ENVIRONMENTAL IMPACT ASSESSMENT

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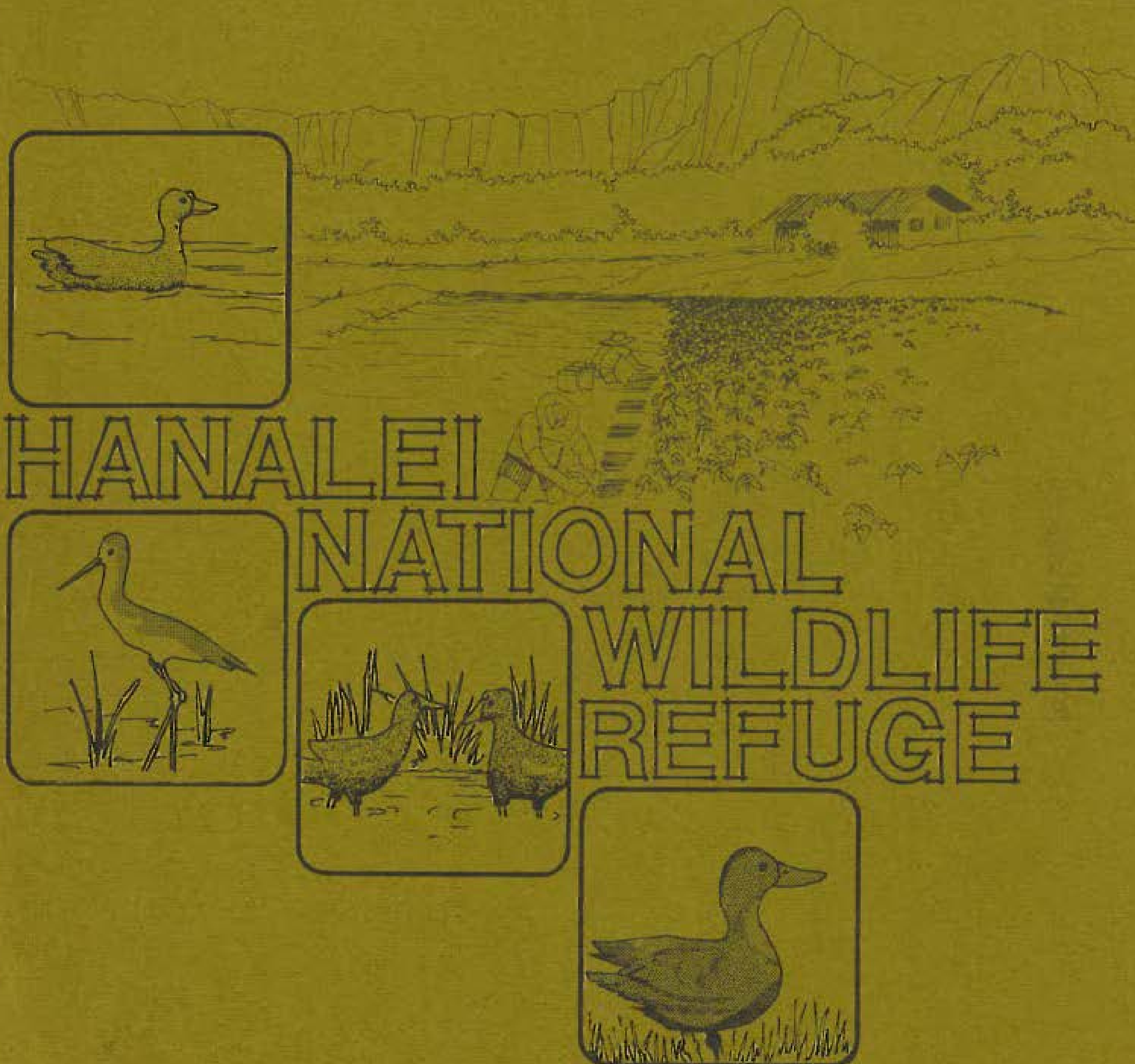
HANALEI NATIONAL WILDLIFE REFUGE



HANALEI DISTRICT, KAUAI
STATE of HAWAII

U.S. FISH and WILDLIFE SERVICE
DEPARTMENT of the INTERIOR

prepared by : Wilson Okamoto & Associates, Inc.

U.S. FISH AND WILDLIFE SERVICE

DEPARTMENT OF THE INTERIOR

HAWAIIAN AND PACIFIC ISLANDS

DRAFT

ENVIRONMENTAL IMPACT ASSESSMENT

FOR

HANALEI NATIONAL WILDLIFE REFUGE

HANALEI DISTRICT, KAUAI

STATE OF HAWAII

PREPARED BY

WILSON OKAMOTO AND ASSOCIATES

SEPTEMBER 1979

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Abstract

ABSTRACT

The Hanalei National Wildlife Refuge, located on the North Shore of Kauai, State of Hawaii, is an important feeding and nesting area for various bird species, particularly endangered waterbird species, i.e., the native stilt (Himantopus mexicanus knudseni), coot (Fulica americana alai), gallinule (Gallinula chloropus sandvicensis), and koloa (Anas wyvilliana). The refuge consists of 917 ± acres; 115 ± acres are in taro utilization and 210 ± acres are used for cattle grazing purposes. It has been determined that the cultivation of taro, utilizing "old style" practices requiring very little mechanization, is compatible with the objectives of a birdlife sanctuary, in that taro fields provide the proper feeding and nesting environment for the endangered waterbird species. In addition, there is an existing demand for the increased production of taro in the State. Therefore, it is desirable to increase the acreage of taro and associated wetlands to increase the populations of the endangered waterbird species. Ultimately, it is planned that there will be 200 ± acres in taro cultivation, and 100 ± acres of ponds and sedimentation basins.

In order to expand the taro acreage in the refuge, it is necessary to implement a new, improved water delivery system to replace the existing irrigation system. The existing irrigation system consists of two ditches; the Kuna Ditch and the China Ditch on the East and West Banks of the Hanalei River, respectively. Both ditches are quite old and sections of each are in need of repair or replacement. The proposed water delivery system will alleviate the problems inherent in the existing irrigation system, and allow for the explansion of taro cultivation.

In developing the proposed water delivery system, four alternatives were considered. Briefly, these alternatiaves are:

1. Rehabilitation of both Kuna and China Ditches.

2. Improvement of the China Ditch to carry all system flows to a junction, where an inverted siphon would carry the necessary flows to the East Bank; the lower portion of the China Ditch would serve the West Bank. The upper portion of the Kuna Ditch would be abandoned.

3. Rehabilitation of the Kuna Ditch for East Bank flows, with a new diversion structure from the Kuna Ditch intake site to supply water in a closed conduit to the West Bank.

4. Abandonment of both China and Kuna Ditches; construction of a new diversion structure and a closed conduit system to carry flows to the East and West Banks.

The last alternative was selected as the most appropriate solution for the implementation of a new water delivery system to supply water to the existing and proposed taro fields. It is estimated that the proposed project will require 18 months for construction, and will cost approximately one million dollars.

The primary construction-related impacts will be the construction of the diversion dam, inverted siphons, and the excavation along the alignment of the closed conduit system. Turbidity in the Hanalei River is expected to increase during construction, however this impact can be mitigated if necessary. Airborne emissions and noise generation will be temporary through the construction of the project, and should have little consequences. Impacts to flora and fauna are expected to be minimal; a permanent "fish chute" will be implemented on the downstream face of the diversion dam to facilitate the upstream movement of aquatic fauna in the river. The endangered waterbird species will benefit from the proposed project. Historical and archaeological interests are being coordinated between the State Historic Preservation Office, the Advisory Council on Historic Preservation, and the U.S. Fish and Wildlife Service. Some increases in population, taro production, and the associated infrastructure can be anticipated.

This project is seen as a positive action in the development of the Hanalei National Wildlife Refuge, benefiting both the endangered waterbird species and the human community.

I.

general description of the proposed project

HANALEI NATIONAL WILDLIFE REFUGE
ENVIRONMENTAL IMPACT ASSESSMENT

I. GENERAL DESCRIPTION OF THE PROPOSED PROJECT

A. Project Location

The Hawaiian Islands are centrally located in the Pacific Ocean, extending approximately 1,700 miles northwest to southeast from about 155° to 179° W. longitude and 19° to 28° N. latitude. The eight major islands, seven of which are inhabited, form a 400-mile arc at the southeastern end of the archipelago. Honolulu, the State capital, is located on the Island of Oahu, approximately 2,400 miles southwest of the U.S. mainland.

Land area of the State totals 6,425 square miles. The Island of Hawaii, the "Big Island", accounts for 4,037 square miles. The remainder is divided among the Islands of Maui (728), Oahu (593), Kauai (549), Molokai (261), Lanai (139), Niihau (70), Kahoolawe (45), and the northwest leeward islands, all of which are small islets, rock atolls, or exposed reefs (total of 3 square miles).

The Hanalei National Wildlife Refuge is located on the North Shore of the Island of Kauai. Kauai is the fourth largest island in the State of Hawaii in terms of size, and has the smallest population of the four major islands, (Kauai, Oahu, Maui, Hawaii), with approximately 34,000 as of 1978. Kauai is geologically the oldest of the major Hawaiian islands. See Figure 1.

The Hanalei National Wildlife Refuge consists of approximately 917 acres of mixed agricultural, grazing, open, and wetlands, which straddle the Hanalei River. The makai boundary is delineated by the ridge above the refuge adjacent to the Hanalei Lookout extending to the Hanalei Bridge; and a portion of the Hanalei River which flows from east to west. The refuge extends nearly two miles up the valley. Hanalei Town, the major residential/resort area on the North Shore of Kauai, is located 1.5 miles northwest of the refuge. The tax map keys of the Hanalei National Wildlife Refuge are the Fourth Division, Zone 5:

Section	Plat	Parcel
3	01	7
4	03	7
4	4	30

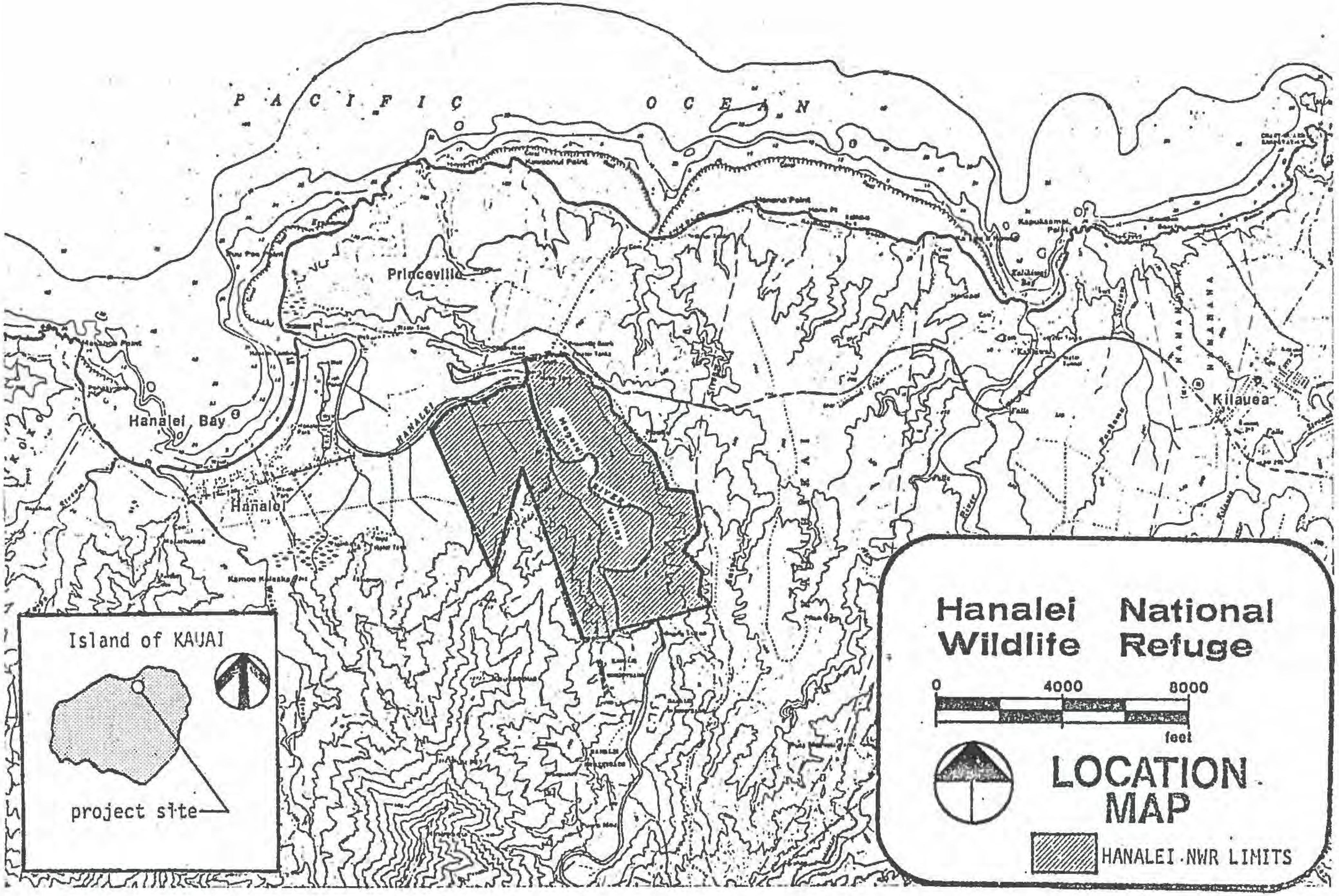
P A C I F I C
O C E A N
Princeville
Hanalei Bay
Hanalei
Kilauea
HANALEI
RIVER
Island of KAUAI
project site
Hanalei Wildlife
National Refuge
0
4000
8000
feet
LOCATION MAP
HANALEI NWR LIMITS

fig. 1

B. History of the Refuge

In 1972, the U. S. Department of the Interior - Fish and Wildlife Service acquired 917± acres of land in Hanalei Valley from the Eagle County Development Corporation. The Eagle County Development Corporation acquired the property in 1970 from the Lihue Plantation Company. The purpose of the acquisition was to establish an endangered waterbird refuge, specifically for the preservation of the native stilt, coot, gallinule, and koloa (a discussion of the specific birdlife is included elsewhere in this report). Limited cultivation of taro (115± acres) and grazing (210± acres) are the only agricultural practices presently occurring within the wildlife refuge boundaries. Land in the Hanalei National Wildlife Refuge is leased to local farmers by the Federal government for the purpose of taro cultivation. Taro cultivation is considered to be compatible and desirable, with the objective of providing suitable habitat for endangered waterbird species. (It should be noted that with increased mechanization, and the use of herbicides and fertilizers, taro cultivation may become less compatible with the endangered waterbirds. However, it is most likely that current manual agricultural practices will continue. This will be examined further in subsequent sections of this document.)

C. Project Description

1. Site Status Quo

In Hanalei Valley, the capacity for utilizing the refuge to its maximum potential, in terms of waterbird habitat, has not been achieved. In order to expand the acreage of taro fields and wetlands within the refuge, the acreage of land in open and grazing uses on the valley floor must be gradually phased out. This also means that the existing irrigation system must be improved and expanded. Taro fields provide an ideal waterbird habitat, because the waterbirds feed on chironomids (midges) and tubificids (worms), which inhabit the taro fields. Also, some waterbirds nest in or adjacent to the taro fields. Ultimately, it is planned that there will be a total of 300± acres of wetlands, of which 200± acres will be under taro cultivation. The remaining acreage will consist of ponds and sedimentation basins, which will be fed by the tailwaters of the taro fields.

The existing taro acreage under cultivation is located on both sides of the Hanalei River. The East Bank taro farms take their irrigation water from the Kuna Ditch; the West Bank is served by the China Ditch. (See Figure 1, Location Map.)

Each ditch has inherent problems. The intake for the China Ditch is located above (toward the head of the valley) the boundaries of the refuge in State land, causing some ambiguity in terms of its jurisdiction, maintenance, and operation. However, the Land Management Division of the State Department of Land and Natural Resources has stated that they would fully cooperate with the U. S. Fish and Wildlife Service for any improvements to the upper reaches of the China Ditch, because of its importance to taro cultivation in the valley.[1] In the upper portions of the China Ditch, water is carried in a wooden flume for about 50 feet; the flume is in poor condition and may soon require replacement. The Kuna Ditch loses much water through seepage and breaks in the ditch walls. In the event of any major ditch failure, accessibility by heavy equipment for repair work would be difficult, if not impossible, because there is no road near the Kuna Ditch, and the ditch is bounded by a hill to the east and the river bed to the west. The river bed is soft and muddy, and 10 to 20 feet below the elevation of the ditch.

2. Purpose of the Project

The purpose of the proposed irrigation project is twofold. First, the acreage of taro fields will be increased to accommodate additional endangered waterbird populations. Second, the proposed irrigation system will alleviate some of the problems of the existing irrigation system.

3. Project Details (Refer to Figure 2)

Synopsis: Abandonment of both China (West Bank) and Kuna (East Bank) Ditches; construction of a closed conduit system to carry flows to the proposed and existing taro fields on the East and West Banks of the Hanalei River.

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[1]Mason Young, Kauai Agent, Land Management Division, State DLNR, 4/3/79.

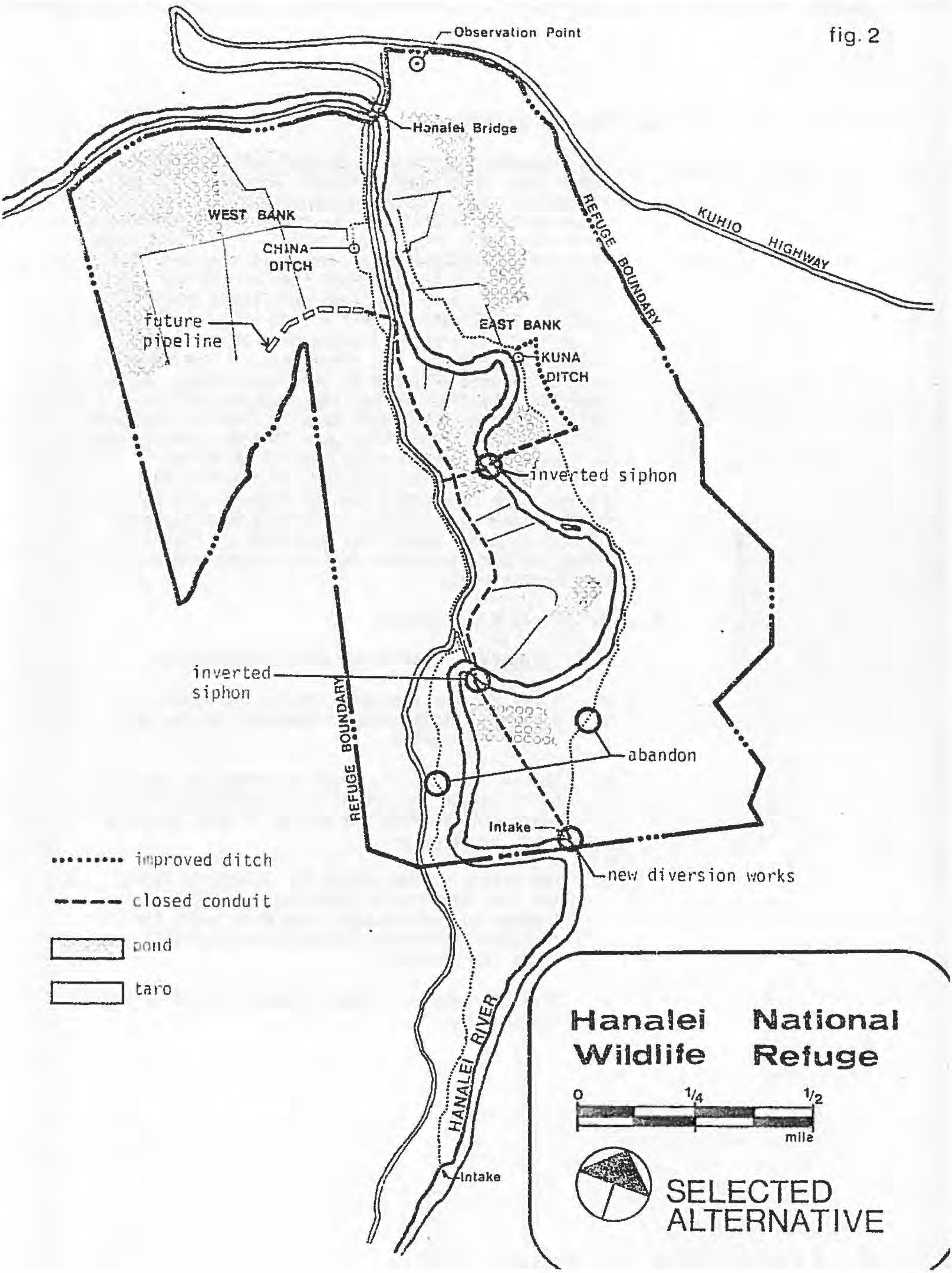


fig. 2
Observation Point
Hanalei Bridge
WEST BANK
CHINA DITCH
future pipeline
EAST BANK
KUNA DITCH
REFUGE BOUNDARY
KUHIO HIGHWAY
inverted siphon
inverted siphon
abandon
Intake
new diversion works
REFUGE BOUNDARY
HANALEI RIVER
Intake
improved ditch
closed conduit
pond
taro
Hanalei National Wildlife Refuge
0
1/4
1/2
mile
SELECTED ALTERNATIVE

a. General Description

The proposed project will abandon both the China (West Bank) and Kuna (East Bank) Ditches. A diversion works will be constructed near the existing Kuna Ditch intake (a cross-section of the diversion works is included in III.A. Land and River Transformation); a bed-load and silt trap will be constructed near the upstream ford across the Hanalei River, along the proposed closed conduit system. The closed conduit system will convey flows to an inverted siphon situated near the existing Hanalei River ford. The closed conduit system will then be aligned adjacent to the China Ditch. At a junction, the flow in the closed system will be split to the East and West Banks. Flows to the East Bank will be conveyed through a 24-inch pipeline and an inverted siphon to a new open ditch to be constructed along the East Bank to a point where flow will be channelled into an improved segment of ditch to the taro fields. The West Bank flows be carried in a new lower East Bank ditch. Figure 2 shows the proposed water delivery system and wetland development areas.

b. Advantages/Disadvantages

The <u>advantages</u> of the selected alternative are:

- It eliminates the China Ditch; the upper portion of this ditch is located outside the refuge boundaries.
- The location of the diversion works at the Kuna Ditch intake is hydraulically optimum, because sediments entering the system in that location would be minimized.
- The entire system except for a section along the East Bank would be enclosed, minimizing leakage and maintenance, and reducing solar exposure (radiation) to maintain desirable low water temperatures.
- This alternative is the shortest length of all alternatives.

- o This alternative would leave both existing ditch systems intact.

- o There would be no interference with the delivery of water to the existing taro fields during construction.

- o Least disruptive to environment as entire system except for a few special structures, would be buried.

The disadvantages of the selected alternative are:

- o Repair of the closed conduit system may be more difficult, e.g. breaks, because much of the system may be underground.

- o Siphon malfunction would cause disruption of the water delivery system.

c. Construction Timing

It is estimated that the time required for construction will be about 18 months, and should commence at the beginning of 1980. The exact phasing of the project will be left up to the discretion of the Contractor. However, it is strongly recommended that the construction of the diversion works and the inverted siphons be timed to coincide with the periods of low flow in the Hanalei River (August - October).

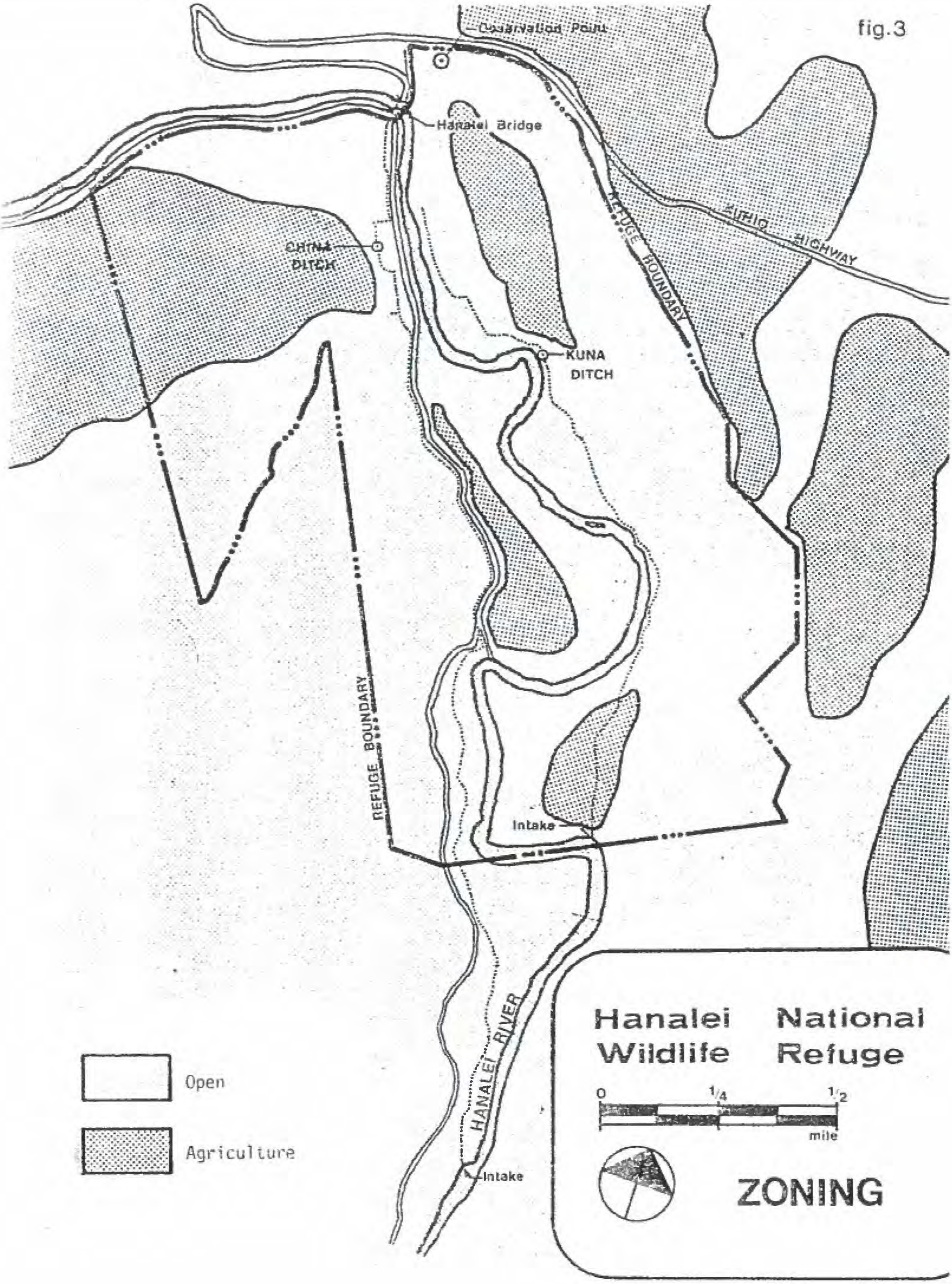
d. Cost

The cost of the proposed project will be nearly one million dollars. A detailed discussion of costs is included in the section entitled, "Costs of Alternative Systems".

D. Relationship of the Proposed Project to Existing Land Use Policies, Plans, and Controls

The Hanalei National Wildlife Refuge is zoned and General Planned by the County of Kauai for Agriculture and Open Space uses. The State Land Use Districts for the refuge are Agriculture and Conservation. See Figures 3, 4, and 5.

fig.3



Hanalei Bridge
CHINA DITCH
KUNA DITCH
REFUGE BOUNDARY
KUHIO HIGHWAY
REFUGE BOUNDARY
Intake
HANALEI RIVER
Intake
Open
Agriculture
Hanalei National Wildlife Refuge
0
1/4
1/2
mile
ZONING

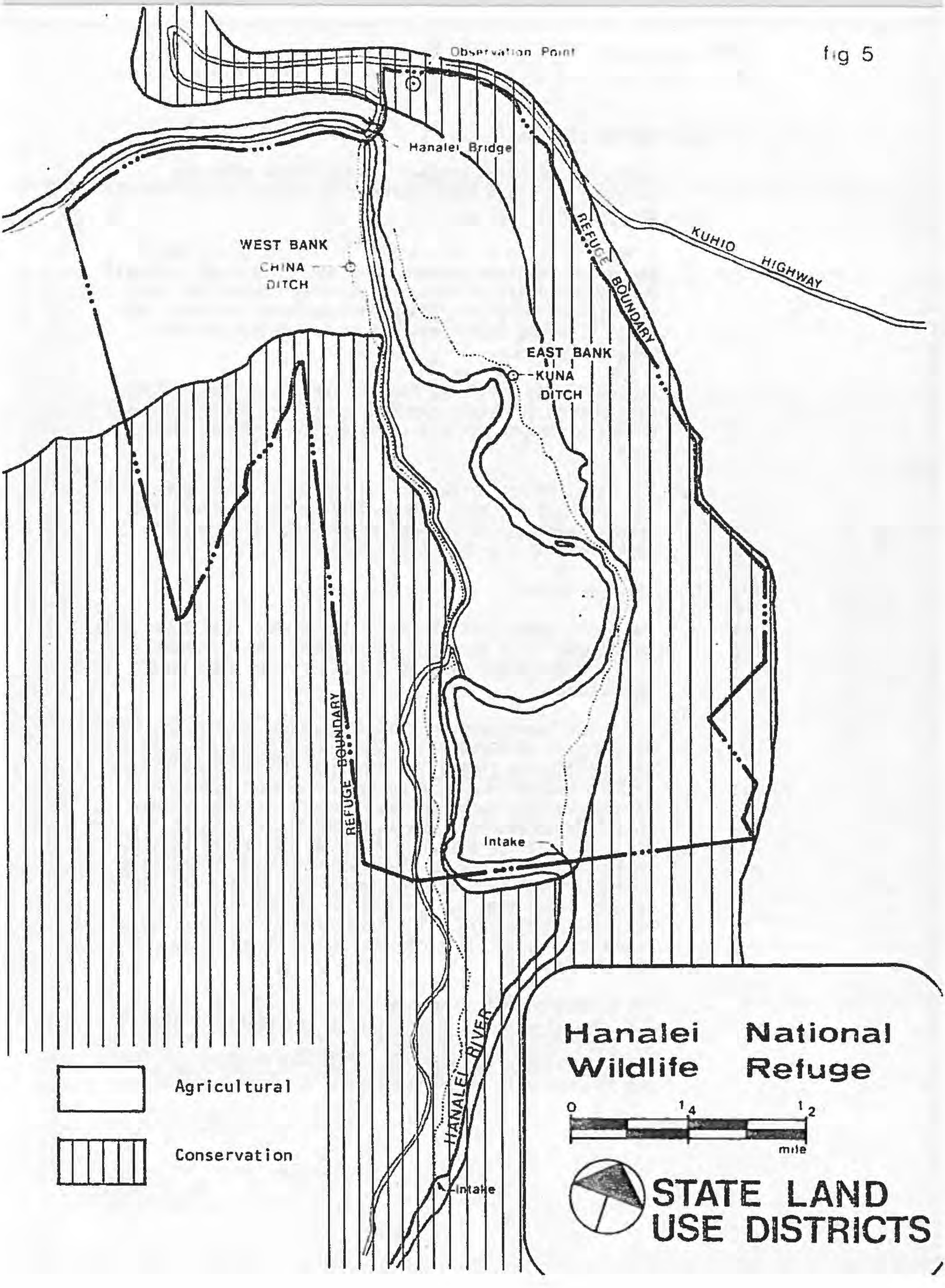


fig 5
Observation Point
Hanalei Bridge
KUHIO HIGHWAY
REFUGE BOUNDARY
WEST BANK
CHINA DITCH
EAST BANK
KUNA DITCH
REFUGE BOUNDARY
Intake
HANALEI RIVER
Intake
Agricultural
Conservation
Hanalei National Wildlife Refuge
0 1/4 1/2
mile
STATE LAND USE DISTRICTS

1. County of Kauai

Since the proposed project is consistent with the existing land use designations, no zoning or General Plan changes are required.

A small portion of the Hanalei River in the northwest corner of the site has been included in the SMA (Special Management Area) of Kauai. Federally controlled lands are excluded from the SMA permit process, however, the Kauai Planning Department has been apprised of the proposed project.

Federal lands utilizing federal funds are also excluded from having to obtain grading, grubbing, stockpiling and building permits, if all actions take place on those lands.

The Kauai Office of Economic Development is in support of the proposed project; and would like to see additional acreage returned to the cultivation of taro, and poi repromoted as a prime staple food.

2. State of Hawaii

The State Department of Health has stated that there does not appear to be any conflict between the 208 Water Quality Management Program and the Proposed project. See Appendices.

The State Department of Land and Natural Resources (DLNR) stated that on October 27, 1972, a Conservation District Use Application (CDUA) was approved for the subdivision of Conservation and Agricultural District lands in Hanalei Valley, owned by the Princeville Corporation. This CDUA encompasses the land within the Hanalei National Wildlife Refuge. The DLNR has requested that "all plans pertinent to the development of the Hanalei National Wildlife Refuge be forwarded" to the Department, in order that they can present an amendment to the original application. The favorable reception of any amendments would eliminate the necessity for a new CDUA for this project.

The proposed project may be subject to 36 CFR PART 63 - "Determinations of Eligibility for Inclusion in the National Register of Historic Places" and 36 CFR PART 800 - "Protection of Historic and Cultural Properties", if any historically or archaeologically significant sites are discovered in the refuge. The Bishop Museum has conducted a field reconnaisance survey, and the State Historic Preservation Office, Department of Land and Natural Resources is being kept abreast of any developments. The field reconnaisance survey is included in the Appendices.

The Department of Planning and Economic Development (DPED) requires that a Federal Consistency Determination be made for the proposed project, to insure that it is consistent with the State Coastal Zone Management program. This Determination must be submitted at least 90 days prior to the final approval of the Federal activity. The period for processing this document is a minimum of 45 days with additional time required if requested by the DPED.

3. Federal Government

Since the proposing agency is the U.S. Fish and Wildlife Service - Department of the Interior, an environmental impact assessment is being prepared for the proposed project, to be submitted in conjunction with the U.S. Army Corps of Engineers Permit application. This permit is required for any construction in navigable waters, discharge of dredged or fill material into navigable waters and contiguous or adjacent wetlands, or transport of dredged material for disposal in ocean waters. Upon public request the District Engineer must hold a public hearing. The time required for processing this permit is 90 days or in some cases as long as one year, if a Federal Environmental Impact Statement is required.

The Endangered Species Act of 1973 and its amendments are administered by the Fish and Wildlife Service, U.S. Department of the Interior. In order for the proposed project to be in compliance with this Act, a Section 7 "Intra-Service" Consultation is required. This process requires that the specific division (in this case the National Wildlife Refuge) consult with the appropriate Regional Director to determine if a particular action will affect any listed endangered species or critical habitats. The subsequent action (acceptance, modification, or denial) will be based on the judgement of the Regional Director. This process could take up to 90 days, unless additional data is requested, then more time would be required.

II.
description of the existing environment

II. DESCRIPTION OF THE EXISTING ENVIRONMENT

In this section, the various physical, biological, historical/archaeological, and socio-economic aspects of the Hanalei National Wildlife Refuge will be examined. Also, the regional infrastructure and facilities will be discussed.

A. Physical Environment

1. Climate

The climate at the Hanalei National Wildlife Refuge, is typical of the climate of other nearshore areas in Hawaii. Through the year the average monthly temperatures vary between lower and upper 70^{o}'s (^{o}F). The median

annual rainfall ranges from about 80 inches at the project site to about 400 inches at the head of the valley.[1] See Figure 6, Rainfall. The wind velocity averages about 7 miles per hour, and blows predominantly from the east.[2]

2. Topography

The Hanalei Valley is a long and relatively narrow river basin, which extends from the sea to Mount Waialeale. Refer to Figure 7, Topography and Gaging Stations. For the first eight miles, the valley floor ascends to an elevation of only 600 feet. In the remaining three miles, however, the valley floor climbs rapidly to the head elevation of 5,124 feet. Its width varies from 1.8 to 3.3 miles. The drainage area of the basin is about 23.1 square miles.

The refuge site extends 1.5 miles south of the Hanalei Bridge along the Hanalei River, and 0.5 miles west of the Hanalei Bridge. The valley floor is approximately 0.5 miles wide, and varies in elevation from 10 feet above MSL (mean sea level) near the Hanalei Bridge to 40 feet above MSL at the refuge's southern boundary. The mountainous valley walls straddling the valley floor extend up to 400 feet above MSL. Cultivation occurs within the Hanalei River flood plan.

---

[1]Taliaferro, William J.; Rainfall of the Hawaiiam Islands, 1959.

[2]Ramage, Colin S. and Oshiro, Norman E.; "Kauai Wind Power Survey"; Department of Meteorology, University of Hawaii, November 1977.

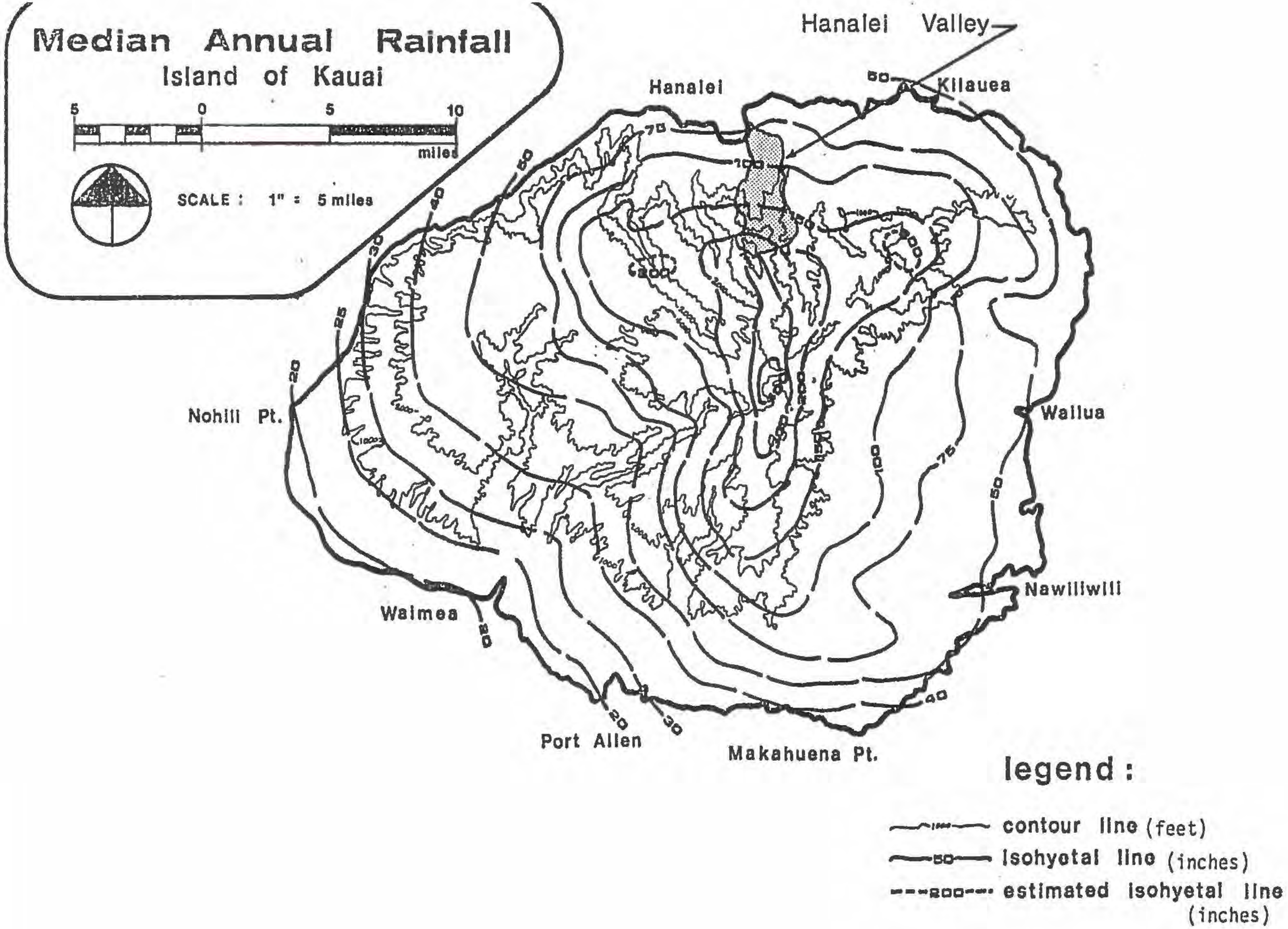

Median Annual Rainfall
Island of Kauai
5 0 5 10
miles
SCALE : 1" = 5 miles
Hanalei Valley
Hanalei
Kilauea
Nohili Pt.
Wailua
Nawiliwili
Waimea
Port Allen
Makahuena Pt.
legend :
contour line (feet)
isohyetal line (inches)
estimated isohyetal line (inches)

fig. 6

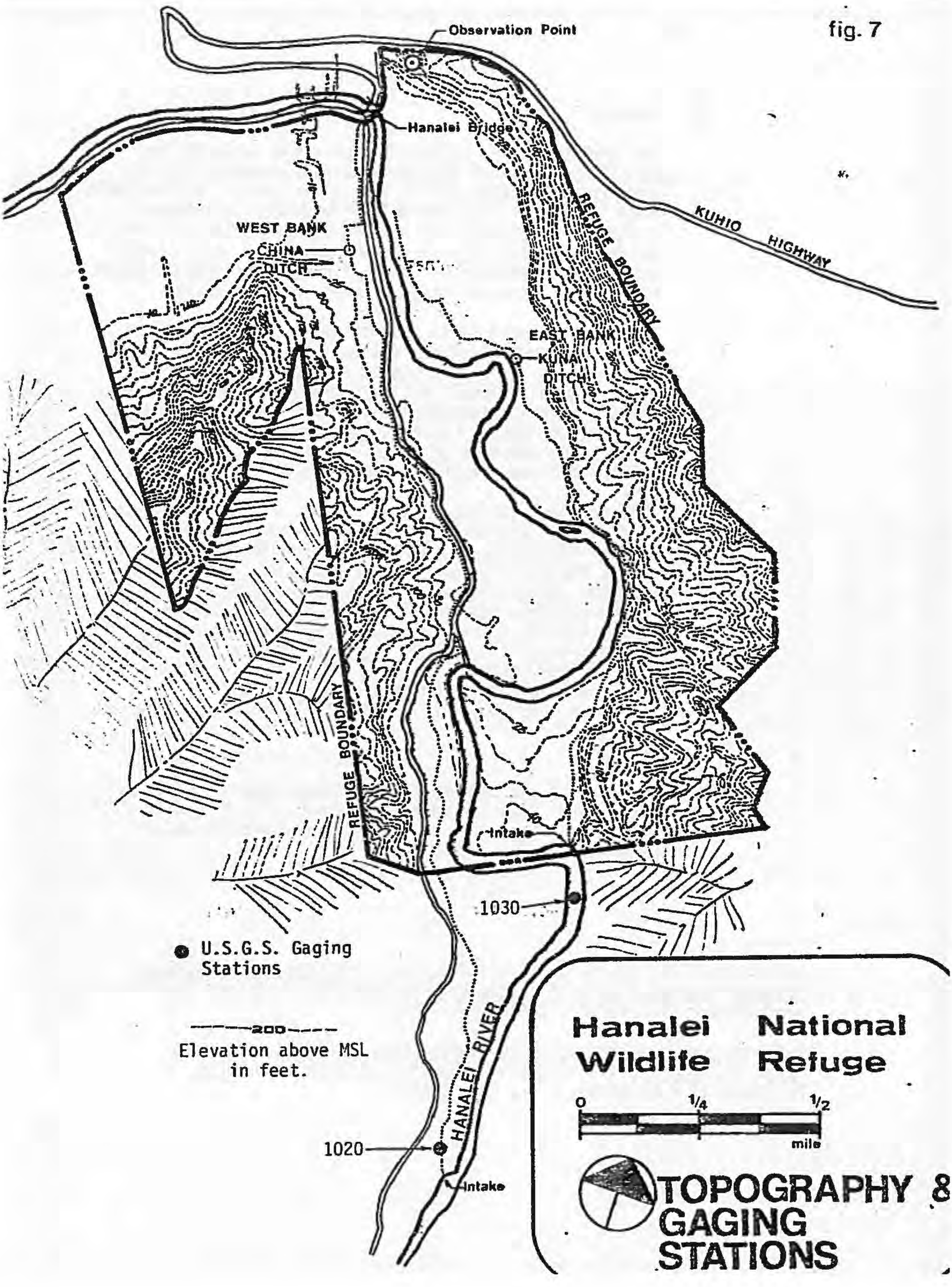


fig. 7
Observation Point
Hanalei Bridge
KUHIO HIGHWAY
REFUGE BOUNDARY
WEST BANK
CHINA DITCH
EAST BANK
KUNA DITCH
REFUGE BOUNDARY
Intake
1030
U.S.G.S. Gaging Stations
200
Elevation above MSL in feet.
HANALEI RIVER
1020
Intake
Hanalei National Wildlife Refuge
0
1/4
1/2
mile
TOPOGRAPHY & GAGING STATIONS

3. Geology[1]

The Hanalei Valley is located where the lavas of the Napali Formation of the Waimea Canyon volcanic series intersect the lavas of Koloa volcanic series, on the North Shore of Kauai. The Hanalei Valley floor is composed primarily of younger non-calcareous sediments, with small pockets of older non-calcareous sediments. Both younger and older sediments are unconsolidated alluvium, produced by erosive action of streams on volcanic material.

The mountainous area to the west of the Hanalei Valley floor is a portion of the eastern boundary of the Napali Formation of the Waimea Canyon volcanic series. The Waimea Canyon volcanic series formed the major volcanic shield, which constitutes most of the Island of Kauai, The lavas of Napali Formation are predominantly olivine basalt, and consists of an equal amount of pahoehoe (vesicular) and a'a (clinkery) lavas.

The ridge area to the east of Hanalei Valley floor is a portion of the western boundary of the Koloa volcanic series. After the Waimea Canyon volcanic series had long ended, the Koloa volcanic series occurred. The Koloa volcanic series lies over eroded material from the Waimea Canyon volcanic series. The lavas of the Koloa volcanic series consist of olivine basalt, nepheline basalt, melitite-nepheline basalt, and basanite. Erosion also occurred intermittently during this series, creating thick deposits of weathered material. A'a lava is more prevalent then pahoehoe lava in the Koloa volcanic series.

4. Soils[2]

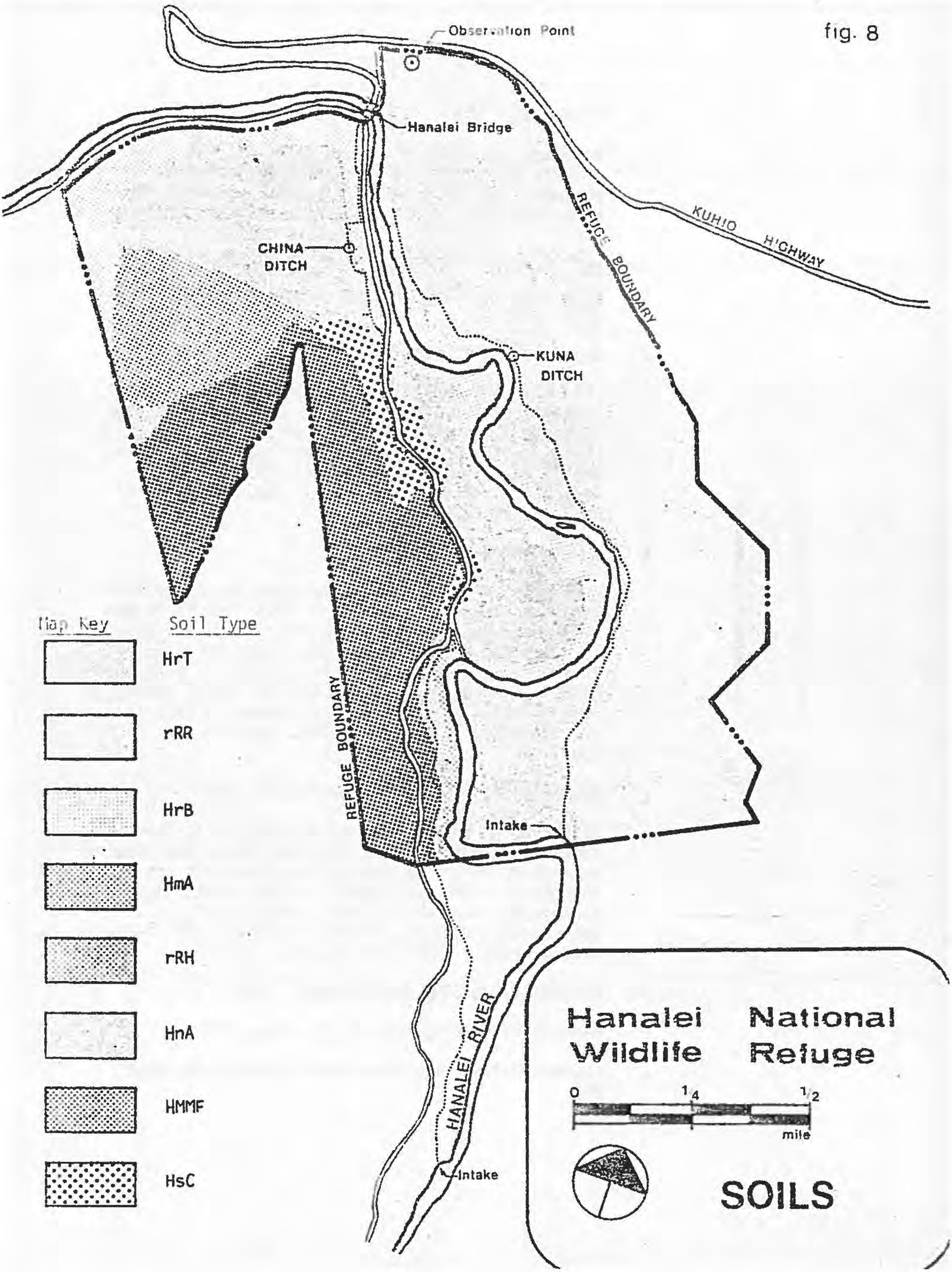
There are eight soil types which have been identified at the Hanalei National Wildlife Refuge. The following will be a brief discussion of each soil's characteristics. Refer to Figure 8.

---

[1]MacDonald, G.A.; Davis, D.A.; and Cox, D.C.; Geology and Groundwater Resources of the Island of Kauai, Hawaii; Bulletin 13, Hawaii Division of Hydrography, U.S. Geological Survey, 1960.

[2]Soils Survey of Islands of Kauai, Oahu, Maui, Molokai, and Lanai, State of Hawaii; Soil Conservation Service, U.S. Department of Agriculture; Washington, D.C.; August 1972.

fig. 8


Observation Point
Hanalei Bridge
CHINA DITCH
KUNA DITCH
REFUGE BOUNDARY
KUHIO HIGHWAY
REFUGE BOUNDARY
Intake
HANALEI RIVER
Intake
Map Key
Soil Type
HrT
rRR
HrB
HmA
rRH
HnA
HMMF
HsC
Hanalei National Wildlife Refuge
0
1/4
1/2
mile
SOILS

- Riverwash - rRH

  Riverwash consists of eroded material, i.e., sand gravel, and stones, and is commonly formed along perennial and intermittent streams in Kauai. In some locations, riverwash consists mainly of larger stones and boulders. Vegetation is sparse; riverwash is subject to shifting, as a result of river action. Riverwash is used for construction purposes; wildlife habitats are also found on riverwash.

- Rough Mountains Land - rRT

  This type of land is found in the vicinity of the Hanalei Lookout. Rough mountainous land is common to steep slopes and narrow ridges. This land may be broken by intermittent drainage channels. The soil mantle is thin (1 to 10 inches) and overlies sapprolite. Uses for this soil include wildlife habitat and recreation.

- Rough Broken Land - rRR

  This type of land can also be found on the eastern slopes of the Hanalei Valley. This land is formed in steeper areas (40% to 70% slope); the elevation may vary between 0 and 500 feet above MSL. Runoff is rapid with active geological erosion. Over the rocky subsurface may be 20 to 60 inches of weathered rock or rocky soil. Land uses common to this soil are watershed, wildlife habitat, pasture and woodland.

- Hanamaulu Silty Clay (8-15% slope) - HsC

  This type of soil can be found adjacent to the West Bank access road, and is found on stream terraces or terrace breaks. The surface layer of this soil is dark reddish brown. Runoff is slow to medium, and the erosion hazard is slight. Sugar cane cultivation, pasture, wildlife habitat, and water shed are uses, which are found on this soil.

- Hanalei Silty Clay (0-2% slope) - HnA

- Hanalei Silty Clay Loam (0-2% slope - HmA

- Hanalei Silty Clay, Deep Water Table (0-6% slope) - HrB

These three soil types predominate the Hanalei Valley floor. HrB is found adjacent to the Hanalei River, and is a stony soil; the water table lies approximately 3 feet below the surface. All three soils are interrelated, because they belong to the same soil group and are poorly drained alluvial soils common to bottomlands on Kauai. Permeability is moderate, runoff is slow, and the erosion hazard is slight. Flooding occurs on these soils. Typical land uses on these soils are taro, sugar cane, and vegetable cultivation, and pasture land.

- Hihimanu Silty Clay Loam (40-79% slope) - HMMF

  This soil is found on the mountainous area adjacent to the Hanalei Valley flow on the West Bank of the Hanalei River. It is a well-drained soil, made from eroded igneous material, which can be found on steep upland areas. Generally, the soil profile is a 15-inch silty clay loam covering a 24 to 57-inch substratum over soft weathered rock. Permeability is rapid, runoff is medium, and the erosion hazard is moderate. Land uses on this soil include water shed, pasture, woodland, and wildlife habitat.

5. Hydrology

a. Hydrologic Data - Hanalei River

Stream flow data collection on the Hanalei River began in January 1912. At that time, staff gages were situated at both Gaging Stations 1020 (China Ditch) and 1030. Again refer to Figure . According to U.S.G.S. documents, these staff gages were read twice a day.[1] Table 1 shows the average and minimum flows recorded at the gaging stations.

[1] U.S.G.S. Description of Station prepared May, 1919.

TABLE 1

FLOW DATA FROM U.S.G.S. GAGING STATIONS 1020 and 1030

STATION	AVERAGE DISCHARGE (CFS)	MINIMUM DISCHARGE (CFS)
1020-China Ditch[1] (7/1913-10/1970)	27.2	0 (Sept., Oct., Nov. 1914 & 1915)
1030-Hanalei River (1/1912-10/1930)	288	40 (March 1914)

In 1925, the Hanalei Tunnel was constructed to divert water to the Wailua Stream from the Hanalei River and its tributary the Kaapoko Stream. During an 18-year recording period from 1933 to 1950, the average flow diverted from the Hanalei River was 36.4 CFS. The Hanalei Tunnel is still in operation at present.

Water resources of the Hanalei basin cannot be readily quantified, because the only existing Gaging Station 1030 is not situated to record the entire stream flow. A half mile upstream from the gaging station, the China Ditch diverts a portion of the stream flow, which presently goes unrecorded, to the west bank of the Hanalei River. Gage 1030 is located about 1.7 miles upstream from Kuhio Highway on the Hanalei River at elevation 40 feet above mean sea level. Stream flow measurements at this gage were not monitored continously during the period of record. Published data is available for periods from January 1912 through October 1920; and December 1962 through the present.

For the period of record (1966-1978), the average discharge at Gage 1030 was determined to be 208.8 CFS. The lowest annual mean flow, 124 CFS, occurred in the record year ending March 1978. The driest period recorded occurred in September 1975 where the mean flow for 30 consecutive days was 35 CFS. The

[1]Gage on the diversion ditch located a half a mile upstream from Gage 1030 on the west side of the valley floor.

minimum flow recorded at this gage, 31 CFS also occurred at that time (September 30, 1975). Table 2 shows the cumulative frequencies for the period of record.

TABLE 2

Hanalei River U.S.G.S. Gage 1030-Stream Flow Characteristics (1965-1978).

Percentage of Time Flow Exceeds	Gage 1030 Flow (CFS)
Minimum	31
99.2	36
95	48
75	73
70	79
50	110
25	210
10	450

As previously mentioned, a portion of the stream flow is diverted into the China Ditch at a point one half mile above Gage 1030; and is therefore not recorded at the gage. Examination of available data indicates there is no correlation between the daily average flows recorded at the gage and the instantaneous measurements taken of the China Ditch flow. See Table 3.

TABLE 3

Instantaneous Flow Measurements - China Ditch and Gage 1030 (CFS)

Date	China Ditch	Gage 1030
February 14, 1977	11.1	40.6
April 11, 1977	11.3	103.0
August 25, 1977	16.0	46.4
October 11, 1977	20.6	43.0
November 30, 1977	12.6	55.2
June 3, 1978	11.4	52.4
February 27, 1978	9.9	40.3
March 13, 1979	10.2	88.0

The physical makeup of the China Ditch intake resembles a natural fork in the river; and therefore, during times of low flows, the main branch may be dammed to increase the diverted flow.

The data above suggest the percent diverted from the main stream varies from 20 to 33%. The minimum flow of the Hanalei River could then be restated, in terms of those percentages and a minimum stream flow of 31 CFS, to fall somewhere between 38.8 to 46.3 CFS, say approximately 42 CFS.

b. Water Quality - Hanalei River

Water quality data on the Hanalei River has been published by the U.S.G.S. from 1971 to the present. Water samples were collected at or near Gage Station 1030.

Due to the relationship between taro pythium rot and water temperature, water temperature data were analyzed. The temperature of the surface water varies depending on the source of the water and on the stream environment. Stream waters originating from a groundwater source and flowing through a shaded environment generally do not vary in temperature more than a few degrees. Whereas stream waters originating from rainfall runoff and flowing through an unshaded environment generally exhibit a wider temperature variation. Radiation is the primary factor affecting surface water temperatures; however, air temperature also influences surface water temperatures.[1] The following is a tabulation of U.S.G.S. data (instantaneous readings) in a cumulative frequency format.

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[1]Stevens, Herbert H., et al., "Water Temperature - Influencial Factors, Field Measurement, and Data Presentation", Washington, 1975.

TABLE 4

Hanalei River U.S.G.S. Gage 1030 - Temperatures (1968-1977):

Percentage of Time Temperature Less Than	Gage 1030 Temperature (°F)
Maximum	80.6
95	77.9
90	75.7
70	71.6
50	69.4
25	67.1
10	65.5
Minimum	59.9

On March 13, 1979 a field investigation was conducted by Wilson Okamoto & Associates, Inc., to collect temperature data along the China and Kuna Ditches, at the taro gates leading to individual fields, within the taro patches and from the tailwater. The following is a tabulation of the pertinent data collected.

TABLE 5

Water Temperature Survey - March 13, 1979. (3 hour p.m. period) Refer to p. 35 and Figure 14 for taro farm locations.

Location	Water Temperature(^{o}F)	Air Temperature(^{o}F)
Along China and Kuna Ditches (5 readings)	70 (Constant)	76
Within one of Haraguchi's fields	82	77
Tail water from Haraguchi's fields along Kuhio Hwy.	81	77
Inflow to one of Fitzpatrick's fields	69.5	77
Tailwater - newly planted	80	77
Temperature of dry soil	80	--
Tailwater from field with mature taro	77	--
Inflow to one of Koga's field	69.5	--
Tailwater from Koga's field	82.5	--
Tailwater from east fields	80	75

The following are some generalities reached from the temperature data collected; however, they may be applicable only for the day the investigation was made.

- The water temperature in the Kuna and China Ditches were nearly constant. This is probable due to the similar shady environments the ditches traverse.

- The water increased a near constant ten degrees (^{o}F) from the point of inflow (to the taro patches) to outflow. Solar radiation is the primary cause. Also, water depth in the patches and flow rate are factors related to the influence of radiation.

- The soil in the fields had the same temperature as the water moving through the fields. Therefore, the water temperature is directly related to the development of a taro plant.

- The dry soil had the same temperature as the water moving through the fields. Water in the taro fields generally exceeds 77^{0}F.

- The two rows of taro patches parallel to Kuhio Highway (owned by Haraguchi) are irrigated from the east end of the patches; the irrigation water flows through seven patches before being released to the drainage ditch. The water temperatures recorded on Table 5 were taken at the tail end of the first patch. Mr. Haraguchi stated that he had not experienced any taro diseases in his taro patches, except when he planted some experimental varieties of taro.

Coliform incidence was another water quality parameter examined. The State of Hawaii, Department of Health conducts periodic water sample tests in the estuary of the Hanalei River. A year's samplings, taken at a frequency of once a month, indicate that the values for the total coliform and fecal coliform bacteria exceed the State's Standard for Class A waters.[1] The Hanalei River is classified in Kauai's Class A waters down to the point in the river, where tidal fluctuations affect the river.

TABLE 6

Hanalei River Coliform Counts (1976)

Type of Count	State's Class A Standard	Sample[2]
Median coliform bacteria during a 30-day period	1000 per 100 ml	7,900 per 100 ml
Mean fecal coliform bacteria during a 30-day period	200 per 100 ml	205 per 100 ml

[1]"Water Quality Standards"; Chapter 37-A, Public Health Regulations; Department of Health, State of Hawaii.

[2]Annual mean of State of Hawaii's sampling.

On a monthly basis, the total coliform bacteria counts exceed the State's standard eleven out of twelve months, and the fecal coliform counts exceeded the standard six months out of twelve.

The presence of coliform bacteria may be an indication of sewage pollution. Hanalei Valley farms and residences have individual cesspools; and therefore, the high counts in the estuary could be attributed to either cesspool failure or pastures used for cattle grazing. Colonies of fecal coliform bacteria generally originate from feces of warm blood animals, i.e. cattle. To determine whether taro cultivation and the presence of waterbirds contribute to the high coliform counts in the estuary, samples were taken for a single day period.

TABLE 7

Coliform Sampling[1] - March 14, 1979

Sampling Location	Fecal	Fecal Strep	Total
Hanalei River - U.S.G.S. Gage 1030	24	140	5,200
Hanalei River at tidal zone	70	210	4,300
Tailwater from east taro fields	260	720	5,900
Tailwater from west taro fields	130	420	3,000

It is interesting to note that the fecal counts for the sample of taro field tailwater are much higher than those taken from the river. The fecal streptococcal bacteria count also verifies the fecal pollution. As mentioned, the above is a single sample count and therefore may not be a fair representation of the long-term water quality. It is difficult to determine without extensive studies what impact the relatively high count in the tailwater samples have on the overall water quality of the river and the estuary.

[1]Concentration is expressed as the number of colonies per 100 ml of sample.

According to the State's standards[1] the pH should not be more than a 1/2 unit difference from natural conditions, but not lower than 8.0 nor higher than 8.5 from other than natural causes (not lower than 7.0 for fresh tidal water).

TABLE 8

pH Sampling - March 13, 1979

Sampling Location	Unit	Discharge (CFS)
Hanalei River - U.S.G.S. Gage 1030	8	92.8
Hanalei River - tidal zone	7.6	95.1
Tailwater from east taro field	7.1	0.05[2]
Tailwater from west taro field	6.0	0.2[2]

The use of fertilizer could account for the difference in the samples.

In summary, based on the limited data collected, it appears that taro cultivation does degrade the quality of the waters used to irrigate the fields. However, the impacts on to the surface water quality on the basin are not known and would require further extensive studies to determine.

Presently, it is estimated that the amount of water used to irrigate the taro fields (13 CFS) comprises about 6.3% of the annual mean stream flow recorded (208.8 CFS) at U.S.G.S. Gage 1030. If the present acreage (115$\pm$ acres) is increased to 200 acres, and the water consumption per acre is maintained, the percentage of the mean flow will double to 12.7%. Since potentially additional water quality degradation may be attributable to increased taro cultivation, the diversion of water for taro irrigation should be conducted prudently.

c. Taro Water Requirements

The amount of water required to cultivate taro is the subject of a current legal controversy over water rights in Hawaii.

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[1]op. cit., "Water Quality Standards".

[2]Discharge estimated.

Prior to the 1973 litigation on water rights, the ancient Hawaiian appurtenant water rights were established by first determining the area of land in taro cultivation at the time of the Great Mahele[1], then calculating the water needs for that cultivated area.

In the past, taro water needs were developed for legal purposes, however, these requirements frequently do not address the optimum water requirements for taro cultivation under today's conditions.

The following is a table showing the amount of water required for taro cultivation from literature research, and the source of the data.

TABLE 9

DIFFERING TARO WATER REQUIREMENTS

Daily Requirement (gal./acre/day)	Data Source
15,000	Watson
40,000	Kidder & Schleusener
60,000	Watson
200,000	Shoichi Nagamine (Kauai-Hanapepe farmer)

The highest figure was recently cited by the Waihee Valley farmers on Oahu, in their controversial water rights case.

In March 1979, Shoichi Nagamine's seven-acre taro farm in the Hanapepe Valley, Kauai, was visited to discuss and verify his stated water requirements for taro. Mr. Nagamine is probably one of the few taro farmers, who is aware of the amount of water flowing onto his taro farm, since he has installed a staff

[1]The Great Mahele was a voluntary division of land in Hawaii during 1848 between the King, the Chiefs (Alii), the government, and the common people.

gauge to read the irrigation water inflow.[1] Mr. Nagamine's estimated water requirement for taro may have been conservative, because at the time of thevisit, a flow of approximately 400,000 gallons per day was recorded, which is about 57,000 gallons/acre/day. Under an agreement with the McBryde Sugar Company, Mr. Nagamine is entitled to 750,000 gallons per day, which equals 107,100 gallons/acre/day.

Because local climatic factors, such as rainfall, humidity, and air and water temperature affect the optimal cultivation of taro, perhaps the best way to estimate future water requirements for taro cultivation in Hanalei is to estimate the present water usage in Hanalei. Unfortunately, water use in the Hanalei Valley for taro cultivation has not been monitored, and the time frame of this study does not permit implementing a statistically reliable monitoring program.

From the very limited data available, it was estimated that during the driest thirty consecutive days on record (September 1975), the mean flow in the China Ditch (West Bank) was 12.9 CFS 500 feet downstream of intake. The China Ditch currently irrigates 65.7 acres of taro. This means that approximately 126,900 gallons/acre/day were provided to the West bank taro fields.

Spot measurements taken on March 13, 1979 indicated a transmission loss of 20% occurred between the ditch intake and the first taro field gate, probably attributable to the poor condition of the ditch, i.e. spillways located at various intersections of the China Ditch with minor drainage tributaries, natural seepage, and evaporation. The ditch flow measurement at the upstream end was 10.2 CFS, and the ditch flow measurement before the first taro gate was 8.02 CFS. Therefore, it is assumed that the current ditch capacity and water consumption for the West Bank taro fields is 8 CFS. For the 65.7 acres presently under cultivation on the West Bank, approximately 78,700 gallons/acre/day has been determined to be the current low water requirement for irrigation. This figure is significant in that

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[1]Water is delivered to Mr. Nagamine's taro fields by an underground pipe system.

based on 200 acres, a minimum of 24.4 CFS would be required for irrigation purposes. The lowest monthly flow recorded in September 1975 was about 36 CFS. This means that downstream of the proposed diversion dam, the Hanalei River will have a minimum flow of at least 12 CFS during dry periods.

From the previous calculations, the future water requirement for taro cultivation in the Hanalei National Wildlife Refuge based on 200 acres in taro is presented on the following table.

TABLE 10

Future Water Requirements Based on Actual Data

Flow	Daily Requirement Gal./acre/day	For 200 Acres (in CFS)
Low	78,700	24.4
High	126,900	39.3

It is felt that the proposed water delivery system should divert and allocate irrigation waters in the most efficient manner possible, in order to minimize detrimental impacts to the Hanalei River. Initially, the system intake could be designed to divert the minimum low flow for 200 acres. If this proved to be insufficient, then this amount of water could be increased by altering the intake. The system itself would be sized to accommodate a larger capacity. Also by using gages throughout the system accurate water usage records could be maintained, to provide taro farmers and refuge personnel with a useful water management tool.

d. Hawaiian Water Rights Laws

Hawaii has no appropriation concept regarding surface water. Up until 1973, appurtenant water rights were granted to lands that were being cultivated in taro during the Great Mahele of 1848. The 1973 State Supreme Court decision made in the

McBryde Sugar Company, Ltd., V. Alyner F. Robinson, et al.,[1] dictated that (1) the waters resulting from the appurtenant water rights could no longer be transferred elsewhere and could only be used on the lands to which they were originally appurtenant (i.e., ancient taro lands). (2) surface water including storm and fresh waters could not be diverted for use outside the watershed of origin, and (3) normal surplus waters are the property of the State.

The sugar plantations were against the McBryde ruling and appealed to the U.S. Supreme Court; the Supreme Court refused to hear the appeal. Subsequently, the plantations appealed to the U.S. District Court; Judge Martin Pense issued an injunction against the State's enforcement of the McBryde ruling. The State countered by appealing to the Ninth Circuit Court of Appeals. The resolution of this issue may be at least five years away, as of this writing. In the meantime, the status quo prevails.[2]

Riparian rights are based largely on the doctrine of reasonable use, resulting in complete uncertainty as to the amount of water available for consumption. The use that one proprietor may make of the available flow depends on the uses that others desire to make and thus conditions and rights to water can always change.

There should be no legal problems in diverting water from the Hanalei River to irrigate the proposed increase in taro and wetland acreages, because (1) the Hanalei Valley was under taro cultivation during the Great Mahele, and is presently under taro cultivation and (2) no waters would be diverted away from the Hanalei River basin.

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[1]McBryde V. Robinson, 54 Haw. 174, 504 P.2d 1330 (1973), on rehearing, 55 Haw 260, P.2d (1973).

[2]Ronald Albu, attorney, Legal Aid Society of Hawaii, 9/6/79.

6. Air and Sonic Quality

There is limited vehicular access both to and within the Hanalei National Wildlife Refuge. Vehicles, which do enter the refuge, belong to the Fish and Wildlife Service personnel, taro farmers, or residents of the Hanalei Homesteads, south of the refuge. One-third of the land in the refuge is either under taro cultivation or grazing. The remaining land is in open space or cannot be developed due to physical constraints (e.g. steep sloped). The air and sonic quality are considered to be excellent, due to the relatively low amount of vehicular traffic.

7. Visual Quality

Irrigation water to the existing taro acreages in Hanalei Valley is provided by the Kuna Ditch on the East Bank of the Hanalei River, and the China Ditch on the river's West Bank. The Kuna Ditch and the China Ditch are both earthen ditches, which will be directly affected by the proposed project.

The Kuna Ditch is in generally poor condition. There are major and minor losses of water from the ditch, through seepage and actual breaks in the dich walls. The taro farmers have attempted to fix the breaks in the ditch by digging the damaged section of the ditch to an even greater depth. However, the ditch walls are porous and weak, invariably resulting in repeated breaks. Another technique is to stuff vegetative material into heavy gauge plastic, and then shore the ditch break with the stuffed plastic. This is also an ineffective method because the water action breaks down the plastic barrier, and the plastic becomes strewn along the banks of the Hanalei River. Near the upper intake, where the ditch flows adjacent and above the Hanalei River, there are a number of tunnels (5-6), which were dug in the early 1900's. Should these tunnels break, it would be difficult to repair them, because they are not accessible by heavy equipment. The intake structure for the Kuna Ditch is in good repair. The following is a location-by-location description of the various features of the Kuna Ditch, as referenced on Figure 9 and shown by the accompanying photographs.

- Point 1 - The lower Kuna Ditch (East bank) adjacent to Walter Koga's farm.

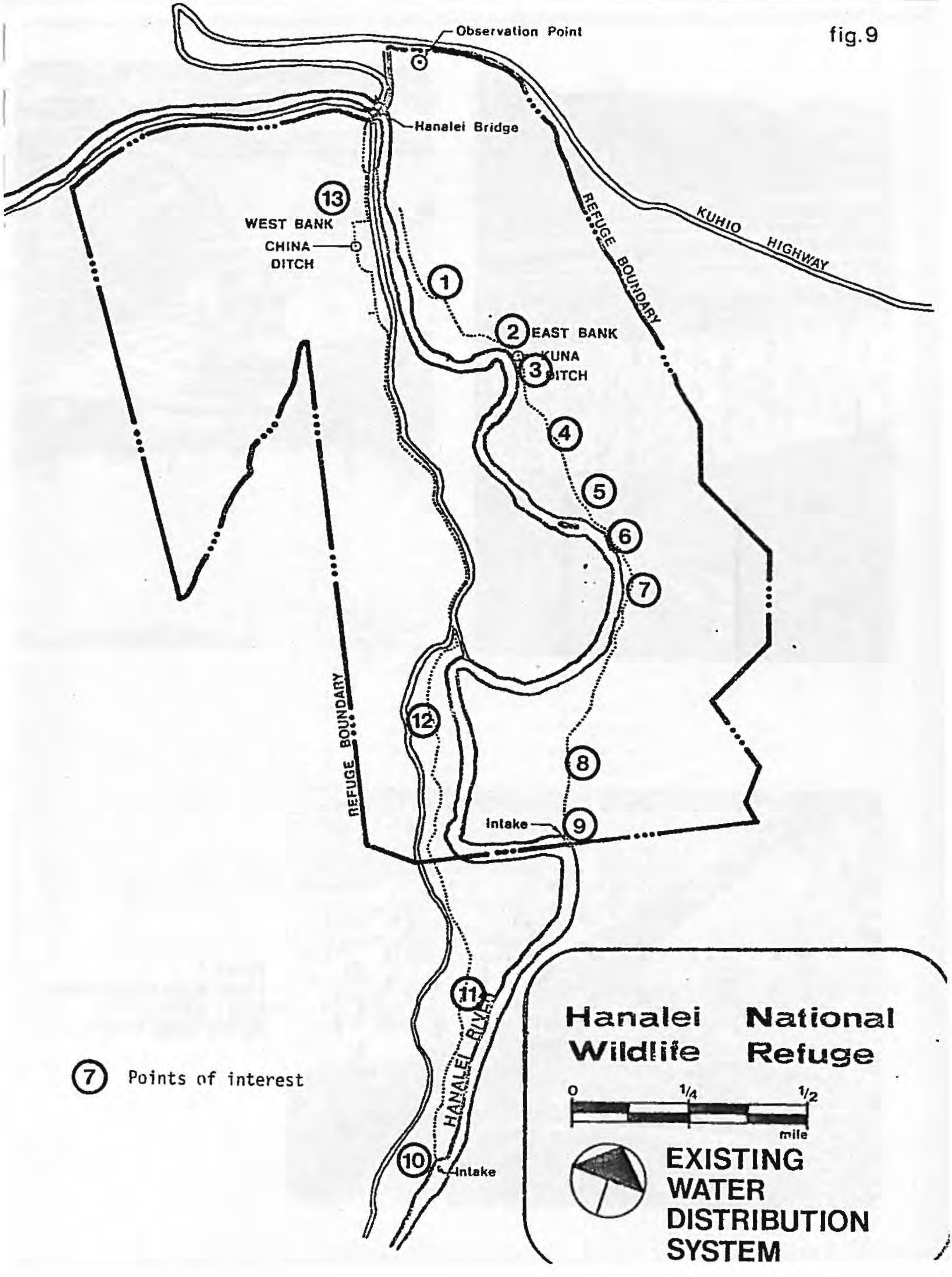
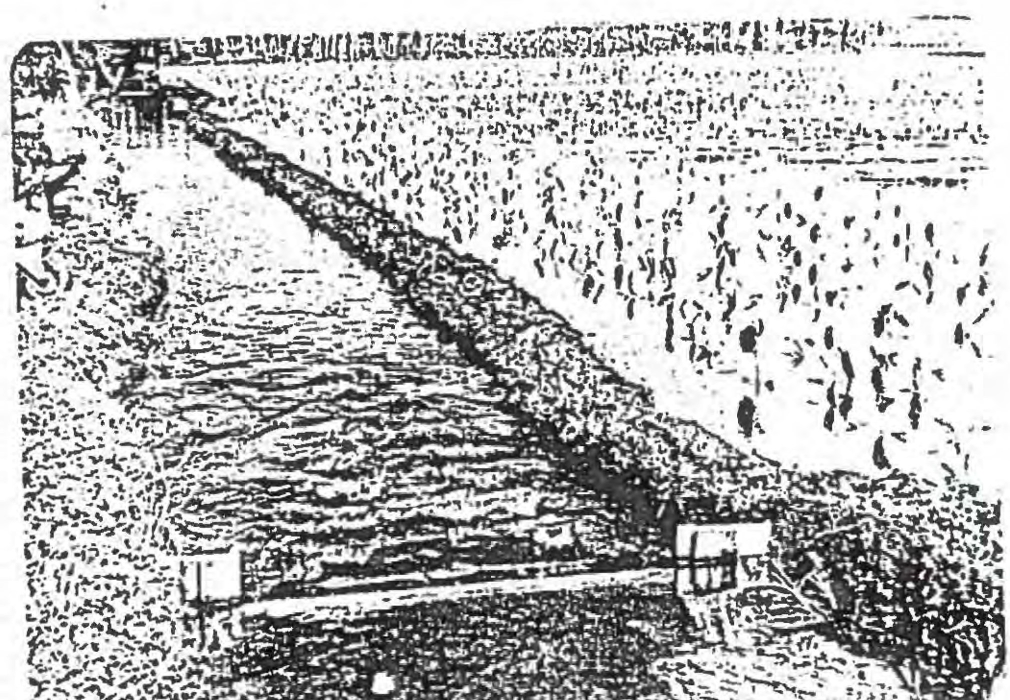
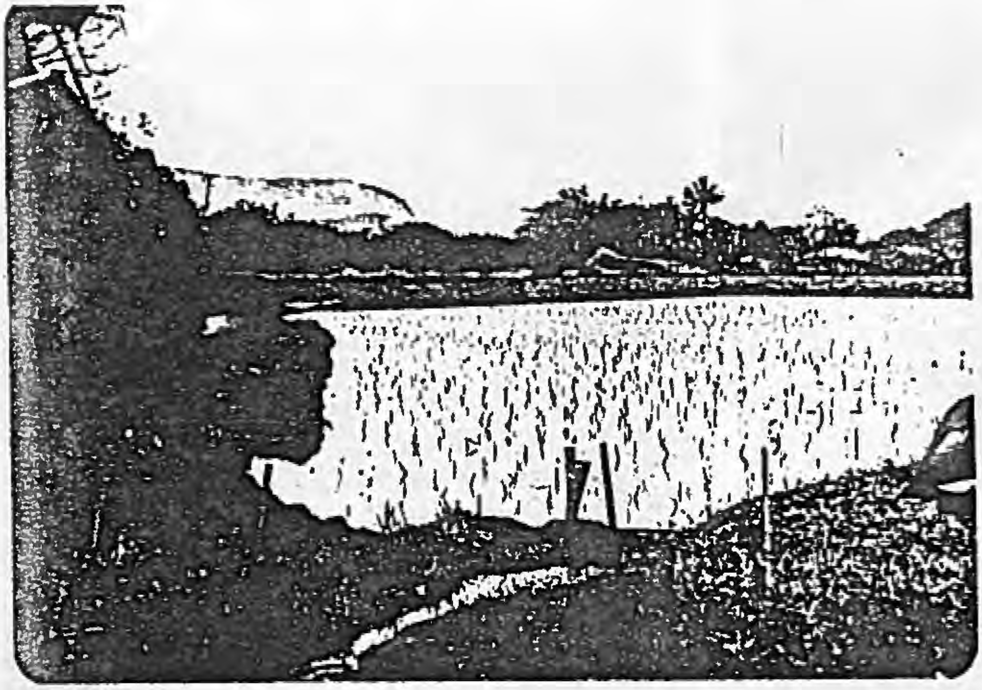


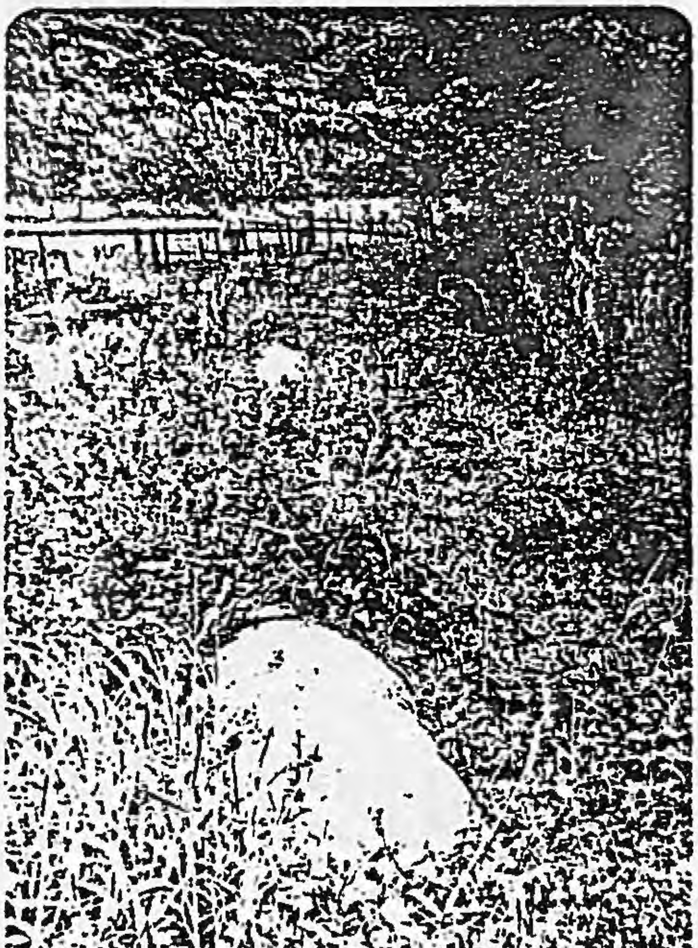
fig.9
Observation Point
Hanalei Bridge
KUHIO HIGHWAY
REFUGE BOUNDARY
WEST BANK
CHINA DITCH
EAST BANK
KUNA DITCH
Intake
HANALEI RIVER
Intake
1
2
3
4
5
6
7
8
9
10
11
12
13
7 Points of interest
Hanalei National Wildlife Refuge
0
1/4
1/2
mile
EXISTING WATER DISTRIBUTION SYSTEM



Point 1.
Lower Kuna Ditch (east bank) adjacent to Walter Koga's farm.

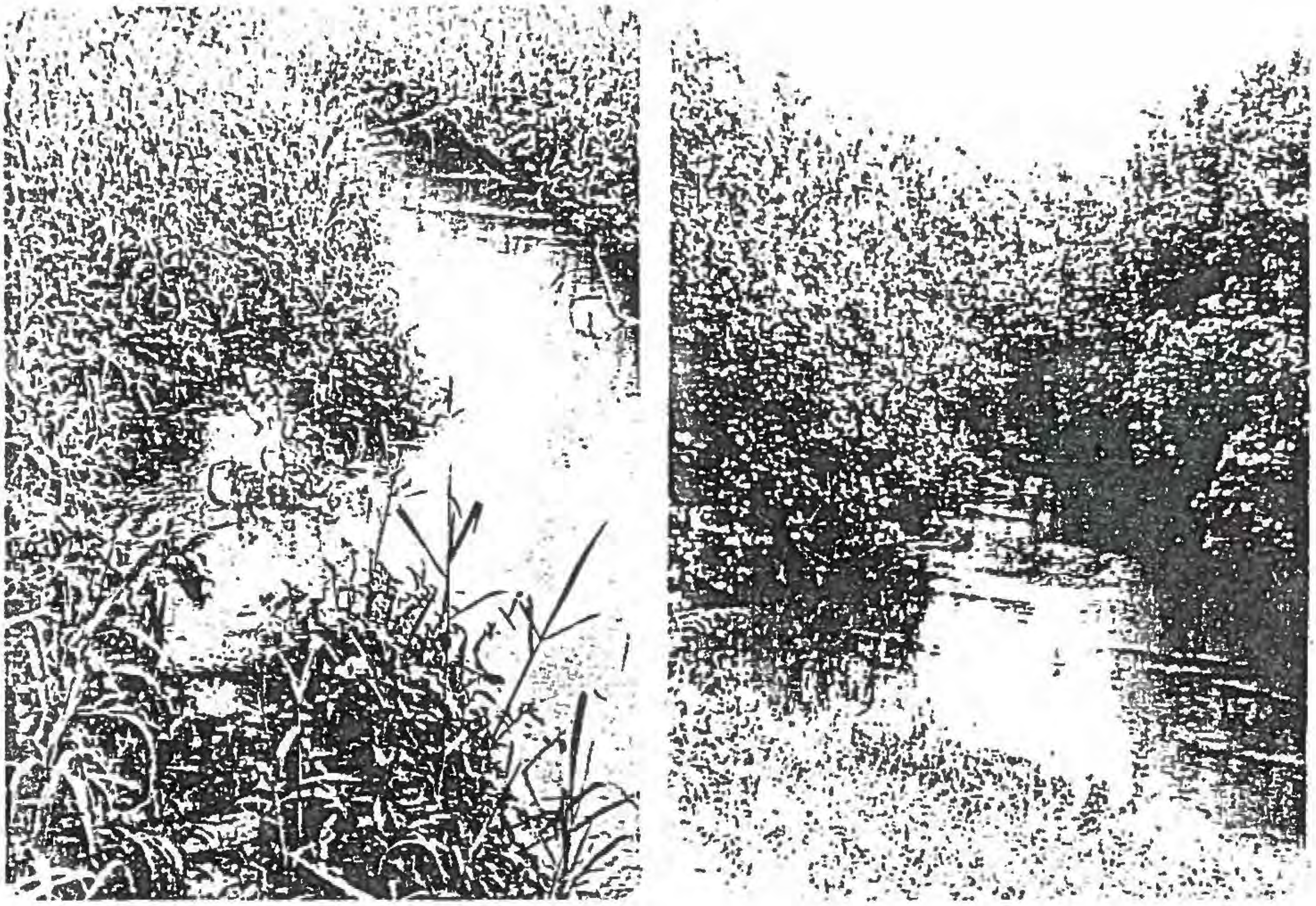


Point 2.
Lower reaches of Kuna Ditch (east bank).

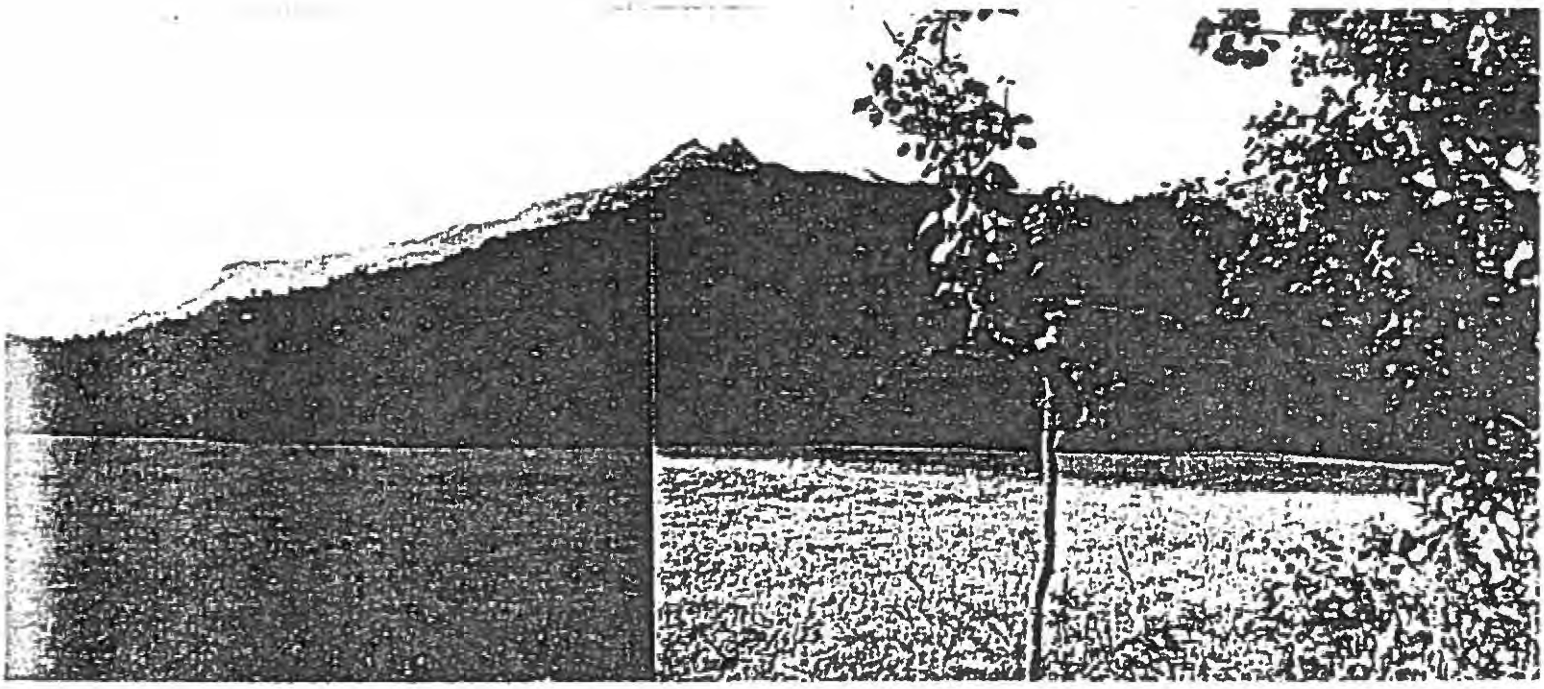


View towards Koga residence.

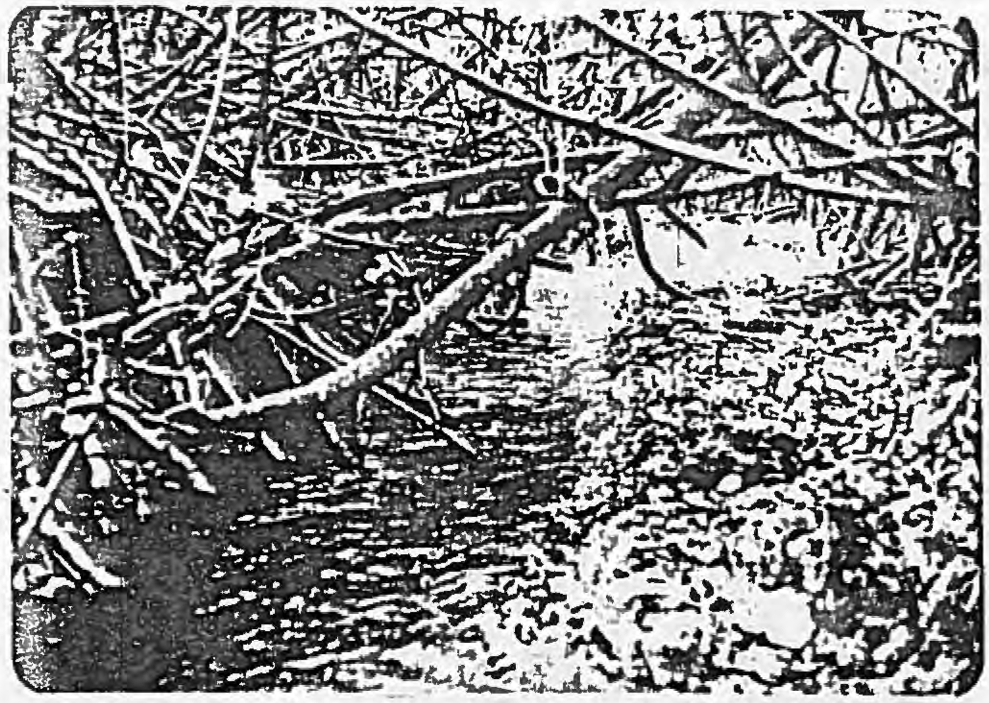
Short pipe section of Kuna Ditch.



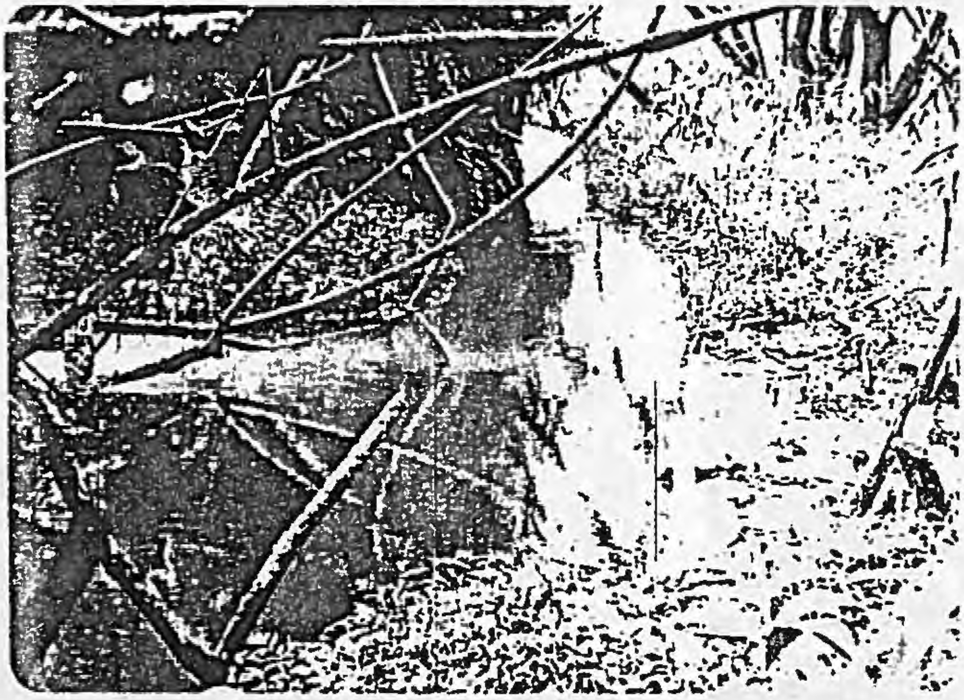
Point 3.
Seepage along the lower reaches of the Kuna Ditch (east bank).

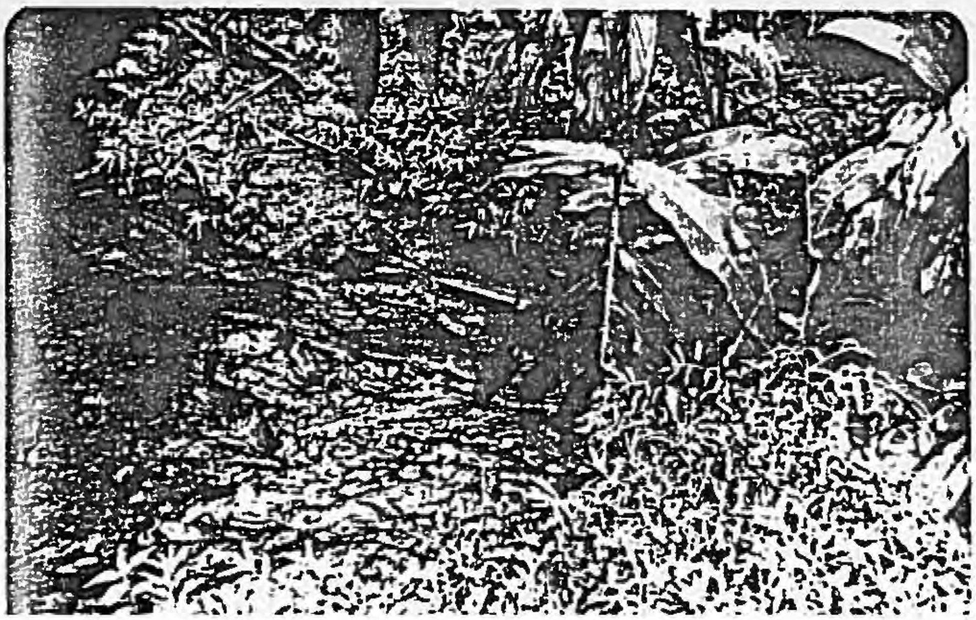


Point 4.
View through pasture where the proposed inverted siphon from the west bank will be constructed.

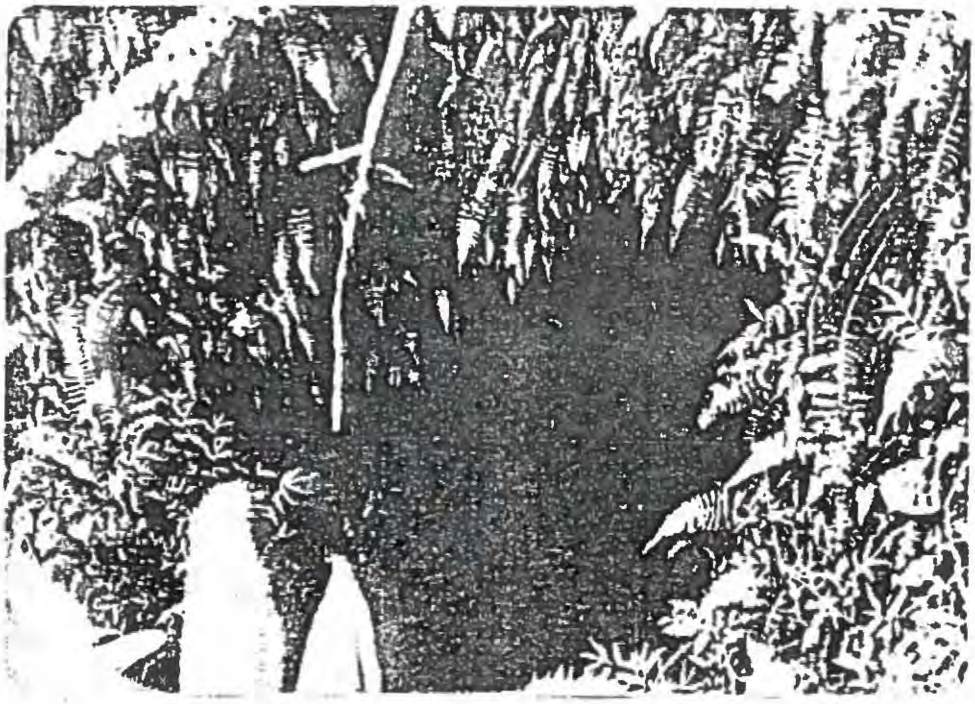


Point 5.
Cleared hau thicket around Kuna Ditch.

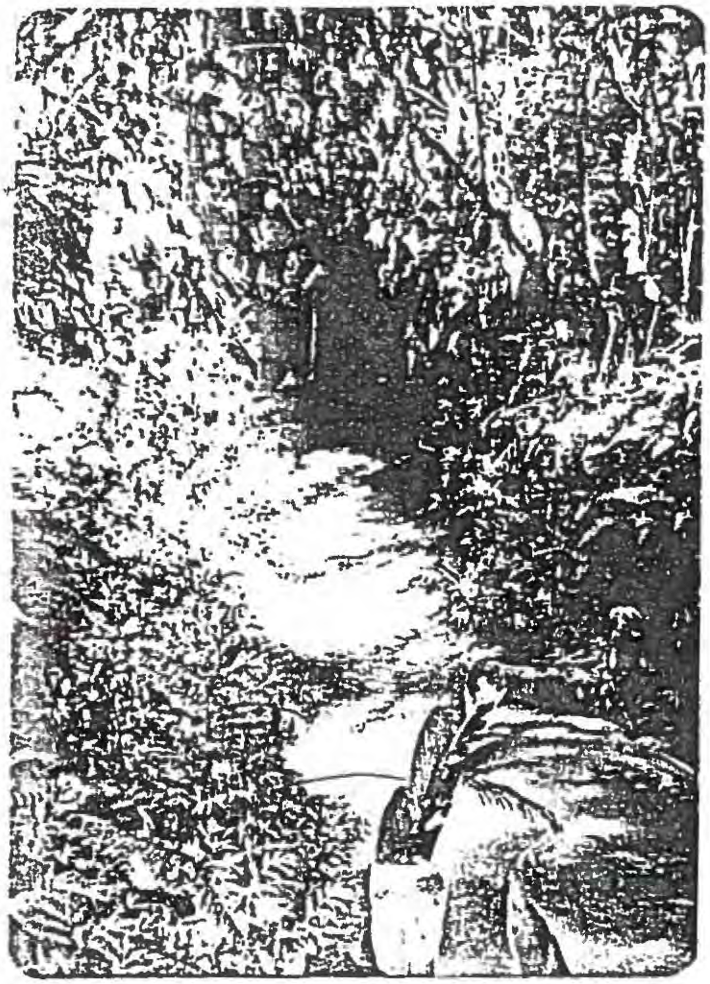


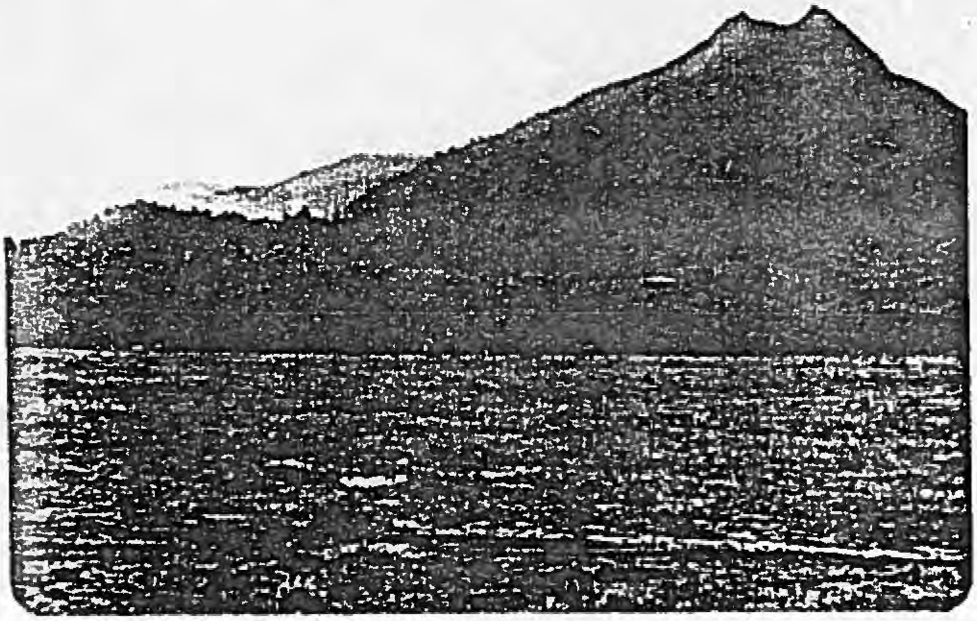


Point 6.
Major breaks occurring; plastic stuffed with vegetation used to shore up ditch breaks.

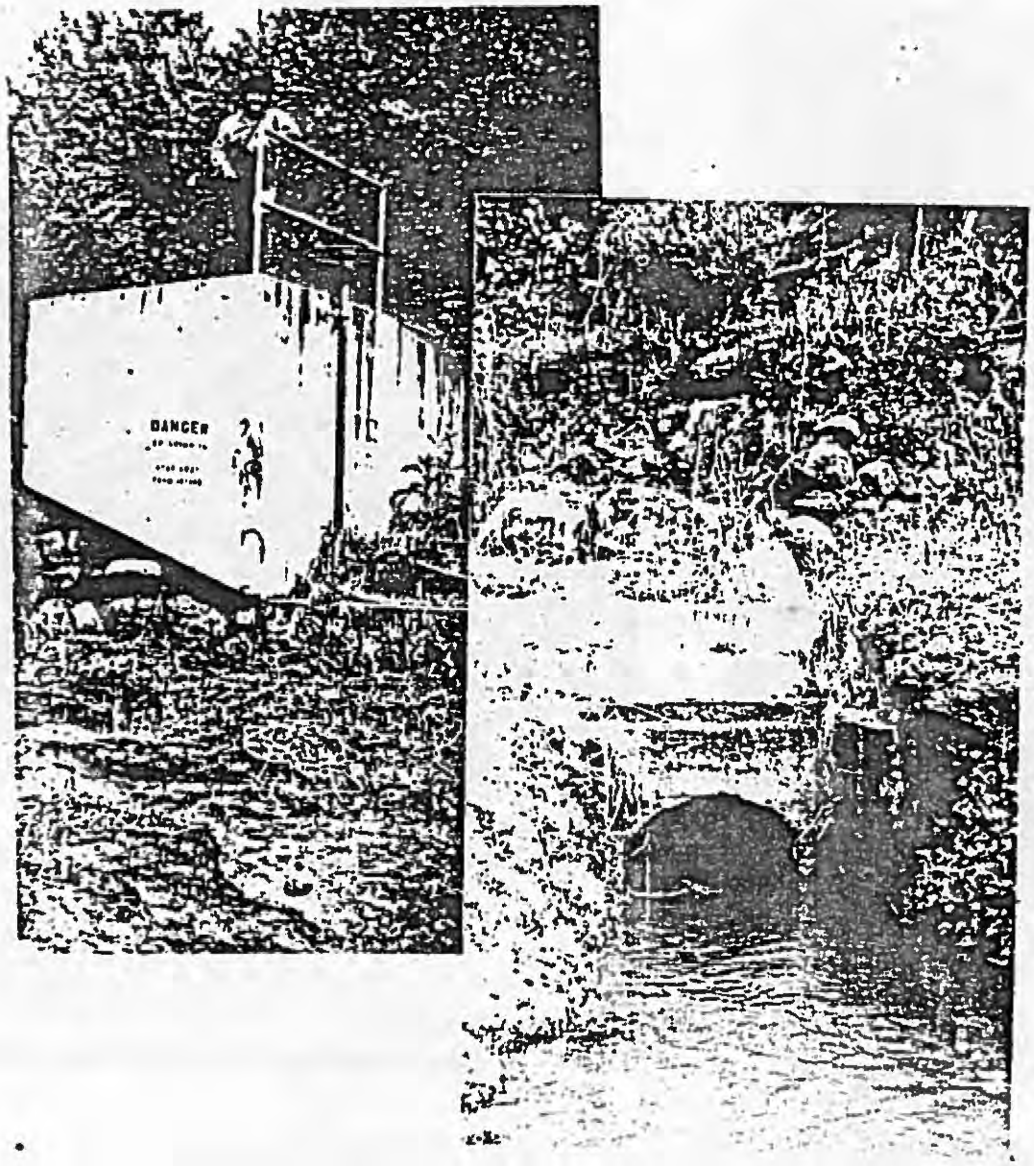


Point 7.
Kuna Ditch tunnels.

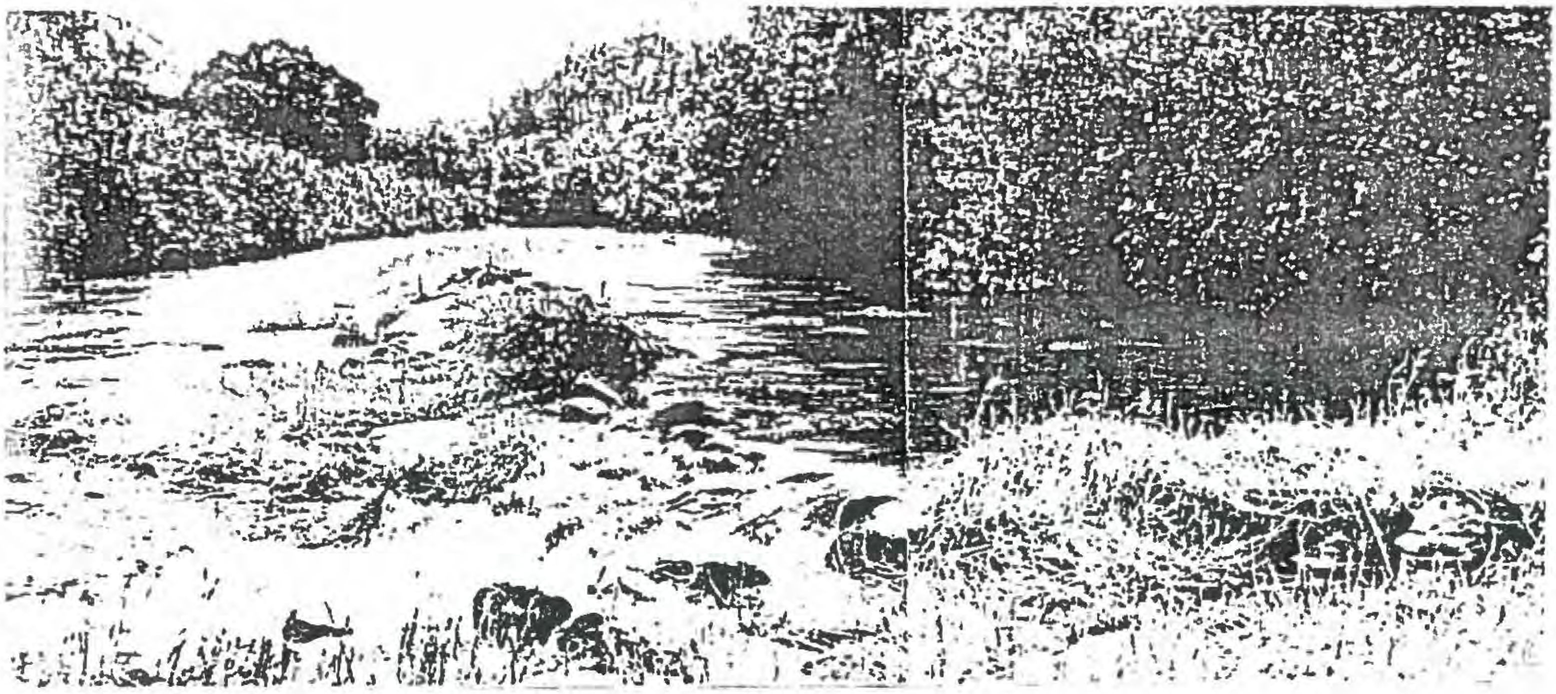




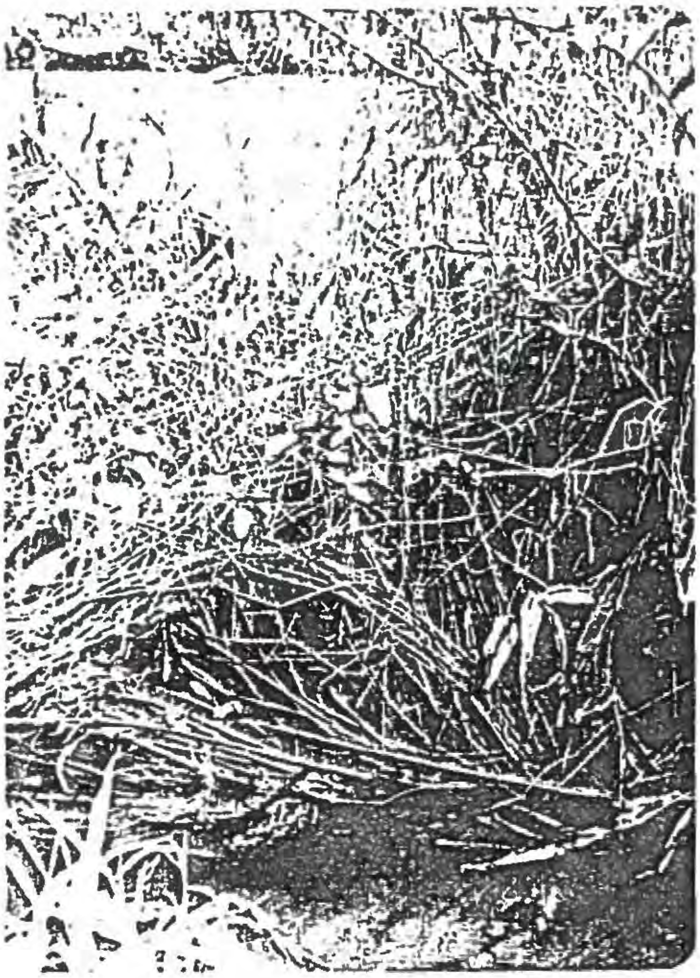
Point 8.
View of the upper pasture adjacent to the Kuna Ditch intake.



Point 9.
Kuna Ditch intake structure on the Hanalei River.

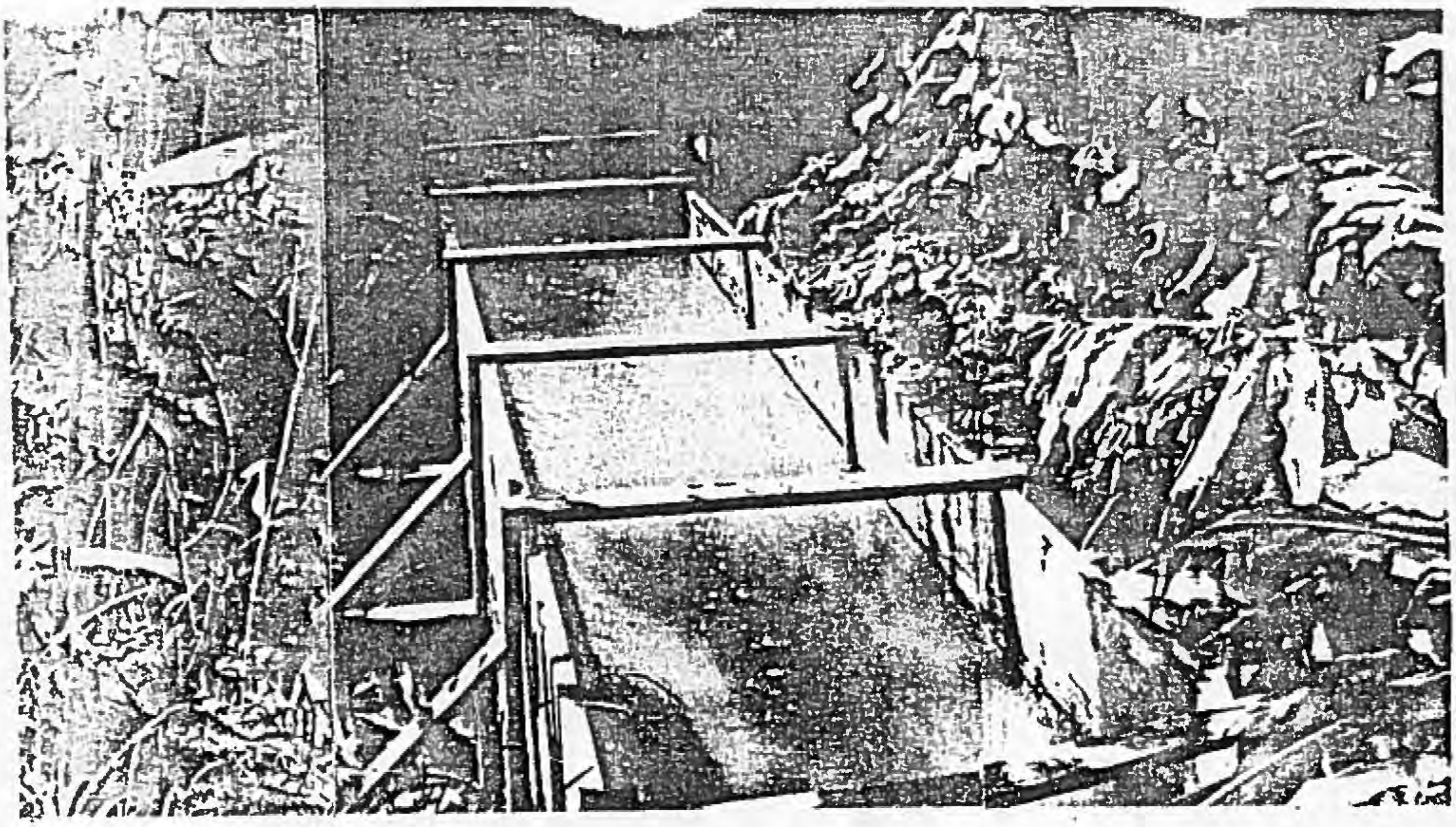


Point 10.
China Ditch intake (west bank) on the Hanalei River.

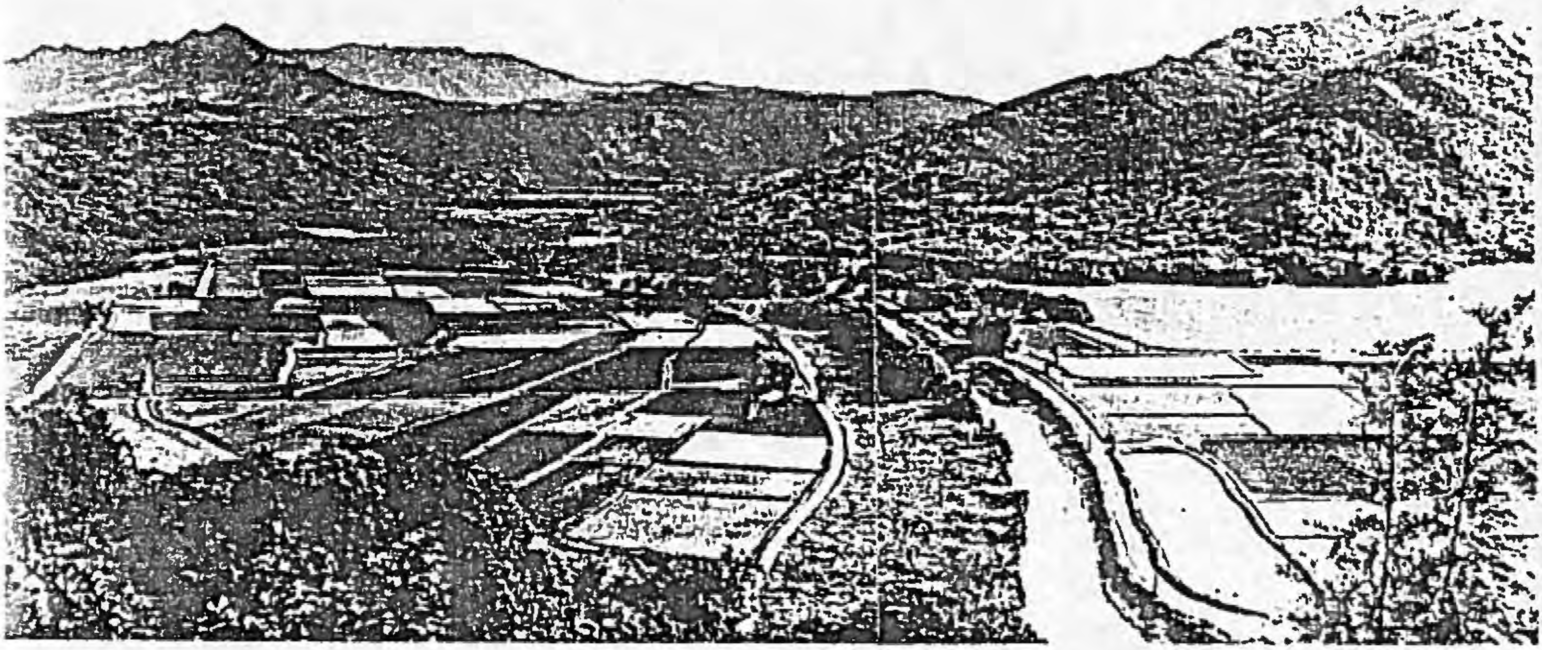


Background - China Ditch
Foreground - Hanalei River

Point 11.
Upper reaches of the China Ditch



Point 12.
The flume (50 ft.) on the China Ditch.



Point 13.
Lower reaches of the Hanalei National Wildlife Refuge as seen from the Hanalei Lookout.

- o Point 2 - Short pipe section of the Kuna Ditch.
- o Point 3 - Seepage along lower reaches of the Kuna Ditch.
- o Point 4 - View through pasture where the proposed inverted siphon from the West Bank will be constructed.
- o Point 5 - Cleared hau thicket surrounding ditch.
- o Point 6 - Major breaks occur, plastic stuffed with vegetation used to shore up ditch breaks.
- o Point 7 - Tunnels (5-6) through which the Kuna Ditch passes.
- o Point 8 - View of the upper pasture, adjacent to the Kuna Ditch intake.
- o Point 9 - The Kuna Ditch (East Bank) intake structure on the Hanalei River.

The lower reaches of the China Ditch along the access road are in relatively good repair, however in the upper reaches of the ditch, there are two problem areas. The ditch flows in a wooden flume for 50 feet, which is in poor condition. This could present replacement problems in the near future. The intake for the China Ditch is located above the refuge boundaries in State land controlled by the Department of Land and Natural Resource. The location of the intake contributes to the clogging of the ditch, because water is diverted directly into the ditch by a weir, which allows debris to flow unobstructed into the ditch. Maintenance of this ditch is presently provided by voluntary work crews farming in the refuge. Again refer to Figure 9.

- o Point 10 - The China Ditch (West Bank) intake on the Hanalei River.
- o Point 11 - Upper reaches of the China Ditch.
- o Point 12 - The flume (50 feet) on the China Ditch.
- o Point 13 - Lower reaches of the Hanalei National Wildlife Refuge as seen from the Hanalei Lookout.

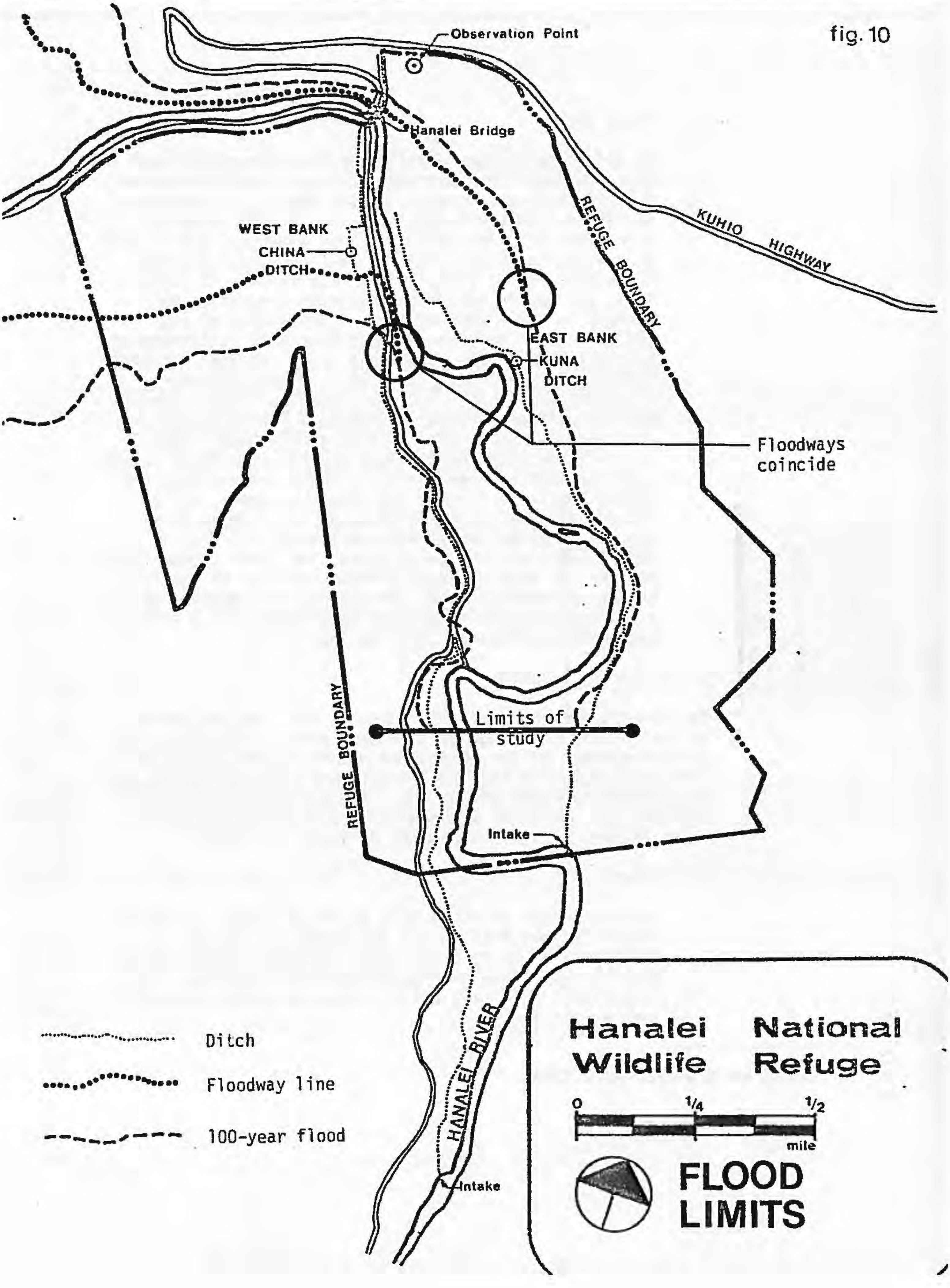


fig. 10
Observation Point
Hanalei Bridge
KUHIO HIGHWAY
REFUGE BOUNDARY
WEST BANK
CHINA
DITCH
EAST BANK
KUNA
DITCH
Floodways coincide
Limits of study
REFUGE BOUNDARY
Intake
HANALEI RIVER
Intake
Ditch
Floodway line
100-year flood
Hanalei National Wildlife Refuge
0
1/4
1/2
mile
FLOOD LIMITS

8. Flood Hazard

At this time, no new dwelling or farm structures have been proposed for construction in the Hanalei National Wildlife Refuge. However, in the future, if structures are desired in the refuge, they would have to be in compliance with the National Flood Insurance Act of 1968, as amended (42 U.S.C. 4001 et seq, the Flood Disaster Protection Act of 1973, (Public Law 93-234, 87 Stat. 975), and the flood plain management program to be adopted by the County of Kauai. The limits of the 100-year flood and the floodway have been delineated up to the limits of the study area in the Hanalei National Wildlife Refuge. See Figure 10. No new structures

would be allowed within the floodway district; however, structures would be allowed within the flood fringe district (between the floodway and 100-year flood limits) provided that (1) residential structure would have the lowest habitable floors, including basements, and all structural flood members, elevated to or above the regulatory flood level (100-year flood) and (2) non-residential structures would have their lowest floors elevated or they would be flood-proofed up to the level of the regulatory flood. Structures in violation of this stature would most likely not be eligible for a mortgage, because the structure could not be insured.

B. BIOLOGICAL ENVIRONMENT

In this section the types of flora and fauna in the Hanalei National Wildlife Refuge will be described. The preservation and enhancement of the endangered waterbird species, which feed and inhabit in the Hanalei National Wildlife Refuge, are the primary concerns of the U.S. Fish and Wildlife Service. However, the refuge is quite diverse in the environments it provides for the various species of flora and fauna.

1. Flora[1]

The discussion of flora will be divided into two parts. The first part will detail the plants, which are considered to be more important, from the standpoint of their usage by the endangered waterbird species. The second part will be a brief listing of other predominant species of plants.

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[1]Study by MKGK/Yamamoto, 1979.

In the flora study by MKGK/Yamamoto, no endangered or threatened plan species were noted.[1]

a. Plants Important to the Endangered Waterbird Species.

- o Hau Thicket (Hibiscus tiliaceus) - indigenous - Hau Thickets are formed along river banks, irrigation ditches, mangrove swamps, and sloped area. Hau thickets are useful as vegetative cover for the waterbirds.

- o Guava (Psidium guajava) - exotic - Guava is prevalent in lower elevations, where there are wetlands. It produces an edible yellow fruit, which is consumed by the coots (to be subsequently described). The coots also feed on the insects that eat guava.

- o Azolla (Azolla filiculoides) - exotic - Azolla is a minute green water fern; which creates continous vegetative cover over water areas. Algae grows within azolla concentrations. Coots and gallinules feed on algae and insects, which live in azolla concentrations.

- o Bulrushes (Scirpus validus) - indigenous - Bulrushes are plants, which grow on edges of ponds or marsh areas. It can grow up to 9 feet tall, with a 1 inch diameter at the base. Bulrushes provide good nesting material for the coot and gallinule.

- o Cattails (Typha angustata) - exotic - Cattails also grow near wet areas and provide nesting material for the coot and gallinule.

- o Greater Duckweed (Spirodela polyrrhiza) - exotic - Greater Duckweed forms dense floating colonies. It has 6-inch long leaves, which are green on the top and purple on the bottom. Greater Duckweed provides feeding areas for the coot and gallinule.

b. Other Predominant Plant Species

The following table presents a brief listing of other plants prevalent at the Hanalei National Wildlife Refuge.

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[1]There is only one officially listed endangered plant in the State of Hawaii, the Hawaiian wild broadbean, found on the Island of Hawaii.

TABLE 11

OTHER PREDOMINANT PLANT SPECIES

Common Name	Scientific Name	Status
California Grass	Brachiaria mutica	exotic
Sword Fern	Nephrolepsis exaltata	exotic
Swollen Finger Grass	Chloris inflata	exotic
Hilo Grass	Paspalum conjugatum	exotic
Wild Ginger	Zingiber Zerumbet	exotic
Basket Grass	Oplismenus hirtellus	exotic
Honohono Grass	Commelina diffusa	exotic
Mango	Mangifera indica	exotic
Java Plum	Eugenia cumini	exotic
Bamboo	Bambusa vulgaris	exotic
Uluhe Fern	Dicronopteris linearis	exotic
Blue-Green Algae	Anabens sp.	exotic
Kukui	Aleurites moluccana	indigenous
Pandanus	Pandanus odoratissimus	indigenous

2. Fauna

There are many different types of fauna which inhabit and feed in the Hanalei National Wildlife Refuge. The various fauna are discussed under three classifications: aquatic, avian, and terrestrial. The aquatic classification includes fishes, insects, and reptiles; the terrestrial classification consists of land mammals; and the avian classification is comprised of waterbirds and other bird species.

a. Aquatic

The aquatic fauna in Hanalei National Wildlife Refuge is found in the taro fields, adjacent wetlands, and the Hanalei River. Many of these fauna are food sources for the endangered waterbirds. The waterbirds are attracted to chironomids (midges) and tubificids (worms), which exist in the taro fields. Chironomids are abundant in shallow waters, while tubificids can flourish in wet and dry environments. Bird feeding is the most intense during the wet fallow period of the taro agricultural cycle, between harvesting and re-planting of the taro fields. Endemic and exotic gastropod mollusks (snails, slugs, etc.), as well as toads and bullfrogs, inhabit some of the taro fields and ponds.

The fish in the ponds include swordtails, guppies, and tilapia. The Hanalei River attracts local fisherman searching for mullet, milkfish, barracuda, gobi (o'opu) and shrimp (opae). In a recent aquatic survey[1], the Hanalei River was found to have a substantial population of native aquatic species. The Hanalei River not only yielded the greatest number of endemic species in the streams surveyed (based on the number of mountain shrimp per sampling station) but also had the highest percentage of endemic species sampled (74%).[2]

Four species of native o'opu are known to inhabit the streams and ponds of Hanalei Valley. These are o'opu nakea (Awaous stamineus), o'opu nopili (Sicydium stimpsoni), o'opu naniha (Awaous geniuttatus), and o'opu okuhe (Eleotris sandwicensis). Following is a table describing the characteristics of the four types of o'opu inhabiting the study area.

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[1] Timbol, Dr. Amadeo S.; A Report on the Aquatic Survey of Stream Macrofauna for the Hydroelectric Power Study for Hawaii; Environmental Impact Study Corp. for U.S. Army Corps of Engineers, Pacific Ocean Division; Honolulu, Hawaii; September 1977.

[2] Stanley Shima, Biologist, Fish and Game Division, State Department of Land and Natural Resources, 6/15/79.

TABLE 12

O'OPU INHABITING THE HANALEI RIVER[1]

SPECIES	STATUS	SIZE	DIET	PREFERRED HABIT	UNIQUE PHYSI CHARACTERIST
O'opu nakea (Awaous stamineus)	Endemic	14-inches	omniverous	all stream areas	color patter
O'opu naniha (Awaous genivittatus)	Indigenous	6-inches	omniverous	lower stream only	stripes and color bar
O'opu nopili (Sicydium stimpsoni)	Endemic	7-inches	herbivorous	all stream areas	Variable col male has lon dorsal fin
O'opu okuhe (Electros sandwicensis)	Endemic	10-inches	carnivorous	lower stream only	brown with variable shading and spotting

O'opu nakea is the largest goby, and is commercially valuable. The spawning season usually occurs between July and November, corresponding with periods of storm flows in the river. Adult o'opu nakea are washed down to the estuary areas where spawning occurs. The other species of o'opu are believed to spawn year-round at any location of the river.

Opae kala'ole, Atya bisulcata, fresh water mountain shrimp, is endemic to the Hawaiian Islands. It is described as a detritivore, consuming suspended organic particles, and generally inhabits the middle and upper portions of streams. Opae have a diadromous life-cycle, requiring access to seawater to spawn. Couret's paper indicates that spawning takes place year-round, suggesting a multivoltine life cycle known for many other tropical species.[2]

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[1]Maciolek, John A.; West Maui Streams, Preliminary Draft; 1977.

[2]Couret, Carl; Biology and Taxonomy of a Freshwater Shrimp, Atya Bisculcata; Randall; May 1976.

Other aquatic fish inhabiting the study area include tilapia (Tilapia spp.), mosquito fish (Gambusia affinis), and swordtails (Xiphophorus spp.). Fish species inhabiting or spawning in the estuary and brackish waters of the Hanalei River include papio (Caranx sp.), mullet (Mugil cephalus), barracuda (Sphyraena barracuda), milkfish (Chanos chanos), and aholehole (Kuhlia sandwicensis). The brackish waters also provide habitat for a number of species of crabs.

b. Terrestrial

All of the terrestrial fauna identified in the Hanalei National Wildlife Refuge, have been introduced to the Valley and are of little value to the refuge, because they are potential predators of the endangered endemic bird species. Terrestrial fauna include feral dogs and cats, mice, rats.

c. Avian[1]

The development of the additional taro fields and the diversion of the Hanalei River's waters serves two purposes: (1) to increase the overall taro acreage in the State and (2) to provide additional habitat and food sources for endemic Hawaiian waterbird avifauna. Waterbirds found in the Hanalei National Wildlife Refuge will be discussed, following a listing of other bird species.

o Non-Waterbird Avifauna

The following table is a listing of non-waterbird avifauna, common and less common, which can be found feeding or nesting within the refuge

---

[1]Data from "Survey of the Hanalei Valley", May-July 1977.

TABLE 13

NON-WATERBIRD AVIFAUNA - HANALEI NATIONAL WILDLIFE REFUGE
(All Exotic Except * - Endemic)

COMMON
Barred Dove (Geopelia striata striata) Spotted Dove (Streptopelia chinensis chinensis) Melodious Laughing Trush (Garrulax canorus) Shama Thrush (Copsychus malabaricus) Japanese White-eye - Mejiro (Zosterops japonica japonica) Common Mynah (Acridotheres tristis) Cardinal (Cardinalis cardinalis) House Finch - Linnet (Carpodacus mexicanus frontalis) Spotted Munia - Ricebird (Lonchura punctulata)
LESS COMMON
Red Junglefowl (Gallus gallus) Barn Owl (Tyto alba) * Hawaiian Owl (Asio flammeus sandwichensis) Western Meadowlark (Sturnella neglecta) House Sparrow (Passer domesticus) Greater Necklaced Laughing-Thrush (Garrulax albogularis)

o Waterbirds

The Hanalei National Wildlife Refuge attracts many different species of waterbirds, due to an adequate amount of suitable nesting habitats and an ample food supply. First, the various types of non-endangered waterbirds will be listed, then the relationship of the endangered waterbird species to the Hanalei National Wildlife Refuge will be separately discussed.

TABLE 14

NON-ENDANGERED WATERBIRD AVIFAUNA - HANALEI NATIONAL WILDLIFE REFUGE

General Category	Common Name	Scientific Name
Year-Round	Black-Crowned Night Heron Cattle Egret	Nycticorax nycticorax hoactili Bubulcus ibis
Common Migatory Ducks	Pintail Northern Shoveler Mallard Green-Winged Teal American Widgeon	Anas acuta Anas clypeata Anas platyrhynchos platyrhynchos Anas crecca Anas americana
Less Common Migatory Ducks	Blue-Winged Teal Garganey Teal Redhead	Anas discors Anas querquedula Aythya americana
Migatory Shorebirds	American Golden Plover Wandering Tattler Ruddy Turnstone Pectoral Sandpiper	Pluvialis dominica fulva Heteroscelus incanus Arenaria interpres Erolia melanotos

By far the most important of these waterbird species, are the Hawaiian stilt (Himantopus mexicanus knudseni), Hawaiian coot (Fulica americana alai), Hawaiian or koloa duck (Anas wyvilliana), and Hawaiian gallinule (Gallinula chloropus sardvicensis), because they are all endemic to Hawaii and are included on the United States "List of Endangered and Threatened Wildlife and Plants", as a result of the Endangered Species Act of 1973. This law seeks to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, to provide a program for the conservation of such endangered species and threatened species, and to take such steps as may be appropriate to achieve the purposes of the treaties and conventions.

According to U.S. Fish and Wildlife Service data, the average population of koloa, stilt, coot, and gallinule at the Hanalei National Wildlife Refuge comprise 1.2%, 3.9%, 5.1%, and 7.5% of the estimated statewide populations of these species, respectively. From the latest counts taken from 1974 to 1977, it can be seen that the number of these birds has increased, due primarily to recent habitat management programs. The management programs have included: (1) limiting the access to the park by feral dogs and cats, (2) educating the farmers as to taro cultivation practices compatible with waterbird preservation, (3) studying the activities of the waterbirds, and (4) regularly recording bird populations within the refuge. A brief discussion of these endemic and endangered species follows.

The Hawaiian Stilt is the most conspicuous of endemic waterbirds in Hanalei Valley. The total statewide population of stilts was estimated to be 1006 in July 1978[1], with 250 on Kauai and Niihau. The Hawaiian stilt stands about 16 inches tall, and is a slender wading bird, with a black upper body and white lower body. It has a straight black bill, and long pink legs. Generally, the majority of the stilts reside in the valley from August to December, and leave the valley in January or February to breed. (Some stilts do nest in the valley). The stilts do not eat taro, preferring fish, crabs, worms, and water insects; they are tolerant of the taro farmers in the fields. They nest close to the water in depressions lined with stones, twigs, and miscellaneous debris.

Because of the proximity of stilt nesting sites to the edge of water bodies, they are particularly susceptible to flooding. Park management (e.g. limiting feral dogs and cats) has brought about the increase in stilt populations.

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[1]Coleman, Richard A., "Observations on Breeding Biology of Hawaiian Stilt (Himantopus mexicanus knudseni) on Oahu, Hawaii", August 1978, p. 2.

The Hawaiian Coot is also a widely distributed, endemic waterbird in Hanalei Valley. It was estimated that of the 1,700+ statwide coot population, about 1,200+ or 70%, inhabit and feed in Kauai and Niihau. The Hawaiian coot is a black "duck-like" bird with a white bill and forehead, which stands about 14 inches tall. No coot nests have been found in Hanalei Valley. In normal years, the coots arrive from outside nesting areas in early summer, and depart in January or February to those outside nesting areas. The coot is highly dependent upon marshes and ponds, and builds floating nests from aquatic vegetation. Coot populations have increased with park management programs.

The Hawaiian Duck (Koloa) numbers about 3,000 in population, most of which are found along the mountain streams and taro patches of Kauai. Suitable feeding, resting and nesting habitats for the Hawaiian duck are located within the Hanalei National Wildlife Refuge. The Hawaiian duck stands between 16 and 20 inches tall, and is brown, with orange legs. These ducks nest and feed in areas with little human activity. There is some concern about interbreeding of the Hawaiian duck with outside migratory duck species. However, refuge management has improved conditions for this species.

It is estimated that the Hawaiian Gallinule numbers between 500 and 700 on Kauai, where it is the most prevalent. Accurate population estimates are difficult because of the birds' secretive behavior. It is a slate-gray bird, standing 13 inches tall, resembling a Hawaiian coot, except with longer legs. It has white feathers on the flanks and under tail, with yellowish-green legs and feet. Its bill is red with a yellow tip. The Hawaiian gallinule is a year-round resident of the wildlife refuge. It inhabits vegetated fresh water areas, and feeds on mollusks, water plants, grasses, and floating vegetative debris. The gallinule nests in hau forests along the streams and in taro fields.

C. Historical/Archaeological Features[1] (Refer to Figure 11)

Hanalei Valley has been an area of extensive agricultural activity, since the time prior to European contact with Hawaii. Therefore, there is great historical and archaeological interest accompanying the proposed development of the Hanalei National Wildlife Refuge.

In 1973, a part of his doctoral dissertation, Dr. Timothy K. Earle located two irrigation systems within the refuge boundaries.[2] System 26 on the West Bank of the Hanalei River corresponds to the China Ditch; System 29 on the East Bank corresponds to the Kuna Ditch. Dr. Earle stated that the Kuna Ditch may be associated with a late 19th century rice system, and that the China Ditch may be part of an ancient ditch system.

In order to be in compliance with 36 CFR PART 63, "Determination of Eligibility for Inclusion in National Register of Historic Places", and 36 CFR PART 800, "Protection of Historical and Cultural Properties", the U.S. Fish and Wildlife Service employed the expertise of the Bernice P. Bishop Museum to conduct on extensive archaeological reconnaissance survey in the Hanalei National Wildlife Refuge between May and June 1979. The following discussion is based on that survey, which is included in its entirety in the appendices of this document.

The floor of the refuge was divided into five survey areas, with ten different sites located throughout the survey areas. Each site will be briefly examined, in terms of what was initially discovered. Again, the sites are located on Figure 11.

Site 1 (Area 1): Numerous distinct levels of agricultural terraces were found, along with three non-functioning 'auwai (irrigation ditches).

Site 2 (Area 1): Two or three agricultural terraces, with one non-functioning 'auwai, were discovered.

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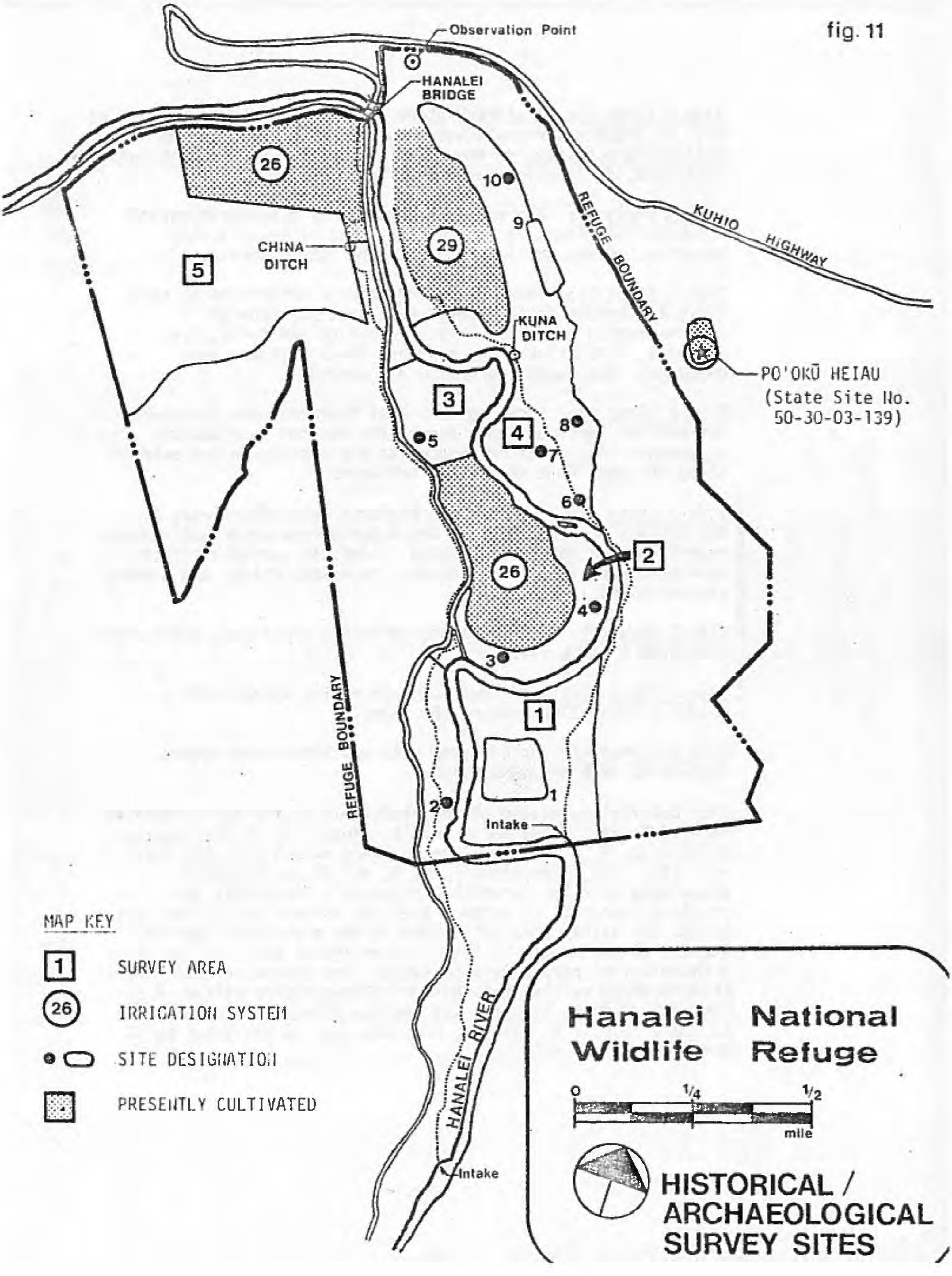
[1] Cleghorn, Paul L.; "Archaeological Reconnaissance Survey Within the Hanalei Wildlife Refuge, Hanalei, Kauai"; Department of Anthropology, Bernice P. Bishop Museum; Honolulu, Hawaii; June 1979.

[2] Earle, Timothy K.; Control Hierarchies in the Traditional Irrigation Economy of Halelea District, Kauai, Hawaii; Ph. D. Dissertation; University Microfilms; Ann Arbor, Michigan, 1973.

fig. 11



Observation Point
HANALEI BRIDGE
KUHIO HIGHWAY
REFUGE BOUNDARY
CHINA DITCH
KUNA DITCH
PO'OKŪ HEIAU
(State Site No. 50-30-03-139)
Intake
Intake
HANALEI RIVER
REFUGE BOUNDARY
1
2
3
4
5
26
29
26
1
2
3
4
5
6
7
8
9
10
MAP KEY
SURVEY AREA
IRRIGATION SYSTEM
SITE DESIGNATION
PRESENTLY CULTIVATED
Hanalei National Wildlife Refuge
0
1/4
1/2
mile
HISTORICAL / ARCHAEOLOGICAL SURVEY SITES

Site 3 (Area 2): A stacked-stone wall was discovered between an area of ongoing taro cultivation and an area disturbed by bulldozing activity; on the south side of the wall, which runs east-west, an inactive 'auwai was located.

Site 4 (Area 2): The cement foundation of a historic period structure was found in an area disturbed by hau-clearing activity. Glass bottle fragments were also observed.

Site 5 (Area 3): Three historic features were found at this site, two cement foundations, and a concentration of cement-covered boulders. Historic period artifacts, i.e. ceramics, fire bricks, and seamless glass bottles, were observed. Two 'auwai were also discovered.

Site 6 (Area 4): Three agricultural features were discovered; two earthen terraces and a depression bounded by a boulder alignment. An 'auwai originates at the depression and extends along the east side of the two terraces.

Site 7 (Area 4): Two historic fratures were discovered; i.e. the remains of a foundation, and a concentration of well-sorted, cement-covered waterworn cobbles. Historic period artifacts were observed; i.e. glass bottles, ceramics, metal, and a metal pickaxe head.

Site 8 (Area 4): A small stone enclosure was found, which also contained a stone fireplace.

Site 9 (Area 4): A discontinuous terracing system with a possible habitation feature was found.

Site 10 (Area 4): An L-shaped wall was discovered, which intersects with the Kuna Ditch.

Rice cultivation played an important role in the agriculture of Hanalei Valley in the early 1900's. According to the survey, sites 1, 2, 3, 4, 5, and 7 are probably associated with this activity. The other sites 6, 8, 9, and 10 are probably associated with the "prehistoric period". From this and previous research, it appears that all broad alluvial terraces within the valley were cultivated in the prehistoric period. Because of the number of sites and artifacts found during the archaeological reconnaissance survey, the course of action will be determined by the State Historic Preservation Office, U.S. Fish and Wildlife Service, and the Executive Director of the Advisory Council on Historic Preservation, as initiated by 36 CFR PARTS 63 and 800.

D. Socio-Economic Environment

The socio-economic environment will deal primarily with the population and its characteristics, and the general economic trends of the Hanalei area. A thorough discussion of taro agriculture will follow this section.

1. Population [1,2]

The most recent census (1975) estimated that the population of the Hanalei District, Census Tract 401, is approximatley 1,700 people. In the Hanalei District females outnumber males 51% to 49%. The median age of the population is about 20 years old. Approximately 40% of the population was born on Kauai, with an additional 14% born elsewhere in the Islands. At least 33% of the population or 56% of the adult population of Hanalei has completed high school or enrolled in college. The median household income is $11,600, which appears to be quite low. About 36% of the population owns their own dwelling units; the rest of the population rents. In the North Shore Special Planning Area study (1972), the population was projected to increase to 2,000 by 1982; however, any increase in population will depend on the future developments in agriculture and resort expansion (e.g. Princeville) in the Hanalei District.

2. Economy of the Hanalei District [3]

The prime sectors of the economy of the Hanalei District are taro and cattle agriculture, and tourism, i.e. Princeville at Hanalei. The following table is a list of tenants in the Hanalei National Wildlife Refuge. Refer to Figure 12 for the parcel location.

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[1] Kauai Socioeconomic Profile; Center for Non-metropolitan Planning and Development, Cooperative Extension Service, Hawaii Agricultural Experiment Station, Unversity of Hawaii, May 1975.

[2] North Shore Special Planning Area; Muroda and Itagaki Inc./Eckbo, Dean Austin and Williams, Inc. for County of Kauai; September 30, 1972.

[3] Anderson, R.N.; Barron, J.C.; and Marders, W.G., Hanalei Development Plan - A Socioeconomic Profile; College of Tropical Agriculture, Hawaii Agricultural Experiment Station, University of Hawaii; Departmental Paper 2; September 1972.

TABLE 15

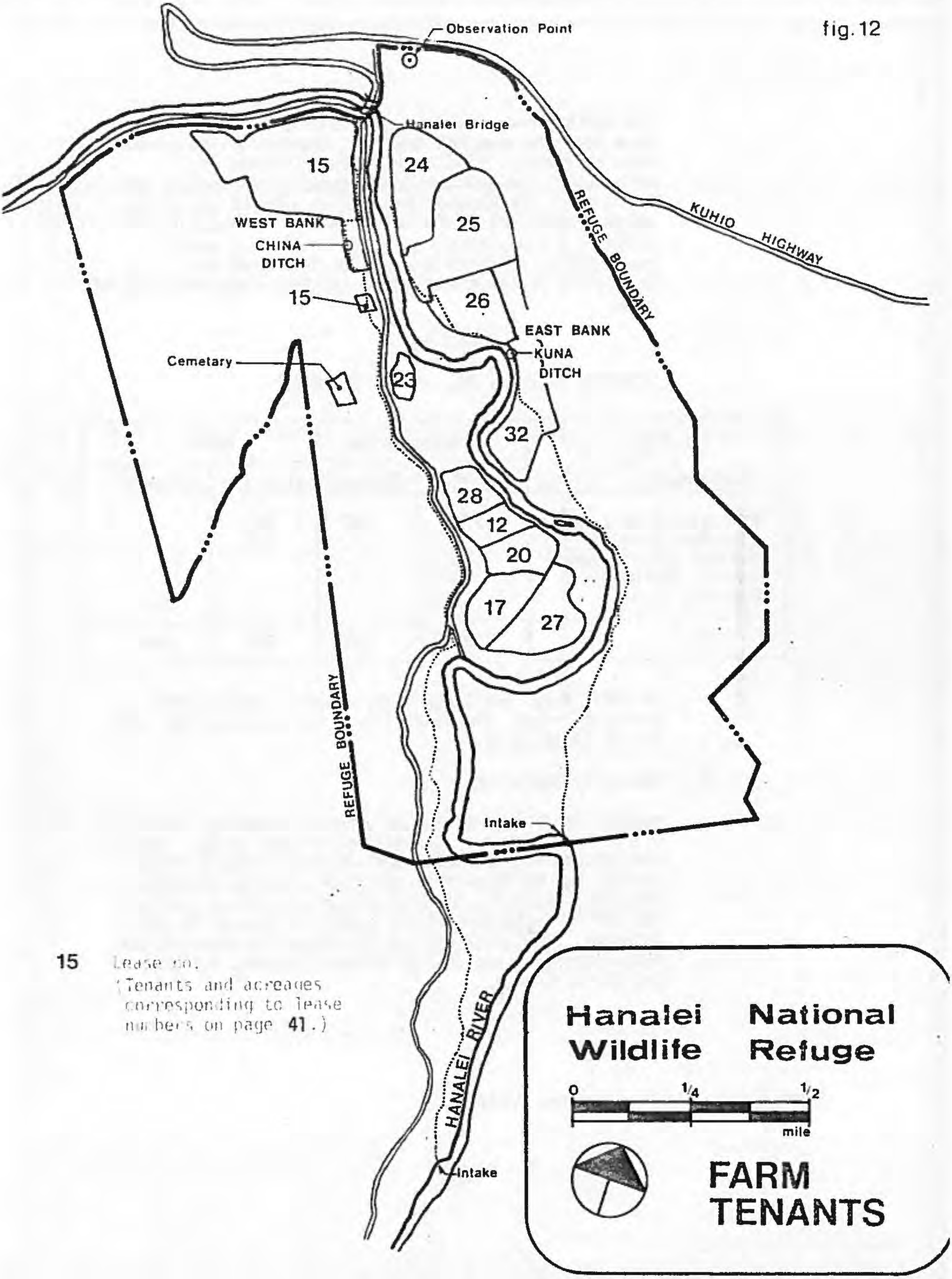
TENANTS IN THE HANALEI NATIONAL WILDLIFE REFUGE

Lease No.	Tenant	Improvements	Acreage
12	Gorgonia Diego	one dwelling	6.41
13	Sueji Haraguchi	one dwelling	0.42
15	Haraguchi Farms	one dwelling one rice mill	35.90
17	Alfred Harada	one dwelling	9.76
20	Frederick J. Y. Wong	two dwellings	9.25
23	Margarita Dawa	--	1.95
24	George Koga	--	14.0
25	Bernabe Mateo	two dwellings	15.58
	Rosita Fitzgerald		
26	Walter Koga	--	11.74
27	Malcom Tia	--	6.41
28	William Tai Hook	--	7.00
Special Use Permit-grazing	Sampson Mahuiki	--	--
	John H. Johnson	--	--

Taro agriculture will be presented in detail in the following section.

There are 10 cattle farms in Hanalei, with Princeville Ranch being the only major full-time operation. Pasture lands are located in the Hanalei, Waikoko, Lumahai, and Wainiha Valley area. No figures were available to illustrate the annual income from sales of cattle in Hanalei; however, in the County of Kauai there are 150 cattle farms. Therefore, the Hanalei District contains about 7% of the total number of cattle farms in the County.

fig. 12



15 Lease no.
(Tenants and acreages corresponding to lease numbers on page 41.)

The North Shore of Kauai, particularly the Hanalei area, is a favorite area for tourists, because of its great natural beauty. Long sandy beaches, mountains, waterfalls, and relatively low density development are features of the Hanalei area, which make it one of the major resort destination areas on Kauai. Hanalei also contains a championship golf course, tennis courts, restaurants, and many shops. The following is a tabulation of the resort units in the Hanalei District of Kauai.

TABLE 16

VISITOR UNITS IN THE HANALEI DISTRICT[1]

Type of Unit / Development	Condominium		Hotel	
	Existing	Planned	Existing	Planned
Princeville at Hanalei	232	153	161	
Club Mediterranee			140	
Hanalei Colony Resort	50			
Hanalei Apartments	5			
Marriott Hotel				300+
TOTAL	287	153	301	300+

In 1977, Kauai had 3,657 visitor units, with an 89% occupancy rate. The Hanalei District accounts for about 20% of those units.

3. Community Character

Hanalei can be classified as a rural community, with most of the land either in cultivation or open space. Hanalei and Kilauea are the main towns on Kauai's North Shore. Hanalei has no television reception, medical services, theaters, sidewalks, parking meters, or police station. The ethnic background of the people in Hanalei is 22% Japanese, 37% Caucasian, and 41% primarily Hawaiian and mixed-Hawaiian, and some Filipinos, Chinese, Portuguese and Puerto Ricans.

[1]From Hawaii Visitors Bureau, 5/11/79.

According to the Hanalei Development Plan[1], there are basically three groups of people, who live in Hanalei. These groups can be characterized as follows: (1) the long-time residents, that is living in Hanalei for greater than 10 years, and including Hawaiian, Japanese, Haoles and other ethnic groups; (2) recent residents, that is having established residence in the Hanalei area within the last 10 years, including retirees, Princeville employees, and commuters to Kapaa and Lihue; and (3) transients or people who have come to the Hanalei area, usually without employment and live in temporary or semi-permanent housing.

Each group has different perceptions of the other groups and Hanalei in general. Permanent residents, both long-time and recent, generally dislike the presence of the transients, because they are culturally different, compete for jobs and housing, and have a negative influence on the youth of the community. However, this group appears to favor some change to improve their families' life styles, and to provide economic opportunities to encourage their children to reside in the area when they reach adulthood.

Transients tend to want to maintain the status quo and preserve the rural nature of the Hanalei area as it exists. Other outside people view Hanalei as an appropriate area for resort investment speculation. The following table relates attitudes towards change in Hanalei to age, schooling, residency, household income, residency and ethnicity.

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[1]op. cit., Hanalei Development Plan - A Socioeconomic Profile; p. 11-14.

TABLE 17

ATTITUDES TOWARD CHANGE[1] - HANALEI
(%)

Variable	Against Change	For Change
Age (years)		
30 or less	59	41
Over 30	43	57
Schooling (years)		
11 or less	32	68
Over 11	58	42
Household income		
$9000 or less	47	53
Over $9000	51	49
Residency (years)		
Short term ---		
3 or less	60	40
Over 3	42	58
Long term ---		
Less than life	52	48
Life	37	63
Ethnicity		
Japanese	38	62
Haole	63	37
Other	40	60

In a survey of community needs, though priorities were different for the various groups of residents, as an aggregate the residents felt that keeping agriculture as a viable activity in Hanalei was the highest priority concern. Resort development was the lowest priority. Table 18 shows the other concerns of the Hanalei residents.

[1]op. cit., Hanalei Development Plan, p. 17.

TABLE 18

RANKING OF HANALEI COMMUNITY NEEDS BY RESIDENTS[1]

Community Needs	Ranking	
Keep agriculture as an important activity in Hanalei	1	High priority
Keep the scenic beauty	2	
Better housing	3	
Ease in getting to shopping and medical services	4	
Opportunities for family outdoor recreation	5	Medium priority
Chance for residents to meet and discuss community needs	6	
Opportunity for youth to stay in area after high school	7	
Opportunity for youth recreation	8	Low priority
Keep the population the same	9	
Resort development even if some agricultural land is given up	10	

The proposed project at the Hanalei National Wildlife Refuge meets the first two priorities of maintaining the agriculture and scenic beauty of the Hanalei District, as expressed by its residents.

[1]op. cit., Hanalei Development Plan, p. 27.

E. TARO AGRICULTURE

In this section, cultivation, and the ramifications of increasing taro acreage in Hanalei on the economy of taro in the State will be examined. Cultivation of taro fields in the National Wildlife Refuge has proven to be beneficial to both the taro farmers and the U.S. Fish and Wildlife Service endangered waterbird preservation efforts. Photographs related to taro cultivation follow this section on Taro Agriculture.

1. Hawaiiana and Taro[1,2]

In the ancient Hawaiian culture, taro was the subsistence and ritual focus of plant use. According to legend, the first son of Wakea (Big Sky) and Ho'ohoku Kalani (Daughter of the Earth), was stillborn at birth. This child was buried in the ground and grew into a taro plant, and was called Haloa, or "the Shivering Tall Stalk". The second son of this couple was a man, who was also called Haloa. Taro, then, was regarded as the older brother of Man. Only males in the ancient society could participate in planting, tending, harvesting, and preparation of the taro plant, due to its relationship to Kane, the God of Procreation. In some instances, specific varieties of taro could be substituted for animal sacrificial offerings to the Gods. Taro was considered to be a strong form of life, and Hawaiian chiefs were proud of being likened to taro; being likened to a sweet potato, gourd, or banana was an insult. Taro was grown in manmade terraces fed by extensive irrigation systems, and in rafts built of organic material placed in marsh areas. Taro cultivation was the basis of ancient Hawaiian land use planning, i.e. the construction of a dwelling on land unfit for agriculture, while maximizing the use of agricultural land. Also, the district land divisions called ahupua'a were based on the irrigation needs for taro cultivation.

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[1] "Taro: Hawaii's Staff of Life", The Garden Island; March 30, 1979; p. 2; Ke Aka O Kauai.

[2] Earle, Timothy K.; Control Hierarchies in the Traditional Irrigation Economy of Halelea District, Kauai, Hawaii, 1973; Ann Arbor, University Microfilms.

2. Taro Plant Description, Cultivation Practices, Diseases[1,2,3]

Taro (Colocasia esculenta) is a root crop, which has been the primary starch staple for the Polynesians and other island peoples in the central and south Pacific. The taro plant has four basic components: leaf (lau), flower (pua), cutting (petiole or huli) and corm (kalo). See Figure 13. The "huli" is planted to produce new taro crops; the corm is the root portion of the taro plant, which is made into table taro or processed into poi; and the leaves are used to make "lau lau" (a Hawaiian food - pork wrapped in taro leaves and then steamed). Other taro products include taro chips and taro flour. Taro is an excellent source of minerals and vitamins; its leaves contain high quantities of calcium, phosphorus, iron, potassium, vitamin A, ascorbic acid, and protein. Taro is comparable in nutritional value to other root and cereal crops.

There are nearly one hundred different varieties of taro in Hawaii, but only five or six varieties have commercial value. The most important variety is Lehua, which has reddish- colored corm flesh, suitable for producing purple-gray poi. Other important varieties of taro include: Pilo Uaua, Pilo Kea, Pilo Uliuli, and Maui Lehua. Lehua taro is the most commonly grown taro in Hanalei Valley.

During the taro life cycle, which takes 12 to 16 months, the taro goes through several growth stages. The first 4 to 6 months are a period of rapid vegetative growth; i.e. leaf number, leaf size, and weight all increase. At the end of this growth stage, the taro leaves achieve maximum growth.

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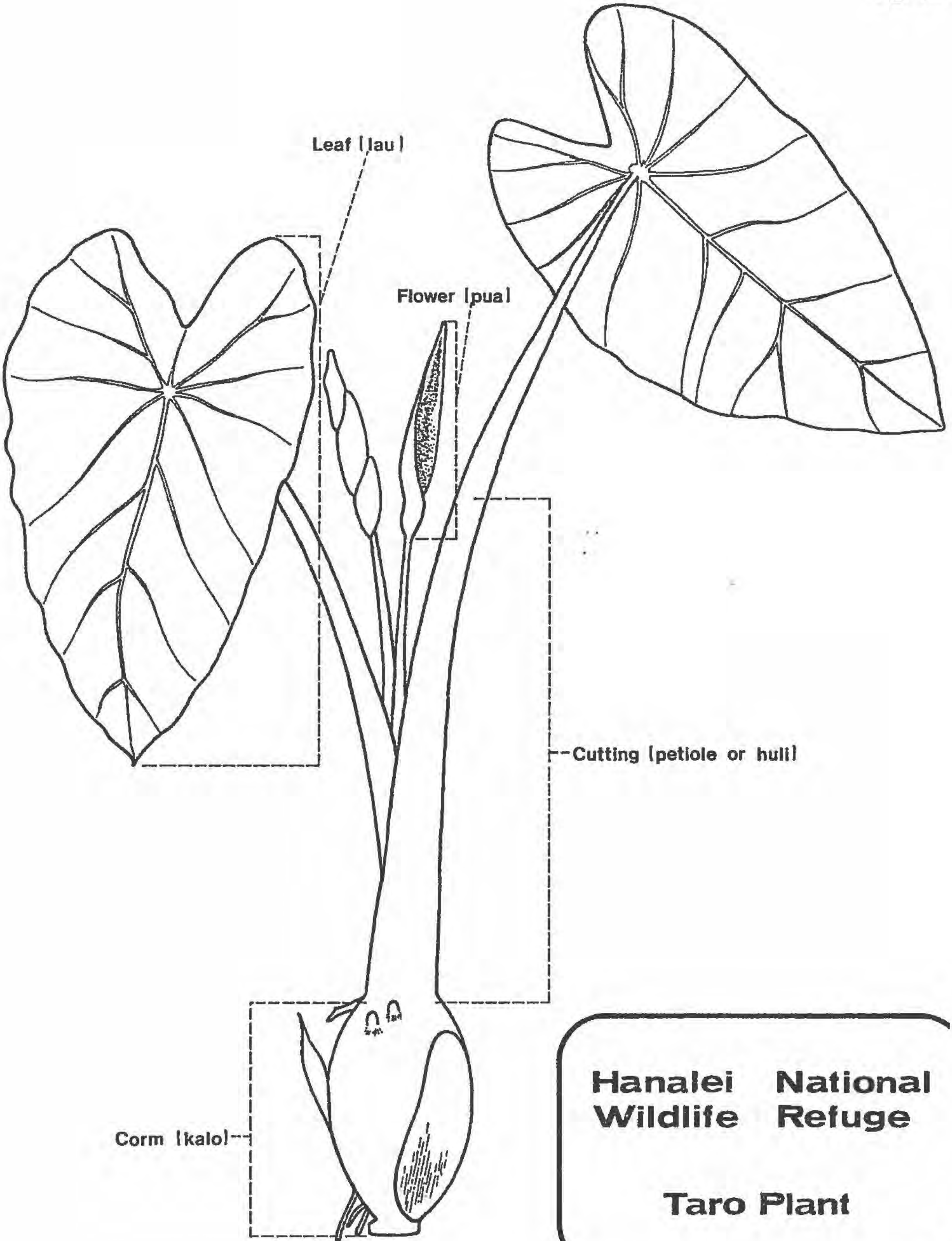
[1]Begley, Brian; "Taro in Hawaii: Study of a Food System", Agricultural and Resources Economics; Honolulu, Hawaii; 1975.

[2]Plucknett, D. L., de la Pena, R. S., Obtero, F.; Field Crop Abstracts; Vol. 23, No. 4; College of Tropical Agriculture, University of Hawaii, Honolulu; November 1079.

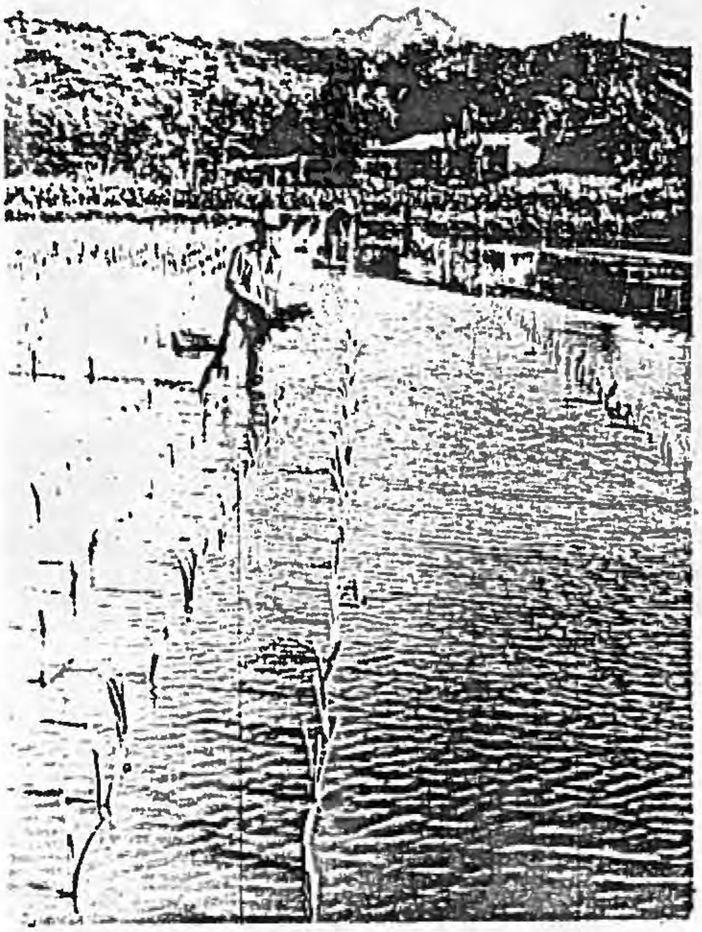
[3]Plucknett, D. L., de la Pena, R. S.; "Taro Production in Hawaii"; World Crops; September/October 1971.

fig. 13



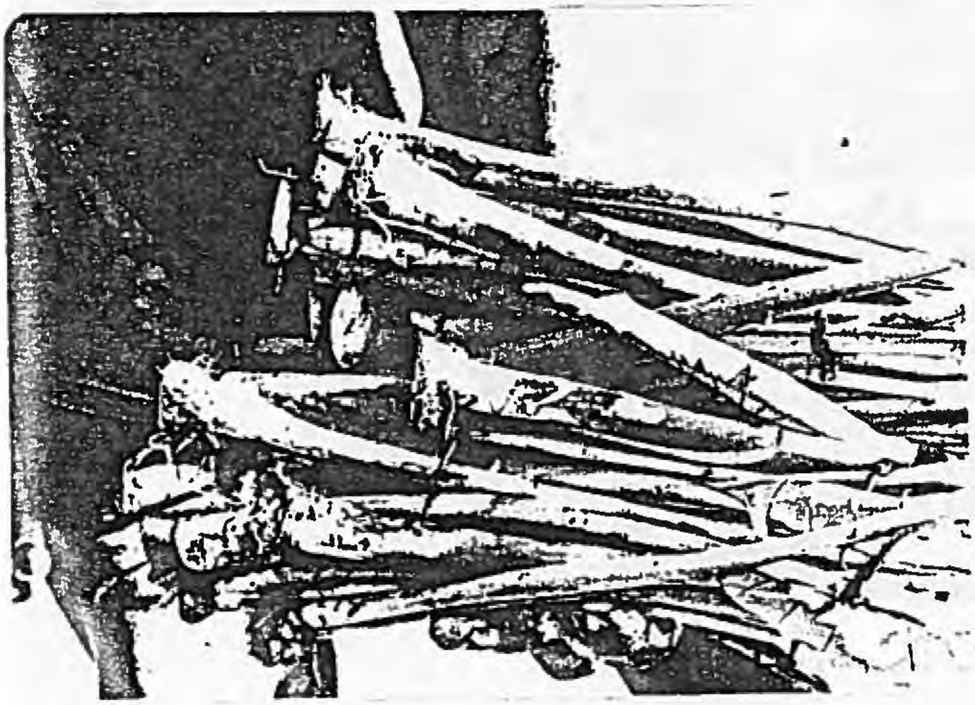
Hanalei National Wildlife Refuge

Taro Plant



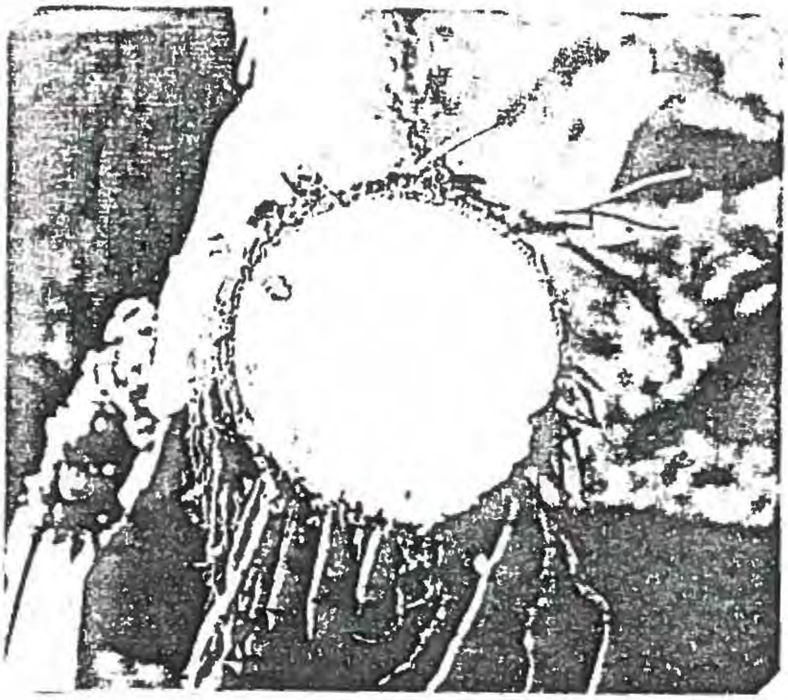
Foreground - planting taro.
Background - harvesting taro.

Planting a new taro field.

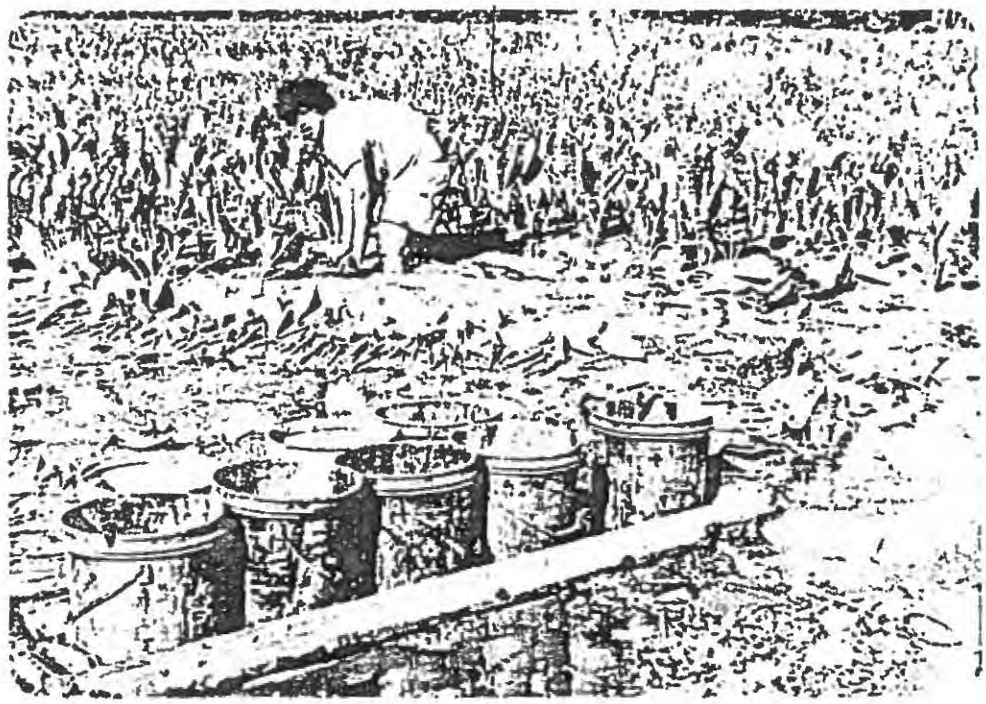


Taro Huli

Harvesting Taro



Diseased Taro Corm:
Pink Color - good quality
Gray White Color - Pythium (soft) rot
Brown Color - guava seed rot



Harvesting Taro

Between 3 to 5 months after planting, corm development begins and continues to the end of the 12-16 month life cycle. During this maturing period, the leaf canopy diminishes until there is very little leaf canopy when the corm is ready for harvest.

a. Cultivation Practices

After a taro crop has been harvested, tractors with rotovators are used to till and level the flooded soil, in preparation of a new crop. The University of Hawaii College of Tropical Agriculture and its Agricultural Experiment Station on Kauai has made recommendations for the preparation of taro fields for new plantings, in order to minimize disease problems related to taro. They have recommended that after every second or third harvest the following steps be taken:

- o The fields should be dried completely.
- o Vegetative material should be completely removed.
- o The land should be thoroughy rotovated to aerate the soil and eliminate any waterborne pathogens.
- o Chemicals (captan or copper sulfate, and lime) be applied, before the fields are re-flooded for planting.

Of prime importance, is that healthy huli be used to propagate new taro plants. Diseased huli will most likely grow into diseased mature plants.

The density of plants per acre varies from 4,840 plants/acre (3x3 feet/plant) to 14,520 plants/acre (1.5x2 feet/plant) with an average of 10,890 plants/acre (2x2 feet/plant). Planting is done by hand, with strings used as a guide for aligning and spacing the new huli. To plant one acre would require between six and nine hours.

During the early stages of development, the level of water in the taro fields is maintained at 1 to 2 inches; the level of water is then increased to 3 to 4 inches, after the plant has established root and leaves. This minimizes the possible encroachment of weeds.

Fertilization will not be discussed in detail, however, taro farmers use more fertilizer per acre than any other crop in Hawaii. Between 2,000 to 4,000 lb./acre of mixed Nitrogen-Phosphorus-Potassium fertilizers are used over the growth period of a crop. The requirement for nitrogen is greatest during the first four to six months, when vegetative growth is the greatest. All fertilizers should be applied within this period. The initial application of fertilizer should take place after the taro has developed some roots and leaves, approximately one month after planting. Experimental results have shown that for lowland taro, such as that grown in Hanalei, an application of 90 lbs./acre of Nitrogen and Potassium, and 180 to 225 lbs./acre of Phosphorous is sufficient. The exact effects of fertilizer applications to the ground water underlying the refuge are unknown, however no sources of domestic water are located on the floor of Hanalei Valley. Domestic water sources for Hanalei Town are located in the mountains to the west of the refuge.

Taro is harvested by hand. The corms are loosened from the field with a sharp pointed pipe or are pulled manually. The huli are cut off, mud and roots are removed from the corms, and then the corms are washed and placed in buckets on floating sleds. Finally, the corms are bagged in 80 to 100 lb. bags, for shipment to the mills.

b. Taro Diseases[1,2]

The two major taro diseases, which affect wetland taro on Kauai are pythium rot (soft rot), and guava seed rot (hard rot).

Pythium rot is caused by a fungus identified as Pythium spp. When pythium rot occurs, the corm of the taro plant becomes whitish-gray in color, the consistency of the corm becomes soft and paste-like, and an offensive, fermented odor becomes noticeable. The disease attacks injured plants, or

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[1]Discussions with Dr. Ramon de la Pena, Agricultural Experiment Station, Kauai; 3/1/79.

[2]Takahashi, M.; "Report of Taro Disease in Hawaii"; Hawaii Agricultural Experiment Station, University of Hawaii; February 20, 1953.

plants with relatively mature corms. It is also propagated by the planting of diseased hulis. Some of the poor agricultural practices, which provide conditions for the promotion of the disease include:

- o Inadequate field preparation and lack of sufficient fallow period.
- o Continuous single cropping system.
- o Excessively close planting distances.
- o Insufficient water circulation in patches.
- o Poor field sanitation.
- o Excessive delay in harvesting after plants are mature.

The critical temperature for increase in the occurrence of pythium rot is 25°C or 77°F; if the temperature increases above this temperature, the fungus appears to increase geometrically. To some degree this can be mitigated by having adequate amounts of cool water circulating through the taro fields.

Because the fungus is waterborne and can survive in wet soil, field preparation is important. Refer to the discussions on field preparation (Cultivation Practices).

Guava seed rot is thought to be a physiological disorder in the taro plant. Despite hundreds of inoculation studies and microscopic examinations, no specific pathogen has been identified. Furthermore, this disease has never been duplicated in the laboratory. Nutritional imbalance could explain the occurrence of this disease. Guava seed rot causes the corm to form hard, wood-like spots, which are inedible. There are two forms of guava seed rot, i.e. the coalesced vascular necrosis (CVN) type and the scatter vascular necrosis (SVN) type. The CVN type is formed in the center, bottom portion of the taro plant; the SVN type is formed anywhere in the corm. The CVN type can usually be attributed to the planting of diseased huli. Unfortunately, although there are varieties of taro which are resistant to either pythium rot or guava seed rot, no variety is resistant to both diseases.

Other forms of taro-related disease are considered less of a problem, and will only be mentioned briefly:

- Loliloli taro - a taro disease, which causes the corm to become soft, spongy, and watery; also physiological, caused by uneven growth, late application of fertilizers and muddy water.
- Taro leaf blight - occurs on leaves during periods of high wind and heavy rainfall, taro plant will usually repair itself.

There are no major problems with insect pests, although infrequent minor damage is incurred on taro leaves by taro leafhoppers, aphids, and mites.

3. Taro Market Overview

In this section, a statewide perspective on the the market for taro will be examined. First a brief post-European contact historical perspective on taro will be presented, then the existing and future market conditions will be discussed. The proposed expansion of taro acreages in the Hanalei National Wildlife Refuge will have a long-term effect on the taro industry.

a. Post-European Contact History[1]

At the time of the discovery of the Hawaiian Islands by Captain James Cook in 1778, taro acreage and production were at their peak. It is surmised that the main cause for the reduction in taro production from that period was the extreme decline in native Hawaiian population, from 300,000 in 1778 to 56,900 in 1872. This can be attributed to diseases (tuberculosis, venereal disease, influenza, mumps, small pox, and measles), which were introduced to the Islands by the Europeans. The decline in population created a corresponding decline in taro consumption and production.

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[1]op. cit.; Takahashi, M.

The second factor related to the decline of taro was the in-migration of foreigners. This new population supplanted acreage formally reserved for taro, sweet potatoes, and bananas, with new crops of rice and sugar cane. Rice reached peak development in the Islands in the 1860's; by 1880 rice acreage had surpassed taro. (Today, no rice is being produced in Hawaii.) Sugar cane was the first crop to exceed taro in acreage; this occurred in 1878. Table 19 shows the historical decline of taro, in terms of acreage, from 1778 to 1950.

TABLE 19

HISTORICAL DECLINE OF AGRICULTURAL LAND IN TARO

Year	Acreage
1778	15,000
1832	6,000
1860	3,000
1872	2,400
1900	2,400
1925	1,800
1950	944

Prior to the mid-1800's, Hawaiians were the prime growers of taro. However, taro was grown solely for home consumption and barter; there was no commercial taro industry at that time. As Hawaii became more trade and industry oriented, Hawaiians left the taro fields in favor of urban careers.

This left a void in the taro fields, which was rapidly filled by the Chinese. Their experience in rice cultivation, helped to spur innovations in taro cultivation, such as use of chemical fertilizers, planting taro in rows, and spacing the taro plants closer together. By the early 1900's, more than 50% of the taro was produced by the Chinese; also 80% of the poi was manufactured by the Chinese. The Chinese turned taro into a commercial, agricultural commodity. Other specific contributions by the Chinese to the taro industry, occurred in processing and included the introduction of (1) boilers to steam taro and (2) poi grinding machines, which increased the per capita factory production of poi.

As the Chinese taro growers became older, and their sons turned away from farm life to the business world, immigrant Japanese farmers gradually took over the cultivation of taro. This resulted in today's situation, where the majority of the taro farms are owned by the Japanese. However, they too are aging and new farmers are needed. The recent past and future of the taro industry will now be discussed.

b. The Recent Past and Future of Taro[1,2,3]

The taro industry is presently going through a most critical period, in regards to its significance in the Hawaiian diet. Table 20 shows the acreages in taro for 1948, and from 1965 to 1977. Compared to the acreages in 1948, the amount of land in taro from 1965 to 1977 was reduced by about 50% statewide. Taro acreage has remained stable on the Island of Kauai during this same period from 1948 to 1977. In the last ten years the acreage of land in taro statewide has remained stable.

TABLE 20

AGRICULTURAL LAND IN TARO BY ISLAND (ACRES)

Island/Year	1948	1965	1974	1975	1976	1977
State	1010	472	460	465	460	470
Oahu	460	60	8	115	120	125
Maui/Molokai	100	102	102			
Kauai	210	180	201	195	190	200
Hawaii	240	130	153	155	150	145

[1]Discussion with Eric Inamoto, Honolulu Poi Company, 2/26/79.

[2]op. cit. Begley.

[3]Statistics of Hawaiian Agriculture 1977, Hawaii Agricultural Reporting Services; Honolulu, Hawaii; June 1978; p. 23.

The State Department of Agriculture tabulation of taro acreages above is slightly misleading, because since 1974 there has been an 11% decline in taro production. This means that some of the land designated for taro was probably unproductive, or had water or disease problems. See Table 21.

TABLE 21

AMOUNT OF TARO MARKETED (X1000 LBS.)

Island/Year	1974	1975	1976	1977
State	8,835	7,592	7,350	7,870
Oahu/Maui/Molokai	1,375	1,316	1,085	1,385
Kauai	5,350	4,253	4,420	4,820
Hawaii	2,110	2,023	1,845	1,665

According to the Honolulu Poi Company there is presently a taro supply deficit of about 20%. This situation can be better understood when the figures for taro shipped to Honolulu for poi processing from the Neighbor Islands are examined in Table 22.

TABLE 22

NEIGHBOR ISLAND TARO SHIPPED TO HONOLULU FOR POI PROCESSING (x1000 LBS)[1]

Island/Year	1974	1975	1976	1977	1978
Molokai	--	--	--	--	--
Maui	891	789	644	661	572
Kauai	4,817	3,718	3,936	4,348	4,389
Hawaii	805	673	536	441	337

[1]Discussion with Keiji Sugawa, Department of Agriculture, 4/6/79.

The major areas for taro cultivation in the State are Hanalei and Hanapepe Valleys - Kauai; Keanae Valley - Maui; and Waipio Valley - Hawaii. Only Kauai remains a strong taro producing island, because Maui and Hawaii have been experiencing water shortage and pythium rot problems, which have substantially reduced their taro production output and exports. In 1976, table taro was imported from Samoa for the first time to Hawaii; in 1978, 228,000 pounds of taro were imported from Samoa.

The primary production problems encountered in the taro market, as viewed by the processors, are:

- Obtaining consistently "good" supplies of taro. "Good" taro means that 70% of the taro per bag is usable; "bad" taro means that only 40% is usable.
- Obtaining enough taro during the summer months. Ironically the best taro is harvested in fall or winter, because it matures through the summer; however, the peak demand for taro occurs in the summer, coinciding with the tourist season.
- Taro disease problems, especially in the summer.
- Lack of adequate quantities of water for taro agriculture, primarily due to competition with urban land uses for water, e.g. Waihee, Oahu.
- Encroachment by urban development.
- Diminishing work force resulting from a lack of new taro farmers coupled with the aging of the current taro farmers.

The implications of this information to the future of the taro market are noteworthy. Taro must be re-promoted in Hawaii as a primary staple food and the supplies increased. If this doesn't occur, prices for poi will eventually rise, causing the primary users of poi to seek less expensive staple foods (e.g. rice). As a result, poi would become an exotic specialty item, and the primary taro/poi market would be lost.

This scenario indicates the importance of the proposed taro acreage in the Hanalei National Wildlife Refuge. (Refer to III-E. Socio-Economic Impacts)

F. Public Services

The public services, which affect the Hanalei National Wildlife Refuge, will be reviewed here. Also public concerns are addressed in this section.

1. Police Protection

The closest police station to the Hanalei National Wildlife Refuge is the main headquarters located in Lihue. The refuge is about 36 miles from Lihue, and the driving time is approximately 45 minutes.

2. Fire Protection

Presently, there is a fire station located in Hanalei Town about a mile from the refuge. Access to the refuge would be directly east via Kuhio Highway, and response time is a matter of minutes.

3. Medical Services

The State of Hawaii operates an emergency ambulance service from Lihue to Hanalei, which is headquartered in Lihue. There is a small private dispensary located in Kilauea 10 miles east of Hanalei; however, the nearest hospital facility to Hanalei is the Samuel Mahelona Memorial Hospital located in Kapaa 27 miles from Hanalei.

The Kauai Department of Health also consulted about the wetland-related disease leptospirosis, which was a concern of the Hanalei taro farmers. Without going into a lengthy discourse, here are a few important details regarding that disease:

- Leptospirosis can be carried in cattle, pigs, dogs and rats, which may not be affected by the disease. The bacteria is secreted in the urine of these animals.
- Leptospira can survive for months in wet soil, but will expire in dry soil, fresh flowing water or salt water.

- Leptospira will penetrate through mucosa, mouth, and broken skin, then via the blood stream, it travels to the liver and kidneys, causing reactions varying from flu to hepatitis to kidney failure and possibly death.

- Leptospirosis can be diagnosed from intravenous samplings of blood. Presently, there is no vaccine available for humans.

- There have been 12 cases of leptospirosis on Kauai from 1970 to the present. Of those cases, 10 were incurred by "haoles" (caucasians), who were not originally from Kauai. This leads to the deduction that susceptibility to leptospirosis may be related to (1) where a person grows up and (2) a person's exposure to wetland environments.

G. Infrastructure

The regional infrastructure as it relates to the Hanalei National Wildlife Refuge will be examined in this discussion.

1. Access and Roads

The primary land corridor, which provides access from Hanalei and the Hanalei National Wildlife Refuge to the Kauai County Capitol of Lihue, is Kuhio Highway State Route 56. Within the refuge, there is an access road on the West Bank which serves the Hanalei Homesteads, south of the refuge; also, there is another service road on the East Bank of the Hanalei River, which terminates at Walter Koga's taro farm (Lease No. 26, Figure 12). There are trails which follow alongside the China and Kuna Ditches. (Refer to Visual Quality).

2. Sewage Disposal

The Kauai Department of Public Works (DPW) has stated that there are no anticipated conflicts between the proposed project and the DPW's objectives. There is no integrated sewage system in the Hanalei Valley area; individual dwelling units have their own cesspools.

3. Domestic Water Supply

The Kauai Department of Water Supply has no plans to expand their services or system in the Hanalei National Wildlife Refuge. Hanalei Valley is served by a 6-inch and a 2.5-inch water line, which follows the alignment of the West Bank access road. Water is supplied from the Maka Ridge Well 73, located immediately south of Hanalei Town. Irrigation water requirements are discussed in the Section on Taro Water Requirements.

4. Electrical Power

Kauai Electric has delineated a 57 KV power line, which is located on portions of the Hanalei National Wildlife Refuge. No power can be supplied directly from those lines. Also, any flooding or use of the electrical easement would require a relocation of their facilities.

III.

potential impacts of the proposed project

III. POTENTIAL IMPACTS OF THE PROPOSED PROJECT

This section will address the potential impacts of the proposed water delivery system project at the Hanalei National Wildlife Refuge. The specific areas of interest to be examined are Land and River Transformation, Biological, Historical/Archaeological, Socio-Economic, Public Facilities and Utilities, Airborne Emissions, Noise Generation, and Natural Hazards. Where possible, the impacts will be quantified.

A. Land and River Transformation

The proposed project was described in Section 1-C, "Project Description". Briefly, the selected alternative entails the abandonment of the China and Kuna Ditches, and the construction of a closed conduit system, which would carry all flows to the existing and proposed taro fields on the East and West Banks of the Hanalei River within the Hanalei National Wildlife Refuge. The proposed conduit system can be divided into four segments; these segments are (1) the upper segment extending from the diversion dam across the upper pasture to the inverted siphon at the Hanalei River ford, (2) the West Bank segment extending from the ford down the West Bank of the Hanalei River, (3) the segment, which connects the West Bank segment to the East Bank via an inverted siphon across the Hanalei River, and (4) the East Bank segment, which will be the construction of a new open ditch, parallel and to the east of the existing Kuna (East Bank) Ditch, and a pipeline from the ditch situated at the base of the valley wall to the taro fields.

Besides the construction of the conduits and ditch segments, the proposed system will include four major structures. These structures are (1) a diversion dam and intake structure on the upstream side of the system, (2) a bed-load and silt trap to be constructed in the pasture near the upper siphon structure, (3) an inverted siphon, to be located at the Hanalei River ford, carrying flows to the West Bank, and (4) an inverted siphon to carry flows from the East Bank to the West Bank, under the Hanalei River.

In terms of construction sequence, the excavation of trenches for the closed conduit (including the bed-load and silt trap) and ditches can occur at any time, and will be left to the discretion of the Contractor. Approximately 1800± cubic yards of earthen material will be excavated for the ditches and closed conduit system. An additional 1300± cubic yards of select materials will be required for the proposed project.

There are specific parameters and guidelines, which are being recommended for the construction of the major structures, which will be addressed here. In implementing the proposed closed conduit system the following parameters should be followed:

- During the construction of the proposed system adequate flow must be maintained to irrigate the existing taro fields on the East and West Banks of the Hanalei River, via the Kuna and China Ditches.

- Construction in the Hanalei River coincide with the months of lowest flow, to ease and expedite construction. The low flow period occurs historically during the months of August, September, and October.

- No bridges will be constructed across the Hanalei River. Access roads will be provided along all conduits and pipes. Vehicles requiring access to the upper pasture (bed-load and silt trap, diversion dam, intake structure) will use the existing ford across the Hanalei River.

- In the creation of sedimentation basins. The excavated material will be used to fill the upstream taro fields, creating agricultural terraces.

1. Diversion Dam (Refer to Figure 14)

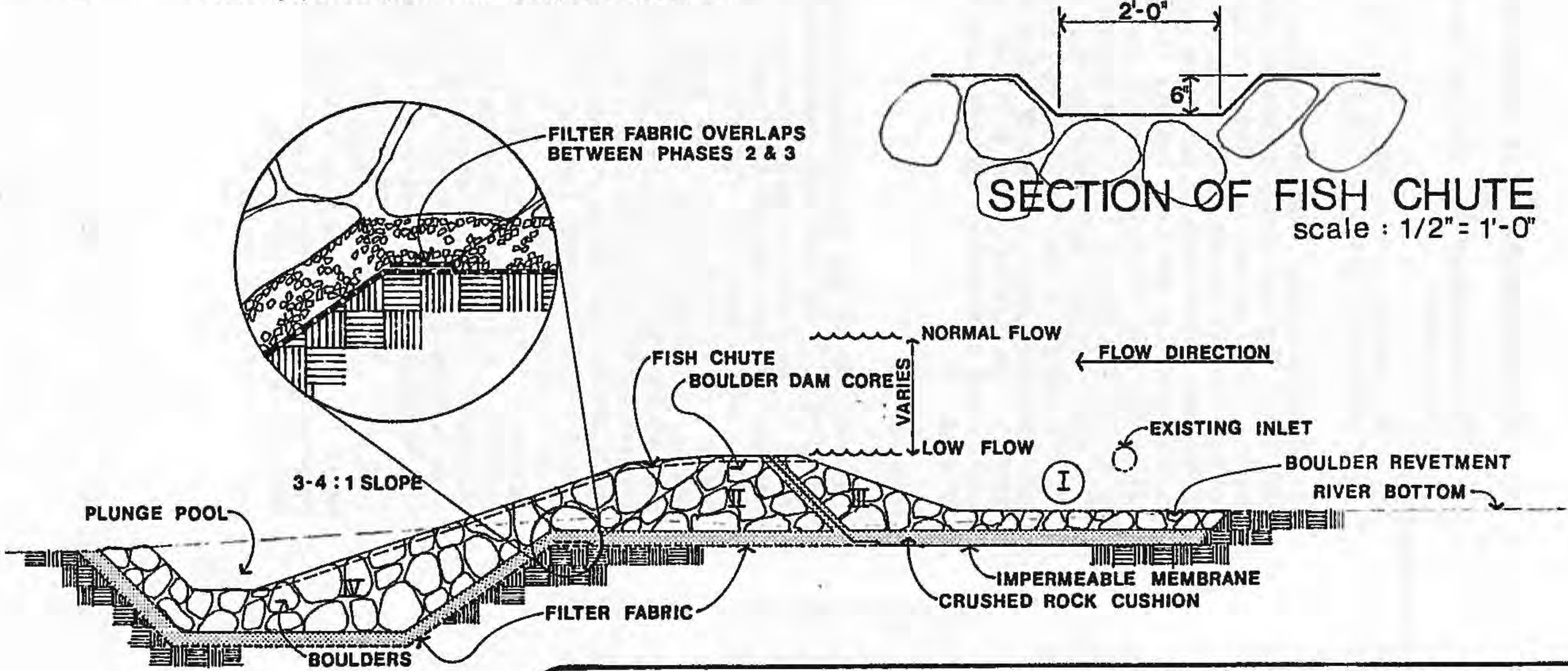
   To construct the diversion dam across the Hanalei River, the river flows must be maintained to irrigate the existing taro fields on the East Bank. This will be accomplished by staging the construction of both the diversion structure and the pipeline from the inlet to the ford across Hanalei River. The construction will be phased as follows:

   a. The construction of the upper segment of the closed conduit system across the upper pasture to the first siphon crossing, which would be used as a temporary bypass channel to divert the river flow away from the construction area.

   b. The construction of the boulder core of the diversion dam.

   c. The construction of the upstream impermeable membrane and boulder revetment.

PHASE	DESCRIPTION
I	Construct pipeline from inlet to ford, including inlet structure, and connecting channel work at inlet.
II	Construct boulder core, including filter fabric. Use completed pipeline to aid in control of river flows.
III	Construct upstream impermeable membrane and boulder revetment, including crushed rock cushion
IV	Construct downstream face of dam, including filter fabric and plunge pool. Grout boulder dam by diverting flows through pipeline and by dewatering.
V	Close pipeline gate and complete pipeline.



SECTION OF FISH CHUTE
scale : 1/2" = 1'-0"

CROSS-SECTION OF PROPOSED DIVERSION DAM
scale : 1/16" = 1'-0"

Hanalei National Wildlife Refuge

fig. 14

d. The construction of the downstream face of the dam.

e. The grouting of the dam, and the construction of the fish chute.

f. The closing of the inlet structure gate, and the completion of the pipeline.

A preferred sequence of construction would be to first construct the new intake structure (including a gate valve), bed-load and silt trap and upper segment of the closed conduit system to the location of the first siphon. Note that the new intake structure would be located downstream from the existing intakes structure, which would allow the Kuna Ditch to continue operation through the time construction of the closed conduit system. Next, the upper segment would be connected to the Hanalei River, thereby diverting the flows into the new intake structure and upper segment of the closed conduit system. The diversion dam will take approximately three months for construction and will most likely be comprised of rock.

2. Siphons

Construction of the two siphons to convey water beneath the Hanalei River will not require that the construction areas be dewatered, or any temporary diversion structure be used, because construction can be undertaken within the flowing river. A 6 feet, 8 inch wide trench, at a minimum depth of 9 to 10 feet below the invert of the stream will be excavated to accommodate 24-inch and 48-inch reinforced concrete pipes (RCP). The depression created by this excavation will trap silt, sand, and rocks during the course of construction, however, a downstream silt-screen to trap silts can be implemented, if it is deemed necessary. A concrete collar may be casted or bolted onto the siphon, in order to counter buoyancy. A drain will be provided in the siphon riser structure. The 48-inch siphon can be constructed simultaneously with the diversion dam, then the system can be completed by constructing the upstream silt trap, which will connect the siphon to the closed conduit system on the land. Each siphon will require about one month for construction; backfilling over the siphon will be provided by the natural settling of waterborne solids over the excavated depression.

3. System Timing and Equipment for Construction

The construction of the entire system, which includes:

- o diversion dam
- o bed-load and silt trap
- o siphons, manholes, riser structures
- o closed conduits and laterals
- o open ditch
- o service roads,

will require an estimated 18 months. Again, the exact phasing of the project will be left to the discretion of the Contractor. The following is a tentative list of construction equipment, which may be used in implementing the proposed project:

- o track-type tractors with blade or side boom
- o backhoes/front-end loaders
- o cranes with drag line
- o trucks
- o patrol graders
- o pneumatic-tired compactors
- o concrete mixer.

After the completion of construction the refuge will appear in its original condition, with the exception of some visible structures (dam, manholes, riser structures, roads).

B. Water Quality

During the construction of the proposed project, it is anticipated that there will be some increase in the turbidity of the Hanalei River at the locations where structures will be constructed in the river. Specifically, those new structures will be the diversion dam, and the two siphons. However, the impact of this activity on water quality is expected to be minimal. It should be pointed out that the Hanalei River is highly sediment-loaded, with as much as an estimated 50± tons per day of waterborne sediments beign carried toward the ocean.[1] Downstream silt-screens can be implemented, if it is necessary.

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[1]"Water Quality Data - Hanalei River"; U. S. Geological Survey; October 1976 to September 1977.

After the completion of construction, an additional 50 to 85 acres of taro will be phased into cultivation over a period of years; it is anticipated that there will be an increase in the levels of nutrients (phosphorus-potassium-nitrates), coliform, dissolved solids, and turbidity in the Hanalei River, because the tailwaters of the taro fields will flow into the river. Initial indications have shown that nutrient and coliform levels in the Hanalei River exceed the State's Class A Water Quality Standard. Table 23 is a summary of water quality data collected by the State Department of Health between January 1973 and July 1977. The tailwater samples from the taro patches, however, appear to have nutrient and coliform levels even greater than that of the river. (See Section II-5-b, "Water Quality-Hanalei River").

The exact impacts to the Hanalei River by additional runoff from taro fields is not known.

TABLE 23

SUMMARY OF WATER QUALITY DATA - HANALEI RIVER[1]
JANUARY 1973 - JULY 1977

Parameter	# Sample	Mean	Max.	Min.
Water T°C	15	24.7°C	28	22
Turbidity (JTU)	15	1.4	3.8	0.3
Dissolved Oxygen (mg/l)	14	7.4	8.8	6.7
ph.	10	8.0	8.3	7.6
Solinity $\frac{\text{parts}}{1000}$	13	24.5	32.0	15.0
TN (mg/l)	15	0.061	.18*	.01
Kjeldahln (mg/l)	15	0.053	.17*	.01
NO_2-NO_3 (mg/l)	15	0.080	.10	.01
T.P. (mg/l)	16	0.013	.035*	.007
T coliform (#/100ml)	75	1,500*	35,000*	2
Fecal coliform (#/100ml)	75	88.6	1,300*	2
Total Dissolved Solids (mg/l)	12	30.090	38.040	15,000*

[1]State of Hawaii, Department of Health. *Below State Class A Waters Standards.

The Water Resources Research Center at the University of Hawaii,[1] and the Pollution Investigation and Enforcement Branch[2] of the State Department of Health were consulted to determine if any studies have be undertaken in Hawaii, regarding the impact of agricultural tailwaters flowing into a river (in this case-tailwaters being returned to their river of origin), on the river's water quality. Unfortunately, no such studies were available. However, Eugene Akazawa of the State Department of Health stated that it could be expected that (1) concentrations of turbidity, suspended solids, and nutrients would be higher in the river during planting and harvesting periods; and (2) algal blooms, which may occur in shallow areas near the river banks downstream, would pose a minor sight and odor nuisance. If these algal blooms increase, as a result of increased nutrient levels, then river BOD levels could also increase, placing stress on aquatic fauna. However, this scenario is not expected to occur, because the 85± acres of additional taro cultivation will be phased in over a period of years, allowing for close monitoring of this situation by the State Department of Health.

C. Biological Impacts

The anticipated impacts of the proposed project to the existing flora and fauna at the Hanalei National Wildlife Refuge will be addressed. The discussion will examine construction and post-construction impacts to the flora and fauna (aquatic, terrestrial, avian). It must be reiterated here, that the primary purpose of the project is to increase the acreage of wetlands (taro fields and ponds) in the refuge, thereby expanding the usable feeding and nesting habitat of the aforementioned endangered waterbird species. Consequently this project is beneficial to the recovery and perpetuation of these endangered waterbird species.

1. Impacts to Flora

Along the alignment of the proposed water delivery system, all vegetation will be cleared for construction purposes. This would include any vegetation, which grows along the Hanalei River near the siphon crossings, and in

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[1]Telephone Conversation with Dr. Reginald Young; Water Resources Research Center, University of Hawaii; 5/22/79.

[2]Telephone Conversation with Eugene Akazawa; Pollution Investigation and Enforcement Branch, State of Hawaii Department of Health; 5/22/79.

the ditch on the East Bank (e.g. hau, bulrushes, cattails, etc.). The MKGK/Yamamoto report did not disclose the presence of any endangered species of flora. However, the areas to be improved have been cleared and improved for past developments. Therefore, any species present today are not occurring in a pristine environment, but have inhabited a disturbed habitat. Most of the proposed alignment will traverse existing China Ditch alignment. In addition, the approximate area requiring excavation is about 6.5 acres, which is a small amount of acreage in comparison to the total area of the refuge. Vegetation will be allowed to re-establish where it will not interfere with the delivery of water (e.g. the ditch sections). Therefore impacts to flora are considered to be minimal.

2. Impacts to Aquatic Fauna

During the construction phase of the proposed project, construction activity will occur in three places within the Hanalei River; i.e. at the locations of the diversion dam and the two inverted siphons. The estimated times required for the construction of these structures are three months and one month, respectively.

The implementation of the diversion dam will require that water be diverted away from, or diverted around the construction area. The inverted siphons will be emplaced directly into trenches excavated on the river bottom. Throughout this period of time, construction and human activity will cause aquatic fauna to move away from and generally avoid these areas. The movement of these species upstream or downstream will not be obstructed or impeded. Temporary turbidity and increases in waterborne solids may occur as a result of required in-water work during construction. Turbidity and waterborne solids would consist primarily of insitu material accummulated within the stream beds. If warranted, a screen or curtain can be placed around the area of construction to mitigate water quality impacts. However, due to the temporary nature of impacts and the absence of toxic pollutants, the overall impact is not expected to be significant.

There has been some concern regarding (1) the diversion of additional waters for irrigation purpose, and the impact of this diversion on the various diadromous aquatic species and (2) the movement of aquatic species past the diversion dam upstream. First, during periods of average flow in Hanalei River, there should be ample water flowing over the proposed diversion dam, in excess of the amount of water needed to irrigate the taro acreage. During periods of low flow in the Hanalei River (e.g. September 1975, 36 CFS), the intake structure can be adjusted to regulate the flow into the irrigation system, thereby insuring a minimum continuous flow of 12 CFS downstream of the diversion dam. This will insure that diadromous endemic o'opu (gobi) and opae (shrimp) populations requiring perennial stream flows, will be protected. However, during periods of extreme low flow conditions, the stretch of river between the diversion dam and the return of irrigation water to the river would be affected. Under such extreme flow conditions, habitat area within the reduced flow segment of the stream would be proportionately eliminated. Prolonged low flow could also have an effect on upstream aquatic populations. According to U.S.G.S. records, flows in excess of 36 CFS occur 99.2% of the time. Based on flow records analyzed, the long-term impact of reducing flow should not have significant impact on aquatic animal species.

Second, a "fish chute" will be designed into the downstream face of the diversion dam to facilitate the upstream movement of fishes in the Hanalei River. The fish chute will have a 1:4 slope, and be covered with natural river rocks; water will continuously flow over the chute.

It is not appropriate that the habitat for one class of fauna (avian) be enhanced, at the expense of the quality of habitat for other classes of fauna (fish and crustacea). Mitigative measures provided will insure that impact on aquatic fauna is minimal.

3. Impacts to Terrestrial Fauna

The terrestrial fauna identified in the refuge (dogs, cats, mice, rats) are detrimental to the enhancement of the habitats for endangered waterbird species, because they interfere with the feeding and nesting of these birds, and destroy their eggs. From the standpoint of waterbird preservation, it would be beneficial to restrict access by dogs and cats into the refuge, and to reduce the rodent population to the extent possible.

Because domestic cattle destroy bird habitats and eggs, through grazing and trampling on pastures within the refuge, the termination of the special use permits allowing for cattle grazing will also be beneficial to the enhancement and propagation of the endangered waterbird species.

4. Impacts to Avian Fauna

During construction, any birds inhabiting areas along the alignment of the proposed water distribution system would have to relocate to nearby areas not impacted by construction.

However, as stated previously, the reason that this project has been proposed is to increase the feeding and nesting areas of the endangered waterbird species, by increasing the acreage of the refuge under taro cultivation and ponds. Briefly, the following will describe how the endangered waterbird species will benefit from the proposed project:

a. The Hawaiian Stilt nests on the banks of fresh or brackish water bodies, and feeds on aquatic insects, fish, crabs and worms. They prefer cleared areas.

b. The Hawaiian Coot builds floating nests and also feeds on aquatic material. They are attracted to open freshwater areas.

c. The Hawaiian Duck (Koloa) responds favorably to cleared areas and flooded pastureland for nesting and feeding; these birds prefer areas with minimal human activity.

d. The Hawaiian Gallinule prefers to nest in taro fields and hau thickets along streams, and feeds on aquatic material. The gallinule is very secretive and generally avoids human activity.

While difficult to quantify, it can be definitely expected that increases in suitable habitat areas will bring about an increase in the populations of these endangered waterbird species.

D. Historical/Archaeological Impacts

The U.S. Fish and Wildlife Service is cooperating fully with the State Historic Preservation Office and all other interested parties, by complying with Federal Regulations 36 CFR Part 63, "Determination of Eligibility for Inclusion in National Register of Historic Places", and 36 CFR Part 600, "Protection of Historical and Cultural Properties". These permit processes have been initiated, and will allow for the survey, documentation, preservation, or recovery of any important historical/archaeological sites or materials.

No work will be initiated outside the five survey areas, without additional archaeological consultation. During the course of construction, if any artifacts, features, or other cultural materials are uncovered, a qualified archaeologist will be contacted to conduct salvage excavations and/or monitoring.

E. Socio-Economic Impacts

The socio-economic impacts of the proposed improvements and expansion of the Hanalei National Wildlife Refuge are closely tied to actual change in agricultural land use. The population and character of the Hanalei community is not expected to change to any great degree, because the potential influx of new farmers will not occur immediately, and the new taro acreage will only require a numerically small number of farm families. The main impact of the project will be on the taro market locally and statewide.

1. Changing Land Uses

Within the Hanalei National Wildlife Refuge, the major changes will be that the existing 115± acres of taro will be increased ultimately to 200± acres, with an additional 100± acres of sedimentation ponds, which will receive the tailwaters of the taro fields before returning these waters to the Hanalei River. The implementation of the new wetland acreage will follow the completion of a new water delivery system in Hanalei Valley, to replace the existing ditch system. The 210± acres of land presently used for cattle grazing will be eliminated.

The farmers in the refuge voiced a concern that the existing Hanalei Bridge needed to be augmented or replaced, in order to sustain larger truck loads of taro, which will be required with the anticipated increase in taro production.[1] The Hanalei Bridge, a one-lane bridge, is currently a topic of great controversy, because some groups would like to see it preserved as a historically-valuable structure, while other groups see it as an impediment to safe, efficient transportation and possible future development in the Princeville-Hanalei-Haena area on the North Shore of Kauai. The Hanalei Bridge is under the jurisdiction of the State Department of Transportation.

2. Population Growth

In previous discussions with farmers and taro experts, it was determined that the ideal minimum size of a taro farm is about 10 acres. The total additional acreage to be placed under taro cultivation will be 85+ acres; to increase all existing "acreage-deficient" farms to 10 acres will require about 20 acres of the additional acreage. This means that about 65+ acres will be available to new taro farmers; roughly this acreage could sustain 6 new farmers and their families. Based on 4 persons per household, this would mean an influx of an additional 24 people in the Hanalei National Wildlife Refuge.[2] There should be little problem in attracting new taro farmers to the refuge, particularly relatives of existing farmers. In addition, existing taro farms could be easily expanded.

Increased demand for agriculture-related goods and services, i.e. fertilizers, pesticides, farm equipment and equipment repair, could contribute to the need for some additional commercial or light industrial development in the Hanalei area, which would be a secondary generator of increased population.

3. Community and Regional Economics[3]

The Hanalei Valley yields on the average of between 30,000 and 35,000 pounds of taro per acre annually, which

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[1]Meeting with the Hanalei National Wildlife Refuge taro farmers, 2/28/78.

[2]Note in Demographic Data for Kauai, 1975, p. 26, the Hanalei District had an average of 3.45 persons per household.

[3]Discussions with Dr. Ramon de la Pena, Agricultural Experiment Station, Kauai, 3/1/79.

is highest yield any where in the State of Hawaii. (Note the State average is between 16,000 and 21,000 pounds per acre.) This means that under present conditions, an increase of approximately 2.6 to 3.0 million pounds of taro will be produced annually by the additional 85± acres in taro at the ultimate development of the proposed project. In 1977, 7.87 million pounds of taro was marketed statewide; therefore the additional production would represent a 33% to 40% increase in taro production statewide. This increased taro production would help to meet the existing taro deficit, as well as to allow poi to become more accessible to great numbers of people. There will be no danger of causing a glut on the taro market, which is presently at a 20% deficit, because the expansion of the taro acreages will be phased incrementally over a period of years, as desired by the Fish and Wildlife Service.

The gross income to the farmers for the additional projected taro production, based on current market values of $15 to $16 per 100 pounds of taro, would be between $390,000 to $416,000 per year. This money would be channelled into the local economy in the forms of farm overhead (equipment, wages, operation, maintenance), family expenses, taxes, and savings. In short, this money would be beneficial to the local economy of the North Shore of Kauai.

F. Impacts to Public Facilities and Utilities

No increases in existing public facilities are foreseen, as a result of the proposed project at the Hanalei National Wildlife Refuge.

With the potential increase in the number of taro farms in the refuge, additional traffic along Kuhio Highway for both domestic and market trips can be anticipated. The actual impact of this traffic increase is expected to be small. However, the future transport of taro to market by larger trucks with heavier loads may warrant the serious consideration of augmenting or replacing the aging, one-lane Hanalei Bridge.

Each of the future taro farms will require the construction of a cesspool to serve each individual dwelling units, because there is no integrated sewage system in Hanalei Valley. The Kauai Department of Health requires that the cesspools be set back from the water delivery system at least 50 feet.

The potential increases in the demand for domestic water in the refuge will be small. The 2.5-inch water line along the West Bank access road can be extended to serve future farm dwellings, when necessary. This also applies to future requirements for domestic electrical power.

G. Airborne Emissions

The amount of airborne emissions (NO_x, SO_x, HC, CO, etc.) generated is directly proportional to the number of automotive vehicles operating in a given area. It is anticipated that during the period of construction, there will be an increase of airborne emissions within the refuge. However, the amount of these emissions is expected to be quite small, and minimally impact the refuge. Therefore, a quantity estimate of the emissions, and a dispersion analysis is considered superfluous and unnecessary.

H. Noise Generation

In regard to the generation of noise, areas nearest to the alignment of the proposed water delivery system will be affected. This would cause any affected fauna to relocate to quieter, less disturbed areas. Based on the list of construction equipment to be employed for the project, the following table shows the noise level ranges which can be expected during construction. There are presently no noise standards established for the County of Kauai. After the completion of construction, noise levels will return to the existing "quiet" levels.

TABLE 24

CONSTRUCTION EQUIPMENT NOISE RANGES
HANALEI NATIONAL WILDLIFE REFUGE

Type of Equipment	Noise Level Range (dBA) at 50 Feet
Track-type tractors	77 - 97
Backhoes	72 - 93
Trucks	82 - 93
Patrol graders	80 - 93
Pneumatic -tired compactors	73 - 75
Concrete mixers	75 - 88
Cranes	76 - 88

Source: Noise from Construction Equipment and Operations Building Equipment, and Home Appliances, EPA, 1971.

I. Impact on Potential for Natural Hazards

The two types of natural hazards to be addressed in this section are flooding and erosion. The project will not cause the refuge to become more susceptible to these hazards, however some topics require discussion.

1. Impact to Flood Hazard

Most of the proposed water delivery system alignment is located within the floodway district, as delineated by the U.S. Army Corps of Engineers. Any dwelling structures would not be allowed within the floodway, but could be built within the flood fringe area. Flooding of the taro fields during periods of high rainfall and river flow will be controlled by limiting the amount of water entering the system at the intake structure. It should be realized that the objective of the project is to increase the acreage of wetland areas. The flooding of the lowland areas will probably occur in the same manner as it has in the past.

2. Impact to Erosion Hazard

Erosion will be a concern during the construction of the proposed project. Construction along the alignment of the proposed water delivery system should not be critical, as the slope of the land is nearly flat within the floodplain. Should erosion in the river from the construction of the diversion dam or inverted siphons become critical, curtains or other devices can be implemented.

Post-construction erosion in the taro fields should be minimized by the use of the sedimentation basins receiving the slow-flowing tailwaters from the taro fields. Runoff from the adjacent sloping areas will probably remain constant.

IV. alternatives of the proposed action

IV. ALTERNATIVES TO THE PROPOSED ACTION

The purpose of the proposed project is to determine, plan, design, and implement the best solution for the improvement and expansion of the existing water delivery systems at the Hanalei National Wildlife Refuge. The two types of alternative considered were alternative water delivery systems, and alternate energy systems to deliver electricity to motor driven pumps alternative water delivery systems. These various alternatives will be briefly reviewed in this section.

A. No Action Alternative

The "no action' alternative is not considered to be acceptable, because (1) the existing system is not functioning to its fullest capacity due to erosion and age and (2) it would not allow for the desired expansion of the taro agricultural land in the refuge.

B. Alternative Water Delivery Systems

All three alternatives deal with the China (West Bank) and Kuna (East Bank) Ditches, in terms of improvement, or abandonment and realignment of portions of the existing system. A general description, and the advantages and disadvantages will be presented for each alternative.

1. Alternative 1: Rehabilitation of both the Kuna (East Bank) and China (West Bank) Ditches.

   a. General Description

   The first alternative is to rehabilitate both the Kuna and China Ditches. The total combined design flow for the ditches is 54 CFS for all of the taro fields. For this alternative, 148 acres of taro were planned for the West Bank, and 52 acres of taro were planned for the East Bank.

   The China Ditch intake would be improved by the construction of a diversion works across the Hanalei River. The flume section of this ditch requires repair.

   The Kuna Ditch would be improved by the construction of a diversion works in the Hanalei River and an inverted siphon to bypass the section of ditch, which flows through a sequence of tunnels, and is in poor condition. With this siphon, special manhole

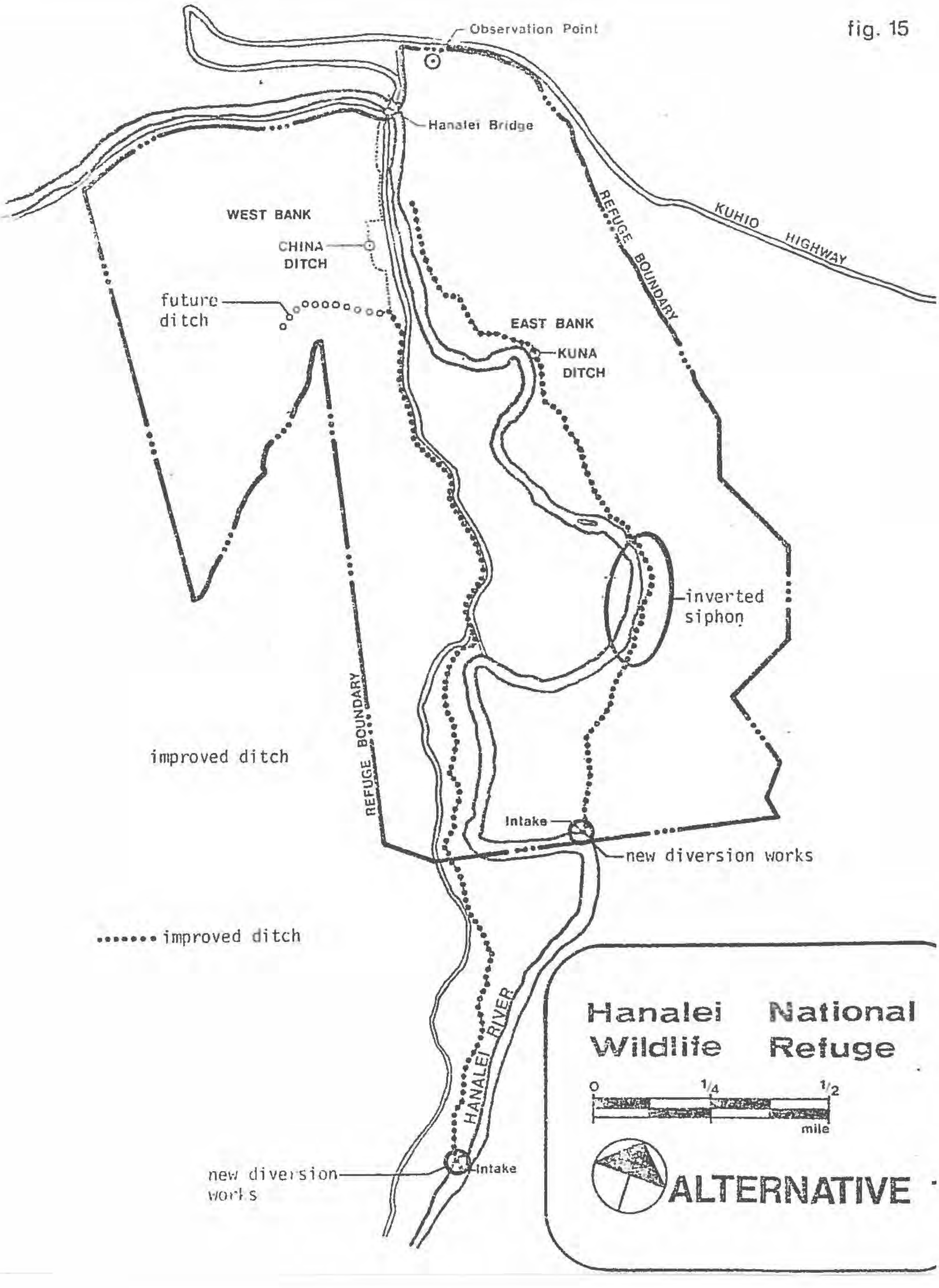


fig. 15
Observation Point
Hanalei Bridge
WEST BANK
CHINA DITCH
future ditch
KUHIO HIGHWAY
REFUGE BOUNDARY
EAST BANK
KUNA DITCH
inverted siphon
improved ditch
REFUGE BOUNDARY
Intake
new diversion works
improved ditch
HANALEI RIVER
new diversion works
Intake
Hanalei National Wildlife Refuge
0
1/4
1/2
mile
ALTERNATIVE

and riser structures would be required. Near the existing intake a bed-load and silt trap would be built to minimize ditch maintenance. See Figure 15.

b. Advantages/Disadvantages

The <u>advantages</u> of Alternative 1 are:

- o The alignment is existing, and would continue to be used.

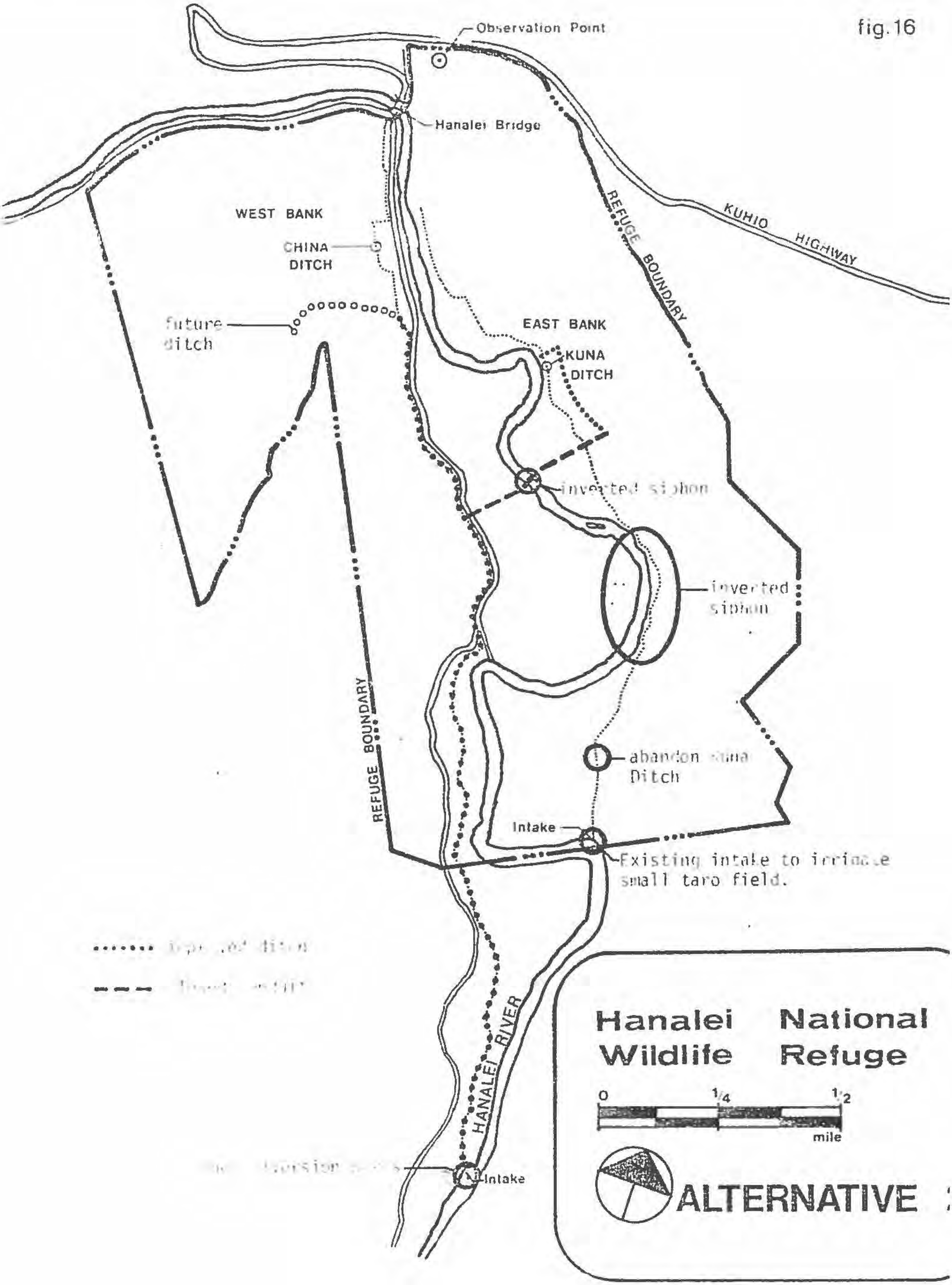
The <u>disadvantages</u> of Alternative 1 are:

- o The China Ditch diversion works would be located in a poor location. The stream would deposit bed load and silt directly upstream and into the ditch, causing maintenance problems.
- o A long inverted siphon would be needed to bypass the tunnel segment of the Kuna Ditch.
- o The unlined or unenclosed system will incur losses of water, through seepage, breaks in the ditches, overgrown vegetation, stormwater damage and siltation.
- o Sections of the Kuna Ditch are inaccessible.
- o It has the maximum length of any of the proposed systems.
- o Construction would interfere with the delivery of water to the existing taro fields.
- o While the alignments would be saved, the ditches would be drastically altered.
- o This alternative would require two diversion structures in the Hanalei Stream.

2. <u>Alternative 2: The China Ditch (West Bank) to carry all system flows to a junction where Kuna Ditch (East Bank) requirements are met via an inverted siphon; upper portion of Kuna Ditch abandoned</u>.

a. General Description:

The second alternative is to expand and improve the China Ditch (West Bank) to convey all the water for the water delivery system to a junction, where the fig.16



Observation Point
Hanalei Bridge
WEST BANK
CHINA
DITCH
future
ditch
EAST BANK
KUNA
DITCH
REFUGE BOUNDARY
KUHIO HIGHWAY
inverted siphon
inverted
siphon
REFUGE BOUNDARY
abandon
Ditch
Intake
Existing intake to
small taro field.
HANALEI RIVER
Intake
Hanalei National
Wildlife Refuge
0
1/4
1/2
mile
ALTERNATIVE

flow is split between the lower China Ditch and the lower Kuna Ditch (East Bank), via an inverted siphon under the Hanalei River. The lower Kuna Ditch would follow a slightly revised alignment to eliminate the section of enclosed pipe. As in the first alternative, this alternative calls for the construction of a diversion structure (dam/weir) at the head of the China Ditch.

The Kuna Ditch would be abandoned except for the intake structure and immediate drainline, which will be used to irrigate one 10-acre taro farm, to be located in the field adjacent to the intake structure. A new ditch would be constructed to furnish water to the taro farms on the east bank, and would be fed by the inverted siphon flowing from the West Bank. See Figure 16.

b. Advantages/Disadvantages

The advantages of Alternative 2 are:

- The China Ditch alignment is existing.
- The Kuna Ditch, which is in poor condition, would be abandoned.

The disadvantages of Alternative 2 are:

- The China Ditch diversion works, again, would be poorly located, causing ditch maintenance problems.
- The existing China Ditch requires extensive rehabilitation to minimize water losses through seepage, breaks, vegetation, and sedimentation.
- This alternative is the second longest of the proposed systems.
- Construction would interfere with the delivery of water to the existing taro fields, temporary water delivery systems would be required.
- The existing China Ditch would be drastically altered.

3. Alternative 3: Rehabilitation of the Kuna Ditch, with a new diversion structure from the Kuna Ditch intake site to supply water in a closed conduit to the West Bank.

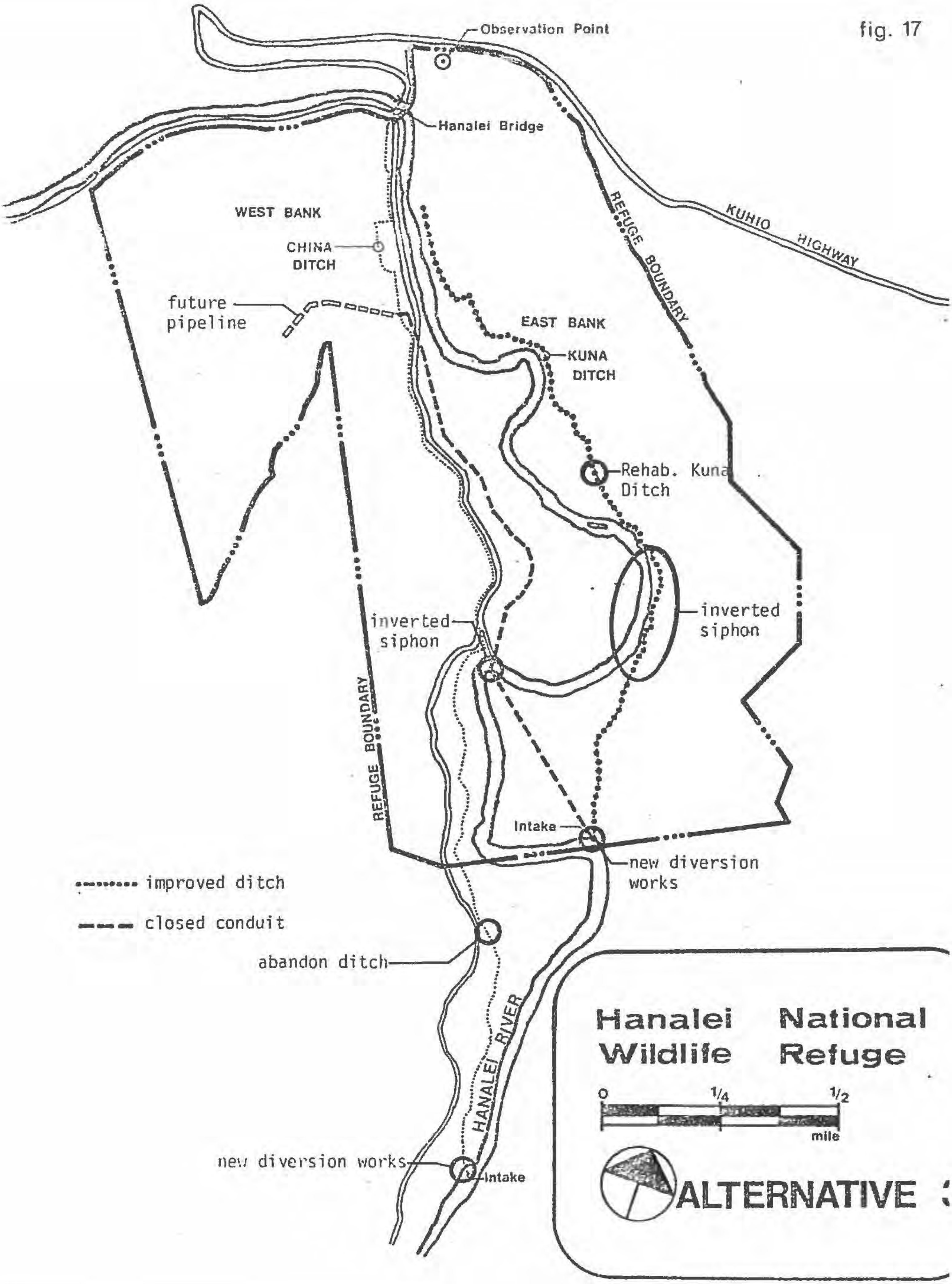


fig. 17
Observation Point
Hanalei Bridge
KUHIO HIGHWAY
REFUGE BOUNDARY
WEST BANK
CHINA DITCH
future pipeline
EAST BANK
KUNA DITCH
Rehab. Kuna Ditch
inverted siphon
inverted siphon
REFUGE BOUNDARY
Intake
new diversion works
improved ditch
closed conduit
abandon ditch
HANALEI RIVER
new diversion works
Intake
Hanalei National Wildlife Refuge
0
1/4
1/2
mile
ALTERNATIVE

a. General Description

The third alternative would be to rehabilitate the entire length of the Kuna Ditch as in Alternative 1.

A diversion works in the Hanalei River would be constructed just downstream from the existing Kuna Ditch intake to convey water to a closed conduit system to the West Bank. The line would run from the intake diagonally northwest to an inverted siphon under the Hanalei River near the existing ford. A bed-load and silt trap would be constructed near the diversion works, to minimize maintenance and damage to the closed conduit system. After the ford, the closed conduit system would generally follow the alignment of the China Ditch. The entire length of China Ditch would be abandoned. See Figure 17.

b. Advantages/Disadvantages

The <u>advantages</u> of Alternative 3 are:

- This would eliminate the ditch (China Ditch) outside the refuge boundaries, except for a portion of the diversion structure.
- The West Bank system would be entirely enclosed, eliminating leakage and minimizing maintenance.
- The diversion works at the Kuna Ditch intake is hydraulically optimal because sediment would be hydraulically controlled and prevented from entering the system.

The <u>disadvantages</u> of Alternative 3 are:

- Rehabilitation of the Kuna Ditch would require much work and capital, since it is in poor condition.
- A long, inverted siphon would be needed to bypass the tunnel segment of the ditch.
- Segments of the Kuna Ditch are inaccessible, which may cause construction and maintenance problems.

- Construction would interfere with the delivery of water to the existing east bank taro fields. A temporary water delivery system would be required.

4. Comparative Summary of Alternative Water Delivery Systems

During the course of the planning, engineering, and design of the proposed improvement and expansion of the water delivery system at the Hanalei National Wildlife Refuge, four alternative systems were developed - i.e. the selected alternative (Alternative 4) and the three alternatives discussed in this section. Here the different alternatives will be compared, using two different sets of criteria: design and environmental criteria.

Design Criteria include:

- Construction costs
- Operation and maintenance costs
- Length
- Access and jurisdiction
- Water conservation and temperature maintenance
- Interference of construction to existing taro cultivation

Environmental Criteria include:

- Archaeological and historical interest
- Effects on endemic and indigenous aquatic fauna
- Water quality impacts
- Post-construction visual impacts

Under each of these criteria, the four alternatives will be compared. Summaries are included on Tables 25 and 26. Again, Alternative 4 is the Selected Alternative.

a. Design Criteria

1) Construction Costs - Alternative 2 is the least expensive, followed by Alternatives 4, 3, and 1, in that order.

2) Operation and Maintenance Costs - Operation and maintenance costs would be the lowest for Alternative 4 under normal conditions; Alternative 1 would have the greatest costs.

3) Length - Alternative 4 is the shortest, followed by Alternatives 3, 2, 1, in that order.

4) Access and Jurisdiction - Alternatives 1 and 2 retain usage of the China Ditch (west bank), which is outside the refuge boundaries. Alternative 3 and 4 abandon the China Ditch, and would be completely contained with the refuge, except for a small section of the diversion dam.

5) Water Conservation and Temperature Maintenance - Alternative 4 is completely enclosed, except for a short length of open ditch on the East Bank, minimizing water losses via leakage, seepage and evaporation. Also, heating due to solar exposure would be minimal for an enclosed system. Alternative 3, employs one conduit and the Kuna Ditch, and would be the next best in terms of water conservation. Alternative 2 carries most of the flow in the China Ditch, but has a section of conduit across the Hanalei River and the East Bank. Alternative 1 would have the greatest water loss, because both ditches remain in operation.

6) Interference of Construction to Existing Taro Cultivation - Alternative 4 would not interfere with the existing taro cultivation. Alternatives 1, 2, and 3 require temporary water delivery systems be implemented, to insure the uninterrupted flow of water to the taro fields.

b. Environmental Criteria

1) Archaeological and Historical Interest - If the ditches were continually maintained, then Alternative 4 is the best for archaeological preservation. If the ditches are allowed to deteriorate, then Alternative 1 is the most beneficial. The China Ditch has more archaeological significance than the Kuna Ditch, because it follows the alignment of an ancient Hawaiian ditch. Therefore, Alternatives 2 or 3 could be better, depending upon the plans for future maintenance of the ditches.

2) Effects on Endemic and Indigenous Aquatic Fauna - Alternative 1 maintains the existing flow conditions, and therefore has the least impact. Alternative 2 takes more water from the Hanalei River at the China Ditch, which is considered to be a minimal impact. Alternatives 3 and 4 would construct a diversion dam across the Hanalei River and would have some impact on fish migration; however fish chutes would be implemented.

3) Water Quality Impacts - Alternative 4 is the alternative in terms of water quality because irrigation flows, for the most part is conveyed in a closed conduit system. Alternative 3, 2, and 1 follow in that order.

4) Post-Construction Visual Impacts - Alternative 1 would be the best, as it maintains the existing system. Alternative 2 would also be unobtrusive, because the China Ditch is fed to a closed conduit system. Alternatives 3 and 4 would also be unobtrusive, if the closed conduit system is placed underground as planned.

TABLE 25

WATER DELIVERY SYSTEM DESIGN CRITERIA COMPARISON

VARIABLES	ALTERNATIVES 1	2	3	Selected Alternative 4
Construction Costs	$1,598,400	$1,041,600	$1,317,400	$1,100,000
Operation and Maintenance Cost	Highest	Middle	Middle	Lowest
Length/feet (approx.)	16,450	13,910	13,950	11,410
Access and Jurisdiction	China Ditch partially off refuge	China Ditch partially off refuge	Totally within refuge	Totally within refuge
Water Conservation and Temperature Maintenance	Worst	Third	Second	Best
Interference of Construction to Existing Taro Cultivation Operations	Temporary Water Delivery System Needed	Temporary Water Delivery System Needed	Temporary Water Delivery System Needed	No Interference

TABLE 26

WATER DELIVERY SYSTEM ENVIRONMENTAL CRITERIA COMPARISON

VARIABLES	ALTERNATIVES 1	2	3	Selected Alternative 4
Archaeological and Historical Interest	With Ditch Maintenance			
	Worst	Third	Second	Best
	Without Ditch Maintenance			
	Best	Second	Third	Worst
Effects on Endemic and Indigenous Aquatic Fauna	Least	Minimal	Some	Some
Water Quality Impacts	Worst	Third	Second	Best
Post-Construction Visual Impacts	Least	Minimal	Minimal	Minimal

C. Alternate Energy Systems

Presented here is to make a conceptual analysis of alternate power sources to supply electricity to motor driven pumps to bring water from an intake point to either taro acreage or wildlife ponds. It is not the purpose of this analysis to make a report on the technical advancements of the various alternate power sources, although the current state-of-the-art will strongly influence certain alternatives. Rather, it is intended to make feasibility studies on the various alternate sources of energy only as applicable to the pumping of water at the Hanalei National Wildlife Refuge.

The various alternate power sources that have been investigated for the refuge site include the following:

1. Kauai Electric Company Service

2. Diesel Generator

3. Gas Generator

4. Wind Power

5. Photovoltaic (Solar) System

The analysis consists of two parts. The first part is the conceptual analysis for the various power systems for the Hanalei National Wildlife Refuge. The second part consists of a brief summary of the various power systems.

1. Alternate A: Electrical Service by Kauai Electric Company (KECO).

   At present there is an existing overhead utility line that extends a part of the way down the road that serves the existing taro fields. The purpose of this utility line is to provide electrical service to the existing homes in the area, and therefore consists only of single phase power. Because of the pump size requirements, three phase service is needed. The cost for Kauai Electric Company to convert from single phase to three phase service is estimated to be $60,000. Kauai Electric Company would also be required to extend their existing overhead lines to the proposed pump location. The estimated cost for this line extension is an additional $30,000. Thus the total initial cost for electric service from Kauai Electric Company would be approximately $90,000.

   The estimated energy charge for three phase service would be about $4850 per month based on the present cost of fuel oil. A conservative estimate on the future increase of the cost of electricity would be 10% per year. There is no operational or maintenance cost for this alternative as Kauai Electric Company has the responsibility of servicing and maintaining their utility lines. However, Kauai Electric Company would require a ten foot wide minimum vehicular access along the pole line for maintenance and servicing purposes.

   The expected life for this alternative before replacement of the system is required would be indefinite as Kauai Electric Company would be responsible for the upkeep of their system.

2. Alternate B: Diesel Generator

This alternate would involve the installation of two engine generator sets; a 100 KW unit and a 75 KW unit. Both generator sets would run during the day when full capacity is required and only the 75 KW unit would operate during the night when only half the pumps are needed. Although the initial cost of two small generator sets is higher than one large unit, the two generator systems would have less operational cost in terms of maintenance requirement and fuel consumption.

The initial cost for the diesel generator system including an underground 5000 gallon diesel fuel tank would be approximately $145,000. This system would include two diesel generator sets, a 5000 gallon fuel tank, the necessary electrical equipment and wiring, fuel piping and a structure to protect the generator sets and electrical equipment from the weather.

The monthly maintenance and operating cost for this alternative is estimated to be $4,710 per month based on today's cost for diesel fuel oil. This monthly cost includes $4,500 for fuel oil and an estimated cost of $2,500 per year for maintenance of the engine generator units. It should be noted that the fuel consumption for the two generator units is approximately 250 gallons per day. At this rate of consumption, the 5000 gallon fuel tank must be refilled about every three weeks. Again, a conservative estimate for the future increases of the cost of diesel fuel would be 10% per year.

The expected life for an engine generator set for this type of operation would be 20-25 years. After this time, the cost to maintain and repair the generator units would be high enough to warrant the replacement of these units.

A service road would also be required for this alternate. The purpose of this road would be to allow the delivery of fuel oil to the underground tank as well as for maintenance and service vehicles access to the generators and pumps.

3. Alternate C: Gas Generator

This alternate would be similar to the diesel generator system. Again a two engine generator system would be utilized; a 115 KW unit and a 85 KW unit. The reason for the increase in capacity as compared to the diesel generator system in that gas generator units must be derated because the units run less efficiently when a gaseous fuel is used. As in the diesel system, both generator sets would run during the day and only the 85 KW unit would run during the night.

The installed cost be would approximately the same as the diesel system i.e. $145,000. However the monthly fuel cost will change. The monthly maintenance and operating cost would be approximately $12,360 per month based on today's cost for gas. This monthly cost includes $12,150 for gas and the same $2,500 per year for maintenance.

As with the diesel alternative, the life expectancy for the system is 20-25 years. A service road would also be required for the maintenance and fuel trucks as in the diesel generator system.

4. Alternate D: Wind Generator

A wind power survey done by the University of Hawaii's Department of Meteorology in 1977 for the Island of Kauai showed that the island was not well suited for wind generated electricity. Recent studies sponsored by the National Science Foundation indicate that the minimum average wind velocity should be at least 15 miles per hour before wind generated electricity can become viable. The survey by the University of Hawaii showed that average wind speed around the Hanalei area to be only about 7 miles per hour (less in the Hanalei Valley).

The initial cost for a wind turbine generator is approximately $5,000 per kilowatt (with average wind velocity of 15 mph). Since 160 kilowatts are required, the initial cost for the wind turbine would be $800,000. However, because the average wind velocity at Hanalei is less than the 15 mph a minimum of two wind turbines would be required for a total cost of $1,600,000. In addition to the turbines, energy storage (batteries) would be required because of the unpredictable winds in the valley. The cost for energy storage capabilities is about $750 per kilowatt or $120,000 for this installation. Thus the total initial cost for this installation would be approximately $1,720,000.

The system consists of a minimum of two 100 foot (30 meter) towers each with a horizontal-axis, 125 foot diameter rotor. A battery housing building approximately 150 square feet would also be required.

Since fuel is not used in this system, the only other cost involved would be a maintenance type cost. However, since wind generated electricity is still in its experimental stages, the National Science Foundation uses a figure of $0.10 per kilowatt-hour for an operational and maintenance cost. This system requires approximately 82,000 kilowatt-hours per month for a cost of approximately $8,200 per month.

The life expectancy for this type of system is 10-20 years for the batteries and an estimated 30 years for the wind turbine. Again, a service road would be required for maintenance and service purposes.

5. Alternate E: Photovoltaic (Solar) System

The present state-of-the-art technology in photovoltaic conversion (solar energy to electricity) is still in its infancy stages of development and experimentation. Presently, the main obstacles that need to be over-come before the photovoltaic system becomes viable are the high cost of the solar cells (presently $35 per watt), the efficiency of the system (presently 12%) and the physical space requirements (2 watts per square foot of solar panels).

Based on the present state-of-the-art technology, the installed cost of the solar array required to meet the power requirements would be approximately $5,600,000 not including the cost for energy storage batteries. Another $120,000 should be added for storage batteries which will bring the total installed cost to approximately $5,720,000.

The solar array would have to consist of about 80,000 square feet of solar panels, which is slightly less than the area of two football fields. As in the case of the wind turbine, a battery housing building of about 150 square feet would be necessary. This building would also house the necessary support equipment such as AC-DC converters.

Because there are still major system unknowns, the maintenance and operating cost and the life expectancy of the system are not really known. An assumption of $0.10 per kilowatt-hour for operation and maintenance cost (similar to the wind turbine system) will result in a monthly cost of about $8,200. Recent reports sponsored by the National Science Foundation have estimated the useful lifetime for the system to be about 5-10 years.

6. Summary

All alternatives may be more costly than the allowed funding will permit. Obviously, if the water flow requirements can be met by gravitational flow rather than pumping, a great deal of initial as well as monthly charges can be saved.

However, if pumping is required, the use of Kauai Electric Service is presently the most viable in terms of costs, initial and monthly. Until the state-of-the-art technology for the wind turbine and photovoltaic systems become economically competitive with conventional generating systems, these alternate sources of energy will remain on an experimental basis. An important measure of the economic viability of the wind turbine and the photovoltaic system is the cost of electricity produced by such systems. This cost is, currently, still relatively large compared to that of fossil-fueled systems. However, the unit price of wind turbines is expected to decrease as the size of the units is increased and as mass-production techniques are introduced. Based on a 10% cost increase of fossil-fuel the break even point should be reached 20 years for the wind turbine system and 40 years for the solar system.

V.

local short - term uses of man's environment versus long - term productivity

V. LOCAL SHORT-TERM USES OF THE ENVIRONMENT VERSUS LONG-TERM PRODUCTIVIY

In this discussion, the existing local short-term uses of the Hanalei National Wildlife Refuge will be weighed against its potential for long-term productivity.

Presently, the wildlife refuge is a prime example of the harmony which can be achieved between human activities and the natural environment. One of the main objectives of the U.S. Fish and Wildlife Service in administering the wildlife refuge is the preservation, enhancement, and propogation of Hawaii's endangered waterbird species (Stilt, Coot, Gallinule, Koloa). These endangered waterbirds are attracted to cleared, wetland areas for nesting and feeding, particularly flooded taro fields. Hanalei Valley is the most productive area for taro cultivation in the State of Hawaii; additionally taro has become a marginal crop in that decreased agricultural yields have caused a statewide deficit in poi production. At the present time only 115± acres of the refuge lands are under taro cultivation; the remainder of the land is in grazing or in its natural state. This is a scenario of the current conditions regarding the Hanalei National Wildlife Refuge.

Agricultural development of the Hanalei National Wildlife Refuge is compatible with the Fish and Wildlife Service's objective of habitat enhancement for the endangered waterbird species. Improvement of the refuge is desirable for the following reasons:

- o Increase in appropriate bird habitat and feeding areas.
- o Increase in taro production.
- o Elimination of cattle grazing, which is undesirable in a wildlife sanctuary.
- o Documentation or recovery of significant historical/ archaeological materials or sites.
- o Improvements to inefficient agricultural practices, which are a result of small farm sizes. (Those less than 10 acres).
- o New opportunities for younger farmers to farm within the refuge.

Therefore, the expansion of the area of taro cultivation from 115± acres to 200± acres, the creation of an additional 100± acres of sedimentation ponds, and the implementation of a new water delivery system for irrigation purposes will serve to achieve the aforementioned desired improvements.

VI. any irreversible/ irretrievable commitment of resources

VI. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

Federal funds, human labor, construction materials, and fuel will be committed to the project for the construction of the new water delivery system and the service/access roads. Manpower and funds will also be expended for the maintenance and operation of the irrigation and service/access road system.

VII.
bibliography

VII. BIBLIOGRAPHY

A. Texts, Articles, and Papers

Anderson, R. N.; Barron, J. C.; and Marders, W. G.; Hanalei Development Plan: A Socioeconomic Prelude; College of Tropical Agriculture, University of Hawaii, May 1972.

Begley, Brian; "Taro in Hawaii: Study of a Food System", Agricultural and Resources Economics; Honolulu, Hawaii; 1975.

Broshears, Bob; and Moriarty, Dan; "Aquatic Habitat and Aquatic Food Sources for Endangered Waterbirds at Hanalei National Wildlife Refuge"; October 1978, January 1979.

Cleghorn, Paul L.; "Archaeological Reconnaissance Survey Within the Hanalei Wildlife Refuge, Hanalei, Kauai"; Department of Anthropology, Bernice P. Bishop Museum; Honolulu, Hawaii; June 1979.

Coleman, Richard A.; "Observations on Breeding Biology of Hawaiian Stilt (Himantopus mexicanus Knudseni) on Oahu, Hawaii"; August 1978.

Compilation of Records of Surface Waters of Hawaii, Through June 1950, United States Department of the Interior.

Couret, Carl; Biology and Taxonomy of a Freshwater Shrimp, Atya Bisulcata; Randall; May 1976.

Earle, Timothy K.; Control Hierarchies in the Traditional Irrigation Economy of Halelea District, Kauai, Hawaii, 1973; Ann Arbor, University Microfilms.

A General Plan for Domestic Water/Island of Kauai; Department of Water, Honolulu, February 1972.

Goulding, Edward W., The Generation of Electricity by Wind Power, 1976.

How, Karl T., Solar Radiation in Hawaii 1932-1975, January 1978.

Kauai General Plan; County of Kauai, State of Hawaii; March 1970.

Kelly, Henry, "Photovoltaic Power System: A Tour Through The Alternatives", Science, Vol. 199, February 10, 1978, p. 634-643.

Maciolek, John A.; West Maui Streams, Preliminary Draft; Honolulu; 1977.

McBryde V. Robinson, 54 Haw. 174, 504 P.2d 1330 (1973), on rehearing, 55 Haw. 260, 517 P.2d (1973).

Merrigan, Joseph A., Sunlight To Electricity: Prospects for Solar Energy Conversion by Photovoltaic, 1975.

National Science Foundation, "Photovoltaic Converssion of Solar Energy for Terrestrial Applications", Workshop Proceedings Vo. I, II, October 23-25, 1973.

National Science Foundation, Wind Machines, October 1975.

North Shore Special Planning Area; Kauai County, State of Hawaii; Honolulu, Hawaii; September 30, 1972.

Plucknett, D. L., de la Pena, R. S., Obtero, F.; Field Crop Abstracts; Vol. 23, No. 4; College of Tropical Agriculture, University of Hawaii, Honolulu; November 1079.

Plucknett, D. L., de la Pena, R. S.; "Taro Production in Hawaii"; World Crops; September/October 1971.

Ramage, Colin S., Oshiro, Norman E., Kauai Wind Power Survey, November 1977.

Statistics of Hawaiian Agriculture 1977, Hawaii Agricultural Reporting Services; Honolulu, Hawaii; June 1978.

Steven, Herbert H., et al., "Water Temperature Influential Factors, Field Measurement, and Data Presentation", Washington, 1975.

Surface Water Supply of the United States, Hawaii and other Pacific Areas, United States Department of the Interior, Washington, 1977.

Takahashi, M.; "Report of Taro Diseases in Hawaii"; Hawaii Agricultural Experiment Station, University of Hawaii; February 20, 1953.

Taliaferro, William J., Rainfall of the Hawaiian Islands, 1959.

"Taro: Hawaii's Staff of Life"; The Garden Island; March 30, 1979.

Timbol, Dr. Amadeo S.; A Report on the Aquatic Survey of Stream Macrofauna for the Hydroelectric Power Study for Hawaii; Environmental Impact Study Corp. for U.S. Army Corps of Engineers, Pacific Ocean Division; Honolulu, Hawaii; September 1977.

Water Resources Data for Hawaii and other Pacific Areas, United Stated Department of the Interior, 1970 thru 1977.

Water Quality Management Plan for the County of Kauai; Department of Water, Honolulu, February 1972.

"Water Quality Standards"; Chapter 37-A, Public Health Regulations; Department of Health, State of Hawaii.

Watson, Leslie J.; "The Legal Importance of the Water Requirements of Taro (Colocasia Esculenta) in Hawaii"; August 23, 1970.

Wylde, Alan F., "Wind Machines for Large - Scale Electricity Production", New Zealand Engineering, October 15, 1978.

B. Persons Contacted (in order of contact date)

Person	Agency or Organization	Date
Salwyn Ching	U.S. Geological Survey	12/18/78
Manny Masuda	U.S. Army Corps of Engineers	1/25/79
Len Bautista	Department of Land and Natural Resources	1/29/79
Yoshiko H. Sinoto Elaine Jourdane Aki Sinoto	Bishop Museum	2/9/79
Jackie Parnell Mel Kunizumi	State Department of Health, Pollution and Technical Review, 208 Program	2/21/79
Ronald Albu	Legal Aid Society, Waihee Farmer Atty.	2/25/79
Glenn Hinazumi	Kauai Electric Company	2/27/79
Eric Inamoto	Honolulu Poi Company	2/26/79
Dr. Al Martinez	Plant Pathologist, College of Tropical Agriculture, University of Hawaii	2/27/79

Person	Agency or Organization	Date
Bernabe Mateo Walter & Wally Koga* Bill*, Rodney, & Carol Haraguchi Mike Fitzgerald* George & Gary Koga	Hanalei Taro Farmers	2/28/79 *(also 2/13/79)
Dr. Ramon de la Pena	Agricultural Experiment Station, Kauai	3/1/79
Keoji Masaki	Kauai Department of Public Works	3/1/79
Dr. Robert Melton	Kauai Department of Health	3/1/79
Wayne Hinazumi	Chief, Kauai Department of Water	3/1/79
Sophia Cluff Barnes Riznik	Historians, Waioli Mission Corp.	3/2/79
Ted Inouye	Kauai Department of Health, Sanitary Division	3/2/79
Herman Texeira	Kauai Office of Economic Development	3/2/79
Dr. Timothy K. Earle	Asst. Professor, UCLA	3/7/79
James Omori	Market Statistics, State Department of Agriculture	3/7/79
Lloyd Garrett	Statistician, State Department of Agriculture	3/9/79
Abe Mariano	Chief, Agricultural Development, State Department of Agriculture	3/9/79
Jerry Allan	C. Brewer Company	3/12/79
Shoichi Nagamine	Hanapepe Taro Farmer	3/13/79
Jane Silverman	State Historic Preservation Office, Department of Land and Natural Resources	4/2/79
Mason Young	DLNR, Land Management Kauai Agent	4/3/79
Joan Yim	Coastal Zone Management Program, Department of Planning	4/4/79

Person	Agency or Organization	Date
Keiji Sugawa	State Department of Agriculture	4/6/79
John Ford	Limnologist, U.S. Army Corps of Engineers	4/9/79
Tom Ushijima	Floodplain Management, U.S. Army Corps of Engineers	4/9/79
Eugene Akazawa	Pollution Investigation and Enforcement Branch, State Department of Health	5/22/79
Dr. Reginald Young	Water Resources Research Center, University of Hawaii	5/22/79
Stanley Shima	Biologist, Fish and Game Division, State Department of Land and Natural Resources	6/15/79
Charles Ewert	U.S. Geological Service	
Nori Kojiri	U.S. Geological Service	
Ruben Lee	U.S. Geological Service	
Johnson Yee	U.S. Geological Service	
Vernon Bird	U.S. Fish and Wildlife Service	
Brent Giezentanner	U.S. Fish and Wildlife Service	
John Maciolek	U.S. Fish and Wildlife Service	
Dan Mariarty	U.S. Fish and Wildlife Service	
Robert McVein	U.S. Fish and Wildlife Service	

appendices

A. LETTERS

C2315-01

CITIZENS UTILITIES
COMPANY
P. O. BOX 278 • ELEELE, KAUAI, HAWAII 96705 (808) 335-3131

March 14, 1979

File #79-6-100
#79-6-101

Wilson, Okamoto & Associates, Inc.
P.O. Box 3530
Honolulu, HI 96811

ATTENTION: Mr. Sampson Mar

SUBJECT: HULEIA & HANALEI NATIONAL WILDLIFE REFUGES

Dear Mr. Mar:

Enclosed find one copy each of the approximate electrical facilities in the vicinity of your proposed projects. It should be noted that we will not be able to supply power directly from the 57KV lines.

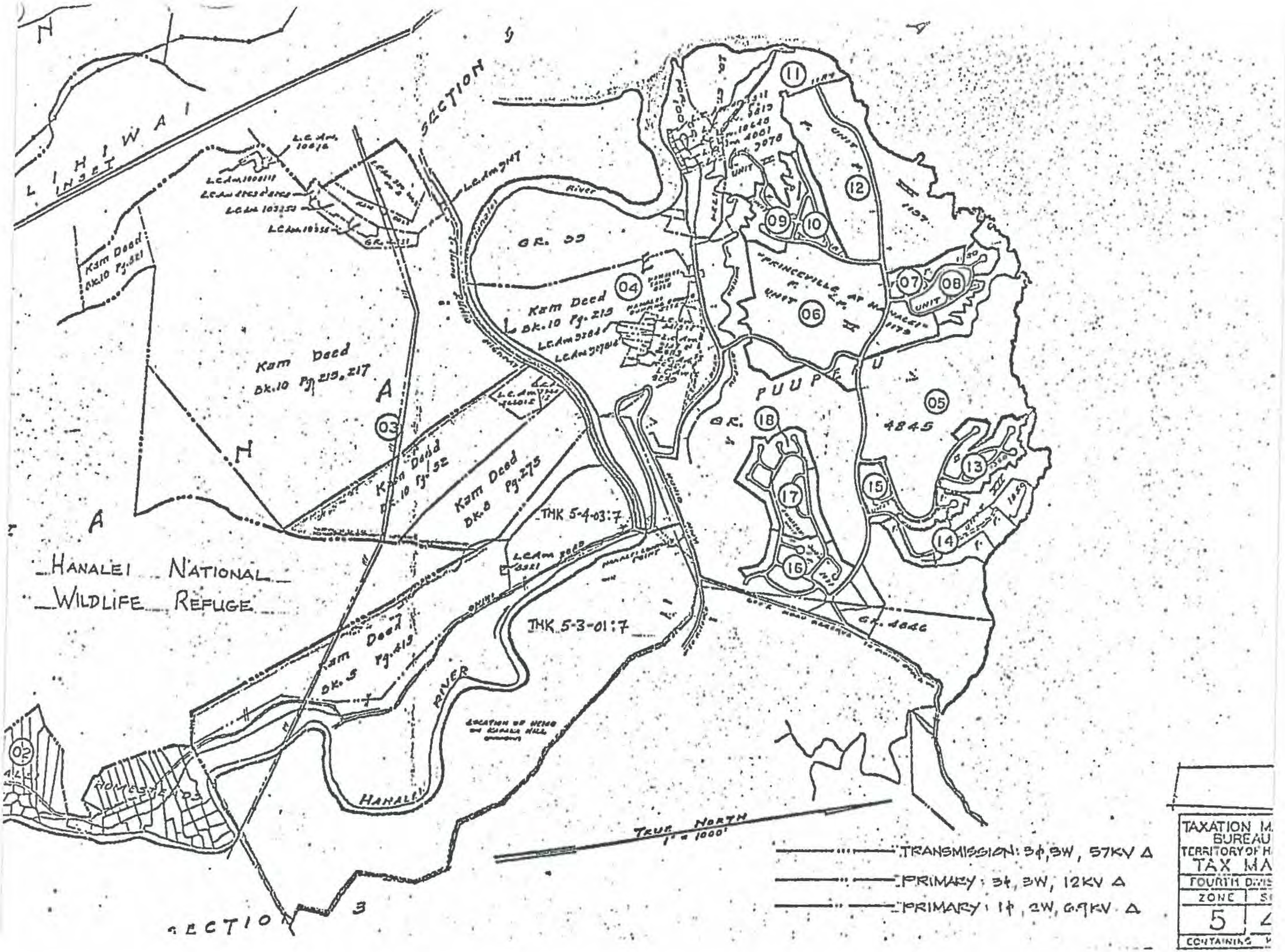
It should be noted that any flooding or use of our easements may require a relocation change of our facilities.

Very truly yours,

BOYD T. TOWNSLEY
Vice President
Kauai Electric Division

BTT:kk

Enclosures


LIHIWAI INSET
SECTION 5
SECTION 3
Kam Deed Bk.10 Pg.321
Kam Deed Bk.10 Pg.215, 217
Kam Deed Bk.10 Pg.215
Kam Deed Bk.10 Pg.152
Kam Deed Bk.8 Pg.275
Kam Deed Bk.5 Pg.419
GR. 33
PRINCEVILLE AT HANALEI
PUUPEHU
GR. 4846
4845
THK 5-4-03:7
THK 5-3-01:7
HANALEI NATIONAL WILDLIFE REFUGE
HANALEI RIVER
TRUE NORTH
1" = 1000'
TRANSMISSION: 3φ, 3W, 57KV Δ
PRIMARY: 3φ, 3W, 12KV Δ
PRIMARY: 1φ, 2W, 6.9KV Δ
TAXATION MAPS BUREAU
TERRITORY OF HAWAII
TAX MAP
FOURTH DIVISION
ZONE
5
CONTAINING

United States Department of the Interior

FISH AND WILDLIFE SERVICE
P.O. Box 26
Kilauea, Hawaii 96754

FILE C231E-01

Sampson S. Mar, Planner
Wilson Okamota & Associates
P.O. Box 3530
Honolulu, HI 96811

Dear Mr. Sampson:

This responds to your letter of 5 April, requesting commentary on the Kauai NWR systems. Bear in mind that these comments are personal and neither reflect my agency affiliation nor do they address FWS policies directly.

In connection with water diversion volume and discharge water quality, you should bear in mind that the Service is interested both in protecting the quality of natural ecosystems [as well as in providing modified habitat for endangered or threatened species. The subject streams are the natural ecosystems] and their present quality is less than pristine because of modifications made by man in the past. There are no strictly aquatic animals in those streams that are listed formally as endangered. However, most of the large native stream animals — in Hawaii, on Kauai, and in the subject streams — have become depleted in the historic past, some of them severely so. A few of those species, such as o'opu nakea and hihiwai, are of recreational and even commercial importance. Populations of all native aquatic species regardless of exploitive value, deserve protective consideration.

I cannot recommend on the matter of stream diversion. My opinion is that there should be no further diversion of any stream in Hawaii. This is not an extreme position — consider that it would be ideal for native ecology if all existing diversions were undone. I can only say that the guidlines provided by the 208 Water Quality Committee on minimum stream flow recommendation are surely the maximum you should consider.

Hence, the reason I addressed groundwater in our conversation. Tapping of high-elevation groundwater can be degrading to stream ecosystems because low stream flow is entirely dependent upon seepage from elevated aquifers. But as a source, groundwater from floodplain areas apparently poses no threat to surface ecosystems. Therefore, I urge you to give groundwater exhaustive consideration. I am not familiar with groundwater hydrology on the floodplains of the subject streams. There is a possibility of excavating ponds into the water table, thus simulating natural ponds such as Green Lake, Opaeula, and Aimakapa (Hawaii), and Nomilu (Kauai). The other alternative, of course, is pumping. Salinity of groundwater is not a significant factor for bird habitat ponds (many native birds seem to prefer brackish or even hyperhaline waters), but salinity is a consideration for taro growth and flow—through systems involving discharge return to the stream.

Discharges is a problem not only regarding salinity but also concerns temperature, turbidity, nutrient elements, and other factors used in designating water quality. I'm sure you are aware that even current water quality standards require that discharges equal or exceed the quality of receiving waters. Present discharges probably are at variance and additional discharge volume could increase the problem.

Sincerely,

John A. Maciolek

John A. Maciolek
Unit Sr. Advisor

cc: Manager, Hawaiian Islands NWR, Honolulu
Regional Director, U.S. Fish and Wildlife Service, Portland

JAM:nb

(Sorry about the messy typing -- that's not our expertise!)

Our scope does not include studying groundwater options in Hanalei, and only superficially at Haleia. My opinion is that shallow wells would be unproductive - also the cost factor of power to pump the water from the wells

WSH

C3215-01

RECEIVED
APR 17 1979
WILSON OKAMOTO & ASSOCIATES

208
308
DEPARTMENT OF HEALTH ENVIRONMENTAL PROTECTION AND HEALTH SERVICES DIVISION
P.O. BOX 3378 HONOLULU, HAWAII 96801

April 12, 1979

Mr. Sampson S. Mar, Planner
Wilson Okamoto & Associates
1150 S. King Street
Honolulu, Hawaii 96814

Dear Mr. Mar:

Subject: Hanalei and Huleia National Wildlife Refuge Improvements, Island of Kauai

We have reviewed your proposed projects to improve and expand the Hanalei and Huleia National Wildlife Refuges on Kauai. It is our opinion that there are no conflicts between these projects and the 208 Water Quality Management Plan for Kauai, and that they fully support the objectives of the plan and State and Federal legislation, which include the enhancement and improvement of water quality and natural habitats.

It appears that any water quality problems that may be generated during construction will be temporary in nature and that the long-term effects will be the enhancement of water quality in these areas. We expect that the detailed project plans and environmental impact assessment will indicate the temporary adverse effects and the measures that will be implemented to minimize their impact. We may have additional comments at that time.

Thank you for giving us the opportunity to review the proposed projects. If we can be of any further assistance, please let us know.

Sincerely,

Jacqueline Parnell

Jacqueline Parnell
Environmental Planner

JP:sy

2-373-0

GEORGE R. ARIYOSHI
GOVERNOR OF HAWAII

SUSUMU ONO, CHAIRMAN
BOARD OF LAND & NATURAL RESOURCES

EDGAR A. HAMASU
DEPUTY TO THE CHAIRMAN

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

RECEIVED
JUL 20 1979
WILSON OKAMOTO & ASSOCIATES

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

July 17, 1979

REF. NO.: CPO-607
FILE NO.: KA-9/22/72-382

Mr. Sampson S. Mar
Wilson, Okamoto and Associates
1150 South King Street
Honolulu, HI 96814

Dear Mr. Mar:

This responds to your June 1, 1979 inquiry as to whether or not application requirements pursuant to Section 183-41, Hawaii Revised Statutes relating to use of Conservation District, will be necessary for water distribution system improvements and expansion of taro field and open areas at the Hanalei National Wildlife Refuge, Hanalei, Kauai. We understand that your inquiry is as project consultant to the U. S. Fish and Wildlife Services who are the managers of the federally-owned refuge.

According to our records, on September 22, 1972, an application for the subdivision of properties involving both Conservation and Agricultural District lands owned by Princeville Corporation was filed. The then proposed subdivision, affecting portions of properties identified by TMK's 5-3-01: 7 and 5-4-03: 1, was to facilitate the conveyance of about 930 acres to the Bureau of Sports Fisheries and Wildlife, U. S. Department of Interior for development, in perpetuity, as a wildlife sanctuary for endangered species of Hawaiian coot, and the Hawaiian gallinule.

Noted in the description of proposed use, the preservation and expansion of the existing taro culture, a compatible habitat for the waterfowl, is expected. Also, if expansion of taro acreage is found impractical, small impoundments to promote the growth of aquatic foods used by the water birds will be created. Other plans included public-oriented uses compatible to the sanctuary development.

On October 27, 1972, the Board of Land and Natural Resources approved the application for subdivision. However, although the purpose of the subdivision was addressed within the submittal, the recommendation then acted on omitted conditions specific to the development of the wildlife refuge.

As such, we intend to correct the oversight by way of a submittal to the Land Board with a recommendation that the application be amended accordingly. To this end, we request that all plans pertinent to the development of the Hanalei National Wildlife Refuge be forwarded to us such that we are able to present the amendment, in the form of a comprehensive plan that, if favorably received and acted on, might obviate the necessity for future applications.

Thank you for your cooperation. Should you have any questions, feel free to contact Messrs. Roger C. Evans or Len Bautista of our Planning Office at 548-7837.

Very truly yours,

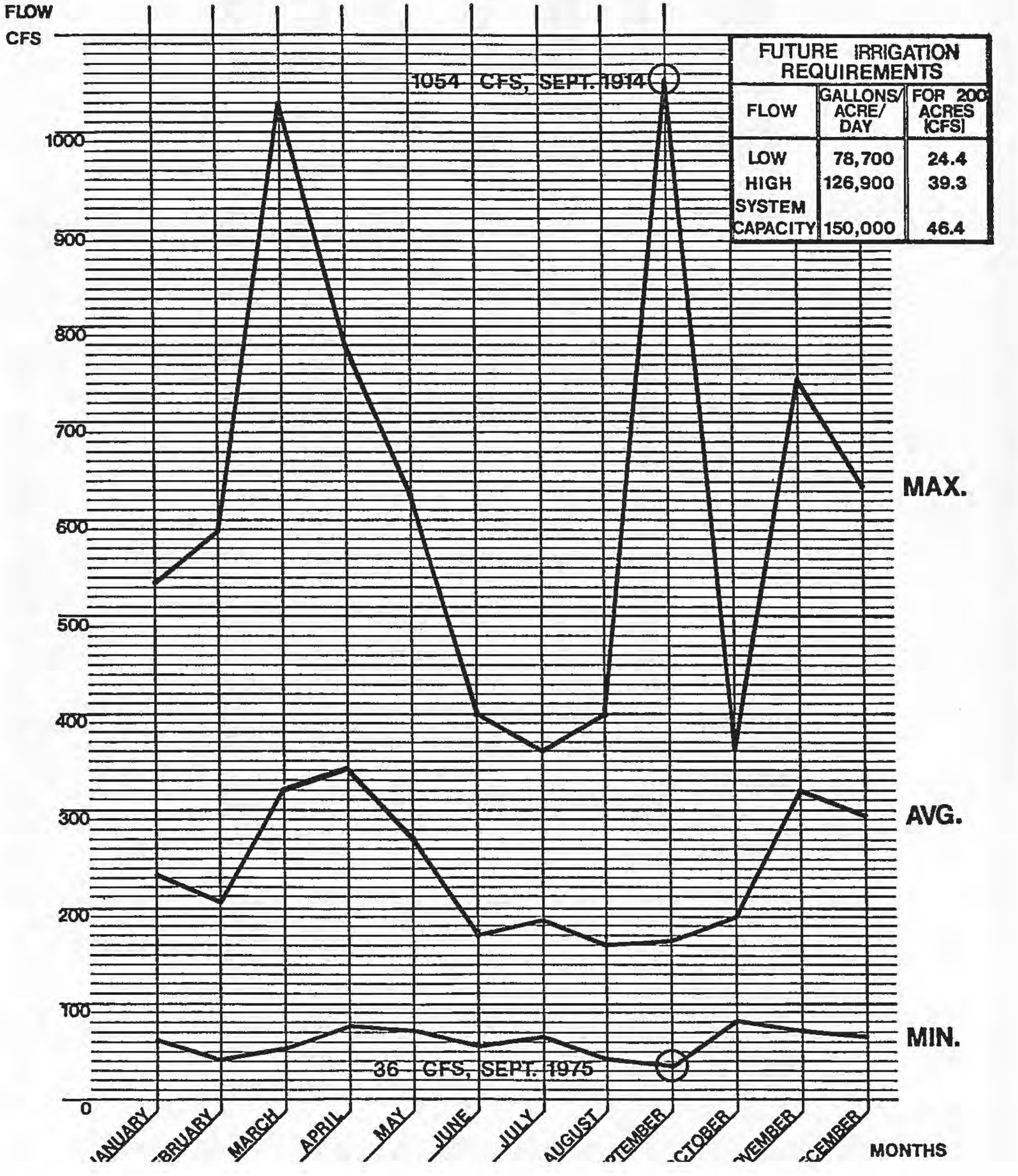
SUSUMU ONO, Chairman
Board of Land and Natural Resources

cc: Kauai Board Member
Kauai Land Agent
U. S. Fish and Wildlife Service
U. S. Corps of Engineers
Kauai Planning Dept.

B. WATER RESOURCES DATA

MONTHLY FLOWS IN THE HANALEI RIVER (USGS)

-January 1912 to October 1920, January 1963 to December 1978-



FUTURE IRRIGATION REQUIREMENTS		
FLOW	GALLONS/ ACRE/ DAY	FOR 200 ACRES (CFS)
LOW	78,700	24.4
HIGH	126,900	39.3
SYSTEM CAPACITY	150,000	46.4

TABLE 3.

HANALEI RIVER

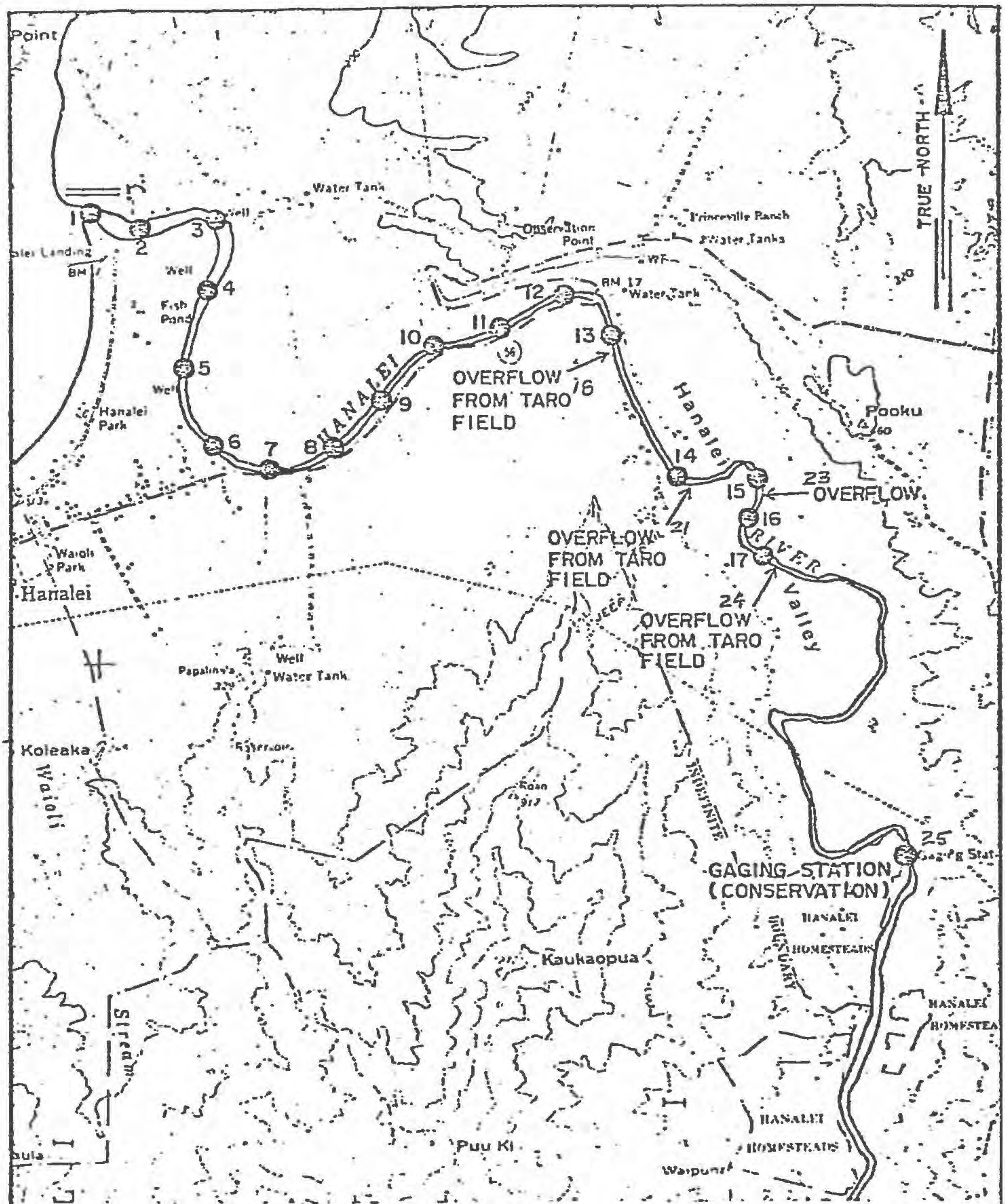
PARAMETER	LOC	TRIP 1	TRIP 2	TRIP 3	TRIP 4	TRIP 5
STATION: 1						
TKN,UG/L	TOP	140.0	56.0	110.0	29.0	93.0
TKN,UG/L	BOT	-1.0	67.0	64.0	94.0	-1.0
NO3N,UG/L	TOP	1.6	17.0	14.0	36.0	43.0
NO3N,UG/L	BOT	-1.0	23.0	14.0	34.0	-1.0
TOT-P,UG/L	TOP	13.0	17.0	30.0	34.0	34.0
TOT-P,UG/L	BOT	-1.0	25.0	20.0	34.0	-1.0
SS,MG/L	TOP	95.0	3.9	2.1	2.6	1.8
TURBID,JTU	TOP	0.9	1.5	2.9	2.3	2.2
TURBID,JTU	BOT	1.3	2.5	1.6	2.8	-1.0
CHLO,MG/M3	TOP	-1.0	0.6	1.0	0.5	0.2
STATION: 3						
TKN,UG/L	TOP	-1.0	28.0	140.0	175.0	210.0
TKN,UG/L	BOT	-1.0	56.0	105.0	102.0	-1.0
NO3N,UG/L	TOP	-1.0	22.0	54.0	56.0	25.0
NO3N,UG/L	BOT	-1.0	17.0	8.0	38.0	-1.0
TOT-P,UG/L	TOP	-1.0	20.0	28.0	27.0	32.0
TOT-P,UG/L	BOT	-1.0	22.0	24.0	19.0	-1.0
SS,MG/L	TOP	-1.0	3.2	3.6	2.3	1.6
TURBID,JTU	TOP	-1.0	1.4	1.7	1.0	1.6
TURBID,JTU	BOT	-1.0	2.0	2.3	1.2	-1.0
CHLO,MG/M3	TOP	-1.0	0.7	1.4	0.8	0.6
STATION: 5						
TKN,UG/L	TOP	-1.0	-1.0	-1.0	53.0	195.0
TKN,UG/L	BOT	-1.0	-1.0	-1.0	131.0	-1.0
NO3N,UG/L	TOP	-1.0	-1.0	-1.0	19.0	18.0
NO3N,UG/L	BOT	-1.0	-1.0	-1.0	12.0	-1.0
TOT-P,UG/L	TOP	-1.0	-1.0	-1.0	27.0	28.0
TOT-P,UG/L	BOT	-1.0	-1.0	-1.0	22.0	-1.0
SS,MG/L	TOP	-1.0	-1.0	-1.0	2.5	1.7
TURBID,JTU	TOP	-1.0	-1.0	-1.0	2.3	1.7
TURBID,JTU	BOT	-1.0	-1.0	-1.0	1.3	-1.0
CHLO,MG/M3	TOP	-1.0	-1.0	-1.0	0.6	0.7
STATION: 8						
TKN,UG/L	TOP	-1.0	34.0	170.0	192.0	82.0
TKN,UG/L	BOT	-1.0	-1.0	60.0	164.0	-1.0
NO3N,UG/L	TOP	-1.0	21.0	39.0	18.0	30.0
NO3N,UG/L	BOT	-1.0	-1.0	33.0	19.0	-1.0
TOT-P,UG/L	TOP	-1.0	39.0	20.0	23.0	38.0
TOT-P,UG/L	BOT	-1.0	-1.0	23.0	29.0	-1.0
SS,MG/L	TOP	-1.0	1.8	1.6	0.1	1.6
TURBID,JTU	TOP	-1.0	2.9	1.3	1.8	1.4
TURBID,JTU	BOT	-1.0	-1.0	2.2	2.3	-1.0
CHLO,MG/M3	TOP	-1.0	0.7	1.2	0.9	1.5
STATION: 12						
TKN,UG/L	TOP	-1.0	40.0	170.0	38.0	114.0
TKN,UG/L	BOT	-1.0	-1.0	169.0	166.0	-1.0
NO3N,UG/L	TOP	-1.0	19.0	39.0	16.0	24.0
NO3N,UG/L	BOT	-1.0	-1.0	19.0	17.0	-1.0
TOT-P,UG/L	TOP	-1.0	23.0	14.0	22.0	27.0
TOT-P,UG/L	BOT	-1.0	-1.0	19.0	35.0	-1.0
SS,MG/L	TOP	-1.0	1.6	0.9	1.8	2.7
TURBID,JTU	TOP	-1.0	1.5	1.1	1.5	1.2
TURBID,JTU	BOT	-1.0	-1.0	4.6	3.0	-1.0
CHLO,MG/M3	TOP	-1.0	0.5	0.8	0.8	0.4
STATION: 14						
TKN,UG/L	TOP	-1.0	-1.0	-1.0	-1.0	82.0
NO3N,UG/L	TOP	-1.0	-1.0	-1.0	-1.0	24.0
TOT-P,UG/L	TOP	-1.0	-1.0	-1.0	-1.0	34.0
SS,MG/L	TOP	-1.0	-1.0	-1.0	-1.0	-1.0
TURBID,JTU	TOP	-1.0	-1.0	-1.0	-1.0	2.1
CHLO,MG/M3	TOP	-1.0	-1.0	-1.0	-1.0	-1.0
STATION: 15						
TKN,UG/L	TOP	-1.0	33.0	18.0	120.0	176.0
NO3N,UG/L	TOP	-1.0	29.0	33.0	9.0	17.0
TOT-P,UG/L	TOP	-1.0	23.0	16.0	20.0	83.0
SS,MG/L	TOP	-1.0	1.2	0.0	1.7	19.5
TURBID,JTU	TOP	-1.0	1.1	0.6	1.8	12.0
CHLO,MG/M3	TOP	-1.0	0.9	0.8	0.8	1.3
STATION: 15						
TKN,UG/L	TOP	-1.0	115.0	110.0	-1.0	-1.0
NO3N,UG/L	TOP	-1.0	8.0	10.0	-1.0	-1.0
TOT-P,UG/L	TOP	-1.0	11.0	15.0	-1.0	-1.0
SS,MG/L	TOP	-1.0	0.6	-1.0	-1.0	-1.0
TURBID,JTU	TOP	-1.0	1.3	3.5	-1.0	-1.0
CHLO,MG/M3	TOP	-1.0	0.9	-1.0	-1.0	-1.0

Table 3, cont.

STATION: 17						
TKN, UG/L	TOP	-1.0	-1.0	-1.0	-1.0	146.0
NO3N, UG/L	TOP	-1.0	-1.0	-1.0	-1.0	18.0
TOT-P, UG/L	TOP	-1.0	-1.0	-1.0	-1.0	29.0
TURBID, JTU	TOP	-1.0	-1.0	-1.0	-1.0	3.3
CHLO, MG/M3	TOP	-1.0	-1.0	-1.0	-1.0	0.8
STATION: 18						
TKN, UG/L	TOP	-1.0	-1.0	-1.0	61.0	216.0
NO3N, UG/L	TOP	-1.0	-1.0	-1.0	45.0	26.0
TOT-P, UG/L	TOP	-1.0	-1.0	-1.0	125.0	60.0
TURBID, JTU	TOP	-1.0	-1.0	-1.0	3.0	4.3
STATION: 21						
TOT-P, UG/L	TOP	-1.0	-1.0	-1.0	-1.0	62.0
TKN, UG/L	TOP	-1.0	-1.0	-1.0	-1.0	120.0
NO3N, UG/L	TOP	-1.0	-1.0	-1.0	-1.0	13.0
SS, MG/L	TOP	-1.0	-1.0	-1.0	-1.0	-1.0
TURBID, JTU	TOP	-1.0	-1.0	-1.0	-1.0	2.6
STATION: 23						
TKN, UG/L	TOP	-1.0	-1.0	-1.0	117.0	460.0
NO3N, UG/L	TOP	-1.0	-1.0	-1.0	31.0	49.0
TOT-P, UG/L	TOP	-1.0	-1.0	-1.0	107.0	126.0
TURBID, JTU	TOP	-1.0	-1.0	-1.0	200.0	8.0
STATION: 24						
TKN, UG/L	TOP	-1.0	-1.0	-1.0	-1.0	163.0
NO3N, UG/L	TOP	-1.0	-1.0	-1.0	-1.0	169.0
TOT-P, UG/L	TOP	-1.0	-1.0	-1.0	-1.0	58.0
SS, MG/L	TOP	-1.0	-1.0	-1.0	-1.0	-1.0
TURBID, JTU	TOP	-1.0	-1.0	-1.0	-1.0	2.5
CHLO, MG/M3	TOP	-1.0	-1.0	-1.0	-1.0	-1.0
STATION: 25						
TKN, UG/L	TOP	-1.0	-1.0	61.0	44.0	105.0
NO3N, UG/L	TOP	-1.0	-1.0	22.0	25.0	17.0
TOT-P, UG/L	TOP	-1.0	-1.0	16.0	5.0	42.0
SS, MG/L	TOP	-1.0	-1.0	-1.0	1.4	3.3
TURBID, JTU	TOP	-1.0	-1.0	0.5	0.5	1.1
CHLO, MG/M3	TOP	-1.0	-1.0	-1.0	2.1	0.4

Note: -1.0 stands for analysis not done

Source: Kauai Water Quality Study (1973)



LEGEND:

1 = SAMPLING STATIONS

2000 0 2000

GRAPHIC SCALE IN FEET

FIGURE 2

DELINEATION OF SAMPLING STATIONS—HANALEI RIVER

C. HISTORIC/ARCHAEOLOGICAL INTEREST

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA FPMR (41 CFR) 101-11.6

UNITED STATES GOVERNMENT

Memorandum

RECEIVED
OCT 1 ? 1976
REFUGES - OAHU

:Palmer C. Sekora, Refuge Manager
Hawaiian Islands Refuges, Kailua, HI

DATE: October 8, 1976

:Assistant Refuge Manager
Hawaiian Islands Refuges, Kilauea, HI

:CT: Historic Landmarks or Archaeological Sites on Huleia and Hanalei NWRs

This is progress report number 1 in response to your memo on above subject dated September 30, 1976. Additional information will be provided in the next week. I have given this matter high priority.

Information obtained October 6 is attached.

Fred
C. Fred Zeillemaker

Initial Contact: Catherine Stauder, Historian
Kauai Historical Society, Kauai Museum
4420 Rice Street (P.O. Box 248)
Lihue, Kauai, Hawaii 96766
Phone: 245-6931

10-6-76
Potential Contacts: (1) Mr. Francis Ching
Archaeological Research Center of Hawaii, Inc.
Lawai, Kauai, Hawaii 96765
Phone: 332-8521

(2) Mr. Bill (William) Kikuchi
Kauai Community College /4519 Ekolu
Puhi, Kauai, Hawaii 96766/Lihue
Phone: 245-6741 /245-4244

Sources: (1) Bennett's Archaeology of Kauai, 1931 (a 9-month inventory)

Hanalei: Site 141, 142, 143 ("one house site 4 miles up valley").

Huleia: Menehune Fish Pond (Chinese rebuilt 1890-1918), a second pond upstream on opposite side silted in.

(2) Albrecht and Belchet's Archaeology of Puna, Kauai

Huleia: Menehune Fish Pond.

(3) E. Craighill Handy and Elizabeth Green's (Ancient Hawaiian Agriculture) or Native Planting in Old Hawaii, Bishop Museum Bulletin No. 233.

(4) Dr. Timothy Earle, PhD Thesis: Irrigation Systems, Hanalei to Kalihiwai (address 7310 Pyramid Drive, Los Angeles, California 90046).

UNITED STATES GOVERNMENT

~~BUREAU OF SPORT FISHERIES AND WILDLIFE~~

Memorandum

TO : Palmer C. Sekora, Refuge Manager
Hawaiian Islands Refuges, Kailua, HI

DATE: October 22, 1976

FROM : Assistant Refuge Manager
Hawaiian Islands Refuges, Kilauea, HI

SUBJECT: Historic Landmarks or Archaeological Sites on Huleia and Hanalei NWRs

This is progress report number 2 in response to your memo on above subject dated September 30, 1976.

I met with Mr. William K. Kikuchi, archeologist and instructor in Anthropology, Kauai Community College, Lihue, Kauai, at noon October 21. We discussed the Service need for subject information and looked over the aerial photographs I took with the refuge boundaries marked on them. Mr. Kikuchi pointed out one site on the Huleia Refuge that he hopes to explore in depth at some future date. He marked the site on my photo, I have marked the approximate site on the attached map. He knows of no other sites on Huleia Refuge. He knows of no sites at Hanalei Refuge.

I met with Mr. Francis K. W. Ching, President of Archaeological Research Center Hawaii, Inc., Lawai, Kauai, at 1300 on October 21. We also discussed the Service need for subject information and looked over the aerial photographs. Mr Ching had topo maps with all known Kauai historical and archaeological sites marked on them. None were located within the boundaries of either refuge. Mr. Ching did recommend, however, that the dikes of the old taro paddies in Huleia Refuge be mapped before we develop new ponds.

Both men said that the type of work we would do on either refuge would not be destructive to any unknown house or village sites anyway, and if we did by some chance unearth something they would be willing to look at it for us. They said the type of activities that are destructive to ancient sites are building and highway or airport construction where extensive bulldozing and permanent construction was done.

While on the subject, I utilized payroll cost code 1500-320-6-- on my pay sheet for pp 702. Although such coding is contained in the Annual Work Plan Advices FY 1977, it was not included in our station Annual Work Plan Narrative. Please advise on further use of that code, as I have expended additional hours with this activity this period.

I would appreciate any recommendations you may have on further persuit of these matters. I have some library work yet to complete, but it now appears that there are no <u>known</u> sites on either Huleia or Hanalei Refuge.

Fred

C. Fred Zeillemaker

attachment

Assistant Regional Director (ER) November 3, 1976
Portland, Oregon

Refuge Manager, Hawaiian Islands NWR
Kailua, Hawaii

Historic Landmarks or Archaeological Sites on Hanalei and Huleia NWRs

Attached is subject memorandum from Assistant Manager Zeillemaker. His investigations indicate that we have no historic landmarks or archaeological sites on the Hanalei Refuge and possibly one on the Huleia Refuge; however, the one on Huleia is in a location which would not interfere with the development of the lowlands into shallow water or deep water impoundments as earlier contemplated.

Palmer C. Sekora

Enclosure

cc: ARD (RF)

BERNICE P. BISHOP MUSEUM

P. O. Box 6037, Honolulu, Hawaii 96818 • Telephone 847-3511

February 16, 1979

RECEIVED
FEB 20 1979
WILSON OKAMOTO & ASSOCIATES

Wilson Okamoto & Associates
1150 S. King Street
Honolulu, Hawai'i 96814

Gentlemen:

This letter is in regard to the project areas in Hanalei and Līhu'e, Kaua'i, as discussed with Mr. Sampson Mar last week.

We have conducted a thorough search of all available documented sources, including the Bishop Museum Hawaiian Archaeology files and the Statewide Inventory files, for any cultural resources that may be affected by the planned activities in each of these areas. This literature search revealed that no previously recorded sites are located within the limits of the areas indicated by you. However, two documented archaeological sites are located in the vicinity:

(1) Po'okū *heiau* in Hanalei (Bishop Museum site no. 50-Ka-D10-1; State site no. 50-30-03-139)

(2) Alakoko fishpond at Hulē'ia(Bishop Museum site no. 50-Ka-A3-5; State site no. 50-30-11-501).

Mr. Mar has informed us that the planned activities entail minimal alteration of land within the project boundaries. It is our conclusion at this time that no adverse impact will be exerted upon the sites in the vicinity. However, we do recommend that Mr. Francis Chang of Archaeological Research Center Hawaii (P. O. Box 285, Lāwa'i; 332-8521) and Dr. William Kikuchi of Kaua'i Community College (RR1, P. O. Box 216, Līhu'e; 245-8278) be contacted for additional and possibly more current information regarding these areas. A memorandum dated October 27, 1976, from Mr. Fred Zeillemaker, detailing information obtained from Mr. Ching and Mr. Kikuchi, was brought to our attention by Mr. Mar. It indicated that no archaeological surface features are present in the two areas, thus an archaeological reconnaissance survey will not be necessary. However, since there is a possibility that subsurface remains exist, if any artifacts, features, or other cultural materials are uncovered or exposed during the course of land alteration activities, a qualified archaeologist should be contacted to conduct salvage excavations and/or monitoring.

We appreciate your concern and if you have any questions please feel free to contact us.

Sincerely,

Yosihiko H. Sinoto
Yosihiko H. Sinoto
Chairman

YHS:gmo

C2315-2

UNIVERSITY OF CALIFORNIA, LOS ANGELES

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DEPARTMENT OF ANTHROPOLOGY
LOS ANGELES, CALIFORNIA 90024

March 7, 1979

RECEIVED
MAR 12 1979
WILSON OKAMOTO & ASSOCIATES

Mr. Sampson S. Mar
Wilson Okamoto and Associates, Inc.
1150 South King, Suite 800
Honolulu, Hawaii 96814

Dear Mr. Mar:

Sophie Cluff of Lihue has recently informed me of plans by the U.S. Fish and Wildlife Service to expand the irrigated taro fields in Hanalei, Kauai. Because my Ph.D. dissertation dealt with traditional taro production on Kauai's north coast, I felt that it would be useful to comment on the expansion plans and their impact on the historically important irrigation systems of Hanalei.

As I discuss in both my dissertation and a recent monograph published by the University of Michigan, the contemporary irrigation technology in Hanalei is remarkably similar to early historic and prehistoric practices. For the largest Hanalei system (which I describe briefly as System 26 on pages 245-247 of my dissertation), we have good evidence that the layout and operation of this system are based on a very old irrigation ditch pattern. This is shown by a sketch map made about 1850 (see Foreign Testimony Vol. 1, pages 55 and 56) and by a 1893 survey map (Government Survey Reg. Map Number 1833). It is my expert opinion that this irrigation ditch is basically unchanged from early historic times. Because of its considerable size and complexity for a tradition Hawaiian irrigation system, I consider it to contain extremely valuable information on historic agricultural practices.

With this in mind, I would make two alternative proposals that would resolve potential loses. First, and most desirable from a historian's viewpoint, the irrigation system on the west back of the Hanalei stream should be maintained without significant structural changes beyond expanding the number of taro patches. I would in fact strongly endorse having the two main systems in Hanalei and Waioli designated as historically significant by the National Historic Register. Second, if changes to the ditch are absolutely unavoidable, then the present ditch system should be accurately surveyed and precise data collected on the ditch size, slope, water carrying capacity, and construction techniques. Also, because there are surely historic and prehistoric sites directly associated with the ditch line, this strip should be carefully surveyed and evaluated by an archaeologist.

Although my interests in Hawaiian history make me favor the first alternative, I am very sympathetic to the need to expand wildlife habitat in the area and hope that this goal can be achieved. It should be noted that the existing ditch has in the past services much wider taro areas (perhaps as much as 100 hectares). Although such a system is somewhat inefficient because of water loss along the ditch, I would suggest that these costs are acceptable because of the clear historic value discussed above.

I am concerned and hope you may keep me informed as plans develop. Please let me know if any additional information would be helpful in your work.

Sincerely,

Timothy Earle
Timothy Earle
Assistant Professor

TE:js

P. S. Full references for the two publications discussed above are:

Earle, Timothy K.

1973 Control hierarchies in the traditional irrigation economy of Halelea district, Kauai, Hawaii. Ann Arbor: University Microfilms. [This is the original dissertation.]

1978 Economic and social organization of a complex chiefdom. Museum of Anthropology, University of Michigan, Anthropological Paper 63.

Both publications should be available in the library of the Bernice P. Bishop Museum, Honolulu.

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DEPARTMENT OF ANTHROPOLOGY
LOS ANGELES, CALIFORNIA 90024

April 5, 1979

RECEIVED
APR 9 1979
WILSON OKAMOTO & ASSOCIATES

Sampson S. Mar
Wilson Okamoto and Associates, Inc.
1150 South King Street
Honolulu, Hawaii 96814

Dear Mr. Mar:

Re: Hanalei and Huleia National Wildlife Refuge Improvements, Island of Kauai

Thank you for your recent letter of March 22 and I will try to offer some useful comments on the potential improvements at the Hanalei Refuge. My dissertation, which you have seen, contains the most detailed information on the Hanalei systems available. System 26 corresponds to your "west bank ditch" and System 29, to your "east bank ditch." As you can see from my dissertation, very little research has been done on these systems, and I am, therefore, most concerned that extensive information on traditional Hawaiian irrigation practices may be lost with any modifications.

With regard to the three areas of responsibility outlined in your letter, I can offer the following comments:

1. The "east bank ditch" (System 29) is not described in historic documentary sources and may be largely a late 19th-century rice system. I feel that piping water and abandoning the present ditch is a reasonable suggestion here. It would be desirable to map and to describe this ditch in some detail because of its possible historical significance.

2. The "west bank ditch" (System 26) is ancient and deserves careful consideration. I would strongly recommend against any changes and, if changes are to be undertaken, careful archaeological investigation of the present system and related features is <u>essential</u>. Would it not be possible to gain control over the upper section? I think this access should be guaranteed by traditional and state laws.

3. The areas which you indicate for expansion of taro have all been farmed in the past and are clearly appropriate for use without changing the historic significance of the area.

I am sending ycu a copy of my recent monograph (price $6) and hope it may clarify some issues. I am impressed by the care with which you are approaching this subject and I hope I will be of some help. Please continue to keep me informed about planned changes.

Sincerely,

Timothy Earle
Assistant Professor

TE:mrk

Ms. 062179

ARCHAEOLOGICAL RECONNAISSANCE SURVEY
WITHIN THE HANALEI WILDLIFE REFUGE
HANALEI, KAUA'I

by

Paul L. Cleghorn

Department of Anthropology
Bernice P. Bishop Museum

Prepared for
U.S. Fish and Wildlife Service
Honolulu, Hawai'i

June 1979

INTRODUCTION

This report presents the results of eight days of reconnaissance survey (May 9-11 and May 29-June 2) in specified areas within the Hanalei Wildlife Refuge, Hanalei Valley, Kaua'i. The survey was conducted by Paul Cleghorn and Tom Dye of the Department of Anthropology, Bernice P. Bishop Museum, under contract to the U.S. Fish and Wildlife Service, Honolulu, Hawai'i.

A walk-through reconnaissance-level survey is an extensive on-site survey to determine the presence or absence of cultural resources within specified parcels of land. Reconnaissance survey is the initial step in determining the need for additional archaeological work to mitigate the effects of proposed development.

The results of the first part of this survey (May 9-11) were reported previously (Cleghorn Ms.). Those findings are included in the present report to give a comprehensive picture of the results of reconnaissance survey within the Hanalei Wildlife Refuge. Area designations assigned in the first part of the survey (Cleghorn Ms.) have been changed in the present report.

DEFINITION AND SETTING OF THE PROJECT AREA

The project area consists of five spatially discrete areas, totalling approximately 315 acres (127.6 hectares), south of Kuhio Highway in Hanalei Valley (TMK 5-4-03) on the northern coast of Kaua'i. For convenience of description, these five areas have been given numerical designations (Fig. 1). The project area is in the traditional land division or *ahupua'a* of Hanalei, Hanalei District (Pukui, Elbert, and Mookini 1974:37, 40-41, Map 5).

The areas surveyed are situated on broad alluvial plains formed by the Hanalei River and on the lower valley slopes. The alluvial plains are composed of silty clay and silty clay loam, which are always wet and have slopes of 0 to 6%. The land is characterized by a high water table and is subject to flooding (Foote et al. 1972:38, 170-171). The project area lies between the less-than-10-ft and 100-ft elevation contours.

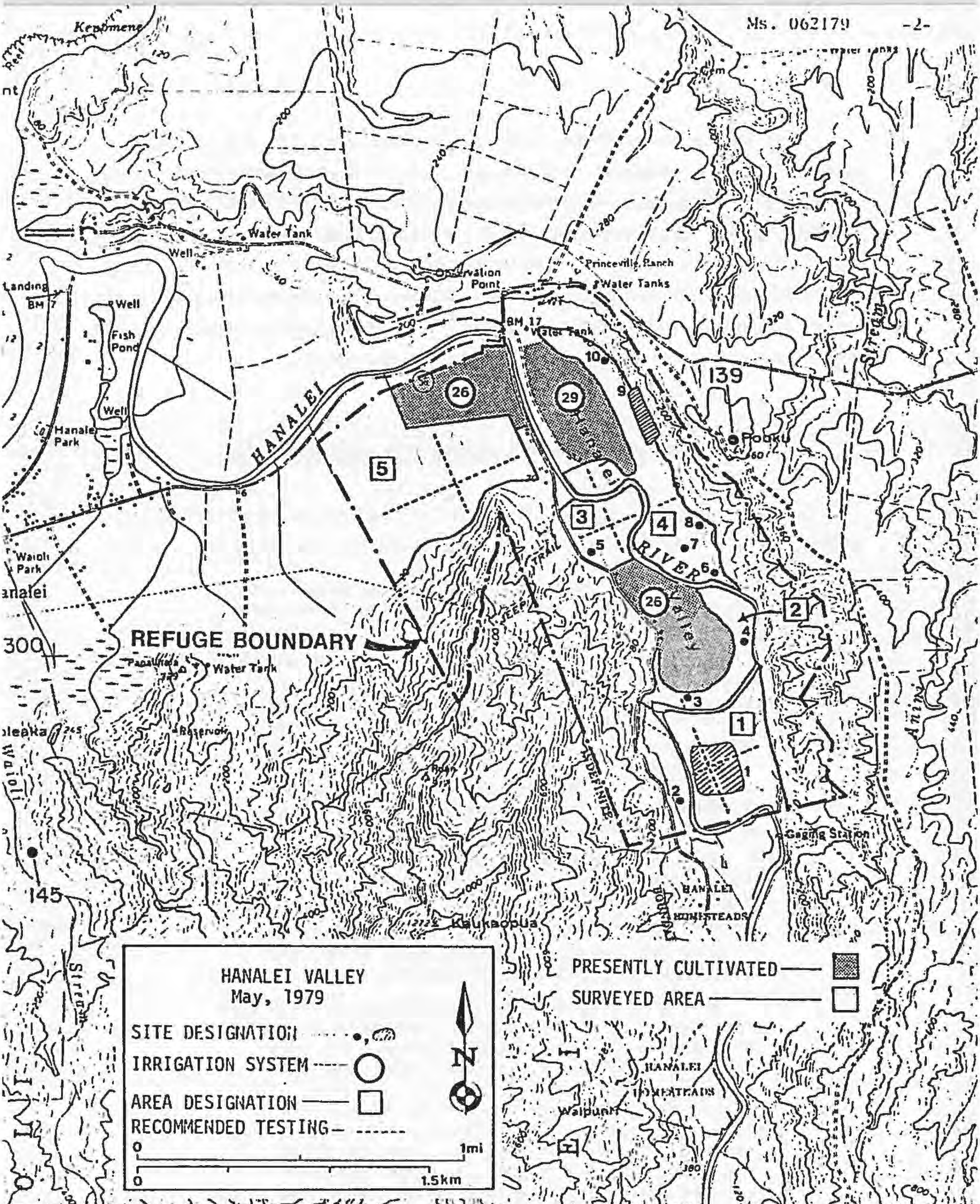

Fig. 1. MAP OF PROJECT AREA SHOWING AREAS SURVEYED AND SITE LOCATIONS. Recommended locations of test trenches on alluvial terraces within the Refuge are shown with dotted lines (see p. 18).

Portions of three of the areas surveyed (Areas 1, 3, and 4) are presently used as pasture land and are characterized as grasslands. Area 5 is totally in grassland. Area 2 and part of Area 3 had been thickly covered in *hau* (*Hibiscus tiliaceus* L.), until cleared by recent bulldozing. The valley slopes of Areas 1 and 4 are primarily covered with *hau*, though *hala* (*Pandanus odoratissimus* L.f.), breadfruit (*Artocarpus communis* Forst.), mango (*Mangifera indica* L.), and guava (*Psidium guajava* L.) trees, as well as various ferns, orchids, and grasses, are also present.

PREVIOUS ARCHAEOLOGICAL RESEARCH IN HANALEI VALLEY

In 1931, as part of his island-wide archaeological survey of Kaua'i, Bennett recorded three sites within Hanalei Valley, as follows:

> Site 141. Heiau and house sites, at Kalama-iki, an old village on the river flats, four miles up Hanalei Valley.
>
> There is a stone structure 18 by 20 feet with walls all around 2.5 feet wide and 2 feet high. In front is a paved section extending 5 feet, like a lanai, to a drop of 4 feet of the river terrace. The river is 50 feet out in front. Both river stones and rough rocks were used, but no coral was seen. The wall was chinked with smaller stones in front. Taro terraces and house sites are on the plains along the river.
>
> Site 142. Kaapoku heiau, inland from Site 141 in Hanalei Valley. This small shrine consists of a paved platform 18 by 20 feet made of rough stones. A village was across the stream.
>
> Site 143. Ditch and house sites, across the river from Site 142 in Hanalei Valley.
>
> Site also includes taro terraces and a ditch that runs from 0.5 mile or so up the stream to water this plain. The water comes through a big rock which is conveniently cracked. The legend runs, that Pele sent lightning to split the rock so that people could get water down to the fields. Upstream from here a large, overhanging rock forms a natural shelter. It has been built up along the front a bit. The house sites of the solidly paved type, as well as those merely outlined with stones, are found [Bennett 1931:134-135].

None of the sites recorded by Bennett are located within the Hanalei Wildlife Refuge boundaries.

Timothy Earle, during his doctoral dissertation research in the early 1970s, recorded six modern irrigation systems within Hanalei Valley (Earle 1973, 1978). Two of these, Systems 26 and 29, are located within the Refuge boundaries (see Fig. 1). In a letter to Sampson S. Mar of Wilson Okamoto & Associates, Dr. Earle stated that the "east bank ditch" ("Kuna Ditch") is not described in historic documentary sources and may be associated with a late-nineteenth-century rice system. Dr. Earle thinks that the "west bank ditch" ("China Ditch") is ancient (Wilson Okamoto & Associates 1979:appendix).

METHODOLOGY

The fieldwork involved traversing the five areas on foot to locate sites, recording brief written descriptions and general map locations, and photographing selected areas. Due to the poorly defined boundaries of some of the areas, the survey was designed to assure coverage of larger areas than were specified in the contract.

Site locations were plotted on an aerial photograph and on an aerial photograph contour map provided by the U.S. Fish and Wildlife Service. These site locations were later transferred onto a U.S.G.S. Quadrangle Map. All measurements were taken in the metric system and orientations were based on Magnetic North. Photographic recording was done using black and white film on 35-mm format.

Given the preliminary nature of this survey, permanent site designations were not assigned to the remains encountered. Permanent designations should be assigned when the remains are recorded in detail.

SURVEY RESULTS
(see Fig. 1)

Site 1 (Area 1)

This site is located on a broad alluvial plain that is bordered on three sides by the Hanalei River; the plain is approximately 2 meters above the present river level. At least eight distinct levels of agricultural terraces were distinguished on the N-S axis; there are also a number of different levels on the E-W axis, but a count was not made. This field system extends for approximately 185.0 meters N-S and 225.0 meters E-W, an area of about 4.7 hectares. In some instances, smaller plots within the larger terraces were distinguished. The most distinct *lo'i* (irrigated terrace) measures approximately 20.0 meters N-S by 55.0 meters E-W.

Just to the east of these terraces are three non-functioning *'auwai* (irrigation ditches). One *'auwai* is located near the present level of the river and runs parallel to it. It measures approximately 0.8 meter wide by 0.8 meter deep, and could be traced for only about 20.0 meters; it has been severly eroded by the river. The banks of this *'auwai* are constructed of earth and stone. Another *'auwai* extends in an E-W direction and measures approximately 0.7 meter wide by 0.3 meter deep. It is fed by a larger ditch (c. 1.4 meters wide by 0.7 meter deep) that is situated approximately 15.0 meters above the river level at the eastern corner of Area 1. This large ditch originates upriver, probably at the next large bend in the river, approximately 1.2 kilometers distant. It could only be traced some 250 meters into Area 1, where it has been obliterated by erosion.

Site 2 (Area 1)

This site is located on an alluvial terrace on the W side of the Hanalei River, SW of Site 1. Two or three possible agricultural terraces were found here. The boundaries of these terraces are indistinct, possibly due to flood erosion. One *'auwai*, extending SE-NW and measuring 1.0 meter wide and 0.2 meter deep, is located here.

Site 3 (Area 2)

This site is located in an area that has been extensively bulldozed, on the W bank of the Hanalei River, N of Site 1. It is a stacked-stone wall (c. 112.0 meters long, 1.6 meters wide, and 0.8 meter high) constructed of waterworn boulders (Fig. 2). The wall is located on the margin between an area of active taro cultivation and the bulldozed area; the E end has been

Fig. 2. SITE 3, STACKED-STONE WALL.

truncated by bulldozing activity. The wall extends in an E-W direction, on the S side of an inactive *'auwai,* which branches off from an active *'auwai* that supplies water to the adjacent taro fields.

Site 4 (Area 2)

This site, located NE of Site 3 and in an area of extensive bulldozing, is the cement foundation of a historic-period structure, that has been disturbed by *hau*-clearing activity. Fragments of glass bottles were observed on the surface near the foundation. Although no measurements were taken at this site, it is comparable in size to Feature C of Site 5 (see below).

Site 5 (Area 3)

This site, on the W side of the river, has been damaged by bulldozer activity. Situated atop the toe of a ridge, approximately 4 to 5 meters above the alluvial plain, are the remains of three historic features, described below.

Feature A is a cement foundation (c. 8.0 by 12.0 meters), with alignments of stone set into the cement on three sides (Fig. 3). The E side is indistinct because of bulldozer disturbance.

Feature B is located approximately 40.0 meters N of Feature A. This feature is almost totally destroyed, but is evidenced by a concentration of small boulders covered with cement (c. 3.0 by 5.0 meters).

Feature C is located approximately 30.0 meters E of Feature B. It is a cement foundation measuring approximately 22.0 by 14.0 meters, and has also been damaged by bulldozer activity.

Artifacts from the historic period litter the surface in the vicinity of these three features. These include ceramics, fire bricks, and seamless glass bottles. No prehistoric artifacts were observed.

Possibly due to the extensive bulldozing in Area 3, surrounding Site 5, no agricultural terraces were found. However, two *'auwai,* with average measurements of 1.0 meter wide by 0.8 meter deep, were observed in the area. One originates from the "China Ditch," which runs parallel to 'Ōhiki Road, and the other from the active taro fields to the S.

Fig. 3. SITE 5, FEATURE A, WITH STONES SET INTO CEMENT ALONG W SIDE.

Site 6 (Area 4)

This site, located on the E side of the Hanalei River, consists of three contiguous agricultural features, situated on an elevation above the "Kuna Ditch." The northern two features are earthen terraces, each measuring approximately 10.0 by 15.0 meters, with the eastern terrace approximately 0.5 meter higher than the western one. The third feature, located S of the eastern terrace, is a depression measuring approximately 15.0 by 15.0 meters by 0.5 meter deep, partially bounded by a boulder alignment. An *'auwai* (c. 0.5 meter wide by 0.3 meter deep), constructed of earth and stone, originates at the depression and extends along the eastern side of the two terraces for approximately 45.0 meters N to a swampy area.

Site 7 (Area 4)

This site, located on the E side of the river, consists of two historic features that have been extensively disturbed by bulldozer activity. They are described below.

Feature A is the remains of a foundation (c. 1.7 by 1.4 meters by 0.4 meter high) constructed of waterworn stones (cobbles and small boulders) and cement (Fig. 4). Approximately 0.6 meter E of this foundation is an alignment of small boulders, measuring approximately 2.5 meters in length. Lying on the surface here are three lengths of threaded metal pipe.

Feature B is a concentration of well-sorted, cement-covered waterworn cobbles. This concentration measures approximately 8.0 by 10.0 meters.

Artifacts from the historic period litter the surface in the vicinity of these two feature. These include fragments of glass bottles (with and without seams) and of ceramics and metal, and the head of a metal pickaxe. No prehistoric artifacts were observed.

Site 8 (Area 4)

This site, situated atop a knoll on the E side of the Hanalei River, is an enclosure measuring 7.0 by 10.5 meters. The downslope boundary is marked by a two-stone-high facing wall (c. 0.4 meter). The sides are marked by alignments of stone, and the back by six boulders. Features within this

Fig. 4. SITE 7, FEATURE A, A HISTORIC FOUNDATION.
Note lengths of metal pipe and stone alignment.

enclosure include an alignment of stone, 3.5 meters in length, and a probable fireplace marked by three stones and with interior measurements of 0.12 by 0.39 meter (Fig. 5).

Site 9 (Area 4)

This site is located on the lower valley slopes, between the 25- and 125-ft elevation contours on the E side of the Hanalei River. It is an extensive, discontinuous terracing system on ridges between four small streams, covering an area of approximately 80.0 by 260.0 meters. Some of the terraces are simply bounded by single-stone alignments, while others have terrace facings approaching 2 meters in height (Fig. 6). One extensively terraced area covers approximately 50.0 by 50.0 meters and has seven terrace levels on the N-S axis. One possible habitation feature was found at this site. It is roughly square in plan (c. 4.5 by 5.0 meters) and is demarcated on three sides with single-stone alignments.

Several economically useful plant species were seen in this site area. These consist of ti (*Cordyline terminalis* [L.] Kunth), *hala* (*Pandanus odoratissimus* [L.f.], banana (*Musa* sp.), and breadfruit (*Artocarpus communis* Forst.). Feral taro (*Colocasia esculenta* [L.] Schott) is growing in a water seep (Fig. 7).

Site 10 (Area 4)

This site is located on the E side of the river, N of Site 9. It consists of an L-shaped wall, measuring approximately 20.0 by 50.0 meters by 0.3 meter high. The wall was cut through by the construction of the "Kuna Ditch."

Area 4

The survey determined that the grasslands of this area, W of Sites 9 and 10, were previously in irrigated cultivation and the fields probably extended over the entire area. Field observation was supported by an early twentieth-century panoramic photograph in the Bishop Museum Photo Archives (Fig. 8). The number and size of the separate *lo'i* could not be determined in the field, due to the high grass cover (c. 1.5 meter high).

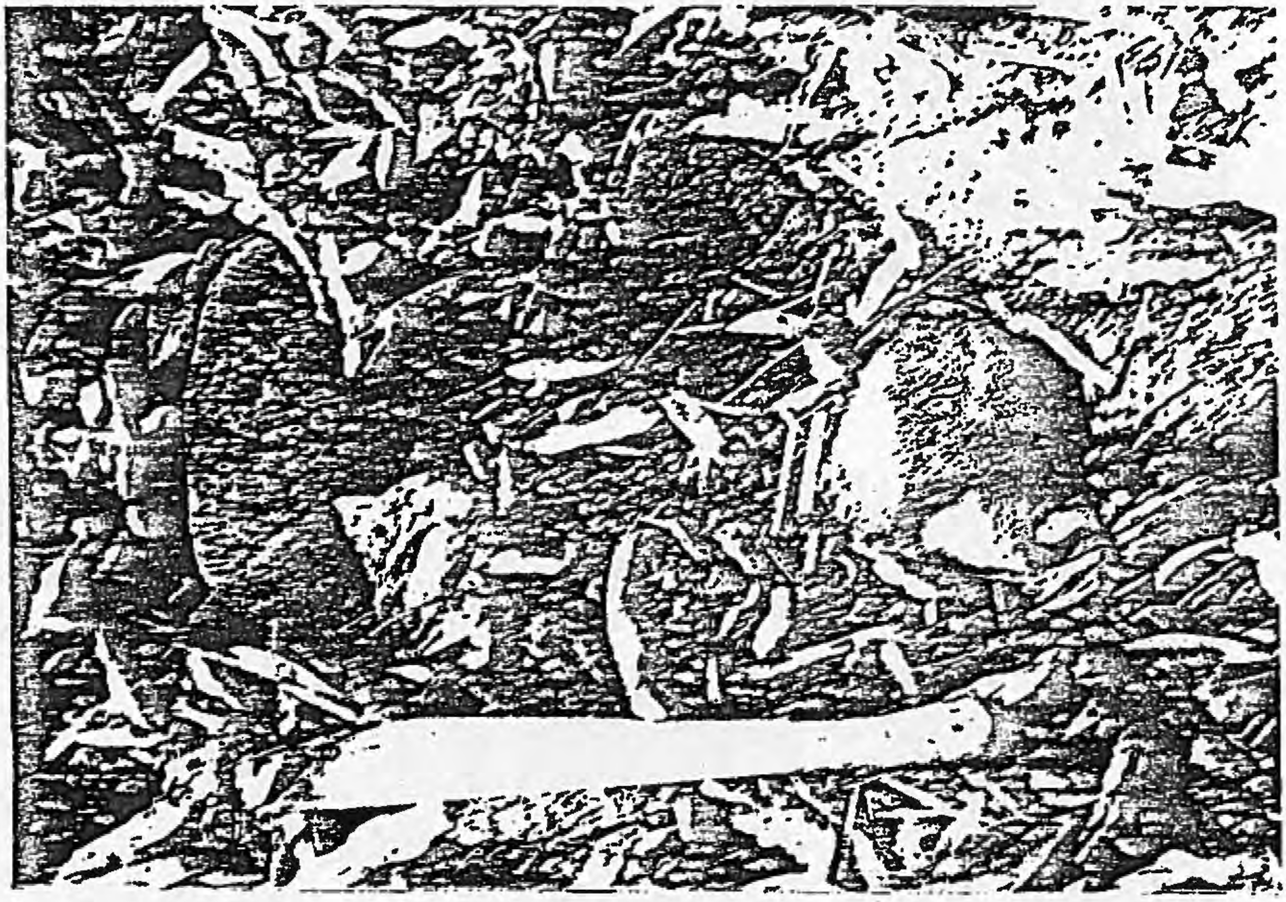

Fig. 5. SITE 8, FIREPLACE. Machete is 54.5 centimeters long.

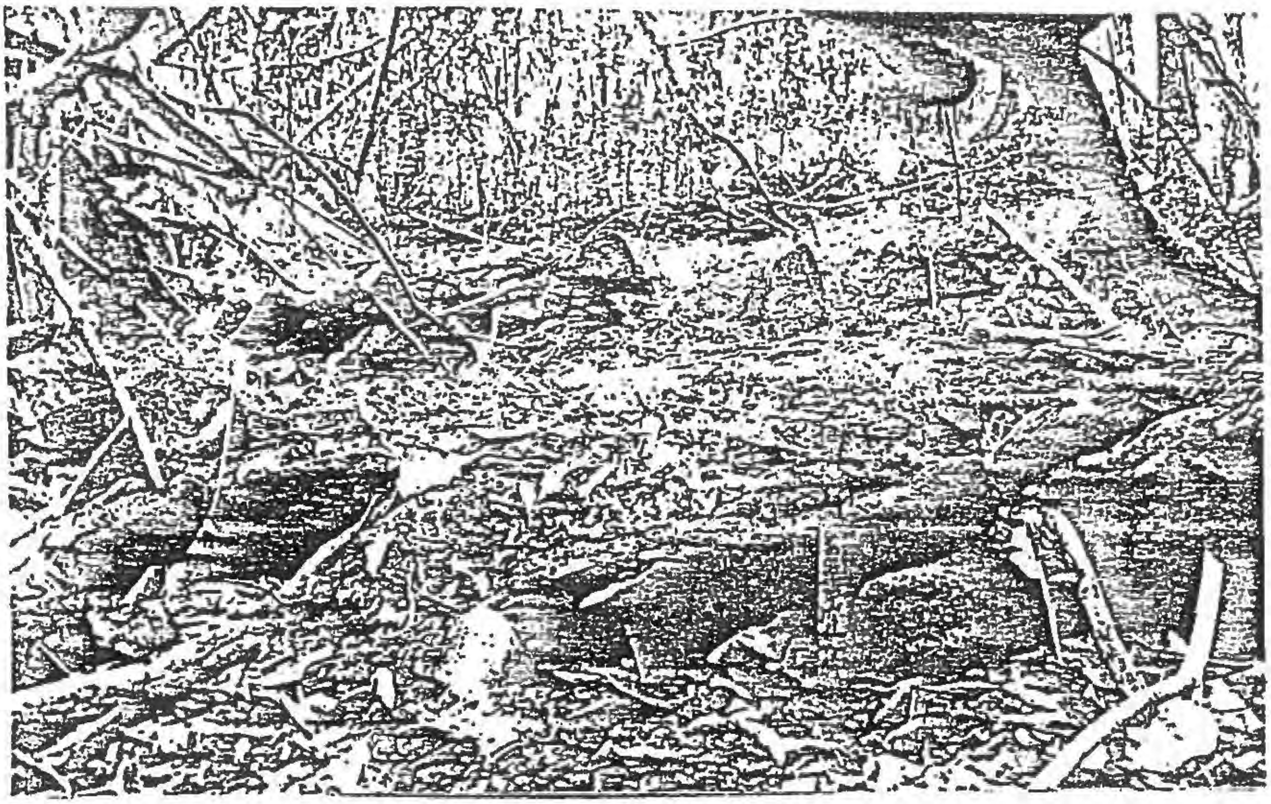

Fig. 6a. SITE 9, SINGLE-STONE ALIGNMENT FORMING TERRACE BORDER.

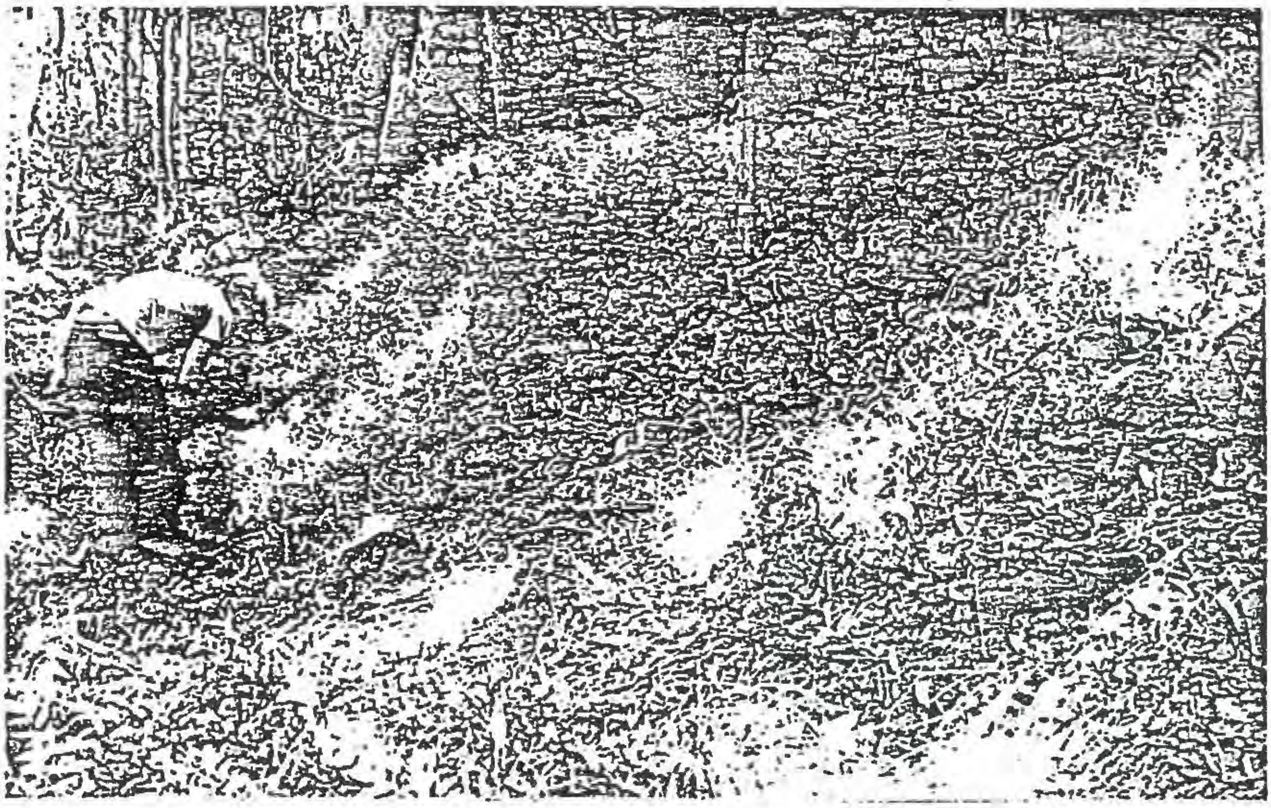

Fig. 6b. SITE 9, TERRACE FACING.

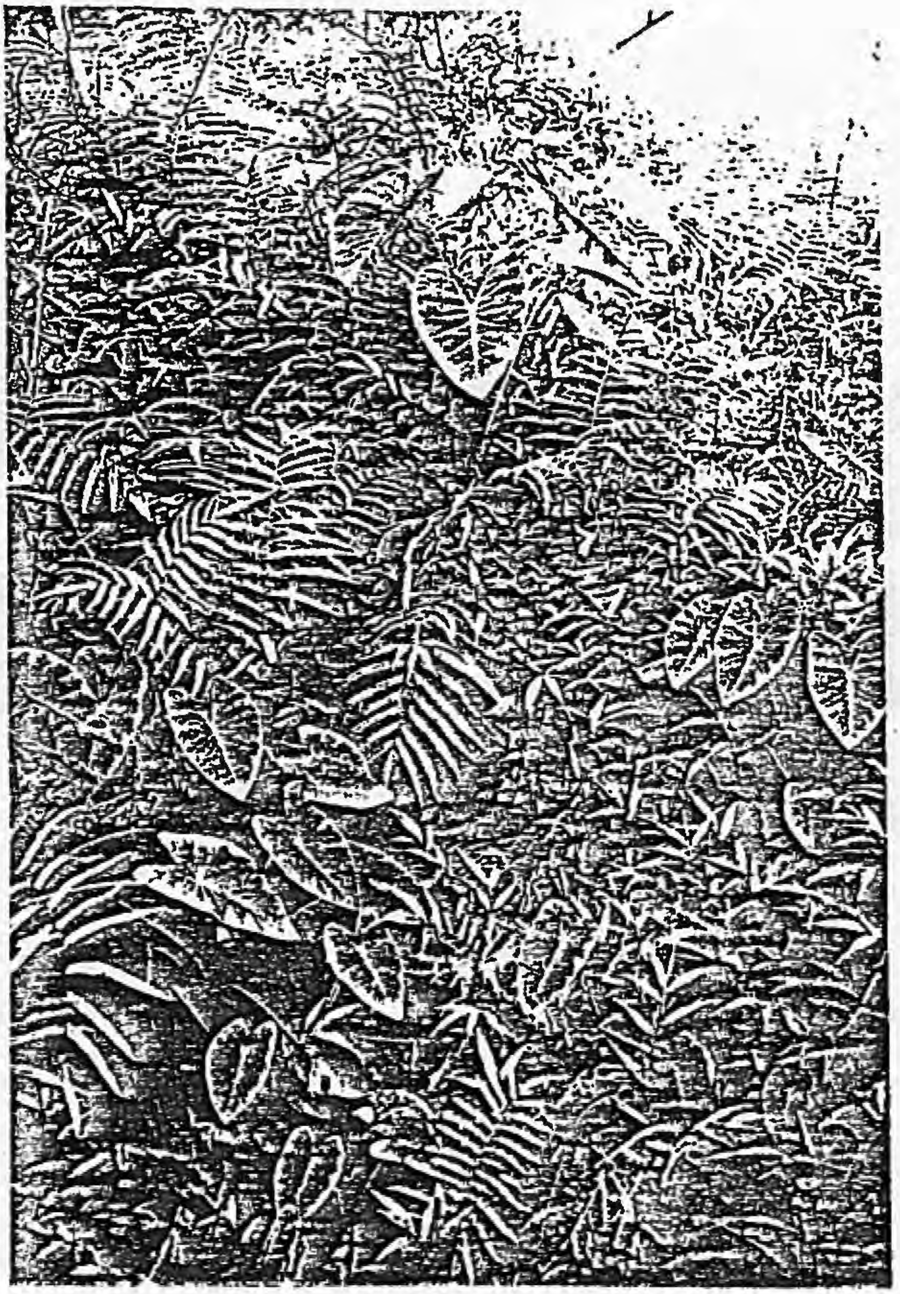

Fig. 7. FERAL TARO GROWING IN WATER SEEP AT SITE 9.

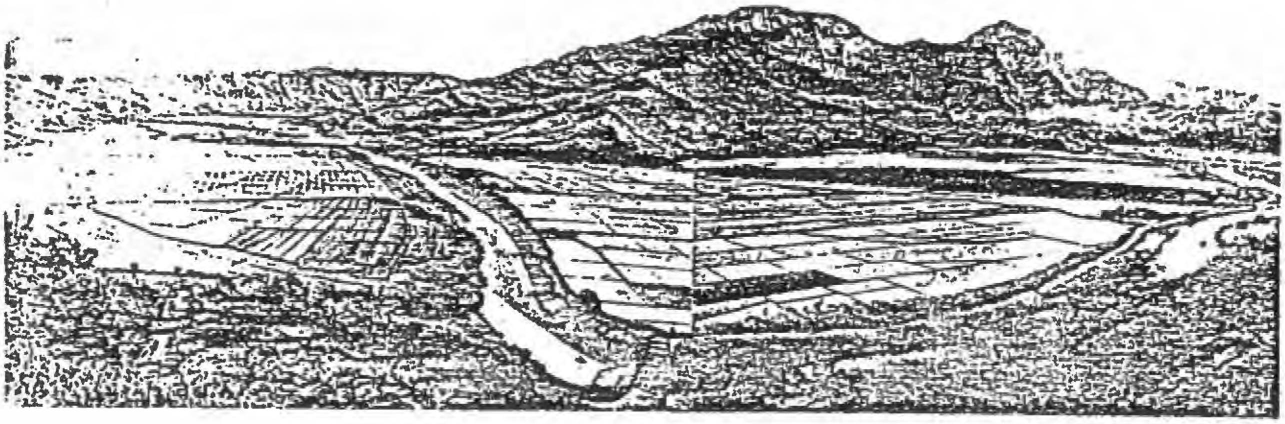

Fig. 8. PANORAMIC PHOTOGRAPH OF HANALEI VALLEY
TAKEN BY BAKER IN THE EARLY TWENTIETH CENTURY.
(Bishop Museum Photo Archives)

Area 5

This area is S of the portion of the Hanalei River that paralles Kuhio Highway and is presently in pasture land. The area was previously in irrigated cultivation, and the field system covered approximately 70 hectares. At least thirteen *lo'i*, separated by *'auwai*, were observed. The *'auwai* range from 0.5 to 7.0 meters wide and 0.2 to 1.2 meters deep. The water that fed these *'auwai* came from a larger ditch (c. 8.0 meters wide by 1.0 meter deep) that runs from E to W near the edge of the ridge slope and probably was connected to the "China Ditch." Examination of Figure 8 shows that our estimate of thirteen *lo'i* is conservative.

DISCUSSION

Evidence of irrigated cultivation was observed on all alluvial terraces surveyed. The terraces on the E side of the Hanalei River were probably irrigated by the "Kuna Ditch," and those on the W side by the "China Ditch."

An examination of photographs taken in the early 1900s indicates that all of the lower valley was in rice cultivation. The formerly irrigated systems that were found on the alluvial terraces (including Sites 1, 2, and 3) were probably associated with this activity. The historic-period foundations (Sites 4, 5, and 7) were probably also related to rice cultivation. Although all of these remains probably date from post-contact times (after 1778), they constitute cultural resources and are an important component of the history of the Hanalei area. It appears, therefore, that these remains may be eligible for nomination to the National Register of Historic Sites based on the criteria that they "may be likely to yield information important in prehistory or history" (36 CFR Part 60.6, criteria d).

The three agricultural sites found (Sites 6, 9, and 10) are situated on the lower valley slopes at an elevation above the historic-period "Kuna Ditch;" they probably date to prehistoric times. These sites could not have been irrigated by the "Kuna Ditch." Site 6 was probably irrigated, though the source of the water was not determined. Site 9 may have been irrigated by the small streams that are located within its boundaries. If the eastern valley ridge was forested prehistorically, more water would have infiltrated and thus increased low flow of the stream, enabling irrigation of these agricultural features. Whether or not Site 10 was irrigated cannot be determined at this time.

Site 8, the remains of a habitation structure, probably also dates to the prehistoric occupation of the valley.

A question put forward in the first report on the Hanalei Wildlife Refuge (Cleghorn Ms.:5-6) regarded the extent of pre-rice or taro cultivation within the survey area. The finding of three agricultural sites (Sites 6, 9, and 10) at elevations above the historic-period "Kuna Ditch," as well as the probable prehistoric habitation site (Site 8), allows us to hypothesize about the extent of prehistoric cultivation. Given that these sites are situated on relatively marginal land, as compared to the fertile alluvial soils on the river flats, it is hypothesized that all of the alluvial terraces in the present Refuge area were cultivated, which forced agricultural pursuits into more marginal lands. Furthermore, given Bennett's (1931) findings farther up the valley, we can predict that all broad alluvial terraces within the valley were cultivated prehistorically.

From the data so far obtained, it appears that the Hanalei Valley has had a long and productive history. Beginning at some time in the past, taro was extensively cultivated; in the late 19th and early 20th centuries rice cultivation supplanted that of taro. Today the lower valley is used for both limited taro cultivation and pasturage for cattle; new taro fields are presently being constructed. The Fish and Wildlife Service, the present ward of this land, is planning to expand the amount of area in taro cultivation and to create ponds for the endangered Hawaiian stilt. The Hanalei Valley should not be considered as a preserved, static site that functions to substantiate a national mythology of a past cultural system (Leone 1973:129ff.), but as a dynamic, living system, where taro, a main staple of the prehistoric Hawaiian culture, is cultivated. It can also serve as an example of how man can co-exist with an endangered species.

RECOMMENDATIONS

Given the results of the reconnaissance survey of specified areas within the Hanalei Wildlife Refuge, the following specific recommendations are offered:

(1) Detailed mapping and surface collection of artifacts at the historic-period sites (Sites 4, 5, and 7), in order to obtain data on the historic use of this area, and test excavations to determine presence/absence of subsurface evidence of prehistoric occupation.

(2) Detailed recording and test excavations at the three probable prehistoric agricultural systems (Sites 6, 9, and 10). Test excavations would be carried out to obtain both direct and indirect evidence for cultivation. Direct evidence would consist of macro-flora remains; indirect evidence would consist of the sediment record, soil structure, and presence of land snails indicative of the habitat at the time of deposition. An ethnobotonist should be consulted in the field so that the agricultural implications of the data recovered can be better interpreted.

(3) Detailed recording and test excavations at the two habitation structures found (Site 8 and one feature in Site 9). Excavations would be directed at recovery of food refuse, artifactual material, and organic material or volcanic glass for dating occupancy and, by association with agricultural systems, determining the antiquity of agricultural pursuits in the valley.

(4) Bi-directional, discontinuous trenching of the alluvial terraces, with the use of a backhoe. Such a system of excavations would cover approximately 2,500 linear meters (Fig. 1), with 2-meter-long trenches excavated at 50.0-meter intervals. This would amount to 50 small profiles through the impacted area. The stratigraphic record obtained from these trenches would enable determination of the presence of older agricultural walls or embankments and earlier pond soils. A complete sedimentological record of the lower valley would also be obtained.

Soil samples collected from these excavations would be analyzed in the laboratory, to substantiate or refute in-field observations.

(5) A review, by a historian, of the legendary history of the area and the literature pertaining to early historic-period land use within Hanalei Valley.

We also recommend that prior to any further land alteration activities, a program of archaeological surveys be implemented that will provide for the location of any cultural resources, determination of significance according to National Register eligibility criteria, and appropriate action to mitigate any adverse impact to any significant cultural resources within the Hanalei Wildlife Refuge.

The recommendations could be implemented either in a single program or phased to coincide with plans for land alterations in the Wildlife Refuge. Either way, they would be important to preserving and augmenting our understanding of the prehistoric agricultural adaptation on Kaua'i and in the Hawaiian Islands in general.

BIBLIOGRAPHY

Bennett, W.C.
1931 *Archaeology of Kauai.* B. P. Bishop Mus. Bull. 80.

Cleghorn, Paul L.
Ms. Archaeological Reconnaissance Survey of Specified Areas within the Hanalei National Wildlife Refuge, Hanalei, Kaua'i (May 1979). On file in Dept. Anthropology, B. P. Bishop Mus.

Earle, Timothy K.
1973 *Control Hierarchies in the Traditional Irrigation Economy of Halelea District, Kauai, Hawaii.* Ph.D. Dissertation. University Microfilms. Ann Arbor.

1978 "Economic and Social Organization of a Complex Chiefdom." *Museum of Anthropology, University of Michigan, Anthropological Paper* 63.

Foote, D.E., E.L. Hill, S. Nakamura, and F. Stephens
1972 *Soil Survey of the Islands of Kauai, Oahu, Maui, Molokai, and Lanai, State of Hawaii.* U.S. Department of Agriculture, Soil Conservation Service, in cooperation with the University of Hawaii Agricultural Experiment Station.

Leone, Mark P.
1973 "Archaeology as the Science of Technology: Mormon Town Plans and Fences." IN C.L. Redman (ed.), *Research and Theory in Current Archaeology.* New York: John Wiley and Sons.

Pukui, Mary Kawena, S.H. Elbert, and E.T. Mookini
1974 *Place Names of Hawaii.* Honolulu: The University Press of Hawaii.

Wilson Okamoto & Associates
1979 *Preliminary Engineering Evaluation for Hanalei National Wildlife Refuge, Hanalei District, Kauai, State of Hawaii.* Honolulu.

D. TARO CONTROVERSY

The purpose of including the following newspaper articles from the Honolulu Advertiser, and the Honolulu Star-Bulletin is to:

(1) present the controversy regarding the amounts of water required to cultivate taro.

(2) show that there are urbanization pressures in Hawaii, which are encroaching upon the agricultural lands, particularly taro. The problems experienced by the taro farms on Oahu, emphasize the importance of the taro cultivation in Hanalei, Kauai.

HONOLULU ADVERTISER - FEBRUARY 13, 1979

Anger flows in torrents at Waihee stream rulin

By VICKIE ONG
Advertiser Staff Writer

A state judge yesterday awarded Waihee taro farmers an additional 400,000 gallons daily in stream flow — but one farmer angrily denounced the decision as a "drop in the bucket."

Another farmer said if the decision is allowed to stand — or even kept in effect during a long appeal process — "there won't be any taro left on the Island." But a water board attorney said it also is a "loser" in the case because it too needs water from Waihee stream.

Their comments came after Circuit Judge Arthur S.K. Fong yesterday upped the guaranteed stream flow to the taro farmers in Windward Oahu's Waihee Valley from 2.3 million gallons to 2.7 million gallons daily. The amount was far less than the farmers sought — 4 million gallons — and far more than the Honolulu Board of Water Supply wanted to give up.

The 400,000 gallons is roughly the amount of water used by 1,200 families each day.

"It sounds like a loser for both sides," said Samuel King Jr., attorney for the water board.

Ronald Albu, attorney for the six farmers, said, "I'm sure it'll be appealed by both sides. There wasn't a shred of evidence that they (the farmers) could get by with less (than 4 million gallons)."

Albu, who may try to expedite the case to the Hawaii Supreme Court, said with the 2.7 million gallons of stream flow, the farmers "can't make it through the summer."

After the decision was announced, Charles Reppun, one of the plaintiffs, exploded in anger in the court corridors.

"It's disgusting the way this thing works . . . 2.3 to 2.7 (million gallons) — what is that? Is that what the people in Hawaii want? The time is coming when there won't be any food and people will be ripping off food from the farmers.

"All he added was a drop in the bucket. We provide food for thousands of people. It's sick; it's sick. We're all going to live in suburbs. Where are we going to get all of our food?"

The taro farmers are fighting the water board because a tunnel and six wells capable of diverting 8 million gallons daily have dropped stream levels.

The farmers wanted some of the projects in the Waihee mountains shut down to allow a stream flow of 4 million gallons — the amount they say is needed to grow healthy taro. The water board maintained that Waihee is an essential source for meeting water needs of Windward residents.

In August 1977, Fong granted a preliminary injunction awarding the farmers 2.3 million gallons daily.

In his ruling yesterday, Fong said the Waihee decision was probably "the most difficult" one in his 4½ years on the bench because of the "confusion" in water rights law.

He said the case was also complicated by the varying amounts of water, ranging from 30,000 to 50,000 gallons per acre daily, said to be needed to grow taro. This particular issue, he said, gave him "much headache."

"The problem is compounded by poor planni water resources by the state," Fong added.

He said based on his on-site inspection and the mony of the farmers themselves, the original aw 2.3 million gallons is "not sufficient" to effectively taro.

But, he said, there is "inadequate water" o Windward side to supply both taro farmers and Windward needs. He felt the addition of 400,000 g would adequately meet the farmers' needs.

In an interview later with The Advertiser, Fong "There is no magic number." He said taro e merely cited gallonage figures they would be "co able" with or gave rough estimates.

"I had to use my best judgment," he said.

He told The Advertiser that "if you grant the fa what they're asking for (4 million gallons), there'd pumping from the Board of Water Supply" at W Fong said under a 4-million-gallon restriction, the board would be unable to build up storage in the W tunnel during the wet months for use during the summer months.

"In effect," Fong said, "there'd be no water Waihee — maybe 2 million gallons at best."

"I think farmers have reasonable water needs — that's all," Fong said, adding that just because one lives adjacent to a stream doesn't mean he ca stream water to wash his car excessively or set commercial car wash.

Fong said there are ways a taro farmer can co "he can pump some of the water back (that is downstream) or maybe he can clean the stream get rid of the weeds.

The farmers reacted with a mixture of anger, fr tion and sadness at Fong's decision.

Charles Reppun, often the spokesman for the ers, said, "We made our decision a long time ago decided this is our way of life and we're not goi give up our way of life."

Reppun complained that "nobody else has to water" — just the farmers by cutting back on pr tion.

He said Oahu had 1,000 acres of taro in 1930, 345 in 1955 and just 15 in 1979. Waihee Valley, where th farmers work their taro fields or hope to get into production, is the source of the only commer grown taro on Oahu.

Paul Reppun, brother of Charles and also a plai said, "Do we have to wait five years for it to go t Supreme Court? In five years' time, there won't be taro left on the Island."

Rachel Hall, a taro farmer since 1945, said, "I operate any more fields. That water is not enoug me. I was just stunned. I thought we could get a more water (than Fong awarded). I have to try an the best I can. I hate to give up taro. I really lov life. It's hard work, but I enjoy it."

Decision in Kauai Case Is Cited as Waihee Water Trial Begins

By Harry Whitten
Star-Bulletin Writer

Water needs of Waihee taro farmers, water needs of Windward Oahu, and riparian rights were among the questions argued yesterday as the Waihee water case trial opened in Circuit Judge Arthur S.K. Fong's court.

Five plaintiffs, Charles and Paul Reppun, Robert and Seiyu Nakata, and Rachel Hall, seek a permanent injunction to stop the Honolulu Board of Water Supply from diverting any water from Waihee Stream in Kahaluu.

Judge Fong had issued a preliminary injunction in August 1977, directing the water board to stop diversion of 600,000 gallons of water per day so the farmers would have at least 2.3 million gallons a day.

Yesterday's trial was a partial education in taro culture and economics, as well as Windward water development.

RONALD ALBU, attorney for the farmers, said the farmers are asking their riparian right to the natural flow of the stream, holding that the Hawaii Supreme Court's decision in the McBryde Sugar Co. vs. Robinson case is applicable.

In this case, which was a dispute between two Kauai sugar plantations over Hanapepe Stream water, the Supreme Court ruled that water rights could not be transferred to the detriment of others along the waterways.

In answer to a question from Judge Fong, Albu said the plaintiffs maintain the Board of Water Supply "bought nothing" when it bought Waihee water rights in 1955 for $1 million.

The water board had filed a condemnation suit to acquire the water rights from the Koolau Co. to which they had been transferred in 1950 from Bishop Trust Co.

"THE PLAINTIFF farmers contend the Bishop Trust Co. could not lawfully sever water rights from the lands that were conveyed to plaintiffs under doctrines enunciated in the McBryde case ..." the farmers' attorneys say in their brief.

The brief says the burden should be on the defendant water board to show that no riparian owner will be injured by its "massive water diversions of more than 6 million gallons per day from Waihee Stream."

Samuel P. King Jr., attorney for the water board, said the condemnation of Waihee waters in 1955 occurred 20 years before the McBryde case.

He said there are only 15 acres of taro being cultivated in Waihee, that the plaintiffs are asking for at least 4 million gallons a day and that this is too much.

HE SAID THIS would add up to more than 200,000 gallons per acre per day and added there is a serious problem supplying water for the Windward system.

"There is no way we could replace that source," he said.

He said equity requires a balance. [...] said with the taro farmers taking [...] million gallons a day, the water bo[...] barely made it through the summer [...] supplying Windward needs, and that i[...] million gallons had been taken, th[...] would have been problems.

The farmers had said, in their br[...] that while they were entitled to all [...] water from Waihee Stream, they'd [...] willing to take 4 million gallons per [...] to give the water board time to ph[...] out its diversion facilities over the n[...] year or so.

They say taro requires cold wa[...] flowing through the fields, in large qu[...]tity, to prevent rot from ruining the t[...]

ALBU CALLED AS witnesses Se[...] Nakata, 83-year-old farmer and his s[...] Robert; Charles and Paul Repp[...] Rachel Hall and Clifford Wong.

The senior Nakata, who still wo[...] daily in his taro fields, said he had b[...] on his present plot for 30 years.

John Y.C. Chang, head of the plann[...] and engineering section in the Board [...] Water Supply, was called as a witn[...] by both Albu and King.

He said the Waihee water source gi[...] the water board a flexibility that [...] other Windward source does. He w[...] questioned extensively about sustain[...] capacity of Windward sources, dema[...] and yield of wells.