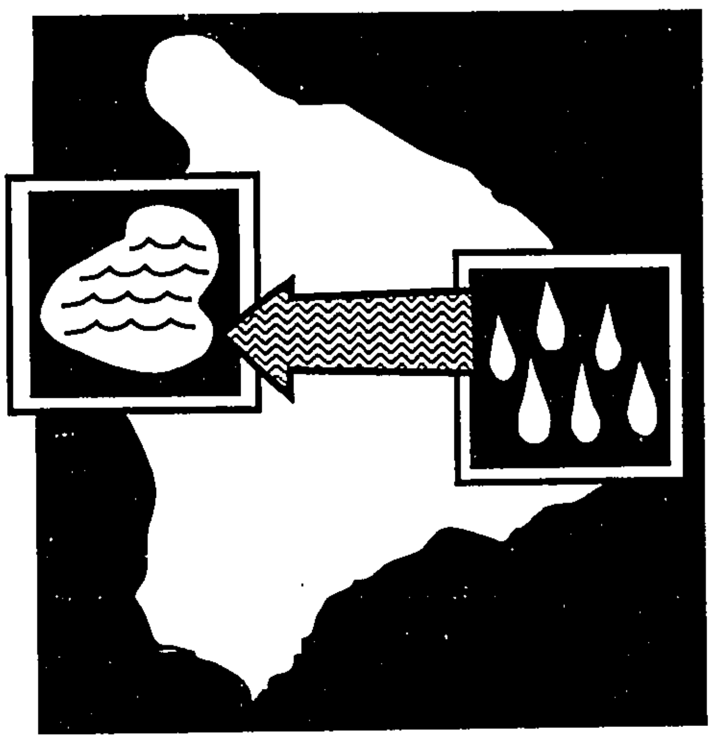
Revised Draft Environmental Impact Statement

Water Resource Development and Across Island Transmission, Island of Hawaii



State of Hawaii
Department of Land and Natural Resources

Division of Water and Land Development

November 1992

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Okahara & Associates, Inc.
ENGINEERING CONSULTANTS

Dear Participant:

Draft Environmental Impact Statement
Water Resource Development and Across Island Transmission
Job No. 22-HW-J

Attached for your review is a Revised Draft Environmental Impact Statement (DEIS) which was prepared pursuant to the EIS law (Hawaii Revised Statues, Chapter 343) and the EIS rules (Administrative Rules, Title 11, Chapter 200).

Written comments must be postmarked by March 9, 1993 Please send original comments to the:

Governor
State of Hawaii
c/o Office of Environmental Quality Control
220 South King Street
Fourth Floor
Honolulu, Hawaii 96813

Copies of the comments should be sent to the Department of Land and Natural Resources - Division of Water Resource Management and to Okahara & Associates, Inc. Their respective addresses are as follows:

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Honolulu, Hawaii 96813

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Hilo, Hawaii 96720

If further information is required, you may call the office of Okahara & Associates, Hilo, Hawaii at 961-5527. Thank you for your participation in the EIS process.

Sincerely,

Donald K. Okahara, P.E.
President

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REVISED

DRAFT ENVIRONMENTAL IMPACT STATEMENT

WATER RESOURCE DEVELOPMENT AND ACROSS-ISLAND TRANSMISSION, ISLAND OF HAWAII

Prepared for:
State of Hawaii
Department of Land and Natural Resources

Prepared By:

OKAHARA AND ASSOCIATES, Inc.
Y. K. Hahn and Associates

Submitted Pursuant to Chapter 343, Hawaii Revised Statutes

Accepting Authority: State of Hawaii

Department of Land and Natural Resources

NOVEMBER 1992

DIVISION OF WATER AND LAND DEVELOPMENT
DEPARTMENT OF LAND AND NATURAL RESOURCES
STATE OF HAWAII

The Environmental Document is Submitted
Pursuant to Chapter 343, HRS

REVISED
DRAFT ENVIRONMENTAL IMPACT STATEMENT
WATER RESOURCE DEVELOPMENT AND ACROSS-ISLAND TRANSMISSION, ISLAND OF HAWAII

PROPOSING AGENCY:
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EXECUTIVE SUMMARY

This revised Draft Environmental Impact Statement (Draft EIS) has been prepared to address the potential environmental impacts of a proposed Water Resource Development and Across-Island Water Transmission Pipeline on the Island of Hawaii. This executive summary includes brief descriptions of the proposed project, beneficial and adverse impacts, proposed mitigative measures, and alternatives. The project's relationship to existing government policies and plans and yet unresolved issues are also discussed.

Purpose, Scope, and Description of Project

The Island of Hawaii has many natural resources, the combination of which are found nowhere else in the State nor in most of the world. The continent-like nature of the island provides a wide range of climatic and agricultural growing conditions along with tremendous water resources and an indigenous base-load energy source. The Water Resource Development and Transmission Project intends to take advantage of this unique combination of resources by pumping water from East Hawaii to the drier leeward areas. The base-load energy requirements will create an opportunity for the utilization of geothermal-produced electricity as well as open up potential agricultural areas along the pipe route. The project was conceived to encourage the potential for integration and utilization of these natural resources within the Island of Hawaii.

The Water Resource Development and Across-Island Transmission Project was conceived to begin to address the potential long-term water imbalance between East and West Hawaii. In recognition of the significant cost of moving water from one side of the island to the other, the project was designed to maximize the options for federal funding by supporting the potential modernization of the U.S. Army's Pohakuloa Training Area (PTA) facility.

While the potential provision of water to PTA was a critical planning element of the project, the State wanted to ensure benefits from a pipeline would extend beyond Pohakuloa to West Hawaii. Consequently, the project design parameters were established to ensure sufficient water was available to West Hawaii even after providing for all the potential water needs of PTA. Based on this requirement, a water source and transmission pipeline capacity of 20 million gallons per day (mgd) was set by the State for planning and design purposes.

The scope of the environmental analysis is to investigate and assess the following:

1. Identify the potential source, location and engineering requirements of the water source development and assess the ability of the aquifer to support the development of 20 mgd of water.

2. Identify the pipeline route, reservoir sites, pumping and related requirements to transmit 20 mgd of water to West Hawaii.

3. Assess the potential for the generation of hydroelectric energy along the leeward portion of the project.

4. Identify and assess the site-specific impacts of the development of the water transmission system on the physical, social and economic environment of the County.

This analysis is intended to identify and assess the impacts directly related to the development of the water resource and transmission line. It is not intended to provide a complete analysis of all impacts related to the final use of water, nor does it identify the final energy source to support the electrical requirements of this project.

It is anticipated that each potential water end user will undertake a separate environmental analysis of its respective project. The information provided in this analysis will assist the end user(s) in assessing this transmission line as a potential water source by identifying the engineering requirements and social, physical and economic impacts of the project.

It is intended that this environmental impact statement be incorporated by reference by any potential end user(s) and the cumulative impacts of the overall project, including construction and operation of the pipeline, be considered as part of the overall project assessment of each potential end user.

The proposed water development site (well field) is located in the Waiakea-Uka area of South Hilo, at an elevation of 830 ft. The pipeline project entails two segments; the first segment, as shown in Figure 1.1, is 38.4 miles long, extending from the well field site to the initial delivery point at PTA. The first 7.3 miles of pipeline traverses an existing powerline easement that intersects with the Saddle Road at an elevation of 2,100 ft. From this junction, the pipeline parallels the Saddle Road and will lie within the 100-foot-of-centerline roadway easement for the next 31.1 miles to a proposed reservoir site at PTA.

The downhill, leeward segment of the pipeline from PTA to the Waimea area involves two alternative routes. Alternative A, as shown in Figure 1.2, is 23.5 miles long and follows Saddle Road from PTA via gravity flow, to the 5,600 ft. level, where it then cuts north across Parker Ranch lands, descending to the terminal reservoir site south of Waimea (elev. 4,150 ft.). The total pipeline length under alternative A will be 61.9 miles (38.4 miles windward and 23.5 miles leeward).

The alternative leeward route B, as shown in Figure 1.3, is 37.8 miles long. It follows Saddle Road and the Mamalahoa Highway, again via gravity flow, to Waimea and from there (elev. 2,700 ft.) it will proceed uphill with two additional pumping stations (#9 and #10) to the same reservoir site in alternative A (elev. 4,150 ft.). The objective of this alternative route is to tie in with the existing County Department of Water Supply potable water systems and State irrigation systems in Waimea. The total pipeline length under alternative B will be 76.2 miles (38.4 miles windward and 37.8 miles leeward).

The proposed pipeline routing from the well field above Hilo to the Parker Ranch area on leeward Mauna Kea traverses areas dominated by native Hawaiian ecosystems occurring within the State Land Use Conservation District. A designated critical habitat of the Hawaiian palila bird (*Loxiodes bailleui*) lies adjacent to the proposed pipeline route on leeward Mauna Kea.

The electrical power requirements (water pumping) associated with this water transmission project are substantial (25 to 30 MW continuous power) and will require development of new electrical generating capacity on the Island of Hawaii. The base load energy requirements of this project are well suited to geothermal energy power plants.

Anticipated Short-term Adverse Impacts and Mitigative Measures

Project development activities will involve the construction of the well field, pipeline, booster pump stations, holding tanks, hydroelectric generation stations, and a terminus reservoir. Short-term construction-related impacts on the environment will be generated by the project, but mitigative measures will be implemented to minimize these impacts.

The anticipated short-term adverse environmental impacts and mitigative measures are listed below.

1. Construction activities will create short-term unavoidable impacts on noise and air quality (fugitive dust) within the project area. These short-term adverse effects will be minimized through the use of standard abatement procedures. Special care will be taken to mitigate dust, noise and related construction activities in order to maintain traffic safety along the steep, narrow and winding Saddle Road.

2. Operation of construction equipment, trucks, and worker vehicles may temporarily impede traffic in the area during the construction period.

3. Negligible releases of air contaminants will occur from construction equipment. Small amounts of dust may be generated during dry periods as a result of construction operations.

4. The visual character of the area will be affected by construction activities and by the presence of construction equipment.

5. Temporary increases in noise levels will result from construction activities.

Anticipated Long-Term Adverse Impacts and Mitigative Measures

Once the pipeline is in place and operational, some long-term adverse effects will have occurred or will continue to occur. Mitigative measures have also been proposed to minimize the long-term adverse effects of the project.

The anticipated long-term adverse impacts and proposed mitigative measures are listed below.

1. Vegetation and Native Plants: Destruction and disturbance of some vegetation and native plants within the easement of the pipeline is unavoidable. Anticipated negative impacts are physical destruction or damage to vegetation and plants and the establishment of alien plants on disturbed sites. These negative impacts will be minimized by:

   a) protocols for project planners and construction workers emphasizing the need to disturb as little vegetation as possible.

   b) carefully siting all facilities close to the existing powerline or to Saddle Road, within a few feet where practical.

   c) relocating pumping stations #4 through #8 away from their initial design locations in sensitive closed forest to locations nearer Saddle Road.

   d) minimizing the total amount of surface disturbed by construction activity since disturbed ground favors the establishment of alien plants.

   e) monitoring and controlling growth of alien plants within the easement and encouraging revegetation by native plants.

   f) avoiding known sites of rare plants as indicated in the text.

2. Archaeological Sites: The following mitigative actions will be adopted during the construction phase to minimize archaeological impacts:

   a) Initial site preparation work (vegetation clearing by hand) at the site of proposed pump station #1 located in the Waiakea-Uka area of Hilo should be monitored by an experienced archaeologist to check for sites (e.g., agricultural, residential, or lava tube caves) covered by the dense vegetation. Should archaeological resources be discovered, a plan for further mitigative steps will need to be formulated.

   b) Construction crews should be informed of the potential with vegetation clearing and other activities to discover prehistoric and historic artifacts, features, buried deposits, and lava tubes. Chances of such discoveries seem greater at pump station #8, at the Pohakuloa reservoir and water tanks, at hydropower stations 1 and 2, and at the terminal reservoir. In the event such resources are discovered, all destructive work will be suspended until a qualified archaeologist can examine the finds and recommend a mitigative plan.

3. Energy Requirements: When the pumping requirement reaches 12 mgd, an additional 16.5 MW of electrical generating capacity is needed to meet the peak load demand, although it will be used for only 4 hours a day.

   a) One mitigative measure to avoid the construction of added capacity would be to have water pumping done on a strictly interruptable schedule basis. Under this option the water pumping will be interrupted during the peak hours. A consequence of this measure, however, would be the smaller amount of water pumped. During winter seasons when the water demands are at a minimum, this option may be feasible up to a certain range.

   b) Another alternative measure is that the pumping schedule be limited to the off-peak schedule until such time as a dependable and economically viable alternative energy source, such as geothermal energy, is fully developed and available to the utility. This consideration may well be the preferred scenario as a trade off between adding additional energy capacity whose private and social costs may exceed the benefit of additional water availability to the end users.

4. Topography and Soils: Modifications to the current topography will be made at the site to accommodate project development. Soils will be disturbed by grading, excavation, and mounding activities at the site during construction. Since soil cover on the site is very sparse, soil will be imported to cover cleared and graded land for planting landscaping materials, except for areas left in natural vegetation.

5. Groundwater: With increased agricultural development, small contributions of nitrogen compounds will enter groundwater from treated wastewater effluent irrigation and fertilizer application, and very small contributions of pesticides will enter groundwater from pesticide application on crop farming.

6. Air Quality: Air quality at area roadways will receive a minor addition of traffic-related emmissions.

7. Public Services and Utilities: Minor demand on public services and utilities will result from the development, including police and fire protection and electrical needs in the Waimea area.

Alternatives to the Proposed Project

1. No project

Short-term:

The "no project" alternative would mean that potential end users of water including PTA, DHHL and private agricultural water users in the Waimea area would be required to seek other sources of water.

Long-term:

The "no-project" alternative means that no long-range development action will be taken to exploit currently under-utilized water resources on windward Mauna Loa to address the increasing shortfall in water supply in leeward Hawaii.

2. Water Development

a) Alternative Water Sources

There are a large number of potential water development sites in East Hawaii areas of Hilo, Hamakua and Puna with proven but undeveloped water resources. However, as defined in the scope of this EIS, the feasible development of a water resource that can meet the dual project goals of providing a potential water source for PTA as well as potential end users in West Hawaii via a single transmission corridor limited available water development sites to areas above Hilo.

A preliminary assessment of water resource development of water resource development within other sectors of East Hawaii was considered during the early stages of this project. These potential water sources were not pursued because of one or more of the following factors:

* distance to PTA
* lack of electrical power for well fields and transmission corridor
* impacts on native forest plant species

In addition, four alternative well fields were considered within the Hilo area. The proposed well field site in Waiakea-Uka is the only appropriate site meeting the necessary design qualifications relating to: available State land, power at site, adjacent transmission corridor available (existing powerline easement), site upslope of existing residential cesspool waste water disposal in the suburban Hilo area. The water resource for the proposed well field site has recently been proven through successful exploratory drilling and well testing at the site. Accordingly, there are no reasonable alternatives to the proposed well site.

b) Alternative Pipeline Routes

Only one alternative pipeline route was evaluated for the windward Mauna Loa segment of the proposed pipeline. This area includes sensitive native ecosystems generally including rare and endangered species. A pipeline routing that closely follows existing disturbance corridors (Saddle Road and power line easement) was considered the only possible alignment that would not involve potentially unacceptable levels of disturbance to existing biological resources of the area.

Two alternative routes from PTA to the terminal reservoir site in Waimea (alternatives A and B) were evaluated in this EIS. These two alternatives offer a number of differing benefits and costs, including amount of energy required for pumping and energy recovery from hydroelectric generation, proximity to the potential end users, and construction costs.

The potential adverse environmental impacts of the leeward route alternatives are not significant since the right of ways traverse generally uniform pasture lands on leeward Mauna Kea. The route B alternative, which would take the pipeline directly into the Waimea town area, may have potential impact on existing archaeological sites in the Waimea area unlike the route A alternative.

Relationship to Existing Plans and Policies

This Draft EIS includes a detailed discussion of how the proposed project is generally consistent with most existing State and County plans and policies. Plans and policies considered in this evaluation are:

1. Hawaii State Plan
   Objectives and Policies and Functional Plan
   Water Resource Development Plan
   Energy Functional Plan
   State Land Use and Control Plan

2. County of Hawaii General Plan
   Land Use
   Economic
   Flood Control and Drainage

Extensive discussion of the project in relationship to these policies and plans is contained in Chapter 4.

Unresolved Issues

1. Funding

The estimated total cost for planning and construction of the project is $250 to $312 million in 1991 dollars. However, the exact source of funding for the project is not clear at this time. Both the State and Federal government as well as a joint venture between government and private parties are possible funding sources.

2. Potential Users

Although we have identified a number of potential end users for this project, and in some cases undertook a detailed evaluation, it is not definite at this time as to the likely candidates.

3. Operating Entity

A number of scenarios can be developed as to the administrative agency. The exact administrative role and responsibilities of such an agency, however, have not been resolved.

4. Electrical Energy Source

In order for the full 20 mgd of water to be utilized, an additional 30 MW of electricity production over that currently anticipated by HELCO would be required. There are several alternative options including additional fossil fuel plants, development of geothermal capabilities or other available technologies. To the extent base load power is required, certain renewable energy sources such as wind and hydroelectric power will not fully satisfy the expansion needs.

Chapter 1: **Introduction**

CHAPTER 1: INTRODUCTION

Chapter 1 discusses the purpose and design criteria for the proposed water transmission pipeline development, including location, land ownership, and water resource characteristics of the region. Detailed project features are discussed in Chapter 2.

1.1 Purpose of Water Development Project

The Island of Hawaii has many natural resources, the combination of which is found nowhere else in the State nor in most of the world. The continent-like nature of the island provides a wide range of climatic and agricultural growing conditions along with tremendous water resources and an indigenous base load energy source. The Water Resource Development and Transmission Project intends to take advantage of this unique combination of resources by pumping water from East Hawaii to the drier leeward areas. The base load energy requirements will create an opportunity for the utilization of geothermal-produced electricity as well as open up potential agricultural areas along the pipe route. The project was conceived to encourage the potential for integration and utilization of these natural resources within the Island of Hawaii.

The Island of Hawaii has a geographic imbalance with respect to water resources, with the windward side regularly exceeding 200 inches of rainfall annually while much of the dry or leeward side receives less than 20 inches of rainfall annually. Unlike the other islands in the Hawaiian Archipelago, the size of Hawaii Island has inhibited the transfer of water from windward to leeward areas except in limited areas within the North Kohala district.

While there is enough water to support the current development in West Hawaii, the long-term projections indicated that certain regions of the island may not be able to sustain their long-term water needs (see Hawaii County Water Use and Development Plan). At the same time, the water recharge levels of the East Hawaii aquifers are significantly greater than any projected long-term use in those regions.

The Water Resource Development and Across-Island Transmission Project was conceived to begin to address the potential long-term water imbalance between East and West Hawaii. In recognition of the significant cost of moving water from one side of the island to the other, the project was designed to maximize the option for federal funding by supporting the potential modernization of the U.S. Army's Pohakuloa Training Area (PTA) facility.

While the potential provision of water to PTA was a critical planning element of the project, the State wanted to ensure benefits from a pipeline would extend beyond Pohakuloa to West Hawaii. Consequently, the project design parameters were established to ensure sufficient water was available to West Hawaii even after providing for all the potential water needs of PTA. Based on this requirement, a water source and transmission pipeline capacity of 20 million gallons per day (mgd) was set by the State for planning and design purposes.

The areas in and around Waimea are among the best agricultural lands within the County. Consequently, the transmission terminus point for the purposes of this analysis was selected to take advantage of the agricultural potential of this area. The planning parameters included a review of the feasibility of providing water to this area for agricultural purposes. The summary of this agricultural feasibility report is provided in Appendix C. The siting of the terminus point also recognized that the water could potentially be used to support the tourism-related coastal developments in West Hawaii (through extension of the transmission line).

The exploration for and development of geothermal power on the Island of Hawaii is on-going. The first commercial power plant is targeted to be on line by September 1992. While the scale of the geothermal resources is still being assessed, it does provide the potential for addressing a significant portion of the County's base load energy requirements in the future. The electrical power requirements of this project are substantial (25-30 MW of continuous power) and will require development of new electrical generating capacity. While the transmission project is not directly linked to geothermal development, the base load energy requirements of the project are well suited to geothermal-powered generating plants.

The actual capacity, route, cost, and energy source of the project will depend on the ultimate end user(s). While a number of potential end users have been identified as part of the following anaylsys, the final end users have not been established and therefore impact related to the use of water cannot be assessed at this time.

This analysis is intended to provide an assessment of the engineering feasibility, cost, and direct environmental impacts of providing water to West Hawaii through the Mauna Loa/Mauna Kea saddle. This information can then be used and incorporated into subsequent studies and analyses by the ultimate water end users.

In this context, the intent of the Water Resource Development and Across-Island Transmission Project is to provide the foundation for the consideration of the costs and impacts of the transferring of water from the Northeast Mauna Loa Aquifer across the island for various potential end users. It is expected that this environmental analysis will be incorporated as part of future Environmental Impact Statements (EIS) that will be undertaken by the final end users as they move ahead with the planning and implementation of their respective projects. These projects will ultimately generate the demand for and ability to finance this water source development and across-island transmission project.

1.2 Scope and Design Criteria of this Environmental Analysis

The scope of the following environmental analysis is to identify and assess the following:

1. Identify the potential source, location and engineering requirements of the water source development and assess the ability of the aquifer to support the development of 20 mgd of water.

2. Identify the pipeline route, reservoir sites, pumping and related requirements to transmit 20 mgd of water to West Hawaii.

3. Assess the potential for the generation of hydroelectric energy along the leeward portion of the project.

4. Identify and assess the site-specific impacts of the development of the water transmission system on the physical, social and economic environment of the County.

This analysis is intended to identify and assess the impacts directly related to the development of the water resource and transmission line. It is not intended to provide a complete analysis of all impacts related to the final use of water nor does it identify the final energy source to support the electrical requirements of this project.

It is anticipated that each potential end user will undertake a separate environmental analysis of its respective project. The information provided in this analysis will assist the end user(s) in assessing this transmission line as a potential water source by identifying the engineering requirements and social, physical and economic impacts of the project.

In a similar manner, the identification of the final energy source is beyond the scope of this analysis. The impacts of the development of the energy source should be considered as part of the permitting requirements for that energy source. However, the energy requirements of this project can be identified and included in the planning parameters by the energy resource developers.

It is intended that this environmental impact statement be incorporated by reference by any potential end user(s) and the cumulative impacts of the overall project, including construction and operation of the pipeline be considered as part of the overall project assessment of each potential end user(s).

1.3 Project Location

The proposed Water Resource Development and Transmission Project is situated on the Island of Hawaii. The proposed water development site (well field) is located in the Waiakea-Uka area of South Hilo at an elevation of 830 ft., as shown in Figure 1.1.

The pipeline project entails two segments. The first segment, as shown in Figure 1.1, is 38.4 miles long from the well field site to the initial delivery point at PTA. The first 7.3 miles of pipeline traverses an existing powerline easement that intersects with the Saddle Road at an elevation of 2,100 ft. From this junction, the pipeline parallels the Saddle Road and will lie within the 100-foot-of-centerline roadway easement for the next 31.1 miles to a proposed reservoir site at PTA.

The downhill, leeward segment of the pipeline from PTA to the Waimea area involves two alternative routes. Alternative A, as shown in Figure 1.2, is 23.5 miles long and follows Saddle Road from PTA via gravity flow, to the 5,600 ft. level, where it then cuts north across Parker Ranch lands, descending to the terminal reservoir site south of Waimea (elev. 4,150 ft.). The total pipeline length under alternative A will be 61.9 miles (38.4 miles windward and 23.5 miles leeward).

The alternative leeward route B, as shown in Figure 1.3, is 37.8 miles long. It follows Saddle Road and the Mamalahoa Highway, again via gravity flow, to Waimea and from there (elev. 2,700 ft.) it will proceed uphill with two additional pumping stations (#9 and #10) to the same reservoir site in alternative A (elev. 4,150 ft.). The objective of this alternative route is to tie in with the existing County Department of Water Supply potable water systems and State irrigation systems in Waimea. The total pipeline length under alternative B will be 76.2 miles (38.4 miles windward and 37.8 miles leeward).

1.4 Land Ownership

The proposed well field development site above Hilo in the Waiakea-Uka area is on State land. The 61.9 mile pipeline route from the well field to the Waimea area (via Pohakaloa) traverses primarily state and Federal lands on windward Mauna Loa and private lands (Parker Ranch) on leeward Mauna Kea. A few small private land owners will be impacted in the pipeline right of way above Hilo. Table 1.1 provides tax map keys (and net easement lengths) for all public and private lands impacted by this project. These areas are within either the State Conservation or Agricultural land use districts.

1.5 Water Resources

The Island of Hawaii receives an average rainfall of approximately 72 inches per year, an equivalent of 13.8 billion gallons per day. However, this rainfall is not evenly distributed, with windward areas receiving over 200 inches per year while much of the dry or leeward side receives less than 20 inches of rainfall annually. This rain water percolates downward through porous rock structure to recharge the island's basal groundwater aquifers.

The sustainable yield is the rate at which groundwater from an aquifer can be withdrawn indefinitely without affecting the quality of the pumped water or the volume rate of pumping. Generally, the sustainable yield is between one-half to three-fourths of the total water recharge.

The Northeast Mauna Loa Aquifer, which will serve as the source for the project, has an estimated sustainable yield of 740 mgd. In comparison, the South Kohala District, which is served by two aquifers which have a total estimated sustainable yield of 54 mgd. The Kailua region's (Hualalai) aquifer has an estimated sustainable yield of 56 mgd.

1.5.1 Future Regional Water Demand

The County of Hawaii Water Use and Development Plan provides an estimate of water needs for the various districts of the County in the year 2010. These estimates were based on a number of factors, including the extrapolation of past water use trends, development plans of public agencies and private land owners and developers, and the State and County land use plans. The water use estimates for the planning areas were as follows:

District	Present Use 1991 (mgd)	Projected Use 2010 (mgd)
Puna	13.3	20.7
South Hilo	90.8	93.2
North Hilo	.2	0.2
Hamakua	26.5	31.8
North Kohala	11.6	27.9
South Kohala	18.2	62.7
North Kona	9.5	38.0
South Kona	2.9	9.7
Ka'u	12.4	14.7

While the South Hilo District has been and will continue to be the single largest water use area, the leeward areas have been the fastest growing areas of the county, the result of the tremendous increase in resort developments over the past ten years. Furthermore, these water needs of the leeward areas may be understated, especially in the Waimea region where significant areas of agricultural lands are underutilized because of the lack of irrigation water. These agricultural water needs were only partially considered in the long-term need assessments of the Water Use and Development Plan.

With respect to South Kohala, the Hawaii County Water Use and Development Plan states:

> The project water needs for the coastal region (of South Kohala) far exceed the estimated sustainable yield of the West Mauna Kea Aquifer, which is the region's primary groundwater source. Although there may not be an immediate urgency since present withdrawals are not large yet, it is critical that a feasible solution be found to match needs with supply if orderly development is to continue in the region.

While not as significant, the North Kona area must also face concerns with respect to the ability of the aquifer to sustain long-term growth.

In addition to the agricultural water uses identified in the County's Water Use and Development Plan, there is the potential additional demand for 18 mgd of water for agricultural uses in the Waimea region according to the Assessment of Agricultural Industry Development in the South Kohala Region of West Hawaii, which was conducted as part of this project (see Appendix C). While there are many potential constraints that must be resolved before this level of water demand will occur, it indicates the potential additional demands for water over and above those considered in the County's WUAD Plan.

In order to sustain the projected growth in these regions, a number of possible solutions are available, including:

1. Reduction in water use through conservation measures;

2. Adding to the toal available water supply through desalinization; or

3. The importation of water from other aquifers/regions.

This study provides an assessment and analysis of one possible source for the importation of water to West Hawaii to address the future needs of the region.

1.5.2 Potable Water Systems

The Hawaii County Water Use and Development Plan reviews future water requirements to the year 2010 for each of the nine aquifer sectors and nine judicial districts of the island (see Kon, M., Water Use and Development Plan, County of Hawaii, 1990). The West Mauna Kea aquifer sector, which occupies the major portion of this study area, is projected to have a demand for groundwater exceeding the sustainable yield by 2010. Although there is a relatively small current draw of about 7 mgd and a sustainable aquifer yield of 24 mgd, expected requirements are projected to match the sustainable yield in 2005. By 2010, demand is expected to be 28.5 mgd, exceeding the sustainable yield.

1.5.3 Potable Water Systems, South Kohala

The County of Hawaii has two major systems serving the South Kohala Region. The Waimea-Puukapu-Nienie System serves the Waimea residential and agricultural communities. The Kawaihae-Puako-Hapuna System serves the coastal area, including the resort destinations of Mauna Kea and Mauna Lani Resorts. In addition, there are a number of private water systems serving this region, including the Waikoloa Water Company which serves the village of Waikoloa as well as the Waikoloa Beach Resort.

1.5.3.1 Waimea-Puukapu-Nienie System

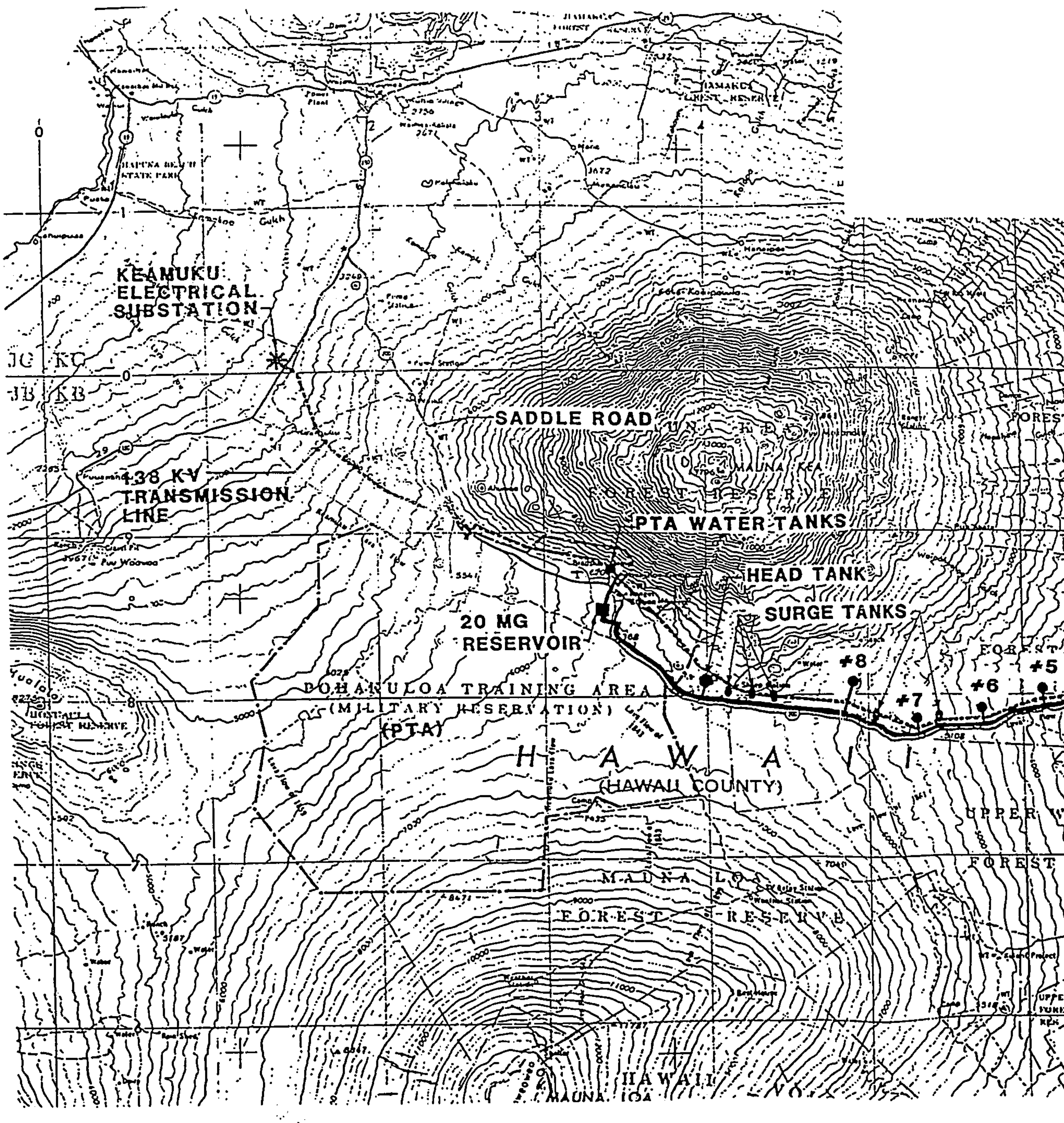
With a water supply capacity of 3.6 mgd and a current demand for only 1.6 mgd, the system at first glance appears well positioned to meet future demands of the growing Waimea community. However, nearly all of the system's reserve capacity has been previously committed to new distribution pipelines that will service existing lots or planned and/or approved projects. These commitments are expected to mature in five to 10 years.

Further water expansion, therefore, can only come with development of additional water resources. Additional raw water storage capacity and/or increased stream diversions may be methods of increasing this surface water system capacity. However, concerns related to the sensitive ecosystem within the Kohala watershed area and storing nearly a quarter of a billion gallons of water steeply upslope of an expanding urban area need to be carefully reviewed.

The Water Use and Development Plan projects a system demand for an additional 2.4 mgd by the year 2010. All of this water is projected to be from surface sources. Should this means be impossible, and in the worst case water is developed by local deep wells (basal lens), domestic water cost at the well could reach $1.25 to $1.50 per 1,000 gallons, and $2.00 to $5.00 per 1,000 gallons at the end user property line. Clearly, under the worst case scenario, future local water development for the Waimea plain becomes an expensive proposition.

1.5.3.2 Parker Ranch 2020 Master Plan System

The Parker Ranch has embarked on an ambitious urban development plan in three separate areas contiguous to the urban perimeter of Waimea (See Parker Ranch 2020 Plan, 1989). Water demand for the development is expected to reach 1.33 mgd after 10 years. Exploratory well drilling for the project has begun. As with the case of the Waimea-Puukapu-Nienie System, a worst case scenario of drilling to the basal lens aquifer will result in water costs well above current DWS water rates. The hope is that this will not be the case, and there are some indications that confined (high level) water may exist.



KEAMUKU ELECTRICAL SUBSTATION
SADDLE ROAD
138 KV TRANSMISSION LINE
PTA WATER TANKS
HEAD TANK
SURGE TANKS
20 MG RESERVOIR
#8
#7
#6
#5
POHAKULOA TRAINING AREA
(MILITARY RESERVATION)
(PTA)
HAWAII
(HAWAII COUNTY)
MAUNA LOA
FOREST RESERVE
MAUNA KEA

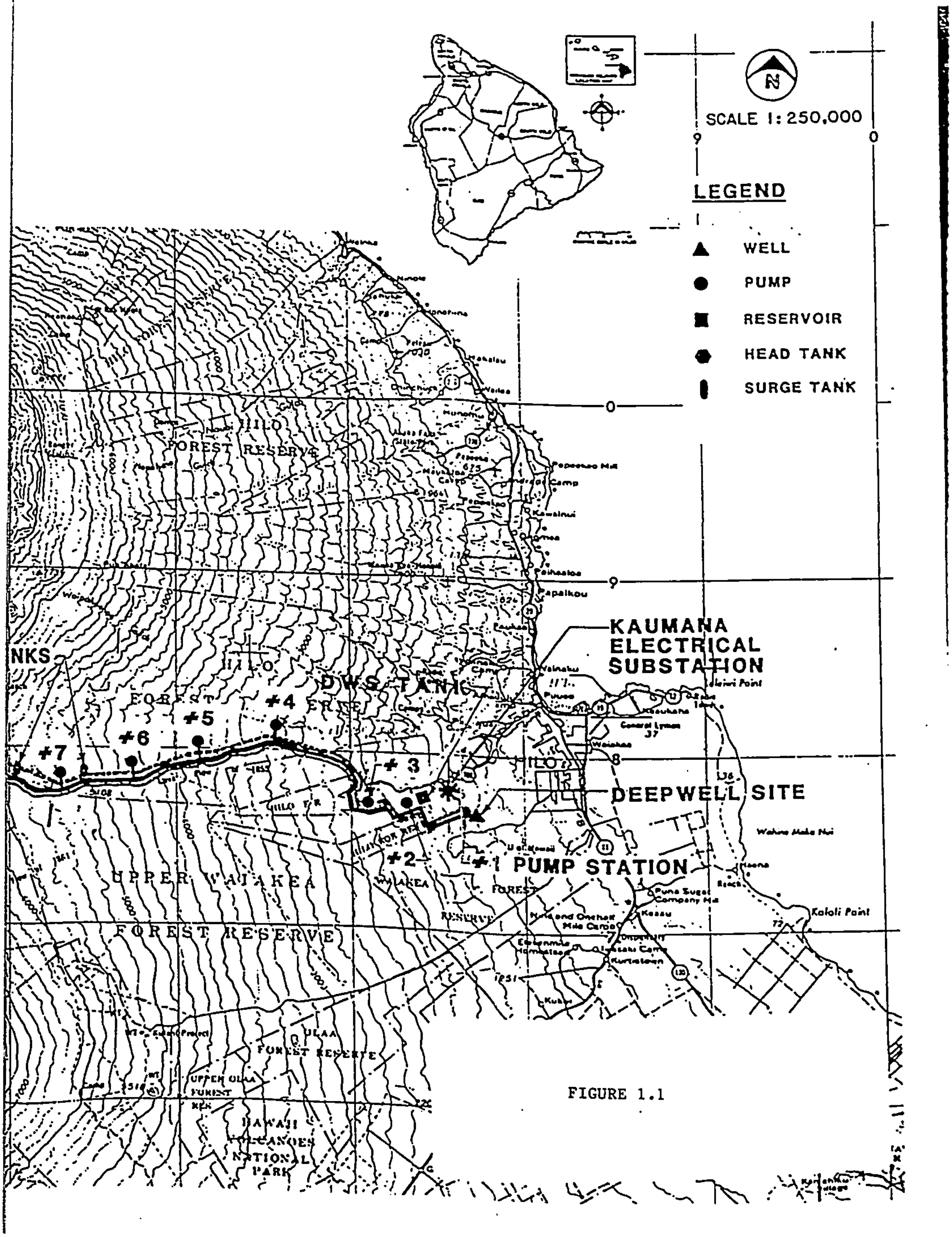
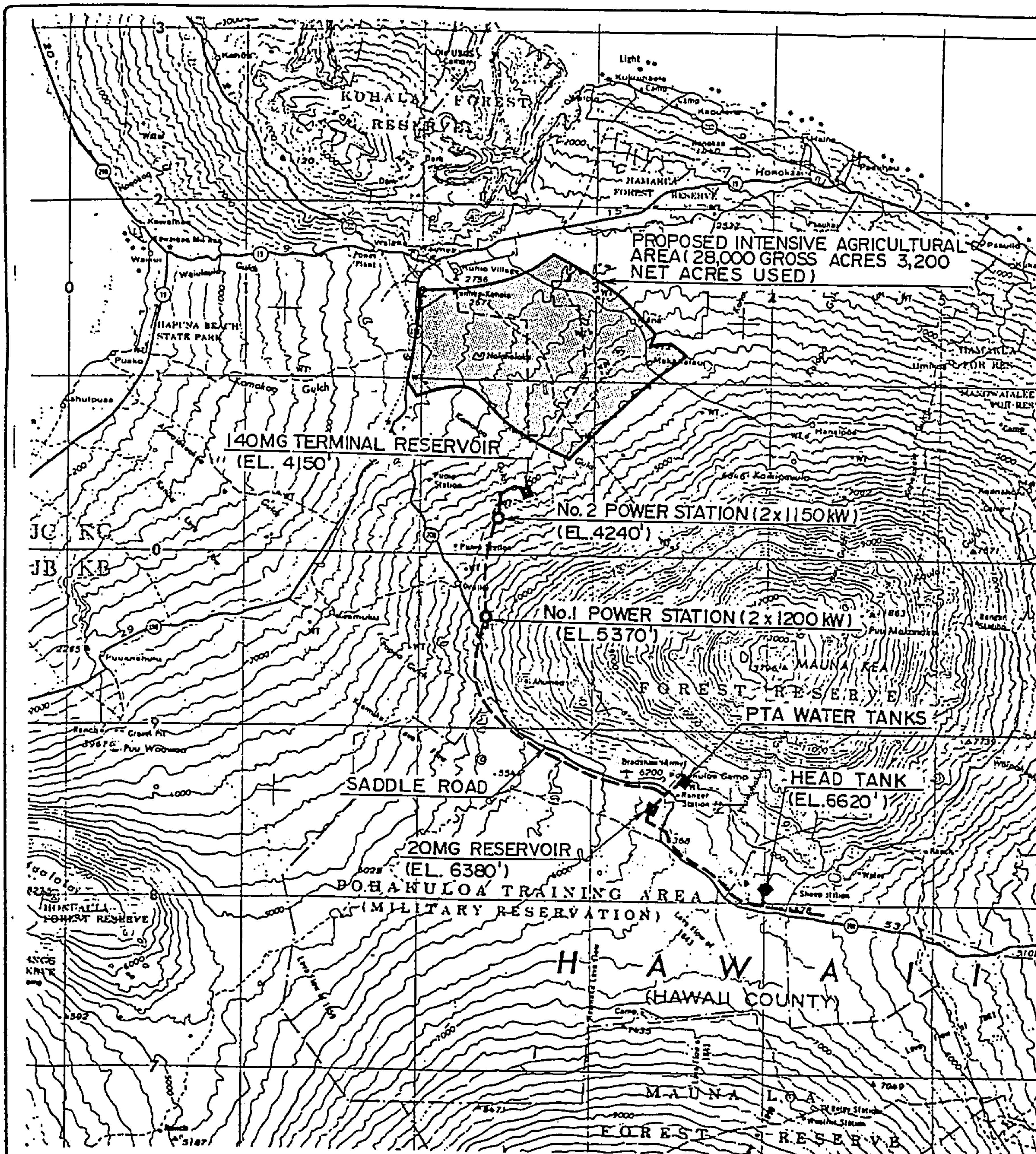

SCALE 1: 250,000
LEGEND
WELL
PUMP
RESERVOIR
HEAD TANK
SURGE TANK
KAUMANA
ELECTRICAL
SUBSTATION
DWS TANK
DEEPWELL SITE
PUMP STATION
#1
#2
#3
#4
#5
#6
#7
NKS
HILO
FOREST RESERVE
UPPER WAIAKEA
FOREST RESERVE
OLAA
FOREST RESERVE
HAWAII
VOLCANOES
NATIONAL
PARK
Kaloli Point

FIGURE 1.1



PROPOSED INTENSIVE AGRICULTURAL AREA (28,000 GROSS ACRES 3,200 NET ACRES USED)
140MG TERMINAL RESERVOIR (EL. 4150')
No.2 POWER STATION (2 x 1150 kW) (EL. 4240')
No.1 POWER STATION (2 x 1200 kW) (EL. 5370')
PTA WATER TANKS
HEAD TANK (EL. 6620')
SADDLE ROAD
20MG RESERVOIR (EL. 6380')
KOHALA FOREST RESERVE
HAMAKUA FOREST RESERVE
HAPUNA BEACH STATE PARK
MAUNA KEA FOREST RESERVE
POHAKULOA TRAINING AREA (MILITARY RESERVATION)
HAWAII (HAWAII COUNTY)
MAUNA LOA FOREST RESERVE

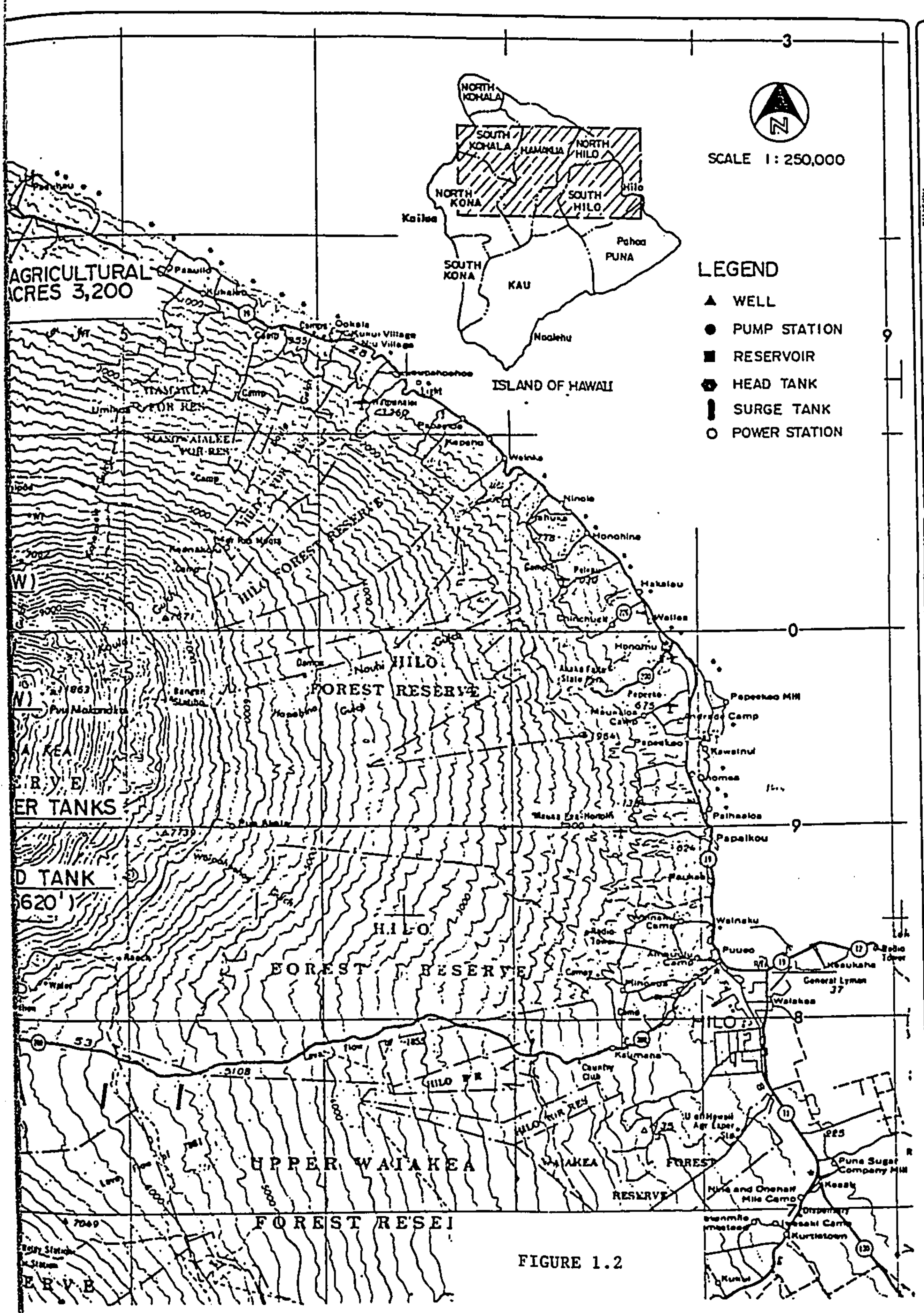


FIGURE 1.2

REVISION

NO	DATE	DWN	CHK

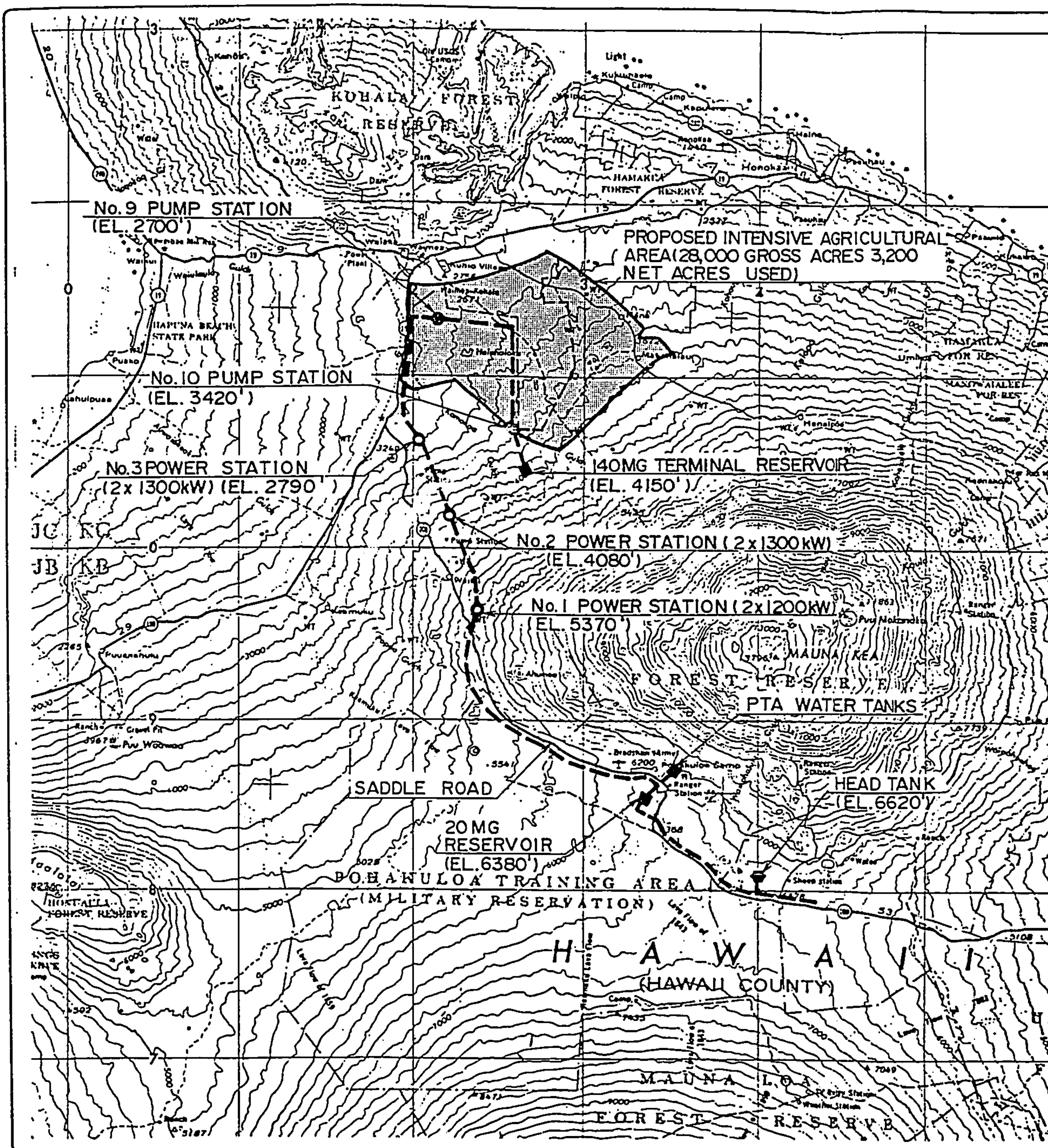
Okahara & Associates Inc.
CONSULTING ENGINEERS
200 KOHOLA STREET HILO HAWAII 96720
470 N NIMITZ HWY SUITE 212 HONOLULU HAWAII 96817

A WATER DEVELOPMENT & TRANSMISSION
ISLAND OF HAWAII
PHASE - II
ALTERNATIVE ROUTE A

DRAWING NO.

SHEET NO.
G - 5

REVISION
0



No. 9 PUMP STATION
(EL. 2700')
PROPOSED INTENSIVE AGRICULTURAL AREA (28,000 GROSS ACRES 3,200 NET ACRES USED)
No. 10 PUMP STATION
(EL. 3420')
No. 3 POWER STATION
(2x 1300kW) (EL. 2790')
140MG TERMINAL RESERVOIR
(EL. 4150')
No. 2 POWER STATION (2x1300kW)
(EL. 4080')
No. 1 POWER STATION (2x1200kW)
(EL. 5370')
PTA WATER TANKS
SADDLE ROAD
HEAD TANK
(EL. 6620')
20 MG
RESERVOIR
(EL. 6380')
KOHALA FOREST RESERVE
HAMAKUA FOREST RESERVE
MAUNA KEA FOREST RESERVE
POHAKULOA TRAINING AREA
(MILITARY RESERVATION)
HAWAII
(HAWAII COUNTY)
MAUNA LOA FOREST RESERVE

FIGURE 1.3

A WATER DEVELOPMENT & TRANSMISSION
ISLAND OF HAWAII
PHASE - II
ALTERNATIVE ROUTE B

Okahara & Associates Inc.
CONSULTING ENGINEERS
200 KOHOLA STREET
HILO HAWAII 96720
470 N NIMITZ HWY SUITE 212
HONOLULU HAWAII 96817

DRAWING NO.

SHEET NO.
G - 6

REVISION
0

Table 1.1

Land Ownership and Regulation[1]

TMK No.	Owner	Length, Feet	Use District	State Land Use Subzone
2-4-06-34	State of Hawaii	5,000	Ag 20	
2-4-08-2	Auto Imports of Hawaii, Inc.	6,200	Ag 20	
2-5-45-11	Joseph Silva & Gentry - Hawaii, Ltd.	200	Ag 20	
2-5-44-4	Joseph Silva & Gentry - Hawaii, Ltd.	3,300	Ag 20	
2-5-01-1	Mauna Kea Sugar Co.	10,000	Ag 20	
2-5-02-3	Mauna Kea Sugar Co.	5,200	Con	Resource Subzone
2-5-01-2	State of Hawaii	8,000	Con	Resource Subzone
2-5-01-3	Mauna Kea Sugar Co.	1,700	Con	Protective Subzone
2-5-01-11	Hawaii Conf. of the United Church of Christ	2,400	Con	Protective Subzone 1200' Resource Subzone 1200'
2-5-01-4	Hawaii Conf. of the United Church of Christ	5,500	Con	Resource Subzone
2-6-18-4	State of Hawaii	47,000	Con	Resource Subzone

[1]In sequence from well field to reservoir.

Table 1.1, continued

TMK No.	Owner	Length, Feet	Use District	State Land Subzone
2-4-08-8	State of Hawaii	11,200	Con	Protective Subzone
2-4-08-4	State of Hawaii	1,900	Con	Protective Subzone
3-8-01-8	HHL	39,000	Ag Con	Ag - 27400' Resource Subzone - 11500'
3-8-01-13	HHL	200	Con	Resource Subzone
4-4-16-5	State of Hawaii	28,300	Con	Resource Subzone
6-7-01-25	Parker Ranch	Variable	Ag	

1.5.3.3 Kawaihae-Hapuna-Puako System

This coastal service area will experience a major increase in demand as resort, recreational, and residential uses in this area expand. The Water Use and Development Plan anticipates a total requirement of 15.8 mgd by the year 2010. This would far exceed the present service capacity of the four Lalamilo wells currently rated at 4.8 mgd.

To accommodate the area's anticipated demand for water, work is progressing on the Kohala Coastal Transmission Pipeline. The conceptual plan is to develop a well field east of Hawi (North Kohala), producing 20 mgd and transmitting that water along the leeward N. Kohala coast to the Kawaihae area.

1.5.3.4 Waikoloa Water Company System

As this urban land development expands, additional deep wells will be drilled to accommodate expanding needs. At present a third production well has been completed and a fourth is under construction. The Water Use and Development Plan has indicated ultimate water consumption may experience a 6 to 7 mgd increase over the current usage of 2 mgd of potable water for resort use and 3.0 mgd of non-potable water for irrigation. This increase is to be supplied by additional deep wells sited on Waikoloa Development Co. lands within three separate well fields. The cost of water may rise as urban development progresses to higher elevations.

1.5.3.5 Waiki'i Ranch System

At the present time, there is no plan to expand the private water system at Waiki'i Ranch, which sells water at approximately $3.50 per 1,000 gallons (from a private deep well system).

1.5.3.6 PTA Water Supply System

The current average daily demand for water for PTA is 40,000 gallons per day to 80,000 gallons per day, depending on whether training soldiers are present. The water is used for potable and other uses such as washing vehicles and aircraft, fire fighting, and irrigation.

The potable water supply at PTA is derived from two sources. The primary source is from Pohakuloa Gulch springs which are tapped and transferred from the Mauna Kea State Park system. The average supply of water from the springs is less than 10,000 gallons per day. The spring water production varies over the year depending on precipitation. The average annual total supply from this source for the 1983-1985 period was less than 3.7 million gallons per year.

The second water source for PTA is purchased water trucked in from Hilo or Waimea. The water is purchased when demand exceeds supply from the Mauna Kea springs source.

Due to the fluctuation in PTA population and limited water storage capacity maintained by PTA, the amount of purchased water varies. However, given the range of average daily demand, it is estimated that 30,000 to 60,000 gallons of water per day are purchased at a cost of $28 per 1,000 gallons.

1.5.4 Non-Potable Water Systems

The coastal developments will continue to drill low elevation wells and utilize sewage effluent to supply most of the resort irrigation needs. These waters are characterized by high levels of dissolved solids and are not suitable for intensive agricultural purposes.

1.5.4.1 Parker Ranch System

A major cross-tie between the larger western water system and the eastern water system is planned for the near future. Running northeasterly at approximately 4000 feet elevation, the pipeline will start at Waiki'i and terminate near Makahalau. This would allow better utilization of rangeland during drought periods. On the other hand, it will have the effect of increasing water delivery costs through incremental amortization of capital and operating maintenance expenses. Stockwater currently costs the ranch approximately $2.00 per 1,000 gallons, delivered. There are currently no plans to increase the maximum usage of stock water on the ranch.

1.5.4.2 Waimea Irrigation System (WIS)

Joint sponsors, the Mauna Kea Soil and Water Conservation District, State Department of Land and Natural Resources, Department of Hawaiian Home Lands, and the State Department of Agriculture have initiated a program to improve and expand the WIS to service an ultimate capacity of 1,240 acres of intensive agriculture farm lots and 22,800 acres of pasture.

With the completion of these improvements, the system will have 80 percent reliability to supply a capacity of 4 mgd. Further, the Puukapu Deep Well Development project has found high level water at 1,300 ft. elevation from a well drilled near the Waimea 60 million gallon reservoir. This 1,700 ft. deep, 1.0 mgd well will be placed on-line in the near future to serve as drought reserve for the irrigation system (See Watershed Plan and Environmental Assessment: Waimea-Paauilo Watershed, Hawaii County, 1989).

1.5.5 Proposed Water Projects, South Kohala

Presently, approximately 3.4 mgd of potable water is supplied by the county municipal water systems, with an additional 1.3 mgd used for agricultural irrigation purposes. The future demand (year 2010) for this region is estimated to be 22.5 mgd for municipal water and 5.5 mgd for irrigation. Beyond the projected increased demand on the municipal water system, private water systems in South Kohala are expected to require 34.6 mgd, bringing the total regional water demand to 62.7 mgd by year 2010 (see Hawaii County Water Use and Development Plan, 1990).

These future needs are to be met, at least partially, by a number of ongoing water development plans and projects:

1. The Waimea Irrigation System is a Federal and State joint program which envisions a new 133 million gallon reservoir and necessary pipeline to support 363 acres of new cropland and to supply livestock water for an additional 8,200 head of cattle.

2. Planning for the Kohala Coastal Transmission Pipeline is underway to determine the route, costs, and engineering requirements to supply potable water to the South Kohala coastal region by importing groundwater from the North Kohala aquifer.

3. The Puukapu Deep Well Development program plans to develop a deep well in the Kohala Forest Reserve in Puukapu and connect it to the Waimea Irrigation System for standby irrigation uses.

4. There are ongoing efforts to seek out high elevation (perched) water in the Waimea area to provide water more cost effectively to the higher elevation areas.

1.5.6 Desalinization

In addition to ground and surface water, there is the potential for augmentation of the water supply through the desalting of brackish or sea water. While desalinization is currently utilized throughout the world, it has not been developed on a commercial scale in the State of Hawaii.

In order to determine the feasibility of desalinization, the State Department of Land and Natural Resources, along with Campbell Estate, the City and County Board of Water Supply and the University of Hawaii Water Resources Research Center is developing a 1-mgd plant in Ewa. The projected unit cost of water production is estimated to be around $3/1,000 gallons. This does not include the cost of storage and distribution. In that the desalinization facility would likely be at a low elevation, the cost of moving water to the higher elevations must also be considered. Consequently, the total cost of this alternative must be assessed.

The actual cost of water desalinization will depend on numerous factors, including the salinity of water, the scale of the facility, the elevation of the water source, the cost of electricity, and the method of desalting the water. It should also be noted that the major operating cost of the plant is for electricity or other energy sources.

The state of the art of desalinization is continually improving. Consequently, any assessment of this alternative water source must consider the most current costs and conditions related to the desalting of water. Consequently, as technology improves, the viability of water augmentation will need to be reassessed.

Chapter 2: **Project Features**

CHAPTER 2: PROJECT FEATURES

2.1 Project Features

The Water Transmission Pipeline project will consist of two segments. The first segment involves the construction of nine (9) vertical deep wells above Hilo with a capacity of 2.5 mgd each, and construction of a 42-inch diameter, buried pipeline linking the well field with a 20 million gallon reservoir at PTA (elev. 6,380 ft.). A total of 8 booster pump stations will be required along this route to lift water to the PTA reservoir (see Figure 1.1). Over this segment's 38.4 mile length, the proposed water pipeline will follow existing roadway or powerline easements across undeveloped private and state lands in the State Agricultural and Conservation Districts. Federal lands are also involved in the vicinity of the Pohakuloa Military Training Area.

The project further involves transmitting the stored water, via gravity flow, to a terminal site above the Waimea plain where a 140 million gallon reservoir is proposed. In areas of leeward Mauna Kea the pipeline will cross pasture lands in the State Agricultural District. This water is proposed to be used for the expansion of intensive agricultural activities in the region and provide an emergency backup system for Waimea's domestic water supply as well as the existing Waimea Irrigation System. Two alternative pipeline routes (Alternatives A, B) have been selected as shown in Figures 1.2 and 1.3, pp. 17-18.

The water transmission project, when fully operational, is expected to use 30 MW of electricity under Alternative A and 37 MW under Alternative B. However, 4.9MW (leeward route Alternative A, Figure 1.2) to 7.4 MW (leeward route Alternative B, Figure 1.3) of electricity are proposed to be generated by hydroelectric plants along the downhill segment of the pipeline, resulting in a net power requirement of approximately 25 MW for Alternative A and 30 MW for Alternative B.

The projected cost of water from this system is expected to range from $1.42 to $8.92 per 1,000 gallons of water, depending on the economic assumptions used. The cost for water development and transmission is expected to be approximately $250 to $312 million.

Development of the pipeline, including the reservoir system, is expected to require eight years, including time needed for permits and approvals. The actual construction of the pipeline itself will require two years. Project implementation, however, will depend on the availability of as yet uncommitted Federal and State funding and development of a dependable energy supply for across-island water pumping.

2.2 Water Well Field Development

There are a large number of potential water development sites in East Hawaii areas of Hilo, Hamakua, and Puna with proven but undeveloped water resources. However, as defined in the scope of this EIS, the feasible development of a water resource that can meet the dual project goals of providing a potential water source for PTA as well as potential end users in West Hawaii via a single transmission corridor limited available water development sites to areas above Hilo.

A preliminary assessment of water source development within other sectors of East Hawaii was conducted during the early planning stages of this project. These potential water sources were eliminated from further review because of one or more of the following factors:

* Relative distance to provide potential water service to both PTA and beyond to West Hawaii as defined in the project scope.

* Lack of power at the well field and along the transmission corridor.

* Potential impact on native species and forest area.

Accordingly, the water resource identified for development in this project is the Hilo Aquifer System (see Appendix A) which contains the largest undeveloped groundwater source in the State of Hawaii. After the evaluation of several alternative well field sites in the Hilo area (see Okahara & Associates, 1990), a site in the Waiakea-Uka area of Hilo (elev. 830 ft., within the Agricultural District) was earlier selected for test drilling to determine the ability of the site to meet the proposed 20 mgd water requirement for this project. This site fulfilled the criteria of being upslope of major residential areas (which use cesspools for waste water disposal), adjacent to the existing HELCO 138KV electrical transmission line, and on State land. The Department of Land and Natural Resources has recently completed drilling and testing of an exploratory well at this site. Well test evaluation indicates an abundance of confined water above the basal lens (250 ft. above sea level; see Appendix A-2) adequate to meet the requirements of this project.

Full development of the well field site will involve the utilization of approximately 15 acres of an undeveloped State land parcel totaling 319.6 acres (TMK: 2-4-06:34). Development of the well field site will include 9 deep wells (20 inches in diameter) located 300 ft. apart, a pumping station, control and administration building, electrical substation, diesel generator building (back-up power), base yard and access road connecting to nearby Hoaka Road (see Figure 1.1).

2.3 Pipeline Segment I: Hilo to Pohakuloa

A 42-inch diameter, buried steel water transmission pipeline will connect the Hilo well field with a 20 million gallon open reservoir proposed to be located at PTA. A total of eight pumping stations will lift water 5,790 ft. from the well field (830 ft. elev.) to a head tank (0.5 million gallons) at the crest of the Mauna Kea-Mauna Loa saddle at 6,620 ft. (Figure 1.1). From this point water will feed by gravity to a 20 million gallon reservoir at PTA (elev. 6,380 ft.). For the first 7.3 miles above the well field the pipeline will follow the existing 138 KV powerline easement to its junction with the Saddle Road (Figure 1.1). From this junction the pipeline will parallel the Saddle Road for the next 24.2 miles to the saddle crest (head tank), remaining within a 100-foot alignment of the road centerline (Figure 2.1). Each pumping station will lie adjacent to the Saddle Road, occupying an approximately 2-acre site which will include a 34-foot diameter intake reservoir, powerhouse, and electrical substation (Figure 2.2). The PTA 20 million gallon reservoir with gross dimensions of 300-850 ft. by 10 ft. deep (rubber lined) will occupy a proposed 10-acre site directly south of the PTA base facilities (Figure 2.3).

2.4 Pipeline Segment II: Pohakuloa to Waimea Area Terminus

Segment II of the water transmission pipeline involves the continuation of the 42-inch diameter pipeline from PTA via gravity flow to a 140 million gallon terminal reservoir (elev. 4,150 ft.) on Parker Ranch lands above the arid Waimea plain. Under route alternative A, the proposed alignment will follow the Saddle Road (south side) from PTA to the 5,400 ft. contour where it will deviate northerly from the road and descend across Parker Ranch pasture lands to the terminal reservoir site (Figure 1.2). Under gravity flow the water will pass through two specially designed hydro-generator turbines (located at 5,370 ft. and 4,240 ft. respectively; Figure 2.4) which will produce a combined 4.7 MW of electrical power for delivery to the HELCO system via the Waiki'i substation. Under this route alternative the 42-inch pipeline and terminal reservoir lie some five to seven miles from Waimea town, and an emergency water tie-in to the existing domestic and agricultural systems will be provided by a 12-18 inch ductile iron pipe running across Parker Ranch from the terminal reservoir to Waimea town.

Under route alternative B (Figure 1.3) the water transmission line would continue parallel to the Saddle Road and Belt Highway (#190) into Waimea (elev. 2,600 ft.) before returning and pumping water back uphill to the same terminal reservoir site (elev. 4,150 ft.). This alternative would require two additional pumping stations and permit one additional hydro-generator turbine as compared with alternative A. Net system power requirements under this alternative would be 30 MW vs. 25 MW under alternative A. The advantage of alternative B is that emergency tie-in with the existing Waimea domestic and irrigation water systems would be achieved with the full 42-inch diameter pipeline (20 mgd capacity).

The 140 million gallon terminal reservoir for this project would be constructed on a 30-acre site in pasture lands belonging to Parker Ranch. The open terminal reservoir will be of earthen design and rubber lined, with overall gross dimensions of 710 ft. by 1,060 ft. (Figure 2.5). The reservoir site has been selected so that the excavation and embankment volume is balanced to the greatest extent possible.

2.5 Cost of Water

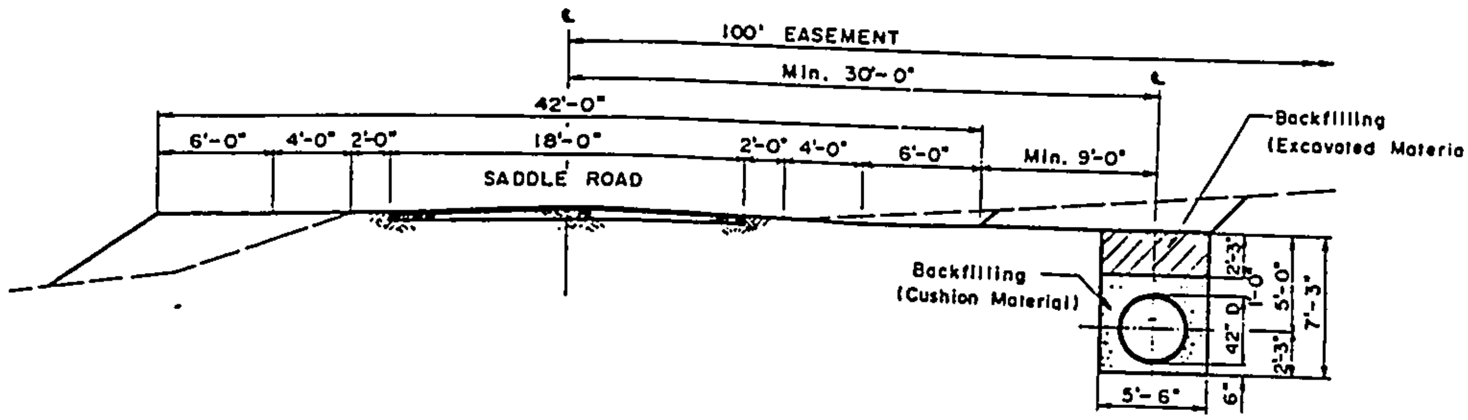
The estimated water cost delivered at the terminal point in the Waimea region by this project ranges from a low of $1.42 per 1,000 gallons to a high of $8.92 per 1,000 gallons, depending on the cost of power and interest and principal involved in financing the project (see Table 2.1). These estimated water costs are much higher than the current price paid for agricultural water in South Kohala ($0.75/1,000 gallons). It should be noted, however, that the current agricultural water rate is heavily subsidized.

The estimated water cost has two major components. The first component is the cost of construction of pipeline, booster pumps, reservoir, hydropower generation, and other related improvements. The total cost for this component is estimated to be $250 to $312 million. The second component is the electrical energy cost to pump the water. Although this cost varies with the actual amount of water being pumped, the annual electrical cost is estimated to be $16 million (assumed $/KWH of 0.06269) for a continuous pumping rate of 20 mgd.

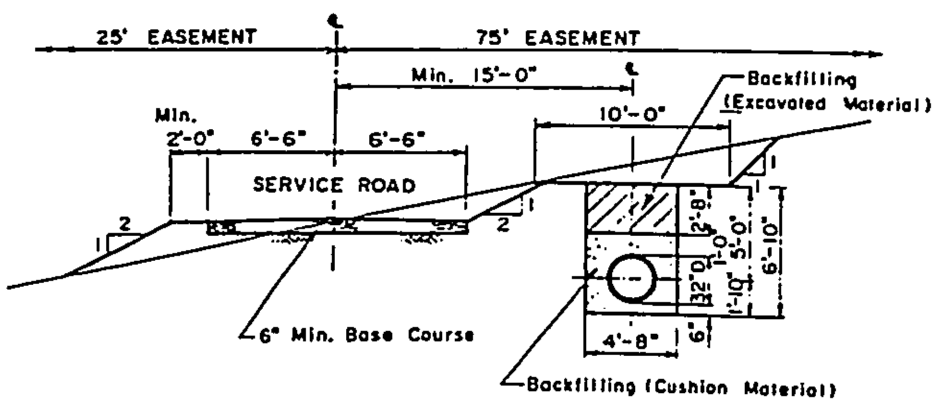
Considering the cost of time value of money (interest rate) and the power cost, a matrix of possible levelized water costs is estimated and presented in Table 2.1. The actual water costs will depend largely on the interest rate at which such funds are available and also on the energy cost. One possibility is that the entire project cost will be government financed. Under such a scenario the cost of water can be as low as $3.20 per 1,000 gallons at energy cost of $0.07/KWH or lower if cheaper energy is available. The current power cost for water pumping during off-peak hours is $0.06269. Alternatively, if the borrowing cost of 8 percent is combined with the energy cost of $0.07/KWH, the water price increases to $7.16 per 1,000 gallons.

The range of the water cost delivered at the Waimea terminus may be compared with the cost of water being developed and provided by Waikoloa Water Company to its urban customers. It should be noted that the cost of water includes both water resource development and distribution costs. The price of water that residents of Hawaii pay, including that of agricultural water, reflects only the distribution cost and excludes water resource development cost which is subsidized by the State.

On the basis of 1990 dollars, it was estimated that the Waikoloa water cost ranges between $3.50 to $3.75 per 1,000 gallons. The future water development cost for the Waikoloa area may be higher as new sources of water are developed at higher elevations. Ultimately, it will be the cost of water, whether locally developed or piped in, that will affect the final decision as to which source of water will be used. Should the proposed across-island piped water, in the future, prove to be cheaper than the locally-developed water, it would justify the pipeline development.

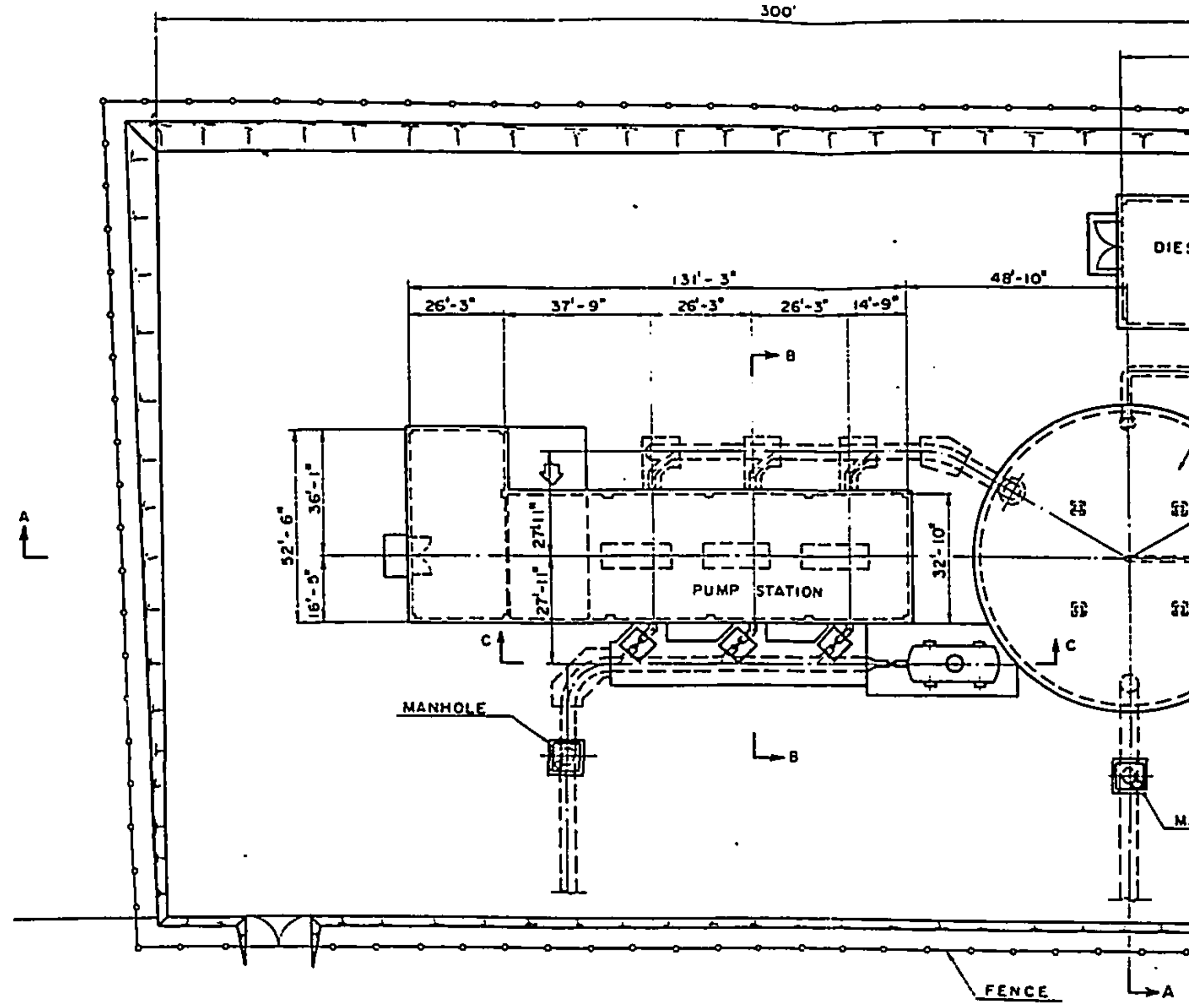


TYPICAL TRENCH SECTION ALONG SADDLE ROAD



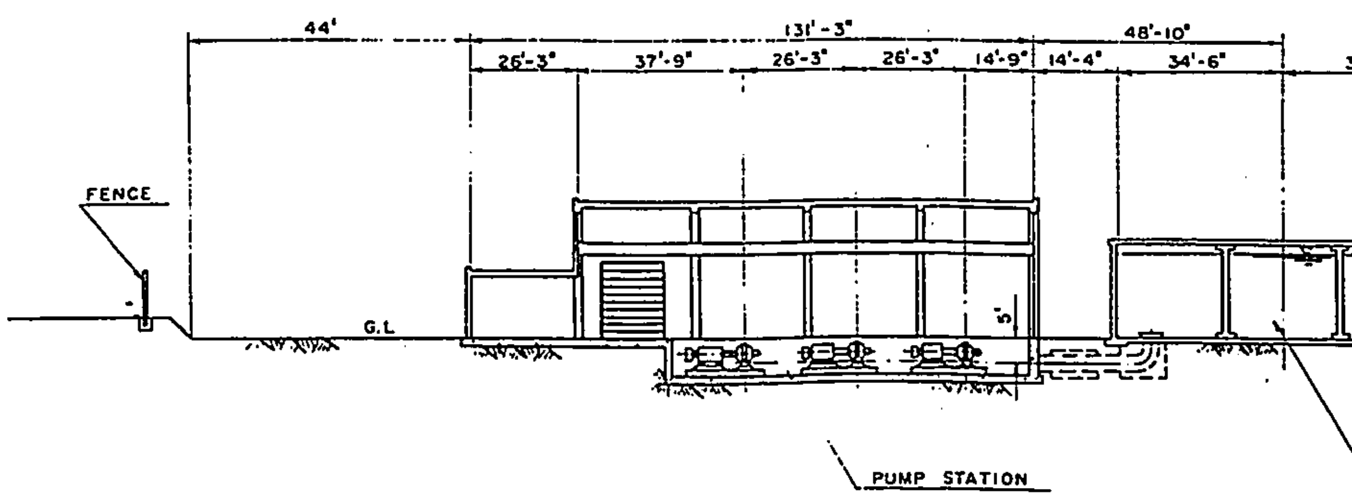
TYPICAL TRENCH SECTION ALONG PARKER RANCH SERVICE ROAD

FIGURE 2.1



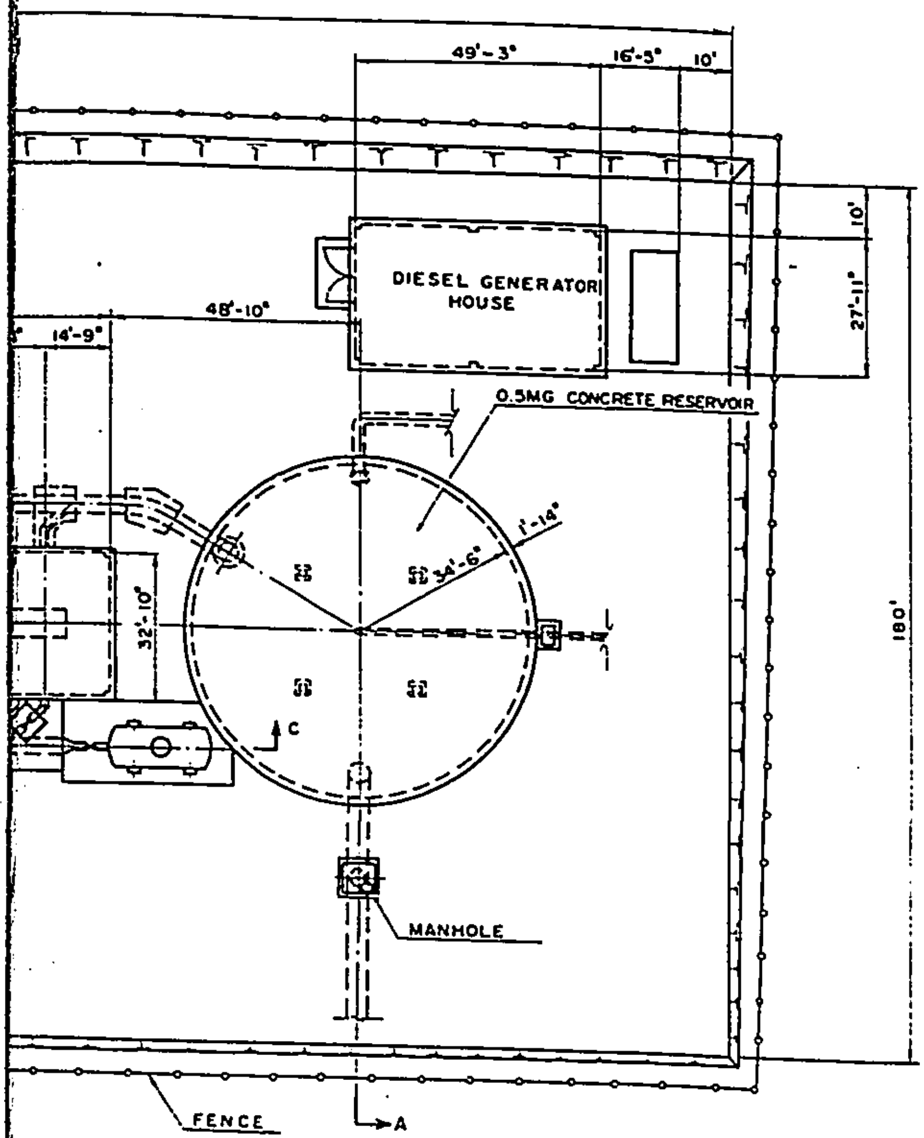
PLAN
SCALE 1" = 20'

NO. 4 – NO. 8 PUMP STATION PLAN AND S

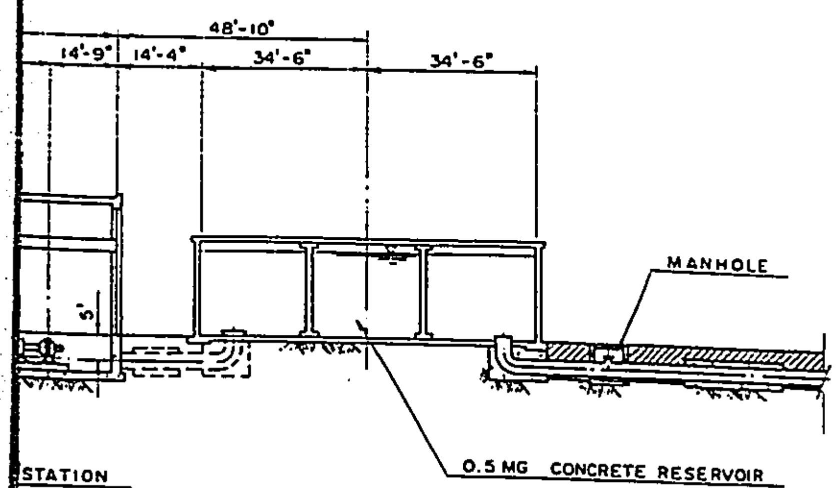


SECTION A–A
SCALE: 1"-20'

FIGURE 2.2

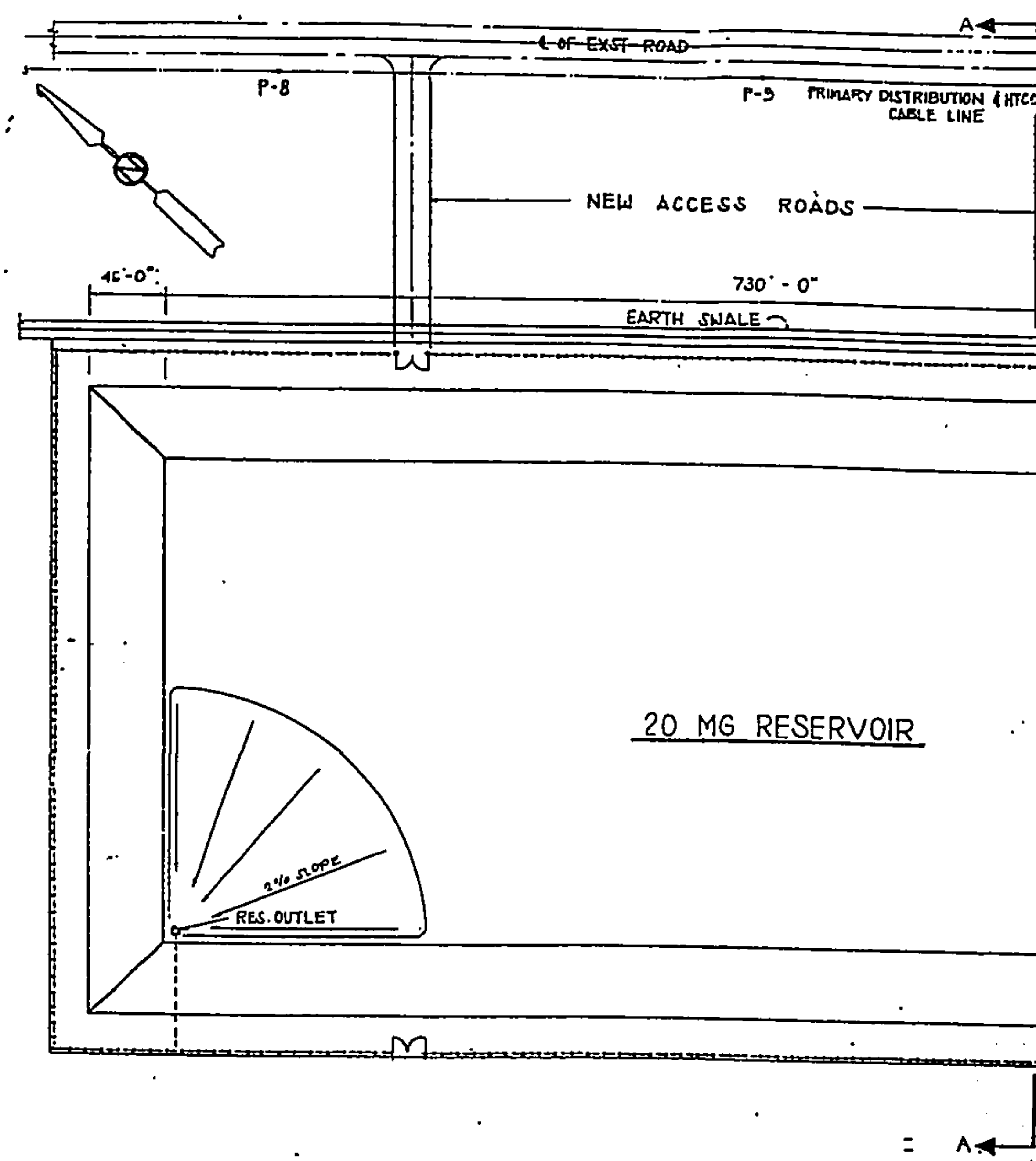


N PLAN AND SECTION

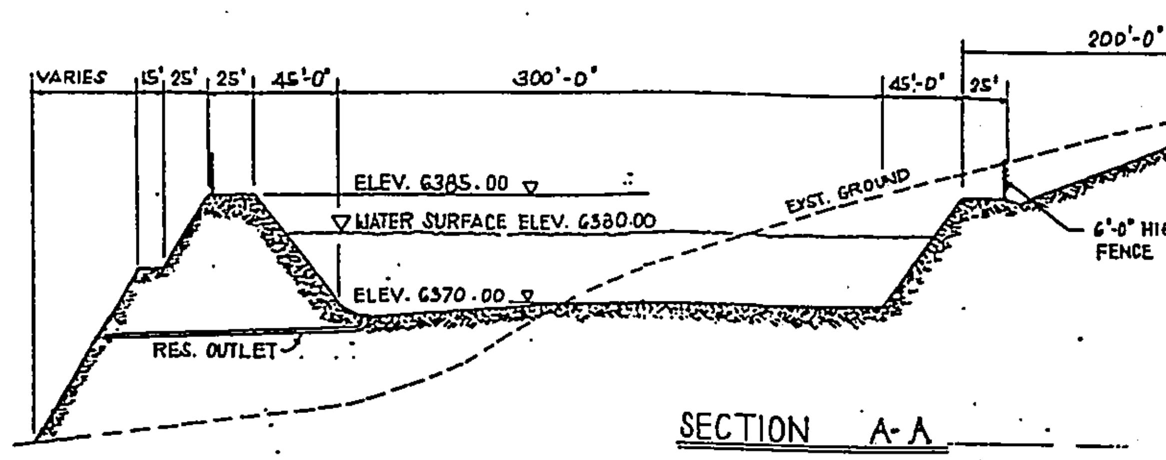


A–A

.2

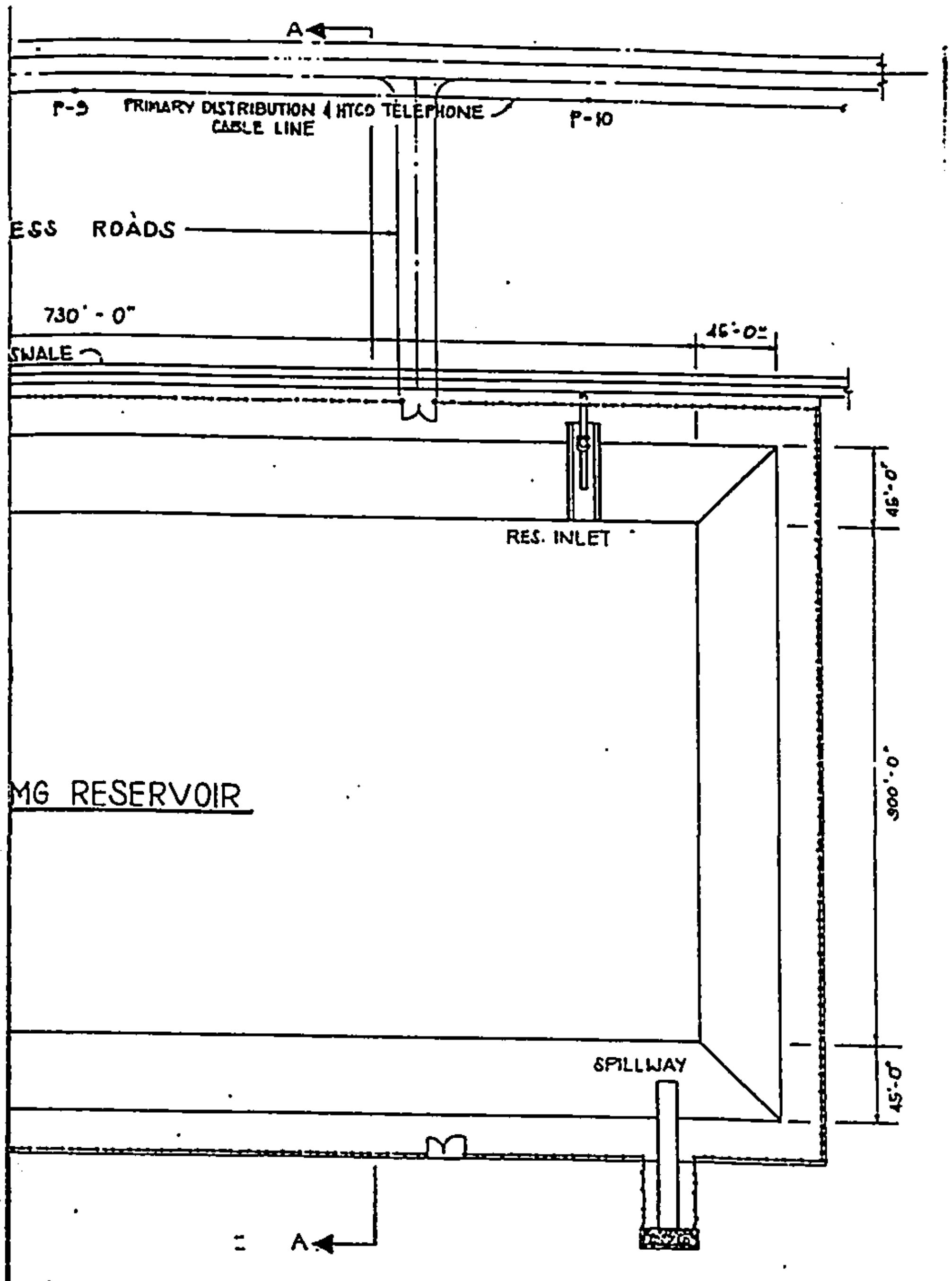


OPEN RESERVOIR PLAN AND SE



SECTION A-A

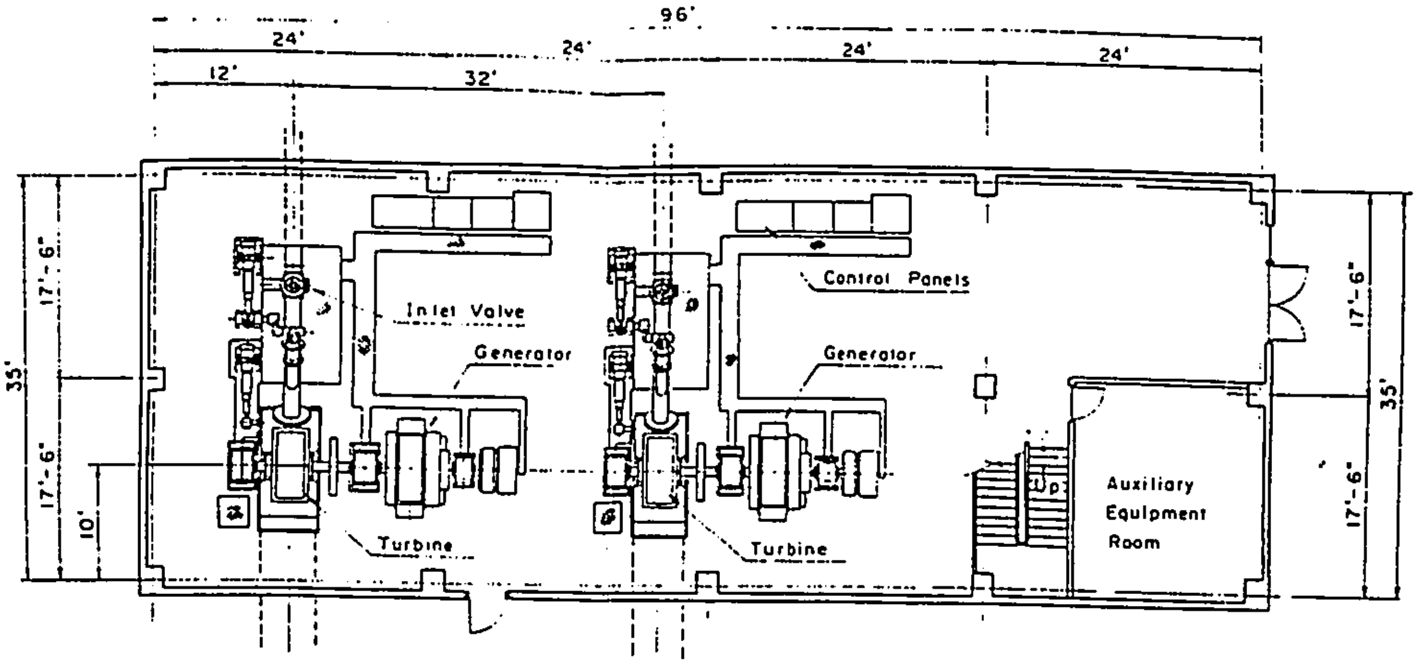
FIGURE 2.3



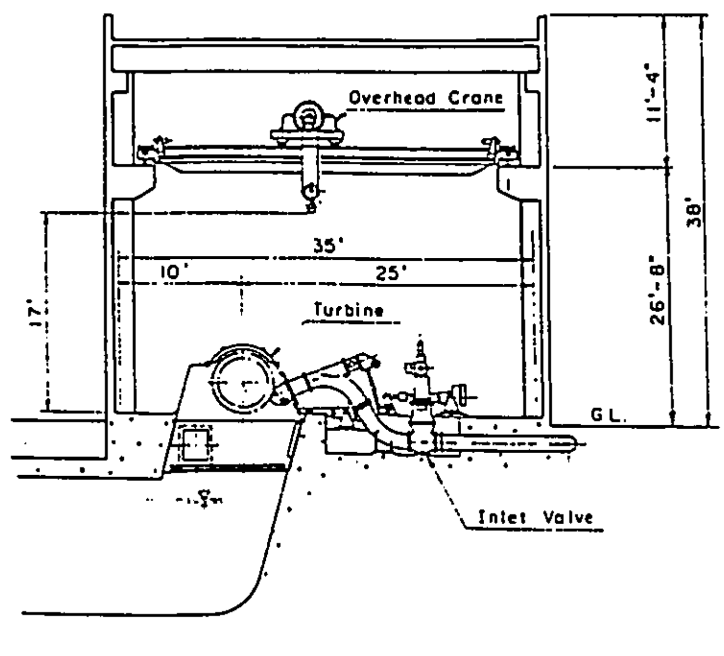
PLAN AND SECTION

ON A-A

GURE 2.3



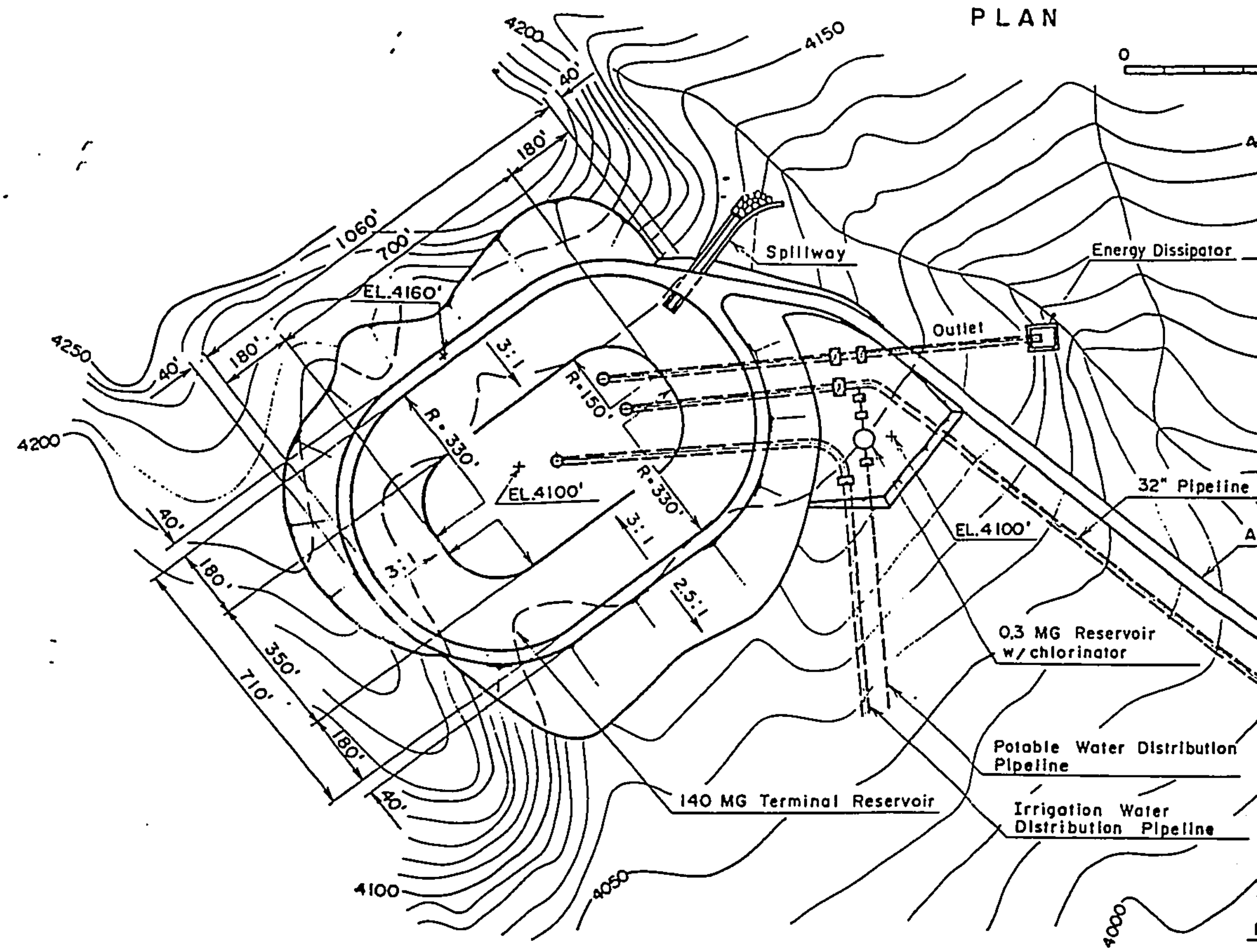
HYDRO-TURBINE PLAN VIEW



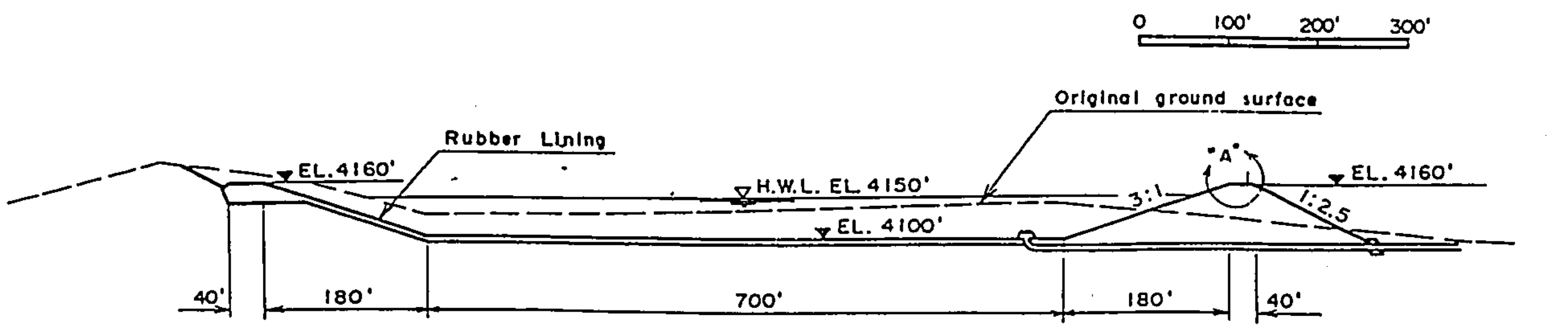
CROSS SECTION

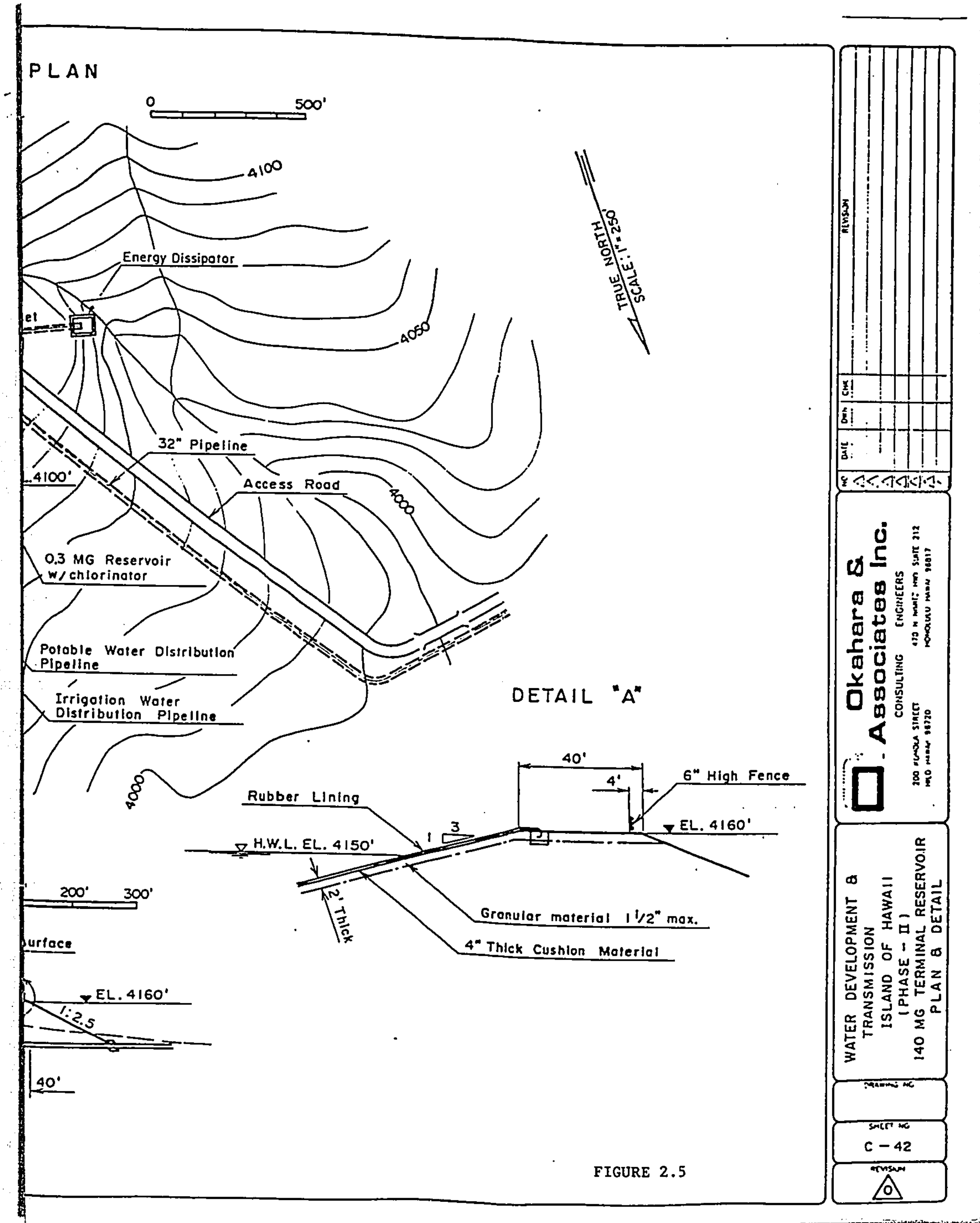
FIGURE 2.4

PLAN



TYPICAL SECTION





PLAN
0
500'
4100
4050
4000
4000
TRUE NORTH
SCALE: 1" = 250'
Energy Dissipator
32" Pipeline
.4100'
Access Road
0.3 MG Reservoir w/chlorinator
Potable Water Distribution Pipeline
Irrigation Water Distribution Pipeline
200'
300'
urface
EL. 4160'
1:2.5
40'
DETAIL "A"
40'
4'
6" High Fence
Rubber Lining
1
3
EL. 4160'
H.W.L. EL. 4150'
2' Thick
Granular material 1 1/2" max.
4" Thick Cushion Material
REVISION
DATE
Okahara & Associates Inc.
CONSULTING ENGINEERS
WATER DEVELOPMENT & TRANSMISSION
ISLAND OF HAWAII
(PHASE - II)
140 MG TERMINAL RESERVOIR
PLAN & DETAIL
DRAWING NO.
SHEET NO.
C - 42
REVISION
0

FIGURE 2.5

Table 2.1
Range of Annualized Water Costs
($ per 1,000 gallons)

Interest Rate (%)	Electricity Cost ($/Kwh) 0.07	0.06	0.05	0.04	0.03	0.02
12	8.92	8.57	8.21	7.85	7.50	7.14
10	8.03	7.67	7.32	6.96	6.60	6.25
8	7.16	6.80	6.45	6.09	5.73	5.38
6	6.33	5.97	5.62	5.26	4.91	4.55
4	5.57	5.21	4.85	4.50	4.14	3.79
2	4.90	4.54	4.18	3.83	3.47	3.12
0	4.35	3.99	3.64	3.28	2.92	2.57
0,0*	3.20	2.84	2.49	2.13	1.77	1.42

Source: Water Development and Transmission, Island of Hawaii, Phase II, Engineering Report, Okahara and Associates, September 1991.

*Case in which all capital costs are funded by the Federal government and thus the water cost represents only operating and maintenance costs.

2.6 Potential End Users

While no specific end user has been identified for the project at this time, there are several potential users of the project water, including:

1. U.S. Army's Pohakuloa Training Area
2. DHHL Homestead Lots
3. UH Institute for Astronomy
4. Intensive agricultural development in the Waimea area
5. West Hawaii urban and resort uses

The amount and source of water that these and other potential end users might require depends on a number of factors that are not as yet fully determined. Consequently, this analysis does not attempt to describe or analyze the specific water needs and requirements of these end users in detail. However, as these end-users finalize their development plans, the option of this pipeline as one potential source will have been fully considered and can be incorporated into the planning and impact assessment of the individual development.

2.6.1 Pohakuloa Training Area

The role of the military in Hawaii is not confined solely to Oahu. On the Big Island, the U.S. Army maintains the Pohakuloa Training Area (PTA) located approximately 38 miles from Hilo in the saddle area between Mauna Kea and Mauna Loa at an elevation of 6,200 ft. First developed during WWII, PTA today incorporates a total area of 182 square miles of land. These lands are leased State lands and Hawaiian Home Lands. A portion of the area is Federal land by presidential proclamation.

The base camp occupies 100 acres of land with 200 temporary buildings housing 40 permanent civilian and army personnel and an airfield (Bradshaw Airfield) which supports fixed-wing aircraft up to the size of C-130s. The remaining areas are used for military training activities including simulated war games, live firing of both small and large caliber weapons and related activities. This extensive area of the base is used intermittently, on a rotating basis, for short-term training exercises for 1,800-3,000 Army and Marine Corps personnel for approximately 260 days/year.

Current average daily potable water consumption at the Pohakuloa Training Area (PTA) is 60-80,000 gallons per day and is supplied by nearby spring water (shared with adjacent Mauna Kea State Park) and is supplemented by purchased potable water trucked from Hilo or Waimea at a cost of $28 per 1,000 gallons.

The existing PTA Masterplan, which is currently being revised by the Army, identifies in its Mission Statement that PTA is to "develop, operate, and maintain a safe, state-of-the-art, multipurpose army training area for the Army and other Pacific Command (PACOM) units." Accordingly, there are on-going plans for the continued modernization of the training facilities. One "planning" computation of water requirements to support this modernization program suggests that additional water demand up to 1.2 mgd of potable and 3.9 mgd of non-potable uses (largely for irrigation, fire fighting, and other military uses) are needed. (Under Correspondence Section, see letter from Department of Army dated April 12, 1991.)

2.6.2 Hawaiian Home Lands (Humuula, Piihonua)

General lease cattle ranching activities currently operate on Hawaiian Home Lands of Humuula and Piihonua (49,000 acres) which adjoin the PTA toward the east. The proposed water transmission line along the Saddle Road will pass through these DHHL lands. Basically the question is whether these waters could serve the future development of Hawaiian Home Lands at Humuula and Piihonua. DHHL has recently leased five 100-acre parcels for homesteading (cattle pasture), but no water or infrastructure is provided. There are no immediate plans for releasing more of this acreage. Current general leases for Humuula and Piihonua will expire at varying times over the next ten years (Piihonua in 1993 and parts of Humuula over the next decade). When these leases expire, there will be more active planning for subdivision and homesteading. Presently, DHHL is thinking of parcels larger than 100 acres as part of its homesteading program. DHHL has no firm plans for the development of Piihonua and Humuula, but in general they are planning to develop these lands for homesteading purposes over the next decade and are therefore interested in accessing water from this pipeline. When the water might be needed and the amounts of water to be used cannot be quantified at this time.

2.6.3 University of Hawaii

Water needs for the University of Hawaii Institute of Astronomy remain comparatively small. The total estimated demand is 4,100 gallons per day at Hale Pohaku and an additional 1,250 gallons per day at the Mauna Kea summit area. At present the water is being trucked in from Hilo at a cost of $90 per 1,000 gallons. The University could substantially reduce current water cost by trucking water from the proposed pipeline route at Humuula.

2.6.4 Intensive Agriculture Development in the Waimea Area

According to the Assessment of Agricultural Industry Development in the South Kohala region of West Hawaii (Appendix C), there is the potential to support up to 5,315 acres of additional agricultural development in the Waimea area for export/import substitution. This would require up to 18 mgd of water. Potential vegetable crops include tomatoes, head and romaine lettuce, potatoes and onions. Orchard crops include apples, grapes, and protea. These crops have been identified as economically viable at the comparatively high project water costs. Many traditional island-grown crops fail the water sensitivity test and are not viable at the projected water costs.

DHHL's Puukapu agricultural lots and Parker Ranch are the major potential agricultural end users for the project's water. However, there are many requirements that must be met before these lands can be brought into intensive agricultural use (see Unresolved Issues in Chapter 6). These include:

1. Adequate capital funding to support the pipeline construction

2. Land owner/users commitment of lands to intensive irrigated farming

3. Adequate funding for farm infrastructure (e.g. possible Agricultural Park development at a cost of perhaps $30 million)

4. Adequate supply of farmers and farm laborers

5. Lowest possible cost of water

2.6.5 West Hawaii Urban Uses

The County has indentified the South Kohala region as one of the prime visitor destination areas of the County. Three major resort areas have already been established with the potential for expansion. In addition, there is potential for the expansion of these resort activities and the establishment of new recreational and visitor amenities in the Puako/Hapuna area as well as the expansion of existing residential communities of Waimea and Waikoloa. The County General Plan also identifies the State's Lalamilo area and Kawaihae as potential urban expansion areas. All of these existing and new areas will require additional water sources to support their growth. Ultimately the timing, cost, and availability of water will determine the source utilized.

Significant growth is also anticipated in the North Kona region. This region faces similar concerns regarding long-term water availability because of rapid growth in water demand and lower average rainfall compared to the windward districts of the island.

2.7 Project Schedule

A general project schedule for water transmission line development and construction is presented in Figures 10-1, 10-2, and 10-3 in Appendix B. As indicated on this schedule, completion of the project is expected to take 5-8 years, depending on appropriate funding availability and timely implementation of all project phases. Once the system is operational, it is further assumed that system water demand will grow at about 2-3 mgd each year from the estimated project completion date in 1999. Full system capacity of 20 mgd would be achieved between 2007-2010.

2.8 Operating Authority

No definite administrative structure has been defined at this time. One possible option is to establish a State Water Transmission Authority by legislative action. In basic structure, the authority would be administratively attached to a State executive department and have powers of condemnation, bond floating, operation and maintenance, and contract issuance.

In this scenario the authority would primarily be responsible for the development, transmission, and sale of water to potential end users. It is implicitly assumed that the authority will have the responsibility of mobilizing the funding for water resource development, pipeline and reservoir construction, setting a price for the water, and determining the end user(s). It is not seen as entering into the area of distribution of water to individuals as is the case with the Department of Water Supply (DWS). Rather, the authority is envisioned as a potential supplier of water to large users including DWS.

Other potential administrative structures include a government agency operating the water system or a public-private utility company. In any case, before this project can proceed, the operating structure must be identified and established.

Chapter 3:
Environmental Setting and Impact Analysis: Potential Impacts and Proposed Mitigation

CHAPTER 3: ENVIRONMENTAL SETTING AND IMPACT ANALYSIS: POTENTIAL IMPACTS AND PROPOSED MITIGATION

This section describes the existing environmental conditions and the probable impacts of the proposed action that would affect the environment. Mitigation measures designed to reduce or eliminate adverse environmental impacts are also presented.

Certain impacts, such as those on the vegetation and on historical and archaeological resources, can be termed "site specific." These are impacts that are confined within the boundaries of the proposed action. A second category of impacts to be evaluated, those with regional implications, would have an effect on the surrounding region regardless of what specific site is selected for the project and would include, for example, off-site air quality impacts associated with the electrical energy requirements of the proposed project.

The specific scope of this EIS is to evaluate the environmental impacts directly associated with site-specific water development, transmission and storage, and to characterize the general feasibility of across-island water transfer with respect to environmental costs.

The potential end users of water (e.g. PTA and Parker Ranch) represent a currently unresolved issue, and any proposed agricultural or other developments that may be initiated to utilize water resources from this project will necessarily be required to address environmental issues related specifically to their use activities. It is intended that to the extent these potential end users consider across-island transmission and with respect to this as a potential water source, the information contained herein will be utilized to assist in understanding the issues, costs, and opportunities presented by this project.

Environmental impacts may further be subdivided into those that have either short-term or long-term effects upon the environment. The temporary noise and fugitive dust associated with project construction would present short-term impacts while, for example, in the present case there would be long-term economic and social impacts relating to the substantial energy requirements for the project.

3.1 Geology & Volcanic Hazard

3.1.1 Existing Conditions

The first thirty-eight miles of the proposed pipeline right of way from Hilo to the Pohakuloa Military area traverses the Mauna Loa volcanic shield from an initial elevation of 800 ft. to the crest at 6,500 ft. in the saddle area between Mauna Loa and Mauna Kea (Figure 1.1). Mauna Loa is an active, basaltic volcano with at least 39 summit and flank eruptions recorded historically since 1832 (see Lockwood, et al., 1988, for generalized ages of surface lava flows on Mauna Loa).

Mullineaux, et al., (1984) have classified the Island of Hawaii into nine lava flow hazard zones in order of decreasing risk of lava inundation. The location of the proposed water transmission project in relation to these lava flow hazard zones is presented in Figure 3.1. It will be noted from this map that the zone (#1) of highest volcanic risk (e.g. more than 25 percent of the land area in this zone was covered by lava since 1800) is associated with those areas immediately adjacent to the calderas and major rift zones of the active volcanoes Mauna Loa and Kilauea.

Hazard zones #2-#3 (with lava flow inundations respectively of 15-25 percent and 1-15 percent of land area covered since 1800) generally characterize areas of increasing distance downslope from the active summits and rift zones of both Mauna Loa and Kilauea. Extracted from Figure 3.1, the proposed water transmission project will include 31.2 miles (50.4 percent of pipeline length, alternative A) crossing within Lava Hazard Zone #2, and 7.0 miles (11.3 percent), including the well field, in Lava Hazard Zone #3. It will be noted (Figure 3.1) that the entire City of Hilo is also included within risk zone #3. The leeward segment (23.5 miles or 38.0 percent following alternative route A) of the water transmission project from Pohakuloa to the Parker Ranch terminal reservoir crosses the geologically older slopes of the dormant volcano Mauna Kea in comparatively low risk Lava Hazard Zones #7-#8 (no lava flow activity in the past 750 years).

3.1.2 Probable Impacts of Proposed Action and Mitigation Measures

Geologic hazards associated with volcanic eruptions from the summit and northeast rift zone of Mauna Loa are significant within the windward project area. Thirty-eight miles of the proposed pipeline corridor is included within volcanic Hazard Zones #2-#3. Although the proposed water pipeline will be buried throughout its entire length for both aesthetic considerations (close proximity to the Saddle Road) and in order to mitigate against the threat of lava inundation, associated surface structures such as booster pump stations and surge tanks (particularly in the 31.2 miles of the proposed route in Hazard Zone #2) will face significant risk of lava inundation over the projected life (50 years) of the project.

Permanent, or "built-at-time-of-threat" deflection berms and barriers were considered as means to protect pumping stations and other above-ground pipeline appurtenances as shown in Figure 3.1, Volcanic Hazard Zones #2-#3 areas of the project (See Appendix A-3).

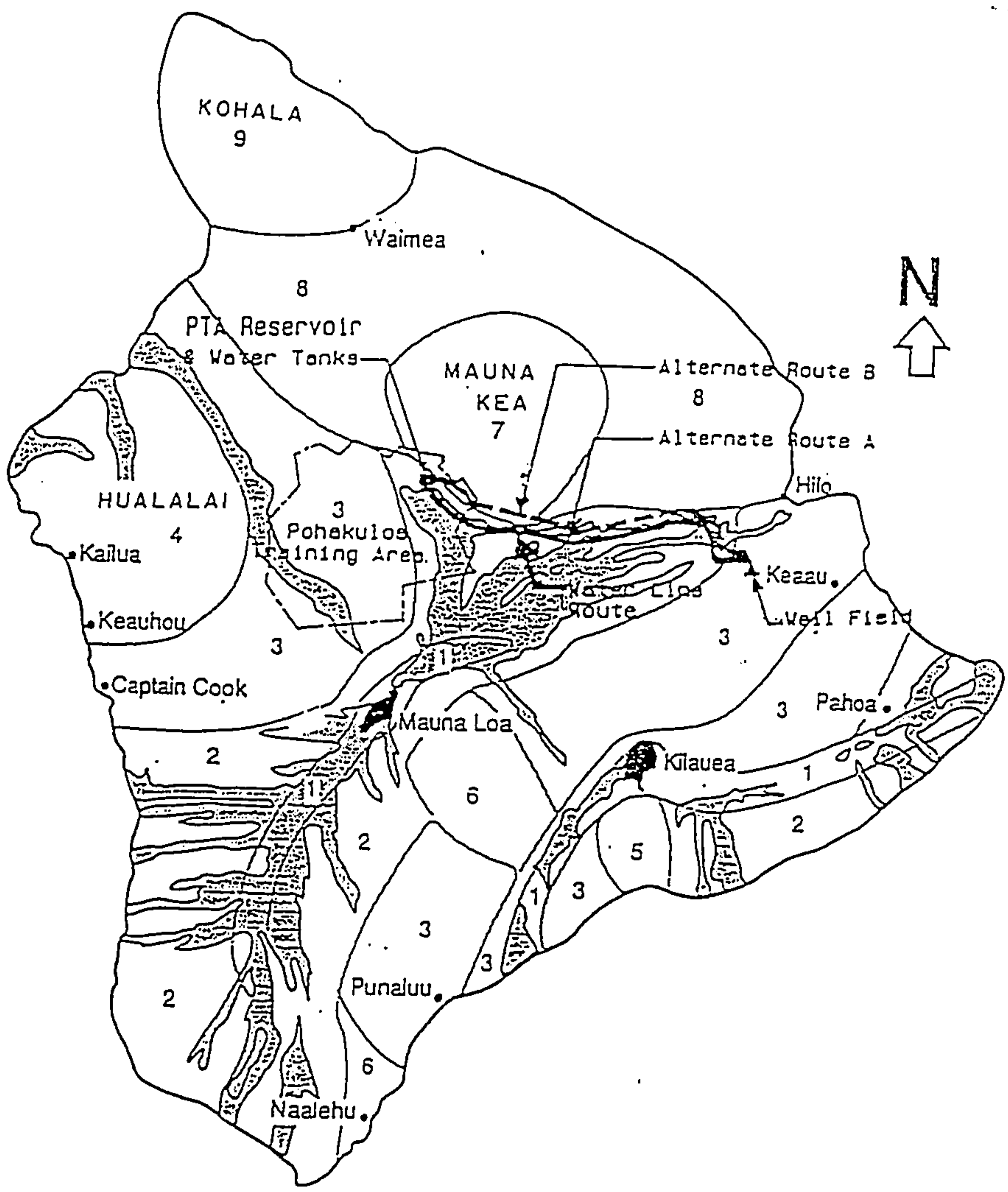
There is extensive literature on the general feasibility of using earthen berms and barriers to deflect advancing lava flows (see for example previous studies on providing lava flow protection for the City of Hilo; U.S. Corps of Engineers, 1980). Recently a lava diversion barrier has been constructed of locally grubbed lava material above the NOAA Mauna Loa Observatory at the 11,000 foot level on the upper slopes of Mauna Loa (Moore, 1982). The current design of the pipeline through this relatively high risk volcanic area includes the provision of pressure taps spaced at approximately 300 ft. intervals along the pipeline to provide water access for fire fighting and lava quenching/diversion contingencies.

In the initial planning for the water transmission project it was proposed to mitigate the lava inundation risk for pumping stations #4-#8 (see Figure 1.1) which are located in lava flow risk zone #2 (Figure 3.1) by the construction of diamond-shaped lava barriers of bermed material (20 ft. high and approximately 94 ft. wide at the base) grubbed at the site from surrounding a'a and pahoehoe lava surfaces (pumping stations #4-#8 are on or adjacent to the historic Mauna Loa lava flows of 1855, 1881 and 1935). Approximately 200,000-250,000 cubic yards of grubbed material would be required to construct the protective levee (perimeter length 2,500-2,800 ft.) which would incorporate an area of approximately 4-5 acres. If grubbed material were to be collected from the surrounding lava flow lands to a depth of 6 ft., approximately 25 acres of land around each pumping station would need to be bulldozed to collect sufficient levee material to protect the 2-acre pumping station site.

After completion of avian and botanical route surveys conducted in conjunction with the development of this EIS (See appendices D and F), it became apparent that this magnitude of native forest disturbance at each of the pumping station sites would be environmentally significant on the ecologically sensitive windward slopes of Mauna Loa. Mitigation of lava hazard to pumping stations through the construction of diversion berms appears to present unacceptable environmental costs and compromise to the aesthetics of roadside vistas along the Saddle Road. The revised plan is to forgo the construction of permanent, in-place diversion structures, while leaving open the option of building temporary diversion structures rapidly, should any or all of these pumping station sites come under the eminent threat of inundation from a future Mauna Loa lava flow.

It should further be noted that in the event of future lava flows in the Saddle Road area, even if lava diversions were successful in protecting pumping stations and other above-ground pipeline appurtenances, the water pumping capabilities of the transmission system would be interrupted once the lava destroyed any portion of the unprotected 138KV electrical transmission lines servicing the pumping stations with power. Although the pumping stations will include on-site electrical generators to facilitate continuous operation during short interval electrical outages (minutes to hours), the water pumping system could not function in any long-term capacity without line power. Because the Saddle Road pumping stations lie generally upslope of the city of Hilo, there remain unresolved legal liability questions with respect to the impact of any upslope lava diversion efforts to protect pipeline components.

Figure 3.1 Volcanic Lava Flow Hazard Zone (Zones 1-9 in order of decreasing hazard)



3.2 Soils

3.2.1 Existing Conditions

The soils occurring along the water transmission corridor are illustrated in Figures 3.2a-3.2f, and are based on U.S. Soil Conservation Service maps prepared for the Island of Hawaii (S.C.S. 1973). For the first 38 miles of the project route above Hilo the pipeline generally follows late prehistoric and historic lava flow substrates (1855, 1981, 1935 and 1843) where soil is either absent or composed of incipient histosols (thin organic muck formed from the litter accumulation under young lava flow vegetation).

Beginning in the vicinity of PTA, the pipeline alignment moves onto the slopes of dormant Mauna Kea volcano where surficial geology includes prehistoric lava and ash deposits of the Lower Laupahoehoe and Upper Hamakua volcanic series. Soils here (Figure 3.2c-3.2e) are better developed and include Ke'eke'e, Kilohana and Waimea soils of loam and sandy textures. Although generally exhibiting only slight erosion hazard from overland water flow, due to high surface porosity the soils are subject to moderate to severe hazard from wind erosion because of small particle sizes associated with these soil types.

3.2.2 Probable Impacts of Proposed Action and Mitigation Measures

No significant soil erosion problems or mitigation actions are anticipated in this windward Mauna Loa area during the trenching and laying of the pipeline due to high surface porosity and the general absence of developed soils on the historic and prehistoric lava flows that constitute the right of way. The fine-textured soils (volcanic ash derived) on leeward Mauna Kea are subject to potential wind erosion (fugitive dust and wind blown soil) during the construction phase of the project (vegetation removal, trenching and soil stockpiling and back filling). Surface sprinkling and wetting down of exposed soil areas will be implemented during the construction phase in wind erosion-prone soil areas to reduce potential short-term adverse environmental impacts. Subsequent to construction, the right of way will be reseeded with grass species presently occupying the area (Parker Ranch pasture grasses) and irrigated until ground cover is reestablished.

3.3 Climate and Air Quality

3.3.1 Existing Conditions

1. Climate

The climatic conditions occurring within the project area are diverse, reflecting the variety of environments traversed by the pipeline right of way on both windward Mauna Loa and leeward Mauna Kea. With respect to the proposed pipeline route, median annual rainfall ranges from more than 200 inches per year on the windward slopes of Mauna Loa to less than 15-20 inches per year in the Pohakuloa (Saddle Road) area and on Parker Ranch lands south of Waimea (see Figure 3.3). Average temperatures decrease systematically with elevation on the mountain slopes (approximately 3 degrees F./1,000 ft. rise in elevation) and range between 70 degrees F. (Hilo well field site) and 55 degrees F. (Pohakuloa area at elevations above 6,000 ft.) within the project area.

2. Air Quality and Noise

Existing air quality within the project area can be characterized as good to excellent due to the general lack of large population concentrations and no significant industrial pollution sources. The persistent northeast tradewinds, combined with nocturnal down-slope mountain winds, provide generally good circulation and throughflow of clean marine air throughout the project area.

The near decade-long continuous volcanic eruption on the northeast rift of Kilauea volcano has resulted in significant air quality deterioration (vog) in down-wind areas such as the leeward Kona district of the island where tradewinds are absent. Occasional short-term vog episodes can also occur in the Hilo, Saddle and Waimea areas during periods of southerly air flow.

Ambient noise levels along the Saddle Road from above Hilo to Pohakuloa are generally low, reflecting the light traffic volume and remote, unpopulated nature of the forested landscape. Noise levels in the vicinity of PTA can be periodically high in association with military training activities (e.g., live firing of artillery) and low-flying military aircraft, including helicopters and jet fighters.

3.3.2 Probable Impacts of Proposed Action and Mitigation Measures

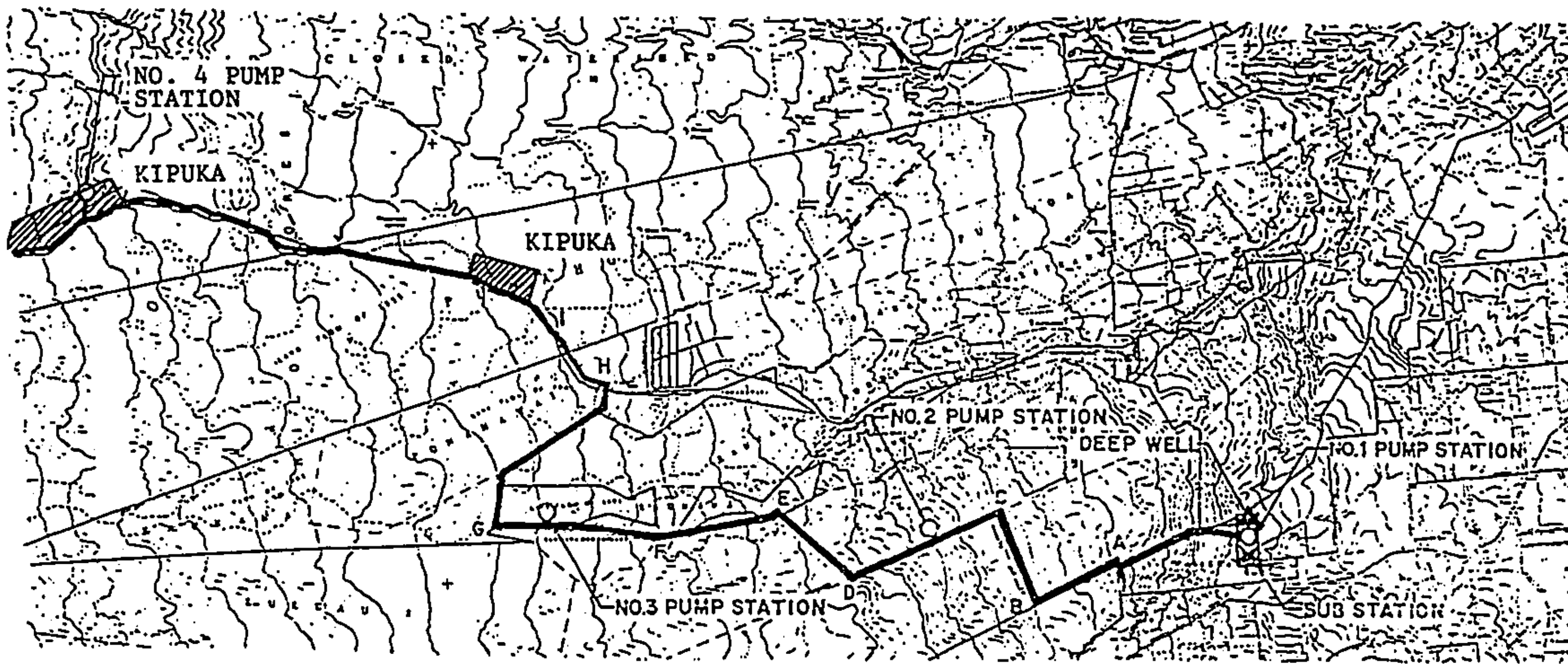
1. Climate

The proposed project should not significantly affect the climate of the pipeline route nor the Waimea plain. The provision of irrigation water to agricultural areas of the Waimea plain will locally elevate atmospheric humidity and depress soil and air temperatures in and immediately adjacent to crop areas. However, the strong and persistent winds that characterize the region will rapidly disperse evaporating water vapor to leeward.

2. Air Quality and Noise

a) Short-term construction-related

Construction activities associated with blasting and trenching for burial of the 42-inch pipeline (to a depth of 7-10 ft. below grade), development of the 13-acre well field,



SUBSTRATE

1855 LAVA FLOW	1881 LAVA FLOW	KEEI ROCKY MUCK	

LAVA HAZARD ZONE

ZONE #2	ZONE #3	

GENERALIZED VEGETATION

WET OHIA – KOA FOREST	

SENSITIVITY

MED	HIGH	MEDIUM	MEDIUM (INSIDE POWERLINE EASEMENT)			
			HIGH	MED	HIGH	

SENSITIVE BIOLOGICAL FEATURES

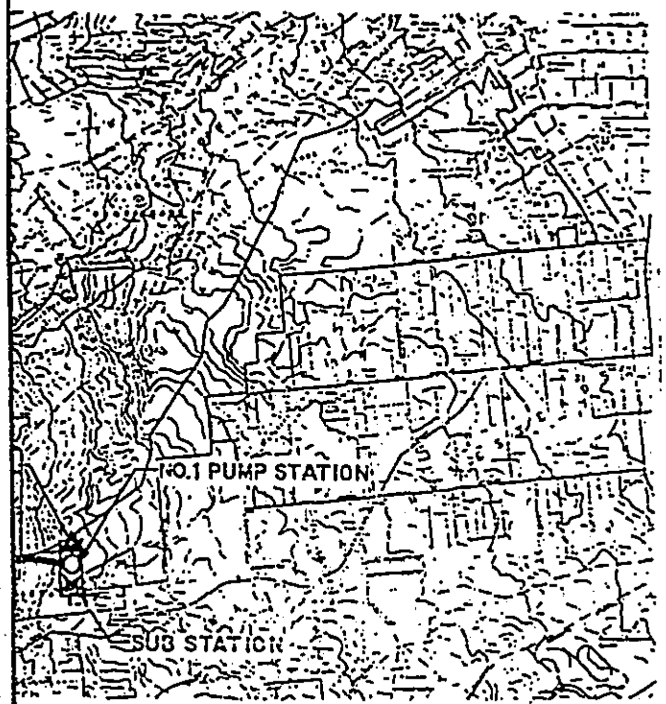
KIPUKA		KIPUKA	

ZONING (LAND USE DISTRICTS)

CONSERVATION RESOURCE (R) & PROTECTED (P) SUBZONES	P	AGRICULTURAL (20 ACRES)	

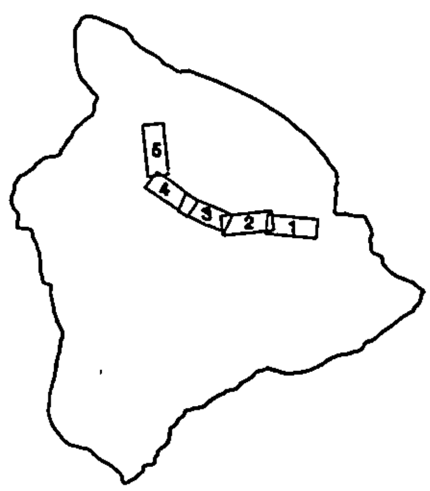
USE OF SURROUNDING PROPERTIES

FOREST	AGRICULTURAL / RE



HIGH

AGRICULTURAL / RESIDENTIAL

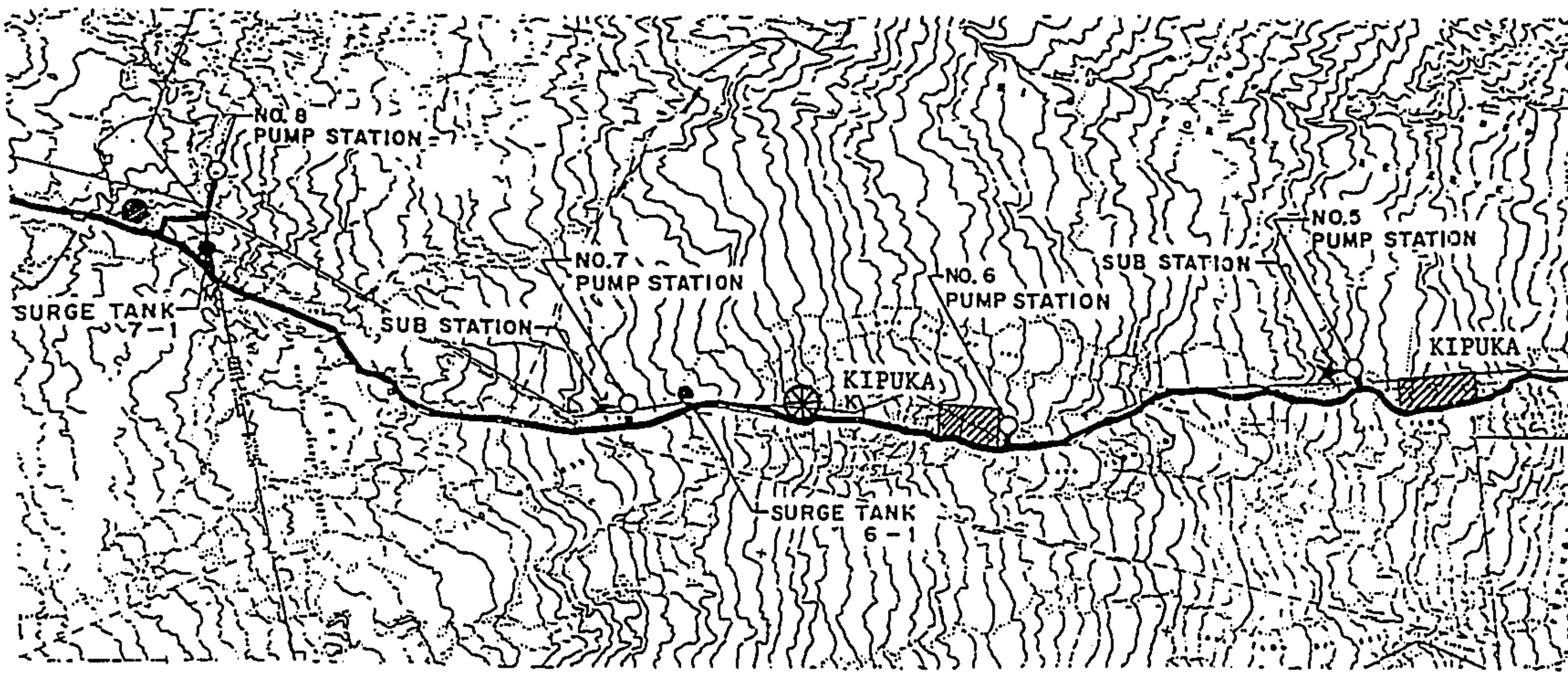


KEY MAP

0 2000' 4000' 6000' 8000'

GRAPHIC SCALE

FIGURE 3.2–a



SUBSTRATE

PREHISTORIC A'A LAVA	1855 LAVA FLOW (A'A AND PAHOEHOE)

LAVA HAZARD ZONE

Z O N E # 2

GENERALIZED VEGETATION

NEAR BARREN	MOIST OHIA VEGETATION	W E T O H I A V E G E T A T I O N

SENSITIVITY

LOW	HIGH	MED	LOW	HIGH	MEDIUM	HIGH	MEDIUM	HIGH	MEDIUM	HIGH	ME

SENSITIVE BIOLOGICAL FEATURES

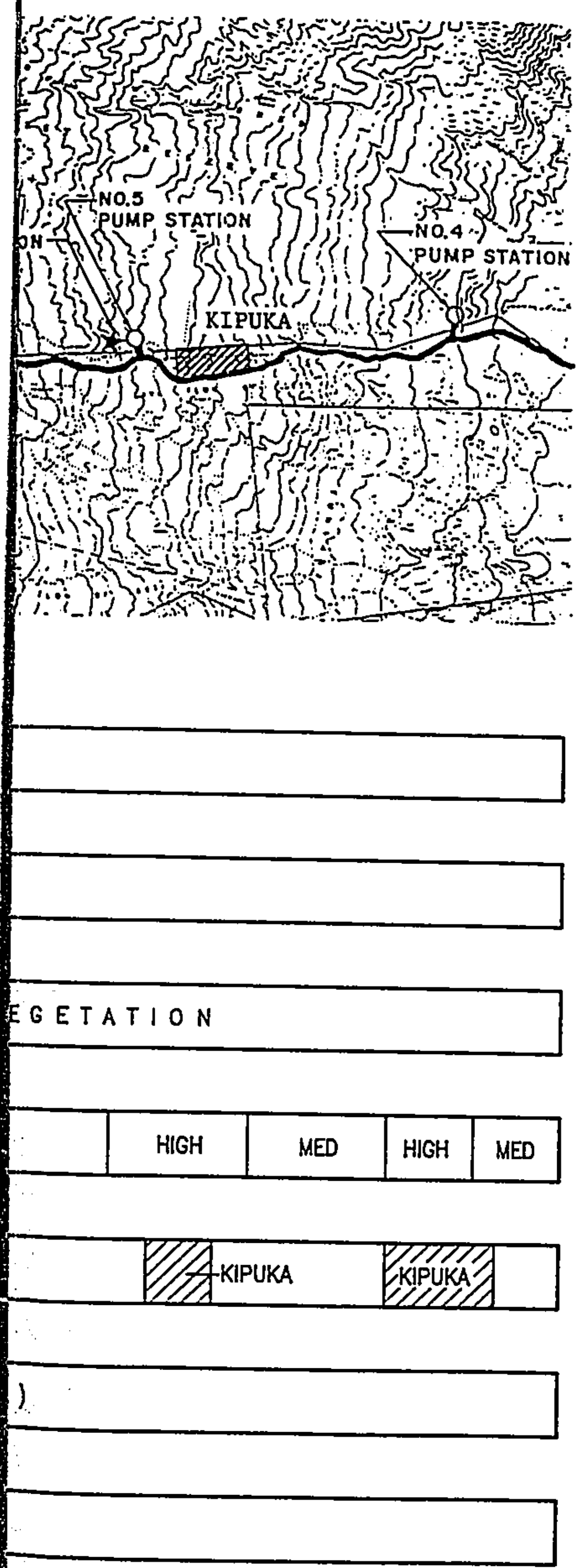
	RUBUS MACRAEI POPULATION	LAVA TUBE	KIPUKA	KIPUKA

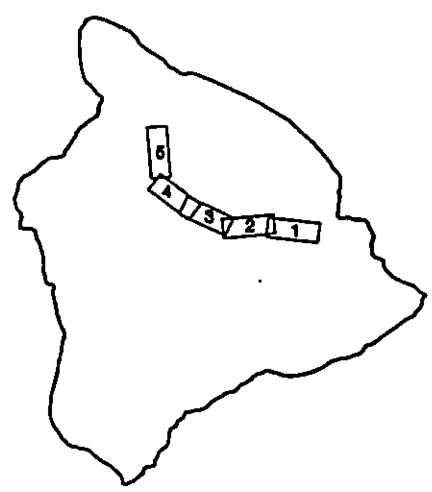
ZONING (LAND USE DISTRICTS)

C O N S E R V A T I O N (R S U B Z O N E)

USE OF SURROUNDING PROPERTIES

F O R E S T W A T E R S H E D





KEY MAP

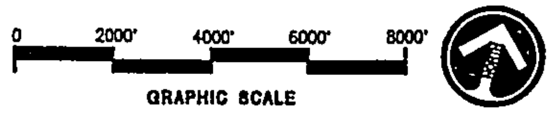
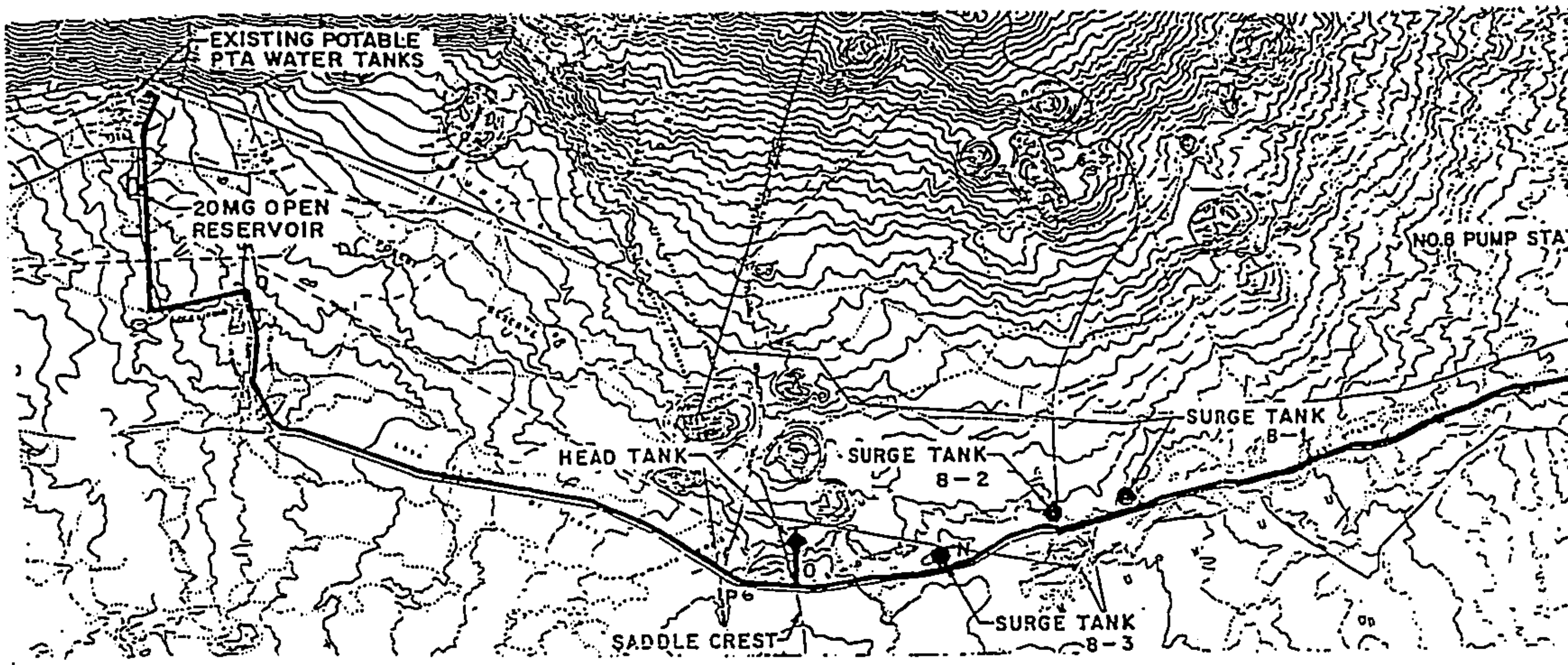


FIGURE 3.2-b



SUBSTRATE

KEEKEE LOAMY SAND	1843 LAVA FLOW (A'A)	1935 LAVA FLOW (PAHOEHOE)	P

LAVA HAZARD ZONE

Z O N E # 2

GENERALIZED VEGETATION

DRY MAMANE NAIO FOREST	DRY – NEAR BARREN	MOIST – NEAR BARREN	

SENSITIVITY

MEDIUM	L O W

SENSITIVE BIOLOGICAL FEATURES

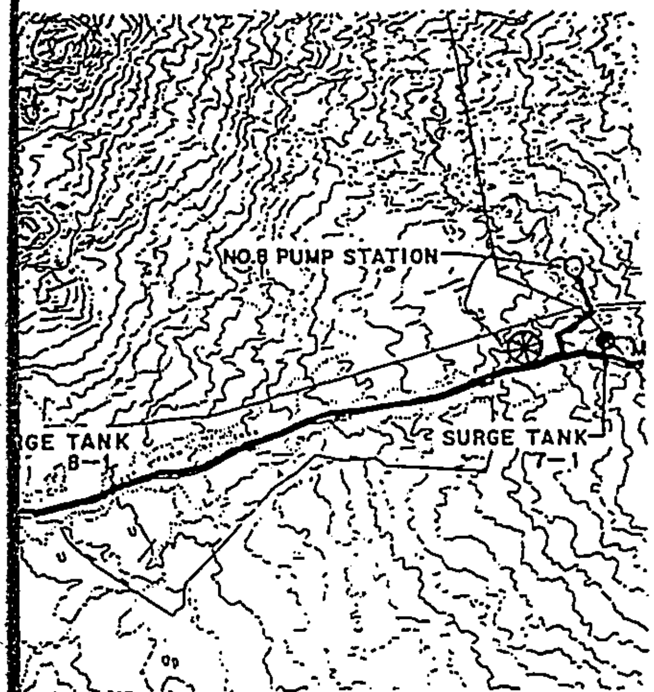
ADJACENT PALIA CRITICAL HABITAT	

ZONING (LAND USE DISTRICTS)

	AGRICULTURAL (AG

USE OF SURROUNDING PROPERTIES

(PTA) MILITARY TRAINING AREA	OPEN LAVA LAND	CATTLE PASTURE



PREHISTORIC A'A LAVA

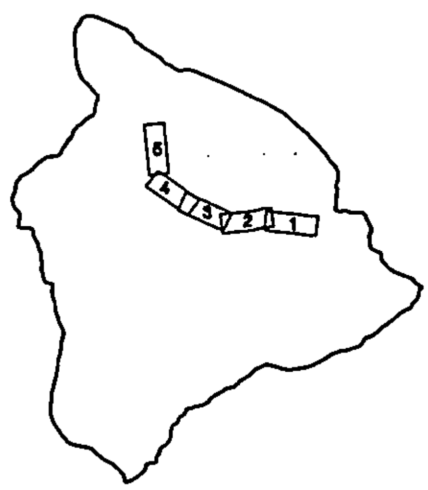
MOIST OHIA

HIGH | MED

LAVA TUBE

AGRICULTURAL (AG 20)

CATTLE PASTURE

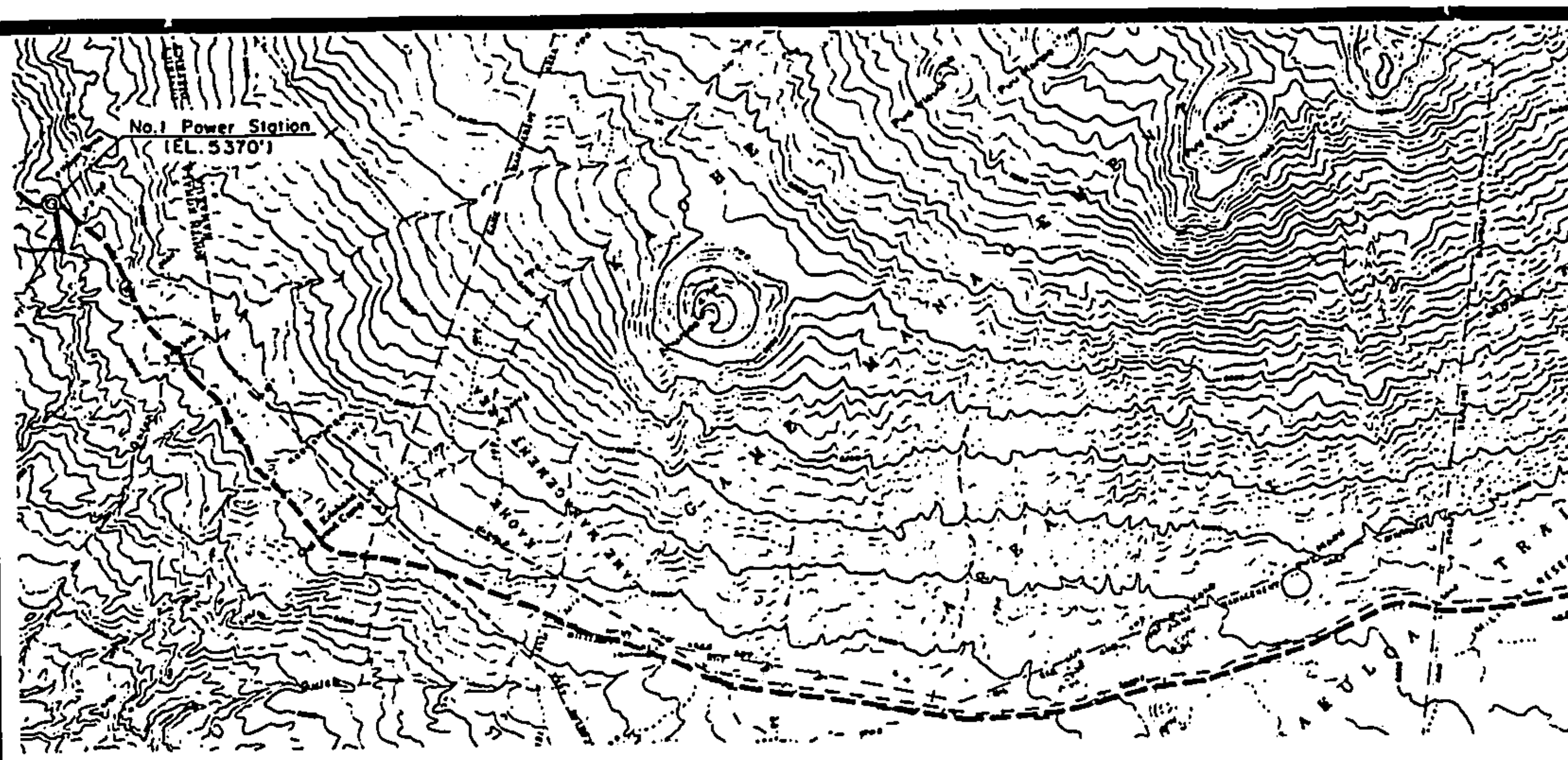


KEY MAP

0 2000' 4000' 6000' 8000'

GRAPHIC SCALE

FIGURE 3.2-c



SUBSTRATE

KILOHANA LOAMY SAND	KE'EKE'E LOAMY SAND

LAVA HAZARD ZONE

ZONE #8	

GENERALIZED VEGETATION

	DRY MAMANE NAIO FOREST	DRY CI

SENSITIVITY

LOW	MEDIUM

SENSITIVE BIOLOGICAL FEATURES

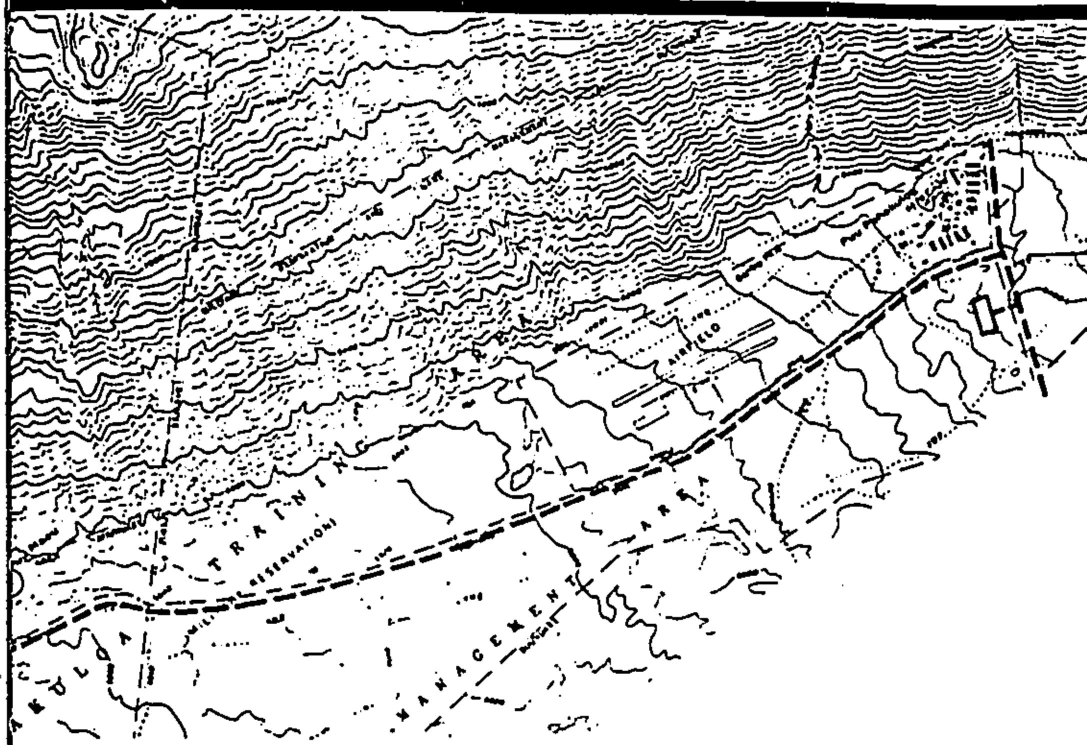
	ADJACENT PALILA CRITICAL HABITAT	UNIQUE NATIV

ZONING (LAND USE DISTRICTS)

AGRICULTURAL	CONSERVATION (P SUBZONE)	CONSERVATI

USE OF SURROUNDING PROPERTIES

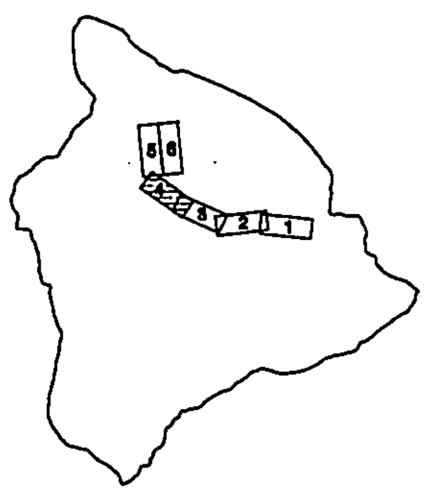
CATTLE PASTURE	MILITARY (POHAKULOA TR



KE'E LOAMY SAND

	ZONE #7

DRY CHENOPODIUM SHRUBLAND
IUM
UNIQUE NATIVE SHRUB AND GRASS COMMUNITY
CONSERVATION (R SUBZONE)
TARY (POHAKULOA TRAINING AREA)

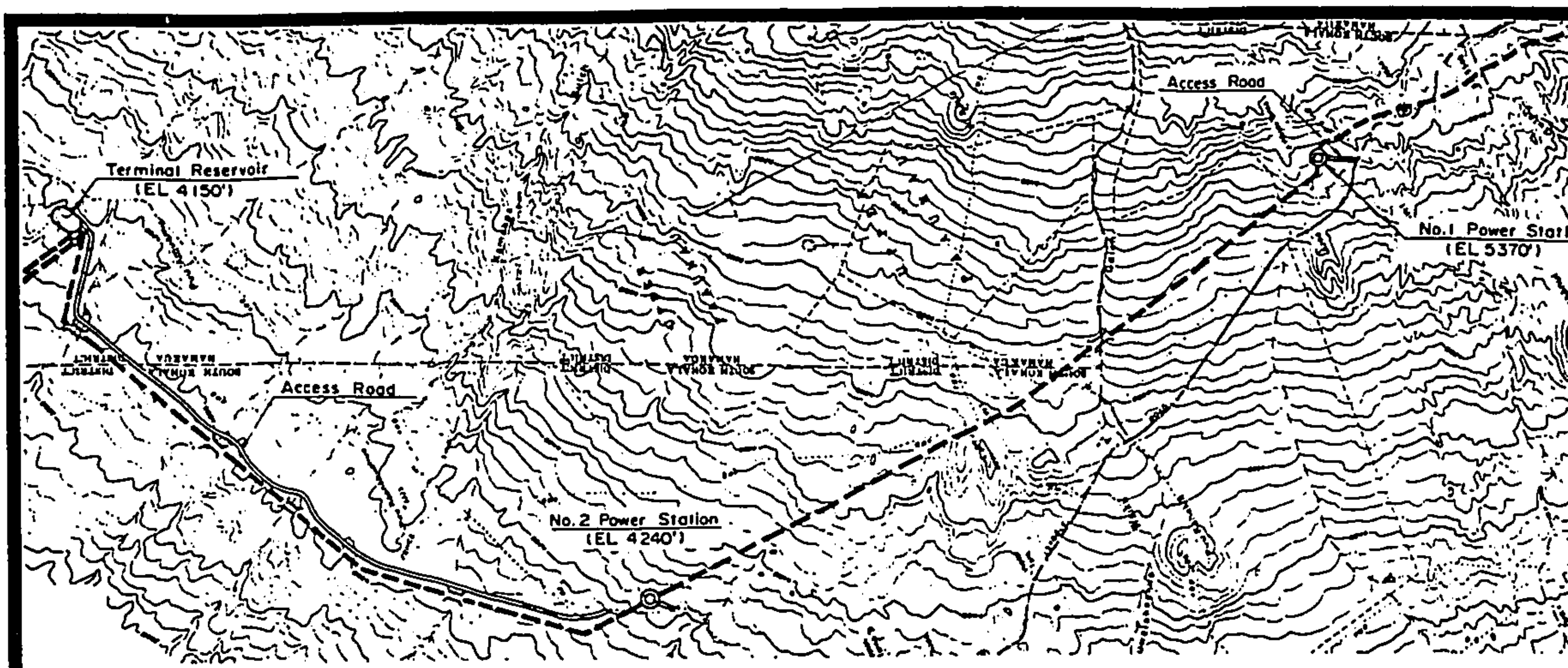


KEY MAP

0 2000' 4000' 6000' 8000'

GRAPHIC SCALE

FIGURE 3.2–d



SUBSTRATE

WAIMEA SANDY LOAM

LAVA HAZARD ZONE

ZONE #8

GENERALIZED VEGETATION

PASTURE GRASSLAND

SENSITIVITY

LOW

SENSITIVE BIOLOGICAL FEATURES

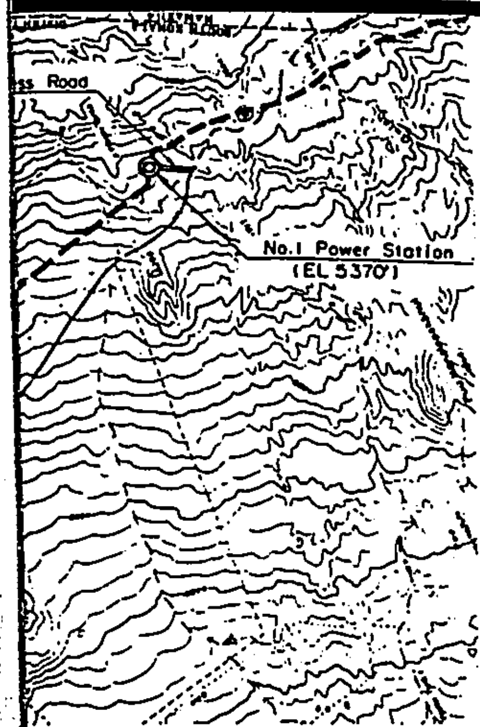
ZONING (LAND USE DISTRICTS)

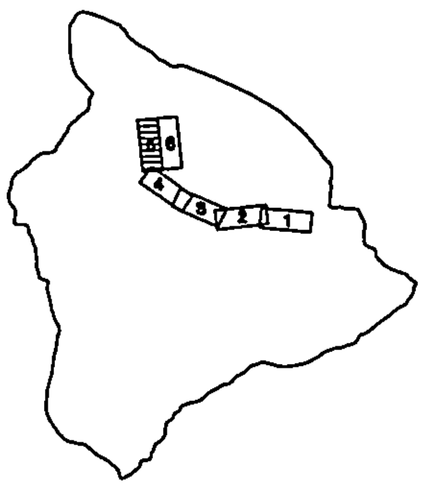
AGRICULTURAL

USE OF SURROUNDING PROPERTIES

CATTLE PASTURE

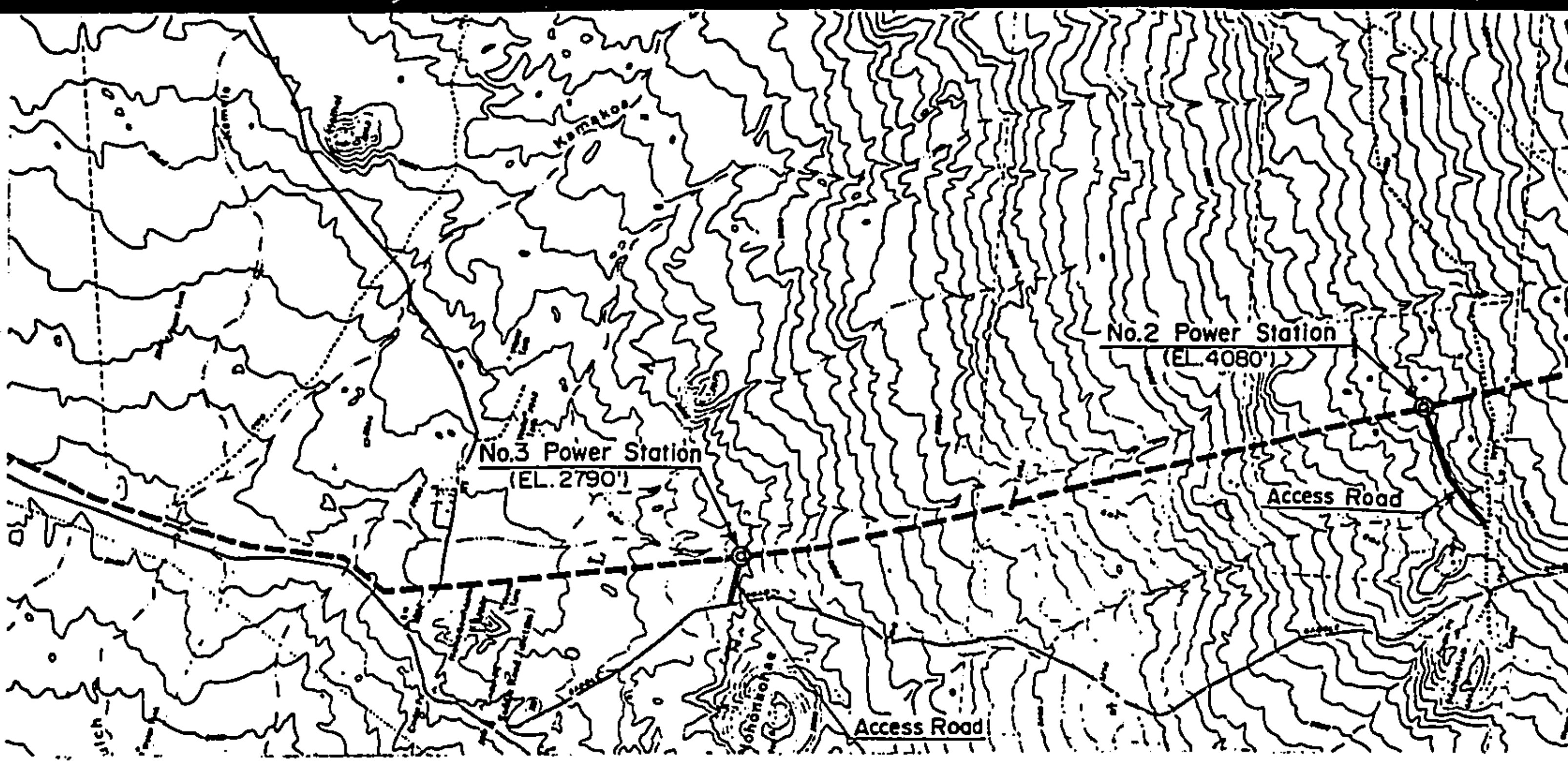
AH. "A"





KEY MAP

FIGURE 3.2-e



SUBSTRATE

KAMAKOA SANDY LOAMY	KILOHANA SANDY LOAM

LAVA HAZARD ZONE

ZONE #8

GENERALIZED VEGETATION

PASTURE GRASSLAND

SENSITIVITY

LOW

SENSITIVE BIOLOGICAL FEATURES

	RARE PLANTS ON CINDER CONES	

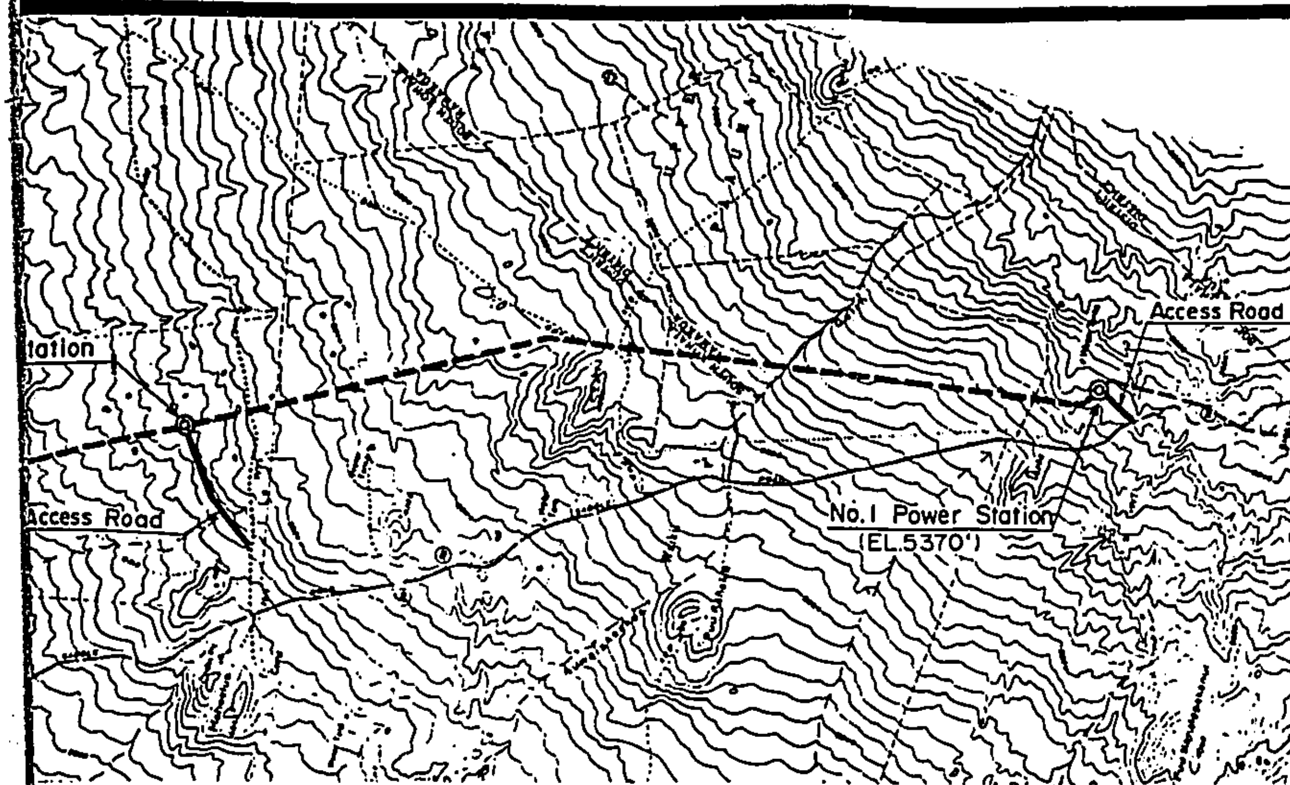
ZONING (LAND USE DISTRICTS)

AGRICULTURAL

USE OF SURROUNDING PROPERTIES

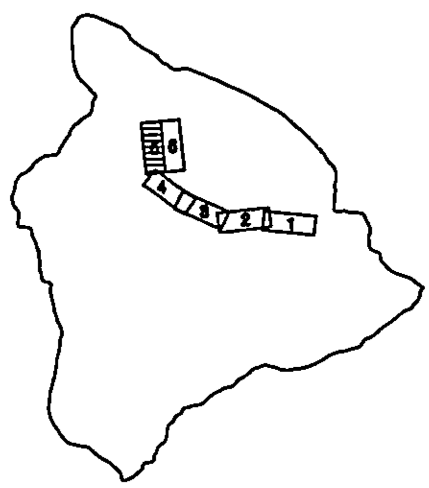
CATTLE PASTURE

Att. "8"



DY LOAM

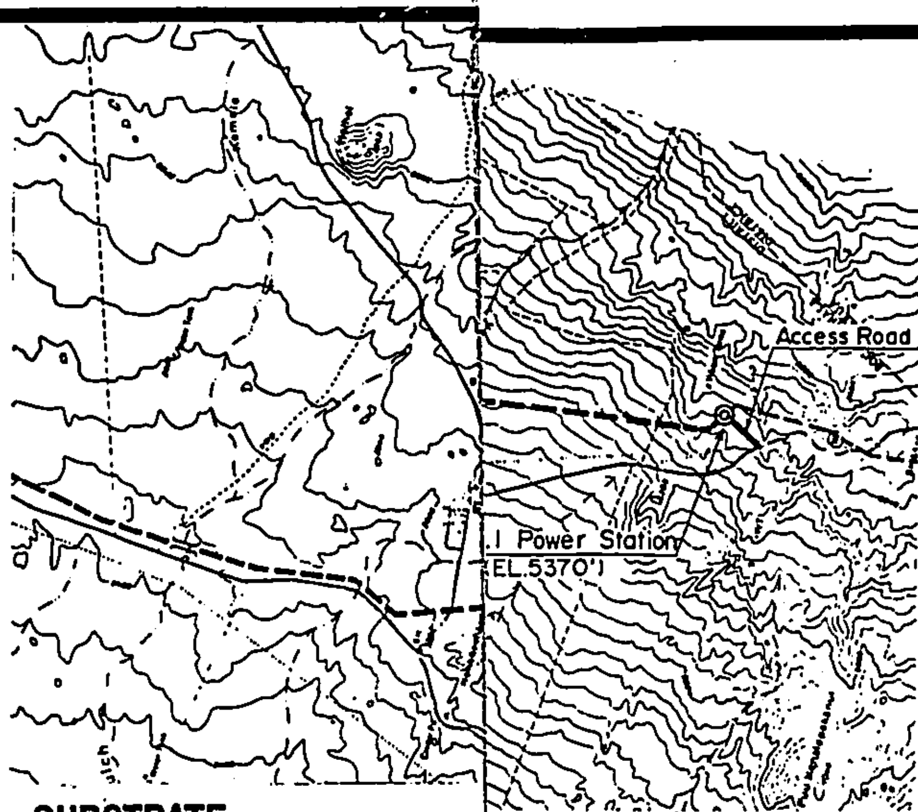
ND



KEY MAP

0 2000' 4000' 6000' 8000'
GRAPHIC SCALE

FIGURE 3.2–e



SUBSTRATE

KAMAKOA SANDY LOAMY	

LAVA HAZARD ZONE

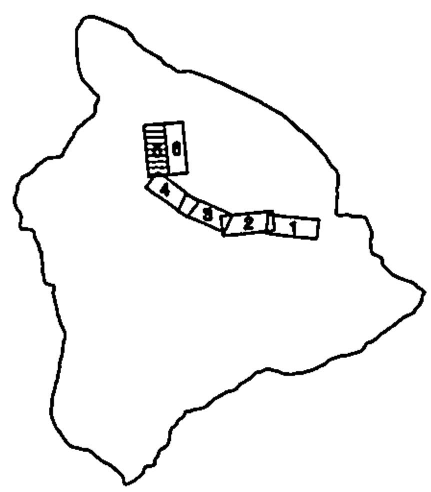
GENERALIZED VEGETATION

SENSITIVITY

SENSITIVE BIOLOGICAL FE

ZONING (LAND USE DISTR

USE OF SURROUNDING PR



KEY MAP

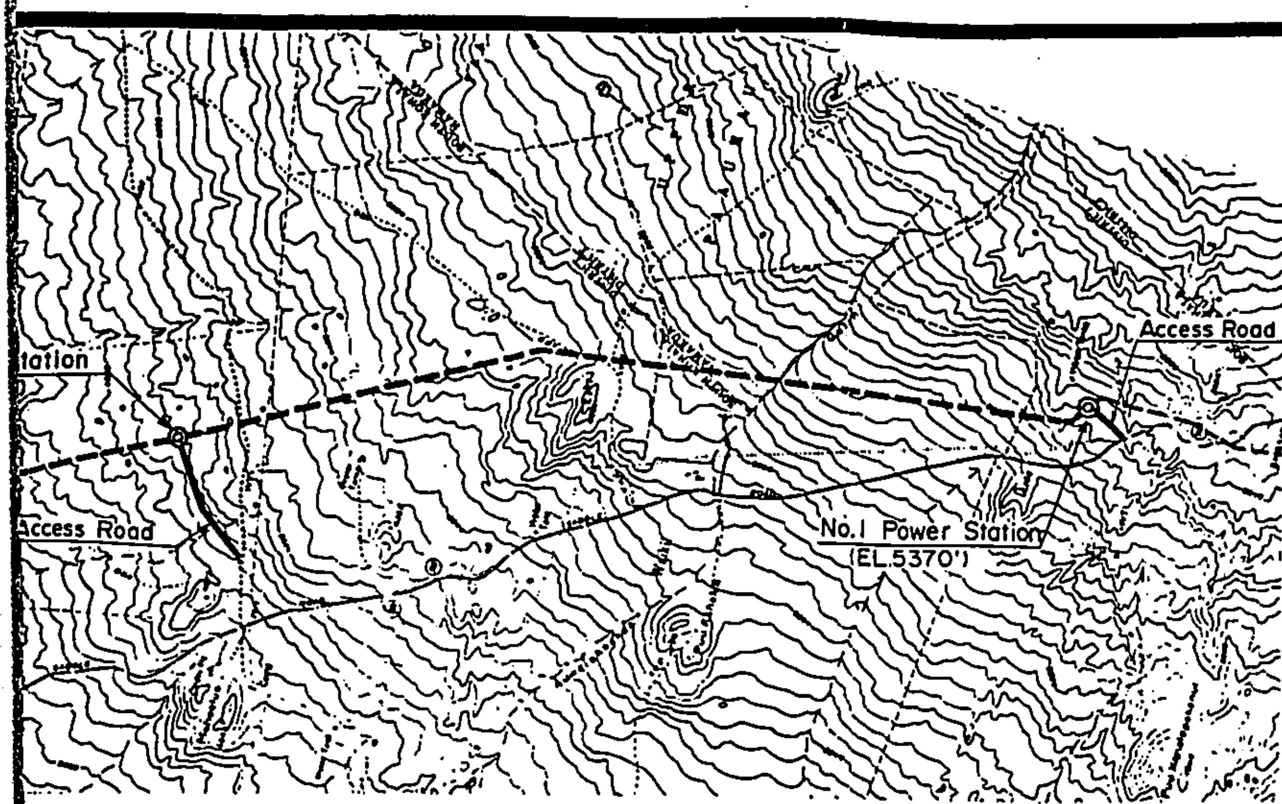
0 2000' 4000' 6000' 8000'
GRAPHIC SCALE

2–e

Att. "B"

CORRECTION

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



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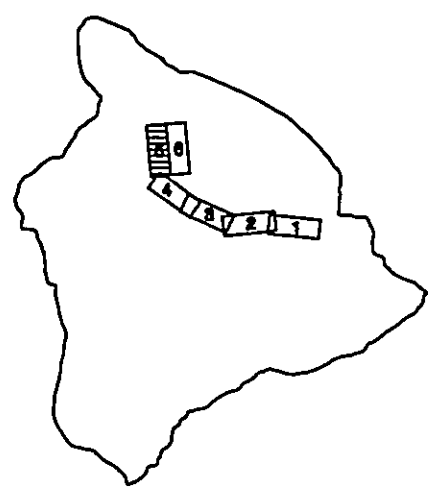
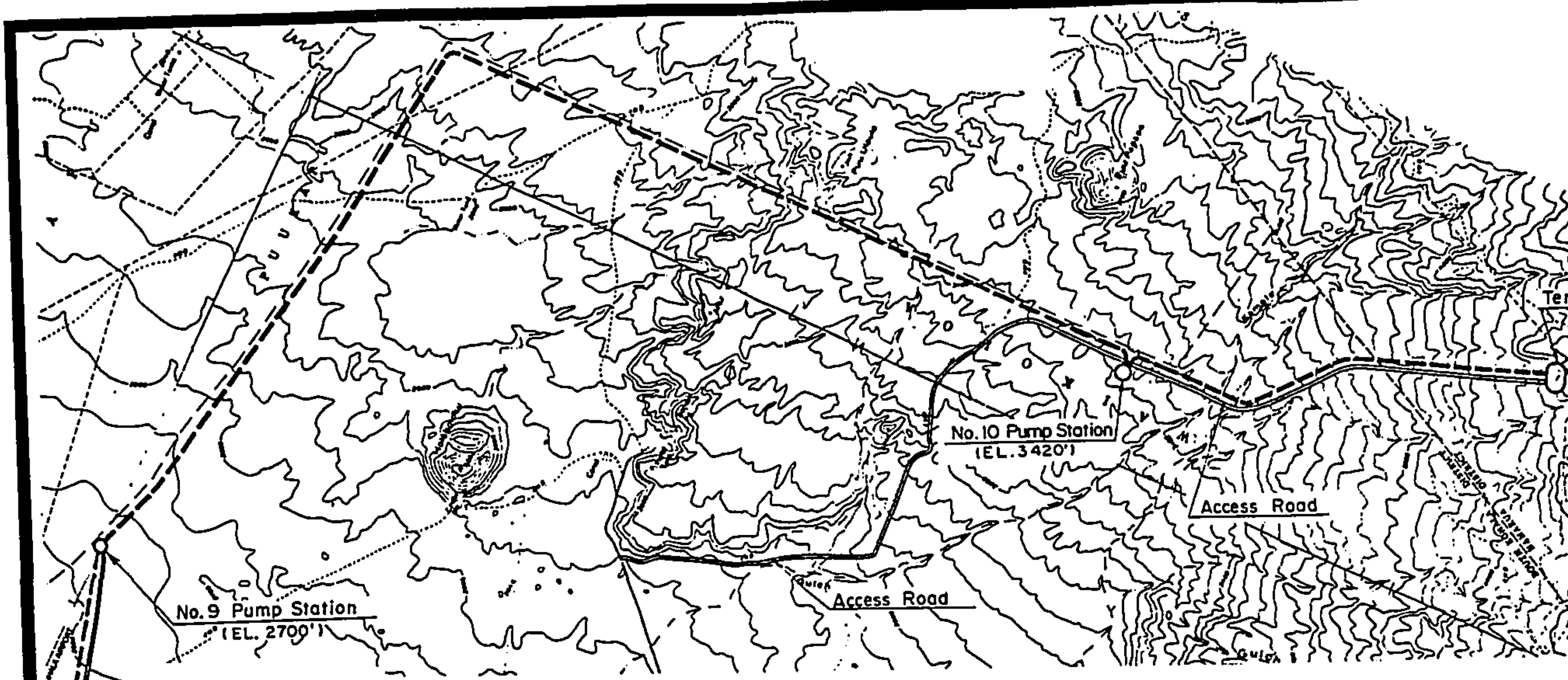


KEY MAP

0 2000' 4000' 6000' 8000'

GRAPHIC SCALE

FIGURE 3.2–e



SUBSTRATE	
PUU PA STONY LOAM	WAIMEA SANDY LOAM

LAVA HAZARD ZONE
ZONE #8

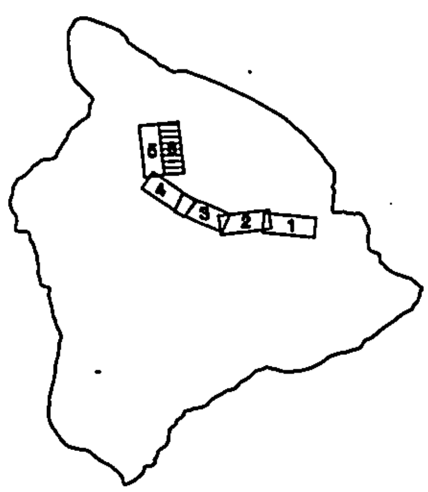
GENERALIZED VEGETATION
PASTURE GRASSLAND

SENSITIVITY
LOW

SENSITIVE BIOLOGICAL FEATURES

ZONING (LAND USE DISTRICTS)
AGRICULTURAL

USE OF SURROUNDING PROPERTIES	
AIRPORT	CATTLE PASTURE

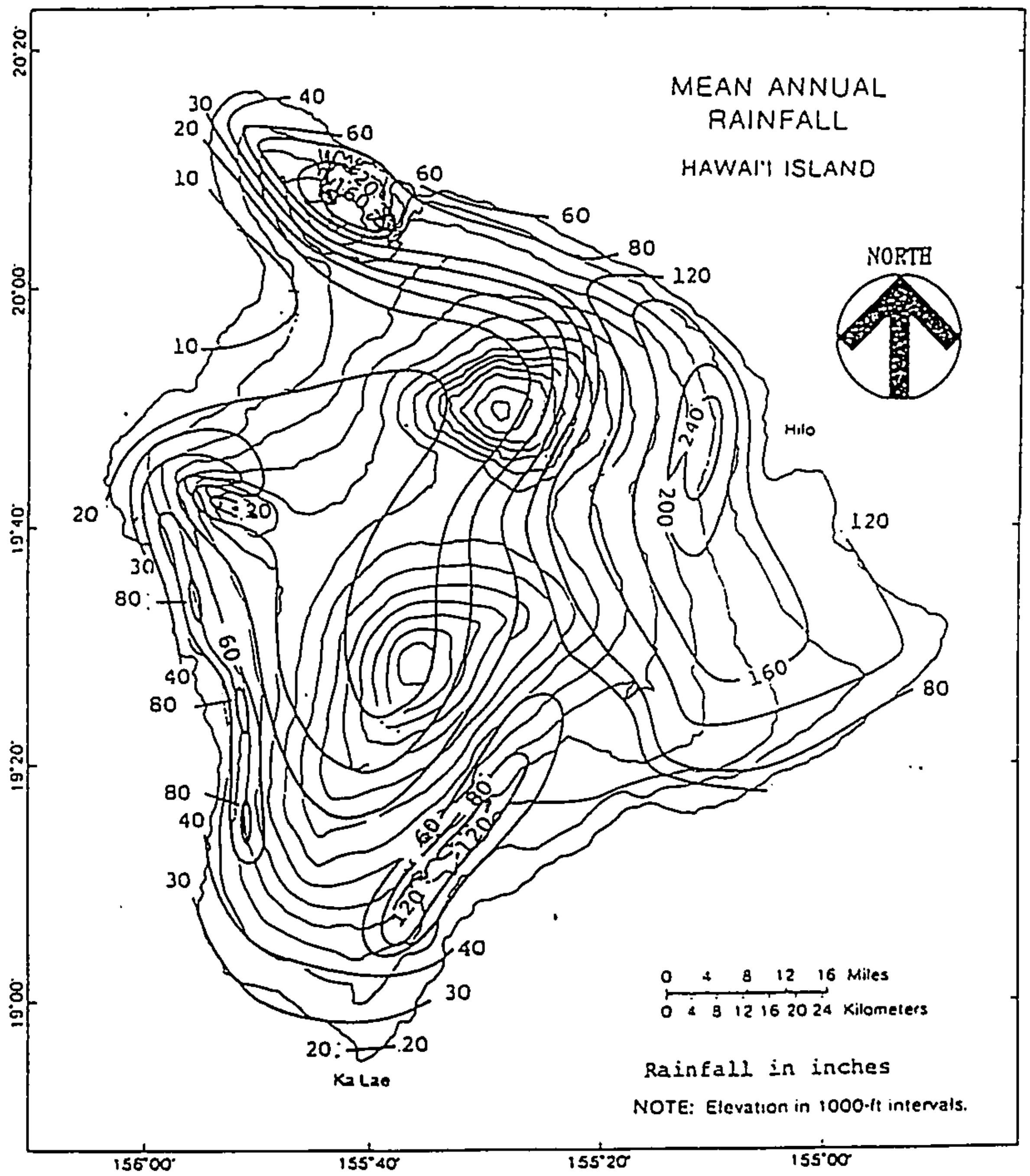


KEY MAP

0 2000' 4000' 6000' 8000'
GRAPHIC SCALE

FIGURE 3.2-f

Figure 3.3 From AG study



construction of the PTA reservoir (20 million gallons) and the terminal reservoir on Parker Ranch pasture lands (140 million gallons) and construction of 8-10 pumping stations and related pipeline appurtenances will create short-term unavoidable impacts on noise and air quality (fugitive dust) within the project area. However, these short-term adverse effects will be minimized through the use of standard abatement procedures. Virtually the entire project area is remote from residential areas, with the exception of the well field site in Waiakea-Uka where 6-8 homes/farms occupy private property within a 1/4 mile radius of this well field facility.

Because much of the proposed pipeline route will lie immediately adjacent (10-100 ft.) to the Saddle Road over a distance of approximately 36 miles (between the 9-45 mile markers; see Figures 1.1-1.3) special care will be necessary to mitigate dust, noise and related construction activities in order to maintain traffic safety along this steep, narrow and winding road.

b) Long-term operation-related

This project involves significant off-site air quality impacts in relation to the 25-30 megawatts (MW) of continuous electrical power required for pumping water over the saddle. At the present time the exact source of this power is an unresolved issue. It should be noted that under the current development scenario this water transmission project would not become operational until completion of construction in 1998 when water pumping would then begin incrementally, increasing (in response to projected demand) at approximately 2 mgd/year until full capacity of 20 mgd is achieved in 2007. For the first four years of operation, while pumping rates remain below 10 mgd, all daily pumping requirements could be met by running the system only during off-peak nighttime hours (see Figure 3.4, in energy section). This would have the effect of utilizing surplus nighttime generating capacity (base load) of the HELCO system and would not require any increase in overall electrical system generating capacity. Once the water system begins approaching system capacity (20 mgd) between 2002 and 2007, pumping would become continuous and more energy would also be required during peak daytime as well as nighttime hours. According to HELCO projections even without the 25-30 MW requirements of this proposed project, electrical system peak demand is expected to rise from a current 178 MW (1991) to an estimated 319 MW in 2007 (Figure 3.5), necessitating the construction of substantial additional power generating capacity on the Island of Hawaii over the next 15 years.

Future increases in electrical generating capacity of the Island of Hawaii will have air quality implications. Conventional oil, coal or bagasse-fired electrical generation, as well as geothermal-powered electrical generation, produce gas and particulate contaminants which impact on the "greenhouse" effect, acid rain and human health. Table 3.1 illustrates comparative carbon dioxide and sulfur oxide emissions using appropriate air pollution abatement technologies available in the late 1980s.

Alternative energy sources such as hydro and wind are currently meeting a small portion of the Big Island energy demand, and the possibilities of solar energy or ocean thermal energy conversion have also been investigated for possible application in the future. However, these energy sources cannot provide "baseload" power such as would be required for the "continuous" water pumping needs of this project.

The exploration for and development of geothermal power on the Island of Hawaii is on-going. The first commercial power plant is targeted to be on line by September 1992. While the scale of the geothermal resources is still being assessed, it does provide the potential for addressing a significant portion of the County's baseload energy requirements in the future. While the transmission project is not directly linked to geothermal development, the baseload energy requirements of the project are well suited to geothermal-powered generating plants.

TABLE 3.1
Typical Power Plant Emissions Per Unit of Energy Produced for Different Fuel Type

Power Plant Fuel	Carbon dioxide Stack Emissions (lb/hr/megawatt)	Sulfur Oxides Stack Emissions (lb/hr/megawatt)
OIL	412-418	10.6
COAL	497-529	12.0
BAGASSE	550	--
GEOTHERMAL	22	0.12-0.45

Source: Goddard, et al., 1989.

How the electrical power requirement for this project ultimately may be met by the local electrical utility is currently unresolved, but will clearly impact to some degree on future air quality of the island. However, when placed in perspective, the water project energy requirements will constitute only a comparatively small fraction (approximately 20 percent) of the projected growth in overall electrical demand on the Island of Hawaii during the next 15 years. If the alternative of water pumping with interrupted power (as opposed to continuous power) were adopted for this project, then water pumping could be suspended by the utility during peak electrical demand hours, reducing the water transfer capacity of the system below the 20 mgd capacity, but providing flexibility to the electrical utility with respect to meeting its future peak demand generating capacity (see Unresolved Issues).

3.4 Water

3.4.1 Existing Conditions

1. Groundwater

The proposed project involves a well field above Hilo from which 20 mgd of perched or basal ground water will be pumped and distributed by pipeline to Pohakuloa and the Waimea plain. The Hilo Aquifer System is part of the large Northeast Mauna Loa Aquifer Sector which is characterized by an average recharge of 1,300 million gallons per day (see Appendix A). Of this, approximately 700 million gallons per day passes through the Hilo Aquifer System, entering the ocean at coastal seeps and springs. So much recharge takes place that basal heads build up to drive the flow and stand at more than five feet (above sea level) within a mile or two of coastal discharge areas.

These unprecedented groundwater volumes result from the very high upslope rainfall (200-300 inches/year) and extreme surface porosity associated with young, unweathered Mauna Loa lavas. The flow of groundwater in the Hilo Aquifer System is very large but little of this potential has been developed at the present time. Of the total estimated water flux through the aquifer, less than one to two percent of the resource is currently developed for domestic or agricultural water supply in the Hilo area.

2. *Surface Water and Drainage*

Over the first 38 miles of its route the proposed pipeline will ascend the eastern (windward) slopes of Mauna Loa volcano with the pipeline alignments following largely historic un-weathered lava flows of Mauna Loa. Due to high substrate porosity, surface water drainage courses are largely absent or poorly defined. No perennial stream courses are located in the project area. Beyond Pohakuloa the pipeline right of way (adjacent to the Saddle Road) moves onto older Mauna Kea substrates where there is moderate erosional dissection by small, intermittent stream courses.

Under leeward route alternative A (Figure 1.2) in the vicinity of Waiki'i (elev. 5,600 ft.) the pipeline will depart from the Saddle Road alignment and cross open pasture lands belonging to the Parker Ranch. The pipeline will terminate at the reservoir near Kamakoa Gulch. For the few minor intermittently flowing drainage gulches on Parker Ranch, elevated viaducts will be constructed to transit the pipeline across. Under leeward route alternative B (Figure 1.3) the alignment of the pipeline would not cross Parker Ranch, but would instead continue to follow the Saddle Road and Mamalahoa Highway into Waimea town, and the same gulches would be crossed with viaducts adjacent to existing highway bridges.

3.4.2 Probable Impacts of Proposed Action and Mitigation Measures.

The magnitude of water resource exploitation from the Hilo Aquifer associated with this proposed project (20 mgd) should have no significant impact on the largely undeveloped Hilo Aquifer System since the total water draw of this project would constitute less that 3 percent of the estimated 700 million gallons per day recharge of the Hilo Aquifer (see Appendix A).

Some small fraction of water pumped under this project to Pohakuloa and the Waimea plain (for agricultural irrigation) will ultimately percolate to recharge ground water aquifers in East and West Hawaii. Any degradation in the quality of this water associated with its end uses (either domestic or agricultural) could impact on future groundwater quality. Mitigation measures would include the maintenance of appropriate water treatment standards and other constraints (e.g. for use of agricultural chemicals) on water users. These water quality issues must necessarily be addressed in the future development plans of water end users.

3.5 Biological Resources

3.5.1 Existing Conditions

A highly diverse assemblage of native and alien species-dominate biological communities occur along the proposed water transmission pipeline right of way, reflecting both substrate variability (from recent lava flows to older, ash-derived soils) and the steep altitudinal gradients in climate and environmental conditions that characterize the windward and leeward slopes of Mauna Loa and Mauna Kea.

In addition to biological field surveys conducted specifically for the formulation of this project EIS, the fact that the proposed water transmission line alignment follows existing disturbance corridors (Saddle Road and HELCO electrical transmission line right of way) for which previously approved Environmental Impact Statements are available, has provided a substantial body of supplemental data upon which to evaluate the potential physical environmental impacts of the proposed project. Early engineering alternatives for this proposed project considered alternative routes through the ecologically sensitive Mauna Kea-Mauna Loa saddle area which were immediately rejected because of biological disturbance potential. Thus, only a single windward Mauna Loa route was seriously considered, which followed existing disturbance corridors along the Saddle Road and power line easement.

1. Flora and vegetation

A botanical field survey and literature review of the existing flora and vegetation of the water system corridor were carried out during the period April-July 1991, by Dr. G. Gerrish. The full botanical report is included in this EIS as Appendix D.

a) Factors controlling the distribution of plant communities on Mauna Loa and Mauna Kea

Although the plant communities along the water system easement appear to make up a complex mosaic pattern, the underlying factors that determine which community occurs at any given location are few and relatively simple. The four that are used in this vegetation description are human activity, rainfall, substrate age and elevation above sea level. The easement can be divided into two distinct sections based on the level of human activity.

A low level of human activity has left native vegetation more or less intact from the well field at Waiakea-Uka through the 138 KV powerline corridor and along Saddle Road to the boundary with Parker Ranch. A high level of human activity associated with ranching has greatly changed the vegetation of the easement within the Parker Ranch where native plants are now infrequent.

Human disturbance also has a role in determining the makeup of plant communities within the powerline and Saddle Road corridors. During powerline construction, a strip up to 200 ft. wide was disturbed in the mid 1980s. Many alien plants now grow in this strip, as well as many native plants that are also vigorously recolonizing the disturbed area. A distinct community of mostly alien plants grows on the shoulder of Saddle Road. This vegetation is maintained in its present state by roadside mowing and other activities associated with the Saddle Road.

Following the easement from east to west, windward to leeward, three climatic zones are recognized based on rainfall. The wet zone receives over 150 inches median annual rainfall, extending from the well field to mile-marker 19 on Saddle Road at about 5,100 ft. elevation on the windward side. The moist zone receives 40 to 150 inches median annual rainfall, beginning above the wet zone at 5,100 ft. and reaching to slightly beyond the summit of the saddle to mile-marker 30 (about 6,400 ft. elevation). All of the remaining portion of the easement, from the saddle to the terminal reservoir, is in the dry zone which receives less than 40 inches median annual rainfall (see Figure 3.3).

The appearance of the vegetation is most directly controlled by the age of the substrate. In the upper elevation of the saddle, the 1935 lava flow in the moist zone and the dry 1843 flow have very few plants at all. In the moist and wet zones on the windward side of the saddle, the easement alternates between scrub and forest. The scrub is always found growing on the 1855 or the 1881 lava flows. This scrub is a vegetation type characterized by short, scattered 'ohi'a (*Metrosideros polymorpha*) trees with an undergrowth of other shrubs and herbs.

Wherever the easement crosses older surfaces with more developed soil, stands of native forest with trees over 50 ft. tall occur. 'Ohi'a and koa (*Acacia koa*) grow together in forest stands below 3,100 ft. elevation. Koa is not found between the 3,100 ft. and 5,500 ft. elevations. In forests above 5,500 ft. elevation, 'ohi'a again shares dominance with koa, and koa can be found in other communities, such as koa-mamane (*Sophora chrysophylla*) pastures.

b) Vegetation Description

The vegetation is described following the easement from east to west. A 100-foot wide easement and the vegetation immediately adjacent to the easement were surveyed. The roadside community of mostly alien species on the Saddle Road shoulder and the disturbed vegetation under the powerline are described separately from the undisturbed vegetation within the easement. A generalized diagram of the vegetation of the easement is shown in Figures 3.2a-3.2e. Detailed diagrams are attached in the botanical report (Appendix A).

The easement begins at the Waiakea well field at 850 ft. elevation, then follows the powerline corridor until it joins the Saddle Road at 2,160 ft. elevation (Figure 3.2a). The vegetation at the well field and along the lower part of the powerline corridor is predominantly 'ohi'a-koa forest. The forest of the lower part has been invaded by many alien plants, but above the Flume Road (1,960 ft. elevation), the forest has few aliens and is very diverse.

Part of the easement through the powerline corridor is on the 1881 lava flow which is vegetated by 'ohi'a scrub. This scrub is a relatively simple community in which scattered 'ohi'a (*Metrosideros polymorpha*) trees less than 25 ft. tall are the dominant woody plant. The lava is densely covered with a growth of native shrubs, herbs and ferns. The disturbed under-powerline vegetation near Flume Road shows strong regeneration of native plants, both in the scrub and forest. Below Flume Road, however, alien plants dominate this strip.

Where the easement follows the Saddle Road on the windward side of the saddle, the road is built on the 1881 and 1855 lava flows up to mile-marker 22 (Figure 3.2b). These recent lava flows form relatively open swaths of scrub, about a mile or less wide, through the rainforests of windward Mauna Loa. The easement also passes through or along small stretches of forest on older substrates. Below 3,100 ft. there are 'ohi'a-koa forests, above that elevation, 'ohi'a forests.

In general these forests have a very diverse native flora and have few alien species. The forest stands below 4,000 ft. have undergone some canopy dieback and are in an advanced stage of regeneration with many young 'ohi'a trees and other species growing vigorously (Mueller-Dombois 1985, Gerrish 1989). Stands above 4,000 ft. appear especially healthy. These can be called "near pristine" because they have very few alien plants. In the moist zone, the scrub on the 1855 lava flows is still dominated by small 'ohi'a trees, but has a sparser groundcover of native shrubs than in the wet zone. Small patches of near-pristine 'ohi'a or 'ohi'a-koa forests occur below 5,800 ft. At 6,100 ft. the Saddle Road and water system easement both climb onto the 1935 lava flow. The lava flow is nearly barren except for a covering of lichen and a few widely scattered native ferns and shrubs. Pockets of older substrate between this elevation and the summit of the saddle usually have an open vegetation of mixed native shrubs.

Approaching the saddle crest, these communities show the increasing influence of the nearby pastures in that they also contain common alien pasture grasses. The head tank at the summit of the saddle is located away from the road in a grazed pasture with koa, mamane, and other native trees.

The dry zone begins on the west, leeward side of the saddle. Initially, the easement crosses the near-barren 1843 lava flow (Figure 3.2c). After the easement enters PTA, it passes on to an older ash substrate with a mamane-naio (*Sophora Chrysophylla-Myoporum sandwicense*) forest that appears to be degraded by human activity. From the main entrance of the base to mile-marker 42 at 5,510 ft. elevation on the leeward side, the easement is through a native ecosystem dominated by the shrub, 'aheahea (*Chenopodium oahuense*), and a native grass, *Eragrostis atropioides*. Although this area has been impacted by human activity, the vegetation is native in character with only a few alien plants. This Chenopodium shrubland is a unique ecosystem found only in this region. Just before leaving the Saddle Road and entering the Parker Ranch, the easement again passes through a small stand of mamane-naio forest.

Inside the Parker Ranch, on the south side of Saddle Road, the easement passes through pasture with remnants of mamane-naio forest before entering open pasture. Near mile-marker 45 (Figure 3.2d), the easement crosses to the north side of Saddle Road, leaving the Saddle Road corridor to cross the Parker Ranch pastures at slightly above the 5,600 ft. contour. Most of this route across Parker Ranch is through improved pasture with no native plants. Throughout the ranch, pockets of native plants persist on cinder cones, stream banks or other sites out of the reach of cattle.

c) Rare Plants

No rare plants currently listed as threatened or endangered by the U.S. Fish and Wildlife Service (USFWS) were found within or immediately adjacent to any part of the water system easement. Nor were any plants currently proposed for listing as threatened or endangered found. Two populations of *Rubus macraei* were found within the easement along Saddle Road. This native raspberry is a "category 2" plant, meaning that it may be endangered, but the USFWS needs further research to determine its true status (Federal Register 1990). One population of about six plants is in the Moist 'Ohi'a Scrub at 5,976 ft. elevation on Saddle Road, above the access line to pump station #8. The plants are near a lava tube entrance about 60 feet from Saddle Road and should be avoided. The other population is in a kipuka of moist 'ohi'a-koa just above 5,540 ft. elevation and a short distance (approximately 150 ft.) north of Saddle Road. These populations should not be disturbed.

Three endangered species listed by USFWS and legally protected are known to occur or to have occurred in the Parker Ranch in the general vicinity of the proposed alternative B route (Wagner, et al., 1990). All known locations of these plants are cinder cones at least 1,500 ft. from the proposed alternative B easement. It would be prudent, however, to consider all cinder cones, and other isolated locations that are not heavily grazed by cattle, to be potential sites for endangered species. Since the proposed easements across Parker Ranch for both alternative routes A and B were not staked before this survey, it is recommended that a qualified botanist survey the staked easement before any clearing or construction begins.

As many as ten rare plant species included on a list to be proposed for endangered status in 1992 may occur in the general vicinity of the water system easement (list provided by USFWS Endangered Species Office, Honolulu, Hawaii). None of these plants were recorded within the easement during the present survey or by Warshauer (1986). It is recommended that within the Saddle Road and powerline corridors, the water system be kept as near as possible to the existing road or powerline right of way to lessen the possibility of damage to any of these plants or their habitats.

d) Ecologically Sensitive Areas

"Ecological Sensitivity," or "sensitivity," is used here as a composite of an estimation of the value of the biological resource and an assessment of the vulnerability of the resource to negative impacts associated with this proposal. A quantitative index of ecological sensitivity has been calculated for each of the predominantly native communities along the powerline and Saddle Road corridors (Table 3.2). For each community, values between zero and two were given for three criteria: percent native dominance, species diversity, and susceptibility to alien plants; the sum of the three values is the sensitivity index of each community (Table 3.3).

Sensitivity ratings of "High," "Medium" and "Low" were assigned to arbitrarily set sub-ranges of the sensitivity index. Any location with rare plants is classified as "High" sensitivity. Sensitivity ratings of the vegetation of the easement are shown in Figure 3.2a-f. A split bar is used for the vegetation of the powerline corridor; the upper half refers to the disturbed vegetation within the powerline easement, and the lower half to the surrounding vegetation not disturbed by the powerline easement. The bars for the rest of the easement refer to the undisturbed vegetation within or immediately adjacent to the water system easement. Sensitivity ratings were assigned to the easement within the Parker Ranch by the same criteria, without formal calculations of the index, since detailed quantitative data had not been recorded and the vegetation is dominated by alien species. The three criteria are discussed in more detail below.

Table 3.2 Calculated indices of sensitivity for plant communities along the powerline and Saddle Road corridors. COM = community symbol; NATIVE = percent native dominance; DIVERSITY = species diversity; SUSCEPTIBILITY = susceptibility to alien plant. Further explanations in Table 2.

COM	NATIVE		DIVERSITY		SUSCEPTIBILITY			COMPOSITE SENSITIVITY INDEX	
	%	Index	No.	Index	Age	Zone	Ind.		
WSO	100	2	5	0	INT	WET	1.5	3.5	MED
WOK	72	1	57	2	OLD	WET	2	5	HIGH
DOK	25	0	27	1	OLD	WET	2	3	MED
WOS	88	2	26	1	INT	WET	1	4	MED
WOF	69	1	56	2	OLD	WET	2	5	HIGH
MOS	100	2	28	1	INT	MST	1	4	MED
MOF	100	2	55	2	OLD	MST	1.5	5.5	HIGH
MOK	100	2	59	2	OLD	MST	1.5	5.5	HIGH
MMS	55	1	10	1	INT	MST	1	3	MED
MSP	100	2	9	0	NEW	MST	.5	2.5	LOW
MKM	0	0	10	1	OLD	MST	1.5	2.5	LOW
MOP	67	1	6	0	OLD	MST	1.5	2.5	LOW
DSP	100	2	6	0	NEW	DRY	.5	2.5	LOW
DMN	75	1	17	1	OLD	DRY	1.5	3.5	MED
DCS	100	2	14	1	OLD	DRY	1.5	4.5	MED

WSO = WET SUCCESSIONAL 'OHI'A FOREST
WOK = WET 'OHI'A-KOA FOREST
DOK = DISTURBED 'OHI'A-KOA FOREST
WOS = WET 'OHI'A SCRUB
WOF = WET 'OHI'A FOREST
MOS = MOIST 'OHI'A SCRUB
MOF = MOIST 'OHI'A FOREST
MOK = MOIST 'OHI'A-KOA FOREST
MMS = MOIST MIXED SHRUBLAND
MSP = MOIST SPARSE PIONEER
MKM = MOIST KOA-MAMANE PASTURE
MOP = MOIST 'OHI'A PASTURE
DSP = DRY SPARSE PIONEER
DMN = DRY MAMANE-NAIO FOREST
DCS = DRY <u>CHENOPODIUM</u> SHRUBLAND

Table 3.3 Formulas and numeric values used to calculate the Sensitivity Indices in Table 3.2

A. PERCENT NATIVE DOMINANCE

% NATIVE = Native spp./Total spp. X 100

(calculation uses only "common" species, Gerrish Appendix, Tables 1-14).

NATIVE INDEX

% Native		Index
0 - 49	=	0
50 - 79	=	1
80 - 100	=	2

B. SPECIES DIVERSITY

No. SPECIES = Total number of native species recorded

(Gerrish Appendix, Tables 1-14)

DIVERSITY INDEX

No. Species		Index
0 - 9	=	0
10 - 49	=	1
>50	=	2

C. SUSCEPTIBILITY TO ALIEN SPECIES

Age

Substrate Age		Age Value
NEW		
1935	=	0
Dry 1847	=	0
INTERMEDIATE		
1855	=	1
1881	=	1
OLD		
Prehistoric	=	2

Zone

Zone		Zone Value
DRY	=	1
MOIST	=	1
WET	=	2

SUSCEPTIBILITY = (Age Value + Zone Value)/2

COMPOSITE SENSITIVITY Index = NATIVE Index + DIVERSITY Index + SUSCEPTIBILITY Index

e) Native vs. Alien Vegetation

All areas with native vegetation are considered ecologically more sensitive than areas with no native plants. By this criterion, parts of the easement crossing open grass pastures in Parker Ranch are not at all sensitive and all the vegetation along the powerline and the Saddle Road are more sensitive. Locations discussed in the previous section with reference to rare plants are the most sensitive.

f) Species Diversity

The environmental assessment for the Saddle Road improvement (Hawaii County Public Works 1986) and the 138 KV transmission line EIS (EDAW 1983) both identified all forested areas between mile-markers 9 and 19 as sensitive areas. These are "kipukas" or other areas of older substrates that have allowed 'ohi'a or 'ohi'a-koa forests to develop. These forests are considered particularly valuable resources because they have high biodiversity, i.e. a high number of native plant species that support native birds and invertebrate animals. Alien plant species are not considered to contribute value to biodiversity.

The 'ohi'a scrub vegetation on the recent lava flows in this area must also be considered worthy of protection. Although the biodiversity is low, this young community is an early developmental stage in forest succession and, as such, an integral part of the dynamic mosaic pattern of Hawaiian rainforests (Gerrish 1989).

g) Susceptibility to Invasion and Damage by Alien Plants

An analysis of alien plant distribution patterns has shown that forests in the wet and moist zones are more likely to be invaded and disrupted by alien plants than is scrub vegetation of these same two zones. Moreover, using the 138 KV transmission line as a model of disturbance during construction, alien plants more readily invade disturbed forest soils than the disturbed recent lava substrate of the scrub community. Thus, the forests are truly more sensitive. The initial project engineering plan sited pump stations #4 - #7 in the forests at a significant distance away from the Saddle Road. Moving the sites of these pump stations out of the forests to locations on the nearby 1855 lava flow would place them in a community with a Medium sensitivity rating, rather than High (Table 3.4).

2. Invertebrate Fauna

A survey of existing lava tube invertebrate fauna occurring along the project right of way was conducted during May 1991 by Dr. Fred Stone and is included in this EIS as Appendix E. Earlier invertebrate surveys (including terrestrial insects and land snails) conducted for portions of the same right of way in conjunction with the Saddle Road widening and HELCO powerline EIS provide additional information for characterization of existing native invertebrate communities (see Wagner, et al., 1983, and Stone, 1986).

Table 3.4 Sensitivity indices (IND) and ratings (RATING) for initially proposed and for alternative pump station sites 4 to 7. COM = community symbol

	INITIALLY PROPOSED SITE			ALTERNATIVE SITE		
Pump Station	COM	IND	RATING	COM	IND	RATING
4	WOK	5	HIGH	WOS	4	MEDIUM
5	WOF	5	HIGH	WOS	4	MEDIUM
6	WOF	5	HIGH	WOS	4	MEDIUM
7	MOF	5.5	HIGH	MOS	4	MEDIUM

WOK = WET 'OHI'A-KOA FOREST
WOS = WET 'OHI'A SCRUB
WOF = WET 'OHI'A FOREST
MOF = MOIST 'OHI'A FOREST
MOS = MOIST 'OHI'A SCRUB

Because recent prehistoric and historic lava flows characterize substrate conditions over the first 38 miles on the project corridor, subterranean lava tubes with their associated endemic invertebrate fauna occur within the general project right of way. The consultant report has identified specific lava tube sites for protection and suggested mitigation measures that may be invoked if lava tubes are accidentally intersected during the construction.

The diversity of other terrestrial invertebrate communities including native insects and land snails are closely associated with botanically rich kipukas and mature forest remnants along the Saddle Road, for which mitigation measures are addressed in sections dealing with reducing disturbance to native vegetation.

3. Vertebrate Fauna

An avian survey of the project area was conducted during June and July 1991 by Ms. Maile Kjargaard and is attached as Appendix F of this EIS. Earlier avian surveys conducted for portions of the same right of way in conjunction with the Saddle Road widening and Helco powerline EIS provide additional information on the status and distribution of avian species occurring along the proposed water transmission right of way (see Berger, 1982 and Warshauer, 1986).

A diverse assemblage of both native and alien bird species occur within the vicinity of the project area. A total of twenty-five bird species were encountered in the course of the avian survey (see Table 1, Appendix F), of which seven were endemic Hawaiian species and the remaining 18 species were alien introductions. The Hawaiian Hawk (*Buteo solitarius*), a federally-listed endangered species, was encountered in wet forest habitat near Pump Station #6. This species ranges widely over moist windward and leeward areas of the island (see Appendix F, Figure 2). The avian consultant identified six additional federally-endangered species that, although not encountered in the field survey, are known to occur in the general vicinity of the project area. These include:

1) nene (*Nesochen sandvicensis*)
2) palila (*Loxiodes bailleui*)
3) 'akiapola'au (*Hemignathus munroi*)
4) 'alawahio (*Oreomystus mana*)
5) 'o'u (*Psittirostra psittacea*)
6) 'akepa (*Loxops c. coccineus*)

In addition to these federally-endangered bird species, Hawaii's only native land mammal, a federally-endangered race of the hoary bat (*Lasiurus cinereus semotus*) is also widely dispersed on the Island of Hawaii and is likely to inhabit forest habitat in the general vicinity of the project area on windward Mauna Loa.

The windward forests along the Saddle Road between the elevations of 3,000 and 6,000 ft. have been previously identified as essential habitats for the endangered 'o'u, 'akiapola'au and 'alawahio. A State of Hawaii designated nene reserve also abuts the Saddle Road right of way to the south of the project area between the 21-28 mile markers (Figure 3.2b). Federally-designated critical habitat for the endangered palila abuts the Saddle Road to the north and east on the upper slopes of Mauna Kea near the 35 mile marker and between the 41-46 mile markers (Figure 3.2c-e).

3.5.2 Probable Impacts of Proposed Action and Mitigation Measures

Biological impacts and mitigation are discussed with specific reference to the native plant communities. Native invertebrate and vertebrate communities are dependent upon the native vegetation, so that any mitigation actions that protect native forests will likewise benefit the native fauna of the project area.

1. Criteria For Identifying Negative Impacts

Evaluation of the impacts of the execution of this proposal requires some objective criteria for identifying what is a negative or adverse impact. The criteria used in this report to evaluate potential impacts are based on the defined use objectives for Protected and Resource subzones of the State Conservation District through which much of the easement passes on windward Mauna Loa. From the Administrative Rules of the Department of Land and Natural Resources, the objective of the Protective subzone " . . . is to protect valuable resources in such designated areas as . . . plant, and wildlife sanctuaries" (HRS 13-2-11); the objective of the Resource subzone " . . . is to develop, with proper management, areas to ensure sustained use of the natural resources of those areas" (HRS 13-2-13).

These stated objectives are interpreted to mean that the existing natural resources of the area, including or especially biological resources, have priority for protection or use above a resource value that is developed by the siting of any facility in these subzones of the Conservation District. Recognizing that the existing native vegetation is one of the natural resources of these subzones, a set of specific criteria have been developed to evaluate potential impacts of this proposal.

Recognized as negative impacts are the consequences of any and all of the following activities that:

a) Destroy individual native plants.
b) Promote the growth and reproduction of any alien plant in native plant habitat.
c) Permanently reduce the area of habitat available to native plants.
d) Fragment native habitat in such a way that the ecological interactions between plant species in the created habitat fragments are altered.
e) Lead to the disappearance or reduction in density of a native plant species in its habitat.

These factors are listed approximately in order of increasing severity and from the specific level of activity to the general level. Activities with these consequences have been widely recognized as detrimental to Hawaiian ecosystems (Stone and Scott 1985).

2. Potential Negative Impacts

a) Fragmentation of habitat. Fragmentation, or the dividing of the forest into small pieces that cannot sustain themselves, is a major threat to native ecosystems (Mueller-Dombois 1985). The submontane and montane rainforests on the windward slopes of Mauna Kea and Mauna Loa are valuable as a biological resource precisely because this large block of habitat minimizes negative edge effects. There is little probability that the presence of the physical facilities associated with the water system, added to those of the road and powerlines, will form a physical barrier interrupting normal ecological processes. However, the Saddle Road corridor is a potential weak point through the forest that can lead to more rapid invasion by alien plants. This corridor could be degraded by alien plant invasions and become a source of further invasion, thus becoming a non-native zone that functions as a barrier to the normal processes between the northern and southern portions of the forest.

b) Unavoidable destruction of native vegetation during construction.

c) Encouragement of noxious alien plants by seed importation and site alterations.

d) Inadvertent destruction of rare plants.

3.5.3 Mitigation of Negative Impacts

1. The threat of forest fragmentation can be reduced by mitigating impacts b and c listed above, i.e. by minimizing the direct destruction of native vegetation and by preventing alien plants from becoming established within the easement. Specific recommendations are given under the next two points.

2. Destruction of some vegetation within the easement as the pipeline is being buried and other facilities are being constructed is, of course, unavoidable. This potential negative impact will be mitigated by minimizing the total area affected by the project. Destruction will be minimized by:

a) carefully siting all facilities as close to the existing powerline or to Saddle Road as possible, within a few feet where practical. In most places a service road associated with the existing powerlines parallels Saddle Road. The water pipeline should be located between the Saddle Road and the service road, never farther from Saddle Road than the service road.

b) Pumping stations #4 through #8 should be moved closer to Saddle Road (from their initial engineering design location) and out of sensitive closed forest areas.

c) The project construction plan should include provision of an education program and protocols for project planners, designers, and construction workers to emphasize the need for no unnecessary disturbance to native vegetation within the project area. Most of the native plants of the Saddle Road corridor are unique to Hawaii.

3. Mitigate potential negative impact of encouraging alien plants by:

a) Minimizing the total amount of surface that is disturbed by construction activity. Disturbed ground or crushed lava favors the establishment of alien plants (Appendix D).

b) Relocating pumping stations #4 through #7 away from their current forest sites; locating them on the 1855 lava flows, preferably close to Saddle Road. This will reduce the total area disturbed and avoid disturbing the more easily invaded forest habitats (Appendix D). Pumping station #2 should be built on the 1881 lava flow rather than in patches of forest in the area (as initially proposed in the engineering plan).

Visibility of the pumping stations can be reduced by taking advantage of the undulating topography and landscape plantings of native species. No alien plants should be used at the pump station sites. Alien plants might spread into and damage the native vegetation and will appear incongruous and unaesthetic in the landscape.

The recent widening of the Saddle Road right of way promoted vigorous volunteer growth of native koa (*Acacia koa*) showing that koa could be grown on disturbed lava around the pumping stations. Koa is quick growing and can be used to shield facilities from sight at elevations less than 3,200 ft., since that is where it naturally occurs. Koa plantings should also be attempted at pumping stations #5 through #7 which are above this elevation; however, it might be necessary to use species that naturally occur in the surrounding 'ohi'a forest, such as 'ohi'a (*Metrosideros polymorpha*) and tree ferns (*Cibotium* spp.). Alien plants should not be used for landscaping any portion of the water system within the Saddle Road corridor.

c) Taking advantage of the natural regeneration capacity of the native vegetation. Observations of disturbed areas under the two powerlines through the Saddle Road corridor indicate that in most areas the native vegetation will eventually regrow following disturbance. By taking advantage of natural succession back to native vegetation, the need to control weeds will be greatly reduced or eliminated.

d) Developing a program to monitor and control growth of alien plants within the easement until it is completely revegetated with native plants. Short-term treatment such as cutting or spot-spraying herbicides may be necessary to eliminate certain populations of aliens.

Continuous monitoring and control of alien plants will be necessary around pumping stations, access roads, and other facilities that receive on-going use. These repeatedly disturbed areas will tend to favor alien plants, as does the Saddle Road shoulder. Populations of alien pest plants should not be allowed to persist (see Appendix D, Table 17 for a list of noxious and pest plants).

4. Inadvertent destruction of endangered or rare plants or their habitat can be mitigated by:

a) Keeping all activities as near the Saddle Road and powerline right of way as possible, and keeping to the routes that have been surveyed by the botanist.

b) If the alternative B route is chosen, having a qualified botanist survey the exact easement through Parker Ranch after it is staked.

c) Avoiding disturbance of the populations of *Rubus macraei* described in "rare plants" section above.

5. Other mitigative actions

In addition to the mitigative actions discussed above for the powerline right of way the following specific commitments should be made to mitigate adverse effects of the project on native wildlife and forest habitat:

a) Kipuka protection Mile 9 to 19, Saddle Road.

Several native forest patches or kipukas surrounded by the 1855 lava flow lie immediately adjacent to the north (Mauna Kea) side of Saddle Road in the area proposed for pipeline routing (see figure 3.2b). Because these kipuka environments have well-developed forest species diversity (compared with the successionally younger vegetation on the surrounding 1855 lava flow), pipeline routing in these areas should be modified to avoid these areas by passing the pipeline under the Saddle Road to the southern road verge where no kipuka forest abuts the road.

b) Replacing Mamane trees destroyed by project construction

Near PTA, a federally-endangered Palila (*Loxioides bailleui*) Bird Habitat abuts the project area (Figure 3.2c-d). The site of the proposed 20 million gallon reservoir for PTA, although outside Palila Critical Habitat (Figure 3.2c), occupies an area where palila can be expected to potentially occupy if ongoing recovery efforts succeed for this species in the future. Development of the 10-acre proposed reservoir site would require removal of 30-60 existing mamane trees (depending on final siting considerations). In order to mitigate the consequences of this native tree removal, a program to replant (and maintain until established) seedling mamane in the same general area, at the rate of twenty trees planted for each tree removed by construction activity, should be established.

c) Landscaping

Except for where the pipeline crosses Parker Ranch and vegetation is completely dominated by alien pasture grasses, all landscaping of pipeline structures should utilize native species naturally occupying the same general area (e.g. 'ohi'a and koa). During the life of the project the operator should also commit to maintain an ongoing alien species control and eradication program along the entire pipeline right of way.

d) Night security lighting

All security lighting associated with pumping stations and other water transmission system appurtenances should be equipped with shielding against upward light diffusion that could adversely affect astronomical activities in the Mauna Kea summit area or cause possible disorientation for nocturnal bird life such as the Newell's shearwater (*Puffinus p. newelli*), a federally-endangered subspecies believed to frequent high altitude environments on Mauna Kea and Mauna Loa.

3.6 Archaeological/Historical Resources

In conjunction with preparation of this EIS, an archaeological and historic site survey was conducted for the entire water transmission corridor by Dr. Terry Hunt and is attached as Appendix G.

3.6.1 Existing Conditions

Archaeological literature review and field surveys were undertaken to assess the potential impact of a project to transport water from Hilo along a Saddle Road transmission line to the northwestern slopes and saddle area of Waimea.

Previous fieldwork for the Saddle Road area and slopes of Mauna Kea indicates that prehistoric and historic sites such as trails, rock walls, enclosures, cairns, modified and utilized caves and rock shelters, quarries, burials, and isolated artifact finds are present in the larger area. These sites represent intermittent or specialized use of upland resources and can include workshops, shrines and encampments. Archaeological work done in the Waimea area has documented historic sites associated with ranching and extensive prehistoric Hawaiian agricultural and residential complexes. These sites represent more intensive and permanent use in prehistoric and historic times.

Much of the project is planned for land already surveyed for archaeological resources and subsequently altered (by bulldozing) for Saddle Road improvements (Rosendahl and Rosendahl, 1986) and powerline realignments (Barrera 1983).

Present plans to place the water transmission line along the existing power transmission line and Saddle Road greatly reduces the need for additional intensive survey or mitigative steps prior to construction activities. In addition, project parcels (for pump stations) not previously surveyed are largely confined to the 1881 and 1955 Mauna Loa lava flows, thus restricting the kind of sites potentially present.

The field survey on the proposed route of water transmission from Hilo along Saddle Road, including pump station locales, revealed the absence of archaeological resources. Similarly, a survey of the proposed water transmission lines on the northwestern side of Mauna Kea showed no evidence of archaeological resources. However, the discovery of any archaeological remains during the course of construction would require a new plan for mitigation. Some monitoring of initial site preparation work is recommended as a mitigative plan for archaeology.

The proposed water development and transmission project following alternative route A as currently planned will have little adverse impact on archaeological resources.

3.6.2 <u>Probable Impacts of Proposed Action and Mitigation Measures</u>

Based on recommendations of the project's archaeological consultant, the following mitigative actions should be adopted during the construction phase of this project:

1. Initial site preparation work (vegetation clearing by hand) at the site of proposed pump station #1 located in the Waiakea-Uka area of Hilo should be monitored by an experienced archaeologist to check for sites (e.g., agricultural, residential, or lava tube caves) covered by the dense vegetation. Should archaeological resources be discovered, a plan for further mitigative steps will need to be formulated.

2. Construction crews should be informed of the potential with vegetation clearing and other activities to discover prehistoric and historic artifacts, features, buried deposits, and lava tubes. Chances of such discoveries seem greater at pump station #8, at the Pohakuloa reservoir and water tanks, at hydropower stations 1 and 2, and at the terminal reservoir. In the event such resources are discovered, all destructive work should be suspended until a qualified archaeologist can examine the finds and recommend a mitigative plan.

In each case, it will be necessary to conduct an intensive archaeological survey of lands not previously examined. This is a first step to making prudent decisions concerning development. Some locations will require little, if any, additional work beyond an initial survey (i.e., little to no archaeological resources are present). Other lands will require intensive data recovery projects prior to loss of archaeological resources with development. And some locations, as mentioned above, should see no development at all in order to preserve resources of cultural and scientific significance.

The interior mountainous areas of Hawaii through which the alternative pipeline alignments pass were not subjected to intensive human settlement or use either during prehistoric or recent times. On the windward Mauna Loa portion of the proposed alignment most of the substrate is composed of recent lava flows 55-150 years in age. Previous archaeological surveys along the Saddle Road or parallel power line easements failed to discover significant or important archaeological or historic sites (trails and walls of historic age are present in several areas).

3.7 Surrounding Land Use

3.7.1 Existing condition: Land Ownership and Their Current and Planned Uses

1. Transmission Corridor

The proposed well field development site above Hilo in the Waiakea-Uka area is on State land in the State Land Use Agricultural District. The 61-mile pipeline route from the well field to Waimea (via Pohakaloa) traverses primarily State and DHHL lands on windward Mauna Loa and private lands (Parker Ranch) on leeward Mauna Kea in either the State Land Use Conservation or Agricultural Districts. A few small private landowners will be impacted in the pipeline right of way above Hilo (see Table 1.1).

Major existing land uses along the proposed pipeline right of way are described in Figures 3.2a-f, and include:

a) Small farms and rural residential usage in the vicinity of the well field.

b) Undeveloped agricultural lands (in forest) along the 7.3 mile powerline easement from the well field site to the pipeline junction with the Saddle Road (between the 8 and 9 mile markers).

c) Forest watershed in the Protected and Resource Subzones of the State Land Use Conservation District between the 9-23 mile markers on the Saddle Road.

d) Pasture lands (cattle) in the Agricultural District (Humuula area) between the 23-28 mile markers on the Saddle Road.

e) Military uses associated with PTA between the 29-43 mile markers (with adjacent Palila Critical Habitat on Mauna Kea).

f) Pasture lands (Agricultural District) of Parker Ranch from the 43 mile marker to the 46 mile marker where the pipeline right of way leaves the Saddle Road to cut across Parker Ranch to the reservoir site.

3.7.2 Probable Impacts of Proposed Action and Mitigating Measures

The buried pipeline and other water transmission appurtenances are not expected to have any significant negative impact on surrounding existing land uses in the project area.

3.8 Social and Economic Features

3.8.1 Existing Condition

The analysis is limited to an assessment of the impacts related to the development and operation of the across-island pipeline. It does not address the impacts related to the potential end users.

Should a potential end user decide to utilize the pipeline to supply its water requirements, the cumulative social and economic impacts, including those involved in the construction and operation of the pipeline, would have to be assessed by that end user.

This section describes existing social and economic conditions of the Big Island and evaluates potential economic and social impacts that the proposed project is expected to have.

1. Island of Hawaii

The Island of Hawaii (Big Island), the largest in the Hawaiian Archipelago, is 93 miles long, 76 miles wide and encompasses approximately 4,035 square miles, representing 63 percent of the State's land area. There is great diversity in landscape and climate, ranging from barren lava fields to lush rain forests, from arid deserts to verdant pastures, from white, black, and green sand beaches to snow-capped mountains rising nearly 14,000 ft. above sea level.

The island mass represents the fusion of volcanic mountains of which Mauna Loa, Kilauea, and Hualalai remain volcanically active. Climatic variation provides for diverse agriculture and aquaculture applications which are steadily replacing the declining sugar industry. Most apparent of the assets afforded by geography, however, is the attractive resort climate and diverse attractions valued by visitors to the island. The cloudless and pollution-free atmospheric conditions at high altitude on Mauna Kea have fostered the growth of the world's leading astronomical research facilities.

2. Economy

With all the environmental diversity the Island of Hawaii offers, the Island's economy over most of the past century has been based largely on agricultural activities, primarily sugar. The sugar industry in Hawaii has been declining steadily over the past twenty years, mainly due to foreign competition. In recent years economic policy on the Island of Hawaii has encouraged growth in the diversified agriculture sector: 1) to replace sugar; 2) to lessen the statewide dependency on imported crops; 3) to develop selected export crops, and 4) to provide diversity in an economy now increasingly dominated by the visitor industry.

The visitor industry of Hawaii County has grown rapidly over the past two decades with the number of annual arrivals reaching one million visitors in 1991. This rapid visitor industry development has been concentrated on the dry leeward (west) side of the island and as a consequence the districts of North Kona and South Kohala have become world-class resort destination communities. As with the rest of the state, Hawaii Island's economy is becoming increasingly dependent on the visitor industry sector.

3. Population Growth

The population of the island has grown rapidly in recent decades in tandem with visitor industry growth, increasing by 45 percent from 63,468 in 1970 to 92,053 in 1980. Over the same period the total state population increased by only 25.3 percent. By 1990 the Big Island's population had undergone a further increase to 120,137, or 30.7 percent growth since 1980 (compared with a 14.9 percent state-wide growth rate in the 1980s). The Big Island's rapid population growth has been heavily concentrated in the districts of West Hawaii.

Table 3.5
Resident Population and Growth Rate of
Hawaii County 1970, 1980, 1990

Growth Rate	1970	1980	1990	1970-80	80-90
Hawaii County	63,468	92,053	120,317	45%	31%

Source: U.S. Census data 1970, 1980, 1990

4. Pohakuloa Training Area

The role of the military in Hawaii is not confined solely to Oahu. On the Big Island, the U.S. Army maintains the Pohakuloa Training Area (PTA) located approximately 38 miles from Hilo in the saddle area between Mauna Kea and Mauna Loa at an elevation of 6,200 ft. First developed during WWII, PTA today incorporates a total area of 182 square miles of land. These lands are leased State lands and Hawaiian Home Lands. A portion of the area is Federal land by presidential proclamation.

The base camp occupies 100 acres of land with 200 temporary buildings housing 40 permanent civilian and army personnel and an airfield (Bradshaw Airfield) which supports fixed-wing aircraft up to the size of C-130s. The remaining areas are used for military training activities including simulated war games, live firing of both small and large caliber weapons and related activities. This extensive area of the base is used intermittently, on a rotating basis, for short-term training exercises for 1,800-3,000 Army and Marine Corps personnel for approximately 260 days/year.

3.8.2 Probable Socio/Economic Impacts of Proposed Action and Mitigation Measures

1. Impacts from Pipeline Construction:

a) Income and Employment

The proposed water transmission project will generate both income and employment from construction of the water well, pipeline, and terminal reservoir. Of the projected total construction cost of $266 million, approximately $160 million will be spent on local construction and related expenditure over 2.5 years (See Tables 2-1 and 9-1, Appendix B, Engineering Report). A direct income of $64.9 million is expected to be generated during this period. When considering indirect and induced impacts, the newly generated income can reach $89 million over the same period.

The construction project is also expected to generate as many as 811 man-years of direct construction and related jobs over the construction period. The Big Island's current 2,250-member construction industry will experience an average increase of 14.4 percent in demand for labor for two and a half years. In addition, approximately 400 man-year equivalent indirect jobs will be created over the same period of time.

b) Traffic, Air Quality, and Noise

Operation of construction equipment, trucks, and worker vehicles may temporarily impede traffic along the Saddle Road during the construction period. Minor increases in noise levels may result from construction activities. However, the actual impact of increased noise level on residents will be confined to only a short segment connecting the water well to Saddle Road.

There will be significant traffic impacts during the construction phase of the pipeline project, particularly in those areas where the right of way lies immediately adjacent to the Saddle Road. These impacts include: congestion, delays, lane closures, use of earth-moving and other heavy equipment, blasting, noise and dust associated with pipe laying. All of these activities will cause temporary construction impacts on traffic flow, noise levels, and air quality on and adjacent to the Saddle Road. The construction contractor will be required to develop work schedules in such a way as to mitigate traffic flow inconvenience.

c) Housing

The proposed project will not significantly or adversely impact the existing housing stock. This will be the case particularly if the construction industry is in the midst of a recession. In this case most of the workers are expected to be residents of the island. In the worst scenario in which the construction industry experiences a boom resulting in a shortage of construction labor, it is possible that temporary housing to accommodate imported construction workers will be needed. However, there is an adequate supply of hostels and reasonably-priced local hotels that can be used to accommodate the transient work forces.

2. Impact During Operational Phase

During the operation of the transmission line, it is estimated that eight permanent professional staff (engineers), one secretary and two part-time staff are required. The annual total income generated by these positions will be approximately $400,000 excluding benefits in 1991 dollars.

3. Other Economic Impacts

The project will also have a positive impact on both State and County resources. Additional revenues to the government will be generated in the form of sales and income taxes, permits and other fees. The projected State revenue from general excise taxes is $10.4 to $13.0 million, based on a 4.16 percent general excise tax rate. The revenue from income taxes is estimated to be $4.7 million from direct and indirect income from the project, based on the average of a 5.8 percent state income tax rate.

4. Community Issues

This evaluation identifies a number of social issues that are either directly or indirectly related to the proposed water pipeline project. Each of these issues is briefly discussed.

a) Water Scarcity Issues

Because of an imbalance in water resource availability and lack of infrastructure for distribution, there are a number of water-scarce areas on the Big Island. As a result, it is possible that residents of the areas that lack water may question the proposed action because they feel that their own regions have equal or greater needs for water than other potential end users. Because of its geographic proximity to the proposed water source, Puna residents may be particularly sensitive to the issue.

b) Linkage with other controversial projects

The water transmission project may be linked to other existing controversial projects as related and interdependent. One such project is geothermal energy development. The water transmission project requires up to 30 MW of continuous or baseload power. While the water transmission project is not directly linked to geothermal development, the base load requirements are well suited to such power plants. Furthermore, geothermal development is one of the few indigenous energy sources providing base load power. The exploration for and development of geothermal power on the Island of Hawaii is currently on-going. The first commercial power plant is targeted to be on line by September 1992. While the scale of the geothermal resources is still being assessed, it does provide the potential for addressing a significant portion of the County's base load energy requirements in the future, including those required by this project, should it be implemen

c) Funding

County residents will be extremely sensitive to the issue of the cost of the project and the funding sources to the extent the project is funded by State and County monies. It may be viewed as competing with other compelling interests. In a state like Hawaii with its high cost of living and taxation rate, this is to be expected. This effect will be particularly pronounced if there is an accompanying belief that the project will benefit certain groups but not others.

d) Demand for Water

Political pressure will increase to modify the original agreement regarding uses of the new water resource. The basic problem is that depending upon who the end user is, the water availability from the project will encourage population increases, which will itself lead to new demands for new water, and the community, though larger and economically more energetic than before, may find itself in the same difficulties that it currently faces. The likelihood of this concern is greater if the end users are PTA or urban residential and commercial entities.

3.9 Energy

3.9.1 Existing Condition

The Island of Hawaii has been leading the way in developing alternative energy resources from biomass, wind, solar, hydroelectric, geothermal, OTEC, and other technologies. Biomass-based energy has long been the most important part of the island's power supply, although the recent decline in the production of sugar cane bagasse somewhat reduced the contribution of biomass-based energy to total production. There is potential for commercial-scale alternative geothermal energy from Puna and other districts of the island.

The Hawaii Electric and Light Co. (HELCO) which serves the Island of Hawaii currently has an installed capacity of 178 MW of electrical generating capacity as of 1991. Of this total, 18 MW of generating capacity is owned by the Hilo Coast Processing Company (HCPC) but is contractually committed to HELCO. An additional 10 MW is owned by the Hamakua Sugar Company and is also contractually committed to HELCO. There is a proposed private development of hydropower in the order of 10 MW. This has been approved but is not yet operating. Wind-based power owned by various private entities amounts to 10 MW. Both hydro and wind power, however, are not firm power and are thus available only intermittently. Table 3.6 summarizes power generation by source for 1990.

CORRECTION

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

in the future, including those required by this project, should it be implemented.

c) Funding

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3.9 Energy

3.9.1 Existing Condition

The Island of Hawaii has been leading the way in developing alternative energy resources from biomass, wind, solar, hydroelectric, geothermal, OTEC, and other technologies. Biomass-based energy has long been the most important part of the island's power supply, although the recent decline in the production of sugar cane bagasse somewhat reduced the contribution of biomass-based energy to total production. There is potential for commercial-scale alternative geothermal energy from Puna and other districts of the island.

The Hawaii Electric and Light Co. (HELCO) which serves the Island of Hawaii currently has an installed capacity of 178 MW of electrical generating capacity as of 1991. Of this total, 18 MW of generating capacity is owned by the Hilo Coast Processing Company (HCPC) but is contractually committed to HELCO. An additional 10 MW is owned by the Hamakua Sugar Company and is also contractually committed to HELCO. There is a proposed private development of hydropower in the order of 10 MW. This has been approved but is not yet operating. Wind-based power owned by various private entities amounts to 10 MW. Both hydro and wind power, however, are not firm power and are thus available only intermittently. Table 3.6 summarizes power generation by source for 1990.

Table 3.6: HELCO ENERGY PRODUCTION BY SOURCE

TOTAL GENERATED BY HELCO (X1000 KWH):	592,141	75.9%
PURCHASED POWER:		
HCPC (biomass/oil/coal)	107,195	13.7%
HAMAKUA (biomass/oil/coal)	59,384	7.6%
HERS KAHUA (wind)	2,702	0.3%
HERS LALAMILO (wind)	1,969	0.3%
KAMAOA (wind)	15,124	1.9%
OTHER WIND	137	0.1%
WAILUKU RIVER (hydro)	1,638	0.2%
TOTAL GENERATED AND PURCHASED	780,289	100.0%

HELCO sold 663 million KWH of electricity in 1989. Residential customers used 259 million KWH, or 39 percent, and the remainder was sold to commercial, industrial, and public sector customers. The projected energy needs for the Island of Hawaii as forecasted by HELCO is shown in Table 3.7.

TABLE 3.7: Projected System Capacity through Year 2009, Hawaii Electric and Light Co. Forecast, March, 1991

Year End	System Capacity(MW)	Peak (MW)	MW Increase	%
1991	177.8	145.0	4.7	5.6
1992	198.6	152.0	7.0	4.8
1993	195.6	163.0	11.0	7.2
1994	216.7	171.0	8.0	4.9
1995	208.6	180.0	9.0	5.3
1996	215.8	186.0	6.0	3.3
1997	232.8	194.0	8.0	4.3
1998	230.0	202.0	8.0	3.9
1999	252.5	209.0	7.0	3.9
2000	241.0	218.0	9.0	3.9
2001	270.0	226.0	8.0	3.8
2002	270.0	234.0	8.0	3.8
2003	270.0	243.0	9.0	3.8
2004	270.0	253.0	10.0	3.8
2005	291.0	262.0	9.0	3.8
2006	291.0	272.0	10.0	3.8
2007	319.0	283.0	11.0	3.8
2008	311.0	293.0	10.0	3.8
2009	311.0	304.0	11.0	3.8

Source: Helco Forecasting Committee, March 1991

Geothermal energy is the newest commercial-scale firm power that is expected to be available sometime in 1992. Commercial scale production by private firms is at different stages of development. The most current is the 25 MW plant developed by Ormat's Puna Geothermal Venture (PGV) that is currently scheduled to be on line sometime in mid-1992. Additional geothermal power in the order of 60 MW is potentially available over the next five years.

The water transmission project is expected to require 30 MW, or 255 million KWH of electricity to lift water to the 6,600 ft. elevation, using eight booster pumps. Approximately 4.5 to 7.4 MW of electricity will be recovered by hydroelectric power generation as the water moves from PTA downhill to its terminus reservoir in Waimea.

It is expected that electrical demand and generation would initially occur during off-peak hours and gradually become a 24-hour operation beginning in the year 2002. Table 3.8 provides the estimated power demand schedule for the proposed water transmission. The hydropower stations will run either one or both of the generating units at each station, accounting for either 2,150 KW or 4,300 KW total generation.

3.9.2 Probable Impacts of Proposed Action and Mitigation Measures

Table 3.8 and Figure 3.5 provide a summary of the projected impacts of water pumping activities on peak demand of electricity. The impact analysis was carried out on the assumption that the funding, design, and construction of the project begins sometime in 1992 and the actual water pumping begins sometime in 1998.

It is assumed that the end users' water demand rise gradually at a rate of 10 percent per year. This assumption is reflected in the water pumping schedule in column (2), Table 3.8. The electrical demands and hydroelectric generation would initially occur during off-peak hours and gradually become a 24-hour operation when the water demand reaches 20 mgd.

In Table 3.8, columns (3) and (4) provide HELCO's projected rated system capacity and peak demand, respectively, before the introduction of water pumping from 1992 to 2007. The difference between the rated system capacity and the peak is the reserve margin that is needed to meet the various system down times, including scheduled maintenance. Thus, the reserve margin cannot be relied upon as additional available load for water pumping or any other uses. Column (5) indicates load demand for water pumping purposes. Column (6) indicates the projected number of hours of water pumping operation. Column (7) examines the impact of additional electricity load requirements for water pumping.

Assuming that the pipeline is ready by year 1998, it is assumed that 2 mgd of water will be pumped during that year, requiring 16.5 MW of electrical power load for the duration of 4.8 hours daily (79.2 million KWH). These pumping hours will occur during off-peak hours beginning at 9:00 p.m. Thus, the impact of an additional 16.5 MW capacity on the peak demand load would be zero because peak demand usually occurs sometime between 6:30 to 7:00 p.m. and by 9:00 p.m. there is enough capacity to service the required 16.5 MW (See Figure 3.4, Daily Load Curve).

TABLE 3.8: Impact of Water Pumping Requirement on System Capacity through Year 2007, (MW)

Year (1)	Water Pumping (2)	Helco's System Capacity (3)	Projected Peak Demand (4)	Demand For Water Pump (5)	Operat'g Hours For Water Pump (6)	Addit'l Capacity Reqr'd (7)
	(MGD)					
1992	0	177.8	145.0	0.0	0.0	0.0
1993	0	198.6	152.0	0.0	0.0	0.0
1994	0	195.6	163.0	0.0	0.0	0.0
1995	0	216.7	171.0	0.0	0.0	0.0
1996	0	208.6	180.0	0.0	0.0	0.0
1997	0	215.8	186.0	0.0	0.0	0.0
1998	0	232.8	194.0	0.0	0.0	0.0
1999	2	230.0	204.2	16.5	4.8	0.0
2000	4	252.5	209.0	16.5	9.6	0.0
2001	6	241.0	218.0	30.0	7.2	0.0
2002	8	270.0	226.0	30.0	9.6	0.0
2003	10	270.0	234.0	30.0	12.0	0.0
2004	12	270.0	243.0	30.0	12.0	16.5
2005	14	270.0	253.0	30.0	12.0	16.5
2006	16	291.0	262.0	30.0	19.2	30.0*
2007	18	291.0	272.0	30.0	21.6	30.0*
2008	20	319.0	283.0	30.0	24.0	30.0*

*There is an impact on peak load by the amount indicated.

Source: HELCO's Forecast of Sales, Peak, and SLF for 1991-2010 March 1, 1991

Figure 3.4 Daily Demand

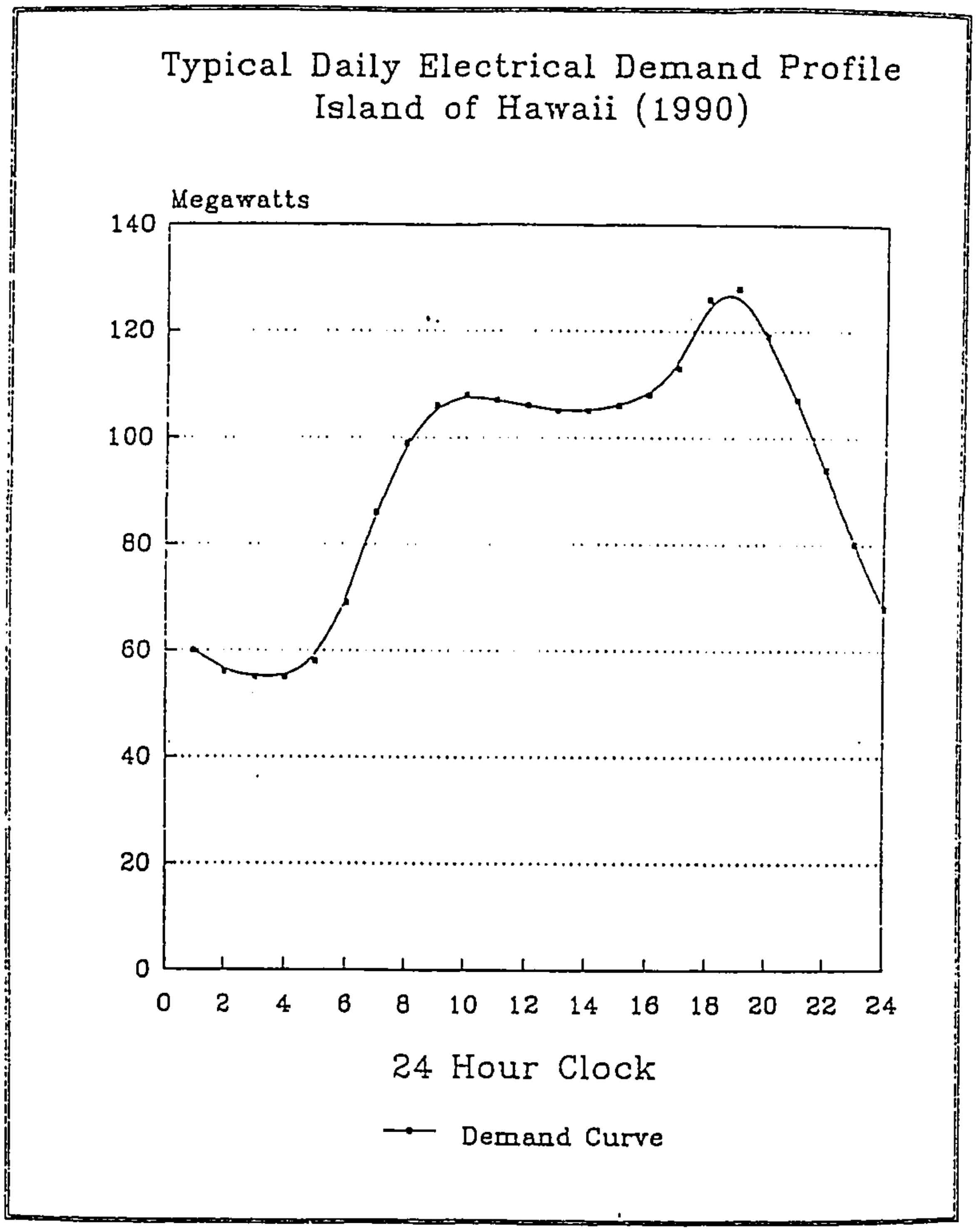
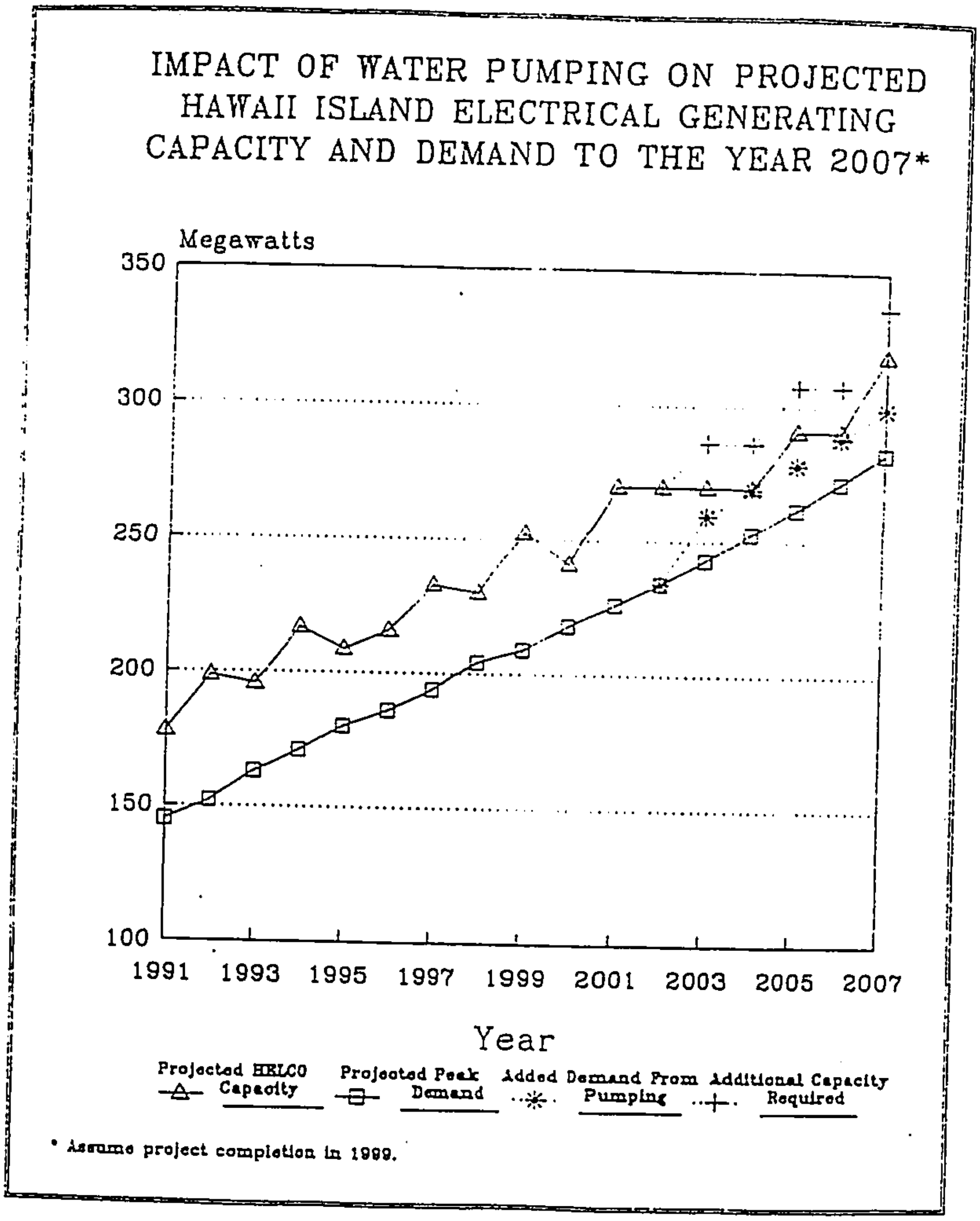


Figure 3.5 System Capacity Projection



It is apparent that by strictly limiting the pumping activities to off-peak hours, up to 10 mgd of water can be pumped with no additional generating capacity required. When the pumping requirement reaches 12 mgd, an additional 16.5 MW of generating capacity is needed, although only for 4 hours a day. When water pumping requirements reach 16 mgd, the additional power requirement is 30 MW.

One possible mitigating measure for avoiding the additional electrical capacity increase would be that the water pumping be done on an interruptable schedule. Under this option, the water pumping will be interrupted, as needed, during the peak hours.

The obvious effect of this option is that the amount of water pumped will be reduced by the same proportion to the interrupted pumping hours. During the winter season when the demand for water is at its minimum, this option may work reasonably well. For any water demand in excess of 14 mgd, however, an interruptable pumping schedule will result in a shortfall of meeting demand and may not be a viable option.

Another mitigative measure may be that the pumping schedule be limited to only the off-peak schedule until such time as a dependable and economically viable alternative energy source is fully developed and available to the utility. This option may well be the preferred scenario as a trade-off between adding additional energy capacity whose private and social costs may exceed the benefit of additional water availability to the end users.

In essence, however, the needs for additional power generation capacity is driven by the rate of growth of water demand by the end users. For instance, if the major end use is for agricultural irrigation water, the overall demand for pumping requirement is likely to be driven by the actual growth rate of farm developments which, in turn, depends on the rate of market penetration of Hawaiian farm products both within and outside of the state. It is very possible that the market growth rate may grow faster than assumed and, if such is the case, the pumping requirement will come to its maximum (20 mgd) much sooner than assumed.

On the other hand, if the market penetration takes place at a slower rate than assumed, it will correspondingly slow the power demand schedule accordingly. In addition, there are a number of factors beyond our control that will govern the actual power demand. Climatic variations such as precipitation rate, winds, drought, and scheduled and non-scheduled power interruptions and the like will also operate in different combinations to make it difficult to estimate the precise quantity of water to be pumped. The reservoir capacity of 140 million gallons should provide some cushion to mitigate some of these possible variations in water demand.

3.10 End Users

As stated earlier, this analysis does not attempt to describe or analyze the water needs of the projected end users. In fact, the final end users may be other than those described herein. However, as these potential end users finalize their development plans, this analysis will assist them in determining the viability and feasibility of the across-island pipeline as a potential water source.

The impacts of the end user(s) will be analyzed in a separate environmental assessment at that time. The cumulative impacts of the across-island transmission line will be incorporated as part of that review.

In order to gain an understanding of the potential impacts of the end user(s) that must be further assessed, a brief description of these potential impacts is provided.

3.10.1 Pohakuloa Training Area

Current average daily potable water consumption at PTA is 60-80,000 gallons per day and is supplied by nearby spring water (shared with adjacent Mauna Kea State Park) and is supplemented by purchased potable water trucked from Hilo or Waimea at a cost of $28/1,000 gallons.

The current PTA Master Plan, which is being revised as part of the USARPAC Mission Statement in 1989, identifies in its mission statement that PTA is to "Develop, operate and maintain a safe, state-of-the-art, multi-purpose army training area for USARPAC and other Pacific Command (PACOM) units." The modernization of PTA will require potential potable and irrigation water demand of approximately 5.1 mgd.

3.10.2 Intensive Agricultural Use in Waimea

If intensive agricultural use of the Waimea plain becomes a viable end use for the water, there will be a number of anticipated impacts and these are briefly discussed here.

1. Land Use Impact

The bulk of lands making up the South Kohala district is owned by the State of Hawaii, Department of Hawaiian Home Lands, Parker Ranch, Waikoloa Development Co., Waiki'i Ranch, Mauna Kea Properties, and Queen Emma Foundation. At the present time the majority of these lands is used for agricultural production including ranching, truck farming, ranch "estate", and other agricultural activities. Other lands are in various urban uses such as resort and related development activities.

All major land owners have their own long-term land use plans which, along with State and County plans, will guide planning and future land uses. Based on a series of discussions with the major landowners regarding their future land use plans, it was clear that not all the lands within the subject site areas are planned for intensive agricultural use. For instance, the Waiki'i area, owned by Waiki'i Ranch (Home Properties Inc.) has restrictive covenants which effectively prevent its tenants from engaging in any type of intensive farming. Most of these lands are currently used for residential and pasture activities or are reserved for such future uses.

These considerations, in practicality, reduce the suitable area for agricultural development to those sites where lands are owned by Parker Ranch and the Department of Hawaiian Home Lands. This area encompasses over 138,000 acres and includes a wide range of climatic conditions, soil types, and planned land use designations.

Figure 3.6 identifies this general area, comprising about 9,700 acres of Puukapu 1 owned by DHHL and approximately 18,000 acres owned by Parker Ranch. Of these Parker Ranch lands, approximately 9,700 acres are "profitably used" by the ranch for intensive grazing. The remaining 8,300 acres are available, if Parker Ranch so chooses, for intensive crop production. It contains areas with elevations ranging from 2,500 to 4,000 ft. The area contains large pockets of lands with varying soil classifications including "excellent for vegetable crops" and "prime when irrigated" ratings on the basis of the ALISH land classification system. Eighteen mgd of water to this area can support 5,315 acres of intensive agricultural use.

2. Water Quality

A potential environmental concern with respect to the impact of the proposed project on groundwater quality relates to the ultimate disposition and quality of irrigation waters applied to new agricultural lands. While most of the applied irrigation water will be transpired or evaporated into the atmosphere by vegetative or soil surfaces (the water costs will virtually dictate the use of efficient drip irrigation technology), some small fraction of applied irrigation water would be expected to percolate into the ground and ultimately make its way into perched or basal aquifers on the leeward slopes of Mauna Kea. These aquifers are currently used for domestic (potable), resort and agricultural water supply in the coastal areas of South Kohala.The current County well system at Lalamilo (elev. 1,100 ft.) above Kawaihae is located downslope from the large (600-acre) existing State Agricultural Park at Lalamilo, on the south side of Waimea (elev. 2,600 ft.). The most recent analysis of water quality at the Lalamilo well (Feb. 1991, by Department of Health) has indicated no detectable or measurable concentrations (less than 0.2 parts per billion, or micro-grams/liter) for a broad range of synthetic and natural contaminants. These results, although limited to a single sampling period, give no indication that existing agricultural practices in the Waimea area are contributing to downslope groundwater quality degradation.

3. Archaeological and Historic Features

The archaeological field survey and descriptions reported in section 3.6 above cover only plans for the proposed well field and a pipeline from Hilo to PTA and on the Parker Ranch area above Waimea. The archaeological research done to date does not directly address the impact of developing some 3,200 acres for intensive agriculture in the Waimea area, PTA, or other as yet undefined water end users.

In the interests of historic preservation and economic feasibility, planning for water development in the Waimea region must take into account the distribution of archaeological resource densities. Areas with a high density of archaeological sites/features, such as the unique Waimea agricultural field systems, should be avoided to assure preservation. Areas better suited to development from an archaeologist's point of view would be southern portions of the Waimea saddle and the western slopes of Mauna Kea where a much lower density of archaeological resources is anticipated.

4. Economic Impact

Use of the water for intensive agricultural development in the Waimea plain will have significant regional and county-wide economic impacts.

a) Range of Economically Viable Crops

An Agriculture Feasibility Study was conducted to determine the potential economic viability of utilizing the across-island transmission line to support agricultural crops in West Hawaii (see Appendix C). The study shows that there are a number of crops with sufficient value to remain economically viable at the projected higher water costs, provided that farm infrastructure, adequate labor supply, and capital and land acquisitions at reasonable prices are assured. The list of crops that can be economically produced along with potential acreage data are summarized in Table 3.9.

Water requirements to produce crops both for the level of consumption in 1988 and in 2007 (the time when the study assumes that the farming industry would be fully developed) were projected and shown in Table 3.10. The expected price of water is high compared to the price that is paid by various users today. The entire range of water prices is provided in Table 2.1 and a complete water cost sensitivity analysis for various crops are carried out in the study. As the industry expands in the targeted areas and as crop production increases, a direct estimated output of $51,387,000 in 1988 dollars can be achieved. This increase in farm value can be produced by the use of 3,032 net acres which can support the production of 102,483,000 lbs. of agricultural crops.

b) Income and Employment Impacts

If the Waimea plain does become the end user of the water and develops intensive farming, this has the potential to create as many as 1,765 farm and farm-related jobs when fully developed and estimated annual farm income would be $65.1 million.

Figure 3.6 Agriculture Area

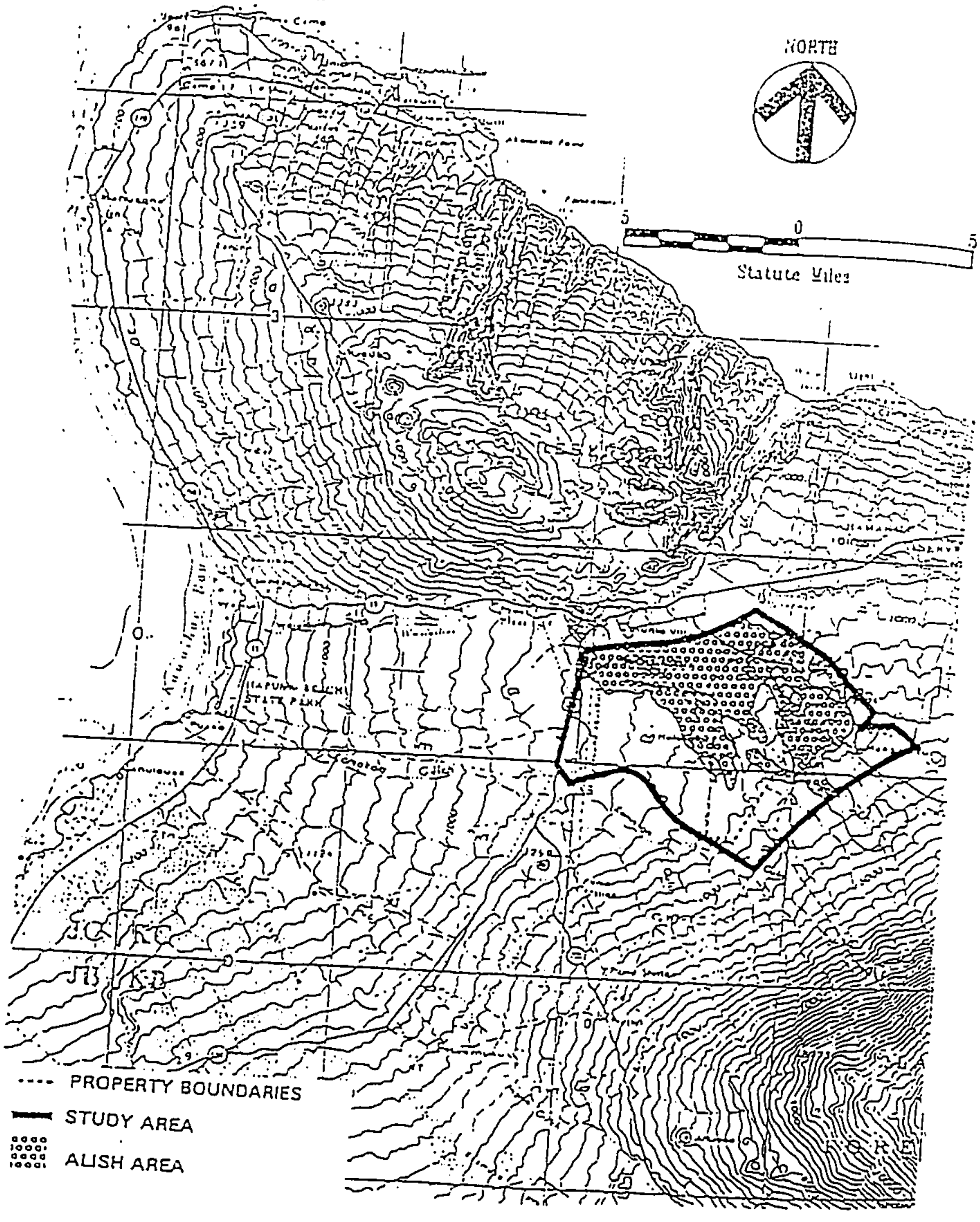


TABLE 3.9 Recommended Crops and Their Implication on Import Replacements, Export Potentials, Required Acreage, and Estimated Farm Value, 1988

Crops	Import Replacement(%)	Quantity (000 lbs.)	Additional Acreage	Estimated Farm Value($1000)
Temperate Orchards				
Apples	30%	4,400	164	2,200
Grapes	10%	2,500	250	1,875
Persimmons	100%	400	15	320
Subtotal		7,300	429	4,395
Vegetable/Leafy Group				
Head Lettuce	85%	16,261	908	5,838
Romaine	85%	2,186	157	767
Dry Onions	85%	15,717	1,310	11,222
Green Pepper	85%	2,024	101	1,287
Potatoes	85%	36,360	2,042	14,544
Tomato	85%	16,147	400	8,364
Subtotal		88,695	4,918	42,022
Correction for average of 2.5 Crop Cycle			1,967	
Export Potential				
Protea	100%	1,488	136	1,220
Wine(Grapes)	20%			
of Total Imports		5,000	500	3,750
Subtotal		6,488	636	4,970
Grand Total		102,483	3,032	51,387
Gross Acreage		5,306*		

* Gross acreage is calculated using 1.75 times the net acreage.

TABLE 3.10
Production and Required Water, Years 1988 and 2007

Crops	Quantity (000 lbs.)	Water Requirement (mgd)	
Temperate Orchards		1988	2007
Apples	4,400	0.488	0.856*
Grapes	2,500	0.967	1.696*
Persimmons	400	0.058	0.102*
Subtotal		1.513	2.654*
Vegetable/Leafy Group			
Head Lettuce	16,261	0.723	1.268*
Romaine	2,186	0.125	0.219*
Dry Onions	15,717	1.891	3.316*
Green Pepper	2,024	0.154	0.270*
Potatoes	36,360	2.947	5.168*
Tomato	16,147	0.223	0.391*
Subtotal		6.063	10.632*
Export Potential			
Protea	1,488	0.775	1.359*
Wine(Grapes) of Total Imports	5,000	1.934	3.391*
Subtotal		2.709	4.750*
Grand Total		10.285	18.036*

* Combined population and per capita consumption growth rate of 3 percent per annum is assumed.

Water requirements to produce crops both for the level of consumption in 1988 and in 2007 (the time when the study assumes that the farming industry would be fully developed) were projected and shown in Table 3.10. The expected price of water is high compared to the price that is paid by various users today. The entire range of water prices is provided in Table 2.1 and a complete water cost sensitivity analysis for various crops was carried out in the study. As the industry expands in the targeted areas and as crop production increases, a direct estimated output of $51,387,000 in 1988 dollars can be achieved. This increase in farm value can be produced by the use of 3,032 net acres which can support the production of 102,483,000 lbs. of agricultural crops.

b) Income and Employment Impacts

If the Waimea plain does become the end user of the water and develops intensive farming, this has the potential to create as many as 1,765 farm and farm-related jobs when fully developed, and estimated annual farm income would be $65.1 million.

One of the requirements for large-scale agricultural operation is to establish necessary infrastructure supports such as access roadways, water resource development, irrigation system development, and oftentimes acquisition of lands. The required improvements are estimated to cost $31.3 million, using 1988 constant dollars. This one-time infrastructure development expenditure will add $15.6 million of additional income and provide over 750 man-year equivalent jobs. It is expected that, wherever possible, those jobs will be occupied by residents of South-Kohala or residents of nearby areas.

Infrastructural improvement activities also generate a total combined (direct, indirect, and induced) income of $21.2 million. The direct employment impact of infrastructure development is estimated to be 359 man years. Combining with indirect and induced effects, the total employment will be 1,067 man years.

It is expected that additional infrastructure will be needed for such ancillary support facilities as packing plants, various warehouses for central collection and interisland distribution, etc. This may require expansion of Kawaihae Harbor's loading dock facility to accommodate importation of chemicals, fertilizers, and other materials, and to handle outgoing shipments.

c) Other Economic Impacts

The project will also have a positive impact on both state and county resources. Additional revenues to the government will be generated in the form of sales and income taxes, property taxes, licenses, permits and other fees. When fully developed, the County government's expenditure may be increased to provide usual public infrastructure services to the expanded Waimea community.

5. Probable Social Services Impacts

The extent of social services impacts from the increased farming activity will basically depend on the extent of net increase of population directly attributable to that activity. When fully developed, the farming activities will add 1,765 farm and farm-related jobs. If these jobs are absorbed by the existing residents, the specifically project-related impacts should be minimum. On the other hand, if the needed farm workers have to be immigrated into the area, this in turn will have service impacts in the area of police and fire protection, school, housing, sewer treatment, traffic congestion, and the like.

3.10.3 West Hawaii Urban/Resort Uses

The consumption of potable water supplied by the county municipal system in the vicinity of the town of Waimea is 3.4 mgd, with an additional 1.3 mgd used for agricultural irrigation. The future demand for this region (by 2010) is estimated to be 15 mgd for municipal potable water and 11 mgd for irrigation (See Hawaii County Water Development Plan, 1989).

These future needs are to be met, at least partially, by a number of ongoing water development plans and projects. The Waimea Irrigation System is a Federal and State joint program which envisions a new 133 million gallon reservoir and necessary pipeline to support 363 acres of new cropland and to supply livestock water for an additional 8,200 head of cattle. Kohala Coastal Transmission Pipeline is underway to supply potable water for the region's resorts by importation from the North Kohala aquifer. Puukapu Deep Well Development plans to develop a deep well in the Kohala Forest Reserve in Puukapu and connect it to the Waimea Irrigation System for standby irrigation uses.

According to the Hawaii County Water Use and Development Plan, the estimated future water demand for South Kohala in the year 2010 will be approximately 63 mgd. The projected sustainable yield for both surface and groundwater in this district is estimated to be 12 mgd of surface water and 51 mgd of groundwater. Consequently, in order to meet these additional water requirements, both municipal and private water systems are at various stages of development.

The possibility of water transmission across the island from East Hawaii presents itself as another alternative water supply source. How much of this water will actually be used for urban uses, if at all, will likely depend on the cost competitiveness of the water delivered.

1. Probable Impacts and Possible Mitigating Measures

Potential West Hawaii urban or resort developments that might be initiated or expanded in response to increased water availability through this water transmission project could be expected to generate a wide range of site-specific and cumulative regional environmental impacts. These impacts would be addressed in the individual environmental review processes for such projects.

3.11 Adverse Environmental Effects Which Cannot Be Avoided

The water transmission project will create limited adverse environmental impacts which cannot be fully mitigated by the measures planned to be implemented at the site. The following list includes those short-term and long-term impacts that are expected to be unavoidable.

3.11.1 Unavoidable Adverse Short-Term Impacts

1. Negligible temporary increases in soil erosion will result from construction operations, and negligible amounts of soil will be carried off-site in surface runoff water.

2. Operation of construction equipment, trucks, and worker vehicles may temporarily impede traffic in the area during the construction period.

3. Negligible releases of air contaminants will occur from construction equipment. Small amounts of dust may be generated during dry periods as a result of construction operations.

4. The visual character of the area will be affected by construction activities and by the presence of construction equipment.

5. Minor increases in noise levels may result from construction activities.

3.11.2 Unavoidable Adverse Long-Term Impacts

1. Soils will be disturbed by grading, excavation, and mounding activities at the site during construction. Since soil cover on the site is very sparse, soil will be imported to cover cleared and graded land for planting landscaping materials, except for areas left in natural vegetation.

2. Modifications to the current topography will be made at the site to accommodate project development.

3. Approximately 30-40 acres of early successional native scrub forest on historic and prehistoric lava flows of windward Mauna Loa will be destroyed for pumping station construction. There will be additional small losses of similar forest along the road-side verge of the Saddle Road between the 9-19 mile markers.

4. Air quality at area roadways will receive a minor addition of traffic-related emmissions.

3.12 Any Irreversible and Irretrievable Impacts

The construction and operation of the proposed water transmission project would involve the irretrievable commitment of certain natural and fiscal resources. Major resource commitments include land, money, construction materials, manpower and energy. The impact of using these resources should, however, be weighed against the economic benefits to the residents of the County and State, and the consequences resulting from taking no action (see Chapter 5.0, Alternatives to the Proposed Action).

The commitment of resources required to accomplish the project includes labor and materials which are primarily nonrenewable and irretrievable. The operation of the project will also include the sustained consumption of electrical energy which also represents an irretrievable commitment of resources.

Chapter 4:
Relationship of Proposed Action to Plans, Policies and Control for the Affected Area

CHAPTER 4: RELATIONSHIP OF PROPOSED ACTION TO PLANS, POLICIES AND CONTROLS FOR THE AFFECTED AREA

4.1 Hawaii State Plan

The Hawaii State Plan establishes a set of goals, objectives and policies which are to guide the State's long-run growth and development activities. The proposed project is generally consistent with such State goals and objectives.

o The goals and objectives relating to the economic vitality of neighbor islands.

Discussion:

The proposed water transmission from water-rich East Hawaii to the Waimea plain in South Kohala can provide new opportunities to develop an intensive agricultural industry and improve productivity of the existing marginal lands. Successful development of the agricultural industry is a welcome addition to diversify the strong tourism-related industry that has been developed in the region in the last decade. It is also important that one of the large beneficiaries of water availability can be the current lessee of Hawaii Home Lands. The extent to which the agricultural industry will develop, given water availability, largely depends on the degree of Hawaii's producers' ability to penetrate the import substitution market, as well as on state and private cooperation in providing necessary farm infrastructure, financial and technical assistance programs, and availability of general farm labor.

o Objectives calling for increases in employment and income, job choices, full employment and growing diversified economic base.

Discussion:

The proposed project is expected to generate as much as $81 million in income during the construction of the water transmission pipeline and its related projects over seven years. As many as 450 man years of labor are required for the completion of the water pipeline project.

Potential end users, such as intensive farming activities and expansion of PTA activities, will also have positive short-term and long-term economic impacts.

4.2 Hawaii State Functional Plan

The Hawaii State Plan contains 12 separate Functional Plans which deal with each specific area of concern. The functional plans relevant to the proposed project are: Energy Functional Plan and Water Resource Development Plan. The Energy Functional Plan is discussed in Chapter 3. A discussion of the Water Development Plan in relation to the proposed project follows:

4.2.1 Water Resource Development Functional Plan

The Water Resource Development Functional Plan amplifies the broader Hawaii State Plan objectives and policies in the matters of water resource management, assessment of water needs and available resources, and opportunities for future management. More pertinent objectives and policies are:

- o "Maintain the long-term availability of fresh water supplies, giving consideration to the accommodation of important environmental value."
- o "Assure the availability of adequate water for agriculture."
- o "Preserve water for existing beneficial agricultural uses and provide additional irrigation water where needed by further development of existing surface and groundwater sources and improvements to diversion, storage, and transmission facilities."
- o "Provide adequate, reasonably priced water supplies for agriculture production."
- o "Encourage and coordinate with other water programs the development of self-supplied industrial water and the production of water-based energy."
- o "Support programs for hydroelectric and geothermal power production."

Implementation Action:

- o "Expand State exploration programs for new resources of surface and groundwater supplies, giving priority support to areas experiencing critical water problems."
- o "Where practical, consider alternative means of increasing water supplies such as ...."
- o "Develop water source and delivery systems in support of agriculture and aquaculture, including in particular those agriculture parks located at Lalamilo, Keaole, ..."
- o "Seek Federal assistance to increase water supply and improve transmission, storage, and irrigation facilities to promote diversified agriculture and aquaculture."

Discussion:

All current water systems in the South Kohala area are at capacity or have reserve capacity committed. The implication is that continued growth, both in the urban and agricultural sectors, is integrally related to the additional development and transmission of water.

4.2.2 State Land Use and Control

The State Land Use Commission classifies all lands in the State into one of four land use districts. The four land use districts are Agricultural, Conservation, Rural, and Urban. The Counties have jurisdiction over land use in the Urban District. Both the State and County regulate land use in the Agricultural and Rural Districts, while the Department of Land and Natural Resources has jurisdiction over lands in the Conservation District.

The proposed project uses lands for 1) water well development, 2) water transmission and storage, and 3) possible agricultural activities. The water well development site above Hilo in the Waiakea-Uka area is on State land. Its state land use designation is Agricultural. The 61-mile pipeline route from the well field to Waimea (via Pohakaloa) traverses primarily state land on windward Mauna Loa and private lands (Parker Ranch) on leeward Mauna Kea. A few small private land owners will be impacted in the pipeline right of way above Hilo.

4.2.3 State Water Use Policy and Control

1. Administrative Rules of the State Water Code

a) Subchapter 3: Water Use and Development Plan

13-17-30 Responsibilities of Counties. A water use and development plan shall be prepared by each separate county and adopted by ordinance, setting forth allocation of water to land use in that county.

13-170-31 Contents of plan. Each county water use and development plan shall include but not be limited to:

i) Status of county water and related land development including an inventory of existing water uses for domestic, municipal, and industrial uses, agriculture, aquaculture, hydropower development, drainage, reuse, reclamation, recharge, and resulting problems and constraints;

ii) Future land uses and related water needs; and

iii) Regional plans for water development including recommended and alternative plans for water development and relationship to the water resource protection plan and water quality plan.

b) Hawaiian Homes Commission Act, Section 22: Development projects; bond issued by legislature; mandatory reservation of water, as amended, to read as follows:

i) For projects pursuant to this section, sufficient water shall be reserved for current foreseeable domestic, stock water, aquaculture, and irrigation activities on tracts leased to native Hawaiians pursuant to section 207 (a).

ii) The DLNR shall notify the DHHL of its intent to execute any new lease of water rights. After consultation with affected beneficiaries, these departments shall jointly develop a reservation of water rights sufficient to support current and future homestead needs. Any lease of water rights or renewal shall be subject to the rights of the DHHL as provided by section 221 of the Hawaiian Homes Commission Act.

iii) Section 174-16, Hawaii Revised Statute:
"The DLNR shall assure that adequate water is reserved for future development and use on Hawaiian Home Lands that could be served by the proposed water project."

iv) In formulating or revising each county's water use and development plan, the state water project plan, the water resource protection plan and the water quality plan, each county and commission shall incorporate the current and foreseeable development and use needs of the DHHL for water as provided in section 221 of the Hawaiian Homes Commission Act.

Discussion

Implementation of the proposed project requires the issuance of appropriate permits and clearance from the State Water Commission for well development and operation. As part of this review, the commission must take into account the future needs of DHHL for water usage.

In that the water project crosses DHHL lands at Humuula and may potentially serve the DHHL lands at Puukapu, the long-range water needs of DHHL must be considered (see Section 2.6.2).

4.3 Hawaii County General Plan

The General Plan for the County of Hawaii is a policy document expressing the broad goals and policies for the long-range development of the Island of Hawaii. The General Plan is organized into twelve elements with goals, policies, and standards for each and their applicability to the nine judicial districts comprising the County of Hawaii. The sections relevant to the proposed project are: environmental quality, economic, energy, flood control and drainage, natural resources and shoreline, and land use.

4.3.1 Land Use

The Land Use Pattern Allocation Guide (LUPAG) Map component of the General Plan is a graphic representation of the Plan's goals, policies, and standards, as well as of the physical relationship between land uses. It also establishes the basic urban and non-urban form for areas within the County.

The County of Hawaii General Plan indicates that the majority of the project site falls within the Agriculture designation. A small percentage of the project site, concentrated within the Hawaiian Homes Lands, are within the Low Density Urban designation. A detailed description of land ownership, use classification, and zoning matters are discussed under the State Land Use section of chapter 1.

4.3.2 Public Utilities

One of the goals of the General Plan is to "ensure that adequate, efficient, and dependable public utility services will be available to users." With respect to water, the General Plan calls for:

> a systematic program by the State, County, and private interests shall identify sources of additional water supply to ensure the development of sufficient quantities of water for future needs of high growth areas.

4.3.3 Flood Control and Drainage

Over the first 38 miles of its route, the proposed pipeline will ascend the eastern (windward) slopes of Mauna Loa volcano with the pipeline alignments following largely historic un-weathered lava flows of Mauna Loa. Due to high substrate porosity surface water drainage courses are largely absent or poorly defined. No perennial stream courses are located in the project area. Beyond Pohakuloa the pipeline right of way (adjacent to the Saddle Road) moves onto older Mauna Kea substrates where there is moderate erosional dissection by small, intermittent stream courses.

Under leeward route alternative A, in the vicinity of Waiki'i (elev. 4,700 ft.) the pipeline will depart from the Saddle Road alignment and cross open pasture lands belonging to the Parker Ranch. The pipeline will terminate near Mana (in storage reservoirs) on the slopes of Mauna Kea above Waimea. For the few larger, intermittently flowing drainage gulches on Parker Ranch (e.g. Kamakoa and Kemole; up to 50 ft. wide) elevated viaducts will be constructed to transit the pipeline across.

The proposed project should not significantly affect the climate or surface hydrology of the site or surrounding area. The proposed agricultural development lands are located in a semi-arid area with few well-defined channels and infrequent stream flows. The agricultural use of this land should help to minimize soil erosion and help to mitigate infrequent but potential flooding.

Discussion

The proposed project is consistent with the General Plan in that its implementation will provide for an additional water source for the West Hawaii Region.

4.4 Required Permits and Approvals

Several permits and approvals will be required to implement this project. They are listed here with their related agencies:

1. Conservation District Use Application (CDUA)
   For clearing areas for pipeline and pumping stations within a Conservation District.
   Agency: Department of Land and Natural Resources

2. New Water Source Development
   Agency: State Department of Land and Natural Resources/Water Commission

3. State Department of Health for Water Quality

4. State Department of Transportation

5. Hawaii County Planning Department

6. County Department of Water Supply

7. County Department of Public Works for building and grading permits. Saddle Road and Hoaka Road access.

   -Installation of utilities with Federal and Secondary County Highways

   -Grading and grubbing permits

   -Outdoor lighting

   -Building, electrical, and plumbing permits

Chapter 5:
Alternatives to the Proposed Action

CHAPTER 5: ALTERNATIVES TO THE PROPOSED ACTION

5.1 No Project

Short-term:
The "no project" alternative would mean that potential end users of water, including PTA, DHHL and private agricultural water users in the Waimea area, would be required to seek water supplies from other sources.

Long-term:
The "no-project" alternative means that no long range development action will be taken to exploit currently under-utilized water resources on windward Mauna Loa and address future water supply imbalances between East and West Hawaii.

5.2 Project Alternatives

5.2.1 Alternative Water Sources

There are a large number of potential water development sites in the East Hawaii areas of Hilo, Hamakua and Puna with proven but undeveloped water resources. However, as defined in the scope of this EIS, the feasible development of a water resource that can meet the dual project goals of providing a potential water source for PTA as well as potential end users in West Hawaii via a single transmission corridor limited available water development sites to areas above Hilo.

A preliminary assessment of water resource development within other sectors of East Hawaii was considered during the early stages of this project. These potential water sources were not pursued because of one or more of the following factors:

* distance to PTA
* lack of electrical power for well fields and transmission corridor
* impacts on native forest plant species

In addition, four alternative well fields were considered within the Hilo area. The proposed well field site in Waiakea-Uka is the only appropriate site meeting the necessary design qualifications relating to: available State land, power at site, adjacent transmission corridor available (existing powerline easement), site upslope of existing residential cesspool waste water disposal in the suburban Hilo area. The water resource for the proposed well field site has recently been proven through successful exploratory drilling and well testing at the site. Accordingly, there are no reasonable alternatives to the proposed well site.

5.2.2 Alternative Pipeline Routes

Only one pipeline route (Figure 1.1) was evaluated for the windward Mauna Loa segment of the proposed pipeline. This area includes sensitive native ecosystems generally including rare and endangered species. At the present time, a pipeline routing that closely follows existing disturbance corridors (Saddle Road and power line easement) is considered the only possible alignment that would not involve potentially unacceptable levels of disturbance to existing biological resources of the area. In the future, any additional alternative roadway system or utility corridor that may be built will be considered as another alternative route for the pipeline to follow.

Two alternative routes from PTA to the terminal reservoir site in Waimea (alternatives A and B) were evaluated in this EIS. These two alternatives offer a number of differing benefits and costs including amount of energy required for pumping and energy recovery from hydroelectric generation, proximity to the potential end users, and construction costs.

The potential adverse environmental impacts of leeward route alternatives are not significant since the right of ways traverse generally uniform pasture lands on leeward Mauna Kea. The route B alternative, which would take the pipeline directly into the Waimea town area, would threaten existing archaeological sites in the Waimea area unlike the route A alternative.

The final alignment and reservoir site will depend on the primary end user of the water resource. To the extent the ultimate end user's plans require alternative pipeline routes and/or terminal reservoir site within West Hawaii, additional environmental review would be required.

5.2.3 Alternative Power Use

One alternative for avoiding the additional electric power capacity increase would be that the water pumping be done on an interruptable schedule basis. Under this option, the water pumping will be interrupted, as needed, during the peak hours.

The obvious effects of this option are that, 1) it saves energy and thus saves operating costs, 2) it may, however, raise the unit cost of pumped water, and 3) the amount of water pumped will be reduced proportionally by the reduced pumping hours. During the winter season when the demand for water is at its minimum, this option may work reasonably well. However, during summer season when water demands are expected to be higher, an interruptable pumping schedule will result in a shortage of meeting demand and may not be a viable option.

Another alternative may be that the water pumping be limited only to the off-peak schedule until such time as a dependable and economically viable alternative energy source is fully developed and available to the utility. This option may well be the preferred scenario as a trade-off between adding additional energy capacity whose private and social costs may exceed the benefit of additional water availability to the end users.

Chapter 6: **Unresolved Issues**

CHAPTER 6: UNRESOLVED ISSUES

6.1 Funding

The estimated total cost for planning and construction of the project is $250 to $312 million in 1991 dollars. However, the exact source of funding for the project is not clear at this time. The potential use of water by PTA may result in Federal as well as State funding for this project. A joint venture between government and private parties is also a possibility. Although the projected cost of delivered water ranges between $1.42 - $8.92/1,000 gallons, the actual cost of water is not certain at this point in time. In part, the cost to the users would vary depending upon the amount of water the users as a whole will be using at any given time. Furthermore, the amount that each end user will be taking on is not certain at this time.

6.2 End User

Although in conjunction with evaluating the feasibility of the across-island water transmission several potential water end users have been identified along the transmission corridor and in South Kohala, at present there are no specific projects proposed to utilize pipeline water. It is anticipated that a decision on the environmental acceptability of the specific water development and transmission route here presented will determine whether large-scale end user projects will be initiated.

6.3 Operating Entity

As discussed in Section 2.8, a number of scenarios can be developed as to the administrative agency. The exact administrative role and responsibilities of such an agency, however, have not been resolved.

6.4 Electrical Energy Source

In order for the full 20 mgd of water to be utilized, an additional 30 MW of electricity production over that currently anticipated by HELCO would be required. There are several alternative options including additional fossil fuel plants, or development of geothermal capabilities or other available technologies. To the extent base load power is required, certain renewable but intermittent energy sources such as wind and hydroelectic power will not fully satisfy the expansion needs.

Chapter 7:
Consulted Parties, List of Preparers, Comments and Responses

CHAPTER 7 CONSULTED PARTIES, LIST OF PREPARERS, COMMENTS, AND RESPONSES

This section includes lists of the various agencies, individuals, and organizations who have been consulted for the preparation of this Draft EIS, the names of preparers and technical consultants who have contributed to producing this document, and comments and responses to the Notice of Preparation and Environmental Assessment.

7.1 List of Agencies and Individuals Contacted in Preparation of Draft Environmental Impact Statement

The following list includes governmental agencies, individuals, and organizations who have been contacted as part of the planning process and analysis process for the preparation of this Draft Environmental Impact Statement.

County of Hawaii

- Planning Department
- Public Works
- Department of Water Supply

State of Hawaii

- Department of Land and Natural Resources
  Division of Water and Land Development
- Department of Agriculture
- Department of Health
- Department of Hawaiian Home Lands

Federal Agencies

- Department of the Army
- Pohakuloa Training Area
- U.S. Department of Interior
- U.S. Geological Survey

Organizations

- Parker Ranch
- Waiki'i Ranch

Individuals

o Sen. Richard Matsuura
o Mr. Warren Gunderson/Parker Ranch

7.2 List of Preparers of Draft EIS

This Draft Environmental Impact Statement has been prepared by the planners and environmental analysts at OKAHARA AND ASSOCIATES engineering/planning, 200 Kohola Street, Hilo, Hawaii 96720, Telephone (808) 961-5527 with the assistance of Y. K. HAHN AND ASSOCIATES, planning/environmental/economic, 1180 Kumuwaina Street, Hilo, Hawaii 96720, Telephone (808) 933-3672. The staff involved in the preparation of this document included:

Youngki Hahn, Ph.D	Principal of Y.K. Hahn and Associates
Melvin Tanaka, P.E.	Project Manager
William Moore	Planner
Keith Kanetani	Graphics
Joy Suzuki	Production
Midori Mersai	Production

Several technical consultants were employed to provide specific assignments of environmental factors for this project. These consultants and their affiliation are listed as follows:

S. Yuzawa, P.E.	O/A	Electrical Engineering
M. Takeoka, P.E.	O/A	Civil Engineering
M. Tanaka, P.E.	O/A	Mechanical Engineering/Lava Inundation
T. Hunt, Ph.D.	UH Manoa	Archaeology
F. Stone, Ph.D.	UH Hilo	Lava Tubes
M. Kjargaard	Ka'io Production	Fauna
G. Gerrish, Ph.D.	UH Hilo	Botany
J. Mejer, Ph.D.	UH Hilo	Socio/Economics
J. Juvik, Ph.D.	UH Hilo	Air Quality
J. Yuen	Mink & Yuen	Ground Water Resource
Y. Hahn	YK Hahn/AS	Economics

7.3 Consulted Parties for Notice of Preparation - Environment Assessment

Listed below are the agencies and organizations consulted in the preparation of the Draft EIS. The table indicates with an "X" those who submitted written comments or a letter stating that they have no comments. This is followed by the written comments received and responses.

A. STATE AGENCIES	Comments on N.O.P*
Office of State Planning	X
Department of Agriculture	X
Department of Health	X
Department of Transportation	X
University of Hawaii, Environment Center	-
Office of Environmental Quality Control	-
Department of Hawaiian Home Lands	X
State Business and Economic Development Energy Division	-
B. FEDERAL AGENCIES	
Department of the Army U.S. Army Engineering	X
PTA, HQ	X
U.S. Department of Agriculture Soil Conservation Service	X
U.S. Geological Survey	-
Water Resource Division	-
U.S. Hawaii Volcanoes National Park	-
U.S. Department of the Interior Fish and Wildlife Service	-
C. COUNTY AGENCIES	
Department of Public Works	X
Department of Planning	X
Department of Water Supply	-
D. COMMUNITY ORGANIZATIONS	
Native Hawaiian Advisory Council	X
Sierra Club Hawaii/Moku Loa Group	X
Environment Hawaii	X
Green Peace Hawaii	-
Life of the Land	-
Farm Bureau, Kohala Chapter	-
Hawaii Electric and Light Company	-
Nature Conservancy	-
Hawaii Audubon Society	-

E. INDIVIDUALS

James Kent and Associates	X
Henry A. Ross	X

* N.O.P. stands for Notice of Preparation

90073 DKO YH

JOHN WAIHEE
GOVERNOR

EDWARD Y HIRATA
DIRECTOR

DEPUTY DIRECTORS
AL PANG
JOYCE T. OMINE
JEANNE K. SCHULTZ
CALVIN M TSUDA

IN REPLY REFER TO:
HWY-PS
2.7669

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
869 PUNCHBOWL STREET
HONOLULU, HAWAII 96813-5097

July 10, 1991

RECEIVED
... 11 1991
OKAHARA & ASSOC., INC.
HILO OFFICE

Mr. Donald K. Okahara, P.E.
President
Okahara & Associates, Inc.
200 Kohola Street
Hilo, Hawaii 96720

Dear Mr. Okahara:

EIS Preparation Notice, Across Island Water Transmission Pipeline and Agricultural Development Project, Island of Hawaii, Pohakuloa Military Training Area

Thank you for your letter of June 14, 1991, requesting our review of the EIS preparation notice for the proposed project.

We have the following comments:

1. The waterline should be placed as close as possible to the highway rights-of-way line.

2. This project should be coordinated with our Saddle Road Improvement project.

3. The applicant should abide and conform to applicable current rules/laws governing the use of Traffic Control Devices at Work Sites, especially on sites adjacent to public streets and highways. Safety should be a prime consideration during construction.

4. Construction plans for work within our State highway right-of-way must be submitted for our review and approval.

Very truly yours,

Edward

Edward Y. Hirata
Director of Transportation

Okahara & Associates, Inc.
ENGINEERING CONSULTANTS

July 13, 1991

Mr. Edward Y. Hirata, Director
Department of Transportation
State of Hawaii
869 Punchbowl St.
Honolulu, Hawaii 96813-5097

Dear Mr. Hirata:

SUBJECT: ENVIRONMENTAL IMPACT STATEMENT PREPARATION NOTICE FOR WATER TRANSMISSION PIPELINE

Thank you for your letter of July 9, 1991 regarding the Environmental Impact Statement Preparation Notice for the proposed Water Transmission Pipeline. We appreciate the time spent by your staff reviewing the document. The information you provided will be useful in the preparation of the EIS.

You will be sent a copy of the Draft EIS for review and comment as soon as it is completed. In the mean time, if you have any questions regarding the project, please contact Mr. Donald Okahara of Okahara & Associates at 961-5527 or Dr. Youngki Hahn of Y.K. Hahn & Associates in Hilo at 933-3672.

Very Truly yours,

Donald K. Okahara

Donald Okahara, President

cc: Environmental Quality Commission
Y.K. Hahn & Associates

Donald K. Okahara, P.E. • Masahiro Nishida, P.E. • Terrance Nago, P.E. • Glenn Suzuki, P.E.
200 KOHOLA STREET • HILO, HAWAII 96720 • TELEPHONE (808) 961-5527 • FAX (808) 961-5529
470 NORTH NIMITZ HWY., SUITE 212 • HONOLULU, HAWAII 96817 • TELEPHONE (808) 524-1224 • FAX (808) 521-3151
P.O. BOX 688 • KEALAKEKUA, HAWAII 96750 • TELEPHONE/FAX (808) 322-2222
73-4100 MAKALILA PLACE • KAILUA-KONA, HAWAII 96740 • TELEPHONE/FAX (808) 325-0750

90073

MOKU · LOA · GROUP

SIERRA CLUB • HAWAI'I CHAPTER

July 23, 1991

Sierra Club, Moku Loa Group requests to be a consulted party in the EIS covering the proposal to develop and transmit water from Hilo to the South Kona region of the Big Island.

We note that the notice in the OEQC Bulletin of June 23, 1991 does not include any mention of the potential use of geothermal energy as an energy source for this proposed project, i.e. the water pumping requirements, as was reported in our Tribune Herald. If this project may use geothermal energy we hereby request that a new description be published in the OEQC with a correspondingly appropriate time for response.

If geothermal is to be used, the EIS should include a description of the environmental, social and economic impacts of all the geothermal exploration, construction and operation on the air quality, noise, groundwater pollution, native biota, cost etc. that will be needed for this proposal.

The EIS should disclose the effect of dewatering of the area where the water is being drawn from and the effects of the construction and operation of the nine vertical deep wells. Included should be an adequate discussion on whether there is any need for the water, alternative sources of water closer to Waimea including untapped water sources in South Kona.

A discussion of whether the water will be used only for intensive agriculture as stated in the Bulletin or whether it will be used to supplement residential and resort growth in Kona Coast. If the latter is a possibility, describe the social, environmental and economic impacts of increased population growth resulting from this water project.

Describe the uses of the water at Pohakuloa Military training Area, including any expansion of personnel or activities and the environmental and social impacts of that action.

Describe the proposed routes and locations of buried pipelines from proposed wellfields to end-use destinations in Kona, including all new reservoirs and power plant stations.

Describe the cost of the project, the cost of the water to end use consumer and any probable financing proposals.

Please send all correspondence to PO Box 590 Mountain View, Hi 96771. ph. 968-6278. Thank you for the opportunity to input at this scoping level.

Nelson Ho

Nelson Ho
for the Conservation Committee
Moku Loa Group

AUG 02 1991
HILO

Okahara & Associates, Inc.
ENGINEERING CONSULTANTS

August 7, 1991

Mr. Nelson Ho
Conservation Committee
Moku Loa Group
Siera Club Hawaii Chapter
P.O.Box 590
Mt. View, Hi 96771

Dear Mr. Ho:

SUBJECT: ENVIRONMENTAL IMPACT STATEMENT PREPARATION NOTICE FOR WATER TRANSMISSION PIPELINE

Thank you for your letter of July 23, 1991 regarding the Environmental Impact Statement Preparation Notice for the proposed Water Transmission Pipeline. We appreciate the time you spent reviewing the document. Many of your concerns and questions are well thought out and they are also being analyzed by the EIS consultant team for our draft EIS.

Whether or not the geothermal energy will be used to for water pumping is not certain at this time. For one thing, the water delivery schedule to Pohakuloa and West Hawaii depends on the growth rate of PTA expansion and also on the long term growth rate of agriculture industry development in South Kohala. Amount of energy needed will follow the these growth pattern and thus like be gradual. In this case the power needs may be able to be met without resorting to any single source as geothermal power.

You will be sent a copy of the Draft EIS for review and comment as soon as it is completed. In the mean time, if you have any questions, please contact Mr. Donald Okahara of Okahara & Associates at 961-5527.

Very Truly yours,

Donald Okahara, President

cc: Environmental Quality Commission

Donald K. Okahara, P.E. • Melvin Tanaka, P.E. • Masahiro Nishida, P.E. • Terrance Nago, P.E. • Glenn Suzuki, P.E.
200 KOHOLA STREET • HILO, HAWAII 96720 • TELEPHONE (808) 961-5527 • FAX (808) 961-5529
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90073

JOHN WAIHEE
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF HEALTH
P. O. BOX 3378
HONOLULU, HAWAII 96801

JOHN C. LEWIN, M.D.
DIRECTOR OF HEALTH

In reply, please refer to:
EMD / SDWB

July 25, 1991

Ref. No. 91-3-202X

AUG 05 1991
OKAHARA & ASSOC., INC.
HILO OFFICE

Mr. Donald K. Okahara, P.E.
President
Okahara & Associates, Inc.
200 Kohola Street
Hilo, Hawaii 96720

Dear Mr. Okahara:

SUBJECT: ENVIRONMENTAL IMPACT STATEMENT PREPARATION NOTICE
WATER RESOURCE DEVELOPMENT AND ACROSS ISLAND TRANSMISSION,
ISLAND OF HAWAII
(PROPOSING AGENCY: DEPARTMENT OF LAND AND NATURAL RESOURCES)

Thank you for the opportunity to review and comment on the subject project. We have examined the Preparation Notice and have the following comments to offer:

Drinking Water

1) The preparation notice indicates that the Department of Land and Natural Resources develop nine water wells, storage facilities, and a 42-inch transmission line. Since the wells will serve 25 or more individuals at least 60 days per year or have a minimum of 15 service connections, the use of a well as a source of drinking water will require compliance with the Department's Administrative Rules, Title 11, Chapter 20, "Potable Water Systems."

2) Section 11-20-29 of Chapter 20 requires that all new sources of potable water serving a public water system be approved by the Director of Health prior to their use. Such an approval is based primarily upon the submission of a satisfactory engineering report which addresses the requirements set in Section 11-20-29.

3) Section 11-20-30 of Chapter 20 requires that new or substantially modified distribution systems for public water systems be approved by the Director. However, if the water system is under the jurisdiction of the County of Hawaii, the Department of Water Supply will be responsible for the review and approval of the plans.

4) The proposed project is situated above the Department's Underground Injection Control (UIC) line. Land areas located above the UIC line are generally considered to contain underground sources of drinking water. Thus, these areas should be protected against all sources of groundwater contamination.

5) Since the project will supply water to the U.S. Army's Pohakuloa Training Area and to intensive agricultural activities in the Waimea area (as well as an emergency back-up system for Waimea's domestic water supply), the potable and non-potable water systems must be carefully designed and operated to prevent cross-connections and backflow conditions. The dual water systems must be clearly labeled and physically separated by air gaps or reduced pressure principle backflow preventers to avoid contaminating the potable water supply.

<u>Noise and Radiation</u>

1) Please note that under section V-A-1 title Construction Noise, the provisions of Department of Health Title 11, Administrative Rules, Chapter 42 and 43 applies only to the island of Oahu. However, mitigative measures toward minimizing noise disturbances from construction activities should be implemented.

If you should have any questions, please contact the Safe Drinking Water Branch at 543-8258.

Very truly yours,

JOHN C. LEWIN, M.D.
Director of Health

Okahara & Associates, Inc.
ENGINEERING CONSULTANTS

Letter No. 39002
Reference No. 90073
August 7, 1991

Dr. John C. Lewin, M.D., Director
Department of Health
State of Hawaii
P.O.Box 3378
Honolulu, Hi 96801

Dear Dr. Lewin:

SUBJECT: ENVIRONMENTAL IMPACT STATEMENT PREPARATION NOTICE FOR WATER TRANSMISSION PIPELINE

Thank you for your letter of July 25, 1991 regarding the Environmental Impact Statement Preparation Notice for the proposed Water Transmission Pipeline. We appreciate the time you spent reviewing the document. All of your comments are noted and will be taken into consideration in our preparation of the draft EIS.

You will be sent a copy of the Draft EIS for review and comment as soon as it is completed. In the mean time, if you have any further questions, please contact Mr. Donald Okahara of Okahara & Associates at 961-5527.

Very Truly yours,

Donald Okahara, President

cc: Environmental Quality Commission

Donald K. Okahara, P.E. • Masahiro Nishida, P.E. • Terrance Nago, P.E. • Glenn Suzuki, P.E.
200 KOHOLA STREET • HILO, HAWAII 96720 • TELEPHONE (808) 961-5527 • FAX (808) 961-5529
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73-4100 MAKALA PLACE • KAILUA-KONA, HAWAII 96740 • TELEPHONE/FAX (808) 325-0750

JOHN WAIHEE
GOVERNOR

YUKIO KITAGAWA
CHAIRPERSON, BOARD OF AGRICULTURE

ILIMA A. PIIANAIA
DEPUTY TO THE CHAIRPERSON

FAX: 548-6100

Mailing Address:
P. O. Box 22159
Honolulu, Hawaii 96823-2159

State of Hawaii
DEPARTMENT OF AGRICULTURE
1428 So. King Street
Honolulu, Hawaii 96814-2512

July 15, 1991

Mr. Donald K. Okahara, P. E.
President
Okahara and Associates, Inc.
200 Kohola Street
Hilo, HI 96720

Dear Mr. Okahara:

Subject: Environmental Impact Statement Preparation Notice (EISPN) for Water Transmission Pipeline and Agricultural Development Project - Big Island

The Department of Agriculture has reviewed the subject document and offers the following comments.

The proposed pipeline is designed to deliver 20 million gallons per day (mgd) of groundwater from east to west Hawaii. Principal beneficiaries are to be the Pohakuloa Training Area (PTA) and agricultural lands south of Waimea town. Expected cost of the delivered water ranges from $1.07 to $5.70 per thousand gallons. The principal benefit to agriculture is the increase in irrigated acreage in South Kohala to 5,315 acres by the year 2007, which may result in an 80 percent replacement of agricultural imports.

We are very supportive of efforts that move the State towards economically viable self-sufficiency in agriculture. Support for agricultural self-sufficiency is specifically mentioned in the State Constitution and alluded to in most planning documents including the Hawaii State Plan and State Agriculture Functional Plan. Development of reliable and adequate irrigation water sources and distribution facilities are keys to agricultural growth.

Insofar as the trans-island pipeline is concerned, the Draft EIS should clearly state the support for the proposal as found in State and Hawaii County plans and policies. This is especially important in light of the projected cost of the project which stands at $282 million (including $32 million in agricultural infrastructure such as roads and irrigation lines), and the critical assumptions that are made regarding the economic viability of the proposed crops.

Agricultural Proposal

The subject document and the related report entitled "Assessment of Agricultural Industry Development in the South Kohala Region of West Hawaii" (dated March, 1991) make some interesting crop suggestions such as apples, grapes (for wine), persimmons, potatoes, and dry onions. These crops are said to be economically viable at the projected higher water costs. Considerable benefits are expected from the full-scale (5,315 acres) agricultural development, including $87.5 million in annual farm revenues (equivalent to one-half of the 1989 total value of crops sold on the Big Island) and 350 full-time farm jobs (equivalent to 10 percent of the 1989 total of hired workers on the Big Island).

Key to the success of the agricultural proposal are a number of stated and implied assumptions such as:

- availability of farm infrastructure, adequate labor supply, capital, and land at "reasonable" prices;

- interest of the Parker Ranch and the Department of Hawaiian Home Lands in intensive agricultural use of their lands which stand to benefit from the proposed project;

- capability of the agricultural lands in question to support the proposed crops without intensive use of fertilizers and other supplements, based upon the Agricultural Lands of Importance to the State of Hawaii (ALISH) study;

- occurrence of appropriate production technology transfer; and

- availability of farmers capable of undertaking risky ventures, especially with those crops that have not been grown commercially in the State such as apples (which take 10 to 14 years to mature) and grapes.

The Assessment identifies specific crops that may grow in the area and mentions foreign and mainland production and marketing forces that may threaten the economic viability of farming ventures (Assessment, Chapter III). The impact of this competition and its effect on the viability of the project's agricultural proposal should be brought to the forefront of the Draft EIS.

The Draft EIS should also address the need for alternative water sources when the water pumps to the storage area are down for repairs/maintenance. The proposed 140 million gallon reservoir contains enough water for about eight (8) days in the 5,315-acre agricultural scenario, exclusive of the water needs of the PTA. In comparison, the existing 60 million gallon Waimea Irrigation System (WIS) can provide its 85 customers with sufficient irrigation water for 30 days with a full reservoir and voluntary reduction in water use.

The Draft EIS should provide an itemized listing of the $32 million in agricultural infrastructure. Does this figure include power lines, county standard roadways, grading, domestic water, fire hydrants, appropriate domestic wastewater treatment facilities, etcetera?

How will the proposed project be physically linked to the WIS, and how will water charges be determined if water is piped into the WIS during a beyond-design drought affecting the WIS? The current WIS charge per thousand gallons is sixteen cents. Furthermore, what about the situation where the new agricultural area requires irrigation water?

We reiterate our support of efforts that move the State towards economically viable self-sufficiency in agriculture. The methodology used to develop the agricultural proposal as found in the Assessment is about the best we have reviewed in some time. However, there appears to be much more work to be done to ensure that the agricultural proposal is practical and economically viable and not just an academic exercise.

We look forward to reviewing the Draft EIS. Thank you for the opportunity to comment.

Sincerely,

Yukio Kitagawa

YUKIO KITAGAWA
Chairperson, Board of Agriculture

c: Office of Environmental Quality Control
Office of State Planning (attention: Land Use Division)
Department of Land and Natural Resources (attention: Division of Water Resource Management)

Okahara & Associates, Inc.
ENGINEERING CONSULTANTS

July 23, 1991

Letter No. 38917
Ref No. 90073

Mr. Yukio Kitagawa, Chairperson,
Board of Agriculture
DEPARTMENT OF AGRICULTURE
P.O. Box 22159
Honolulu, Hawaii 96823-2159

Dear Mr. Kitagawa:

SUBJECT: ENVIRONMENTAL IMPACT STATEMENT PREPARATION NOTICE FOR WATER TRANSMISSION PIPELINE

Thank you for your letter of July 15, 1991 regarding the Environmental Impact Statement Preparation Notice for the proposed Water Transmission Pipeline. We appreciate the time spent by your staff reviewing the document. The information you provided will be useful in the preparation of the EIS.

You will be sent a copy of the Draft EIS for review and comment as soon as it is completed. In the mean time, if you have any questions regarding the project, please contact Mr. Donald Okahara of Okahara & Associates at 961-5527 or Dr. Youngki Hahn of Y.K. Hahn & Associates in Hilo at 933-3672.

Very Truly yours,

Donald K. Okahara

Donald Okahara, President

cc: Environmental Quality Commission
Y.K. Hahn & Associates

Donald K. Okahara, P.E. • Masahiro Nishida, P.E. • Terrance Nago, P.E. • Glenn Suzuki, P.E.
200 KOHOLA STREET • HILO, HAWAII 96720 • TELEPHONE (808) 961-5527 • FAX (808) 961-5529
470 NORTH NIMITZ HWY., SUITE 212 • HONOLULU, HAWAII 96817 • TELEPHONE (808) 524-1224 • FAX (808) 521-3151
P.O. BOX 688 • KEALAKEKUA, HAWAII 96750 • TELEPHONE/FAX (808) 322-2222
73-4100 MAKALA PLACE • KAILUA-KONA, HAWAII 96740 • TELEPHONE/FAX (808) 325-0750

410073

DEPARTMENT OF THE ARMY
HEADQUARTERS, POHAKULOA TRAINING AREA
UNITED STATES ARMY SUPPORT COMMAND, HAWAII
APO SAN FRANCISCO 96556-0008

REPLY TO ATTENTION OF:

July 16, 1991

Commander
Pohakuloa Training Area

RECEIVED JUL 19 1991
OKAHARA & ASSOC., INC.
HILO OFFICE

Mr. Donald K. Okahara, P.E.
Okahara & Associates, Inc.
200 Kohola Street
Hilo, Hawaii 96720

Dear Mr. Okahara:

We have reviewed your Notice of Preparation, Environmental Impact Statement for the Water Resource Development and Across Island Transmission, Island of Hawaii and have the following comments:

a. What will be the impact on training at Pohakuloa Training Area (PTA) during the construction of the pipeline, booster stations and 20 million gallon reservoir?

b. Page 2, mention should be made of the other future users of the system in the saddle (State Park, Mauna Kea, Girl Scouts, etc).

c. You should check with the Federal and State Governments on the Saddle Road realignment project.

d. Page 6, paragraph D. Project Description - "Federal lands" are actually lands leased from the State of Hawaii.

e. Page 9, 4th paragraph, spring yield is 10-20 thousand gallons per day. The "emergency" water is actually budgeted water and the cost is about $25/1000 gal for trucking only. Water is paid for separately. The 2 million gallon tank project was dropped.

f. The Master Plan for the expansion of PTA has not been completed as of this date. Ranges as well as possible new base camp are being studied.

g. Page 18, paragraph D.2, Probable Impacts of Proposed Action and Mitigation Measures - How much total early successional native forest is there now. Information would be helpful in determining the total impact of the 20 acres to be cleared (20 acres out of 30 is worse than 20 acres out of 10,000 acres).

h. Page 22, may want to "bring up to date" the geothermal issue.

i. Page 24, paragraph B.1, need to check the proximity of the nearest cesspool/leaching well on the upslope side of Saddle Road at the PTA base camp.

If you have any questions, feel free to call Mr. Anthony Paresa, Chief, Hawaii County Support Division at 969-2434.

Sincerely,

Richard S. Beahm
Lieutenant Colonel, U.S. Army
Commanding

Okahara & Associates, Inc.
ENGINEERING CONSULTANTS

July 24, 1991
Letter No. 38915
Reference No. 90073

Mr. Richard S. Beahm, Lieutenant Colonel
U.S. Army Commanding
DEPARTMENT OF THE ARMY
Headquarters, Pohakuloa Training Area
United States Army Support Command, Hawaii
APO San Francisco 96556-0008

SUBJECT: ENVIRONMENTAL IMPACT STATEMENT PREPARATION NOTICE FOR WATER TRANSMISSION PIPELINE

Dear Lt. Col. Beahm:

Thank you for your letter of July 16, 1991 regarding the Environmental Impact Statement Preparation Notice for the proposed Water Transmission Pipeline. We appreciate the time spent by your staff reviewing the document. The information you provided will be useful in the preparation of the EIS.

You will be sent a copy of the Draft EIS for review and comment as soon as it is completed. In the mean time, if you have any questions regarding the project, please contact Mr. Donald Okahara of Okahara & Associates at 961-5527 or Dr. Youngki Hahn of Y.K. Hahn & Associates in Hilo at 933-3672.

Very truly yours,

Donald K. Okahara, P.E.
President

cc: ✓Environmental Quality Commission
✓Y.K. Hahn & Associates

Donald K. Okahara, P.E. • Melvin Tanaka, P.E. • Masahiro Nishida, P.E. • Terrance Nago, P.E. • Glenn Suzuki, P.E.
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Okahara & Associates, Inc.
ENGINEERING CONSULTANTS

July 23, 1991

Mr. Richard S. Beahm, Lieutenant Colonel
U.S. Army Commanding
DEPARTMENT OF THE ARMY
Headquarters, Pohakuloa Training Area
United States Army Support Command, Hawaii
APO San Francisco 96556-0008

Dear Mr. Beahm:

SUBJECT: ENVIRONMENTAL IMPACT STATEMENT PREPARATION NOTICE FOR WATER TRANSMISSION PIPELINE

Thank you for your letter of July 16, 1991 regarding the Environmental Impact Statement Preparation Notice for the proposed Water Transmission Pipeline. We appreciate the time spent by your staff reviewing the document. The information you provided will be useful in the preparation of the EIS.

You will be sent a copy of the Draft EIS for review and comment as soon as it is completed. In the mean time, if you have any questions regarding the project, please contact Mr. Donald Okahara of Okahara & Associates at 961-5527 or Dr. Youngki Hahn of Y.K. Hahn & Associates in Hilo at 933-3672.

Very Truly yours,

Donald Okahara, President

cc: Environmental Quality Commission
Y.K. Hahn & Associates

RECEIVED

OKAHARA & ASSOC., INC.
HILO OFFICE

Donald K. Okahara, P.E. • Masahiro Nishida, P.E. • Terrance Nago, P.E. • Glenn Suzuki, P.E.
200 KOHOLA STREET • HILO, HAWAII 96720 • TELEPHONE (808) 961-5527 • FAX (808) 961-5529
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90073

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
BUILDING 230
FT. SHAFTER, HAWAII 96858-5440

REPLY TO ATTENTION OF:

July 24, 1991

Planning Division

Mr. Donald K. Okahara, P.E.
President
Okahara & Associates, Inc.
200 Kohola Street
Hilo, Hawaii 96720

Dear Mr. Okahara:

Thank you for the opportunity to review and comment on the Environmental Impact Statement Preparation Notice for proposed Water Resource Development and Across Island Transmission, Island of Hawaii. The following comments are provided pursuant to Corps of Engineers authorities to disseminate flood hazard information under the Flood Control Act of 1960 and to issue Department of the Army (DA) permits under the Clean Water Act; the Rivers and Harbors Act of 1899; and the Marine Protection, Research and Sanctuaries Act.

a. If the pipeline crosses any stream or wetland, and if the discharge of fill material is required for any of these crossings, then a DA permit would be required for the project.

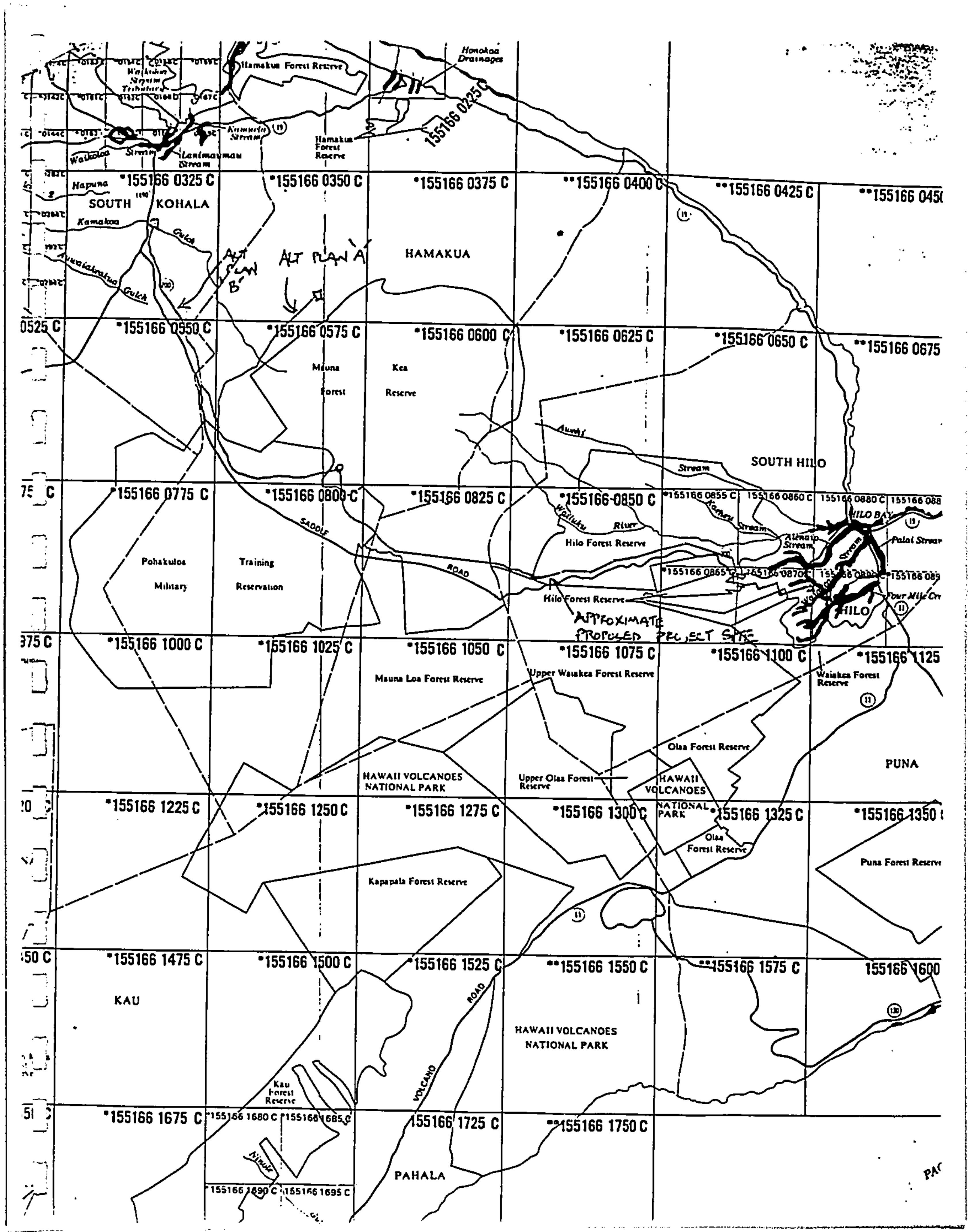
b. According to the Federal Emergency Management Agency's Flood Insurance Rate Map, Panel 155166-0001-1900, dated July 16, 1990 (copy enclosed), the proposed site is located in Zone X - unshaded (areas determined to be outside the 500-year flood plain).

Sincerely,

Kisuk Cheung
Director of Engineering

Enclosure

xc DKO
YH ✓



Hamakua Forest Reserve
Honokaa Drainages
155166 0225 C
Waikoloa Stream
Lanimaumau Stream
Kamuela Stream
Hamakua Forest Reserve
Hapuna
SOUTH KOHALA
Kamakoa
Gulch
Gulch
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*155166 0350 C
*155166 0375 C
**155166 0400 C
**155166 0425 C
HAMAKUA
ALT PLAN 'B'
ALT PLAN 'A'
*155166 0550 C
*155166 0575 C
*155166 0600 C
*155166 0625 C
*155166 0650 C
**155166 0675
Mauna Kea Forest Reserve
Awehi Stream
SOUTH HILO
*155166 0775 C
*155166 0800 C
*155166 0825 C
*155166 0850 C
*155166 0855 C
155166 0860 C
155166 0880 C
HILO BAY
SADDLE ROAD
Wailuku River
Hilo Forest Reserve
Alenaio Stream
Palai Stream
Pohakuloa Military Training Reservation
Hilo Forest Reserve
APPROXIMATE PROPOSED PROJECT SITE
*155166 0865
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Four Mile Cr
HILO
*155166 1000 C
*155166 1025 C
*155166 1050 C
*155166 1075 C
*155166 1100 C
*155166 1125
Mauna Loa Forest Reserve
Upper Waiakea Forest Reserve
Waiakea Forest Reserve
Olaa Forest Reserve
PUNA
HAWAII VOLCANOES NATIONAL PARK
Upper Olaa Forest Reserve
HAWAII VOLCANOES NATIONAL PARK
Olaa Forest Reserve
*155166 1225 C
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*155166 1300 C
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Puna Forest Reserve
Kapapala Forest Reserve
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VOLCANO ROAD
HAWAII VOLCANOES NATIONAL PARK
Kau Forest Reserve
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155166 1680 C
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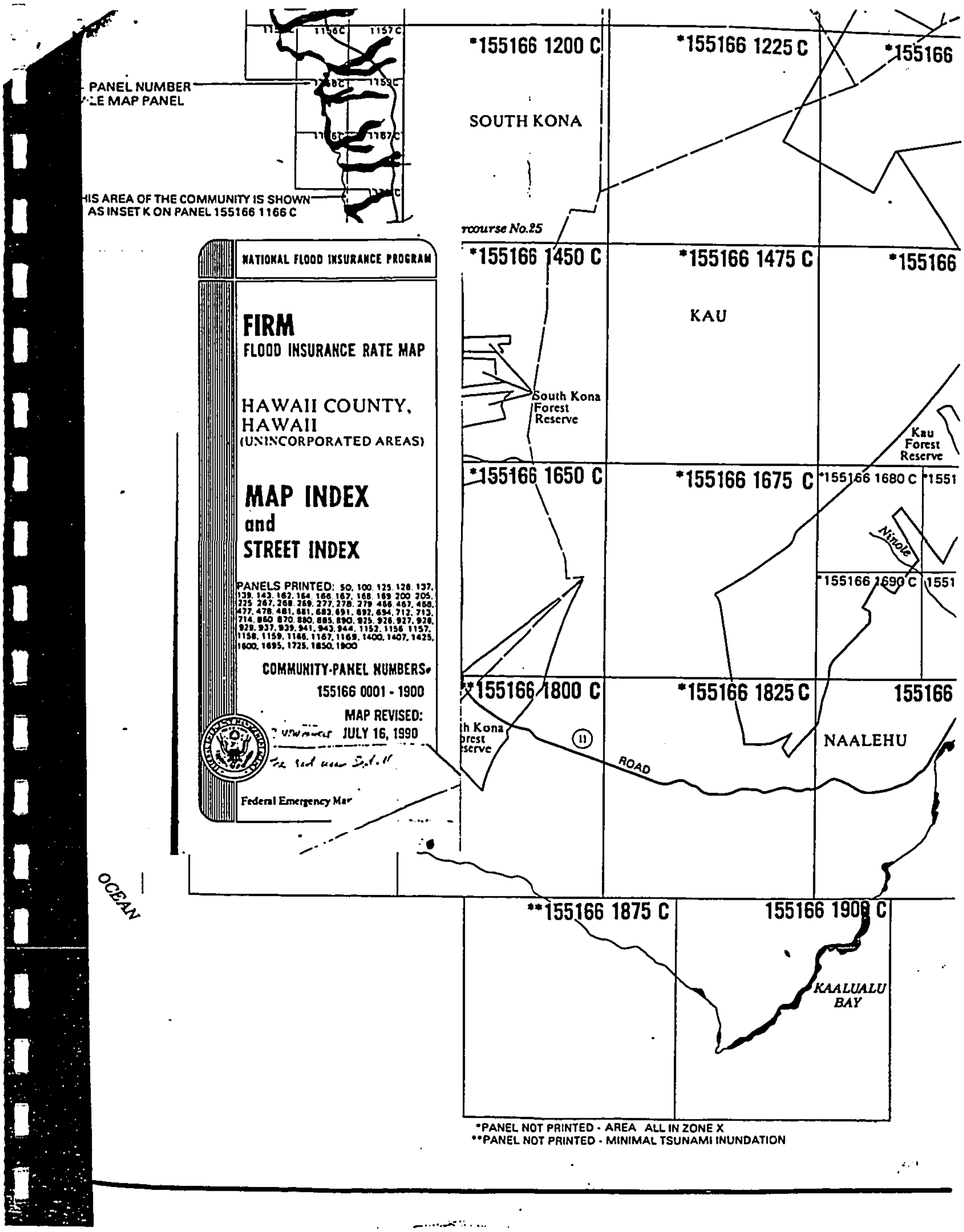
155166 1725 C
**155166 1750 C
PAHALA
155166 1690 C
155166 1695 C


PANEL NUMBER
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*155166 1200 C
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SOUTH KONA
*155166 1450 C
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South Kona Forest Reserve
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*155166 1650 C
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*155166 1680 C
*155166 1690 C
Ninole
**155166 1800 C
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NAALEHU
ROAD
11
OCEAN
**155166 1875 C
155166 1900 C
KAALUALU BAY
NATIONAL FLOOD INSURANCE PROGRAM
FIRM
FLOOD INSURANCE RATE MAP
HAWAII COUNTY, HAWAII
(UNINCORPORATED AREAS)
MAP INDEX
and
STREET INDEX
COMMUNITY-PANEL NUMBERS
155166 0001 - 1900
MAP REVISED:
JULY 16, 1990
Federal Emergency Ma
*PANEL NOT PRINTED - AREA ALL IN ZONE X
**PANEL NOT PRINTED - MINIMAL TSUNAMI INUNDATION

Okahara & Associates, Inc.
ENGINEERING CONSULTANTS

Letter No. 39001
Reference No. 90073
August 7, 1991

Mr. Kisuk Cheung
Director of Engineering
U.S. Army Engineering District,
Honolulu
Building 230
Ft. Shafter, Hawaii 96858-5440

Dear Mr. Cheung:

SUBJECT: ENVIRONMENTAL IMPACT STATEMENT PREPARATION NOTICE FOR WATER TRANSMISSION PIPELINE

Thank you for your letter of July 25, 1991 regarding the Environmental Impact Statement Preparation Notice for the proposed Water Transmission Pipeline. We appreciate the time you spent reviewing the document and providing us with useful information regarding flood zone. All of your comments are noted and will be taken into consideration in our preparation of the draft EIS.

You will be sent a copy of the Draft EIS for review and comment as soon as it is completed. In the mean time, if you have any further questions, please contact Mr. Donald Okahara of Okahara & Associates at 961-5527.

Very Truly yours,

Donald K. Okahara

Donald Okahara, President

cc: Environmental Quality Commission

Donald K. Okahara, P.E. • Masahiro Nishida, P.E. • Terrance Nago, P.E. • Glenn Suzuki, P.E.
200 KOHOLA STREET • HILO, HAWAII 96720 • TELEPHONE (808) 961-5527 • FAX (808) 961-5529
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73-4100 MAKAULA PLACE • KAILUA-KONA, HAWAII 96740 • TELEPHONE/FAX (808) 325-0750

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
P. O. BOX 50004
HONOLULU, HAWAII
96850

July 5, 1991

Mr. Donald K. Okahara
Okahara & Associates, Inc.
200 Kohola Street
Hilo, Hawaii 96720

RECEIVED
JUL 11 1991
OKAHARA & ASSOC., INC.
HILO OFFICE

Dear Mr. Okahara:

Subject: Environmental Impact Statement Preparation Notice (EISPN) - Water Transmission Pipeline and Agricultural Development Project, Island of Hawaii

Due to the internal policies of the Hawaii Soil Conservation Service, I am responding to the Environmental Impact Statement Preparation Notice (EISPN) for Water Transmission Pipeline and Agricultural Development Project in place of Mr. Tommy Robins. In the future, please send any EIS or related documents to my office if they are prepared for any State of Hawaii agency. Any EIS or related documents prepared for County of Hawaii agencies should be directed to:

Mr. Lindsay Carter
District Conservationist
USDA Soil Conservation Service
154 Waianuenue Avenue, Room 322
Hilo, Hawaii 96720

We have reviewed the EISPN for the Water Transmission Pipeline and Agricultural Development Project, Island of Hawaii and would like to offer the following comments:

1) We believe that the draft EIS for this project should specifically name the types of vegetative ground covers to be used for erosion control. The existing vegetation vary widely both in species and effectiveness as erosion control groundcovers.

2) All earth moving work should follow the County of Hawaii ordinance relating to excavations, fills, grading, grubbing, and stockpiling operations.

Thank you for the opportunity to comment on this proposed project. We would appreciate reviewing the draft EIS when it is completed.

Sincerely,

ACTING

WARREN M. LEE
State Conservationist

COPY
ORIGINAL FILED
IN 90073

Okahara & Associates, Inc.
ENGINEERING CONSULTANTS

July 13, 1991

Mr. Lindsay Carter
District Conservationist
USDA Soil Conservation Service
154 Waianuenue Avenue, Room 322
Hilo, Hawaii 96720

Dear Mr. Lindsay:

SUBJECT: ENVIRONMENTAL IMPACT STATEMENT PREPARATION NOTICE FOR WATER TRANSMISSION PIPELINE

Thank you for your letter of July 11, 1991 regarding the Environmental Impact Statement Preparation Notice for the proposed Water Transmission Pipeline. We appreciate the time spent by your staff reviewing the document. The information you provided will be useful in the preparation of the EIS.

You will be sent a copy of the Draft EIS for review and comment as soon as it is completed. In the mean time, if you have any questions regarding the project, please contact Mr. Donald Okahara of Okahara & Associates at 961-5527 or Dr. Youngki Hahn of Y.K. Hahn & Associates in Hilo at 933-3672.

Very Truly yours,

Donald Okahara, President

cc: Environmental Quality Commission
Y.K. Hahn & Associates

Donald K. Okahara, P.E. • Masahiro Nishida, P.E. • Terrance Nago, P.E. • Glenn Suzuki, P.E.
200 KOHOLA STREET • HILO, HAWAII 96720 • TELEPHONE (808) 961-5527 • FAX (808) 961-5529
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73-4100 MAKAULA PLACE • KAILUA-KONA, HAWAII 96740 • TELEPHONE/FAX (808) 325-0750

JOHN WAIHEE
GOVERNOR OF HAWAII

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

WILLIAM W. PATY, CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES

DEPUTIES
KEITH W. AHUE
MANABU TAGOMORI
DAN T.KOCHI

AQUACULTURE DEVELOPMENT PROGRAM
AQUATIC RESOURCES
CONSERVATION AND ENVIRONMENTAL AFFAIRS
CONSERVATION AND RESOURCES ENFORCEMENT
CONVEYANCES
FORESTRY AND WILDLIFE
HISTORIC PRESERVATION PROGRAM
LAND MANAGEMENT
STATE PARKS
WATER RESOURCE MANAGEMENT

REF:WRM-LC

AUG 27 1991

Mr. David L. Martin
Native Hawaiian Advisory Council
1088 Bishop Street, Suite 1204
Honolulu, Hawaii 96813

Dear Mr. Martin:

Environmental Impact Statement (EIS)
Preparation Notice for Water Resources Development and
Across Island Transmission, Island of Hawaii

Thank you for your letter of July 22, 1991 regarding the subject EIS Preparation Notice. We appreciate the time and effort you spent reviewing and providing us with pertinent concerns and input for the preparation of the Draft EIS. We have noted your interest in this project and will keep you informed along with other interested parties.

Issues you brought out in your letter will be addressed during the Draft EIS preparation.

We appreciate your interest in and concern with this project.

If you have any further questions, please contact Mr. Manabu Tagomori at 548-7533.

Very truly yours,

WILLIAM W. PATY
Chairperson

c: Environmental Quality Commission
Div. of Water Resource Mgmt., DLNR
Okahara & Associates, Inc.

NATIVE HAWAIIAN ADVISORY COUNCIL
A NONPROFIT CORPORATION
1088 Bishop Street, Suite 1204, Honolulu, Hawaii 96813
Telephone (808) 523-1445
Facsimile (808) 599-4380

1991 July 22

Department of Land and Natural Resources
Division of Water Resource Management
Attn: Edward Lau
1151 Punchbowl Street
Room 227
Honolulu, HI 96813

RE: Water Resource Development and Across Island Transmission, Hilo to Kohala

Native Hawaiian Advisory Council, Inc. (NHAC) wishes to be actively consulted during the preparation of the draft EIS for the proposed project (Notice of Preparation published in OEQC Bulletins on June 23, 1991). NHAC, in the course of completing its Native Hawaiian Water Resources Control Project, actively assists Hawai'i water use declarants in complying with the requirements of the State Water Code and in increasing their ability to assert control over their resources.

In addition to your initial solicitation of comments from interested parties concerning the scope and depth of draft EIS coverage, we believe that these parties must have ongoing involvement throughout EIS preparations, including the scoping of subcontract work, selection of contractors, and all subsequent assessments and evaluations. Especially for a proposal of this magnitude, better assessments result when information flows freely, not when it is compiled into a massive document which is then dumped on the public for a hasty and uninformed review. Frequent interaction between project proponents, EIS preparers, and the community during the entire EIS process will enhance the quality of the EIS and insure that the interests of the community are protected. Community knowledge of local conditions helps guide assumptions and methods used in environmental assessment. It behooves all concerned to actively pursue and incorporate this knowledge at all times.

Hawai'i island and its Native Hawaiian community would be irreparably affected by the proposed project, especially with regard to existing water rights and uses in the proposed source areas and allocation of water in the proposed delivery areas. The unique and powerful water rights attached to Hawaiian Home Lands along the transmission corridor, as well as those of other ceded lands, must be addressed. The existing Waimea Irrigation System, as part of the distribution network, must also be examined under these lights. Because the proposed project would develop so-called "government water," the needs of Hawaiian Home Lands for this water must be considered. Also, the implications of developing water on public lands must be considered in light of their status as ceded lands and ensuing trust obligations to Native Hawaiians.

In order to better inform our constituents about the proposed project, we request that you make the following available for our immediate review:

1. A detailed chronological history of all correspondence, planning, government action, and funding leading up to this proposal.

2. A complete synopsis of the County, State, and Federal Approvals required for the proposed project, including current status and projected timetables for each.

3. The scope of work, advertisement for bids, and signed contract with Okahara and Associates and any other contractors involved.

4. Specific locations of the proposed deep wells and reservior.

5. The location and ownership of "the 3,020 acres of lands for intensive agricultural production" and the 5,315 acres to be supported by 2007.

In addition, the EIS preparation process must include:

6. Comprehensive survey of Hawaiian Home Lands water needs under various alternative development plans.

7. Comprehensive hydrological analysis of water available to meet these demands.

8. State-funded education concerning the relationships between the proposed project and the State Water Code.

9. Complete due process in providing area residents, landowners, water users, water use declarants, beneficiaries of the Hawaiian Home Lands and Ceded Lands trusts, and all of their agents and representatives with direct and timely notice of the proposed project's fate, including all meetings, hearings, and related government actions. Copies of all documentation, including staff submittals for future proceedings and minutes of previous proceedings must be available for timely public review on Hawai'i island.

NHAC represents numerous water users in Hilo and Kohala who filed water use declarations as required by the State of Hawaii Commission on Water Resource Management. To provide the information necessary for protecting the interests of these declarants, the EIS must evaluate the impacts of proposed well water extraction upon water rights and water uses in all surrounding areas, including impacts upon groundwater storage and sustainable yields, streamflows, and coastal and submarine discharges and their relationships to ocean productivity and coastal water quality. The EIS must also evaluate the ecological ramifications of long-distance inter-basin water transfer for both source areas and delivery areas. This requires assessments of community dynamics, source water quality and biology, and the relationships among them. Psycho-spiritual impacts of the proposed project must also be assessed and evaluated.

To reiterate and clarify where the EIS preparation process must begin, the initial scoping process must include a detailed chronological history of all government correspondence, planning, action, and funding dating from the time the proposed project was first conceived. This is especially important given that:

1) The Division of Water Resource Management has, on numerous occasions, publicly announced its intentions to "get out of the water development business."

2) The proposed project is not referenced in the State of Hawaii Water Projects Plan nor in the County of Hawaii Water Code and Development Plan.

The language of the EIS preparation notice published on 6/23/91 is misleading. If the DLNR is indeed "investigating the feasibility of transmitting water from Hilo to the South Kohala Region...", then it is inappropriate to state that "The study entails construction..." Rather, the study would, if approved, entail construction..." and likewise in subsequent paragraphs.

NHAC thanks you for involving us in the subsequent EIS process and other aspects of project development. We invite you to use the resources and depth of experience available to you through the Native Hawaiian community.

NATIVE HAWAIIAN ADVISORY COUNCIL, INC.
1088 Bishop Street, Suite 1204
Honolulu, Hawaii 96813

JUL 22 1991

pc: Ka Lahui Hawai'i
Sierra Club (Hawai'i Chapter)
Governor John Waihe'e c/o OEQC
State Water Commissioners
Environment Hawai'i
Hawaiian Homes Commissioners
Donald Okahara
John Harrison c/o UH Environmental Center

Okahara & Associates, Inc.
ENGINEERING CONSULTANTS

August 8, 1991

Native Hawaiian Advisory Council
1088 Bishop Street, Suite 1024
Honolulu, Hawaii
96813

Dear Sir:

SUBJECT: ENVIRONMENTAL IMPACT STATEMENT PREPARATION NOTICE FOR WATER TRANSMISSION PIPELINE

Thank you for your letter of July 22, 1991 regarding the Environmental Impact Statement Preparation Notice for the proposed Water Transmission Project. We appreciate the time you spent reviewing and providing us with pertinent concerns and input for the preparation of the Draft EIS. We have noted your interest in this project and will keep you informed along with other interested parties.

The following is in response to the specific requests in your letter:

1. & 3. The Department of Land and Natural Resource's files are open for review in accordance with the Freedom of Information Act.

2. Synopsis of government approvals will be included in the Draft EIS. This is a required component of the EIS process under Chapter 343, HRS.

4. & 5. Detailed maps, including location and ownership of the well sites and areas identified for potential agricultural use will be included in the Draft EIS.

6. The Draft EIS will include an assessment of the water demands of the potential agricultural activities within the project site. This include Department of Hawaiian Home Lands at Lalamilo.

7. A detailed hydrologic analysis of the proposed water sources has already been undertaken and will be fully discussed in the Draft EIS. This includes potential impacts on groundwater. The Draft EIS will also assess the impacts of the transference of

Donald K. Okahara, P.E. • Masahiro Nishida, P.E. • Terrance Nago, P.E. • Glenn Suzuki, P.E.
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the water from East to West Hawaii, including biological, social, economic and other potential impacts.

8. & 9. The draft EIS will include a discussion of the relationship of the project with respect to the State Water Code and the requirements thereof, including water rights and ownership.

For your information, the following is a brief statement of the project background and planning parameters. Hopefully, it will provide you with a better understanding of the scope and purpose of the project.

The County's economy has traditionally been based on agricultural activities, primarily sugar. Consequently, development of the island was primarily centered around Hilo and other windward communities. However, recent trends have resulted in a decline in sugar and a significant increase in tourism as the primary economic sector. This in turn has shifted the growth areas on the island from the water rich east Hawaii to the relatively dry west Hawaii regions of the County.

The Island of Hawaii has a tremendous imbalance of water resources with the windward side regularly exceeding 200 inches of rainfall annually while much of the dry or leeward side receives less than 20 inches of rain per year.

While there is enough water to support the current development in West Hawaii, the long term projections indicate that certain regions of the island will not be able to sustain the long term water needs. This in turn will require the importing of water from other districts or the desalination of non-potable water. In recognition of these trends, the State of Hawaii has been investigating the feasibility of transporting water across the island to better balance the water sources with the water demand.

The Water Transmission and Agricultural Development (WT&AG) Project was conceived to begin to address these potential long term water imbalances between east and west Hawaii. In recognition of the significant cost of moving water from one side of the island to the other, the project was designed to maximize the potential for federal funding by supporting the continued growth of the U.S. Army's Pohakuloa Training Area (PTA) facility. This in turn limited the water source and pipeline routing options to those which can feasibly serve the Pohakuloa area.

While the provision of water to PTA was a critical element of the WT&AD project, the State wanted to ensure the benefits from a pipeline extended beyond Pohakuloa to West Hawaii. Consequently, project design parameters were established to ensure sufficient water was available to West Hawaii even after providing for all the potential needs of PTA. Based on this requirement, a water source and transmission pipeline capacity of 20 million gallons per day (GDP) was set by the State for planning and design purposes.

The proposed was also designed to support the State's goal of providing for the continue diversification of its economy. Consequently, the planning parameters of the WT&AD project were established to review the feasibility and impacts of providing water to West Hawaii for agricultural purposes. Should other uses of the water be proposed, additional planning and review beyond this project will be required.

Again, we appreciate you interest in and concern with this project. If you have any further questions, please contact Donald Okahara of Okahara & Associates, Inc. at 961-5527.

Very Truly Yours,

Donald Okahara, President

cc: Environmental Quality Commission
DWRM/DLNR

OFFICE OF STATE PLANNING
Office of the Governor
STATE CAPITOL, HONOLULU, HAWAII 96813 TELEPHONE (808) 548-5893
JOHN WAIHEE, Governor

70C12

August 9, 1991

14 1991
OKAHARA & ASSOC., INC.
HILO OFFICE

Mr. Donald K. Okahara, P.E.
Okahara and Associates, Inc.
200 Kohola Street
Hilo, Hawaii 96720

Dear Mr. Okahara:

Subject: Comments on Environmental Impact Statement Preparation Notice (EISPN) for Water Resource Development and Across Island Transmission, Island of Hawaii

The Office of State Planning (OSP) has reviewed the subject document and offers the following comments.

The State Department of Land and Natural Resources (DLNR) has retained Okahara and Associates to assist in the establishment of its Water Transmission and Agriculture Development project on the east side of the island of Hawaii. The proposed projectd consists of two segments: 1) construction of nine vertical deep wells above Hilo with a capacity of 2.5 mgd each, a 42-inch diameter underground pipeline and related facilities; and 2) continuation of the 42-inch above-ground pipeline via gravity flow to a terminal site above the Waimea plain, where a reservoir and clorination facility will be constructed.

OSP concurs with the State Department of Agriculture's (DOA's) comment that "we are very supportive of efforts that move the State towards economically viable self-sufficiency in agriculture" (DOA letter to Okahara and Associates, Inc. dated July 15, 1991). However, OSP has concerns regarding the proposed action which are not addressed in the EISPN. Pursuant to §11-200-17 of the Department of Health, Environmental Impact Statement (EIS) Rules, the draft EIS should provide information which would address these concerns, which are summarized below.

OSP is concerned with the impacts of the proposed project on regional growth and land use patterns in the area. The draft EIS should discuss the relationship of the proposed action to land use plans, policies, and controls for the area to be affected. The discussion should include an analysis on "how the proposed action may conform or conflict with objectives and specific terms of approved or proposed land use plans, policies, and controls, if any, for the area affected." In addition, the draft EIS should include estimates of population and growth impacts of the proposed action, and an evaluation of population patterns or growth upon the area's resources, including land use, water, and public services.

OSP is also concerned with the potential socio-economic impacts of redistributing water resources from one side of the island to another (in this case, from the east side to the So. Kohala region of the Big Island). As specified in EIS Rules, §11-200-17(j), the draft EIS should discuss "the extent to which the proposed action involves tradeoffs between short-term losses and long-term losses, or vice versa, and a discussion of the extent to which the proposed action forecloses future options, narrows the range of beneficial uses of the environment..." In addition, the draft EIS should provide more information regarding the economic feasibility of transmitting water from the east side to the So. Kohala region of the Big Island.

Although the EISPN includes a Statement of Objectives, the draft EIS should more fully address the need for the proposed action. A discussion of the need for water transmission/redistribution from the east side to the So. Kohala region of the island, and the need for agriculture in that particular area of Waimea should be included.

In light of continuing problems with electrical generation on the island, the draft EIS should disclose the capability of existing or planned energy facilities to meet the necessary energy requirements of the proposed project. If this project is primarily dependent on the development of geothermal energy sources, that dependency should be disclosed and fully discussed.

Thank you for the opportunity to comment. Should you have any questions, please contact the Land Use Division at 548-2066.

Sincerely,

Harold S. Masumoto
Director

cc: Honorable William W. Paty
Honorable Yukio Kitagawa
Honorable Murray E. Towill

Okahara & Associates, Inc.
ENGINEERING CONSULTANTS

Letter No. 39031
Reference No. 90073
August 16, 1991

Mr. Harold Masumoto, Director
Office of State Planning
250 S. King Street, Rm # 802
Honolulu, Hawaii 96813

Dear Mr. Masumoto:

SUBJECT: ENVIRONMENTAL IMPACT STATEMENT PREPARATION NOTICE FOR WATER TRANSMISSION PIPELINE

Thank you for your letter of August 9, 1991 regarding the Environmental Impact Statement Preparation Notice for the proposed Water Transmission Pipeline. We appreciate the time you spent reviewing the document and providing us with support, useful input, and guidence in preparation of Draft EIS. All of your comments have been included in our analyses and being addressed, hopefully, satisfactorily.

You will be assured of receiving a copy of the Draft EIS for review and comment as soon as it is completed. In the mean time, if you have any further questions, please contact Mr. Donald Okahara of Okahara & Associates at 961-5527.

Very Truly yours,

Donald K. Okahara

Donald Okahara, President
Okahara and Associates

c.c. Youngki Hahn
Y.K. Hahn and Associates

Donald K. Okahara, P.E. • Masahiro Nishida, P.E. • Terrance Nago, P.E. • Glenn Suzuki, P.E.
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90073 xc OKO YH

To: Consultant Donald Okahara of Okahara and Associates Inc.
200 Kohola Street. Hilo. Hawaii, 96720, and
Edward Lau of Department of Land and Natural Resources
1151 Punchbowl Street, Room 227, Honolulu, Hawaii, 96813.

From: Henry A. Ross, P.O. Box 99, Kapaau, Hawaii, 96755, consulted party.
889-5587

Re: E.I.S. for Water Resource Development and Across Island Transmission. (42 inch pipeline along the Saddle Road)

RECEIVED
JUL 23 1991
OKAHARA & ASSOC., INC.
HILO OFFICE

22 July 1991

The consultants' address in the Environmental Assesment is incorrect which may lead to lost responses to the EIS.

This obviously politically motivated but highly impractical project needs very close scrutiny. As its goals can be obtained so much more easily and cheaper than here proposed by putting a pipeline along the Hamakua coast one wonders what its protagonists' motives really are. Senator Matsuura, as one of them, also pushes hard for geothermal energy against all common sense negative indicators. Is it really coincidence that in the convoluted way water is to be pumped over the hump of the saddle road with 7000 feet elevation to its purported destination around Kamuela at 3000 feet high 25 megawatt of power will be needed that are to be produced by geothermal wells because there is no present other source. This is twice as much as would be needed by pumping along the Hamakua coast to the same destination. And the given reason of also providing water to Pohakuloa is not very credible, unreliable as the military is as a customer in these days of massive reduction of activities and manpower requirements that will be the trend of the future. Or is Pohakuloa going to pay the unnecessary half of the operating cost of the system forever in the future and will that be contractually settled? Even then it would be at taxpayers' expense, be it indirectly. All these things and much more will have to be explained in extenso in the EIS. This water is going to be too expensive for drinking water purposes, let alone for agricultural use as is projected by the consultants. This project as proposed is a 61 mile 42 inch pipe-dream. Nobody in his right mind would pump water up to the seventh floor of a building to then let it fall down to the third floor where it could possibly be used, just because a tenant on the seventh floor indicates that he may be willing to pay something for the pipe and use a tiny bit of the water.

What happens after the users are established and rely on this system and there is a county-wide brown out or its own pumps brake down? The water department has portable generators that help out in temporary breakdowns around the county but they cannot ever provide 25 megawatt of power.
One wonders why so much money is wasted over planning and an

1

EIS for such a monstrous idea, while pumping Hilo water along the Hamakua coast would be far cheaper and provide back-up security for the water systems of all the communities along the coast. If the EIS can honestly explain why this is an unviable alternative (and if anything is needed at all) everybody except Matsuura and cohorts and maybe the DLNR would be greatly and pleasantly surprised, because directly or indirectly the public would have to pay for this folly.

The EIS will also have to explain if the mineral content of the irrigation water will not build up in the soil like in California and create a future desert and further treat as an alternative to - at very little cost - educate the farmers in drip irrigation and provide them with assistance for this. The present water supply to the area would the be sufficient.

How severily are the pipe and pump stations and water tanks going to deface the landscape? Is this environmentally acceptable at all and will the tourist industry not suffer from these unnecessary ugly decorations of a pristine and unique volcanic terrain. What will happen in case of Mauna Loa eruptions as we have experienced not too long ago?

Instead of expanding on intensive agriculture in the indicated Kamuela area which would provide a projected 1300 farm jobs for which the labor is not available and must be imported at great cost to the state and county services, would it not be far better to contemplate the Hamakua coast area for this intensive agriculture because sugar is on the way out anyway and labor there will then be plentifull. The coast scenario for the pipe would accomplish that and prevent the loss of jobs and failure of existing communities.

It seems utterly ridiculous to pump 20 million gallons per day over the hump of the saddle because maybe a very tiny fraction of that water, 4/10th of 1 percent (80,000 gallons), could be used on the hump itself.
Pohakuloa gets almost all its water from its own natural well and seldom pays for trucking additional water at $20/1000 gallons. This is nothing compared to the running cost of water through the proposed pipeline. And with military bases closing willy nilly around the country how long is PTA going to hold out. It may have disappeared before the project is finished. It takes a contortionist to write an EIS that answers all these questions satisfactorily. It also raises the question if it might not be cheaper to dig wells in the Pohakuloa area and drop the water by gravity to any place below at no pumping cost. We know there is water there, how much will have to examined. The wells would cost more but no pump stations and the like are necessary. Better even to do that at a lower elevation on the Kamuela side of Mauna Kea and pump a trifle up to the army for its needs. There are quite some viable alternatives that must all be shown in the EIS with cost figures for comparison. -SAVE US FROM FOLLY-

Henry A Ross

2

FROM OKAHARA
SENT BY:DWRM ... P. 3

JOHN WAIHEE
GOVERNOR OF HAWAII

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

WILLIAM W. PATY, CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES

DEPUTIES
KEITH W. AHUE
MANABU TAGOMORI
DAN T. KOCHI

AQUACULTURE DEVELOPMENT PROGRAM
AQUATIC RESOURCES
CONSERVATION AND ENVIRONMENTAL AFFAIRS
CONSERVATION AND RESOURCES ENFORCEMENT
CONVEYANCES
FORESTRY AND WILDLIFE
HISTORIC PRESERVATION PROGRAM
LAND MANAGEMENT
STATE PARKS
WATER RESOURCE MANAGEMENT

REF:WRM-LC

AUG 27 1991

Mr. Henry A. Ross
P.O. Box 99
Kapaau, Hawaii 96755

Dear Mr. Ross:

Environmental Impact Statement (EIS)
Preparation Notice for Water Resources Development and
Across Island Transmission, Island of Hawaii

Thank you for your letter of July 22, 1991 regarding the subject EIS Preparation Notice. We appreciate the time and effort you spent reviewing and providing us with pertinent concerns and input for the preparation of the Draft EIS. We have noted your interest in this project and will keep you informed along with other interested parties.

Issues you brought out in your letter will be addressed during the Draft EIS preparation.

We appreciate your interest in and concern with this project.

If you have any further questions, please contact Mr. Manabu Tagomori at 548-7533.

Very truly yours,

WILLIAM W. PATY
Chairperson

c: Environmental Quality Commission
Div. of Water Resource Mgmt., DLNR
Okahara & Associates, Inc.

RECEIVED FROM ...

90073

YC: Hahn DWR

JAMES KENT ASSOCIATES

July 19, 1991

Governor, State of Hawaii
c/o Office of Environmental
Quality Control
220 South King Street
4 th Floor
Honolulu, HI 96813

JUL 29 1991

OKAHARA & ASSOC., INC.
HILO OFFICE

Governor Waihee,

I am responding to your call for comments concerning "Water resource development and across island transmission" preparation notice. James Kent Associates are internationally recognized leaders in the environmental impact statement (EIS) field with over 20 years experience. Mr. Kent, the firm's founder, was instrumental in interpreting the National Environmental Policy Act (NEPA) which created the EIS process.

Our firm is requesting "consulting agency" status with regard to the pipeline EIS. I recommend that your scoping process include extensive public involvement in both Hilo and Waimea. I would encourage you to delay preparation until issues can be adequately scoped along the pipeline route and both supply and reception areas. The state would then be encouraged to pursue an public-oriented EIS process throughout the analysis.

In addition to the anticipated public issues, Kent Associates feel that the following concerns must be incorporated into an acceptable EIS:

* How would the proposed project impact resident adjacent to the well sites? What mitigations will be provided for negative impacts?

* How would the proposed project impact public and/or private wells sharing a basin of origination? What mitigations will be provided for negative impacts?

* What are other previously identified and new alternative sources of water for Pohakuloa Military Training Area (PTA)? Why would this alternative be selected over less costly means of providing water for PTA use?

* Why would "intensive" agriculture be pursued on the "dryside" of Waimea instead of the "wetside" which naturally receives adequate rainfall?

* What are the assumptions behind the need for 3020 and 5315 acres of state sponsored intensive agriculture in Waimea? How was this location selected? What is the model upon which these numbers are based?

* Where would the intensive agriculture occur? Who would have access to water supplies? What would be the cost?

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1000 Bishop, Suite 401 • Honolulu, HI 96813 • 808/533-5657 • FAX 808/599-4161

* Define the socio-economic impact area and the assumptions upon which the delineations were made. What would be the socio-economic impacts of a 140 mg reservoir on the impact area? What would be the socio-economic impacts of 3020 and 5315 acres of intensive agriculture on the impact area? Examples of concerns include but are not limited to affects on the current culture, local work force, housing supply, social support services, traffic, and land values.

* How would the project impact flora, fauna, and wildlife at the well sites?

* How would the project and cumulative affects of additional water availability affect flora, fauna, wildlife, and possible endangered species at PTA?

* What does the proposal assume the additional activities at PTA will be? What is the basis for these assumptions? How would these activities affect the flora, fauna, wildlife, and possible endangered species at PTA?

* How would the project impact flora, fauna, wildlife, and possible endangered species in the area of the proposed reservoir and proposed agricultural areas?

* How would the project affect flora, fauna, wildlife , and possible endangered species along the pipeline route?

* What are the assumptions regarding available energy for the project given the current situation on the Big Island? What are the impacts of the energy needs of this project on the island?

* Under what conditions could this water be used for domestic or commercial needs? How would this "emergency" be identified? When would the water return to agricultural use? What are the socio-economic impacts of having a "back-up system"? Could this water ever be used for new development or current or future resorts?

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1000 Bishop, Suite 401 • Honolulu, HI 96813 • 808/533-5657 • FAX 808/599-4161

JAMES KENT ASSOCIATES

I hope these comments are helpful to your scoping of this EIS. Again, I encourage a issue based public participation process for this study. Kent Associates would appreciate any and all documentation concerning this project. If I may be of any assistance, please call or write me.

Sincerely,

Robert Schultz
James Kent Associates
P.O. Box 640
Kapaau, HI 96755

1000 Bishop St. #401
Honolulu, HI 96813

cc:
Department of Land and
Natural Resources, Division of
Water Resource Management
attn: Edward Lau
1151 Punchbowl St.
Room 227
Honolulu, HI 96813

Donald Okahara
c/o Okahara & Associates, Inc.
200 Kohola St.
Hilo, HI 96720

Okahara & Associates, Inc.
ENGINEERING CONSULTANTS

Letter No. 39904
Reference No. 90073
August 7, 1991

Mr. Robert Schultz
James Kent Associates
P.O.Box 640
Kapaau, Hi 96755

Dear Mr. Schultz

SUBJECT: ENVIRONMENTAL IMPACT STATEMENT PREPARATION NOTICE FOR WATER TRANSMISSION PIPELINE

Thank you for your letter of July 19, 1991 regarding the Environmental Impact Statement Preparation Notice for the proposed Water Transmission Pipeline. We appreciate the time you spent reviewing the document. Many of your concerns and questions are well thought out and they are also being analyzed by the EIS consultant team for our draft EIS.

You will be sent a copy of the Draft EIS for review and comment as soon as it is completed. In the mean time, you may wish to review draft final copy of Assessment of Agricultural Industry Development In the South Kohala Region of West Hawaii, which provides some of your agriculture and land use related questions. Please contact Mr. Monden of Water Resource Management Division of DLNR for possible availability of a copy of the study. If you have further questions please contact Mr. Donald Okahara of Okahara & Associates at 961-5527.

Very Truly yours,

Donald K. Okahara

Donald Okahara, President

cc: Environmental Quality Commission

Donald K. Okahara, P.E. • Masahiro Nishida, P.E. • Terrance Nago, P.E. • Glenn Suzuki, P.E.
200 KOHOLA STREET • HILO, HAWAII 96720 • TELEPHONE (808) 961-5527 • FAX (808) 961-5529
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XEROX COPY

Environment Hawaii
733 Bishop Street
Suite 170-51
Honolulu, Hawaii 96813

... 0 9 1991

July 4, 1991

Office of Environmental Quality Control
220 South King St., 4th Floor
Honolulu HI 96813

RE: EIS Preparation Notice for Water Resource Development and Across-Island Transmission, Hilo to Kohala, Hawai`i

To whom it may concern:

I read with interest the EIS preparation notice for the above-referenced project. I believe that the scope of the EIS should include the following topics, among others:

* Effect of removal of groundwater on surface stream flows;

* Effect of removal of groundwater on riparian ecosystems;

* Effect of removal of groundwater from deep wells above Hilo upon aquifers providing potable water to Hilo and other East Hawai`i communities;

* Effect of electrical demands of pumping water on island-wide electrical resources;

* Effect of removal of groundwater on near-shore ocean ecosystems on Hilo side;

* Effect of expanson of "intensive agricultural activities" anticipated in the Kohala region on native ecosystems (this should include discussion of erosion, potential pesticide contamination of air and water, and potential increase in demand on fossil fuel resources for cultivation of land);

* Effect of expansion of "intensive agricultural activities" on near-shore ocean quality along the Kohala coast;

XEROX COPY

To: OEQC

July 4, 1991

I thank you very much for including these issues in the scoping process for this environmental impact statement.

Best wishes,

Patricia Tummons

Patricia Tummons
Editor, Environment Hawai'i

cc: DLNR, Division of Water Resource Management
Donald Okahara, Okahara & Associates, Inc.

Okahara & Associates, Inc.
ENGINEERING CONSULTANTS

July 13, 1991

Ms. Patricia Tummons, Editor
Environment Hawaii
733 Bishop Street, Suite 170-51
Honolulu, Hawaii 96813

Dear Ms. Tummons:

SUBJECT: ENVIRONMENTAL IMPACT STATEMENT PREPARATION NOTICE FOR WATER TRANSMISSION PIPELINE

Thank you for your letter of July 04, 1991 regarding the Environmental Impact Statement Preparation Notice for the proposed Water Transmission Pipeline. We appreciate the time spent by your staff reviewing the document. The information you provided will be useful in the preparation of the EIS.

You will be sent a copy of the Draft EIS for review and comment as soon as it is completed. In the mean time, if you have any questions regarding the project, please contact Mr. Donald Okahara of Okahara & Associates at 961-5527 or Dr. Youngki Hahn of Y.K. Hahn & Associates in Hilo at 933-3672.

Very Truly yours,

Donald Okahara, President

cc: Environmental Quality Commission
Y.K. Hahn & Associates

Donald K. Okahara, P.E. • Masahiro Nishida, P.E. • Terrance Nago, P.E. • Glenn Suzuki, P.E.
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9CC 7.3

DEPARTMENT OF THE ARMY
HEADQUARTERS, UNITED STATES ARMY SUPPORT COMMAND, HAWAII
DUNNING HALL
FORT SHAFTER, HAWAII 96858-5000

REPLY TO ATTENTION OF:

Directorate of Facilities
Engineering

05 AUG 1991

RECEIVED
AUG 06 1991
OKAHARA & ASSOC., INC.
HILO OFFICE

Mr. Donald K. Okahara
President
Okahara and Associates, Inc.
200 Kohola Street
Hilo, Hawaii 96720

Dear Mr. Okahara,

Per your request, this office reviewed the Environmental Impact Statement Notice of Preparation for Water Resource Development and Across-Island Transmission, Island of Hawaii. In accordance with the Council of Environmental Quality regulations, State of Hawaii, this office forwarded comments regarding the above subject to the accepting authority, Governor, State of Hawaii, c/o Office of Environmental Quality Control (enclosed).

If further information is required, please contact Mr. Alton Kanno, Environmental Branch, Planning Division, at 656-2878.

Sincerely,

Charles R. Wilson
Colonel, U.S. Army
Director of Facilities
Engineering

Enclosure

DEPARTMENT OF THE ARMY
HEADQUARTERS, UNITED STATES ARMY SUPPORT COMMAND, HAWAII
DUNNING HALL
FORT SHAFTER, HAWAII 96858-5000

REPLY TO ATTENTION OF:

Directorate of Facilities
Engineering

05 AUG 1991

Honorable John Waihee
Governor of Hawaii
c/o Office of Environmental
Quality Control
220 South King Street
Honolulu, Hawaii 96813

Dear Governor Waihee:

In response to the EIS Preparation Notice, Water Resource Development and Across-Island Transmission, Island of Hawaii, published in the June 23, 1991 issue of the OEQC Bulletin, the following comments are provided:

- The Army tentatively has no objections to the proposed project and would be willing to help support the project pending prior approval from the Secretary of the Army and the House Armed Services Committee. Site location of the 140 mg reservoir will require approval from the U.S. Army Support Command, Hawaii (USASCH), Installation Commander and from the USASCH Installation Master Planning Branch. Also, there is in the works a proposal to reroute Saddle Road near the vicinity of the Pohakuloa Training Cantonment area and possibly around other nearby training/maneuvering areas. The exact reroute alignment is not known at this time.

The response deadline for this EIS Preparation Notice is July 23, 1991. In accordance with the Council of Environmental Quality regulations, USASCH hereby requests an extension to the deadline not to exceed the 30-day extension limit.

Sincerely,

Charles R. Wilson
Colonel, U.S. Army
Director of Facilities
Engineering

Okahara & Associates, Inc.
ENGINEERING CONSULTANTS

September 3, 1991
Letter No. 39087
Reference No. 90073

Col. Charles R. Wilson
Director of Facilities
Engineering
Dunning Hall, Fort Shafter
Hawaii 96858-5000

Dear Col. Wilson:

In response and comments on the EISPN for the proposed Water Transmission Project in the Island of Hawaii (August 5, 1991), you have indicated that "there is in the works a proposal to reroute Saddle Road near the vicinity of the Pohakuloa Training Cantonment area and possibly around other nearby training/maneuvering areas." You did also indicated that "the exact reroute alignment is not known at this time."

We have finalized our drawings for the conceptual study and will be submitting the report to DLNR by September 30, 1991. We will consider the rerouting of the Saddle Road as an alternative route and include the construction cost of the pipeline in the report if we receive the routing drawings from you before September 25, 1991. The EIS shall be done for only one route. Please advise us of your preference.

Please send us whatever documents and drawings that you have so that we can incorporate the alternative route in our drawings.

Please let us know what the design and construction schedule is for the alternative route.

If you have any further questions or comments call Dr. Hahn (933-3672) or myself (961-5527).

Cordially,

Donald K. Okahara, P.E.
President

DKO:mmq

Donald K. Okahara, P.E. • Masahiro Nishida, P.E. • Terrance Nago, P.E. • Glenn Suzuki, P.E.
200 KOHOLA STREET • HILO, HAWAII 96720 • TELEPHONE (808) 961-5527 • FAX (808) 961-5529
470 NORTH NIMITZ HWY., SUITE 212 • HONOLULU, HAWAII 96817 • TELEPHONE (808) 524-1224 • FAX (808) 521-3151
P.O. BOX 688 • KEALAKEKUA, HAWAII 96750 • TELEPHONE/FAX (808) 322-2222
73-4100 MAKAULA PLACE • KAILUA-KONA, HAWAII 96740 • TELEPHONE/FAX (808) 325-0750

9/10/91 xe
Dante Carpenter

Okahara & Associates, Inc.
ENGINEERING CONSULTANTS

Letter No. 39000
Reference No. 90073
August 7, 1991

Col. Charles R. Wilson
Director of Facility Engineering
Department of Army, HQ
U.S. Army Support Command, Hawaii
Dunning Hall
Ft. Shafter, Hawaii 96858-5000

Dear Col. Wilson:

SUBJECT: ENVIRONMENTAL IMPACT STATEMENT PREPARATION NOTICE FOR WATER TRANSMISSION PIPELINE

Thank you for your letter of August 5, 1991 regarding the Environmental Impact Statement Preparation Notice for the proposed Water Transmission Pipeline. We appreciate the time you spent reviewing the document and providing us with useful information regarding the possible realignment of Saddle Road near Pohakuloa Trainning Area. All of your comments are noted and will be taken into consideration in our preparation of the draft EIS.

You will be sent a copy of the Draft EIS for review and comment as soon as it is completed. In the mean time, if you have any further questions, please contact Mr. Donald Okahara of Okahara & Associates at 961-5527.

Very Truly yours,

Donald K. Okahara

Donald Okahara, President

cc: Environmental Quality Commission

Donald K. Okahara, P.E. • Masahiro Nishida, P.E. • Terrance Nago, P.E. • Glenn Suzuki, P.E.
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73-4100 MAKAULA PLACE • KAILUA-KONA, HAWAII 96740 • TELEPHONE/FAX (808) 325-0750

90073 XC DKO YH

Lorraine R. Inouye
Mayor

Bruce C. McClure
Chief Engineer

Laurence E. Capellas
Deputy Chief Engineer

Department of Public Works

25 Aupuni Street, Room 202 • Hilo, Hawaii 96720 • (808) 961-8321 • Fax (808) 969-7138

July 9, 1991

RECEIVED
JUL 11 1991
OKAHARA & ASSOC., INC.
HILO OFFICE

MR DONALD K OKAHARA
OKAHARA & ASSOCIATES INC
200 KOHOLA STREET
HILO, HI 96720

SUBJECT: EISPN
Water Transmission Pipeline (Hilo to Waimea)

Thank you for the opportunity to review the subject document. Our comments are as follows:

1. Who is this project being planned for? P.T.A., Waimea Agricutural Land, Waimea or West Hawaii? If this is for Waimea why isn't the water taken from the Windward side of the Kohala Mountains? The Kohala source is not as dependable as the Waiakea-Uka source would be and hence a higher storage capacity will be needed. It is, though, much closer to Waimea than Waiakea-Uka is.

2. What is planned for the Agricultural area. Who will plan and construct the subdivision? What will be the size of the lots? Is the P.T.A. going to expand. Who will shoulder the cost of the proposed project?

3. The Saddle road route is a high energy user. Is the power requirement too much of a drain on HELCO facilities? Who will shoulder the cost of the power facilities? Does HELCO have the capacity to serve the project without adversely affecting them overall generating, transmission and distribution system.

4. The availability of water is a major impetus for growth and development. Who will this water be available for? What is the impact of this project on the land use along and beyond the alignment?

5. Submit alignment plans and typical roadway sections showing the location and depth of the waterline.

Donald Okahara
page 2
July 9, 1991
EISPN

6. Can the capacity of the porposed project be increased in the future? Eventually, transporting water from East Hawaii to West Hawaii will make sense since the surface and ground water resources in East Hawaii are more abundant and reliable.

for ROBERT K. YANABU, Division Chief
Engineering Division

DHM:thk

cc: ENG
Planning

Okahara & Associates, Inc.
ENGINEERING CONSULTANTS

July 13, 1991

Mr. Robert Yanabu, Division Chief
Engineering Division
County of Hawaii
25 Aupuni St. Hilo, Hawaii
96720

Dear Mr. Yanabu:

SUBJECT: ENVIRONMENTAL IMPACT STATEMENT PREPARATION NOTICE FOR WATER TRANSMISSION PIPELINE

Thank you for your letter of July 9, 1991 regarding the Environmental Impact Statement Preparation Notice for the proposed Water Transmission Pipeline. We appreciate the time spent by your staff reviewing the document. The information you provided will be useful in the preparation of the EIS.

You will be sent a copy of the Draft EIS for review and comment as soon as it is completed. In the mean time, if you have any questions regarding the project, please contact Mr. Donald Okahara of Okahara & Associates at 961-5527 or Dr. Youngki Hahn of Y.K. Hahn & Associates in Hilo at 933-3672.

Donald Okahara, President

cc: Environmental Quality Commission
Y.K. Hahn & Associates

Donald K. Okahara, P.E. • Masahiro Nishida, P.E. • Terrance Nago, P.E. • Glenn Suzuki, P.E.
200 KOHOLA STREET • HILO, HAWAII 96720 • TELEPHONE (808) 961-5527 • FAX (808) 961-5529
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73-4100 MAKALILA PLACE • KAILUA-KONA, HAWAII 96740 • TELEPHONE/FAX (808) 325-0750

Chapter 8: **Technical Appendices**

Appendix A

THE SADDLE ROAD EXPLORATORY WELL

HOAKA, HAWAII

COMPLETION OF DRILLING AND TESTING

Prepared for

Okahara & Associates, Inc.

Hilo, Hawaii

Prepared by

MINK & YUEN, INCORPORATED

100 North Beretania Street, Suite 303

Honolulu, Hawaii 96817

December, 1991

I. INTRODUCTION

In early 1989, discussions were held concerning exploration for and development of a groundwater supply in the Hilo District for transmission along the Saddle Road to West Hawaii. A study suggested that groundwater could be provided by high-capacity wells, and a recommendation was made to go ahead with exploratory drilling to verify the existence of a developable resource.

The site proposed for a well field was at elevation 850 feet about 1000 feet north of Hoaka Road near the high voltage line corridor. Subsequently, it became apparent that constructing an access road to this site for a single exploratory well would be unacceptably costly. A reconnaissance was then made to find a geologically similar location nearby to which access would neither be difficult nor expensive.

The final site selected for the exploratory well is approximately 2000 feet northwest of the original recommendation (Fig. 1). The new location is geologically identical to the first one. The aquifer encountered during drilling no doubt extends to and includes the area of the initially proposed well field. The region is in the Hilo Aquifer System of the Northeast Mauna Loa Aquifer Sector.

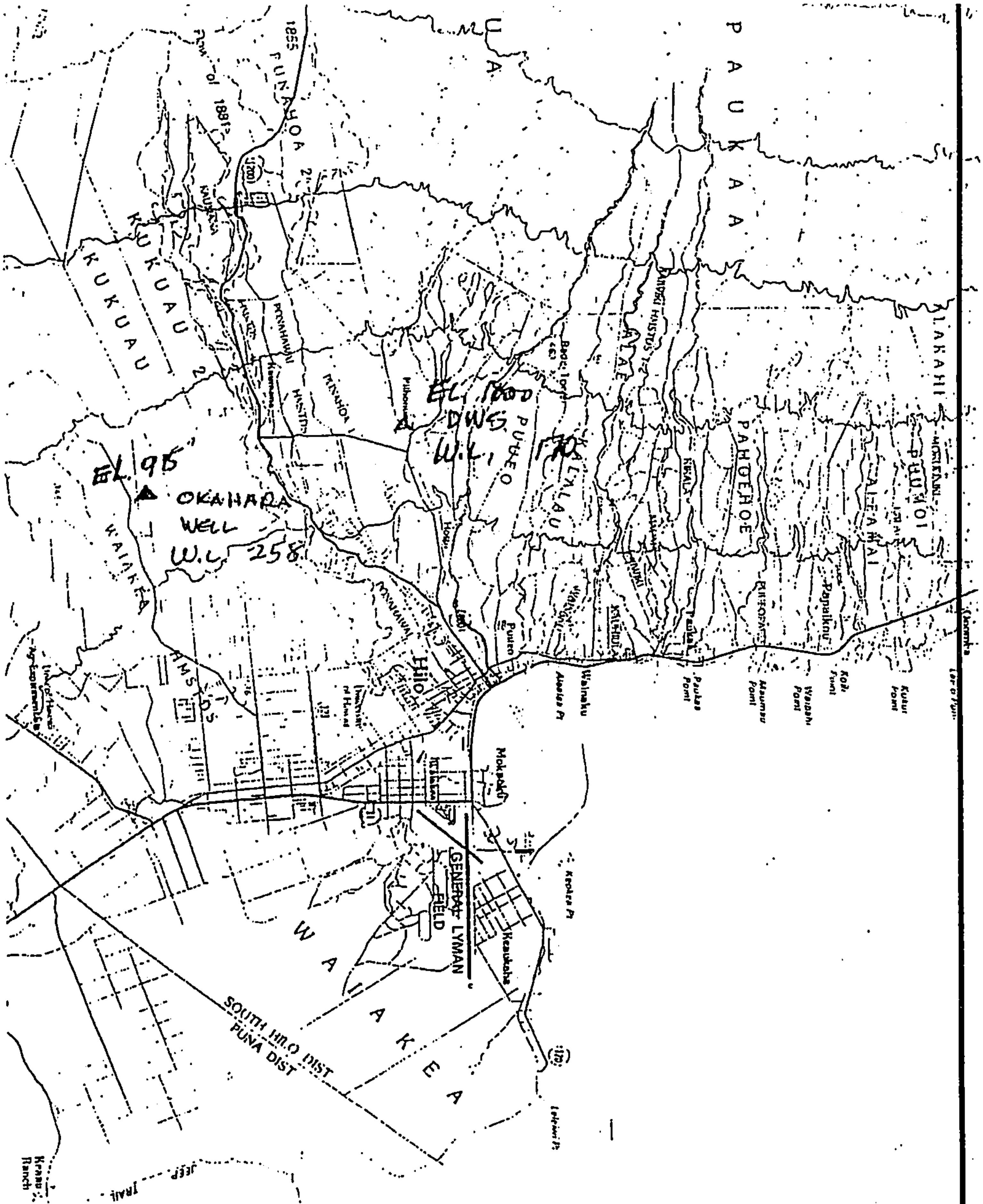


Fig. 1 - Well Site

II. WELL DESIGN AND DRILLING

The well was designed and drilled with the simple objective of determining the depth to groundwater and the existence of an aquifer. The stability of the water table was to be tested with a low-capacity pump, and the quality of the groundwater was to be ascertained. These objectives were achieved and proved the existence of a developable high-level aquifer having a head approximately 250 feet above sea level and pure, low salinity water.

The well is strictly exploratory; it cannot be converted to a production well unless it is reamed to a larger diameter, cased and grouted. It was specified to be an open 9.75-inch diameter pilot hole, although before completion casing had to be installed because of difficulties caused by unstable formations. It does not contain a crushed rock pack, and only at the surface is the annulus protected against downward leakage by a grout seal. The drilling contractor was Water Resources International, Inc.

Ground elevation at the site is about 915 feet, and the depth of the well is 954 feet (bottom at 40 feet below sea level). Drilling started on July 16, 1991 and proceeded easily until a depth of 754 feet was reached a month later. Because of the instability of the hole at this depth, a 7-inch diameter casing had to be inserted, below which the open hole was filled with cement so that drilling could proceed. A 6-inch diameter boring was drilled through the cement and beyond to the full depth of 954 feet. The initial water table was encountered at 258 feet above sea level. Much phreatic water cascades into the well from higher formations, however.

III. GEOLOGICAL FORMATIONS

Drilling first penetrated young lavas of the Kau volcanic series from Mauna Loa volcano, then an unconformity marked by about 10 feet of Pahala Ash before entering the basement Kahuku volcanic series, also from Mauna Loa. Both the Kau and Kahuku series are extremely permeable, while the Pahala Ash behaves like an aquitard and perches groundwater. Most of the phreatic water that cascades down the boring drains from the top of the ash layer.

Rotary drill cuttings from a depth of 20 to 270 feet were examined. Below 270 feet the cuttings from the Kahuku series were similar to cuttings from the same formation higher up.

A log of the cuttings (examined by J.F. Mink) is as follows:

Depth (ft)	Description and Comments
20 - 60	Red, gray scoriaceous lava. Kau series.
60 - 70	Red, gray to brown, fresh. Kau series.
70 - 80	Red, gray, scoriaceous, fresh. Kau series.
80 - 90	Gray, black fine fragments. Kau series.
90 - 100	Weathered, clayey. Pahala Ash unconformity.
100 - 110	Gray, red weathered. Saprolite Kahuku series.
110 - 120	Weathered basalt. Kahuku series.
120 - 270	Red, gray, mostly fresh basalt. Kahuku series.
270 - 954	Not examined by intervals. Same as fresh Kahuku series.

The aquifer penetrated by the boring is in the highly permeable Kahuku volcanic series consisting of primitive basalt and olivine basalt. The high-water table reflects either groundwater impounded among structures and intrusives or groundwater perched on low permeability layers. The limited pump test suggests that the groundwater body is extensive, but not until a high-capacity test is performed in a larger well for a much longer period will an accurate assessment of aquifer size and properties be possible.

IV. PUMP TEST

A 24-hour pump test was conducted between September 9 and 10, 1991. Overseeing the test was Kiyoshi J. Takasaki, formerly a chief hydrologist with the U.S. Geological Survey in Hawaii, and personnel of Water Resources International, Inc. A full record of the test is in the Appendix.

The pump was set in the 7-inch diameter boring at 225 feet above sea level, about 32 feet below the water table (see appended diagram). The pumping rate stabilized at 134 gpm, and the maximum stable drawdown was about 1.62 feet. After the pump was turned off, recovery was rapid and completed to the original water table in about two minutes. The aquifer evidently is readily developable. The test was brief, but nevertheless the results indicate the existence of an extensive aquifer. All of the objectives of drilling and testing were met.

V. WATER QUALITY

The quality of the groundwater is superb. Complete chemical analyses performed by Brewer Environmental Services are attached. The salinity is vanishingly small, only 2 mg/l chloride, the result of a high rate of recharge. Typical water temperature is 19°C (66.2°F), although a low of 18.8°C (64.8°F) was measured. The temperature indicates that the major recharge area is centered around an elevation of 2500 feet.

In the lab analysis of September 20, 1991, iron was determined at 0.46 mg/l, which is somewhat high. A recheck on October 8, 1991 showed the iron concentration at 0.13 mg/l, which is satisfactory. The higher reading of September 20, 1991 was probably due to sampling procedure. A check for silica was made on October 1, 1991 with acceptable results. Attached in the Appendix are copies of the lab reports of October 1 and October 9, 1991.

No concentrations of heavy metals approach the minimum levels set by the State and the U.S. EPA. Pesticide and organic residuals were not detected.

VI. CONCLUSIONS

The exploratory well successfully proved the existence of an apparently substantial groundwater resource in a high-level aquifer having a water table 257 feet above sea level. The water is pure and likely can be exploited with high capacity wells,on the order of 1.5 to 3.0 mgd each. More exhaustive pump testing is needed, however, before well field capacities can be assigned. It is already clear, nevertheless, the producing well fields for the Saddle Road project may be located over a wide area in the vicinity of the exploratory well.

High-level groundwater in the Hilo Aquifer System also was encountered in the Piihonua wells (4306-01, 02). These wells are at an elevation of about 1000 feet, approximately three miles from Hilo Bay. It is probable that high-level groundwater starts less than three miles inland of the Bay and reaches all the way across the saddle between Mauna Loa and Mauna Kea to West Hawaii. In South Kohala and North Kona the high-level water has been encountered starting at an elevation of about 1200 feet and extending inland. At Waikii, where the Saddle Road meets Mamalahoa Highway, the water table stands about 1500 feet above sea level. At Waimea, high-level water has also been identified during exploratory drilling.

The high-level aquifers inland of Hilo and extending through the saddle region are undoubtedly voluminous enough to supply the 20 mgd demand of the Saddle Road project. In fact, a much greater supply can be produced. If costs of development and pumping are acceptable, the resource can be relied upon.

APPENDIX

BREWER ENVIRONMENTAL SERVICES
Department of Brewer Environmental Industries
P.O. BOX 552 PAPAIKOU, HAWAII 96781 PHONE: 964-5522 FAX: 964-5309

JOB NO. 5122-A
DATE OCT. 09, 1991
PAGE 1 OF 1

LABORATORY ANALYSIS REPORT (1)

TO: MINK & YUEN ATTN: MR. GEORGE YUEN
ADDRESS: 100 N. BERETANIA STREET, SUITE 303 PHONE:
HONOLULU, HAWAII 96817
SAMPLES OF: WATER
SAMPLED BY: CLIENT SAMPLING DATE: 09/10/91 TIME: 0340
RECEIPT DATE: 09/10/91 TIME: 1000

DATE SAMPLE ANALYZED			10/07-08/91			
TIME SAMPLE ANALYZED						
SAMPLE TYPE						
SAMPLE DESCRIPTION	UNITS		#3			
IRON	mg/l		0.13			

LABORATORY REMARKS: Samples analyzed according to "Methods for Chemical Analysis of Water and Wastes", U.S. Environmental Protection Agency, March, 1979 and/or "Microbiological Methods for Monitoring the Environment", U.S. Environmental Protection Agency, August, 1978.

Jana Malcolm-Brown

BREWER ENVIRONMENTAL SERVICES
a Department of Brewer Environmental Industries
P.O. BOX 552 PAPAIKOU, HAWAII 96781 PHONE: 964-5522 FAX: 964-5309

JOB NO. 5122-A
DATE OCT. 01, 1991
PAGE 1 OF 1

LABORATORY ANALYSIS REPORT (1)

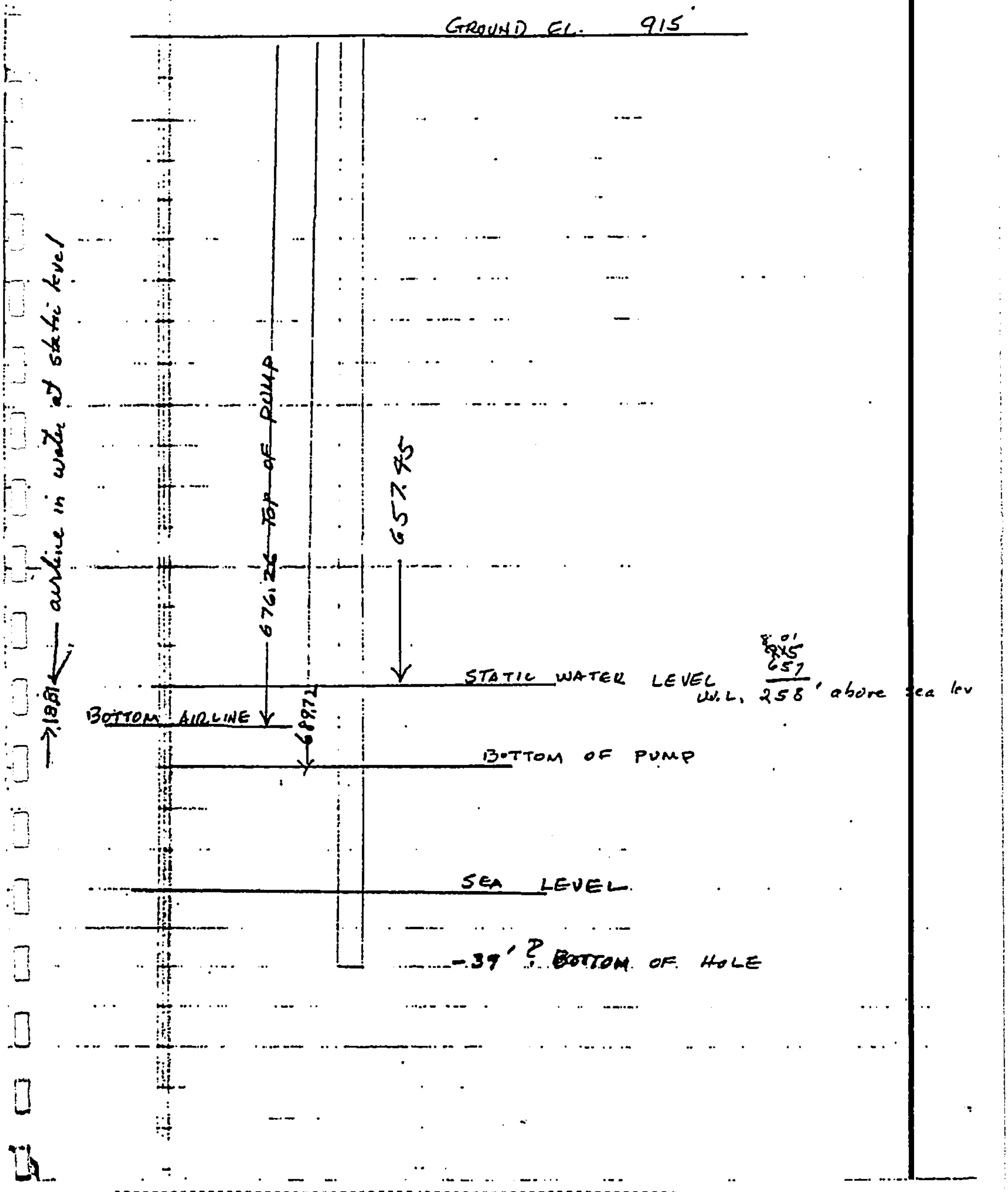
TO: MINK & YUEN ATTN: MR. GEORGE YUEN
ADDRESS: 100 N. BERETANIA STREET, SUITE 303 PHONE: 536-0081
HONOLULU, HAWAII 96817
SAMPLES OF: WATER
SAMPLED BY: CLIENT SAMPLING DATE: 09/10/91 TIME: 0340
RECEIPT DATE: 09/10/91 (09/30/91) TIME: 1000

DATE SAMPLE ANALYZED			09/30/91			
TIME SAMPLE ANALYZED						
SAMPLE TYPE						
SAMPLE DESCRIPTION			#3			
	UNITS					
SILICA	mg/1		43.8			

LABORATORY REMARKS: Samples analyzed according to "Methods for Chemical Analysis of Water and Wastes", U.S. Environmental Protection Agency, March, 1979 and/or "Microbiological Methods for Monitoring the Environment", U.S. Environmental Protection Agency, August, 1978.

Jana Malcolm-Brown

Mr. Fujimoto


GROUND EL. 915'
TOP OF PUMP
676.26
657.75
airline in water at static level
188'
STATIC WATER LEVEL
915
657
W.L. 258' above sea lev
BOTTOM AIRLINE
689.72
BOTTOM OF PUMP
SEA LEVEL
-39' ? BOTTOM OF HOLE

PUMP TEST OKAHARA WELL HILO, HAWAII 9/9 TO 9/10/91

TIME 9/9/91	RATE GPM	AIRLINE PSI	DRAWDN FT.	OBSERVER	REMARKS
3:13p	0	7.95	0	TAKASAKI	PRESSURE GAUGE 0-60 psi SUBDIV: 1 psi
:14	0	7.95	0	"	START PUMP
:16	140	7:10	1.96	"	
:18	–	7:10	1.96	"	
:20	138	7:10	1.96	"	Water temp. 20°C
:25	–	7:10	1.96	"	
:30	135	7:25	1.62	"	Water sample # 1 at 3.
:45	135	7:25	1.62	"	Water temp. 19°C at :
4:00	137	7:25	1.62	"	
:16	135	7:25	1.62	"	
:28	–	–	–	"	Generator kicked off
:30	0	7.95	0	"	
:40	–	–	–	"	Start pump
:45	134	7.25	1.62	"	
5:00	134	7:25	1.62	"	Water temp. 19°C
:30	134	7.25	1.62	"	
6:00	134	7.40	1.27	TAKASAKI	
7:00	134	7.40	1.27	WATER RESOURCES	
8:00	135	7.40	1.27	"	
9:00	135	7.40	1.27	"	
9:40	135	7.40	1.27	"	WATER SAMPLE # 2, TEMP. 19
10:00	134	7.40	1.27	"	
11:00	135	7.40	1.27	"	
12:00	135	7.40	1.27	"	
9/10/91 1:00a	135	7.40	1.27	"	
2:00	135	7.40	1.27	"	
3:00	135	7.40	1.27	"	
3:40	134	7.40	1.27	"	WATER SAMPLE #3, temp 19°.

HILO, HAWAII

TIME 9/10/91	RATE GPM	AIRLINE PSI	DRAWDN FT	OBSERVER	
4:00 am	134	7.40	1.27	WATER RESOURCES	
5:00	134	7.40	1.27	"	
6:00	133	7.30	1.50	"	
7:00	134	7.40	1.27	"	
8:00	134	7.40	1.27	"	
8:12	–	–	–	TAKASAKI	CHANGE PRESSURE GAUGE TEST 0-30 PSI, 0.1 PSI
8:14	–	–	–	"	PUMP OUT, GENERATOR DRAWDOWN IS 7.60-7.49=
:16	0	7.49	.25	"	
:18	0	7.51	.21	"	
:20	0	7.51	.21	"	Needed to boost pressure on gauge
:22	0	7.51	.21	"	
:27	0	7.51	.21	"	
:29	0	7.08	1.20	"	START PUMP
:30	–	7:08	1.20	"	
:31	–	7:00	1.39	"	
:32	134	7:00	1.39	"	
:34	–	7:00	1.39	"	
:35	–	7:00	1.39	"	
:45	133	6.90	1.62	"	
:58	–	6.90	1.62	"	
9:00	134	6.90	1.62	"	
:20	133	6.90	1.62	"	
:40	–	6.90	1.62	"	
10:00	133	6.90	1.62	"	FINAL SAMPLE, TEMP. 18.8 AIR TEMP. 26.C
:30	134	6.92	1.57	"	METER 152,300
11:00	135	6.92	1.57	"	METER 156,100
:30	134	6.94	1.52	WATER RESOURCES	
12:00	134	6.94	1.52		
:30	134	6.92	1.57		Meter 169,400 at 12:37

TIME 9/10/91	RATE GPM	AIRLINE PSI	DRAWDN FT	OBSERVER	
1:00p	134	6.92	1.57	TAKASAKI	Meter 172,400 at 1:01 p Water temp. 18.8°C
:16	—	—	—	"	
:20	134	-		"	
:25	—	6.92	1.57	"	
1:30	0	0		"	STOP PUMP, METER 176,30.
:15	↓	7.08	1.20	"	
:30		7.08	1.20	"	
:45		-	-	"	
31:00		7.12	1.11	"	
:15		7.12	1.11	"	
:30		7.18	.97	"	
:45		7.20	.92	"	
32:00		7.20	.92	"	gauge sluggish needed to boost pressure
:30		7.20	.92	"	
33:00		7.20	.92	"	
:30		7.20	.92	"	
34:00		7.50	.23	"	
:30		7.52	.18	"	
35:00		7.52	.18	"	
36:00		7.60	0	"	
37:00		7.60	0	"	
38:00		7.60	0	"	
39:00		7.60	0	"	
1:40:00		7.60	0	"	
1:42:00		7.60	0	"	
45:00		7.60	0	"	
50:00		7.60	0	"	
2:00:00		7.60	0	"	
2:01		7.95	0	"	

PUMP TEST CONDUCTED BY KIYOSHI TAKASAKI AND CREW OF WATER RESOURCES INTERNATIONAL.

BREWER ENVIRONMENTAL SERVICES
A Department of Brewer Environmental Industries
P.O. BOX 552 PAPAIKOU, HAWAII 96781 PHONE: 964-5522 FAX: 964-5309

JOB NO. 5122
DATE SEPT. 20, 1991
PAGE 1 OF

LABORATORY ANALYSIS REPORT (1)

TO: MINK & YUEN ATTN: MR. GEORGE YUEN
ADDRESS: 100 N. BERETANIA STREET, SUITE 303 PHONE:
HONOLULU, HAWAII 96817
SAMPLES OF: WATER
SAMPLED BY: CLIENT SAMPLING DATE: 09/10/91 TIME: ---
RECEIPT DATE: 09/10/91 TIME: 1000

DATE SAMPLE ANALYZED			09/10-20/91			
TIME SAMPLE ANALYZED						
SAMPLE TYPE						
SAMPLE DESCRIPTION	UNITS		FINAL			
ARSENIC	mg/l		<0.002			
BARIUM	mg/l		<0.1			
CADMIUM	mg/l		<0.005			
CHROMIUM	mg/l		<0.01			
LEAD	mg/l		<0.01			
MERCURY	mg/l		<0.0002			
SELENIUM	mg/l		<0.002			
SILVER	mg/l		<0.01			
FLUORIDE	mg/l		0.24			
NITRATE + NITRITE	mg/l		0.35			
TURBIDITY	NTU		0.75			
COPPER	mg/l		0.02			
IRON	mg/l		0.46			
MANGANESE	mg/l		0.02			
SODIUM	mg/l		9.2			
ZINC	mg/l		0.10			
CHLORIDE	mg/l		1.5			
SULFATE	mg/l		9.7			
TOTAL DISSOLVED SOLIDS	mg/l		119			

LABORATORY REMARKS: Samples analyzed according to "Methods for Chemical Analysis of Water and Wastes", U.S. Environmental Protection Agency, March, 1979 and/or "Microbiological Methods for Monitoring the Environment", U.S. Environmental Protection Agency, August, 1978.

Jana Malcolm-Brown

BREWER ENVIRONMENTAL SERVICES
a Department of Brewer Environmental Industries
P.O. BOX 582 PAPAIKOU, HAWAII 96781 PHONE: 964-5522 FAX: 964-5309

JOB NO. 5122
DATE SEPT. 20, 1991
PAGE 2 OF 4

LABORATORY ANALYSIS REPORT (1)

TO: MINK & YUEN ATTN: GEORGE YUEN
ADDRESS: 100 N. BERETANIA STREET, SUITE 303
HONOLULU, HAWAII 96817 PHONE:
SAMPLES OF: WATER
SAMPLED BY: CLIENT SAMPLING DATE: 09/10/91 TIME: ----
RECEIPT DATE: 09/10/91 TIME: 1000

DATE SAMPLE ANALYZED			09/10-19/91			
TIME SAMPLE ANALYZED						
SAMPLE TYPE						
SAMPLE DESCRIPTION	UNITS		FINAL			
PHOSPHORUS	mg/l		0.13			
COLOR			1			
pH	units		8.6			
ELEC. CONDUCTIVITY	umhos/cm		117			
ALKALINITY	$mgCaCO_3/l$		41			
CALCIUM	mg/l		4.6			
MAGNESIUM	mg/l		3.0			
TOTAL HARDNESS	$mgCaCO_3/l$		24.4			
CORROSIVITY						
LANGLIER'S INDEX			(-)0.20			

LABORATORY REMARKS: Samples analyzed according to "Methods for Chemical Analysis of Water and Wastes", U.S. Environmental Protection Agency, March, 1979 and/or "Microbiological Methods for Monitoring the Environment", U.S. Environmental Protection Agency, August, 1978.

a Department of Brewer Environmental Industries
P.O. BOX 552 PAPAIKOU, HAWAII 96781 PHONE 964-5622 FAX 964-5309

LABORATORY ANALYSIS REPORT (1)

JOB NO. 5122
DATE SEPT. 20, 1991
PAGE 3 OF 4

TO: MINK & YUEN
ATTN: GEORGE YUEN
ADDRESS: 100 N. BERETANIA STREET, SUITE 303
HONOLULU, HAWAII 96817
PHONE:
SAMPLES OF: WATER
SAMPLED BY: CLIENT
SAMPLING DATE: AS NOTED
TIME: AS NOTED
RECEIPT DATE: 09/10/91
TIME: 1000

DATE SAMPLE ANALYZED			09/10-13/91	09/10-13/91	09/10-13/91	
TIME SAMPLE ANALYZED						
SAMPLE TYPE						
SAMPLE DESCRIPTION	UNITS		#1 09/09/91 (1540)	#2 09/09/91 (2140)	#3 09/10/91 (0340)	
CHLORIDES	mg/l		2.0	2.0	1.0	
NITRATES	mg/l		0.32	0.33	0.35	
NITRITES	mg/l		<0.01	<0.01	<0.01	
SULFATES	mg/l		10.5	10.6	10.8	
pH	units		9.1	8.8	8.6	
ALKALINITY	$mgCaCO_3/l$		50	42	41	
TURBIDITY	NTU		2.6	0.75	0.70	

LABORATORY REMARKS: Samples analyzed according to "Methods for Chemical Analysis of Water and Wastes", U.S. Environmental Protection Agency, March, 1979 and/or "Microbiological Methods for Monitoring the Environment", U.S. Environmental Protection Agency, August, 1978.

Lorna Malcolm-Brown

BREWER ENVIRONMENTAL SERVICES
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JOB NO. 5122
DATE SEPT. 17, 1991
PAGE 4 OF 4

LABORATORY ANALYSIS REPORT (1)

TO: MINK & YUEN ATTN: GEORGE YUEN
ADDRESS: 100 N. BERETANIA STREET, SUITE 303
HONOLULU, HAWAII 96817 PHONE:
SAMPLES OF: WATER
SAMPLED BY: CLIENT SAMPLING DATE: 09/10/91 TIME: ---
RECEIPT DATE: 09/10/91 TIME:

DATE SAMPLE ANALYZED			09/11-17/91			
TIME SAMPLE ANALYZED						
SAMPLE TYPE						
SAMPLE DESCRIPTION	UNITS		FINAL			
ENDRIN	mg/l		<0.00002			
LINDANE	mg/l		<0.00002			
METHOXYCHLOR	mg/l		<0.0001			
TOXAPHENE	mg/l		<0.0005			
2,4,-D	mg/l		<0.005			
2,4,5-TP (Silvex)	mg/l		<0.001			
BENZENE	mg/l		<0.001			
CARBON TETRACHLORIDE	mg/l		<0.001			
1,2-DICHLOROETHANE	mg/l		<0.001			
para-DICHLOROBENZENE	mg/l		<0.001			
TRICHLOROETHYLENE	mg/l		<0.001			
1.1-DICHLOROETHYLENE	mg/l		<0.001			
1,1,1-TRICHLOROETHANE	mg/l		<0.001			
VINYL CHLORIDE	mg/l		<0.001			

LABORATORY REMARKS: Samples analyzed according to "Methods for Chemical Analysis of Water and Wastes", U.S. Environmental Protection Agency, March, 1979 and/or "Microbiological Methods for Monitoring the Environment", U.S. Environmental Protection Agency, August, 1978.

Jana Malcolm-Brown

Appendix B

JOB NO. 22-HW-J

WATER DEVELOPMENT AND TRANSMISSION, ISLAND OF HAWAII

PHASE II

INTERIM PIPELINE ENGINEERING REPORT

prepared by

Okahara and Associates, Inc.

Hilo, Hawaii

EXECUTIVE SUMMARY

The purpose of this report was to determine a conceptual plan for developing 20 million gallons of water daily from resources on the east side of the Island of Hawaii and transmitting the water to the Pohakuloa Training Area. System demand evaluation indicated that approximately two million gallons per day (mgd) can be used in the Pohakuloa area. A later phase of the water transmission project, which was not evaluated in this work, would transmit the remaining water to the Waimea, Kawaihae, Hapuna area. This follow on evaluation work is required to specifically identify the potential end users and system terminal sites and to determine system costs of delivery for the total 20 mgd. In connection with the identification of the potential end users, a report is currently being prepared by the University of Hawaii, College of Tropical Agriculture that will specifically identify commercial crops and water demands.

The water resource site was selected in the Waiakea-Uka area of Hilo at an elevation of 830 feet, and is depicted in Figure 1. Nine vertical deep wells would be drilled for submersible pumps, each with a capacity of 2.5 mgd. Of the nine deep well pumps, eight would operate simultaneously, producing a total of 20 mgd. The ninth well would be a standby for system reliability.

All of the deep well water would be piped to a common receiving tank at the well field site. Two booster pumps, each rated at 10 mgd, draw water from the tank and pump the water into the transmission pipeline to the Saddle Road area. A third booster pump, identical to the other two, will be in place as a standby unit. The three pumps and the tank basically comprise the first of eight booster pumping stations located along the transmission pipeline to lift the water vertically a total of 5,790 feet. Each booster pump station will require approximately 2 acres.

The total length of the 42-inch diameter steel transmission pipeline is 38.4 miles. In gross terms, it follows an almost straight route from the well field site to the Pohakuloa Training Area. All transmission piping will be buried, with allowance for additional parallel pipelines for future expansion of the project. Clear cutting of vegetation for the pipeline alignment can vary in width from 40 to 100 feet. The required width will depend on the availability of existing service roads and the topography of the area.

The first 7.3 miles of piping traverses wooded areas that breaks out at the intersection with Saddle Road. From this junction, the pipeline parallels the Saddle Road for the next 24.2 miles to a head tank, remaining within a 100 foot alignment of the road centerline.

A 16-inch diameter branch line will connect the tank at Pump Station No. 2 with the County Department of Water Supply (DWS) system Wilder Road Tank. Upgrading the distribution piping from this DWS tank, which is not part of this project, will allow substantial emergency use of water from this project. An alternative tie-in at the Pump Station No. 1 tank could allow emergency water use to reach other parts of the DWS system.

Water transmission from the head tank located at the Saddle crest (elevation 6,620 feet) will continue 6.5 miles by gravity pipeline towards PTA, again in an alignment parallel to Saddle Road. It would finally leave the Saddle Road alignment south of the Mauna Kea State Park and terminate near a 20 MG open reservoir (elevation 6,380 feet) which will be constructed as part of this project. Branch lines would service the non-potable water open reservoir and the potable water tanks at the PTA base camp. Other water users in the area can obtain water directly from the head tank at the Saddle crest or anywhere along the gravity pipeline to PTA.

An administration/control/maintenance facility will be erected as part of Pump Station No. 1 at the well field site and all system control and monitoring is expected to channel from this facility. System administration and maintenance will also be conducted at this building.

Another feature of the pipeline will be pressure taps spaced at approximately 300 foot intervals along the route for fire fighting and lava diversion contingencies. Virtually the entire route is situated on the Mauna Loa lava flows and as such, are subject to potential future lava inundation. Design for an underground pipeline should preclude lava damage to the transmission line. A contingency plan is being recommended at each pump station that must depend on rapid mobilization and construction of earthen lava diversion barriers, and backed up by application of water to cool lava flow surfaces that may threaten to crest the diversion levees. The concept here is to divert lava only around the installation and not to redirect the entire lava flow in a continuing tangency. The tort question of major lava flow diversion was not addressed in this report.

The system is expected to require 30 MW of continuous power, nearly equal to the current Helco base load demand. All power is expected to be obtained from the new Helco power transmission line that will be energized at 138 kV prior to construction on this project. Annual energy consumption is calculated to be 255 million kWh or over 40% of the entire 1988 Helco demand. Obviously a careful utility system planning study must be carried out to integrate this power demand into the Helco system.

A separate bound set of conceptual engineering drawings is also included as part of this submittal. These 58 drawings depict, in greater detail, the construction features of the recommended system.

Initial capital cost of the project is expected to be $164 million. Life cycle cost evaluation determined that the major contributors to the cost of water is the debt service and energy costs. "Other Operating and Maintenance Costs" were relatively small compared to the two major factors.

The primary driving force of debt service, besides capital repayment, is the interest rate. The energy price based on the current Helco rate structure was calculated to be 6.26 cents/kWh. On the other hand, there is ample reason to believe that this unit purchase price can be negotiated downwards because of a number of influences, among which is an ideal type demand and the possibility of large scale geothermal development.

A matrix of life cycle project costs was developed based on varying interest rates and energy costs. Within that matrix a maximum water cost of $5.70 per 1000 gallons for 12% interest and 7 cents/kWh energy to a low of $1.07 per 1000 gallons for no debt repayment at 2 cents/kWh energy was calculated. Tables 1 and 2 represent this relationship in total annualized cost and unit cost.

It is not the intent or scope of this work to determine a specific target price for water. Some users may place high values to water delivery and a rate study may be needed to determine an equitable target water fee. Further investigation is also needed to narrow the matrix of Tables 1 and 2 and more clearly establish whether or how system costs can meet the "target equitable water fee".

The system is assumed to be operated by an authority created by the State legislature and administratively attached to a department of the State of Hawaii. In part, it would have powers to do the following.

- Condemnation
- Issue bonds
- Own and operate facilities
- Issue contracts
- Purchase and sell water

Seven to eleven years is expected to be required to have a functioning system, depending on how optimistic design and construction funding are projected. In any case, even with a conservative funding approach, the system can technically be expected to be functional by the year 2000.

Table 1

Annualized System Costs[1,2]

Interest Rate (%)	Unit Energy Cost (cents/kWh) 7.0	6.269	6.0	5.0	4.0	3.0	2.0
12	40,332	38,468	37,783	35,234	32,684	30,135	27,586
10	37,219	35,355	34,670	32,121	29,571	27,022	24,473
8	34,194	32,330	31,645	29,096	26,546	23,997	21,448
6	31,312	29,448	28,763	26,214	23,664	21,115	18,566
4	28,654	26,790	26,105	23,556	21,006	18,457	15,908
2	26,320	24,456	23,771	21,222	18,672	16,123	13,574
0	24,408	22,544	21,859	19,310	16,760	14,211	11,662
No Repayment, of Capital & Interest	20,303	18,439	17,754	15,205	12,655	10,106	7,557

Notes:

1. Cost in ($ x 10^6)
2. Annual "Other O&M Costs" of $2,459,000 included in each cell of matrix

Table 2

Annualized System Costs[1,2]

Interest Rate (%)	Unit Energy Cost (cents/kWh) 7.0	6.269	6.0	5.0	4.0	3.0	2.0
12	5.70	5.43	5.34	4.98	4.62	4.26	3.90
10	5.26	4.99	4.90	4.54	4.18	3.82	3.46
8	4.83	4.57	4.47	4.11	3.75	3.39	3.03
6	4.42	4.16	4.06	3.71	3.34	2.98	2.63
4	4.04	3.78	3.68	3.33	2.96	2.60	2.25 2.07
2	3.71	3.45	3.35	2.99	2.63	2.27 2.00	1.92 1.74
0	3.44 2.81	3.18 2.62	3.08 2.54	2.72 2.27	2.36 2.00	2.00 1.73	1.65 1.47
No Repayment of Capital & Interest	2.87 2.24	2.60 2.04	2.51 1.97	2.15 1.79	1.79 1.43	1.43 1.16	1.07 0.89

Notes:

1. Cost in ($/1,000 gallons)

2. Annual "Other O&M Costs" of $0.35/1,000 gallons included in each cell of matrix

Electricity Cost	2.52	2.25	2.14	1.80	1.44	1.08	0.72
25% Electricity Cost	0.63	0.56	0.54	0.45	0.36	0.27	0.18
Grant w/ 25% Electricity Recovery	2.24	2.04	1.97	1.79	1.43	1.16	0.89

EXECUTIVE SUMMARY

Phase II of the Water Development & Transmission project involves the continuation of the 42-inch water pipeline from the vicinity of the Pohakuloa Military Training Area (PTA) via gravity flow to a 140 million gallon reservoir terminal site in the agricultural plain southeast of the town of Waimea on the Island of Hawaii. This water is proposed to be used for the expansion of intensive agricultural activities in the drought-prone but otherwise prime agricultural District of South Kohala. In addition, Phase II will produce 4,700 kW of electrical power by introduction of hydro-generation and also will provide separate emergency backup systems for the County Domestic Water Supply System in Waimea as well as the existing State Irrigation System serving the present farming community.

This report is to follow-on a conceptual plan to develop 20 million gallons daily (mgd) of water from resources on the east side of the Island of Hawaii, and to transmit the water via PTA. A revised demand evaluation indicates that approximately 5 mgd will be used in PTA. The balance will be used for electrical power generation and to serve other downstream irrigation needs in accordance with the "Water demands Distribution" contained in Section III of this report, and recommendations in the report entitled, "Assessment of Agricultural Industry Development in the South Kohala Region of West Hawaii", produced in March, 1991.

The South Kohala District contains a majority of the Island of Hawaii's Agricultural Lands of Importance to the State of Hawaii (ALISH), either unused, or in minimal pasture use because of limitations in the existing water systems. Parker Ranch and the Department of Hawaiian Homes Lands (DHHL) beneficiaries are the principal landowners affected, although numerous farmers are served by the state irrigation system and will be indirectly affected as well. The relatively dry Waimea area is one of the fastest growth areas in Hawaii County and has experienced increasing water demand fueled by the growth in both agricultural and tourist-related industries. It is subject to extreme drought conditions due to weather variations. In years past, major losses in both crops and livestock have cost the farmers untold millions of dollars.

A dependable irrigation system will make possible the intensive farming of an additional 3,200 net acres of a potential 28,000 acres of prime agricultural land in the Waimea plain. The initial water requirements to support some 3,200 acres of land exceeds 10 mgd and will increase proportionately with additional acreage of truck or orchard crop plantings under irrigation.

Phase I covers 8 pump stations which transmit 20 mgd of water continuously in a 24-hour operation through transmission piping to a 20 mg storage reservoir and head tank at the Humuula Saddle area. Pohakuloa Training Area and the Mauna Kea State Park will consume approximately 5 mgd and the balance of 15 mgd of water will then be caused to flow by gravity to the terminal reservoir southeast of Waimea after generating a maximum capacity of 4,700 kW of electrical power at two power stations.

Phase II begins downstream of the 20 mg Saddle Reservoir and from the junction of the main 42-inch diameter pipe and the take-off to the PTA storage facilities. Project costs including pipeline, power stations, pump stations, access road, substations, power lines and other support construction requirements are estimated to be $91 million. The total project cost including Phases I and II is estimated to be $275 million. The subsequent cost of water is expected to range from $1.33 to $8.15 per thousand gallons of water, depending on economic assumptions used. The time frame for the complete development and construction of the transmission system is through the end of 1999.

Future Saddle Road realignment is anticipated in PTA between the 30 and 43 mile markers (13 miles). Funding commitments by the Federal Government for the road improvement presently is $5.35 million and may be increased due to the realignment. However, plans for the road realignments are not available at the time of this writing. System design modifications can be made if mutual benefits can be derived by the new routing when that information becomes available.

The system is expected to require up to 30 mW of nearly continuous power by the year 2007 as the system is used and expanded. All power is expected to be obtained from the new HELCO 69 kV power transmission lines. The recommended system will regenerate to the HELCO grid 4.7 mW of power and reduce the net requirement to approximately 25 mW. The water transmission system may be subject to an interruptable schedule, however, to avoid excessive peak loading on the HELCO system.

Electrical power is produced by the differential in feet of head between the head tank located at elevation 6,620 feet in the Humuula Saddle area of the Big Island and the terminal reservoir at elevation 4,150 feet, southeast of the town of Waimea. Approximately 15 of the 20 mgd of water pumped to the head tank from Hilo in Phase I will be utilized for hydro-electric power production and the Waimea irrigation project. The water will flow by gravity and pass through specially designed hydro-generator turbines to produce the electrical power that will enter the HELCO system via the Waikii substation. The water transmission system will be comprised of predominantly 42 and 32 - inch diameter steel pipe placed below ground level. Refer to G-1 Phase II, Recommended system.

The recommended route, Alternative A, takes a shorter more direct piping route, by deviating northerly from the Saddle Road at approximately the 5,400 feet contour, then running mainly through the private lands of Parker Ranch to the terminal reservoir. The first power station is 16.6 miles from the head tank and located at elevation 5,370 feet. The water will flow from the first power station to the terminal reservoir through the second power station at elevation 4,240 feet.

The electrical power generated will be 2,400 kW in the first power station and 2,300 kW in the second for a combined total of 4,700 kW. The total static head is

2,398 feet. The water used for power generation at the No. 1 power station then flows into the 0.5 mg water reservoir located immediately below it and continues to the second power station through 3.5 miles of piping route. The static head between the reservoir and No. 2 power station is 1,120 feet. The No. 2 power station discharge flows into a 0.5 mg reservoir and then proceeds to the terminal reservoir at elevation 4,150 feet (full level) through 3.4 miles of water transmission pipe. A control valve mounted just before the open reservoir reduces the energy caused by a head difference of 80 feet within the route.

Due to the complexity of the electrical system requirements, close communications shall continue throughout all phases of this project with HELCO staff engineers. Formal agreements shall be developed with HELCO and HECO officials regarding technical matters, i.e., electric power system analysis, system protection and total project schedules for power source arrangement as well as costs for receiving and dispatching power.

The complete combined system including the 8 deepwell pump stations of Phase I, and two power stations of Phase II, is designed to start up, operate and stop sequentially within the same piping route.

The operations of each pump, turbine-generator and associated water flow component, will be goverened by the control of water levels in both the preceding and succeeding 0.5 mg reservoir tanks. The control system of each pump station consists of a pump-pipeline-reservoir combination. Each station will be controlled independently of other stations. A pump station will start automatically when water level at the station reservoir exceeds a preset minimum. Water will then be pumped to the next station's reservoir. The wound-rotor motor pump drive control allows a small speed variation of plus or minus 10 percent (±10%). Each independent control loop can therefore be fine-tuned by this speed adjustment to maintain stable water tank levels.

The power stations will also automatically start up and operate when the upstream reservoir level reaches a preset point. The first power station will start to generate electrical power when the head tank reaches its preset level. Finally, the downstream power station will start to generate power when the upstream 0.5 mg reservoir reaches its preset level.

System supervision will be maintained by a central supervisory control panel within the administrative/control/maintenance facility located in Hilo at the well field site. The control room in the administration building will completely control each pump station in Phase I as well as monitor and control the power stations in Phase II. All data transmission and control signals will be conveyed via optical fiber cable between the central control panel and all operating stations.

"Assessment of Agricultural Industry Development in West Hawaii" states: "In conclusion, the Water Development & Transmission Project can provide a potentially viable water source to the Waimea region, which would otherwise not be available.

While the water costs of the system would be greater than that presently available in the Waimea region, there are candidate crops which can potentially support the contemplated water prices provided other costs can be maintained at reasonable levels."

Finally, the viability of conducting water to the Waimea irrigation project, selected crops for market, electrical power generation, domestic and irrigation backup systems, can stabilize the economic future of the District of South Kohala. The system can be expanded to accommodate the needs of both the private and public sectors and concurrently serve the needs of agriculture and urban growth.

No assessment or property value determinations have been made regarding private, federal, state, county, or DHHL lands which may be affected by this project. It is anticipated that route alignments, site locations, access roads, easements and rights-of-way approvals may be subject to slight modifications from the plan to implementation phase and will require separate agreements with each of the parties concerned.

We wish to thank the many individuals and agencies of the public and private sector for their time and valuable suggestions which have been incorporated and have made this technical report more complete. We could not have properly presented this complex and comprehensive report without their assistance.

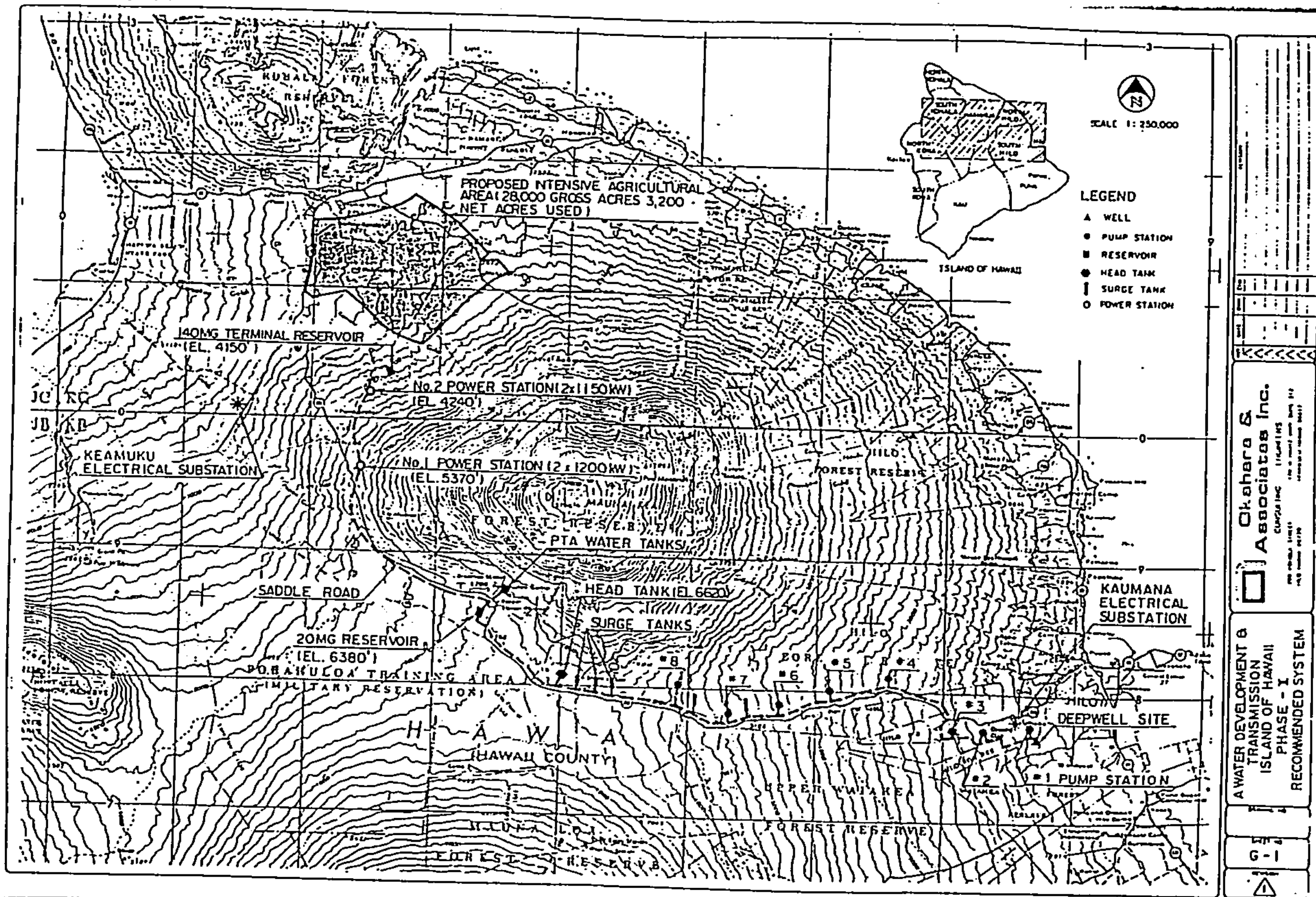
PROPOSED INTENSIVE AGRICULTURAL AREA (28,000 GROSS ACRES 3,200 NET ACRES USED)
140MG TERMINAL RESERVOIR (EL. 4150')
No.2 POWER STATION (2 x 1150 kW) (EL. 4240')
KEAMUKU ELECTRICAL SUBSTATION
No.1 POWER STATION (2 x 1200 kW) (EL. 5370')
PTA WATER TANKS
SADDLE ROAD
HEAD TANK (EL. 6620')
SURGE TANKS
20MG RESERVOIR (EL. 6380')
POHAKULOA TRAINING AREA (MILITARY RESERVATION)
HAWAII COUNTY
KAUMANA ELECTRICAL SUBSTATION
DEEPWELL SITE
#1 PUMP STATION
HILO
FOREST RESERVE
ISLAND OF HAWAII
SCALE 1:250,000
LEGEND
WELL
PUMP STATION
RESERVOIR
HEAD TANK
SURGE TANK
POWER STATION
Okahara & Associates Inc.
A WATER DEVELOPMENT & TRANSMISSION ISLAND OF HAWAII PHASE - I RECOMMENDED SYSTEM
G-1

TABLE 2-1

CONSTRUCTION COST FOR PHASE I WORKS

DESCRIPTION		CONSTRUCTION COST ORIGINAL	CONSTRUCTION COST REVISED
1.	DEEPWELL		
	Deep Well	11,700,000.00	11,700,000.00
	Electrical Equipment	910,000.00	910,000.00
	SUB TOTAL	$ 12,610,000.00	$ 12,610,000.00
2.	BOOSTER PUMP STATION		
	Civil Works	19,664,000.00	16,664,000.00
	Mechanical Equipment	13,920,000.00	13,920,000.00
	Electrical Equipment	10,264,000.00	10,290,000.00
	Standby Generator	8,000,000.00	8,000,000.00
	SUB TOTAL	$ 51,848,000.00	$ 51,874,000.00
3.	TRANSMISSION PIPELINE		
	No. 9 Pipeline	80,979,800.00	80,979,800.00
	SUB TOTAL	$ 80,979,800.00	$ 80,979,800.00
4.	SUBSTATION		
	138 kV Substation	2,151,000.00	0.00
	69 kV Substation	0.00	2,400,000.00
	12.46 kV Switch Gear	1,092,000.00	0.00
	Switching Station	0.00	2,000,000.00
	SUB TOTAL	$ 3,243,000.00	$ 4,400,000.00
5.	TRANSMISSION LINE		
	138 kV Line	46,000.00	0.00
	69 kV Line	0.00	450,000.00
	SUB TOTAL	$ 46,000.00	$ 450,000.00
6.	DISTRIBUTION LINE		
	Distribution Line	1,527,200.00	1,540,000.00
	Switch Gear	0.00	1,100,000.00
	SUB TOTAL	$ 1,527,200.00	2,640,000.00
7.	TELECOMMUNICATION	$ 3,470,000.00	$ 3,470,000.00

8.	0.5 MG. STORAGE TANK	$ 3,480,000.00	$ 3,480,000.00
9.	SURGE TANK	$ 378,000.00	$ 378,000.00
10.	HEAD TANK	$ 477,000.00	$ 477,000.00
11.	20 MG SADDLE RESERVOIR	$ 1,650,000.00	$ 1,650,000.00
12.	ACCESS AND SERVICE ROAD	$ 4,233,000.00	$ 4,233,000.00
	CONSTRUCTION COST	**$ 163,942,000.00**	**$ 166,641,800.00**
	OTHER COSTS		$ 16,664,200.00
	PROJECT COST	**$ 163,942,000.00**	**$ 183,306,000.00**

TABLE 9-1

PROJECT COST

RECOMMENDED SYSTEM (With Power Generation)
Total length of pipeline: 89,875 ft. (17.02 miles)

ITEM	QUANTITIES	UNIT	UNIT COST	TOTAL COST
1. TRANSMISSION PIPELINE				
Transmission Pipeline		LS		32,561,000
2. POWER STATION				
Civil Works	2	Station	1,227,000	2,454,000
Mechanical Equipment	2	Station	2,460,000	4,920,000
Electrical Equipment	2	Station	2,135,000	4,270,000
Sub Total				11,644,000
3. SUBSTATION				
No. 1 & 2 Power Station	2	Station	110,000	220,000
Saddle Reservoir	1	Station	47,000	47,000
Terminal Reservoir	1	Station	50,000	50,000
New Waikii S.S.	1	Station	315,000	315,000
Sub Total				632,000
4. DISTRIBUTION LINE				
12.46 kV Line	17.2	Miles	66,800	1,148,960
5. EMERGENCY WATER DISTRIBUTION PIPELINE				
Irrigation Pipiline	L= 58,000'	LS		9,175,000
Potable Water Pipeline	L= 53,000'	LS		5,887,000
Sub Total				15,062,000
6. ACCESS ROAD & SERVICE ROAD				
Access Road	17,500	Ft.	140	2,450,000
Service Road	37,870	Ft.	55	2,082,850
Sub Total				4,532,850
7. TELECOMMUNICATION SYSTEM		LS		1,338,000
8. 0.5 MG RESERVOIR	2	Units	435,000	870,000

9. 140 MG TERMINAL RESERVOIR	LS	14,699,000
10. WATER TREATMENT FACILITY	LS	451,190

TOTAL CONSTRUCTION COST (1-10) .... $ 82,939,000

OTHER COSTS .... $ 8,294,000

PROJECT COST $ 91,233,000

Appendix C

Assessment of Agricultural Industry Development In The South Kohala Region of West Hawaii

Water Development and Transmission
Island of Hawaii

Job No. 22-HW-J

Prepared by
Okahara & Associates, Inc.
200 Kohola Street
Hilo, Hawaii

State of Hawaii
Department of Land & Natural Resources
Division of Water Management
Honolulu, Hawaii

March 1991

EXECUTIVE SUMMARY

E.1 PROJECT BACKGROUND AND RATIONALE

The island of Hawaii has an abundance of undeveloped water supply sources, however, the distribution of these sources is uneven. The relatively dry West Hawaii region of the island of Hawaii has experienced increasing water demand, fueled by the growth in agricultural and tourism-related industries. However, continued development of this region will almost surely be constrained by the water resources of the region. At the same time, East Hawaii has an excess of water resources.

In order to assess the feasibility of balancing of these regional differences in supply and demand, the State of Hawaii through its Department of Land and Natural Resources, has initiated a major planning effort. Phase I of this project, the Water Development and Transmission Study, was conducted in 1990 to develop a conceptual plan and preliminary cost estimate for developing and delivering 20 million gallons per day of water from wells drilled in the eastern water-rich section of the island of Hawaii to an intermediate terminus at Pohakuloa.

Part of Phase II of this study, and the subject of this report, is to assess the potential feasibility of utilizing that water for agricultural purposes in West Hawaii. More specifically, the study considers potential agricultural activities with the South Kohala District, which contains a majority of the island of Hawaii's ALISH lands, or Agricultural Lands of Importance to the State of Hawaii, much of which are unused or are in minimal pasture use, because of limitations in the existing water systems.

Transmission of the water to the South Kohala area will increase agricultural development options for the region. This is significant because of State's policy objective of agricultural self-sufficiency, particularly in those products in which Hawaii farmers may have a comparative advantage. At the same time, any recommended crops must be able to support the projected water costs. Consequently, a major part of this study is not just to identify potential crops, but to assess each crop's sensitivity to different water rates and their impacts on total production costs and profit levels.

In recognition of the importance of measuring the benefits of the water development and transmission project, this study identifies and assesses the agriculturally related benefits of water development. It proceeded in the following manner:

- Identification and description of the general target area, including physical and climatic conditions, agricultural capacity, land ownership patterns and zoning regulations, existing water systems, and regional economic conditions. (Chapter 2)
- Identification and assessment of the market potential for candidate crops, selected on the basis of import substitution (intra state sale) and export potential. (Chapter 3)
- Identification of specific areas within the general target area suitable, in terms of physical requirements, for candidate crops. (Chapter 3)
- Assessment of production costs for each of the candidate crops and identification of economic viability. (Chapter 3)
- Assessment of sensitivity to variation in water costs and determination of break-even water costs. (Chapter 3)
- Identification of public and private land use planning constraints on agricultural development. (Chapter 3)
- Selection of viable crops and assessment of output impacts in terms of additional land and water use. (Chapter 4)
- Assessment of the potential macroeconomic impacts of large scale agricultural development. (Chapter 5)
- Preliminary environmental sensitivity assessment of agricultural development within the project area. (Chapter 6)

E.2 PROJECT SITE SELECTION

All of West Hawaii, which extends from North Kohala to South Point was reviewed for potential agriculture development. However, very early on in the study, the area of investigation was reduced to the vicinity of South Kohala based on its proximity to the proposed intermediate pipeline terminus at Pohakuloa and the amount and extent of prime agricultural lands as identified by ALISH.

The preliminary study area is in South Kohala (Figure E.1) in the northern portion of the island of Hawaii. The area includes approximately 138,000 acres, an area one-third the size of Oahu. It extends mauka from the Queen Kaahumanu Highway across the Waimea plain and is bounded on the north at the 4000 foot level in the Kohala mountains, on the east at the 4000 foot level on Mauna Kea, on the South by the district boundaries between Hamakua and North Kona and South Kohala. A portion of the western boundary follows the Waikoloa Development Co. property boundary, primarily to avoid potential lava inundation areas.

The project site encompasses a variety of land resources in terms of climatic conditions, soil characteristics, and elevation. For this reason a wide range of both tropical and temperate crops can be considered for potential development.

Four communities, Waimea, Waikoloa, Kawaihae, and Honokaa bound the perimeter of the project site. Waimea, located 55 miles north of Hilo with population of 6,500, is transforming from a rural farming and ranching community to the major commercial/industrial center of South Kohala. Waikoloa, located 15 miles south west of Waimea town, is a relatively new community of 1,200 people. Some ranching activities are located there, but it is basically a bedroom community for the South Kohala tourism based economy. Kawaihae is a small but rapidly growing commercial and industrial center 10 miles southwest of Waimea town. Kawaihae harbor provides shipping for both import and export of goods for the west portion of the island. The bulk of future agricultural products from Waimea are expected to be shipped out of this harbor. Honokaa town is located 15 miles southeast of Waimea town and has served as a center of sugar, ranching and macadamia nut activities for the past several decades. It also serves as a bedroom community for many of the workers employed by the resort hotels in South Kohala and North Kona areas.

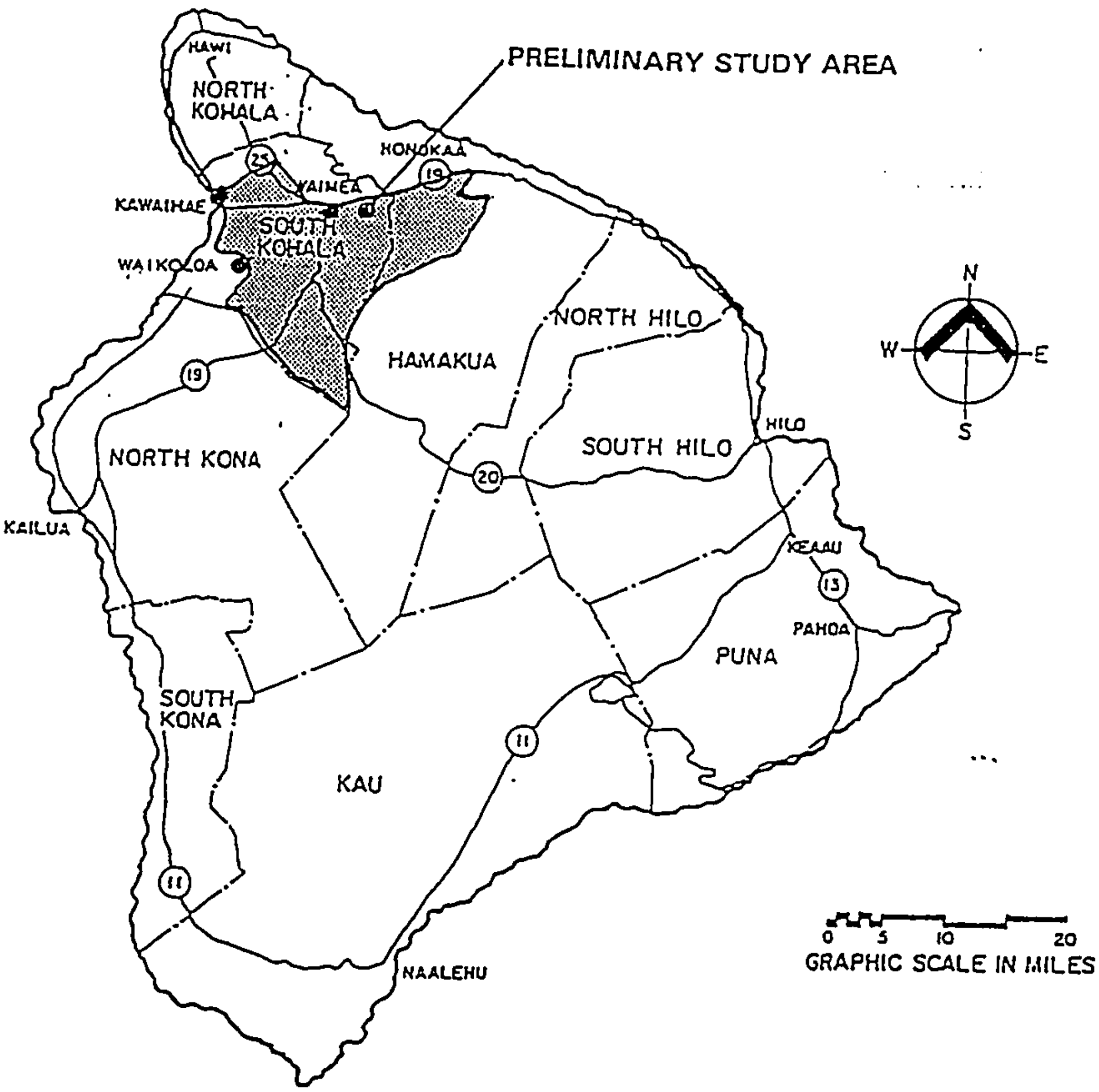

FIGURE E.1 - PRELIMINARY STUDY AREA

E.3 MAJOR FINDINGS OF THE ASSESSMENT OF AGRICULTURAL DEVELOPMENT

Phase I of the Water Transmission and Development Study provided a conceptual plan and preliminary cost estimate for developing and delivering 20 million gallons per day of water from East Hawaii to an intermediate terminus point at Pohakuloa.

Based on the conceptual plan, a matrix of life cycle project costs was developed based on varying interest rates and energy costs. Within that matrix a maximum water cost of $5.70 per 1,000 gallons for 12% interest and 7 cents/Kwh energy to a low of $1.07 per 1,000 gallons for no debt repayment at 2 cents/Kwh energy was calculated. Table E.1 summarizes the relationship between total annualized cost and unit cost per thousand gallons of water.

TABLE E.1

ANNUALIZED SYSTEM COSTS (1,2)

Interest Rate (%)	Unit Energy Cost (cents/kWh) 7.0	6.27	6.0	5.0	4.0	3.0	2.0
12	5.70	5.43	5.34	4.98	4.62	4.26	3.90
10	5.26	4.99	4.90	4.54	4.18	3.82	3.46
8	4.83	4.57	4.47	4.11	3.75	3.39	3.03
6	4.42	4.16	4.06	3.71	3.34	2.98	2.63
4	4.04	3.78	3.68	3.33	2.96	2.60	2.25
2	3.71	3.45	3.35	2.99	2.63	2.27	1.92
0	3.44	3.18	3.08	2.72	2.36	2.00	1.65
No Repayment, of Capital & Interest	2.87	2.60	2.51	2.15	1.79	1.43	1.07

Notes : 1. Cost in ($/1,000 gallons)
2. Annual "Other O & M Costs" of $0.35/1,000 gallons included in each cell of matrix

Source: Phase I, Water Development and Transmission, Island of Hawaii, Okahara & Associates, 1990.

Phase II of the Water Transmission and Development Project, which is the subject of this report, assessed the potential feasibility of utilizing this water for agricultural activities within the South Kohala District. The following is a summary of the major findings of this study.

There are a number of crops that can be competitively grown either for export purposes or for import substitution in the West Hawaii of the County of Hawaii, particularly vegetable and root crops and temperate orchard crops.

Within the Study area, as shown in Figure E.2, there are over 27,000 acres of land including 20,000 acres designated as "Prime Land when Irrigated" according to ALISH. These lands, which are under the control of Parker Ranch and the Department of Hawaiian Home Lands, satisfy the various growing conditions of the potential crops in terms of soil type, solar insolation, elevation, climatic conditions and so on.

Based on the potential market for export or for import substitution, as of 1988, the volume of crop that can be supported is approximately 5,300 gross acres or 3,020 net acres of land.

By the year 2007, an estimated 9,320 gross acres or 5,315 net acres of land are needed to accommodate the potential demand for these agricultural products.

The initial water requirements to support the 1988 estimated potential increase in agricultural demand is 10.3 million gallons of water per day. This will increase to a potential demand for 18 million gallons per day in 2007.

The cost of any new agricultural water is likely to be much higher than what farmers currently pay. The project water cost delivered at the terminal point in the Waimea region by the WT&D project ranges from a low of $1.07 per thousand gallons to a high of $5.70 per thousand gallons.

Of these potential crops, there are a number with sufficient value to support potential significant increases in water costs, provided that farm infrastructure, adequate labor supply, capital and land acquisitions at reasonable prices are assured. These crops are identified in Table E.2.

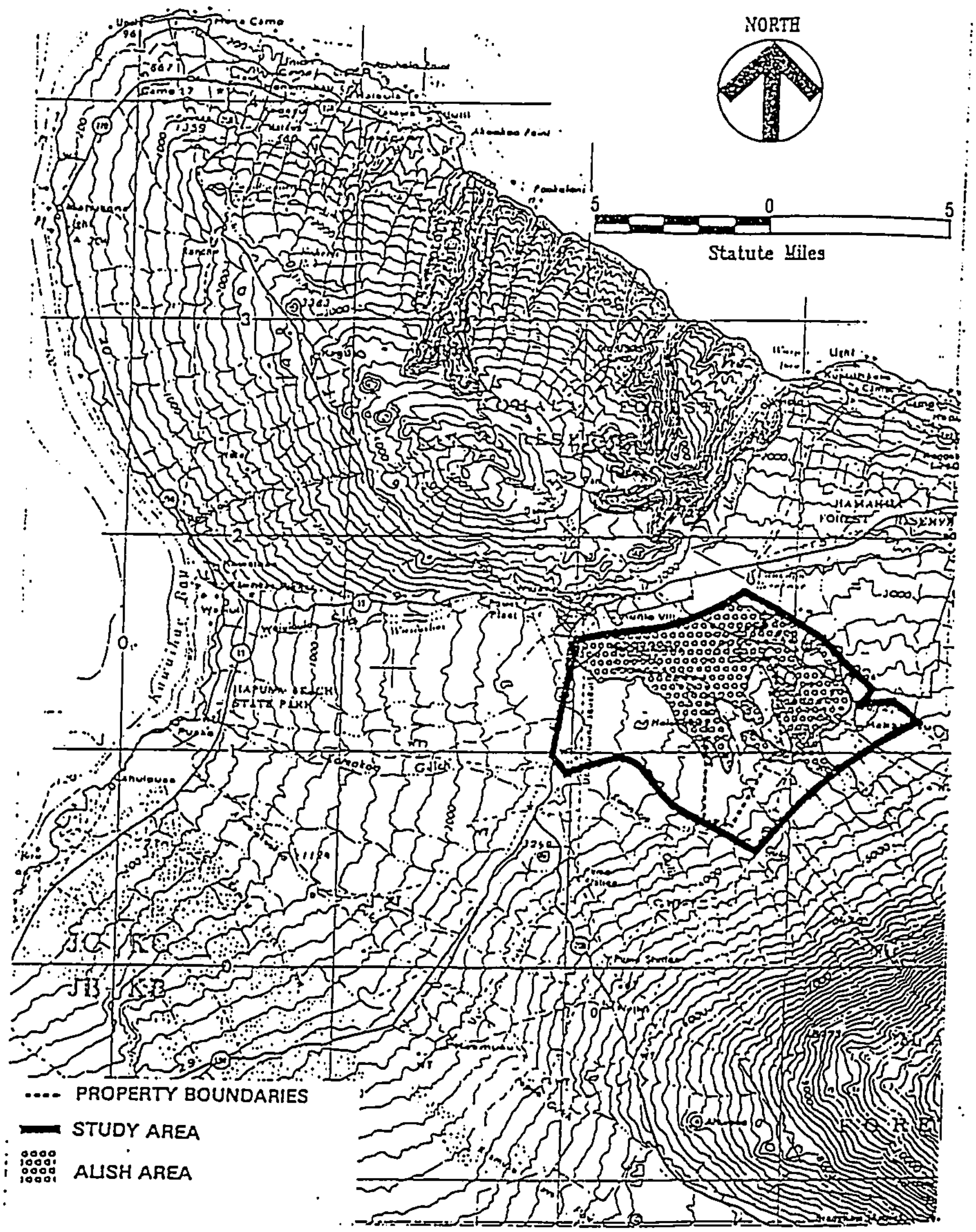

FIGURE E.2 - REVISED STUDY AREA WITH ALISH DESIGNATION

TABLE E.2

LIST OF RECOMMENDED CROPS, ITS IMPORT REPLACEMENT AND EXPORT POTENTIALS, QUANTITY OF PRODUCTION, AND REQUIRED ACREAGE, year 2007

Crops	Import Replacement(%)	Quantity (000 lbs.)	Required Acreage	Required Water (MGD)
Temperate Orchards				
Apples	30 %	7,714	289	0.856
Grapes	10 %	4,383	438	1.696
Persimmons	100 %	701	26	0.102
Sub Total		12,798	753	2.654
Vegetable/Leafy Group				
Head Lettuce	85 %	28,507	1,592	1.268
Romaine	85 %	3,832	275	0.219
Dry Onions	85 %	27,554	2,297	3.316
Green Pepper	85 %	3,548	177	0.270
Potatoes	85 %	63,743	3,580	5.168
Tomato	85 %	28,307	701	0.391
Sub Total		155,492	8,622	10.632
Correction for average of 2.5 Crop Cycle			3,448	
Export Potentials				
Protea	100 %	2,609	238	1.359
Wine(Grapes) of Total Imports	20 %	8,766	877	3.391
Sub Total		11,375	1,115	4.750
Grand Total		179,664	5,315	18.036

Among the vegetable crops, tomatoes, head lettuce, romaine lettuce , potato, and onion appear to be viable. The analysis shows that while macadamia and citrus are marginally profitable, they cannot support increased water costs. The temperate orchard crops consisting of apples, grapes, and protea can support increased water costs. However, only protea has actually been commercially cultivated in Hawaii to any significant degree. Further consideration of apply and grape cultivation is then conditioned on the appropriate production technology transfer to Hawaii.

There are many positive impacts associated with the potential expansion of the agricultural industry in the Waimea Region. Based on the 1988 demand, the potential agricultural development would provide nearly 50 million dollars per year in income and over 200 farm jobs. By 2007, the annual farm income would increase to $87.5 million and involve 350 full time farm jobs. One-time infrastructure development expenditures will add over 1,000 jobs and $67 million of income into the island economy. In addition to the direct benefits, there will be significant indirect and induced benefits as the expansion of the agricultural industry supports growth in other sectors of the economy.

Planning for water development in the Waimea region must take into account the distribution archaeological resource. There are areas with a high density of archaeological sites/feature, such as the unique Waimea agricultural field system situated in the westerly portion of the study area. Areas with lower potential for archaeological sites include the southern portions of the Waimea saddle and the western slopes of Mauna Kea.

In any case, further archaeological work may be required for lands not previously examined. Some locations will require little additional work beyond and initial survey; other lands may require intensive data recovery prior to development and loss of archaeological resources; and some locations should see no development at all in order to preserve resources of cultural and scientific significance.

Although intact native ecosystems are absent from the subject area, a remnant population of several rare and endangered native Hawaiian plants and vegetables are known to occur at restricted sites or as transient occupants of the region. Any site specific agricultural development plan should be sensitive to these biotic resources, including development of appropriate mitigation measures.

E.4 CONCLUSIONS

The Water Development and Transmission Project could provide up to 18 million gallons of water per day to the region. Based on the Phase I analysis, water costs could range from a low of $1.07 to a high of $5.70 per thousand gallons depending on the assumptions.

However, for the WT&D Project to be implemented, a number of constraints must be overcome. These potential constraints include:

- Adequate initial funding must be obtained to construct the water transmission line from east to west Hawaii. There must be a commitment by HELCO to supply the electrical power at a reasonable cost.
- Lands must be made available to potential individuals or firms with the ability to conduct intensive agricultural production. Lands within the study area are owned by Parker Ranch and DHHL. Parker Ranch is presently utilizing its lands for cattle grazing. The use of lands within the study area for other agricultural purposes must be consistent with the Ranch's long term land use strategy. DHHL and their lessees may face additional hurdles in establishing intensive farming activities including the provision of adequate financing and infrastructure.
- Adequate financing must be available to support the necessary infrastructure for intensive agricultural activities. An estimated $31.1 million is required for construction of farm irrigation lines, roads and other improvements.
- There is an adequate supply of farmers and farm laborers to undertake the intensive farming activities.

The development of the WT&D project will also have implications on the overall water system serving the Waimea Region. While the ultimate water costs for this system cannot be finalized at this time, several implications and conclusions can be reached. These include:

- Water Costs from the WT&D project will not be competitive with the existing Department of Water Supply System and the Waimea Irrigation System Consequently, the water systems should be segregated from an operational standpoint.
- The WT&D system provides a potential backup to the existing water systems in Waimea. Consequently, the systems should be interconnected to supply water during periods of drought or other emergencies.

- While it appears that agricultural use of the water may be feasible, other potential non-agricultural end-users should be considered.

In conclusion, the Water Transmission and Development Project can provide a potentially viable water source to the Waimea region which would otherwise not be available. While the water costs of the system would be greater than that presently available in the Waimea region, there are candidate crops which can potentially support the contemplated water prices provided other costs can be maintained at reasonable levels.

Appendix D

BOTANICAL ASSESSMENT FOR THE PROPOSED WAIAKEA TO PARKER RANCH WATER TRANSMISSION SYSTEM

ENVIRONMENTAL IMPACT STATEMENT
Water Development and Transmission, Island of Hawaii
Job No.22-HW-J

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July 15, 1991

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BOTANICAL ASSESSMENT FOR THE PROPOSED WAIAKEA TO PARKER RANCH WATER TRANSMISSION SYSTEM

INTRODUCTION AND OVERVIEW

A botanical assessment of the proposed water transmission and development system easement (hence forward, "the easement"), from the well field in Waiakea to the terminal reservoir at Makahalau, has been completed. The purpose of this assessment was to characterize the plant communities along the easement and to identify any sensitive plant communities or populations of rare plants that may require protection as biological resources. The analysis and recommendations take into account both direct destruction of plants and habitat during construction and operation, and the potential negative impact of increased dispersal of alien plants during the construction and operation of the water system.

This botanical assessment takes advantage of several previous botanical assessments and data bases covering major portions of the proposed easement. These previous assessments provide a classification of the communities along the easement and a list of native and alien plant species previously encountered. This baseline information was compared with a new ground survey of the entire easement, and is especially useful in evaluating recent dispersal of alien species and possible interactions with previous construction activities.

The proposed route begins above Hilo at the Waiakea well field at about 800 ft. elevation on the windward side of Hawaii. The proposed pipeline follows the existing 138KV power transmission line westward to the 2200 ft. elevation where it joins the Saddle Road (state route 200) near the nine mile marker. The proposed easement then closely follows Saddle Road westward across the summit of the Humuula Saddle at 6400 ft. elevation and continues along Saddle Road on the leeward side to near mile marker 43 where it turns northward and enters Parker Ranch pasture lands for the rest of the route, approximatey following the 4000 ft contour to the terminal reservoir.

Fourteen predominantly native plant communities are recognized along this route as the easement passes through three major climatic zones and crosses lava flows and ash deposits of various ages. On the windward side, from the well field to about the 6000 ft. elevation, the easement follows Saddle Road through lowland, submontane, and montane rainforest. These rainforests are part of the largest remaining section of native vegetation in the Hawaiian Islands and are valued as a biological resource precisely because they are so extensive that they provide adequate habitat for their constituent plant and animal species (Cuddihy 1989). Their conservation and watershed value is recognized by their incorporation in the state forest reserves and the state Conservation District.

The dryland native plant communities between the Humuula Saddle and Parker Ranch are of much smaller extent and are unique ecosystems found only at these elevations on leeward Mauna Kea and Mauna Loa. These dry forest and shrub communities are known to contain isolated populations of legally protected plant species. The Parker Ranch pastures still have native trees in a few places, but are dominated by alien grasses and have generally no conservation value for the native biota. However, isolated populations of legally protected endangered species are known to occur within Parker Ranch.

Fortunately, the potential for negative impact to native plant communities is strongly mitigated by the proposal to have the water system easement closely follow the existing 138 KV powerline and the Saddle Road through the regions with predominantly native vegetation.

METHODS

DATA ACQUISITION

Data were acquired in two ways: from a new ground survey of the floristics and vegetation of the entire easement, and from data bases including environmental assessments for projects geographically congruent with the proposed water system easement.

GROUND SURVEY

Seven field days were spent along the length of the water system easement. Data recorded included lists of plant species observed and general vegetation descriptions for each community type. Visual estimates of the abundance of each plant species within its community were recorded using the following codes:

C = Common: the dominant and most abundant species
O = Occasional: widely distributed but less conspicuous
U = Uncommon: few and far between
R = Only one individual observed in community

The easement had not been staked or otherwise marked on the ground, thus the area covered by the botanical survey was determined by interpretation of drawings and plans provided by Okahara & Associates Inc.

The first section of the water system, from the well field to Saddle Road, follows the easement of the Hawaii Electric Light Company, Inc., Kaumana to Keamuku 138 KV Transmission Line (hence forward called "the powerline"). The vegetation directly beneath the powerline and 75 to 100 feet on either side shows evidence of having been disturbed during powerline construction, including felled trees, bulldozing, and at least casual maintenance of a service road. This section was surveyed in one day while driving and walking along the easement. Species lists and vegetation notes were recorded for the plant communities in the disturbed areas and for the undisturbed communities outside the powerline corridor.

The longest section of the water system easement follows Saddle Road from below mile marker 9, across the saddle to near mile marker 43. This section was surveyed by driving along Saddle Road and making frequent stops for walking through the easement. The vegetation was surveyed in an easement considered to extend 100 feet on the north side of Saddle Road up to the US Army Pohakuloa Training Area (PTA) where it crosses to the south side of the road. Sites of the proposed pumping stations and their approaches were also surveyed. In addition to the more or less undisturbed vegetation within the easement, the roadside plant community was also surveyed and species lists were made.

The final section of the water system enters Parker Ranch near mile 43 of the Saddle Road, first on the south side, then crossing the road to the north side and then leaving the vicinity of the Saddle Road to cross the west and northwest slope of Mauna Kea just above the 4000 ft. contour. This section was surveyed with the help of a Parker Ranch guide by following jeep roads near the proposed easement. Because the easement had not been staked, it was possible to survey the general vicinity of the easement only. It is recommended that a qualified botanist survey the staked easement before any clearing or construction begins.

DATA BASES AND PREVIOUS EIS'S

A data base provided by the Hawaii Heritage Program of The Nature Conservancy of Hawaii was consulted for the portion of the easement from the headquarters of PTA to the terminal reservoir at Makahalau. This data base gives map locations of all known sitings of rare plants and locations of unique ecosystems. This information was used to alert the botanist to the possibility of the presence of rare plants in specific locations.

The botanical report of an EIS prepared for the US Army's Pohakuloa Training Area provided background information, including locations of rare plants, for the easement section within the training area (USACH 1977).

A botanical assessment prepared for a 138 KV transmission linve built by Hawaii Electric Light Company, Inc., (Wagner et al 1983) was useful and appropriate since the first section of the water system easement is directly along this powerline corridor, and, through the second section, the powerline follows the Saddle Road corridor.

The most useful document, however, was "The Native Vegetation Along the Saddle Road, Hawaii County" (Warshauer 1986), a part of "CDUA, CDUA Supplement and Environmental Impact Assessment For the Saddle Road Improvements, Island of Hawaii," prepared by Dept. of Public Works, County of Hawaii. From this report, I adopted the vegetation zonation and community names and used the species list as a base for field surveys. Use of Warshauer's system is justified becasue it was devised for a very similar environmental assessment, it can be substantiated in the field, and comparability of studies will enhance understanding of impacts of these construction projects in the Saddle Road corridor.

VEGETATION ZONES AND COMMUNITIES

Because the vegetation of the section of the easement that crosses Parker Ranch is mostly alien pasture grasses, that part of the easement will be discussed in a framework different from that of the predominantly native vegetation that flanks the easement from the well fields to mile marker 43 on Saddle Road.

Following Warshauer (1986), I recognize three vegetation zones determined by annual rainfall along the powerline and Saddle Road corridors. For the purposes of this report the wet, moist, and dry vegetation zones are defined with the following limits.

Wet: over 3000 mm median annual rainfall
up to 5100 ft. elevation on windward side
from the Waiakea well field to mile 19 on Saddle Road

Moist: 1000 to 3000 mm median annual rainfall
5100 to 6400 ft. elevation on windward side
mile 19 to mile 30 on Saddle Road

Dry: 500 to 1000 mm median annual rainfall
6400 to 4000 ft. elevation on leeward side
mile 30 to mile 43 on Saddle Road

Several different communities exist along the easement within each of these vegetation zone. The actual community present at any site is determined by the nature and age of the substrate and, to a lesser extent, the disturbance history at the site. Substrate ages range from the 1935 a'a lava flow near the summit of the saddle to prehistoric ash soils on the leeward side of Mauna Kea. These various-aged lava flows form a mosaic such that the easement passes back and forth between communities.

The 14 communities recognized are:

RS : Roadside
WSO : Wet Successional 'Ohi'a
WOS : Wet 'Ohi'a Scrub
WOF : Wet 'Ohi'a Forest
WOKF : Wet 'Ohi'a-Koa Forest
MSP : Moist Sparse Pioneer
MMS : Moist Mixed Shrubland
MOS : Moist 'Ohi'a Scrub
MOF : Moist 'Ohi'a Forest
MOKF : Moist 'Ohi'a-Koa Forest
MKMP : Moist Koa-Mamane Pasture
MOP : Moist 'Ohi'a Pasture
DSP : Dry Sparse Pioneer
DMNF : Dry Mamane-Naio Forest
DCS : Dry _Chenopodium_ Shrubland

With the exception of WSO, these community designations are the same as used by Warshauer (1986). Two disturbance community subtypes were recognized within the powerline corridor in the wet zone:

WDOS: Wet disturbed 'ohi'a scrub

WDOK: Wet disturbed 'ohi'a-koa forest

Most of the communities listed above were subdivided into sections corresponding to a geographically defined segment of the easement. A species list was compiled for each of these community subdivisions.

Note that the community types 'Ohi'a Scrub (OS), 'Ohi'a-Koa Forst (OK), and 'Ohi'a Forest (OF) occur in both the wet and moist vegetation zones. These communities are differentiated in this report by the letters "W" and "M" in the community symbols, eg. WOS and MOS, Wet 'Ohi'a Scrub and Moist 'Ohi'a Scrub, respectively. Similarly, the Sparse Pioneer community exists in both the moist and dry zones, i.e. MSP and DSP, respectively.

FINDINGS

OVERVIEW AND SUMMARY

The results of the ground survey and the review of previous EIS's and data bases are interpreted in three major sections: floristics and vegetation, alien plant patterns, and rare plants. These findings are followed by recommendations. These three sections are summarized in the following paragraphs.

From the Waiakea well field to the Parker Ranch, the water system easement passes through 14 native plant communities, as well as a roadside weed community (RS). Within the Parker Ranch, most of the easement crosses pastures of alien grasses, legumes, and weeds that are of no conservation importance. Two sections of the easement within Parker Ranch pass through pasture many trees remaining from the former mamane-naio forest. Pockets of rare plants, some listed as endangered by the US Fish and Wildlife Service, are known to occur within Parker Ranch.

Many alien plants occur in the roadside along the Saddle Road. Some of these are noxious weeds that disrupt native ecosystems and/or are detrimental to rangeland. Analysis show that native communities in the wet vegetation zone are more susceptible to alien plant invasion than in the moist or dry zones. The 'ohi'a forests and the 'ohi'a-koa forests are more susceptible to invasion than the pioneering communities or the shrub communities on the 1855 or more recent lava flows. The distribution patterns of some of the alien species indicate that activities associated with use and maintenance the Saddle Road or construction of the powerline are responsible for the spread of these weeds into the surrounding vegetation. It is reasonable to believe that construction of the water development and transmission system may also encourage the dispersal and growth of unwanted weeds. Recommendations are given to minimize this impact.

No rare plant species listed as threatened or endangered by the US Fish and Wildlife Service were found within the easement or its immediate vicinity. Two populations of one plant, Rubus macraei (Macrae's akala), that may be under consideration for listing were found within the easement. Populations of legally protected plants and plants proposed for legal protection are known to occur in the vicinity through which the easement passes.

FLORISTICS AND VEGETATION DESCRIPTIONS

All vascular plant species recorded within the easement during this survey or by Warshauer (1986) are listed in Appendix A. Nomenclature of flowering plants generally follows that of St. John (1973).

The vegetation of this region is a mosaic of community types determined by the age and type of the substrate. These community types are forests, which occur on older substrates with developed soil, scrub, shrublands, or very sparse pioneering communities which occur on the 1855 and younger lava flows. The elevation and climate determine the nature of each community within the community type.

The sequence of communities within the easement as it passes through the powerline and saddle road corridors are shown in the strip diagrams (Figures 1-4). The three vegetation zones are fairly broad, encompassing floristic variation within each community. The community designations in the strip diagrams are followed by a letter indicating a species list in Tables 1 to 15 for each segment of the easement allowing more accurate identification of the location and abundance of each species along the easement. Where two communities occur together within the easement, both community designations are given, with the upper being the more dominant of the two. Each strip diagram indicates a species list for the Saddle Road roadside or the under-powerline disturbed community, and a community and species list designation for the surrounding vegetation crossed by the easement.

Wet Zone: The Waiakea Well Field. The proposed Waiakea well field is within the wet vegetation zone (Figure 1, Table 1). The well field is in an open Successional 'Ohia Forest (WSO). Vigorously growing 'ohi'a trees have an irregular cover of 10 to 40% of the site. A very dense mat of uluhe (Dicranopteris linearis) dominates the understory and groundcover. A few scattered tree ferns (Cibotium glaucum) and neneleau (Rhus sandwicensis) trees and huehue (Cocculus ferrandinanus) complete the complement of native species observed in this simple community. A few trees or shrubs of alien malabar melastome (Melastoma malabarthicum), waiawi (Psidium cattleianum), and common guava (P. guajava) have also emerged through the uluhe. Within the water system easement, this early successional forest occurs only at the well field.

Wet Zone: The Powerline Corridor. From the well field to 1860 feet elevation, almost to Flume Road, the easement passes through an 'Ohi'a-Koa Forest (WOK-A) (Figure 1, Table 2). Much of this forest is in dieback, some with a vigorous subcanopy (about 8 m high) of 'ohi'a in a dense matrix of uluhe. In addition to having nearly-impenetratble vegetaion, water stands on the soil in many places, making a survey of the forest outside the easement very difficult and, thus, incomplete. At lower elevations near the well field, the forest is degraded with many alien trees and, in some places, an understory dominated by waiawi. However, most of the alien trees disappear with increasing elevation.

Below Flume Road, the disturbed part of the powerline corridor that was partially bulldozed during construction of the powerline is densely covered by a swath of second growth that reflects the make-up of the surrounding vegetation plus the addition of a large number of aggressive aliens, including wai'awi, broomsedge (Andropogon virginicus), malabar melastome, and fast-growing alien trees, including gunpowder tree (Trema orientalis), albizia (Albizia falcataria), melochia (Melochia umbellata), and paperbark (Melaleuca leucadendra) (WOK-AA). Regeneration of koa is low within this disturbed part of the easement and 'ohi'a regeneration is very low.

From Flume Road to the junction with Saddle Road at 2240 ft. elevation, the easement alternates between the 1881 lava flow vegetated by 'Ohi'a Scrub (WOS-A) and 'Ohi'a-Koa Forest (WOK-B) on older soil (Figure 1, Tables 2 and 3). In the scrub, the low stature of the 'ohi'a trees (less than 8 m tall) and the very open canopy reflect the poorly drained and shallow soil of this early successional site. The ground is generally covered with a dense low growth of 'uki (Machaerina angustifolia), uluhe, and wawae-'iole (Lycopodium cernuum). The only alien with a significant presence in the undisturbed 'Ohi'a Scrub is broomsedge. The disturbed areas under the powerline show good regeneration of most of these native plants plus significant growth of alien broomsedge, sourbush (Pluchea odorata), and Tibouchina herbacea (WOS-AA and WOK-BB). A small population of the forest pest, Himalayan raspbery (Rubus ellipticus), was found under the powerline at Flume Road. This giant bramble is currently undergoing dramatic range expansion (Gerrish et al unpublished manuscript).

The undisturbed, forested parts of the easement between Flume Road and Saddle Road are generally free of alien species, except in areas near Saddle Road that have been fenced and grazed by cattle (WOK-B). These perturbed areas have significant populations of wai'awi, Tibouchina, and broomsedge. The undisturbed 'Ohi'a-Koa Forests have a diverse understory and groundcover of native species. Most of the bulldozed strip along the powerline shows powerful regeneration of koa and a mat of uluhe suggesting that the future vegetation here will be predominantly native. However, established populations of wai'awi and Tibouchina will probably also be part of the future community. In many areas, the powerline corridor is on the boundary of the 'Ohi'a-Koa Forest and the 'Ohi'a Scrub. In these places the bulldozed parts of the 1881 lava flow are being colonized by koa from the surrounding forest illustrating how the scarifying of the lava substrate hastens plant succession (WOS-AA).

Wet Zone: Saddle Road Corridor. In this section of the easement, 'Ohi'a Scrub (WOS) occurs on the 1881 and the 1855 lava flows; 'Ohi'a-Koa Forests (WOK) occur on older soils below about 3200 ft. elevation, and 'ohi'a forests (WOF), without koa, on older substrates above that elevation (Figure 2, Tables 2 to 4 and 15). The mixed 'ohi'a-'koa forests again appear around 5500 ft. elevation in the moist zone. This pattern of a lower and an upper 'ohi'a-koa belt with pure 'ohi'a in between is consistent with the findings of other vegetation studies (Mueller-Dombois et al 1981).

The undisturbed 'Ohi'a Scrub (WOS-B) between 2100 and 2900 ft. elevations is little different from that described along the powerline corridor, having the same native dominants and broomsedge as the most important alien invader. Above 2900 ft. elevation in the wet zone, the scrub (WOS-C&D) is richer in native species, adding kukai-nene (Coprosma ernodeoides), pukiawe (Styphelia tameiameiae), ohelo (Vaccinium reticulatum), 'ama'u (Sadleria cyatheoides), and other native shrubs as important components of the vegetation.

A kipuka of 'Ohi'a-Koa Forest (WOK-C) occurs at the 2300 ft. elevation. Most of the kipuka is on the south side of the road, but a sliver several meters wide occurs within the water system easement on the north side of Saddle Road. Given its small extent, this bit of forest, sandwiched between Saddle Road and the powerline service road has a remarkably diverse flora of native woody plants. Unfortunately, the groundcover is completely dominated by the alien shrub, Tibouchina. Interestingly, the Tibouchina is not found in the surrounding 'ohi'a scrub (WOS-B).

'Ohi'a-Koa Forest (WOK-D) also occurs between 2900 and 3100 ft. elevations at and around pumping station 4. This forest has undergone complete canopy dieback and now is in a stage of advanced regeneration (Jacobi et al 1983). A diverse growth of vigorous native trees and shrubs is emerging from a dense mat of uluhe and uluhe-nui-lau (Hicriopteris pinnata). A single native lo'ulu palm (Pritchardia beccariana) occurs on the west side of the proposed pump station. Scattered patches of groundcover dominated by alien broomsedge and Tibouchina cover about 5% of the area.

The easement passes through several patches of 'Ohi'a Forest (WOF-A), with no koa, between 3300 ft. elevation and the upper limit of the wet zone at 5100 ft. There are some areas of canopy dieback in these forests, others with the canopy intact. These forests are very diverse with many native plants in the understory and the groundcover. A few alien plants occur in the 'Ohi'a Forest (WOF-A) below 4000 ft. elevation; only broomsedge and Glenwoodgrass (Saciolepis indica) are common. The serious forest pest wai'awi was absent above, and uncommon below, 4000 ft. elevation. Above 4000 ft. elevation, the forest is diverse and near-pristine (WOF-B).

The makeup of the roadside vegetation is less dependent upon the substrate and surrounding vegetation than the vegetation of the disturbed under-powerline community. This disclimactic roadside community gradually changes with elevation rather than with the underlying substrate. The roadside vegetation contains many 'ohi'a seedlings, but is dominated by alien grasses. Below 2900 ft. elevation (RS-A), broomsedge and molassasgrass are most important; with increasing elevation, kikuyu (Pennisetum clandestinum) and sweet vernalgrass (Anthoxanthum odoratum) become dominant (RS-B&C). A large number of other native and weedy alien plants are also found on the shoulder of the road.

Moist Zone: Saddle Road Corridor. The atmospheric inversion layer that occurs at about 5000 ft. elevation on the windward side of the saddle, marks the transition between the wet and moist vegetation zones. The marked decline in rainfall above this inversion layer affects the vegetation, most noticeably in the slower development of vegetation on recent lava flows.

From mile-marker 19 (5100 ft. elevation) to almost mile-marker 22 (5600 ft. elevation), the easment passes through 'Ohi'a Scrub (MOS-A) on the 1855 lava flow with two small forested parts on older substrates (Figure 3, Tables 5-11, and 15). From mile-marker 22 to the dry zone boundary at mile-marker 30 (6600 ft. elevation), the easement primarily follows the sparsely vegetated (MSP-A to D) 1935 lava flow which surrounds small pockets of forest, scrub, or shrubland vegetation.

The 'Ohi'a Scrub of both the moist and wet zones are characterized by low stature 'ohi'a trees, but their ground covers differ strongly in structure and floristic makeup. The ground cover of the moist zone lacks the dense mat of uluhe and the native sedge, 'uki (Machaerina angustifolia), as well as the troublesome alien broomsedge. In the moist zone, the ground cover is a discontinuous layer of low shrubs with much exposed lava. In this zone, exposed lava is often densely covered with a lichen, Stereocaulon vulcani. The dominant plants in the ground cover include some shrubs that become prevalent in the upper part of the wet zone (above 3100 ft. elevation), such as kukai nene and pukiawe, and some herbaceous plants not present in the wet zone, such as the bunch grass, Deschampsia australis, and the tufted fern, lau-kahi Dryopteris paleacea. The kipukas of scrub (MOS-B&C) above 5600 ft. elevation within the 1935 flow, also contain elements of the subalpine vegetaion, including hinahina (Geranium cuneatum) and the rare Macrae's raspberry (Rubus macraei) (MOS-B & C). Alien plants are almost entirely absent from the Moist 'Ohi'a Scrub.

The only 'Ohi'a Forest that occurs on the easement is at the proposed site of pump station 7 (MOF-A). This is a healthy and diverse tall stature 'ohi'a forest with no significant alien weeds except the noxious blackberry (Rubus argutus). The other small areas of forest within the easement are 'Ohi'a-Koa Forests (MOK-A&B), all between the 5500 and 5900 ft. elevations. This community type has high species diversity as witnessed by the long species list compiled by Warshauer (1986), but the limited areas within the easement possess a smaller subset of these species (Table 7).

The 'Ohia'a-Koa Forest (MOK-A) between mile-marker 21 and 22 (5540 to 5600 ft. elevations) is a pristine example of this community type and contains the rare Macrae's raspberry. This area should not be disturbed and can probably be easily avoided since a strip of near barren lava separates the forest from Saddle Road. The other stands of 'Ohi'a-Koa Forest (MOK-B) are both within fenced pastures and have been somewhat degraded by grazing. Nevertheless, they contain tall, healthy 'ohi'a and koa trees as well as sandalwood (Santalum ellipticum) and other native species.

Most of the easement between mile-markers 22 and 30 (5650 and 6600 ft. elevations) passes through a Sparse Pioneer community on the 1935 lava flow. This flow is near-barren with widely scattered native shrubs and ferns (MSP-A to D). No alien plants were recorded on the 1935 flow. The small areas of forest and scrub within the 1935 flow have been described above. However, it should be mentioned that a population of at least 6 plants of the rare Macrae's raspberry was found in a lava tube entrance not far from the road at the 5976 ft. elevation (MOS-B). This site should not be disturbed. Above about 6000 ft. elevation, the kipukas of older lava bear a community of mixed native shrubs similar to the 'ohi'a scrub, without the 'ohi'a. Below mile-marker 27 (6480 ft. elevation), these small communities contain only native shrubs (MMS-A & B), but at higher elevations they have several alien species associated with the nearby dry zone (MMS-C), eg. mullein (Verbascum thapsis), or the surrounding pastures, eg. gorse (Ulex europaeus) and velvetgrass (Holcus lanatus).

Throughout the moist zone, the Roadside (RS-A to C) community is sparser than in the wet zone. It is dominated by grasses, including the native Deschampsia, but more importantly, the alien grasses Paspalum urvillei, Glenwoodgrass (Saciolepis indica), sweet vernalgrass (Anthoxanthum odoratum), and velvetgrass.

Dry Zone: Saddle Road Corridor The arid appearance of the Saddle Road corridor west of mile marker 30 is exagerated by the barrenness of the massive 1843 a'a lava flow. From mile marker 30 to just past mile marker 33 the only vegetation on the lava flow is a few very widely scattered pioneering native plants (DSP-A, Figure 4, Table 12). A mamane-naio forest which was not surveyed is a short distance north of the one-hundred foot-wide easement. The more developed Roadside community (RS-F) is dominated by the noxious fountain grass (Pennisetum setaceum), sweet vernalgrass, other pasture legumes and weeds, and the native bunchgrass, Deschampsia (Figure 4, Tables 12-15).

West of mile marker 33, the easement is on an older ash deposit with a Mamane-Naio Forest (DMN-A, Figure 4, Table 13) that appears to be degraded by trampling and, perhaps, grazing. This community contains only a few native species and a number of weedy aliens. The shoulder of the road is dominated by fountain grass (RS-G). The easement diverges from the Saddle Road west of mile marker 34 to the existing Pohakuloa water tanks. This part of the easement has not been surveyed as of July 11, 1991. It appears that this section of the easement traverses a heavily disturbed community like the Mamane-Naio Forest (DMN-A) just described.

The easement again joins Saddle Road just east of mile marker 36. From this point, up to beyond mile-marker 42 where the easement again leaves Saddle Road, the dominant vegetation is a _Chenopodium_ scrub (DCS-A, Figure 4). While 'aheahea (_Chenopodium oahuense_) is recognized as the dominant shrub, most of the plant cover in this community is contributed by two native grasses, hard-stemmed lovegrass (_Eragrostis atropioides_) and _Deschampsia_. Fountain grass, abundant on the roadside (RS-H), has not penetrated the _Chenopodium_ Scrub community between mile markers 36 and 42. The few alien plants found have low abundance and cover. This area has been heavily impacted, and probably simplified, by human activities such as grazing and fire (Warshauer 1986). Nevertheless, the vegetation has maintained its native character. This community of 'aheahea and hard-stemmed lovegrass is unique, occuring nowhere else on Earth.

In the final mile along Saddle Road, near mile marker 42, the scrub becomes richer in woody species with a'ali'i (_Dodonaea vicosa_) becoming an important dominant (DCS-B, Figure 4) as other species of the Mamane-Naio Forest (DMN¬B) become more prominent.

Dry Zone: Parker Ranch The easement veers away from the Saddle Road, first to the West, but then turns north and crosses the road near mile marker 45 one last time before leaving the Saddle Road corridor. Most of the route from the Saddle Road to the proposed terminal reservoir near Makahalau crosses improved pastures with no native plants or other features of plant-conservation interest. The two exceptions are areas where many native trees and shrubs grow within pastures as remnants of the former forest. The first of these two areas is at 5400 ft. elevation where the easement first enters Parker Ranch after leaving the Saddle Road. Native trees and shrubs that still persist in this heavily grazed pasture include 'aheahea, a'ali'i, mamane (Sophora chrysophylla), naio (Myoporum sandwicense), pilo (Coprosma montana), 'akoko (Euphorbia olowaluana), uulei (Osteomeles anthyllidifolia), sandalwood (Santalum paniculatum), ko'oko'olau (Bidens menziesii var. filliformis) and kolea (Myrsine lanaiensis).

The second such area is a more extensive stretch just below 4200 ft. elevation approximately between Puu Amuamu and Kemole Gulch. This area is an ancient a'a flow that appears to have been less completely cleared of forest and, perhaps, less hospitable to cattle. Native plants found here include all the species named in the paragraph above, plus koa, pukiawe, 'akia (Wikstroemia sp.), and ilima (Sida fallax).

The survey across Parker Ranch from Saddle Road to the terminal reservoir followed the approximate route of the easement. At the time of staking, before clearing or construction begins, the actual easement should be resurveyed by a qualified botanist. Federally protected endangered species are known to occur in isolated areas of less-disturbed vegetation on Parker Ranch and in habitats similar to those found on the ranch.

Vegetation of "Alternative B" A second route has been proposed as an alternative to having the easement leave the Saddle Road south of Waikii (mile marker 45) and traverse the slope of Mauna Kea at the 4000 ft. contour within the pastures of Parker Ranch. This "Alternative B" route continues to follow Saddle Road past Waikii, then the Belt Highway and Mana Road to the terminal reservoir. This alternative easement leaves this series of roads near the Waimea-Kohala Airport to bypass the town of Kamuela.

This route was very briefly surveyed by car. Another detailed survey of the route should be made by a qualified botanist if this route is selected. However, in general, the route of alternative B passes through improved pastures with little consequence for plant-conservation. Some common native species, such as a'ali'i, 'ilima, and Hawaiian poppy were seen along the route.

As this alternative route follows Saddle Road, it passes between cinder cones at about 2800 ft. elevation which are known habitats of listed endangered plant species, eg. nehe (Lipochaeta venosa) and Haplostachys haplostachya. The nearest of these cones (Nahonaohae) is about .3 mile from the Saddle Road. If the water system is built where Alternative B is shown on the preliminary drawings, there should be no danger of disturbing these endangered plants. Because these areas are known habitats of endangered plants, a detailed plant survey should be conducted at the time of staking the easement.

ALIEN PLANT PATTERNS

Introduction. Invasion by alien plant species is a most serious threat to native plant communities (Smith 1985, Stone and Stone 1989). Some aggressive and fast-growing alien plants can shade-out and otherwise out-compete native species. Most alien plants are slow to invade native Hawaiian plant communities unless the existing plant cover is distrurbed by some activity, such as construction. The aliens act as "weeds" in the sense that they rapidly become established in these disturbed sites. In some cases, these aliens can then spread further into the native vegetation. Allowing aliens to become established can lead to the degradation of the surrounding vegetation.

During this survey, careful attention was given to the alien plants growing within the surveyed plant communities of the powerline and Saddle Road corridors. The various patterns of distribution of the aliens have been analysed to determine which are threats to the native vegetation, what role human disturbance may have in spreading them, and what actions might mitigate potential negative impacts of building the proposed water system. The easement through the Parker Ranch as well as the Moist Koa-Mamane Pasture (MKM) and Moist 'Ohi'a Pasture (MOP) are not included in this analysis since these areas are already dominated by alien plants due to their use as pastures.

In addition to 12 native plant communities, the easement includes the Saddle Road roadside community (RS) and the disturbed area under the 138KV transmission line. Both of these two latter communities have been heavily influenced by human activity, have a higher number of alien plants, and offer models of plant invasion after disturbance by construction activities that may be similar to construction of the proposed water system. These two situations represent two different disturbance treatments. The history of the roadside community includes the initial road construction, maintenance mowing (and perhaps spraying), frequent automobile traffic, and recent widening activities. Such repeated disturbances favor plants, such as grasses, that are adapted to recurring disturbances. The "under-powerline" represents more of a one time construction disturbance. It appears that during powerline construction an approximately 200 foot-wide easement was bulldozed, including removal of all large trees. No further maintenance has been done on this right-of-way, except the continual use of a jeep road along it. This disturbance initiated a secondary plant succession on the site. Since the disturbance has not been repeated, the vegetation is continuing to develop. The makeup of this successional vegetation is analyzed.

Construction activity can be expected to promote the spread of alien plants in two ways: introduction of seeds and propagules, and site alteration. Propagules will be inadvertantly carried to the construction site on vehicles, eg. fountain grass (Pennisetum setaceum) is known for its ability to stick to radiators and other vehicle parts (Smith 1985), and kikuyugrass (Pennisetum clandestinum) can be transplanted from pieces of stem caught in earthmoving equipment.

Just as important as vectoring of propagules are site changes caused by construction. In the initial stage, plants reinvade the ground that has been left bare. Some of these early colonizers are ruderals or true weeds that only grow in bared soil and will not persist after the vegetation begins to develop. Such plants are of little danger to the native communities. Other, more dangerous aliens, colonize early but do persist and will seed into any small break in the vegetaion, forming a more serious invasion. Many of these latter species are shrubs or trees.

On lava substrates, heavy equipment breaks up some of the solid lava and produces rubble that is more soil-like. At many points within the Saddle Road corridor it can be seen that this disturbed lava is more readily colonized. Growth of populations of alien species in or near the predominantly native communities is a potential danger since they provide seed-sources for any suitable point of invasion. Mitigating actions should be taken to minimize new growth of alien plants along the easement.

Analysis. Seventy-five species of alien plant were recorded within the water system easement in the Saddle Road and powerline corridors (Table 16). Thirty-seven of the alien species occur only on the Saddle Road shoulder or in the area under the powerline that was disturbed during construction. Of the 37 aliens found within the undisturbed native communities, 25 are considered invasive aliens that may disrupt native communities (Table 17). It should be noted that the denotation of "noxious" implies a serious pest, especially on agricultural lands

Some of the thirty-seven species of alien plants that occur only on the Saddle Road shoulder or in the under-powerline area might be considered early successional species that will have little long-term impact on the dynamics of the native communities. However, comparing the results of the present survey to those of Warshauer's in 1986 shows that some "roadside" species may be pests in the early stages of dispersal. Warshauer (1986) found vasseygrass (Paspalum urvillei) present on the roadside but nowhere else, and Tibouchina herbacea present on the roadside and uncommon in the Wet 'Ohi'a-Koa Forest. Today both of these weeds are common in the 'Ohi'a-Koa Forest community (Tables 2, 15 & 19). Other data from a system of permanent plots in the wet vegetation zone show both of these weeds to have greatly increased their range and local dominance in recent years (Gerrish unpublished data). Molassesgrass (Melinis minutiflora) was not recorded by Warshauer, but is now common on the roadside and in the Wet 'Ohi'a-Koa Forest (Tables 2, 15 & 19). Similarly, the pestiferous yellow Himalayan Raspberry (Rubus ellipticus), was not seen by Warshauer, but today a few clumps occur on the roadside and in Wet Disturbed 'Ohi'a Scrub (Tables 3, 15 & 19). Although this pest is uncommon today and has been found only on disturbed sites, it is known as a major forest pest in the Hawaii Volcanoes National Park area and can be expected to infest forests along the Saddle Road corridor.

Analysis shows that some of the native communities are more heavily invaded by alien species than are others communities. It is assumed that this pattern indicates that these communities are more susceptible to invasion than the others. A larger number of alien species are found in the wet zone than either the moist or dry zone (Table 18).

A hierarchy of susceptibility to invasion among the communities of each vegetation zone correlates with primary succession, age of the substrate, and soil development. Overall, the commuities with the fewest alien species are the sparse pioneer communities on recent lava of the moist and dry zones. The most heavily invaded communities are the forests which grow on older substrates with more developed soils. The scrub communities on the 1855 and 1881 lava flows (in the wet and moist zones) are less invaded than the forests (Table 18). It has been previously found that, at least in some vegetation types, hospitable habitats are more readily dominated by alien plants than are stressful sites (Gerrish 1980). That principle can be applied here, with the younger substrates representing the more stressful sites.

Sites disturbed by human activity were found to have more species of alien plants than undisturbed communities. The Saddle Road Shoulder has a higher number of alien plants and proportionately fewer natives than any other community surveyed (Table 18). The repeated disturbance of the roadside favors this disclimactic community dominated by early succession species. Kikuyu grass (Pennisetum clandestinum) is representative of an alien found only on the roadside in the Saddle Road corridor (Table 19) The disturbed under-powerline communities also have alien species not found in their surrounding counterparts. The Disturbed Wet 'Ohi'a Scrub has 5 alien species "occasional" or "common" that are absent or "uncommon" in the nearby undisturbed scrub (Table 3); the disturbed Wet 'Ohi'a-Koa Forest has 11 such aliens compared to the nearby forest (Table 2). Sourbush (Pluchea odorata) and yellow Himalyan raspberry are species representative of these patterns (Table 19).

Disturbance has a greater impact on Wet 'Ohi'a-Koa Forest than on Wet 'Ohi'a Scrub. Sixteen alien species were recorded as "occasional" or "common" in under-powerline segments through the forest that were absent or "uncommon" in segments through the scrub on the 1881 lava flow (Tables 2 & 3). Vasseygrass, molassesgrass, and kahili ginger (Hedychium gardnerianum) are representative of aliens in Disturbed 'Ohi'a Koa Forest but not in Disturbed 'Ohi'a Scrub (Table 19). This finding follows the observation that undisturbed scrub is less susceptible to invasion than undisturbed forest.

Casual observation of alien species along the Saddle Road may wrongly conclude that many roadside weeds are not dispersing into the surrounding communities. This observation is misled because most of the Saddle Road is built upon 1881 and 1855 lava flows which have been shown to be somewhat resistant to invasion. Twelve alien species that are "occasional" to "common" on the roadside and in Wet 'Ohi'a-Koa Forest are absent or "uncommon" in the Wet 'Ohi'a Scrub. The species in Table 19 from Paspalum urvillei to Tibouchina herbacea are representative of species with this pattern.

A relatively large number of native plants have vigorously reestablished in the disturbed areas under the powerline (Table 18). On the older substrates of t ? 'Ohi'a-Koa Forest, these include "common" or "occasional" occurrence of these native dominants: 'ohi'a, koa, uluhe (Dicranopteris linearis), treeferns (Cibotium spp. and Sadleria cyatheoides), and a number of other native small trees and shrubs (Table 2). The disturbed 'Ohi'a Scrub on the1881 lava flow below the powerline is recolonized with 'ohi'a, 'uki (Machaerina angustifolia), other natives; and, surprisingly, koa. Apparently the scarification of the lava by bulldozing has encouraged the invasion by koa (Table 3). It must be also noted that many pestiferous aliens are also abundant in these areas (Table 2 & 3).

The nearby 69 KV transmission line built in the mid-1950s (Wagner et al 1983) offers an observation of secondary succession following that construction event. On the 1881 lava flow, the 'Ohi'a Scrub shows strong reassertion of dominance by 'ohi'a and other natives. Similar areas within forest habitat were not surveyed and no observations can be reported.

Some Problem Species While all alien species, especially those known as noxious or pests (Table 17), are threats to native vegetation and should be controlled, a few that may have special implications to the powerline and Saddle Road corridors or may be poorly known are briefly discussed here.

Paspalum urvillei--vasseygrass

This tall grass is found in much of the wet zone in poorly drained sites under an open canopy. As such, it readily invades forest dieback areas and may develop a dense cover that will compete with seedlings of native plants. This is a recent invasion that is documented by its appearance in a number of permanently monitored survey plots in the wet zone (Gerrish, unpublished data). Efforts should be made to keep this grass from establishing in any parts of the Wet 'Ohi' or Wet 'Ohi'a-Koa Forests that might be disturbed during construction or operations. This is a plant that may cross the 'ohi'a scrub without growing on it.

Hedychium gardnerianum--kahili ginger

This aggressive herbaceous shrub occurs infrequently in the project vicinity, but is a major plant pest in the Hawaii

Volcanoes National Park. It was recorded on the roadside, in disturbed 'ohi'a-koa forest under the powerline, and in undisturbed 'ohi'a-koa forest. Kahili ginger spreads rapidly by both seed and rhizome forming dense, monotypic stands over a meter tall (Smith 1985). Efforts should be made to keep this plant from establishing in the Wet 'Ohi'a or Wet 'Ohi'a-Koa Forests disturbed during construction or operations, and should be eradicated wherever found.

Psidium cattleianum--waiawi or strawberry guava

Perhaps the most serious pest of Hawaiian rainforests, this tree should *not* be tolerated on any site. Efforts should be made to keep this plant from establishing in parts of the Wet 'Ohi' or Wet 'Ohi'a-Koa Forests that might be disturbed during construction or operations. It's fruit can readily be carried by animals to other favorable sites in the surrounding forest communities.

Tibouchina herbacea

This slender shrub has been found in many parts of the wet zone. It is another recent invader whose dispersal has been noted in permanent survey plots (Gerrish, unpublished data). Tibouchina is common in the disturbed under-powerline and in many slightly disturbed parts of the 'ohi'a-koa forest. It is uncommon in the scrub on the recent lava flows and, therefore, may appear to be non-invasive.

Rubus ellipticus--yellow Himalayan raspberry

During this survey, a single clump was seen above mile-marker 18 on the roadside, and a number of clumps were seen at the point where flume road crosses the powerline corridor (1960 ft. elevation). The two findings along roads may indicate that it is being spread by vehicles. This large bramble is now considered a major threat to closed forests in the Hawaii Volcanoes National Park, which is the center of its distribution on the island of Hawai'i (Gerrish et al unpublished manuscript). If uncontrolled, this alien will probably invade native forests of the wet zone.

RARE PLANTS

No plant species listed by the US Fish and Wildlife Service as threatened or endangered were found within or immediately adjacent to the easement. Nor were any plants currently proposed for listing as threatened or endangered found. Two populations of Rubus macraei were found within the easement along Saddle Road. This native raspberry is designated a "category 2" plant by the USFWS, meaning that there is evidence that it may be endangered, but further research is needed before its true status will be known (Federal Register 1990). One population of about 6 plants is in the Moist 'Ohi'a Scrub at 5976 ft. elevation on Saddle Road, above the access line to pump station 8. The plants are near a lava tube entrance about 60 feet from Saddle Road and should be avoided. The other population is in an 'ohi'a-koa kipuka just above 5540 and a short distance (perhaps 150 feet) north of Saddle Road.

Three legally protected endangered species (Lipochaeta venosa, Haplostachys haplostachys, and Isodendrion hosakae) are known to occur or to have occurred in the Parker Ranch in the general vicinity of the proposed "Alternative B" route (Wagner et al 1990). Recorded locations of these plants are all at least 500 m from the proposed alternative route as shown on drawings. Furthermore, all known locations are cinder cones that would naturally be avoided by the water system. It would be prudent, however, to consider all cinder cones and other isolated locations that are not heavily grazed by cattle to be potential sites for endangered species. Such cinder cones and other locations should be consciously avoided.

As many as ten rare plant species included on a list to be proposed for endangered status in 1992 may occur in the general vicinity of the water system easement (list provided by US FWS Endangered Species Office, Honolulu, Hawai'i). None of these plants were recorded in the present survey or by Warshauer (1986). Many of these species occur on the leeward side of Mauna Kea and could be within the Parker Ranch. Since the proposed easement across Parker Ranch was not staked before this survey, it is recommended that a qualified botanist survey the staked easement before clearing or construction begins. It is also recommended that within the Saddle Road and powerline corridors, the water system be kept as near the existing road and powerline right of way as possible to lessen the possibility of damage to any of these plants or their habitats.

RECOMMENDATIONS

POTENTIAL NEGATIVE IMPACTS

1) Fragmentation of habitat. Fragmentation, or the dividing of the forest into small pieces that cannot sustain themselves, is a major threat to the native ecosytems along the easement. The smaller fragments are more vulnerable to alien plant invasion or other degradation because they have a high ratio of habitat edge to habitat area. The rainforests of the wet and moist subzone extend to the north onto the windward slopes of Mauna Kea and to the South on to Mauna Loa and Kilauea. This submontane and montane rainforest is one of the largest extents of native vegetation remaining in the state. It is valuable as a biological resource precisely because it is a large block that minimizes the negative edge effect.

There is little worry that the presence of the physical facilities associated with the water system, added to those of the road and powerlines, will form a physical barrier interupting the normal ecological processes. However, the Saddle Road corridor is a potential weak point through the forest that can lead to more rapid invasion by alien plants. This corridor could be degraded by alien plant invasions and thus become a non-native zone that functions as a barrier to the normal processes within the forest.

the Saddle Road and the service road, never farther from Saddle Road than the service road.

b) move pumping stations 3 to 6 closer to Saddle Road.

c) avoid unneccessary driving or parking of equipment on undisturbed vegetation. Educate project planners, designers, and construction workers to the value of native Hawaiian plants and ecosystems. Most of the native plants of the Saddle Road corridor are found no where else on Earth. These plant communities are part of what visitors and researchers from all over the world come to see.

3) Mitigate potential negative impact of encouraging alien plants by:

a) Reduce the total amount of surface that is disturbed by construction activity since disturbed ground or crushed lava favors the establishment of alien plants.

b) Avoid disturbing 'ohi'a forests and 'ohi'a-koa forests in the wet zone by relocating pumping stations 3 through 6 on to the 1881 or 1855 lava flows closer to the Saddle Road. Pumping station 2 should also be built on the 1881 lava rather than in patches of forest in the area. This will both reduce the total area disturbed and avoid the

2) Unavoidable destruction of native vegetation during construction.

3) Encouragement of noxious alien plants by seed importation and site alterations.

4) Inadvertant destruction of rare plants.

MITIGATION OF NEGATIVE IMPACTS

1) The threat of forest fragmentation can be reduced by mitigating impacts 2 and 3 listed above, i.e. by minimizing the direct destruction of native vegetation and by preventing alien plants from becoming established within the easement. Specific recommendations are given below.

2) Destruction of some vegetation within the easement as the pipeline is being buried and other facilities are being constructed is, of course, unavoidable. This potential negative impact can be mitigated by minimizing the total area affected by the project. Destruction can be minimized by:

a) carefully siting all facilities as close to the powerline and Saddle Road as possible, within a few feet if this is practical. In most places, a service road associated with the existing powerlines parallels Saddle Road. The water pipeline should always be located between more easily invaded 'ohi'a forest and 'ohi'a-koa forest habitats. Visibility of the pumping stations can be reduced by:

b1) taking advantage of the undulating topography;

b2) landscape plantings of native plants. No alien plants should be used at the pump station sites. Alien plants might spread into and damage the native vegetation. Alien plants will appear incongruous and unaesthetic in the landscape.

The recent widening of the Saddle Road right-of-way promoted vigorous volunteer growth of native koa (<u>Acacia koa</u>) where the 1881 and 1855 lava flows had been crushed by heavy equipment, showing that koa could be grown on disturbed lava around the pumping stations. Koa is quick growing and could be used to shield facilities from sight at elevations less than 3200 feet, since that is where it naturally occurs. Koa plantings could also be attempted at pumping stations 4 and 5 which are above this elevation, but it might be necessary to use species that naturally occur in the surrounding 'ohi'a forest, such as 'ohi'a (<u>Metrosideros polymorpha</u>) and tree ferns (<u>Cibotium</u> spp.). Alien plants should not be used for landscaping any portion of the water system within the Saddle Road corridor.

c) Take advantage of natural regeneration capacity of the native vegetation. Observations of disturbed areas under the two powerlines through the Saddle Road corridor indicate that in most areas the native vegetation will eventually regrow following disturbance. By taking advantage of natural succession back to native vegetation, the need to control weeds will be greatly reduced or eliminated. A program should be developed to monitor and control growth of alien plants within the easement until it is completely revegetated with native plants. While short term treatment such as cutting or spot-spraying herbicides may be necessary to eliminate certain populations of aliens and to prevent them from releasing seed, encouraging the reestablishment of the normal native vegetation on the easement will be more effective in the long run.

4. Inadvertant destruction of endangered or rare plants can be avoided by:

a) Keeping all activities as near the Saddle Road and powerline right of way as possible and keeping to the routes that have been surveyed by the botanist.

b) Have a qualified botanist survey the easement through Parker Ranch after it is staked. If the "alternative B" route is chosen, have a botanist survey it after it is staked.

c) Avoid disturbing the populations of <u>Rubus macraei</u> described in "rare plants" section above.

Smith, C. W. 1985. Impact of alien plants on Hawai'i's native biota. in Hawai'i's Terrestrial Ecosystems Preservation and Management. Stone, C. P. and J. M. Scott eds. CPSU University of Hawai'i at Manoa, Honolulu, Hawai'i.

Wagner, W. L., D. R. Herbst, and S. H. Sohmer. 1990. Manual of the Flowering Plants of Hawai'i. University of Hawaii Press & Bishop Museum Press, Honolulu, Hawaii.

USACH. 1977. The Botanical Survey for the Installation Environmental Impact Statement U.S. Army Support Command, Hawai'i: Pohakuloa Training Area. Environment Impace Study Corp., Honolulu, Hawaii.

Wagner, W. L., F. R. Warshauer, W. C. Gagne, F. G. Howarth, G. M. Nishida, G. A. Samuelson, and C. C. Christensen. 1983. Biological Reconnaissance and Environmental Impact Assessment of HECO/HELCO Proposed Cross-Hawaii Island 138 KV Transmission Line: Botanical, Entomological & Malacological Report. in Environmental Impact Statement: Kaumana to Keamuku 138 KV Transmission Line. Prepared for Hawaii Electric LIght Company, Inc. by EDAW Inc.

Warshauer, F. R. 1986. Native Flora and Vegetaion Along The Saddle Road Right-Of-Way. in CDUA, CDUA Supplement and Environmental Impact Assessment For the Saddle Road

Smith, C. W. 1985. Impact of alien plants on Hawai'i's native biota. in Hawai'i's Terrestrial Ecosystems Preservation and Management. Stone, C. P. and J. M. Scott eds. CPSU University of Hawai'i at Manoa, Honolulu, Hawai'i.

Wagner, W. L., D. R. Herbst, and S. H. Sohmer. 1990. Manual of the Flowering Plants of Hawai'i. University of Hawaii Press & Bishop Museum Press, Honolulu, Hawaii.

USACH. 1977. The Botanical Survey for the Installation Environmental Impact Statement U.S. Army Support Command, Hawai'i: Pohakuloa Training Area. Environment Impace Study Corp., Honolulu, Hawaii.

Wagner, W. L., F. R. Warshauer, W. C. Gagne, F. G. Howarth, G. M. Nishida, G. A. Samuelson, and C. C. Christensen. 1983. Biological Reconnaissance and Environmental Impact Assessment of HECO/HELCO Proposed Cross-Hawaii Island 138 KV Transmission Line: Botanical, Entomological & Malacological Report. in Environmental Impact Statement: Kaumana to Keamuku 138 KV Transmission Line. Prepared for Hawaii Electric LIght Company, Inc. by EDAW Inc.

Warshauer, F. R. 1986. Native Flora and Vegetaion Along The Saddle Road Right-Of-Way. in CDUA, CDUA Supplement and Environmental Impact Assessment For the Saddle Road

Improvements, Island of Hawaii. County of Hawaii Dept. of Public Works.

Table 1. Representative species of the Wet Successional O'hi'a community (WSO). WSO community entirely within section A, located at the Waiakea well field (Figure 1). Species sorted to emphasize relative importance. N/A = native (N) or alien (A). Abundance = common (C), occasional (O), uncommon (U).

N/A	Species	Section A
N	Metrosideros polymorpha	C
N	Dicranopteris linearis	C
N	Cibotium glaucum	O
A	Psidium cattleianum	O
A	Melastoma malabarthicum	O
N	Cocculus ferrandianus	O
N	Rhus sandwicensis	U
A	Psidium guajava	U

Table 2. Representative species of the Wet O'hi'a-Koa Forest (WOK) along the water system easement recorded by Warshauer in 1986 (FRW) or by Gerrish in 1991. WOK community geographically subdivided into sections A to D beginning at easternmost part of easement (Figure 1 &2). AA and BB are disturbed communities under the 138 KV powerline within the A and B sections, respectively. Species sorted to emphasize geographic domain and relative importance. N/A = native (N) or alien (A). Abundance = common (C), occasional (O), uncommon (U), rare (R), not recorded (NR).

			Sections					
N/A	Species	FRW	A	B	C	D	AA	BB
N	*Metrosideros polymorpha*	C	C	C	C	C	U	O
N	*Acacia koa*	C	C	C	C	O	C	C
N	*Dicranopteris linearis*	C	C	C	C	C	C	C
N	*Cibotium chamissoi*	C	C	C	C	O	U	O
N	*Ilex anomala*	C	C	C	O	O		C
N	*Psychotria hawaiiensis*	O	O	C	O	U		O
N	*Broussaisia arguta*	C	O	C	C	O		
N	*Coprosma ochracea*	C	O	O	O	O		
N	*Coprosma rhynchocarpa*	O	O	O	O	O		
A	*Psidium cattleianum*	O	O	C		U	C	C
N	*Cheirodendron trigynum*	C	O	O				U
N	*Pritchardia beccariana*	U	O	U		R		
N	*Antidesma platyphyllum*	O	O	R				
N	*Sadleria cyatheoides*	C	O		C	O	O	O
N	*Astelia menziesiana*	U	U		O			
A	*Melaleuca leucodendra*	NR	C				C	
A	*Fraxinus uhdei*	NR	O				O	
A	*Spathodea campanulata*	NR	O				O	
N	*Pisonia umbellifera*	NR	U					
N	*Tetraplasandra meiandra*	U	R					
A	*Tibouchina herbacea*	U		C	C	O	C	C
N	*Cibotium glaucum*	C		C	C	O		O
N	*Clermontia parviflora*	O		C	C			O
N	*Pelea clusiifolia*	O		O	O	O		O
N	*Freycinetia arborea*	O		C	O			
N	*Clermontia montis-loa*	U		O		O		
N	*Scaevola chamissoniana*	U		U		O		
N	*Gouldia terminalis*	NR		O		O		
N	*Perrottetia sandwicensis*	O		O				O
N	*Elaphoglossum alatum*	O		C				
N	*Peperomia* sp.	O		O				
N	*Pelea pseudoanisata*	O		U				
N	*Alyxia olivaeformis*	O		U				
N	*Cyrtandra lysiosepala*	U		U				
A	*Hedychium gardnerianum*	NR		O				O
A	*Paspalum urvillei*	NR		O				C
A	*Grevillea robusta*	NR		C				
A	*Eucalyptus robusta*	NR		U				

Table 2. (Continued) WET 'OHI'A-KOA FOREST (WOK)

			Section					
N/A	Species	FRW	A	B	C	D	AA	BB
N	Hedyotis centranthoides	NR			O	O		O
N	Vaccinium calycinum	O			O	O		O
A	Arundinia bambusifolia	O			O	O	O	O
A	Rubus rosifolius	O			O		O	
A	Melinis minutiflora	NR			C			
N	Psilotum nudum	U			O			
N	Machaerina angustifolia	O				O	O	C
A	Andropogon virginicus	U				O	C	C
A	Saciolepis indica	O				O		O
A	Sphenomeris chusana	NR				O	O	
A	Hypericum degenerii	NR				O		
N	Luzula hawaiiensis	NR				C		
N	Pipturus albidus	O				O		O
N	Myrsine lessertiana	O				O		O
N	Lycopodium cernuum	NR				O		
N	Elaphoglossum hirtum	NR				O		
N	Hicriopteris pinnata	NR				O		
N	Pittosporum hawaiiense	NR				U		
N	Labordia hedyosmifolia	NR				U		
N	Gahnia gahniiformis	O				O		
N	Stenogyne calaminthoides	O				O		
N	Myrsine sandwicensis	U				O		
N	Smilax sandwicensis	U				U		
N	Styphelia tamaeiameiae	U				U		
A	Pluchea odorata	NR					C	C
A	Melastoma malabarthicum	NR					O	O
A	Melochia umbellata	NR					O	R
A	Cuphea carthagenensis	NR					O	O
A	Passiflora edulis	NR					O	O
A	Ludwigia octivalis	NR					O	U
A	Trema orientalis	NR					U	
A	Albizia falcataria	NR					O	
A	Juncus spp.	NR					C	
A	Ageratum conyzoides	NR					O	
A	Schizachyrium condensatum	NR					U	
A	Panicum repens	NR					O	
A	Setaria palmifolia	NR					U	
N	Adenophorus spp.	C						O
A	Buddleja asiatica	NR						O

Table 2. (Continued) WET 'OHI'A-KOA FOREST (WOK)

N/A	Species	FRW	A	B	C	D	AA	BB
N	Rubus hawaiiensis	O						
N	Asplenium lobulatum	O						
N	Athyrium sandwicianum	O						
N	Psychotria hillebrandii	O						
N	Carex alligata	O						
N	Microlepia strigosa	O						
N	Lycopodium phyllanthum	U						
N	Polypodium pellucidum	U						
N	Cyrtandra platyphyllum	U						
N	Cibotium hawaiiense	U						

Table 3. Representative species of the Wet O'hi'a Scrub (WOS) along the water system easement recorded by Warshauer in 1986 (FRW) or by Gerrish in 1991. WOS community geographically subdivided into sections A to D beginning at easternmost part of easement (Figure 1 & 2). AA is disturbed community under the 138 KV powerline within the A section. Species sorted to emphasize geographic domain and relative importance. N/A = native (N) or alien (A). Abundance = common (C), occasional (O), uncommon (U), rare (R), not recorded (NR).

			Section				
N/A	Species	FRW	A	B	C	D	AA
N	*Metrosideros polymorpha*	C	C	C	C	C	C
N	*Dicranopteris linearis*	C	C	C	C	C	
N	*Machaerina angustifolia*	C	C	C	C	C	C
N	*Lycopodium cernuum*	NR	C	C	C	C	O
A	*Andropogon virginicus*	O	O	C	O	O	C
A	*Arundinia bambusifolia*	O	U	O		O	O
A	*Albizia falcataria*	NR	U	R			
A	*Tibouchina herbacea*	NR	U				C
A	*Melaleuca leucodendra*	NR	U				
N	*Cibotium glaucum*	NR	O				
N	*Pritchardia beccariana*	NR	R				
N	*Vaccinium calycinum*	U		U	O	O	
N	*Polypodium pellucidum*	NR		U	O	O	
N	*Hedyotis centranthoides*	NR		O		O	
A	*Psidium cattleianum*	NR		U			U
A	*Melastoma malabarthicum*	NR		U			O
N	*Coprosma ernodeoides*	NR			C	C	
N	*Styphelia tameiameiae*	NR			C	O	
N	*Dubautia scabra*	NR			O	C	U
N	*Sadleria cyatheoides*	C			O	O	U
N	*Cheirodendron trigynum*	O			O	O	
N	*Cibotium glaucum*	O			O	O	
N	*Vaccinium reticulatum*	NR			O	O	
N	*Deschampsia australis*	NR				O	
N	*Coprosma ochracea*	O				O	
N	*Acacia koa*	NR					O
N	*Pipturus albidus*	NR					U
N	*Rhus sandwicensis*	NR					R
A	*Sphenomeris chusana*	NR					O
A	*Rubus rosifolius*	NR					U
A	*Pluchea odorata*	NR					C
A	*Rubus ellipticus*	NR					U
A	*Trema orientalis*	NR					R
A	*Melochia umbellata*	NR					U
A	*Polygonum capitatum*	NR					O
N	*Gahnia gahniiformis*	O					
N	*Ilex anomala*	U					
N	*Psilotum nudum*	U					
N	*Adenophorus* spp.	O					

Table 4. Representative species of the Wet O'hi'a Forest (WOF) along the water system easement recorded by Warshauer in 1986 (FRW) or by Gerrish in 1991. WOF community geographically subdivided into sections A and B beginning at easternmost part of easement (Figure 2). Species sorted to emphasize geographic domain and relative importance. N/A = native (N) or alien (A). Abundance = common (C), occasional (O), uncommon (U), rare (R), not recorded (NR).

N/A	Species	FRW	Sections A	Sections B
N	Metrosideros polymorpha	C	C	C
N	Machaerina angustifolia	C	C	C
N	Coprosma ochracea	C	C	C
N	Sadleria cyatheoides	C	C	C
N	Myrsine lessertiana	U	C	O
N	Dicranopteris linearis	C	C	U
N	Clermontia montis-loa	U	C	U
N	Cibotium glaucum	C	O	C
N	Cheirodendron trigynum	C	O	O
N	Broussaisia arguta	C	O	O
N	Cibotium chamissoi	C	O	O
N	Coprosma rhynchocarpa	O	O	O
N	Styphelia tamaeiameiae	U	O	O
N	Peperomia spp.	O	U	O
N	Alyxia olivaeformis	O	U	U
N	Labordia hedyosmifolia	NR	U	O
N	Hedyotis centranthoides	NR	U	O
N	Thelypteris spp.	NR	U	C
N	Astelia menziesiana	NR	U	O
N	Gouldia terminalis	NR	U	O
A	Juncus spp.	NR	C	C
A	Nephrolepis cordifolia	NR	O	C
A	Uncinia uncinata	NR	O	O
A	Rubus rosifolius	O	U	U
N	Asplenium lobulatum	O	R	U
A	Andropogon virginicus	O	C	
A	Saciolepis indica	O	C	
A	Paspalum urvillei	NR	C	
N	Lycopodium cernuum	NR	C	
N	Clermontia parviflora	O	O	
N	Carex alligata	O	O	
N	Gahnia gahniiformis	O	O	
N	Hicriopteris pinnata	O	O	
N	Sticherus owhyhensis	NR	O	
N	Nertera granadensis	NR	U	
N	Wikstroemia spp.	NR	U	
N	Pelea clusiifolia	NR	U	
N	Stenogyne calaminthoides	O	U	
N	Tetraplasandra meiandra	U	R	

Table 4. (Continued) WET 'OHI'A FOREST (WOF)

N/A	Species	FRW	Sections A	Sections B
A	Paspalum conjugatum	O	O	
A	Cuphea carthagenensis	NR	O	
A	Sphenomeris chusana	NR	O	
A	Erechtites hieracifolia	NR	O	
A	Psidium cattleianum	O	U	
A	Tibouchina herbacea	U	U	
A	Aristea ecklonii	U	U	
N	Elaphoglossum hirtum	NR		C
N	Vaccinium calycinum	O		O
N	Ilex anomala	O		O
N	Rubus hawaiiensis	O		O
N	Athyrium sandwicianum	O		O
N	Pelea pseudoanisata	O		U
N	Microlepia strigosa	O		U
N	Cyrtandra lysiosepala	NR		U
N	Cyrtandra platyphyla	NR		U
N	Adenophorus spp.	C		
N	Antidesma platyphyllum	O		
N	Perrottetia sandwicensis	O		
N	Psychotria hawaiiensis	O		
N	Psychotria hillebrandii	O		
N	Freycinetia arborea	O		
N	Pipturus albidus	O		
N	Elaphoglossum alatum	O		
N	Rhsu sandwicensis	U		
N	Myrsine sandwicensis	U		
N	Scaevola chamissoniana	U		
N	Smilax sandwicensis	U		
N	Lycopodium phyllanthum	U		
N	Polypodium pellucidum	U		
N	Psilotum nudum	U		
A	Arundinia bambusifolia	O		
A	Melastoma malabarthicum	U		

Table 5. Representative species of the Moist O'hi'a Scrub (MOS) along the water system easement recorded by Warshauer in 1986 (FRW) or by Gerrish in 1991. MOS community geographically subdivided into sections A to C beginning at easternmost boundary of the moist vegetation zone along the easement (Figure 3). Species sorted to emphasize geographic domain and relative importance. N/A = native (N) or alien (A). Abundance = common (C), occasional (O), uncommon (U), not recorded (NR).

N/A	Species	FRW	Section A	Section B	Section C
N	Vaccinium reticulatum	O	C	C	C
N	Coprosma ernodeoides	C	C	C	C
N	Metrosideros polymorpha	C	O	C	C
N	Styphelia tamaeiameiae	C	O	C	C
N	Deschampsia australis	C	O	C	C
N	Dryopteris paleacea	C	O	C	C
N	Pteridium aquilinum	O	O	O	C
N	Vaccinium calycinum	NR	O	C	O
N	Polypodium pellucidum	U	O	U	
N	Sadleria cyatheoides	C	O	C	
N	Dicranopteris linearis	C	O	U	
N	Dubautia scabra	O	O		
N	Hedyotis centranthoides	O	O		
N	Cibotium glaucum	O	O		
N	Pellaea ternifolia	NR	O		
N	Myrsine lessertiana	NR	O		
N	Luzula hawaiiensis	U	U		
N	Uncinia uncinata	U	U		
A	Rubus argutus	NR	U		
A	Myoporum sandwicensis	NR	U		
N	Rubus hawaiiensis	NR		U	
N	Rubus macraei	NR		U	
N	Geraneum cuneatum	NR		U	
N	Dubautia cilliolata	NR			O
N	Carex wahuensis	U			O
N	Adenophorus spp.	NR			O
N	Machaerina angustifolia	O			
N	Gahnia gahniiformis	O			
N	Astelia menziesiana	O			
N	Psilotum nudum	O			
		U			

Table 6. Representative species of the Moist O'hi'a Forest (MOF) along the water system easement recorded by Warshauer in 1986 (FRW) or by Gerrish in 1991 (A) (Figure 3). Species sorted to emphasize geographic domain and relative importance. N/A = native (N) or alien (A). Abundance = common (C), occasional (O), uncommon (U), not recorded (NR).

N/A	Species	FRW	A
N	Metrosideros polymorpha	C	C
N	Cheirodendron trigynum	C	C
N	Myrsine lessertiana	C	O
N	Ilex anomala	C	O
N	Cibotium glaucum	C	C
N	Cibotium chamissoi	C	C
N	Sadleria cyatheoides	C	C
N	Dryopteris paleacea	C	O
N	Coprosma ernodeoides	C	C
N	Elaphoglossum wawrae	O	C
N	Elaphoglossum hirtum	NR	C
N	Dicranopteris linearis	O	O
N	Styphelia tamaeiameiae	O	O
N	Gouldia terminalis	NR	O
N	Coprosma ochracea	O	O
N	Coprosma rhynchocarpa	O	O
N	Vaccinium reticulatum	O	O
N	Vaccinium calycinum	O	O
N	Dubautia scabra	O	O
N	Hedyotis centranthoides	O	O
N	Broussaisia arguta	O	O
N	Rubus hawaiiensis	O	O
N	Astelia menziesiana	U	O
N	Stenogyne calaminthoides	U	O
N	Machaerina angustifolia	O	O
N	Deschampsia australis	O	O
A	Uncinia uncinata	NR	O
N	Gahnia gahniiformis	O	U
N	Athyrium sandwicianum	O	O
N	Microlepia strigosa	O	O
N	Thelypteris globulifera	NR	O
N	Lycopodium cernuum	NR	O
N	Smilax sandwicensis	U	U
N	Stenogyne rugosa	U	U
A	Rubus argutus	NR	U
A	Rubus rosifolius	O	
A	Saciolepis indica	O	
N	Polypodium pellucidum	C	
N	Adenophorus spp.	O	
N	Pelea clusiifolia	O	

Table 6. (Continued) Moist O'hi'a Forest (MOF).

		FRW	A
N	<u>Alyxia</u> <u>olivaeformis</u>	O	
N	<u>Clermontia</u> <u>parviflora</u>	O	
N	<u>Pipturus</u> <u>albidus</u>	O	
N	<u>Asplenium</u> <u>lobulatum</u>	O	
N	<u>Carex</u> <u>alligata</u>	O	
N	<u>Peperomia</u> sp.	O	
N	<u>Nertera</u> <u>granadensis</u>	O	
N	<u>Panicum</u> <u>tenuifolium</u>	O	
N	<u>Pteridium</u> <u>awuilinum</u>	O	
N	<u>Psilotum</u> <u>nudum</u>	U	
N	<u>Luzula</u> <u>hawaiiensis</u>	U	
N	<u>Clermontia</u> <u>montis-loa</u>	U	
N	<u>Myrsine</u> <u>sandwicensis</u>	U	
N	<u>Cyrtandra</u> <u>platyphyllum</u>	U	
N	<u>Dodonaea</u> <u>viscosa</u>	U	
N	<u>Trisetum</u> <u>glomeratum</u>	U	

Table 7. Representative species of the Moist O'hi'a-Koa Forest (MOK) along the water system easement recorded by Warshauer in 1986 (FRW) or by Gerrish in 1991. MOK community geographically subdivided into sections A and B, beginning at easternmost boundary of the moist vegetation zone along the easement (Figure 3). Species sorted to emphasize geographic domain and relative importance. N/A = native (N) or alien (A). Abundance = common (C), occasional (O), uncommon (U), rare (R), not recorded (NR).

N/A	Species	FRW	Section A	Section B
N	Metrosideros polymorpha	C	C	C
N	Rubus hawaiiensis	O	C	O
N	Elaphoglossum wawrae	O	C	C
N	Stenogyne calaminthoides	O	C	O
N	Acacia koa	C	O	C
N	Coprosma ernodeoides	O	O	C
N	Styphelia tamaeiameiae	O	O	C
N	Deschampsia australis	O	O	O
N	Vaccinium calycinum	O	O	O
N	Carex alligata	O	O	O
N	Elaphoglossum hirtum	NR	O	O
N	Thelypteris globulifera	NR	O	O
A	Uncinia uncinata	NR	O	O
N	Polypodium pellucidum	C	C	
N	Sadleria cyatheoides	C	C	
N	Myrsine lessertiana	C	C	
N	Cheirodendron trigynum	C	C	
N	Alyxia olivaeformis	O	C	
N	Cibotium chamissoi	C	O	
N	Ilex anomala	C	O	
N	Gahnia gahniiformis	C	O	
N	Athyrium sandwicianum	O	O	
N	Dubautia scabra	U	O	
N	Dryopteris paleacea	NR	O	
N	Coprosma ochracea	O	U	
N	Coprosma rhynchocarpa	O	U	
N	Microlepia strigosa	O	U	
N	Peperomia sp.	O	U	
N	Smilax sandwicensis	U	U	
N	Carex wahuensis	NR	U	
N	Gouldia terminalis	NR	U	
N	Myoporum sandwicensis	NR	R	
N	Rubus macraei	NR	R	
A	Fragaria sp.	NR		O
N	Santalum paniculatum	NR		O
N	Cibotium glaucum	C		O

Table 7. (Continued) Moist O'hi'a-Koa Forest (MOK).

N/A	Species	FRW	Section A	Section B
N	Adenophorus spp.	C		
N	Machaerina angustifolia	O		
N	Broussaisia arguta	O		
N	Pelea clusiifolia	O		
N	Pelea pseudoanisata	O		
N	Psychotria hawaiiensis	O		
N	Psychotria hillebrandii	O		
N	Clermontia parviflora	O		
N	Pipturus albidus	O		
N	Asplenium lobulatum	O		
A	Rubus rosifolius	O		
A	Saciolepis indica	O		
N	Nertera granadensis	O		
N	Panicum tenuifolium	O		
N	Pteridium aquilinum	O		
N	Astelia menziesiana	U		
N	Psilotum nudum	U		
N	Luzula hawaiiensis	U		
N	Clermonita montis-loa	U		
N	Myrsine sandwicensis	U		
N	Cyrtandra platyphyllum	U		
N	Dodonaea viscosa	U		
N	Stenogyne rugosa	U		
N	Trisetum glomeratum	U		
N	Tetraplasandra meiandra	U		
N	Sophora chrysophylla	U		
N	Peperomia macraeana	U		

Table 8. Representative species of the Moist Mixed Shrubs community (MMS) along the water system easement recorded by Warshauer in 1986 (FRW) or by Gerrish in 1991. MMS community geographically subdivided into sections A to C, beginning at easternmost boundary of the moist vegetation zone along the the easement (Figure 3). Species sorted to emphasize geographic domain and relative importance. N/A = native (N) or alien (A). Abundance = common (C), occasional (O), uncommon (U), not recorded (NR).

			Section		
N/A	Species	FRW	A	B	C
N	<u>Deschampsia australis</u>	O	C	C	C
A	<u>Anthoxanthum odoratum</u>	NR	C	C	C
A	<u>Hypochoeris radicata</u>	NR	C	O	C
N	<u>Vaccinium reticulatum</u>	C	C	C	
N	<u>Coprosma ernodeoides</u>	O	C	C	
N	<u>Dryopteris paleacea</u>	NR	C	O	
N	<u>Styphelia tamaeiameiae</u>	C		C	C
A	<u>Rumex acetosella</u>	NR		C	C
N	<u>Geranium cuneatum</u>	O		U	
N	<u>Vaccinium calycinum</u>	U		U	
N	<u>Dubautia cilliolata</u>	U		U	
N	<u>Pteridium aquilinum</u>	NR			C
A	<u>Ulex europaeus</u>	NR			C
A	<u>Holcus lanatus</u>	NR			C
A	<u>Verbena litoralis</u>	NR			O
A	<u>Verbascum thapsis</u>	NR			O
N	<u>Dicranopteris linearis</u>	O			

Table 9. Representative species of the Moist Sparse Pioneer community (MSP) along the water system easement recorded by Warshauer in 1986 (FRW) or by Gerrish in 1991. MSP community geographically subdivided into sections A to D, beginning at easternmost boundary of the moist vegetation zone along the easement (Figure 3). Species sorted to emphasize geographic domain and relative importance. N/A = native (N) or alien (A). Abundance = common (C), occasional (O), uncommon (U), not recorded (NR).

			Section			
N/A	Species	FRW	A	B	C	D
N	_Coprosma ernodeoides_	C	O	C	O	O
N	_Vaccinium reticulatum_	C	O	O	O	O
N	_Polypodium pellucidum_	C	C	C		O
N	_Metrosideros polymorpha_	C	C			
N	_Hedyotis centranthoides_	O	O			
N	_Dubautia scabra_	C		O	U	O
N	_Pteridium aquilinum_	NR			U	U
N	_Styphelia tameiameiae_	C				U
N	_Dubautia cilliolata_	NR				U

Table 10. Representative species of the Moist Koa-Mamane Pasture community (MKM) along the water system easement recorded by Warshauer in 1986 (FRW) or by Gerrish in 1991 (A) (Figure 3). Species sorted to emphasize geographic domain and relative importance. N/A = native (N) or alien (A). Abundance = common (C), occasional (O), uncommon (U), not recorded (NR).

N/A	Species	FRW	A
A	Pennisetum clandestinum	C	C
A	Anthoxanthum odoratum	NR	C
N	Deschampsia australis	NR	O
N	Acacia koa	O	O
N	Metrosideros polymorpha	NR	O
N	Myoporum sandwicense	NR	O
N	Pteridium aquilinum	O	O
N	Sophora chrysophylla	O	O
N	Vaccinium reticulatum	NR	O
N	Coprosma ernodeoides	NR	O
N	Dryopteris paleacea	NR	O
N	Trisetum glomeratum	U	

Table 11. Representative species of the Moist 'Ohi'a Pasture community (MOP) along the water system easement recorded by Gerrish in 1991 (A) (Figure 3). Species sorted to emphasize geographic domain and relative importance. N/A = native (N) or alien (A). Abundance = common (C), occasional (O), uncommon (U), not recorded (NR).

N/A	Species	A
N	*Metrosideros polymorpha*	C
A	*Anthoxanthum odoratum*	C
N	*Deschampsia australis*	C
A	*Acacia koa*	O
N	*Myoporum sandwicense*	O
N	*Vaccinium reticulatum*	O
N	*Coprosma ernodeoides*	O
N	*Dryopteris palleacea*	O

Table 12. Representative species of the Dry Sparse Pioneer community (DSP) along the water system easement recorded by Warshauer in 1986 (FRW) or by Gerrish in 1991 (A) (Figure 4). Species sorted to emphasize relative importance. N/A = native (N) or alien (A). Abundance = common (C), occasional (O), uncommon (U), not recorded (NR).

		FRW	A
N	Polypodium pellucidum	NR	O
N	Styphelia tamaeiameiae	U	U
N	Vaccinium reticulatum	U	U
N	Metrosideros polymorpha	NR	U
N	Coprosma ernodeoides	O	
N	Dubautia scabra	O	

Table 13. Representative species of the Dry Mamane-Naio Forest (DMN) along the water system easement recorded by Warshauer in 1986 (FRW) or by Gerrish in 1991. DMN community geographically subdivided into sections A and B beginning at easternmost boundary of the dry vegetation zone along the easement (Figure 4). Species sorted to emphasize geographic domain and relative importance. N/A = native (N) or alien (A). Abundance = common (C), occasional (O), uncommon (U), not recorded (NR).

N/A		1986 FRW	Section A	Section B
N	*Sophora chrysophylla*	C	C	C
N	*Myoporum sandwicense*	C	C	C
N	*Chenopodium oahuense*	O	C	O
A	*Hypochoeris radicata*	NR	C	
A	*Verbascum thapsis*	U	O	
A	*Pennisetum setaceum*	U	O	
A	*Centaureum erythraea*	NR	O	
A	*Brassica campestris*	NR	O	
A	*Lactuca scariola*	NR	O	
N	*Argemone glauca*	NR	U	
N	*Eragrostis atropioides*	O		C
N	*Coprosma montana*	O		O
N	*Bidens menziesii* var. *filiformis*	U		O
N	*Osteomeles anthyllidifolia*	U		O
N	*Santalum paniculatum*	U		O
N	*Euphorbia olowaluana*	U		O
N	*Myrsine lanaiensis*	NR		O
N	*Polypodium pellucidum*	O		
N	*Stenogyne microphylla*	U		
N	*Pteridium aquilinum*	U		
N	*Panicum tenuifolium*	U		
N	*Trisetum glomeratum*	U		
N	*Sicyos pachycarpus*	U		

Table 14. Representative species of the Dry *Chenopodium* Scrub (DCS) along the water system easement recorded by Warshauer in 1986 (FRW) or by Gerrish in 1991. DCS community geographically subdivided into sections A and B, beginning at easternmost boundary of the dry vegetation zone along the easement (Figure 4). Species sorted to emphasize geographic domain and relative importance. N/A = native (N) or alien (A). Abundance = common (C), occasional (O), uncommon (U), not recorded (NR).

N/A		FRW	Section A	Section B
N	*Chenopodium oahuense*	C	C	C
N	*Eragrostis atropioides*	C	C	C
N	*Deschampsia australis*	U	C	C
N	*Dodonaea viscosa*	U	U	C
N	*Sophora chrysophylla*	U	O	
A	*Bromus* sp.	NR	O	
A	*Brassica campestris*	NR	O	
N	*Myoporum sandwicense*	U	U	
A	*Dactylis glomeratus*	NR		C
A	Pennisetum setaceum	U		O
N	*Bidens menziesii* var. *filiformis*	U		O
N	*Osteomeles anthyllidifolia*	U		O
A	*Verbascum thapsis*	U		
N	*Panicum tenuifolium*	U		
N	*Trisetum glomeratum*	U		
N	*Euphorbia olowaluana*	U		
N	*Santalum paniculatum*	U		
N	*Myrsine lanaiensis*	U		
N	*Dubautia linearis*	U		

Table 15. Representative species of the Roadside community (RS) growing on the Saddle Road shoulder along the water system easement recorded by Warshauer in 1986 (FRW) or by Gerrish in 1991). The roadside community divided into vegetation zones: WET, MOIST and DRY; and into geographic sections A to H following the Saddle Road from east to west (Figures 1-4). Species sorted to emphasize geographic domain and relative importance. N/A = native (N) or alien (A). Abundance = common (C), occasional (O), uncommon (U), rare (R), not recorded (NR).

N/A		FRW	WET			MOIST		DRY		
			A	B	C	D	E	F	G	H
A	<u>Andropogon virginicus</u>	C	C	C		O	O			
A	<u>Paspalum urvillei</u>	O	O	C	C	C				
A	<u>Saciolepis indica</u>	O	O	O	C	C				
N	<u>Metrosideros polymorpha</u>	C	C	C	C	O				
N	<u>Cyperus polystachyus</u>	NR	O	O	O					
A	<u>Pluchea odorata</u>	NR	O	O	O					
A	<u>Arundinia bambusifolia</u>	O	U	O	U					
A	<u>Axonopus affinis</u>	NR	C		C					
A	<u>Melinus minutiflora</u>	NR	C		O					U
A	<u>Tibouchina herbacea</u>	O	O		U					
A	<u>Juncus</u> spp.	NR	O		O					
A	<u>Hypochoeris radicata</u>	NR	O		O			C	O	
A	<u>Setaria geniculata</u>	NR	C			C				
N	<u>Dicranopteris linearis</u>	NR	C							
A	<u>Desmodium uncinatum</u>	NR	C							
A	<u>Paspalum orbiculare</u>	O	O							
A	<u>Paspalum conjugatum</u>	C	C							
A	<u>Polygonum capitatum</u>	NR	C							
A	<u>Nephrolepis cordifolia</u>	NR	C							
A	<u>Mimosa pudica</u>	NR	C							
A	<u>Hedychium gardnerianum</u>	NR	U							
A	<u>Tritonia crocosmiflora</u>	NR	U							
A	<u>Impatiens sultani</u>	NR	U							
A	<u>Castilleja arvensis</u>	NR	U							
A	<u>Plantago major</u>	NR	U							
A	<u>Aristea ecklonii</u>	U	U							
A	<u>Ageratum conyzoides</u>	NR	O							
A	<u>Buddleja asiatica</u>	NR		O	C	O				
A	<u>Pennisetum clandestinum</u>	O		C	O	O				
A	<u>Trifolium repens</u>	NR		O	O			O		
A	<u>Anthoxanthum odoratum</u>	NR		C	C			C		
A	<u>Holcus lanatus</u>	NR		O	O			O		
A	<u>Melilotus indica</u>	NR		O	C					O
A	<u>Geranium homeanum</u>	NR		O	C					
N	<u>Rhus sandwicensis</u>	U		U						
N	<u>Dubautia scabra</u>	NR		U						
A	<u>Eupatorium riparium</u>	NR		U						
A	<u>Verbena litoralis</u>	NR		U				U	O	O
A	<u>Lotus subbiflorus</u>	NR		O						

Table 15. (Continued) Roadside community (RS).

N/A		FRW	WET A	WET B	WET C	MOIST D	MOIST E	DRY F	DRY G	DRY H
N	Sophora chrysophylla	U			U	U				
A	Schizachyrium condensatum	NR			U					
A	Rubus rosifolius	O			O					
A	Rubus ellipticus	NR			U					
N	Rubus hawaiiensis	NR			O					
A	Anemone japonica	NR			O					
N	Luzula hawaiiense	NR			C					
A	Gnaphalium japonicum	O	U			O	O	O	C	O
A	Oenothera affinis	NR				O	O	C	O	O
A	Verbascum thapsis	NR				C	C			
N	Vaccinium reticulatum	NR				C	O			
N	Machaerina angustifolia	NR				O				
A	Sporobolus indicus	NR				O		C		
N	Deschampsia australis	U					O	O		C
N	Pteridium aquilinum	NR					O			
A	Bromus sp.	NR						O	O	O
A	Pennisetum setaceum	O	R			U		C	C	O
A	Trifolium arvense	NR						C		
A	Dactylis glomeratus	NR						O		
A	rumex acetosella	NR						O		
N	Pellaea ternifolia	NR						O		
A	Plantago lanceolata	NR						U		
N	Dodonaea viscosa	NR						U		
N	Chenopocium oahuensis	NR						U		C
A	Brassica campestris	NR							O	O
A	Lactuca scariola	NR							C	
A	Medicago sativa	NR								O
A	Heterotheca grandiflora	NR								C
A	Psidium cattleianum	O								
A	Melastoma malabarthicum	U								

Table 16. Numbers of alien species recorded by Warshauer (1986) or Gerrish in 1991 within the powerline corridor or the Saddle road corridor; and a division of those that occur only on the Saddle Road shoulder or in disturbed area under the powerline and those that occur in relatively undisturbed native communities.

TOTAL ALIEN SPECIES:	75
FOUND ONLY ON ROADSIDE OR UNDER POWERLINE:	37
ON ROADSIDE (RS) ONLY:	22
UNDER POWERLINE ONLY:	9
ON ROADSIDE AND UNDER POWERLINE ONLY:	6
FOUND WITHIN UNDISTURBED COMMUNITIES:	38
SPECIES LISTED AS PESTS:	19
SPECIES LISTED AS NOXIOUS:	3
ADDITIONAL SPECIES CONSIDERED PESTS BY GERRISH:	3

Table 17. Alien plants recorded by Warshauer (1986) or Gerrish in 1991 within the Powerline corridor or Saddle Road corridor whose STATUS is listed as either "weed pests" (P) or "noxious" by Smith (1985); or are considered to be serious forest pests based on unpublished data (Gerrish). COMMUNITY abbreviations given in text.

SPECIES	STATUS		COMMUNITY				
Albizia falcataria	P		WOS	WOK*			
Andropogon virginicus	P	RS	WOS	WOK	WOF		
Anthoxanthum odoratum	P	RS	MMS	MKM	MOP		
Fraxinus uhdei	P		WOK				
Grevillea robusta	P		WOK				
Hedychium gardnerianum	P	RS	WOK				
Holcus lanatus	P	RS	MMS				
Hypochoeris radicata	P	RS	MMS	DMN			
Melaleuca leucadendra	P		WOS	WOK			
Melastoma malabarthicum	P	RS	WSO	WOS*	WOF	WOK	
Melinis minutiflora	P	RS	WOK				
Melochia umbellata	P		WOS	WOK			
Paspalum conjugatum	P	RS	WOF				
Paspalum urvillei	G	RS	WOK	WOF			
Pennisetum clandestinum	P	RS	MKM				
Pennisetum setaceum	N	RS	DMN	DCS			
Pluchea odorata	P	RS	WOS*	WOK*			
Psidium cattleianum	P	RS	WSO	WOS	WOK	WOF	
Psidium guajava	P		WSO				
Rubus argutus	N		MOS	MOF			
Rubus ellipticus	P	RS	WOS*				
Rubus rosifolius	G		WOS*	WOK	WOF	MOF	MOK
Saciolepis indica	P	RS	WOK	WOF	MOF	MOK	
Schizachyrium condensatum	P	RS	WOK*				
Setaria palmifolia	P		WOK*				
Spathodea campanulata	P		WOK				
Tibouchina herbacea	G	RS	WOS	WOK	WOF		
Ulex europaeus	N		MMS				
Verbascum thapsis	P	RS	MMS	DMN	DCS		

* Found only in disturbed part of habitat under powerline.

Table 18. The number of alien and native species recorded by Warshauer (1986) or Gerrish in 1991 in each community. "Wet 'Ohi'a-Koa Forest" and "Wet 'Ohi'a Scrub" do not include species found only in the distrubed under-powerline area. Grazed pasture communities (Moist Koa-Mamane Pasture and Moist 'Ohi'a Pasture) not included.

COMMUNITY	TOTAL ALIENS	ALIEN PESTS*	NOXIOUS ALIENS**	TOTAL NATIVES
Wet Successional 'Ohi'a	3	2	1	5
Wet 'Ohi'a-Koa Forest	16	12	0	57
Wet 'Ohi'a Scrub	7	5	1	25
Wet 'Ohi'a Forest	16	7	1	56
Disturbed Wet 'Ohi'a-Koa Forest	27	15	0	27
Disturbed Wet 'Ohi'a Scrub	12	7	0	8
Moist 'Ohi'a Scrub	2	0	1	28
Moist 'Ohi'a Forest	4	2	1	55
Moist 'Ohi'a-Koa Forest	4	2	0	59
Moist Mixed Shrubs	7	4	1	10
Moist Sparse Pioneer	0	0	0	9
Dry Sparse Pioneer	0	0	0	6
Dry Mamane-Naio Forest	6	2	1	17
Dry *Chenopodium* Scrub	4	1	1	14
Roadside	54	16	1	15

* Listed as "pests" by Smith (1985) or additional species considered pests by Gerrish.
** Listed as "noxious" in Smith (1985).

Table 19. Selected alien species in the various communities of the WET, MOIST, and DRY vegetation zones with distributions illustrative of the major trends of alien species invasions. RS = Roadside, DOK = Disturbed 'Ohi'a-Koa Forest, DOS = Disturbed 'Ohi'a Scrub, OK = 'Ohi'a-Koa Forest, OF = 'Ohi'a Forest, MS = Mixed Shrubs, SP = Sparse Pioneer, CS = *Chenopodium* Scrub, MN = Mamane-Naio Forest; C = Common, O = Occasional, U = Uncommon.

Alien Species	COMMUNITIES																
	WET						MOIST						DRY				
	RS	DOK	DOS	OK	OF	OS	RS	OK	OF	OS	MS	SP	RS	CS	MN	SP
PRIMARILY WET WEEDS																	
*Andropogon** *virginicus*	C	C	C	C	-	C	O	-	-	-	-	-	-	-	-	-
Arundinia bambusifolia	O	O	O	O	O	O	-	-	-	-	-	-	-	-	-	-
*Pennisetum** *clandestinum*	C	-	-	-	-	-	O	-	-	-	-	-	-	-	-	-
*Pluchea** *odorata*	O	C	C	-	-	-	-	-	-	-	-	-	-	-	-	-
*Rubus** *ellipticus*	U	-	U	-	-	-	-	-	-	-	-	-	-	-	-	-
Paspalum# *urvillei*	C	C	-	O	C	-	C	-	-	-	-	-	-	-	-	-
*Melinis** *minutiflora*	C	O	-	C	-	-	-	-	-	-	-	-	-	-	-	-
*Hedychium** *gardnerianum*	U	O	-	O	-	-	-	-	-	-	-	-	-	-	-	-
*Psidium** *cattleianum*	O	C	U	C	O	U	-	-	-	-	-	-	-	-	-	-
Tibouchina# *herbacea*	O	C	C	C	U	U	-	-	-	-	-	-	-	-	-	-
*Melastoma*** *malabarthicum*	U	O	O	-	U	U	-	-	-	-	-	-	-	-	-	-

Table 19. (Continued) The distribution of selected alien species in the various communities of the wet, moist, and dry vegetation zones.

Alien Species	COMMUNITIES: WET RS	WET DOK	WET DOS	WET OK	WET OF	WET OS	MOIST RS	MOIST OK	MOIST OF	MOIST OS	MOIST MS	MOIST SP	DRY RS	DRY CS	DRY MN	DRY SP
WET AND MOIST WEEDS																
<u>Rubus</u># <u>rosifolius</u>	O	O	U	O	U	-	-	O	-	-	-	-	-	-	-	-
<u>Saciolepis</u>* <u>indica</u>	C	O	-	O	C	-	C	O	-	-	-	-	-	-	-	-
PRIMARILY MOIST WEEDS																
<u>Rubus</u>** <u>argutus</u>	-	-	-	-	-	-	-	-	U	U	-	-	-	-	-	-
MOIST AND DRY WEEDS																
<u>Verbascum</u>* <u>thapsis</u>	-	-	-	-	-	-	C	-	-	-	O	-	O	U	O	-
<u>Oenothera</u> <u>affinis</u>	-	-	-	-	-	-	O	-	-	-	-	-	C	-	-	-
PRIMARILY DRY WEEDS																
<u>Pennisetum</u>** <u>setaceum</u>	R	-	-	-	-	-	U	-	-	-	-	-	C	O	O	-
<u>Bromus</u> sp.	-	-	-	-	-	-	-	-	-	-	-	-	O	O	-	-
<u>Brassica</u> sp.	-	-	-	-	-	-	-	-	-	-	-	-	O	O	-	-
WEEDS WITH WIDE RANGE																
<u>Anthoxanthum</u>* <u>odoratum</u>	C									C			O			
<u>Gnaphalium</u> <u>prupureum</u>	U	-	-	-	-	-	O	-	-	-	-	-	C	-	-	-
<u>Hypochoeris</u>* <u>radicata</u>	O	-	-	-	-	-	-	-	-	-	-	-	C	-	-	-

* Listed as "pest" in Smith (1985).
** Listed as noxious in Smith (1985).
\# Considered by Gerrish to be "pests" in native communities.

APPENDIX

Table A. NATIVE TREES found in the communities traversed by the water system easement. These species were recorded by Gerrish in the 1991 survey or by Warshauer (1986). Nomenclature of flowering plants generally conforms to St. John (1973).

BOTANICAL NAME	COMMON NAME
Acacia koa Gray	koa
Antidesma platyphyllum Mann	hame
Cheirodendron trigynum (Gaud.) Heller	olapa
Cibotium chamissoi Kaulf.	hapu'u-'i'i
Cibotium glaucum (Sm.) H. & A.	hapu'u
Cibotium hawaiiense Nakai & Ogura	meu
Coprosma montana Hbd.	pilo
Coprosma ochracea Oliver	pilo
Coprosma rhynchocarpa Gray	pilo
Dodonaea viscosa Jacq.	a'ali'i
Euphorbia olowaluana Sherf	'akoko
Gouldia terminalis (H. & A.) Hbd.	manono
Ilex anomala H.& A.	kawa'u
Metrosideros polymorpha Gaud.	'ohi'a-lehua
Myoporum sandwicense Gray	naio
Myrsine lanaiensis Hbd.	kolea
Myrsine lessertiana A. DC.	kolea-lau-nui
Myrsine sandwicensis A. DC.	kolea-lau-li'i
Perrottetia sandwicensis Gray	olomea
Pipturus albidus (H. & A.) Gray	mamaki
Pisonia umbellifera (J. R. & G. Forst.) Seem	papala-kepau
Pittosporum hawaiiensis Hbd.	hoawa
Pritchardia beccariana Rock	lo'ulu
Psychotria hawaiiense (Gray) Fosb.	kopiko
Rhus sandwicensis Gray	neneleau
Santalum paniculatum Hook. & Arnott	'iliahi
Sophora chrysophylla (Salisb.) Seem	mamane
Styphelia tameiameiae (Cham.) F. Muell.	pukiawe
Tetraplasandra meiandra (Hbd.) Harms	ohe

Table B. NATIVE SHRUBS found in the communities transversed by the water system easement. These species were recorded by Gerrish in the 1991 survey or by Warshauer (1986).

BOTANICAL NAME	COMMON NAME
Alyxia olivaeformis Gaud.	maile
Bidens menziesii (Gray) Sherff var. filiformis Sherff	ko'oko'olau
Broussaisia arguta Gaud.	kanawao
Chenopodium oahuense (Meyen) Aellen	'aheahea
Clermontia montis-loa Rock	'oha-wai
Clermontia parviflora Gaud. ex Gray	'oha-wai
Coprosma ernodeoides Gray	kukai-nene
Cyrtandra lysiosepala (Gray) C. B. Clark	ncn
Cyrtandra platyphyla Gray	'ilihia
Dubautia cilliolata (DC) Keck	ncn
Dubautia linearis (Gaud.) Keck	ncn
Dubautia scabra (DC) Keck	ncn
Freycinetia arborea Gaud.	ie'ie
Geranium cuneatum Hook.	hinahina
Hedyotis centranthoides (H. & A.) Steud.	Kilauea hedytis
Labordia hedyosmifolia Bail.	ncn
Osteomeles anthyllidifolia Lindl.	uulei
Pelea clusiifolia Gray	alani
Pelea pseudoanisata Rock	alani
Rubus hawaiiensis Gray	'akala
Rubus macraei Gray	'akala
Sadleria cyatheoides kaulf.	'ama'u
Scaevola chamissoniana Gaud.	naupaka
Sticherus owhyhensis	ncn
Vaccinium calycinum Sm.	ohelo-kau-la'au
Vaccinium reticulatum Sm.	ohelo
Wikstroemia sp. Endl.	'akia

Table C. NATIVE HERBS AND FERNS found in the communities transversed by the water system easement. These species were recorded by Gerrish in the 1991 survey or by Warshauer (1986).

BOTANICAL NAME	COMMON NAME
Adenophorus spp.	various
Asplenium lobulatum Mett.	'anali'i
Astelia menziensiana Sm.	pa'iniu
Athyrium sandwicianum Presl	Ho'i'o
Carex alligata F. Boot	Hawaiian sedge
Cocculus ferrandianus	huehue
Cyperus polystachyus Rottb.	ncn
Deschampsia australis Nees ex Steud.	ncn
Dryopteris paleacea (Sw.) Robinson	lau-kahi
Elaphoglossum alatum Gaud.	'ekaha
Elaphoglossum hirtum var *micans* (Matt.) C. Chr.	'ekaha
Elaphoglossum wawrae (Luerss.) C. Chr.	'ekaha
Eragrostis atropioides Hbd.	hard-stemmed lovegrass
Gahnia gahniaformis (Gaud.) Kern	'uki
Luzula hawaiiense Buch.	ncn
Lycopodium cernuum L.	wawae-'iole
Lycopodium phyllanthum H. & A.	wawae-'iole
Machaerina angustifolia (Gaud.) Koyama	'uki
Microlepia strigosa (Thunb.) Presl	pala-palai
Nertera granadensis (L. f.) Druce	ncn
Panicum tenuifolium H. & A.	mountain pili
Pellaea ternifolia (Cav.) Link	cliffbrake
Peperomia macraeana C. DC.	'ala-'ala-wai-nui
Peperomia sp. R. & P.	'ala-'ala-wai-nui
Polypodium pellucidum Kaulf.	laua'e
Psilotum nudum (L.) Griseb.	moa
Pteridium aquilinum var. *Decompositum* (Gaud.) Tryon	bracken
Sicyos hillebrandii St. John	ncn
Smilax sandwicensis Kunth	hoi-kuahiwi
Stenogyne calaminthoides Gray	Hawaii stenogyne
Stenogyne microphylla Benth.	ncn
Stenogyne rugosa Benth.	ma'ohi'ohi
Thelypteris globulifera Brack.	Palapalai-a-kama-pua'a
Trisetum glomeratum (Kunth) Trin. in Steud.	he'u-pueo

Table D. ALIEN PLANTS found in the communities traversed by the water system easement. These species were recorded by Gerrish in the 1991 survey or by Warshauer (1986). Nomenclature of flowering plants generally conforms to St. John (1973). ncn = no common name.

BOTANICAL NAME	COMMON NAME
Ageratum conyzoides L.	maile-honohono
Albizia falcataria L.	albizia
Andropogon virginicus L.	broomsedge
Anemone hupehensis (Lem & Lem f.) Lem & Lem f.	Hupeh anemone
Anthoxanthum odoratum L.	sweet vernal grass
Aristea eckloni Baker	aristea
Arundinia bambusifolia (Roxb.) Lindl.	bamboo orchid
Axonopus affinis Chase	narrow-leaved carpet grass
Brassica campestris L.	wild mustard
Bromus sp. [Mont.] L.	bromegrass
Buddleja asiatica Lour.	butterfly bush
Castilleja arvensis Schlecht. & Cham.	paintbrush
Centaureum erythraea Rafn.	bitter herb
Cuphea carthagenensis (Jacq.) Macbride	tarweed
Dactylis glomeratus L.	orchardgrass
Desmodium uncinatum (Jacq.) DC	Spanish clover
Erechtites hieracifolia (L.) Raf.	fireweed
Eucalyptus robusta Sm.	swamp mahogany
Eupatorium riparium Regel	pa'makani
Fragaria vesca L.	strawberry
Fraxinus uhdei (Wenzig) Lingelsh.	tropical ash
Geranium homeanum Turcz.	crane's bill
Gnaphalium japonicum Thunb.	ncn (herb)
Grevillea robusta A. Cunn. in R. Br.	silk oak
Hedychium gardnerianum Roscoe	kahili ginger
Heterotheca grandiflora Nutt.	telegraph plant
Holcus lanatus L.	velvetgras
Hypericum degeneri Fosb.	ncn (herb)
Hypochoeris radicata L.	gosmore
Impatiens sultani Hook f.	impatiens
Lactuca scariola L.	prickly lettuce
Lotus subbiflorus Lag.	ncn (herb)
Ludwigia octivalis (Jacq.) Raven	primrose willow
Medicago sativa L.	alfalfa
Melaleuca leucadendra	paperbark
Melastoma malabarthicum L.	Malabar melastome
Melilotus indica (L.) All.	ncn (herb)
Melinis minutiflora Beauv.	molassesgrass
Melochia umbellata (Houtt.) Staph.	melochia
Mimosa pudica L.	sensitive plant
Nephrolepis cordifolia (L.) Presl	ncn (fern)
Oenothera affinis Camb.	evening primrose

Table D. (Continued) ALIEN PLANTS.

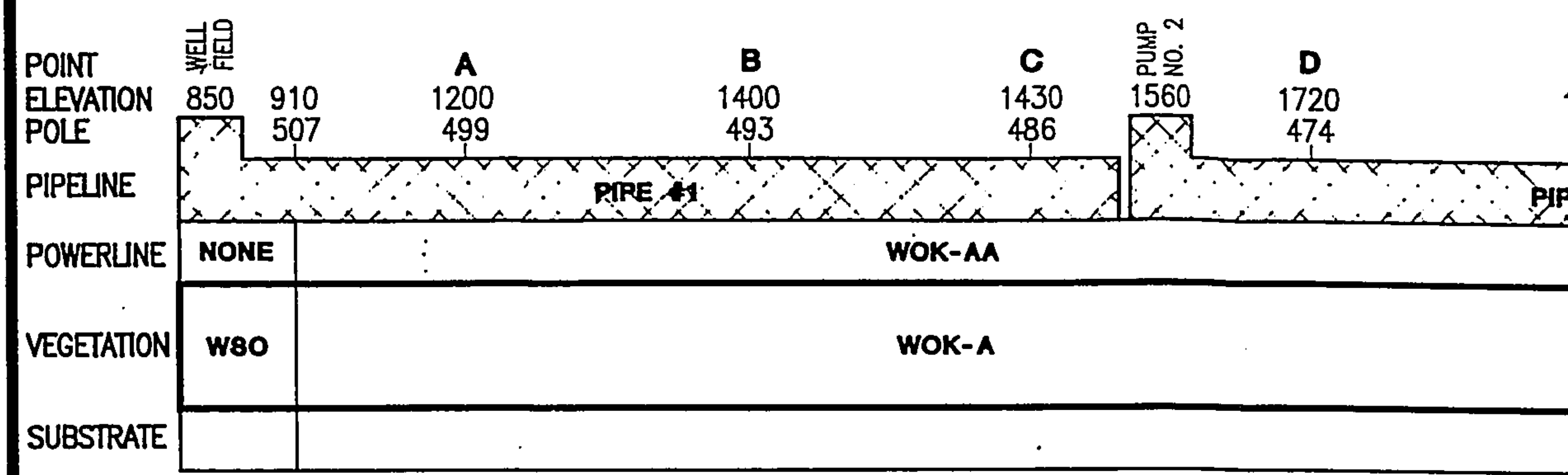
BOTANICAL NAME	COMMON NAME
Panicum repens L.	wainaku grass
Paspalum conjugatum Berg.	Hilo grass
Paspalum orbiculare Forst. f.	ricegrass
Paspalum urvillei Steud.	vaseygrass
Passiflora edulis Sims	liliko'i
Pennisetum clandestinum Hochst. ex Chiov.	kikuyugrass
Pennisetum setaceum (Forsk.) Chiov.	fountaingrass
Plantago lanceolata L.	narrow-leaved plantain
Plantago major L.	common plantain
Pluchea odorata (L.) Cass.	sourbush
Polygonum capitatum Ham. ex Don	ncn (herb)
Psidium cattleianum Sabine	waiawi, strawberry guava
Psidium guajava L.	common guava
Rubus argutus Link	blackberry
Rubus ellipticus Sm.	yellow Himalayan raspberry
Rubus rosifolius Sm.	thimbleberry
Rumex acetosella L.	sheep sorrel
Sacciolepis indica (L.) Chase	Glenwoodgrass
Schizachyrium condensatum (Kunth) Nees	ncn (grass)
Setaria geniculata (Poir.) Beauv.	perennial foxtail
Setaria palmifolia (Koen.) Stapf	palmgrass
Spathodea campanulata Beauv.	African tulip tree
Sporobolus indicus (L.) R. Br.	West Indian dropseed
Tibouchina herbacea (DC) Cogn.	glorybush
Trema orientalis (L.) Bl.	gunpowder tree
Trifolium arvense L.	rabbit-foot clover
Trifolium repens L.	white clover
Tritonia crocosmiflora Nichols.	montbretia
Ulex europaeus L.	gorse
Uncinia uncinata (L. f.) Kuek.	ncn (sedge)
Verbascum thapsus L.	common mullein
Verbena litoralis Kunth	vervain

Figure 1. Strip Diagram of the plant community sequence of the wet vegetation zone along the water system easement through the powerline corridor, i.e. from the Waiakea well field to the junction of the 138 KV transmission line with Saddle Road. Point = reference points on construction drawings; El. = elevation above sea level; Pole = number of the nearest pole of the 138 KV transmission line; P'line (powerline) = community symbol for the vegetation found in disturbed areas under the 138 KV powerline; Veg = community symbol for the vegetation of the surrounding undisturbed community; Sub. (Substrate)= year of lava flow. Key to community symbols: WSO = Wet Succeesional 'Ohi'a, WOK = Wet 'Ohi'a-Koa Forest, WOS = Wet 'Ohi'a Scrub. Letter following community symbols refer to relevant species lists in Tables 1-3.

Figure 2. Strip Diagram of the plant community sequence of the wet vegetation zone along the water system easement through the Saddle Road corridor, i.e. from the the junction of the 138 KV transmission line with Saddle Road to the upper elevation limit of the wet zone at 5100 ft. elevation. Pole = number of the nearest pole of the 138 KV transmission line; Elevation = elevation above sea level; Mile = Saddle Road mile-markers; Pipeline = pipe number from construction drawings; Roadside = community symbol for the plant community on road shoulder; Vegetation = community symbol for the vegetation of the surrounding undisturbed community; Substrate = year of lava flow. Key to community symbols: WOK = Wet 'Ohi'a-Koa Forest; WOS = Wet 'Ohi'a Scrub; WOF = Wet 'Ohi'a Forest. Letter following community symbols refer to relevant species lists in Tables 2-4.

Figure 3. Strip Diagram of the plant community sequence of the moist vegetation zone along the water system easement through the Saddle Road corridor, i.e. from 5100 ft. elevation to the head tank at 6620 ft. elevation. Pole = number of the nearest pole of the 138 KV transmission line; Elevation = elevation above sea level; Mile = Saddle Road mile-markers; Pipeline = pipe number from construction drawings; Roadside = community symbol for the plant community on road shoulder; Vegetation = community symbol for the vegetation of the surrounding undisturbed community; Substrate = year of lava flow. Key to community symbols: RS = Roadside (Table 15); MOS = Moist 'Ohi'a Scrub; MOF = Moist 'Ohi'a Forest; MOK = Moist 'Ohi'a-Koa Forest; MSP = Moist Sparse Pioneer; MMS = Moist Mixed Shrubs; MKMP = Moist Koa-Mamane Pasture; MOP = Moist 'Ohi'a Pasture. Letter-symbols within strips refer to relevant species lists in Tables 5-11.

Figure 4. Strip Diagram of the plant community sequence of the dry vegetation zone along the water system easement through the Saddle Road corridor, i.e. from the head tank at 6620 ft. elevation to the Parker Ranch boundary at 5440 ft. elevation. Elevation = elevation above sea level; Mile = Saddle Road mile-markers; Pipeline = pipe number from construction drawings; Roadside = community symbol for the plant community on road shoulder; Vegetation = community symbol for the vegetation of the surrounding undisturbed community; Substrate = year of lava flow. Key to community symbols: RS = Roadside (Table 15); DSP = Dry Sparse Pioneer; DMN = Dry Mamane-Naio Forest, DCS = Dry *Chenopodium* Scrub. Letter-symbols within strips refer to relevant species lists in Tables 12-14.



WET VEGETATION: POWERLINE

LEGEND - COMMUNITY SYMBOLS

MARK	DESCRIPTION
WSO	WET SUCCESSIONAL 'OHI'A FOREST
WOK	WET 'OHI'A – KOA FOREST
WOS	WET 'OHI'A SCRUB

Figure 1. Strip diagram o
vegetation zone along the
powerline corridor, i.e. from
of the 138 KV transmissio
points on construction draw
POLE = number of the ne
POWERLINE = community s
areas under the 138 KV p
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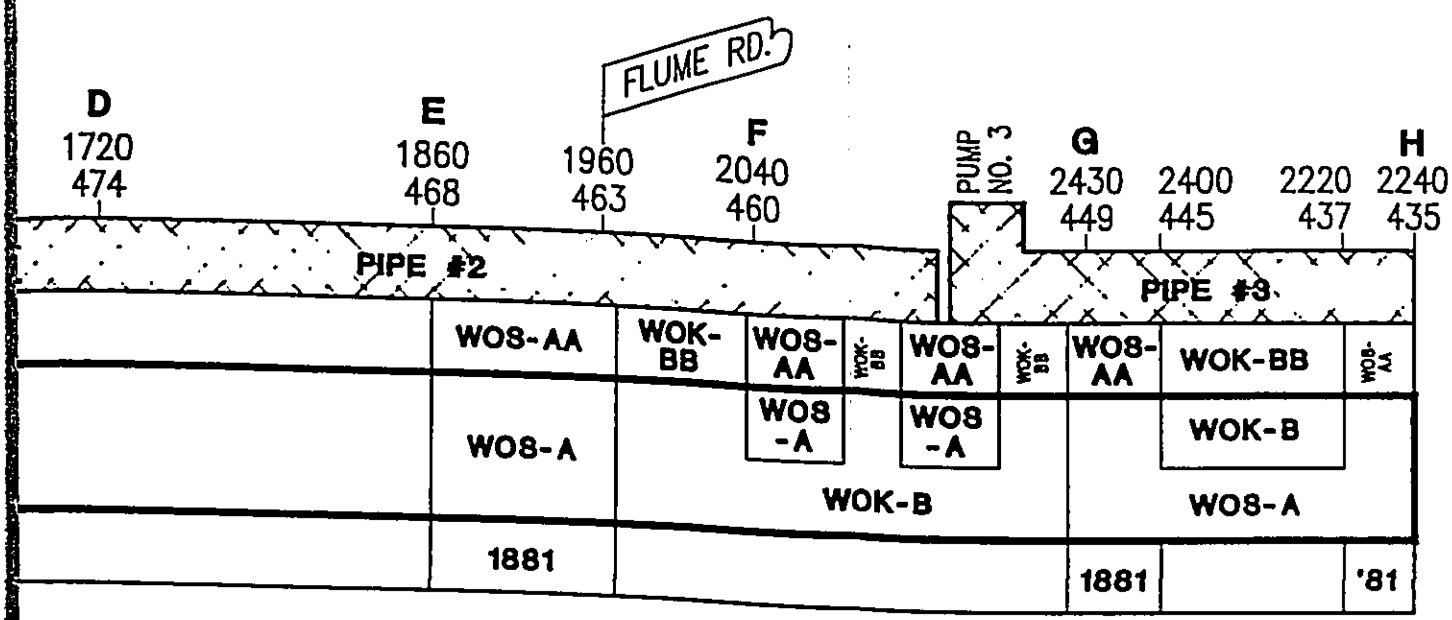
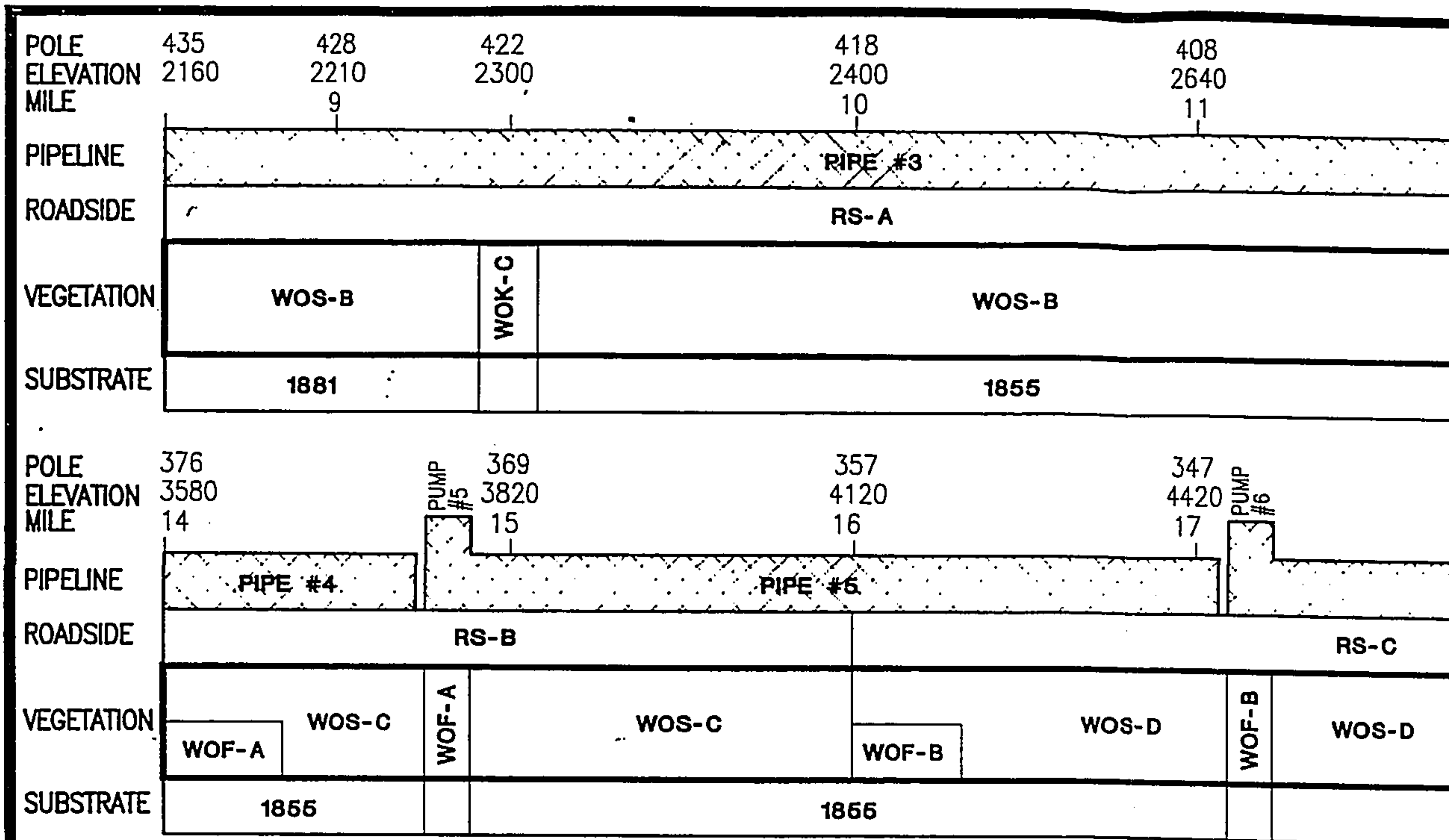


WERLINE CORRIDOR

re 1. Strip diagram of the plant community sequence of the wet
etation zone along the water system easement through the
erline corridor, i.e. from the Waiakea well field to the junction
he 138 KV transmission line with Saddle Road. POINT = reference
ts on construction drawings; ELEVATION = feet above sea level
E = number of the nearest pole of the 138 KV transmission line;
ERLINE = community symbols for the vegetation found in disturbed
is under the 138 KV powerline; VEGETATION = community symbol for
vegetation of the surrounding undisturbed community; SUBSTRATE =
of lava flow. Letters following community symbols refer to
ant species lists in Tables 1–3, & 15.



WET VEGETATION: SADDLE ROAD

LEGEND - COMMUNITY SYMBOLS

MARK	DESCRIPTION
WOS	WET 'OHI'A SCRUB
WOK	WET 'OHI'A – KOA FOREST
WOF	WET 'OHI'A FOREST
RS	ROADSIDE

Figure 2. Strip Diagram of
vegetation zone along the w
Road corridor, i.e. from the
line with Saddle Road to th
at 5100 ft. elevation. POL
KV transmission line; ELEV
Saddle Road mile–markers;
drawings; ROADSIDE = com
road shoulder; VEGETATION
the surrounding undisturbed
flow. Letters following com
list in Tables 2–4, & 15.

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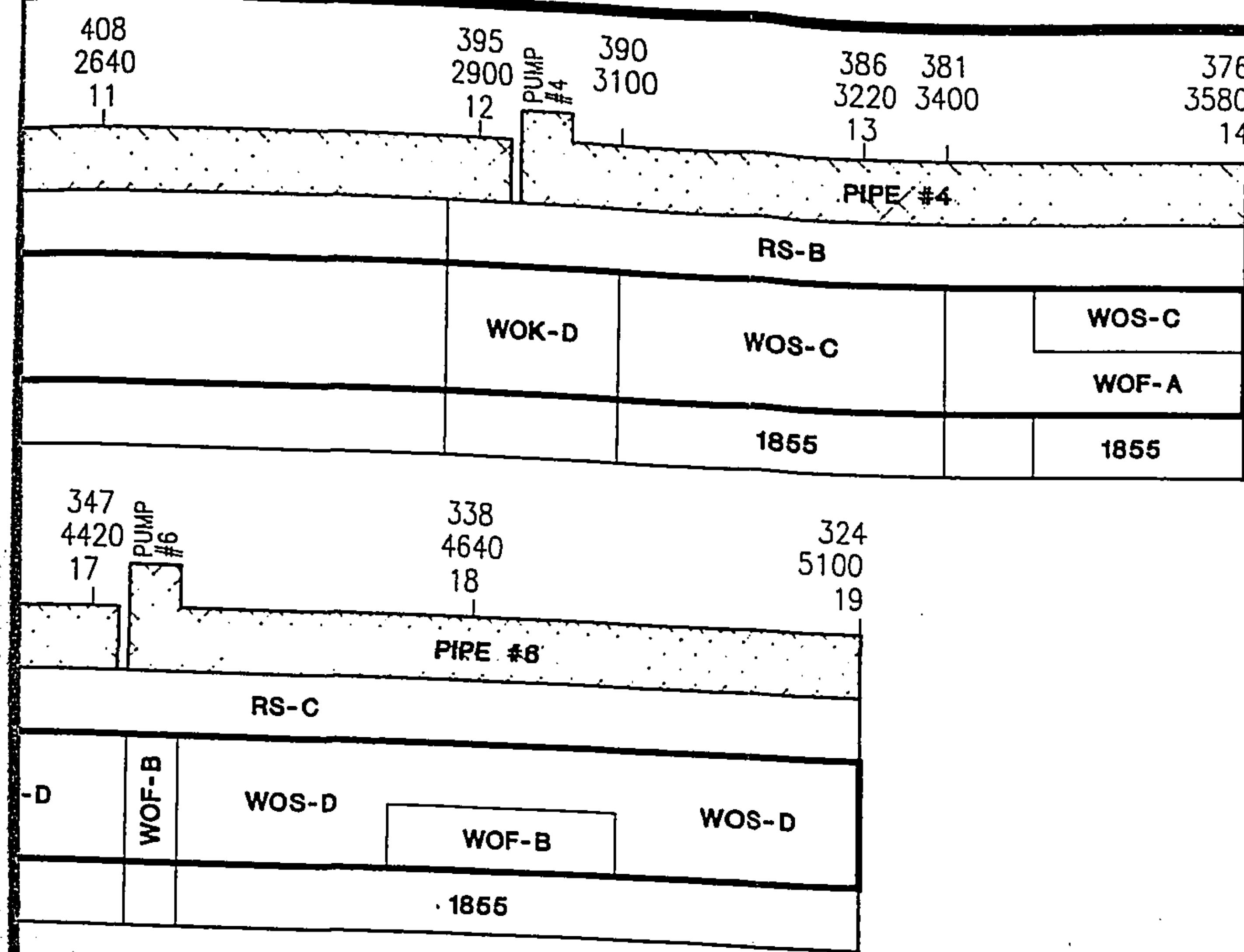
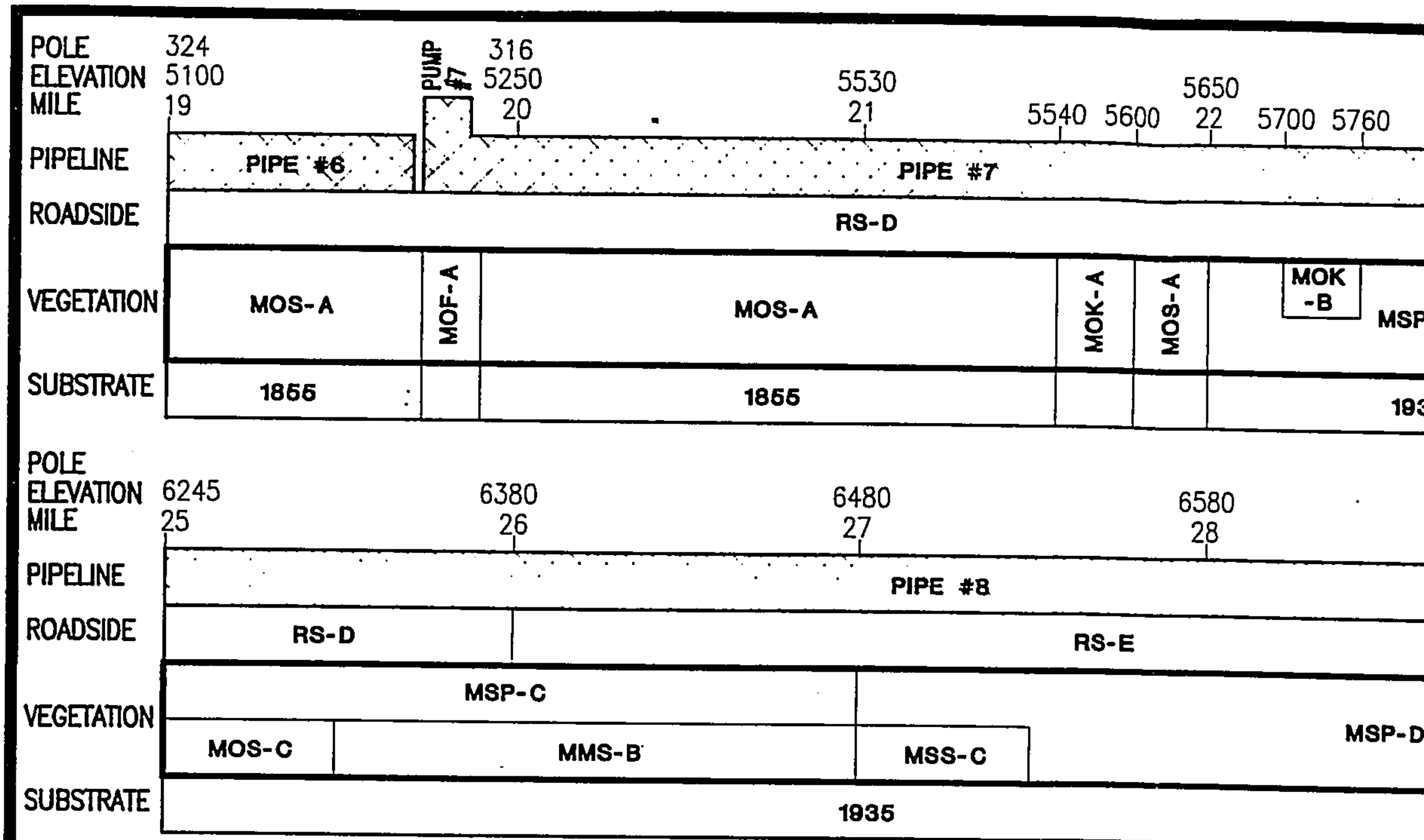


DDLE ROAD CORRIDOR

gure 2. Strip Diagram of the plant community sequence of the wet getation zone along the water system easement through the Saddle oad corridor, i.e. from the junction of the 138 KV transmission e with Saddle Road to the upper elevation limit of the wet zone 5100 ft. elevation. POLE = number of the nearest pole of the 138 / transmission line; ELEVATION = feet above sea level; MILE = ddle Road mile-markers; PIPELINE = pipe number from construction awings; ROADSIDE = community symbol for the plant community on ad shoulder; VEGETATION = community symbol for the vegetation of e surrounding undisturbed community; SUBSTRATE = year of lava w. Letters following community symbols refer to relevant species t in Tables 2–4, & 15.



MOIST VEGETATION: SADDLE RO

LEGEND - COMMUNITY SYMBOLS

MARK	DESCRIPTION	MARK	DESCRIPTION
MOS	MOIST 'OHI'A SCRUB	**RS**	ROADSIDE
MOF	MOIST 'OHI'A FOREST		
MOK	MOIST 'OHI'A KOA		
MSP	MOIST SPORSE PIONEER		
MMS	MOIST MIXED SHRUBLAND		
MKMP	MOIST KOA – MAMANE PASTURE		
MOP	MOIST 'OHI'A PASTURE		

Figure 3. Strip Dia
moist vegetation zo
Saddle Road corrido
at 6620 ft. elevatio
KV transmission line
pipe number from c
for the plant comm
symbols for the veg
SUBSTRATE = year c
refer to relevant sp

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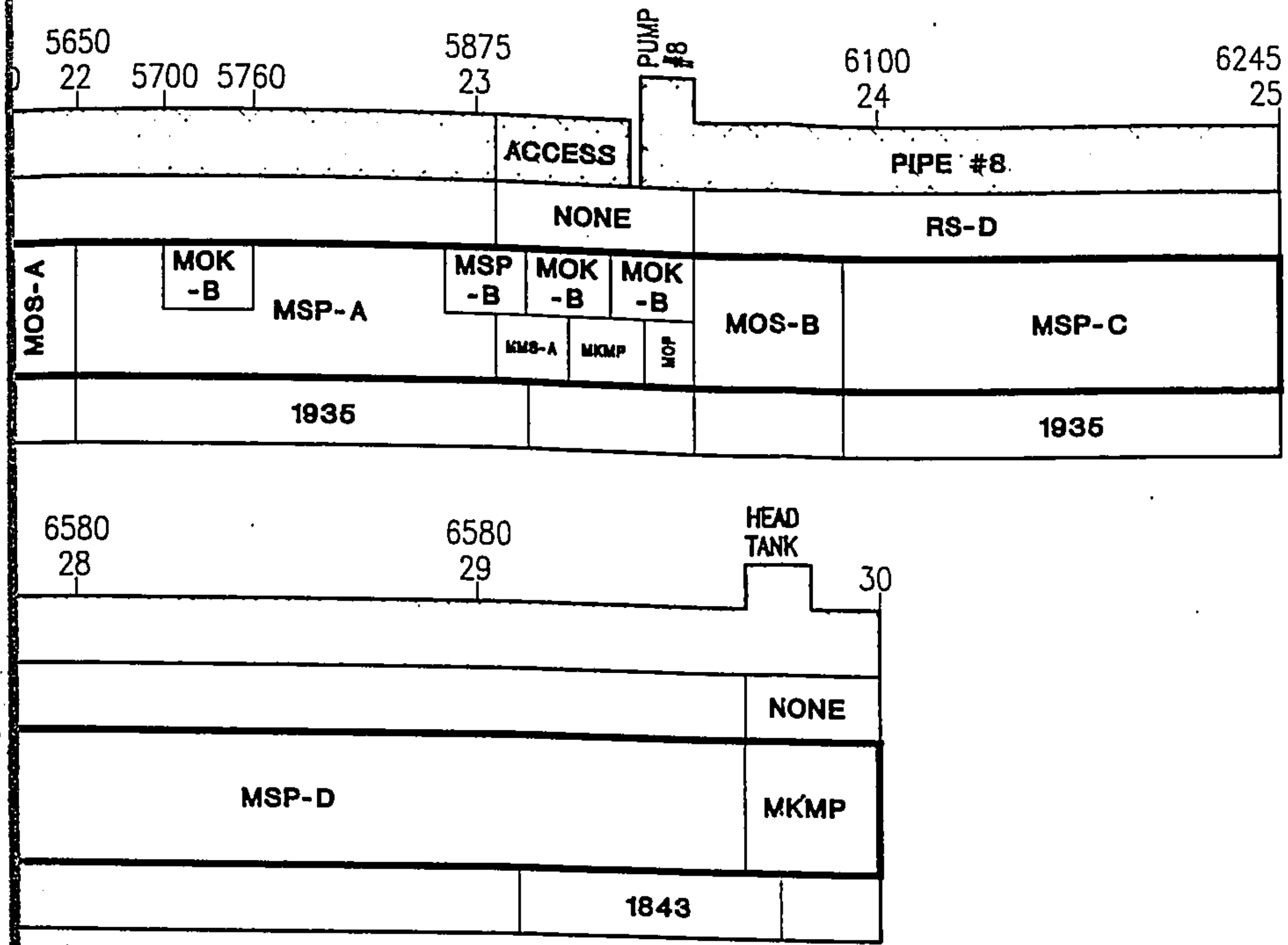
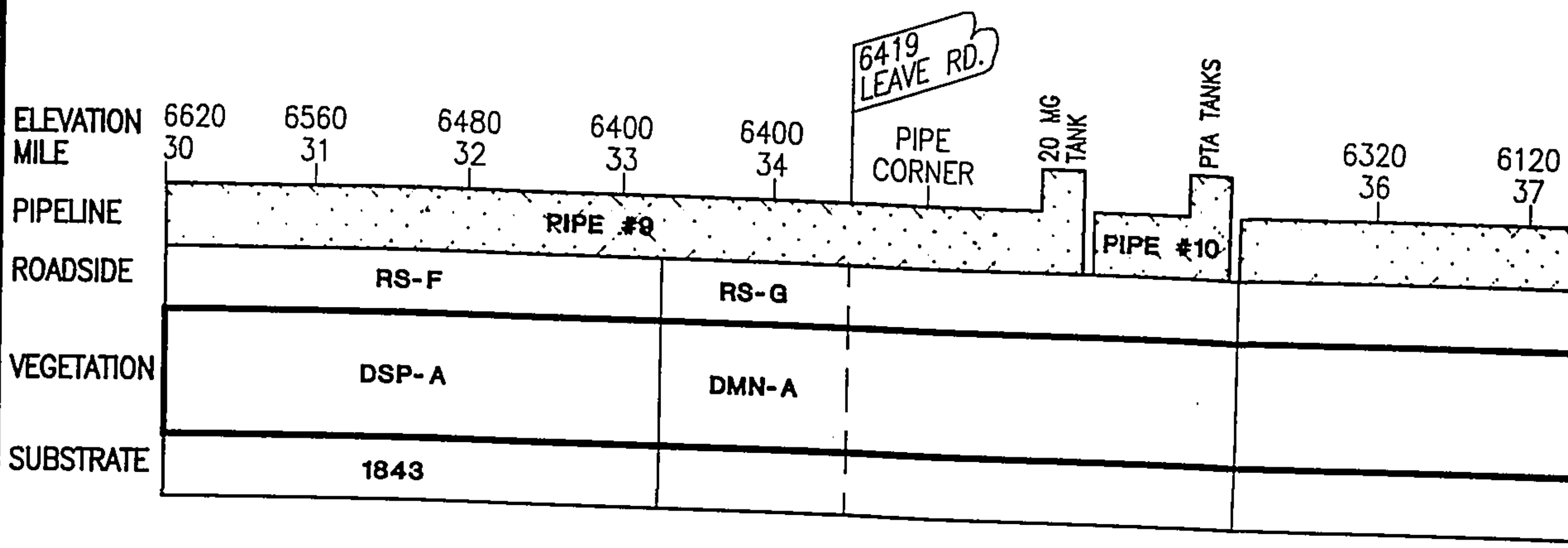


DDLE ROAD CORRIDOR

Figure 3. Strip Diagram of the plant community sequence of the moist vegetation zone along the water system easement through the Saddle Road corridor, i.e. from 5100 ft. elevation to the head tank at 6620 ft. elevation. POLE = number of the nearest pole of the 138 KV transmission line; ELEVATION = feet above sea level; PIPELINE = pipe number from construction drawings; ROADSIDE = community symbols for the plant community on road shoulder; VEGETATION = community symbols for the vegetation of the surrounding undisturbed community; SUBSTRATE = year of lava flow. Letters following community symbols refer to relevant species list in Tables 5–11, & 15.



DRY VEGETATION: SADDLE ROAD

LEGEND - COMMUNITY SYMBOLS

MARK	DESCRIPTION
DSP	DRY SPARSE PIONEER
DMN	DRY MAMANE – NAIO FOREST
DCS	DRY CHENOPODIUM SHRUBLAND
RS	ROADSIDE

Figure 4. Strip Diagram of the plan
vegetation zone along the water syst
Road corridor, i.e. from the head ta
Parker Ranch boundary at 5440 ft.
sea level; MILE = Saddle Road mile
from construction drawings; ROADSID
plant community on road shoulder;
the vegetation of the surrounding un
= year of lava flow. Letters followin
relevant species list in Tables 12–14

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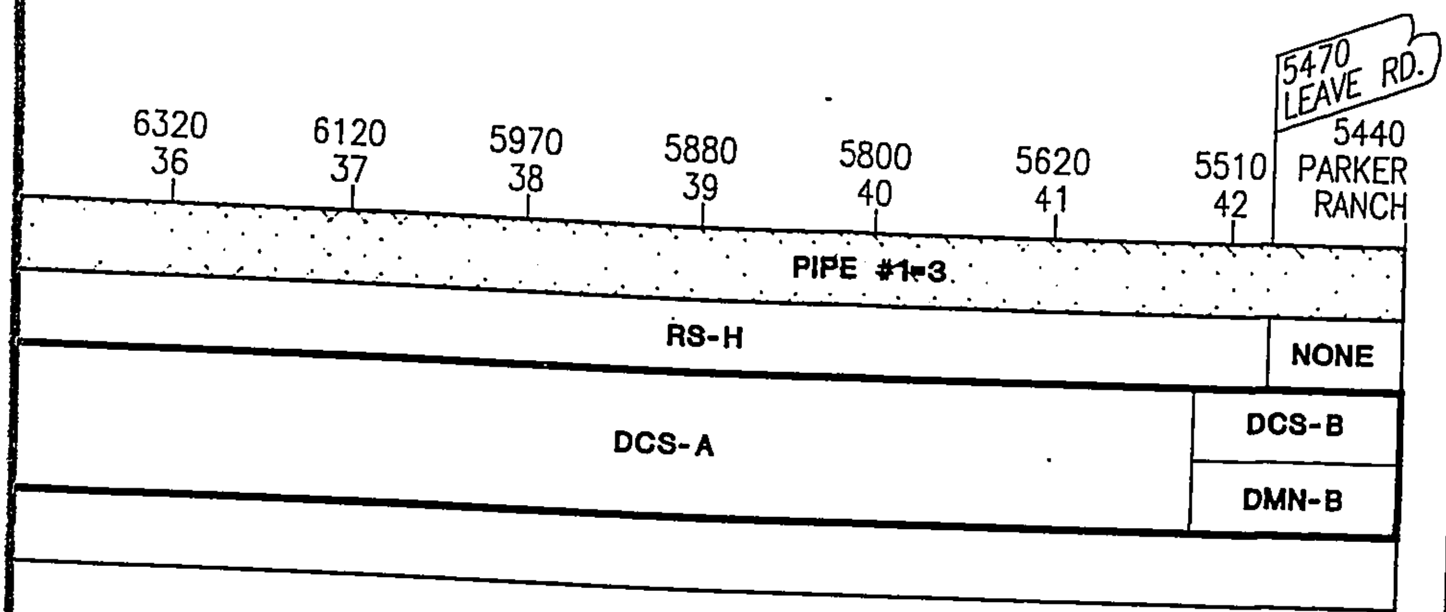

DLE ROAD CORRIDOR

trip Diagram of the plant community sequence of the dry
one along the water system easement through the Saddle
r, i.e. from the head tank at 6620 ft. elevation to the
n boundary at 5440 ft. elevation. ELEVATION = feet above
MILE = Saddle Road mile-markers; PIPELINE = pipe number
ction drawings; ROADSIDE = community symbol for the
nity on road shoulder; VEGETATION = community symbol for
n of the surrounding undisturbed community; SUBSTRATE
va flow. Letters following community symbols refer to
ies list in Tables 12-14 & 15.

Appendix E

HILO TO WAIMEA PIPELINE ENVIRONMENTAL IMPACT STUDY:

LAVA TUBES

Dr. Fred D. Stone

Hawaii Community College, Hilo, Hawaii

Introduction:

Lava tubes in Hawaii have biological, cultural, archaeological, geological, recreational and aesthetic values that are worthy of protection (Howarth and Stone, 1982). Large lava tubes are hazardous to construction equipment and their operators.

Potential impacts of the proposed pipeline are:

1. Direct intersection and collapse of lava tubes by heavy machinery.

2. Indirect effects due to removal of native plants whose roots serve as the main food source for endemic lava tube species.

3. Disturbance of Hawaiian archaeological sites and burial caves.

Mitigating measures include:

1. Planning the route to minimize additional damage to native ecosystems by following existing powerlines and roadways.

2. Relocation of the pipeline route away from areas of known lava tubes.

3. Investigation of lava tubes intersected during

construction to determine whether cultural, archaeological or biological features are present which require mitigation. Since the proposed pipeline follows the HELCO 138 kv transmission line and the Saddle Road for much of its length, the environmental impact studies for both of those projects should be taken into consideration (Wagner et al, 1983; Stone, 1986).

Preliminary Reconnaissance Survey:

Since the exact route of the proposed pipeline has yet to be decided, this survey should be considered a preliminary reconnaissance. When the exact pipeline route is known, a detailed field survey of the route should be conducted focussing on the most critical lava flows and habitats.

The main segments of the proposed pipeline that are likely to intersect lava tubes are:

1. Above Kaumana Village from elevation 1850 ft. to 2200 ft. where the pipeline follows the 138 kv line along the 1881 lava flow. The 1881 lava flow is known to contain large lava tubes above and below this section, and the major feeder tubes must follow this section, but we were unable to locate entrances leading into these tubes. The proposed pipeline route crosses nearly the entire width of the 1881 flow between elevations 1850 ft and 2200 ft., so it will definitely cross one or more major lava tubes. Known sections of the 1881 lava tubes have populations of endemic cave invertebrates, listed in the accompanying invertebrate survey. The main danger to these species comes from removal of native vegetation overlying the

lava flows. Additional disturbance of native vegetation will be minimized by following the existing 138 kv power line route.

2. Along Saddle Road where the 1855 lava flow has tube-fed pahoehoe, particularly between the 13-17 mile markers. A large lava tube exists south of Saddle Road near the 15 mile marker. The elevation, 4000 ft., is at the transition between the lower elevation and upper elevation lava tube species, making it a particularly rich community. Upper elevation species include cave tree crickets (Thaumatogryllus), thread-legged bugs (Nesidiolestes) and the only cave adapted carabid beetle currently known from the Big Island.

3. The proposed pumping station #8 near the Saddle Road 23 mile marker is in the vicinity of several lava tubes with endemic upper elevation cave species. The road and pumping station site should be examined in detail to determine whether they will impact these lava tubes.

4. Along Saddle Road from approximately miles 23 to 28 the route follows the 1935 pahoehoe flow which contains many small lava tubes. Preliminary surveys conducted in 1982 were not successful in locating native species from the 1935 lava tubes. However, further detailed surveys should be conducted when the exact pipeline route is known.

5. Near the 34 mile marker at Pohakuloa lava tubes exist west of Saddle Road, in the vicinity of a proposed storage reservoir. Current status of these tubes is not known, since extensive habitat alteration has taken place with the development of the Pohakuloa Military Training Area. As with the previous

sites, detailed field work should be done as soon as the exact location of the pipeline and reservoir is known.

Table 1

Native Invertebrates Occurring in Lava Tubes and Crack Habitats Along the Proposed Pipeline Route

Arthropoda

Crustacea:	? sp.	(Isopoda)
Chilopoda:	Lithobius sp.	(Lithobiid)
Diplopoda:	Dimerogonus sp.	(Cambalid)
Araneida:	Erigone stygius	(Linyphiid)
	Oonops ? sp.	(Oonopid)
	Lycosa howarthi	(Lycosid)
Insecta:	Caconemobius varius	(Gryllid)
	C. sp. A	(Gryllid)
	C. sp. B ?	(Gryllid)
	Thaumatogryllus sp.	(Gryllid)
	Oliarus polyphemus ?	(Cixiid)
	Nesidiolestes ana	(Reduviid)
	Schrankia 2+sp.	(Noctuid)
	Forcipomyia sp.	(Ceratopogonid)
	Limonia cf. jacobus	(Tipulid)
	Phytosciara volcanata	(Sciarid)
	Mycetophilidae	(Mycetophilid)

REFERENCES:

Howarth, F.G. and Stone, F.D. 1982. The Conservation of Hawaii's Cave Resources. in C.W. Smith, ed. Proceedings of the Fourth Conference in Natural Sciences, Hawaii Volcanoes National Park. Dept. of Botany, Univ. of Hawaii, Honolulu, Hawaii.

Stone, Charles P. and Stone, D.B. 1989. Conservation Biology in Hawaii. Univ. of Hawaii National Park Resources Studies Unit. Honolulu, Hawaii.

Stone, Fred D. 1986. Native fauna along the Saddle Road right-of-way. Saddle Road improvements Environmental Impact Study. County of Hawaii. Hilo, Hawaii

Stone, Fred D. 1986. Lava tube survey along the Saddle Road right-of-way. Saddle Road improvements Environmental Impact Study. County of Hawaii. Hilo, Hawaii

Wagner, W.L. et al. 1983. Biological reconnaissance and environmental impact assessment of HECO/HELCO proposed cross-Hawaii Island 138 kv transmission line: botanical, entomological and malacological report. Prepared for EDAW, Inc. by B.P. Bishop Museum. Addendum to Environmental Impact Statement, Kaumana to Keamuku 138 kv transmission line. EDAW, Inc., August, 1983.

Appendix F

An Avifaunal Survey of the Proposed Water Pipeline
South Hilo to South Kohala and Hamakua Districts,
Hawai'i Island, Hawai'i.

October 20, 1991

Prepared By:
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P. O. Box 476
Volcano, Hawai'i

INTRODUCTION

The Hawaii State Department of Land and Natural Resources, Division of Water and Land Development proposes to build a pipeline to transport water from the District of South Hilo across the saddle between Mauna Loa and Mauna Kea to Waimea in the South Kohala District. Associated with the pipeline are a system of pump stations, electrical substations, surge tanks, and reservoirs for pumping and storing water along the route.

The following report summarizes the results of a six day avifaunal survey of the route. The purpose of the survey was to characterize the avifauna utilizing the area and to identify endangered species or unique communities that could be adversely affected by pipeline construction.

LITERATURE REVIEW

A number of previous surveys have been performed in the general vicinity of the pipeline route. The most comprehensive of these was the Hawaiian Forest Bird Survey of the U. S. Fish and Wildlife Service, which took place between 1976 and 1981 Scott et al. 198. Forty-seven percent of the island of Hawaii was censused along a series of 117 transects located 2 miles apart and running perpendicular to elevation contours in all potential forest bird habitat above 500 meters in elevation. Several of these transects in the Upper Waiakea Forest Reserve and in the Pohakuloa Flats area were close to the proposed pipeline sites. Forest Bird Survey censuses of these areas took place during the summer of 1978. Figures 1 through 7 in Appendix 1 show range maps assembled from the results of these surveys for the seven endangered bird species known from this region. All of these species have ranges that potentially overlap the area affected by the pipeline construction, particularly that portion of the Saddle Road between 1300 and 1700 meters (pump stations 6 and 7 are located in this elevational band, and 8 is on the upper edge). In the twelve years since these surveys were performed, the range of at least one of these species has become much more restricted than shown in the figures. The 'Ou (Psittirostra psittacea) has not been observed in the Ola'a Tract portion of its range (in Hawaii Volcanoes National Park) since January 2, 1984 (Katahira, pers. comm.), and this bird is clearly declining elsewhere as well. Attempts to locate 'Ou between the Saddle Road and Stainback Highway in recent years have been unsuccessful (Jacobi, pers. comm.). The status of the remaining species appears to be much more stable (at least in areas where their populations are being monitored such as in the Hakalau Forest National Wildlife Refuge), but there is almost no recent information about these birds in the Saddle Road portion of their ranges.

More specific information pertaining to the Saddle Road portion of the study area is available from various environmental surveys conducted in association with powerline construction (Berger, 1983) and Saddle Road widening (Freed, 1990). Berger found a total of 32 bird species during his survey; none of these were endangered. More recently, Freed observed Palila (Loxiodes bailleui) near the Saddle Road in the Pohakuloa Flats area. Although this was the first record of Palila here since 1984

(Jacobi, pers. comm.) it indicates that these birds utilize the area more regularly than is commonly believed.

METHODS

The field survey for this project took place between June 15 and July 4, 1991. A total of six days (eight person-days) was spent in the field. I spent proportionally more time surveying the windward portions of the Saddle Road (three days, four person-days) than at the remaining locations since the proposed sites in this area are in relatively undisturbed habitats and (in some cases) are within the ranges of one or more endangered species. One day was spent surveying the ranchlands from Waiki'i to Kamuela, one day (two person-days) was spent from Waiki'i to Humu'ula, and one day was spent along the powerline road from the Saddle Road to Waiakea Uka.

I used two basic census methods depending on the density of birds in the area or the potential impact of the project on natural populations. The least intensive of these methods was useful in areas that were either poor habitat (e.g., barren lava flows) or that had a relatively simple avian community (e.g., heavily grazed pastures). In these areas, I kept a running tally and noted the relative abundances for each of the species observed. In some cases, these counts were done on foot, but they were often performed while moving through the area in a vehicle. The portions of the Saddle Road from mile marker 19 to mile marker 31 and from mile marker 33 to Waiki'i Ranch were censused in this manner, as were the remaining parts of the pipeline route that pass through pasture habitat.

In areas that were more diverse or where there would be a significant impact from project activities in a given site (such as at a pump station), I used more rigorous standardized census methods (Reynolds et al. 1980). Here, I conducted eight minute counts, recording all birds heard and seen at the count site. In the case of several of the pump station sites that were within known endangered species habitat, as many as 10 counts were performed at various locations around the proposed site and along the proposed access road.

I also used eight minute counts at one mile intervals along the Saddle Road from mile marker 9 to mile marker 19. Between these stations, I kept a running tally of the numbers of each species encountered and noted relative densities of birds as described above. A similar protocol was used in the off-road areas below mile marker 9. Here, however, the censuses were performed at 1/2 mile intervals.

The section of the pipeline route that includes Palila critical habitat (roughly between mile markers 33 and 35) was covered on foot using a modification of these techniques. All species except Palila were censused using the running tally method. In order to maximize the probability of detecting any Palila in the area, I stopped at 1/10 mile intervals and listened for vocalizations and scanned trees in the immediate area for these birds. An additional person performed the same routine in the opposite direction.

RESULTS

A. Avian Habitats

This project potentially impacts a wide variety of avian habitats. These may be grouped into major types.

1. Mesic and Wet Ohia Forest. This the predominant habitat type on the windward part of the Saddle Road below mile marker 19. Ohia is the dominant canopy tree species, even in low elevation sites. The variety of different substrate ages and types in the Saddle Road area results in a wide range of stand characteristics. The understory also varies widely depending on the substrate and drainage regimes. This large category may be further subdivided based on the elevation, the age of the substrate, and the presence of alien plants:

1A. Lowland disturbed ohia forest. Below approximately 600 meters in elevation, wet forests become increasingly characterized by the presence of alien plant species. These include a wide variety of both tree species and subcanopy shrubs and herbs. In parts of the pipeline route near the number 2 pump station, there are extensive planted stands of sugi and paperbark.

1B. Closed canopy ohia forest, and

1C. Open canopy ohia forest. Both of these habitat types occur in a mosaic throughout the saddle area. On relatively young substrates such as the 1855 and 1881 lava flows, open canopy forests predominate, particularly in higher elevations where rainfall is less intense. Stand age and substrate determine the stature of the trees in any given area, which is also highly variable. In some of the older kipukas in middle elevation areas along the saddle Road, stand-level dieback has killed the canopy trees. Although extensive regeneration is occurring in many of these areas, avian densities are still drastically reduced in dieback stands as compared to former abundances.

In early successional open ohia forests, the understorey is often composed of mat ferns or (in higher elevations) scattered native shrubs. In older stands, there is often a diverse understorey composed of many different native herbs, shrubs, and small trees.

Pump stations 1 through 7 are in ohia forests: The wells and pump stations 1, 3, and 5 are in open ohia forests, pump stations 4, 6, and 7 are in closed canopy forests, and pump station 2 is in disturbed ohia forest habitat.

2. Ohia-koa forest

Ohia-koa forest occurs in the Saddle Road area in a relatively narrow band from about 1880 m elevation to about 1600 m elevation. Much of this forest has been heavily impacted by cattle ranching in the area and occurs as remnant stands of trees where grazing activity has been relatively light. Pump station 8 and its access road are in this habitat.

3. Mamane-naio forest

This habitat occurs in the Pohakuloa Flats area, along the Saddle Road from about mile marker 33 to slightly past the Pohakuloa State Park. Although this area is primarily important as critical habitat for the endangered Palila, it supports a wide variety of other native and alien bird species as well.

4. Mixed mesic shrubland

A sizeable tract of this habitat occurs in the Kamakoa gulch area. It has been heavily impacted by grazing activity. Because it provides greater cover and food supply than the nearby pasture habitats, these shrublands support a wider variety of bird species. These include both gamebirds and a variety of non-native passerine species.

5. Subalpine shrubland

This habitat occurs from Pohakuloa State Park westward into PTA and as far along the Saddle Road as the Girl Scout Camp, where it gives way to the pastures of Parker Ranch. In this area, it is dominated by 'aweoweo (a native *Chenopodium*), but also has a large number of aliens because of extensive disturbance by military activity and fires. Alien game birds have thrived here, but little use is made of this habitat by native bird species.

6. Pastures

A large part of the study area (from the Girl Scout Camp to Waiki'i, and around to Mana) consists of pastureland. The upper elevation section of this habitat still has scattered mamane trees, but by and large it is a monotonous habitat consisting of a monoculture of pasture grasses with the occasional windbreak of eucalyptus trees. Avian densities and species diversity are both low in this habitat. The only native species seen here was the Pueo (*Asio flammeus*). However, several migratory shorebird species (primarily the lesser Golden-plover, *Pluvialis dominica*, and the Ruddy Turnstone, *Arenaria interpres*) undoubtedly occur here in winter months. The native Koloa (*Anas wyvilliana*), and migratory waterfowl may occasionally utilize man made ponds in these areas (as they do along the Keanakolu Road).

7. Barren lava flows.

A large section of the pipeline route passes over barren lava flows which are rarely used by any bird species.

B. Summary of Findings

A total of 25 bird species were encountered in the course of this survey. Of these, 7 are endemic and 18 are alien species. One federally listed endangered species (the Hawaiian Hawk, *Buteo solitarius*) was found during the survey. Table 1 lists these species and their relative abundances for the various habitat types in the study area. This table clearly shows the strong correlation between habitat type and avian community composition for this area. Along the Saddle Road, native birds are present in fair to good numbers in forest habitats on the windward side of the island from above 600 meters to the kipuka at 1850 meters (mile 24). The six miles from here to Pu'u Nene are mostly barren lava; the only birds found in this area were flying between kipukas. In the forested areas in the Pohakuloa Flats area, numbers of at least one native species are fairly high, but native species diversity is generally quite low. Alien species are abundant and diverse here, reaching numbers not seen in the windward portion of the study area except below 500 meters elevation. The xeric shrublands from Pohakuloa to Kilohana were characterized by relatively low densities of a number of alien species. Game birds were not uncommon in this area. The pastures from Kilohana to ~~Mana~~ Kamaoka had the lowest avian densities in the entire project area. Both game birds and passerines were preferentially found in the shrubby habitats or in windbreaks and plantations that occasionally dotted the landscape.

A number of species were not detected during the survey in spite of records of their presence in the study area. In most cases, the absence of these species results from the "snapshot" nature of a survey such as this which can detect neither seasonal nor short term changes in avian density and distribution. This is certainly the case for the migrant shorebird species that are known to utilize upland habitats. Chance is also a factor for some of the less common gamebird species and all of the endangered forestbirds. Because of time limitations, it is impossible to conduct a survey such as this so that all of the species known from a given area are counted when they are either present or most active and detectable there. Appendix 2 provides a list of species which I did not see during the survey but which are known from the areas affected by pipeline construction.

C. Annotated List

The following list includes information of the status, distribution, and relative abundance of the bird species found during the survey. Scientific nomenclature and common names follow Pyle (1988).

Notes on distribution, habitat preferences, and behavior are from H.A.S. (1989), Pratt et al. (1987), Berger (1981), Schwartz and Schwartz (1949), and my own field experience. The status of each species is indicated by the following abbreviations: RA=resident breeding species, alien (introduced); RE=resident breeding species, endemic. An asterisk next to the entry indicates federal endangered species status.

Family Accipitridae

Buteo solitarius ('Io, Hawaiian Hawk) RE*

Three individuals were seen on the access trail to pump station 6. This species is seen regularly throughout the windward side of the island, utilizing wet and mesic forest habitats up to about 2000 meters elevation (Griffin 1984). There are some who feel that this species is common enough to be delisted.

Family Phasianidae

Francolinus erckelii (Erckel's Francolin) RA

This species was initially released from three sites on Hawai'i, one of which was Pohakuloa. It now occurs from sea level to about 7000 feet on Mauna Kea. During the survey several individuals were seen along the road near the Pohakuloa State Park and in Pastures above Waiki'i. Larger numbers were found in the mesic shrubland habitat in Parker Ranch.

Alectoris chukar (Chukar) RA

Chukar were first released in Hawai'i from Pohakuloa, and are now very common in the area; they are found in arid areas from sea level to 11,000 feet elevation and frequent open rocky habitats. Chukar were common in the two scrub habitats. They were also encountered in the mamane forest in Pohakuloa Flats, but were much less abundant there. One individual was observed in pasture habitat in the vicinity of pump station 9.

Lophura leucomelana (Kalij Pheasant) RA
Kalij Pheasant were initially introduced at Hualalai but have become a common breeding species in forests throughout the island. They were common to abundant in closed ohia habitats, and were also found in more open ohia forests. All of the birds seen during the survey were found above 1300 m elevation in areas with relatively dry substrates.

Phasianus colchicus (Ring-necked Pheasant) RA
One pheasant was heard along the access road to pump station 8, and several more were seen and heard in Parker Ranch below Waiki'i.

Meleagris gallipavo (Wild Turkey) RA
Turkey are common residents of upland habitats on much of Hawai'i. During the survey Turkey were seen along the access road to Pump Station 8, in the Pasture mauka of Pump station 9, and along the highway in the Pohakuloa Training Area.

Turkey scat was found on the a'a lava flow crossed by the access road to pump station 8, and Dr. Gerrish collected egg shell fragments of this species nearby.

Callipepla californica (California Quail) RA
A number of small groups of California Quail were seen in the mamane-naio forest at Pohakuloa Flats. Smaller numbers were observed in the subalpine shrublands in the Pohakuloa Training Area.

Family Columbidae
Streptopelia chinensis (Spotted Dove) RA
Very few Spotted Doves were seen during the survey: 2 were found along the pipeline route below pump station 2, and one was seen in a eucalyptus grove between the two Parker Ranch power station sites. Both of the two columbid species are most common in urban and agricultural habitats.

Geopelia striata (Barred Dove) RA
This species was a little commoner in the study area than the Spotted Dove. Several were seen on the powerline road below the flume road intersection, and a small group was observed near the Mana Road in Parker Ranch.

Family Strigidae
Asio flammeus sandwichensis (Pueo, Short-eared Owl) RE
Pueos are not an uncommon sight in the Waiki'i area, along the Saddle Road below Kilohana, and on the Mana Road. During this survey, I saw only two Pueo: one was on the PTA side of the Kilohana Girl Scout Camp, and the other was above Waiki'i. I have no doubt that this species utilizes the Parker Ranch portion of the study site extensively.

Family Alaudidae
<u>Alaudia</u> <u>arvensis</u> (Eurasian Skylark) RA

Skylark were introduced in the late 1800's and are now exceedingly common in upland pasture habitats on Hawai'i. Large numbers of skylark were observed in the Parker Ranch during this survey. Fewer were seen in other areas, but they were still common residents of dry upland areas from mile marker 23 onward.

Family Musicapidae
<u>Chasiempis</u> <u>s</u>. <u>sandwichensis</u> ('Elepaio) RE

This attractive native forest bird is common in both wet and dry native forests throughout much of the island. During the survey, it was seen or heard along the pipeline corridor from 660 meters elevation to about 1830 meters elevation (just above the access road to pump station 8). In the low elevation portions of this area, 'Elepaio were fairly rare, but they were common to abundant between 1100 and 1700 meters elevation in ohia forests. They were present but less frequently observed in the open ohia-koa forest in the vicinity of pump station 8.

<u>Myadestes</u> <u>obscurus</u> ('Omao, Hawaiian Thrush) RE

'Omao typify many of the wet forest habitats on the windward side of the island. They were seen or heard from above the 11 mile marker as far up the Saddle Road as the 20 mile marker. Greatest numbers were detected at the proposed site of pump station 6.

<u>Garrulax</u> <u>canorus</u> (Hwamei, Melodious Laughing-thrush) RA

This species was particularly abundant in disturbed forest habitats adjacent to the powerline road below 600 meters in elevation. It was also found in smaller numbers along the Saddle Road up to about 1200 meters elevation.

<u>Leiothrix</u> <u>lutea</u> (Red-billed Leiothrix) RA

Leiothrix populations on Hawai'i have recently undergone a great reduction in densities; few of these birds were found during the survey in areas were they were once abundant. One bird was heard at the site of pump station 6, and two were detected along the proposed access road to pump station 8.

Family Mimidae
<u>Mimus</u> <u>polyglottos</u> (Mockingbird) RA

Mockingbirds are typical residents of many arid habitats in Hawai'i. During the survey, I saw three birds near Pohakuloa State Park. They are also undoubtedly present in the shrubland habitats, but none were detected here during the survey.

Family Sturnidae
<u>Acridotheres</u> <u>tristis</u> (Common Myna) RA

Myna detections were surprisingly scarce during the survey. They were uncommon in disturbed ohia forests, mamane-naio forests, shrublands, and pastures throughout the study area. This species is a commensal, and reaches its highest densities in urban and agricultural areas. In outlying locations they may occur in high numbers near barns or livestock feeding areas, but are normally more scattered than in developed sites.

Family Zosteropidae

Zosterops japonicus (Japanese White-eye) RA

The Japanese White-eye was introduced in the 1930's and has rapidly become one of the commonest birds in the state. It was the found in all of the habitats in the study area except the barren lava. Highest densities of this species were encountered below mile marker 17 on the Saddle Road and in the mamane-naio forest near Pohakuloa.

Family Emberizidae

Cardinalis (Northern Cardinal) RA

Small numbers of Cardinals were found in closed ohia forests below mile marker 14 on the Saddle Road. They were most regularly detected in disturbed ohia forest below 650 meters elevation.

Carpodacus mexicanus (House Finch) RA

The House Finch was almost as abundant as the Japanese White-eye in the study area. It was much less common in closed forest habitats than the White-eye, but reached high densities in open ohia-koa forest and mamane-naio forest habitats. They were also much more common than the White-eye in shrubland habitats.

Family Fringillidae

Hemignathus v. virens (Common 'Amakihi) RE

This species was rare to uncommon in windward sections of the study site: one 'Amakihi was observed in ohia forest habitats, and two were seen at the proposed site of pump station 8. However, it was abundant in mamane-naio forest in the Pohakuloa area. The very low densities of this species in wet forest habitats was unexpected and probably reflects seasonal variations in abundance.

Vestiaria coccinea ('I'iwi) RE

'I'iwi densities were also anomalously low in much of the windward portion of the study area. A few were heard at the proposed site for pump station 7, but none were found below that area. They were much more common in the ohia-koa forest habitats along the access route and at the proposed site of pump station 8.

Himatione s. sanguinea ('Apapane) RE

This is the commonest of the hawaiian honeycreeper species. During the survey, 'Apapane were seen in both open and closed ohia forests above mile marker 13 on the Saddle Road. The highest densities of 'Apapane were found at the proposed locations of pump stations 6 and 7.

Family Estrillidae

Lonchura malabarica (Warbling Silverbill) RA

This species is a recent introduction to Hawai'i, and has become increasingly common on the leeward side of the island since the late 1970's. A small flock of 6 individuals was seen in the Pohakuloa Training Area at about mile marker 39. Silverbills are probaly much more abundant than this single observation would suggest, since they are abundant and widespread in many arid habitats on the island.

Lonchura punctulata (Nutmeg Mannikin) RA

The Nutmeg Mannikin was found in low numbers in several of the wetter portions of the study area, but was quite common in the two shrubland habitats. It is a seed eater that only invades native forests in areas where alien grass species are present, such as in trailside and roadside habitats. Mannikins can reach enormous numbers in ungrazed pastures were seed densities are high; in these situations they form flocks that may number in the hundreds of individuals.

IMPACTS AND MITIGATION

This project potentially affects a wider variety of avian habitats than most, but in general its immediate impacts will be fairly minor. Many of the habitats the pipeline will affect are already highly disturbed, and so construction will pose few problems.

The exception to these generalizations, and a cause for real concern, is the proposed siting of most of the pumping stations on the windward slope of the Saddle Road. Pump stations 4 through 8 are presently proposed for locations well away from the already disturbed areas near the road or the powerline corridor. Each of them (along with their access roads) will destroy sizable amounts of good native bird habitat in the elevational band that is most important for the endangered species populations of windward Hawai'i. Although it is true that I found no endangered species on any of these sites, I cannot say that they do not occur there. The reasons for this are both methodological and biological. This survey was intensive yet very brief: I was unable to make repeated visits to any of the areas to determine seasonality or even to make replicate counts. In addition, I was forced by time limitations to census at all times of the day and in sometimes suboptimal weather conditions. The biological variability of these bird populations compounds the problems created by the survey constraints. Many hawaiian forest birds are known to be extremely sensitive to the phenological changes of their food plants. 'I'iwi, 'Apapane, and Palila move in response to flowering and fruiting of their forest trees, both laterally and elevationally (Macmillen and Carpenter 1983, Scott et al. 1984. Without censuses at different times of the year, it is impossible to unequivocally say that the results of my counts are at all typical of the areas they are meant to represent. In addition, since most of these areas were only censused once, I cannot determine how diurnal changes would affect the results. A number of hawaiian honeycreeper species have large home range sizes. One of the endangered species known from the Saddle road vicinity (the 'Akiapola'au, Hemignathus munroi) wanders extensively (pers. obs., Lepson, unpubl. data). Clearly, there is no way of determining the use of an area by such a species without repeated censuses.

The impacts of pump stations in these areas go beyond the immediate affects of clearing and construction. The sites for Pump stations 5 through 7 were relatively intact biologically. While there were alien plants in these locations, by and large they were a small component of the community. Opening up these areas will totally change their floristic composition by greatly increasing the ease of alien plant invasions. There also is the potential problem of increased run-off and erosion, especially where drainage is already poor. Even the sites for pump stations 4 and 8 (which were more disturbed) would be greatly affected by these changes.

For all these reasons, I am inclined to be cautious in recommending that the project proceed as presently planned. I strongly suggest moving the sites of pump stations 4 through 8 as close to the present road easement as possible to mitigate potential impacts on all of the forest birds in these areas (Not only the endangered species). To site the pump stations in locations that require minimal clearing of native forest (i.e., close to the road) is sensible for both biological and economic reasons; to do otherwise for the sake of aesthetics is wasteful of both money and invaluable biological resources.

None of the other sites slated for extensive modification pose significant impacts to present bird habitat. The deep wells, pump stations 1, 2, 3, and 9, the two power stations, and the terminal reservoir are all proposed for locations that are not significant native bird habitat: all are in areas that are already disturbed. Likewise, the head tank and surge tanks are to be located near enough to the present roadway that additional impact will be minimal.

Operational impacts on avifauna in the immediate vicinity of the pipeline will also be small. However, one source of concern needs to be addressed in the planning stages of the operation. Populations of the endangered Dark-rumped Petrel (Pterodroma phaeophygia sandwichensis) breed in several locations on the upper slopes of Mauna Kea and Mauna Loa (Conant 1980, Banko 1981). Unshielded bright lights are particularly attractive to Dark-rumped Petrel fledglings as they embark on their first seaward flights in October and November (Reed et al. 1985, Simons 1983, Simons and Simons 1981). Accidental mortality of these birds due to groundings and collisions with structures has been quite high in some parts of the state. To prevent lights from pump stations in middle and high elevation areas from disorienting birds flying in the area, they should be designed to include shields to prevent upward glare. Similar concerns apply at low elevation sites since the endangered Newell Shearwater (Puffinus newelli) breeds in small numbers in the Hamakua/Wailuku River area. Young birds of this species have been found in Kaumana (Conant 1980), indicating that downings are a potential concern at pump stations and substations in the vicinity.

Literature Cited

Banko, W. 1981. C.P.S.U./U.H. Avian History Report. History of Endemic Hawaiian Birds. Part 1. Population Histories--Species Accounts. Dark-rumped Petrel.

Berger, A.J. 1981. Hawaiian Birdlife. University Press of Hawaii, Honolulu.

Conant, S. 1980. Recent records of the 'Ua'u (Dark-rumped Petrel) and the 'A'o (Newel's Shearwater) in Hawaii. 'Elepaio 41(2): 11-13.

Freed, L. 1990. Ornithological Survey for Saddle Road Improvements.

Griffin, C. 1984. Hawaiian Hawk Recovery Plan. U. S. Fish and Wildlife Service, Portland Oregon.

MacMillen, R. E. and F. L. Carpenter. 1983. Evening Roosting Flights of the Honeycreepers Himatione sanguinea and Vestiaria coccinea on Hawaii. Auk 97:28-37.

Pyle, R. 1988. Checkist of the Birds of Hawaii--1988. 'Elepaio 48:95-106.

Pratt, H.D., P.L. Bruner, and D.G. Berret. 1987. A Field Guide to the Birds of Hawaii and the Tropical Pacific. Princeton University Press, Princeton, New Jersey.

Reed, J. R., J. L. Sincock, and J. P. Hailman. 1985. Light attraction in endangered Procelliiform birds: reduction by shielding upward radiation. Auk 102:377-383.

Reynolds, R. T., J. M. Scott, and R. A. Nussbaum. 1980. A variable circular plot method for estimating bird numbers. Condor 82:309-313.

Schwartz, C. W. and E. R. Schwartz. 1949. The Game Birds in Hawaii. Board of Agriculture and Forestry, Territory of Hawaii.

Scott, J. M., S. Mountainspring, C. van Riper III, C. B. Kepler, J. D. Jacobi, T. A. Burr, and J. G. Giffin. 1984. Annual variation in the distribution, abundance, and habit of the Palila (Loxiodes baileui). Auk 101:647-664.

Scott, J.M., S. Mountainspring, F.L. Ramsey, and C.B. Kepler. 1986. Forest Bird Communities of the Hawaiian Islands: Their Dynamics, Ecology, and Conservation. Studies in Avian Biology 9:1-431.

Simons, T. R. and P. M. Simons. 1981. Breeding biology of the Dark-rumped Petrel in the Hawaiian Islands. In: Proc. Third Conf. Nat. Sci., HAVO. C.P.S.U./U.H., University of Hawaii, Honolulu. Pp. 289-300.

Simons, T.R. 1983. Biology and Conservation of the endangered Hawaiian Dark-rumped Petrel (*Pterodroma phaeophygia sandwichensis*). N.P.S./C.P.S.U., University of Washington, Seattle.

Table 1. Relative abundance of bird species detected during the avifaunal survey of the proposed pipeline route. R=rare, U=uncommon, C=common, A=abundant, +=sign present, but no actial detections.

SPECIES	HABITAT 1A	1B	1C	2	3	4	5	6	7
Buteo solitarius	U	U	U						
Francolinus erckelii					U		C	U	
Alectoris chukar					U	C	C	R	
Lophura leucomelana		C/A	U						
Phasianus colchicus				R			R	U	
Meleagris gallipavo				U		R	R		+
Callipepla californica					A	C			
Streptopelia chinensis	R							R	
Geopelia striata	U							U	
Asio flammeus sandwichensis								U	
Alaudia arvensis				U	U	C	A	A	
Chasiempis s. sandwichensis	R	C/A	U	U					
Myadestes obscurus		C	R						
Garrulax canorus	A	C	R						
Leiothrix lutea		R		U					
Mimus polyglottos					C				
Acridotheres tristis	U				U	U	U	U	
Zosterops japonicus	A	A	C	U	A	U	U	R	
Cardinalis cardinalis	U	R			R				
Carpodacus mexicanus	C	U	U	A	A	C	C	R	
Hemignathus v. virens		R		C	A	R			
Vestiaria coccinea		U		C					
Himatione s. sanguinea		A	C	U					
Lonchura malabarica						U			
Lonchura punctulata	U		R		C	C	U	U	

Appendix 1.

The maps on the following pages are modified from Scott et al. (1986). They show the distributions of endangered forest bird species in the proposed project area as of 1977. The only modifications I have made are to include the proposed locations of pump stations 6,7, and 8 (stars on Figures 1 and 3-6), and the 20MG reservoir at Pohakuloa (stars on Figure 7). Since the proposed pipeline follows the route of the Saddle Road in the pertinent parts of the maps, I did not indicate it separately.

Figure 1. Distribution of the Hawaiian Goose (Nene).
No Nene were detected during the survey. Presently, two populations of Nene occur on the south and east slopes of Mauna Loa and in the Saddle area between the two mountains (Pratt et al. 1987, R. Bachman, Pers. comm.). The northern population consists of birds in the Saddle area, including Pohakuloa Training Area (particularly Hill 6677), Parker Ranch, and Kipuka Ainahou. The latter area has been designated a Nene Sanctuary by the State: it is adjacent to the Saddle Road between mile markers 23 and 26 and contains a significant amount of the Nene habitat in the saddle area. It is a release site for captive-bred birds, and is subject to ongoing monitoring by DLNR personnel. Birds regularly move back and forth between Kipuka Ainahou and both Parker Ranch and PTA. There is also less frequent interchange between the Saddle population and the population in the HVNP/Keauhou area on the southeastern slope of Mauna Loa, across the NE rift zone in the vicinity of the Powerline Rd. (R. Bachman, pers. comm.).

Figure 2. Island-wide distribution of Hawaiian Hawk.

Figure 3. Distribution of the Hawaii Creeper in windward Hawai'i.

Figure 4. Distribution of the Hawaii 'Akepa in Windward Hawai'i.

Figure 5. Distribution of the 'Akiapola'au in Windward Hawai'i.

Figure 6. Distribution of the 'O'u in Windward Hawai'i.

Figure 7. Distribution of the Palila (top) and the 'Akiapola'au (bottom) on the upper slopes of Mauna Kea. The approximate location of the Pohakuloa 20MG reservoir is indicated by the star in each figure.

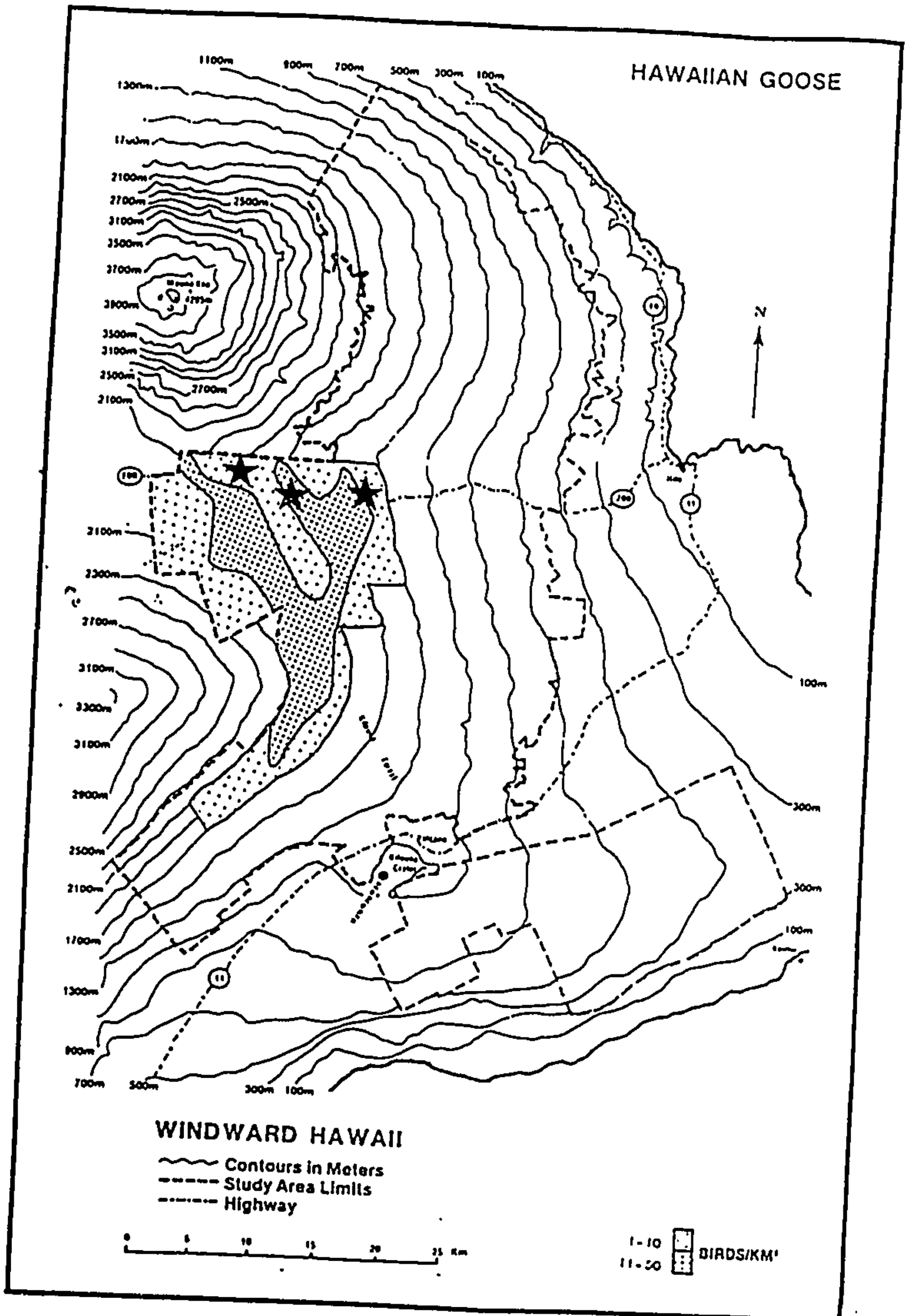

HAWAIIAN GOOSE
N
WINDWARD HAWAII
Contours in Meters
Study Area Limits
Highway
BIRDS/KM²

Figure 1.

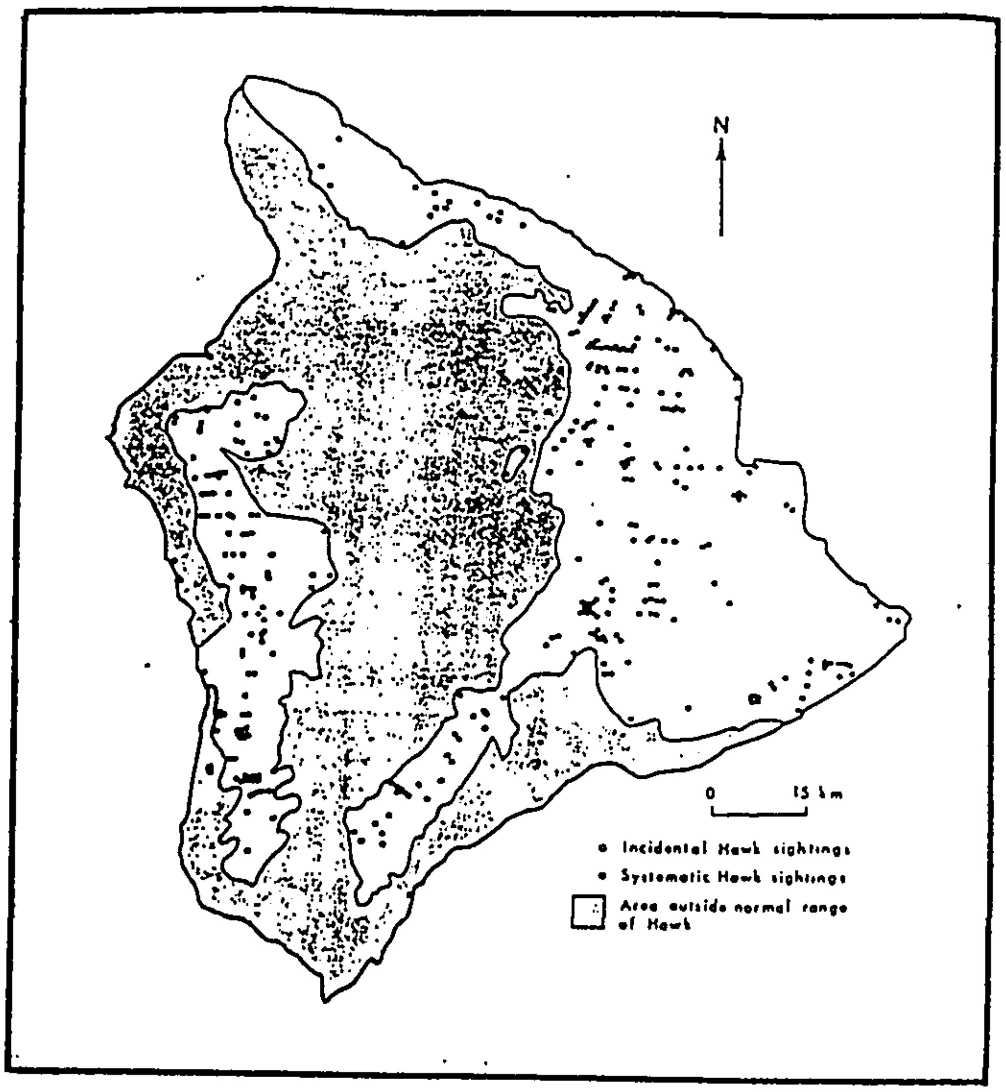

N
0
15 km
Incidental Hawk sightings
Systematic Hawk sightings
Area outside normal range of Hawk

Figure 2.

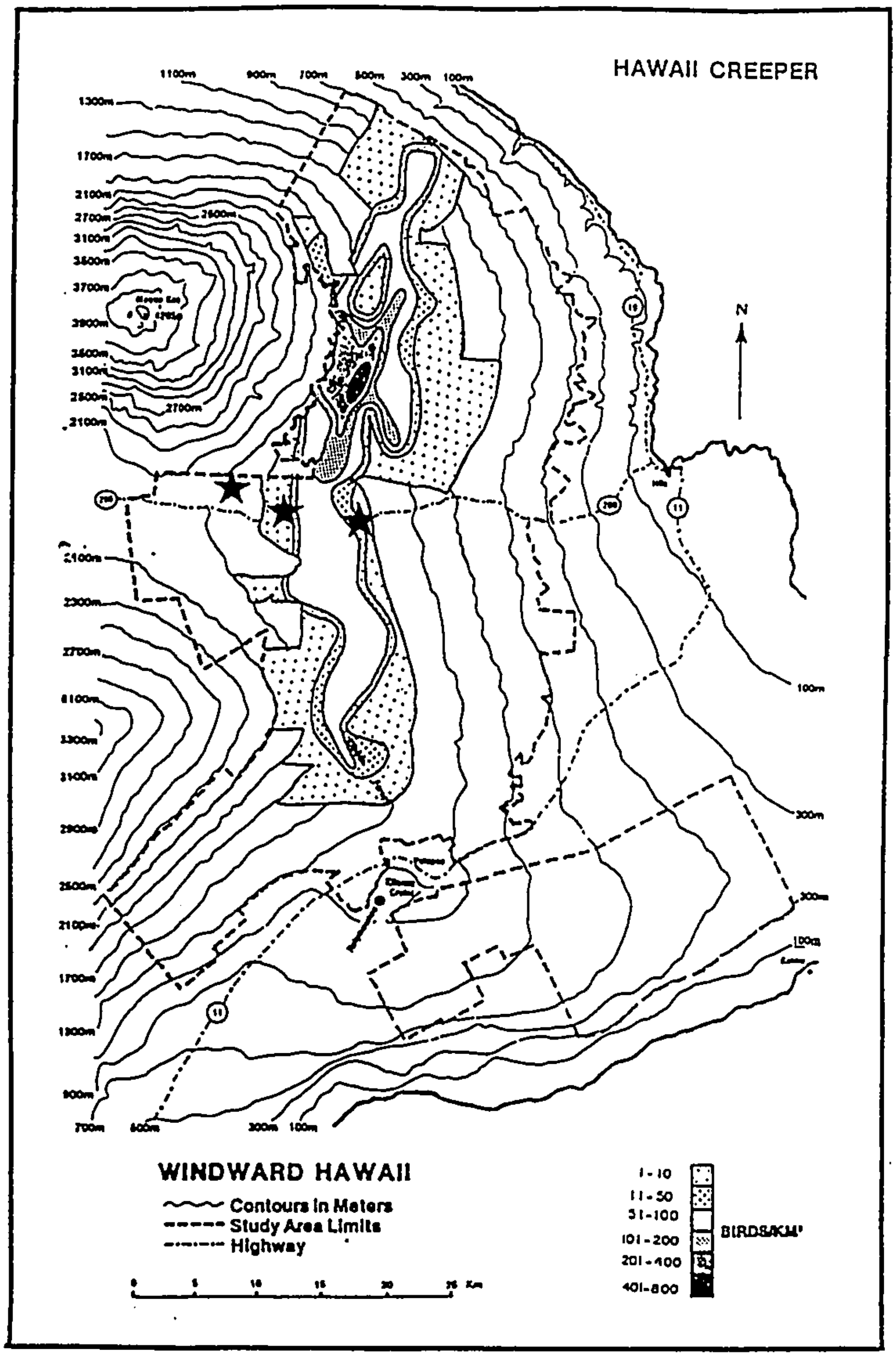

HAWAII CREEPER
N
WINDWARD HAWAII
Contours in Meters
Study Area Limits
Highway
1-10
11-50
51-100
101-200
201-400
401-800
BIRDS/KM²

Figure 3.

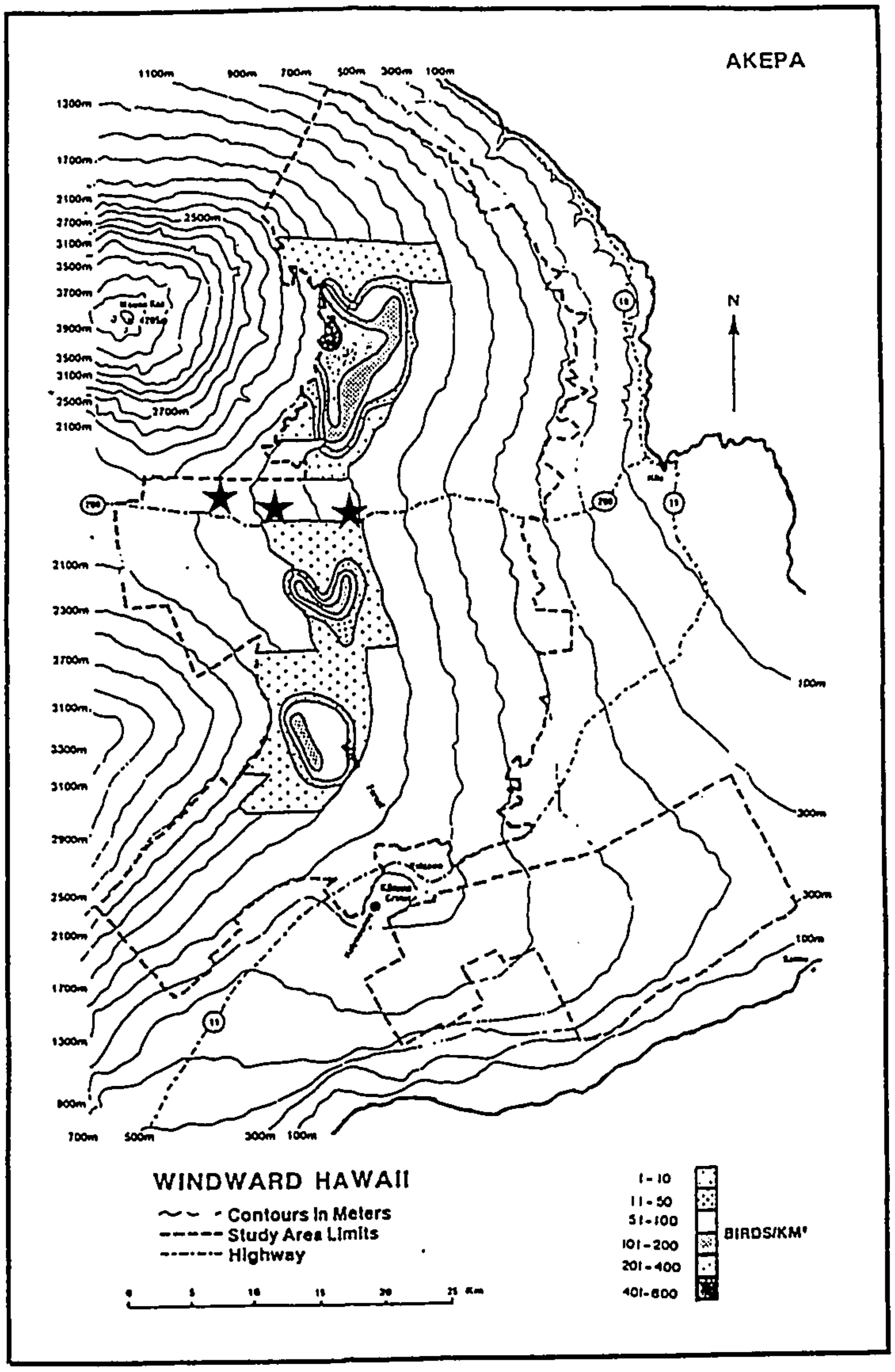

AKEPA
N
WINDWARD HAWAII
Contours In Meters
Study Area Limits
Highway
1-10
11-50
51-100
101-200
201-400
401-600
BIRDS/KM²

Figure 4.

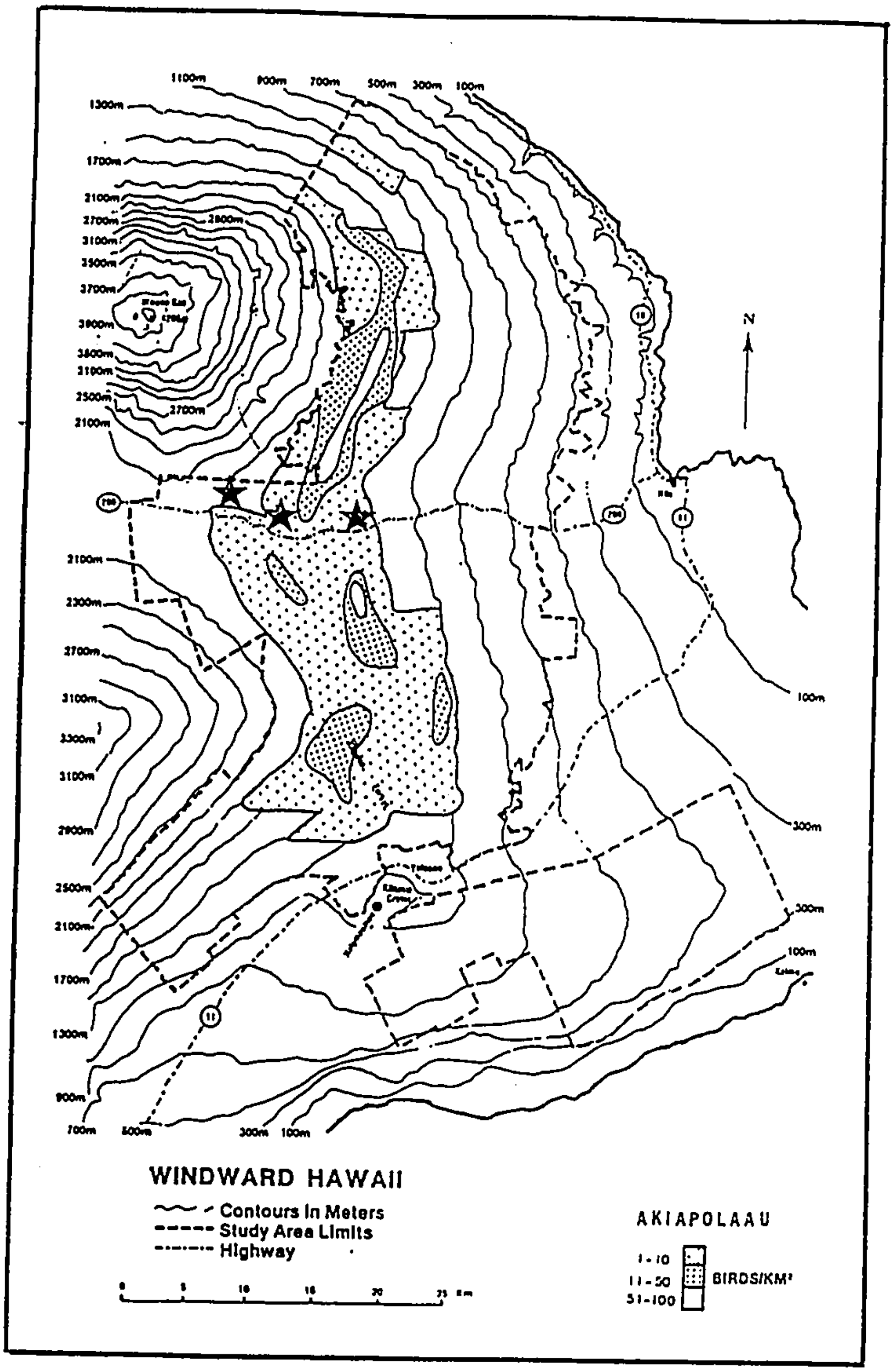

WINDWARD HAWAII
Contours in Meters
Study Area Limits
Highway
AKIAPOLAAU
1-10
11-50
51-100
BIRDS/KM²
N

Figure 5.

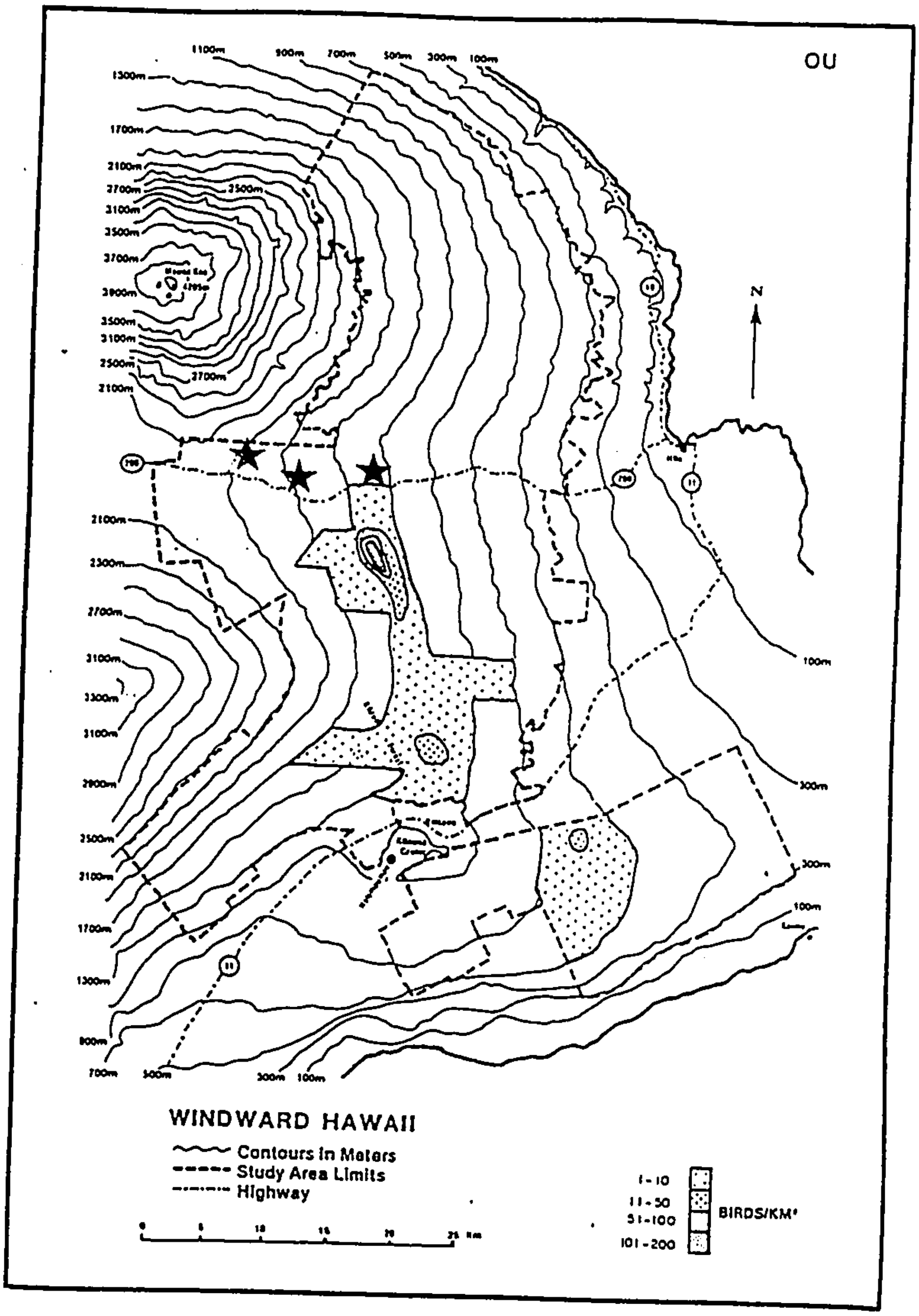
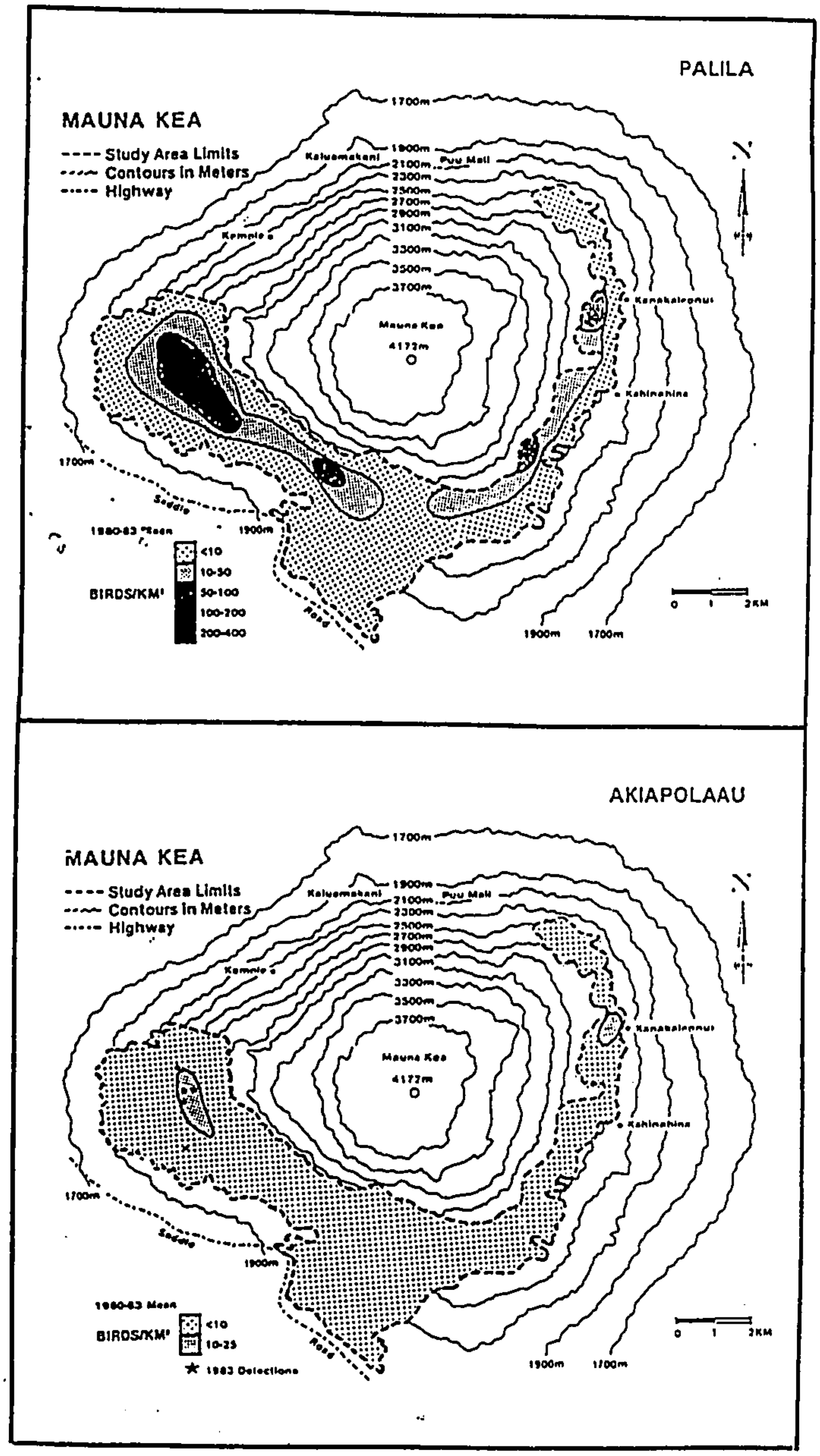

OU
WINDWARD HAWAII
Contours in Meters
Study Area Limits
Highway
1-10
11-50
51-100
101-200
BIRDS/KM²
N

Figure 6.

Figure 7.


PALILA
MAUNA KEA
Study Area Limits
Contours in Meters
Highway
1700m
1900m
2100m
2300m
3100m
3300m
3500m
3700m
Puu Mali
Mauna Kea
4172m
1980-83 Mean
BIRDS/KM²
<10
10-50
50-100
100-200
200-400
Saddle
Road
0
1
2KM
AKIAPOLAAU
MAUNA KEA
Study Area Limits
Contours in Meters
Highway
1980-83 Mean
BIRDS/KM²
<10
10-25
1983 Detections

Appendix 2. Species known from the study area not detected during the survey. Species highlighted by an asterisk are endangered. Those enclosed in parentheses have distributions that include parts of the study site but have not been confirmed in the areas directly affected by the project. Abbreviations are as in the annotated checklist; MI=indigenous migrant.

Family Anatidae
(Nene (<u>Nesochen</u> <u>sandvicensis</u>))* RE

Family Charadriidae
Lesser Golden-Plover (<u>Pluvialis</u> <u>dominica</u>) MI

Family Scolopacidae
Wandering Tattler (<u>Heteroscelus</u> <u>incanus</u>) MI

Family Pteroclididae
Cestnut-bellied Sandgrouse (<u>Pterocles</u> <u>exustus</u>) RA

Family Tytonidae
Barn Owl (<u>Tyto</u> <u>alba</u>) RA

Family Emberizidae
Saffron Finch (<u>Sicalis</u> <u>flaveola</u>) RA

Family Fringillidae
('O'u (<u>Psittirostra</u> <u>psittacea</u>))* RE
(Palila (<u>Loxiodes</u> <u>bailleui</u>))* RE
('Akiapola'au (<u>Hemignathus</u> <u>munroi</u>))* RE
('Alawahio, Hawai'i Creeper (<u>Oreomystus</u> <u>mana</u>))* RE
(Hawai'i 'Akepa (<u>Loxops</u> <u>coccineus</u> <u>coccineus</u>))* RE

Appendix G

Archaeological Survey of Proposed Water Transmission Lines and Pump Stations, Saddle Road and Waimea, Island of Hawai'i

Prepared by Terry L. Hunt, Ph.D.

Abstract

Reported here are the results of archaeological studies conducted to determine the impact to cultural resources in the proposed water development and transmission project on the Island of Hawai'i. Previous field work for the Saddle Road area and slopes of Mauna Kea indicates that prehistoric and historic sites such as trails, rock walls, enclosures, platforms, cairns, modified and utilized caves and rockshelters, quarries, burials, and isolated artifact finds are present in the larger area. These sites represent intermittent or specialized use of upland resources, and can include workshops, shrines, and encampments. Archaeological work done in the Waimea area has documented historic sites associated with ranching, and extensive Hawaiian residential and agricultural complexes. These sites represent more intensive and permanent use in prehistoric and historic times.

Field survey on the proposed route of water transmission from Hilo along Saddle Road, including pump station locales, revealed the absence of archaeological resources. Similarly, survey of the proposed water transmission lines on the northwestern side of Mauna Kea showed no evidence of archaeological resources. However, the discovery of any archaeological remains during the course of construction would require a new plan for mitigation. Some monitoring of initial

site preparation work is recommended as a mitigative plan for archaeology.

Purpose

Archaeological literature review and field survey were undertaken to assess the potential impact of a project proposed to transport water from Hilo along a Saddle Road transmission line to the northwestern slopes and saddle area of Waimea (see project maps....). This report provides a summary of the literature search of the region and the results of field survey on lands included in the water development plan. Fortunately, field study showed that little mitigative action will be needed to protect against impact to archaeological resources. Some monitoring of early construction activities at some construction sites is recommended.

Background: Literature Review

An overview of the archaeology known for the region provides a basis for expectations of resources in areas not yet studied, including those that could be encountered in project areas. In order to assess the archaeology known for the Waimea-Saddle region, I first conducted a literature search and overview using published and unpublished sources held in the library of the State Historic Preservation Office and the Hamilton Library at the University of Hawai'i. Sources on archaeology within the overall region (including some work done in Pohakuloa and the slopes of Mauna Kea) were reviewed. Sources for archaeology along the coast (i.e., makai of the Queen Ka'ahumanu Highway) were consulted, but not included in the overview, as these areas lie well outside the area under consideration. Archaeology known for the region reveals a pattern of historic and prehistoric occupation and land use that allows assessment of archaeological potential for areas not yet surveyed in the field. Reported here are patterns deduced from an overview of the archaeology presently known.

Numerous archaeological field projects and historical studies have been reported for the Waimea region, especially in the native land divisions (ahupua'a) of Lalamilo, Waikoloa, 'Ouli, Kawaihae, and Pu'ukapu (see bibliography). The majority of field projects are small in scale, but together form a larger picture of patterns in the archaeological record for the region.

The largest single project in the region (i.e., the greatest coverage of area, variability, and synthesis) was undertaken by J.T. Clark, P.V. Kirch and their associates at Bishop Museum (Barrera and Kelly 1974; Kirch and Claus 1981; Clark and Kirch 1983). Clark and Kirch (eds., 1983) report the archaeology of the Mudlane-Waimea-Kawaihae road corridor--a transect of intensive investigation that crossed the varied environmental zones from coastal Kawaihae (hot, leeward) to the eastern portion of the Waimea Saddle (cool, windward). The transect was 32.3 km long (20 miles) and approximately 610 meters (2,000 ft) wide. A total of 4,561 features was recorded in the transect, with most located near the coast or in the upland area of Lalamilo, near Waimea (Kamuela). Their findings were described by four sections intensively surveyed along the road corridor, and are summarized below.

Section 1, from the coast to about 145 m (475 ft) elevation, has more than 235 sites comprising hundreds of features (Clark and Kirch 1983:64). These resources include burials (in mounds, platforms, and terraces), midden scatters, agricultural sites, residential complexes (numerous associated structures and features), and isolated midden and artifacts. These finds span prehistoric and historic periods.

Section 2 stretches from 145 to 620 m (ca. 464-2,000 ft) in elevation. This zone is hot, arid, open grassland with a stony substrate. A total of 64 sites comprising 381 features are found in this section. Included in the list are stone-stacked cairns, enclosures (shelters), and alignments (including trail segments). Some of these together form site complexes. Remains from prehistoric and historic periods are present.

Section 3 extends from 620 to 797 m (ca. 2,000-2,550 ft) across the interior of the Waikoloa ahupua'a. This zone is also parched grassland. Only 25 sites comprising 96 features are found in this section. These sites include a cremation burial, enclosures (shelters or "encampments"), and agricultural features (mounds, terraces, swales, and a ditch for intermittent irrigation ['auwai]).

Section 4 crosses the relatively flat Waimea Saddle from 797 to 853 m (2,550-2,730 ft) in elevation. In contrast to the slopes below (to the west), this zone is comparatively cool and moist. A total of 20 sites consisting of 52 features, plus two prehistoric (and native historic) agricultural field complexes with a set of irrigation ditches (<u>'auwai</u>) are found in Section 4. The agricultural field complexes include bounded field units, small planting swales, pondfields, ditches (<u>'auwai</u>), stone mounds, and small terraces. In addition to the extensive agricultural remains, residential complexes are also located in the section.

The agricultural field complexes recorded for Section 4 are but a portion of four large field complexes that form an arc to the west and south of Waimea town. At least three of these complexes had supplemental water intake systems that used ditches (<u>'auwai</u>) for intermittent irrigation. This prehistoric design innovation is unusual in Hawai'i, and adds to the significance of these well preserved agricultural complexes (see Clark 1986).

Significantly, the archaeological sites of Section 4 are clustered at its western end. The eastern end of the highway corridor, near Mudlane Road, appears virtually free of archaeological sites or features. This area is notably wetter and foggier than the western end of Section 4, where prehistoric and historic activity was located.

Several other small-scale surveys in the region (e.g., Bonk 1985a; 1985b; Clark et al. 1990; Cox 1983; Hammatt et al. 1988; Hammatt and Shideler 1988; Kam 1983; Neller and Beggerly 1980; Soehren 1984) provide results consistent with the pattern documented in the Mudlane-Waimea-Kawaihae road corridor. Some of these studies (e.g., Bonk 1985a; 1985b; Clark et al. 1990) are projects for additional data recovery/mitigation on sites reported by Clark and Kirch (1983).

In terms of the general pattern for the Waimea area, there exists a very high density of archaeological sites and features in a zone adjacent to the shoreline (sea level to about 100 m [300 ft]). The density of archaeological resources drops along the leeward slopes from about 100 to 800 m (ca. 300-2,600 ft), indicative of sporadic use of the zone. Archaeological resources increase dramatically on the Waimea Saddle and the lower slopes of the Kohala Mountains at Waimea with four extensive agricultural complexes and associated residential sites. Based on present evidence, the Hawaiian agricultural field complexes here seem to be limited to this area. This observation is consistent with the early historical records for the area (see Clark, in Clark and Kirch 1983). Perhaps not surprisingly, the presence of agricultural complexes coincides with average rainfall amounts of between 1020 and 1900 mm (40-75 in). Lower rainfall areas found to the west and south, and while agricultural features are known, no major agricultural complexes have been recorded. Areas of the Waimea Saddle to the east with higher rainfall, and associated cloud cover or fog, show very little evidence of prehistoric agriculture or other activity.

In addition to the pattern of Hawaiian (prehistoric or traditional historic) settlement and land use is the archaeological record of ranch activities and foreign settlement in the region beginning in the mid-nineteenth century. The distributional pattern of these resources over the landscape will overlap, but not necessarily mirror the Hawaiian record for the region.

Archaeological field studies from upland Hilo, the Mauna Kea-Mauna Loa Saddle and slopes of Mauna Kea provide evidence for the kind of archaeological resources to expect in the windward and leeward upland zones--where most project construction will occur. Several studies (e.g., Barrera 1983; Cox 1983; Haun 1986; Hommon 1982; McCoy 1984; 1986; McEldowney 1982; Streck 1986; Rosendahl and Rosendahl 1986) reveal the presence of sites that include trails, rock walls, enclosures, platforms, cairns, modified and utilized caves and rockshelters, quarries, burials, and isolated artifact finds (e.g., adzes used in taking forest resources). These sites represent intermittent use of upland resources, and can include sites interpreted to be encampments and religious sites (shrines). These kinds of archaeological remains often mark particular natural resources in the environment such as caves, lava tubes, and rock sources (e.g., fine-grained basalt or volcanic glass). In other cases, sites (as structures and/or clusters of artifacts) and isolated finds are sparse and seemingly random in their distribution.

As part of the Mudlane-Waimea-Kawaihae road corridor project, McEldowney (in Clark and Kirch 1983) reconstructed vegetation patterns for the Waimea-Mauna Kea region using classification of present plant communities, together with plotting of relict tree associations and interpretations of landscape descriptions in early historic documents. Because vegetation patterns reflect, on the one hand human activity, and on the other hand, zones of different kinds of resource use, McEldowney's results (see Fig. 16.1 in McEldowney, in Clark and Kirch 1983:435) provide a useful guide to expectations for the archaeological record of the region.

McEldowney (1983) distinguishes 12 vegetation communities for the period between 1792 to 1850 A.D. The pili lands (1) zone corresponds to the shoreline and adjacent lowlands where very high densities of sites are known to exist. The pili lands (2) vegetation zone approximates the areas surveyed in the Mudlane-Waimea-Kawaihae road corridor Sections 2 and 3. This is a zone with a relatively sparse distribution of archaeological sites, and apparently saw little if any intensive agriculture. Further field studies should add to this observation. The kula lands (1 & 2) represent the major inland expanse of agricultural land comprised of predominantly open grasslands "that formed the matrix for actively tended plant communities around residential features and in agricultural plots" (McEldowney, in Clark and Kirch 1983:418). Similarly, the ulula'au vegetation zone is described as "a patchwork of scattered agricultural and residential features interspersed with numerous trees" (McEldowney 1983:422). The <u>kula</u> and <u>ulula'au</u> zones correspond to the high density of archaeological sites near Waimea, on the Waimea Saddle and the slopes of the Kohala Mountains, including both residential complexes and agricultural field systems. These zones of intense inland occupation and land use coincide with adequate, but not excessive rainfall (between 1020 and 1900 mm [40-75 in]). The moist forest zones (mixed open canopy, <u>mamane/koa</u>, tall stature <u>koa</u>, and open <u>mamane</u>) and the rainforests (<u>ohi'a</u> and <u>ohi'a/koa</u>) would have seen some use by Hawaiians, but the record of this use will be in the form of isolated artifacts (e.g., adzes or flakes) or sites of special function (e.g., lava tube burials or shelters). Overall, the density of archaeological resources in these zones will be comparatively low. The last vegetation zone, the wet unforested agricultural lands, lie to the east (windward) of the area considered in this report.

In sum, the highest densities for archaeological resources are known for the coast and the northwestern portion of the Waimea Saddle. Sites in the Waimea Saddle appear to coincide with adequate rainfall for agriculture and associated residential sites. Areas to the south on the Waimea Saddle and the north, northwestern, and western slopes of Mauna Kea are unlikely to have agricultural or residential complexes, but do, and undoubtedly will, include more archaeological resources such as burials (in caves or lava tubes), enclosures (shelters or "encampments"), trails/trail segments, cairns, lithic and midden scatters, and isolated artifacts.

Finally, two sites previously recorded on or near the proposed water transmission lines or other construction sites associated with the project have been described and evaluated in work done for Saddle Road improvements (Rosendahl and Rosendahl 1986). First, the Pu'u O'o foot trail (Site "T-101" see Rosendahl and Rosendahl 1986 for description) constructed on the 1855 Mauna Loa lava flow is outside the project areas (south of Saddle Road). Second, Site "T-102" (Rosendahl and Rosendahl 1986) is a wall constructed of a'a boulders on the 1843 lava flow. This wall appears to be associated with the Humu'ula Sheep Station (Site 50-10-32-7119). Rosendahl and Rosendahl (1986) evaluated the significance of these resources as low in the three categories of research, interpretive, and cultural value. They recommended no additional work on these sites with Saddle Road improvements.

Field Survey Results

Field surveys were conducted at construction sites shown on maps provided by Okahara and Associates, Hilo (1990). Project lands include the water transmission line and eight pump stations between Waiakea-Uka to Pohakuloa Training Area. Plans also call for water transmission from Pohakuloa to Waimea with two power stations and a terminal reservoir. Much of the project is planned for land already surveyed for archaeological resources and subsequently altered (by bulldozing) for Saddle Road improvements (Rosendahl and

Rosendahl 1986) and powerline realignments (Barrera 1983). Present plans to place the water transmission line along the existing power transmission line and Saddle Road greatly reduces the need for additional intensive survey or mitigative steps prior to construction activities. In addition, project parcels (for pump stations) not previously surveyed are largely confined to the 1881 Mauna Loa lava flow, thus restricting the kind of sites potentially present.

Water Transmission Lines

The entire length of the proposed water transmission line was surveyed by jeep and on foot as necessary on May 3-4, 1991. Plans call for placement of buried piping and some tanks (head and surge tanks) along a corridor approximately 12-30 m (40-100 ft) wide that follows the existing Saddle Road and 138 kv powerline alignments. These areas in particular have been surveyed for archaeological resources (Barrera 1983; Rosendahl and Rosendahl 1986) and have seen the impacts of previous development, including bulldozing that would destroyed archaeological evidence at the surface.

Water transmission from Pohakuloa to Waimea is proposed as two alternatives. Alternative A departs from the Saddle Road near Waiki'i Ranch and traverses the west and northwestern slopes of Mauna Kea. This route crosses grassland associated with Parker Ranch grazing. While the ground surface is not visible in most places, stone or earthen features would likely be visible under these conditions. No archaeological resources were observed in the proposed water transmission line of Alternative A.

Alternative B follows Saddle Road for much of its route. Where it departs from the Saddle Road alignment (i.e., areas of previous impact by bulldozing, etc.), field survey will be necessary to check for the presence of archaeological resources. Field survey was not undertaken for this report, as Alternative B is _not_ recommended. The negative recommendation for Alternative B is made because the proposed water transmission line would cross areas of the prehistoric/ historic agricultural complexes, or additional sites associated with these complexes reported by Clark (in Clark and Kirch 1983:240-314). Alternative A is recommended as a more practical option in terms of historic preservation. Should Alternative B be chosen for other reasons, additional archaeological survey would be necessary to make recommendations for minimal impact to those resources.

Pump Station 1/Water Resource Site

The site of proposed pump station 1 (water resource) is located in the Waiakea-Uka area of Hilo at 253 m (830 ft) elevation. The proposed construction site is heavily vegetated in a dense understory of _uluhe_ fern (_Dicranopteris linearis_) with some _ti_ (_Cordyline fruticosa_) plants, and _ohi'a_ (_Metrosideros polymorpha_) trees. The heavy groundcover meant that little of the surface could be observed in the field survey. No archaeological resources were discovered at the pump station 1 locale.

The present vegetation pattern of disturbed rainforest and secondary growth suggests that the area has been used for economic purposes, perhaps for grazing. In addition, the presence of ti plants (feral Cordyline fruticosa) suggests the possibility of former cultivation of Hawaiian crops. This possibility means that agricultural features might be discovered in the area, yet would not have been visible in the field survey. Construction activities could also expose lava tubes that might contain human burials, or other evidence of human activity. For these reasons it is recommended that with initial clearing operations, an archaeological monitor be present to check for the presence of archaeological resources and plan for further mitigative steps at that time.

Pump Station 2

The site of proposed pump station 2 would be situated near the Saddle Road (ca. 60 m north) at an elevation of 470 m (1,540 ft) on the 1881 Mauna Loa lava flow. The substrate is boulder rubble, resulting from the weathering of young lava. No archaeological resources were discovered. While ground surface visibility was poor due to vegetation, no archaeological resources are likely to exist at this location. No mitigative action is recommended for construction at pump station 2.

Pump Station 3

The site of pump station 3 at 695 m (2,280 ft) elevation is also situated on the 1881 Mauna Loa lava flow. The substrate is pahoehoe lava with sparse growth of various ferns and ohi'a (Metrosideros polymorpha), making the surface clearly visible. Some of the area proposed for pump station 3 development has been bulldozed (with powerline alignment work). No archaeological resources were discovered, and it is likely that none are present. No mitigation is recommended for development of pump station 3.

Pump Station 4

The proposed site of pump station 4 is at 910 m (2,985 ft) elevation on a prehistoric Mauna Loa lava flow. The vegetation at this site is relatively heavy, including ohi'a (Metrosideros polymorpha) koa (Acacia koa) and a dense understory of uluhe (Dicranopteris linearis), that makes visibility of the ground surface difficult. No archaeological resources were discovered. While ground surface visibility was poor due to vegetation, no archaeological resources are likely to exist at this location. No mitigative action is recommended for construction at pump station 4.

Pump Station 5

The proposed site of pump station 5 is at 1,146 m (3,758 ft) elevation covers both Mauna Loa flows from 1855 and a much older prehistoric one. The 1855 flow near Saddle Road is vegetated in grasses and fern and is relatively open. The surface is clearly visible, and only modern artifacts (i.e., litter in association with the road) was present. Farther north from the road on the older lava flow is forest vegetation that includes ohi'a (Metrosideros polymorpha) and koa (Acacia koa). Surface visibility in this area is poor.

No archaeological resources were discovered, and it is likely that none exist at this location. In terms of archaeology, no mitigative action is recommended for construction at pump station 5.

Pump Station 6

The proposed site of pump station 6 is at 1,360 m (4,460 ft) elevation on a prehistoric Mauna Loa a'a flow. There is very little vegetation, and visibility of the rugged lava surface is excellent. No archaeological resources were discovered. No mitigative action is recommended for construction at pump station 6.

Pump Station 7

The proposed site of pump station 7 is at 1,580 m (5,182 ft) elevation and crosses the 1855 and a much older Mauna Loa lava flow. The 1855 a'a flow has very little vegetation and the surface is clearly visible. Only modern artifacts (i.e., litter) from road use and hunter's use of the area were observed. Along the north edge of the 1855 flow is a modern trail used by hunters. The area beyond the 1855 flow includes some established native forest. No archaeological resources were discovered at this site. In terms of archaeology, no mitigative action is recommended for development of pump station 7.

Pump Station 8

The proposed site of pump station 8 is at 2,018 m (6,620 ft) elevation on the slopes of Mauna Kea. The substrate is volcanic ash soil with grass comprising the primary vegetation. This vegetation reflects use of the area for grazing. While the surface of the ground (i.e., any exposed soil) is not visible in most places, archaeological features of stone or earth would be easily seen. No archaeological resources were discovered at this site, but vegetation clearance and earthwork could uncover buried remains. Workers on the site, as for other locations, should be made aware of this potential. Any signs of archaeological remains must be reported while work is suspended so that a mitigative plan can be made with an archaeologist. No other mitigative action is recommended for development of pump station 8.

Pohakuloa Reservoir

The site of the proposed 20 million gallon reservoir is situated adjacent to Saddle Road at an elevation of 1,945 m (6,380 ft) on the slopes of Mauna Kea. The substrate at this site is soil formed in volcanic ash with dry shrubland vegetation. Much of the reservoir site has been disturbed by vehicular traffic, including activities associated with the Pohakuloa Training Area. The ground surface is easily visible at this location and no archaeological features were observed. It is possible, however, that clearing of vegetation and/or earthworks at this site could reveal or unearth archaeological remains. Discovery of any isolated artifacts, features (e.g., stone walls, mounds, hearths, etc.), or buried deposits must be reported and work suspended until an archaeologist can assess the situation. Otherwise, no mitigative action is recommended.

Pohakuloa Water Tanks

The proposed Pohakuloa water tanks are to be located just north of Saddle Road at an elevation of 0,000 m (0000 ft) on the slopes of Mauna Kea. This location is much like that described for the reservoir, above. While no archaeological resources were observed at this site, clearing of vegetation and other construction activities could reveal them. The discovery of any archaeological features, artifacts, or buried deposits must be reported with work suspended until the need for a mitigative plan can be assessed by an archaeologist. No other mitigative plan is recommended.

Power Station 1

The site of proposed power station 1 (Alternative A) is located near Saddle Road, well above the Waiki'i Ranch buildings, on the western slope of Mauna Kea at an elevation of 1,646 m (5,400 ft). This location is open grassland associated with modern ranching. While the ground surface is not exposed in most places, the low grass vegetation would make stone or earthen archaeological features visible. No archaeological remains were observed at this location. Construction activities could unearth archaeological remains, and any such discoveries must be reported, work suspended, and a mitigative plan made with the recommendations of an archaeologist. No mitigative plan is otherwise necessary.

Power Station 2

Proposed power station 2 (Alternative A) is located on the northwestern slope of Mauna Kea at an elevation of 1,326 m

(4,350 ft). This location is open grassland used for grazing. While the ground surface is not exposed in most places, the low grass vegetation would make stone or earthen archaeological features visible. No archaeological remains were observed at this location. Construction activities could unearth archaeological remains, and any such discoveries must be reported, work suspended, and a mitigative plan made with the recommendations of an archaeologist. No mitigative plan is otherwise necessary.

Terminal Reservoir

The site of the proposed terminal reservoir (million gallon capacity) is situated on the northern slopes of Mauna Kea at 1,295 m (4,250 ft). Vegetation at this location is dryland shrubs and grass associated with present day ranching activities. This site also shows signs of soil erosion, exposing much of the substrate. No archaeological remains were observed at this site of proposed reservoir development. Again, construction activities could unearth archaeological remains, thus requiring the suspension of work while a mitigative plan is devised with an archaeologist.

Recommendations

Fortunately, the proposed water development and transmission project following Alternative A, as currently planned, will have little adverse impact on archaeological resources. Alternative B, as presently planned, is not recommended because it crosses areas known to have significant archaeological resources. Areas that would be affected by development with Alternative B are also likely to have additional archaeological sites of significance that have not yet been recorded.

To mitigate potential impact on the Alternative A plans, I make the following recommendations:

1) Initial site preparation work (hand vegetation clearing) at the site of proposed pump station 1 located in the Waiakea-Uka area of Hilo should be monitored by an experienced archaeologist to check for sites (e.g., agricultural, residential, or lava tube caves) covered by the dense vegetation. Should archaeological resources be discovered, then a plan for further mitigative steps will need to be formulated.

2) Construction crews must be informed of the potential with vegetation clearing and other activities to discover prehistoric and historic artifacts, features, buried deposits, and lava tubes. Where chances of such discoveries seem greater are at pump station 8, Pohakuloa reservoir and water tanks, power stations 1 and 2, and at the terminal reservoir. In the event such resources are discovered, any destructive work should be suspended until a qualified archaeologist can examine the finds and recommend a mitigative plan.

A Note on Future Work

The field survey and descriptions reported here cover only the plans to develop sites and a pipeline from Hilo to the Pohakuloa Training Area and from there to Waimea. This report does not address the impact of developing some 3,200 acres for intensive agriculture in the Waimea area. In the interests of historic preservation and economic feasibility in that additional development, planning for water development in the Waimea region must take into account the distribution of archaeological resource densities. Areas with a high density of archaeological sites/features, such as the unique Waimea agricultural field systems must be avoided to assure preservation. Areas better suited to development from an archaeologist's point of view, would be southern portions of the Waimea Saddle and the western slopes of Mauna Kea where a much lower density of archaeological resources is anticipated.

In each and every case, it will be necessary to conduct intensive archaeological survey on lands not previously examined. This is a first step to making prudent decisions concerning development. Some locations will require little, if any, additional work beyond an initial survey (i.e., little to no archaeological resources are present). Other lands will require intensive data recovery projects prior to loss of archaeological resources with development. And some locations, as mentioned above, should see no development at all in order to preserve resources of cultural and scientific significance.

Bibliography

Barrera, W. Jr.
1983 Saddle Road, Hawaii Island: Archaeological Reconnaissance. Prepared for EDAW, Inc., Honolulu.

Barrera, W. Jr., and M. Kelly
1974 Archaeological and Historical Surveys of the Waimea to Kawaihae Road Corridor, Island of Hawaii. Departmental Report Series 74-1. Department of Anthropology, Bishop Museum.

Bonk, W.J.
1985a An archaeological survey in the Waimea-Paauilo watershed area of portions of the Districts of South Kohala and Hamakua, County of Hawaii, Hawaii. Papers in Ethnic and Cultural Studies 85-3.

1985b An archaeological survey in portions of Waikoloa, Pu'ukapu, and Ouli, District of South Kohala, Hawaii. Unpublished report, State Office of Historic Preservation.

Clark, J.T.
1981 Preliminary report on the intensive archaeological survey of the proposed Lalamilo agricultural park, Kohala, Island of Hawaii. Unpublished report, State Office of Historic Preservation.

1986 Continuity and change in Hawaiian agriculture. Journal of Agricultural History 60 (3):1-22.

Clark, J.T. and P.V. Kirch (Eds.)
1983 Archaeological Investigations of the Mudlane-Waimea-Kawaihae Road Corridor, Island of Hawai'i: An interdisciplinary study of an environmental transect. Departmental Report Series 83-1, Department of Anthropology, Bishop Museum.

Clark, S.D., E.D. Davidson, and P. Cleghorn
1990 Archaeological testing and data recovery for the Waimea School improvements Lot A (TMK 6-7-2: Part 17), Waikoloa, South Kohala, Hawai'i Island. Applied Research Group unpublished report, Bishop Museum.

Cox, D.W.
1983 Preliminary cultural resources reconnaissance report for tank trail from Kawaihae to Pohakuloa training area. Unpublished report, State Office of Historic Preservation.

Hammatt, H. and D. Borthwick
1986 Archaeological reconnaissance of 50 acres for proposed Lalamilo Houselots, Subdivision Unit 2: Lalamilo, South Kohala, Hawaii. Unpublished report, State Office of Historic Preservation.

Hammatt, H., D. Borthwick, and D. Shideler
1988 Intensive archaeological survey of 12.4 acres for proposed Lalamilo House Lots Unit 2, Lalamilo, Kohala, Hawai'i. Unpublished report, State Office of Historic Preservation.

Hammatt, H. and D. Shideler
1989 Archaeological investigations at Ka La Loa Subdivision, Lalamilo, South Kohala, Hawai'i. Unpublished report, State Office of Historic Preservation.

Haun, A.E.
1986 Archaeological survey and testing at the Bobcat Trail Habitation Cave Site. Pohakuloa Training Area, Island of Hawai'i. Paul H. Rosendahl, Ph.D., Inc.

Hommon, R.J.
1982 An aerial culture resources reconnaissance of two areas near Pohakuloa training area, Island of Hawaii. Unpublished report, State Office of Historic Preservation.

Kam, W.W.S.
1983 Staff reconnaissance, Waimea Homesteads, South Kohala, Hawaii. Unpublished report, State Office of Historic Preservation.

Kirch, P.V. and B.T. Clause (Eds.)
1981 The Mudlane-Waimea-Kawaihae Archaeological Project: Interim Report 1. Unpublished report, Department of Anthropology, Bishop Museum.

McCoy, P.C.
1984 Archaeological reconnaissance of Hopukani, Waihu, and Liloe Springs, Mauna Kea, Hawai'i. Unpublished report, Contract Archaeology Section, Bishop Museum.

1986 Archaeological investigations in the Hopukani and Liloe Springs, Area of the Mauna Kea Adze Quarry, Hawai'i: A data summary report. Unpublished report, Department of Anthropology, Bishop Museum.

McEldowney, H.
1982 Ethnographic background of the Mauna Kea Summit Region. Unpublished report, Department of Anthropology, Bishop Museum.

Neller, E. and P.E. Beggerly
1980 An archaeological reconnaissance of the route of proposed improvements to the Lalamilo-Pu'ukapu irrigation system, Waimea, Hawaii. Unpublished report, State Office of Historic Preservation.

Rosendahl, M. and P. Rosendahl
1986 Saddle Road improvements. Letter report to Juvik and Juvik, Environmental Consultants, Hilo.

Soehren, L.J.
1984 Archaeological reconnaissance survey of the proposed Lalamilo Wind Farm Site, Lalamilo, South Kohala, Hawaii (TMK 6-6-01: Part 2). Unpublished report, State Office of Historic Preservation.

Streck, C.
1986 Aerial archaeological reconnaissance site survey for the proposed artillery firing points, firebreak/road route and other facilities at Pohakuloa Training Area, Island of Hawai'i. U.S. Army Engineer District, Honolulu.

References

REFERENCES[1]

Barrera, W. Jr., and M. Kelly
1974 Archaeological and Historical Surveys of the Waimea to Kawaihae Road Corridor, Island of Hawaii. Departmental Report Series 74-1. Department of Anthropology, Bishop Museum.

Beck. R.W.,
Water Rate Study, Hawaii County Department of Water Supply, Hilo, Hawaii, May 1989

CH2M Hill,
A Study of Integrating Hawaii's Energy and Water Resources. Honolulu, Hawaii, Feb, 1987

Clark, J.T.
1981 Preliminary report on the intensive archaeological survey of the proposed Lalamilo agricultural park, Kohala, Island of Hawaii. Unpublished report, State Office of Historic Preservation.
1986 Continuity and change in Hawaiian agriculture. Journal of Agricultural History 60 (3):1-22.

Clark, J.T. and P.V. Kirch (Eds.)
1983 Archaeological Investigations of the Mudlane-Waimea-Kawaihae Road Corridor, Island of Hawai'i: An interdisciplinary study of an environmental transect. Departmental Report Series 83-1, Department of Anthropology, Bishop Museum.

Clark, S.D., E.D. Davidson, and P. Cleghorn
1990 Archaeological testing and data recovery for the Waimea School improvements Lot A (TMK 6-7-2: Part 17), Waikoloa, South Kohala, Hawai'i Island. Applied Research Group unpublished report, Bishop Museum.

Commission on Water Resource Management,
1992 Draft Water Resources Protection Plan, Volumes I & II. Honolulu, Hawaii.

Cox, D.W.,
1983 Preliminary cultural resources reconnaissance report for tank trail from Kawaihae to Pohakuloa training area. Unpublished report, State Office of Historic Preservation.

EDAW,
State of Hawaii Land Use Districts and Regulations Review for Land Use Commission, State of Hawaii, Honolulu, Hawaii, 1969

EDAW
Environmental Impact Statement, Kaumana to Keamuku, 138 KV Transmission Line, Honolulu, Hawaii, 1983.

Hahn, Youngki, and Juvik, J.
1985 Agricultural Industry Master Plan for Kauai, Okahara and Shigeoka Associates, Hilo,Hawaii

Hahn, Youngki, et. al.,
Assessment of Agricultural Industry Development and the South Kohala Region of West Hawaii. Okahara and Associates, Hilo, Hawaii, 1991

Hammatt, H. and D. Shideler
1989 Archaeological investigations at Ka La Loa Subdivision, Lalamilo, South Kohala, Hawai'i. Unpublished report, State Office of Historic Preservation.

Haun, A.E.
1986 Archaeological survey and testing at the Bobcat Trail Habitation Cave Site. Pohakuloa Training Area, Island of Hawai'i. Paul H. Rosendahl, Ph.D., Inc.

Kon, Megumi
Hawaii County Water Use and Development Plan, Hilo, Hawaii, December, 1989

Hawaii State Dept. of Agriculture,
Hawaii Agricultural Statistics Service. Hawaii fruits annual summary. May and June 1990.

Hawaii State Dept. of Agriculture,
Market News Service. Honolulu arrivals: fresh fruits and vegetables 1988

Hawaii State Dept. of Business and Economic Development.
Data Book 1989.

Hawaii State Dept. of Land and Natural Resources,
State Water Resources Development Plan and Technical Reference Document, Honolulu, Hawaii, Sept, 1980

Hawaii State Dept. of Planning and Economic Development,
De facto Population Projections for Counties 1978-2000, Statistical Memorandum 79-5 Honolulu, Hawaii, April 26, 1979.

Hommon, R.J.
1982 An aerial culture resources reconnaissance of two areas near Pohakuloa training area, Island of Hawaii. Unpublished report, State Office of Historic Preservation.

Kam, W.W.S.
1983 Staff reconnaissance, Waimea Homesteads, South Kohala, Hawaii. Unpublished report, State Office of Historic Preservation.

Kennedy, Jenks, Chilton,
Water Resources and Supply study for PohakuloaTraining Area, Pohakuloa, Hawaii, Sept. 1986

Kirch, P.V. and B.T. Clause (Eds.)
1981 The Mudlane-Waimea-Kawaihae Archaeological Project: Interim Report 1. Unpublished report, Department of Anthropology, Bishop Museum.

Lockwood, J.P., Lipman, P.W., Petersen, L.D., Warshauer, F.R.,
Generalized Ages of Surface Lava Flows of Mauna Loa Volcano, Hawaii. U.S. Geological Survey, Miscellaneous Investigation Series, Map 1-1908. 1988.

Lockwood, J. P.,
Lava Diversion - Techniques and Strategy, Kagoshima International Conference on Volcanos. 1988

Mauna Lani Resort,
Parker Ranch 2020: Request For Zoning Change, Kohala Coast, Hawaii, July 1988

Moore, H.J.,
A Geological Evaluation of Proposed Lava Diversion Barriers for the NOAA Mauna Loa Observatory, Mauna Loa Volcano, Hawaii, in U.S. Geological Survey, Open-File Report 82-314. 1982.

Neller, E. and P.E. Beggerly
1980 An archaeological reconnaissance of the route of proposed improvements to the Lalamilo-Pu'ukapu irrigation system, Waimea, Hawaii. Unpublished report, State Office of Historic Preservation.

Okahara and Associates,
Water Development and Transmission, Island of Hawaii,
Hilo, Hawaii, November, 1991

Soehren, L.J.
1984 Archaeological reconnaissance survey of the proposed Lalamilo Wind Farm Site, Lalamilo, South Kohala, Hawaii (TMK 6-6-01: Part 2). Unpublished report, State Office of Historic Preservation.

Streck, C.
1986 Aerial archaeological reconnaissance site survey for the proposed artillery firing points, firebreak/road route and other facilities at Pohakuloa Training Area, Island of Hawai'i. U.S. Army Engineer District, Honolulu.

USDA-Agricultural Marketing Service. April 1989. Fresh fruit and vegetable shipments by commodities, states, and months, calendar year 1988.

USDA-Economic Research Service.
Foreign agricultural trade of the United States: FATUS calendar year 1988 supplement

USDA-Soil Conservation Service,
Inventory of Selected Water, Land and Related Resources Data: Island of Hawaii Type IV River Basin Survey, Honolulu, Hawaii, July, 1975.

USDA, Soil Conservation Service,
Waimea-Paauilo Watershed: Watersed Plan and Environmental Assessment, Hawaii County, 1989

1. For further reference, see technical reports in Chapter 8