FILE COPY

GEORGE R. ARIYOSHI
GOVERNOR OF HAWAII

SUSUMU ONO, CHAIRMAN
BOARD OF LAND & NATURAL RESOURCES

EDGAR A. HAMASU
DEPUTY TO THE CHAIRMAN

DIVISIONS:
AQUACULTURE DEVELOPMENT PROGRAM
AQUATIC RESOURCES
CONSERVATION AND RESOURCES ENFORCEMENT
CONVEYANCES
FORESTRY AND WILDLIFE
LAND MANAGEMENT
STATE PARKS
WATER AND LAND DEVELOPMENT

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

REF. NO.: CPO-0560
FILE NO.: KA-1797
Exp. Date: 9/1/86

MAY 21 1986

Mr. Jeff Burt
c/o BBB Power Associates
100 Lindbergh Plaza 2
5160 Wiley Post Way
Salt Lake City, Utah 84116

Dear Mr. Burt:

Subject: Determination on the Final Environmental Impact Statement for the Wailua River Hydroelectric Project at Wailua, Kauai, Hawaii

We have completed our review of your Final Environmental Impact Statement (EIS) prepared for the Conservation District Use Application (CDUA KA-1797) on the subject project.

As you are aware, the U.S. Army Corps of Engineers prepared a Final Interim Survey Report and Environmental Statement for the Wailua River Hydropower Project in December of 1982. Although this final document was prepared in accordance with the National Environmental Policy Act (NEPA), the document did not fulfill the procedural requirements of Chapter 343, Hawaii Revised Statutes (HRS), as amended. As a consequence, we required that you submit an EIS in accordance with the EIS Rules and Regulations established under Chapter 343, HRS, as amended.

We are now required to issue a determination on this Final EIS by May 21, 1986. The determination in question is whether the Final EIS is an acceptable or non-acceptable document under Chapter 343, HRS, as amended.

In our view, acceptance means that the document fulfills the definition of an EIS, adequately describes identifiable environmental impacts, and satisfactorily responds to comments received during the review of the Draft EIS.

The EIS means to us that an informational document has been prepared in compliance with the rules and regulations promulgated under Chapter 343-5, HRS, as amended, and discloses the environmental effects of the proposed action, effects of the proposed action on the economic and social welfare of the community and State, effects of the economic activities arising out of the proposed action, measures proposed to minimize adverse effects, and alternatives to the action and their environmental effects.

We consider the following criteria in our determination on the acceptance/non-acceptance of the Final EIS:

A. General

(1) Acceptability of a statement shall be evaluated on the basis of whether the statement, in its completed form, represents an informational instrument which fulfills the definition of an EIS and adequately discloses and describes all identifiable environmental impacts, and satisfactorily responds to review comments.

b. Specific Criteria

A statement will be deemed to be an acceptable document only if all the following criteria are satisfied:

(1) Procedures for assessment, consultation process, a review responsive to comments, and the preparation and submission of the statement, have all been completed satisfactorily;

(2) The content requirement described under Section 11-200-17 and 18 of the EIS Rules and Regulations have been satisfied;

(3) Comments submitted during the review process have received responses satisfactory to the accepting authority, and have been incorporated or appended, at the discretion of the applicant or proposing agency, whichever applicable, to the statement.

After review of the document, we find that the document does serve as an "information instrument" which adequately discloses and describes identifiable environmental impacts. Furthermore, we find that the procedures for assessment, consultation, response to comments, and the preparation and submission of the statement have all been completed satisfactorily.

Therefore, we find that the Final EIS for the Wailua River Hydroelectric Project is an acceptable document prepared in accordance with Chapter 343, HRS, as amended.

Finally, we have consistently maintained that the document, in and of itself, should not be used as a vehicle to promote or detract from any subsequent required decisions on the project itself. Thus, be advised that although this Final EIS has been accepted, the final decision (approval/denial) on your Conservation District Use Application (KA-1797) for the Wailua River Hydroelectric Project will be rendered by the Board at one of its regularly scheduled meetings. We will be notifying you of the time, date, and place of this meeting when it has been scheduled.

Should you have any further questions regarding this matter, please feel free to contact our Office of Conservation and Environmental Affairs in Honolulu, at (808) 548-7837.

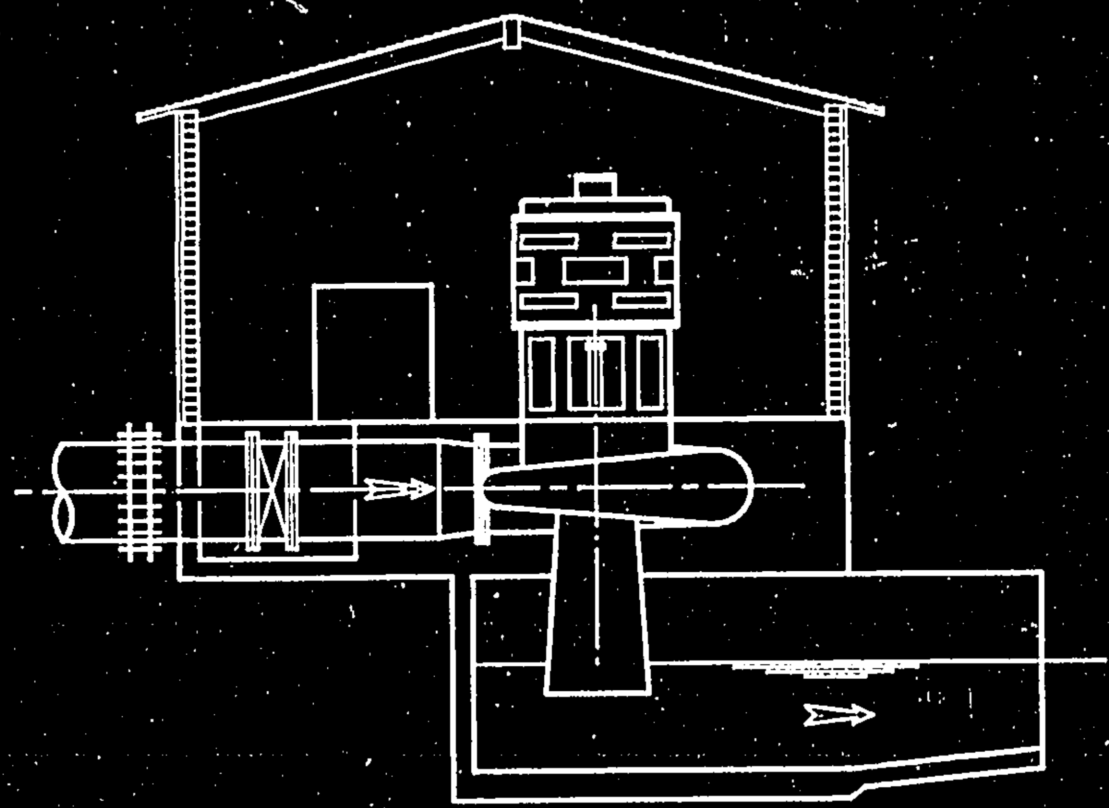
Very truly yours,

SUSUMU ONO, Chairperson
Board of Land and Natural Resources

cc: Kauai Board Member
Kauai District Land Agent
County of Kauai, Planning Dept./DWS/DPW
DOH/OEQC/EC/OHA/DPED
U.S. Fish and Wildlife Serv./Corps of Engineers
All Divisions/Historic Sites/NARS

WAILUA RIVER HYDROELECTRIC PROJECT

KAUAI, HAWAII



FINAL

ENVIRONMENTAL IMPACT STATEMENT

FOR

ISLAND POWER COMPANY INC.

PREPARED BY:

Bingham Engineering
100 Lindbergh Plaza 2
5160 Wiley Post Way
Salt Lake City, Utah 84116
(801) 532-2520

MAY 1986

B[illegible]GHAM ENGINEERING
100 Lindbergh Plaza 2, 5160 Wiley Post Way, Salt Lake City, Utah 84116, 801-532-2520

WAILUA RIVER HYDROPOWER

KAUAI, HAWAII

FINAL

ENVIRONMENTAL IMPACT STATMENT

Bingham Engineering wishes to acknowledge
State of Hawaii and Federal Agencies in
particularly appreciative for the permission
Corps of Engineers, Honolulu District to u
their "Final Interim Survey Report and Envir
"Wailua River Hydropower, Kauai, Hawaii dat

MAY, 1986

BINGHAM ENGINEERING
100 Lindbergh Plaza 2, 5160 Wiley Post Way, Salt Lake City, Utah 84116, 801-532-2520

WAILUA RIVER HYDROPOWER

KAUAI, HAWAII

FINAL

ENVIRONMENTAL IMPACT STATMENT

Bingham Engineering wishes to acknowledge the cooperation and help of State of Hawaii and Federal Agencies in preparing this report and is particularly appreciative for the permission granted by the U.S. Army Corps of Engineers, Honolulu District to use information contained in their "Final Interim Survey Report and Environmental Statement" for the "Wailua River Hydropower, Kauai, Hawaii dated December 1982."

MAY, 1986

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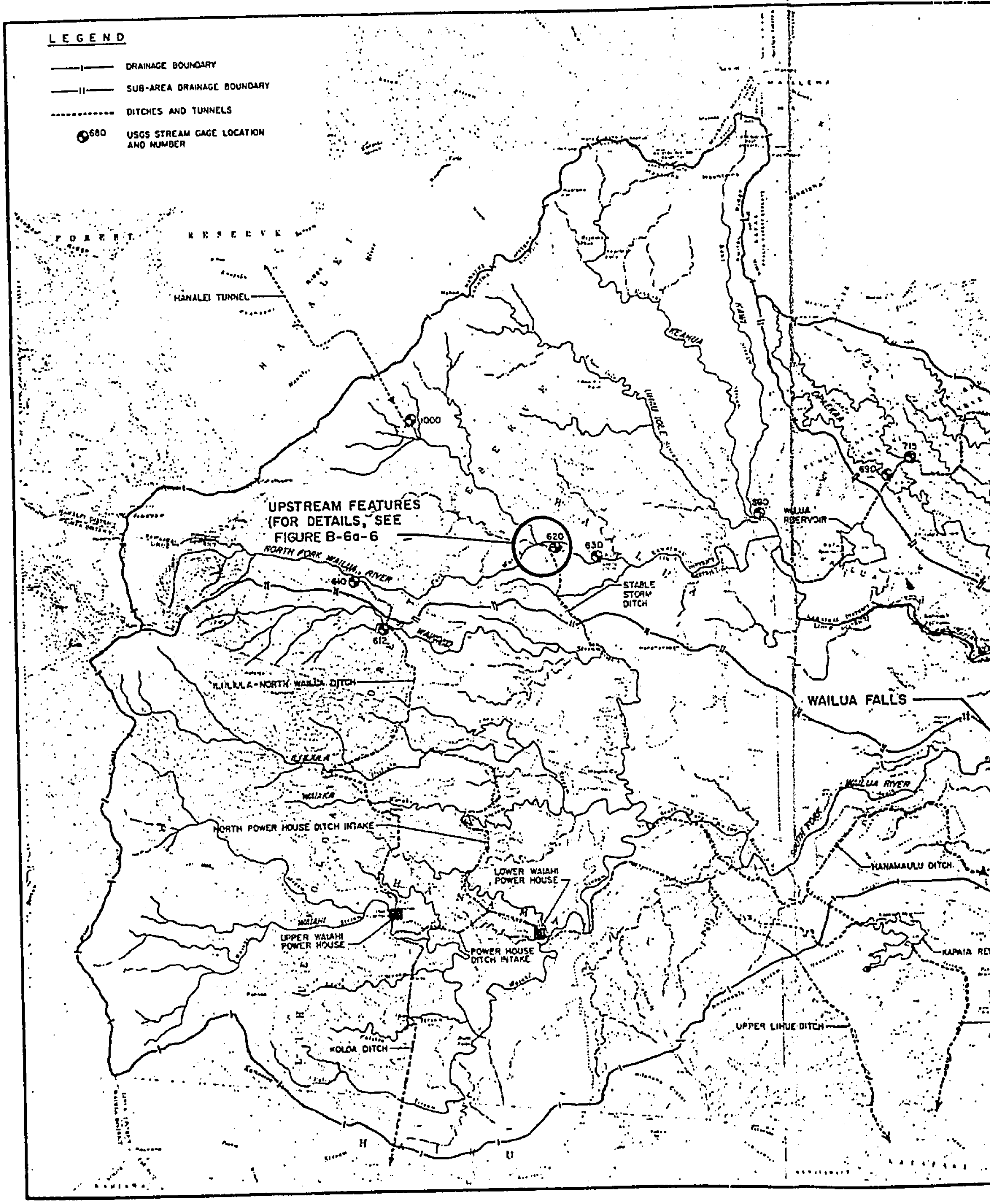
B. PROJECT DESCRIPTION

B-1 DETAILED MAPS


LEGEND
DRAINAGE BOUNDARY
SUB-AREA DRAINAGE BOUNDARY
DITCHES AND TUNNELS
680 USGS STREAM GAGE LOCATION AND NUMBER
FOREST RESERVE
HANALEI TUNNEL
1000
UPSTREAM FEATURES (FOR DETAILS, SEE FIGURE B-6a-6
620
630
NORTH FORK WAILUA RIVER
640
612
STABLE STORM DITCH
WAILUA RESERVOIR
715
690
ILIILIULA-NORTH WAILUA DITCH
WAILUA FALLS
WAILUA RIVER
SOUTH FORK
NORTH POWER HOUSE DITCH INTAKE
LOWER WAIAHI POWER HOUSE
UPPER WAIAHI POWER HOUSE
POWER HOUSE DITCH INTAKE
HANAMAULU DITCH
KOLOA DITCH
UPPER LIHUE DITCH
WAIAHI
WAIAKA
KEAHUA
KAWI
IWAIWA

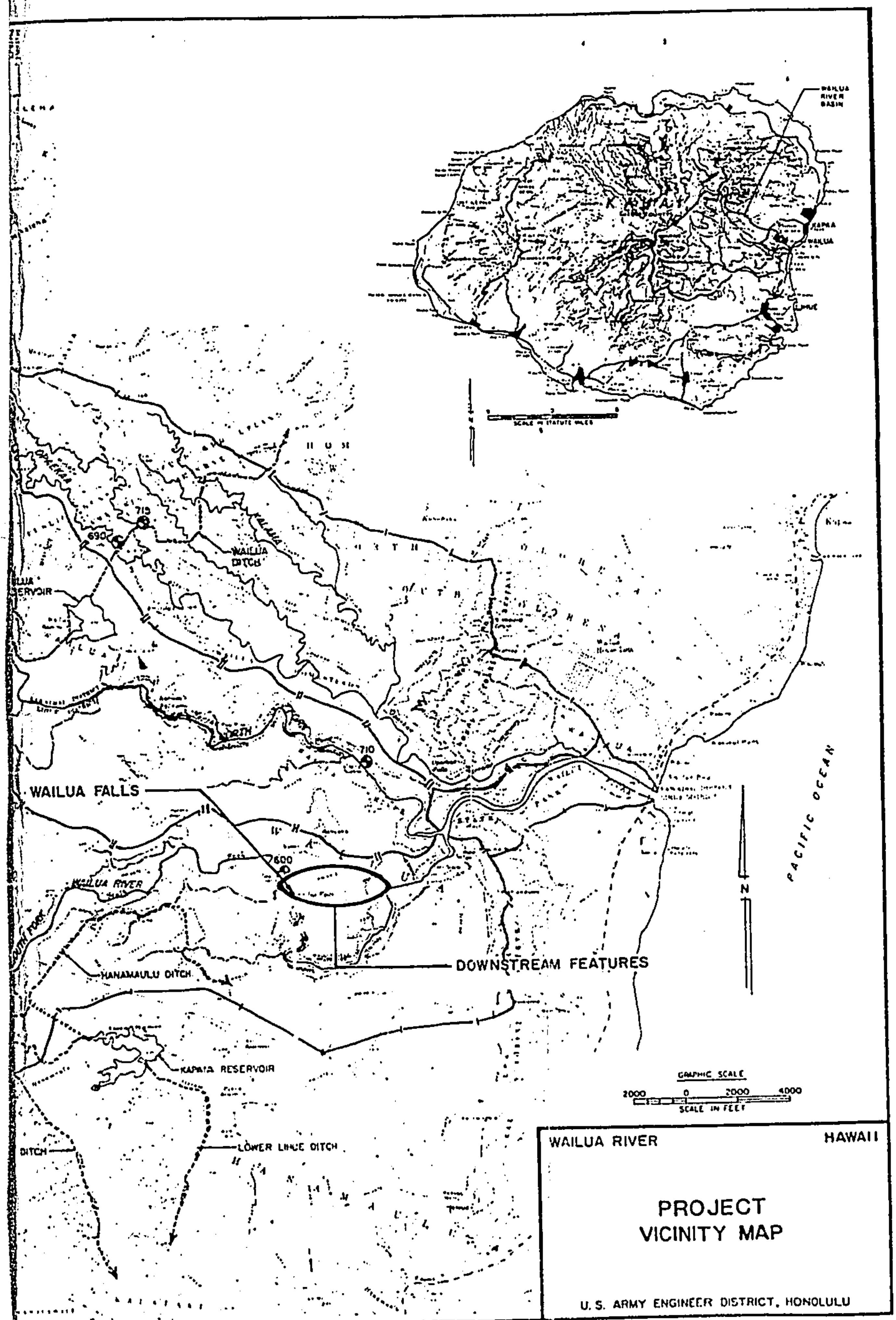
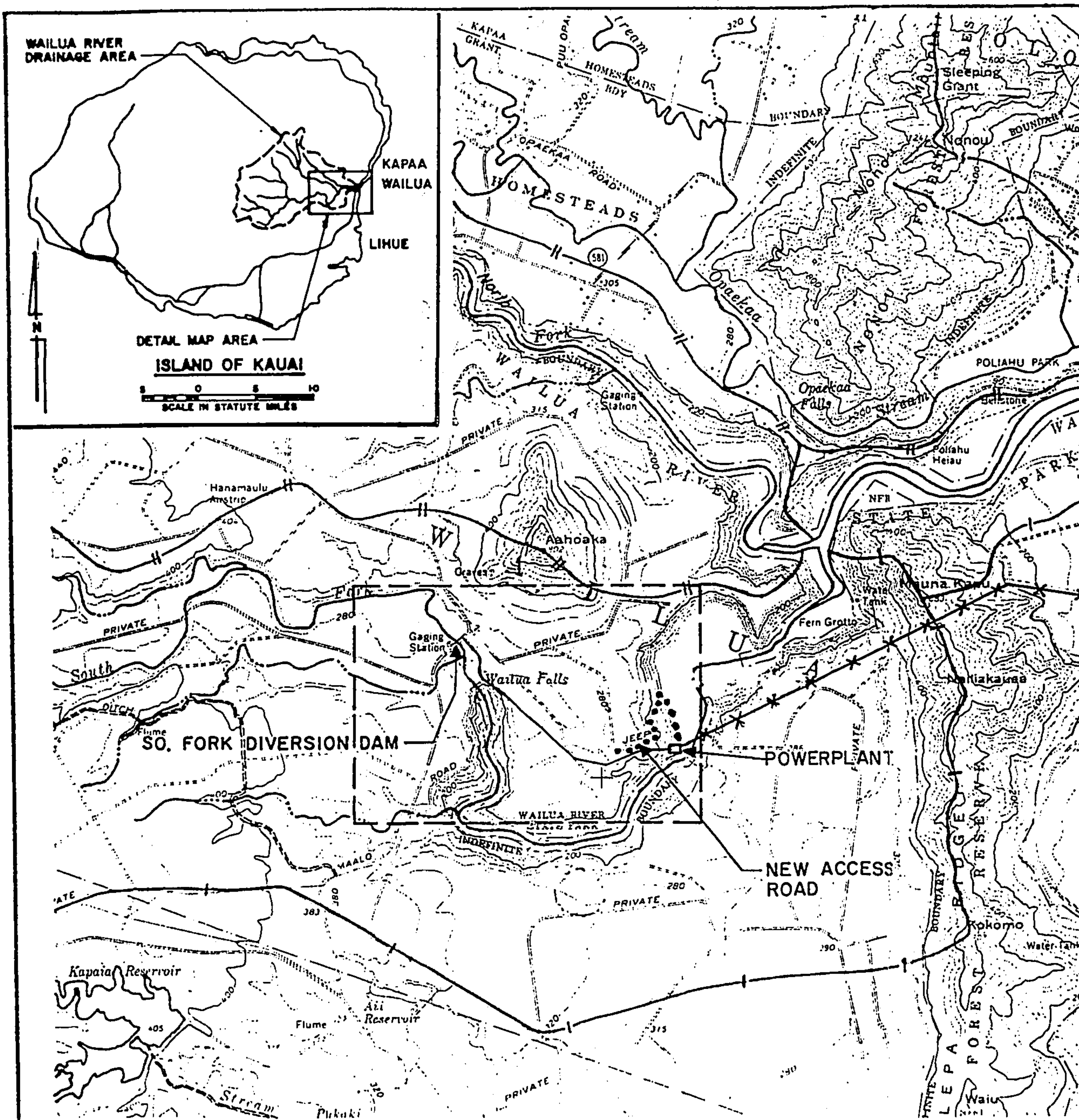
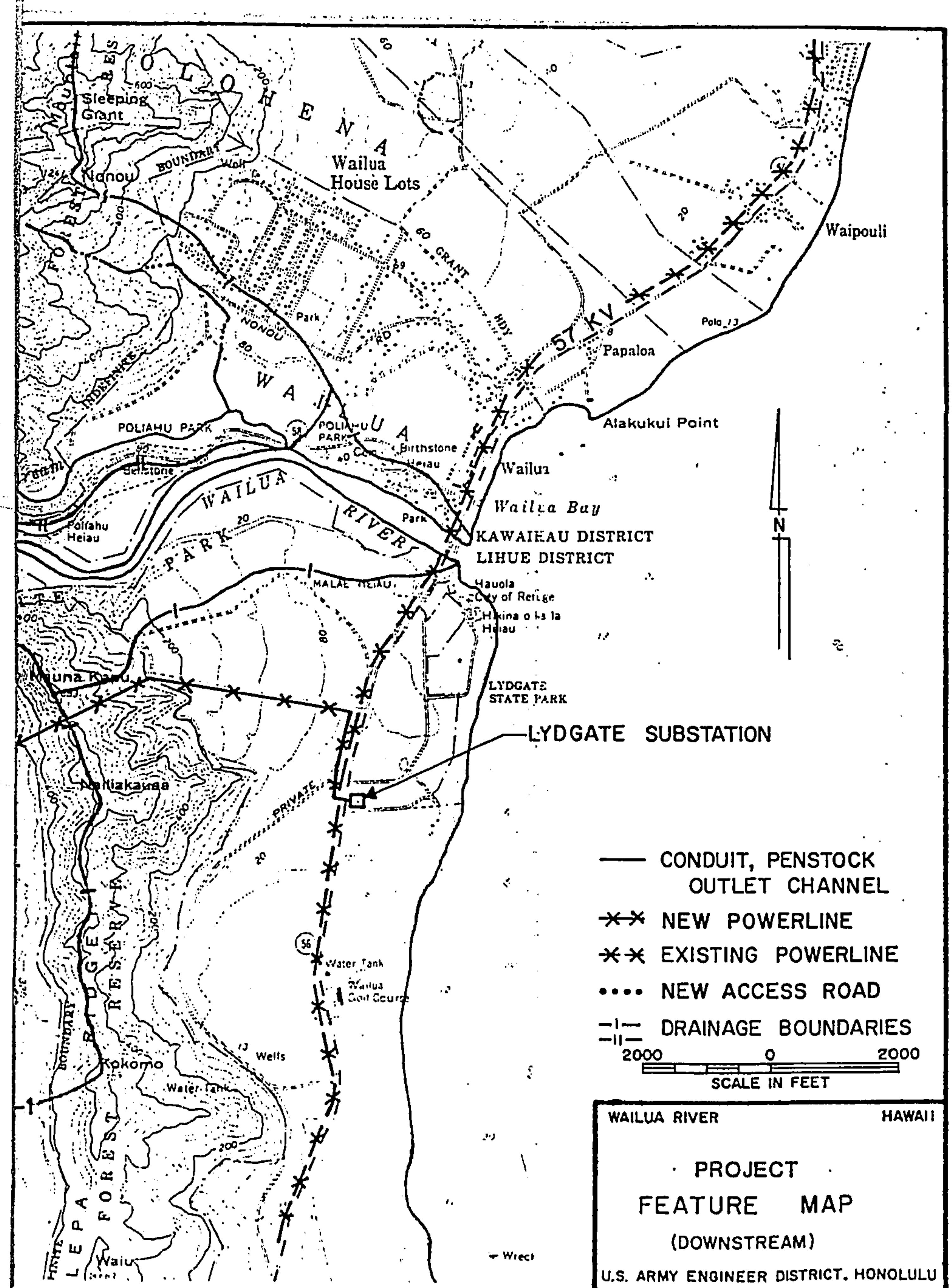

WAILUA FALLS
DOWNSTREAM FEATURES
WAILUA DITCH
WAILUA RIVER
HANAMAULU DITCH
KAPAIA RESERVOIR
LOWER LIHUE DITCH
DITCH
PACIFIC OCEAN
719
690
710
600
N
GRAPHIC SCALE
2000 0 2000 4000
SCALE IN FEET
WAILUA RIVER
HAWAII
PROJECT
VICINITY MAP
U. S. ARMY ENGINEER DISTRICT, HONOLULU

FIGURE B-1a



WAILUA RIVER DRAINAGE AREA
KAPAA
WAILUA
LIHUE
DETAIL MAP AREA
ISLAND OF KAUAI
SCALE IN STATUTE MILES
SO. FORK DIVERSION DAM
POWERPLANT
NEW ACCESS ROAD
Wailua Falls
Gaging Station
Fern Grotto
Opaekaa Falls
Kapaia Reservoir
Hanamaulu
Aahoaka
Sleeping Grant
Nonou
HOMESTEADS
WAILUA RIVER
POLIAHU PARK
Poliahu Heiau
Kokomo
Flume
PRIVATE
BOUNDARY
INDEFINITE



Sleeping Giant
Nonou
Wailua House Lots
Waipouli
57 KV
Papaloa
Alakukui Point
POLIAHU PARK
Birthstone Heiau
Bellstone
Wailua
Wailua Bay
WAILUA RIVER
PARK
KAWAIKAU DISTRICT
LIHUE DISTRICT
MALAE HEIAU
Hauola City of Refuge
Hikina o ka la Heiau
LYDGATE STATE PARK
LYDGATE SUBSTATION
Mauna Kapu
Kalliakaua
PRIVATE
Water Tank
Wailua Golf Course
Wells
Kokomo
Water Tank
LEPA FOREST RESERVE
Waiu
N
CONDUIT, PENSTOCK OUTLET CHANNEL
NEW POWERLINE
EXISTING POWERLINE
NEW ACCESS ROAD
DRAINAGE BOUNDARIES
2000 0 2000
SCALE IN FEET
WAILUA RIVER
HAWAII
PROJECT FEATURE MAP
(DOWNSTREAM)
U.S. ARMY ENGINEER DISTRICT, HONOLULU

FIGURE B-1b

B-2 STATEMENT OF OBJECTIVES

B-2a PURPOSE

The purpose of this study is to establish the environmental and financial feasibility of a potential hydroelectric power facility for the Wailua River Basin, Island of Kauai, State of Hawaii.

B-2b NEED

The Wailua River Hydroelectric Project was originally proposed for construction by the U.S. Army Corps of Engineers, Honolulu District. Due to public and local utility interest, on April 9, 1980, the State of Hawaii, Department of Land and Natural Resources requested the Corps of Engineers to study the feasibility of a hydroelectric facility on the Wailua River Basin, Island of Kauai, Hawaii. A subsequent study was thoroughly carried out by the Corps following National Environmental Policy Act (NEPA) Guidelines in which many public meetings were held and local agency response was gathered. The general consensus of the public and commenting agencies was overwhelmingly in favor of constructing the project. The project was also adopted as part of the plan for the future development for the County of Kauai. On June 1, 1983, the Corps of Engineers published their revised Final Interim Survey Report and Environmental Statement which concluded that the Wailua River Hydroelectric Project was economically and environmentally feasible. The Corps of Engineers also recommended that Congress appropriate $12.3 million to fund construction of the project which would produce 13.8 million killowatt hours of electricity annually. President Reagan later denied appropriation to fund the Wailua River Hydroelectric Project and others like it, in favor of development by private enterprise.

Unlike many new energy developments, the techonology of hydropower has been firmly established. Over the past decade, hydropower as a renewable energy resource has rekindled interest for its role in alternative energy development nationally and in the State of Hawaii. The Island of Kauai, similar to most insular areas, is highly dependent upon petroleum-based fuels for the production of electricity. This condition has led to relatively high costs of energy production and reliance on a potentially volatile worldwide fuel market. The goal is to alleviate oil dependence in energy production and greater energy self-sufficiency for the Island of Kauai.

The economic aspects of the project are significant and beneficial. The benefits are derived solely from displacement of energy from Kauai Electric's system assuming fuel price escalation and power-on-line effective date of 1987. The project would contribute significantly toward the goals of alleviation of oil dependence and increased energy self-sufficiency. The Wailua River Hydroelectric Project as currently proposed will cost $9 million to construct and would produce approximately 17.5 million kilowatt hours of electricity per year or about 9% of the total energy consumed on the Island of Kauai. The Project would supplant the need to import 36,000 barrels of oil annually and service an equivalent of 3,300 households or 10,600 individuals, assuming the current rates of fuel oil utilization and household demands are maintained.

CORRECTION

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

B-2 STATEMENT OF OBJECTIVES

RECEIVED AS FOLLOWS

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B-3 GENERAL DESCRIPTION OF THE ACTION'S TECHNICAL, ECONOMIC, SOCIAL AND ENVIRONMENTAL CHARACTERISTICS

B-3a TECHNICAL

Island Power Company, Inc. proposes to construct and operate a hydroelectric powerplant on the South Fork of the Wailua River, Island of Kauai, State of Hawaii. The project will cost approximately $9 million dollars to construct and will generate about 17 million kilowatt hours of electricity per year. The powerplant will have a maximum generating capacity of approximately 6,600 kilowatts with a maximum hydraulic capacity of 365 cubic feet per second ("cfs").

The proposed project will utilize stream flows from the North Fork and the South Fork of the Wailua River to generate hydroelectric power. Water will be diverted from the North Fork into the South Fork by using the existing Stable Storm Ditch diversion and canal system operated by Lihue Plantation Company, Ltd. Some modifications will be made to the existing diversion structure on the North Fork of the Wailua River to facilitate the diversion of flows up to 100 cfs into the Stable Storm Ditch. No modifications will be made to the Stable Storm Ditch.

Water from the Stable Storm Ditch will then flow into the South Fork of the Wailua River.

A new diversion weir will be constructed on the South Fork of the Wailua River approximately 4.5 river miles downstream from the confluence with the Stable Storm Ditch and approximately 1000 feet upstream from Wailua Falls. The intake structure will be screened to prevent entrainment of fish. Screening criteria will be established in conjunction with the U.S. Fish & Wildlife Service and the Department of Land & Natural Resources. A buried pipeline varying in diameter from 96 inches to 84 inches and approximately 4,950 feet long will convey the water from the new diversion weir to a powerhouse approximately 1.5 river miles downstream from Wailua Falls. The flow will then be discharged from the powerhouse and return to the natural channel of the South Fork of the Wailua River.

In order to maintain the historic and existing diversion practices of Lihue Plantation Company, no new provisions will be added for any minimum bypass flows at the Stable Storm Ditch diversion. However, flows in excess of 100 cfs will bypass this diversion and will remain in the North Fork of the Wailua River. A minimum flow of 9,700,560 gallons per day or 15 cfs will bypass the new diversion weir on the South Fork of the Wailua River to preserve the existing aquatic resources and to preserve the visual characteristics of Wailua Falls. When flows in the South Fork become less than 45 cfs, they will bypass the new diversion weir and flow down the natural channel over Wailua Falls. All flows in excess of 380 cfs will also bypass the new weir. Although flows of 15 cfs or less occur frequently in the South Fork of the Wailua River, the proposed project will decrease the frequency of flows in this range. However, the proposed project will increase the frequency of flows in the range of 15-45 cfs.

A new transmission line approximately 2.2 miles in length will be constructed to interconnect the project with Kauai Electric at the existing Lydgate Substation. The project power will be sold to Kauai Electric which will then be distributed to their customers.

B-3b ECONOMIC

The economic aspects of the project are significant and beneficial. The benefits are derived solely from displacement of Kauai Electric's system energy and assume fuel price escalation and a power-on-line effective date of 1987. The project would contribute significantly toward the goals of the alleviation of oil dependence and increased energy self-sufficiency. The hydroelectric facility would supplant the need to import 36,000 barrels of oil annually and service an equivalent of 3,300 households or 10,600 individuals, assuming the current rates of fuel oil utilization and household demands are maintained.

There will be an increase in employment opportunities for local laborers and construction companies as a result of the construction of the proposed project. Local suppliers will also be used for concrete, backfill materials and other major components of the project.

The project will cost $9 million to construct, which includes all direct and indirect construction costs, easements and rights-of-way, land and agricultural damages, and interest during construction. Operation and maintenance of the project will also involve local personnel.

The following list is an itemization of the total project costs.

COST ESTIMATES

BASIS FOR COST ESTIMATES

Construction Cost. The basic assumptions for the construction cost estimates were as follows:

a. The contractor and labor would be Kauai, Hawaii based. Labor would be performed on 6-8 hours shifts per week.

b. Construction period would be 12 months.

c. Escalation to mid-point of construction was included. Annual construction inflation would be 9 percent. Contingencies are 20 percent. However, for turbine/generator and related electrical/mechanical items, based on manufacturer's bid prices, contingencies are 10 percent. Transmission line contingencies are 15 percent.

d. Excavation below elevation 255.0 feet msl would require blasting for rock removal. Material above 255.0 feet msl would be composed of loose soil and cobbles with 15% boulders.

e. Mechanical and electrical equipment would be from continental United States. Installation labor from the mainland would be required for turbine-generator features. Itemized costs include delivery costs to site.

f. Suitable temporary diversions will be constructed at Stable Storm Ditch and South Fork Wailua for construction.

g. Price level for all work is July, 1986.

Indirect Costs. Indirect costs include technical and administrative costs associated with the design and construction of the project.

a. Engineering and Design. These indirect costs would be for engineering efforts in the preparation of design memoranda; construction plans and specifications; and engineering during construction. All associated overhead amounts are included in the Engineering and Design totals.

b. Supervision and Administration. The construction contract would include contract administration and field inspection. Associated overhead amounts are included in the total.

c. Right-of-Way Indirect Costs. Indirect costs included the management of construction rights-of-way, easements and inter-agency coordination during construction.

Easements. The costs required to acquire construction rights-of-way would be borne by the developer. These costs included purchase of lands in fee and compensation for damages to agricultural lands to private interests. Lands under ownership by the State of Hawaii will be leased on a fair market value basis.

Operational and Maintenance and Replacement Costs. These costs are annual costs required to keep all facilities in good working condition and repair.

Interest During Construction (IDC). Interest during construction accounts for the capital incurred during the construction period. The computed amount is to be included in the total project investment cost and forms a portion of the average annual costs. The turbine-generator procurement process is normally an independent contract. Hence, construction inflation was computed on the basis of 12 months and IDC was computed on the basis of 12 months.

Table B-3b-1 Cost Estimate

	Quantity	Unit	Unit Cost	Total Cost, $
Construction				
DIRECT CONSTRUCTION COSTS				
Civil Features				
Access Road		LS	25,000	25,000
Contingency 20%				5,000
Subtotal				30,000
Stable Storm Ditch Structure				
Dewatering		LS		5,000
Culvert & Structure		LS		45,000
Contingencies 20%				10,000
Subtotal				60,000
Diversion Dam				
Excavation	3,500	CY	10	35,000
Dewatering		LS		10,000
Concrete Dam	3,000	CY	150	450,000
Contingencies 20%				99,000
Subtotal				594,000
Intake Structure				
Excavation & Backfill	250	CY	20	5,000
Structure	150	CY	300	45,000
Trash Rack	250	SF	40	10,000
Sluice Gate	1	EA	10,000	10,000
Contingencies 20%				14,000
Subtotal				84,000
Penstock Gate				
Transitions & Vent	2	EA	3,000	6,000
6' x 8' Sluice Gate	1	EA	40,000	40,000
Vault	1	EA	4,000	4,000
Contingencies 20%				10,000
Subtotal				60,000
Penstock				
Earth Excavation & Backfill	140,000	CY	8.00	1,120,000
Rock Excavation	2,000	CY	15.00	30,000
SR Steel 96"-inch	4,286	LF	182	780,000
Smooth Steel 84"	600	LF	200	120,000
Bifurcation		LS		80,000
Contingencies 20%				426,000
Subtotal				2,556,000
Tailrace				
Open Channel	2,000	CY	12.50	25,000
Riprap	500	CY	20	10,000
Contingencies 20%				7,000
Subtotal				42,000
TOTAL CIVIL FEATURES				3,426,000

Table B-3b-1 Cost Estimate (Cont)

	Quantity	Unit	Unit Cost	Total Cost,$
Power Plant Features				
Powerhouse		LS		295,000
Dewatering & Drainage				5,000
Contingencies 20%				60,000
Subtotal				360,000
Turbines & Generators				
Turbines & Generators				
Excitation Equipment				
Switchgear, Breakers & Buses				
Station Service Unit				
Control System				
Misc. Electrical Equipment				
Heating & Ventilating				
Station, Brake & Governor Air				
Misc. Mechanical Systems				
Power Transformer				
Disconnects & Electrical Equipment				
				2,800,000
Contingencies 10%				280,000
Subtotal				3,080,000
Transmission				
Transmission Line 12 kv	2.3	MI	100,000	230,000
Interconnection		L.S.		182,000
Subtotal				412,000
TOTAL POWER PLANT FEATURES				3,852,000
TOTAL DIRECT CONSTRUCTION COSTS				7,278,000
INDIRECT CONSTRUCTION COSTS				
Engineering & Design				561,000
Supervision & Administration				561,000
TOTAL INDIRECT COST				1,122,000
TOTAL CONSTRUCTION COSTS				8,400,000

Table B-3b-1 Cost Estimate (Cont)

	Quantity	Unit	Unit Cost	Total Cost, $
LANDS AND DAMAGES				
LANDS, EASEMENTS & RIGHTS-OF-WAY				
Damages to Agricultural Lands	5.0	AC	8,000	40,000
State Lease	5.5	AC	10,000	55,000
Misc. Acquisitions		LS		55,000
Contingencies 10%				15,000
Subtotal				165,000
TOTAL LAND COSTS				165,000
TOTAL FIRST COSTS				8,563,000

Table B-3b-1 Cost Estimate (Cont)

SUMMARY OF PROJECT INVESTMENT COSTS

Item	
CONSTRUCTION	
Direct Construction Costs	7,278,000
Indirect Costs	1,122,000
Subtotal	8,400,000
LANDS AND DAMAGES	
Lands, Easements & Rights-of-Way	165,000
TOTAL FIRST COSTS	8,565,000
INTEREST DURING CONSTRUCTION	435,000
TOTAL PROJECT INVESTMENT COST	9,000,000

B-3c SOCIAL

All of the project's components are physically located far from population centers, and in fact would displace no people, or individual businesses or farms. No changes in existing income, employment or population distribution or composition are anticipated as a result of implementing the project. The quality of community life will be affected, but the nature of that quality is believed to be related to recreational activities and aesthetic perception more than any other factors. There are few life, health and safety considerations. The likelihood of dam failure with resultant flash floods is miniscule both because of the design of the diversion structure (designed up to the Probable Maximum Flood) and because of the comparatively small amount of water impounded behind the barrier. There are some safety elements involved in provision of new access to the stream and creation of an enlarged pool above the Falls, but these will not be significant.

Major portions of the Project lie almost entirely within Wailua River State Park which has 1,113 acres of outstanding scenic, natural, historical and recreational resources. The State Park was established by the Territory of Hawaii in 1954 with a focus on Fern Grotto and the Wailuanuiho'ainana, a complex of heiau and kapu areas and habitation areas alongside the river estuary. Fern Grotto is the principal visitor attraction. The present park has long-range plans to expand to about 1,700 acres. Development and expansion of the Park is governed by the Wailua River State Park plan prepared for the State in 1970. Almost none of the many recommended components of the plan relating to recreation, circulation or landscaping have yet been implemented, but State Park officials report that the 1970 plan still remains the only planning guideline for the area. Between 1965 and 1969, Wailua River State Park accounted for almost 20 percent of all state parks and historic site attendance. State Department of Land and Natural Resources statistics for the fiscal year ending June 30, 1981, show this percentage increasing to over 30 percent, or about 4,532,000 visits. Sixty-five percent of the visits were made to areas excluding Fern Grotto and Lydgate Beach Park. In 1970, it was estimated that only about 50 percent of the park visitors were from out-of-state.

The proposed project features would in some cases conflict with the recommended park facilities and in other cases would complement them. Creation of an enlarged slack-water pool of almost 35.0 acres above the Falls could conflict with the siting of the proposed horse stables near there. In any case, it would be inappropriate to site a horse stable so close to a body of water that could be used for swimming or fishing. There is a possibility that the new impoundment may enhance the existing smallmouth bass fishery.

B-3d Environmental

The majority of the effects are related to construction impacts. The significant considerations would be the aesthetic diminution of Wailua Falls resulting from the increased flow frequency of low flows. The social acceptability of a new man-made structure at or near a largely undeveloped site may also be a public concern. There are no endangered or threatened species affected in the project site. Also, there are no listed or nominated sites on the Historical Register of Historic Sites which would be disturbed from construction activities. There would be diminution of flows on the North Fork Wailua River. Related to this impact is the existence of a smallmouth bass fishery on the North Fork Wailua River. There is expected to be some impact on the habitat.

The Project would result in temporary increases in turbidity, both in the immediate project area and downstream during project construction. Concurrent temporary increases in sedimentation of stream habitat below the falls could alter composition of the aquatic community in the affected area. The diversion dam would increase the area of the pool behind the Falls to approximately 35.0 acres, creating a smallmouth bass habitat. Approximately 5.0 acres of prime agricultural land would be disturbed during construction of the penstock from the diversion dam to the powerplant. The land would be restored to its previous state subsequent to completion of the Project.

B-4 USE OF PUBLIC FUNDS OR LANDS FOR THIS ACTION

B-4a FUNDS

The use of public funds are not anticipated for the proposed hydroelectric facility. The use of state bonding to finance the Wailua Project would be the most favorable for the developer and could greatly enhance the economic viability of the Project. The developer is in the process of applying to the State of Hawaii to seek approval for a bond issue.

If bonding cannot be used for the Project, a private lending institution would likely be used to supply the long-term financing. The equity portion of the financing would come from private sources.

B-4b LANDS

The majority of the lands needed for the Project are owned by the State of Hawaii. No federally owned properties will be needed for the Project.

The lands needed for the proposed project are summarized in Tables B-4-1 and B-4-2. Figures B-4-3 and B-4-4 illustrate the proposed project features with relationship to the required lands.

TABLE B-4-1

WAILUA RIVER HYDROELECTRIC PROJECT

ACREAGE NEEDED FOR PROJECT COMPONENTS

DIVERSION STRUCTURE

A 600 ft x 100 ft easement will be needed for the diversion structure and associated equipment.

ZONE	SECTION	PLAT	PARCEL	OWNER	LEASEE	ACREAGE
3	9	02	31	State	Lihue Plantation	0.2
3	9	02	1	State	Lihue Plantation	1.0
3	9	02	20	State	Lihue Plantation	0.2
					TOTAL ACREAGE	1.4 Acres

DIVERSION IMPOUNDMENT

A 35.0 acre easement will be needed within the existing flood plain of the South Fork Wailua River for the maximum pool elevation of 274.5 MSL. It is proposed that this pool be managed primarily as an endangered Hawaiian water bird habitat area in coordination with the State of Hawaii Division of Forestry, Division of Wildlife and the U.S. Fish and Wildlife Service.

ZONE	SECTION	PLAT	PARCEL	OWNER	LEASEE	ACREAGE
3	9	02	31	State		15.0
3	9	02	1	State	Lihue Plantation	13.0
3	9	02	20	State	Lihue Plantation	7.0
					TOTAL ACREAGE	35.0 Acres

TABLE B-4-1 (Cont.)

PENSTOCK

A 50-foot wide easement, 25 feet either side of centerline, approximately 4,950 feet long, running from the diversion structure to the powerhouse will be needed for the penstock.

ZONE	SECTION	PLAT	PARCEL	OWNER	LEASEE	ACREAGE
3	9	02	1	State	Lihue Plantation	1.1
3	9	02	33	State		0.6
3	9	02	1	State	Lihue Plantation	2.6
3	9	02	33	State		1.4
					TOTAL ACREAGE	5.7

POWERHOUSE

A 208.71-foot by 208.71-foot easement will be needed for the powerhouse and associated features.

ZONE	SECTION	PLAT	PARCEL	OWNER	LEASEE	ACREAGE
3	9	03	9	B.P. Bishop	O. Thronas	1.0
					TOTAL ACREAGE	1.0

TAILRACE

A 75-foot by 150-foot easement will be needed for the tailrace and associated features.

ZONE	SECTION	PLAT	PARCEL	OWNER	LEASEE	ACREAGE
3	9	03	9	B.P. Bishop	O. Thronas	0.4
					TOTAL ACREAGE	0.4

TABLE B-4-1 (Cont.)

TRANSMISSION LINE

A 50-foot wide easement, 25 feet either side of centerline, approximately 2.2 miles long, running from the powerhouse to the existing Lydgate Substation will be needed for the transmission line.

ZONE	SECTION	PLAT	PARCEL	OWNER	LEASEE	ACREAGE
3	9	02	21	State		0.6
3	9	02	33	State		0.6
3	9	02	20	State	Lihue Plantation	4.0
3	9	02	14	State		3.2
3	9	02	12	State	Lihue Plantation	4.9
					TOTAL ACREAGE	13.3

ACCESS ROADS

No new access roads will be needed for the project. However, use of the existing haul cane road leading from state road 583 to the project will be required. Some modification of the access road located in TMK 3-9-02, Parcel 33, owned by the State of Hawaii may be needed.

STABLE STORM DIVERSION

No new easements will be necessary for this portion of the project. Use of the existing access located in TMK 3-9-01, Parcel 1, will be needed to make modifications of the existing diversion structure and for long-term operation and maintenance purposes.

TABLE B-4-2

SUMMARY OF LANDS NEEDED FOR PROJECT

The following easements are needed for the proposed project and are summarized as follows:

STATE OF HAWAII:

Lands owned by the State of Hawaii which are currently leased for agricultural use by Lihue Plantation Company, Ltd.

PROJECT FEATURE	ZONE	SECTION	PLAT	PARCEL	ACREAGE
Diversion Structure (100' x 83')	3	9	02	20	0.2
Diversion Structure (100' x 433')	3	9	02	1	1.0
				SUBTOTAL	1.2 Acres
Diversion Impoundment	3	9	02	20	7.0
Diversion Impoundment	3	9	02	1	13.0
				SUBTOTAL	20.0 Acres
Penstock (Sta 0 + 00 — 9 + 53)	3	9	02	1	1.1
Penstock (Sta 14 + 72 — 37 + 32)	3	9	02	1	2.6
				SUBTOTAL	3.7 Acres
Transmission Line (50' x 3,485')	3	9	02	20	4.0
Transmission Line (50' x 4,300')	3	9	02	12	4.9
				SUBTOTAL	8.9 Acres
				TOTAL ACREAGE	33.8 Acres

TABLE B-4-2 (Cont.)

STATE OF HAWAII:

Lands owned by the State of Hawaii which are within the existing channel of the South Fork of the Wailua River, which are not used for agricultural purposes and are not within "Conservation District" or "State Park System" boundaries.

PROJECT FEATURE	ZONE	SECTION	PLAT	PARCEL	ACREAGE
Diversion Structure	3	9	02	31	0.2
			SUBTOTAL		0.2 Acres
Diversion Impoundment	3	9	02	31	15.0
			SUBTOTAL		15.0 Acres
			TOTAL ACREAGE		15.2 Acres

STATE OF HAWAII:

Lands owned by the State of Hawaii which are within the State Park System -- "Wailua River Reserve" boundaries.

PROJECT FEATURE	ZONE	SECTION	PLAT	PARCEL	ACREAGE
Transmission Line (50' x 520')	3	9	02	21	0.6
			SUBTOTAL		0.6 Acres
			TOTAL ACREAGE		0.6 Acres

TABLE B-4-2 (Cont.)

STATE OF HAWAII:

Lands owned by the State of Hawaii which are within "Conservation District" boundaries having a Resource (R) Subzone.

PROJECT FEATURE	ZONE	SECTION	PLAT	PARCEL	ACREAGE
Penstock (Sta 9 + 53 — 14 + 72)	3	9	02	33	0.6
Penstock (Sta 37 + 32 — 49 + 50)	3	9	02	33	1.4
			SUBTOTAL		2.0 Acres
Transmission Line (50' x 520')	3	9	02	21	0.6
			SUBTOTAL		0.6 Acres
			TOTAL ACREAGE		2.6 Acres

TABLE B-4-2 (Cont.)

STATE OF HAWAII:

Lands owned by the State of Hawaii which are within Kalepa Forest Reserve.

PROJECT FEATURE	ZONE	SECTION	PLAT	PARCEL	ACREAGE
Transmission Line (50' x 2,790')	3	9	02	14	3.2
				SUBTOTAL	3.2 Acres
				TOTAL ACREAGE	3.2 Acres

B.P. BISHOP

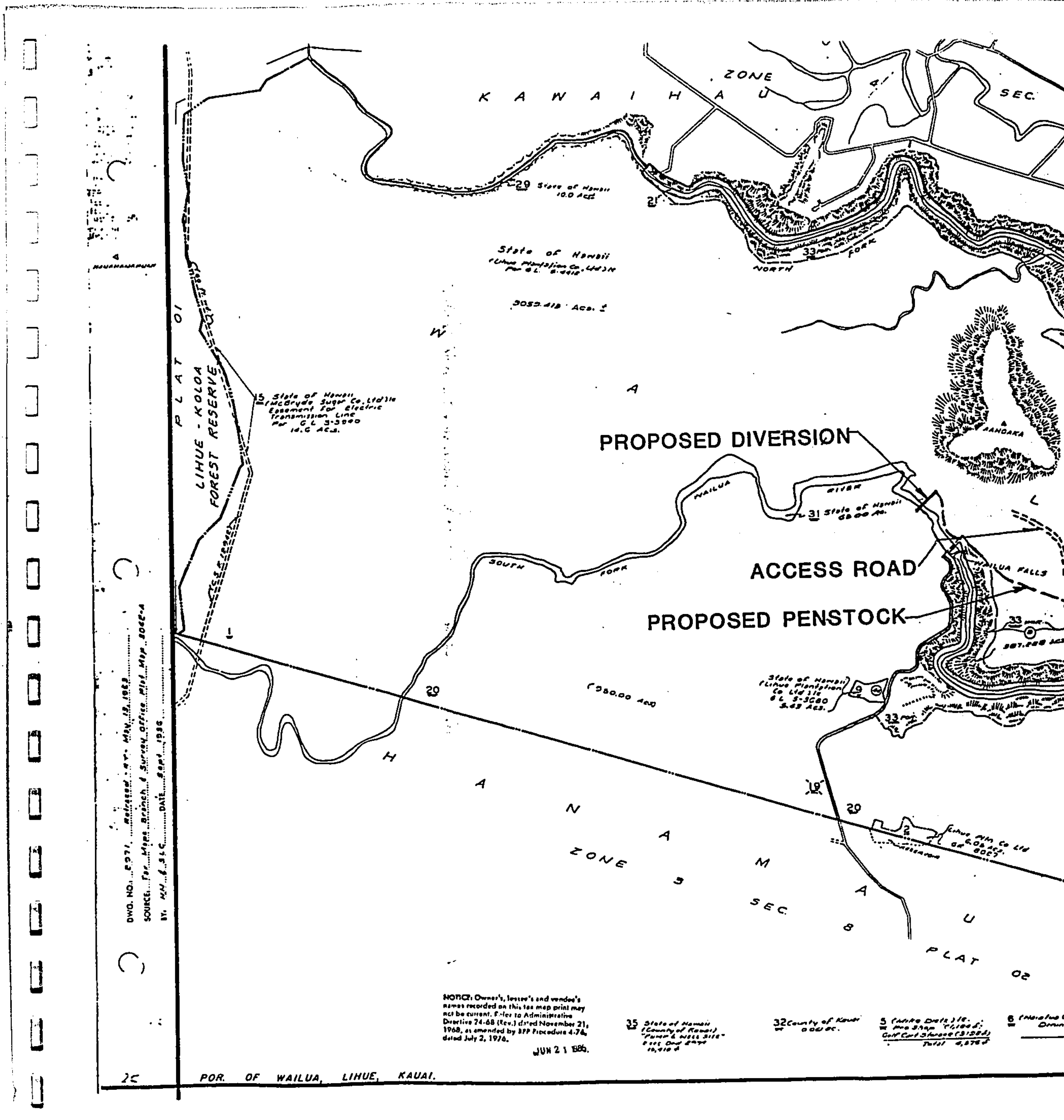
Lands owned by by B.P. Bishop which are currently leased for grazing purposes by O. Thronas.

PROJECT FEATURE	ZONE	SECTION	PLAT	PARCEL	ACREAGE
Powerhouse (208.71' x 208.71')	3	9	03	9	1.0
Tailrace (75' x 220')	3	9	03	9	0.4
				SUBTOTAL	1.4 Acres
				TOTAL ACREAGE	1.4 Acres

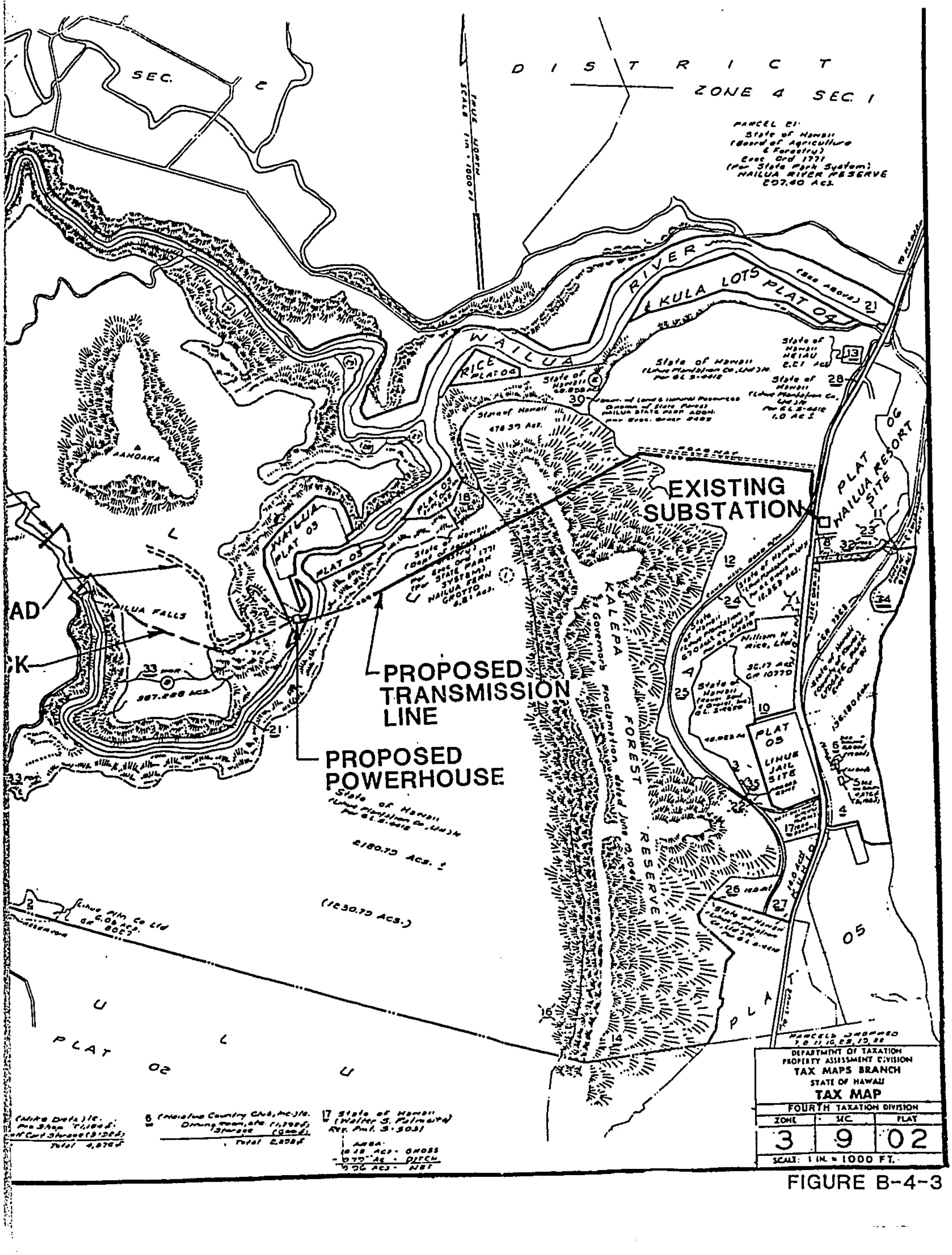
TABLE B-4-2 (Cont.)

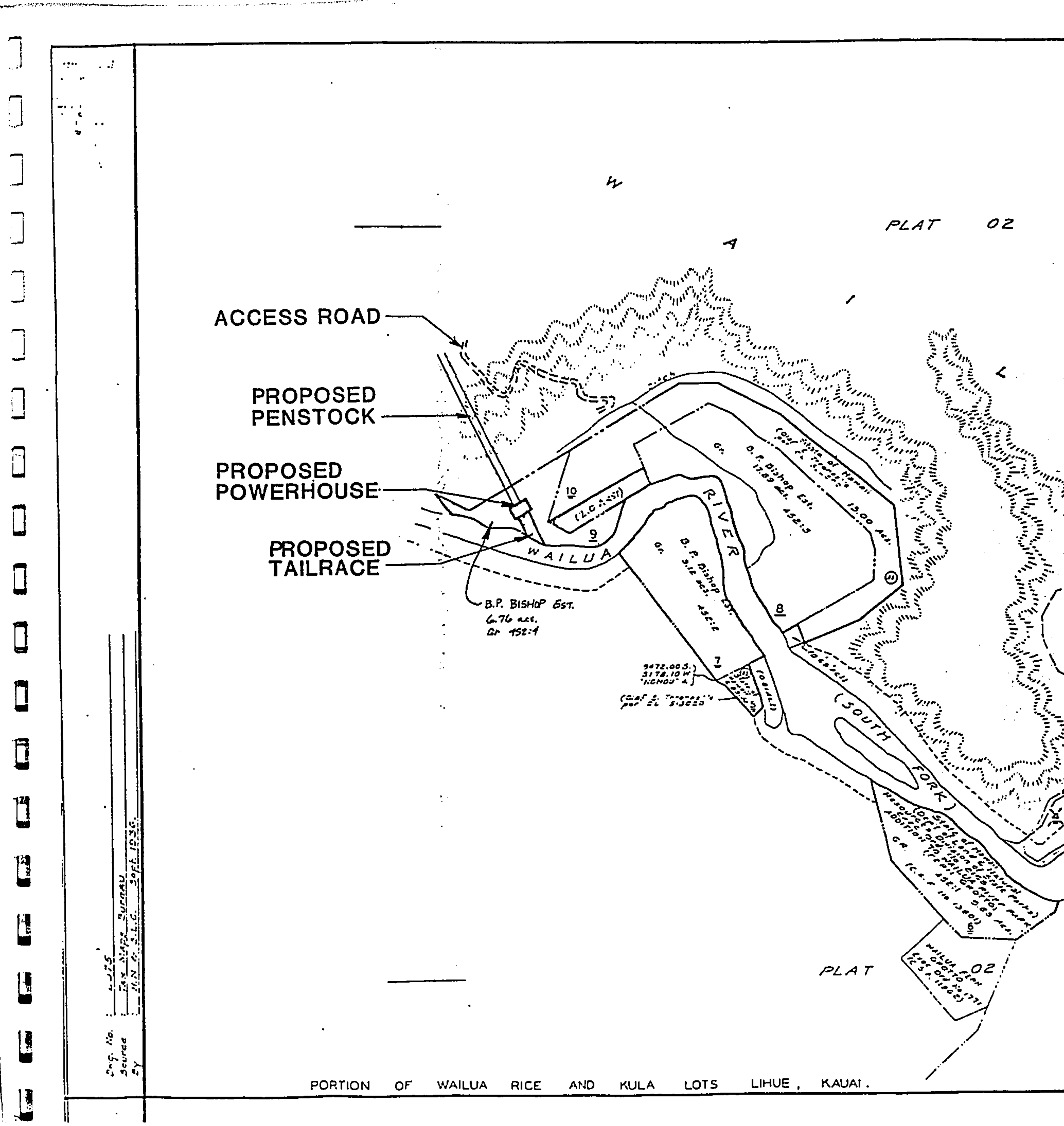
SUMMARY

OWNER	USE	ACREAGE
State of Hawaii	Agricultural Lands	33.8
State of Hawaii	Conservation Lands	2.6
State of Hawaii	Non-Specific Use Lands	15.2
State of Hawaii	State Park Lands	0.6
State of Hawaii	Kalepa Forest Lands	3.2
B.P. Bishop	Grazing Lands	1.4
	TOTAL ACREAGE	56.8



KAWAIHAU
ZONE
SEC.
PROPOSED DIVERSION
ACCESS ROAD
PROPOSED PENSTOCK
AAHOAKA
WAILUA FALLS
NORTH FORK
SOUTH FORK
WAILUA RIVER
LIHUE - KOLOA FOREST RESERVE
PLAT 01
HANAMAULU
ZONE 3 SEC. 8 PLAT 02
29 State of Hawaii 10.0 Acs.
State of Hawaii (Lihue Plantation Co. Ltd.) Por. G.L. S-4412
3053.419 Acs.
15 State of Hawaii (McBryde Sugar Co. Ltd.) Easement for electric transmission line Por. G.L. S-3940 14.6 Acs.
31 State of Hawaii 66.00 Ac.
State of Hawaii (Lihue Plantation Co. Ltd.) G.L. S-3680 3.43 Acs.
NOTICE: Owner's, lessee's and vendee's names recorded on this tax map print may not be current. Refer to Administrative Directive 74-68 (Rev.) dated November 21, 1968, as amended by BPP Procedure 4:74, dated July 2, 1976.
JUN 2 1 1986
POR. OF WAILUA, LIHUE, KAUAI.


DISTRICT
ZONE 4 SEC 1
SEC. 2
WAILUA RIVER
KULA LOTS PLAT 04
RICE PLAT 04
WAILUA PLAT 05
PLAT 03
PLAT 02
EXISTING SUBSTATION
PLAT 06 WAILUA RESORT SITE
PLAT 05 LIHUE JAIL SITE
PROPOSED TRANSMISSION LINE
PROPOSED POWERHOUSE
KALEPA FOREST RESERVE
WAILUA FALLS
AD
K
PLAT 02
PLAT 05
DEPARTMENT OF TAXATION
PROPERTY ASSESSMENT DIVISION
TAX MAPS BRANCH
STATE OF HAWAII
TAX MAP
FOURTH TAXATION DIVISION
ZONE SEC. PLAT
3 9 02
SCALE: 1 IN. = 1000 FT.
FIGURE B-4-3



PORTION OF WAILUA RICE AND KULA LOTS LIHUE, KAUAI.

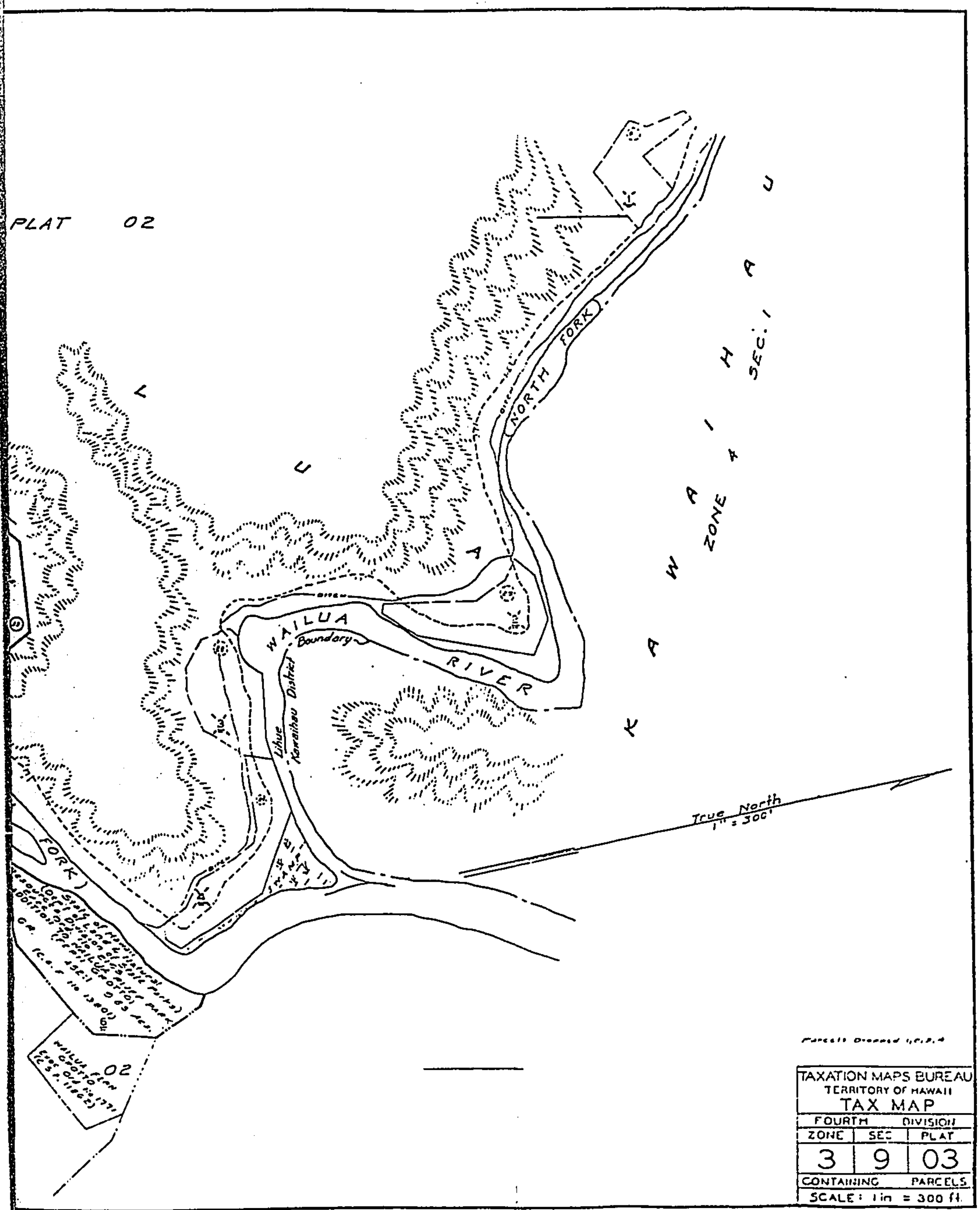

PLAT 02
L U A
KAWAIHAU
NORTH FORK
ZONE 4 SEC. 1
WAILUA RIVER
Boundary
Lihue Kawaihau District
FORK
02
True North
1" = 300'
TAXATION MAPS BUREAU
TERRITORY OF HAWAII
TAX MAP
FOURTH DIVISION
ZONE SEC PLAT
3 9 03
CONTAINING PARCELS
SCALE: 1 in = 300 ft.

FIGURE B-4-4

B-5 PHASING AND TIMING OF ACTION

B-5a DEVELOPMENT STEPS

The entire project, from initial planning to plant operation, is scheduled to proceed as follows:

1. Preliminary Planning -- This has been completed and is documented in this report.

2. Feasibility Study -- This phase includes preliminary engineering design, cost analysis, field studies, environmental analysis and applications for permits and approvals required to build the project. The products of this phase are a Feasibility Report, permit applications and an Environmental Impact Statement. This phase will conclude when the Final Environmental Impact Statement has been completed and the major required permits and approvals are obtained.

3. Design -- This phase includes preparing contract documents and specifications and ends when building and grading permits have been obtained and contracts are placed.

4. Financing -- This phase entails the completion of long-term financing agreements and the release of funds needed for construction of the Project.

5. Construction -- This phase involves the actual building of the Project. Plant operation marks the end of the construction phase.

The approximate schedule, by phase, for this project is depicted in Figure B-5-1.

PROJECT SCHEDULE

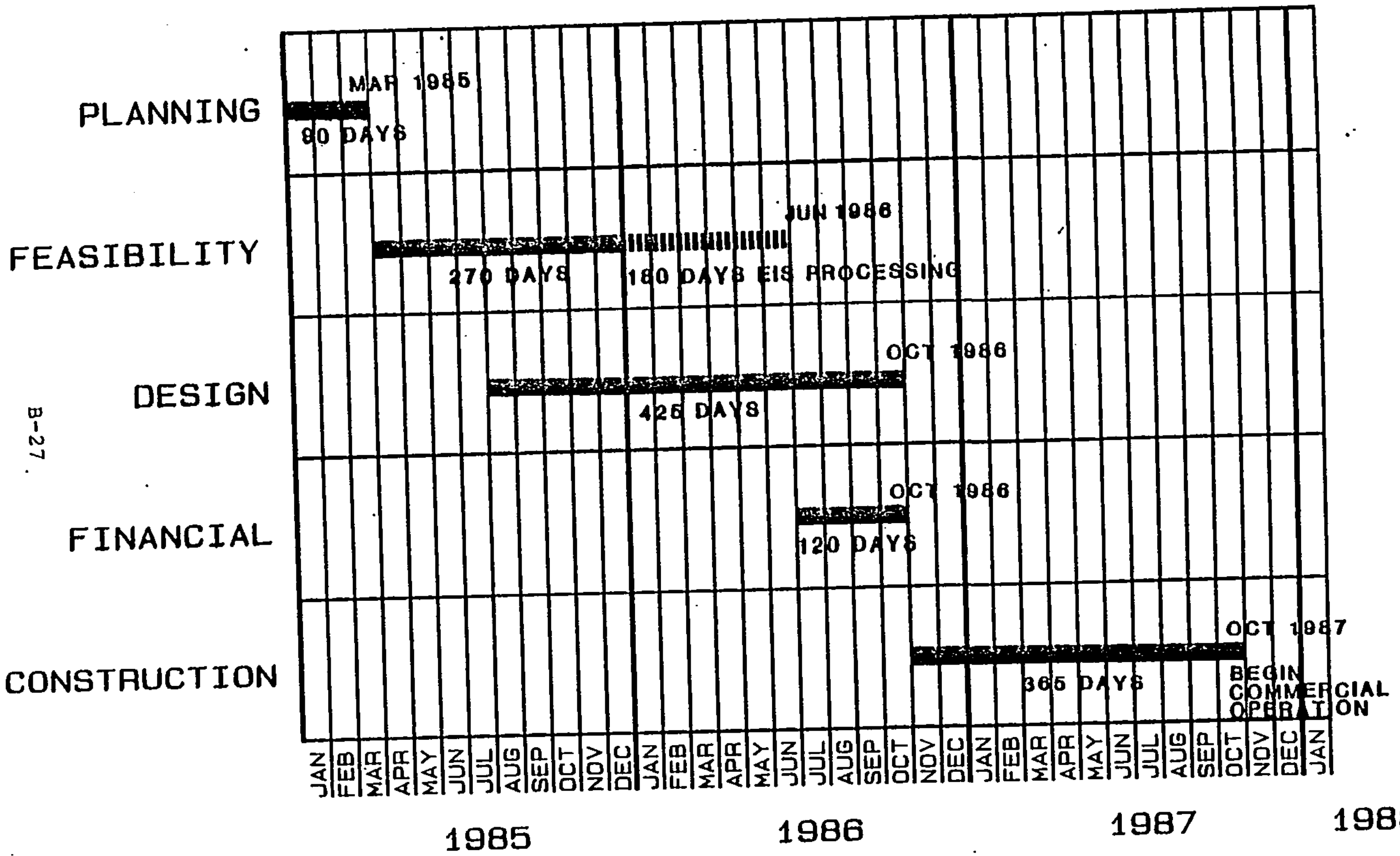


FIGURE b-5-1

B-6 SUMMARY OF TECHNICAL DATA

B-6a FUNCTIONAL ELEMENTS AND DESIGN DRAWINGS

1. FUNCTIONAL ELEMENTS

The project would consist of improvements at the existing diversion structure for the Stable Storm Ditch, a new diversion dam on the South Fork Wailua River, a penstock, a powerhouse and new transmission line. The Stable Storm Ditch improvements, relatively minor in construction effects would increase the diversion capability of the existing structure to provide more discharge into the South Fork River system than under prevailing conditions.

Improvements near the Wailua Falls would consist of a diversion dam to control the South Fork Wailua River waters, various water transmission and control structures, a powerplant, and access features. The diversion dam, located approximately 1,000 feet upstream of the falls would be a gravity, overtopping type structure, 23.0 feet high and with a crest length of 400 feet. The structure would be designed to withstand overtoping by the Probable Maximum Flood.

The area ponded upstream would be approximately 35.0 acres. Although a small storage of 300 acre-feet capacity would be provided, as a conservative measure, storage has not been considered for power diversion capability. The ponding would, however, add to the stability of flows, and provide a fishery.

The major water conveyance feature would be a buried 4950 foot long steel penstock comprised of 96" spiral rib pipe and 84" steel pipe located on the left side of the river. The penstock would transport diverted flows from the diversion dam to the powerhouse. Other control and water conveyance structures along the transmission route are the intake structure and tailrace.

The powerplant would be sited at the base of the penstock and would encompass an area of approximately 1512 square feet (42'x36'). Inside would be housed two vertical Francis type water turbines. The larger unit, rated at 5.0 Mw, would be designed for flows ranging from 90 cfs to 294 cfs at a net head of 257 feet. The smaller unit, rated at 1.60 Mw, would be designed for flows ranging from 30 cfs to 96 cfs. The dual turbine concept would allow operation over a wide range of flows. Due to the non-firm nature of discharges and the minimum discharge required for turbine operation, the powerplant will be in operation approximately 60 percent of the time. Natural flows in the South Fork Wailua River must exceed 45 cfs for operation under the current design. Wicket gates and butterfly valves would be provided to control inflow into the turbines. The generator would be of the vertical shaft synchronous type, directly connected to the turbine. Additional electrical and mechanical equipment would be provided.

The powerhouse station would be unmanned and remotely controlled. The 12 kv powerline would be mounted on poles and would extend from the powerhouse to the existing Lydgate substation along Route 56. The total length of powerlines would be 2.2 miles.

WAILUA HYDROELECTRIC POWER PROJECT

PERTINENT DATA

2. HYDROLOGIC AND HYDRAULIC

Drainage area at So Fork diversion, sq mi		22.4
Daily median flow (at 50%), cfs		36
Conservation discharge on So Fork, cfs		15
Ponding storage volume, acre-ft		300
Turbines: vertical Francis units		
Net head, ft		257
Discharge range: Unit 1, cfs	30 to 90	
Unit 2, cfs	90 to 275	
Maximum diversion discharge, cfs		365

3. MAJOR CONSTRUCTION FEATURES

Diversion dam, height, ft		23.0
crest length, ft		400
Penstock,		
96-inch spiral rib, length, ft.	2180	
90-inch spiral rib, length, ft.	2270	
87-inch steel, length, ft.	220	
84-inch steel, length, ft.	220	
Bifurcation, length, ft.	60	
Total Penstock Length		4950
Powerline, 12 kv, length, mi		2.2
Powerplant		
Capacity, Unit 1, kw	5,000	
Unit 2, kw	1,600	
Total, kw		6,600
Average annual energy, million kwh		17.5

4. MECHANICAL AND ELECTRICAL

a. The Powerhouse. The powerhouse would be a conventional indoor plant constructed of reinforced concrete, housing two generating units with adequate space for maintenance and auxiliary equipment. Removal and servicing of powerplant equipment would be through hatches located in the powerhouse roof utilizing a mobile crane.

b. Controls. Control facilities would be for an unmanned plant, and protective devices would operate automatically to protect equipment without the need for operator assistance.

c. Mechanical Equipment. Station brake and governor air would be provided to the powerhouse by a single air compressor. Draft tube unwatering and drainage would be through a common sump using an automatic duplex pump system. Miscellaneous raw water systems would be supplied via a tap from the intake and boosted by pumps as necessary.

d. Cooling System. Powerhouse and generators would be cooled by using outside air. Generators would be cooled by drawing powerhouse air through the generator housing and discharging it directly outside. Powerhouse heating would not be required. Dehumidification would not be provided.

e. Bulkheads and Valves. The flow of water to the units would be through intake pipes fitted with hydraulically operated butterfly valves. Draft tube bulkhead installation and removal would be accomplished by a mobile crane.

f. Turbines and Governors. The installation of two "custom-built" vertical single-runner, Francis type turbines with wicket gates and butterfly valves would match the site's hydraulic conditions. The individual turbines selected are of differing size and capacity. This would allow efficient operation over a wide variation of flow conditions.

g. Generators and Excitation Systems. The generators would be of the vertical shaft, synchronous type, with shaft directly connected to the turbine. The generators would be open ventilated with an 80% C rise, Class B insulation system without provisions for overload. The generators would have full run-away speed capability. The excitation systems would be specified to be the manufacturer's standard type. This can be either a direct connected brushless exciter or a bus-fed power potential source static exciation system. Solid-state continuously acting dynamic type voltage regulators would be used and would be incorporated in the unit switchgear.

h. Generator Voltage System. The connection between the generator and breaker would be with non segregated bus. The generator and station service breakers would be metal clad drawout type rated 250 MVA (nominal), 5 kV 1200 amps continuous. The breakers would be combined in a common switchgear lineup along with generator surge protection and instrument transformers.

i. Station Service. The station service power would be obtained via a tap, between the generator breaker and main power transformer. The station service transformer would be adjacent to the generator switchgear lineup. Station service power distribution would be at 480 volts 3-phase and 120/240 volts single phase.

j. Transmission Line. A 3-phase 12 kV overhead electrical transmission line would tie the power plant to the existing Lydgate substation. The transmission line would be approximately 2.2 miles long. The line would be connected to the powerhouse through a disconnect switch shown on the one line diagram (Figure B-6a-7).

k. Unit Control and Protective Equipment. A complete compliment of control and protective equipment would be provided on the Switchgear cubicles. Controls will provide for generator starting, stopping, and circuit breaker operation, including automatic synchronizing. Start and stop functions would be performed automatically as result of water level and frequency changes.

5. OPERATION AND MAINTENANCE

a. Operation. During normal operation the Powerhouse would be unmanned. The plant output would be monitored by the local utility and distributed through the existing power system.

b. Maintenance. A visual inspection and check of the plant, turbines, mechanical and electrical equipment would be required a minimum of 2 or 3 times a week.

6. POWER PRODUCTION

Tables B-6a-1 through B-6a-4 illustrate the potential monthly power generation of the Project based upon the combined daily flow data from the U.S.G.S. recording Station #16060000 on the South Fork of the Wailua River and Station #16063000 on the North Fork of the Wailua River. Minimum instream flow of 15 cfs for the South Fork was subtracted from flows used in the calculations. Tables B-6a-5 and B-6a-6 show the daily flow duration curve and tables of the flows available for hydropower production. Figures B-6a-1 through B-6a-8 illustrate the specific design details of the proposed project.

POWER PRODUCTION SUMMARY
MINIMUM YEAR

BINGHAM ENGINEERING HYDROLOGY DIVISION
WAILUA HYDROELECTRIC PROJECT

PENSTOCK LENGTH=3875. TAIL WATER ELEVATION= .0 PIPE INSIDE DIA. (FT)= 6.96 "C" FACTOR =143.
MINIMUM FLOW (cfs) 30. MAXIMUM FLOW (cfs) 390.

WAILUA HAWII HYDROELECTRIC PROJECT, WATER YEAR OCTOBER 1983 TO SEPTEMBER 1984
MEAN DAILY VALUES GWH

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	.0701	.0149	.0000	.0000	.1021	.0000	.0000	.0232	.0000	.0000	.0000	.0000
2	.0452	.0156	.0000	.0000	.0708	.0523	.0000	.0000	.0000	.0000	.0000	.0000
3	.0391	.0167	.0000	.0000	.0146	.0000	.0000	.0000	.0000	.0000	.0000	.0000
4	.0373	.0161	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
5	.0227	.0130	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
6	.0124	.0121	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
7	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
8	.0227	.0000	.0000	.0000	.0163	.0000	.0000	.0000	.0000	.0000	.0000	.0000
9	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
10	.0634	.0000	.0000	.0000	.0000	.0000	.0491	.0000	.0000	.0000	.0000	.0000
11	.0195	.0000	.0000	.0000	.0000	.0000	.0786	.0000	.0124	.0000	.0000	.0000
12	.0263	.0195	.0000	.0000	.0000	.0000	.0211	.0000	.0384	.0000	.0000	.0000
13	.0493	.1267	.0000	.0000	.0000	.0000	.0398	.0000	.0489	.0000	.0000	.0000
14	.0528	.0000	.0000	.0000	.0000	.0000	.0387	.0000	.0000	.0000	.0000	.0000
15	.0736	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
16	.0532	.0000	.0000	.0000	.0331	.0000	.0000	.0000	.0000	.0000	.0000	.0000
17	.0449	.0000	.0000	.0423	.0195	.0000	.0000	.0000	.0864	.0000	.0000	.0000
18	.0158	.0000	.0000	.0384	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
19	.0385	.0440	.0000	.0241	.0000	.0000	.0179	.0000	.0000	.0000	.0000	.0000
20	.1675	.0939	.0000	.0000	.0000	.0000	.0430	.0000	.0000	.0000	.0000	.0000
21	.0667	.0832	.0000	.0000	.0000	.0000	.0801	.0000	.0000	.0000	.0000	.0000
22	.0380	.0326	.0000	.0000	.0000	.0000	.0457	.0000	.0000	.0000	.0000	.0000
23	.0337	.0191	.0000	.0000	.0000	.0000	.0420	.0000	.0000	.0000	.0000	.0000
24	.0237	.0163	.0000	.1192	.0000	.0000	.0200	.0687	.0000	.0000	.0184	.0000
25	.0211	.0279	.0000	.0310	.0000	.0000	.0148	.0000	.0000	.0000	.0000	.0000
26	.0457	.0139	.0000	.0000	.0000	.0000	.0357	.0000	.0000	.0000	.0143	.1128
27	.0398	.0000	.0000	.0000	.0000	.0000	.1675	.0000	.0000	.0000	.0000	.0000
28	.0222	.0000	.0000	.0000	.0000	.0000	.0468	.0000	.0000	.0000	.0000	.0000
29	.0183	.0000	.0000	.0000	.0000	.0000	.0326	.0000	.0000	.0000	.0000	.0000
30	.0188	.0000	.0000	.0000	.0000	.0000	.0258	.0000	.0000	.0000	.0000	.0000
31	.0161	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
TOTAL	1.1986	.5657	.0000	.2551	.2564	.0523	.7992	.0920	.1860	.0000	.0327	.1128

WATER YEAR 1984 TOTAL 3.5506 GWH

TABLE B-6a-1

TABLE B-6a-1

WAILUA HYDROELECTRIC POWER PRODUCTION (garbled) — MAXIMUM YEAR

MAXIMUM YEAR

BINGHAM ENGINEERING HYDROLOGY DIVISION
WAILUA HYDROELECTRIC PROJECT

PENSTOCK LENGTH=3875. TAIL WATER ELEVATION= .0 PIPE INSIDE DIA. (FT)= 6.96 "C" FACTOR =143.
MINIMUM FLOW (cfs) 30. MAXIMUM FLOW (cfs) 390.

WAILUA NAHII HYDROELECTRIC PROJECT, WATER YEAR OCTOBER 1981 TO SEPTEMBER 1982
MEAN DAILY VALUES GWH

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	.0000	.1675	.1675	.0532	.0406	.1182	.1675	.0427	.0253	.1030	.1675	.1675
2	.0305	.1675	.1312	.0489	.0542	.1675	.1675	.0499	.0247	.0977	.1675	.1675
3	.0977	.1675	.0918	.0470	.0342	.1543	.1675	.0557	.0211	.0452	.1189	.1604
4	.1596	.1675	.0640	.0449	.0278	.0953	.1675	.0402	.0163	.0468	.1045	.1076
5	.0430	.1418	.0532	.0537	.0284	.0722	.1675	.0353	.0153	.0929	.0944	.0822
6	.0148	.1242	.0487	.1675	.0289	.0602	.1675	.0348	.0133	.1172	.0552	.0640
7	.0376	.0832	.0743	.1675	.0253	.0557	.1675	.1675	.0000	.1675	.0537	.0508
8	.0168	.0587	.0455	.0687	.0305	.0497	.1675	.1675	.0000	.1675	.0457	.0470
9	.0173	.0487	.0398	.0523	.0667	.0542	.1675	.1102	.0000	.1675	.0402	.0446
10	.0000	.0444	.0284	.0552	.1675	.0562	.1675	.0654	.0000	.1026	.0793	.0452
11	.0000	.0406	.0373	.0736	.1675	.1675	.1615	.1050	.0200	.0750	.1667	.1675
12	.0000	.0380	.0402	.0750	.1289	.1675	.1675	.1179	.0148	.0963	.1250	.1675
13	.0153	.0369	.0268	.0495	.0667	.1675	.1675	.0587	.0227	.1675	.0468	.1675
14	.0000	.0348	.0273	.0457	.0460	.1675	.1675	.0537	.0373	.1523	.0434	.1675
15	.0000	.0361	.0242	.0427	.0409	.1675	.1030	.0460	.0138	.0997	.0622	.1675
16	.0000	.0518	.0206	.0430	.0365	.1675	.1675	.0398	.0440	.1487	.1675	.1076
17	.0000	.0420	.0179	.0896	.0331	.1675	.1675	.1675	.1675	.1675	.1675	.0708
18	.0000	.1675	.0163	.1140	.0294	.1675	.1675	.1675	.0674	.1675	.1675	.0729
19	.0000	.0743	.0263	.1675	.0321	.1675	.1507	.1045	.0949	.1467	.1306	.0497
20	.0000	.0444	.1675	.1675	.1675	.1588	.1675	.0750	.1045	.0987	.0793	.0455
21	.0000	.0376	.1675	.1675	.1675	.1675	.1634	.0793	.0468	.1494	.1675	.0416
22	.0000	.0342	.1675	.1675	.1675	.1675	.1196	.0480	.0337	.0949	.1317	.0361
23	.0000	.1675	.1675	.1675	.1675	.1675	.0854	.0497	.0398	.1675	.1675	.0278
24	.0848	.1675	.1675	.1334	.1295	.1675	.0939	.1471	.0315	.1558	.1675	.0227
25	.0000	.1607	.1675	.1574	.1675	.1675	.0918	.0729	.0337	.0822	.1675	.0592
26	.0000	.1568	.1675	.0918	.1675	.1675	.0597	.0607	.0000	.0480	.1675	.0562
27	.0827	.1675	.1235	.0722	.1675	.1675	.0499	.0528	.0000	.0449	.1273	.0602
28	.1675	.1106	.1072	.0567	.1035	.1675	.0880	.0444	.0321	.0416	.0973	.1675
29	.1675	.1385	.0822	.0462	.0000	.1675	.0523	.0391	.0278	.0444	.0886	.0503
30	.1136	.1430	.0708	.0427	.0000	.1675	.0470	.0361	.1675	.1072	.1006	.0493
31	.0764	.0000	.0654	.0395	.0000	.1675	.0000	.0342	.0000	.0597	.1179	.0000
TOTAL	1.1252	3.0212	2.6026	2.7696	2.4906	4.3921	4.1135	2.3690	1.1158	3.4232	3.5843	2.6919

WATER YEAR 1982 TOTAL 33.6990 GWH

TABLE B-6a-2

TABLE B-6a-2

MEDIAN YEAR

BINGHAM ENGINEERING HYDROLOGY DIVISION
WAILUA HYDROELECTRIC PROJECT

PENSTOCK LENGTH=3875. TAIL WATER ELEVATION= .0 PIPE INSIDE DIA. (FT)= 6.96 "C" FACTOR =143.
MINIMUM FLOW (cfs) 30. MAXIMUM FLOW (cfs) 390.

WAILUA KAUAI HYDROELECTRIC PROJECT, WATER YEAR OCTOBER 1962 TO SEPTEMBER 1963
MEAN DAILY VALUES GWH

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	.0000	.0000	.0434	.0268	.0886	.0000	.0896	.1588	.0409	.1157	.0440	.0000
2	.0000	.0204	.0508	.0000	.0493	.0000	.1189	.1093	.0294	.0413	.1675	.0000
3	.0000	.0000	.0348	.0000	.0409	.0000	.1675	.1675	.0508	.1552	.0622	.0000
4	.0000	.0000	.0263	.0285	.0294	.0000	.1675	.1675	.1021	.0475	.0528	.0000
5	.0000	.0000	.0200	.0000	.0294	.0000	.1418	.1675	.0462	.0348	.0326	.0000
6	.0000	.0000	.0163	.0759	.0326	.1675	.1136	.1675	.0232	.0348	.0337	.0000
7	.0000	.0000	.0163	.1675	.0278	.0000	.0843	.1675	.0562	.0391	.0119	.0000
8	.0000	.0000	.0195	.1675	.0158	.0000	.0299	.1189	.0449	.0128	.0133	.0000
9	.0000	.0000	.0184	.0838	.0000	.0000	.0153	.1329	.0503	.0143	.0000	.0000
10	.0000	.0000	.0189	.0437	.0000	.0000	.0484	.1267	.1182	.0000	.0000	.0000
11	.0000	.0000	.0120	.0315	.0000	.0000	.0477	.1675	.1115	.0128	.0000	.0000
12	.0000	.0000	.0000	.0195	.0000	.0000	.0440	.1675	.0455	.0000	.0000	.0000
13	.0000	.0000	.0000	.0168	.0000	.0000	.1219	.1487	.0449	.0000	.0000	.0000
14	.0000	.0000	.0308	.0148	.0000	.1675	.1675	.1675	.0875	.0000	.0000	.0000
15	.0000	.0000	.1110	.0875	.0000	.1675	.1675	.1451	.1479	.0000	.0000	.0000
16	.0000	.0000	.0294	.1675	.0000	.1675	.1675	.1675	.1593	.0000	.0772	.0000
17	.0000	.0000	.0491	.1262	.0000	.1675	.1675	.1675	.0681	.0000	.1072	.1675
18	.0121	.0000	.0342	.0582	.0000	.1675	.1675	.1394	.0416	.0179	.0427	.1596
19	.0816	.0000	.0156	.0416	.0000	.0949	.1675	.0843	.0446	.0138	.0373	.0000
20	.0000	.0232	.0000	.0331	.0000	.0687	.1672	.0552	.0353	.0416	.0163	.0000
21	.0000	.0353	.0000	.0195	.0000	.1675	.1526	.0587	.1157	.1030	.0000	.0000
22	.0000	.0315	.0143	.0253	.0000	.1675	.1229	.0493	.1675	.1675	.0000	.0000
23	.0000	.0258	.0133	.0395	.0000	.1675	.1443	.0440	.1165	.0934	.0000	.0000
24	.0000	.0206	.0222	.1675	.0000	.0622	.1443	.0384	.0757	.0870	.0080	.0000
25	.0000	.0143	.0227	.0722	.0000	.0674	.1267	.0310	.0816	.0413	.0253	.0000
26	.0000	.0000	.0000	.0289	.0000	.1675	.1675	.0294	.1629	.0211	.0184	.0000
27	.0000	.0200	.0000	.0242	.0000	.1675	.1675	.0750	.0660	.0537	.0373	.0000
28	.0000	.0473	.0000	.0217	.0000	.0944	.1675	.0491	.0423	.0484	.0321	.0148
29	.0000	.0437	.0368	.0452	.0000	.0501	.1675	.0409	.0365	.0195	.0128	.0000
30	.0000	.0387	.0291	.0480	.0000	.1675	.1675	.0457	.0395	.0000	.0000	.0000
31	.0000	.0000	.0273	.1675	.0000	.1295	.0000	.0480	.0000	.0000	.0080	.0000
TOTAL	.0930	.3208	.7125	1.8497	.3130	2.5771	3.8909	3.4037	2.2530	1.2166	.9124	.3419

WATER YEAR 1963 TOTAL 17.8861 GWH

TABLE B-6a-3

TABLE B-6a-3

POWER PRODUCTION SUMMARY
PERIOD OF RECORD

BINGHAM ENGINEERING HYDROLOGY DIVISION

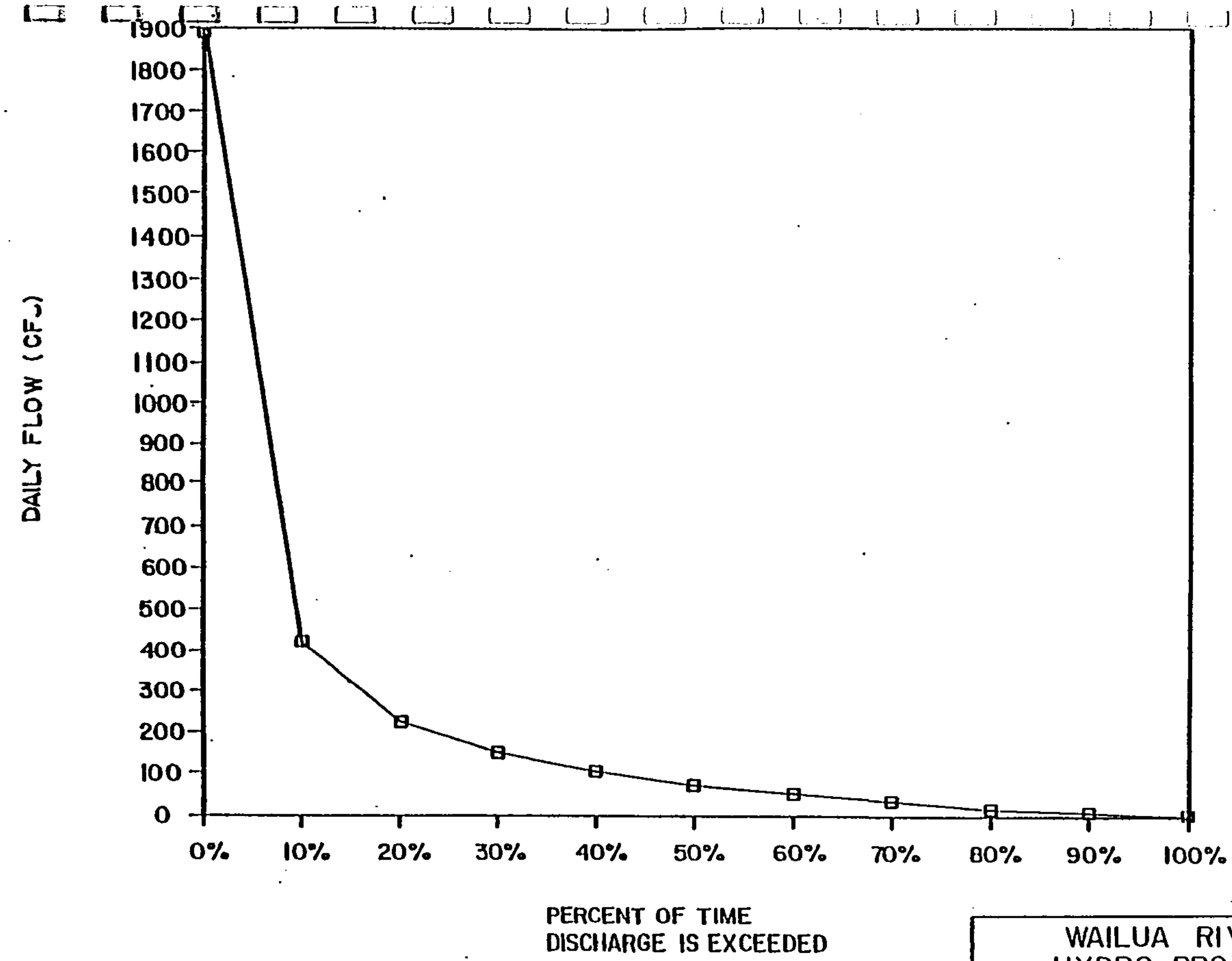
WAILUA HYDROELECTRIC PROJECT

SUMMARY TABLE (GWH)

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1959	1.3005	1.6071	0.7831	1.5192	0.7589	0.0495	0.7492	0.4282	0.0146	0.4981	1.6976	0.5420	9.9481
1960	0.0861	1.6259	1.7659	1.8493	0.6421	2.3958	1.5451	2.1098	0.4348	0.6483	0.9871	0.8933	14.9833
1961	2.6565	1.2291	1.8083	0.5669	0.6368	1.0805	1.2885	1.2446	0.7033	0.9763	1.3969	1.2579	14.8455
1962	2.6776	2.2455	3.0954	3.0236	1.0179	3.3095	2.2271	2.7299	1.3794	0.6666	0.2934	0.0466	22.7104
1963	0.0938	0.3208	0.7125	1.8497	0.3138	2.5771	3.8909	3.4037	2.2530	1.2166	0.9124	0.3419	17.0861
1964	0.9993	0.2314	0.3084	2.3430	1.4056	3.9852	2.8596	3.1008	0.6453	1.5533	1.0810	0.7002	19.2129
1965	1.7563	4.1951	3.2608	2.6551	0.8454	0.2841	2.9265	3.3792	0.9768	1.4768	0.2395	0.4903	22.4859
1966	1.2764	4.2365	3.3717	1.1368	1.0490	0.3618	0.0000	0.0000	0.1413	0.6956	1.2922	0.5522	14.1134
1967	1.7728	3.3893	2.3274	2.7690	2.3294	3.3788	3.7336	2.7422	1.4020	1.5779	2.2889	1.2950	29.0063
1968	1.2171	1.8743	4.4977	2.8419	1.0375	2.1793	1.7358	0.3434	0.0964	0.5990	0.3534	0.1740	16.9498
1969	1.8239	1.0902	4.0317	1.7971	3.3437	1.9809	1.1115	1.2685	0.1387	1.8170	0.4414	1.5246	20.3692
1970	0.7812	2.7764	1.9494	3.3061	0.1029	0.0000	0.7671	1.2072	0.2739	0.8164	0.2645	0.5399	12.7851
1971	0.2645	2.1238	4.3382	3.5953	1.8774	2.4880	4.0756	1.0036	0.0000	0.2927	0.0173	0.4495	20.5261
1972	1.1189	2.3143	3.3810	2.1171	3.2835	1.1720	2.5061	0.5952	0.1481	1.3900	0.1378	0.4235	18.5877
1973	1.4732	1.9813	0.4010	0.1170	0.3019	1.8631	0.7776	1.3970	0.5923	0.0958	0.0000	0.1765	9.1766
1974	1.4484	2.9417	2.7634	4.1167	1.7375	3.1020	3.9560	2.1846	2.0903	2.3020	0.6927	1.3920	28.7272
1975	1.3441	2.4158	1.7743	3.1980	2.2106	1.9093	3.0340	1.6074	0.0000	0.4064	0.0649	0.0000	17.9648
1976	0.2610	1.6980	0.8751	2.0121	1.8490	3.2255	4.5825	1.6457	0.5641	1.0749	0.6647	0.0544	18.5072
1977	0.6263	0.0718	0.1569	0.1319	0.5968	2.5608	1.5525	2.8082	0.8755	1.0922	0.7935	0.2546	11.5211
1978	0.4309	1.7001	0.8513	0.2698	0.0000	0.0000	0.9491	2.0064	3.3669	2.5668	3.2297	1.4407	16.8117
1979	0.5040	2.1012	1.4592	1.2117	3.7677	1.0409	0.1793	0.3276	1.7714	0.5496	0.4425	0.0434	13.3983
1980	0.4804	1.3033	0.6160	0.9283	0.0000	2.0328	2.4640	3.0430	3.2316	3.5721	0.9462	1.5113	20.1291
1981	1.6974	0.9139	0.9952	0.2916	0.3406	0.3013	1.9147	0.6698	0.0000	2.1741	2.4022	0.5549	12.2558
1982	1.1252	3.0212	2.6026	2.7696	2.4906	4.3921	4.1135	2.3690	1.1158	3.4232	3.5843	2.6919	33.6990
1983	2.5129	3.2481	2.0703	1.0268	0.0000	0.0149	0.3717	1.0619	0.0796	2.4777	1.7936	2.7006	15.3580
1984	1.1986	0.5657	0.0000	0.2551	0.2564	0.0523	0.7992	0.0920	0.1860	0.0000	0.0327	0.1128	3.5506
AVERAGE	1.1895	1.9701	1.9306	1.8346	1.2383	1.7591	2.0812	1.6450	0.8647	1.3061	1.0019	0.6986	17.5196

TABLE B-6a-4

TABLE B-6a-4



WAILUA RIVER
HYDRO PROJECT

FLOW DURATION CURVE
COMBINED DAILY FLOWS
SO. FORK & NO. FORK
WAILUA RIVER

TABLE B-6a-5

TABLE B-6a-5

FLOW DURATION TABLE

1	2	1	2	1	2	1	2
3	100.00	4	99.18	5	97.16	6	94.57
7	91.83	8	89.54	9	87.39	10	85.73
11	84.28	12	83.22	13	82.28	14	81.57
15	80.80	16	79.91	17	79.19	18	78.59
19	77.98	20	77.34	21	76.65	22	76.09
23	75.67	24	75.15	25	74.59	26	74.12
27	73.45	28	72.99	29	72.56	30	72.03
31	71.51	32	71.03	33	70.60	34	70.04
35	69.55	36	69.02	37	68.38	38	67.71
39	67.17	40	66.51	41	65.93	42	65.48
43	64.89	44	64.27	45	63.67	46	63.06
47	62.43	48	61.82	49	61.23	50	60.65
51	60.13	52	59.46	53	58.99	54	58.41
55	57.76	56	57.22	57	56.70	58	56.14
59	55.65	60	55.24	61	54.87	62	54.41
63	53.88	64	53.42	65	53.03	66	52.60
67	52.13	68	51.63	69	51.24	70	50.81
71	50.36	72	49.98	73	49.62	74	49.22
75	48.90	76	48.51	77	48.13	78	47.73
79	47.41	80	47.17	81	46.89	82	46.56
83	46.30	84	46.07	85	45.71	86	45.47
87	45.12	88	44.84	89	44.53	90	44.13
91	43.92	92	43.74	93	43.47	94	43.15
95	42.89	96	42.54	97	42.17	98	41.88
99	41.59	100	41.41	101	41.14	102	40.81
103	40.45	104	40.23	105	40.00	106	39.73
107	39.45	108	39.17	109	38.94	110	38.72
111	38.43	112	38.17	113	37.91	114	37.61
115	37.30	116	36.98	117	36.67	118	36.45
119	36.24	120	36.02	121	35.72	122	35.43
123	35.22	124	35.12	125	34.82	126	34.67
127	34.48	128	34.32	129	34.15	130	33.98
131	33.87	132	33.67	133	33.44	134	33.27
135	33.11	136	32.87	137	32.66	138	32.46
139	32.27	140	32.15	141	31.89	142	31.66
143	31.50	144	31.28	145	31.03	146	30.81
147	30.67	148	30.53	149	30.31	150	30.13
151	29.94	152	29.73	153	29.47	154	29.36
155	29.22	156	29.09	157	28.89	158	28.68
159	28.54	160	28.38	161	28.21	162	28.06
163	27.88	164	27.69	165	27.52	166	27.37
167	27.26	168	27.16	169	27.02	170	26.88
171	26.68	172	26.49	173	26.35	174	26.20
175	26.02	176	25.84	177	25.70	178	25.54
179	25.41	180	25.28	181	25.20	182	25.05
183	24.89	184	24.74	185	24.61	186	24.51
187	24.34	188	24.24	189	24.07	190	23.94
191	23.80	192	23.72	193	23.61	194	23.42
195	23.28	196	23.21	197	23.09	198	22.95
199	22.84	200	22.77	201	22.68	202	22.54

1- FLOW IN C.F.S.
2- PRECENT OF TIME DISCHARGE IS EXCEEDED

TABLE B-6a-6

TABLE B-6a-6

FLOW DURATION TABLE

1	2	1	2	1	2	1	2
203	22.43	204	22.31	205	22.18	206	22.03
207	21.91	208	21.87	209	21.75	210	21.65
211	21.52	212	21.48	213	21.39	214	21.31
215	21.19	216	21.09	217	20.94	218	20.75
219	20.65	220	20.54	221	20.44	222	20.34
223	20.25	224	20.14	225	20.03	226	19.94
227	19.86	228	19.83	229	19.70	230	19.63
231	19.55	232	19.48	233	19.39	234	19.28
235	19.17	236	19.09	237	19.02	238	18.91
239	18.84	240	18.75	241	18.64	242	18.58
243	18.55	244	18.51	245	18.44	246	18.32
247	18.24	248	18.16	249	18.10	250	18.02
251	17.94	252	17.88	253	17.83	254	17.76
255	17.69	256	17.65	257	17.61	258	17.54
259	17.50	260	17.42	261	17.32	262	17.29
263	17.23	264	17.11	265	17.02	266	16.94
267	16.88	268	16.86	269	16.81	270	16.74
271	16.63	272	16.59	273	16.54	274	16.45
275	16.38	276	16.33	277	16.27	278	16.21
279	16.14	280	16.10	281	16.04	282	15.98
283	15.89	284	15.85	285	15.76	286	15.66
287	15.60	288	15.51	289	15.45	290	15.39
291	15.34	292	15.31	293	15.28	294	15.22
295	15.10	296	15.04	297	14.99	298	14.95
299	14.91	300	14.87	301	14.84	302	14.73
303	14.66	304	14.60	305	14.56	306	14.49
307	14.46	308	14.43	309	14.42	310	14.36
311	14.33	312	14.28	313	14.22	314	14.13
315	14.10	316	14.04	317	13.99	318	13.95
319	13.92	320	13.89	321	13.88	322	13.86
323	13.83	324	13.73	325	13.69	326	13.68
327	13.61	328	13.55	329	13.51	330	13.47
331	13.43	332	13.38	333	13.36	334	13.30
335	13.27	336	13.23	337	13.15	338	13.12
339	13.08	340	13.03	341	12.97	342	12.93
343	12.90	344	12.88	345	12.84	346	12.80
347	12.75	348	12.70	349	12.63	350	12.55
351	12.51	352	12.49	353	12.44	354	12.40
355	12.35	356	12.32	357	12.29	358	12.24
359	12.17	360	12.13	361	12.07	362	12.06
363	11.99	364	11.97	365	11.95	366	11.93
367	11.91	369	11.87	370	11.82	371	11.81
372	11.79	373	11.71	374	11.68	375	11.65
376	11.54	377	11.51	378	11.50	379	11.48
380	11.44	381	11.40	382	11.39	383	11.37
384	11.30	385	11.22	386	11.19	387	11.18
388	11.14	389	11.09	390	11.06	391	11.04
392	10.99	393	10.94	394	10.92	395	10.89
396	10.85	397	10.80	398	10.73	399	10.72
400	10.70	401	10.67	402	10.65	403	10.61

1- FLOW IN C.F.S.
2- PRECENT OF TIME DISCHARGE IS EXCEEDED

TABLE B-6a-6 (cont.)

TABLE B-6a-6 (cont.)

FLOW DURATION TABLE

1	2	1	2	1	2	1	2
404	10.59	405	10.53	406	10.49	407	10.48
408	10.45	409	10.39	410	10.35	411	10.32
412	10.28	413	10.27	414	10.25	415	10.22
416	10.20	417	10.14	418	10.11	419	10.05
420	10.00	421	9.97	422	9.94	423	9.93
424	9.92	425	9.89	427	9.83	429	9.80
431	9.76	432	9.72	433	9.68	435	9.63
436	9.61	437	9.56	438	9.51	440	9.49
441	9.45	442	9.43	443	9.41	444	9.39
445	9.37	447	9.35	448	9.34	449	9.33
450	9.31	453	9.29	454	9.25	455	9.22
456	9.20	457	9.18	458	9.15	459	9.13
460	9.11	461	9.06	462	9.00	463	8.97
464	8.96	465	8.95	466	8.93	467	8.89
468	8.84	469	8.82	470	8.80	472	8.76
473	8.73	474	8.70	475	8.69	476	8.66
478	8.64	479	8.60	481	8.57	482	8.56
483	8.52	484	8.50	485	8.48	487	8.47
488	8.43	489	8.41	490	8.39	491	8.38
492	8.34	493	8.32	494	8.31	495	8.28
496	8.27	497	8.24	498	8.23	499	8.22
500	8.20	502	8.18	503	8.17	504	8.14
505	8.11	506	8.10	507	8.07	508	8.04
509	8.03	510	8.02	511	7.97	512	7.93
513	7.92	514	7.88	515	7.86	517	7.82
518	7.81	520	7.80	521	7.77	522	7.74
523	7.73	524	7.70	526	7.68	527	7.66
528	7.63	530	7.62	531	7.59	532	7.57
534	7.56	535	7.53	536	7.51	537	7.47
538	7.45	539	7.44	542	7.43	543	7.40
544	7.38	545	7.37	547	7.35	549	7.30
550	7.29	551	7.24	552	7.21	554	7.18
555	7.16	556	7.15	557	7.14	558	7.11
559	7.10	560	7.07	561	7.03	563	7.01
564	7.00	567	6.98	568	6.97	569	6.95
570	6.93	571	6.92	572	6.91	573	6.88
574	6.87	575	6.83	576	6.82	577	6.79
580	6.77	581	6.76	583	6.74	584	6.72
585	6.68	586	6.62	587	6.59	588	6.58
589	6.57	590	6.56	591	6.54	593	6.51
595	6.50	596	6.47	598	6.45	599	6.43
600	6.41	601	6.39	602	6.38	603	6.37
604	6.36	605	6.35	606	6.34	607	6.31
608	6.30	609	6.28	610	6.23	611	6.21
612	6.19	613	6.16	614	6.15	615	6.13
616	6.12	617	6.09	618	6.07	619	6.04
621	6.03	622	6.01	623	5.96	624	5.92
626	5.89	627	5.88	632	5.85	633	5.84
634	5.82	635	5.78	637	5.76	638	5.75
639	5.73	640	5.72	642	5.71	643	5.68

1- FLOW IN C.F.S.
2- PRECENT OF TIME DISCHARGE IS EXCEEDED

TABLE B-6a-6 (cont.)

TABLE B-6a-6 (cont.)

FLOW DURATION TABLE

1	2	1	2	1	2	1	2
644	5.66	645	5.65	646	5.63	647	5.61
648	5.58	651	5.56	652	5.54	653	5.53
654	5.52	655	5.51	656	5.50	657	5.48
658	5.46	659	5.42	661	5.41	664	5.39
669	5.38	670	5.37	671	5.36	674	5.35
675	5.32	676	5.31	680	5.26	683	5.24
687	5.22	688	5.21	691	5.20	692	5.19
695	5.18	699	5.16	700	5.15	701	5.12
702	5.10	704	5.06	706	5.05	707	5.04
709	5.01	711	5.00	712	4.99	718	4.98
720	4.97	722	4.96	723	4.94	726	4.93
727	4.90	728	4.88	729	4.86	730	4.85
732	4.84	733	4.81	734	4.78	736	4.76
739	4.74	740	4.72	742	4.71	744	4.69
746	4.68	747	4.66	748	4.64	749	4.62
750	4.61	752	4.60	754	4.59	755	4.58
756	4.57	757	4.55	758	4.54	759	4.52
762	4.51	763	4.50	766	4.49	767	4.48
768	4.46	769	4.45	770	4.43	772	4.42
776	4.41	780	4.40	783	4.39	784	4.36
786	4.34	787	4.33	793	4.32	796	4.31
797	4.30	798	4.29	799	4.28	809	4.25
811	4.24	814	4.21	816	4.20	818	4.19
819	4.18	820	4.17	822	4.15	823	4.14
824	4.13	828	4.11	830	4.10	831	4.09
832	4.06	834	4.03	835	4.02	837	4.01
842	4.00	843	3.99	845	3.98	846	3.97
847	3.96	848	3.94	849	3.93	850	3.92
852	3.91	857	3.90	860	3.89	864	3.86
865	3.85	866	3.84	867	3.83	869	3.82
870	3.81	872	3.80	874	3.79	875	3.77
876	3.76	877	3.75	881	3.74	884	3.73
885	3.70	887	3.67	888	3.66	889	3.65
890	3.64	892	3.63	894	3.62	897	3.60
899	3.59	900	3.58	906	3.57	907	3.55
900	3.54	910	3.53	911	3.52	913	3.51
917	3.50	918	3.49	920	3.47	921	3.45
923	3.42	924	3.40	925	3.38	926	3.37
929	3.36	933	3.35	934	3.34	936	3.33
941	3.32	947	3.30	950	3.27	953	3.26
954	3.25	956	3.24	957	3.23	958	3.22
959	3.21	962	3.20	963	3.19	964	3.17
968	3.16	969	3.15	973	3.14	983	3.13
985	3.12	986	3.11	991	3.10	993	3.07
997	3.06	998	3.05	999	3.04	1001	3.02
1004	3.01	1006	3.00	1008	2.99	1009	2.98
1011	2.97	1016	2.96	1017	2.95	1022	2.94
1024	2.93	1031	2.92	1035	2.91	1043	2.90
1046	2.89	1040	2.87	1049	2.86	1051	2.85
1052	2.82	1058	2.81	1060	2.79	1061	2.77

1- FLOW IN C.F.S.
2- PRECENT OF TIME DISCHARGE IS EXCEEDED

TABLE B-6a-6 (cont.)

TABLE B-6a-6 (cont.)

1	2	1	2	1	2	1	2
1068	2.76	1073	2.75	1074	2.74	1080	2.73
1082	2.72	1084	2.70	1091	2.69	1098	2.66
1100	2.65	1104	2.63	1109	2.62	1112	2.61
1118	2.60	1127	2.59	1129	2.58	1131	2.57
1137	2.56	1141	2.55	1142	2.52	1145	2.51
1147	2.48	1153	2.47	1155	2.46	1159	2.45
1161	2.44	1164	2.43	1166	2.42	1168	2.41
1170	2.40	1173	2.38	1176	2.37	1182	2.36
1183	2.34	1184	2.33	1195	2.30	1197	2.28
1198	2.27	1199	2.26	1200	2.25	1201	2.24
1202	2.23	1205	2.22	1213	2.21	1214	2.20
1218	2.19	1222	2.17	1227	2.16	1228	2.14
1240	2.13	1241	2.12	1251	2.11	1253	2.10
1254	2.08	1265	2.07	1273	2.06	1274	2.04
1279	2.03	1282	2.02	1285	2.01	1288	2.00
1290	1.98	1295	1.97	1299	1.96	1301	1.94
1306	1.93	1315	1.92	1321	1.91	1322	1.90
1329	1.88	1330	1.87	1331	1.86	1332	1.85
1333	1.84	1337	1.83	1338	1.82	1340	1.81
1347	1.80	1349	1.79	1374	1.78	1386	1.77
1392	1.76	1393	1.75	1400	1.74	1403	1.73
1405	1.72	1407	1.71	1411	1.70	1413	1.68
1419	1.67	1422	1.66	1428	1.65	1430	1.64
1436	1.63	1445	1.62	1448	1.61	1451	1.60
1456	1.59	1476	1.58	1477	1.57	1483	1.55
1487	1.54	1488	1.53	1493	1.51	1509	1.50
1518	1.48	1522	1.47	1531	1.46	1532	1.45
1533	1.44	1545	1.43	1562	1.42	1566	1.41
1572	1.40	1591	1.39	1597	1.38	1599	1.37
1617	1.36	1624	1.35	1625	1.34	1627	1.33
1650	1.32	1653	1.31	1667	1.30	1672	1.28
1677	1.27	1680	1.26	1689	1.25	1702	1.23
1727	1.22	1729	1.21	1739	1.20	1749	1.19
1750	1.18	1762	1.17	1764	1.16	1771	1.15
1777	1.14	1784	1.13	1810	1.12	1833	1.11
1835	1.10	1839	1.08	1848	1.07	1850	1.06
1852	1.05	1854	1.04	1859	1.03	1871	1.02
1883	1.01	1885	1.00	1895	.99	1907	.98
1908	.96	1910	.95	1918	.94	1955	.93
1960	.92	1963	.90	1973	.88	1988	.87
1992	.86	2016	.85	2022	.84	2024	.83
2032	.82	2034	.81	2039	.80	2040	.79
2053	.78	2059	.77	2074	.76	2075	.75
2080	.74	2100	.73	2109	.72	2123	.71
2137	.69	2141	.68	2258	.67	2260	.66
2279	.65	2287	.64	2310	.63	2339	.62
2342	.61	2346	.60	2411	.59	2429	.58
2457	.57	2497	.56	2502	.55	2515	.54
2600	.53	2605	.51	2611	.49	2630	.48
2641	.47	2678	.46	2682	.45	2687	.44

1- FLOW IN C.F.S.
2- PRECENT OF TIME DISCHARGE IS EXCEEDED

TABLE B-6a-6 (cont.)

TABLE B-6a-6 (cont.)

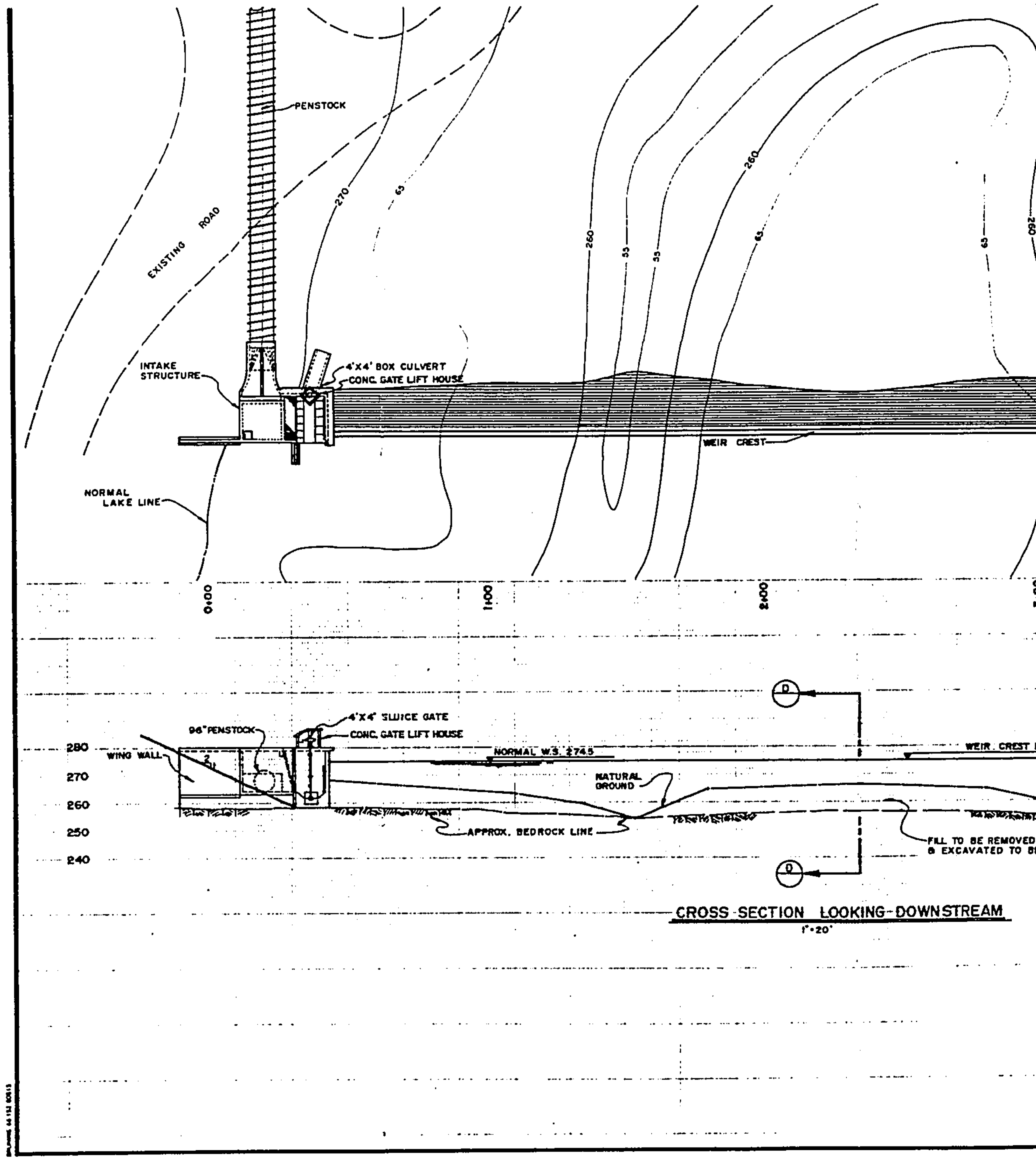
FLOW DURATION TABLE

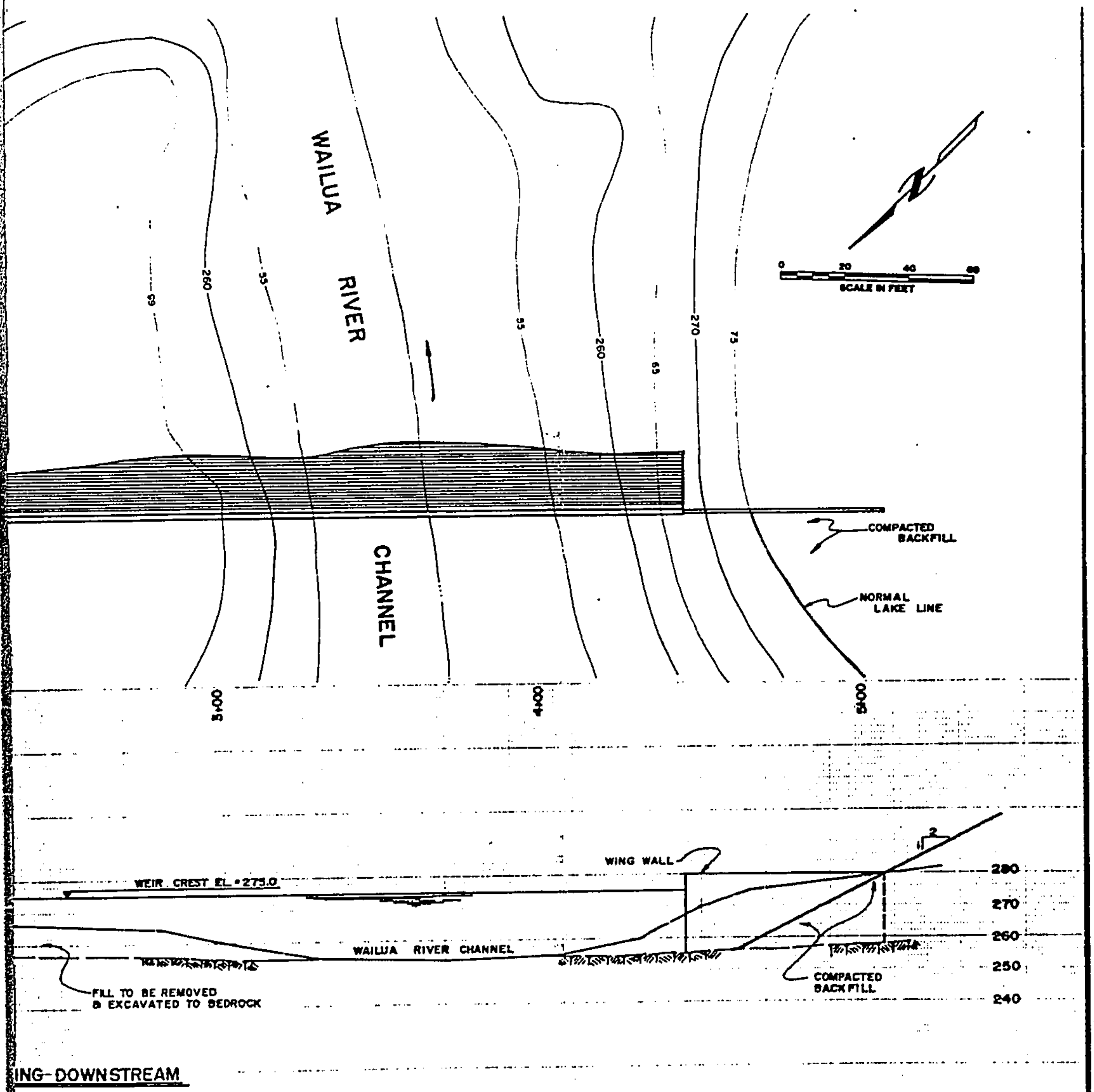
1	2	1	2	1	2	1	2
2710	.43	2765	.42	2855	.41	2860	.40
2878	.39	2879	.38	3040	.37	3050	.36
3070	.35	3100	.34	3120	.33	3146	.32
3255	.31	3302	.29	3330	.28	3344	.27
3348	.26	3370	.25	3381	.24	3420	.23
3442	.22	3450	.21	3510	.20	3540	.19
3561	.18	3673	.17	3830	.16	3850	.15
3855	.14	3870	.13	4120	.12	4140	.11
4176	.09	4200	.08	4660	.07	4750	.06
5534	.05	5950	.04	6180	.03	6640	.02
10200	.01	0	.00	1	.00	0	.00

1- FLOW IN C.F.S.
2- PRECENT OF TIME DISCHARGE IS EXCEEDED

TABLE B-6a-6 (cont.)

TABLE B-6a-6 (cont.)


PENSTOCK
EXISTING ROAD
270
63
260
55
55
260
63
63
260
INTAKE STRUCTURE
4'X4' BOX CULVERT
CONC. GATE LIFT HOUSE
WEIR CREST
NORMAL LAKE LINE
0+00
1+00
2+00
96" PENSTOCK
4'X4' SLUICE GATE
CONC. GATE LIFT HOUSE
NORMAL W.S. 274.5
WEIR CREST
WING WALL
NATURAL GROUND
APPROX. BEDROCK LINE
FILL TO BE REMOVED
& EXCAVATED TO
280
270
260
250
240
D
D
CROSS SECTION LOOKING-DOWNSTREAM
1"=20'



WAILUA RIVER
HYDROELECTRIC PROJECT

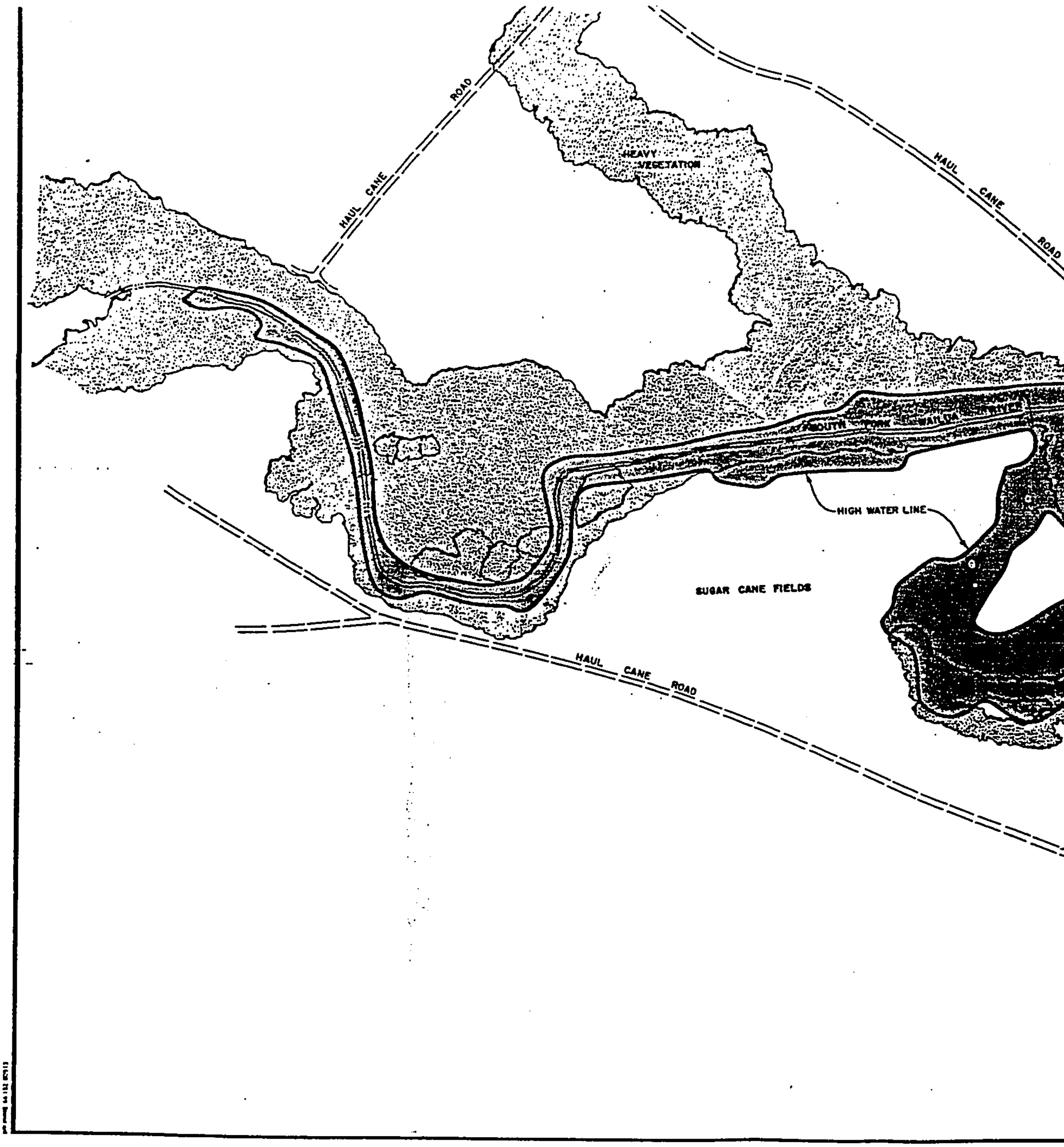
WAILUA RIVER
INTAKE STRUCTURE

Bingham Engineering

JRB
MHG
JRB

OCT. 1985
609-015

FIGURE B-6a-1


HAUL CANE ROAD
HEAVY VEGETATION
HAUL CANE ROAD
SOUTH FORK WAILUA RIVER
HIGH WATER LINE
SUGAR CANE FIELDS
HAUL CANE ROAD

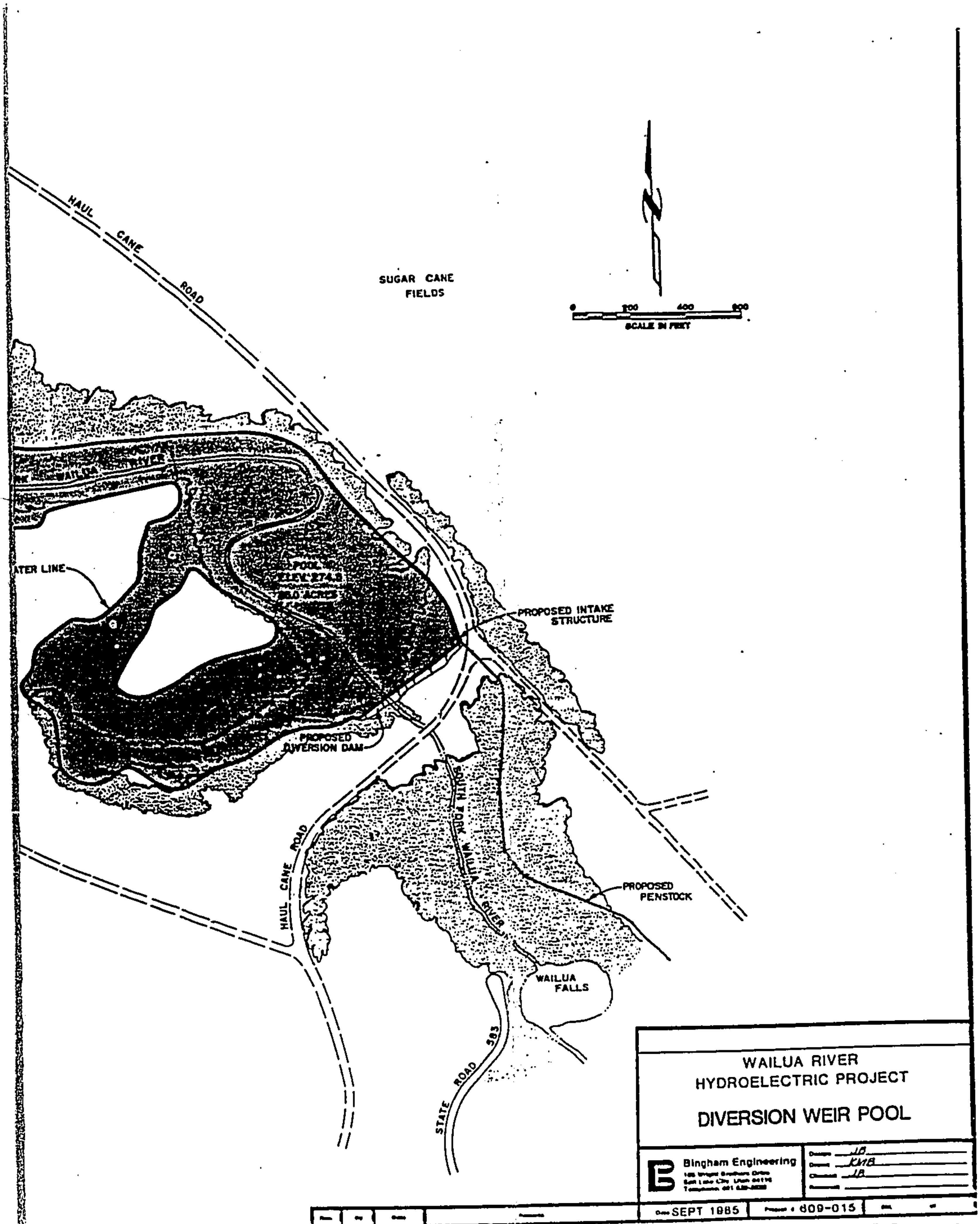
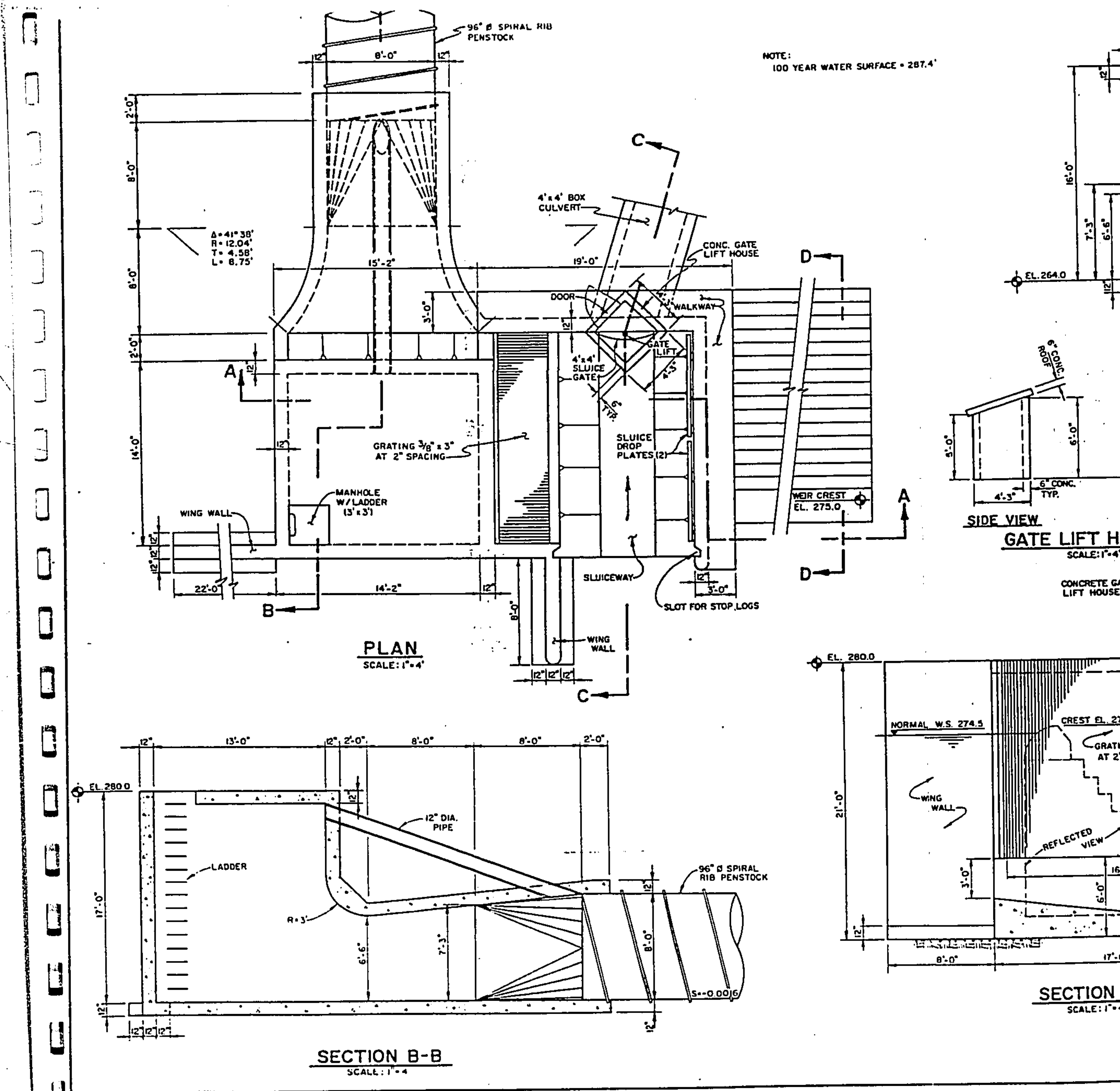
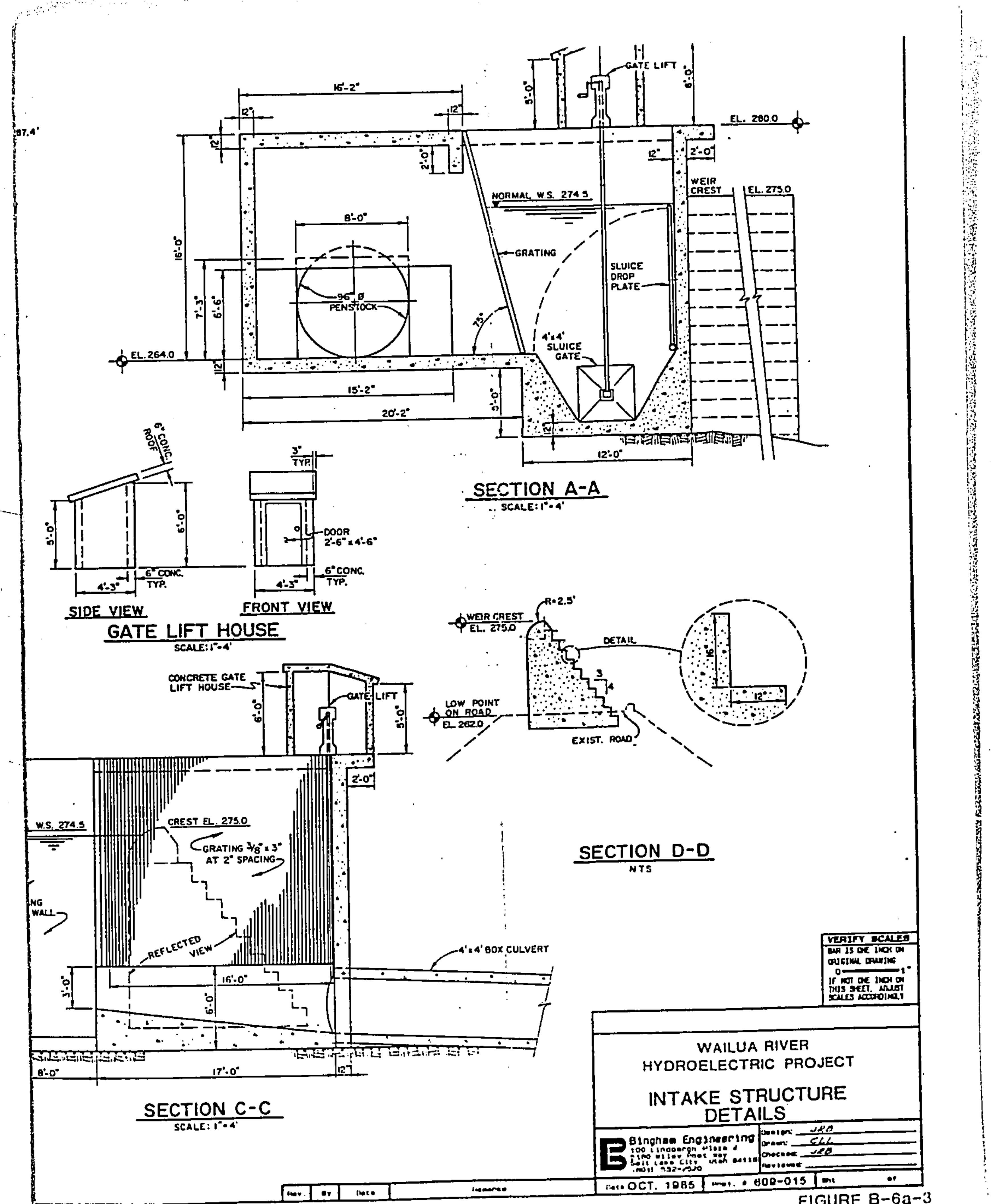

HAUL CANE ROAD
SUGAR CANE FIELDS
0 200 400 800
SCALE IN FEET
ATER LINE
PROPOSED INTAKE STRUCTURE
PROPOSED DIVERSION DAM
HAUL CANE ROAD
PROPOSED PENSTOCK
WAILUA FALLS
STATE ROAD 583
WAILUA RIVER
HYDROELECTRIC PROJECT
DIVERSION WEIR POOL
Bingham Engineering
SEPT 1985
609-015

FIGURE B-6a-2

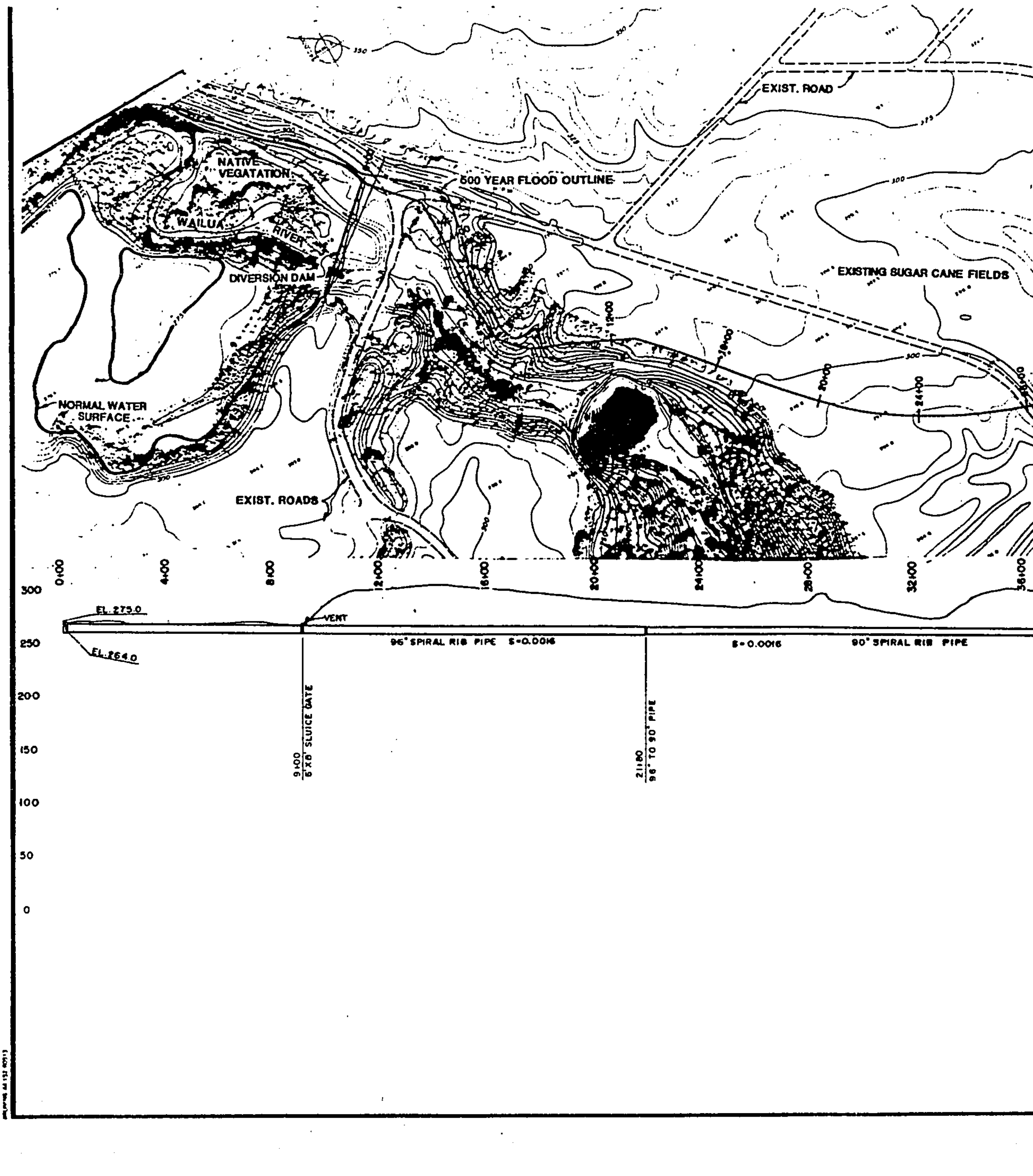


NOTE:
100 YEAR WATER SURFACE = 287.4'
96" Ø SPIRAL RIB PENSTOCK
4'x4' BOX CULVERT
CONC. GATE LIFT HOUSE
DOOR
WALKWAY
GATE LIFT
4'x4' SLUICE GATE
SLUICE DROP PLATES (2)
GRATING 3/8" x 3" AT 2" SPACING
MANHOLE W/LADDER (3'x3')
WING WALL
WEIR CREST EL. 275.0
SLUICEWAY
SLOT FOR STOP LOGS
Δ = 41° 38'
R = 12.04'
T = 4.58'
L = 8.75'
PLAN
SCALE: 1"=4'
SIDE VIEW
GATE LIFT H
6" CONC. ROOF
6" CONC. TYP.
EL. 264.0
EL. 280.0
NORMAL W.S. 274.5
CREST EL. 2
REFLECTED VIEW
SECTION
SECTION B-B
SCALE: 1"=4
EL. 280.0
12" DIA. PIPE
LADDER
R=3'
96" Ø SPIRAL RIB PENSTOCK
S=-0.0016

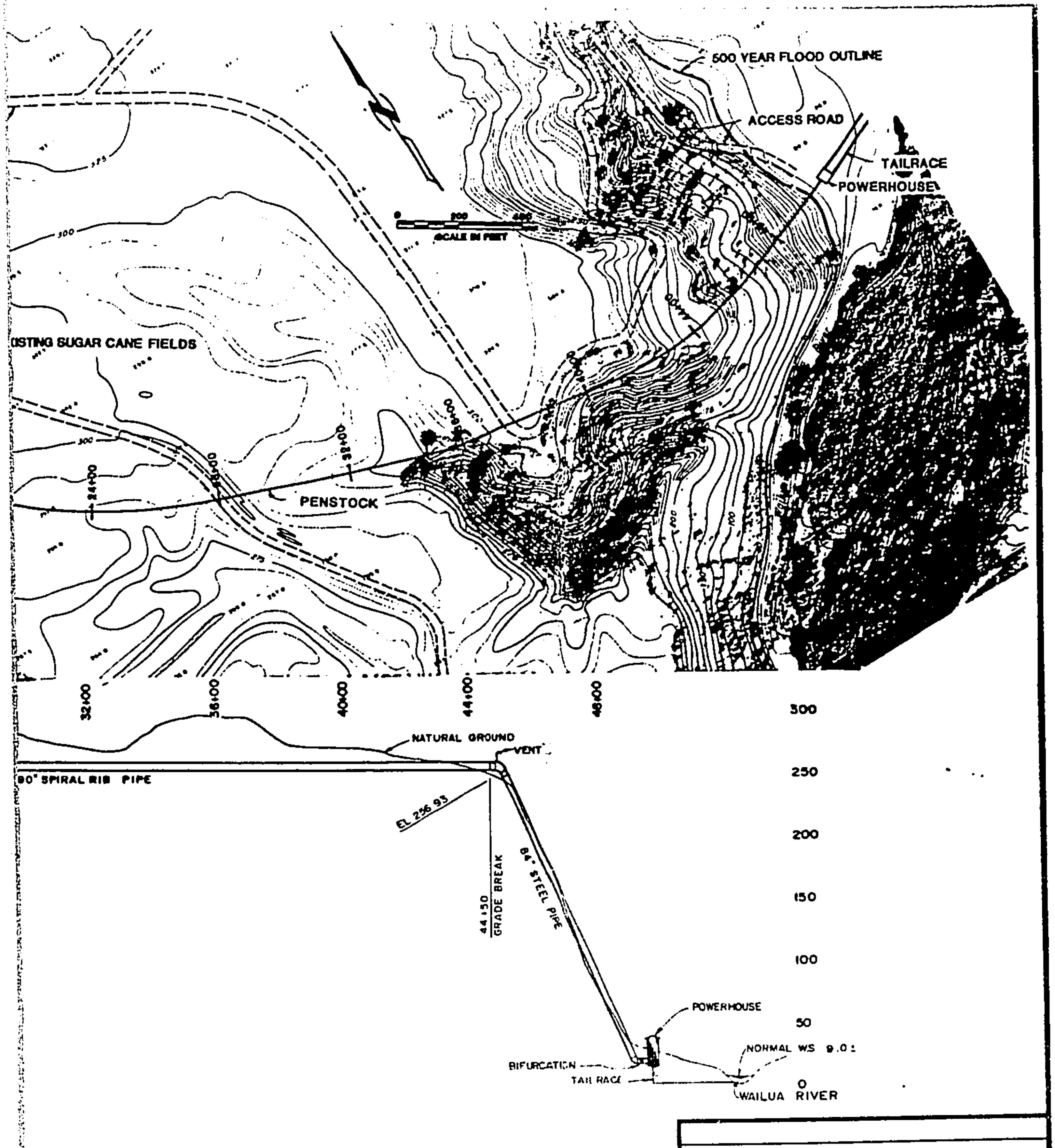


SECTION A-A
SCALE: 1"=4'
GATE LIFT
EL. 280.0
NORMAL W.S. 274.5
GRATING
SLUICE DROP PLATE
4'x4' SLUICE GATE
96" Ø PENSTOCK
WEIR CREST
EL. 275.0
EL. 264.0
16'-2"
8'-0"
15'-2"
20'-2"
12'-0"
SIDE VIEW
FRONT VIEW
GATE LIFT HOUSE
SCALE: 1"=4'
6" CONC. ROOF
DOOR 2'-6"x4'-6"
6" CONC. TYP.
WEIR CREST EL. 275.0
R=2.5'
DETAIL
LOW POINT ON ROAD EL. 262.0
EXIST. ROAD
SECTION D-D
NTS
CONCRETE GATE LIFT HOUSE
W.S. 274.5
CREST EL. 275.0
GRATING 3/8"x3" AT 2" SPACING
REFLECTED VIEW
4'x4' BOX CULVERT
SECTION C-C
SCALE: 1"=4'
VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY
WAILUA RIVER
HYDROELECTRIC PROJECT
INTAKE STRUCTURE
DETAILS
Bingham Engineering
Design: JRB
Drawn: CLL
Checked: JRB
Date OCT. 1985
Proj. # 609-015

FIGURE B-6a-3



EXIST. ROAD
NATIVE VEGATATION
500 YEAR FLOOD OUTLINE
WAILUA RIVER
DIVERSION DAM
EXISTING SUGAR CANE FIELDS
NORMAL WATER SURFACE
EXIST. ROADS
0+00
4+00
8+00
12+00
16+00
20+00
24+00
28+00
32+00
36+00
300
250
200
150
100
50
0
EL. 275.0
EL. 264.0
VENT
96" SPIRAL RIB PIPE S=0.0016
S=0.0016
90" SPIRAL RIB PIPE
9+00
6'X6' SLUICE GATE
21+00
96" TO 90" PIPE



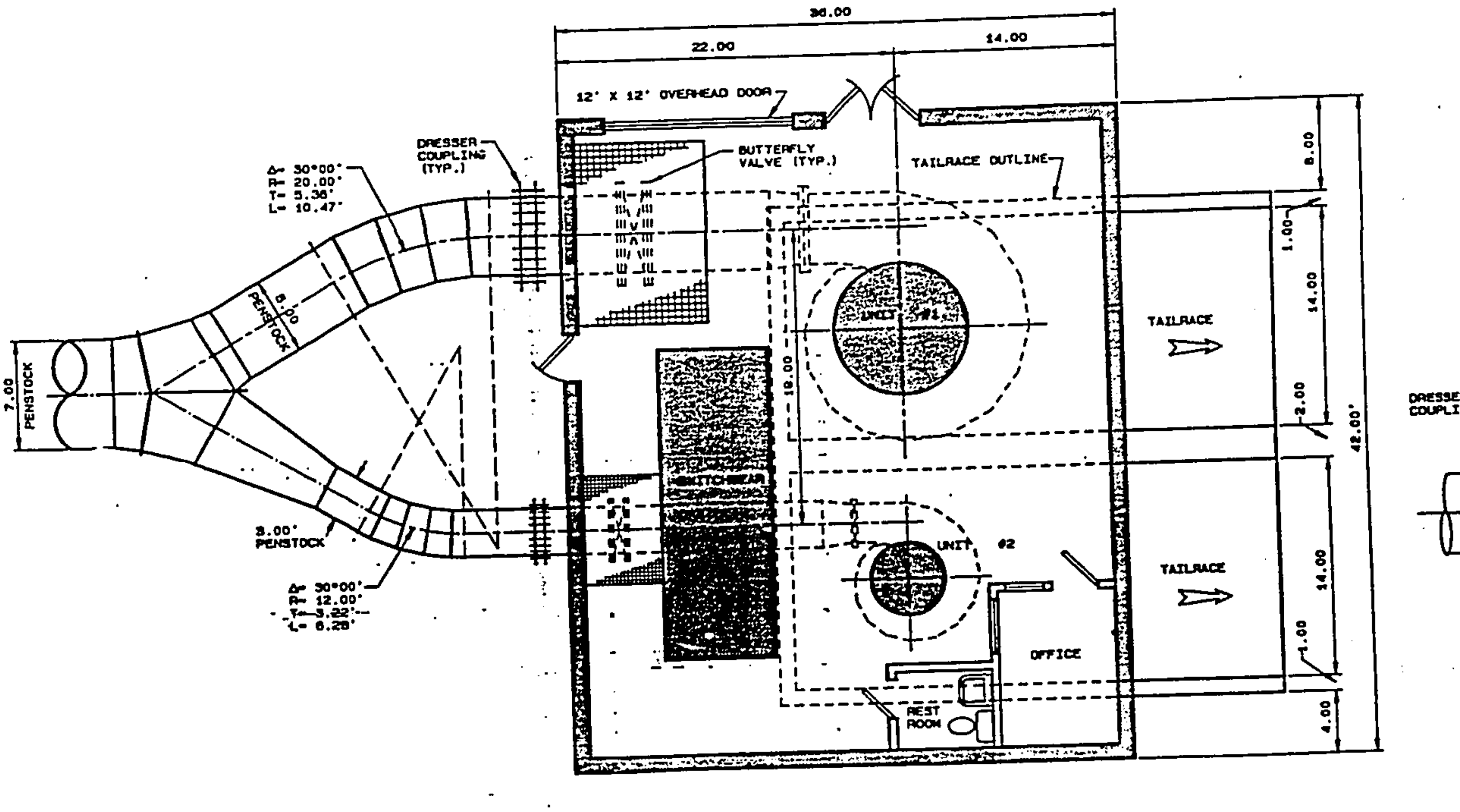
WAILUA RIVER
HYDROELECTRIC PROJECT
PLAN & PROFILE

Bingham Engineering

JULY 1985

609-015

FIGURE B-6a-4



FLOOR PLAN

0 5 10 15

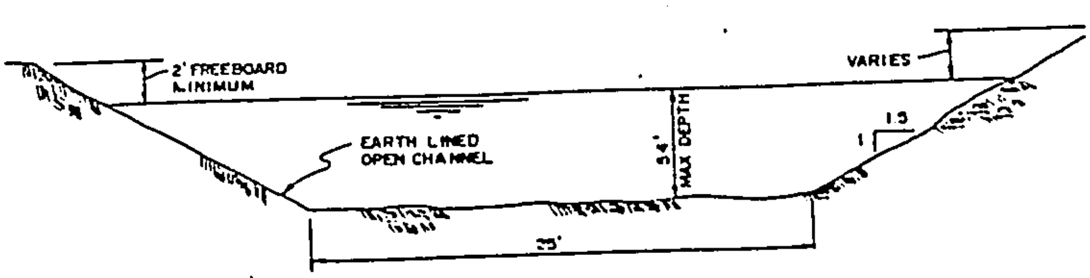
SCALE IN FEET

EQUIPMENT DATA

	UNIT #1	UNIT #2
GENERATOR RATING	5000 KW	1600 KW
TURBINE OUTPUT	6700 HP	2145 HP
MAXIMUM FLOW	294 CFS	96 CFS
MINIMUM FLOW	90 CFS	30 CFS
EFFECTIVE HEAD	257 ft.	257 ft.
RPM	514	900
OUTPUT VOLTAGE	4160	4160
RUNNER DIA.	42"	24"

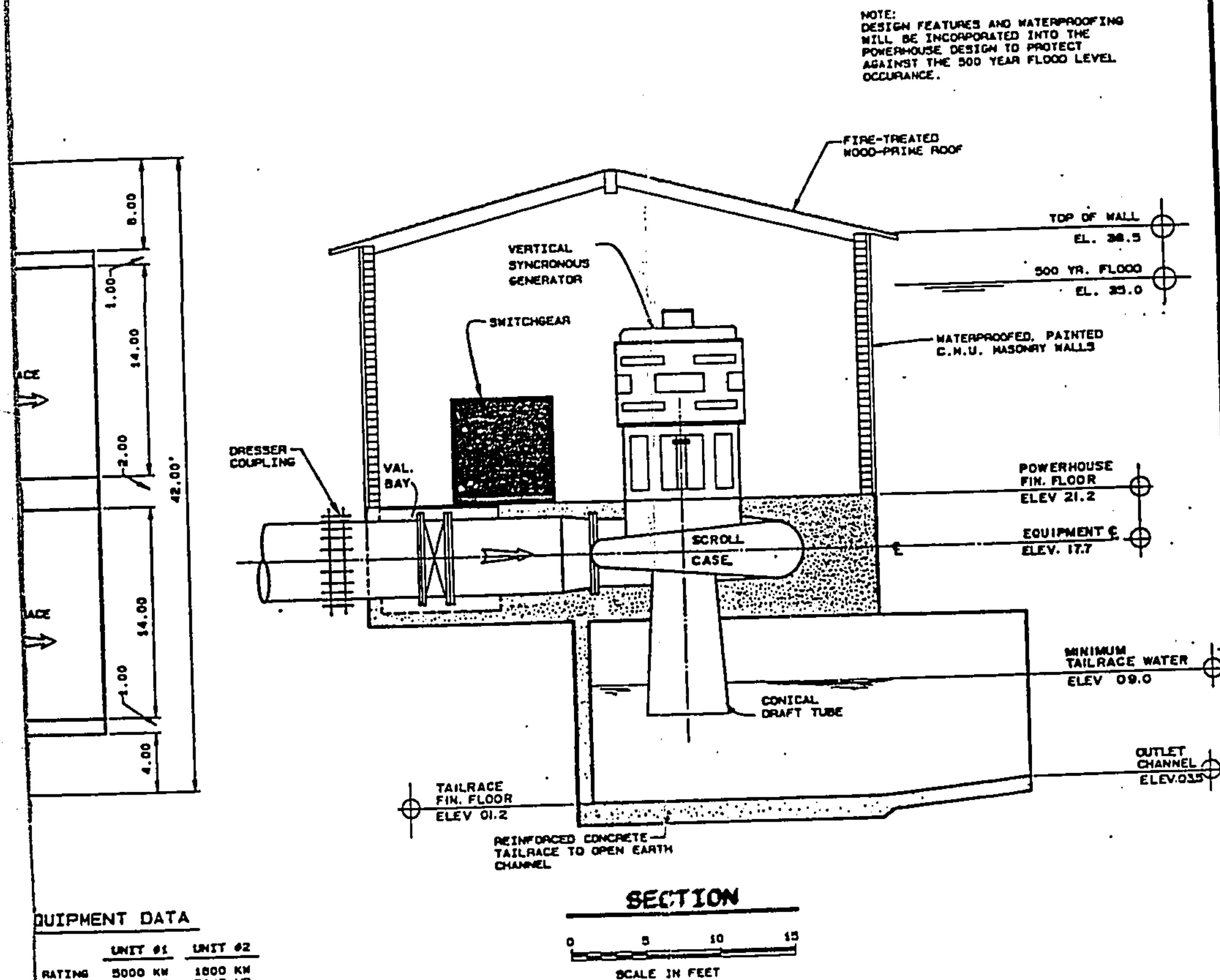
SWITCHGEAR – REMOTE, PROGRAMMABLE CONTR

SUBSTATION – TO CONTAIN TRANSFORMER WIT
STEP-UP VOLTAGE 4160 TO 57 KV



OUTLET CHANNEL

SCALE 1"= 5'



QUIPMENT DATA

	UNIT #1	UNIT #2
RATING	5000 KW	1600 KW
UTPUT	6700 HP	2145 HP
LOW	294 CFS	96 CFS
LOW	90 CFS	30 CFS
HEAD	257 ft.	257 ft.
	514	900
LTAGE	4160	4160
A.	42"	24"

R - REMOTE, PROGRAMMABLE CONTROLLED

H - TO CONTAIN TRANSFORMER WITH
EP-UP VOLTAGE 4160 TO 57 KV

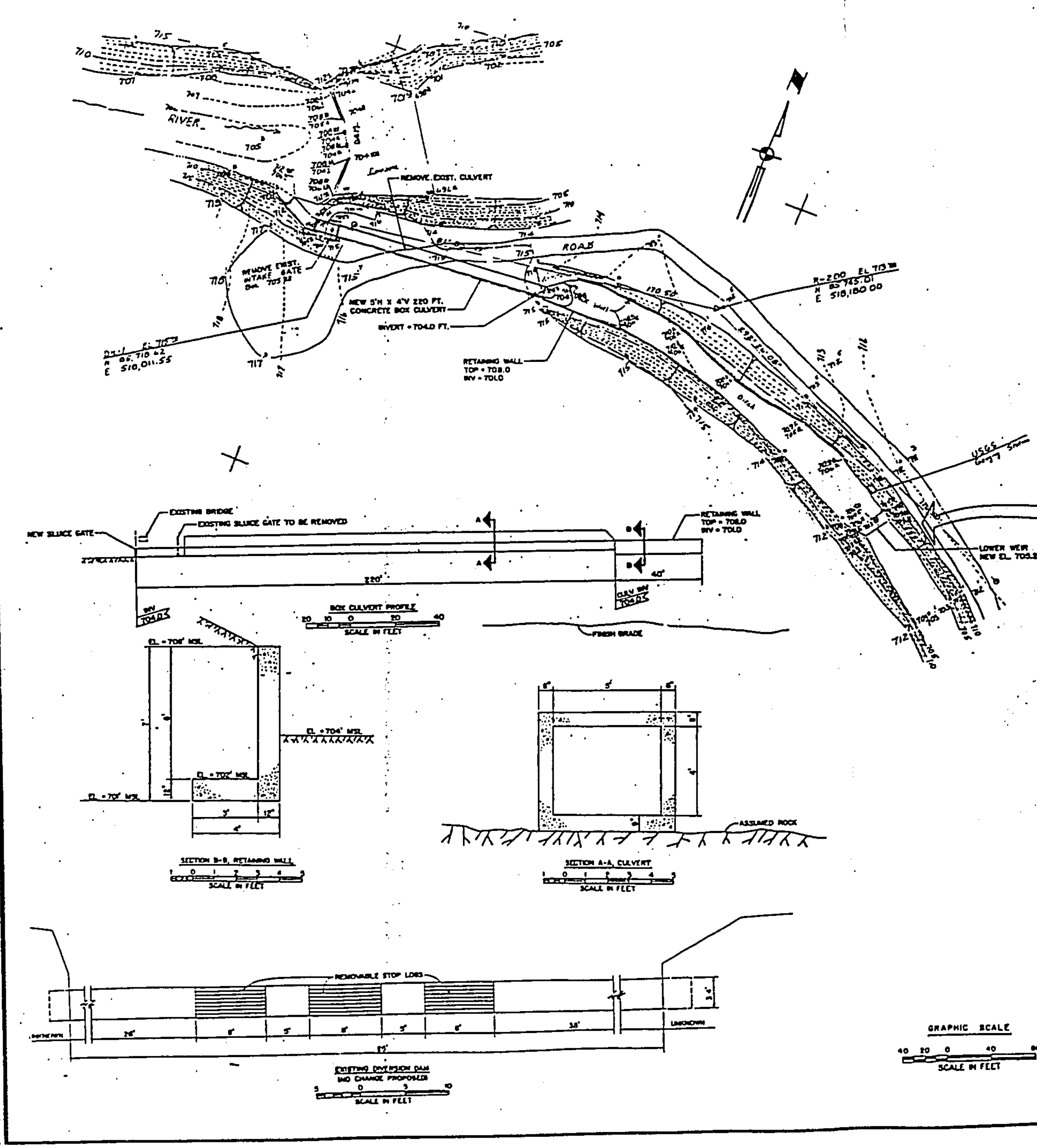
WAILUA RIVER
HYDROELECTRIC PROJECT

POWERHOUSE
PLAN AND SECTION

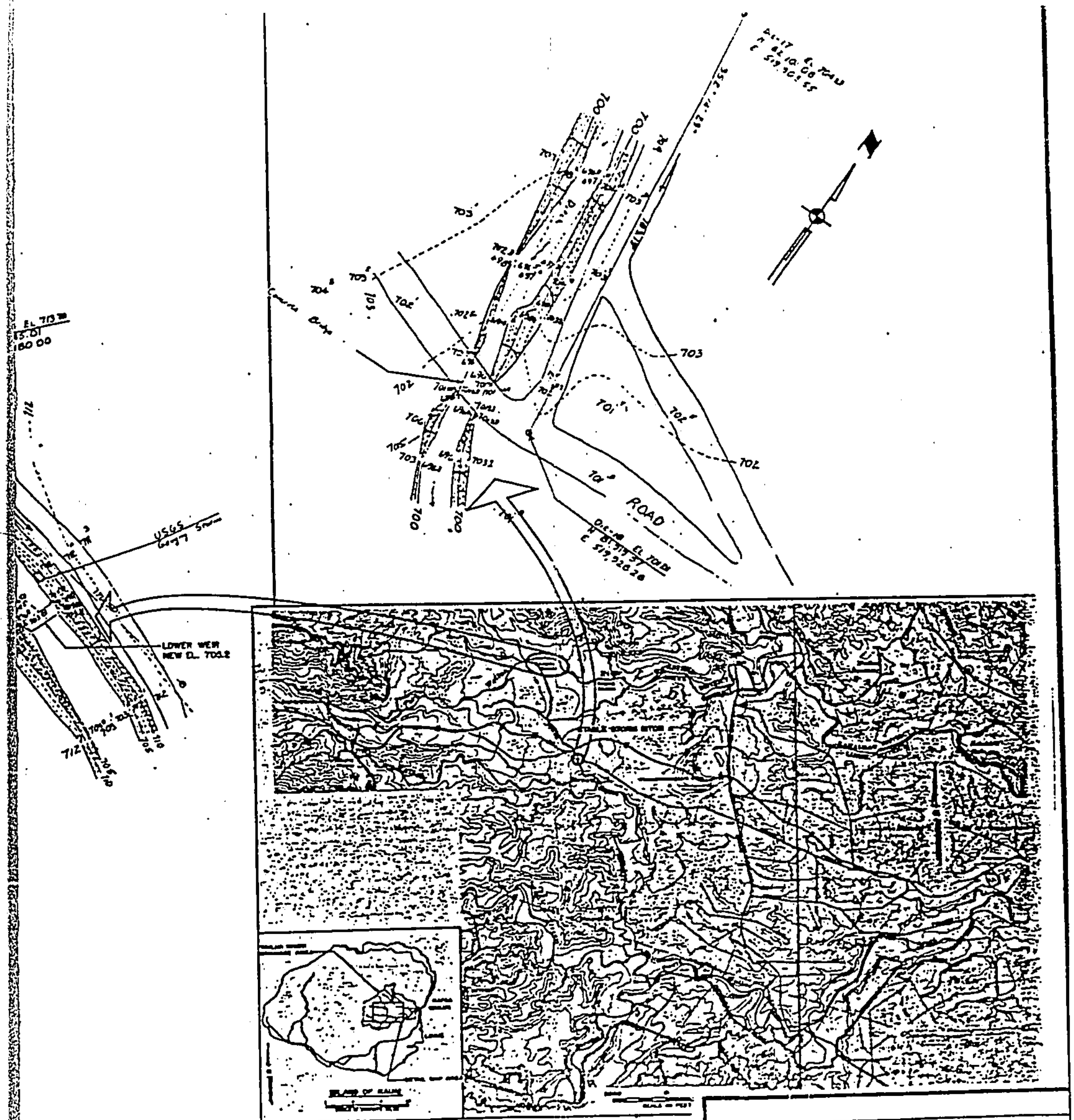
Bingham Engineering

JULY 1985 | 609-015

FIGURE B-6a-5



RIVER
ROAD
REMOVE EXIST. CULVERT
REMOVE EXIST. INTAKE GATE
NEW 5'H X 4'V 220 FT. CONCRETE BOX CULVERT
INVERT = 704.0 FT.
RETAINING WALL TOP = 708.0 INV = 701.0
DAM
LOWER WEIR
EXISTING BRIDGE
EXISTING SLUICE GATE TO BE REMOVED
NEW SLUICE GATE
RETAINING WALL TOP = 708.0 INV = 701.0
220'
40'
FINISH GRADE
BOX CULVERT PROFILE
SCALE IN FEET
EL = 708' MSL
EL = 704' MSL
EL = 702' MSL
EL = 701' MSL
SECTION B-B, RETAINING WALL
SCALE IN FEET
ASSUMED ROCK
SECTION A-A, CULVERT
SCALE IN FEET
REMOVABLE STOP LOGS
UNKNOWN
EXISTING DIVERSION DAM
(NO CHANGE PROPOSED)
SCALE IN FEET
GRAPHIC SCALE
SCALE IN FEET



SURVEY NOTES:

1. COORDINATES BASED ON HAWAII STATE PLANE COORDINATE SYSTEM, ZONE 3.
2. ALL ELEVATIONS BASED ON MEAN SEA LEVEL.
3. NORTH ARROW IS TRUE NORTH
4. TRAVERSE DONE BY TURNING ANGLES AND TAPING. THIRD ORDER SURVEY.
5. BENCHMARK IS STATE BENCHMARK # 20. RAILROAD SPIKE LOCATED IN CENTERLINE MAALO ROAD AND HAUL CANE ROAD NEAR EXPERIMENT STATION. EL 303.22 FT MSL.
6. DATE OF SURVEY: OCT - NOV 1981.

GRAPHIC SCALE

40 20 0 40 80

SCALE IN FEET

WAILUA RIVER
HYDROELECTRIC PROJECT

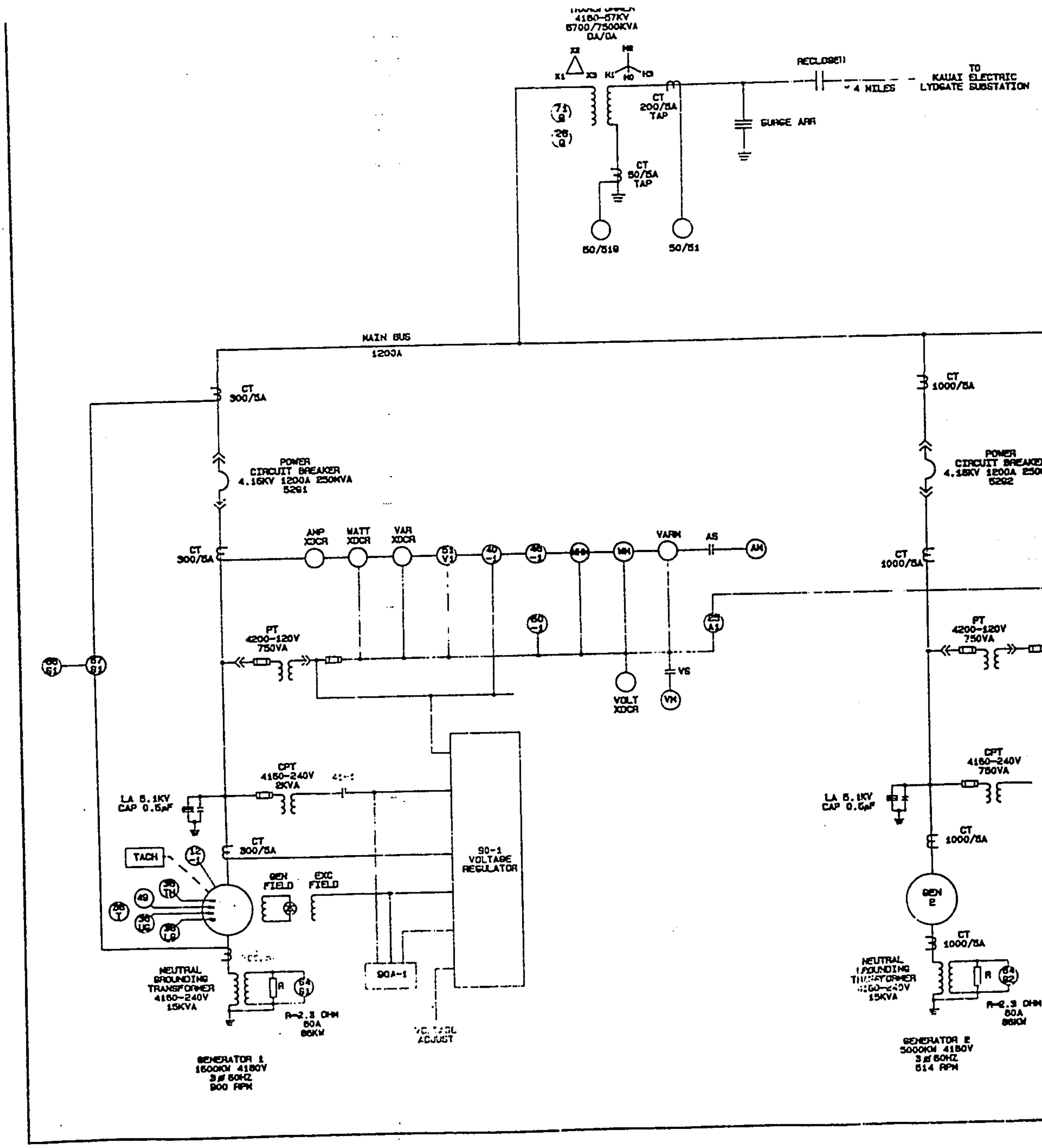
DIVERSION FEATURES
STABLE STORM DITCH

Bingham Engineering

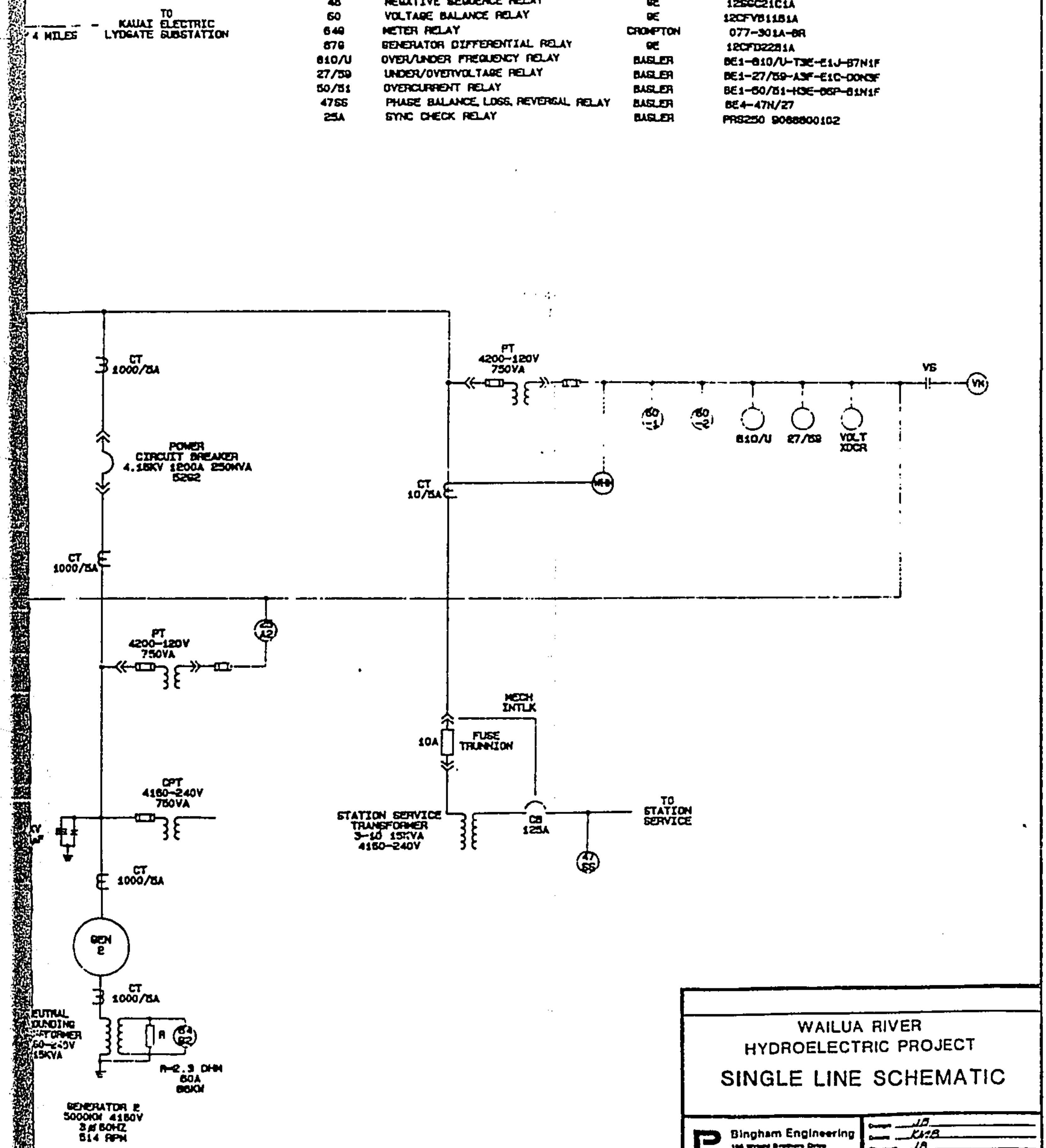
Design: JR
Drawn: KMB
Checked: JR

Date SEPT 1985 | Project # 609-015

FIGURE B-6a-6


4160-57KV
5700/7500KVA
OA/OA
X1
X2
X3
H1
H2
H3
H0
CT
200/5A
TAP
CT
50/5A
TAP
50/51G
50/51
RECLOSER
4 MILES
TO
KAUAI ELECTRIC
LYDGATE SUBSTATION
SURGE ARR
MAIN BUS
1200A
CT
300/5A
POWER
CIRCUIT BREAKER
4.16KV 1200A 250MVA
5201
CT
300/5A
AMP
XDCR
WATT
XDCR
VAR
XDCR
VARM
AS
AM
PT
4200-120V
750VA
VOLT
XDCR
VS
VM
CPT
4160-240V
2KVA
LA 5.1KV
CAP 0.5µF
CT
300/5A
TACH
GEN
FIELD
EXC
FIELD
90-1
VOLTAGE
REGULATOR
90A-1
NEUTRAL
GROUNDING
TRANSFORMER
4160-240V
15KVA
R=2.3 OHM
60A
86KW
GENERATOR 1
1500KW 4160V
3ø 60HZ
900 RPM
CT
1000/5A
POWER
CIRCUIT BREAKER
4.16KV 1200A
5202
CT
1000/5A
PT
4200-120V
750VA
CPT
4160-240V
750VA
LA 5.1KV
CAP 0.5µF
CT
1000/5A
GEN
2
CT
1000/5A
NEUTRAL
15KVA
GENERATOR 2
5000KW 4160V
3ø 60HZ
514 RPM

ANSI SCHEME NO.	DESCRIPTION	MANUFACTURER	CATALOG NO.	RELAY SETTING
51V	TIME OVER CURRENT RELAY	GE	12IFCV51AD1A	
40	LOSS OF EXCITATION RELAY	GE	12CEH51A1A	
46	NEGATIVE SEQUENCE RELAY	GE	12SGC21C1A	
60	VOLTAGE BALANCE RELAY	GE	12CFVB11B1A	
64G	METER RELAY	CROMPTON	077-301A-6R	
87G	GENERATOR DIFFERENTIAL RELAY	GE	12CFD22B1A	
810/U	OVER/UNDER FREQUENCY RELAY	BASLER	BE1-810/U-T3E-E1J-B7N1F	
27/59	UNDER/OVERVOLTAGE RELAY	BASLER	BE1-27/59-A3F-E1C-D0N3F	
50/51	OVERCURRENT RELAY	BASLER	BE1-50/51-H3E-B6P-B1N1F	
47SS	PHASE BALANCE, LOSS, REVERSAL RELAY	BASLER	BE4-47N/27	
25A	SYNC CHECK RELAY	BASLER	PRS250 9068800102	



WAILUA RIVER HYDROELECTRIC PROJECT

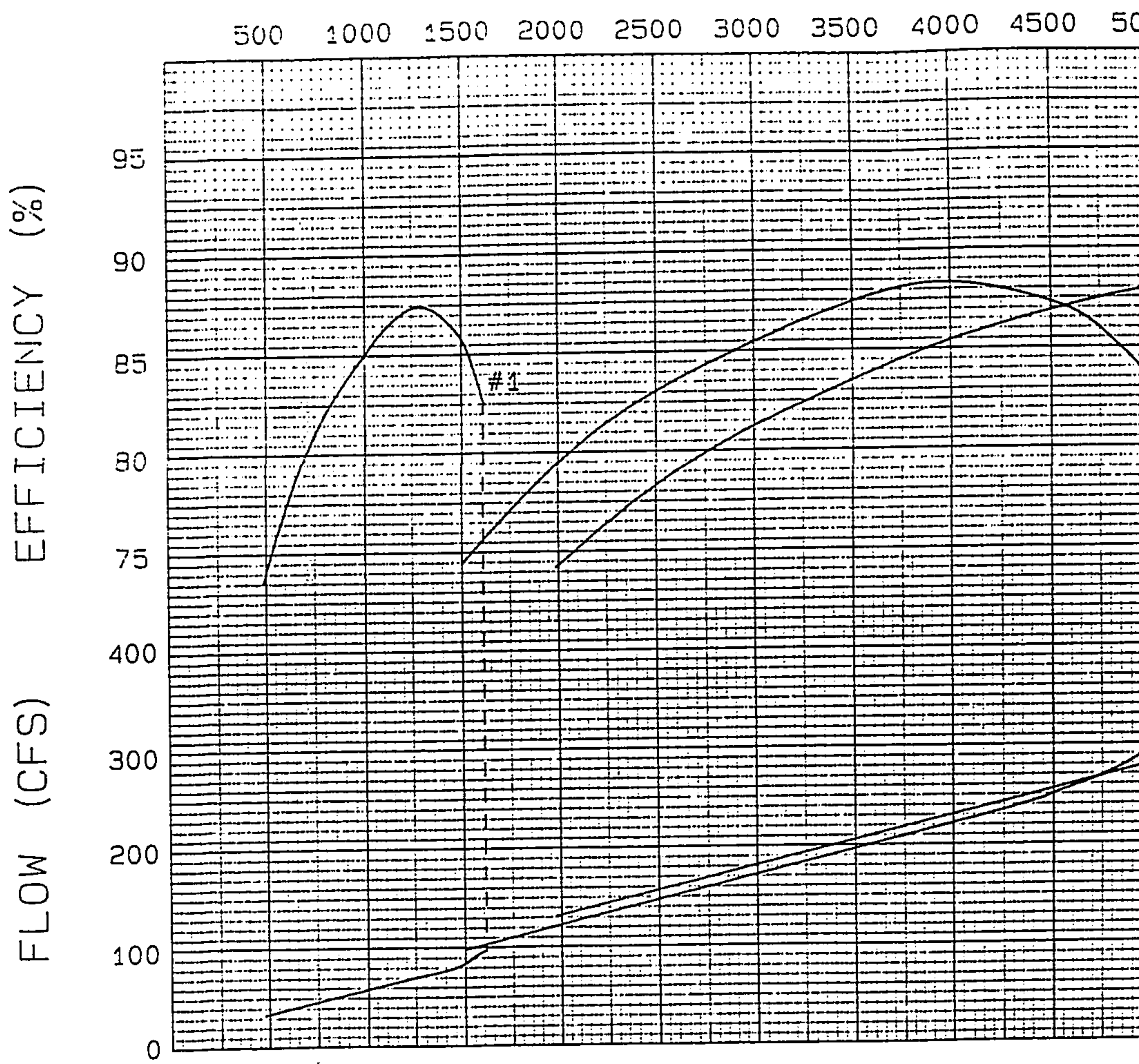
SINGLE LINE SCHEMATIC

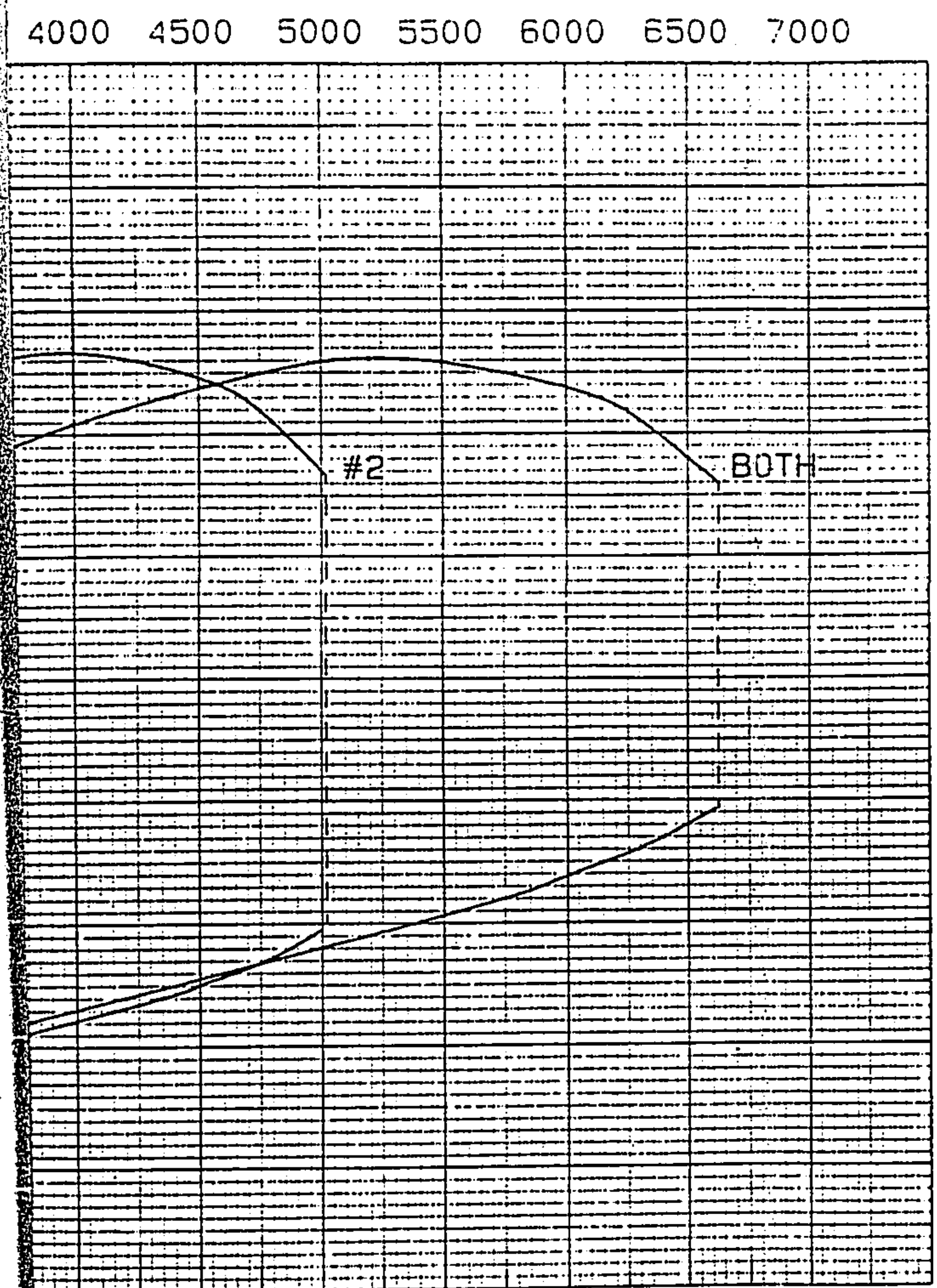
Bingham Engineering

SEPT 1985

609-015

FIGURE B-6a-7


500
1000
1500
2000
2500
3000
3500
4000
4500
EFFICIENCY (%)
95
90
85
80
75
#1
FLOW (CFS)
400
300
200
100
0



UNIT #1
FRANCIS TURBINE IN
SPIRAL CASE
Ns: 46
He (ft):
SPEED: 900 RPM
SETTING: 4 ft ABOVE
MINIMUM TAILWATER

UNIT #2
FRANCIS TURBINE IN
SPIRAL CASE
Ns: 46
He: Ft
SPEED: 514 RPM
SETTING: 4 Ft ABOVE
MINIMUM TAILWATER

WAILUA RIVER
HYDROELECTRIC PROJECT

EXPECTED TURBINE PERFORMANCE

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FIGURE B-6a-8

B-6b. HYDROLOGIC INVESTIGATIONS

B-6b. HYDROLOGIC INVESTIGATIONS

RAINFALL

1. Average annual rainfall varies from approximately 50 inches near the coastline to over 450 inches on Mount Waialeale. An isohyetal map of the Wailua Basin is shown on Plate B-1. Rainfall stations shown on Plate B-1 are listed on Table B-6b-1.

STREAMFLOW

2. Principal watercourses in the Wailua River Basin are the North and South Forks of the Wailua River and Opaekaa Stream, with drainage areas of 18.5, 26.0 and 6.4 square miles, respectively. Total drainage area in the Wailua Basin is 51.6 square miles. Principal watercourses and tributaries are shown on Plate B-2. Table B-6b-2 lists the stream and ditch-gaging stations operated by the U.S. Geological Survey in the Wailua Basin and Table B-6b-3 lists the ditch stations operated by Lihue Plantation.

IRRIGATION DIVERSION

3. The network of streams and irrigation ditches in the Wailua River Basin, shown on Plate B-2, create a complex pattern of surface flow. A description of the diversions occurring the Basin follows:

a. The Hanalei Tunnel conveys waters from the Hanalei River basin into the North Fork Wailua River Basin from which the water is diverted downstream for irrigation in the vicinity of Lihue and Kapaa.

b. Streamflows from the North Fork are diverted at four locations. The upper two diversions, the Iliiliula-North Wailua Ditch and Stable Storm Ditches, take water to the South Fork Basin. The third diversion, the Wailua Ditch, takes water to Wailua Reservoir and from there for irrigation above Kapaa. The fourth diversion, the Aahoaka Ditch is the lowest of the diversions on the North Fork. This ditch is used for irrigation of sugar cane in the Aahoaka area. The main function of the Iliiliula-North Wailua Ditch is to provide water for hydroelectric generation at Lihue Plantation's Upper Power House. The diverted water via the Stable Storm Ditch is used for irrigation in the vicinity of Lihue.

c. Water comes into the South Fork basin via the two North Fork diversions and is diverted at three locations: The Koloa Ditch transports water south to the McBryde Sugar Company fields in Koloa, and the Upper Lihue Plantation's use. The Upper Lihue Ditch branches into the Upper Lihue Ditch conveys water to Kapaia Reservoir for mill and irrigation use.

d. In formulating alternatives, it was assumed that the diversions and the external inflows and outflows will continue.

TABLE 6-6b-1

RAINFALL STATIONS

State Key Number	Station Name	Elevation Above MSL (Feet)	Latitude Deg-Min-Sec	Longitude Deg-Min-Sec	Period of Record	Frequency of Observations	Observer
1022	Hanamaulu	176	21-59-42	159-21-30	1893-date	Daily	Lihue Plantation
1047	Mt. Waialeale	5,075	22-04-06	159-30-00	1910-date	Continuous	USGS
1050	Iliiliula Intake	1,070	22-02-24	159-28-10	1935-date	Daily	Lihue Plantation
1051	N. Wailua Ditch	1,110	22-03-36	159-27-54	1928-date	Daily	Lihue Plantation
1052	Waiahi Upper	780	22-01-24	159-28-00	1931-date	Daily	Lihue Plantation
1053	Hanalei Tunnel	1,220	22-05-00	159-28-12	1928-date	Monthly	Lihue Plantation
1054	Waiahi Lower	550	22-01-06	159-26-40	1910-date	Daily	Lihue Plantation
1055	N. Wailua River	650	22-03-40	159-26-10	1915-date	Monthly	Lihue Plantation
1056	Wailua River #1	800	22-04-43	159-25-27	1963-date	Continuous	USGS
1056.1	Wailua River #2	1,600	22-05-40	159-26-27	1963-date	Continuous	USGS
1056.2	Wailua River #3	1,970	22-06-10	159-26-54	1963-date	Continuous	USGS
1056.3	Wailua River #4	2,177	22-07-02	159-26-26	1963-date	Continuous	USGS
1057	Hanamaulu 46	670	22-03-40	159-25-24	1935-date	Monthly	Lihue Plantation
1061	EKM 6	425	22-03-36	159-24-12	1932-date	Daily	Lihue Plantation
1062	Wailua Uka	260	22-01-30	159-24-06	1924-date	Daily	Lihue Plantation
1063	Field 619	300	22-04-30	159-21-40	1940-date	After rain	Hawaiian Fruit Packers
1065	Wailua Kai	70	22-02-24	159-20-36	1924-date	Daily	Lihue Plantation

Note: Above data from "Climatologic Stations in Hawaii", Report R42, State of Hawaii.

TABLE B-6b-2

STREAM AND DITCH GAGING STATIONS

USGS STATION NUMBER	USGS STATION NAME	DRAINAGE AREA (SQ. MI.)	ELEVATION (FEET)	PERIOD OF RECORD
600	South Fork Wailua River Near Lihue	22.4	240	1911-current
610	North Fork Wailua Near Lihue	--	1,105	1932-current
612	North Wailua Ditch Below Waikoko Stream	--	1,070	1965-current
620	Stable Storm Ditch Near Lihue	--	710	1936-current
630	North Fork Wailua River at Altitude 650 ft.	5.29	650	1914-current
680	East Branch of North Fork Wailua River	6.27	500	1912-current
690	Wailua Ditch near Kapaa	--	462	1936-current
700	Aahoaka Ditch near Kapaa	--	400	1966-current
710	North Fork Wailua River near Kapaa	17.9	18	1952-current
715	Left Branch Opeakaa Stream	0.65	458	1960-current
1000	Hanalei Tunnel Outlet near Lihue	--	1,120	1932-current

TABLE B-6b-3

LIHUE PLANTATION STATIONS

Station Description	Elevation (Feet)	Period of Record Comments
Hanamaulu Ditch	400	Ditch constructed in 1903; there are 13 years of no record between 1903 and 1926.
Upper Lihue Ditch	520	Ditch constructed in 1903; there are 13 years of no record between 1903 and 1926.
Lower Lihue Ditch	470	Date of ditch construction circa 1903; more than 20 years of no record prior to 1925.
Koloa Ditch	780	Ditch constructed in 1915; first 12 years of diversion not measured.

FLOW DURATION

4. Basic Data. Information from two USGS stream gaging stations were used to construct flow duration information for this study. The two stations were Station 600, South Fork Wailua River near Lihue and Station 630, North Fork Wailua River at altitude 650 feet near Lihue. The respective drainage areas are 22.4 and 5.29 square miles. Station 600 has 67 years of daily flow values available from 1903 to 1984 with missing data years for 1919, 1921, 1925, 1957 and 1958. Station 600 has 68 years of daily flow values available from 1916 to 1984 with missing flow data for year 1919. Flow duration curves for Stations 600 and 630 are shown on Plates B-3 and B-4.

5. Role in Project Formulation. In the preliminary screening of sites for the relative location of diversion and powerplant, an inspection of the topography, the constructability and the relationship of discharge and differences in elevation were analyzed. A graphical relationship of discharge at 20 percent flow duration exceedance frequency and elevation of the length of the South Fork Wailua River is shown on Plate B-4A. The discharge along the lower river was determined from the actual records of USGS Gage 600 (Plate B-3) and supplemental analysis from othe related studies. The 20 percent flow near Wailua Falls was determined to be 150 cubic feet per second (cfs). From the Belt, Colllins and Associate Study, approximately 83 percent (or 124 cfs) of the runoff was generated from areas of higher elevation where there are a significant number of tributaries. Finally, from a recent U.S. Army Engineer District, Honolulu

Study of headwaters for the Island of Kauai, the headwater point was determined to be located 17.7 miles above the mouth. The 20 percent discharge at this location would be less than one cfs.

6. The relationship of various powerplant locations are shown in Table B-6b-4. The information developed for this table was used in conjunction with the visual evaluation of topographpy and constructability to derive the suitable alternative location of the hydropower facilities.

TABLE B-6b-4

RELATIVE POWERPLANT CAPACITIES
AT LOCATIONS ALONG THE SOUTH FORK WAILUA RIVER

Location, Mile Above Mouth Powerplant	Diversion	Relative Difference in Elevation (Feet)	Approx. Discharge (cfs)	Approx. Discharge (cfs)
2	3	4	154	40
4	5	210	150	2,200
8	9	50	127	440
13	14	60	69	290
16	17	210	15	220

7. Project Flow Duration Curves. To derive the total flow available at Station 600 with the additional diverted flow from Station 630 via the Stable Storm Ditch, the following table was used with the results tabulated on Table B-6a-6. Flow duration curve flows for Station 630 were read at selected intervals and tabulated. High flows between the 0 to 20% interval were allowed to pass downstream into the North Fork Wailua River and only flows between 20% to the 100% interval were allowed to be diverted via the Stable Storm Ditch to the South Fork Wailua River. The diverted flows were added to the flows of Station 600 at selected intervals.

8. The combined flows represent the flow available for power near Station 600. Fifteen cfs was subtracted from the combined flows for instream use in the South Fork Wailua River. The flow duration curve depicting the total flows available near Station 630 were assumed to remain the same when arriving at Station 600. Table B-6b-5 shows the historic measurements for the two gages. Station 585 is a low flow partial record station and is located about 3 miles upstream of Station 600.

9. In comparing the natural and project flow conditions, the existing gaged records satisfactorily represent the expected flow conditions at the proposed diversions. Both Station 630 (North Fork Wailua) and Station 600 (South Fork Wailua) are sufficiently close enough to the proposed diversion points to directly utilize the records without adjustment.

10. The impact of the project on the existing streamflow regime were similarly derived. Plates B-5A, B-5B, B-5C and B-5D illustrate the estimated effects of the project implementation upon the existing flow duration curves at existing USGS gage sites. As shown on Plate B-5A, the natural regime on the South Fork Wailua River is acutally enhanced from 50 to 100 percent exceedance points. This increase is due to the added diversion flowing through the Stable Storm Ditch (Plate B-5B). In contrast, there exists an adverse impact on the North Fork Wailua River (Plates B-5C and B-5D). In all cases of these flow duration curves, the discharges were assumed to be directly and linerally added or subtracted at the respected exceedance percentage.

TABLE B-6b-5

LOW FLOW MEASUREMENTS SHOWING THE GAINING NATURE OF SOUTH FORK WAILUA RIVER

Date	Q in cfs Station 585 (DA = 20.2 SQ. MI.)	Q in cfs Station 600 (DA = 22.4 SQ. MI.)
10-01-74	4.8	10.0
06-03-75	2.8	4.8
06-24-75	4.0	8.1
06-27-75	3.2	5.1
07-11-75	2.2	4.0
07-23-75	2.0	4.6
08-26-75	2.1	3.9
09-26-75	1.5	2.5
10-28-75	2.7	5.7
06-03-76	3.4	5.7
09-01-76	2.3	5.1
01-21-77	1.7	4.0
03-25-77	2.9	7.1
07-25-77	2.5	9.3
02-01-78	2.3	4.2
01-03-79	3.2	7.5
04-03-79	3.3	7.7
05-01-79	3.2	6.1
12-05-79	4.1	6.9
02-27-80	6.0	8.2
04-01-80	5.2	10.0
07-01-80	8.5	52.0

Note: Station 585 is a low flow partial record station and is located about 3 miles upstream of Station 600.

11. The ranges of turbine discharge are described in Section B-6A (Functional Elements). Based on the flow duration curves and the design conditions, specific discharge impacts for the South Fork Wailua River on the Falls and downstream of the tailrace are shown on Table B-6b-6. Similarly, the impacts for the North Fork River are provided in Tables B-6b-7 and B-6b-8. To summarize, all flows from the North Fork River up to 100 cfs would be diverted to the South Fork River via the Stable Storm Ditch. On the South Fork, flows would not be diverted unless the project condition discharge exceeds the sum of the minimum turbine discharge (30 cfs) plus the conservation flow (15 cfs) for a total flow of 45 cfs. Below this project condition discharge value, the flows will pass unaffected to downstream reaches. The maximum diversion discharge would be the sum of the maximum turbine discharge (365cfs) plus the conservation discharge (15 cfs) totaling 380 cfs.

TABLE B-6b-6

DISCHARGE IMPACT ON FALLS AND ON DOWNSTREAM SOUTH FORK WAILUA RIVER

Condition	Range of Flows (cfs)			
	0-15	15-45	45-380	380 to peak
Impact on Falls				
Existing Condition (percent)	44%	16%	34%	6%
Project Condition (percent)	19%	71%	6%	4%
Net (percent)	-25%	+55%	-28%	-2%
Time (days/year)	-91	+201	-102	-7
Impact on Downstream South Fork				
Existing Condition (percent)	44%	16%	34%	6%
Project Condition (percent)	19%	17%	52%	12%
Net (percent)	-25%	+1%	+18%	+6%
Time (days/year)	-91	+4	+66	+22

Minimum flow in river for diversion = 45 cfs
Range of turbine flows = 30 to 365 cfs

TABLE B-6b-7

DISCHARGE IMPACT ON NORTH FORK WAILUA
IMMEDIATELY DOWNSTREAM OF STABLE STORM
DITCH DIVERSION

Condition	Range of Flows (cfs) 0-10	10-100	100-400	400 to peak
Impact on Falls				
Exisiting Condition (percent)	19%	61%	18%	2%
Project Condition (percent)	82%	11%	5%	2%
Net (percent)	+63%	-50%	-13%	0%
Time (days/year)	+230	-183	-47%	0

Based on USGS Gage 630, DA = 5.3 Mi^2
(Plate B-5C)

TABLE B-6b-8

DISCHARGE IMPACT ON NORTH FORK WAILUA
NEAR WAILUA HOMESTEADS

Condition	Range of Flows (cfs) 0-10	10-100	100-400	400 to peak
Impact on Falls				
Exisiting Condition (percent)	18%	44%	32%	6%
Project Condition (percent)	61%	22%	11%	6%
Net (percent)	+43%	+22%	+21%	0%
Time (days/year)	+157	+80	+77%	0

Based on USGS Gage #710, DA = 17.9 Mi^2
(Plate B-5D)

LOW FLOW FREQUENCY ANALYSIS

12. Low flow frequency curves for Station 600, South Fork Wailua River near Lihue and Station 630, North Fork Wailua River at altitude 650 feet near Lihue, using duration period of 1, 3, 7, 30, 60, 90 and 183 days were computed using the USGS Watstore computer program. Curves for the 1-day and 7-day duration for both stations are shown on Plates B-6 and B-7. For Station 600, 15 cfs was selected as a minimum flow criterion for instream use. From the curves from Plate B-6, the 1-day and 7-day low flows have a nonexceedance frequency of 97 and 94 percent respectively. This means that 97 and 94 percent of the time, the 1-day and 7-day low flows in any given year will be less than 15 cfs. Therefore, the selection of 15 cfs for instream use represents a sufficient amount of flow at this site. In fact, the proposed project will reduce the amount of time that flows occur between 0-15 cfs. No provisions for minimum bypass flows have been made at the existing Stable Storm Ditch diversion. Total diversion of the North Fork into the Stable Storm Ditch is made each year for irrigation purposes. New provisions for minimum bypass flows at this diversion would have a significant impact upon Lihue Plantation operations. Therefore, the existing condition of no minimum bypass flows at the Stable Storm Ditch diversion will be maintained.

13. Although there is some concern for increasing periods of total diversion from the North Fork into the Stable Storm Ditch, Table B-6b-9 shows the gaining nature of the North Fork in which flows increase significantly. USGS Station 16063000 located just below the Stable Storm Ditch diversion at elevation 650, shows low flow measurements during various times of the year. USGS Station 16068000 shows flows from the East Branch of the North Fork at elevation 500 just above the confluence with the North Fork. Station 16067100 shows flows in the North Fork at elevation 18 which reflects the contribution of the East Branch North Fork. Table B-6b-10 shows the average monthly flows of the East Branch North Fork, USGS Station 16068000 for the period 1913-1984. These flows contribute significantly to the North Fork which provides irrigation flows and sufficient flows for aquatic resources and the visual appeal of Kaholalele Falls.

FLOOD FREQUENCY

14. The Wailua River Basin has several long term gaging stations as listed in Table B-6b-2. Key among these are Station 630, North Fork Wailua, which depict conditions in the lower part of the basin. A floodflow frequency curve for Station 630 was calculated based on its own systematic record of 61 years of record and is shown on Plate B-8.

15. Floodflow frequency curves for Station 600 and Station 710 were calculated from the respective systematic records and are shown on Plates B-9 and B-10. There is one high flow that plots above the curves shown on Plate B-10. Although it is probably a high outlier, it was included in calculating the curve for Station 710 because curve adjustment information is unavailable on past historical flood peaks.

TABLE B-6b-9

LOW FLOW MEASUREMENTS SHOWING GAINING NATURE
OF THE NORTH FORK WAILUA RIVER BELOW STATION 160630000
FOR PERIOD BETWEEN OCTOBER 1965 — SEPTEMBER 1970

DATE	Flow (cfs) Station 16063000 North Fork Wailua Elevation 650	Flow (cfs) Station 16068000 East Branch North Fork Elevation 500	Flow (cfs) Station 160671000 North Fork Wailua Elevation 18
October 11, 1965	1.2	19	39
January 28, 1966	1.6	23	43
March 29, 1966	0.43	15	22
June 21, 1967	0.74	21	21
July 2, 1967	1.2	17	24
September 28, 1967	0.74	22	20
March 2, 1968	0.62	15	22
April 6, 1968	0.76	26	34
June 2, 1968	0.44	15	23
February 27, 1970	0.74	14	29
March 1, 1970	0.69	12	30

TABLE B-6b-10

BINGHAM ENGINEERING HYDROLOGY DIVISION
WAILUA RIVER HYDROELECTRIC PROJECT

STATION NUMBER 16068000 · LATITUDE 220419 · LONGITUDE 1592505
EB OF NF WAILUA RIVER NR LIHUE, KAUAI, HI
DRAINAGE AREA 5.27 · PROJECT STREAM · DATUM 500.90 · SOURCE AGENCY USGS

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1913	39.	39.	51.	45.	30.	25.	43.	38.	39.	34.	30.	28.	441
1914	35.	79.	51.	38.	25.	24.	30.	48.	62.	60.	55.	79.	583
1916	81.	170.	35.	146.	49.	122.	51.	100.	44.	47.	40.	27.	971
1917	29.	65.	121.	80.	37.	139.	42.	38.	40.	43.	37.	25.	697
1919	31.	36.	34.	36.	48.	91.	67.	45.	46.	35.	25.	22.	516
1920	18.	25.	26.	78.	20.	72.	51.	35.	32.	35.	53.	61.	506
1921	54.	42.	97.	392.	43.	34.	45.	32.	28.	33.	36.	31.	867
1922	41.	29.	111.	68.	66.	63.	53.	51.	27.	23.	24.	106.	662
1923	47.	78.	30.	180.	44.	78.	55.	29.	21.	26.	29.	33.	631
1924	48.	33.	97.	40.	35.	22.	115.	57.	25.	38.	30.	17.	555
1925	45.	37.	31.	50.	44.	31.	61.	33.	32.	41.	41.	44.	490
1926	48.	45.	24.	21.	17.	15.	11.	10.	31.	12.	18.	71.	322
1927	28.	25.	54.	89.	30.	75.	173.	134.	44.	36.	49.	54.	791
1928	32.	54.	142.	35.	37.	28.	85.	51.	24.	40.	49.	42.	518
1929	26.	102.	42.	22.	33.	47.	43.	52.	32.	65.	39.	29.	540
1930	38.	50.	67.	77.	51.	56.	48.	34.	44.	56.	58.	32.	670
1931	59.	76.	31.	29.	23.	28.	24.	21.	20.	36.	63.	66.	476
1932	59.	43.	54.	59.	152.	45.	50.	79.	35.	30.	35.	27.	668
1933	23.	59.	53.	95.	70.	80.	30.	50.	42.	42.	31.	22.	597
1934	19.	17.	38.	31.	16.	13.	42.	38.	46.	58.	32.	53.	402
1935	55.	61.	41.	39.	37.	58.	29.	24.	28.	27.	39.	52.	488
1936	36.	41.	49.	41.	23.	61.	23.	43.	22.	51.	72.	49.	513
1937	79.	38.	53.	81.	76.	91.	51.	87.	25.	43.	56.	39.	729
1938	45.	55.	38.	45.	72.	65.	59.	41.	51.	36.	48.	29.	583
1939	29.	48.	32.	32.	44.	62.	81.	49.	41.	37.	23.	20.	496
1940	40.	71.	28.	25.	19.	33.	36.	66.	25.	32.	65.	39.	479
1941	52.	30.	19.	22.	18.	25.	17.	31.	25.	31.	36.	52.	329
1942	68.	40.	33.	20.	24.	76.	77.	42.	52.	33.	43.	50.	568
1943	23.	37.	38.	88.	31.	39.	37.	58.	53.	41.	45.	48.	604
1944	29.	25.	34.	21.	55.	83.	25.	35.	25.	40.	25.	16.	413
1945	20.	25.	42.	22.	15.	44.	111.	32.	18.	29.	32.	23.	415
1946	36.	39.	61.	46.	72.	34.	64.	25.	22.	41.	32.	23.	496
1947	17.	54.	105.	29.	18.	30.	28.	35.	25.	46.	38.	50.	476
1948	31.	65.	65.	86.	37.	69.	72.	67.	37.	49.	111.	45.	734
1949	22.	55.	30.	128.	124.	52.	37.	36.	25.	28.	30.	17.	665
1950	19.	35.	60.	78.	48.	34.	74.	51.	27.	24.	59.	25.	533
1951	20.	19.	24.	42.	41.	162.	49.	21.	17.	19.	37.	32.	484
1952	71.	68.	90.	106.	44.	83.	42.	39.	51.	43.	27.	28.	592
1953	35.	54.	35.	29.	43.	57.	21.	19.	18.	15.	17.	12.	353
1954	12.	29.	34.	27.	50.	65.	34.	31.	41.	65.	65.	36.	489
1955	34.	49.	36.	80.	125.	41.	48.	44.	29.	33.	59.	36.	678
1956	38.	114.	56.	131.	127.	58.	38.	53.	41.	35.	49.	35.	766
1957	82.	65.	61.	114.	117.	22.	46.	34.	16.	25.	47.	29.	561
1958	18.	46.	121.	32.	19.	21.	17.	27.	18.	59.	71.	31.	479
1959	80.	45.	42.	42.	47.	21.	44.	33.	16.	22.	75.	30.	497
1960	18.	56.	46.	44.	39.	93.	50.	36.	25.	35.	35.	34.	511
1961	88.	31.	51.	24.	39.	53.	53.	40.	38.	32.	39.	32.	521
1962	73.	54.	101.	63.	29.	79.	38.	55.	36.	28.	34.	18.	668
1963	15.	22.	21.	54.	15.	66.	125.	88.	60.	47.	37.	25.	575
1964	36.	18.	12.	69.	30.	105.	79.	61.	30.	54.	32.	31.	558
1965	57.	109.	109.	63.	57.	52.	132.	117.	36.	59.	30.	30.	850
1966	53.	187.	68.	34.	57.	22.	17.	16.	17.	33.	42.	22.	567
1967	62.	91.	39.	75.	88.	115.	101.	144.	35.	36.	52.	30.	368
1968	33.	89.	156.	46.	25.	73.	59.	31.	17.	24.	23.	22.	598
1969	61.	112.	149.	43.	87.	42.	35.	42.	13.	40.	22.	33.	581
1970	43.	51.	36.	64.	12.	11.	48.	55.	21.	27.	22.	25.	395
1971	20.	59.	85.	85.	66.	72.	162.	43.	24.	22.	20.	25.	583
1972	35.	52.	92.	52.	34.	55.	91.	38.	23.	53.	31.	33.	660
1973	45.	46.	22.	23.	37.	62.	34.	49.	28.	26.	18.	19.	408
1974	39.	111.	79.	54.	44.	51.	133.	73.	57.	55.	29.	45.	770
1975	34.	88.	38.	136.	52.	59.	51.	38.	20.	21.	17.	14.	569
1976	18.	44.	32.	40.	59.	81.	92.	40.	34.	38.	30.	30.	528
1977	28.	19.	17.	16.	31.	44.	49.	97.	28.	28.	27.	16.	400
1978	21.	28.	30.	16.	11.	16.	40.	52.	85.	49.	54.	36.	448
1979	63.	71.	43.	45.	163.	30.	21.	34.	48.	25.	23.	15.	572
1980	19.	38.	32.	34.	13.	61.	79.	93.	76.	78.	29.	57.	510
1981	39.	41.	33.	17.	25.	24.	53.	36.	19.	49.	54.	27.	419
1982	55.	127.	30.	86.	84.	270.	132.	54.	35.	76.	74.	61.	1145
1983	35.	100.	47.	27.	16.	12.	23.	32.	25.	44.	52.	32.	505
1984	42.	25.	15.	19.	21.	13.	39.	19.	19.	15.	11.	18.	256

MONTHLY AVERAGE IN (CFS)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
	41.	57.	59.	61.	49.	58.	58.	48.	33.	38.	40.	36.	578

Frequency curves for Stations 600 and 710 depict conditions at their respective sites. Frequency curves were needed on the Wailua River below the confluence of the North and South Forks and below the confluence with Opeakaa Stream.

16. A multiple regression study was conducted for Kauai correlating the geometric mean flood (dependent variable) to the physiographic and meterological characteristics (independent variables) of each gaging station used in the study. Discharges were calculated for these different concentration points in the lower reaches of the Wailua River. The results do not show reliable and consistent relationships between the discharges below the confluence of the North and South Forks below the confluence with Opaekaa. As a result, further analysis using this method was not warranted.

17. To provide meaningful relationships of the discharges in the lower Wailua Basin, a regional frequency analysis was conducted utilizing the mean annual peak flows from 15 gaging stations on Kauai. Basic data for the 15 gages are listed on Table B-6b-11. Drainage areas versus mean annual peak flows in cfs/square mile were plotted and are shown on Plate B-11. A graphical best fit curve was drawn through the points and is labeled "base curve." A curve parallel to the "base curve" was then drawn through the plotted point representing the area gaged at Station 600. This curve, labeled "Sta. 600," was used to derive the frequency curve for Station 600 on the South Fork. Based on the influence of the Station 600 from the South Fork on the flows below the confluences in the lower Wailua River Basin, another curve was drawn lower than but closer to the "Sta. 600" curve and parallel to the "base curve." This curve was labeled "Wailua River Curves below confluences" and was used for the lower Wailua River Basin. Mean annual peak flow values were picked from the drainage area -- mean annual peak flow curves for different concentration points such as for Wialua River at the mouth, DA = 51.6 square miles. The mean annual peak flow value was plotted on log probability paper and a curve was drawn parallel to the computed curve for Station 600. The computed curve was adjusted for expected probability using N = 67 years, after Station 600. Plate B-12 shows the expected probability flood frequency curves for the Wailua River at the mouth and at Station 600 and Table B-6b-12 summarized the peak flows.

TABLE B-6b-11

STATIONS USED IN REGIONAL FREQUENCY ANALYSIS

USGS Station Number	Station Name	Drainage Area (Sq. Miles)	Years Record Years	Mean Annual Peak Discharge (cfs)	Mean Annual Peak Discharge (cfs/Sq. Mi.)
100	Kawaikoi Stream	3.95	64	3,590	909
160	Waimea River	20.0	43	5,330	267
190	Waialae Stream	1.79	37	2,240	1,251
280	Waimea River	45.0	47	10,200	227
310	Waimea River	57.8	41	13,100	227
360	Makaweli River	26.0	35	7,840	302
490	Hanapepe River	18.5	52	7,380	399
550	Huleia Stream	17.6	15	7,120	405
600	South Fork Wailua River	22.4	67	14,100	629
630	North Fork Wailua River	5.29	61	4,190	792
680	East Branch North Fork Wailua River	6.27	65	2,850	455
710	North Fork Wailua River	17.9	28	6,940	388
800	Kapaa Stream	3.86	40	3,080	798
890	Ananola Stream	4.27	62	2,970	696
1080	Wainiha River	10.2	27	6,870	674

TABLE B-6b-12

SUMMARY OF PEAK FLOWS

Location	Drainage Area (Sq. Miles)	Q-2 (cfs)	Q-10 (cfs)	Q-100 (cfs)	Q-500 (cfs)
Wailua River at Mouth	51.6	17,500	40,500	83,000	124,000
Wailua River Downstream of Confluence of N.F. and S.F.	44.5	16,500	38,500	79,000	115,000
S.F. Wailua River above Confluence with N.F.	26	14,800	34,500	70,000	106,000
S.F. Wailua River at Station 600	22.4	14,100	33,700	68,000	103,000

18. Probable Maximum Flood (PMF) estimates were needed for the design of improvements near Station 600, South Fork Wailua River and Station 630, North Fork Wailua River. The probable maximum flood estimate of 115,000 cfs for Station 600 was taken directly from the study by the State of Hawaii, Department of Land and Natural Resources, "Waialeale Hydropower Study," 1978, which is a detailed study of hydropower in the Wailua Basin. The procedure used in delivering the PMF followed Corps criteria. The 0.15 hour unit hydrograph used is shown on Plate B-13. The probable maximum storm hyetograph and probable maximum flood hydrograph are shown on Plate B-14. A uniform loss rate of 0.3 inch per hour was used.

19. The "Waialeale Hydropower Study" did not have an estimate of the PMF near Station 630; therefore, the following procedure was used in estimating one. Unit hydrograph studies were conducted on Station 680, East Branch of North Fork Wailua River near Lihue, where rainfall runoff data was available. Station 680 is located about 1.4 miles east of Station 630 and has a drainage area of 6.27 square miles compared to 5.29 square miles for Station 630. A unit hydrograph from the storm of October 16, 1966 was selected to represent Station 680 and was transferred to Station 630 using Snyder's synthetic unit hydrograph procedures. (See Plate B-15). The probable maximum storm hyetograph and probable maximum flood hydrograph are shown on Plate B-16. A uniform loss rate of 0.3 inch per hour was used. The peak of the PMF was 26,00 cfs.

HYDRAULIC INVESTIGATIONS

GENERAL

20. The project features would be located on the left bank and would extend across a plateau before dropping down a bluff to the river. It would also divert flow from the North Fork Wailua River to the South Fork Wailua river through the existing Stable Storm Ditch. Pertinent information for the project are shown on Table B-6b-13.

TABLE B-6b-13

PERTINENT PROJECT INFORMATION

Modified Intake at Stable Storm Ditch	Yes
Diversion Dam on Wailua River	Yes
Intake Structure Height at River, feet	23.0
Ponding Storage	
Elevation, ft ms 1	274.5
Flooded Area, Acres	35.0
Volume, Acre-feet	300
Steel Penstock Length	4950
Design Discharge (cfs)	365
Gross Head (ft)	265
Approximate Net Head (ft)	257
Tailrace	200 LF Open Channel

21. Water Surface Profiles. The water surface profile for the 500-year flood was developed for the Wailua River throughout the reaches where the proposed hydropower facilities are impacted or create an impact on the natural flows. The powerplant would have a watertight hatch to keep out the 500-year flood levels. Water surface profiles were computed using cross sections derived from aerial surveys dated Dec 1975 at a horizontal scale of 1" = 200' with 5-foot contours. The Corps' HEC-2 water surface profile computer program was used for all of the profile analysis. The limits of the 500-year flood are shown on Figure B-6a-4. Tailwater rating curves are shown on Plates B-18 and B-19.

22. Power Generation Discharges. Instantaneous discharges for the river, the hydropower system, and the Falls are shown on Table B-6b-14. The hydropower system operates only when river flows exceed 45 cfs. The minimum discharge released for conservation purposes is 15 cfs and is included in the above flow values. The maximum flow used by the hydropower system is 365 cfs. When the river flow exceeds 380 cfs, all excess flow is passed over the diversion dam.

TABLE B-6b-14

INSTANTANEOUS FLOW RANGES FOR POWER DEVELOPMENT AND FOR RELEASE OVER FALLS

Average Yearly Duration (Days)	Percent of Year	River Flow Upstream of Hydropower Intake (cfs)	Hydropower Flow (cfs)	Flow Over Wailua Falls (cfs)
212	60	0 to 45	0	0 to 45
113	34	45 to 380	30 to 365	15
40	6	380 to Peak	365	15 to peak

23. Gross and Net Head. Gross head is the difference in water surface elevation from the diversion structure to the assumed tailwater elevation. Net head is the gross head less friction and other hydraulic losses. Net head is the head available for power generation.

24. Stable Storm Ditch Diversion. The Lihue Plantation currently diverts water from the North Fork Wailua River to the South Fork Wailua River through the Stable Storm Ditch. To divert larger quantities of water to the South Fork, the existing intake would be replaced with a 220-foot 5'H x 4'V box culvert. The box culvert invert would be depressed 1.9 feet below the existing invert to allow the design flow of 100 cfs through the culvert. The weir on USGS gaging station 620, located just downstream from the culvert, would be depressed by 1.35 feet to a crest elevation of 705.17 feet msl. The weir elevation is the hydraulic control on flow into the Stable Storm Ditch. The modified rating curve is shown on Plate B-28. The Stable Storm Ditch, at an average depth of 7 feet, can pass the diverted flow of 100 cfs at a depth of 2.6 ft and a velocity of 3.1 ft/sec with no modifications. The Lihue Plantation would continue using the ditch during dry periods when the hydropower plant would be shut down or running at reduced capacity. During wet periods, the Plantation has no need for the diverted flows. The existing diversion dam in the North Fork Wailua River would have a small notch cut in the stoplogs to pass the conservation flow (Plate B-18). No other modifications to the diversion dam are proposed.

25. Wailua River Diversion Dam. A concrete diversion dam would be constructed across the Wailua River to divert flows into the intake structure. The diversion dam would be about 23.0 feet high with a crest elevation at 274.5 feet msl and would extend about 400 feet across the Wailua River. The diversion structure would pond an area of 35 acres with a storage of about 300 acre-feet. The area-capacity curve is shown on Plate B-20. The diversion dam serves several functions: raised water level and increases head on the turbine, diverts low water flows into the intake structure, and provides minor pondage. The diversion structure crest was designed to be overtopped by the Probable Maximum Flood.

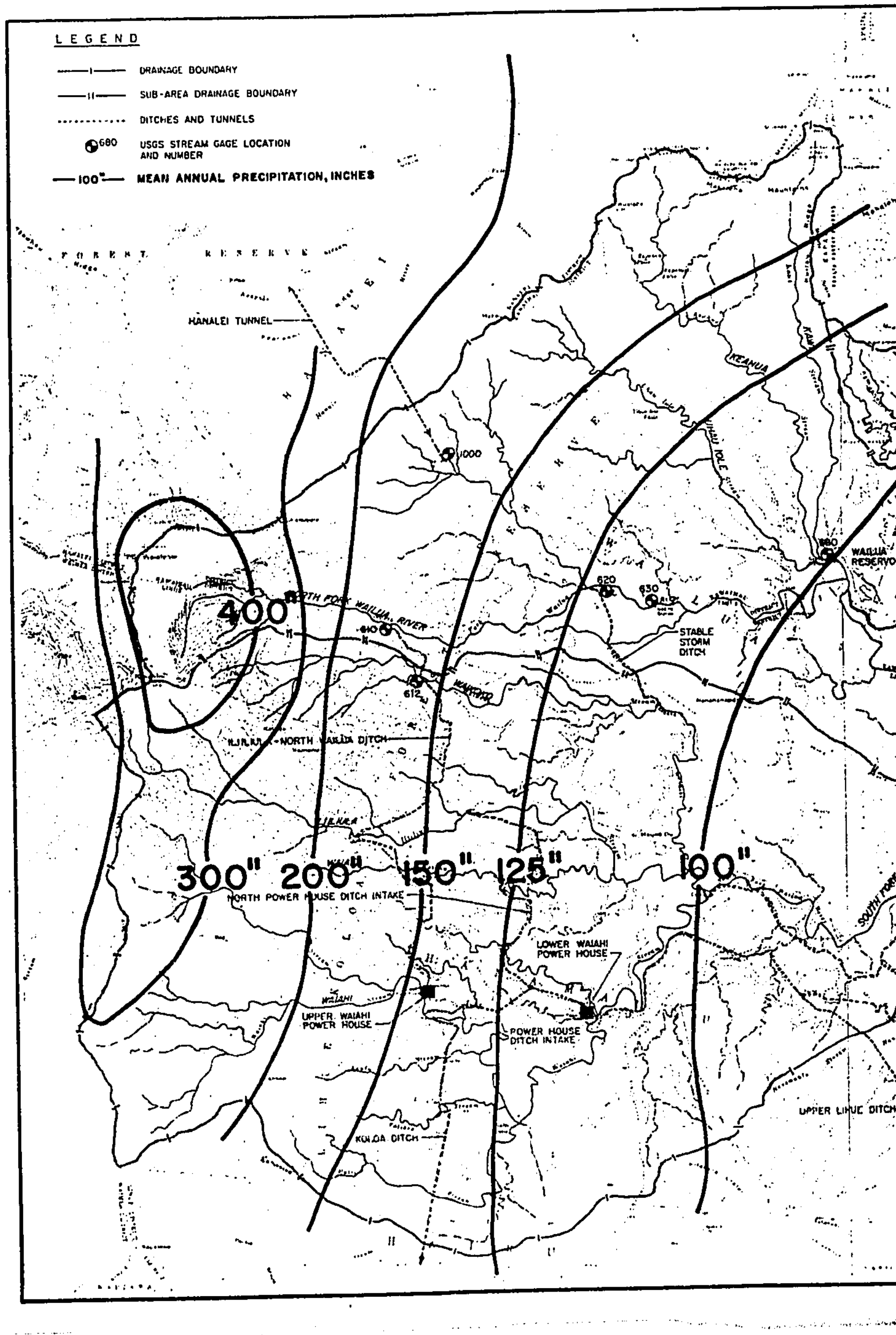
26. Intake Structure. The intake structure consists of a trash rack, sluice gate, 48"x48"- diameter low-level outlet, stop log grooves, and concrete work to divert flows into the conduit. The intake structure would be inundated by all flows greater than 15,000 cfs discharge. The 48" x 48" low-level sluice gate and outlet in the intake structure would allow conservation flows to bypass the diversion works. The sluice gate would also be capable of draining the ponding area to allow removal of sediment deposits. The stoplogs would be used for temporary dewatering of the low level outlet and trash rack and have no operational function relative to the hydropower facility.

27. Penstock. The penstock was sized based on a design flow of 365 cfs at maximum velocity of 7.3 to 9.6 ft/sec. The 96" to 84" penstock will be approximately 4,950 feet long.

28. Tailrace. The tailrace from the powerhouse would be a concrete and reprap-lined channel approximately 200 feet long which would discharge the flow back into the Wailua River. The tailrace and river channel confluence was designed for a smooth transition to reduce backwater effects.

29. Trashrack. The trashrack on the intake structure must be periodically cleaned to remove accumulated debris. The trashrack was designed for installation of automatic raking equipment with provision for manual cleanout.

30. Ponding Area. The ponding area behind the diversion dam is approximately 300 acre-feet covering about 35.0 acres which would tend to accumulate sediment deposits and would need periodic cleanout to keep debris from filling in the area behind the diversion dam. It is proposed that this impoundment be managed primarily as endangered Hawaiian water bird habitat in coordination with the State of Hawaii Division of Forestry, Division of Wildlife and the U.S. Fish & Wildlife Service. The increased volume of water will also improve the existing small mouth bass fishery habitat. The area of the reservoir is on State-owned lands. Public access to the facility can be provided as determined by a consensus of the agencies. Multi-resource use of the pond seems to be possible without conflicting with the management of the area or endangered water bird habitat.


LEGEND
DRAINAGE BOUNDARY
SUB-AREA DRAINAGE BOUNDARY
DITCHES AND TUNNELS
680 USGS STREAM GAGE LOCATION AND NUMBER
100" MEAN ANNUAL PRECIPITATION, INCHES
HANALEI TUNNEL
NORTH FORK WAILUA RIVER
STABLE STORM DITCH
NORTH POWER HOUSE DITCH INTAKE
LOWER WAIAHI POWER HOUSE
UPPER WAIAHI POWER HOUSE
POWER HOUSE DITCH INTAKE
KOLOA DITCH
UPPER LIHUE DITCH
400"
300"
200"
150"
125"
100"

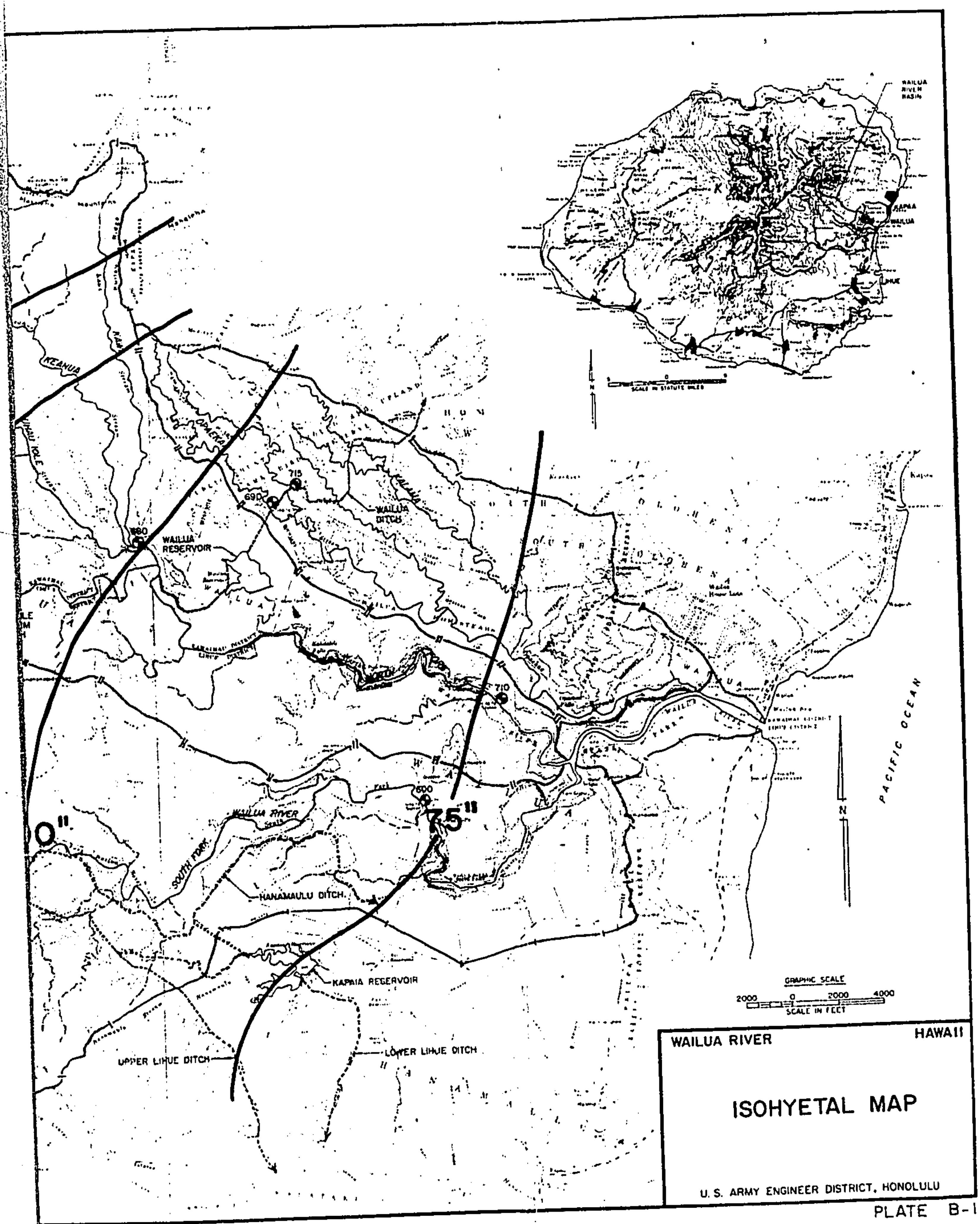
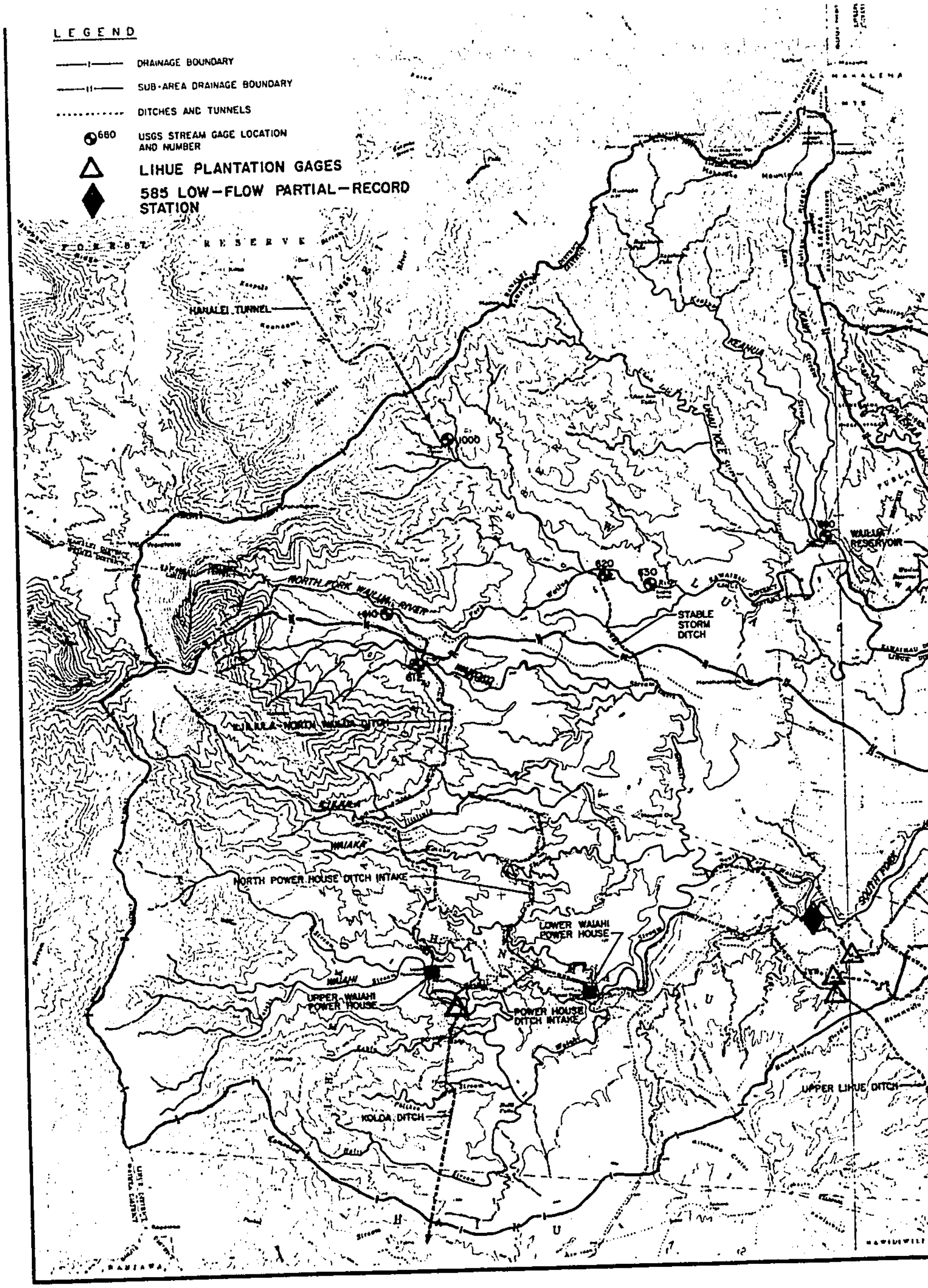

WAILUA RIVER
HAWAII
ISOHYETAL MAP
U. S. ARMY ENGINEER DISTRICT, HONOLULU
75"
WAILUA RESERVOIR
WAILUA DITCH
WAILUA RIVER
SOUTH FORK
HANAMAULU DITCH
KAPAIA RESERVOIR
UPPER LIHUE DITCH
LOWER LIHUE DITCH
PACIFIC OCEAN
GRAPHIC SCALE
2000 0 2000 4000
SCALE IN FEET
680
690
715
710
600

PLATE B-1


LEGEND
DRAINAGE BOUNDARY
SUB-AREA DRAINAGE BOUNDARY
DITCHES AND TUNNELS
680 USGS STREAM GAGE LOCATION AND NUMBER
LIHUE PLANTATION GAGES
585 LOW-FLOW PARTIAL-RECORD STATION
HANALEI TUNNEL
1000
NORTH FORK WAILUA RIVER
620
630
STABLE STORM DITCH
WAILUA RESERVOIR
NORTH POWER HOUSE DITCH INTAKE
LOWER WAIAHI POWER HOUSE
UPPER WAIAHI POWER HOUSE
POWER HOUSE DITCH INTAKE
UPPER LIHUE DITCH
KOLOA DITCH

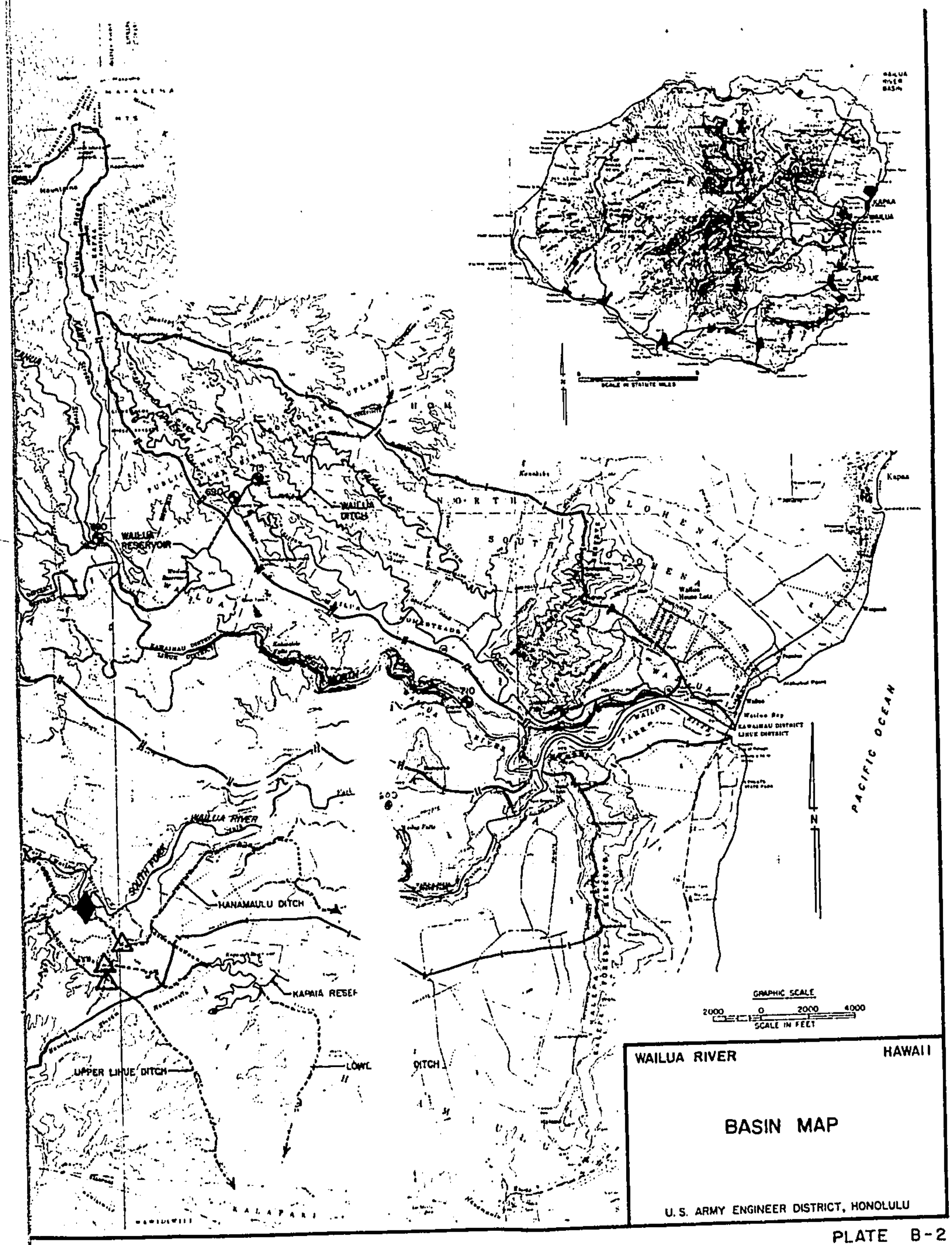
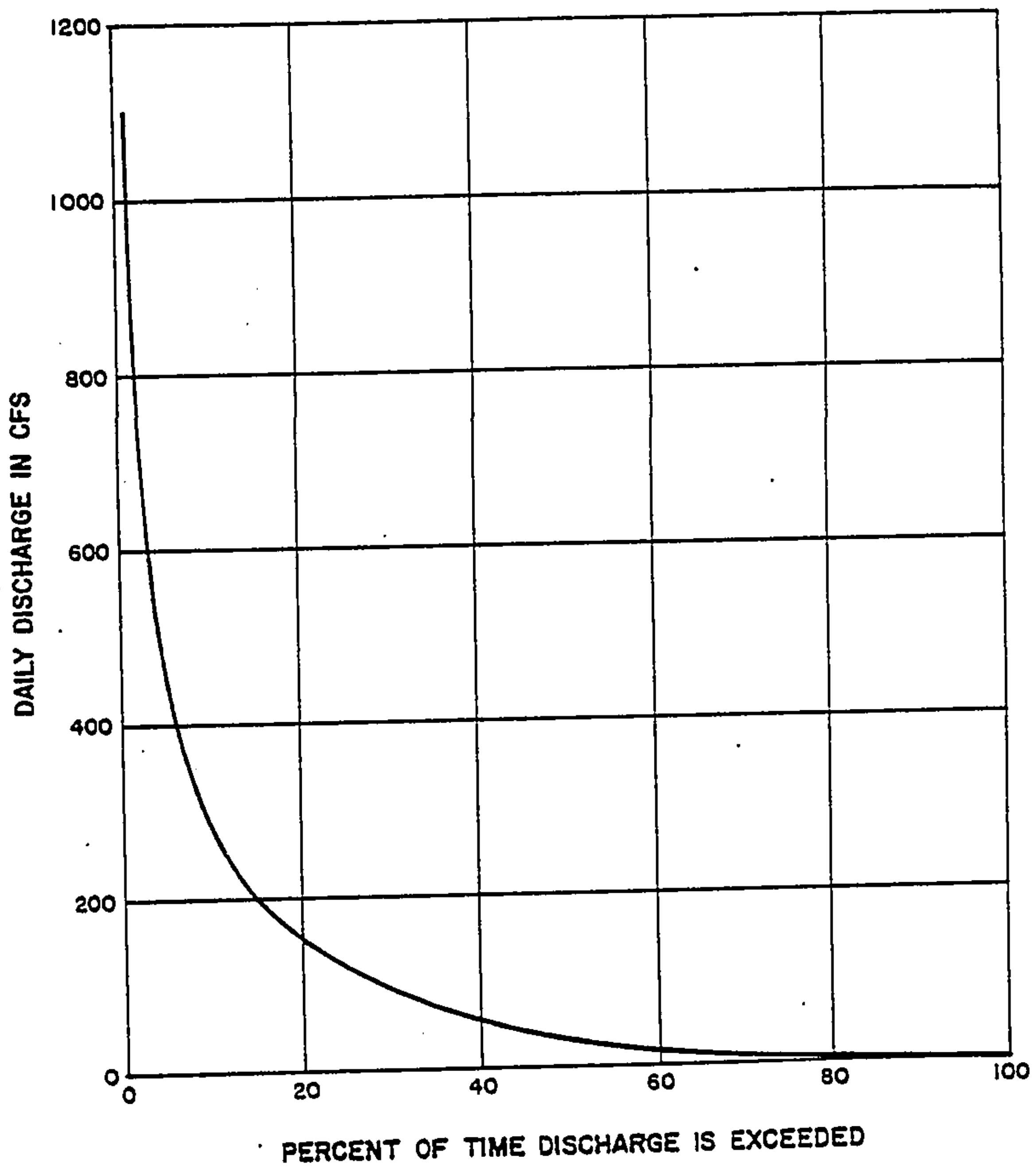

WAILUA RESERVOIR
WAILUA DITCH
WAILUA RIVER
SOUTH FORK
HANAMAULU DITCH
UPPER LIHUE DITCH
PACIFIC OCEAN
GRAPHIC SCALE
2000 0 2000 4000
SCALE IN FEET
WAILUA RIVER
HAWAII
BASIN MAP
U. S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE B-2

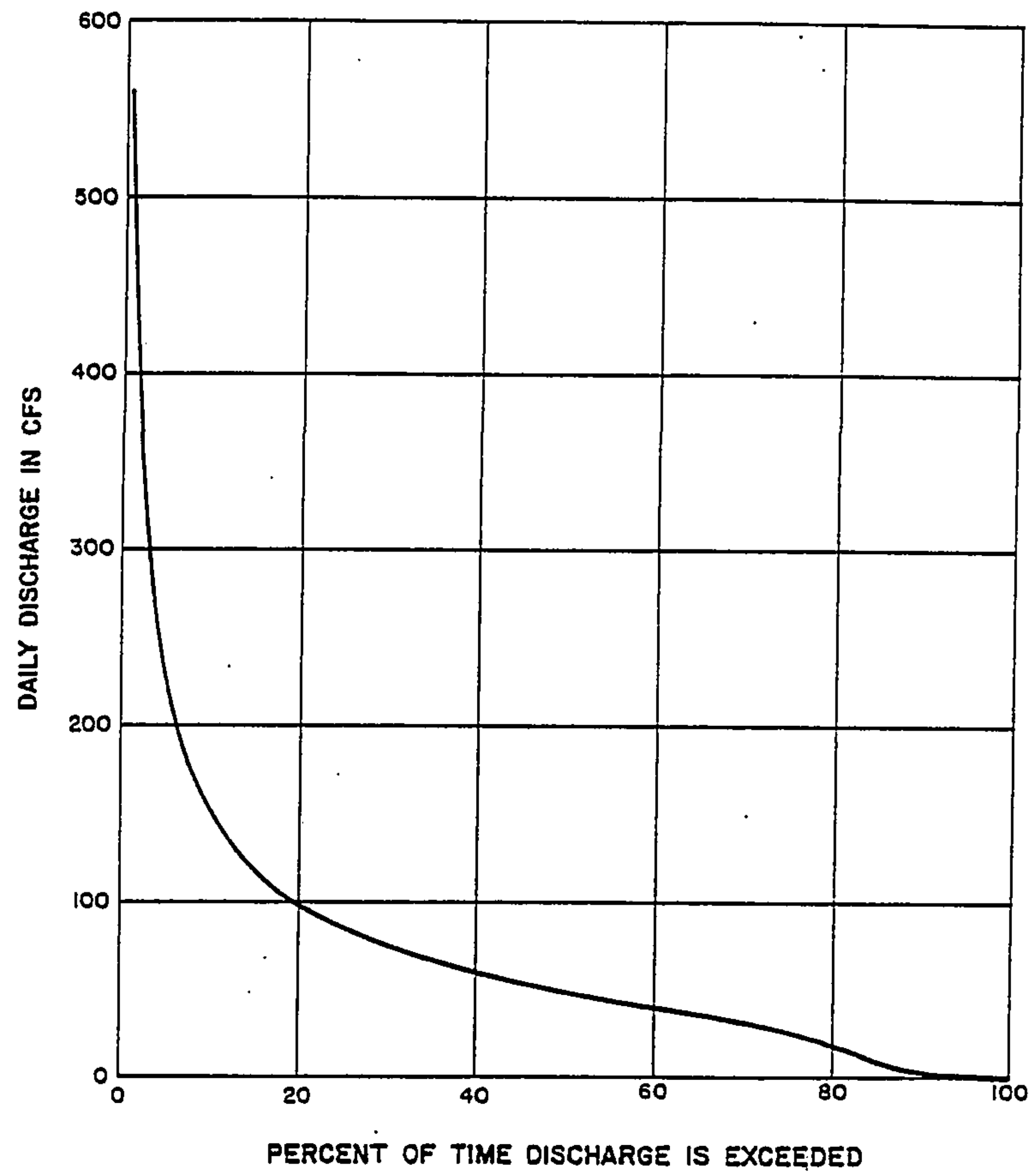


WAILUA RIVER HAWAII

FLOW DURATION CURVE
SOUTH FORK WAILUA RIVER
(STATION 600)
DA=22.4 SQ MI

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE B-3

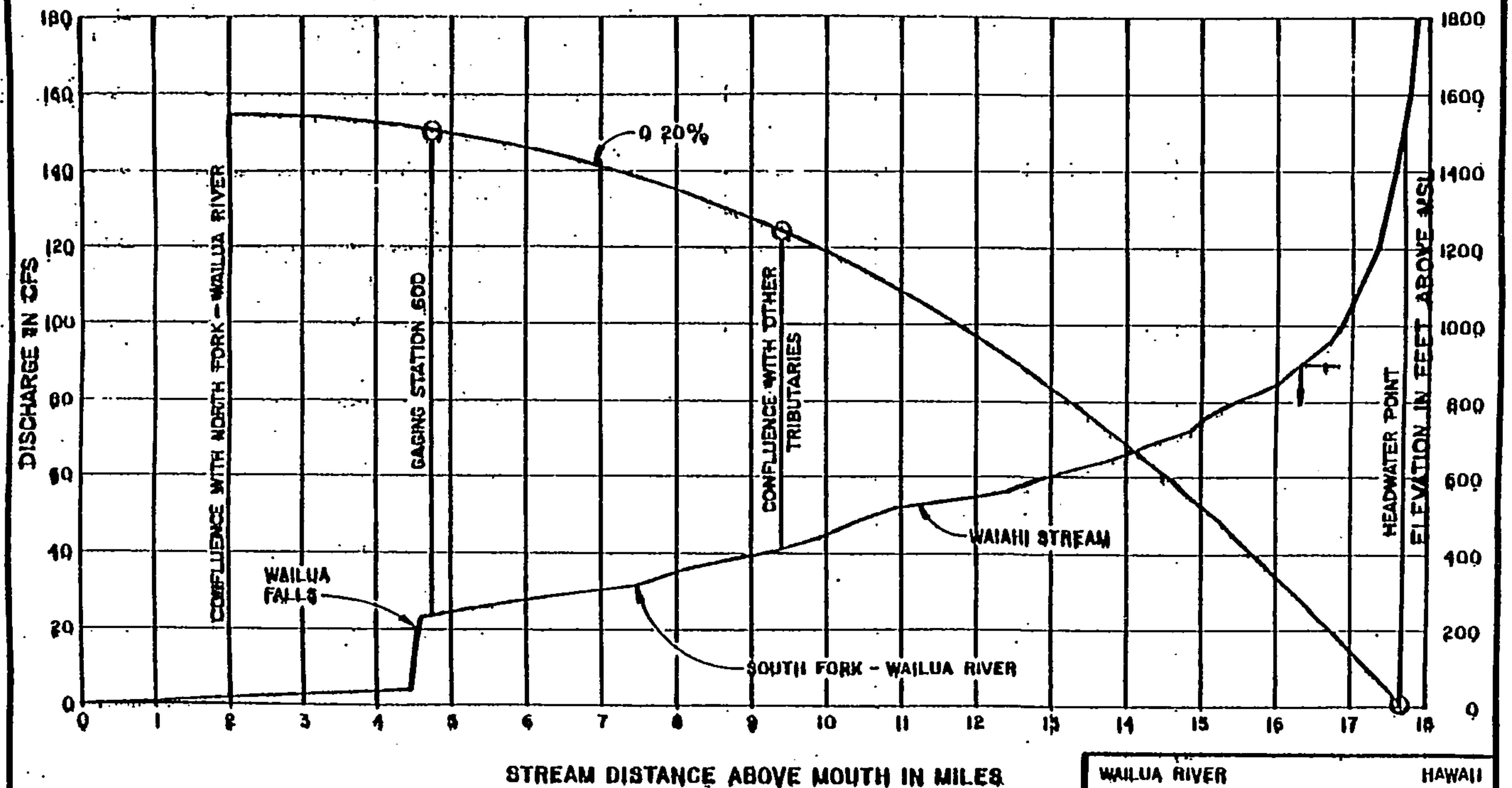


WAILUA RIVER HAWAII

FLOW DURATION CURVE
NORTH FORK WAILUA RIVER
STATION 630
DA=5.29 SQ MI

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE B-4

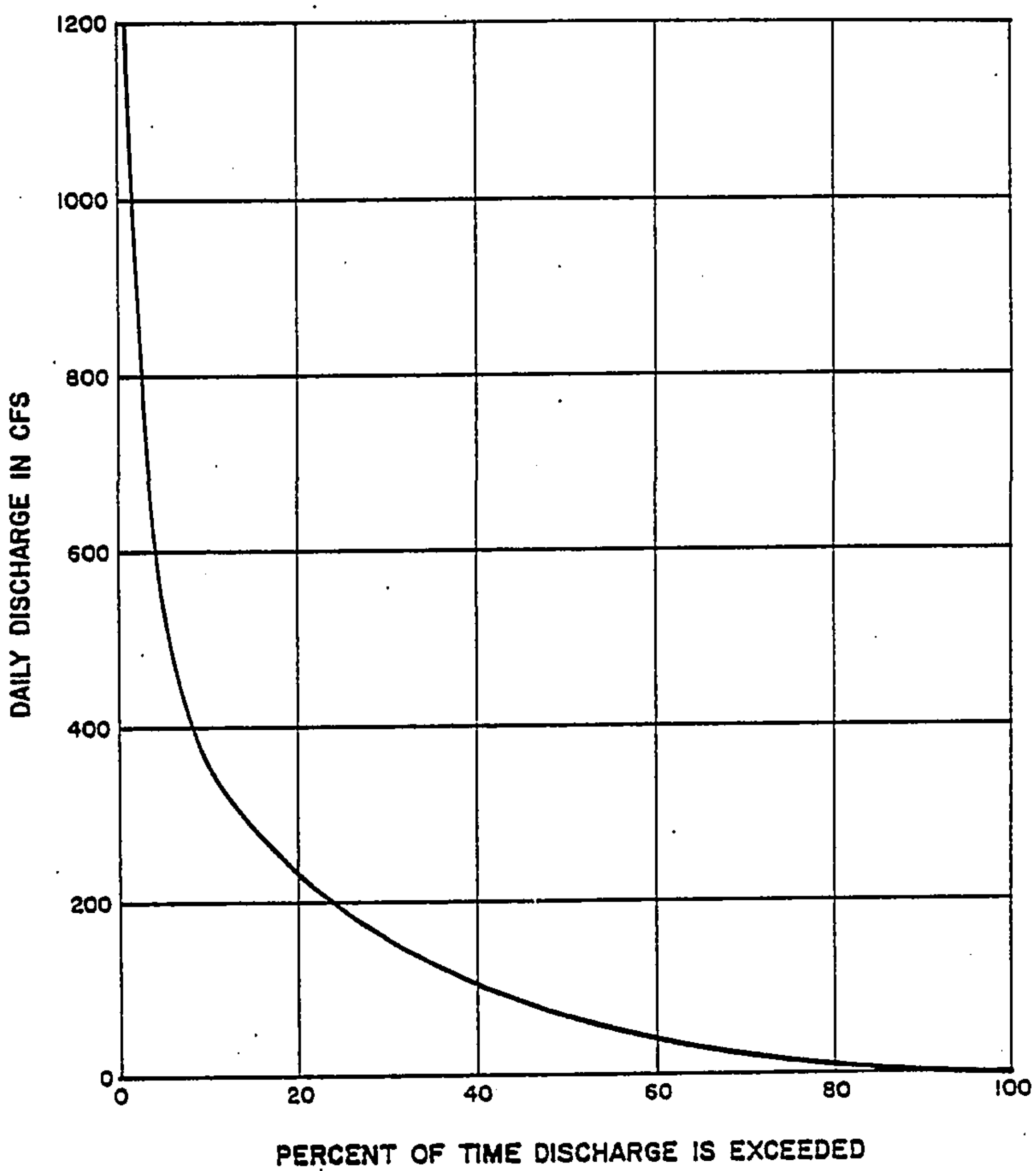


WAILUA RIVER	HAWAII

STREAM PROFILE AND RELATIONSHIP BETWEEN 20% DISCHARGE VS STREAM DISTANCE

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE B-4A

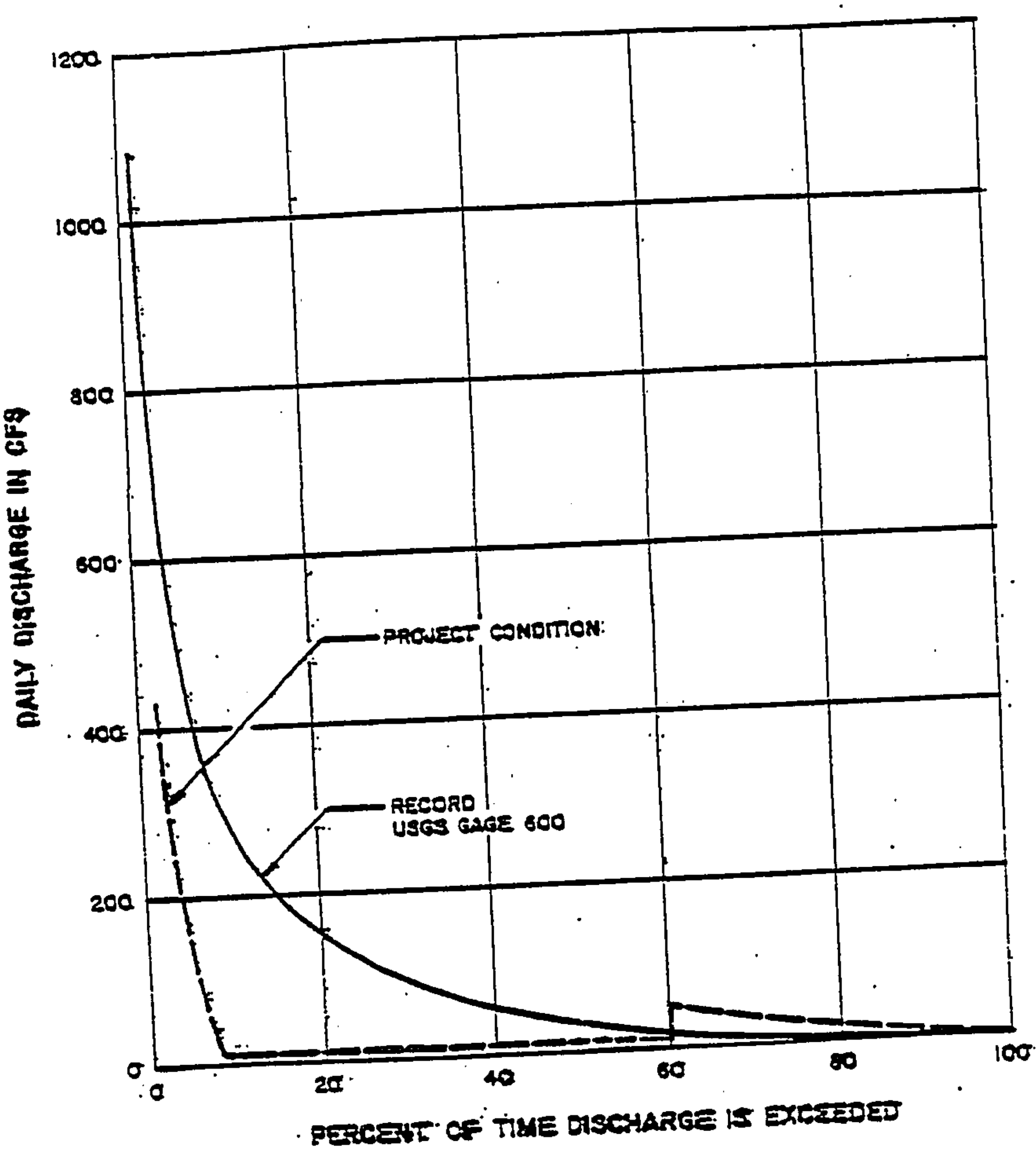


WAILUA RIVER HAWAII

FLOW DURATION CURVE
TOTAL FLOW AVAILABLE
NEAR STATION 600

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE B-5



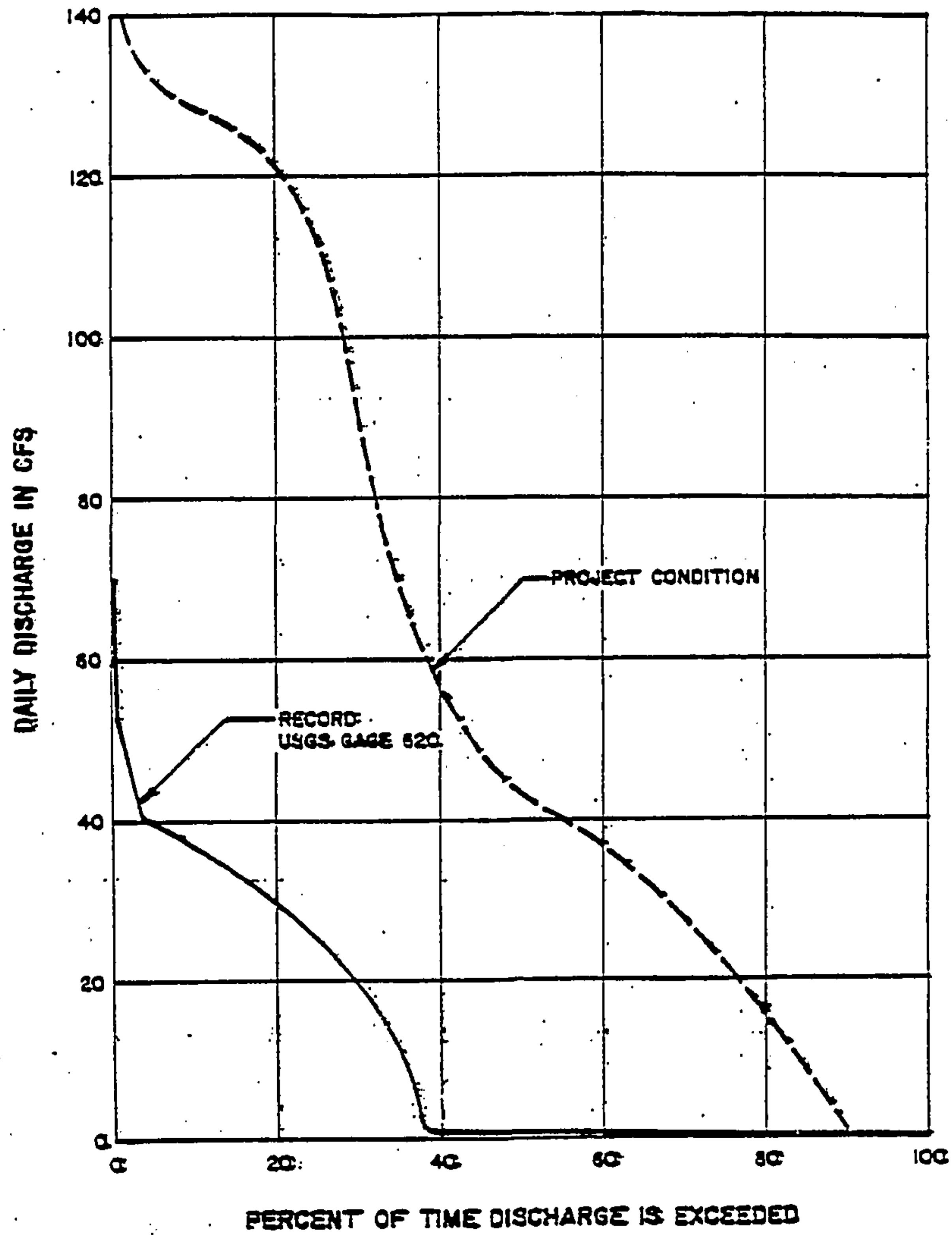
WAILUA RIVER HAWAII

FLOW DURATION CURVES

SOUTH FORK – WAILUA RIVER
EXISTING & PROJECT CONDITIONS

U.S. ARMY ENGINEER DISTRICT, HONOLULU

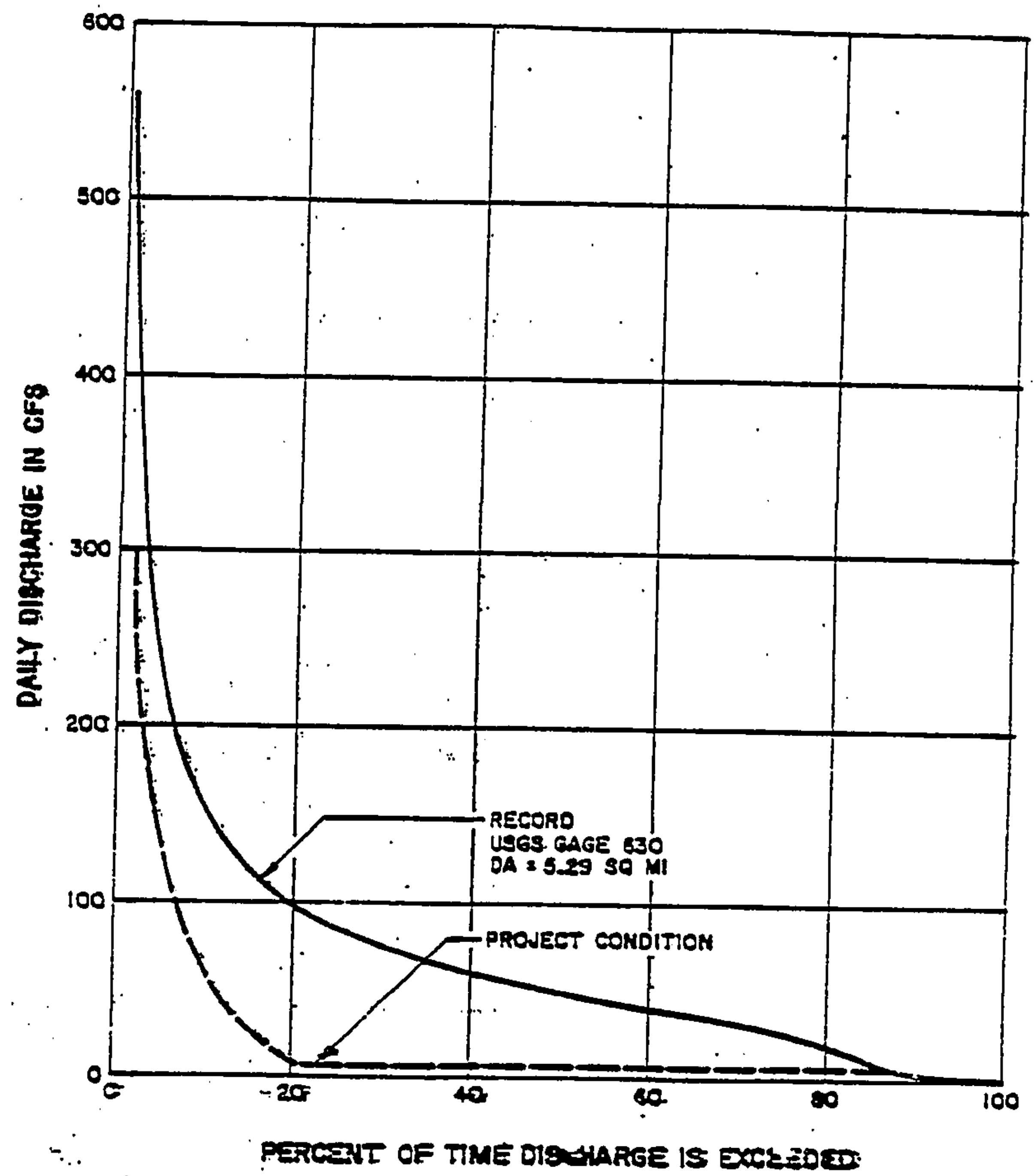
PLATE B-5A



WAILUA RIVER HAWAII

FLOW DURATION CURVES
STABLE STORM DITCH
EXISTING & PROJECT CONDITIONS

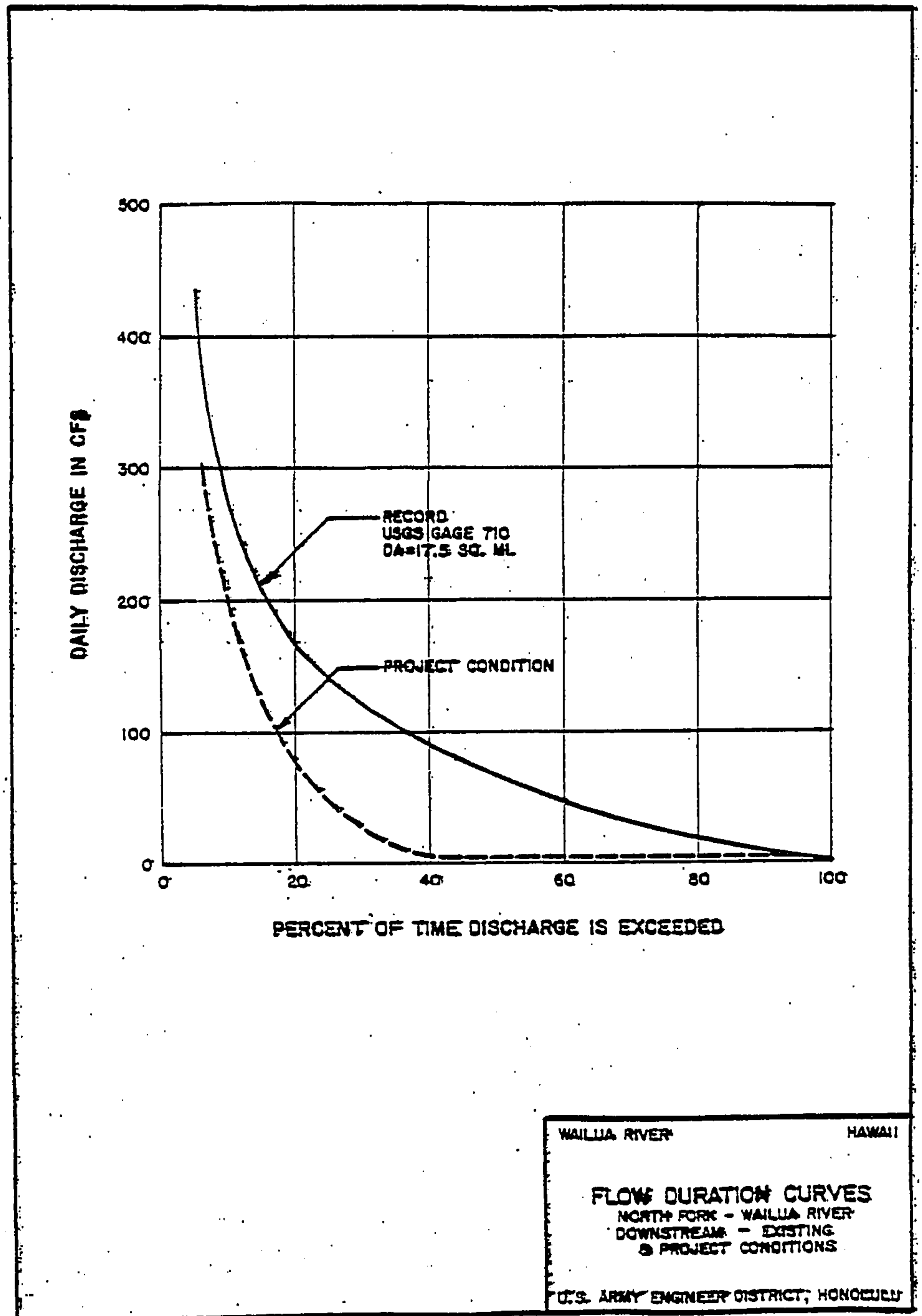
U.S. ARMY ENGINEER DISTRICT, HONOLULU



WAILUA RIVER HAWAII

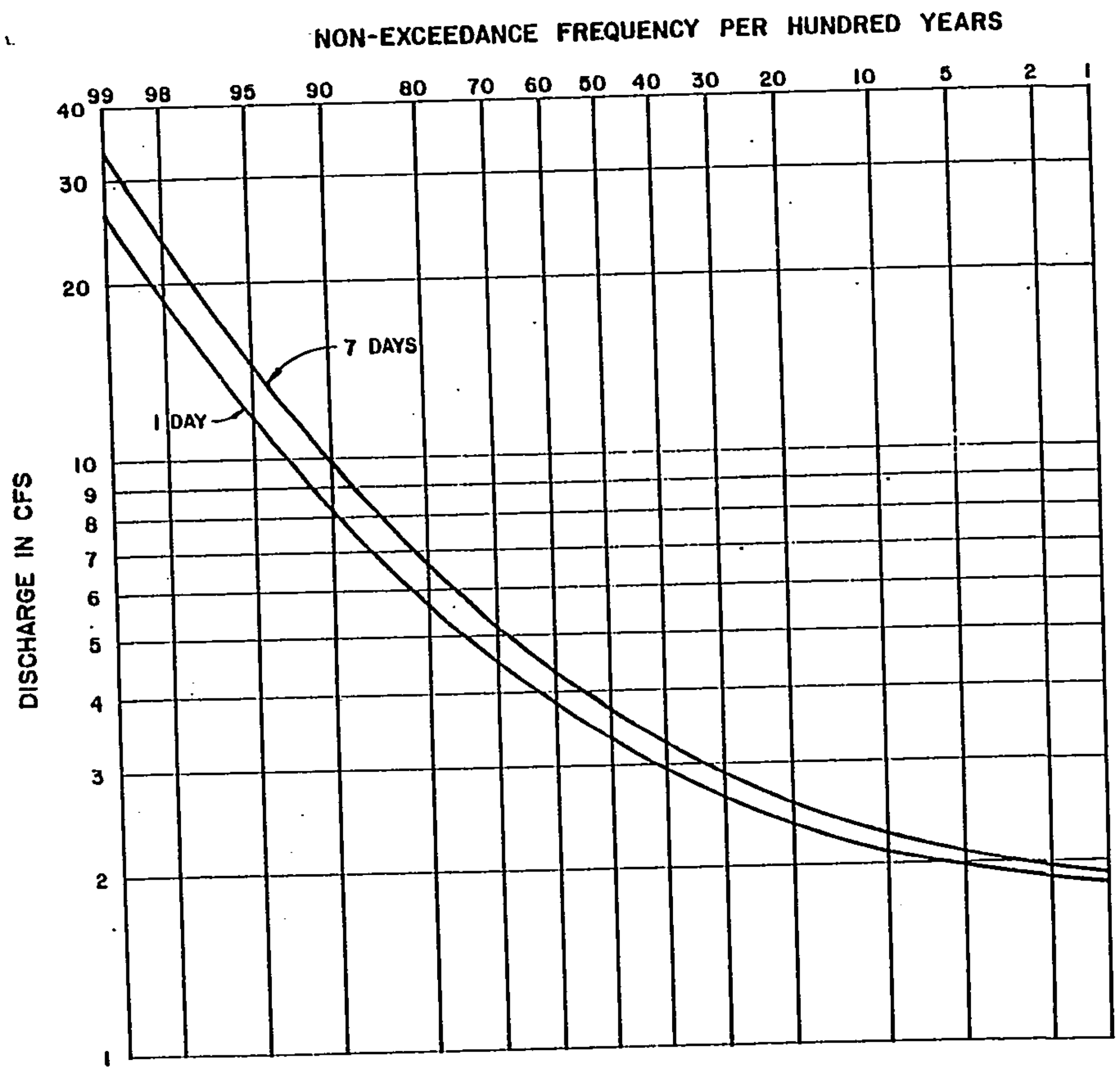
FLOW DURATION CURVES
NORTH FORK-WAILUA RIVER
UPSTREAM - EXISTING
& PROJECT CONDITIONS

U.S. ARMY ENGINEER DISTRICT, HONOLULU



500
400
300
200
100
0
DAILY DISCHARGE IN CFS
0
20
40
60
80
100
PERCENT OF TIME DISCHARGE IS EXCEEDED
RECORD
USGS GAGE 710
DA=17.5 SQ. MI.
PROJECT CONDITION
WAILUA RIVER
HAWAII
FLOW DURATION CURVES
NORTH FORK - WAILUA RIVER
DOWNSTREAM - EXISTING
& PROJECT CONDITIONS
U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE B-50

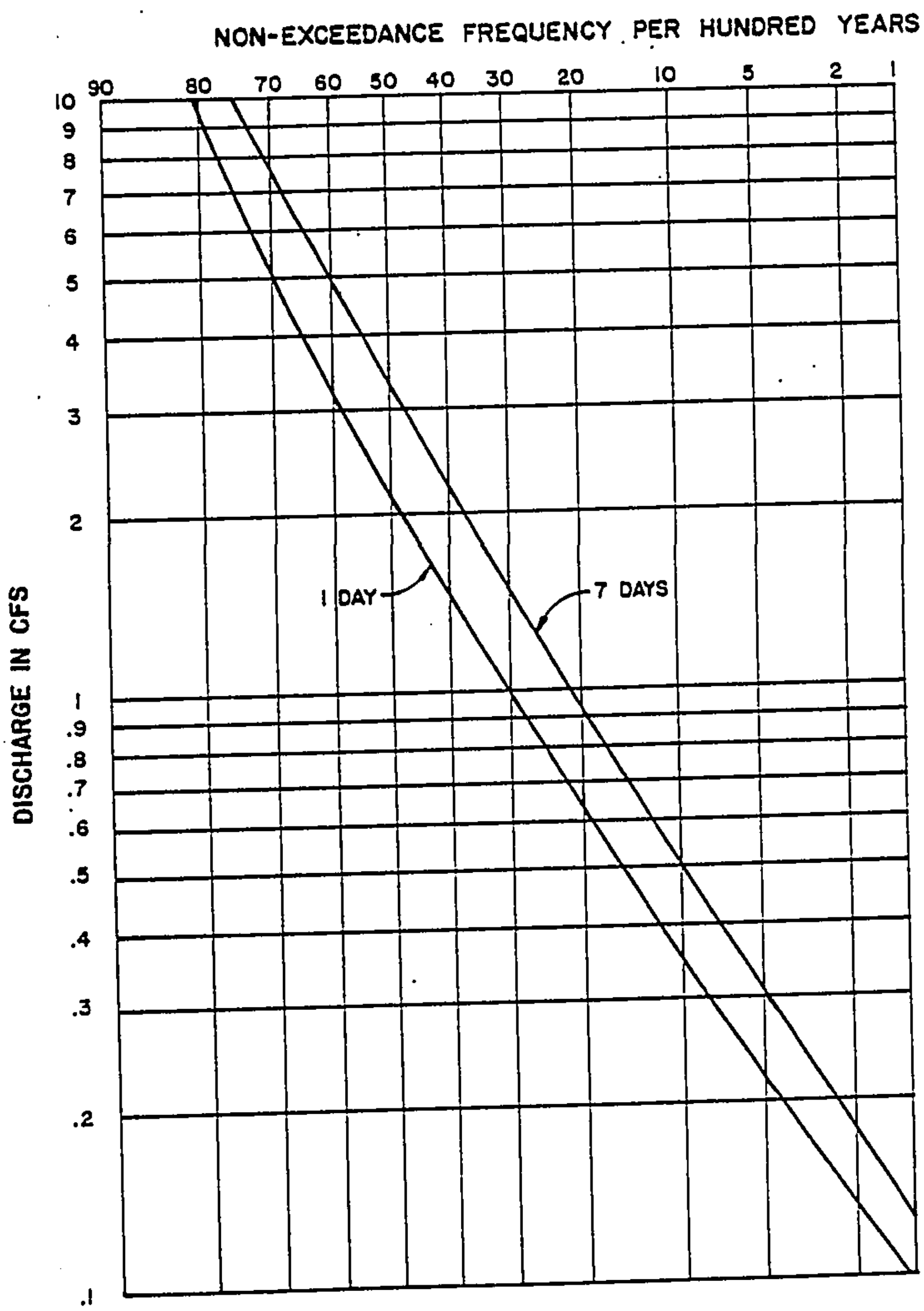


WAILUA RIVER HAWAII

LOW FLOW FREQUENCY CURVE
SOUTH FORK WAILUA RIVER
(STATION 600)

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE B-6



WAILUA RIVER HAWAII

LOW FLOW
FREQUENCY CURVE
NORTH FORK WAILUA RIVER
(STATION 630)

U.S. ARMY ENGINEER DISTRICT, HONOLULU

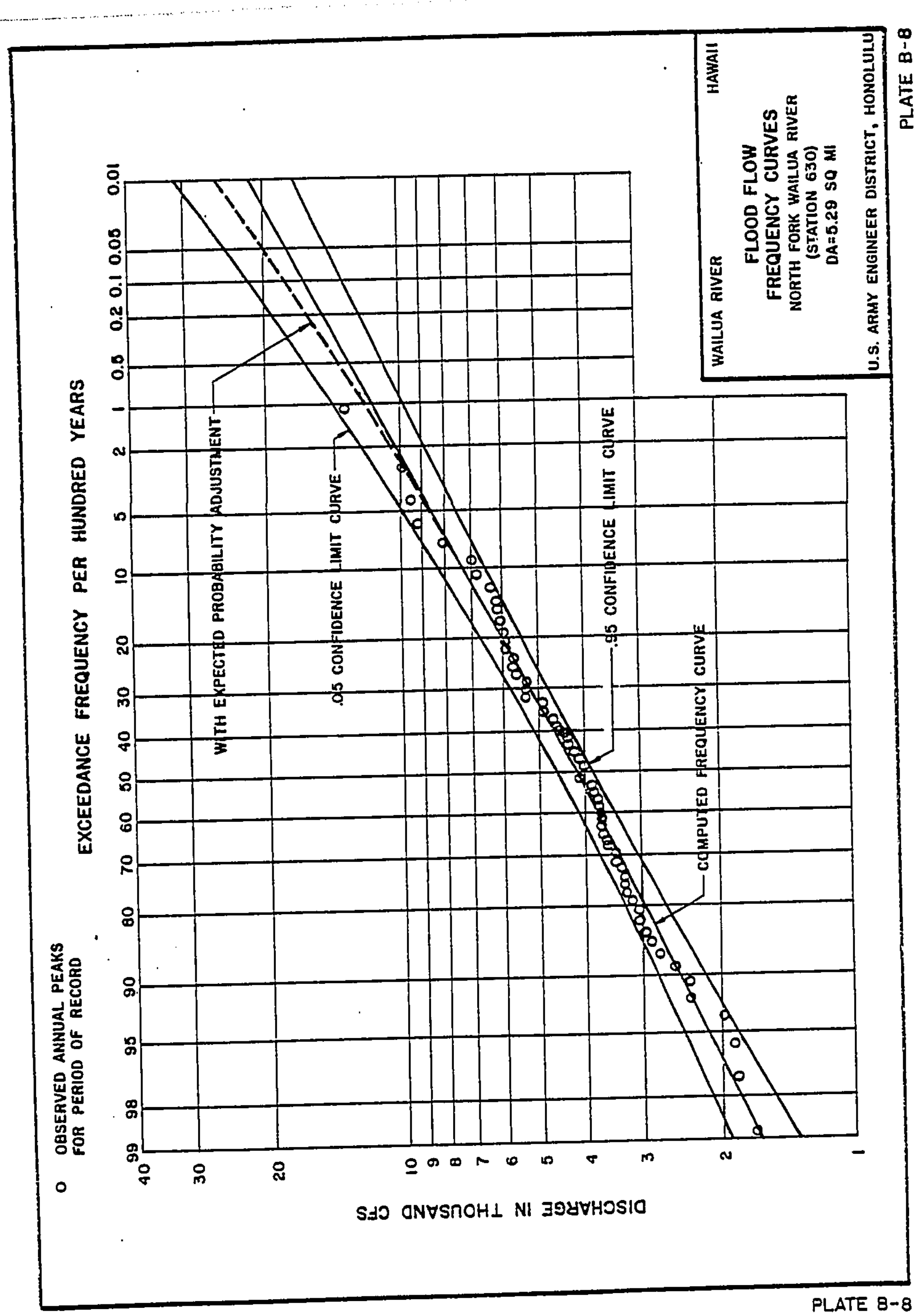

WAILUA RIVER
HAWAII
FLOOD FLOW
FREQUENCY CURVES
NORTH FORK WAILUA RIVER
(STATION 630)
DA=5.29 SQ MI
U.S. ARMY ENGINEER DISTRICT, HONOLULU
PLATE B-8
EXCEEDANCE FREQUENCY PER HUNDRED YEARS
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99
DISCHARGE IN THOUSAND CFS
40 30 20 10 9 8 7 6 5 4 3 2 1
O OBSERVED ANNUAL PEAKS FOR PERIOD OF RECORD
WITH EXPECTED PROBABILITY ADJUSTMENT
.05 CONFIDENCE LIMIT CURVE
.95 CONFIDENCE LIMIT CURVE
COMPUTED FREQUENCY CURVE

PLATE B-8

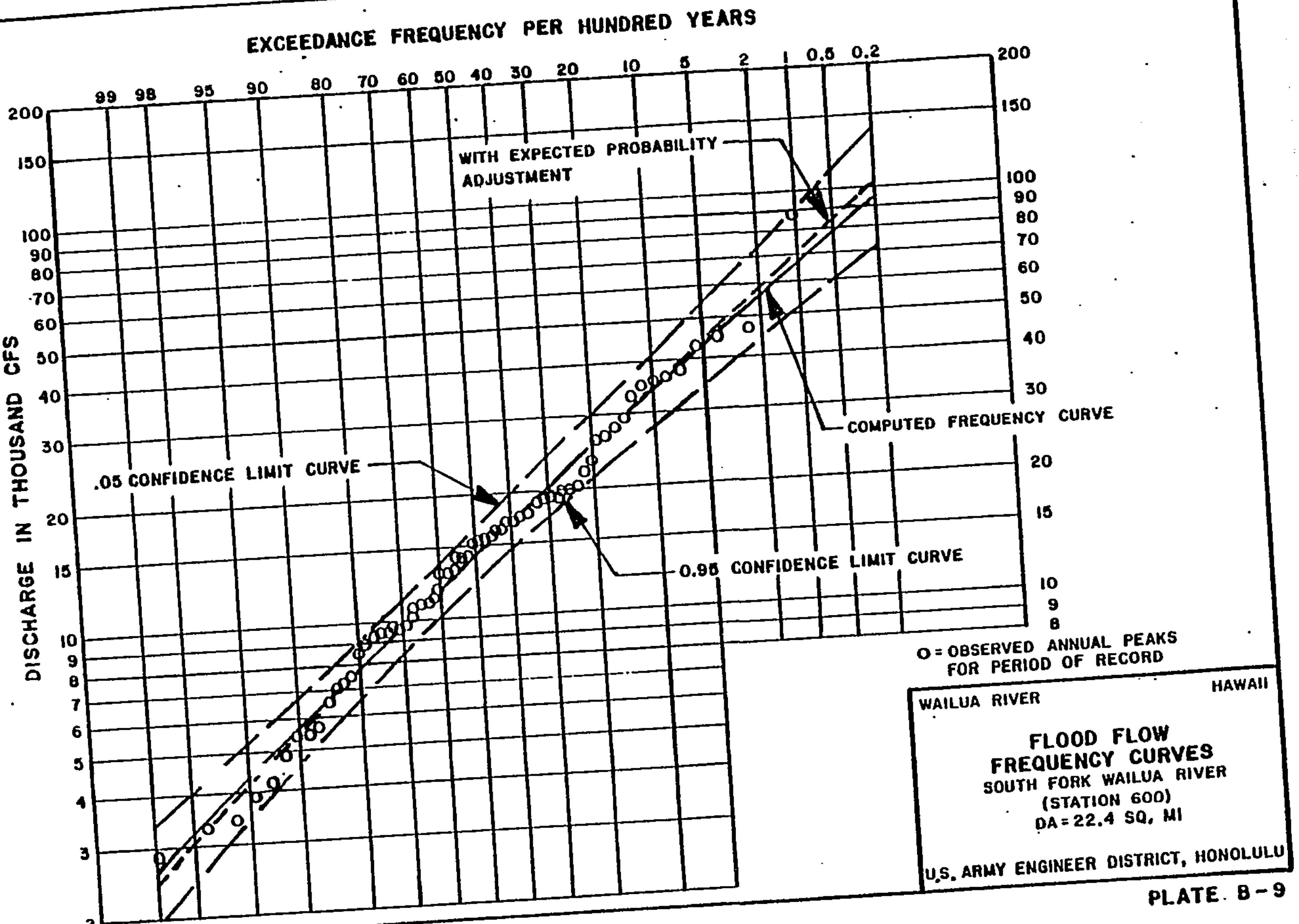
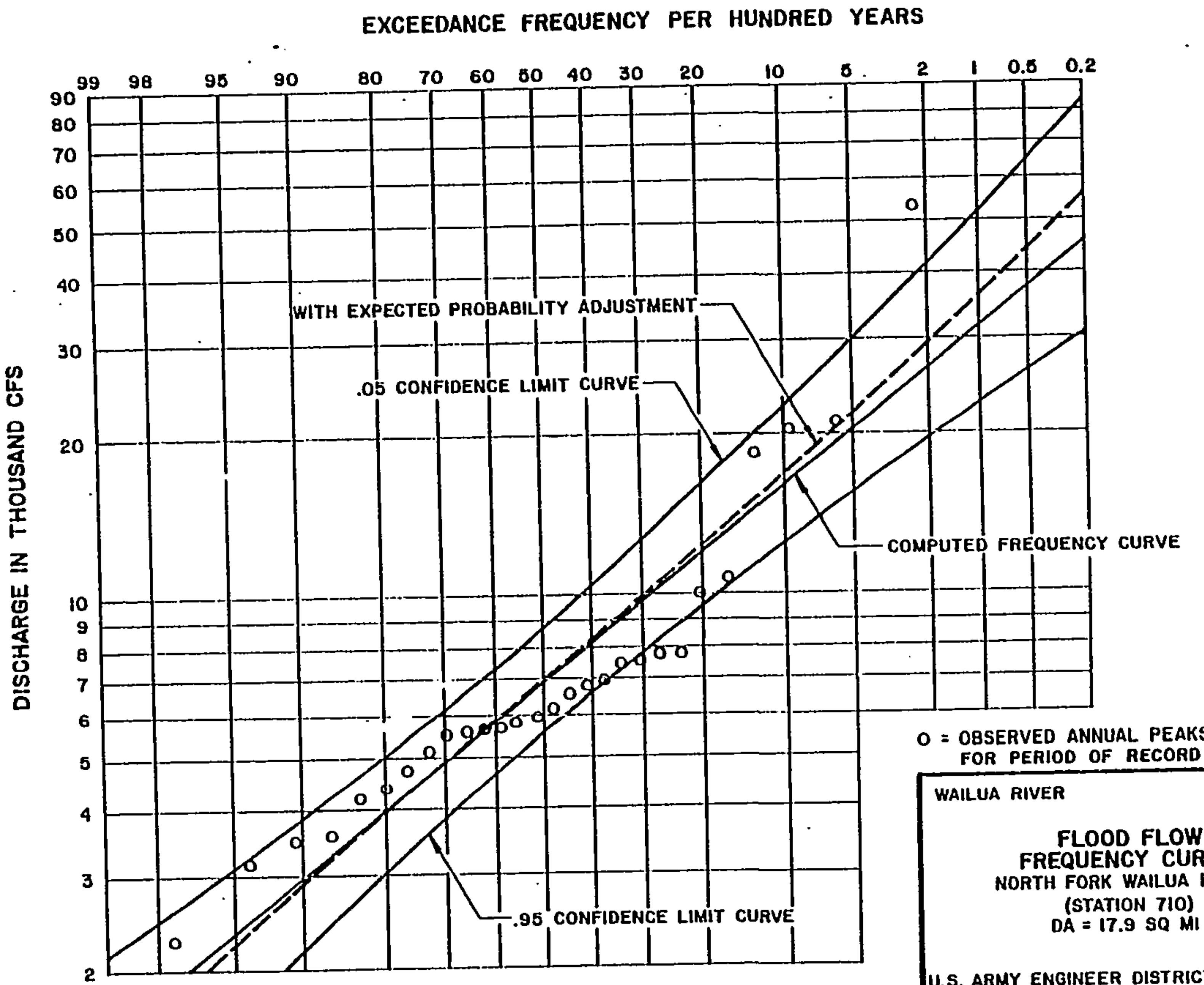

EXCEEDANCE FREQUENCY PER HUNDRED YEARS
99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2
DISCHARGE IN THOUSAND CFS
200 150 100 90 80 70 60 50 40 30 20 15 10 9 8 7 6 5 4 3 2
WITH EXPECTED PROBABILITY ADJUSTMENT
COMPUTED FREQUENCY CURVE
.05 CONFIDENCE LIMIT CURVE
0.95 CONFIDENCE LIMIT CURVE
O = OBSERVED ANNUAL PEAKS FOR PERIOD OF RECORD
WAILUA RIVER
HAWAII
FLOOD FLOW
FREQUENCY CURVES
SOUTH FORK WAILUA RIVER
(STATION 600)
DA = 22.4 SQ. MI
U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE B-9



WAILUA RIVER HAWAII

FLOOD FLOW FREQUENCY CURVES

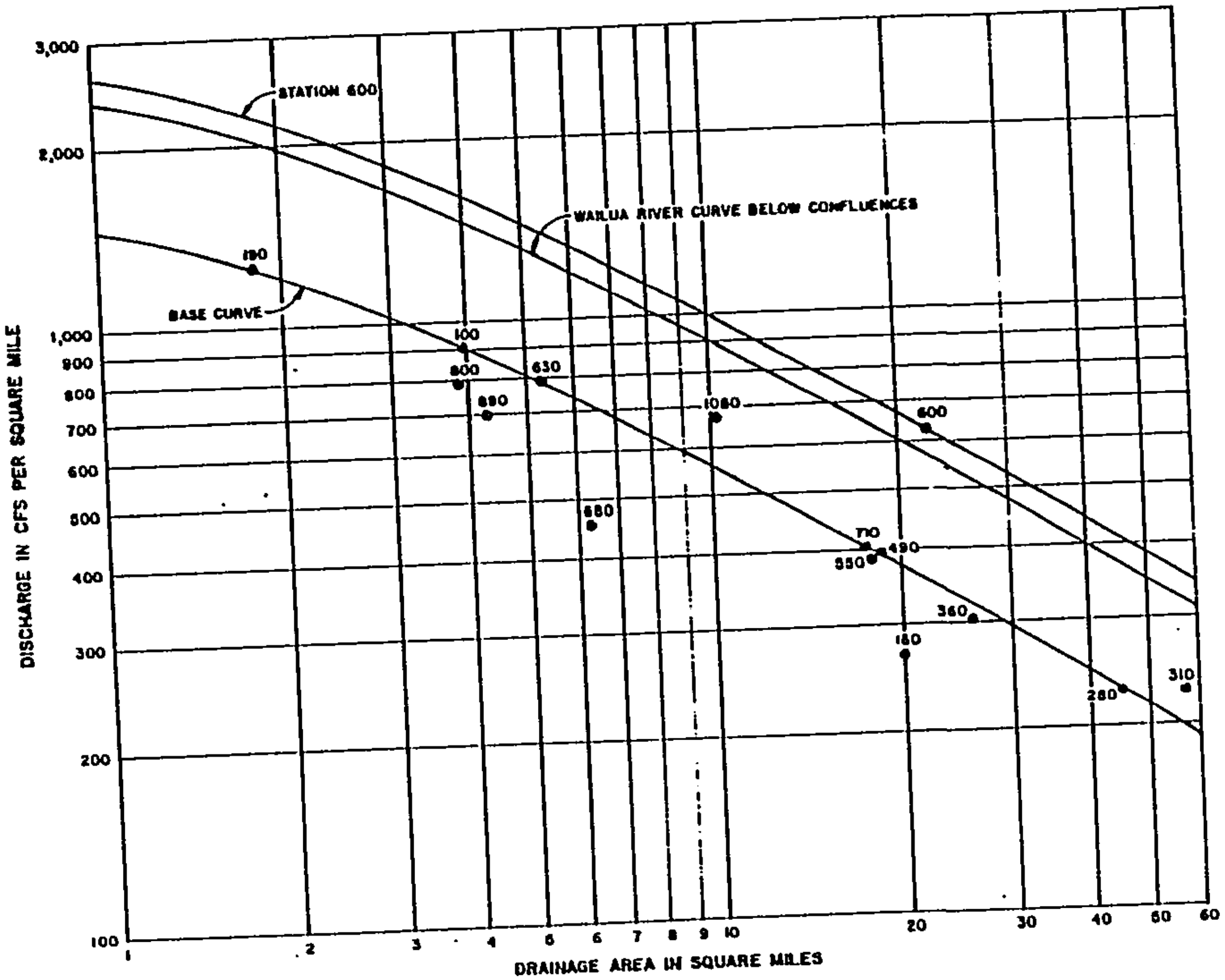
NORTH FORK WAILUA RIVER

(STATION 710)

DA = 17.9 SQ MI

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE B-10



LEGEND:

● 680 USGS GAGE NUMBER (SEE TABLE FOR INFORMATION)

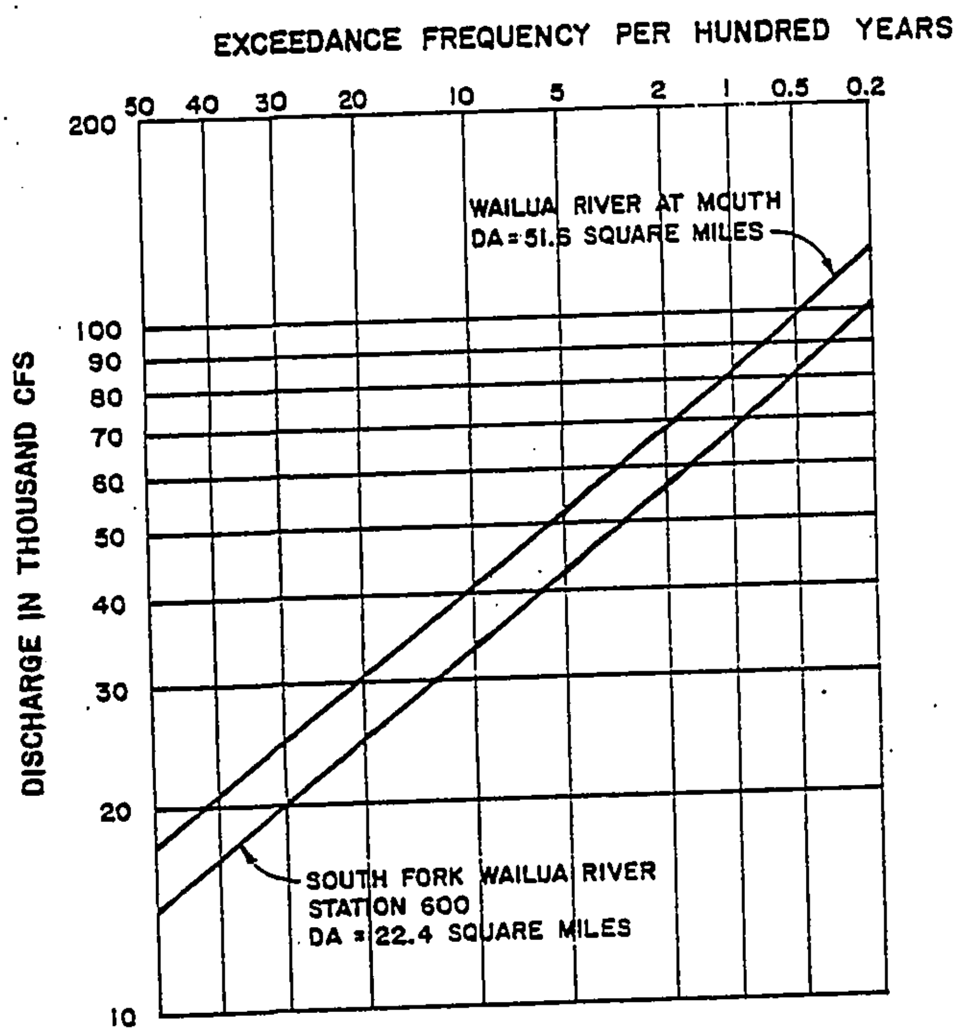
WAILUA RIVER — HAWAII

DRAINAGE AREA
MEAN ANNUAL PEAK FLOW
RELATIONSHIP

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE B-11

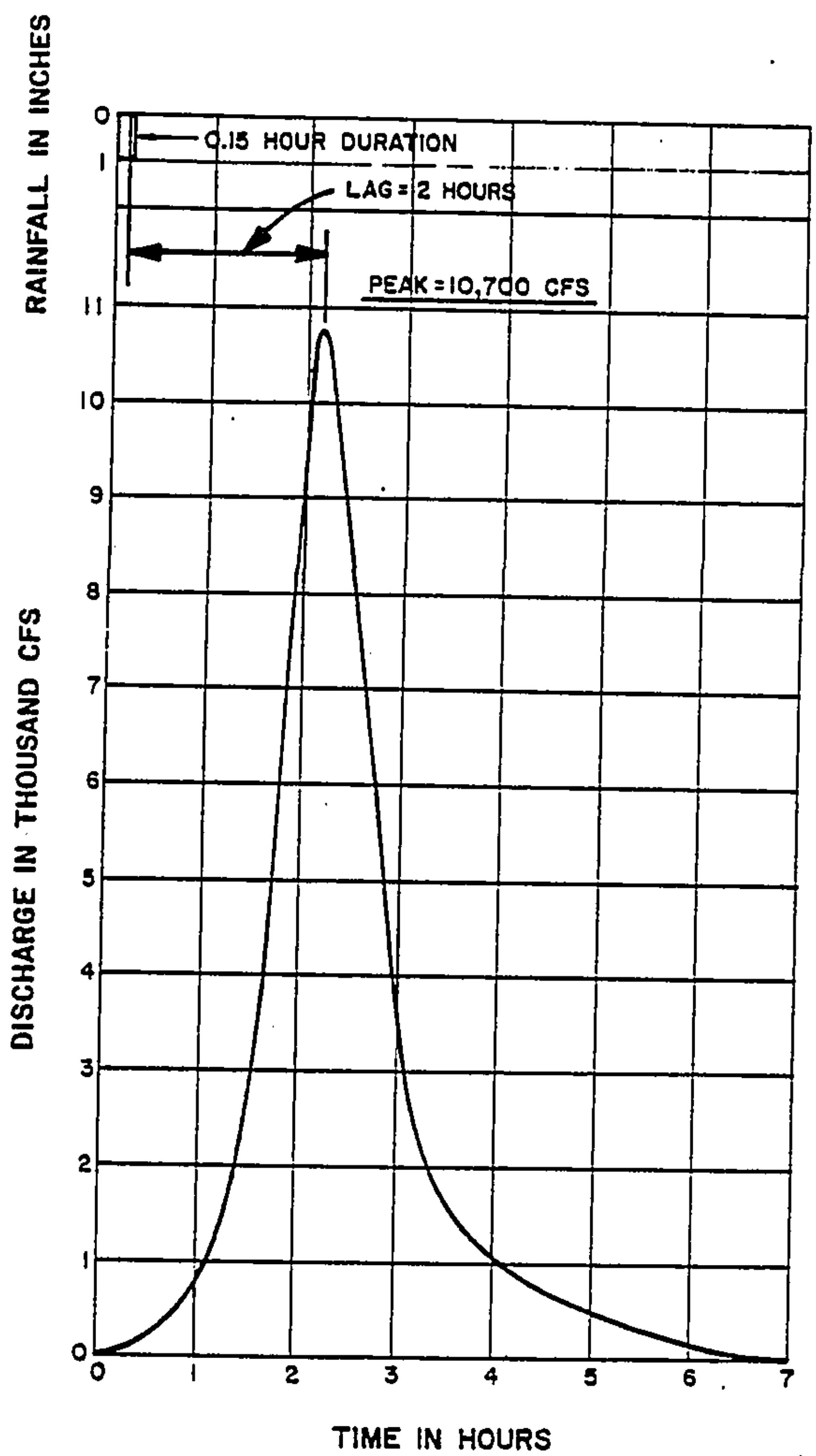
PLATE B-11



NOTE: THESE CURVES ARE WITH EXPECTED PROBABILITY ADJUSTMENT.

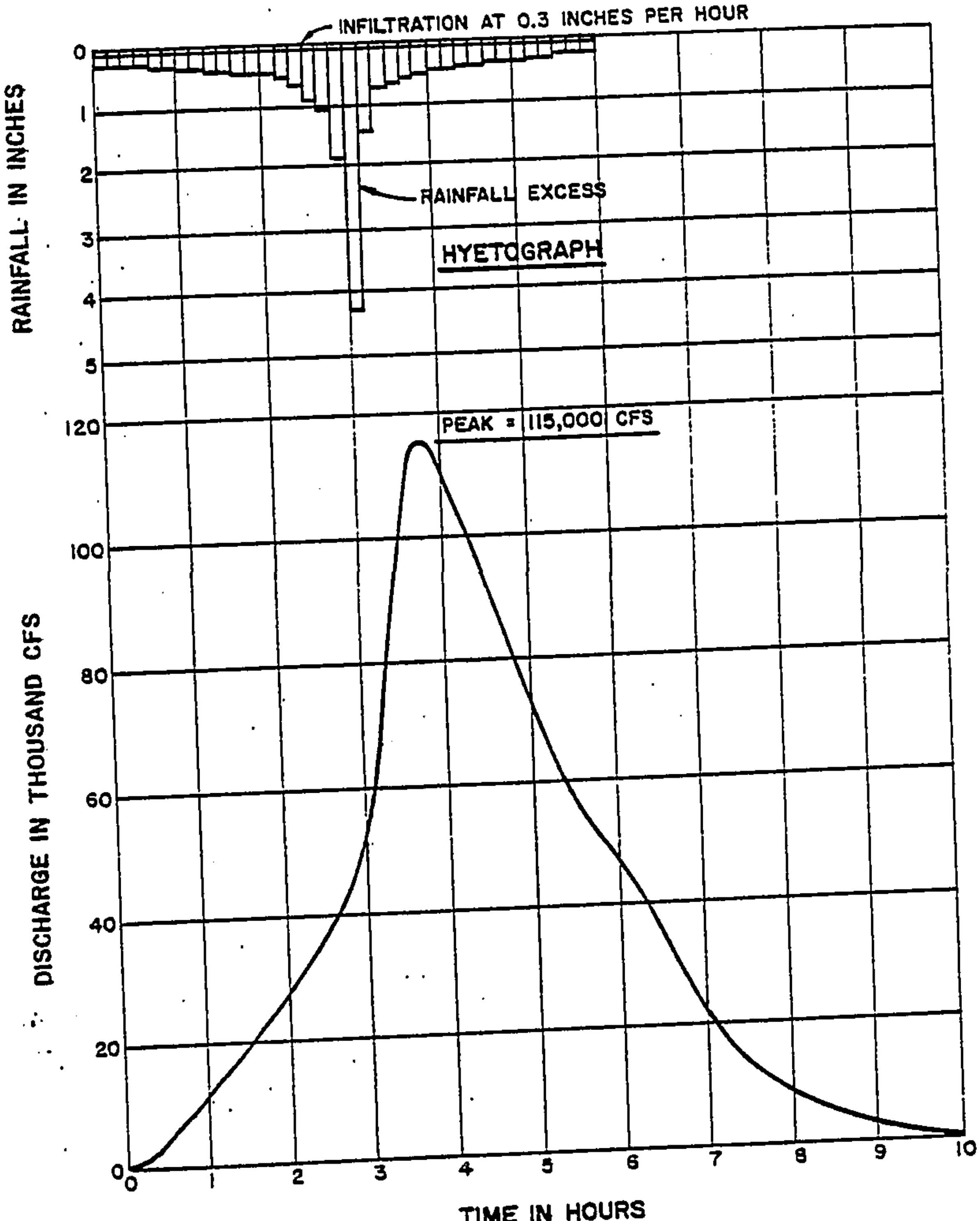
WAILUA RIVER	HAWAII
FLOOD FLOW FREQUENCY CURVES WAILUA RIVER	
U.S. ARMY ENGINEER DISTRICT, HONOLULU	

PLATE B-12



NOTE: THIS PLATE WAS TAKEN FROM THE "WAIALEALE HYDROPOWER STUDY."

WAILUA RIVER	HAWAII
UNIT HYDROGRAPH SOUTH FORK WAILUA RIVER (STATION 600) DA = 22.4 SQ. MI.	
U.S. ARMY ENGINEER DISTRICT, HONOLULU	



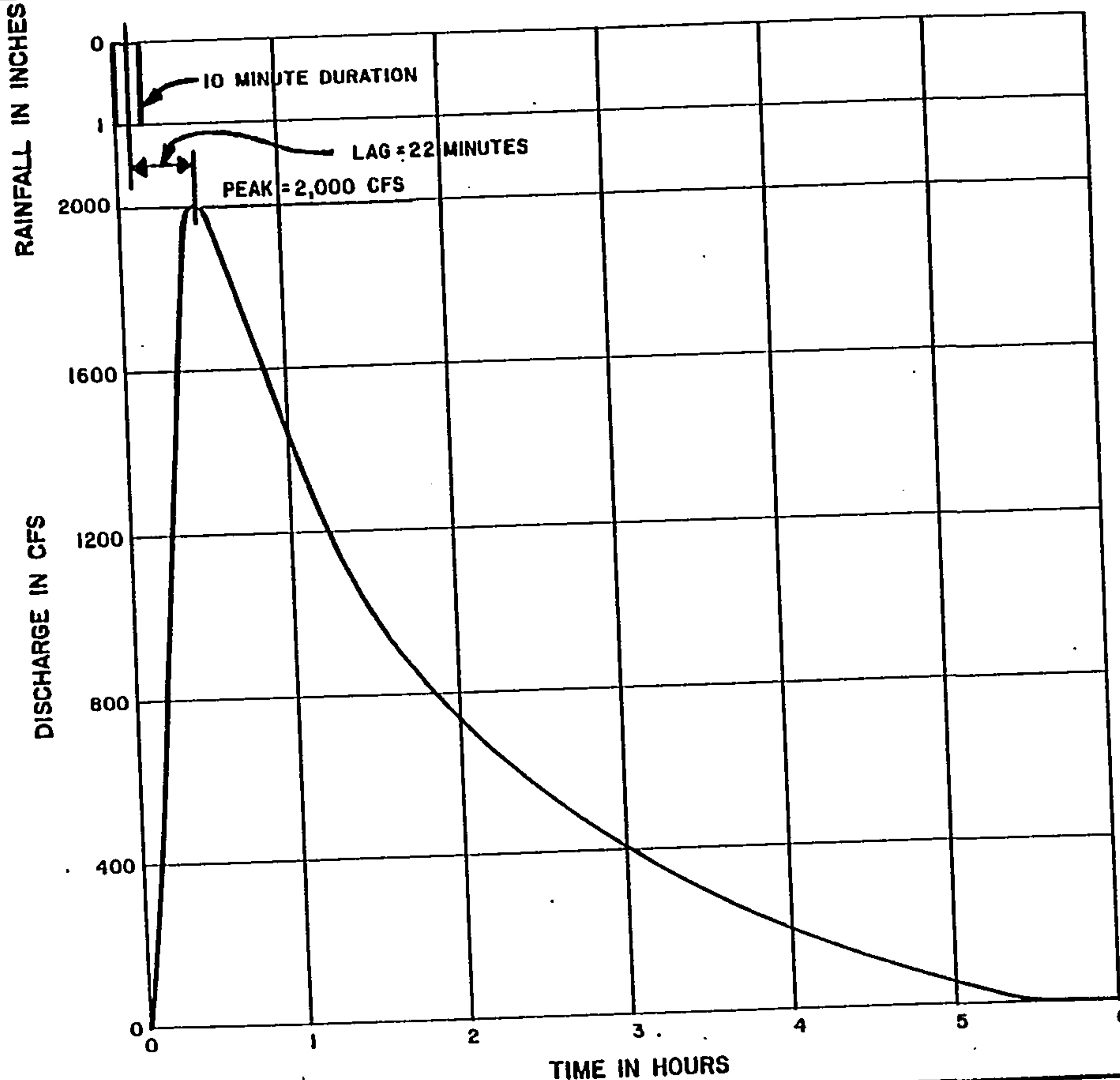
NOTE: THIS PLATE WAS TAKEN FROM THE "WAIALEALE HYDROPOWER STUDY."

WAILUA RIVER HAWAII

PROBABLE MAXIMUM FLOOD
SOUTH FORK WAILUA RIVER
(STATION 600)
DA = 22.4 SQ.MI.

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE B-14



WAILUA RIVER HAWAII

UNIT HYDROGRAPH

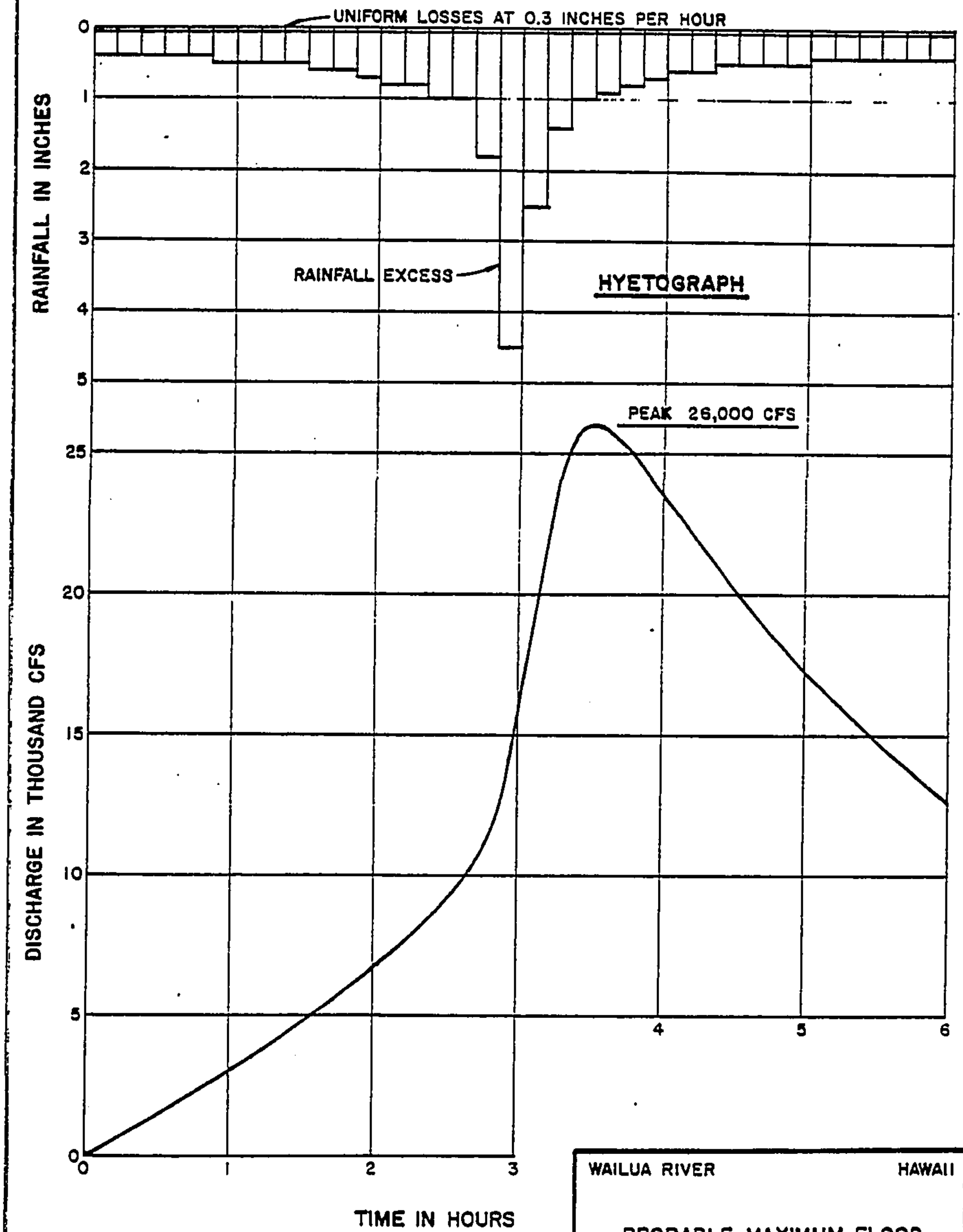
NORTH FORK WAILUA RIVER

(STATION 630)

DA = 5.29 SQ. MI.

U.S. ARMY ENGINEER DISTRICT, HONOLULU

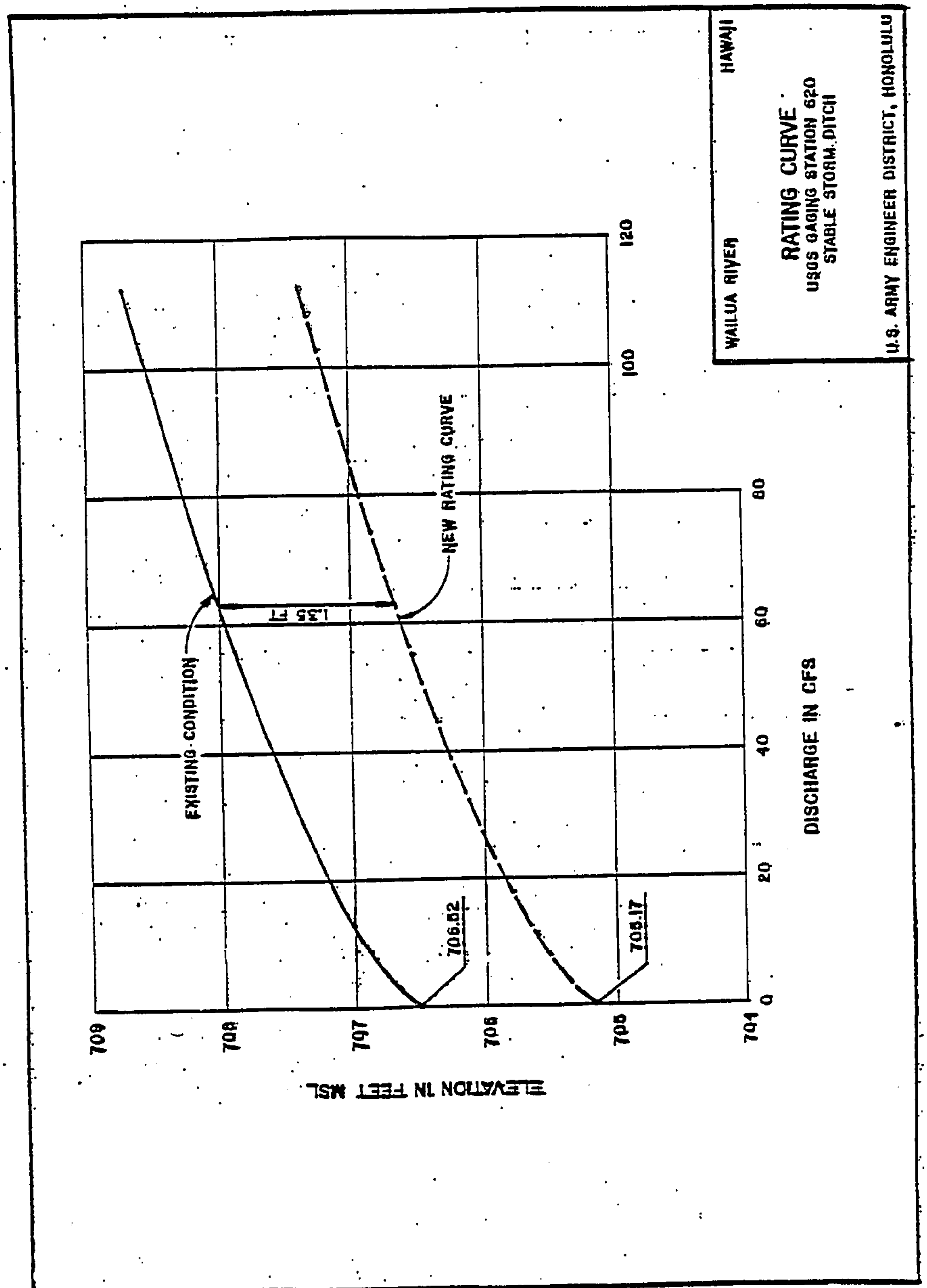
PLATE B-15



WAILUA RIVER HAWAII

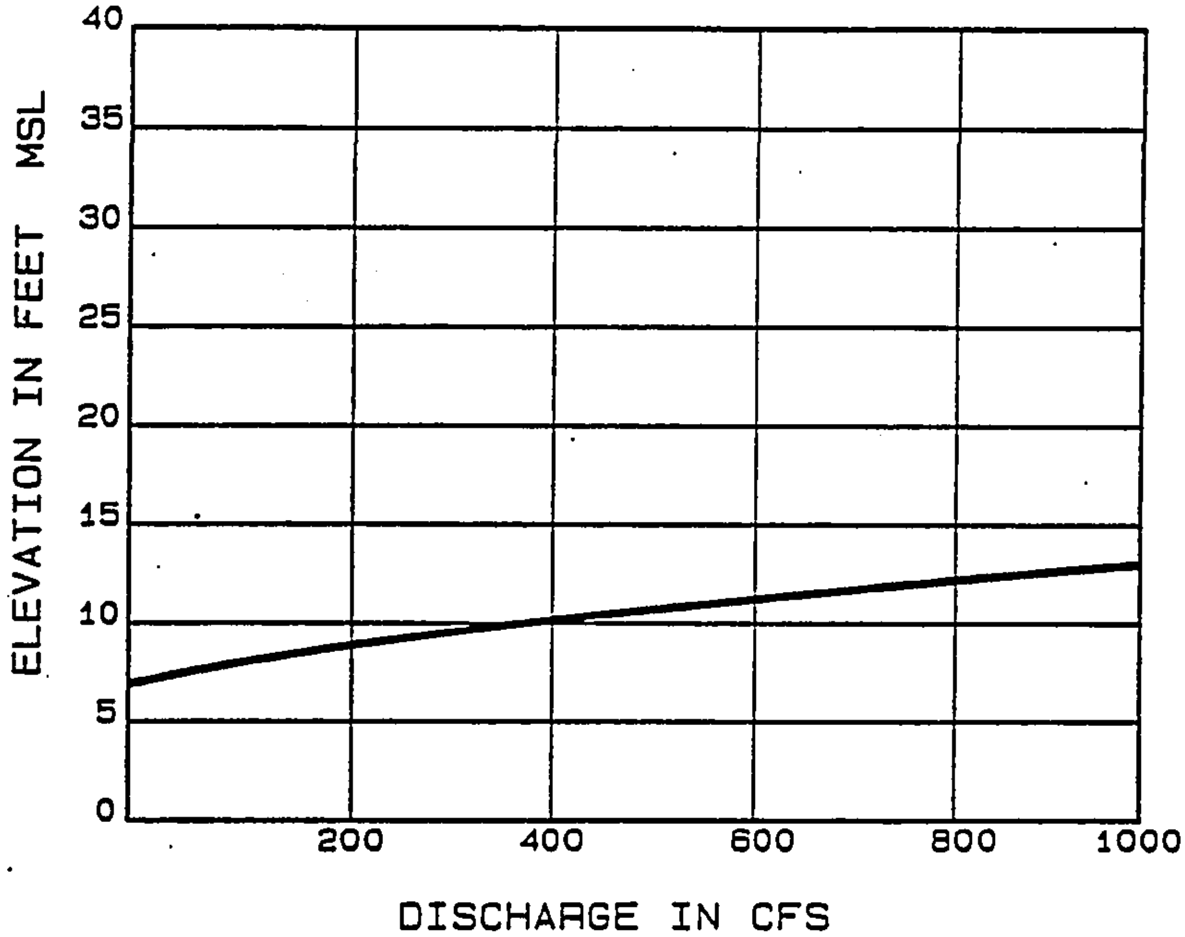
PROBABLE MAXIMUM FLOOD
NORTH FORK WAILUA RIVER
(STATION 630)
DA=5.29 SQ.MI.

U.S. ARMY ENGINEER DISTRICT, HONOLULU



WAILUA RIVER
HAWAII
RATING CURVE
USGS GAGING STATION 620
STABLE STORM DITCH
U.S. ARMY ENGINEER DISTRICT, HONOLULU
EXISTING CONDITION
NEW RATING CURVE
1.35 FT
706.62
705.17
ELEVATION IN FEET MSL
709
708
707
706
705
704
DISCHARGE IN CFS
0
20
40
60
80
100
120

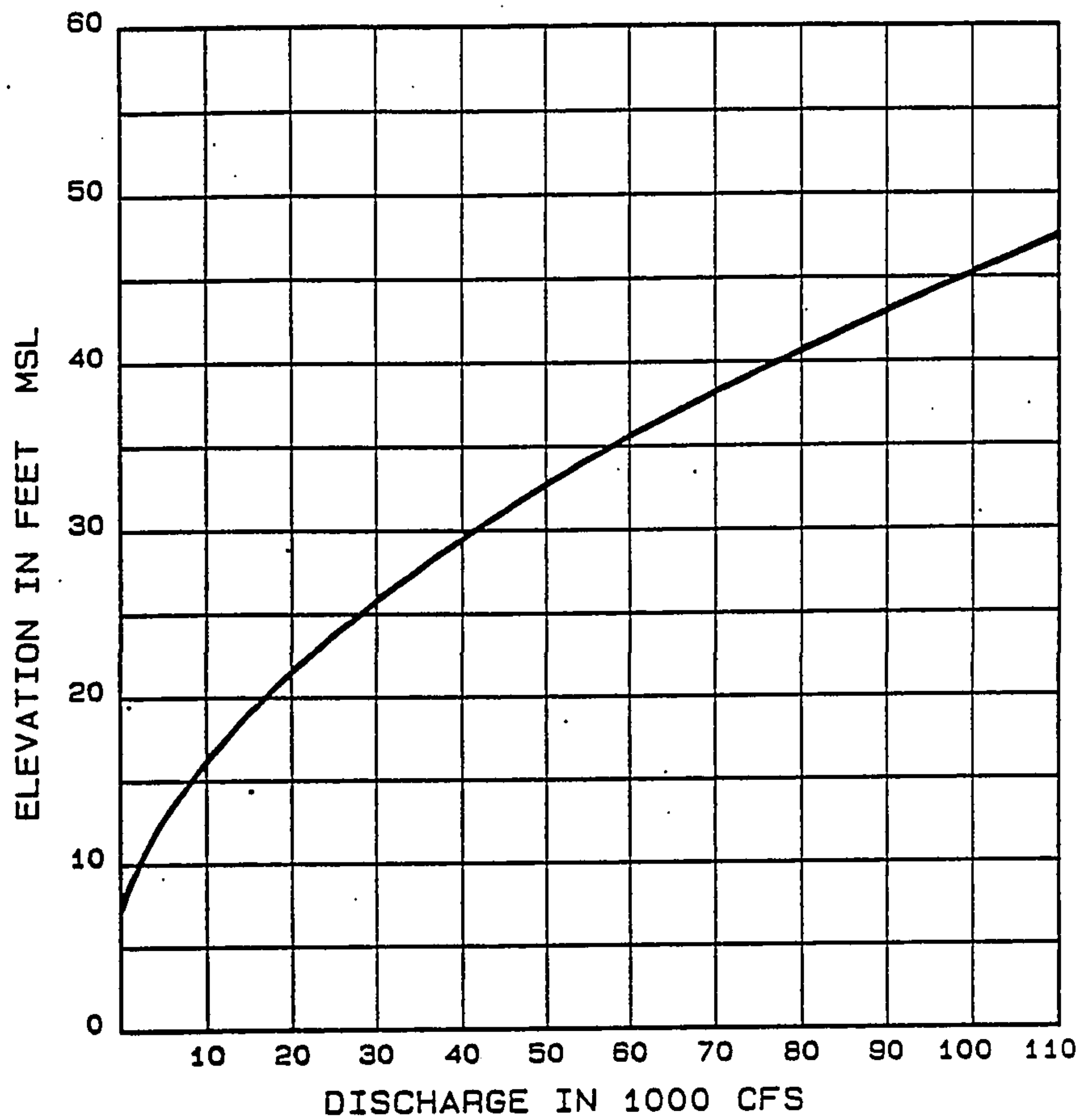
PLATE B-17



WAILUA RIVER
HYDRO PROJECT

TAILWATER
RATING CURVES
0–1000 CFS

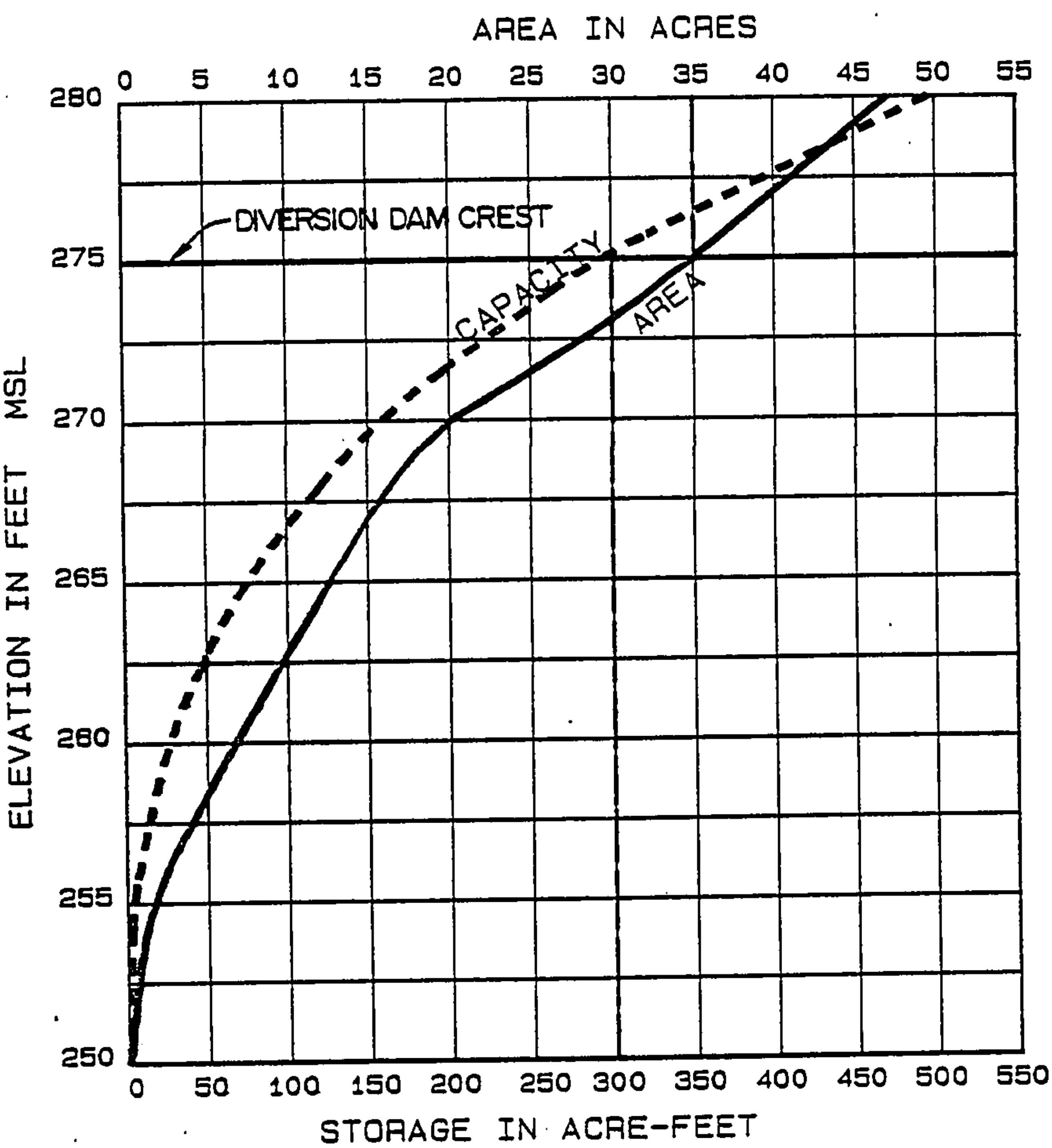
PLATE B-18



WAILUA RIVER
HYDRO PROJECT

TAILWATER
RATING CURVES
OVER 1000 CFS

PLATE B-19



WAILUA RIVER HYDRO PROJECT

DIVERSION POND AREA - CAPACITY CURVE

PLATE B-20

B-6c GEOTECHNICAL INVESTIGATIONS

GEOTECHNICAL INVESTIGATIONS

REGIONAL GEOLOGY

1. Kauai was formed by the activity of one large shield-shaped volcano. Toward the end of the growth of the shield, its summit and east flank collapsed and formed a broad depression or caldera known as the Lihue depression. Subsequent faulting and lava filling caused other collapses on the mountain. The rim of the depression or basin is formed by the Haupu Ridge on the south, the main mountain mass of central Kauai on the west, the Makaleha mountains on the north, and Nonou and Kalepa Ridges on the east. The basin rim consists of rocks of the Waimea Canyon Volcanic Series. These rocks are 5 to 6 million years old (Pliocene geologic age) and comprise the bulk of the island volcano. After the completion of the great Kauai shield and collapse of its summit, volcanic activity ceased and a long period of erosion formed thick soil over much of the mountain. Then, a new period of volcanism began that rests on the erosional unconformity. The eruptions occurred from a series of about 40 minor vents forming cinder cones, one tuff cone, and some lava cones. This period of volcanism is known as the Koloa Volcanic Series. The Lihue depression floor was buried under the later flows of the Koloa volcanics which are estimated to be one to 1-1/2 million years old (late Pliocene to Pleistocene geologic age). The present basin floor is made of younger lava basalts, mudflows, and thick alluvium from the decay of basalt and accumulation of saprolitic and lateritic rock-soil mixtures. Just before and during eruptions of the Koloa volcanics, landslides and mudflows brought down large amounts of debris and soils from the steep slopes of the central uplands. The Nonou and Kalepa Ridges and Aahoaka hills are steptoes or islands of older Waimea volcanics protruding through much younger lava flows of the Koloa volcanic series. The three conspicuous landforms influenced stream alignment and drainage in the basin. The north and south forks of the Wailua River join at the water gap between Nonou and Kalepa Ridges.

2. The Wailua River Basin and Wailua Falls (site of proposed facility) are located almost entirely within the Lihue depression. The surface geology in the vicinity of the falls is shown on the "Geologic Map," Plate D-1. It shows the land around the falls to consist of late Pliocene to Pleistocene lava flows of nepheline basalt, melilite-nepheline basalt, olivine basalt, picrite-basalt and basanite of the Palikea Formation. These lava basalts are in contact with and perhaps overlain by Pleistocene non-calcareous alluvial sediments (also of the Palikea Formation). Younger (recent-geologic age) unconsolidated, non-calcareous, alluvial sediments have been deposited along the channel of the Wailua River on both sides of the falls.

GEOTECHNICAL SITE CONDITIONS

3. Wailua Falls is located on the South Fork of the Wailua River approximately 2.5 miles upstream of the confluence of the north and south forks. The topography of the basin (ground surface) at the site is characterized by a low (elev. 275 feet to 325 feet msl) rolling terrain. The South Fork has cut approximately 250 feet into the basin surface downstream from the falls. Above the falls, the river has eroded about 50 feet below the basin surface. The erosion resulted in steep to vertical blocky cliffs along the river below the falls and comparatively gentle bank slopes in overburden above the falls. From its headwaters, the South Fork flows east but is diverted south by Aahoaka Hill at a distance of 2,000 feet north of the falls. The flow resumes an easterly to northeasterly direction approximately

* The following pages B-95 to B-98 is information from the U.S. Army Corps of Engineers from their "Final Interim Survey Report and Environmental Statement"

2,500 feet below the falls. All bank slopes along the river are heavily vegetated with trees, brush, and other tropical plants. The rolling terrain of the basin surface on each side of the river is cultivated for sugarcane and traversed by unpaved haul roads.

SUBSURFACE INVESTIGATIONS

4. Subsurface materials along the proposed conduit alignments were explored on a preliminary basis with seven borings from 7 December 1981 to 31 December 1981. Locations of borings and a subsurface profile are shown on the "Boring Location Plan," Plate D-2 and "Profile of Borings," Plates D-3 and D-4, respectively.

The borings show massive lava basalt lying 35 to 50 feet below the ground surface in all borings except numbers 6 and 7. Lava basalt is overlain by alluvial/colluvial soils consisting of silts, clays, and gravel to cobble size pieces of basalt. In borings 6 and 7, massive lava basalt was not encountered and depths to rock were not determined. Additionally, the lava basalts in hole #5 are found intercalated with layers or zones of soil. Localized perched water was found at depths of 20 to 30 feet below the ground surface in boring numbers 1, 3, and 4.

SUBSURFACE CONDITIONS

6. Silts predominate the overburden materials. Resistance to standard penetration testing (SPT) indicates the silt to be of medium stiff to stiff consistency above the groundwater elevation. Below the perched water table, silts are considerably more penetrable with a consistency of soft to medium stiff. Frequent partially to wholly decomposed basalt rock fragments (gravels to cobbles) within these silts often demonstrate greater resistance to SPT.

7. Ten to 20-foot thick zones of basalt gravel and cobbles in a silt-clay matrix were encountered at or near the top of the lava basalt in boring numbers 1, 2, and 3. The top of a gravel zone was also encountered at a depth of 80 feet in hole #5. The basalt fragments vary in size from 3/8" diameter gravel to 12" diameter cobbles and are randomly graded (well to poor) and rounded (angular to round). These rock fragments also vary in stage of decomposition from unweathered to completely decomposed. These zones could not be effectively penetrated and sampled by SPT, and required coring. Core recovery in these zones was generally poor, ranging from 0 to 60 percent. The fine grain materials in these zones consist of a soft, reddish brown, plastic, clayey silt.

8. Although nearly all overburden is alluvial, some gravel and cobble materials directly overlying the lava basalt appear to be saprolitic (weathered in place). Several SPT samples displayed obvious rock structure suggesting that a portion of the overburden is a residual soil weathered from the basalt. The physical characteristics of overburden materials are treated in further detail in following paragraphs on laboratory testing.

9. The flow of solidified lava basalt appears continuous across borings 1 through 4. It is not known if the basalt found in boring 5 is an extension (or part) of the flow lavas around the falls. Although it appears similar in physical characteristics, it differs because it is found at higher elevations

and, as mentioned earlier, is intercalated with and underlain by soils. The stratigraphic profile "Rock Face Profile Sketch," Plate D-5 shows that, at the falls, the massive basalt extends in depth approximately to elevation 170 feet. The massive basalt layer is 80 to 100 feet thick. No lava basalt was found in borings 6 and 7. The proximity of boring 6 to the slope down to the Wailua River may account for its lack of lava basalt to the depth of boring. The slope of a wide floodplain (as the Wailua) receives more alluvial deposit than the plateau above it. Boring 7, which is located within the Wailua River floodplain, was also filled with alluvial deposit. The lava basalt at the site is massive, bluish-gray, hard, and vesicular. It is moderately fractured and exhibits a columnar fracture pattern in the vertical outcrops at the falls. With depth, vesicles are less frequent and smaller. Vugs, up to several inches in diameter and possibly larger, appear more frequent with depth. Some of the vesicles and smaller vugs are filled with a soft, white, sugar-textured quartzitic (silica) precipitate and larger vugs sometimes contain quartz crystals up to 0.5-inch in length. The rock in boring 5 is less massive than the basalt in the holes near the falls. Fractures and joints in rock contain little or no filling and may transmit water easily. Infrequent water losses during drilling and the presence of a high perched water table suggests the lava basalt layer is saturated. The rock is generally unweathered with fracture and joint surfaces showing only slight weathering. Sometimes the joints are partially filled with white quartzitic precipitate.

SEISMICITY

10. Practically all earthquakes of the Hawaiian Islands are associated with intermittent volcanic activity. Potential earthquakes on Kauai can be caused by deep-seated 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. The seismic risk for Kauai should be determined 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. A Richter magnitude 7 earthquake on January 23, 1938 had an epicenter on the Molokai Fracture Zone 25 miles north of Pauwela Point on the north shore of Haleakala, Maui. The intensity of this earthquake at Wailua Falls is not known.

11. Technical Manual 5-809-10, February 1982, assigns a Zone One (1) seismic probability (seismic risk rating) and a Z-coefficient of 3/16 for the study area. Zone One (1) is described as minor damage hazard. No seismograph stations operate on Kauai, and no records are available on which to base a seismic risk evaluation.

LABORATORY TESTING

12. Testing of the overburden soils from the seven borings consisted largely of identification and classification. The silts vary from very fine-grained, as an ash or clay, to slightly coarse, as a fine sand. Laboratory values are shown on the boring profile Plates D-3 and D-4, and are summarized in Plates D-6 and D-7. Silts are generally a MH classification, in accordance with the Unified Soil Classification System; however, by grain size distribution the silt can be classified as a clay. The gravel layers are filled with a

silt-clay mixture, becoming less gravelly and more silty with depth. For design purposes, the following values may be assigned to the overburden material:

Unit weight	= 115 lbs per cubic foot
Internal friction	= 15 degrees
Cohesion, C	= 400 lbs per square foot
Maximum dry density (recompacted)	= 92 lbs per cubic foot
Optimum moisture content	= 32 percent

DESIGN CONSIDERATIONS

13. Conduit. - The excavation method for the conduit of Alternatives 1A and 2A is cut-and-cover excavation. The subsurface investigations show that the majority of excavation will be through silty alluvium. Although existing road cuts in the material stand at near vertical slopes for 15-foot depths, the excavation depth for the conduit is approximately 50 to 60 feet. Therefore, recommended slope for the excavation is 1 horizontal to 1 vertical. Additionally, 10-foot-wide benches at each vertical interval of 20 to 30 feet will provide stability from erosional forces during the period the excavated slopes are exposed.

14. Before the alluvium, approximately 10 to 15 feet of basalt will be excavated to reach the design invert elevation. As demonstrated by the exposed formation at Wailua Falls, the basalt is capable of standing on vertical cuts. The borings show that the basalt is more jointed and fractured at or near the upper surface of the flow than within the flow. Most of these rock defects are tension cracks formed as the lava cooled. It was also noted that the rock is more vesicular near the upper surface. The vesicular nature of the rock and moderately fractured condition within 10 feet of the upper surface of the flow should make excavation by ripping practical. However, hard massive zones of basalt are anticipated and will require blasting.

15. The strength of the basalt foundation below the conduit precludes the need for bedding material, except to level the floor of the excavation and to serve as a cushion to preclude point bearing.

16. Three of the seven borings recorded perched water at 20 to 30 feet below the ground surface. Dewatering by conventional methods, such as sump pumping or perimeter wells points, should be considered during excavation.

17. Penstock Foundation. No foundations investigations have been made for the penstock foundation design of either alternative. Future investigations will provide bearing and stability information for the design of footings, surface embedment, or alternative foundation proposals.

18. Diversion Dam at Wailua Falls. The proposed diversion dam would be a shaped, concrete gravity structure. The riverbed foundation material is firm lava basalt and would provide adequate support for the structure. Tie-in reinforcing bars with the basalt would require drilling effort into the basalt.

19. Upstream Stable Storm Ditch Diversion. The upstream flow diversion channel was designed as a rectangular concrete conduit. The foundation material in this area was investigated visually and consists of alluvial silts and river gravel on the surface, with lava basalt underlying it at an unknown, but shallow depth. Outcrops of cobble-covered basalt are visible in the river adjacent to the existing diversion. The existing structure would be removed, and approximately 2 feet of material would be excavated below it. It is probable that the excavation woudl remove the surface soils and expose the basalt beneath near the diversion. However, the alluvium is competent in bearing and would support the designed structure. Due to the highly erodible nature of the alluvium, revetment material or concrete shielding would be recommended in all areas where the soil is exposed.

20. At the downstream outlet of the conduit, the retaining wall provides protection against slope erosion. Provision for keying the retaining wall into the underlying basalt will be necessary. Further investigations of the subsurface profile will be provided at the next design stage.

CONSTRUCTION CONSIDERATIONS

21. Sources of Construction Materials. 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 Balley, Waipao Valley, Kahoana Valleys (east and west), and Niu Valley. Any competent material from the excavation for the conduit will be considered for use as armor stone.

22. 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. or from O. Thronas Construction Company. An asphaltic concrete batch plant operated by Hawaiian Bitumuls and Paving Company is located at Halfway Bridge near the Hale Kauai quarry.

23. Excess soil-rock material from excavation may be used for grading and fill at the proposed plant site. Placement should be 95 percent maximum density and at optimum moisture content plus or minus 3 percent. Cobbles in excess of 6" diameter are not suitable for fill. Unsuitable and excess material may be placed in a disposal site to be determined.

24. Dewatering. As discussed in the Design Consideration, dewatering may be required to facilitate excavation and placement of the conduit. At the diversion dam above the falls, re-routing of the riverflow by caissons or alternative channelling will be required during the placing and curing of the concrete. During construction a portion of the structure will be constructed while the river is temporarily rerouted along the construction area. The rerouting of the river; however, will take place within the reservoir and will not be outside of the area affected by reservoir construction. The rerouting of the river channel will be over a 3-4 month period and will only affect the channel immediately below the river within approximately 500 feet of the proposed structure and will not affect any area above the structure that is not included within the reservoir basin. Similar treatment may be necessary at the Stable Storm Ditch Diversion for the culvert construction.

25 Access. A private gravel-and-dirt roadway presently gives access t the proposed powerhouse site. However, the grade, curves, and poor surface condition preclude its use by heavy construction equipment. Widening of the existing road will be developed for this alternative. Existing cane haul roads to the general site area are adequate to support normal construction traffic with some maintenance.

EXPLANATION AND LEGEND FOR PLATE D-1.

GEOLOGY ADAPTED FROM:
Macdonald, G. A., Davis, D. A. and Cox, D. C. "Geology and Ground-water Resources of the Island of Kauai, Hawaii," Bulletin 13, Hawaii Division of Hydrography, 1960.

LEGEND

SEDIMENTARY ROCKS

Qb	RECENT - calcareous sediments. Modern beaches composed largely of unconsolidated calcareous fragments of marine organisms.
Qd	RECENT - calcareous sediments. Dunes of unconsolidated calcareous sand blown inland from modern beaches.
Qa	RECENT - younger non-calcareous sediments. Unconsolidated alluvium along stream valleys and coastal plains, graded approximately to present base level.
Qao	PLEISTOCENE - older non-calcareous sediments, poorly to moderately well consolidated alluvium graded to former base levels and now undergoing dissection; in part, correlative in age with the Koloa volcanics.

KOLOA VOLCANIC SERIES

Qkp	PLEISTOCENE OR LATE (?) PLIOCENE - masses of poorly sorted breccia and beds of conglomerate of the Palikea formation lie at the contact with the Waimea Volcanic Series and are intercalated between lavas of the Koloa Volcanic Series. Poorly permeable. Locally, small bodies of water are perched at high levels in the Palikea formation.
Qkl	PLEISTOCENE OR LATE (?) PLIOCENE - Aa and Pahoehoe lava flows of nepheline basalt, melilite-nepheline basalt, olivine basalt, picrite-basalt and basanite erupted from a large number of vents. Poorly to moderately permeable. Locally, small bodies of fresh water are perched at high levels by beds of ash and soil.

WAIMEA CANYON VOLCANIC SERIES

Twn	PLIOCENE - lower member (Napali formation). Thin flows of predominately olivine basalt accumulated on the flanks of the Kauai Shield Volcano. Highly permeable and yields basal water to wells and to high levels between dikes.

* The page B-101 is information from the U.S. Army Corps of Engineers from their "Final Interim Survey Report and Environmental Statement"

SUMMARY OF SOILS IN PROJECT VICINITY

Using the SCS and LSB Classification Units as referenced in the February 24, 1986 comment from the Hawaii Department of Agriculture a complete review of the project soils was completed. The Land Study Bureau Detailed Land Classification for the Island of Kauai is out of print and not on file at any Federal, State or local Utah facility. With the cooperation of Mr. Earl Yamamoto of the Hawaii Department of Agriculture we received copies of the pertinent portions of LSB #9 for our response. Some are now included in the EIS.

As referenced below on Tables B-6c-1 and 2 and on Plates D-7 and D-8, the SCS and LSB soil types which occupy the area along the proposed project alignment are briefly summarized as to their textural, chemical, agricultural and engineering characteristics.

Soil Conservation Service Classification (SCS)

At the diversion site the principal soil type is the Kolokolo series which are well drained bottom land soils. They are alluvial soils on fairly level terrain between 50-500 foot elevation. Most specifically the series is the extremely stony clay loam (KUL). Basically this soil is quite stony with boulders. Principle excavation will be to bedrock or to competant foundation conditions in this unit. The initial penstock alignment will be within this unit as well. The remainder of the penstock will pass through the Hanamaulu and Ioleau soil units which are both well drained soils. The Hanamaulu series are formed on alluvium of upland origin. The Ioleau series is found on the uplands and is of weathered basalt composition (saprolitic). These are both silty to stony clays and silty clay loams.

The proposed powerhouse foundation is within the same Kolokolo series as the diversion but of the clay loam unit. This is due to the stream bottom siting. Outcrops of basaltic rock with rather steep slopes are found on either side of the canyon.

Penstock excavations both totally within soil and totally within rock are anticipated and excavation methods for each will be incorporated and the areas will be returned to a natural grade after placement of the penstock within the narrow corridor required.

Detailed Land Classification (LSB)

Included in the EIS is a portion of the Detailed Land Classification - Island of Kauai, from the Land Study Bureau Bulletin No. 9 dated December 1967. Also presented is a table showing the pertinent data for those soils along the project alignment. The text of the LSB clearly explains the method of classification and the interpretation of numbers on the accompanying 1" = 400' map of the area. This map is adapted from the Land Study Bureau. The 1" = 400' map showing the Soil Conservation Service distribution and classification of their units correlates well with those of the LSB map.

Using the LSB classification the units of interest are:

Diversion Dam: E89, E90
Penstock: B78:, D11:, E89, E90, E92, C79
Powerhouse: C8
Transmission Line: B78:, C43, E87

TABLE B-6c-1

U.S. SOIL CONSERVATION SERVICE CLASSIFICATION DATA

	Physical Characteristics								Possible Uses		
Soil	Depth to Bedrock	Depth to High Water Table	USCS*	Permeability	pH	Shrink Swell Pot.	Corrosivity Uncoated	Corrosivity Concrete	Road Fill	Roadway	Foundation
Hanalei HnA	> 5'	> 0-5'	MH	0.63-2.0	4.5-7.3	Mod.	High	Mod.-Low	Poor (wet)	Poor (wet)	Fair (high water)
Hanamaulu HsB-HsC-HsD	> 5'	> 5'	MH	2.0-6.3	4.0-5.5	Low	High	Low	Good	Good (40% slope)	Good (sloped)
Ioleau IoB-IoC	> 5'	> 5'	MH	0.06-0.63	4.0-5.0	Mod.	High	High	Good	Fair (sloped)	Fair (sloped)
Kapaa KkB-KkD	> 5'	> 5'	MH	2.0-6.3	4.5-6.0	Low	High	Mod.	Good	Poor (100% slope)	Fair (100% slope)
Kolokolo Kw	> 5'	> 5'	MH	0.63-2.0	6.6-7.3	Mod.	High	Low	Good	Good (close to stream)	Good (close to stream)
Kolokolo Kul	> 5'	> 5'	MH	0.63-2.0	6.6-7.3	Mod.	High	Low	Poor	Fair	Good (stoney)
Puhi PnB	> 5'	> 5'	MH	2.0-6.3	4.5-6.5	Mod.-Low	High	Low	Good	Fair (sloped)	Fair (40% sloped)
Rough Broken Land rRR	± 5'	--	--	--	--	--	--	--	Fair	Fair	Fair to Poor
Rock Outcrop rRo	--	--	--	--	--	--	--	--	Good (requires crushing)	Good	Very Good

* USCS = Unified Soil Classification System

TABLE B-6c-2

LAND TYPES: PRODUCTIVITY RATINGS AND DESCRIPTIONS – ISLAND OF KAUAI

Land Type	Overall Rating	Selected Crop Productivity Ratings: Pine-apple	Vege-tables	Sugar Cane	Forage	Grazing	Orchard	Timber	Machine Tillability	Stoniness	Depth (inches)	Slope (percent)
8	C	e	c	c	b	b	b	Co	Well-suited	Nonstony	Deep,over 30	0-10 predominantly
11i	D	e	d	c	d	c	c	--	Moderately-suited	Nonstony	Deep,over 30	0-10
43	C	c	d	d	d	b	c	Co	Moderately-suited	Nonstony	Deep,over 30	11-20
78i	B	b	b	b	b	a	b	--	Well-suited	Nonstony	Deep,over 30	0-10
87	E	e	e	e	e	d	e	Co	Not suited	Nonstony to rocky	Variable	36-80
89	E	e	e	e	e	d	e	Co	Not suited	Rocky	Variable	0-35
90	E	e	e	e	e	e	e	Co	Not suited	Nonstony to rocky	Variable	36-80
92	E	e	e	e	e	e	e	NCo	Not suited	Rocky	Variable	80+

TABLE B-6c-2 (cont.)

Land Type	Texture	Drainage	Median Annual Rainfall (inches)	Elevation (feet)	Color	Soil Series	Existing Uses	Vegetation Zone
8	Mod. fine	Moderately well-drained; flooding on occasion	40-60	500	Dark grayish brown	Hanalei	Grazing, sugar cane, taro	C_1
11i	Fine	Moderately well-drained	60-150	100-1000	Very dark grayish brown	Hanamaulu & Waikane	Sugar cane, grazing	D_1
43	Mod. fine	Well-drained	40-60	0-800	Dusky red to dark reddish brown	Lihue & Kamilo	Sugar cane (irr.) pineapple, grazing	C_1
78i	Mod. fine	Well-drained	50-75	150-500	Very dark brown to brown	Puhi	Sugar cane, grazing	C_1
87	Medium to fine	Well-drained	40-60	0-2500	Dark reddish brown to dark brown	Rough broken lands	Grazing, forest	C_1
89	Medium to fine	Well-drained	60-200	0-2500	Dark brown to grayish brown	Rocky lands	Grazing, forest, recreation	D_1
90	Medius to fine	Well-drained	60-200	0-2500	Dark brown to grayish brown	Rough broken lands	Forest, recreation	D_1
92	Variable	Well-drained	20-450	0-5000	Dark brown to black	Pali lands	Forest	All

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TAILED LAND CLASSIFICATION - ISLAND OF KAUAI

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The procedure for inventorying and evaluating the land resources of the State involves the compilation and interpretation of a wide array of information, as well as a thorough knowledge of the lands being classified. Classification requires competence in soils, geology, plant ecology, plant physiology, climatology, and farming practices.

Initially, it was necessary to find out what kind of lands there are and where they are located. The Soil Conservation Service soil survey field sheets (10) were utilized for this purpose. Additional surveys were made in areas where the SCS field sheets were lacking or did not meet Bureau requirements. Frequent field trips were made to verify the soils, slope of land, existing land use, and other pertinent information. Finally, these facts were recorded on aerial photo maps.

Preliminary estimates were made of crop adaptations and productivities of individual soils from the aforementioned information. These estimates provided a starting basis for separating lands of significantly different levels of crop productivity. Tentative boundaries were then drawn on the aerial photo base maps.

Using these aerial photos as work sheets, field observations were then made to: 1. determine the accuracy and adequacy of existing information, 2. supplement such information when necessary, 3. refine tentative topographic and land classification boundaries, 4. inventory existing land use and record observations on the sheets, and 5. confer with land operators and other informed sources for additional information on land quality, use limitations, and cultural practices.

Major land features recognized and noted on the maps were soil series, slope, and present land use. Irrigation status and modifying conditions such as stoniness, rockiness, and salinity were also recorded.

The next phase involved the grouping of lands with essentially similar conditions of fertility, topography, temperature, moisture, sunlight, wind exposure, etc., into homogeneous units called Land Types. All Land Types were then rated by productivity class on an unirrigated basis. In addition, the cultivatable Land Types were rated with irrigation. By reporting ratings for both irrigated and unirrigated situations, it is possible to anticipate the change in agricultural productivity if irrigation is applied or removed from a particular Land Type. The land classification maps indicate the irrigation status of specific tracts at the time of field inspection.

After developing a satisfactory grouping of soils and other characteristics, the final Land Types and their boundaries were established on the photo classification sheets by consolidating some of the initial delineations.

Final on-site field reviews were made to verify the accuracy of Land Type boundaries and ratings, and to determine if further refinements were necessary. Land operators and other informed sources were consulted at this stage to obtain the benefit of their firsthand knowledge of specific tracts of land.

The land classification maps were put in final form by making adjustments considered necessary as a result of the final field reviews. Areas delineated on the land classification maps were then measured to determine acreages of land in different uses and acreages having different levels of agricultural suitability.

LAND TYPE

All lands, other than those in urban areas, are classified into basic classification units known as Land Types. A Land Type is a grouping of lands having similar characteristics, such as soil properties, topography, and climate which result in similar productive capacities. Thus, the Land Type permits 1. grouping and description of lands with similar characteristics regardless of their location, and 2. rating of their productivity.

The Land Types and their productivity ratings are listed and described in Table 2.

To better understand the factors that are considered in the classification of land, the following discussion is presented.

Soil provides anchorage, moisture, and mineral nutrients to the crop. The degree to which a particular soil serves these functions is a measure of its suitability for agriculture. Significant soil properties include: texture, structure, depth, drainage, parent material, mode and degree of weathering (development), stoniness, and fertility.

Texture refers to the proportion of sand, silt, and clay in a particular soil. Soils are generally classified as coarse-, medium-, or fine-textured. Coarse-textured soils have a high proportion of sand; they are easily tilled but have low moisture-holding capacities. Medium-textured soils have nearly equal portions of sand, silt, and clay. Under laboratory analyses, most Hawaiian soils of volcanic origin are classified as fine-textured (having a high clay content). In the field, however, they may not exhibit clay-like properties, depending on the clay. The kaolinitic clays and certain amorphous oxides of iron and aluminum exhibit physical properties more like medium-textured soils and are referred to here as moderately fine-textured soils. The moderately fine- and medium-textured soils are generally the most desirable for agriculture because they have good tillability and water retention. In contrast, soils having a high montmorillonitic clay content are difficult to till because they exhibit most strongly the clay-like characteristics of stickiness and plasticity when wet, and hardness and cloddiness when dry.

Soil structure refers to the cohesion of soil material (sand, silt, and clay) into aggregates or clumps. The size, shape, and amount of these aggregations are significant because they affect the pore spaces which contain the air and moisture necessary for active root growth. Surface soils tend to be well aggregated, but subsoils are highly variable. In many instances the subsoil can be so compacted and stable that they can conduct irrigation water for years without being lined.

Soil depth refers to the distance to which roots can penetrate. Generally, the deeper the rooting depth the more desirable the soil because more moisture can be stored and more soil volume is available from which nutrients can be obtained. Obviously, rooting depth is related to the soil texture because roots can go deeper in the voids of coarse-textured soils as opposed to fine-textured soils. Rooting depth is also related to soil structure because a soil with good structure enhances root penetration. In lands having compacted, structureless subsoils, rooting depth is frequently restricted to the plow layer even though the soil material may be deep. Oftentimes, this restricted depth is an inherent characteristic of that particular soil, although compaction may be caused by machinery. In addition, a high water table will restrict rooting depth to the unsaturated zone because soil air is lacking. It is evident then that rooting depth can be effectively restricted by means other than a solid layer of material such as rock. Shallow rooted crops such as vegetables are not adversely affected. However, more deeply rooted crops such as sugar cane and orchard crops could benefit from greater soil depths.

Soil drainage refers to the frequency and duration of soil saturation with moisture. In Hawaii, unlike the continental U.S., two major causes of impeded drainage are recognized: 1. accumulation or ponding of limited rainfall in depressions or flats, and 2. excessively high rainfall throughout most of the year such that soils are saturated even on sloping land that would ordinarily be well-drained. Five drainage classes are recognized: excessively-drained, well-drained, moderately well-drained, imperfectly- or somewhat poorly-drained, and poorly-drained. They are defined in the glossary. Well-drained soils are preferred for most agricultural purposes.

Parent material refers to the unconsolidated geologic material from which a soil has developed. In Hawaii, these materials can be broadly grouped into calcareous marine deposits, such as coral, and volcanic ejecta, which includes lava, cinders, and ash. These materials in various stages of weathering form the basic soil material in which plants take root. The significant characteristic of coral is its high concentration of calcium carbonate, which is the basic constituent of lime. Soils formed from coral have neutral to alkaline reactions, and are high in calcium. As a consequence, they are unsuited to pineapple and a few other crops because of the unavailability of certain minerals. Also, the sandy coral soils tend to be droughty.

Most of the soils have developed from volcanic material. The weathering process has altered, both physically and chemically, the lava, cinders, and ash to form numerous kinds of soils. Under tropical conditions of high temperature and rainfall, soils tend to become leached and relatively inert as compared to those in more temperate regions. For this reason, soil reaction tends to be acid, and fertility levels are relatively low with most soils responding to fertilizer applications.

Stoniness affects the productivity of land by limiting the use of machinery and hence the selection of crops. There are three levels of stoniness recognized in this report: nonstony—stones are not a hindrance to machine tillage; stony—sufficient stones are present to interfere with machine tillage but not enough to make it impractical; rocky—sufficient stones are present to make machine tillage impractical. This gradation is practical but necessarily subjective because stones vary in size as well as by quantity and can equally limit land use. The degree of stoniness is sufficiently important for Land Type differentiation.

Topography deals with slope and surface configuration. Other things being similar, lands with flatter terrain are generally suitable for a wider variety of agricultural uses than lands having steeper slopes. To express the slope of the land, five groupings were established: 0 to 10 per cent, 11 to 20 per cent, 21 to 35 per cent, 36 to 80 per cent, and 80+ per cent. Cultivated lands generally have slopes of less than 20 per cent, although some steeper sloping lands are used. Thus, the 0 to 10 per cent group presents the least difficulty in using tillage machinery, in irrigation and in harvesting. The 11 to 20 per cent group is more difficult to cultivate. The upper slope limit for the use of land clearing machinery was considered to be about 35 per cent. Usually, lands with slopes between 20 to 35 per cent are not machine-tilled but are still suitable for certain uses such as orchards and grazing. Lands with slopes up to 80 per cent were considered suitable for commercial forestry and low intensity grazing, but lands having slopes in excess of this were considered unsuited to timber production and agriculture. Also, lands with undulating terrain were usually differentiated from areas having uniform slopes because the former are more difficult to farm.

Climate, with its elements of temperature, sunlight, and rainfall, constitutes the exterior environment of land, whereas soil properties form the interior segment. Since the seasonal fluctuations of temperature vary within a very narrow range, greater variations can be attributed to changes in elevation. Temperature at sea level averages 75° F; there is a lowering of about 1° F for every 200 to 300 foot rise in elevation. For most of the lands under 2500 feet, nearly all types of tropical crops can be grown provided soil, terrain, and moisture are satisfactory. From the 2500 to the 5000 foot level, which includes Kokee, the temperature is sufficiently low to permit growth of selected temperate crops which normally do poorly in warm environs.

Seasonal variations in daylength are not very great; however, they have an influence on crop yields, with a marked decrease in production during the winter months. This decrease is believed to be related to both shorter days and lower sunlight intensity due to cloudier skies during this period. Thus, yields are generally lower in the northern and windward areas that are shaded with heavy clouds and afternoon mountain shadows.

Rainfall varies in both quantity and distribution and cannot be depended upon to fall at the required time and in the required amount to satisfy crop requirements. Most of the better crop producing lands are located in the drier, higher sunlight areas where most of the precipitation falls during the winter months. Hence, irrigation is necessary during the drier periods. On the other hand, where rainfall is frequent and heavy, the soils are perennially wet making the land difficult to work and causing leaching of nutrients from the soil. Arable lands with an ideal distribution of rainfall are almost non-existent.

PRODUCTIVITY RATINGS

An evaluation of the quality, or productive capacity, of Kauai's lands is one of the objectives of this report. To make this evaluation, all Land Types were rated in two ways: 1. for selected crops or uses (pineapple, vegetables, sugar cane, forage, grazing, orchards, and forestry), and 2. for over-all suitability in agricultural use. The Selected Crop Productivity Rating provides flexibility to the evaluation process by permitting comparison between alternative uses both within and between Land Types. The Over-all Productivity Rating allows ready comparison between Land Types on a broader basis. For convenience in use, this rating is combined with the Land Type number and printed directly on the classification maps; for example, C78 where C is the Over-all Productivity Rating and 78 is the Land Type number.

A five-class productivity rating is applied, using the letters A, B, C, D, and E, with A representing the class of highest productivity and E the lowest. To distinguish between the two types of evaluations, capital letters are used for Over-all Productivity Ratings and lower-case letters, a, b, c, d, and e, are used for Selected Crop Productivity Ratings.

The application of irrigation oftentimes results in increased productivity. Therefore, ratings were given for cultivatable Land Types under both irrigated and unirrigated conditions. Irrigated counterparts are identified with an i following the Land Type number, such as B78i; whereas, C78 is the same Land Type without irrigation. The B and C are Over-all Productivity Ratings.

The specifications for the productivity ratings were developed so that all lands throughout the State could be evaluated on a uniform basis. The rating system also leaves intact the Land Type identities for additional study or interpretation for non-agricultural uses.

Every effort was made to insure that the land's productive capacity was being evaluated, not the skill of management. Thus, the ratings interpret the interacting complex influence of climate, surface relief, drainage, wind velocities, and soil characteristics that are inherent in each Land Type under modal cultural practices.

These ratings stop short of placing monetary values on the lands classified, but many users of land data are not immediately concerned with dollar values. Others prefer to make their own economic evaluations, using these ratings as the basis. Thus, as developed, the ratings facilitate subsequent calculations of income possibilities in alternative uses or for land valuation purposes.

ile 3. Land Class Rating Defined by Estimated Productivity of Selected Crops and Uses — Island of Kauai

: estimated crop yields are based upon prevailing cultural ractices as described in this report. These yield estimates are onsidered reasonable, but crop by crop fluctuations in yields be expected.

ineapples

ass a: 14 tons or more fruit per acre per year (based on a 4-year crop cycle of plant and ratoon crops)
lass b: 12-14 tons per acre per year
lass c: 10-12 tons per acre per year
ss d: 8-10 tons per acre per year
ass e: Less than 8 tons per acre per year

gar Cane

ss a: Irrigated lands: 0.53 TSAM* or more
Unirrigated lands: 0.44 TSAM or more
lass b: Irrigated lands: 0.42-0.53 TSAM
Unirrigated lands: 0.37-0.44 TSAM
lass c: Irrigated lands: 0.33-0.42 TSAM
Unirrigated lands: 0.30-0.37 TSAM
ss d: Irrigated lands: 0.22-0.33 TSAM
Unirrigated lands: 0.19-0.30 TSAM
lass e: Irrigated lands: Less than 0.22 TSAM
Unirrigated lands: Less than 0.19 TSAM

egetables

lass a: Tomatoes over 25,000 pounds per acre per crop; Carrots over 11,000 pounds per acre per crop; Irish potatoes over 10,000 pounds per acre per crop; Dry onions over 17,000 pounds per acre per crop
ss b: Tomatoes 20,000-25,000 pounds per acre per crop; Carrots 9,500-11,000 pounds per acre per crop; Irish potatoes 8,000-10,000 pounds per acre per crop; Dry onions 15,000-17,000 pounds per acre per crop
ss c: Tomatoes 15,000-20,000 pounds per acre per crop; Carrots 8,000-9,500 pounds per acre per crop; Irish potatoes 6,000-8,000 pounds per acre per crop; Dry onions 13,500-15,000 pounds per acre per crop
lass d: Tomatoes 10,000-15,000 pounds per acre per crop; Carrots 6,500-8,000 pounds per acre per crop; Irish potatoes 4,000-6,000 pounds per acre per crop; Dry onions 10,000-13,500 pounds per acre per crop
lass e: Tomatoes less than 10,000 pounds per acre per crop; Carrots less than 6,500 pounds per acre per crop; Irish potatoes less than 4,000 pounds per acre per crop; Dry onions less than 10,000 pounds per acre per crop

*SAM is Tons Sugar per Acre per Month.

Forage (Alfalfa)

Class a: Over 9 tons hay per acre per year
Class b: 6-9 tons hay per acre per year
Class c: 4-6 tons hay per acre per year
Class d: 2-4 tons hay per acre per year
Class e: Less than 2 tons hay per acre per year

Grazing (Pasture)

Class a: Carrying capacity less than 2.5 acres per AUY (animal unit year) or estimated live beef gains 110 pounds per acre per year or more*
Class b: Carrying capacity 2.5-5 acres per AUY or estimated live beef gains 110-55 pounds per acre per year
Class c: Carrying capacity 5-10 acres per AUY or estimated live beef gains 55-27 pounds per acre per year
Class d: Carrying capacity 10-30 acres per AUY or estimated live beef gains 27-9 pounds per acre per year
Class e: Carrying capacity more than 30 acres per AUY or estimated live beef gains 9 pounds or less per acre per year

Orchard Crops

Crop yields are based upon irrigated status except for orchards in the wetter sections.

Class a: Oranges over 12,000 pounds per acre per year; papayas over 25,000 pounds per acre per year; bananas over 8,500 pounds per acre per year
Class b: Oranges 10,000-12,000 pounds per acre per year; papayas 20,000-25,000 pounds per acre per year; bananas 6,500-8,500 pounds per acre per year
Class c: Oranges 8,000-10,000 pounds per acre per year; papayas 15,000-20,000 pounds per acre per year; bananas 5,000-6,500 pounds per acre per year
Class d: Oranges 6,000-8,000 pounds per acre per year; papayas 10,000-15,000 pounds per acre per year; bananas 4,000-5,000 pounds per acre per year
Class e: Oranges less than 6,000 pounds per acre per year; papayas less than 10,000 pounds per acre per year; bananas less than 4,000 pounds per acre per year

Forestry

Co Commercial forest land: land which is producing, or is capable of producing, usable crops of woods for industrial purposes. Industrial products include sawlogs and pulpwood, but not fuelwood.
NCo Non-commercial forest land: land which is incapable of yielding usable crops of industrial wood because of adverse site conditions.

*Live beef gains are estimates unsupported by research but are considered reasonable by veteran stockmen who were consulted. Yield values shown represent long-run average expectations. Yields for individual single years may differ from these values.

SELECTED CROP PRODUCTIVITY RATINGS

The Selected Crop Productivity Ratings express the productive capacity of a Land Type for pineapple, vegetables, sugar cane, forage, grazing, orchards, and forestry. These crops and agricultural uses were selected because they are the most probable alternatives in Hawaii. The evaluation criteria are based on crop yields, expressed in pounds per acre or by some other similar but appropriate means. The only exception is forestry which is simply differentiated into lands physically capable, or incapable, of commercial forestry use. The yield criteria for Selected Crop Productivity Ratings are shown in Table 3. Initial development of these yield specifications incorporated information and judgments of specialists of the Cooperative Extension Service and the Hawaii Agricultural Experiment Station of the University of Hawaii and knowledgeable individuals from *plantations, ranches, and farms.*

The actual rating of each Land Type in the selected crops or land uses was at times somewhat subjective because yield data were not always available. In these instances, ratings were established by careful projection from areas of known performance and associated land conditions. The Selected Crop Productivity Ratings for each Land Type are presented in Table 2.

In field operations, management skills vary widely causing fluctuations in yields. Thus, to evaluate all lands on a uniform state-wide basis, the crop yields are based on a standard set of cultural practices for each crop or use. In vegetable, orchard, and forage production, these practices are outlined by types of crops because precise needs of individual crops are beyond the scope of this report. The cultural practices described below are reasonably applicable throughout the State and reflect the prevailing or modal situations; they are not to be construed as recommendations. Specific advice should be sought from appropriate agricultural experiment and extension agencies.

Prevailing Cultural Practices by Land Uses

Pineapple Production. Pineapples are adapted to a drier environment than most other crops; thus, they can be grown without irrigation in areas too dry for other crops. The best locations, however, are in the zone between the very dry and the very wet environments, where annual rainfall averages between 25 to 50 inches.

LAND PREPARATION: Pineapples are grown on subhumid lands of low and medium elevations. Where annual rainfall exceeds 25 inches or where irrigation water is available, clean tillage is practiced. Trash mulching is used on fields receiving less than 25 inches of annual rainfall and where irrigation is not possible. Land preparation practices for these two situations are as follows:

CLEAN TILLED LAND: Old pineapple plants are removed or chopped with a disc or cut-a-way harrow. The residue is then dried and burned or plowed under. The field, when cleared of vegetation, is smoothed with a drag to prepare it for planting.

TRASH MULCHED LANDS: Old plants are chopped and allowed to dry on the surface of the land. No additional tillage is performed. At the time of planting, a trash mulch machine parts the trash, tills the soil below the area to be planted, injects fumigants, and lays mulch paper or plastic sheets.

SOIL FUMIGATION: Soil fumigation treatment is required because of the high susceptibility of pineapple plants to root nematodes. The common application is 400 to 450 pounds of DD* (soil fumigant) per acre, or its equivalent, prior to planting.

PLANTING: About 18,000 plants per acre are planted by hand. Slips are the common planting material, although some crowns and suckers are used. Most of the slips grow with reasonably favorable moisture conditions, and replanting is necessary only on a very limited scale.

FERTILIZATION: Pineapple lands have been farmed intensively for a number of years, and heavy applications of fertilizers are necessary for continued production. The following rates approximate present applications:

Nitrogen (N)	600 pounds per acre per crop cycle
Phosphorus (P_2O_5)	0 to 300 pounds per acre per crop cycle**
Potassium (K_2O)	200 to 600 pounds per acre per crop cycle**
Ferrous sulfate ($FeSO_4$)	100 pounds per acre per crop cycle

Some of the more acid soils are limed at the time of planting.

IRRIGATION: Although some lands receive supplemental irrigation in drier sections, irrigation is used primarily on a limited basis during the driest period. Irrigaton is not practiced on Kauai.

*Use of trade name does not represent endorsement of the product.
**Application rates adjusted as needed. A crop cycle is plant crop plus ratoon.

In evaluating the erosion control for this project both the type of rock and the soil overlying it must be categorized as to its erosion potential. This evaluation must accommodate the frequency and intensity of rainfall unique to this island environment.

As outlined in the EIS part B (p. 98) Summary of Soils in Project Vicinity, the soils are predominantly MH soils (clayey silts-silty clays) many of which may be silty eolian soils. The physical characteristics of these soils are described in Table B-6c-1 "USSCS Classification Data" in the EIS. The primary concerns for erosion control are on access roadways, construction staging areas, spoil piles (soil), temporary topsoil storage piles and actual excavation. The effects of clearing, grading, trenching and foundation excavation have been planned for in this erosion control plan.

Three types of topography have been classified for the plan, a) steep slopes composed primarily of basalt bedrock with variable thicknesses of poorly developed/stabilized soils, b) gently sloping covered flows with minor drainages between more prominent drainages (basaltic) with thick more well developed soils covered by grasses and cropland, c) alluvial and active channel deposits from massive bedrock with no soil cover to wider alluvial segments containing typical flood plain deposits.

As would be anticipated different mitigation methods for erosion control are required for each of the three units and for each type of anticipated erosion. These three units are delineated on PLATE D-8, EROSION CONTROL PLAN with USSCS SOIL CLASSIFICATION in the EIS.

Of the three soil types the one most susceptible to erosion which may have serious conseqences is the more gentle sloped area between the diversion and powerhouse along the penstock and access road alignments. The steep bedrock areas have such shallow soil cover on steep slopes that serious erosion potential is low. The alluvial sections are either all bedrock or gently sloping alluvial deposits. The ridge between the two river segements has a thicker soil cover thus requiring deeper excavation. This will generate more temporary and permanent spoil materials which become susceptible to wind and water induced erosion. These soils are much finer grained, at least in the matrix, and many are topsoils which need to be stored for rejuvenation of the construction area. This area of flatter slopes will also be used for construction staging which may induce more erosion potential. As represented on Plate D-8 the existing road which shall be used as the primary access road is on these same soils. The latter portion of this road alignment down to the powerhouse site is on much steeper terrain with bedrock control although there is some erosion potential.

Erosion Control Plan

A. Steep Transitional Areas

This type of terrain occurs near the diversion but primarily along the transition of the penstock and access road down to the powerhouse.

Using SCS criteria these areas are classified as Rock Outcrop (rRO) with very shallow soil cover. The SCS designates this area as having at least 90% bedrock exposure. Soil erosion is therefore not a primary concern and small thin areas of soil can easily be protected from erosion along the alignment by leaving as much of the natural vegetation in-place as possible. Those soils encountered along the actual alignment will be removed and used for backfill or stockpiled and used for re-vegetation. Erosion mitigation plans are not extensive along this area however slope stabilization with rock-rip-rap and re-vegetation where appropriate will be implemented.

B. Gently Sloping Covered Flows

These soils which are covered by sugar cane at present are the most susceptible to project induced erosion. The primary control plan is to limit disturbance to only the minimum required and preserve temporary spoil piles. Ultimately the area excavated for the penstock will be re-vegetated with cane and the access road will be maintained throughout the construction process using the existing control methods on other cane haul roads in the area. Watering for dust control and grading to accommodate run-off and drainage into the cane areas is the most effective method.

The plan to limit erosion of temporary spoil piles and stockpiled top soils is to provide broad gently sloping berms of compacted top soil which have internal drainage. The avoidance of typical, narrow, steep sided piles will discourage rapid run-off and sorting of the soil. Broad berms which are graded will encourage infiltration, limit run-off and keep the profile low and uniform reducing susceptibiltiy to wind erosion.

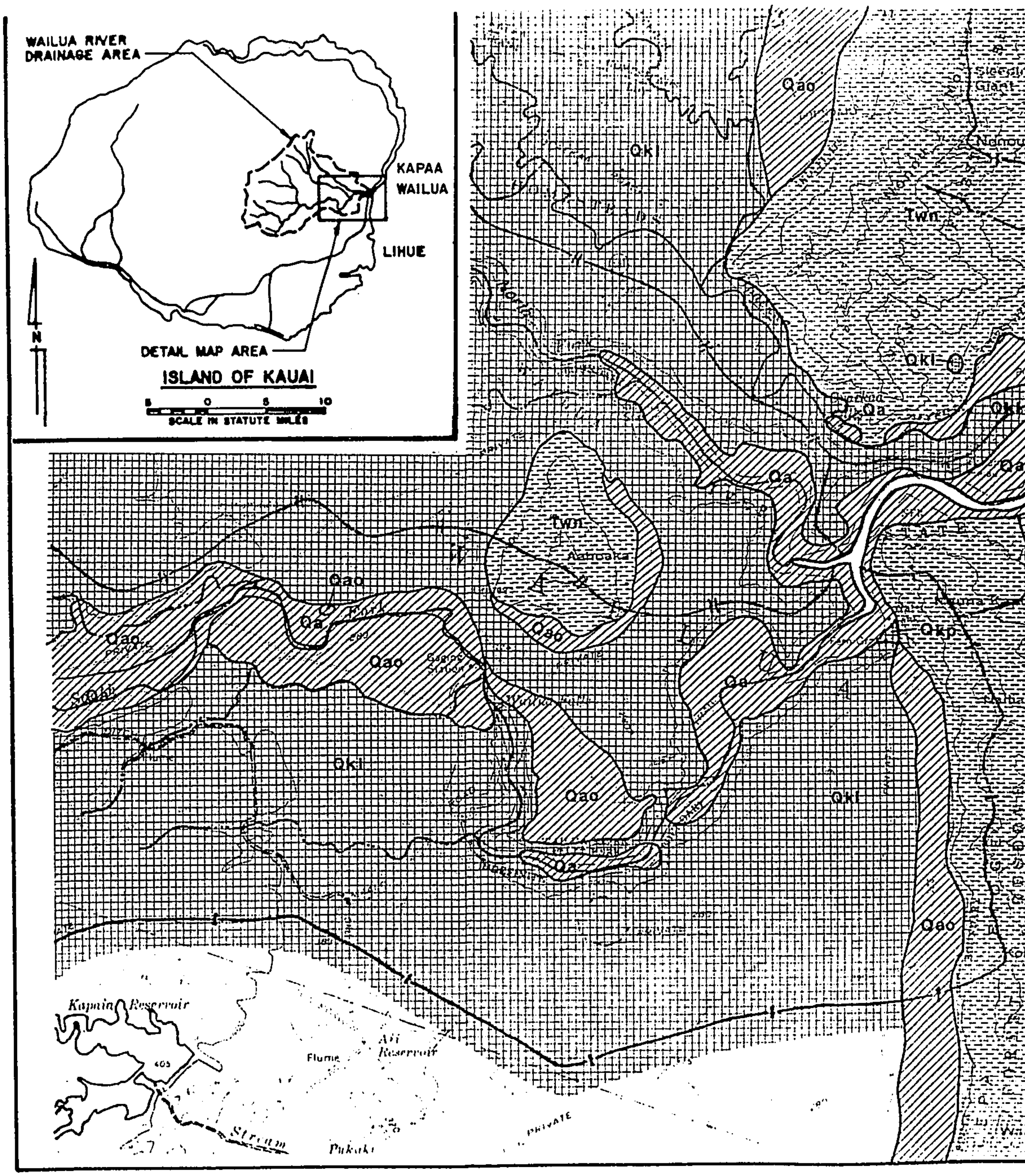
It becomes important to eliminate sorting of the soil and seepage of soil bearing water into more granular subgrade soils, or bedrock. This may remove critical constituents from the top soil. It may be prudent to place a geotextile filter fabric on the surface prior to the top soil. As represented on the control plan drawing (Plate D-9) the installation of french drains lined with a geotextile filter fabric will allow transmission of water away from the berm. The use of the correct fabric would encourage seepage through the soils without passage of fines through it. With this method and grading of the berm to a common point it will eliminate run-off into the drainage or surrounding cane land. If upon completion this system is still susceptible to excess wind erosion it could easily be covered with a geotextile that once anchored would allow infiltration of water but protect the soil from erosion.

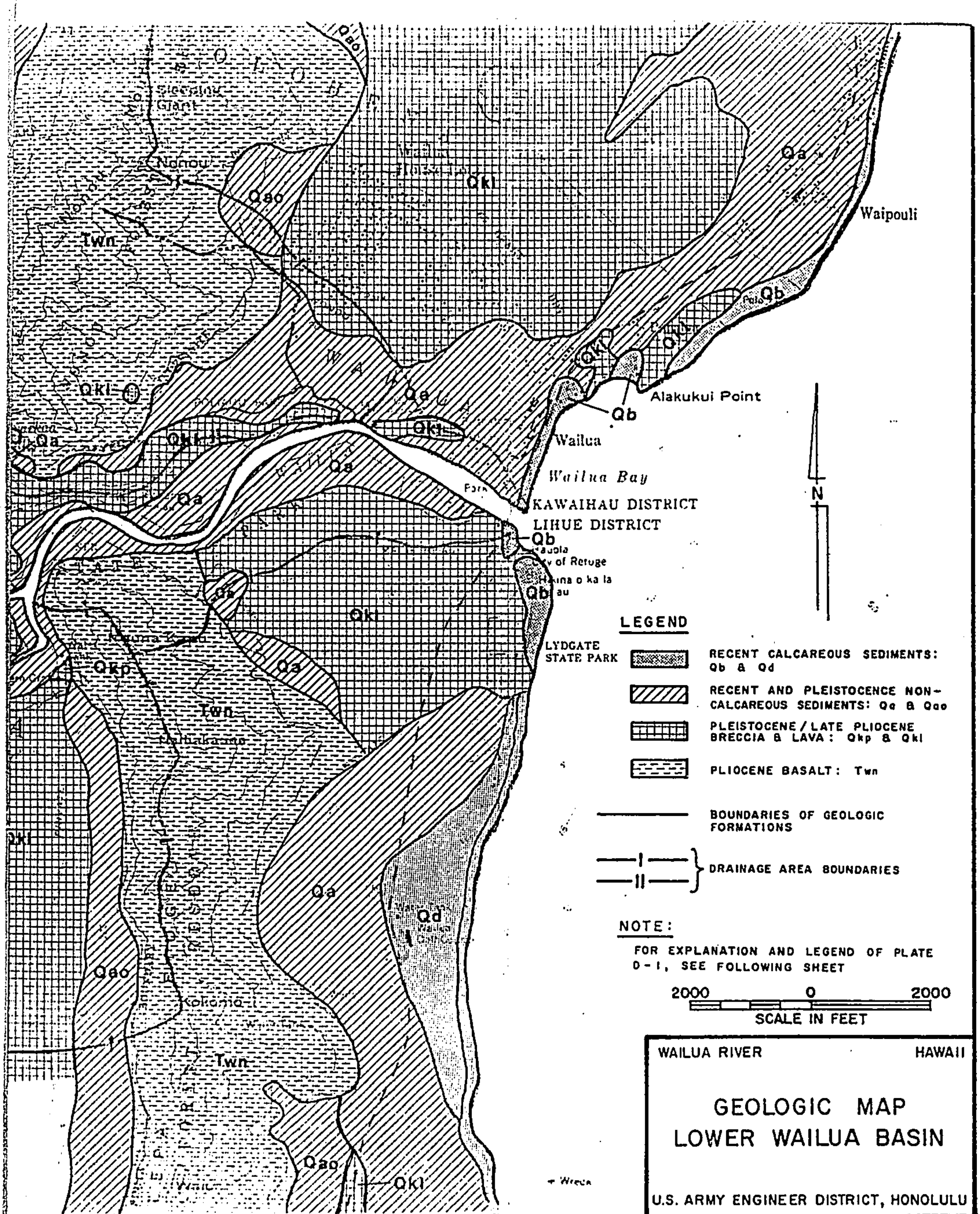
During construction primary erosion control will pertain to the excavated material prior to backfill and the disturbed penstock alignment after placement of the pipe. Grading for drainage, replacement of topsoil and re-planting will be the control measure for the latter disturbance. In areas where downslope drainage may enter the river small, lined sediment basins will be placed to allow only clear water to flow into the drainage Plate D-9). Ideally the basins would be built of low permeability compacted clayey soils. In the absence of suitable clayey soils a geotextile could again be used as an artificial liner. Once stabilized these basins could be removed and the area rejuventated.

The control of excavated soils will be primarily through phased sequential construction procedures. Excavation of only enough trench to accomodate penstock placement and burial within a given stretch of the alignment will limit exposure of spoil piles to extended erosive forces. The grading and clean-up of each section after completion will limit the exposure time as well. Staging areas for equipment and material shall also be graded and re-juvenated immediately after use. The use of centrally located staging areas with consistent use of regular access corridors to the penstock alignment will also eliminate extensive re-vegetation requirements. All access roads will be graded and maintained to limit gullying and vehicle induced erosion.

C. Alluvial Sections and Active Channel

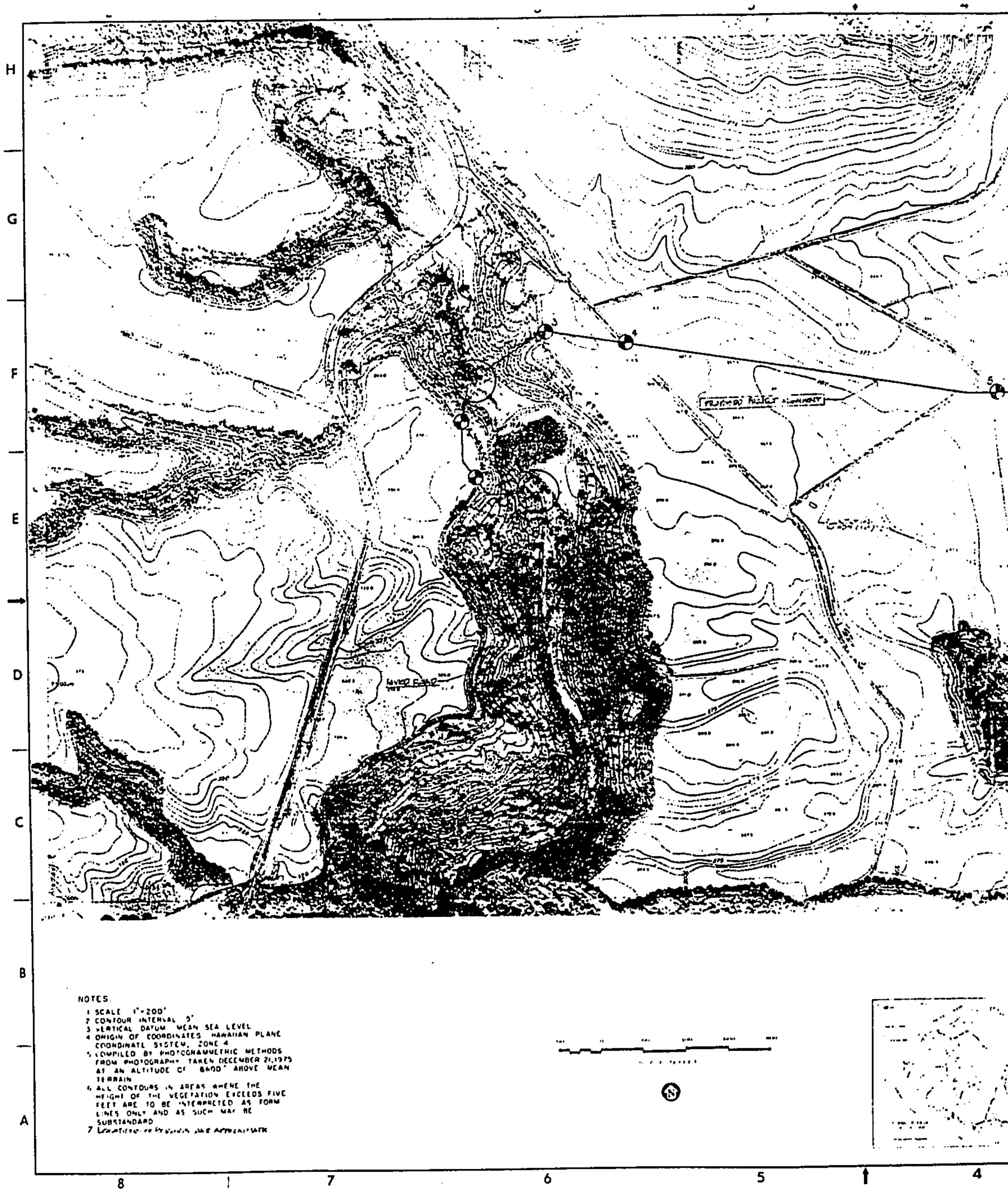
These are flat sections along the active channel and flood plain of the Wailua River. Within the channel most anticipated excavations for the diversion will be to bedrock. Excavation will be through shallow alluvial deposits then a gravel and cobble horizon prior to vesicular basalt lava flow. The powerhouse site will be in a somewhat thicker alluvial section and elimination of excess sediment laden water from foundation excavation will be through a temporary sediment basin off channel. The areas disturbed shall be restored to a natural state and graded to drain into the river. The access road here will also be graded and maintained for regular access.

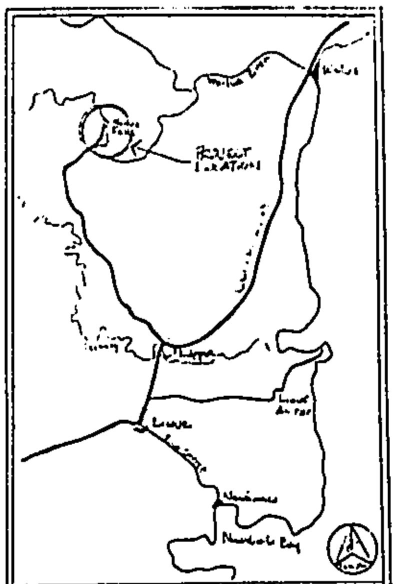

WAILUA RIVER
DRAINAGE AREA
KAPAA
WAILUA
LIHUE
N
DETAIL MAP AREA
ISLAND OF KAUAI
5 0 5 10
SCALE IN STATUTE MILES
Qao
Qkl
Twn
Qa
Qkp
Kapaia Reservoir
Flume
Stream
Pukaki
PRIVATE



Sleeping Giant
Nonou
Twn
Qao
Qkl
Qa
Waipouli
Qb
Alakukui Point
Wailua
Wailua Bay
KAWAIHAU DISTRICT
LIHUE DISTRICT
Qkp
Qd
LYDGATE STATE PARK
LEGEND
RECENT CALCAREOUS SEDIMENTS: Qb & Qd
RECENT AND PLEISTOCENCE NON-CALCAREOUS SEDIMENTS: Qa & Qao
PLEISTOCENE / LATE PLIOCENE BRECCIA & LAVA: Qkp & Qkl
PLIOCENE BASALT: Twn
BOUNDARIES OF GEOLOGIC FORMATIONS
DRAINAGE AREA BOUNDARIES
NOTE:
FOR EXPLANATION AND LEGEND OF PLATE D-1, SEE FOLLOWING SHEET
2000 0 2000
SCALE IN FEET
N
WAILUA RIVER
HAWAII
GEOLOGIC MAP
LOWER WAILUA BASIN
U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE D-1


H
G
F
E
D
C
B
A
8
7
6
5
4
NOTES.
1 SCALE 1"=200'
2 CONTOUR INTERVAL 5'
3 VERTICAL DATUM MEAN SEA LEVEL
4 ORIGIN OF COORDINATES HAWAIIAN PLANE COORDINATE SYSTEM, ZONE 4
5 COMPILED BY PHOTOGRAMMETRIC METHODS FROM PHOTOGRAPHY TAKEN DECEMBER 21,1975 AT AN ALTITUDE OF 8400' ABOVE MEAN TERRAIN
6 ALL CONTOURS IN AREAS WHERE THE HEIGHT OF THE VEGETATION EXCEEDS FIVE FEET ARE TO BE INTERPRETED AS FORM LINES ONLY AND AS SUCH MAY BE SUBSTANDARD



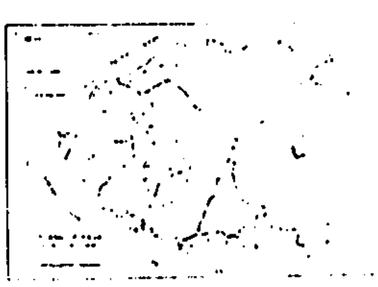
PROJECT VICINITY MAP

LEGEND

Location and Identification No. of Boring

Boring No.	Estimated Depth
1	60'
2	65'
3	70'
4	75'
5	87'
6	78'
7	30'

Location of Proposed Intake or Outlet

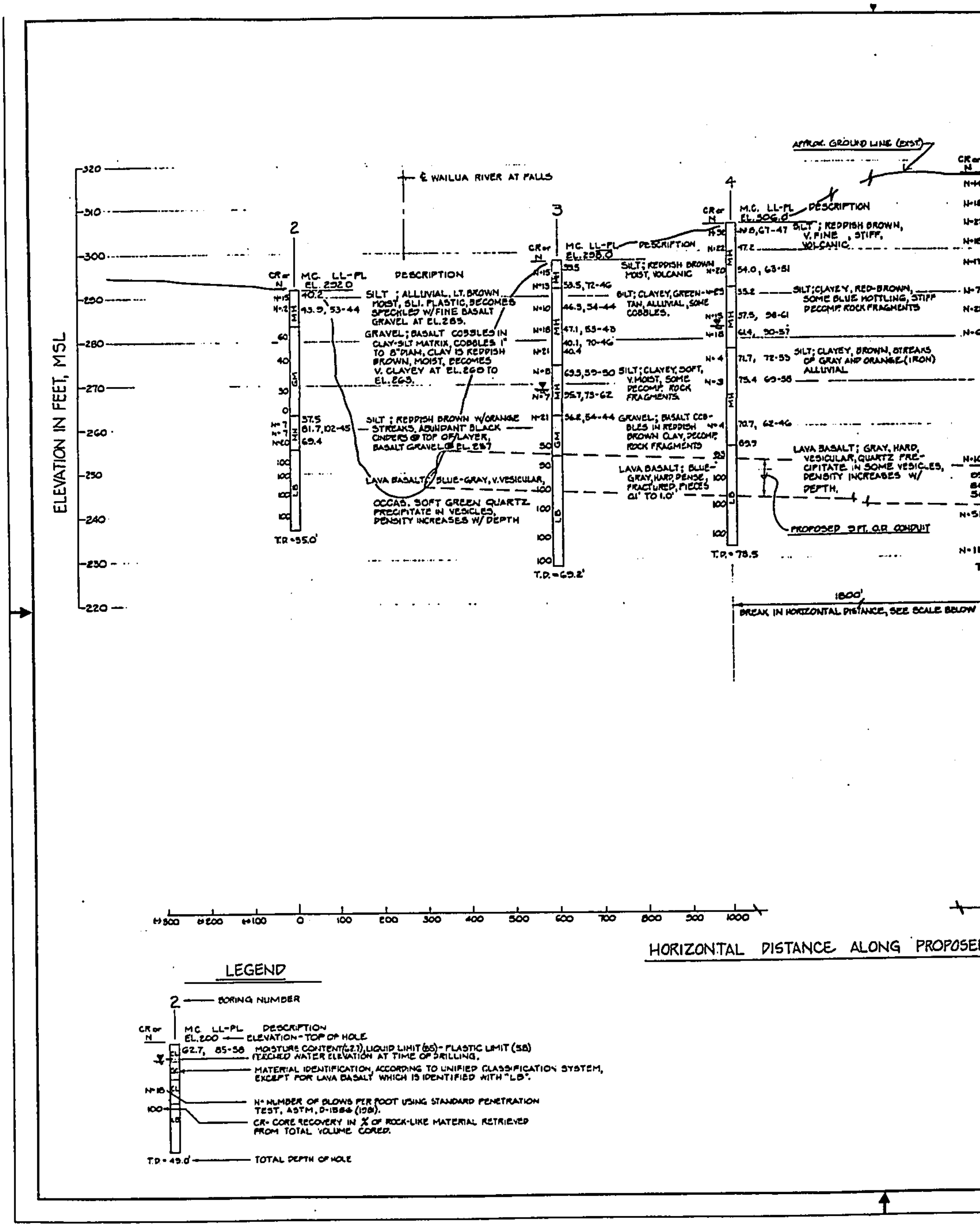


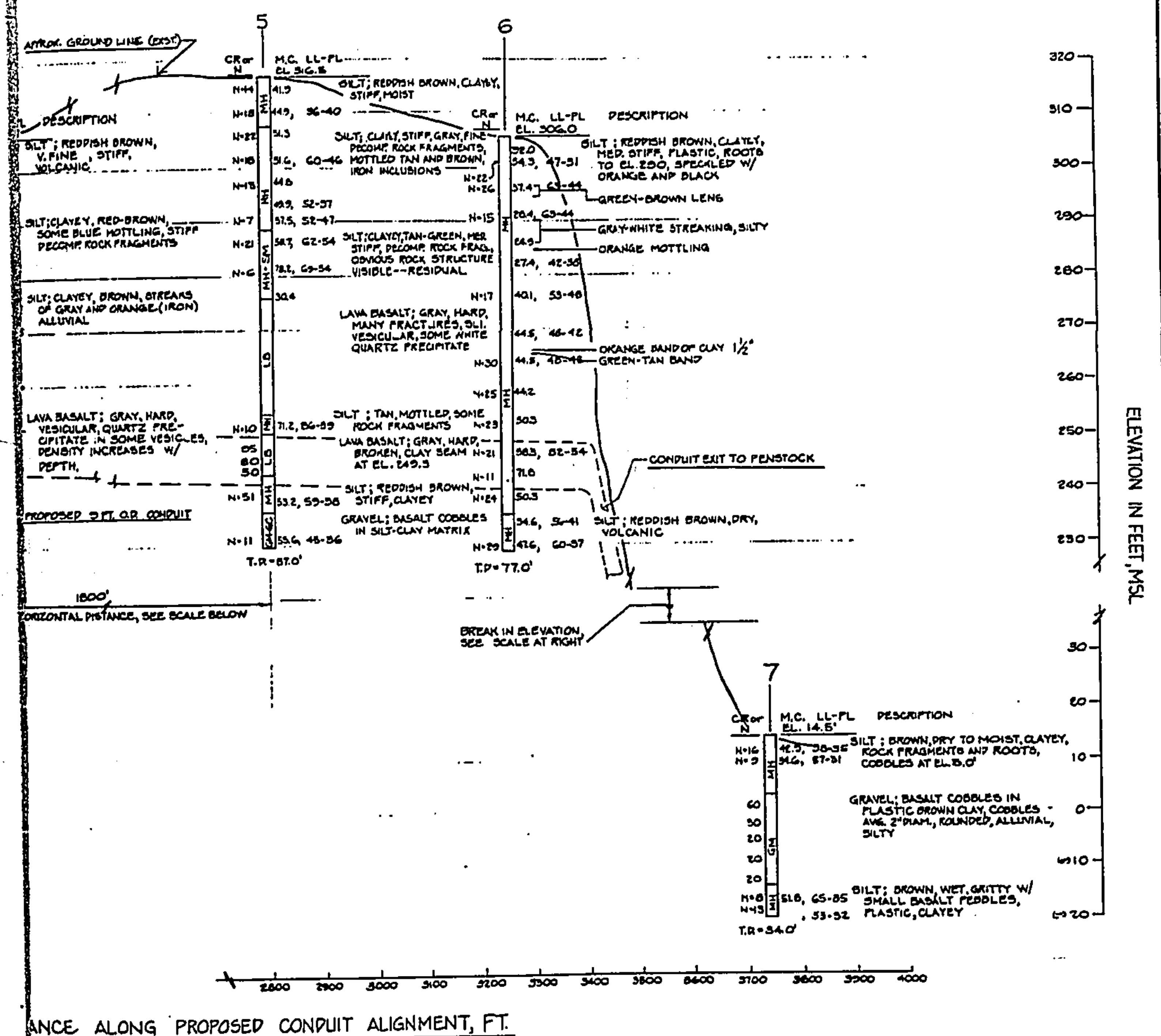
WAILUA RIVER — HAWAII

BORING LOCATION PLAN

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE D-2


ELEVATION IN FEET, MSL
℄ WAILUA RIVER AT FALLS
APPROX. GROUND LINE (EXIST.)
SILT ; ALLUVIAL, LT. BROWN MOIST, SLI. PLASTIC, BECOMES SPECKLED W/FINE BASALT GRAVEL AT EL.285.
GRAVEL; BASALT COBBLES IN CLAY-SILT MATRIX, COBBLES 1" TO 8" DIAM., CLAY IS REDDISH BROWN, MOIST, BECOMES V. CLAYEY AT EL.280 TO EL.265.
SILT ; REDDISH BROWN W/ORANGE STREAKS, ABUNDANT BLACK CINDERS @ TOP OF LAYER, BASALT GRAVEL @ EL.257
LAVA BASALT; BLUE-GRAY, V.VESICULAR, OCCAS. SOFT GREEN QUARTZ PRECIPITATE IN VESICLES, DENSITY INCREASES W/ DEPTH
T.D.=55.0'
T.D.=69.2'
T.D.=78.5
SILT; REDDISH BROWN MOIST, VOLCANIC
SILT; CLAYEY, GREEN-TAN, ALLUVIAL, SOME COBBLES.
SILT; CLAYEY, SOFT, V.MOIST, SOME DECOMP. ROCK FRAGMENTS
GRAVEL; BASALT COBBLES IN REDDISH BROWN CLAY, DECOMP. ROCK FRAGMENTS
LAVA BASALT; BLUE-GRAY, HARD, DENSE, FRACTURED, PIECES 0.1' TO 1.0'
SILT ; REDDISH BROWN, V. FINE , STIFF, VOLCANIC
SILT; CLAYEY, RED-BROWN, SOME BLUE MOTTLING, STIFF DECOMP. ROCK FRAGMENTS
SILT; CLAYEY, BROWN, STREAKS OF GRAY AND ORANGE (IRON) ALLUVIAL
LAVA BASALT; GRAY, HARD, VESICULAR, QUARTZ PRECIPITATE IN SOME VESICLES, DENSITY INCREASES W/ DEPTH.
PROPOSED 5FT. O.R. CONDUIT
BREAK IN HORIZONTAL DISTANCE, SEE SCALE BELOW
HORIZONTAL DISTANCE ALONG PROPOSED
LEGEND
BORING NUMBER
ELEVATION - TOP OF HOLE
MOISTURE CONTENT (62.7), LIQUID LIMIT (85) - PLASTIC LIMIT (58)
PERCHED WATER ELEVATION AT TIME OF DRILLING.
MATERIAL IDENTIFICATION, ACCORDING TO UNIFIED CLASSIFICATION SYSTEM, EXCEPT FOR LAVA BASALT WHICH IS IDENTIFIED WITH "LB".
N= NUMBER OF BLOWS PER FOOT USING STANDARD PENETRATION TEST, ASTM, D-1586 (58).
CR= CORE RECOVERY IN % OF ROCK-LIKE MATERIAL RETRIEVED FROM TOTAL VOLUME CORED.
TOTAL DEPTH OF HOLE



NOTES:

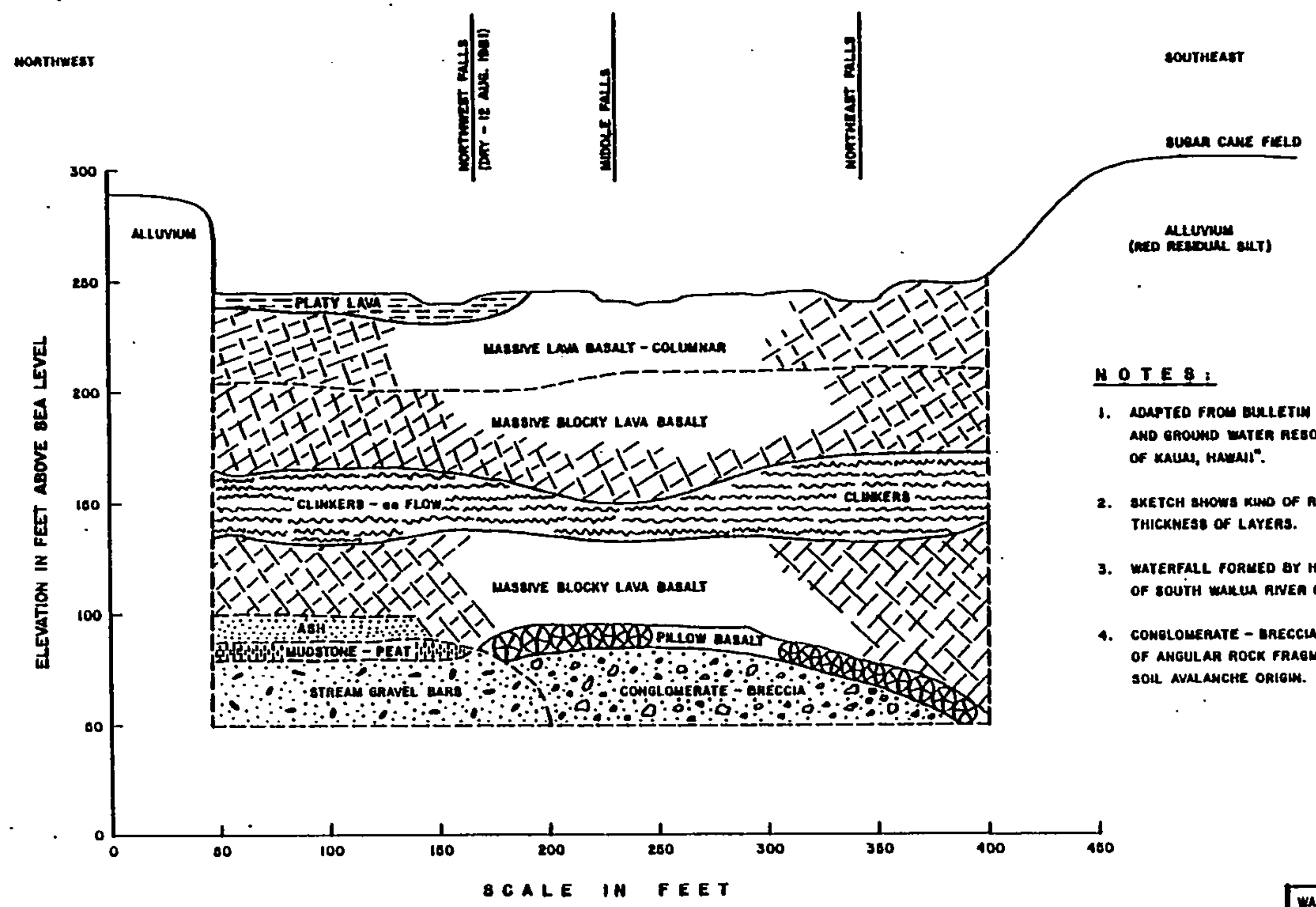
1. GROUND LINE AND ELEVATIONS ARE APPROXIMATE.
2. SEE PLATE D-2 FOR BORING LOCATION PLAN.

WAILUA RIVER HAWAII

PROFILE OF BORINGS

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE D-4



NOTES:

1. ADAPTED FROM BULLETIN 13, FIGURE 13, "GEOLOGY AND GROUND WATER RESOURCES OF THE ISLAND OF KAUAI, HAWAII".
2. SKETCH SHOWS KIND OF ROCK AND RELATIVE THICKNESS OF LAYERS. NOT TO SCALE.
3. WATERFALL FORMED BY HEADWARD EROSION OF SOUTH WAILUA RIVER GORGE.
4. CONGLOMERATE - BRECCIA ARE CHAOTIC ASSEMBLAGE OF ANGULAR ROCK FRAGMENTS FROM MUD FLOW - SOIL AVALANCHE ORIGIN.

WAILUA RIVER KAUAI, HAWAII

ROCK FACE PROFILE SKETCH OF WAILUA WATERFALL
(SOUTH FORK OF WAILUA RIVER)

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE D-5

PLATE D-5

TEST DATA SUMMARY SHEET

1/2

Boring No.	Sam. No.	Depth or Elev. of Sample	Laboratory Classification (Field Classification)	Mechanical Analysis: Gravel %	Sand %	Fines %	D_{10}	Atterberg Limits: LL	PL	Specific Gravity G	Nat. Water Cont. %	Organic Content %	Compaction Data: Opt. Water %	Maximum Dry Density lb/cu ft
1	54	0°-2°	(Alluv. SILT)								47.9			
	55	5°-7°	(Alluv. SILT)					57	37		44.3			
	56	10°-12°	(Silty GRAVEL)					52	46		49.7			
	57	14°-15°	(" ")								39.6			
	58	29°-[illegible]	(" ")					100	49		91.5			
2	1	0°-2°	(Alluv. SILT)								40.2			
	2	3°-6°	SM (" ")	19	61	20	–	53	44		43.9			
	3	29°-31°	(" ")								37.5			
	4	31°-34°	MH (" ")	0	26	74	–	120	45		31.7			
	5	34°-36°	(" ")								69.4			
3	46	0°-2°	(Alluv. SILT)								39.5			
	47	5°-7°	MH (" ")	0	3	97	–	76	46		53.5			
	48	10°-12°	(" ")					54	42		46.3			
	49	15°-17°	MH (" ")	0	16	84	–	53	43		47.1			
	50	20°-22°	(" ")								40.6			
	51	25°-27°	(" ")					59	50		69.3			
	52	30°-32°	MH (" ")	0	31	69	–	73	62	3.06	95.7	12.0		
	53	35°-37°	(Silty GRAVEL)					54	44		54.2			
	B-10	17°-25°	MH (Alluv. SILT)	0	12	88	–	70	46	2.29	40.1	11.1	32	91.5
4	36	0°-2°	(Alluv. SILT)					67	47		49.4			
	37	5°-7°	(" ")								47.2			
	38	10°-12°	(" ")					63	51		84.0			
	39	15°-17°	(" ")								55.2			
	40	20°-22°	MH (" ")	0	0	100	–	99	61		57.9			
	41	25°-27°	(" ")					90	57		61.4	11.6		
	42	30°-32°	MH (" ")	0	7	93	–	77	53	2.94	71.7	11.1		
	43	35°-37°	(" ")					69	55		76.4			
	44	40°-42°	(" ")					62	46		70.7			
	45	50°-52°									89.9			
5	24	1°-3°	(Alluv. SILT)								41.9			
	25	5°-7°	(" ")					56	40		44.9			
	26	10°-12°	(" ")								51.3			
	27	15°-17°	(" ")					60	46		51.6			
	28	20°-22°	(" ")								[illegible]			
	29	25°-27°	(" ")					52	47		57.5			
	30	30°-32°	(" ")					62	54		53.7			

FORM 2086 EDITION OF 1 MAR 58 IS OBSOLETE.
1 JAN 73

Wailua Hydropower

PLATE D-6

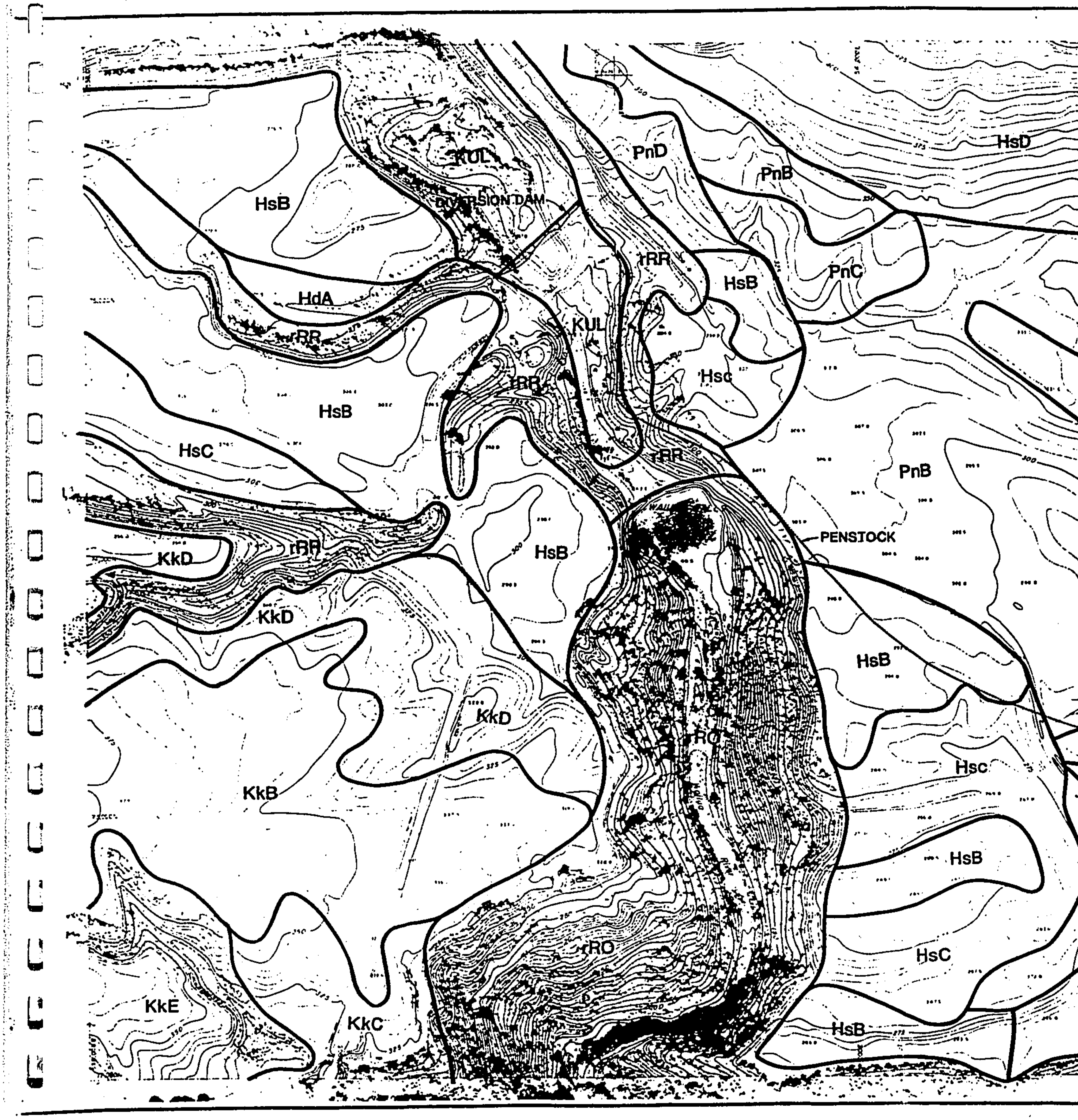
TEST DATA SUMMARY SHEET (CONT) 2/2

BORING NO.	SAM. NO.	DEPTH OR ELEV. OF SAMPLE	LABORATORY CLASSIFICATION (FIELD CLASSIFICATION)	MECHANICAL ANALYSIS: GRAVEL %	SAND %	FINES %	D_{10}	ATTERBERG LIMITS: LL	PL	SPECIFIC GRAVITY G	NAT. WATER CONT. %	ORGANIC CONTENT %	COMPACTION DATA: OPT. WATER %	MAXIMUM DRY DENSITY LB/CU FT
5	31	35'-37'	SM (Alluv. SILT)	1	61	38		67	54		78.2			
	32	40'-42'	(" ")								47.4			
	33	63'-65'	(" ")					86	39		71.2			
	34	70'-72'	MH (" ")	0	2	98		59	38		53.7			
	35	15'-17'	(Silty Gravel)					45	36		55.6			
	B-7	22'-25'	SM	0	61	39		52	37		49.9	12.4		
6	8	0'-2'	(Alluv. SILT)								32.0			
	9	2'-4'	ML (" ")	0	12	88		47	31		34.3			
	10	8'-10'	(" ")								37.4			
	11	14'-16'	MH (" ")	0	45	55		63	44		28.4			
	12	18'-20'	(" ")								24.9			
	13	22'-24'	(" ")					42	35		27.4			
	14	28'-30'	(" ")					53	48		40.1			
	15	35'-37'	(" ")								44.5			
	16	40'-42'	ML (" ")	0	34	66		43	42		46.5			
	17	45'-47'	(" ")					43	42		47.2			
	18	50'-52'	(" ")								50.3			
	19	55'-57'	(" ")								58.3			
	20	60'-62'	(" ")					82	46		71.5			
	21	65'-67'	(" ")								52.3			
	22	70'-72'	(" ")					56	41		34.6			
	23	75'-77'	MH (" ")	0	1	99		60	37		47.6			
	B-4,2	0'-2'		0	9	91		63	42		-		30	95.3
7	6	0'-2'	(Alluv. SILT)					53	37					
	7	3'-6'	MH (" ")	0	31	69		57	31	2.90		8.9		
	8A	28'-30'	(" ")					65	35					
	9A	31'-34'	MH (" ")	16	33	51		53	32					

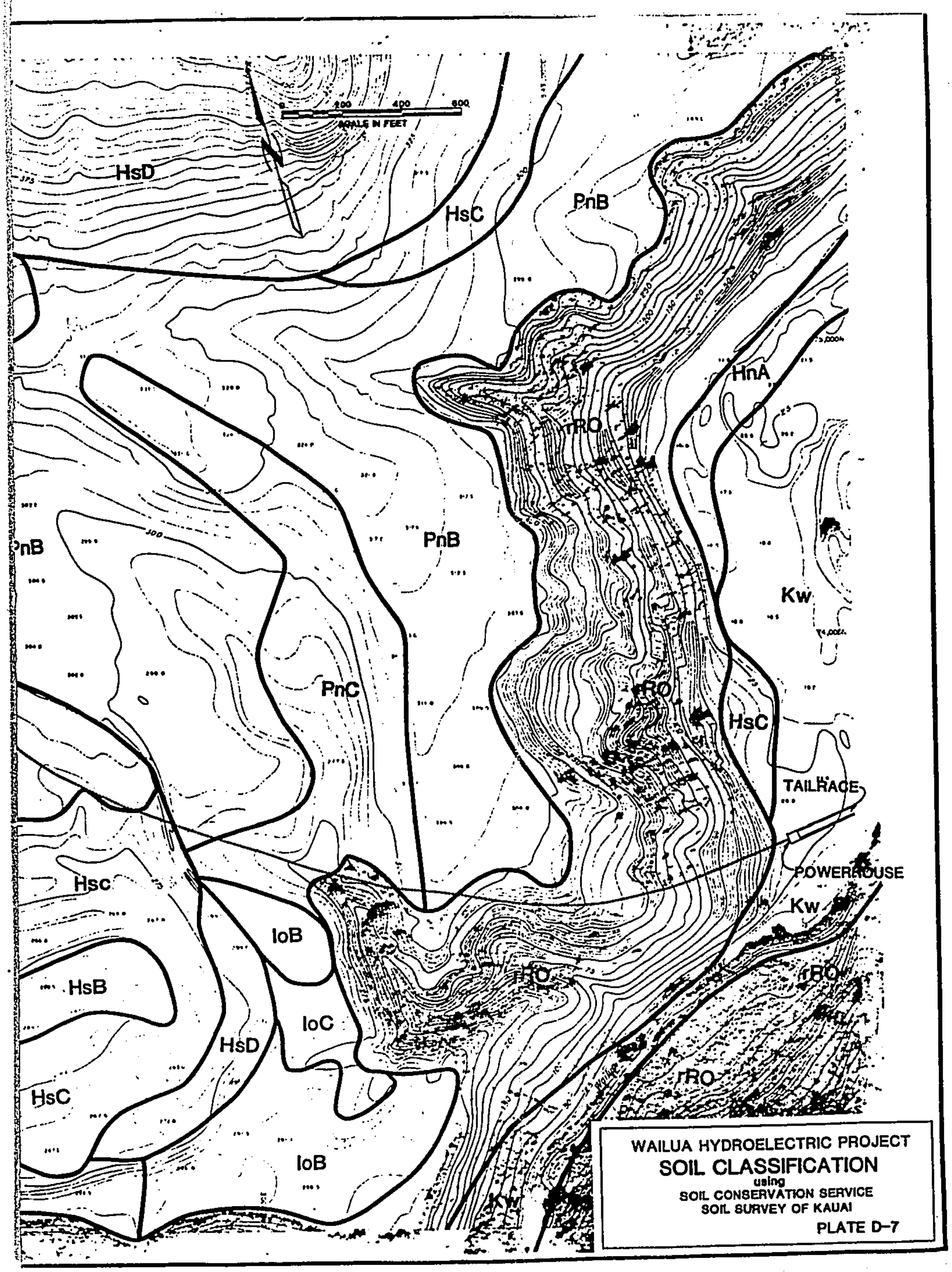
ENG FORM 2086 1 JAN 73 EDITION OF 1 MAR 68 IS OBSOLETE.

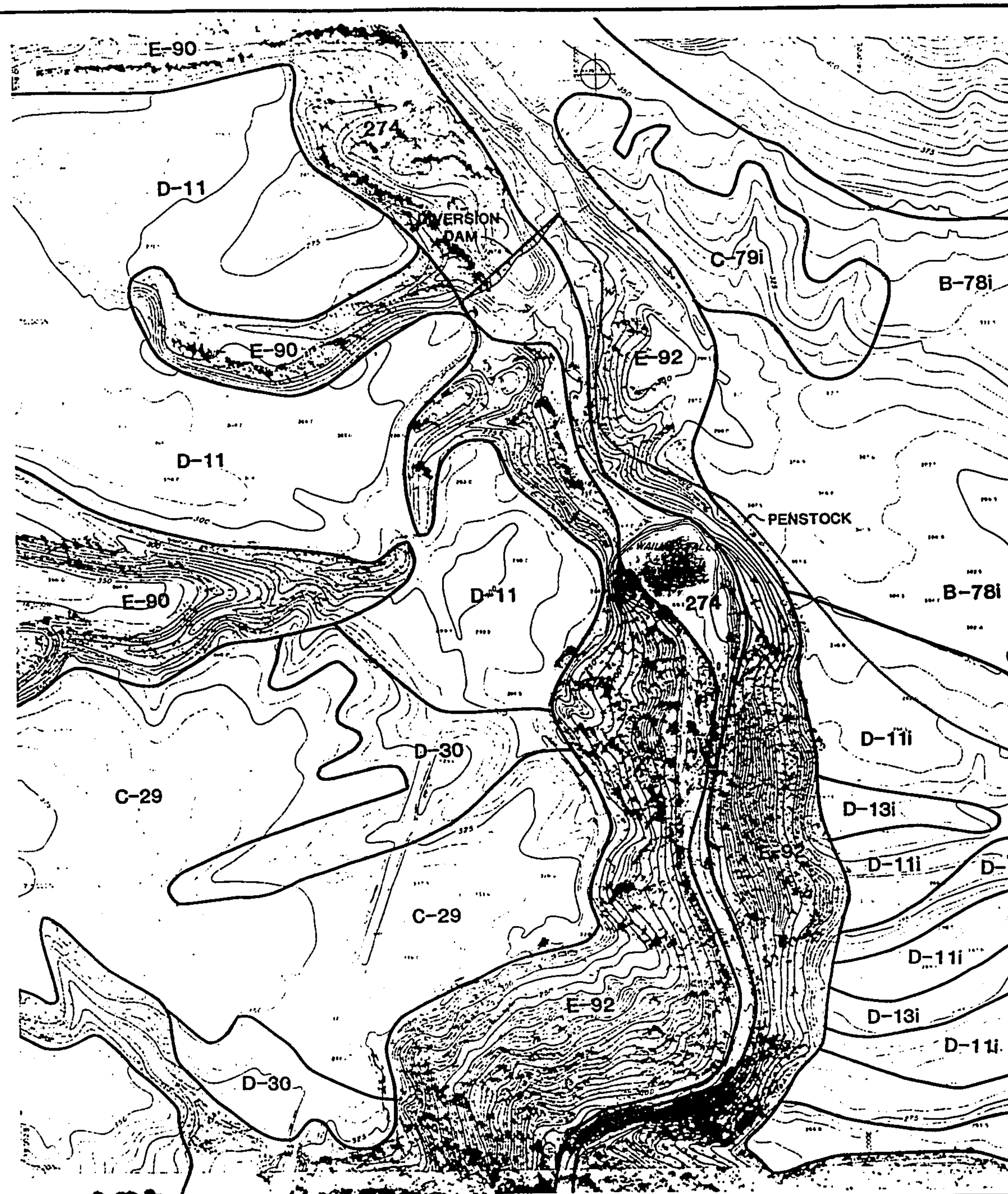
WAILUA HYDROPOWER

PLATE D-6

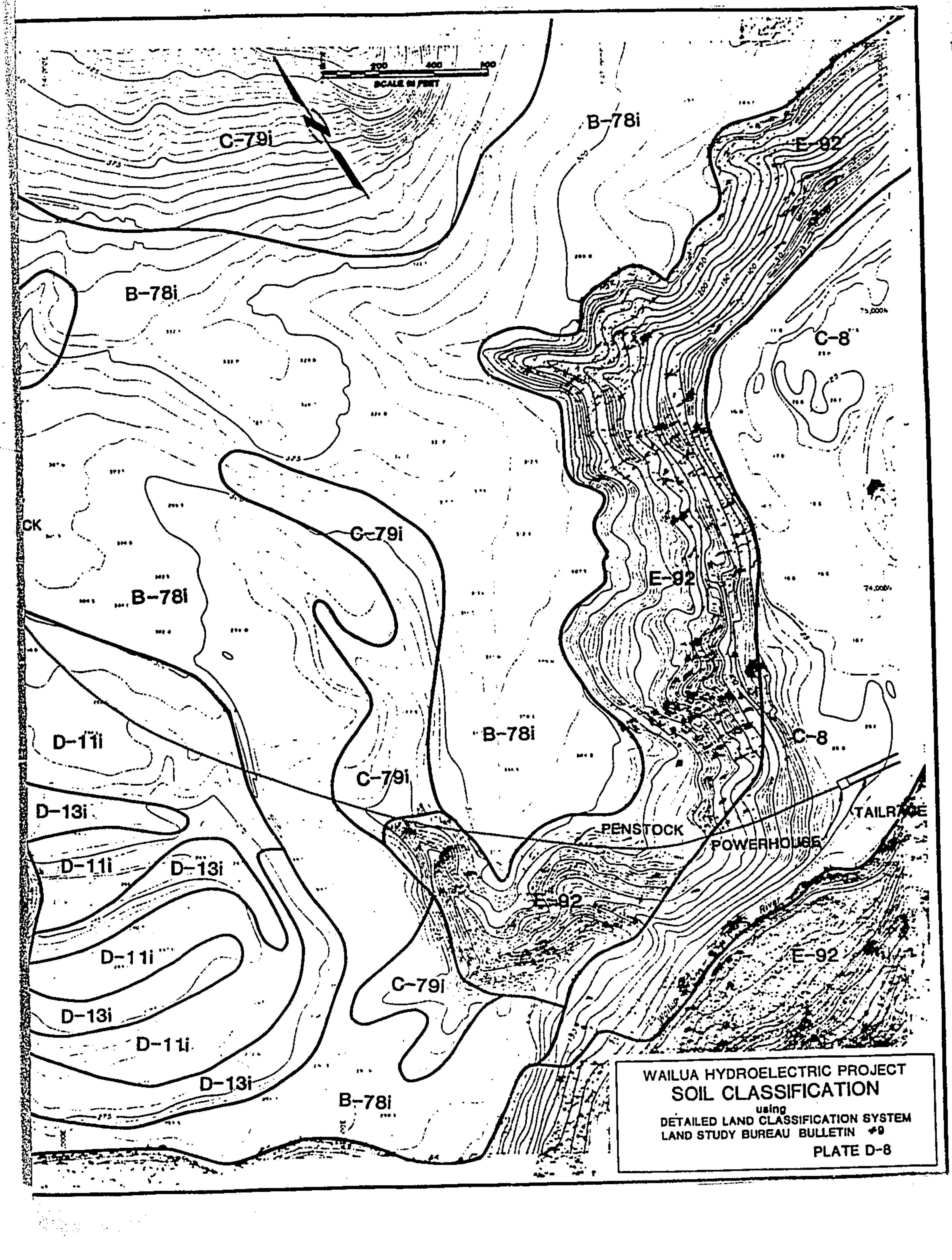


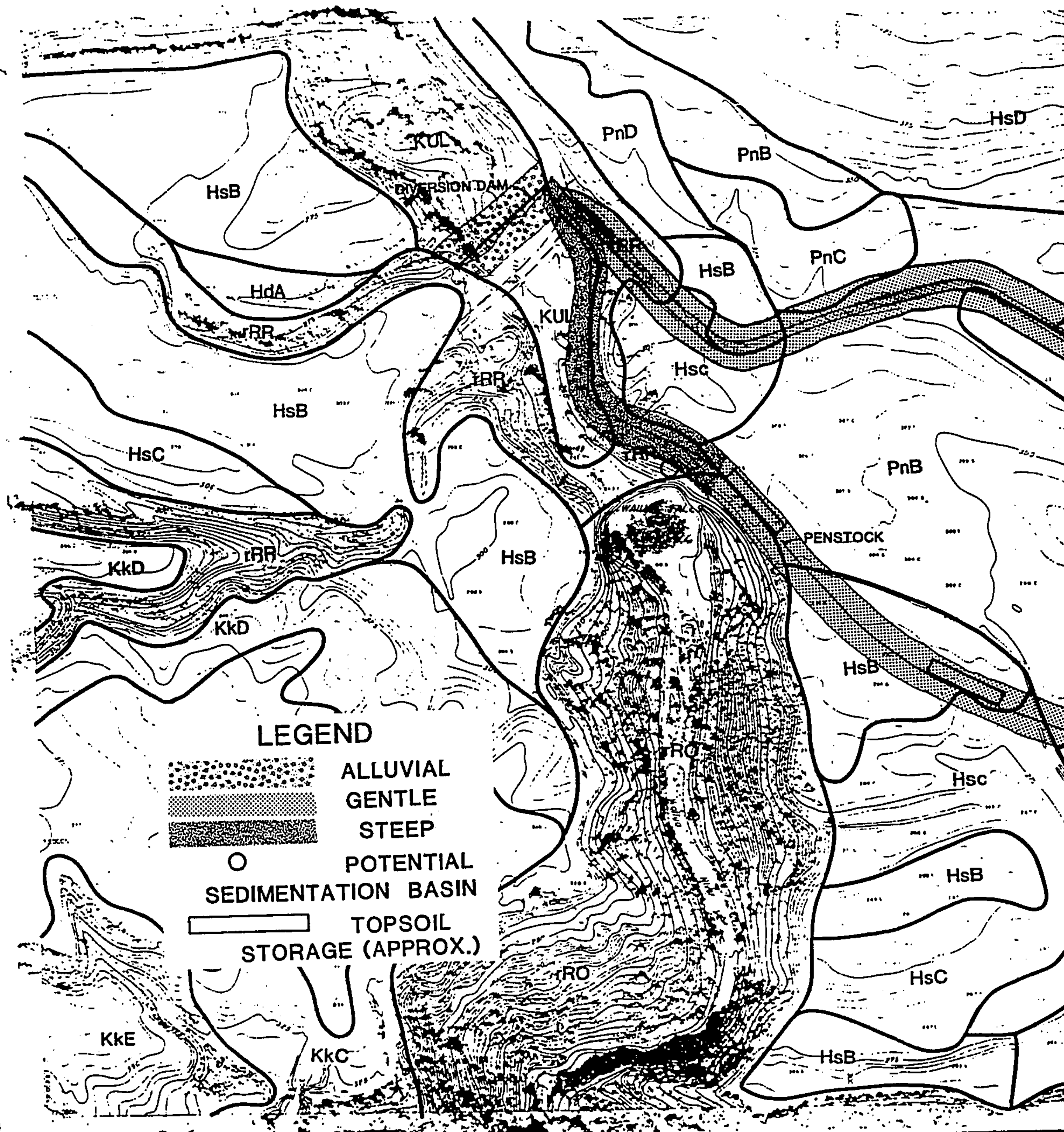
HsD
PnD
PnB
KUL
DIVERSION DAM
HsB
rRR
HsB
PnC
HdA
rRR
KUL
Hsc
rRR
HsB
HsC
RR
PnB
PENSTOCK
KkD
rRR
HsB
KkD
HsB
KkD
RO
Hsc
KkB
HsB
rRO
HsC
KkE
KkC
HsB

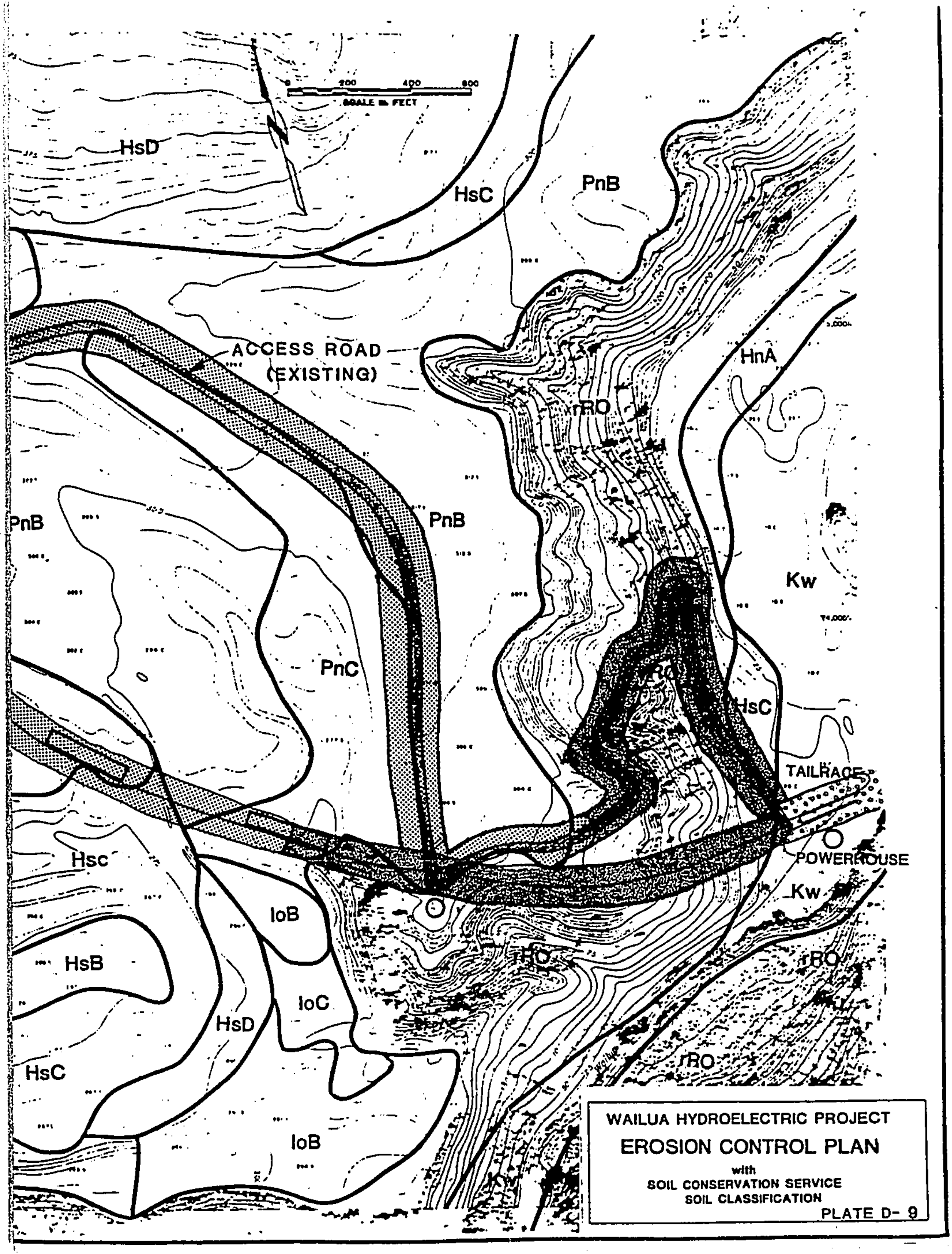

0
200
400
600
SCALE IN FEET
HsD
HsC
PnB
HnA
rRO
PnB
PnB
Kw
PnC
rRO
HsC
TAILRACE
POWERHOUSE
Hsc
Kw
IoB
rRO
rRO
HsB
IoC
HsD
rRO
HsC
IoB
Kw
WAILUA HYDROELECTRIC PROJECT
SOIL CLASSIFICATION
using
SOIL CONSERVATION SERVICE
SOIL SURVEY OF KAUAI
PLATE D-7

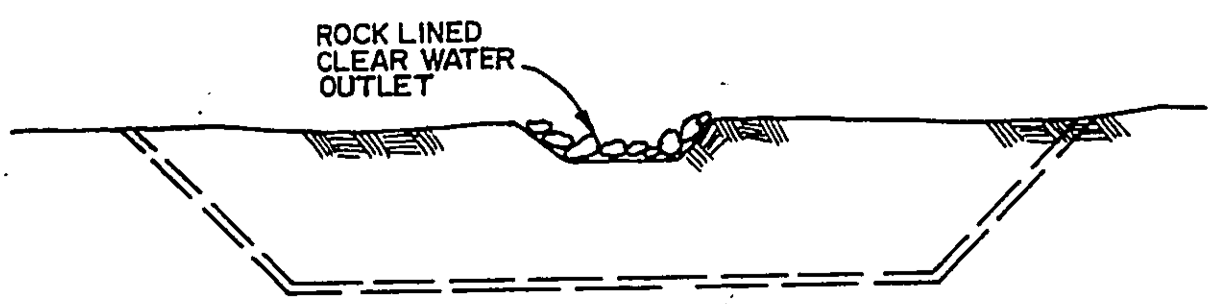


E-90
274
D-11
DIVERSION
DAM
C-79i
B-78i
E-92
E-90
D-11
PENSTOCK
E-90
D-11
274
B-78i
D-11i
D-30
C-29
D-13i
D-11i
C-29
D-11i
E-92
D-13i
D-11i
D-30

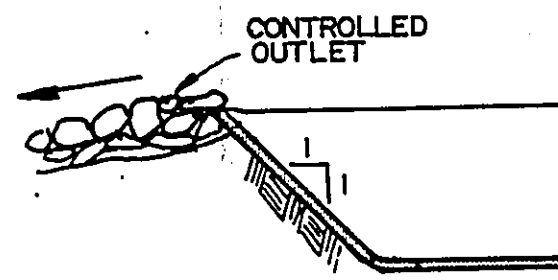

SCALE IN FEET
200
400
600
C-79i
B-78i
E-92
C-8
B-78i
C-79i
B-78i
E-92
D-11i
B-78i
C-8
C-79i
D-13i
PENSTOCK
TAILRACE
POWERHOUSE
D-11i
D-13i
E-92
D-11i
E-92
C-79i
D-13i
D-11i
D-13i
B-78i
WAILUA HYDROELECTRIC PROJECT
SOIL CLASSIFICATION
using
DETAILED LAND CLASSIFICATION SYSTEM
LAND STUDY BUREAU BULLETIN #9
PLATE D-8


KUL
DIVERSION DAM
PnD
PnB
HsD
HsB
PnC
HdA
rRR
KUL
Hsc
HsB
HsC
PnB
PENSTOCK
KkD
rRR
KkD
HsB
HsB
rRO
Hsc
HsB
HsC
rRO
KkE
KkC
HsB
LEGEND
ALLUVIAL
GENTLE
STEEP
POTENTIAL SEDIMENTATION BASIN
TOPSOIL STORAGE (APPROX.)


0 200 400 800
SCALE IN FEET
HsD
HsC
PnB
ACCESS ROAD
(EXISTING)
HnA
rRO
PnB
PnB
Kw
PnC
HsC
TAILRACE
POWERHOUSE
Hsc
Kw
IoB
rRO
rRO
HsB
IoC
HsD
rRO
HsC
IoB
WAILUA HYDROELECTRIC PROJECT
EROSION CONTROL PLAN
with
SOIL CONSERVATION SERVICE
SOIL CLASSIFICATION
PLATE D- 9

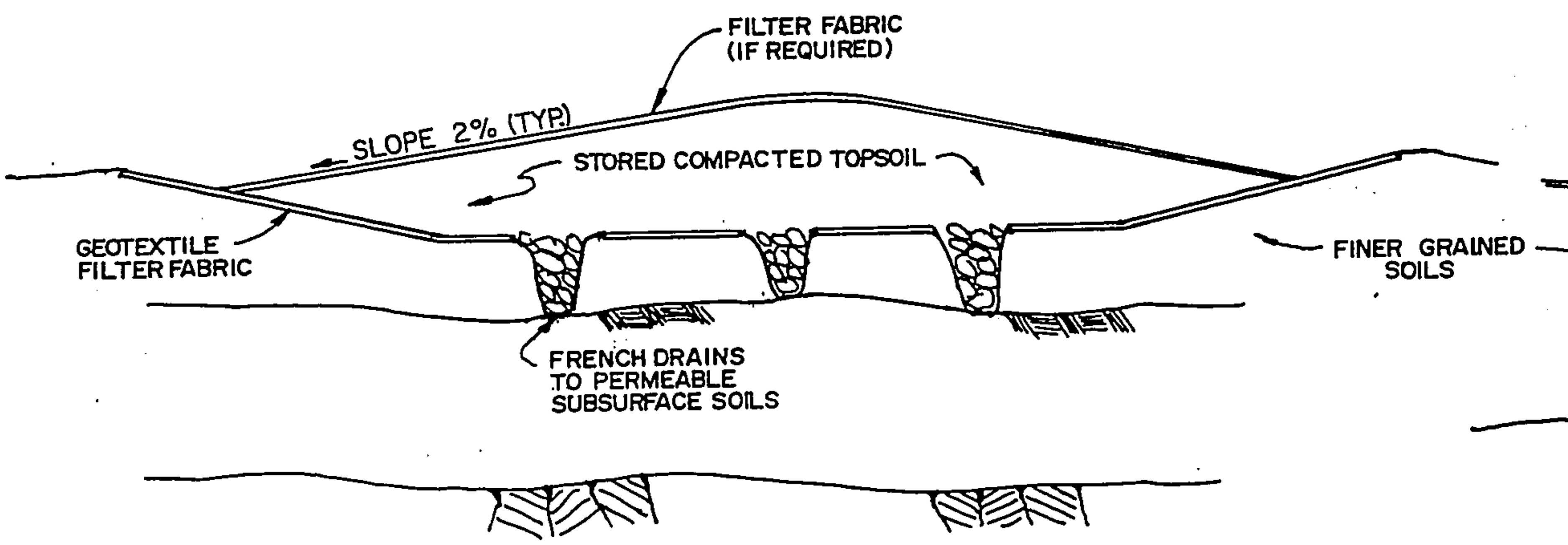


END VIEW



SEDIMENT BASIN

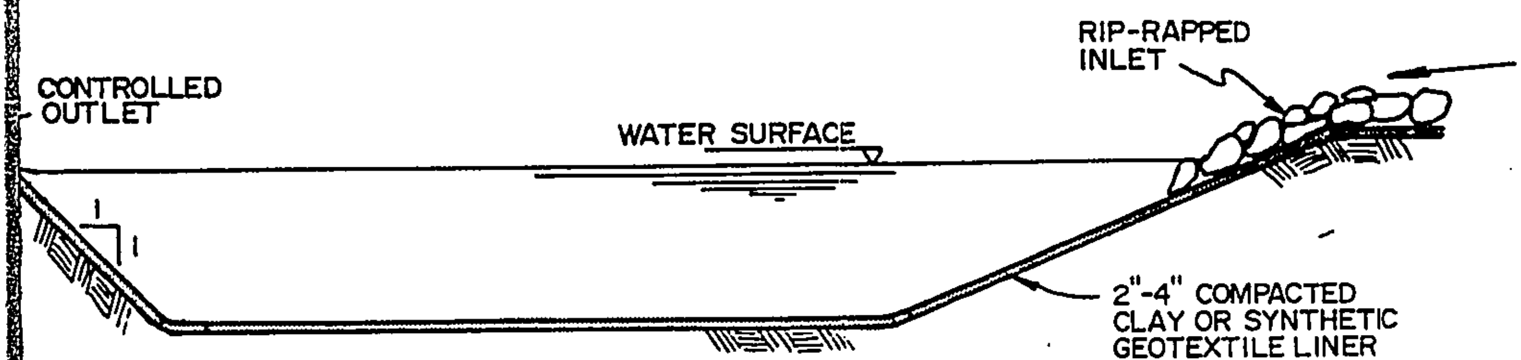
NTS



X-SECTION

TOPSOIL STORAGE EROSION CONTRO

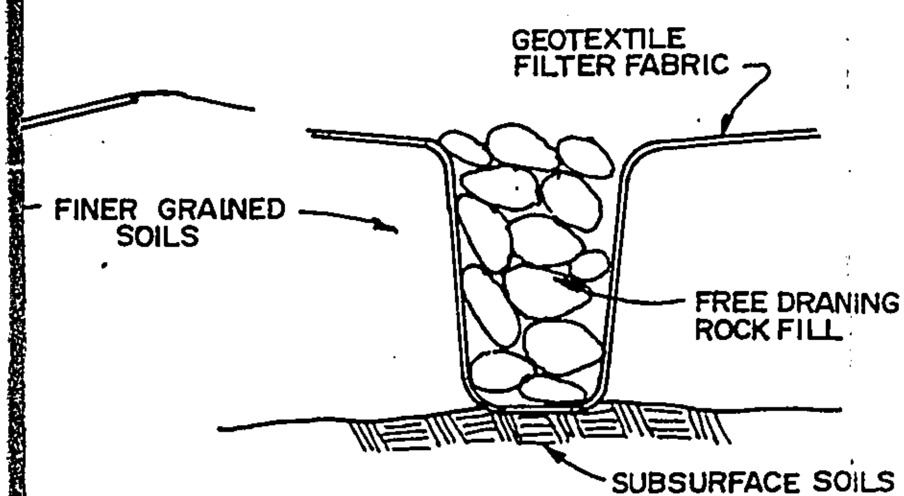
NTS



SIDE VIEW

ENT BASIN

ITS



FRENCH DRAIN DETAIL

N CONTROL

WAILUA HYDROELECTRIC PROJECT

EROSION CONTROL DETAILS

with

SOIL CONSERVATION SERVICE
SOIL CLASSIFICATION

PLATE D- 10

B-6d ECONOMIC INVESTIGATIONS

INTRODUCTION

1. A potential hydropower project must satisfy two basic criteria for authorization and construction. First, the project must be economically feasible. The economic value of the output must be greater than the cost of production. Second, the project must be financially feasible. Its output must be marketable at rates sufficient to recover costs. Economic feasibility is measured with benefit cost analysis. The benefit is utility companies' measured willingness to pay for energy produced by the hydroelectric powerplant. The cost of the energy displaced by the production of hydroelectric output is taken as a benefit. Appropriate sizing of the most economically efficient hydropower plant was performed.

ECONOMIC CONDITIONS

POPULATION

2. There are two main sources of projected population growth for Kauai. They are the State of Hawaii Department of Planning and Economic Development ("DPED"), and OBERS 1980 projections by the Bureau of Economics Analysis ("BEA"), US Department of Commerce. The OBERS BEA projections for the non-SMSA portion of Hawaii, which includes Kauai, shows a growth rate somewhat lower than the latest figures resulting from DPED projections. The validity of the OBERS projections follows from the soundness of the control total approach, in which reliable national projections are first made, from which smaller regional projections are derived by disaggregation. The validity of the DPED projections, however, follows from County growth rate forecasts based on historical trends. The two projections are shown in Table E-1, and depicted graphically in Plate E-1.

BENEFITS AND FEASIBILITY

POWER VALUES

3. Benefits are based on the estimated value of the hydroelectric production. They are measured as the average cost of energy production requirements eliminated, or displaced, by the hydroelectric powerplant. The actual value of this displaced energy is a weighted average, reflecting the incremental costs of energy production for a mix of affected powerplants. Current WRC and FERC procedures provide for an escalation of real fuel costs in the determination of average annual energy values. The fuel prices are escalated in accordance with Department of Energy forecasts from the price level date for a period of thirty (30) years. Following the 30-year period in the future, the prices are to remain constant for the balance of the 100-year economic life of the project. The discounting methodology is shown on Plate E-2. Studies by FERC and DOE presently indicate that benefit values per unit of energy are as shown in Table E-4. The FERC correspondence is provided at the end of this appendix. Due to the relatively low plant factors resulting from non-firm flows, firm capacity would not be available for the hydropower schemes. As noted elsewhere in this report, the energy future for Kauai remains relatively uncertain, at least in the long term. With the electrical energy production tied to a significant extent to activity in the sugar industry, electrical generation could eventually be even more dependent on imported fossil fuels.

SUMMARY AND CONCLUSIONS

4. Based on the power value data, which assumes continued real price escalation for fossil fuel, and which reflect a system energy displacement effect, the hydropower project is economically justifiable.

Table E-1. HISTORICAL AND PROJECTED POPULATION GROWTH FOR KAUAI

POPULATION (1,000's)

		PROJECTED		
		OBERS[1/]		
	Historical	Low	High	OPED[2/]
1950	30.7			
1960	27.8			
1970	30.1			
1980	39.1			36.5
1985		42	43	40.6
1990		45	47	46.5
1995		48	51	53.1
2000		51	55	60.4
2010		55	60	
2020		58	65	
2030		63	70	

1/ Based on growth rate for non-SMSA portions of Hawaii, 1980 OBERS BEA Regional Projections, US Department of Commerce, Bureau of Economic Analysis, July 1981.

2/ State of Hawaii, Series II-F Projections, March 1978.

5. The OPED projections are under revision at this time in response to 1980 census figures. Kauai's census, for example, is 39,082, or 6.6% higher than had been projected for 1980. All three scenarios show continuing growth, although at different rates.

ENERGY USE

6. Barring drastic changes in the economy and lifestyle, all three population growth scenarios represent a continuing requirement for electricity production. Population is of course only one of the variables linked to electricity generation and use. While population growth averaged about 2.6% per year during the 1970's, electricity generated increased by an average of about 5.3% per year, as shown in Table E-2. In addition to residential use, for which population is the primary indicator, commercial, industrial, and public use all have contributed to this growth. Future growth will be tied to developments in the economy in general, specifically in the agriculture and tourism sectors, and by extension the construction industry. The behavior of the world petroleum market will also be a significant factor along with related trends and developments in alternate forms of energy use and production, conservation, and changes in lifestyle. A forecast prepared for the Hawaii State Energy Plan shows electricity demand forecasts by County to the year 2000. The forecast shows growth rates of around 4% annually through 1990, decreasing to below 1% per year by the end of the forecast period. Projections by the utility, Kauai Electric Division, however, show a relatively constant rate of increase.

* The following pages B-128--B-131 are information from the U.S. Army Corps of Engineers from their "Final Interm Survey Report and Environmental Statement"

Table E-2. ANNUAL ELECTRICITY GENERATION, KAUAI 1/

		Annual % Change	
Year	Net Electricity Generated (millions of kwh)	From Previous Year	From 1975
1975	167.6		
1976	169.6	1.2	1.2
1977	183.2	8.0	4.7
1978	201.0	9.7	6.6
1979	204.2	1.6	5.5
1980	211.1	3.4	5.2
1981	218.6	3.6	5.1

1/ FPC Form 12 data and State of hawaii PUC report for Kauai Electric 1980 and 1981.

Table E-3. KAUAI COUNTY ELECTRICITY DEMAND FORECAST, 1977-2000 (Million KWH)

	OPED Projection 1/		Kauai Electric Projection 2/	
Year	Energy Sold	Average Annual Percent Change	Energy Sold	Average Annual Percent Change
1977	167	-	167	-
1980	187	4.4	189	4.4
1985	230	3.7	227	4.0
1990	272	3.7	271	3.9
1995	297	1.8	323	3.8
2000	306	0.6	385	3.8

1/ From State Energy Plan and Technical Reference Document, Hawaii Department of Planning and Economic Development, September 1980.

2/ From Communication, Kauai Electric Division, February 1982.

ALTERNATIVE ENERGY AND SELF SUFFICIENCY

7. Kauai is remote for submarine transmission cable intertie systems. While a link via cable is the subject of a feasibility study for the islands of Oahu and Hawaii, Kauai's remoteness (102 miles from Honolulu, and 10,800 feet of water depth) makes any such intertie highly unlikely for the foreseeable future. With escalating world oil prices affecting Kauai, other non-fossil fuel sources have been the subject of planning efforts. The most recent step in Kauai's drive for oil independence came this year with the start-up of the Lihue Plantation Company's bagasse-fueled powerplant. Excess output is purchased under contract agreement by the local utility. Recent (1978) legislation enables private entities such as sugar companies to get higher prices for such excess electricity production. The new bagasse plant on Kauai is in part a response to this legislative incentive. Under a 20-year agreement, 12,000 kw of the plants' 20,000 kw capacity is at the disposal of the utility. In 1980, 13 percent of the utility's requirements were met by such agreements. With the new bagasse plant in operation, exceeding its expected performance, plantation-supplied power on Kauai was 43 percent of Kauai's total in 1981. This energy from both hydropower and bagasse - fuel sources represents a significant step toward oil independence for Kauai.

PLATE E-1. KAUAI POPULATION GROWTH

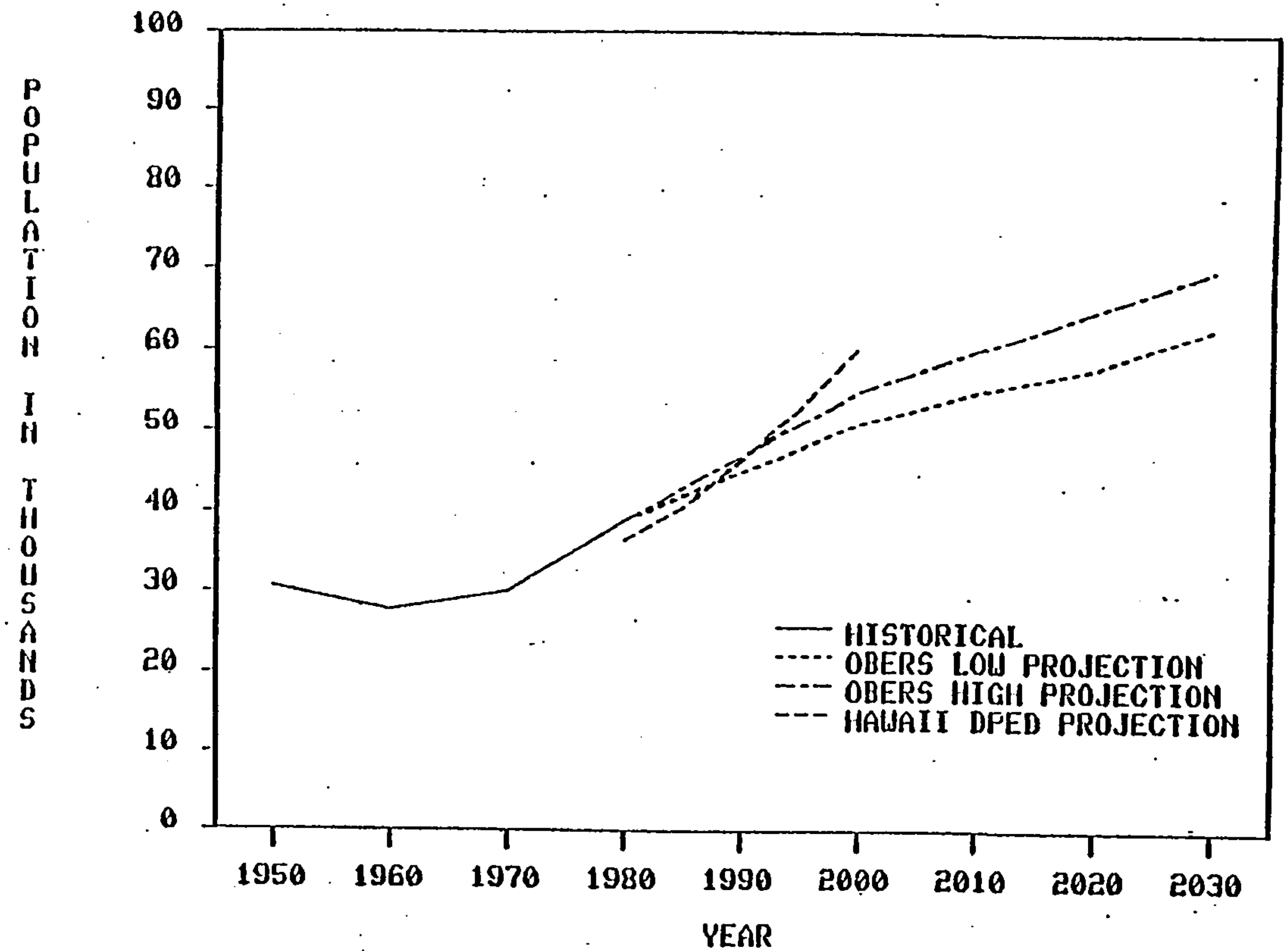
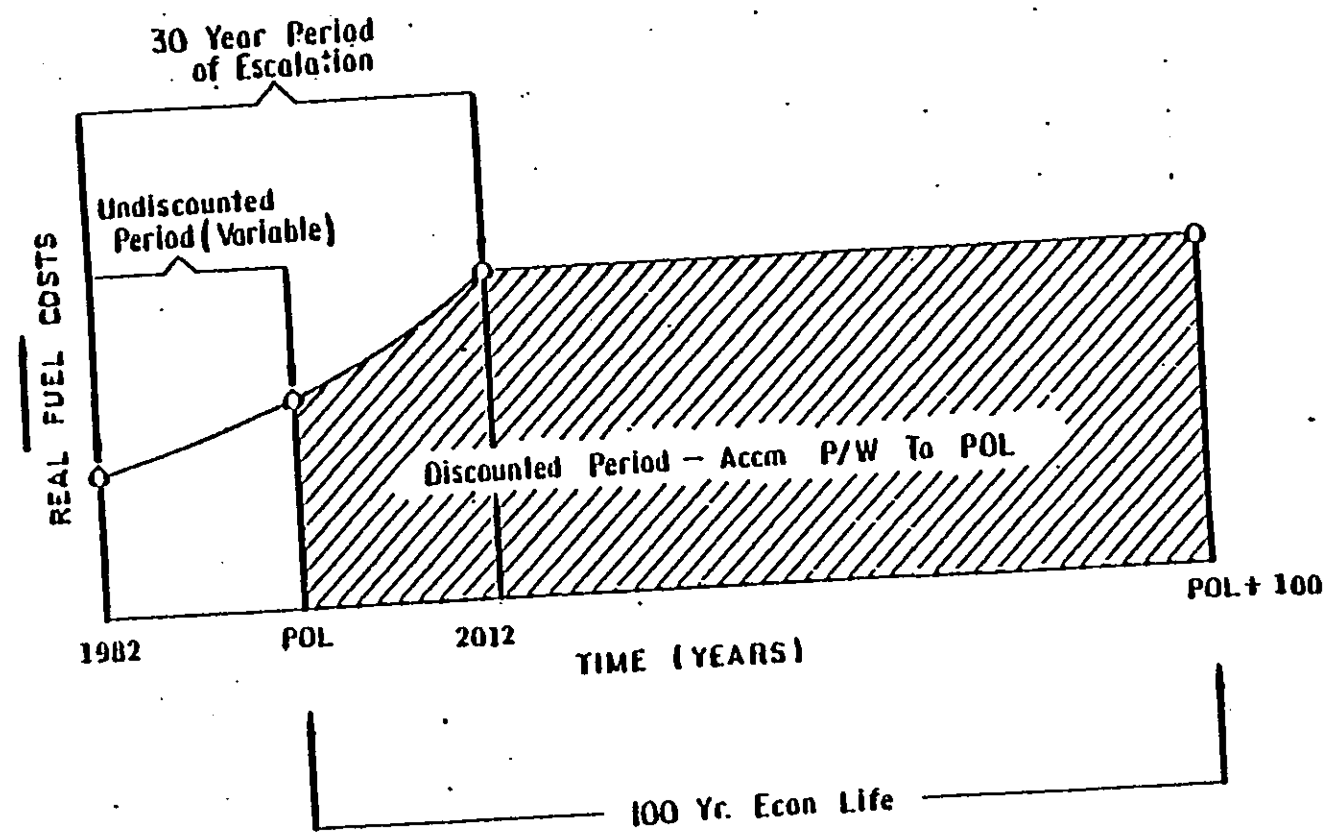


PLATE E-1



DISCOUNTING METHODOLOGY REAL FUEL ESCALATION

SOURCE: US Water Resources Council, Water and Energy Task Force, <u>Evaluating Hydropower Benefits</u>. Dec 1981.

PLATE E-2

B-6e POWER MARKETING INVESTIGATIONS

EXISTING POWER SYSTEM (1981)

1. The existing electric generation systems consist of a mix of diesel generators, residual oil-fired steam boilers, gas turbines, hydroelectric plants, and one biomass fueled (Bagasse) unit (refer to Table A). These units exhibit the following mix:

	Units	Installed Capacity MW
Diesel Generators	7	13.15
Resid. Oil-Fired Boilers	12	46.75
Gas Turbines	2	39.93
Hydroelectric	9	8.70
Bagasse	1	20.00
TOTAL	31	128.75

2. The Kauai Electric Division (KED) assumed control of the major oil-fired generators at Port Allen in 1969, while the sugar companies (which had previously owned all electric generation facilities) retained ownership of several small oil units and all of the hydroelectric facilities. In addition, Lihue Sugar developed one new bagasse-fired unit in conjunction with KED in 1981. The split in ownership of existing units is as follows:

	Oil & Gas Fired	Hydro & Other	Total %
KED	62.08 MW	0 MW	48%
Sugar Co.	37.65 MW	28.7 MW	52%

3. The KED units were installed from 1964 to 1977; the sugar company units are typically 25-30 years or older. No new hydroelectric facility has been built on Kauai since 1954 except for an extremely small, privately owned (0.0015 MW) unit and some relatively minor upgrades.

4. 78% of the installed capacity on the island is oil or gas fired. All capacity on the island that is not oil or gas fired is fueled from renewable energy sources. (Note: prior to the 1981 installation of the 20 MW Lihue bagasse facility, 92% of the island's capacity was oil or gas fired).

* The following pages B-132--B-144 is information from the U.S. Army Corps of Engineers from their "Final Interim Survey Report and Environmental Statement"

5. KED's existing base load, peak capacity, and firm purchases are as follows (based upon a KED letter to the Western Area Power Administration February 2, 1982):

			Base Load KW	Peak Load KW
Diesel:	#1		1,825	2,000
	#2		1,825	2,000
	#3		2,500	2,750
	#4		2,500	2,750
	#5		2,500	2,750
		Subtotal	11,150	12,250
Steam:			9,700	10,000
Gas Turbine:		Hitachi	16,100	17,650
		JBE	20,530	22,180
		Subtotal	36,630	39,830
Firm Purchase:		Lihue	12,000	12,000
		TOTAL	69,480	74,080

6. For discussion of the existing electric transmission system, rates, and relationship of the sugar companies' system to KED refer to the MAIN REPORT.

TABLE A
COUNTY OF KAUAI - EXISTING ELECTRIC GENERATION FACILITIES (1981)

	OIL & GAS FIRED GENERATION				HYDRO & RENEWABLE GENERATION			
	CAPACITY (MW)		LIFETIME (YR)		CAPACITY (MW)		LIFETIME (YR)	
OWNERSHIP AND UNIT	INSTALLED	ACTUAL[1/]	ONLINE	EST. RETIRE	INSTALLED	ACTUAL	ONLINE	EST. RETIRE
KAUAI ELECTRIC DIVISION								
Diesel 1	2.00	1.325	1964	1994				
Diesel 2	2.00	1.325	1964	1994				
Diesel 3	2.75	2.50	1968	1998				
Diesel 4	2.75	2.50	1968	1998				
Diesel 5	2.75	2.50	1968	1998				
Steam	10.00	9.70	1969	1999				
Gas Turbine 1(Hitachi)	17.53	16.10	1972	2000+				
Gas Turbine 2 (GE)	22.18	20.53	1977	2000+				
Subtotal	62.08	57.48			0	0		
McBRYDE SUGAR CO.								
Steam 1	7.75	7.75	1965	1995				
Steam 2	7.75	0	1965	1995				
Steam (Old Site)	2.50	0	1952	1982				
Wainiha 1					1.8	1.5	1929	----
Wainiha 2					1.3	1.5	1928	----
Kalaheo					1.0	0.3	1928	----
Waiahi					0.3	0.0	1919	Retired
Subtotal	18.0	7.75			4.3	4.0		
KEKAHA SUGAR CO.								
Steam 1	1.0	1.0	1930	----				
Steam 2	2.5	2.5	1950	----				
Steam 3	2.5	2.5	1929	----				
Lower Waiawa					0.50	0.33	1907	----
Mauka					1.00	0.75	1954	1984
Subtotal	6.0	6.0			1.50	1.00		
LIHUE PLANTATION SUGAR CO.								
Steam 1	2.0	1.75	1949	----				
Steam 2	4.0	4.0	1957	1987				
Steam 3	4.0	4.0	1957	1987				
Hydro 1					0.3	0.3	1941	----
Hydro 2					0.5	0.5	1930	----
Bagasse 1					20.0	20.0[2/]	1981	2000-
Subtotal	10.0	9.75			21.3	21.3		
OLOKELE SUGAR CO.								
Steam 1	2.0	2.0	1965	1995				
Steam 2	0.75	0	1941	----				
Diesel 1	0.45	0.45	1970	2000				
Diesel 2	0.45	0.45	1970	2000				
Wainiha					0.5	0.5	1930	----
Subtotal	3.65	2.90			0.5	0.5		
TOTAL	99.73	83.38			28.7	26.3		
TOTAL GENERATION (MW)								
Installed	(128.43)							
Actual	(110.78)							

1/ Actual capacity for KED units reflects KED estimates of baseload capacity (Feb. 1, 1982 letter to HAPA from KED)
2/ 12 MW firm capacity sold to KED 11 months out of the year (except January).

FUTURE POWER AND ENERGY REQUIREMENTS

7. This section will discuss forecasts of electric capacity and energy for Kauai exclusive of the demand by the sugar companies, since these companies supply 100% of their demand through company-owned generation.

8. A report by the U.S. Army Corp of Engineers, "National Hydro-Electric Power Study Regional Report: Vol. XXIII," Hawaii, May 1981; has summarized energy and peak demand projections for the state of Hawaii based on several sources. Table B summarizes the applicable projections from Chapter 4 of the aforementioned report.

9. One of the two most recent reports analyzing future energy and power demand for the state of Hawaii was the Harza Engineering Company Report, "The Magnitude and Regional Distribution of Needs for Hydropower, The National Hydropower Study: Phase II - Future Electric Power Demand and Supply," 1980. This report made three projections based on different economic scenarios. Growth rates in energy and peak demand projections were as follows:

	Energy G.R. 1978-2000	Peak Demand G.R. 1978-2000
Projection I	3.2%	3.3%
Projection II	3.9%	4.0%
Projection III	5.2%	5.2%

Population in all cases was assumed to grow at an average annual rate of 1.3%. As this range of forecasts indicates, the state of Hawaii "State Energy Plan" Energy (GWH) Growth rate of 2.5% for KED (see Table B) is lower than projection I for the State. Similarly, KED's 1979 projections of 3.2% (see Table B) growth rate for peak load are comparable with the most conservative (Projection I) statewide forecasts in the Harza report.

10. The Federal Power Commission's Form 12 requires a four-year projection of energy and peak demand. KED's 1980 data is as follows:

	1981	1982	1983	1984	Ave. Annual Gr.
Peak (MW)	39.8	41.3	42.8	43.3	2.85%
Energy (GWH)	219.5	227.3	235.5	238.3	2.80%

(The 2.8% rate in peak growth is substantially lower than the 4.0% (1980-1984) growth rate KED submitted in Table B. Also note that these forecasts are before line losses of about 10.5% have been accounted.)

TABLE 8

Summary of energy and peak demand forecasts relevant to Kauai - based on U.S. Army Corp of Engineer Report; "National Hydroelectric Power Study Regional Report," Hawaii, May 1981.

Table 8-1: Kauai Electrical Energy Demand Forecast

	1980	1985	1990	1995	2000	2005
Energy	187	230	272	297	306	314
Growth Rate %		4.26	3.38	1.81	0.58	0.54

(Note: Average Annual Growth Rate 1980-2000 = 2.50%)

Source: "State Energy Plan," Dept. of Planning and Economic Development, State of Hawaii, Sept. 1980. State Projected Electrical Energy Demand Forecast, Hawaii, 1980-2005 (Kauai Data Excerpted from Table 4-1).

Table 8-2: Kauai Peak Load and Generation Capacity Forecasts

	1980	1982	1984	1986	1988
Peak Load (MW)	38.0	41.2	44.4	47.7	50.9
Capacity (MW)	62.1	74.1	74.1	74.1	74.1
	1990	1992	1994	1996	1998
	54.2	57.4	60.7	63.9	67.2
	82.1	82.1	92.1	114.3	114.3

(Note: Average Annual Growth Rate (Peak Load Growth) 1980-1998 = 3.2%)

Source: Official KED projections 1979. Public Utilities Project Peak Load and Generating Capacities 1979-1998

11. The most recent report analyzing the state's and Kauai's electricity energy demand was the "Hawaii Integrated Energy Assessment" LBL, June 1981. This report used "an econometric-based simulation" model to develop forecasts to the year 2005 by fuel type. The results of cases assuming various macro-economic conditions were as follows:

(GWH)	1980	1985	1990	1995	2000	2005
Baseline Macro	191.4	237.2	290.4	339.4	378.8	415.5
High World Oil Price	191.4	216.8	227.2	220.8	201.6	179.2
Low Macro-econ.	186.4	205.6	244.9	284.7	329.9	376.7
High Macro-econ.	196.9	258.0	355.9	515.4	760.4	1089.5

12. The last communication Western Area Power Administration received from KED was February 2, 1982. In Table 1 of this letter, KED projected a 3.6% average annual growth rate from 1982 to 1991 in both firm peak load and energy; the results of such a trend would be as follows:

	1981[1]	1982	1983	1984	1985	1986	1987
GWH	218.7	226.6	234.7	243.2	251.9	261.0	270.4
Peak (MW)	39.5	40.9	42.4	43.9	45.5	47.1	48.8

	1988	1989	1990	1991
GWH	280.1	290.2	300.7	311.5
Peak (MW)	50.6	52.4	54.3	56.3

(Note: Energy is prior to line losses of about 10.5%)

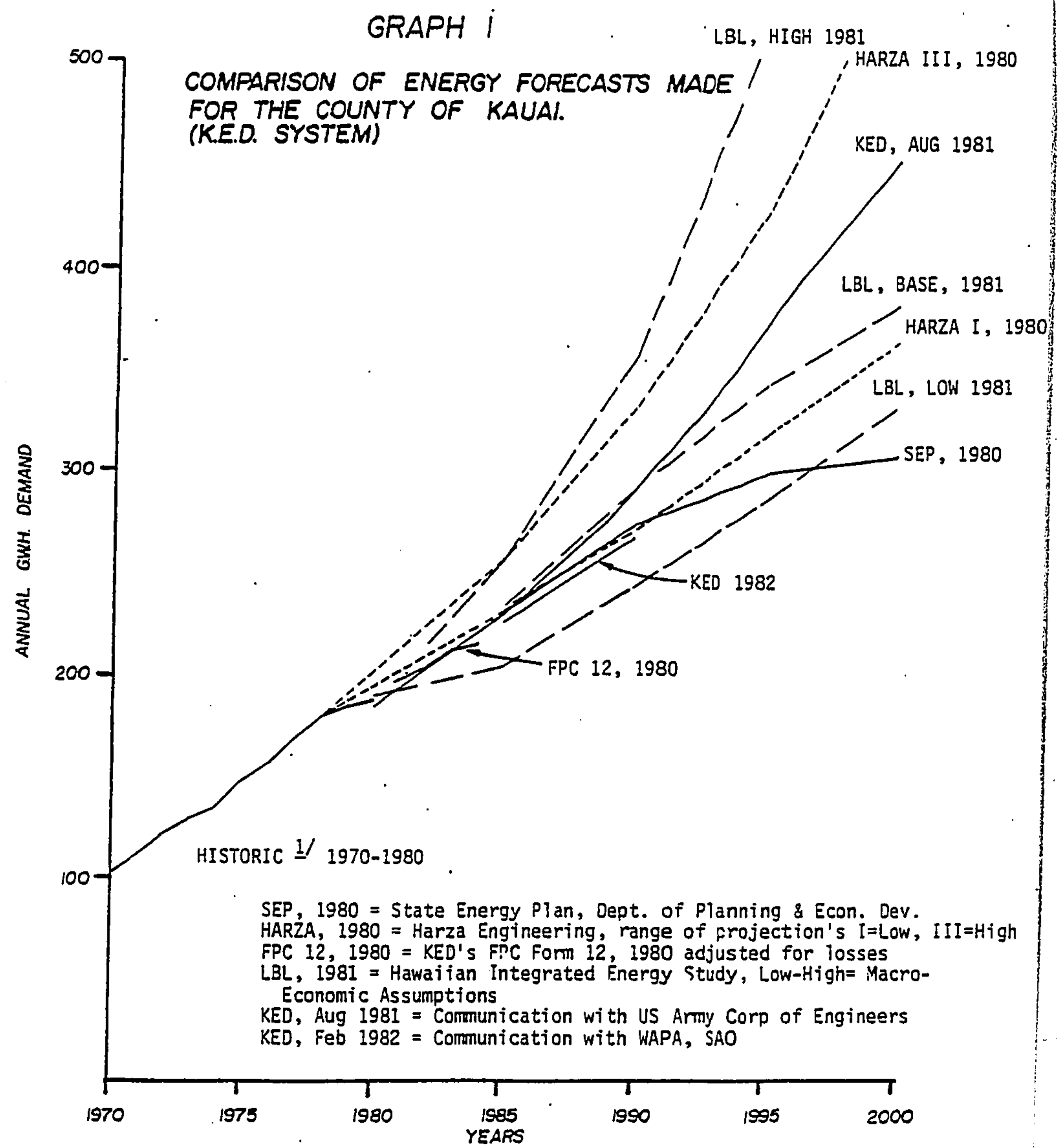
The energy growth rate is similar to Projection II of the Harza Report and is also similar to both the "State Energy Plan" and the Baseline Macroeconmic Scenario of the "Hawaiian Integrated Energy Assessment" of June 1981 (LBL).

13. The remaining data point regarding peak and energy forecasts is "personal communication" from KED officials to the U.S. Army Corp of Engineers in August 1981.[2] KED forecasts in that instance indicated the following future requirements:

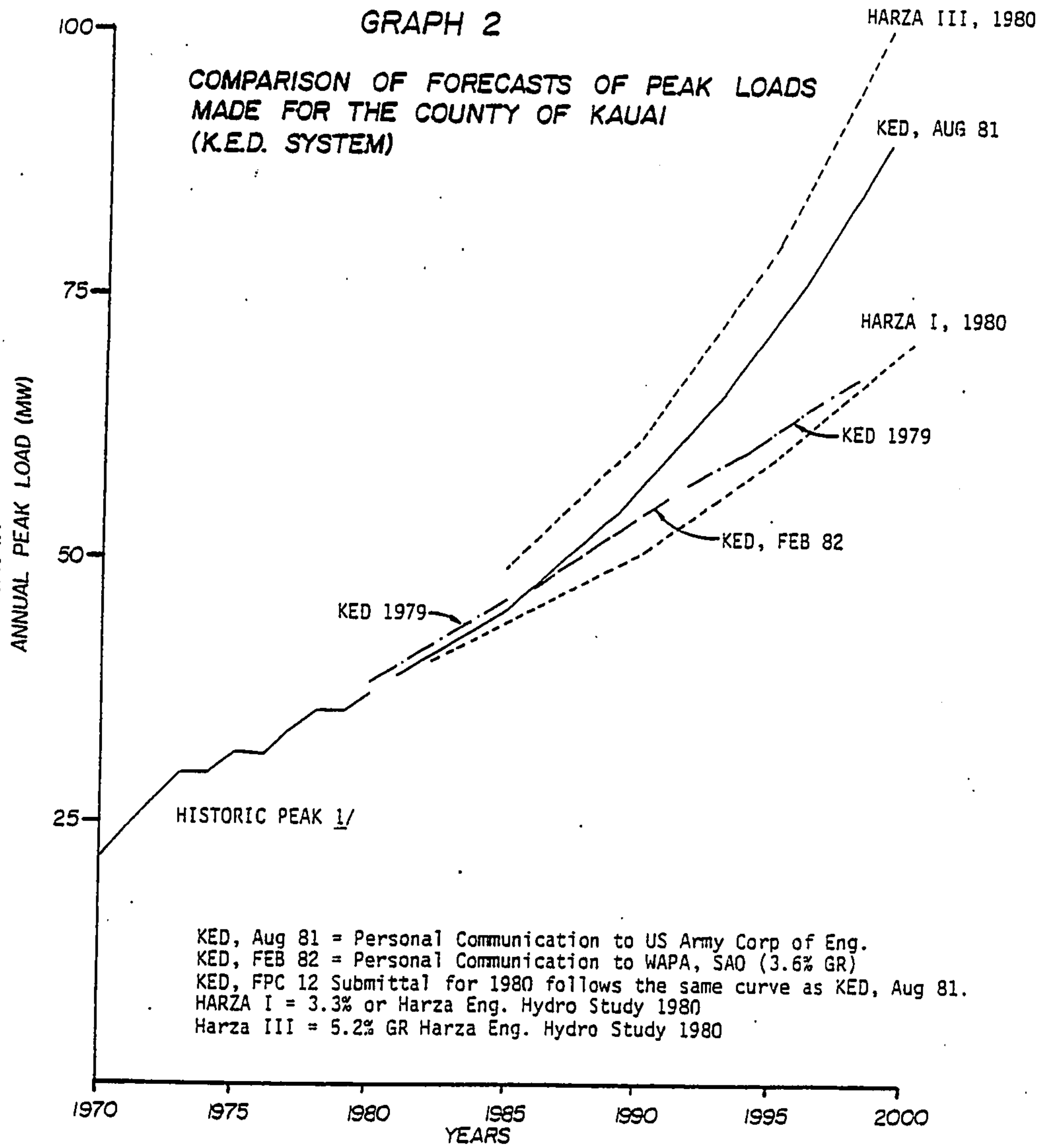
	1980	1981	1985	1989	1993	1996	1999
Peak Load (MW)	37.3	38.8	45.4	54.6	66.4	76.9	89.0
Energy (GWH)	189.2	196.8	230.2	277.1	336.8	389.9	451.4

14. Graph 1 (Energy) and Graph 2 (Peak) summarize the various projections of future energy and capacity requirements by the county of Kauai. Examination of Graphs 1 and 2 indicate that there is a wide range of variation in even the most recent energy and peak load forecasts. Since most energy forecasting models are driven by economic assumptions, (such as the rate of inflation, GNP, and real personal income growth) the more recent forecasts have shown less optimistic growth rates reflecting current economic conditions.

1/1981 data (actual) contained in 2/1/82 letter.
2/This data is contained on page 21 of the 1981 draft report.



1/ Based on various FPC Form 12's



1/ Historic data from " Annual Report of Kauai Electric Division" to the state PUC

FUTURE GENERATION PLANS AND OPTIONS

15. Table C summarizes all planned generation capacity additions on the island of Kauai as currently estimated (1981-1982) by the island utilities. The planned additions are proportioned as follows:

	Oil & Gas (MW)	Hydro (MW)	Other (MW)
KED	18 MW	0	0
Sugar Companies	0	5.25 MW	0
State of Hawaii	0	22.00 MW	0
U.S.Army Corp of Engrs.	0	4.0 to 7.0 MW	0
Total	18 MW	31 to 34 MW	0

Note that the 22 MW of hydro capacity planned by the State of Hawaii has all been indefintely suspended and that the Corp of Engineers' project is in the initial stages of a 10 to 14 year planning, engineering and construction cycle; therefore, the viability of all but the 18 MW planned by KED and 5.25 MW planned by the sugar companies is speculative.

16. The total installed capacity including the future planned additions and assuming no retirement of existing units will be 187.18 MW by year 2000 with 127.73 being oil or gas fired, 39.45 MW hydro electric, and 20 MW bagasse fired.

17. The 18 MW planned additions of KED are based on a February 2, 1982 letter from KED to the Sacramento Area Office of WAPA which contained the following information as "Table 3:"

> "18 MW steam turbine installed in 1989, to be operated at 8 MW using steam generated by the existing HRSG. HRSG installed in 1993 to operate in combined cycle with the Hitachi gas turbine and generate steam to operate the steam turbine at 18 MW."

This information reflects a change in KED's resource planning from as recently as August 1982 when KED's plans reflected an 8 MW addition in 1989 and a 22.2 MW addition in 1996.

18. Bagasse, solar, and wind power would be the most likely alternative energy source other than oil, gas, or hydro electricity based on the documents, "Energy Self-Sufficiency for the Island of Kauai, Vol. 1 & 2," Hawaii Natural Energy Institute, June 1979, and "Hawaii Integrated Energy Assessment, Vol. 2" LBL June 1981. Geothermal energy would not be considered as a likely option for Kauai based on the LBL study.

TABLE C

POTENTIAL AND PLANNED ADDITIONS IN GENERATION CAPACITY

OWNERSHIP/UNIT	OIL & GAS FIRED: INSTALLED CAPACITY	OIL & GAS FIRED: EST. ONLINE DATE	HYDRO PROJECTS: INSTALLED CAPACITY	HYDRO PROJECTS: EST. ONLINE DATE	OTHER POTENTIAL: INSTALLED CAPACITY	OTHER POTENTIAL: EST. ONLINE DATE	TOTAL MW 2000
KAUAI ELECTRIC DIVISION							
Existing Capacity (81)	62.08		0		0		
Planned Additions:			0		0		
1/ Steam Turbine	8.0	1989					
Steam Turbine	10.0	1993					
Subtotal	90.08		—		—		90.08
McBRYDE SUGAR CO.							
Existing Capacity	18.0		4.9		0		
Planned Additions	0		0		0		
Subtotal	18.0		4.9		0		22.90
KEKAHA SUGAR CO.							
Existing Capacity	6.0		1.5		0		
Planned Additions	0				0		
Waiawa Upgrade (w/AMFAC)			0.7	1986+			
Kokee Ditch (W/AMFAC)			1.4	1986+			
Subtotal	6.0		3.5		0		9.50
LIHUE PLANTATION SUGAR CO.							
Existing Capacity	10.0		1.3		20.0 (Bagasse)		
Planned Additions:	0				0		
Hydro Upgrade Project			1.9	1986+			
Subtotal	10.0		3.2		20.0		33.20
OLOKELE SUGAR CO.							
Existing Capacity	3.55		0.50		0		
Planned Additions:	0				0		
Hydro Upgrade Project			1.25	1982			
Subtotal	3.55		1.75		0		5.40
STATE OF HAWAII							
Planned Additions:	0						
Kokee Water Project			10.0	1990+			
Wataieale Hydro Proj.			9.2	1990+			
Puu Opae-Wana (w/AMFAC)			3.0	1990+			
Subtotal			22.0				22.0
U.S.CORP OF ENGINEERS							
Planned Additions:	0						
Wailua River Project			4 to 7	1990+			4.00
TOTALS	127.73		39.45		20.0		187.13

1/ Based on KED letter to WAPA 2/1/82. (Note: Only one 18 MW turbine to be installed in 1979: an additional HPSG adds 10 MW capacity in 1993.)

19. In regards to bagasse fuel potential, approximately 32.3 thousand tons of bagasse were being disposed of yearly as of 1978 with a heat content as a boiler fuel of about 4,500 BTU/lb.1/ This estimate indicates a substantial potential for additional bagasse units; however, the estimate of bagasse availability is contradicted by the 1979 Hawaiian Natural Energy Institute Report that indicates that almost all of the bagasse waste (96%) was being used as fuel in industry operations as of 1978.

20. The most recent resource addition on Kauai was a 20 MW bagasse unit in 1981. This indicates that such a facility is commercially available and cost competitive with at least marginal oil and gas fired generation. Bagasse units would appear to be able to produce firm capacity 11 out of 12 months of the year based on crop production.

21. For further discussion of alternative resources reference the text of the MAIN REPORT and the LBL June 1981 report "Hawaiian Integrated Energy Study, Vol. II: Alternative Energy Technologies for Hawaii."

1/ Hawaiian Integrated Energy Study, June 1981, LBL, P.102.

RESOURCE PLANNING ANALYSIS

22. The previous three sections have discussed the existing electric generation system's installed MW, age and diversity; identified the range in forecasts of energy and capacity; and, summarized potential generation capacity additions. This section will examine peak capacity versus peak loads and the balance of resources necessary to meet energy demand. A brief qualitative discussion of the integration of future units into the system will conclude the section.

23. Although it is assumed that all future sugar-company generation additions will serve only company loads, Graph 3 illustrates the magnitude of all existing, planned, and potential resource additions on the island of Kauai to year 2000 in terms of installed MW. If the Wailua River Hydro Project is compared to the capacities in Graph 3, it proportionally appears as the following (assuming 5.1 MW installed; option 1A):

	1990	1995	2000
% of total installed MW	3.2	3.0	3.6
% of KED installed MW	7.3	6.7	8.8
% of Hydro installed MW	14.6	14.6	14.6
% of KED additions after 1981	38.9	22.1	22.1

24. In considering peak capacity versus peak load projections, only KED resources and potential resources will be examined. To properly assess peak capacity available to KED in the long term, system dependable capacity needs to be assessed for each future year considering future retirements, and the single largest contingency. The following assumptions regarding the dependable capacity were applied in Graph 4:

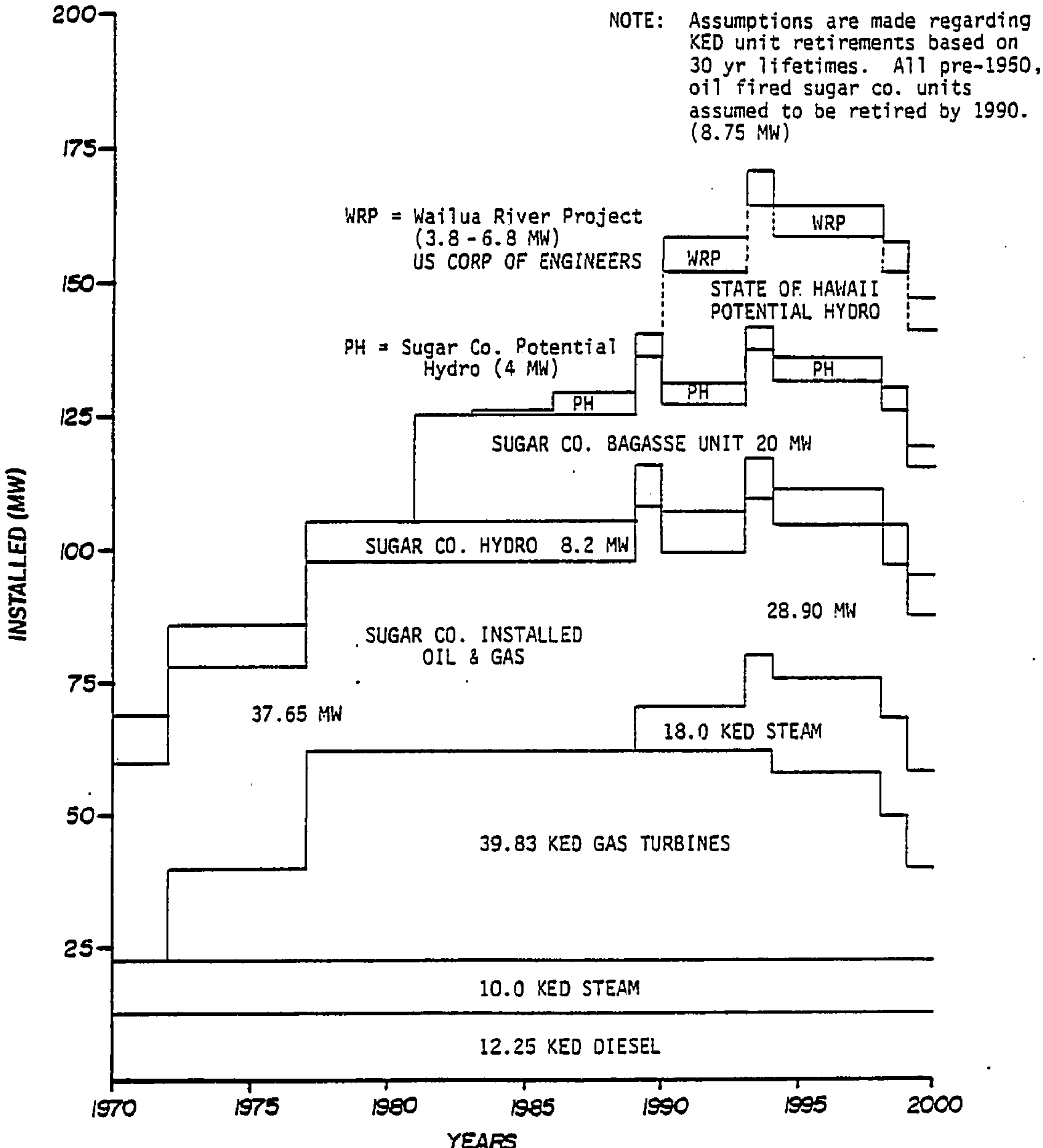
- Future retirements: KED system oil and gas-fired units were assumed retired at a 30-year lifetime which translates to 4 MW of diesel-fired generations being retired in 1994, and 8.25 MW in 1998. In addition, the 10 MW steam unit which was constructed in 1969 would be retired in 1999.

- Single largest contingency situation: Based on a review of the plant availability factors for KED's system, the units' per cent time down for scheduled or unscheduled maintenance is typically much less than 5% except for the JBE combustion turbine which is down 13.5% of the time. In the case of a system the size of KED's with no hydro increment, calculating the reserve margin as that capacity necessary to ensure system reliability when the single largest unit is down, is common practice2/.

2/ FPC form 12, schedule 16, "Dependable and Assured Capacity Instructions."

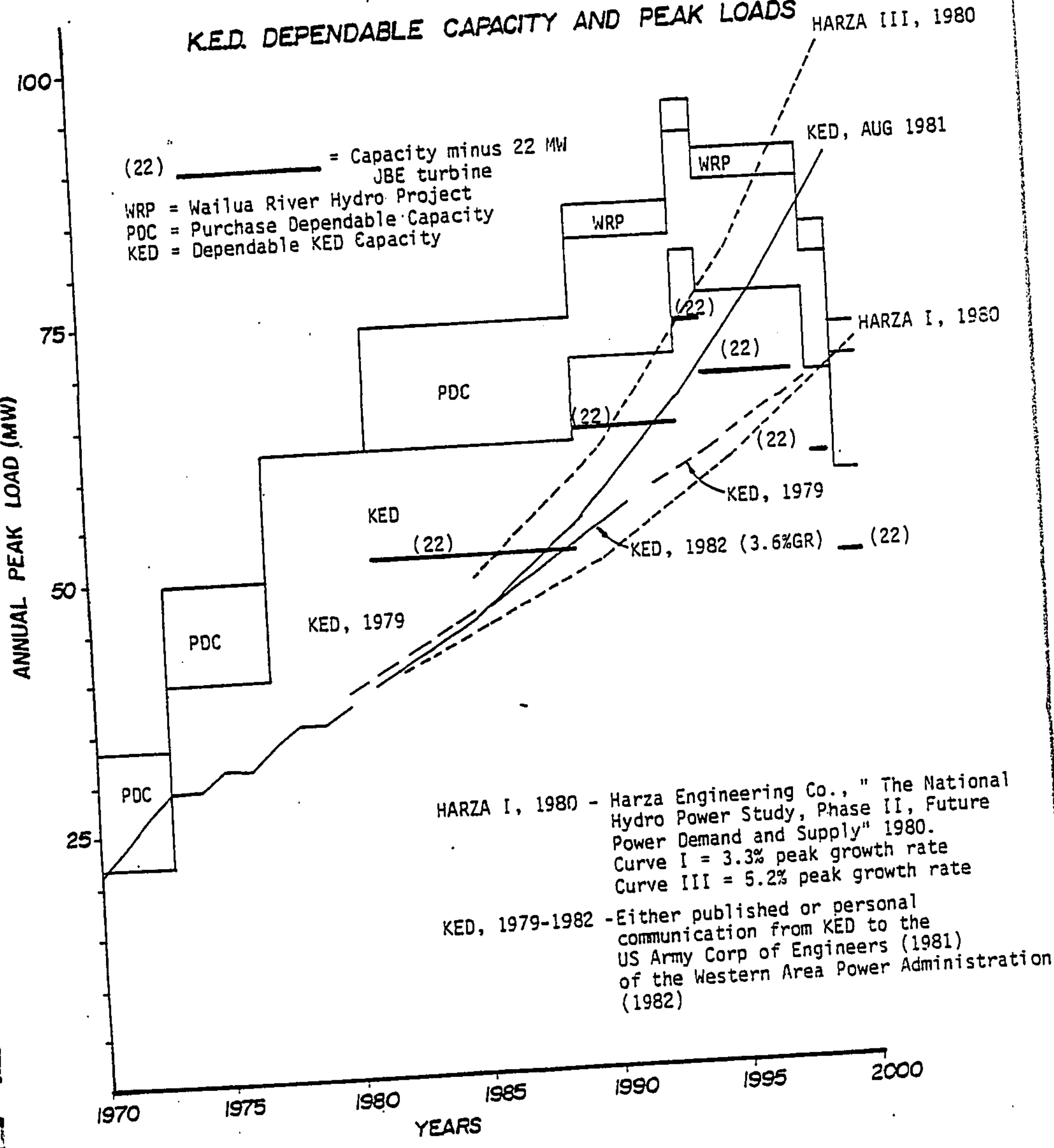
GRAPH 3

KAUAI POWER MARKETING STUDY — TOTAL EXISTING, PLANNED, AND POTENTIAL CAPACITY FOR THE COUNTY OF KAUAI.



GRAPH 4

K.E.D. DEPENDABLE CAPACITY AND PEAK LOADS



Firm capacity purchases and the Wailua River Project: The Lihue Plantation bagasse unit is contractually committed to serve KED with 12 MW of firm (dependable) capacity except for the month of Janaury. When considering the Wailua River Hydro Project, the associated capacity of 6.6 MW will be discounted by a conservative 40% to represent average hydro conditions, which leaves approximately 3 MW as dependable capacity. In addition, it will be assumed that all such capacity will be available to KED's system with a plant on line date of 1987.

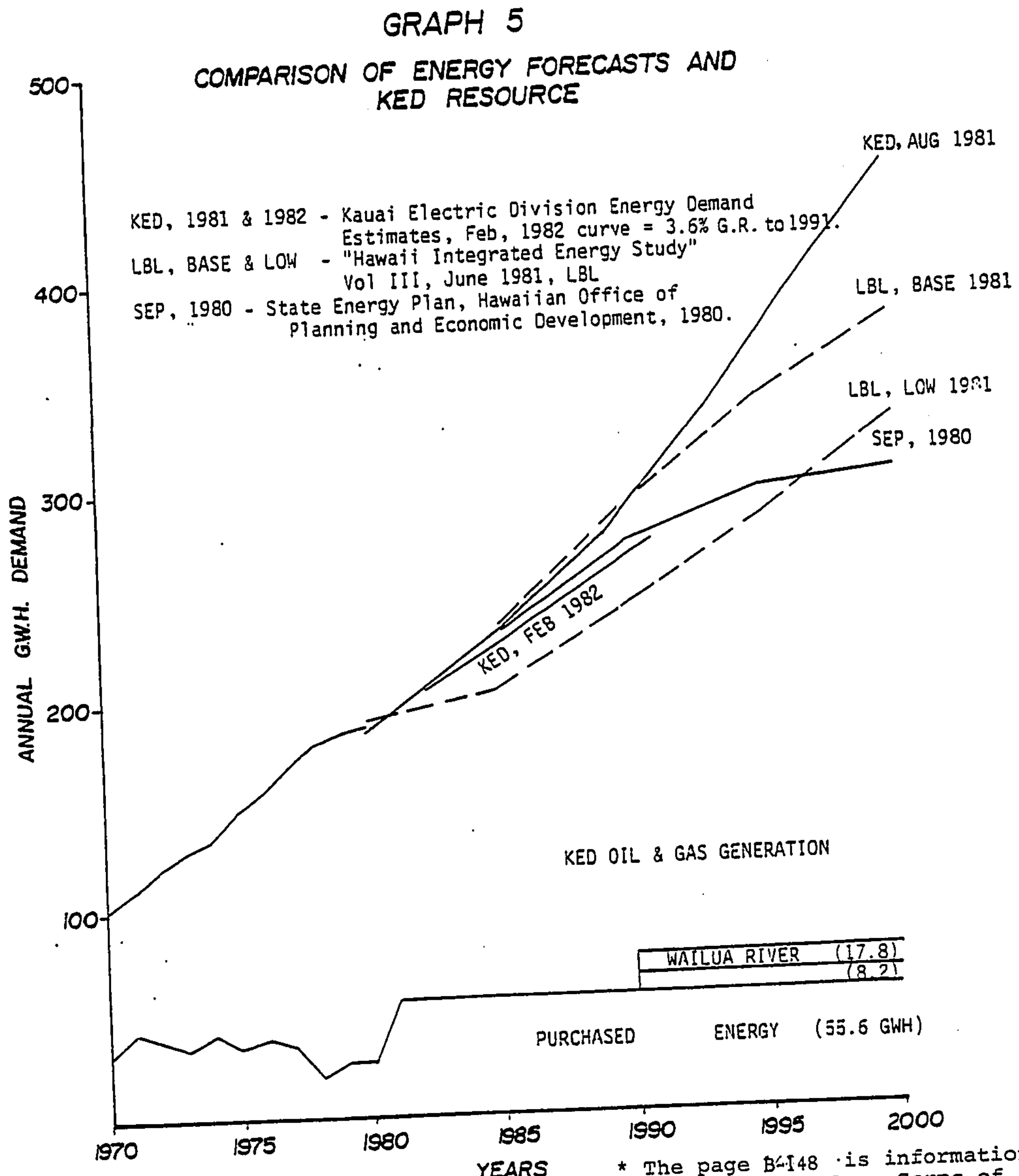
25. Graph 4 illustrates that even with the Lihue firm capacity purchase, that in the period 1981 to 1989 reserve margin will diminsh to about 30% (when considering the KED, 1982 forecast), which is just sufficient to meet load without the JBE turbine on-line. After 1989, with the planned 18 MW additions, KED should have adequate reserve margins until 1998 (assuming no retirements). However, if the oil and gas are retired as assumed, KED would have a reserve deficit. In the event of oil and gas retirements, the Wailua River Project seems to assist KED in terms of dependable capacity over the 1994 to 1998 time period. Finally, if the high peak growth forecasts (Harza III and KED August 1981) acutally occur, the Wailua River Project would make no siginificant difference; in that KED would have to install or purchase additional capacity than already planned by the early 1990's.

26. A final important point in regard to peak loads, is that the purchased dependable capacity (Lihue 12 MW) will not be available in the month of January. During January, KED would appear to be extremely capacity short as shown in Graph 4 when PDC is ignored.

27. In terms of resource planning to meet energy demand need, KED essentially must meet energy demand using its oil and gas generation after consideration of firm energy purchases. Graph 5 illustrates the historic and projected energy demand from resources available to KED. Historically, KED has not had to operate its oil and gas units at extremely high yearly average capacity factors to meet demand, as shown in 1978 and 1980 (based on FPC from 12 data):

	1978	1980
Diesel Units, CF%	9%	5%
Steam Unit, CF%	62%	62%
Hitachi-CT, CF%	25%	8%
JBE-Ct, CF%	39%	60%

28. Graph 5 assumes that the Lihue bagasse unit will apply 55.6 GWH energy annually, and that the Wailua River Project would produce between 3.6 and 33.7 average GWH per year.



* The page B-148 is information from the U.S. Army Corps of Engineers from their "Final Interim Survey Report and Environmental Statement"

29. According to Graph 5, the KED oil and gas system would have to generate the following approximate amounts of energy in future years to meet various forecasts (in GWH and assuming no Wailua River Project):

	1985	1990	1995	2000
LBL, Low 1980	149	194	229	274
LBL, Base 1980	177	235	285	324
SEP, 1980	175	217	243	238
KED, 1981	175	235	319	395
KED, 1982	169	210	-	-
(KED, MW of Oil & Gas)	62	70	76	58

30. Given the oil and gas capacities listed above (same retirement assumptions as for the capacity assessment), then the total KED oil and gas system would have to operate at an average yearly capacity factor to meet the forecasts as follows:

	1985	1990	1995	2000
LBL, Low 1980	27	32	34	54
LBL, Base 1980	33	38	43	64
SEP, 1980	32	35	36	47
KED, 1981	32	38	48	77
KED, 1982	31	34	-	-

If the Wailua River Hydro Project were considered, these capacity factors would be lowered by about 3 to 4% in 1990 and 2 to 3% in 1995 and 2000. The capacity factors shown are not unreasonable to expect from combustion turbines and combined cycle units, although the 77% average is at the margin.

31. Since the KED system is comprised of oil and gas units which are dispatched at the discretion of the utility, integration of a 3.8 to 6.5 MW hydro facility (project size under consideration) which would fluctuate in energy and capacity capability based on hydrologic conditions, should not present a problem to the integrity of the system.

DISTRIBUTION OF POWER BY KED

32. Investor-owned utilities in Hawaii (such as KED) are presently not allowed rates of returns on purchased power. Therefore, while no capital profit would be realized by KED through the purchase of the project power, KED would use the project's output to displace its most expensive generation.

33. The sale of the project power to KED would allow the benefits of the project to be directly melded into the existing energy system in Kauai, and as such, each KED customer would receive a proportion of the facility's benefits. In examining the end-use sectors which would receive the benefit one must review the KED distribution of sales and revenues for 1981 as illustrated in Table D.

TABLE D

KED NET REVENUES BY END-USE SECTOR

Sector	% of Total KWH Sold, 1981	Average Net Revenue Per KWH Sold, 1981
Residential	36.2%	15.15¢/kWh
Commercial	27.7%	15.60¢/kWh
Industrial	33.5%	14.56¢/kWh
Governmental St., Hwy, Park Lighting	1.2%	21.63¢/kWh
Irrigation	0.9%	10.87¢/kWh
Electric Service for KED Employees	0.4%	9.93¢/kWh

34. As shown in Table D, about 36 percent of the project energy would actually be delivered to residences in Kauai with a large proportion of the benefits of the developed resource going to private industrial and commercial businesses. In addition, prior to this distribution of energy to the end-use sectors approximately 8.6 percent (FPC Form 12, 1981, KED) of the energy would be lost or unaccounted for in the KED system.

35. The distribution of benefits to non-public interests is shown further by KED rate structure, in which the residential, governmental, and commercial building customers pay higher average electricity prices than industrial, irrigation and KED employee sectors. This rate structure is depicted by listing the 1981 average net revenue per kWh sold, by end-use category, in Table D above. In Kauai, the average residential customer

rate on a kWh basis is 53 percent higher for energy than a KED employee; 39.3 percent more than an industrial customer. The government as a customer pays the highest price for its energy service -- street, highway and park lighting -- a service that is 48.6 percent more than industrial users. These differences may in fact by attributed to the "cost of service" in delivering electricity to each end-use sector. It should also be noted, however, that the industrial sector receives a declining block rate, i.e., the average unit energy cost declines as more energy is consumed.

36. The amount of energy assumed to be availble from the project yearly is 17,500,000 kWh. This amount compares to energy sales by KED in 1981 of approximately 200,000,000 kWh. The project energy, if melded into the KED 1981 level of sales would represent approximately 8.75 percent of total energy sales.

i.e. 9%

B-7 HISTORIC PERSPECTIVE

HISTORIC PROPERTIES

1. Identification of historic sites is required by the Reservoir Salvage Act of 1960 as amended, Section 110 of the National Historic Preservation Act of 1966, and Executive Order 11593 (1971). The Federal agency must evaluate the significance of the sites in order to determine possible eligibility for the National Register of Historic Places. If any sites in the project area are determined eligible for or already listed on the National Register, they would be protected by Federal law and regulation to the extent that the Federal agency must consult with the State Historic Preservation Office and the U.S. Advisory Council on Historic Preservation to determine the effect of the Federal project and to identify measures to either avoid or mitigate for any adverse affects.

2. The identification of historic sites within the study area is based on an "Archaeological Surface Survey of Wailua State Park, Kauai" conducted by Mr. Francis K.W. Ching in 1968 when he was employed by the State Department of Land and Natural Resources. The results of this study are reported in the planning document "Wailua River State Park, Island of Kauai, State of Hawaii" prepared by the joint of Eckbo Dean, Austin & Williams and Muroda Tanaka & Itagaki, Inc. for the State in 1970 and in Ching's "A Cultural Resources Reconnaissance for the Wailua River Hydropower Study, Wailua, Puna, Kauai Island" by Archaelogical Research Center Hawaii ("ARCH"), Inc., in 1981 for the U.S. Army Corps of Engineers. Ching's report is reproduced in this appendix without its large-scale maps of sited areas in conformance with the Archaelogical Resources Protection Act of 1979 (P.L. 96-95) and applicable Corps regulations (Engineering Regulation 1105-2-50, 29 January 1982). Most of the sites identified and discussed in the ARCH report lie within areas of potential environmental impact that were considered earlier in the planning process for this hydropower study. At present, construction is proposed only in ARCH Study Areas A, B, and I. The areas which would be potentially impacted by construction of the diversion barrier, intake structure and conduit above Wailua Falls (excepting Lihue Plantation sugarcane land) and the penstock and powerplant below the falls was previously examined by Ching in 1968. None of the sugarcane lands proposed for excavation and placement of conduit lines will be archaeolically surveyed because of the low likelihood of finding any remains of agricultural sites in areas so heavily modified by long-term mechanized agriculture.

3. Plate H-1 depicts the historic sites known as of 1970 in the study area (shown in outline inscribed on the map). The square symbol on Plate H-1 above Wailua Falls refers to the approximate location of Kawelowai (underwater) cave, as discussed on Page 18 of the ARCH report. M.D. Monsarrat's 1900 Map of the Lihue Plantation, Nothern Portion, Scale 1:6,000, however, indicates the Cave to be located about 750 feet upstream of Ching's location. Ching's Sites 205, 206, 207 and 208 are depicted in the State Park Plan as proposed lagoon for future development.

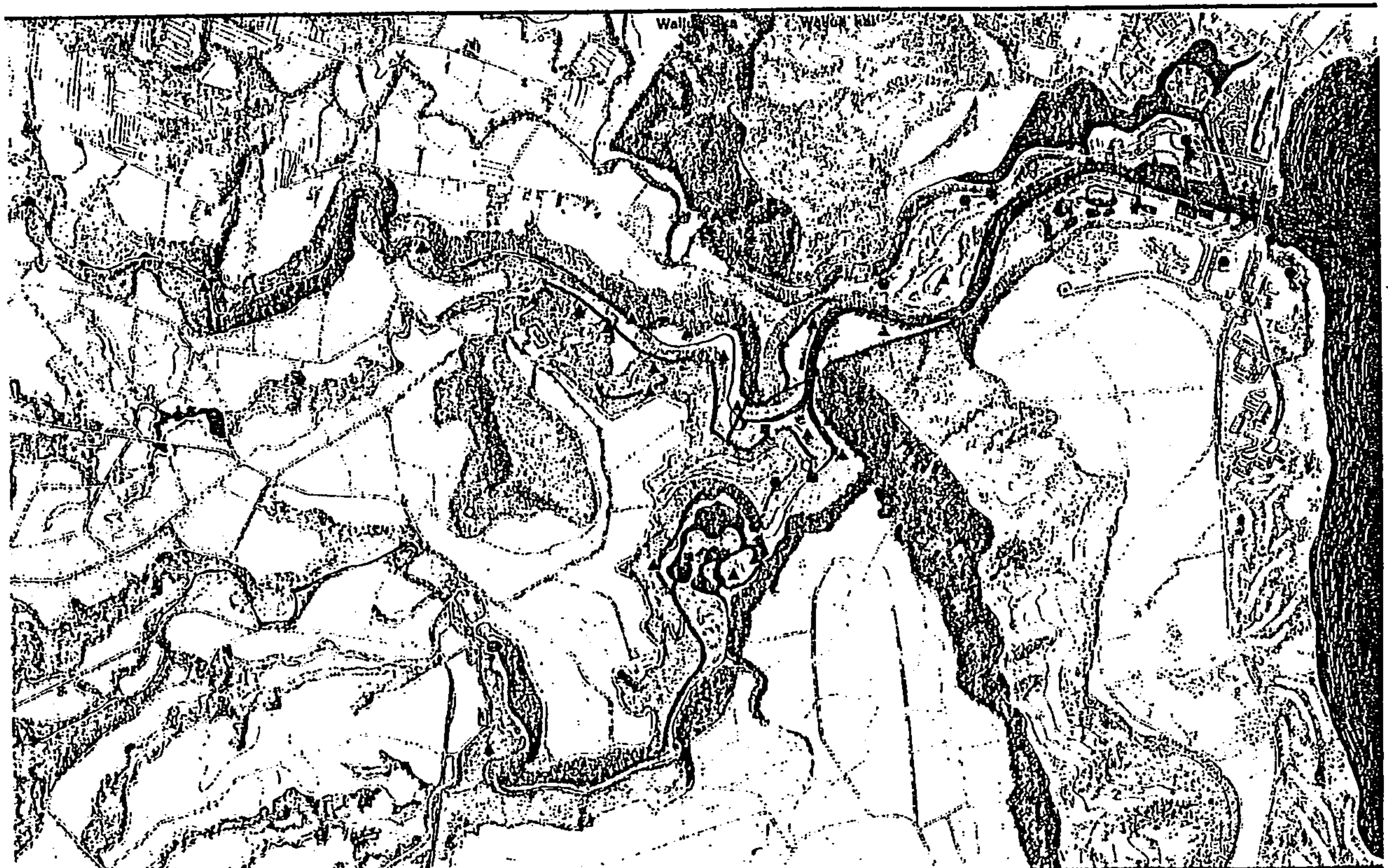
4. About 200 feet above Wailua Falls is an abandoned railroad bridge spanning the shallow ridge gorge (Plate H-1). Just upstream from the bridge is an abandoned cable car crossing the gorge. The railroad was an internal 30-inch guage standard system owned and operated by Lihue Plantation Company to haul cane initially to its mill at Hanamaula and thence by railroad to Ahukini Landing on Hanamaula Bay (U.S. Geological Survey, Topographic Map of the Island of Kauai, Scale 1:62,500, Surveyed 1910). Monsarrat's earlier 1900 map indicates that the railroad, the construction of which began in 1895, has not yet been extended to the South Fork Wailua River. Thus the bridge probably was constructed between 1900 and 1910. The track has been removed from the bridge and all that remains are two concrete bridge abutments and the truss. The truss forms have not yet been analyzed.

5. No archaeological surveys have been conducted along the two proposed rights-of-way for electric powerlines connecting the powerplants with the Lydgate Park substation. The exact route of the powerlines have not been determined so that conducting premature archaeological surveys would not be cost effective. An archaeological reconnaissance survey will be performed following project authorization.

EFFECTS EVALUATION

6. The project, as now conceptually designed, would not affect the railroad bridge but consideration may be given in future planning to constructing a walkway through the existing truss to span the river gorge. The pool backed up behind the 23.0 foot high diversion dam should not cover the area which Ching previously identified as the legendary location of Kawelowai Cave and because the cave has not acutally been physically located, no adverse effect is anticipated by the creation of the pool. Based on the recent archaeologic surveys (conducted by ARCH near the old rice mill and State Park proposed lagoon feature and Ching's earlier 1968 survey) construction of a penstock and powerplant would appear not to affect any remaining Hawaiian agricultural features. Construction of the powerline running east to the Lydgate Substation will be performed after an archeological survey has been conducted. Minor changes in the alignment will be made if necessary to avoid impacts to unknown historic properties. Construction will not affect any sites in the vicinity of the Stable Storm Ditch in the upper Wailua River watershed.

The existing historic values are further discussed in Section C of this report and the probable impacts to potential historic sites are discussed in detail in Section E of this report.



- O Shrine
- ● Heiau
- O Burial Site
- ● Stone
- □ Cave
- ■ Mill Site
- ▲ Agriculture
- — 'auwai
- -- King's Highway

Wailua River State Park

Island of Kauai / State of Hawaii / Division of State Parks
Department of Land and Natural Resources
Eckbo Dean Austin & Williams / Muroda Tanaka & Itagaki

HISTORY·ARCHAEOLOGY

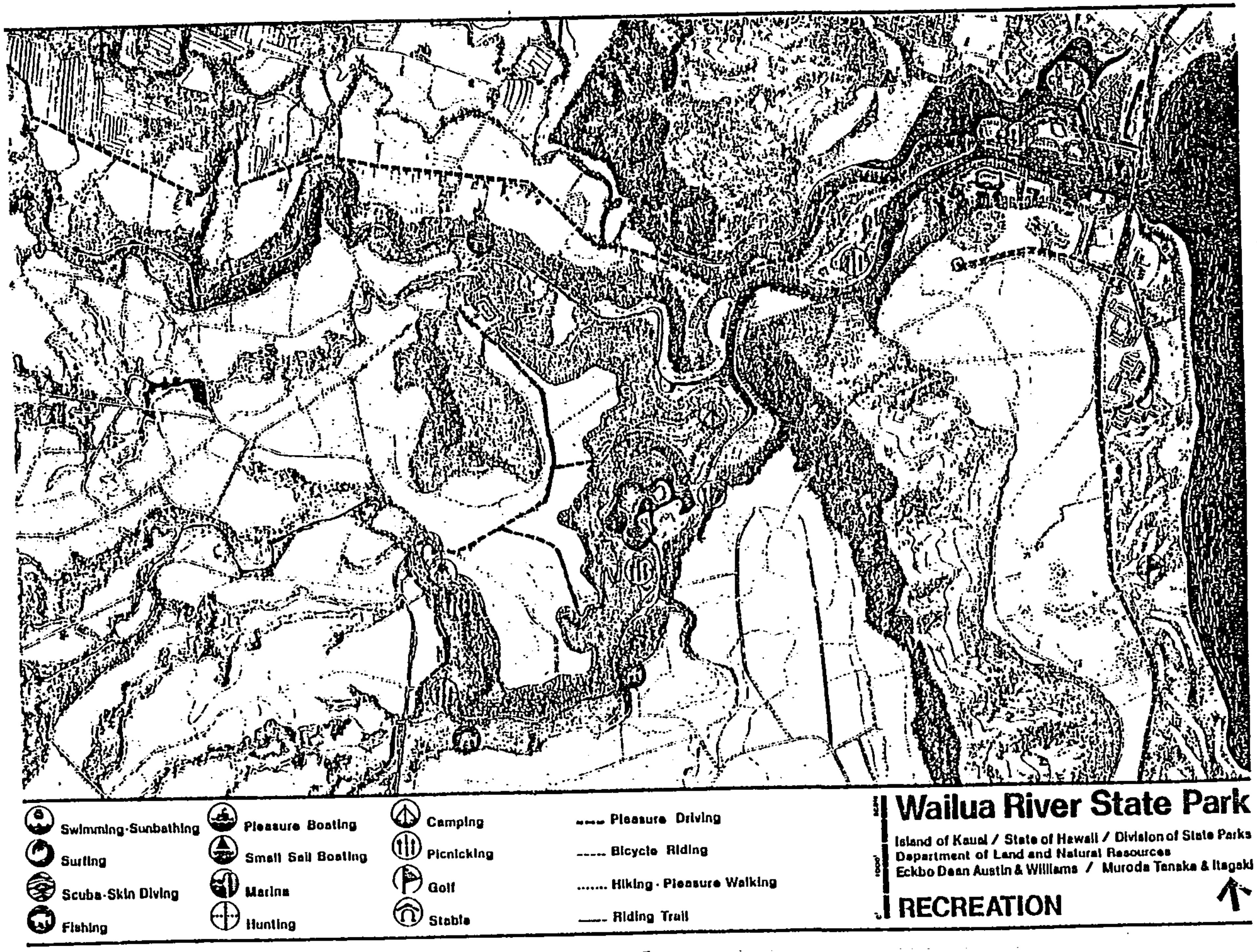
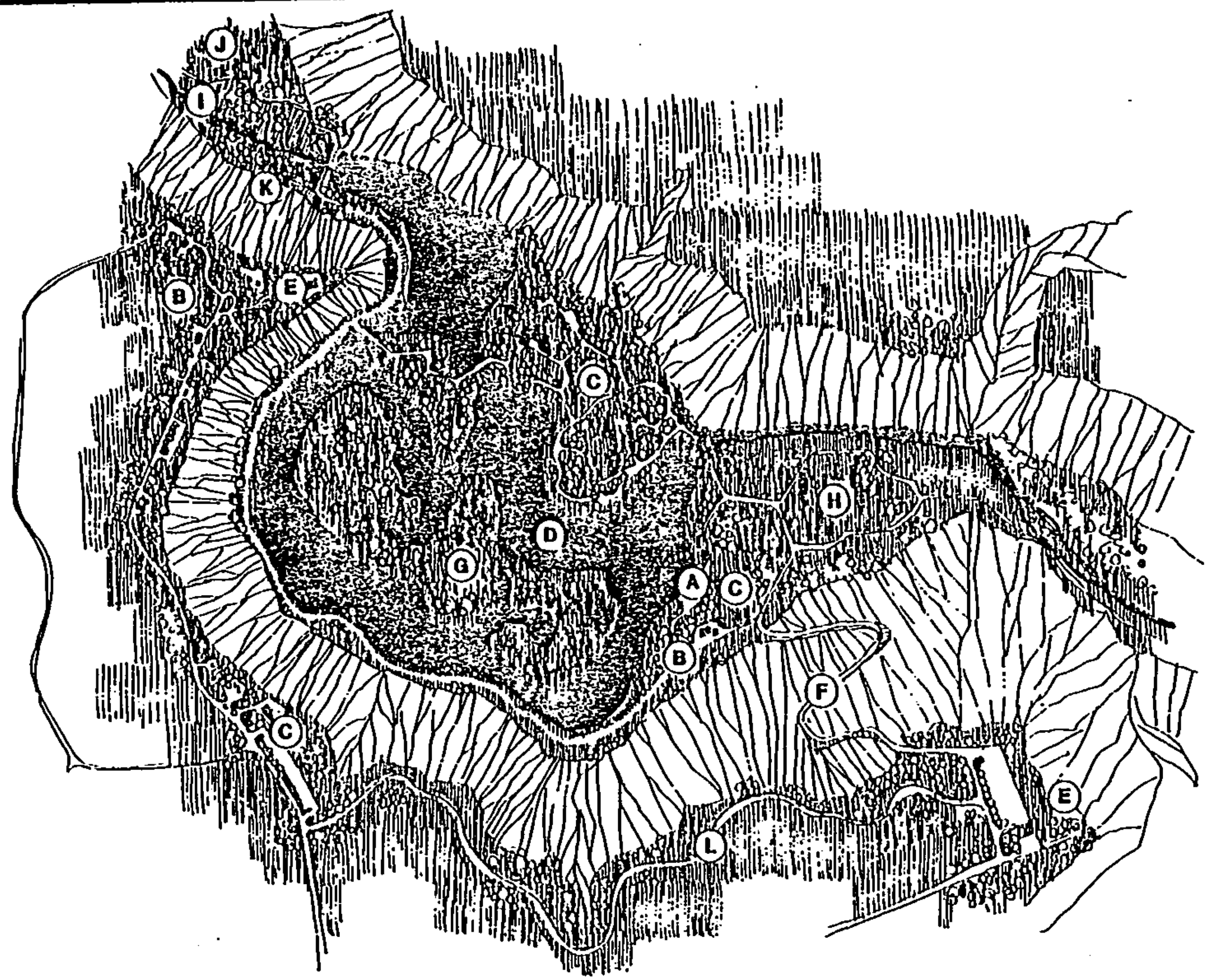

Swimming·Sunbathing
Surfing
Scuba·Skin Diving
Fishing
Pleasure Boating
Small Sail Boating
Marina
Hunting
Camping
Picnicking
Golf
Stable
Pleasure Driving
Bicycle Riding
Hiking · Pleasure Walking
Riding Trail
Wailua River State Park
Island of Kauai / State of Hawaii / Division of State Parks
Department of Land and Natural Resources
Eckbo Dean Austin & Williams / Muroda Tanaka & Itagaki
RECREATION

PLATE H-2



A	Swimming	G	Wildlife Refuge
B	Camping	H	Meadow Grass
C	Picnicking	I	South Fork
D	Fishing / Canoeing	J	Plant Demonstration
E	Overlook	K	Veranda House
F	Wiki-Wiki Access	L	River Rim Way

Wailua River State Park

Island of Kauai / State of Hawaii / Division of State Parks
Department of Land and Natural Resources
Eckbo Dean Austin & Williams / Muroda Tanaka & Itagaki

THE MEADOW

PLATE H-3

C. DESCRIPTION OF ENVIRONMENTAL SETTING

STUDY AREA

The study area is located on the island of Kauai, Hawaiian Islands. Except for the Midway Islands in the northwest part of the Hawaiian Islands, the archipelago is under the jurisdiction of the State of Hawaii. The capital and major urban center in the State is Honolulu, island of Oahu. The Hawaiian Islands are geographically important, based on military and economic relationships to the Pacific Basin and to the Far East. The location of the islands relative to important centers is shown in Figure 1.

The island of Kauai is the fourth largest island in the chain with an area of 553 square miles and the fourth largest island in population at 39,082 persons (Census, April 1980). The County seat is located at Lihue. The major population centers are located at Kapaa (4,467 persons), Lihue (4,000), Kekaha (3,260), and Hanamaulu (3,227). The location of the Wailua River basin on Kauai is shown in Figure 2.

SCOPE OF THE STUDY

This study provided an analysis of the electrical utility energy needs and the alternatives available to meet the needs for the island of Kauai. In accordance with the study request, the investigation of hydropower resources was confined to the Wailua River basin and principally was directed to small-scale hydropower development. This report provided a definition of the problem, description of alternative solutions, evaluations of the technical, economic, and environmental characteristics, and documentation of the costs and benefits associated with the solutions.

* The following pages C-1-C-33 is information from the U.S. Army Corps of Engineers from their "Final Interim Survey Report and Environmental Statement"

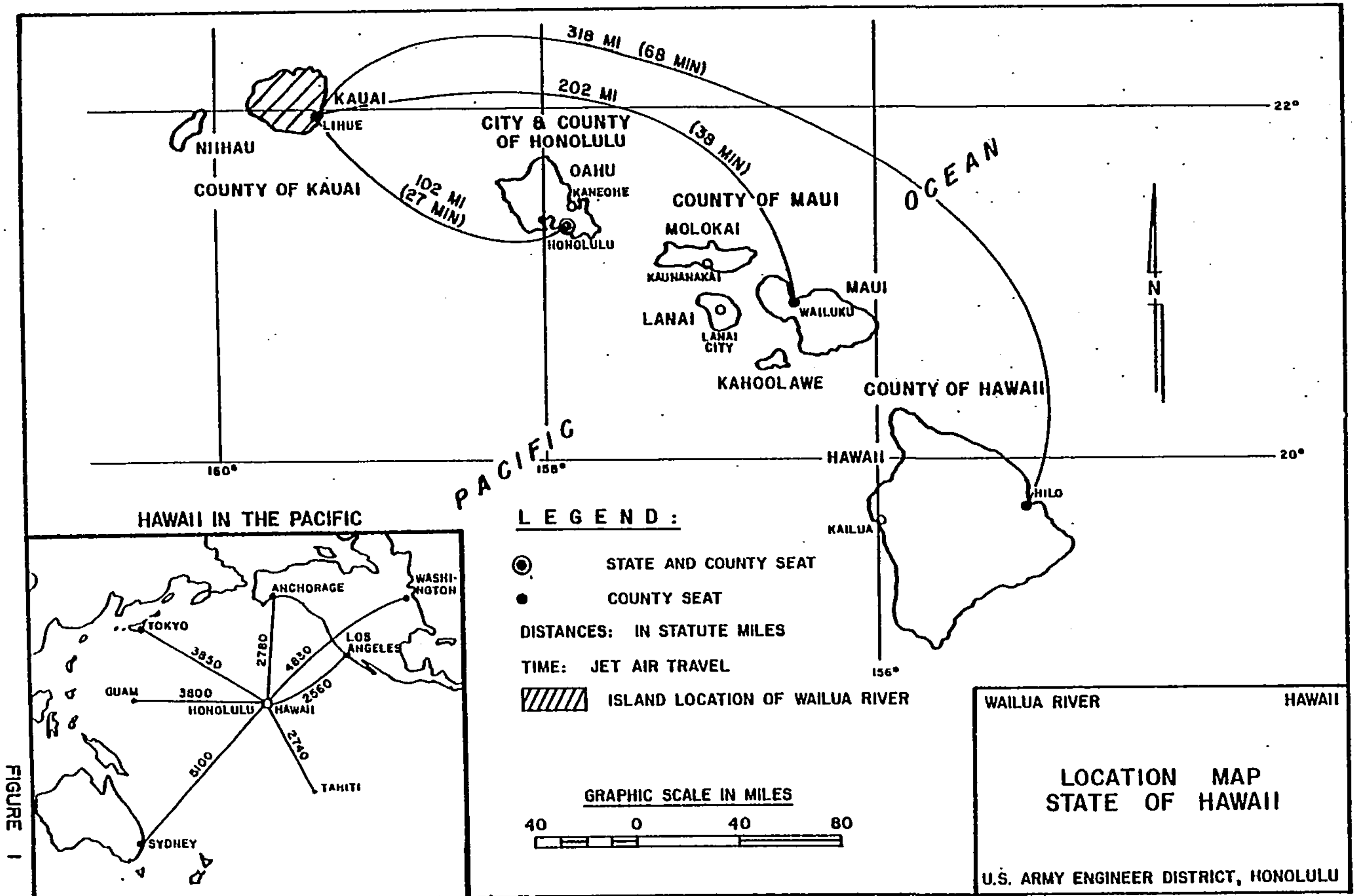


FIGURE I

FIGURE I

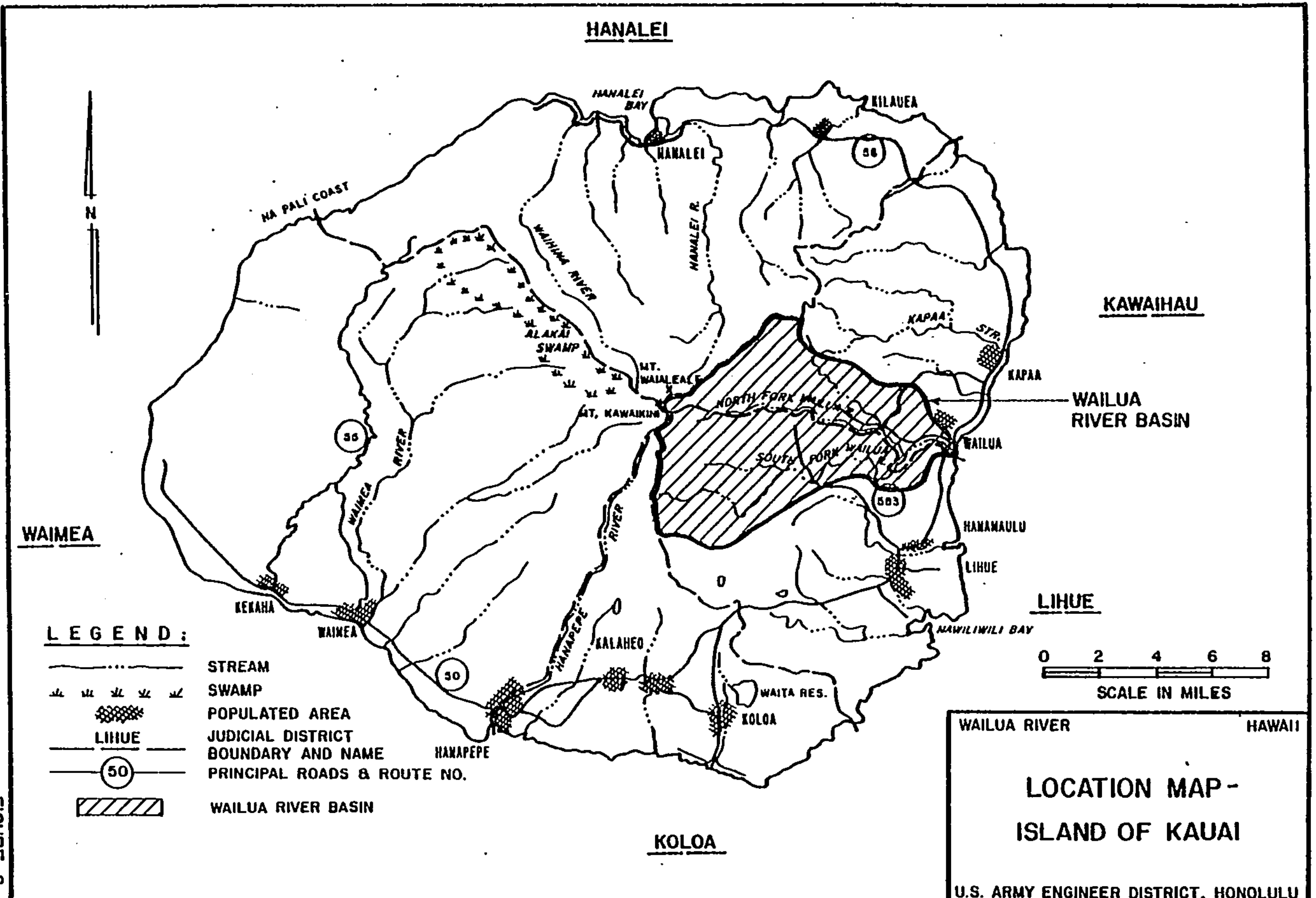


FIGURE 2

FIGURE 2

EXISTING CONDITIONS

PHYSICAL RESOURCES

Climate. Kauai is located just south of the Tropic of Cancer. It enjoys a relatively mild and uniform temperature condition because of its location in mid-ocean and the small seasonal variation in the amount of energy received from the sun. Mean annual temperature is 74°F at Lihue Airport, located about 4.5 miles south of Wailua. Also, extreme temperatures recorded at the airport of 50°F in January and 90°F in October are representative of the seaward areas of the Wailua basin. The features of the Wailua River basin are shown in Figure 3.

In contrast to the equable temperature conditions, the interaction between the moist tradewinds and the island's high mountains result in extreme variation of rainfall. Average annual rainfall in the Wailua basin varies between 50 inches near the coastline to over 450 inches at the summit. The Wailua basin has a distinct wet and dry season. The wet season is usually from October through April and the dry season from May through September.

Geology and Physiography. 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 Wailua River is located on the east flank of the volcano in what is known as the Lihue depression, a broad caldera formed by the collapse of the volcano's summit. Volcanism following the collapse covered the floor of the depression with gently sloping lava aprons and streams from the rainy uplands have since cut deep and relatively short gorges. Wailua Falls is one of the most renowned erosional features of Kauai. The falls are the result of headward erosion of thick basalt layers overlying mudflow deposits of the Wailua River.

Hydrography. The Wailua River basin is on th eastern side of the island of Kauai. The pear-shaped basin is about 52 square miles in area and extends 11 miles from the ocean to the 5,000 foot summit of Waialeale Mountain in the central part of the island. The topography is generally hilly and rugged in the upper sections with a rolling plain in the central portion terminating in a small flat area at the coast. The relatively high rainfall and moderate temperatures are conducive to heavy vegetation and grass, shrubs, ferns and trees pervade the entire drainage basin. Sugarcane occupies most of the central plains. Rainfall in the upper regions is channeled into three principal tributaries to Wailua River: North Fork Wailua River, South Fork Wailua River, and Opaekaa Stream. The North Fork and South Fork, with drainage area of 18.5 and 25 square miles, respectively, merge into Wailua River about 2 miles from the ocean. Opaekaa Stream drains an area of 6.4 square miles and discharges into the Wailua River at a point about 5/8 of a mile from the ocean. The Wailua River is a perennial river with range of flow (at Wailua Falls) varying from 2 cubic feet per sand (cfs) to 39,000 cfs. Similar to typical Hawaiian rivers, the flows are highly variable. The median discharge is 36 cfs.

SOCIO-ECONOMIC RESOURCES

Institutions. The State of Hawaii is governed by a bicameral legislature, a judiciary and an executive branch where power is vested in a governor. The principal executive department responsible for the management of the State's public lands, water and mineral resources, fish and game resources, forest reserves, and State parks, including historic sites is the Department of Land and Natural Resources (DLNR). The Division of Water and Land Development, within the DLNR, provides for the development of water resources, including hydroelectric power facilities. The DLNR is administered by the Board of Land and Natural Resources, headed by its chairman. As the authorized representative of the Governor, the chairman may execute agreements, within his powers, on behalf of the State.

The promotion of long-range socio-economic development, including general planning, technical analyses, redevelopment, and employment is a function of the Department of Planning and Economic Development (DPED). The Energy Division within the DPED compiles detailed information on energy and fuel consumption, sales, generation, and shipment. In addition, DPED is charged with management of State energy research and development funds and coordination of inter-agency energy developments, including hydroelectric power.

Electric generating companies servicing the public in the State of Hawaii are governed by the rules set forth by the Public Utilities Commission (PUC) of the State of Hawaii under the Department of Budget and Finance. This commission was created and is chartered under Chapter 269, the revised laws of Hawaii 1955, as amended. The Commission examines the propriety of rates, capital expenditures, and regulates standards of electrical service. Companies generating power primarily for their own use, such as sugar companies, are not directly controlled by the PUC.

Local government in the Wailua River basin is vested in the County of Kauai. The County of Kauai includes the islands of Kauai and Niihau, adjacent waters and islets within three nautical miles of their shores. The executive power of the County is exercised by the Mayor. The principal local agencies involved with hydroelectric development are the departments of Public Works, Planning and the Office of Economic Development.

The only electric utility on the island of Kauai is the Kauai Electric Division of Citizens Utilities Company whose corporate headquarters are located in Stamford, Connecticut. Approximately 60 percent (as of 1981) of the system energy is developed at the Port Allen main thermal plants, the balance being purchased energy from industrial sugar companies.

Unlike the mainland United States there does not exist any National Electric Reliability Council Region (NERC) similar to the Western Systems Coordinating Council (WSCC) for the area west of the Rocky Mountains. There are no Federal projects supplying public power in Hawaii; hence there are no Department of Energy Power Marketing Administrations (PMA's) in the area.

Population. Island population levels on Kauai remained relatively stable during the 1950-1970 period. In the 1970's, however, population growth was somewhat faster than had been anticipated. Hawaii Department of Planning and Economic Development (DPED) projections had predicted growth during the 70's to 36,500 by 1980. Census figures reveal that this estimate has been exceeded, as 1980 population was 39,082, about 7% higher than the forecast.

This translates into an equivalent annual growth rate from 1970-1980 of about 2.6%, compared to a growth rate for the entire State of Hawaii of about 2.3% annually for the same period. Future growth will most likely fall into the range of 1.4% to 2.2% annually through the year 2000, leveling off to less than one percent annual growth in the period 2000-2030. These projections are derived from OPED forecasts as well as the 1980 projections by the Bureau of Economic Analysis, US Department of Commerce for non-SMSA portions of Hawaii. Population in the Lihue, Kawaihau Districts of Kauai, which surround the immediate study area, also rose faster in the 1970's then had been expected by OPED. By 1980, these districts had grown to a combined population of just over 19,000 about 14% higher than projected.

Economic Development. Hawaii is a prosperous State with a growing population and economy. Between 1950 and 1980, the total resident population increased by over 92 percent from 500,000 to 964,624. The gross state product increased over tenfold between 1950 and 1979, from $900 million to $10.3 billion. The three largest contributors to the State economy are tourism, defense expenditures and agriculture. The bulk of agricultural activity is in the production of sugar and pineapple. The most rapid growth in the past decade has been in the tourist industry. Tourist arrivals increased from 243,000 annually in 1959 to 3,934,000 in 1980. Visitor expenditures have grown by an average of over 17 percent annually since 1959, when they amounted to $109 million. Estimated 1979 visitor expenditures were over $2.6 billion. While visitor expenditures increased by a factor of 20 over this period, defense expenditures tripled. The trend in tourist industry growth will probably continue, although at a slower pace, together with the State economy in general.

Until recently, sugar was the mainstay of Kauai's economy. At it's peak, eight sugar plantations on Kauai produced over one-fifth of the State's total sugarcane yield. Pineapple was at one time a major sector of the Kauai economy, but has not been cultivated since the closing of the county's last cannery in the early 1970's. The largely agrarian base of the island's economy has changed with the surge in tourism in the past decade. Sugar is still a major economic base, but tourism is now the island's leading industry. Lihue is the center of economic activity in the county, with the two major transportation facilities, Lihue Airport and Nawiliwili Harbor, located nearby. Plans for airport expansion exist in anticipation of continued growth in interisland traffic. There are also petroleum storage facilities situated in the Lihue area.

Major employers in the island's economy are the visitor industry and agriculture. Other important employers are Federal, State, and County governments, as well as commercial and business services. Table 1 shows some selected statistics for recent years for the County of Kauai.

Table 1. SELECTED STATISTICS, COUNTY OF KAUAI1/

	1976	1977	1978	1979	1980	1981
Population, Resident	34,000	36,200	37,000	38,100	39,082	NA
Per Capita Personal Income ($)	5,762	6,633	7,147	7,673	8,472	NA
Civilian Labor Force	17,150	18,550	18,350	18,500	20,000	20,700 p
Employment	15,550	17,350	17,100	17,450	19,050	19,100 p
Unemployment	1,600	1,200	1,250	1,050	950	1,650 p
Unemployment Rate (%)	9.4	6.5	6.8	5.6	4.6	7.9 p
Estimated Westbound Visitors (1000's)	699.3	740.5	837.7	825.4	781.4	513.8 p
Intended Length of Stay--Westbound (Days)	2.85	2.97	3.08	3.29	3.40	3.53
Hotel Inventory (Rooms)	3,724	3,868	4,097	4,064	4,435	5,207
Hotel Occupancy (%)	76.8	80.6	83.3	76.5	69.0	60.7
Sugar Production, raw sugar 96° (thousand tons)	217	232	223	232	223	134
Diversified Agriculture (million $)	5.3	6.5	7.4	9.5	10.4	NA
Crops	2.3	2.9	3.1	5.1	4.7	NA
Livestock	3.0	3.6	4.3	4.4	5.7	NA

NA = Not available p = preliminary

1/ From Economic Indicators, First Hawaiian Bank, November 1981 and October 1982.

Kauai's visitor industry has suffered the effects of three consecutive visitor years of progressively worsening visitor totals. This major sector of the economy has in turn contributed to a measurable decline in business activity in 1980. Although the unemployment rate is at its lowest level in several years, the island's economy is presently suffering somewhat of a decline. While the sugar industry might ordinarily have countered such a trend with increased production, a substantial drop in 1981 sugar prices made receipts significantly lower than in 1980. The sugar industry in the State suffered a devastating $83.5 million loss in 1981. Losses on the island of Kauai totalled approximately $22 million.

However, prospects for long term prosperity and stability are encouraging. Major developers at one of Kauai's resort destinations, Poipu Beach, are well along in additional developments, and the county administration has made revival of tourism a top priority, having begun a program of heavy promotion in cooperation with the private sector and the Hawaii Visitors Bureau. Master plans are being developed for fishing and agriculture, and the Administration is pushing for high technology enterprise to strengthen the economy's base. Despite efforts to diversity and thereby further stabilize the economic growth prospects of the island, particularly in view of an uncertain sugar industry future, agriculture continues to be a dominant sector of the economy. Guava and papaya are significant areas of promising cultivation.

On 23 November 1982, Hurricane Iwa struck the Hawaiian Islands causing an estimated $92 million public and private property damage on Kauai. Shortly thereafter on 27 November 1982, the President declared the State of Hawaii a Federal disaster area, enabling the Federal Emergency Management Agency (FEMA) to provide assistance. Damages blacked out the electrical system over the island and services were not restored at most community for two weeks. Although there were no fatalities on Kauai, recovery and reconstruction operations will be extensive and are expected to take many months.

Kauai has taken a step toward energy self-sufficiency by increasing its capacity to generate electric power from nonfossil fuel sources. In November 1980, Lihue Plantation Company's new bagasse-fired powerplant entered the electric power generating service on Kauai. Turning sugarcane fiber into electricity, the plant produced 32 percent of Kauai's 1981 electrical energy need. Prior to this new service, only about 26 percent of the island's electricity came from nonfossil fuel sources, but the new plant has increased this level to about 44 percent for the total plantation and utility system. Kauai Electric has also been looking into the area of wind energy development. The county is considering other biomass fuel development programs involving municipal refuse, and cane trash. Kauai has also adopted an energy self-sufficiency plan, stressing conservation and efficient government energy use.

Land Use. Land use on Kauai is characterized generally by forest land covering the fairly rugged interior, with small concentrations of urban development scattered along the coastline, and agricultural development (predominantly sugarcane) in a belt adjacent to the ocean. There is neither urban use nor agricultural use on the rugged northwest coastline. The major land use, constituting over half of the island's area is forest, forest reserve, and recreation. Agricultural use accounts for another approximately 1/3 of the island. The remainder, less than 10%, is in urban and urban-related uses. This pattern of land use is generally the same for the State of Hawaii as a whole with the exception that Oahu, the major population center is more urbanized than the "neighbor islands" of Hawaii, Molokai, Lanai, Maui, Niihau, and Kauai. As with the rest of the neighbor islands, Kauai's land use tendencies give the island a rural, agrarian flavor. The Wailua River basin is approximately equally divided between conservation and agricultural land use districts. Small portions in the lower reaches adjacent to the river are designated as rural and urban districts.

Land Ownership. The lands in the upper watershed of the Wailua River basin are divided between the State of Hawaii and Lihue Plantation Company, Ltd., an industrial company involved in irrigation, production, and processing of sugarcane. The parent company of Lihue Plantation is Amfac, Inc., a diversified commercial, development, and agribusiness enterprise. A limited area including lands in the lower watershed and at the mouth are under private ownership. Approximately, four miles of the lower North Fork Wailua River on high ground form part of the Wailua Homestead Lots. As described under "Water Rights," the use of water has been historically tied to land rights.

WATER RIGHTS

The water rights in the State of Hawaii are based on a series of judicial decisions since 1920. These judicial decisions reflect a particular brand of riparian doctrine orginating from nature Hawaiian "kuleana" land and water rights. In the 1974 McBryde v. Robinson case, the Hawaii State Supreme Court ruled that the State, as owner of all surplus water and land owners of appurtenant lands, cannot divert waters outside the drainage area. In effect, it mandates that the natural flow of the stream may be legally enforced as a minimum level of stream flow. The case is still under consideration by the courts. However, historically for irrigation and on Kauai, stream waters were considered owned by the land owners subject to prescriptive rights and use of water. In the specific case of the Wailua River and its associated irrigation diversion system, land ownership is divided between the Lihue Plantation and the State of Hawaii. The lower 6 miles of the South Fork Wailua River are under direct ownership or under lease from the State of Hawaii. Lands of the Hanalei River and the North Fork Wailua River from which diverted flows influence the South Fork River are also under control of the State. Remaining upstream areas of the South Fork River are under ownership of Lihue Plantation.

Lihue Plantation, as administrative successor to East Kauak Irrigation Company, maintains a water lease agreement with the State of Hawaii for waters affecting the North Wailua, Kapaa, Anahola and Hanalei Rivers. Based on the financial limits of the lease, Lihue Plantation would have to divert an average discharge of 190 cfs for the four drainage areas. The lease expires May, 1994.

If the McBryde decision is to be rendered binding, the State, both as land owners and local sponsor for this particular hydropower project, may be required to uphold conflicting positions. The diversions would be subject to cessation or control to uphold natural stream flows and in the same instance, the continuity of existing and future diversions would be necessary for sugar and hydropower development. The resolution and implementation of necessary water rights are local responsibilities.

Since the proposed project is non-consumptive in nature, a water right should not be necessary for the generation of electricty. However, the developer will request a final ruling from the State of Hawaii in this matter prior to construction and will acquire any permits necessary for construction of the Project.

WATER USE

A fee for water use is expected to be assessed to the developer by the State of Hawaii and possibly by Amfac for the use of waters which arise on their respective properties. A mutual agreement will be reached by all parties in determining the methods for dividing these fees. It is expected that these fees will be assessed annually, based upon a percentage of gross revenues from the project.

ENVIRONMENTAL RESOURCES

Water Quality. The State of Hawaii does not regularly monitor water quality within the Wailua River; therefore, there are no long-term water quality records available which describe the physical and chemical environment. Limited seasonal data does exist. The data indicate nitrates and turbidity are higher in waters associated with irrigation discharges.

The major influence on both the quality and quantity of water within the Wailua River has been and continues to be commercial sugarcane production. A complicated network of diversion dams, intakes and ditches divert a significant proportion of flow from both the North and South Forks of the Wailua River. Analysis of residual streamflow below the lowest diversion ditch on the South Fork reveals that flows approached zero during the months of April through October 1953 (driest year over the past 30 years). Average residual flow in the South Fork normally exceeds 16 cfs. This substantial reduction of flow in concert with the introduction of exotic species has altered the structure of the river's biological community. In many areas where flows are sluggish or intermittant, small pools of stagnant water form. These pools are not buffered from solar irradiation and may become heated above 30°C. Pools often become eutrophic. Reduced flow also allows excessive siltation of the streambed. Freshet discharge is normally turbid with suspended terrigenous sediments which have runoff from surrounding agricultural lands.

Aquatic Fauna. The aquatic fauna above Wailua Falls is dominated by introduced species which come from both Asia and continental North America, including the smallmouth bass (Micropertus dolomieui), Chinese catfish (Clarius fuscus), and the wild guppy (Poecilia reticulata). Along with the bass and catfish, the less abundant bluegill sunfish (Lepomis macrochirus) provides a sport and subsistence fishery on Kauai. The middle and upper reaches of the river are devoid of native Hawaiian fishes or mullusks; however, diadromous mountain shrimp (Atya bisulcata) has been found above the lip of Wailua Falls. The introduced Tahitian prawn Macrobrachium lar occurs uncommonly above the falls. A significant number of native, diadromous species occur in the stream below Wailua Falls.
geological configuration of the face of Wailua !

Avifauna and Mammals. Three species of endemic waterfowl, the Hawaiian coot, gallinule and duck are found in the Wailua River basin. The coot and gallinule have been observed in the upper reaches of the South Fork above the proposed project site but occur most commonly below the convergence of the North and South Fork and in adjacent taro fields. All three birds are listed endangered species. Other water birds associated with the river system include the black-crowned night heron and cattle egret. Non-waterbird avifauna include the shama, melodious laughing-thrush and northern cardinal within the hau thicket bordering the streams. Western meadowlark, ring-necked pheasant and spotted dove are associated with the canefields and open pasturelands within the river basin.

Mammals within the Wailua River basin include dogs, cats, feral pigs, cattle, horses, rats and mongoose. No wetlands, wildlife sanctuaries or refuges occur within the proposed project area.

Flora. The entire watershed of the South Fork Wailua River is dominated by sugarcan cultivation. Only the headwaters lie in steep, heavily forested areas. The dominant riparian vegetation along the South Fork Wailua are exotic species (hau, California grass, Java plum). Indigenous plants such as tis, gingers and a variety of ferns and mosses are also common along the stream.

Cultural and Historical Resources. There are no historic properties in the area of potential environmental impact currently listed or eligible for listing on the National Register of Historic Places. Outside this area at the mouth of the Wailua River is the Wailua Complex of Heiaus which contains four heiaus, a city of refuge, royal birthstones and a sacrificial rock. The Wailua Complex of Heiaus is listed on the National Register and is also considered to be of paramount national significance, being a National Historic Landmark. Long the home of the ruling chiefs (alii nui) of Kauia, the ahupuaa of Wailua has been a major center of cultural development and political activity on the island from the earliest times. Upland of the river mouth area, the entire area of potential impact lies within the traditional ahupuaa of Wailua. Handy and Handy, writing in 1940, describe the ahupuaa as having (presumably prehistoric) agricultural terraces in both the North and South Forks of the Wailua River, particularly immediately above Wailua Falls, as well as in the flatlands and lower courses of small tributaries to the North and South Forks. Studies conducted for the Wailua River State Park Plan identified prehistoric or early historic agircultural terraces on the slopes along the South Fork beginning about 3,000 feet below the Wailua Falls and continuing intermittently all the way to the sea. A small heiau or platform was also reported above the northern bank about 3,500 feet below the Falls. The legend of Kapunohu and Kemamo tell of the cave named Kawelowai beneath the river aboe Waiehu (now called Wailua Falls), which is believed to be located near the Lihue Plantation Company ford. An archeological survey conducted for this study found no sites along the Stable Storm Ditch. Neither that survey nor the State Park survey found any remains of significant agricultural terraces or irrigation systems at the proposed powerplant sites. An abandoned plantation railroad bridge lies about 400 feet above the Falls.

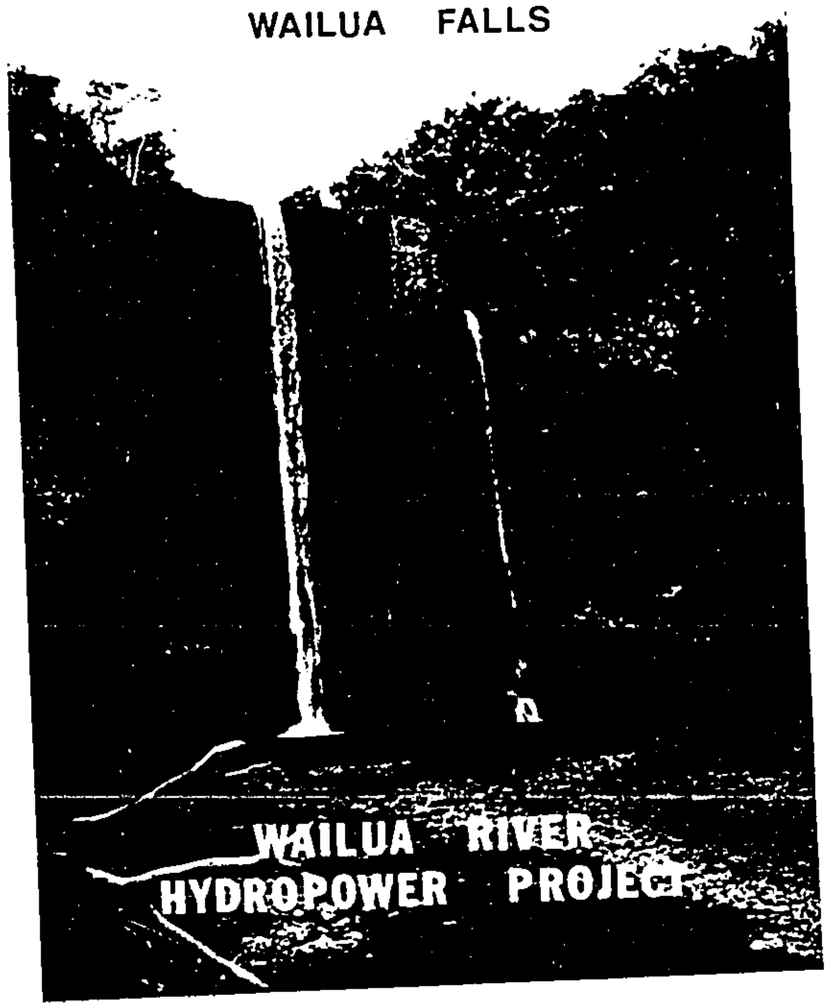
Recreational and Aesthetic Resources. Lihue Plantation Company oversees an unmanaged smallmouth bass fishery along 21 miles of the South Fork of the Wailua River which is used primarily by plantation workers. The Company also offers restricted access to public hunting areas and game bird reserves. The terminal estuary near the coast is a popular, recreational area which accommodates water skiing, boat rides, fishing and crabbing and tours of a botanical garden.

The three principal waterfalls in the study area, Wailua Falls on the South Fork, Kaholalele Falls and Opaekaa Falls on the North Fork of the Wailua River, lie within the sinuous Wailua River State Park. In 1979, an estimated 2,5 million visitors toured the park. Opekaa Falls is the most readily accessible to tourists, being only 2 miles inland of State Highway

Route 56. Wailua Falls and Kaholalele Falls are less accessible each at approximately 4 miles from Route 56. Wailua Falls provides the sole destination of State Route 583, which ends at a turn-around overlooking the Falls about 4 miles from the main highway. Informal trails lead down to the top of the Falls. Wailua Falls was observed in June, 1983 when the instaneous flow was 3 cfs, as shown in Figure 4. The Falls were later observed on April 12, 1985, when the instanteous flow was 8.7 cfs, as shown in Figure 5. A typical scene from the lookout was observed on January 2, 1982 when the instanteous flow was 440, as shown in Figure 6.

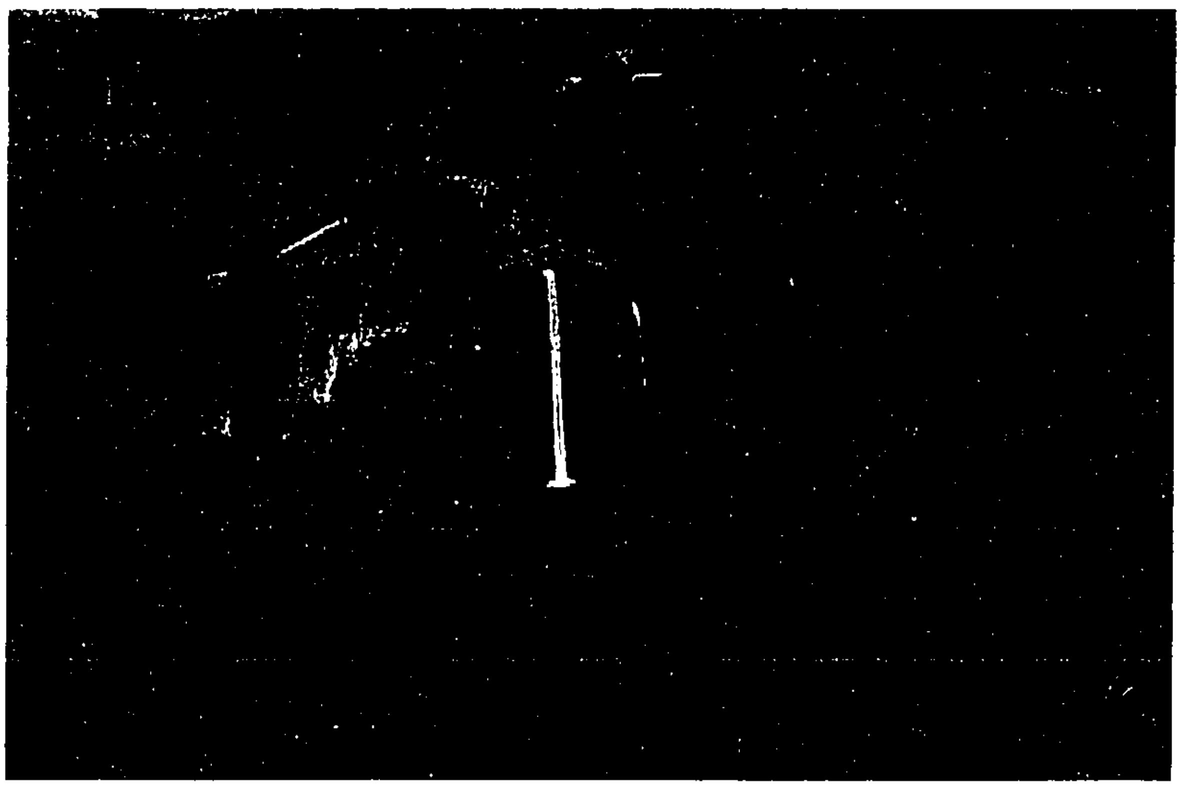
FIGURE 4

PROJECT SITE
WAILUA FALLS



WAILUA FALLS
FLOW - 3CFS
(TAKEN JUNE 1983)
CORPS OF ENGINEERS

FIGURE 5

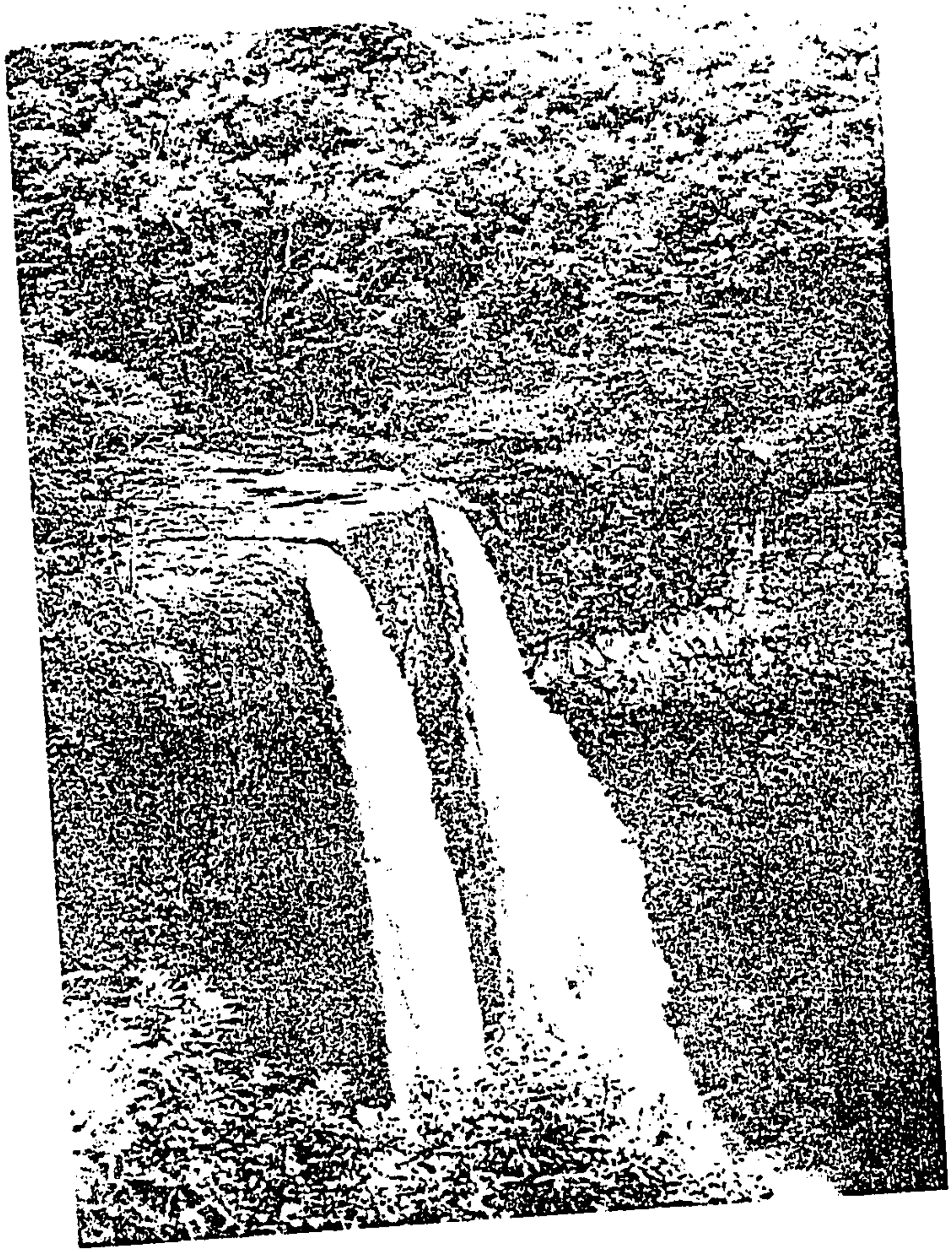


WAILUA FALLS

FLOW - 8.7CFS

(TAKEN APRIL 12, 1985)

BINGHAM ENGINEERING



WAILUA FALLS

6 Jan 82 Discharge = 440 cfs

FIGURE 6

KAUAI ELECTRICAL UTILITY SYSTEM

System Features. Prior to 1964 the island of Kauai's electrical facilities were under ownership by the sugar plantations. From 1964 to 1969, independent electrical generation facilities were owned and operated by Amfac, Inc. Since 1969 the major electrical features have been owned and operated by the Kauai Electric Division (KED) of Citizens Utilities Company. However, smaller purchased power facilities and associated transmission lines remain under sugar plantation jurisdiction. All the principal KED generation units are petroleum-based fueled plants. Internal combustion diesel units and gas turbine units utilize Number 2 diesel fuel and the steam unit utilizes Number 6 Bunker C fuel oil. There are no nuclear, coal nor hydropower plants operated by KED. A general map of the system is shown on Figure 7.

The transmission lines parallel the road transportation system except for the cross-island connection between Wainiha and Port Allen. The principal transmission lines are rated at 57.1 kv; secondary lines are at 12.47 kv, 11.5 kv and 6.9 kv. The major 57.1 kv lines, totalling approximately 113 miles in length, are under lease or ownership by Kauai Electric.

The island's electrical generation and consumption are restricted to Kauai; electrical inter-ties between the islands do not exist.

Installed Capacity and Energy Production. All energy generation for the utility system's plant is located at Port Allen. The KED system includes a mix of diesel, oil-fired steam, and gas turbine units. The bulk of the capacity (64%) is provided by the gas turbine units. A summary of the plant inventory is shown in Table 2. The gas turbines are also operated in combined cycle with flue gases firing the waste heat boiler of the steam unit.

The mix of electrical utility generation by fuel type for Kauai differs radically from the typical mix in the United States, as a whole. Nationwide oil accounts for roughly 9 percent of utility generation whereas in Kauai it accounts for 60 percent of electrical utility energy. Bagasse totals a significant 33 percent of energy in Kauai whereas solid waste and other sources total an insignificant 0.3 percent in the U.S. A graphical display of the relative proportions of fuel types is shown in Figure 8.

Table 2. KAUAI ELECTRIC DIVISION PLANT INVENTORY 1/

Location, Unit Type & Year Installed		Installed Capacity, Mw	Generation (Net) 2/ million kwh	Demand 4/ On Plant Mw
PORT ALLEN				
Diesel				
#1	1964	2.0		
#2	1964	2.0		
#3	1968	2.75		
#4	1968	2.75		
#5	1968	2.75		
		12.25	17.0	7.7
Steam				
	1969	10.0	53.2	7.5
Gas Turbine				
#1	1972 (Hitachi) 3/	17.65	18.6	--
#2	1977 (John Brown) 3/	22.18	35.8	19.5
TOTAL		62.08	124.6	34.7

1/ Year ending 31 December 1981. Excludes Lihue Plantation 12.0 Mw purchased capacity. Data provided by KED, 1982.
2/ Inclusive of energy consumed by in-plant use
3/ Operated also in combined cycle mode.
4/ At time of peak.

In addition to the Kauai Electric Division owned and operated powerplant and system features, KED maintains separate agreements with the four island sugar plantations for purchased capacity and energy. The four sugar plantations (Lihue, McBryde, Kekaha, and Olokele) use a combination of hydroelectric, diesel, and bagasse-steam plants to produce electrical energy for their respective plant operations. As of 1981, approximately 46 percent of the industrial energy output or 94 million kwh was transferred to KED. This total also constituted approximately 43 percent of the energy output of KED. The distribution of sugar plantation energy generation by fuel type is shown on Table 3.

Since 1969 the proportion of purchased energy has decreased from approximately 50 percent to 15 percent in 1980. From 1969 to 1976 KED maintained agreements for purchasable capacity; 1977 to 1980 required no purchasable capacity (except for emergencies). In March of 1981 a 20 MW bagasse-fired powerplant became fully operational at Lihue Plantation. In accordance to an agreement with KED, Lihue would furnish 12.0 MW firm capacity and a minimum of 55.6 million kwh per year. The plant became fully integrated into the KED system and operations are directly controlled from KED's Port Allen headquarters. The proportion of purchased energy rose to 43 percent in 1981. The relative impact of the purchased and KED plants is shown on Table 4.

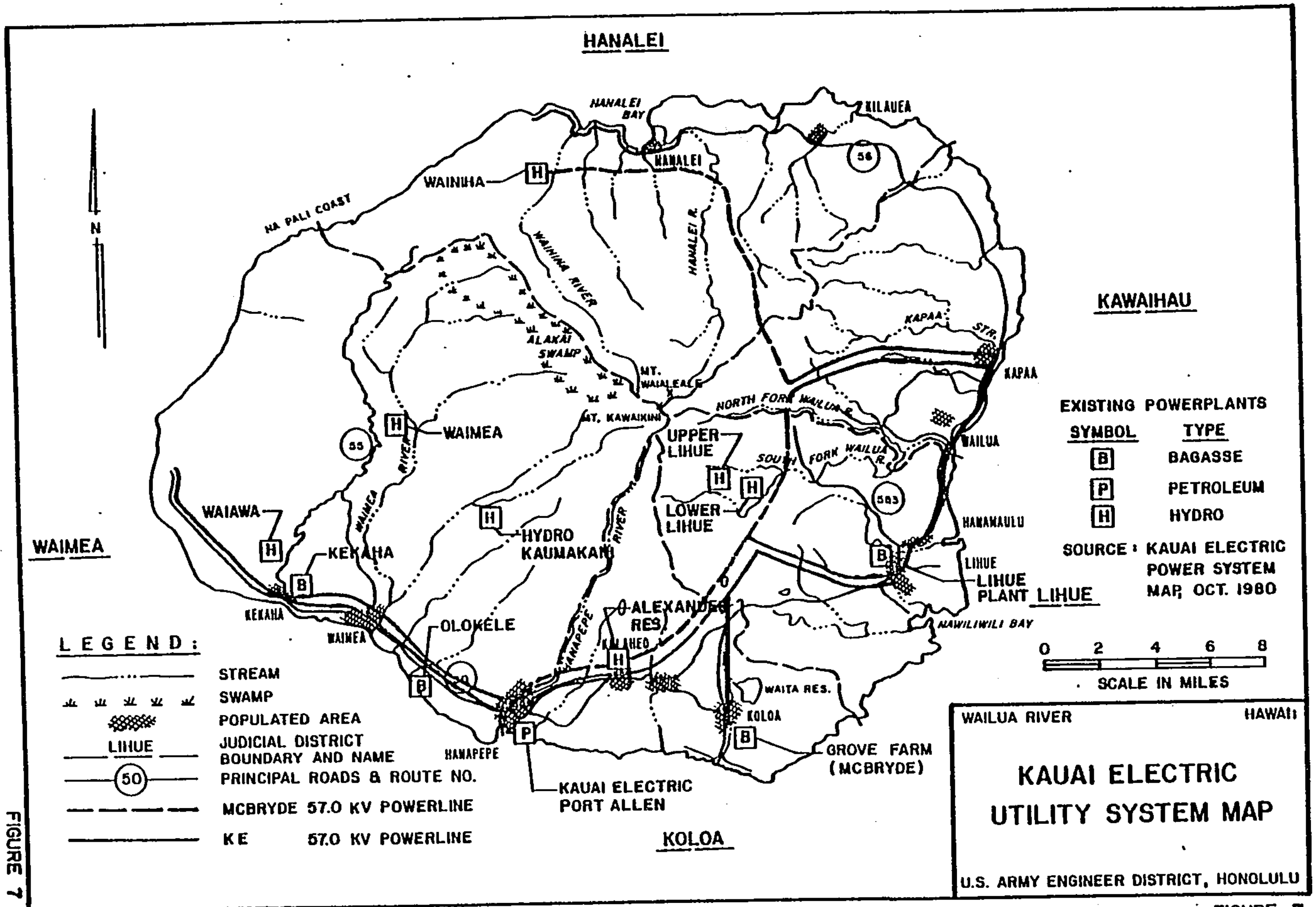

HANALEI
KAWAIHAU
WAIMEA
KOLOA
LIHUE
HANALEI BAY
HANALEI
KILAUEA
56
WAINIHA
NA PALI COAST
WAINIHA RIVER
HANALEI R.
KAPAA
STR.
KAPAA
ALAKAI SWAMP
MT. WAIALEALE
MT. KAWAIKINI
NORTH FORK WAILUA R.
SOUTH FORK WAILUA R.
WAILUA
UPPER LIHUE
LOWER LIHUE
583
HANAMAULU
LIHUE
LIHUE PLANT
NAWILIWILI BAY
WAIMEA
55
WAIMEA RIVER
WAIAWA
KEKAHA
HYDRO KAUMAKANI
OLOKELE
ALEXANDER RES.
KALAHEO
HANAPEPE
KEKAHA
WAIMEA
HANAPEPE
WAITA RES.
KOLOA
GROVE FARM (MCBRYDE)
KAUAI ELECTRIC PORT ALLEN
EXISTING POWERPLANTS
SYMBOL TYPE
B BAGASSE
P PETROLEUM
H HYDRO
SOURCE: KAUAI ELECTRIC POWER SYSTEM MAP, OCT. 1980
0 2 4 6 8
SCALE IN MILES
N
LEGEND:
STREAM
SWAMP
POPULATED AREA
LIHUE JUDICIAL DISTRICT BOUNDARY AND NAME
50 PRINCIPAL ROADS & ROUTE NO.
MCBRYDE 57.0 KV POWERLINE
KE 57.0 KV POWERLINE
WAILUA RIVER
HAWAII
KAUAI ELECTRIC UTILITY SYSTEM MAP
U.S. ARMY ENGINEER DISTRICT, HONOLULU

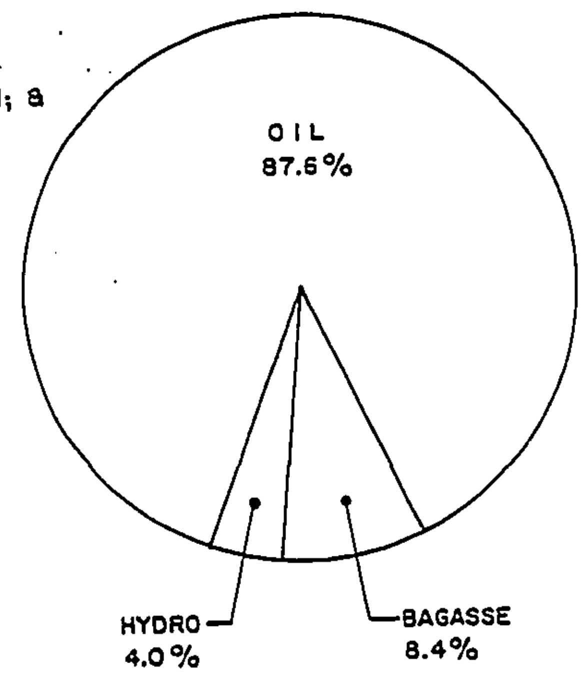
FIGURE 7

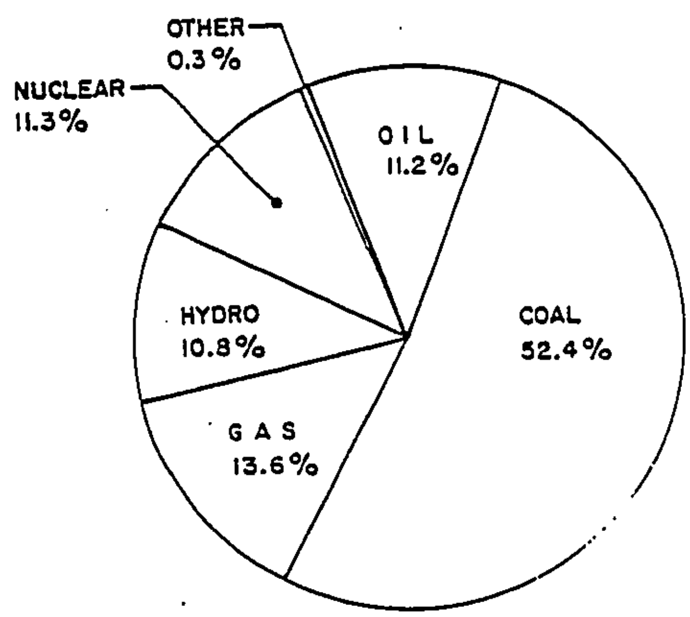
ISLAND OF KAUAI

ANNUAL TOTAL GENERATION = 184 MILLION KWH

SOURCES:

MURATA & KINOSHITA, 1981; & DOE, FPC FORM 12 FOR KAUAI ELECTRIC





UNITED STATES

ANNUAL TOTAL GENERATION = 2,270,000 MILLION KWH

SOURCE:

DOE, ELECTRIC POWER MONTHLY, NOV 1981.
(NOV 1980 PERCENT DISTRIBUTION)

WAILUA RIVER	HAWAII
UTILITY ELECTRIC GENERATION BY FUEL TYPE, 1980	
U.S. ARMY ENGINEER DISTRICT, HONOLULU	

FIGURE 8

Table 3. ELECTRICAL GENERATION ON KAUAI BY FUEL TYPE - 1981 1/

	Fuel Type			
	Petroleum	Bagasse	Hydro	Total
Total Plantation & Utility System				
Plantation Generation, million kwh	11.0 2/	146.1 3/	48.7	205.8
Percent by Fuel Type	5.4	71.0	23.6	100.0
Utility, Generation, million kwh	124.6	0	0	124.6
Percent by Fuel Type	100.0	--	--	100.0
Total Generation, million kwh	135.6	146.1	48.7	330.4
Percent by Fuel Type	41.0	44.2	14.8	100.0
Electrical Utility System				
Plantation Generation Sold to Utility, million kwh	6.9 4/	72.7 4/	14.4 4/	94.0
Percent of Total Generation	--	--	--	43.0
Utility Generation, million kwh	124.6	0	0	124.6
Percent of Total Generation	--	--	--	100.0
Total Generation, million kwh	131.5	72.7	14.4	218.6
Percent by Fuel Type	60.1	33.3	6.6	100.0

1/ Sources: Kinoshita, C.M. "Energy Inventory for Hawaiian Sugar Plantations 1981" Honolulu: 1981; State of Hawaii, Public Utilities Commission, "Annual Report of Kauai Electric Division...1981."

2/ Diesel units plus percent of total boiler generation based on utilization of boiler fuel oil.

3/ Total boiler generation less fuel oil generation. Also includes an estimated 2.6 million kwh generated by wood chips.

4/ Estimated based on generation proportion by fuel type for the individual plantations.

Table 4. KAUAI ELECTRIC DIVISION AND SUGAR PLANTATION POWERPLANTS

Summary for Year Ending 31 December 1981 1/

Plant	Power, MW		Energy, Million kwh	
	Installed Capacity	Utility Demand	Generation by Sugar Companies	Purchased/ Generated by KED
Kauai Electric at Port Allen 2/	62.1	34.7	--	124.6
Purchased Power/Energy				
Lihue	21.3	12.0 3/	105.5	71.1
McBryde	19.7	3.6 3/	60.0	16.4
Kekaha	8.0	1.0 3/	28.9	5.9
Olokele	4.2	0.2 3/	11.4	0.6
Total (KED)	74.1	39.5	--	218.6
Total (System)	115.3	--	205.8	--

1/ Sources: Kinoshita, C.M. "Energy Inventory for Hawaiian Sugar Plantations - 1981" Honolulu: 1981; State of Hawaii, Public Utilities Commission, "Annual Report of Kauai Electric Division...1981."

2/ Excludes 12.0 MW capacity purchased from Lihue Plantation.

3/ Not coincident with peak demand.

Distribution and Load Centers. The load or service areas are designated by judicial districts. The largest peak demand and total energy consumption are located in Lihue District. The 1980 FPC data indicates the Lihue District was provided approximately 58.0 million kwh and experienced a peak demand of 12.0 MW. In the Lihue District the largest consumer area is the industrial sector constituting approximately 43 percent of the distribution or 25.1 million kwh. However, on an island-wide basis, the non-farm residential is the largest user category at 66.9 million kwh (39 percent), followed closely by the industrial user category of 64.5 million kwh (34 percent). The summary of the system load and associated population by judicial district is shown in Table 5. The distribution of load and population is illustrated in Figure 9.

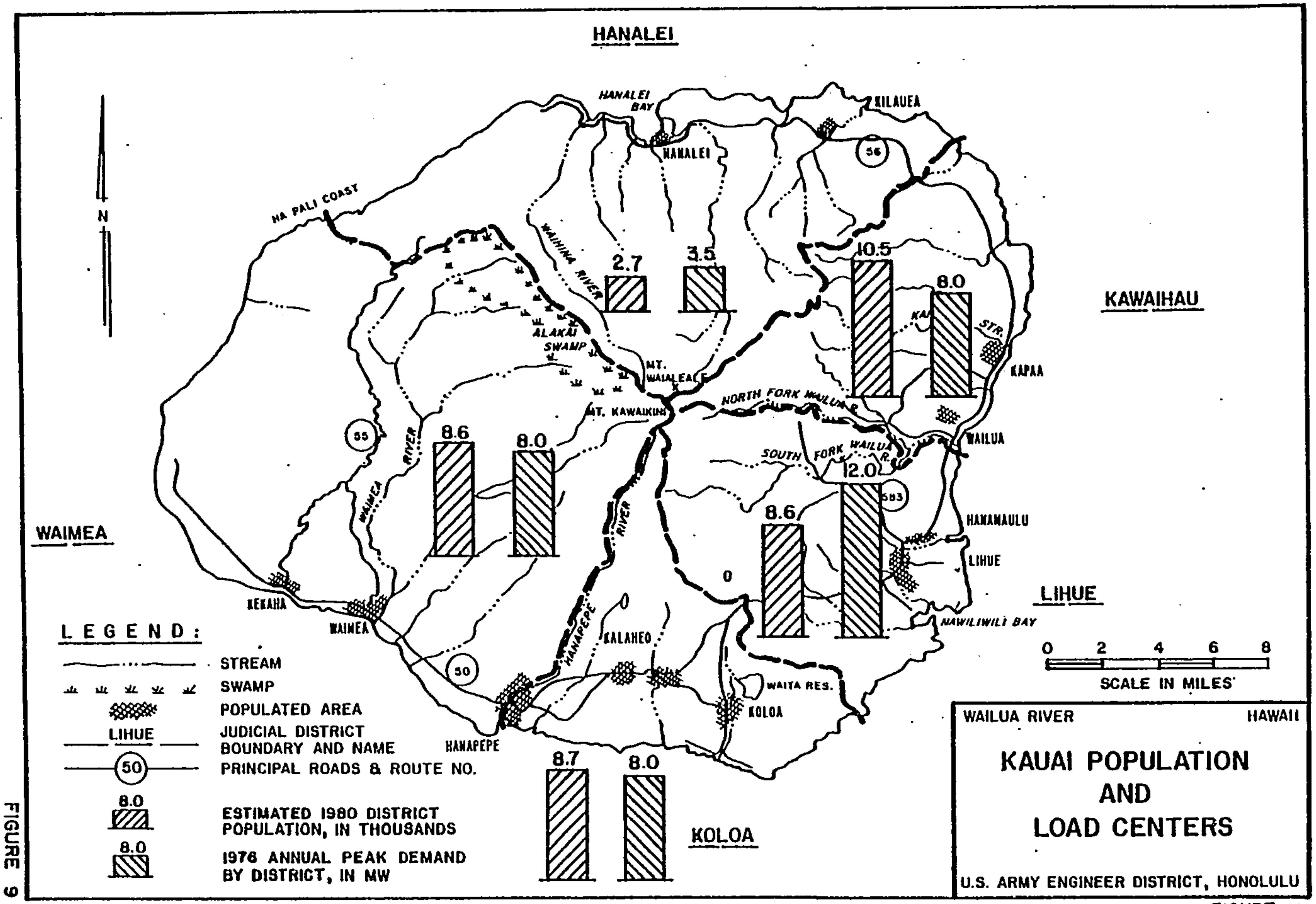

HANALEI
KAWAIHAU
WAIMEA
LIHUE
KOLOA
HANALEI BAY
HANALEI
KILAUEA
HA PALI COAST
WAIHINA RIVER
ALAKAI SWAMP
MT. WAIALEALE
MT. KAWAIKINI
NORTH FORK WAILUA R.
SOUTH FORK WAILUA R.
WAIMEA RIVER
HANAPEPE RIVER
KAPAA
WAILUA
HANAMAULU
LIHUE
NAWILIWILI BAY
WAITA RES.
KOLOA
KALAHEO
HANAPEPE
WAIMEA
KEKAHA
N
56
55
50
583
2.7
3.5
10.5
8.0
8.6
8.0
12.0
8.6
0
8.7
8.0
0 2 4 6 8
SCALE IN MILES
LEGEND:
STREAM
SWAMP
POPULATED AREA
LIHUE
JUDICIAL DISTRICT BOUNDARY AND NAME
50
PRINCIPAL ROADS & ROUTE NO.
8.0
ESTIMATED 1980 DISTRICT POPULATION, IN THOUSANDS
8.0
1976 ANNUAL PEAK DEMAND BY DISTRICT, IN MW
WAILUA RIVER
HAWAII
KAUAI POPULATION AND LOAD CENTERS
U.S. ARMY ENGINEER DISTRICT, HONOLULU

FIGURE 9

Table 5. DISTRIBUTION OF SYSTEM LOAD [2]

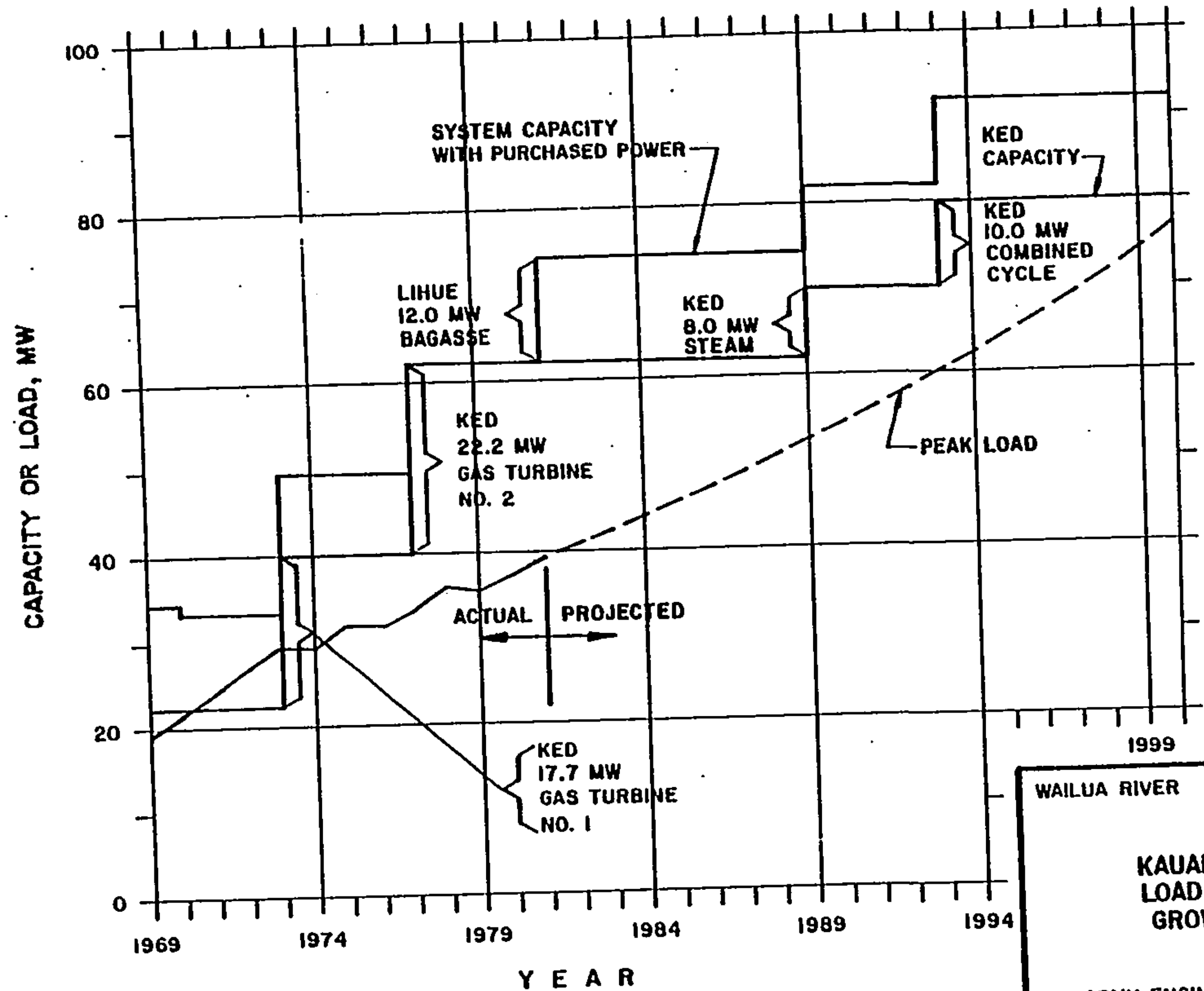
Load Area (Judicial District)	Population[1] 1980	Energy Sold Total Million kwh	Energy Sold %	Peak Demand MW	Annual Load Factor	Energy Classification User Category	%
Waimea	8,593	34.8	19.1	8.0	52	Nonfarm residential	32.0
						Commercial	17.9
						Industrial	48.5
						Other	1.6
						Total	100.0
Koloa	8,734	31.5	17.3	8.0	54	Nonfarm residential	52.0
						Commercial	31.5
						Industrial	14.8
						Other	1.7
						Total	100.0
Lihue	8,590	57.9	31.8	12.0	62	Nonfarm residential	23.6
						Commercial	32.0
						Industrial	43.3
						Other	1.1
						Total	100.0
Kawaihau	10,497	44.3	24.3	8.0	62	Nonfarm residential	44.2
						Commercial	21.6
						Industrial	32.9
						Other	1.3
						Total	100.0
Hanalei	2,668	13.7	7.5	3.5	48	Nonfarm residential	44.5
						Commercial	30.4
						Industrial	24.2
						Other	0.9
						Total	100.0
Total		156.1				Nonfarm residential	39
						Commercial	26
						Industrial	34
						Other	1
						Total	100

1/ Preliminary 1980 Census. State of Hawaii, DPED Data Book 1981.
2/ FPC Form 12. Year ending 31 December 1980.
(Energy data reflects 1976 condition).

FUTURE POWER AND ENERGY REQUIREMENTS

Peak Demand Forecast. The annual rate of increase in the peak demand has gradually decreased since 1969 from an initial 12 percent down to approximately 4 percent per year. However, since 1969 the demand has doubled from 19.6 MW to 39.5 MW in 1981. According to officials of KED, the annual increase should remain steady at 3.6 percent compounded per year up to and including 1991 (Figure 10). Historical and projected data on peak demand and related capacities of KED are shown on Table 6.

The monthly peak load distribution has remained relatively constant over time. The highest peak demand occurs in the fall during the months of September to November, corresponding to main sugar plantation operations. The remainder of the year is relatively constant in demand. A distribution of monthly peak load for the years 1970 and 1980 is shown in Table 7. The peak hourly loads occur generally between the hours of 6 p.m. to 9 p.m. The period of low demand occurs in the early morning hours and varies between 45 to 50 percent of the peak hourly load. Typical monthly and hourly system load charts are shown in Figure 11.

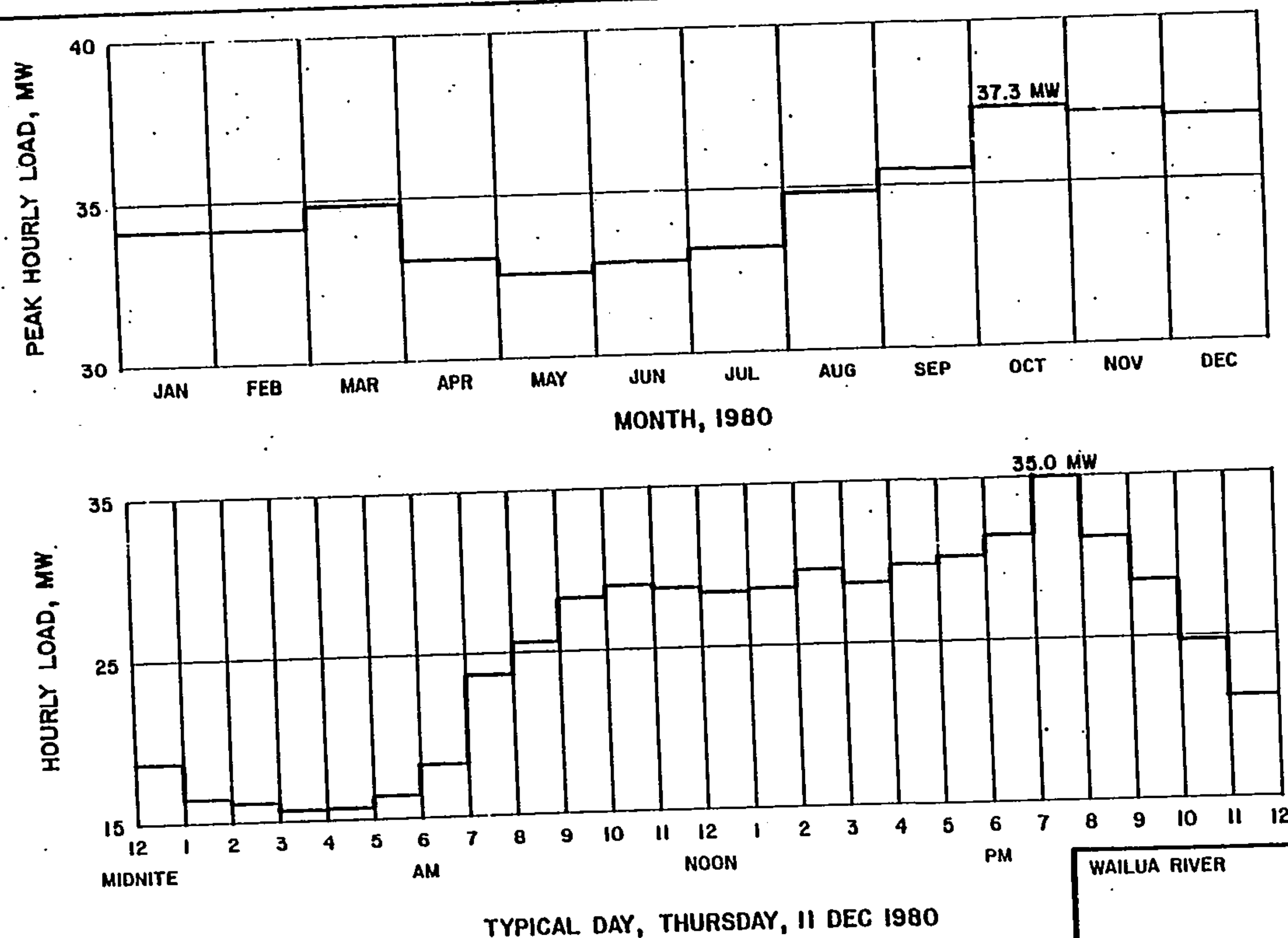


WAILUA RIVER HAWAII

KAUAI ELECTRICAL LOAD & CAPACITY GROWTH CHART

U.S. ARMY ENGINEER DISTRICT, HONOLULU

FIGURE 10



SOURCE:

UNITED STATES DEPARTMENT OF ENERGY, ENERGY INFORMATION ADMINISTRATION, 1980 POWER SYSTEM STATEMENT, FPC FORM 12 FOR CITIZENS UTILITIES, KAUAI ELECTRICAL

WAILUA RIVER HAWAII

TYPICAL SYSTEM LOADS

U.S. ARMY ENGINEER DISTRICT, HONOLULU

FIGURE 11

FIGURE 11

Table 6. HISTORICAL & PROJECTED GROWTH OF PEAK DEMAND/CAPACITY
Capacity or Demand, MW

(1) Year	(2) Addition to Capacity	(3) Total KED Capacity	(4) Available Purchasable Capacity	(5) Total Utility Capacity Col (3)+(4)	(6) Peak Demand	(7) Reserve Capacity Col (5)-(6)
1969	10.0	22.2	12.0	34.2	19.6	14.6
1970		22.2	11.2	33.4	21.9	11.5
1971		22.2	11.2	33.4	24.3	9.1
1972		22.2	11.2	33.4	27.0	6.4
1973	17.7	39.9	9.5	49.4	29.4	20.0
1974		39.9	9.5	49.4	29.4	20.0
1975		39.9	9.5	49.4	31.9	17.5
1976		39.9	9.5	49.4	31.7	17.7
1977	22.2	62.1	--	62.1	33.7	28.4
1978		62.1	--	62.1	35.9	26.2
1979		62.1	--	62.1	35.7	26.4
1980		62.1	--	62.1	37.3	24.8
1981		62.1	12.0	74.1	39.5	34.6
1982		62.1	12.0	74.1	40.9 2/	33.2
1983		62.1	12.0	74.1	42.4 2/	31.7
1984		62.1	12.0	74.1	43.9 2/	30.2
1985		62.1	12.0	74.1	45.5 2/	28.6
1986		62.1	12.0	74.1	47.1 2/	27.0
1987		62.1	12.0	74.1	48.8 2/	25.3
1988		62.1	12.0	74.1	50.6 2/	23.5
1989	8.0 2/	70.1	12.0	82.1	52.4 2/	29.7
1990		70.1	12.0	82.1	54.3 2/	27.8
1991		70.1	12.0	82.1	56.2 2/	25.9
1992		70.1	12.0	82.1	58.3 3/	23.8
1993	10.0 2/	80.1	12.0	92.1	60.4 3/	31.7
1994		80.1	12.0	92.1	62.6 3/	29.5
1995		80.1	12.0	92.1	64.8 3/	27.3
1996		80.1	12.0	92.1	67.1 3/	25.0
1997		80.1	12.0	92.1	69.6 3/	22.5
1998		80.1	12.0	92.1	72.1 3/	20.0
1999		80.1	12.0	92.1	74.7 3/	17.4
2000		80.1	12.0	92.1	77.3 3/	14.8

1/ Hawaii, State of, DPED. State Energy Plan, 1980
Pacific Analysis Corp. An Inventory & Analysis of the Electric Energy Industry in the State of Hawaii, 1977.
Hawaii, State of, Public Utilities Commission. "Annual Report of Kauai Electric Division." Various Years.
2/ Communication from KED Officials, Feb 1982: Projected at 3.6 % increase.
3/ Extrapolated at 3.6% increase.

Table 7. HISTORICAL MONTHLY SYSTEM PEAK LOAD[1/]

Month	1980 Load MW	1980 Load Factor, %	1980 Percent of Peak, %	1970 Load, MW	1970 Load Factor %	1970 Percent of Peak, %
Jan	34.2	66.5	91.7	17.8	63.6	81.3
Feb	34.2	67.1	91.7	18.9	61.5	86.3
Mar	34.9	65.4	93.6	18.9	67.1	86.3
Apr	33.1	69.6	88.7	19.1	66.4	87.2
May	32.6	72.1	87.4	19.3	68.9	88.1
Jun	32.9	72.4	88.2	19.9	65.1	90.9
Jul	33.2	74.6	89.0	20.7	68.0	94.5
Aug	34.9	72.1	93.6	20.5	70.5	93.6
Sep	35.5	70.9	95.2	21.7	65.3	99.1
Oct	37.3	68.1	100.0	21.9	62.1	100.0
Nov	37.2	67.0	99.7	21.7	62.3	99.1
Dec	37.0	65.0	99.2	20.9	58.7	94.5

1/ U.S. Dept of Energy. "Power System Statement" (Covering Kauai Electric Division) FPC Form 12. Years 1970 and 1980.

Energy Projection. Similar to the peak demand projections, the energy required has increased at comparable rates of increase. During the initial years of complete operations, KED system energy requirements were increasing at approximately 12 percent per year. In recent years the rate of increase has declined to 4 percent per year. The transmission and distribution losses have declined from approximately 15 percent to 10-1/2 percent. The energy sold has doubled from approximately 90 million kwh in 1969 to 189 million kwh in 1980. Similar to the peak demand projections, KED officials estimate that the annual increase in energy should remain constant at 3.6 percent per year up to and including 1991 (Figure 12). Historical and projected data on energy generation and energy sold are shown on Table 8.

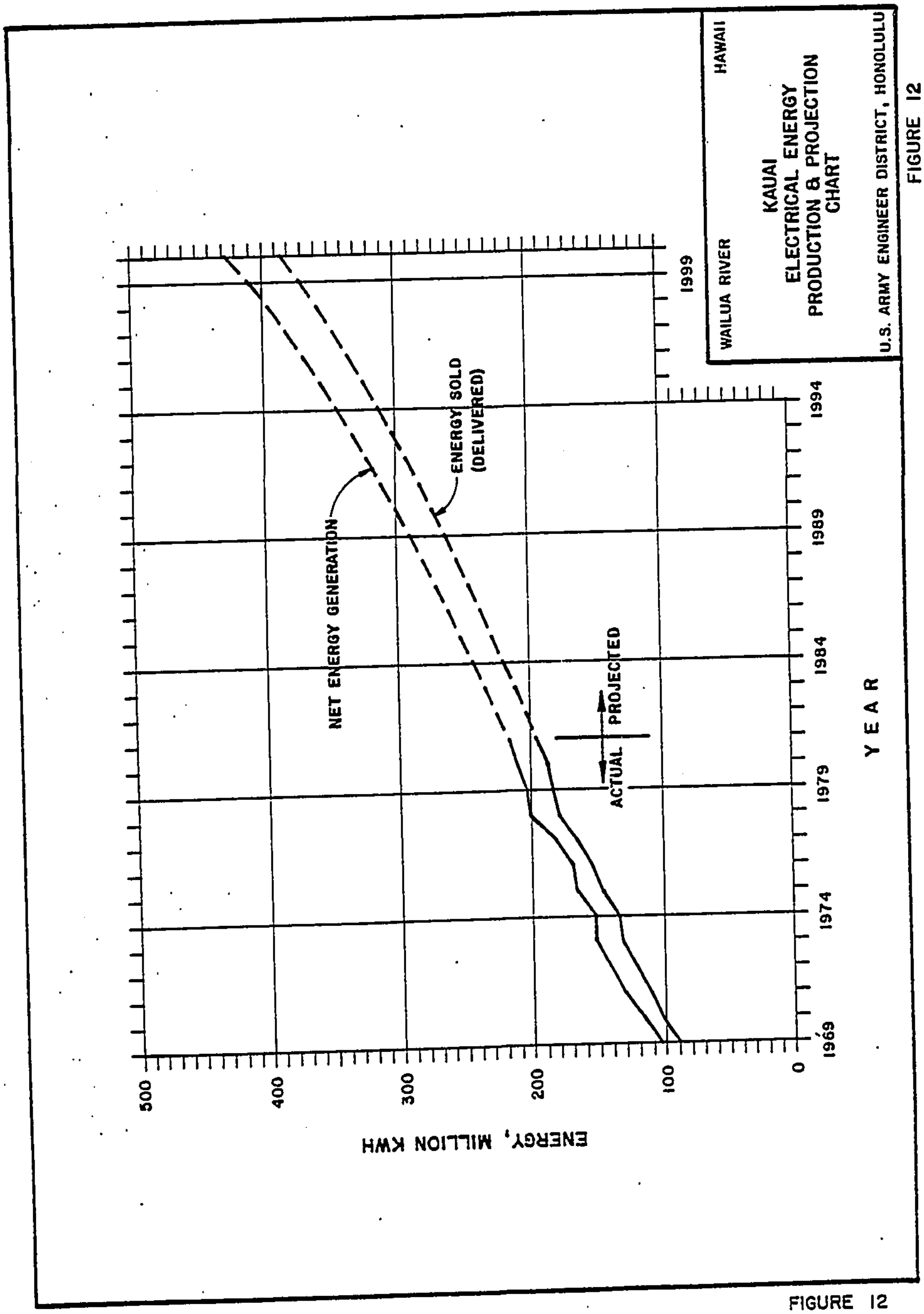

WAILUA RIVER
HAWAII
KAUAI
ELECTRICAL ENERGY
PRODUCTION & PROJECTION
CHART
U.S. ARMY ENGINEER DISTRICT, HONOLULU
FIGURE 12
ENERGY, MILLION KWH
0
100
200
300
400
500
YEAR
1969
1974
1979
1984
1989
1994
1999
NET ENERGY GENERATION
ENERGY SOLD
(DELIVERED)
ACTUAL
PROJECTED

FIGURE 12

Table 8. HISTORICAL & PROJECTED GROWTH OF ENERGY GENERATION

Million kwh

(1) Year	(2) KED Net Generation	(3) Purchased Energy	(4) Net for System Col (2)+(3)	(5) Transmission & Distribution Losses	(6) Energy (Sold) Delivered Col (4)-(5)
1969	54.1	52.2	106.3	16.0	90.3
1970	88.2	30.7	118.9	16.2	102.7
1971	87.3	44.7	132.0	20.1	111.9
1972	103.5	38.3	141.8	20.6	121.2
1973	119.4	32.8	152.2	20.6	131.6
1974	111.9	42.4	154.3	18.7	135.6
1975	133.5	34.1	167.6	19.1	148.5
1976	131.9	37.7	169.6	13.6	156.0
1977	148.6	34.7	183.2	15.9	167.3
1978	179.3	21.7	201.0	21.4	179.6
1979	177.7	26.5	204.2	19.4	184.8
1980	184.4	26.7	211.1	21.9	189.2
1981	124.6	94.0	218.6	19.2	199.4
1982			226 3/		204 2/
1983			234 3/		211 2/
1984			243 3/		219 2/
1985			252 3/		227 2/
1986			261 3/		235 2/
1987			270 3/		243 2/
1988			280 3/		252 2/
1989			290 3/		261 2/
1990			300 3/		271 2/
1991			311 3/		280 2/
1992			322 3/		290 4/
1993			334 3/		301 4/
1994			346 3/		312 4/
1995			358 3/		323 4/
1996			371 3/		334 4/
1997			385 3/		347 4/
1998			398 3/		359 4/
1999			413 3/		372 4/
2000			428 3/		385 4/

1/ Pacific Analysis Corp. An Inventory & Analysis of the Electric Energy Industry in the State of Hawaii, 1977.
US Dept. of Energy, Energy Information Adm. "Power System Statement" for Kauai Electric Division. FPC Form 12. Various Years.
2/ Communication from KED Officials, Feb 1982: Projected at 3.6% increase.
3/ Based on 1.11x Col (6) Projection.
4/ Extrapolated at 3.6% increase.

System Operational Characteristics. The Kauai Electric Division (KED) power system is operated, similar to normal electrical utilities, by a computer dispatch model. The computer assesses the operational costs of each component of the system and adjusts the power output from both the KED and purchased sources. As a result, depending on the load and time of day, the capacity for each component may vary.

The critical month for operation appears not to be in the period of October through December during periods of peak demand but in the month of January. During this entire month the Lihue 12.0 MW bagasse plant is normally shut down (in accordance to the contract) because of the cessation in sugar mill operations. The actual reserve capacity would decrease from 33.2 MW (for 1982, noted in Table 7) to 21.2 MW which is less than the capacity of the largest gas turbine unit (22.2 MW). The possibility of simultaneous shutdown of both the 12.0 MW Lihue plant and the 22.2 MW gas turbine No. 2, although remote, is of concern to KED officials. Hence, KED is required by the State Public Utilities Commission to maintain at least 22.2 MW reserve capacity in the absence of additional utility or purchasable capacity.

The combined cycle operation of the gas turbine units is definitely an economic asset for KED. The exhaust gases of the gas turbine units are utilized to charge the waste heat boiler of the 10 MW unit. As a result, the combined cycle operation cannot be operative if both gas turbines and the steam units were on-line simultaneously.

The potential additions to the KED system further considers utilizing the advantages of steam boiler and gas turbine. The 18 MW steam turbine is planned for construction in 1989. However, it will be operated at 8 MW utilizing the steam from the existing heat recovery steam generator (HRSG) unit. In 1993 the capability will reach 18 MW when a new HRSG will be hooked up independently with the existing gas turbine No. 1, operating in a combined cycle mode.

HYDROPOWER RESOURCES

Hydropower Perspective. The basic physical resources required for hydropower energy extraction are differences in elevation or head for the captured water, the rate of water flow, and the stability of flow over a time period (reflecting water storage and/or high perennial flows). The man-made resources required are a structure in the river to impound or capture the waters, a waterway to transport the waters, and electromechanical devices (turbines and generators) to convert the fall of flowing water ultimately to electrical energy.

Existing Hydropower Developments. The island of Kauai, benefitting from topographic and hydrologic conditions combined with historical development, produces more energy from hydropower sources than any of the Hawaiian islands. The existing hydropower facilities were originally installed by the sugar industry in conjunction with their irrigation, pumping, or mill operations. Table 9 shows the characteristics of the existing hydropower facilities.

Conventional hydropower developments are in general categorized in terms of operational type, capacity, and head requirements. The physical operational categories are storage, run-of-the-river, and conduit and are illustrated in

Figure 13. All of the existing hydropower facilities in the State of Hawaii and the island of Kauai (except for Alexander Reservoir) are considered conduit hydropower. A conduit system for hydropower development operates on instantaneous streamflow. The flows are diverted to a powerplant by means of a diversion system (dam, channel, canal, or tunnel) with limited pondage. The head to be developed depends on the difference in elevation between the penstock intake point and the powerplant location. Power generated by a conduit system depends on streamflow fluctuations and may not be significant nor dependable during low flow periods.

In terms of capacity, hydropower developments are usually categorized in terms of large (greater than 30 MW), small (0.1 MW to 30 MW), and micro (less than 0.1 MW). All existing hydropower plants in Hawaii and any foreseeable development are small scale or smaller. Finally, in terms of head requirements hydropower formulation are usually categorized as normal head (greater than 20 meters or 65.8 feet), low head (5 meters to 20 meters), and ultra low head (less than 5 meters or 16.4 feet). All existing and any new facilities in Kauai would be normal head facilities. There are no large, high rate of flow rivers in Kauai which warrant significant low head facilities.

A total of nine hydropower plants owned by the four sugar plantations and two businesses are currently operational at various stream and ditch locations on the island (Figure 14 and Table 9). The total capacity is 7.9 MW and the average annual energy is 46.9 million kwh. By far the most productive hydropower plant is the Wainiha plant operated by McBryde Sugar Company. The Wainiha plant produces approximately 27 million kwh of energy annually and essentially runs at full capacity throughout the year.

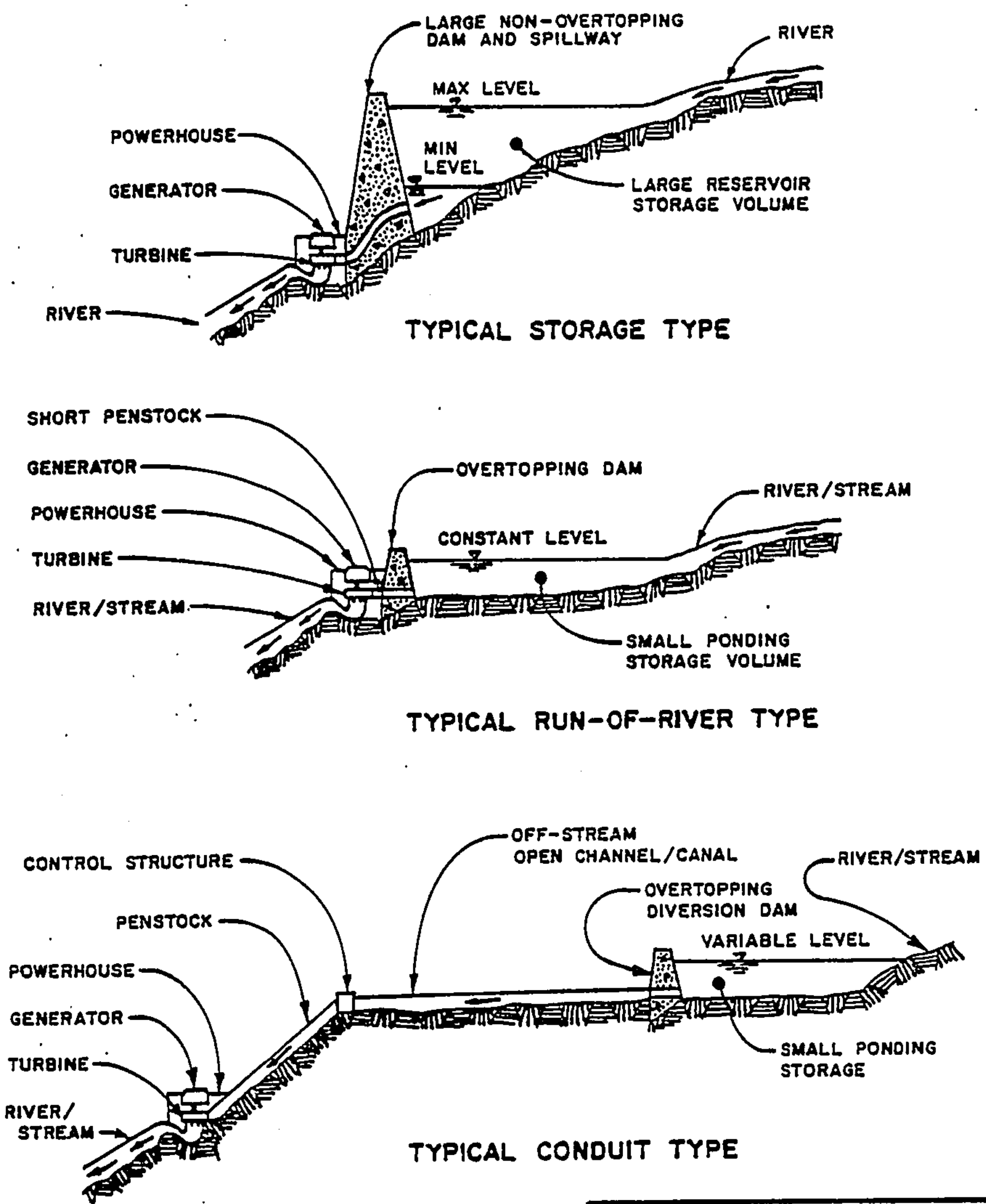
When energy at all hydropower plants is developed beyond the needs of individual plantations, the excess is transferred to the Kauai Electric Division for the utility's electrical system. As of 1980 (last year of complete published data) and based on pro-rated figures, approximately 14 million kwh of hydropower-developed energy was delivered. This transfer corresponded to 30 percent of the total hydroelectric energy production of the island.

Planned Hydropower Developments. There have been a number of proposals for hydropower development or rehabilitation in Kauai since the last significant plant was constructed in 1954. Pertinent data on the projects are provided in Table 10. The two principal areas of new development are Waimea/Kokee and the Wailua area. The Waimea/Kokee area is the location of the Kokee, Olokele, Kekaha, Kitano, and Puu Opae-Mana improvements. The Wailua area includes the Waialeale and Lihue projects.

The most ambitious projects were the Kokee Water and the Waialeale Hydropower projects. Each project involved substantial dam/reservoir and penstock construction and powerplant on the order of 10 MW. However, neither has progressed beyond the feasibility stage and currently appears less favorable because of high financial commitments required. The Kokee project had been deferred indefinitely principally because of lack of Federal funding from the U.S. Department of Interior's Bureau of Reclamation. Activity for the Waialeale project has been suspended because of infeasibility and the high cost of ($72 million, 1978 price level) construction.

The projects under current construction or investigation are much less massive in scope. Capacities vary between 0.7 to 3 MW and average annual energy vary between 3 to 10 million kwh. The projects have received high level of interest primarily because of the energy pricing impact of the Public Utility Regulatory Policies Act of 1978 (PURPA). Essentially, PURPA requires rates for purchases by utilities shall be based on "avoided cost" or the incremental cost to the utility for energy or capacity that the utility would generate itself or purchase from other sources. In accordance with this basic principle, the Kauai Electric Division has been receptive to higher energy rates paid to sugar companies.

Based on existing planning information, none of the proposed projects would be impacted by other small hydropower improvements in the Wailua River system. The Lihue upgrading project proposed by Lihue Plantation/Amfac involves rehabilitation of two existing run-of-the-river hydropower plants and increasing the ditch diversion capacity leading to the respective turbines. Both Lihue powerplants (Upper Lihue and Lower Lihue) are located at the ditches in the upper South Fork Wailua drainage area.



SOURCE: U.S.A. CORPS OF ENGINEERS
NATIONAL HYDROPOWER STUDY
ENVIRONMENTAL ASSESSMENT
(DRAFT, JULY 81)

WAILUA RIVER HAWAII

TYPICAL SCHEMATIC PROFILES OF CONVENTIONAL HYDROPOWER OPERATIONAL TYPES

U.S. ARMY ENGINEER DISTRICT, HONOLULU

FIGURE 13

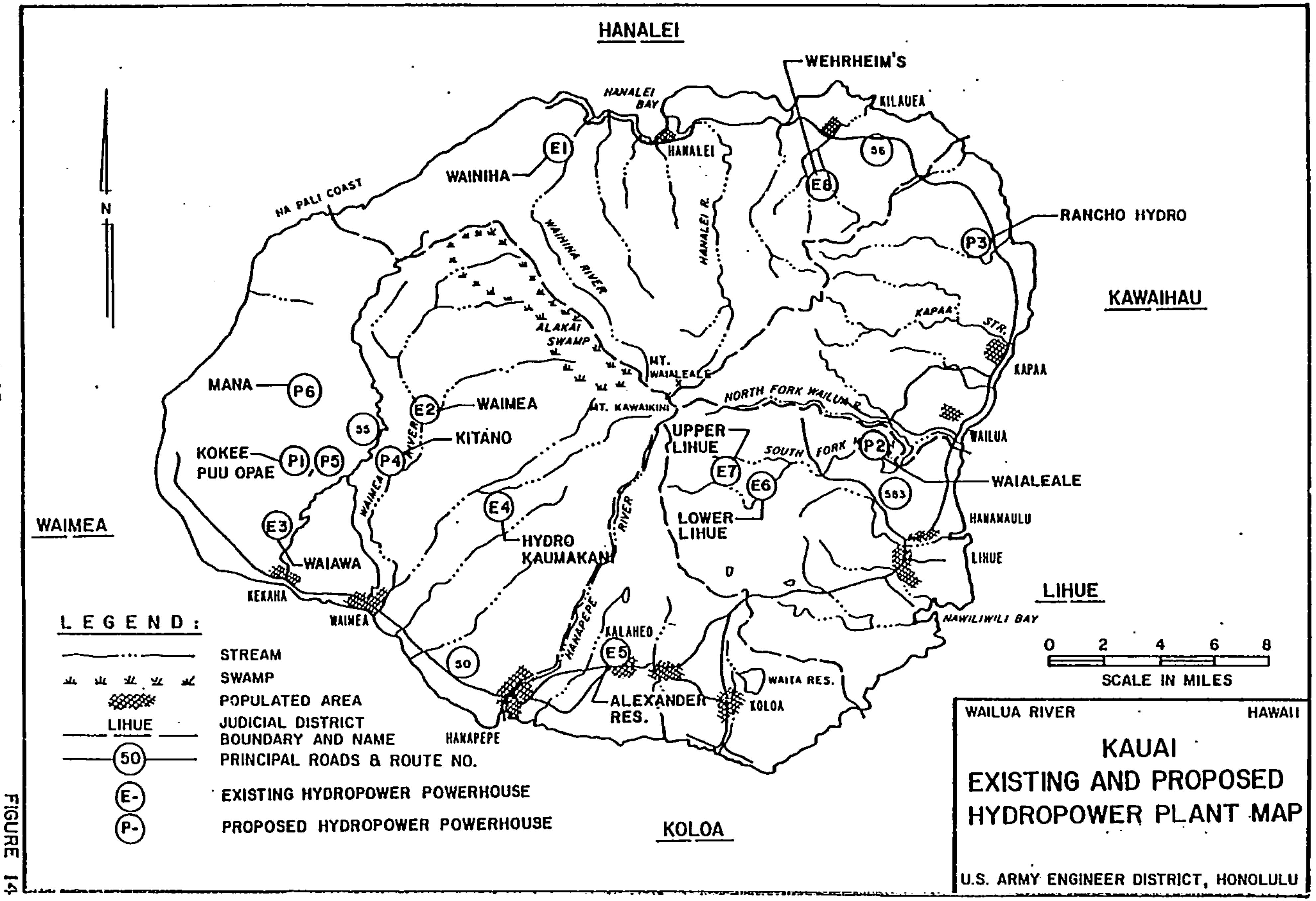

HANALEI
WEHRHEIM'S
HANALEI BAY
HANALEI
KILAUEA
56
E8
E1
WAINIHA
NA PALI COAST
WAINIHA RIVER
HANALEI R.
RANCHO HYDRO
P3
KAWAIHAU
KAPAA
STR.
KAPAA
ALAKAI SWAMP
MT. WAIALEALE
MT. KAWAIKINI
NORTH FORK WAILUA R.
WAILUA
MANA
P6
E2
WAIMEA
55
KITANO
KOKEE
PUU OPAE
P1
P5
P4
WAIMEA RIVER
UPPER LIHUE
E7
SOUTH FORK
P2
WAIALEALE
E6
583
LOWER LIHUE
E4
HYDRO KAUMAKANI
RIVER
HANAMAULU
WAIMEA
E3
WAIAWA
LIHUE
KEKAHA
WAIMEA
HANAPEPE
KALAHEO
E5
50
LIHUE
NAWILIWILI BAY
ALEXANDER RES.
WAITA RES.
KOLOA
HANAPEPE
0 2 4 6 8
SCALE IN MILES
LEGEND:
STREAM
SWAMP
POPULATED AREA
LIHUE
JUDICIAL DISTRICT BOUNDARY AND NAME
50
PRINCIPAL ROADS & ROUTE NO.
E-
EXISTING HYDROPOWER POWERHOUSE
P-
PROPOSED HYDROPOWER POWERHOUSE
KOLOA
WAILUA RIVER
HAWAII
KAUAI
EXISTING AND PROPOSED
HYDROPOWER PLANT MAP
U.S. ARMY ENGINEER DISTRICT, HONOLULU

FIGURE 14

Table 9. EXISTING HYDROPOWER PLANTS IN KAUAI 1/

Code	Plant Name	Stream	Owner	Static Head, feet	Installed capacity MW	Average Annual Energy million kwh	Year First Operated
E1	Wainiha	Wainiha	MBSC	565	3.6	26.6	1906
E2	Waimea	Waimea	KESC	265	1.0	5.0	1954
E3	Waiawa	Kahoana	KESC	275	0.5	1.9	1907
E4	Hydro Kaumakani 2/	Hakaweli	OLSC	211	0.5	3.1	1920
E5	Alexander Res 3/	Wahiawa	MBSC	700	1.0	2.1	1928
-	Halumalu	Waihohonu	MBSC	150	0.128*	---	1919
E6	Lower Lihue 4/	North Wailua & Iliiliula Ditches	LIPC	206	0.8	5.0	1941
E7	Upper Lihue 4/	North Wailua & Iliiliula Ditches	LIPC	247	0.5	3.1	1930
E8	Namahana Farms	--	Namahana Farms	270	5.0 kw	0.025	1980
E9	Kauai Papaya	--	Kauai Papaya	177	14.0 kw	0.10	1981

1/ Sources:
- a. "Alternate Energy Sources for Hawaii," Hawaii Natural Energy Institute, University of Hawaii, and Department of Planning and Economic Development, State of Hawaii, February 1975.
- b. Input from owners, 1979-1982.
- c. Energy generation estimated by the Pacific Ocean Division, U.S. Army Corps of Engineers.
- d. Personal communication with Ms. JoAnne Yukimura, October 1982.

2/ Also known as Honopahu or Kaumakani.
3/ Also known as Kalaheo.
4/ Also known respectively as Lower Waiahi and Upper Waiahi.

Abbreviations:

MBSC - McBryde Sugar Co., Ltd.
KESC - Kekaha Sugar Co., Ltd.
OLSC - Olokele Sugar Co., Ltd.
LIPC - Lihue Plantation Co.
* Denotes inactive sites

Code: Map location designation

Table 10. PLANNED HYDROPOWER IMPROVEMENTS IN KAUAI 1/ 2/

Code	Name of Project/ Stream or Affected Plant	Developer	Stage of Investigation/ Status	Type of Improvement	Development Capacity MW	Development Energy million kwh
P1	Kokee Water Project/ Kawaikoi Stream, Kokee Ditch	State of Hawaii, U.S. Dept of Interior	Feasibility/Deferred indefinitely	240-ft high dam, 13,700 ft penstock, powerhouse	10.0	29.2
P2	Waialeale Hydropower Project/ South Fork Wailua River	State of Hawaii	Feasibility/Suspended indefinitely	219-ft high dam, 22,700 ft penstock, powerhouse	9.2	50.0
-	Olokele Upgrading Project/ Hydro Kaumakani Plant	Olokele Sugar Co.	Under construction/ POL: Early 83	New turbogenerator powerline, electrical line, work at existing powerhouse	1.25	9.0
P3	Rancho Hydro/ Anahola Stream	John D. Harder	Under construction/ POL: Mid 83	New turbogenerator, diversion	0.0015 (1.5 kw)	0.005 (5,000 kwh)
-	Lihue Upgrading Project/ Upper Lihue Powerplant	Lihue & Amfac	Engineering/Environmental, Economics 75% complete. POL: Post 1984	Increase ditch/tunnel capacity, second turbogenerator for upper powerplant	0.8	5.7
	Lower Lihue Powerplant			Increase ditch/tunnel capacity, larger turbine for lower powerplant	1.0	7.1
-	Kekaha Upgrading Project/ Waiawa Powerplant	Kekaha & Amfac	Engineering/ POL: post 1986	Upgraded turbogenerator at existing plant	0.55	3.5
P4	Kitano Hydroplant Project/ Kokee Ditch	Kekaha & Amfac	Feasibility/study completed, engineering pending completion late 1982, POL: 1984	Diversion intake, 9,100 ft penstock, powerhouse	1.5	8.0

Table 10. PLANNED HYDROPOWER IMPROVEMENTS IN KAUAI 1/ 2/ (Cont)

Code	Name of Project/ Stream or Affected Plant	Developer	Stage of Investigation/ Status	Type of Improvement	Development Capacity MW	Development Energy million kwh
P5, P6	Puu Opae-Hana/ Kawaikoi Stream, Kokee Ditch	Amfac & State of Hawaii	Feasibility pending completion mid-1983/ status uncertain	#1 14,000 ft penstock, powerplant (Puu Opae)	0.7	Approx 3.0
				#2 18,000 ft penstock, powerplant (Hana)	2.0	Approx 9.0
P7	Wainiha/Wainiha River	McBryde Sugar	Feasibility pending completion early 1983	Improve existing project and new upstream project	3.0	Approx 19.0

1/ Listed in approximate order of project planning

Code: Map location designation

2/ Sources:
a. Hawaii, State of, Board of Land & Natural Resources. Kokee Water Project Report R22. Honolulu: 1964
b. Belt, Collins & Assoc. Waialeale Hydropower Study. Honolulu: 1978
c. Personal communication with Mr. H. Poppinga, Olokele Sugar Co., 1981/82
d. U.S. Dept of Army Permit PODCO-O 1602-S, May 1981
e. Broadbent, Ned. "Upgrading Potential of Existing Hydroelectric Units at Lihue Plantation Co., Ltd. and Kekaha Sugar Co. Ltd., Jan 1980
f. Personal communicaton with Messrs B. Hatton and N. Broadbent, 1981/82
g. Tudor Engineering Co., Feasibility Report on the Potential Development of the Kitano Hydroplant, San Francisco, July 1981
h. Personal communication with Mr. J. Harder, April 1982
i. EDAW, Inc. Wainiha Hydroelectric Project - Planning Report. Prepared for McBryde Sugar Co., Ltd., March 1982

D. THE RELATIONSHIP OF THE PROPOSED ACTION TO LAND USE PLANS, POLICIES AND CONTROLS FOR THE AFFECTED AREAS.

EFFECTS TO THE EXISTING LANDS

The proposed Wailua River Hydroelectric Project will primarily affect lands owned by the State of Hawaii which have a variety of uses.

Approximately 60% (33.8 acres) of the land needed for construction and operation of the Project are owned by the State of Hawaii and are leased by the Lihue Plantation Company, Ltd. (a subsidiary of AmFac), for agricultural purposes. These lands are identified as Parcels 1, 20, and 12 shown on Zone 3, Section 9, Plat 02 of the State of Hawaii tax maps. These lands have been historically used for the growing and harvesting of sugar cane. Although they are currently being used to produce sugar cane, the future of this particular crop is not certain. However, many possbilities exist for other agricultural crops to be harvested on these lands with nutrient rich soils.

The current irrigation methods used on these lands are considered to be among the least efficient compared to modern day drip irrigation and other systems. Sugar cane is also one of the highest water consumptive crops which is commercially produced. In the event that another agricultural crop is implemented to replace sugar cane, it is highly unlikely that the replacement crop will consume an equivalent or greater amount of irrigation water. In fact, it is highly possible that the new crop would consume much less water. It is also very probable that a more modern irrigation system would be used to replace the existing system which requires a great deal of maintenance and unnecessary waste of irrigation water. Since the proposed project is based upon historic availability of flows remaining at the proposed diversion point after withdrawals have been made for irrigation and other purposes, any changes in agricultural crops or uses will likely not adversely affect the Project. Further, the Project would likely benefit from any changes in this respect. Potential conflicts could arise from harvest fires in the area of the transmission line poles. However, a minimum of 35 feet clearance between the ground and powerlines is typically recommended by the plantations to avoid the potential conflicts. Coordination must take place between Lihue Plantation and Island Power to avoid these and any other potential conflicts.

No other conflicts are expected to be experienced with existing uses of this land. The majority of these lands will be restored to their previous condition and the current use of this portion of land will only be temporarily interrupted.

Approximately 27% (15.2 acres) of the land needed for the Project is owned by the State of Hawaii, which apparently lies near the existing channel of the South Fork of the Wailua River. This land is idenitifed as Parcel 31, Zone 3, Section 9, Plat 02 as shown on the State of Hawaii tax maps. Identity is not given as to any specific uses or proposed uses of these lands which are closely bounded on both sides by Parcels 20 and 1, previously mentioned as lands for agricultural uses. It is assumed that the lands in Parcel 31 are reserved for non-agricultural uses as to minimize a high potential for long-term sedimentation or erosion which might be caused by agriculture in close proximity to the river channel.

The proposed project will create approximately 300 acre-feet of pondage behind the diversion structure. The creation of this impoundment could have a positive potential impact to the bass fishery resources found in the river. An increase to the recreational resources in the area is also a likely result of the pond. No significant conflicts will be caused by the proposed project to land uses in this Parcel.

Approximately 6% (3.4 acres) of the land needed for the Project is owned by the State of Hawaii which are within "Conservation District" boundaries. The subzone designation for these lands is defined as Resource (R). These lands are identified as Parcel 33, Zone 3, Section 9, Plat 02 on the State of Hawaii tax maps. The objective of this subzone is to develop, with proper management, areas to ensure sustained use of the natural resources of those areas. The proposed project would locate penstock, powerhouse, tailrace and transmission line features on these lands. The majority of the penstock will be buried and precautions will be taken to minimize visual impacts to the area as much as possible.

No conflicts will be caused to the existing land uses in this parcel. The proposed project would appear to conform with the objectives specified in "Resource Use" areas.

Approximately 6% (3.2 acres) of the land needed for the Project are owned by the State of Hawaii which are within "Kalepa Forest Reserve" boundaries. These lands are identified as Parcel 14, Zone 3, Section 9, Plat 02, on the State of Hawaii tax maps.

The project proposal calls for an overhead transmission line to cross lands near the northern tip of this parcel. It is unclear as to the specific objectives of the land use in this parcel. However, several alternatives could be used to minimize the visual impacts to the area caused by the construction of the transmission line. The transmission could possibly be placed in an existing irrigation tunnel in the area, which would minimize the visual impacts of this action. Potential conflicts exist in this parcel.

Approximately 1% (0.6 acres) of the land needed for the Project are owned by the State of Hawaii which are within the Wailua River Reserve of the State Park System. These lands are identified as Parcel 21, Zone 3, Section 9, Plat 02 on the State of Hawaii tax maps. These lands have been designated to be developed in phases as part of the State Park System. The proposed project would cross these lands with an overhead transmission line for approximately 520 feet. The majority of impacts that would be caused to these lands would be visual. No significant conflicts to land uses in this parcel are expected.

Less than 1% (0.2 acres) of the land needed for the proposed project are privately owned by the B.P. Bishop Foundation. These lands are identified as Parcel 9, Zone 3, Section 9, Plat 03, on the State of Hawaii tax maps. These lands were historically used for agricultural development reportedly in the form of rice paddies and tarrow patches. These lands are currently leased by O. Thronas for the purpose of livestock grazing. The proposed project would locate the tailrace on these lands. A preliminary agreement has been reached by the Applicant and the landowner for the lease or purchase of these lands. A final agreement will be executed at a later date. No conflicts will be caused to the existing use of these lands.

E. THE PROBABLE IMPACT OF THE PROPOSED ACTION ON THE ENVIRONMENT

WATER QUALITY

The terminal and lower reaches of the Wailua River which fall within the boundaries of the Wailua River State Park have been designated as Class 1.a. waters by the State of Hawaii, Departments of Health Water Quality Standards. The objective of this classification is to protect waters in their natural state as nearly as possible with an absolute minimum of pollution from any human-caused source. Uses to be protected in Class 1.a. waters include scientific, educational, compatible recreation, aesthetic enjoyment and other nondegrading uses. The middle and upper reaches of the South Fork Wailua are Class 2 in inland waters protected for fish and wildlife propogation, agricultural and industrial water supplies, and recreation. The State of Hawaii does not regularly monitor river quality, and there is a lack of recent data which describes the physical and chemical environment of this river system. The principal factors influencing water quality in the South Fork Wailua are the activities associated with large scale sugarcane cultivation: soil erosion, water diversion and stream dewaterment, channel modification (causeways, culverts and fords) and leaching of agricultural chemicals. A system of diversion dams, intakes and ditches exports a significant volume of flow from both the North and South Fork Wailua. Although average residual flow downstream exceeds 16 cfs, minimum flows approached zero during the lowest flow on record (October 1953).

Construction of the Project would result in short-term impacts to stream 7
water quality. Activities including access roads, excavation and placement of fill material in the water would increase sedimentation of the river in the project area. Water turbidity would increase correspondingly, both in the Project area and downstream. The introduction of potentially toxic substances such as petroleum products from construction machinery could be a hazard during construction.

Upon completion of the construction phases, sedimentation would diminsh and eventually achieve pre-project conditions. Based upon the observations at existing run-of-the-river (new conduit) hydropower plants on Kauai, no long-term effects such as thermal stress from powerplant effluent are anticipated.

AIR QUALITY

Existing air quality within the project area is generally good and usually free of pollutants. It is effectively removed from urban areas and industrial point sources such as sugar mills. Influence from these sources is negligible. However, activities related to sugar cultivation, most notably cane burning and soil preparation prior to planting, periodically contribute significant amounts of dust and other objectionable pollutant materials.

Temporary increases in dust and smoke levels will be caused by the construction activities and the possible burning of vegetation removed from the construction site. These impacts will be short-lived and are not considered significant.

no mention here of nopili

nor even of what occurs below the falls

birds — but mentioned in appendix

AQUATIC BIOLOGICAL RESOURCES

Stream Biota. The aquatic fauna above Wailua Falls is dominated by introduced species which come from both Asia and continental North America, including the small-mouth bass (*Micropertus dolomieui*), Chinese catfish (Clarius *fuscus*), and the wil guppy (*Poecilia reticulata*). Along with the bass and catfish, the less abundant bluegill sunfish (*Lepomis macrochirus*) provides a sport and subsistence fishery on Kauai. The middle and upper reaches of the river are devoid of native Hawaiian fishes or mollusks; however, diadromous mountain shrimp (*Atya bisulcata*) has been found above the lip of Wailua Falls. The introduced Tahitian prawn (*Macrobrachium lar*) occurs uncommonly above the falls. A significant number of native, diadromous species occur in the stream below the Wailua Falls. Apparently, because of the geological configuration of the face of Wailua Falls, most diadromous species are not able to ascend beyond the Falls and thus do not inhabit the mid and upper reaches of the river. Those that do are subject to intensive predation by smallmouth bass and bluegill.

Implimentation of the project could result in temporary degradation of productive habitat for native species below Wailua Falls due to increased sedimentation from construction activities. Displacement or destruction of aquatic fauna resulting from excavation, transport and placement of fill material in the water during construction of diversion and intake structures and outlet channel would be additional anticipated short-term effects. Measures which could be practicably employed to minimize construction related adverse effects on aquatic resource are as follows:

(1) Construction in the water and along the channel walls would be scheduled during June-September, the months of least rainfall.

(2) During construction of the diversion structure and conduit, allowance must be made to provide continuous streamflow downstream of the construction.

(3) Dredged and excavated material should be removed from the stream channel and not be temporarily stockpiled in the water.

(4) Movement of heavy construction equipment in the stream should be avoided or minimized.

Long-term impacts associated with the project include partial diversion of the stream causing reduction of flow below the diversion structure, alteration of the normal seasonal flow regimes, subsequent habitat reduction and population decline of indigenous and exotic fauna inhabiting the lower stream course between Wailua Falls and the powerplant outfall. Approximately 1.7 miles of stream would be affected by the diversion.

The effects of partial dewaterment will be significantly reduced by supplementing existing flow with water diverted from the North Fork. The diversion structure would be designed to allow the continuous discharge of a conservation flow (minimum flow) of 15 cfs. Streamflows of less than 15 cfs and greater than 380 cfs would also pass through the diversion structure. The structure would also have the capability of allowing periodic passage of flows between 15 - 380 cfs when necessary to flush sediment accumulation from the lower stream course and to accommodate spawning requirements of the native fishery resources in the lower reaches of the South Fork.

The diversion structure above the falls will create an approximately 35.0-acre impoundment behind the diversion dam. Some of the riparian vegetation in this area will be cleared prior to being submerged by the increased water level. The pool will provide additional habitat for the smallmouth bass fishery above Wailua Falls. Additional diversion of water from the North Fork Wailua River via the Stable Storm Ditch could result in the loss of smallmouth bass habitat below the diversion. Historically, there have been no provisions for minimum bypass flows at the existing Stable Storm Ditch diversion. As a result, the entire amount of flow has been diverted from the North Fork Wailua River for extended periods of time. It is highly unlikely that a viable smallmouth bass fishery could exist under these conditions. Therefore, the proposed project is not expected to significantly impact these resources.

TERRESTRIAL BIOLOGICAL RESOURCES

Vegetation. The entire watershed of the South Fork Wailua River is dominated by sugarcane cultivation. Only the headwaters lie in steep, heavily forested areas where native plant species remain abundant. The dominant riparian vegetation along the South Fork Wailua are exotic species (hau, California grass, Guava, Java Plum). Indigenous plants such as tis, gingers, and a variety of ferns and mosses also occur along the stream. The terminal reaches of the river are bordered by relatively flat pasturelands. The lowest flat lands along the Wailua River along Wailua River were modified considerably in the 1960's by the construction of several ponds for the Paradise Pacifica Garden. Experimental taro farms line the terminal reach of the Opaekaa tributary.

Some clearing of vegetation will be necessary along riparian areas near the upper and lower components of the proposed project. The majority of the Project will be buried and restored to its previous state. The existing vegetation has the ability to re-establish itself in a relatively short period of time. The effects to the vegetation are considered to be short-term and insignificant.

Avifauna. Three species of endemic waterfowl, the Hawaiian coot, gallinule and duck are found in the Wailua River basin. The coot and gallinule have been observed in the upper reaches of the South Fork above the proposed project site but occur most commonly below the convergence of the North and South Fork and in adjacent taro fields. All three birds are listed endangered species. Other water birds associated with the river system include the black-crowned night heron and cattle egret. Non-waterbird avifauna include the shama, melodious laughing-thrush and northern cardinal within the hau thicket bordering the streams. Western meadowlark, ring-necked pheasant and spotted dove are associated with canefields and open pasturelands within the river basin.

Since no critical habitat to these species is found in the immediate Project area, no significant impacts are expected to the existing avifauna.

Mammals. Mammals within the Wailua River basin include dogs, cats, feral pigs, cattle, horses, rats and mongoose. No wetlands, wildlife sanctuaries or refuges occur within the proposed project area.

No significant impacts are expected to the existing mammals.

ENDANGERED SPECIES

Three Endangered Species, the Hawaiian coot, gallinule and duck, are found in the Wailua River basin. The coot and gallinule have been observed in the upper reached of the South Fork above the proposed project site but occur most commonly below the confluence of the North and South Fork and in adjacent taro patches. The Hawaiian duck is also most common in the lower reaches of the river. According to the U.S. Fish and Wildlife Service, Office of Endangered Species, no listed or proposed species have been observed in the immediate project area. No endangered species critical habitat is located in the project area. No adverse effects on the Kalao or other listed species resulting from the hydropower project are anticipated.

CULTURAL AND HISTORICAL RESOURCES

The impounded pool created by the diversion barrage would not inundate the mythical Kawelowai underwater cave above the Falls. The abandoned 19th century railroad bridge would not be adversely affected by any of the structural plans. Construction of the powerline from the powerplant eastward to Lydgate Beach Park substation will be performed so as to not significantly affect the agricultural terrace complex known in 1846 as Makea (Ching's Site 205). The right-of-way for a powerline may also affect unknown historic properties in the Kalepa (Ridge) Forest Reserve, east of the Wailua River.

No significant impacts to the cultural or historical resources are expected.

WETLANDS

No wetlands are located in the proposed project area in the vicinity of Wailua Falls. The lower reaches of Wailua River and Opaekaa Stream, which runs parallel to and eventually joins Wailua River, approximately 1/2 miles west of its mouth, is bordered by extensive pasture land, some of which is flooded during heavy rain. The lowest flatland along the Wailua River, once a tidal marsh, was modified considerably by the construction of Paradise Pacifica, a tropical botanical garden built in the 1960's. A portion of the undeveloped marshlands still exists to the Paradise Pacifica boundary.

No effects to wetlands in the area are expected.

TABLE H-1. POPULATION DISTRIBUTION ON KAUAI ISLAND, 1970-1980

CENSUS TRACTS

Year	Total Kauai	401 Hanalei	402 Wailua Anahola	403 Kapaa	404 Puhi-Hanamulu	405 Lihue	406 Koloa-Poipu	407 Eleele-Kalaheo	408 Kaumakani-Hanapepe	409 Kekaha-Waimea
1970[1]	29,524	1,182	3,599	3,794	3,642	3,124	3,141	3,660	3,173	4,159
1974[2]	29,460	1,700	4,220	3,630	3,140	3,090	2,850	3,910	2,700	4,220
1980[1]	38,856	2,668	6,030	4,467	4,590	4,000	3,879	4,855	3,111	5,256

1 State Department of Planning and Economic Development. The State of Hawaii Data Book 1981, A Statistical Abstract. November 1981.

2 Anderson, Robert N. and others. Kauai Socioeconomic Profile. Departmental Paper 35. Honolulu; Center for Nonmetropolitan Planning and Development, Cooperative Extension Service and Hawaii Agricultural Experiment Station, University of Hawaii, May 1975, Table 9.

* The following pages is information from the U.S. Army Corps of Engineers from their "Final Interim Survey Report and Environmental Statement"

TABLE II-2. POPULATION CHARACTERISTICS BY CENSUS TRACTS
KAUAI, 1974

Characteristics	Total	401	402	403	404	405	406	407	408	409
					Census Tracts					
Number of households	8,550	490	1,240	1,030	800	1,210	880	1,210	800	1,110
Percentage	100	5.7	14.5	12.0	9.4	11.6	10.3	14.2	9.4	13.0
Median household size	3.2	2.75	2.89	3.04	3.75	2.85	3.00	2.89	2.50	3.40
Median household income in dollars	10,750	11,600	13,620	10,190	10,330	14,290	10,600	9,680	7,750	10,110
Median number of years of adults in the community	27.7	14.5	24.0	26.7	27.0	32.5	23.5	27.9	37.5	34.5
Adults born on Kauai in percentages	53.6	36.8	48.8	57.5	43.5	63.9	50.3	56.8	54.2	59.4
Sex										
Male	51.8	49.4	48.4	50.9	55.7	52.8	51.1	54.7	53.4	50.0
Female	48.2	50.6	51.6	49.1	44.3	47.2	48.9	45.3	46.6	50.0
Median age	27.1	23.7	26.9	24.9	23.9	28.5	27.0	29.7	35.3	24.1
Adults living their whole life on Kauai										
Yes	52.8	30.5	47.2	57.3	43.5	63.9	46.6	56.8	54.9	60.5
No	47.2	69.5	52.8	42.7	56.5	36.1	53.4	43.2	45.1	39.5

Source: Anderson, Robert N. and Others. Kauai Socioeconomic Profile. Departmental Paper 35. Honolulu: Center for Nonmetropolitan Planning and Development, Cooperative Extension Service and Hawaii Agricultural Experiment Station, University of Hawaii, May 1975.

PRIME AGRICULTURAL LANDS

The proposed penstock alignment would traverse approximately 2200 feet of sugarcane fields owned by Lihue Plantation. The pipe would be buried using a cut-and-cover technique to minimize stockpiling of excavated soil. The excavation would cut a swath approximately 80 feet wide through the sugarcane, affecting almost 5 acres of cane land. Lihue Plantation would be fully compensated for the resultant loss of crops. This would be a "one-time" temporary impact. Once the backfilling is completed, the lands will be restored to their former use for sugarcane cultivation.

The tailrace (outlet channel) would affect approximately 1/2 acre of pastureland. The outlet would consist of a 200-foot long, 20-foot wide channel. Following construction, the area would be grassed and accessibility would be provided.

Although approximately 5 acres of prime agricultural land will be affected by the Project, the area will be immediately restored to its previous state. Lihue Plantation will be fully compensated for the damages to agricultural crops caused by construction of the Project. These impacts will be short-term and are considered to be insignificant.

SOCIAL, ECONOMIC AND POPULATION

Urban and community impacts such as income distribution, employment distribution, population distribution and composition, the fiscal condition of the local government, and the quality of community life; (b) Life, health and safety; (c) Displacement including people, businesses, and farms; (d) Long-term productivity involving renewable resources; and (e) Energy requirements and energy conservation both during construction and operation of facilities.

The social effects of the proposed project are mainly island-wide in nature. All of the project's components are physically located far from population centers, and in fact would displace no people, or individual businesses or farms. No changes in existing income, employment or population distribution or composition are anticipated as a result of implementing the Project. The quality of community life will be affected, but the nature of that quality is believed to be related to recreational activities and aesthetic perception more than any other factors. There are few life, health and safety considerations. The likelihood of dam failure with resultant flash floods is miniscule both because of the design of the diversion structure (designed up to the Probable Maximum Flood) and becuase of the comparatively small amount of water impounded behind the barrage.

The following table (Table H-1) depicts the changing population distribution on Kauai between 1970 and 1980 which saw unusally high grouth of the census tracts comprising Hanalei and Wailua-Anahola (excluding Kapaa). Even by the 1974 sample survey, these trends could be perceived. Detailed census tract-level socioeconomic data for 1980 are not yet available. Table H-2 depicts these regional characteristics for the inter-census of 1974. Census tracts 402 to 405 surround the project area.

Although some temporary increases in employment and related economic factors will be realized during construction of the Project, no significant or long-term impacts to the existing social, economic and population factors in the area are expected.

RECREATIONAL RESOURCES

A minor portion of the Project lies within Wailua River State Park which has 1,113 acres of outstanding scenic, natural, historical and recreational resources. The State Park was established by the Territory of Hawaii in 1954 with a focus on Fern Grotto and the Wailuanuiho'ainana, a complex of heiau and other kapu areas and habitation areas alongside the river estuary. Fern Grotto is the principal visitor attraction. The present park has long-range plans to expand to about 1,700 acres. Development and expansion of the Park is governed by the Wailua River State Park plan prepared for the State in 1970. Almost none of the many recommended components of the plan relating to recreation, circulation or landscaping have yet been implemented, but State Park officials report that the 1970 plan still remains the only planning guidelines for the area. Between 1965 and 1969, Wailua River State Park accounted for almost 20 percent of all state parks and historic site attendance. State Department of Land and Natural Resources statistics for the fiscal year ending 30 June 1981 show this percentage increasing to over 30 percent or about 4,532,000 visits. Sixty-five percent of the visits were made to areas excluding Fern Grotto and Lydgate Beach Park. In 1970, it was estimated that only about 50 percent of the park visitors were from out-of-state.

Very few of the many tropical scenes along the Wailua River (North or South Fork) upstream of Fern Grotto are readily accessible to Park visitors. Ground access to the upper reaches of the river is possible but seldom utilized. No count of visitors is available. The falls is the only and terminal destignation of County Road 583. A turn-around or unimproved parking lot terminates the County Road with space for about 16-20 cars. Based on a short visit to the falls area in August, 1980, it was estimated that 20 cars per hour visit the falls. Assuming 3 passengers per car and 20 cars per hour over an 8-hour visitor day, approximately 175,000 people visit the waterfall each year. It is also estimated that about 25% of the visitors may climb down a forty-foot high embankment to visit the upper falls area during periods of low flow. Another 10 percent or less may climb down the arduous, and unimproved trail to the lower falls area, which lies about 100 feet down a rather precipitous bank. The 1.4 acre pool at the foot of the waterfalls is an occasional swimming place when the flow is low.

Approximately 30 percent of the entire length of the South Fork comprises smallmouth bass fishery under control of the Lihue Plantation Company. This 17 mile stretch of the river is accessible primarily only to plantation workers. Chinese catfish, mosquitofish and guppies are also found there. Several groups of presumed plantation workers and their families were observed in slack-water portions of the upper South Fork swimming in the river and picnicking along its banks. These activities were observed just above the Falls.

The State Park long-range development plan prepared in 1970 recommends construction of a horse stable above the falls, a walkway over the Falls via the old railroad bridge, and a downsteam trail access to the pools beneath the Falls for swimming and picnicking. In the meadow east of the powerplant, a lagoon feature would be provided to combine water-oriented recreational activities, a refuge for wildlife, and a flood control detention basin. None of these features have been provided to date.

The proposed project features would in some cases conflict with the recommended park facilities and in other cases would complement them. Under both structural plans, creation of an enlarged slack-water pool of almost 35.0 acres above the Falls could conflict with the siting of the proposed horse stables near there. In any case, it would be inappropriate to site a horse stable so close to a body of water that could be used for swimming or fishing. There is a possibility that the new impoundment may enhance the existing smallmouth bass fishery.

The recreational smallmouth bass fishery on the South Fork above Wailua Falls will not be adversely affected by the project. In fact, the impoundment area behind the intake structure will enchance this fishery, creating additional preferred habitat and fishing area for bass. As the Applicant does not have the authority to permit access to the diversion impoundment, the State of Hawaii will be responsible for deciding if the public should have access to this impoundment to utilize the improved fishery.

On the North Fork, diversion of water via the stable storm ditch to the South Fork, would result in the loss of smallmouth bass habitat below the diversion. However, total dewatering of the North Fork into the Stable Storm Ditch has historically occurred for extended periods of time. This practice has essentially destroyed the fishery in this stretch of the North Fork. There are significant tributaries below this diversion which recharge the flows into the North Fork.

The project will have short and long-term adverse effects on Wailua Falls, a popular tourist destination. However, flows of 15 cfs or less occur approximately 44% under existing conditions and the Project will actually decrease the number of days that flows in this range will occur. This factor will significantly help to insure that Wailua Falls will still offer a spectactular attraction and will not deter tourism.

Construction and operation of the powerplant near the meadow that is proposed for long-range development as a lagoon by the Wailua River State Park plan could have a disruptive effect on the landscape and recreational activity carried out there. If the park plan is implemented, placement of powerlines and poles across the proposed lagoon would be disruptive.

A construction staging area would not impinge upon the existing visitor parking area but will extend into the adjacent sugar cane lands. Construction related trafffic would not impact the already limited access to the Wailua Falls overlook via the improved cane road. The hydropower generating facility may itself attract visitors. The diversion structure would be situated far enough back from the falls that it would not be visible from the visitor overlook. Similarly, the conduit would be buried and the penstock and power plant situated enough distance below the falls to be hidden from view at the lookout.

Long-term effects on this recreational/aesthetic resource would result from the diversion of water above the falls. The proposed powerplant design would limit plant operation to periods during which the flow exceeds 45 cfs. Flows less than 45 cfs, occurring approximately 60% of the time under present conditions, would not be diverted. During project operation flows over the falls would be reduced to 15 cfs approximately 55% of the time during periods in which streamflows are between 45-380 cfs. The degree of loss of aesthetic appeal resulting from reduction of water flowing over the falls would be difficult to evaluate. However, during periods in which flows are reduced to 15 cfs as a result of the hydropower diversion, the visual impact of the falls would be less spectacular than with greater flows under natural conditions. The Falls were observed during June, 1983 (Figure 4) and April 12, 1985 (Figure 5) when flows were 3 cfs and 8.7 cfs respectively. The Falls still appeared to be quite spectactular and a number of tourists were at the overlook. The Falls were observed on April 12, 1985 with a flow of 8.7 cfs. A photograph of the Falls taken on that date is included for reference. The conservation flow of 15 cfs will be approximately twice the flow shown in the picture. The significance of this impact can be related to the importance of Wailua Falls compared to other scenic waterfalls on Kauai and the other major Hawaiian Islands. The 1978 State Date Book lists 26 major named waterfalls in the State of Hawaii, Kauai having the largest number with eight. Major falls are defined as being at least 250 feet in height. Most of the waterfalls are defined as cascades with the highest on Kauai being Waipoo (800 feet for two falls). The highest sheer-drop waterfall on Kauai is Hinalele. Both falls are not readily accessible by automobile nor can they be easily seen from a distance. The most accessible falls are Wailua and Opaekaa Falls, 160 feet and 120 feet in height, respectively. Both these falls are close to each other and close to hotels in Wailua area. Both falls can be easily observed from overlooks with parking facilities which are part of the Wailua River State Park system. Access to the streambed above and below the falls is available only at Wailua Falls. Only the upper falls streambed can be reached safely. For the island of Kauai, Wailua Falls may be considered the most significant waterfall because of the combination of height, average discharge volume and, most important, accessibility. There are equally spectular falls and cascades on Kauai and other islands, particularly, the island of Hawaii, but most of them must be viewed from at least a distance of several miles or more.

FOREST RESERVE AREA

A corridor approximately 50 feet wide would be subject to selective removal of trees and other high vegetation along the transmission line alignment. Only vegetation that could come in contact with the power lines would be affected. The length of this corridor through the Kalepa Forest Reserve is approximately 2800 feet. A biological survey of the transmission line corridor through the Kalepa Forest Reserve will be conducted prior to construction. Copies of the survey will be forwarded to the affected agencies and their recommendations will be incorporated in the construction plan prior to construction. To reserve the natural appearance of the Forest and to minimize the visual impact of clearing a 50-foot right-of-way, alignment will be angled up and down the ridge so that it can be screened by natural undisturbed vegetation.

The alignment mainly follows an existing irrigation tunnel used by Lihue Plantation Company, Ltd. The proposed transmission line would affect 3.2 acres of Kalepa Forest Reserve Lands mainly in the permanent loss of vegetation and trees within this corridor. This effect is not considered to be significant. The pre-construction archeological survey may determine that portions of the transmission line may require alignment changes to prevent significant adverse effects.

IMPACTS TO DOWNSTREAM WATER USERS

During periods of irrigation needs, total diversion of the North Fork has been made by Lihue Plantation at the Stable Storm Ditch diversion. Downstream water users have made diversions at the Wailua Ditch near elevation 462 and at the Aahoaka Ditch near elevation 400. These lower ditches are supplied with flows from the East Branch North Fork which meets the North Fork near elevation 500 as shown on tables B-6b-9 and B-6b-10 (pages B-62 and B-63). These flows are significant which is why these lower diversions were placed at their respective locations.

During periods of irrigation there will not be sufficient flows for hydropower production under normal cicumstances. Therefore, the total diversion of the North Fork will continue to be made by Lihue Plantation which will not be available for use to downstream water users. They will remain dependant upon the flows from the East Branch North Fork to supply the flows needed for irrigating lower lands. The proposed project will not have significant impacts to water users downstream.

OTHER SOURCES OF NATIONAL OR LOCAL SIGNIFICANCE

Wildlife Refuges

No national or local wildlife refuges occur within the project areas.

Migratory Birds

No migratory bird breeding or nesting habitat is located within or adjacent to the project area.

Scenic and Wild Rivers

None are present in the project area.

National Trails

None are located in the project area.

National Shoreline, Parks or Beaches

None are located in the project area.

Resources and Values Identified in Section 122 of Public Law 91-611

Project related impacts on the environmental resources and values identified in Section 122 of P.L. 91-611 have been fully considered. Potential adverse impacts upon these resources resulting from project implementation are summarized below and in Table E-1.

(1) Air, Noise and Water Pollution. Air, noise and water pollution would be temporary impacts during construction of hydropower facilities. Effects on water quality have been discussed in paragraph a of this section. Minimization of these impacts would be effected by employment of construction methods that do not create excessive dust, hydrocarbon emissions, noise or turbidity. Environmental protection procedures and controls would be included in the project plans and specifications to insure compliance with applicable air, noise and water pollution regulations during construction operations.

(2) Man-made or natural resources, aesthetic values, community cohesion and availability of public facilities and services: The project would not affect man-made resources, community cohesion and the availability of public facilities and services. Project effects on natural resources and aesthetic values have been discussed in the preceding paragraphs of this section.

(3) Employment effects and tax and property value. Adverse employment effects and tax or property value losses would not result from implementation of the project.

(4) Displacement of people, businesses and farms. Implementation of project alternatives would not result in the displacement of people, businesses or farms.

TABLE E-1
COMPARATIVE IMPACTS OF PROJECT ON SIGNIFICANT RESOURCES

·IGNIFICANT ·ESOURCES	WATER QUALITY	AQUATIC RESOURCES	ENDANGERED SPECIES	PRIME AGRICULTURAL LANDS	CULTURAL AND HISTORICAL RESOURCES	RECREATIONAL AND AESTHETIC RESOURCES	FOREST RESERVE
·ase Condition	Lower reaches within Wailua State Park are designated as Class 1a waters under the State DOH Water Quality Stds. Middle and upper reaches of S. Fork Wailua River are Class 2 inland waters protected for fish and wildlife propogation, agricultural and industrial water supply and recreation.	Aquatic fauna above Wailua Falls is dominated by introduced species including small mouth bass and Chinese catfish. Below the falls, a number of native diadromous species occur.	No listed or proposed species known to occur in immediate project area. The endangered Hawaiin coot, gallinule and duck inhabit the lower reaches of the Wailua River.	Lands adjacent to the Wailua River in the the vicinity of the project area are classified as prime agricultural lands.	There are no historic resources listed on the National Register of Historic Places within the proposed project area. Potentially significant historic resources include an old railroad bridge 200 ft. upstream of Wailua Falls and Kaholalele Falls.	Recreational and aesthetic resources in the Wailua River area include a small mouth bass fishery picnic and swimming area within Wailua River State Park and the scenic Wailua and Kaholalele Falls.	The Kalepa Forest Reserve has been classified by the State Division of Forestry as an exotic non-commercial forest, possessing less than 50% native cover. The forest is characterized by exotic trees including naole koa, guava, lantana, Christmas berry and Java Plum. Other introduced tree species, planted for erosion control by the Division of Forestry, include eucalyptus, iron wood, monkey pod and paper bark. Much of the eastern flank of the reserve is grassland.
·ithout Condition	No anticipated change in existing condition.	No anticipated change in existing condition.	No anticipated change in existing condition.	No anticipated change in existing condition.	No anticipated changes in existing condition.	No anticipated change in existing condition.	No anticipated change in existing condition
·ith Project ·ondition	Temporary increase in water turbidity both in the project area and downstream during project construction. No long-term effect on stream water quality.	Temporary increase in sedimentation of stream habitat. Increase in area of pool behind falls of of 35.0 acres as a result of diversion dam. Possible reduction in small mouth bass habitat below the water diversion on 1.7 mi. stream reach. A corresponding reduction in habitat is anticipated along this reach.	No effect.	Approximately 15 acres of prime agricultural land would be disturbed during construction of of the conduit. Lands would be restored to previous use subsequent to completion of the project.	No effect on possible RR bridge. Effects on unknown site along powerline corridor in Kalepa Ridge.	Increase in preferred small mouth bass habitat with potential increase in recreational bass fishery. Possible reduction in bass habitat below the diversion on the No. Fork. Temporary disruption of Wailua Falls viewing area during project construction. Long term intermittent effect on Wailua Falls resulting from hydropower water diversion above falls.	The transmission line alignment ment would require clearing of trees within a 30 foot wide corridor transecting the forest. (Figure 17 Main Report). Areas Areas planted for erosion control would not be affected.

SUMMARY

Major Conclusions and Findings. The proposed project meets the primary objective in alternative energy resources development/conservation, contributing to the transition to an indigenous renewable energy economy. An evaluation of the effects on the discharge of fill material, in accordance with guidelines set forth in Section 404 of the Clean Water Act of 1977, indicates that the site and fill material are suitable for this purpose. No threatened or endangered species or their critical habitat would be affected by the Project. No known cultural resources eligible for or listed on the National Register of Historic Places would be affected by the plans.

The relationship of the alternative plans to Federal and State environmental laws and regulations affecting this study are presented in Table E-2.

Table E-2
Relationship of Plans to Environmental Requirements

Federal Statutes	
Archaeological and Historic Preservation Act	Full
Clean Air Act	Full
Clean Water Act	Full
Coastal Zone Management Act	Not Determined
Endangered Species Act	Full
Estuaries Protection Act	NA
Federal Water Project Recreation Act	NA

Table E-2
Relationship of Plans to Environmental Requirements (Cont)

<u>Federal Statutes</u>	
Fish and Wildlife Coordination Act	Full
Land and Water Conservation Fund Act	Full
Marine Protection, Research and Sanctuaries Act	NA
National Historic Preservation Act	Full
Natonal Environmental Policy Act	Full
Rivers and Harbors Act	NA
Watershed Protection and Flood Prevention Act	NA
Wild and Scenic Rivers Act	NA
<u>Executive Orders, Memoranda, Etc.</u>	
Floodplain Management (E.O. 11988)	Full
Protection of Wetlands (E.O. 11990)	NA
Environmental Effects Aboard of Major Federal Actions (E.O. 12114)	NA
Analysis of Impacts on Prime and Unique Farmlands (CEQ Memorandum)	Full
<u>State and Local Policies</u>	
State Land Use Plan	Full
Coastal Zone Management Program	Not Determined
Federal Coastal Zone Consistency Determination	Not Determined
State Environmental Policy Act	Full
County General Plan	Full

Notes:

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

NA— Not Applicable, there is no requirement for the statute, E.O. or other environmental requirement fot the current stage of planning.

F. ANY PROBABLE ADVERSE ENVIRONMENTAL EFFECTS WHICH CANNOT BE AVOIDED

UNAVOIDABLE IMPACTS

Partial diversion of the stream for hydropower generation would cause a reduction of flow in the South Fork Wailua River between the diversion structure and powerplant tailrace during periods of powerplant operation. This would result in a reduction of aquatic habitat in the affected stream reach. This will also increase the period of time that stream flows over Wailua Falls will be between 15 cfs and 45 cfs. However, flows of 15 cfs or less occur frequently under existing conditions and the proposed project will actually decrease the frequency of flows in this range. An increase in the amount of flows which are to be diverted from the North Fork Wailua River below the Stable Storm Ditch diversion would be realized. During construction, temporary disruption of 56.4 acres of land would occur. The land occupied by major project features such as the diversion structure, area of impoundment and powerhouse location will be permanently withdrawn from their current use.

Temporary impacts would be caused to air quality, water quality and noise levels in the immediate project area due to construction activities, i.e., mobilization and use of heavy construction equipment, clearing of vegetation, excavation in or near the existing river channel and installation of major project components.

Several insignificant but long-term impacts related to periodic use of the area for continued operation and maintenance of the Project are expected.

Increased periods of total diversion of the North Fork will have an impact upon Kaholalele Falls. However, significant flows are contributed by the East Branch North Fork upstream from these falls which will insure that flows will be sufficient for these and other needs downstream.

G. ALTERNATIVES TO THE PROPOSED ACTION

THE WITHOUT-PLAN CONDITION

The "without-plan condition" is the projection of the basic demographic, economic, and physical parameters to the project area. This projection condition is assumed to exist prior to the implementation of the selected plan of improvement and is used to evaluate the effects of each of the alternative plans.

PLANNING CONSTRAINTS

Based on the foregoing analysis of the existing condition and future plans, the without-plan condition is limited by certain planning constraints which may constrain the attainment of the desired levels of economic or environmental output.

The nature of the existing powerplant features and the state of energy technology clearly point to the continuation of conventional fossil - fuel plants for the electrical utility on Kauai. The most likely alternative system will be the utilization of fossil fuel units. This scenario is generally consistent with the evaluation provided by the Federal Energy Regulatory Commission.

The consumption of electrical energy will continue to be a function of the long term economic growth and normal increases in population. However, unless consistent and concerted effort is provided through a combination of personal initiative, normal technological changes, economic elasticity effects, and governmental programs, the overall growth in both peak demand and energy is expected to remain at current projected levels.

The topographic and landform features of the Wailua River basin make large scale dam and reservoir features relatively costly to construct. The general drainage slope although mild by Hawaii standards, is steep enough to limit effective reservoir impoundment. In addition, as demonstrated by the prior State of Hawaii Waialeale study, locating a large structure upstream would not fully control hydrologically significant portions of the drainage area.

Although Wailua River is perennial, and by practical application, one of few commercially navigable rivers in the State of Hawaii, the firm flow is demonstrably low. At the USGS streamflow station 600, the discharge has historically been as low as 1.7 cubic feet per second. Hence, any proposed small hydropower facility would be relatively limited in scope consistent with hydrologic limitations.

The Wailua River watershed is substantially influenced by irrigation facilities, sugarcane lands, agricultural roadways, and other facilities related to the sugarcane industry. The upper elevations are designated conservation lands under ownership and use-control by the State of Hawaii. However, the lower areas above the urbanized strips along existing roadways are largely in active sugarcane production use by Lihue Plantation. Most of the lands under sugarcane operation are under long term lease by Lihue Plantation from the State of Hawaii. Lihue Plantation Company, Incorporated and its parent company, Amfac Incorporated, do not plan to significantly change operations or use of their agricultural lands.

*The following pages, G-1 -- G-29 is information from the U.S. Army Corps of Engineers from their "Final Interim Survey Report and Environmental Statement"

The environmental attributes of the Wailua River basin are highly influenced by man's utilization of the area. Only the headwaters contain heavily forested vegetation relatively secure from human encroachment. Areas below approximately elevation 600 feet (msl) and above Wailua Falls are dominated by introduced vegetation and aquatic organisms. A number of native diadromous species are located below the falls and due to topography limited to lower stream reaches. There are no known endangered species, wildlife refuges, sanctuaries, designated municipal water supply or prime natural recharge areas within the Wailua River reaches affected by the project.

The aesthetic resources include the natural waterway and adjoining lands of the Wailua State Park, and the Opaekaa, Kaholalele, and Wailua waterfalls. The State park reach, especially from the mouth to the famous Fern Grotto has been a popular scenic tourist destination. The Opaekaa Falls is the primary scenic attraction due to its ease of accessibility along State Highway 580. Wailua and Kaholalele Falls although not as popular as Opaekaa, do have significant appeal and potential for scenic development.

Although the Wailua area has been a major center of cultural and political development in ancient Hawaiian times, there are currently no historic properties listed or eligible for listing on the National Register of Historic Places in the potential area of improvement. A cultural reconnaissance survey was undertaken and no cuturally significant remains were found. However, portions of the area contain agricultural terraces which may contain material appropriate for further investigation or preservation.

The economy of Kauai prior to the early 1960's was dominated by the sugar industry. However, during the last two decades tourism has reached a prominent position. Business, labor, and associated commercial enterprises will continue to reflect these two major industries.

Kauai, similar to the islands of Molokai, Maui, and Hawaii, is less populated and more rural in lifestyle and activities than Oahu. Various commercial and private development projects over the past several years have generated public attention and interest. Community sentiment appears, in general, to support the relatively non-urbanized setting and living patterns.

DESCRIPTION OF THE "WITHOUT-PLAN" CONDITION

In summary, the without-plan condition will be considered to consist of the following technical, economic, environmental, and socio-institutional elements.

Technical. The existing mix of powerplant types available to the island's utility will continue and be relatively unaffected by potential new hydroelectric plant facilities. The current patterns of peak demand and rate of growth for both demand and energy will continue at present levels. The existing state of irrigation ditches and diversions will continue at existing locations and rates of flow.

Economic. The economic growth of Kauai will continue to progress at present rates. The major dependent elements will be the progress and contribution of the tourism and agricultural sectors of the economy. The sugar industry will also continue to exist at present locations and extent. Any significant change in the role of sugar is highly subject to individual management decisions by the respective parent companies of the plantations related to worldwide sugar prices and U.S. support. Hence, any projections of decline or expansion of the sugar industry would be speculative.

Environmental. The existing ecological, aesthetic, and cultural resources will continue to exist in the present condition. The flora and fauna will propagate without significant external encroachment and adversity.

Socio-Institutional. The public will continue to value the worth of the scenic and agricultural setting of the Wailua Valley. This perception is especially important in view of the physical and financial aspects of large construction projects. The State of Hawaii (through the Department of Land and Natural Resources) and the County of Kauai as well as the local utility will also maintain their present open and receptive positions regarding construction, energy, and public works endeavors. The Federal government will continue to provide institutional and financial support for new hydropower development.

SUMMARY OF STUDY PROBLEMS AND CONSTRAINTS

In terms of significance of problems and constraints, the following major items must be addressed in the project's impact analysis and contribution to national economic development.

a. Dependence on Petroleum-based Powerplants. The island of Kauai is currently and will, in the foreseeable future be highly dependent on petroleum-based fuels for electrical utility generation. The immediate problem is the alleviation of this dependence such that economic productivity and growth will not be stymied by external oil price fluctuations.

b. Recreational and Aesthetic Resources. The Wailua Falls is one of the attractive recreational and aesthetic resources on the island. It is important to provide power but concurrently to preserve at least a reasonable magnitude of discharge for aesthetic enjoyment.

c. Potential Consumer Impacts. The principal public concern is the potential impact on consumer electric utility rates. This concern is related to dependence on petroleum-based fuels. If the dependence is decreased then the rate of price increase will tend to decline.

d. Federal Participation in Hydropower Development. The potential implementation of the project will be highly dependent on the financial participation by Federal and local interests.

PLAN FORMULATION

MANAGEMENT MEASURES

In any given engineering investigation there exists a wide variety of technical and institutional means to satisfy the project purpose and national objectives. All appropriate measures are to be identified regardless of Corps of Engineers, local governmental agency, or other institutional capabilities. The consideration of various measures should include various opportunities. factors:

a. National Objectives. Measures should be developed which offer significant differences in their contributions to the National Economic Development (NED) and Environmental Quality (EQ) objectives.

b. Structural/Nonstructural Measures. Traditional measures which involve physical modification to the existing natural environment are structural plans. For hydropower projects these measures would normally include dams, waterways, and powerplant structures. In contrast, nonstructural measures are defined as plans which make minimum use of traditional structural measures and also contribute to national objectives. Nonstructural plans are to be fully considered in the development of alternatives.

c. Plans of Other Agencies. Plans of other agencies regardless of jurisdictional control, may offer contributions to the national objectives and should be considered.

d. Other Considerations. Plans may consider changes in statutes and laws or be in compliance with existing laws. Plans should consider effects of reduced water demand or conservation. Mitigation measures are to be included where appropriate. Finally, various implementation schedules are to be considered which would result in favorable mixes of NED and EQ effects.

PLAN FORMULATION RATIONALE

The formulation and analysis of alternative plans were based on the Water Resources Council's Principles and Standards, and related Corps regulations and guidelines. Each alternative was considered on its relationship to technical, economic, environmental, and socio-institutional factors.

TECHNICAL CRITERIA

The following technical criteria were established in the plan formulation process:

a. Any structural features should be designed to withstand the maximum reasonable external and internal loading conditions to minimize failure potential.

b. The improvements should be sized in a manner for efficient utilization of the surface water resources for energy development.

c. Features should be designed to provide for adequate accessibility for operation and maintenance purposes.

d. Electrical generation and tie-in should be compatible with the existing utility system.

e. Any change in flow rate should not adversely affect the existing irrigation operations.

ECONOMIC CRITERIA

To realize economic benefits the following criteria were established:

a. The plans under consideration should, as far as practicable, maximize net NED benefits.

b. The relative benefits and costs should be expressed in quantitative economic terms. The evaluation should be expressed for a 100-year period of analysis and at the current discount rate established for national water resources projects.

ENVIRONMENTAL CRITERIA

The following environmental criteria were established for the plan formulation process:

a. The plans should not significantly disrupt or destroy existing ecosystems within the area of improvement.

b. The plans should not significantly impair the scenic beauty of Wailua Falls through physical structures or major diminution of flow.

c. Any increases in flows along man-made or natural channels should be within reasonable capacity of the facility and not cause failure of banks or significant increase in sedimentation.

d. Potential cultural features exposed or documented through investigation in the area of improvement should be evaluated for preservation or other measures.

SOCIO-INSTITUTIONAL CRITERIA

The following socio-institutional criteria should guide the evaluation of alternative plans:

a. The plans should be consistent with County and State agency plans for the vicinity.

b. The plans should be acceptable to the general public and various interest groups.

c. The plans should be compatible to the maximum extent practicable with existing laws, regulations, and public policies.

POSSIBLE SOLUTIONS

IDENTIFICATION

To effectively undertake plan formulation, all possible measures must be listed regardless of their potential contribution to the national objectives or to the established technical criteria. Preliminary screening was performed to narrow the selection to candidate plans meriting detailed examination. Table 13 lists possible solutions categorized in accordance to the opportunity factors previously described. These solutions are itemized in terms of generalized features and qualitative evaluation without specific quantitative dimensions or impacts. The potential contributions are simply listed in terms of significantly positive (++), positive (+), uncertain (?), negative (-), and significantly negative (--) contributions.

DISCUSSION OF POSSIBLE SOLUTIONS

No Action. In accordance with current Principles and Standards regulations, the alternative of taking no action is to be fully considered in the planning process. In the no action alternative, the future scenario would be no growth in either peak demand or energy consumption. Under this setting, no additional powerplants or conservation measures would be warranted. The basis of this scenario would be essentially a static or declining population and accompanying economic rate of growth. The current projections of Kauai's economy and general planning direction do not support this hypothesis. Hence, no further consideration of this alternative was warranted.

New Fossil Fuel Powerplant. The existing diesel, oil, and gas turbine fueled powerplants will continue to function as dependable energy sources. The local utility has projected that, subject to other developments, new powerplants may be required in 1989 (8 MW) and 1993 (10.0 MW) to meet peak demand and energy growth of the island. As shown in Table 14, the price of Number 2 (diesel) and Number 6 (bunker) oils were fairly stable prior to 1974. However, as a result of the 1973-1974 Arab fuel embargo in 1974, the prices of both fuels took a quantum jump to practically double their former levels. In 1980 the fuel prices rose again sharply such that the prices of No. 2 and No. 6 oils experienced 6-fold and 9-fold increases, respectively, since 1969. As of the end of 1981 the fuel oil price was $28.90 per barrel and that of diesel oil, $41.57 per barrel. Despite the current world oil surplus, the long-term outlook of oil availability and prices do not appear favorable. High dependence on fossil fuel plants will simply be a continuation of high dependence on external and potentially unstable world-wide conditions. Based upon these considerations, it is very desirable that alternative methods of generation be implemented. For the purposes of general evaluation, the current dependable powerplant will be utilized to evaluate the benefits of other systems.

Table 13. POSSIBLE SOLUTIONS

Measure	Opportunity Factors Addressed	Potential Contributions
a. No action	NED objective	--
	EQ objective	--
	Nonstructural	--
	Plans of Other Agencies	--
b. New fossil fuel Powerplant	NED objective	+
	EQ objective	?
	Nonstructural	--
	Plans of Other Agencies	+
c. Electrical interties	NED objective	--
	EQ objective	?
	Nonstructural	+
	Plans of Other Agencies	--
d. Conservation and solar hot water heating	NED objective	+
	EQ objective	++
	Nonstructural	++
	Plans of Other Agencies	++
e. New bagasse powerplant	NED objective	+
	EQ objective	-
	Nonstructural	--
	Plans of Other Agencies	-
f. Wind powerplant	NED objective	--
	EQ objective	-
	Nonstructural	-
	Plans of Other Agencies	-
g. Hydropower retrofitting and development at existing damsites	NED objective	--
	EQ objective	?
	Nonstructural	-
	Plans of Other Agencies	--
h. New conduit hydropower diversion and powerplant	NED objective	+
	EQ objective	?
	Nonstructural	-
	Plans of Other Agencies	+
i. New dam/reservoir and hydropower plant	NED objective	--
	EQ objective	--
	Nonstructural	--
	Plans of Other Agencies	+

Table 14. LIQUID FUEL COST FOR ELECTRICITY GENERATION, KAUAI [1/]

Year	Fuel Oil (No. 6) Cost, $/bbl	Fuel Oil (No. 6) Avg Annual % Growth	Diesel (No. 2) Cost, $/bbl	Diesel (No. 2) Avg Annual % Growth
1969	2.78	--	6.03	-7.5
1970	2.95	6.1	5.88	-2.5
1971	4.11	39.3	6.20	5.4
1972	4.34	5.6	6.21	0.2
1973	4.84	11.5	6.92	11.4
1974	12.21	152.3	12.57	81.6
1975	11.50	-5.8	14.10	12.2
1976	11.96	4.0	13.96	-1.0
1977	12.57	5.1	16.28	16.6
1978	12.69	1.0	16.58	1.8
1979	16.23	27.9	23.96	44.5
1980 2/	24.21	49.2	35.53	48.3
1981 2/	28.90	19.4	41.57	17.0

1/ Average price of fuel consumed during calendar year. Sources 1969-1979: State of Hawaii, OPED. Hawaii Integrated Energy Assessement. Vol IV, Honolulu: 1980.

2/ Sources: Hawaii, State of, Public Utilities Commission. "Annual Report of Kauai Electric Division of Citizens Utilities Co." for years ending December 31, 1980 and December 31, 1981.

Electrical Interties. The Kauai Electric Division system is completely self-contained within the island of Kauai. The utility is one of the two smaller utilities in the state, the other being Molokai Electric Company. The remaining systems in the islands of Oahu, Maui, Lanai, and Hawaii are controlled by the larger Hawaiian Electric Company (HECO). Kauai Electric, as a result, does not have financial and institutional ties to the other islands' utilities.

Technically, submarine high voltage power cables to the depths required between islands are still in the developmental stage. To date (June 1981), the deepest high voltage direct current cables are deployed in water depths of 1,800 feet. The depths of Kauai Channel between Oahu and Kauai is deepest among all the major Hawaiian Islands, down to 10,800 feet and would have to be 73 miles (at the water surface) long. Plans are currently underway to initiate a $12.4 million feasibility study to investigate intertie between the islands of Hawaii and Oahu. The maximum depths would be 7,500 feet and a distance of 150 miles. The technical difficulties of structural/mechanical stresses, water tightness, sheathings, and conductors have not been resolved for very deep cables. Due to the institutional and technological problems and potential enormous cost (on the order of $1 million per mile)[1/] this potential solution would not be considered further.

1/ Hawaii, State of, OPED. Hawaii Integrated Energy Assessment Vol II. Honolulu: 1981.

Conservation and Solar Hot Water Heating. Conservation measures, including solar hot water heating, have received considerable publicity, commercial advertising, and government support. The encouragement of energy conservation has been one of the pillars of the national energy programs since the President's address to Congress of 20 April 1977 and has been adopted as one of the evaluation criterion in the Other Social Effect (OSE) account of Principles and Standards.

Outside of existing biomass (bagasse-fueled steam plant) and hydropower alternative energy sources, the other existing technology which will significantly contribute to Kauai's electrical system is solar energy. Although ultimately all sources of energy are directly or indirectly attributable to solar radiation, the three principal categories of solar technologies are solar thermal energy conversion (STEC), photovoltaic (PV) conversion and solar collector/heat exchange systems. STEC systems are large, centralized power facilities which include collectors, thermal storage, and turbogenerators. The PV conversion system utilizes direct conversion of solar energy to electrical current when sunlight strikes semiconductor cell devices. The economic application of either solar thermal energy conversion or photovoltaics in Kauai is estimated to be approximately 10 years in the future. Significant technological development and marketing techniques still remain. Hence, no further discussion of these two categories of solar technologies will be presented.

The remaining solar technology applicable for Kauai is solar collector/heat exchange. Solar hot water systems have been highly accepted systems in Kauai as well as other Hawaiian islands. Unlike STEC and PV systems, solar hot water systems do not generate electricity, are consumer/conservation oriented and are decentralized and not directly controlled by the central utility entity. The system consists of flat plate collectors, liquid heat conductor elements, thermal storage and backup alternative thermal heating element.

Energy conservation is expected to make significant contribution to increasing the State's and Kauai's energy independence. Conservation will enable the island to consume petroleum fuels at a slower rate and serve as a partial moderator until effective alternative energy technologies are implemented. The qualitative evaluation of opportunity factors suggest that this potential solution does offer potential as a viable solution. Additional discussion is contained in the following section.

New Bagasse Powerplant. Bagasse is the fibrous material remaining after the extraction of juices in sugar mill operations. This waste product is the plantation's main source of fuel. The gross heat value of bagasse fiber is 3,350 Btu/lbs and roughly 1 ton of bagasse will produce as much steam as 1 barrel of number 6 fuel oil when both fuels could be burned in the same boiler. Historically, because the electric utility system on Kauai originated from the sugarcane industry, bagasse-fueled powerplants have continued to be a significant energy source. In 1980, prior to the implementation of the new Lihue Powerplant, bagasse contributed 78 million kwh, islandwide, of which 18 million kwh 1/ was sold to Kauai Electric Division (KED). This sold energy amounted to 8.4 percent of the total electrical energy supplied by the utility.

With the rise in high petroleum cost and receptiveness of the public utility to price negotiations for bagasse-fueled energy, bagasse has risen in importance. The most significant development stemming from the new financial scene, has been the completion of the Lihue Plantation's 20 MW boiler. The plant was the largest single construction project on the island of Kauai, completed at the end of 1980 with base cost of $25 million. The 1981 impact of this single project was that the bagasse-fueled contribution on the island rose to 146 million kwh, of which 73 million kwh 1/ sold to Kauai Electric. This added energy increased the bagasse contribution to the electric utility to 33.3 percent. Including the use of boiler fuel oil, the new Lihue powerplant produced 99.8 million kwh in 1981. As a result, the older 10 MW Lihue units installed in 1939, 1949, and 1957 have been essentially shutdown. Although the implementation of the Lihue powerplant provides a lead step in the direction of energy self-sufficiency for Kauai, the contribution of new bagasse power facilities remains uncertain.

The future of bagasse-fueled power is highly dependent on the long term and economic well-being of the sugar industry in Hawaii. All 14 sugar companies in the State are either wholly- or partially-owned subsidiaries of five major agri-business corporations: C. Brewer, Ltd.; Castle and Cooke, Inc.; Theo. H. Davies, Ltd.; Alexander and Baldwin, Ltd.; and Amfac, Inc. The sugar companies own interest in the California and Hawaiian Sugar Company (C&H) which refines and markets almost all (96 percent) of Hawaii sugar at its Crockett, California refinery. Hawaiian sugar plantations supply approximately 10 pecent of the nation's sugar needs. On the island of Kauai, sugar is by far the dominant agricultural crop, totalling 45,600 acres out of approximately 48,000 acres or 95 percent of agricultural acreage. 2/ The extent of sugar lands is shown on Figure 14A. However, considering the 22-month sugarcane growing cycle, the actual 1981 harvested area totaled 21,800 acres. Although over the past 20 years statewide sugar yields and acreages have remained relatively constant there have been ominous signs of economic problems. In recent years three planations have closed operations (Kahuku on Oahu, Kilauea on Kauai, Kohala on Hawaii) and one has been scheduled for closure in 1984 (Puna on Hawaii).

1/ Excludes contribution of boiler fuel oil.

2/ Hawaii, State of, Department of Planning and Economic Development. The State of Hawaii Data Book, 1982. November 1982.

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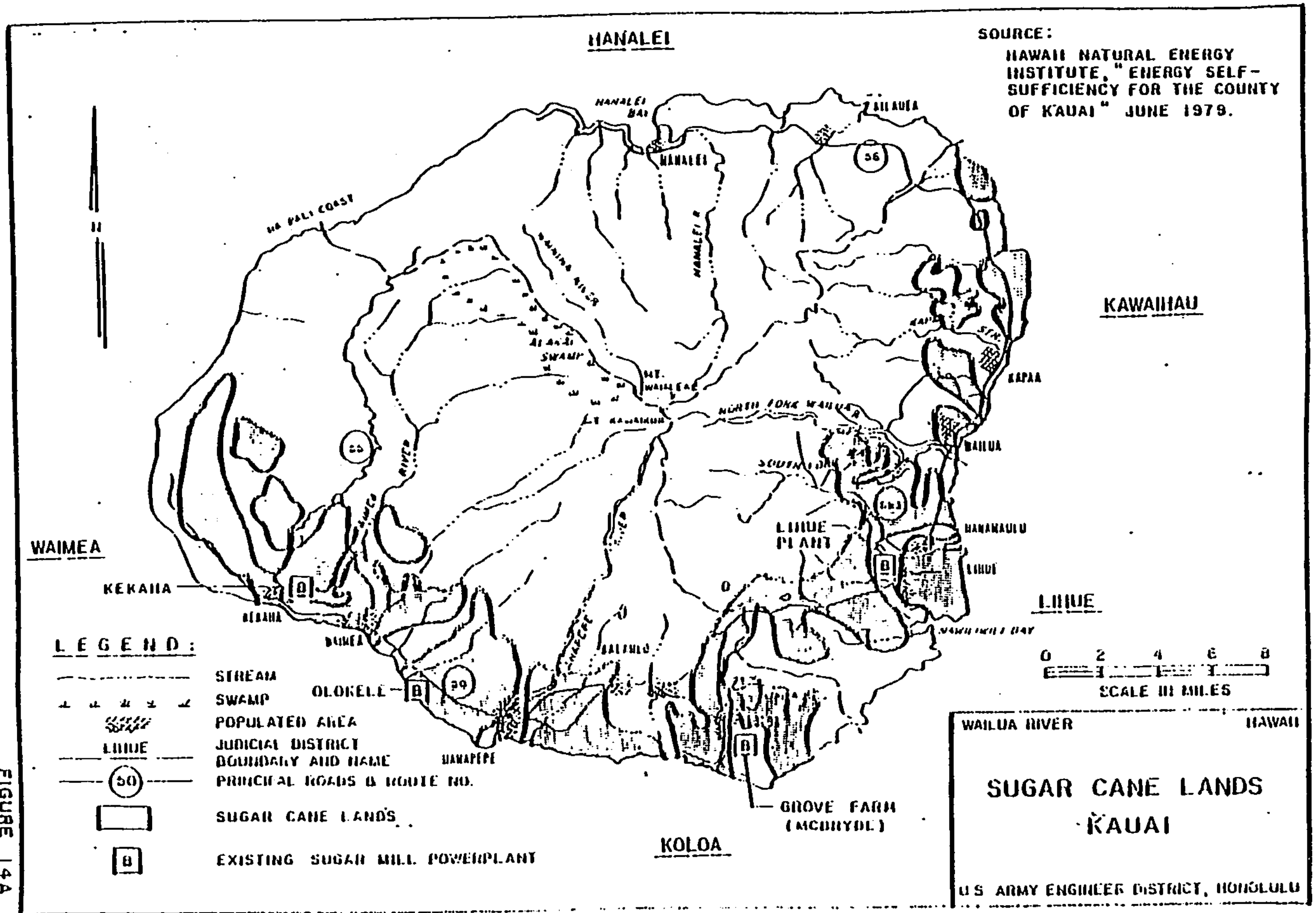

HANALEI
SOURCE:
HAWAII NATURAL ENERGY INSTITUTE, "ENERGY SELF-SUFFICIENCY FOR THE COUNTY OF KAUAI" JUNE 1979.
HANALEI BAY
HANALEI
KILAUEA
56
NA PALI COAST
HANALEI R
ALAKAI SWAMP
MT. WAIALEALE
NORTH FORK WAILUA R
SOUTH FORK
KAPAA
WAILUA
KAWAIHAU
HANAMAULU
LIHUE
LIHUE PLANT
NAWILIWILI BAY
LIHUE
WAIMEA
KEKAHA
WAIMEA RIVER
HANAPEPE
OLOKELE
50
KALAHEO
GROVE FARM (MCBRYDE)
KOLOA
0 2 4 6 8
SCALE IN MILES
LEGEND:
STREAM
SWAMP
POPULATED AREA
LIHUE JUDICIAL DISTRICT BOUNDARY AND NAME
50 PRINCIPAL ROADS & ROUTE NO.
SUGAR CANE LANDS
B EXISTING SUGAR MILL POWERPLANT
WAILUA RIVER
HAWAII
SUGAR CANE LANDS
KAUAI
U.S. ARMY ENGINEER DISTRICT, HONOLULU

FIGURE 14A

In retrospect and potentially in the future, several factors will both restrict and endanger the Hawaiian sugar industry. First, there are continued urban pressures upon the land. Several plantations are relatively close to urban areas (e.g., Oahu Sugar Company on Oahu, Pioneer Mill on Maui, Lihue Plantation on Kauai). Higher use and worth of lands may eventual cause the plantations to grant the development rights or to divest themselves of unprofitable lands. This may lead to decreased productivity and adverse economic scale effects for the remaining lands. Second, labor cost in Hawaii for sugar production are among the highest in the world. Unlike most mainland United States sugarcane workers, field and factory hands are unionized. In 1981, the industry-wide average annual wage was $16,700. 1/ Third, the sugar industry has been subject to considerable uncertainty in world sugar prices. Most sugar-producing countries trade in controlled markets stabilized by government ownership, tariffs, subsidies, and related methods. Since 1950, the world's sugar prices fluctuated from 4¢ to 42¢ per pound and sugar is acknowledged as the most volatile of 40 major commodities on the international market. 2/ Although the U.S. sugar market currently is price controlled, there remains the danger of reverting to the "free" market, subject to strong price fluctuations. Hence, the sugar industry lobby keeps abreast of possible adverse Congressional action.

Partially due to adverse prices, Hawaiian sugar industry has suffered dramatic losses. In 1981, the industry lost an estimated $83.5 million, of which Kauai's loss was approximately $22 million. In the seven-year period from 1976 through 1982, the industry has had five years of losses. 3/ The net result in planning has been general conservatism and reluctance for costly capital and land improvements.

Bagasse production is not, a course, the principal purpose of the sugar industry. The sugar industry has no projection of bagasse quantities. However, in analysis of the past production and availability of bagasse will provide insight on its future energy production. As shown by Table 14A and Figure 14B, there has been a slight decline in bagasse production since 1973. An important trend has been the decline in the quantity of discarded bagasse. This apparently reflects a greater utilization of bagasse for the plantation's powerplant. Assuming the harvested acreage of Kauai sugar industry remains relatively constant, the net long-term annual value of discarded bagasse amounts to less than 1 million kwh. The sugar industry on Kauai is effectively utilizing its bagasse resources. In fact, during 1981 only one plantation disposed of excess bagasse.

1/ Hawaii, State of, Department of Planning and Economic Development. The State of Hawaii Data Book, 1982. November 1982.

2/ Hawaii, State of, Department of Planning and Economic Development. Hawaii's Sugar Industry. April 1981: Constant 1979 dollars cited.

3/ Honolulu Star Bulletin. "Hurricane Iwa Intensifies Plight of Sugar" 1 December 1982.

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Table 14A. HISTORICAL BAGASSE PRODUCTION, ISLAND OF KAUAI

Year	Bagasse Production, 1,000 Wet Tons: Total 1/	Discarded 2/	Energy Value of Discarded Bagasse, million kwh 3/
1973	674	27	3.2
1974	665	27	3.2
1975	657	30 1/	3.6
1976	614	20	2.4
1977	610	20	2.4
1978	628	32 1/	3.8
1979	621	20	2.7
1980	585	2 1/	0.2
1981	663	6 1/	1.4
1982	608	4	1.0

1/ Actual data derived from Hawaiian Sugar Planter's Association and individual plantations.

2/ Estimated except as noted.

3/ Computed.

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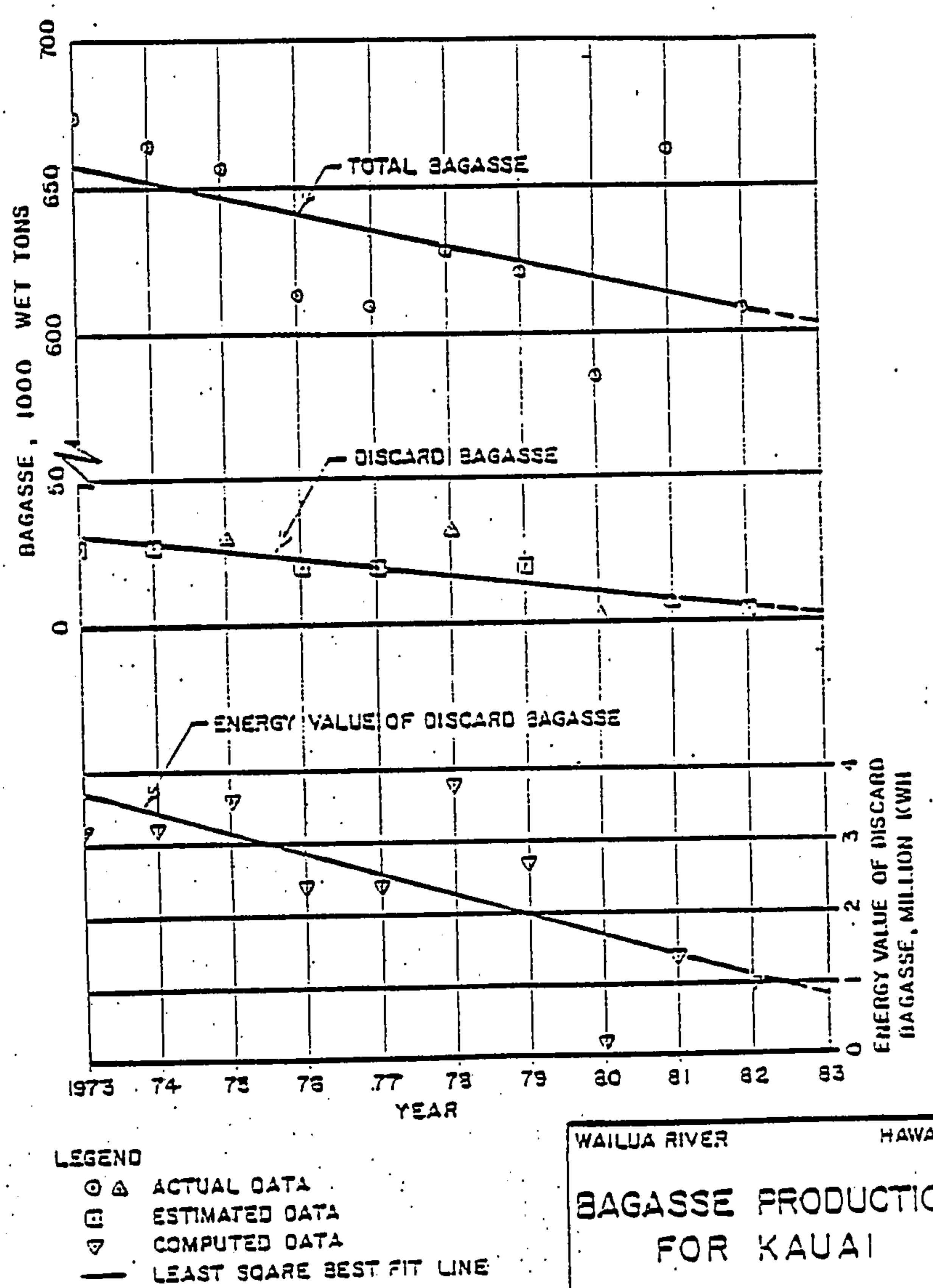

WAILUA RIVER HAWAII

BAGASSE PRODUCTION FOR KAUAI

U.S. ARMY ENGINEER DISTRICT, HONOLULU

FIGURE 148

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The potential contribution of bagasse-fuel power on Kauai remains relative constant. The Hawaii Integrated Energy Assessment 1/, the latest comprehensive analysis of the State's energy needs has projected a constant capacity and energy contribution of plantation steam plants (utilizing both bagasse and oil) under the baseline scenario. In the projection condition, it is recognized that bagasse production could be increased by growing high fiber sugar and utilizing marginal lands for fiber production. However, this would effectively alter the entire goal of the plantations from sugar production to fiber production, a change of far reaching consequences that no one is prepared to support at this time.

The Lihue 20 MW powerplant has undoubtedly been beneficial to all interested concerns. The powerplant was implemented by favorable institutional arrangement between Foster-Wheeler Corporation (the manufacturer), Lihue Plantation/Amfac (processing plant and land owner), and Kauai Electric Division (utility). The Foster-Wheeler Corporation, one of the nation's largest boiler manufacturers, financed, built, and are the owners of the steam plant. In return for the investment, they will receive income from the energy produced from the plant over a 20-year period. Lihue Plantation provided the site location, would operate the plant, and would share in electric revenues beyond the minimum 55.6 million kwh of energy. Kauai Electric would pay for the energy produced and control the plant operation to match the load. The KED contract was signed for a 20-year period and provided an escalated rate of energy prices depending upon the sugar grinding seasons, consumer price index, and price of oil at Port Allen. The total base cost of $25 million did not include the existing bagasse house, nor included the implementation of an improved conveyor system, cooling tower, and wet stack scrubbers which would add an estimated $3.3 million. 2/ When escalated to the October 1982 price level (from the base price level of October 1978), and including the effects of economic worth of lands and interest during construction, the investment cost would increase to $42.7 million, or $2,100 per kilowatt of capacity. If the plant were down sized to a comparable small hydropower plant of 5 megawatts, the high fixed cost would boost the unit cost up to $5,400 per kilowatt. This unit cost is not favorable when compared with hydropower facilities.

Due to economies of scale, it would be infeasible to install small modular boiler turbo generators unless the excess low pressure steam were marketable in addition to the energy sales. Rehabilitation of existing steam generators has been considered by several plantations. However, because of uncertain economic future of the industry the plans have not progressed beyond concepts.

1/ Lawrence Berkeley Laboratory, University of California and State of Hawaii, Department of Planning and Economic Development, Hawaii Integrated Energy Assessment. Vol. I, June 1981.

2/ Personal communication with officials of Foster-Wheeler, E. E. Black, and Amfac. May 1983.

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Finally, the implementation of the Lihue powerplant may be considered practically unique in its institutional setting amidst a favorable economic climate. The financing of such a large private endeavor requires the availability of funds (as in Foster-Wheeler case), feasibility of improvements at an existing sugar plant (as with Lihue Plantation), receptiveness of the local utility (Kauai Electric) and accompanied by governmental approvals (State Public Utilities Commission and the US Environmental Protection Agency). A related project on Oahu, formerly known as Honolulu Program of Waste Energy Recovery (H-POWER), designed to extract energy from solid municipal waste has met significant political and social opposition and uncertainty for the past two years. There would also be a large risk of hurdling the financial, institutional, and social elements for a similar biomass powerplant on Kauai.

In summary, the factors of the uncertainty of the sugar industry, the effective negligible quantities of additional bagasse, the relatively high fixed cost of comparable bagasse-fuel powerplant and the unlikely repetition of a financial/institutional arrangement similar to the Lihue powerplant, makes the implementation of the new bagasse power system improbable for the near future. For these reasons, the bagasse system was deleted from further consideration.

Wind Powerplant. Wind power has historically been in use since the 14th century for irrigation, pumping, and grinding grain. However, in recent times most technical programs were phased out with the advent of inexpensive gas and oil fuels. By the early 1970's with the shortages of cheap petroleum, developmental programs were resurrected by leading industrial nations. From FY 1977 to FY 1983 the US Department of Energy (DOE) had been authorized almost $300 million for various programs for demonstration and commercialization of wind energy conversion systems (WECS). 1/ In the State of Hawaii, the principal result has been the data acquisition, construction experience, and performance study of the joint DOE/Hawaiian Electric Company 0.2 megawatt MOD-OA model turbine located at Kahuku, island of Oahu. From May 1980 to November 1981, the unit had generated 1.2 million kilowatt hours and registered a plant factor of 46.3 percent.

With this increase emphasis on alternative energy systems, estimates of wind regimes power potential throughout the State have been prepared. According to estimates prepared under the Hawaii Integrated Energy Assessment (HIEA) program, Kauai would achieve significant wind generating capacity by the year 1995 2/. Under the baseline future scenario ("Future I"), as much as 22 megawatts of capacity and an additional 77 million kilowatt hours of energy would be possible. Prior to 1995, the wind contribution would be negligible. Admittedly, the "potential" for wind power is not well defined and must be tempered with the knowledge of other considerations.

The wind environment on Kauai is not as advantageous compared to other counties. For example, based on the same HIEA projection condition, for Honolulu, Maui, and Hawaii counties the wind potential would be 370 megawatts, 82 megawatts, and 51 megawatts, respectively. The key factors related to favorable siting are high mean wind speed, minimal local turbulence, reliable wind turbo-generating hardware, available and institutionally approved lands, proximity of high voltage transmission lines, and construction accessibility. These factors are very site and project specific. However, generalizations may be inferred from a locational analysis of mean wind speed. To implement a feasible utility-type WECS, mean wind speeds of 15 miles per hour are desirable. As related to wind power densities, a site should be located in wind power classes 6 or 7 (at 10 meters in height). On Kauai, as shown by Figure 14C, there exists only two suitable small areas, one located near Kilauea and the other at Poipu. In contrast, on the island of Oahu, the entire Koolau mountain range, Waianae mountain range and the Kokohead areas are designated within these classes. The islands of Molokai and Hawaii also have similar favorable, large areas.

With the incentives of Federally-funded research and development, energy tax credits, and competitive marketing by numerous wind turbine manufacturers, there have been a number of WECS installed throughout the State. Despite the optimistic forecast, none have been installed as either part of an island's utility system or which would provide capacities approaching utility application (equal or greater than 0.1 MW). The cumulative total capacity of all small scale WECS, installed Statewide, is approximately 1.5 MW. The

1/ Personal Communication. U.S. Department of Energy, Honolulu Area Office. May 1983.

2/ Lawrence Berkeley Laboratory, University of California and State of Hawaii, Department of Planning and Economic Development. Hawaii Integrated Energy Assessment. Vol I, June 1981.

largest facility planned to date is an 80-megawatt windfarm located near Kahuku, Oahu. The proposal has been delayed since development plans were initiated in 1979 due primarily to lack of a satisfactory turbine system. The target unit cost is $3,500 per kilowatt of installed capacity. In terms of location, the Kahuku site is the only one in the State suitable for large wind turbines (equal or greater than one megawatt, each) 1/.

The only commercial WECS installation on the island of Kauai is a 10 kilowatt Jacobs unit located at the Dairy Queen, Eleele. The wind powerplant, completed in July 1982, has averaged 57 kwh per day or at a 24 percent plant factor. The actual installed unit cost was $3,800 per kilowatt. 2/ There are no other wind powerplants on Kauai under construction or in known planning stages.

Among the wind turbines on the market, only a few equal or exceed 100 kilowatts in capacity. In fact, among 85 models identified by the State of Hawaii as commercially available, only five models are 0.1 MW or greater in capacity. 3/ The turbine for the Kahuku Windfarm previously described has not been selected because of performance problems. The state-of-the-art does not appear to be yet at the stage for practical large scale utility application.

Finally, the implementation of WECS is extremely dependent on continuation of government incentives. Currently 35 percent of the cost can be written off as tax credits (15 percent Federal alternate energy credit, 10 percent State alternate energy credit, 10 percent capital investment tax credit). 3/ The individual investor obviously considers these credit essential for project's financial feasibility. If the Federal tax credits are allowed to terminate on the scheduled expiration date of December 1985, the planning and implementation of WECS would be adversely affected.

Based upon the above, wind powerplants on Kauai will not be significant for the utility system nor would be implemented on a wide scale in the near future. In comparison to other islands in the State, Kauai has relatively low wind potential. Investors and businessmen would naturally look to other places before considering Kauai (such as Kahuku on Oahu, east Molokai, and Kohala/Waimea on Hawaii). The turbo-generator hardware has not been sufficiently developed for practical electrical utility application. With large units, performance becomes critical and is compounded by potential problems in construction and maintenance. The cost also appears relatively high compared to hydropower systems. Excluding government credits, the current range of cost appears to be $3,000 to $4,000 per installed kilowatt of capacity, well above the unit cost of a hydropower plant. The uncertainty of continued tax credits also casts a cloud on future implementation. As a result of these findings, the wind powerplant was deleted from further consideration.

1/ Personal communication with Mr. Thomas Morton, Project Manager, Wind Farms, Ltd. April 1983.

2/ Personal communication with Mr. Doug Cravalho, Manager, Dairy Queen, April 1983.

3/ Hawaii Natural Energy Institute, University of Hawaii. Guidebook on Wind Energy Conversion Applications in Hawaii. 2d Ed. Dec 1982.

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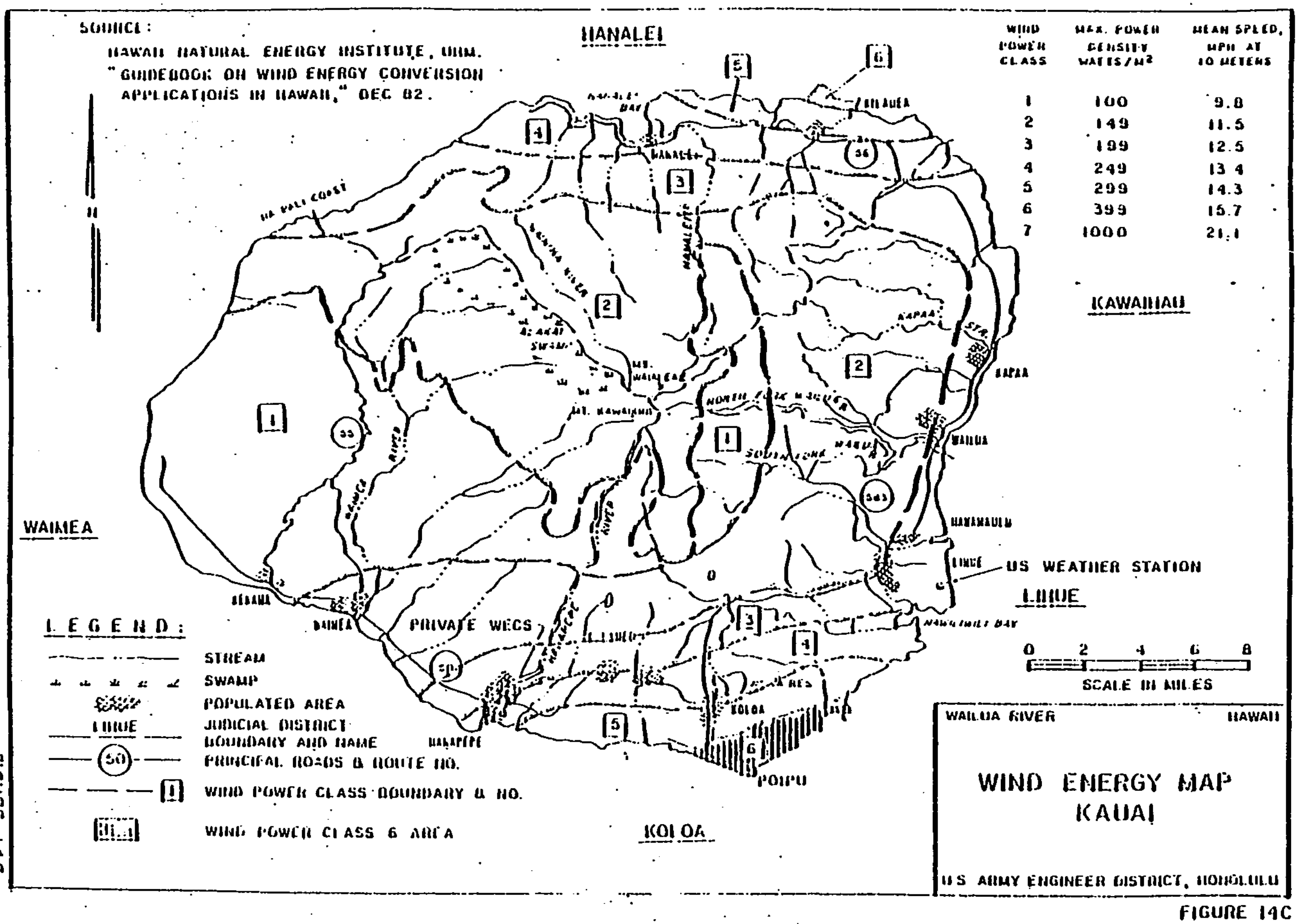

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FIGURE 14C

Hydropower Retrofitting and Development at Existing Damsites.

In Kauai, similar to other areas of the United States, there exists a significant number of non-Federal dams being subject to evaluation in accordance to the National Program for Inspection of Dams (Public Law 92-367). The program investigated dams 25 feet or more in height or dams with impoundment capacity of 50 acre-feet or more. A total of 52 dams were categorized for Kauai, all of which are either currently or were historically used by the sugar industry for irrigation. All dams are of the earth-fill type and all except five were constructed during the period 1890 to 1932.

Among the Kauai dams, Alexander Dam, located on the Wahiawa Stream in the Koloa district, is the only facility with a hydropower plant. The dam, under the ownership of McBryde Sugar Company, is an earthfill structure with a height of 119 feet and a reservoir maximum capacity of 2,500 acre-feet. The powerplant is located approximately 8,000 feet downstream of the dam. Water is conveyed via open channel through a forebay and down a 5,000-foot, 30-inch steel penstock.2/ The installed capacity is 1.0 MW and the average annual energy produced is 2.1 million kwh. The parent company of McBryde Sugar, Alexander and Baldwin, indicates there are no major plans for major retrofitting at the existing Alexander Dam.

Under the Corps' National Hydropower Study conducted during the period 1978-1980, the analysis of Kauai sites revealed only one other existing damsite which had hydropower potential. The Koloko Reservoir located on a ditch near Kilauea, Kauai, was formerly an irrigation facility of the defunct Kilauea Sugar Company. However, a 70 kw potential capacity was judged to be incrementally too small for an effective powerplant.

Finally, based upon the U.S. Department of Energy's Program Research and Development Announcements and Feasibility Study and Licensing Program the State of Hawaii Natural Energy Institute (HNEI) and the U.S. Department of Energy attempted to elicit responses from existing dam owners to apply for hydropower assistance. Material and coordination during the period December 1977 to June 1979 did not result in any application for assistance from any Kauai dam owner. As a result of the above findings, it appears that there exists no significant potential for retrofitting or developing incremental hydropower of existing damsites in Kauai.

1/ Hawaii, State of, OPED. Hawaii Integrated Energy Assessment. Vol II. Honolulu: June 1981.

2/ U.S. Army Corps of Engineers, Pacific Ocean Division. "Phase I Inspection Report on Alexander Dam" Honolulu: June 1978.

New Conduit Hydropower Diversion and Powerplant.

Stemming from renewed interest in hydropower since 1977 various Federal agencies including the Corps, the Department of Energy and the Federal Energy Regulatory Commission have implemented combinations of studies, grants, new regulations, technical documents, and demonstration projects which address small scale hydropower facilities. In general, the advantages of conduit systems as compared to other energy technologies are:

a. Less massive physical modification and disturbance to natural conditions.

b. Minimal utilization of prime lands available for industry, agriculture, or urban development.

c. Less initial capital expenditures than large hydropower or new thermal plants.

d. Minimal development or technological advances required.

e. Institutional frameworks already established for governmental review and evaluation processes.

Prior studies performed by the Corps during the period 1970-78 under the same study authority included the South Fork Wailua River as a prime suggested study site on Kauai. The Wailua River also had been subject of study in 1978 with the State of Hawaii's Waialeale Hydropower Study. Finally for the Reconnaissance Study conducted under the current investigation, a potential conduit system appears in the realm of feasibility. Early results of the reconnaissance indicated capacities in the ranges of 2 to 11 MW and annual energy products of 4 to 25 million kwh depending on the scope of improvements.

New Dam/Reservoir and Hydropower Plant. A dam and reservoir system consists of a dam to store water, outlet structures to regulate flow, and powerplant. The powerplant may be located at the base of the dam or further downstream to obtain the necessary head. Power generated by a dam and reservoir system is generally dependable provided there is sufficient reservoir storage capacity. Storage type hydropower facilities have been previously proposed for Kauai for the Kokee (1964) and Waialeale (1978) studies. Both facilities although based on multipurpose benefit evaluation, were financially costly. Due to insufficient flows both facilities also required very long penstock to develop the power. The Waialeale project was estimated to cost $72 million (1978 prices) with a resulting benefit-to-cost ratio of 0.3.

For Kauai and the Hawaiian Islands in general, erosion has changed the topography of the islands from huge, gently sloping volcanoes to dissected and incisioned cliffs, valleys and basins. The topography of many of the drainage areas is characterized by relatively steep stream courses and steep, rugged basaltic formations. As a result, the streams generally do not meander and traverse through alluvial areas. Characteristic of Hawaiian topography impoundment of significant volumes for stable hydropower releases would require very massive dam structures. Combined with relatively low rates of streamflow, the generalized conclusion is that dam and reservoir projects would be very difficult to economically justify and finance. For these reasons, this potential solution was deleted for further consideration.

ALTERNATIVES TO BE CONSIDERED

The analysis of generalized alternatives indicated potential solutions worthy of further consideration are conservation/solar hot water heating and conduit hydropower. Each of these alternatives would provide contributions to meet the energy demands of the island. The quantitative contributions to the national objectives are the subject of the detailed evaluation and are contained in the following report section.

ASSESSMENT AND EVALUATION OF DETAILED PLANS

Based upon the results of the preliminary screening process, one basic final structural concept and one nonstructural concept were designated for detailed assessment and evaluation: conduit hydropower and conservation/solar.

EARLY FORMULATION EFFORTS

STATEWIDE STUDY

Prior to the initiation of this site-specific Wailua River study, the Corps conducted a statewide hydropower investigation under the same study authority during the period 1977-78 (as referenced on page 5, Main Report). In the early site identification process, 59 US Geological Survey stream gage sites on the island of Kauai were briefly evaluated for hydropower potential. In view of the ongoing State of Hawaii study of a large dam and reservoir complex in the same basin (Waialeale study), the Wailua basin was not selected for further investigation. Sites on Kauai which were considered in intermediate planning studies were in the Hanalei, Wainiha, and Lumahai river basins. Principally due to the prevailing evaluation method of not considering relative fuel cost escalation, all sites in the state, including on Kauai, were considered economically infeasible. The study was discontinued in October 1978.

ISLAND OF KAUAI SITES

Identification of Sites. The island of Kauai, as explained in prior sections, constitutes a single electrical utility area. Hence, to contribute to energy development, it was necessary to consider hydropower development on an island-wide basis. Among the 59 stream gage sites itemized under the state-wide hydropower study, only a fraction has been considered or identified from various studies for hydropower improvements. Many of the high potential areas have previously been investigated or currently under study by non-Federal interests. Other areas would be limited by significant environmental/social or institutional considerations. The potential types of hydropower improvements (retrofitting, new conduit, new dam/reservoir) and their applicability for Kauai were discussed in the prior section.

An early hydropower report for the State of Hawaii was published by the Bureau of Power (currently the Federal Energy Regulatory Commission) in 1968. At that time, there were two potential sites identified, at Wainiha and at Kokee, totalling 35 megawatts in capacity. Since the Arab oil embargo in 1974 and the passage of the Public Utilities Regulatory Policies Act (PURPA) in 1978, there has been a greater interest in the investigation of hydropower sites throughout the State. Based upon all available sources of information, a tabulation of sites is summarized in Table 14B. The site inventory combines the information shown in Tables 9 and 10 and Figure 14. The 19 drainage areas constitute all previously designated potential hydropower drainage areas.

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TABLE 14B. EXISTING AND POTENTIAL HYDROPOWER SITES ON THE ISLAND OF KAUAI

1 Watershed 1/ / River or Stream	2 Existing Hydro in River Basin	3 4 Project Name of Potential or (Existing) Hydro 2/	5 References 3/	6 Type of Project	7 Potential Power (Incremental)	8 Potential Economic Feasibility	9 Potential Environmental Impact	10 Land Ownership	11 Implementation Institution	12 Potential Federal Interest 5/
						Assessment of Potential Hydro Project 4/				
1. Hanalei: Kalalau to Anahola										
Wainiha River	E	(Wainiha)	3,4,7-10,17,19	C,P	M	P	H	P	P	H
Lumahai River	-	-	9,7,10,17,19	C	H	P	H	P	-	H
Hanalei River	-	-	9,7,8,10,15,19	C,D	M	P	H	S	-	H
Halaulani Stream	E	(Hanahana Farms)	-	-	-	-	-	P	-	-
Puu Ka Ele Stream	E	-	17,8	C	L	H	L	P	-	H
		(Kauai Papaya)	17	C	L	-	L	P	-	H
Anahola Stream	-	Rancho Hydro	16,8,11,17	C	L	P	L	P	P	H
2. Lihue: Anahola to Nawiliwili										
Kapaa Stream	-	-	17,8	C	L	H	L	S/P	-	H
Wailua River	-	Wailua River	18,7-10,15,17	C	H	P	H	S/P	P	P
	-	Waialeale	1,7,8,15	D	H	H	H	S/P	S	H
Hanalei Tunnel	-	-	9,7,10	C	H	H	L	S	-	H
Waiahi Stream	E	(Lower Lihue & Upper Lihue)	2,12	R	H	H	L	P	P	H
Hanamaulu Stream (Kapaia Res)	-	-	15	R	L	-	L	P	-	H
3. Koloa: Nawiliwili to Hanapepe										
Wahiawa Stream	E	(Alexander Res)	-	-	-	-	-	P	-	-
Hanapepe River	-	-	17,8	C	L	H	H	P	-	H
4. Waimea: Hanapepe to Waimea										
Makaweli River	E	(Hydro Kaumakani)	13,3,15,17	R	L	P	L	P	P	H
Waimea River	E	(Waimea)	15,8,17	R	H	-	L	S	-	H
Kokee Ditch	-	Kitano, Puu Lua	14,7,9,10,15,17	C	H	P	H	S	P	H
Koaie Stream	-	-	17,8	C	L	-	-	S	-	H
Kawaikoi Stream	-	Kokee	4,4,15,17	D	H	H	H	S	S	H
	-	Puu Opae-Mana	12	C	H	H	H	S	S/P	H
5. Kekaha: Waimea to Kalalau										
Kahoana Stream	E	(Waiawa)	2,12	R	L	P	L	S	P	[illegible]

Footnotes to Table 14B

1. Major watersheds in accordance with reference 5. Areas cited described from north Kauai counter clockwise around island.
2. Names of existing hydropower facilities shown parenthetically. Names are shown for potential projects in which implementation institution [illegible].
3. First cited reference is principal or primary reference for potential project. See reference list below.
4. See legend below
5. For narrative reason see Table 14C.

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LEGEND TO TABLE 1[illegible].

Column	Item	
2	Existing Hydropower Development in River Basin	= E
6	Type of Project	
	Retrofit	= R
	New Conduit	= C
	Dam/Reservoir	= D
7	Potential Power	
	High (≥5 MW)	= H
	Moderate (1-5 MW)	= M
	Low (<1 MW)	= L
8	Potential Economic Feasibility	
	Likely Positive	= P
	Marginal	= M
	Likely Negative	= N
	Unknown	= -

Column	Item	
9	Potential Environmental Impact	
	Highly Negative	= H
	Moderate	= M
	Low or Insignificant	= L
	Unknown	= -
10	Land Ownership	
	State	= S
	Major Private Landowner	= P
11	Implementation Institution	
	Federal	= F
	State	= S
	Private	= P
	Not Established	= -
12	Potential Federal Interest	
	Likely Positive	= P
	Likely Negative	= N
	Not Applicable, Existing Facility	= -

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References to Table 14B

1. Belt, Collins and Associates, Wailuku Hydropower Study. Prepared for the Division of Water and Land Development, Department of Land and Natural Resources, State of Hawaii. Honolulu: Nov 1978.

2. Broadbent, Ned. "Upgrading Potential of Existing Hydroelectric Units at Lihue Plantation Co., Ltd. and Kekaha Sugar Co, Ltd.," Jan 1980.

3. CH2M, Inc. Waiulha Hydroelectric Project - Planning Report. Prepared for McBryde Sugar Co., Ltd., March 1982.

4. Federal Power Commission, Bureau of Power. "Planning Status Report - Water Resources Appraisals for Hydroelectric Licensing - Hawaii River Basins." 1969.

5. Hawaii, State of Hawaii Water Resources Plan. January 1979.

6. Hawaii, State of, Board of Land and Natural Resources. Kokee Water Project, Island of Kauai, Hawaii. Report R22 Honolulu: 1964.

7. Hawaii, State of, Department of Land and Natural Resources. State Water Resources Development Plan. Honolulu: Oct 1981.

8. Hawaii, State of, Hawaii Natural Energy Institute and Department of Planning and Economic Development. Alternate Energy Sources for Hawaii. Feb 1975

9. Hirai, W.A. and Associates, Inc. Hydroelectric Power in Hawaii - A Reconnaissance Survey. Prepared for the State of Hawaii Department of Planning and Economic Development. Honolulu: Feb 1981.

10. Lawrence Berkeley Laboratory of the University of California and State of Hawaii Department of Planning and Economic Development. Hawaii Integrated Energy Assessment. Honolulu: Jan 1981.

11. Personal communication with Mr. J. Harder, April 1982.

12. Personal communication with Messrs R. Watson and N. Broadbent, 1981/82.

13. Personal communication with Mr. B. Poppinga, Olokele Sugar Co., 1981/82.

14. Tudor Engineering Company, et al. Feasibility Report on the Potential Development of the [illegible] Hydroplant. Prepared for the Kekaha Sugar Company. San Francisco: July 1981.

15. U.S. Army Corps of Engineers, North Pacific Division and Pacific Ocean Division. National Hydroelectric Power Study: Regional Assessment, Alaska and Hawaii. Prepared for the U.S. Army Corps of Engineers, Institute for Water Resources. Fort Belvoir: September 1981.

16. U.S. Department of Army Permit PODCO-O 1602-S, May 1981.

17. U.S. Army Engineer District, Honolulu. Plan of Study for Hydroelectric Power and Allied Purposes - State of Hawaii. Honolulu: Sep 1977.

18. U.S. Army Engineer District, Honolulu. Reconnaissance Report for Hydroelectric Power, Wailua River, Kauai, Hawaii. Honolulu: Jan 1981.

19. U.S. Army Engineer District, Honolulu. Summary Report for Hydroelectric Power - State of Hawaii. Honolulu: Oct 1978.

Measures of Federal Interest. The technical measures for potential study and implementation are the engineering scope, economic feasibility, and environmental/social acceptability. Potential projects with very low power potential would be more appropriate for private or local governmental agencies to implement. For micro-hydropower projects, the unit cost would be expected to be high in comparison to alternative higher capacity plants and may result in economic infeasibility. If there are potentially severe environmental problems, such as the existence of relatively undisturbed organisms and endangered species in the area, then compliance to environmental statutes and mitigation measures would be extremely difficult to carry out. Certain projects also may have unresolved social constraints. For example, potential projects in the north Kauai area are expected to have social problems based upon opposition to general public works and development projects.

In addition to the strictly technical concerns (engineering, economic, and environmental/social measures), institutional impacts are critical for the assessment of potential Federal interest. The basic considerations for Federal study are whether prior Federal interest has been established, the determination of providing widespread public benefits, and the policy of encouraging non-Federal initiatives.

The issue of prior Federal interest is not applicable on Kauai because there are no authorized Federal hydropower facilities nor any Federal dam/reservoirs on the island. Regarding public benefits, a project should be implemented for widespread public benefit and not directly provide windfall benefits to a major private entity. Projects involving retrofitting facilities which are currently under private ownership or implementation of new facilities which would be sited on major private lands 1/ would be questionable in terms of public benefit. Finally, if non-Federal interests, (either State or private interests) have ongoing investigations, the Federal Government would encourage this action when not in conflict with the law or clear public interests. Hence, those potential projects on Kauai which already have ongoing non-Federal action would not be considered for further Federal investigation.

Assessment of Federal Interest. Considering the above items, an assessment was made on each drainage area with hydropower potential. Table 148 lists all known existing and potential drainage areas on Kauai suitable for hydropower development accompanied by a qualitative evaluation.2/

1/ Defined in State inventories as lands under title of entities owning 5,000 or more acres, Statewide.

2/ In comparison to the 1968 Bureau of Power study, if all sites that are currently considered nearing implementation (Olokele, Lihue, Kekaha, Kitano, Puu Opae-Mana, Wainiha, and Wailua) were put on-line, 14 megawatts of additional capacity would be achieved.

A supplemental narrative on the reasons for lack of Federal interest on the 19 sites is provided in Table 14C. Of the 19 sites, nine were deleted because of shortcomings in technical issues (engineering, economic, environmental/social) and ten were deleted because of institutional problems (potential lack of public benefits, non-Federal prior or current action). Among the sites deleted because of technical issues, three were dropped due to engineering problems (Halaulani, Kapaa, Koaie), two were elminated due to potential economic feasibility problems (Wailua-Waialeale, Hanalei Tunnel), and four were dropped because of environmental problems (Lumahai, Hanalei, Kawaikoi-Kokee, Kawaikoi-Puu Opae/Mana). Among the sites deleted because of institutional issues, five were dropped because of the existence of private facilities (Anahola, Hanamaulu-Kapaia, Makaweli, Waimea, Puu Ka Ele), one was eliminated due to potential legal problems (Hanapepe), and the remaining four sites were deleted because private interests were already investigating the sites' hydropower potential (Wainiha, Waiahi, Kokee, Kahoana). As a result of the evaluation conducted, there appeared only one drainage area suitable at this time for potential Federal investigation; the Wailua River drainage area.

RECONNAISSANCE REPORT

Following initiation of the Wailua River study, the Corps formulated several preliminary plans to determine the advisability of further investigative efforts. The results were documented in the Reconnaissance Report, published in January 1981. The base data included available US Geological Survey topographic maps (at a scale of 1 inch = 2,000 feet horizontal and 40-foot contours) and existing streamflow records. In compliance with the intent of assessing small-scale run-of-the-river hydropower improvements in the Wailua River basin, four preliminary schemes were formulated. The principal consideration were the relative locations of the diversion structure and powerplant considering the potential for flow control and available difference in elevation between the respective locations. Facilities were sited based on inspection of the existing topography and stream confluence locations.

The two principal tributaries of the Wailua River system are the North Fork Wailua River and the South Fork Wailua River. The South Fork Wailua River drainage area, in contrast with the North Fork Wailua River, is relatively unencumbered by adjacent urban areas. For approximately 4 miles along the left bank of the North Fork, there exists urban and rural residential housing. The two waterfall on the North Fork, the Kaholalele Falls (80-foot drop) and the Opaekaa Falls (120-foot drop) provide a lower elevation difference than the Wailua Falls (160-foot drop) on the South Fork. In addition, the North Fork waterfalls are located in narrower, more confined gorges than the Wailua Falls. For these reasons, in conjunction with prior local interest investigations in the same area, the South Fork was the selected tributary of investigation.

Among four schemes, three involved a powerplant located below Wailua Falls. Clearly, the Wailua Falls location offered the steepest elevation difference along the river. The only scheme (Scheme 2) which included the powerplant above the falls resulted in the lowest capacity (1.9 MW) and the highest cost per unit energy developed (exceeding 120 mills/kwh). The other remaining schemes varied in capacity between 3.4 MW to 11.7 MW. However, in all schemes, the waterway lengths were inordinately long, 12,000 feet for Schemes 1 and 4 and approximately 22,000 feet for Schemes 2 and 3.

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TABLE 14C. SCREENING OF HYDROPOWER SITES FOR [illegible]

River or Stream or Potential Hydropower Facility	Reason for Negative Federal Interest: Principal Reason	Reason for Negative Federal Interest: Secondary Reason(s)
Wainiha River	Private interests are underway in investigations.	Existing lands and existing hydropower plant under private control.
Lumahai River	Site is in pristine, undisturbed valley. Significant environmental problems anticipated - endangered species.	Social/institutional acceptability problems expected.
Hanalei River	River is site of National Wildlife Refuge. Potential severe environmental problems.	Social/institutional acceptability problems expected.
Halaulani Stream	Very low power potential anticipated (175 kw)	
Anahola Stream	Private interests are underway in construction	
Kapaa Stream	Very low power potential anticipated (270 kw)	
Wailua River - Waialeale	State of Hawaii already conducted study - determined economically infeasible.	Alternative development plan for same site conflicts with conduit scheme.
Hanalei Tunnel	Very long penstock (8,000 LF ±) through existing tunnel with potential construction and economic feasibility problems.	
Waiahi Stream	Private interests are underway in investigations.	
Hanamaulu Stream - Kapaia Reservoir	Private Reservoir	Very low power potential (120 kw)
Hanapepe River	Legal problems regarding water rights. Action in courts since 1976.	Existing lands and irrigation under private control.
Makaweli River	Private interests are underway in construction.	Existing lands and existing hydropower plant under private control.
Waimea River	Existing hydropower facility under private control.	
Kokee Ditch	Private interests are underway in investigations.	
Koaie Stream	Relatively low power potential ([illegible]) with very long penstock.	Very rugged terrain will result in constructability problems.
Kawaikoi (Kokee)	Potentially severe environmental problems - wetlands and endangered species.	Site investigated by State of Hawaii. Alternative development plan for same site with Puu Opae - Mana.
Kawaikoi (Puu Opae - Mana)	Potentially severe environmental problems - wetlands and endangered species.	Joint State/private study underway.
[illegible] Stream	Private interests are underway in investigations.	Existing hydropower plant under private control.
Puu Ka Ele Stream	Existing hydropower in drainage area.	Very low power potential (50 kw)

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An ideal penstock alignment would maintain a positive hydraulic gradient and minimize losses resulting from excessive horizontal and vertical grade changes. However, the assessment of the originally conceived long penstocks would involve considerable tunneling, excavation, and bridging over gulches or steep river banks. As a result, the prior four schemes, although sound in principle, were judged impractical, and necessitated additional project formulation.

NEW FORMULATION ANALYSIS

Based on fundamentals of hydropower development, the highest power potential results from harnessing the highest discharges at locations of steepest elevation change. A preliminary hydrographic analysis was conducted considering the relative effects of discharge and topographic relief. For purposes of preliminary sizing analysis of run-of-the-river or conduit systems, a 20 percent value of the daily flow duration curve was selected as an appropriate discharge criterion. In addition, to provide a relatively economical system, a limit of 1 mile length of waterway was specified to evaluate locations of powerplants. The Wailua Falls provides for the largest elevation difference with relatively high discharge. High elevation differences do exist at upper river reaches; however, the discharge rapidly diminishes due to lack of tributary drainage area. Sites below Wailua Falls are located at very flat slopes without significant additional discharge. Hence, to take advantage of the maximum contributing drainage area and change in elevation over a short distance, the diversion structure would be located above the falls and the powerplant below the falls.

INTAKE AND POWER PLANT SITING

Considering that the intake structure should be sited just upstream of the Wailua Falls, the intake of the conduit alternative would be in a relatively fixed location. The power plant site would be located approximately 9,000 feet downstream of the falls. This location would benefit from approximately 60 feet of additional elevation change but at a cost of approximately 3,000 feet of conduit (the conduit would take a shorter overland route, meeting the river downstream). The downstream site would be easily accessible and sufficient area would be available. Although there are innumerable other potential combinations of intake and powerplant locations, topographical analysis demonstrated that none would achieve as significant changes in elevation in relatively short distances.

STABLE STORM DITCH ADDITIONAL DIVERSION

An additional consideration was the potential for increasing the available flow on the South Fork Wailua River. As described in the prior Reconnaissance Report, there is a possibility of increasing the existing diversion capability of the Stable Storm Ditch which connects the North Fork and South Fork Rivers. The additional discharge would add to the seasonal flow stability of the South Fork River for hydropower development. The additional discharge would result in increased power capacity and energy generation. However, consideration would be given to the potential additional costs of diversion modification at the North Fork, larger capacity of the conduit from the South Fork intake to accomodate large design flow, and finally, higher power plant costs for the additional power capacity.

"WITHOUT DIVERSION" ALTERNATIVES

The evaluation revealed that including the additional diversion would double the net NED benefits. In addition, the physical impact of improving the Stable Storm ditch diversion would not adversely affect the environment nor would significantly affect the consumption use of waters downstream. The additional cost of improving the diversion capability of the Stable Storm Ditch would be more than offset by the benefits from the additional energy generated. Hence, the "without additional diversion alternatives" were deleted from further detailed analysis.

CAPACITY SCOPING

As the powerplant size required scoping, due to the physical constraints, the head was relatively constant and the design discharge was the key variable. The civil works facilities (diversion structure, conduit, and penstock) were relatively fixed, escalating mildly as a function of increased discharge. The powerplant costs (turbine-generators, electrical works) also varied with increased discharge. The civil and powerplant costs were combined to obtain a total project cost and was essentially a function of the discharge.

Characteristically if conduit hydropower facilities (where no storage is available), the optimization of plant capacities requires maximum utilization of available discharges, graphically shown on flow duration curves. The actual computational process utilized a variant of the flow duration curve, the power duration curve, essentially a cumulative frequency curve of power as function of percent of occurence. The results showed that the costs were a linear function of capacity and the benefits curvilinear, after achieving a peak value. Based upon the differences between the two functions, the approximate plant capacities were selected.

SINGLE TURBINE/DOUBLE TURBINE

In a similar analysis, the relatively steep descent of the flow duration curve severely limited the effectiveness in a single sized turbine unit. In general, turbines can operate over a limited range of discharges. A single turbine would not effectively capture all flows for streams exhibiting steep flow duration curves. Hence, a single turbine-generator unit would incur relatively high initial powerplant costs and would forego generating energy from either high or low discharges. In contrast, the two turbine concept although more costly, would capture a wider range of flows and would develop correspondingly greater amounts of energy, Hence, the single turbine concept was deleted from the final analysis.

SELECTED PLAN

The project would consist of the basic hydropower features of hydraulic control and conduit structures, powerplant, transmission line, and access facilities. The general locations of the features are shown on Figures B-1a and B-1b. Near the confluence of the Stable Storm Ditch and the North Fork Wailua River (Figure B-1a), the existing culvert would be improved and the existing weir at the USGS gaging station 620 would be raised. These improvements would provide a minimum of 100 cfs higher flow into the South Fork Wailua River than under existing conditions. Improvements to the existing Stable Storm Ditch would not be required for hydraulic capacity. Access to the facilities are available along existing cane haul roads.

The downstream improvements (Figure B-1b) would include the principal water transmission and power development features. The concrete diversion dam, located approximately 1,000 feet upstream of the falls, would be 23.0 feet high and have a crest length of 400 feet. The ponded water would flood approximately 35.0 acres upstream of the dam to an elevation of 274.5 feet msl. An intake structure adjacent to the dam would be connected to the penstock which is a combination 4,450 feet of 96" spiral rib pipe and 440 feet of 84" steel pipe. A minimum conservation flow of 15 cfs would be maintained for the river. The 96" penstock would be constructed by cut-and-cover methods and upon completion would be completely below ground. The 84" steel penstock would be installed above the ground.

The lower end of the 84" penstock would bifurcate into 60" and 36" turbine feed pipes. The powerhouse, located approximately 8,000 feet downstream from Wailua Falls on the left bank of the Wailua River. The powerhouse dimensions would be approximately 42 feet (transverse to penstock) by 36 feet. Housed would be 2 turbine-generators with a total capacity of 6.60 Mw developing an average of 17.5 million kwh of energy annually. The plant will be not operative during periods of low flow and as a result no firm capacity can be provided to the existing utility system. Access to the powerhouse will be provided by existing access roads maintained by the Lihue Plantation Company. The transmission line would consist of a 12 kv, 2.2 mile long overhead pole line ultimately connected to the existing Kauai Electric Lydgate substation.

PLAN ACCOMPLISHMENTS

The selected plan would provide an additional source of energy for the island of Kauai, effectively utilizing the available Wailua River flows. The benefits were derived from power values furnished by the Federal Energy Regulatory Commission (FERC) and were based on displacement of system energy. Since the facility is a conduit hydropower plant with no effective storage capability, no capacity credit was provided in the benefit evaluation.

The existing electrical utility system is highly dependent on fuel and diesel oils (60 percent as of 1981) for electrical generation. Although according to latest demand projection; the local utility company has sufficient reserve capacity, its capability is limited when its major purchased capacity is shut down. Any additional capacity, especially from non-fossil fuel generated sources would be beneficial.

The proposed facility would not conflict with the operation of any water resource facility. The irrigation system of Lihue Plantation would continue to be operative with existing diversions. There are no authorized nor constructed Federal dam or hydropower facilities on the island. In addition, there are no existing permits or licenses issued by FERC for potential hydropower facilities in the area.

The selected plan addresses the major study problems previously enumerated in the "Problem Identification" section of the Main Report. The plan of improvement would decrease the dependence of the island of Kauai on petroleum-based fuels and would add to its energy self sufficiency goal. Based on current fuel oil utilization rate, the plan would displace the need to import approximately 36,000 barrels of oil annually. The plan would add to the energy supply of the local utility and would provide the equivalent energy service to approximately 3,300 households on the island.

The electrical rates to consumers, although important for public accountability, would be indirectly affected for the implementation of this project. The energy developed from the selected plan would constitute approximately four percent of the total required system energy. However, in the broader perspective, this plan would constitute one among several planned hydropower projects. If all the existing and planned hydropower projects as well as existing bagasse powerplants contribute to the utility system, approximately 60 percent of the 1990 energy demand could be satisfied. Hence, although the selected plan, as an isolated project, would not be monetarily significant to the consumer, its part in the overall contribution would be significant and would ease the acceleration of rate increases.

Table 11. RESIDENTIAL ELECTRIC SALES AND RATES FOR KAUAI 1/

Year	Energy Sales million kwh	Annual Percent Growth Rate	Residential Utility Rate cents/kwh 2/	Annual Percent Growth Rate
1969	35.8	7.9	3.98	-0.6
1970	38.5	7.5	4.33	9.0
1971	41.6	8.2	4.62	6.6
1972	44.8	7.7	4.65	0.7
1973	48.3	7.7	4.80	3.2
1974	49.7	2.9	6.05	25.9
1975	52.7	6.2	6.73	11.4
1976	56.7	7.5	7.33	8.9
1977	60.3	6.2	7.94	8.3
1978	63.5	5.3	8.60	8.3
1979	67.2	5.9	10.69	24.3
1980 3/	70.1	4.3	13.98	30.8
1981 3/	73.1	4.3	15.09 4/	7.9

1/ Hawaii, State of, DPED. Hawaii Integrated Energy Assessment, Vol IV: 1980 (except as noted).
2/ Total net revenue divided by total energy for residential sales classification of Residential Combined Lighting, Heating, and Small Power (Sched D) and Electric Service for Employees.
3/ Hawaii, State of. Public Utility Commission, "Annual Report of Kauai Electric Division" Years 1980 and 1981.
4/ Varies from the nominal retail price from 500 kwh consumption shown on Table 12.

*The information on page G-35 is information from the U.S. Army Corps of Engineers from their "Final Interim Survey Report and Environmental Statement."

Table 12. COMPARATIVE RESIDENTIAL ELECTRICAL RETAIL PRICES FOR SELECTED CITIES IN THE UNITED STATES, DEC 1981 1/

City and State	National Electric Reliability Council Region	Retail Price, 1/ Cents/kwh
New York, NY	Northeast Power Coordinating Council (NPCC)	14.68
Washington, DC	Mid-Atlantic Area Electric Reliability Council (MAAC)	5.74
Atlanta, GA	Southeastern Electric Reliability Council (SERC)	5.89
Minneapolis, MN	Mid-Continent Area Reliability Coordination Agreement (MARCA)	6.35
New Orleans, LA	Southwest Power Pool (SWPP)	6.49
Denver, CO	Western Systems Coordinating Council (WSSC)	5.91
San Francisco, CA	Western Systems Coordinating Council (WSSC)	7.79
Hawaiian Islands		
Island of Hawaii	None	12.13
Island of Maui	None	12.10
Island of Molokai	None	18.67
Island of Oahu	None	12.38
Island of Kauai	None	16.27

1/ US Dept of Energy, Electric Power Monthly, Dec 1981 and State of Hawaii, Department of Commerce, Consumer Affairs, Division of Consumer Advocacy. Based on typical 500 kwh energy consumption charges and demand charge.

H. THE RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

EFFECTS AND USES AND PRODUCTIVITY

The proposed Wailua River Hydroelectric Project will cause a number of impacts to the immediate project area. However, the majority of these impacts are construction-related and are short-term in nature. The reduction of flows in the North Fork and South Fork Wailua River will remain the most significant impact to the area. This impact will be long-term in nature.

Future options for use of the water for power generation or for other uses will no longer be available between the diversion site and powerhouse locations. Any future uses that might be linked with the use of the flows will no longer be available. Potential beneficial uses for these flows are not apparent since all existing diversions for agriculture, etc., remain above the project diversion.

The options for additional hydroelectric power generation will not be available at this site since the proposed project will utilize the maximum amount of flow and power head potential in the project area.

No short-term or long-term risks to health or safety will be caused by the proposed project.

Since the proposed project will utilize flows that have been subject to upstream diversions for irrigation and other uses, no significant impacts will be caused to the long-term productivity of the area.

The majority of productivity in the project area comes from the agricultural production of sugar cane. Construction-related impacts will temporarily affect approximately 5.0 acres of prime agricultural land currently leased from the State of Hawaii by Lihue Plantation Company, LTD. These lands will be restored to their previous condition after the Project has been constructed. Any losses by damages to crops or lands will be monitarily compensated at fair market value by the developer.

I. MITIGATION MEASURES PROPOSED TO MINIMIZE IMPACT

Impact Mitigation

Although most of the proposed project impacts cannot be avoided altogether, many can be reduced or minimized by prudent construction practices and timing of the construction phases.

By limiting movement of heavy construction equipment in the stream, removing dredged and excavated material from the stream channel, and scheduling construction activities in the water or along the channel banks and walls to the months of least rainfall (June-September), degradation of the stream habitat can be greatly reduced.

The following actions are proposed to mitigate the unavoidable short-term and long-term impacts which the proposed project will cause to the existing resources in the immediate project area.

IMPACT: Reduction of flow in the South Fork and the North Fork Wailua River during periods of power production resulting in a reduction of aquatic habitat and flows over Wailua Falls.

MITIGATION: A minimum instream flow will by-pass the proposed new diversion in the South Fork Wailua River, to maintain the aquatic and aesthetic resources in the diversion reach and to maintain the visual appeal of Wailua Falls.

A minimum flow of 9,700,560 gallons per day or 15 cubic feet per second (cfs) will by-pass the new diversion in the South Fork Wailua River and will remain in the natural channel during all periods of power production. When natural flows in the South Fork Wailua River become less than 29,101,680 gallons per day or 45 cfs, the proposed powerplant will not operate and all flows will by-pass the new diversion weir and will remain in the natural river channel. All flows in excess of 380 cfs will also by-pass the new diversion and remain in the natural channel.

All flows in excess of 100 cfs will by-pass the Stable Storm Diversion in the North Fork Wailua River and will remain in the natural channel during periods of diversion for power production.

IMPACT: Disruption of prime agricultural lands and crops during construction.

MITIGATION: All agricultural losses due to project-related impacts will be monitarily compensated at fair market value by the Developer.

All agricultural lands will be returned to their previous state and top soil will be stockpiled and replaced.

IMPACT: Decreases in water quality and air quality due to construction related impacts.

MITIGATION: Precautions will be made to minimize the use of heavy construction machinery in the river channel. Measures will also be taken to prevent blockage of flows during placement of materials in the river channel. Precautions will be taken to minimize excessive dust from the construction area and the disposal of slash will be accomplished at a landfill to be determined by the State of Hawaii Department of Health.

IMPACT: The reduction of instream flows will reduce the available habitat for endangered Hawaiian water birds and smallmouth bass.

MITIGATION: The 35.0 acre diversion pool on the South Fork will create a significant amount of ideal habitat for endangered Hawaiian water birds and smallmouth bass. This pool will be managed primarily as endangered water bird habitat in coordination with the State of Hawaii Division of Forestry, Division of Wildlife and the U.S. Fish & Wildlife Service.

IMPACT: The diversion impoundment on the South Fork may accumulate sediments deposited from agricultural activities in the project area.

MITIGATION: Periodic flushing will be made at the new diversion weir on the South Fork which will allow for passage of any sediments that have accumulated. Scheduling of flushing will be coordinated with the State of Hawaii Division of Aquatic Resources.

IMPACT: Mortality rates for adult native diadromass species may increase due to entrainment into the penstock and passage through the turbine units.

MITIGATION: Screening of the intake to the penstock will be incorporated to prevent or reduce entrainment. Screening design will be made in coordination with the State of Hawaii Division of Aquatic Resources and the U.S. Fish & Wildlife Service.

IMPACT: Potential impacts to unknown historical sites may occur as a result of constructing the Project.

MITIGATION: Additional archeological studies will be conducted prior to construction of the Project to identify any unknown historical sites. If any significant sites are thought to be impacted by the Project, changes or modifications to the Project alignment or location of various components may be necessary.

IMPACT: Erosion and loss of topsoil may occur during construction of the Project causing an increase in sedimentation to the South Fork and a decrease in productivity in the area for agricultural use.

MITIGATION: An erosion control plan has been formulated and will be utilized during construction of the Project to prevent any significant erosion of soils or increases in sedimentation to the South Fork.

J. ANY IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

Affected Non-Renewable Resources

The proposed project will make use of a limited amount of non-renewable resources, both during the construction and operation phases.

Non-renewable resources of wood, concrete and steel will used in construction of the project. The loss of these resources, though insignificant will not be retrievable.

K. AN INDICATION OF WHAT OTHER INTERESTS AND CONSIDERATIONS OF GOVERNMENTAL POLICIES ARE THOUGHT TO OFFSET THE ADVERSE ENVIRONMENTAL EFFECTS OF THE PROPOSED ACTION.

ENERGY GOALS

The proposed project is a step toward fulfilling both National and State goals of developing renewable energy resources. This will help to alleviate the dependence upon foreign resources which will eventually help to reduce costs of electricity to the ratepayer and will help ensure a reliable source of power.

Since the project can be implemented without significant impacts to the environment and a need for the Project exists, the benefits associated with the action would appear to offset the environmental impacts.

EFFECTS UPON TOURISM

The proposed project will pose adverse impacts to the degree of visual appeal of Wailua Falls caused by diminuation of flows over the Falls. However, a minimum flow of 9,700,560 gallons per day will be maintained at all times during project operation to ensure a reasonable degree of visual appeal of the Falls. The Project is not expected to cause any significant impacts to the existing qualities for tourism attraction at this site. Flows of this magnitude occur very frequently at this site under existing conditions but it still remains a popular tourist attraction because the Falls offer a spectacular view even under low flow conditions. The proposed project will actually decrease the frequency that flows of 15 cfs or less will occur over the Falls from 44% to 19%

At least three new major hotel developments are expected to be placed into service during the period of 1985-1989. The demand for increased electrical energy to meet the expected needs will rise sharply during this period. Kauai Electric Division's base and peak load requirements will increase significantly. The proposed project will insure that a substantial power source will be available which is not dependent upon resources which are vulnerable to shortages or embargos. It is important to the tourism industry on the Island of Kauai that electrical power always be available for hotels and popular destinations to operate. The Wailua River Hydroelectric Project will add to the energy self-sufficiency of the Island of Kauai and will help to reduce the long-term cost of electric energy which may indirectly benefit tourism.

L. ORGANIZATIONS AND PERSONS CONSULTED

We note for example that a discrepancy exists between Ching's and Monsarrat's suggested location for Kawelowai cave (p. B130-1). Although no exact location for this feature has been achieved, impact upon possible sites, noted by Ching, from the project have been addressed. This section should also inlcude possible impacts should Kawelowai cave be located where the Monsarrat study had indicated.

Page B131 notes the proposed powerline to Lydgate substation "may affect unknown properties in the Kalepa (Ridge) Forest Reserve but will not affect any sites in the vicinity of the Stable Storm ditch." Later on in the DEIS, there is mention that this powerline may adversely affect a known agricultural terrace complex noted as (Ching's site 205). This is the first mention of possible impacts to an already known site, and should have been covered earlier in the document. The inconsistencies between the statements made in B131 and E9 need to be resolved.

Plate H-1, a map, depicts the historic sites known as of 1970, but fails to include sites located in Ching's 1981 study. Given the availability of the data, the current map is inadequate.

Issues of concern have also been raised with regard to low-flow frequencies on the South and North Forks of the Wailua River, and the aesthetic impact of decreased water flow over the Wailua and Kaholalele falls.

In the "Low-Flow Frequency Analysis" section (p.B62), flows of 10 cfs at station 600 on the South Fork and 5cfs at station 630 on the North Fork are stated to be "minimum flow criteria for instream use." Reference to these criteria as minima is misleading. Lesser flows of the South Fork are experienced now and will be under post-project construction.

The intent with respect to the South Fork seems to be, that the South Fork flows of 10 cfs or greater will not be reduced by the project diversion to less than 10 cfs and that South Fork flows of 10 cfs or less will not be further reduced by the project diversion. However, it is not clear whether the 10 cfs criterion applies to the equivalent of present flows of the South Fork, including flow diverted from the North Fork through the Stable Storm ditch but not including flows diverted from the South Fork by Lihue Plantation ditches upstream, or whether it applies to the South Fork flows in the future which will be augmented by an increased diversion from the North Fork through the Stable Storm ditch.

With respect to the 5 csf criterion for the North Fork the intent appears to be similar, but, again, it is uncertain whether this criterion applies to the equivalent of the present North Fork flows, which include flows diverted from the Hanalei River but do not include flows diverted by Lihue Plantation ditches including the Stable Storm ditch, or whether it applies to the future North Fork flows reduced by the increased diversion to the South Fork.

Table B-7 (p. B-60) indicates that flows of 10 cfs or less over Wailua Falls occur 32 percent of the time under present conditions and will occur 54 percent of the time if the hydropower plant is put into operation. A more comprehensive representation of the impact on flows over the falls should be provided by a graph comparing a low-flow duration-discharge curve for the falls under present conditions with one for conditions after the power plant is put into operation. No more data would be needed for the computation than that which was used for other duration-discharge curves presently included in the DEIS, and that are much less significant with respect to environmental impacts. The discharge scale for this suggested graph should be at least as large as that used in Plate B5-B.

No quantitative information seems to have been presented in the DEIS on the reduction of flow over Kaholalele falls, which should be represented by the same kind of graph.

One of the most important impacts of the project will be reductions in the low-water flows over the Wailua Falls on the South Fork that are ~~a scenic~~ attraction for both resident visitors. The project will also reduce flows over Kaholalele falls on the North Fork, that are even more impressive but seldom seen because it is difficult to get to a point from which they can be viewed.

There is discussion of the effects of the proposed project on the flows over Wailua Falls in the section on " Recreational Resources" (p.E 8), but the quantitative data presented there are even less complete than in the section on "low-flow analysis", and the presentation of the data is somewhat misleading. It is, however, at least recognized in the "Recreational Resources" section that the "visual impact of the falls would be far less spectacular than with greater flows under natural conditions." In this section there is no mention of the diminution of flows over Kaholalele falls. The aesthetic effects of this diminution are of negligible present concern with respect to recreation, but the potential for capitalizing on the aesthetic quality of Kaholalele falls is great, and hence, also, the potential for loss of recreational value with the diminution of flows over the falls.

In the chapter on "Unavoidable Impacts" it is recognized that the diversion of water from the Wailua South Fork for power development would result in a diminution in the flow of the stream between the points of diversion and return during periods of power plant operation, and that "this would result in a reduction of aquatic habitat in the affected stream reach." However, there is no recognition in this section of either the unavoidable aesthetic effect on Wailua Falls or on that of Kahololele Falls. The failure to mention the aesthetic effects as unavoidable impacts should be rectified by citing them in the final EIS.

If it is judged that the economic benefits of the Wailua Hydropower Project outweigh its adverse environmental impacts, the judgement seems to depend critically on the proposed limitation of times when the flow over Wailua Falls will be 10 cfs or less by limiting diversion from the Wailua South Fork through the power plant to periods when the South Fork flow is 40 cfs or greater. At present the statement of such a limitation in an EIS does not seem to be recognized as a binding commitment. Therefore, it is suggested that DLNR require as part of the CDUA permit for this project, that the hydroelectric station be designed and constructed in such a way that flows of 40 cfs or less bypass the station and flow directly down the South Fork and over Wailua Falls.

We appreciate the opportunity to review this document and hope you will find our comments useful in your completion of a final EIS for the Wailua River Hydroelectric Project.

Yours truly,

Jacquelin N. Miller
Acting Associate Director

cc: Merv Kimura
OEQC
Patrick Takahashi
Doak Cox
Matthew Spriggs
Scott Derrickson

Bingham Engineering
100 Lindberg Plaza II / 5160 Wiley Post Way / Salt Lake City, Utah 84116 / 801-532-2520

TRANSMITTAL

To: Ms. Jaquelin N. Miller
University of Hawaii at Monoa
Environmental Center 2550 Campus Road
Honolulu, Hawaii 96822

Date: 3/31/86

Project: Wailua River Hydroelectric Project No.

Subject: Archaeological Survey - Ching

We are sending you ☒ attached ☐ under separate cover via
the following items:

One copy of "A Cultural Resources Reconnaissance For The Wailua River Hydropower Study"

These are transmitted as checked below:

- ☐ For Approval
- ☐ For Your Records
- ☐ For Review and Comment
- ☐ As Requested
- ☐ Distribution
- ☒ For Your Information

We will make an official response to your March 25, 1986 letter in the very near future.

cc:

BINGHAM ENGINEERING

By: Jeff Burt
Jeff Burt

1033

CED

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

March 12, 1985

12 A8:57

REPLY TO ATTENTION OF

Operations Branch

4/1/86

Mr. Susumo Ono, Chairperson
Department of Land and Natural Resources
State of Hawaii
P.O. Box 621
Honolulu, Hawaii 96809

Dear Mr. Ono:

This is in response to your letter of February 20, 1986 — where? concerning CDUA File No. KA-12/5/85-1797 Wailua River Hydropower Project, Kauai, Hawaii.

The Corps has been meeting with Bingham Engineering on their needed submittal of the Department of Army permit application for the construction of the intake storage reservoir and outfall structure within Wailua River. A permit under section 404 of the Clean Water Act is required for any fill in the river for the hydropower project. Please contact the Operations Branch at 438-9258 if you have any questions on this matter.

Sincerely,

Barisa
for Everette A. Flanders
Chief, Construction-Operations Division

Island
Power
Company,
Inc.

April 1, 1986

Mr. Everette A. Flanders
Chief, Construction-Operations Division
U.S. Army Engineer District, Honolulu
Fort Shafter, Hawaii 96858-5440

Re: Draft Environmental Impact Statement
Wailua River Hydroelectric Project

Dear Mr. Flanders:

This acknowledges receipt of a copy of your letter dated March 12, 1986 to Mr. Susumu Ono, summarizing your comments concerning the Draft Environmental Impact Statement ("DEIS") for the Wailua River Hydroelectric Project.

We are currently compiling all of the necessary information to complete the 404 Application as required by the Department of the Army. We expect to complete the Application and forward it to your department shortly.

We appreciate the tremendous support that has been given to Island Power Company by the Corps of Engineers, especially Mr. James Pennaz.

No changes will be made to the DEIS with respect to any comments made on your behalf.

We thank you for the time and effort you have expended in reviewing and commenting on our proposal. If you have any further questions or need further information, please contact me.

Sincerely,

ISLAND POWER COMPANY, INC.

Jeff Burt

Jeff Burt
President

JB:km

5160 Wiley Post Way
Salt Lake City,
Utah 84116

P.O. Box 625,
Kalaheo, Kauai
Hawaii, 96741

GEORGE R. ARIYOSHI
GOVERNOR
KENT M. KEITH
DIRECTOR
MURRAY E. TOWILL
DEPUTY DIRECTOR
LINDA KAPUNIAI ROSEHILL
DEPUTY DIRECTOR

DEPARTMENT OF PLANNING AND ECONOMIC DEVELOPMENT

KAMAMALU BUILDING, 250 SOUTH KING ST., HONOLULU, HAWAII
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DIVISIONS
BUSINESS AND INDUSTRY DEVELOPMENT DIVISION
ENERGY DIVISION
FOREIGN-TRADE ZONE DIVISION
LAND USE DIVISION
PLANNING DIVISION
RESEARCH AND ECONOMIC ANALYSIS DIVISION
OFFICES
ADMINISTRATIVE SERVICES OFFICE
INFORMATION OFFICE

Ref. No. P-3712

March 19, 1986

MEMORANDUM

TO: The Honorable Susumu Ono, Chairperson
Department of Land and Natural Resources

FROM: Kent M. Keith

SUBJECT: Draft Environmental Impact Statement (DEIS), Wailua River Hydroelectric Power Plant, Kauai

We have reviewed the subject document and offer the following comments.

We strongly support energy development projects that would lessen Hawaii's dependence on imported fossil fuels. Hydroelectric generation is generally an attractive method because it uses a renewable and non-polluting resource. At the proposed site, however, there are important visual and aesthetic impacts that need to be considered with respect to the objectives and policies of the State Tourism Functional Plan and Hawaii Coastal Zone Management (CZM) Program.

We believe that the long-term value of Wailua Falls as a scenic resource and visitor attraction should be preserved as much as possible. In this respect, we are concerned with the effects the proposed project will have on the waterfall attraction. According to the environmental impact statement, when the stream flow is below 40 cubic feet per second (cfs), water will not be diverted. When the flow is in the range of 40-375+ cfs, however, the stream flow will be diverted to the extent of leaving a flow of only 10 cfs. This raises the question of what is or should be the minimum flow level to maintain a viable waterfall. We believe that the DEIS does not adequately address the potentially adverse consequences on the natural aesthetic value of Wailua Falls. We note in this regard the absence of any assessment of alternative minimum stream flow levels and lack of any pictorial representations of low flows. Resolution of this concern is important relative to the State's CZM policy which provides for the preservation of valued scenic resources.

The Honorable Susumu Ono
Page 2
March 19, 1986

This project would have some potential impacts on the tourism industry in Kauai. The County has placed increased emphasis on extending the length of stay of visitors on Kauai. One alternative is to expand visitor activities such as sightseeing. If the scenic quality of the Wailua Falls is diminished by this project, it could have detrimental effects on its value as a visitor attraction.

Also, there might be some limited impact on the film industry on Kauai. Wailua Falls is a picturesque and highly accessible waterfall. It has been used in several motion picture and television spots. Among the most famous would be the opening of the Fantasy Island television program.

In addition, we note the assertion on pages E-14 and E-15 of the DEIS that full compliance with the CZM Program and the Federal CZM consistency determination requirements has been achieved. We cannot agree with this statement at this time given our previous letter of December 16, 1982, to the Corps of Engineers and the fact that we have not yet administered the Federal consistency review for the current proposal.

Thank you for the opportunity to review and comment on this document.

cc: Island Power Company, Inc.

April 30, 1986

Island
Power
Company,
Inc.

Mr. Kent M. Keith
State of Hawaii
Department of Planning
and Economic Development
250 South King Street
Honolulu, Hawaii 96804

Re: Draft Environmental Impact Statement Wailua River Hydroelectric Project.

Dear Mr. Keith,

This letter acknowledges reciept of a copy of your letter dated March 19, 1986 to Mr. Susumu Ono, summarizing your comments concerning the Draft Environmental Impact Statement ("DEIS") for the Wailua River Hydroelectric Project.

We appreciate your continued support of our project throughout all of the various stages of development.

As a result of your comments we have further investigated the minimum by-pass flow issue. The Final EIS will include a 50% increase of the 10 CFS by-pass flow to 15 CFS. Historically the flows over Wailua Falls are 15 CFS or less 44% of the time under natural conditions. — no!

The proposed project will divert flows from the North Fork into the South Fork and will actually decrease the amount of time that flows are 15 CFS or less. This represents a 25% improvement or 91 less days of low flow conditions. However, the project will increase the amount of time that flows will occur between 15-45 CFS. — but you lose 200 days of sig. flow

We have included three photographs of Wailua Falls in the Final EIS which are shown as Figure 4, Figure 5, and Figure 6 (pages C-13, C-14, and C-15)) These photographs depict the Falls at flows of 3 CFS, 8.7 CFS, and 440 CFS respectively. The proposed 15 CFS minimum by-pass flow is nearly twice the flow shown on Figure 5. Wailua Falls still offers a spectacular view even when flows are of this magnitude. Further, flows of 15 CFS or less occur very frequently under existing conditions and it does not appear that tourists do not visit the Falls or are disappointed with the view when this frequent event occurs. Thus, the impacts to Wailua Falls and to the tourists who are attracted to them will not be significant with the 15 CFS minimum by-pass flow. The impacts to the motion picture industry will not be significant because Wailua Falls will still offer a spectacular view as shown on Figure 5 in the Final EIS.

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Kalaheo, Kauai
Hawaii. 96741

Further, if flows of greater magnitude are desired, this could be accomplished for short periods of time by opening the sluice gate at the base of the new diversion weir on the South Fork. This could be coordinated with Island Power and would assure that a higher flow over the Falls could be released even when natural flows are low.

We have eliminated the references to full compliance with the CZM Programs and have shown them in the Final EIS as "not determined", these pages will be E-15 and E-16 in the Final EIS.

We thank you for the time and effort you have expended in reviewing and commenting on our proposal.

If you have any questions or need any further information, Please contact me.

Sincerely,

ISLAND POWER COMPANY, INC.

Jeff Burt

Jeff Burt
President

JJB:lb

UNITED STATES
DEPARTMENT OF
AGRICULTURE

SOIL
CONSERVATION
SERVICE

P. O. BOX 50004
HONOLULU, HAWAII
96850

March 19, 1986

Department of Land and Natural Resources
Attention: Mr. Dean Uchida
Planning Branch
P.O. Box 621
Honolulu, Hawaii 96809

Dear Mr. Uchida:

Subject: Wailua River Hydroelectric Project, Kauai, Hawaii

We reviewed the subject draft environmental impact statement and have no comments to make.

Thank you for the opportunity to review the document.

Sincerely,

Francis C.H. Lum

FRANCIS C.H. LUM
State Conservationist

cc:
Mr. Merv Kimura
Island Power Co., Inc.
P.O. Box 625
Kalaheo, Kauai, HI 96741

Island Power Company, Inc.

April 2, 1986

Mr. Francis C.H. Lum
State Conservationist
U.S.D.A. Soil Conservation Service
P.O. Box 50004
Honolulu, Hawaii 96850

Re: Draft Environmental Impact Statement — Wailua River Hydroelectric Project

Dear Mr. Lum:

This acknowledges receipt of a copy of your letter to Mr. Susumu Ono, summarizing your comments concering the Draft Environmental Impact Statement ("DEIS") for the Wailua River Hydroelectric Project.

No changes will be made to the DEIS with respect to any comments made on your behalf.

We thank you for your time and effort you have expended in reviewing and commenting on our proposal. If you have any further questions or need further information, please contact me.

Sincerely,

ISLAND POWER COMPANY, INC.

Jeff Burt

Jeff Burt
President

JB:km

5160 Wiley Post Way
Salt Lake City,
Utah 84116

P.O. Box 625,
Kalaheo, Kauai
Hawaii, 96741

University of Hawaii at Manoa

Environmental Center
Crawford 317 • 2550 Campus Road
Honolulu, Hawaii 96822
Telephone (808) 948-7361

March 25, 1986

Mr. Dean Uchida
Department of Land and Natural Resources
P.O. Box 621
Honolulu, Hawaii 96809

Dear Mr. Uchida,

RE: Draft Environmental Impact Statement
Wailua River Hydroelectric Project
Wailua, Kaua'i, Hawaii

The Environmental Center has reviewed the DEIS for Wailua River Hydroelectric project with the assistance of Matthew Spriggs, Anthropology; Doak Cox, Joint Institute for Marine and Atmospheric Research; and Scott Derrickson, Environmental Center. The following issues are called to your attention.

The proposed project seeks to establish the environmental and economic feasibility of a new hydroelectric power facility for the Wailua River basin on the island of Kauai. In section B-7, p. B130, the cited archaeological report prepared by Mr. Francis K.W. Ching which was used in the planning process for this project has not been reproduced in the appendices, as was noted.

We requested a copy of this report from Bingham Engineering in Utah however it has not yet arrived. Without this report, evaluation of potential impacts to archaeological sites is difficult and speculative given the various inconsistencies between different discussions in the DEIS regarding historic sites.

LIST OF PREPARERS

This statement was prepared in behalf of Island Power Company, Inc. (the "Applicant") by Bingham Engineering, 100 Lindbergh Plaza 2, 5160 Wiley Post Way, Salt Lake City, Utah 84116.

Bingham Engineering has prepared this document utilizing portions of information contained in the "Final Interim Survey Report and Environmental Statement," prepared by the U.S. Army Corps of Engineers, Honolulu District. Permission was granted by the Corps to Bingham Engineering and other interested parties, to use this report for assistance in the private development of the Wailua River Hydroelectric Project.

The following list identifies the personnel responsible for preparing the Draft Environmental Impact Statement and the Final Envrionmental Impact Statment.

NAME	EXPERIENCE	TITLE
Jay R. Bingham President Bingham Engineering	Civil Engineer Hydraulic Engineer	Engineering and Design of Civil and Hydraulic Works
Clark M. Mower Vice President Bingham Engineering	Civil Engineering Environmental and Ecological Specialist	Preparation of Environmental documents, principal agency coordination
Galen W. Williams Bingham Engineering	Geotechnial Engineering Soils Specialist	Geotechnical Engineering Erosion Control
E. Farley Eskelson Bingham Engineering	Civil Engineering Hydrological Engineering	Hydrological Studies and Flow Analysis
Judd R. Lawrence Bingham Engineering	Civil Engineering Hydraulic Engineering	Consulting for Civil and Hydraulic Works
Jack B. Matheson Bingham Engineering	Drafting and Technical Specialist	Design Drawings and Report Exhibits
Jeff Burt President Island Power Company	Project Development	Project Director and Principal Developer
Mervyn Kimura Director Island Power Company	Project Management	Director of Island Operations

The following list identifies the personnel from the Corps responsible for the preparation of the "Final Interim Survey Report and Environmental Statement" for the Corps of Engineers.

NAME	EXPERIENCE	TITLE
Paul Mizue	Hydraulic Engineer Civil Engineer	Study Manager
James E. Maragos	Environmental Biologist/ Marine Ecology	NEPA Coordinator
Robert Moncrief	Ecologist Marine Biologist	Study Preparer
David G. Sox	Social Environmental Specialist/ Historical and Cultural Specialist	Social and Cultural Resource Assessments
John I. Ford	Fishery Biologist	U.S. Fish & Wildlife Service
James Pennaz	Hydraulic Engineer	Hydraulic Engineering and Design

M. REPRODUCTION OF COMMENTS AND RESPONSES MADE DURING THE CONSULTATION PROCESS

January 14, 1986

State of Hawaii
Department of Land and
Natural Resources
P. O. Box 621
Honolulu, HI 96809

ATTENTION: Mr. Susumu Ono

Gentlemen:

SUBJECT: CONSERVATION DISTRICT USE APPLICATION KA-12/5/85 - 1797 WAILUA RIVER HYDRO-ELECTRIC PROJECT, KAUAI, HAWAII

We have completed our review of the subject application and offer the following comments:

A. Flood Requirements

1. Plate B-17 of the "Feasibility Report and Environmental Statement" shows the proposed power plant location. The power plant appears to be located within the 500-year flood. As such, we have no flood requirements for the power house.

2. The dam will be constructed across the South Fork Wailua River. Although no detailed flood study have been made, the dam would traverse the flood zone called the floodway. Ordinance No. 416 prohibits construction of structures in the floodway.

   However, we will approve the construction of the dam. The dam is at an elevation where no residence or structures are in existence nor will they probably be built. Consequently, the dam should not present flood threats to surrounding structures. The dam itself is not regularly occupied by people. The dam is a structure which usually is built in the river or stream. We will exempt the dam from the requirements of Ordinance No. 416.

1/15

Dept. of Land & Natural Resources
January 14, 1986
Page (2)

If you have any questions, please feel free to contact my office at 245-4751.

Very truly yours,

for LAWRENCE KITAMURA
County Engineer

WK/sb

Island Power Company, Inc.

April 1, 1986

Mr. Lawrence Kitamura
Kauai County Engineer
4396 Rice Street
Lihue, Kauai, Hawaii 96766

Re: Draft Environmental Impact Statement —
Wailua River Hydroelectric Project

Dear Mr. Kitamura:

This acknowledges receipt of a copy of your letter dated January 14, 1986 to Mr. Susumu Ono, summarizing your comments concerning the Draft Environmental Impact Statement ("DEIS") for the Wailua River Hydroelectric Project.

We appreciate your support of the Project and your commitment to exempt the diversion dam from Ordinance 416. No changes will be made to the DEIS with respect to any comments made on your behalf.

We thank you for the time and effort you have put forth toward reviewing and commenting on our proposal. If you have any questions or need further information, please contact me.

Sincerely,

ISLAND POWER COMPANY, INC.

Jeff Burt

Jeff Burt
President

JB:km

5160 Wiley Post Way
Salt Lake City,
Utah 84116

P.O. Box 625,
Kalaheo, Kauai
Hawaii, 96741

GEORGE R. ARIYOSHI
GOVERNOR

HIDEO MURAKAMI
COMPTROLLER

MIKE N. TOKUNAGA
DEPUTY COMPTROLLER

STATE OF HAWAII
DEPARTMENT OF ACCOUNTING AND GENERAL SERVICES
DIVISION OF PUBLIC WORKS
P. O. BOX 119, HONOLULU, HAWAII 96810

LETTER NO. (P)1187.6

FEB 20 1986

Department of Land and
Natural Resources
P. O. Box 621
Honolulu, Hawaii 96809

Attention: Mr. Dean Uchida

Gentlemen:

Subject: Wailua River Hydroelectric Project
Draft Environmental Impact Statement

We have reviewed the subject document and have no comments to offer.

Very truly yours,

TEUANE TOMINAGA
State Public Works Engineer

SS:jk
cc: Mr. Merv Kimura

Island
Power
Company,
Inc.

April 2, 1986

Mr. Teuane Tominaga
State Public Works Engineer
State of Hawaii
Division of Public Works
P.O. Box 119
Honolulu, Hawaii 96810

Re: Draft Environmental Impact Statement —
Wailua River Hydroelectric Project

Dear Mr. Tominaga:

This acknowledges receipt of a copy of your letter to Mr. Susumu Ono, summarizing your comments concering the Draft Environmental Impact Statement ("DEIS") for the Wailua River Hydroelectric Project.

No changes will be made to the DEIS with respect to any comments made on your behalf.

We thank you for your time and effort you have expended in reviewing and commenting on our proposal. If you have any further questions or need further information, please contact me.

Sincerely,

ISLAND POWER COMPANY, INC.

Jeff Burt

Jeff Burt
President

JB:km

5160 Wiley Post Way
Salt Lake City,
Utah 84116

P.O. Box 625.
Kalaheo. Kauai
Hawaii. 96741

GEORGE R. ARIYOSHI
GOVERNOR

JACK K. SUWA
CHAIRPERSON, BOARD OF AGRICULTURE

SUZANNE D. PETERSON
DEPUTY TO THE CHAIRPERSON

State of Hawaii
DEPARTMENT OF AGRICULTURE
1428 So. King Street
Honolulu, Hawaii 96814-2512

Mailing Address:
P. O. Box 22159
Honolulu, Hawaii 96822-0159

February 24, 1986

MEMORANDUM

To: Mr. Susumu Ono, Chairman,
Board of Land and Natural Resources

Attention: Mr. Dean Uchida

Subject: Draft Environmental Impact Statement (DEIS) for
Wailua River Hydroelectric Project
Island Power Company, Inc.
TMK: 3-9-02: 1, 12, 14, 20, 21, 31, 33
3-9-03: 9
Wailua River, Kauai
Acres: 56.8

The Department of Agriculture has reviewed the subject document and offers the following comments.

According to the DEIS, the applicant is seeking to construct and operate a hydroelectric power facility in the Wailua River Basin adjacent to the Wailua Falls.

The proposed project and its location is similar to what was proposed by the Corps of Engineers in their revised Final Interim Survey Report and Environmental Statement (Revised June 1, 1983). The principal difference between the two proposals is the design and siting of the penstock, power plant and powerlines.

According to the subject document, there will be approximately five acres of land currently in sugarcane cultivation and grazing that will be affected by the construction of the penstock. Lihue Plantation will be fully compensated for losses caused by the construction of the facilities (DEIS, pages B-11 and E-10). Furthermore, all agricultural lands will be returned to their previous state and topsoil will be stockpiled and replaced (DEIS, page I-1).

The project is not expected to affect wetlands in the area (DEIS, page E-9).

The DEIS should include a summary of the soils and related information that are found in the vicinity of the proposed diversion dam, penstock and power plant. Sources for this information include the Soil Conservation Service Soil Survey (August 1972) and the Land Study Bureau Detailed Land Classification for the Island of Kauai (L.S.B. Bulletin No. 9, December 1967).

The penstock and portions of the proposed powerline pass under and over lands classified "Prime" and "Other Important" according to the Agricultural Lands of Importance to the State of Hawaii (ALISH) system. The remaining facilities are situated on lands that are not classified according to the ALISH system.

The lands within the "Prime" and "Other Important" ALISH designations also appear to be within the preliminary "Important Agricultural Land" boundary as defined by the Land Evaluation and Site Assessment Commission ("A Draft Report of the State of Hawaii Land Evaluation and Site Assessment System", November 1985).

Thank you for the opportunity to comment.

Jack K. Suwa

JACK K. SUWA
Chairman, Board of Agriculture

cc: Mr. Merv Kimura,
Island Power Company, Inc.

OEQC

Island
Power
Company,
Inc.

April 1, 1986

Mr. Jack K. Suwa
Chairman, Board of Agriculture
State of Hawaii
Department of Agriculture
1428 South King Street
Honolulu, Hawaii 96814-2512

Re: Draft Environmental Impact Statement —
Wailua River Hydroelectric Project

Dear Mr. Suwa:

This acknowledges receipt of a copy of your letter dated February 24, 1986 to Mr. Susumu Ono, summarizing your comments concerning the Draft Environmental Impact Statement ("DEIS") for the Wailua River Hydroelectric Project.

As a result of your comments, we have revised the DEIS to include a summary of the soils and related information found in the Project vicinity. Both the SCS and LSB classifications were used in developing the summary. The added Soil Summary will be found in the Final Environmental Impact Statement, pages B-98 — B-108, with accompanying Plates D-7 and D-8, which is contained in Section 6.C — Geotechnical Investigations.

We thank you for your time and effort you have put forth toward reviewing and commenting on our proposal. If you have any questions or need further information, please contact me.

Sincerely,

ISLAND POWER COMPANY, INC.

Jeff Burt

Jeff Burt
President

JB:km

5160 Wiley Post Way
Salt Lake City,
Utah 84116

P.O. Box 625.
Kalaheo. Kauai
Hawaii. 96741

GEORGE R. ARIYOSHI
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF HEALTH
KAUAI DISTRICT HEALTH OFFICE
3040 UMI STREET
LIHUE, HAWAII 96766

LESLIE S. MATSUBARA
DIRECTOR OF HEALTH

JEFFRY A. SMITH, M.D., M.P.H.
DISTRICT HEALTH SERVICES ADMINISTRATOR

February 26, 1986

L6d

Department of Land and Natural Resources
P.O. Box 621
Honolulu, Hawaii 96809

Attention: Mr. Dean Uchida

Gentlemen:

SUBJECT: Wailua River Hydroelectric Project

This is to transmit our comments regarding the proposed project as requested.

SECTION I - MITIGATION MEASURES PROPOSED TO MINIMIZE IMPACT

This section does not adequately address soil erosion control measures to be utilized during construction including soil erosion in graded areas and from stock piles of top soil.

The Draft states that "the burning of slash will be accomplished at locations used by Lihue Plantation for burning sugar cane". The applicant shall be informed that the open burning of "slash" or grub material is not permitted and the proposed burning would be a violation of Chapter 60 of Title 11, Administrative Rules, State of Hawaii. Such wastes shall be disposed of at a landfill having a permit issued by the Department of Health.

Thank you for the opportunity to review and comment on this project.

Sincerely,

Theodore Inouye
Chief Sanitarian, Kauai

TI:HFE/plo

cc: Mr. Merv Kimura

Island Power Company, Inc.

April 22, 1986

Mr. Theodore Inouye
Chief Sanitarian
State of Hawaii
Department of Health
Kauai District Health Office
3040 Umi Street
Lihue, Hawaii 96766

RE: Draft Environmental Impact Statement - Wailua River Hydroelectric Project

Dear Mr. Inouye:

This letter acknowledges receipt of a copy of your letter to Mr. Susumu Ono summarizing your comments concerning the Draft Environmental Impact Statement ("DEIS") for the Wailua River Hydroelectric Project.

As a result of your comments we have added a section addressing erosion control to our Geotechnical Investigations. This added section will be found on Pages B110-B113 in the final EIS. We have also added two drawings which are entitled Erosion Control Plan (Plate D-9, Page B-122) and Erosion Control Details (Plate D-10, Page B-123).

We have also omitted the statements on Pages F-1 and I-1 which refer to burning of slash. We have added the following statement to Page I-1 of the Final EIS; "The disposal of slash will be accomplished at a landfill to be determined by the State of Hawaii Department of Health".

We thank you for the time and effort you have expended in reviewing and commenting on our proposal. If you have any questions or need further information, please contact me.

Sincerely,

ISLAND POWER COMPANY, INC.

Jeff Burt

Jeff Burt
President

JB/rr
609-015

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Utah 84116

P.O. Box 625,
Kalaheo, Kauai
Hawaii, 96741

CEA

808

TONY T. KUNIMURA
MAYOR

LAWRENCE KITAMURA
COUNTY ENGINEER
TELEPHONE 245-3318

CLAY KAGAWA
DEP. COUNTY ENGINEER
TELEPHONE 245-3602

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

February 27, 1986

4/1/86

State of Hawaii
Department of Land &
Natural Resources
P. O. Box 621
Honolulu, HI 96809

ATTENTION: Mr. Susumu Ono

Gentlemen:

SUBJECT: DRAFT ENVIRONMENTAL IMPACT STATEMENT FOR CONSERVATION DISTRICT USE APPLICATION KA-1797, WAILUA RIVER HYDROELECTRIC POWER PLANT

We have no comments on the subject Draft Environmental Impact Statement.

Thank you for the opportunity to comment.

Very truly yours,

KIYOJI MASAKI
Acting County Engineer

WK/sb

Island Power Company, Inc.

April 1, 1986

Mr. Kiyoji Masaki
County of Kauai — Engineer
4396 Rice Street
Lihue, Kauai, Hawaii 96766

Re: Draft Environmental Impact Statement
Wailua River Hydroelectric Project

Dear Mr. Masaki:

This acknowledges receipt of a copy of your letter dated February 27, 1986 to Mr. Susumu Ono, summarizing your comments concerning the Draft Environmental Impact Statement ("DEIS") for the Wailua River Hydroelectric Project.

No changes will be made to the DEIS with respect to any comments made on your behalf.

We thank you for your time and effort your have put forth reviewing and commenting on our proposal. If you have any questions or need further information, please contact me.

Sincerely,

ISLAND POWER COMPANY, INC.

Jeff Burt

Jeff Burt
President

JB:km

5160 Wiley Post Way
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P.O. Box 625,
Kalaheo, Kauai
Hawaii, 96741

cen

DEPARTMENT OF WATER

COUNTY OF KAUAI
P. O. BOX 1706
LIHUE, HAWAII 96766-5706

929

7 A8:28

STATE OF HAWAII

March 4, 1986

Honorable Susumu Ono
Board of Land
and Natural Resources
P.O. Box 621
Honolulu, HI 96809

Re: Conservation District Use Application
File No.: KA-12/5/85-1797; Develop Hydroelectric Power, Wailua River, Kauai; TMK: 3-9-01:1

We have no objections to this Conservation District Use Application.

Raymond H. Sato
Raymond H. Sato
Manager and Chief Engineer

GF:at
cc: Planning Department

Island Power Company, Inc.

April 1, 1986

Mr. Raymond H. Sato
Manager and Chief Engineer
County of Kauai
Department of Water
P.O. Box 1706
Lihue, Kauai, Hawaii 96766-5706

Re: Draft Environmental Impact Statement
Wailua River Hydroelectric Project

Dear Mr. Sato:

This acknowledges receipt of a copy of your March 4, 1986 letter to Mr. Susumu Ono, summarizing your comments concerning the Draft Environmental Impact Statement ("DEIS") for the Wailua River Hydroelectric Project.

We appreciate you not objecting to the use of State Conservation Lands for the Project. No changes will be made to the DEIS with respect to any comments made on your behalf.

We thank you for the time and effort you have expended in reviewing and commenting on our proposal. If you have any questions or need further information, please contact me.

Sincerely,

ISLAND POWER COMPANY, INC.

Jeff Burt

Jeff Burt
President

JB:km

5160 Wiley Post Way
Salt Lake City,
Utah 84116

P.O. Box 625,
Kalaheo, Kauai
Hawaii, 96741

University of Hawaii at Manoa

Water Resources Research Center
Holmes Hall 283 • 2540 Dole Street
Honolulu, Hawaii 96822

11 March 1986

State of Hawaii
Department of Land and Natural Resources
Attn: Mr. Dean Uchida
P. O. Box 621
Honolulu, Hawaii 96809

Gentlemen:

SUBJECT: Draft Environmental Impact Statement for Wailua River Hydropower, Kauai, Hawaii, February 1986

We have reviewed the DEIS and offer the following comments:

1. Since the aesthetics of the Falls is not critical at night when no one is viewing it, consideration should be given to the possibility of storing the flow upstream over night, with subsequent release during the day. This would allow greater flow over the Falls during daylight hours. Or alternatively the stored water could be diverted into the penstock for producing additional power, particularly at peak demand periods.

2. Figure B-4-3 needs a pointer arrow to indicate location of powerhouse.

Thank you for the opportunity to comment. This material was reviewed by WRRC personnel.

Sincerely,

Edwin T. Murabayashi
EIS Coordinator

ETM:jm

Island
Power
Company,
Inc.

April 2, 1986

Mr. Edwin T. Murabayashi
EIS Coordinator
University of Hawaii at Monoa
Water Resources Research Center
2540 Dole Street
Honolulu, Hawaii 96822

Re: Draft Environmental Impact Statement —
Wailua River Hydroelectric Project

Dear Mr. Murabayashi:

As a result of your comments, we have further investigated your suggestion of storing flows overnight to be released during the day. You are correct that the visual aesthetics of Wailua Falls is not critical during the night. However, the flow requirements needed to maintain the fishery values are equally important during nighttime hours as well as daylight hours.

— not on full-moon phases

The Army Corps of Engineers has expended an extensive amount of time and effort toward preparing a plan for developing the hydroelectric power resources in the Wailua River Basin. The Corps' plan did not conclude that to store and release flows for project operation would be economically or environmentally feasible.

The Project proposed by Island Power is primarily based upon the Corps' plan with a few modifications needed to reduce the Project costs and environmental impacts. Thus, we believe the mode of project operations, as proposed, are best suited to the existing characteristics of the Project area.

As a result of your comments, we have added a pointer arrow to Figure B-4-3 to indicate the location of the powerhouse.

We thank you for the time and effort you have expended in reviewing and commenting on our proposal. If you have any further questions or need further information, please contact me.

Sincerely,

ISLAND POWER COMPANY, INC.

Jeff Burt

Jeff Burt
President

JB:km

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Salt Lake City,
Utah 84116

P.O. Box 625.
Kalaheo, Kauai
Hawaii. 96741

Island
Power
Company,
Inc.

April 30, 1986

Ms. Jaquelin N. Miller
Acting Associate Director
University of Hawaii at Manoa
Environmental Center
Crawford 317-2550 Campus Road
Honolulu, Hawaii 96822

RE: Draft Environmental Impact Statement-- Wailua River Hydroelectric Project.

This ackowledges reciept of a copy of your letter to Mr. Dean Uchida summarizing your comments concerning the Draft Environmental Impact Statement ("DEIS") for the Wailua River Hydroelectric Project.

As a result of your comments we have included " A CULTURAL RESOURCES RE-CONNAISSANCE FOR THE WAILUA RIVER HYDROPOWER STUDY " by Francis K.W. Ching as Appendix "H" within the final EIS. We have also stated that an Archaeological Study will be conducted by Island Power in coordination with the state of Hawaii PLNR, to identify any possible historical sites in the project area. If it is determined that the project as proposed will adversely affect archaeological sites of any significance, the alignment of the project or its major components will be reasonably shifted or relocated to minimize such impacts. Thus, no significant impacts to histroical resources are expected.

You have made several references to minimum by-pass flows and potential impacts of reduced flows over Wailua and Kaholalele Falls. Several changes have been made to the DEIS with respect to these issues as a result of comments made by you and other individuals or groups.

The proposed 5 cfs minimum by-pass flow on the Stable Storm Diversion as stated in the DEIS cannot be implimented because Lihue Plantation has no existing provisions for minimum by-pass of this nature at this diversion. Historically the entire flows of the North Fork have been diverted for extended periods of time into the Stable Storm Ditch for irrigation purposed. Any new provisions of this nature would have a significant impact upon the operations of Lihue Plantations Agricultural Crops. A letter was recieved by Island Power from AMFAC on April 7, 1986 stating Lihue Plantation's consern over this provision and informed Island Power that "Your Proposed Project must not hamper the existing operational procedures which Lihue Plantation Utilizes. The applicant has since contacted the State of Hawaii Department of Aquatic Resources and the U.S. Fish and Wildlife Service and initiated and outside evaluation of the existing aquatic habitat on the North Fork just below the Stable Storm Ditch, It was learned that virtually no habitat for smallnouth bass or other aquatic life exists at the Stable Storm Ditch Diversion and running serveal miles upstream and downstream. However, significant tributaries restore the base flow to the North Fork a few miles downstream from the diversion which creates adequate habitat for smallmouth bass and other aquatic species. The majority of these flows arise from the East Branch of

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Hawaii. 96741

the North Fork which join the North Fork at elevation 500 just above Kaholalele Falls. These flows are significant and will assure that ample flows will be available for Kaholalele Falls and the minor amount of irrigation requirements that are used in this area.

The Final EIS has been changed to include a 15 cfs minimum by-pass flow at the new diversion on the South Fork Wailua River. This substantiates a 50% increase to the 10 cfs by-pass flow proposed in the Draft EIS. The Final EIS will include photographs of Wailua Falls taken by the Corps of Engineers and Bingham Engineering: As shown on Figure 4 and Figure 5, Pages C-13 and C-14 in the Final EIS, flows of 3 and 8.7 cfs are pictured over Wailua Falls. The 15 cfs by-pass flow will be nearly twice the flow as shown in Figure 5. Wailua Falls still offers a spectacular view at flows of this magnitude.

As shown on Figure B-6b-6 Page B-59 in the Final EIS flows of 15 cfs occur 44% of the time under natural conditions. The proposed project will reduce the amount of time flows are 15 cfs or less to only 19% which is a 25% improvement or 41 less days. This could be considered an improvement over existing low flow conditions.

We have revised section F, UNAVOIDABLE IMPACTS to include reduced flows over Wailua Falls and Kaholalele Falls.

We thank you for your time and effort you have expended in reviewing and commenting on our proposal.

If you have any questions or need further information, please contact me.

Sincerely

ISLAND POWER COMPANY, INC.

Jeff Burt

JEFF BURT
PRESIDENT

GEORGE R. ARIYOSHI
GOVERNOR OF HAWAII

SUSUMU ONO, CHAIRMAN
BOARD OF LAND & NATURAL RESOURCES

EDGAR A. HAMASU
DEPUTY TO THE CHAIRMAN

DIVISIONS:
AQUACULTURE DEVELOPMENT PROGRAM
AQUATIC RESOURCES
CONSERVATION AND RESOURCES ENFORCEMENT
CONVEYANCES
FORESTRY AND WILDLIFE
LAND MANAGEMENT
STATE PARKS
WATER AND LAND DEVELOPMENT

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

FILE NO.: KA-12/5/85-1797
180-Day Exp. Date: 6/3/86
REF. NO.: 0333-86
DOC. NO.: 0887B

MAR 25 1986

Mr. Jeff Burt
c/o BBB Power Associates
100 Lindbergh Plaza 2
5160 Wiley Post Way
Salt Lake City, Utah 84116

Dear Mr. Burt:

SUBJECT: Comments on the Draft Environmental Impact Statement (EIS) for Conservation District Use Application (CDUA) No. KA-1797 for the Wailua River Hydroelectric Power Plant at Wailua, Kauai, Hawaii

We have reviewed the subject draft document and have the following comments:

The major portion of the Draft EIS (by Bingham Engineering) was prepared using available reports and studies (i.e., U.S. Army Corps of Engineers' Wailua River Hydropower Final Interim Survey Report and Environmental Statement). Like this Corps document, the Draft EIS proposes use of water from both the North (diverted through the Stable Storm Ditch) and South Forks of the Wailua River, and proposes a minimum flow of 3,233,520 gallons/day or 5 cfs in the North Fork and 6,467,040 gallons/day or 10 cfs in the South Fork. We note that Bingham Engineering's proposed project is similar to the Corps Alter- nate Plan 2A; changes include the location and height of the diversion dam and subsequent crest height, size of the conduit and penstock pipes, and location and size of the powerplant.

The Draft EIS also indicates that a new ± 35-acre impoundment will be created on the South Fork above Wailua Falls by the proposed diversion dam which may enhance the smallmouth bass habitat and fishery; however, the low flow in the North Fork below the Stable Storm Ditch diversion, will affect the small-mouth bass habitat and fishery.

The degree of the enhancement on the South Fork and effects on the North Fork is not provided. The EIS should predict/assess such benefits and effects, and the minimum stream flow should be then based on such findings. Further, during and post-construction, aquatic resource monitoring activities would be desirable to assess changes in the ecosystem; contingencies are also needed to remedy unforeseen adverse impacts.

We note that public access to the South fork is currently limited; most of the fishing activity for smallmouth bass is along the North Fork. Accordingly, unless public access to the new impoundment can be assured, the "benefits" could not be utilized.

As indicated in the Draft EIS, the screening of the intake structure at the diversion dam (impoundment) will prevent the entrainment of fishes; screening of the tailrace area may also be required during periods of low and/or no operation.

Page B-8: Rights of Way, states that "Land under ownership by the State of Hawaii were considered to be nominally leased to the developer." This is an assumption that should not be made. Since the proposed project is for commercial purposes, lease of State lands would most likely be on a fair market rental basis and sold at public auction. The EIS should also addresss the question of water rights and water use permit required for the project.

We do not have sufficient information to determine the impact of the penstock upon State land leased to Lihue Plantation. If the penstock will affect cultivated lands or lands that are immediately necessary to the growth of cane, then a number of potential issues such as crop loss, disruption of irrigation, etc. should be addressed.

The proposed power line crosses cultivated land leased to Lihue Plantation, goes over Kalepa Ridge, then crosses cultivated State land once again before terminating at the Lydgate Power Station. Potential conflicts should include the impact of any harvest fires upon the pole line installation.

An archaeological survey conducted by Archaeological Research Center Hawaii, Inc. in 1981 located several sites within the hydropower project area. However, these sites were only located on a map and the site information was inadequate for review.

Mr. Jeff Burt
BBB Power Associates

MAR 25 1986

CPO-0333
KA-1797

We have recommended additional site descriptions, archaeological fieldwork, and archival research to determine the historic land use in the project area. The sites should be recorded with maps, photographs, and archaeological excavations to determine the significance of the sites. To our knowledge this work has not been acocmplished. When this additional site information becomes available, it should be forwarded to our office for review and comment.

The recommended project and its hydroelectric generation alternative both have very significant impacts on the upper undeveloped portion of Wailua River State Park. A master plan was developed for the entire park in 1970. This plan has not been updated and there is no implementation scheduled for the upper South Fork area.

The subject study has addressed State Park interests to the extent they are known through the 1970 master plan and the impacts on these known interests have been addressed (see EIS-19, H-6). Unfortunately, the natural features and recreation opportunities of this portion of the park have not been adequately studied so the full impact of the subject proposal cannot be determined. However, it would be very helpful to us if pictures of the falls flowing at 10 cfs could be supplied. Much in your analysis depends upon this as a minimum flow, but we have no way to evaluate it with the information supplied.

The major recreation concern is that unknown cultural and recreation values within an existing state park are being jeopardized. We note in Appendix H, page 6, that post authorization planning, coordination will be carried out to develop a recreation plan suitable to both Park and Corps planning purposes. But this pits known hydroelectric power values against unknown park values unless further park research is done.

Concerning the Kalepa Forest Reserve, the proposed alignment of the transmission line across the Kalepa Forest Reserve, in a straight up and down fashion, needs further attention. The line approach will likely be of less negative visual impact if it took an angled path up and down the ridge so that tree screening could be effective. Another alternative, if it is feasible, would be to cross the Forest Reserve underground via cable through the Lihue Plantation irrigation tunnel which is located in this same general area.

Mr. Jeff Burt
BBB Power Associates

Stable Storm Ditch Intake is to be modified to divert larger quantities of water to the South Fork of the Wailua River. Tables B-5 (pg. B-57), B-8 and B-9 (pg. B-61), all excerpted from the COE document, indicate changes in flow on the North Fork after modification of the Stable Storm Ditch. This additional diversion will likely impact downstream water users on the North Fork; however, there is no discussion of this aspect. Impact to North Fork and other stream and ditch water users should be fully discussed. Riparian rights of down- stream property owners should also be addressed.

Although no native stream fauna, except opae, are found above Wailua Falls, these species are found below the falls. Habitat in the stream reach between the diversion dam and powerplant tail race will be reduced; however, there is no discussion regarding the extent of habitat degradation in this stream reach resulting from the increased frequency of low flow conditions.

Impact to Wailua Falls is also a primary concern. The text on page C-10, excerpted from the COE document, cites Figure 6; however, this figure showing Wailua Falls at 440 cfs has not been included. The text on page E-8 indicates the falls were observed at an estimated 10 cfs in December 1985 and January 1986. A photo of the 10 cfs condition would provide a good visual estimate of the impact of reduced flows following project construction. If available, a photograplh of the falls at 10 cfs should be included with the COE Figure 6 in the final EIS.

A discrepancy was noted between the texts on pgs. B-4 and E-3. Technical description on pg. B-4 indicates that flows less than 40 cfs will pass through the diversion structure; whereas, the text on page E-3 indicates that only 10 cfs will pass through.

Project feasibility and facility maintenance are addressed in this review primarily because almost all of the property required for the project is state-owned. Although construction cost estimates are presented, no annual costs (including operating costs) seem to be provided (the earlier Feasibility Report on this project had the same deficiency).

Fuel price escalation is assumed (pg. B-3, par. 4) There is no discussion of project feasibility without the assumed escalation.

MAR 25 1996

Mr. Jeff Burt
BBB Power Associates

CPO-0333
KA-1797

Should the project not be feasible to construct and operate, protection should be provided to the state in its leases and easements. Discussion of this aspect should be provided.

Responsibility for maintenance of the Stable Storm Ditch after intake modification is not addressed. Maintenance will be important since the ditch will be subject to higher discharges after modification. ∴ ↑ erosion/sed.

A number of pages in Section E appear to be out of sequence or missing. We also note that the cost estimate on page B-9 includes a $90,000 error.

If the Corps' tables and drawings are to be used, an explana- tion and comparison of the two projects is necessary. The discussion should include all changes including those proposed for the Stable Storm Ditch and the weir on the North Fork.

Clarification is needed on the existing and proposed South Fork discharge information provided on page B-60 (table B-7), page B-66 (Table B-13), and page E-8. The information in these three sections appears to be conflicting.

Finally, the document should be checked to insure that when references are made to Tables and/or Figures in the text, the appropriately labeled Tables and/or Figures are included. For example, on pages B-128 and 129, the text references Table F; however, no Table F is included in the document. Furthermore, we find Tables B-1 and B-2 listed twice in the document under different Tables.

Thank you for providing us the opportunity to comment. Should you have any questions regarding this matter, please feel free to contact Dean Uchida of our Office of Conservation and Environmental Affairs staff in Honolulu at (808) 548-7837.

Very truly yours,

SUSUMU ONO, Chairperson
Board of Land and Natural Resources

cc: Mervyn Kimura
OEQC

Island Power Company, Inc.

April 9, 1986

Mr. Susumu Ono
Chairperson
State of Hawaii
Department of Land and Natural Resources
P.O. Box 621
Honolulu, Hawaii 96809

Re: 180-day Deadline for Conservation District Use Application
Wailua River Hydroelectric Project

Dear Mr. Ono:

Island Power Company, Inc. respectfully requests a 30-day extension to the 180-day deadline for the subject application. The additional time should allow the Applicant and the Department of Land and Natural Resources enough time to adequately conduct public meetings and to complete the EIS requirements. The deadline would be changed from June 3, 1986 to July 3, 1986.

Sincerely,

ISLAND POWER COMPANY, INC.

Jeff Burt

Jeff Burt
President

JB:km

5160 Wiley Post Way
Salt Lake City,
Utah 84116

P.O. Box 625.
Kalaheo, Kauai
Hawaii, 96741

GEORGE R. ARIYOSHI
GOVERNOR OF HAWAII

RECEIVED
APR 18 1986
Salt Lake City, Utah

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:
AQUACULTURE DEVELOPMENT PROGRAM
AQUATIC RESOURCES
CONSERVATION AND RESOURCES ENFORCEMENT
CONVEYANCES
FORESTRY AND WILDLIFE
LAND MANAGEMENT
STATE PARKS
WATER AND LAND DEVELOPMENT

APR 16 1986

REF. NO.: CPO-0379
FILE NO.: KA-12/5/85-1797
180-Day Exp. Date: 6/3/86

Mr. Jeff Burt, President
Island Power Company
c/o BBB Power Associates
100 Lindbergh Plaza 2
5160 Wiley Post Way
Salt Lake City, Utah 84116

Dear Mr. Burt:

SUBJECT: Draft Environmental Impact Statement (EIS) for the Conservation District Use Application (CDUA) on the Wailua River Hydroelectric Project, Wailua, Kauai, Hawaii

Thank you for your letter of April 3, 1986 requesting a 30 day extension to the 60 day acceptance/non-acceptance review period on the subject EIS.

According to your information, you are currently preparing responses to comments made on the document by this Department, and other agencies. Many of these comments will require a significant amount of research in order to be adequately addressed. Consequently, you need additional time to address each of the concerns raised.

After reviewing your request, and pursuant to Section 11-200-23,(3)f, of Chapter 200, Title 11, Administrative Rules (Environmental Impact Statement Rules), we hereby grant your 30 day extension request.

As you are aware, the existing 60 day acceptance/non-acceptance review period on the EIS ends on April 21, 1986 (official receipt date was February 20, 1986). Given this 30 day extension, the new date, at which a decision on the acceptability/non-acceptability of the EIS must be made, is May 21, 1986. Since this date is the deadline at which a Final decision must be made on the acceptability/non-acceptability of your document, we strongly recommend that you submit your revised (Final) EIS in a timely manner to allow us sufficient time for review and analysis.

Be advised that the acceptance/non-acceptance decision is based strictly on the substance of the document meeting the requirements of Chapter 343, Hawaii Revised Statutes. The final decision on your project will be made by the Board of Land and Natural Resources through the CDUA process.

Finally, as was discussed with you by our staff, an extension to the 180 day CDUA processing time would also be advisable. This would allow us ample time to assess your proposal, and schedule the required public hearing, after the EIS has been completed.

Should you have any further questions regarding this matter, please feel free to contact our Office of Conservation and Environmental Affairs in Honolulu, at (808) 548-7837.

Very truly yours,

SUSUMU ONO, Chairperson
Board of Land and Natural Resources

cc: OEQC
Mervyn Kimura

Island
Power
Company,
Inc.

April 18, 1986

Mr. Susumu Ono, Chairperson
State of Hawaii
Department of Land and Natural Resources
P O Box 621
Honolulu, Hawaii 96809

RE: 180 Day Deadline for Conservation District Use Application Wailua River Hydroelectric Project

Dear Mr. Ono:

Please let this letter supersede my April 9, 1986 letter requesting a 30 day extension to the 180 day deadline for the subject application.

We now believe that a time extension of up to 90 days may be necessary to complete the CDUA process.

The new deadline would now be September 1, 1986.

Sincerely,

ISLAND POWER COMPANY, INC.

Jeff Burt

Jeff Burt
President

JB/rr
609-015

5160 Wiley Post Way
Salt Lake City,
Utah 84116

P.O. Box 625.
Kalaheo. Kauai
Hawaii. 96741

April 30, 1986

Mr. Susumu Ono, Chairperson
State of Hawaii
Department of Land and Natural Resources
P.O. Box 621
Honolulu, Hawaii 96809

Island Power Company, Inc.

RE: Draft Environmental Impact Statement-
Wailua River Hydroelectric Project

Dear Mr. Ono:

This acknowledges receipt of your letter dated March 25, 1986 summarizing your comments with respect to the Draft Environmental Impact Statement ("DEIS") for the Wailua River Hydroelectric Project.

As a result of your comments, we have spent a great deal of time further evaluating the proposed project and this response is intended to fully address the concerns you have raised.

You have requested that the degree of enhancement on the South Fork should be provided in the EIS. You also state that the minimum instream flow should be based upon a balance of benefits and effects. The Final EIS includes an assessment of the degree of effects upon the flows in the South Fork and North Fork which is found on table B-6b-7, B-6b-8 and B-6b-9 (Pages B-59 and B-60). These tables depict the probable effects to the flows in these streams as a result of the project operation. On April 7, 1986 AMFAC informed Island Power by letter that no provisions for any minimum bypass flows exist at the Stable Storm Ditch and that the proposed modifications to this diversion would seriously impact the Lihue Plantation operations. Historic flow records verify that the entire diversion of the North For into the Stable Storm Ditch has taken place for extended periods of time each year. However, the North Fork has a significant gaining nature which is shown on Table B-6b-9 (Page B-62) in the Final EIS. Much of these flows are contributed by the East Branch North Fork which joins the North Fork at about elevation 500. These flows are significant and provide a base flow for aquatic and riparian habitat and other downstream uses. Table B-6b-10 (Page B-63) in the Final EIS summarizes the flows of the East Branch NOrht Fork for the period of record. NOT True

Because of this historic practice and the use of the surrounding area for agricultural purposes, the North Fork of the Wailua River below the Stable Storm Ditch diversion has been subject to high sediment loading. Silt and turbidity in this stretch of the river are significantly higher than that found in the North Fork of the Wailua River above the areas of agricultural use. A preliminary field analysis of conditions in the North Fork of the Wailua River was conducted by representatives of the U.S. Fish and Wildlife Service and Mr. Don Heacock of the State of Hawaii Department of Aquatic Resources on April 15, 1986. During their investigation they determined that the reach of the North Fork of the Wailua below the Stable Storm Ditch diversion (the area to be affected by the project) has suffered extensive degradation due to the historic diversion (the area to be affected by the project) has suffered extensive degradation due to the historic diversion and use patterns on the river and that the area was of a very low aquatic value. There are endangered water birds in the area that uses the ditches associated with irrigation. out of context this referred to native spp not [illegible]

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Utah 84116

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Hawaii. 96741

It is felt that these birds will continue to use the Stable Storm Ditch and probably will utilize the impoundment created above the diversion on the South Fork of the Wailua. Some smallmouth bass were also found in that stretch of the river. The river was viewed in an extreme high water condition and it was thought that the few smallmouth bass in the river below the Stable Storm Ditch diversion were probably washed down during periods of high water flows. The native indemic species were generally found upstream of the upper weir. The upper weir is a significant distance above the Stable Storm Ditch Diversion. Benthic invertebrates were significantly more abundant in the reach of the river above the Stable Storm Ditch diversion will not be affected by the proposed project.

Although the proposed project will increase the length of time that the entire flow from the North Fork is diverted into the Stable Storm Ditch, the impacts to the existing low aquatic values in this area will not be significant. Therefore, the 5 CFS minimum by-pass flow as proposed in the Draft EIS has been deleted and the existing condition of no minimum by-pass flow at the Stable Storm Ditch diversion has been included in the Final EIS. re-instate

The minimum by-pass flows of 10 cfs and 5 cfs as shown in the Draft EIS, were selected using a comparison of existing low flow frequency and economic constraints of the project. The project as originally proposed by the Corps was not economically feasible. Many refinements were made to the project which reduced the total cost and increased the power output. Also, low interest special purpose bonding is being pursued as the source of project financing. Even given these factors, the project will require a payment of between 8.5¢ to 9.0¢ per kilowatt hour from Kauai Electric. The debt-coverage ration for the project is in the range of 1.25 to 1.30 which is marketable but coverage of at least 1.50 to 1.75 is preferrable. Because flows of 15 cfs or less occur frequently in the South Fork, flows for hydroelectric power are not always available. The total minimum by-pass flow of 15 cfs is necessary to insure that the project will be economically feasible.

The final EIS has been revised to include a minimum by-pass flow of 15 cfs in the South Fork. Flows of this magnitude occur 44% of the time under natural conditions. The aquatic habitat and riparian values of the area have adapted to exist with the frequent low flow conditions of this drainage. The proposed project would actually reduce the frequency of flows 15 cfs or less by 25% or 91 days per year. This would substantially improve the base flow condition of this area for aquatic life and the visual appeal of Wailua Falls. The project would, however increase the amount of time that flows of 15-45 cfs are available for Wailua Falls. The applicant will cooperate with the State of Hawaii Aquatic Resources and U.S. Fish and Wildlife Service if monitoring activities and/or contingencies are necessary.

does this mean ⊖ Hanalei H_2O? ie: from 160d.

Public access to the South Fork is currently limited by canefield operations in the area. The North Fork of the Wailua River in the area of the proposed project has historically been available for public access; however, the quality of fishery in that area has been extremely poor. The 35-acre impoundment along the South Fork of the Wailua River and the associated tailwater could provide for a viable smallmouth bass fishery. Following discussions with the U.S. Fish and Wildlife Service, the Applicant has agreed to manage the diversion dam pool as an endangered water bird habitat. The Fish and Wildlife Service in their March 26, 1986 response to the Draft Environmental Impact Statement for the project have requested that the main body of the 35-acre pool be fenced. After discussing this with Mr. Donald Heacock, aquatic biologist for the Department on Kauai, we understand that the use of the area as endangered water bird habitat and as a fishery are not mutually exclusive of each other. The Applicant is agreeable to allowing public access to the area. However, the area of the impoundment is on State owned lands and the ultimate use of the area will be decided by the State. The Applicant has no preferrance with respect to public access to the area along the diversion weir pool, including the tailwater area and will abide by any ruling made by the State of Hawaii DLNR in conjunction with the CDUA Permit. Page E-9 in the Final ESI reflects these statements..

The Applicant has stated in both the Draft and Final EIS that screening criteria will be made in conjunction with the appropriate agencies. If screening of the tailrace is required, the Applicant will incorporate the requested changes into the project design and construction.

Page B-8 has been revised to include a statement indicating that fair market value will be used to determine the rental fee for the State owned property. The powerhouse was intentionally moved to B.P. Bishop lands in order to avoid a public auction. An easement should only be necessary for the diversion, penstock, and transmission features which are to be located on State owned lands. Statements about Water Rights and Water Use are made on Page C-9 in the Final EIS.

The proposed project will directly impact approximately 5.0 acres of prime agricultural lands, used by Lihue Plantation for harvesting sugar cane. Page E-8 in the Final EIS summarizes the impacts to Lihue Plantation crops and explains that the developer will pay fair market value for all crop losses associated with construction of the project. These lands are not irrigated and coordination with Lihue Plantation will be made to minimize impacts to these lands and crop values.

Lihue Plantation has requested that a minimum of 35 feet clearance between the ground and powerlines be used to avoid any conflicts with harvest fires. Page D-1 of the Final EIS makes statements with respect to this issue.

As part of mitigation to avoid significant impacts to unknown archaeological resources in the project area, an archaelogical study will be made by the developer in coordination with the State of Hawaii DLNR prior to construction activities. If it is determined that the project as proposed will impact significant historical resources, reasonable changes to the location of project components will be made to minimize these impacts. Page I-2 in the Final EIS and numerous other areas reflict these statements.

As you have suggested, photographs showing various flows over Wailua Falls have been included in the Final EIS as Figures 4,5, and 6 found on pages C-13, C-14 and C-15. These pictures show flows of 3cfs, 8.7 cfs and 440 cfs respectively. The proposed 15 cfs minimum by-pass flow is nearly twice the amount of flow shown on Figure 5.

As shown on page B-20 in the Final EIS, only 0.6 acres of Wailua River Reserve boundaries will be affected by the overhead transmission lines. Much of the project will be buried beneath the ground and will not have long-term effects to the area. However, the diversion of flows will be visually evident over Wailua Falls during periods when storms bring bring higher flows into the basin.

The 35-acre diversion impoundment could potentially be included within the State Park System which would add to the diversification of used in the area. Many parks have been designed completely around the creation of an impoundment of water. It would appear from the developers viewpoint, that the inclusion of the 35-acre diversion impoundment which would be permanent in nature, would offset the diversion of flows which would occur only when flows become 45 cfs or greater. The visual appeal of Wailua Falls would be impacted but would still offer a spectacular view to tourists. The project would improve the base flows of the South Fork by reducing the amount of time that flows of 15 cfs or less occur by 25% or 91 days per year less.

Since the final alignment of the transmission line will be determined by the archaeological study to be completed,changes would also be made to avoid visual impacts as well. This will be done in coordination with the State of Hawaii DLNR Division of Forestry. The underground alternative would be much too costly and could not be used.

Total diversion of the North Fork has historically taken place during periods when irrigation is needed. Downstream water users have diversions on the North Fork at the Wailua Ditch at elevation 462 and the Aahoaka Ditch at elevation 400. Because the North Fork is totally diverted upstream, these diversions were placed downstream from the confluence with the East Branch North Fork which joins the North Fork at approximately elevation 500. The flows from the East Branch North Fork are significant as shown on Tables B-6b-9 and B-6b-10 (Pages B-62 and B-63) in the Final EIS. Discussions are provided on pages B-61 and E-13.

As shown on Tables B-6b-6 (page B-59) in the Final EIS, theimpacts to flows in the South Fork are assessed. The project will actually reduce the period of time that flows 15 cfs or less will occur by 25% or 91 days less per year. It is these extremely low flows which impact the critical habitat of these native fishes. Ihe improvement of this base flow condition will for the most part, enhance the critical habitat for native fish species.

As indicated on pages B-4, B-5a and E-3 in the Final EIS, the minimum by-pass flows during project operation is 15 cfs. The minimum flows for project operation is 30 cfs. Thus, if flows are less than 45 cfs, the project will not operate and the flows will pass the diversion weir. When the project is operating a 15 cfs minimum by-pass flow will pass the diversion weir and flow over Wailua Falls and downstream. Because the project can only handle a maximum of 365 cfs, flows above 380 cfs (365+15) will also pass the diversion weir.

The total annual costs for the project including operation and maintenance, insurance, taxes and rental and water use fees are expected to be approximately $125,00 per year. An accurate estimate can be made when all of the necessary easements and agreements have been reached.

The agreed price for the power to be paid by Kauai Electric will not fluctuate with the price of fuels. A fixed rate with a levelized or slight escalation will be used for this project which will assure long-term project feasibility.

A provision should be made in the land lease to protect the State of Hawaii from non-performance by the developer. Provisions such as this surely must be in existance in the previous agreements made by the State. If they do not exist, Island Power would not object to the addition of a provision to address this concern.

Island Power has been negotiating with Lihue Plantation (AMFAC) to reach an agreement for additional maintenance caused by the project. Island Power would not object to maintaining the Stable Storm Ditch or any other important components of the project.

Section E has been corrected to the proper sequential order in the Final EIS.

A $90,000 error was not made on page B-9 but rather the 180 should have been 150 which does not affect the cost estimate total.

All of the incorrect references and tables have been changed and corrected in the Final EIS.

We thank you for the time and effort you have expended in reviewing and commenting on our proposal.

If you have any questions or need further information, please contact me.

Sincerely,

ISLAND POWER COMPANY, INC.

Jeff Burt

JEFF BURT
PRESIDENT

GEORGE R. ARIYOSHI
GOVERNOR
KENT M. KEITH
DIRECTOR
MURRAY E. TOWILL
DEPUTY DIRECTOR
LINDA KAPUNIAI ROSEHILL
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 • TELEX: 7430250 HIDPED

DIVISIONS
BUSINESS AND INDUSTRY DEVELOPMENT DIVISION
ENERGY DIVISION
335 Merchant St., Room 110, Honolulu, Hawaii 96813
FOREIGN-TRADE ZONE DIVISION
Pier 2, Honolulu, Hawaii 96813
LAND USE DIVISION
PLANNING DIVISION
RESEARCH AND ECONOMIC ANALYSIS DIVISION
OFFICES
ADMINISTRATIVE SERVICES OFFICE
INFORMATION OFFICE

Ref. No. 2209

March 25, 1986

Mr. Dean Uchida
Department of Land
and Natural Resources
P.O. Box 621
Honolulu, Hawaii 96809

Dear Mr. Uchida:

Thank you for the opportunity to comment on the Wailua River Hydroelectric Project EIS.

The aesthetic diminuation of Wailua Falls and energy self-sufficiency for Kauai are two primary concerns. The EIS on page K-1 states that a minimum flow of 6,500,000 gpd will be maintained during operation to ensure a reasonable degree of visual appeal of the Falls. Page B-4 states that the project will generate about 17 million kWh per year. This would provide about five percent of Kauai's energy demand and would be a significant advance towards the State's goal of energy self-sufficiency.

Sincerely,

Tom O'Brien

Tom O'Brien
Alternate Energy Program Manager

TOB/JK:stk

cc: Mr. Merv Kimura
Island Power Company

Island
Power
Company,
Inc.

April 2, 1986

Mr. Tom O'Brien
Alternate Energy Program Manager
State of Hawaii
Department of Planning and Economic Development
250 South King Street
Honolulu, Hawaii 96804

Re: Draft Environmental Impact Statement —
Wailua River Hydroelectric Project

Dear Mr. O'Brien:

This acknowledges receipt of a copy of your letter to Mr. Susumu Ono, summarizing your comments concerning the Draft Environmental Impact Statement ("DEIS") for the Wailua River Hydroelectric Project.

We appreciate your continued support of our project throughout all of the various stages of development. No changes will made to the DEIS with respect to any comments made on your behalf.

We thank you for the time and effort you have expended in reviewing and commenting on our proposal. If you have any questions or need further information, please contact me.

Sincerely,

ISLAND POWER COMPANY, INC.

Jeff Burt

Jeff Burt
President

JB:km

5160 Wiley Post Way
Salt Lake City,
Utah 84116

P.O. Box 625,
Kalaheo, Kauai
Hawaii, 96741

0-C69

1337

United States Department of the Interior

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

ES
Room 6307
MAR 26 1986

STATE OF HAWAII

Mr. Susumu Ono
Chairperson, Board of Land
and Natural Resources
State of Hawaii
P.O. Box 621
Honolulu, Hawaii 96809

Re: Draft Environmental Impact Statement (EIS) for Conservation District Use Application (CDUA) KA-1797, Wailua River Hydroelectric Power Plant, Wailua, Kauai

Dear Mr. Ono:

We have reviewed the referenced Draft EIS and offer the following comments for your consideration.

General Comments

The Draft EIS addresses many of the concerns raised in our January 17, 1986 letter. In particular, the Draft EIS discusses the use of the 35-acre pond as endangered waterbird habitat, the use of fish screens to limit fish larvae and adult entrainment, the flushing of accumulated sediments in downstream reaches, and removes references that the Service conducted an analysis that determined 10 cubic feet per second (cfs) to be an adequate instream flow.

The primary omissions in the Draft EIS include a discussion of the biological justification for the proposed 10 cfs conservation flow in the South Fork and 5 cfs in the North Fork, and an analysis of the effects of different conservation flows on the economic viability of the project.

Specific Comments

a. Figure B-6 a-2. Diversion Weir Pool. This figure shows the area inundated by the 35-acre diversion weir pool. In order for this 35-acre pool to function as waterbird habitat, several features must be provided:

(1) The pool should provide a stable water level that effectively isolates the small island formed in the pool from predators such as dogs and cats. In addition, predators that may be living on the island such as rats, cats, and dogs should be removed. The EIS should discuss how water levels in the pool will vary over time.

(2) The boundary of the 35-acre pool should be fenced to limit predation on waterbirds that may use the edges of the pond.

b. The breakdown of riparian vegetation submerged by the 35-acre pond may temporarily deplete oxygen levels in the pond. This oxygen depletion may affect aquatic communities downstream from the diversion weir. We recommend that the vegetation be removed prior to the filling of the pool.

c. Figure B-6 a-4. Wailua River Intake Structure. A spillway or notch cut in the crest of the diversion weir to allow upstream migration of native diadromous fauna and allow the conservation flow to be released is not shown in this figure. A notch in the crest of the diversion weir would automatically provide the required conservation flow. In addition, the downstream face of the spillway should be grouted with boulders or cobble to mimic natural cascades and reduce the laminar flow over the weir. The spillway should be located over the existing river channel.

We recommend that the sluice pipe, that passes through the weir, not be used for the release of the conservation flow. The sluice pipe may be used to flush downstream reaches of accumulated sediments and to drain the pond.

d. Page B-73. Plate B-5A. It is not clear if the flow duration curve is for this project or the previous Corps' proposal. The difference between the proposed project and the Corps' proposal may affect the shape of the flow duration curve.

e. Page B-74. Plate B-5B. The labels for the project condition and existing conditions are switched on the flow duration curve.

f. Page B-96. Construction Considerations. The Draft EIS states that rerouting of the stream may be necessary during the excavation and placement of the conduit. The amount of time that the stream would be rerouted and the length of stream habitat affected by the rerouting should be discussed.

g. Page E-8. Forest Reserve Area. A biological survey of the transmission line corridor through the Kalepa Forest Reserve should be conducted.

h. We recommend that the mesh for the fish screens at the intake be 0.2 inches in size.

Summary Comments

As stated in our January 17, 1986 letter, the Service has no overriding environmental objections to this project. Our primary remaining concern is the biological justification of the 10 cfs conservation flow in the South Fork and the 5 cfs conservation flow in the North Fork. The level of biological data and analysis presented in the Draft EIS is insufficient to determine a biologically sound instream flow. In our Final Coordination Act Report to the U.S. Army Corps of Engineers for this project, we recommended that an instream flow be determined through "field analysis in consultation with the Service and the State." To the best of our knowledge, this field analysis has not been done.

We also recommend that the EIS include an analysis of the effects of different instream (conservation) flows on the economic viability of the project.

Our office remains available to provide technical assistance in determining an adequate instream flow in coordination with your Division of Aquatic Resources. We realize that your decision on an instream flow will balance biological, esthetic, and economic considerations.

We appreciate this opportunity to comment.

Sincerely,

for Ernest Kosaka
Project Leader
Office of Environmental Services

cc: CE, Operations Branch
DAR

April 30, 1986

Island Power Company, Inc.

Mr. Ernest Kosaka, Project Leader
U.S. Department of Interior
Fish and Wildlife Service, Room 6307
P.O. Box 50167
Honolulu, Hawaii 96850

RE: Draft Environmental Impact Statement Wailua River Hydroelectric Project

Dear Mr. Kosaka,

This acknowledges receipt of a copy of your letter dated March 26, 1986 to Mr. Susumu Ono, summarizing your comments concerning the Draft Environmental Impact Statement ("DEIS") for the Wailua River Hydroelectric Project.

Island Power has no objections to many of the suggestions made by the USFWS in the March 26, 1986 letter. As the diversion pool will provide a stable water level which will only vary about 1 foot under normal project operations, many of the suggested provisions for removal of predators from the island, fencing, stripping of vegetation, provisions for conservation flows, fish passage and screening, etc. should be mutually agreed upon by the State of Hawaii, USFWS, and the developer. Island Power will not object to these conditions which should be specified to the developer prior to construction. If construction of the project is authorized, Island Power will coordinate with the State of Hawaii and the USFWS to develop specific design drawings to incorporate these suggestions into the final construction plans.

We have made the suggested corrections to Plate B-5a which is page B-76 in the Final EIS.

The labels on Plate B-5b which is page B-77 in the Final EIS were correct in the Draft EIS because the flows in the Stable Storm Ditch will increase as a result of the diversion of more flows from the North Fork.

We have added a discussion of the planned re-routing of the stream to page B-99 in the Final EIS.

If a biological survey of the Kalepa Forrest Reserve Area is deemed neccessary by the State of Hawaii and USFWS, the developer will not object.

We believe that the 15 CFS by-pass flow provision is adequate and is discussed fully in the Final EIS. Photographs of the Falls at various flows are also included as Figures 4, 5, and 6.

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Salt Lake City,
Utah 84116

P.O. Box 625,
Kalaheo, Kauai
Hawaii, 96741

Many changes have been made to the originally proposed corps project in order to make it economically feasible for private development. Improvements were made to lower costs and increase power production. Also, special purpose revenue bonds with a low interest rate have been sought for project financing. Further, a higher than average rate for project power output must be made by Kauai Electric to acheive economic feasibility. This can be made only if a fully levelized or slight increase is made to insure a fair deal for the rate payers. An increase in by-pass flows would lower the power output and would make the project unfeasible.

We thank you for the time and effort you have expended in reviewing and commenting on our proposal. If you have any questions or need any further information, Please contact me.

Sincerely,

ISLAND POWER COMPANY, INC.

Jeff Burt

Jeff Burt
President

JJB:lb

AMFAC PROPERTIES

700 Bishop Street
P.O. Box 3140
Honolulu, Hawaii 96802
(808) 945-8144

Amfac

April 7, 1986

Mr. Jeff Burt
Island Power Company, Inc.
5160 Wiley Post Way
Salt Lake City, Utah 84116

Subject: Wailua Hydroelectric Project

Dear Jeff:

After reviewing the draft environmental impact statement for the proposed Wailua River Hydroelectric project on Kauai, we have some comments and concerns which we feel should be addressed.

1) What effect will the diversion dam pool have on Lihue Plantation land upstream of the diversion? At high water, the pool will occupy 35 acres.

2) Why was the section on water rights, which was in the Corp of Engineers' report, deleted from the EIS?

3) Page B-4 mentions that a minimum of 5cfs will always bypass the stable storm ditch diversion. This is contrary to existing operating procedure which diverts almost all the water at certain times of the year. Your proposed project must not hamper the existing operational procedures which Lihue Plantation utilizes.

We look forward to your response on these very important items of concern.

Very truly yours,

Michael Burke
Project Manager

MB/kk

xc: H. Kawazoe
B. Hatton
D. Uchida (DLNR)

Island Power Company, Inc.

April 30,1986

Mr. Michael Burke - Project Manager
AMFAC Properties
700 Bishop Street
Honolulu, Hawaii 96802

RE: Draft Environmental Impact Statement-
Wailua River Hydroelectric Project

Dear Mr. Burke:

This ackowledges reciept of your letter dated April 7, 1986 summarizing your comments concerning the Draft Environmental Impact Statement ("DEIS") for the Wailua River Hydroelectric Project.

The proposed diversion weir pool will submerge lands within the existing flood plain and channel of the South Fork Wailua River. These lands have not been used for agricultrual purpose because of the steepness of the sideslopes and unaccessability. Thus, the diversion pool will not adversely effect Lihue Plantations operations in this area.

We have revised the DEIS to include a section covering water rights which will be found on Page C-9 of the Final EIS.

As a result of your comments with respect to the proposed 5 cfs minimum by-pass flow at the Stable Storm Ditch diversion, we have spent much time evaluating this issue. The State of Hawaii Department of Aquatic Resources and the U.S. Fish and Wildlife Service have made a resent site visit of this area to assess the condition of the North Fork in the vicinity of the Stable Storm Ditch diversion. There findings conclude that virtually no habitat for small mouth bass or other aquatic life exists on the North Fork near this diversion. This condition is probably because of the total diversion of the North Fork into the Stable Storm Ditch which has historically sustained the agricultural crops belonging to Lihue Plantation.

During the on-site field visit of this area, several significant tributaries were observed contributing significant flows into the North Fork below the Stable Storm Ditch diversion. These flows are mainly derived from the East Branch of the North Fork which are gaged by the USGS at station 16068000. These flows are significant and restore a base flow to the North Fork which is used for irrigation downstream and contributes to aquatic habitat and flows over Kaholalele Falls. Table B-6b-9 and B-6b-10 (Pages B-62, B-63) in the Final EIS depict the contribution of the East Branch North Fork into the North Fork Wailua River.

Island Power agrees that any new provisions for minimum by-pass flows at the Stable Storm Ditch diversion would seriously impact Lihue Plantations operations. Since the existing aquatic life and riparian habitat has been subject to the historic total diversion of flows from the North Fork, additional diversion of this nature would not significantly impact the existing condition. The DEIS has been revised to include that the existing

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condition of no minimum by-pass flows at the Stable Storm Ditch diversion will not be changed. Thus, the 5 CFS by-pass flows have been deleted.

Because Island Power has expected to leave a total of 15 CFS for minimum by-pass flows, the 10 CFS by-pass flows in the South Fork have been revised to 15 CFS. This will further insure that Wailua Falls will maintain its visual appeal and will remain a popular tourist destination.

We thank you for the time and effort that you have expended in reviewing and commenting on our proposal.

If you have any questions or need any further information, Please contact me.

Sincerely,

ISLAND POWER COMPANY, INC.

Jeff Burt

JEFF BURT
PRESIDENT

JB:lb

N. SUMMARY OF UNRESOLVED ISSUES

There are no known issues which have not been adequately addressed or mitigated by the Developer.

O. LIST OF NECESSARY APPROVALS

Approval must be given by the State of Hawaii, Department of Land and Natural Resources to construct and operate the Project. Approval must be given for use of the land and water needed for the Project.

The County of Kauai must issue a permit to construct and operate the Project.

Amfac Properties must fully approve of the proposed construction and operation procedures of the Project to insure a minimal impact to Lihue Plantations' sugar cane and agricultural operations.

B.P. Bishop Estate must come to a full agreement with the Developer for the purchase or long-term lease of the property needed for the powerhouse, tailrace, transmission features and other major project components including ingress and egress to the Project site.

The State of Hawaii Public Utilities Commission must approve the Power Sales Agreement between Island Power Company and Citizens' Utilities Company, Kauai Electric Division.

The U.S. Army Corps of Engineers must issue a 404 Permit prior to any construction activities within the river channel.

The Federal Energy Regulatory Commission must declare no jurisdiction over the construction and operation of the Project or otherwise grant a license for the Project.

APPENDICES

APPENDIX G

ENVIRONMENTAL COMPLIANCE DOCUMENTS

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LIST OF TABLES

COASTAL ZONE MANAGEMENT ACT

FEDERAL COASTAL ZONE MANAGEMENT CONSISTENCY DETERMINATION

The following consistency determination is prepared in accordance with the Coastal Zone Management (CZM) Act of 1972 (Public Law 92-583) and the regulations on Federal Consistency with approved Coastal Management Programs (15 CFR 930). Federal activities must be consistant to the maximum extent practicable with approved State CZM programs. The Hawaii Coastal Zone Management Program (HCZMP) has been authorized by State law, Hawaii Revised Statutes, Chapter 205A, enacted 1977. Furthermore, the State program was approved by National Oceanic and Atmospheric Administration, Department of Commerce in 1978.

The determination, as documented below, specifically addresses the impacts of the selected plan for hydropower improvements on the Wailua River, Kauai, Hawaii on the Hawaii Coastal Zone Management Program (HCZMP). The specific items of documentation are defined in the Procedures Guide for Achieving Federal Consistency With the Hawaii Coastal Zone Management Program, prepared by the Department of Planning and Economic Development, State of Hawaii (1980).

RECREATIONAL RESOURCES

1. Objective: Provide coastal recreational opportunities accessible to the public.

2. Policies:

a. Improve coordination and funding of coastal recreation planning and management.

Consistency: Existing institutional processes and funding mechanisms would be utilized by local interests subsequent to project completion in relation to the project's recreational features. The project planning and implementation will not specifically improve coordination and funding of coastal recreation planning.

b. Provide adequate, accesisble, and diverse recreational opportunities in the coastal zone management area by the itemized methods.

(1) Protecting coastal resources uniquely suited for recreational activities that cannot be provided in other areas.

Consistency: The recreational resources would be under the protection and jurisdiction of the Department of Land and Natural Resources, State of Hawaii. However, the resources, although valuable and not exactly reproduced elsewhere, cannot be considered unavailable in other areas.

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

Consistency: The proposed action will not require replacement of any resources unavoidably damaged.

(3) Providing an adequate supply of shoreline parks and other recreational activities.

Consistency: The gross area and number of recreational facilities on Kauai will not be significantly affected.

(4) Encouraging expanded public recreational use of County, State, and Federally owned or controlled shoreline lands and waters having recreational value.

Consistency: The area of improvements is owned by the State of Hawaii. Certain portions above the existing Wailua River State Park may require dedication for specific recreational use. No areas within two miles of the shoreline would be affected.

(5) Adopting water quality standards and regulating point and non-point sources of pollution to protect and where feasible, restore the recreational value of coastal waters.

Consistency: The project will not result in point source pollution nor significantly impact the existing State water quality standards in the vicinity.

(6) Developing new shoreline recreational opportunities, where appropriate, such as artificial reefs for surfing and fishing.

Consistency: The hydropower improvement will not result in development or damage to any existing shoreline recreational area.

(7) Encouraging reasonable dedication of shoreline areas with recreational value for public use as part of discretionary approvals or permits by the land use commission, board of land and natural resources, county planning commissions; and crediting such dedication against the requirements of section 46-6.

Consistency: Any dedication of additional recreational areas will be the responsibility of the State of Hawaii.

HISTORIC RESOURCES

1. Objective: Protect, preserve, and where desirable, restore those natural and man-made historic and prehistoric resources in the coastal zone management area that are significant in Hawaiian and American history and culture.

2. Policies:

a. Identify and analyze significant archaeological resources.

Consistency: In partial compliance to the National Historic Preservation Act and to the National Environmental Policy Act (NEPA), the cultural resources in the area of improvement were investigated in reconnaissance surveys associated with the Corps' Survey Report process. Additional surveys will be conducted in Advanced Engineering and Design stages.

b. Maximize information retention through preservation of remains and artifacts or salvage operations.

Consistency: Provided cultural and archaeological artifacts are discovered which are eligible for nomination to the National Register of Historic Places, recovery and salvage operations will be conducted prior to project construction.

c. Support State goals for protection, restoration, interpretation, and display of historic resources.

Consistency: The investigations and salvage operations will indirectly support State goals for historic resources.

SCENIC AND OPEN SPACE RESOURCES

1. Objective: Protect, preserve and, where posssible, restore or improve the quality of coastal scenic and open space resources.

2. Policies:

a. Identify valued scenic resources in the coastal zone management area.

Consistency: The proposed project will not add to the identification of scenic resources. The Wailua Falls and Wailua River are already known for their scenic value.

b. Insure that new developments are compatible with their visual environment by designing and locating such developments to minimize the alteration of natural landforms and existing public views to and along the shoreline.

Consistency: The proposed features of the hydropower project would be designed to minimize adverse visual impacts and to be located in a manner compatible with existing landforms to the maximum extent practicable. The diversion dam would not be readily visible from visual vantage points of the Wailua Falls. The powerplant would be suitably placed against the existing formations and would not adversely affect views except when visitors are directly in the river bottom.

c. Preserve, maintain and, where desirable, improve and restore shoreline open space and scenic resources.

Consistency: Impacts to the existing scenic resources will be minimized by strategic location of the diversion dam and powerhouse and by burying the penstock. This will help to maintain these values.

d. Encourage these developments which are not coastal dependent to locate in inland areas.

Consistency: The project will not specifically encourage any development.

COASTAL ECOSYSTEMS

1. Objective: Protect valuable coastal ecosystems from disruption and minimize adverse impacts on all coastal ecosystems.

2. Policies:

a. Improve the technical basis for nature resource management.

Consistency: Existing technical information was used predominantly to forumulate and to evaluate impacts of the plan of improvement. Research-oriented and new technical information were not within the scope of the investigation.

b. Preserve valuable coastal ecosystems of significant biological or economic importance.

Consistency: The coastal ecosystems of the Wailua River will remain essentially unaffected by the proposed improvements and will be preserved in their natural state. Short-term adverse construction impacts are expected in the immediate area of improvements. However, the habitats are expected to recover to their former state prior to construction.

c. Minimize disruption or degradation of coastal water ecosystems by effective regulation of stream diversions, channelization, and similar land and water uses, recognizing competing water needs.

Consistency: An improved diversion through the Stable Storm Ditch for additional waters from the North Fork Wailua River to the South Fork Wailua River is proposed. The additional flow would significantly add to the energy development but would not alter existing stream patterns nor water needs. Although limited channelization would be required in the areas of powerplant discharge waters, there would be no disruption of the natural water course along the river. Natural water flows will be decreased from the South Fork diversion to the powerplant outlet for approximately 35 percent of the time. However, high flows (occurring 15 percent of the time or less) and low flows (occurring 50 percent of the time and more) would not be affected.

d. Promote water quantity and quality planning and management practices which reflect the tolerance of fresh water and marine ecosystems and prohibit land and water uses which violate State water quality standards.

Consistency: This project would not specifically add to planning and management practices related to ecosystems nor would prohibitions be imposed on land and water use.

ECONOMIC USES

1. Objective: Provide public or private facilities and improvements important to the State's economy in suitable locations.

2. Policies:

a. Concentrate in appropriate areas the location of coastal dependent development necessary to the State's economy.

Consistency: The plan of improvement would be located in an appropriate physical location of abundant water resources for the development of hydropower. In addition, the project would add to the developed supply of an indigenous non-fossil energy source, effectively reducing dependence upon petroleum fuels.

b. Insure that coastal dependent development such as harbors and ports, visitor industry facilities, and energy generating facilities are located, designed, and constructed to minimize adverse social, visual, and environmental impacts in the coastal zone management area.

Consistency: The proposed energy generating facility would be located, designed, and constructed to minimize, to the maximum extent practicable, potential adverse environmental impacts. The specific nature of the impacts are documented in the Environmental Statement for the subject project.

c. Direct the location and expansion of coastal dependent developments to areas presently designated and used for such development and permit reasonable long-term growth at such areas, and permit coastal dependent development outside of presently designated areas when: utilization of presently designated locations is not feasible, adverse environmental effects are minimized, and important to the State's economy.

Consistency: The project's intent and purpose does not direct or designate any area for development. The land use, development, and zoning issues would be State and local responsibilities.

COASTAL HAZARDS

1. Objective: Reduce hazard to life and property from tsunami, storm waves, stream flooding, erosion, and subsidence.

2. Policies:

a. Develop and communicate adequate information on storm wave, tsunami, flood, erosion, and subsidence hazard.

Consistency: Information on flood hazard in the area has been developed in the evaluation report pursuant to Executive Order 11988 on Floodplain Management contained in the Interim Survey Report. The proposed facilities have been formulated for structural integrity under the 0.2 percent flood conditions. The pool area upstream of the diversion structures and the tailwater outlet channel will be the only significant portions of the project which would require cleanout and repair subsequent to major floods.

b. Control development in areas subject to storm wave, tsunami, flood, erosion, and subsidence hazard.

Consistency: The project would not have direct influence on controlling future development.

c. Insure that developments comply with requirements of the Federal Flood Insurance Program.

Consistency: The Federal Flood Insurance Program is not specifically applicable for Federal water resource projects. The hydropower improvements, however, comply with the general provisions of the Executive Order 11988 on Flood Plain Management.

d. Prevent coastal flooding from inland projects.

Consistency: The project would not impact coastal flooding. Flood control is not a project purpose.

MANAGING DEVELOPMENT

1. Objective: Improve the development review process, communication, and public participation in the management of coastal resources and hazards.

2. Policies:

a. Effectively utilize and implement existing law to the maximum extent possible in managing present and future coastal zone development.

Consistency: The project would comply with existing laws to the maximum extent practicable. Any adjustment to State and/or County administrative rules and regulations pursuant to any laws would be the responsibility of the local interests.

b. Facilitate timely processing of application for development permits and resolve conflicting permit requirements.

Consistency: The project in its planning, engineering, or construction phases would not influence processing times nor the administration of permits.

c. Communicate the potential short- and long-term impacts of proposed significant coastal developments early in their life cycle and in terms understandable to the general public to facilitate public participation in the planning and review process.

Consistency: A public involvement program is an integral part of the project's planning process. The public, including government agencies and special interest groups, would have periodic opportunities to review project reports. The public involvement program has been documented in this Interim Survey Report.

PRESIDENTIAL EXECUTIVE ORDER 11988 ON FLOOD PLAIN MANAGEMENT

EVALUATION REPORT

GENERAL

Presented in this evaluation report is pertinent information required by Executive Order (E.O.) 11988 on Flood Plain Management, dated 24 May 1977, for any proposed action in the base flood plain. The "action" is any Federal activity involving:

a. Acquiring, managing, and disposing of Federal lands and facilities.

b. Providing Federally undertaken, financed, or assisted construction and improvements.

c. Conducting Federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating and licensing activities.

OBJECTIVE

The objective of E.O. 11988 is to avoid to the extent possible, the long- and short-term adverse impacts associated with the occupancy and modification of flood plains, and to avoid the direct and indirect support of flood plain development whenever 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 hazards and risk associated with floods.

c. Minimize the impact of floods on human safety, health, and welfare.

d. Restore and preserve the natural and beneficial values of the flood plain.

POLICY

The order establishes general policy on flood plain management by citing the above requirements for compliance by Federal agencies.

The preferred method for satisfying these requirements is to avoid sites on the base flood plain altogether. If an action must be located on the base flood plain, the order then requires that agencies minimize potential harm to people and property, and to natural and beneficial flood plain values.

IDENTIFICATION OF THE FLOOD PLAIN

The term flood plain refers to any land area susceptible to being inundated from any source of flooding. The base flood plain is defined as the area subject to inundation from a 100-year flood which is an event that has a one percent chance of being equaled or exceeded in any given year. The Federal

Insurance Administration (FIA) of the Federal Emergency Management Agency prepared the Flood Insurance Study for the County of Kauai, which is a detailed study of the flood-prone areas on the island of Kauai.

FLOOD HAZARD EVALUATION OF THE PROPOSED ACTION LOCATION

The site of the proposed Wailua Hydropower project is designated Zone C, or area of minimal flooding under the FIA flood study, and is beyond the limit of the existing FIA Wailua River flood map. The proposed project siting, however, constitutes activity in the 100-year flood plain, based on extending the Wailua River flood plain approximately 1.5 miles upstream.

IMPACT OF THE PROPOSED ACTION

The selected plan for the hydropower features includes powerplant, diversion dam, intake structure and other appurtenant facilities. The inclusion of the powerplant structure, being relatively small in area, will have no significant impact on the regulatory flood elevation. The structures also would be designed to withstand all foreseeable impacts of major flooding and no additional flood damage potential would result. The hydropower project purpose will provide additional energy production for development purposes. However, the project measures and use of the surrounding lands do not specifically encourage or increase incompatible flood plain development. The tailrace outflows from the powerplant (maximum of 400 cfs) will not be significant compared to the regulatory flood discharge in the river (approximately 68,000 cfs).

MITIGATIVE MEASURES

Any future development in the flood plain areas adjacent of the hydropower site should conform to Federal flood plain management criteria for proposed structures in flood-prone areas. These requirements would include such measures as siting outside of the flood plain whenever there is a practicable alternative, or adjusting to the flood plain by flood proofing to minimize or eliminate flood damage potential. Although there are numerous other potential sites for a hydropower facility on the Wailua River, none would be as economically and technically practical as the selected plan site. Environmental quality enhancement measures would be provided by the inclusion of an additional lookout and access into the river. The stream habitat would not be significantly affected; hence, additional mitigative measures would not be mandatory.

PUBLIC NOTICE

The general public was advised by public notice that the recommended plan for improvements will result in activity in the flood plain. The public was given the opportunity to address and comment on the proposed action during the formal public meeting held on 28 July 1982 in Lihue, Kauai. There were no significant comments or concerns expressed by the public regarding flood plain management.

UNITED STATES DEPARTMENT OF THE INTERIOR

Fish and Wildlife Service

(1982)

FINAL COORDINATION ACT REPORT

Wailua River Hydroelectric Power Study
(Phase 3 Pre-authorization Survey Report)

Wailua, Kauai, Hawaii

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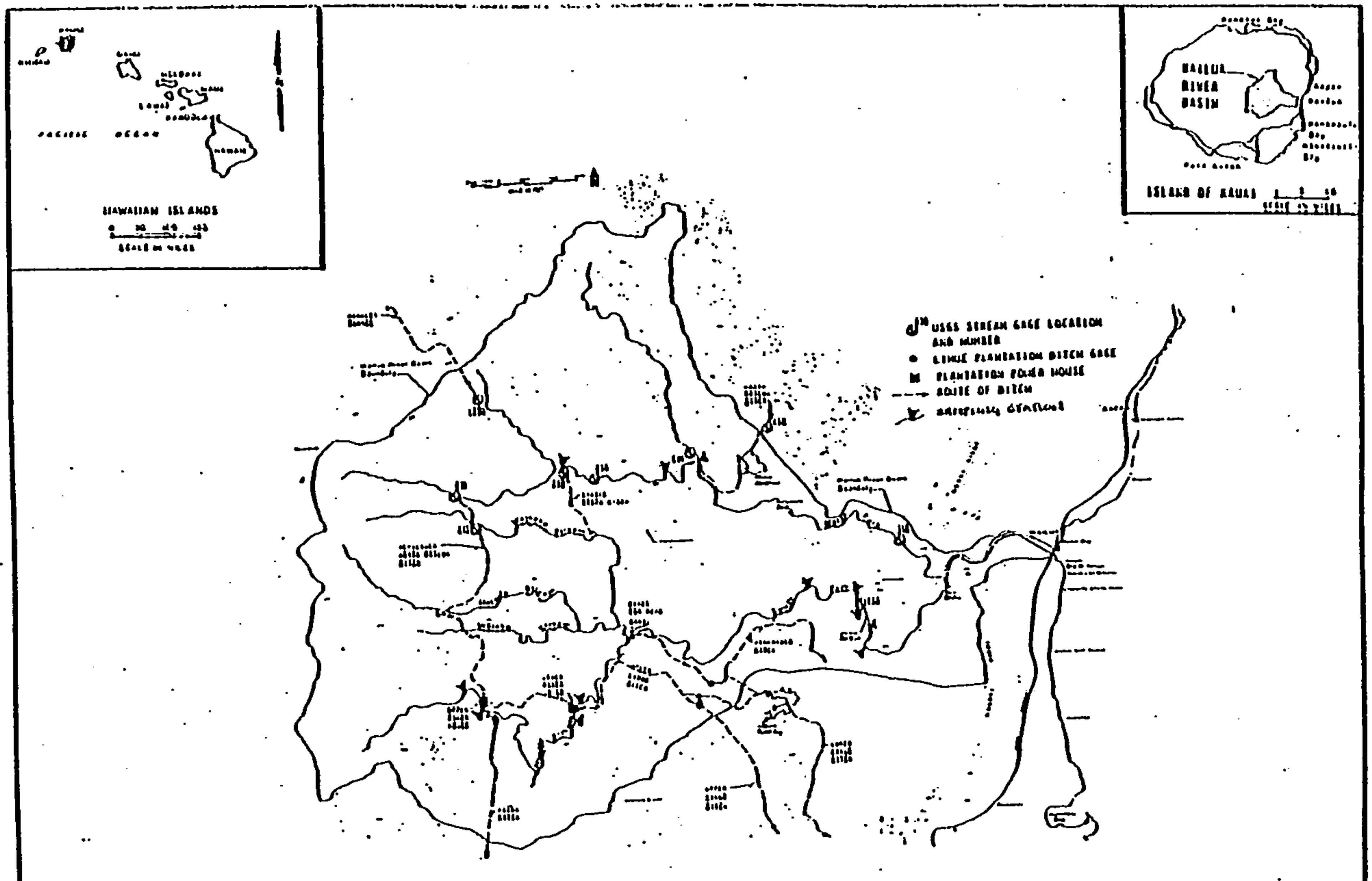
PREFACE

This document constitutes the U.S. Fish and Wildlife Service's report on the Wailua River Hydropower Interim Survey Report (Phase 3 Pre-authorization). It has been prepared under the authority of the Fish and Wildlife Coordination Act, P.L. 85-624 Section 2(b), and in keeping with the spirit and intent of the National Environmental Policy Act. As required by law, a copy of the Service's report shall accompany the Corps' Survey Report to Congress.

This study was authorized by Section 209 of the River and Harbor Flood Control Act of 1962 (P.L. 87-874). It was restricted to two principal alternatives identified by the Honolulu District, Corps of Engineers. The goals of the Service in its study involvement were: (1) to evaluate the impact each of the principal alternatives would have on fish and wildlife resources, their habitat, and their utilization by the public, and (2) to recommend methods for preserving, compensating and enhancing these resources. The Service's findings are based on project data furnished prior to July 28, 1982. A prior Service report and a Planning Aid Letter provided on July 7, 1981 and June 25, 1982 are superseded by this report.

This document includes a review of various reports, unpublished materials and personal communications provided by the Corps and the Hawaii Division of Aquatic Resources during the course of the study. Field data from three site inspections made in 1977, 1981 and 1982 by Corps and Fish and Wildlife Service biologists, and other relevant information about the Wailua River watershed are incorporated in the report. Field surveys were conducted at sampling stations shown in Figure 1 utilizing electroshockers and opae nets. Visual surveys were also made with the use of face masks. No attempt has been made to quantitatively evaluate populations of indigenous fauna or introduced game fishes during this phase of investigation. Recommendations for detailed fish and wildlife studies during Phase 1 Post-authorization Studies appear later in this report.

This report was prepared by John I. Ford, Fishery Biologist (Management), of the Office of Environmental Services, U.S. Fish and Wildlife Service, Honolulu, Hawaii.



WAILUA RIVER BASIN
KAUAI, HAWAII

BASIN MAP

U.S. ARMY ENGINEER DISTRICT
HONOLULU

FIGURE 1

GENERAL DESCRIPTION OF THE PLANNING AREA

1. Wailua River Watershed

The study area lies within the Wailua River watershed, which is situated on the east coast of the Island of Kauai, Hawaii (Figure 1). The Wailua River basin is the second largest drainage on the island, and occupies a large portion of the Lihue depression. The basin lies between the massifs of Kawaikini and Waialeale and has a total drainage basin area of approximately 53 square miles. Except for the western wall of the basin, the Wailua area is characterized by relatively open, rolling country which presents a contrast to the rugged terrain of Kauai's other stream basins.

The Wailua River is a fourth-order, perennial river. The North and South Fork streams comprise the two principal branches of the river, and drain areas of 23 square miles and 29 square miles, respectively. These two branches converge into a terminal estuary which is some 2.4 miles in length. A smaller stream, Opaekaa, also drains into the estuary but is not included within the study area. Together, the North and South Fork streams form a broad, dendritic, drainage pattern. The total tributary length from headwaters to the head of the estuary is 89 miles.

The major tributaries enter the mainstream between 500-750 feet elevation. Streams entering the mainstream below this altitude are few in number and inconsequential in discharge (Davis 1960). The headwaters of the North Fork tributaries are located at 1,800-3,000 feet altitude between Waialeale and Kapehuaala peaks. The South Fork headwaters are situated near 2,200-4,000 feet between Kawaikini and Kapalaoa peaks.

The bounding ridges of the Wailua River basin consist of eroded Pliocene lavas of the Napali formation (MacDonald, Davis, and Cox 1960), which are considered part of the original dome. These lavas are highly permeable and confine much water to high elevations. The floor of the Lihue depression is believed to have been formed by the collapse of the dome on the eastern portion of the island. Headwater tributaries of the North and South Fork Wailua River indent the west wall of the depression, forming deep and relatively short gorges. About two miles upstream from the terminus, the Wailua River is incised in Pleistocene lava flows that overflowed the depression. The gap carved by the river between Kalepa and Nonou ridges marks the remains of the east wall of the depression. West of the gap, the headward erosion of waterfalls in both the North and South Fork has entrenched the lower reaches in 200-300-foot deep gorges.

Soils which form the stream channel and banks have been described only as rough, broken lands and rock outcroppings (USDA 1973). Kolokolo clay loam and Kolokolo extremely stoney clay loam also are found along a major portion of the stream course. Soils in the terminal reach of the stream are principally stream-laid gravel, sand, and silt. This alluvium underlies the bottom lands along the Wailua estuary.

The transverse profile of the Wailua River watershed shows an average rise in elevation along the South Fork of only 70 feet per mile from the sea to the headwall (Davis 1960). The precipitous headwater regions and broad, gradully sloping plain are characteristic of relatively older, well weathered, stream valleys in Hawaii.

Average annual rainfall over the basin ranges from 45 inches along the western wall of the depression to 50 inches near the shore (Belt, Collins & Associates 1978). Rainfall within the basin averages approximately 325 million gallons per day (mgd).

Development of an accurate surface runoff budget within the Wailua River basin is extremely difficult due to the extensive diversion of streamflow for irrigation and because stream gauging stations are located well up into the watershed. Transportation of water outside the watershed for agricultural irrigation dates from 1856 when the Rice Ditch was constructed to carry water from the mountain streams to lands cultivated in sugarcane. Four major ditch systems divert an average of about 158 mgd from the rivers. Maximum and minimum flows do not always occur in the same year on the North and South Forks due to differences in rainfall within each sub-basin changing water use demands (Davis 1960).

Average discharge at elevation 240 feet (USGS Gauge No. 600) on the South Fork over the 63-year period of record is 116 cubic feet per second (cfs), or about 75 mgd, taking into account upstream diversions of flow. Minimum instantaneous discharge over the same period of record occurred on September 21, 1953 and equalled only 2.69 cfs, or 1 mgd (USGS 1980). The average discharge of the North Fork measured at USGS Gauge No. 710 at an elevation 18 feet below Kaholalele Falls over a 28-year period of record is 127 cfs, or about 82 mgd. Minimum instantaneous flow occurred on October 28, 1953 and dipped to 2.12 cfs, or 1.4 mgd. About 88% of the flow in the North Fork originates in the basin, while the remainder is supplemented by diverted flows from the Hanalei River. Some of the water from the Hanalei flows into the South Fork through the Stable Storm Ditch, while the remainder enters the North Fork. The Hanalei flow is particularly important for the maintenance of aquatic resources during extended dry periods, when it can provide up to 20% of Wailua's total flow.

The dry season extends from June through October. Flows in the North Fork during this period are approximately 26% below the year-round average; and flows in the South Fork are 23% below the year-round average during this period. Detailed descriptions and estimates of stream and ditch flow in the Wailua River basin are presented in Belt, Collins & Associates (1978).

2. Riparian Resources

Land use within the North and South Fork sub-basins is predominantly sugarcane cultivation. The headwaters lie within the Lihue-Koloa Forest Reserve (State). Activities within the Reserve include tree-planting experiments (*Eucalyptus spp.*), an arboretum, hiking trails, and preservation of native floral habitat. Public hunting areas and game bird reserves are located within the Opaekaa and North Fork sub-basins. A significant recreational fishery exists within the South and North Fork Wailua River. Access to most of the Wailua Basin is controlled by the Lihue Plantation Company. Two small run-of-the-river hydroelectric power plants are operated by the sugar company within the Waiahi tributary of the South Fork. The South Fork, from Wailua Falls to the sea, lies within the Wailua River State Park. The terminal estuary is a popular recreational area which accommodates water skiing, boat rides, fishing and crabbing, and a botanical garden maintained as a tourist attraction (Paradise Pacifica). The Hawaii Department of Parks and Outdoor Recreation has estimated that 4 million persons visited the park in 1980.

3. Wildlife Resources

Wetlands surrounding the terminal estuary and botanical garden provide habitat for three species of endangered Hawaiian waterbirds: the gallinule (*Gallinula chloropus sandvicensis*), coot (*Fulica americana alai*), and duck (*Anas wyvilliana*). Only the Hawaiian duck, or koloa, is known to occur infrequently within the reach of the Wailua River which will be affected by the proposed action. No other species listed or eligible for listing as endangered is known to inhabit the project area.

4. Aquatic Resources

The terminal estuary is believed to support populations of euryhaline and itinerant marine fishes and crustaceans of sport and commercial fishing value. The lower reaches of the South Fork Wailua River below Wailua Falls and the North Fork below Kaholalele Falls support indigenous Hawaiian stream fauna. The stream above Wailua Falls and Kaholalele Falls supports populations of introduced fishes, predominantly smallmouth bass, and swordtails (Poeciliidae). A major portion of the Wailua supports an important sport fishery based upon smallmouth and largemouth bass, bluegill, carp, Chinese catfish, and tilapia.

DETAILED PROJECT DESCRIPTION

The purpose of the present Corps study is to establish the feasibility of potential improvements in the interest of hydroelectric power development for the Wailua River basin, Island of Kauai, State of Hawaii. The Corps' study provided an analysis of the electrical utility needs and the alternatives available to meet the needs for this Island of Kauai.

Among the technical criteria and plan formulation goals identified by the Corps, the following concepts are important to fish and wildlife resources:

a. Any change in flow rate should not adversely affect the existing irrigation operations.

b. Plans should not significantly disrupt or destroy existing ecosystems within the area of improvement.

c. Plans should not significantly impair the scenic beauty of Wailua Falls and Kaholaleie Falls through physical structures or major diminution of flow.

d. Any increases in flow along man-made or natural channels should be within reasonable capacity of the facility and not cause failure of banks or significant increase in sedimentation.

Possible solutions investigated within the Wailua River basin area have included new fossil fuel power plant(s), electrical interties, conservation and solar hot water heating, a new bagasse power plant, wind power plant, hydropower plant retrofitting and development at existing small hydro sites, new conduit hydropower diversion and power plant, and a new dam/reservoir and hydropower plant.

New conduit hydropower diversion and power plant is the alternative considered in detail in this report.

This plan involves a low 23.0-foot high, 400-foot wide, concrete diversion structure located approximately 1000 feet upstream of Wailua Falls. The structure would be an overtopping spillway constructed to withstand the effects of a probable maximum flood. Streamflows exceeding the conduit capacity would pass downstream. Under design conditions, the diversion would pond water upstream to an approximate elevation of 274.5 feet (MSL). The permanent pool would have a surface area of 35.0 acres, and would store 300 acre-feet of water. Pool depths will range from 15 to 32 feet depending upon discharge. The intake would range from 15 to 32 feet depending upon discharge. The intake would include a trash rack upstream from the conduit connector, a sluice gate for debris cleanout, a vortex preventer, and a second trash rack of one-inch diameter at the opening. For the purpose of initial estimates, the design flow included additional waters diverted from the North Fork Wailua River via the Stable Storm Ditch to augment flows available for hydropower development and to provide sufficient downstream flows for native fisheries. A 4,350-foot long, 96-inch diameter, spiral rib steel pipe would be constructed along and buried on the left side of the Wailua River and through existing cane fields. At the terminus of the 96-inch pipe, water would flow into an 84-inch smooth steel penstock approximately 600 feet long.

Flows would enter the power plant, to be located at the left bank of the Wailua River, approximately 3,700 feet below the Wailua Falls. The power plant would be sized 6.6mw, and would operate in the range of 30-365 cfs with a vertical Francis two-turbine system.

The outlet channel would be a trapezoidal-shaped, riprap-lined channel approximately 200 feet long which would exit into the river. Access to the power plant would be made possible by utilizing existing access roads. Electrical transmission lines would connect directly to the Kauai Electric Lydgate Substation located near Lydgate State Park.

In order to divert additional flows from the North Fork, some structural changes to the Stable Storm Ditch will be necessary. To supplement flow by some 92 cfs, a 5-foot wide by 5-foot high, rectangular head gate and concrete transition will be used to replace the existing head gate structure.

BIOLOGICAL AND SOCIAL EVALUATIONS

1. Future Without the Project

a. Riparian Resources. Flat pasture lands border the terminal reach of the Wailua River although most of the sloping hillsides are heavily forested. A dense overgrowth of hao (Hibiscus tiliacenous) lines the estuary. The lowest flatlands along the Wailua, once a tidal marsh, were modified considerably in 1960 by the construction of seven ponds for the Paradise Pacifica gardens. Only a portion of the undeveloped marshlands lies adjacent to the boundary of Paradise Pacifica today. Experimental taro farms line the terminal reach of the Opaekaa Tributary.

Riparian vegetation throughout the lower and middle reaches of the river remains relatively constant, and is dominated by exotic or naturalized species. Characteristic plants include hao, kukui (Aleurites moluccana), guava (Psidium guajava), java plum (Eugenia cumini), California grass (Brachyaria mutica), and other exotic and native trees, shrubs, and herbs. Native species of plants are abundant only in the headwater regions of the streams beyond the boundaries of the project area. Most of the watershed has been cleared for either sugarcane and/or forestation projects based largely on trees.

b. Wildlife Resources. Non-aquatic avifauna observed by Shallenberger (1977) within the terminal reaches of the Wailua River and estuary included exotic passerines such as common mynah (Acridotheres tristis), Japanese white-eye (Zosterops japonicus), house finch (Carpodacus mexicanus), house sparrow (Passer domesticus), and barred dove (Geopelia striata). The western meadowlark (Sturnella neglecta), ring-necked pheasant (Phasianus versicolor), and spotted dove (Streptopelia chinensis) were less common and confined to open pasturelands. Within the dense hao forests bordering the stream, shama thrush (Copsychus malabricus), Chinese thrush (Garrulax canorus), and northern cardinal (Cardinalis cardinalis) were common.

Observations of waterbirds within the lower reaches of the Wailua River and estuary were made by Shallenberger (1977). The wetlands of the Wailua River and Opaekaa Stream provide good waterbird habitat for the Hawaiian coot (Fulica americana alai), gallinule (Gallinula chloropus sandvicensis), and duck (Anas wyvilliana). Coots prefer the Opaekaa taro fields to the lower Wailua River; however, gallinule were widely dispersed throughout the river bottomlands. Paradise Pacifica was found to support the largest population of gallinule in the river system. In fact, more gallinule were observed within the botanical garden than in any other wetland habitat within the state. Few ducks (koloa) have been observed in the lower Wailua area since the decline of rice farming; however, one recent sighting (1981) of a single duck near the proposed power plant.

The Hawaiian Waterbirds Recovery Plan (1977) identifies the Opaekaa-Wailua wetlands as areas of secondary importance for the enhancement of endangered waterbird habitat.

c. Aquatic Resources. The Wailua River system was not included in the statewide inventory of streams conducted by Timbol and Maciolek (1978). There are few published biological or limnological studies about the Wailua watershed. Unpublished records of the Hawaii Cooperative Fishery Research Unit indicate that the river system supports several introduced species of continental, warm-water game fishes and crustaceans. Populations of the native fauna appear to be in decline, possibly due to interactions with exotic competitors and predators, and to habitat reduction caused by dewaterment. Figure 3 illustrates the present distribution of aquatic resources in the Wailua River system based upon field surveys conducted by the Corps and the Fish and Wildlife Service during the course of study for the proposed development, and upon information provided by state aquatic biologists. This figure demonstrates that habitat for native stream Gobiidae is presently confined to the stream reaches below Wailua Falls on the South Fork of the Wailua River, and below Kaholalele Falls on the North Fork. Endemic atyid shrimp (*Atya bisulcata*) are still known to be abundant in the upper reaches of most North and South Fork tributaries. Their populations are locally depressed where smallmouth bass are abundant.

Table 1 presents a rough estimate of the availability of habitat (stream length) with each of the principal tributaries of the Wailua River system.

Table 2 lists species which have been collected or observed in the stream within the study area. Smallmouth bass, swordtails, Chinese catfish, and mosquito fish appear to be the most abundant fishes throughout the stream above Wailua Falls. Smallmouth bass were introduced to Kauai in 1956 and have flourished throughout the Wailua River system. It is the dominant species in streams wherever it occurs on the islands of Kauai and Oahu.

The smallmouth bass fishery, which exists within the South Fork between Wailua Falls and the mauka ditch intake on all tributaries and in the North Fork between Kaholalele Falls and the Iliiliula Ditch, involves more than 40 river miles, or roughly 47% of the total South Fork stream length and 50% of the North Fork stream length. Remnant populations of largemouth bass from reservoir spillover are also known to exist within the North and South Forks. Population estimates for either species are not available. Other species which are occasionally taken by recreational fishermen include tilapia, bluegill, carp, and Chinese catfish.

Figure 3
STREAM HABITAT

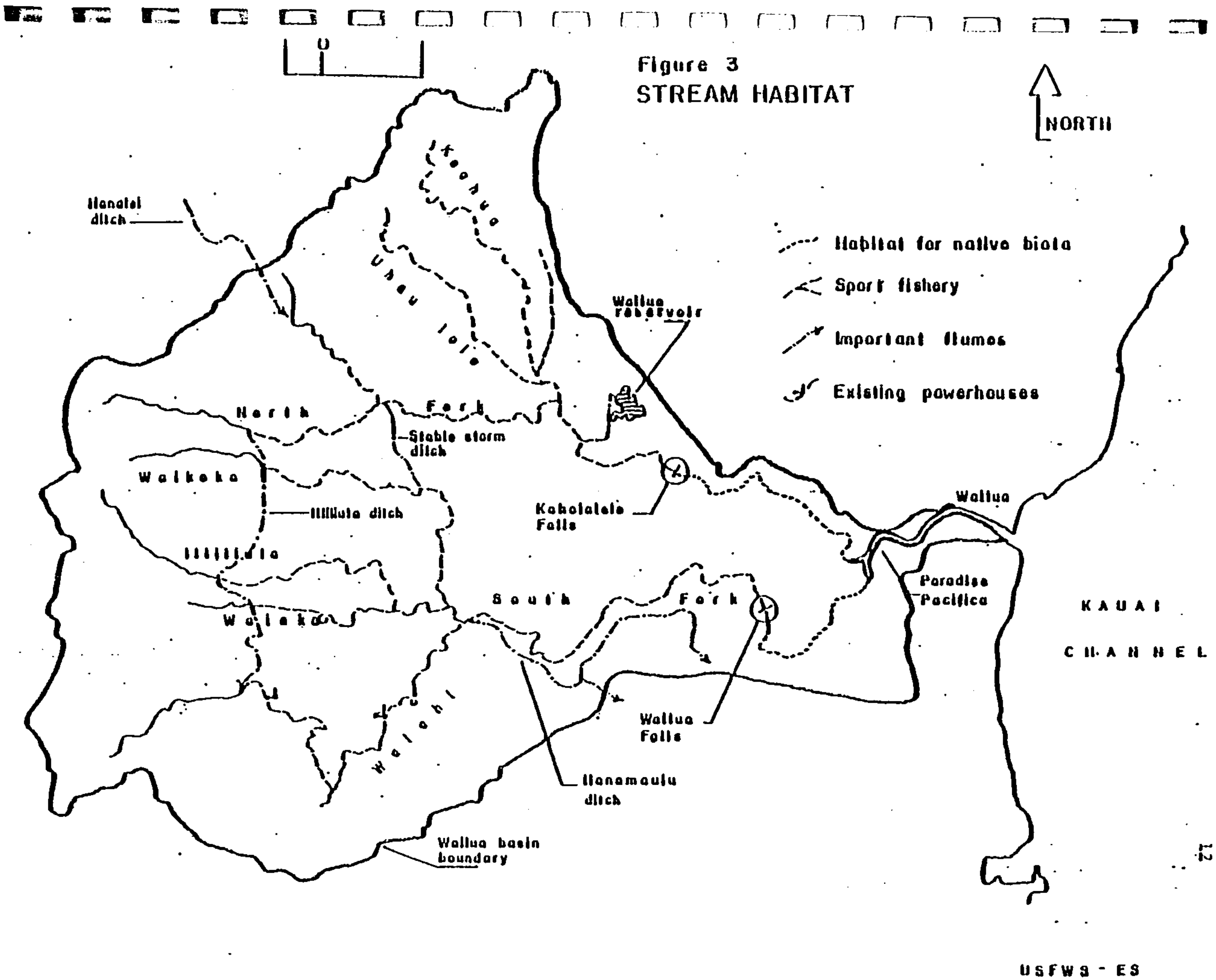


TABLE 1. TRIBUTARY LENGTHS FOR WAILUA RIVER[1]

Tributary Name	Length in miles[1]	Productive Habitat[2]
North Fork	18.41	9.00
Uahu Iole	6.63	2.50
Keahua	4.05	2.50
Kawi	2.88	2.00
Total North Fork	31.97	16.00
South Fork	11.10	10.90
Halii[3]	3.41	00
Palikea[3]	1.59	00
Kaulu[3]	1.52	00
Waiahi	12.50	7.00
Iole	3.03	2.00
Waiaka	3.52	0.50
Iliiliula	10.23	3.00
Waikoko	9.70	4.00
Total South Fork	56.60	27.40
Total Stream Length	88.57	43.40
Wailua Estuary	2.40	2.40
GRAND TOTAL	90.97	45.80

Note: [1]Opaekaa Stream not included within project area or this estimate. Lengths (to headwaters) estimated by map measure using USGS quadrangle maps.
[2]Includes habitat (in miles) for both indigenous and game fishery resources.
[3]Intermittent streams.

TABLE 2. AQUATIC MACROFAUNA OBSERVED IN WAILUA RIVER 1980-1982.

Key: - rare; + occasional; ++ common; +++ abundant; [1] endemic; [2] native; [3] introduced

Class / Family / Species	Common Name	Above Wailua Falls	Below Wailua Falls	Above Kaholalele Falls North Fork
Insecta				
Chironomidae[2]	midges		++	
Ephydridae[2]	brine flies		++	
Culicidae[3]	mosquitoes	+++	+++	
Tipulidae[2]	crane flies		++	
Order: Tricoptera				
Cheumatopsyche analis[3]	caddisfly	++	+++	++
Order: Odonata				
Coenagriidae				
Enalagma civile[3]	damselfly			++
Crustacea				
Atyidae				
Atya bisulcata[1]	opae	++	+++	++
Palaemonidae				
Macrobrachium grandimanus[1]	opae oeha'a		+++	
Macrobrachium lar[3]	Tahitian prawn	+	+++	++
Procambarus clarkii	crayfish	++	++	++
Gastropoda				
Ancylidae				
Ferrissia sharpi[1]	limpet		-	

TABLE 2 (Continued)

Class Family Species	Common Name	Above Wailua Falls	Below Wailua Falls	Above Kaholalele Falls North Fork
Lymnaeidae				
Erinna aulacospira[1]			++	
Pseudisidora rubella[1]			++	
Thiaridae		+++		
Osteichthyes (Pisces)				
Centrarchidae				
Micropterus salmoides[3]	largemouth bass	+	+	+
Micropterus dolomieui[3]	smallmouth bass	+++	++	+++
Lepomis macrochirus[3]	bluegill	++		+
Clariidae				
Clarias fuscus[3]	Chinese catfish	+++	+	
Poeciliidae				
Poecilia reticulata[3]	guppy	+		
Gambusia affinis[3]	mosquitofish	+++		
Xiphophorus sp.	swordtail	+++	+++	+++
Cyprinidae				
Cyprinus carpio	carp	–	–	–
Gobiidae				
Eleotris sandwicensis[1]	o'opu akupa		+++	
Awaous stamineus[1]	o'opu nakea	+	+++	
Sicydium stimpsoni[1]	o'opu nopili		+	

Limnological reconnaissance surveys have identified significant numbers of indigenous species in the South Fork below Wailua Falls. This reach is not easily accessible due to steep valley walls and slippery trails. This may account for the infrequent exploitation of this native fishery. Fishing for native, itinerant marine species, such as mullet, barracuda, and certain crabs, also occurs within the estuary. Wailua Falls apparently acts as a passage barrier to some of the native, diadromous species during prolonged periods of reduced streamflow. Those individuals that are able to surmount the falls must contend with predation pressure by exotic species. The native mountain opae and introduced Tahitian prawn are the only diadromous species found in abundance above Wailua Falls.

No significant biological surveys of the Wailua River estuary have been identified. No surveys were conducted as part of this study since the estuary lies beyond the area of the river which will be impacted by the proposed hydropower development. A general description of characteristic fauna, and physicochemical parameters of small Hawaiian estuaries appear in Maciolek and Timbol (1981).

d. Social/Economic Resources. The smallmouth bass is the central species of interest in the unmanaged recreational fishery. Unfortunately, there are no catch or user/day statistics available for the fishery. No published information is available which describes the fishing effort exerted on the native fishery within the estuary and lower reaches of the stream. It is believed that the take is regular and occasionally quite heavy.

Kauai is still recognized as the center of the State's seasonal commercial fishery based upon gobiid fishes. Heaviest fishing pressure appears to be exerted on Lumahai, Wainiha, Kalihiwai, and Hanalei rivers along Kauai's north coast. The Hanapepe and Waimea rivers were once also major centers of this native fishery. The fishery is not managed or monitored, and catch in recent years may have declined. Principal species of interest in this fishery are *Awaous* (*Chonophorus*) *stamineus*, "o'opu nakea"; and *Eleotris sandwicensis*, "o'opu akupa." Other species of interest include the native shrimp *Atya bisulcata*, "opae kalaole"; and *Macrobrachium grandimanus*, "opae oeha'a"; and the endemic mollusk *Neritina granosa*, "wi." The introduced Tahitian prawn (*M. lar*) is also one of the more commonly sought-after species in streams.

The existing conditions within the South Fork and North Fork Wailua River are not expected to change significantly in future years provided that water demands, floodplain and upland development do not increase significantly. Populations of native stream fauna may decline unless water development projects or upland development do not seriously jeopardize remaining stream habitat.

2. Future With Project

a. Riparian Resources. The proposed alternative schemes for hydropower development on the South Fork Wailua will not adversely affect any significant resources.

b. Wildlife Resources. Some nesting sites for exotic birds will be removed, and other terrestial fauna may be displaced during construction. A total of approximately .75 acres of riparian habitat will be cleared for the project. The permanent pool above the proposed intake is expected to inundate approximately 35.0 acres of wooded stream bank. (Creation of a recreational pond below the power plant as illustrated in the Interim Survey Report is not a component of the Corps project; rather it is part of the Wailua River State Park master plan.)

c. Aquatic Resources. The project has a potential for damage from sedimentation; however, a total of 1.7 river miles (including the falls) would be subject to partial dewaterment. Diversion of North Fork waters through the Stable Storm Ditch would significantly reduce the impacts of partial South Fork dewaterment; however, it would also result in a reduction of flow and important habitat for smallmouth bass in the North Fork below the Stable Storm Ditch.

Short-term impacts of the project involve excavation, transport, and placement of fill material within the Wailua River can be expected. Impacts will include disturbance, displacement, and destruction of aquatic fauna, suspension of fine sediments resulting in increased turbidity, and introduction of potentially toxic substances, such as petroleum products from construction machinery. Short-term impacts mentioned above may also extend to the Wailua estuary during construction.

The long-term impacts of sediment resulting from construction and operation of the diversion may result in the loss or reduction of significant aquatic habitat unless sufficient flow velocities are maintained to prevent sediment accumulation, and to periodically purge the fines.

Long-term impacts include partial diversion of the stream below the diversion structures causing reduction of flow, alteration of normal seasonal flow regimes, and subsequent habitat reduction and population decline of indigenous and introduced fauna inhabiting the lower stream course between Wailua Falls and the power plant outfall, and below the Stable Storm Ditch on the North Fork. The impoundment structures may constitute barriers to migration of shrimp and prawns. No thermal stress is anticipated due to power plant effluent; however, reduced flows between the intake and power plant may increase solar insulation of waters within this reach, possibly leading to thermal stress and exclusion of some organisms (Hathaway 1978).

No adverse impacts to fishes are anticipated due to potential gas saturation of power plant tailwaters; however, periodic monitoring of total gas pressures in tailwaters should be conducted to insure that conditions which may lead to mass mortality of fishes are not allowed to occur. These impacts have been observed and documented at small hydro facilities within the continental U.S. (Ross Antipa, Washington State Fisheries; pers. comm.).

d. <u>Social/Economic Resources</u>. None of the proposed alternative plans <u>will</u> significantly <u>impact</u> the smallmouth bass fishery above Wailua <u>Falls</u> on the South Fork, <u>provided</u> that public access to the stream and [illegible]acre pool above the intake is maintained year-round. Unless mitigated by appropriate technology (such as rotating fish screens), substantial numbers of game fishes may be lost through the intake structure. The additional flow made available from the North Fork <u>will</u> not significantly alter or enhance habitat in the South Fork for this species. No decrease in flow will occur in the South Fork above the intake structure as a result of the proposed development. <u>It is imperative that future Coordination Act studies conducted during Phase 1 Post-authorization identify and quantify the most important reaches for maintenance of sport fishery habitat so that adequate allotment of instream flows will be insured in both North and South Forks</u>.

The impoundment pond above the intake should be enhanced for public sport fishing and should provide facilities for additional water-related recreation.

MITIGATION PROPOSAL

1. Plan Description and Justification

The Fish and Wildlife Service is recommending mitigation to minimize adverse impacts associated with short-term impacts to water quality and long-term alteration of flow regimes. Studies to be conducted during Post-authorization are also identified here.

The following measures have been identified as the most effective mitigation measures which may be practicably employed to protect fish and wildlife resources within the project area:

Erosion Control

a. Construction in the water (diversion structure, outlet structures) and along the channel walls (access roads, penstocks, power plant) is to be conducted during periods of low rainfall, and should be scheduled for the months of June-September.

b. Dredged or excavated material should be removed from the stream channel, and may not be temporarily stockpiled into the water.

c. Movements of heavy construction machinery in the stream should be avoided or minimized.

d. Automatic shutoff valves should be installed to prevent soil erosion on riparian areas in case of penstock failure.

e. Silt should be periodically cleaned from the pool above the intake structure.

f. Stream and impoundment banks subject to clearing during construction should be stabilized as soon as practicable to reduce soil erosion.

Maintenance and Stream Flows

a. The diversion structure must be designed to allow continuous downstream discharge during peak power development. Adequate instream flow regimes to conserve important sport fishing habitat in the South Fork must be determined through field analysis in consultation with the Service and the State.

Furthermore, the diversion must be designed to permit periodic passage of flows necessary to flush accumulated silt from the lower stream course, and to accomodate spawning requirements of the native fishery resources in the lower reaches of the South Fork.

TABLE 3. SUMMARY OF PRIMARY EFFECTS OF ALL PLANS ON STREAM HABITAT IN THE WAILUA RIVER, KAUAI

	ESTIMATED AVAILABLE HABITAT[1]					
	Future Without Project		Future With Project			
			Without Mitigation		With Mitigation[2]	
	native fisheries	game fisheries	native fisheries	game fisheries	native fisheries	game fisheries
South Fork	2.4	27.4	0.6	27.4	2.3	27.4
North Fork	2.8	16.0	0.5	10.0	2.5	16.0
TOTAL	5.2	43.4	1.1	37.4	4.8	43.4

NOTES: 1) All values in river miles; 2) FWS mitigation recommendations.

Passage and spawing flows must be negotiated through consultation with the State and the Service.

b. The diversion structure on the North Fork at the Stable Storm Ditch must provide for continuous downstream discharge. Adequate instream flow regimes to conserve important sport fishery habitat in the North Fork must be determined through field analysis in consultation with the Service and the State.

c. During construction of the diversion structure and conduit, allowance must be made to provide continuous flows downstream on the construction.

d. Appropriate ramping rates must be negotiated with the State and Service to prevent dewaterment during rapid start-up and shutdown.

e. Consideration must be given to the installation of automatic flow continuation valves to protect instream flows below the diversion structure in the event of sudden rejection at the powerhouse.

Maintenance of Passage

a. Rubble and/or boulders should be grouted into a portion of the downstream face of the diversion structure forming an irregularly shpaed, sloping cascade to provide appropriate pathway for migration of indigenous species.

b. Powerhouse tailwaters should be agitated (by jumps, baffles, or falls) to prevent excessive total gas pressures.

c. To prevent migration of fishes and crustaceans into tail race waters, falls and/or a flow dissipation structure should be installed below the powerhouse.

General

a. All applicable grading ordinances and water quality standards shall be met during construction. Should the applicant be advised with appropriate particularity by the Fish and Wildlife Service that the hydropower development is resulting in unacceptable impacts to fish, wildlife or riparian resources, the applicant will temporarily cease construction or hydropower plant operations until such time as said impacts are mitigated.

b. Detailed surveys of sport fishery populations and their instream flow requirements will be conducted during Post-authorization studies.

c. If required, the applicant shall conduct a systematic pre-, during, and post-construction water quality and aquatic biology monitoring program. This program will be initiated preeceding construction, and the scope of study will be prepared with the assistance of the Fish and Wildlife Service. Biological surveys will be conducted within the Kalepa Forest Reserve, along the alignment of the proposed power transmission lines, during Post-authorization studies.

Implementation of these mitigation measures is necessary and appropriate to minimize expected adverse impacts to water quality and fishery resources in the Wailua River, and to meet planning criteria identified by the applicant.

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U. S. ARMY ENGINEER DISTRICT, HONOLULU
BUILDING 230
FT SHAFTER, HAWAII 96858

PODED-PV

29 October 1982

Mr. Dale Coggeshall
Pacific Islands Administrator
Fish and Wildlife Service
U.S. Department of Interior
P. O. Box 50167
Honolulu, HI 96850

Dear Mr. Coggeshall:

We are responding to your 3 September 1982 letter forwarding the Fish and Wildlife Service Final Coordination Act (FWCA) Report for the Wailua Hydropower Study Interim Survey Report. Measures recommended in your report will be generally adopted by the U.S. Army Corps of Engineers. However, there are certain items in the FWCA report which we wish to clarify or which require statements of our current position. Further explanations are provided in the inclosure.

We appreciate your cooperative effort in this study, particularly the timeliness of your draft and final report submission. We will keep you informed of further developments with the study.

Sincerely,

1 Incl
As stated

ALFRED J. THIEDE
Colonel, Corps of Engineers
District Engineer

PODED-PV

29 October 1987

WAILUA RIVER HYDROPOWER STUDY
CORPS RESPONSES TO FWCA REPORT

EROSION CONTROL

Item d. The penstock will be designed for all foreseeable hydraulic conditions, hence penstock failure is extremely unlikely. A gatewell with manual shutoff valve is provided in the present design (refer to Plates 3-18 and 3-26 of the draft survey report). Conversion of this feature to an automatic valve will be considered for the protection of hydraulic machinery.

MAINTENANCE OF STREAM FLOWS

Item d. Dewatering will not take place during start-up or shutdown of the hydropower systems proposed in the draft interim survey report.

Item e. The features proposed in item e. are not considered necessary. The flow gates would be designed to close gradually, allowing flow to simultaneously increase over the diversion structure and downstream so that flows below the tailrace will not be subject to sudden decreases as a result of powerplant operations.

MAINTENANCE OF PASSAGE

Item b. These features will be considered during design of the confluence. At the present time it has not been determined that total gas pressures would be great enough to warrant treatment. The final FWCA report (para 3, p 19) states that no adverse impacts to fish are anticipated due to potential gas saturation of powerplant tailwaters.

Item c. These features are not considered necessary because the tailrace will be short and water velocities at the outlet will be relatively high (greater than 10 feet/sec). This will preclude the possibility of aquatic organisms migrating into powerplant machinery. Organisms migrating into the tailrace will have no problem returning to the main stream.

GENERAL

Item a. This requirement would be subject to discussion and negotiation. The Corps is charged with administering the construction contract. Any work stoppage would result in contractor claims. The limits of acceptability would require enforceable specifications by the USFWS. If these requirements are adopted by the Contracting Officer, they will be incorporated into the contract documents.

Item b. These surveys would be conducted during post-authorization studies but not necessarily during Phase I.

Item c. Identified potential impacts resulting from the proposed project do not at this point warrant the recommended intensive water quality and aquatic biology monitoring program. If during the course of post-authorization investigations, unforeseen adverse impacts to water quality or aquatic biota appear likely, a monitoring program may be necessary.

Biological surveys along transmission line alignments within the Kalepa Forest Reserve will be conducted during post-authorization studies.

CLEAN WATER ACT

SECTION 404(b)(1)
EVALUATION OF THE EFFECTS OF THE
DISCHARGE OF DREDEGED OR FILL MATERIAL INTO
WATER OF THE U.S.[1]

PROJECT DESCRIPTION

a. Location: Wailua River, Wailua, Island of Kauai.

b. General Description: The Honolulu District, U.S. Army Corps of Engineers, has investigated the feasibility of hydroelectric power generation on the South Fork Wailua River and associated impacts on the environmental, social, cultural and economic resources of the area. Two structural plans have been developed that would require the discharge of fill material, mainly concrete and riprap, within the stream. The principal structural feature within the stream would be a diversion structure. Portions of the penstock and tail race structures would also require placement of fill material. The nonstructural plan (Alternative 3) would not affect waters of the U.S.

c. Authority and Purpose: This report was prepared under the authority of Section 209 of the Flood Control Act of 1962 (Public Law 87-874). This section authorizes the Secretary of the Army, through the Chief of Engineers, to study water and related resources problems and needs in the State of Hawaii. The Honolulu District, U.S. Army Corps of Engineers, was reqested to perform investigations for small-scaled hydropower development in the Wailua River, Kauai, by the State of Hawaii. This study is in reponse to that request.

d. General Descriptions of Dredged or Fill Materials:

(1)	General Characteristics of the Material.	Concrete consisting of cement, aggregates and water with reinforcement bars. Riprap material consisting of quarried rock.
(2)	Quantity of Material to be Discharged[2].	3,160 CY
(3)	Source of the Material.	Aggregates will probably come from existing quarries to the vicinity of Hilo, Hawaii. Cement will be factory produced.

1 Using U.S. Environmental Protection Agency (EPA) Guidelines.

2 Material includes concrete and bedding.

e. <u>Description of the Proposed Discharge Site</u>

(1) Location (see map,) Figure 2 & 3 of Main Report).	Diversion structure would be located approximately 1000 feet upstream of Wailua Falls. Tailrace would be located 1.7 miles below the falls.
(2) Size (acres)	0.25 acres
(3) Type of Site	Perennial stream
(4) Type(s) of Habitat	Aquatic freshwater habitat
(5) Timing and Duration of Discharge	The project will probably be implemented within 1 to 2 years and will take 12 months construct.

f. <u>Description of Disposal Method:</u>

(1) Method of Discharge	Material will be used to construct a diversion dam and tailrace at the discharge sites.

PHYSICAL DETERMINATIONS

a. Physical Substrate Determinations

(1) Substrate Elevation and Slope	240'-260' MSL
(2) Sediment Type	(pp. D-1-6)
(3) Dredeged/Fill Material Movement	NA[2]
(4) Physical Effects on Benthos	Burial
(5) Other Effects	NA
(6) Actions Taken to Minimize Impacts	NA

b. Water Circulation, Fluctation and Salinity Determination:

(1) Water, Effects on:

(a) Salinity	NA
(b) Water Chemistry	No effect
(c) Clarity	No effect
(d) Color	No effect
(e) Odor	No effect
(f) Taste	No effect
(g) Dissolved Gas Levels	Increased below powerplant tailrace
(h) Nutrients	No effect

[2] Not applicable

b. Water Circulation, Fluctation and Salinity Determination:

(2) Current Patterns and Circulation

(a) Current Patterns	No effect
(b) Velocity	Decrease during power plant operation between diversion structure and powerplant tailrace
(c) Stratification	No effect
(d) Hydrologic Regime	The dam will divert water from the river to a hydroelectric powerplant and return it to the river. When the plant is in operation, 10 CFS conservation flow will be maintained in the river reach between diversion and the tailrace
(3) Normal Water Level Fluctations	No effect
(4) Salinity Gradients	NA
(5) Actions That Will Be Taken To Minimize Impacts	10 CFS conservation flow will be maintained during periods of powerplant operation

c. Suspended Particulate/Turbidity Determination:

(1) Expected Changes in Suspended Particulate and Turbidity Levels in Vicinity of Disposal	No effect
(2) Effects (degree and duration) on Chemical and Physical Properties of the Water Column	
(a) Light penetration	No effect
(b) Dissolved Oxygen	No effect
(c) Toxic Metals and Organics	No effect
(d) Pathogens	No effect
(e) Aesthetics	No effect

APPENDIX H

A CULTURAL RECONNAISSANCE FOR THE WAILUA RIVER HYDROPOWER STUDY

A CULTURAL RESOURCES RECONNAISSANCE FOR THE WAILUA RIVER HYDROPOWER STUDY

by
Francis K.W. Ching (Ed.)

prepared by
ARCHAEOLOGICAL RESEARCH CENTER HAWAII, INC.

for
UNITED STATE ARMY CORPS OF ENGINEERS
U.S. ARMY ENGINEER DISTRICT, HONOLULU

Lawa'i
April 1981

ARCH 14-79

The opinions, findings and conclusions expressed in this publication are those of the authors and not necessarily those of the United States Army Corps of Engineers.

ABSTRACT

An archaeological reconnaissance requested by the U.S. Army Corps of Engineers was conducted on nine (9) separate parcels of land in the Wailua River gorge, Wailua and Hanamā'ulu ahupua'a(s), Kaua'i Island as part of the Wailua Hydropower Study. Three (3) agricultural terrace complexes in study Areas E and H and one (1) 'auwai in Area A were located. Feral pig (Sus scrofa) tracks were observed throughout the areas and one Koloa (Anas spp.) was observed in Area B. Relict cultigens (kalo), and Hawaiian forest products (koa, kukui, kī, 'ohe, hau, pū hala) are also present. Major modern disturbances are present in all of the study areas as well. The literature search has shown that without the survival of Hawaiian place names, mo'olelo and ka'ao our present knowledge of Wailua would be very scant. Recommendations include archaeological clearance for all of the study areas, consideration of the impact of the project upon avifauna observed in study Area B and exercising caution to avoid impacting the remaining archaeological sites adjacent to study Areas A, B and south of area H (east end).

ACKNOWLEDGEMENTS

Members of the field crew for this project were Mr. Francis K.W. Ching, Mr. William H. Folk, Mr. Gerald Kamalu Ida and Mr. Warren T. Yoshioka. Gerald Ida and Warren Yoshioka deserve special acknowledgement for their unerring judgement and adeptness in negotiating the steep and densely vegetated slopes and precipices of the Wailua River gorge.

Mr. Brian P. Donahue prepared all the final maps and sketches of the archaeological sites from field notes. His professional skills are gratefully acknowledged.

We would like to thank Mr. David Sox of the U.S. Army Corps of Engineers, for providing maps of the area and arranging access to the properties.

Mr. Ishimoto, of the Construction and Water Supply Division, Līhu'e Plantation, Mr. Gahran and Mr. Penhallow of the Kauai Museum and Mrs. Peters, Head Librarian and the staff of the Kauai Community College Library assisted in the historical literature and map search.

Grateful acknowledgement is extended to Mrs. Diane K. Shimizu for typing this report and Mr. Francis K.W. Ching, President of Archaeological Research Center Hawaii, Inc. for editing it. Mr. Francis Ching's knowledge of the area and access roads helped greatly during the field work. Mr. Ching offered continued support and advice throughout the report preparation.

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INTRODUCTION

This report presents the results of an archaeological reconnaissance in portions of the south fork of the Wailua River, Wailua and Hanamā'ulu ahupua'a(s), Kaua'i Island. The study was requested by the United States Army Corps of Engineers as part of a hydropower feasibility study.

The locations of the study areas designated A through I are shown in Figure 3. Figures 4, 5 and 6 are smaller scale maps of Areas A, E and H respectively, and show the distribution and configuration of the archaeological sites found during the reconnaissance. These latter figures are included in the "Reconnaissance Results" section in addition to brief descriptions of the topography, vegetation and archaeological sites of each study area. Table 1 contains an accession list of the archaeological sites by permanent State of Hawaii system numbers.

A summary of traditional mo'olelo and ka'ao, early westerner's accounts, interpretation of place names, the physical geography of the ahupua'a and the region, and previous archaeological work are presented together in the section "Background".

Consideration of the distribution of the sites, the site types found and posssible reasons for their locations is given in the final section of the report "Conclusions". Following is a glossary and "Bibliography"; this is annotated giving the facility where the reference is available.

Reference to the various tributaries and branches of the Wailua River system are based on the 1963 U.S.G.S. 7.5 minute series topographical maps. Place name differences between the above map and early maps are discussed in "Background". Spellings of place names are from "Atlas of Hawaii" (Armstrong Ed., 1973).

SUMMARY OF RESULTS AND RECOMMENDATIONS

The archaeological reconnaissance reported herein was requested by the United State Army Corps of Engineers as part of the Wailua River Hydropower Study (Figures 1 and 2). Nine (9) separate areas for study were defined by the Corps (Figure 3). Eight (8) areas are located along the south fork of the Wailua River (Areas A through H) and one (Area I) is located along an existing Līhu'e Sugar Company ditch between the Wailua River north fork and Waikoko Stream (a tributary to the south fork). These areas were selected for study because they were presumed to be in a relatively natural state, that is, least affected by modern agricultural activities. The remaining areas that will be crossed by the proposed penstock are presently under sugar cane cultivation and have therefore been extensively modified.

The vegetation in all of the study areas is a mixture of indigenous, Hawaiian introduced and recently introduced cultigens, grasses, herbs, shrubs and trees. The presence in remote areas of cultigens and Hawaiian introduced plants important in traditional Hawaiian domestic and economic activities complements early accounts and ethnographic records concerning the geographical extent of Hawaiian horticultural endeavors and the type localities utilized. This also gives perspective to other Euro-American interpretations such as the undeveloped nature of traditional Hawaiian land use policy.

Archaeological clearance is recommended for study Areas B, C, D, F, G and I because they do not contain positively identifiable modifications of the landscape resulting from prehistoric Hawaiian cultural activities. The modern debris present is of little or no significance to the study of Hawaiian history or archaeology. Historic modification in Areas A and H have impacted sites and in Area E have helped preserve them. However, the sighting of Koloa (*Anas* spp.), a federally listed endangered species, in study Area B during the mating season should be considered by the appropriate State or Federal agency prior to impact of this area.

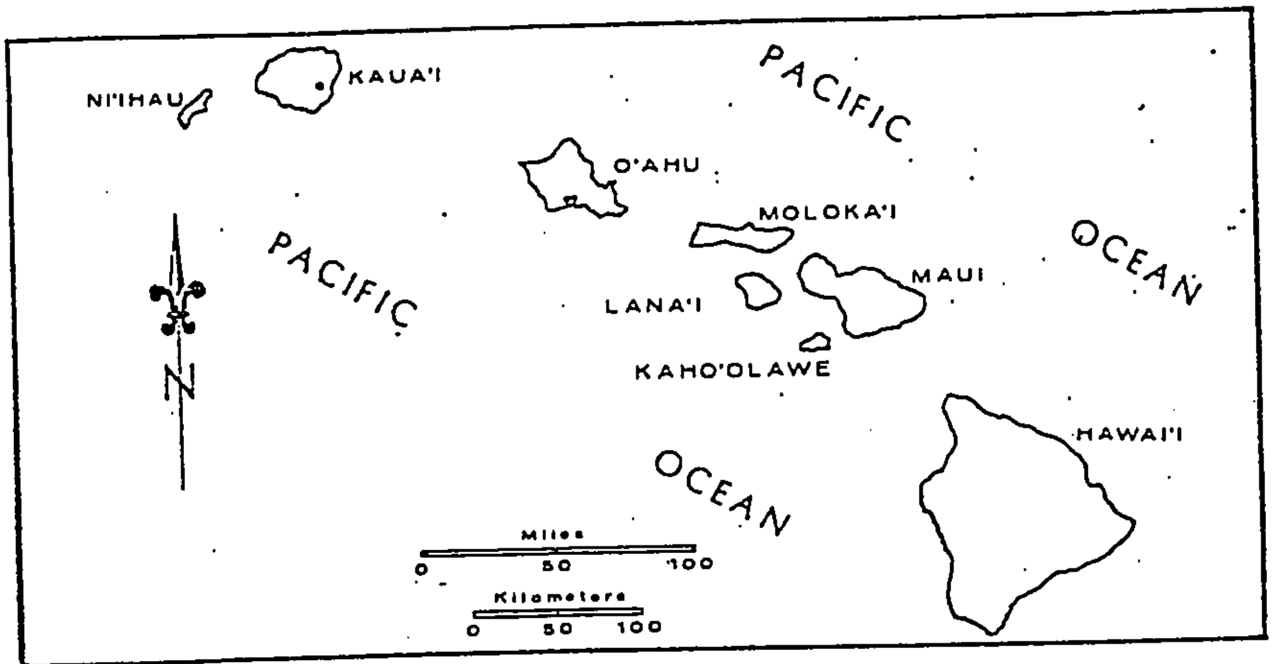


FIGURE 1
Map of the State of Hawai'i

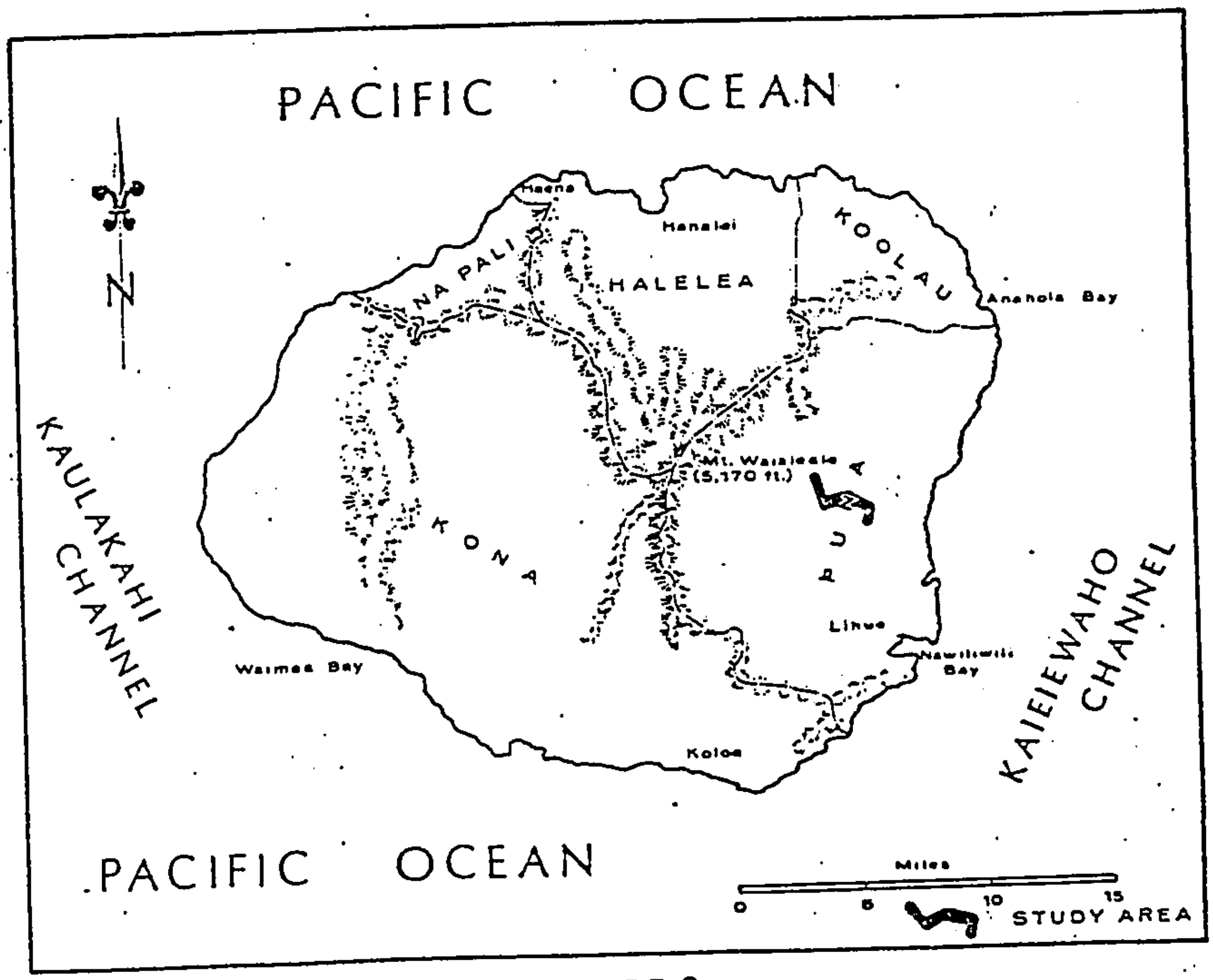
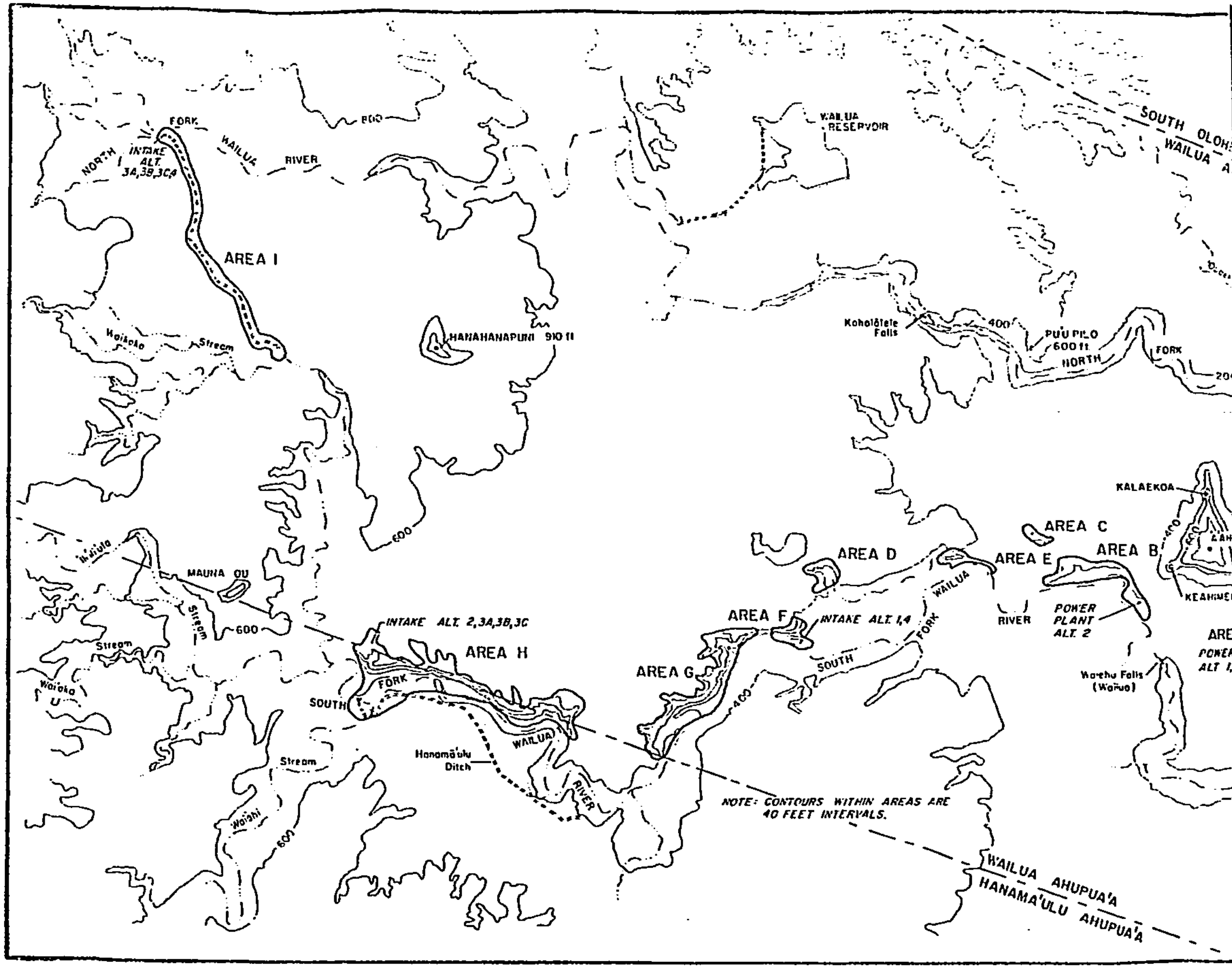


FIGURE 2
General Location Map, Koua'i Island


FORK
NORTH
INTAKE ALT. 3A,3B,3C4
WAILUA
RIVER
AREA I
HANAHANAPUNI 910 ft
WAILUA RESERVOIR
SOUTH
WAILUA
Kohololele Falls
400
PUU PILO 600 ft
NORTH
FORK
MAUNA OU
600
Stream
INTAKE ALT. 2,3A,3B,3C
AREA H
FORK
SOUTH
Hanamā'ulu Ditch
WAILUA
RIVER
AREA G
AREA F
INTAKE ALT. 1,4
AREA D
SOUTH
FORK
WAILUA
AREA E
AREA C
AREA B
KALAEKOA
KEAHUMEKI
RIVER
POWER PLANT ALT. 2
POWER ALT 1
Waoahu Falls (Waʻiuo)
NOTE: CONTOURS WITHIN AREAS ARE 40 FEET INTERVALS.
WAILUA AHUPUA'A
HANAMA'ULU AHUPUA'A

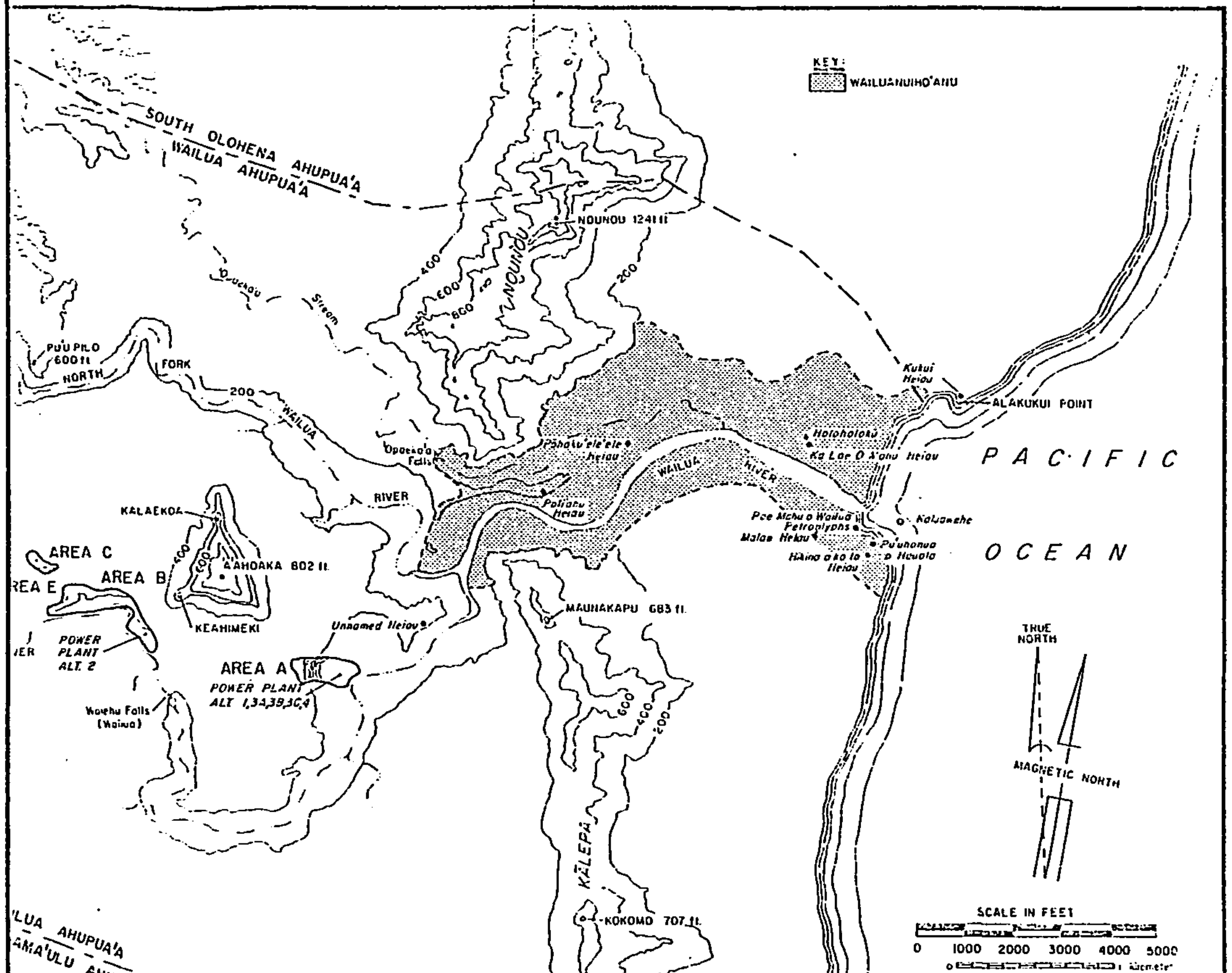


FIGURE 3 TOPOGRAPHIC MAP SHOWING STUDY AREAS

Archaeological clearance with no further work is also recommended for study Areas A, E and H although they contain identifiable remnants of Hawaiian agricultural terraces and _'auwai_ (Table 1). In the case of Area A this consists of a single possible _'auwai_ which continues northward and eastward. In Area H the sites consist of isolated agricultural terraces that are in a very deteriorated condition. And in Area E, two (2) agricultural terraces are in a fair state of preservation, due primarily to the reduced volume of stream flow because of the tapping of water for sugar cane cultivation around the study area.

In Areas E and H the archaeological remains are disturbed and unimposing and are considered inappropriate for preservation or excavation because there are numerous other functionally and architecturally similar recorded sites (Ching 1968) in a good state of preservation within the bounds of the Wailua State Park that are now preserved for future scientific research and the public. In Area A agricultural terraces shown on Metcalf's (1846) survey map are no longer discernible as a result of bulldozing, flooding and slopewash. However, a portion of these terraces immediately north of the study area are still intact and should be protected from impact during the construction of the power plant as they are prime targets for future scientific research, preservation or reconstruction.

TABLE 1
ACCESSION LIST OF ARCHAEOLOGICAL SITES

Permanent Site Number	Field Number Ching (1968)	Study Area	Recorded Name	Site Function
205	25	A	Mākea	Lo'i complex
206	26	A	-	Rice mill
207	27	A	Konolea	Lo'i complex
208	28	A	-	'Auwai
209	-	E	-	Terrace complex
210	-	H	-	Terrace complex
211	-	H	-	Terrace complex

BACKGROUND

GEOLOGY

Wailua is located on the eastern side of the Island of Kaua'i, semiexposed to the prevailing northeasterly tradewinds. The rainfall averages about 70 inches per year in the area behind the Nounou and Kālepa mountains (Study Area A) to about 100 inches per year in more western (mauka) localities (study Area I) (Macdonald, Davis and Cox: 1960). The whole ahupua'a is situated in the Līhu'e basin, a geologic feature of the island. This large, semicircular depression, 7 to 10 miles across, is bordered on the west by the central Kaua'i mountain range, on the east by the Nounou and Kālepa mountains, on the north by Makaleha ridge, and on the south by Hā'upu range. The basin was actually a caldera formed by the collapse of a large portion of the eastern flank of the main shield volcano that forms the island. This collapse probably occurred late in the Waimea Canyon volcanic series, which formed the original land mass of the island in the Pliocene period. During the second major volcanic series, the Kōloa series, (late Pliocene period), lava flowed over the entire floor of the basin except for Pu'u Pilo, 'A'ahoaka hill, Kālepa and Nounou mountains, remnants of the Waimea Canyon series, which were high enough so as not to be totally buried and exist today as kīpuka (Macdonald and Abbott:1970). Two (2) vents of the Kōloa series near the vicinity of the project area are Kilohana Crater and Hanahanapuni cinder cone (Macdonald, Davis and Cox 1960). A different view as to the origin of the Līhu'e basin is offered by Hinds (1930) who maintains that the depression is a marine platform cut by the erosional forces of wave action combined with fluctuating sea levels and the tilting of the land mass.

SOILS AND DRAINAGE

The soil in the general area has been classed as the Kapa'a-Po'okū-Hāli'i-Makapili association. "Deep, nearly level to steep, well drained and moderately well drained soils that have a fine textured or moderately fine textured subsoil; on uplands . . . (Foote, et al:1972)."

The Wailua River, the largest in the State, and its tributaries comprise the major drainage system for the central area of the Līhu'e basin. The north fork of the river has its source at the base of the central Kaua'i mountains, below Wai'ale'ale and Kawaikini. The major streams flowing into the north fork are Uhau'iole, Keāhua, Kāwī, and Kalama, all originating at the north part of the basin in the southwest portion of Makaleha ridge.

The south fork, which is paralled by most of the project area, is formed by the convergence of several small streams at the western edge of the basin, south of Kawaikini. These are Palikea, Ka'ulu, Waikoko, 'Ili'ili'ula, Wai'aka, 'Iole, Hāli'i and Wai'ahi. The north and south forks meet just west of the gap between the ridges of Nounou and Kālepa. From this junction to the sea, a distance of almost 2 miles, the river is tidal-affected and navigable by small craft. 'Ōpaeka'a Stream, often referred to as the "north fork" also empties into the Wailua River below the north (middle)-south fork junction.

AHUPUA'A

The ahupua'a of Wailua is located in the moku of Puna, between south Olohena to the north and Hanamā'ulu to the south. It is traditionally known to be one of the most sacred places on the island. Powerful ali'i, from legendary through historic times, such as Mo'ikeha, Manokalanipō, Palila, and Kaumuali'i, resided there throughout most of the year (Salisbury 1936) (during the "wet season" they probably moved to Waimea on the dry leeward side of the island).

The name "Wailua" is generally thought to refer to the two (2) main forks of the Wailua River (wai = water, lua = two), however, Dickey (1916) displays some puzzlement insofar as "this explanation never seems to occur to a native Hawaiian." Some insight may be gained here if one examines the name as one word, which translated means "spirit, ghost; remains of the dead" (Puku'i and Elbert 1971). This may well have possible implications as to the sacred nature of the place.

The general area makai of the Nounou and Kālepa mountains was known in ancient times as Wailuanuiho'ānu*, or "great, sacred Wailua," a place that was kapu to the maka'āinana (Dickey 1916) (see shaded area Figure 3). In this light Wailua was comparable to other localities in the islands such as Waipi'o and Kahalu'u, Hawai'i or Kualoa, O'ahu where ali'i resided, young chiefs were raised and trained and numerous heiau were constructed. In Wailuanuiho'ānu and its vicinity there are no less than eight (8) prehistoric Hawaiian heiau.

HEIAU

Malae Heiau

Also known as Mākaukiu, this heiau sits in a cane field just mauka of Kaumuali'i Highway, at the top of a hill on the south bank of the Wailua River. It is the largest known, existing heiau on the island today measuring 273 feet by 324 feet (Thrum 1906) with walls that once stood 7 to 10 feet high (Salisbury 1936). It is said that Mo'ikeha built this structure during the period that Wailuanuiho'ānu ruled Kaua'i (BPBM Ms. 1885). The companion heiau to Malae is said to be Poli'ahu, situated on a ridge across the river.

Around 1830, soon after the lapsing of the kapu and the arrival of Christian missionaries, Deborah Kapule, wife of Kaumuali'i the ali'i of Kaua'i, tore down the interior walls of the heiau and used the structure as a pen to keep her cattle (Thrum 1906). She was among the first ali'i converts to Christianity, being baptized with Ka'ahumanu and

*After a chief of the same name. The area is also known as Wailuanuilani (Dickey:1916).

others at Kawaiaha'o Church, Honolulu, 1825 (Kamakau 1961). Her actions concerning Malae may have played a role in efforts to move her people from the "old ways" toward the "new religion".

The part of Malae nearest the river is reputed to be the birthplace of Ka'ililauokekoa, the girl made famous in an often told legend of Wailua. She was the granddaughter of the legendary Kaua'i ali'i, Mo'ikeha, and was skilled at surfing and kōnane. In this romantic story she is courted by Kauakahiali'i who lives at Pihanakalani (also known as Hanahanapuni, a cinder cone far up the north fork of the Wailua River, formed during the Kōloa volcanic series) with his mother, the sorceress Waha, and his sister Kahalelehua in a <u>hale</u> made of flowering <u>'ōhi'a lehua</u> branches and decorated with red feathers (Dickey 1916).

Kauakahiali'i invents the first nose flute ('ohehanoihu)* which he names Kanikāwī and lures Ka'ililauokekoa away from Malae by his skillful playing of it (Salisbury 1936).

<u>Pu'uhonua o Hauola/Hikinaakalā Heiau</u>

This complex is located on the south bank of the river, near its mouth. Hauola was a place of refuge where <u>kapu</u> breakers would find immunity from punishment, and others, safety from the ravages of war. Within its walls at the southern part of it is Hikinaakalā Heiau, a long and narrow structure said to contain the remains of a family killed as punishment for cultivating this sacred ground. Also contained within Hauola is a <u>pōhakupiko</u>, in the crevices of which would be placed the <u>piko</u> or navel cord of new-born infants (Dickey 1915).

*Several small stands of <u>'ohe</u> Hawai'i, the type of bamboo used in making nose flutes, were observed in and around the project area during the course of field work (refer to "Area and Site Descriptions"-Area I).

Kalaeokamanu Heiau

At the foot of the small hill called Pu'ukī, on the makai side, stands Kalaeokamanu Heiau, thought to be the oldest on Kaua'i. The first human sacrafices on the island were offered here. Also, the first temple drum* was placed here (Kaua'i Historical Society 1934). Its name was Hāwea and was brought to Kaua'i by La'amaikahiki, son of Mo'ikeha. The stone on which sacrifices were placed is called Pā'aikanaka (Ching 1968).

Poli'ahu Heiau

This heiau measures roughly 242 feet by 165 feet with walls 5 feet to 6 feet high (Bennett 1931). This temple is of the luakini class, its outer walls demonstrate the unique style of Kaua'i core fill wall construction in that the core is dirt instead of rock rubble. It is considered to be the personal temple of the ruling chief in that it is located in the area where the ali'i nui(s) compound was situated. It may have been named after Poli'ahu the Hawaiian goddess of snow.

Pōhaku'ele'ele Heiau

Located on the ridge between 'Ōpaeka'a Stream and the Wailua River, only remnants remain of this old heiau. A rock marked with a cross supposedly locates the former position of the temple drum that was sounded on the nights of Lono and Kāne. A little further mauka on this ridge is a stone representing a shark demi-god. Part of this stone was broken off by Hūmānienie who was sent from the Island of

*The Kaua'i Historical Society identifies this drum as a kā'eke, a term generally applied to the percussive instruments of bamboo cut in varying lengths to produce a distinctive note when tamped on the ground. Pahu would more correctly describe a temple drum of a hollowed coconut tree base and shark skin head.

Hawai'i to destroy all idols on Kaua'i. Past this stone is a place called Ka'elialinaakamāhu where the tattooing of Palila, a legendary warrior of Kaua'i, was done. Two (2) stones, one for his head and the other for his body to rest on, marks this spot (Dickey 1916).

Mele'ahaanounou was another heiau in Wailua, and was the first belonging to Wailunuiho'āno. Its specific location is unknown today (BPBM Ms. 1885).

An unnamed heiau was located on the slope of the ridge just behind the Kālepa-Nounou gap. The only reference to it is on an old map by Metcalf (1846). This heiau along with the others makes seven (7), traditionally said to be the number of heiau encountered when traveling up the river to Wai'ale'ale (Ching 1968).

Viewed as a group, the significance of these heiau cannot be overstated. Only a few other places in Hawaii can match the kind of concentration attained in Wailua, needless to say, an important religious and political center in ancient times.

OTHER SITES

Other sites in Wailua of traditional importance include the Paemāhū O Wailua petroglyphs near Hauola. The rocks holding the petroglyphs are said to be the brothers of Maui, who at one time lived in Wailua. Maui, the famous demi-god, is also connected with other geographic features in the area. Several stones in various areas of the river are said to be the fishhook, fishing sinker and canoe of Maui. Stratigraphic markings in the face of the cliff to the north are said to have been made when he hung his malo there to dry after fishing. Maui's home was on a hill just above 'Ōpaeka'a Falls (Dickey 1916).

The Holoholokū birthstones were important in that a child of Kaua'i irregardless of his bloodlines, would not be considered royalty unless he were born here. A chant from the legend of Kawelo expounds this tradition:

"Hanau ke 'lii iloko o Holoholoku-he alii nui;

Hanau ke kanaka ilioko o Holoholoku, he alii no;
Hanau ke alii nui mawaho a'e o Holoholoku, aohe
alii, he kanaka ia!"

"The child of a chief born at Holoholoku is a high chief;
The child of a commoner born at Holoholoku becomes a chief,
also;
The child of a high chief born outside of Holoholoku is no
chief, a commoner he!"

(Kaua'i Historical Society 1934)

The last person born at Holoholokū is said to be Kaumuali'ili'ili'i, the youngest son of King Kaumuali'i and Queen Deborah Kapule (Lydgate 1916).

Kaluawehe or the King's Highway began just offshore near the mouth of the Wailua River. An ali'i, upon his return from a sea voyage, would come up the "highway" in his canoe until he hit the beach whereupon both man and vessel would be carried up mauka to his hale (Salisbury 1936). The "highway" closely follows the present Poli'ahu Road (Ching 1968).

HISTORICAL INFORMATION

In historic times there are virtually no substantial written accounts or descriptions of Wailua. This, in part, can be traced to the fact that no Protestant mission station was established in or close to the area, a condition that has benefited the reconstruction of history in other locales through the use of journals, diaries, letters, etc.

A check of land awards as a result of the Great Mahele (1848) shows only a total of approximately 75 acres of Wailua awarded to 25 individuals, among them D. Kapule and Iosia Kaumuali'i, wife and son of Kaumuali'i, the last chief of Kaua'i. The rest of this large ahupua'a was kept as Crown Lands or the private lands of Kamehameha III (Kauikeaouli), another testament of the importance and value of the area at that time.

Handy, in 1935, studied the ahupua'a as an agricultural area. He found extensive agricultural terracing along the lower two miles of the river. However, by 1935 little of the original Hawaiian agricultural staples were being cultivated. Most of the terraces, once in taro, were given over to rice by Chinese farmers along with some limited areas in sweet potato and pasture (Handy 1940).

PREVIOUS WORK

Previous archaeological studies in the Wailua River valley (with one exception) are limited to sites of major significance in Wailuanui ho'ānu (Great Sacred Wailua). The mauka limit of this sacred area is defined by Dickey (1916) as being mounts Nounou on the north and Kapu on the south side of the river about 2,000 feet mauka of Poli'ahu Heiau (Bennett 1931:127, Site 107). Thus, this area includes most of the tidewater portion of the river but does not extend inland to the areas under study. Bennett (1931:128, Site 110) has recorded a site consisting of agricultural terraces in minor stream valleys mauka of Kapa('a) homesteads. These terraces are north of the present study areas but their geographic location is similar as a type locality.

The exception noted above is an archaeological study mauka of Wailuanuiho'āno conducted by Francis Ching (1968) on the alluvial terraces in the Wailua River gorge. This survey covered the north and south forks of the river from Koholālele (Falls) and Waiehu (now Wailua Falls) respectively to the confluence of the north and south forks. The survey recorded four (4) archaeological sites, 205, 206, 207, and 208 on the alluvial terraces where the present study Area A is located. Site 205 is an agricultural terrace complex situated across the river, northeast of Area A that appears on Metcalf's (1846) map indicated as being under rice cultivation and called by the name Mākea. Konole'a is the name given the terrace complex on the west side of the river. This complex is shown by Metcalf (1846 map) as extending through our study Area A (refer to Figure 4) but was present only to the north of Area A

TABLE 2

Selected Place Names Relating to Wailua, Kaua'i

This table is not intended as a comprehensive or definitive study of place names of Wailua. Rather, it should be viewed as a general guide, assembled from major written and recorded sources to give the reader some insights to the cultural background of the area.

'A'ahoaka	A hill, kīpuka of the Waimea Canyon Volcanic Series. Lit. (possibly), crescent-shaped belt or to defy (the) spirit.
Hāli'i	Tributary of S. fork, Wailua River, Lt., strewn.
Hanahanapuni	Cindercone of the Kōloa Volcanic Series. Lit., surrounding warmth. (see Pihanakalani).
Hauola	Pu'uhonua at mouth of Wailua River. Lit., dew (of) life.
Hikinaakalā	Heiau within Pu'uhonua o Hauola. Lit., the rising of the sun.
Holoholokū	Royal birthing place. Lit., to run (and) stand.
'Ili'iliula	Tributary of S. fork, Wailua River. Lit., red pebbles.
'Iole	Tributary of S. fork, Wailua River. Lit., rat. This may have a connection to the legend of Kawelo, who was born at Wailua and whose brother could transform himself into a rat.
Kaholālele	A falls at the 200 foot elevation on the north fork (middle fork) of the Wailua River.
Kalaekoa	Secondary peak on 'A'ahoaka. Lit., (possibly) koa tree point.
Kalaeokamanu	Locality and heiau on the makai end of Pu'ukī. Lit., the crest of the bird.
Kalama	Tributary, N. fork, Wailua River. Lit., the torch or the light.
Kālepa	Ridge, part of the western boundary of Wailuanui-ho'ano. Lit., trade.

Kaluawehe	The King's highway (see text) and surfing spot. Lit., the open pit.
Ka'ulu	Tributary, S. fork, Wailua River. Lit., the breadfruit.
Kāwī	Tributary, N. fork, Wailua River. Lit., (possibly) to press. In the legend of Ka'ililauokekoa, Kauakahiali'i's nose flute was named Kanikawī (sounding Kāwī).
Keahimeki	Secondary peak on 'A'ahoaka. Lit., the fire pit.
Keāhua	Tributary, N. fork, Wailua River. Lit., the mound. This was also the name of a famous Kaua'i chief.
Kokomo	A peak on Kālepa ridge. Lit., to enter.
Konole'a	Lo'i along S. fork, Wailua River. Lit., (possibly) to invite joy.
Kukui	Heiau at the shore near Wailua-Olohena boundary. Also called Kaikīhaunaka or Kūhua Heiau. Lit., candlenut tree.
Līhu'e	Town and judicial district, east Kaua'i. Lit., gooseflesh. This name was brought over from O'ahu by Kaikio'ewa, the appointed governor of Kaua'i who called his residential compound, around which the present town grew, Līhu'e.
Mākea	Lo'i along S. fork, Wailua River. Lit., once uncultivated land, as for bananas, sweet potato, taro. It is also the name for a variety of taro and 'awa.
Malae	Heiau. Also recorded as Malaea.
Maunakapu	Peak on Kālepa ridge. Lit., sacred mountain.
Mauna'ou	Hill far upland in Wailua. Lit., piercing mountain.
Nounou	Ridge forming part of western boundary of Wailuanuiho'ano. Also known as "Sleeping Giant". Lit., to throw or stone fighting. In legend, Kawelo and 'Aikanaka conflict in a stone throwing battle on this ridge.
'Ōpaeka'a	Falls and stream that flows into Wailua River. Lit., rolling shrimp.

Paemāhū o Wailua	Rocks near Wailua River mouth on which petroglyphs are carved. Lit., homosexual row (of Wailua). The rocks are said to be the brothers of Maui or in another story, men turned to stone by Kapo.
Palikea	Tributary, S. fork, Wailua River. Lit., fair cliff.
Pihanakalani	A legendary spot near the source of the N. fork of the Wailua River. Some say it is another name for Hanahanpuni. Lit., gathering place (of) high supernatural beings.
Pōhaku'ele'ele	Heiau. Lit., black rock.
Poli'ahu	Heiau. Lit., garment (for the) bosom, goddess of snow.
Pu'uki	Small ridge on the north bank of the Wailua River. Lit., ti plant hill.
Pu'upilo	Hill, a kīpuka from the Waimea Canyon Volcanic Series. Lit., hill (of the) swampy odor or pilo plant hill.
Uhau'iole	Tributary, N. fork, Wailua River. Lit., rat hitting.
Wai'aka	Tributary, S. fork, Wailua River. Lit., laughing water.
Waiehu	Falls on S. fork of Wailua River. Also known as Wailua Falls. Lit., water spray.
Waikoko	Tributary, S. fork, Wailua River. Lit., blood water.

Spellings of these place names, including the placement of macrons (-) and glottal stops ('), were taken mainly from Armstrong (1973) and Pukui, Elbert, Mo'okini (1974). Literal translations are from Pukui, Elbert, Mo'okini (1974), Pukui, Elbert (1971), Beckwith (1970), and others.

during Ching's (1968) survey. Thus the terraces shown by Metcalf (1846 map) at the southwest corner of this alluvial terrace had already been destroyed.

The fourth site (208) is recorded on Monsarrat's (1900) map. This is the 'auwai observed during the present reconnaissance and described in "Reconnaissance Results - Area A".

The legend of Kapunohu and Kemamo cited by Dickey (1916:34) gives the name Kawelowai to a cave beneath the river above Waiehu (Falls). Ching (1968) approximates the location of this place next to the present study Area B and the ford on the sugar company's haul cane road. An archaeological reconnaissance of a similar nature to the present study was conducted by Cordy (1978) in Waihe'e, Maui and Lumaha'i, Kaua'i. There are a number of important differences in terrain, project area size, archaeological sites present and historical records available for the present Wailua study, nevertheless, some hypotheses forwarded by Cordy (1978) are applicable to Wailua (see "Conclusions" this report).

Additional information concerning Hawaiian land use of the Wailua River system and adjacent lands must be deduced from the archaeological and biogeographical data collected during the present study and ethnographic data, the most complete and detailed being Handy and Handy (1972).

RECONNAISSANCE RESULTS

FIELD METHODS

The study areas consist of nine (9) separate pieces of territory along the south fork of the Wailua River. Each area for study was assigned a letter from A through I for convenience during the field work (refer to Figure 3). Area A includes the Power Plant Alternatives 1, 3A, 3B, 3C and four (4) sites and is located approximately 4,000 feet upstream from the confluence of the north and south forks. Area B includes the Power Plant Alternative 2 site. Area F is the site of Intake Alternative 1 and 4. Area H includes the site of Intake Alternatives 2, 3A, 3B, and 3C and area I Intake Alternatives 2A, 3B, 3C and 4. Areas C, D, E and G are sections of undisturbed territory to be crossed by the pipeline. These areas consist of minor stream gullies on the north bank of the Wailua River valley (south fork).

Access to the study areas was facilitated by the network of sugar company roads that allowed us to arrive directly above the study areas, all of which (except area I) are situated on the steep banks and lower alluvial terraces of the river and minor streams.

Each study area was entered on foot and all alluvial terraces were visually inspected by traversing their length and breadth. The steep banks of the valley were checked where ledges or older alluvial terraces were found, along our access routes (from river bottom to cane field above) and where minor stream gullies were present. Two-way radios were used to coordinate and direct the ground movements in the study area. This was necessary because of the dense vegetation, rain and precipitous cliffs in some areas.

Data on the archaeological sites found and on vegetation encountered were recorded in a field notebook. Sketches were drawn showing the configuration of the remains and their relative position to prominent topographical features on U.S.G.S. 7.5 minute series maps. Schematic cross-sections were also drawn for areas where cultural remains were present. Dimensions of the sites were paced off and translated to feet (1 pace being equal to 3 feet) or estimated when pacing was impossible due to thick stands of hau (Hibiscus tiliaceus). Photographs were not taken (except at the site of the intake in Area H and in a portion of area I) because of the frequent rain and difficulty of climbing through stands of hau and up and down the steep, densely vegetated sides of the valley.

Each of the nine (9) study areas are described below. These descriptions include a discussion of the access route used, the vegetation encountered, the natural configuration of the area, the location and configuration of the archaeological sites and the modifications that identify them as such.

AREA AND SITE DESCRIPTIONS

Area A

Area A (Figures 4 & 5) was entered from the south side. This involved traversing the steep (approaching 85%) slope in the vicinity of the pasture fenceline shown. Near the valley bottom a low cliff, ranging from 15 feet to over 25 feet high was encountered. At the base of this cliff is a level terrace-like 'auwai feature (Site 208) approximately 10 feet wide and an estimated 40 feet above the valley bottom. Both the cliff and the terrace extend along the south and west margins of the valley floor. Near the northwest extreme of the study area a minor stream trickles over the low cliff and pools upon the terrace then escapes southward finally flowing down the bank to the valley floor in the vicinity of the fenceline. A few young 'ulu (Artocorpus communis) trees and two (2) male papaya (Carica papaya) trees are growing on the terrace bank in this vicinity. Prominent vegetation on the slopes above include occasional ki (Cordyline terminalis), patches of lau'ae (Polypodium phymatodes), guava (Psidium guajava), java plum (Eugenia spp.), kukui (Aleurites moluccana) and hau.

The valley floor consists of an old meander of the river that runs along the western edge and an alluvial terrace bounded on the west,

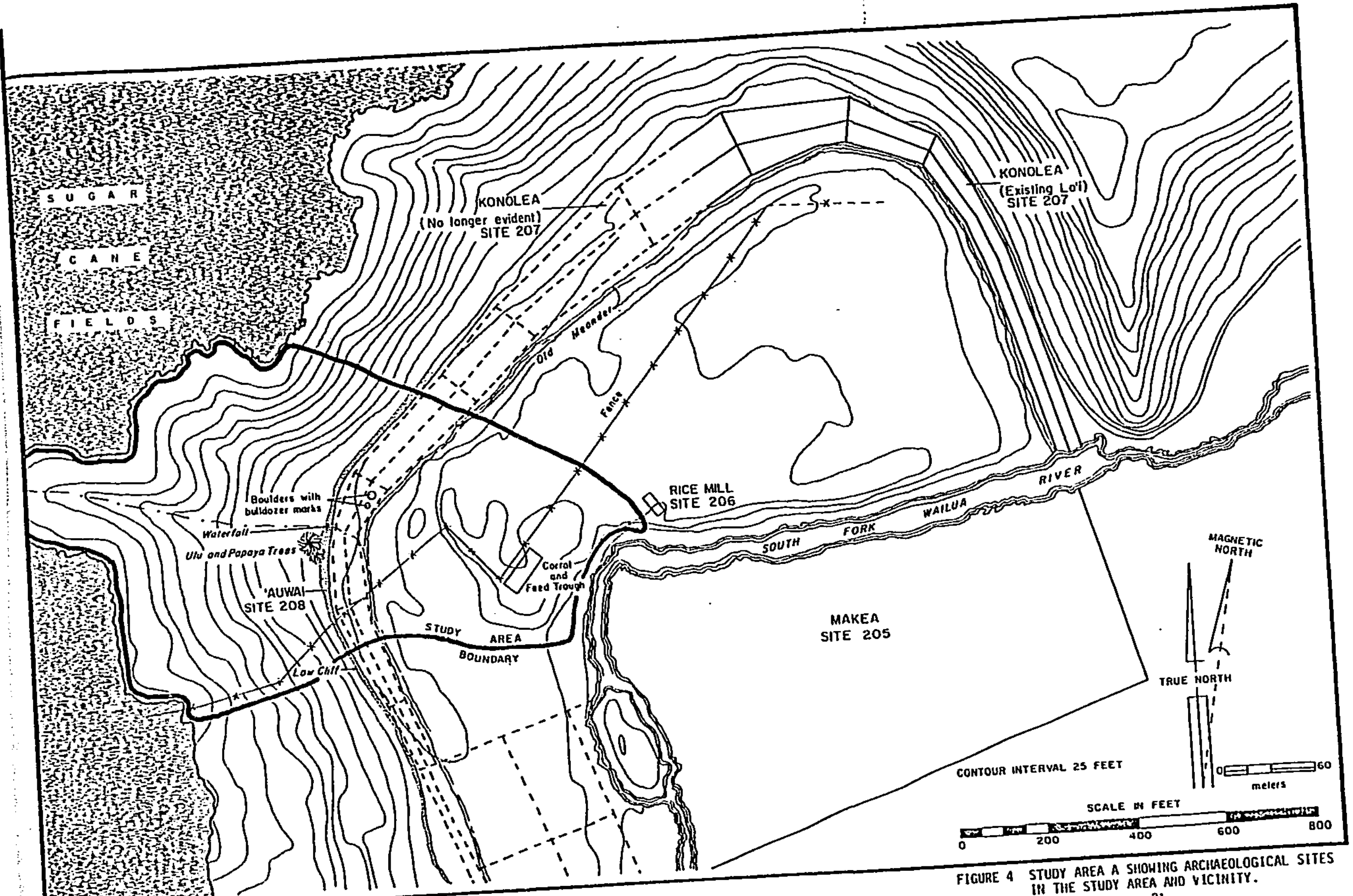


FIGURE 4 STUDY AREA A SHOWING ARCHAEOLOGICAL SITES IN THE STUDY AREA AND VICINITY.

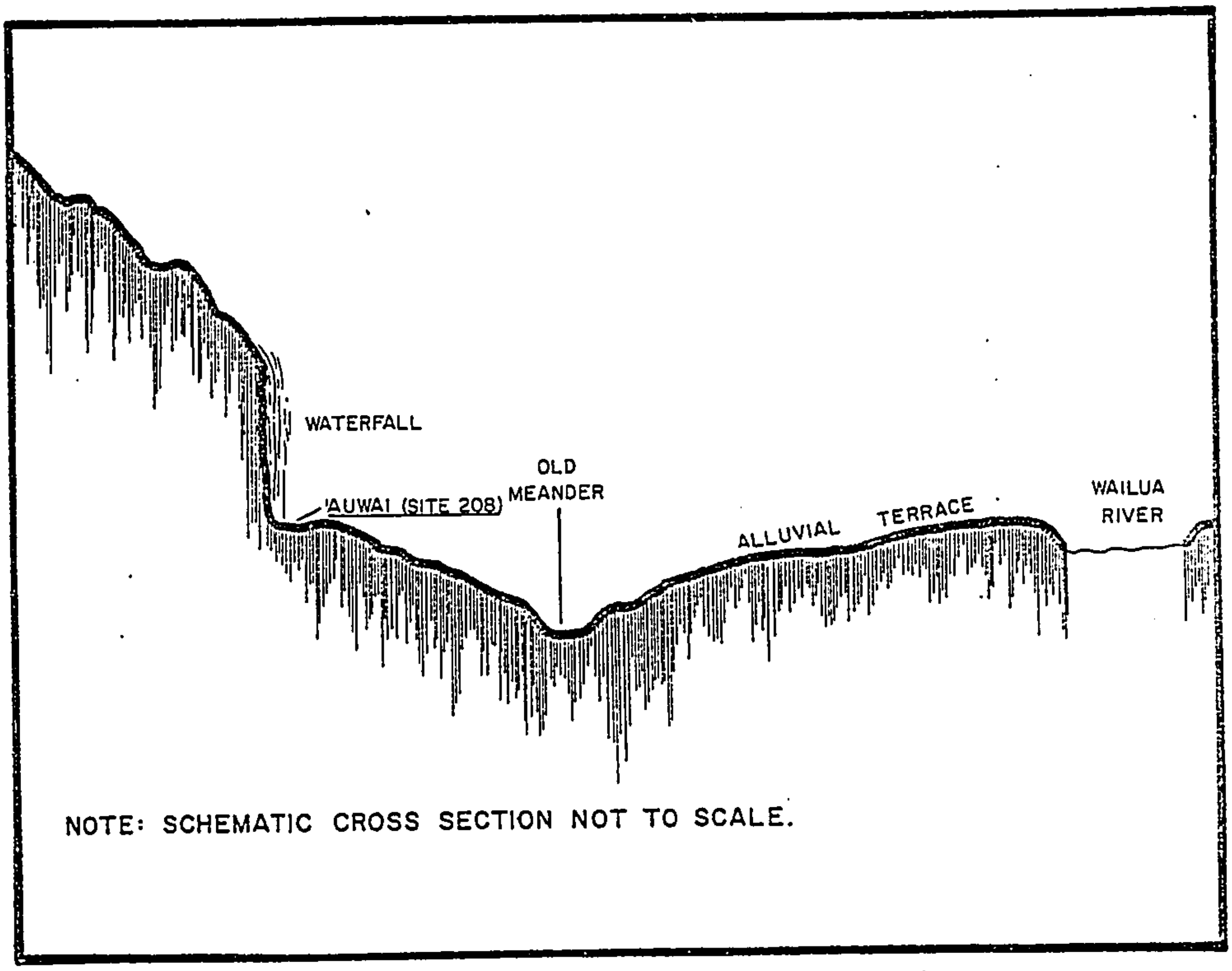


FIGURE 5 SCHEMATIC CROSS SECTION OF AREA A.

south and north by the old meander and on the east by the present river. This terrace is elevated about 20 feet to 30 feet above the river bed. These parts of the study area have been previously bulldozed for pasture improvement and presently support grazing animals.

Archaeological features in Area A consist of only Site 208 ('auwai). North of the study area agricultural terrace complexes are present on the west (Site 207) and east (Site 205) sides of the river (Ching 1968). The Site 207 terraces were present in the study area prior to alterations of the land (Metcalf 1846:map) for grazing, however, no discernible surface traces of these terraces remain in the study area.

Area B

Area B is situated along the north bank of Wailua River's south fork. It extends from the ford about 1,000 feet upstream from Wailua Falls northward and westward to a minor stream bed that originates in the cane fields near the Hanamā'ulu airstrip. Area B was entered from the minor stream bed originating in Area C (below). The northern, mauka portion of this area slopes steeply and is heavily vegetated with low trees (primarily java plum) completely overgrown with an exotic vine. The southern area boundary (i.e., the river bank) is low and wide, subject to inundation during periods of increased flow of the river. This portion of the study area is heavily vegetated with spreading stands of hau reaching 40 feet to 60 feet high and being so dense that we were forced to climb through the hau in order to continue down stream. Numerous young (1 foot to 8 feet tall) 'ōhi'a'ai (Eugenia malaccenis)) trees were noted growing from the swampy ground within the stands of hau. These plants are probably growing from seed washed down by the river or thrown from the road north of Area B as no large, old 'ōhi'a'ai were seen in the vicinity. Many of these trees were flowering. No archaeological sites were found.

The makai one-third of Area B is covered with a thick growth of grass (probably Panicum purpurasens) ranging from 3 feet to 6 feet high. No archaeological sites could be found beneath this dense vegetative cover and it is probable that the area was disturbed during construction of the haul cane road and ford.

A single, large alluvial gravel bar in study Area B is notable for its contrasting vegetation. This gravel bar is located in the makai portion of Area B where the river takes a sharp U-turn and is vegetated with 50 feet to 60 feet tall exotic *Acacia* spp. trees with a understory of honohono (*Commelina nudiflora*) grass and abundant wild yam vines. No archaeological sites were found, however, during the reconnaissance a koloa (*Anas* app.) flushed from the honohono grass.

Area C

Area C the upper reaches of a minor stream, is a narrow gully surrounded on the north, west and south by existing cane fields. Access was gained from the cane field road along the north side of the area. A large mango tree (*Mangifera indica*) marks the west end of Area C and dumps of mai'a (*Musa* spp.) are probably cultivated by sugar company employees. The mai'a are growing on a narrow terrace of boulders among which is buried an old automobile, evidence of modern age and mechanized construction for the terrace resulting from cane field clearing. A path was found which leads to the gully bottom where a large stand of bamboo (possibly *Bambusa vulgaris* var. *aureo-variegata*) is growing in the trickling stream. Across the stream bed about 5 to 10 small kalo (*Colocasia esculenta*) plants were found growing in swampy ground but no other evidence of human activity, such as archaeological sites or other cultivated plants, were found in Area C.

Area D

Area D is situated in a minor stream gully immediately makai ofthe sugar company reservoir collecting runoff from the pu'u

Hanahanapuni. This study area was entered from the northeast side accessed by a cane field road bordering the gully.

The vegetation in this area is predominantly waiawī (Psidium cattleianum f. lucidum), trees of 10 feet to 15 feet in height growing 0.5 feet to 1 foot apart. The ground is wet and soft on the north side of the stream and on the south side gives way to swampy conditions with some areas under standing water. Here the vegetation gives way to a predominance of pū hala (Pandanus odoratissimus) in the swampy areas and expanses of uluhe (Dicranopteris linearis) on the gully sides with occasional 'ohi'a lehua (Metrosideros collina) on the slopes or along the edge of the cane field.

No Hawaiian archaeological sites were found in this area although irregular concrete blocks were found in the stream bed adjacent to the road which passes on the makai side of the reservoir above the study area. These were probably a part of the reservoir having since been left in situ and consequently destroyed by heavy overflow of the reservoir. Pig tracks were also noted in this area.

Area E

Study Area E (Figure 6) encompasses the extreme lower section (at its point of confluence with the Wailua River south fork) of the same minor stream that is part of study Area D (above). This area contains remnants of two (2) agricultural terraces (Site 209) in the stream bottom with remains of a terrace retaining wall discernible (refer to Figure 5). Access was gained from the sugar company road along the north side. This bank of the gully is heavily vegetated and our access route from the northwest was obscured by a thick growth of vines. Access from the northeast is not possible due to a shear cliff over 60 feet high. Near the stream bottom the dense vegetation opens into a wide alluvial terrace on the north side of the stream with an overstory of kukui (Aleurites moluccana) trees and ground cover of honohono grass. Inspection of this terrace did not reveal any conclusive evidence of human modification and immediately upstream a dense

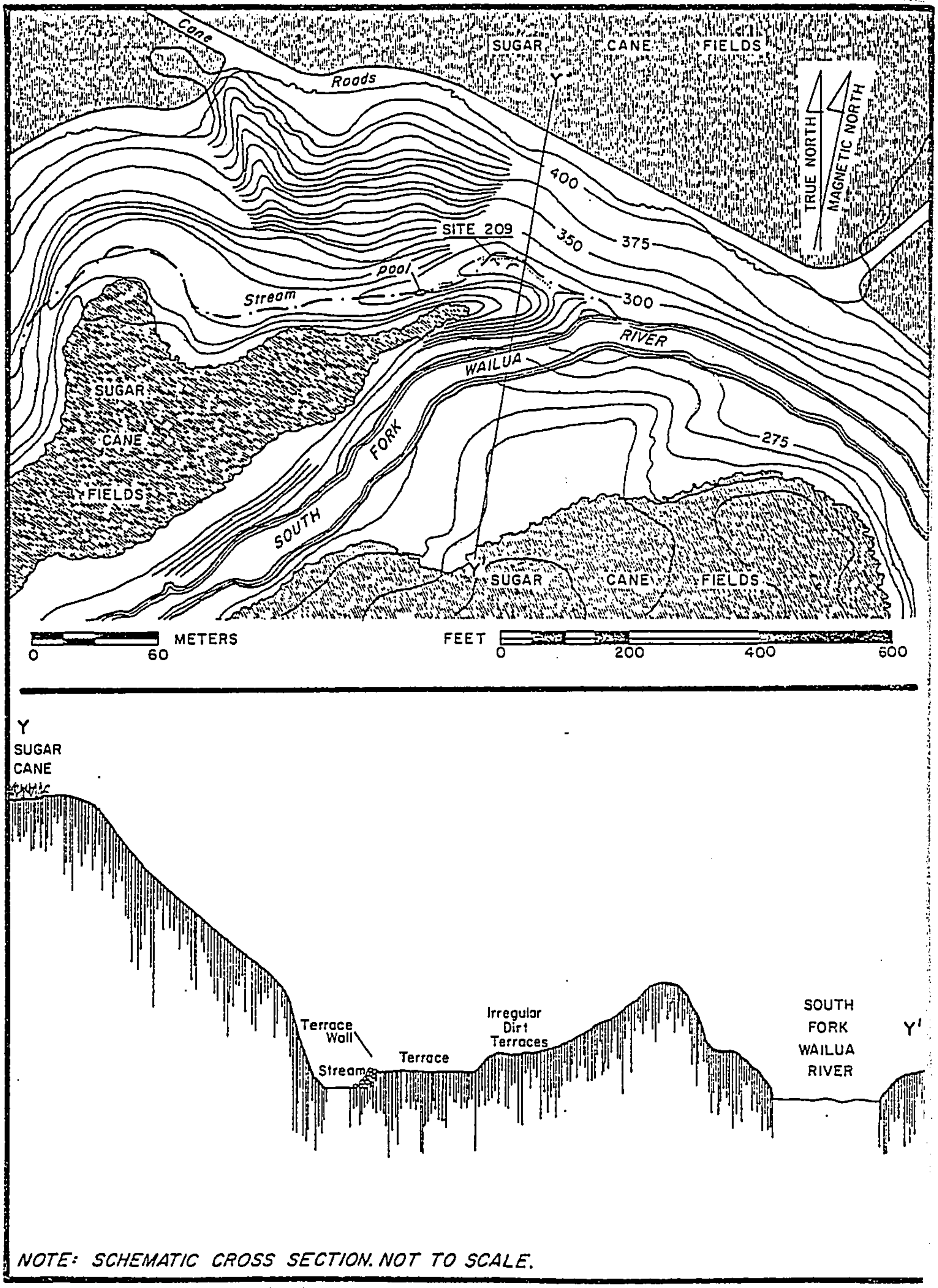


FIGURE 6 STUDY AREA E SHOWING ARCHAEOLOGICAL SITE.

stand of hau chokes both banks and the stream bed. However, makai of the upper terrace a second bi-level alluvial terrace on the south bank of the stream retains a set stone wall that extends for approximately 100 to 150 feet along the stream bed. The makai portion of the retaining wall is interrupted by a large mango tree and further makai a section of the wall has been washed out by stream flow. This terrace ranges from about 12 feet to 24 feet wide and is bordered on the south by a low narrow ridge with irregular, unfaced dirt terraces stepping down to the larger walled terrace. Relict kalo plants were noted along the mauka edge of the terrace adjacent to the stream. A conglomeration of boulders in the stream may be the remains of a dam for raising the water level of the stream for diversion into the terrace, however, evidence of 'auwai upon the terraces is not discernible.

A few flowering 'ōhi'a'ai trees are present in the valley bottom and few ki plants are present on the steeper slopes. Pū hala is common on the steep slopes of the gully and surmounting the cliff areas.

Area F

Area F is situated on the south fork of Wailua River south of study Area D (discussed above). The area is bisected by an existing sugar company road oriented east-west. The north bank of the river gorge is predominantly pali (cliff) which drops 60 feet to 100 feet from the road to the river. Native vegetation along the top of this pali consists mostly of pū hala and hau with various low shrubs comprising the understory. North of the road through the study area a low pali (20 feet to 30 feet high) borders the cane field to the east. Above this pali the ground continues at a steep slope to cane fields above and on the west. The strip of uncultivated land is barely 200 feet wide, is densely vegetated with a mixture of native and exotic low trees and shrubs and no archaeological sites are present here on the north of the cane road nor on the south between the road and the river gorge.

Area G

Area G begins a few hundred feet west of Area F (above) and extends along the north bank of the gorge of the south fork. The area includes a portion three minor stream channels all of which are very steep, narrow gullies which drop precipitously in places beneath extensive growth of uluhe. The upper limits of these gullies, vegetated with hau, waiawī and some kukui, were inspected but the lower extremes and the sides of the primary gorge were inaccessible. No archaeological sites were found.

Area H

Area H (Figures 7 and 8) is situated in the bottom of the south fork gorge and extends approximately 6,000 feet makai from the confluence of 'Ili'ili'ula and Wai'ahi Streams, southeast of Mauna 'Ou (refer to Figure 3). The mauka extreme includes the dams and intake for the Hanamā'ulu Ditch system.

Access to the study area was gained from the northwest, down a narrow and rocky, minor stream bed originating at the edge of the cane fields above the gorge. The dam area was inspected first. We were able to cross 'Ili'ili'ula between the dam and its point of confluence with Wai'ahi as the stream flow is diverted to Wai'ahi Stream and the Hanamā'ulu ditch intake by a short deep ditch excavated through the ridge between the two rivers. Bulldozer tracks were noted in the dry section of 'Ili'ili'ula Stream bed and cuts in the ridge between the streams, as well as a short section of bulldozer road paralleling the river along the north bank are a result of construction of the dams and ditches. The route of access of the bulldozer could not be discerned, however, it is probable that access was gained from the south bank of the river. No evidence of prehistoric use of the ridge between the rivers could be discerned beyond the presence of numerous wild yams growing in the area.

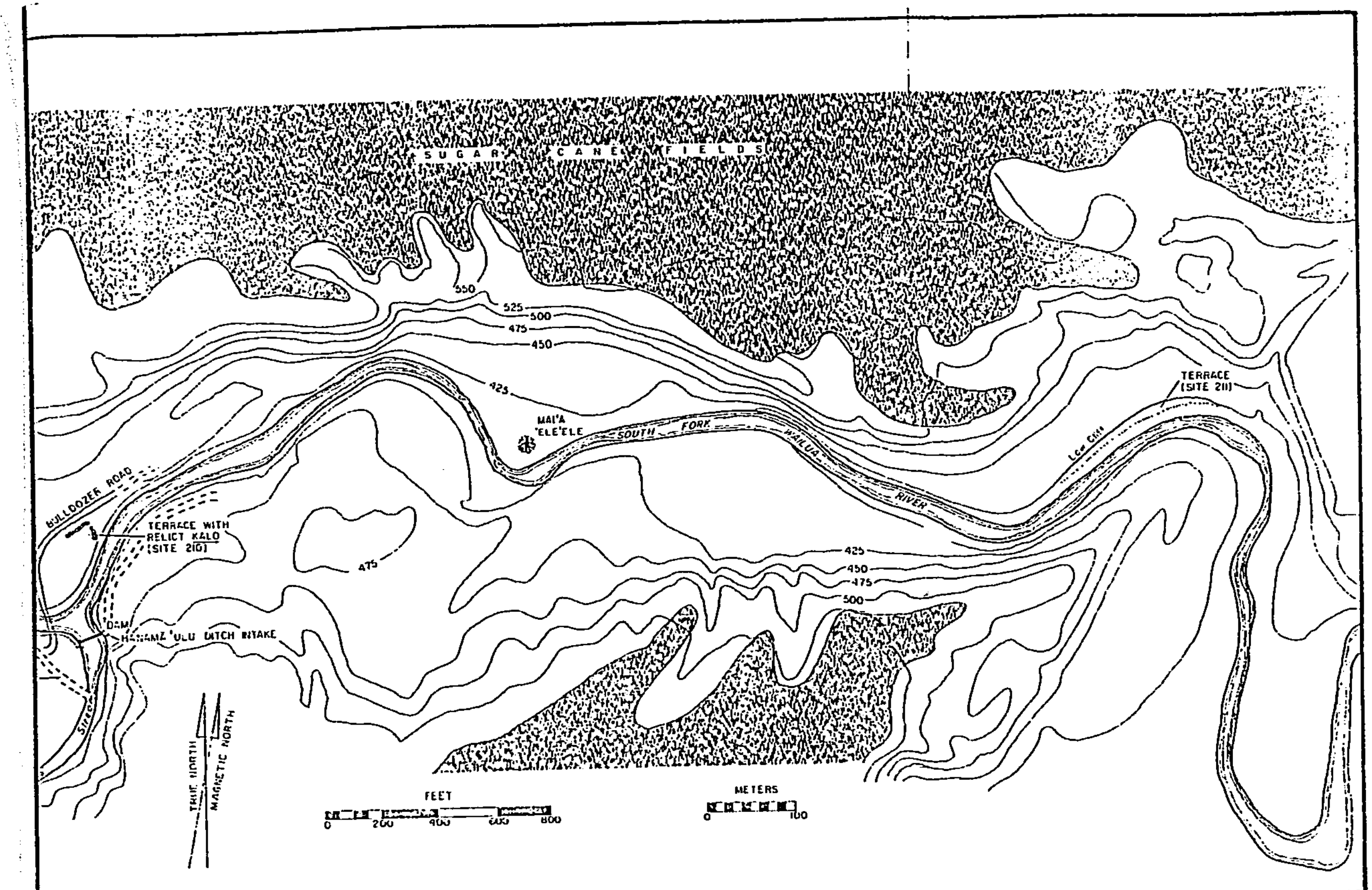


FIGURE 7 STUDY AREA H SHOWING ARCHAEOLOGICAL SITES.

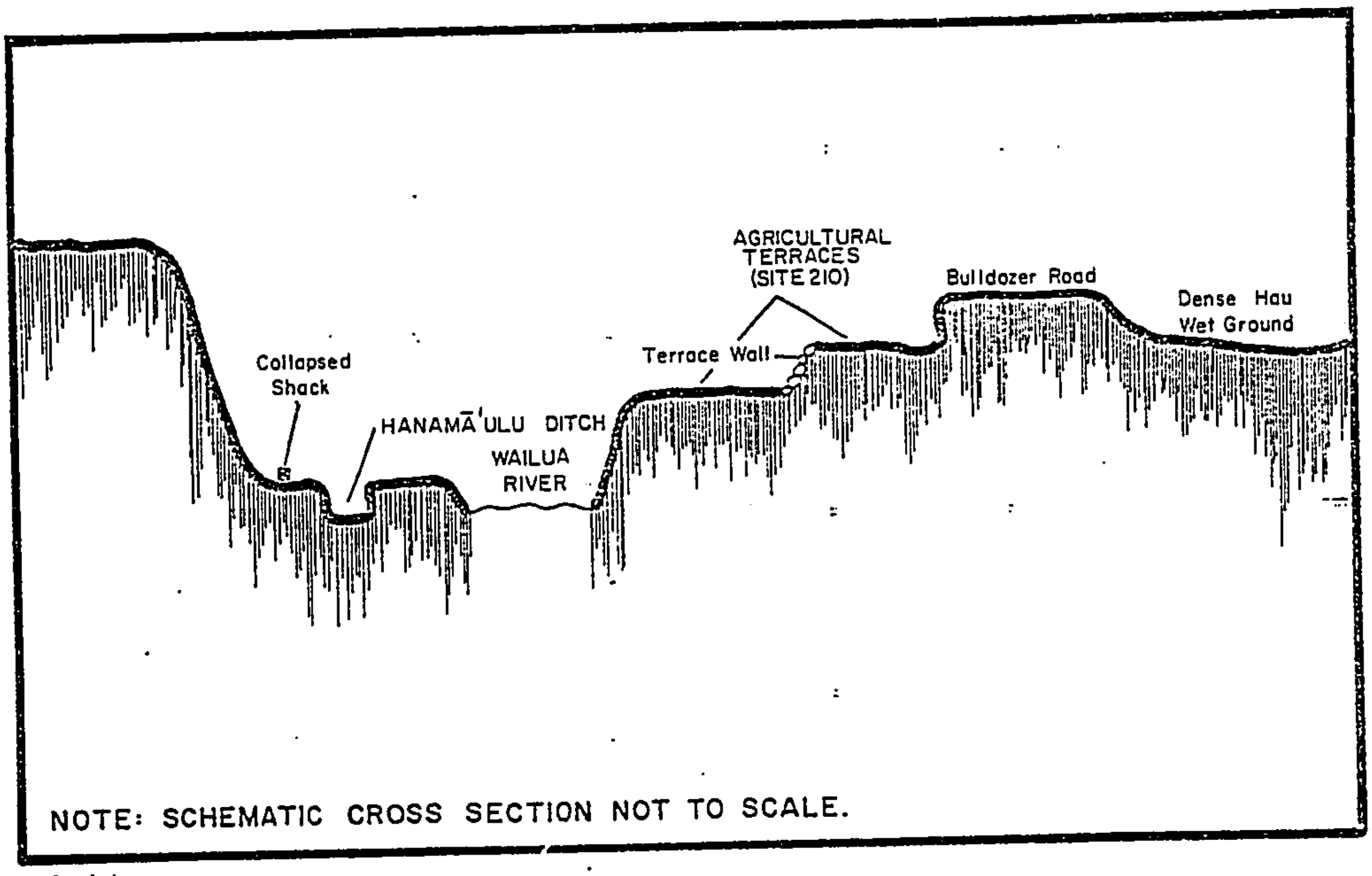


FIGURE 8 STUDY AREA H SHOWING ARCHAEOLOGICAL SITES.

Along the north bank, below the confluence of the streams, an elevated (approximately 20 feet to 30 feet above the present river) alluvial terrace contains remnants of agricultural terraces. This complex (Site 210) is bounded on the south by the river, on the north and east by a low (about 15 feet high) verticle cliff and on the west by the bulldozer road where it crosses 'Ili'ili'ula Stream. The cultural remnants consist of a very deteriorated terrace retaining wall about 2 feet high that parallels the low cliff on the north thus creating a long (about 200 feet) narrow (maximum 12 feet wide) terrace 2 feet above the larger terrace area. The larger terrace has a short (about 15 feet) 1 foot to 2 feet high, north-south oriented retaining wall situated near the makai end of the terrace. Twenty (20) to 40 relict kalo plants are present on the larger terrace near this wall. A linear depression running makai on the larger terrace, adjacent to a narrow terrace at the cliff base may have been an 'auwai but was not traceable in a mauka direction. Water for these térraces may have come from the minor stream by which we gained access to the river, however, the bulldozer road has apparently obliterated structural remains beyond the immediately definable terraces.

Makai of the sites described above, the north bank steepens abruptly and is disected by another minor stream. We were able to cross above the 40 foot high pali on the river's edge by climbing up, crossing the minor stream bed and then dropping down to the next alluvial terrace. The descent to this second alluvial terrace (gravel bar) was made more difficult by dense stands of hau. This vegetative cover opened on to a continuous, deep grass understory and overstory of giant, exotic Acacia spp. trees (about 70 feet to 80 feet high) upon the alluvial terrace. This terrace is separated from the north bank of the gorge by a narrow boulder strewn secondary river channel that although dry during this reconnaissance (a period of relatively low river flow) isolates the alluvial terrace from the north bank during periods of high water.

Inspection of this terrace resulted in the discovery of a discontinuous and very deteriorated 2 foot high bank along the south side of the terrace. The condition of the bank and the generally low elevation of the entire terrace relative to the river (5 feet to 6 feet) precludes positive identification. Near the makai extreme of the terrace is a clump of four (4) or five (5) mai'a plants. These are tentatively identified as mai'a 'ele'ele based on the dark-red to black variegated trunks. None were in flower. This alluvial terrace terminated (makai end) at a sheer pali in excess of 90 feet high in the vicinity of the powerline showin in Figure 3. Thus we were obliged to ascend the north bank to the cane fields above and reenter this study area makai of the powerline and pali.

The study area was reentered by way of the minor stream gully at the northeast end of Area H. The sides of this gully are very steep and heavily vegetated with hau, pū hala, waiawī and various shrubs and weeds. 'Ie'ie (Freycinetia arborea), a native liana was also observed. The stream bed is narrow and rocky. This minor stream does not flow directly into the river below rather it terminates on a 40 foot high, roughly 60 feet wide, swampy terrace where a large mango tree is growing along with the hau and waiawī. Heading directly for the river we encountered a 15 foot to 20 foot high pali below which a lower terrace could be seen. Heading in a makai direction along the top of this pali an access route to the lower terrace was found and the terrace reconnoitered.

The terrace is roughly level and is 10 feet to 20 feet above the present river directly below the south boundary. This terrace is vegetated with dense hau and wild yams, a few 'ōhi'a'ai and a few kī plants are interspersed beneath. Along the north edge (the intermediate pali) of this lower terrace is the remnant of a low (2 feet) discontinuous agricultural terrace retaining wall that forms a 10 foot to 15 foot wide terrace (Site 211) against the base of the pali. These terraces are similar in characteristics to those found in the mauka extreme of Area H (discussed above) except that no additional terrace walls nor kalo plants were found.

Area I

Area I is the most mauka of the study areas and contains a man made ditch that collects water from the north fork of Wailua River and delivers it to the Hanamā'ulu ditch intake on the south fork via Waikoko Stream. A gaging station access road runs along the northeast side of this ditch (except the southernmost 2,000 to 3,000 feet) providing access to the study area.

No evidence of cultural remains was found in Area I aside from the ditch, gaging station and road, two (2) stands of 'ohe (probably Melocanna baccifera), two (2) large stands of palepiwa (Eucalyptus spp.) or Melalenca leucadendra (paper bark) of the family Myrtaceae. These stands are located on the north side of the downstream end of the ditch and on the south side of the upstream end near the gaging station. They are planted in straight rows, probably by forestry personnel experimenting with various introduced trees for industry. The 'ohe noted above is located near the gaging station at the north end of the area and is of the Hawaiian variety in that nodes are about 18 inches apart and the walls of the stalk, thin. This is the type of 'ohe used in making pū'ili (bamboo rattle) and 'ohehanoihu (nose flute).

CONCLUSIONS

The information compiled from early accounts and the recording of Hawaiian oral history (Wilkes 1848; Thrum 1907; Dickey 1915 and 1916; Lydgate 1916; Salisbury 1936; Beckwith 1970), early land and geologic survey maps (Metcalf 1846; Monsarrat 1900; Marshall 1910; Wall 1923), previous archaeological research (Bennett 1931; Sloggett 1934; Ching 1968), ethnographies (Handy 1940; Handy and Handy 1972) and government records (Indices of L.C. Awards 1929) constitute a substantial body of data relating to Wailua, Kaua'i. The data is, however, weighted towards sites located along the coast and the tidewater portion of Wailua River with the following exceptions:

1) Bennett's (1931) Site 110 in Kapa'a mauka (type locality).
2) Ching's (1968) Survey.
3) House sites shown on Marshall's (1910) Geologic Survey Map of Kaua'i Island.
4) Oral history - place names and mo'olelo.

The present study has located three (3) additional agricultural terrace complexes along the south forks between Waiehu (Falls) and the Hanamā'ulu ditch intake at the confluence of 'Ili'ili'ula and Waiawa Streams.

The data resources (above) are sufficient for making some general statements. According to Hawaiian oral history, Wailua was the most politically and religiously important ahupua'a of Kaua'i (refer to "Background"). Archaeological evidence for this could be inferred from the numerous heiau, if we use Cordy's (Kelly 1978:62) criteria for determining political centers with corresponding dense populations. However, this clearly is not appropriate for Kaua'i considering that Kōloa ahupua'a has no less than 14 heiau. Obviously Cordy is assuming that all heiau are contemporaneous; an assumption for which there is no factual evidence. Rather mo'olelo and other oral history are evidence against Cordy's assumption. Futhermore, population estimates based on number of heiau and size of heiau is equally assuming because an ali'i nui ruled the ali'i ai moku and thereby the entire populous of the island. Thus, people from any community (as defined by Cordy in Kelly 1978:1) could be and were called upon to participate in the construction of heiau or other public works projects (Ching 1981 personal communication).

The Līhu'e basin is a relatively unique geologic feature in the Hawaiian Islands. The Wailua River that drains the central portion of this basin is comprised of an extensive system of youthful gorges cut into a nearly level plain. Thus it differs considerably from the amphitheater type valley in that the vast majority of territory in Wailua (ahupua'a) uka is level, deep volcanic ash dissected by inumerable minor streams and creeks. This type area was, in fact, better suited and more valuable for exploitation by means of swidden type forest plantings, irrigated and dry-land cultivation and natural resource collection (Handy and Handy 1972:470). It is unfortunate that all evidence of Hawaiian land use outside the river and stream gorges has been obliterated and will always be an uncontrollable variable in statistical analyses of site distribution within the ahupua'a.

The archaeological sites located by the previous and present studies show that the alluvial terraces within the primary gorge of the Wailua River were also utilized. The present reconnaissance has shown that there are three (3) major exploitable zones (excluding the river) situated in the river system. These are: 1) three (3) levels of alluvial terraces, 2) minor, tributary stream bottoms, and 3) the steeper slopes of the gorge. The steep slopes support pū hala, 'ōhi'a lehua (Metrosideros collina), laua'e, hau, kī and 'ie'ie. The uppermost terraces capture water from the minor streams on the gorge flanks, are swampy and presently support hau primarily, however, it is assumed that these terraces were also utilized to raise other cultigens. The upper terraces are generally 30 feet or more above the present level of the river. The middle level terraces of the primary gorge and minor, tributary stream bottoms were definitely modified and utilized for raising cultigens, evidenced by constructed terrace remnants and relict kalo (cultigen). These terraces are generally 10 feet to 30 feet above the present river and may have been watered by 'auwai or minor stream flow or seepage. The lower alluvial terraces range from 1 or 2 feet to 10 feet above the present river. They are small boulder or gravel bars and are presently subject to total inundation or separation from the river bank during maximum flow of the river. This flooding is a result of increased siltation since tapping and damming of the river for cane cultivation and probably did not occur prior to these changes. No definable modification or remnant structures were located on these lower terraces, however, banana, wild yam, and kukui are present on one or more of these terraces suggesting their previous use as resource areas.

In lieu of the terrain contrasts between amphitheater valleys and the Wailua River gorge, the limited extent of archaeological research in Wailua and the irretrievable loss of data from lands under modern cultivation, the existing data appears to support Cordy's (Kelly 1978:56) formula on site types and their distribution. However, broad generalizations based on reconnaissance or even survey data are subjective at best. The framework (Kelly 1978:66) for testing and interpreting settlement and demographic expansion is workable for the ahupua'a type socio-political system. Consideration of the colonization-exploration period, that may account for some of the early coastal sites and the possible necessity and desirability during this early period of inland resources has been overlooked by Cordy. That is some early coastal sites may not represent permanent settlement of the area and some early inland camp sites should be expected.

GLOSSARY

ahupua'a	Largest land unit within a district (moku); were self sufficient economic units extending from the mountains to the outer reef - where there was a reef, or a half mile to a mile to sea - where there was no reef; so called because the boundaries of these land units were marked by a cairn of stone (ahu) on which a pig (pua'a) or other tribute was laid as a tax to the ruling chief (ali'i nui).
'Aikanaka	An ancient high chief of Kaua'i.
ali'i	Chief; a member of the ruling class (nobility) in ancient Hawaiian society.
ali'i 'ai moku	Chief that rules over a moku or district.
ali'i nui	Ruling chief.
alluvial	A mode of sediment deposition, i.e., deposited by streams.
'auwai	A constructed ditch, usually for irrigation purposes.
avifauna	The birds or the kinds of birds of a region, period or environment.
cultigen	A cultivated organism of a variety or species for which a wild ancestor is unknown.
Great Mahele of 1848	An event in the "reformation of the land system in Hawaii" that "separated and defined the undivided land interests of King Kamehameha III and the high-ranking chief and konohiki(s)." This was carried out by the Board of Commissioners To Quiet Land Titles comprised of five commissioners appointed by King Kamehameha III. (Chinen 1974).
hale	House or building.
hau	A lowland tree, often found growing along streams (*Hibiscus tiliaceus*).
heiau	Hawaiian temple.
honohono	This work is used in the text to generally characterize several species of creeping grasses.
in situ	In an original or natural position.

Ka'ahumanu	Favorite wife of Kamehameha I, who later married Kaumuali'i, King of Kaua'i. She was also at one time Kuhina nui or executive officer of the kingdom.
ka'ao	A traditional Hawaiian fictional story.
kāeke	Or Kā'eke'eke. Bamboo pipes, varying in length with one end open. A player held one vertically in each hand tapping them down on a mat or the ground with the resulting tone varying according to the length of the bamboo (see footnote in text).
Kahiki	Tahiti or a general term describing any foriegn country.
kalo	Taro (Colocasia esculenta).
Kamehameha III Kauikeauoli	The third ruling monarch of the Kamehameha dynasty over the Kingdom of Hawaii.
kapu	Prohibited, forbidden, off limits; sacred, consecrated.
Kapule, Deborah	Wife of Kaumuali'i and Queen of Kaua'i. Deborah was her baptismal name, she being an early convert to Christianity. Ha'akūlou was her Hawaiian name.
Kaumuali'i	The last ruling chief of Kaua'i previous to the unification of all islands under the rule of Kamehameha I.
Kawelo	A heroic chief of Hawaiian legend who was born at Hanamā'ulu, Kaua'i. Some of his exploits take place in Wailua such as his battle with 'Aikanaka at Nounou.
kī	The ti plant (Cordyline terminalis).
kīpuka	Variation of change of form, as a calm area in rough seas, a clearing in a forest, or, as used in the text, a remnant of older volcanic activity surrounded by later lava flows.
koloa	General term for duck (Anas spp.). The Hawaiian duck was sometimes called koloa maoli or native duck.
kōnane	A traditional Hawaiian game similar to checkers.
konohiki	Land manager (headman) of an ahupua'a.
kukui	Candlenut tree (Aleurites moluccana).
laua'e	A fern (Polypodium phymatodes). Its fragrance, when crushed, resembles that of the maile, and is famous on Kaua'i.

liana	A climbing plant that roots in the ground.
lo'i	Wet taro lands as opposed to kula lands, that was used for dry land farming.
mai'a	General term for all types of bananas. Another descriptive word follows to denote the specific variety such as mai'a'ele'ele.
maka'āinana	Commoner; the largest class of people in ancient Hawaiian society.
makai	Towards the sea.
mauka	Towards the uplands.
middle fork	The old term, as seen on historic maps, for what is today called the north fork of the Wailua River (see north fork).
Mo'ikeha	The grandson of Maweke who came to Hawai'i from Kahiki. His brother was Olopana, chief of Waipi'o, Hawai'i. Mo'ikeha became the ali'i nui of Kaua'i, inheriting the title from his father-in-law Puna.
moku	To divide, land district.
mo'olelo	A traditional story that is based on what the Hawaiians believed to be historical fact.
north fork	A name, often found on old maps, used to identify what is known today as 'Ōpaeka'a Stream, the northern most of the three large tributaries of the Wailua River. What is known today as the north fork was then called the middle fork.
'ohe	General name applied to all varieties of bamboo. Use in this text refers to 'ohe Hawaii (Bambusa vulgaris var. aureo variegata) or 'ohe kahiki (Schizostachyum glaucifolium).
'ohehanoihu	Nose flute.
'ōhi'a'ai	Mountain apple tree (Eugenia malaccensis).
'ōhi'a lehua	A native tree (Metrosideros collina).
palepīwa	All species of Eucalyptus trees. The name literally means to ward-off fever because the leaves were prepared medicinally for that purpose.

pali	cliff; precipice.
Palila	A demigod, chief and warrior of Kaua'i. Some of his exploits are related in legends of Wailua. He later became the ruling chief of Hilo.
piko	Umbilical cord, navel.
pōhaku piko	A significant boulder or outcrop, in the crevices and vesicles of which are ceremoniously placed the piko of new born infants, secured by a pebble or section of the pū hala fruit.
pū hala	Pandanus tree. Also known simply as hala.
pu'u	Any kind of protuberance from a pimple to a hill.
pu'uhonua	Place of refuge, asylum.
site	A discreet structure (including sinkholes) which contains evidence of construction or modification.
slope wash	Sheet erosion or the material transported by sheet erosion.
terrace complex	Two or more separable (for purposes of analysis), relatively level areas arranged in a step-like order to conserve moisture or to minimize erosion for planting.
uka	Uplands.

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