Revised Environmental Impact Statement for the Proposed Waikane Golf Course Project

Waikane, Koolaupoko District, Oahu, Hawaii

Volume II

Prepared for
Waikane Development Company

February 1989

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REVISED ENVIRONMENTAL IMPACT STATEMENT
FOR THE PROPOSED
WAIKANE GOLF COURSE PROJECT
WAIKANE, KOOLAUPOKO DISTRICT, OAHU, HAWAII

VOLUME II
TECHNICAL REPORTS

PREPARED FOR

WAIKANE DEVELOPMENT COMPANY

February 1989

VOLUME II

TECHNICAL APPENDICES

A. "Roads Report for the Proposed Waikane Golf Course"; Waikane, Koolaupoko, Oahu, Hawaii; October, 1988, Engineering Concepts, Inc.

B. "Wastewater Management Plan for the Proposed Waikane Golf Course Project"; Honolulu, Hawaii; October 1988, Engineering Concepts, Inc.

C. "Water Supply Report for the Proposed Waikane Golf Course Project"; Honolulu, Hawaii; October 1988, Engineering Concepts, Inc.

D. "Proposed Groundwater Development Lower Waikane Valley, Oahu"; Honolulu, Hawaii; 21 March 1988, Mink, John F.

E. "Socio-Economic Impact Assessment for Proposed Waikane Golf Course"; October 1988, Community Resources, Inc.

F. "Drainage Report for the Proposed Waikane Golf Course Project"; Honolulu, Hawaii; October 1988, Engineering Concepts, Inc.

G. "Environmental Aspects of Storm Water Runoff Waikane Golf Course"; March 1988, Dugan, Gordon L.

H. "Soil Erosion Report for the Proposed Waikane Golf Course Project"; Honolulu, Hawaii; October 1988, Engineering Concepts, Inc.

I. "Waikane Golf Course Traffic Impact Assessment Report"; February 1988, Pacific Planning & Engineering, Inc.

J. "Archaeological Reconnaissance Survey and Limited Subsurface Testing for Waikane Golf Course"; Hilo, Hawaii; July 1988, Paul H. Rosendahl, Ph.D., Inc.

K. "Biological Survey of Waikane Stream, Windward O'ahu"; Waimea, Hawaii; February 1988, Archer, Kelly M.

L. "Environmental Impact of Fertilizer and Pesticide Use on the Proposed Waikane Golf Course Project"; Honolulu, Hawaii; 5 April 1988, Murdoch, C.L. and Green, R.E.

M. "Marine Environmental Survey in the Vicinity of the Waikane Golf Course", Oahu, Hawaii; 26 March 1988, Marine Research Consultants

N. "Botanical Survey Waikane Golf Course, Oahu"; Honolulu, Hawaii; 9 February 1988, Nagata, Kenneth M.

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O. "Terrestrial Vertebrates of the Waiahole/Waikane Area"; Honolulu, Hawaii; December 1987, Berger, Andrew J.

P. "Air Quality Study for the Proposed Waikane Golf Course"; Honolulu, Hawaii; 26 March 1988, Root and Neal, Inc.

Q. "Noise Impact Evaluation for the Proposed Waikane Golf Course Draft Report"; Honolulu, Hawaii; 1 April 1988, Darby & Associates

R. "Feasibility and Need of Waikane Golf Course for Agriculture"; Honolulu, Hawaii; March 1988, Scott, Frank S.

S. "Feasibility of Agricultural Use of Wetlands in the Waikane Golf Course Project"; Honolulu, Hawaii; November 1988, Scott, Frank S.

APPENDIX A
Roads Report

ROADS REPORT
FOR THE
PROPOSED WAIKANE GOLF COURSE
WAIKANE, KOOLAUPOKO, OAHU, HAWAII

Prepared for:

Waikane Development Company
Honolulu, Hawaii

Prepared by:

Engineering Concepts, Inc.
250 Ward Avenue
Honolulu, Hawaii 96814

October 1988

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FIGURES

INTRODUCTION

The proposed golf course complex is located in Waikane Valley, Koolaupoko District, Oahu, Hawaii. The project site occupies over 500 acres and lies approximately 3.5 miles north of Kahaluu (see Figure 1). It is bordered on the north by the Puu Ohulehule-Puu Pueo Ridge, on the south by a low ridge of the Waiahole Agricultural Park, on the east by Kamehameha Highway, with its western (mauka) boundary cutting the 200- to 250-foot contours.

The objective of this report is to present the necessary facilities planning and preliminary engineering documentation for the proposed roadway infrastructure to accommodate traffic to and from the proposed Waikane Golf Course. Specifically, this report addresses the following:

1. Background information on the proposed project
2. Existing conditions
3. Proposed road improvements

PROJECT BACKGROUND

Proposed Project

The proposed Waikane Golf Course will consist of a 27-hole golf course, a driving range, maintenance building, and a clubhouse. Several small ponds and landscaping features will be included to function as water storage and/or storm runoff abatement facilities.

The golf course will be positioned within the southern portion of the property and west of the wetlands fronting Kamehameha Highway.

The clubhouse will be situated in the central portion of the golf course at the 135- to 150-foot elevation, with the driving range situated west (mauka) of the clubhouse complex.

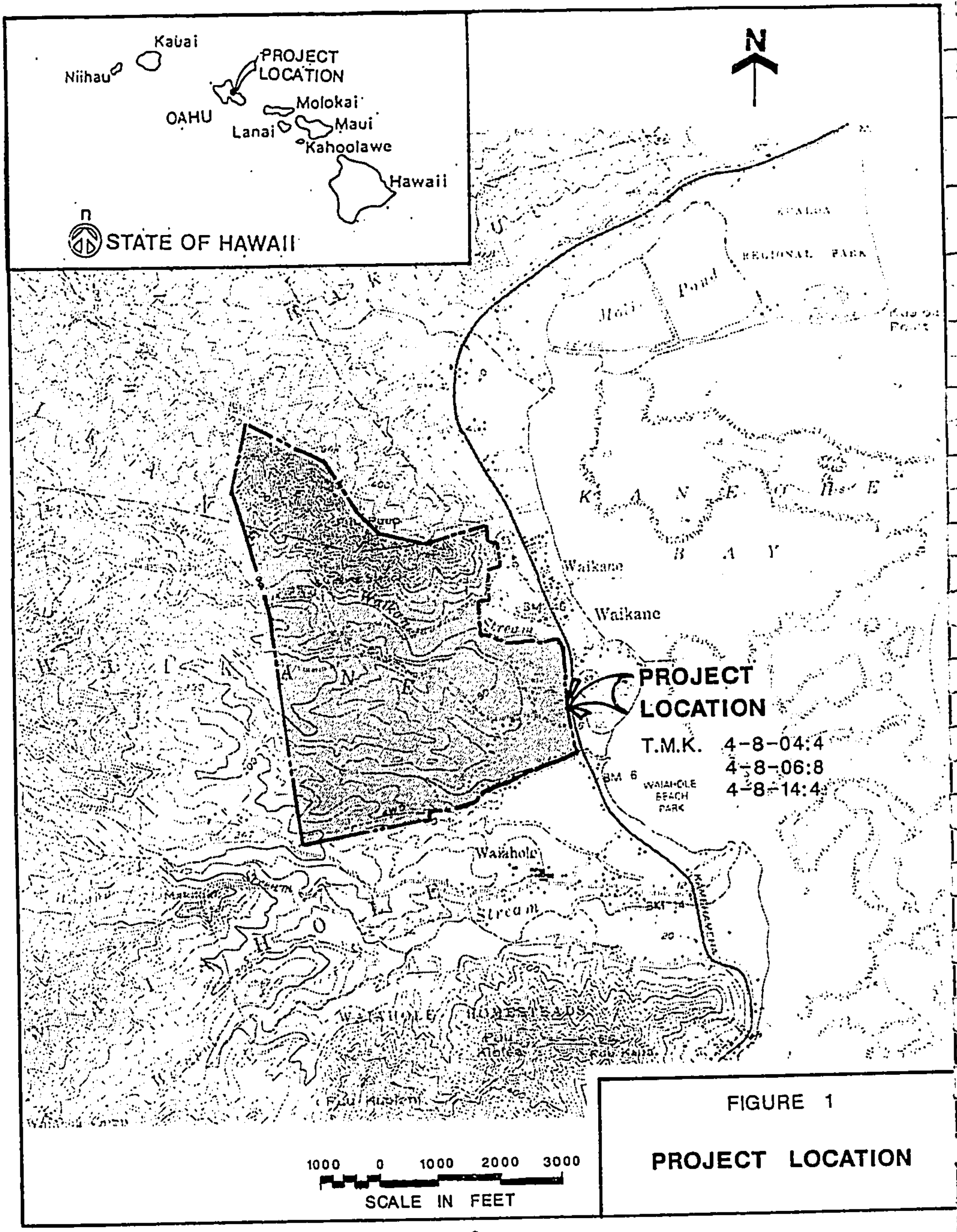

FIGURE 1

PROJECT LOCATION

The maintenance building will be located in the lower portion of the golf course (50- to 60-foot elevation), west (mauka) of the wetlands.

Topographic Features

The elevation of the project site ranges from about 10 feet above mean sea level fronting Kamehameha Highway to 250 feet in the western portion. The terrain is extremely hilly along the northern boundary, with slopes in excess of 30 percent over most of the area.

A swamplike low area, classified as "wetlands" by the U.S. Army Corps of Engineers, is situated on the eastern portion of the property.

Waikane Stream traverses the property and discharges into Kaneohe Bay. Waikane Stream has a drainage basin of 1,800 acres and a perennial mean discharge of 8.3 cfs (measured by a gauge station at the 75-foot elevation).

The southern portion of the site has numerous ridges and relatively small plateaus.

Climate

The median annual rainfall ranges from 65 inches in the lower edges of the property to 79 inches in the western (mauka) boundary. Rainfall increases to approximately 200 inches at the head of the Waikane watershed, the crest of the Koolau Range. Seasonal variation in rainfall is typified by the wet winter months and the generally dry summer months.

The temperature is generally mild and uniform. Data indicate that February is normally the coolest month, with a mean annual temperature of 68 degrees F, while September is generally the hottest month, averaging 80 degrees F.

The prevailing north-northeast tradewinds generally make for a comfortable environment, even during periods of high relative humidity.

Land Use and Zoning Designation

The majority of the property is presently designated Agricultural by the State Land Use Commission. A small portion of the property (Tax Map Key:4-8-14:4) is designated Conservation. All of the proposed activities will take place within the lands designated Agricultural.

The majority of the land is zoned Ag-2, with a smaller portion (Tax Map Key:4-8-14:4) zoned Preservation (P-1).

EXISTING CONDITIONS

Vehicular traffic to and from the areas surrounding the project site is served by Kamehameha Highway. In this vicinity, Kamehameha Highway is a two-lane road that serves as the only route between the project environs and other communities on Oahu.

Waikane Valley Road, an existing dirt road intersecting Kamehameha Highway near the southeast corner of the project site, provides access to kuleanas within the project site and to other properties mauka of the site. This dirt road is narrow and in poor condition due to soil erosion caused by frequent rain experienced in Waikane. Much of the storm runoff from areas adjacent to the road flows within and across the dirt road.

PROPOSED ROAD IMPROVEMENTS

Onsite

Access to the golf course and clubhouse will be via the existing Waikane Valley Road (the existing dirt road extending from Kamehameha Highway). Approximately 1,400 feet from the entrance, a new road alignment is proposed for the entry road to the clubhouse. The total length of this road will be approximately 3,000 linear feet (Figure 2). The road will have a paved asphaltic concrete finish approximately 24 feet.

A second road will be provided to furnish access to properties mauka of the project site presently using the existing dirt road (Waikane Valley Road) traversing the site. This road will be a 3,800-foot extension of Haupoa Road, an existing public road intersecting Kamehameha Highway near the northern limits of the proposed golf course development. The road will be designed to conform to City and County of Honolulu standards for public roads.

<u>Intersection</u>

Analysis of the intersection of Waikane Valley Road at Kamehameha Highway was conducted by Pacific Planning and Engineering, Inc. Construction of an exclusive left turn storage lane along Kamehameha Highway at Waikane Valley Road was recommended. Refer to the Traffic Impact Assessment Report (February 1988) for more information.

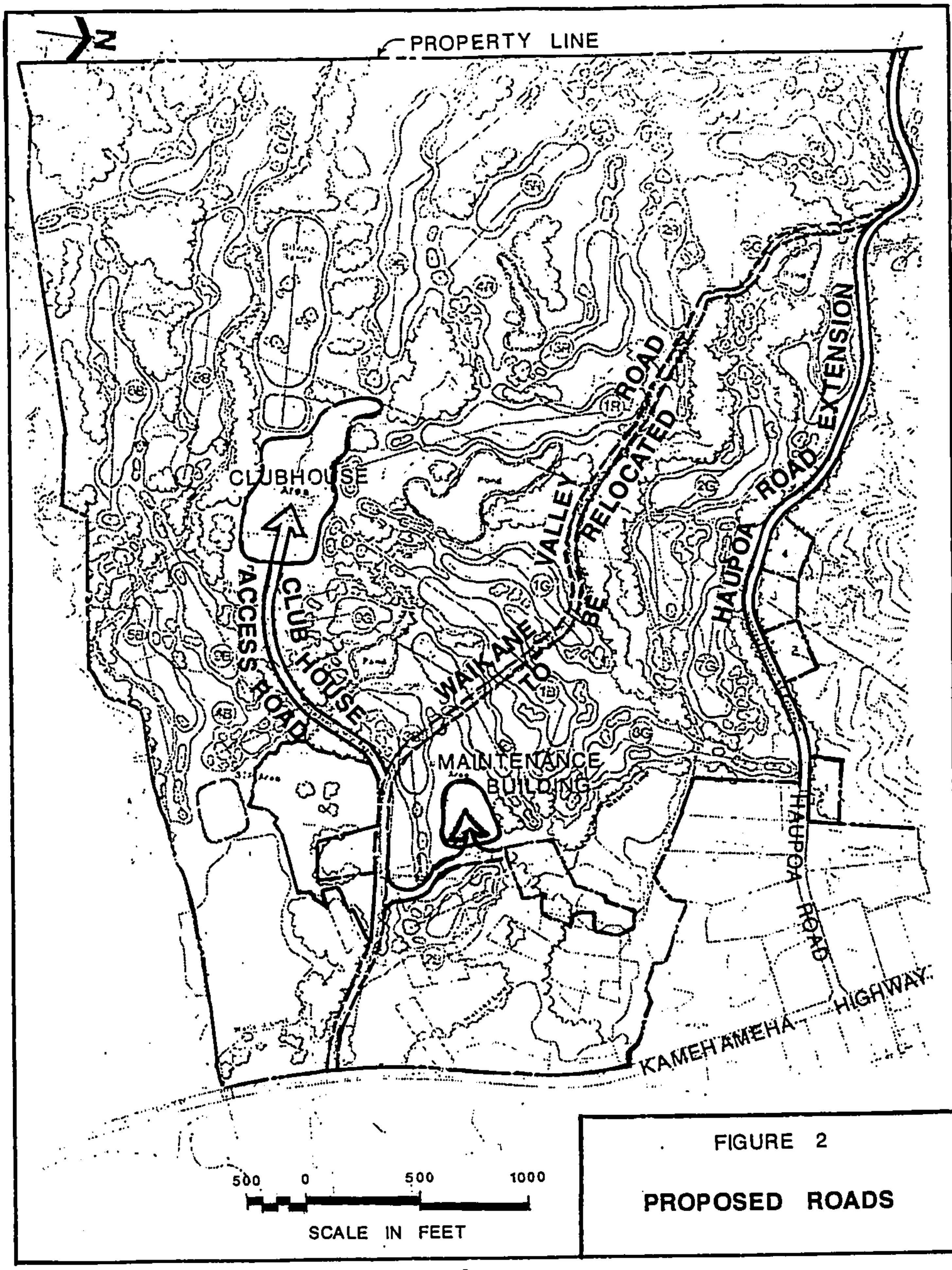

FIGURE 2

PROPOSED ROADS

APPENDIX B
Wastewater Management Plan

WASTEWATER MANAGEMENT PLAN

FOR THE

PROPOSED WAIKANE GOLF COURSE

WAIKANE, KOOLAUPOKO, OAHU, HAWAII

Prepared for:

Waikane Development Company
Honolulu, Hawaii

Prepared by:

Engineering Concepts, Inc.
250 Ward Avenue
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October 1988

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The objective of this report is to present the necessary facilities planning and preliminary engineering documentation for wastewater infrastructure for the proposed Waikane Golf Course. Specifically, this report addresses the following:

1. Background information on the proposed project
2. Wastewater flows
3. Proposed infrastructure alternatives
4. Impacts and mitigation

PROJECT BACKGROUND

Proposed Project

The proposed Waikane Golf Course will consist of a 27-hole golf course, a driving range, maintenance building, and a clubhouse complex. Several small ponds and landscaping features will be included to function as water storage and/or storm runoff abatement facilities.

The golf course will be positioned within the southern portion of the property and west of the wetlands fronting Kamehameha Highway.

The clubhouse will be situated in the central portion of the golf course at the 135- to 150-foot elevation, with the driving range situated west (mauka) of the clubhouse complex.

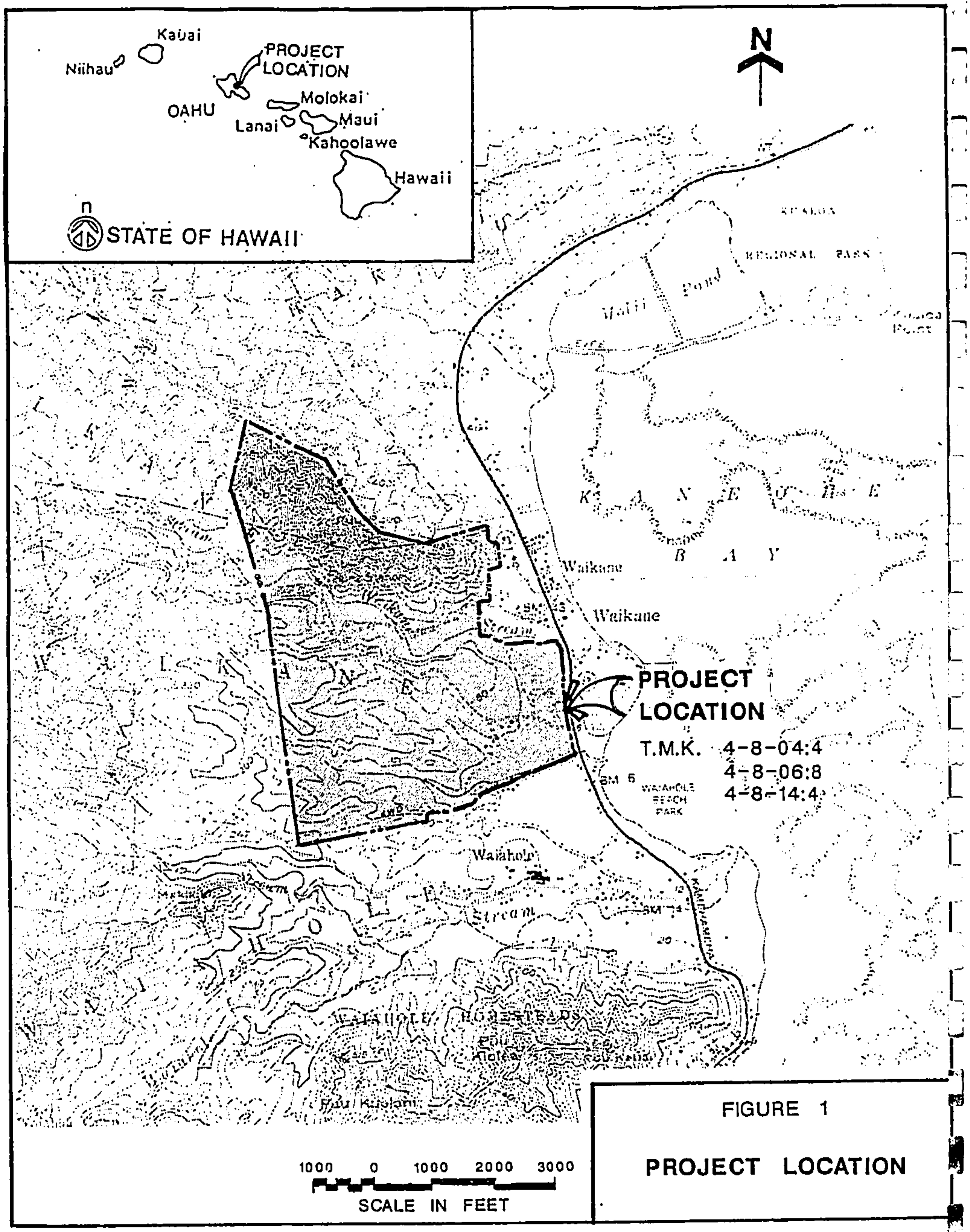


FIGURE 1

PROJECT LOCATION

The maintenance building will be located in the lower portion of the golf course (50- to 60-foot elevation), west (mauka) of the wetlands.

Topographic Features

The elevation of the project site ranges from about 10 feet above mean sea level fronting Kamehameha Highway to 250 feet along the western boundary. The terrain is extremely hilly along the northern boundary, with slopes in excess of 30 percent over most of the area.

A swamplike low area, classified as "wetlands" by the U.S. Army Corps of Engineers is situated on the eastern portion of the property.

Waikane Stream traverses the property and discharges into Kaneohe Bay. Waikane Stream has a drainage basin of 1,800 acres and a perennial mean discharge of 8.3 cfs (measured by a gauge station at the 75-foot elevation).

The southern portion of the site has numerous ridges and relatively small plateaus.

Climate

The median annual rainfall ranges from 65 inches in the lower edges of the property to 79 inches in the western (mauka) boundary. Rainfall increases to approximately 200 inches at the head of the Waikane watershed, the crest of the Koolau Range. Seasonal variation in rainfall is typified by the wet winter months and the generally dry summer months.

The temperature is generally mild and uniform. Data indicate that February is normally the coolest month, with a mean annual temperature of 68 degrees F, while September is generally the hottest month, averaging 80 degrees F.

The prevailing north-northeast tradewinds generally make for a comfortable environment, even during periods of high relative humidity.

Land Use and Zoning Designation

The majority of the property is presently designated Agricultural by the State Land Use Commission. A small portion of the property (Tax Map Key:4-8-14:4) is designated Conservation. All of the proposed activities will take place within the lands designated Agricultural.

The majority of the land is zoned Ag-2, with a smaller portion (Tax Map Key:4-8-14:4) zoned Preservation (P-1).

EXISTING WASTEWATER FACILITIES

The proposed golf course is located in the Waikane-Hakipuu planning area, as designated by the Facility Planning Process (Step 1) of the U.S. Environmental Protection Agency's Construction Grants Program.

As of 1977, there were 125 houses in the entire Waikane-Hakipuu area. Generally, the houses are widely scattered on large lots. Cesspools are presently used for the disposal of wastewater.

The 1980 Facility Plan by R.M. Towill recommended the continued application of cesspools for wastewater disposal. The factors justifying this approach are--

1. Low population density;
2. Low cost per home; and
3. Low population growth projections.

PROJECTED WASTEWATER FLOWS

Wastewater flows from the golf course are anticipated to be primarily generated from clubhouse activities. These activities include meal preparation and other related activities; personal hygiene, including toilet, lavatory, and showers; and a laundry area for washing towels. A small portion of the wastewater flow will be generated from the employee restrooms and service sinks in the maintenance building.

The estimated average wastewater design flow is 20,000 gpd, based on calculations for water use. Wastewater generated from the golf course activities will be of typical domestic composition.

PROPOSED WASTEWATER INFRASTRUCTURE

This section will address three major components of the wastewater infrastructure related to the proposed Waikane Golf Course: (1) the wastewater collection system; (2) treatment alternatives; and (3) effluent disposal. Wastewater infrastructure will exclusively serve the Waikane Golf Course development. No other areas are planned to be serviced by this wastewater treatment facility.

Collection System

The proposed wastewater collection system is presented on Figure 2. The collection system is located along the proposed roadways, as shown, for ease in construction and maintenance.

A gravity sewer will convey wastewater to the wastewater treatment facility site from a sewer manhole at the intersection of the golf course access road and the wastewater treatment facility access road. The sewer manhole will receive wastewater flows from two sources: (1) a gravity sewer from the clubhouse, and (2) a force main from the maintenance building site. Due to site topography, the maintenance building requires a small pumping station for wastewater transport.

Treatment Alternatives

Two alternatives are considered for treatment of wastewater generated at the proposed golf course: stabilization ponds and mechanical methods. A typical flow diagram of the two alternatives is shown on Figure 3.

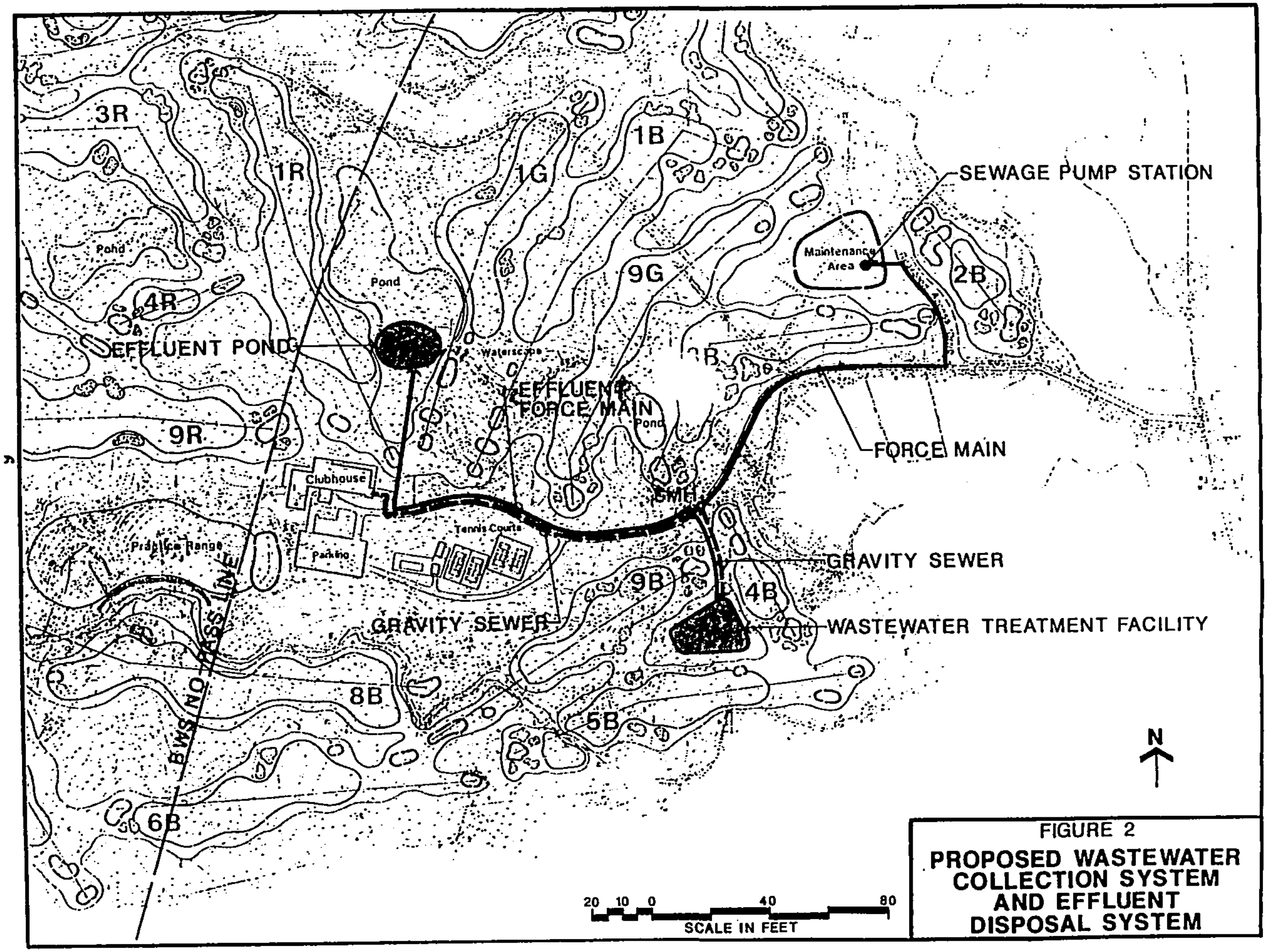
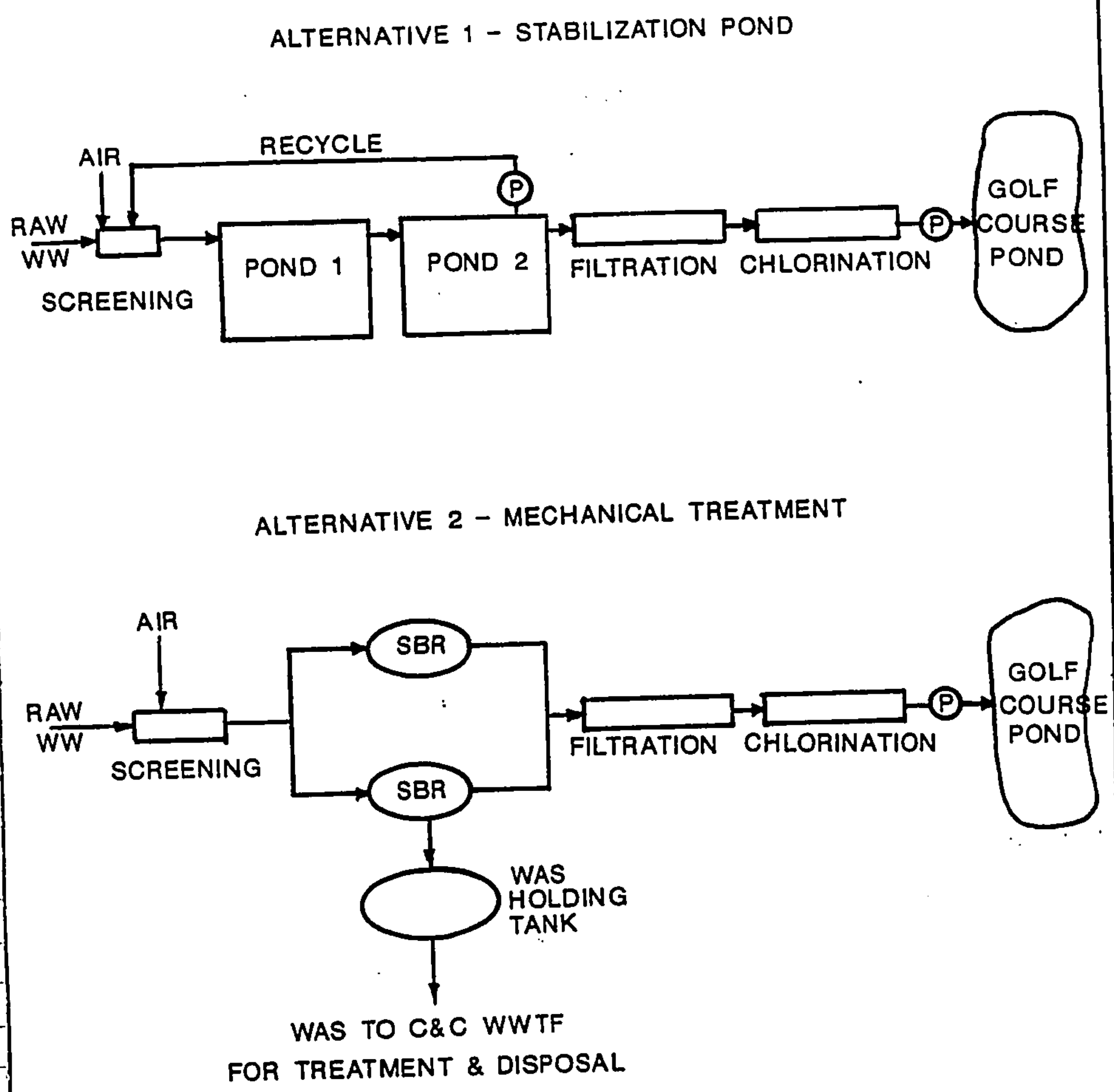


FIGURE 2
PROPOSED WASTEWATER COLLECTION SYSTEM AND EFFLUENT DISPOSAL SYSTEM



LEGEND

P - PUMP

WW - WASTEWATER

WWTF - WASTEWATER TREATMENT FACILITY

WAS - WASTE ACTIVATED SLUDGE

FIGURE 3
TYPICAL FLOW DIAGRAM FOR WASTEWATER TREATMENT ALTERNATIVES

Alternative 1 - Stabilization Ponds

Facultative ponds are the most common type of stabilization pond and the easiest to maintain. A pond depth of 6 feet is typical, providing aerobic stabilization in the upper layer, anaerobic fermentation in the lower layer, and sludge storage. Mechanical aeration is generally not required due to surface reaeration by winds and oxygen production by photosynthetic algae. However, aerating the headworks is recommended as an odor control measure. Pond effluent is normally filtered for additional removal of algae and suspended solids and disinfected by chlorination.

Based on a projected wastewater flow rate of 20,000 gpd, a total of 30,000 square feet of pond surface area is required. Thus, two ponds operating in series will require 15,000 square feet each. Berms 10 feet wide, encircling the ponds, provide sufficient access for mowing machines and vehicles used for maintenance. Berm walls normally provide 2-foot freeboard above the maximum liquid level to prevent overtopping. Wall slopes of 4 horizontal to 1 vertical on the inside face and 3 horizontal to 1 vertical on the outside should be incorporated in the pond construction.

The entire wastewater treatment facility would require about 80,000 square feet of fenced area to accommodate the ponds, berms, perimeter and access roads, office/storage building, filter, chlorination facilities, pumps, piping, and appurtenances.

Alternative 2 - Mechanical Methods

The sequencing batch reactor (SBR) is a fill-and-draw, nonsteady state activated sludge process. Each SBR, operating in batch treatment mode, provides equalization, aeration, and clarification in a timed sequence. Thus, extensive piping and multiple tanks for these processes are not required. Two SBRs operating alternately are required. The

SBR concept is generally favored where the quantity of wastewater flows is highly variable.

In addition to the SBRs, the following will also be required: headworks with manual bar screen, filtration unit, chlorination facilities, access road, office/storage building, pumps, piping, and appurtenances. A total fenced area of 50,000 square feet should be sufficient for this wastewater treatment facility alternative.

It is desirable to exclude solids treatment, stabilization, and dewatering facilities from the wastewater treatment facility due to space limitations and possible odor problems. Currently, the City and County of Honolulu will accept waste activated sludge (WAS) from private wastewater treatment facilities free of charge. The owner must arrange and finance pumping of the WAS to one of four WAS disposal locations on the island. Disposal of WAS at the approved locations (Kalihi, Pearl City, Waianae, and Ewa Beach) requires a permit from the Division of Wastewater Management.

Waste activated sludge will be stored in a holding tank prior to transport to the City and County for treatment. The holding tank will be aerated to maintain aerobic conditions, thus reducing odors. Based on typical domestic wastewater conditions, approximately 600 gpd of waste activated sludge is expected. The holding tank will be pumped one to two times a week by tanker truck to transport waste activated sludge for treatment.

Selection of Treatment Alternative

The use of stabilization ponds for wastewater treatment is favorable due to the relative technical simplicity in operation and maintenance compared to mechanical treatment methods. However, a major disadvantage of this form of treatment is the requirement of large areas of flat land. The absence of available flat land within the project site--particularly within the

WWTP site (see Figure 4)--makes stabilization ponds an unfavorable alternative. The proposed method of wastewater treatment is by sequencing batch reactor.

Effluent Disposal

Treated effluent will be pumped to a golf course pond located across the clubhouse access road northeast of the wastewater treatment facility site. Effluent in the pond will be diluted with nonpotable water from the main irrigation pond and used to irrigate portions of the golf course makai of the Board of Water Supply's no-pass line (see Figure 2). Approximately 2 percent of daily irrigation water requirement can be supplied by wastewater effluent.

Effluent storage in the golf course pond would also provide additional treatment due to disinfection by ultraviolet radiation from the sun.

IMPACTS AND MITIGATION

Short-Term Impacts and Mitigation

Short-term impacts would be construction related and may include dust, noise, and traffic disruption along Kamehameha Highway. Traffic would be affected primarily by trucks and heavy equipment entering and leaving the wastewater treatment facility site, while dust and noise would occur from construction activities. These impacts can be mitigated by implementing a watering program for dust control, regulating the hours of construction to minimize the impact of noise on adjacent neighbors, and scheduling construction traffic during off-peak hours.

Long-Term Impacts and Mitigation

Irrigation of portions of the golf course with treated effluent will reduce the demand for irrigation water from nonpotable onsite wells.

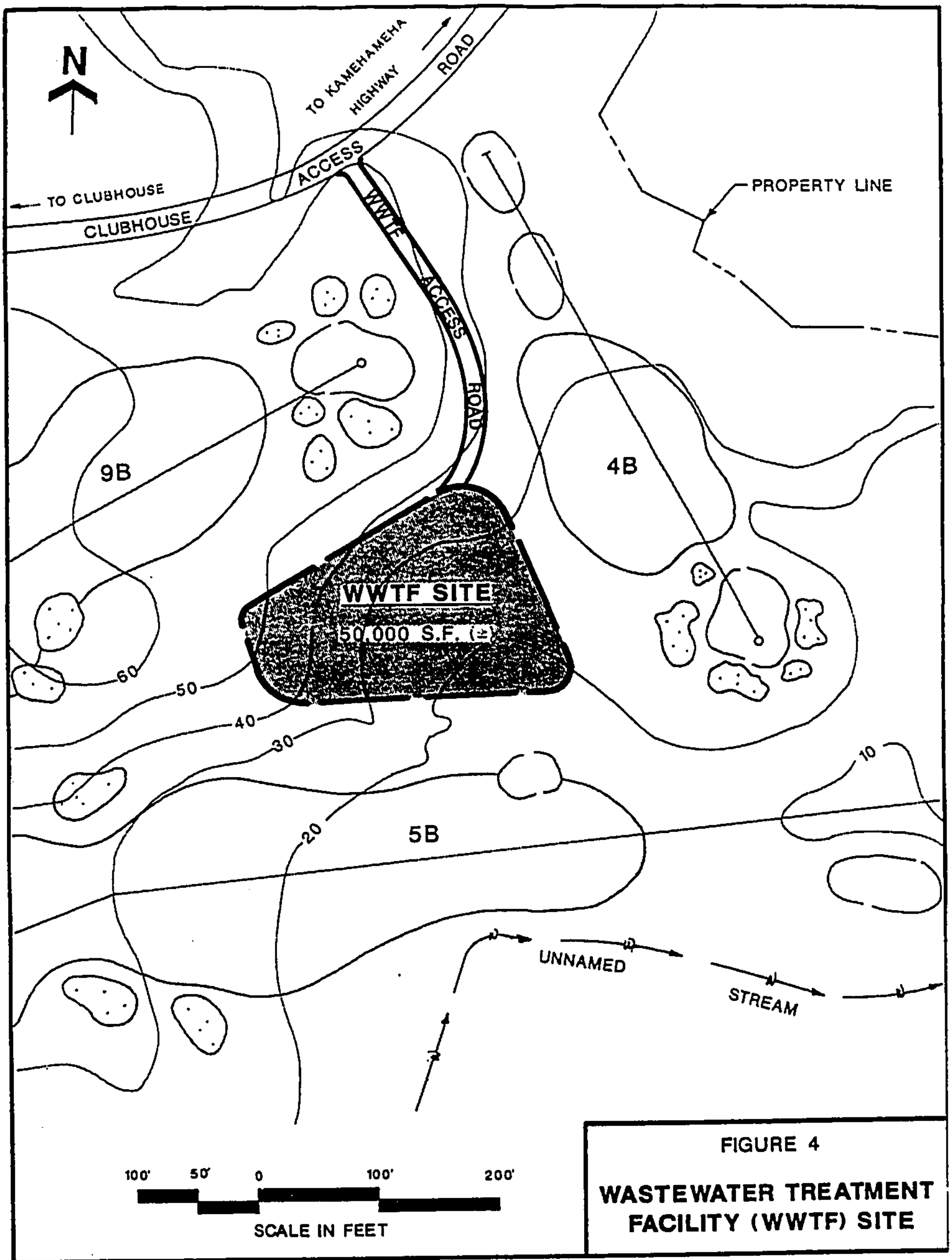


FIGURE 4

WASTEWATER TREATMENT FACILITY (WWTF) SITE

Possible negative impacts due to the wastewater treatment and disposal plan are--

1. Odors generated from the wastewater treatment facility and effluent storage pond;

2. Noise from equipment at the wastewater treatment facility; and

3. Visual impacts due to the location of the wastewater treatment facility on the golf course grounds.

With proper operation, objectionable odors should not be generated from the wastewater treatment facility or effluent storage pond. Maintenance of aerobic conditions will minimize odor generation; thus, portions of the facility prone to septic conditions (i.e., headworks, WAS holding tank) will be aerated for odor control. The exclusion of solids treatment units is another odor control measure.

Pumps and blowers are the primary noise-generating equipment at the wastewater treatment facility requiring noise abatement. Enclosures for pumps and locating blowers within the blower room of the control building will reduce the impact of operating noises.

Landscaping around the wastewater treatment facility perimeter fence will reduce the visual impact of the facility on the golf course users.

REFERENCES

1. Metcalf & Eddy, Inc., Wastewater Engineering: Treatment, Disposal, Reuse, 2nd Edition, 1979.

2. U.S., Environmental Protection Agency, Municipal Wastewater Stabilization Pond Design Manual, October 1983.

APPENDIX C
Water Supply Report

WATER SUPPLY REPORT
FOR THE
PROPOSED WAIKANE GOLF COURSE
WAIKANE, KOOLAUPOKO, OAHU, HAWAII

Prepared for:

Waikane Development Company
Honolulu, Hawaii

Prepared by:

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The objective of this report is to present the necessary facilities planning and preliminary engineering documentation for the proposed potable and nonpotable water infrastructure to accommodate domestic and irrigation water needs of the proposed Waikane Golf Course. Specifically, this report addresses the following:

1. Background information on the proposed project
2. Existing water supply infrastructure
3. Projected water requirements
4. Proposed water system

PROJECT BACKGROUND

Proposed Project

The proposed Waikane Golf Course will consist of a 27-hole golf course, a driving range, maintenance building, and a clubhouse. Several small ponds and landscaping features will be included to function as water storage and/or storm runoff abatement facilities.

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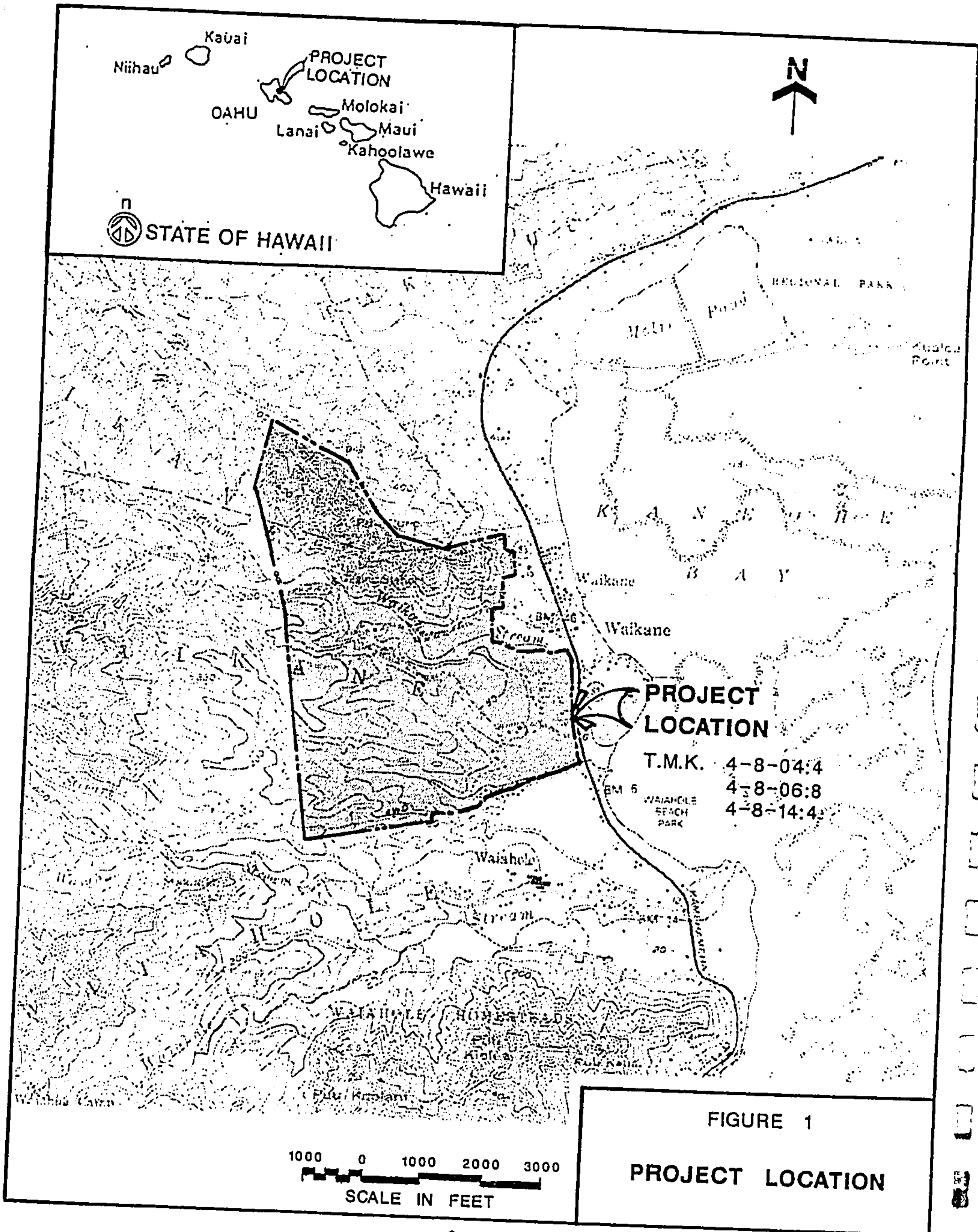

FIGURE 1

PROJECT LOCATION

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Topographic Features

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Land Use and Zoning Designation

The majority of the property is presently designated Agricultural by the State Land Use Commission. A small portion of the property (Tax Map Key:4-8-14:4) is designated Conservation. All of the proposed activities will take place within the lands designated Agricultural.

The majority of the land is zoned Ag-2, with a smaller portion (Tax Map Key:4-8-14:4) zoned Preservation (P-1).

EXISTING INFRASTRUCTURE

The Board of Water Supply's (BWS) Windward Low Service System services the lower portions of Windward Oahu from Punaluu to Makapuu. Sources of water in the vicinity of the project site are Waihee Well I, Waihee Tunnel, and Waihee Inclined Wells. The estimated sustainable yield from these three sources is 5 to 8 million gallons per day (MGD). The storage facility located closest to the project site is Waihee 265 Reservoir, with a 1.0 MG capacity. Waihee 265 services portions of Waihee, Kaalaea, Waiahole, and Waikane through a 12-inch distribution main along Kamehameha Highway. Currently, the kuleanas makai of the golf course along Waikane Valley Road are serviced by private water lines tapping off the BWS system (see Figure 2).

PROJECTED WATER DEMAND

The projected water demand for the golf course site is based on the BWS Water System Standards (1985) and on the book, Wastewater Engineering: Treatment, Disposal, Reuse (1979).

A domestic water demand of 25,000 gallons per day (gpd) is estimated, based on typical domestic requirements for the

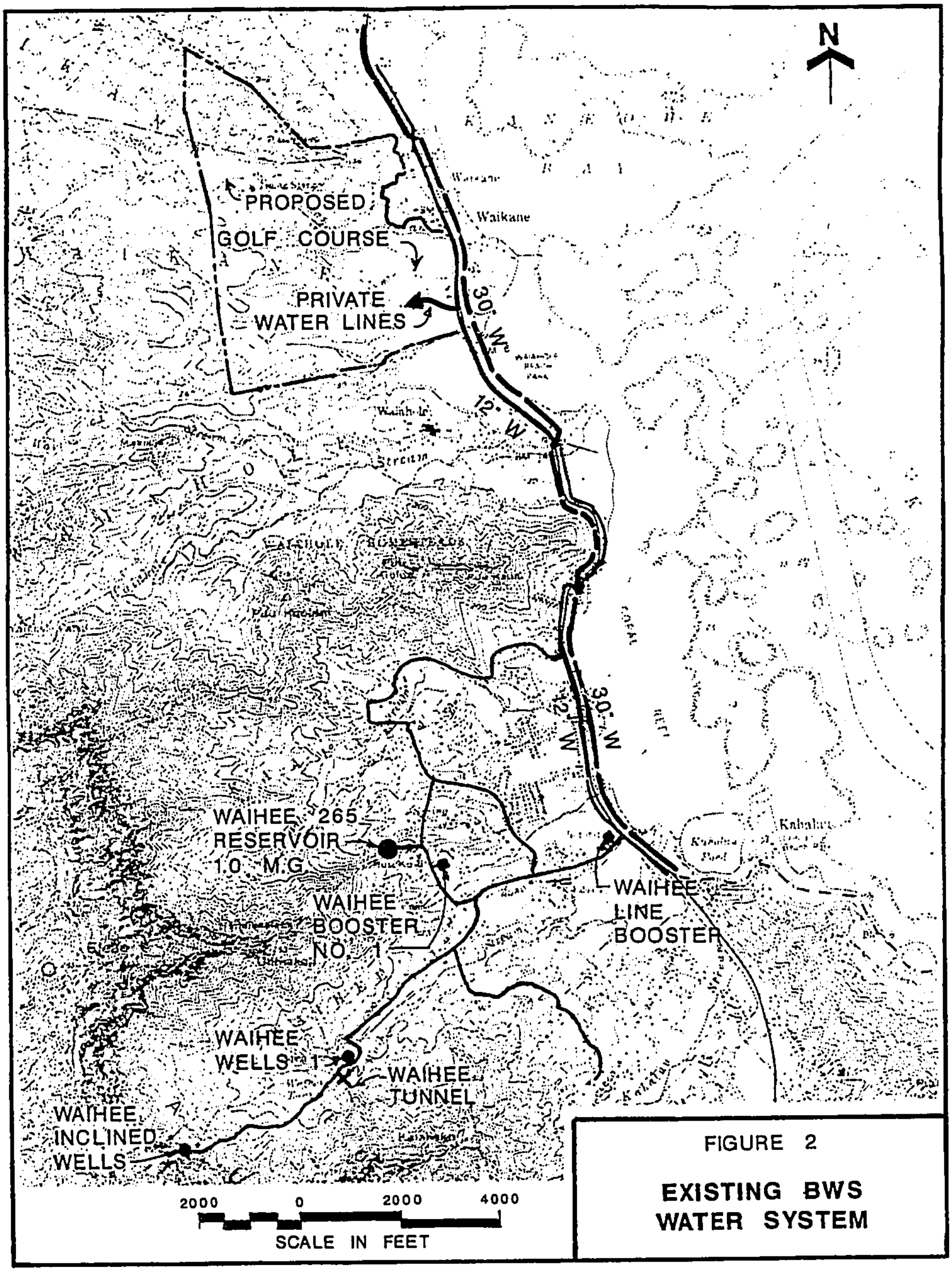

FIGURE 2

EXISTING BWS WATER SYSTEM

maintenance building and clubhouse and on actual water usage for the kuleanas (Roberts family) and church along Waikane Valley Road.

Specifically, domestic water demand is based on the following projections:

			GPD
150-seat restaurant	@ 40 gpd/seat	=	6,000
450 golfers (peak day)	@ 10 gpd/person	=	4,500
60 employees (peak day)	@ 20 gpd/person	=	1,200
250 showers (peak day)	@ 25 gal/shower	=	6,250
2 washing machines	@ 500 gpd/machine	=	1,000
7 residential lots and church*	@ 750 gpd	=	6,000
			24,950
			Say 25,000

* Existing water users.

A water demand of 1.0 MGD is estimated for golf course irrigation of approximately 150 acres. Irrigated areas include greens, tees, fairways, and roughs; driving range; clubhouse landscaping; and plant nursery. A typical golf course irrigation rate of 1.5 inches per week is assumed. Nonpotable water from three onsite wells will supplement rainfall to meet the irrigation requirement.

The projected water demand for fire protection is 2,000 gallons per minute (gpm) over a two-hour duration for the clubhouse and maintenance building. This demand is based on the Water System Standards' fire flow rate for schools, small shopping centers, neighborhood businesses, and hotels.

PROPOSED DEVELOPMENT

The proposed water supply plan is separated into two distinct systems outlined below.

1. Potable Water System. Includes domestic supply to the clubhouse; domestic supply and fire protection for the maintenance building; and domestic supply and fire protection for the kuleanas (Roberts family) and church along Waikane Valley Road.

2. Nonpotable Water System. Includes fire protection for the clubhouse and irrigation.

Potable Water System

The proposed potable water system will tap off the 12-inch BWS water line along Kamehameha Highway at Waikane Valley Road (see Figure 3). A new water line will be located along Waikane Valley Road to the clubhouse site. The water line will be public from Kamehameha Highway to the clubhouse meter and private beyond. The water line will also serve the Roberts family and church on the southern side of Waikane Valley Road. Eight individual water meters will be located off of Waikane Valley Road for hook up to private water service laterals. Fire protection for the kuleanas and church will be provided by two fire hydrants spaced 350 feet apart on Waikane Valley Road.

Two parallel water lines will tap off the new water line and will be located within the maintenance building access road. The first line, sized to meet fire protection demands, will lead to a fire hydrant near the maintenance building. A second water line will be sized to meet the domestic needs of the maintenance building. A water meter will be installed on the maintenance building domestic line and a detector check meter will be installed on the fire line.

The proposed potable water system is shown on Figure 3. The new water line will be public from Kamehameha Highway to the club-house water meter and private beyond.

Nonpotable Water System

Drilling of three onsite wells is required for the nonpotable water system. The proposed wells, located between the 100- and

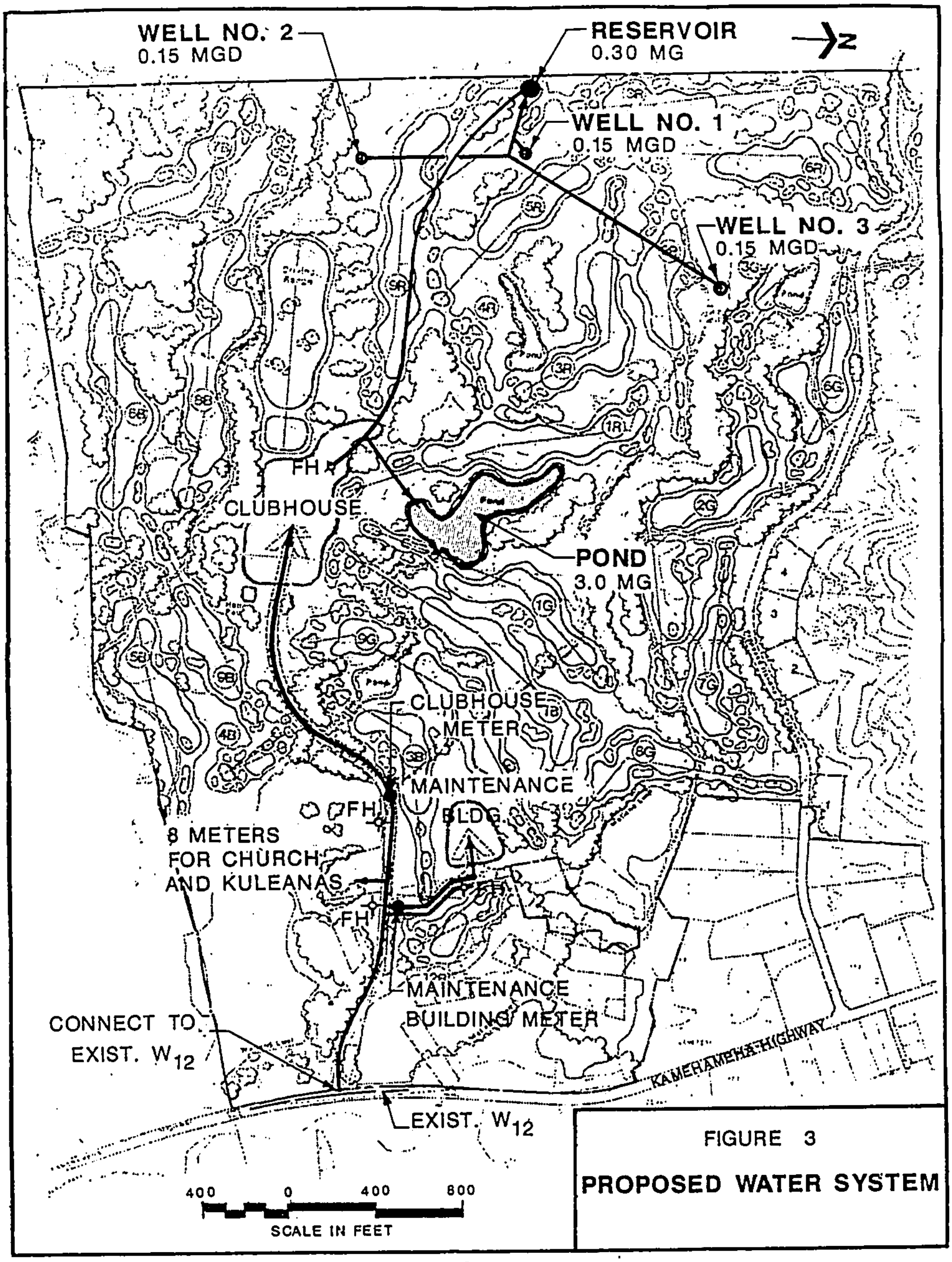

FIGURE 3

PROPOSED WATER SYSTEM

220-foot elevation at the mauka end of the site, are expected to deliver 0.15 MGD per well. The wells will pump to a 0.30 million gallon (MG) glass-lined steel reservoir at elevation 220±. A reservoir of this size is of sufficient capacity to meet the clubhouse fire flow requirement.

A gravity line from the reservoir will be sized to provide the necessary fire flow and water pressure to the clubhouse. The line will also supply water to an irrigation storage pond north of the clubhouse. Pond capacity will be about 3 MG, providing a minimum of three days' storage for irrigation.

POTENTIAL IMPACTS AND MITIGATION

Positive impacts resulting from the proposed water supply system are--

1. Fire protection provisions for the existing church and kuleanas (Roberts family) along Waikane Valley Road;

2. Individual water meters for the existing church and kuleanas (Roberts family) along Waikane Valley Road; and

3. Conservation of potable water supplies by using non-potable sources for golf course irrigation.

Possible negative impacts resulting from the proposed water supply system are--

1. Short-term construction impacts along Waikane Valley Road and Kamehameha Highway during installation of the new water lines;

2. Increased burden on Waihee reservoir and distribution system due to approximately 20,000 gpd estimated for golf course domestic requirements;

3. Significant decreases in stream flow due to drilling three nonpotable source wells are possible but not foreseen. The wells will be located to minimize loss of groundwater to Waikane Stream by capturing a portion of groundwater lost to the wetlands. Refer to the report, "Proposed Groundwater Development, Lower Waikane Valley, Oahu," by John F. Mink (March 1988) for more information. Should significant decreases in stream flow be detected through monitoring programs, use of the wells for irrigation water will cease and other alternatives will be considered.

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3. Mink, John F., "Proposed Groundwater Development, Lower Waikane Valley, Oahu," March 21, 1988.

4. VTN Pacific, "Draft EIS for Windward Oahu Regional Water System Improvements," Prepared for the City and County of Honolulu, Board of Water Supply, 1987.

APPENDIX D
Proposed Groundwater Development

PROPOSED GROUNDWATER DEVELOPMENT

LOWER WAIKANE VALLEY, OAHU

Submitted to

Engineering Concepts, Inc.

March 21, 1988

John F. Mink

Proposed Groundwater Development Lower Waikane Valley, Oahu
Groundwater Occurrence and Streamflow

<u>Geology and Hydrology</u>

Waikane Valley lies entirely within the dike complex of the Koolau rift zone. In the dike complex intrusive rocks comprise more than 10 percent of the total rock mass. Intrusives are virtually impermeable compared to normal lavas, and therefore the hydrologic environment of the dike complex is unfavorable for the accumulation and movement of groundwater. The aquifer compartments between dikes are small and poorly connected. In fact, subsurface conditions are so poor as to have discouraged attempts at groundwater development for municipal and other purposes requiring producing units of several hundred gallons per minute or more.

Waikane Stream courses through the heart of the Koolau dike complex. Its low flows are sustained by seepage of groundwater from overflowing dike compartments, but it also frequently discharges direct surface runoff due to appreciable rain showers, especially from the high rainfall area in its headwaters, and general storms. The most voluminous springs in the drainage basin emerge above an elevation of 800 feet, but since 1916 these discharges, which average 5.5 mgd, have been diverted by the Waiahole Tunnel System and never reach the lower valley. All of the groundwater that now accumulates in the stream originates below an elevation of 800 feet.

Stream Flow

The U.S. Geological Survey has had a continuous stream flow recorder at elevation 75 feet on Waikane Stream since 1959, providing nearly 30 years of record. The gage location is shown on the attached map. It is 1.7 miles inland of the coast and drains an area of 2.22 square miles, but the most productive portion of the drainage area is intercepted by the Waiahole Tunnel System.

Average flow at the gage (USGS 294900) has been 5.37 mgd and the median 2.59 mgd. The lowest daily flow has been 0.71 mgd, recorded during September and October in a number of years, but the longest run of flows near the minimum took place in the Fall of 1984 at the height of the four year drought which started in 1983. During September-October of 1984 record lows in many streams and collection tunnels were set throughout the State. Normal base flow of Waikane is about twice the recorded minimum, or approximately 1.5 mgd.

In 1959 during a dry period miscellaneous stream measurements were made by the U.S. Geological Survey on October 19 at a number of sites on Waikane. Where the recording gage is now located the flow was 1.23 mgd. Upstream 1000 feet at elevation about 80 feet flow was 0.87 mgd, indicating an increase in groundwater seepage of 0.36 mgd over this distance. A perennial spring, Ulawini on the left bank, occurs in this reach. A further 3000 feet upstream at elevation about 150 feet the flow was 0.42 mgd, suggesting a lower unit rate of discharge in this reach, and still another

700 feet further at elevation 200 feet the flow was 0.39 mgd. Thus over a length of 4700 feet and an elevation range of 125 feet, about two thirds of the groundwater seepage measured at the gage site originates.

On the same day, 1.38 mgd was measured 1500 feet downstream of the gage site, a gain of only 0.15 mgd. In the lower reach of the valley a blanket of compacted alluvium impedes upward seepage from the dike aquifers. Groundwater discharge, instead of draining to the stream channel, is diffused over an area of alluvial lowland. The marshy conditions at the mouth of the valley result from this conjugation of diffuse seepage and alluvium.

Groundwater seepage is most productive in the vicinity and for several thousand feet upstream of the gaging station. At too high elevations in the portion of the valley still within the drainage area of the gage the groundwater level is not high enough to yield substantial overflow from dike aquifers, while downstream of the gage outflow is impeded by a blanket of alluvium. Before the diversions at the head of the valley started three fourths of a century ago, base flow of the stream in the lower valley was five times what it is today. The lost groundwater now drains to Waikane 1 and Waikane 2 collection tunnels of the Waiahole System.

Proposed Wells

Three wells are proposed to supply water for golf course operations. Locations of the wells are shown on the attached map. They are numbered in order of drilling as follows: no. 2 is on the south, no. 1 in the middle, and no. 3 on the north, nearest Waikane Stream. Well 2 at elevation 220 feet is on the ridge north of a short stream having a very small perennial flow. The U.S. Geological Survey measured a flow of 0.063 mgd on October 19, 1959, about 3500 feet downstream of the proposed well. Upstream the perennial flow probably is very small and may not be measureable. Site 2 lies 2500 feet from Waikane Stream.

The first well to be drilled is at elevation 200 feet on the ridge just north of a dry gulch lying between it and Well 2. The site is 2000 feet from Waikane Stream. The last well scheduled for drilling is on a low bluff 750 feet from Waikane at elevation 100 feet.

The wells will be drilled in the dike complex with the objective of extracting several hundred gpm per well from an unfavorable hydrogeologic environment. High drawdowns and low specific capacities are anticipated. No wells have been drilled within two miles of lower Waikane. The nearest drilled well in the dike complex is in Kaalaea at an elevation of 19 feet near the mouth of the valley. The test yield was 20 gpm with a drawdown of 27 feet. Further to the south several dike complex wells in Ahuimanu were tested at 150 to 300 gpm with drawdowns to 140 feet. This is the target for the Waikane wells, yet because of the complexity of the subsurface each drilling is an exploratory venture.

Relationship Between Well Production and Waikane Stream Flow

The low flow of streams in the Waikane drainage consists of groundwater which drains from saturated dike compartments. Not all of the groundwater is captured by Waikane Stream; a portion moves as underflow toward the coast and surfaces as diffuse discharge at low elevations, creating the wetlands in the lower reach of the valley. Waikane acts as a drain because the dikes trend to the northwest, about perpendicular to the stream channel, and many small aquifer compartments are cut by the stream. In the lower valley, below an elevation of about 40 feet, a cover of poorly permeable alluvium inhibits free drainage of the aquifers and is responsible for artesian conditions.

Virtually all of the groundwater ultimately escapes either to the stream or to the wetlands near the coast. A small quantity may seep into the alluvial cover on the sea bottom just off the coast. Consequently any groundwater removed by wells will diminish outflow either to streams or the wetlands. The proposed wells were located to minimize loss of groundwater to Waikane Stream by capturing a portion of groundwater lost to the wetlands. The marshes are sustained both by diffuse groundwater seepage and runoff from streams. The loss of a portion of the diffuse seepage might not significantly affect the wetlands because runoff is appreciable.

The wells lie on a line striking south of the Waikane gaging station, downstream of the maximum seepage rate into the stream channel. About two thirds of the low flow at the gage is accumulation of seepages entering the channel over several thousand feet upstream. Because the wells are seaward of this channel reach and groundwater drainage to Waikane is northwesterly, parallel to the dike trend of approximately 35 degrees NW, production from the wells should not seriously diminish flow at the gage station.

Whether or not Waikane Stream will be affected by well pumpage will not be quickly or easily determinable. Fortunately a reliable record of flow exists for the U.S. Geological Survey gaging station. Statistically significant deviation from the long term base flow record will indicate what effect, if any, pumping has on the stream. During pumping tests flow behavior at the gage will be closely examined to ascertain whether a short term stream-well connection is detectable.

The minor streams in the area, such as the one adjacent to Well 2, are weakly perennial at best. There are no continuous records for them; in fact, a single stream measurement is all that could be found. Nevertheless, before and during the pump tests these streams will be observed to establish whether those that may contain seepage are affected.

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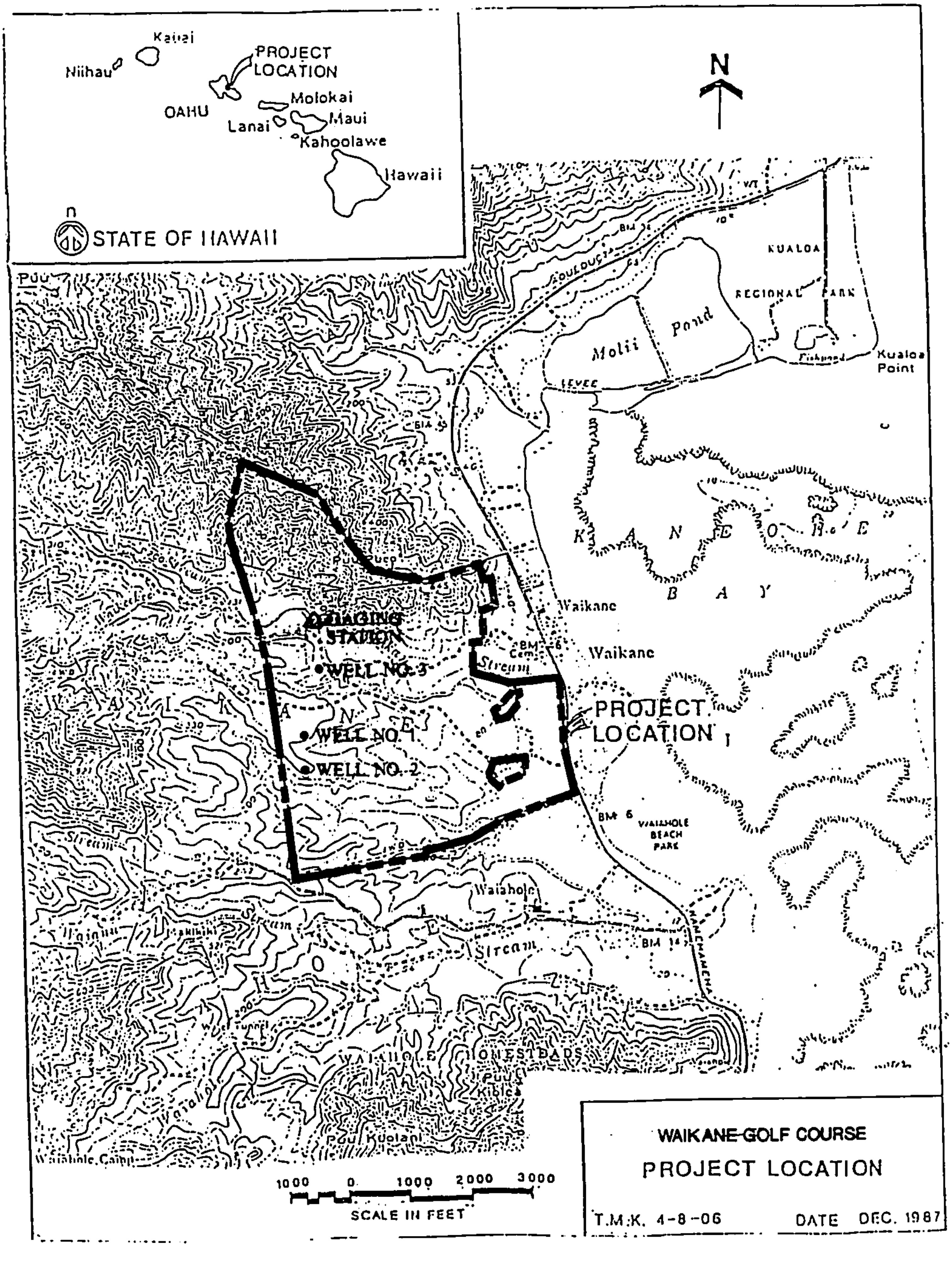

WAIKANE GOLF COURSE
PROJECT LOCATION

T.M.K. 4-8-06 DATE DEC. 1987

APPENDIX E
Socio-Economic Impact Assessment

Socio-Economic Impact Assessment for Proposed Waikane Valley Golf Course

-- October 1988

Prepared for:

Waikane Development Co.

Prepared by:

Community Resources, Inc.
Honolulu, Hawaii

Principal: John M. Knox, Ph.D.

Co-Authors: John T. Kirkpatrick, Ph.D.
George T. Mozingo

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1.0 BACKGROUND

1.1 THE PROPOSED PROJECT

The Waikane Development Company, a division of Pan-Pacific Development, Inc. plans to develop approximately 505 acres of property in the Koolaupoko District, on Oahu's Windward coast. The land is in Waikane Valley, mauka of Kamehameha Highway.

The companies propose to create a 27-hole golf course. A clubhouse and driving range will also be built on the property. The clubhouse complex will include a swimming pool and about four tennis courts. No residential development is proposed.

Construction of the golf course and infrastructure is expected to take about 21 months. Within the same period, construction of the clubhouse should take about 10 months.

The proposed golf course will be used partly by a club. It will also be open for public play. While some of the members and their guests might be residents of the Windward area, most members and other golfers will come to the club from Honolulu.

1.2 SCOPE OF THIS REPORT

The following sections provide information on:

- the history of the region and the area immediately surrounding the proposed development;
- existing socio-economic conditions;
- forces for change in the region apart from the project; and
- the socio-economic impacts that may be expected with the project, and possible mitigations of such impacts.

2.0 DESCRIPTION OF STUDY AREA

The property lies in the historic ahupuaa of Waikane, within the boundaries of the City and County's Kahaluu Neighborhood Board (No. 29). The Neighborhood Board area includes the more populous areas of Kahaluu and Ahuimanu to the south, and several areas to the north -- Waihee, Kaalaea, Waiahole, Waikane, Hakipuu, and Kualoa -- with smaller populations and a more rural appearance.

Kahaluu lies within the Koolaupoko District of Oahu; immediately to the north of the Kahaluu Neighborhood Board area is the Koolauloa District. These districts, stretching from the southeast point to the northern tip of Oahu, include both rural areas and population centers. For present purposes, they are unwieldy, and will only be discussed in describing the historical background of the area.

Figure 1 shows the project site in relation to the island of Oahu and its major districts. It also shows the Koolauloa Neighborhood Board area, which includes nearly all the Koolauloa District. Figure 2 shows the Kahaluu and Kaneohe Neighborhood Board areas, and the Census Designated Places within them. Figure 3 identifies the ahupuaa's of the Kaneohe Bay Region.

The areas considered in this report as of special concern are:

(1) Waikane valley and the adjacent ahupuaa's, Waiahole and Hakipuu.

(2) The lands included in Block Group 9 of Census Tract 103.03 in 1980. (This Block Group is the census area most closely corresponding to (1). It covers Kualoa, Hakipuu, Waikane, Waiahole, and areas to the south within the Waiahole Forest Reserve.)

(3) The Kahaluu Neighborhood Board area.

Some discussion of the entire island of Oahu is useful since changes in the Windward region have been part of islandwide developments. (Quantitative data about Oahu are usually gathered for the City and County of Honolulu, which includes Oahu and little else.) Also, for comparative purposes, it is helpful to view the Kahaluu Neighborhood Board area in relation to the adjacent Neighborhood Board areas, the more urbanized area of Kaneohe (Neighborhood Board No. 30) and the rural Koolauloa Neighborhood Board (No. 28).

To avoid confusion, the words "district" and "neighborhood" are used here only in limited senses. "District" is used for the major parts of Oahu, such as Koolaupoko and Koolauloa (usually identical with Census Divisions). "Neighborhood" will be used in discussing Neighborhood Board areas.

FIGURE 1
PROJECT LOCATION

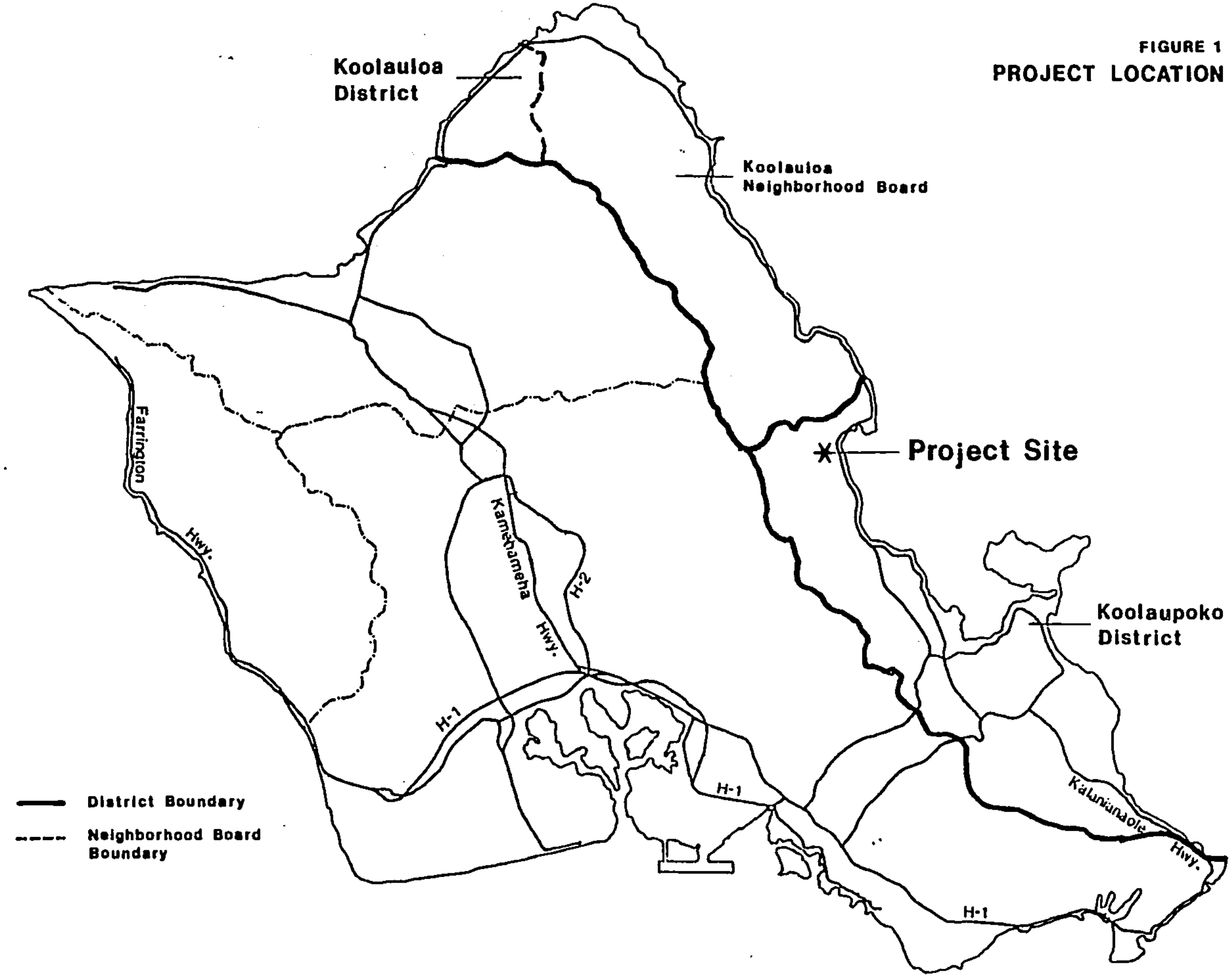


FIGURE 2
STUDY AREA

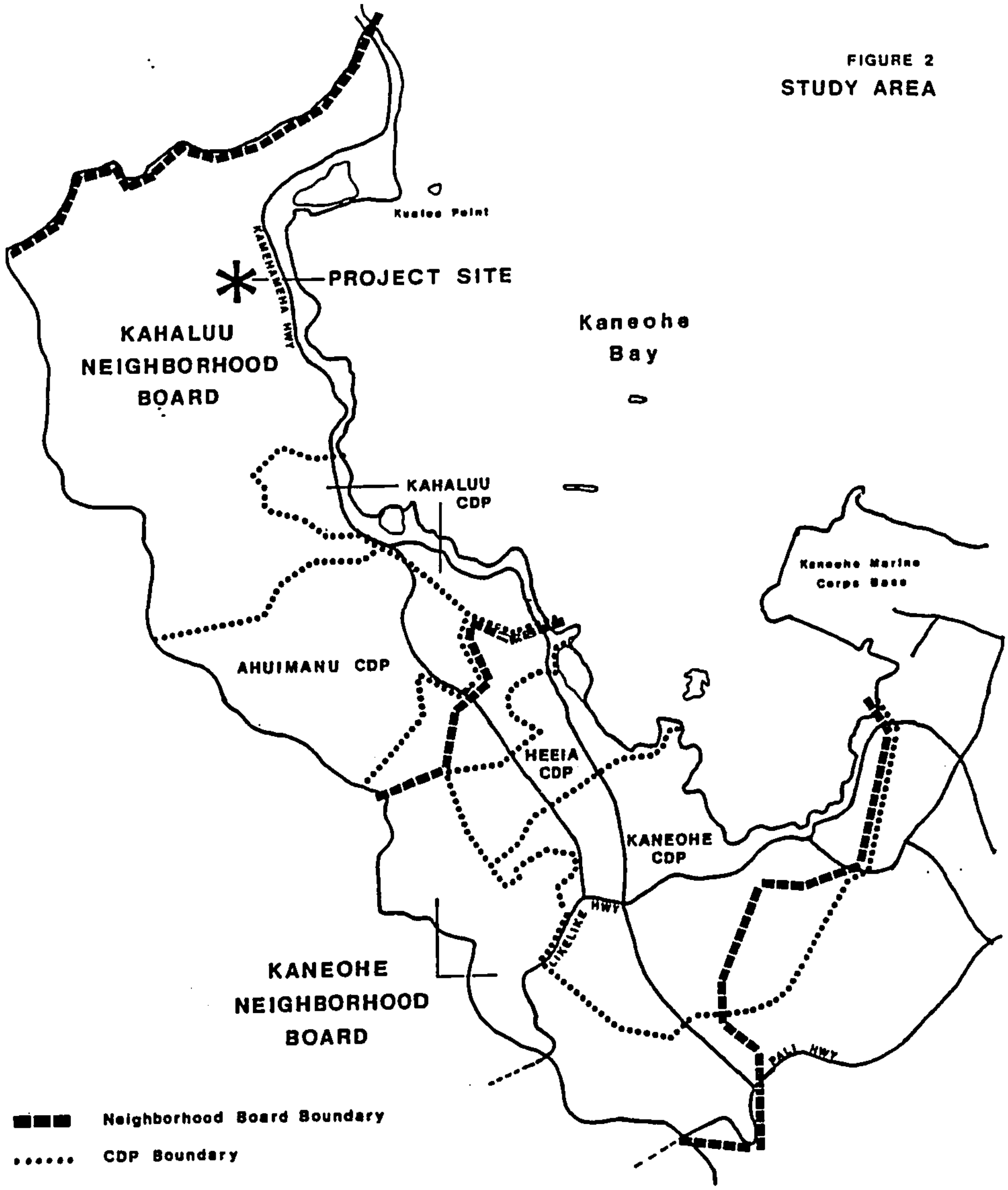
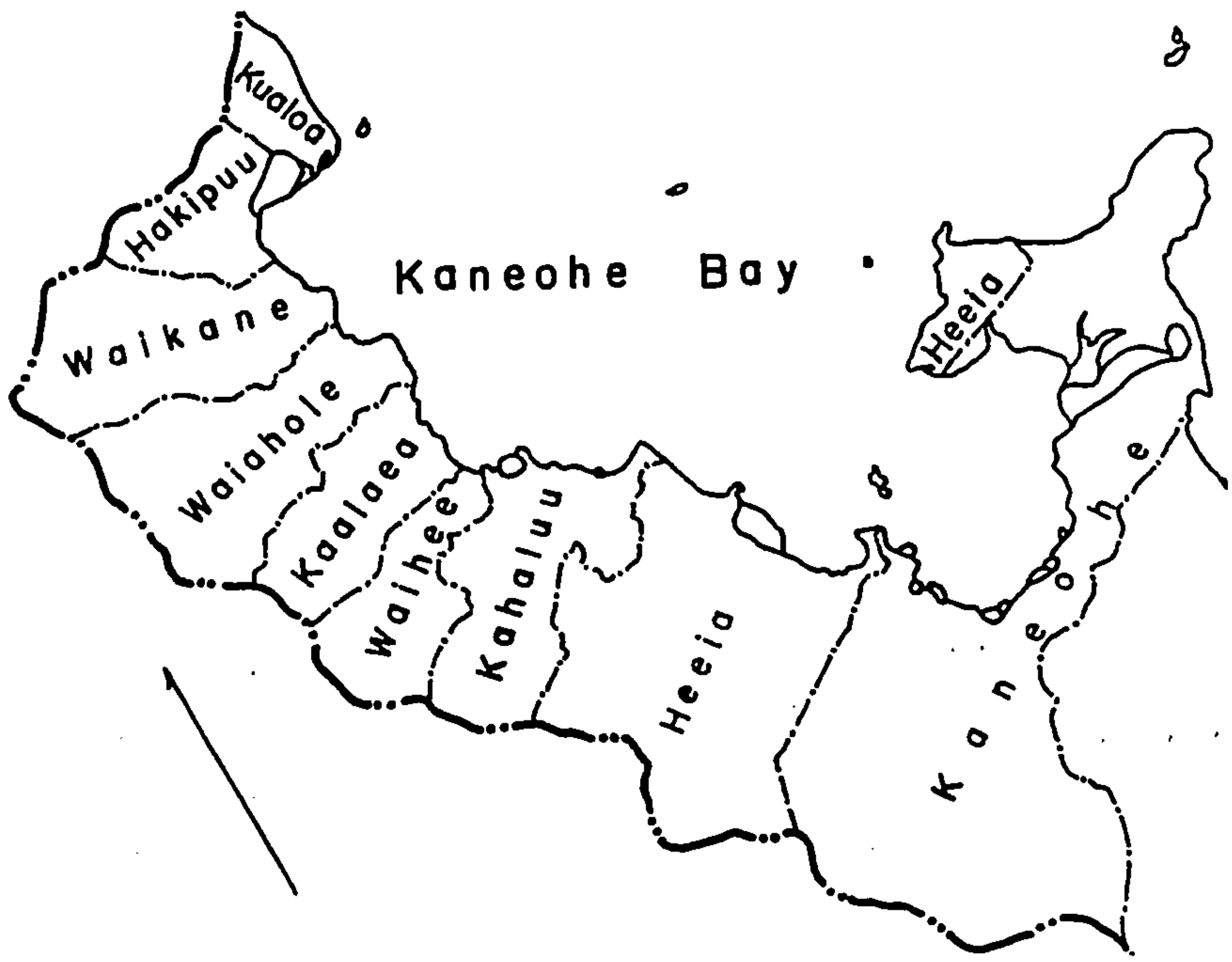


FIGURE 3

AHUPUAA'S IN KANEOHE BAY REGION



2.1 GENERAL CHARACTER OF STUDY AREA

2.1.1 Physical Character and Land Uses

Kahaluu, at the southern part of the study area, is the most populated community in Neighborhood Board Area No. 29. However, it has no central business core, or "downtown." Rather, it is a collection of subdivisions, small farms, open space, and scattered small businesses. Consequently, Kahaluu residents themselves have differed on whether to characterize the area as "suburban" or "agricultural" (see Section 2.3.5).

Within the Neighborhood Board area, the only site that combines relatively dense residential land use and commercial activity is in Ahuimanu, where subdivisions and a small shopping center exist. That zone is at the far southern end of the area, about 4.5 miles from the project site. Kahaluu is home to several nurseries, but no large-scale commercial or industrial sites.

Along Kamehameha Highway at the northern end of Kahaluu, the area has a suburban, residential character. Moving northward, the highway makes several sharp turns into Waiahole, where the character of the surrounding land becomes abruptly rural -- and remains so through much of Waikane and Hakipuu to Kualoa Regional Park.

Waiahole Valley above the highway is a lush, expansive, and lightly populated region combining truck farms, nurseries, rural residential properties, and open space. The smaller part of Waiahole below the highway has a few farms and residences, but also a great deal of open space. Most or all of the legal residents below the highway are month-to-month lessees of McCandless family heirs, who also once owned the mauka agricultural land until the State purchased it in the 1970's as a result of the Waiahole-Waikane "struggle" (see Section 2.2.2).

This character and tenancy pattern makai of the highway continues into Waikane, the next community, until the Waikane Congregational Church. Beyond the church, land on the highway and two short entry roads is zoned Residential. Most of those lots are small. On one of the larger lots, papayas are cultivated.

Most of the Waikane land immediately bordering the highway on the mauka side is vacant. However, Waikane Valley Road -- now a dirt lane -- leads to a small church and several rural homes. About five of the homes are on a kuleana owned by the extended family which occupies these particular homes (as well as a few family members living elsewhere). A few of these kuleana residents raise a limited number of pigs, but do not otherwise farm the land. The family also has another parcel of about three acres in the back of the valley (about 75 yards above the Waikane Development Co. mauka boundary), and this is used for a prawn farm.

This kuleana is surrounded by the 505-acre project site. The project site occupies much of the central part of Waikane Valley. There are now four occupied houses on the land, and several small truck farm operations. These will be more fully described in Section 4.2, dealing with "Displacement/Relocation of Existing Uses."

Above the project site, at the back of Waikane Valley, are two large parcels zoned Agriculture and Preservation. Current uses are limited to farming and forest preservation. A 187-acre parcel includes an area used during World War II for military training. When the lease expired in 1976, much scrap, including some unexploded shells, was removed (Morse, 1984). It is likely that live rounds of ammunition remain, so the Department of the Navy is proceeding with plans to acquire the property. (The Honolulu City Council, however, has urged the Government to seek another solution to the problem (Resolution 88-292).)

At the northern end of Waikane, bordering the project site, Haupoa Road extends about 1,000 feet to a dead end. Bordering this lane are a few Agriculture-zoned lots. Two are vacant; one contains a small flower nursery; one has a stable as well as a house; and the other three have homes.

Past Waikane [redacted] are the <u>ahupuaa</u> of Hakipuu and Kualoa. Much of Hakipuu's upland area is pasturage. Along Hakipuu Stream are farms, including an experimental aquaculture venture run by the University of Hawaii.

Hakipuu and Kualoa include some land zoned Country and used as residences. The major uses of land in these sections are ranching and recreation. Kualoa Ranch holds extensive agricultural lands in Hakipuu and Kualoa, as well as Molii fishpond, which is still used for raising mullet. Recreational activities are found on Kualoa Ranch -- visitors are brought from Waikiki to enjoy various outdoor activities -- and at Kualoa Regional Park.

2.1.2 <u>Socio-Economic Character of Waihaole-Waikane Population</u>

Subsequent sections will provide detailed U.S. Census information on the Kahaluu Neighborhood Board area and on the Census "Block Group" containing Waiahole and Waikane, plus other rural communities. However, no separate Census information exists for Waiahole-Waikane alone.

The following approximate descriptions were provided by Mr. David Chinen, president of the Waiahole-Waikane Community Association. (NOTE: The Waiahole-Waikane Community Association was formed in response to the "struggle" in the 1970's against potential evictions from the former McCandless lands. Its membership is comprised primarily of these current or former tenants, and thus does not include Hakipuu and some of the Waikane fee-simple families below the highway).

According to estimates provided by Mr. Chinen (personal communication, October 13, 1988):

- There are now about 100 households in the Waiahole-Waikane area, with the great majority of these located in Waiahole. About 80 are Community Association members. Households average five to six persons each.

- Roughly 25 percent operate family farms. About 90 percent of these work the farm full-time, while the rest do some subsistence farming to supplement incomes from other jobs or retirement benefits.

- Most of the outside jobs are blue-collar and/or governmental in nature -- skilled trades, firemen, police officers, etc.

- Perhaps 15 percent of the adults are unemployed; these are primarily young people.

- The great majority of families are of low to moderate income. About a third receive some form of welfare.

- A substantial number of householders are retired or approaching retirement. Many of these share their homes with grown children and grandchildren.

- The population is ethnically mixed, with many Filipinos and part-Hawaiians.

2.1.3 Economic Activities in Waiahole-Waikane Area

Farming is the primary activity, although most farms are small and are worked primarily by a husband and wife with some help from other family members during heavy seasons. Some farms may employ one or two non-family workers, although these are often part-time or seasonal.

Other employment in the area is minimal. Waiahole Elementary School has a staff of 18 full-time and 10 part-time employees (personal communication, Ray Sugai, Principal, October 13, 1988). The Waiahole Water Co., owned by Oahu Sugar Co., employs a few people to work on the water system in the back of the valley. There are several fruitstands on the highway, as well as a small family-run general store and several churches.

In the nearby Hakipuu-Kualoa area, Kualoa Ranch employs 57 people. The ranch raises 600 to 800 head of cattle (personal communication, Laurel Mahoney, Corporate Secretary, Kualoa Ranch, October 14, 1988). The ranch raises exotic plants, and exports plants valued at $15,000 or more each month. In recent years, its owners have explored ways to generate additional income through recreational activities such as dune cycle rides. Also in Hakipuu, the Coral Kingdom gift store complex was a favorite tour bus stop until it burned down in a recent fire; it is now being rebuilt.

2.2 HISTORIC FORCES AFFECTING THE STUDY AREA

2.2.1 Changing Land Uses

Much of Windward Oahu is highly suited for agriculture, but not for any single use over the whole area. With rich soil, abundant streams and regular rainfall, the valley bottoms and coastal lands on Kaneohe Bay, from Waikane to Kaneohe, once constituted "the most extensive wet-taro area on Oahu" (Handy and Handy, 1972, p. 272).

The district's history in the last century has been marked by successive attempts to adapt much of this complex landscape to one purpose or another (sugar, rice, then pineapple cultivation, then residential development). Those attempts have left a complex land use pattern. Residential areas, farms, nurseries, and a ranch are all now found near the project site.

In the late nineteenth century, taro was largely replaced as a primary crop. Kualoa Plantation, with the first mill on Oahu, planted land from Hakipuu north to Kaaawa in sugar. Its operations ended in 1871. Sugar plantations in Kaneohe and Heeia were more successful, but the uneven terrain made large-scale operations difficult. The last sugar plantation in the Kaneohe Bay region closed in 1902. Rice was cultivated on both kuleana lands and larger holdings in the <u>ahupuaa</u>'s of Waihee, Kaalaea, Waiahole, and Waikane. Miyagi (1963, p. 106) notes that the low-land areas previously planted in taro "were ideal" for rice cultivation.

Rice cultivation declined because of pests and competition from outside Hawaii. Pineapples were the next major crop. In Waiahole and Waikane, Libby, McNeill & Libby acquired leases for about 600 acres (Devaney et al., 1982, p. 63). Pineapples were planted by small growers on hill land where rice and taro could not be grown (Miyagi, 1963, p. 115). Several archeological sites were modified or dismantled by planters. As had been the case earlier with sugar, the small scale of operations in Windward Oahu made pineapple plantations relatively unprofitable. Canning was centralized in Honolulu in the 1920's, and many of the growing areas were abandoned (Harper, in Devaney et al., 1982, p. 64).

Small-scale farmers had planted varied crops along with the major plantation crops. Rice farmers also raised pigs, dogs, and poultry. Diversified agriculture succeeded the major crops in many of the Kaneohe Bay <u>ahupuaa's</u> early in this century. While Kualoa and parts of Hakipuu were devoted exclusively to ranching by 1880, livestock were also raised, on a smaller scale, in the <u>ahupuaa's</u> to the south (Devaney et al., 1982, p. 71).

A major resource of the region, water, was tapped for the Waiahole Ditch Tunnel, completed in 1916. Water was diverted from Waikane for this project, and the flow of Waikane stream was reduced. In the 1920's, the Waiahole Forest Reserve, created partly for water conservation purposes, was enlarged to include land in Waikane valley (Devaney et al., 1982, pp. 81, 90).

Suburban and urban development of the region came more recently, when the cross-Pali tunnels and highways made access between the Windward coast and Honolulu easier. That development affected first Kailua, then Kaneohe. In the Kahaluu Neighborhood Board area, large-scale residential development was proposed for Waiahole and Waikane in the mid-1970's.

2.2.2 The Waiahole-Waikane "Struggle"

In 1974, the McCandless family heirs, owners of important water rights and nearly all the private land in Waiahole and Waikane, proposed a land use redesignation to allow for a housing development of about 6,700 units. A year later, a group of investors, Windward Partners, took out an option on the McCandless holdings in Waikane and bought much of Waikane for the proposed residential development.

Residents of the two valleys protested the project, arguing that their area should retain its rural character. The case was widely discussed, and many citizens and legislators voiced support for the residents in opposition to the landowners and developer (Peterson, 1979; Eighth Legislature, House Resolution No. 685, 1975).

In 1977, two governmental decisions halted plans for large-scale residential development. The State Land Use Commission rejected a request for redesignation of over 400 acres in Waikane, and Governor George Ariyoshi announced that the State would acquire 600 acres in Waiahole from the landowner. When the would-be developers did not exercise their option to buy in Waiahole, the Hawaii Housing Authority, acting for the State, proceeded with the purchase.

Windward Partners suggested several residential uses for its Waikane land between 1975 and 1986. They filed a Shoreline Management Permit application in 1979 for a subdivision in Waikane, to include 144 lots. Kahaluu representatives, as well as members of the City and State governments, raised questions about the ecological impacts of the proposed development and about dealings between the developer and certain area residents.

Eventually, a scaled-down proposal for over 30 lots on 90 acres at the mouth of the valley was proposed. This proposal gained the City Land Use Director's tentative permision in 1985 (Dooley, 1986), but no subdivision was done.

The failure of the Waiahole-Waikane proposal had several important outcomes. First, an active and effective community organization took shape. Next, many residents acquired, in the end, more secure rights to property.

The Hawaii Housing Authority is making long-term leases available for over 80 existing tenants in Waiahole. It has given older tenants the opportunity to have small residential lots in an agricultural area. Residents of nearby areas such as Waikane who are tenants in good standing of the McCandless heirs and are likely to be displaced have priority in applying for leases for the remaining lots (Kato, 1981; M & E Pacific, 1985; personal communications, Carlton Ching, Agricultural Specialist, Housing Finance Development Corporation, December 21, 1987 and October 17, 1988).

In Waikane, Windward Partners worked out arrangements to transfer title to the existing tenants of five plots (Honolulu Advertiser, 1980). Title was not transferred by Windward Partners or by its successor, Phoenix Partners. Waikane Development Company has worked out agreements with tenants (see Section 4.2).

A final result of the "struggle" had to do with public perceptions. Waiahole-Waikane became known as the scene of a fight against development. However, the Waiahole-Waikane Community Association and the government agencies that supported its position consistently argued a case for the preservation of a rural lifestyle, of agriculture, and of open, relatively undeveloped land on the Windward side of Oahu (Peterson, 1979; Department of Agriculture, 1975).

2.3 SOCIO-ECONOMIC CHARACTERISTICS

2.3.1 Population Levels and Composition

Population Growth: In 1779, the Kaneohe Bay region supported a population estimated at 15,000 to 17,000. By 1832, the regional population was only 3,000. The population of Waikane and Waiahole, taken together, was 419 (Devaney et al., 1982, pp. 1, 9). The Koolaupoko District population continued to decline until 1890. (Similar patterns of rapid population loss, largely attributable to introduced diseases, then continuing decline, occurred in most rural sectors of Hawaii (Schmitt, 1978).) After 1890, Koolaupoko's population increased steadily until 1950. Since then, it has increased even more rapidly, as suburban developments were built at the base of the cross-Koolau highways, and Kaneohe and Kailua both become urban centers.

The resident population of Oahu has grown since 1950. The rate of growth has, however, been declining. Particular areas on Oahu have experienced major increases in population at different times (see Table 1). The Koolaupoko District as a whole boomed in the 1950's, with an average annual population growth rate of 11.2 percent. The Kahaluu Census Designated Place -- the most built-up area in Kahaluu -- underwent a major increase in the 1970's.

The growth rates of Windward areas are linked to the spread of suburban residential areas. Developments in Kailua and then Kaneohe accounted for substantial growth in the 1950's and 1960's, once the Pali and Wilson Tunnels made Honolulu more accessible from the Windward side of the island. More recently,

Table 1:
Population Increases, Oahu and Koolaupoko District, 1950 - 1980

	Honolulu County	Koolaupoko District*	Kahaluu CDP
April 1, 1950	353,020	20,779	N/A
April 1, 1960	500,409	60,238	1,125
April 1, 1970	630,528	92,219	1,657
April 1, 1980	762,565	109,373	2,925
July 1, 1985	814,642	114,600	N/A
<u>Average Annual Growth Rates</u>			
1950 to 1960	3.6%	11.2%	N/A
1960 to 1970	2.3%	4.4%	3.9%
1970 to 1980	1.9%	1.7%	5.8%
1980 to 1985	1.3%	0.9%	N/A

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* The Koolaupoko District is identical with the Census Division of that name.

N/A: Not available.

Sources: U.S. Census, as reported in Hawaii State Department of Planning and Economic Development, <u>Community Profiles for Hawaii</u>, 1972, and <u>State of Hawaii Data Book, 1986</u>, 1986.

such areas as Kahaluu and Kaaawa have grown due in part to residents who commute to urban areas for work.

Population growth in the Koolaupoko District has slowed during the 1980's. The district population grew at an annual rate of 1.7 percent during the 1970's, and an estimated rate of 0.9 percent from 1980 to 1985 (Hawaii State Department of Planning and Economic Development, 1986, p.17).

Kahaluu's population is far smaller than that of suburban Kaneohe to the south (see Table 2). While it has about the same number of people as the Koolauloa Neighborhood Board area along the coast to the north, the Kahaluu Neighborhood Board land area is less than half that of the Koolauloa Board. Hence it is much more densely populated.

The population of the southern part of the Kahaluu Neighborhood Board area has risen in recent years, but little change has occurred in the northern sections of the area, where the proposed project would be located. One indication of this can be found in the population figures for Census Tract 103.03, in the north, and Census Tract 103.04, including most of the residential concentration in the Neighborhood Board area (Hawaii State Department of Business and Economic Development, 1987):

Census Tract	1970	1980	1985 est.
103.03	3,413	3,593	3,700
103.04	4,776	9,784	10,900

Composition of the Population: In all the Windward areas examined here, the Hawaii-born formed a majority of the population in 1980. In other ways, the areas differed. Notable differences include age structure and residence. In the *ahupuaa*'s nearest the project site, labelled as the "Waikane Area" in Table 2, the population was older and people were far more likely than in nearby areas to have lived for five years in the same house.

In all three Neighborhood Board areas under discussion, people born in Hawaii formed the majority of the population. In the Kahaluu and Kaneohe areas, they were found in higher proportion than in Oahu as a whole. Similarly, people in these two areas were more likely than the island population to have lived in the same house in the past five years.

In terms of education, Kahaluu residents resembled the Oahu population as a whole. A higher proportion of Kahaluu area residents than residents of the other two Neighborhood Board areas had a high school education. Also, the age structure of the Kahaluu Neighborhood Board area was similar to that of Kaneohe and the City and County as a whole -- while the Koolauloa area was inhabited by a much younger population.

In the less developed part of the Kahaluu area (Census Tract 103.03, Block Group 9, including the project site) three-quarters

TABLE 2:

Population and Demographic Characteristics: City and County of Honolulu and Various Parts of Study Area, 1980

	CITY AND COUNTY OF HONOLULU 1980	KOOLAULOA NEIGHBORHOOD BOARD, No. 28 1980	KAHALUU NEIGHBORHOOD BOARD, No. 29 1980	KANEOHE NEIGHBORHOOD BOARD, No. 30 1980	WAIKANE AREA (C.T. 103.03, Block Group 9) 1980
TOTAL POPULATION	762,565	10,983	11,782	36,553	714
	%	%	%	%	%
ETHNICITY					
Caucasian	33.1	28.7	33.8	32.1	20.9
Japanese	24.9	N/A	N/A	N/A	16.9
Chinese	6.9	N/A	N/A	N/A	4.2
Filipino	12.8	N/A	N/A	N/A	6.6
Hawaiian	10.5	N/A	N/A	N/A	40.1
Other	11.8	71.3	66.2	67.9	11.3
AGE					
Less than 5 yr.	7.8	12.4	10.4	7.4	10.1
5 - 17 yr.	24.2	30.6	27.6	27.7	20.2
18 - 64 yr.	60.7	50.8	57.4	59.0	58.7
65 or more yr.	7.2	6.2	4.6	6.0	11.0
Median age	28.1 yr	22.5 yr	27.6 yr	28.6 yr	30.0 yr
PLACE OF BIRTH*					
Hawaii	55.1	53.2	71.2	72.5	76.6
Other U.S.***	30.1	26.9	24.0	21.9	14.4
Foreign country	14.8	19.9	4.8	5.6	9.0
RESIDENCE 5 YRS. PREVIOUS* (people aged 5+)					
Same house	48.2	47.6	57.1	63.8	74.6
Same island	25.5	28.4	32.8	22.6	24.6
Different island	1.3	0.6	0.8	1.1	0.0
Different state	18.4	10.9	7.8	9.6	0.6
Different country	6.6	12.5	1.5	5.6	0.0
EDUCATION (people aged 25+)					
0-8 years only	14.4	27.3	16.0	20.0	26.2
Hi school only	46.0	32.1	41.7	39.6	55.5
Some post H.S.	18.3	22.0	19.2	17.9	3.1
College, 4+ yr.	21.7	18.5	23.0	22.5	15.2

Notes: *Figures based on 15% sample; hence, numbers represent estimate.
***Including persons born in U.S. territories, and persons born abroad or at sea to American parent/s.
"NC" = 1970 categories or bases "Not Comparable" to 1980 (1970 Census kept a "non-response" category, while 1980 Census allocated non-responses to other categories shown). "N/A" = "Not Available."

Sources: 1980 Summary Tape Files 1-A and 3-A; State of Hawaii, U.S. Bureau of the Census, 1980 Census of Population and Housing--Special Report: Neighborhood Statistics Program, Part 13--Hawaii--PHC80-SP1-13, 1983; percentages computed by Community Resources, Inc.

of the population lived in the same house in 1975 and 1980 . The population was also relatively old. Ethnically, the Block Group population included an unusually high proportion of Hawaiians (compared to Oahu as a whole) and substantial groups of Caucasian and Japanese ancestry, as Table 2 shows. As for education, the people of the Block Group were less likely to have advanced education than the City and County population, or the populations of any of the Neighborhood Board areas shown in Table 2.

A survey of 95 households in Waiahole and Waikane combined, done in 1974, showed that the population included a high proportion of Hawaiians and part-Hawaiians (46 percent) (Architects Hawaii, 1978). While a quarter of the population had moved into their houses within the last five years, over 40 percent had been in their homes for over 20 years.

Studies of Waiahole alone (Miyagi, 1963; M & E Pacific, 1985) indicate some changes in ethnic composition. The proportion of the population identified as Filipino or "mixed" increased from 1962 to 1977, while Japanese, Hawaiians and Caucasians came to form smaller parts of the population. Yet, nearly two-thirds of the valley's people in 1977 had lived there for over 20 years. The valley's people are relatively old -- the median age reported for 1977 was 31, compared to an Oahu median of nearly 26 (p. III-49). (The Block Group 9 median age was 30, as shown in Table 2.)

2.3.2 Family Characteristics and Income

As of 1980, Windward Oahu's people were more apt than the island population as a whole to live in family units, as Table 3 shows. Nearly all the Kahaluu population lives in family units. Nearly all the Kahaluu population lived in familes, and Kahaluu families were somewhat more likely than the island population as a whole to have dependent children in the household.

The income level of most families in the Kaneohe and Kahaluu Neighborhood Board areas was above the island average in 1980.

In the relatively rural Block Group 9 (including Waikane), however, most people were not affluent. The median income of families was under half the island average, and the proportion of households below the poverty line was well above the island average, for both family and non-family households.

When families in Waiahole and Waikane were surveyed in 1974, the median income reported was 80 percent of the Oahu median (Architects Hawaii, 1978).

The area surrounding the project site (Block Group 9) broadly resembles the Koolauloa area in regard to family and income characteristics. An important difference is that only 39.8 percent of Block Group 9 family heads had own children under 18 with them in 1980. The absence of co-resident children and the decline in income levels (from 1974 to 1980) reported above are both largely attributable to an aging population.

TABLE 3:

Family Characteristics and Income Levels: City and County of Honolulu and Various Parts of Study Area, 1980

	CITY AND COUNTY OF HONOLULU 1980	KOOLAULOA NEIGHBORHOOD BOARD, No. 28 1980	KAHALUU NEIGHBORHOOD BOARD, No. 29 1980	KANEOHE NEIGHBORHOOD BOARD, No. 30 1980	WAIKANE AREA (C.T. 103.03, Block Group 9) 1980
POPULATION IN FAMILIES	653,118	9,126	11,276	33,742	484
as percentage of total population	85.6%	83.1%	99.5%	94.9%	67.8%
NUMBER OF FAMILIES	178,516	2,177	2,922	8,720	148
	%	%	%	%	%
HEAD					
Husband/wife	82.8	85.4	81.4	84.8	85.8
Male only	4.5	4.4	4.6	3.8	6.8
Female only	12.7	10.2	13.9	11.3	7.4
WITH OWN CHILDREN UNDER 18	54.9	62.6	62.4	56.4	39.8
Female head	7.5	6.8	9.6	6.7	7.4
BELOW POVERTY LEVEL	7.5	16.0	7.3	3.8	16.2
MEDIAN FAMILY INCOME	$23,554	$17,005	$25,572	$29,453	$10,500
NON-FAMILY HOUSEHOLDS	52,415	1,014	937	2,109	52
percentage below poverty level	15.9%	N/A	N/A	N/A	46.2%

Notes: All figures (except "Population in Families") based on 15% sample; hence, numbers represent estimates. "N/A" = "Not Available."

Sources: 1980 Summary Tape File 3-A; State of Hawaii, U.S. Bureau of the Census, 1980 Census of Population and Housing--Special Report: Neighborhood Statistics Program, Part 13--Hawaii--PHC80-SP1-13, 1983; percentages computed by Community Resources, Inc.

2.3.3 Labor Force Characteristics

With an economy based on tourism and defense, Oahu has a large proportion of professional, technical and service workers in the civilian population, and relatively few manual workers. Due in part to the high cost of living, a high proportion of Hawaii's adults are in the labor force.

As of 1980, the people of the Neighborhood Board areas of Kaneohe and Kahaluu resembled the entire Oahu civilian population in regard to both labor force involvement and occupation (see Table 4).

Even a majority of the workers living in the relatively rural Block Group 9 (including Waikane) held white-collar jobs in 1980. About eight percent of the employed civilian labor force were farmers. While this proportion is small, it marks out the area as more agricultural than the suburban zones nearby.

For some time, a minority of residents in the area around the project site have been farmers. Only 15 percent of the households surveyed in Waiahole and Waikane in 1974 included a member or members involved in agriculture.

In a 1975 study (U.S. Army Corps of Engineers, 1975), a sample from the area from Waiahole to Kualoa provided information about involvement in agriculture. In almost all cases, less than a quarter of family income derived from agriculture -- a pattern of responses similar to that of more suburban Kahaluu residents -- although two-fifths of the sample reported that they grew fruits or vegetables on their land.

A further consequence of the area's relatively undeveloped character is that the proportion of workers commuting over 45 minutes to work each day is high.

The mean commuting time of Block Group 9 residents was well above the island average in 1980. In 1974, over 60 percent of the households surveyed in Waiahole and Waikane had a member working in the Windward area. (Still, many residents, from other households or from ones with Windward workers, may have commuted to the other side of the island regularly.)

Nearly half the Kahaluu area residents who responded to a question about commuting in 1981 (Rural Land & Water, 1981) said that they worked in Honolulu; over a quarter worked in Kahaluu itself.

As Table 4 shows for 1980, no unemployment was reported for Block Group 9 -- but a high proportion of adults was not counted as part of the labor force. (Also, these figures are based on samples, and are often less accurate for smaller populations than for larger ones.) In the Neighborhood Board areas listed in Table 4, unemployment was somewhat below the City and County average in 1980. In the Kahaluu and Kaneohe Neighborhood Board areas, the proportion of the population outside the labor force was similar to that of the City and County population.

TABLE 4:
Labor Force Size and Characteristics: City and County of Honolulu and Various Parts of Study Area, 1980

	CITY AND COUNTY OF HONOLULU 1980	KOOLAULOA NEIGHBORHOOD BOARD, No. 28 1980	KAHALUU NEIGHBORHOOD BOARD, No. 29 1980	KANEOHE NEIGHBORHOOD BOARD, No. 30 1980	WAIKANE AREA (C.T. 103.03, Block Group 9) 1980
POTENTIAL LABOR FORCE (aged 16+)	574,903	7,349	8,154	26,102	418
not in labor force	30.8%	38.3%	30.3%	31.1%	50.0%
armed forces	10.1%	0.9%	2.3%	2.2%	0.0%
civil. labor force	59.1%	60.8%	67.4%	66.5%	50.0%
CIVILIAN LABOR FORCE	339,863	4,468	5,497	17,355	209
unemployed	4.6%	3.7%	3.3%	4.4%	0.0%
TOTAL EMPLOYED CIVIL. LABOR FORCE	324,113	4,303	5,318	16,600	209
OCCUPATION					
service	17.6%	26.9%	15.4%	14.4%	15.8%
manager./profes.	24.7%	22.6%	28.4%	26.2%	22.5%
technical, sales & adminis.	33.8%	24.8%	32.6%	34.5%	27.8%
farm/fish/forest	1.8%	5.9%	2.5%	1.3%	8.1%
precision, craft, repair	11.3%	9.9%	12.6%	12.9%	3.8%
operators, fabricators, laborers	10.9%	9.9%	8.5%	10.6%	22.0%
INDUSTRY (selected)					
agric., forest, fish, mining	1.7%	4.9%	3.6%	1.5%	26.8%
construction	6.6%	6.7%	7.1%	7.8%	2.4%
manufacturing	7.7%	3.1%	6.8%	8.5%	13.9%
retail trade	20.5%	10.7%	18.1%	18.0%	9.1%
financial, insur., real estate	8.1%	23.9%	9.7%	8.6%	8.1%
personal, entertain. & recreat. services	8.1%	29.3%	4.9%	5.1%	3.8%
health, educ., & professional	18.5%	29.3%	20.6%	19.9%	11.5%
public adminis.	10.9%	7.9%	14.0%	11.4%	7.2%
COMMUTE TO WORK					
45 minutes or more	13.4%	N/A	N/A	N/A	21.1%
mean travel (min.)	22.6 m	N/A	N/A	N/A	30.0 m

Notes: All figures based on 15% sample; hence, numbers represent estimates.
"N/A" = "Not Available" in published form.

Sources: 1980 Summary Tape File 3-A; State of Hawaii. U.S. Bureau of the Census, 1980 Census of Population and Housing--Special Report: Neighborhood Statistics Program, Part 13--Hawaii--PHC80-SP1-13, 1983; percentages computed by Community Resources, Inc.

2.3.4 Housing

The Oahu housing market is shaped by high land costs, Hawaii's distinctive leasehold system, and the presence of many condominium units. Housing units are less likely to be owner-occupied than in other states. Yet, many householders seek fee simple title to land. The relatively high proportion of owner-occupied units in the Kaneohe and Kahaluu areas is partly due to recent suburban development (see Table 5).

Rented units are relatively numerous in the northern, less developed part of the Kahaluu area (Block Group 9) where the project will be located. The level of rental housing may reflect the continued existence of large landholdings, and hence the preponderance of land leases, rather than fee simple title, in the area. The proportion of renter-occupied units in the Block Group resembles that found in the Koolauloa Neighborhood Board area. Leases (and hence rents) are unusually low in the Block Group, as a result of a gubernatorial decision, not market forces (Peterson 1979).

2.3.5 Lifestyle and Values

As was noted above, the Windward Oahu area includes a large suburban concentration, but becomes increasingly rural as one travels north through Kahaluu to Koolauloa District. Many in Waikane and the rest of Block Group 9 work outside Kahaluu, and hence are commuters like the residents of named subdivisions in Kaneohe and Kailua. Nonetheless, both residents and local representatives view Waiahole and the ahupuaa's north of it as undeveloped or rural, and have expressed opposition to residential or commercial development.

During the 1970's, residents' views of Waiahole and Waikane as a community were documented in demonstrations and surveys. (Survey results from that period must be interpreted with the political context of the time in mind.)

Residents of Waiahole and nearby areas strongly expressed satisfaction with their community and a determination not to move (U.S. Army Corps of Engineers, 1975, M & E Pacific, 1985). They showed their high regard for their home area both by finding no disadvantage worth mentioning in the area (69 percent of respondents) and by valuing it for reasons linked to its undeveloped situation. The major advantages mentioned (in 1974, reported in Architects Hawaii, 1978) were:

Peace and quiet	46%
Inexpensive	19%
Backyard agriculture	14%
Close to job	12%
Family ties	6%
Other	3%

TABLE 5:

Housing Stock and Characteristics: City and County of Honolulu and Various Parts of Study Area, 1970 and 1980

	CITY AND COUNTY OF HONOLULU 1980	KOOLAULOA NEIGHBORHOOD BOARD, No. 28 1980	KAHALUU NEIGHBORHOOD BOARD, No. 29 1980	KANEOHE NEIGHBORHOOD BOARD, No. 30 1980	WAIKANE AREA (C.T. 103.03, Block Group 9) 1980
TOTAL YEAR-ROUND HOUSING UNITS	250,866	3,481	3,607	10,049	260
vacant (total)	8.2%	22.8%	6.8%	3.5%	15.4%
vacant for sale	0.5%	1.0%	1.8%	0.4%	0.8%
vacant for rent	3.6%	11.0%	2.6%	2.1%	6.5%
held for occas'l use	0.9%	7.9%	0.6%	0.2%	4.6%
other	3.2%	2.9%	1.8%	0.8%	3.5%
TOTAL YEAR-ROUND OCCUPIED UNITS	230,214	2,687	3,360	9,698	220
TENURE					
owner-occupied	49.9%	35.6%	66.2%	72.0%	37.7%
renter-occupied	50.1%	64.4%	33.8%	28.0%	62.3%
SELECTED CONDITIONS					
lacking some or all plumbing	1.5%	2.9%	1.0%	0.5%	8.1%
1.51 or more persons/room	7.4%	19.9%	6.0%	5.2%	14.6%
PERSONS PER HOUSEHOLD	3.15	3.26	3.31	3.43	3.21
MEDIAN CASH RENT (renter-occupied)	$279	$324	$275	$390	$145
as % of median family income	14.2%	22.9%	12.8%	15.9%	16.6%
MEDIAN VALUE* (owner-occupied)	$130,400	$82,800	$139,100	$122,500	$133,900
MEDIAN MONTHLY MORTGAGE* (owner-occupied)**	$494	$438	$532	$442	$375
as % of median family income	25.2%	30.9%	25.0%	18.0%	42.8%

Notes: * For 1980, median values are for non-condominium housing units.
** Figures based on 15% sample, hence, numbers represent estimates.
"N/A" = "Not Available."

Sources: 1980 Summary Tape File 1-A and 3-A; State of Hawaii, U.S. Bureau of the Census, 1980 Census of Population and Housing--Special Report: Neighborhood Statistics Program, Part 13--Hawaii--PHC80-SP1-13, 1983; percentages computed by Community Resources, Inc.

Nearly half the residents of the area from Waiahole to Kualoa polled in 1975 identified their community as "closely knit; that is, residents share similar views and values and see each other frequently."

In the 1975 study, a sample of Kaneohe residents was also polled. The Kaneohe residents and these respondents from the ahupuaa's around Waikane reported similar patterns of neighborhood visiting, but only a fifth of the Kaneohe sample reported such a strong sense of community (U.S. Army Corps of Engineers, 1975).

In response to the possibility of large-scale residential development in the 1970's, the Waiahole-Waikane Community Association formulated goals which may be taken as expressions of residents' values. They sought assurances of a continuing rural community life, guaranteed by long-term leases, expanded agriculture, guarantees for community integrity, and regional planning (Peterson, 1979).

Residents of Waiahole who were not in the Community Association also expressed support for the dedication of that valley to agriculture, and opposition to further residential development of the valley (Architects Hawaii, 1978). In Waiahole, lengthy efforts have been made by planners and members of the community to minimize disruption of residents' lives and to preserve the rural character of the valley (M & E Pacific, 1985).

In the 1980's, Kahaluu area survey respondents have shown that they value a rural atmosphere, while they also favor infrastructural improvements.

One survey (Rural Land and Water, 1981) asked residents how they viewed Kahaluu. "Agricultural" was the answer of 52 percent of the respondents, while 34 percent chose "suburban" and only ten percent chose "urban." The large majority of those who viewed Kahaluu as agricultural or suburban did not want it to change.

A Kahaluu Neighborhood Board survey in 1986 brought out residents' support for open space. (Forms were returned by 542 Kahaluu households, a return rate of 15 percent.) For 88 percent of the respondents, the preservation of agricultural lands in the area was important or very important. Asked about possible uses for agricultural land, if changes were necessary, nearly half supported conversion of agricultural land for parks, while residential uses were supported by a fifth of respondents. Commercial and industrial uses were favored by very few.

A majority of respondents to the 1986 questionnaire favored widening Kahekili Highway, construction of H-3, construction of a public sewer system for the area, and the preservation of historic sites. While most valued Kahaluu's "country" quality, then, they also sought improved facilities.

2.4 COMMUNITY ISSUES AND CONCERNS INDEPENDENT OF THE PROJECT

The purpose of this section is to identify major community concerns which may be directly or indirectly relevant to the project. The focus here is on general needs and issues. The particular concerns and issues that have been mentioned by local residents as important in relation to the proposed project will be discussed further below, in section 4.1.

2.4.1 Islandwide Issues and Concerns

Data on the concerns of Oahu residents in general can be found in the results of opinion polls. Respondents to the February 1988 Hawaii Poll conducted by SMS Research, Inc. mentioned traffic first among "most important problems in Hawaii that government should do something about" (Keir, 1988a).

Aloha United Way and the Health and Community Services Council (1987) have compiled results from surveys in which Oahu residents indicated their priorities. (The sources include polls taken by the Honolulu Advertiser, the 1984 State Plan Survey, a 1986 Chamber of Commerce study, and the Hawaii Quarterly Consumer Survey that SMS Research, Inc. has conducted since 1983.)

Oahu residents have consistently expressed concern with regard to five major issues: jobs, crime, traffic, education, and housing. In some surveys, the high cost of living and inflation have been mentioned as important. Environmental issues, social problems, land use, and such economic issues as tourism, economic growth, and the preservation of agricultural land have all scored lower in measures of residents' priorities in the 1980's.

The ranking of the five or six most prominent issues has changed from survey to survey. The summary prepared for the Aloha United Way and Health and Community Services Council argues that (1) the issue of housing has been responsive to economic shifts, while (2) public concern with traffic conditions has been rising rapidly in the past few years, independent of economic conditions.

In addition to these issues, media attention and public debate have recently focused on foreign investment in Hawaii. Of 701 persons polled in May 1988, a majority opposed the purchase of land by foreign investors in order to develop housing, golf courses or hotels (Keir 1988b, 1988c). Oahu residents voted in roughly equal numbers for and against hotel purchases by outside investors.

2.4.2 Kahaluu Area Residents' Concerns

The findings on values presented in section 2.3.5 indicate that Kahaluu area residents are concerned over maintaining the rural atmosphere of their surroundings, yet largely favor infrastructural improvements, some of which could lead to more urban development.

More detailed expression of the current concerns of residents is available mainly from the minutes and decisions of the Neighborhood Board.

Members of the Board have repeatedly stressed a view of the Kahaluu area as dedicated to agriculture and as supporting a rural lifestyle. In its concern with land use issues, the Board has shown vigilance and a comprehensive understanding the development process.

Some of the major items under discussion by the Board from January 1986 to September 1988 (not necessarily in order of importance) were:

<u>Land Use and Community Control</u>: The Neighborhood Board has repeatedly expressed concern for orderly planning of developments, control over land use to assure community input in decision-making, and safeguarding rural character and agriculture in the area. Although Neighborhood Boards usually consider particular projects or complaints, the Kahaluu Neighborhood Board has consistently taken a regional view of issues before it.

The Board's views about land use controls are clear in its responses to several matters:

- <u>Tri-Party Agreements</u>: The Board discussed a proposal to involve the community in the evaluation of proposed developments. A letter was drafted, identifying the Board's concerns with equality, feasibility, possible litigation, and the effect of the proposal on the Board's advisory status.

- <u>Heeia Kea Development</u>: The Board had previously opposed plans for a residential development at Heeia Kea, but in 1986 supported the developer's application for a Development Plan amendment, as responsive to their concerns. Some members raised further questions concerning the planning process, the effects of the proposed development on traffic, and community views of the proposed development. Later, the Board urged a new potential developer to treat all future displacees equally. The Board expressed a sense of involvement in the negotiations and in the fate of all those living on land slated for new development.

- <u>Coral Kingdom</u>: The Board opposed a request for a zoning variance for the Coral Kingdom in Hakipuu. The Board emphasized its concern with traffic and safety in this connection. It further noted that the permit process should be followed, and that a plan should be made available to the Board and the community before any variance is granted. The Board further opposed a request for a special use permit on several grounds: (1) nonagricultural uses of land should not be approved in areas zoned or designated for agriculture; (2) Alternative sites for commercial use are available; (3) concerns over traffic safety; (4) limited sewage resources; and (5) questions of the legality of the proposed use.

- <u>PAK Ranch</u>: The Board refused to support an application for a Conditional Use Permit for this group living facility, citing its concern with (1) failure to apply for permits before beginning operations; (2) violation of building and zoning codes; (3) increased traffic on an unimproved road; (4) sewage; and (5) the consequences of the development on the tax assessments of adjacent properties.

- <u>Future Growth</u>: The Board discussed General Plan and Development Plan guidelines that could act as a curb on growth in the area. It voted unanimously in support of the goal of a smaller population in Koolaupoko, and "keeping rural areas rural."

<u>Water</u>: The Board expressed opposition to the Board of Water Supply's (BWS) proposed changes in the Windward Oahu Regional Water System. It called for studies of instream levels and the development of instream flow standards. It opposed the BWS"s water use priorities, holding that the provision of water for small-scale agriculture should be a high priority.

The Board unanimously opposed the BWS proposal for well development in Hakipuu. Earlier, the Board drafted a resolution for a moratorium on the diversion of stream water until instream levels are determined. It also opposed the BWS proposal to abolish agricultural water rates.

<u>Traffic and Road Improvements</u>: Traffic and road safety issues, including possible road improvements, were repeatedly discussed.

<u>Parks</u>: The Board expressed concern over problems of maintenance and erosion at Kualoa Regional Park. It voted that the creation of a Kahaluu Regional Park was of high priority. The condition of other parks in the Neighborhood Board area was reviewed.

<u>Kualoa Ranch</u>: The owners proposed recreational ventures at the ranch, including dune cycle tours, scuba diving, jet skiing and helicopter rides. The Board indicated its concern that these activities not affect the environment, water resources, and Hawaiian burial sites adversely. Some supported the ranch's proposal as preferable to an alternate plan for condominium development and as providing jobs.

<u>Statewide Ocean Recreation Management Plan</u>: The Board's concerns with planning, with community input, with protection of Kaneohe Bay, and with recreation emerged in a

discussion of a plan which would designate certain water areas for particular recreational activities, including jet skis in some sites. The Board voted unanimously against the current plan, favoring a process of further study and community consultation.

Crime: The Board heard reports about drug arrests, speeding and DUI violations, and vandalism.

At a June 1988 working session, the Board identified four topics which it intended to emphasize during the coming year:

- o transportation;
- o parks;
- o community education; and
- o developing criterial to evaluate land use and water issues.

These emphases are similar to many of the concerns noted in the Board's minutes. They suggest that both the rural atmosphere valued by area residents and the difficulties of commuting to work outside Kahaluu continue to command attention.

3.0 FORCES FOR CHANGE WITHOUT THE PROJECT

Specific project impacts are discussed in Section 4.0, below. This section provides information on anticipated and announced projects which could lead to important changes in the study area, apart from the project. They are part of the context in which the potential impacts of the project must be assessed. Possible infrastructural changes will be discussed in some detail, while potential sources of housing and employment, which are expected to have a smaller impact on the area, will be summarized.

3.1 THE WAIAHOLE AGRICULTURAL PARK

The opening of the Waiahole Agricultural Park, scheduled for 1989 (discussed in Section 2.2.2), must be considered an important force for change in the Waiahole-Waikane area, even though most of the tenants will be persons currently on the State land in Waiahole. Several aspects of the project could affect the surrounding area:

- The Agricultural Park will offer long-term leases to tenants of the McCandless heirs, and may thus lead to the relocation of several families within the Waiahole-Waikane area;
- Consequently, some of the McCandless lands will no longer have tenants -- a situation with uncertain implications;
- By offering low leases but demanding that tenants on Agricultural lots develop income from agriculture, the Agricultural Park will stimulate agricultural production; for some tenants, the regulations amount to a demand to concentrate their efforts on farming as a livelihood, not a supplement to a job elsewhere; and
- The water system developed for the project will supply residents of the Agricultural Park, allowing the diversion (or reversion) of some of the water from the McCandless water system into Waianu Stream.

3.2 INFRASTRUCTURAL CHANGES

The largest proposed development affecting the Koolaupoko District is the H-3 Highway. By providing a third cross-Koolau route, it promises to make commuting between the Windward side and the urban areas of Honolulu and Pearl City easier. It may hence expand the variety of employment opportunities considered by Windward residents, while making the Windward area more attractive as a residential choice to some persons now living in Honolulu and areas to the west of Honolulu.

The widening of Kahekili Highway has been discussed. This proposal could decrease traffic congestion in Kaneohe, making commuting easier for Kahaluu residents. No plans for significantly enlarging Kamehameha Highway, closer to the project site, have been announced.

The Board of Water Supply has filed an Environmental Impact Statement for projects aimed at developing new sources of potable water in Windward Oahu, to provide for anticipated demand throughout Oahu (VTN Pacific, 1988). These projects could affect streams and groundwater in much of the study area.

A well site and an alternate site have been identified in Waikane valley, on privately owned land above the project site. Some 500,000 gallons per day are projected as tapped from an operating well; a standby well is also to be drilled. No reservoir in Waikane is planned. While the existing dirt road that runs through the project site would be used to reach the well sites, construction would demand modification of that road, in order to transport drilling equipment to the proposed well sites. Two pipelines, to the main water line at Kamehameha Highway and to a proposed reservoir in Waiahole, are planned.

The draft Environmental Impact Statement notes that, "with few exceptions, all of the existing windward Oahu stream users could be adversely affected by BWS projects" (VTN Pacific, 1987, Vol. I, p. 210). Waikane stream is included in the list of affected streams, although it is claimed that two (of six) Waikane stream users would not be adversely affected. The Final Environmental Impact Statement notes that both ground water springs in the wetlands and stream flow could be affected by the Waikane well (VTN Pacific, 1988, Vol. I, p. 210).

The Windward Oahu Regional Water System plan also calls for wells in Hakipuu and Waiahole, the ahupuaa's adjacent to Waikane. These, however, seem less certain of being drilled than the proposed Waikane wells.

In Waiahole, competing plans by the State (for the Waiahole Agricultural Park) and the Waiahole Irrigation Company have been announced. Since the two government-sponsored projects are seen as probably having "mutual interference effects," it is likely that the Board of Water Supply would not dig wells in Waiahole, should the State wells be dug (VTN Pacific, 1987, Vol. I, p. 212).

As for Hakipuu, the major landholder has objected that the proposed wells would adversely affect existing ranch activities, aquaculture, and agriculture (Francis S. Morgan, in Ibid., vol. II, p. G-72.). As was noted above (Section 2.3.6), the Kahaluu Neighborhood Board has opposed well development in Hakipuu.

3.3 EXPANDED RECREATIONAL OPPORTUNITIES IN THE KAHALUU TO KUALOA AREA

In recent years, the recreational resources of the Kahaluu area have increased notably, with expanded facilities at Kualoa

Regional Park and the creation of a visitor-oriented recreation program at Kualoa Ranch. This trend will continue:

- Plans have been maded to consolidated small parcels in Kahaluu now dedicated to park or preservation use into a Kahaluu Regional Park, providing sports facilities;

- On Pulama Road in Kahaluu, Senator Fong's Plantation and Gardens has opened as a visitor attraction emphasizing exotic plants and flowers. This represents an investment of about $5 million, and will be maintained partly with visitor revenues, partly with continuing support from the Fong family (Jokiel and Ma, 1988);

- Nearer the project site, Kualoa Ranch plans to allow catamarans on Molii Pond, but no increase in the number of on-site visitors is planned (personal communication, Laurel Mahoney, Corporate Secretary, Kualoa Ranch, October 14, 1988); and

- State plans for a "living park" in Kahana valley -- inhabited by residents but open to visitors -- have long been maturing.

The proposed changes will provide additional facilities for recreation to both visitors and area residents. They could hence marginally increase the interest and appeal of the area for both potential residents and tourists.

3.4 OTHER FORCES FOR CHANGE

In Kahaluu, plans for residential development were proposed for Heeia Kea, but the Planning Commission denied approval, most recently in 1987. No further plans for development have been announced; instead it is likely that the owner will sell the property (Wagner, 1988).

No amendments to the Koolaupoko Development Plan were proposed in 1987 that would affect Kahaluu directly. In the 1988 Development Plan Review package, Alexander and Baldwin requested a Land Use Amendment for 23 acres in Kahaluu. Single-family residential and commercial developments were proposed. Government agencies have opposed the amendment because (1) most of the site is wetland; (2) no need for new commercial land in Kahaluu has been shown; and (3) the community is unanimously opposed to the proposal (Honolulu City and County Department of General Planning, 1988b).

An amendment to the Special Provisions for Koolaupoko (88/KP-SP1) opposing "further urban development" makai of the highway in the Kahaluu area (and in Waimanalo) has been proposed. The Chief Planning Officer has rejected the proposal on the grounds that existing provisions provide adequate design controls for rural areas and a protect a <u>greater</u> area -- up to 1,000 feet makai of the highway, rather than 300 feet -- from intensive development (Ibid.) Agency and community responses to the proposal indicate a consensus against more intensive land use in makai areas from Kahaluu to Kualoa.

So far, no amendments to the Development Plan for Koolaupoko affecting the Kahaluu area have been submitted for the 1989 Development Plan Review package (personal communication, Faith Miyasako, Area Planner for Koolaupoko, October 14, 1988).

4.0 SOCIAL AND ECONOMIC IMPACTS

This section includes analysis of:

- Community issues and concerns to date;
- Displacement/relocation of existing uses and occupants;
- Employment impacts;
- Government revenues;
- Population impacts;
- Off-site property taxes and other implications for surrounding community;
- Socio-economic mitigations and enhancements.

4.1 COMMUNITY ISSUES AND CONCERNS TO DATE

This sub-section (1) describes the developer's community involvement process and the nature of community response; and (2) outlines the major issues and concerns which have emerged to date (i.e., as of late October 1988).

4.1.1 Community Involvement and Response

The Waiahole-Waikane Community Association (WWCA) has voted to support the proposed project, following extensive discussions with the developer. Following is a history of those and related community discussions.

Waikane Development Co. formed a community relations team and began informal one-on-one talks with various residents and community leaders in late 1987. These went on for only a short time before the project team:

(1) learned of reported agreements by the previous owner to relocate some individuals now living on or farming parts of the project site; and

(2) was advised by a number of community people to work primarily through the WWCA before dealing with the broader Kahaluu area community.

The first part of 1988 was spent in working out voluntary agreements to relocate occupants and farmers and in establishing preliminary linkages with the WWCA. The WWCA was involved in determining relocation or compensation arrangements for three residential households and one farmer. Two other households decided to work separately and directly with the developer. The general nature of the agreements is discussed in Section 4.2.

Once relocation agreements had been reached, the project team -- including management and technical consultants -- began a series of regular meetings with the WWCA Steering Committee, a group of about 16 people, including WWCA officers. These meetings, which are still ongoing, began in early July 1988 and have continued at the rate of one or two a month.

The meetings have focused on additional project concerns discussed below (with a particular emphasis on water issues), as well as potential developer "give-backs" (with a particular emphasis on job training and contributions to Waiahole Elementary School).

Appearing jointly with the WWCA president, Waikane Development Co. representatives made an initial presentation to the Kahaluu Neighborhood Board on August 10 and a brief return update presentation on October 12. The Kahaluu Neighborhood Board did not vote to take a position on the project at either meeting. It did vote in August to request a full EIS for the project.

At the August 10 Neighborhood Board meeting, WWCA president David Chinen stated that the full WWCA membership had unanimously endorsed the Waikane golf proposal at its most recent meeting.

According to notes provided by Mr. Chinen, the decision to support the project followed "a most difficult period of philosophical debate and discussion -- a clash between our idealistic principles and reality." He said the reasons for deciding to support the project involved:

- The developer's agreement to relocate or compensate the tenants and farmer, although Waikane Development Co. was under no legal obligation to negotiate with the WWCA and tenants.

- The current developer's willingness to "recognize" the WWCA, which was not recognized by some past owners or developers, and to address WWCA concerns about water and environmental impacts.

- The developer's willingness to make the project "more than a golf course -- because it will also take care of the needs of the community and school."

  He cited agreements to provide job training, contributions to the Waiahole Elementary School, and land for a neighborhood park (see Section 4.7).

- Finally, Mr. Chinen noted that, "The WWCA supports only one golf course in the community. We do not support any additional courses in the Waiahole-Waikane valleys."

In addition to meetings with the WWCA and the Kahaluu Neighborhood Board, the project team has also met with some of the adjacent property owners. There have been particularly detailed discussions with the extended family which owns the kuleana and houses along the entry road into Waikane Valley.

Family members have taken no official "position" on the project; however, the tone of the discussions has been favorable in light of the potential improvements to the property (e.g., paved road, new water lines, etc.). (Personal communications, Mr. Tom Pickard and Mr. Les Anderson, Waikane Development Co. community representatives, October 13, 1988.)

4.1.2 Resident Issues and Concerns

The following issues and concerns have been identified from the previously listed meetings with community groups, as well as a few letters in response to the Environmental Impact Statement Preparation Notice:

WAIAHOLE-WAIKANE COMMUNITY ISSUES

(1) Project potential for preventing large-scale residential development; helping maintain ag/open character of Waikane.

(NOTE: Previous proposals for developing the Waiahole-Waikane area have all involved substantial residential development, even if on "agricultural" subdivisions. The proposed project has no residential component.

(Arguably, the *major* socio-economic impact of this project will be at least partial preservation of the current open, lightly populated character of Waikane. This is subject to debate, since it cannot be said with certainty that rejection of the current proposal would result in renewed efforts by future landowners to urbanize the valley. However, there are some historical grounds to support this view.)

(2) Relocation or compensation for tenants and farmers.

(NOTE: See Section 4.2)

(3) Impacts on Waikane Stream capacity for downstream farmers.

(NOTE: This is a physical impact which falls within the scope of other EIS consultants and is discussed elsewhere in the EIS.)

(4) Water quality impacts on Kaneohe Bay and Waikane Stream.

(NOTE: This is a physical impact which falls within the scope of other EIS consultants and is discussed elsewhere in the EIS.)

(5) Developer partnership with Waiahole Elementary School.

(NOTE: See Section 4.7.1.)

(6) Job opportunities/training for Waiahole-Waikane residents.

(NOTE: See Sections 4.3 and 4.7.2.)

(7) Project use by local people: (a) golf rates; (b) clubhouse use.

(NOTE: See Section 4.7.3.)

(8) Community park creation.

(NOTE: See Section 4.7.4.)

ADDITIONAL ISSUES RAISED BY KAHALUU NEIGHBORHOOD BOARD

(1) Property tax and related pressures for change in use of nearby lands from rural to urban uses.

(NOTE: See Sections 4.6 and 4.7.6.)

(2) Desire for assurances that wetland ecology would not be affected.

(NOTE: This is a physical impact discussed elsewhere in the EIS.)

(3) Feasibility of agriculture on project site.

(4) Comparison of traditional Ag vs. Golf Course uses on Ag lands in general.

(NOTE: Both of the above issues involve questions of agricultural economics and land use planning which fall within the scope of other EIS consultants.)

(5) Possible taro farming on wetlands below golf course.

(NOTE: See Section 4.7.5.)

(6) Fill for regional park.

(NOTE: See Section 4.7.4.)

ADDITIONAL ISSUES RAISED BY OTHER CITIZEN GROUPS

(1) Linkage between estuary and ocean life ecosystems.

(NOTE: This is a physical impact discussed elsewhere in the EIS.)

(2) Traffic implications for Kamehameha Highway.

(NOTE: This is addressed elsewhere in the EIS.)

ISSUES RAISED BY ADJACENT PROPERTY OWNERS

(1) Easements to mauka properties.

(2) Potential water and sewage hook-ups in kuleana area.

(3) Drainage improvements for kuleana area.

(4) Location of sewage treatment plan relative to kuleana.

(NOTE: Most of the foregoing have been largely if not completely resolved as of this writing. However, since several of the concerns involve specific agreements and/or legal documents, it is inappropriate to discuss them in detail in a public document.)

4.2 DISPLACEMENT/RELOCATION OF EXISTING USES AND OCCUPANTS

As previously noted, Waikane Development Co. was initially unaware of reported agreements between the previous property owner and a number of tenants to relocate or compensate these individuals. In order both to expedite the project and to establish good faith with the community, Waikane Development Co. voluntarily assumed this responsibility, although it was not a condition of purchase from the previous owner.

Current uses, occupants, or claimants to rights on the property include:

- A small church on Waikane Valley Road (La Mauna O Oliveta);
- Four residential householders (some with other family and nonfamily members living with them) -- except for some limited livestock raising, none of these householders are now directly involved in agriculture on the property;
- One former residential tenant now living off the property but desirous of returning and recognized by the WWCA as having a legitimate claim under agreements with the previous owner;

- Two small truck farms -- one on a longtime tenancy basis and recognized by the WWCA as having a claim under agreements with the previous owner, and the other operating on a fairly recent informal agreement with one of the residential householders and not recognized by the WWCA as having any claim extending back to original rental agreements with the McCandless heirs.

Following are the general agreements which have been reached between the developers and the above parties:

- The church has been granted a lifetime lease, subject to project approval. So long as the parcel is used for church purposes, it will remain church property.

- The WWCA represented two current residential tenants, the former residential tenant, and the longtime farmer in negotiations with the developer. In an Agreement dated June 28, 1988, the various parties agreed (subject to project approval):

  - The three current or former residential tenants represented by the WWCA will be given, in fee simple and free of charge, individual lots of about two acres each on a planned extension of Haupoa Road. The developer will bear the costs of extending Haupoa Road; obtaining subdivision approval for the lots; grading an 8,000 square-foot section on each lot; and installing water meters and utility lines.

    The two current residential tenants will be allowed to continue to use existing lots free of charge for one year after the developer meets the above conditions. All three residential tenants agreed to assume responsibility for taxes and similar assessments after receiving the lots, and to refrain from selling or transferring the lots for a certain period of time after the lots have been conveyed to them.

  - The longtime farmer will be paid a cash sum -- deliverable when the deeds to the residential lots have been delivered -- to compensate for the termination of his agricultural activities.

- After the above Agreement had been determined, a similar but separate Agreement was reached with one of the remaining two current residential tenants. That individual will also receive a lot on the extended Haupoa Road. It will be set apart from the other three.

- The final current residential tenant did not seek a lot on Haupoa Road. The developer has assured her that she will be allowed to live out her life somewhere on the property, although her house may be relocated. A member of her household has been given first opportunity to help with various maintenance and security jobs on the property.

This householder is the one who has recently allowed the second farmer to work her own former five-acre cultivated area. Those agricultural operations will probably cease when the project begins.

There have also been some indications of recent small-scale farming or residential activities (in an abandoned vehicle rather than a house) not authorized by this property owner. Such activities, if still ongoing, would be terminated when the project begins.

4.3 EMPLOYMENT IMPACTS

4.3.1 Construction Phase

Based on information provided by Waikane Development Co., on-site employment for this project would be:

Component	No. Employees	Timeframe	Full-Time Equivalent Person-Years	Average
Golf Course	22 - 28	21 mo.	39 - 49	44
Clubhouse/ Structures	22 - 40	10 mo.	18 - 33	26
TOTALS			57 - 82	70

On-site construction work also supports other direct construction jobs off-site (e.g., support personnel, estimated at 25 percent of the number of on-site workers), plus secondary employment generated by purchase of materials from other businesses and expenditure of workers' wages (equal to 80 percent of the total on- and off-site direct jobs, according to the State of Hawaii's construction model).

Taking the approximate mid-point average estimate of 70 on-site person-years, the total construction-related employment generated throughout the state would be:

70 x 1.25 x 1.8 = 157.5 person-years

4.3.2 Operational Phase

The "operational" phase refers to the time when the golf course and clubhouse are open and operating -- i.e., permanent jobs.

On-Site Employment: Based on interviews by Community Resources, Inc. with about ten Hawaii and California private golf course and country club managers, it is estimated that the Waikane golf course would provide about 100 to 120 full-time equivalent on-site jobs. (Some of these may be broken into several part-time jobs.)

Table 6 provides a breakdown by job type, pay range, and qualifications. It may be noted that job types include both indoor and outdoor work, as well as jobs suitable for full-time breadwinners, part-time workers supplementing family incomes, and young people just starting out.

It may also be noted that the great majority of projected jobs require little technical training or experience. Thus, they feature the characteristic advantages and disadvantages of service jobs: relatively few high-paying skilled jobs, but easy entry for younger and/or less educated workers.

Hawaii in general is currently experiencing a labor shortage. The Hawaii State Department of Labor and Industrial Relations (DLIR) officially estimates there were only 122 unemployed individuals in the Kahaluu-to-Kualoa area (Census Tracts 103.03 and 103.04) as of June 1988 (personal communication, Silvino Bayudan, DLIR statistical clerk, October 17, 1988). However, DLIR estimates for particular areas within the state are based on the assumption that statewide unemployment is proportionately distributed exactly as observed in the 1980 Census. Thus, there are no truly reliable figures on the labor market for the late 1980's. As noted in Section 2.1, the president of the Waiahole-Waikane Community Association estimates a 15 percent unemployment rate for that particular area. Also, as noted in Table 4, employed Waiahole-Waikane residents as of 1980 commuted an average 30 minutes to work, and 21 percent commuted more than 45 minutes one way; some portion of these people may well be interested in work closer to home.

Off-Site and Total Employment: Off-site jobs are created when the golf course or clubhouse operators purchase services and supplies from other businesses, providing jobs there ("indirect employment") -- or when golf course/clubhouse employees spend their wages and create employment in local stores ("induced employment").

However, according to economic theory, indirect and induced jobs would only be counted for jobs generated by <u>visitor</u> expenditures, since this is "new" money entering Hawaii's economy for the first time. In the absence of a market study for this project, Community Resources, Inc. will assume that 40 percent of the employment derives from visitor play and expenditures. This would include overseas members and guests, as well as visitors who are non-members.

Table 7 indicates the Waikane golf course would generate another 27 to 34 indirect and induced jobs (located throughout the state), for a total employment impact of 123 to 156. Taking the mid-point for an average estimate, the impact is <u>139</u> total new jobs statewide.

TABLE 6:
ON-SITE WAIKANE GOLF COURSE PERMANENT JOBS

Job Title	No. of Jobs Available*	Pay Range*	Required Qualifications
A. GROUNDS			
Superintendent	1	$2,000-3,000/month	5 years or more horticulture experience. Expertise in growing and maintaining grass. Personnel management skills also required. No college degree necessary.
Assistant Superintendent	1	$1,500-2,000/month	Some prior horticulture experience needed. No college degree necessary.
Maintenance Superint.	1	$1,300/month	Mechanical/carpentry/air conditioning repair. Heavy work.
Mechanic	2-3	$1,600/month	Knowledge of general heavy machinery, both diesel and gas operated. Heavy work involved.
Equipment Operator	8-10	$1,300-1,400/month	No experience necessary. Must learn to operate heavy and light equipment such as gangmowers and greenmowers. Heavy work involved.
Groundskeeper	8-10	$1,300-1,400/month	No experience necessary. Must learn to use grounds equipment. Heavy work involved.
Laborer	8-10	$1,300-1,400/month	No experience necessary. Heavy work involved.
SUBTOTAL:	29-36		
B. GOLF			
Directing Golf Professional	1	$2,000-3,000/month	Managerial skills, knowledge of golf course operations.
Teaching Golf Pro	2	$1,500-2,000/month	Experienced golfer with teaching skills.
Attendant**	7	$1,000/month	No experience necessary. Heavy work involved.
Golf Pro Shop Sales Assistants**	7-8	$1,000/month	No experience necessary.
SUBTOTAL:	17-18		
C. OTHER RECREATIONAL			
Tennis Professional	1	$2,000-2,500/month	Experienced tennis player with teaching skills.
Lifeguard**	2	$6.25/hour	Lifesaving Certificate.
Tennis Pro Shop Sales Assistant	7-8	$1,000/month	No experience necessary.
SUBTOTAL:	10-11		

(CONTINUED)

TABLE 6:
ON-SITE WAIKANE GOLF COURSE PERMANENT JOBS

Job Title	No. of Jobs Available*	Pay Range*	Required Qualifications
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Superintendent	1	$2,000-3,000/month	5 years or more horticulture experience. Expertise in growing and maintaining grass. Personnel management skills also required. No college degree necessary.
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Equipment Operator	8-10	$1,300-1,400/month	No experience necessary. Must learn to operate heavy and light equipment such as gangmowers and greenmowers. Heavy work involved.
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SUBTOTAL:	29-36		
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Attendants**	7	$1,000/month	No experience necessary. Heavy work involved.
Golf Pro Shop Sales Assistants**	7-8	$1,000/month	No experience necessary.
SUBTOTAL:	17-18		
C. OTHER RECREATIONAL			
Tennis Professional	1	$2,000-2,500/month	Experienced tennis player with teaching skills.
Lifeguards**	2	$6.25/hour	Lifesaving Certificate.
Tennis Pro Shop Sales Assistant	7-8	$1,000/month	No experience necessary.
SUBTOTAL:	10-11		

(CONTINUED)

TABLE 6 (CONTINUED)

Job Title	No. of Jobs Available*	Pay Range*	Qualifications
D. CLUBHOUSE: GENERAL			
Club Manager	1	$2,000-3,000/month	Managerial skills, knowledge of golf course operations. College degree required.
Assistant Manager	1	$1,500-2,000/month	Some prior managerial experience needed.
Accountant	1	$2,000-2,500/month	Certified Public Accountant.
Secretary	1	$1,000-2,000/month	Executive secretary skills. Prior experience not necessary.
Receptionist**	1	$5.00/hour	No experience necessary.
Janitor	3-6	$5.00/hour	No experience necessary.
Locker Attendant**	3-6	$5.00/hour	No experience necessary.
Valet Parking Attendant**	1-2	$4.00/hour	Driver's license and clean driving record. No experience necessary.
Security**	2-4	$8.50/hour	No experience necessary.
SUBTOTAL:	14-23		
E. CLUBHOUSE: FOOD AND BEVERAGE			
Specialist/Supervisory Cook	1	$8.00-10.00/hour	Experienced cook.
General Cook	5-6	$5.00/hour	General cooking experience.
Cashier**	2	$8.00/hour	Prior experience necessary.
Waithelp**	12-16	$6.80/hour plus tips	No experience necessary.
Bushelp**	4-6	$5.00/hour	No experience necessary.
Bartender**	2-3	$5.00/hour plus tips	Prior experience necessary.
SUBTOTAL:	26-34		
TOTALS:	96-122		

* All figures about "No. of Jobs Available" and "Pay Range" are APPROXIMATE and PRELIMINARY.

** Some of these jobs may be part-time.

TABLE 7:
OFF-SITE AND TOTAL WAIKANE GOLF COURSE PERMANENT JOBS

Industry (1)	On-Site Jobs (2)	Visitor Share (3)	Industry Multiplier (4)	Indirect/ Induced Jobs	Statewide Jobs
Amusement Services	63 to 76	40%	1.6947	18 to 21	81 to 97
Eating and Drinking	33 to 46	40%	1.7139	9 to 13	42 to 59
TOTALS:	96 to 122			27 to 34	123 to 156
AVERAGE (based on Mid-Point:)	109			30	139

(1) Industry Definitions from State Input-Output Matrix (Hawaii State Department of Planning and Economic Development, 1977).

(2) From Table 6. "General" Clubhouse jobs allocated equally to Amusement and Eating/Drinking industries.

(3) Source: Community Resources, Inc. See text.

(4) From Input-Output Matrix (Hawaii State Department of Planning and Economic Development, 1977).

4.4 FISCAL IMPACTS

Fiscal impact analysis is concerned with the financial impact of private development on government's capital improvement and operational budgets. It is a comparison of net increases in governmental revenues associated with this project to both State and County governments and public costs. Since the project will not require any additional expenditures by governmental authorities, governmental costs will be assumed to be zero.

The State will derive revenues during both construction and operational phases of the project. Initially, those revenues will come from income tax on construction employment both on- and off-site, as well as from income from induced and indirect employment. Table 8 indicates these income tax revenues will be in the range of $65,000 (in 1987 dollars).

During the operational phase, the State will derive tax revenues from income of employees of the golf course and clubhouse, as well as indirect and induced employment from golf course operations and sales. The State will also receive tax revenues from the excise tax on greens fees and clubhouse sales. Table 9 indicates State revenues from these two sources combined would slightly exceed $200,000 per year (1987 dollars).

The City and County will derive tax revenues from building permits and from property taxes assessed to the golf course and the associated clubhouse.

The revenue from building permits is calculated as 0.14% of the estimated construction cost (shown in Table 8), plus a fee of $2,492. The total permit revenue amounts to $47,292.

The City and County property tax revenues would be in addition to current property tax revenues from the project site. Table 9 indicates these City and County property tax revenues would be about $140,000 per year (1987 dollars).

4.5 POPULATION IMPACTS

De Facto: Assuming that about two-thirds of the golfers (200 rounds per day) and three-fourths of the employees are physically present during peak periods, and that some 25 friends and family members of golfers are at the clubhouse complex -- playing tennis, swimming, or dining -- the project site would have about 210 people present at the busiest times.

Residential: Compared with the present situation, the project will have zero direct residential population impact, since there is no housing component and all current tenants will be relocated.

However, compared with alternative approved or potential uses of the land, the project will result in a lower future

TABLE 8:
STATE INCOME TAX REVENUES FROM CONSTRUCTION PHASE

Assumptions

1. $17 million expended for golf course
2. $8.5 million expended for clubhouse complex
3. $6.5 million expended for infrastructure
4. 21 months of construction time to complete
5. 70 on-site full-time equivalent construction jobs (1)
6. 18 off-site construction jobs (1)
7. 70 induced and indirect jobs Statewide (1)

Construction Phase Revenues

Jobs	Avg. Annual Income	Total Income
On-site (1) 70	$29,883 (2)	$2,091,810
Off-site (1) 18	$29,883 (2)	$ 537,894
Induced & Indirect (1) 70	$19,060 (2)	$1,334,200
TOTAL		$3,963,904
TOTAL STATE INCOME TAX DURING CONSTRUCTION PHASE		$ 63,422 (3)

Sources:

(1) Section 4.3.1.

(2) Hawaii State Department of Labor and Industrial Relations (1987), Employment and Payrolls in Hawaii.

(3) State Income Tax rate of 1.6%.

TABLE 9:
LOCAL GOVERNMENT REVENUES FROM OPERATIONAL PHASE

Assumptions

1. 200 Rounds of golf per day
2. 40% of player are members; 60% non-members
3. 40% are visitors; 60% Hawaii residents
4. $70 for one round of golf for a non-member (average of various rates)
5. $12 per person per day for food and beverages at clubhouse complex
6. $ 6 per person per day additional sales at the clubhouse complex
7. 109 on-site jobs (4)
8. 30 induced and indirect jobs in State (4)

Operational Phase Revenues

STATE INCOME TAX REVENUES

Jobs	Avg. Annual Income	Total Income
Golf course and clubhouse 109	$11,850 (1)	$1,291,650
Indirect and Induced 30	$19,060 (4)	$ 571,800
Total Income from Operational Employment		$1,863,450
Total Yearly State Income Tax Revenues		$ 27,951 (2)

Sales	Yearly	Yearly Sales
Non-Member Rounds	43,800	$3,066,000
Food and Beverage		$ 876,000
Other Clubhouse Sales		$ 436,000
Total Sales		$4,378,000
Total Yearly State Excise Tax Revenues		$ 175,120 (5)
TOTAL STATE REVENUES DURING OPERATIONAL PHASE		$ 203,071/YEAR

(CONTINUED)

TABLE 9 (CONTINUED)

CITY AND COUNTY PROPERTY TAX REVENUES (INCREMENT OVER EXISTING)

Improvements to Property	Assessed Value	Tax
Golf Course	$ 17 million (6)	$ 153,000 (7)
Clubhouse Complex	$ 8.5 million (6)	$ 80,325 (8)
Infrastructure	$ 6.5 million (6)	$ 61,425 (8)
TOTAL CITY AND COUNTY PROPERTY TAX REVENUES		$ 294,750/YEAR

Sources:

(1) Hawaii State Department of Labor and Industrial Relations (1987), Employment and Payrolls in Hawaii.

(2) State Income Tax rate of 1.6%.

(3) Table 7.

(4) Average of survey by Community Resources of golf course employment (Table 6) and (1) above.

(5) State Excise rate 4%.

(6) Assessed at construction cost (personal communication, Richard Nathaniel, Supervisor, City and County Department of Finance, Office of Real Property Appraisal, October 31, 1988.)

(7) City and County tax rate on golf course fairways and greens of $9.00 per $1000 of assessed value.

(8) City and County commercial tax rate of $9.45 per $1000 of assessed value.

population for Waikane Valley (i.e., zero additional residents rather than the occupants of potential future agricultural subdivisions).

When Windward Partners owned the property, it applied for agricultural subdivision approval to create 144 two-acre lots, with an anticipated population impact of about 650 residents (Environmental Communications, Inc., 1983). (Approval was granted for creation of slightly more than 30 initial lots, with the possibility of re-application for the additional area.)

4.6 PROPERTY VALUES AND RELATED IMPLICATIONS FOR NEARBY COMMUNITY

While the golf course development would prevent more intensive residential use of the property site, it might have impacts on other nearby land uses. Kahaluu Neighborhood Board members in particular have been concerned about the potential impacts of a Waikane golf course on current property taxes and rural lifestyles throughout the Kahaluu Neighborhood Board area.

This concern is consistent with the Neighborhood Board's historical desires to preserve rural and agricultural characteristics of the area (Section 2.4.2). For many people, the Waiahole- Waikane "struggle" of the 1970's made the valleys a symbol of these agricultural and rural characteristics (although the WWCA's own efforts have been primarily focused on achieving secure leases -- of a residential as well as agricultural nature).

The concern also arises in the context of current sensitivities about Japanese investment in general (and the ability of Japanese purchasers to pay higher prices due to exchange rates) and several specific proposals to create golf courses in other agricultural areas of Oahu.

As noted below, there are no Hawaii historical precedents which allow a clear and definitive answer to the question about impacts of a Waikane golf course on surrounding community property values and lifestyles. This section reviews evidence which <u>suggests</u> some tentative answers, but it is impossible to forecast all impacts with certainty.

4.6.1 <u>Comparable Past Hawaii Golf Course Outcomes</u>

To be truly comparable with the Waikane situation, an existing development would be (1) a private or semi-private golf course, which is (2) unrelated to any surrounding resort or residential development that could have more effect than the golf course itself, and which is (3) located in a rural area with many small farms (as opposed to a suburban or sugar plantation setting).

There are no Hawaii golf course situations meeting all these criteria.

However, the Waimanalo agricultural lands are located at the back of Waimanalo Valley, which has a mixture of rural and suburban uses similar to those found in Kahaluu. (City land use policies for Kahaluu and Waimanalo are nearly identical.) The Olomana Golf Links are sited at the northern part of Waimanalo. Around the southern corner of Waimanalo is the Hawaii Kai Golf Course. Neither course has private members, but both courses are Japanese-owned and have many Japanese tour groups as players.

Only a few Realtors have handled many transactions in the Waimanalo agricultural area. Community Resources, Inc. interviewed two such individuals (personal communications, Stewart Wade and Patsy Hawthorne, October 17, 1988) -- as well as the Supervisor of the City and County's Real Property Assessment Division (personal communication, Richard Nathaniel, October 18, 1988) and the owner of the "Saddle City" equestrian and rural-residential complex adjacent to the Olomana golf course (personal communication, Fred Teixeira, October 17, 1988).

According to these informants:

- The golf courses have had no impact on tax assessments for nearby rural/agricultural properties.

- Neither golf course has had any noticeable effect on Waimanalo real estate transactions.

  (NOTE: Less than a mile north of the Olomana Golf Course, outside Waimanalo, a new subdivision on the slopes of Mount Olomana is successfully marketing two-acre "estates." However, the Olomana course is not considered a factor in the success of this particular development, in part because the Olomana course caters to a less affluent market.)

- There has been no significant interest in Waimanalo lands (whether agricultural or residential) on the part of Japanese investors.

- City land use policies have been strongly oriented toward preserving agricultural/rural designations. The City and County government has unilaterally downzoned the adjacent "Saddle City" from commercial to residential and then to agricultural, denying a request to build some additional houses there. According to the property owner, the major consequence of being next to a golf course is "ending up with a lot of golf balls bouncing against our houses."

- Recent polo activities in Waimanalo have had more effect on land use patterns and values. There has been some turnover from nursery and crop use (usually at distressed operations) to equestrian activities. Polo has been more effective than golf in converting Waimanalo's "tough" image to one of a beautiful place with appeal to an international elite. However, this is a recent development, and the full implications remain to be seen.

4.6.2 Factors Which May Affect Outcomes at Waikane

The following factors are likely to play major roles in determining what would actually happen in the area from Kahaluu to Kualoa following construction of a Waikane golf course:

(1) **Tax Assessment Criteria/Policies:** Community Resources, Inc. asked officials of the City and County Finance Department's Real Property Assessment Division how property tax valuations for surrounding areas would be affected by golf course development in Waikane Valley. According to the Real Property Appraiser for this area (personal communication, John Lakes, October 18, 1988), it is impossible to make predictions for specific parcels of land. However, the following points were made about assessment procedures:

- Properties are assessed by a "market" approach -- looking at recent sales prices of comparable land in the immediate area. If for some reason there were no sales in the area following development of the Waikane golf course, the tax assessors would examine sales prices in some place they judge to be a "comparable neighborhood."

- Golf courses are not considered a valuable amenity for agricultural-zoned land in active agricultural use. If <u>residential</u>-zoned land values were to rise around a golf course, it would not result in a similar rise for <u>agricultural</u>-zoned land assessed values. (However, residential zoning and "country" zoning, if improved with a residence, <u>are</u> considered similar.)

- For lands in essentially residential use (whether zoned residential or agricultural), improvements on nearby residential-type properties affect nearby property values. Thus, if one of the agricultural-zoned lots on Haupoa Road with a golf course view were to be developed with a mansion (and no farming), other Haupoa Road lots with little or no farming would have higher assessments.

- Waikane, Waiahole, Hakipuu, and Kahaluu are all considered different neighborhoods and <u>not</u> "comparables." Increased values for Waikane agricultural or residential lands would not result in increased assessments for agricultural land elsewhere in the general area.

- Future residential leases in the Waiahole Agricultural Park will be unaffected by any rise in residential values in Waikane. This is because those leases cannot be sublet, sold, or transferred, except to the State Housing Finance Development Corporation.

- Based on the above -- and on anticipated market patterns such as have been observed elsewhere -- the Real Property Appraiser would expect that land values and property taxes will increase in residential- and country-zoned land near the Waikane golf course in Hakipuu and Waikane itself. There may also be increased assessments in Waikane and makai (below the highway) Waiahole agricultural lands which are not in actual agricultural use -- but only to the extent that residential-style improvements are made on some of the lands. Any impact on Kahaluu properties is doubtful.

(2) **Actual Increased Market Demand for Currently Zoned Land:** The question here is whether the golf course would stimulate more interest in existing properties -- hence, higher values and, on a delayed basis, higher property taxes -- no matter what the current zoning is.

There can be no certain answer to this question. However, to seek an "expert" consensus, Community Resources, Inc. interviewed real estate officials of two types: (1) people familiar with the current Kahaluu/Waiahole-Waikane market; (2) people familiar with the tastes and preferences of affluent Japanese purchasers. (See Table 10 for list of persons interviewed.)

- Real Estate Personnel Familiar with the Area: All those interviewed felt that the golf course would increase values in the immediate Waikane Valley area, for both residential- and agricultural-zoned lands. (None would hazard a guess as to the magnitude of increase.) Most also felt the golf course could stimulate rezoning applications for current agricultural-zoned land in Waikane and parts of Waiahole below the highway.

  There was no consensus on whether the golf course would have any significant impacts outside Waikane. Three of the seven people interviewed said "no," while four said "yes." Of these four, two thought values would increase toward Hakipuu and Kaaawa (where these individuals thought future development most likely to occur anyway), while the other two thought the impact would be felt more toward Kahaluu and Kaneohe (where, again, they thought development was occurring anyway).

- Real Estate Personnel Familiar with the Japanese Market: Although the Realtors interviewed all have proven track records in dealing with the affluent Japanese market, there was no consensus on whether the Waikane golf course would attract Japanese investors or vacation home purchasers to the immediate area.

  However, the majority felt that the project would have little or no effect in terms of attracting many overseas Japanese. They said that Japanese prefer to stay in urban or resort settings, where (unlike Waikane) stores and Japanese-speaking service people are aware of their tastes; that Japanese are used to traveling great distances to play golf; that they are uninterested in

TABLE 10:
LIST OF REAL ESTATE PERSONNEL INTERVIEWED FOR STUDY

Real Estate People Familiar with Kahaluu and Waiahole-Waikane

(All interviews conducted by telephone, October 14 - 15, 1988)

Paul Davis, Paul Davis Realty

Barbara Evants, Cooperative Realty

Irene Fragioa, Koolau Properties

Bruce Kennedy, ERA, Stott Realty

Gail Kosiorek, Cooperative Realty

Megan Meyer, Coldwell Banker

[Anonymous Informant], Locations, Inc.

Real Estate People Familiar with Japanese Market for Hawaii

(All interviews conducted by telephone, October 17 - 18, 1988)

Tom Abe, ASSTEK Hawaii

Jeannie Machiyo Fogarty, J. Fogarty Realty

Seiji Fukayama, Hawaiian Joy, Ltd.

Lorinda Hadsell, Bradley Properties

Masako Kiwada, Locations, Inc.

Tony Oishi, Central Realty

Jerry Sprinkle, Century 21 Kahala Hale, Inc.

Yoko Tomita, Conley Dew

living or vacationing in the rainy Windward side of Oahu; and that the Kahaluu/Waikane area lacks the "prestige" factor needed to attract Japanese.

Several others were confident that the golf course could be marketed in such a way as to create international "prestige" for the Waikane area. They predicted definite Japanese interest in purchasing in this area for vacation use. However, they did not foresee Japanese interest in acquiring existing properties. Rather, they felt the Japanese market would be for a new planned development of at least several hundred homes, preferably bordering the golf course (if one existed). They doubted there would be Japanese interest even in nearby oceanfront properties, because of the Japanese desire to congregate in relatively large high-activity homogenous communities.

(3) **Market Opportunities for More Intensive Land Uses:** Some property owners (or future purchasers) may perceive a market demand for more intensive uses -- e.g., subdividing agricultural land into "gentlemen's estates," or upzoning from agricultural to country zoning, or from country to residential zoning.

As noted above, some of the real estate personnel interviewed for this study foresaw that the Waikane golf course could create opportunities for more intensive uses. Those who made this prediction particularly focused on several parcels in Waiahole-Waikane:

- Agriculture-zoned lands makai of the highway, if and when they are vacated by longtime tenants involved in the Waiahole-Waikane "struggle;" and

- The agriculture-zoned parcel of 300+ acres mauka of the proposed golf course, which some considered a potential candidate for a second golf course or a residential development adjacent to the currently proposed course.

However, market opportunities to subdivide or upzone land do not automatically result in the lands actually going into more intensive uses. Government approval is required.

(4) **Government Policies and Approval Processes:** Policies and processes are subject to change over time. However, at least for the foreseeable future, the following factors must be considered in predicting the likely success of attempts to gain approvals for large new subdivisions or upzonings:

- General Plan Population Guidelines: The General Plan requires the City to develop guidelines for future Oahu population growth, using official State population projections. These guidelines are used as a basis for deciding how much additional development to allow in various parts of the island.

The current guidelines -- based on the "M-F Series" of population projections (Hawaii State Department of Planning and Economic Development, 1984) -- would permit extremely limited further development in Koolaupoko (Department of General Planning, 1987). New guidelines under consideration -- based on the State's preliminary "M-K Series" (Hawaii State Department of Business and Economic Development, 1988) -- would drastically reduce opportunities for further growth in Koolaupoko, if ratified by City Council:

Projection	Year	Koolaupoko Population Estimate	Percentage of Total Oahu Population
	1985	114,631	14.0%
"M-F Series"	2005	118,400-129,800	12.4%-13.6%
"M-K Series"	2010	111,400-121,600	11.0%-12.0%

(The percentages indicated for 2005 and 2010 are derived from present and proposed City guidelines (Honolulu Department of General Planning, 1987; Notice of Publication of Resolution 88-404, Honolulu Advertiser, October 19, 1988, p. D-9), not State forecasts.)

Since the high point of each projection is greater than the existing population, both allow for some growth in the population. That growth can be accomodated within existing residential areas. Current zoning in Koolaupoko provides space for 36,400 housing units -- and hence 123,900 persons, using the Department of General Planning's (1987) figures. Consequently, the proposed guidelines for 2010 call for a population that can be accomodated in Koolaupoko without creating any new residential zoning.

- Development Plan Provisions: The Koolaupoko Development Plan calls for Waiahole, Waikane, and Kualoa to remain "relatively lightly settled, rural areas." The Plan also mandates some general controls: "Development controls shall provide for compatibility with existing single-family residential areas and the preservation of the general rural character of these areas" (Section 32-6.2(5)).

- Community Attitudes: When evaluating land use proposals, City agencies consider (1) General Plan/Development Plan policies; (2) policy issues related to the request; and (3) community concerns (personal communication, Calvin

Ching, Branch Chief for Zoning, Honolulu Department of Land Utilization, October 17, 1988).

Community groups such as the Kahaluu Neighborhood Board have consistently opposed intensified land uses in rural parts of the area. Section 3.4 notes specific instances in which City authorities have rejected subdivision approvals. Furthermore, past proposals for residential upzoning by a major Waiahole-Waikane landholder have been repeatedly rejected.

o <u>Implications for New Upzoning or Subdivision Requests</u>: Given the foregoing policies and precedents, it is highly unlikely that any proposed major new upzoning to residential use would be approved by the City, according to the Department of Land Utilization's Branch Chief for Zoning (personal communication, Calvin Ching, October 17, 1988). One-acre "country" zoning or subdivision of agricultural lots into two-acre parcels <u>might</u> be considered compatible with the area's rural character. However:

- To subdivide large agricultural-zoned parcels into smaller "estates," the applicant must submit a study showing that agriculture on the small lots is economically feasible. The City has approved very few such applications in recent years.

- To receive country zoning for a large new subdivision, the applicant must satisfy infrastructure requirements. A sewage treatment plant (rather than cesspools) is likely to be required for any large new subdivision. The City has tended to require developers to provide either an up-front bond or a guarantee to maintain any private sewage treatment plant. As a result, the infrastructure for any new private country-zoned subdivision would be very costly.

4.6.3 <u>Preliminary Analysis of Potential Waikane Outcome</u>

As previously stated, such an analysis must be regarded as very tentative and preliminary, in light of the lack of truly comparable historical precedents in Hawaii. However, the factors discussed on the foregoing pages suggest different possible outcomes for different nearby areas.

Table 11 provides an overview, with some additional comments below.

4.6.3.1 Kahaluu (and/or Kaaawa)

The tax assessor and most real estate informants saw no project impacts extending this far outside the immediate area. Realtors who did anticipate possible impacts saw them as part of

TABLE 11:
OVERVIEW OF POTENTIAL IMPACTS ON NEARBY USES AND VALUES

	Current Zoning		
	RESIDENTIAL	COUNTRY	AGRICULTURAL
Kahaluu (and/or Kaaawa)	(Little likelihood of any effects this far outside immediate area, except perhaps as part of general trends for more recreational development.)		
Waiahole Valley (Mauka)	N/A (Residential leases are in Ag Park.)	Little or no impact (very few country-zoned parcels).	No effect, due to active agricultural status of area and to terms of lease.
Waiahole-Waikane Makai of Highway	Probable increases in land values/ property tax, due to anticipated purchases in area.	N/A	Possible stimulation of landowner interest in upzoning or subdivision -- countered by City policies.
Waikane Valley Mauka of Project	N/A	N/A	Possible stimulation of landowner interest in upzoning or subdivision -- countered by City policies.
Haupoa Rd. and Waikane Valley Rd. Properties	N/A	N/A	Probable increases in land values/ property tax, due to anticipated purchases and improvements in area.
Hakipuu/ Kualoa Properties	N/A	Probable increases in land values/ property tax, due to anticipated purchases in area.	No effect for land in active use -- increase in values possible for land not being actively used for agriculture.

a larger development trend which is occurring anyway (e.g., the development of more recreational facilities and attractions in the upper part of Koolaupoko).

4.6.3.2 Waiahole Valley (Mauka)

The planned State subdivision effectively "locks in" Waiahole Valley to agricultural and rural-style residential uses for the next several generations. (NOTE: The residential lease area is zoned agricultural. Residential leases, like the agricultural leases, cannot be sold and thus are not subject to market pressures.)

Waiahole contains a very few country-zoned lots excluded from (but mostly surrounded by) the agricultural park and hence open to market pressures. However, relatively few outside people may be simultaneously attracted by both the rustic Waiahole lifestyle and the Waikane golf experience.

4.6.3.3 Waiahole-Waikane Lands Makai of Highway

There are two land use designations makai of the highway: (1) Residential for about 25 lots makai of the subject property; and (2) Agriculture for some 100 acres owned by the McCandless heirs, Magoon Estate, and one or two other small property owners.

The residential lands clearly have the potential for attracting some new purchasers, resulting in higher values. (The purchasers, however, are <u>not</u> likely to be Japanese nationals paying with cheap dollars, so that increases in value would be relatively reasonable.) A number of the existing residential properties consist of small lots with aging cottages; consolidation might be needed to achieve real value.

Agricultural-zoned lands makai of the highway would have clear market potential as a new oceanfront housing area. However, the longstanding City policies and precedents described earlier would have to be overcome for residential upzoning. "Country" zoning or agricultural subdivision requests would face difficult infrastructure and economic feasibility assessments.

4.6.3.4 Waikane Valley Lands Mauka of Golf Course

Of the two major parcels in the back of the proposed project, one is being acquired by the U.S. Navy, which intends to restrict any uses due to unexploded ordnance. The other consists mostly of Preservation land, but does include some 300+ acres with market suitability for another golf course or the sort of upscale residential development considered necessary to attract overseas Japanese.

However, the Waiahole-Waikane Community Association has announced its political opposition to a second golf course anywhere in the area. And any residential or country upzoning request, or estate-type agricultural subdivision, would have to deal with the barriers just discussed.

4.6.3.5 Haupoa Road and Waikane Valley Road Properties

Of approximately seven Haupoa Road properties, three or four will probably have good golf course views. If and when these views result in sales at higher prices, or if and when current owners not actively using the land for agriculture build more expensive homes to capitalize on these views, property values for similar non-agricultural Haupoa Road will also rise.

The kuleana property on Waikane Valley Road, at the entrance to the project, also has the potential to increase in value -- in part due to the road paving and other infrastructure improvements that will occur. It may be noted, however, that all members of the extended family must agree to any purchase offers.

4.6.3.6 Hakipuu/Kualoa Properties

Lands in active farm or ranch use would be unaffected by rising property values. Country-zoned properties in the vicinity of Johnson Road or on the waterfront -- along with any agri-cultural-zoned land not in active use -- could be the focus of some additional demand. The nature and quality of these proper-ties vary greatly, but the overall setting is very attractive. Demand is likely to increase for these properties in the future, and it will probably be difficult to separate out the effects of the Waikane Golf Course from effects of other recreational attractions drawing people to the upper Koolaupoko and Koolauloa areas.

4.6.3.7 Summary and Concluding Comments

Property value and related impacts on nearby rural communities cannot be predicted with accuracy. However, the available evidence suggests they will be primarily confined to the immediate Waikane (and perhaps makai Hakipuu) area and will not extend to Kahaluu. A relatively small number of current property owners will reap the benefits of increased values and/or bear the costs of additional property taxes. (The issue of undesired property tax increases is discussed in Section 4.7.6.)

Arguably, the golf course could add to existing market pressures for residential use of nearby agricultural-zoned parcels. However, there is a history of community opposition to such proposals, as well as City land use policies against more intensive land uses in the area. Without some major upzoning or large new subdivision, any significant "wave" of Japanese purchases seems unlikely in the foreseeable future.

There is the possibility that <u>expectations</u> (even if incorrect) of large-scale international investments could generate a short period of land speculation near the project site. This depends to a large extent on whether government agencies and community groups themselves perceive and characterize approval of the Waikane golf course as:

- o an urban or suburban-type use, indicative of future urban or suburban-type development; or
- o a use which effectively downzones the land from currently approved two-acre subdivision status (Section 4.5) and prevents, for the foreseeable future, applications for further subdivision of the Waikane Valley property.

Thus, to a certain extent, community interpretation of a Waikane golf course approval could determine the extent of impact on land values and "pressures" to upzone nearby parcels.

4.7 SOCIO-ECONOMIC MITIGATIONS AND ENHANCEMENTS

In its June 28, 1988 Agreement with the WWCA on relocation of project site tenants (Section 4.2), the developer also agreed "to use its best efforts to be a positive, constructive and active member of the Waiahole-Waikane Community. These efforts may take the forms of

"(a) contributing services, materials, and money for needed projects and facilities of the Waiahole Elementary School,

"(b) working with the WWCA to train residents of the Waiahole-Waikane Community for employment at the proposed Golf Course,

"(c) according the opportunity to residents of the Waiahole-Waikane Community for employment at the proposed golf course and related facilities,

"(d) working with the WWCA to organize a junior golfing program for full-time students living in the Waiahole-Waikane Community with designated hours for free play to be determined by [the developer], and

"(e) working with the WWCA to provide a graded and seeded area for a baseball/softball field for use by the Waiahole-Waikane Community, if [the developer] determines that land is available and if all governmental approvals can be obtained."

The following section provides updated information on these and other potential actions to mitigate problems or enhance benefits.

4.7.1 Partnership with Waiahole Elementary School

In the four months since the above Agreement was signed, developer representatives have met with the WWCA, the school principal and selected teachers, and members of the school Parent-Teacher Association (PTA).

The school and PTA assembled a priority list of immediate school needs which the regular budgetary process could not meet. This initial year's list involves substantial developer contributions. In the future, similar lists and contributions will be made, although the requests and donations will drop to a lower level as the arrangement becomes a regular one.

Among the items which Waikane Development Co. has agreed to purchase for Waiahole Elementary School this year are lights for the basketball field, a videocassette recorder, cafetorium stage curtains, a stencil machine, an electronic scanner, and two personal computers and related items (software, computer cabinet, etc.).

Waikane Development Co. is also assisting the school with a scheduled December 1988 fundraiser (by supplying a large tent, chairs, and tables) and is sponsoring school involvement in a Career Education Fair at the Waikiki Sheraton Hotel.

4.7.2 Job Opportunities and Training

Waikane Development Co. has assigned its socio-economic consultant to work with the WWCA and appropriate agencies to develop a training program. Some preliminary conversations with the State Department of Labor and Industrial Relations (DLIR) and with other golf course employers (both in the area and throughout the state) have been held.

WWCA officers have informally polled their membership and report definite interest in full- and part-time employment. The next scheduled activity, in November 1988, will be to conduct a more formal survey of WWCA members to determine exact interests, worker characteristics, and existing skill levels.

Preliminary conversations with golf course and clubhouse operators indicate that the vast majority of jobs do not require specific technical skills. Rather, job requirements include basic communication skills, good work habits, and a cheerful attitude. Most operators prefer to train their own employees -- after selection among applicants -- in job-specific skills such as handling particular types of groundskeeping machinery.

Under the U.S. Constitution, no individual can be guaranteed a job simply because he or she is a resident of Waiahole-Waikane or the overall Kahaluu area. However, all other qualifications being equal, employers often prefer to hire applicants who have lived nearby for a substantial period of time, since these people are less likely to turn over.

Thus, the objective is to assure that local residents are competitive in applying for jobs. And the most useful types of developer-sponsored activities would involve pre-employment (or "pre-selection") training of Waiahole-Waikane residents -- assistance in developing self-presentation and job interview skills, basic reading and mathematics, and perhaps some evidence of familiarity with groundskeeping or clubhouse activities.

Potential program components would include:

- o A basic skills, job interview, and work habits counseling effort, which can be provided by DLIR or various private human resource training firms;
- o Summer job apprenticeship programs for young people at nearby golf courses prior to the Waikane opening;
- o A junior golfing program with area schools, both familiarizing young people with golf course environments and also providing an opportunity to develop skills needed to become golf "pro's."

4.7.3 Community Access to Golf Course and Facilities

Both the WWCA and the Kahaluu Neighborhood Board have expressed strong desires for the Waikane Golf Course to be integrated into the community and not function as a private reserve for the affluent which excludes local residents. Questions have been raised about the affordability of golf rates and the availability of the clubhouse for community uses.

Golf Course Rates: No fee structure has yet been worked out, and so no dollar figures can be stated. However, the developer has approved the following general principles:

- o There will definitely be reduced "kamaaina" rates for local residents and golf clubs at selected days and hours. No final policy has been set, but such kamaaina rates normally run at about 40 percent of the rate charged for other public play (e.g., drop-in tourist trade).
- o The course will be open to the public (non-members) about 40 to 50 percent of the time.
- o Local membership costs will be substantially less than international memberships. Although a formal market study has not been conducted for this project, the developers expect there will be more local members using the golf course than international members.

Use of Clubhouse: The Waikane Golf Course clubhouse may be available at reduced fees to local groups for special banquets and meetings. The amount of fee reduction has yet to be determined. In addition, the developer is receptive to the idea of making a banquet or meeting room available for local groups' special events. However, scheduling and cost considerations have not yet been worked out, particularly for nighttime events.

4.7.4 Community Park Development

Waikane Development Co. on project approval would give approximately three or four acres of land along the highway (on the Kahaluu side of the entry road) to the WWCA for development as a small community park. The developer would also assist the community in submitting necessary applications to government agencies for park approval.

Ideally, the WWCA would like to use this property for a ballfield-style "active" park. However, the parcel is in the U.S. Army Corps of Engineers' officially-designated "wetlands" area, and it has yet to be determined whether such uses would be allowed there. If not, the parcel would still be given to the WWCA for whatever use is permitted.

Additionally, Kahaluu Neighborhood Board members have asked if any of the dirt from golf course construction can be used as fill at the Kahaluu Regional Park expansion. The developer has agreed to donate any excess dirt left over after construction of the golf course and WWCA park, if this is desired by the City Parks Department.

4.7.5 Agricultural Use of Wetlands

Neighborhood Board members have also asked about the possibility of using other parts of the wetlands below the planned golf course for active agriculture, particularly taro.

The developer has indicated a willingness to pursue this possibility, if feasible. The WWCA has raised some concerns about water implications for downstream farmers and siltation of Kaneohe Bay during flood seasons. Another concern is the potential for increased flood hazards. These issues are still being researched.

4.7.6 Tax Relief for Nearby Off-Site Property Owners

Project impacts on land values and property taxes are uncertain but probably limited to a relatively few nearby properties with residential or "country" zoning (Section 4.6). For some these impacts will be welcome; others may not seek the additional value and may find increases in property taxes to be burdensome.

The threat of sudden, unexpected tax increases has been a general concern on Oahu (see Section 2.4.1). In response, several bills have been introduced with the aim of lessening tax increases for non-speculating property owners, especially owner-occupants. These cannot be put into effect until at least 1989 due to current State controls on county tax assessment procedures. Thus, while no change in assessment procedures can be made now, the tax structure could change in profound ways before the Waikane project opens.

Three proposed changes may be mentioned here as examples:

- City Ordinance No. 88-84 raised the exemption on real property occupied by the owners from $20,000 to $40,000, and thereby lowered the taxable value of such property (as of 1989, when City Ordinances alone suffice to change the real property tax structure);

- The 1988 City Council's Bill No. 94 would in effect impose a cap on real property taxes on all owner-occupied properties, determined by the homeowner's income; and

- Bill No. 43 would allow the dedication of residential land for use, not sale, with the consequence that taxes on such land would be based on average rates of increase in value islandwide, not on changes in value in the immediate area. (This bill also directs the City Finance Department to assess golf courses such as the project as commercial property.)

These three proposals all provide protection for homeowners who do not wish to sell their property from tax increases based on property sales by others. They differ in many respects, and a great deal more public debate may be expected before a total legislative solution is achieved. However, that debate is already underway, and the consequences may help mitigate potential project impact on nearby residential property taxes and associated changes in ownership and use patterns.

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APPENDIX F
Drainage Report

DRAINAGE REPORT
FOR THE
PROPOSED WAIKANE GOLF COURSE
WAIKANE, KOOLAUPOKO, OAHU, HAWAII

Prepared for:

Waikane Development Company
Honolulu, Hawaii

Prepared by:

Engineering Concepts, Inc.
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Honolulu, Hawaii 96814

October 1988

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FIGURES

INTRODUCTION

The proposed golf course complex is located in Waikane Valley, Koolaupoko District, Oahu, Hawaii. The project site occupies over 500 acres and lies approximately 3.5 miles north of Kahaluu (see Figure 1). It is bordered on the north by the Puu Ohulehule-Puu Pueo Ridge, on the south by a low ridge of the Waiahole Agricultural Park, on the east by Kamehameha Highway, with its western (mauka) boundary cutting the 200- to 250-foot contours.

The objective of this report is to present the necessary facilities planning and preliminary engineering documentation pertaining to storm drainage for the proposed project. Specifically, this report addresses the following:

1. Background information on the proposed project
2. Existing site and watershed conditions
3. Proposed development and resulting drainage modifications
4. Impacts and mitigation of the proposed development affecting the site and the watershed

PROJECT BACKGROUND

Proposed Project

The proposed Waikane Golf Course will consist of a 27-hole golf course, a driving range, maintenance building, and a clubhouse. Several small ponds and landscaping features will be included to function as water storage and/or storm runoff abatement facilities.

The golf course will be positioned within the southern portion of the property and west of the wetlands fronting Kamehameha Highway.

The clubhouse will be situated in the central portion of the golf course at the 135- to 150-foot elevation, with the driving range situated west (mauka) of the clubhouse complex.

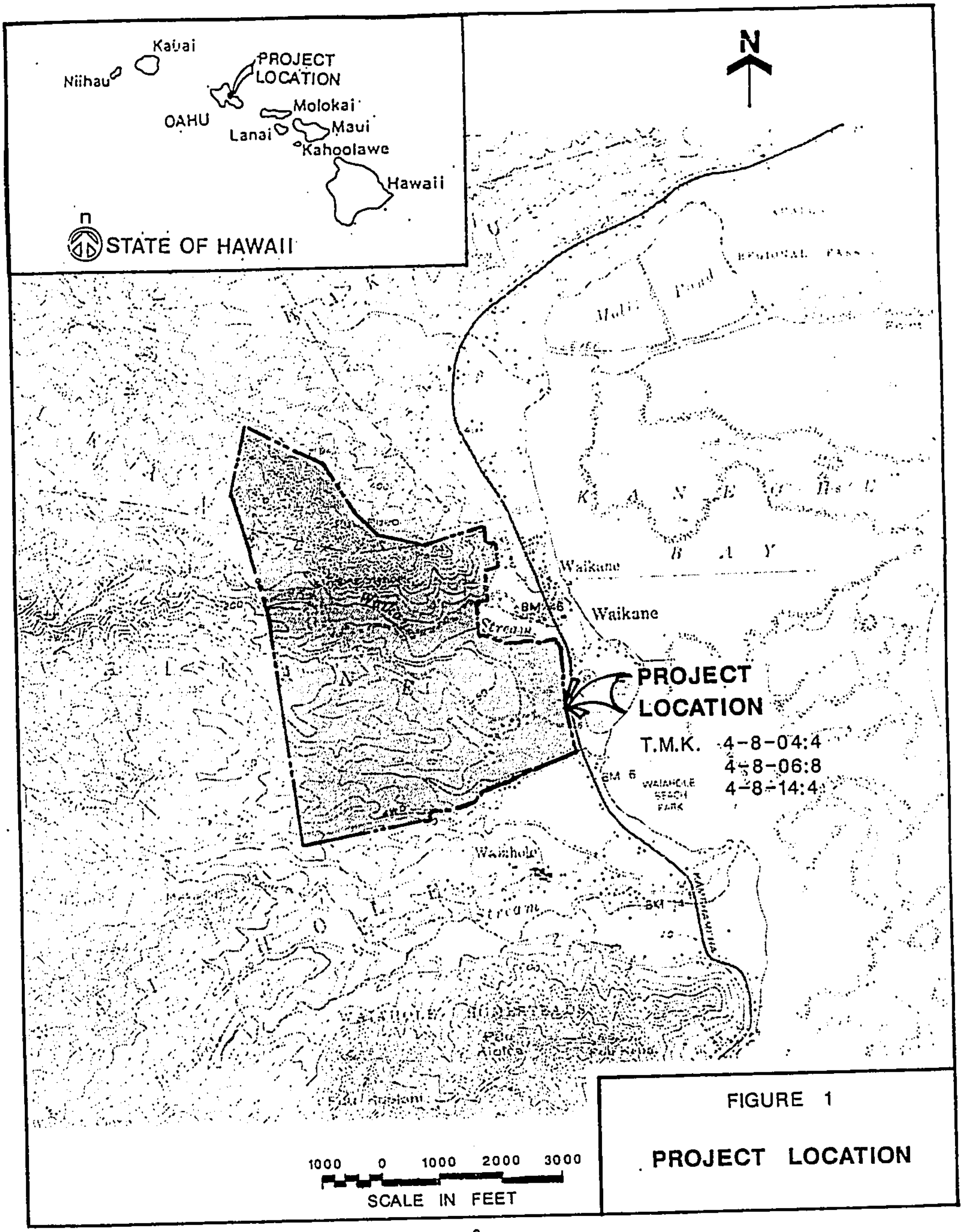


FIGURE 1

PROJECT LOCATION

The maintenance building will be located in the lower portion of the golf course (50- to 60-foot elevation), west (mauka) of the wetlands.

Land Use and Zoning Designation

The majority of the property is presently designated Agricultural by the State Land Use Commission. A small portion of the property (Tax Map Key:4-8-14:4) is designated Conservation. All of the proposed activities will take place within the lands designated Agricultural.

The majority of the land is zoned Ag-2, with a smaller portion (Tax Map Key:4-8-14:4) zoned Preservation (P-1).

EXISTING CONDITIONS

Topographic Features

The project site exhibits varying terrain, with elevations ranging from 10 feet above mean sea level (MSL) along Kamehameha Highway to 250 feet at the western boundary. Slopes of 1 to 10 percent are found in the makai portion of the site, with steep slopes in excess of 30 percent over much of the mauka area. Numerous ridges and small plateaus characterize the southwestern portion of the property, while the northern portion features very steep slopes carved by erosion.

Waikane Stream, a perennial stream, traverses the project site at the northern third of the property, and a small, unnamed stream crosses near the southern boundary. The two streams converge makai of Kamehameha Highway, discharging into Kaneohe Bay. Swamplike low areas, classified as "wetlands" by the U.S. Army Corps of Engineers, are found bordering the streams in the vicinity of Kamehameha Highway.

The site is heavily vegetated with tall grass, scrub brush, and trees. Open areas in the form of dirt roads and pockets of erosion are also seen within the project site.

Climate

The project site experiences a temperate climate, with the average annual rainfall ranging from 65 inches in the lower portion of the site to 79 inches at the mauka boundary. The rainfall increases to approximately 200 inches per year at the crest of the Koolau Mountain Range. Seasonal variation of rainfall is typified by wet winter months and generally dry summer months, with approximately 70 percent of the rainfall occurring between November and April.

The project site enjoys generally mild and uniform temperatures. Data indicate that February is normally the coolest month, with a mean annual temperature of 68 degrees F, while September is generally the hottest month, averaging 80 degrees F. The prevailing north-northeast tradewinds generally make for a comfortable environment, even during periods of high relative humidity.

Waikane Stream Drainage Basin

The Waikane Stream Drainage Basin is irregular in shape and is comprised of two subdrainage areas totaling approximately 3.6 square miles (see Figure 2).

The Waikane Stream Watershed, the larger of the two subdrainage areas, encompasses approximately 1,800 acres and contains several tributaries that discharge into Waikane Stream. A U.S. Geological Survey continuous flow measuring gauge located at the 75-foot elevation of Waikane Stream indicates a mean discharge of 8.3 cubic feet per second (cfs). The Waikane Stream Watershed stretches from the ocean to the crest of the Koolau Mountain Range for a distance of over 3 miles.

The unnamed stream drains the smaller watershed, which covers approximately 660 acres. Currently, there are no continuous stream gauging facilities on this stream. A little less than half of the project site is located in this watershed, with the remainder falling within the Waikane Stream Watershed.

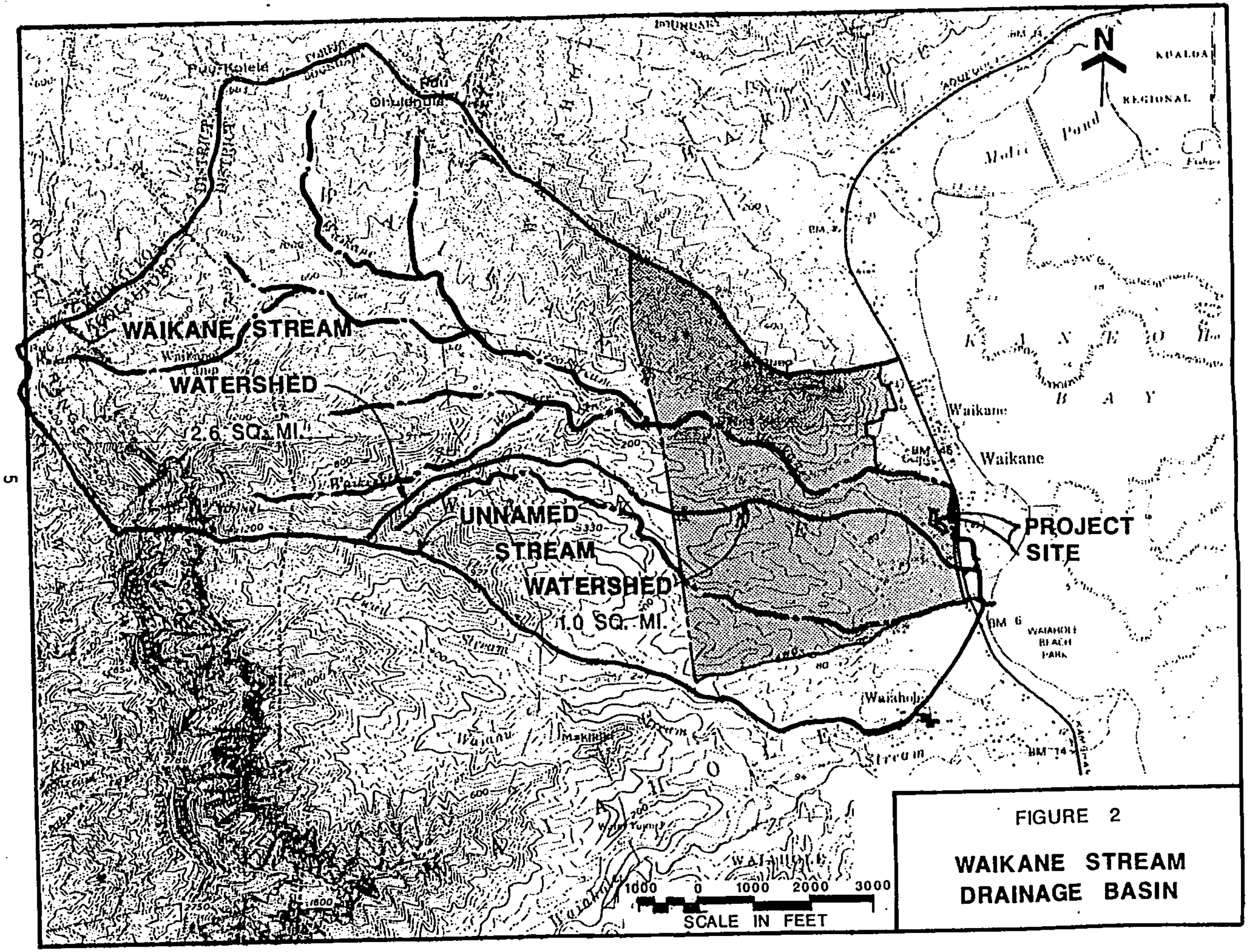


FIGURE 2

WAIKANE STREAM DRAINAGE BASIN

Runoff

There are over 25 years of records for the Waikane Stream gauging station (Station 16-2949). Recorded annual peak discharges range from 292 cfs to 8,800 cfs (February 4, 1965).

A flood insurance study covering the City and County of Honolulu by the U.S. Army Corps of Engineers contains frequency-discharge-drainage area curves for Waikane Stream and the unnamed stream. Peak discharges for the 10-, 50-, and 100-year intervals are listed below.

Stream	10-Year	50-Year	100-Year
Waikane	5,500 cfs	8,600 cfs	10,300 cfs
Unnamed	2,000 cfs	3,400 cfs	4,300 cfs
Total	7,500 cfs	12,000 cfs	14,600 cfs

The project site was divided into seven subwatershed areas in an effort to determine the peak runoff generated onsite using the Rational Method. The peak runoff for storms with recurrence intervals of 10 years and 50 years was estimated for the existing site conditions as follows:

Storm Recurrence Interval (yr)	Intensity (in/hr)	Peak Runoff (cfs)
10	2.5	276
50	3.5	386

Flood Hazard

Portions of the project site currently experience flooding. Areas inundated by a 100-year flood are indicated on the Flood Insurance Rate Map (Figure 3). The Flood Insurance Study by the Corps of Engineers states that the primary cause of flooding is the inadequate channel capacities and the backwater caused by bridges and culverts at Kamehameha Highway. There are currently

LEGEND

SPECIAL FLOOD HAZARD AREAS INUNDATED BY 100-YEAR FLOOD

ZONE A	No base flood elevations determined.
ZONE AE	Base flood elevations determined.
ZONE AH	Flood depths of 1 to 3 feet (usually areas of ponding); base flood elevations determined.
ZONE AO	Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
ZONE A99	To be protected from 100-year flood by Federal flood protection system under construction; no base elevations determined.
ZONE V	Coastal flood with velocity hazard (wave action); no base flood elevations determined.
ZONE VE	Coastal flood with velocity hazard (wave action); base flood elevations determined.

FLOODWAY AREAS IN ZONE AE

OTHER FLOOD AREAS

ZONE X	Areas of 500-year flood; areas of 100-year flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 100-year flood.

OTHER AREAS

ZONE X	Areas determined to be outside 500-year flood plain.
ZONE D	Areas in which flood hazards are undetermined.

Flood Boundary

Floodway Boundary

Zone D Boundary

Boundary Dividing Special Flood Hazard Zones, and Boundary Dividing Areas of Different Coastal Base Flood Elevations Within Special Flood Hazard Zones.

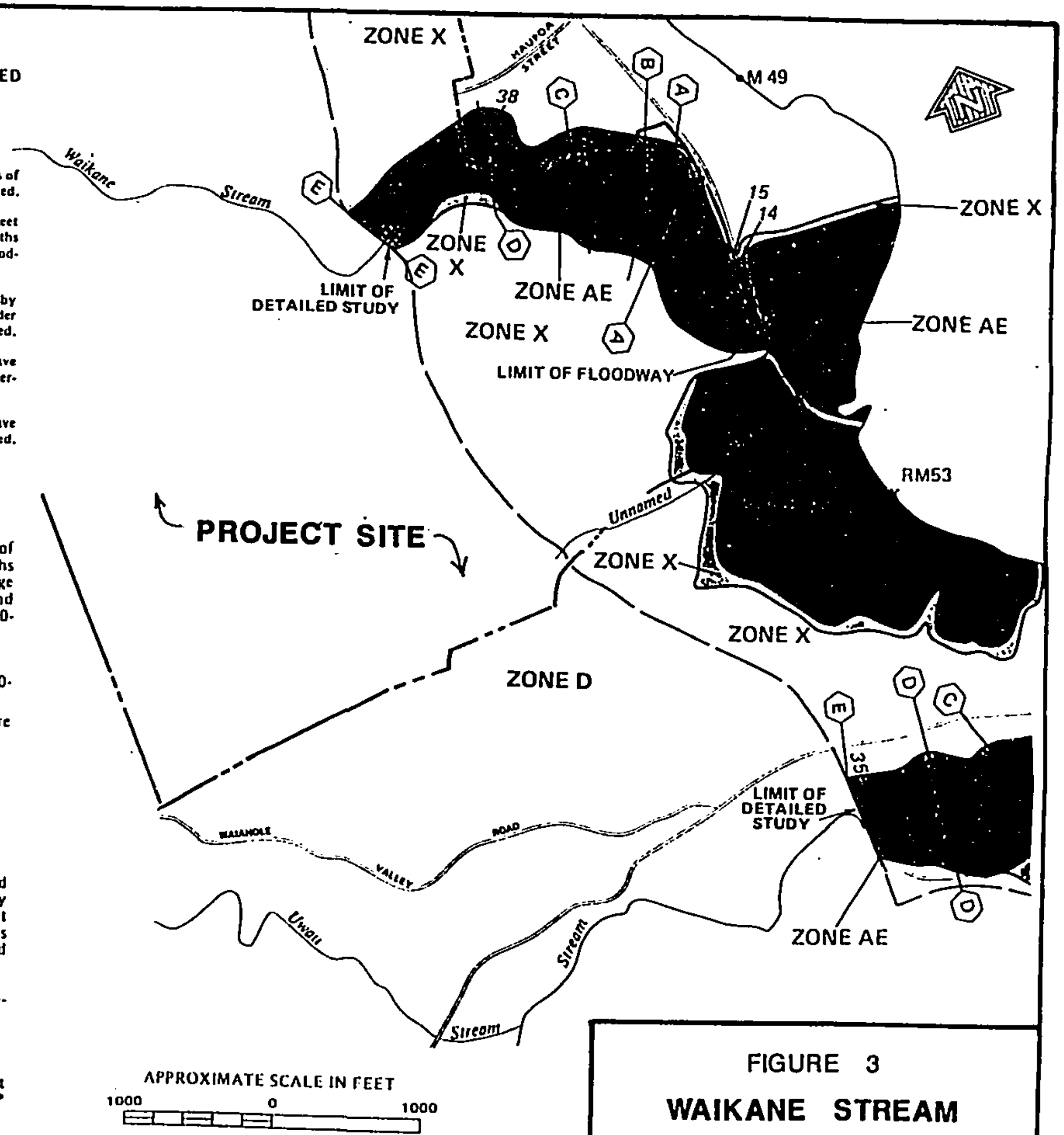
513 — Base Flood Elevation Line; Elevation in Feet*

(D)—(D) Cross Section Line

(EL 987) Base Flood Elevation in Feet Where Uniform Within Zone*

$RM7_X$ Elevation Reference Mark

*Referenced to the National Geodetic Vertical Datum of 1929



SOURCE: FLOOD INSURANCE RATE MAP (1987)

FIGURE 3

WAIKANE STREAM FLOOD HAZARD AREA

no drainage improvements within the project site other than the bridges and culverts at Kamehameha Highway.

MODIFICATIONS AFTER DEVELOPMENT

The proposed golf course development would change the character of approximately 143 acres of the project site. The dense vegetative cover currently found on the site would be replaced by a more open, close-cropped landscaping typically associated with golf course developments. Roadways, parking lots, buildings, ponds, and other features normally supporting a golf course would further add to the modification of the project site.

As a result of the proposed improvements, peak runoff generated onsite is expected to increase. However, the total volume of runoff is not expected to increase. Refer to the report, "Environmental Aspects of Storm Water Runoff," by Gordon L. Dugan, Ph.D. (February 1988) for more information. Estimated peak runoff for 10-year and 50-year storms is as follows:

Recurrence Interval (yr)	Peak Runoff (cfs)
10	438
50	612

Drainage patterns are expected to remain similar to existing conditions, although diversion of some onsite runoff to the golf course ponds is proposed. It is anticipated that the natural slopes and vegetation of most of the areas unaffected by golf course construction would be maintained.

Construction of the golf course will not affect the 100-year flooding of Waikane Stream. Portions of the golf course may encroach into the flood fringe, with tees and greens being placed above flood elevations.

A 600-foot segment of the unnamed stream is proposed to be realigned to a new course approximately 300 feet long. The segment of stream is located near the proposed driving range (see Figure 4). The proposed realignment will require a Stream Diversion Permit from DLNR.

IMPACT AND MITIGATION

Development of the proposed golf course improvements may result in a potential increase in the offsite discharge of peak runoff generated onsite. Without mitigation, the downstream discharge of the onsite runoff has the potential to increase approximately 58 percent for a 10-year storm and 59 percent for a 50-year storm. However, runoff entering Waikane Stream and the unnamed stream can remain near levels experienced for existing conditions when mitigating measured are employed. These measures include routing runoff to ponds within the golf course layout.

It is intended that the ponds serve as detention basins, dampening the peak runoff generated onsite. Additional detention basins can be created to dampen major storm runoff by selective sizing of drain culverts under cart paths crossing gullies and depressed areas between fairways. By incorporating these detention basins into the golf course design, the discharge of peak storm runoff from the project site is not expected to increase from existing conditions.

The impacts of the increased onsite peak runoff are greatly reduced when compared to the impact of peak runoff generated over the entire drainage basin. The increase in onsite peak runoff represents 2 percent of the total peak runoff from the drainage basin.

A positive impact of the proposed development is the probable reduction of erosion and sediment transport to Kaneohe Bay. Bare areas currently found would be planted, with the project site as a whole having better control and maintenance of its landscaping.

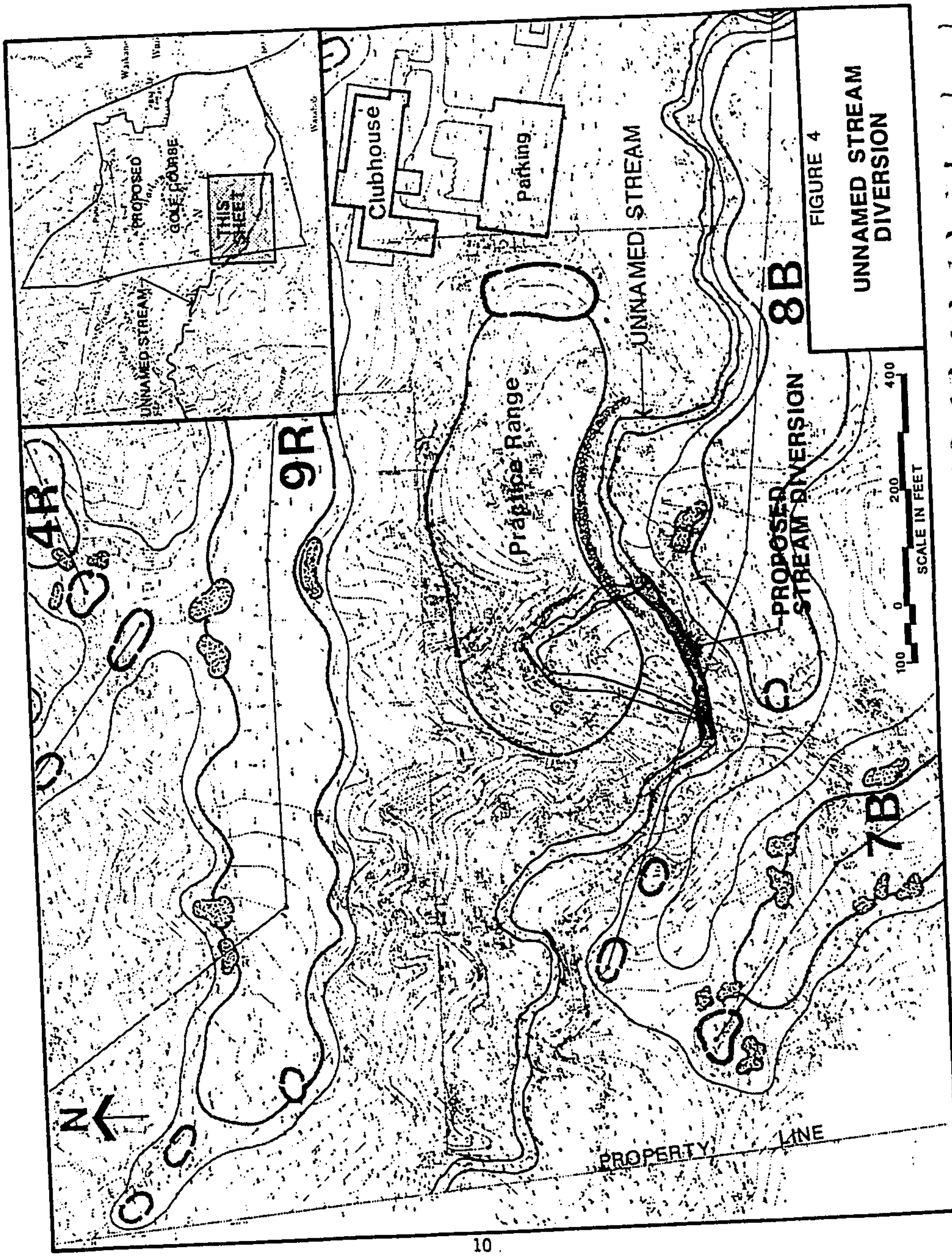


FIGURE 4
UNNAMED STREAM DIVERSION

APPENDIX G
Environmental Aspects of Storm Water Runoff

ENVIRONMENTAL ASPECTS OF STORM WATER RUNOFF

WAIKANE GOLF COURSE
WAIKANE, KOOLAUPOKO, OAHU, HAWAII

March, 1988

by

Gordon L. Dugan, Ph.D.
Environmental Consultant

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INTRODUCTION

The proposed Waikane Golf Course Development Project is located in Waikane Valley, the northern-most watershed in the Kaneohe Bay drainage basin, as shown in Figure 1. The project proposes to develop three 9 hole golf courses along with a clubhouse, driving range, four ponds (covering nearly 7 acres), a wastewater treatment plant facility, and a connecting roadway system. The total area planned to be developed consists of approximately 155 acres out of over 500 acres that are included within the property boundaries.

The golf course greens and fairways, intermingled within undeveloped areas, are primarily positioned within the southern 2/3 of the property, and mauka of the approximately 25.8 acres of determined wetlands (Department of the Army, 1988) that are included within the property mauka of Kamehameha Highway. The property boundaries are shown in Figure 2, along with the gross area of the proposed development site. The wastewater treatment facility is located near the southern boundary, approximately 2000 ft makai of the City and County of Honolulu Board of Water Supply's Pass-No Pass Line, which is outlined in Figure 2.

As can be observed in Figure 2 the project area proposed to be developed is approximately equally divided within the main 1800 acre Waikane Watershed and the adjacent (south) unnamed ditch 660 acre subdrainage area. The proposed site ranges from about 25 ft to nearly 245 ft. The unnamed ditch and Waikane Watersheds extend from sea level at Kaneohe Bay to a maximum

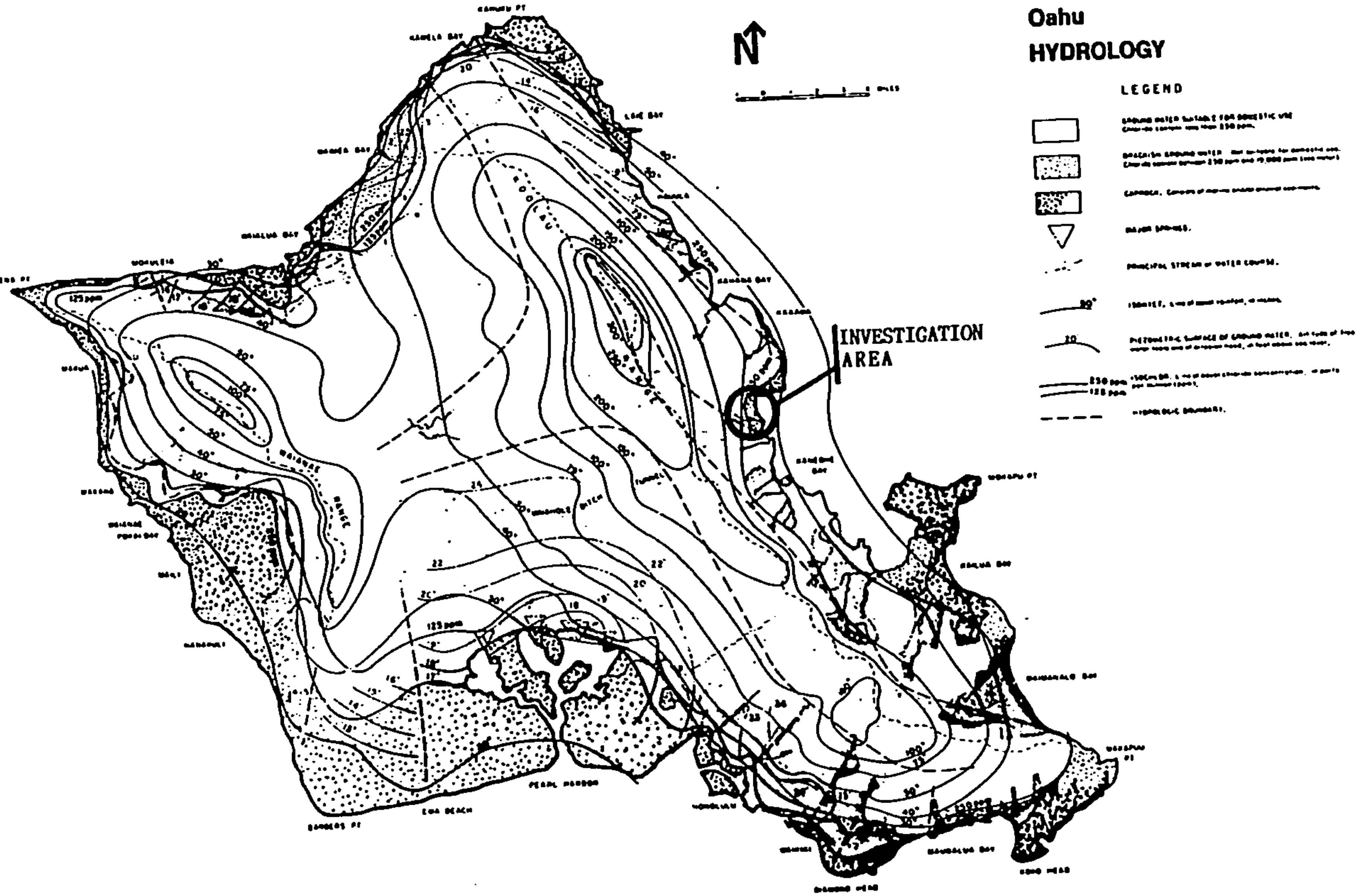


Figure 1. Hydrologic and Geologic Characteristics of Oahu

(Source: "2020 Plan," Board of Water Supply, City and County of Honolulu, 1971, pg. 13)

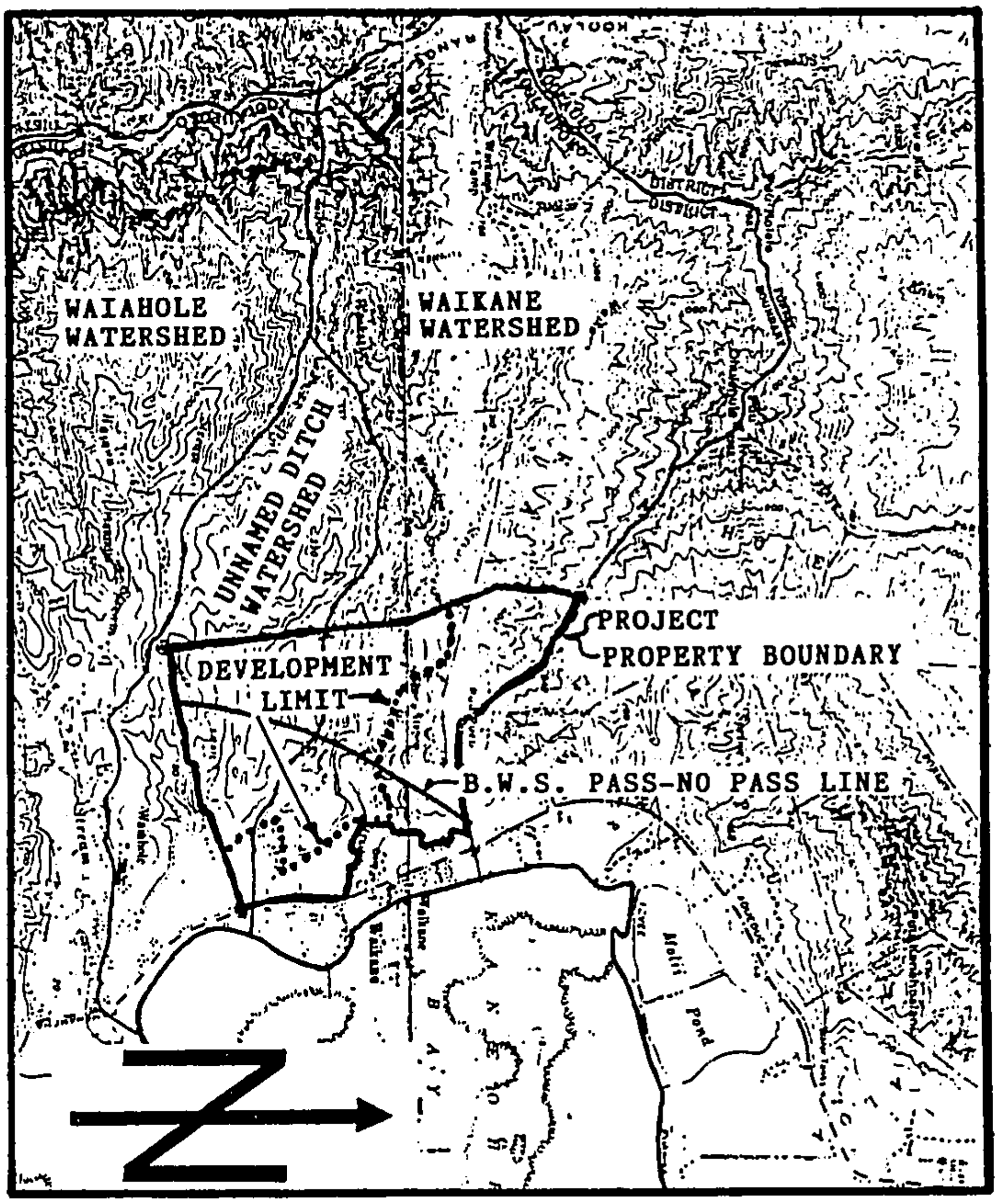


Figure 2. Site Location of Waikane Golf Course, Waikane, Koolaupoko, Oahu, Hawaii

elevation of approximately 1250 ft and 2681 ft, respectively, the latter of which is at the crest of the Koolau Range (U.S.G.S. 7½ minute quadrangles, Kaneohe, Kahana, and Hauula), a distance of over 3 miles. The Koolau Range on the windward (east) side is characterized by abrupt steep palis that rapidly merge with a rolling plain that gently slopes toward the coast.

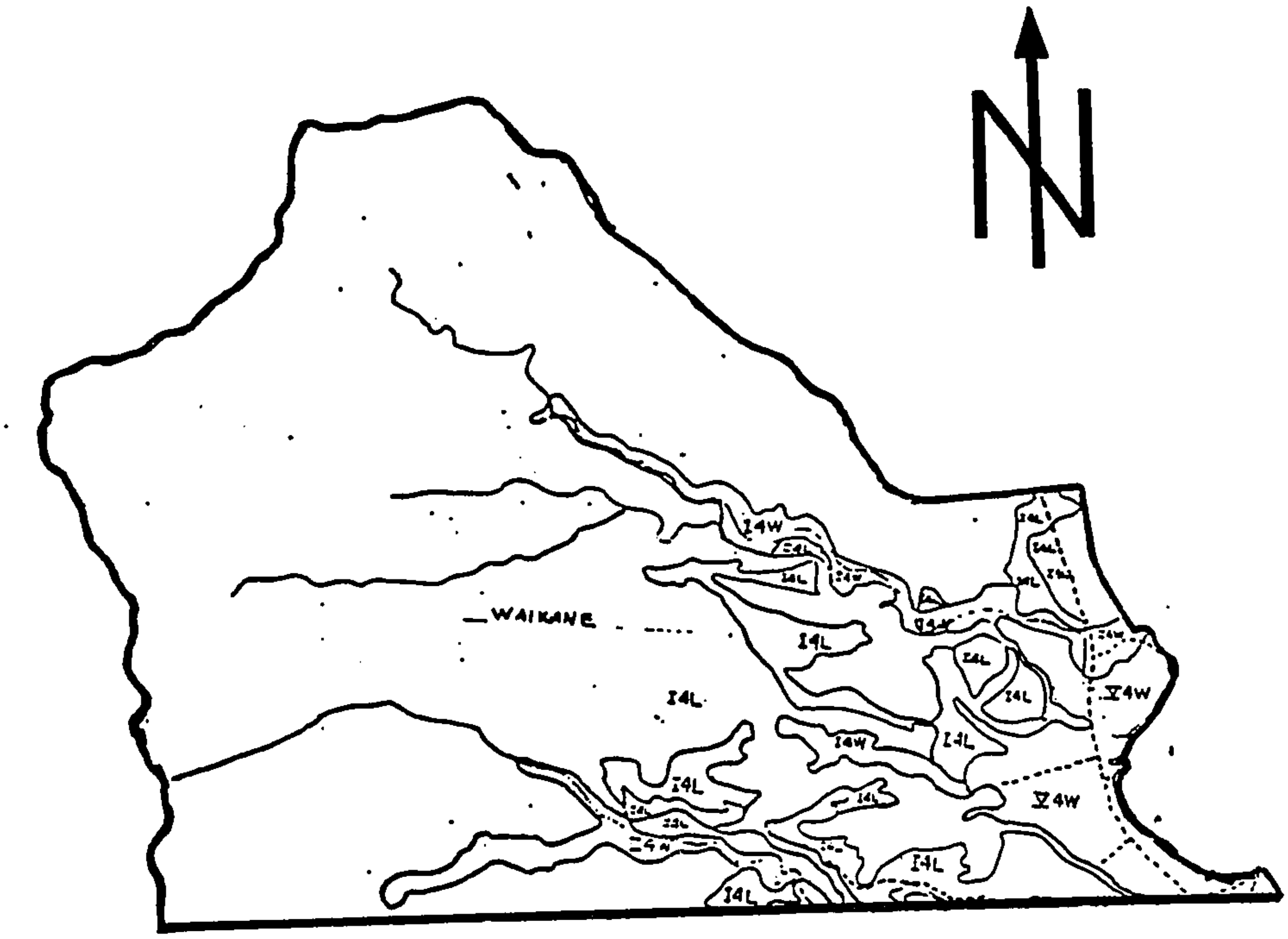
The median annual rainfall at the project site ranges from nearly 65 in. at sea level to approximately 79 in. at the mauka end of the development area. The rainfall continues to increase to approximately 200 in. at the head of the Waikane Watershed, the crest of the Koolau Range. Seasonal variation is typically manifested by wet winter months and dry summer months. The temperature in Valleys near the project site area is mild and uniform, with the coolest and warmest months averaging approximately 72 and 79°F, respectively. These temperatures are characteristic of Windward Oahu. During the winter months, the relative humidity approaches 80%, while during the summer months it is somewhat less humid (State of Hawaii, 1986).

Soils and Geology of the Area

The geologic history of Waikane Watershed, the unnamed ditch drainage area, and adjacent Waiahole Watershed to the south is essentially that described by Takasaki, Hiroshima, and Lubke (1969) for the Kaneohe Bay drainage basin. The valley is formed by steep-sided basaltic ridges that project northeastward from the Koolau Range, which developed during the Koolau Volcanic Series in Pliocene times. Most of this volcanic rock at the lower elevations is a dike complex of the Koolau Volcanic Series, generally striking N 35°W, and at the higher elevations, marginal dike zones exist. These dikes are remnant conduits through which the volcanic lavas travelled to the earth's surface, and they consist of nearly vertical slabs of dense, massive rock, generally a few feet thick, that extend for considerable distances. Normal permable lavas containing water occur between these slabs. A dike complex refers to those areas where dikes constitute more than 5% of the rock, whereas a marginal dike zone refers to those areas where the dikes constitute less than 1% of the rock. It is apparent that the marginal dike zone would be more significant from a groundwater resource standpoint in that a greater volume of stored water is available.

Erosion of the basaltic rock over the years has provided an alluvium material which filled much of the valleys and extends to the coastal areas, and unlike other areas of Windward Oahu, calcareous sedimentary material is sparce. Generally speaking, this material consists of an older, moderately to well consolidated alluvium, and a younger, more poorly sorted alluvium, which overlies the older in the coastal regions. These soils are acidic, humic latosols, typified by the Waikane Soil Series (Foote, et al., 1972) and are characteristically well-drained silty clays, with low fertility value for topsoil. Depth of soil material over underlying consolidated materials is almost exclusively greater than 15 ft, as shown in Figure 3.

Two separate soil series, Waikane and Hanalei, are included in the 155 acres proposed to be developed. The relationship of these soil series to storm water runoff will be discussed in a



Soil Character Code

- I Non-expanding, non-rocky, surface well-drained
- II Non-expanding, rocky, surface well-drained
- III Expanding soil, non-rocky, surface well-drained
- IV Marshy soil, non-rocky, surface well-drained
- VI Coral sands, non-rocky, surface well-drained
- VII Coral sands, rocky, surface well-drained

Slope Categories

0 - 10%
11 - 20%
21 - 30%
30+%

Depth of Consolidated Material Code

1. 0 - 5 ft
2. 6 - 10 ft
3. 11 - 15 ft
4. 15+ ft

Underlying Material Code

- C Consolidated Coral
- L Consolidated Lava
- W High Water Level

Figure 3. Land and Slope Categories for Waikane and Unnamed Ditch Watershed, Waikane, Oahu, Hawaii

(Source: Ref. Murabayahi and Kuwahara, 1969) later section of the report. The existing vegetation of the area proposed to be developed is best described as herbaceous, with a mixture of grass, weeds, low lying brush intermingled with some trees, but brush is considered the minor element. Vegetation coverage, quite heavy in some locations, averages greater than 90% over the developed area.

Groundwater Occurrence and Movement

Shown in Figure 4 is a cross-section of a typical stream channel in the Kaneohe Bay drainage basin. The low volume dike complex is located generally in the lowlands while the high capacity marginal dike zone is located at the higher elevations. The latter dike system represents the most reliable water resource of the Waiahole-Waikane area, which is typically considered as similar units. A system of seven tunnels, penetrating the dikes, provide the major source of water for the Waiahole ditch-tunnel system of the Waiahole Water Company. A long-term average flow of nearly 25 mgd is diverted to south-central Oahu (near Waipahu) for cane irrigation on Oahu Sugar Company land. This flow also includes some storm runoff, but excludes occasional pumpage from Waiahole Stream. The water table at the higher elevations generally exceeds 800 ft. An upper zone of discharge exists near this point where the perennial tributories that form Waiahole and Waikane Streams undercut the high-level water for a major portion of their base flow. At around 200 ft. elevation a second zone of discharge exists. Furthermore, there is a nearly continuous discharge of groundwater along the stream channel, and an associated absence of sea water-

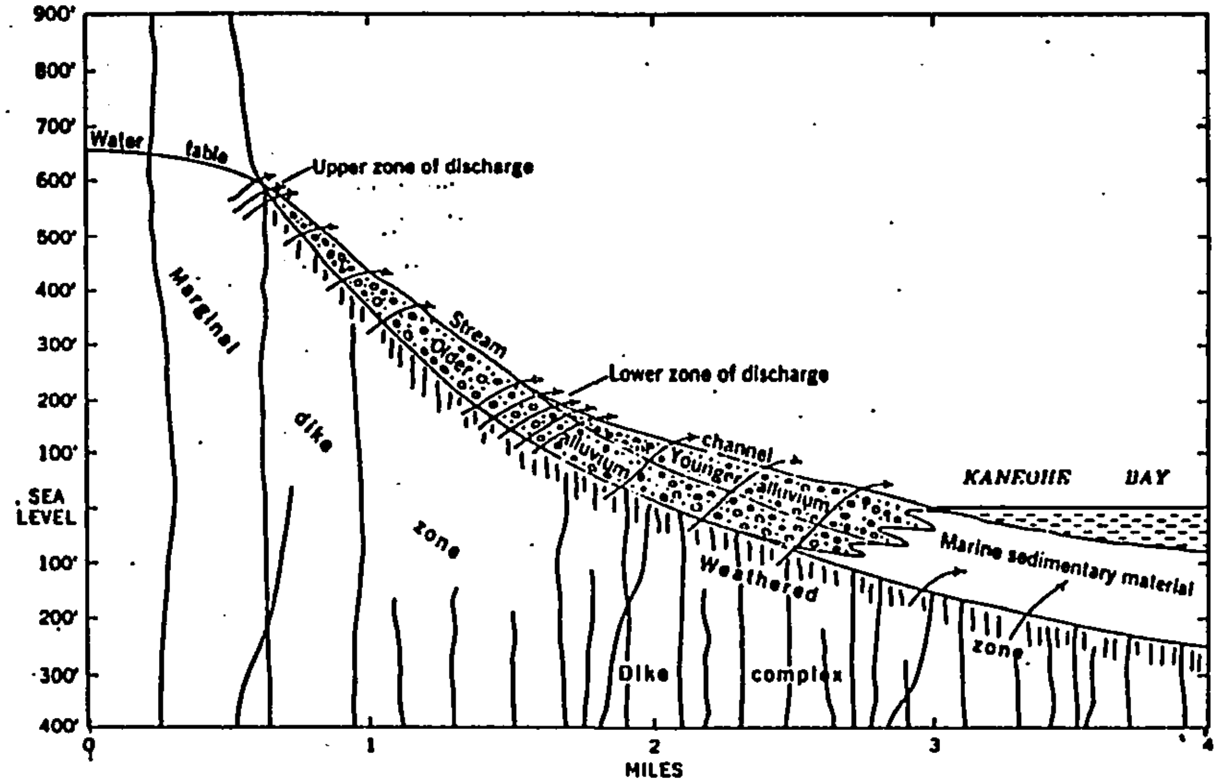


Figure 4. Cross-section of Typical Stream Channel in Kaneohe Bay Drainage Basin

(Source: Takasaki, et al., 1969; pg. 68) basal water interchange in the inland areas due to the impervious dikes. The net result of this geologic feature is that much of the groundwater not developed in these valleys eventually rises to the surface and flows into the streams and marsh areas, such as in the wet lands makai of the areas proposed to be developed.

Surface Runoff and Drainage

The Waikane Watershed, as shown in Figure 2, is drained by several tributaries that converge into Waikane Stream, while the unnamed ditch only has one water channel. A USGS continuous flow measuring gage (station 16294900), which has been in operation since December 1959, is located approximately 7000 ft upstream from Kaneohe Bay at an elevation of 75 ft. The position of the gage enables surface water runoff from 1420 acres, of the 1800 acres, to be continuously recorded. The mean discharge at this station (through 1985) is 8.30 cfs (6,010 acre-ft per year).

The unnamed ditch and subdrainage area, shown in Figure 2, which consists of approximately 660 acres, is situated between the Waikane and Waiahole Watersheds, starting about one-third the distance down from the merger of the two watersheds, at the crest of the Koolau Mountain Range. There is presently no continuous stream gaging facilities located on this unnamed ditch, although average stream and base flows have been determined in the past.

As previously discussed, high mountain dike water is withdrawn from six lateral tunnels within the Waiahole and Waikane watersheds, in addition to an open ditch that extends to the north into the Kahana Watershed, where water is collected from a seventh lateral tunnel. These tunnels and ditch which tie into the Waiahole tunnel and ditch system were monitored at several points by USGS continuous flow recorders from January 1951 through May 1969.

Based on the preceding description it is apparent that a meaningful water inventory in Waikane, Waihole and unnamed watersheds is difficult and requires considerable scientific and engineering assumptions and judgements. To this end the USGS Water Supply Paper 1894 (1969), the University of Hawaii's WRRC Technical Report No. 31 (Young, Morphew, and Burbank, 1969), and work Area 3 of the Water Quality Program for Oahu (Department of Public Works, 1971), contain published water inventory data. However reported data in the latter two are based primarily on the data developed in the USGS Water Supply Paper 1894. The USGS water inventory was based on detailed studies of all inputs, storage, and outputs which were determined by actual measured values, or estimated by correlation to similar streams or to the long term records (1927-1960) of East Branch Manoa Stream. In addition to the average observed discharges and the computed long term discharges the USGS Water Supply Paper also reported Q_{90} (flow equal or exceeded 90 percent of the time) values for both the observed and computed flows in the Kaneohe Bay Area. The Q_{90} values are assumed to represent base flow conditions, thus the difference between the average or mean flow value and the Q_{90} value is assumed to represent storm runoff. However, for the present study the concern will be the incremental difference of the storm water quantity and quality between the existing (1988) conditions and full development conditions.

Flooding Considerations

Flooding on Oahu, particularily in the Kaneohe Bay area is characterized by intense rainfalls in relatively short watersheds, with the result that the time of concentration (considered as the time required for rainfall-derived surface runoff to flow from the most remote point in the watershed to the drainage point under consideration) is relatively short (generally much less than one-hour). Streams in the Kaneohe Bay area thus tend to surge quickly and return to near normal flow in a half-a-day.

Flooding has been a recurring problem in the Kaneohe Bay area throughout recorded history, however, as mentioned previously streamflow records for Waikane Stream at an altitude of 75 ft, date back from 1960. The State of Hawaii Department of Land and Natural Resources (DLNR) (1970) used the USGS annual maximum flow data to develop the probability of the recurrence interval for flood frequences. Flood frequencies for Waikane Stream for the years of record are shown in Table 1. The number of events, or annual maximum flows, was 10 for Waikane Stream. The curves have been extended to 200 years, or well beyond what would normally be considered statistically valid.

Flood frequencies for 50 and 100 year intervals have also been developed by DLNR in cooperation with the Pacific Ocean Division, Corp of Army Engineers (Department of Land and Natural Resources, 1973). Graphs illustrating flood frequencies and corresponding runoff in time intervals of 1 to 100 years for Waiahole, Waikane, and the unnamed ditch are shown in Figure 5. The magnitude of the ratio of peak discharge for Waiahole and Waikane Streams to

TABLE 1

Flood Frequencies for Waikane Stream*

WAIKANE STRM AT ALT 75 FT WAIKANE   1960-1969 PEAKS   N = 10   STATION 16-2949. 0   DA = 2.22

INPUT DATA

2370.000	361.000	1070.000	4560.000	2180.000	8800.000	3230.000	2930.000	1200.000	4020.000

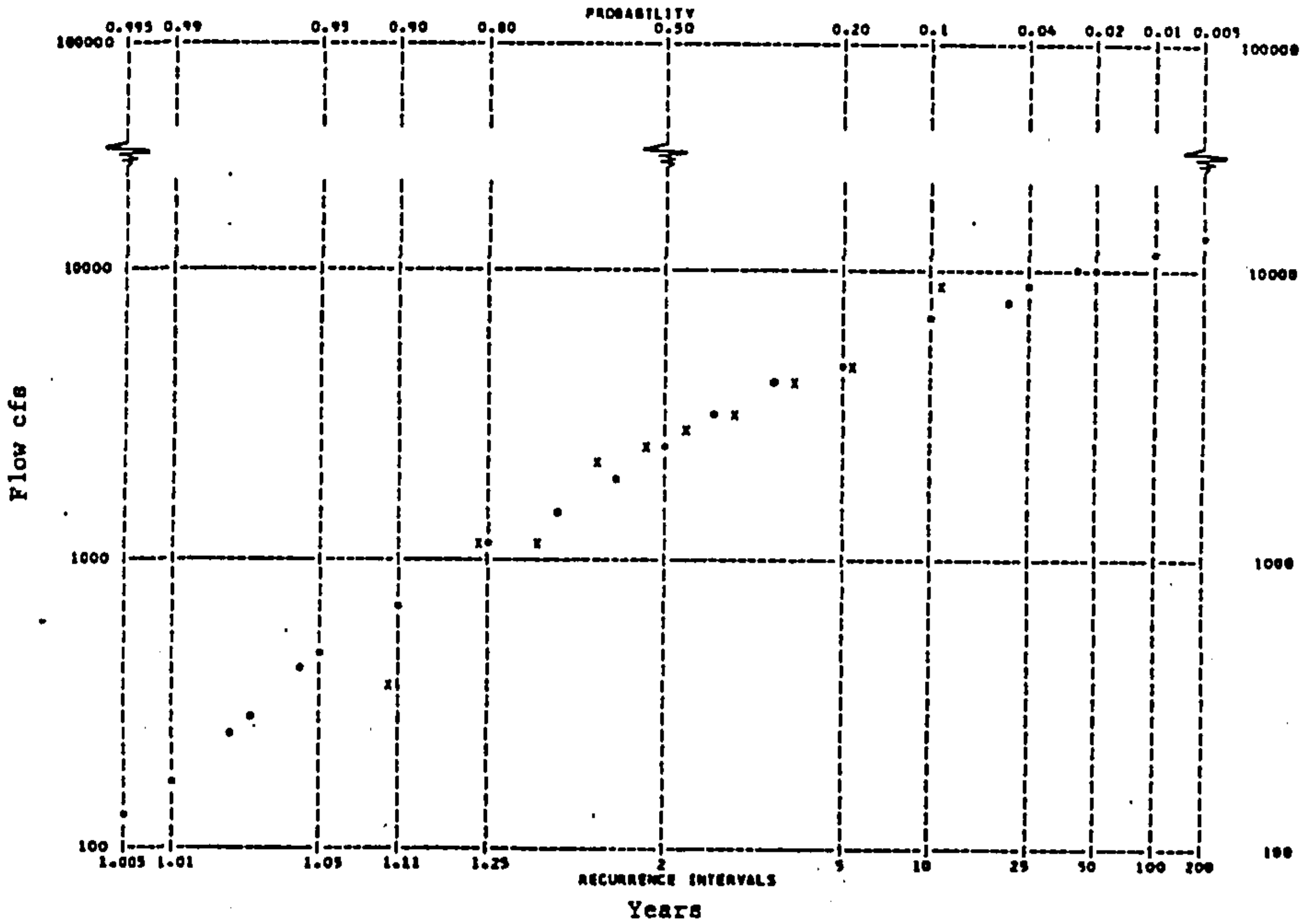
MEAN LOGS = 3.356

STANDARD DEVIATION LOGS = 0.388

SKEWNESS LOGS = -0.746

STANDARD ERROR OF SKEWNESS LOGS = 0.687

EXCEEDANCE PROB	RECURRENCE INTERVAL	MAGNITUDES
0.9900	1.01	176.935
0.9500	1.05	443.033
C.9000	1.11	688.795
0.8000	1.25	1125.501
0.5000	2.00	2536.044
0.2000	5.00	4885.570
0.1000	10.00	6496.387
0.0400	25.00	8454.125
0.0200	50.00	9815.359
0.0100	100.30	11079.047
0.0050	200.00	12249.828



* From "Flood Frequencies for Selected Streams in Hawaii," Dept. of Land and Natural Resources, Div. of Water and Land Development, State of Hawaii, Report R36, July 1970, pgs. 66-67.

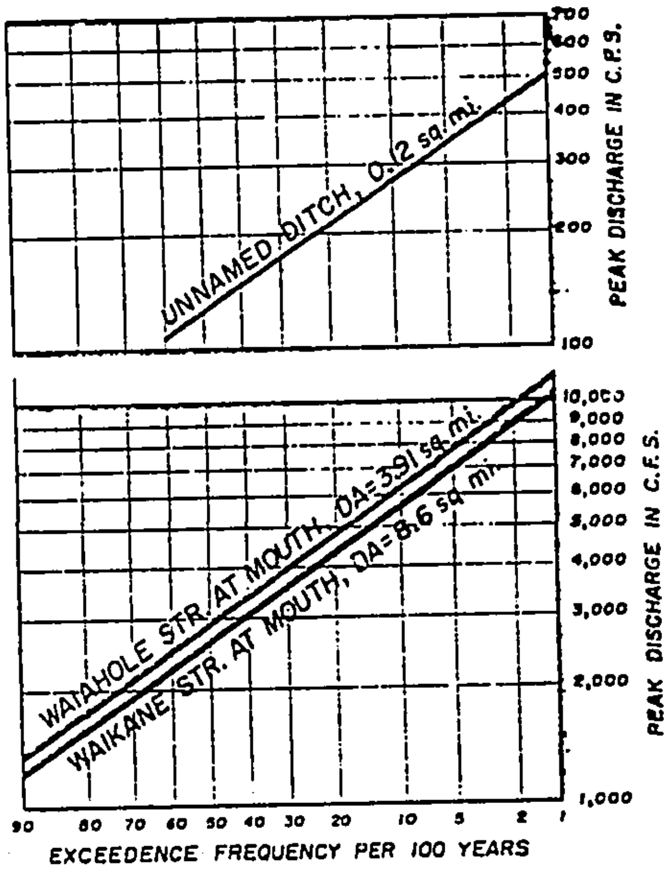


Figure 5. FREQUENCY OF WAIKANE AND WAIAHOLE STREAM FLOOD DISCHARGES *

* From "Waikane and Waiahole Flood Hazard Area," Dept. of Land and Natural Resources, Div. of Water and Land Development, State of Hawaii, MAP, FP-16, April 1973.

that for the unnamed ditch is shown if Figure 5 to be greater than 20 to 1. The aerial extent of flooding expected in the 100 yr event for the Waikane and Waiahole area (Department of Land and Natural Resources, 1973) indicates that less than 6 acres of the golf course lies within the flood zone. Essentially the same area is designated as Zone AE and Zone X (less than 1 acre) in the Flood Insurance Rate Map, City and County of Honolulu, a part of the National Flood Insurance Program. The designation AE indicates that the base flood elevations have been determined for the 100-yr event. Zone X includes areas of the 500-yr flood; areas of the 100 yr flood with average depths of less than 1 ft or with drainage areas less than 1 sq mi and areas protected by levees from 100 yr flood.

The effect of the bridge on the unnamed ditch on Kamehameha Highway (also called Waiahole Stream Bridge but a different bridge than the one crossing Waiahole Stream) can be seen in Figure 6. The effect of the Waikane Stream Bridge on Waikane Stream is not as pronounced as that in the two preceding cases, as shown in Figure 7, however, the flow in Waikane Stream is restricted by a relatively shallow, undeveloped, poorly defined, and meandering stream bed which tends to collect debris near its mouth. Thus, it is apparent that the extent of potential flood plain boundaries for the 50 and 100 yr events could be reduced by proper stream channel maintenance and/or a larger opening at the Kamehameha Highway.

Associated with a development project such as is being herein proposed are alterations in surface water runoff resulting from modifying the existing ground conditions. Interest in these runoff changes is generally a result of concern over two factors--one, public safety, and two, environmental impact. The first factor requires the identification of changes in peak discharge rates, the magnitudes of which are necessary for designing adequate

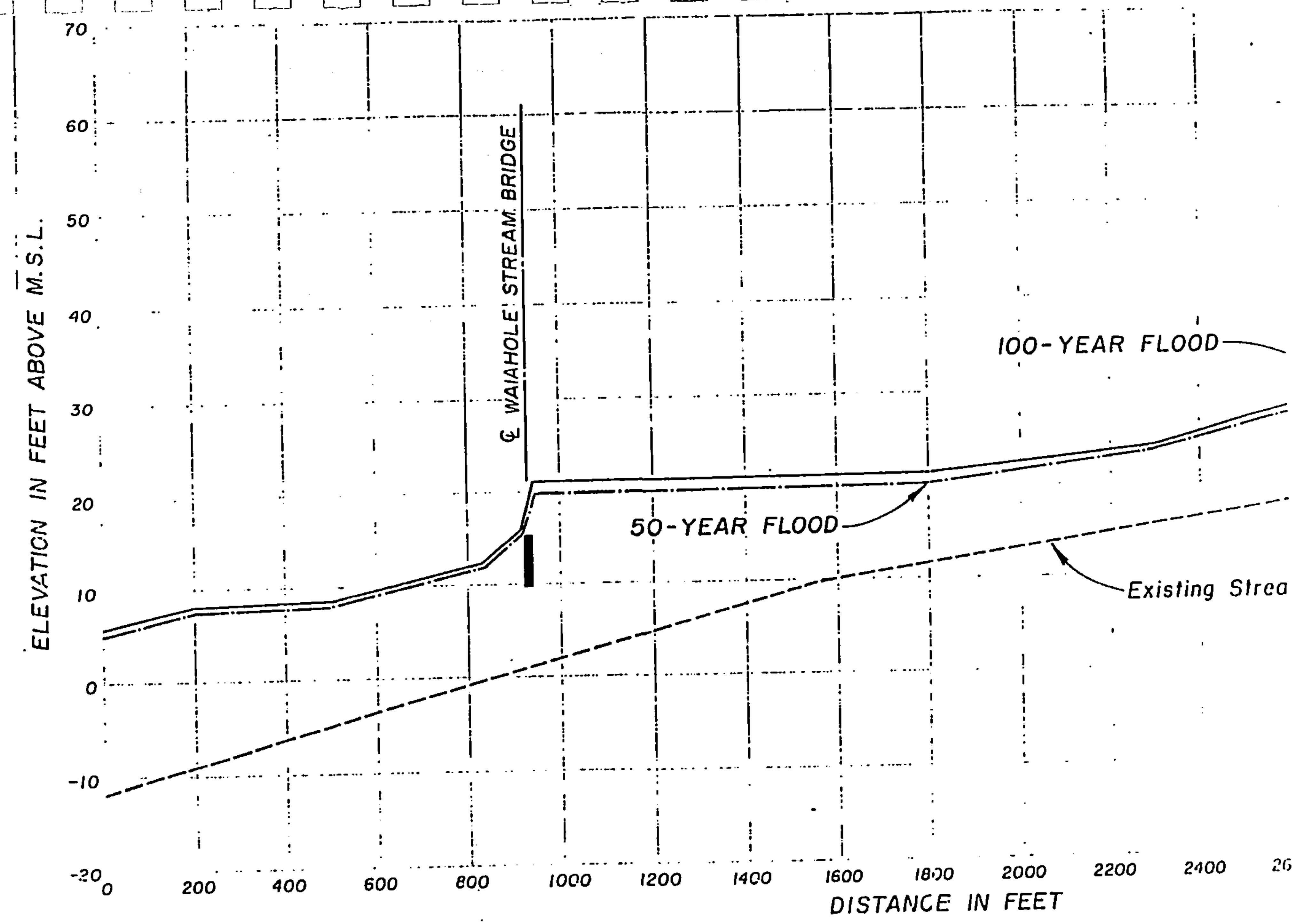


Figure 6. UNNAMED DITCH FLOOD PROFILES

* From "Waikane and Waiahole Flood Hazard Area," Dept. of Land and Natural Resources, Div. of Water and Land Development, State of Hawaii, MAP, FP-16, April 1973.

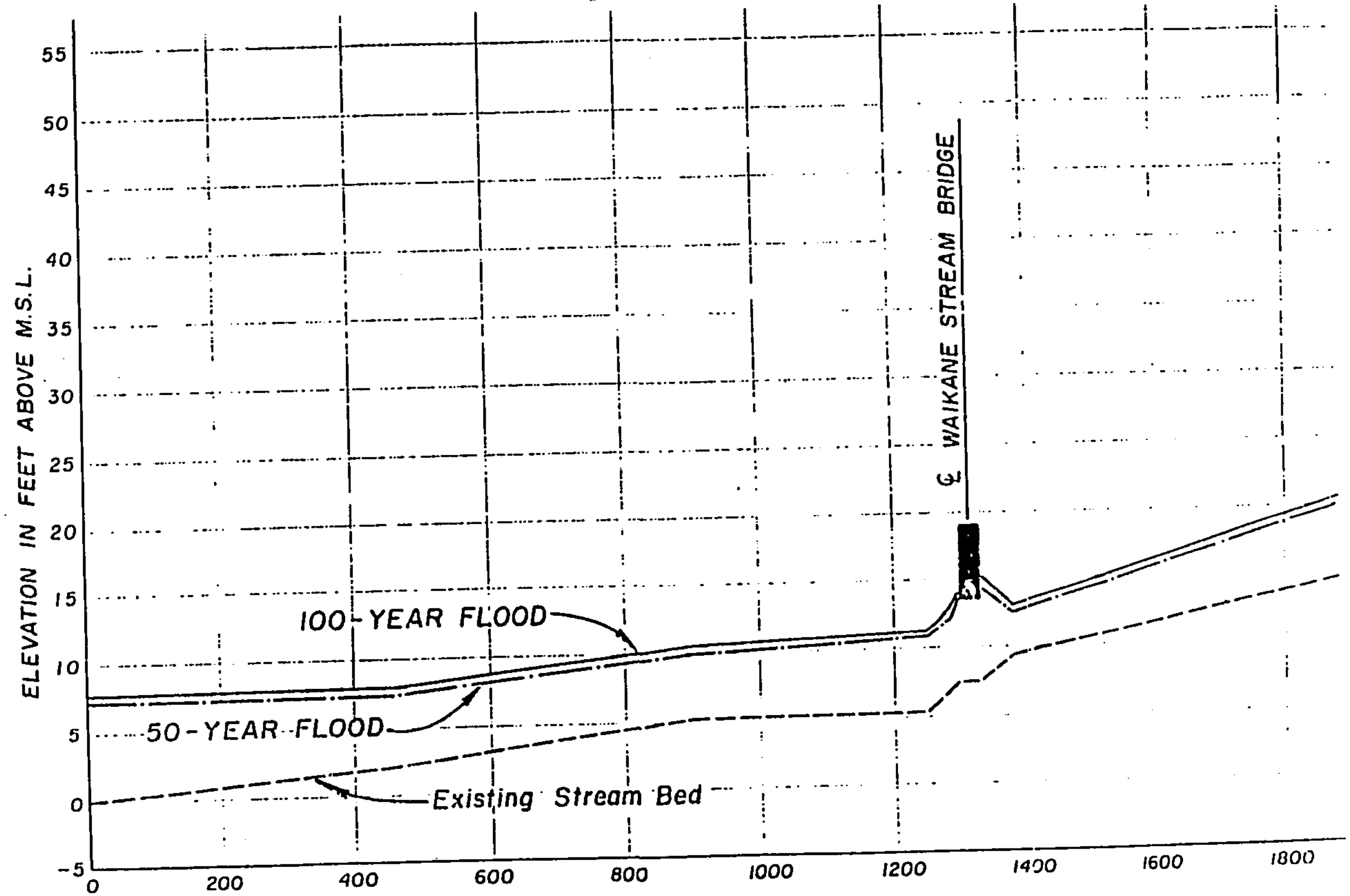


Figure 7. WAIKANE STREAM FLOOD PROFILES*

* From "Waikane and Waiahole Flood Hazard Area," Dept. of Land and Natural Resources, Div. of Water and Land Development, State of Hawaii, MAP, FP-16, April 1973.

drainage structures to prevent flooding, while the second requires indentification of changes in total runoff volume, as well as sediment, nutrient, and other constituent loads, and effects these will have on the ecosystems of the natural resource serving as the "sink." It is this second concern, environmental impact resulting from increased runoff and sediment loads, and nutrient loads, and its probable effect on subsequent receiving water (Kaneohe Bay) that is under study in the present investigation as herein reported. The potential effects that changes in storm runoff quantity and quality may have upon the receiving waters per se will be addressed in a separate companion report.

It should be noted that the determination of peak discharge rates results in a theoretical maximum instantaneous flow, such as cubic feet per second (cfs), which is a volume per unit of time relationship, whereas the determination for environmental impact involves calculation of the total volume of flow over a set time period, such as 1-hr, or 24-hr. Thus, a peak discharge rate of up to 3 to 4 times or more over the total volume per fixed time period is typical. In addition, since safety is involved with the determination of the peak discharge rates for storm drainage facilities, a very conservative engineering approach is taken, in contrast to the volumetric determinations needed for environmental impacts, which are based on average incremental differences between pre-and-post development conditions. Thus, if more severe conditions occur in the latter the incremental differences are likewise affected.

The need for conservation in the design of storm drainage facilities have been particularly emphasized as a result of the 1988 New Years floods on Oahu. The result of the notably conservative approach for peak discharge determinations and consequently the design of storm drainage facilities is that the incremental differences between peak discharges and volumetric determinations for environmental impact considerations can be considerable.

PURPOSE AND SCOPE

The purpose of this study is to evaluate the environmental impact of the proposed approximately 155 acre Waikane Golf Course Development Project as it relates to surface water runoff. From an assembledge of baseline hydrologic and water quality data, an estimate of the existing and projected volume and quality characteristics of surface water runoff will be made, along with an assessment of the environmental impact resulting from this runoff, in the form of written comments.

METHODOLOGY

The methodology used in this study consisted of assembling, analyzing, and interpreting existing data from federal, state, and county agencies, as well as from on-site surveys of field conditions.

Inasmuch as the scope of work consisted of estimating the alterations in volume and quality of surface water runoff resulting from the proposed project, it was necessary to identify those factors that affect runoff generation and runoff quality for both present and full development conditions.

Methods currently available to estimate the surface water runoff volume from a specific storm event requires the determination of reasonable rainfall runoff coefficients for varying magnitude and duration storms, and for different land management, vegetation, soil, and soil moisture conditions, to name but a few hydrologic factors. In most practical situations, it is not considered feasible, due to the numerous influencing factors, to determine varying rainfall-runoff coefficients; rather, it is more practical for design and evaluation purposes to use a single coefficient for a particular land-use over a given rainfall intensity range. However, in order to circumvent a major portion of the unavoidable error created by using a constant rainfall-runoff coefficient, methods developed by the Hawaii Environmental Simulation Laboratory (HESL) of the University of Hawaii, (Lopez, 1974: Lopez and Dugan, 1978) and the U.S. Soil Conservation Service (SCS)(1986), were utilized to determine representative storm water volumes under varying conditions.

The HESL/SCS method is based on the use of soil maps (Foote et al., 1972) and the incorporation of curve numbers from the SCS which were obtained from empirical data, including precipitation, soil, and changing soil moisture conditions, and vegetative cover information from the classification of thousands of soils throughout the nation. These soils were classified into four groups, labeled A, B, C, and D, with Class A having the highest water intake rates and Class D soils the lowest. Two separate soils series dominate the developed project site, Waikane and Hanalei, which cover approximately 119 and 36 acres, respectively. The HESL/SCS method also included the use of rainfall-frequency values for given recurrence and duration storms (Giambella et al., 1984). The rainfall recurrence interval storms chosen for evaluation purposes were 2, 10, 50, and 100 yr with 1 and 24 hr durations.

Once the increase in surface water runoff volume has been established, it is necessary to determine the runoff quality for present and full development conditions.

The quality parameters of storm water runoff considered the most representative to identify potential changes under different land management practices (i.e. present and full development conditions) are: total nitrogen, total phosphorus; and suspended solids (sediments).

Records of chemical water quality analyses of the streams in the project area are primarily limited to those for Waikane Stream from previously mentioned University of Hawaii's WRRC Technical Report No. 31 (Young, Morphew, and Burbank, 1969) and the U.S. Geological Survey's (USGS) Water Resources Data for Hawaii and other Pacific Areas (1967-1985). The Water Quality Program for Oahu (Department of Public Works, 1971) also reported water quality values and loadings for Kaneohe Bay streams, however, the basic water quality values were derived from the WRRC Technical Report No. 31.

The USGS water quality samples for the active Waikane Stream gaging site are collected at the site. As would be expected, since the site is located upstream of significant human activity, the water quality as judged by the analyses appears excellent. However only the nitrite and nitrate and orthophosphate concentrations are reported rather than the desired total nitrogen and total phosphorus values.

The Waikane Stream water samples for the WRRC Technical Report No. 31 were collected from the Kamehameha Highway bridge that crosses over Waikane Stream. Although samples from the bridge site would be more representative of existing conditions than the upstream USGS site, and the concentrations of both nitrogen and phosphorus vary somewhat, they are believed to be more representative of dry weather flows, rather than storm water induced flows.

To circumvent the problem of determining representative nitrogen and phosphorus values in surface runoff, for comparative purposes, nitrogen and phosphorus values of 3.0 and 0.3 lb/acre-yr, respectively, were selected to represent pre-project (1988) development conditions. These values were derived from a compilation of data relating to nutrient outputs from rural and agricultural lands throughout the nation that were reported by Loehr (1972). To convert the output loads to concentration values the nitrogen and phosphorus values of 3.0 and 0.3 lb/acre-yr, respectively, were utilized along with the median annual weighted rainfall of 73 in. for the project site area, and a rainfall-runoff coefficient of 0.30, to result in concentration values of 0.60 and 0.06 mg/L, respectively, for present (1988) development conditions.

Representative suspended solids values in storm water runoff from the presently developed (1988) project site area are again difficult to determine, inasmuch as it is commonly presumed, by mainly indirect methods, that the majority of the annual suspended solids load is carried by the heavy storm water runoff events which tend to occur on an infrequent basis. Sediment transport in streams of the Kaneohe Bay area can be very significant. This aspect can often be observed in Kaneohe Bay near the outlets of the streams after a significant rainfall event. There is a certain annual quantity of sedimentation created by natural phenomena, including erosion, however, some human activities and development can increase the quantity of sedimentation, while others could decrease sedimentation in comparison to natural conditions.

Only a limited number of analyses have been performed on suspended solids for the northern Kaneohe Bay Streams, Waiahole and Waikane. Sediment loads for Kaneohe Bay Streams, including Waiahole and Waikane have been reported by the USGS (Jones, Nakahara, and Chinn, 1971). An empirical expression relating quantity of flow to sediment load for Kaneohe Bay Streams was developed by the USGS for the Oahu Water Quality Study Program (Department of Public Works, 1971). The empirical sedimentation relationship for Kaneohe Bay is:

$$S = 452\ Q^{1.53}$$

in which "S" is expressed in ton/yr and "Q" in mgd. Utilizing this relationship for the 1800 acre Waikane watershed and incorporating the parameters of a median annual weighted rainfall of 120 in. (for the entire 1800 acre Waikane watershed), and a rainfall-runoff coefficient of 0.3, a rounded-off suspended solids (sediment) concentration value of 650 mg/L was obtained. A slightly higher (> 700 mg/L) value was obtained if the calculated sediment load was divided by the 25-yr average Waikane flow records, (gaging station located in the upper makai area of the project site), but for conservative reasons the 650 mg/L value was utilized.

Quality data for urban storm water is sparce, both locally and nationally. Loehr (1974) compiled urban storm water runoff quality data collected from throughout the United States, as well as from a few international locations. As expected, the data are diverse. Locally, Fujiwara (1973) reported urban storm water quality data collected from storm drains in different drainage areas of Honolulu, as shown in Table 2. For the present study, Fujiwara's results were used to simulate full development runoff quality from the golf

TABLE 2

Representative Storm Water Quality Data for a Honolulu Residential Area[a/*]

All units in mg/L:

Constituent	Concentration
Total Solids	511
Suspended Solids	252
COD	142
BOD	10
Dissolved Oxygen	7.1
NO_3 - N	0.211
TKN	0.381
Total P	0.57
Ortho P	0.27
Iron	0.377
Lead	0.407
Chromium	0.013
Zinc	0.512
Copper	0.036

a/ Storm water samples collected on Aupuni Street near Nuhelewai Stream.

* Values obtained from Fujiwara (1973).

course development for phosphorus and suspended solids, which were respectively, 0.57 and 250 mg/L. Inasmuch as golf courses use fertilizers that contain a high amount of nitrogen, a higher concentration of nitrogen could potentially be expected in the runoff. However, as previously mentioned, the developed grassed areas are interspersed among the natural vegetation, thus resulting in a buffer area which would undoubtably take up a significant quantity of any excess nutrients, if they should occur. Also fertilization is applied under professional supervision with attention given to the application rate as well as abstaining from fertilization during periods of probable heavy rainfall, for economic as well as environmental reasons. Nevertheless, the total nitrogen concentration for conservative reasons is assumed to be double that reported for the residential area runoff, or 1.2 mg/L.

Applying these concentrations to the full development runoff volumes, the projected sediment and nutrient loads from the project site could then be estimated for both the present (1988) and full project development conditions.

SURFACE WATER RUNOFF ALTERATIONS

Quantity

The estimated storm water runoff and constituent changes due to the proposed 155 acre Waikane Golf Course Development Project are shown in Table 3. The values presented, it must be emphasized, are for comparative purposes only, and are not intended to be representative of the accuracy implied by the practice of reporting results to one decimal place. This was done primarily for convenience of calculations and balancing. No attempt was made to compare these changes with contributions from its surrounding, or parent watershed areas, which would significantly negate apparent changes caused by the land use change within the project site.

As can be observed in Table 3 there is actually a calculated decrease in storm water runoff for the specific storm events being considered. Such a situation is unusual for developments in relatively undeveloped areas. However, in this situation the SCC Curve numbers for golf courses are nearly the same as the existing land use vegetative cover, and even though that approximately 8 acres of paved areas are developed there are also about 7 acres of ponds being added within the golf course area. The area of the ponds per se would not result in runoff as long as the banks are high enough to contain the rainfall. Consequently, as a general statement the proposed development would not be expected to significantly alter the quantity of storm water runoff within the project area.

These runoff values (acre-ft/event) represent a volume of water and should not be confused with peak discharge rates which represent the maximum volume of storm water runoff discharge per unit of time (e.g., cfs). Peak discharge rates are required for engineering design of proposed drainage facilities and ascertaining the capacity of existing facilities, while total

TABLE 3

Estimated Storm Water Runoff and Constituent Changes due to the Proposed Waikane Golf Course, Waikane, Koolaupoko, Oahu, Hawaii

Storm[a]			Storm Water Runoff											
Dur-ation	Recur-rence Interval	Quantity	Hydraulic			Nitrogen[b]			Phosphorus[c]			Suspended Solids[d]		
			Development 1988	Development Full	Δ	Development 1988	Development Full	Δ	Development 1988	Development Full	Δ	Development 1988	Development Full	Δ
hr	yr	in.	AF/event	AF/event	AF/event	lb/event	lb/event	lb/event	lb/event	lb/event	lb/event	ton/event	ton/event	ton/event
1	2	1.5	0.4	0.2	- 0.2	0.6	0.7	+ 0.1	0.1	0.3	+ 0.2	0.35	0.07	- 0.28
1	10	2.3	2.9	2.3	- 0.6	4.7	7.5	+ 2.8	0.5	3.6	+ 3.1	2.56	0.78	- 1.78
1	50	3.2	7.8	6.7	- 1.1	12.7	21.9	+ 9.2	1.3	10.4	+ 9.1	6.89	2.28	- 4.61
1	100	3.9	12.5	11.2	- 1.3	20.4	36.6	+ 16.2	2.0	17.4	+ 15.4	11.05	3.81	- 7.24
24	2	6.2	32.3	29.9	- 2.4	52.7	97.6	+ 44.9	5.3	46.4	+ 41.1	28.55	10.17	- 18.38
24	10	10.7	79.7	76.1	- 3.6	130.1	248.4	+ 118.3	13.0	118.0	+ 105.0	70.45	25.87	- 44.58
24	50	14.3	121.4	117.1	- 4.3	198.1	382.2	+ 184.1	19.8	181.6	+ 161.8	107.32	39.81	- 67.51
24	100	16.4	146.5	141.9	- 4.6	239.1	463.2	+ 224.1	23.9	220.0	+ 196.1	129.51	48.25	- 81.26

a) From "Rainfall Frequency for Oahu," (Giambelluca, et. al., 1984)

b) Based on a nitrogen value of 0.60 mg/L for 1988 conditions, and 1.20 mg/L for full development.

c) Based on a phosphorus value of 0.06 mg/L for 1988 conditions and 0.57 mg/L for full development.

d) Based on a suspended solids value of 650 mg/L for 1988 conditions and 250 mg/L for full development.

runoff volume provides a more realistic estimate of impact on water quality. Calculated peak discharge rates and the resulting flooded area for the streams or drainage courses within the project boundaries are usually determined from the City and County of Honolulu's Drainage Standards procedure (City and County of Honolulu, 1986).

Quality

Besides the changes in volume of storm water runoff, the quality of the various constituents being transported is of equal, if not of more importance. However, estimates of water quality constituents resulting from significant storm water runoff that occurs at the most, only a few times a year, is very perplexing, especially since information on this subject essentially only became available at both the local and national level in the 1970's.

The summation of nitrogen, phosphorus, and suspended solids loads from both present (1988) and projected (full) development conditions for storms of 1- and 24-hr duration at recurrent intervals of 2-, 10-, 50-, and 100-years are shown in Table 3. The incremental changes per storm event for the present and projected development conditions for the various duration and recurrence interval storms indicate that from the least to the greatest amount of rainfall: nitrogen and phosphorus increases, while suspended solids decreases for all storm events. It should be noted though that nitrogen and phosphorus are expressed in lb/event, in comparison to ton/event for suspended solids. The interspersion of the developed areas among undeveloped areas should tend to notably decrease the actual calculated constituent loads flowing from the property.

The ecology of the wetland plants in the 25.8 acres of designated wetlands (Department of the Army, 1988), generally makai and downstream of the proposed project, that are within the property boundaries, are not expected to be affected by the increased incremental nitrogen and phosphorus loads. Rather it is generally agreed that water depth is the major factor in governing the distribution of wetland plants and that sedimentation is closely related (Smith, 1978). The expected decrease in sedimentation as a result of the proposed project should tend to enhance the preservation of the wetlands. As previously mentioned the potential changes in the quantity and quality of storm water runoff in relation to the receiving water (ultimately Kaneohe Bay) will be addressed in a separate companion report.

The hydrologic and water quality aspects of the surface water runoff were only considered for the present and projected full developed conditions. However, increases in constituent loads could result from construction activities, especially if a significant storm occurs during the interim period between earth moving operations or exposed soil conditions and soil stabilization completion. The impact of construction activities can be minimized by adhering to strict erosion control measures, as outlined in the City and County of Honolulu (1981) ordinance relation to grading, grubbing, and stockpiling.

Other water quality constituents of general concern include biocides and heavy metals. Typically, the biocides in general use tend to breakdown more readily in comparison to the more long lasting types of a few years ago; consequently, except for runoff from agricultural land operations, the types and concentrations are usually considered insignificant. The use of biocides in golf course operations will be discussed in a separate companion report.

Heavy metals, on the other hand, do apparently increase somewhat as a result of urbanization; however, their output from golf course operations are not well defined. Nevertheless, it is presumed that the output of heavy metals in storm water runoff from golf course operations is less than from a residential area. The possible long-term effect, if any, that the apparent slightly increased heavy metals have upon the biological life of the receiving waters (Kaneohe Bay and the project's tributary streams) at the concentrations and especially at the very low loading rates expected is not presently well defined.

On a comparison basis; however; although it is not directly applicable for storm water runoff, only lead and iron (by a slight margin), according to the values in Table 2, actually exceed the primary (Department of Health, 1981) and secondary (U.S. Environmental Protection Agency, 1979) Drinking Water Standards, respectively. Inasmuch as essentially all new automobiles have switched over to unleaded gasolines since the mid-1970's it would be expected that the concentration of lead in storm water runoff would be steadly decreasing. Additionally, it is presumed that, in general, there would be far less automotive traffic per unit area in golf course operations than in a residential area. The concern with iron concentrations in drinking water is due to its potential for staining fixtures and producing taste in drinking water. Many soils in Hawaii have a high iron content, and iron may be included with fertilizers, depending on its preceived need.

SUMMARY AND CONCLUSIONS

The proposed Waikane Golf Course Development, located in Waikane Valley in the northern portion of Kaneohe Bay drainage basin, consists of the development of 155 acres that includes three 9 hole golf courses, a country club, driving range, and necessary appurtenances. The golf course greens and fairways are intermingled within the undeveloped areas. The developed portion of proposed project ranges in elevation from approximately 25 ft to nearly 245 ft. The project is about equally divided between the 1800 acre Waikane Watershed, which extends to the crest of the Koolau Range, and the 660 acre unnamed ditch drainage area that is positioned on the Kaneohe side of Waikane Watershed. Both Waikane stream and the unnamed ditch flow through the proposed developed area. The median annual rainfall over the project site ranges from nearly 65 in. to approximately 79 in. at the mauka end of the proposed development.

Two soil series, Waikane and Hanalei, (119 acres and 36 acres, respectively) cover the entire proposed project site, The existing vegetation of the development area is best described as herbaceous, with a mixture of grass, weeds, low lying brush, intermingled with some trees. Existing vegetation coverage, quite heavy in some locations, averages greater than 90% over the developed area. A total of 25.8 acres of designated wetlands, within the over 500 acres of project property, are located generally makai and downstream of the proposal project site. Less than 6 acres of the golf course lie within the 100 yr flood plain.

The purpose of this study is to evaluate the environmental impact of the proposed 155 acre golf course development as it relates to surface water runoff. To this end the study indentified changes in total volume, as well as sediment and nutrient loads, and what these potential changes are expected to have on the ecosystem of the natural resource serving as the sink, which in this situation is Kaneohe Bay. However, for the present study the anticipated affects that changes in storm water runoff quantity and quality, including golf course maintenance biocide applications, may have on Kaneohe Bay will be addressed in separate companion reports. The study does not directly relate itself to peak discharge rates resulting from storms, which are required for designing adequate drainage structures to prevent flooding and other excess storm water runoff related aspects.

The methodology utilized in the evaluation of the environmental impact of storm water runoff from the project site consisted of the incorporation of methods developed by the Hawaii Environmental Simulation Laboratory of the University of Hawaii and the U.S. Soil Conservation Service, soil maps, a rainfall frequency atlas and derived storm water quality constituent values. The rainfall recurrence interval storms chosen for evaluation purposes were 2-, 10-, 50-, and 100-yr, with 1-, and 24-hr durations.

The results of the storm water runoff volume calculations indicate that the golf course development should not increase the total volume of runoff, in fact the calculations show a slight decrease. The reason for this is that the U.S. Soil Conservation Services curve numbers for the existing vegetation and the proposed golf course are nearly the same.

Besides the changes in the volume of storm water runoff, the quality of the various constituents being transported is of equal, if not of more importance. The incremental load changes per storm event for the present (1988) and full developed project conditions for the various duration and recurrence interval storms indicate that from the least to the greatest amount of rainfall: nitrogen and phosphorus loads increase, while suspended solids loads decrease. An increase of nitrogen and phosphorus is expected to have little effect on wetland plant species distribution; however, water depth is generally agreed to be a major factor in governing the distribution of wetland plants and sedimentation is closely related. Thus, the indicated decrease in sediment load after full development conditions are achieved should tend to enhance the wetland areas.

The foregoing hydrologic and water quality aspects were only considered for the present and projected full developed conditions. However, increases in constituent loads could result from construction activities, especially if a significant storm occurs during the interim period between exposed and stabilized soil conditions. Thus, to limit these potential increases it is imperative that strict erosion control measures be adhered to.

Other water quality constituents of general concern include biocides and heavy metals. Typically, the biocides in general use tend to breakdown more readily in comparison to the more long lasting types in past years; consequently, except for runoff from agricultural land operations the types and concentrations are usually considered insignificant.

Heavy metals, on the other hand, do apparently increase somewhat as a result of urbanization, however, their output from golf course operations are not well defined, but the heavy metal output in storm water runoff from golf courses would be expected to be less than from residential areas. Nevertheless, for a comparison basis only lead and iron (by slight margin) are actually reported to exceed the primary and secondary drinking water standards, respectively. With essentially all new automobiles switching over to unleaded gasolines since the mid-1970's the concentration of lead would be expected to decrease with time. The concern with iron concentrations in drinking water is due to its potential for staining fixtures and producing tastes.

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APPENDIX H
Soil Erosion Report

SOIL EROSION REPORT
FOR THE
PROPOSED WAIKANE GOLF COURSE PROJECT
WAIKANE, KOOLAUPOKO, OAHU, HAWAII

Prepared for:

Waikane Development Company
Honolulu, Hawaii

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October 1988

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FIGURES

INTRODUCTION

The proposed golf course complex is located in Waikane Valley, Koolaupoko District, Oahu, Hawaii. The project site occupies over 500 acres and lies approximately 3.5 miles north of Kahaluu (see Figure 1). It is bordered on the north by the Puu Ohulehule-Puu Pueo Ridge, on the south by a low ridge of the Waiahole Agricultural Park, on the east by Kamehameha Highway, with its western (mauka) boundary cutting the 200- to 250-foot contours.

This report will assess the soil erosion potential at the project site before and after development of the proposed golf course. The short-term impacts of soil erosion during construction will also be addressed, along with methods to mitigate the potential impacts.

PROJECT BACKGROUND

Proposed Project

The proposed Waikane Golf Course will consist of a 27-hole golf course, a driving range, maintenance building, and a clubhouse. Several small ponds and landscaping features will be included to function as water storage and/or storm runoff abatement facilities.

The golf course will be positioned within the southern portion of the property and west of the wetlands fronting Kamehameha Highway.

The clubhouse will be situated in the central portion of the golf course at the 135- to 150-foot elevation, with the driving range situated west (mauka) of the clubhouse complex.

The maintenance building will be located in the lower portion of the golf course (50- to 60-foot elevation), west (mauka) of the wetlands.

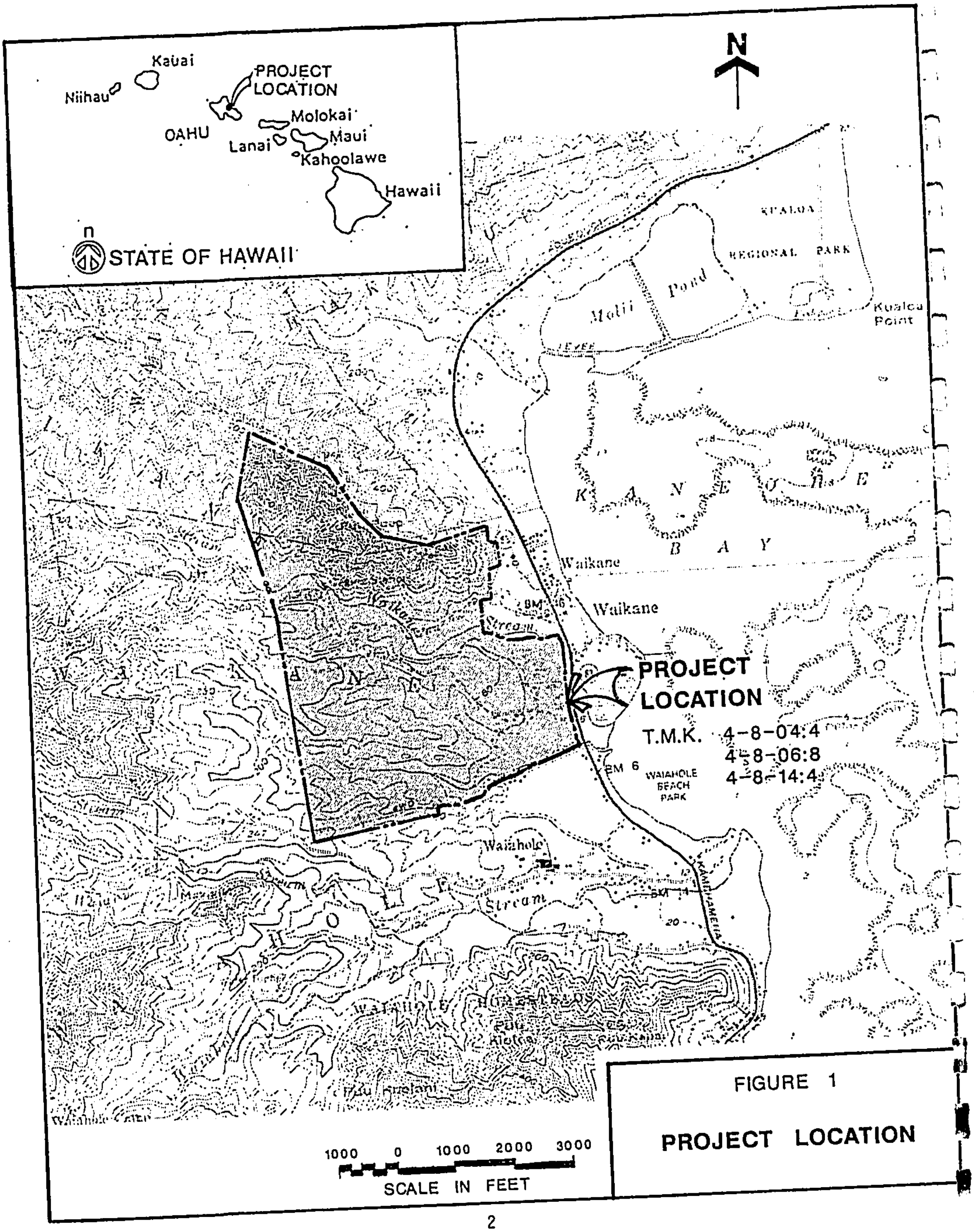

FIGURE 1

PROJECT LOCATION

Topographic Features

The elevation of the project site ranges from about 10 feet above mean sea level fronting Kamehameha Highway to 250 feet in the western portion. The terrain is extremely hilly along the northern boundary, with slopes in excess of 30 percent over most of the area.

A swamplike low area, classified as "wetlands" by the U.S. Army Corps of Engineers, is situated on the eastern portion of the property.

Waikane Stream traverses the property and discharges into Kaneohe Bay. Waikane Stream has a drainage basin of 1,800 acres and a perennial mean discharge of 8.3 cfs (measured by a gauge station at the 75-foot elevation).

The southern portion of the site has numerous ridges and relatively small plateaus.

Climate

The median annual rainfall ranges from 65 inches in the lower edges of the property to 79 inches in the western (mauka) boundary. Rainfall increases to approximately 200 inches at the head of the Waikane watershed, the crest of the Koolau Range. Seasonal variation in rainfall is typified by the wet winter months and the generally dry summer months.

The temperature is generally mild and uniform. Data indicate that February is normally the coolest month, with a mean annual temperature of 68 degrees F, while September is generally the hottest month, averaging 80 degrees F.

The prevailing north-northeast tradewinds generally make for a comfortable environment, even during periods of high relative humidity.

Land Use and Zoning Designation

The majority of the property is presently designated Agricultural by the State Land Use Commission. A small portion of the property (Tax Map Key:4-8-14:4) is designated Conservation. All of the proposed activities will take place within the lands designated Agricultural.

The majority of the land is zoned Ag-2, with a smaller portion (Tax Map Key:4-8-14:4) zoned Preservation (P-1).

SITE CHARACTERISTICS

The project site is divided into four subareas for the purpose of calculating soil erosion potential (see Figure 2). These subareas represent sites within the project that vary in soil erosion potential characteristics such as terrain and/or drainage network.

Subarea A, part of the unnamed stream drainage basin, is located on the southern side of the project site. The subarea occupies 215 acres and is bounded on the south, east, and west by the project limits and on the north by Waikane Valley Road. Approximately two-thirds of subarea A will be graded for golf course development. The subarea is currently a medium-stocked woodland area with plateaus bordered by steep gullies. An unnamed stream runs through the subarea to Waikane Stream and Kaneohe Bay.

Subarea B is located in the central plateau area on the east (makai) side of the site. Approximately 55 acres are located in this subarea, which is bordered on the south by Waikane Valley Road, on the east by the project limits (Kamehameha Highway), and on the north by Waikane Stream. The subarea is characterized by abandoned farm land on the mauka side and wetlands adjacent to Waikane Stream on the makai side toward Kamehameha Highway. The mauka half of subarea B (about 50 percent) will be graded for golf course development.

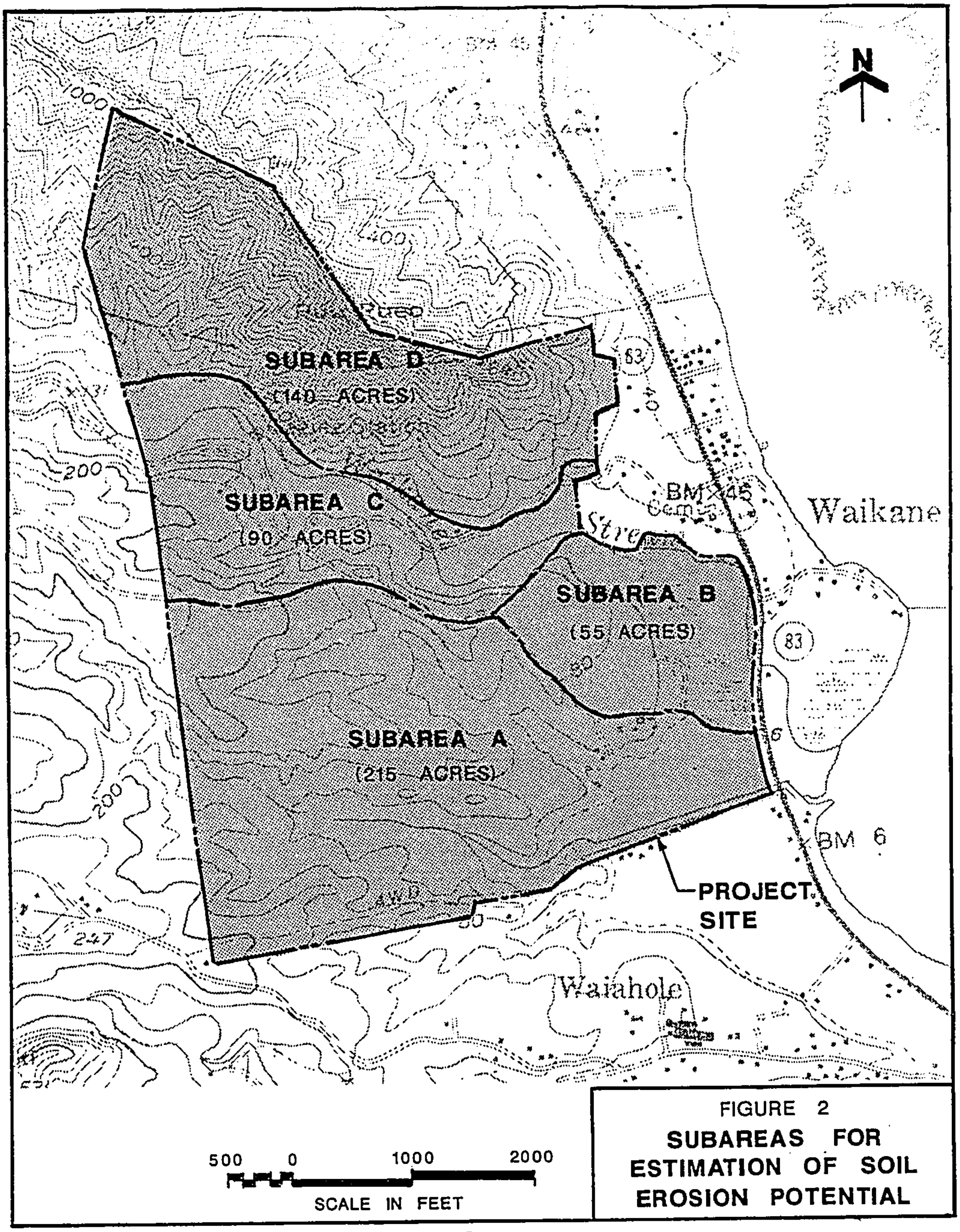

FIGURE 2
SUBAREAS FOR ESTIMATION OF SOIL EROSION POTENTIAL

Subarea C is located in Waikane Stream Valley and is bounded on the south by Waikane Valley road, on the east and west by the project limits, and on the north by Waikane Stream. The terrain and vegetation are similar to subarea A, and approximately two-thirds will be graded for golf course development.

Subarea D, located in the Waikane Stream Drainage Basin, is bounded on the north, east, and west by the project limits and on the south by Waikane Stream Valley. This subarea is a well-stocked woodland with eroded slopes ranging from 40 to 70 percent. Golf course development is not planned for this subarea.

CALCULATION OF SOIL EROSION POTENTIAL

The U.S. Department of Agriculture, Soil Conservation Service, uses the Universal Soil Loss Equation (USLE) to estimate long-term average annual soil losses from sheet and rill erosion. It is used to estimate erosion on forest land, farm fields, construction/development sites, and other areas. Soil losses can be estimated for present conditions or for a future condition. The soil loss equation is--

$$A = RKLSCP$$

where:
- A = soil loss (tons per acre per year)
- R = rainfall factor
- K = soil erodibility factor
- L = slope length factor
- S = slope gradient factor
- C = cover and management factor
- P = erosion control practice factor

Based on the U.S. Soil Conservation Service (SCS) Erosion and Sediment Control Guide for Hawaii, the rainfall factor (R) is 450. A soil erodibility factor (K) was selected for each subarea after evaluating the U.S. Department of Agriculture Soil Survey and the City and County of Honolulu Soil Erosion Standards and Guidelines. The K values for the site are based on a weighted average of all K values for soil types in each subarea. The cover and management factor (C) is also based on a weighted average for C values within each subarea and will be recalculated accordingly after development of the golf course. Both R and K factors will remain the same for the site before and after the proposed golf course is constructed.

The slope length factor (L) and slope gradient factor (S) are combined into an LS factor for calculations. This factor also remains constant before and after development. However, each subarea will have different factors to reflect the differences in topography.

EXISTING SOIL EROSION POTENTIAL

The existing soil erosion potential for the site can be estimated by the USLE using the following parameters:

USLE Parameters	Subarea A	Subarea B	Subarea C	Subarea D
R	450	450	450	450
K	0.17	0.16	0.17	0.15
LS	1.8	1.3	5.2	97
C	0.0279	0.011	0.03	0.011
P	1	1	1	1

The existing soil erosion potential for each subarea is listed below.

Existing Soil Erosion Potential

Subarea	Acres	Tons/Acre/Yr	Tons/Yr
A	215	3.8	826
B	55	1.0	57
C	90	11.9	1,074
D	140	72	10,083

Thus, for the entire project, the existing erosion potential is 12,040 tons/year.

SOIL EROSION POTENTIAL AFTER DEVELOPMENT

The long-term change in soil erosion potential can be estimated by the USLE for the new land use at the site. Appropriate USLE factors for the site after golf course development are--

USLE Parameters	Subarea A	B	C	D
R	450	450	450	450
K	0.17	0.16	0.17	0.15
LS	1.8	1.3	5.2	97
C	0.0124	0.0105	0.015	0.011
P	1	1	1	1

The C factor for subareas A, B, and C have decreased to account for golf course development. Subarea D will not be developed and the C factor remains the same.

The estimated soil erosion potential after development is listed below.

		Estimated Soil Erosion Potential	
Subarea	Acres	Tons/Acre/Yr	Tons/Yr
A	215	1.7	367
B	55	1.0	57
C	90	6.0	537
D	140	72	10,083

Thus, for the entire project, the estimated soil erosion potential after development of the golf course is 11,044 tons/year.

IMPACTS AND MITIGATION

Long-Term Impacts

Based on the USLE, soil erosion potential at the project site should decrease after development of the golf course. The erosion potential of subarea A is estimated to decrease by 2.1 tons/acre/year (459 tons/year), or 56 percent. Thus, sediment transport to the unnamed stream should decrease after development. The erosion potential in subarea B should remain the same. Thus, sediment transport to the wetland area should remain the same. A decreased erosion potential of 5.9 tons/acre/year (537 tons/year), or 50 percent, is expected in subarea C. The erosion potential of subarea D should remain the same since development is not planned for the area. Sediment transport to Waikane Stream should decrease by 5.9 tons/acre/year (537 tons/year), or 4.8 percent.

Short-Term Impacts and Mitigation

Construction of the golf course will involve land disturbing activities that result in soil erosion. These land disturbing activities include removal of existing vegetation (clearing and grubbing) and leveling, removing, and replacing soil. Short-term impacts due to construction are estimated to last one year.

The USLE can be used to estimate soil erosion potential based on these short-term construction impacts. For purposes of calculation, it is assumed that the areas will be exposed for a period of one year (January through December) progressing from subarea A to B and finally C. The rainfall factor, R, is revised to represent the fraction of annual rainfall falling within the grading period for each subarea. The CP factor is 1.0 for bare soil without mitigation measures.

Thus, in the short term, 9,489 tons of soil erosion are calculated for a one-year grading period. Of this amount, approximately 78 percent (7,384 tons) will impact the unnamed stream from subarea A; less than 1 percent (17 tons) will impact the wetlands from subarea B; and 22 percent (2,088 tons) will impact Waikane Stream from subarea C.

Mitigation measures can be implemented to reduce short-term soil erosion. For example, limiting grading to not more than 15 consecutive acres at a time and installation of a sedimentation basin at least 12,000 square feet in size at the onset of grading will reduce estimated soil erosion potential for the site by 58 percent to 3,985 tons. Thus, the estimated impact on the unnamed stream is reduced by 35 tons/acre/year (3,101 tons); the estimated impact on the wetlands is reduced to 2 tons/acre/year (7 tons); and the estimated impact on Waikane Stream is reduced to 58 tons/acre/year (877 tons).

Additional erosion control measures could be taken to lessen construction impacts even further. These are--

1. Minimize time of construction.

2. Retain existing ground cover until latest date before construction.

3. Early construction of drainage control features.

4. Use of temporary area sprinklers in nonactive construction areas when ground cover is removed.

5. Station water truck on site during construction period to provide for immediate sprinkling, as needed, in active construction zones (weekends and holidays included).

6. Use temporary berms and cut-off ditches, where needed, for control of erosion.

7. Thorough watering of graded areas after construction activity has ceased for the day and on weekends.

8. Sod or plant all cut and fill slopes immediately after grading work has been completed.

APPENDIX I
Traffic Impact Assessment

WAIKANE GOLF COURSE

TRAFFIC IMPACT ASSESSMENT REPORT

FEBRUARY 1988

PACIFIC PLANNING & ENGINEERING, INC.

TRAFFIC IMPACT ASSESSMENT REPORT

FOR THE PROPOSED WAIKANE GOLF COURSE

Waikane, Koolaupoko, Oahu, Hawaii
TMK: 4-8-04: 4, 4-8-06: 8 and 4-8-14: 4

February 1988

Prepared for:

Engineering Concepts, Inc.

Prepared by:

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INTRODUCTION

Pacific Planning & Engineering, Inc. (PPE) was engaged to undertake a study to identify and assess future traffic impacts caused by the proposed Waikane Golf Course. This report presents the findings and recommendations of the traffic study.

The organization of this study includes a description of the proposed project, existing roadways, traffic conditions, methodology used in developing trip generation and an assessment of traffic impacts resulting from the project.

Project Description

The Pan Pacific Development Company is proposing to develop a twenty-seven hole championship golf course in Waikane, Koolaupoko, Oahu, Hawaii. Figure 1 shows the general project location. The project site is located on 290 acres of agricultural zoned land identified by Tax Map Key: 4-8-04: 4, 4-8-06: 8 and 4-8-14: 4.

The proposed development consists of a 27 hole golf course, a driving range with 10 stalls, a club house containing a restaurant with 150 seating capacity, and tennis courts. Figure 1 shows the proposed golf course site plan. Waikane Golf Course is planned to be a semi-private golf course that will be open to the public. Priority for the use of the facilities will be for private members and the general public will be allowed to play on a space available basis. The entire development is expected to be completed in 1991.

This traffic study report identifies and evaluates the probable impact of the forecasted traffic generated by the proposed golf course. The analysis primarily focuses on the traffic impact at the intersection of Kamehameha Highway and the proposed golf course entry road. The study describes the impacts during the afternoon peak hour when traffic from the proposed project is expected to have the most effect on the intersection of Kamehameha Highway and the entry road.

A review of State Department of Transportation (DOT) traffic count data for station C-29-B along Kamehameha Highway near the old Kualoa Sugar Mill indicated that the afternoon peak hour generally occurs between 3:30 and 4:30 pm, on weekdays and Saturdays. However, the same count station also consistently registers the heaviest

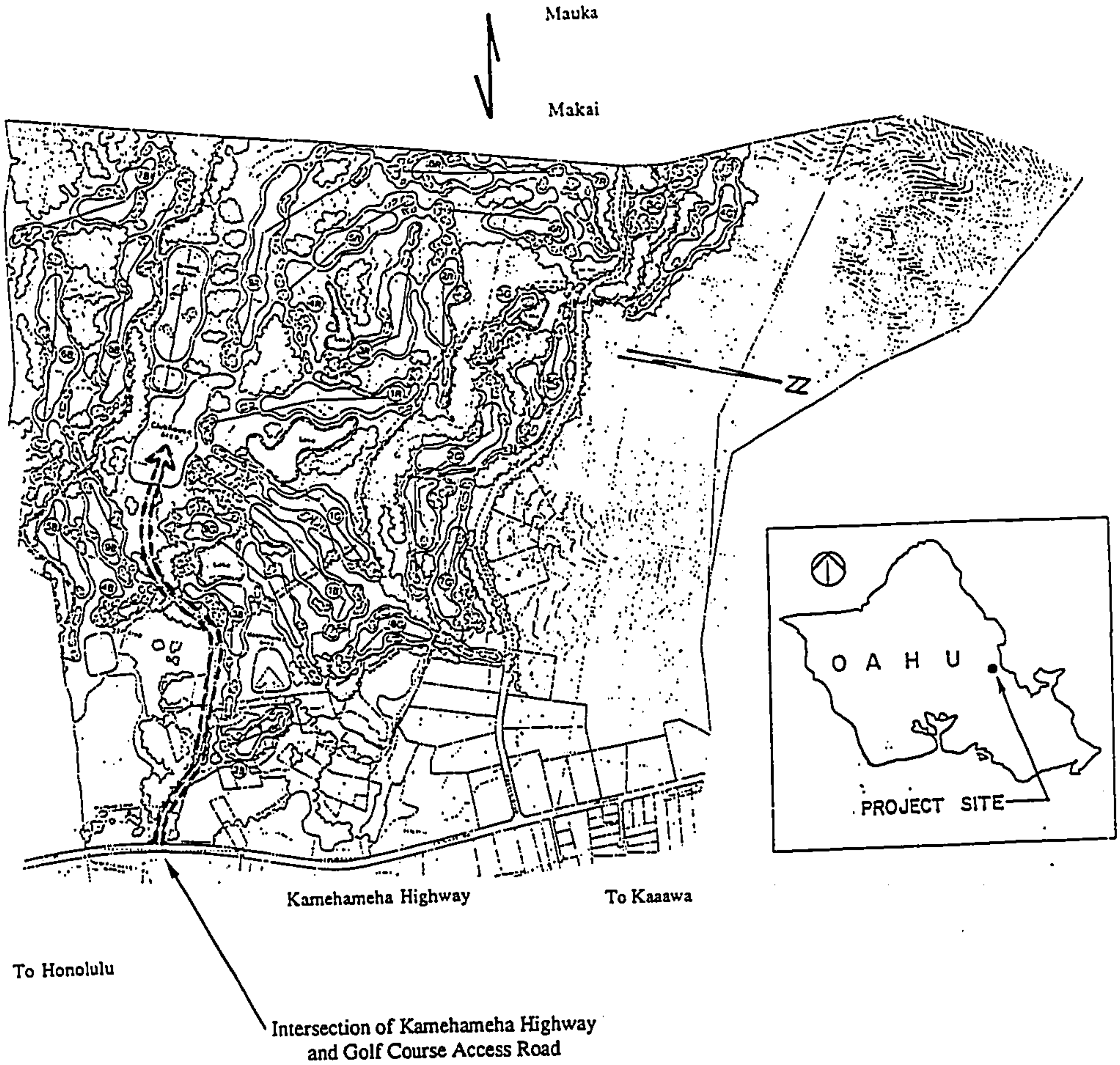


Figure 1. Project Location Map and Site Plan

vehicular traffic on Sundays with the afternoon peak hour occurring between 2:00 and 3:00 pm. Table 1 shows the DOT 24-hour traffic count for the week of February 1 to 7, 1988.

Table 1. Seven Day (Monday to Sunday) 24-Hour Traffic Count
With AM and PM Peak Hour Traffic Volumes Along Kamehameha Highway

	24-Hour Traffic Count	Morning Peak Hour Traffic Vol.				Afternoon Peak Hour Traffic Vol.			
Date	Both Dir.	Time (am)	NB[1]	SB[2]	Total	Time (pm)	NB	SB	Total
Mon (Jan 31-Feb 1)	7864	11:00-12:00	306	343	649	12:00-1:00	410	357	767
Tue (Feb 1-2)	9778	10:45-11:45	263	381	644	3:30-4:30	411	440	851
Wed (Feb 2-3)	9379	11:00-12:00	246	376	622	3:15-4:15	379	413	792
Thu (Feb 3-4)	9646	11:00-12:00	234	347	581	3:45-4:45	406	474	880
Fri (Feb 4-5)	9696	10:00-11:00	297	273	570	3:30-4:30	366	433	799
Sat (Feb 5-6)	10801	10:00-11:00	284	322	606	3:45-4:45	383	495	878
Sun (Feb 6-7)	11828	10:30-11:30	359	430	789	2:00-3:00	471	621	1092

[1]NB - Northbound
[2]SB - Southbound

Appendix C contains the State DOT Highways Division 24-Hour continuous traffic count for the period February 6, 1988, 12:00 midnight to February 7, 1988, 12:00 midnight at Station C-29-B.

EXISTING CONDITIONS

Area Conditions and Roadway System

The proposed project is located on marginal agricultural land surrounded by a largely rural community consisting of residential homes, plant nurseries, banana patches and cattle grazing. There are no urban-type uses existing in the general area, nor any planned for the future. Thus, future traffic on Kamehameha Highway will not be affected by the immediately adjacent land area to the proposed golf course.

Vehicular access to the proposed golf course club house will be from Kamehameha Highway. A paved entry road is planned from the intersection with Kamehameha Highway to the clubhouse and maintenance area.

Roadway Conditions

Kamehameha Highway is a State-maintained highway with a 20-foot wide pavement and 6 foot to 10 foot grassed shoulders. It is the only major road serving the area. The posted speed of Kamehameha Highway is 35 miles per hour (mph) along this section of the highway.

A recent Sunday traffic volume obtained from traffic count station C-29-B registered 1092 cars for two directions between 2:00 to 3:00 peak hour on February 7, 1988.

Observed Traffic Conditions

Traffic counts along Kamehameha Highway were obtained from the State DOT. Additional turning movement counts were taken at the intersections of Kamehameha Highway and the proposed entry road by Pacific Planning and Engineering, Inc., on Sunday, February 14, 1988, between 2:00 and 3:00 pm. Figure 2 shows the traffic counts at the intersection during the peak hour.

Manual traffic count data is shown in Appendix B. Manual counts were taken of passenger cars, trucks, buses, bicycles, motorcycles and pedestrians by turning

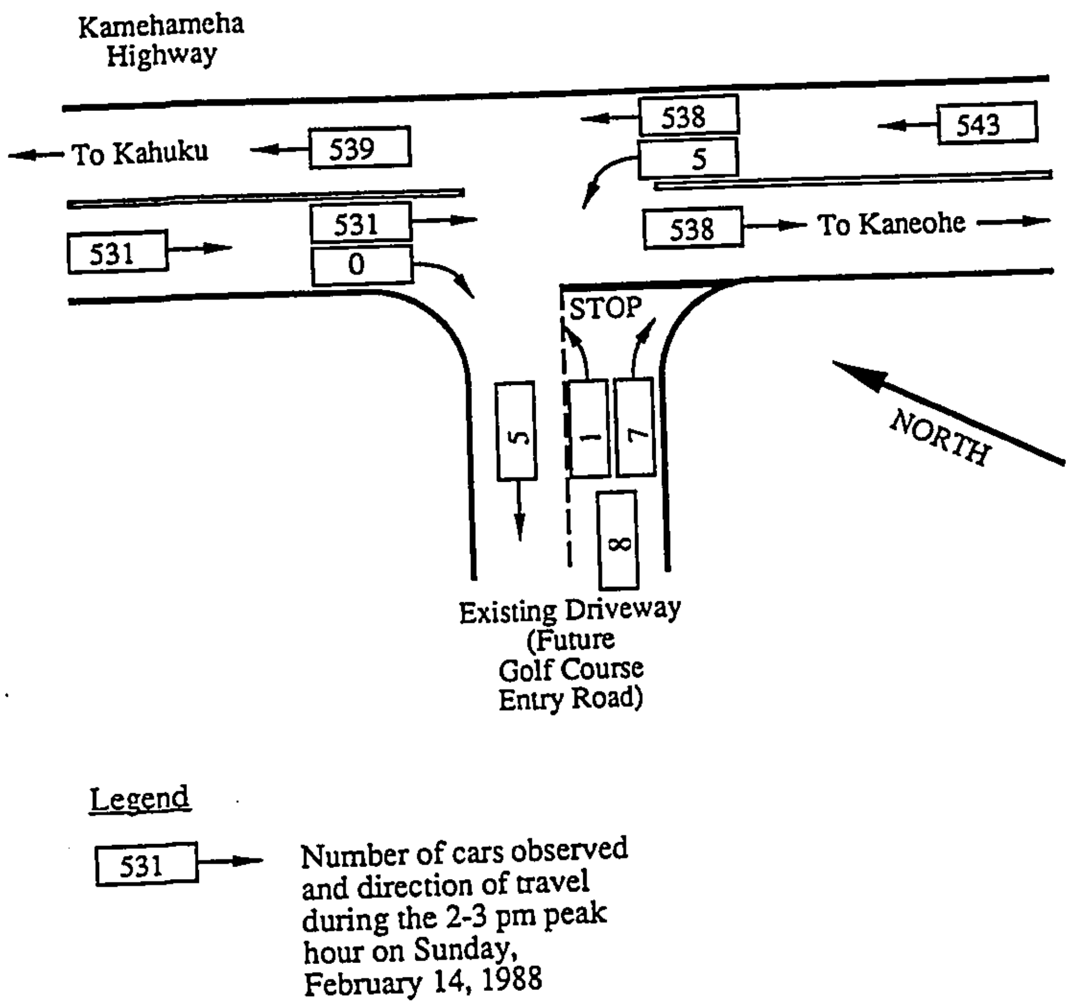


Figure 2. Observed Turning Movements

movements and approaches. During the field counts, the weather was clear and the pavement was dry. The survey was conducted to establish a baseline condition to compare against estimated future traffic.

The peak hour two-way traffic at the intersection of Kamehameha Highway and the proposed golf course entry road registered between 2:00 and 3:00 pm on Sunday, February 14, 1988, was 1082 vehicles. Fifty percent of the vehicles approaching the intersection were travelling southbound towards Kaneohe, with the other 50 percent heading towards Kaaawa. Eight vehicles exited from the existing driveway during the period, and five entered the driveway.

The following observations were noted at the intersection of Kamehameha Highway and the existing driveway during the field survey:

1. Church of the True God sign and six mailboxes were located at the northwest corner of the T-intersection of Kamehameha Highway and the existing unpaved driveway leading to the proposed Golf Course Clubhouse.
2. A 4' x 4' concrete box culvert is located under the Kamehameha Highway, approximately 80' north of the intersection. Also, a half-inch copper waterline was found inside the box culvert crossing under the highway.
3. Occasionally, long lines of vehicles were observed following a slow-moving vehicle or bus.
4. Most of the vehicles observed held picnic equipment, fishing poles, and other recreational equipment, apparently driven by tourist or local residents on Sunday outings.

Traffic Accident Reports

Traffic accident records maintained by the State DOT, Highways Division for the sections along Kamehameha Highway between mileposts 33.5 and 34.5 were reviewed and analyzed. The Purpose of this review is to partially identify any undue hazards along this one mile section of highway. It is not meant as a complete accident investigation report.

During the period 1983 to 1985, there were 23 traffic accidents resulting in four deaths and 13 injuries. Ten of the accidents consisted of moving vehicles collisions. Nine vehicles ran into fixed roadside objects. One accident resulted from a vehicle colliding with a pedestrian. Of the four fatalities, two were a result of a single accident. The thirteen injuries resulted from six accidents.

Level-of-Service Analysis of Existing Traffic

The intersection of Kamehameha Highway and the existing driveway was analyzed to determine its Level-of-Service (LOS) using the field data from the manual traffic count and analysis techniques for unsignalized intersections from the Highway Capacity Manual (HCM) Special Report 209 (1985 Edition). The LOS for the traffic movements in an intersection is classified into six categories ranging from little or no delay (LOS A) to very long traffic delays (LOS F). Appendix A provides the definitions for each LOS category.

At the intersection of Kamehameha Highway and the existing driveway the results of LOS analysis indicated:

1) Little or no delay--(LOS A)--for northbound vehicles turning left from Kamehameha Highway into the driveway,
2) Moderate to long traffic delays--(LOS D)--for vehicles turning left from the driveway onto Kamehameha Highway, and
3) Little or no delay--(LOS A)--for southbound vehicles turning right from the driveway onto Kamehameha Highway.

TRAFFIC IMPACT ANALYSIS

Study Methodology

The focus of the analysis is to determine the impact of the project generated traffic at the intersection of Kamehameha Highway and the proposed entry road, when the golf course is completed in 1991.

Twenty-four hour traffic counts at the DOT traffic count Station C-29-B for the seven day period between February 1 to 7, 1988, were obtained from the State DOT Highways Division. Manual traffic counts were also taken by Pacific Planning & Engineering, Inc., at the intersection of Kamehameha Highway with the proposed golf course entry road.

Future traffic forecasts with and without the project were estimated for 1991 when the golf course is expected to be opened. The Sunday peak hour was used as a basis for forecasting because it represents the worst case condition. The State DOT 24-hour continuous traffic count station near the project site indicates that traffic is heavier on Sunday than on any other weekday, which is the day when the Waikane Golf Course is expected to generate the highest vehicular traffic (however, due to the limitation of tee times, the traffic generated by the golf course will be evenly distributed throughout the day). The estimated traffic impact is calculated by adding the expected golf course traffic to the estimates of future traffic on Kamehameha Highway.

Future Ambient Traffic

Future ambient traffic along Kamehameha Highway was forecasted based on trend analysis, as shown on Figure 3. The analysis used twenty-four-hour traffic count data over the last nine years on Kamehameha Highway near the old Kualoa Sugar Mill (DOT traffic count station C-29-B). This count station was selected because it is the closest station (approximately 3 miles north of the project site) and the most representative of the traffic in the Waiahole-Waikane area.

The results of the trend analysis indicates a 3.25% annual growth in daily traffic on Kamehameha Highway. This method of estimating future traffic based on past trends was deemed adequate for estimating 1991 traffic along Kamehameha Highway because of the short term nature of the forecast, and the lack of any substantive development in the area.

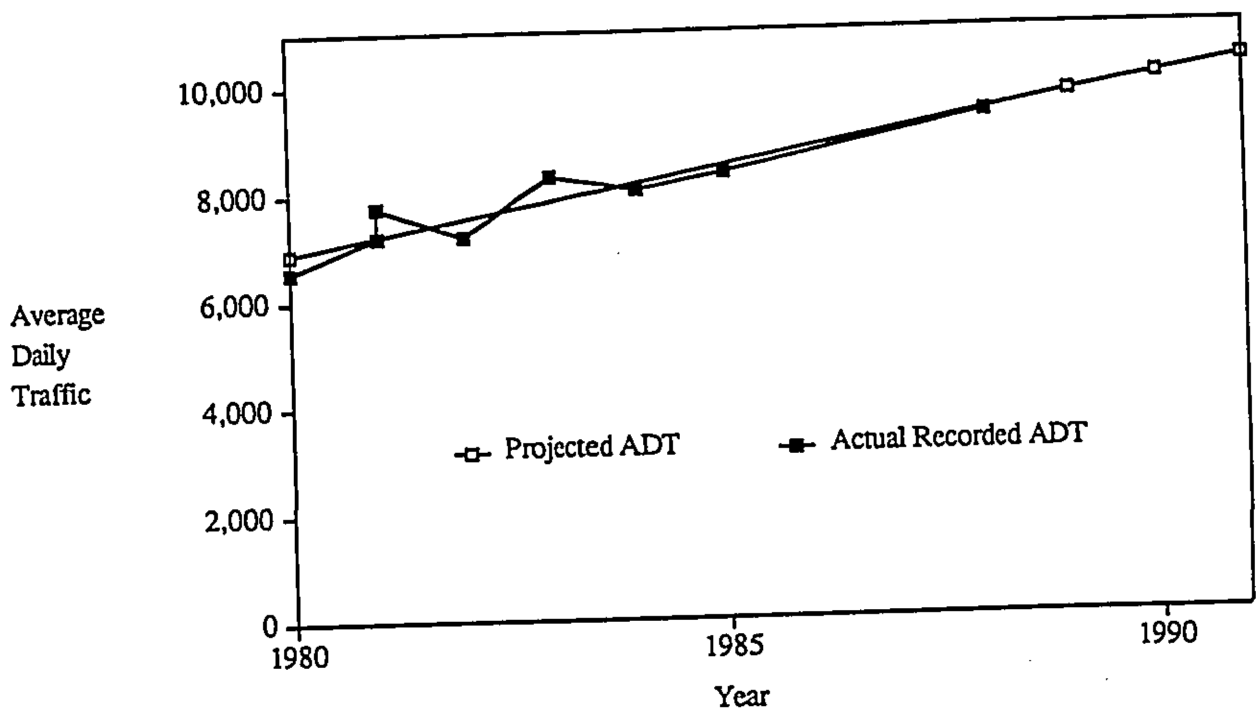


Figure 3. Recorded and Projected Traffic on Kamehameha Highway

Trip Generation, Distribution, and Assignment

One method of determining the number of trips generated by the golf course project is based upon trip rates established in the Institute of Transportation Engineers, "Trip Generation Report" (Third Edition) 1982. These vehicle trip rates are based on average conditions and were reviewed for possible adjustment for local conditions.

The rates are used to calculate vehicles entering and exiting the project during the Sunday afternoon peak hour when ambient traffic counts are the heaviest. Table 2 lists the land uses and trip generation rates, while Table 3 list the number of trips generated by the land use activities.

Table 2. Trip Generation Rates

Land Use	Daily (vpd)[1] Enter & Exit	Sunday Peak Hour (vph)[2] Enter	Exit
Golf Course (290 acres)	5.90/acre	0.07	0.30
Clubhouse (150 seat or 5000 sf)	39.0/1000 sf	6.50	2.60

[1]vehicles per day
[2]vehicles per hour

Table 3. Trip Generation

Land Use	Daily (vpd) Enter & Exit	Sunday Peak Hour (vph) Enter	Exit
Golf Course (290 acres)	1711	20	87
Clubhouse (150 seat or 5000 sf)	195	33	13
Total Trip Ends	1906	53	100

Another method of determining the number of trips generated by the project is based upon actual traffic count data obtained at a similar golf course on Oahu during the Sunday afternoon peak hour between 2:00 and 3:00 pm. Traffic count data was obtained at the Pearl Country Club golf course on Sunday, February 14, 1988, between the hours of 2:00 and 3:00 pm. Thirty-seven vehicles were observed entering with a 1.46 occupancy rate, and 41 vehicles leaving the golf course with a 1.26 occupancy rate.

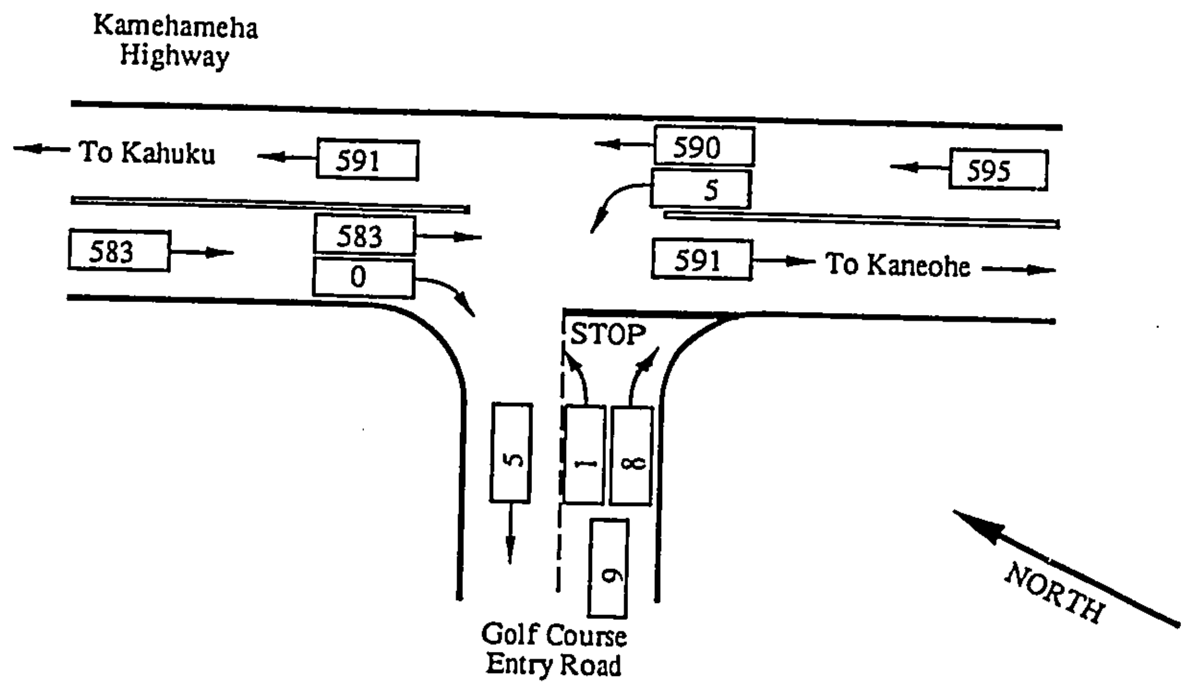
A comparison of the standard ITE rates and the rates observed at the local golf course was then made. The results indicate that actual vehicle trips observed at Pearl County Club Golf Course registered 49% lower than estimates based on ITE trip generation rates. The higher number of trips estimated from the ITE trip generation rates was used for the analysis since this number represents the worst case condition for either entering or exiting the golf course.

It is assumed that the majority of the golfers will be arriving from the Honolulu or Kaneohe direction. Based on that assumption it was estimated that 90% of the golfers will be arriving at the golf course from the South or Kaneohe direction. Thus, traffic generated by the golf course was assigned 10% arriving from the north or Kaaawa direction and 90% arriving from the south or Kaneohe direction. The results of the traffic assignment is given in Tables 4 and 5, and Figure 4. Referring to Figure 4, it can be seen that the largest volume increases are for the northbound left turn into the entry road, and the right turn out of the entry road heading South towards Kaneohe.

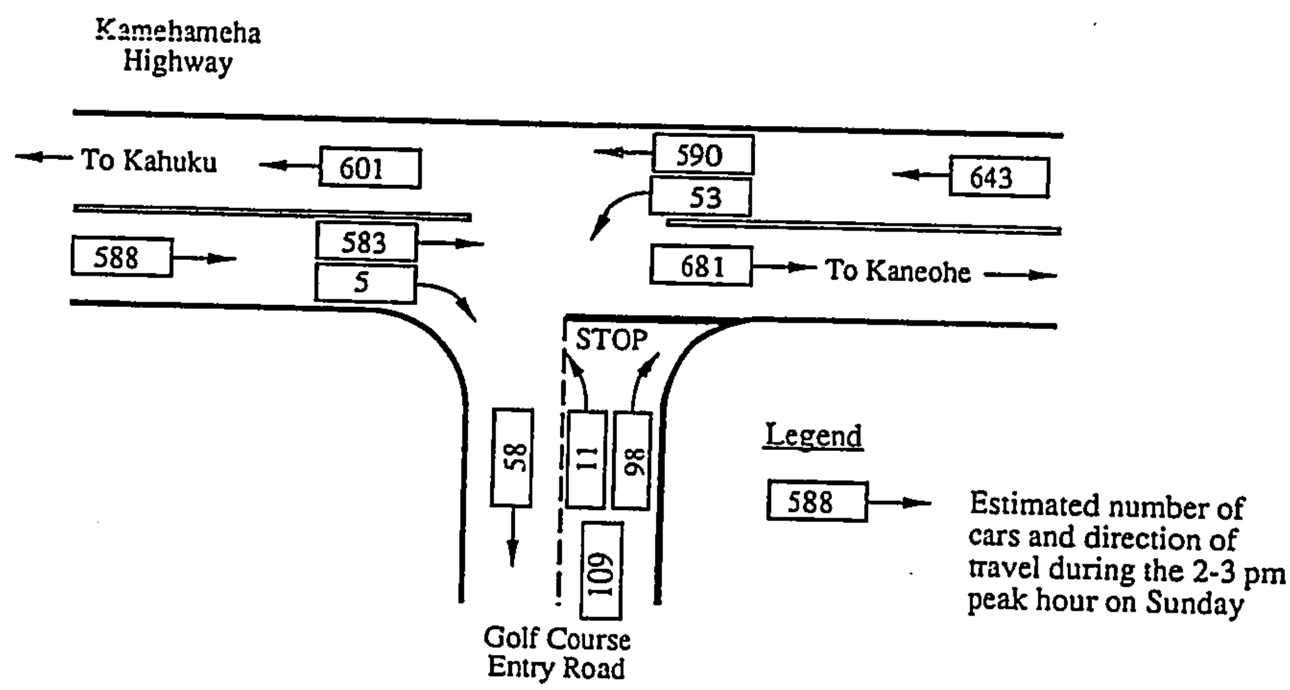
Traffic Impacts

Impacts on traffic resulting from the proposed Waikane Golf Course are measured by the change in Level-of-Service (LOS) at the study intersection with and without the project for the Sunday 2:00-3:00 pm peak hour in the year 1991.

Based on this data, the intersection of Kamehameha Highway and the entry road was analyzed to determine the LOS for unsignalized intersections. The analysis was done in accordance with the latest Highway Capacity Manual analysis techniques (Special Report 209, 1985). The results of the LOS analysis are shown in Table 5.



Future (1991) Traffic Volumes Without Project



Future (1991) Traffic Volumes With Project

Figure 4. Projected 1991 Traffic Without and With Golf Course

The results indicate that traffic along Kamehameha Highway will not need to stop or be delayed beyond normal driving conditions. The left turn volume, while much greater than now existing, will operate at a excellent level of service. The table also indicates that the left turn movement will not be affected. While not a desirable condition, the estimated level "D" delay is acceptable. The left turn movement is currently "D" and will not be worsened by the golf course.

Table 4. Sunday Afternoon Peak Hour Forecast Traffic--Kamehameha Highway @ Golf Course Entry Road

Turning Movement		1988	1991 w/o Golf Course	1991 w/ Golf Course
Kamehameha Highway				
Northbound	TH[1]	538	590	590
	LT[2]	5	5	53
Southbound	TH	531	583	583
	RT[3]	0	0	5
Golf Course Entry Road				
Eastbound	LT	1	1	11
	RT	7	8	98

Table 5. Level-of-Service--Kamehameha Highway @ Golf Course Entry Road

Turning Movement		1988	1991 w/o Golf Course	1991 w/ Golf Course
Kamehameha Highway				
Northbound	LT	A	A	A
Golf Course Entry Road				
Eastbound	LT	D	D	D
	RT	A	A	A

[1]Through Traffic
[2]Left Turn Movement
[3]Right Turn Movement

CONCLUSION AND RECOMMENDATIONS

The proposed Waikane Golf Course project is not expected to have an adverse impact on traffic flow along Kamehameha Highway, with the creation of a left-turn storage lane on Kamehameha Highway. For the Study, traffic analysis was conducted for the intersection of Kamehameha Highway and the Golf Course entry road under the conditions with and without the project.

The results indicate that the intersection will continue to operate under capacity during the Sunday 2:00-3:00 pm peak hour on Kamehameha Highway. Most of the forecast traffic exiting the golf course is projected to turn right onto Kamehameha Highway heading South towards Kaneohe. This turn will have minimal impact on the intersection traffic movements. Due to heavy traffic on Kamehameha Highway travelling in both directions, traffic turning left from the golf course entry road onto Kamehameha Highway will experience medium to long delays. However, the projected "D" level-of-service for this turning movement is acceptable.

We recommend that an exclusive left turn storage lane be constructed along Kamehameha Highway as shown on Figure 5. This change will minimize long delays for Northbound vehicles on Kamehameha Highway and avoid rear end accidents with the vehicles slowing down or stopping to turning left into the golf course entry road.

The majority of the vehicles will be making right turns heading towards Kaneohe instead of the more difficult left-turn crossing two lanes of traffic. The low golf course traffic volumes are deemed insignificant in adding to any undue traffic hazard. The recommended storage lane will significantly improve flow and safety. For drivers exiting from the golf course access road, the sight distances in both directions is excellent for the posted speed of 35 mph along Kamehameha Highway.

The State DOT Highways Division is planning to resurface and incorporate safety improvements such as guardrail modifications at bridge approaches and delineators along the edge of shoulders to improve driving conditions. The Kamehameha Highway improvement project between Waiahole Bridge and Kualoa Old Sugar Mill is scheduled for advertising on march 17, 1988, and construction is expected to be completed by late 1988. Completion of this Kamehameha Highway resurfacing and safety improvement project is expected to improve driving conditions and reduce traffic accidents.

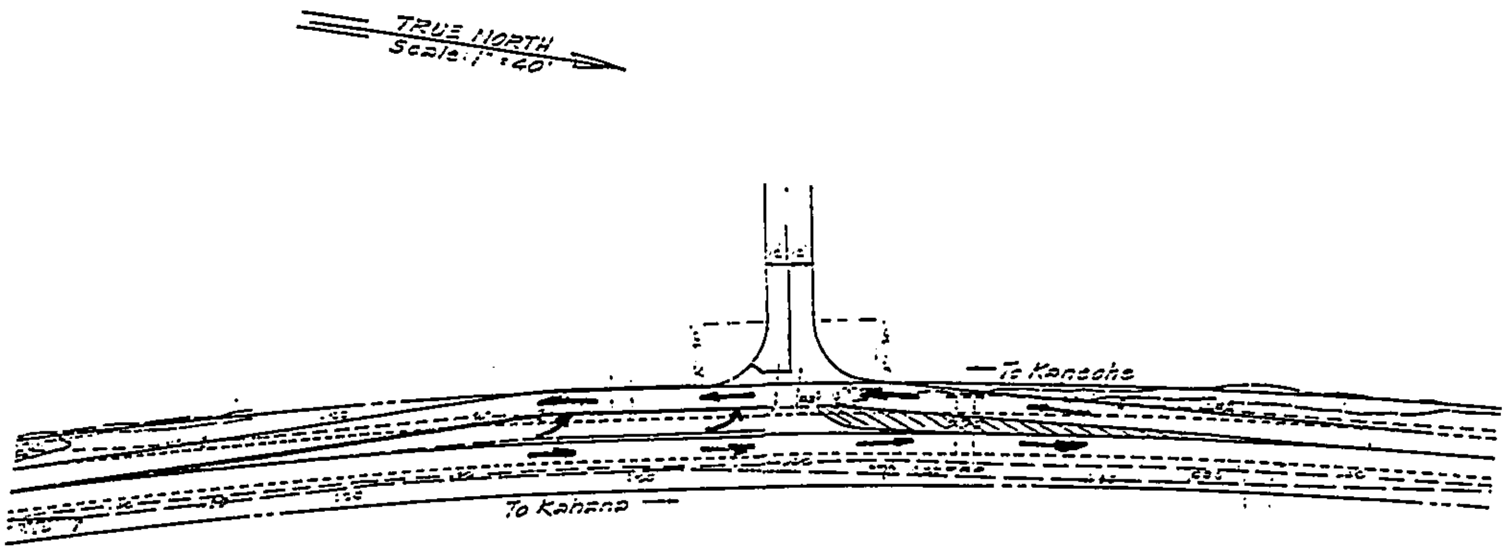


Figure 5. Intersection Modification

APPENDIX A

Definition of Level-of-Service
for
Unsignalized Intersections

APPENDIX A
DEFINITION OF LEVEL-OF-SERVICE

For unsignalized intersections, the traffic most impacted will be the minor or cross-street with the stop or yield control. The major roadway will have the right-of-way. The level-of-service is the amount of delay expected for the average vehicle desiring to cross or enter the major road. The following gives a general description of the measure.

The concept of levels of service is defined as a qualitative measure describing operational conditions within a traffic stream, and their perception by motorists and/or passengers. A level of service definition generally describes these conditions in terms of such factors as speed and travel time, freedom to maneuver, traffic interruptions, comfort and convenience, and safety.

Six levels of service are defined for each type of facility for which analysis procedures are available. They are given letter designations, from A to F, with level-of-service A representing the best operating conditions and level-of-service F the worst.

Level-of-Service definitions--In general, the various levels of service are defined as follows for uninterrupted flow facilities:

Level-of-service A represents free flow. Individual users are virtually unaffected by the presence of others in the traffic stream. Freedom to select desired speeds and to maneuver within the traffic stream is extremely high. The general level of comfort and convenience provided to the motorist, passenger, or pedestrian is excellent.

Level-of-service B is in the range of stable flow, but the presence of other users in the traffic stream begins to be noticeable. Freedom to select desired speeds is relatively unaffected, but there is slight decline in the freedom to maneuver within the traffic stream from LOS A. The level of comfort and convenience provided is somewhat less than at LOS A, because the presence of others in the traffic stream begins to affect individual behavior.

Level-of-service C is in the range of stable flow, but marks the beginning of the range of flow in which the operation of individual users becomes significantly affected by interactions with others in the traffic stream. The selection of speed is now affected by the presence of others, and maneuvering within the traffic stream requires substantial vigilance on the part of the user. The general level of comfort and convenience declines noticeably at this level.

Level-of-service D represents high-density, but stable, flow. Speed and freedom to maneuver are severely restricted, and the driver or pedestrian experiences a generally poor level of comfort and convenience. Small increases in traffic flow will generally cause operational problems at this level.

Level-of-service E represents operating conditions at or near the capacity level. All speeds are reduced to a low, but relatively uniform value. Freedom to maneuver within the traffic stream is extremely difficult, and it is generally accomplished by forcing a vehicle or pedestrian to "give way" to accommodate such maneuver. Comfort and convenience levels are extremely poor, and driver or pedestrian frustration is generally high. Operations at this level are usually unstable, because small increases in flow or minor perturbations within the traffic stream will cause breakdowns.

Level-of-service F is used to define forced or breakdown flow. This condition exists wherever the amount of traffic approaching a point exceeds the amount which can traverse the point. Queues form behind such locations. Operations within the queue are characterized by stop-and-go wave, and they are extremely unstable. Vehicles may progress at reasonable speeds for several hundred feet or more, then be required to stop in a cyclic fashion. Level-of-service F is used to describe the operating conditions within the queue, as well as the point of the breakdown. It should be noted, however, that in many cases operating conditions of the vehicles or pedestrians discharged from the queue may be quite good. Nevertheless, it is the point at which arrival flow exceeds discharge flow which causes the queue to form, and level-of-service F is an appropriate designation for such points.

These definitions are general and conceptual in nature, and they apply primarily to uninterrupted flow. Levels of service for interrupted flow facilities vary widely in terms of both the user's perception of service quality and the operational variables used to describe them.

APPENDIX B

MANUAL TRAFFIC COUNT DATA

APPENDIX B

MANUAL TRAFFIC COUNT DATA

Location: Kamehameha Highway @ Waikane Golf Course Entry Road

Date: February 14, 1988

Time (pm)	Kamehameha Southbound		Kamehameha Northbound		Entry Road. Eastbound		Total All Approaches
	RT	TH	TH	LT	RT	LT	
2:00-2:15	0	126	126	2	1	0	255
2:15-2:30	0	114	169	1	5	1	290
2:30-2:45	0	150	126	1	1	0	278
2:45-3:00	0	141	117	1	0	0	259
Peak Hour Total	0	531	538	5	7	1	1082

Note:

There were a total of 1063 cars, 6 tour buses, 4 City Transit buses, 8 motorcycles, 1 bicycle and no trucks counted during the Sunday 2:00-3:00 pm peak hour on February 14, 1988.

APPENDIX C

24-HOUR TRAFFIC COUNT DATA

SUNDAY

STATION NO.:000029 STATION DESCRIPTION: ,KAMEHAMEHA HWY, KUALOA OLD SUGAR MILL FAP 0083, MP 30.60, OAHU
POLLING DATE (07-FEB-88) POLLING TIME (00:05:00)
CHNA- TO CASTLE JUNCTION * CHNB- TO WEED JUNCTION

TIME-AM	CH-A	CH-B	TOTAL	TIME-AM	CH-A	CH-B	TOTAL	TIME-PM	CH-A	CH-B	TOTAL	TIME-PM	CH-A	CH-B	TOTAL
S 12:00-12:15	7	21	28	6:00- 6:15	34	15	49	12:00-12:15	95	144	239	6:00- 6:15	111	86	197
12:15-12:30	12	26	38	6:15- 6:30	45	29	74	12:15-12:30	80	142	222	6:15- 6:30	82	92	174
12:30-12:45	10	28	38	6:30- 6:45	39	27	66	12:30-12:45	106	156	262	6:30- 6:45	70	69	139
12:45- 1:00	7	19	26	6:45- 7:00	43	22	65	12:45- 1:00	96	152	248	6:45- 7:00	60	70	130
1:00- 1:15	9	15	24	7:00- 7:15	53	26	79	1:00- 1:15	75	145	220	7:00- 7:15	67	78	145
1:15- 1:30	11	11	22	7:15- 7:30	60	49	109	1:15- 1:30	93	154	247	7:15- 7:30	66	61	127
1:30- 1:45	6	15	21	7:30- 7:45	82	28	110	1:30- 1:45	109	125	234	7:30- 7:45	42	55	97
1:45- 2:00	3	6	9	7:45- 8:00	71	30	101	1:45- 2:00	82	138	220	7:45- 8:00	39	35	74
2:00- 2:15	4	13	17	8:00- 8:15	75	33	108	* 2:00- 2:15	114	196	310	8:00- 8:15	27	39	66
2:15- 2:30	4	13	17	8:15- 8:30	69	56	125	* 2:15- 2:30	127	132	259	8:15- 8:30	27	38	65
2:30- 2:45	2	11	13	8:30- 8:45	81	41	122	* 2:30- 2:45	114	127	241	8:30- 8:45	52	41	93
2:45- 3:00	3	7	10	8:45- 9:00	64	54	118	* 2:45- 3:00	116	166	282	8:45- 9:00	35	34	69
3:00- 3:15	3	4	7	9:00- 9:15	90	76	166	3:00- 3:15	106	113	219	9:00- 9:15	39	27	66
3:15- 3:30	4	6	10	9:15- 9:30	88	101	189	3:15- 3:30	115	118	233	9:15- 9:30	192	48	240
3:30- 3:45	2	12	14	9:30- 9:45	97	74	171	3:30- 3:45	127	132	259	9:30- 9:45	59	51	110
3:45- 4:00	7	10	17	9:45-10:00	76	80	156	3:45- 4:00	124	127	251	9:45-10:00	30	39	69
4:00- 4:15	7	7	14	10:00-10:15	101	68	169	4:00- 4:15	133	125	258	10:00-10:15	43	54	97
4:15- 4:30	5	7	12	10:15-10:30	85	98	183	4:15- 4:30	130	113	243	10:15-10:30	27	37	64
4:30- 4:45	9	4	13	*10:30-10:45	91	103	194	4:30- 4:45	129	94	223	10:30-10:45	32	30	62
4:45- 5:00	15	13	28	*10:45-11:00	92	116	208	4:45- 5:00	119	83	202	10:45-11:00	25	45	70
5:00- 5:15	25	3	28	*11:00-11:15	93	79	172	5:00- 5:15	97	93	190	11:00-11:15	25	32	57
5:15- 5:30	26	16	42	*11:15-11:30	83	132	215	5:15- 5:30	106	96	202	11:15-11:30	16	26	42
5:30- 5:45	37	19	56	11:30-11:45	75	98	173	5:30- 5:45	115	82	197	11:30-11:45	13	25	38
5:45- 6:00	27	22	49	11:45-12:00	77	131	208	5:45- 6:00	92	65	157	11:45-12:00	12	24	36

	CH-A	CH-B	TOTAL
AM-TOTAL	2009.	1874.	3883.
6:00-12:00 TOT	1764.	1566.	3330.
AM-PEAK HR TIME	10:30-11:30		
*PEAK-HR TOTAL	359.	430.	789.
AM D-% (PEAK-HR)	45.5	54.5	100.0
AM D-% (MN-12N)	51.7	48.3	100.0
AM K FACTOR			6.7

	CH-A	CH-B	TOTAL
PM-TOTAL	3791.	4154.	7945.
12:00-6:00 TOT	2600.	3018.	5618.
PM-PEAK HR TIME	2:00- 3:00		
*PEAK-HR TOTAL	471.	621.	1092.
PM D-% (PEAK-HR)	43.1	56.9	100.0
PM D-% (12N-MN)	47.7	52.3	100.0
PM K FACTOR			9.2

DIRECTIONAL TOTALS CHAN-A = 5800. CHAN-B = 6028. 24-HOUR TOTAL = 11828.
CH-A D% = 49.0 CH-B D% = 51.0

APPENDIX J
Archaeological Reconnaissance Survey

PAUL H. ROSENDAHL, Ph.D., Inc.
Consulting Archaeologist

Report 398-042188

ARCHAEOLOGICAL RECONNAISSANCE SURVEY AND LIMITED SUBSURFACE TESTING WAIKANE GOLF COURSE PROJECT AREA

Land of Waikane, Koolaupoko District

Island of Oahu

July 1988

305 Mohouli Street • Hilo, Hawaii 96720 • (808) 969-1763 or 966-8038

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ARCHAEOLOGICAL RECONNAISSANCE SURVEY AND LIMITED SUBSURFACE TESTING WAIKANE GOLF COURSE PROJECT AREA

Land of Waikane, Koolaupoko District
Island of Oahu
(TMK:4-8-04:4,5; 4-8-06:8; 4-8-14:4)

by

William A. Shapiro, B.A.
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Prepared for

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924 Bethel Street
Honolulu, Hawaii 96813

July 1988

305 Mohouli Street • Hilo, Hawaii 96720 • (808) 969-1763 or 966-8038

SUMMARY

During the period January 12-April 20, 1988, Paul H. Rosendahl, Ph.D., Inc. (PHRI) conducted an archaeological reconnaissance survey and limited subsurface testing at Waikane Golf Course project area, located in the Land of Waikane, Koolaupoko District, Island of Oahu (TMK:4-8-04:4,5; 4-8-06:8; 4-8-14:4). The survey and testing consisted of variable coverage (partial to 100%), variable intensity (30-90 ft transect intervals) ground surface reconnaissance of approximately 300 acres of the project area to be impacted by development, and limited backhoe trenching in the SMA portion of the project area. Areas excluded from the survey and testing included the wetlands portion of the project area, areas within the immediate vicinity of existing residences, areas under current cultivation, and areas above the 75- to 100-ft elevation contours which will not be affected by development. The objectives of the survey and testing were (a) to identify all sites and site complexes present within the project area, (b) to evaluate the potential significance of all identified archaeological remains, (c) to determine the possible impacts of any proposed development upon the identified remains, and (d) to define the scope of subsequent archaeological work that might be necessary or appropriate.

Twenty-nine archaeological sites (60 component features) were recorded within the project area--one previously identified site and 28 newly identified sites. Formal feature types present in the project area include terraces, mounds, ditches, boulder concentrations, walls, lithic scatters, coral scatters, alignments, burials, pits, a debris scatter, man-made caves, sunken fields, a trail, a midden scatter, a house site, depressions, a possible terrace, and an inclined ramp. Probable functional types include agricultural, boundary, tool manufacture, habitation, transportation, religious (cemetery, burial, shrine, and heiau), and indeterminate. In addition to the recorded archaeological sites, several road cuts were noted and plotted on project maps. Also noted were possible historically/prehistorically used agricultural areas which lacked surface evidence. At one of the lithic sites (T-23), a profile was taken from an eroding cut bank, some soil was collected for a radiocarbon sample, and two adze preforms were collected. Volcanic glass samples were collected from Sites T-9, T-10, T-15, T-18, and T-23.

Of the total 29 sites recorded in the project area, 21 sites are assessed as significant solely for information content. For nine of these 21 sites, no further work is recommended. Further data collection is recommended for 12 of the 21 sites. Of the remaining eight sites: (a) four are assessed as significant for information content, and are tentatively assessed as culturally significant. Further data collection and a tentative recommendation of preservation "as is" are recommended for these four sites; (b) two are assessed as culturally significant and

significant for information content. Further data collection and preservation "as is" are recommended for these two sites; and (c) two sites are assessed as significant for information content, as excellent examples of site types, and as culturally significant. Further data collection and preservation with interpretive development are recommended for these two sites.

CONTENTS

ILLUSTRATIONS

ILLUSTRATIONS (Cont.)

TABLES

INTRODUCTION

BACKGROUND

At the request of Group 70, planning consultant for their client, Mr. Norman Quon, Paul H. Rosendahl, Ph.D., Inc. (PHRI) conducted a combined surface and subsurface reconnaissance survey of the Waikane Golf Course project area, located in the Land of Waikane, Koolaupoko District, Island of Oahu (TMK:4-8-04:4,5; 4-8-06:8; 4-8-14:4). The basic objective of the survey was to provide information appropriate to and sufficient for preparation of (a) an Environmental Impact Statement (EIS)-level planning document, and (b) all relevant city and county and/or state permit applications. The survey consisted of two phases--a surface and subsurface (limited backhoe testing) survey of the non-wetlands portion of the Special Management Area (SMA) (c. 50 acres), and a surface survey of approximately 250 acres (of the total 500 acres comprising the project area) expected to be affected by proposed development. The field work for the SMA portion was conducted January 12-19, 1988, under the supervision of PHRI Supervisory Archaeologist James D. Mayberry, and under the overall direction of PHRI Senior Archaeologist Dr. Alan E. Haun. Approximately 90 man-hours of labor and 12 backhoe trenching hours were expended in conducting the field work. The second phase of the field work (for the 250-acre portion of the project area) was conducted March 23-April 20, 1988, under the supervision of PHRI Supervisory Archaeologist William A. Shapiro, and under the overall direction of PHRI Senior Archaeologist Dr. Alan E. Haun. Approximately 530 man-hours of labor were expended in conducting the phase two field work.

The present document represents the final report on the archaeological reconnaissance and limited subsurface testing of the Waikane Golf Course project area.

SCOPE OF WORK

The goal of a reconnaissance survey is to identify--to discover and locate on available maps--sites and features of potential archaeological significance. A <u>reconnaissance survey</u> is extensive rather than intensive in scope, and is conducted to determine the presence or absence of archaeological resources within a specified project area. A reconnaissance survey indicates both the general nature and variety of archaeological remains present, and the general distribution and density of such remains. A reconnaissance survey permits a general significance assessment of the archaeological resources, and facilitates formulation of realistic recommendations and estimates for such further work as might be necessary or appropriate. Such further work could include <u>intensive survey</u>--detailed recording of sites and features, and selected test excavations, interpretive planning, and/or preservation of sites and features with significant scientific research, interpretive, and/or cultural values.

The specific objectives of the Waikane Golf Course project area reconnaissance survey and limited subsurface testing were (a) to identify (find and locate) all sites and features present within or immediately adjacent to the project area (including previously identified and as yet unidentified sites and features), (b) to evaluate the potential general significance of all identified archaeological remains, (c) to determine the possible impacts of any proposed development upon the identified remains, and (d) to define the scope of any subsequent mitigation work that might be necessary or appropriate.

The reconnaissance survey was carried out in accordance with the minimum requirements for reconnaissance-level survey recommended by the Society for Hawaiian Archaeology (SHA). These standards are currently used by the Department of Land and Natural Resources-Historic Sites Section (DLNR-HSS) as guidelines for the review and evaluation of archaeological reconnaissance survey reports submitted in conjunction with various development permit applications.

Based on a preliminary review of available background literature and records, and on discussions with Mr. Ralph Portmore and Mr. Vincent Shigekuni of Group 70 and Staff Archaeologist Dr. Joyce Bath of the DLNR-HSS, the specific tasks outlined below were determined to constitute an adequate scope of work for the Waikane Golf Course project area:

1. Background Research. To locate and review readily available relevant archaeological and historical literature and documentary resources (books, maps, journals, archival records, and other materials) relating to the project area. In addition, assess the potential for any further more detailed historical research that might be appropriate in connection with any subsequent archaeological work;

2. Archaeological Reconnaissance Survey Field Work. Conduct variable coverage (partial to 100%), variable intensity (30- to 90-ft intervals) ground surface reconnaissance of the approximately 300-acre portion of the project area to be affected by development. In addition, conduct sample coverage, subsurface reconnaissance testing of selected areas within the project area;

3. Data Analysis and Reports. Analyze field data and prepare final reports. Two final reports will be submitted; an SMA Final Report and a Combined Final Report. The SMA Final Report will deal solely with the SMA part of the project area, while the Combined Final Report will deal with the entire project area (including the SMA findings). Each report will include (a) a full description of findings, (b) interpretation and evaluation of findings, and (c) specific recommendations and justifications for any subsequent mitigation work that might be necessary or appropriate;

4. *Coordination and Consultation*. PHRI will keep the client informed of the progress of the various aspects of the project work, and will notify the client of any problems encountered as soon as possible. As part of the reconnaissance survey work, PHRI will maintain close contact with appropriate staff in the City and County of Honolulu-Department of Land Utilization, and the Hawaii State Historic Preservation Office (Department of Land and Natural Resources-Historic Sites Section).

PROJECT AREA DESCRIPTION

The Waikane Golf Course project area consists of c. 500 acres located in the Land of Waikane, Koolaupoko District, Island of Oahu (TMK:4-8-04:4,5; 4-8-06:8; 4-8-14:4) (Figures 1 and 2). The project area is bordered on the north by the steep slopes of Puu Ohulehule-Puu Pueo ridge, on the south by a 4-wheel-drive dirt road paralleling a low ridge, on the east (*makai*) by Kamehameha Highway and a residential area, and on the west (*mauka*) by the 200- to 240-ft contour interval. Waikane Stream flows from west to east through the project area. In addition, two large gulches which had running water during the time of the survey are within the project area.

Nagata has conducted a detailed botanical survey of the project area (Nagata 1988). According to Nagata, vegetation within the project area consists primarily of Java Plum (*Eugenia cuminii* [L.] Druce.), *hau* (*Hibiscus tiliaceus* L.), octopus tree (*Brassaia actinophylla* Endl.), mango (*Mangifera indica* L.), guava (*Psidium guajava* L.), albizzia (*Albizzia falcata* [L.] Fosb.), monkeypod (*Samanea saman* [Jacq] Merr.), rose apple (*Eugenia jambos* L.), Christmas-berry (*Schinus terebinthifolius* Raddi), taro (*Colocasia esculenta* [L.] Schott), banana (*Musa* sp.), papaya (*Carica papaya* L.), *kukui* (*Aleurites moluccana* [L.] Willd.), *koa-haole* (*Leucaena leucocephala* [Lam.] de Wit), ti (*Cordyline terminalis* [L.] Kunth), coconut (*Cocos nucifera* L.), false *kamani* (*Terminalia catappa* L.), Boston Fern (*Nephrolepis exaltata* [L.] Schott), and various grasses.

Ten soil types have been identified in the project area (Foote et al. 1972). The upper slopes of Puu Ohulehule-Puu Pueo ridge consist of rockland. The wetlands in the project area consists of marshland. The southeast corner of the project area consists of Pearl Harbor clay (used for sugar cane, taro, bananas, and pasture). Hanalei silty clay, 0 to 2 percent slopes, is present along Waikane Stream. Hanalei silty clay, 2 to 6 percent slopes, is present along gulches in the project area. Hanalei silty clay is good for cultivating taro and sugar cane, and is also good for pastureland. Waikane silty clay, 3 to 8 percent slopes, is found on flat ridges and residential areas. Waikane silty clay, 8 to 15 percent slopes is present in residential areas. Waikane silty clay, 25 to 40 percent slopes, is found on the steeper ridges and ravines, and is used as pasture. Waikane silty clay, 40 to 70 percent slopes (with erosion hazard), occurs on the steep slopes south of Waikane Stream. Waikane silty clay, 40 to 70 percent slopes (eroded), occurs on the steep slopes

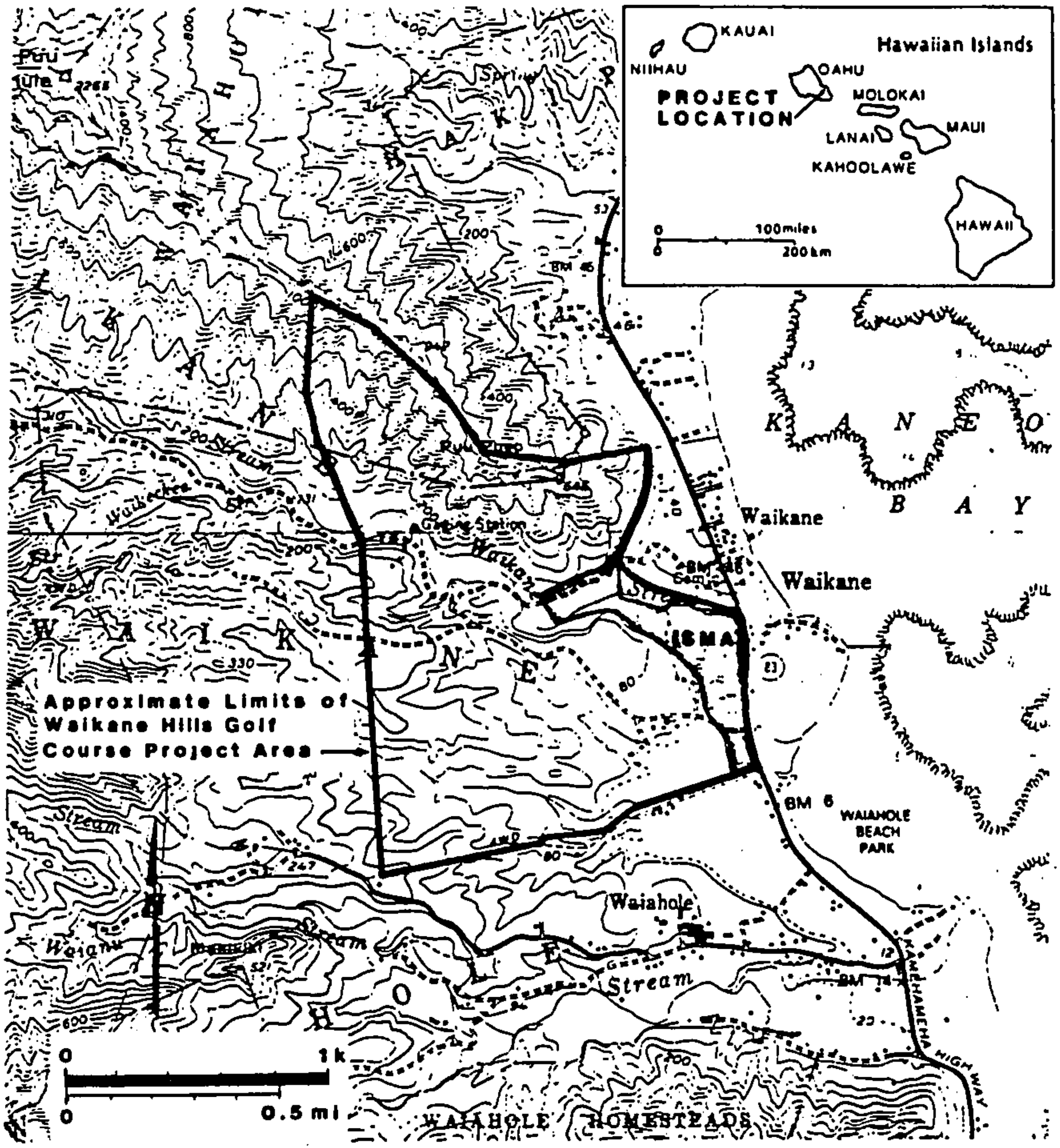

Figure 1. PROJECT LOCATION MAP

Archaeological Reconnaissance Survey
and Limited Subsurface Testing
Waikane Golf Course Project Area
Land of Waikane, Koolaupolo District
Island of Oahu (TMK:4-8-04:4,5; 4-8-06:8; 4-8-14:4)

PHRI Project 87-398 April 1988

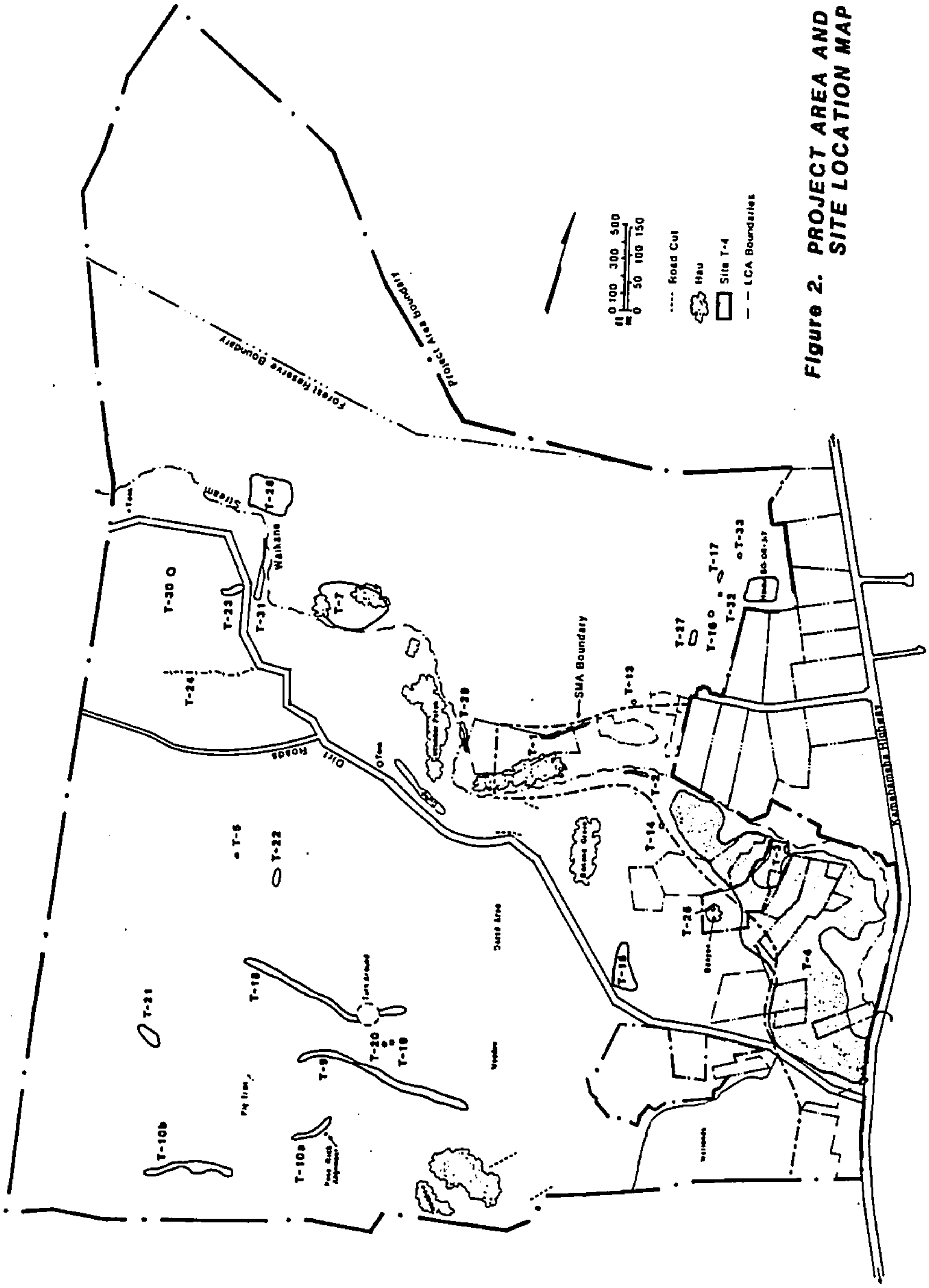

Figure 2. PROJECT AREA AND SITE LOCATION MAP

of Puu Ohulehule-Puu Pueo ridge and on the steepest slopes of the gulches. In the project area, Waikane silty clay is used to cultivate truck crops, and is also used as pastureland and woodland and for house sites.

The climate within the Waikane Golf Course project area is typical of windward Oahu. Average annual rainfall is c. 75 inches and the temperature varies from 72-82 degrees F (Armstrong 1983: 62-64).

PREVIOUS ARCHAEOLOGICAL WORK

There are a number of previous archaeological investigations relevant to the present project area. These investigations include studies that have been conducted in nearby Waiahole Valley (adjacent to Waikane Valley) and studies that have been conducted specifically in Waikane Valley, in the vicinity of the present project area and within the present project area.

Investigations in nearby Waiahole Valley include studies by Kikuchi (1964), Griffen and Pyle (1974), Tomonari-Tuggle (1983), and Tomonari-Tuggle and Tuggle (1984). During Kikuchi's study, two adze quarries were recorded. These quarries, situated on a talus leading up to Puu Kuolani, consisted of a number of large boulders patined a dull grey--boulders which when quarried yielded a fine-grained bluish basalt. The quarries are one of the sources for the lithic materials found in the present project area.

During the Griffen and Pyle study, 2.5 square miles of Waiahole and Waikane valleys were surveyed. The Griffen and Pyle study did not locate any new archaeological sites; however, it is mentioned in the study that flats along the streams, "[a]ll show evidence that taro was once grown... [t]he flats seem man made, but all traces of the <u>lo'i</u> themselves are eradicated" (1974:15).

During the 1983 Tomonari-Tuggle study, 28 sites representing occupation from prehistoric times to the early 20th century were located. Functional site types encountered during the study included residential areas, possible stone tool manufacturing workshops, and agricultural features representing both Hawaiian taro and historic rice cultivation. One site (Site 3512) contained multiple components which reflected late prehistoric to historic period agriculture and habitation (1983:I-29). A buried cultural deposit at the site contained considerable evidence for early Hawaiian occupation. Among the activities represented at Site 3512 were lithic chipping and wood-working. In 1984, detailed mapping and mitigation excavations were conducted at six of the sites which were to be affected by construction activities (Tomonari-Tuggle and Tuggle 1984). Mitigation focused on Site 3512, since it appeared to have the greatest research potential.

Studies conducted in Waikane Valley, in the general vicinity of project area, include studies by Newman (n.d.) and Welch and Streck (1984). The Newman study, a survey along Waikane Stream, located two sites--Site 1057* (a rectangular rock enclosure) and Site 1078 (the Waikane Taro Flats). The Waikane Taro Flats is a precontact to early historic taro field complex consisting of lo'i, stone terrace walls, irrigation ditches, planting mounds, and possible shelters. Newman observed that several of the lo'i contained internal mounds, evidence which indicated that the traditional Hawaiian aulai planting method was used. These mounds represent the only known archaeological evidence representing the aulai planting method (Welch and Streck 1984:4). The Waikane Taro Flats was subsequently entered on the National Register of Historic Places (on April 1973) (Hawaii Register of Historic Places 1972).

The Welch and Streck study consisted of a survey along Waikane Stream, a survey which was part of an ordnance removal project. During the survey, an agricultural shrine was located. This shrine (Site 2889), situated within the Waikane Taro Flats, is still in use. Welch and Streck located several other sites associated with the Waikane Taro Flats--Site 1079 (a destroyed taro lo'i), Site 2890 (taro lo'i), Site 2889 (an agricultural shrine), and Site 1057 (a rectangular enclosure). Welch and Streck interpreted the Waikane Taro Flats and associated sites as a prehistoric agricultural/religious/habitation complex. The area of the complex is still in use today.

Archaeological work conducted within the specific Waikane Golf Course project area includes work by Thrum (1917), McAllister (1933), Griffen and Pyle (1974), Napoka (1977), Bath (pers. comm.), and Mayberry and Haun (1988). In 1908, Thrum briefly described two heiaus within the valley--Kukuianiani Heiau (Site 80-06-317) and Kaawakoa Heiau (Site 80-06-318). McAllister, in 1933 mapped Kukuianiani Heiau and noted that Kaawakoa Heiau had been destroyed (1933:170). The study by Griffen and Pyle, which as mentioned previously did not locate any new archaeological sites, does mention that Kukuianiani Heiau was found to be in fair condition (1974:15).

The work by Napoka includes a reference to Kukuianiani Heiau. Napoka went on a field trip (on Oct. 20, 1977) to examine historic taro lo'i. According to Napoka's notes, his guide, and owner of the lo'i, a Mr. Kamaka, explained that "Kukuianiani Heiau was supposed to have been a medicinal heiau. It was a large stone structure but...during WWII it was taken apart and the stones were used to pave the road. Thus, only a small...[part of] the original structure is still there." The work by Joyce Bath, staff archaeologist with the DLNR-HSS, consisted of excavating

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*Hawaii Register of Historic Places (HRHP) site designation system: all four-digit site numbers prefixed by 50-80-06- (50=State of Hawaii, 80=Island of Oahu, 06=USGS 7.5' series quad map ["Kahana, Hawaii"]).

a series of backhoe trenches in an elevated terrace southwest of the SMA project area. The excavation, conducted in 1986, yielded no cultural materials (Bath pers. comm.).

The study by Mayberry and Haun comprises the most recent archaeological study conducted in Waikane Valley. Mayberry and Haun surveyed and conducted subsurface testing within the SMA portion of the present project area. Their findings, presented earlier under separate cover (Mayberry and Haun 1988), are included in the present report.

SUMMARY OF HISTORIC LAND USE

There are two legends concerning how Waikane got its name. One legend says that Waikane was named so "because it was here [Waikane] that Kane first dug for water for the benefit of Paliuli" (Sterling and Summers 1978:187). The other legend is more involved and abstruse. A resting place for holua sledders, a place called Kapahu, was said to have been located where Lincoln McCandless' house was later built. "The holua started on the hill back of the Catholic Church. The holua sled was very famous for at this place the prominent people as well as the ordinary folks came here to sled. That is why this place was named Waikane" (Sterling and Summers 1978:188). No evidence of the holua sled was found during the present survey.

Waikane Valley historically and prehistorically has been used primarily for cultivation of wetland crops. Taro and rice have been the principle crops grown in the area, as the terrain is ideal for their cultivation. Much of the valley floor is flat or slopes gently, and fine alluvial soils cover much of the floodplain of Waikane Stream, which flows through the valley. Historic use of the land within the project area is documented by early tax records and by informant information. Tax maps indicate that 17 Land Commission Awards (LCAs) were granted within the project area: 10880:1 and 10880:2 to Puaa; 5658-B:6 to Kaheana; 6085:2 and 6085:3 to Melewahine; 8998:1 and 8998:2 to Kauoleloa; 5727:3 to Kauhoe; 5716:2 and 5716:3 to Ku; 5651-B:1 and 5651:1 to Kaupaakai; 5656 to Kahinu; 10158 to Manoanoa; 5723:2 to Kaikaina; 5658:5 to Kaheana; and 5954:1 to Moku (Figure 3). The LCAs, it is interesting to note, are concentrated adjacent to Waikane Stream in an area ideal for cultivating wetland crops.

Handy (in Sterling and Summers 1978:187) indicates that numerous taro terraces once existed along the coastal portion of Waikane Stream. Handy describes the area between Kamehameha Highway and the sea--an area which is adjacent to and similar in nature to the coastal portion of the present project area--as "a broad area of terraces where large crops of taro are raised to sell to poi factories." Handy describes the entire seaward end of the ahupua'a watered by Waikane Stream (which includes land mauka [inland] of Kamehameha Highway) as "a continuous area of terraced land" and describes the present Waikane Taro Flats as a "beautiful plantation of about 40 terraces, all planted in taro grown for milling" located "about 1/2 mile inland, where broad flats flank a wide curve in the stream."

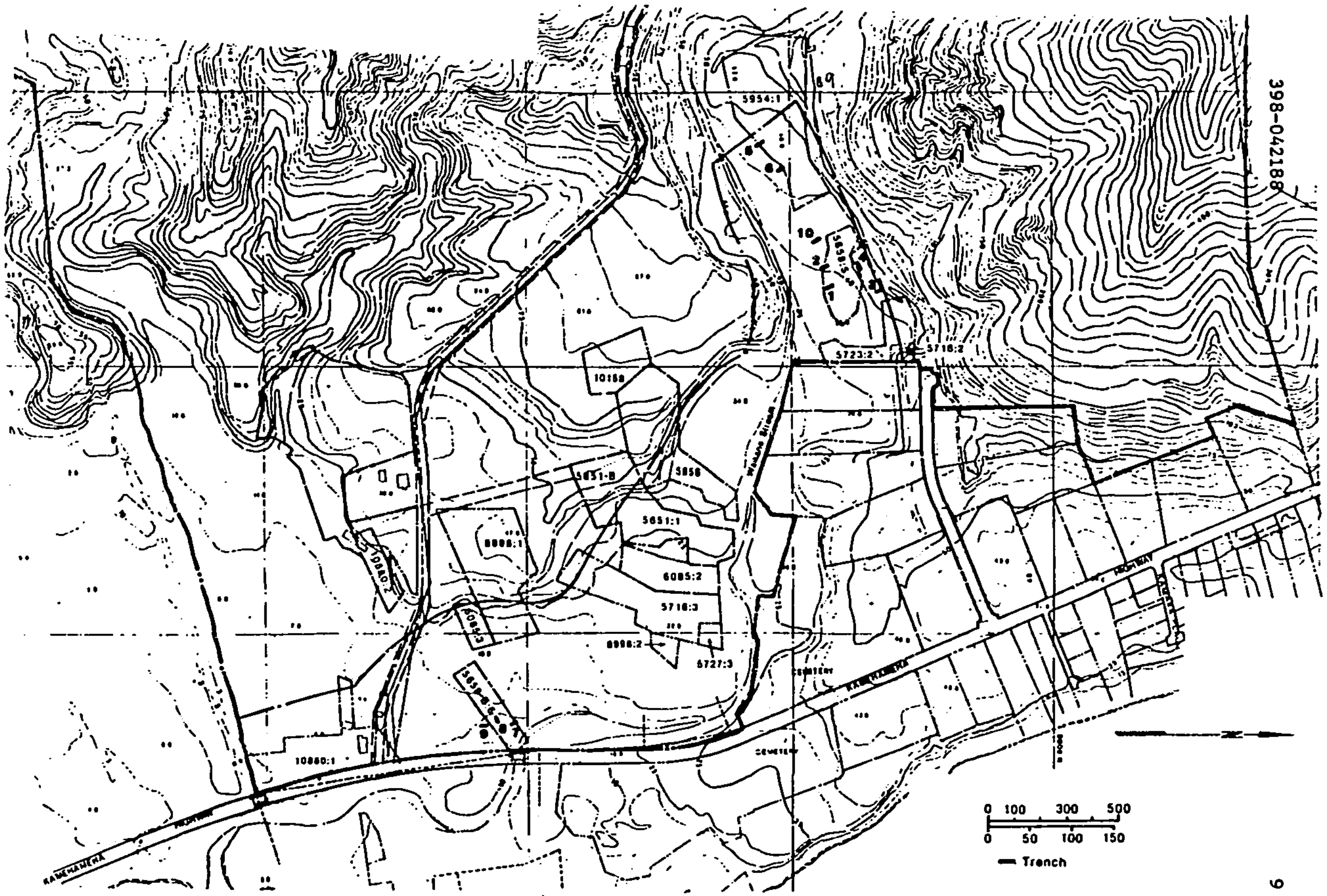

Figure 3. BACKHOE TRENCH AND LCA LOCATION MAP

Handy also mentions that (a) several small terraces within Waikane Valley were cleared by Hawaiians in 1935, (b) kuleana with terraces planted in taro were located on the north side of Waikane Stream, and (c) that the "southern part of Waikane Valley, divided from the larger northern section by a low ridge" had terraces. The taro terraces mentioned in (b) and (c) were no longer visible during the 1974 survey of the area by Griffin and Pile (1974:15).

The same general area of the taro terraces were later used by the Chinese to grow rice. The Waikane area has a long history of Chinese occupation. The following information on Chinese occupation is derived from the notes and recollections of Lum Pui Young (n.d.):

> Most of the Chinese in the Waikane area were farming rice long before the turn of the century. Milled rice was not consumed locally but was shipped to Honolulu by the S.S. John A. Cummings, which called at Waikane at intervals. The Sing Kee Wai rice plantation farmed about 100 acres and employed c. 15 workers. In addition, other Chinese families farmed about 200 acres, so that at least 300 acres of rice were farmed in the area. By 1913, rice was no longer profitable to grow and many of the Chinese began to move from the region. In 1925 nearly all the rice fields were idle, and most of the Chinese had moved to Honolulu or back to China.

According to a sketch map prepared by Lum Pui Young, several features were once located in or near the project area; no evidence remains for most of these features. One feature, a Chinese cemetery site, roughly corresponds to the historic cemetery identified as Site T-27 during the present survey.

A 1933 tax map of the project area depicts much of the property along Waikane Stream as under taro or rice cultivation. The map shows two taro patches on the north side of Waikane Stream, near the western edge of the project area. No evidence for these patches were located during the current survey. The map shows rice being cultivated in an area corresponding to Site T-31 of the present project, and also shows a taro patch serviced by a ditch which corresponds to Site T-7, and rice and taro patches in LCAs in the SMA and wetlands portions of the project area. The map also indicates that rice once grew in the flat currently cultivating cucumbers (see Figure 2).

FIELD METHODS AND PROCEDURES

The field work for the SMA portion of the project area was conducted January 12-19, 1988 by PHRI Supervisory Archaeologist James D. Mayberry, assisted by PHRI Field Archaeologists Edward Kaler, Diane Guerriero, and Mikele Fager. PHRI Senior Archaeologist Dr. Alan E. Haun provided overall supervision and direction for the project. Ninety (90) man-hours of labor (11.25 man-days) and 12 backhoe trenching hours were expended in conducting the field work.

One hundred percent of the non-wetland parts of the SMA portion project area was inspected by means of high- to medium-intensity pedestrian sweeps. Because the project area boundaries were irregular and unfenced, except along Kamehameha Highway, transects were usually oriented parallel to Waikane Stream or roads and field margins. Transects were generally east-west, except near Kamehameha Highway, where they ran north-south. Distance between sweeping crew members was 8.0-15.0 m, depending on vegetation encountered and terrain. All identified sites were assigned PHRI sequential temporary field numbers prefixed by "T-," and all were plotted on 1"=400' scale maps and on aerial photos provided by Group 70.

Backhoe trenching in the SMA portion project area was conducted on January 18 and 19, 1988. Ten trenches were excavated; all were placed either in 19th century LCA parcels or in other areas thought to have been suitable for historic/prehistoric irrigation agriculture. The trenches measured 4.0-6.0 m long and were excavated either to the top of the water table or to a depth of 2.0 m. Each trench was faced and profiled. Pollen and dating samples (not submitted for analysis) were recovered from six of the ten trenches (Trenches 2, 5-7, 9-10).

The survey field work for the non-SMA portion of the project area to be affected by development (c. 250 ac) was conducted March 23-April 20, 1988 under the supervision of PHRI Supervisory Archaeologist William A. Shapiro, and under the overall direction of PHRI Senior Archaeologist Dr. Alan E. Haun. Field personnel included PHRI Field Archaeologists Mike Fager, Erik Pearthree, and Jack Harris. Approximately 530 man-hours of labor were expended conducting the field work. The 250-acre portion was inspected using variable intensity (30- to 90-ft intervals) pedestrian sweeps. Areas of the overall project area not surveyed included the wetlands portion and areas immediately adjacent to occupied residences. Transects were oriented in a north-south direction following the western project boundary, which was partially flagged. Transect distances between crew members varied depending upon vegetation and terrain encountered. Identified sites were assigned sequential temporary field numbers (T-#) and were plotted on project maps (1"=200' scale) and on aerial photographs (12-03-1974) of the project area. Subsequent to initial site identification, certain sites were dropped either because (a) upon closer inspection they proved not to be sites, (b) they were too insignificant to be considered actual sites, or (c) they were incorporated into other sites.

All sites in the project area were fully recorded. Each recorded site and/or primary feature within each site complex was marked with pink-and-blue flagging tape, and with an aluminum tag bearing the site number, date, the letters "PHRI," and the PHRI project number (87-398). Recording included mapping all sites to scale using metric tape and compass, 35 mm black-and-white photographs of each site, and fully describing sites using standard PHRI record forms.

In addition to the above work, at Site T-23, a cut bank was profiled and a bulk sample collected so that a radiocarbon date could be obtained.

At Sites T-9, T-10, T-15, T-18, and T-23 volcanic glass samples were collected for hydration-rind age determinations.

Because the SMA portion of the project area and the remaining portion of the project area to be affected by development were surveyed under the direction of different supervising archaeologists, there were discrepancies between feature-type terminologies used during the two surveys. For example, what were identified as "irrigated pondfields" during the SMA survey were identified as "sunken agricultural fields" during the later survey. For the purposes of discussing the project as a whole, which is the intention of this report, the feature designations assigned Sites T-1 thru T-4 during the SMA survey have been changed to conform with the feature designations used during the later survey. Site T-3, identified as a "stone and earthen embankment" in the SMA report, is categorized as a "retaining wall" in the present report; Sites T-1 and -2, identified earlier as "irrigation ditches" are categorized simply as "ditches" in the present report; and Site T-4, identified earlier as "irrigated pondfields" is categorized as a "sunken agricultural field" in the present report.

FINDINGS

ARCHAEOLOGICAL SURVEY

During the reconnaissance survey of the Waikane Golf Course project area, 28 sites were newly identified and one previously identified site was relocated (total 60 component features). Five of the 29 sites (Sites T-16, T-17, T-32, T-33, and 80-06-317) are within the project area, just outside the area which is scheduled for development. These sites may not be directly impacted by the proposed development; however, due to their high research, interpretive, and cultural values, they were recorded. Figure 2 shows the locations of all 29 sites. Appendix A provides detailed descriptions for each site.

Appendix A includes the following information for each site:

1. Site number - either HRHP numbers, if previously assigned, or PHRI temporary site numbers;

2. A site type designation - provides formal feature type for sites consisting of a single feature, or designates the site as a complex if the site is comprised of more than one feature. Also lists total number of features present;

3. A listing of site topography - a brief description of the terrain in the area of the site;

4. A listing of the site vegetation - lists principal components of the vegetation within and in the vicinity of the site;

5. A statement of site condition - overall state of preservation of the site (poor, fair, good, or excellent);

6. An assessment of site integrity - degree of historic modification by human agencies (unaltered, partially altered, and completely altered) and nature of the modification, if any;

7. A probable age - indicates probable/possible (?) age of the site (i.e., historic or prehistoric);

8. A functional interpretation - probable or possible (?) functions for each site; or, if function cannot be determined, assigns indeterminate function. For sites with multiple functions, functions separated by "/";

9. A site description - a brief overall description of the site listing types of constituent features, portable remains present, if any, and other site data; and

10. Feature dimensions - maximum length, width, and height or depth. Dimensions immediately followed by a description of feature construction, associated portable remains, and other descriptive information.

Nine site complexes and 20 single-feature sites were identified in the project area (Table 1). Formal feature types present include terraces, mounds, ditches, boulder concentrations, retaining walls, lithic scatters, coral scatters, alignments, historic burials, pits, a debris scatter, man-made caves, sunken agricultural fields, a trail, a midden scatter, a historic house site, a boulder with mortar depressions, a possible terrace, and a possible inclined ramp (Table 2).

The most common feature types in the project area are terraces (10 examples-16.67% of total features) and pits from exhumed burials (10 examples-16.67%). Other prominent feature types include mounds (10.00%), lithic scatters (10.00%), intact historic burials (5.00%), man-made caves (3.33%), and sunken agricultural fields (5.00%).

Probable functional interpretations were determined for most sites. Functional types present in the project area include agricultural, religious, tool manufacture, habitation, transportation, retaining wall and indeterminate. Among the indeterminate sites are possible agricultural, religious, military, or shelter sites. Six sites were assigned two or more probable functions. Table 3 indicates the number and percentage of sites by functional type.

Sites assigned an agricultural function comprise the highest percentage of functional site types (12 sites - 41.38% of total sites). Agricultural sites include rock mounds and boulder concentrations, ditches, terraces, retaining walls, and sunken agricultural fields. Among the agricultural sites are Sites T-1, T-2, T-4, T-5, T-7, T-17, T-21, T-25, T-26, T-29 and T-31 (Figures 4 and 5). Site T-33, which has been assigned an indeterminate function, may have an agricultural function.

Sites in the project area assigned a religious function (17.25%; N=5) include a heiau, an historic cemetery, a shrine with a possible burial, either a burial or a shrine, and a tool manufacture site which may have a religious component. In addition, two of the sites with indeterminate functions may be of religious significance (Sites T-16 and T-33). The religious sites include Sites 80-06-317 (Kukuianiani Heiau, Figure 6), ı-27 (historic cemetery, Figure 7), T-19 (burial or shrine, Figures 8 and 9), T-32 (a shrine or possible burial, Figures 10 and 11), and T-10 (complex with possible religious function).

Six sites in the project area were assigned tool manufacture functions (20.69%). Tool manufacturing is represented by basalt flake scatters, volcanic glass, grindstones, hammerstones, and adze preforms. Four sites

Table 1.

SUMMARY OF IDENTIFIED SITES - WAIKANE GOLF COURSE PROJECT AREA

Site Number	Formal Site/ Feature Type	Tentative Functional Interpretation	CRM Value* R	I	C	Comments
T-1	Ditch	Agriculture (Irrigation)	L	L	L	Historic; filled with recent alluvium
T-2	Ditch	Agriculture (Irrigation)	L	L	L	Historic; branch of ditch services wetlands
T-3	Wall	Boundary/ retaining wall	L	L	L	Historic; possible field boundary remnant
T-4	Sunken fields	Agriculture	L	L	L	Historic; used for 20th-century rice cultivation
T-5	Complex (2#)	Agriculture	M	L	L	Rock mound and boulder concentration
T-7	Complex (7)	Agriculture	M	L	L	Irrigation ditch, retaining wall, four terraces, and a mound
T-9	Lithic scatter	Tool manufacture	M	L	L	Basalt flakes, volcanic glass, coral fragments, and waterworn cobbles
T-10	Complex (2)	Tool manufacture-religious?	M	L	L/H	Lithic scatter and coral surface scatter (may be religious)

*Cultural Resource Management
Value Mode Assessment--Nature: R = scientific research, I = interpretive, C = cultural;
--Degree: H = high, M = moderate, L = low.

#Number of component features within complex.

Table 1. (Cont.)

Site Number	Formal Site/ Feature Type	Tentative Functional Interpretation	CRM Value R	I	C	Comments
T-13	Cave	Indeterminate (military?)	L	L	L	Probably WWII related
T-14	Cave	Indeterminate (military?)	L	L	L	Probably WWII related
T-15	Lithic scatter	Tool manufacture	M-H	L	L	Basalt flakes, volcanic glass, coral, grindstone, hammerstones, and adze preforms
T-16	Mound	Indeterminate (religious?)	M	L	L/H	May represent a possible burial
T-17	Terrace	Agriculture?	L-M	L	L	May be associated with 80-06-317
T-18	Lithic scatter	Tool manufacture	L	L	L	Heavily disturbed; volcanic glass collected
T-19	Alignment	Religious? burial or shrine	M-H	L	L/H	Rectangular rock alignment with coral offerings
T-20	Midden scatter	Habitation	L-M	L	L	Surface scatter
T-21	Complex (3)	Agriculture	M	L	L	Irrigation ditch and two possible terraces
T-22	Lithic scatter	Tool manufacture	L-M	L	L	Sparse basalt scatter and a rock concentration, one worked flake
T-23	Lithic scatter	Tool manufacture/ habitation	M-H	L	L	Very dense scatter (1000+ basalt flakes, several adze preforms, 20-50 cm deposit; C-14 sample and volcanic glass)

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Table 1. (Cont.)

Site Number	Formal Site/ Feature Type	Tentative Functional Interpretation	CRM Value R	I	C	Comments
T-24	Trail	Transportation	L	L	M	Has been recently improved by surveyors; follows small drainage
T-25	Mound	Agricultural?	L	L	L	Surrounded by historic debris
T-26	Complex (2)	Agriculture	L-M	L	L	Terrace and rectangular rock alignment (historic)
T-27	Complex (15)	Religious-cemetery	M-H	L	H	Historic cemetery with at least three intact burials and 10 exhumed and relocated burial pits, and alignment, and a debris scatter
T-29	Ditch	Agriculture	L	L	L	May be uppermost section of previously recorded T-1 ditch site
T-30	House site	Habitation	L-M	L	L	Historic house site which has been bulldozed and leveled
T-31	Complex (3)	Agriculture	M	L	L	Irrigation ditch and two rice fields
T-32	Mound	Religious-shrine/burial	H	H	H	Small shrine with upright stone; may be associated with 80-06-317
T-33	Complex (2)	Indeterminate (religious, agricultural?)	M	L	L/H	Stone mound and possible terrace; mound had historic bottle fragment; may be a burial

Table 1. (Cont.)

Site Number	Formal Site/ Feature Type	Tentative Functional Interpretation	CRM Value R	I	C	Comments
80-06-317	Heiau complex (4)	Religious	H	H	H	In fair condition; deteriorating and being encroached by development; recorded by McAllister (1933) known as the Kukuianiani Heiau; two leveled structure consisting of two terraces, a possible ramp-like entrance, and a large stone with two mortar depressions

are assigned only tool manufacture functions: Sites T-9, T-15 (Figure 12), T-18, and T-22. Site T-10 is assigned a tool manufacturing function and a possible religious function. Present at Site T-10 is a dense scatter of surface coral which may be of religious significance. Site T-23 is the largest tool manufacturing site in the project area. Present at the site were thousands of basalt flakes, several adze preforms, volcanic glass, and a midden deposit 20-50 cm deep. Site T-23, based on the amount of midden which has accumulated at the site, was also assigned a habitation function (Figures 13 and 14).

Three sites (10.35%) were assigned a habitation/possible habitation function: Site T-23, Site T-30 (the remains of an historic house), and Site T-20 (a light surface midden scatter). One site (Site T-24, a trail) was assigned a transportation function. Sites T-13 and T-14, which were assigned an indeterminate function, may represent man-made caves used by the military.

SUBSURFACE TESTING

Ten backhoe test trenches, each four to six meters long, were excavated in the Waikane Golf Course SMA portion project area (Figure 15). The trenches were excavated within two sections of the project area. Trenches 1-6 and 10 were placed in the midsection of Waikane Valley, while Trenches 7-9 were placed in the lower portion of the

Table 2.

FREQUENCIES OF FORMAL FEATURE TYPES

Formal Type	Number	%
Alignment	1	1.67
Cave (man-made)	2	3.33
Coral surface scatter	1	1.67
Debris scatter	1	1.67
Ditch	6	10.00
Grave	3	5.00
House site	1	1.67
Large boulder w/ mortar depressions	1	1.67
Lithic scatter	6	10.00
Midden scatter (surface)	1	1.67
Mound	6	10.00
Pit	10	16.67
Possible ramp	1	1.67
Possible terrace	1	1.67
Retaining wall	2	3.33
Rock alignment	2	3.33
Sandstone boulder concentration	1	1.67
Sunken agricultural field	3	5.00
Terrace	10	16.67
Trail	1	1.67

Table 3.

FREQUENCIES OF FUNCTIONAL SITE TYPES

Formal Type	Number	%
Agriculture	12	41.38
Habitation	1	3.45
Indeterminate/Religious-Burial	1	3.45
Indeterminate/Religious/Agri.	1	3.45
Indeter/(poss. military shelter)	2	6.90
Possible Habitation	1	3.45
Religious-Heiau	1	3.45
Religious-Burial/Shrine	1	3.45
Religious-Cemetery	1	3.45
Religious-Shrine/Poss. Burial	1	3.45
Tool Manufacture	4	13.79
Tool Manufacture/Habitation	1	3.45
Tool Manufacture/Religious	1	3.45
Transportation	1	3.45

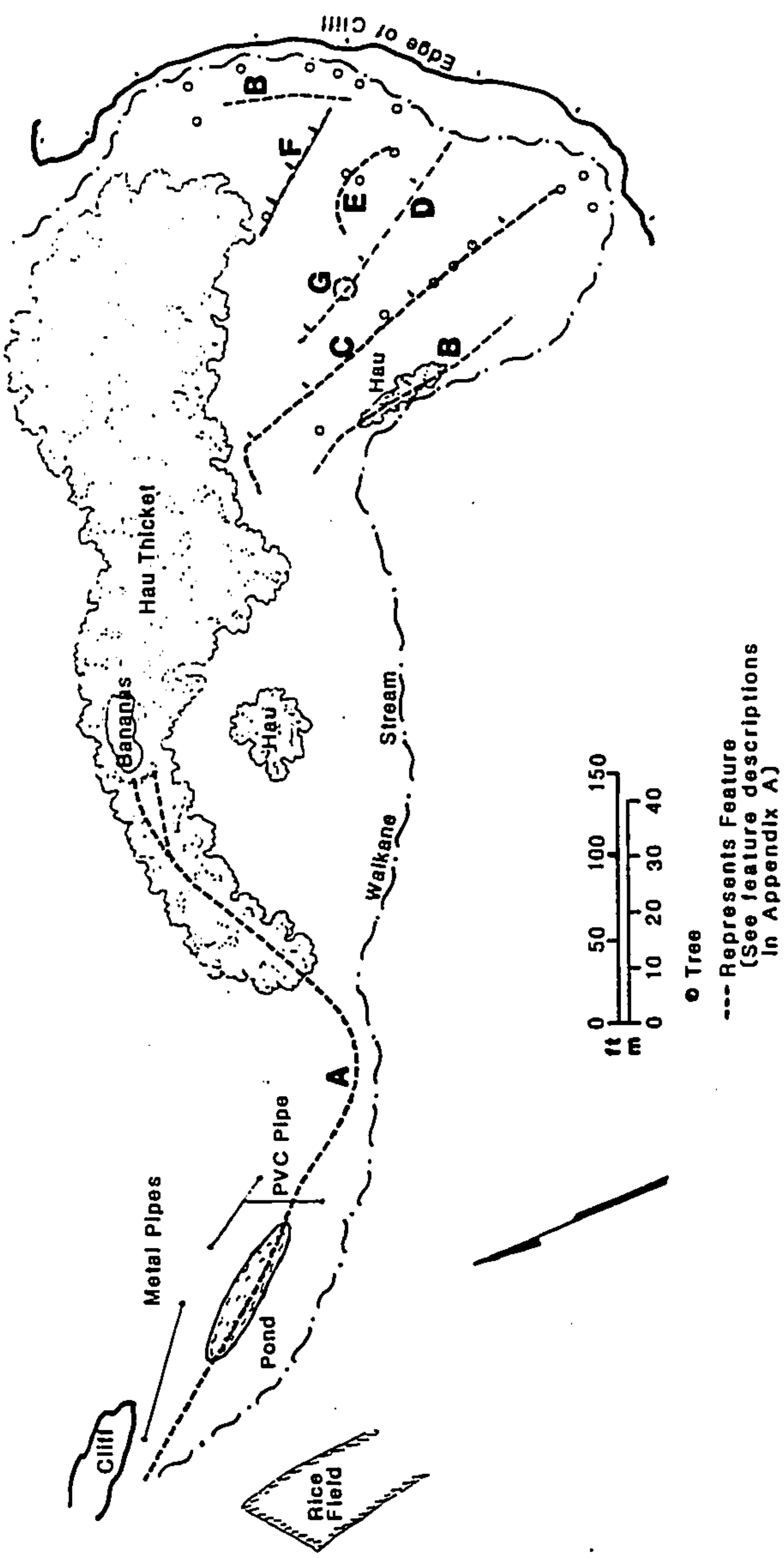

Figure 4. ***SKETCH MAP OF SITE T-7***

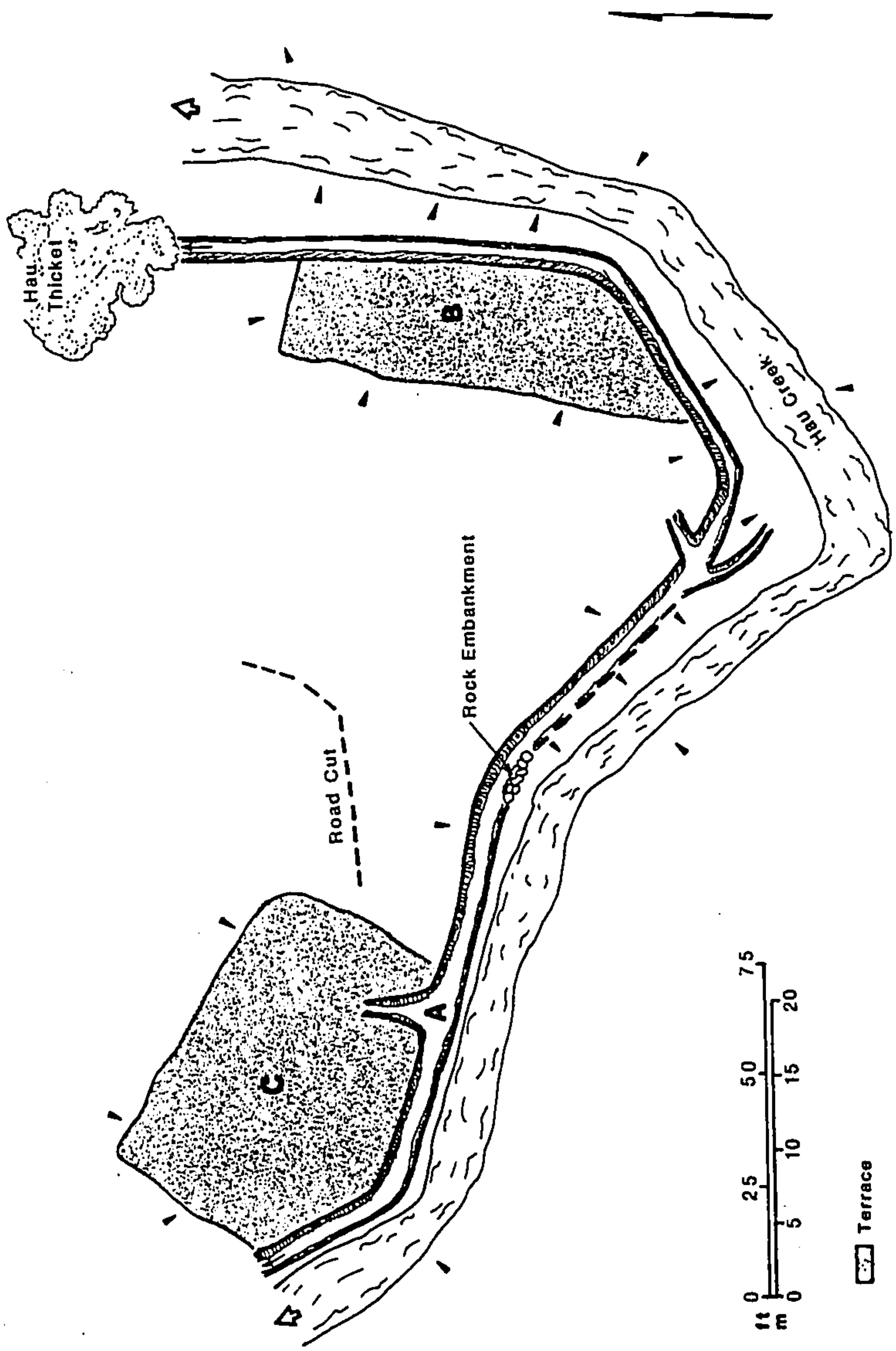

Figure 5. SITE T-21

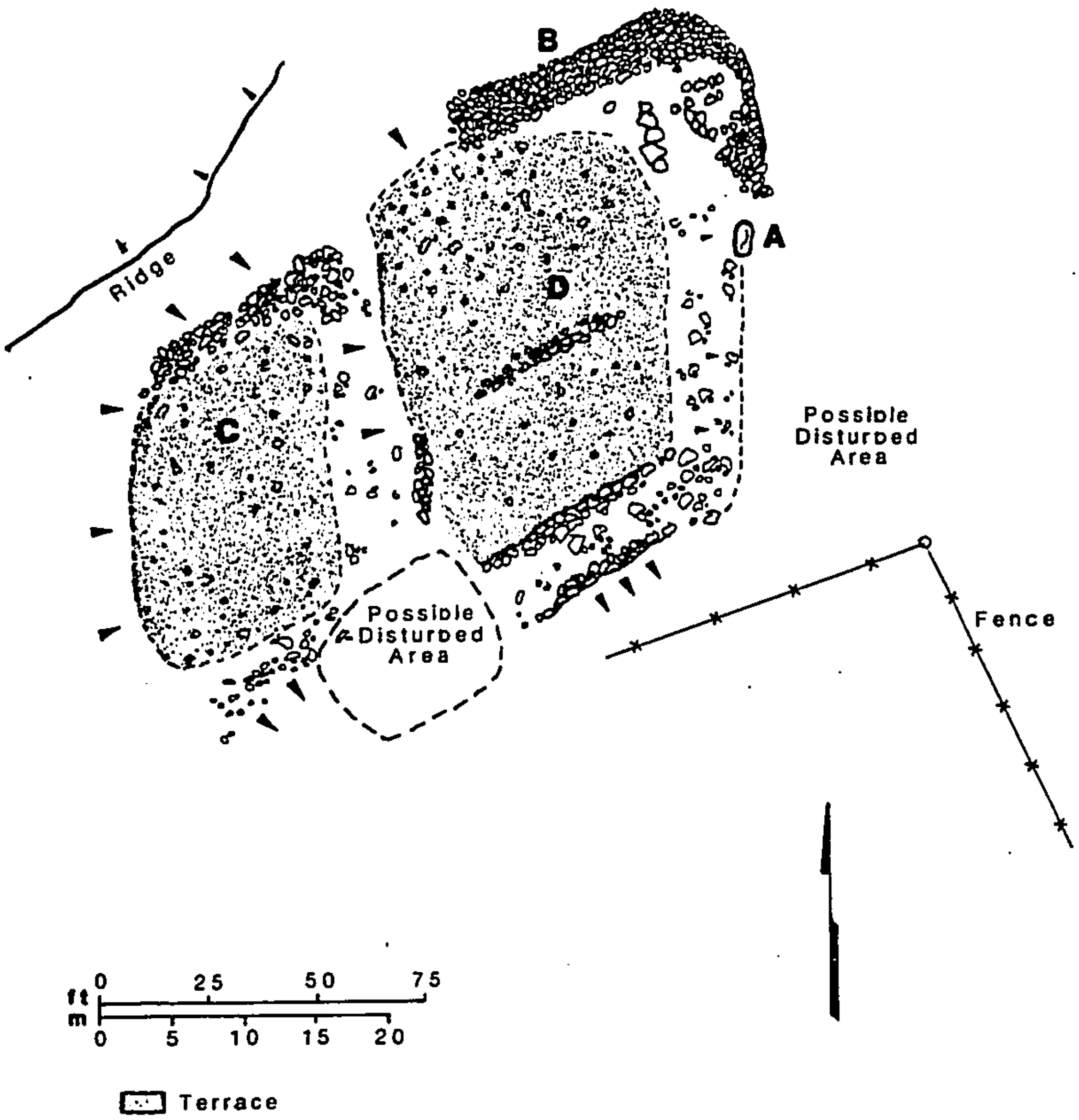

Figure 6. SITE 80-06-317

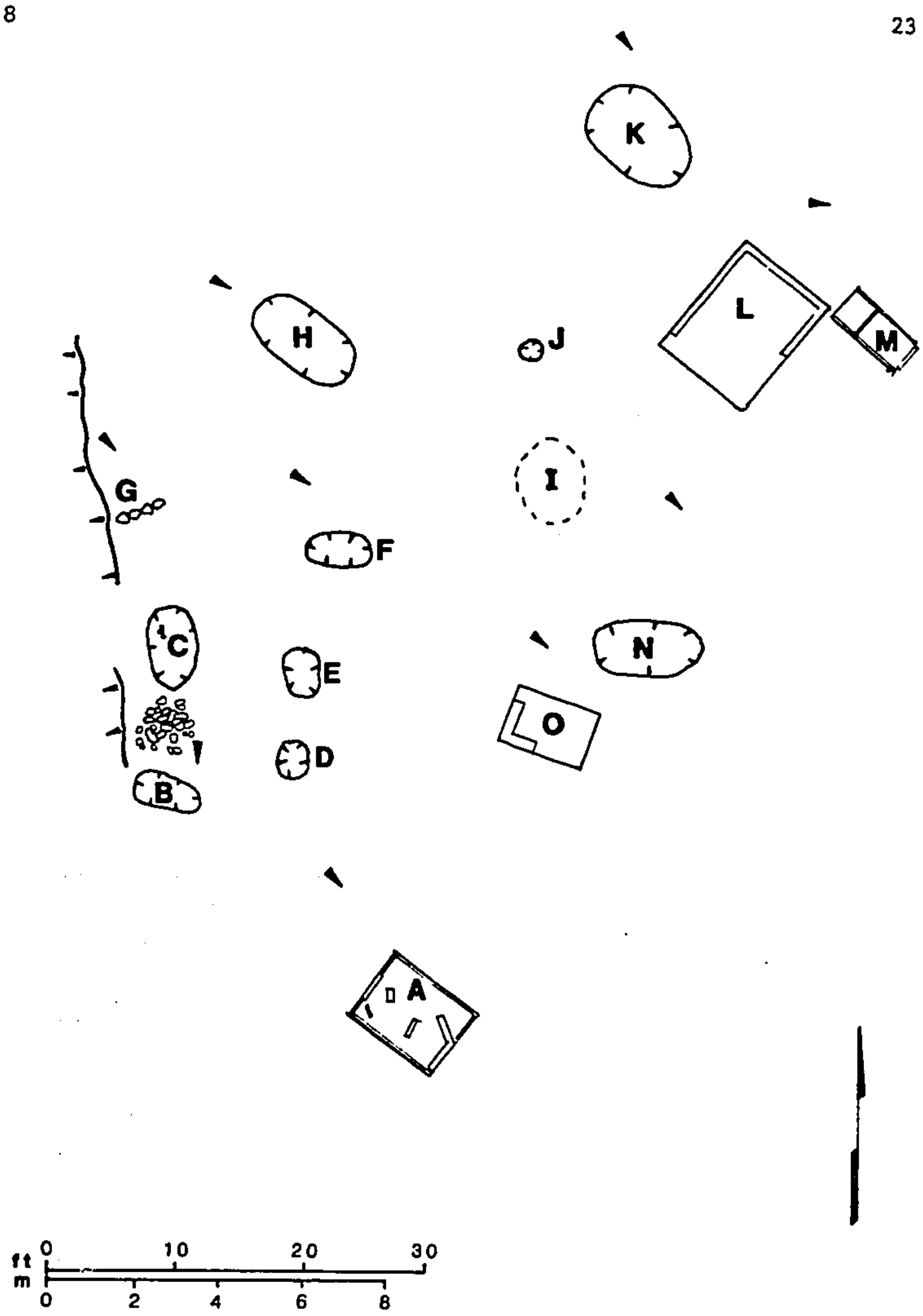

Figure 7. SITE T-27

Figure 8. SITE T-19. View to east. (PHRI Neg.722-27)

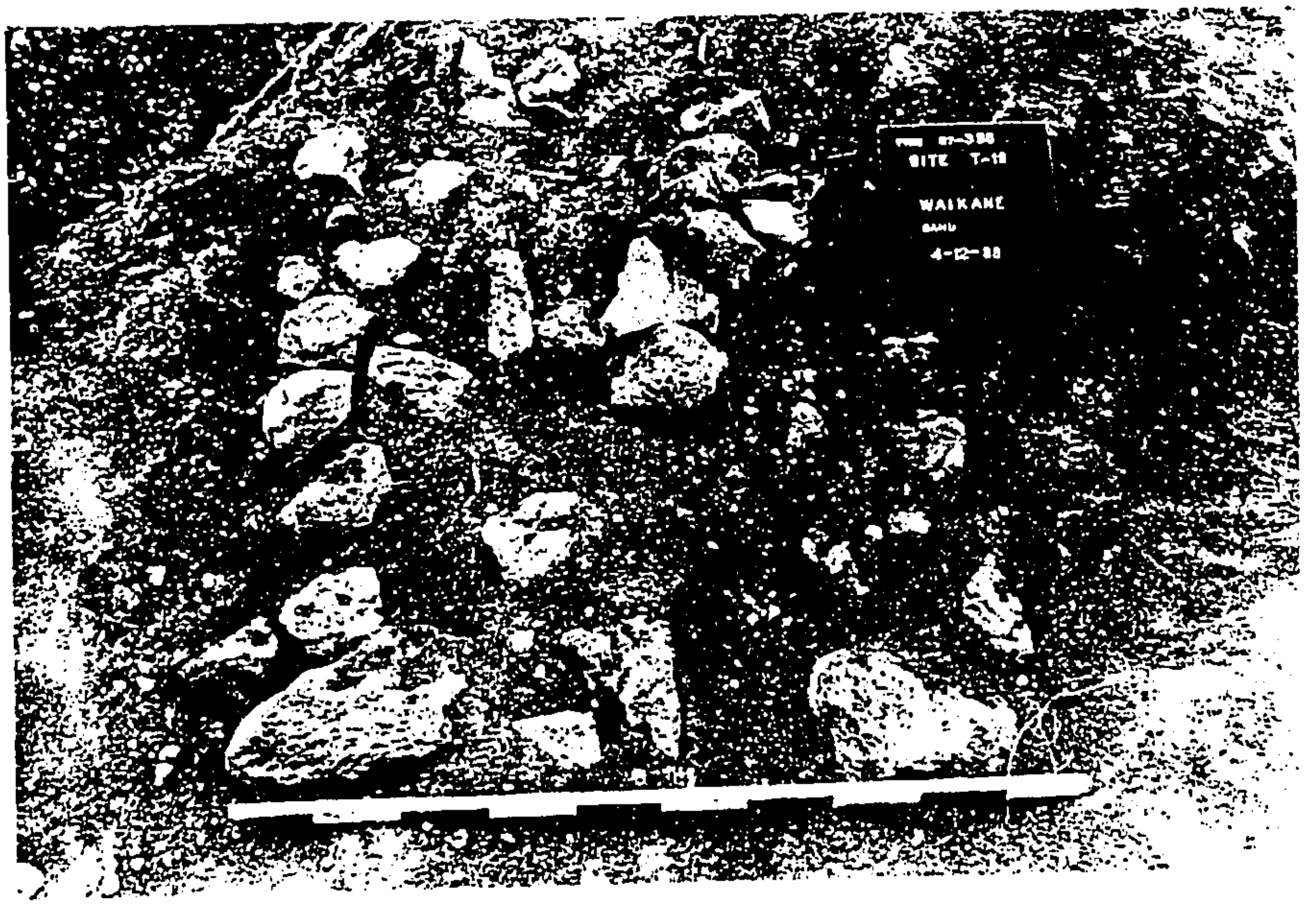

Figure 9. SITE T-19, CLOSE-UP. View to west. (PHRI Neg.772-24)

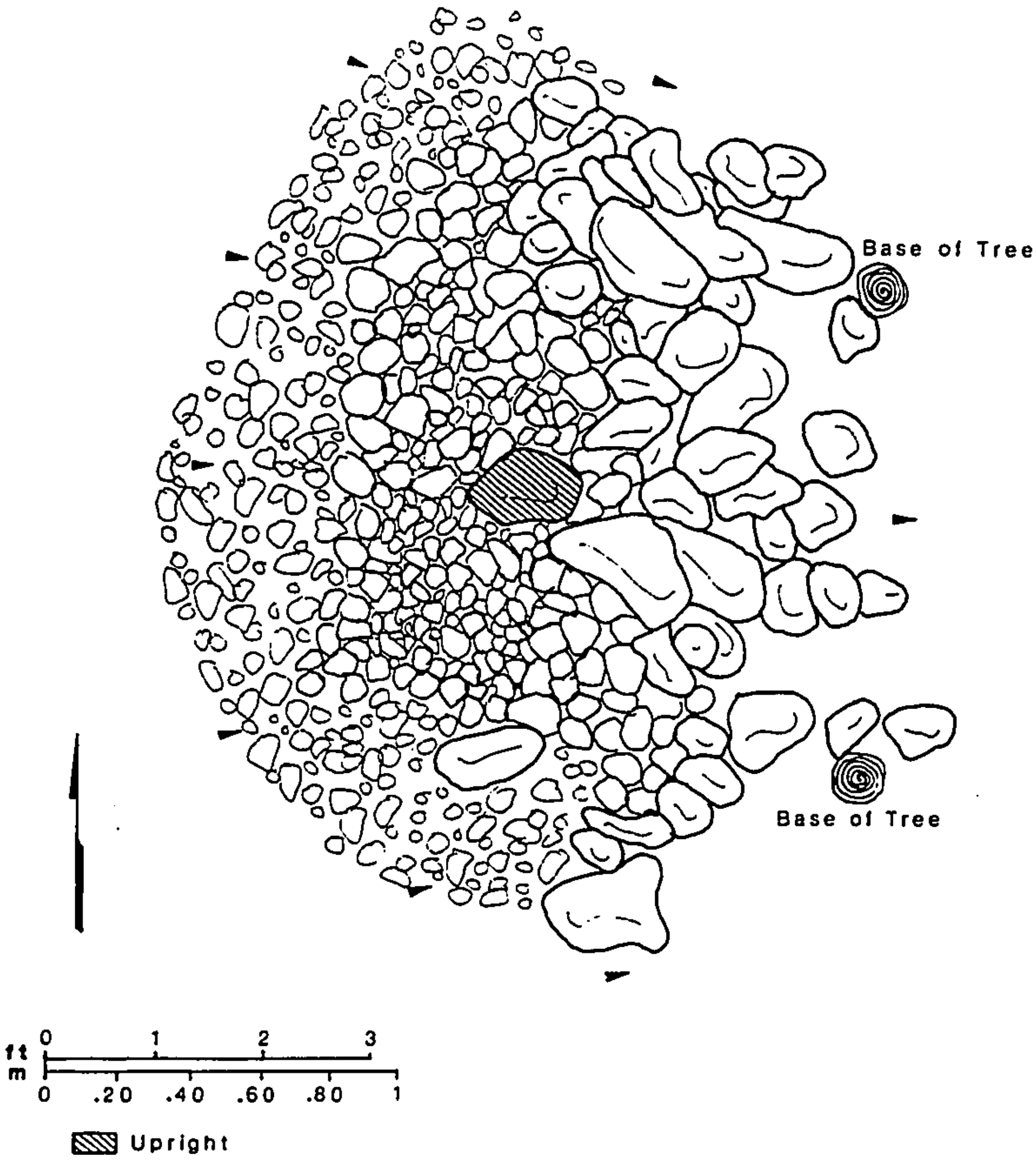

Figure 10. SITE T-32

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Figure 11. SITE T-32, SHRINE. View to northeast.
(PHRI Neg.775-7)

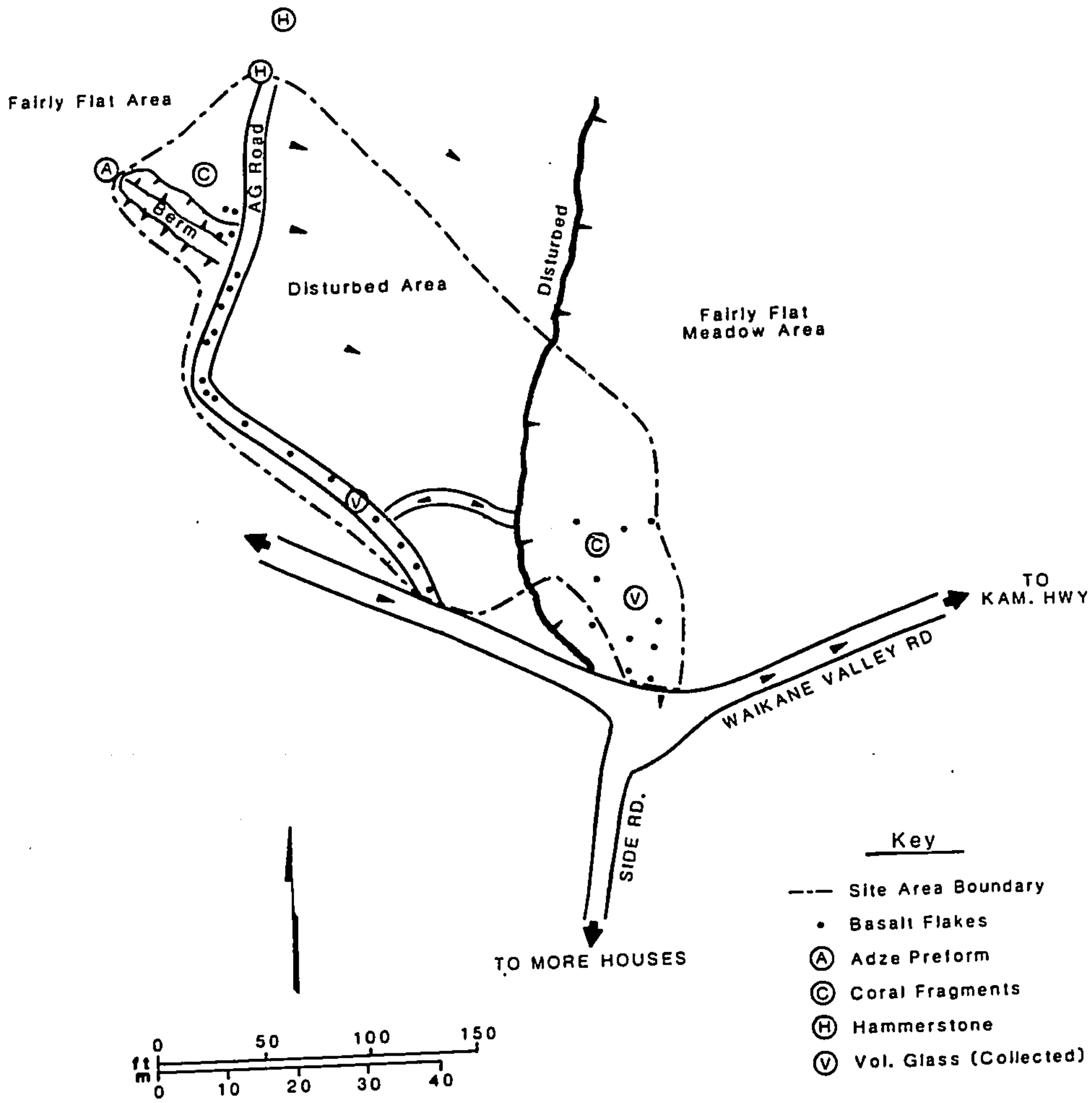

Figure 12. SITE T-15

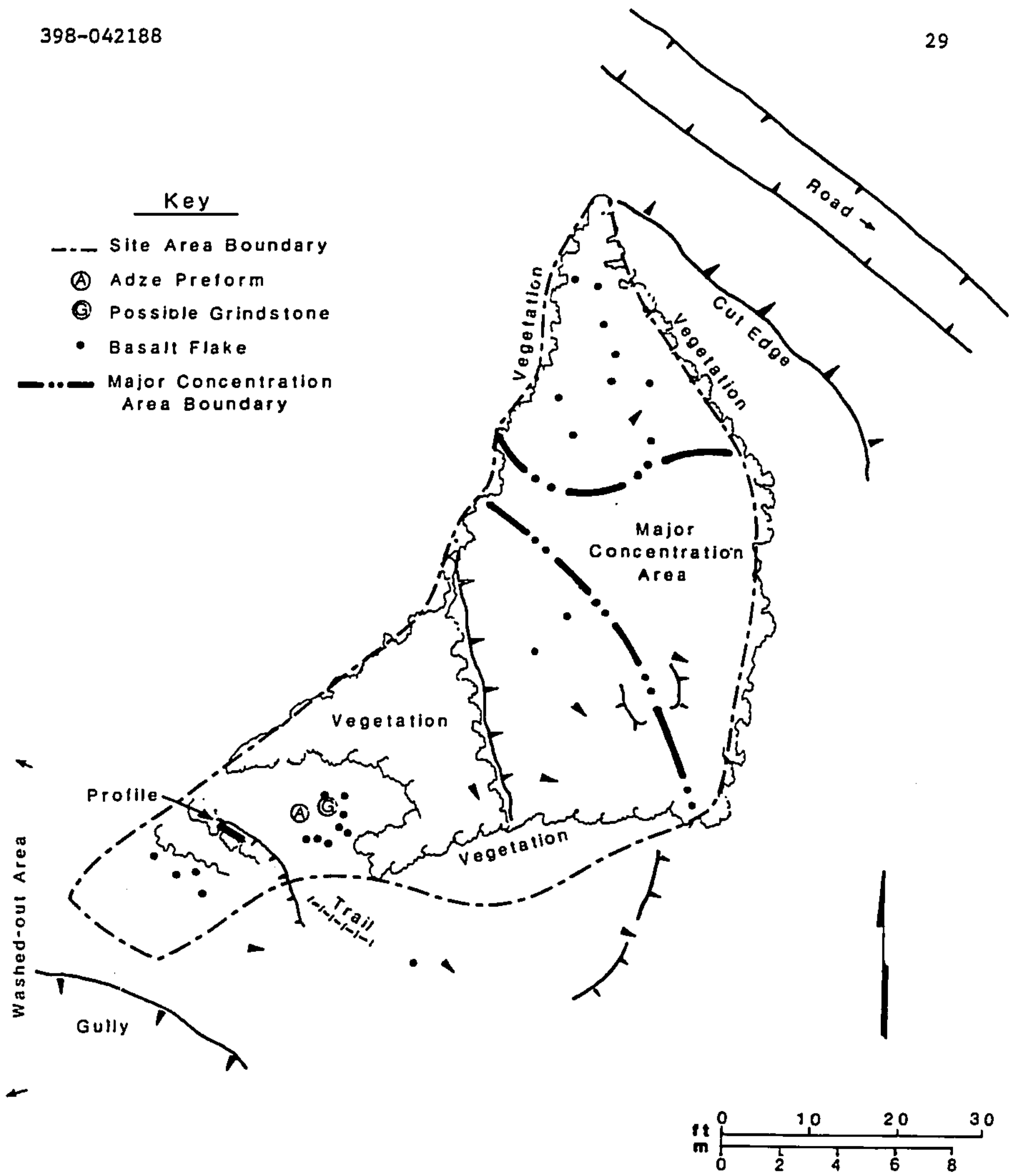

Figure 13. SITE T-23

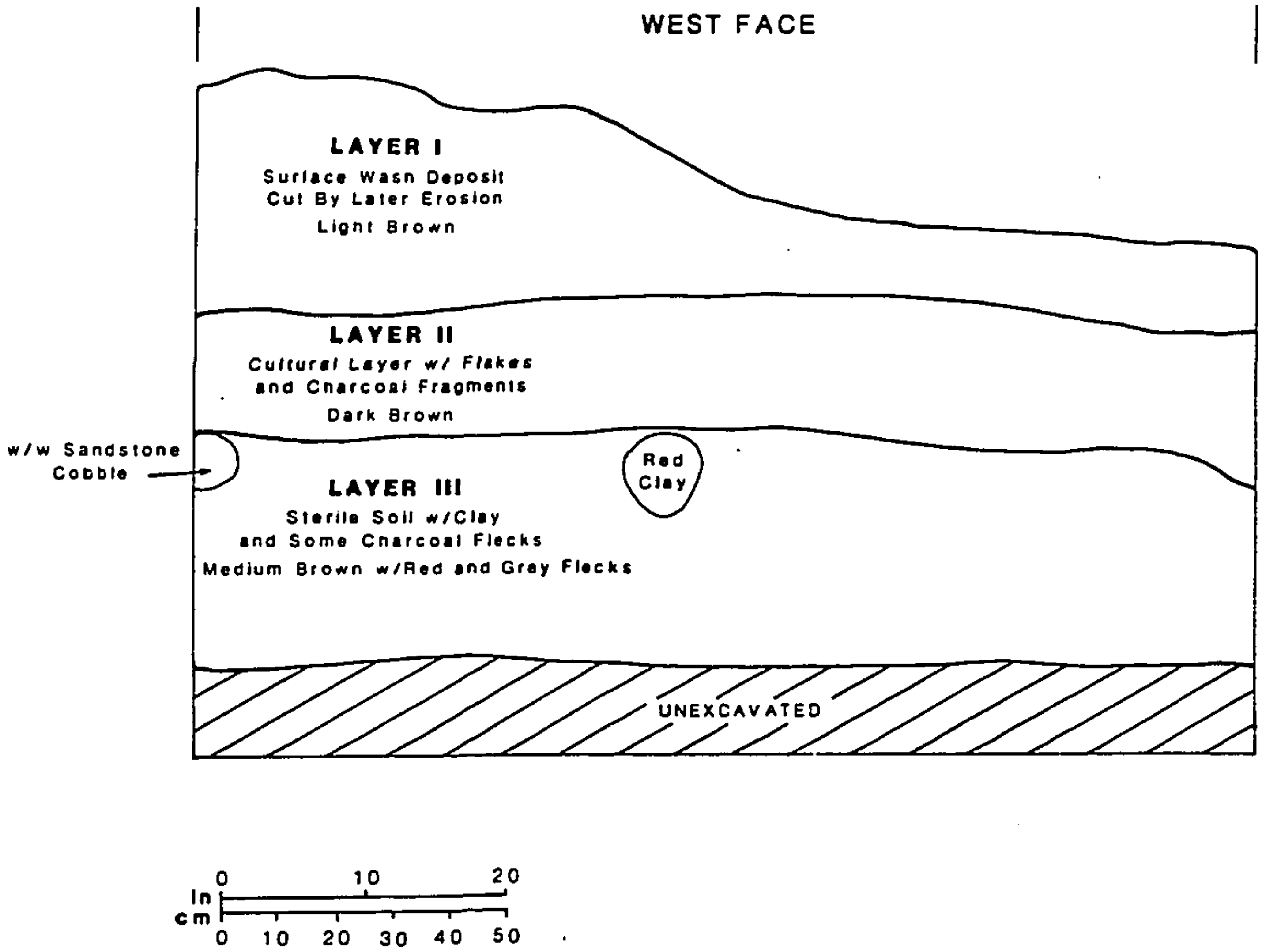

Figure 14. SITE T-23, PROFILE OF CUT BANK

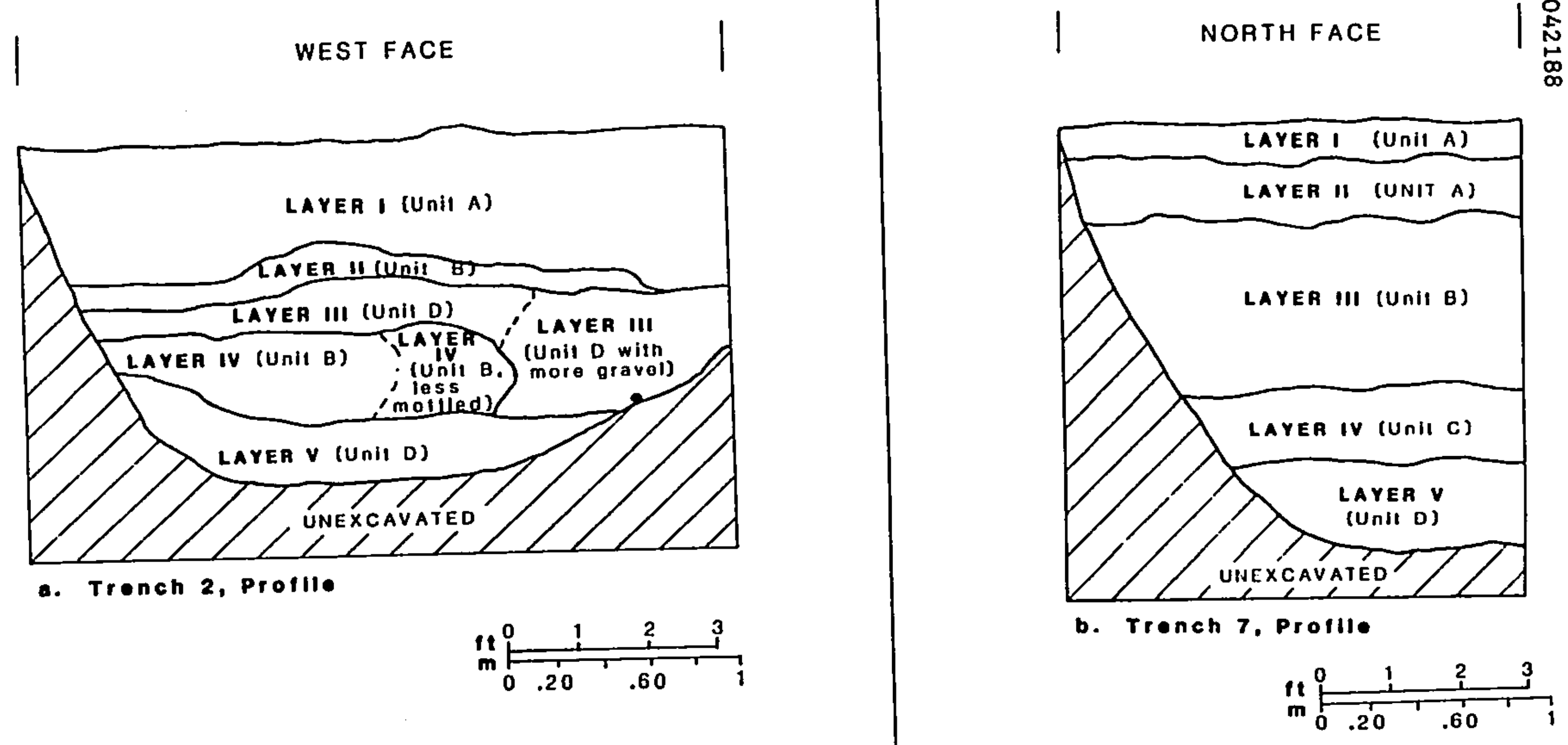

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Figure 15. PROFILES OF TRENCHES 2 AND 7

valley (Table 4). The trenches in both areas yielded A-horizons corresponding to Hanalei silty clay (HnA) (Foote, et al. 1972:38) (Figure 15). Trench profiles were recorded for all trenches except Trench 8, which collapsed. Soils layers in the trenches were categorized according to the following four macro-soil units (See Table 5):

Unit A: - Unit A soils, present in every trench, represent A-horizons totally within the root zone. The unit is comprised of mostly recent alluvial deposits--sandy to silty clay loam, dark to light brown. Depth of the unit varies from 18-70 cmbs (average c. 40 cmbs);

Unit B: - Unit B soils are also present in every trench. These soils are comprised of gley or gley-like clays. The soils are primarily grey to grey-brown and are mottled. The soils contain orange-red (oxidized) silty and sandy loam/clay lenses and varying amounts of charcoal fragments and carbonized plant remains. In some trenches, the soils also contain colluvium in the form of small pockets of waterworn basalt pebbles and gravel. Unit B soils are 10-80 cm thick and are present 24-80 cmbs (average thickness of overburden is 40 cm). The soils in Unit B extend to a depth of 74-120+ cmbs;

Unit C: - Unit C soils are present in Trenches 1, and 3-7. When present, they are always immediately beneath a layer of Unit B soil. Unit C soils often are found between two Unit B layers. Unit C soils are probably alluvial deposits. They are red to reddish-brown and are comprised of sandy loam/clay and small amounts of colluvium; and

Unit D: - Unit D soils are present in Trenches 2, 3, 5, 7, 9 and 10. The soils are present (a) between Unit B soils (Trenches 2 and 5), (b) underneath Unit B soils (Trenches 2, 9, and 10), (c) underneath Unit C soils (Trenches 3 and 7), and (d) above Unit C soils (Trench 5). Unit D soils are probably alluvial marsh deposits. The soils consist of grey-brown to brown sandy clay-loam, and sometimes contain small amounts of colluvium and charcoal.

The subsurface testing included taking pollen and radiocarbon dating samples from the trenches (samples not submitted for analysis). Pollen samples were taken from Unit B deposits, and were also taken from strata directly above and below Unit B deposits. When the Unit B deposits were thick, radiocarbon samples were taken from both upper and lower portions of the deposits.

Table 4.

SUMMARY OF SUBSURFACE TESTING RESULTS

Trench No.	No. of Layers	Length (m)	Depth (m)	Comments
1	5	6	1.5	Evidence for taro cultivation; gley strata at 25-52 cmbs and 70-80 cmbs
2	5	4	1.5	Gley strata at 45-70 cmbs and 80-120 cmbs; irrigation ditch in NE corner of trench
3	4	3	1.25	Possible gley strata at 65-80 cmbs and 95-105 cmbs
4	3	3	1.4	Gley strata 60-75 cmbs
5	7	6	1.4	Gley strata at 45-60 cmbs and 100-110 cmbs
6	5	6	1.3	Gley strata 30-70 cmbs and 70-95 cmbs
7	5	6	1.8	Gley at 40-110 cmbs
8	2	5	1.5	Gley strata present below A-horizon
9	3	5	1.5	Gley 15-100 cmbs
10	5	6	1.7	Gley 40-110 cmbs

CHRONOLOGY

Fourteen volcanic glass samples from five sites, and one charcoal sample from Site T-23 were submitted for age determination analyses. The volcanic glass samples were collected from the surface of Sites T-9, T-10, T-15, T-18, and T-23. The charcoal sample was collected from Site T-23, from a bulk soil sample obtained while profiling an eroded cut bank at the site (Figure 14). Detailed provenience information for each sample submitted are given in Tables 6 and 7.

Table 5.

TRENCH LAYER AND MACRO SOIL UNIT CORRELATION

Trench No.	Macro Soil Unit A	B	C	D
1	I	II, V	III, IV	-
2	I	II, IV	-	III, V
3	I	II	III	IV
4	I	II	III	-
5	I, II	III, VI	VII	IV, V
6	I, II	III, IV	V	-
7	I, II	III	IV	V
8	I	II	-	-
9	I	II	-	III
10	I, II	III, IV	-	V

The 14 volcanic glass samples were submitted to MOHLAB, State College, Pennsylvania. In order to determine applicable hydration rates for the samples, nine samples underwent source affinity tests. Source affinities for the remaining five samples were determined by petrographic comparison. Analyses indicated that the 14 samples were from two volcanic glass sources: Oahu A (Michels 1986a) and Oahu B (Michels 1986b) ("sources" refers to a documented volcanic glass chemical composition, not necessarily to a geographic location). Six of the samples were from the Oahu B source, and eight samples were from the Oahu A source.

The volcanic glass age determination results span 200 years (AD 1628-1821). The majority of the age ranges span the mid- to late-1700s (Table 7). The one radiocarbon sample from Site T-23 yielded a date of 1430-1640 AD. The volcanic glass sample collected from T-23 yielded a date of 1734-1754 AD. Although the radiocarbon age is earlier than the volcanic glass range, the more recent end of the radiocarbon range approximates the earlier end of the volcanic glass range.

All of the volcanic glass samples came from surface lithic scatter deposits. The radiocarbon sample from Site T-23 was from an eroded cutbank soil sample at a depth of 0-50 cmbs. Site T-23 was the only site

Table 6.

SUMMARY OF RADIOCARBON AGE DETERMINATIONS

PHRI Lab.No. RC-	Lab. No. BETA-	Provenience	C-14 Age Yrs. B.P. (one sigma)	C-13/ C-12 Ratio	C-13 Adjusted C-14 Age Yrs. B.P.	*Calendric Range Yrs. AD
Site T-23						
395	25830	0-50 cmbs	390±50	-25.1	390±50	1430-1640

* Calibrated according to Stuiver and Pearson (1986). Range at two sigmas.

Table 7.

SUMMARY OF HYDRATION-RIND AGE DETERMINATIONS

PHRI Lab. No. VG-	MOHLAB Lab. No.	Source*	Provenience	Hydration Rind (microns)	Calendric Date Yrs. AD	Calendric Range Yrs. AD (2 sigma)
Site T-9						
767	469-T-9-767	60	Surface	6.19±0.11	1773±08	1757-1789
768	469-T-9-768	60	Surface	6.51±0.21	1750±15	1720-1780
769	469-T-9-769	67	Surface	2.59±0.07	1788±11	1766-1810
770	469-T-9-770	67	Surface	2.82±0.04	1751±7	1737-1765
771	469-T-9-771	60	Surface	6.28±0.15	1766±10	1746-1786
772	469-T-9-772	60	Surface	6.42±0.07	1756±5	1746-1766
773	469-T-9-773	67	Surface	2.53±0.06	1797±8	1781-1813
Site T-10						
774	474-T-10-774	67	Surface	3.30±0.07	1714±12	1690-1738
775	474-T-10-775	60	Surface	6.56±0.15	1746±11	1724-1768
Site T-15						
777	474-T-15-777	60	Surface	6.40±0.10	1757±7	1743-1771
778	474-T-15-778	67	Surface	3.38±0.05	1648±10	1628-1668
Site T-18						
780	474-T-18-780	60	Surface	5.60±0.08	1811±5	1801-1821
782	474-T-18-782	67	Surface	3.36±0.06	1652±12	1628-1676
Site T-23						
779	474-T-23-779	60	Surface	6.58±0.07	1744±5	1734-1754

*Hawaii glass source: 60=Oahu "A," 67=Oahu "B" (Michels 1986a, 1986b).

sampled which had a substantial midden deposit, which suggested habitation as well as tool manufacturing took place at the site.

The age determination results from the Waikane Golf Course project area suggest that occupation in the project area may have taken place as early as the mid-1400s, with the majority of the sites being utilized during the mid-1700s. It is of interest to note that the three earliest volcanic glass age determinations (from three different sites; Sites T-10, T-15, and T-18) are from the Oahu B source. This suggests that the Oahu B source may have been the original source used in the area. Based on the volcanic glass results, Oahu B volcanic glass continued to be used through the late 1700s concurrently with the Oahu A source.

CONCLUSION

DISCUSSION

The archaeological reconnaissance survey of the Waikane Golf Course was a two-part project. The first phase consisted of a surface and subsurface survey of the non-wetlands portion of the Special Management Area (SMA). The second phase consisted of a surface reconnaissance of the remaining acres which were to be affected by proposed development (c.250 ac). The two phases combined recorded a total of 29 sites (60 component features). Twenty-eight sites were newly identified and one previously identified site was relocated. Formal feature types present within the project area include terraces, mounds, ditches, boulder concentrations, retaining walls, lithic scatters, coral scatters, alignments, historic burials, debris scatters, pits, man-made caves, sunken agricultural fields, a trail, a midden scatter, a historic house site, a possible terrace, a boulder with mortar depressions, and a possible inclined ramp.

The 29 sites consist of remains dating to the prehistoric and historic periods. Historic period remains consist of agricultural, habitation, religious, transportation, and indeterminate functional features. Prehistoric sites include agricultural, tool manufacture, religious, habitation, possible transportation, and indeterminate functional features.

The subsurface testing of the SMA portion of the project area consisted of excavating ten backhoe trenches. Trenches 1, 2, 3, 4, and 10 were excavated in or in the vicinity of LCA 5658:5; Trenches 5 and 6 were excavated within LCA 5954:1; and Trenches 7, 8, and 9 were excavated in LCA 5658:6 (see Figure 3). The soils in the trenches were categorized according to four macro soil units. Briefly, Unit A is comprised of recent silty loam/clay alluvium, and Unit D is comprised of alluvial marsh deposits. All ten backhoe trenches yielded Unit A deposits. Seven trenches (Trenches 1, 2, 5, 6, 7, 9, 10), possibly eight (Trench 3), yielded Unit B deposits. Based on an examination of maps, an examination of trench stratigraphy, and based on informant information, it is concluded that Unit A deposits were used to cultivate rice and other crops from c. 1900 until as late as the 1970s (informant Emma Yoshida indicates the areas of Trench 1, 2, 5, 6, and 10 were under rice cultivation as recently as the 1970s). As indicated by prior depositional studies, Unit B deposits--deposits of grey gley containing lenses of oxidized soil, abundant quantities of charcoal, and carbonized floral remains--represent buried rice or taro fields (Kirch 1977; Allen 1987; Riley 1973). In the SMA portion of the project area, Unit B soils usually directly underlie Unit A deposits. These Unit B soils then date prior to the 1900s. In Trenches 1, 2, 5, and 6 (and possibly Trench 3), however, two strata of gley and gley-like material were found; these two Unit B strata were separated by alluvium 15-30 cm thick. The lower gley strata were no closer than 80-100 cm from ground surface, and they extended to 100-120 cmbs. The depth of the lower Unit B deposits--the fact that the deposits are present below (a) recent agricultural alluvium (Unit A), (b) other gley deposits representing taro cultivation (Unit B), and (c) buried marsh alluvium (Unit C) indicates that the lower Unit B deposits are quite old. They may date to at least the late prehistoric period. Based on extent, depth, and thickness of Unit B deposits, and based on the discontinuity of Unit B deposits, it can at least be concluded that Unit B deposits represent former widespread, intensive irrigation agriculture that may likely include use of Site T-4.

GENERAL SIGNIFICANCE ASSESSMENTS AND RECOMMENDED GENERAL TREATMENTS

To facilitate outside review, general significance assessments and recommended general treatments for all identified sites are summarized in Table 8. Significance categories used in the site evaluation process are based on the National Register criteria for evaluation, as outlined in the Code of Federal Regulations (36 CFR Part 60). The DLNR-HSS/State Historic Preservation Office (SHPO) uses these criteria for evaluating cultural resources. Sites determined to be potentially significant for information content (Category A, Table 8) fall under Criterion D, which defines significant resources as ones which "...have yielded, or may be likely to yield, information important in prehistory or history." Sites potentially significant as representative examples of site types (Category B, Table 8) are evaluated under Criterion C, which defines significant resources as those which "...embody the distinctive characteristics of a type, period, or method of construction...or that represent a significant and distinguishable entity whose components may lack individual distinction" (36 CFR Sec. 60.4).

Sites with potential cultural significance (Category C, Table 8) are evaluated under guidelines prepared by the Advisory Council on Historic Preservation (ACHP) entitled "Guidelines for Consideration of Traditional Cultural Values in Historic Preservation Review" (ACHP 1985). The guidelines define cultural value as "...the contribution made by an historic property to an ongoing society or cultural system. A traditional cultural value is a cultural value that has historical depth." The guidelines further specify that "[a] property need not have been in consistent use since antiquity by a cultural system in order to have traditional cultural value."

Of the total 29 sites recorded in the Waikane Golf Course project area, 21 sites are assessed as significant solely for information content. For nine of these 21 sites, no further work is recommended. Further data collection is recommended for 12 of the 21 sites. Of the remaining eight sites: (a) four are assessed as significant for information content and are tentatively assessed as culturally significant. Further data collection and a tentative recommendation of preservation "as is" are recommended for these four sites; (b) two are

Table 8.

SUMMARY OF GENERAL SIGNIFICANCE ASSESSMENTS AND RECOMMENDED GENERAL TREATMENTS WAIKANE GOLF COURSE PROJECT AREA

Site Number	Significance Category				Recommended Treatment			
	A	X	B	C	FDC	NFW	PID	PAI
T-5	+	-	-	-	+	-	-	-
T-7	+	-	-	-	+	-	-	-
T-9	+	-	-	-	+	-	-	-
T-15	+	-	-	-	+	-	-	-
T-17	+	-	-	-	+	-	-	-
T-20	+	-	-	-	+	-	-	-
T-21	+	-	-	-	+	-	-	-
T-22	+	-	-	-	+	-	-	-
T-23	+	-	-	-	+	-	-	-
T-26	+	-	-	-	+	-	-	-
T-30	+	-	-	-	+	-	-	-
T-31	+	-	-	-	+	-	-	-
Subtotal: 12	12	0	0	0	12	0	0	0

General Significance Categories:

A=Important for information content, further data collection necessary (PHRI=research value);
X=Important for information content, no further data collection necessary (PHRI=research value, DLNR-HSS=not significant);
B=Excellent example of site type at local, region, island, State, or National level (PHRI=interpretive value); and
C=Culturally significant (PHRI=cultural value).

Recommended General Treatments:

FDC=Further data collection necessary (intensive survey and testing, and possibly subsequent data recovery/mitigation excavations);
NFW=No further work of any kind necessary, sufficient data collected, archaeological clearance recommended, no preservation potential;
PID=Preservation with some level of interpretive development recommended for consideration (including appropriate related data recovery work); and
PAI=Preservation "as is," with no further work (and possible inclusion into landscaping) (and possible subsequent data recovery/mitigation excavations).

Table 8. (Cont.)

Site Number	Significance Category				Recommended Treatment			
	A	X	B	C	FDC	NFW	PID	PAI
T-10	+	-	-	*	+	-	-	*
T-16	+	-	-	*	+	-	-	*
T-19	+	-	-	*	+	-	-	*
T-33	+	-	-	*	+	-	-	*
Subtotal: 4	4	0	0	4	4	0	0	4
T-24	+	-	-	+	+	-	-	+
T-27	+	-	-	+	+	-	-	+
Subtotal: 2	2	0	0	2	2	0	0	2
T-32	+	-	+	+	+	-	+	-
80-06-317	+	-	+	+	+	-	+	-
Subtotal: 2	2	0	2	2	2	0	2	0
T-1	-	+	-	-	-	+	-	-
T-2	-	+	-	-	-	+	-	-
T-3	-	+	-	-	-	+	-	-
T-4	-	+	-	-	-	+	-	-
T-13	-	+	-	-	-	+	-	-
T-14	-	+	-	-	-	+	-	-
T-18	-	+	-	-	-	+	-	-
T-25	-	+	-	-	-	+	-	-
T-29	-	+	-	-	-	+	-	-
Subtotal: 9	0	9	0	0	0	9	0	0
Total: 29	20	9	2	8	20	9	2	6

*Tentative assessment pending further data collection.

assessed as culturally significant and significant for information content. Further data collection and preservation "as is" are recommended for these two sites; (c) two sites are assessed as significant for information content, as excellent examples of site types, and are culturally significant. Further data collection and preservation with interpretive development are recommended for these two sites.

It should be noted that the above evaluations and recommendations are based on the findings of a surface reconnaissance survey with only limited subsurface testing. Thus, there is always the possibility, however remote, that potentially significant unidentified cultural remains will be encountered in the course of future development activities. In such a situation, archaeological consultation should be sought immediately.

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APPENDIX: A

DETAILED SITE DESCRIPTIONS

SITE NO.: **State:** 00317 **BPBM:** -- **PHRI:** --
SITE TYPE: Complex (4 Features)
TOPOGRAPHY: On slope of Puu Pueo ridgeline.
VEGETATION: Octopus tree, koa-haole, ti, Christmas-berry, Java Plum, papaya, lilikoi
CONDITION: Fair
INTEGRITY: Altered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Religious-Heiau
DESCRIPTION: Some bulldozing may have occurred around southern periphery of the site area. A new residence with wire fenceline is 12.5 m. to the south of the southern edge of lower terrace (Feature C). Some extensive clearing of vegetation will be necessary to do detailed recording of the site. Additional features are undoubtedly buried and hidden in the thick vegetation. The soil on the slope of Puu Pueo ridgeline contains a significant amount of angular basalt cobbles (small-large) and boulders (small). These rocks were utilized in the construction of the site and its features. The dirt and rock slope of ridgeline appears to have been cut into and used to build the two terraces. It appears that bulldozing activity has occurred along the southern and perhaps the eastern edges of the site. A recent wire fenceline is located 12.5 m south of the southern edge of the lower terrace (Feature C). Just beyond the fenceline a new residence is currently under construction. As development continues to occur around the site, the likelihood for further indirect impacts and deterioration is inevitable. Attempts should be made to stabilize the site and minimize its continuing deterioration. Several other sites are within the vicinity of Kukuianiani Heiau and are probably related to it. These include sites: T-16, a roughly cresent-shaped mound which may be an exhumed burial; T-17, a terrace with a rock alignment on the downslope edge; T-32, a small shrine/possible burial with an upright stone; and a T-33, a rock mound and rock alignment. There are undoubtedly more sites and features associated with Site 0317 up the slopes of Puu Pueo ridgeline.

FEATURE A: Large boulder with mortar depressions
DIMENSIONS: 1.35 m by 0.70 m by 0.50 m

Large, rectangular, dense, basalt boulder with two pounded/ground out depressions on the surface. The boulder appears waterworn and is supported with cobbles on the north end. The depressions average 0.5 m by 0.45 m by 0.15 m in depth. Feature A is located at the end of Feature B ramp at the base of Kukuianiani Heiau.

FEATURE B: Possible ramp
DIMENSIONS: 15.00 m by 15.00 m by 0.50 m (approx.)

Possible ascending ramp/entrance to main structure of heiau. Constructed on an incline and is paved with angular basalt cobbles (small to large) with some waterworn basalt cobbles. Ramp is approximately 1.75 to 2.0 m wide and curves around the NE corner of Feature C terrace. Possible post holes noted on the NE surface of the feature. No definite cultural deposit visible, but possibly present subsurface.

FEATURE C: Terrace
DIMENSIONS: 29.00 m by 20.00 m by 3.00 m (approx.)

A large flat and basically level terrace area which is a part of Kukuianiani Heiau. The surface is littered with angular basalt cobbles and soil. The east side of the terrace is a sloping retaining wall of basalt cobbles rising 2.5 to 3.0 m above Feature B ramp. There is a boulder alignment in the north end of this retaining wall. It is 3.0 m in length and 1.5 m above Feature B ramp. At 1.8 m north of boulder alignment, along the north side of Feature C, is the E-W extension of Feature B ramp. A possible collapsed wall or mound is at the north central edge of the terrace, at the west end of Feature B ramp. Sloping basalt cobble wall on the west side supports the upper terrace Feature D. No definite cultural deposit visible, but possibly present subsurface. New house construction to south at c. 20.0 m.

FEATURE D: Terrace
DIMENSIONS: 20.00 m by 13.50 m by 2.50 m (approx.)

The upper (western most) terrace area of Kukuianiani Heiau. The soil surface is basically flat and level and is littered with angular basalt cobbles. There is a basalt cobble and boulder retaining wall to the north and a sloping retaining wall to the west. The SE corner appears to have been impacted by a bulldozer. A possible collapsed rock wall or alignment in this corner area may be bulldozer push. No definite cultural deposit visible in this terrace, but possibly present subsurface.

SITE NO.: State: -- **BPBM:** -- **PHRI:** T-1
SITE TYPE: Ditch
TOPOGRAPHY: At base of steep slope on northern edge of Waikane Valley.
VEGETATION: Christmas-berry, lantana, and various grasses.
CONDITION: Fair
INTEGRITY: Unaltered
PROBABLE AGE: Historic
FUNCTIONAL INTERPRETATION: Agriculture
DESCRIPTION: Ditch may have serviced LCA parcels 5954:1 and 5658:5 during the first half of the 20th century. Site measures about 183.0 m long by 2.2 m wide, by 1.0 m deep. Much of the site is partially filled with recent alluvium.

SITE NO.: State: -- **BPBM:** -- **PHRI:** T-2
SITE TYPE: Ditch
TOPOGRAPHY: At base of low tableland on south margin of Waikane Valley.
VEGETATION: Java Plum, Christmas-berry, lantana, guava, and various grasses.
CONDITION: Fair-Good
INTEGRITY: Unaltered
PROBABLE AGE: Historic
FUNCTIONAL INTERPRETATION: Agriculture
DESCRIPTION: The site measures c. 166.0 m long by c. 3.0 m wide by c. 80 cm deep. Site T-2 is better-preserved than Site T-1. At its downstream end, the ditch branches into two ditches. One ditch leads to the north and back to Waikane Stream, the other outlet ditch turns south and parallels the edge of Site T-4, which is within the wetlands of the SMA portion project area. The outlet ditch is presently blocked with sandbags and debris. If the sandbags and debris were removed the outlet could once again transport water.

SITE NO.: State: -- **BPBM:** -- **PHRI:** T-3
SITE TYPE: Wall
TOPOGRAPHY: Next to flood-scoured, braided channels of Waikane Stream
VEGETATION: Various grasses.
CONDITION: Fair-Poor
INTEGRITY: Unaltered
PROBABLE AGE: Historic
FUNCTIONAL INTERPRETATION: Retaining Wall
DESCRIPTION: Site T-3 is a 6.0 m long retaining wall located at the edge of T-4. The site consists of two sections--a 1.5 m long, two course high alignment of waterworn basalt cobbles and boulders, and a 4.5 m long earthen embankment. Both cobble and earthen portions of the alignment are 50 cm wide.

SITE NO.: State: -- **BPBM:** -- **PHRI:** T-4
SITE TYPE: Sunken fields
TOPOGRAPHY: Level terrain
VEGETATION: Mangrove and various grasses.
CONDITION: Fair-good
INTEGRITY: Unaltered
PROBABLE AGE: Historic/Prehistoric?
FUNCTIONAL INTERPRETATION: Agricultural
DESCRIPTION: The fields comprise most of the wetlands of the SMA portion project area. Within the pondfields are earthen bunds and berms, some interconnected. Site T-4 was used for rice cultivation, most intensively from 1900-1925 (Young, n.d.); results of subsurface testing conducted along the western margin of Site T-4 suggest that prior to rice cultivation the fields may have been used prehistorically to grow taro.

SITE NO.: State: -- BPBM: -- PHRI: T-5
SITE TYPE: Complex (2 Features)
TOPOGRAPHY: At bottom of ravine.
VEGETATION: Hau, vervain, various ferns, grasses, Java Plum, octopus tree
CONDITION: Good
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Agricultural
DESCRIPTION: Appears to represent prehistoric agricultural features. No terraces were observed in the vicinity, but due to erosion and deposition along the drainage such features could be obscured. Overall complex measures c. 25.0 m by 7.0 m. Site datum tag is located at Feature B. From Feature A to center of drainage: 230 degrees, c. 9-10.0 m/130 degrees, 15.0 m. Feature B to center of drainage: 150 degrees, 6.0 m.

FEATURE A: Mound
DIMENSIONS: 5.00 m by 3.70 m by 0.60 m

Roughly rectangular in plan. Constructed of large basalt and sandstone boulders and cobbles loosely piled 1-5 courses high. Rocks vary from 0.10-0.75 m in diameter. Mound is located on north side of ravine (intermittent drainage). Exact age and function of the feature are uncertain. Based on its proximity to the drainage, it probably represents an agricultural feature. Some of the boulders and cobbles are rounded, while others are sharp and angular. From Feature A to Feature B it is 20.5 m (center to center) at 63 degrees. A series of recent survey stakes and flag lines run through the drainage area through the drainage, along the SE edge of Features A and B. Survey stake marked "WAI-8-R" located between Features A and B.

FEATURE B: Sandstone boulder concentration
DIMENSIONS: 3.80 m by 2.20 m by 0.60 m

Twelve sandstone boulders varying in size from 0.3-1.2 m in diameter. Alluvial brown soil matrix present around boulders. The boulders are concentrated in a 3.8 m by 2.2 m area. Unlike at Feature A, the boulders are not stacked or piled. From Feature B to Feature A it is 243 degrees at 20.5 m. Feature B is located north of the ravine (intermittent drainage).

SITE NO.: State: -- BPBM: -- PHRI: T-7
SITE TYPE: Complex (7 Features)
TOPOGRAPHY: On flat to the north side of Waikane Stream.
VEGETATION: Dense hau, octopus tree, albizzia, lauhala, Boston fern, grasses, banana, mango, ginger, arums, noni, kukui, rose apple
CONDITION: Good
INTEGRITY: Unaltered

PROBABLE AGE: Prehistoric with possible historic use
FUNCTIONAL INTERPRETATION: Agricultural
DESCRIPTION: Site represents an extensive agricultural complex. T-6 ditch and T-11 mound were incorporated into the T-7 site complex as Features A and Feature G, respectively. Some extensive clearing of hau vegetation will be necessary prior to intensive survey. There may be buried rock features within the terraces at T-7. The use of a backhoe for trenching would enable buried rock features to be located, and hopefully will help determine the terrace boundaries and function more accurately.

FEATURE A: Ditch
DIMENSIONS: 160.00 m by 2.40 m by 0.90 m (approx.)

Previously referred to as T-6. Dug out into loamy clay with segments of stone retaining wall along creek edge. Stone ditch retaining wall measures 4.00 m long (120/300 degrees) by 0.85 m high, and is 4-5 courses high. From edge of stone wall to creek is 2.0 m. East end of ditch goes through very dense hau thicket and has been partially filled. West end of ditch appears to divert from Waikane Stream at eastern end of cliffs across stream from rice fields at Mr. Wade Okuda's meadow. A metal pipeline is located above the ditch and is currently transporting water at the western end of the ditch. A possible holding pond or reservoir is located SE of where the water is initially diverted. The ditch appears to fan out to the west of the main terrace area near the remnant of a banana orchard. It is possible the ditch was used in prehistoric times and was modified historically to water the banana patch. There are also a number of snare traps located throughout the terrace area along pig trails.

FEATURE B: Retaining wall
DIMENSIONS: 120.00 m by 1.20 m by 0.80 m (approx.)

Combination stacked waterworn large cobble wall and berm running basically parallel to Waikane Stream; acts as retainer/flood control for an agricultural terrace. Certain sections consist of stacked river rock (1-4 courses high), mostly large cobbles. In other sections of this berm, either no rock was used, or it has washed away. The SE section of this berm is mounded on the top between the river and Feature C terrace. As the mound dissipates to the SE there is another river cut which looks natural, but the river may have eroded away a part of the feature. There is also another possible section of retainment east of Feature F terrace, above the stream, c. 20.0 m in length, though this section is sloping towards the river and consists of many small cobbles and pebbles.

FEATURE C: Terrace
DIMENSIONS: 78.00 m by 13.00 m by 0.30 m

A low agricultural terrace with retaining wall running at roughly right angle to stream. There is a low bench on the stream side downstream from the retaining wall (Feature B). Terrace has a flat surface with earthen retaining wall on downslope edge and a rock and earthen berm (Feature B, partially destroyed) on the stream edge. A rock clearing mound is incorporated in the retaining wall. Mound is 2.0 m diameter and is 0.30 m high. Alluvial sediment of unknown depth present upstream of earthen retaining wall.

FEATURE D: Terrace
DIMENSIONS: 45.00 m by 18.00 m by 0.30 m (approx.)

A low agricultural terrace formed by an earthen retaining wall roughly perpendicular to the stream. It is partially eroded and the retaining wall incorporates Feature G, a low rock clearing mound. Alluvial sediment of unknown depth present upstream of retaining wall. Located downstream of Feature C, on the north side of stream, on a flood plain.

FEATURE E: Terrace
DIMENSIONS: 23.00 m by 11.00 m by 0.20 m (approx.)

A low terrace formed by an earthen retaining wall; two rock clearing mounds incorporated into wall. One mound measures c. 2.00 m in diameter by 0.25 m in height. The other measures c. 5.00 m in diameter by 0.15 m in height. Alluvium of unknown depth upstream of retaining wall.

FEATURE F: Terrace
DIMENSIONS: 30.00 m by 13.00 m by 0.20 m

A low terrace formed by an earthen retaining wall running roughly perpendicular to stream. Located on flood plain of Waikane Stream. Alluvium of unknown depth present upstream of retaining wall. Downstream from Feature F is an area of drainage lines, perpendicular to the creek, where water from the ditch to the terraces may have reentered the creek.

FEATURE G: Mound
DIMENSIONS: 3.30 m by 2.75 m by 0.50 m (approx.)

A low, centrally raised mound of loosely piled waterworn basalt cobbles, small to large, with one small waterworn basalt boulder. Located on the floor of Feature D terrace. Probably a clearing mound. Feature G was previously referred to as Site T-11. Three smaller rock concentrations (clearing piles) were observed. One was c. 10.0 m/145 degrees from Feature G and measured 0.90 m by 0.80 m by 0.15 m high. The second was c. 12.0 m/125 degrees from Feature G and measured 0.85 m by 0.75 m by 0.15 m in height. The third was c. 8.0 m/245 degrees from Feature G and measured 1.15 m by 1.00 m by 0.20 m in height.

SITE NO.: **State:** -- **BPBM:** -- **PHRI:** T-9
SITE TYPE: Lithic scatter
TOPOGRAPHY: Ridge top with steeply sloping sides to north and south.
VEGETATION: Java Plum, guava, grasses, ferns, octopus tree
CONDITION: Fair-eroded
INTEGRITY: Altered--motorcycle track, jeep and ATVs
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Tool manufacture
DIMENSIONS: 345.00 m by 8.00 m
DESCRIPTION: No formal construction. Three meters east of site tag is a concentration of waterworn cobbles which extend north to a gully bottom. Entire ridge top has sparse scattering of lithics. The main lithic concentration was in area of site tag area where 13 piece of volcanic glass were collected. A smaller concentration of lithics located on the south slope scar. East end of ridge erodes into a flat area. The west end slopes downward toward a stream. Portable remains include basalt flakes, volcanic glass, coral fragments, and waterworn basalt cobbles. The cultural deposit depth is undetermined (0.20+ m).

SITE NO.: **State:** -- **BPBM:** -- **PHRI:** T-10
SITE TYPE: Complex (2 Features)
TOPOGRAPHY: Ridge top with steep edges on the north and south. Slight slope east towards ocean
VEGETATION: Java Plum, guava, grasses, and ferns
CONDITION: Fair-eroded slope
INTEGRITY: Altered--motorcycle track
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Tool manufacture/religious
DESCRIPTION: No formal construction. Two boulders with possible surveyor markings located c. 25-35.0 m NNE of Feature A. Overall complex measures c. 330.0 m (E-W) by 5-12.0 m N-S.

FEATURE A: Lithic scatter
DIMENSIONS: 50.00 m by 6.00 m (approx.)

Located on crest of ridge on western side of Waikane Valley. Consists of scattering of flakes with one dense cluster at the upslope end of site. Collected material includes four pieces volcanic glass, one piece green chert flake, and one piece possible cut bone. Other portable remains consist of basalt flakes, a waterworn sandstone cobble, volcanic glass, two possible hammerstones, a coral grindstone, and an adze preform. Some cortex present on flakes. The A-horizon on the ridge appears to be c. 0.25 m thick and all the cultural material appears to be in the A-horizon. A possible rock alignment was noted 22.0 m downslope to the east at 98 degrees from the downslope end of the site. The alignment is similar to one at Site T-19, but no coral or cultural material associated with alignment.

FEATURE B: Coral surface scatters
DIMENSIONS: 6.00 m by 20.00 m (approx.)

An extensive surface scatter of waterworn coral fragments along the crest of the ridge. Scatters range from c. 0.5-0.8 m in length. One relatively dense cluster eroding out of motorcycle trail. One unifacially flaked "chopper" tool, coral sinker, several basalt flakes found at ends of feature. Dense cluster of waterworn coral fragments noted near high spot along ridge. Cultural material appears to be within A-horizon.

SITE NO.: **State:** -- **BPBM:** -- **PHRI:** T-13
SITE TYPE: Cave (man-made)
TOPOGRAPHY: Slope of hill
VEGETATION: Octopus tree, rose apple, ferns, and grasses
CONDITION: Good
INTEGRITY: Unaltered
PROBABLE AGE: Historic; probably WWII related
FUNCTIONAL INTERPRETATION: Indeterminate/Shelter?
DIMENSIONS: 3.80 m by 1.80 m by 1.50 m
DESCRIPTION: Site is very similar to T-14 cave on south side of Waikane Stream. Complete entry into T-13 not possible due to safety reasons. Cave did not appear to have niches or shelves, as at T-14. Like at T-14, a gully extends out from cave. There is a large mound of backfill soil at the end of the gully. Although the exact age and function of T-13 is unknown, there is little doubt that it is of historic origin. May be WWII related. Excavation in orange-brown clay present; probably excavated with pick or maddox. The entrance is 1.00 m wide and is 0.85 m high. Some collapsing at cave entrance.

SITE NO.: **State:** -- **BPBM:** -- **PHRI:** T-14
SITE TYPE: Cave (man-made)
TOPOGRAPHY: Near (c. 15.0 m.) flood plain on east side of Waikane Stream, in valley on windward side.
VEGETATION: Guava, mamake, schefflera, sword fern, lilikoi
CONDITION: Fair
INTEGRITY: Unaltered
PROBABLE AGE: Historic; probably WWII related
FUNCTIONAL INTERPRETATION: Indeterminate/Shelter?
DIMENSIONS: 4.70 m by 1.05 m by 1.50 m
DESCRIPTION: Two notches on western wall and three notches on east wall. Notches 10.0-60.0 cm in length by 9.0-47.0 cm in height by 8.0-31.0 cm in depth. From the entrance of the cave to the center of T-2 ditch is 12.5 m at 359 degrees. Excavated gallery into side of earthen bank. Sides show mattock and pick marks on clay walls. Several shallow niches have been cut into wall presumably to hold lamps. Entrance measures 1.65 m by 0.60 m. There is some

collapse at entrance. One machined wood fragment, a possible fragment of a window mullion, noted in niche on left side of cave.

SITE NO.: **State:** -- **BPBM:** -- **PHRI:** T-15
SITE TYPE: Lithic scatter
TOPOGRAPHY: Flat
VEGETATION: Java Plum, albizzia, various grasses, and scrub weeds
CONDITION: Fair
INTEGRITY: Altered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Tool manufacture
DIMENSIONS: 120.00 m by 30.00 m
DESCRIPTION: Site disturbed by recent agricultural activity--dirt berm, dirt road, and leveling present throughout site. Although impacted by agricultural activity, there may still be some information at the site. No intact deposit observed at site. Maybe intact deposit under thick grass. Over fifty basalt waste flakes, 3+ volcanic glass fragments, 4 pieces of coral, sandstone grindstone, basalt hammerstones, and two adze preforms noted at site. Materials may extend 0.1-0.2 m below surface, but difficult to determine due to agricultural activity. Fairly extensive lithic-adze manufacturing site. Coral (possible abrader fragments), basalt flake debitage, hammerstones, sandstone grind stones, and adze preforms could provide data on adze manufacturing sequences. The presence of volcanic glass, although sparse, could provide chronological information. Collected two pieces of volcanic glass for processing.

SITE NO.: **State:** -- **BPBM:** -- **PHRI:** T-16 (1 Feature)
SITE TYPE: Mound
TOPOGRAPHY: On east slope of ridge around toe from Waikane Valley flood plain.
VEGETATION: Schefflera, guava, Christmas-berry, palm tree, fern
CONDITION: Fair-good
INTEGRITY: Altered
PROBABLE AGE: Indeterminate/Historic?
FUNCTIONAL INTERPRETATION: Indeterminate/Religious-burial
DIMENSIONS: 5.00 m by 2.00 m by 0.80 m
DESCRIPTION: Large portion of mound surface appears to have been excavated over past year or so. Site is being impacted, probably by residents c. 50.0 m downslope. Feature is oval in plan at base, with foundation of boulders c. 0.30-0.40 m in diameter well set into earth. The west (upslope) wall consists of well-stacked cobbles/boulders up to 4 courses high. Wall slopes inward at 60-70 degrees. A 1.8 cm wide leather strap c. 12.0 cm long noted protruding from a partially collapsed portion of the rear wall. This strap had two oblong holes punched in it

and one hole cut rudely with a knife (?); iron one-piece buckle associated with strap. Area which has been excavated is on downslope side of feature. Floor of excavation is sloping and is possibly paved with small boulders and cobbles of angular basalt. There is an area of piled boulders to the south of the main feature and another flat concentration of cobbles on the surface SW of the feature.

SITE NO.: State: -- BPBM: -- PHRI: T-17
SITE TYPE: Terrace
TOPOGRAPHY: On flat bench at steep slope of ridge.
VEGETATION: Octopus tree, rose apple, false kamani
CONDITION: Good
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Agricultural
DIMENSIONS: 23.50 m by 4.70 m by 0.20 m
DESCRIPTION: Site may be associated with Kukuianiani Heiau. A shrine (T-32) is located just below the southern edge of the site. Shrine is c. 140 degrees at 23.0 m from T-17 datum. Extensive vegetation removal will be necessary. Small to large cobbles scattered about terrace and slopes above terrace. Large cobbles and smaller boulders appear to be roughly piled along the eastern edge of the terrace to form a linear rock alignment c. 0.50 m to 1.15 m wide (4-6 courses wide) by c. 0.1-0.2 m high (1-3 courses high). Alignment is along the downslope edge of the terrace, with the steep slope of the ridgeline below. Based on size and overall shape, site appears to represent agriculture rather than habitation. No portable remains, features, or midden accumulation visible.

SITE NO.: State: -- BPBM: -- PHRI: T-18
SITE TYPE: Lithic scatter
TOPOGRAPHY: Ridgeline
VEGETATION: Java Plum, Boston Fern, and various grasses
CONDITION: Fair
INTEGRITY: Altered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Tool manufacture
DIMENSIONS: 300.00 m by 45.00 m
DESCRIPTION: The ridgeline where the site is located has been dozed level and is planted with Java Plum trees. In addition, the area is currently being used as a dirt bike track, which contributes to its erosion. No dense concentration of material present; much of site disturbed. Sparse surface scatter of volcanic glass present, of which 10 pieces were collected. One basalt flake collected. Two dirt roads parallel length of ridgeline. The sparse

scatter of volcanic glass was observed within the southern dirt road cut. Much of ridgeline covered in thick grass, which makes it difficult to view the ground surface. Additional flakes may be present within the grass areas. However, the entire ridgeline has been bulldozed and planted with Java Plum trees making it unlikely that an intact deposit still exists on the ridge. Sites T-19 and T-20 are located at the eastern edge of the ridgeline, to the south of the eastern end of T-18. An area of basalt waterworn cobbles is located in the ravine between T-18 and Site T-9, which parallels the T-18 ridgeline. These cobbles do not appear to form any feature (like those at T-19) but they may represent manuported material.

SITE NO.: **State:** -- **BPBM:** -- **PHRI:** T-19
SITE TYPE: Alignment
TOPOGRAPHY: Slope below ridgeline.
VEGETATION: Java Plum, octopus tree, and grasses
CONDITION: Fair-good
INTEGRITY: Altered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Religious burial/shrine
DIMENSIONS: 1.60 m by 1.00 m by 0.20 m
DESCRIPTION: The site has been leveled flat by bulldozer; extensive erosion taking place as a result. In addition, the area is currently being used as a dirt bike area, contributing to the site's erosion. Rock alignment is still clearly defined and may contain an intact deposit. The site is on an eastern slope of a ridgeline, with a beautiful view of Kaneohe Bay and the islands north of Kaneohe Marine Air Station. Small boulders and large cobbles stacked in a rectangular alignment N-S and E-W. Rocks are of basalt and vary from 0.12 m to 0.25 m in diameter. Rocks appear to be sunken 0.1-0.2 m into the ground surface. Portable remains consist of 10+ coral fragments within the rock alignment, and several more coral fragments with rock cobbles which have eroded out of the alignment situated downslope. The site appears to represent a burial. The rectangular outline formed by the basalt cobbles and boulders plus the presence of several pieces of waterworn coral makes the site similar to other prehistoric burial sites. Due to the slope of the site below the main ridge and the dozer and dirt bike activity, several basalt cobbles and coral fragments undoubtedly originally part of the rock alignment have eroded downslope c. 20.0 m. The site is probably related to T-20 midden site and T-9 and T-18 lithic sites.

SITE NO.: **State:** -- **BPBM:** -- **PHRI:** T-20
SITE TYPE: Midden scatter (surface)
TOPOGRAPHY: Slope below ridgeline

VEGETATION: Java Plum and various grasses
CONDITION: Good
INTEGRITY: Unaltered
PROBABLE AGE: Indeterminate/Prehistoric
FUNCTIONAL INTERPRETATION: Possible habitation
DIMENSIONS: 8.00 m by 7.50 m
DESCRIPTION: Although the site is on a side slope below the ridgeline of Site T-18 lithic scatter, it does not appear to represent erosion or washout from T-18. The midden is concentrated in an 8.0 m diameter area, with material on the surface, and no apparent subsurface deposit. Much of the site is within thick grasses, and by clearing this area the site limits could be better established and it will be easier to determine if the site represents prehistoric or historic activity. Surface deposit of 20+ pieces of Tellinidae spp. shell and six (+) very small bone fragments (bone appears burnt) present. Scatter does not appear to have depth. Some erosion has occurred along eastern edge of site. Although the site is situated near known prehistoric sites, the recent bottle glass, plastic forks, aluminum beer cans, and other garbage at the site suggests some of the shells may be from recent consumption. Site located 15.0 m and 72 degrees Az, from T-20 datum to T-19 datum.

SITE NO.: **State:** -- **BPBM:** -- **PHRI:** T-21
SITE TYPE: Complex (3 Features)
TOPOGRAPHY: Flat along north side of "Hau Creek" drainage
VEGETATION: Dense hau thicket, octopus tree, Java Plum, Boston Fern, lilikoi, various grasses
CONDITION: Good
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Agriculture
DESCRIPTION: Overall complex area measures 75.0 m (E-W) by 50.0 m (N-S). A dirt road cut is located above the Feature C terrace area. Undoubtedly used in prehistoric times; possibly used during historic times. Some erosion of Feature A ditch has occurred along stream. Will require extensive clearing of vegetation. Will probably want to have a backhoe trench placed through the terrace features to locate possible buried rock features.

FEATURE A: Ditch
DIMENSIONS: 273.00 m by 1.40 m by 0.80 m (approx.)

Ditch is supported by a rock embankment at west edge near Feature C. The embankment is constructed of waterworn cobbles and small boulders c. 0.30 m in diameter. Embankment is 5 courses high; it measures 2.60 m by 1.50 m by 0.65 m high. The ditch is dug out of the loamy clay above the creek. Two possible diversions located along the ditch bring water to the Features B and C terrace areas. Ditch is eroded in areas between Features B and C, probably as a result of flooding. The possible diversions for Feature B and C off of Feature A are slight cuts off of the ditch near the upper sections of the terraces. These cuts are only visible along the ditch.

FEATURE B: Terrace
DIMENSIONS: 30.00 m by 6.50 m by 0.75 m (approx.)

Earthen terrace; no visible rocks as part of construction. Large boulders located on top of terrace, but they appear to be natural and are not part of the agricultural feature. Soil matrix is a brown loamy clay. The terrace may have been used in historic times.

FEATURE C: Terrace
DIMENSIONS: 20.00 m by 12.00 m by 0.80 m (approx.)

Flat area along the creek just above Feature A ditch; no visible rock construction.

SITE NO.: **State:** -- **BPBM:** -- **PHRI:** T-22
SITE TYPE: Lithic scatter (sparse)
TOPOGRAPHY: Ridgeline
VEGETATION: Plums, octopus trees, grasses, ferns, and orchids
CONDITION: Fair
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Tool manufacture
DIMENSIONS: 42.00 m by 3.00 m
DESCRIPTION: Some erosion has occurred, partly due to dirt bikes. A sparse deposit of basalt rock, a basalt core, and worked and unworked basalt flakes. An area of small basalt cobbles (4.0 m and 300 degrees from lower sandstone outcrop) measures 0.45 m by 0.35 m. Cobbles roughly piled and clustered. Cobbles do not appear to form a hearth. One rock appears to be polished--may be a grinding stone fragment. May want to excavate concentration in order to determine if subsurface feature is present. A few rocks 1.5 m downslope of the concentration apparently have eroded out of the concentration. Average size of the basalt cobbles is 0.7-0.13 m. in diameter. No deposit or portable remains associated with rock concentration. The large basalt core measures 0.31 m by 0.22 m by 0.8 m.

SITE NO.: **State:** -- **BPBM:** -- **PHRI:** T-23
SITE TYPE: Lithic scatter
TOPOGRAPHY: On steep slope of ridgeline
VEGETATION: Octopus tree, mango, pili, schefflera, albizzia, sword fern
CONDITION: Good

INTEGRITY: Unaltered--some erosion of intact deposit has occurred
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Tool manufacture/habitation
DIMENSIONS: 35.00 m by 23.00 m
DESCRIPTION: A 0.40-0.60 m cultural deposit on top of orange-brown clay soil. This site has the greatest research potential of all lithic sites in the project area. The substantial (1000+) basalt waste flakes, several adze preforms, and volcanic glass is likely to yield significant information on lithic technology, manufacturing sequences and stages of adze tool making. In addition, the midden deposit could provide important information on temporary habitation related to lithic working areas. A few very fine-grained basalt or chert waste flakes present. A sample of chert waste flakes, 2 adze blanks, and volcanic glass were collected. A substantial amount of charcoal material, present in an eroded cut, can yield a C-14 date to cross check with volcanic glass data. Although much of the site area has eroded, there are still areas of intact deposits where several test units could be excavated.

SITE NO.: **State:** -- **BPBM:** -- **PHRI:** T-24
SITE TYPE: Trail
TOPOGRAPHY: Stream bank
VEGETATION: Java Plum, octopus tree, guava, mountain apple, Boston Fern, grasses
CONDITION: Fair
INTEGRITY: Altered by recent land survey work
PROBABLE AGE: Indeterminate
FUNCTIONAL INTERPRETATION: Transportation
DIMENSIONS: 130.00 m by 1.00 m by 0.00 m
DESCRIPTION: Trail located on the north side of stream bank. It roughly parallels small stream surrounded by historic debris. Trail may lead to Site T-27 cemetery. No formal construction. Worn in red clay soil with no retaining or constructed gully crossings noted. West end of trail appears to be erosional gully. The east end of trail ends at dirt road. Brush and trees have been cut along trail.

SITE NO.: **State:** -- **BPBM:** -- **PHRI:** T-25
SITE TYPE: Mound
TOPOGRAPHY: Edge of meadow, flat.
VEGETATION: Banyan, and various grasses
CONDITION: Good
INTEGRITY: Unaltered
PROBABLE AGE: Historic
FUNCTIONAL INTERPRETATION: Agriculture
DIMENSIONS: 2.50 m by 1.90 m by 0.50 m
DESCRIPTION: Banyan tree has grown around feature. Historic shacks and debris within and around the banyan. Rock mound may

represent a clearing pile. Consists of loosely piled basalt boulders (0.25-0.55 m in diameter). Exact dimensions difficult to obtain due to banyan tree growing around the rock mound. One piece of coral (possible abrader fragment) was located on NW side of banyan tree in a disturbed area. Mound may represent a clearing pile.

SITE NO.: State: -- **BPBM:** -- **PHRI:** T-26
SITE TYPE: Complex (2 Features)
TOPOGRAPHY: Valley bottom, adjacent to Waikane stream on north side
VEGETATION: Hau, kukui, octopus tree, guava, ginger, rose apple, unidentified trees, and ground cover
CONDITION: Fair
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric/Historic
FUNCTIONAL INTERPRETATION: Agriculture
DESCRIPTION: Backhoe trenching would help to confirm if the flat does represent an agricultural terrace, and would also reveal any buried construction features. The site area is within the area to be impacted by the proposed golf course. Overall complex area measures c. 65.0 m (N/S) by c. 55.0 m (E/W). *Feature A is relatively flat and level (possible* flood plain). Feature B is a a rectangular rock alignment. There is a possible spring drainage from the north cliff, c. 10.0 m east of Feature B.

FEATURE A: Terrace
DIMENSIONS: 65.00 m by 40.00 m by 0.60 m (approx.)

Relatively flat and level area adjacent to Waikane Stream on the SW side; abuts steep mountain slopes on north side. There is a NE-SE swale running through the SE side of the terrace; swale may be natural stream erosion. A 4-in ferrous pipe emerges from the east corner of the swale at 0.20 m below the upper NW terrace area. Pipe might be connected to the spring area. The spring area from cliff edge is c. 20.0 m away at 335-340 degrees. The terrace was probably used prehistorically.

FEATURE B: Rock alignment
DIMENSIONS: 2.70 m by 2.60 m by 0.30 m (approx.)

Rectangular in plan; built on Feature A terrace abutting rock cliff on the north side. Constructed mostly of small angular basalt boulders with a few waterworn boulders and large cobbles aligned in single courses against cliff edge. No cultural deposit noted. Historic charcoal deposit under cliff overhang includes melted historic rubbish. Feature B appears to be historically constructed.

SITE NO.: **State:** -- **BPBM:** -- **PHRI:** T-27
SITE TYPE: Complex (15 Features)
TOPOGRAPHY: Flat bench on slope of ridgeline
VEGETATION: Octopus tree, Boston fern, Christmas-berry, guava, sleeping grass, rose apple, vervain, albizzia, mango, koa-haole
CONDITION: Good
INTEGRITY: Unaltered-altered
PROBABLE AGE: Historic
FUNCTIONAL INTERPRETATION: Religious-cemetery
DESCRIPTION: The site is close to lot #1 boundary area of proposed impacts. Although most of the graves appear to have been disinterred and relocated, at least four are intact and should be preserved or relocated if impacts to the area are proposed. According to Emma Yoshida, several of the burials which were located at this cemetery were disinterred by relatives and removed to other cemeteries. Overall complex area measures 23.0 m (N-S) by 17.0 m (E-W). It would take at least 2 full man-days to clear the area of vegetation for detailed mapping and recording. The estimated man-days does not include disinterment.

FEATURE A: Burial
DIMENSIONS: 2.45 m by 1.20 m by 1.17 m

Constructed on the side of a steep hill above the Waikane flood plain. Remains of a rectangular structure with board walls and an asphalt shingle roof. A simple intact wooden cross constructed of 2" by 4" lumber, two glass jars, and a coffee can present. It appears to be an intact grave site (not disinterred).

FEATURE B: Pit
DIMENSIONS: 1.70 m by 0.90 m by 0.35 m

An exhumed historic grave dug into the hillside; mound of excavated earth and stone cobbles and small boulders upslope of pit. 2.0 m upslope is Feature C. A 6 oz. clear drinking glass was set upright into center of mound of stones upslope of pit. Possibly 0.30 m of material piled into the excavated portion of mound.

FEATURE C: Pit
DIMENSIONS: 2.10 m by 1.30 m by 0.55 m

Oval pit (in plan) dug in red clay. Some angular and waterworn basalt cobbles remain in the excavated pit and in the NW wall. One broken soda bottle in pit. A rock pile to the south between Features B and C may consist of material from both Features C and B.

FEATURE D: Pit
DIMENSIONS: 0.85 m by 0.75 m by 0.22 m

Similar to Features B and C. Pit excavated in red clay. Loosely piled basalt rocks and cobbles immediately to the SE. Rocks may have been excavated from pit.

FEATURE E: Pit
DIMENSIONS: 1.20 m by 0.75 m by 0.20 m

Pit excavated into hillside. There is no noticeable berm surrounding pit indicating no recent excavation. A small porcelain tea cup was noted in the center of the depression. About 1.5 m to the west of Feature E is a shallow depression. This depression is situated midway between Feature E and Feature B. The function of the depression is indeterminate at present but it may also be a grave, possibly a child's grave.

FEATURE F: Pit
DIMENSIONS: 1.50 m by 0.80 m by 0.25 m

Oval pit excavated in red clay. Similar to Features B, C, D, and E.

FEATURE G: Rock alignment
DIMENSIONS: 1.25 m by 0.55 m by 0.08 m

Four large angular basalt cobbles, exposed above surface in an E-W line. Several other cobbles exposed just north of alignment. The cobbles are placed in red clay, further rock may be below the surface. This is a possible intact burial.

FEATURE H: Pit
DIMENSIONS: 2.50 m by 1.40 m by 0.85 m

No rocks noted around pit. Pit is linear with the axis oriented NW-SE. Excavated in red clay and is similar to Features B to F. Based on its linear shape (in plan), pit may contain an extended burial or a coffin.

FEATURE I: Debris scatter
DIMENSIONS: 1.80 m by 1.60 m

A pile of rotten lumber--2 by 4 and 1/2 in siding painted bright green and light pastel green. Glass and plastic on surface of lumber, including 2 feet of steel mesh. Feature may be remains of a grave house.

FEATURE J: Pit
DIMENSIONS: 0.50 m by 0.50 m by 0.08 m

A shallow circular depression dug into a sloping soil surface. On the surface are two glass soda bottles, a fragment of a one-gallon paint can, and a short-stemmed porcelain vessel that was probably used for flowers and offerings associated with the depression.

FEATURE K: Pit
DIMENSIONS: 2.80 m by 2.10 m by 0.62 m

A relatively large pit dug in order to exhume the remains of a historic burial. Several screw top glass jars and one neck of a glass gallon jug associated with pit. The pit was excavated to c. 1.0 m.

FEATURE L: Burial
DIMENSIONS: 3.25 m by 2.00 m by 1.00 m (approx.)

A rectangular poured-concrete retaining wall with a row of 4" by 8-12" cinder blocks laid on top of wall all around grave. There might have been a railing around the grave, a railing supported by steel fence posts. Three posts still stand in corners of the grave enclosure. Burial appears to be intact. Screw top glass jars and plastic jugs associated with feature.

FEATURE M: Burial
DIMENSIONS: 1.57 m by 0.88 m by 0.70 m

Intact burial located in hill; just NE of Feature L. A number of large angular cobbles present; also, wooden railing 0.70 m high supported by four pieces of metal water pipe. The four pieces of pipe are driven into the ground at the corners. The railing and the upper surface of the grave slopes downward with the ground surface. A Diamond Head soda bottle and a #10 can wrapped in aluminum is associated with the grave.

FEATURE N: Pit
DIMENSIONS: 3.00 m by 1.35 m by 0.30 m

Similar to Feature H. The pit is rectangular in plan with the long axis running E-W. It is excavated in red clay and appears to have been exhumed. A ceramic flower vase in the center of the pit floor measures 0.24 m by 0.13 m by 0.09 m.

FEATURE O: Pit
DIMENSIONS: 2.03 m by 1.25 m (approx.)

Grave on sloping hillside delineated by a single row of 4" by 8" by 16" cinder blocks laid on edge. Only portions of pit remain intact. Glass jars associated with pit. A piece of corrugated iron roofing and rotted wood framing present just downslope of feature.

SITE NO.: **State:** -- **BPBM:** -- **PHRI:** T-29
SITE TYPE: Ditch
TOPOGRAPHY: Waikane Stream bank
VEGETATION: Mango, plum, banana, hau, guava, albizzia, ferns, grasses, unidentified trees
CONDITION: Poor-fair
INTEGRITY: Altered--historic flume gate, road cut
PROBABLE AGE: Prehistoric/historic
FUNCTIONAL INTERPRETATION: Agriculture
DIMENSIONS: 68.00 m by 1.30 m by 0.25 m
DESCRIPTION: May be uppermost section of Site T-1 (ditch). Possible old taro terraces in area.

Constructed with waterworn basalt boulders and cobbles and concrete. A laid cobble/retaining wall is present on the stream side of the ditch. A concrete "Tee" was noted, with notches for wooden gates. "Tee" was for probable 0.40 m by 0.30 m wooden flume constructed to carry water across stream to flood plains. Portable remains at site include concrete, wood, and historic rubbish.

SITE NO.: **State:** -- **BPBM:** -- **PHRI:** T-30
SITE TYPE: House site
TOPOGRAPHY: Flat ridge top.
VEGETATION: Albizzia, guava, ginger, grasses, Java Plum, octopus tree, mango, ferns, heliconia
CONDITION: Poor
INTEGRITY: Altered-evidence of bulldozing
PROBABLE AGE: Historic
FUNCTIONAL INTERPRETATION: Habitation
DIMENSIONS: 24.00 m by 20.00 m
DESCRIPTION: Furrows noted in site area are probably bulldozer tracks. A portion of the site has intact foundation blocks. Present in area are scattered lumber, roofing, tiles etc. Intact joist sections and cinder block foundations are present at north end of house site. Possible privy pit (0.45 m deep) south of site. Other portable remains include corrugated metal, steel, a refrigerator, a kitchen sink, bottles, and waterworn cobbles.

SITE NO.: **State:** -- **BPBM:** -- **PHRI:** T-31 (3 Features)
SITE TYPE: Complex
TOPOGRAPHY: On flat south of Waikane Stream. Located at northwest end of meadow where Mr. Wade Okuda resides.
VEGETATION: Hau, mango, octopus tree, albizzia, Java Plum, grasses, guava, ginger, rose apple, various ferns, sugar cane
CONDITION: Fair-good
INTEGRITY: Unaltered-altered
PROBABLE AGE: Prehistoric/historic
FUNCTIONAL INTERPRETATION: Agriculture

DESCRIPTION: Backhoe trenching may help determine if areas of rice fields were previously used for growing taro. Overall complex area measures c. 100.0 m (NW-SE) by 30.0 m (NE-SW). Although the present features represent historic irrigation, it is very likely that the area was also used for prehistoric agriculture.

FEATURE A: Ditch
DIMENSIONS: 120.00 m by 2.80 m by 0.80 m (approx.)

Earthen ditch, no rock construction observed. Southeast end of ditch severely disturbed by dirt road and outhouse. The ditch may have extended beyond the outhouse, but this is difficult to determine. The most intact section of the ditch is the northwest end near the Waikane Stream Gauge Station. The ditch was probably used for irrigation of the rice fields and may have irrigated the open meadow beyond the rice areas. A 12.0 segment of wire fence is located to the west of the ditch near its northern end. A definite cultural deposit is not visible. Loamy clay alluvium of unknown depth present. The ditch has a PVC pipe running through sections of it. The irrigation ditch is historic, but may have also been used prehistorically.

FEATURE B: Sunken agricultural field
DIMENSIONS: 47.00 m by 20.00 m by 1.00 m (approx.)

Located on flat south of Waikane Stream, at the northwest end of where Mr. Wade Okuda resides. Field is overgrown with grass and currently holds some water. The field is of earthen construction. It was probably used as taro fields both historically and prehistorically. The field-meadow area southeast of Feature B was most likely used for agriculture at one time or another.

FEATURE C: Sunken agricultural field
DIMENSIONS: 47.00 m by 25.00 m by 1.10 m (approx.)

Located on flat south of Waikane Stream, at the northwest end of where Mr. Wade Okuda resides. It is overgrown with grass and currently holds some water. The field is of earthen construction; it was probably used as taro fields both historically and prehistorically. The field-meadow area southeast of the rice fields was most likely used for agriculture at one time or another.

SITE NO.: State: -- **BPBM:** -- **PHRI:** T-32
SITE TYPE: Mound
TOPOGRAPHY: On steep slope of ridgeline
VEGETATION: Octopus tree, Christmas-berry, lilikoi, rose apple, ferns
CONDITION: Good
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric possibly historic
FUNCTIONAL INTERPRETATION: Religious-shrine/possible burial
DIMENSIONS: 2.45 m by 1.60 m by 0.60 m

DESCRIPTION: This mound is probably related to Kukuianiani Heiau and may also be associated with Sites T-16 (mound) and T-17 (terrace). The mound is 23.0 m at 140 degrees from T-17. The mound is in good shape, with an upright stone still in-situ. The site is not within the area to be impacted by the proposed golf course; however, attempts should be made to insure preservation of the site. The shrine is impressive even though it is relatively small. It is highly recommended that the site be preserved. Mound is constructed of stacked basalt cobbles and small boulders; upright stone measures 0.30 m by 0.18 m by 0.56 m in height. Rough facing on eastern (downslope) side is 1.3 m in length and 0.6 m in height and 3-4 courses high. No associated portable remains or other materials.

SITE NO.: **State:** -- **BPBM:** -- **PHRI:** T-33 (2 Features)
SITE TYPE: Complex
TOPOGRAPHY: Located on a steep slope, which slopes northeast toward the coast
VEGETATION: Christmas-berry, guava, octopus tree, koa-haole, vines, ferns, unidentified tree
CONDITION: Fair
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Indeterminate/Religious/Agriculture
DESCRIPTION: May want to test excavate in order to determine function of site--if religious or agricultural. If it is a burial it is a fairly large feature and may contain more than one individual. Overall complex area measures c. 17.0 m (E-W) by 9.0 m (N-S). Kukuianiani Heiau is located c. 75.0 m and 90 degrees downslope. Feature B is 14.0 m and 250 degrees from the northeast corner of Feature A. Feature B is aligned at 162/342 degrees.

FEATURE A: Mound
DIMENSIONS: 7.00 m by 3.50 m by 1.10 m

Piled angular cobbles and small boulders, centrally raised on the west side. The east side is partially faced 3-7 courses high. A bottle top is present in the faced portion, c. 3.30 m from the northeast corner of the mound. May be burial or clearing mound. Kukuianiani Heiau is located just downslope at c. 75.0 m.

FEATURE B: Possible terrace
DIMENSIONS: 8.00 m by 3.00 m by 0.50 m (approx.)

Retaining wall of terrace comprised of stacked basalt boulders and cobbles. Possible faced section at the southeast end. The terrace retains a fill of cobbles and soil.

APPENDIX K
Biological Survey

BIOLOGICAL SURVEY OF WAIKANE STREAM
WINDWARD O'AHU

Submitted to Group 70

by Kelly M. Archer
Aquatic Biologist

February 1988

INTRODUCTION

A biological survey of the aquatic fauna of Waikane Stream was conducted during the month of January, 1988. The purpose of the survey was to identify conspicuous native stream fauna, determine their relative population sizes and comment on the possible deleterious effect developing a golf course within Waikane Valley would have on the aquatic biosystem.

Waikane Stream flows into Kaneohe Bay on the northeastern shore of the island of O'ahu. The proposed project site stretches from the lower reaches of the valley (from Kamehameha Highway) to approximately one mile inland, where the stream elevation is 125 ft.

The headwaters of Waikane Stream originate along the ridge of the Koolau mountain range above 2200 ft. elevation. Waikane is a second order stream joined by a tributary, Waikeekee Stream, from the eastern portion of the valley, at approximately 120 ft. elevation. Above the planned project area the stream is characterized by strong-flowing riffle reaches with boulder, cobble and gravel substrate. Within the project area the mainstream meanders along the valley floodplain toward Kaneohe Bay. The stream is a series of riffle and pool reaches and the substrate changes from cobble, gravel and sand, to sand and gravel in the wetland area. Within the wetlands, the stream branches several times leaving a poorly defined channel until the stream runs adjacent to the highway and passes under the highway bridge.

Waikane Valley has been highly modified by man's activities for many decades. Farming and small ranching enterprises have used the valley since before the turn of the century. Native plant and animal populations can no longer be found in the area (Refs. 1,2). Waikane Stream is currently being used as a source of irrigation water for the farmers and a family prawn farm just mauka of the planned project area. Erosion of the ridges and hills within the valley cause even the lightest rainfall to dramatically increase the sediment load of the stream. Make-shift residences and rusting automobiles and busses upstream from the wetland area contribute to the poor esthetic quality of much of the stream's banks. The riparian vegetation, almost entirely alien in origin, completely covers the stream in a number of areas and is often quite thick and impassable.

LITERATURE REVIEW

There are two recent studies which include a discussion of the biology of Waikane Stream: the first, in 1977 (Ref. 3), was completed by the U.S. Fish and Wildlife Service. In this study of the water-dependent fish and wildlife resources of Kaneohe Bay, the Service sampled Waikane Stream at a single location along the highway. In 1983, this author sampled the same location (Ref. 4). The findings of these two reports will be discussed later in this survey. Apparently, a thorough study of Waikane Stream had not been undertaken until now.

METHODOLOGY

Sampling Methods

Two basic sampling methods have been used to complete stream surveys in this state. The use of a backpack electroshocker, which temporarily stuns the affected fauna to facilitate capture and identification; and visual sampling - using snorkle and mask when possible. The latter method is suitable for determining the presence and relative abundance of fish and large invertebrates in small streams in Hawaii and involves careful observation from alongside and within the stream. When combined with snorkeling, only the most cryptic organisms avoid detection. This survey was completed using visual sampling. Native stream fauna, though usually benthic, are not cryptic and are identified readily by the experienced observer.

Sampling Stations

The stream within the project area, as well as approximately 200 meters above the mauka boundary of the project, was sampled during this survey. The entire stream reach was surveyed on at least two different occasions, with many reaches surveyed more often.

To facilitate discussion of the results of this survey, the stream was divided into three regions within the project site. Although no clear boundary exists between the regions, there were obvious physical and biological differences. The lower region of the stream is within the wetlands of the valley floor. The substrate is predominently sand and silt and the vegetative canopy is open.

In the middle region, the stream meanders between the hills within the valley and the valley walls. Deep pools separate slow flowing riffle areas and both the riparian vegetation and the high, steeply cut stream banks prevent direct light from reaching much of the stream. The substrate in the middle region is mainly gravel and cobble.

The upper region includes the most mauka portion of the project area as well as the 200 meter stream reach just above. The vegetative canopy is open and there are few steep banks to prevent light penetration. The substrate is composed of cobble, gravel and boulders.

HAWAIIAN STREAM FAUNA

Stream fauna in this state are often discussed in terms of their origin. Native fauna are those species which are found naturally in streams within the state. Alien species are present as a result of the actions of man. Fauna commonly found in streams in Hawaii are listed in Table 1.

Ten of the 24 species listed in Table 1 are considered native stream fauna. Two crustaceans, two molluscs and six fishes are either found naturally only in Hawaii (endemic) or are found naturally here and in other regions of the world (indigenous). Most of the native species are diadromous, meaning that passage to the sea and back is necessary for their reproductive success. These diadromous species live and spawn in freshwater and their hatchlings must spend a period of development in the ocean prior to migrating upstream. Most of the aquatic animals now found in Hawaiian streams have been intentionally or unintentionally introduced by man. Apparently only the prawn, Macrobrachium lar, and possibly some tilapia require a saltwater stage to complete their life cycle.

RESULTS

The species of stream fauna identified in Waikane Stream during this survey are listed in Table 2. Information regarding the relative abundances of these species can also be found in this table.

As shown in Table 2, the lower region of Waikane Stream supports a much richer faunal community than the other stream regions. Two crustacean and six fish species were identified in the lower stream region. Of these species, four are native (Macrobrachium grandimanus, Stenogobius genivittatus, Awaous stamineus and Kuhlia sandvicensis). In the middle region the only native species was the o'opu, (Awaous stamineus). Only a very few o'opu were observed in this stream region while the prawn population (M. lar) was large. The upper region of the stream within the project area supported a much larger population of the native o'opu and fewer prawns than downstream. Notably absent from all sampled reaches of the stream was the small native shrimp, Atyoida bisulcata (common in perennial Hawaiian streams), and the native mollusc Neritina granosa, rarely found on the island of O'ahu.

Native Stream Fauna

The following is a summary of the lifestyle and distribution of each of the four native species found in Waikane Stream during this survey (Refs. 4). Also included is a description of native species previously reported in Waikane but which were not located during this survey.

1. Macrobrachium grandimanus: o'pae o'eha'a.

An endemic, diadromous, palaemonid prawn which inhabits lower reaches of streams and mixohaline shoreline ponds throughout the State and ranges in size from 2 to 9 cm in total length (distance from the tip of the rostrum to the tip of the telson). This o'pae is an omnivore that ingests mostly detritus, although adults appear to prey on other benthic animals.

2. <u>Stenogobius genivittatus</u>: o'opu naniha.

One of the smaller (5-6 cm in length) diadromous native stream gobies, the naniha is widely distributed in Hawaii in mixohaline waters and lower stream reaches. This o'opu is also found in other areas in the tropical Pacific. Omnivorous, naniha eat plant material, plankton and small invertebrates.

3. <u>Awaous stamineus</u>: o'opu nakea.

This endemic, diadromous o'opu is the largest of the native gobies, reaching a maximum length of 30 cm. A small fishery is supported by nakea on the island of Kauai. The nakea is widely distributed on all islands but is found in smaller numbers on O'ahu and is considered "depleted" (Ref. 5). This o'opu is omnivorous, feeding on filamentous algae and benthic animals.

4. <u>Kuhlia sandvicensis</u>: aholehole.

A mixohaline kuhliid bass which is endemic and widely distributed throughout the State. Aholehole may reach 20 cm and, being mostly marine, are a principal predator in stream mouths and estuaries in Hawaii.

The following native species have been previously identified in Waikane Stream (Refs. 3,4).

<u>Atyoida bisulcata</u>: o'pae kala'ole.

A small (2-4 cm) endemic shrimp, usually common to abundant in perennial Hawaiian streams to 1,000 m elevation. The opae is primarily a detrital filter feeder and is diadromous, although there is still some question as to whether the diadromy is obligatory.

Eleotris sandwicensis: o'opu okuhe.

This diadromous eleotrid lacks the ventral sucking disk of the true gobies but is similar in appearance and is a ubiquitous endemic with a distribution similar to o'opu naniha. Okuhe may reach a size of 25 cm and is sometimes caught as a food fish. This o'opu is a carnivore, ingesting fish, insects and benthic animals.

DISCUSSION

The results of this survey show the typical decline in species richness found in Hawaiian streams as distance from the ocean increases. Commonly, opportunistic euryhaline species dominate lower stream reaches.

Waikane Stream has previously been identified as one of six "high quality" streams in Windward O'ahu (Ref. 4). The quality ratings were based upon criteria which included the complement of native species, whether the stream channel had been altered (channelized, diverted, etc.), whether the stream contained reaches with high stream flow velocities and, finally, the clarity of stream water. This same report indicated that "high quality" for O'ahu streams would be considered "moderate" or even "low" quality when compared to streams on the neighbor islands. It is also important to note that the quality designation for Waikane Stream was based upon sampling at one location near Kamehameha highway.

The present survey confirm the presence of four native species in Waikane Stream which occur in population sizes indicating active recruitment. It is apparent that the physical and biological conditions of the stream at this time are suitable to support these species. It is important to note that none of these species can be considered particularly sensitive to even moderate levels of environmental degradation. The fish species,; A. stamineous, S. genivittatus, K. sandvicensis and the prawn, M. grandimanus can all be found to inhabit streams of considerably lower quality (Ref. 4).

The two native stream species of special concern to aquatic biologists in the state; the goby, Lentipes concolor and the mollusc, Neritina granosa, were not found to inhabit Waikane Stream. L. concolor is considered "functionally extinct" on O'ahu (Ref. 6) and the mollusc has been found in only two O'ahu streams in recent years (Kaluanui and Koloa Streams) (Ref. 4).

CONCLUSIONS AND RECOMMENDATIONS

The biology of Waikane Stream is not unique to streams in the less-developed watersheds of Windward O'ahu. Native species found in the stream are also found in other streams in the district and are not, by any means, considered rare or endangered. Apparently, all of the native species in Waikane Stream tolerate a wide range of environmental degradation as indicated by their presence in many of the altered streams in the state (Ref. 7). There are, however, certain stream-related environmental issues which need to be considered in the development of a golf-course in the lower portion of Waikane Valley. Each issue demands attention during the planning, construction and operating stages of the development.

1. Any removal of riparian vegetation will have an impact on the stream. The vegetation provides shelter and an organic input to the stream which is critical to many aquatic species. Although the stream is currently subject to frequent high turbidity conditions, an additional silt load would be undesireable. Erosion and the resultant siltation of stream water must be controlled when vegetation is removed. Certain stream reaches would actually benefit from controlled clearing of the existing riparian species and replanting. Native vegetation would particularly enhance the esthetic value of much of the stream channel within the project area.

2. The use of chemical fertilizers, herbicides and petrochemicals in the operation of the golf course must follow sound management practices. A "buffer zone" of vegetation along the stream banks, where spraying would not occur, would certainly be a wise precaution to prevent runoff into the stream.

3. Adequate handling of the small amount of wastewater produced by the users of the project must also be considered. Although perhaps unlikely, seepage of nutrient rich water into the stream should be avoided.

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Table 1. List of conspicuous invertebrates and fishes commonly found in streams in the Hawaiian Islands.

Scientific Name	Local Name	Origin
Crustaceans		
Atyoida bisulcata	o'pae kala'ole	endemic
Macrobrachium grandimanus	o'pae o'eha'a	endemic
Macrobrachium lar	Tahitian prawn	alien
Procambarus clarkii	crayfish	alien
Molluscs		
Melanoides sp.	pond snail	indigenous
Neritina granosa	hihiwai	endemic
Fishes		
Awaous stamineus	o'opu nakea	endemic
Clarius fuscus	chinese catfish	alien
Cichlasoma sp.	cichlid	alien
Cyprinus carpio	carp	alien
Eleotris sandwicensis	o'opu okuhe	endemic
Gambusia affinis	mosquitofish	alien
Kuhlia sandvicensis	aholehole	endemic
Lentipes concolor	o'opu alamo'o	endemic
Lepomis macrochirus	bluegill	alien
Micropterus dolomieui	smallmouth bass	alien
Misgurnus anguillicaudatus	dojo, loach	alien
Ophicephalus striatus	snakehead	alien
Poecilia spp.	guppys, mollies	alien
Sicyopterus stimpsoni	o'opu nopili	endemic
Stenogobius genivittatus	o'opu naniha	indigenous
Tilapia (Sarotherodon) spp.	tilapia	alien
Xiphophorus helleri	swordtail	alien
Xiphophorus maculatus	Southern platyfish	alien

Origin: endemic - found naturally in Hawaii only
indigenous - found naturally in Hawaii and elsewhere
alien - not naturally found in Hawaii, introduced by man

Table 2. Distribution and relative population size of aquatic fauna identified in Waikane Stream.

STREAM REGION	SPECIES	COMMON NAME	ORIGIN	ABUNDANCE
LOWER				
	Crustaceans			
	Macrobrachium grandimanus	o'pae o'eha'a	endemic	+++
	Macrobrachium lar	Tahitian prawn	alien	+++
	Fishes			
	Awaous stamineous	o'opu nakea	endemic	+++
	Gambusia affinis	mosquitofish	alien	++
	Kuhlia sandvicensis	aholehole	endemic	+++
	Poecilia spp.	guppys, mollies	alien	+++
	Stenogobious genivittatus	o'opu naniha	indigenous	++
	Xiphophorus helleri	swordtail	alien	+++
MIDDLE				
	Crustaceans			
	Macrobrachium lar	Tahitian prawn	alien	+++
	Fishes			
	Awaous stamineous	o'opu nakea	endemic	+
	Poecilia spp.	guppys, mollies	alien	+++
	Xiphophorus helleri	swordtail	alien	+++
UPPER				
	Crustaceans			
	Macrobrachium lar	Tahitian prawn	alien	++
	Fishes			
	Awaous stamineous	o'opu nakea	endemic	+++
	Poecilia spp.	guppys, mollies	alien	++
	Xiphophorus helleri	swordtail	alien	++

Key: +++ = abundant (5-15 per 20 m stream reach)
++ = common (2-5 per 20 m stream reach)
+ = rare (1 per 20 m stream reach)

APPENDIX L
Environmental Impact of Fertilizer and Pesticide Use

ENVIRONMENTAL IMPACT OF FERTILIZER AND PESTICIDE USE ON THE PROPOSED WAIKANE GOLF COURSE PROJECT

A REPORT TO

Engineering Concepts Inc.

April 5, 1988

PREPARED BY

Charles L. Murdoch, Ph. D

Richard E. Green, Ph. D.

I. INTRODUCTION

The development of the proposed golf course will require application of fertilizers to supply essential nutrients to turfgrasses and ornamental plants and pesticides to control their associated weed, disease, and insect pests. These chemicals may be subject to movement from the site of application, either by runoff during high intensity storms, or by movement toward groundwater when water infiltration exceeds evapotranspiration (ET). Irrigation in excess of ET contributes water recharge to groundwater, thus water management is an important determinant in the control of chemical movement.

This report provides an assessment of the anticipated environmental impact of chemicals applied to a golf course at this site based on an analysis of site factors and recommended management practices. In addition, the impact of a golf course with appropriate management is compared with that of the agricultural park which is planned for the adjacent Waiahole valley.

II. APPROACH AND SOURCES OF INFORMATION

Background information on topography, drainage and storm runoff was obtained from a report entitled "Environmental Aspects of Storm Runoff, Waikane Hills Country Club, Waikane, Koolau poko, Oahu, Hawaii" (Dugan, 1988). Detailed soils reports and maps (Foote et al. 1972) and topographic maps provided information required for an assessment of the potential for pesticide retention at the site of application. Recommendations for fertilizer and pesticide use are provided based on local requirements and environmental considerations. Conclusions about pesticide behavior in soils and impact on the environment are based principally on published properties of pesticides and our experience with pesticide use in Hawaii.

III. ANALYSIS OF RELEVANT FACTORS WHICH MAY IMPACT ON CHEMICAL MOVEMENT

A. Site factors

1. Geology, soils, topography

The project area is located west of the north-west end of Kaneohe Bay on the east coast of Oahu. The Koolau mountains rise rapidly to the west from the coastline and are highly dissected into ridges and valleys. The project area includes both lowlands and ridges with golf course development on the ridges being limited principally to the more level areas. The mountains are of basaltic origin (now deeply weathered) and the valley and coastal plain areas contain alluvium which is quite deep at lower elevations. The soils of the area consist of the Waikane series (clayey, oxidic, isothermic Humoxic Tropohumults) on upland areas and the Hanalei series (fine, mixed, nonacid, isohyperthermic Typic Tropoaquepts) on the stream bottoms and flood planes. The Waikane soils are generally well-drained and are formed on alluvium and colluvium derived from basic igneous rock. They are nearly level (3-8% slope) to very steep (40-70% slope). Permeability of these soils is moderately rapid, and runoff is medium to rapid, depending upon the degree of slope. Erosion hazard is moderate to severe, due mainly to the predominantly steep slopes. The Hanalei soils are somewhat poorly-drained to poorly-drained soils on nearly level bottom lands. They are derived from alluvium. The distribution of soils within the project property boundary is shown on the soils map in Appendix Figure 1. The property boundary is approximate. The Hanalei soil (Hn A and Hn B on the map) can be seen following stream beds throughout the property. The A and B in the symbols Hn A and Hn B refer to slopes of 0-3% and 3-8% respectively. The Waikane soils (Wp) are also scattered throughout the property, with slopes of 3-8% on the most level land (Wp B) and 40-70% on the steepest Wp F). Steep slopes (Wp F) will not be developed. By necessity, the golf course greens, tees and fairways will be on the more level surfaces.

Both the Waikane and Hanalei soil series are characterized by relatively high organic matter contents throughout the soil profile. By definition the Humoxic Tropohumult soils (of which the Waikane series is a member) have a high organic carbon content (about 2%) in the argillic (B) horizon. Surface soil organic carbon contents are even higher. Published data for the Hanalei soil (Foote, et al., 1972) indicate organic carbon contents ranging from 2.3% in the surface soil (0-15 inches) to 0.42% at 26-36 inches. Pesticides applied to the soil or washed off plants into the soil will be retained most effectively by soil organic matter. If top soils are not removed by erosion or grading operations, the soil will retard pesticide movement in runoff and leaching below the soil profile. This is desirable, both from the standpoint of effective pest control and the effect on environmental quality. Although some surface soil will undoubtedly be removed during golf course construction, care should be exercised to minimize removal, especially on steeper slopes where erosion has already removed soil rich in organic matter.

2. Climate and hydrology

The climate and hydrology of the project area is discussed throughout the report by Dugan (1988). In his calculations of nutrient and sediment loads in runoff waters, he uses a median annual weighted rainfall of 73 inches (1854 mm) and notes that the median annual rainfall over the project site ranges from nearly 65 inches (1651 mm) in the low land areas to about 79 inches (2007 mm) at the mauka end of the proposed development. Rainfall data in the Rainfall Atlas of Hawaii (Giambelluca et al., 1986) indicate high rainfall months during the period of October through April (about 150 to 220 mm per month, with the larger figure corresponding to mauka areas) and lower rainfall period during the summer (about 100 to 130 mm per month).

B. Management factors

1. Fertilizers

Fertilizers are applied to golf courses to supply those essential nutrients which are used in large amounts and which are deficient in most soils. In typical soils, the elements which are normally applied in a turfgrass fertilization program are nitrogen (N), phosphorus (P), and potassium (K). Fertilizers are normally applied to only the greens, tees, fairways, and part of the roughs of a golf course. Typical areas in these types of turfgrasses are estimated in the discussion below.

Turfgrasses use much more N than other elements. Based on turfgrass clipping composition, it has been shown that the turfgrasses grown in Hawaii use about twice as much N as K and about 4 times as much N as P.

The primary fertilizer elements of concern for contamination of ground and surface waters are nitrogen and phosphorus. Phosphorus is attached very tightly to iron and aluminum hydroxides which are plentiful in the soil of this location and moves little if any from the site of application. Phosphorus, therefore, will not cause any problem with contamination of drainage water. Ammonium nitrogen (NH_4) likewise moves little in soils. Nitrogen applied in the ammonium form, however, is rapidly converted to the nitrate form (NO_3) which is not bound to the soil and moves readily with water. Because of high N uptake by turfgrasses, however, nitrogen will be used rapidly after application. Only under conditions where rainfall occurs soon after application of a soluble nitrogen source would there be excessive loss by surface runoff or by leaching below the root zone. This nitrogen movement could be avoided by applying a slow-release nitrogen fertilizer.

Fertilizer use rates for the different golf course areas are shown in Table 1. Complete fertilizers (ones containing N, P, and K) are usually applied. Because nitrogen is applied in larger quantities and also because it is the only fertilizer element likely to cause contamination of ground or surface waters, only nitrogen application rates are given.

Table 1. Approximate fertilizer use rates for different areas of a typical 27 hole golf course in Hawaii.

Type of turf	Area (acres)	Fertilizer amount (lb. N/1000 sq. ft.)	Application frequency	Total annual application (tons N)
Greens	4.5	0.5	2 weeks	1.27
Tees	4.5	1.0	4 weeks	1.27
Fairways	67.0	1.5	8 weeks	13.13
Roughs	40.0	1.0	3 months	3.48
Total	116.0			19.15

2. Pesticides

There are a number of weed, insect and disease pests of turfgrasses in Hawaii which sometimes require application of chemical pesticides. Pesticides are normally applied only in response to outbreaks of pests. There are few instances in which pesticides are applied in a regularly scheduled, preventative program. A typical pesticide program for golf courses in Hawaii is given in Table 2 below. There are several chemicals which may be substituted for certain ones in this suggested program. Properties of the chemicals listed in Table 2 (Hartley and Kidd, 1983), as well as those of most chemicals used in turf in Hawaii, are given in Appendix Table 1.

Table 2. A typical pesticide program for an 27 hole golf courses in Hawaii.

Turfgrass area	Area (acres)	Chemical	Frequency	Amt./application	Annual total
I. Herbicides					
A. Greens	4.5	MSMA	6 times/year	2lb. ai/acre	54 lb. ai
		bensulide	2 times/year	12 lb ai/acre	108 lb. ai
B. Tees	4.5	MSMA	6 times/year	2 lb. ai./acre	54 lb. ai
		33 Plus	3 times/year	1 pint/acre	13.5 pints
		bensulide	2 times/year	12 lb. ai./acre	108 lb. ai
C. Fairways	67	MSMA	6 times/year	2 lb. ai./acre	800 lb. ai
		33 Plus	3 times/year	1 pint/acre	25 gallons
		metribuzin	2 times/year	0.75 lb. ai./acre	100 lb. ai.
D. Perimeter areas	30	glyphosate	3 times/year	1.5 lb ai./acre	135 lb. ai.
II. Insecticides					
A. Greens	4.5	chlorpyrifos	As needed	1 lb. ai./acre	Approx. 32 lb. ai.
B. Tees	4.5	chlorpyrifos	As needed	1 lb. ai. acre	Approx. 32 lb. ai.
C. Fairways (Spot treatments)		chlorpyrifos	As needed	1 lb. ai./acre	Approx. 89 lb. ai.
III. Fungicides					
A. Greens	4.5	metyalaxyl	As needed	1.3 lb. ai./acre	Approx. 44 lb. ai.
		chlorothailonil	As needed	8 lb. ai./acre	Approx. 128 lb. ai.
B. Tees	4.5	metyalaxyl	As needed	1.3 lb. ai./acre	Approx. 44 lb. ai.
		chlorothailonil	As needed	8 lb. ai./acre	Approx. 128 lb. ai.
C. Fairways (Spot treatments)		chlorothailonil	As needed	8 lb. ai./acre	Approx. 442 lb. ai.

3. Irrigation

Because rainfall is not uniformly distributed throughout the year, all golf courses are irrigated to supplement rainfall. Golf courses usually have permanent sprinkler irrigation systems with sophisticated controllers. Many are computer controlled, so that each sprinkler head on the golf course can be adjusted from a computer terminal to apply a selected amount of water on each cycle.

Because golf greens are constructed of sand (or mixes dominated by sand), the water holding capacity is less than for other areas containing soil. For this reason, golf greens must be watered more frequently than other areas.

Typical evapotranspiration rates for well-watered turf in Hawaii range from 0.1 to 0.3 inches per day, depending on temperature, the amount of sunlight, relative humidity, wind speed and the amount of available water in the soil. Soils store approximately 0.5 to 2.5 inches of available water per foot of depth, depending on soil texture. Sands hold less, clays hold more. Irrigation should be applied when about one-half the available water has been used. The effective rooting depth for mown turf is approximately one foot. Therefore, turfgrasses will need to be watered every day to about once a week depending upon the type of soil and the water use rate. Amounts of water applied at each irrigation for a typical 27 hole golf course are about 27,000 gal. for greens and 665,000 gals. for fairways.

Irrigation practices may have a large influence on the movement of soluble nitrogen fertilizers in soils. If excessive irrigation water is applied soon after application of soluble nitrogen sources, the chance for runoff or leaching of nitrogen below the root zone is increased. Because of the high cost of irrigation water, there is little incentive to over-water golf courses. As was previously mentioned, golf course irrigation systems are sophisticated, allowing precise control of the amount of water applied.

IV. ENVIRONMENTAL IMPACT OF CHEMICALS APPLIED TO THE PROPOSED GOLF COURSE

A. Groundwater

Considering the relatively high organic matter content of the soils, which will retard movement of pesticides through the soil profile, and the limited persistence of those pesticides which are not highly sorbed (eg., 2,4-D), it is not likely that significant quantities of pesticides will move below the soil profile (approximately 1 meter). In addition, Dugan (1988) provides evidence that ground water in this area moves on a hydraulic gradient toward the ocean and actually emerges at the surface where stream beds intersect the groundwater table. Thus, there appears to be little likelihood of deep penetration of leachate to the aquifer in the dike complex below the project area.

B. Runoff

Dugan (1988) has addressed the effect of the golf course development on runoff and the associated load of sediment and chemical constituents. He concluded that suspended solids would decrease after development, but nitrogen and phosphorus would increase. We concur with his conclusion.

We do not anticipate pesticide use on the development area to contribute significant quantities of pesticides or their degradation products to low-land or coastal areas. The treated turf areas are small in relation to the total watershed, so that any runoff waters containing pesticide residues from the treated areas would be highly diluted by runoff from untreated areas and from high-level groundwater emerging in stream beds. Additionally, sorption of pesticides on soil organic matter in these soils will retard the movement of most pesticides. Those few pesticides which are not highly sorbed are readily degraded in the soil and thus should not constitute a source of down-stream contamination.

C. Impact on Migratory Birds and Endangered Hawaiian Waterbirds.

The fertilizers, herbicides, and fungicides used in golf course maintenance pose little or no hazard to birds frequenting the grassed areas or ponds associated with golf courses. Fertilizers are relatively non-toxic unless ingested in large amounts. All herbicides and fungicides used in golf course maintenance in Hawaii are of low to moderate toxicity (Appendix Table 1). The only chemicals used in golf course maintenance in Hawaii which are highly toxic to birds are the organic phosphate insecticides, especially chlorpyrifos. The Environmental Protection Agency (EPA) which controls the use of all pesticides, has cancelled all golf course uses of diazinon because of bird kills on the mainland United States. Chlorpyrifos will, therefore, be the most frequently used organic phosphate insecticide.

Although chlorpyrifos is highly toxic to birds, it is strongly adsorbed on the thatch layer of turf and moves little from the site of application. One reason for its weakness in controlling soil infesting insects is the inability to get the insecticide through the thatch layer to the depth needed to contact these insects. Recent studies (Sears and Chapman, 1980; Tashiro, 1980) have shown that chlorpyrifos applied to turfgrasses does not penetrate more than 2 to 3 centimeters in the soil. In addition to resistance to movement in the soil, it has been shown that it is rapidly degraded in the soil, both by hydrolysis and microbial action. Data on persistence of eight organic phosphate insecticides are given below.

Because of the adsorption of organic phosphate insecticides on organic layers in turf and their rapid break down, there is little chance of their movement from grassed areas into the ponds or waterways associated with the proposed golf course. Label instructions for application of these pesticides (which turfgrass managers are required by law to follow) specifically prohibit their direct application to streams and ponds.

Table 3. Half-life and time required for 95% disappearance of eight organic phosphate insecticides in non-sterile sandy loam soil (adapted from Miles et al. 1979)

Insecticide	Half-life (wks.)	Wks. for 95% decomposition
Diazinon	<1	1
Chlorpyrifos	<1	1
Parathion	<1	3
Fensulfothion	<1	4
Chlorfenvinphos	<1	5
Trichloronat	1.5	20
Fonofos	3.0	20
Ethion	7.0	>24

The likelihood of bird injury by pesticides used in maintenance of the proposed golf course can be reduced by proper application of pesticides with reduced toxicity to birds. As shown in Appendix Table 1, carbaryl and trichlorfon are less toxic to birds than diazinon or chlorpyrifos. In most cases these insecticides may be substituted for chlorpyrifos with little loss of effectiveness.

The labeling of pesticides for particular uses by EPA with strict laws (enforced by the Hawaii Department of Agriculture) for their use are perhaps the best assurance of protection of humans and wildlife from pesticide hazards. Labeled uses are also reviewed when EPA finds evidence that a pesticide is creating hazardous environmental impact or is likely to create hazardous conditions. The removal of golf courses from labeled uses permitted for diazinon is an example of the ability of EPA to remove specific uses of a pesticide when it is beleived that that use is creating unecessary hazards to humans or wildlife. It is impossible to predict what pesticides will be developed in the future or what hazardous conditions may be created by specific uses of pesticides already labeled. However, all pesticides must be applied in compliance with federal and state laws regulating their use. Hazards to both humans and wildlife are included in the decision to label a pesticide for specific uses, including use on golf courses, and in developing regulations on allowable application procedures of the pesticide for various uses.

D. Impact on Air Quality.

The pesticides used on golf courses are of relatively low mammalian toxicity, ranging from hundreds to several thousand mg/kg body weight (Appendix Table 1). Because they are not highly volatile and are applied in dilute sprays (50 to 100 gallons of spray solution per acre) to open areas, there is little likelihood of toxic levels in the atmosphere because of volatility once the pesticides are applied. The greatest danger of significant airborne concentrations of pesticides is from aerial application. Golf course pesticides are applied with ground spray equipment. Boom height of spray equipment is usually 40 to 50 cm (16 to 20 inches). Low spray pressures (20 to 40 psi) and coarse spray droplets further reduce the hazard of airborne fine droplets. Droplets larger than 100 micrometers diameter are not highly subject to drift. Figure 1 below illustrates the effect of spray droplet size on spray drift.

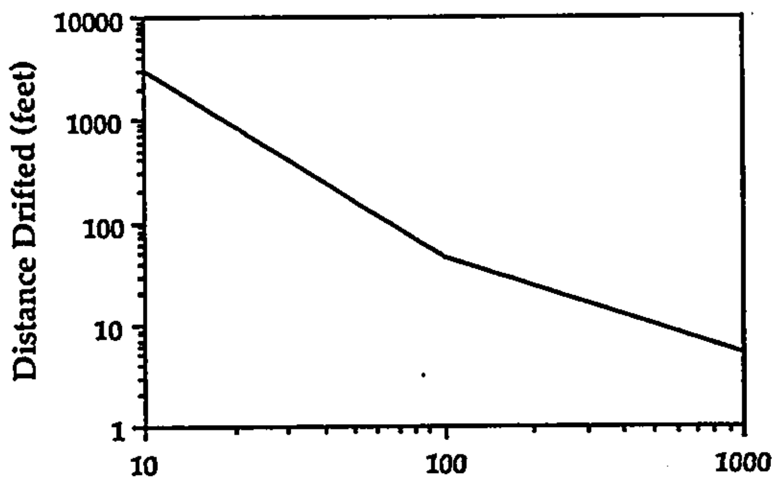

Figure 1. Relationship between spray droplet size and spray drift (based on droplets falling 10 feet in a 3 MPH wind). (from Hofman et al. 1986).

Most of the spray volume from typical flat-fan nozzles used in agricultural spray equipment is from droplets larger than 100 micrometers. Table 4 below shows a typical distribution of droplet sizes for a flat-fan nozzle (the type used in most golf course spray equipment).

Table 4. Droplet size range for a typical flat-fan nozzle at 20 and 40 psi. (from Hofman et al. 1986)

Droplet size range (microns)	Percent of spray volume 20 psi	40 psi
0-21	0.1	0.4
21-63	3.0	10.4
63-105	10.7	20.1
105-147	16.2	25.4
147-210	36.7	35.3
210-294	27.5	7.7
>294	5.8	0.7

At the low concentrations used in pesticide application, this would not result in significant quantities of pesticides being carried downwind. High wind speed would increase the likelihood of drift of fine spray droplets, however, because high wind speed distorts spray patterns and results in poor pesticide coverage, spraying in periods of high wind is not common practice. Table 5 below shows the percent of spray application volume deposited at 4 and 8 feet downwind and the distance downwind for the volume to drop to 1% or below for flat-fan nozzles under different conditions. Even under high wind conditions (almost 10 mph) and spraying at 40 psi, the distance downwind at which 1% or less of the total spray volume was deposited was only 17 feet.

Table 5. Percent of spray volume deposited at 4 and 8 feet downwind and the distance in feet for the volume of spray solution to drop to 1% of the total spray volume (from Hofman et al. 1986).

Comparison	Pressure (psi)	Wind speed (mph)	Percent deposited 4 ft.	Percent deposited 8 ft.	Distance to drop to 1% of volume
14" nozzle ht.	40	3.5	3.1	0.6	7.0
27" nozzle ht.	40	3.5	5.9	1.5	13.0
18" nozzle ht.	30	5.3	9.3	2.2	14.0
18" nozzle ht.	25	9.9	10.3	3.1	15.5
18" nozzle ht.	40	9.9	9.1	3.6	17.0

To facilitate spray operations and to comply with label instructions of some pesticides, spray applications are only made in late afternoon or early morning hours when golfers are not on the golf course. This reduces the risk of exposure of people to airborne spray particles. Sufficient buffer space with tall vegetation between facilities such as the clubhouse which will be used by people. and areas where pesticides are applied will further reduce the chance of exposure to airborne pesticide particles.

The greatest danger of airborne pesticides is to the applicators of pesticides themselves. Mixing of wettable powder formulations and being in close proximity to airborne spray particles, particularly when operating spray equipment in a downwind position, places spray operators in particularly vulnerable positions. EPA and OSHA have strict standards which specify that spray operators wear appropriate protective clothing and breathing apparatuses.

V. AMOUNTS OF FERTILIZERS APPLIED TO THE PROPOSED GOLF COURSE IN COMPARISON TO THAT FOR THE PROPOSED AGRICULTURAL PARK IN WAIAHOLE VALLEY.

A. Proposed golf course

Fertilizer, pesticide and irrigation applications to the proposed golf course have been discussed previously. Approximately 19.15 tons of nitrogen would be applied annually in the maintenance of a 27 hole golf course. Although figures for P and K were not given in Table 1 of the text, based on the composition of turfgrass fertilizers, approximately 2.1 tons of P and 8 tons of K annually would be applied.

B. The agricultural park planned for Waiahole Valley

Acreages of different crops proposed for the agricultural park in Waiahole valley were obtained from the report entitled " Agricultural Feasibility and Environmental Impact, Waiahole Valley Agricultural Park" prepared by Frank S. Scott, Jr. in May, 1980 for M&E Pacific Inc. Fertilizer rates for the different crops were also taken from the same report with the exception of that for the ornamentals under shade for which Scott's report gave no fertilizer rates. Fertilizer recommendations for this was obtained from the University of Hawaii, Agricultural Extension Service. These acreages and fertilizer amounts are shown in Table 6 below.

From the figures in Table 6 and those given above for N and P application for the proposed 27 hole golf course, it is apparent that only approximately 41% as much N and 8% as much P will be applied in maintenance of the proposed 27 hole golf course as for the crops suggested for the agricultural park planned for Waiahole Valley. These figures are given to illustrate that, while most people assume that golf courses apply large amounts of fertilizers, the amount is much less than for agricultural crops on similar acreages. While the area to which fertilizers will be applied in the proposed 27 hole golf course is estimated to be only about 116 acres compared to 370 acres for the agricultural park in Waiahole valley, the total acreage of the development is over 500 acres. This is primarily due to the fact that only fairways, greens and tees of golf courses are fertilized. These areas are relatively small compared to the total acreage in the development.

Table 6. Acreage and total annual application of N and P for crops suggested for the agricultural park, Waiahole Valley, Oahu.

Crop	Acres	Total annual application (tons N)	Total annual application (tons P)
Banana	125	18.8	4.1
Papaya	25	3.8	1.7
Tomatos	20	2.5	2.2
Snap beans	10	1.3	1.1
Cucumbers	30	3.8	3.3
Sweet potatoes	40	5.0	4.4
Misc. truck crops	20	2.5	2.2
Truck crops-multi-cropped	60	7.5	6.6
Taro	10	0.5	0.2
Flowers, Foliage & Potted Plants	30	1.1	0.5
TOTAL	370	46.8	26.3

VI. SUMMARY AND CONCLUSIONS

Analysis of the site and management factors involved in golf course maintenance suggest that it is unlikely that development of the proposed Waikane golf course would pose environmental risks associated with the use of chemical fertilizers and pesticides.

Nitrate would be the only fertilizer element of concern since phosphorus is bound tightly to soil colloids and does not move appreciably from the site of application. Since Dugan (1988) has indicated that groundwater in this area emerges at the surface and moves toward the ocean in stream beds which intersect the groundwater table, movement of nitrate would be in runoff waters. However, because of the small amount applied at any one application, and the large dilution from water off-site in the surface drainage way, nitrate content of drainage water would likely be insignificant.

With the exception of herbicides, pesticide applications are normally made only to greens on golf courses. Since greens comprise only approximately 4.5 acres of a typical 27 hole golf course, contribution of fungicide and insecticide contamination of surface waters would be small. The herbicides used on golf fairways are primarily MSMA, metribuzin and 33 plus (or other mixtures of 2,4-D, mecoprop and dicamba). These herbicides are rapidly degraded and/or are tightly sorbed on soil colloids and organic matter and have little potential for water contamination.

Once the golf course is developed, the sediment load in streams and eventually Kaneohe bay would likely be reduced. Turfed areas are very efficient in reducing sediment levels in surface drainage.

All pesticide use, including that on golf courses, is regulated by EPA. In Hawaii, enforcement of EPA regulations for all agricultural uses, including golf courses, is by the Hawaii Department of Agriculture. These regulations are perhaps the best assurance of protection of humans and wildlife from pesticide hazards. Labeled uses may be removed by EPA at any time if it is determined that specific uses of a pesticide are creating excessively hazardous conditions for humans or wildlife. The pesticides listed in previous sections are those that are presently labeled by EPA for use on golf courses. It is impossible to predict what new pesticides will be developed in the future, some of which may be safer than those presently used. Regardless of development of new pesticides or cancellation of labeled uses of presently available pesticides, only chemicals approved by EPA will be used on golf courses in Hawaii.

VII. RECOMMENDATIONS

Irrigation management is critical to the conclusions reached above. If excessive irrigation water is applied, the likelihood of nitrate movement in surface waters is increased. For this reason we recommend that a U. S. Weather Bureau class A evaporation pan be used to measure evaporation and schedule irrigation application in the management of the proposed golf course. Excellent discussion of irrigation scheduling can be found in the book Golf Course and Grounds Irrigation and Drainage (Jarret, 1985). Likewise, fertilizer application schedules should be timed so that heavy applications of soluble fertilizers are not made during the rainy months for this area (October through April). During the rainy season, slow-release fertilizers can be applied which will release nitrogen at a rate comparable to the rate at which it is used by turf.

As our conclusions are based on the assumption that sound management practices will be followed with regard to fertilizer and pesticide application and irrigation, we recommend that a well qualified Golf Course Superintendent (preferably a Certified Golf Course Superintendent) be given the responsibility of managing the golf course.

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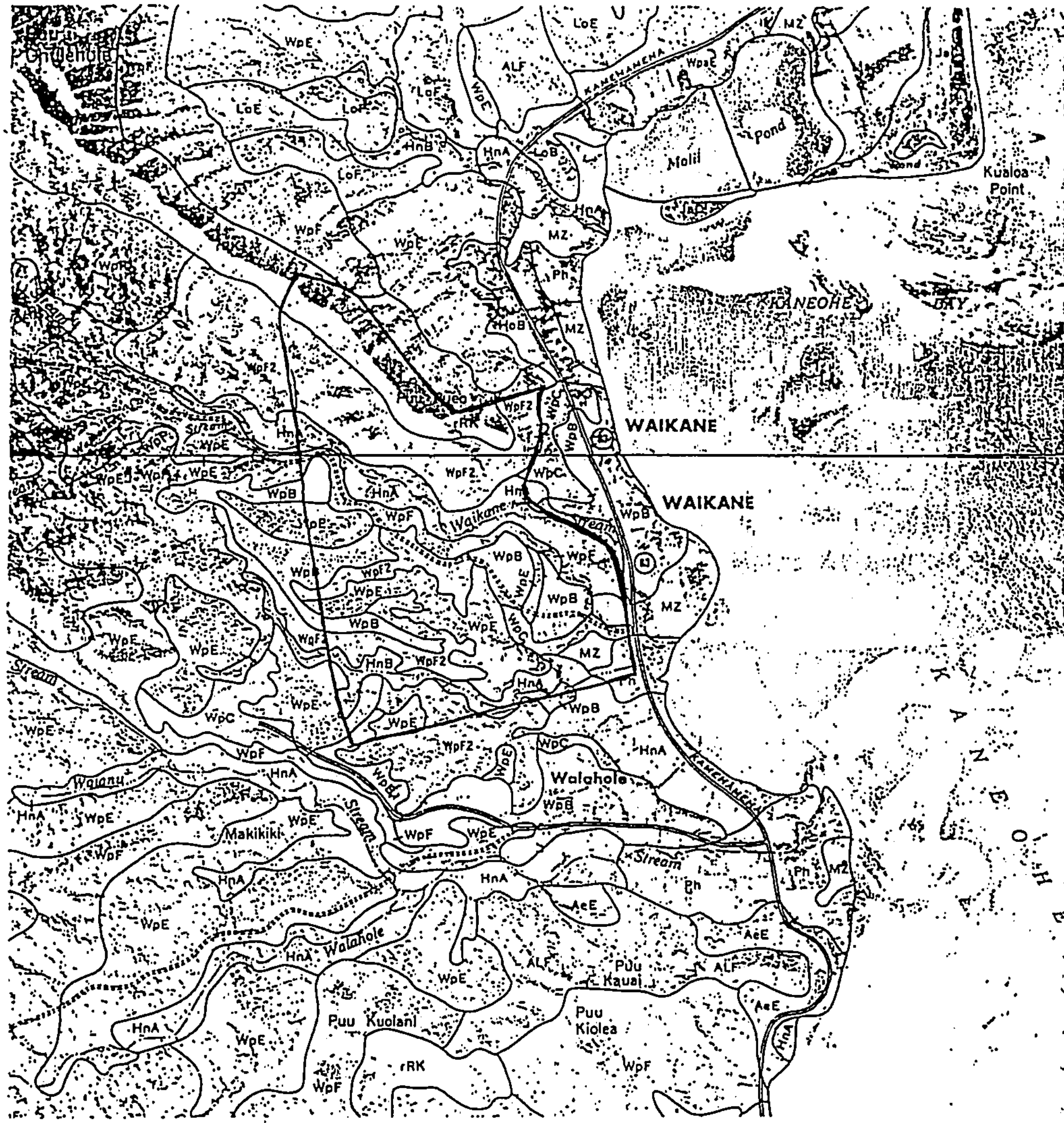
APPENDIX

Appendix Table 1. Properties of pesticides used in turfgrasses in Hawaii.

Pesticide common name	Trade name (s)	Oral LD-50 (mg/kg body wt.)	Toxicity to fish & wildlife	Water solubility	Soil behavior
Herbicides:					
MSMA	WeedHoe etc.	1800	Low	Very soluble	Tightly sorbed
glyphosate	Roundup, Kleenup	150	Mod. to birds, none to fish	Very soluble	Inactivated on soil contact
metribuzin	Sencor	2200	Moderate	122 mg/l	Moves readily, Rapidly degraded
2,4-D	part of mixtures	370-700	High to fish	46 mg/l	Rapidly degraded
mecoprop	ditto	700-1500	Low	0.62 mg/l	Moderately residual
dicamba	ditto	1000-2000	Non toxic to fish	0.08 mg/l	Moderately residual
oryzalin	Surflan	10000	Mod. to birds, toxic to fish	2.5 mg/l	Moderately residual
oxadiazon	Ronstar	8000	Toxic to fish	0.7 mg/l	Half-life 1-6 months
propyzamide	Kerb	5620-8350	Low	15 mg/l	Half-life approx. 1 mo.
simazine	Princep	>5000	Low	5 mg/l	Half-life approx. 2-3 mo.
chlorthal-dimethyl	Dacthal	>3000	Low	0.5 mg/l	Residual activity approx. 3 mo.
bensulide	Betasan, Betamec	770	Mod. to fish	25 mg/l	Tightly sorbed-long residual
parquat dichloride	Ortho Paraquat CL	150	Mod. to birds, none to fish	Readily soluble	Immediate inactivation
benfluralin	Balan	10000	Low to birds, high to fish	<1 ppm	Strongly sorbed
Insecticides					
chloropyrofos	Dursban	135-163	High	2 mg/l	Slowly degraded, strongly sorbed
bendiocarb	Ficam	40-156	High	40 mg/l	Rapidly degraded
carbaryl	Sevin	400-850	Moderate	<1 ppm	No information
trichlorfon	Dylox	450-630	Moderate	154 g/l	No information
Fungicides					
anilazine	Dyrene	<5000	Low	8 mg/l	Half-life 12 hours
benomyl	Benlate	9590	Low	2 mg/l	Half-life 6-12 mo.
chlorothalonil	Daconil 2787	>10000	Low to birds, mod. to fish	0.6 mg/l	Half-life 1.5-3.0 mo.
iprodione	Chipco 26019 RP	3500	Low	13 mg/l	Rapidly metabolized
mancozeb	Dithane M-45	>8000	Low	practically insoluble	No information
qunitozone	PCNB, Terrachlor	12000	Non-toxic	0.44 mg/l	No information
thiram	Tersan	7500	Low	30 mg/l	Rapidly degraded
triadimefon	Bayleton	568	Low	260 mg/l	Rapidly degraded
metalaxyl	Subdue	669	Non-toxic	7.1 g/l	Rapidly degraded
thiophanate-methyl	Cleary 3336	7500	Low	3.5 mg/l	Rapidly degraded



Appendix Figure 1. Approximate boundary (outlined area) and soil types for the proposed Waikane Hills Country Club (from Foote et al. 1972). Soil types are; HnA=Hanalei Series, 0-2% slope, HnB=Hanalei Series, 2-6% slope, WpB= Waikane Series, 3-8% slope, WpC= Waikane Series, 8-15% slope WpE Waikane Series, 25-40% slope, WpF=Waikane Series, 40-70% slope, WpF2 =Waikane Series, 40-70%% slope,eroded, Mz=marsh, rRK=rock land.

APPENDIX M
Marine Environmental Survey

MARINE ENVIRONMENTAL SURVEY
IN THE VICINITY OF THE
WAIKANE GOLF COURSE, OAHU, HAWAII

PREPARED FOR:
GROUP 70

MARCH 26, 1988

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MARINE ENVIRONMENTAL SURVEY IN THE VICINITY OF THE WAIKANE GOLF COURSE, OAHU, HAWAII

Prepared by:

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For:

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March 26, 1988

INTRODUCTION

Plans are currently being developed to construct the Waikane Golf Course on windward Oahu. The project will consist of a 27-hole golf course and clubhouse on a site mauka of Kamehameha Highway. Waikane stream flows through the project site and empties into Kaneohe Bay near the southwestern corner of the project property. A possible consequence of the planned project is alteration of water quality characteristics of Waikane stream. If such changes should occur, it is also possible that the region of Kaneohe Bay influenced by stream water input will be altered. This report describes the results of a study carried out in Kaneohe Bay in the vicinity of the proposed Waikane Golf Course for the purpose of evaluating the potential for alteration to water chemistry and marine biota as a result of changes in stream discharge associated with golf course construction and operation.

Kaneohe Bay is a semi-enclosed embayment located on the northeast coast of Oahu (see Figure 1). The landward boundary of the Kaneohe watershed is sharply delineated by a nearly vertical mountain range (Koolaus); the seaward boundary of the bay is a barrier reef that extends across the bay mouth. The bay includes components of both estuaries and coral reefs, two quite different kinds of ecosystems. Coral reefs develop best in environments free of terrestrial influence, while estuaries are characterized by input from rivers and streams. Kaneohe Bay is a weakly developed estuary and thus has moderate land influences in the form of freshwater, sediment, and nutrients. In addition, the shape of the bay, as well as submarine topography and relatively weak tidal exchange give the bay a rather poor circulatory pattern. As a result, impacts from shoreline activities can be more acute than along areas of open coastline.

Kaneohe Bay is also one of the most-studied marine ecosystems in the world, owing to the location of the Hawaii Institute of Marine Biology on Coconut Island (see Figure 1). As a result, there is documentation of impacts to the Bay associated with man-induced activities such as sewage discharge and episodes of intense flooding and sedimentation from run-off. A brief review of these impacts provides a useful background for the present investigation.

Banner (1974) reviewed the impacts of urbanization associated with dredging of ship channels to provide access to Kaneohe Marine Corps Air Station, and a ten-fold increase in population in the watershed of the Bay in the decades following WWII. Banner reports that dredging activity prior to World War II caused the removal of about 29% of the living reef, but that the remaining reefs were not permanently damaged by sediment created by dredging. Removal of vegetative cover, exposing soil during the urbanization process, resulted in substantial increases in siltation to the Bay floor. In 1965, torrential rains falling on newly bulldozed lands caused run-off of fine, red silt that caused alteration of normal coral community structure. In addition, lowering of salinity by flood run-off contributed to reef organism mortality. Torrential rains and floods from a recent storm in January of 1988 were similar in magnitude to the 1965 event. The recent floods also resulted in substantial mortality to corals in the south sector of the bay

(P. Jokiel, personal communication).

The effects of sewage discharge, as well as relaxation of the discharge in Kaneohe Bay, have been thoroughly documented by Smith et al. (1981). A major response of biota to the nutrient subsidy was internal water-column cycling between dissolved nutrients, phytoplankton, zooplankton, microheterotrophs, and detritus at rates of productivity far exceeding the rate of nutrient loading. The primary benthic response to nutrient loading was a build-up of detritovorous heterotrophic biomass. During peak sewage discharge, available evidence suggested that even near the sewer outfalls, no major taxa were totally eliminated, but the structure of benthic communities was severely altered owing to increased biomass and productivity. This response was most pronounced in the central and northern bay, nutrient subsidy from sewage supported dense growths of "green bubble algae" (Dictyosphaeria cavernosa), which outcompeted corals for space and smothered many living colonies (Maragos 1972). Much of the observed taxonomic alteration apparently represented synergistic effects of biotic "kills" from freshwater run-off and siltation, combined with biotic succession in response to altered nutritional status from sewage. Smith (personal communication), however, feels that without the stresses associated with flooding and siltation caused by shoreline development, coral communities could have probably endured the nutrient subsidies from sewage without alteration in community structure.

After diversion of sewage effluent to an open ocean outfall off Mokapu Peninsula, biomass of both plankton and benthos in Kaneohe Bay decreased rapidly. Five years after diversion, total coral coverage increased, and small colonies were noted in the south bay. Dictyospharia cavernosa coverage decreased by about 75% overall, with the greatest reduction in areas where the alga had previously exhibited peak abundance (Maragos et al. 1985). These studies indicate that while Kaneohe Bay has been subjected to severe environmental insult in the past decades, much of the detrimental changes appear to be reversible when the perturbations are removed.

The present study followed periods of flooding in Kaneohe Bay. A very intense storm one month prior to field surveys resulted in approximately 30 cm of rain in Kaneohe, which caused salinity in south bay to drop below 20 o/oo. A minor flood event (approximately 12 cm of rain) occurred one day prior to the survey. The major storm event was equal in magnitude to the episode documented in 1965 by Banner. Resurvey of reef stations established by Banner showed that the 1988 event caused mortality to corals in the southern bay in nearshore areas subjected to freshwater input (Jokiel, personal communication). The relevance of this "flood timing" to the present study is that examination of reef areas indicate the degree of resistance inherent in the community to severe natural events. Such observations put into perspective the potential for alteration to community structure from man-induced activities.

ANALYTICAL METHODS

Water Quality

All field work was conducted on January 30-31 and February 11, 1988. Water quality was evaluated at 12 stations in Kaneohe Bay fronting the proposed golf course site (see Figure 2). Stations 1 through 5 consisted of a transect perpendicular to the shoreline from a point approximately approximately 20 meters seaward of the shoreline at the mouth of Waikane Stream (#1), to the main Kaneohe Bay channel (#5). Stations 7 through 11 were parallel to the shoreline, and extended from the northern boundary of the proposed golf course (#7), to the mouth of Waiahole Stream (#12).

Water quality parameters that were evaluated included salinity, total nitrogen (TN), ammonia nitrogen (NH_4^+, nitrate + nitrite nitrogen (NO_3^-+NO_2^-, orthophosphate phosphorus (PO_4^{3-}), dissolved silica (Si), nephelometric turbidity, and suspended solids. Water samples for nutrient analysis were taken in 2 liter (l) acid-washed polyethylene bottles. Sub-samples were filtered through glass-fiber filters into triple-rinsed, acid washed 125 milliliter (ml) bottles and immediately placed on ice. Samples for ammonium, nitrate + nitrite, TN and orthophosphate, were frozen until analysis. A separate sub-sample for Si was chilled, but not frozen. Nutrients were analyzed using standard techniques on a Technicon autoanalyzer. Total nitrogen was analyzed in a similar fashion following persulfate digestion. All nutrient analyses were conducted by the Analytical Services

Laboratory, at the Hawaii Institute of Marine Biology, Honolulu, Hawaii.

Sub-samples for salinity, turbidity and suspended solids were stored in 125 ml polyethylene bottles until analysis. Salinity was measured to an accuracy of ±0.003 o/oo using a AGE Model 2100 laboratory salinometer standardized against a primary Copenhagen standard. Turbidity was measured on a Turner Designs Nephelometer (No. 40) and reported in nephelometric turbidity units (NTU). Suspended solids was assessed gravimetrically on the residue of 1 liter of filtered water. Turbidity and suspended solids sub-samples were analyzed within 24 hours of collection.

Marine Community Structure

All field work was conducted from a 17-foot boat, or by walking from shore. Several methods were employed in the collection of qualitative and quantitative data. Qualitative reconnaissance surveys covering the entire bay were conducted by walking and swimming throughout the area from the shoreline to the main channel along the length of the proposed project site boundaries. These surveys were useful in making relative comparisons between areas, identifying any unique or unusual biotic resources, and providing a general picture of the physiographic structure and benthic assemblages occurring throughout the region of study.

Following the preliminary survey, which indicated that the majority of the area consisted of mud flats, 4 quantitative transect stations were selected. These stations were situated on patch reefs between the shoreline and the main channel (see Figure 2).

Quantitative benthic surveys were conducted by stretching a 50 m surveying tape over the reef surface. An aluminum quadrat frame, with dimensions of 1 m by 0.66 m, was sequentially placed over 10 random marks on the transect tape so that the tape bisected the long axis of the frame. At each quadrat location a color photograph recorded the segment of reef area enclosed by the quadrat frame. In addition, a diver knowledgeable of the taxonomy of resident species visually estimated the percent cover and occurrence of organisms and substrata types within the quadrat frame. Only macrofaunal species greater than approximately 2 cm were noted; no attempt was made to identify and enumerate cryptic species dwelling within the reef framework.

Following the period of field work, quadrat photographs were projected onto a grid and units of bottom cover for each species and bottom type were calculated. This information was combined with the in-situ cover estimates and the combined assessment provided the data base for the benthic community structure analysis. Species diversity was calculated using the Shannon-Wiener Index, and can be equated with the equitability, or dominance, of distribution of the species occurring on each transect.

The practical advantages of photo-transects are numerous; most species can be easily and accurately identified from transparencies, and the transparencies provide a permanent record for subsequent time-series comparisons. Also, photo-quadrat sampling is rapid and efficient with respect to time and data collected, an important consideration under conditions where underwater time is restricted by cost and depth.

Quantitative assessment of reef fish community structure was conducted in conjunction with the benthic surveys. As the transect tape was being laid along the bottom, all fishes observed within a band approximately 6 feet wide along the transect path were identified to species and enumerated. Care was taken to conduct the fish surveys so that the minimum disturbance by divers was created, ensuring the least possible dispersal of fish. Only readily visible individuals were included in the census. No attempt was made to seek out cryptic species or individuals sheltered within coral.

RESULTS

Physical Environment

The nearshore area fronting the the Waiahole-Waikane area is composed of depositional mud flats, composed of particulate organic materials emanating from stream flow. At the time of this survey, the shoreline was covered with a thick mat of organic material deposited from flood drainage. Moving offshore sediment particle size decreases, becoming fine, silty mud (see Plate 1). Beginning approximately 200 m from shore, a network of patch reefs is interspersed in the mud flats. The seaward extension of the patch reefs terminates in the main channel. The top surface of the patch reefs is from 1 to 2 m in depth, and they are composed of limestone, deposited by reef organisms.

Sides of the reefs are steep and extend down to mud flats. Such topographic features are typical of the northern sector of Kaneohe Bay, and the area off Waikane does not appear to represent any unique or unusual environment.

Water Chemistry

Table 1 shows values of salinity, dissolved nutrients, turbidity and suspended solids at the 12 sampling stations. It can be seen that there is an inverse relationship between salinity and all other parameters. Salinity is a conservative tracer that mixes between end members of freshwater from stream input (0 o/oo) and sea water from the open ocean (34 o/oo). Salinity, therefore, indicates the degree of mixing at any specific site (i.e. the lower the salinity, the larger the component of stream water that has mixed with oceanic water. Moving offshore from station 1 through 6 salinity steadily increases from a low of 19.8 o/oo near the mouth of Waikane stream to 33.2 o/oo in the main channel which connects to the open ocean. Sampling stations parallel to shore indicate that to the north of Waikane Stream (#7-#9) salinity is within 1 o/oo of the values in the channel. Decreased salinity at stations to the south of Waikane Stream in the nearshore zone (#10,#11) indicate a southerly water flow in the inner reaches of the north bay. It appears that the majority of material that reaches the Kaneohe Bay via stream flow is either deposited near the shoreline, or is carried south along the shoreline toward Waiahole stream. These results agree with the generalized circulation pattern described by Smith et al. (1981). In Figure 3, which shows the circulation pattern in the Bay, it can be seen that material emanating from Waikane stream will be carried south, and then away from the shoreline back out to the open ocean via the main channel. This circular flow will carry materials entering the nearshore zone out of the north Bay without dispersing these materials over the reef areas off of Waikane stream. Owing to this circulation pattern, dissolved nutrients, suspended solids, and turbidity are elevated in the nearshore region between Waikane and Waiahole streams relative to areas either farther offshore or to the north.

Biological Community Structure

Benthic Community Structure

As described above, the physical structure of the marine environment in the area off Waikane consists of mud flats and patch reefs. Water clarity in the nearshore area (within 200 m from shore) was so poor that it was not possible to observe any biota, had they been present. This region may be the habitat of burrowing organisms that are adapted to areas of high particulate loading. The offshore mud flats are characterized by burrow openings, predominantly from Alpheid shrimp than inhabit the upper meter of sediment throughout Kaneohe Bay (Harrison 1981) (see Plate 1).

Patch reef community structure consists mainly of coral colonies and calcareous algae. Assemblages of coral on patch reefs differs between the "edges" of the reef and the shallow, interior areas. The dominant coral on the edges is Porites compressa, commonly called "finger coral". In Kaneohe Bay, this species occurs predominantly as solid, hemispherically-shaped structures that grow from the reef base at the coral-mud interface (see Plate 2). Destructive energy from storm waves is absorbed by these colonies on the edge of the reef, and during episodes of intense storm stress blocks of P. compressa calve off from the reef and roll to the lagoon floor (see Plate 3). Transect 2 traversed an edge of a patch reef directly offshore from Waikane stream. It can be seen in Table 2 that P. compressa cover accounts for 43% of bottom cover, mostly in the form of large colonies. The only other coral that occurred in substantial proportions on the reef edge (8%) is Pocillopora damicornis. P. damicornis occurs as small colonies with a delicate branching growth form.

The flat, shallow interior parts of the patch reefs are dominated by a coral with a very different growth form as on the reef edge. Montipora verrucosa accounts for between 24% and 64% of benthic cover on the 3 transects which bisected in interiors of patch reefs (transects 1, 3, and 4). In Kaneohe Bay, this species occurs predominantly in a ramose growth form characterized by thin pinnacles and flat plates (see Plates 4-6). These colonies are extremely fragile and break into fragments with only slight mechanical stress. However, on the reef tops, wave energy is dissipated to a great extent by the P. compressa edges. With the reduction in wave stress M. verrucosa is competitively superior to other species, and dominates bottom cover. It can be seen that percentage cover of _M. verrucosa_ decreases moving seaward on the patch reefs, probably in response to the degree of wave stress. Several other corals contributed small percentages of coral cover on the patch reefs. Coral species diversity on all transects is low owing to domination by a single species. It is important to note that none of the patch reefs surveyed in the Waikane area showed any signs of damage from recent floods.

Algae that were observed on patch reefs included species of _Porolithon_ and _Halimeda_. _Porolithon_ was more abundant on the reef edges, while _Halimeda_ was observed on the interior of patch reefs. _Dictyosphaeria cavernosa_, the species that dominated benthic cover to the point of excluding corals during the period of sewage discharge, was observed on patch reefs. Percent cover, however, of _Dictyosphaeria_ was low, with a peak value of 3% on the reef edge (transect 2). With the relaxation of nutrient subsidy associated with sewage discharge, _Dictyosphaeria_ has lost the competitive advantage to enable it to smother corals, and is presently a minor component of reef biota.

Other conspicuous benthic macro-fauna observed on reef transects included the sea urchins _Tripneustes gratilla_, _Heterocentrotus mammillatus_, _Echinometra matheai_, and _Echinothrix diadema_, and the sea cucumbers _Holothuria spp._. None of these organisms were observed in large aggregations on any of the patch reefs, or on the mud flats between reefs.

Reef Fish Community Structure

Fishes inhabiting muddy areas adjacent to the shoreline and between patch reefs were not quantitatively assessed because most species are not site attached and avoid divers. Species of interest that are found in such habitats include the mullet (Mugil cephalus), milkfish (Chanos chanos), barracuda (Sphyraena barracuda), flagtail (Kuhlia sandvicensis), various jacks (Caranx spp.), and bonefish (Albula vulpes). Also, during the present survey, a commercial skipjack tuna fishing boat was observed catching anchovy (Stolephorus purpureus) for bait.

The population and settlement of fishes on patch reefs in Kaneohe Bay has been described by Wass (1967). In the present study, the total number of species observed on transects was 34; on a single transect species number ranged from 8 to 27, while individual fish encountered on transects ranged from 36 to 315 (see Table 3). In general, the tops of the patch reefs (transects 1, 3, and 4) had both low numbers of species and low numbers of total individuals, while the edges and sides harbored a diverse and abundant fish fauna (transect 2). This is likely due to the abundance of large fissures and crevices on the reef edge and slopes; these features are essentially absent on the top of the reef. The reduced shelter available on the top of the reef makes this habitat less suitable for fishes.

The most common fishes on the reef tops were the saddleback wrasse (Thalassoma duperrey) and aggregations of small parrotfishes (Scarus spp.). Several representative groups of reef fish were predominant on the edge and sides of the reefs.

Algal-feeding acanthurids were the most numerous single group of fishes observed. The convict tang (Acanthurus sandvicensis), yellow tang (Zebrasoma flavescens), and the yellow-eye tang (Ctenochaetus strigosus) were particulary abundant. Schools of small juvenile parrotfishes (Scarus spp.) also contributed to the abundance of herbivores. Aggregations of planktivorous sergeant-major damselfish (Abudefduf abdominalis) were also abundant. The reefs further hosted an assemblage of butterflyfish (Chaetodon spp.) and wrasses (fam. Labridae).

Overall, the fish community at the Waikane site is fairly typical of assemblages found throughout Kaneohe Bay. The number of species, total number of individuals, and overall composition indicate a healthy and diverse fish community in deeper reef sites with suitable habitat, but the upper surfaces of the patch reefs tend to be depauperate, due to a lack of shelter.

Threatened or Endangered Species

Three species of marine animals that occur in Hawaiian waters have been declared threatened or endangered by Federal jurisdiction. The threatened green sea turtle (Chelonia mydas) occurs commonly along the windward coast of Oahu and is known to feed on selected species of macroalgae. The endangered hawksbill turtle (Eretmochelys imbricata) is found infrequently in waters off Hawaii. One small green sea turtle was observed during the course of the survey swimming near the patch reefs. No nesting sites, however, were encountered near the study site.

Populations of the endangered humpback whale (Megaptera novaeangliae) are known to spend the winter months in the Hawaiian Islands. It is not possible, owing to shallow depth for whales to occupy areas off Waikane that were surveyed. It does not appear that the proposed action will cause any effects to endangered or protected species.

DISCUSSION AND CONCLUSIONS

The most important result of the survey of the marine environment offshore of the proposed Waikane Golf Course is that the influence of freshwater from stream flow is not causing detrimental impacts beyond the nearshore region. Counter-clockwise currents carry sediment-laden freshwater parallel to the shoreline fronting the development site, followed by flow to the open ocean via the main channel. Thus, materials coming from the stream are not carried directly offshore to the region of patch reefs between the shoreline and main channel. As a result, benthic and fish community structure are not presently adversely affected by freshwater input at the shoreline, even when such input reaches catastrophic proportions, as happened in early January. While reefs in the southern bay experienced massive coral kills owing to flood run-off, no dead corals were observed in the north bay fronting Waikane.

Construction and operation of the proposed golf course would alter characteristics of flow in Waikane stream. Gordon Dugan of the University of Hawaii Dept. of Civil Engineering, has estimated the changes that will occur in storm run-off, nutrient load, and particulate load for Waikane stream if the golf course is developed (see Table 4). Dugan calculates these changes for storms of 1 and 24 hour duration, with recurrence intervals of 2 to 100 years. In all cases, estimates of change in hydraulic loading and suspended solids show decreases with the golf course in place compared to present conditions. These parameters change in inverse proportion to the duration of the storm event and the recurrence interval. Thus, long but infrequent storms on the golf course have the effect of minimizing water and suspended solids delivery to the marine environment, compared to present conditions. Freshwater and sediment from storm run-off have been shown to be the factors responsible for past reef coral destruction in Kaneohe Bay. Thus, if the proposed golf course serves to decrease these input functions, it appears that development will actually decrease, rather than increase, the potential for detrimental environmental alteration, even though such alteration has not been realized at the Waikane site following floods.

Dugan's estimates of nitrogen and phosphorus change associated with golf course development indicate that nutrient input to the nearshore zone would increase following storms. Following the major flooding event of 1988, nitrate levels in the south bay increased by approximately 100%, quickly followed by a phytoplankton bloom (S. Toguchi, personal communication). The bloom was short-lived, however, and within 2 weeks nitrate and phytoplankton had returned to pre-flood conditions. Damage to corals from the flood did not appear to be a response to increased nutrient levels, or the related phytoplankton bloom, but rather to salinity decreases below 20 o/oo (Jokiel, personal communication). In addition, as stated above, it is possible that detrimental effects to reef ecosystems were not direct responses to nutrient loading in Kaneohe Bay, but rather to a combination of response to flood conditions and nutrient subsidy.

Through the range of estimated storm scenarios, including worst case events such as the January 1988 storm, total nitrogen input would approximately double, while total phosphorus would increase as much as 9 fold with the golf course in place (see Table 4). In order to estimate how these additional inputs might affect water quality, the percentage increase of nutrients in bay waters from the 2 and 100 yr. recurrence 24 hour storms can be calculated. If the *receiving environment is considered to be the* northern sector of Kaneohe Bay, the approximate volume of water is 66 x $10^6 m^3$ (Smith et al. 1981), with average TN and TP concentrations of 8 uM and 0.6 uM, respectively (see Table 1). The 100 yr. storm would increase TN and TP by about 1.4% and 7%, respectively, while the 2 yr. storm would increase TN and TP by about 0.3% and 1.5% respectively. The small magnitude of these increases indicates that even with the "worst case scenario", it is not likely that nutrient inputs from the golf course would cause impacts associated with run-off beyond pre-development levels.

Another aspect of operation of the golf course that might provide the potential for alteration of the marine environment is the used of biocides to control insect pests, weeds and disease. Murdoch and Green (1988) have addressed the potential for environmental impacts of biocide use on the Waikane Golf Course.

These chemicals may be subject to movement from the site of application, either by runoff during high intensity storms, or by movement to groundwater when water infiltration exceeds evapotranspiration. However, Murdoch and Green state that biocides are generally not applied except in response to outbreaks of pests. Thus, the quantity of chemical material applied on a regular basis is very limited. Of the chemicals that are applied, the relatively high organic matter content of the soils in the Waikane region will result in sorption of most biocides within the soil profile. Biocides that are not sorbed will likely be degraded to non-toxic compounds before movement through the soil profile is complete. It appears, therefore, that virtually none of the small quantity of biocides that may be used on the golf course will find its way to the nearshore marine ecosystem in a form that could result in environmental damage.

In summary, it appears that the planned Waikane Golf Course does not present the potential to cause negative impacts to any constituents of the marine environment. The nearshore area fronting the development site is presently subjected to input of materials from Waikane stream; this material appears to be carried south along the shoreline and does not, even after intense flooding events, affect the offshore network of patch reefs. The golf course is estimated to cause decreased volumes of freshwater and suspended sediment discharge into north Kaneohe Bay. These two factors have been observed to be responsible for the majority of flood-related damage to reefs. Thus, construction of the golf course may actually serve as a buffer during future intense storms to lessen the impacts of flooding. It appears that dissolved nutrient input to the marine environment will increase as a result of golf course construction. However, the magnitude of these increases is small in relation to flood-related increases. In addition, nutrients *per se* have not been shown to cause detrimental effects to reef environments. There does not appear to be any potential for marine environmental alteration from biocides that may be used for pest and disease control on the golf course.

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TABLE 1. Water chemistry parameters in the vicinity of the proposed Waikane Golf Course. For station locations, see Figure 2.

STATION	SALINITY (o/oo)	NO3+NO2 (uM)	NH4 (uM)	TOTAL N (uM)	PO4 (uM)	TOTAL P (uM)	Si (uM)	TURBIDITY (ntu)	SUSPENDED SOLIDS (mg/l)
1	19.826	3.21	4.17	17.79	0.61	0.72	174.27	0.75	230.0
2	30.285	1.57	1.97	7.77	0.42	0.72	52.75	15.60	54.2
3	32.484	0.81	0.79	8.08	0.26	0.56	18.84	3.69	27.3
4	32.646	0.76	0.69	8.05	0.30	0.63	16.58	1.16	2.6
5	32.964	0.78	0.69	6.98	0.26	0.57	15.07	0.61	6.3
6	33.168	0.71	0.53	6.46	0.26	0.61	13.19	0.43	4.5
7	32.264	0.54	0.65	9.29	0.29	0.63	16.96	0.86	3.6
8	32.179	0.54	0.65	7.54	0.22	0.59	20.72	0.95	3.2
9	32.342	0.64	1.00	6.00	0.30	0.63	19.41	3.90	5.9
10	14.402	6.00	1.69	15.81	0.43	0.72	240.21	10.47	246.8
11	16.978	5.98	1.23	13.81	0.31	0.64	216.66	5.23	241.7
12	32.341	1.40	1.23	9.20	0.30	0.63	37.68	8.26	50.6

TABLE 2. Percent cover of coral species and non-coral substrata encountered on photo-transects in the vicinity of the proposed Waikane Golf Course. For location of transects, see Figure 1.

CORAL SPECIES	TRANSECT 1	2	3	4
Montipora verrucosa	42.4	0.5	64.2	24.3
Montipora patula	0.0	0.2	0.0	0.0
Pocillopora damicornis	0.6	7.8	0.2	4.6
Pocillopora meandrina	0.0	0.0	0.5	5.4
Porites compressa	3.7	43.0	0.0	1.0
Cyphastrea ocellina	0	0.1	0	0
Anthelia edmondsoni	0	0.1	0	0.1
ALGAE SPECIES				
Halimeda	0.4	0.1	0	0.2
Dictyospheria cavernosa	0.1	0	0	3.1
Porolithon gardneri	0	5	0	1
NON-CORAL/ALGAL BOTTOM COVER				
Solid limestone	0.0	41.1	0.0	0.0
Limestone rubble/sand	49.7	2.2	35.08	52.7
NUMBER OF CORAL SPECIES	4	4	3	5
PERCENT CORAL COVER	49.9	51.6	64.9	43.0
CORAL SPECIES DIVERSITY	0.57	0.51	0.06	1.21

TABLE 3. Reef fish community structure parameters for Kaneohe Bay patch reef transects in the vicinity of Waikane stream.

	T-1	T-2	T-3	T-4
MURAENIDAE				
Gymnothorax eurostus				1
FISTULARIIDAE				
Fistularia petimba	2	2		
MULLIDAE				
Mulloidichthys flavolineatus		6		
Parupeneus porphureus		1		2
P. multifasciatus	2	4	2	
CHAETODONTIDAE				
C. miliaris	2	19		2
C. ornatissimus		2		1
C. unimaculatus		1		
C. kleinii		2		
C. auriga	1	4		
C. lineolatus		2		
Forcipiger flavissimus		3		
POMACENTRIDAE				
Abedefduf abdominalis		34		
Dascyllus albisella		6		
LABRIDAE				
Cheilinus unifasciatus		2		
Thalassoma duperrey	7	14	3	28
Gomphosus varius		4		
Labroides phthirophagus		3		
Stethojulis balteata	3	3	7	5
Halichoeres ornatissimus	1			
SCARIDAE				
Scarus sordidus		8		
juvenile *Scarus*	7	51	31	17
ACANTHURIDAE				
Zebrasoma flavescens		27		
A. sandvicensis		53	4	2
A. dussumieri		2		
A. blochii	1	4	5	1
A. nigrofuscus				2
Ctenochaetus strigosus		48		
ZANCLIDAE				
Zanclus cornutus	3	8	1	
MONOCANTHIDAE				
Pervagor spilosoma	7		3	
TETRAODONTIDAE				
Canthigaster jactator		2		1
NUMBER SPECIES	11	27	8	11
NUMBER INDIVIDUALS	36	315	56	62
SPECIES DIVERSITY	2.149	2.593	1.495	1.626

Storm[a]			Storm Water Runoff												
			Hydraulic			Nitrogen[b]			Phosphorus[c]			Suspended Solids[d]		
Dur-ation	Recur-rence Interval	Quan tity	Development 1988	Development Full	Δ	Development 1988	Development Full	Δ	Development 1988	Development Full	Δ	Development 1988	Development Full	Δ
hr	yr	in.	AF/event	AF/event	AF/event	lb/event	lb/event	lb/event	lb/event	lb/event	lb/event	ton/event	ton/event	ton/event
1	2	1.5	0.4	0.2	- 0.2	0.7	0.7	0.0	0.1	0.3	+ 0.2	0.35	0.07	- 0.28
1	10	2.3	2.9	2.3	- 0.6	4.7	7.5	+ 2.8	0.5	3.6	+ 3.1	2.56	0.78	- 1.78
1	50	3.2	7.8	6.7	- 1.1	12.7	21.9	+ 9.2	1.3	10.4	+ 9.1	6.89	2.28	- 4.61
1	100	3.9	12.5	11.2	- 1.3	20.4	36.6	+ 16.2	2.0	17.4	+ 15.4	11.05	3.81	- 7.24
24	2	6.2	32.3	29.9	- 2.4	52.7	97.6	+ 44.9	5.3	46.4	+ 41.1	28.55	10.17	- 18.38
24	10	10.7	79.7	76.1	- 3.6	130.1	248.4	+ 118.3	13.0	118.0	+ 105.0	70.45	25.87	- 44.58
24	50	14.3	121.4	117.1	- 4.3	198.1	382.2	+ 184.1	19.8	181.6	+ 161.8	107.32	39.81	- 67.51
24	100	16.4	146.5	141.9	- 4.6	239.1	463.2	+ 224.1	23.9	220.0	+ 196.1	129.51	48.25	- 81.26

a) From "Rainfall Frequency for Oahu," (Giambelluca, et. al., 1984)

b) Based on a nitrogen value of 0.60 mg/L for 1988 conditions, and 1.20 mg/L for full development.

c) Based on a phosphorus value of 0.06 mg/L for 1988 conditions and 0.57 mg/L for full development.

d) Based on a suspended solids value of 650 mg/L for 1988 conditions and 250 mg/L for full development.

TABLE 4. Estimated storm water run-off and constituent changes owing to proposed Waikane Golf Course. Data supplied by G. Dugan.

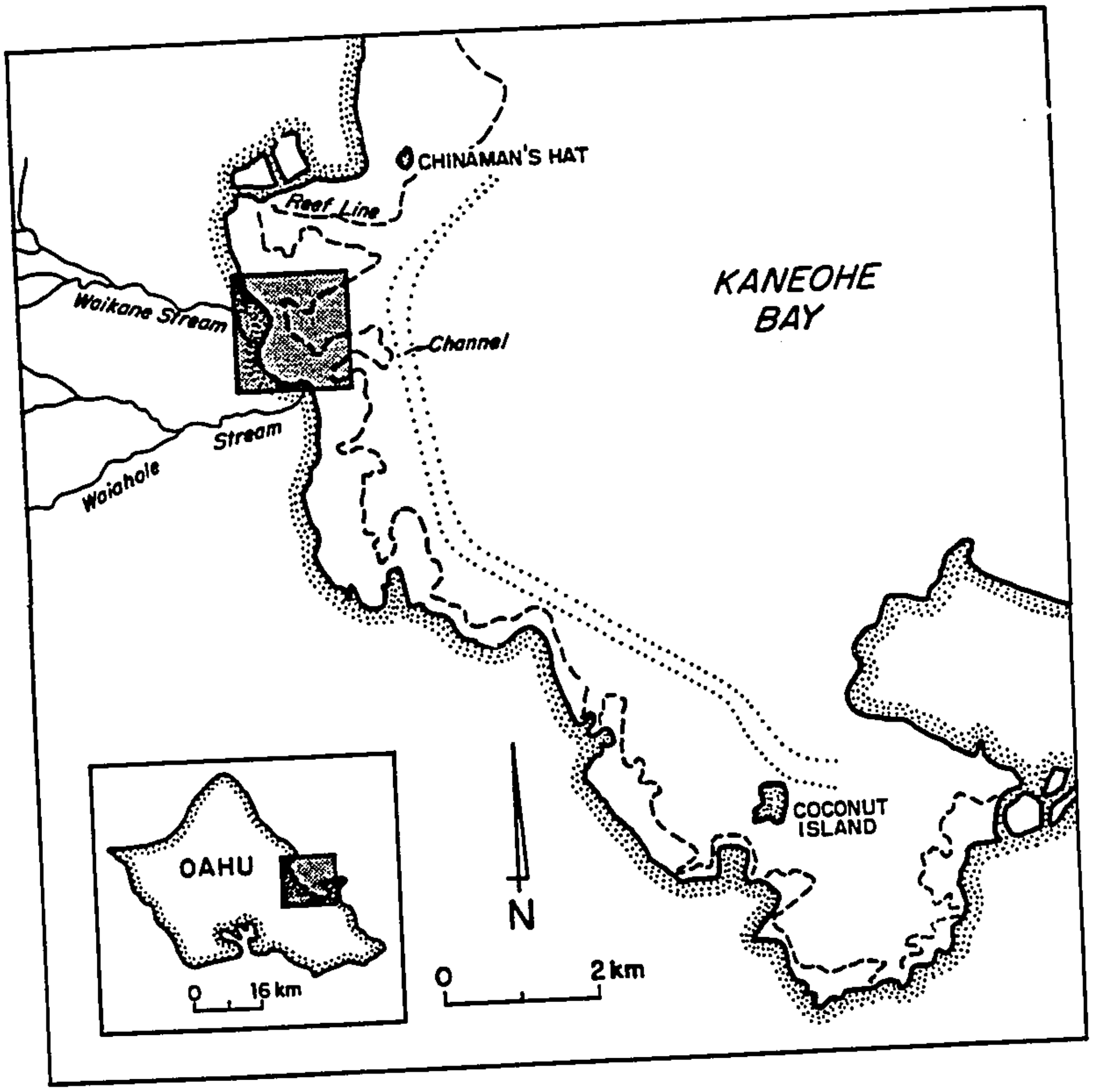

FIGURE 1. Map showing location of Kaneohe Bay on northeast coast of Oahu, and location of study area off of Waikane stream (shaded box).

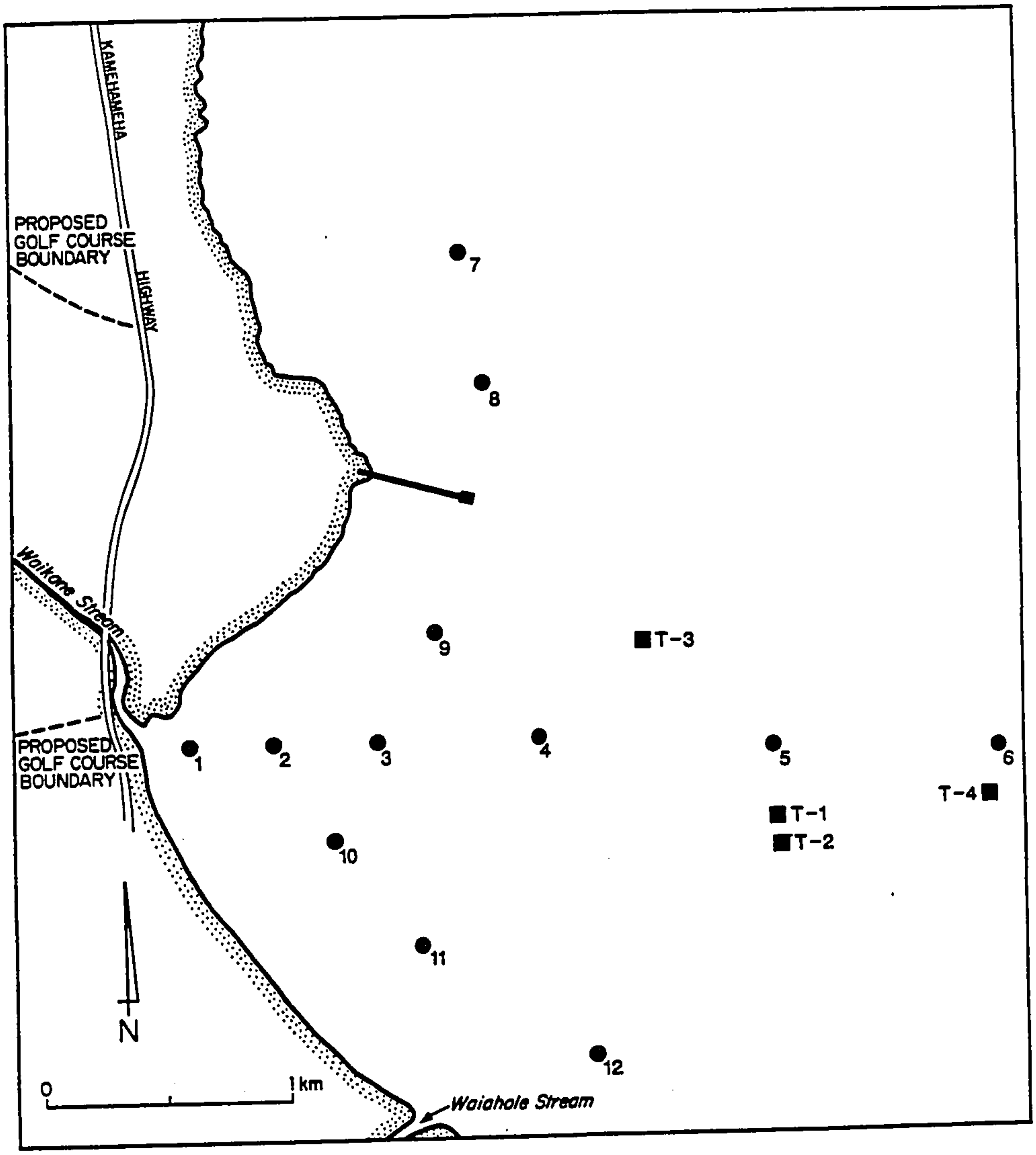

FIGURE 2. Map showing locations of numbered chemistry sampling stations (circles) and reef transects (squares).

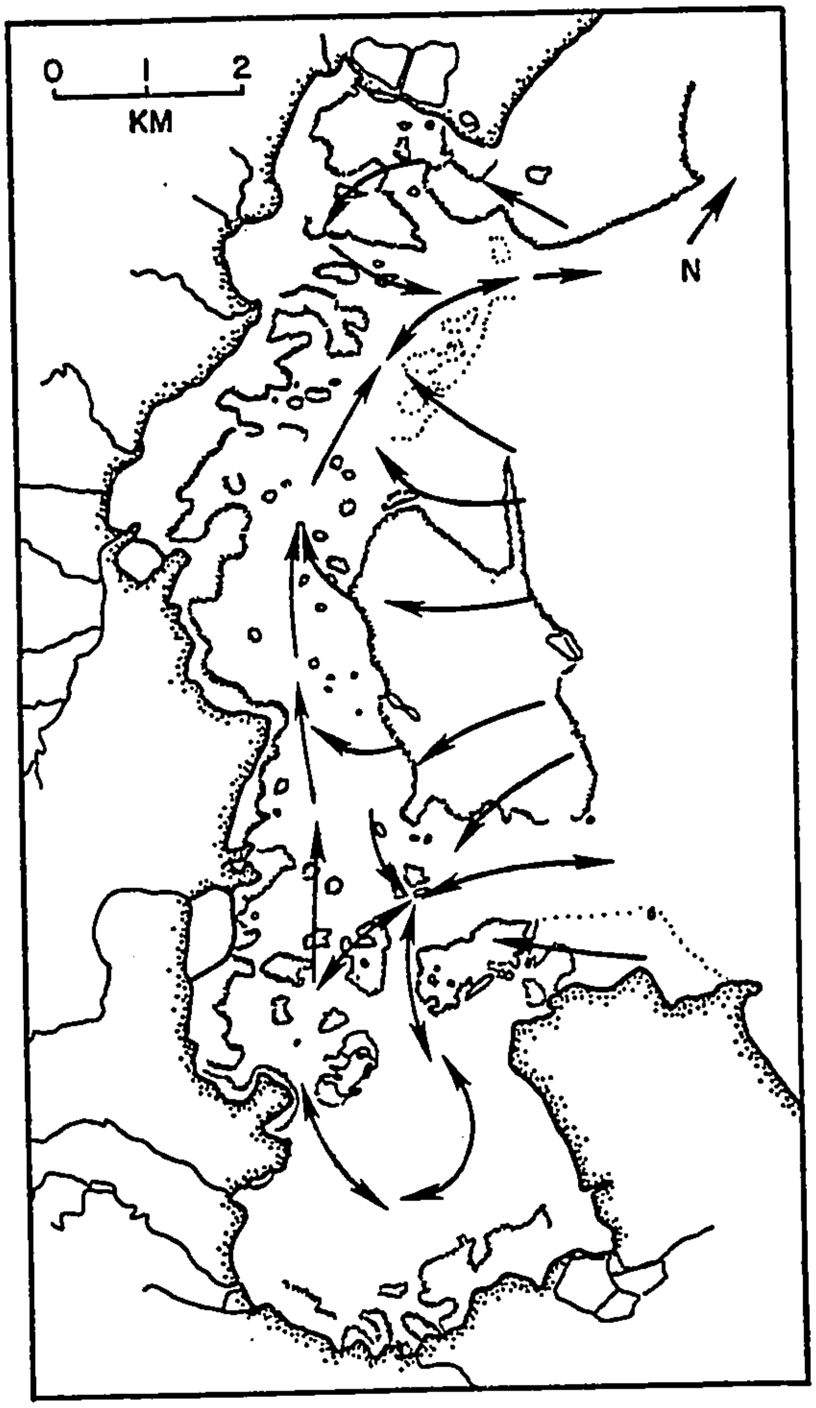

FIGURE 3. Generalized circulation pattern in Kaneohe Bay (from Smith et al. 1981). Note southerly flow in nearshore area in the vicinity of Waikane stream.

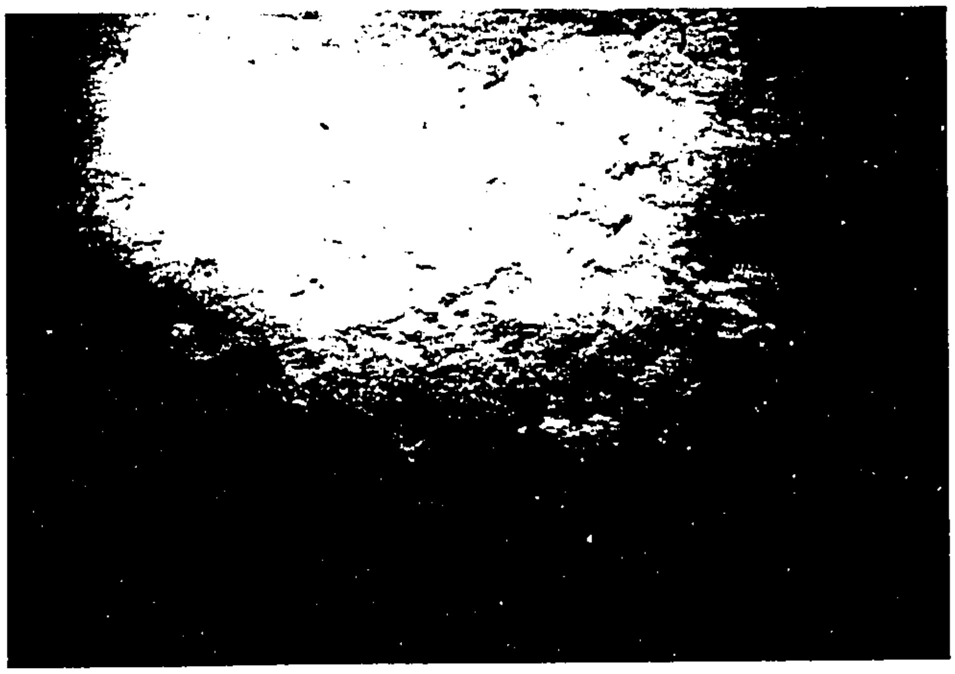

PLATE 1. Typical bottom in mud flats between patch reefs in north Kaneohe Bay. Holes are burrow entrances for Alpheid shrimp.

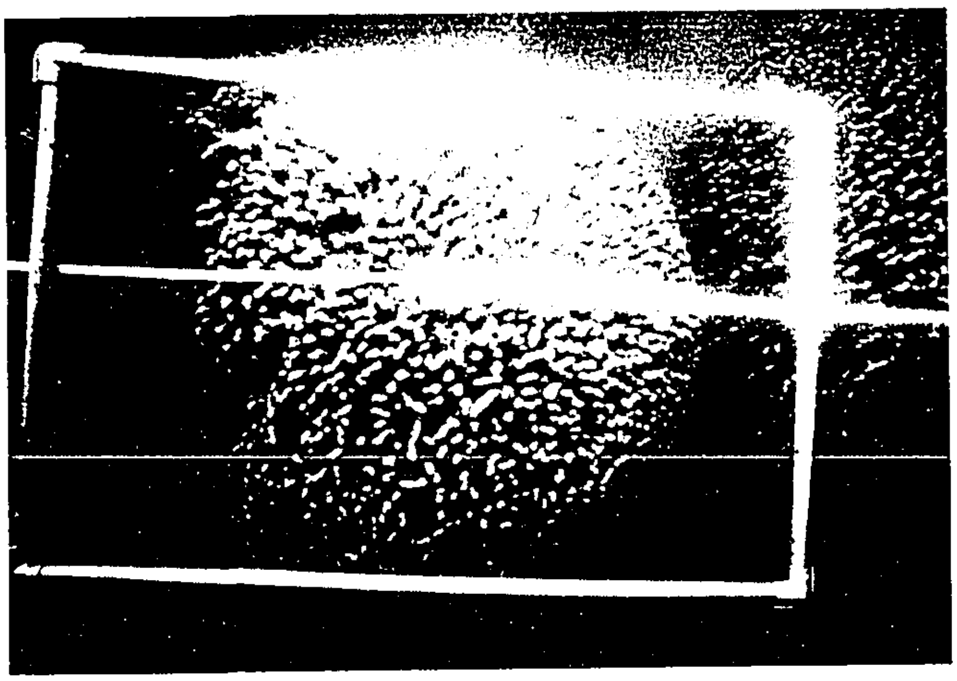

PLATE 2. Typical transect photograph on patch reef edge (transect 2). Visible coral colonies are large dome-shaped heads of Porites compressa.

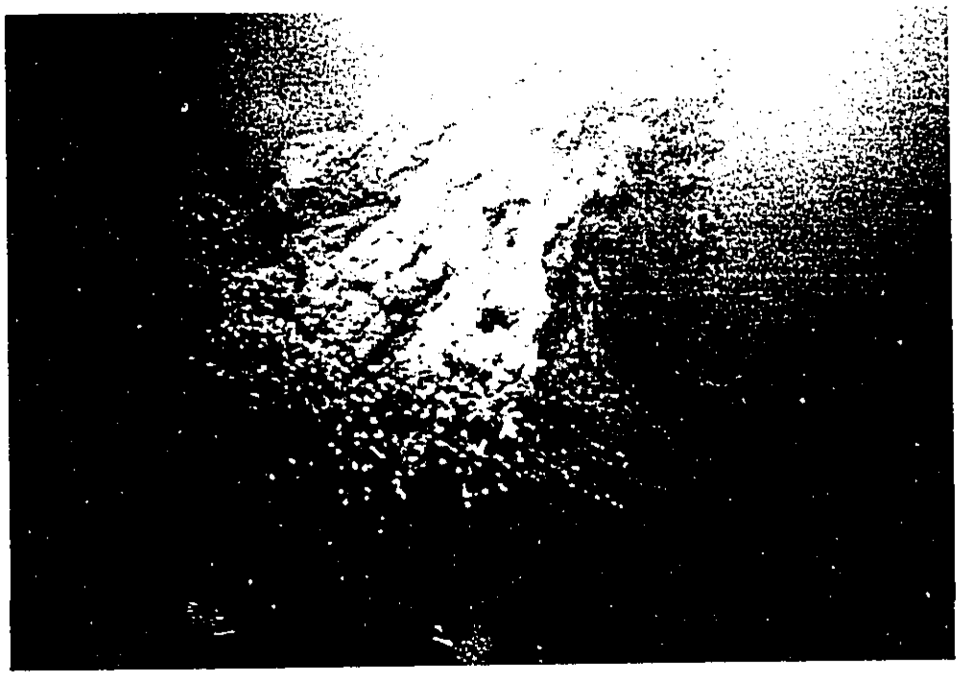

PLATE 3. Section of patch reef that was broken off and fallen onto mud flat. Fingers of P. compressa can be seen growing in "new" upward direction. Such calving and re-growth is responsible for enlarging patch reefs.

PLATE 4. Typical transect photograph on center of Kaneohe Bay patch reefs (transects 1, 3, 4). Majority of living coral is Montipora verrucosa. Small white reticulated colonies in upper left corner are Pocillopora damicornis.

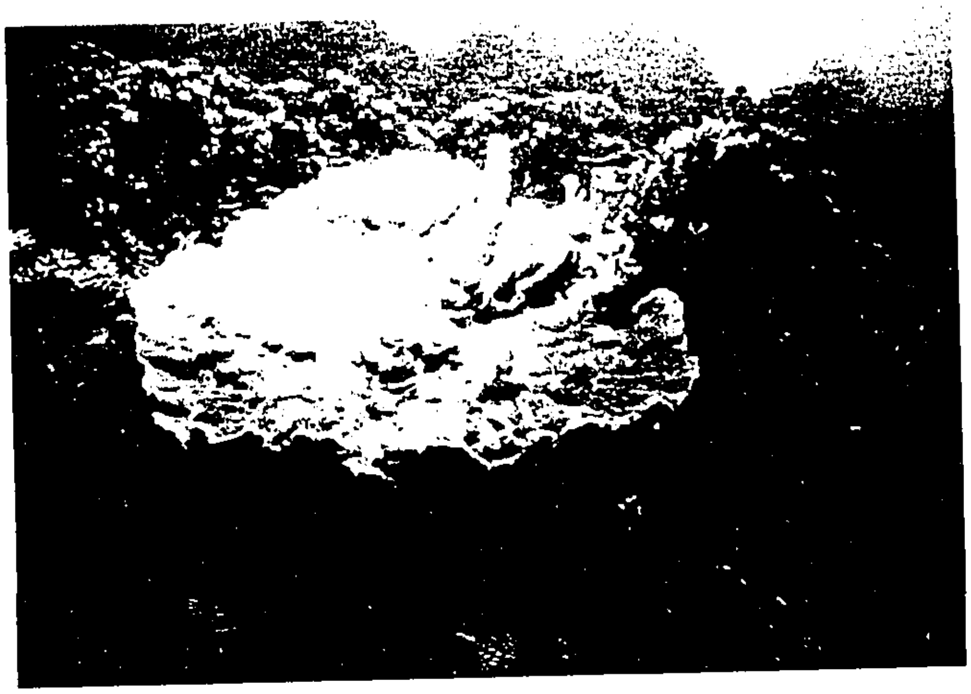

PLATE 5. Colony of Montipora verrucosa showing thin plating, and pinnacles. Such colonies are very fragile and susceptible to breakage from wave stress.

PLATE 6. Large colony of M. verrucosa showing spreading ramose growth form.

APPENDIX N
Botanical Survey

BOTANICAL SURVEY

WAIKANE PROJECT AREA
KOOLAUPOKO, OAHU

Prepared for: Group 70

By: Kenneth M. Nagata

Date: 9 February 1988

INTRODUCTION

The project site occupies approximately 500 acres in the lower portion of Waikane Valley, Koolaupoko District, Oahu. It is bordered on the Kahuku side (north) by the Puu Ohulehule-Puu Pueo ridge, on the Kaneohe side (south) by a low ridge near the Waiahole Agricultural lots, and Kamehamcha Highway on the _makai_ side. The _mauka_ boundary cuts across the 200-250 foot contours. Prominent topographic features of the site include two tablelands, two large gulch complexes, the Waikane Stream complex, and the slopes up to the 100 foot contour on the Puu Ohulehule-Puu Pueo ridge. The areas designated "Wetlands" along Kamehemcha Highway and the steep slopes above the 100 foot contour on the Puu Ohulehule-Puu Pueo ridge together accounting for approximately 200 acres, have been excluded as intensive survey areas but included as part of the overall site.

The vegetation of the region has been broadly classified into two zones by Ripperton and Hosaka (1942). In the lower portion of the valley where the annual rainfall is less than 60 inches the vegetation falls within their Zone C, Low Phase (Mixed Open Forest and Shrubs) which is characterized by open forests and grasses. Guava (_Psidium guajava_) is the most predominant shrub below 1500 feet in this zone. Other important shrubs include lantana (_Lantana camara_) and koa-haole (_Leucaena leucocephala_) which forms dense thickets below 700 feet elevation. Important grasses of this zone are Bermuda grass (_Cynodon dactylon_), Natal red top (_Rhynchelytrum repens_), golden beardgrass (_Chrysopogon aciculatus_) and yellow foxtail (_Setaria glauca_). Where the annual rainfall exceeds 60 inches the vegetation was classified as Zone D, Low Phase (Shrub and Closed Forest). Here, guava continues to be the predominant shrub with hala (_Pandanus odoratissimus_) and kukui (_Aleurites moluccana_) the characteristic trees. Grasses such as Hilo grass (_Paspalum conjugatum_), yellow foxtail and carpetgrass (_Axonopus_ sp.)

are also characteristic.

More recent botanical investigations have been conducted in the valleys adjacent to the project site. Kahana Valley was surveyed by Thoebald and Wirawan in 1973. Of the 13 plant communities they recognized, five were native. These native communities consisted of various associations of koa (Acacia koa), hala, 'ohi'a (Metrosideros collina subsp. polymorpha) and hau (Hibiscus tiliaceus), and occupied a considerable portion of the valley. Pastures and cultivated areas occupied a smaller portion of the site. The prominent non-native species which were dominant in certain areas included rose apple (Eugenia jambos), Java plum (E. cumini), guava, and octopus tree (Brassaia actinophylla). Several species of bamboo were also abundant. Grasses such as broomsedge (Andropogon virginicus), Hilo grass and golden beardgrass were found to be dominant on the ridges in the drier part of the valley.

The vegetation in Waiahole Valley is also well known (M & E Pacific, Inc., 1985). According to that survey, the floor of the valley consists of agricultural crops, pastures and waste areas dominated by Guinea grass (Panicum maximum), pluchea (Pluchea odorata), Christmas berry (Schinus terebinthifolius) and Java plum. Species common along the stream include elephantgrass (Pennisetum purpureum), mango (Mangifera indica), octopus tree, kukui and hau, and the valley slopes are dominated by mixed open-canopied forests of octopus tree, hala, Java plum and mango. Scattered native koa, uluhe (Dicranopteris linearis) and 'ie'ie (Freycinetia arborea) are also found on the slopes. Only at the very head of the valley do the less common native species occur. Several species of Cyrtandra, Pteralyxia, Charpentiera and Pisonia were recorded in these regions.

METHODS

A walk-through survey was conducted during four days in January 1988 to determine the floristic composition of the project site. Transects were established through each different vegetation type with approximately 75% coverage. Special emphasis was given to locating native ecosystems and rare and endangered native species. The upper slopes of the Puu Ohulehule-Puu Pueo ridge were surveyed with the aid of field glasses and the Wetlands were surveyed by only two transects. Only general observations were made in these two zones and their vegetation is not included in the Species Checklist.

RESULTS

The vegetation in the project site consists of mixed secondary Java plum forests, grasslands, and cultivated areas. The nature of the vegetation is entirely secondary, indicating a long history of disturbence and alteration. According to Mr. Davis, a life-long resident of the valley, pineapples were once grown on the tablelands, small truck farms were established in many areas in the valley, and rice and taro were cultivated in the lowlands, in the present Wetlands and along Waikane Stream. In addition, the foothills and tablelands were extensively used for military training exercises especially during the Korean Conflict. He contends that numerous unexploded rounds may still be found in the mauka areas. The result is the complete obliteration of the native ecosystems which once existed.

Four main vegetation types and several subtypes were recognized. These are presented in the accompanying vegetation map with distinct boundaries but it must be understood that in nature no sharp boundaries exist. Rather, vegetation exists as a continuum with one type grading into another.

Mixed Eugenia Forests (F)

The dominant species throughout the site is Java plum. It occurs in abundance in all topographic situations except on the narrow ridge crests but reaches its fullest potential in the moist ravines and along Waikane Stream where the trees attain heights of more than 50 feet. On the slopes and on poorer soils the trees are dwarfed and widely scattered. Often they are festooned with yellow granadilla (Passiflora laurifolia) which may be the second most abundant species in the project site. Although Java plum occasionally forms small pure stands, it is more commonly found in association with other species. Three forest subtypes can be distinguished.

1. Brassaia Subtype (map unit Fb). This is the single most prevalent vegetation unit in the project site. Octopus tree is a co-dominant element in this subtype which is best developed in gullies and ravines where moisture is more readily available. In these situations the Java plum and octopus trees reach heights of 35 feet or more. Mango and albizia (Albizia falcataria) which grow to more than 100 feet tall, are common in these situations. On exposed slopes and on the tablelands the trees are shorter and more widely spaced and the herb and shrub layers generally consist of Boston fern (Nephrolepis exaltata), broomsedge and 'akia (Wikstroemia oahuensis). On more protected slopes the trees are very closely spaced, forming dense growth. On the slopes in the Kahuku side of the project site octopus tree is often dominant over Java plum. Yellow granadilla, Boston fern and strawberry guava (Psidium cattleianum) are common species in this subtype. On drier slopes, Christmas berry is an important element.

2. Hibiscus Subtype (map unit Fh). In the gulch system on the Kaneohe side of the project site hau is a co-dominant element in the Java plum

forests. Typically, this subtype consists of dense tangles of hau in association with stands of closed-canopied Java plum more than 30 feet tall. Because of the deep shade the understory is poorly developed. In the upper portions of the small gullies the forest is open-canopied and the trees much shorter. Here, Boston fern, Koster's curse (Clidemia hirta) and lantana are common in the understory and octopus tree, strawberry guava and Christmas berry become increasingly important. This forest extends down to Kamehameha Highway where the land is marshy and false kamani (Terminalia catappa) is a conspicuous element.

This subtype is also found on the mauka edge of the Wetlands along Waikane Stream. The forest here is open-canopied with the trees festooned with maile pilau (Paederia foetida) and moon flower (Ipomoea alba). The resulting shrub and herb layers are well developed and consist mostly of Guinea grass, basketbrass (Oplismenus hirtellus), paragrass (Brachiaria mutica) and burbush (Triumfetta semitriloba).

3. Eugenia jambos Subtype (map unit Fe). A large stand of rose apple is found in the right branch of the gulch on the Kaneohe side of the property. The vegetation here consist of closed-canopied rose apple trees 30 feet tall with occasional emergent Java plum, hala and mango. The dense shade provided by these trees precludes any significant understory development. Boston fern, Java plum and rose apple seedlings and basketbrass are the most common elements in the sparse herb layer.

Grasslands (G)

Most of the upper slopes, ridge crests, tablelands and several flat sections in the lowlands are dominated by Grasslands of varying species composition. Many are being used as horse or cow pastures and several are abandoned crop lands. Quantitatively, Grasslands are the second most important vegetation type in the project site.

1. Andropogon Grasslands (map unit Ga). This type of Grassland is common on the upper ridge slopes, on ridge crests and on the tablelands on the Kahuku side of the project site. It is dominated by broomsedge up to five feet tall which usually provides 100% cover. Small stands or individuals of Java plum and strawberry guava and stands of Boston fern are typical in this community. Also associated with the Andropogon Grasslands are sensitive plant (Mimosa pudica var. unijuga), perennial foxtail (Setaria geniculata), Spanish clover (Desmodium canum), Hilo grass, golden beardgrass and yellow granadilla.

2. Microlaena Grasslands (map unit Gm). On the tablelands and ridge crests where the soils are probably deeper, richer or moister, broomsedge is replaced by what appears to be meadow ricegrass (Microlaena stipoides). Fertile material was not seen during the survey period and thus the determination is only tentative. This grass often forms dense pure stands 12 to 24 inches high. Hilo grass is a common component in some areas and small stands or individuals of Java plum and Boston fern are common in other sections. Herbaceous species such as sensitive plant, partridge pea (Cassia leschenaultiana) and three-flowered beggarweed (Desmodium triflorum) and grasses such as Bermuda grass and goosegrass (Eleusine indica) are common along paths and roadways through this grassland. All of the Microlaena Grasslands in the project site are being used as horse pastures.

3. Brachiaria Grasslands (map unit Gb). This type of Grassland is generally found in moist lowlands. In its purest form, it consists of open fields of paragrass with very few associated species. Honohono (Commelina diffusa) and Hilo grass are occasional species in this Grassland and a few

hau and Java plum trees can be found generally at the periphery. The Wetlands are excellent examples of this vegetation type. Other Brachiaria Grasslands are abandoned farm lands and are more heterogeneous in composition. Numerous "weedy" species are associated with these sites including phyllanthus weed (Phyllanthus debilis), comb hyptis (Hyptis pectinata), Bidens alba var. radiata, burbush and sensitive plant. Although upper canopy cover is typically sparse in this type of Grassland, the extensive community along Waikane Stream and a small community near the mauka-Kahuku corner of the property are being invaded by albizia. In these sites the tree cover approaches 75%.

Several of the Brachiaria Grasslands, especially the extensive community opposite the church and also the Wetlands, are being used as cow pastures.

4. Axonopus Grasslands (map unit Gax). The smallest of the Grassland communities is the Axonopus Grasslands which are dominated by the low-growing narrow-leaved carpetgrass (Axonopus affinis). Other low-growing species such as Asiatic pennywort (Centella asiatica), three-flowered beggar-weed, sensitive plant and Hilo grass are common in this community. In certain areas such as beneath the Java plum trees, Boston fern, burbush and meadow ricegrass are common. Horses and cows are being pastured in this community.

Mixed Riparian Association (R)

The vegetation along Waikane Stream is a mosaic of different plant communities which for the purposes of this report, are unified into a single but artificial vegetation type. Broadly defined, the Mixed Riparian Association includes the vegetation along the flood plain of Waikane Stream. Three completely different subtypes are recognized; none are considered botanically important from the stand point of native ecosystems.

1. Mixed Forest Subtype (map unit Rf). The forest along Waikane Stream is itself a mosaic of several species each forming nearly pure stands in certain areas and mixed stands in others. Typically the forest is closed- canopied but the understory varies from sparse to exceedingly dense. For instance, along Kamehameha Highway the forest is closed-canopied and consists of tall mango, Java plum and false kamani (Java plum often forms pure stands here), but the land is generally one of mud and gravel outwash and gravel bars. The resulting understory is sparse and consists largely of tree seedlings, 'ape (Alocasia macrorrhiza) and blue 'ape (Xanthosoma violaceum). On the other hand, the understory in some of the upstream portions of the forest is so dense that passage is made extremely difficult.

Conspicuous trees include Java plum which grow to 50 feet or more in height, mango, octopus tree, hau which forms impenetrable thickets, albizia which grow to heights of 100 feet or more, and false kamani. The most common understory species are Boston fern and basketgrass. Maile pilau, yellow granadilla and moon flower occasionally grow into the trees and may become locally abundant. Several banana (Musa x paradisiaca) groves are found in these forests but in small numbers. A small stand of an undetermined species of Rubiaceae was discovered on the banks of Waikane Stream. Although it is definitely not a native species, proper identification cannot be made until flowers or fruits are seen.

2. Grassland Subtype (map unit Rg). Several Brachiaria Grasslands are found along Waikane Stream and are here considered part of the riparian vegetation. These are situated on flat sections adjacent to the stream and are believed to be former taro paddies. Honohono, Job's tears (Coix lachryma-jobi), primrose willow (Ludwigia octivalvis) and canna (Canna

indica) are generally associated with these sites.

3. Cultivated Area Subtype (map unit Rc). A small portion of the flood plain is being farmed by Asian immigrants. Typical of these farmlands are such familiar crops as banana, red pepper (Capsicum annuum) and papaya (Carica papaya). Also cultivated are the more ethnic Asian species such as lemongrass (Cymbopogon citratus), ung-choi (Ipomoea aquatica), khaa (Alpinia galanga), Citrus hystrix, Polygonum odoratum, and Limnophila aromatica. Weeds and ornamentals in these areas are typical of those in other cultivated areas.

Cultivated Lands (C)

Lands designated as Cultivated Lands include residences and farms (except those along Waikane Stream which are included as a subunit of Mixed Riparian Association), but not pastures which are included as Grasslands. An enormous number of ornamental and weedy species are associated with these areas. Mango, Java plum, monkeypod (Samanea saman), coconut (Cocos nucifera) and avocado Persea americana) are the typical trees while the lawns are generally a mixture of Hilo grass, Bermuda grass, kyllinga (Cyperus kyllinga), Henry's crabgrass (Digitaria adscendens) and Hemigraphis reptans. Among the numerous ornamentals are poinsettia (Euphorbia pulcherrima), impatiens (Impatiens sultani), yellow ginger (Hedychium flavescens), red ginger (Alpinia purpurata) and monstera (Monstera deliciosa). Several cultivated species have escaped from the numerous trash piles scattered along the road beyond the residential area and are now found as wayside species. The most conspicuous of these is wedelia (Wedelia trilobata). Coconuts, papaya, monstera, Calliandra sp. and Philodendron radiatum have also become established in certain areas. Common weeds in the Cultivated Lands include burbush, honohono, phyllanthus weed, Spanish clover, goosegrass, sensitive plant, Asiatic pennywort, ageratum (Ageratum conyzoides) and sourgrass (Tricachne insularis).

Unsurveyed Areas

1. Slopes of the Puu Ohulehule-Puu Pueo Ridge. Observation with field glasses revealed the vegetation to consist of Andropogon Grasslands on the ridge crests and exposed slopes and mixed short-statured forests in the ravines and on protected slopes. Dominant forest species include octopus tree, strawberry guava, Christmas berry and hala. Scattered on these slopes are also emergent albizia and ironwood (Casuarina equisetifolia). In the lower portion of the major ravines the albizia forms tall, closed-canopied stands probably exceeding 75 feet in height. Java plum becomes dominant in the lower slopes and the vegetation slowly grades into the Mixed Eugenia Forest (Brassaia Subtype).

2. Wetlands. Once rice and taro paddies, the areas designated as Wetlands today consist of nearly pure stands of paragrass with emergent hau and Java plum. Hilo grass and honohono are co-dominant in certain areas. Primrose willow, pluchea (Pluchea odorata), candlebush (Cassia alata), pua-nānā-honua (Solanum auriculatum), Jamaica vervain, sensitive plant and koa-haole are among the very few additional species associated with the Wetlands. Conspicuous in their absence are rushes and sedges such as the great bulrush (Scirpus californicus) which are characteristic of marshes and other wetlands.

NATIVE SPECIES AND NATIVE ECOSYSTEMS

Very few native plant species occur in the project site. The most abundant are the indigenous hau which is a co-dominant component in one of the vegetation subtypes, the endemic 'ākia which is common on many of the slopes and the indigenous Boston fern which is common in several vegetation subtypes. Two other indigenous ferns, pala'a (Sphenomeris chusana) and uluhe (Dicranopteris linearis), are present in smaller numbers. All are common species in Hawaii.

Of the major native forest trees, only two 'ohi'a-lehua and two koa trees were encountered. Additionally, the native (indigenous ?) hala occurs in small to moderate numbers along Waikane Stream and in the mauka-Kaneohe portion of the property.

The vegetation in the project site is almost totally secondary in nature. Only three native species are present in any significant numbers and although one is co-dominant in one vegetation subtype, it cannot be interpreted as comprising a native plant community. Indeed, no native communities are present in the site and the few native species present are all common in Hawaii.

POTENTIAL PROBLEMS AND MITIGATING MEASURES

Native vegetation and endangered plant species can be eliminated as concerns in any development in the project site. However, soil erosion, alteration of stream discharge and load, and ocean siltation are always potential problems whenever a significant amount of vegetation is removed. Excessive erosion and runoff during construction may result in excessive silting of the Wetlands along Kamehameha Highway. This may alter the ecosystem in favor of arborescent species and might be undesirable if the Wetlands serve as habitat for certain birds. Also in the long term, fertilizer and other chemical run-off may alter the growth and vegetational composition of these areas. Proper precautions and adequate drainage will alleviate such potential problems.

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SPECIES CHECKLIST

Plant families are arranged alphabetically in three groups - Pteridophytes, Gymnosperms and Angiosperms. The Angiosperms are subdivided into Monocotyledones and Dicotyledones. Genera and species are arranged alphabetically within each family. Taxonomy of the Pteridophytes follows that of Wagner's unpublished list and common names for the ferns are those which are commonly accepted. Taxonomy, common names and the status of the Gymnosperms and Angiosperms generally follow that of St. John (1973).

EXPLANATION OF SYMBOLS

Species Status:

E - Endemic to the Hawaiian Islands, ie. occuring naturally nowhere else in the world.

I - Indigenous, ie. native to the Hawaiian Islands but also occuring naturally elsewhere.

X - Exotic (alien), ie. plants introduced after the Western discovery of the islands.

P - Polynesian introduction, plants introduced before the Western discovery of the islands.

N - Native, endemic or indigenous (for Pteridophytes only)

FR - Federal Register status; official listing by U.S. Fish & Wildlife Service (if applicable).

FH - Endangered status listing by Fosberg & Herbst (1975) (if applicable)

Vegetation Types:

F - Mixed Eugenia Forests

G - Grasslands

R - Mixed Riparian Association

C - Cultivated Lands

Relative Abundance Rating:

A - Abundant, generally the major or dominant element in an area.

C - Common, generally distributed throughout a given area in large numbers.

O - Occasional, generally distributed throughout a given area in small numbers.

U - Uncommon, observed uncommonly but more than 10 times in a given area.

R - Rare, observed 2-10 times in a given area.

X - An indication of presence, used for cultivated species in R and for presence in C.

C H E C K   L I S T   O F   P L A N T S

SCIENTIFIC NAME	COMMON NAME	STATUS	FR	FH	RELATIVE ABUNDANCE F	G	R	C
PTERIDOPHYTES								
ADIANTACEAE								
Pityrogramma austroamericana Domin	Gold fern	N			U	-	-	-
BLECHNACEAE								
Blechnum occidentale L.		X			U	-	U	-
DAVALLIACEAE								
Nephrolepis exaltata (L.) Schott	Boston fern	N			C	O	C	-
GLEICHENIACEAE								
Dicranopteris linearis (Burm.) Underw.	Uluhe	N			U	-	-	-
LINDSAEACEAE								
Sphenomeris chusana (L.) Copel.	Pala'a	N			O	O	-	-
POLYPODIACEAE								
Microsorium scolopendrium (Burm.) Copel.	Lauae	N			R	R	U	X
Pleopeltis thunbergiana Kaulf.		N			U	-	U	-
PSILOTACEAE								
Psilotum nudum (L.) Beauv.	Moa	N			R	R	R	-
WOODSIACEAE								
Christella dentata (Forssk.) Brownsey & Jermy		X			U	-	O	X
GYMNOSPERMS								
ARAUCARIACEAE								
Araucaria sp.		X			-	R	-	X
CUPRESSACEAE								
Cupressus sp.		X			-	R	-	X
Thuja occidentalis L.	Eastern arborvitae	X			-	-	-	X
ANGIOSPERMS - MONOCOTYLEDONES								
AMARYLLIDACEAE								
Pancratium littorale Jacq.	Spider lily	X			-	-	X	X
ARACEAE								
Aglaonema X								
Alocasia cucullata (Lour.) G. Don	Chinese taro	X			-	-	-	X
A. macrorrhiza (L.) Sweet	'Ape	X			-	-	U	X
Colocasia esculenta (L.) Schott	Taro	P			-	-	O	X
Dieffenbachia X		P			-	-	R	X
Monstera deliciosa Liebm.	Monstera	X			-	-	-	X
Philodendron radiatum Schott		X			-	-	R	X
Scindapsus aureus (Lind. ex Andre) Engl.	Taro vine	X			-	-	-	X
Syngonium auritum (L.) Schott		X			R	-	-	X
Xanthosoma sagittifolium (L.) Schott		X			R	-	-	X
		X				R		-

CHECK LIST OF PLANTS

SCIENTIFIC NAME	COMMON NAME	STATUS	FR	FH	RELATIVE ABUNDANCE F	G	R	C
ARACEAE								
Xanthosoma violaceum Schott	Blue 'ape	X			-	-	U	-
CANNACEAE								
Canna indica L.	Ornamental canna	X			R	-	U	X
COMMELINACEAE								
Commelina diffusa Burm. f.	Honohono	X			U	U	O	X
CYPERACEAE								
Cyperus alternifolius L.	Umbrella plant	X			R	-	O	X
C. gracilis R. Br.	McCoy grass	X			-	-	X	X
C. kyllinga Endl.	Kyllinga	X			-	R	X	X
C. rotundus L.	Nut grass	X			-	U	-	X
Eleocharis radicans (Poir.) Kunth		X			-	-	X	X
Fimbristylis dichotoma (L.) Vahl	Tall fringe rush	I			U	-	-	-
DIOSCOREACEAE								
Dioscorea bulbifera L.	Pi'oi	P			-	-	U	X
GRAMINEAE								
Andropogon virginicus L.	Broomsedge	X			U	A	-	-
Axonopus affinis Chase	Narrow-leaved carpetgrass	X			-	O	-	-
Bambusa vulgaris Schrad. ex Wendl.	Feathery bamboo	X			-	-	R	-
Brachiaria mutica (Forsk.) Stapf	Paragrass	X			U	A	O	X
Chloris virgata Sw.	Feather fingergrass	X			-	R	R	X
Chrysopogon aciculatus (Retz.) Trin.	Golden beardgrass	X			U	O	-	-
Coix lachryma-jobi L.	Job's tears	X			R	U	U	X
Cymbopogon citratus (DC. ex Nees) Stapf	Lemongrass	X			-	-	X	X
Cynodon dactylon (L.) Pers.	Bermuda grass	X			-	U	R	X
Digitaria adscendens (HBK.) Henr.	Henry's crabgrass	X			-	-	-	X
D. pruriens (Fisch. ex Trin.) Buse	Kūkaipua'a	X?			-	U	R	X
Echinochloa crusgalli (L.) Beauv.	Barnyard grass	X			-	-	R	X
Eleusine indica (L.) Gaertn.	Goosegrass	X			-	U	R	X
Hyparrhenia rufa (Nees) Stapf	Thatchinggrass	X			R	U	-	-
Melinis minutiflora Beauv.	Molassesgrass	X			U	U	-	-
Oplismenus hirtellus (L.) Beauv.	Basketgrass	X			O	-	C	X
? Microlaena stipoides (Labill.) R. Br.	Meadow ricegrass	X			U	A	-	-
Panicum maximum Jacq.	Guinea grass	X			U	R	-	-
Paspalum conjugatum Berg.	Hilo grass	X			O	O	O	X
P. dilatatum Poir.	Paspalum grass	X			U	-	-	-
P. fimbriatum HBK.	Panama paspalum	X			-	R	-	-
P. orbiculare Forst. f.	Ricegrass	X			U	U	-	-
Pennisetum purpureum Schumach.	Elephantgrass	X			-	R	-	-
P. setosum (Sw.) L.C. Rich.	Feathery pennisetum	X			R	R	-	-
Phyllostachys sp.		X			R	-	-	X
Rhynchelytrum repens (Willd.) C.E. Hubb.	Natal redtop	X			R	R	-	-
Saccharum officinarum L.	Sugar cane	X			-	R	X	X
Sacciolepis indica (L.) Chase	Glenwoodgrass	X			O	O	-	-

CHECK LIST OF PLANTS

SCIENTIFIC NAME	COMMON NAME	STATUS	FR	FH	RELATIVE ABUNDANCE F	G	R	C
GRAMINEAE								
Setaria geniculata (Poir.) Beauv.	Perennial foxtail	X			O	C	-	-
Sporobolus africanus (Poir.) Robyns & Tournay	Smutgrass	X			-	R	-	X
Tricachne insularis (L.) Nees	Sourgrass	X			-	U	R	X
Zoysia matrella (L.) Merr.	Manilagrass	X			-	-	-	X
LILIACEAE								
Cordyline terminalis (L.) Kunth	Ti	P			R	-	U	X
Ophiopogon japonicus (L. f.) Ker-Gawl.	Mondo	X			-	-	-	X
Pleomele marginata (Lam.) N.E. Br.		X			-	-	-	X
MUSACEAE								
Heliconia aurantiaca Ghiesbr.		X			-	-	X	X
H. humilis (Aubl.) Jacq.	Common heliconia	X			-	-	X	X
H. psittacorum L.f.		X			-	R	X	X
Musa x paradisiaca L.	Banana	P			R	-	U	X
ORCHIDACEAE								
Arundina bambusaefolia (Roxb.) Lindl.		X			-	R	-	-
Spathoglottis plicata Bl.		X			U	U	-	-
PALMAE								
Chrysalidocarpus lutescens (Bory) H. Wendl.	Areca	X			-	-	-	X
Cocos nucifera L.	Coconut	P			R	-	R	X
Livistona chinensis (Jacq.) Mart.	Chinese fan palm	X			R	-	R	-
Roystonea oleracea (Jacq.) O.F. Cook	Caribbee royal palm	X			R	-	R	-
PANDANACEAE								
Pandanus amaryllifolius Roxb.		X			-	-	X	-
P. odoratissimus L.F.	Hala	I?			R	R	O	-
ZINGIBERACEAE								
Alpinia galanga (L.) Willd.	Khaa	X			-	-	X	-
A. purpurata (Vieill.) K. Schum.	Red ginger	X			-	-	-	X
A. zerumbet (Pers.) Burtt & Smith	Shell ginger	X			-	-	-	X
Hedychium coronarium Koenig	White ginger	X			-	-	U	X
H. flavescens Carey	Yellow ginger	X			-	-	-	X
Zingiber zerumbet (L.) Roscoe	'Awapuhi kuahiwi	P			-	-	O	-
ANGIOSPERMS - DICOTYLEDONES								
ACANTHACEAE								
Dicliptera chinensis (L.) Juss.	Dicliptera	X			-	-	-	X
Hemigraphis reptans (Forst. F.) T. Anders.		X			-	-	-	X
Thunbergia fragrans Roxb.	White thunbergia	X			R	R	U	X
AMARANTHACEAE								
Amaranthus spinosus L.	Spiny amaranth	X			-	R	-	-

CHECK LIST OF PLANTS

SCIENTIFIC NAME	COMMON NAME	STATUS	FR	FH	RELATIVE ABUNDANCE F	G	R	C
ANACARDIACEAE								
Mangifera indica L.	Mango	X			U	U	O	X
Schinus terebinthifolius Raddi	Christmas berry	X			U	U	-	X
ANNONACEAE								
Annona muricata L.	Soursop	X			-	-	-	X
Artabotrys uncinatus (Lam.) Merr.	Ylang-ylang	X			-	-	U	X
APOCYNACEAE								
Allamanda cathartica L.	Allamanda	X			-	-	-	X
Plumeria obtusa L.	Singapore plumeria	X			-	-	-	X
ARALIACEAE								
Brassaia actinophylla Endl.	Octopus tree	X			C	R	U	X
Schefflera arboricola Hayata		X			-	-	-	X
BALSAMINACEAE								
Impatiens sultani Hook. f.	Impatiens	X			-	-	-	X
CARICACEAE								
Carica papaya L.	Papaya	X			R	R	X	X
CARYOPHYLLACEAE								
Drymaria cordata (L.) Willd. ex R. & S.	Drymaria	X			-	-	X	X
COMBRETACEAE								
Terminalia catappa L.	False kamani	X			R	-	O	X
COMPOSITAE								
Ageratum conyzoides L.	Ageratum	X			-	R	R	X
Bidens alba var. radiata (Schz. Bip.) Ballard ex Melchert		X			U	O	U	X
B. pilosa L.	Spanish needle	X			-	R	-	-
B. pilosa var. minor (Bl.) Sherff		X			-	R	-	-
Calyptocarpus vialis Less.		X			-	-	-	X
Crassocephalum crepidioides (Benth.) Sp. Moore		X			R	R	R	-
Eclipta alba (L.) Hassk.	False daisy	X			-	-	R	X
Emilia fosbergii Nicolson		X			R	R	R	X
E. sonchifolia (L.) DC.	Lilac pualele	X			R	U	R	X
Erigeron bonariensis L.	Hairy horseweed	X			R	R	-	-
Pluchea odorata (L.) Cass.	Pluchea	X			R	R	R	-
Pseudoelephantopus spicatus (Juss. ex Aubl.) Gleason	False elephant's foot	X			-	R	-	-
Synedrella nodiflora (L.) Gaertn.	Synedrella	X			-	U	R	-
Vernonia cinerea (L.) Less.	Ironweed	X			-	U	R	X
Wedelia trilobata (L.) Hitchc.	Wedelia	X			R	U	-	X
CONVOLVULACEAE								
Argyreia nervosa (Burm. f.) Bojer	Small wood rose	X			R	-	-	-
Convolvulus arvensis L.	Field bindweed	X			-	R	-	X
Ipomoea alba L.	Moon flower	X			U	-	O	-

CHECK LIST OF PLANTS

SCIENTIFIC NAME	COMMON NAME	STATUS	FR	FH	RELATIVE ABUNDANCE F	G	R	C
CONVOLVULACEAE								
Ipomoea aquatica Forsk.	Ung-choi	X			–	–	X	–
I. batatas (L.) Poir.	Sweet potato	P			–	–	X	X
I. congesta R. Br.	Koali-'awania	I			U	–	R	–
Merremia aegyptia (L.) Urban	Merremia	X			–	–	–	X
CRASSULACEAE		.						
Kalanchoe pinnata (Lam.) Pers.	Air plant	X			R	–	–	X
CUCURBITACEAE								
Benicasa hispida (Thunb.) Cogn.	Chinese preserving melon	X			–	–	–	X
Momordica charantia var. pavel Crantz	Peria	X			–	R	–	–
EUPHORBIACEAE								
Aleurites moluccana (L.) Willd.	Kukui	P			–	–	U	X
Bischofia javanica Bl.	Koka	X			–	–	P	–
Codiaeum variegatum var. pictum (Lodd.) Muell.-Arg.	Croton	X			–	–	–	X
Euphorbia cotinifolia L.	Herba mala	X			–	–	X	–
E. hirta L.	Garden spurge	X			–	R	–	X
E. pulcherrima Willd. ex Klotzsch	Poinsettia	X			–	–	–	X
Macaranga grandifolia (Blanco) Merr.	Bingabing	X			–	–	U	–
Manihot esculenta Crantz	Cassava	X			–	–	X	X
Phyllanthus debilis Klein ex Willd.	Phyllanthus weed	X			R	R	X	X
LABIATAE								
Hyptis capitata Jacq.		X			–	R	–	X
H. pectinata (L.) Poit.	Comb hyptis	X			R	U	U	–
Mentha arvensis var. javanica (Bl.) Hook.		X			–	–	X	–
Ocimum basilicum L.	Basil	X			–	–	X	–
LAURACEAE								
Persea americana Mill	Avocado	X			–	R	–	X
LEGUMINOSAE								
Acacia confusa Merr.	Formosan koa	X			U	–	–	–
A. koa Gray	Koa	E			–	R	–	–
Albizia falcataria (L.) Fosb.	Albizia	X			U	U	C	–
A. lebbeck (L.) Benth.	Siris tree	X			R	R	–	–
Bauhinia purpurata L.		X			–	–	X	–
Cajanus cajan (L.) Millsp.	Pigeon pea	X			–	–	–	X
Calliandra sp.		X			–	–	–	X
Canavalia cathartica Thouars	Mauna-loa	X			R	R	–	–
Cassia alata L.	Candlebush	X			–	R	R	–
C. leschenaultiana DC.	Partridge pea	X			O	O	R	X
Crotalaria incana L.	Fuzzy rattle-pod	X			–	R	–	X
C. pallida Ait.		X			R	U	–	X
Desmanthus virgatus (L.) Willd.	Virgate mimosa	X			–	R	–	–
Desmodium canum (Gmel.) Schinz & Thell.	Spanish clover	X			U	C	R	X

C H E C K   L I S T   O F   P L A N T S

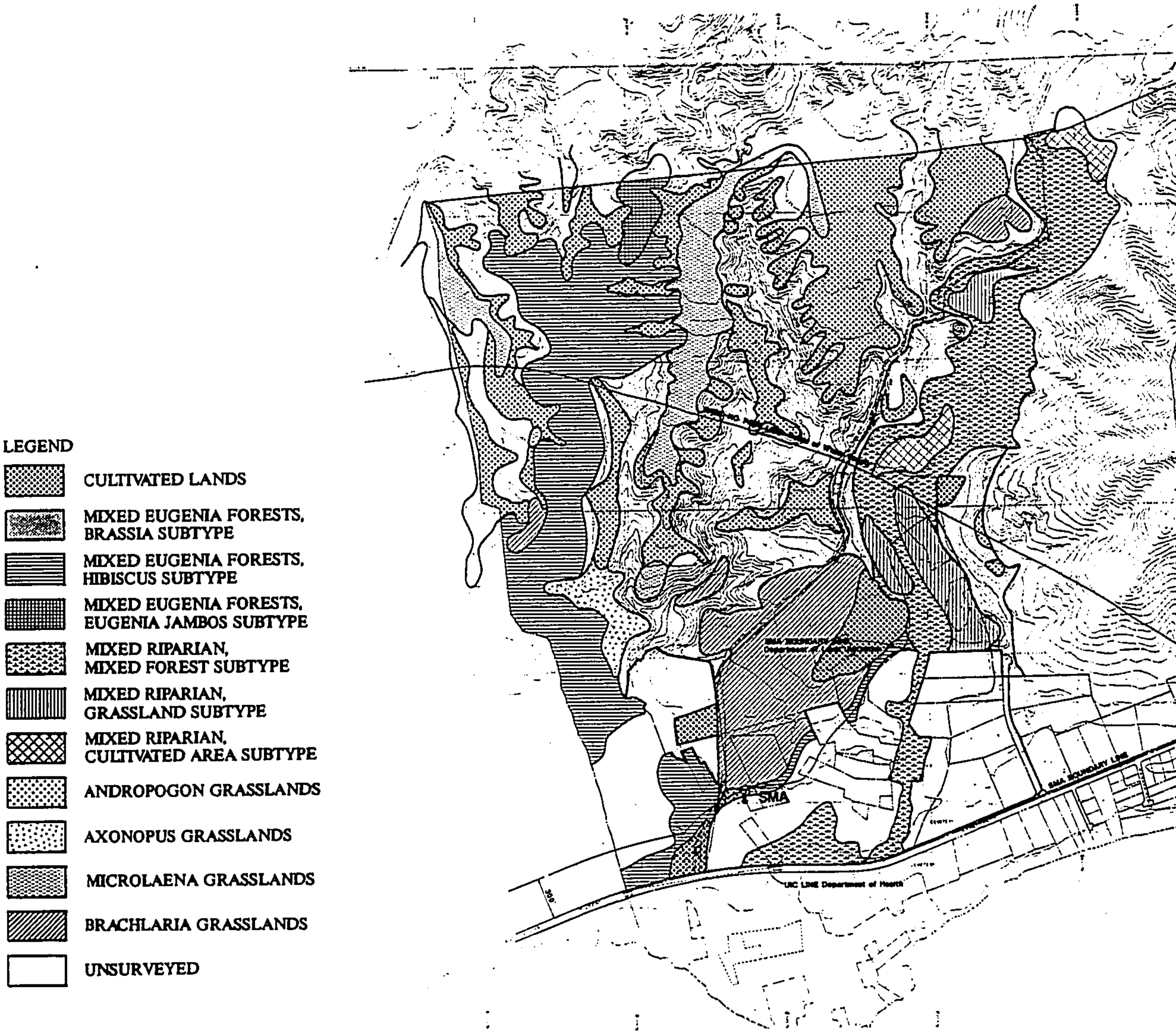
SCIENTIFIC NAME	COMMON NAME	STATUS	FR	FH	RELATIVE ABUNDANCE F	G	R	C
LEGUMINOSAE								
Desmodium triflorum (L.) DC.	Three-flowered beggarweed	X			-	O	-	X
Indigofera suffruticosa Mill.	Indigo	X?			R	R	R	X
Leucaena leucocephala (Lam.) de Wit	Koa-haole	X			-	R	R	X
Mimosa pudica var. unijuga (Duchass. & Walp.) Griseb.	Sensitive plant	X			O	O	R	X
Samanea saman (Jacq.) Merr.	Monkeypod	X			R	-	R	X
LYTHRACEAE								
Cuphea carthagenensis (Jacq.) Macbride	Tarweed	X			-	R	X	-
MALVACEAE								
Abutilon grandifolium (Willd.) Sweet	Hairy abutilon	X			-	R	-	X
Hibiscus tiliaceus L.	Hau	I			U	R	C	-
Hibiscus X	Hibiscus	X			-	-	-	X
Malvastrum coromandelianum (L.) Garcke	False mallow	X			-	-	-	X
Sida rhombifolia L.	Cuba jute	X			-	R	-	X
Urena lobata L.	Aramina	X?			U	U	R	-
MELASTOMATACEAE								
Clidemia hirta (L.) D. Don	Koster's curse	X			O	U	U	-
MORACEAE								
Artocarpus altilis (Parkins. ex Z) Fosb.	Breadfruit	P			-	-	-	X
Ficus benjamina L.	Benjamin tree	X			-	-	X	-
F. microcarpa L. f.	Chinese banyan	X			R	R	R	X
MORINGACEAE								
Moringa oleifera Lam.	Horseradish tree	X			-	-	-	X
MYRSINACEAE								
Ardisia humilis Vahl	Shoebutton ardisia	X			U	-	O	-
MYRTACEAE								
Eugenia cumini (L.) Druce	Java plum	X			A	O	A	X
E. jambos L.	Rose apple	X			O	-	-	-
E. malaccensis L.	Mountain apple	P			-	-	R	X
Metrosideros collina subsp. polymorpha (Gaud.) Rock	'Ohi'a-lehua	E			R	R	-	-
Psidium cattleianum Sabine	Strawberry guava	X			C	O	R	-
P. guajava L.	Guava	X			U	U	X	X
NYCTAGINACEAE								
Bougainvillea spectabilis Willd.	Bougainvillea	X			-	-	-	X
OLEACEAE								
Ligustrum ovalifolium Hassk.	California privet	X			-	-	-	X
ONAGRACEAE								
Ludwigia octivalvis (Jacq.) Raven	Primrose willow	X			-	U	R	-

CHECK LIST OF PLANTS

SCIENTIFIC NAME	COMMON NAME	STATUS	FR	FH	RELATIVE ABUNDANCE F	G	R	C
OXALIDACEAE								
Averrhoa carambola L.	Star fruit	X			–	–	X	–
Oxalis corniculata L.	Yellow wood sorrel	X			R	R	–	X
O. martiana Zucc.	Pink wood sorrel	X			–	R	R	X
PASSIFLORACEAE								
Passiflora edulis f. flavicarpa Deg.	Yellow liliko'i	X			R	–	–	X
P. laurifolia L.	Yellow granadilla	X			C	O	O	–
P. subpeltata Ortega	White passionflower	X			–	–	–	X
PIPERACEAE								
Piper methysticum Forst. f.	'Awa	P			–	–	X	–
PLANTAGINACEAE								
Plantago major L.	Common plantain	X			–	–	–	X
POLYGONACEAE								
Polygonum odoratum Lour.		X			–	–	X	–
PORTULACACEAE								
Portulaca oleracea L.	Common purslane	X			–	–	X	–
ROSACEAE								
Rubus rosaefolius Sm.	Thimbleberry	X			–	–	R	X
RUBIACEAE								
Gardenia augusta (L.) Merr.	Gardenia	X			–	–	–	X
Morinda citrifolia L.	Noni	P			U	–	U	–
Paederia foetida L.	Maile pilau	X			O	U	O	X
Undetermined		X			–	–	R	–
RUTACEAE								
Citrus hystrix DC.	Kaffir lime	X			–	–	X	–
C. reticulata Blanco	Tangerine	X			–	–	–	X
C. sp.		X			–	–	–	X
Murraya paniculata (L.) Jack	Mock orange	X			–	–	–	X
SAPINDACEAE								
Euphoria longana Lam.	Longan	X			–	–	X	–
SCROPHULARIACEAE								
Limnophila aromatica (Lam.) Merr.		X			–	–	X	–
SOLANACEAE								
Capsicum annuum L.	Red pepper	X			–	–	X	X
Lycopersicon pimpinellifolium Hill.	Currant tomato	X			–	R	–	–
Solanum auriculatum Ait.	Pua-nānā-honua	X			U	R	U	X
S. melongena L.	Eggplant	X			–	–	X	X
grum[illegible]	Po[illegible]	I?			[illegible]	[illegible]	P	[illegible]

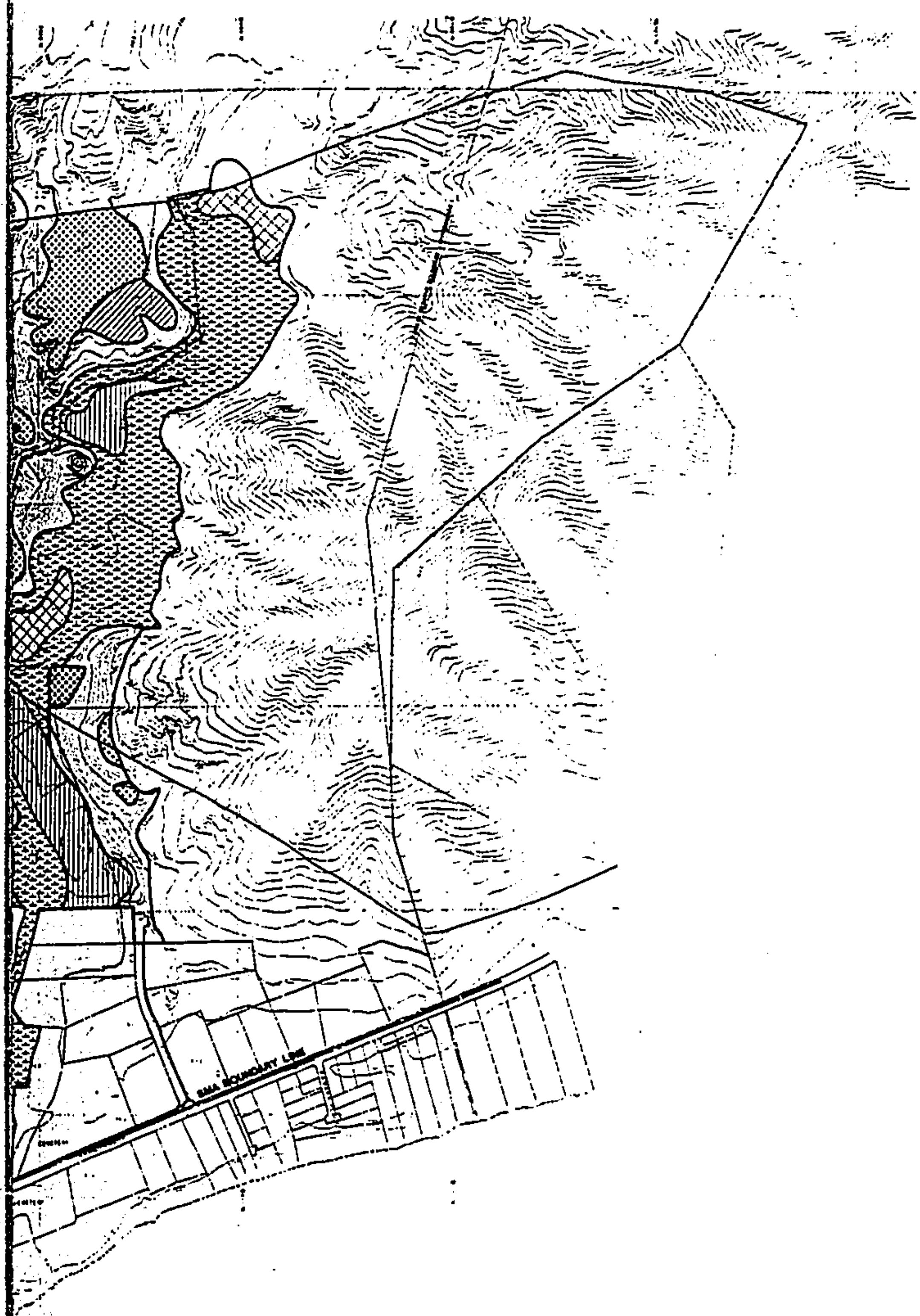
CHECK LIST OF PLANTS

SCIENTIFIC NAME	COMMON NAME	STATUS	FR	FH	RELATIVE ABUNDANCE F	G	R	C
STERCULIACEAE								
Waltheria americana L.	'Uhaloa	I			-	U	-	-
THYMELEACEAE								
Wikstroemia oahuensis (Gray) Rock	'Ākia	E			O	U	-	-
TILIACEAE								
Heliocarpus popayaensis HBK.	White moho	X			R	-	U	X
Triumfetta semitriloba (L.) Jacq.	Burbush	X			U	U	U	X
ULMACEAE								
Trema orientalis (L.) Bl.	Gunpowder tree	X			-	R	-	-
UMBELLIFERAE								
Centella asiatica (L.) Urban	Asiatic pennywort	X			O	O	U	X
Eryngium foetidum L.	Spirit weed	X			-	-	X	-
Hydrocotyle sibthorpioides Lam.	March pennywort	X			-	-	R	-
VERBENACEAE								
Citharexylum caudatum L.	Juniper berry	X			-	R	-	-
Lantana camara L.	Lantana	X			U	U	R	-
Stachytarpheta jamaicensis (L.) Vahl	Jamaica vervain	X			O	O	U	X
S. urticaefolia (Salisb.) Sims		X			-	R	-	-
Vitex parviflora A.L. Juss.	Small-flowered vitex	X			U	R	-	-



VEGETATION MAP
WAIKANE GOLF COURSE

SOURCE: KENNET



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0' 250' 500' 1000'

APPENDIX O
Terrestrial Vertebrates

Terrestrial Vertebrates of the Waiahole/Waikane Area

by Andrew J. Berger

This report was prepared on instructions received from Mr. Vincent Shigekuni, Group 70, Honolulu, Hawaii. A site visit was made on December 9, 1987, when Mr. Rodney Kawelo served as a guide for Les Anderson, Gordon Dugan, and myself. I made additional field observations on December 10.

This study presents information on the terrestrial vertebrate animals (amphibians, reptiles, birds, and mammals) as it pertains to the proposed Waikane Golf Course Project. The Waiahole and Waikane districts of the area comprise one large continuous unit so that reference is made to both parts of the complex.

Historical Overview

The history of the Kahaluu/Waiahole/Waikane area of the windward coast of Oahu has been described by Handy (1972), Kuykendall (1947), McCandless (1936), Parker (1852), and others. According to these sources, a large Hawaiian population occupied, these valleys during the last century, growing taro, bananas, and other crops. Later, both rice and sugarcane were grown, and pineapple was grown in Kahaluu Valley from about 1909 to 1926. Consequently, most of the native vegetation was destroyed in these windward valleys more than a century ago. Moreover, both domesticated and feral goats, pigs, and cattle also were abundant on Oahu during the last century and well into the present century. These grazing and rooting animals contributed to the destruction of the native vegetation in the more remote areas and on ridges and slopes that were too steep for cultivation (Tomich, 1969). Severe erosion scars are visible on some of the steeper slopes today, and are especially conspicuous as one approaches the valley by boat on Kaneohe Bay.

Because of the destruction of the native vegetation in the mountains on Oahu by cattle, goats, and pigs, the Hawaiian Government appropriated $12,000 for tree planting in 1882. The first forest reserve was established in 1903. L.W. Bryan (1947) said that 1,057 different species of exotic plants were tested in arboreta on the island of Hawaii alone during the period of 1921-1946. On Oahu, the Waiahole Forest Reserve was establsihed on June 19, 1918; it consisted of 1,683 acres of State land and 6,922 acres of privately owned land. The State Division of Forestry planted about 34 acres with several species of Australian eucalyptus (_Eucalyptus_ spp.), 35 acres of conifers (e.g., Norfolk Island pine, _Araucara excelsa_, sugi, _Cryptomeria japonica_), and 7 acres of a wide variety of hardwoods (e.g., turpentine tree, _Syncarpia glomulifera_, brush box, _Tristania coniferta_, lance-leafed gum myrtle, _Angophora lanciolata_, Australian kauri, _Agathia robusta_).

Moreover, the residents of the islands imported many species of fruit trees (e.g., papaya, mango, lychee, citrus), and flowering plants to the islands. In fact, watermelon seeds were brought to Hawaii by Captain James Cook as early as 1779, and Don Francisco de Paula Marine introduced avocados and other fruits and flowering plants to Oahu during the early 1800s. St. John

(1973) lists 4,643 different species of exotic trees and shrubs that have been introduced to the Hawaiian Islands. As a result, very few native plants can be found in lowland areas where man and introduced mammals have had an influence. Therefore, one finds primarily introduced species of birds in these areas because the endemic species are largely dependent on the native ecosystems in which they evolved.

Amphibians and Reptiles

There are no endemic amphibians or land reptiles in the Hawaiian Islands. All have been introduced by man.

I. Amphibians

1. Giant Neotropical Toad (Bufo marinus). This toad was first introduced to the Hawaiian Islands in 1932 "when Dr. C.E. Pemberton brought 148 adult toads from Puerto Rico. Eighty of these were liberated in a taro patch near Waipio, Oahu, and 68 were released in a swampy part of Manoa Valley" (Oliver and Shaw, 1953:77). The toads were successful, and "in a li· over two years more than 100,000 descendents of the original stock were distributed through Dr. Pemberton's activities throughout the islands." Hunsaker and Breese (1967) wrote that Bufo marinus was the "commonest species of amphibian in Hawaii." This toad apparently is found throughout the valleys, and, in the past, I have found this toad as high as 280 feet elevation.

2. Gold and Black Poison Frog (Dendrobates auratus). This frog was introduced to Oahu to "assist in the control of insect pests." Oliver and Shaw state that the species was

released in upper Manoa Valley in 1932. Hunsaker and Breese (1967) wrote that "additional plantings with subsequent establishment have been made in Waiahole Valley, and the population has been observed to fluctuate in size at this locality, again according to the amount of water available." Although said to be diurnal in habits, they are "most active in the morning after a rain." McKeown (1978) said that this frog is found in well-foliated moist valleys on both Leeward and Windward Oahu." He added that, in summer and fall, "these frogs spend their time in moist places such as under debris, logs, stones, tangled root systems or under elevated valley homes." I did not see any of these frogs during my field work, although they probably have spread to Waikane Valley since their introduction into Waiahole Valley.

3. American Bullfrog (Rana catesbeiana). "This was probably one of the first species of amphibians to be introduced into the Hawaiian Islands and may have been one of the frogs that was imported prior to 1867" (Oliver and Shaw, 1953). The frogs were abundant enough to be harvested commercially by 1900. Tinker (1941) wrote that "the University of Hawaii has organized 'frog clubs' to encourage the production of frogs for food." The species is not nearly so common now, presumably because of the drainage of so many wetland areas and, perhaps also, because of the widespread use of pesticides during recent decades. A small population appears to be established at mid-elevations along Waikane Stream, above the upper limit of the proposed project.

II. Reptiles

1. Blind Snake (*Typhlops braminus*). "This small, secretive snake was apparently introduced from the Philippines in the dirt surrounding plants that were brought in for land-scaping the campus of the Kamehameha Boys School in Honolulu. It was first found there in January of 1930" (Oliver and Shaw, 1953). By 1967, Hunsaker and Breese wrote that "it now appears to occupy the lowland area over the entire island." These blind, worm-like snakes are rarely seen until they are flooded from their underground burrows by heavy rain or unless one looks for them under branches and other debris on the ground. I did not search for these snakes because they are of no significance for an impact assessment.

2. Skinks and Geckos. Eleven species of skinks (family Scincidae) and geckos (family Gekkonidae) occur on Oahu. All are foreign to theislands, all are insect eaters, and all adapt well to both urban and rural habitats. Their presence is irrelevant to an impact assessment.

Birds

Three groups of birds are found in the Hawaiian Islands: 1. introduced or exotic, 2. indigenous, and 3. endemic. All of the birds within the boundaries of the project site are introduced or alien birds.

I. Introduced Birds

More than 170 species of alien birds have been intentionally introduced to the Hawaiian Islands (Berger, 1981). The following have been reported in the Waiahole/Waikane valley region.

Family Ardeidae, Herons and Egrets

1. Cattle Egret (Bulbucus ibis). This species was imported to Hawaii from Florida to aid "in the battle to control house flies, horn flies, and other flies that damage hides and cause lower weight gains in cattle" (Breese, 1959). A number of birds were released on Oahu in 1959 and 22 additional birds were released during July 1961. Thistle (1962) reported that the population of Cattle Egrets on Oahu exceeded 150 birds by July 1962; the population has increased greatly since that time. Personnel of the State Division of Forestry and Wildlife counted 621 egrets on Oahu during their January 1986 census. (Walker, et al., 1986). There is a rookery on the lands of the Kaneohe Marine Corps Air Station. I saw several small flocks (6 to 8 birds) in pasture land along Kamehameha Highway and in small wetland areas in Waikane Valley.

Family Columbidae, Pigeons and Doves

2. Feral Pigeon or Rock Dove (Columba livia). The pigeon probably was the first exotic bird introduced to the Hawaiian Islands; their importation has been traced back to 1796. There is at least one small flock in the Waiahole/Waikane Valley area. Schwartz and Schwartz (1949) found heavy parasitism of feral pigeons by tapeworms, and they stated that tapeworm infestation retards proper nutrition "and occludes the intestine, produces undesirable toxins, and hinders breeding." Navvab Gojrati (1970) reported infection by bird malaria, Haemoproteus, and

Leucocytozoon in birds at the Honolulu Zoo. Kishimoto and Baker (1969) reported finding the fungus *Cryptococcus neoformans* in 13 out of 17 samples of pigeon droppings collected on Oahu. The full significance of their findings has not been determined, but, in man, this fungus causes a chronic cerebrospinal meningitis; Hull (1963:468) remarked that "in all but the cutaneous form the prognosis is very grave."

3. Spotted or Chinese Dove (*Streptopelia chinensis*). This Asian dove was introduced to the Hawaiian Islands at an early date; the exact date is unknown, but the birds are said to have been very common on Oahu by 1879. The species is now very common on all of the islands and is classified as a game bird. This dove also is called the lace-necked dove because of the conspicuous band of white spots on the back of the neck. Although this species occurs where the rainfall exceeds 100 inches per year, the highest densities are found in drier areas where the introduced kiawe (mesquite) is one of the dominant plants. Schwartz and Schwartz (1949), for example, reported densities as great as 100 birds per square mile in dry areas on Molokai. This dove is found through Waikane Valley and adjacent areas.

4. Barred Dove (*Geopelia striata*). This species also is called the zebra dove in its native habitat in the Orient and Australia. This species is said to have been introduced to Hawaii sometime after 1922 (Bryan, 1958). It now is common to abundant on all of the islands. This dove also prefers the drier areas. Schwartz and Schwartz (1949) reported densities

as high as 400 t0 800 birds per square mile in some areas on Oahu (e.g., from Barber's Point to Makaha). The Barred Dove is an abundant species through the valley except in densely wooded areas. During former field trips to this area, I have seen very large (50 to 100 birds) mixed flocks of Spotted Doves and Barred Doves feeding on weed seeds in fallow pastures, old banana plantations, and papaya groves.

The Barred Dove also is classifed as a game bird in Hawaii. One study of the food habits in Hawaii revealed that the diet consists of 97 percent seeds and otherplant materials; the 3 percent animal matter included several species of beetles, weevils, and wireworm larvae.

Family Tytonidae, Barn Owls.

5. The first Barn Owls (Tyto alba pratincola) were imported from California and released on Hawaii island during April 1958. Barn Owls were released at Hauula, Oahu, on two different occasions. Seven birds were imported from the San Diego Zoo and released during September 1959; 11 additional birds were imported from the San Antonio Zoo, Texas, and released at Hauula during October 1959 (Tomich, 1962). As with the mongoose during the last century, the Barn Owls were introduced in the hope that they would prey on the abundant rats in the sugarcane fields. No food habits study has been conducted on the Barn Owls inhabiting Oahu. On Hawaii, Tomich (1971) found that almost 90 percent of Barn Owl pellets that he examined contained only the remains of house mice. He commented that,

although the Barn Owl sometimes feeds on rats, it is not likely a significant factor in the economic control of rats in Hawaii. Byrd and Telfer (1980) reported that Barn Owls had killed more than 100 seabirds and their chicks on Kauai and Kaula Island.

No study of the spread of the Barn Owl from the Hauula region since 1960 has been conducted, but the birds have been seen or found injured or dead in both the windward and leeward sides of the island. This owl is nocturnal in habits, and I did not see any during my daytime field work. It is reasonable to assume, however, that one or more pairs occupy this region.

Family Timaliidae, Babblers and Laughing-thrushes

6. Melodious Laughing-thrush (Garrulax canorus). Long called the Hwa-mei or Chinese Thrush in Hawaii, this species is a babbler and not a thrush (family Turdidae). It was introduced to the islands from China or Formosa as a cage bird many years ago. "A number obtained their freedom at the time of the great fire in the Oriental quarter of Honolulu in 1900, and took to the hills behind the city" (Caum, 1933). This babbler is found in both the Koolau and the Waianae mountains. It seems to prefer the wetter areas where there are thickets and clumps of dense vegetation. The birds have a loud, attractive song, and they more often are heard than seen. I have seen this babbler at elevations above 300 feet in both Waiahole Valley and Waikane Valley.

Family Pycnonotidae, Bulbuls

7. Red-vented Bulbul (Pycnonotus cafer). Although all

members of this family are listed as "prchibited entry" by the State Quarantine Division of the Department of Agriculture, two species are now well established on Oahu. The history of the spread of the Red-vented Bulbul since the mid-1960s has been discussed by Berger (1975). Bulbuls are a scourge to both fruit and flower growers, because they eat not only ripe fruits, peppers, but buds and flowers. This bulbul now is found in the project area.

Family Turdidae, Thrushes and Solitaires

8. White-rumped Shama (Copysychus malabaricus). According to Caum (1933), this attractive thrush was first released on Oahu by the Hui Manu in 1932; Bryan (1958) said that this species was introduced to Kauai in 1931 and that it was established on that island and in the Tantalus region of Oahu. Shama is the Indian name for this thrush, which is native to India, Nepal, Burma, Malaysia, and throughout Indochina. The Shama is now common on both leeward and windward sides of Oahu. The birds prefer lush vegetation, and the Shama was singing throughout the valley during my field studies.

Family Sylviidae, Old-world Warblers

9. Japanese Bush Warbler (Horeites cantans).

This warbler, which is native to Japan and Formosa, was first released on Oahu in 1929 (Caum, 1933). The Japanese name is Uguisu. Berger (1975b) summarized our knowledge of the distribution of this species on Oahu. These are shy and secretive birds, typically occurring in habitats with dense underbrush. Their songperiod lasts from January to mid-July and I neither heard nor saw this Bush Warbler on my December 1987 field work. However, during past field studies in this area, I have seen this Bush Warbler at elevations above 400 feet in both Waiahole Valley and Waikane Valley.

Family Sturnidae, Starlings and Mynas

10. Common Indian Myna (Acridotheres t. tristis).

The Common Myna, which is native to Ceylon, India, Nepal, and adjacent regions, "was introduced from India in 1865 by Dr. William Hillebrand to combat the plague of armyworms that was ravaging the pasture lands of the islands. It has spread and multiplied to an amazing extent; reported to be abundant in Honolulu in 1879, it now is extremely common throughout the Territory" (Caum, 1933). The Myna is still common to abundant in lowland areas of the inhabited islands, being most common in residential and urban areas, especially in the vicinity of human habitation. The Myna is generally distributed throughout the area, being much more common at lower elevations.

Family Zosteropidae, White-eyes and Silver-eyes.

11. Japanese White-eye (Zosterops j. japonicus).

Caum (1933) wrote that the Japanese White-eye, or Mejiro, was first imported from Japan to Oahu by the Territorial Board of Agriculture and Forestry in 1929. Later importations were made by the Hui Manu and by private individuals. The White-eye rivals the House Sparrow and the European Starling in North America as a successful exotic species, and the White-eye now undoubtedly is the most common song bird species in Hawaii (Berger, 1981). It is found from sea level to tree line (on Maui and Hawaii) and it is found in the driest and the wettest areas in the Hawaiian Islands. The White-eye is ubiquitous throughout windward Oahu. There is no habitat where I did not find this species.

Family Ploceidae, Weaverbirds and their Allies

This is a large family of birds, predominantly Old World in distribution. The best known example in Hawaii is the House Sparrow. However, since the mid 1960s more than 15 different species of this family have been intentionally or accidentally released on Oahu (Elepaio, 1966:79; 33, 1973:81-82).

12. Nutmeg Mannikin or Ricebird (*Lonchura punctulata*)

Also called the Spotted Munia, this Asian species was released in Hawaii by Dr. William Hillebrand about 1865 (Caum, 1933). Caum wrote that the ricebird "feeds on the seeds of weeds and grasses and does considerable damage to green rice." Rice is no longer grown in Hawaii, but the Nutmeg Mannikin has become a serious pest by eating the seeds of experimental crops of sorghum (see the House Finch). The Nutmeg Mannikin is another abundant species on all islands, and is widespread throughout windward Oahu.

13. House Sparrow (*Passer domesticus*).

The House Sparrow (also erroneously called the English Sparrow) was first imported to Oahu in 1871, when nine birds were brought from New Zealand (where the species had previously been introduced from England). Caum (1933) wrote that "whether or not there were further importations is not known, but the species was reported to be numerous in Honolulu in 1879." In North America (first introduced to Brooklyn, New York, in 1852), the House Sparrow became a serious pest and tens of thousands of dollars were spent in attempting to control the population. This sparrow apparently never became a serious problem in Hawaii; it is omnivorous in diet, eating weed seeds, insects, insect larvae, and table scraps. House Sparrows are common at lower elevations in the valley, especially near houses and sheds.

Family Fringillidae, Sparrows, Cardinals, Buntings.

14. Cardinal (<u>Cardinalis cardinalis</u>)

This species has been given a number of vernacular names: e.g., Virginia Cardinal, Kentucky Cardinal, Kentucky Redbird. Its native range is the eastern part of North America east of the Plains and northward in Ontario. The Cardinal was released several times in Hawaii between 1929 and 1931 (Caum, 1933). The Cardinal has a wide distribution in the Waiahole/Waikane valley system, being found from near sea level to the highest ridges and subvalleys in the valley. It occurs in shrub-grown areas as well as in the introduced forests and on the relatively dry plateus.

15. Red-crested Cardinal (<u>Paroaria coronata</u>)

This species traditionally has been called the Brazilian Cardinal in Hawaii, but the native range includes Uruguay, Paraguay, Brazil, and parts of Bolivia and Argentina. The species was released in Hawaii on several occasions between 1928 and 1931 (Caum, 1933). The Red-crested Cardinal is a common species in urban and residential areas as well as in the introduced vegetation in lowland areas of both leeward and windward Oahu. It occurs in open areas at lower elevations in the valleys, where it inhabits the same type of habitat used by the Cardinal. It does not penetrate dense forests, nor did I find it as the higher elevations where the Cardinal was a common species.

16. House Finch (<u>Carpodacus</u> <u>mexicanus</u> <u>frontalis</u>).

Also known as the Papayabird in Hawaii, the House Finch was introduced from California "prior to 1870, probably from San Francisco" (Caum, 1933). The House Finch is now an abundant species in Hawaii in both urban and rural areas on all of the islands, and probably is the second most common song bird species in the State now. Although the birds sometimes eat overripe papaya and other soft fruits, the House Finch is predominantly a seed eater. House Finches and Nutmeg Mannikins caused great damage to experimental sorghum crops planted on Kauai and Hawaii during 1971-1972. "A report by the Senate Committee on Ecology, Environment & Recreation says ricebirds and linnets [House Finches] caused a 30 to 50 percent loss in the sorghum fields at Kilauea on Kauai last year. ... Seedeating birds at Kohala ate about 50 tons of sorghum grain in a 30-acre experimental field that was expected to produce 60 tons" (Honolulu Advertiser, March 14, 1972, page B-2).

Hence, the growing of small grain crops in the islands is not a promising potential for the much talked about "diversified agriculture" in the State. Other seed-eating birds have become widely established in some areas and on some of theislands. The House Finch is widely distributed throughout windward and leeward Oahu.

II. Indigenous Birds

These are species that occur in the Hawaiian Islands but whose total range includes other islands in the Pacific Basin or in North America. These are the Black-crowned Night Heron, 22 species of seabirds, and a number of migratory species that nest in North America or Siberia and which spend their winter or nonbreeding season in the islands.

Family Ardeidae, Herons and Egrets

1. Black-crowned Night Heron (Nycticorax n. hoactli).

This subspecies has a breeding range that includes Hawaii and the Western Hemisphere, extending from Washington and Oregon south to northern Chile and south-central Argentina. Herons inhabit marshes, swamps, and rivers; they feed on a wide variety of aquatic and terrestrail life: e.g., fish frogs, mice, crayfish, and insects. In Hawaii this heron also is known to eat the downy young of seabirds. The future of the Black-crowned Night Heron depends on the preservation of suitable wetland areas.

I did not see any herons during my two days of field work in 1987. In the past, I flushed one heron from a grove of trees at an elevation of about 350 feet along the Waianu Stream. I know of no evidence that this heron nests in the valley.

2. Migratory Species

The most conspicuous of these is the Lesser Golden Plover (Pluvialis dominica fulva), which occurs from sea level to about 10,000 feet elevation on Hawaii and Maui. The birds frequent lawns in residential areas, golf courses, weedy pastures, open areas in the mountains, and mud flats along the shore. I saw several plovers along the dirt roads during my December 1987 field studies.

The other migrant species are found in the beach area makai of the highway.

III Endemic Species

These are birds that are restricted to the Hawaiian Islands; they are unique to the islands. At least 40 percent of these unique birds are extinct; another 40 percent are classified as threatened or endangered with extinction. None of the rare or endangered Hawaiian forest birds are found in the Waiahole-Waikane Valley complex. None of the endemic forest birds occur within the boundaries of the proposed golf course project.

During past field work in this area, I found three species of endemic nonendangered Hawaiian forest birds in Waiahole or Waikane Valleys but at elevations of 600 and 750 feet. There is, however, not enough native vegetation to provide food or nesting sites for these birds. One assumes that they were birds of passage only, and not permanent residents in the habitat where I found them.

Mammals

I. Endemic Mammals

The only endemic land mammal in Hawaii is the Hawaiian bat (*Lasiurus cinereus semotus*), a subspecies of the North American hoary bat. The Hawaiian bat occurs primarily on the islands of Kauai and Hawaii (Tomich, 1969; Kramer, 1971; Ten Bruggencatem 1983). For Maui and Oahu, "the bats seem to appear only during the months from August to December," I did not see any bats during my daytime field work. I know of no evidence that there is a resident population of bats on the island of Oahu.

II. Introduced Mammals

All of these introduced species of mammals in Hawaii have proven highly detrimental to man, his buildings, products, agricultural crops and/or to the native forests and their animal life. None is an endangered species and none is of any concern as far as detrimental effects resulting from the proposed project. It would, in fact, be a great boon to the islands if it were possible to exterminate all of them.

With the possible exception of the house mouse (*Mus musculus*), all of the smaller alien mammals prey on birds, their eggs and young. These small mammals include the roof rat (*Rattus rattus*), Polynesian rat (*Rattus exulans*), Norway rat (*Rattus* norvegicus), and the small Indian mongoose (Herpestes auropunctatus), as well as feral cats (Felis catus) and dogs (Canis familiaris). Because all of the rodents are serious pests, primarily nocturnal in habits, I did not set traplines in order to sample the population. It is reasonable to assume that all of them occur in the project area (Tomich, 1969; Kramer, 1971), and their occurrence is irrelevant to the proposed project.

The Polynesian ancestors of the Hawaiian brought pigs (Sus scrofa) with them, and Captain Cook and later ship captains also released English pigs on the islands. In 1925, the central forest of Oahu was "riddled with wild pigs which were destroying the undergrowth." In writing about the Kilauea Forest on Hawaii island, Mueller-Dombois, et al. (1981) noted that this was "the best intact example of this forest type remaining in the state" and that "the effect of feral pig is very noticeable, and there is little doubt that the widespread pig digging in the Kilauea forest has been a major factor in reducing the native ground vegetation." It is doubtful that pigs now inhabit the lower elevations in Waikane Valley, although apparently someone had dumped a pig carcass along the road. It was badly decomposed and covered with flies and their larvae.

Summary and Conclusions

1. The entire Waiahole/Waikane valley system has been drastically disturbed for more than a century. The vegetation consists primarily of introduced or exotic plants, trees, shrubs, vines, and ferns, as well as different species of grasses. There is no semblance of any endemic or native ecosystem in the valleys or even near them. As far as endemic or native vegetation and its animal life is concerned, the area properly can be called a "waste land."

This last statement applies to at least three of the four major plant zones in the valley: beach area, main valley and stream beds, and ridges and puus. In addition to pasture grasses, the dominant vegetation along the beach area consists of hau (Hibiscus tiliaceus) and two species of introduced mangrove (Rhizophora mangle; Bruguiera conjugata). A few scattered tree heliotropes (Messerschmidia argentea) grow along the beach; this plant is widely distributed on Pacific Islands but was introduced to Hawaii according to St. John (1973). Much of the main valley floor in the past was devoted to growing taro, bananas, rice, or sugarcane. Today a wide variety of introduced plants grow there: e.g., koa haole (Leucaena glauca), coral hibiscus (Hibiscus schizopetalus), Christmas berry (Schinus terebinthifolius), guava (Psidium guajava), Java plum (Eugenia cuminii), and octopus tree (Brassaia actinophylla). Many of these same plants occur on the ridges and puus, although some of the steeper slopes are covered almost exclusively by a dense growth of uluhe or false staghorn fern (Dicranopteris linearis), which presumably is a reflection of the destruction of the original vegetation many years ago.

2. All of the amphibians, land reptiles, and mammals that occur in the project area are introduced or alien animals. Many of them are predators on birds and several are destructive to agriculture and forest lands and/or to man, his buildings and products. None of these animals is of any importance for an environmental impact assessment.

3. None of the 16 species of introduced or alien birds found in the project area is an endangered species and a number have proven to be serious pests in Hawaii. The destruction of sorghum crops by the Ricebird and the House Finch already has been mentioned. The doves and the myna have been implicated in spreading the seeds of such noxious pests as Lantana camara. The Red-vented Bulbul and the Japanese White-eye cause considerable damage to ornamental flowers and to fruit crops (see Keffer, et. al., 1976). The Barn Owl is known to eat birds on Kauai and probably on other islands (Byrd and Telfer, 1980). Some of the introduced birds apparently cause no damage, and they do provide pleasure to many people. However, development, including landscaping, actually would provide habitat for many of the introduced species.

4. There are no endemic forest birds in the project area or near it.

5. There is no suitable habitat for any of the endangered Hawaiian waterbirds.

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APPENDIX P
Air Quality Study

AIR QUALITY STUDY

FOR THE PROPOSED

WAIKANE GOLF COURSE

WAIKANE, KOOLAUPOKO, OAHU, HAWAII

Prepared by:

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March 26, 1988

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FIGURE

1. INTRODUCTION AND PROJECT DESCRIPTION

The Waikane Golf Course is proposed for development in Waikane, Koolaupoko, Oahu on 505 acres of agricultural-zoned land as shown on Figure 1. The entire development will consist of a 27 hole golf course, a driving range with ten stalls, a restaurant with seating for 150 people, a club house and tennis courts. The proposed site plan is also shown on Figure 1. The use of the facilities will be limited to private members and guests. Development is expected to be completed by 1991.

The purpose of this study is to describe existing air quality in the project area and to assess the potential short term and long term direct and indirect air quality impacts that could result from construction and use of the proposed facility as planned. Possible measures to mitigate these impacts are suggested where applicable.

2. AMBIENT AIR QUALITY STANDARDS (AAQS)

State of Hawaii and Federal Ambient Air Quality Standards (AAQS) have been established for six classes of pollutants as shown in Table 1. An AAQS is a pollutant concentration not to be exceeded more than once per year over a specified sampling period which varies from as little as one hour to a year depending on the pollutant and type of exposure necessary to cause adverse effects. Each of the regulated pollutants has the potential to create or exacerbate some form of adverse health effect or to produce environmental degradation when present in sufficiently high concentration.

Federal AAQS have been divided into primary and secondary levels for particulates and sulfur dioxide. For these pollutants, primary AAQS are relevant to the prevention of adverse health impacts, while secondary AAQS refer to public welfare impacts such as decreased visibility, diminished comfort levels, or other potential damage to the natural or man-made environment, e.g. soiling of materials or other economic damage.

State of Hawaii AAQS have been set at a single level which is in some cases significantly more stringent than Federal AAQS. In particular, the State of Hawaii one-hour AAQS for carbon monoxide is four times more stringent than the comparable Federal limit.

Under the provisions of the Federal Clean Air Act [1], the U.S. Environmental Protection Agency (EPA) is required to periodically review and re-evaluate Federal AAQS in light of research findings more recent than those which were available at the time the standards were originally set. Occasionally new standards are created as well. Most recently the Federal standard for particulate matter has been revised to include specific limits for particulates 10 microns or less in diameter (PM-10) [2]. The State of Hawaii has not explicitly addressed the question of whether to set more stringent limits for this category of air pollutant, but Federal AAQS prevail where States have not set their own more stringent levels.

Federal AAQS are specified in 40 Code of Federal Regulations (CFR) Part 50, while State of Hawaii AAQS are set in Chapter 11-59, Hawaii Administrative Rules. Hawaii AAQS for particulates and sulfur dioxide were amended in 1986 to make them essentially the same as Federal limits. It has been proposed in various forums that the State of Hawaii relax its carbon monoxide standards to Federal levels, but at present there are no indications that such a change is being considered.

3. PRESENT AIR QUALITY

Present air quality in the Waikane area is likely to be affected by air pollutants from four different types of sources: natural, industrial, agricultural, and vehicular. Natural air pollutant producers which could affect Waikane include the ocean (sea spray), plants (aero-allergens), dust (from the wind blowing over areas with no vegetative cover), or perhaps distant volcanic emissions from the Island of Hawaii.

Industrial and agricultural sources of air pollutants are located on the leeward and central portions of Oahu. The 3000-foot Koolau Mountain Range separates Waikane from these source areas. Upwind in the normal trade wind direction there are no industrial or agricultural air pollution sources for thousands of miles. The nearest representative long term State of Hawaii monitoring station on the windward side of Oahu is located at Waimanalo, about 15 miles to the southeast of Waikane. This monitoring site was selected to measure background levels of particulates and recent reported levels have been running in the range of 25 to 30 micrograms per cubic meter, far below allowable AAQS.

Unfortunately there are no nearby long term measurements of carbon monoxide, ozone, or lead on the windward side of Oahu, so current levels of vehicular pollutants are difficult to estimate using anything other than a modeling approach. Measurements of lead from sites in urban Honolulu indicate that most recent levels are barely above the threshold of detection for current measuring techniques. Airborne lead is thus not considered to be a problem anywhere on Oahu.

On the other hand, carbon monoxide and ozone readings from urban Honolulu indicate that allowable State of Hawaii standards for these vehicle-related pollutants are being violated at a rate of up to three times a year. Ozone is an indicator of the formation of photochemical smog, a condition which tends to develop over Oahu if the air mass is fairly stable with light southerly winds prevailing for a period of two or more days. Concentrations of carbon monoxide are more directly related to local vehicular emission rates and thus serve as the best indicator of vehicle-related air pollution problems. Because of the extremely stringent State of Hawaii one-hour limit for this pollutant it is also the one most likely to cause problems in meeting allowable AAQS when new projects are evaluated under worst case traffic and dispersion conditions.

4. SHORT TERM DIRECT AND INDIRECT IMPACTS OF PROJECT CONSTRUCTION

There will be two types of short term direct air quality impact from project construction: fugitive dust and on-site emissions from construction equipment. There will also be short term indirect impacts from slow-moving construction equipment travelling to and from the project site and a temporary increase in local traffic caused by commuting construction workers.

Fugitive dust emissions will arise from grading and dirt-moving activities within the project site and from any off-site dirt hauling as well. The quantitative emission rate for fugitive dust is almost impossible to estimate because the potential for its generation will vary greatly depending upon the amount of dirt-disturbing activity taking place and the moisture content of exposed soil in work areas. The EPA has provided a rough estimate for fugitive dust emissions from construction activity [3]: 1.2 tons per acre per month of activity under conditions of "medium" activity, moderate soil silt content (30%), and precipitation/evaporation (P/E) index of 50. On the one hand, fugitive dust emissions could be lower than the nominal rate because the area is wetter than normal. On the other hand, construction of a golf course is likely to require fairly extensive modification to the landscape and topography and will no doubt require far more dirt-moving than occurs under typical "medium" level construction activity. In any case State of Hawaii Air Pollution Control Regulations [4] require that visible emissions of fugitive dust from construction activity be essentially nil.

Adequate fugitive dust control can usually be accomplished by establishment of a frequent watering program to keep bare-dirt surfaces in work areas from becoming significant dust generators. Control regulations also require that open-bodied trucks be covered at all times when in motion if they are transporting materials likely to give rise to airborne dust. Paving of parking areas and establishment of landscaping as early in the construction process as possible can also lower the potential for fugitive dust emissions.

On-site mobile and stationary construction equipment will also emit some air pollutants in the form of engine exhausts. The largest of this equipment is usually diesel-powered. Nitrogen dioxide emissions from diesel engines can be quite high, but the standard for nitrogen dioxide is set on an annual basis and is not likely to be violated by short term construction equipment emissions. Furthermore, carbon monoxide emissions from diesel engines are very low and should be essentially insignificant compared to normal vehicular emissions on nearby Kamehameha Highway.

Indirectly, slow-moving construction vehicles on the two-lane Kamehameha Highway can obstruct the normal flow of traffic to such an extent that overall vehicular emissions of carbon monoxide are increased, but this impact can be mitigated by moving heavy construction equipment during periods of low traffic volume. Likewise the schedules of commuting construction workers can be adjusted to avoid peak hours in the project vicinity. Thus most potential short term air quality impacts from project construction should be relatively easy to mitigate.

5. LONG TERM DIRECT IMPACT

A. On-Site

Once the Waikane Golf Course is completed and in use it will be necessary to regularly apply various chemical fertilizers and pesticides to maintain grass quality. The potential air quality impact of fertilizer and pesticide use is described in detail in a report by Murdoch and Green [5] elsewhere in this EIS.

AAQS have not been established for any of the pesticides presently in use even though most of them carry Warning or Caution labels on their containers. The primary purpose of these labels is to provide occupational safety and health guidance regarding proper handling and application. The primary risk of using these chemicals is to the applicator rather than to individuals at possible receptor sites downwind, since these individuals should encounter airborne concentrations of these chemical substances only in greatly diluted form. There are, however, certain precautions that must be followed by pesticide applicators in order to prevent significant downwind drift from spraying. Primary among these is use of a coarse rather than fine spray and application under wind conditions that will not contribute to drift towards the clubhouse area or to nearby residences. Provided that proper safety precautions are followed the potential for serious air quality degradation from chemical spraying for golf course maintenance is judged to be minimal.

B. Off-Site

Electrical energy requirements and solid waste generation by patrons of the Waikane Golf Course should be relatively low. Restaurants are estimated to require about 77 kilowatt hours of electricity per square foot. In the worst case this new energy requirement would be met by burning additional fuel oil in existing power plants, primarily the Kahe power plant on the Waianae coast. This new energy requirement could be reduced significantly by installation of a solar water heater and by incorporating solar design features into construction plans, e.g. use of landscaping to provide afternoon shade to cut down on use of air conditioning and positoning of windows to maximize indoor light without unduly increasing indoor heat.

It is also possible that the new demand could be met by sources other than burning fuel oil. In fact, an operating wind farm has been developed on the north shore of Oahu, and other low-pollution energy generating systems might be developed in coming years. If the HPOWER project is completed as planned solid waste generated from the project will be transported to a windward compaction site from which it will then be transported to the HPOWER site in Campbell Industrial Park to be used as fuel to generate electical energy. Because of the relatively low levels of both solid waste and electrical energy associated with the proposed project, neither of these items is likely to constitute a quantitatively significant proportion of the HPOWER throughput budget.

6. LONG TERM INDIRECT IMPACT OF PROJECT-RELATED TRAFFIC

By serving as an attraction for increased motor vehicle traffic the Waikane Golf Course must be considered to be a potential indirect air pollution source.

Motor vehicles with gasoline-powered engines are significant sources of carbon monoxide. They also emit some nitrogen dioxide and those burning leaded gasoline can contribute some lead to the atmosphere as well. The use of leaded gasoline in new automobiles is prohibited. As older vehicles continue to disappear from the numbers of those currently operating on Oahu roadways, lead emissions are approaching zero. Nationally, so few vehicles now require leaded gasoline that the EPA is proposing a total ban on leaded gasoline to take effect immediately. Even without such a ban, reported quarterly averages of lead in air samples collected at the Department of Health building on Punchbowl and Beretania Streets in urban Honolulu have been zero since early 1986.

Federal control regulations also call for increased efficiency in removing carbon monoxide and nitrogen dioxide from vehicle exhausts. By the year 1995 carbon monoxide emissions are expcted to be about one fourth less than the amounts now emitted. At present, however, no further reductions in vehicular emissions have been mandated and increases in traffic levels after 1995 will result in directly proportional increases in vehicle-related pollutant emissions.

In order to evaluate the potential long term indirect air quality impact of increased traffic associated with project development a carbon monoxide modeling effort was carried out. Carbon monoxide was selected for modeling because it is both the most stable and the most abundant of the motor vehicle generated pollutants and it is also the air polluant with the greatest likelihood of violating allowable AAQS.

7. CARBON MONOXIDE DIFFUSION MODELING

A single critical receptor area near the intersection of Kamehameha Highway and the existing driveway that would become the sole Golf Course Entry Road in project plans was selected for analysis. The modeling study considered a string of receptor sites located 10 meters from the edge of the roadways forming the simple T-intersection. The location of the receptor site with the highest carbon monoxide levels is indicated on Figure 1. While this site can be considered to be a place where Ambient Air Quality Standards apply, it is not a place where an individual could be expected to spend an hour doing anything other than hitch-hiking.

The modeling study was designed to yield current and projected levels of carbon monoxide which could be directly compared to allowable AAQS. The traffic impact assessment report for the project [6] indicates that peak traffic volumes with or without the project are expected to occur on Sunday afternoons. Worst case meteorological dispersion conditions usually occur during the early morning hours, but traffic volumes associated with the proposed project would not be very large then. Thus, for this particular case, afternoon meteorological conditions are the ones most likely to be associated with the peak project traffic volumes needed to generate potential worst case carbon monoxide levels.

Modeling was performed for 1988 and 1991 (the planned year of project completion). Using recent Oahu vehicle registration figures, the present and projected peak hour vehicle mix in the Waikane area is estimated to be 91.9% light-duty gasoline-powered vehicles, 4.2% light duty gasoline-powered trucks and vans, 0.5% heavy duty gasoline-powered vehicles, 1% diesel-powered trucks and buses, and 1% motorcycles.

Vehicle operating characteristics were computed assuming that 20.6% of the vehicles equipped with catalytic converters and 20.6% of the vehicles without catalytic converters would be operating in the cold start mode and that 27.3% of all vehicles would be operating in the hot start mode. The EPA computer model MOBILE3 [7] was run using the above parameters to produce vehicular carbon monoxide emission estimates for each of the years studied. National averages for "mis-fueling" were assumed. A relatively cool 68 degrees F was used for afternoon peak hour emission computations.

The computer model CALINE4 [8] was used to compute carbon monoxide concentrations for each of the scenarios studied. Stability category 4 was used for determining diffusion coefficients. This is the least favorable stability category that can be used for daytime pollutant diffusion in model calculations. A surface roughness factor of 100 was assumed with a mixing depth of 1000 meters. Only two roadway links were required to adequately represent roadway geometry in the vicinity of the critical intersection studied.

Worst case wind conditions are defined as uniform wind speed of one meter/sec with the worst case wind direction determined by model results (northwest in this case). Carbon monoxide concentrations were computed for a receptor height of 1.5 meters to simulate levels within the normal human breathing zone.

Background contributions of carbon monoxide from sources or distant roadways not directly considered in the analysis were assumed to be zero in order to more clearly indicate the impact of project-related traffic. In fact, background levels in this area would be very near zero in any case.

Results of the peak hour carbon monoxide study are presented in Table 2. Present and future peak hour carbon monoxide levels with or without the proposed Waikane Golf Course are expected to be well within all Federal and State of Hawaii AAQS even under the worst case scenario considered here.

Eight hour carbon monoxide levels are estimated by multiplying the peak hour values by a "meteorological persistence factor" of 0.6 which is recommended in EPA modeling guidelines [9] to account for the fact that average one hour traffic volumes over an eight hour period are lower than peak hour volumes and the fact that meteorological dispersion conditions are more variable (and hence more favorable) over an eight hour period than they are for a single hour. Eight hour estimates thus computed are shown in Table 3. Both present and projected levels are well within allowable AAQS with or without the proposed project.

It is important to note that the worst case conditions used here have a relatively low probability of occurrence. A steady wind of one meter per second blowing from a single direction for an hour is not very likely. With wind speeds of two meters per second, for example, computed carbon monoxide concentrations would be only about half as high as those shown in Table 2. Furthermore, the light wind speeds needed to produce worst case values would be most likely to occur in conjunction with highly variable wind directions rather than the single direction assumed in the computations. Finally, a wind from the norhtwest is not very common anywhere on Oahu.

8. SUMMARY OF IMPACTS AND MITIGATIVE CONSIDERATIONS

A. SHORT TERM

The major short term air quality impact of project construction will be the potential emission of significant quantities of fugitive dust. Strict compliance with State of Hawii Air Pollution Control Regulations regarding establishment of a regular dust-watering program and covering of dirt-hauling trucks will be required to effectively mitigate this concern.

B. LONG TERM

Once completed, the proposed Waikane Hills Country Club Golf Course would have little direct impact on ambient air quality in the area. Compliance with existing safety guidelines for the spraying of chemicals for golf course maintenance should mitigate potential air quality impacts from this activity. Long term indirect air quality impact is expected to be minimal since detailed carbon monoxide modeling has indicated that worst case projected levels of carbon monoxide at the highway intersection leading to the project will be very low compared to allowable State of Hawaii and Federal Ambient Air Quality Standards. For this reason no specific mitigative measures are proposed in this regard.

REFERENCES

1. U.S. Congress. Clean Air Act Amendments of 1977 (P.L. 95-95), Section 109, Natonal Ambient Air Quality Standards, August, 1977.

2. U.S. EPA. Revisions to National Ambient Air Quality Standards for Particulate Matter, Federal Register, Vol. 52, p.2463, July 1, 1987.

3. U.S. EPA. Compilation of Air Pollutant Emission Factors, 1978.

4. State of Hawaii. Hawaii Administrative Rules, Chapter 11-60, Air Pollution Control.

5. Murdoch and Green. Environmental Impact of Fertilizer and Pesticide Use on the Proposed Waikane Golf Course, March, 1988.

6. Pacific Planning and Engineering, Inc. Waikane Golf Course, Traffic Impact Assessment Report, February, 1988.

7. U.S. EPA. User's Guide to MOBILE-3 (Mobile Source Emissions Model), June, 1984.

8. Trinity Consultants. FHWA User's Guide for CALINE4 - A Dispersion Model for Predicting Air Pollutant Concentrations near Roadways, with July 1985 Revisions, July, 1987.

9. U.S. EPA. Guidelines for Air Quality Maintenance Planning and Analysis; Indirect Sources. Volume 9. Revised, September, 1978.

TABLE 1

SUMMARY OF STATE OF HAWAII AND FEDERAL
AMBIENT AIR QUALITY STANDARDS (AAQS)
(micrograms per cubic meter)

POLLUTANT	SAMPLING PERIOD	FEDERAL PRIMARY	FEDERAL SECONDARY	STATE OF HAWAII
Total Suspended Particulate Matter (TSP)	Annual Geometric Mean	75	60	60
	24 Hour	260	150	150
PM-10 Particulates <10 microns in diameter	Annual Mean	50	50	50
	24 Hour	150	150	150
Sulfur Dioxide	Annual Mean	80		80
	24 Hour	365		365
	3 Hour		1300	1300
Nitrogen Dioxide	Annual Mean		100	100
Carbon Monoxide (milligrams per cubic meter)	8 Hour		10	5
	1 Hour		40	10
Photochemical Oxidants (as Ozone)	1 Hour		240	100
Lead	Calendar Quarter		1.5	1.5

TABLE 2

RESULTS OF PEAK HOUR CARBON MONOXIDE MODELING
(milligrams per cubic meter)

LOCATION	YEAR/SCENARIO 1988	1991 WITHOUT PROJECT	1991 WITH PROJECT
Intersecton of Kamehameha Highway and Golf Course Entry Road	1.9	1.9	3.8

NOTE: See Figure 1 for location of critical receptor. See text, Section 7, for description of models and assumptions.

TABLE 3

ESTIMATED EIGHT HOUR CARBON MONOXIDE CONCENTRATION
(milligrams per cubic meter)

LOCATION	YEAR/SCENARIO 1988	1991 WITHOUT PROJECT	1991 WITH PROJECT
Intersecton of Kamehameha Highway and Golf Course Entry Road	1.1	1.1	2.3

NOTE: See Figure 1 for location of critical receptor. See text, Section 7, for description of models and assumptions.

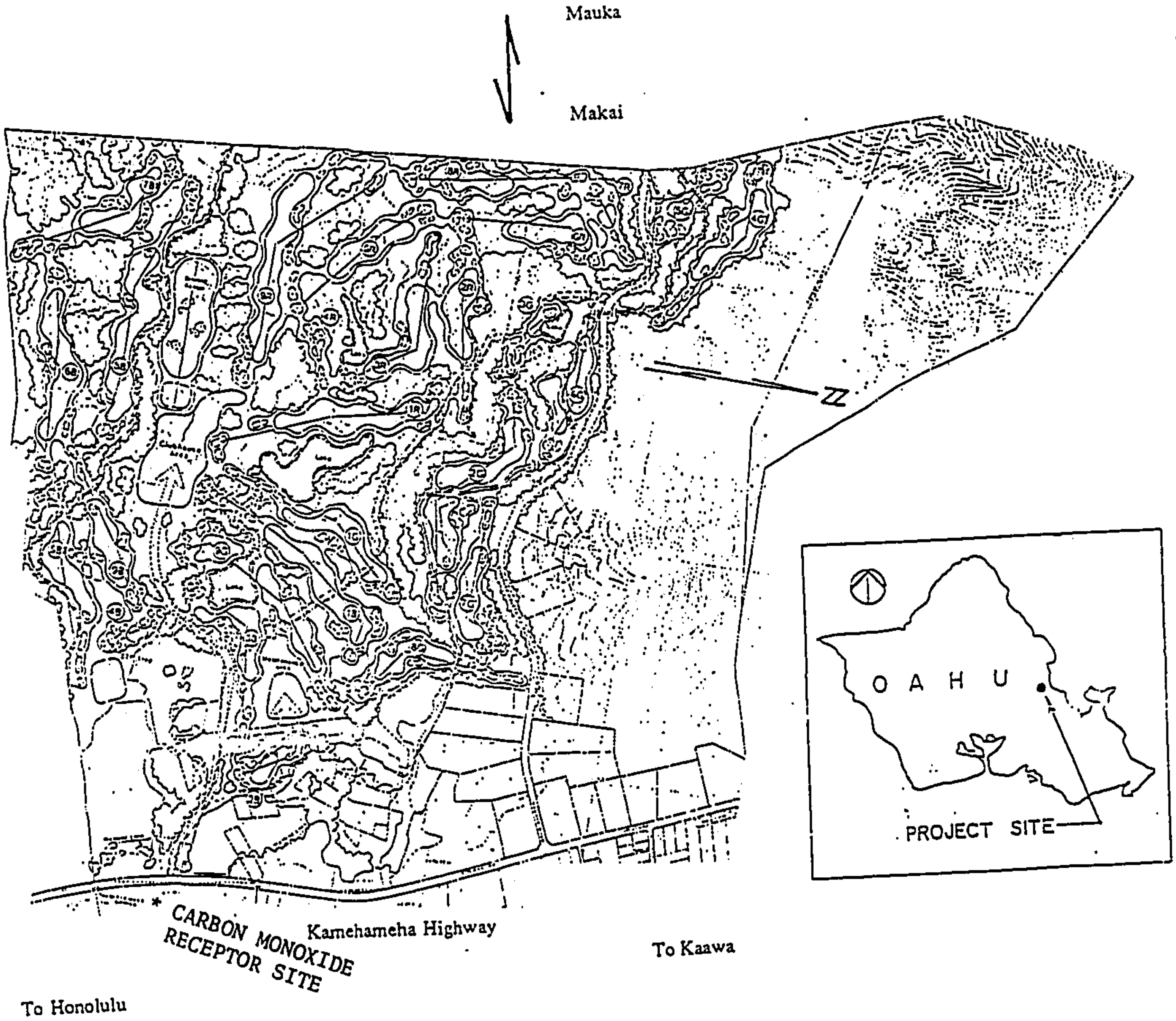


Figure 1. Project Location Map and Site Plan

APPENDIX Q
Noise Impact Evaluation

DARBY
& ASSOCIATES
ACOUSTICAL CONSULTANTS

#87-41
October 21, 1988

Group 70
924 Bethel Street
Honolulu, Hawaii 96813

Attention: Mr. Ralph Portmore

Subject: Noise Impact Evaluation for the Proposed Waikane Golf Course, Koolaupoko, Oahu, Hawaii

Dear Mr. Portmore:

Based on phone conversations with you and information you forwarded to me, I provide the following:

1. General Considerations - The proposed golf course site shown in Figure 1 is situated away from noise sensitive locations except for those houses and the church on the entry road and any houses that may exist on the proposed Haupoa Road Extension. Only a few houses and the church should be impacted by the new access road which is to be implemented between Kamehameha Highway and the Clubhouse Facility. The Clubhouse, which would be the most intensively used feature in the project, is to be located about 1,200 feet from the nearest known residence.

The ambient noise levels at the structures along the access road and Haupoa Road will be low in consideration of the low traffic volumes and the few civilian aircraft operations over the area. At residences away from Kamehameha Highway, the background noise would be dominated by neighborhood self-

PALI PALMS PLAZA • 970 NO. KALAHEO AVENUE • SUITE A-311
KAILUA, HAWAII 96734 • (808) 254-3318 • FAX (808) 254-5295

generated sounds, e.g. occasionally local vehicle movements, lawn mowers, weed wackers, TV's, radios, and sounds from children and animals. Wind blowing in the foliage may often be the dominant sound along with occasional muffled noise events from traffic on Kamehameha Highway.

The existing residents periodically hear the sounds from jet aircraft flights and engine testing as well as helicopters associated with Kaneohe Marine Corps Air Station.

2. Potential Noise Impact from Clubhouse Activities - Noise sources from Clubhouse operations could include kitchen equipment, fans, air conditioning equipment, refrigeration equipment, pool pumps, as well as sound systems for announcements and music. The sounds from these sources should not usually be audible to the closest residents 1,200 feet distant in consideration of the sound level that would be acceptable at the Clubhouse and because of the large sound transmission losses involved.

The actual sound transmission losses will depend largely on the topography as well as upon the amount and type of foliage involved in the 1,200 foot distance. A worst case exists if there is (a.) a direct line of sight (i.e. also direct sound transmission) from the noise source to a listener; and (b.) that direct line is at least about nine feet above the ground or foliage. This situation can also be simulated if there is sound refraction, e.g. sound bending over topographic features and foliage caused by a wind gradient with the listener being downwind of the sound source. For this case, the sound diminishes six decibels (6 dB) for each doubling of the distance, e.g. 80 dB at 12 feet; 74 dB at 25 feet; 68 dB at 50 feet; and so on to 40 dB at 1,200 feet. Noise sources creating 80 dB at 12 feet would not be considered acceptable to persons at the Clubhouse while 40 dB would probably not be audible at houses 1,200 feet away during the daytime.

Usually sound grazing over grass and sporadic foliage decreases at least 8 dB per double distance. In this case, in order to cause 40 dB at 1,200 feet, the noise source at the Clubhouse would have to produce about 93 dB at 12 feet. Such intense exterior sound levels are not likely to occur at the Clubhouse.

It is to be noted that a wall or berm near an exterior sound source can introduce up to 15 dB additional sound lessening beyond the above considerations. Also, if the sound source is located in an enclosed, air conditioned building, an additional 25 to 35 dB lessening of the noise levels can be achieved with standard construction.

The air conditioning equipment, fans, pool pumps, and any other stationary equipment on the project site will not exceed the allowable noise levels in local noise regulations (references 1 and 2). Public address sound systems and entertainment sounds will not cause "unreasonable" or "excessive" noise as defined in reference 1. The Clubhouse will not be in operation late into the night, but should cease operations by 7 p.m.

3. Ground Maintenance Noise - Noise from equipment associated with ground maintenance activities, including lawn mowers and leaf blowers, could have an adverse impact on surrounding residential neighborhood particularly when the equipment is near the housing. However, noisy equipment is also incompatible and disruptive with golf play. All equipment powered by internal combustion engines will have exhaust mufflers. Schedules will be developed so noisier maintenance operations do not occur near residences before 7 a.m. The noise from ground maintenance operations will not cause "unreasonable" or "excessive" noise as defined in reference 1.

4. Traffic Noise - Reference 5 provides predictions of traffic volumes in the years 1991 and 2001 that would occur with, and without, the project along Kamehameha Highway and the golf course entry road. Traffic noise level estimates have been made using the Federal Highway Administration (FHWA) Highway Traffic Noise Prediction Model (reference 6). Averaged noise level measurements made on February 18, 1988 in the mid-day at 119 feet from the center of Kamehameha Highway with the microphone about 10 feet above the ground ranged from 60 dBA to 61 dBA over short time periods. Traf-

fic counts including the mix of vehicles were also made during the noise sample periods in order to validate the FHWA Traffic Noise Prediction Model. Table I summarizes the comparison of the measured short term measurement Equivalent Noise Levels, e.g. (L_{eq} [10 minutes]), with predicted hourly noise levels (L_{eq} [60 minutes]). The fact that the two values agree within two dB for measurements is considered acceptable.

Table II shows the estimated present and future traffic volumes along Kamehameha Highway and the entry road. The table also presents the traffic noise level increases that are anticipated with and without the project in the years 1991 and 2001. Calculations show that typical housing set back about 120 feet from the center of Kamehameha Highway will have traffic noise levels during the noisiest hour of the week for the worst case in 2001 with the project to be just below 65 dBA. From Table II it can be seen that the increase in traffic noise level along Kamehameha Highway is less than one dB and thus it is not considered a significant noise impact.

Presently occupants in the housing on the entry road experience very little traffic; and from Table II, it can be seen that traffic noise level increases of about 10 dBA will exist when the project is in operation. However, the total traffic noise level at the structures on the entry road will be very low compared to those on public roadways.

5. Noise Impact from Construction - Development of the project site will involve grubbing, grading, and the construction of infrastructure and buildings. The various construction phases of a development project may generate significant amounts of noise; the actual amounts are dependent upon the methods employed during each stage of the process. Typical construction equipment noise ranges in dB(A) are shown on Figure 2. Earthmoving equipment such as bulldozers and diesel powered trucks will probably be the loudest equipment used during construction. Since it is anticipated that noise generated during construction will exceed allowable limits in reference 1, a permit will be obtained from DOH. DOH may grant permits to operate vehicles, construction equipment, power tools, etc. which emit noise levels in excess of the allowable limits. Required permit conditions for construction activities are:

> "No permit shall allow construction activities creating excessive noise...before 7:00 a.m. and after 6:00 p.m. of the same day."

> "No permit shall allow construction activities which emit noise in excess of ninety-five db(A)...except between 9:00 a.m. and 5:30 p.m. of the same day."

> "No permit shall allow construction activities which exceed the allowable noise levels on Sundays and on... [certain] holidays. Activities exceeding ninety-five dB(A) shall [also] be prohibited on Saturdays."

In addition, construction equipment and on-site vehicles or devices requiring an exhaust of gas or air must be equipped with mufflers. Also, construction vehicles using trafficways will satisfy the noise level requirements defined in reference 3.

6. Noise Mitigation Measures - The design of the facility will include noise mitigation measures in the planning of the location and orientation of the air conditioning equipment, exhaust fans, pool pumps, etc. such that local noise regulations (references 1 and 2) will be satisfied.

Sincerely,

Ronald A. Darby, P.E.

RAD:dba

References:

1. "Chapter 43 - Community Noise Control for Oahu", Department of Health, State of Hawaii, Administrative Rules, Title 11, 1981
2. "Section 3.100, Noise Regulations", Land Use Ordinance, City and County of Honolulu, October 22, 1986
3. "Chapter 42 - Vehicular Noise Control for Oahu", Department of Health, State of Hawaii, Administrative Rules, Title 11, 1981
4. "FHWA Highway Traffic Noise Prediction Model", Federal Highway Administration, December 1978
5. "Traffic Impact Assessment Report for the Proposed Waikane Golf Course", Pacific Planning & Engineering, Inc., Feb. 1988
6. "FHWA Highway Traffic Noise Prediction Model", Federal Highway Administration, December 1978.

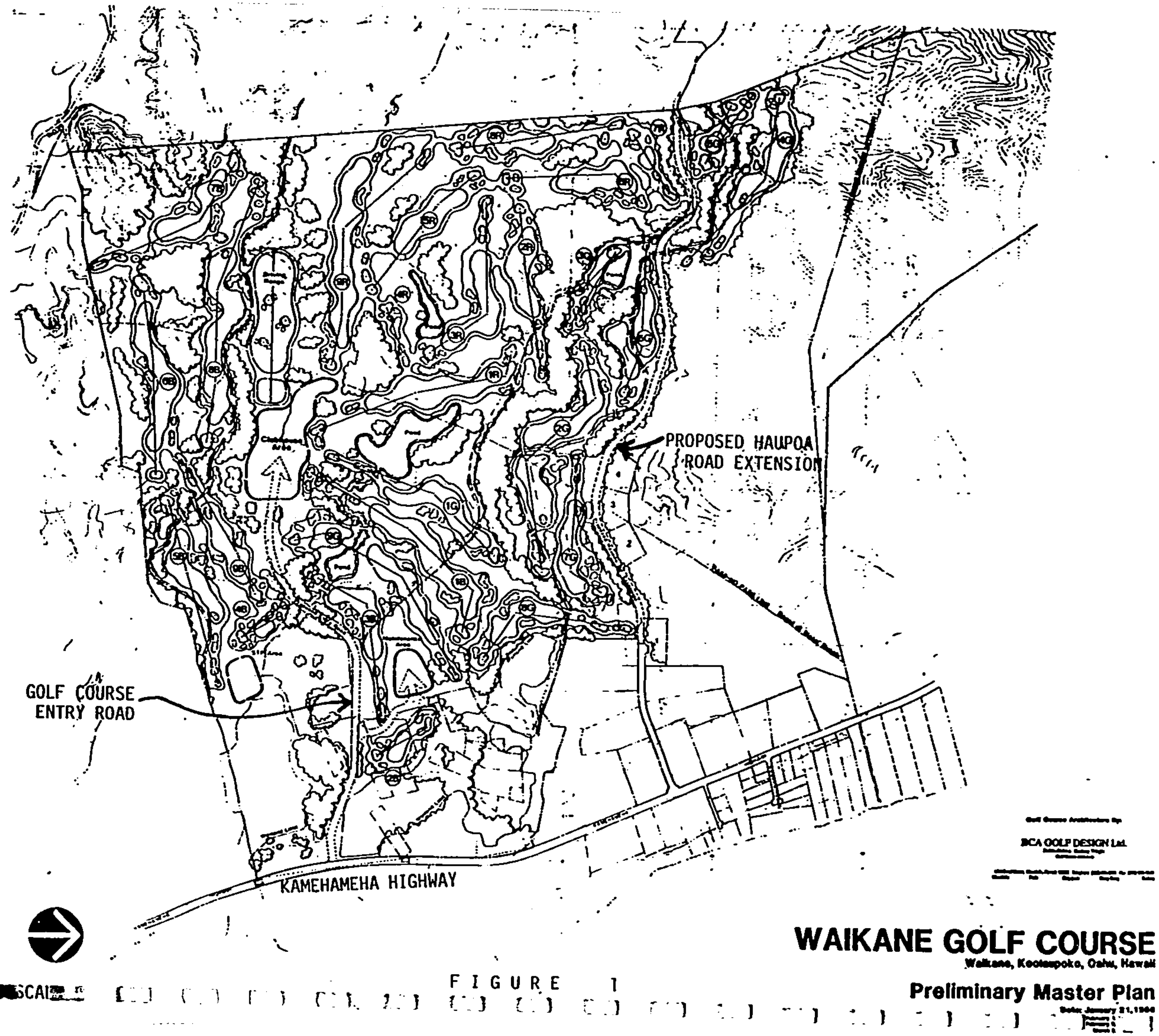
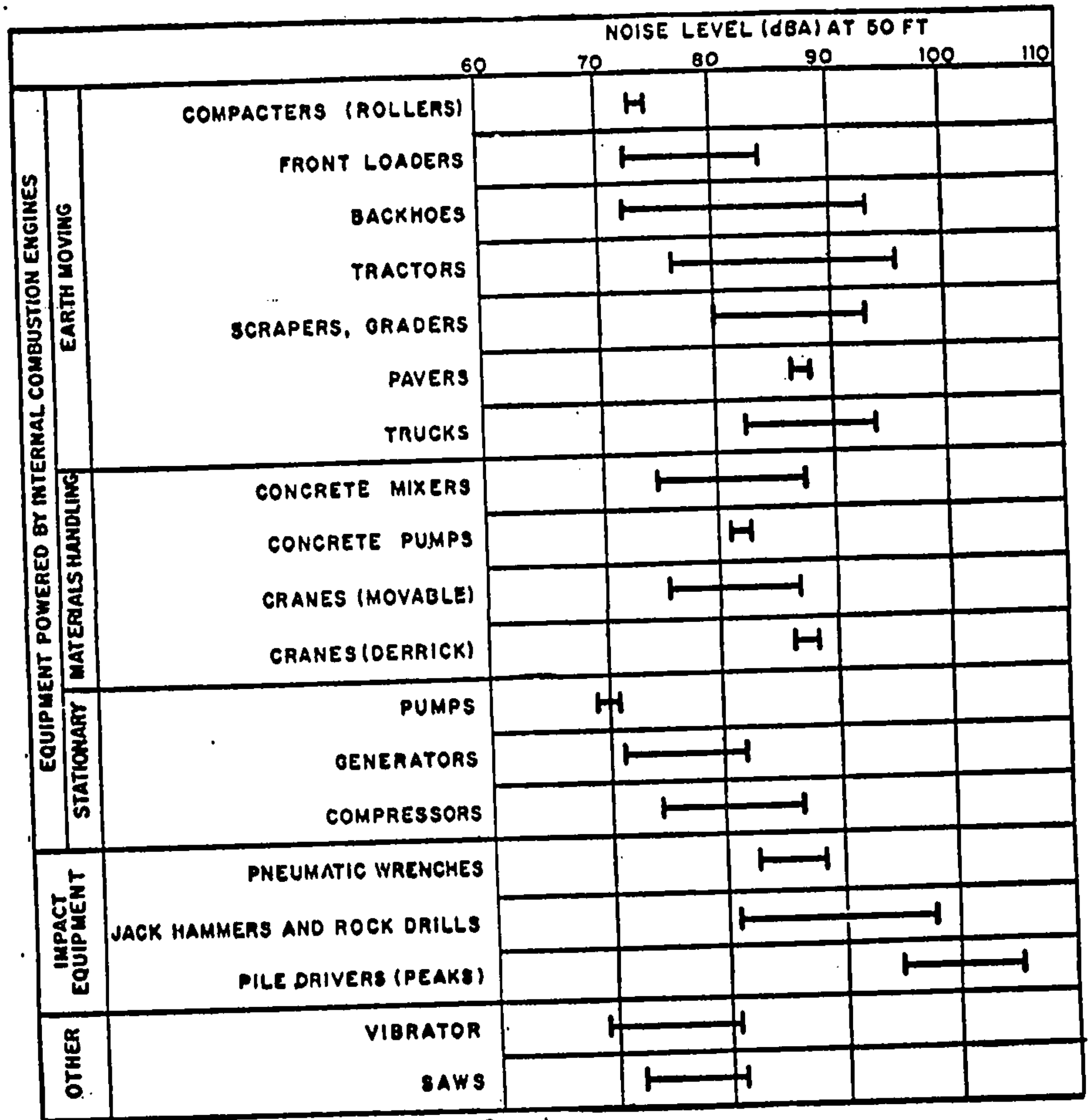

PROPOSED HAUPOA
ROAD EXTENSION
GOLF COURSE
ENTRY ROAD
KAMEHAMEHA HIGHWAY
BCA GOLF DESIGN Ltd.
WAIKANE GOLF COURSE
Waikane, Koolaupoko, Oahu, Hawaii
Preliminary Master Plan

FIGURE 1



Note: Based on Limited Available Data Samples

FIG. 2 CONSTRUCTION EQUIPMENT NOISE RANGES.

APPENDIX R
Agricultural Feasibility

FEASIBILITY AND NEED OF WAIKANE GOLF COURSE LANDS FOR AGRICULTURE

PREPARED FOR
GROUP 70

By
Frank S. Scott, Jr.
Agricultural Economist

March, 1988

(Revised February, 1989)

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SUMMARY AND CONCLUSIONS

The Findings in this report indicate that a maximum of 134 acres of the 505 acres in the Waikane Golf Course Project are ecologically adaptable to agricultural production under irrigation. The ecologically adaptable acreage consists of a large number of isolated parcels on plateaus and bottom-lands scattered throughout the project. The crops considered best adapted to the better lands in the project are bananas, selected truck crops and, to a lesser extent, papayas. All of these crops would require supplemental irrigation water, since rainfall in the area is seasonal and extremely variable for individual months from year to year.

The cost of water development for 82 of the 134 acres is indicated to be prohibitive. The poor configuration of arable land, consisting of many small parcels scattered throughout the project and the fact that they are surrounded by deep gulches or steep, eroded hillsides would further add to the cost of crop production.

Projected increases in acreage needed to supply market requirements for crops ecologically adaptable to the project area exceed the 134 acres of usable acreage, but crops that could be grown in the project area would have a comparative disadvantage in competing for sales potentials because of higher costs of production than alternative areas. Oahu production of these crops has leveled off or is declining because of the inability to compete with imports or because of shifts in production to the Neighbor Islands where labor, land and irrigation costs are lower. Also, better production areas than in Waikane are available on Oahu.

A further factor affecting the feasibility of agricultural development in the project area is the decreasing need for these lands as better lands are withdrawn from crop production. The acreage in cultivated crops on Oahu has steadily declined from 49,100 acres in 1987 to 41,100 acres in 1986. The acreage of LSB A and B lands (SCS I and II lands) outside of urban zoning on Oahu is estimated at 49,121 acres in 1987 or 8,421 acres in excess of requirements for cultivated crop production. This difference is expected to widen as production centers for bananas, guavas and truck crops continue to shift to the Neighbor Islands. In spite of the declining need for agricultural land on Oahu, the State Land Use Commission Classified 141,065 acres of land as Agricultural on Oahu in 1987.

Considering the limited land area ecologically adaptable to crop production, the infeasibility of irrigation development for the majority of usable land, projected high costs of production, the inability to compete in the market place and the availability of better lands and better production conditions elsewhere in the State, it is concluded that project lands offer limited opportunity for commercial agriculture. The isolated, better parcels of land could however, be utilized for part-time family farming where economies of scale and profit maximization are of less concern. Golf courses would provide a higher use value than agriculture and at the same time would provide open space and erosion control. Lands conserved through use for golf courses could readily be converted to agriculture in the future if conditions warranted.

FEASIBILITY AND NEED OF WAIKANE GOLF COURSE LANDS FOR AGRICULTURE[1]

INTRODUCTION

This report investigates the feasibility of and need for utilizing lands in the Waikane Golf Course Project for agricultural production relative to the alternative use for golf courses.

Determination of agricultural feasibility is based on appropriate criteria which are defined in the following section of the report. The need for utilizing project lands for crop production considers the comparative advantage of producing ecologically adaptable crops in the project as compared to alternative production areas and the availability of prime agricultural lands on Oahu relative to potential needs for crop production. Projections of land needs for crop production on Oahu consider current and impending shifts in crop production to the Neighbor Islands.

AGRICULTURAL FEASIBILITY CRITERIA

The feasibility of utilizing lands in the Waikane Golf Course project is based on the following criteria:

1. Ecological Adaptation
   Ecological considerations consist of soil type, topography, configuration, rainfall, availability of irrigation water, temperature, wind, light intensity and environment related disease problems.

2. Sales Potentials
   Extent of the market and the comparative advantage of ecologically adaptable corps to compete in the marketplace.

---

[1] Prepared by Frank S. Scott, Jr., Agricultural Economist.

3. Economic Viability
Potential profitability and comparative costs of production in relation to competing areas for crops that meet criteria (1) and (2).

4. Intensity of Production
Gross and Net returns per acre as indicators of use value of the land.

ALISH CLASSIFICATIONS

The Hawaii State Department of Agriculture classifies 262.0 acres in the project area as Agricultural Lands of Importance to the State of Hawaii (ALISH), of which 70.1 acres are classified as Prime Agricultural Land and 191.9 acres are classified as Other Agricultural Land (Figure 1). The remaining 243 acres are unclassified. Prime Agricultural Land consist of 7 small parcels scattered throughout the project, which are surrounded by Other Agricultural Land and Unclassified Land.

CITY AND COUNTY OF HONOLULU ZONING

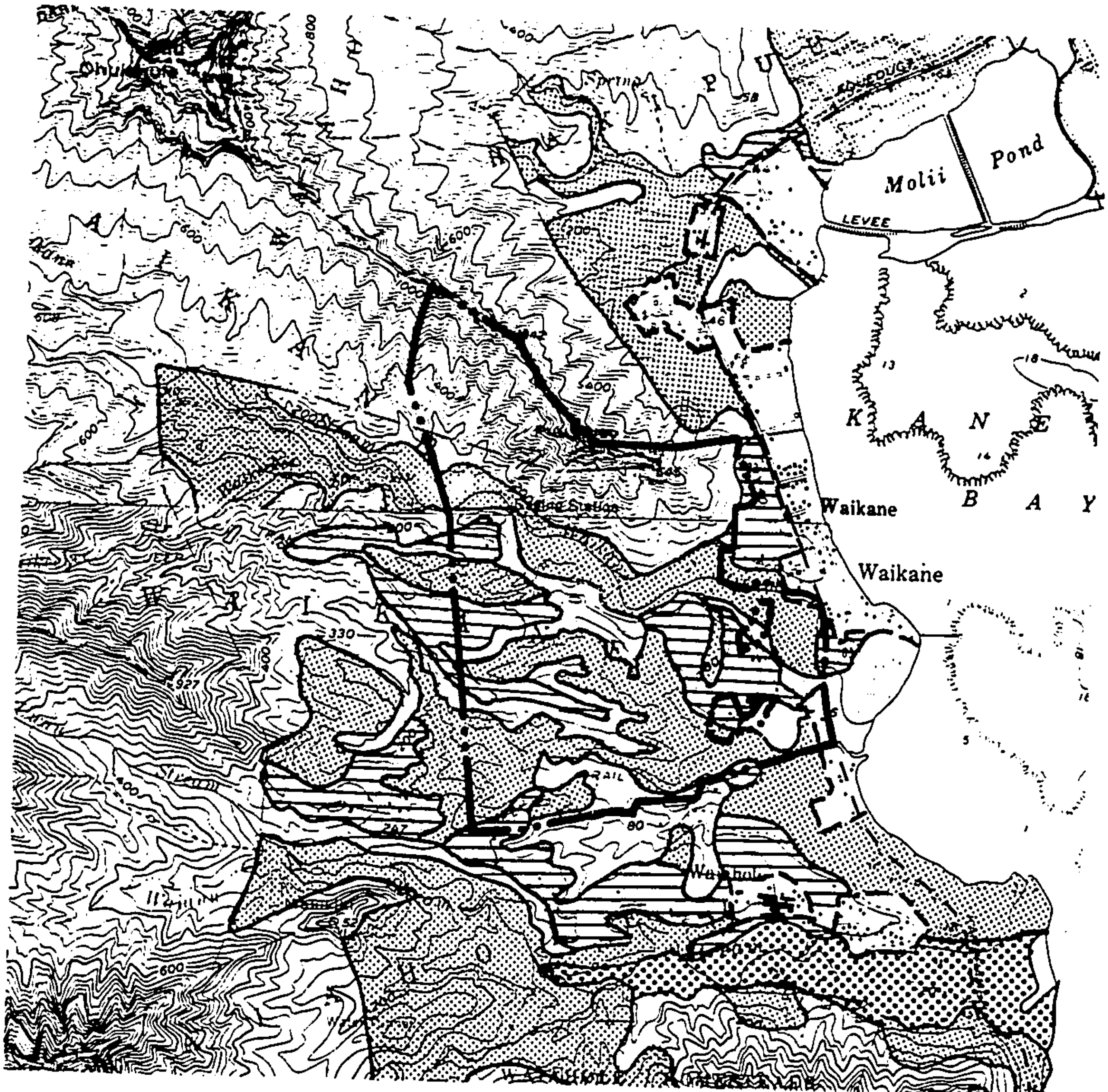
All of the project area is zoned Agricultural Zone General (AG-2) by the Department of Land Utilization, City and County of Honolulu, except for 72 acres in the Kahuku-mauka corner that are zoned Preservation (Figure 2).

SOILS AND TOPOGRAPHY

Soil capability classifications for agriculture in this report are based on soil surveys by the USDA Soil Conservation Service (12) and the University of Hawaii Land Study Bureau (9) plus on-site observations by the subcontractor.

SOIL CONSERVATION SERVICE CLASSIFICATIONS (SCS)

SCS soil capability classifications are based on soil profile, topography, water holding capacity, drainage,



SOURCE: STATE DEPARTMENT OF AGRICULTURE

LEGEND

PRIME AGRICULTURAL LAND

OTHER IMPORTANT AGRICULTURAL LAND

UNCLASSIFIED

AGRICULTURAL LANDS OF IMPORTANCE TO THE STATE OF HAWAII

WAIKANE GOLF COURSE

0' 1000' 2000' 4000'

FIGURE 1

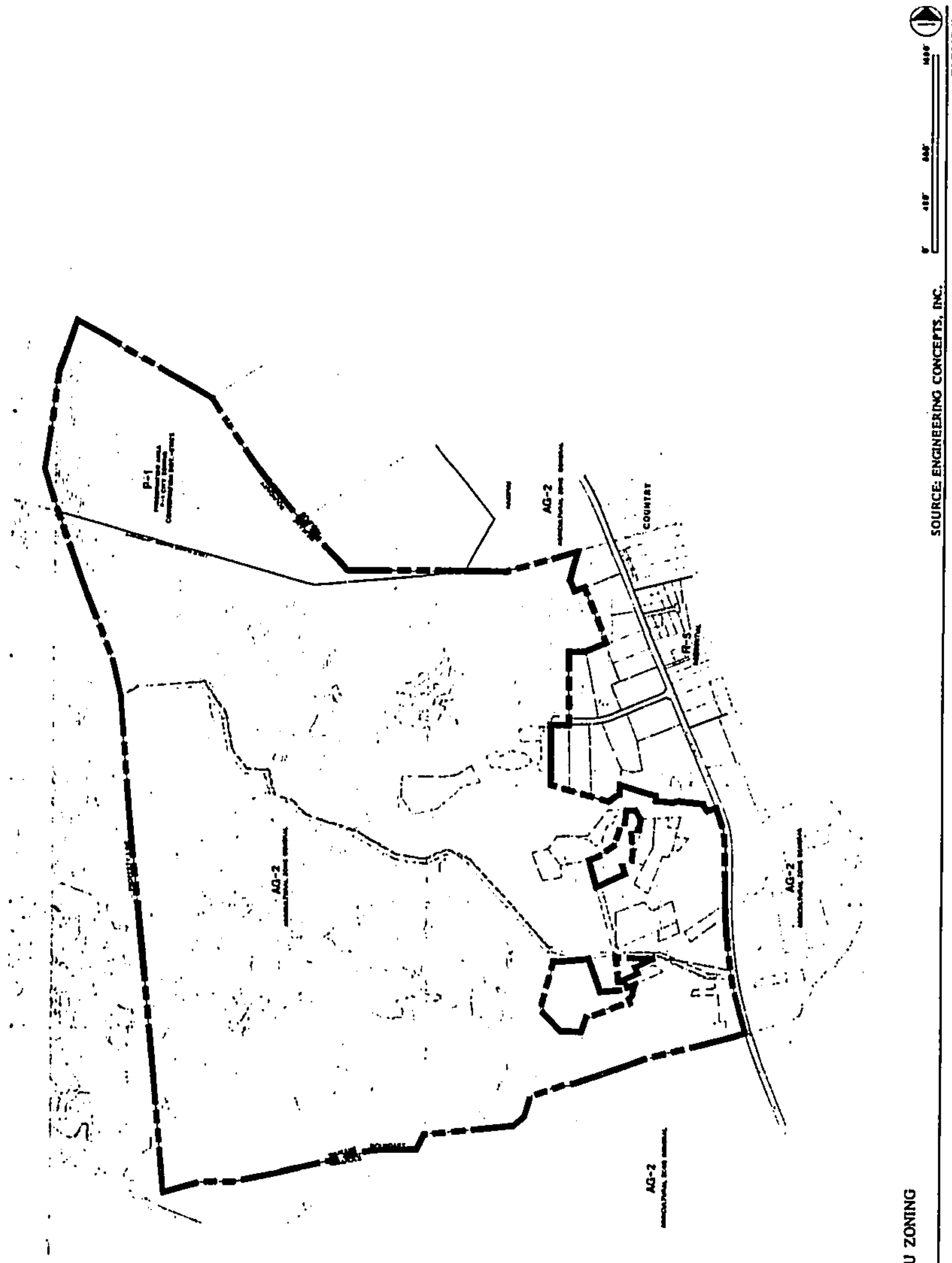


Figure 2. City and County of Honolulu Zoning, Waikane Golf Course

erosion hazard, pH, workability and depth of root penetration. SCS soil capability classifications range from I to XIII, with I being the best. Class I soils have no more than minimal limitations that restrict crop production and soil classes IV to VIII are unsuitable for crop production, with class VIII having the most severe limitations. SCS capability classifications are delineated in Figure 3 and are described as follows:

Hanalei Series

The Hanalei series includes 75.1 acres of HnA and 13.8 acres of HnB in the project area.

The HnA subseries consists of two parcels. The larger parcel of 63.9 acres borders Waikane Stream in the Kahuku section of the project from the mauka border about three-fourths of the way to Kam Highway where the soil becomes Wetland. The other parcel consists of a narrow strip of 11.2 acres near or in the Kaneohe-makai corner of the project, just mauka of a Wetland area. The HnB parcel extends makai from the smaller HnA parcel to the mauka border. The Hanalei series consists of somewhat poorly drained to poorly drained soils on bottomlands. The soils developed in alluvium derived from basic igneous rock.

Hanalei Silty Clay, 0 to 2 Percent Slopes, HnA (75.1 Acres)

The typical topsoil is dark gray and very dark gray silty clay with dark brown and reddish mottles, about 13 inches thick, including a 3 inch subsurface layer. The subsoil is mottled dark gray and dark grayish-brown silty clay loam with angular blocky structure about 13 inches thick. The substratum is stratified alluvium. The topsoil is strongly acid to very strongly acid and the subsoil is neutral. Permeability is moderate, runoff is slow and the erosion hazard is no more than slight, but flooding is a hazard. The available water holding capacity is 2.1 inches per foot of soil. Roots penetrate to the water table. This unit is slightly downgraded to IIw because of drainage and flooding problems. The soil is good for bananas and truck crops if properly drained and is adaptable to grazing under proper management. The poor drainage and flooding are adverse to papayas and fruit trees.

Hanalei Silty Clay, 2 to 6 Percent Slopes, HnB (13.8 Acres)

This soil is the same as HnA, except that run-off, although slow, is slightly greater and the erosion hazard is slight

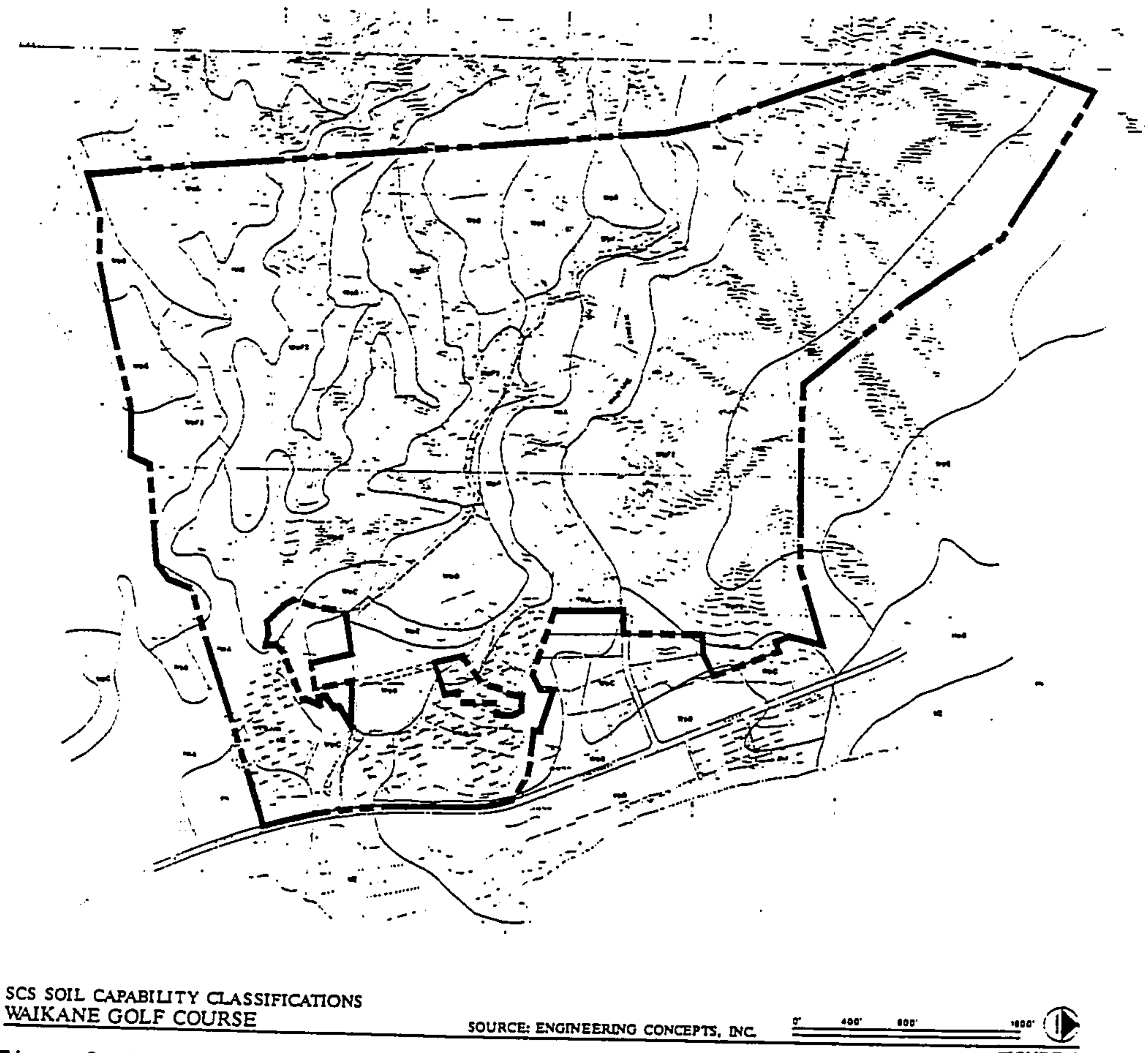


Figure 3. SCS Soil Capability Classifications, Waikane Golf Course

as compared to not more than slight for HnA. This subseries is classified IIw, the same as for HnA, and the same crops are adaptable.

Marsh (M2)

There are 8.9 acres of Marshland adjoining Kam Highway and intersected by Waikane road, with 5.4 acres on the Kaneohe side and 3.7 acres on the Kahuku side. The Marshlands are in low lying areas along coastal plains. The areas are periodically flooded, with water covering the surface and adaptable only to marsh vegetation. The water is fresh or brackish, depending upon the distance from the ocean. Marsh water in the project area is fresh. The SCS capability classification is VIIIw because of severe limitations due to excess water. This soil type cannot be used for crop production.

Pearl Harbor Series

A small parcel of 3.7 acres of Pearl Harbor Clay (Ph) is located in the Kaneohe-makai corner of the property adjoining Kam Highway. The soil is nearly level and very poorly drained. The topsoil consists of very dark gray mottled clay about 12 inches in depth and the subsoil is very dark grayish-brown mottled clay with an angular or subangular blocky structure about 19 inches thick. The substratum is muck or peat. The pH is 5.5 in the topsoil and slightly alkaline in the subsoil. Permeability is low, runoff is slow and drainage is poor. Water holding capacity is 1.4 inches per foot in both the topsoil and subsoil. The soil has a high shrink-swell potential and workability is very difficult. The soil is subject to flooding and the water is brackish along Kam Highway at a depth of 20 to 33 inches. This unit is classified as IVw because of the severe water problems and has severe limitations for crop production. Bananas and vine-type vegetables are marginally adaptable to this area with proper drainage. This soil is not adaptable to papaya and fruit tree production.

Rock Land (rRK)

A 38.1-acre strip of Rock Land adjoins the Kahuku boundary of the project from a point not far from the makai boundary to the mauka boundary. The terrain is gently sloping to precipitous and exposed bedrock covers more than 90 percent of the surface. The unit is downgraded to VIIIs because of the steep, rocky conditions. The land cannot feasibly be used for any type of crop production or grazing.

Waikane Series

The Waikane Series predominates in the project with 315.5 acres or 72 percent of the total land area of 505.0 acres. There are 5 subseries in the project area, consisting of 58.3 acres of WpB, 11.4 acres of WpC, 85.1 acres of WpE, 25.0 acres of WpF and 185.7 acres of WpF2. Crop capability groupings of the subseries vary from IIe for WpB to VIIe for WpF and WpF2.

This series consists of well drained soils on alluvial fans and terraces. The soils developed in alluvium and colluvium from basic igneous rock. The topsoil consist of dark brown silty clay about 8 inches thick and the subsoil is dark reddish-brown silty clay with a subangular blocky structure about 52 inches thick. The substratum consist of soft, weathered, gravelly alluvium and colluvium. The soils are strongly acid, with a pH of 4.1 to 5.0 in both topsoil and subsoil. The available water holding capacity is a low 1.1 inches per foot in the top soil and 1.3 inches per foot in the subsoil. Roots may penetrate to a depth of 5 feet or more.

Waikane Silty Clay, 3 to 8 Percent Slopes, WpB (58.3 Acres)

This subseries consists of 4 isolated high plateaus of 13.7, 10.2, 5.4 and 3.8 acres in the mauka section of the project and two plateaus of 15.0 and 10.2 acres in the central makai section of the project. The mauka plateaus consist of narrow strips running makai-mauka surrounded by steep, eroded gulches. According to SCS, runoff on this soil type is slow and the erosion hazard is slight. This is assumed to be the case under natural vegetation. On-site observation reveals a very serious erosion problem, particularly where the plateaus are cut up by unpaved roads. Gullys 6 feet in depth can be found along roadways at the edges of the plateaus. The soils have a low shrink-swell potential and workability is good, except in eroded areas. SCS classifies the soil as IIe, non-irrigated or irrigated, with the slight downgrading because of the erosion problem. This subseries is good for bananas, truck crops, papayas and tree fruits.

Waikane Silty Clay, 8 to 15 Percent Slopes, WpC (11.4 Acres)

This subseries consists of two parcels of 4.9 and 2.9 acres in the makai section of the project in the Kaneohe direction from Waikane road and two parcels of 1.9 and 1.7 acres in the Kahuku-makai corner of the project. According to SCS, these soils are the same as WpB, except that runoff is slow to medium, the erosion hazard is slight to moderate and workability is slightly difficult. This unit is classified as IIIe because of potential severe erosion problems under cultivation if not protected. On-site inspection indicated severe erosion in areas previously cultivated, particularly in roadways. This soil is considered marginal for truck crops and fair for papayas, bananas and tree fruits and grazing under good management. Because of the badly eroded condition of these soils, they are not recommended for crop production unless the steeper areas are terraced, plowing is contoured and roads are paved.

Waikane Silty Clay 25 to 40 Percent Slopes, WpE (85.1 Acres)

This subseries consists of 5 steep rocky, badly eroded gulches of 44.3, 18.6, 12.2, 6.6 and 3.4 acres scattered throughout the project, but mostly in the mauka section. These gulches prevail between the plateaus of WpB and WpC soils. Run-off is rapid, erosion is severe (based on on-site observations) and workability is very difficult. The SCS capability classification is downgraded to VIe because of the very severe erosion problems. The erosion problems become progressively more severe in moving from the makai to mauka direction as elevation increases. This soil is not practicably adaptable to crop procution or grazing.

Waikane Silty Clay, 40 to 70 Percent Slopes, WpF (25.0 Acres)

This subseries constitutes a makai-mauka strip of steep, rocky slopes bordering the Hanalei soils along the Kaneohe side of Waikane stream. Runoff is very rapid, erosion is severe and workability is prohibitive. The SCS capability classification is VIIe because of the very serious erosion problem. This soil type is not usable for crop production or grazing.

Waikane Silty Clay 40 to 70 Percent Slopes, Eroded, WpFw (185.7 Acres)

The 185.7 acres in this soil type constitute 37 percent of the entire project area. This unit consists of four parcels of 122.1, 32.7, 19.7 and 11.2 acres, which constitute steep rocky hillsides separating the low lying Hanalei soils from the Waikane Silty Clay plateaus or from gulches between the

Waikane Silty Clay plateaus. This subseries is the same as WpF, except that the erosion hazard is even more severe and the soil has undegone greater erosion. The SCS capability classification is VIIe because of the very severe erosion problems. This soil type cannot be used for crop production or grazing and should be kept in woodland to help control erosion. Extremely severe erosion has taken place along unpaved roadbeds and the paving of roads is essential.

LAND STUDY BUREAU CLASSIFICATIONS (LSB)

LSB classifies soils by land type in which classifications are provided for an overall crop productivity rating, with and without irrigation, and for selected crop productivity ratings for 7 crops; namely, pineapple, vegetables, sugarcane, forage, grazing, orchards and timber. The timber rating is not utilized in this report, since it is not concerned with agricultural crop production and grazing. Overall ratings range from A to E, with A being the best. Selected ratings for individual crop categories range from a to e, with a being the best. Ratings are generally comparable to those of SCS, but differ somewhat because of fewer categories (A to E for LSB and I to VIII for SCS) and some differences in evaluating soils in specific areas. Some differences also exist because of the use of somewhat different soil capability criteria. In spite of the differences between the two systems, the use of both methods leads to a more thorough evaluation than can be obtained through one system alone. LSB crop productivity evaluations for the various parcels in the 505.0 acre project area are shown in Figure 4 and are described as follows:

C14

This soil type encompasses 89.9 acres, consisting of 3 parcels of 59.3, 26.5 and 4.1 acres. These parcels constitute the Hanalei bottomlands under the SCS classifications. The 59.3-acre parcel lies along Waikane stream along the Kahuku border of the project. The 26.5-acre parcel parallels the Kaneohe border in a low lying drainage basin and the 4.1-acre parcel is in a low lying area in the Kaneohe-mauka corner. This unit is given an overall rating of C, irrigated or non-irrigated. Selected crop productivity ratings are e for pineapple and c for all other crops, irrigated or non-irrigated. Machine tillability is good. This soil is good for bananas and fair for vine type vegetables if properly drained. It is also good for wetland taro. It is not recommended for papayas, tree fruits and sweet potatoes.

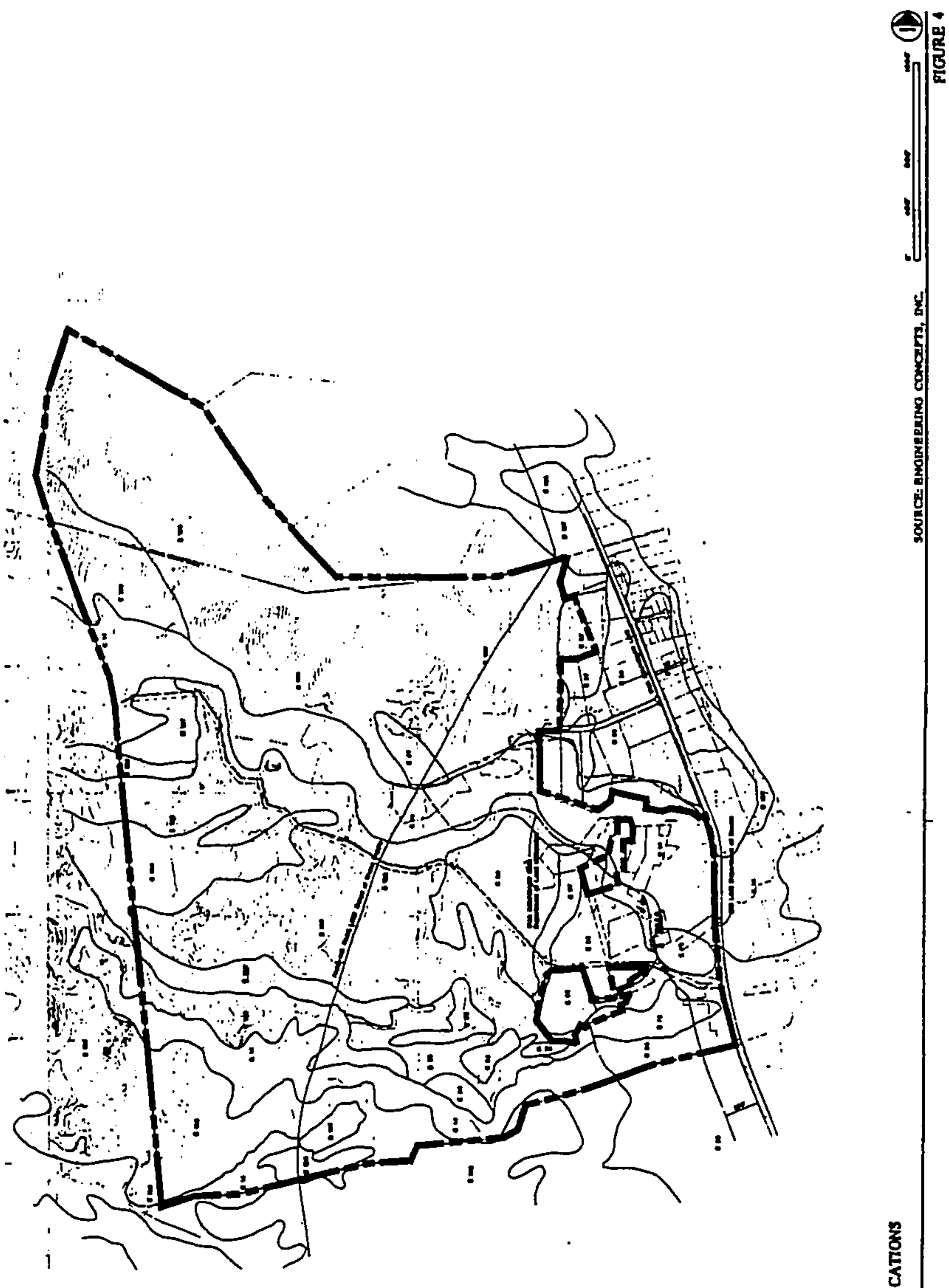


Figure 4. LSB Soil Capability Classifications, Waikane Golf Course

C56

This unit totals 38.7 acres, consisting of 7 isolated parcels of 19.5, 10.1, 3.5, 3.2, 2.4, 2.2 and 0.8 acres located in the Kaneohe-makai section of the project mauka of the Marshlands. Most of these parcels are classified as Waikane Silty Clay WpB in the SCS series. This unit is given an overall rating of C if non-irrigated and B if irrigated. Selected crop productivity ratings are d for sugarcane, c for vegetables and b for all other crops if non-irrigated and a for forage, grazing and orchards and b for all other crops if irrigated. Machine tillability is good. This soil is also good for bananas and papayas.

C57

A total of 8.2 acres in this unit includes two small parcels adjoining the Waikane stream bottomland in the Kahuku-makai section of the project. One parcel of 4.3 acres is on the Kaneohe side of the stream and the other parcel of 3.9 acres is on the Kahuku side in the steep, rocky border section. This soil is similar to C56 except that it has a steeper slope and is more rocky and eroded. Machine tillability is indicated to be moderately good. LSB provides an overall rating of B, irrigated or non-irrigated for this unit. LSB selected crop productivity ratings are b for orchards and grazing, c for pineapples and d for all other crops if non-irrigated. If irrigated, the ratings are a for grazing, b for orchards, c for pineapples, vegetables and sugarcane and d for forage. A study of the contour map and on-site observation indicate an overall rating of C for the 4.3 acre parcel and E for the 3.9 acre parcel. The 4.3 acre parcel could be utilized for bananas, truck crops, tree fruits or grazing if irrigated. The 3.9-acre parcel is not recommended for any type agriculture and should be in conservation to prevent erosion.

C126

This unit of 27.8 acres consists of three narrow makai-mauka strips of 15.9, 10.1 and 1.8 acres extending to the mauka border of the property. These areas are classified as Waikane Silty Clay WpB by SCS. LSB provides an overall rating of C for these parcels, irrigated or non-irrigated. Selected crop productivity ratings are d for pineapple and c for all other crops, irrigated or non-irrigated. SCS gives these soils a higher capability rating of IIe. The severity of the observed erosion problem indicates that the lower LSB rating better reflects the current conditions of the parcels. These areas can be used for truck crops, bananas, papayas, and tree fruits, if irrigated and under strict erosion control. They can also be used for grazing under good management to prevent over-grazing and erosion.

D55

This unit totals 13.0 acres and consists of 2 parcels; one of 10.5 acres in the Kaneohe-makai corner of the property, where SCS classifies part of the area as Pearl Harbor Clay and part as Marsh and the other of 2.5 acres Kahuku of Waikane road in the Marsh area. LSB provides an overall rating of D for these parcels, irrigated or non-irrigated. Selected crop productivity ratings are c for vegetables and sugarcane, d for forage, grazing and orchards and e for pineapple. Since most of this soil type is in Marshlands, its use for crop production or grazing is not recommended.

D58

This area consists of a steep, rocky knoll surrounded by gently sloping C56 soils in the central-Kaneohe section of the property. The overall rating is D, irrigated or non-irrigated. Selected crop productivity ratings are b for grazing, c for orchards, d for pineapples and sugarcane, and e for vegetables and forage, if non-irrigated and a for grazing, c for orchards, d for pineapples and sugarcane, and e for vegetables and forage, if irrigated. This area is considered good for grazing under proper grazing management and strict erosion control. It is not recommended for cultivated crop production.

D127

This 9.5-acre unit contains two parcels of steeply sloping hillsides, consisting of 2.6 acres in the Kaneohe-mauka section and 6.9 acres near the Kahuku-mauka corner of the property. The overall LSB rating is D, irrigated or non-irrigated. Selected crop productivity ratings are c for sugarcane, grazing and orchards, d for vegetables and forage, and e for pineapple, irrigated or non-irrigated. These steep areas are submarginal for most crops and have the further disadvantage of constituting part of steep rocky slopes separating the high plateaus from the bottomlands. These three parcels are not recommended for crop production or grazing.

D128

This small 3.5-acre parcel consists of steep rocky slopes extending from high ridges to bottomlands in the Kaneohe-mauka section of the project. The slopes are somewhat steeper than those of D127. The overall rating is D, irrigated or non-irrigated. Selected crop productivity ratings are c for grazing, d for orchards and sugarcane and e for all other crops. Considering the steep slopes and the extreme potential for erosion, this parcel is not recommended for crop production or grazing.

E78

This unit consists of 8.9 acres of Marshlands near the Kam Highway border of the property. It consists of a 5.6-acre parcel on the Kaneohe side and 3.3-acre parcel on the Kahuku side of Waikane road. The overall rating is E and all selected crop productivity ratings are e, irrigated or non-irrigated. The land is not usable for crop production or grazing.

E108

This unit encompasses 151.0 acres, consisting of 5 parcels in the mauka section of the project. The parcels consist of deep gulches separating plateaus or steep hillsides separating plateaus and bottomlands. A large parcel of 90.6 acres dominates the center of the project and extends to the mauka border. Three other parcels of 30.2, 15.3 and 14.0 acres extend to the mauka boundary. A small parcel of 0.9 acres is located on the Kaneohe boundary about midway between the makai and mauka border. The overall rating is E, irrigated or non-irrigated, and selected crop productivity ratings are d for grazing and orchards and e for all other crops, irrigated or non-irrigated. It is essential that this unit be kept in woodland for erosion control. No agriculture is feasible.

E109

This large 143.7 acre parcel is located along the Kahuku boundary from the makai border most of the way to the mauka border. It consists of steep rocky slopes extending from the lowland areas along Waikane stream to the 800 foot elevation at the Kahuku boundary. The overall rating is E, irrigated or non-irrigated, and selected ratings are e for all crops. The area is badly eroded and should be kept in woodland where possible. This unit is not adaptable to any type of agricultural production.

SUMMARY - SOILS AND TOPOGRAPHY

Crop capability classifications for project lands are summarized in Table 1 for SCS Classifications and in Table 2 for LSB Classifications.

Only 147.2 acres of land or 29 percent of the 505.0 acres in the project are classified in capability classification II, which has only minimal limitations for crop production or grazing, irrigated or non-irrigated. None of the land area is in Class I. There are 11.4 acres or 2.2 percent of the land area in Class III, which is marginal for crop production, and 346.4 acres or 69 percent of the area in classes IV to VIII, which are ecologically infeasible for crop production or grazing. Irrigation is essential for crop production.

LSB classifications are more restrictive than SCS classifications in the project area. Without irrigation, none of the project area is Classified as A and B, comparable to SCS I and II, but 164.6 areas are classified as C or marginal (comparable to SCS III). Thus most of the land classified as good (II) by SCS is classified as marginal (C) by LSB. The acreage classified as D and E (infeasible for agriculture) is almost identical to that of SCS classifications VI to VIII, 340.4 acres as compared to 346.4 acres, non-irrigated. On-site inspection supports the more restrictive LSB classifications for the better soil types.

A major deterrent to commercial agricultural production in the project area is that the good and marginal soil types (SCS II and III; LSB B and C) are scattered throughout the project as small isolated plateaus surrounded by deep, rocky gulches or bottomlands surrounded by steep, rocky hillsides. The separation of usable parcels by rocky cliffs would interfere with or prevent economies of scale. Plantation crops, such as pineapple and sugarcane, are not viable candidates for the project area. The inability to increase efficiency through economies of scale and the higher cost of transporting produce and equipment in the field would also impose limitations on the economics of banana, papaya, truck crop and tree fruit production. On-site inspection indicates that previous cultivation or grazing under less than optimal production practices have resulted in loss of topsoil and subsoil through severe erosion, even on the better lands. This problem is particularly bad along unpaved roadways. Areas that were formerly adaptable to

Table 1. Acreage of Each Land type, Waikane Golf Course, SCS Classifications

Soil type	Acreage	capability classification Nonirrigated	Irrigated
HnA	75.1	IIw	IIw
HnB	13.8	IIw	IIw
M2	8.9	VIIIw	IIIw
Pn	3.6	IVw	IVw
rRK	38.1	VIIIs	VIIIs
WpB	58.3	IIe	IIe
WpC	11.4	IIIe	IIIe
WpE	85.1	VIe	VIe
WpF	25.0	VIIe	VIIe
WpF2	185.7	VIIe	VIIe
Total	505.0	505.0	505.0
Class I & II		147.2	147.2
Class III		11.4	20.3
Class IV-VIII		346.4	337.5

Table 2. Acreage of Each Land type, Waikane Golf Course, LSB Classifications

Soil type	Acreage	Nonirrigated	Irrigated
C14	89.9	C	C
C56	38.7	C	B
C57	8.2	C	C
C126	27.8	C	C
D55	13.0	D	D
D58	10.8	D	D
D127	9.5	D	D
D128	3.5	D	D
E78	8.9	E	E
E108	151.0	E	E
E109	143.7	E	E
Total	505.0		
Class A & B		0.0	38.7
Class C		164.6	125.9
Class D & E		340.4	340.4

commercial crop production are no longer feasible for that purpose and conservation measures, such as well managed grass cover and woodlands are essential to the prevention of further erosion. Turf and woodlands of well managed golf courses would serve this purpose.

CLIMATE

Temperature

The nearest weather station for temperature recordings at an elevation approximating that of the plateau lands in the Waikane Golf Course is the Kaneohe Mauka Weather Station at an elevation of 190 feet. Recordings in degrees Fahrenheit at the station for a 29-year period are presented in Table 3. The mean daily annual average is 74.1°, ranging from 70.9° in February to 77.1° in August. The mean daily maximum is 79.9° and the mean daily minimum is 68.2°. The highest and lowest temperatures recorded are 93.0° and 54.0°, respectively. Seasonal variation is minimal, ranging from a mean daily maximum of 82.0° in September to a mean daily minimum of 64.8° in February. Temperatures in the project area are near optimal for warm climate truck corps, bananas, papayas, tropical tree fruits and pasture lands.

Light Intensity and Humidity

Light intensity is somewhat restricted because of heavy cloud cover, particularly during the Winter months. This would have a minor retarding effect on the growth of bananas, papayas and truck crops.

Humidity is fairly high in the valley, which tends to promote fungus disease of fruits, melons and vegetables.

Wind

Bananas, papayas, tree fruits and truck crops are subject to minor damage from prevailing trade winds. However, almost complete devastation of banana and papaya crops can be expected from Kona storms with winds in excess of 50 miles per hour on the average of once in three years. Kona storms also severely damage staked vegetables, but have less serious effects on root crops. The Kona winds are also highly destructive to shade houses, used for floriculture

Table 3. Temperatures Recorded at the Kaneohe Mauka Station by the National Oceanic and Atmospheric Administration for a 29-Year Period

Month	Mean Daily	Mean Daily Maximum	Mean Daily Minimum	Highest	Lowest
	degrees fahrenheit				
January	71.1	77.6	65.1	88	57
February	70.9	77.5	64.8	90	54
March	71.4	77.3	65.1	90	54
April	72.5	78.1	66.9	87	56
May	74.2	79.7	68.3	92	56
June	75.8	81.5	70.1	89	61
July	76.6	82.1	70.9	89	61
August	77.1	82.3	71.5	90	63
September	76.9	82.6	70.6	92	60
October	76.2	81.9	70.3	93	61
November	74.1	80.0	68.4	91	59
December	72.4	77.9	66.3	90	56
Annual	74.1	79.9	68.2	93	54

and nursery crops. Windbreaks are essential for partial wind protection. Bananas require wind support systems.

Rainfall

The nearest rainfall gage at an elevation approximating the mean elevation of the better soil types in the project area is SKN 885.10 Kaaawa Mauka at an elevation of 160 feet, for which complete rainfall data were recorded from 1948 to 1960.

Median annual rainfall for this station during the period recorded was 81.9 inches (Table 4). Seventy five percent of the annual recordings did not exceed 92.3 inches and only 25 percent of the recordings were less than 66.9 inches. The annual maximum was 98.3 inches and the annual minimum was 44.1 inches.

Whereas annual median rainfall is sufficient for most crops, this does not indicate rainfall adequacy, since seasonal distribution is uneven and the rainfall for any given month varies appreciably by year.

IRRIGATION REQUIREMENTS

Truck crops require a net delivery of 4,073 gallons per acre per day (4.5 acre-inches per month) and a gross delivery of approximately 5.0 acre-inches per month, depending on the type of irrigation system and microclimatic factors. Bananas have a higher requirement of a net delivery of 5,431 gallons per acre per day (6.0 acre inches per month) and a gross delivery of 6.7 acre inches per month. Based on the difference between monthly rainfall requirements and supplemental median monthly rainfall, irrigation totalling 6.5 acre-inches would be required during May, June, July, September and October for truck crops. But 25 percent of the time, truck crops would require a total of 20.2 or more acre-inches of irrigation water to supplement the inadequate rainfall for all months except February and December. For years when rainfall approximates the minimum for each month, a total of 37.2 acre-inches of irrigation water would be required to supplement inadequate rainfall for all 12 months. All 12 months would not, of course, be expected to be droughty during the same year, but over time, the foregoing analysis would be valid.

Table 4. Rainfall recorded at SKN 885.10, Kaawa Mauka, 1948 to 1960.

Month	Median	Mean	Maximum	Minimum	75% Max. a/	25% Min. b/
	-------	-------	-------	inches	-------	-------
January	5.5	9.2	20.4	2.3	17.0	4.2
February	7.4	8.4	24.7	3.9	8.8	5.1
March	8.1	10.2	25.5	3.8	14.7	4.6
April	5.3	5.9	18.3	0.5	7.9	2.4
May	3.3	4.1	12.6	1.1	4.4	2.3
June	3.1	3.0	6.5	1.0	4.0	1.7
July	3.6	4.4	8.2	0.2	7.6	2.4
August	5.8	5.9	8.3	2.7	7.7	4.1
September	3.8	3.8	6.4	0.7	5.6	1.8
October	4.7	7.1	14.4	1.8	11.8	3.2
November	6.7	8.2	21.6	2.9	12.5	3.1
December	8.6	8.8	15.1	1.9	13.5	5.3
Annual	81.9	79.4	98.3	44.1	92.3	66.9

a/ 75% of the recordings did not exceed amounts indicated in this column.

b/ 25% of the recordings were below the amounts indicated in this column.

Applying the same type of analysis, bananas would require annual supplemental irrigation of 15.0 acre-inches based on median requirements, 44.2 acre-inches or more 25 per cent of the time and 67.6 acre-inches based on minimum monthly rainfall. Since some months can be expected to have essentially no rainfall during drought periods, the irrigation system would require a per acre per day delivery of 4,521 gallons for truck crops and 6,028 gallons for bananas. The maximum area with sufficiently good soil types to justify irrigation consists of 167.5 acres, including 147.2 acres with an SCS capability classification of II, if irrigated, and 20.3 acres with an SCS capability classification of III, if irrigated. Assuming that roads, other supporting infrastructures and badly eroded areas constitute 20 percent of this land area, irrigation water delivery for 134 acres would be required. Assuming that two-thirds of the area would be planted to truck crops and one-third to bananas, the required delivery during droughty periods of complete dependence on irrigation would be 5,023 gallons per acre per day (4,521 x 2/3 plus 6,028 x 1/3). The system, therefore, would need to be capable of providing 673,082 gallons of water per day for the 134 acres.

The project currently has no developed water source or infrastructure for an irrigation system. Of the 134 acres considered for possible crop production, 52 acres are located in bottomlands along Waikane stream. These lands could possibly obtain water from Waikane stream, primarily by pumping, with possible adverse effects on wildlife downstream. The remaining 82 acres that are adaptable to crop production with respect to ecology consist primarily of high plateaus in the mauka section of the project, with some bottomlands near the Kaneohe boundary without access to irrigation water.

Providing that water can be pumped from Waikane stream for the 52 acres of bottomlands, the water cost for this area is indicated to be affordable for bananas and truck crops. An updating of other studies where estimated costs were determined for pumping water from windward streams, indicates that water could be made available to producing areas, including infrastructure and pumping costs, at 35 cents per 1,000 gallons. In addition, the on-farm irrigation system would cost $170 per acre per year, including depreciation on a 10-year schedule and maintenance. Total annual irrigation costs per acre for bananas would thus amount to $313 per acre per year (407,310 gallons x $.35 plus $170).

Providing irrigation water for the 82 acres located on high plateaus or on bottomlands not accessible to Waikane stream would be much more difficult than for the 52 acres along Waikane stream. One possible source would be from the municipal water transmission line at Kamahameha highway, which would require a main delivery system to the various isolated parcels, through gulches and steep hillsides. Irrigation water from this source would cost an estimated $760 per acre annually, including $285 per acre for water at BWS rates (13,000 gallons at $.98 per 1,000 plus 407,310 gallons at $.69 per 1,000 gallons), $305 per acre amortized on an annual basis for construction of the main delivery system to the isolated mauka parcels from the Kam highway hookup ($500,000 ÷ 20 years ÷ 82 acres) plus $170 per acre for the on-farm irrigation system ($1,500 per acre ÷ 10 years plus $20 annual operating cost). Development of a new private system from wells in the mauka section of the property would cost an estimated $710 per acre annually, about the same as for municipal water. Annual costs of components of the cost would be $549 per acre for the water system (wells, $200,000; delivery line to tank or reservoir, $100,000; tank or reservoir, $200,000; transmission lines to parcels to be farmed, $400,000, for a total cost of $900,000 ÷ 20 years ÷ 82 acres) and an annual amortized cost of $170 per acre for the on-farm irrigation system plus maintenance. The projected water cost for the 82 acres of mauka Class II lands is excessively high for either of the indicated sources because these lands consist of small parcels, surrounded by gulches on steep rocky hillsides. The projected high irrigation water coast is a major deterrent to the utilization of these lands for crop production and would place them at a competitive disadvantage in relation to lands with lower irrigation costs for crops ecologically adaptable to the project area.

Taro would require direct water diversion from Waikane stream to assure a flow of 77,000 gallons per acre per day, which is required to keep the water temperature below 78° F for fungal disease (pithium) control. Not more than an estimated 6,000 gallons per acre per day would actually be required for plant growth and evaporation loss and the rest could be reused for other taro patches or other purposes, providing that this does not result in the spread of fungal diseases. It is questionable, however, that disease could be controlled sufficiently to permit further use of the water.

Prawns require a continued flow of 21,600 gallons of fresh water per acre per day. This requirement would make prawn production uneconomic if it were necessary to pump water from Waikane stream and divert it through transmission lines to production areas. Thus the only probable means of providing water for prawn production would be through direct stream diversion, which would require strict flow control to provide the required amount of fresh water on a continuing basis throughout the year. Since prawn production is not a highly intensive crop with respect to net returns, it is likely that a higher use value for the water might be obtained by allocating it to enterprises other than prawn production.

Floriculture and nursery products under shade house production require 3,000 gallons of fresh water per acre per day throughout the year. For this purpose, water would need to be piped from the upper unpolluted area of Waikane stream or from the Kam Highway outlet of the municipal system. The high cost of irrigation water would not limit this enterprise with respect to absolute cost but in relation to competing areas with lower costs.

CROP SELECTION BASED ON ECOLOGY

Bananas are ecologically adaptable to all areas of the project where better soil types prevail, but are subject to limitations. Waikane silty clay soils located on the plateaus of the middle and mauka sections of the valley are excellent for banana production on capability Class II soils and fair for banana production on capability Class III soils, if irrigated. Mean monthly temperatures are near optimal. Erosion control is generally not serious because the fibrous mats protect the soil and plowing and replanting is required only once every seven years. Humidity is sufficiently high to promote black leaf streak, but this disease can be controlled with fungicide sprays. Bananas are subject to only moderate damage from prevailing tradewinds in the mauka sections of the Valley, but Kona storms can be devastating and a complete crop loss on the average of one year out of three can be expected. Staking of the banana plants is essential. Soil treatment for nemotodes is essential prior to replanting of bananas. Hanalei Silty Clay soils in the bottomlands, primarily along Waikane stream, are good for banana production, if properly drained. Black leaf streak is a somewhat more serious problem and nemotodes are somewhat less damaging in the bottomland areas than on the plateaus.

Vine type vegetables, such as snap beans and cucumbers, are fairly well adapted to the Class II soils on the plateaus. Hybrid vine type tomatoes with resistance to some viruses are marginally well adapted with control of leaf miners and fruit flies. Sweet potatoes do well on the Waikane clay loam plateaus with adequate irrigation and insect control. Sweet potatoes are not recommended for the bottomlands because of drainage problems. Green peppers and eggplant are well adaptable to the well drained Waikane Silty Clay Loam soils but are only marginally adapted to the Hanalei Silty Clay Loam bottomlands because of excessive water in the soil. Miscellaneous warm climate vegetables that would be grown on the better project lands would require only minimal land areas because of the limited acreage required to supply the market. Many vegetables grown in Hawaii, such as celery, cabbage, onions and head lettuce, require a more temperate climate than in the project area, such as Kula on Maui and Waimea on Hawaii.

Papayas require fairly deep, well drained soils of non-plastic texture. Thus the better Waikane Silty Clay soils on the plateaus provide a good medium. Heavy winter rains in these areas would cause a moderate Phytophtera root rot problem. Trade wind storms would cause some damage and severe Kona storms would severely damage the plants. Phytophtera poses a very serious problem in the poorly drained bottomlands and papayas are not recommended for these areas.

Wetland taro is ecologically adaptable to the Hanalei silty clay soils in the low lying areas along Waikane stream and other drainage channels. The crop is only marginally adaptable to the Pearl Harbor clay soils because of low fertility and poor workability. A serious fungal disease (pithium) is prevalent in the area and an excessive water requirement of 77,000 gallons per acre per day is essential to keep the water temperature below 78° F for control of this disease. This disease can readily be transmitted from one taro patch to another through diversion of contaiminated water.

Some areas of heavy clay soils in the makai area of the project provide a good medium for the construction of prawn ponds and could be used for prawn production, providing that the daily requirement of 21,600 gallons of fresh water can be diverted from stream flow. Protection from polluted flood waters may pose a problem. Temperatures are satisfactory, but not optimal for prawn production in this area. Any source of water other than diverted stream flow would be too costly for prawn production because of the high daily water requirement and low level of net returns for this enterprise.

Flowers and nursery crops are adaptable in varying degrees to certain areas in the project. Production of potted plants in shade houses should be limited to level or gently sloping lands in the makai section of the project, where Kona storms are less severe. Drainage would be required to prevent flooding of shade house floors to avoid adverse working conditions. Shade houses are not recommended for the steeper sloping plateau lands in the mauka section of the project because of excessive winter rains and severe damage from Kona storms. Stock plants could be grown in the plateau areas if adequately irrigated and in the bottomlands if adequately drained.

Cattle grazing is marginally adaptable to the well drained plateau lands, but carrying capacity is limited without irrigation and the cost of irrigation water would be prohibitive for this purpose. Ponding would pose a problem for cattle grazing on the bottomlands and drainage would not be affordable because of minimal net return per acre. Grazing offers the least productive use value of the land and would be viable only on a subsistence basis. The Land Study Bureau estimated mean live beef cattle gains on Class b (SCS Class II) lands with adequate rainfall at 80 pounds per acre per year at a 1986 live weight farm price of 31.1 cents per pound. This would provide a gross annual return of only $25 per acre. This would be inadequate to cover management costs and provide no margin for base rent and pasture improvement. Unsupervised grazing would lead to further erosion of the already badly eroded lands.

The project area is not a good location for hog or dairy production because of heavy winter rains and ponding of the bottomlands. These intensive enterprises require only limited land areas and are better adapted to drier, well drained locations.

The poor configuration of project lands poses a major obstacle to commercial use for crop production. Most of the parcels ecologically adaptable to crop production are scattered throughout the project and surrounded by either deep gulches or steep, badly eroded hillsides. This configuration requires costly road and irrigation delivery systems and is a major obstacle to economies of scale.

SALES POTENTIALS

Sales potentials in this analysis are relevant only for those crops which are ecologically adaptable to SCS class II (LSB class B) soils and to some class III soils that are interspersed with class II soils. There are no class I (LSB class A) soils in the project. An estimated 134 acres of the 505.0 acres in the project area could be utilized for cultivated crop production, considering ecological restraints, only, and assuming that good quality irrigation water could be made available at affordable cost, which is not the case.

Crops considered best adapted to the area from a production standpoint are some varieties of truck crops, bananas, papayas and tree fruits. Sugarcane and pineapple require large acreages to permit economies of scale and are not feasible for the many small, isolated parcels of plateaus and bottomlands that contain the better soils in the project. Cattle grazing constitutes the lowest use value for project lands and expected returns would be inadequate to meet costs of pasture improvement, including irrigation and fertilization. Thus grazing could only be considered as a subsistence operation. Necessary erosion control under grazing would be difficult or impossible, since the small parcels of good land are surrounded by steep, badly eroded gulches or hillsides.

The market potential for Hawaii produced truck crops, bananas and tree fruits is essentially the acreage required to displace imports. Sales potentials for Waikane for the above crops plus papayas depend on the ability to compete in the marketplace against other Hawaii producing areas or in shipments from the U.S. mainland. For flowers and nursery products, the Waikane sales potential depends upon the ability to compete with other growers both for the local market and for export.

Bananas are grown commercially on Waikane and Hanalei Silty Clay soils in Windward valleys with conditions similar to those of Waikane and could be expected to do equally well in Waikane under adequate irrigation and good management.

Truck crops which are considered best adaptable to the project area with respect to ecology are snap beans, cucumbers, eggplant, green peppers and sweet potatoes. Other truck crops, including watermelons, are better adapted ecologically to other areas in the state. Onions, celery and head cabbage, for example, do best in more temperate areas, such as Kula and Waimea. Tomatoes are primarily grown in greenhouses in Hawaii and require a continuing source of high quality water, readily accessible locations and freedom from devastating winds. Irish potatoes are produced primarily in temperate climates. Papayas have recently been grown in the project area and some papaya production could be expected in spite of some adverse ecological conditions.

The 1987 Hawaii market supply and acreage required to displace imports of vegetables, melons and fruit crops which might be grown in the project area are shown in Table 5. The total of 747 acres required to displace imports plus an estimated 20 acres of papayas considerably exceeds the 134 acres ecologically adaptable to the production of these crops in the project area. The next step is to determine the comparative advantage of Waikane to supply the indicated market requirements. Trends in production, the competitive position of each county in supplying the market for each commodity and relevance to Waikane are discussed in the following analysis.

The area devoted to snap bean production on Oahu declined from 75 acres in 1978 to 40 acres in 1987, with a proportionate decrease in marketings. Neighbor Island production also decreased and imports increased during the period. These trends indicate that it is highly unlikely that the Waikane Project could provide the additional output required to displace inshipments.

Cucumber production in Hawaii has shown a slight decline during the past 10 years. Acreage declined from 260 acres for the State and 100 acres for Oahu in 1978 to 200 acres for the State and 55 acres for Oahu in 1987. Hawaii production declined from 4,300,000 pounds in 1978 to 3,960,000 pounds in 1987. During the same period, inshipments increased from 1,241,000 pounds to 1,732,000 pounds, indicating no opportunity under existing technology and costs to displace imports.

Hawaii is essentially self-sufficient in eggplant production. Thus this product is not a candidate for acreage expansion.

Green pepper acreage in Hawaii expanded appreciably during the past 10 years from 60 acres in 1978 to 200 acres in 1987. But the major expansion in production has been on the

Table 5. Hawaii Market Supply and Acreage Required to Displace Imports of Selected Fruits and Vegetables, 1987

Crop	Market Supply Hawaii (1,000 pounds)	Market Supply Imports (1,000 pounds)	Yield Per Acre (pounds)	Acreage Required To Displace Imports (acres)
Beans, snap	890	416	12,000	35
Corn, sweet	1,450	865	8,000	108
Cucumbers	3,960	1,732	20,000	87
Eggplant	1,290	308	30,000	10
Peppers, Green	2,300	1,595	20,000	80
Sweet potatoes	1,600	799	30,000	27
Taro	5,700	917	20,000	46
Bananas	11,400	10,607	30,000	354
TOTAL				747

outside islands, primarily Maui, Molokai and Kauai, where labor and land costs are lower than on Oahu. Oahu had only 19 acres in 1978 and 15 acres in 1986. Oahu and Kauai data were combined in 1987 with a total of only 12 acres. Hawaii production increased from 1,595,000 pounds in 1978 to 2,050,000 pounds in 1987. During the same period inshipments increased from 1,595,000 pounds in 1978 to 2,300,000 pounds in 1982 but decreased to 1,595,000 pounds in 1987. It appears likely that Hawaii producers will plant an additional 80 or more acres, depending upon efficiency of production, to displace green pepper imports. But all expansion can be expected on the Neighbor islands.

Hawaii's sweet potato acreage increased from 130 acres in 1978 to 180 acres in 1987. But during the same period, Oahu acreage decreased from 60 acres to 10 acres. Hawaii production increased from 1,520,000 pounds in 1978 to 1,600,000 pounds in 1987. Imports increased from 533,000 pounds in 1978 to 799,000 pounds in 1987. The data indicate that Hawaii production is expanding only in response to increased local demand. Imports consist of different varieties and qualities of sweet potatoes and substantial additional displacements are not likely. Contrary to the State trend, Oahu production might be expected to decline further.

Harvested banana acreage in Hawaii increased from 580 acres in 1978 to 1,070 acres in 1987. Most of the increase was in the Puna district on Hawaii. Hawaii county harvested acreage increased from 110 acres in 1978 to 380 acres in 1987. During the same period, Oahu harvested acreage increased from 420 acres to 475 acres. Most Hawaii county acreage consists of high yielding Williams bananas and the majority of Oahu production consists of low yielding, but higher priced, Brazilian (apple) bananas. Hawaii banana production increased from 5,700,000 pounds in 1978 to 11,400,000 pounds in 1987. During the same period, inshipments increased from 7,792,000 pounds to 10,607,000 pounds. Thus, whereas Hawaii production has been increasing, local producers have not been successful in displacing imports, which would require a very substantial additional 354 acres at 30,000 pounds per acre. There is good indication that Hawaii banana production will continue to expand, but this expansion is likely to take place in Hawaii and Kauai Counties and not on Oahu. Furthermore, the Waikane Project is at a disadvantage in relation to other existing and potential banana producing areas on Oahu with respect to soil type, accessibility and cost and availability of irrigation water.

Papaya is a major export crop, but expected expansion of the industry has not been realized because of problems in developing an effective low cost fruit fly treatment, the high cost of air freight and failure to develop a satisfactory method to extend shelf life for surface shipment. Harvested acreage increased only minimally from 2,190 acres in 1978 to 2,350 acres in 1987. Utilized production increased from 64,000,000 pounds in 1978 to 67,000,000 pounds in 1987. Most of the production is in Hawaii county, where farmers depend primarily on natural rainfall, land is available to permit replanting for root rot control and labor rates are lower than on Oahu. Oahu acreage is very small and growth has been insignificant. There were 70 acres in 1978 and 61 acres in 1987. It is quite evident that the Waikane project would not be an important contender for the papaya market and the total area which might be converted to papayas in Waikane would not be expected to exceed 20 acres, considering the comparative disadvantage in competing with other existing and potential production areas.

Hawaii production of taro has been losing its competitive position in the marketplace during the past 10 years. Hawaii's share of the market supply decreased from 94 percent of 8,213,000 pounds in 1978 to only 86 percent of 6,617,000 pounds in 1987. A number of factors account for the decline in Hawaii's market share. Taro is highly labor intensive and the product can be produced at much lower cost in areas of low labor cost. Another important deterrent to Hawaii production of taro is the low net return per acre in relation to alternative crops. The need for disease control and decreasing availability of low cost fresh water also discourage taro production. Oahu is at a particular disadvantage because of low yields and, in most areas, high land and water costs. Fifty percent of the 400 acres in taro production in Hawaii in 1987 was on Kauai, mostly in Hanalei valley, where yields amounted to 20,850 pounds per acre as compared to 9,444 pounds per acre for Oahu/Maui/Molokai. This low yield results in lower gross and net returns per acre on Oahu than on Kauai. Whereas the outlook for commercial taro production on Oahu is not promising, the Hanalei and Pearl Harbor soils in Waikane Wetlands could be used for taro production as a part time family enterprise, with no out-of-pocket costs for labor, assuming that stream water can be diverted for that purpose. The extent to which farmers are interested in producing taro under these conditions has not been determined.

The Hawaii floriculture and nursery products industry has undergone continuing expansion for several years. Gross values of sales increased from $17,458,000 in 1978 to $55,767,000 in 1987. Oahu sales during this period increased even more rapidly, from $6,085,000 in 1978 to $22,967,000 in 1987. But in spite of the encouraging historical trends, competition from other areas with lower labor cost is an increasing threat and caution is needed in projecting sales potentials for Hawaii. Whereas the market appears to justify expansion of floriculture and nursery products on Oahu, this does not necessarily indicate that the project area would be the best place for expansion. The isolated plateau areas at the higher elevation has serious wind problems and the wetland areas would require filling for greenhouse and shadehouse structures. Daily fresh water requirements of 3,000 gallons per acre per day throughout the year may adversely affect the comparative advantage of the project area because of the high cost of water development as indicated in the irrigation section of this report.

This analysis clearly indicates that market limitations and the inability to compete in the market place constitute a major deterrent to the utilization of Waikane Golf Course lands for commercial agricultural production.

LAND REQUIREMENTS IN RELATION TO AVAILABILITY OF AGRICULTURAL LAND ON OAHU

The acreage in cultivated crops on Oahu has steadily declined during the past ten years from 49,100 acres in 1978 to 47,100 acres in 1981 and 41,100 acres in 1987. The very marked decline of 6,000 acres in crop production between 1981 and 1987 exceeds that which has been converted to use other than agriculture, resulting in a stockpile of unused agricultural land of good quality. Land zoned Urban by the State Land Use Commission increased by 3,469 acres from 1981 to 1987. Land zoned Agricultural decreased by 2,052 acres during the same period, most of which was rezoned to Urban. Most of the decline has been in sugar and pineapple acreage. Some of this land offers a potential for expansion in diversified crop production with respect to ecology, but high land prices, market limitations and difficulties in obtaining agricultural subdivision permits from the City and County of Honolulu have prevented its use for agriculture.

The LSB classified 53,039 acres of land on Oahu outside urban areas as good agricultural land in 1972, of which

20,583 acres were given crop productivity ratings of A and 32,456 acres were rated as B. In addition, 17,837 acres were classified as C, which is marginal for cultivated crop production. This compares to a total of only 41,100 acres in cultivated crop production on Oahu in 1987, of which an undetermined number of acres in production had productivity ratings lower than B. These data indicate that the total acreage of good agricultural land (A and B) exceeds the total acreage in cultivated crop production on all classes of lands by 11,939 acres. With Class C land included, the availability of cultivated land based on the 1972 data exceeds the 1987 acreage in cultivated crop production by 29,776 acres. However, some of excess good agricultural land has been converted to other uses and is no longer available for agriculture.

Land zoned Urban by the State Land Use Commission increased by 10,620 acres from 1972 to 1987 (79,700 acres to 90,320 acres). During the same period land zoned Agricultural decreased by 7,835 acres (148,900 acres to 141,065 acres). It is conservatively estimated, based on a study of soils maps of urban areas approved for development during that period, that not more than half of the area zoned from agricultural to urban consisted of A and B soils. On this basis, A and B lands available for agriculture would have decreased from 53,039 acres to 49,121 acres from 1972 to 1987. This would decrease the amount by which A and B lands outside urban areas exceed acreage in cultivated crops in 1987 from 12,339 acres to 8,421 acres. On the same basis, the excess of A, B and C lands outside of urban areas would have decreased to 25,858 acres in 1987.

The SCS classified 67,342 acres as good agricultural land in 1972, with 23,551 acres rated as I and 43,791 acres rated as II, with irrigation. Since an undetermined amount of this is in urban areas, the relationship of this acreage to acreage in cultivated crops cannot be determined without a detailed analysis of land use by land capability type, which is beyond the scope of this study. However, since SCS and LSB land productivity ratings are fairly comparable, a similar excess of 8,421 acres of good agricultural land not in urban use over all land in cultivated corp production on Oahu is indicated.

The State Land Use Commission classified 141,065 acres of land on Oahu as Agricultural in 1987. These lands are, with some exceptions, restricted to agricultural use and are separate from lands zoned as Urban or Conservation. The land area zoned as Agricultural is far in excess of the 41,100 acres in cultivated crop production in 1987, the 53,039 acres classified as A and B by LSB (adjusted to 49,121 acres for 1987) and the 67,342 acres classified as I and II by SCS in 1972.

The large acreage zoned as Agricultural is not only far in excess of the acreage of good agricultural land outside of urban areas, but increasingly exceeds the land needed, for crop production on Oahu as the area in crop production declines. Another important consideration is that unused good agricultural land is available at lower cost on the outside islands. Because of lower land cost and lower or no irrigation water cost, production centers for crops such as bananas, guava and truck crops are moving to the outside islands. Oahu sugar plantations continue to divert less productive sugar lands out of sugar. Substantial areas of former pineapple fields lie fallow. Thus the supply of unused prime agricultural land on Oahu continues to increase as the agricultural need for it decreases.

NEED FOR AGRICULTURAL LAND IN THE PROJECT AREA

The previous section of the report indicated a substantial excess of prime agricultural land on Oahu over what is required for agricultural production. This excess continues to increase as crop production declines. Much of the land area being withdrawn from agriculture consists of SCS Class I (LSB Class A) soil types.

There are no SCS Class I soils and only 147.2 acres of Class II soils, irrigated or non-irrigated, and 20.3 acres of Class III soils, if irrigated, out of a total of 505.90 acres in the project area. Most of the land, 337.5 acres, consists of soils with capability classification of IV to VIII, which are infeasible for any type of crop production or grazing.

Project lands have the further disadvantage of consisting of many isolated parcels of high plateaus and bottomlands surrounded by steep, severly eroded gulches or hillsides.

Most of the lands in the project area have not been farmed for many years, except for three parcels of lower Waikane Silty Clay Class II plateau lands Kahuku of Waikane road, which were farmed until recently, and a 50-acre parcel of

Hanalei Silty Clay bottomlands near the mauka section of the property along Waikane stream.

The project is unsuitable for commercial agricultural production as one unit because the limited acreage of usable land and the poor configuration of the small parcels that are adaptable to agricultural production. An estimated one-third of the project could be utilized for an agricultural subdivision of small lots which would serve as homesites and provide the opportunity for small scale or subsistence farming. A 58-acre small lot agricultural subdivision was proposed in 1982, but rejected by the City and County of Honolulu. Without such a subdivision, it is highly unlikely that the subject area would be used for agriculture. Utilization of the land for golf courses would result in higher use value, preserve open space and provide badly needed erosion control. The need for erosion control is crucial not only for maintaining the soils, but for preservation of watersheds and flood control.

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APPENDIX S
Agricultural Use of Wetlands

FEASIBILITY OF AGRICULTURAL USE OF WETLANDS IN THE WAIKANE GOLF COURSE PROJECT

Prepared for
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Coordinated by Group 70

November 1988

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SUMMARY AND CONCLUSIONS

This report addresses the feasibility of outleasing Waikane Wetlands for agriculture. The study indicates that 16.7 acres of the 25.8 acres designated as Wetlands in the Waikane Golf Course Project, including 13.0 acres of Hanalei Silty Clay and 3.7 acres of Pearl Harbor Clay, are ecologically adaptable to cultivated crop production. The 9.1 acres of Marshland in the unit are adaptable only to marsh type vegetation and cannot be used for cultivated crop production in their present state. Alteration by filling would not likely be permitted by the controlling Army Corps of Engineers.

Certain vine type vegetables, bananas and taro are identified as fairly well adptable to Hanalei Silty Clay soils and marginally adaptable to Pearl Harbor Clay soils in the wetlands area. Whereas crop production is feasible ecologically, commercial economic feasility under an outleasing program is questionable because of indicated lower yields, high water costs and additional costs of other activities, such as drainage, in relation to competing areas. In addition, the cost of establishing a horizontal property regime (condominium), estimated at $300 to $600 per acre, and the cost of administering outleasing would further erode the competitive position of lessees in the marketplace.

Outleasing of the better wetlands for crop production under good management and in compliance with Army Corps of Engineers regulations would appear to be compatible with the golf course project, particulary since farming activities would, for the most part, border Kam highway. The more critical considerations are costs of administering an outleasing program for only 16.7 acres and reservations concerning the economic viability of potential crop production in the wetlands.

FEASIBILITY OF AGRICULTURAL USE OF WETLANDS IN THE WAIKANE GOLF COURSE PROJECT

by

Frank S. Scott, Jr., Agricultural Economist

INTRODUCTION

This report addresses the feasibility of outleasing Waikane Wetlands for agricultural production based on (1) ecological adaptation, (2) sales potentials, (3) economic viability and (4) financial and regulatory requirements for implementation.

DESCRIPTION OF WAIKANE WETLANDS

Land areas designated as Wetlands in the Waikane Golf Course Master Plan encompass 25.8 acres in the makai section of the project, mauka of Kam highway (Figure 1). The Wetlands are composed of two separate parcels of different soil types. The parcel in the Kaneohe-makai section consists of 10.8 acres, of which 3.7 acres are Pearl Harbor Clay (Ph), 1.7 acres are Hanalei Silty Clay (HnA) and 5.4 acres in the central part of the parcel are Marsh (MZ). A larger parcel of 15.0 acres, located in the Kahuku-makai section, consists of 3.7 acres of MZ bordered by Kam highway and the proposed golf course entry and 11.3 acres of HnA bordering Waikane stream.

CROP PRODUCTION CAPABILITIES

Soil capability classifications for agriculture in this report are based on soil surveys by the USDA Soil Conservation Service (SCS) and the University of Hawaii Land Study Bureau (LSB) plus on-site observations. The Land Evaluation and Site Assessment System (LESA) established at the request of the Hawaii State Legislature in 1983 is not used in this analysis because the final report has not yet been approved by the State Legislature.

SCS soil capability classifications are based on soil profile, topography, water holding capacity, drainage, erosion hazard, pH, workability and depth of root penetration. SCS soil capability classifications range from I to VIII, with I being the best. Class I soils have no more than minimal limitations that restrict crop production and soil classes IV to VIII are unsuitable for crop production, with class VIII having the most severe limitations.

LSB classifies soils by land type in which classifications are provided for an overall crop productivity rating, with and without irrigation, and for selected crop productivity ratings

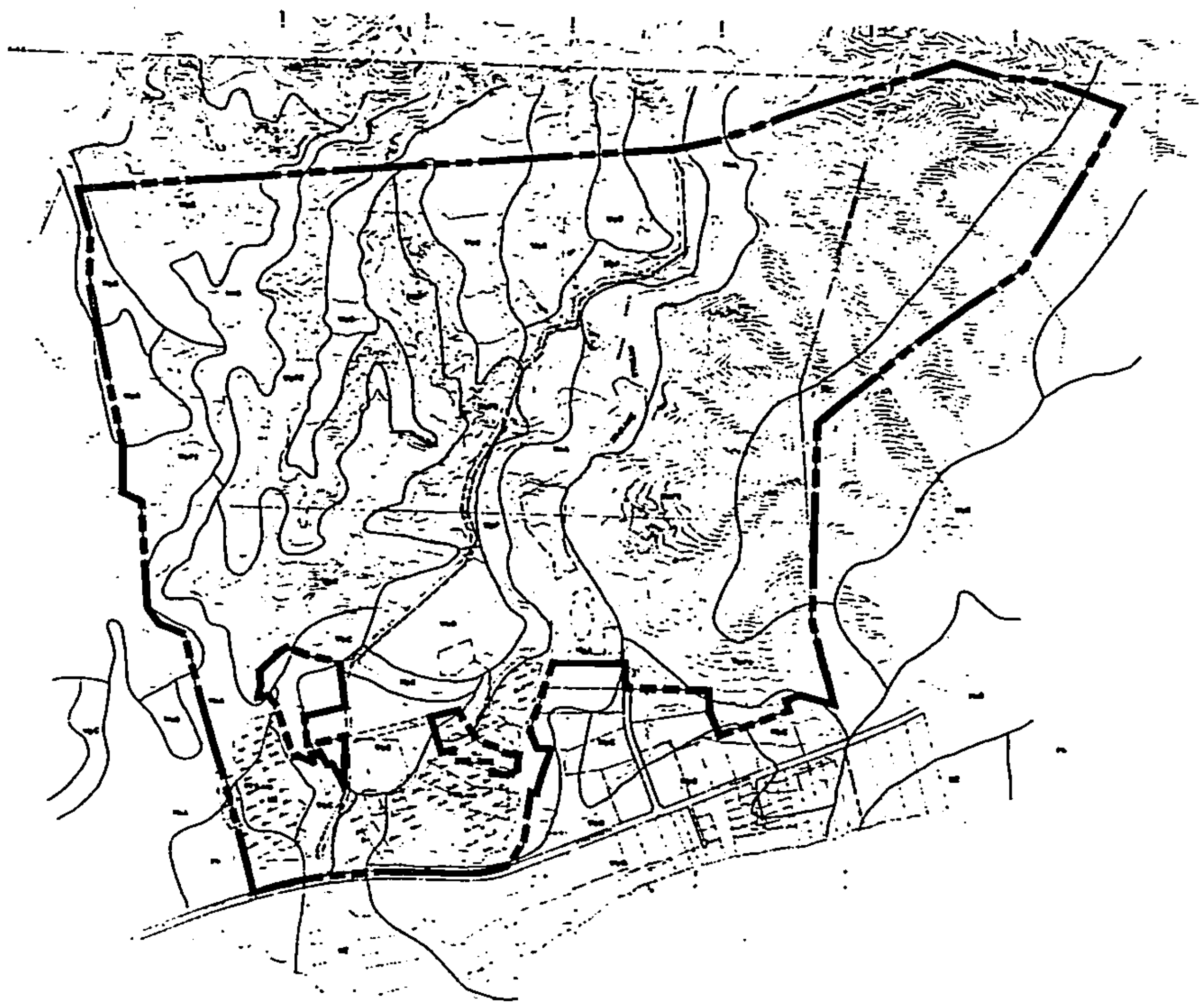

Figure 1. Location of Waikane Golf Course Wetlands and SCS Soil Capability Classifications

SOURCE: ENGINEERING CONCEPTS, INC.

LSB classifies soils by land type in which classifications are provided for an overall crop productivity rating, with and without irrigation, and for selected crop productivity ratings for 7 crops; namely, pineapple, vegetables, sugarcane, forage, grazing, orchards and timber. Overall ratings range from A to E, with A being the best. Selected ratings range from a to e, with a being the best.

Hanalei Silty Clay, 0 to 2 Percent Slopes, HnA (13.0 Acres)

HnA is a subseries of the Hanalei Series, which consists of somewhat poorly drained soils on bottomlands. The soils developed in alluvium derived from basic igneous rock. The typical topsoil is dark gray and very dark gray silty clay with dark brown and reddish mottles, about 13 inches thick, including a 3-inch subsurface layer. The subsoil is mottled dark gray and dark grayish-brown silty clay loam with angular block structure about 13 inches thick. The substratum is stratified alluvium. The topsoil is strongly acid to very strongly acid and the subsoil is neutral. Permeability is moderate, runoff is slow and the erosion hazard is no more than slight, but flooding is a hazard. The available water holding capacity is 2.1 inches per foot of soil. Roots penetrate to the water table. This unit is slightly downgraded to IIw because of drainage and flooding problems. The soil is excellent for taro and good for bananas and truck crops if properly drained and is adaptable to grazing under proper management. The poor drainage and flooding are adverse to papaya and tree fruit production. LSB classifies Hanalei Silty Clay as C14, with an overall rating of C and selected crop productivity ratings of e for pineapple and c for all other crops, irrigated or nonirrigated.

Pearl Harbor Clay, Ph (3.7 Acres)

The Pearl Harbor Series is nearly level and very poorly drained. The topsoil consists of very dark gray mottled clay about 12 inches in depth and the subsoil is very dark grayish-brown mottled clay with an angular or subangular blocky structure about 19 inches thick. The substratum is muck or peat. The pH is 5.5 in the topsoil and slightly alkaline in the subsoil. Permeability is low, runoff is slow and drainage is poor. Water holding capacity is 1.4 inches per foot in both the topsoil and the subsoil. The soil has a high shrink-swell potential and workability is very difficult. The soil is subject to flooding and the water is brackish along Kam Highway at a depth of 20 to 33 inches. This unit is classified as IVw because of the severe water problems which severely limit crop production. Taro, bananas and vine type vegetables are marginally adaptable to this area with proper drainage. The soil is not adaptable to papaya and tree fruit production. LSB classifies this soil as D55, with an overall rating of D and selected crop productivity ratings of c for vegetables and sugarcane, d for forage, grazing and orchards and e for pineapple.

Marshland, MZ (9.1 Acres)

Marshlands are in low lying areas along coastal plains. The soils are periodically flooded, with water covering the surface. The water is fresh or brackish, depending upon the distance from the ocean. The SCS capability classification is VIIIw because of the severe limitations due to excess water. This unit is adaptable only to marsh type vegetation and cannot be used for cultivated crop production. LSB classifies this soil as E78 and gives it the lowest crop capability rating of E.

CLIMATE

Temperature

The nearest weather station for temperature recordings appoximating those of the project area is the Kaneohe Mauka Weather Station. Recordings in degrees fahrenheit for a 29-year period are shown in Table 1. The mean daily annual average is 74.1 degrees, ranging from 79.9 degrees In February to 77.1 degrees in August. The mean daily maximum is 79.9 degrees and the mean daily minmum is 68.2 degrees. The highest and lowest temperatures recorded are 93.0 degrees and 54.0 degrees, respectively. Seasonal variation is minimal, ranging from a mean daily maximum of 82.0 degrees in September to a mean daily minimum of 64.8 degrees in February. Temperatures in the project area are near optimal for warm climate truck crops. High daytime temperatures during the warm season may promote pithium disease to the extent that water temperatures exceed 78 degrees.

Light Intensity and Humidity

Light intensity is somewhat restricted because of heavy cloud cover, particularly during the winter months. This has a minor retarding effect on the growth of truck crops and bananas.

Humidity is fairly high, which tends to promote fungal diseases of fruits, melons and vegetables.

Wind

Truck crops and bananas are subject to minor damage from prevailing trade winds. However, almost complete devastation of bananas can be expected from Kona storms with winds in excess of 50 miles pser hour on the average of once in three years. Kona storms also severely damage staked vegetables but have less serious effects on root crops. Windbreaks are essential for partial wind protection. Bananas require wind support systems.

Rainfall

Rainfall recorded at Hakipuu at an elevation of 45 feet is considered comparable to that which could be expected in Waikane wetlands. The average annual rainfall recorded at Hakipuu as shown in Table 2 is 66.5 inches. There is considerable variation from year to year, with a maximum of 92.6 inches and a minimum of 34.3 inches during the period recorded. However, during 75 percent of the time, the rainfall did not exceed 77.3 inches or drop below 45.2 inches. Whereas median annual rain-

Table 1. Temperatures Recorded at the Kaneohe Mauka Station, SK No. 781 for a 29-Year Period

Month	Mean Daily	Mean Daily Maximum	Mean Daily Minimum	Highest	Lowest
		degrees fahrenheit			
January	71.1	77.6	65.1	88	57
February	70.9	77.5	64.8	90	54
March	71.4	77.3	65.1	90	54
April	72.5	78.1	66.9	87	56
May	74.2	79.7	68.3	92	56
June	75.8	81.5	70.1	89	61
July	76.6	82.1	70.9	89	61
August	77.1	82.3	71.5	90	63
September	76.9	82.6	70.6	92	60
October	76.2	81.9	70.3	93	61
November	74.1	80.0	68.4	91	59
December	72.4	77.9	66.3	90	56
Annual	74.1	79.9	68.2	93	54

Source: National Oceanic and Atmospheric Administration

Table 2. Rainfall Recorded at Kualoa Ranch , Hakipuu, 1948-1960

Month	Mean	Maximum	Minimum	75% High a/	25% Low b/
			(inches)		
January	4.8	21.2	1.5	13.1	3.8
February	5.7	21.3	2.8	9.9	3.9
March	5.8	22.6	0.6	10.8	1.7
April	3.9	14.5	0.2	6.5	1.5
May	1.9	9.2	0.9	4.4	1.4
June	1.3	5.2	0.1	2.9	1.1
July	2.3	10.9	0.7	3.3	1.3
August	4.3	7.5	1.2	6.4	2.0
September	3.4	7.4	0.4	4.7	2.2
October	4.2	10.8	1.1	7.9	2.5
November	6.7	19.6	2.0	10.2	2.2
December	7.7	22.4	1.5	10.4	3.1
Annual	66.5	92.6	34.3	77.3	45.2

a/. 75% of recordings did not exceed maximum amounts indicated.

b/. 25% of recordings were below minimum amounts indicated.

fall approximates the annual requirement for most crops, this does not indicate rainfall adequacy since seasonsal distribution is uneven and the rainfall for any given month varies appreciably from year to year.

Irrigation

Truck crops require a net delivery of 4,073 gallons of water per acre per day (4.5 acre-inches per month) and a gross delivery of approximately 5.0 acre-inches per month, depending on the type of irrigation system and microclimatic factors. Bananas have a higher requirement of a net delivery of 5,431 gallons per acre per day (6.0 acre-inches per month) and a gross delivery of 6.7 acre-inches per month. Taro requires 77,000 gallons of continually flowing water per acre per day to keep pithium disease under control. Requirements for plant growth are estimated at 5,000 gallons per acre per day.

Continual truck crop production on the same acreage requires a gross delivery of 60 acre-inches annually. This is less than the mean annual rainfall at Hakipuu of 66.5 inches annually (Table 3). However, the annual total does not reflect rainfall available for crop production because of the poor seasonal distribution pattern, with very low rainfall during the warm months which are generally better for crop production. On the average, supplemental irrigation is required for the 8-month period from April through October plus January, but usually not for the same months during any one year. Truck crop water requirements of 40.0 acre-inches (8 x 5.0) during this period exceed aggregrate mean rainfall of 26.1 inches for the 8 months by 13.9 inches, which amounts to the average annual supplemental irrigation requirement. The supplemental irrigation water requirement varies considerably from year to year. Some years the requirement is minimal, but substantial during years of minimum annual rainfall. The maximum annual supplemental irrigation requirement based on Table 3 during the driest year recorded amounts to 25.7 acre-inches or more, depending upon whether normally high rainfall months have adequate rainfall (60 acre-inches required minus 34.3 inches of rainfall.

Bananas require a gross delivery of 6.7 acre-inches of water per month or 1.7 acre-inches more than truck crops. Thus the mean annual supplemental irrigation requirement for bananas in the wetlands is 27.5 acre-inches (8 x 6.7 = 53.6 acre inches required minus 26.1 inches of rainfall).

Taro water requirements are constant at 77,000 gallons per acre per day or 2,310,000 gallons (84 acre-inches) per month of continual flow from stream diversion.

There is currently no irrigation system in place in Waikane Wetlands. If a water allocation from Waikane stream is obtainable, it is estimated that the cost of pumping plus the amortized cost of the pumping system would cost 35 cents per 1,000 gallons. In addition, the estimated annual amortized cost of an on-site delivery and sprinkler system is $170 per acre. On this basis, mean annual irrigation costs would amount to an affordable $304 per acre for truck crops (383,000 gallons x 35 cents per 1,000 gallons = $134 plus $170 for the on-site system). If stream use were not permitted and it becomes necessary to tap water from the BWS transmission line on Kam highway, the cost would amount to $538 annually (13,000 gallons @ 98 cents plus 370,000 gallons @ 69 cents per 1,000 gallons = $268 plus $100 annually for the amortized cost of a delivery line, plus $170 annually for the on-site system). This high cost may be affordable for intensive truck crops but would seriously affect the ability to compete in the marketplace against truck crops produced in lower cost areas.

For bananas, the annual irrigation cost per acre if water were to be pumped from Waikane stream is $435 (756,000 gallons x 35 cents per 1,000 gallons = $265 plus $170 for the on-site system). This cost is probably not prohibitive but would affect the competitive position of banana production in the wetlands in relation to competing areas. If it were necessary to divert water from the BWS transmission line, the annual per acre cost of supplemental irrigation water for bananas would amount to $796 (13,000 gallons @ 98 cents per 1,000 gallons plus 743,000 gallons @ 69 cents per 1,000 gallons = $526 plus $100 annually for the delivery line, plus $170 annually for the on-site system). This high cost of water would likely make banana production in the wetlands economically non-viable at a banana price determined by areas with lower costs of production.

Taro would require direct water diversion from Waikane stream to assure a flow of 77,000 gallons per acre per day, which is required to keep the water below 78 degrees F for fungal disease (pithium) control. Not more than an estimated 6,000 gallons per acre per day would be required for plant growth and evaporation loss and the rest could be reused for other taro patches or for other purposes, providing that this does not result in the spread of disease. Any source of water other than direct diversion from the stream would be too costly.

Prawns require a continual flow of 21,600 gallons of fresh water per acre per day. This requirement would make prawn production uneconomic if it were necessary to pump water from Waikane stream and divert it through transmission lines to production areas. It is questionable that a continual supply of unpolluted water could be obtained through low cost direct diversion from Waikane stream.

Floriculture and nursery products under shadehouse production require 3,000 gallons of fresh water per acre per day (1,095,000) gallons annually). For this purpose, water would need to be piped from the upper unpolluted areas of Waikane stream or diverted from the Kan highway outlet of the municipal system. If pumped from the stream, the estimated water cost would amount to $553 per acre annually (1,095,000 gallons at $.35 plus $170). If obtained from the municipal system, the cost would amount to a prohibitive $1,130 per acre per year (including water cost, delivery lines and on-farm system).

CROP SELECTION BASED ON ECOLOGY

Truck crops, bananas and taro have been determined to be fairly well adapted to the 13.0 acres of Hanalei Silty Clay and marginally adaptable to the 3.7 acres of Pearl Harbor Clay designated as Wetlands in the project area. The 9.1 acres of Marshland can only be used for marsh type vegetation and are not adaptable to cultivated crop production.

Because the wetland soils are poorly drained, truck crop production should be restricted to vine type vegetables and not include root crops, except for wetland taro. Vegetable crops identified as fairly well to well adapted ecologically are snap beans, sweet corn, cucumbers, eggplant, green peppers, taro and miscellaneous specialty crops with similar growing habits. Wetland taro is particularly well adapted to Hanalei Silty Clay soils and marginally adaptable to Pearl Harbor Clay. Bananas do well in Hanalei Silty Clay soils, if properly drained, and are marginally adaptable to Pearl Harbor Clay Soils, if properly drained. Deep rooted fruit trees are subject to root rot in poorly drained soils and are not recommended for the wetland areas.

Grazing is not recommended because of the difficulty of management in wetland areas and because net returns are too minimal to cover lease rent in outleasing.

The heavy clay soils near Kam highway provide a good medium for construction of prawn ponds. Water temperatures in the area are satisfactory, but not ideal for prawn production. The most serious problem with respect to prawn production would be to assure a continuing flow of 21,600 gallons of fresh water per acre per day at an affordable cost. This may require tapping the stream above areas where it is polluted, which would likely be too costly for this enterprise. Diversion from the municipal water supply for this purpose would not be economically feasible.

Selected flowers and foliage crops are adaptable to the project area. Strong winds, heavy winter rains, some windborn salt spray and cloud cover would have limiting effects on crop selection. Stock plants may be feasible, depending upon availability and cost of water. Shadehouses would require strong construction for wind protection on the high plateaus and fill to prevent flooding in the low lying areas. The potentially high cost of irrigation water may adversely affect the competitive position of floriiculture and nursery production on the project site.

SALES POTENTIALS

This analysis is limited to the projection of sales potentials for crops which are ecologically adaptable to the 13.0 acres of wetlands identified as Hanalei Silty Clay and the 3.7 acres identified as Pearl Harbor Clay. The 9.1 acres of Marshland are not adaptable to crop production. Crops considered ecologically adaptable and for which a market analysis is relevant are shown in Table 3. Based on the acreage required to displace imports at yields expected under good management, the market potential in itself is not a limiting factor to crop production on the small acreage of wetlands ecologically adaptable to crop production. However, the ability to compete in the marketplace against other producing areas is a limiting factor to the economic viability of crop production in the wetlands. An analysis of the probable sales potential for each crop considered is as follows:

No growth potential is indicated for snap bean production in Hawaii. Hawaii production amounted to only 890,000 pounds in 1987 as compared to average annual marketings of 1,228,000 pounds during the previous 10 years. Oahu acreage decreased from 75 acres in 1978 and 90 acres in 1979 to only 40 acres in 1987. Oahu yield per acre has also gradually decreased from a high of 13,700 pounds per acre in 1981 to only 6,300 pounds per acre in 1987. A further consideration negating against potential production in the project area is that if the decline in Oahu production of snap beans were reversed, the increase would likely take place on upland silty clay loam soils rather than on bottom lands because of higher yields and lower costs of production.

Hawaii was self sufficient in sweet corn production until 1981, at which time inshipments began replacing Hawaii production. Hawaii marketings amounted to 1,480,000 pounds in 1987, only slightly less than the 1,590,000 pounds marketed in 1978, but this was associated with an increase in imports from zero through 1980 to 865,000 pounds in 1987. Oahu is the major sweet corn producer in Hawaii, but yields are lower than on the neighbor islands and acreage has stabilized. Any possible increase would not likely take place in the wetlands, which are less adapted to sweet corn production than well drained silty clay loam soils.

Both Hawaii marketings and imports of cucumbers have increased during the past 10 years, but Hawaii's share of the market has declined from 78 percent of the total market supply of 5,541,000 pounds in 1978 to 70 percent of 5,692,000 ponds in 1987. Oahu acreage has decreased from 100 acres representing 38 percent of

Table 3. Hawaii Market Supply and Acreage Required to Displace Imports, Selected Fruits and Vegetables, 1987

Crop	Market Supply Hawaii	Market Supply Imports	Yield Per Acre	Acreage Required To Displace Imports
	(1,000 pounds)		(pounds)	(acres)
Beans, snap	890	416	12,000	35
Corn, sweet	1,480	865	8,000	108
Cucumbers	3,960	1,732	20,000	87
Eggplant	1,290	308	30,000	10
Peppers, gr	2,300	1,595	20,000	80
Taro	5,700	917	20,000	46
Bananas	11,400	10,607	30,000	354
TOTAL				720

the state total in 1978 to 75 acres representing 33 percent of the state total in 1987. Eighty seven acres of additional production would be required to displace 1987 imports. Oahu's competitive position is affected adversely by low yields, which averaged only 13,900 pounds per acre during the 5-year period from 1982-86 as compared with 28,140 pounds per acre, primarily under greenhouse production, on the Island of Hawaii. It is possible, but not likely, that some additional production to displace imports could take place in the Hanalei Silty Clay soils in the Waikane wetlands.

Most of the Hawaii market supply of eggplant is from Hawaii production and only 10 acres would be required to displace 1987 imports. Oahu is the major producer of eggplant and yields are comparable to those of the neighbors islands. With proper drainage, affordable irrigation water and good management, additional production to displace imports could take place on Hanalei Silty Clay soils in the wetlands.

The opportunity for further expansion in green pepper production is promising. Hawaii producers provided 59 percent of the market supply of 3,895,000 pounds of green peppers in 1987 as compared to 34 percent of 2,415,000 pounds in 1978. Most of the increase in Hawaii production has taken place on Kauai and Maui-Molokai. Oahu acreage has levelled off to 15 acres, representing only 8 percent of the 190 acres in production statewide in 1986(Oahu data were combined with data from Maui and Molokai in 1987). Thus trends indicate that probable expansion in green pepper production will not likely take place on Oahu.

Hawaii production of taro has been losing its competive position in the marketplace during the past 10 years. Hawaii's share of the market supply decreased from 94 percent of 8,213,000 pounds in 1978 to 86 percent of 6,617,000 pounds in 1987. A number of factors account for the decline in Hawaii's market share. Taro is highly labor intensive and the product can be produced at much lower cost in areas of low labor cost. Another important deterrent to Hawaii production of taro is the low net return per acre in relation to alternative crops. The need for disease control and decreasing availability of low cost fresh water also discourage taro production. Oahu is at a particular disadvantage because of low yields and, in most areas, high land and water costs. Fifty percent of the 390 acres in taro production in Hawaii in 1987 was on Kauai, mostly in Hanalei valley. The other major producer was Hawaii, with 110 acres or 28 percent of the state total. Yields amounted to 20,850 pounds per acre on Kauai as compared to 9,444 pounds per acre on Oahu/Maui/Molokai.

The low yield results in lower gross and net returns per acre on Oahu than on Kauai. Whereas the outlook for commercial taro production on Oahu is not promising, the Hanalei and Pearl Harbor soils in Waikane Wetlands could be used for taro production as a part time family enterprise, with no out-of-pocket costs for labor, assuming that stream water can be diverted for that purpose. The extent to which farmers are interested in producing taro under these conditions has not been determined.

Bananas offer the best opportunity for expanded production of all crops ecologically adapted to the wetlands insofar as the market is concerned, with 354 acres required to displace 1987 imports. Hawaii banana production inreased to 11,400,000 pounds in 1987, which is the highest production in the past 10 years, but imports also increased to a record level of 10,607,000 pounds in 1987. But in spite of the increase in imports, Hawaii's market share increased from 42 percent in 1978 to 52 percent in 1987. Whereas the center of cavendish production (mostly Williams) has moved to the Puna district on Hawaii, Oahu continues to produce most of the Brazilian (apple) bananas. Quality and regularity of supply are major considerations in competing with imports. With good drainage, affordable water and good production and harvesting practices, including quality control, there is a reasonably good indication that bananas produced on Hanalei Silty Clay Soils in Waikane Wetlands could partially displace imports.

Hawaii production of floriculture and nursery products has expanded rapidly for several years. Gross value of marketings increased from $17,458,000 in 1978 to $55,767,000 in 1987, of which 57 percent was marketed outside of Hawaii. Oahu sales during the same period increased even more rapidly, from $6,085,000 in 1978 to $22,967,000 in 1987. In spite of the encouraging historical trends, competition from other producing areas with lower labor costs is an increasing threat amd caution is needed in projecting sales potentials. Whereas the market appears to justify expansion of floriculture and nursery production on Oahu, this does not necessarily include the project area, which may be at a competitive disadvantage. The wetland areas would require filling to prevent flooding of shadehouses and there is no assurance that the irrigation water requirement of 3,000 gallons per acre per day of fresh water throughout the year could be provided at an affordable cost.

In summary, the ability to compete in the marketplace is the major deterrent to the feasibilty of producing those crops which are ecologically adaptable to the better wetlands. Of the crops considered, bananas and eggplant appear to have the best possibilities of competing in the marketplace. However, cost-revenue relationships are subject to change and production of other ecologically adaptable crops should not be ruled out. Shifting from one crop to another would likely take place as economic conditions change. With respect to possible outleasing of the wetlands, it is important that lessees have a cropping plan that remains economically viable.

ARMY CORPS OF ENGINEERS JURISDICTION OVER WETLANDS

The land areas designated as Wetlands in the Waikane Golf Course Project are under the jurisdiction of the U.S. Army Corps of Engineers (ACE) as provided under Section 10 of the Rivers and Harbors Act of 1899 and Section 404 of the Clean Water Act. Under Section 1344 (c) of the Code of Feberal Regulations, the Environmental Protection Agency (EPA) has veto powers over actions regarding enforcement of the Federal Clean Water Act. ACE specifies that production of hydrophtic plants is permitted in wetlands. Hydrophytic crops consist of plants that grow in water or in soil too waterlogged for most plants to survive. Insofar as Hawaii agricultural production is concerned, taro and watercress are examples of crops that fall into this category. ACE further specifies that producers of hydrophytic plants in wetlands must assure that there will be no detrimental effects on health and safety through alteration of the topography or storage capacity of wetland areas, particularly with respect to adding fill. Discussions with officials in ACE indicated that non-hydrophytic crops can be grown in wetland areas, providing that there is no alteration of the topography. Plowing and drainage of areas subject to occasional flooding, such as Hanalei Silty Clay soils, are permitted if the topography is not altered. A general or generic permit for agricultural use which specifies specific conditions is required.

OUTLEASING FEASIBILITY

Outleasing of wetlands in the Waikane Golf Course Project is indicated to be feasible and compatible with golf course management providing that potential agricultural enterprises are economically viable, with assurances of compliance with Army Corps of Engineers regulations and ability to pay reasonable lease fees. An appropriate lease charge per acre could be based on the lease rent formula for adjoing Waiahole State Agricultural Park, which specifies an annual flat fee of $100 per acre plus 0.9 percent of gross income for the preceding year.

Of crops ecologically adaptable to the wetlands, bananas and eggplant are indicated to have the best potentials for competing in the marketplace and thus to be economically viable. This does not preclude the production of certain other crops, such as specialty crops and other truck crops as revenue-cost relationships change. Taro, although it best meets the hydrophtic requirements specified the the Corps of Engineers, is not a likely candidate for Waikane Wetlands because of its indicated inability to compete with imports and other Hawaii taro production as a commercial enterprise. The seriousness of disease problems and the related high water requirements also limit its potential. Taro, nevertheless, might be a candidate for production on the wetlands as a family endeavor, with no out-of-pocket costs for labor and management. However, recent history of crop production in windward valleys does not demonstrate major interest in subsistence taro production, although there is considerable discussion of land not being available for that purpose.

A potential problem with respect to outleasing of the 16.7 acres of wetlands adaptable to crop production is the cost of establishing a horizonal property regime (HPR) as a condominium for such a small acreage at an estimated cost of $5,000 to $10,000 for field surveys and legal work (re: 10/6/88 letter from George Atta to Norman Quon). This cost, amounting to $300 to $600 per acre, would need to be collected form lease rents over time.

Taro production poses the most serious problem with respect to water use, with the need for continual stream diversion of 77,000 gallons of water per acre per day for disease control. Water used for plant growth and evaporation is estimated at not more than 6,000 gallons per acre per day. The remainder could be diverted to other taro patches, but this could transmit pithium disease unless properly controlled.

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