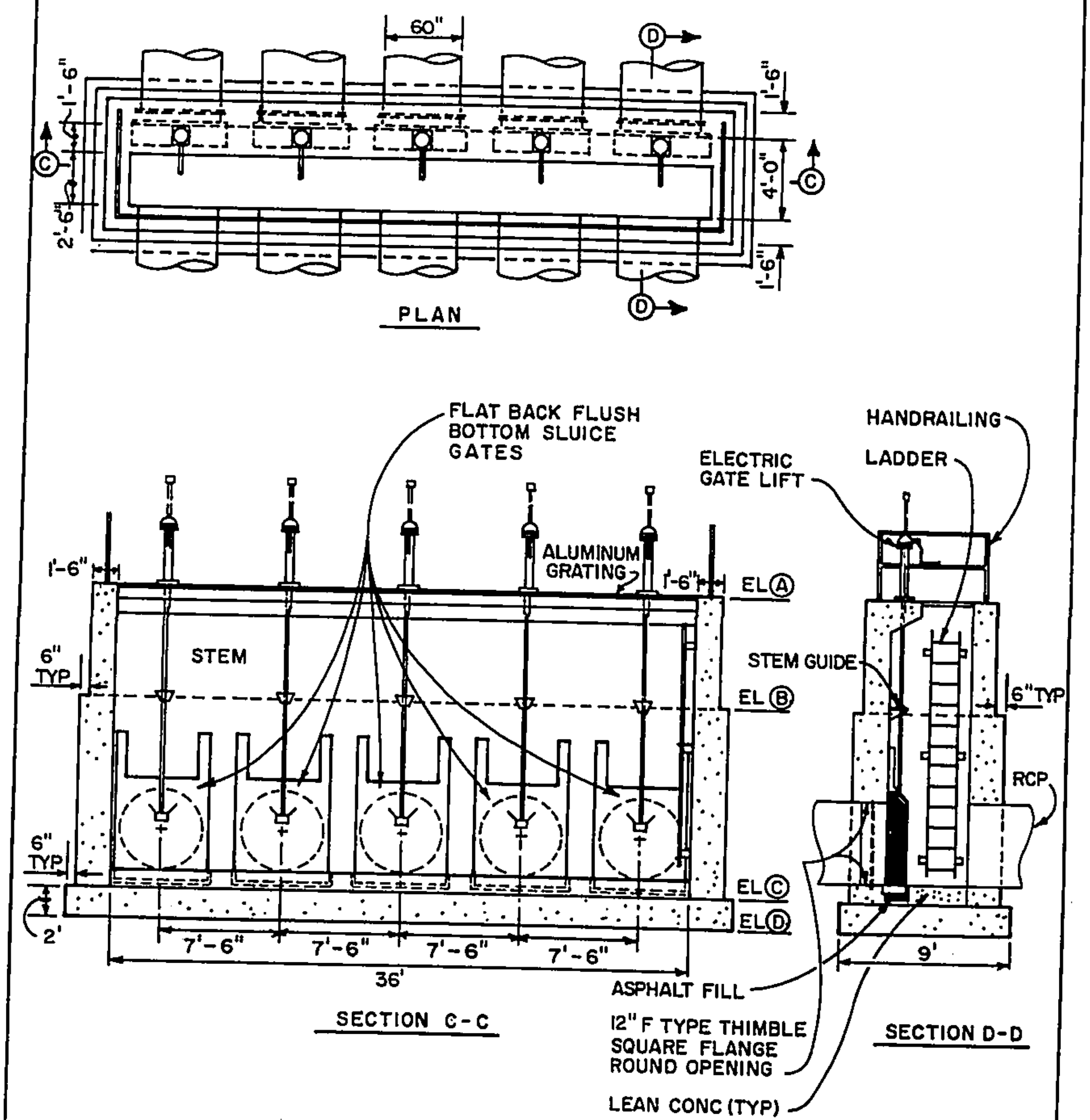


DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI

NEW FLOOD GATE
STA 10+50
INLET AND OUTLET HEADWALLS

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE C-9



ELEV Ⓐ 16.5 FT MSL

ELEV Ⓑ 11.0 FT MSL

ELEV Ⓒ -3.0 FT MSL

ELEV Ⓓ -5.0 FT MSL

DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI

NEW FLOOD GATE
STA 10+50
GATE WELL

U.S. ARMY ENGINEER DISTRICT, HONOLULU

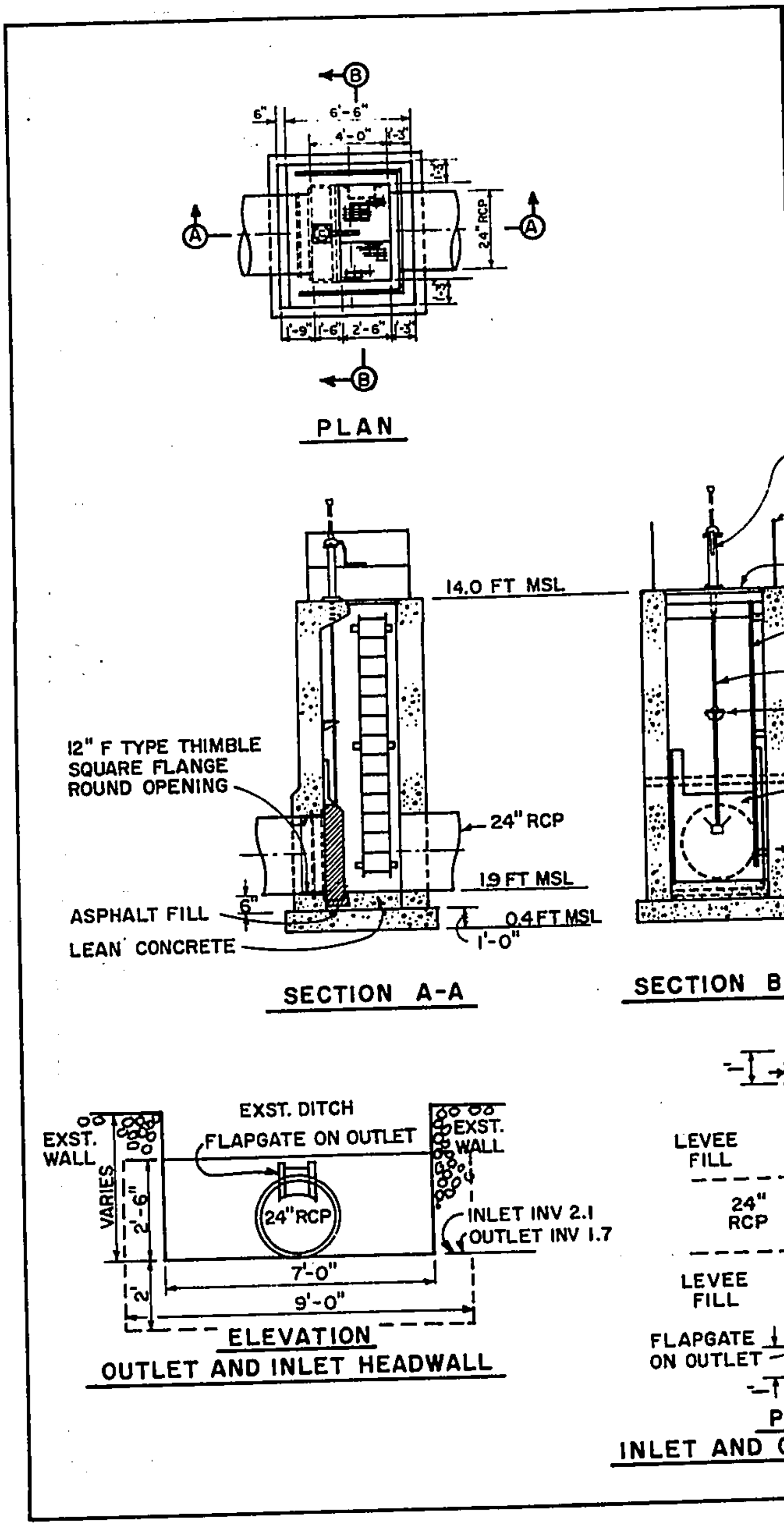
PLATE C-10

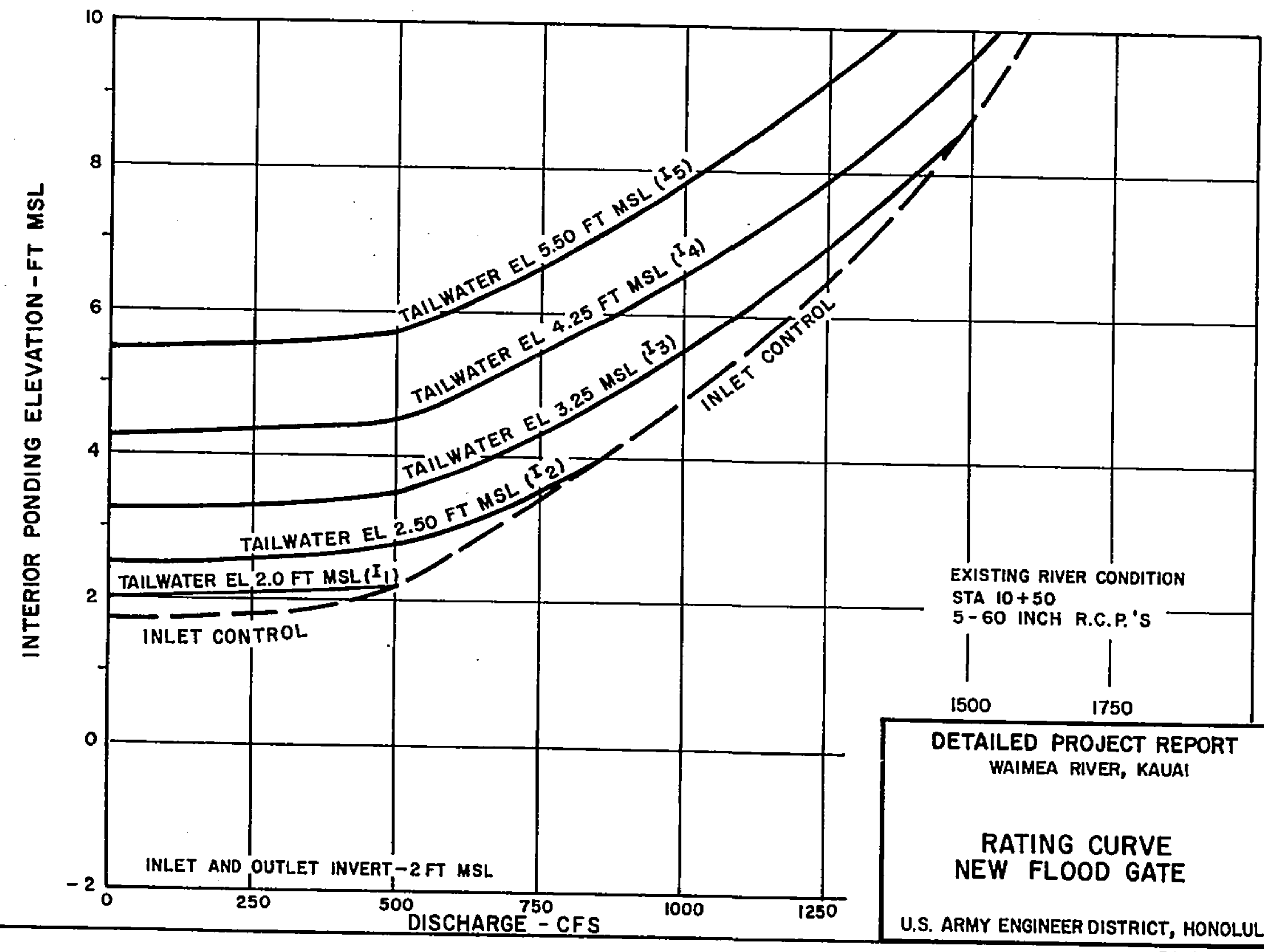
DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI

24" GATEWELL
STA 6+90
GATE WELL AND HEADWALL

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE C-11

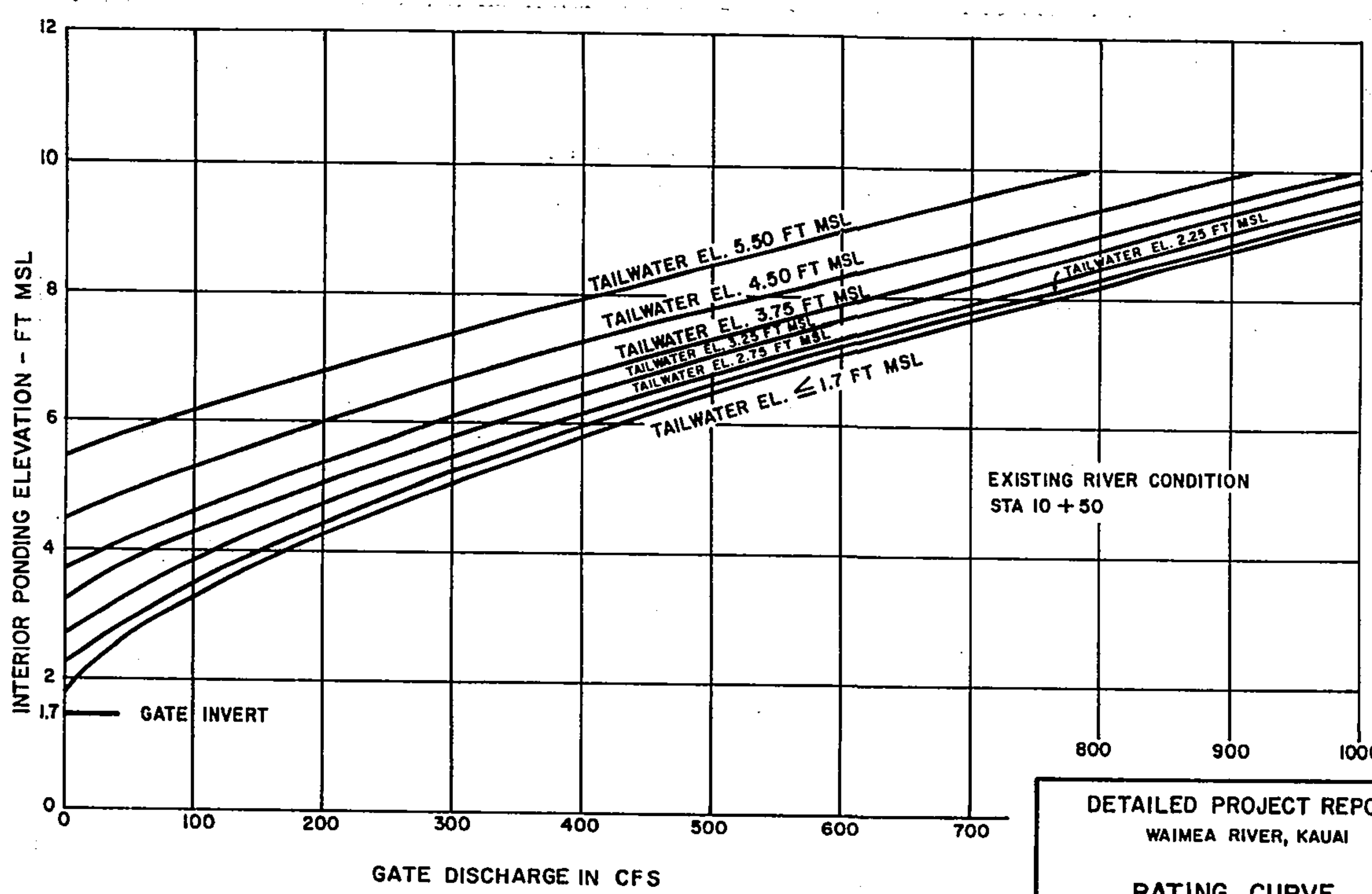




DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI

RATING CURVE
NEW FLOOD GATE

U.S. ARMY ENGINEER DISTRICT, HONOLULU

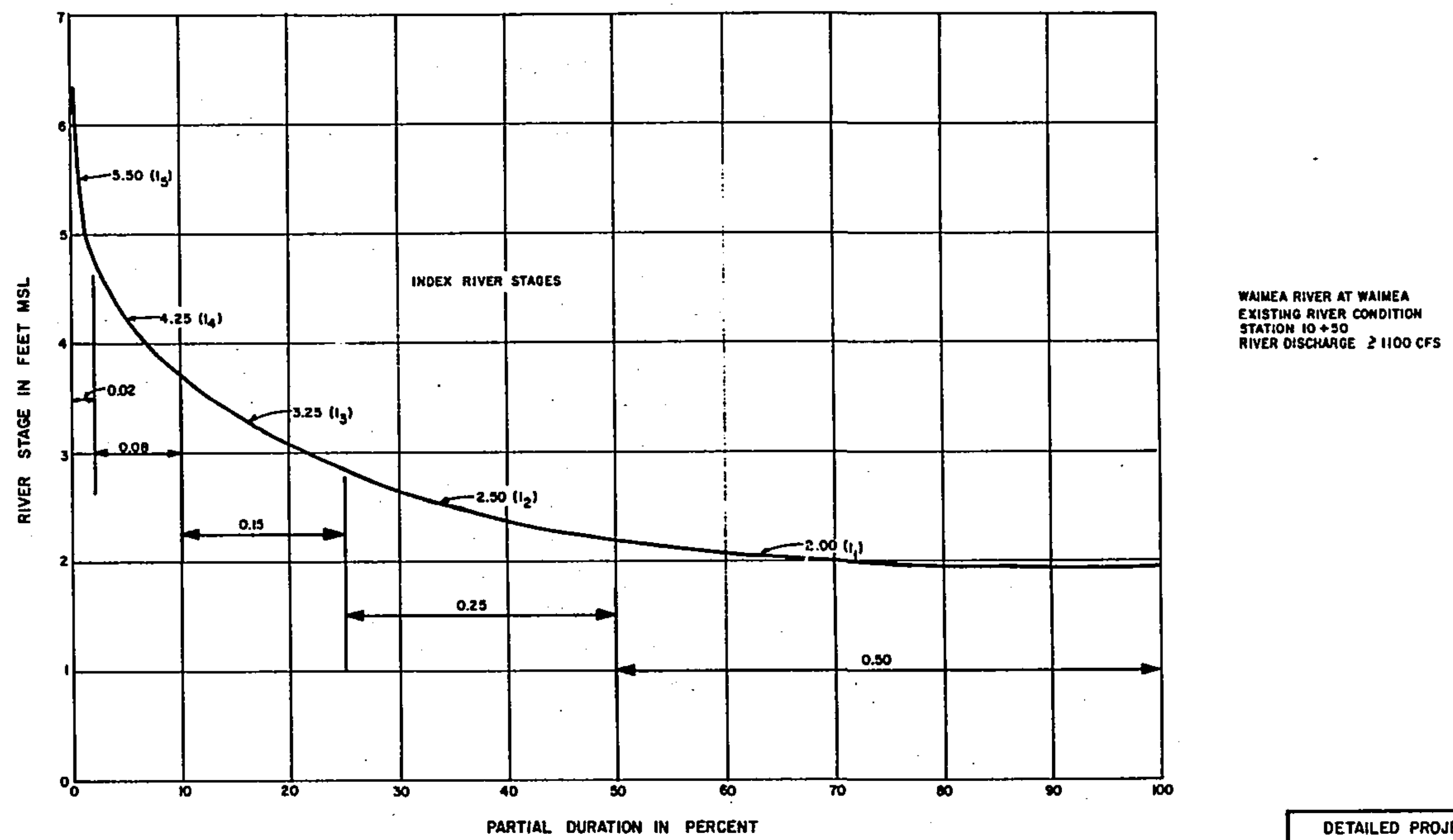


DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI

RATING CURVE
EXISTING FLOOD GATE
4 - 4' x 9' GATES

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE C-13

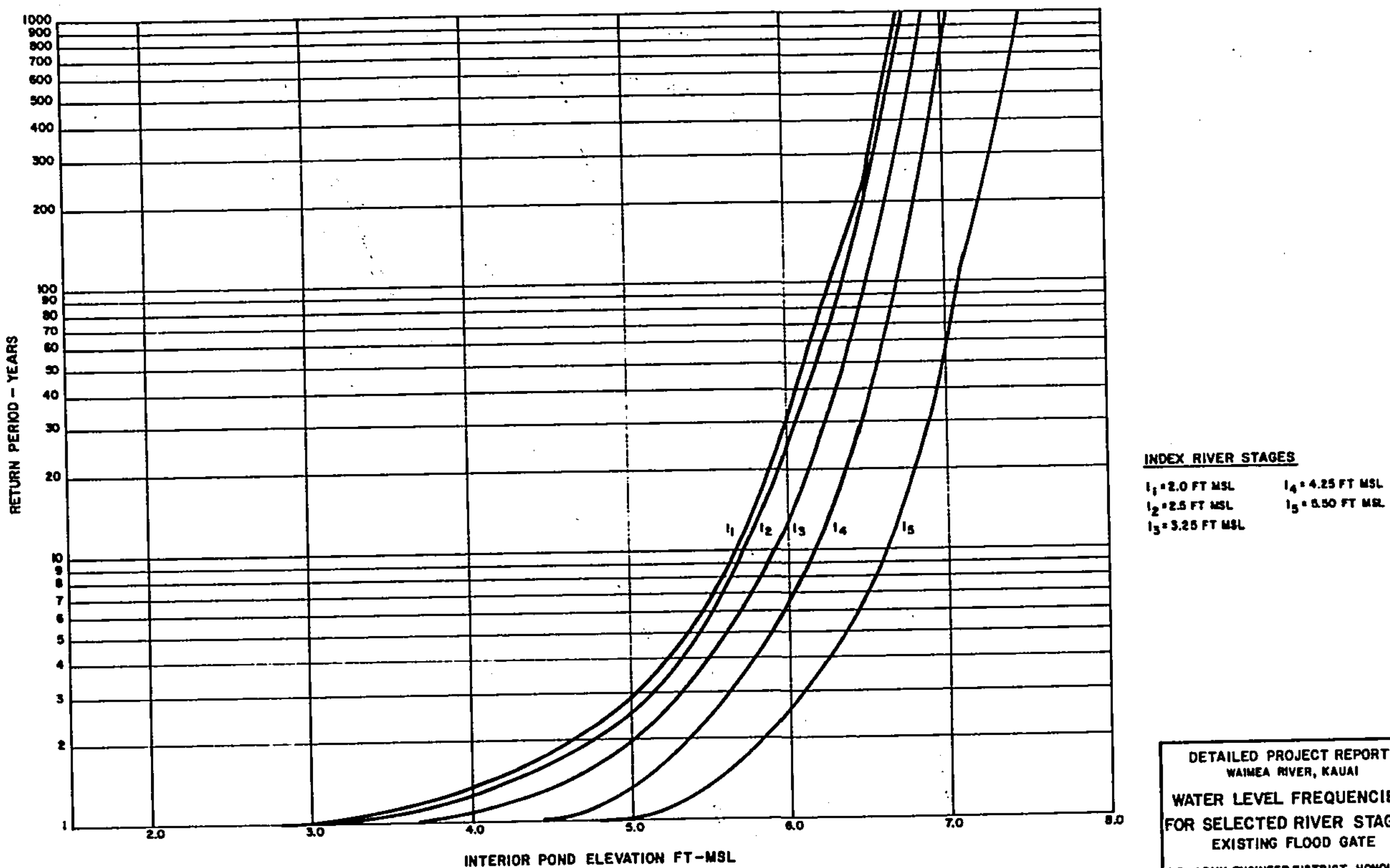


DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI

PARTIAL STAGE-DURATION CURVE

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE C-14

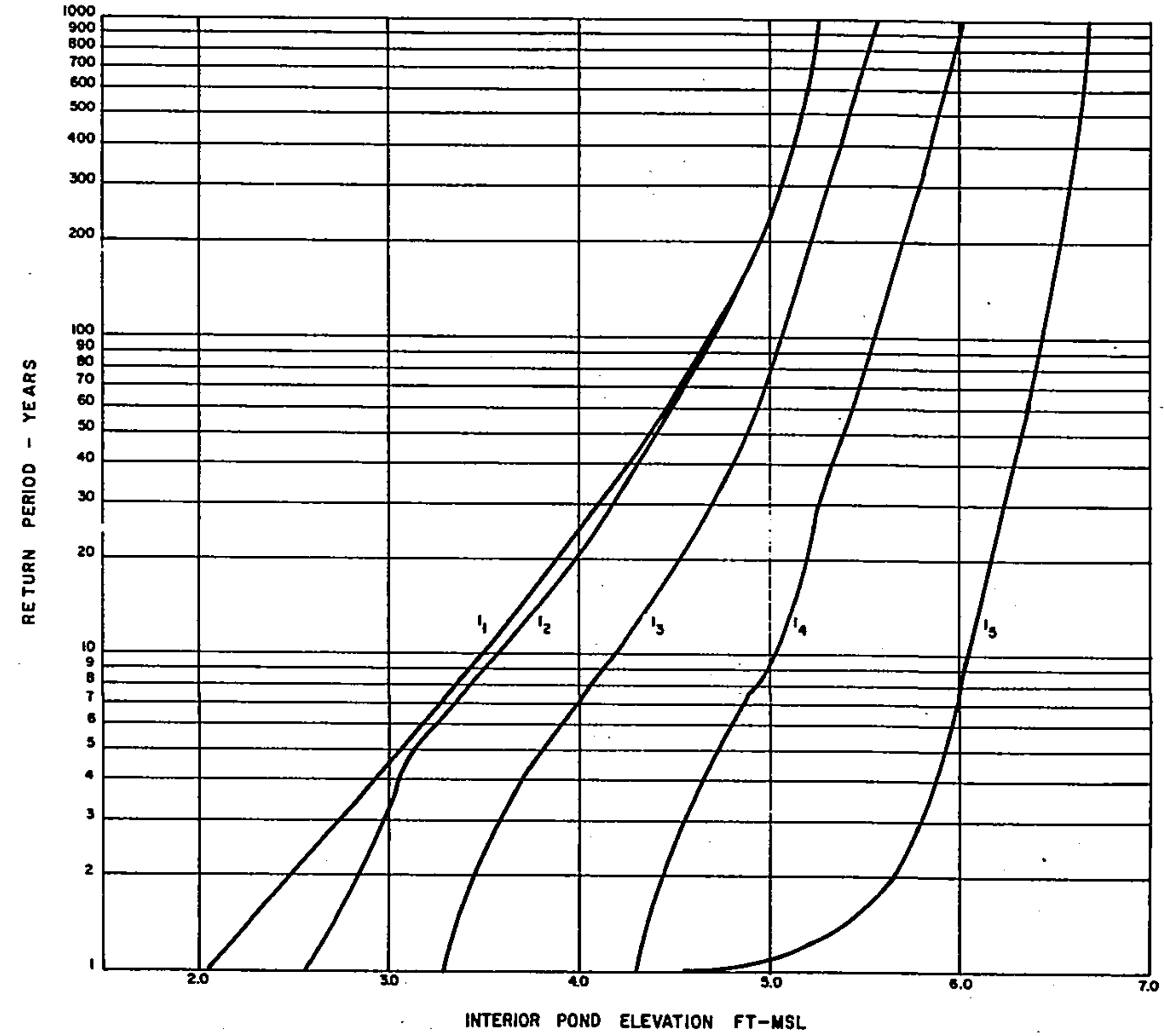


DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI

WATER LEVEL FREQUENCIES
FOR SELECTED RIVER STAGES
EXISTING FLOOD GATE

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE C-15



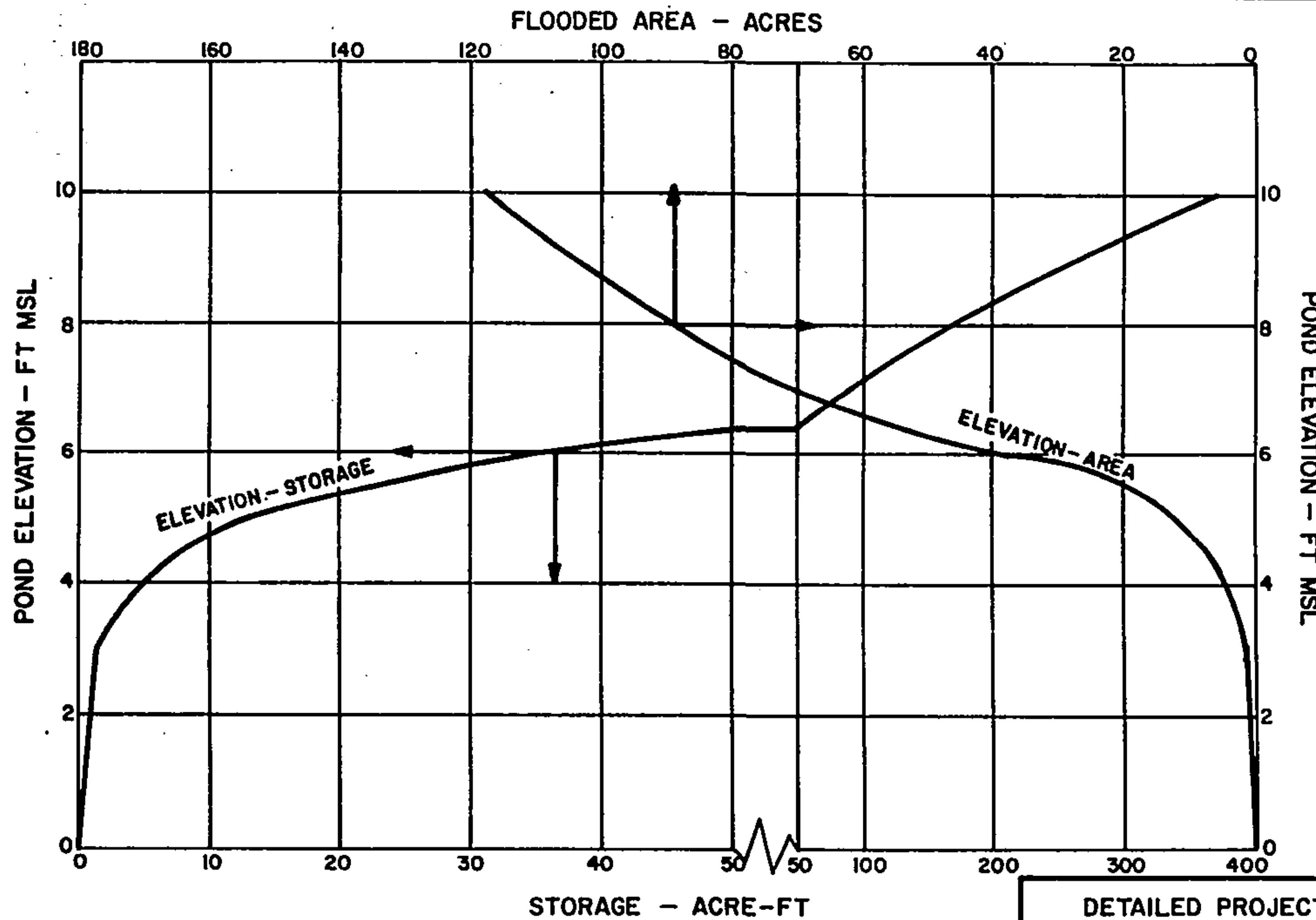
INDEX RIVER STAGES

I_1 = 2.0 FT MSL
I_2 = 2.5 FT MSL
I_3 = 3.25 FT MSL
I_4 = 4.25 FT MSL
I_5 = 5.50 FT MSL

DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI

WATER LEVEL FREQUENCIES FOR SELECTED RIVER STAGES NEW FLOOD GATE
(5 60-INCH REINFORCED CONCRETE PIPES)

U.S. ARMY ENGINEER DISTRICT, HONOLULU

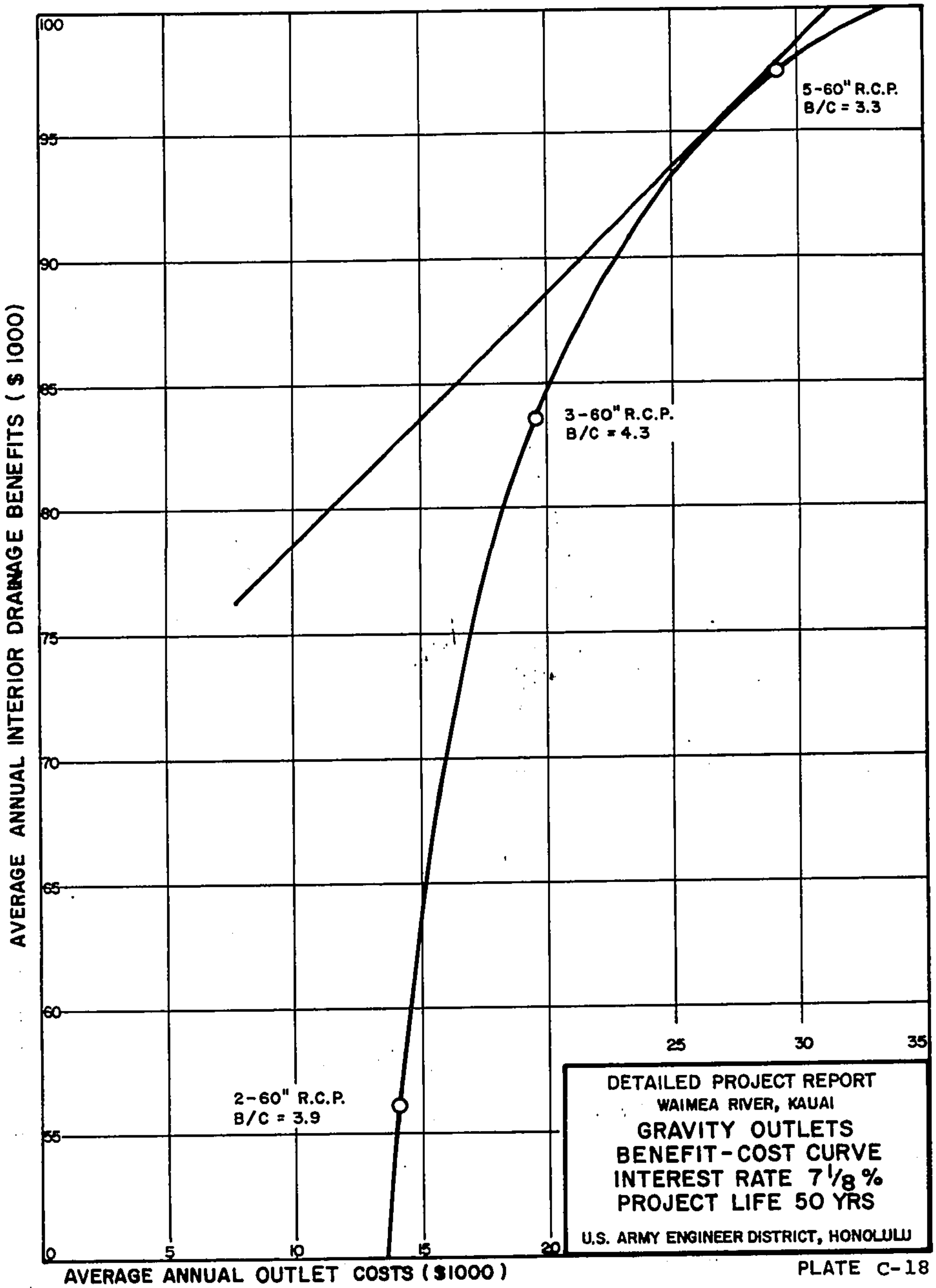


DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI

ELEVATION VS STORAGE
ELEVATION VS FLOODED AREA

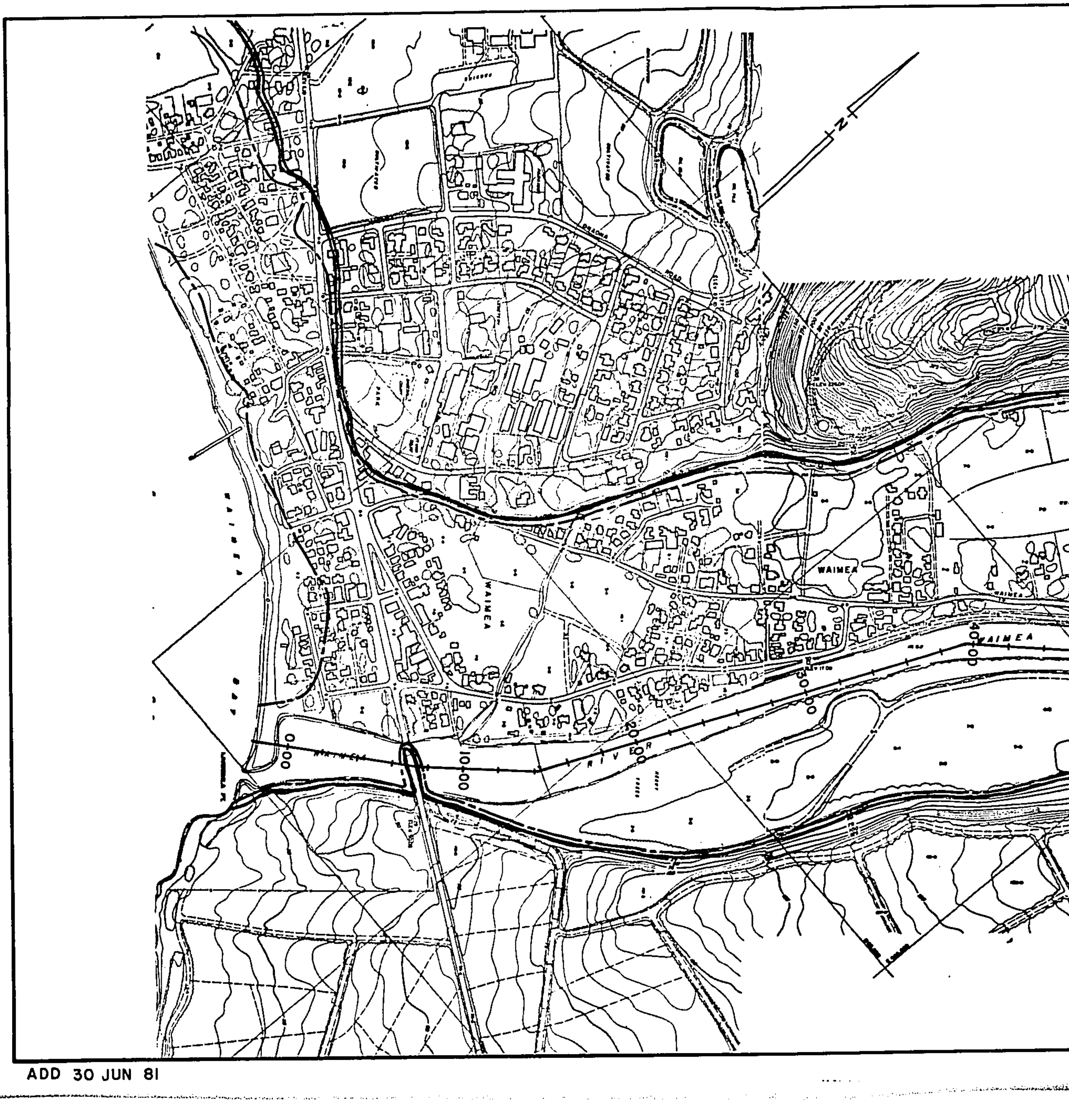
U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE C-17



100
95
90
85
80
75
70
65
60
55
0
5
10
15
20
25
30
35
AVERAGE ANNUAL INTERIOR DRAINAGE BENEFITS ($ 1000)
AVERAGE ANNUAL OUTLET COSTS ($1000)
5-60" R.C.P.
B/C = 3.3
3-60" R.C.P.
B/C = 4.3
2-60" R.C.P.
B/C = 3.9
DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI
GRAVITY OUTLETS
BENEFIT-COST CURVE
INTEREST RATE 7 1/8 %
PROJECT LIFE 50 YRS
U.S. ARMY ENGINEER DISTRICT, HONOLULU

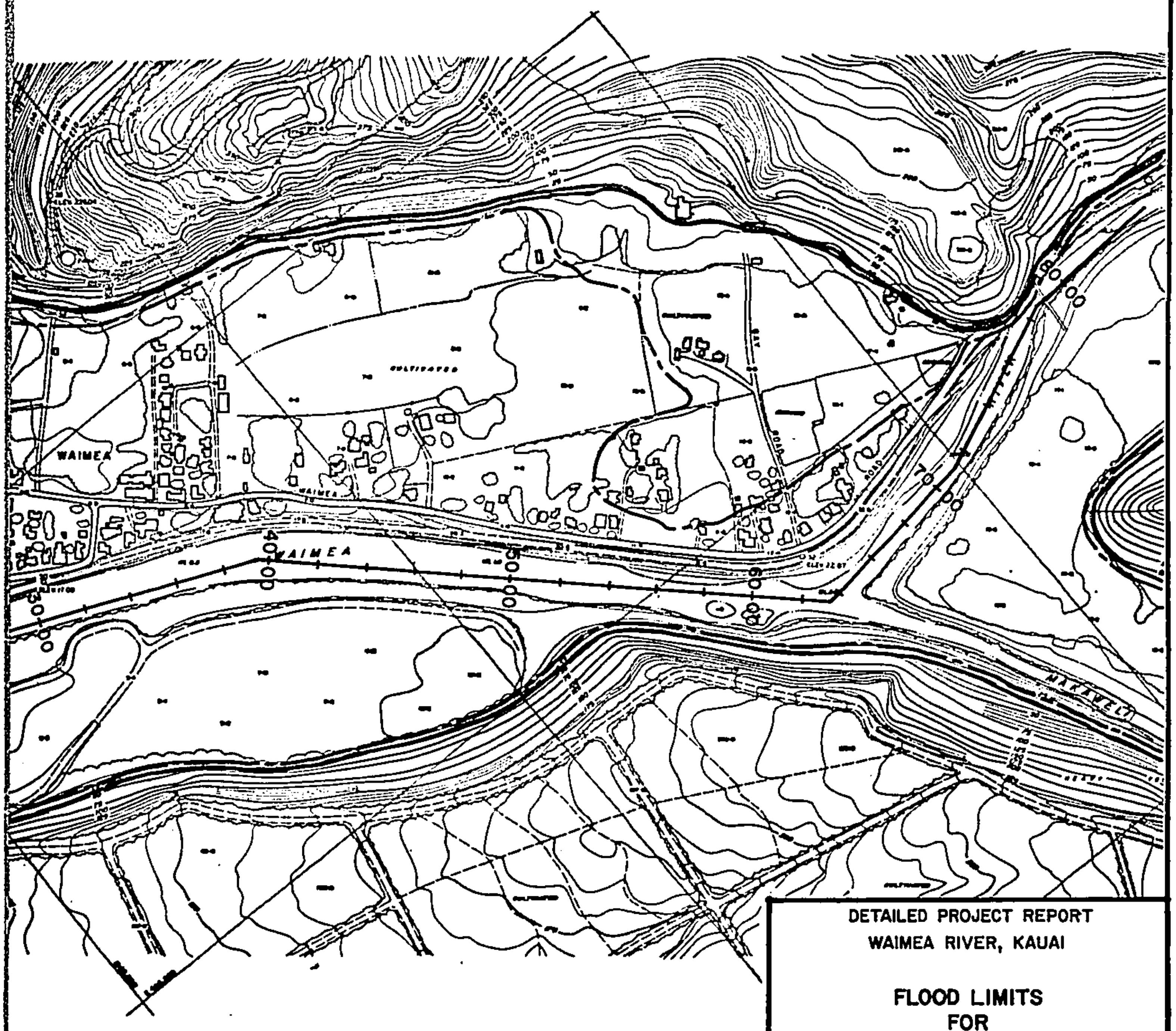
PLATE C-18



ADD 30 JUN 81

L E G E N D

———————	STANDARD PROJECT FLOOD
———•———	500-YEAR FLOOD

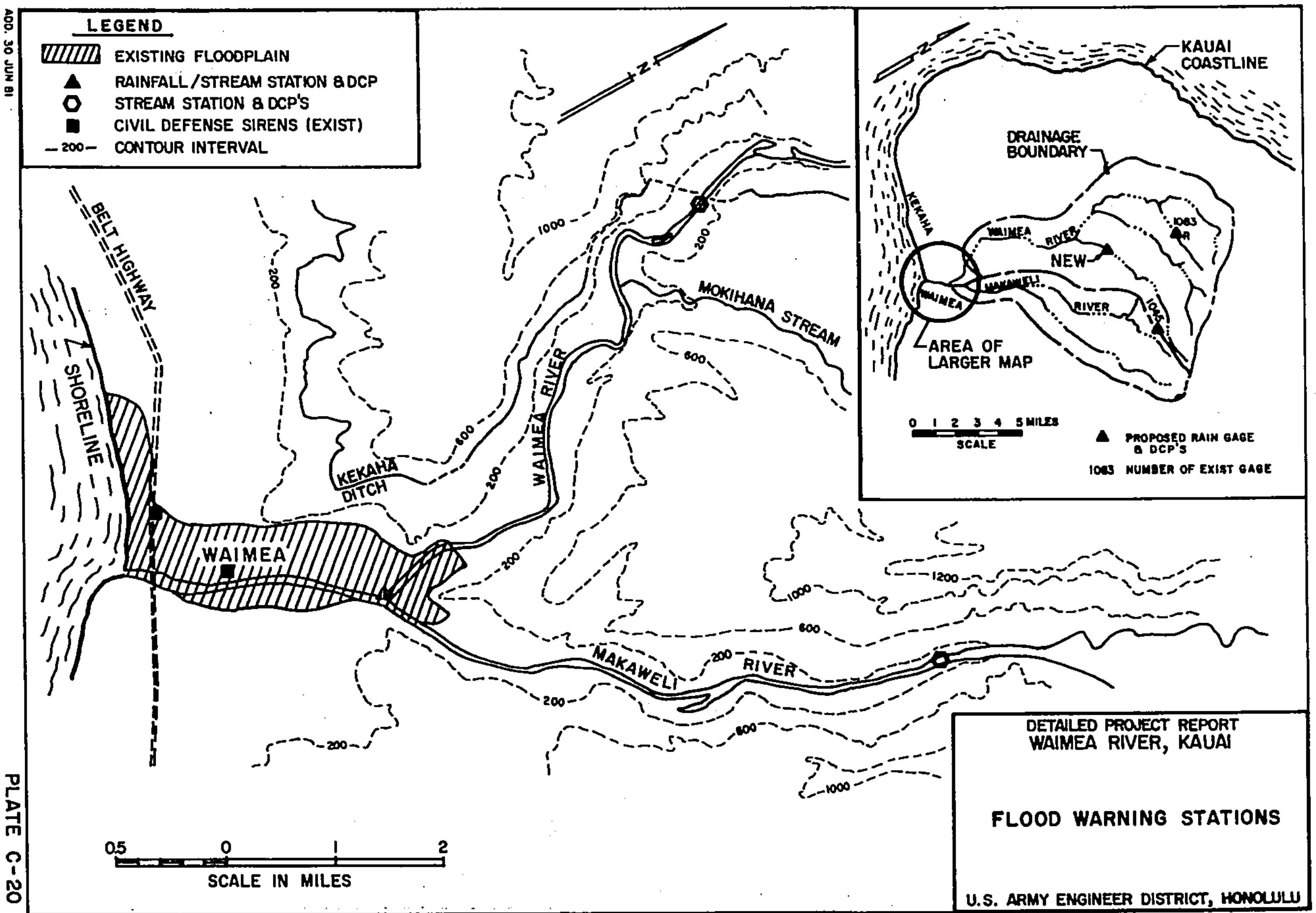


0 200' 400' 600'
SCALE IN FEET

DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI

FLOOD LIMITS FOR OVERTOPPING THE DESIGN LEVEE

U.S. ARMY ENGINEER DISTRICT, HONOLULU



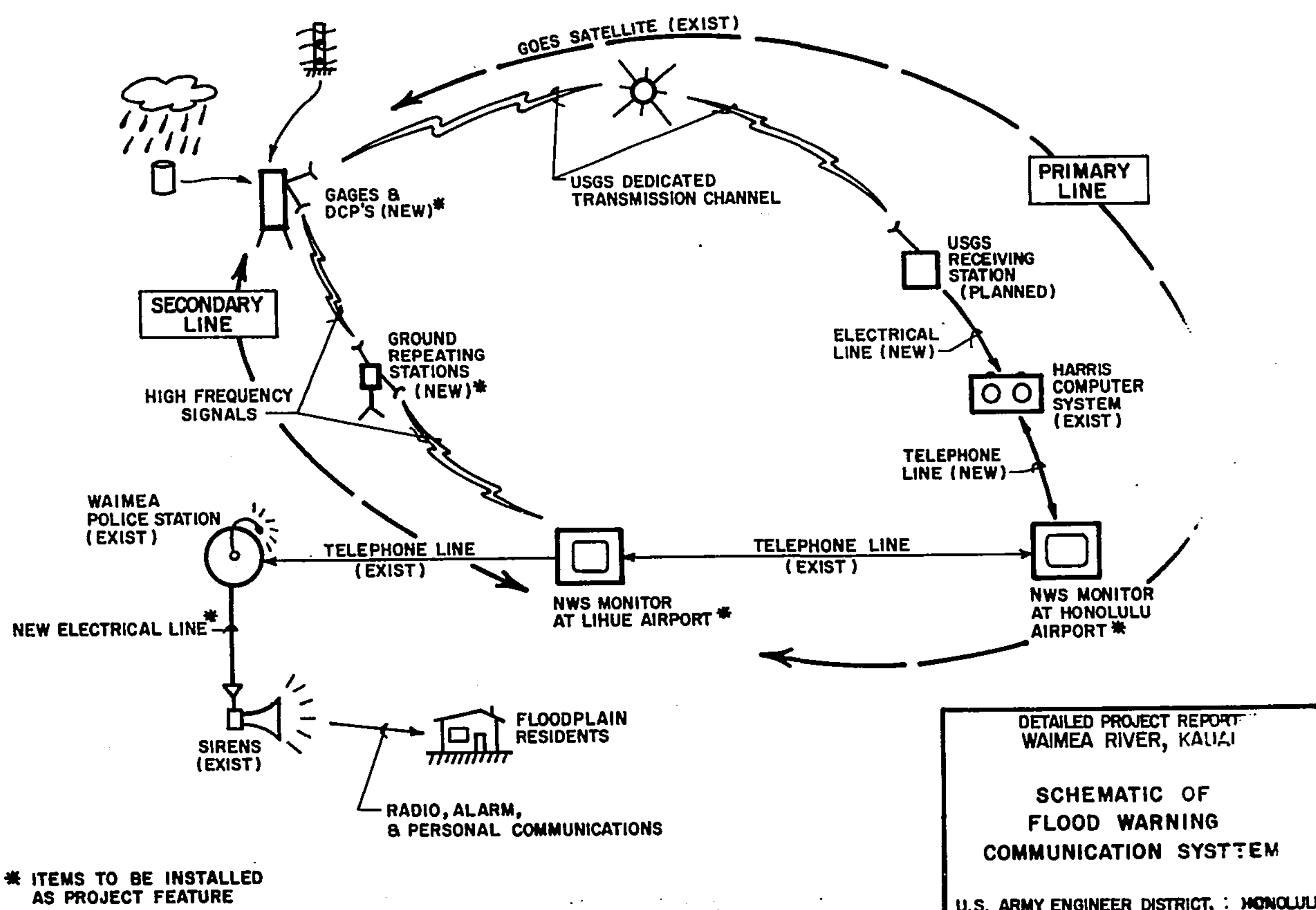
DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI

FLOOD WARNING STATIONS

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE C-20

ADD. 30 JUN 81



DETAILED PROJECT REPORT
WAIMEA RIVER, KAUAI

SCHEMATIC OF FLOOD WARNING COMMUNICATION SYSTTEM

U.S. ARMY ENGINEER DISTRICT, : HONOLULU

PLATE C-21

WAIMEA RIVER FLOOD CONTROL
WAIMEA, KAUAI

ECONOMIC

APPENDIX D

ECONOMIC APPENDIX

LIST OF TABLES AND PLATES

PLATES

ECONOMIC APPENDIX

1. The study evaluation was performed for present conditions without and with different alternatives. The primary source of benefits for the three plans described in the main report is inundation damage reduction. A secondary source is economic development benefits for which the area qualifies. Average annual benefits were compared at a discount rate of 7-1/8 percent and based on an economic life of 100 years.

2. This appendix shows the development of annual damages for existing conditions as well as those for Plans 1, 2, and 3. A description of the alternative plans follows:

a. Plan 1 - Floodproofing.

b. Plan 2 - Channel Deepening, Floodwall, Toe Protection, and Levee Extension.

c. Plan 3 - Floodwall, Toe Protection, and Levee Extension.

Different levels of flood protection provided by varying the scale of Plan 3 (selected plan) were analyzed to determine an optimum plan. This produced a candidate NED plan. Scaling of the other considered measures would be academic since recommendations for any plan would provide for a high level (return period) of protection given the urban nature of the area. However, net benefits for Plan 1 might be lower than for Plan 3 at low protection levels due to the high initial marginal cost of flood proofing, i.e., a large portion of house raising costs is in the preparation. Thereafter, cost per extra foot of elevation is relatively low. Similarly, the initial dredging cost component suggests Plan 2 net benefits would be lower at lower levels of development than for Plan 3.

3. Damages were developed for both sources of flooding: overflows from Waimea River, and interior runoff that ponds when the floodgates are closed. Recent flooding has been minor in Waimea; historical damage data being impractical to obtain, stage damage relations were constructed using data from similar areas in Hawaii.

4. Under existing conditions, damages were calculated for three categories: residential; commercial and public building losses; and emergency and public relief costs.

5. Average annual damages to residences were calculated using percentage structural value and content value loss versus flood depth relationships for Hawaiian single wall construction. Individual housing values were averaged according to tax plats (Table D-1). Empirical relationships between structure value and total content value found in Hilo, Hawaii were assumed applicable to Waimea. The stage-damage relationships were computed for various reaches of the river (Tables D-2 thru D-9). Only residences were included in stage-damage relationships; damage to sheds and minor buildings were not estimated.

TABLE D-1. AVERAGE RESIDENTIAL STRUCTURE VALUES FOR WAIMEA

	Number of Houses		Average Value
	23		$ 5,000
	18		8,000
	30		9,000
	23		15,000
	37		17,000
	51		26,000
	169		29,000
Total	351	Weighted Average	$21,000

TABLE D-2. STAGE-DAMAGE RELATION FOR REACH 1
RESIDENTIAL

ELEV. MSL	NUMBER BUILDINGS	ACCUM. BUILDINGS	STRUC. DAMAGE	CONTENT DAMAGE	ACCUM. DAMAGE	MISC. DAMAGE	TOTAL DAMAGE
10	0	0	0.	0.	0.	0.	0.
11	0	0	0.	0.	0.	0.	0.
12	12	12	3600.	0.	3600.	0.	3600.
13	0	12	14400.	14040.	28440.	0.	28440.
14	0	12	32400.	21600.	54000.	0.	54000.
15	7	19	47100.	28080.	75180.	0.	75180.
16	4	23	63600.	40590.	104190.	0.	104190.
17	0	23	84900.	53460.	138360.	0.	138360.
18	0	23	103650.	62460.	166110.	0.	166110.
19	0	23	116700.	69300.	186000.	0.	186000.
20	0	23	127500.	74025.	201525.	0.	201525.

TABLE D-3. STAGE-DAMAGE RELATION FOR REACH 2
RESIDENTIAL

ELEV. MSL	NUMBER BUILDINGS	ACCUM. BUILDINGS	STRUC. DAMAGE	CONTENT DAMAGE	ACCUM. DAMAGE	MISC. DAMAGE	TOTAL DAMAGE
5	0	0	0.	0.	0.	0.	0.
6	0	0	0.	0.	0.	0.	0.
7	3	3	300.	0.	300.	0.	300.
8	6	9	1800.	3900.	5700.	0.	5700.
9	0	9	5100.	13800.	18900.	0.	18900.
10	0	9	9150.	19800.	28950.	0.	28950.
11	14	23	13400.	24600.	38000.	0.	38000.
12	0	23	19700.	46250.	65950.	0.	65950.
13	0	23	28350.	58900.	87250.	0.	87250.
14	0	23	34450.	69400.	103850.	0.	103850.
15	0	23	38850.	76500.	115350.	0.	115350.
16	0	23	42550.	82450.	125000.	0.	125000.
17	0	23	45550.	87000.	132550.	0.	132550.
18	0	23	47850.	90250.	138100.	0.	138100.
19	0	23	50150.	92100.	142250.	0.	142250.
20	0	23	52450.	94650.	147100.	0.	147100.

TABLE D-4. STAGE-DAMAGE RELATION FOR REACH 3
RESIDENTIAL

ELEV. MSL	NUMBER BUILDINGS	ACCUM. BUILDINGS	STRUC. DAMAGE	CONTENT DAMAGE	ACCUM. DAMAGE	MISC. DAMAGE	TOTAL DAMAGE
3	13	13	6760.	0.	6760.	0.	6760.
4	13	26	33800.	21970.	55770.	0.	55770.
5	20	46	98280.	55770.	154050.	0.	154050.
6	0	46	186940.	111540.	298480.	0.	298480.
7	0	46	279500.	146640.	426140.	0.	426140.
8	5	51	348920.	174915.	523835.	0.	523835.
9	0	51	406380.	203905.	610285.	0.	610285.
10	0	51	457080.	225160.	682240.	0.	682240.
11	0	51	495300.	240630.	735930.	0.	735930.
12	0	51	525720.	252655.	778375.	0.	778375.
13	0	51	554840.	260910.	815750.	0.	815750.
14	0	51	582660.	268125.	850785.	0.	850785.
15	0	51	609180.	272415.	881595.	0.	881595.
16	0	51	635700.	276055.	911755.	0.	911755.
17	0	51	655460.	279175.	934635.	0.	934635.
18	0	51	668460.	280800.	949260.	0.	949260.
19	0	51	671060.	281125.	952185.	0.	952185.
20	0	51	673660.	281450.	955110.	0.	955110.

TABLE D-5. STAGE-DAMAGE RELATION FOR REACH 4
RESIDENTIAL

ELEV. MSL	NUMBER BUILDINGS	ACCUM. BUILDINGS	STRUC. DAMAGE	CONTENT DAMAGE	ACCUM. DAMAGE	MISC. DAMAGE	TOTAL DAMAGE
4	0	0	0.	0.	0.	0.	0.
5	0	0	0.	0.	0.	0.	0.
6	9	9	1440.	0.	1440.	0.	1440.
7	9	18	7200.	11606.	18806.	0.	18806.
8	0	18	18720.	29462.	48182.	0.	48182.
9	0	18	30960.	41069.	72029.	0.	72029.
10	0	18	39600.	49997.	89597.	0.	89597.
11	0	18	46080.	56693.	102773.	0.	102773.
12	0	18	51120.	62050.	113170.	0.	113170.
13	0	18	54720.	66067.	120787.	0.	120787.
14	0	18	57600.	68746.	126346.	0.	126346.
15	0	18	60480.	70978.	131458.	0.	131458.
16	0	18	63360.	72763.	136123.	0.	136123.
17	0	18	66240.	73656.	139896.	0.	139896.
18	0	18	69120.	74549.	143669.	0.	143669.
19	0	18	72000.	75442.	147442.	0.	147442.
20	0	18	73440.	75888.	149328.	0.	149328.

TABLE D-6. STAGE-DAMAGE RELATION FOR REACH 5
RESIDENTIAL

ELEV. MSL	NUMBER BUILDINGS	ACCUM. BUILDINGS	STRUC. DAMAGE	CONTENT DAMAGE	ACCUM. DAMAGE	MISC. DAMAGE	TOTAL DAMAGE
4	3	3	1740.	0.	1740.	0.	1740.
5	7	10	11020.	5655.	16675.	0.	16675.
6	18	28	42340.	21895.	64235.	0.	64235.
7	23	51	113390.	65540.	178930.	0.	178930.
8	3	54	225910.	134995.	360905.	0.	360905.
9	0	54	348000.	185237.	533237.	0.	533237.
10	0	54	440220.	223372.	663592.	0.	663592.
11	0	54	508370.	251865.	760235.	0.	760235.
12	0	54	560860.	274267.	835127.	0.	835127.
13	0	54	600590.	291015.	891605.	0.	891605.
14	0	54	632780.	303122.	935902.	0.	935902.
15	0	54	664100.	311967.	976067.	0.	976067.
16	0	54	695420.	319435.	1014855.	0.	1014855.
17	0	54	726740.	323785.	1050525.	0.	1050525.
18	0	54	756320.	327482.	1083802.	0.	1083802.
19	0	54	781840.	330672.	1112512.	0.	1112512.
20	0	54	796920.	332557.	1129477.	0.	1129477.

TABLE D-7. STAGE-DAMAGE RELATION FOR REACH 6
RESIDENTIAL

ELEV. MSL	NUMBER BUILDINGS	ACCUM. BUILDINGS	STRUC. DAMAGE	CONTENT DAMAGE	ACCUM. DAMAGE	MISC. DAMAGE	TOTAL DAMAGE
4	0	0	0.	0.	0.	0.	0.
5	0	0	0.	0.	0.	0.	0.
6	0	0	0.	0.	0.	0.	0.
7	0	0	0.	0.	0.	0.	0.
8	0	0	0.	0.	0.	0.	0.
9	9	9	1620.	0.	1620.	0.	1620.
10	21	30	10260.	11583.	21843.	0.	21843.
11	0	30	29700.	44847.	74547.	0.	74547.
12	0	30	54270.	64746.	119016.	0.	119016.
13	0	30	71550.	80784.	152334.	0.	152334.
14	0	30	84240.	92218.	176458.	0.	176458.
15	0	30	94230.	101722.	195952.	0.	195952.
16	0	30	101520.	108702.	210222.	0.	210222.
17	0	30	106920.	113751.	220671.	0.	220671.
18	0	30	112320.	117166.	229486.	0.	229486.
19	0	30	117720.	120730.	238450.	0.	238450.
20	0	30	123120.	122215.	245335.	0.	245335.

TABLE D-8. STAGE-DAMAGE RELATION FOR REACH 7
RESIDENTIAL

ELEV. MSL	NUMBER BUILDINGS	ACCUM. BUILDINGS	STRUC. DAMAGE	CONTENT DAMAGE	ACCUM. DAMAGE	MISC. DAMAGE	TOTAL DAMAGE
4	0	0	0.	0.	0.	0.	0.
5	0	0	0.	0.	0.	0.	0.
6	0	0	0.	0.	0.	0.	0.
7	9	9	5220.	0.	5220.	0.	5220.
8	9	18	26100.	16965.	43065.	0.	43065.
9	16	34	77140.	43065.	120205.	0.	120205.
10	80	114	195750.	90190.	285940.	0.	285940.
11	1	115	413250.	270280.	683530.	0.	683530.
12	0	115	702960.	377072.	1080032.	0.	1080032.
13	0	115	909730.	464797.	1374527.	0.	1374527.
14	0	115	1059370.	526060.	1585430.	0.	1585430.
15	0	115	1177980.	576955.	1754935.	0.	1754935.
16	0	115	1268460.	614365.	1882825.	0.	1882825.
17	0	115	1335450.	642857.	1978307.	0.	1978307.
18	0	115	1402150.	659532.	2061682.	0.	2061682.
19	0	115	1468850.	679542.	2148392.	0.	2148392.
20	0	115	1535550.	688025.	2223575.	0.	2223575.

TABLE D-9. STAGE-DAMAGE RELATION FOR REACH 11
RESIDENTIAL

ELEV. MSL	NUMBER BUILDINGS	ACCUM. BUILDINGS	STRUC. DAMAGE	CONTENT DAMAGE	ACCUM. DAMAGE	MISC. DAMAGE	TOTAL DAMAGE
4	0	0	0.	0.	0.	0.	0.
5	37	37	12580.	0.	12580.	0.	12580.
6	0	37	50320.	47427.	97747.	0.	97747.
7	0	37	113220.	72964.	186184.	0.	186184.
8	0	37	157250.	94853.	252103.	0.	252103.
9	0	37	188700.	109446.	298146.	0.	298146.
10	0	37	213860.	122215.	336075.	0.	336075.
11	0	37	232730.	131335.	364065.	0.	364065.
12	0	37	245310.	138632.	383942.	0.	383942.
13	0	37	257890.	142280.	400170.	0.	400170.
14	0	37	270470.	147752.	418222.	0.	418222.
15	0	37	283050.	149576.	432626.	0.	432626.
16	0	37	295630.	151400.	447030.	0.	447030.
17	0	37	308210.	153224.	461434.	0.	461434.
18	0	37	320790.	155048.	475838.	0.	475838.
19	0	37	320790.	155048.	475838.	0.	475838.
20	0	37	320790.	155048.	475838.	0.	475838.

6. Commercial property values were based on tax assessor's records. Inventory values were based on previous experience for similar type establishments. Percent damage factors for comparable mainland buildings and establishments were used to calculate stage-damage relationships for commercial and public buildings in Waimea (Table D-10).

7. Public building values were determined from tax assessment records. Comparable damage factors from commercial buildings were used. These public buildings are included with commercial structures (Table D-10).

8. The total number of structures located in the floodplain is shown by property type in Table D-11. Also shown in the table is a projection by decade of the number of structures in the project condition (Plan 3) over the 100-year life of the project.

TABLE D-11. NUMBER OF STRUCTURES IN THE FLOODPLAIN

Property Type	Structures				
	P0	P10	P20	. . .	P100
Residential					
Reach 1	23	23	23		23
Reach 2	23	23	23		23
Reach 3	51	51	51		51
Reach 4	18	18	18		18
Reach 5	54	54	54		54
Reach 6	30	30	30		30
Reach 7	115	115	115		115
Reach 11	37	37	37		37
	351	351	351	. . .	351
Commercial 1/	48	48	48	. . .	48
Total	399	399	399	. . .	399

1/ Includes public buildings

9. Stage damage data were combined with exceedance probability information from hydrologic studies to calculate annual damages. Average annual damages from Waimea River flooding are shown in Table D-12.

10. In addition to Waimea River overflows, another source of flooding is interior runoff (on the land side of the levee) that ponds when river stages force the closing of the flood gates. To analyze this situation, a stage damage curve was prepared to reflect lower flood water velocities that would have less damaging effects than Waimea River flood waters.

11. Stage-frequency relationships were used to determine the expected damage value. Coincidental probabilities wre·estimated for the joint occurrence of high Waimea River stages and interior runoff. A partial duration curve based on the historical pattern when stages of greater than or equal to 3 feet MSL occur was multiplied by the frequency curve points for interior peak discharges. Hydraulic studies determined the peak stages associated with this coincident probability. The annual damages for interior flooding are shown on Table D-12.

TABLE D-10. STAGE-DAMAGE RELATION FOR COMMERCIAL STRUCTURES (INCL PUBLIC BLDGS).

ELEV. MSL	NUMBER BUILDINGS	ACCUM. BUILDINGS	STRUC. DAMAGE	CONTENT DAMAGE	ACCUM. DAMAGE	MISC. DAMAGE	TOTAL DAMAGE
7	1	1	546.	0.	546.	0.	546.
8	21	22	43347.	850.	44197.	0.	44197.
9	13	35	95936.	140200.	236136.	0.	236136.
10	6	41	165217.	367760.	532977.	0.	532977.
11	7	48	283694.	539500.	823194.	0.	823194.
12	0	48	376792.	738750.	1115542.	0.	1115542.
13	0	48	451585.	909550.	1361135.	0.	1361135.
14	0	48	560761.	1038480.	1599241.	0.	1599241.
15	0	48	639346.	1092720.	1732066.	0.	1732066.
16	0	48	707587.	1109980.	1817567.	0.	1817567.
17	0	48	749794.	1114850.	1864644.	0.	1864644.
18	0	48	768816.	1117200.	1886016.	0.	1886016.
19	0	48	785940.	1117600.	1903540.	0.	1903540.
20	0	48	803064.	1118000.	1921064.	0.	1921064.
21	0	48	820188.	1118000.	1938188.	0.	1938188.
22	0	48	837234.	1118000.	1955234.	0.	1955234.

TABLE D-12. AVERAGE ANNUAL RIVERINE DAMAGES UNDER EXISTING CONDITIONS AND PLAN 3 AT VARIOUS LEVELS OF PROTECTION

TYPE	EXISTING CONDITION	PLAN 3 CONDITION				
		50-YEAR PROTECTION	100-YEAR PROTECTION	200-YEAR PROTECTION	500-YEAR PROTECTION	SPF PROTECTION
Residential	$174,500	$ 88,700	$ 65,800	$ 37,600	$ 16,500	$ 8,700
Commercial	60,500	41,600	29,300	14,400	4,700	1,200
Emergency	2,600	2,100	1,100	0	0	0
TOTAL	$237,600	$132,400	$ 96,200	$ 52,000	$ 21,200	$ 9,900

TABLE D-13. ANNUAL BENEFITS AND COSTS (DOLLARS) FOR PLAN 3

TYPE	LEVEL OF PROTECTION 50-YEAR	100-YEAR	200-YEAR	500-YEAR	SPF
BENEFITS					
Interior Damage Reduction	97,300	97,300	97,300	97,300	97,300
Riverine Damage Reduction					
Residential	85,800	108,700	136,900	158,000	165,800
Commercial	18,900	31,200	46,100	55,800	59,300
Emergency	500	1,500	2,600	2,600	2,600
EDA	13,100	14,900	18,000	25,800	32,900
TOTAL	215,600	253,600	300,900	339,500	357,900
SAY ROUNDED TOTAL	216,000	254,000	301,000	340,000	358,000
COSTS					
I&A	114,000	186,000	228,000	292,000	328,000
O&M	11,000	16,000	18,000	22,000	23,000
TOTAL	125,000	202,000	246,000	314,000	351,000
NET BENEFIT	91,000	52,000	55,000	26,000	7,000
B/C RATIO	1.7	1.3	1.2	1.08	1.02
B/C RATIO W/O EDA BENEFIT	1.6	1.2	1.15	1.00	0.93

TABLE D-14. DAMAGE FREQUENCY RELATIONS - EXISTING CONDITIONS

ELEV	REACH 1	REACH 2	REACH 3	REACH 4	REACH 5	REACH 6	REACH 7	REACH 11	DAMAGE - RESIDENTIAL (ALL REACHES)	DAMAGE - COMMERCIAL	TOTAL 1/ DAMAGE	EXCEEDANCE 2/ FREQUENCY
	$	$	$	$	$	$	$	$	$	$	$	
3			6,760						6,760			
4			55,770		1,740				57,510		57,510	0
5			154,050		16,675			12,580	183,305		183,305	0
6			298,480	1,440	64,235			97,747	461,902		461,902	0
7		300	426,140	18,806	178,930		5,220	186,184	815,580	546	816,126	0
8		5,700	523,835	48,182	360,905		43,065	252,103	1,233,790	44,197	1,277,987	0
9		18,900	610,285	72,029	533,237	1,620	120,205	298,146	1,654,422	236,136	1,890,558	0
10		28,950	682,240	89,597	663,592	21,843	285,940	336,075	2,108,237	532,977	2,641,214	0
11		38,000	735,930	102,773	760,235	74,547	683,530	364,065	2,759,080	823,194	3,582,274	2.9
12	3,600	65,950	778,375	113,170	835,127	119,016	1,080,032	383,942	3,379,212	1,115,542	4,494,754	2.0
13	28,440	87,250	815,750	120,787	891,605	152,334	1,374,527	400,170	3,870,863	1,361,135	5,231,998	1.45
14	54,000	103,850	850,785	126,346	935,902	176,458	1,585,430	418,222	4,250,993	1,599,241	5,850,234	1.0
15	75,180	115,350	881,595	131,458	976,067	195,952	1,754,935	432,626	4,563,163	1,732,066	6,295,229	0.7
16	104,190	125,000	911,755	136,123	1,014,855	210,222	1,882,825	447,030	4,832,000	1,817,567	6,649,567	0.45
17	138,360	132,550	934,635	139,896	1,050,525	220,671	1,978,307	461,434	5,056,378	1,864,644	6,921,022	0.3
18	166,110	138,100	949,260	143,669	1,083,802	229,486	2,061,682	475,838	5,247,947	1,886,016	7,133,963	0.2
19	186,000	142,250	952,185	147,442	1,112,512	238,450	2,148,392	475,838	5,403,069	1,903,540	7,306,609	0.18
20	201,525	147,100	955,110	149,328	1,129,477	245,335	2,223,575	475,838	5,327,288	1,921,064	7,448,352	0.17

1/ These damages represent the total structural and content damage sustained in all reaches from flooding for any given stage elevation.
2/ Under existing conditions, the levee will not overtop until El. = 10.4 feet is reached. Therefore, the exceedence frequency for all elevations below 10.4 feet will be 0.

12. Benefits and costs for the with project conditions (Plan 3) for different levels of protection (from both river and interior runoff flooding) are shown in Table D-12. NED benefits are graphically shown on Plate D-1. The net benefits are maximized at a 50-year protection; however, the reduction in net benefits would be only $36,000 by choosing the 100-year protection level. Net benefits for increasing levels of protection diminish as seen in Plate D-1. A significant marginal benefit is obtained from increasing levels of protection, although it is not sufficient to overcome marginal cost increases.

13. Significant new development within the floodplain is not expected. The completion of the Waimea Valley Estate subdivision will occur with or without any federal project. The majority of the floodplain that is subject to flooding is already developed. Hence, location benefits are not expected.

14. Damage frequency relations were determined for Plans 1 and 2 (in addition to Plan 3) for 100-year protection level. The damage frequency relation for existing conditions was plotted using data from Table D-14. Table D-14 is a summary of Tables D-2 thru D-10 and includes a breakdown of the total residential and commercial damages associated with specific flood stage elevations. Total damages incurred at selected stage elevations can be related to the exceedance frequency. This relation as well as those for Plans 1, 2, and 3 are illustrated on Plates D-2, D-3, and D-4. Flood proofing by elevation results in a damage frequency curve similar to existing conditions except shifted to the right (Plate D-2). This is a simplification. In actuality, minor flood damages would continue to yards, cars, and underground utilities in Plan 1. The magnitude of those losses is believed relatively small, and, no historical data is available to reliably estimate the magnitude of such damages. Hence they are not calculated for either the existing conditions or Plan 1 damage frequency curves.

15. For Plan 2, residential damage begins when the design frequency is exceeded, however, the channel modification will alter damage levels for floods above the design discharge. For Plan 3, it is assumed the damage curve approximates the existing damage frequency curve once the design stage is exceeded.

16. A brief description is given of the various types of benefits that would accrue with implementation of an alternative plan.

a. Interior Damage Reduction - Based on a maximization of net benefits, the most appropriate design for reducing interior runoff flooding consisted of five 60-inch reinforced concrete pipes (RCP's). In the selected plan, the interior damage reduction benefits were computed by taking the difference between the average annual damages incurred under existing conditions and the residual damages sustained when using five 60-inch RCP's. An economic evaluation of the interior damage reduction benefit is discussed in Appendix C on Page C-23.

b. Riverine Damage Reduction.

(1) Residential/Commercial - Damage reduction benefits were computed by taking the difference in the average annual damages between the existing condition and the alternative plans. A summary of these damages for a 100-year protection is shown for Plans 1, 2, and 3 on Table D-15.

TABLE D-15. SUMMARY OF AVERAGE ANNUAL RESIDUAL DAMAGES UNDER DIFFERENT IMPROVEMENT CONDITIONS 1/

Type	Existing Condition	100-YEAR PROTECTION, RESIDUAL DAMAGES Plan 1	Plan 2	Plan 3
Residential	$174,500	$9,600	$54,800	$65,800
Commercial	60,500	7,200	18,100	29,300
Emergency	2,600	0	1,100	1,100
Total	$237,600	$16,800	$74,000	$96,200

1/ For benefit summary see Table D-18.

(2) Emergency Cost - Emergency costs resulting from Red Cross relief activities and state and federal disaster assistance were based on operations experienced during past floods in Hawaii. To arrive at the emergency costs, an average cost of $300 per home was multiplied by the number of residences affected at each stage elevation. For example, during a 100-year flood (Plans 2 and 3) 351 homes will be affected resulting in emergency costs of $105,300. The benefit accrued from this cost will be the difference in the average annual damages between the existing condition and the 100-year protection or $1,500 per year.

c. Employment Benefits (EDA). EDA benefits were derived in accordance with part IX of the Water Resources Council's final rule dated 14 December 1979. The construction industry on Kauai, with a total labor force of 680 in 1978, had 140 unemployed workers during the year representing an unemployment rate of 21 percent. The proposed construction improvements for the alternative would have total labor costs ranging from $610,600 for Plan 3 to $2,177,000 for Plan 1 (floodproofing). The construction work force was estimated to be 75 percent skilled and 25 percent unskilled labor. Total wages paid to skilled and unskilled workers were multiplied by 30 and 47 percent, respectively, to compute the NED portion of the wages. The total NED appropriate wage benefits were then amortized over a 100-year project life at a discount rate of 7-1/8 percent yielding EDA average annual benefits of $53,100, $16,700, and $14,900 from Plans 1, 2, and 3 respectively. All of the alternative plans were compared for a 100-year level of protection.

17. Projected flood damages during the next century is the without project cost are shown by decade in Table D-16. Residual flooding damage at 100-year protection levels for the alternative projects are detailed in Table D-17.

18. A summary of total annual benefits and costs for each alternative plan is shown in Table D-18.

TABLE D-16. HISTORICAL FLOOD DAMAGE & PROJECTED FLOOD DAMAGE BY DECADE WITHOUT PROJECT 1/

Applicable Discount Rate: 7.125
All figures in $1,000's

Property Type	P-64 1916	P-59 1921	P-53 1927	P-38 1942	P-31 1949	Exstg 1980	P10 1990	P20 2000	P100 2080	AAE2/
Residential	N/A	N/A	N/A	N/A	$ 818	$174.0	$174.0	$174.0	$174.0	$174.0
Comml & Publ	"	"	"	"	1,945	60.5	60.5	60.5	60.5	60.5
Agricultural	"	"	"	"	121	-	-	-	-	-
Emergency	-	-	-	-	-	2.6	2.6	2.6	2.6	2.6
Total	$1,047	$1,784	$301	$1,067	$2,884	$237.1	$237.1	$237.1	$237.1	$237.1

1/ A levee was completed by local interests in the early 1950's, and is discussed on pages 8-9 of the main report.

Historical flood damages have been converted into January 1980 dollars. Existing and projected levels represent average annual damages.

2/ Average annual equivalent.

TABLE D-17. RESIDUAL FLOOD DAMAGE AT 100-YEAR PROTECTION BY DECADE UNDER ALTERNATIVE PROJECTS

Applicable Discount Rate: 7.125%

	Time Period				
Alternative	P0 1980	P10 1990	P20 2000 ...	P100 2080	AAE 1/
Plan 1	$16,800	$16,800	$16,800	$16,800	$16,800
Plan 2	74,000	74,000	74,000	74,000	74,000
Plan 3	96,200	96,200	96,200	96,200	96,200

1/ Average annual equivalent

TABLE D-18. SUMMARY OF ANNUALIZED NED BENEFITS
AND COSTS FOR ALTERNATIVE PROJECTS
APPLICABLE DISCOUNT RATE = 7.125%

Type	Alternatives at 100-Year Protection Plan 1	Plan 2	Plan 3
BENEFIT			
Interior Damage Reduction	0	$ 97,300	$ 97,300
Riverine Damage Reduction			
Residential	$164,900	119,700	108,700
Commercial	53,300	42,400	31,200
Emergency	2,600	1,500	1,500
EDA	53,100	16,700	14,900
Total Average Annual Benefits	$273,900	$277,600	$253,600
Costs			
I&A	499,000	373,000	186,000
O&M	1,000	28,000	16,000
Total Average Annual Cost	$500,000	$401,000	$202,000
NET BENEFITS	$(226,000)	($123,000)	$ 52,000
BENEFIT/COST RATIO (BCR)	0.6	0.7	1.3
BCR W/O EDA BENEFITS	0.4	0.6	1.2

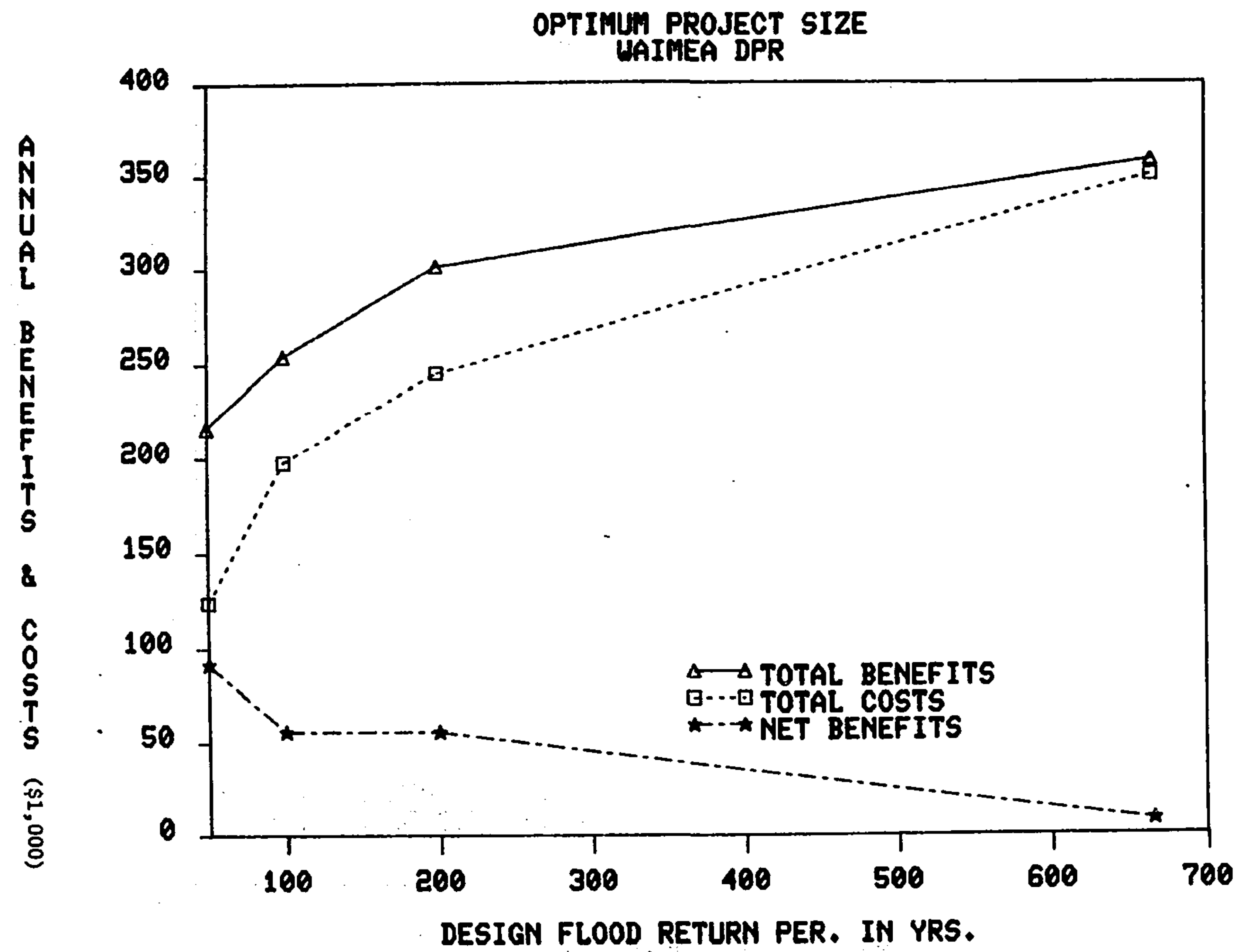


PLATE D-1

PLATE D-1

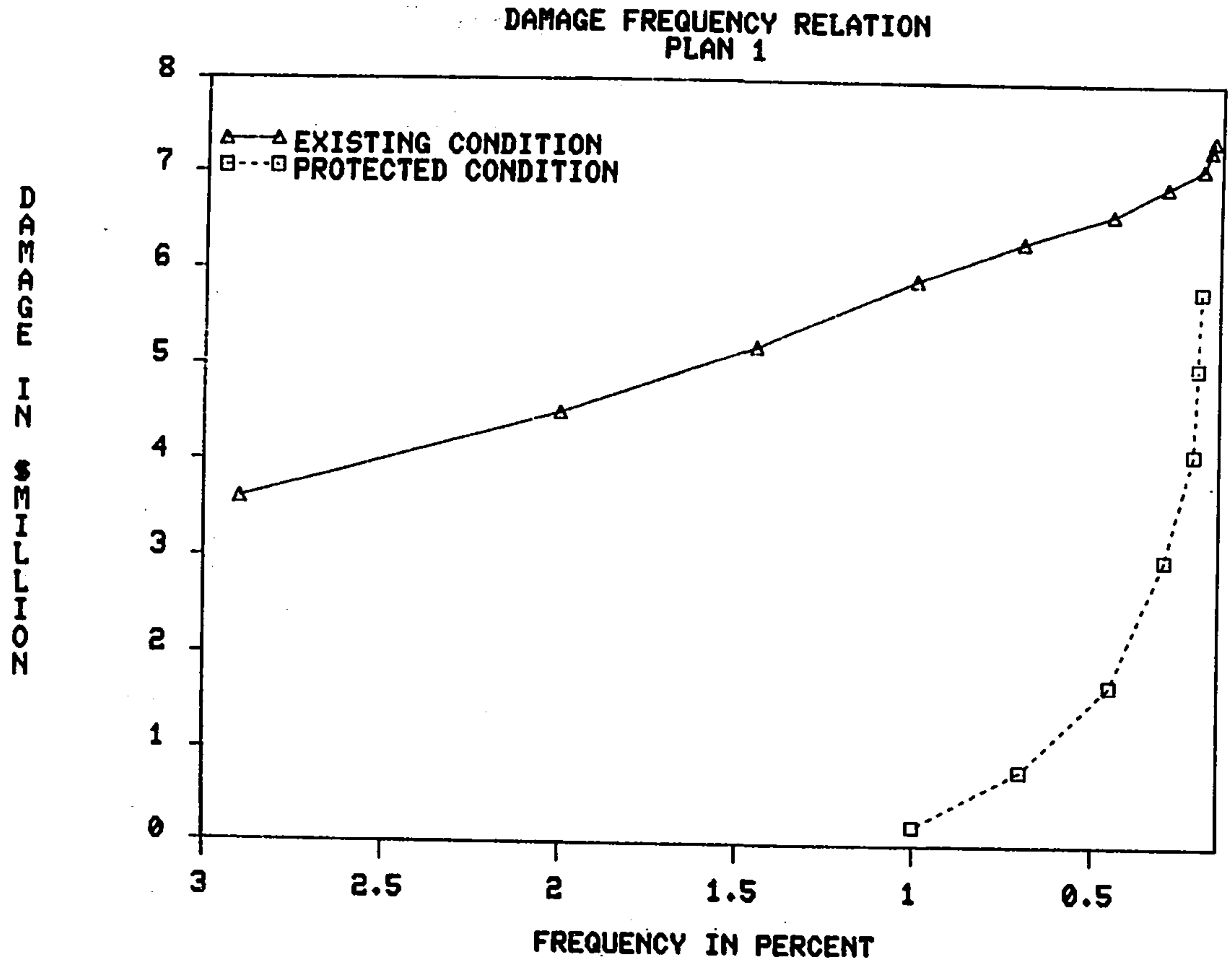
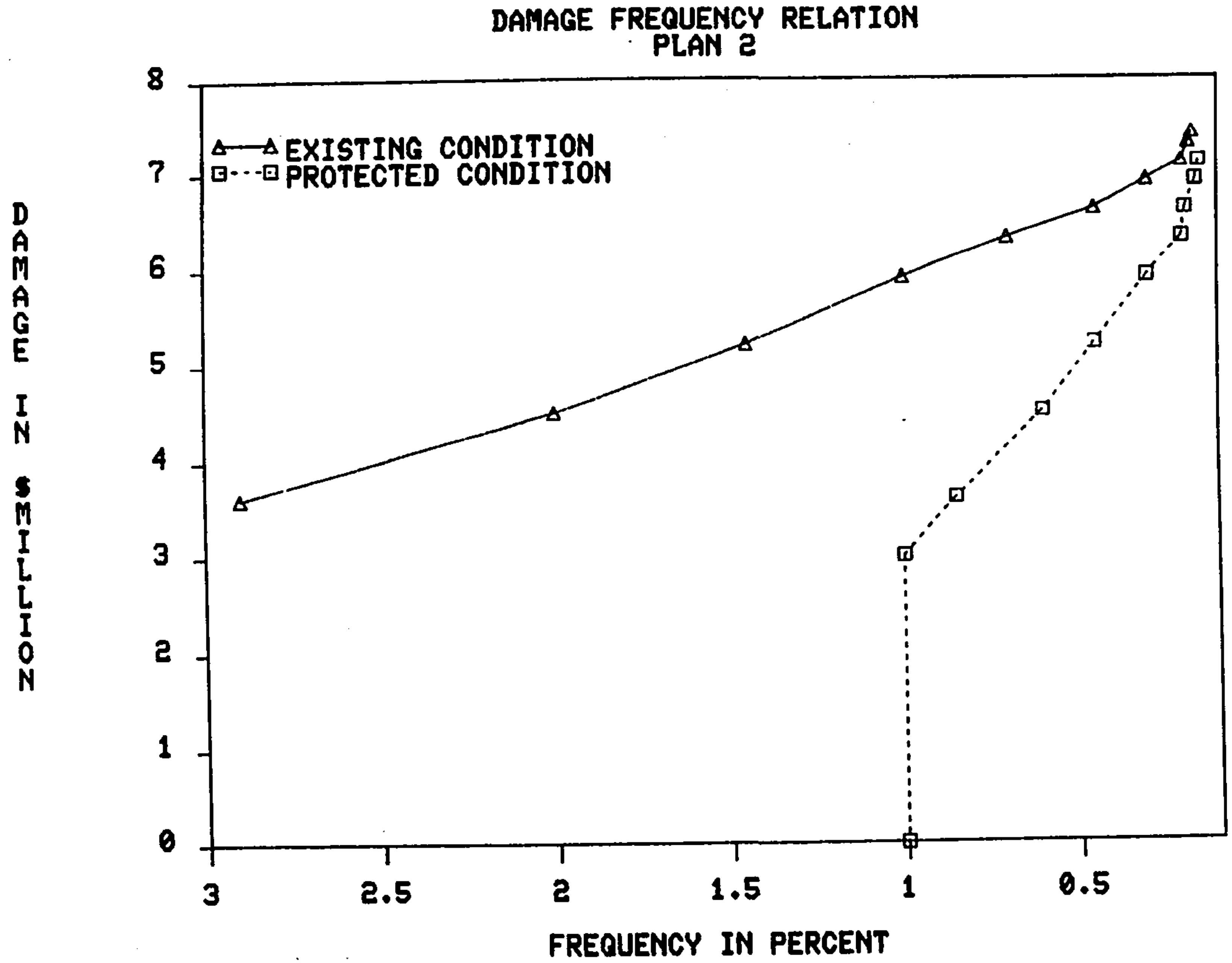

DAMAGE FREQUENCY RELATION
PLAN 1
EXISTING CONDITION
PROTECTED CONDITION
DAMAGE IN $MILLION
8
7
6
5
4
3
2
1
0
3
2.5
2
1.5
1
0.5
FREQUENCY IN PERCENT

PLATE D-2


DAMAGE FREQUENCY RELATION
PLAN 2
EXISTING CONDITION
PROTECTED CONDITION
DAMAGE IN $MILLION
FREQUENCY IN PERCENT
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1
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6
7
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3
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2
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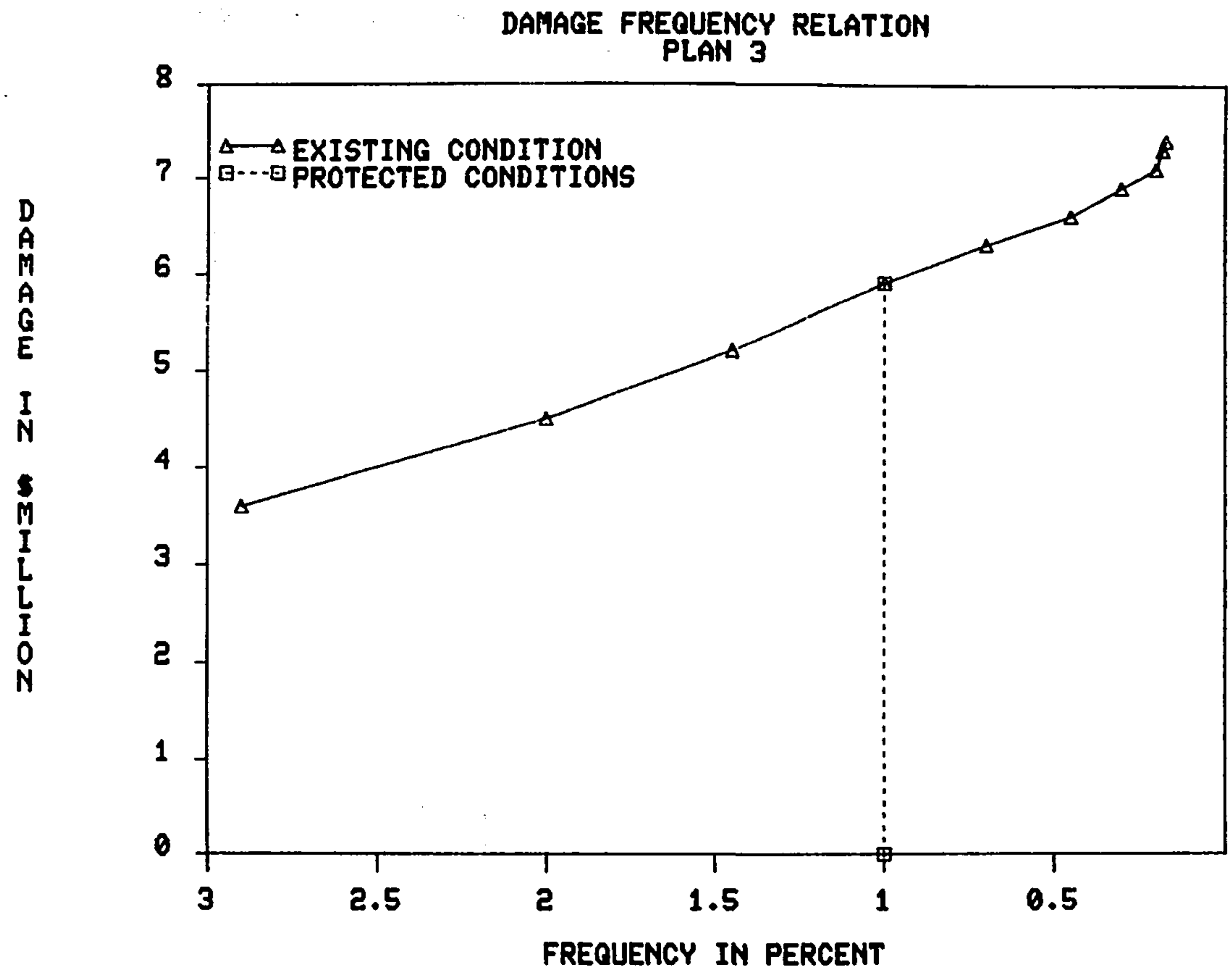
1
0.5


DAMAGE FREQUENCY RELATION
PLAN 3
EXISTING CONDITION
PROTECTED CONDITIONS
DAMAGE IN $MILLION
FREQUENCY IN PERCENT
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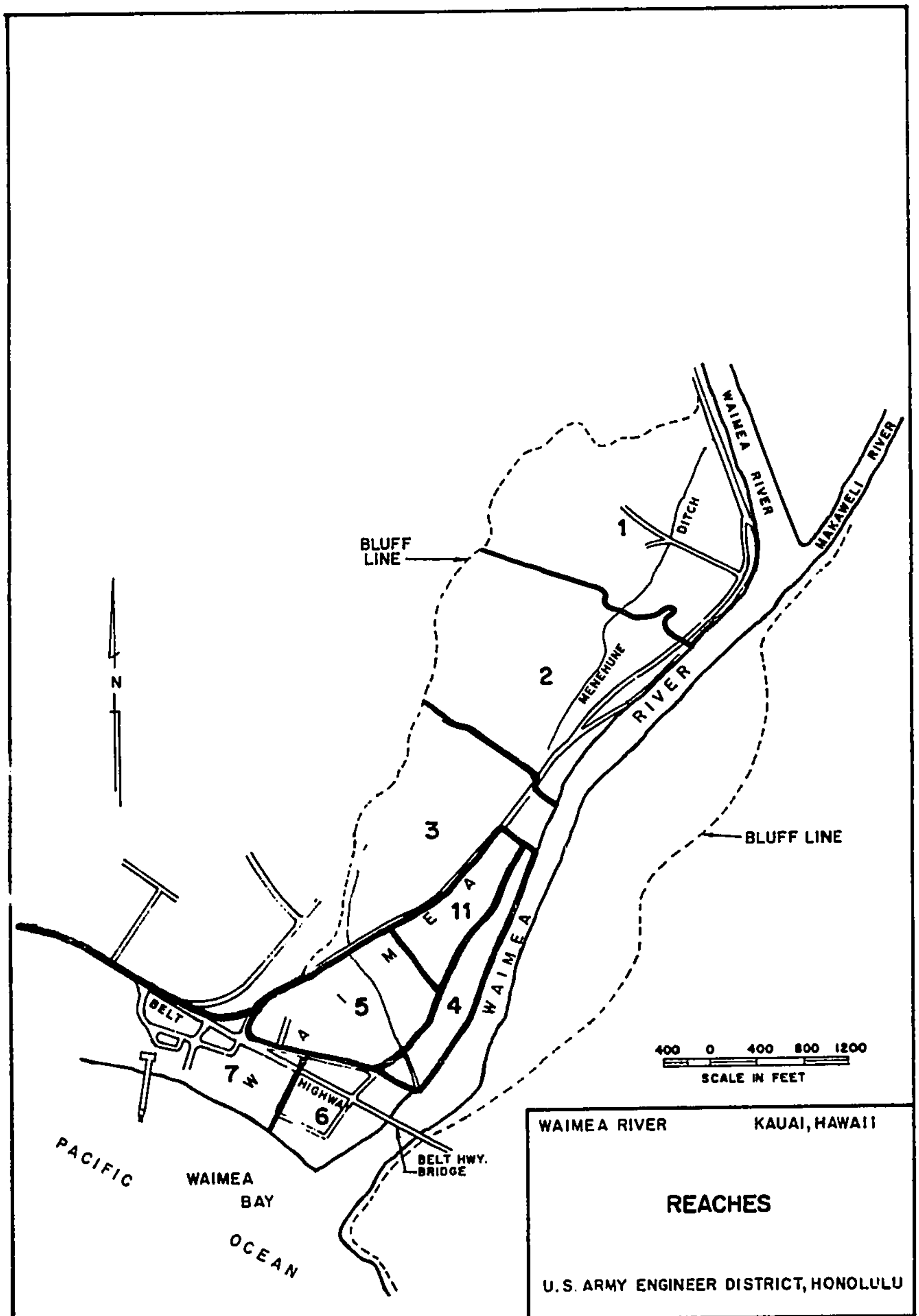
7
6
5
4
3
2
1
0
3
2.5
2
1.5
1
0.5

PLATE D-4



WAIMEA RIVER KAUAI, HAWAII

REACHES

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE D-5

WAIMEA RIVER FLOOD CONTROL
WAIMEA, KAUAI

SOCIAL AND CULTURAL RESOURCES

APPENDIX E

SOCIAL AND CULTURAL RESOURCES APPENDIX

PAGE

SOCIAL AND CULTURAL APPENDIX

1. The Water Resource Council's "Principles and Standards for Planning Water and Related Land Resources" (P&S), 38 "Federal Register" 24778-24869, 10 September 1973, requires that impacts of a proposed action be measured and the results displayed or accounted for in terms of contributions to four accounts: National Economic Development (NED), Environmental Quality (EQ), Regional Development (RD), and Social Well-Being (SWB). The first part of this appendix assesses the social well-being components of the three alternative plans in terms of (a) effects on health, safety, welfare, and emergency preparedness, (b) displacement of people and farms, (c) effects on distribution of real income and community/regional growth, (d) effects on educational, cultural and recreational opportunities, and (e) effects on community cohesion and well-being. The second part of the appendix summarizes the cultural resources reconnaissance of the lower reach of Waimea River. All numbered references are listed in the references for the EIS.

2. The evaluation of the alternative solution in relation to social and cultural criteria was based on the following planning objectives:

a. Reduce potential flood damages and insure the health and safety of the community of Waimea.

b. Eliminate or minimize adverse effects on sites listed on or eligible for the National Register of Historic Places; and protect and enhance, where possible, water quality and biological resources in the study area.

COMPARATIVE EVALUATION OF SOCIAL WELL-BEING COMPONENTS

3. The socio-economic, land use, and community service characteristics of the Waimea-Kekaha region, and particularly Waimea, are fully described in the Environmental Impact Statement. The effects of the three alternative plans are also discussed in that document. Those effects are summarized here in terms of the five subcomponents of the Social Well-Being (SWB) account of the P&S. These subcomponents are liberally defined and reworded to suit this particular study and its projected effects. Each of the plans will be compared within each subcomponent of the SWB account.

HEALTH, SAFETY, WELFARE, AND EMERGENCY PREPAREDNESS

4. The two structural measures, Plan 2 and the recommended Plan 3 would provide identical protection against the 100-year flood. Floodproofing would

prevent structural damage from the 100-year flood, but would not prevent transportation or social type losses. Should the floodproofing alternative (Plan 1) be implemented, temporary evacuation would also be required, the latter for at least some areas. Flood-related health and safety problems related to stagnating water, possible disruption of emergency services and utilities such as water, electricity, telephone, and sewage would remain. The two structural plans would probably eliminate most potential problems related to disruption of utilities and emergency services, as they relate to the protected areas, as well as the effect of being able to concentrate emergency services and facilities in other regional areas.

DISPLACEMENT OF FARMS AND PEOPLE

5. Plan 1 would not permanently displace any farms or people. Plans 2 and 3 may affect one-half of a duplex and the family occupying it and an adjacent greenhouse or garden house. One additional non-residential structure may be displaced belonging to the County Maintenance Yard.

DISTRIBUTION OF REAL INCOME AND COMMUNITY/REGIONAL GROWTH

6. Neither plan should affect real income as reflected by increased property values and their possible sale. Should a large flood (up to and including a standard project flood, SPF) occur, substantial cost savings to real and personal property would be provided by the levels of protection: an average of $297,000 for the floodproofing alternative and $264,500 each for the two structural benefits. A direct effect on real income of local construction laborers and firms would accrue from construction activities of about $92,000 for Plan 1, $41,000 for Plan 2, and $20,000 for Plan 3. The indirect multiplier effect on the local economy of these wages and profit would be considerably higher.

7. All plans would promote greater community/regional growth within the floodplain with the structural plans offering more protection and providing potentially more beneficial effects. However, floodproofing and other nonstructural alternatives would also offer considerable benefits. Some up-valley areas may be encouraged to transform land from agriculture to residential or apartment uses, despite the constraints offered in local land plans. For the area now officially designated as a ponding area, there may be adverse effects on possible plans to build in this small area because of project restrictions on development, such as the prohibition of filling activities and the requirement that the main floor of buildings must be constructed above 4.5 feet, Mean Sea Level (MSL).

EDUCATIONAL, RECREATIONAL, AND CULTURAL OPPORTUNITIES

8. Plan 1, floodproofing would have no obvious effect upon educational, recreational, or cultural opportunities. Plans 2 and 3 would have no

effect upon educational opportunities. Under Plans 2 and 3 there would be some interruption of recreational fishing during construction. The floodwall would act as a permanent obstacle to those using the stream for recreational fishing. In addition, there would be a decrease of park land and of park facilities. The new levee under Plans 2 and 3 would provide new habitat for estuarine biota and a new platform for recreational fishing for these species. Toe protection of Plans 2 and 3 during construction would involve the removal of private floating docks along the existing levee bank. Plans 2 and 3 would involve the removal of the Cook Landing monument from its existing location for temporary storage and replacement at the completion of the project, or relocation to another area of the park not affected by construction. Improvements to Menehune Road could be made without affecting any portions of the Peekauai (Menehune Ditch). Further study will be conducted to determine the spatial relationship of the alleged old wall to the proposed road improvements. A request of eligibility to the National Register is being sought for the prehistoric ditch.

COMMUNITY COHESION AND WELL-BEING

9. None of the plans may affect community cohesion to any great degree because the degree of flood protection that already exists serves to relegate flooding concerns to a minor level compared to a community without any substantial protection which is flooded every ten years or so. There would be beneficial social and community well-being effects if any of the plans were implemented and perhaps slightly more significant ones for Plans 2 and 3, especially for commercial or business areas. These effects, however, are probably imperceptible until flood danger losses occur.

10. An imaginative floodproofing program could also realize some beneficial community effects especially in residential areas. The elevating of houses and other damagable structures could involve pole-type and other designs which are popular in the islands and which may be accepted by the community if planned and constructed in a satisfactory or tasteful manner. Floodproofing of houses in Hanalei Valley, for example, has met with community acceptance. In addition, living areas would be increased and scenic views improved from the floodproofed houses. However, some residents may not desire to have their houses elevated. On the other hand, floodproofing may be more socially acceptable than either no additional flood protection or structural plans involving channels or levees.

CULTURAL RESOURCES RECONNAISSANCE REPORT

11. This part of the Social and Cultural Appendix presents a summary of the US Army Corps of Engineers' cultural resource reconnaissance report. In compliance with the Reservoir Salvage Act of 1960, as amended (88 Stat. 1741, the Advisory Council on Historical Preservation's "Protection of

Historic and Cultural Properties" (36 CFR Part 800), and the Corps' regulation "Identification and Administration of Cultural Resources" (36 CFR Part 800), the Honolulu District sponsored a reconnaissance-level investigation of the proposed project areas in the lower reach of the Waimea River Basin. The report was prepared by Hawaii Marine Research, Inc. in collaboration with a consultant on Hawaiian history, Dr. Pauline Joerger of the University of Hawaii. Archaeological and historic site field work was conducted in August 1979 and the final report was submitted in September 1979 (Ref 6). The results and conclusions of this report are abstracted in the following historical and archaeological sections.

ARCHAEOLOGICAL

12. The only known archaeological site which could possibly be affected by the project is the Peekauai or Kiki-a-Ola (Menehune) Ditch. This linear feature was listed on the Hawaii Register of Historic Places and its eligibility for inclusion on the National Register of Historic Places is currently being sought. In March 1979, the site was removed from the Hawaii Register for administrative deficiencies in its registration. This auwai, or Hawaiian irrigation ditch, is of major importance to the understanding of Hawaiian agricultural technology and organization of the pre-Contact (pre-1778) period. Originally, presumably in-situ portions of the ditch are visible outside the project area, north of Kikiaola Ridge, and west of Menehune Ditch Road. The retaining wall consists of faced and fitted basalt slabs unique in Hawaii for use in irrigation canals. The total present length of the ditch appears to be about 2.8 miles. Its original prehistoric length is not known nor is it clear what portions of the modern ditch are unmodified. The portion of Peekauai Ditch included within the project area flows out of a 20th Century tunnel through the bedrock, thence under a modern road. The road was constructed in the 1920's and the original course of the historic ditch was realigned and the original stone facing of the ditch wall diverted to other purposes. The ditch now flows through a two-foot diameter concrete culvert and exits on the southwestern edge of the road shoulder into a stone-lined ditch which continues down towards Waimea Town. Multiple stacked basalt chunks form the retaining wall of this part of the ditch, standing to a height of 1.6 feet. It has not been determined whether this section is of original in-situ construction, but the technique of construction of the retaining wall is completely different and less sophisticated than the portion of the ditch to the northeast and outside the project area.

HISTORICAL

13. The only known historic site within the proposed project area is the Captain Cook Landing Monument, which was designated a National Historic landmark in 1962 and placed on the National Register in 1966. In 1969, the plaque, mounted on a large boulder, was moved to its present site on the west bank of the Waimea River. It is realized that the present location of the monument probably does not represent the actual landing site of Captain Cook but is located at its present place as a convenience to tourists so they could also view the Russian Fort Elizabeth across the river.

COMPARATIVE EVALUATION OF ALTERNATIVE PLANS

14. Without the project the Captain Cook Landing monument could be subject to periodic flooding and possible damage. The same impact could occur with the floodproofing alternative (Plan 1). The recommended Plan 3, floodwall, protection and new levee would protect the monument from flooding; however, the monument would have to be temporarily removed during levee construction. After completion of construction, the monument may be replaced in the same area on top of the new levee or it could be relocated nearby to another area. It is recognized that the monument is not situated at the actual landing place of Captain Cook, rather, the location was apparently selected as a convenience to tourists. The recommended plan proposes raising the existing road by 1.5 feet where it intersects the course of Peekauai Ditch. No portion of the ditch, whether of possible prehistoric origin or of modern origin, will be affected in any way by construction activities on the road. Normal protective clauses in the construction specifications will further preclude or minimize the accidental discharge of dirt, gravel, or other materials into the ditch. The road will be graded so as to not encroach outside the existing shoulder adjacent to the road at this point.

WAIMEA RIVER FLOOD CONTROL
WAIMEA, KAUAI

PUBLIC INVOLVEMENT

APPENDIX F

APPENDIX F

PUBLIC INVOLVEMENT APPENDIX

PUBLIC INVOLVEMENT APPENDIX

PUBLIC INVOLVEMENT PROGRAM

1. Public participation was conceived and carried out as a key element throughout the study process. During the early study period, planning efforts were concentrated on problem identification. The Honolulu District staff, through meetings and personal contacts with federal, state, and local agencies, and private citizens, attempted to identify the concerns of the public relating to flood problems. Feedback from the coordination was used to develop the study scope, planning objectives, the extent of the study area, applicable constraints and controls, and how subsequent planning action would be scheduled.

2. Special effort was made to maintain close liaison with the County Department of Public Works. Representatives of the Public Works Department have been actively involved in data gathering, discussions of plans of others and alternative solutions. The Public Works Department participated in the public workshop on 25 January 1979 and assisted in workshop arrangements and efforts to increase public attendance. Active participation from the Department of Public Works was also maintained during the public meetings of 8 November 1979 and 28 February 1980.

SUMMARY OF PUBLIC MEETINGS AND WORKSHOP

3. In conjunction with an earlier investigation and in response to the resolution adopted 6 July 1949 by the Committee on Public Works, US House of Representatives, a public meeting was conducted by the District Engineer on 23 June 1950 at Waimea, Kauai. Total attendance was approximately 50 persons. Testimony given by local interests was in favor of flood control improvements. They noted that floods in 1916, 1921, 1927, 1942, and 1949 caused an estimated total damage of more than $1.0 million. On 17 August 1950, another damaging flood occurred along the Waimea River. In 1951, the Territory of Hawaii provided funds to the county government to construct the existing levee along the west bank of Waimea River.

4. A public workshop held in conjunction with the current study was conducted in Waimea on 25 January 1979. The purpose of the workshop was to inform the public of this detailed study and at the same time, to provide the public an opportunity to express their views. About 45 persons, representing residents, businessmen, and farmers, attended the meeting. The reaction to the study and possible improvements were favorable. Major steps for project conception, authorization, and construction of Corps projects were discussed. Significant points and/or concerns voiced during the workshop are summarized below:

a. Prior to the construction of the existing county levee, the following depths of inundation were noted: three to four feet of water in the business district during the 1941 flood, more than six feet in the Big Sav Market vicinity, and four feet in the Kitamura Fish Market for the 1949 flood.

b. Channel improvements are considered a sound alternative. Although the existing levee provides some protection, a number of people emphasized that widespread damage could result because of decreasing river flow capacity due to sediment deposits and the sandbar problem at the river mouth which restricts the outlet flows.

c. Estimated household content damages by three feet of water in homes under existing conditions ranged from $5,000 to $10,000 per residence.

d. Since the completion of the county levee, Waimea has not experienced a major floodflow. Localized problems are primarily related to ditch overflows when river stages are high and interior drainage runoffs are prevented from discharging into the river.

e. For the farmers, the flood runoff of 1975 was the worst in recent years. Flood stage near the confluence of Waimea and Makaweli Rivers came within one-and-a-half feet of overtopping the levee. There are about 100 acres under cultivation above the confluence.

5. On 8 November 1979, a plan formulation public meeting was held in Waimea to discuss the planning considerations and preliminary study findings. The meeting was attended by 14 persons. Possible alternative plans were presented for public review and comment. During the discussion period, the following views and questions were expressed:

a. The Irrigation Superintendent of Kekaha Sugar Company suggested an impoundment reservoir for multipurpose use: flood control, irrigation water storage, fish and wildlife enhancement, and hydropower.

b. Statements against the reservoir alternative noted that there should be improvements of the interior drainage system; flood proofing is too costly and ineffective.

c. The sand berm at the river mouth is causing flow problems and it should not be there. (Response: The sand berm is a natural occurrence. In relation to high river flows, the berm would be washed out and is not considered a flood hazard. Permits have been granted to the County to maintain the opening at river mouths.)

d. Upstream water diversion is causing sediment deposition along the lower Waimea River.

e. The need for land acquisition and for setting aside adequate funds for this purpose was raised. (Response: Project implementation will require lands for new structures and facilities. Local cooperation for lands, easements, and rights-of-way will be settled prior to construction.)

6. To provide the public an opportunity to participate in the plan selection process, a final public meeting was held on 28 February 1980. Total attendance was 12 persons. The presentation included detailed discussions on plan features of the alternatives; economic, social and environmental factors; engineering considerations and appropriate levels of protection; designation

of NED and EQ plans and the tentatively recommended plan; local cooperation requirements; and necessary steps leading to project construction. In addition, public concerns on the sand berm and interior draiange problems were addressed with respect to the proposed plan of improvement.

7. On behalf of the Department of Public Works, a county official testified in support of the tentatively selected plan designed for protection against the 100-year flood event. He noted that the 100-year flood level is in conformance with the Federal Flood Insurance Program, and it meets all the county requirements. He also expressed their appreciation to the Corps for conducting the study and general assistance in solving their overall interior drainage problems. Comments and remarks made by the public were generally in the cost-sharing area, construction time requirements, and construction impacts. No objection was voiced on the study recommendations.

DRAFT REPORT AND ENVIRONMENTAL STATEMENT REVIEW

8. The draft document was sent to the following agencies for review:

a. U.S. Government Agencies

*Advisory Council on Historic Preservation, Washington and Denver Offices

Department of Agriculture
- Office of the Secretary
- Soil Conservation Service
- Director, Forest Service

Department of Commerce
- Deputy Assistant Secretary for Environmental Affairs
- Regional Representative
- Coastal Zone Management, Pacific Region
- *National Marine Fisheries Service
- National Oceanic & Atmospheric Administration, SW Region

Department of Defense
- Commander, Pacific Missile Range Facility
- *Commander, Naval Base, Pearl Harbor, Hawaii
- Commander, Fort Shafter
- Commander, Tripler Hospital
- *Department of the Air Force, Dir. of Civil Engineering

Environmenmtal Protection Agency
- *Regional IX, EIS Coordinator
- Officer of Field Activities

Department of Health, Education and Welfare
- Regional Administrator

Department of Housing and Urban Development
- Assistant Secretary for Community Planning and Management
- Regional Administrator
- *Honolulu Area Office

Department of the Interior
*Office of Environmental Project Review
Interagency Archaeological Services
Fish and Wildlife Service, Portland and Honolulu Offices
*National Park Service, San Francisco and Honolulu Offices
Geological Survey
Department of Transportation
Commander, 14th Coast Guard District

. State of Hawaii
*Department of Defense
*Department of Transportation
*Department of Health
*Department of Land and Natural Resources
Department of Education
*Department of Planning and Economic Development
*Department of Agriculture
*Environmental Center, University of Hawaii
Water Resources Research Center, University of Hawaii
*Department of Social Services & Housing
*State Historic Preservation Officer
*Office of Environmental Quality Control
*Department of Accounting and General Services

c. County of Kauai
Kauai County Council
*Department of Water Supply
*Department of Public Works
Parks and Recreation Division
Planning Department
Public Information Officer
Office of Economic Development

* Indicates review comments were received.

REPORT COMMENTS AND RESPONSES

9. Pertinent correspondence received from government agencies, groups, and individuals are displayed in this section. Following the local sponsor's letter of assurances are the individual letters received from reviewing agencies. Review letters containing numerous or substantive comments are followed by the District's letter of response.

EDUARDO E. MALAPIT
MAYOR

COUNTY OF KAUAI
DEPARTMENT OF PUBLIC WORKS
4396 RICE STREET
LIHUE, KAUAI, HAWAII 96766

HENRY MORITA
COUNTY ENGINEER
TELEPHONE 245-3318

CLAY KAGAWA
DEP. COUNTY ENGINEER
TELEPHONE 245-3602

MAY .. 1980

May 13, 1980

Colonel B. R. Schlapak, District Engineer
U. S. Army Engineer District, Honolulu
Department of the Army
Building 230
Fort Shafter, HI 96858

Dear Colonel Schlapak:

RE: WAIMEA RIVER FLOOD CONTROL STUDY, WAIMEA, KAUAI, HAWAII

This is in response to your letter dated March 6, 1980, requesting assurances of local cooperation in the implementation of the recommended flood control plan for Waimea.

We wish to first advise you that local funds to finance costs in excess of the $2 Million Federal limitation is currently non-existent. However, just as soon as State statistics, which currently limits bond interest rates to a maximum of 8% are amended to allow for higher rates, the County expects to float a bond which will provide funds for the subject project. The matter of bond interest rates is with the Hawaii State Legislature presently in session.

Regarding your request for specific items of local cooperation to comply with requirements specified in Section 3 of the 1936 Flood Control Act, as amended, the County of Kauai does hereby declare its intention under the authority of its delegated power to enter into an agreement with the Secretary of the Army to:

a. Provide without cost to the United States, all lands, easements, rights-of-way necessary for the construction and subsequent maintenance of the project;

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b. Hold and save the United States free from damages due to the construction and maintenance of the project, excluding damages due to the fault or negligence of the United States or its contractors;

c. Maintain and operate all the works after completion in accordance with regulations prescribed by the Secretary of the Army;

d. Provide without cost to the United States all relocations or alterations of buildings, utilities, highway bridges, sewers, and other structures and improvements;

e. Provide assurances that encroachment on improved channels or on required flowage easements will not be permitted; and

f. Assume all costs inexcess of the $2 Million Federal limitation for the channel improvements and related works.

In carrying out the specified non-federal responsibilities for the Waimea River project, the County of Kauai agrees to comply with the provisions of the "Uniform Relocation Assistance and Real Property Acquisitions Policies Act of 1970", Public Law 91-646, approved 2 January, 1971; and Section 221, Public Law 91-611, approved 31 December, 1970, as amended.

We have reviewed the draft Section 221 agreement. It is understood that the agreement must be executed by the Secretary of the Army prior to commencement of construction of the project. It is also understood that the District Engineer will determine the final project costs after actual project costs are known.

Very truly yours,

HENRY MORITA
County Engineer

APPROVED:

EDUARDO E. MALAPIT
Mayor, County of Kauai

ROBERT K. YOTSUDA, Chairman
Kauai County Council

EDUARDO E. MALAPIT
MAYOR

OFFICE OF THE MAYOR
4396 RICE STREET
LIHUE, KAUAI, HAWAII 96766

James Kurita
ADMINISTRATIVE ASST.

MAY -- 1981

May 19, 1981

Colonel Alfred J. Thiede
District Engineer
U. S. Army Engineer District, Honolulu
Building 230
Fort Shafter, Hawaii 96858

Dear Colonel Thiede:

This will follow up our letter dated May 13, 1981, which provided our local cooperation intents for the recommended Waimea River flood control project, Island of Kauai. In addition to the specific items of local cooperation noted on our May 13, 1980 letter, we wish to further clarify certain particulars as follows:

a. The recommended plan would provide protection from floods up to the one percent flood (100-year). At a meeting with your staff on May 12, 1981, the chance and risk, and consequences of flows exceeding the design flood were discussed. We acknowledge full understanding and acceptance of the risk involved. Also, we agree to notify the public in Waimea periodically on the degree of flood protection provided and to publicize flood plain information in the area concerned.

b. Certain lands within the project area and forming a part of the flood plain will be regulated for future use (see inclosed map). The agricultural land totalling approximately 52 acres on the opposite side of the river from the existing levee will, with the completion of the recommended project, become a floodway necessary for its operation. In addition, the internal drainage ponding area, totalling 11 acres up to elevation +5, will require

Add. 30 Jun 81

stability of its storage capacity for functioning of the drainage outlet project feature. The County of Kauai will agree to regulate the respective areas so as to control usage in a manner consistent with the flood hazard and operational characteristics, including adoption of regulations as may be necessary to insure compatability between future land use and operation of the recommended project.

c. As an added protection measure, an early warning system would further minimize the threat to life associated with floods exceeding the level of protection. We understand that the first costs of the flood warning system shall be apportioned 80 percent federal and 20 percent non-federal. We accept responsibility for periodic operations, maintenance, and replacement to the flood warning system on Kauai.

Please accept this letter as our intent to enter into a formal agreement covering our participation prior to the initiation of construction.

Very truly yours,

Eduardo E. Malapit

EDUARDO E. MALAPIT
Mayor, County of Kauai

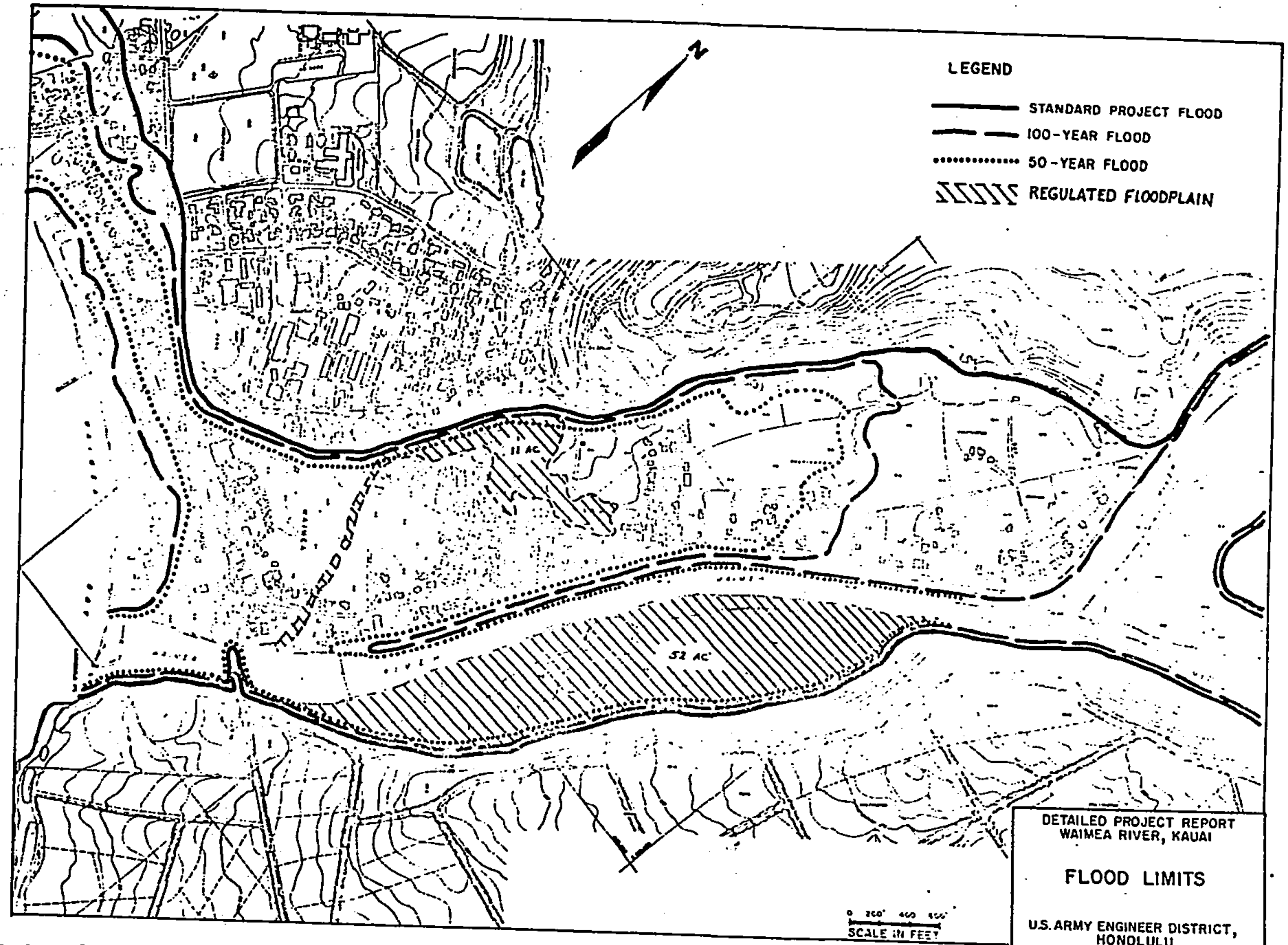

PLATE A-24

Add. 30 Jun 81

FEDERAL AGENCIES'

LETTERS AND RESPONSES

Advisory Council On Historic Preservation

1522 K Street NW.
Washington D.C.
20005

Reply to: P. O. Box 25085
Denver, Colorado 80225

This response does not constitute Council comment pursuant to Section 106 of the National Historic Preservation Act, nor Section 2(b) of Executive Order 11593.

November 30, 1979

Mr. Kisuk Cheung
Chief, Engineering Division
Corps of Engineers, Honolulu District
Department of the Army
Building 230
Ft. Shafter, Hawaii 96858

Dear Mr. Cheung:

The Council has received the Corps of Engineers' draft detail project report and draft environmental statement (DES) for the Waimea River Flood Control Study circulated for comment pursuant to Section 102(2)(C) of the National Environmental Policy Act. We note that the undertaking may affect the Russian Fort Elizabeth and Cook Landing Site, properties included in the National Register of Historic Places and other cultural properties that may be eligible for inclusion in the National Register. Circulation of a DES, however, does not fulfill your agency's responsibilities under Section 106 of the National Historic Preservation Act of 1966 (16 U.S.C. Sec. 470f, as amended, 90 Stat. 1320).

Prior to the approval of the expenditure of any Federal funds or prior to the granting of any license, permit, or other approval for an undertaking, Federal agencies must afford the Council an opportunity to comment on the effect of the undertaking on properties included in or eligible for inclusion in the National Register in accordance with the Council's regulations, "Protection of Historic and Cultural Properties" (36 CFR Part 800). Until these requirements are met, the Council considers the DES incomplete in its treatment of historical, archeological, architectural, and cultural resources. You should obtain the Council's substantive comments through the process outlined in 36 CFR Sec. 800.9. These comments should then be incorporated into any subsequent documents prepared to meet requirements under the National Environmental Policy Act. Mr. Michael C. Quinn may be contacted at (303) 234-4946, an FTS number, for further assistance.

Sincerely,

Louis S. Wall
Chief, Western Division
of Project Review

PODED-PV

10 December 1979

Mr. Louis S. Wall
Chief, Western Division of Project Review
Advisory Council on Historic Preservation
P. O. Box 25085
Denver, Colorado 80225

Dear Mr. Wall:

In partial compliance with your letter of November 30, 1979 and in accordance with U.S. Army Corps of Engineers policies and procedures (33 CFR Part 305), Section 106 of the National Historic Preservation Act of 1966 as amended, and the Advisory Council on Historic Preservation's "Protection of Historic and Cultural Properties" (36 CFR Part 800), we are transmitting to you for review and comment a copy of "A Cultural Reconnaissance of the Waimea River Flood Control Study Area, Kauai, Hawaii" prepared under contract by P. K. Jeorger and C. F. Streck, Jr. (Hawaii Marine Research, Inc), September 1979 (Incl 1).

In an earlier letter to the Advisory Council (8 June 1979), a copy of which was provided to you, we identified three historic sites within the study area: Russian Fort Elizabeth, Cook Landing Site and Peekauai or Menehune Ditch. The first two are listed on the National Register of Historic Places and Cook Landing Site is further designated as a National Landmark. We determined at that time and subsequently in the draft environmental impact statement (provided to you by letter 8 October 1979) that none of the alternative plans would have any effect on the Russian Fort Elizabeth but that Plans 2 and 3 would have an effect on the boulder-plaque commemorating the Cook Landing Site. Plans 2 and 3 were also determined to have a potential effect on parts of Peekauai Ditch which is believed likely eligible for the National Register.

Based on the findings of the Jeorger and Sterch report we have determined that construction of a low flood levee seaward of the Waimea River highway bridge and temporary relocation of the boulder plaque commemorating Cook Landing Site does not appear to have an adverse effect on the National Register and National Landmark property. The report revealed considerable doubt about the actual location of Cook's landing and further showed that

the southern river bank has undergone much modification in the past fifty years. The Cook Landing Site does not consist of an historical landscape frozen in time but rather a convenient place to commemorate a very significant event in Hawaiian history that occured in the near vicinity. We acknowledge that the flood control levee will be a visual intrusion on the existing setting, but we do not believe that the historic character of the cultural property will be affected. We maintain that none of the Advisory Council's "Criteria of Adverse Effect" (36 CFR 800.3(b)) apply to either of the proposed structural flood control plans (Plans 2 and 3).

The commemorative Cook Landing Site plaque has attained, according to the contract report, "local historical importante and (has) become a visitor attraction." Should either Plans 2 or 3 be selected for implementation, the Corps will closely coordinate with the local community and with County authorities to assure that the selected plan is compatible with existing use of the area and that, if required, the boulder monument is relocated so as to maintain adequate accessibility to it and a continued unimpaired view of the surrounding area.

Flood-proofing measures associated with Plan 1 would require construction of reinforced concrete walls at least 2-3 feet high around the Bishop National Bank of Hawaii building, listed on the National Register, as well as four other State-registered buildings and three unregistered historic buildings. Should alternative Plan 1 be selected, these modifications to the immediate surrounding environment of the historic structures could result in adverse visual effects.

We concur with the Joerger and Streck report that the Peekauai Ditch appears eligible for the National Register, based on the two criteria (36 CFR 60.6) that (1) portions of it apparently represent the only form of prehistoric waterway construction in Hawaii using faced and fitted basalt slabs and that (2) these unique portions of the waterway "have yielded, or may likely yield, information important to prehistory" of the region.

We believe there currently exist sufficient documentation in our report and in the State Historic Preservation Officer's files to justify the National Register eligibility of Peekauai (Menehune) Ditch for inclusion. We are uncertain whether or not the Corps is the proper agency to submit this linear cultural property for a determination of eligibility when its most original and significant portion lies outside the "area of the undertaking's potential environmental impact." Much of the original waterway has been covered, destroyed or modified in the last 100 years. The portion of the original waterway exhibiting the above characteristics (see Figure 19, Joerger and Sterck, 1979) are on the oposite side of a mountain spur about 300 feet from the northern most portion of the proposed road-raising feature of Plans 2 and 3 (detailed Project Report, letter of 8 October 1979). Within about 10 feet south of the road proposed for possible raising the ditch exits from a modern concrete pipe and culvert and enters a ditch constructed of multiple stacked basalt chunks (Figure 20, Joerger and Streck, 1979). This latter portion may or may not be of prehistoric origin and is the only portion of the irrigation ditch that could be considered within the project study area. The degree to which the road may require raising, should Plans 2 or 3 be selected for implementation, still remains to be determined in detail.

The invert of the concrete pipe-enclosed irrigation line lies 6-8 feet below the surface of the road. Raising the road would not affect this portion of the irrigation line. We also will assure that the rock-lined portion of the irrigation ditch south of the road will not be affected by construction activities. Actually the road raising would protect the ditch from possible flood damage. Even if the road were not raised, the immediate area would still be protected from significant flood damage.

The Joerger and Streck-report (p.29) also states that cultural deposits such as those associated with prehistoric (or historic) taro terraces and other auwai irrigation systems in Area 2 (near Peekauai Ditch) may also be disturbed by modification of the present land surface. We maintain that none of the features of any of the three alternative plans will directly disturb the terrain in this area. There are known to be prehistoric and early historic agricultural features in a low area between the Kaimea and Makeweli Streams just above their confluence (see Figure 11, Incl. 1). Part of this area is also known to flood and will continue to flood even with the proposed improvements of Plans 2 and 3. The proposed raising of the road near Peekauai Ditch would not change upstream or adjacent flooding characteristics to any appreciable degree because the raising would only be providing a freeboard degree of protection as required by the Corps flood protection standards It does not cut off an existing drainage way at that particular location.

In summary, we have determined that implementation of either Plans 2 and 3 would not adversely affect the Cook Landing Site, which is listed on the National Register and which is a National Historic Landmark. Based on our present knowledge, it is also likely that Peekauai Ditch, which may be eligible for the National Register, would not be affected in any way by features of Plans 2 or 3. We, are uncertain about our agency's authority to request a determination for this cultural resource, the most significant parts of which lie outside the area of our undertaking. Implementation of Plan 1 could very well adversely affect Bishop National Bank of Hawaii which is listed on the National Register. We anticipate making a final plan selection within a few months.

Prior to issuance of the final environmental statement, we will refine and resubmit our request for comments. At that time, we should also be able to provide more detailed information on the exact nature of the selected plan and how it relates to the historic sites in question.

For your information we are simultaneously providing the State Historic Preservation officer with a very similar letter.

We would request your review or the Joerger and Streck report and comments on our determination and questions. Should you have any questions, please contact Mr. David Sox of my staff, Telephone (FTS) 438-2264.

Sincerely yours,

1 Incl
as stated

KISUK CHEUNG
Chief, Engineering Division

Advisory Council On Historic Preservation

1522 K Street NW.
Washington D.C.
20005

Reply to: P. O. Box 25085
Denver, Colorado 80225

January 8, 1980

Mr. Kisuk Cheung
Chief, Engineering Division
Corps of Engineers, Honolulu District
Department of the Army
Building 230
Fort Shafter, Hawaii 96858

Dear Mr. Cheung:

The Council has received your letter of December 10, 1979, in which the various effects on historic and cultural properties of the alternatives being considered for the Waimea River Flood Control Project are discussed. It appears that all of the project alternatives being considered would affect one or more properties included in or eligible for inclusion in the National Register of Historic Places and, thereby, require compliance with Section 106 of the National Historic Preservation Act of 1966, as amended, prior to approval of any of them.

While we can appreciate the logic employed in assessing the effects of the three alternatives, please remember that such determinations of effect and the nature of any effects is to be done in consultation with the Hawaii State Historic Preservation Officer. Further, that any determinations of no adverse effect must be supported by the documentation called for in Section 800.13(a) of the Council's regulations, "Protection of Historic and Cultural Properties" (36 CFR Part 800).

Although the Corps cannot nominate property for inclusion in the National Register which is not under its control or jurisdiction, it is required to seek determinations of eligibility in accordance with the National Register's guidelines (36 CFR Part 63) for any historic or cultural property that appears to meet the National Register criteria and would be affected by its undertaking regardless of

ownership. If the Peekauai Ditch will be affected by the alternative selected for the proposed flood control project it will be necessary to seek a determination of eligibility for that property even though more significant elements of that cultural feature may be beyond the potential zone of impact. The process of determining a property eligible for inclusion in the National Register fixes the property's significance, providing the basis for determining effect and the nature of any effect found.

We look forward to working with the Corps in accordance with the Council's regulations once it has refined its determinations of effect. It is suggested that the documentation submitted at that time, with the Corps' formal request for Council comment on the flood control project, take the form of a preliminary case report as detailed in Section 800.13(b) of the regulations.

Should you have any questions or require additional assistance, please call Michael C. Quinn or Jane King of this office at (303) 234-4946, an FTS number. Your continued cooperation is appreciated.

Sincerely,

Louis S. Wall
Chief, Western Division
of Project Review

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
215 Fremont Street
San Francisco, Ca. 94105

Project #D-COE-K36039-HI

Mr. Kisuk Cheung
Chief, Engineering Division
U.S. Army Engineer District, Honolulu
Building 230
Ft. Shafter HI 96855

DEC 21 1979

Dear Mr. Cheung:

The Environmental Protection Agency (EPA) has received and reviewed the Draft Environmental Impact Statement (DEIS) titled WAIMEA RIVER FLOOD CONTROL STUDY.

The EPA's comments on the DEIS have been classified as Category ER-2. Definitions of the categories are provided on the enclosure. The classification and the date of the EPA's comments will be published in the Federal Register in accordance with our responsibility to inform the public of our views on proposed Federal Actions under Section 309 of the Clean Air Act. Our procedure is to categorize our comments on both the environmental consequences of the proposed action and the adequacy of the environmental statement.

The EPA appreciates the opportunity to comment on this DEIS and requests three copies of the Final Environmental Impact Statement when available.

If you have any questions regarding our comments, please contact Susan Sakaki, Acting EIS Coordinator, at (415) 556-6925.

Sincerely yours,

Paul C. Kohmutt (for)
Paul De Falco, Jr.
Regional Administrator

Enclosure

EIS CATEGORY CODES

Environmental Impact of the Action

LO--Lack of Objections

EPA has no objection to the proposed action as described in the draft impact statement; or suggests only minor changes in the proposed action.

ER--Environmental Reservations

EPA has reservations concerning the environmental effects of certain aspects of the proposed action. EPA believes that further study of suggested alternatives or modifications is required and has asked the originating Federal agency to reassess these aspects.

EU--Environmentally Unsatisfactory

EPA believes that the proposed action is unsatisfactory because of its potentially harmful effect on the environment. Furthermore, the Agency believes that the potential safeguards which might be utilized may not adequately protect the environment from hazards arising from this action. The Agency recommends that alternatives to the action be analyzed further (including the possibility of no action at all).

Adequacy of the Impact Statement

Category 1--Adequate

The draft impact statement adequately sets forth the environmental impact of the proposed project or action as well as alternatives reasonably available to the project or action.

Category 2--Insufficient Information

EPA believes that the draft impact statement does not contain sufficient information to assess fully the environmental impact of the proposed project or action. However, from the information submitted, the Agency is able to make a preliminary determination of the impact on the environment. EPA has requested that the originator provide the information that was not included in the draft statement.

Category 3--Inadequate

EPA believes that the draft impact statement does not adequately assess the environmental impact of the proposed project or action, or that the statement inadequately analyzes reasonably available alternatives. The Agency has requested more information and analysis concerning the potential environmental hazards and has asked that substantial revision be made to the impact statement.

If a draft impact statement is assigned a Category 3, no rating will be made of the project or action, since a basis does not generally exist on which to make such a determination.

404(b) Permit Comment

The EPA has reviewed the Draft EIS in accordance with EPA Regulations 40 CFR 230 promulgated pursuant to Section 404(b) of the Clean Water Act (1977).

Since flood proofing under Plan 1 is the least environmentally damaging alternative, the EPA recommends its implementation. However, if a structural alternative is necessary due to other considerations, under EPA guidelines 40 CFR 230.5(a), the disruption of the chemical, physical and biological integrity of the aquatic ecosystem should be avoided.

This Office recognizes Plan 3 as being environmentally more desirable than Plan 2, since river dredging would not be required. In any event, the Final EIS evaluation of the selected plan should address the impacts of the project on the chemical, physical and biological integrity of the aquatic ecosystem.

PODED-PV

4 January

Mr. Paul De Falco, Jr.
Administrator Region IX
U. S. Environmental Protection Agency
San Francisco, California 94105

Dear Mr. De Falco:

Thank you for your review and comment on our Draft Detailed Project Report and Environmental Statement for the Waimea River Flood Control Study, Waimea, Kauai.

Plan 3 is being considered as the Plan of Improvement for the study. This plan consists of an "I"-wall, a levee extension, and dredging in conjunction with the placement of stones for toe protection. The suitability of the project site and the justification for discharge of dredged or fill materials at the site have been evaluated in accordance with the Section 404(b) Guidelines. This will be reflected in the Final Environmental Statement.

Your comments will be helpful in preparation of the final document. Three copies of the Final Environmental Statement will be provided to you when they become available.

Sincerely yours,

KISUK CHEUNG
Chief, Engineering Division

UNITED STATES
DEPARTMENT OF THE INTERIOR
OFFICE OF THE SECRETARY
PACIFIC SOUTHWEST REGION
BOX 36098 • 450 GOLDEN GATE AVENUE
SAN FRANCISCO, CALIFORNIA 94102
(415) 556-8200

ER79/1036 December 13, 1979

Mr. Kisuk Cheung
Chief
Engineering Division
Department of the Army
US Army Engineer District
Building 230
Ft. Shafter, Hawaii 96858

Dear Mr. Cheung:

The Department of the Interior has reviewed the draft environmental statement for the Waimea Flood Control Study, Maui, Hawaii. Our comments follow:

General Comments

It is noted (Page 41, Plan 2) that channel deepening would be conducted during the dry season, but the study does not discuss the availability of disposal sites for dredged spoils. This matter should be addressed and the potential impact of these spoil areas on environmental and cultural resources fully described.

Except for spoil locations, both the Detailed Project Report and the Environmental Statement adequately address project related impacts on fish and wildlife resources. However, further consideration should be given in both documents to including the removal of the sandbar at the mouth of the Waimea River in project plans, both to reduce flooding hazards and to minimize damage to aquatic habitat from sedimentation.

Encroachment of the levee on to Lucy Wright County Park could involve lands increased with Land and Water Conservation Fund Act monies. This problem must be dealt with in both reports and specific arrangements and clearances described.

Cultural resources have not been adequately described in these reports and legal and administrative procedures relating to handling archeological resources have not been met.

Specific Comments

Fish and Wildlife Resources. The recommendation of the US Fish and Wildlife Service that the sandbar be removed from the mouth of the Waimea River is not included in any of the preliminary plan alternatives. The reason given is that high flows would wash out this obstruction shortly after the onset of flood conditions. However, Table A-7 (Appendix A) states that the actual crest height of the two-year-frequency flood is two feet greater than expected (5.7 vs. 3.7 feet MSL) because of the failures of the two-year flood to wash out the sandbar. If accompanied by heavy rainfall in Waimea town, considerable damage could result from a flood at this magnitude.

In addition to increasing the risk of flooding, the sandbar creates a backwater which encourages deposition of siltland fines and impedes upstream migration of diadromous aquatic fauna, especially during relatively low flood periods. Therefore, we continue to recommend that removal of this obstruction be made a part of the selected plan.

Recreational Resources. Construction of the proposed levee adjacent to/or on portions of Lucy Wright County Park may be subject to the provisions of the Land and Water Conservation Fund Act (LWCF). Development of the Park was paid for with matching state and LWCF monies. Section 6(f) of the LWCF provides that "No property acquired or developed with assistance under this section shall, without the approval of the Secretary, be converted to other than public outdoor recreation uses. Substitution of other recreation properties of at least equal fair market value and reasonably equivalent usefulness and location" may be required for approval of such conversion. Request for conversion of the portion of Lucy Wright County Park proposed for levee implacement should be sent to the Director, Heritage Conservation and Recreation Service. Capital improvements may be deemed acceptable as substitutable recreation properties by the Director.

The boundary of Lucy Wright County Park in our files is unclear. We suggest that Mr. Susumu Ono, Chairman, Board of Land and Natural Resources (SLO) be contacted for an official determination of the park boundary.

Cultural Resources. The final environmental statement should contain the results of any ongoing historic and archeological resource work (see p. 37). This should include a formal request for a determination of eligibility from the Keeper of the National Register for the Menehune (Peekauai) Ditch, along with evidence of consultation with the Hawaii State Historic Preservation Officer concerning treatment of all of the resources in the study area.

Depending on the plan selected as the preferred alternative, the final statement should also contain evidence of consultation with the Advisory Council, including a copy of any memorandum of agreement concerning mitigation measures for either the Menehune Ditch or other affected resources.

The State Historic Preservation Officer should be consulted to elucidate a specific policy on flood proofing of historic buildings. Determination should be made whether flood proofing procedures would detrimentally alter the architectural or esthetic characters of the structures.

Both the Cook Landing Site and the Russian Fort are registered National Historic Landmarks. This should be noted in the final statement.

Thank you for the opportunity to comment on these documents. If you have any questions, please contact me directly.

Sincerely yours,

Patricia Sanderson Port
Regional Environmental Officer

cc: Director, OEPR (w/copy incoming)
Director, Fish and Wildlife Service
Director, National Park Service
Director, Geological Survey
Director, Heritage Conservation and Recreation Service
Director, Bureau of Mines
Regional Director, FWS
Regional Director, NPS
Regional Director, HCRS
Regional Director, BOM
Assistant Director, GS
SHPO

PODED-PV 31 January 1980

Ms. Patricia Sanderson Port
Regional Environmental Officer
Office of the Secretary
U.S. Department of the Interior
450 Golden Gate Avenue, Box 36098
San Francisco, California 94102

Dear Ms. Port:

Thank you for your comments dated 13 December 1979 on the draft Detailed Project Report and Environmental Impact Statement (EIS) for the Waimea River Flood Control Study, Kauai, Hawaii. Responses to your general and specific comments are combined as follows:

a. Riverbed material dredged from channel deepening and excavation would be discharged at the Kekaha Sanitary Landfill located four miles from the project site. We will address this in the final report.

b. The U.S. Army Corps of Engineers does not consider the 2-year flood a high flow. For the higher flows, such as the 50- or 100-year event, the values on Table A-7 show the closeness of the actual and expected water surface elevations. Our evaluation indicates that the sandbar would be washed out by those higher flood peaks. Heavy rainfall and flood runoff through Waimea town will likely result in events greater than the 2-year frequency flood. Currently, the County of Kauai maintains an opening in the sandbar to pass the average daily river discharges. The frequency of maintenance by the local government is about 6 to 8 times per month. Because the formation of sandbars is a common occurrence at many river outlets in the Hawaiian Islands, removal work would only be a temporary solution unless performed on a continuous basis. The County will be required to maintain the stream mouth as a part of the proposed project. Since the sandbar has minimal impact on the overall damage potential, we gave no further consideration to its removal in our alternative plans.

c. In regard to the Lucy Wright County Park, we will initiate coordination with the Director, Heritage Conservation and Recreation Service to assure compliance with provisions of the Land Water Conservation Fund Act. The official boundaries of Lucy Wright Park are shown in Inclosure 1 (TMK 1-6-06).

d. In the final EIS, we will discuss the findings of our cultural resources reconnaissance which was completed in late September 1979. We have sent the State Historic Preservation Officer (SHPO) a copy of the cultural reconnaissance report. Based on his comments and after we consult with members of your Pacific Southwest Regional Office, we will be seeking a determination of eligibility to the National Register for the Peekauni (Menehune) Ditch. We have kept the Advisory Council on Historic Preservation informed about the project and its possible effects, and we will consult with the council as necessary regarding Peekauai Ditch. At this time, we hope to be able to avoid any effect whatsoever on the irrigation ditch. The SHPO has concurred with our determination of no adverse effect of Plans 2 and 3 on the Captain Cook Landing Site Memorial, and we will forward documentation supporting this determination to the Advisory Council in compliance with the Council's regulations (36 CFR 800).

e. We do not anticipate that the nonstructural alternative involving floodproofing will be recommended as the Plan of Improvement. Should we recommend some floodproofing, however, we will coordinate the specific floodproofing measures with the SHPO to assure that conflicts with the aesthetic and architectural characteristics of the particular historic buildings be minimized or avoided. Alternatively, we will consider deleting the need for floodproofing of specific buildings, including those of historic significance.

f. We will amend the final EIS to state that the Cook Landing Site and Russian Fort are registered National Historic Landmarks.

Sincerely yours,

1 Incl
As stated

KISUK CHEUNG
Chief, Engineering Division

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

December 7, 1979 F/SWR1:JJN

Mr. Kisuk Cheung
Chief, Environmental Division
U. S. Army Engineer District,
Honolulu
Building 230
Ft. Shafter, Hawaii 96858

Dear Mr. Cheung:

The National Marine Fisheries Service (NMFS) has reviewed the draft environmental impact statement (DOC DEIS #7910.37), Waimea River Flood Control Study, Waimea, Kauai (CE).

Resources for which NMFS bears a responsibility and alternatives to reduce adverse impacts on these resources have been addressed to our satisfaction in the DEIS. This agency recommends the implementation of Plan 3, construction of the "I" wall and toe protection but without the deepening of the river channel by excavation.

We hope these comments will be of assistance to you in selecting the appropriate alternative. Please send us a copy of the final EIS as soon as it becomes available.

Sincerely yours,

Doyle E. Gates
Administrator

cc: Gary Smith, F/SWR3
Office of Habitat Protection,
F/HP (4 copies)

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

PODED-PV

17 December 1979

Mr. Doyle E. Gates, Administrator
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

Dear Mr. Gates:

Thank you for your comments on the Detailed Project Report and Draft Environmental Impact Statement for the Waimea River Flood Control Study. Your comments will be considered and included as part of the Final Environmental Impact Statement, which will be sent to your office.

Sincerely yours,

KISUK CHEUNG
Chief, Engineering Division

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
AREA OFFICE
300 ALA MOANA BLVD., RM. 3318, P. O. BOX 50007
HONOLULU, HAWAII 96850

REGION IX
450 Golden Gate Avenue
P.O. Box 36003
San Francisco, California 94102

December 11, 1979

IN REPLY REFER TO:
9.1SS (Johnson/
546-5554)

Mr. Kisuk Cheung, Chief
Engineering Division
Department of the Army
U.S. Army Engineer District, Honolulu
Building 230
Fort Shafter, Hawaii 96858

Dear Mr. Cheung:

Subject: Draft Detailed Project Report and Environmental Statement, Waimea River Flood Control Study, Waimea, Kauai

The Honolulu Area Office has reviewed the subject document on the proposed action. Implementation of the proposed action would provide structural and non-structural measures to mitigate flood damage in the Waimea River drainage basin.

We have no substantive comments to make but appreciate the opportunity to review the Draft EIS and look forward to receiving the Final Project Report and EIS.

Sincerely,

Alvin K. H. Pang
Area Manager

United States Department of the Interior
NATIONAL PARK SERVICE
HAWAII STATE OFFICE
300 ALA MOANA BLVD., SUITE 6305
BOX 50165
HONOLULU, HAWAII 96850

IN REPLY REFER TO:

October 26, 1979

Mr. Kisuk Cheung
Chief, Engineering Division
Department of the Army
U. S. Army Engineer District, Honolulu
Building 230
Fort Shafter, HI 96858

Dear Mr. Cheung:

We have reviewed the Draft Detail Project Report with Draft Environmental Statement for the Waimea River Flood Control Study and have no comments.

This reply does not constitute an official position or comment of the National Park Service or of the U. S. Department of the Interior, but this review was of a technical and professional nature and concerned only cultural resources.

We are returning the draft report for your use.

Sincerely yours,

Robert L. Barrel
State Director

Enclosure

HEADQUARTERS
NAVAL BASE PEARL HARBOR
BOX 110
PEARL HARBOR, HAWAII 96860

IN REPLY REFER TO:
002A:JWC:amn
Ser 2034

1 NOV 1979

From: Commander Naval Base, Pearl Harbor
To: District Engineer, U.S. Army Engineer District, Honolulu

Subj: Draft Detailed Project Report and Environmental Statement for Waimea River Flood Control Study, Waimea, Kauai

Ref: (a) DISTENGR USAED HONO ltr PODED-PJ of 16 Oct 1979

1. Enclosure (1) to reference (a) has been reviewed and the Navy has no comments to offer at this time.

2. The opportunity to review the subject Report with Statement is appreciated.

J. W. CARL
By direction

STATE AND LOCAL AGENCY

LETTERS AND RESPONSES

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

November 26, 1979

REF. NO.: CPO-1119

Mr. Kisuk Cheung, Chief
Engineering Division
Department of the Army
U. S. Army Engineer District, Honolulu
Building 230
Ft. Shafter, HI 96858

Dear Mr. Cheung:

Subject: Draft Detailed Project Report and Environmental Statement, Waimea Rover Flood Control Study, Waimea, Kauai

This provides our comments as requested by your letter of October 16, 1979 to the Division of Fish and Game of the Department of Land and Natural Resources regarding documents on the subject proposed project by the U. S. Army Corps of Engineers.

We understand from the project documents that three alternative plans are being considered to protect Waimea town on Kauai from future floods as a result of overbank flow from the Waimea River. The plans are:

Plan 1. *Floodproofing* — Buildings would be raised and floodwalls constructed.

Plan 2. River channel deepening — Raising the existing levee, toe protection and construction of a new levee.

Plan 3. Raising the existing levee, toe protection and construction of a new levee.

The aquatic resources of the Waimea River and the coastal areas near the river mouth would be least affected by Plan 3. Since dredging of the estuary would not be required under this plan, it is considered to be environmentally more desirable than Plan 2. We therefore support the adoption of Plan 3.

Thank you for the opportunity to review and comment on the proposed subject.

Very truly yours,

SUSUMU ONO, Chairman
Board of Land and Natural Resources

cc: Division of Fish & Game

PODED-PV

17 December 1979

Mr. Susumu Ono, Director
Department of Land and
Natural Resources
State of Hawaii
P.O. Box 621
Honolulu, Hawaii 96809

Dear Mr. Ono:

Thank you for your comments on the Detailed Project Report and Draft Environmental Impact Statement for the Waimea River Flood Control Study. Your comments will be considered and included as part of the Final Environmental Impact Statement, which will be sent to your office.

Sincerely yours,

KISUK CHEUNG
Chief, Engineering Division

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

December 12, 1979

Mr. Kisuk Cheung
Chief, Engineering Division
Department of the Army
Building 230
Fort Shafter, Hawaii 96858

Dear Mr. Cheung:

Subject: Draft Detailed Project Report and Environmental Statement Waimea River Flood Control Study Waimea, Kauai

Thank you for the opportunity to review and comment on the above named document.

The statement on page 37 of the document which states that the Menehune Ditch (Site 30-09-26) is not eligible for listing on the National Register and cites the State of Hawaii, "Register of Historic Places" is incorrect. The National register is a listing of sites which have been processed and accepted for registration and does not address the eligibility or values of sites not yet placed on the register. It is therefore necessary that a Determination of Eligibility be requested pursuant to 36 CFR 63 for this site.

On page 37, the statement that, "preliminary results indicate that no additional sites appear in the study area" is a misinterpretation of the archaeological report. The cited report (Joerger & Streck, 1979) clearly states specific areas where no further sites were located, i.e.,

(1) "In recently created seaward portion of Area 1 (Joerger & Streck, 1979, p. 22)

(2) Portion of Area 1 north of highway bridge (Joerger & Streck, 1979, p. 22)

Conversely, in their discussion of Area 2, they state that unlike Area 1, there are cultural resources in addition to the Menehune Ditch which may be affected by any landform modifications. A Determination of Eligibility pursuant to

36 CFR 63 should be requested for these sites also.

It is stated on page 44 of the Draft EIS that improvements to the Menehune Road may affect a portion of the Menehune Ditch. It is further stated that further study will be conducted to determine if the proposed development will impact this site and if so, the appropriate federal regulations will be addressed. We concur with the need for such a study and suggest that the site should be addressed as a whole, rather than addressing only the portion of the archaeological feature that lies within the area of impact. This would be logical from the standpoint of any archaeological feature, i.e., if a federal project were to impact a corner of a house which was eligible for nomination to the National Register, it would be necessary to consider the impact on the entire house not just the corner. Likewise, the impact on the whole of an archaeological feature should be addressed, not just that portion that lies within the project area

It is the Federal agency's responsibility to identify and inventory all cultural resources within the area of the undertakin· potential environmental impact that are included in or eligible for inclusion in the National Register.

Additionally because the project plans suggest that the Cook Landing Site Memorial (Site 30-05-9303), a site listed on the National Register of Historic Places may need to be moved, it will be necessary for you to meet criteria set forth in 36 CFR 800 regarding consultation with the Advisory Council on Historic Preservation.

Sincerely yours,

Susumu Ono
Susumu Ono
State Historic Preservation Officer

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

December 26, 1979

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

Dear Mr. Cheung,

SUBJECT: Waimea River Flood Control Study
Cultural Reconnaissance - Joerger & Streck, Jr.

In response to your letter of December 6, 1979, the following comments are offered.

We agree with you that the present placement of the Cook Landing Site Memorial does not represent the actual place of landing, but rather a convenient place to commemorate this significant event. We therefore concur that none of the Advisory Council's "Criteria of Adverse Effect" apply to the necessity of relocation of this memorial in an area agreeable to the community where it will have adequate accessibility and an unimpaired view of the surrounding area.

We further concur that should Plan I be implemented, several historic buildings would be adversely effected including sites on or likely to be eligible for inclusion on the National Register of Historic Places. It would therefore be necessary for the developing agency to clearly delineate the area that would be impacted by implementation of Plan I and to evaluate whether the impacted sites are eligible for inclusion on the National Register in concurrence with 36 CFR 63.

In regard to the Menehune "Peekauai" Ditch, we agree that this property appears to be eligible for the National Register in concurrence with 36 CFR 60.6. We further suggest that this site should be addressed as a whole, and even though implementation of Plan 2 or 3 may likely not impact any portion of the ditch that possible adverse effect to even a portion of this extremely important archaeological site must be seriously weighed taking into consideration all possible alternatives.

In evaluating the possible environmental impact on the historic and prehistoric taro terraces and auwai irrigation systems in Area 2, we are unclear as to the meaning of your statement that these will not be indirectly impacted to "any appreciable degree". It is our opinion that all adverse impact must be considered and evaluated.

In regard to the Joerger and Streck report, we find it to be adequate except in addressing the historic buildings in the town of Waimea which may be impacted by implementation of Plan I. However, it is possible that this portion of a cultural resource reconnaissance was not included in the scope of work for their contract.

We agree with most of the recommendations made by Streck for the archaeological remains. However, it is our opinion that preservation of the Peekauai Ditch is much more desirable than intensive monitoring during construction in the vicinity of this resource as suggested in the Joerger and Streck report.

In summary, we feel that the Peekauai Ditch may be eligible for the National Register and that appropriate federal regulations should be followed by the Corps to request a Determination of Eligibility from the Keeper of the National Register of Historic Places. We further suggest that any alteration of this important cultural resource would be a great loss to both the scientific community and the people of Hawaii generally. Additionally, we also suggest that implementation of Plan I would severely impact several historic sites of importance.

Very truly yours,

Susumu Ono
SUSUMU ONO
Chairman of the Board

RECEIVED

79 NOV 6 A8:50

DIVISION OF FORESTRY

HAWAII DEPARTMENT OF LAND AND NATURAL RESOURCES
DIVISION OF FORESTRY
KAUAI DISTRICT
P.O. BOX 1671
LIHUE, KAUAI, HAWAII 96766

IN REPLY REFER TO
A-29b

November 2, 1979

MEMORANDUM

To: Libert K. Landgraf, State Forester

From: Ralph E. Daehler, District Forester, Kauai

Subject: Waimea River Flood Control Study
(ref. Kisuk Cheung letter dated October 16, 1979)

I have reviewed the Draft Detail Project Report with Draft Environmental Statement for the Waimea River Flood Control Study.

The project does not affect watershed or Forest Reserve management function of our Division as it zeros in on downstream measures to reduce flood damage potentials in the Waimea Community.

I am in agreement and support Plan 3 as outlined on page 21 in table III of the report.

Ralph E. Daehler
District Forester, Kauai

attach: return Draft Report

cc: T. Yamamoto

(OVER)

ENDORSEMENT: 11/13/79

Concur with District Forester Daehler's comments.

LIBERT K. LANDGRAF

cc: Kauai District

GEORGE R. ARIYOSHI
GOVERNOR

STATE OF HAWAII
OFFICE OF ENVIRONMENTAL QUALITY CONTROL
OFFICE OF THE GOVERNOR
550 HALEKAUWILA ST
ROOM 301
HONOLULU, HAWAII 96813

RICHARD O'CONNELL
DIRECTOR
TELEPHONE NO.
548-6915

December 24, 1979

Mr. Kisuk Cheung, Chief
Engineering Division
U.S. Army Engineer District
Honolulu
Building 230
Fort Shafter, Hawaii 96858

SUBJECT: Draft Detailed Report and Environmental Impact Statement, Detailed Waimea River Flood Control Study, Waimea, Kauai

Dear Mr. Cheung,

We have reviewed the subject document and offer the following comments for your consideration:

1. Page 16

The 200-year protection level was used in scoping the preliminary alternative plans. Since, for relatively small floodplains, the relative merit and ranking of alternative solutions are essentially the same for various degrees of protection, why was the 200-year flood chosen over the 100-year flood.

2. Pages 31, 40

Table 4 indicates that the Marine Protection Research and Sanctuaries Act is not applicable. However, on December 15, 1979, a team of whale experts approved by the NOAA CZM Office recommended that all Hawaiian coastal waters within 100-fathom depth contour be designated as a marine sanctuary for the humpback whale. Therefore, the document should should discuss the impact of the proposed action on the proposed marine sanctuary.

3. Beach Erosion

Because the northwestern shores of Kauai is subjected to increasing beach erosion, the possible impact of the proposed action on the littoral drift and beach erosion should be discussed.

4. Joint EIS

We note that county lands will be affected by the proposed action and that the county Department of Public Works is a cooperating agency. Under the Council of Environmental Quality EIS Regulations and Chapter 343, HRS, a joint statement should be prepared if the action is subject to both the National Environmental Policy Act and the State EIS statute. Since this is the case for this project a joint environmental impact statement should be prepared.

5. Funding

The amount of any state or county funds required for the proposed action should be stated.

6. Record of Decision

When an alternative for the proposed action has been chosen, we would like a copy of the record of decision.

We trust that these comments will be helpful to you in preparing the final document. For your convenience, we have listed the commenting agencies and/or organizations on the attached sheet. We would like to request twenty-two copies of the final EIS when it becomes available.

We thank you for the opportunity to review this statement. We look forward to the final document.

Sincerely,

for Richard L. O'Connell
Director

Attachment

LIST OF COMMENTING AGENCIES AND/OR ORGANIZATIONS

FEDERAL	
Department of the Air Force	December 5, 1979
STATE	
Department of Agriculture	October 30, 1979
Department of Accounting and General Services	October 31, 1979
Department of Defense	November 2, 1979
Hawaii Housing Authority	November 8, 1979
Department of Transportation	November 28, 1979
*Department of Health	November 29, 1979
*Department of Planning and Economic Development	November 30, 1979
Department of Social Services	December 4, 1979
COUNTY OF KAUAI	
Department of Water	October 30, 1979
UNIVERSITY OF HAWAII	
Environmental Center	December 4, 1979

*Denotes comment previously forwarded to Corps.

21 January 1980

Mr. Richard L. O'Connell, Director
Office of Environmental Control
State of Hawaii
550 Halekauwila Street
Honolulu, Hawaii 96813

Dear Mr. O'Connell:

Thank you for your review and comments dated 24 December 1979 on the Draft Detailed Project Report and Environmental Statement for the Waimea River Flood Control Study, Waimea, Kauai. Our comments are as follows:

a. Page 15. Our general policy is that the Standard Project Flood (SPF) be considered for levees in urban areas. However, in determining the appropriate degree of protection other planning factors are used in the process. These factors include maximization of net economic benefits, desire of local interests, environmental considerations, and engineering and design considerations. During the preliminary evaluation of these factors, and in consideration of the chance and risk of exceeding various floods, and the consequences of exceeding those floods, the 200-year flood level was viewed as a reasonable order of magnitude. The 200-year level would be (1) above the point of benefit maximization at about the 50-year flood, (2) above the 100-year level, which is noted in County ordinances, and adopted by the Federal Insurance Administration as the base flood, and (3) below the SPF criterion that should be sought as a general rule for urban areas. The exact levels of protection for the alternative plans are currently being evaluated and more information on this will be incorporated in the final report.

b. Pages 31,40. The recommended humpback whale sanctuary within the 100-fathom contour will be addressed in the EIS in Table III, under Section 4 (Affected Environment), and Section 5 (Environmental Effects). The project will not affect any whales since it is located within a river estuary.

c. Beach Erosion. The project is not located along the northwestern shore of Kauai. It is located along the southwestern shore.

d. Joint EIS. We have already issued a draft EIS. At this time the County of Kauai has neither requested nor expressed interest in preparing a joint EIS for the project.

e. Funding. The amount of funding by federal and non-federal interests for the alternative plans are shown on pages 17 and 18.

f. Record of Decision. We are currently in the plan selection stage of study. A public meeting to present the selection process and recommendations is being scheduled. The final plan selection will be made after the public meeting. As requested, 22 copies of the final document will be sent to you.

Sincerely yours,

KISUK CHEUNG
Chief, Engineering Division

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS 15TH AIR BASE WING (PACAF)
HICKAM AIR FORCE BASE, HAWAII 96853

REPLY TO ATTN OF: DEEV (Mr Shiroma, 449-1831)

5 DEC 1979

SUBJECT: Draft Detailed Project Report and Environmental Statement
Waimea River Flood Control Study, Waimea, Kauai

TO: Office of Environmental Quality Control
550 Halekauwila Street, Room 301
Honolulu, Hawaii 96813

1. This office has reviewed the subject Draft EIS and has no comment to render relative to the proposed project.

2. We greatly appreciate your cooperative efforts in keeping the Air Force apprised of your project and thank you for the opportunity to review the document.

ROBERT Q. K. CHING
Chief, Engrg & Envmtl Plng Div
Directorate of Civil Engineering

GEORGE R. ARIYOSHI
GOVERNOR

STATE OF HAWAII
DEPARTMENT OF AGRICULTURE
1428 SO. KING STREET
HONOLULU, HAWAII 96814

JOHN FARIAS, JR.
CHAIRMAN, BOARD OF AGRICULTURE
YUKIO KITAGAWA
DEPUTY TO THE CHAIRMAN

October 30, 1979

MEMORANDUM

To: Office of Environmental Quality Control

Subject: Draft EIS - Waimea River Flood Control Study

The Department of Agriculture has reviewed the subject report and has no comments to offer.

Thank you for the opportunity to comment.

JOHN FARIAS, JR.
Chairman, Board of Agriculture

GEORGE R. ARIYOSHI
GOVERNOR

STATE OF HAWAII
DEPARTMENT OF ACCOUNTING AND GENERAL SERVICES
DIVISION OF PUBLIC WORKS
P. O. BOX 119, HONOLULU, HAWAII 96810

HIDEO MURAKAMI
COMPTROLLER

MIKE N. TOKUNAGA
DEPUTY COMPTROLLER

LETTER NO. (P)2106.9

Office of Environmental
Quality Control
550 Halekauwila Street, Room 301
Honolulu, Hawaii 96813

Gentlemen:

Subject: Detailed Project Report and Environmental Impact Statement for Waimea River Flood Control Study

Thank you for this opportunity to review and comment on the subject project.

The project will not have any adverse environmental effect on any existing or planned facilities serviced by our department.

Very truly yours,

RIKIO NISHIOKA
State Public Works Engineer

MI:jm

GEORGE R. ARIYOSHI
GOVERNOR

STATE OF HAWAII
DEPARTMENT OF DEFENSE
OFFICE OF THE ADJUTANT GENERAL
~~Fort Ruger, Honolulu, Hawaii 96816~~
3949 DIAMOND HEAD ROAD, HONOLULU, HAWAII 96816

VALENTINE A. SIEFERMANN
MAJOR GENERAL
ADJUTANT GENERAL

HIENG

2 NOV 1979

Office of Environmental Quality
550 Halekauwila Street, Room 301
Honolulu, Hawaii 96813

Gentlemen:

Waimea River Flood Control Study

Thank you for sending us a copy of the "Waimea River Flood Control Study" Environmental Statement Draft. We have no comments to offer at this time. The enclosed document is returned for your use.

Sincerely,

WAYNE R. TOMOYASU
Major, CE, HARNG
Contr & Engr Officer

Enclosure

GEORGE R. ARIYOSHI
GOVERNOR

STATE OF HAWAII
DEPARTMENT OF SOCIAL SERVICES AND HOUSING
P. O. Box 339
Honolulu, Hawaii 96809

ANDREW I. T. CHANG
DIRECTOR
LAWRENCE K. KOSEKI, DSW
DEPUTY DIRECTOR
RICHARD PAGLINAWAN
DEPUTY DIRECTOR

December 4, 1979

Office of Environmental Quality Control
550 Halekauwila Street, Room 301
Honolulu, Hawaii 96813

Dear Sirs:

Enclosed is the comment of the Department of Social Services and Housing Agency which has the greatest interest in the Waimea River Project.

Sincerely,

George D. White
Personnel Office-Safety Unit

Attachment

GEORGE R. ARIYOSHI
GOVERNOR

STATE OF HAWAII
DEPARTMENT OF SOCIAL SERVICES AND HOUSING
HAWAII HOUSING AUTHORITY
P. O. BOX 17907
HONOLULU, HAWAII 96817

FRANKLIN Y. K. SUNN
EXECUTIVE DIRECTOR
WILLIAM A. HALL
ASSISTANT EXEC. DIRECTOR

IN REPLY REFER
TO:

November 8, 1979

MEMORANDUM

TO: George White, Assistant Training Specialist
Department of Social Services and Housing
Training, Employee Relations & Safety Staff

FROM: Harold I. Kurihara, Development Administrator

SUBJECT: Draft Environmental Statement, Waimea River Flood Control Study

We have reviewed the draft Detailed Project Report and Environmental Statement, Waimea River Flood Control Study, Waimea, Kauai, by the U. S. Army Engineer District, Honolulu and have no negative comments to offer.

The completion of the project, however, will benefit the residents of Waimea, as well as an elderly project (Ho'me Nani) owned and operated by the Authority in Waimea.

The study is returned for your further action.

HAROLD I. KURIHARA

Enclosure - Draft of
Detailed Project Report &
Environmental Statement

GEORGE R. ARIYOSHI
GOVERNOR

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
869 PUNCHBOWL STREET
HONOLULU, HAWAII 96813

RYOKICHI HIGASHIONNA, PH.D.
DIRECTOR

DEPUTY DIRECTORS
[illegible]
[illegible]
JAMES R. CARRAS
DOUGLAS S. SAKAMOTO
Jack K. Suwa
James B. McCormick
IN REPLY REFER TO:

November 28, 1979

STP 8.5860

Dr. Richard O'Connell
Director
Office of Environmental
Quality Control
550 Halekauwila Street, Rm. 301
Honolulu, Hawaii 96813

Dear Dr. O'Connell:

Subject: Draft Detailed Project Report
and Environmental Statement
Waimea River Flood Control Study
Waimea, Kauai

Thank you very much for giving us the opportunity to review and comment on the above-captioned report. The proposed action is not anticipated to affect existing or future programs of the Department of Transportation. The applicant is advised, however, that three (3) copies of the construction plans should be submitted to our Highways Division for review and approval.

Very truly yours,

for Jack K. Suwa
Ryokichi Higashionna
Director of Transportation

DEPARTMENT OF PLANNING
AND ECONOMIC DEVELOPMENT

GEORGE R. ARIYOSHI, Governor
HIDETO KONO, Director
FRANK SKRIVANEK, Deputy Director

Kamamalu Building, 250 South King St., Honolulu, Hawaii • Mailing Address: P.O. Box 2359, Honolulu, Hawaii 96804

November 30, 1979

Ref. No. 0302

Mr. Kisuk Cheung
Chief, Engineering Division
Department of the Army
U.S. Army Engineer District, Honolulu
Building 230
Ft. Shafter, Hawaii 96858

Dear Mr. Cheung:

SUBJECT: Draft Detail Project Report and Environmental Statement - Waimea River Flood Control Study

We have reviewed the above document and offer the following comments for your consideration:

Exploration of Other Non-Structural Solutions

The document lists one non-structural solution (Plan 1) to the problem of flooding, namely, the flood proofing of all existing structures within the delineated flood-plain area and, by inference, all new structures. With particular attention to the comments offered by the Fish and Wildlife Service, it appears that another non-structural solution should be explored--a plan which may aid in the restoration of stream flow by reducing the diversion of water by the twenty-eight or so stream diverters. From the data available, it appears that approximately seventy-five percent or more of the daily average flow is being diverted.

The Fish and Wildlife Service raises an additional point in its recommendation for the removal or regular dredging of the sandbar which blocks the mouth of the Waimea River. This would allow flood waters to flow directly to the sea to ameliorate inland flooding. If a portion of the presently diverted stream flow is restored, it may aid in keeping the channel open and reduce buildup of the sandbar at the mouth of the river.

Structural Solutions

Of the two structural solutions offered, Plan 3 appears to be the preferred option. It offers the lowest overall cost with the highest benefit/cost ratio. Its disruption of the terrestial and aqueous environment also appears to be less than Plan 2.

We appreciate very much the opportunity to review the draft document. Should any questions arise concerning this matter, please feel free to contact us at any time.

Sincerely,

Hideto Kono

cc: Mr. Richard L. O'Connell, Director
Office of Environmental Quality Control

PODED-PJ

15 January 1980

Mr. Hideto Kono, Director
Department of Planning and
Economic Development
State of Hawaii
250 South King Street
Honolulu, Hawaii 96813

Dear Mr. Kono:

Thank you for your review comments on the Draft Detailed Project Report and Environmental Statement on the flood control study for Waimea River, Kauai.

In regard to the items in paragraphs under "Exploration of Other Non-Structural Solutions" of your letter, we have evaluated the sandbar and its effects relative to the flood problems. On restoration of stream flow by reducing the diversion of water—first of all, we wish to note that we have no jurisdiction over local streamflow diversion. Secondly, we do not consider flow diversion causes the flood problems which we are attempting to solve. While flow restoration may aid in keeping the river mouth open, our study indicated that the sandbar is not a flood control problem as it would be washed out by the higher peak discharges. It should also be noted that the existence of the sandbar at Waimea is a long-standing problem and is shown on photographs taken in 1949.

As sandbar formations are typical at the outlets of many rivers and streams in the Hawaiian Islands, we believe removal work would only be a temporary solution to a natural occurrence, and that subsequent periodic maintenance will be required to maintain the desired opening. Currently, the County of Kauai maintains a small opening (approximately 20 feet wide) to pass the average daily discharges. The frequency of maintenance by county government is about six to eight times per month. Since the sandbar has minimal impact on the overall flood damage potential, no further consideration was given to its removal in our alternative plans.

Your views and commentsare appreciated.

Sincerely yours,

KISUK CHEUNG
Chief, Engineering Division

University of Hawaii at Manoa

Environmental Center
Crawford 317 • 2550 Campus Road
Honolulu, Hawaii 96822
Telephone (808) 948-7361

Office of the Director

December 4, 1979

RE:0292

Mr. Richard O'Connell, Director
Office of Environmental Quality Control
550 Halekauwila Street
Honolulu, Hawaii 96813

Dear Mr. O'Connell:

Draft Detailed Project Report and Environmental Statement
Waimea River Flood Control Study
Waimea, Kauai

The Environmental Center has reviewed the above cited DEIS with the assistance of Marshall Mock, Kauai Community College; John Sorensen, Geography; and Doak C. Cox, Barbara Vogt, Elizabeth Cunningham, and Vincent Shigekuni, Environmental Center.

Evaluation of the alternatives:

On page 15, Table 2 summarizes the screening of possible measures that could be taken to reduce flood damages. The inclusion of the criteria used in evaluating the various structural and non-structural measures should be included. In particular, the the conclusion that all combinations of non-structural and structural" measures are less desirable than either purely structural or purely non-structural alternative needs explanation, if it is valid.

Choice of the 200-year design flood:

On page 16, the reasoning behind the decision to use the 200-year design in evaluation of the alternative plans is discussed. The methods used to estimate the standard project flood and probable maximum flood are described so briefly that even if the references cited were consulted it would probably be impossible to check the results. It appears that the Corps of Engineers has selected, for the distribution of the standard project storm rainfalls, that combination which would yield the highest flood discharges. The probability of such a distribution is extremely low, probably not in keeping with the probability associated with the standard project storm estimates themselves.

National flood insurance program:

In the "Description of Preliminary Plans" (pages 17-20), there is a noticeable omission of the National Flood Insurance Program. A discussion of the relationship of the NFIP to the proposed plans (1, 2, and 3) should be provided to indicate compliance and coordination with the overall Federal policies on flood control.

Public involvement

We note the DEIS discusses alternatives which have not been presented to the citizens of Waimea. It would appear inappropriate to make a choice among the alternatives until full public input on the problems and needs concerning floodcontrol measures has been obtained from the community. In the final EIS, a report on the October 1979 public hearing discussing alternative plans for flood control should be included.

Menehune Ditch

The DEIS mentions the Peekauai or Menehune Ditch which (page 37) it describes as running "close to the west bank of the Waimea River about 1000 feet above its confluence with the Makaweli River," and recognizes that the ditch is included in the highest value category of the Hawaii State Reporter of Historic Places.

The present ditch is actually a modern equivalent more or less following the alignment and grade of a pre-historic Hawaiian ditch. The very high value attaches to a part of the ditch with a cut-stone wall believed to be pre-historic but unlike any other pre-historic Hawaiian stone work. At this cut stone wall, the grade of the present ditch may be slightly higher than the original ditch, because the top of the ditch wall is an earth bank on top of the stone work. The ditch is separated from the river at this site by the Waimea Valley road, whose fill conceals the base of the cut-stone wall.

Downvalley from the site of the cut-stone work, the ditch passes through a short tunnel through a late lava flow, and then emerges onto the floodplain.

The DEIS indicates (page 44) that the raising of the Waimea Valley road that is a part of alternative Plans 2 and 3 for flood protection may possibly affect small portions of a "dry-stacked basalt-stone retaining wall" of the ditch at its exit from the tunnel. The DEIS also indicates that the wall retaining the ditch at this point may be of pre-European contact origin.

In these discussions the DEIS actually deals with three separate portions of the ditch: 1) the portion mauka of the short tunnel, which is believed to be of ancient origin; 2) the tunnel itself, which is clearly modern; and 3) the portion makai of the tunnel, which may possibly be pre-contact. The possible impacts discussed on page 44 seem to relate to the third, downvalley part. However, readers of the EIS who are not intimately familiar with the area may very well be confused and consider that it is the upper and more valuable part of the Menehune Ditch that may be affected. The EIS should specifically state whether or not this upper part will be affected.

Required coordination

The DEIS indicates that ongoing archaeological, ecological and water quality investigations are being made. In the final EIS relevant discussions of the reports made by the agencies involved, and the probable social/historical impacts of the alternatives should be included.

We appreciate the opportunity to comment on this DEIS.

Sincerely,

Doak C. Cox
Director

DCC/cu

cc: U.S. Army COE, Pacific Ocean Division
Barbara Vogt
Elizabeth Cunningham
Vincent Shigekuni
Marshall Mock
John Sorensen

PODED-PV 25 January 1980

Dr. Doak Cox, Director
Environmental Center
University of Hawaii at Manoa
Crawford 317, 2250 Campus Road
Honolulu, Hawaii 96322

Dear Dr. Cox:

We are responding to your comments dated 4 December 1979 on our Draft Detailed Project Report and Environmental statement for the Waimea River Flood Control Study, Waimea, Kauai.

Evaluation of the Alternatives. The formulation and analysis of alternative plans to achieve the planning objectives (stated on page 12) were based on the Water Resources Council's Principles and Standards (P&S) and related U.S. Army Corps of Engineers' regulations and guidelines. The two national objectives under the P&S, and general evaluation criteria are explained on page 4. The conclusion on combined structural and nonstructural measures is discussed in the text (page 15). We will incorporate more information in the final report.

Choice of the 200-year Design Flood. The description of the Standard Project Flood (SPF) and probable maximum flood derivation provides an explanation on the methods used and their applicability to the study. It is not our intent in the description to provide readers detailed data to check the mathematical accuracy or step-by-step procedures. The selection of the standard project storm rainfall distribution pattern which will yield the highest peak discharge is our criterion. The rainfall analysis is based primarily on past recorded rainfall data. While the selected distribution has an extremely low probability of occurrence, it is, nonetheless fitting with the description and use of the SPF event. The SPF hydrograph represents the most severe combination of precipitation that is considered reasonably characteristic of the drainage basin.

National Flood Insurance Program. The Flood Disaster Protection Act of 1973 stipulates that future federal financial assistance to a community would be contingent upon the community's implementation of an effective

floodplain management program, participation in the National Flood Insurance program (NFIP) or implementation of improvements to alleviate future flood losses. The NFIP is an ongoing program; however, insurance alone merely indemnifies property owners for flood losses, but does not reduce physical damages from flooding as requested by local interests and as defined by the study objectives. The above information will be added to the "Problems and Needs" section of the report.

Public Involvement. A public meeting was held on 24 October 1979 at Waimea, Kauai. The three preliminary plans were presented to the public. A late stage public meeting will be held to present the tentative recommended plan. As stated on page 23 of the draft document, the final recommended plan will be made following our review of the public meeting testimony, and written comments received. We will update the Public Involvement Appendix of the draft report to include details on public meetings, workshops, pertinent correspondence.

Menehune Ditch. The final Environmental Impact Statement (EIS) will clearly delineate between the three portions of the Peekauai irrigation ditch. It will state that a possible federal project will have no effect on the northern portion of the Peekauai Ditch. This portion is constructed with faced and fitted basalt slabs and is believed to be of prehistoric origin. Questions about a request of National Register eligibility for Peekauai Ditch and our determinations of project effects on this cultural property and Cook landing are now being coordinated with the appropriate state and federal agencies. Results of this coordination will be provided in the final EIS.

Required Coordination. The final EIS will include relevant discussions of the reports and comments made by the agencies involved. Social/historical impacts of the alternatives will be included.

Sincerely yours,

KISUK CHEUNG
Chief, Engineering Division

Copy Furnished:
Mr. Richard O'Connell, Director
Office of Environmental Quality Control
550 HalekauwilaStreet
Honolulu, Hawaii 96813

GEORGE R. ARIYOSHI
GOVERNOR OF HAWAII

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

GEORGE A. L. YUEN
DIRECTOR OF HEALTH
VERNE C. WAITE, M.D.
DEPUTY DIRECTOR OF HEALTH
HENRY N. THOMPSON, M.A.
DEPUTY DIRECTOR OF HEALTH
JAMES S. KUMAGAI, PH.D., P.E.
DEPUTY DIRECTOR OF HEALTH
TADAO BEPPU
DEPUTY DIRECTOR OF HEALTH

November 29, 1979

In reply, please refer to:
File: EPHS-SS

MEMORANDUM

To: Mr. Kisuk Cheung, Chief, Engineering Division
Department of the Army

From: Deputy Director for Environmental Health

Subject: Environmental Impact Statement (EIS) for Waimea River Flood Control Study, Waimea, Kauai

Thank you for allowing us to review and comment on the subject EIS. On the basis that the project will comply with all applicable Public Health Regulations, please be informed that we have no objections to this project.

We realize that the statements are general in nature due to preliminary plans being the sole source of discussion. We, therefore, reserve the right to impose future environmental restrictions on the project at the time final plans are submitted to this office for review.

for JAMES S. KUMAGAI, Ph.D.

cc: Office of Environmental Quality Control

DEPARTMENT OF WATER

COUNTY OF KAUAI
P. O. BOX 1706
LIHUE, HAWAII 96766

October 30, 1979

Environmental Quality Commission
Office of the Governor
550 Halekauwila Street, Room 301
Honolulu, Hawaii 96813

Re: Detailed Project Report and Environmental Statement - Waimea River Flood Control Study

We have reviewed the subject study and offer the following comment for Plans 2 and 3:

Our existing transmission main is located within the road-raising section on Menehune Road, above the confluence of the Waimea and Makaweli Rivers.

Thank you for the opportunity to comment.

Walter L. Briant Jr.
Manager and Chief Engineer

HM:at

PODED-PV

22 January 1980

Mr. Walter Briant, Jr.
Manager and Chief Engineer
Department of Water
County of Kauai
P.O. Box 1706
Lihue, Hawaii 96766

Dear Mr. Briant:

Thank you for your review and comments dated 30 October 1979 on our Draft Detailed Project Report and Environmental Impact Statement (EIS) for the Waimea River Flood Control Study, Kauai, Hawaii. Should Plans 2 or 3 be authorized for implementation, we will coordinate with your office during the advanced engineering and design stage of the project in regard to your existing transmission main located within the road-raising section on Menehune Road.

Sincerely yours,

KISUK CHEUNG
Chief, Engineering Division

EDUARDO E. MALAPIT
MAYOR

COUNTY OF KAUAI
DEPARTMENT OF PUBLIC WORKS
4396 RICE STREET
LIHUE, KAUAI, HAWAII 96766

HENRY MORITA
COUNTY ENGINEER
TELEPHONE 245-3318

CLAY KAGAWA
DEP. COUNTY ENGINEER
TELEPHONE 245-3602

December 4, 1979

Mr. Kisuk Cheung
Chief, Engineering Division
Department of the Army
U.S. Army Engineer District, Honolulu
Building 230
Fort Shafter, Hawaii 96858

Dear Mr. Cheung:

RE: WAIMEA RIVER FLOOD CONTROL STUDY

Thank you for the opportunity to comment on the Detailed Project Report and Environmental Impact Statement prepared by your staff.

The following comments are offered for your consideration in finalizing your report for subject study.

1. Your study adopts a 200-year recurrence interval for the standard project flood. Inasmuch as we understand that the ranking of alternatives will not change with a lesser recurrence interval, we recommend that the study be based on the 100-year recurrence being that existing County ordinances, as well as the Federal Flood Insurance Program calls for this level of protection. It appears that by using the 100-year recurrence interval, the three alternatives being considered will all result in a benefit to cost ratio of one or better.

2. From the meetings you've conducted in Waimea and from our talks with the people from time to time, it appears the people are mostly concerned with the back-up of normal and flood flows caused by the high sand berm at the mouth of the river. The concern during normal flow is the frequent blockage of flow by the berm which causes the river and water table to rise and which, in turn, cause cesspool malfunctions and frequent overflow of an interior drainage channel. The concern during a heavy rainstorm is the inability of the more frequent flood flows to cut through the berm in time to prevent flooding of some farmlands above the fork of the Waimea and Makaweli Rivers. We believe that unless something is done to eliminate the berm on a permanent basis in any of the alternate plans, it would not meet the satisfaction of the Waimea people.

3. Your report touched on the use of pump to drain the interior area while the flood gates are closed. However, your report does not indicate the feasibility of same. We would appreciate a more in-depth study on the use of a pump to help drain the interior area, being that we are contemplating the design and installation of same in the near future. The report would be useful to us, insofar as the pump station is concerned, if it contained information such as the following:

   a. Size of pump and related cost to accommodate the 100-year storm without storage.

   b. Size of pump and related cost to accommodate the 100-year storm with storage confined to the existing drainage/irrigation ditch (presuming that the ditch can be maintained at a low level during dry weather).

   c. What would be the size of the storage basin if a pump accommodating a lesser than the 100-year frequency storm is installed?

Again, thank you for the opportunity to comment.

Very truly yours,

HENRY MORITA
County Engineer

/s

PODED-PJ

2 January 1980

Mr. Henry Morita
County Engineer
Department of Public Works
County of Kauai
4396 Rice Street
Lihue, Kauai, Hawaii 96766

Dear Mr. Morita:

Thank you for your review comments on the Draft Detailed Project Report and Environmental Statement on the flood control study for Waimea River, Kauai. In response to your specific comments, we furnish the following:

a. We have initiated the detailed analysis portion of the subject study. As a part of the detailed analysis, an appropriate level of protection will be determined for each alternative plan based on factors such as desires of local interests, engineering, design, environmental and social considerations. Your suggestion of a 100-year level of protection will be considered.

b. Regarding the problems associated with the sand berm at the river mouth, we do not have solutions which would eliminate the berm permanently from the technical standpoint. Although berm removal could provide immediate relief to your stated problems, it is only a temporary solution to a natural occurrence. Subsequent periodic maintenance will be required to maintain the desired opening. As discussed during our 24 October 1979 meeting, we indicated that the sand berm is not considered as a flood control problem because of the likelihood of a "washout" due to higher peak discharges during periods of high flood flow. Since the berm has minimal impact on the overall flood damage potential, we believe there is no federal interest with respect to its removal.

c. We have studied the feasibility of using pump(s) for interior drainage. The study results will be incorporated in our final report. For your information, we would like to clarify certain aspects of the pump study as well as data that would be useful to you:

(1) The interior drainage study was conducted based on the design criterion for a 25-year event, rather than the 100-year storm. The five 60-inch concrete gravity outlets being considered for Plans 2 and 3 can

economically solve the interior drainage problem with ponding as described in the report. For the 25-year event, the peak discharge is estimated to be 430,000 gallons per minute. If the gravity outlet is replaced by a pump station, the approximate cost of the pump station and pertinent facilities would be about $10 million.

(2) It is estimated that the gates will be closed on an average of only one day a year.

We trust that the above information is helpful to you and we appreciate your views on the Waimea River Study.

Sincerely yours,

KISUK CHEUNG
Chief, Engineering Division

WAIMEA RIVER FLOOD CONTROL
WAIMEA, KAUAI

NATURAL RESOURCES

APPENDIX G

NATURAL RESOURCES APPENDIX

Description	Item No.
Water Quality Measurements, State Department of Health	I
Section 401 Certification, State Department of Health	II
Section 404 Evaluation Report	III
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US Fish and Wildlife Service, 2B Report and Addendum of Corrections	VIII

Water Quality Measurements
State Department of Health

PHYSIOCHEMICAL MEASUREMENTS AT WAIMEA BEACH PARK

Parameter			NUMBER	MEAN	VARIANCE	STAN DEV	COEF VAR	STAND ER	MAXIMUM	MINIMUM	BEG DATE	END DATE
WATER	TEMP	CENT	12	26.7083	9.11257	3.01870	.113025	.871425	35.5000	23.5000	76/01/13	78/12/05
TURB	JKSN	JTU	10	14.2900	113.397	10.6488	.745192	3.36744	26.0000	.700000	76/01/13	78/12/05
DO		MG/L	9	6.98888	.548645	.740706	.105983	.246902	8.30000	6.20000	76/04/27	76/11/13
PH		SU	6	8.05666	.044434	.210793	.026164	.086056	8.21000	7.70000	76/04/27	78/01/09
SALINITY		PPTH	13	31.8307	14.8457	3.85301	.121047	1.06863	34.8000	23.5000	76/01/13	78/11/13
RESIDUE	TOT NFLT	MG/L	5	68.4600	1891.51	43.4915	.635284	19.4500	142.000	27.0000	78/01/09	78/12/05
TOTAL N	N	MG/L	13	.101538	.008247	.090815	.894395	.025188	.230000	.000000	76/04/27	78/12/05
TOT KJEL	N	MG/L	13	.089231	.007274	.085290	.955836	.023655	.210000	.000000	76/04/27	78/12/05
NO2&NO3	N-TOTAL	MG/L	13	.064615	.002194	.046836	.724841	.012990	.100000	.000000	76/04/27	78/12/05
PHOS-TOT		MG/L P	14	.042286	.000547	.023391	.553168	.006252	.086000	.010000	76/01/13	78/12/05
TOT COLI	MPN CONF	/100ML	59	2248.34	.383E+08	6192.05	2.75406	806.137	35000.0	5.00000	74/01/28	78/12/11
FEC COLI	MPNECMED	/100ML	58	102.448	44220.3	210.286	2.05261	27.6119	1300.00	2.00000	74/01/28	78/12/11
FECSTREP	MPN	TUBECODE	31	682.516	4071133	2017.70	2.95627	362.390	11000.0	2.00000	74/02/19	77/01/24
RESIDUE	DISS-180	C MG/L	1	38000.0					38000.0	38000.0	77/04/12	77/04/12

Source: State of Hawaii, Department of Health

PHYSIOCHEMICAL MEASUREMENTS OF THE UPPER WAIMEA RIVER

Parameter			NUMBER	MEAN	VARIANCE	STAN DEV	COEF VAR	STAND ER	MAXIMUM	MINIMUM	BEG DATE	END DATE
WATER	TEMP	CENT	8	24.1875	3.42411	1.85043	.076504	.654227	27.5000	22.0000	76/01/13	77/10/11
TURB	JKSN	JTU	7	5.07143	34.2390	5.85141	1.15380	2.21163	18.0000	1.30000	76/01/13	77/10/11
DO		MG/L	7	7.08571	3.29146	1.81424	.256042	.685718	8.90000	4.20000	76/04/27	77/10/11
PH		SU	5	7.86000	.242493	.492435	.062492	.220224	8.60000	7.20000	76/04/27	77/10/11
SALINITY		PPTH	8	.362500	.045536	.213391	.588665	.075445	.800000	.200000	76/01/13	77/10/11
TOTAL N	N	MG/L	8	.205000	.011457	.107038	.522137	.037844	.400000	.020000	76/01/13	77/10/11
TOT KJEL	N	MG/L	8	.177500	.012564	.112091	.631498	.039630	.380000	.000000	76/01/13	77/10/11
NO2&NO3	N-TOTAL	MG/L	8	.075000	.002143	.046291	.617215	.016366	.100000	.000000	76/01/13	77/10/11
PHOS-TOT		MG/L P	8	.039875	.000684	.029739	.745807	.010514	.092000	.014000	76/01/13	77/10/11
TOT COLI	MPN CONF	/100ML	24	22591.7	.477E+09	21840.8	.966764	4458.23	92000.0	1400.00	75/12/15	77/12/12
FEC COLI	MPNECMED	/100ML	24	712.083	288825	537.425	.754721	109.701	2300.00	110.000	75/12/15	77/12/12
FECSTREP	MPN	TUBECODE	14	4707.85	.195E+08	4417.93	.938417	1180.74	16000.0	700.000	75/12/15	77/01/24

Source: State of Hawaii, Department of Health

GEORGE R. ARIYOSHI
GOVERNOR OF HAWAII

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

GEORGE A. L. YUEN
DIRECTOR OF HEALTH
~~Audrey W. Mertz, M.D., M.P.H.~~
Deputy Director of Health
Henry N. Thompson, M.A.
Deputy Director of Health
James S. Kumagai, Ph.D., P.E.
Deputy Director of Health

In reply, please refer to:
File: EPHS-SS

February 4, 1980

Mr. Kisuk Cheung
Chief, Engineering Division
Department of the Army
Building 230
Ft. Shafter, Hawaii 96858

Dear Mr. Cheung:

Subject: Waimea River Flood Control Project

The Department of Health concurs that the subject project impacts on water quality are acceptable and have been mitigated to the extent practicable and will conform to State water quality standards of the project and proposed mitigative measures.

Sincerely yours,

Melvin K. Koizumi

MELVIN K. KOIZUMI
Deputy Director for
Environmental Health

WAIMEA RIVER FLOOD CONTROL

EVALUATION OF THE EFFECTS OF THE
DISCHARGE OF DREDGED OR FILL MATERIAL INTO WATERS
OF THE UNITED STATES USING THE SECTION 404(b) GUIDELINES

1. PROJECT DESCRIPTION

a. Description of the Proposed Discharge of Dredged or Fill Materials.

(1) General Characteristics of the Material

(a) Basaltic field stones will be used for toe protection riprap.

(b) Basaltic gravel and spalls for the toe protection bedding layer.

(c) Terrestrial sediments dredged from the riverbed for toe protection backfill.

(2) Quantity of Material Proposed for Discharge

(a) Toe Protection; Levee Riprap: Approximately 11,000 cubic yards of riprap. Approximately 2,190 cubic yards of bedding material. Approximately 4,000 cubic yards of dredged material backfill.

(3) Source of Material

(a) Toe Protection; Levee Riprap: Fieldstone from the Kekaha area will be used for riprap. Gravel and spalls will be obtained from a nearby quarry. Backfill will consist of a portion of the riverbed material dredged for the toe protection foundation.

b. Description of the Proposed Disposal Site.

(1) Location - See Main Report, Figure 1.

(2) Type of Discharge Site - In the Waimea River along the west bank.

(3) Method of Discharge - Stones and bedding for toe protection and backfill will be lowered into place by crane and bucket.

(4) When Will Discharge Occur - During a 3-month period during construction.

(5) Projected Life of Discharge Site - Not Applicable.

(6) Bathymetry (if open water discharge) - Not Applicable.

2. PHYSICAL EFFECTS

a. Potential Destruction of Wetlands - Effects on (40 CFR 230.0-1(a)(1)(i-iv). Not Applicable.

b. Impact of Water Column.

(1) Reduction in Light Transmission - A temporary, minor and localized reduction in light transmission will be caused by turbidity generated during placement of toe protection stones (fill material).

(2) Aesthetic Values - A temporary, minor and localized reduction in aesthetic values will be caused by water turbidity during placement of toe protection stones (fill material).

(3) Direct Destruction Effects on Nektonic and Planktonic Populations - No effects.

c. Covering of Benthic Communities.

(1) Actual Covering of Benthic Communities - Placement of toe protection and backfill will smother small area of aquatic sandy community.

(2) Changes in Community Structure or Function - Preparation for placement of toe protection stones will involve dredging and may temporarily preclude the use of this area by benthic biota. Benthic biota will recolonize the portion of the bottom that is backfilled. The ungrouted toe protection structure will provide suitable habitat for indigenous estuarine algae, invertebrate, and fish species.

d. Other Effects.

(1) Changes in Bottom Geometry and Subsurface Composition - The placement of toe protection rocks will permanently cover a portion of the existing river bottom resulting in shallower depths of water along the west riverbank. A portion of the existing sediment bottom in the toe protection area will be permanently changed from a soft sediment to a hard rock bottom.

(2) Water Circulation - No significant changes in water circulation will occur as the result of the discharge of dredged or fill materials for the project.

(3) Salinity Gradients - Salinity gradients will not be affected by the discharge of project fill materials.

(4) Exchange of Constituents Between Sediments and Overlying Water with Alterations of Biological Communities - Not applicable.

3. CHEMICAL - BIOLOGICAL INTERACTIVE EFFECTS

a. Does the material meet the exclusion criteria? - Yes, refer to Project Description (1a(1), (3)).

b. Water Column Effects of Chemical Constituents - Not applicable.

c. Effects of Chemical Constituents - Not applicable.

4. DESCRIPTION OF SITE

a. Total Sediment Analysis. Fill consists of materials larger than silt size.

b. Biological Community Structure Analysis. Those benthic organisms present will be covered and destroyed by the stone toe protection and motile organisms will be displaced. Motile and sessile organisms will probably recolonize the completed toe protection rock.

5. REVIEW APPLICABLE WATER QUALITY STANDARDS

a. Compare Constituent Concentrations. Not applicable.

b. Consider Mixing Zone. Not applicable.

c. Based on a and b above, will disposal operation be in conformance with applicable standards? Yes.

6. SELECTION OF DISCHARGE SITES

a. Need for the Proposed Activity. Placement of rock fill for the toe protection is required as part of the project design.

b. Alternatives Considered. The following alternatives were considered:

(1) floodproofing

(2) channel deepening, levee extension and toe protection, and
(3) floodwall, toe protection and levee extension.

c. Objectives to be Considered in Discharge Determination (40 CFR 230.5 (a)):

(1) Impacts on Chemical, Physical, and Biological Integrity of the Aquatic Ecosystem - No long-term or irreversible impacts anticipated.

(2) Impact on the Food Chain - No quantifiable impact on the food chain is anticipated.

(3) Impact on Diversity of Animal Species - No significant long-term changes in species diversity are anticipated.

(4) Impact on Movement Into and Out of Feeding, Spawning, Breeding, and Nursery Areas - Proposed discharge of fill material will not inhibit natural seasonal migrations of indigenous diadromous fishes and invertebrates.

(5) Impact on Wetland Areas Having Significant Functions of Water Quality Maintenance - No wetland impacts.

(6) Impact on Areas that Serve to Retain Natural High Waters or Flood Waters - Not applicable.

(7) Methods to Minimize Turbidity - Care will be taken that unstable slopes do not slump into the water. Extreme care will be taken to insure that no debris, petrolsum products, or other deleterious materials will be allowed to fall, flow, leach or otherwise enter the water. All fill construction activities within the water will be conducted so as to minimize turbidity and control erosion.

(8) Methods to Minimize Degradation of Aesthetic, Recreational, and Economic Values of Navigable Waters - No other measures related.

(9) Threatened or Endangered Species - None.

d. Impacts on Water Uses at Proposed Disposal Site.

(1) Municipal Water Supply Intakes - None.

(2) Shellfish - None.

(3) Fisheries - No effects upon commercial fish stocks are anticipated.

(4) Widlife - None.

(5) Recreation Activities - Some interruption of river bank recreational fishing during project construction.

(6) Benthic Life - Refer to 2c.(1)(2).

(7) Wetlands - None.

(8) Submerged Vegetation - None.

(9) Size of Disposal Site - Approximately 1.3 acres.

(10) Coastal Zone Management Programs - Consistent: Improvement of an existent waterway.

e. Considerations to Minimize Harmful Effects.

(1) Water Quality Criteria - Construction contractor will be required to conform to State of Hawaii Water Quality Standards during project construction.

(2) Investigate Alternatives to Open Water Disposal - Not applicable.

(3) Investigate Physical Characteristics of Alternative Disposal Sites - Not applicable.

(4) Ocean Dumping - Not applicable.

(5) Where Possible, Investigate Covering Contaminated Dredged Material with Cleaner Material - Not applicable.

(6) Investigate Method to Minimize Effect of Runoff from Confined Areas on Aquatic Environment - Not applicable.

(7) Coordinate Potential Monitoring Activities at Disposal Site with Environmental Protection Agency - Not applicable.

7. STATEMENT AS TO CONTAMINATION OF FILL MATERIAL IF FROM A LAND SOURCE

There will be no contamination since material will be basaltic stones from nearby land sites.

8. DETERMINE MIXING ZONE. Not applicable.

9. CONCLUSIONS AND DETERMINATIONS

a. Alternatives to the proposed discharge have been considered and none that are practicable will have less adverse impact on the aquatic and semi-aquatic ecosystem.

b. There are no unacceptable environmental impacts on the aquatic and semi-aquatic ecosystem.

c. The discharge of the fill material will be accomplished under conditions which will minimize, to the extent practicable, adverse environmental effects on the aquatic and semi-aquatic ecosystem.

10. FINDINGS

The suitability of the discharge site for the Waimea River Flood Control Project has been determined through the application of the Section 404(b) guidelines.

EXECUTIVE ORDER 11988 ON FLOOD PLAIN MANAGEMENT
EVALUATION REPORT

1. This evaluation report presents pertinent information required by Executive Order 11988, Flood Plain Management, dated 24 May 1977. The objectives of the Executive Order are the avoidance to the maximum extent possible of long and short term adverse impacts associated with the occupancy and modification of floodplains and the avoidance of direct and indirect support of floodplain development wherever there is a practicable alternative. The Order requires Federal agencies to:

a. Avoid the base flood plain unless it is the only practicable alternative;

b. Reduce the hazard and risk associated with floods;

c. Minimize the impact of floods on human safety, health, and welfare; and

d. Restore and preserve the natural and beneficial floodplain values.

2. PROCEDURE. The basic determinations necessary to implement the Executive Order are:

a. Determine whether the proposed action is in the base floodplain. The base floodplain is defined as the area inundated by a flood with a one percent chance of occurrence in any given year.

b. If the action is in the base floodplain, determine whether there is a practicable alternative to the action. The "action" is any Federal activity including (1) acquiring, managing, and disposing of Federal lands and facilities; (2) providing federally undertaken, financed, or assisted construction and improvements; and (3) conducting Federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating, and licensing activities.

c. Identify beneficial and adverse impacts due to the action and any expected losses of natural and beneficial floodplain values. Where actions are proposed to be located outside of the base floodplain, identify impacts resulting from these actions which affect the base floodplain.

d. If the action is likely to induce development in the base floodplain, determine if there is a practicable non-floodplain alternative for the development.

e. Determine viable methods to minimize any adverse impacts of the action and methods to restore and preserve the natural and beneficial floodplain values.

f. Advise the general public if the proposed action will be located in the floodplain.

g. Recommend the plan most responsive to the planning objectives established by the study and consistent with the requirements of the Executive Order.

DESCRIPTION OF FACTORS FOR THE PROBABLE SELECTED PLAN

1. Proposed Action Location. The proposed action is located within the Waimea base floodplain limits. The base floodplain is defined as the one percent (1%) exceedance frequency floodplain.

2. Existing Federal Activities on Kauai, State of Hawaii. Existing Federal activities offer practicable alternatives to the proposed action and are described below:

a. Floodplain management services are available from the US Army Corps of Engineers under the authority of Section 206 of the River and Harbor and Flood Control Act of 1960 (Public Law 89-789). These services include providing flood hazard data, maps, and technical assistance, and are currently being provided for Kauai.

b. Flood insurance is available on Kauai, which is administered by the US Federal Emergency Management Agency (FEMA) through the Federal Insurance Administration under the authority of the National Flood Insurance Act of 1968, as amended.

c. The US Department of Housing and Urban Development (HUD) has minimum building standard requirements for federally subsidized housing projects administered by the agency. County of Kauai building standards are administered by the Building Division, Department of Public Works.

d. Emergency and disaster operations, when in effect, are also administered by FEMA. Disaster recovery assistance includes protection of life and property, damage surveys, restoration of public services, and technical services.

e. Relocation assistance for persons displaced as a result of federal and federally-assisted programs are authorized by the Uniform Relocations Assistance and Real Property Acquisition Act of 1970 (Public Law 91-646). This statute provides moving and related expenses to insure fair and equitable treatment of displaced persons. This Act will be applicable for the Waimea River recommended plan.

3. Potential Floodplain Development with the Project. The existing levee and improvements constructed by local interests provide partial protection for the Waimea residents. The potential floodplain development is not expected to differ, with or without the project. That is, significant changes in land use are not anticipated in the future. Vacant lands zoned for urban use have continued to be developed and developed areas are being redeveloped for higher density use. The business district in Waimea, which serves as a trade and service center for the Kekaha-Waimea region, is expected to continue to experience moderate developmental pressure. Based on the trend of development in Waimea, the project is not expected to induce accelerated or greater development.

4. Adverse Impacts on the Floodplain Due to the Proposed Action:

a. No adverse hydraulic impacts on the floodplain are expected. Main channel velocities for major floods will be slightly increased. An average increase of four percent is expected for the 100-year flood. The increased velocities are not expected to adversely affect the foundation stability of the highway bridge or drastically increase the riverbed scour during peak flows. There are no communities or developments lying upstream or downstream of the proposed action.

b. No long-term environmental adverse impacts on the aquatic and estuarine biota are expected. Dredging for the rock toe protection foundation would disturb the benthic habitat and bottom-dwelling organisms within the project area. The hard surface and rock interstices of the completed toe protection structure would provide a new habitat suitable for possible recolonization by aquatic and estuarine biota. The construction and operation of the proposed structures are not expected to cause a significant reduction in population size of any resident species within the Waimea River.

c. The proposed action will have a visual impact on the community. The determination of the impact is subjective but it is anticipated that the action will not be an eyesore. The proposed modifications to the existing levee range from minor to moderate changes. During construction, the community will be exposed to construction hazards and inconveniences.

5. Loss of Natural and Beneficial Values of the Floodplain. No permanent loss of the natural and beneficial values of the floodplain are expected. Implementation of the proposed action would result in a minor increase of the natural (ecological) value of the floodplain.

6. Viable Methods to Minimize the Adverse Impacts of the Proposed Action.

a. The only probable long-term adverse impact of the proposed action is the visual impact. To minimize its impact, the proposed action will be designed to match existing levee features. The proposed levee height extension will be a grouted rock wall to match the existing concrete rubble masonry wall which protects the existing levee.

b. The short-term impacts due to construction activity will be minimized by proper scheduling and control. These items will be specified in the contract document and will be enforced by proper inspection.

7. Methods to Restore and Preserve the Natural and Beneficial Values of the Floodplain. The beneficial values of the existing floodplain will not be affected by the proposed action. Restoration of the floodplain to its natural condition, i.e., removing the existing levee, residences, and all improvements, is not acceptable.

8. Recommendation of the Desired Plan. The proposed action is the most desired plan. It satisfies the needs and desires of the local community and the County of Kauai governmental agencies. It also satisfies the goals of EO 11988. The proposed project needs to be constructed in the base floodplain and is the only practicable alternative. It will reduce the hazard and risk of flood loss. It minimizes the impact of floods on human safety, health, and welfare. Overall, it will slightly improve the existing beneficial floodplain values.

FEDERAL CONSISTENCY DETERMINATION
STATE OF HAWAII, COASTAL ZONE MANAGEMENT PROGRAM
12 March 1980

The project meets the objectives and policies of the CZM program as follows:

SECTION 205A-2(b)(1). Recreational Resources.

OBJECTIVE: "Provide coastal recreational opportunities accessible to the public."

The construction of project features will temporarily disturb the water quality at the river mouth, affecting the activities of shoreline fishermen. Normal recreational activities should resume once construction is completed. The project construction would also require removal and/or transplanting of trees and possible relocation of park structures at the Lucy Wright County Park. Measures to minimize disturbance to the park will be utilized so that upon completion of the project, no adverse long-term impacts on park activities will result.

SECTION 205A-2(b)(2). Historic Resources.

OBJECTIVE: "Protect, preserve, and where desirable, restore those natural and man-made historic and prehistoric resources in the coastal zone management area that are area significant in Hawaiian and American history and culture."

Construction of the levee is expected to impact upon the Cook Landing Site, which is listed on the National Register and was formerly a National Historical Landmark. The boulder and plaque commemorating the landing would require temporary removal from its present location during construction, but would be replaced in the same general vicinity. The plaque marks the general vicinity of the landing, and the impact is not expected to significantly change the integrity or appearance of the site.

SECTION 205A-2(b)(3). Scenic and Open Space Requirements.

OBJECTIVE: "Protect, preserve, and where desirable, restore or improve the quality of coastal scenic and open space resources."

a. The Lucy Wright County Park, located at the mouth of the Waimea River, is a 2.25-acre beach park which provides a pleasant tree-covered shoreline setting. Located within the park is a boulder upon which is affixed a plaque commemorating the landing of Captain Cook in 1778. The park is also a favorite spot from which tourists view the Russian Fort Elizabeth across the river.

b. Alterations and relocations within the park during construction of the levee work are not expected to cause more than temporary problems. The open, shoreline, setting, and the views of nearby historic sites will remain unchanged. Within the park, the levee would be approximately four to five feet high; however, it would not obstruct any views. Rather, the levee would provide a readily accessible viewing platform.

SECTION 205A(b)(4). Coastal Ecosystems.

OBJECTIVE: "Protect valuable coastal ecosystems from disruption and minimize adverse impacts on all coastal ecosystems."

a. Construction of the raised "I" wall along the existing levee would have minimal effects upon any terrestrial or aquatic biota within the river channel. Some common grasses covering the outer bank of the levee would be destroyed or damaged by construction activities; however, it is expected to recover rapidly after completion of construction. Rock toe protection would provide a new environment consisting of shelter and hard surfaces for possible colonization by aquatic biota.

b. Similarly, aquatic biota utilizing the existing revetment would be destroyed or displaced by the levee construction, however, the structure would provide a new habitat for colonization by the same species, and no long-term adverse impacts are foreseen. Overall, the existing conditions and aquatic resources probably would change little over the project life, provided water demands, as well as floodplain and upland development do not increase significantly.

SECTION 205A-2(b)(5). Economic Uses.

OBJECTIVE: 'Provide public or private facilities and improvements important to the State's economy in suitable locations.'

The project would protect life and property and enhance the well-being of residents living within the floodplain. Property values of the flood-protected land parcels would increase in value. Strict adherence to applicable County zoning regulations and the Kekaha-Waimea Regional Development Plan will be essential to prevent lands currently in agriculture from being upgraded to urban uses.

SECTION 205A(b)(6). Coastal Hazards.

OBJECTIVE: "Reduce hazard to life and property from tsunami, storm waves, stream flooding, erosion, and subsidence."

While the project would reduce safety and health hazards due to stream flooding, future development controls are primarily the responsibility of the local government. As a project requirement, a flowage easement in the interior area would be designated. This easement would have a restrictive effect upon future development within the ponding area since no fill would be allowed there.

SECTION 205A-2(b)(7). Managing Development.

OBJECTIVE: "Improve the development review process, communication, and public participation in the management of coastal resources and hazards."

The project planning was conducted in accordance with existing regulations associated with present and future coastal zone management. While the project itself is not considered a significant coastal development project, all potential short- and long-term impacts of the alternative actions were identified, evaluated, and brought to the attention of the affected public through meetings and review of study documents.

GEORGE R. ARIYOSHI
Governor

HIDETO KONO
Director

FRANK SKRIVANEK
Deputy Director

DEPARTMENT OF PLANNING
AND ECONOMIC DEVELOPMENT

Kamamalu Building, 250 South King St., Honolulu, Hawaii • Mailing Address: P.O. Box 2359, Honolulu, Hawaii 96804

April 15, 1980

Ref. No. 1073

Mr. Kisuk Cheung
Chief, Engineering Division
U.S. Army Corps of Engineers
Building 230
Fort Shafter, Hawaii 96858

Dear Mr. Cheung:

Subject: Federal Consistency Determination for Waimea River Flood Control Project

We have reviewed the subject project report and consistency determination dated March 12, 1980, and offer the following comments to assure consistency with the objectives and policies of the State's Coastal Zone Management (CZM) Program. As with our previous correspondence on this matter, our concurrence with the following considerations apply only to the adoption and implementation of Plan 3 ("I" wall and levee extension) as described in the project report.

<u>Section 205A-2(b)(2) Historic Resources</u>

We recommend that potential or real effects on the Peekauai Ditch, which might result from proposed project improvements to Menehune Road, be assessed and approved by State (or County) historic preservation authorities. This is of particular importance since Peekauai is listed in the State's Historic Register.

<u>Section 205A-2(b)(3) Scenic and Open Space</u>

The project should include requirements for the full restoration of recreational facilities which are altered as a result of project construction activity. Assurance should also be provided that construction activity will not alter or physically affect Fort Elizabeth as well as its present scenic or aesthetic value from the project side of the river mouth.

Section 205A-2(b)(5) Economic Use

Mitigation of flood damage from possible future construction should be provided by appropriate easements for the flood ponding area and flood runoff alignments. Future zoning regulations should adhere to existing land use so as to prevent urbanization of flood prone areas.

Section 205A-2(b)(4) Coastal Ecosystems

Minimization of siltation on the coastal ecosystem should be assured. Disposal and stockpiling of the dredged material should be restricted. If deemed necessary by appropriate authorities, however, the use of siltation screens should be required.

Inasmuch as the above comments are limited to Plan 3, we request an opportunity for subsequent review in the event that an alternative plan is selected on as a result of the scheduled public hearing.

We appreciate your continued assistance and cooperation in the State's CZM Program. Should any questions arise concerning this matter, please feel free to contact us at any time.

Sincerely,

Hideto Kono

United States Department of the Interior
FISH AND WILDLIFE SERVICE
LLOYD 500 BUILDING, SUITE 1692
500 N.E. MULTNOMAH STREET
PORTLAND, OREGON 97232

August 28, 1979

In reply refer to:
AFA-SE - 1-2-79-In-23

Kisuk Cheung, Chief
Engineering Division
U.S. Army Engineer District, Honolulu
Building 230
Fort Shafter, Hawaii 96858

Dear Mr. Cheung:

This replies to your request of July 18, 1979 for information on endangered or threatened species, listed or proposed, which may be present in the Waimea River Flood Control project area.

There are no endangered or threatened species of birds or plants, listed or proposed, present on the project area.

Thank you for sharing our concern for conserving endangered species.

Sincerely yours,

John A. Sayre

John . Sayre
Acting Regional Director

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

April 2, 1980

Colonel B. R. Schlapak
U. S. Army Engineer District Honolulu
Building 230
Fort Shafter, Hawaii 96858

Re: Detailed Report, Waimea River Flood Control Project Kauai, Hawaii

Dear Sir:

This is the detailed report of the U.S. Fish and Wildlife Service on plans developed by the Honolulu District U.S. Army Corps of Engineers for a flood protection project in the lower reaches of the Waimea River, Waimea, Kauai, Hawaii.

This report has been prepared under the authority of and in accordance with the provisions of the Fish and Wildlife Coordination Act (48 Stat. 401 as amended; 16 U.S.C. et seq.) and other authorities mandating Department of Interior concern for environmental values and fulfills the responsibilities of the Fish and Wildlife Service under Section 2(b) of the Act. It is also consistent with the intent of the National Environmental Policy Act.

This project is being planned under the authority of Sec. 205 of the 1948 Flood Control Act, as amended. The analysis and recommendations of the Service are based on information as described in the Corps' Detailed Project Report and Environmental Statement - Waimea River Flood Control Study (October 1979) and as specified by the Corps in a letter to the Service dated December 14, 1979. Biological resource data were obtained from U.S. Fish and Wildlife Service field surveys and reports, and from information provided by other federal and state agencies and literature sources.

Introduction

The Waimea River watershed (Figs. 1 and 2) is the largest drainage basin on western Kauai, covering about 89 square miles (16 percent) of the island (1). Its dendritic headwaters drain state park and forest reserve lands in the Alakai Swamp, between 4000 and 5000 feet in

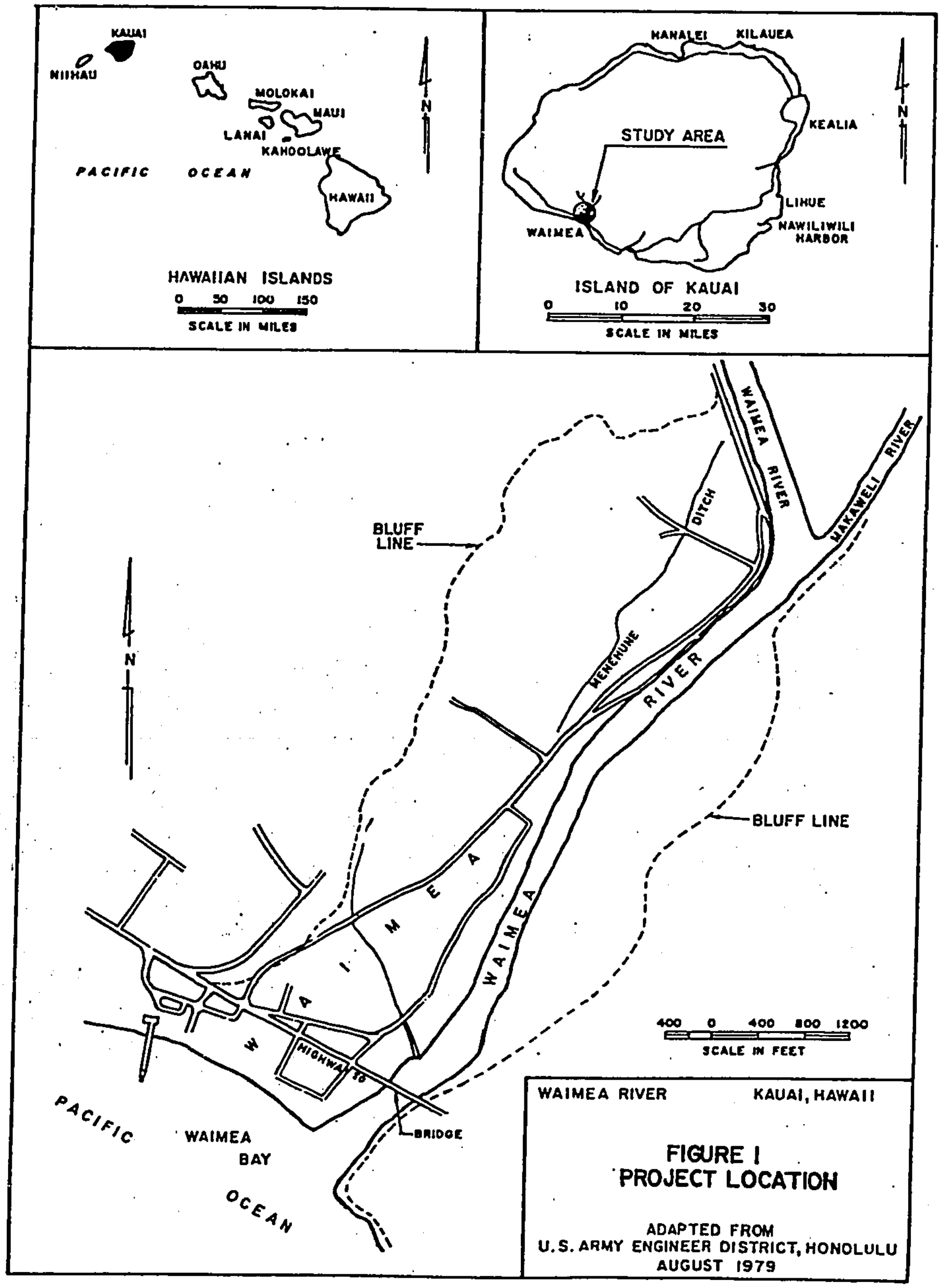
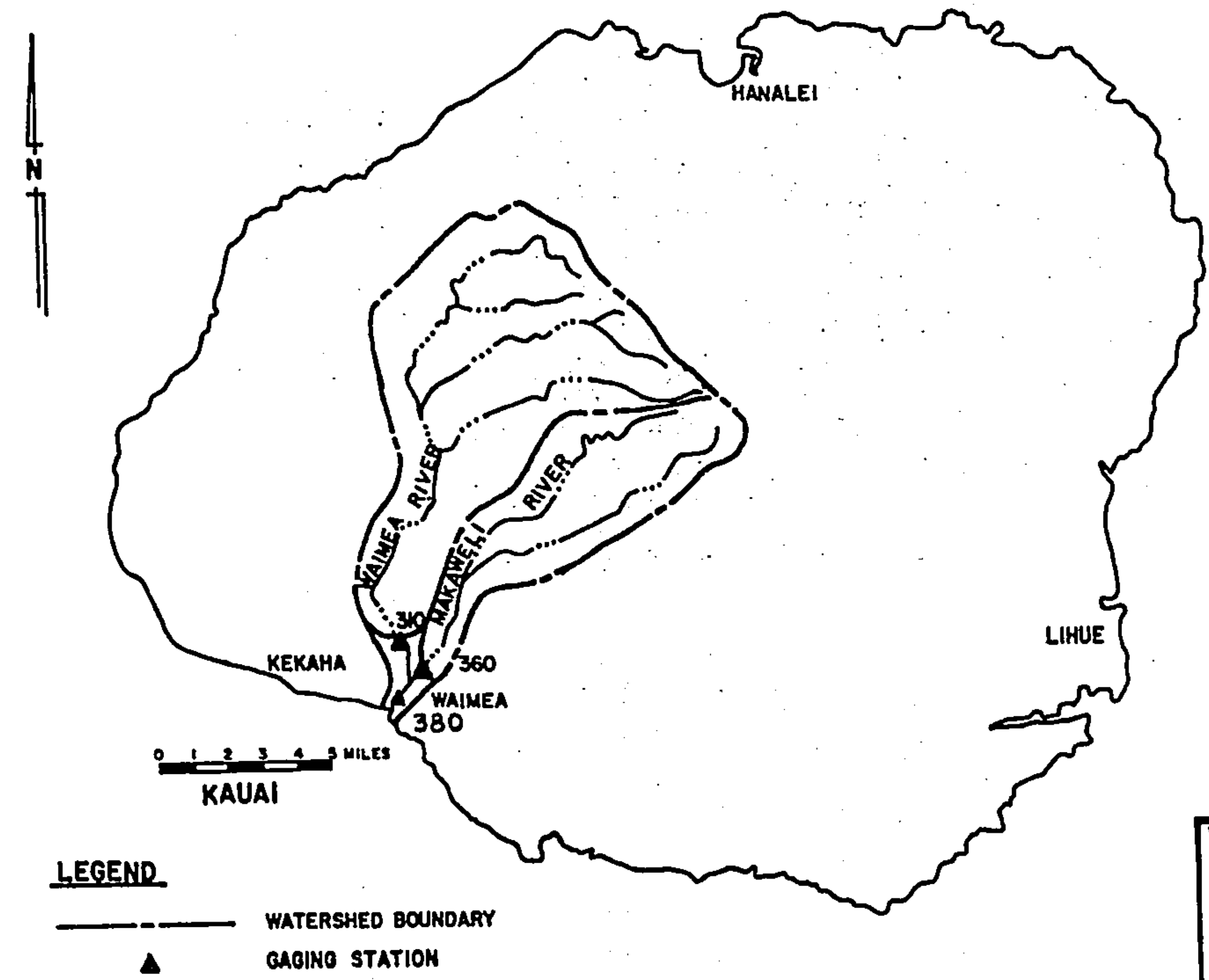


FIGURE I
PROJECT LOCATION

ADAPTED FROM
U.S. ARMY ENGINEER DISTRICT, HONOLULU
AUGUST 1979



WAIMEA RIVER — KAUAI, HAWAII

FIGURE 2
WAIMEA WATERSHED

ADAPTED FROM
U.S. ARMY ENGINEER DISTRICT, HONOLULU

elevation, and flow through approximately 233 miles of channels before discharging into Waimea Bay at the southeastern edge of Waimea Town (2).

The largest tributary is the Makaweli River, which joins Waimea River about 1.1 miles above its mouth. The estuary is relatively well developed based on survey data (Table 1) and extends about 1.3 miles upstream into both the Waimea and Makaweli branches. The normal tidal range is 1.7 feet, and the extreme tidal range is 4.0 feet (3). A sand berm extends nearly across the entire river mouth (Fig. 3 and Plate 1).

Average discharges at the lowest USGS gaging stations on the Waimea and Makaweli River branches (Fig. 2) are about 86 million gallons per day (mgd) at Station 310, and 58 mgd at Station 360 (4). Extreme discharges for the Waimea and Makaweli River branches vary from zero to 37,000 cubic feet per second (cfs) and from 3.2 to 26,000 cfs, respectively, with the lower extremes during dryer summer months.

The Waimea River basin is bounded on the east and west by extensive tracts of cultivated sugarcane. Crops, such as taro, corn, and alfalfa, are produced in lower Waimea Valley, and some low-density cattle production occurs there as well (5). Water is diverted from the Waimea River system at 28 locations for agricultural irrigation, hydroelectric power generation, or domestic uses (2, 6). It was estimated in 1970 that the total amount of water removed by these diversions averaged about 55 mgd from Waimea River and 46 mgd from Makaweli River (7). More recent data indicates that the Kokee Ditch diverts an average of 15.7 mgd from the headwaters in Alakai Swamp and the Kekaha Ditch diverts an average of 36.2 mgd from the middle reaches of Waimea River. These two diversions represent approximately 60 percent of the present average flow at Station 310 (Fig. 2). In addition, the Olokele Ditch diverts all of the low flows of the Olokele River, a tributary of Makaweli (8). It is apparent that extensive water diversions in the Waimea River system are resulting in frequent critical low flows reported during the summer months (4, 7, 8, 9). It has been estimated that a minimum of 20 mgd could otherwise flow through Waimea estuary instead of only several million gallons per day under present conditions (7).

Although less than one percent of the Waimea River and its tributaries have been affected by flood control structures, the entire estuary of the Waimea River has been affected (Fig. 4). Existing modifications above the Kaumualii Highway (Hwy. 50) bridge include a 6,400-foot-long earthen levee with grouted riprap lining along the west bank of the river. The levee is trapezoidal in cross-section with a crest height from 5 to 14 feet above ground level. It is surfaced with grouted riprap on the river side (Plates 2, 3, and 4). At the southern (downstream)

TABLE 1

Physicochemical measurements in the Lower Reach of the Waimea River, Kauai during January 24-26, 1979. (Probe depth ≤1 ft. except where noted).

Site	Temperature (°C)	Conductivity (µmhos)	Salinity (ppt)	Date/Time (hrs)	Tide[1] (± mean sea level in feet)
1	21	—	15	24/1715	LLW (-0.2)
2	19-20	425-1000	<1	24/1611-1625	LLW (+ 0.2 to 0.0)
	22	—	24	26/0910	HLW (+ 0.1)
3	20	125-900	<1	24/1611-1644	LLW (+ 0.2 to 0.0)
	19.5-20	—	1.9[2]	26/1025	HLW (+ 0.1)
	19.5-20	—	1.9[3]	26/1025	HLW (+ 0.1)
	19.5-20	—	6.5-7.0[4]	26/1025	HLW (+ 0.1)
	19.5-20	—	5.8[5]	26/1025	HLW (+ 0.1)
4	22	2150	<1	24/1649	LLW (0.0)
5	17.5	1010	<1	25/0841	HLW (+ 0.2)
6	17-18	120-150	0	25/0730	HLW (+ 0.3)
7	16.5-18.5	103-115	0	25/0746-1053	HLW (+ 0.2 to + 0.4)
8	18	80	0	25/1112	not affected by tides
9	17.8	76	0	24/1200	not affected by tides
10	19.8	98	0	26/1309	not affected by tides
11	19	90	0	26/1325	not affected by tides

footnotes:

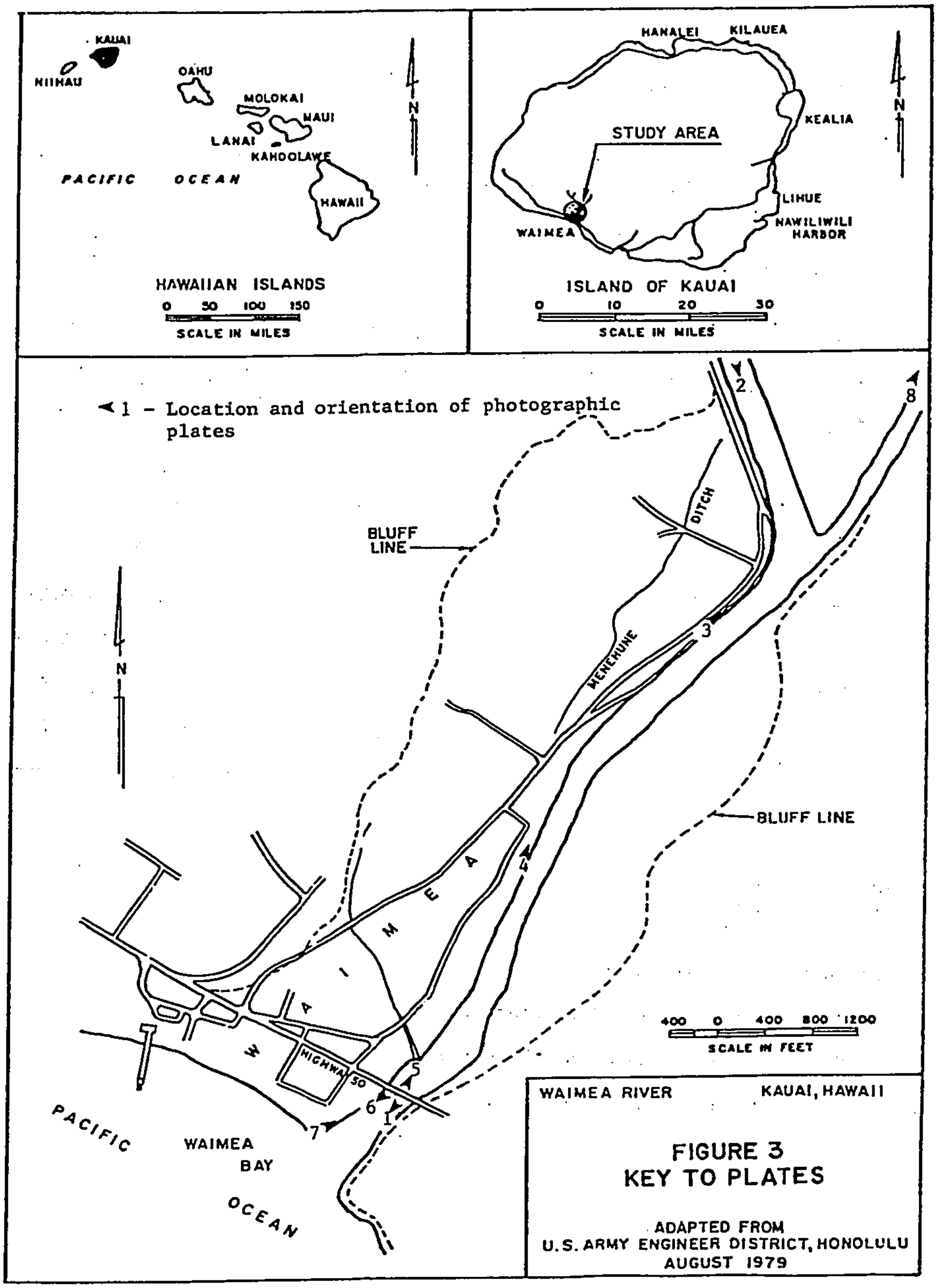
1 HLW-higher low water
  LLW-lower low water
  LHW-lower high water

2 probe at surface near shoreline

3 probe at 1 foot depth, 2 feet from shoreline

4 probe at 2 foot depth, 3 feet from shoreline

5 probe at 3 foot depth, 4 feet from shoreline



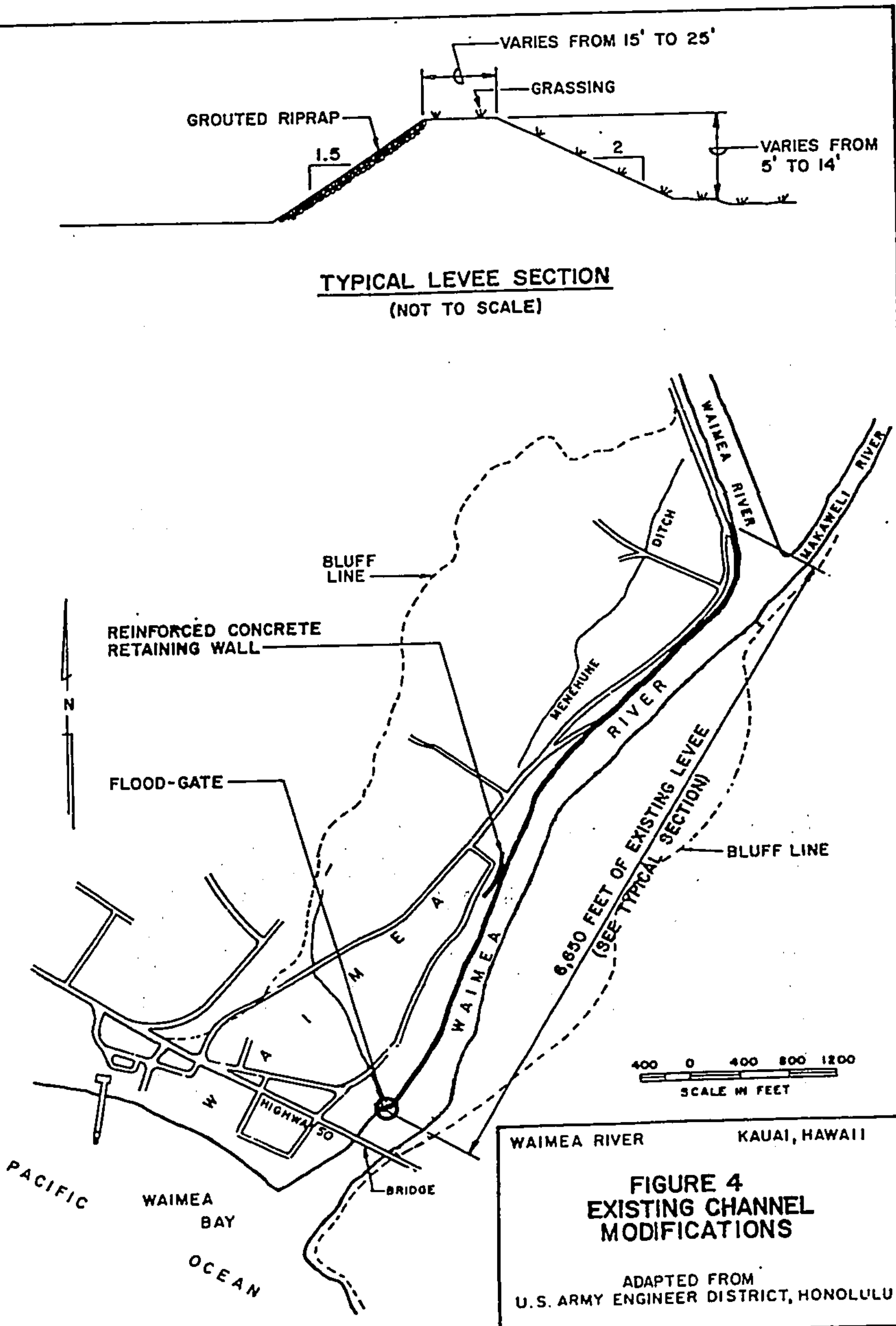
WAIMEA RIVER KAUAI, HAWAII

FIGURE 3
KEY TO PLATES

ADAPTED FROM
U.S. ARMY ENGINEER DISTRICT, HONOLULU
AUGUST 1979

PLATE 1 (above): Sandbar at the mouth of Waimea River. View from highway bridge facing SW.

PLATE 2 (below): Northern (upstream) terminous of the existing levee. View facing SSE.



WAIMEA RIVER KAUAI, HAWAII

FIGURE 4
EXISTING CHANNEL MODIFICATIONS

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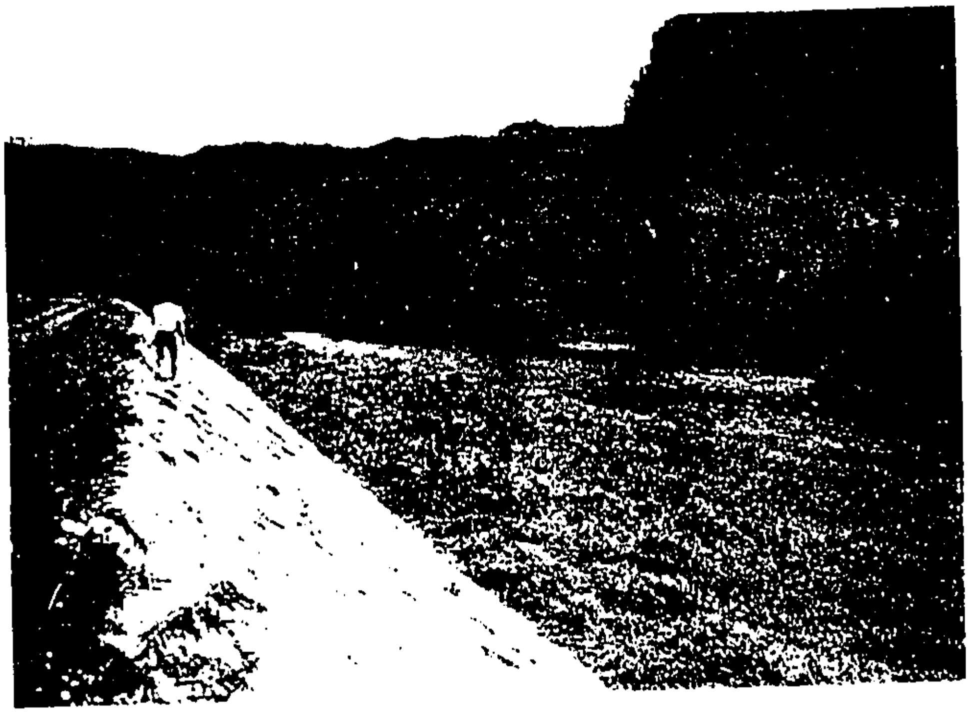


PLATE 3 (above): Upper reach of the existing levee; confluence of Waimea and Makaweli Rivers in background. View facing NE.

PLATE 4 (below): Middle reach of the existing levee. View facing NNE.

terminous of the levee, a flood control gate was installed to permit interior drainage from Waimea town to discharge into the river (Plate 5). From the flood control gate to the river mouth (1,050 feet), the west bank of the river is protected by a revetment constructed of ungrouted armor stone (Plates 6 and 7).

The existing structures were constructed between 1950 and 1954 to protect Waimea from damaging floods such as that which occurred on February 7, 1949, when a crest gage height of 11.40 feet was recorded. This discharge is equal to a 50-year frequency flood (10).

Although the present levee is sufficient in its upper reaches to withstand a 100-year frequency flood, such a flood would overtop the lower section of the levee, and even lower flows could circumvent the southern terminous of the levee and cause extensive flooding in Waimea. According to the Corps of Engineers (11), the portion of Waimea below the southern terminous of the levee is subject to inundation by a 29-year frequency flood. In addition, existing floodgates are inadequate to handle interior drainage from Waimea during periods of locally heavy rainfall, especially when such events coincide with high stream flows.

There is a 40 percent probability that the 100-year flood will be met or exceeded one or more times during the 50-year life of the proposed project (10, 11). High flows in the past have eroded the riverbed along the toe of the existing levee. However, such erosion is unpredictable as to location and extent. Severe erosion could result in undermining and subsequent failure of the levee. Furthermore, overtopping of the levee could result in erosion of the levee crest and backslope, causing a breach in the structure.

In order to augment and upgrade existing flood control structures, the Corps of Engineers proposes to undertake Federally-funded flood control modifications on the mainstem of the Waimea River. Preliminary designs were formulated based on a standard project flood (SPF) having a peak discharge of 100,000 cfs at the mouth of Waimea River. By comparison, the 100-year flood has a peak discharge of 62,500 cfs at the river mouth.

In addition to the selected plan, two other alternatives were considered for implementation, one non-structural and one structural. The non-structural plan, floodproofing, was designated the least environmentally damaging (LED) plan; however, the Corps did not deem it to be a feasible or practical solution to the problem of flooding in Waimea. The structural alternative plan was similar in many respects to the selected plan; however, it included extensive dredging in the Waimea River mainstem which was considered unacceptable for economic and environmental reasons.

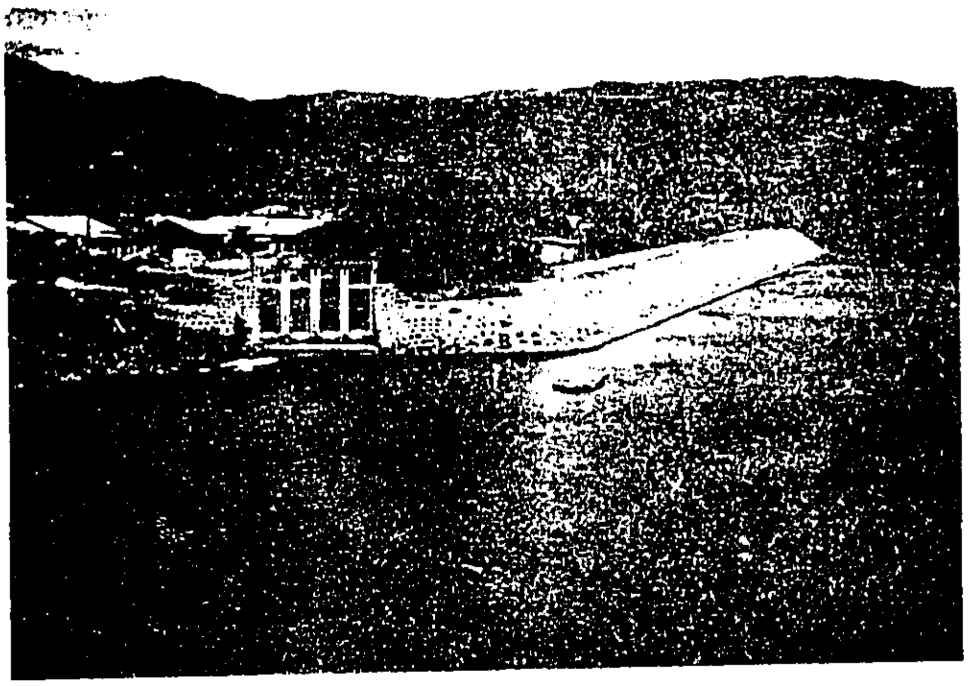
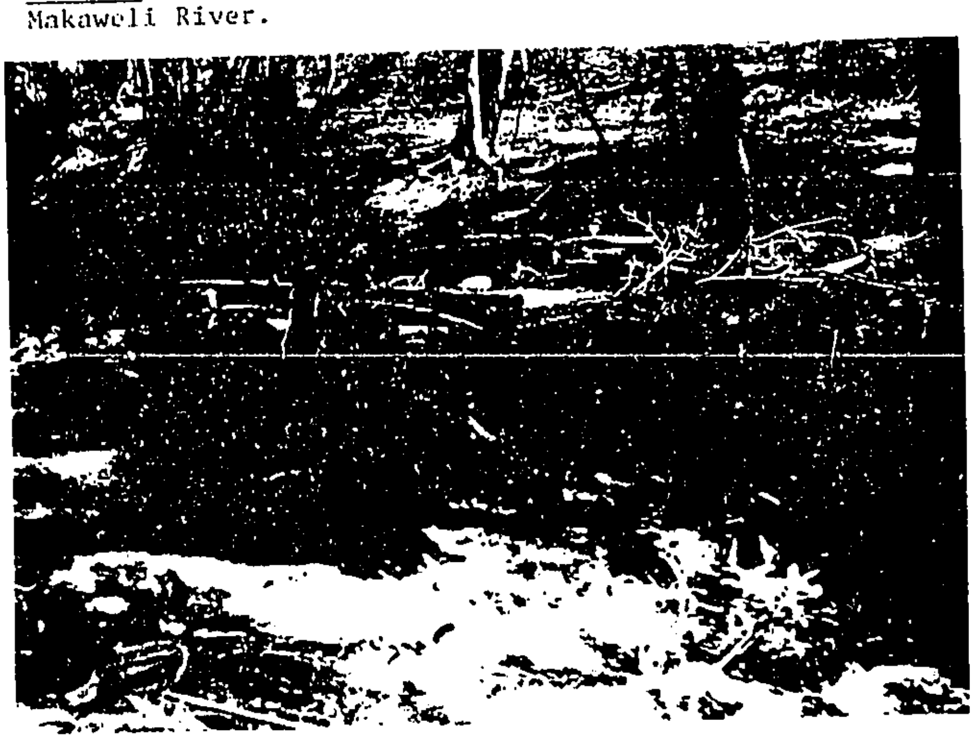


PLATE 5 (above): Lower reach of the existing levee; floodgate in the left foreground. View facing NNE.

PLATE 6 (below): Ungrouted riprap revetment on west bank of Waimea River below highway bridge. View facing SW.

PLATE 7 (above): Ungrouted riprap revetment below highway bridge (background). View facing NE.

PLATE 8 (below): Illegal "kahi" or goby trap on the Makaweli River.



Project Description

The selected plan (Fig. 5) has been designated the National Economic Development (NED) plan. It consists of six major parts:

1. Levee extension: A 1575-foot-long extension of the existing west levee would be constructed from station 0+00 to 15+75. This structure would vary in height from +11 feet with respect to mean sea level (MSL) at the river mouth to +17 feet MSL at its upstream terminous, with a crest width of 10 feet and side slopes of 1V:3H on the river side and 1V:2H on the inland side. The levee extension would be protected from erosion by a 27-inch layer of ungrouted armor stone (250-pound-stone average) over a 6-inch bedding.

2. Concrete "I"-wall construction: A floodwall would be constructed of precast concrete sections set in trenches for 3,175 feet along the crest of the existing levee from station 15+75 to 36+00 and from 61+00 to 72+50. Joints between the sections would be sealed to prevent leakage.

3. Rock toe protection: To prevent erosion of the levee, 3,800 feet of the levee would be protected with ungrouted armor stone placed at the toe. The riverbed would be excavated to a depth of -7.5 feet MSL. A layer of riprap 42 inches thick (260-pound-stone average) would be placed over 9 inches of bedding material on a slope of 1V:2H, and would be backfilled with the excavated material.

4. Road raise: A 500-foot-long section of the road between stations 72+00 and 77+00 would be raised to prevent overtopping by design flows.

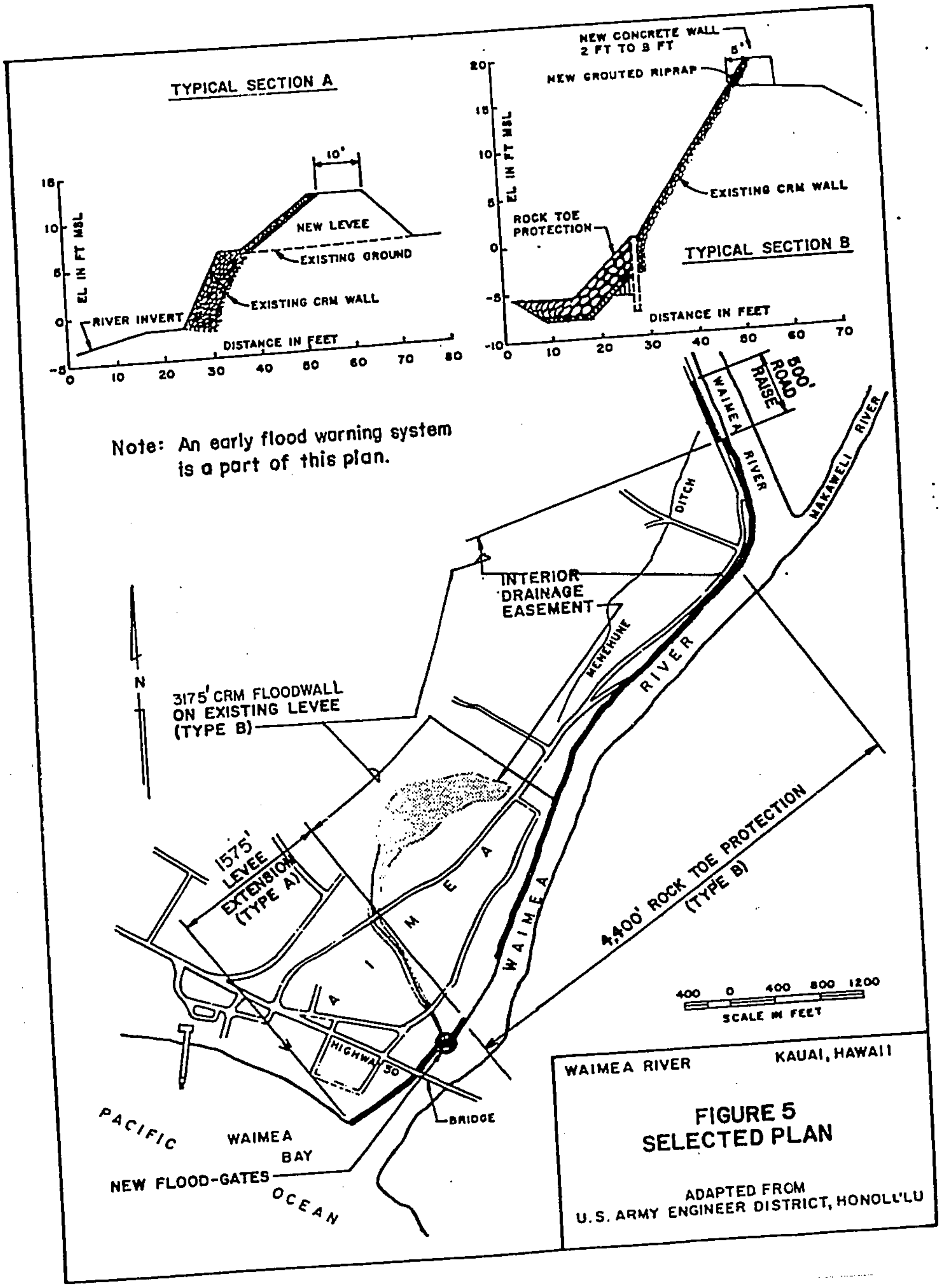
5. Floodgate: The existing floodgate would be replaced with a new structure to provide for adequate interior drainage from Waimea Town.

6. Flood warning: An early flood warning system consisting of rain and stream gauging stations are to be located in the Waimea and Makaweli basins.

Environmental Setting Without-the-Project

A. Aquatic Resources

The lower one-mile reach of the Waimea River estuary is heavily silted with alluvial deposits, and in mid-channel below the highway bridge, the river is less than four feet deep at several points. About 1,000 feet below the Waimea-Makaweli River confluence the river bed changes to boulder and gravel interspersed with silt. In reaches above tidal influence, the Makaweli River becomes noticeably clearer and less heavily



WAIMEA RIVER KAUAI, HAWAII

FIGURE 5
SELECTED PLAN

ADAPTED FROM
U.S. ARMY ENGINEER DISTRICT, HONOLULU

silted than in the estuary. However, the main stem continues to show evidence of heavy siltation below the USGS gaging station No. 310. Physicochemical parameters were measured at and above the project site (Fig. 6). Data for these eleven sample sites are listed in Table 1. These measurements indicate that temperature, salinity and conductivity in the project area vary considerably between stations. At estuarine stations these parameters also vary with tidal phase, sample depth, and volume of freshwater discharge.

During the Service field investigation (January 24-26, 1979), small schools of juvenile mullet and in-migrating "hinana" or juvenile gobies (Sicydium stimpsoni), as well as two species of adult gobies (Awaous genivittatus and Eleotris sandwicensis), "papio" (Caranx sp.), and tilapia (Sarotherodon mossambica) were observed along the shoreline (Table 2). A variable-mesh 60-foot gill net was set perpendicular to the west bank of the river near the mouth during low tide (0900-1100 hrs., Jan. 26). Although only four Samoan mullet (Chelon engeli) and one "aholehole" (Kuhlia sandvicensis) were caught, yields are expected to be greater and more diverse during strong flood and ebb tides and at night.

Intertidal species observed at the project site (Table 2) include the dotted periwinkle (Littorina pintado) (up to 50/m^2), mytilids, and an occasional small "opihi" or limpet (Cellana sp.) on the riprap groin at the river mouth. Inside the river mouth along the riprap bank, grapsid crabs (about one crab per linear meter of shoreline) were observed for about 200 meters upstream. Brown "wi" (Theodoxus vespertinus) were abundant (about 30/m^2) throughout the estuary, as was the endemic prawn, Macrobrachium grandimanus. Barnacles (Balanus sp.) were observed in clumped distributions on loose stones in a riffle area about 300 meters below the Waimea-Makaweli River confluence.

Above the estuary, four goby species, neritid, thiarid and ancylid molluscs, palaemonid and atyid shrimp and a variety of benthic insect nymphs and larvae (e.g. Diptera, Trichoptera, and Odonata) were observed. Only the egg cases of the endemic neritid snail, Neritina granosa, were observed. Macrofaunal populations were particularly abundant in the Makaweli River. Tilapia, swordtails (Xiphophorus helleri) and guppies (Poecilia reticulata) were relatively common to abundant in all areas examined above the estuary.

Interviews with local fishermen indicate that throw-net fishing, angling, and crabbing occur within the Waimea River estuary. Surf casters are commonly observed outside the river mouth. During the Service field investigation, two surf casters were observed west of the river mouth and crab nets were hung from the highway bridge. In addition, a commercial seiner, using three outboard motorboats to deploy a net off the river mouth, was observed catching "akule" (Trachurops crumenophthalmus). Catches reported from the estuary include Samoan

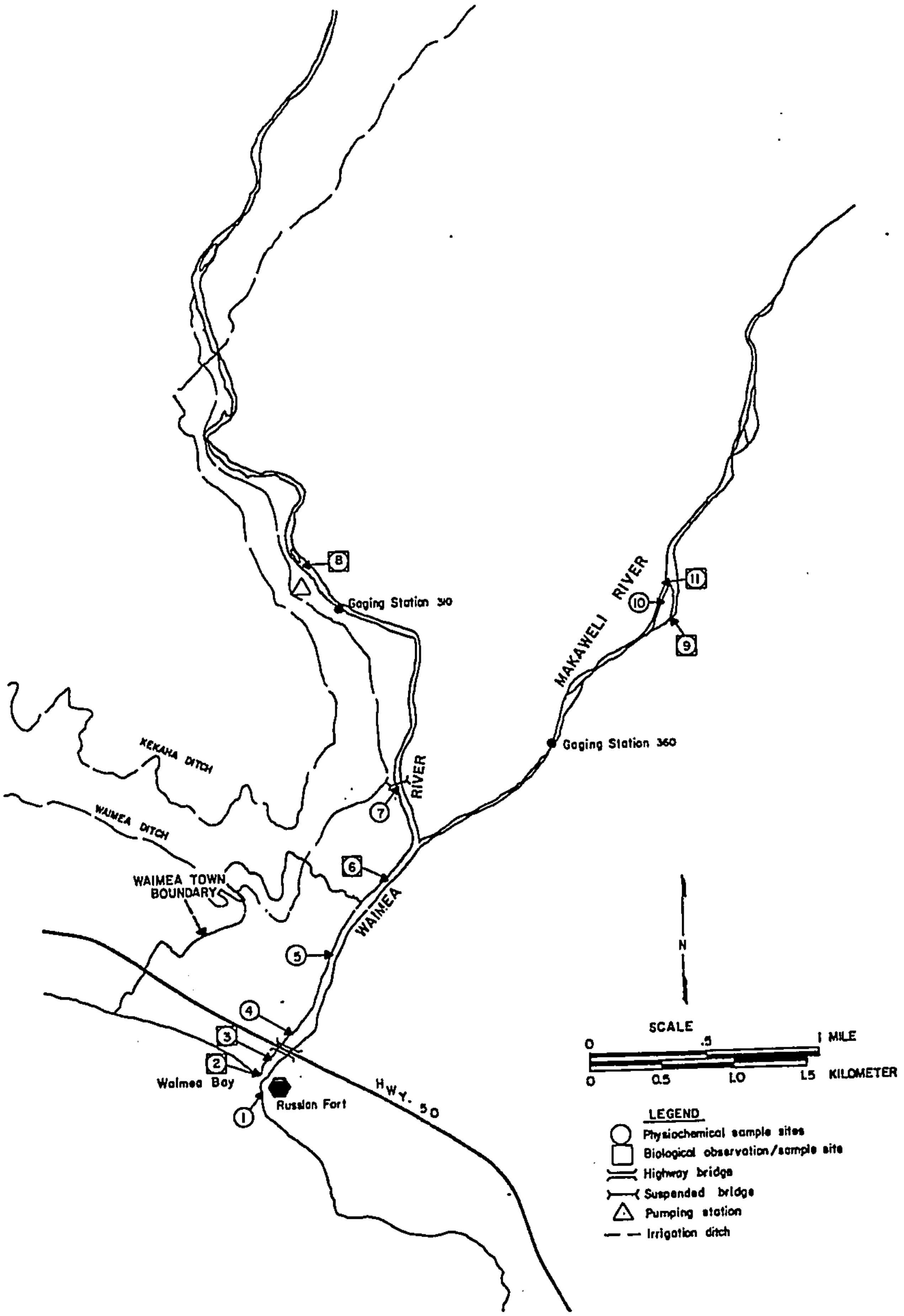


Figure 6. Stations in Waimea River, Kauai, Hawaii sampled duringJanuary 24-26, 1979.

TABLE 2
List of Estuarine/Freshwater Fauna
Observed or Reported in Waimea River

PHYLUM / CLASS / FAMILY / Genus/species/subspecies	Common Name
ARTHROPODA	
CRUSTACEA	
BALANIDAE	
Balanus sp.	barnacle
GRAPSIDAE	
Metapograpsus sp.	rock crab,"a'ama"
PORTUNIDAE	
Scylla serata	Samoan crab
PALAEMONIDAE	
Macrobrachium grandimanus(*)	Hawaiian prawn, "opae oeha'a"
M. lar	Tahitian prawn
ATYIDAE	
Atya bisulcata(*)	"opae kala'ole"
INSECTA	
ORDER: DIPTERA	
CHIRONOMIDAE	midge (larvae)
EPHYDRIDAE	brinefly (larvae)
EMPIDIDAE	(larvae)
HEMERODROMIINAE(Subfamily)	(larvae)
TIPULIDAE	cranefly (larvae)
ORDER: ODONATA	
AESHNIDAE	
Anax strenuus(*)	dragonfly (nymph)
COENAGRIIDAE	
Megalagrion spp.(*)	damselfly (nymph)
ORDER: TRICOPTERA	
Cheumatopsyche analis	caddisfly (larvae)

(*) Endemic species

TABLE 2 (continued)

MOLLUSCA	
GASTROPODA	
PATELLIDAE	
Cellana exarata(*)	black limpet, "opihi"
C. argentata(*)	kneecap shell, "opihi"
ANCILLIDAE	
Ferrissia sharpi(*)	ancillid snail
NERITIDAE	
Nerita picea	common nerite, "pipipi"
Theodoxus vespertinus	brown "wi"
Neritina granosa(*)	"hihiwai"
LITTORINIDAE	
Littorina pintado pintado	dotted periwinkle
THIARIDAE(MELANIIDAE)	
Thiara sp.	thiarid snail
PELECYPODA	
MYTILIDAE	
Mytilis sp.	mussel
VERTEBRATA	
OSTEICHTHYES(PISCES)	
ENGAULIDAE	
Stolephorus purpureus(*)	anchovy, "nehu"
Misgurnus anguillicaudatus	weatherfish, dojo
SPHYRAENIDAE	
Sphyraena spp.	barracuda
MUGILIDAE	
Mugil cephalus	striped mullet, "ama'ama"
Chelon engeli	Engel's mullet
POLYNEMIDAE	
Polydactylus sexfilis	threadfin, "moi"
KUHLIIDAE	
Kuhlia sandvicensis(*)	Hawaiian flag-tail, "aholehole"
LUTJANIDAE	
Lutjanus kasmira	blue-lined snapper, "ta'ape"
CARANGIDAE	
Caranx spp.	"papio," "ulua"

(*) Endemic species

crab, prawn, goby, grey mullet, Samoan mullet, "moi", "aholehole", "papio", and tilapia. Occasionally, large "ulua" and yellow perch or "ta'ape" are caught within the estuary, particularly during the "o'opu" (goby) spawning runs around September and October. "O'opu nakea", the main goby species taken in this popular part-time fishery, may reach up to 14 inches in length. In the middle and upper stream reaches, they are often caught by spearing during low flows. During their spawning migrations to the estuary, throw-netting is the most popular fishing method, although angling and gill-netting are popular also. Gobies are reported to be selling for about $4-5 per pound wholesale (in season).

Apparently the goby fishery has been declining slowly over the past 30 years (Stan Shima, Hawaii Fish and Game - pers. comm). The presence of illegal "kahi" or goby traps in the Waimea and Makaweli River branches suggest that illegal fishing pressures on this resource are quite heavy. The "kahi" shown in Plate 8 is small compared to some which are constructed with bulldozers or other heavy equipment. There is also legal but unmanaged overfishing using nets (U.S. Army Corps of Engineers, written communication).

The existing conditions and aquatic resources within Waimea River probably will change little over the project life, provided water demands, as well as floodplain and upland development (residential and agricultural), do not increase significantly. Based on the limited economic opportunity and past low population growth in the Waimea area (5), these assumptions seem reasonable.

B. Terrestrial Resources

Vegetation in the project area (Table 3) is characteristic of highly altered shoreline areas in Hawaii. Paragrass (Brachiaria mutica) and Guinea grass (Panicum maximum) extend from the levee bank out about 30 meters in the shallow upper portion of the river below the confluence (Fig. 6). There are various grasses, forbs, and shrubs on the top and landward embankment of the levee, which is used for pasturage.

The Waimea River mouth and estuary provide feeding habitat for a variety of migratory shorebirds (Table 4), including the American golden plover (Pluvialis dominica fulva), sanderling (Calidris alba), wandering tattler (Heteroscelus incanus), and ruddy turnstone (Arenaria interpres). Resident avian species reported or observed during the January 24-26 survey were the white-tailed tropic bird (Phaethon lepturus), "pueo" (Asio flammeus sandwichensis), and black-crowned night heron (Nycticorax n. hoactli). Due to the extent of human development and activity, the stream, taro patches, and abandoned rice fields near and above the confluence provide only marginal habitat for the endangered Hawaii duck (Anas wyvilliana), Hawaiian stilt (Himantopus mexicanus knudseni), Hawaiian gallinule (Gallinula chloropus sandvicensis), and

TABLE 3
Dominant Terrestrial Flora in
the Lower Waimea River Valley

FAMILY Genus/species/author	Common Name
GRAMINAE	
Bothriochloa pertusa (L.) Camus	pitted beard grass
Brachiaria mutica (Forsk) Stapf.	paragrass, California grass
Chloris inflata Link	swollen-finger grass
Panicum maximum Jacq.	Guinea grass
PORTULACACEAE	
Portulaca cyanosperma Egler (*)	blue-seeded purslane, "ihi"
MALVACEAE	
Sida paniculata L.	paniculate sida
Hibiscus tiliaceus L.	"hau"
STERCULIACEAE	
Waltheria indica var. *americana* (L.) Hosaka	"hi'aloa," "'uhaloa"
CONVOLVULACEAE	
Ipomoea obscura (L.) Kev-Gawe	"koali"
VERBENACEAE	
Verbena littoralis Hbk.	vervain
COMPOSITAE	
Verbesina encelioides (Cav.) Gray	golden crown beard
LEGUMINOSAE	
Leucaena leucocephala (Lam.) deWit	"koa haole"
Prosopis pallida (Humb. & Bonpl.) Hbk.	"kiawe"
ANACARDIACEAE	
Mangifera indica L.	mango

(*) Endemic species

TABLE 4
List of Terrestrial Fauna Observed or
Reported in the Lower Waimea River Valley

PHYLUM / CLASS / FAMILY / Genus/species/subspecies	Common Name
VERTEBRATA	
AVES	
ARDEIDAE	
Bubulicus ibis	cattle egret
Nycticorax n. hoactli	black-crowned night heron
ANATIDAE	
Anas wyvilliana(E)(*)	Hawaiian duck, "koloa"
RALLIDAE	
Gallinula chloropus sandvicensis(E)(*)	Hawaiian gallinule, "'alae'ula"
Fulica americana alai (E)(*)	Hawaiian coot, "'alae ke'oke'o"
CHARADRIIDAE	
Pluvialis dominica fulva(M)	American golden plover
SCOLOPACIDAE	
Heteroscelus incanus(M)	wandering tattler
Arenaria interpres(M)	ruddy turnstone
Calidris alba(M)	sanderling
PHAETHONTIDAE	
Phaethon lepturus	white-tailed tropicbird
RECURVIROSTRIDAE	
Himantopus mexicanus knudseni(E)(*)	Hawaiian stilt, "a'eo"
COLUMBIDAE	
Streptopelia chinensis chinensis	lace-necked dove
Geopelia striata striata	barred dove
PYCNONOTIDAE	
Pycnonotus cafer	red-vented bulbul
ZOSTEROPIDAE	
Zosterops japonica japonica	white-eye, mejiro
STRIGIDAE	
Asio flammeus sandwichensis(*)	Hawaiian owl, "pueo"

(*) Endemic species
(E) Endangered species
(M) Migratory species

TABLE 4 (continued)

VERTEBRATA	
AVES	
STURNIDAE	
Acridotheres tristis	common mynah
FRINGILLIDAE	
Cardinalis cardinalis	American cardinal
MAMMALIA	
ORDER: RODENTIA	
MURIDAE	
Mus musculus	house mouse
Rattus rattus	roof, black rat
R. norvegicus	Norway rat
R. exulans hawaiiensis	Polynesian rat
ORDER: CARNIVORA	
FELIDAE	
Felis catus	domestic cat
CANIDAE	
Canis familiaris	domestic dog
ORDER: PERISSODACTYLA	
EQUIDAE	
Equus caballus	horse
ORDER: ARTIODACTYLA	
BOVIDAE	
Bos taurus	domestic cattle
AMPHIBIA	
BUFONIDAE	
Bufo marinus	marine toad

the Hawaiian coot (Fulica americana alai). One Hawaiian coot was observed along the east bank of the Waimea River opposite the project site, where overhanging "hau" (Hibiscus tiliaceus), "koa haole" (Leucaena leucocephala), and various grasses and shrubs provide substantially more cover than on the west bank. Use of this area by endangered species is considered incidental, however (Telfer, Hawaii Division of Fish and Game-pers. comm.). A variety of urban avian species were also observed in the project area (Table 4). Other common terrestrial fauna found in the project area include the Norway rat (Rattus norvegicus), roof rat (R. rattus), Polynesian rat (R. exulans), house mouse (Mus musculus), marine toad (Bufo marinus), feral/domestic cat (Felis catus) and dog (Canis familiaris), and some domestic livestock (Table 4).

Environmental Impacts With-The-Project

A. Aquatic Resources

The proposed project should have little significant adverse impacts on aquatic resources. Short-term impacts due to excavation, transport, and placement of materials in the water can be expected, including disturbance and displacement of aquatic fauna, suspension of fine sediments resulting in increased turbidity, and introduction of potentially toxic substances, such as petroleum products, from heavy machinery used during construction.

The levee extension and rock toe protection will eliminate some intertidal, littoral, and river bottom habitat. However, the interstices in the ungrouted riprap should provide habitat for a variety of organisms, especially molluscs and crustaceans, and may enhance the estuary for recreational and subsistence fishing, provided that the proposed project does not restrict public access to the water.

Organisms which require a soft substrate, such as polychaete worms, some crustaceans, and certain fishes, will be displaced from approximately 1.5 acres of benthic riverine habitat, and feeding opportunities for shorebirds and waterbirds may be reduced.

B. Terrestrial Resources

The proposed project will not adversely affect any significant terrestrial resources at the project site. Terrestrial fauna may be temporarily displaced during construction activities, and some feeding opportunities for birdlife may be lost, as previously described. However, the new structures should provide additional feeding opportunities for species such as the wandering tattler, black-crowned night heron and American golder plover to offset habitat which is lost.

While endangered endemic waterbirds are known to inhabit the project vicinity, the estuary of Waimea River does not provide significant habitat for these species.

Impacts associated with the quarrying of armor stone cannot be addressed, because specific quarry sites have not been selected.

Discussion/Recommendations

Prior to completion of the existing improvements in 1954, Waimea was subject to frequent damaging floods. In spite of these improvements, flooding continues to occur within the business district because of inadequate interior drainage to conduct storm runoff out of the area.

Another factor which may contribute to the problem of flooding in the town of Waimea is the substantial sand berm which exists across the mouth of Waimea River. It is thought that the 2-year-frequency flood is insufficient to wash out the berm, resulting in unexpectedly high water surface elevations (5.7 feet observed versus 3.7 feet calculated)(9).

Although sand berms are natural phenomena resulting from the littoral transport and deposition of sand, the situation at Waimea is aggravated by upland erosion and alluvial deposition at the river mouth concomitant with reduced flows resulting from extensive diversion of instream flows. The County of Kauai periodically removes a portion of this obstruction under a Department of the Army permit. However, dredged materials are stockpiled on the remaining portion of the berm from which they can easily be redistributed by wave action across the river mouth. Furthermore, fast-peaking flood flows may be incapable of removing such an obstruction.

The Service believes that a combination of improved upland soil conservation efforts, increased flows through the estuary, particularly during the dryer summer months, improved interior drainage in Waimea Town, and the periodic and complete removal of the sand berm from the river mouth would reduce the flooding potential and contribute significantly to the maintenance and enhancement of aquatic resources in the Waimea River. If river mouth clearing can be accomplished as an alternative to, or in conjunction with other project plans, we believe environmental benefits will probably be realized in estuarine and upstream aquatic communities and to recreational fishing.

In view of the preceding, the U.S. Fish and Wildlife Service recommends that the following measures be implemented to protect or enhance fish and wildlife resources:

1. Final project plans make provision for complete and, if necessary, periodic removal of the sand berm at the mouth of Waimea River.

2. The levee extension and other project features be designed to permit fishermen access to the estuary.

3. All project activities in or near the water be done so as to minimize erosion and control turbidity.

4. All dredging operations be performed during periods of seasonally low stream flows.

5. Excess excavated materials, other than clean beach sand, be deposited behind maintained berms above the influence of the tide. Clean sand be graded downcurrent from the project site or be used to replenish beaches off-site.

6. Extreme care be taken to insure that no debris, petroleum products, or other deleterious materials be allowed to fall, flow, leach, or otherwise enter the water.

We appreciate this opportunity to comment.

Sincerely yours,

Maurice H. Taylor

Maurice H. Taylor
Field Supervisor
Division of Ecological Services

cc: Pacific Islands Administrator
OEC, Washington, D.C. (2)
ARD-E, Portland, (2)
ES Field Offices, Region 1
Boise
Olympia
Sacramento
Public Affairs Office, Portland
EPA, San Francisco
National Marine Fisheries Service, HI
Division of Fish and Game, HI

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

PODED-PV

10 April 1980

Mr. Maurice Taylor, Field Supervisor
Division of Ecological Services
Fish and Wildlife Service
U.S. Department of the Interior
300 Ala Moana Blvd.
Honolulu, Hawaii 96850

Dear Mr. Taylor:

The Corps of Engineers has reviewed your final 2(b) report for the Waimea River Flood Control Study, Kauai, Hawaii, and find it to be satisfactory except for the need for a few minor corrections. In order to meet our committment for submission of the Detailed Project Report/Environmental Impact Statement in April 1980, we have compiled an Addendum of corrections (Incl 1) which will be attached to the final 2(b) report. We request that you reflect these changes by attaching the Addendum to all your copies of the final 2(b) report.

Sincerely,

KISUK CHEUNG
Chief, Engineering Division

1 Incl
As stated

ADDENDUM

CORRECTIONS TO THE FINAL DETAILED 2(B) REPORT
FOR THE WAIMEA RIVER FLOOD CONTROL STUDY

1. The word appearing as "terminous" throughout the report should read "terminus".

2. On page 10, paragraph 5, change "62,500" to read "64,000".

3. On page 13, item 2, change the paragraph to read "CRM Floodwall Construction: Two segments of CRM Floodwall would be constructed totalling 3,175 feet along the crest of the ...".

4. Delete the last sentence of item 2, page 13.

5. On page 13, item 3 change "3,800" to read "4,650".

6. Change Figure 5 per attached drawing.

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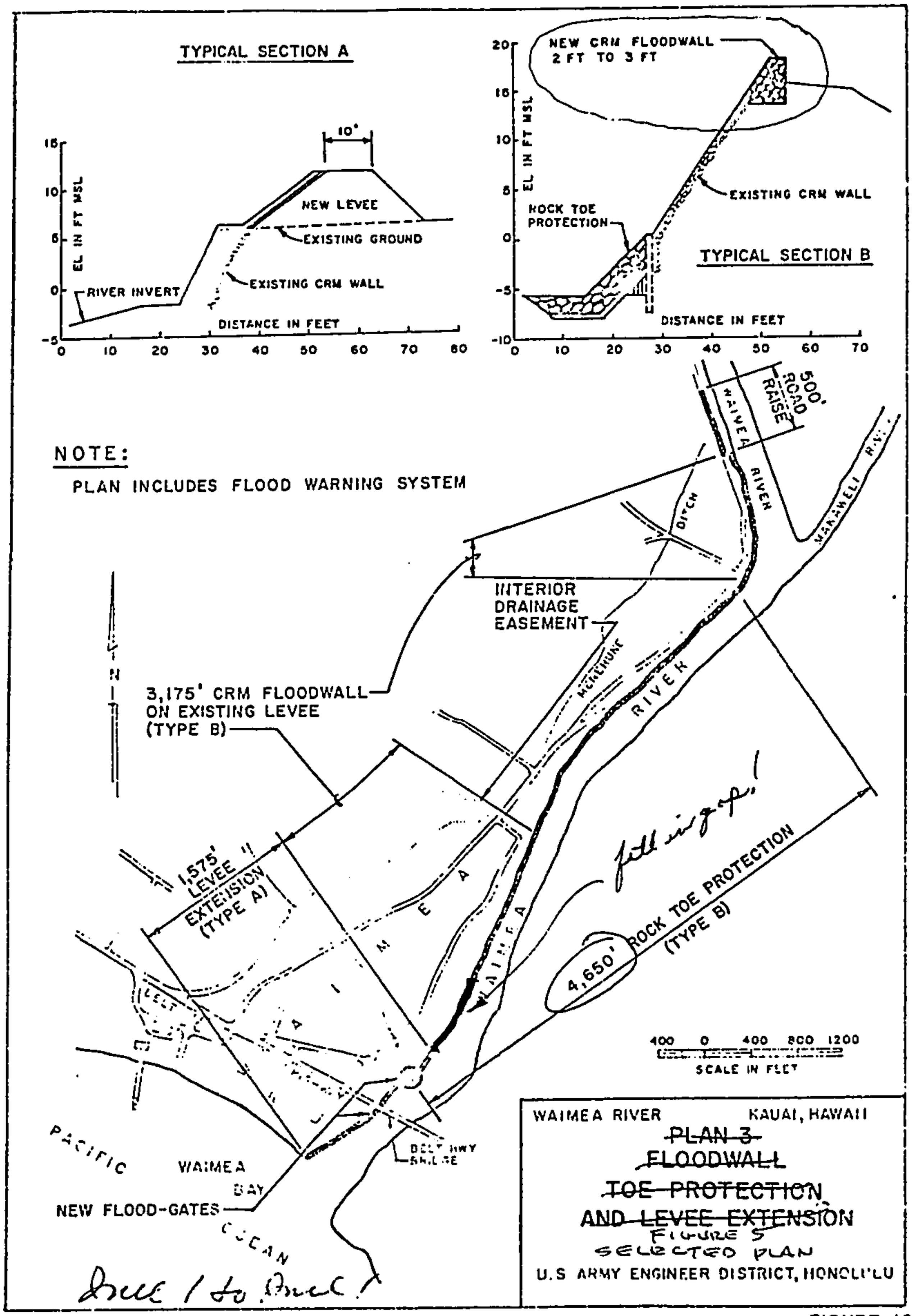
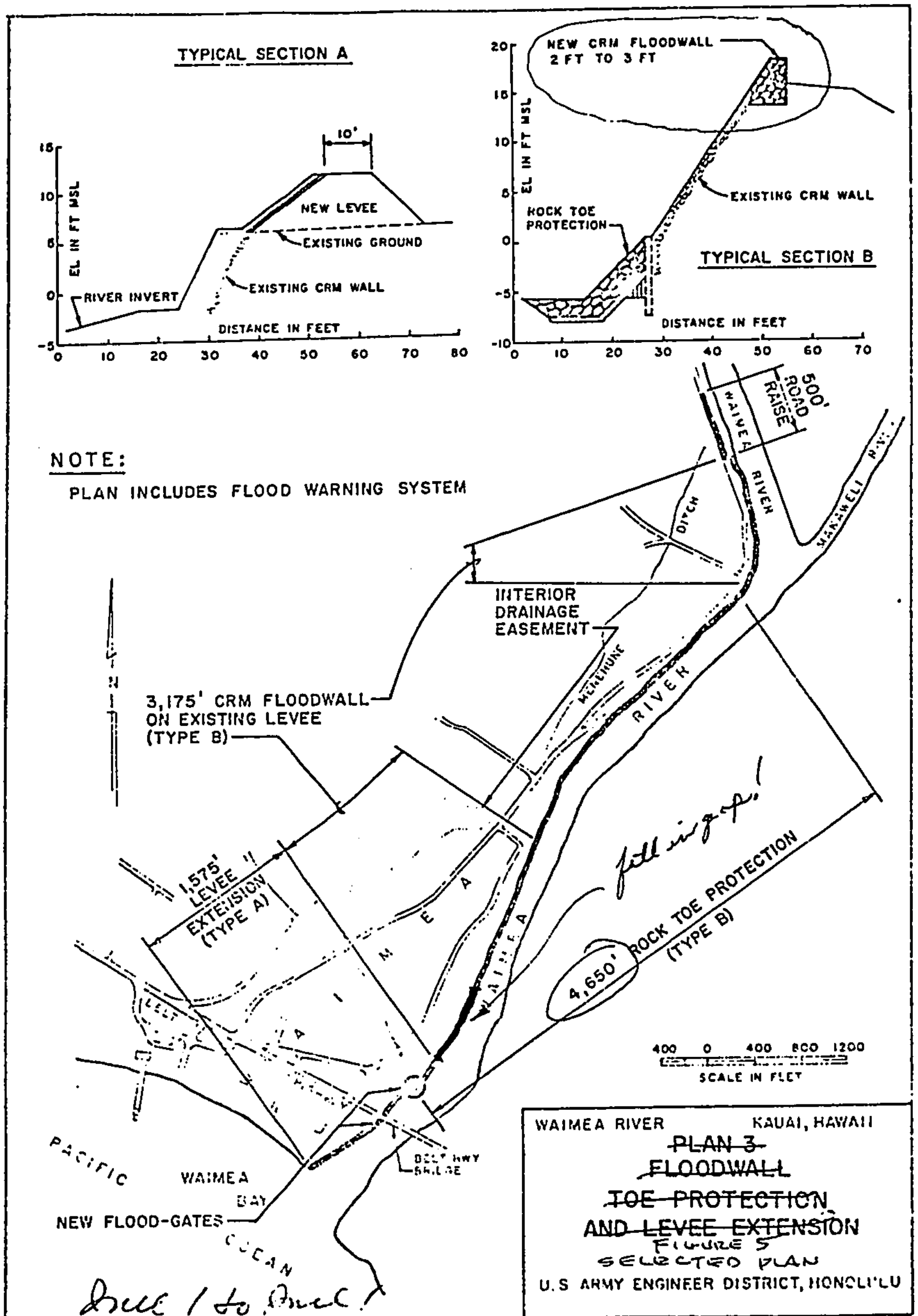


~~FIGURE 10~~



WAIMEA RIVER KAUAI, HAWAII

~~PLAN 3~~
~~FLOODWALL~~
~~TOE PROTECTION~~
AND ~~LEVEE EXTENSION~~

FIGURE 5
SELECTED PLAN

U.S ARMY ENGINEER DISTRICT, HONOLULU

~~FIGURE 10~~