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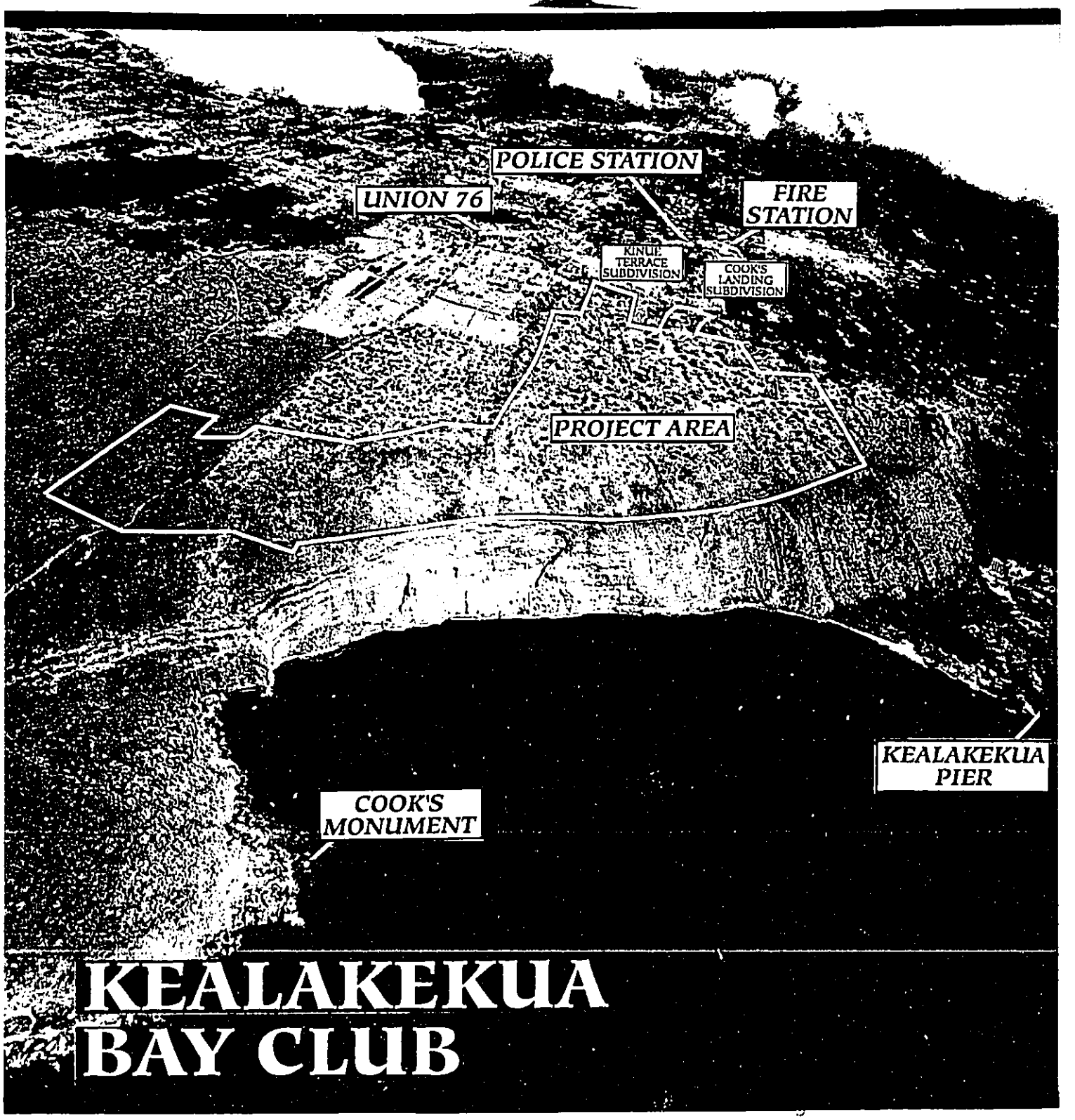

KEALAKEKUA BAY CLUB

Draft Environmental Impact Statement

NOVEMBER 1991

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KEALAKEKUA BAY CLUB

Draft
Environmental Impact Statement

This document is prepared pursuant to Chapter 343, Hawaii Revised Statutes, for submission to the Hawaii County Planning Department

Petitioner:

Royal Coast Development Corporation
and PAC INV Hawaii, Inc.
P.O. Box 44394
Kawaiahae, Hawaii 96743

Prepared by:

Belt Collins & Associates
680 Ala Moana Boulevard, First Floor
Honolulu, Hawaii 96813

SUBMITTED BY:

Thomas P. Papandrew

Thomas P. Papandrew, President
Belt Collins & Associates

November 8, 1991

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3. Botanical Survey, Kealakekua Ranch Golf Course Project, Char & Associates, May 1990

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6. Fertilizer and Pesticide Management Plan, Environmental Impact Consultants, October 1990

7. Full Archaeological Reconnaissance Survey, Kealakekua Ranch Makai Land Subdivison, Paul H. Rosendahl, Ph.D., Inc., April 1987

8. Irrigation Well Alternatives for the Kealakekua Bay Club in South Kona, Hawaii, Tom Nance Water Resources Engineering, April 1991

9. Kealakekua Ranch Makai, Interim Archaeological Investigations, Chiniago Inc., July 1989

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14. Noise Study for the Kealakekua Bay Golf Course Project, Y. Ebisu & Associates, March 1991

15. Subsurface Pesticide Migration Study, Harding Lawson Associates, July 1991

16. Survey of the Avifaunal and Feral Mammals on Kealakekua Ranch Property, Phillip L. Bruner, November 1989

17. Traffic Impact Assessment Report, Pacific Planning & Engineering, March 1991

Chapter I:
INTRODUCTION AND SUMMARY

CHAPTER I - INTRODUCTION AND SUMMARY

1. APPLICANT AND BRIEF PROJECT SUMMARY

The applicants for the proposed project are Royal Coast Development Corporation and Pac Inv Hawaii, Inc. (hereinafter, 'the applicant'), together representing the general partnership, Kealakekua Bay Club Partners.

The applicant proposes the development of a world class championship golf course with clubhouse and restaurant, and a low profile, low density 36 room Members' Lodge, to be collectively known as the Kealakekua Bay Club. In addition, the applicant proposes that the two small land areas abutting Napoopoo Road be subdivided into a total of five two-acre lots consistent with the current zoning. The Kealakekua Bay Club, appurtenant uses, supportive infrastructure and subdivided lots are hereinafter referred to as 'the project'.

2. PROPOSED GOVERNMENT ACTION

The proposed project is located within the Kealakekua Bay Historic District and a portion of it is located on lands classified Conservation. A conservation district use permit will be required from the State's Department of Land and Natural Resources. The entire project area is also located within the County's Special Management Area. A portion of the project will require a General Plan and zoning amendment.

3. PURPOSE OF THIS DOCUMENT

This environmental impact statement (EIS) contains a comprehensive description of the proposed action, an analysis of the impacts of that action upon the physical, natural, social and economic environment, recommendations for the mitigation of any potential adverse impacts resulting from the action, comments from public agencies, elected officials, private business persons, and the general public, and responses to those comments from the applicant. This EIS is intended to fulfill the requirements of Chapter 343, HRS and is also presented as a supportive informational document to accompany the applicant's CDU and SMA permit applications, as well as a General Plan amendment.

4. STATEMENT OF OBJECTIVES

Development of the proposed project will accomplish the following objectives.

- to provide a world-class golf course in the South Kona area;
- to operate a private club with overnight facilities for its members;
- to provide times of play for State residents at kama'aina rates;
- to develop an economically viable low-density use for the project site;
- to contribute to the region's economic diversification;
- to provide public access to the pali together with a public parking area;
- to design and operate the project to avoid or mitigate potentially negative project impacts;
- to participate in the improvement of vehicular access from Napoopoo Road onto Mamalahoa Highway.

5. PROJECT DESCRIPTION

5.1 Project Setting

The site of the proposed project consists of a privately owned property approximately 262 acres in size. It is located in the South Kona district of the Island of Hawaii, as depicted in Figure 2-1. The nearest urban settlements are Captain Cook, approximately one quarter mile east of the property, and Napoopoo, about one half mile south of the property. The property is approximately eleven and a half miles south of Kailua-Kona, the largest urban area on the leeward side of Hawaii, and about eighteen miles south of Keahole airport. Access to Kailua-Kona is via Mamalahoa Highway.

The property contains three distinct parcels of record, identified as Tax Map Key 8-2-02: portion of 2, 8-2-02:39, and 8-1-10: 3 (see Figure 2-2, 2-3 and 2-4). The latter parcel is owned by the Royal Coast Development Corporation and the former are owned by Pac Inv Hawaii, Inc..

The property is situated on a moderate slope rising in a northeastern direction from the top of a steep cliff known as Pali Kapu-O-Keoua up to Napoopoo Road (formerly the Lower Government Main Road). The cliff stands directly behind Kealakekua Bay. Although the property overlooks Kealakekua Bay and the Kealakekua Bay Historic Park, views of the bay are limited by the existing vegetation, the topography of the property, and the steepness and height of the pali. As a point of fact, the makai boundary of the property is about 600 feet above the bay and about 300 feet inland from the water's edge.

5.2 Planned Development

It is the applicant's intent to develop the property in a manner that is compatible with the existing character of the region, benefits the community, and provides an economic means of protecting an historic area. Rather than encourage or participate in the construction of up 36 homes, which would be permitted on the property under its current zoning classification, the applicant is seeking an economic return from the property that does not compromise its historic character and the beauty of its location. The pristine quality of Kealakekua Bay and its historic and cultural importance establish a unique value and attraction to the property, as well as a significant burden of responsibility to its owner. Mindful of this, the applicant is proposing a land use plan which preserves the vast majority of the property in open space, protects the quality of Kealakekua Bay, improves public access to the area, preserves the property's historical and archaeological resources, and prevents future development of the property and any increases in development density. A Preliminary Concept Plan of the overall project is presented in Figure 2-5.

5.2.1 Golf Course

The principal element of the proposed project is an 18-hole, par 72 championship golf course. The golf course will be situated on that portion of the property situated below the 1,100 foot elevation and will be set back from the makai property edge from 350 to 600 feet. A buffer area between the golf course and the edge of the pali will be permanently protected from development and dedication to a public agency or public trust will be considered. The buffer area will be planted with native Hawaiian endemic plants as a means of helping to reestablish native vegetation in the area. Public play on the course will be permitted with regular times and rates established for kama'ainas.

5.2.2 Golf Club House

A full-serviced golf club house will be located on a 4-acre parcel of land near the eastern mauka corner of the project area. The 4-acre parcel will include an access road with a circular turn-around, the club house with a landscaped entry feature, a swimming pool, four tennis courts and two parking lots separated by an existing grove of trees (see Figure 2-6). The club house will include a pro shop, dining facilities, cart storage, and related amenities in approximately 17,000 square feet of interior space in a two-story structure. In addition, approximately 6,700 square feet of lanai and other outdoor space are planned around the club house facility. The architectural character of the two-story clubhouse will be of the Hawaiian plantation style and landscaping will incorporate many existing mature trees as well as the cultivation of native Hawaiian endemic plants. Exterior views of the clubhouse are presented in Figure 2-7.

5.2.3 Maintenance Facility

The golf course facility also includes a maintenance facility of about one acre in size at the eastern mauka corner of the property. The maintenance facility will consist of a main storage building, a separate area for pesticide storage (see Appendix 6 for building plan), a bulk storage area and a 16-stall parking area for maintenance vehicles and employee vehicles (see Figures 2-8 and 2-9).

5.2.4 Members' Lodge

A unique component of the proposed project is the Members' Lodge, a lodging facility that will be available to club members only. The lodge is located on a 4.5 acre parcel near the south eastern corner of the project area. The Members' Lodge will accommodate members in 36 units in a two-story structure, centered around an inner courtyard (see Figure 2-10). The lodge complex will also include an oval-shaped porte cochere with a 20-stall parking lot on either side. Other than an indoor lounge and recreation area, no other recreational amenities such as a pool or tennis courts are included at the lodge. Nor will the lodge include dining facilities. Members are expected to focus most of their activities at the golf clubhouse complex and on the golf course. Rooms at the lodge will range from 780 square feet to 823 square feet, including lanai areas from 102 square feet to 168 square feet. The Members' Lodge will be a two-story structure as presented in Figure 2-11.

5.2.5 Agricultural Lots

In addition to the golf course facilities and lodge, the project proposes the subdivision of 5 2-acre lots fronting Napoopoo Road. The current RA-2 zoning will be retained for these lots. A buffer of coffee trees along Napoopoo Road will be maintained in the 60-foot building setback and will shield the five 2-acre lots from traffic and the passerby from a direct golf course view.

5.3 Proposed Infrastructure

5.3.1 Water

The proposed project will require the development of an on-site potable water distribution system as well as a non-potable irrigation system. This potable system will consist of the appropriate transmission lines and valves linking it to the County's municipal water line. All on-site water infrastructure (potable and non-potable) will be developed and funded by the applicant.

Potable water demand generated by the proposed development is about 23,500 gallons per day (gpd). Projected demand exceeds existing allocation by approximately 1,300 gallons per day. To address the potable water deficit, the applicant will either seek an additional allocation from the County, negotiate with surrounding property owners for the acquisition of additional water, or if no other recourse exists, construct a new well at a location upslope from the project area. It should be noted that the potable water deficit will not materialize until such time as the proposed Members' Lodge is certified for occupancy. Under the current development schedule, the lodge will be opened in 1997, subject to approval by the County of General Plan and zoning amendments to permit its development. The applicant believes that this time frame provides ample time to obtain additional potable water to serve the property should it be determined that it will be necessary.

Anticipated golf course irrigation (non-potable) at the Kealakekua Bay Club is estimated at 3,100 gallons per acre per day to maintain turf and landscaping for 150 acres of golf course fairways, tees and greens. This amount is equal to about .465 mgd on an average daily basis. A well constructed on-site providing between 0.7 million gallons per day (mgd) and 1.2 mgd will be sufficient to address the project's irrigation requirements and ensure sufficient reserve for extended periods of dry weather.

5.3.2 Wastewater

In order to protect the surrounding environment from the impacts of sewage disposal resulting from the proposed project, an onsite wastewater management system is proposed. It is anticipated that between 11,500 and 12,000 gallons per day of wastewater will be generated at full development of the site. The five agricultural lots will each be served by individual septic tanks. The design, construction and operation of the proposed system will conform to Hawaii County and State health and sanitation standards.

The proposed wastewater treatment plant will be constructed to accommodate a total capacity of about 20,000 gallons of wastewater per day. It will be located at the proposed maintenance area situated mauka of the golf course's ninth tee. The facility will be funded, constructed and operated by the applicant.

After treatment in the facility, the disinfected secondary effluent will be used to supplement irrigation of the golf course. It would be blended with non-potable irrigation water. Due to the relatively small volume of effluent that might be used, its overall impact upon the golf course in terms of a potential health concern is minimal. Assuming an average daily volume of wastewater totaling about 12,000 gallons, effluent will constitute less than 3% of the total daily volume of irrigation water required. The applicant will work with the State Department of Health and the County Public Works Department to ensure that treated effluent disposal is conducted in a manner which minimizes environmental impacts.

5.3.3 Drainage

The watershed for the proposed development has no natural drainage ways or streams crossing the project site. There is some drainage runoff that reaches the site from the mauka side of Napoopoo Road, however, all rainwater falling on and reaching the site appears to percolate through the soil. There is no runoff over the pali at the makai boundary of the subject property.

The proposed development will result in about 9.3 acres of land being converted from its

natural state to built-on land. This area includes parking lots, sidewalks, buildings and maintenance facilities. Because over 97% of the project's total land area will remain as open space in the form of a golf course, landscaped areas around development sites, and the undisturbed 50-acre Conservation District area, the impact upon the existing runoff pattern is minimal.

To address runoff across the site, the use of drywells at specified locations as well as the development of retention basins within the golf course area is recommended. These facilities will enable stormwater to percolate through the ground and will prevent runoff from reaching the pali.

5.3.4 Solid Waste Disposal

At full buildout, the proposed project is anticipated to generate approximately 723 pounds of solid waste per day, or about 132 tons per year. Solid waste will be collected by a private refuse disposal service and disposed of at the nearest landfill.

5.3.5 Power and Communications

The proposed project will not require additional sources of electrical energy for its development or operation. The project will utilize electrical energy provided by the existing 69 kv transmission line.

Increased telephone service to the project area will not significantly impact the capacity of the Hawaiian Telephone company to provide service to its existing or future customers.

5.3.6 Traffic Circulation

The project will add about 50 vehicle trips on Napoopoo Road with the majority in the northern direction during the afternoon peak hour. The north bound trips at total build-out will have a significant impact upon the intersection of Napoopoo Road with Mamalahoa Highway. A traffic impact analysis prepared for the project demonstrates that without the project, conditions involving left turns at the intersection of Napoopoo Road and Mamalahoa Highway will continue to worsen from the present Level-of-Service (LOS) D; high density traffic flow with severe maneuvering ability, to LOS F; extreme delays, by the time the entire project is completed. The proposed project will, therefore, exacerbate the problem. Even without the project, improvements are needed at the intersection to provide better sight distances and adequate storage lanes.

Three alternatives are presently being considered to resolve not only the project's impacts, but to help alleviate the existing situation. The first alternative is to signalize the Napoopoo Road intersection with Mamalahoa Highway. The second alternative is to make substantial improvements to the intersections including improving sight distances along Mamalahoa Highway and constructing a left turn storage lane on Napoopoo Road. A third alternative is to construct a new access road linking the project area to Mamalahoa Highway. If this third alternative were to be implemented, it would result in the eventual closure of the existing intersection at Napoopoo Road and Mamalahoa Highway. The applicant is presently working with the County Public Works Department and surrounding landowners to determine the most appropriate alternative to solve the continuing traffic problem.

5.3.7 Public Access

Napoopoo Road provides vehicular access to the subject property. New internal access roadways from Napoopoo Road to the golf clubhouse and the members' lodge will be constructed on-site. The northern branch of the internal access road will terminate at the 900 foot elevation where a public parking area will be provided. This parking area will be situated approximately 1,600 feet upslope from the top of the cliff. It will provide about 20 public parking stalls for persons wishing to visit a new scenic lookout proposed to be built at the top of the Pali Kapu O Keoua. A new pedestrian access trail will be provided from the parking area to the scenic overlook. Although there are no specific plans for the development of the overlook at this time, it is anticipated that it will be administered by a public agency such as the Department of Land and Natural Resources. No specific development proposal for the scenic lookout is included as part of the proposed Kealakekua Bay Club golf course project. However, public access improvements will include improvements to existing trails in the area as well as the development of new trails in coordination with the Department of Land and Natural Resources, including a lateral trail along the the top of the pali. Historic Ka'awaloa Road will be preserved in its current alignment. Although it may be crossed by golf cart paths or infrastructure easements, no other improvements are planned for it. Pedestrian trails on-site will provide new access to Ka'awaloa Road, enabling people visiting the proposed scenic lookout to walk down to the Ka'awaloa-Cook's Point area. The applicant will work closely with the DLNR's Division of Parks and Recreation, Historic Sites Office and the Na Ala Hele organization to integrate the project public access improvements with planned State improvements.

6. SUMMARY OF IMPACTS AND PROPOSED MITIGATION MEASURES

This environmental impact statement details impacts to the physical, social and economic environment resulting from development of the proposed project. In those instances where impacts are identified as being negative, specific and detailed mitigation measures are recommended. Following is a summary of major impacts identified and measures recommended to mitigate them. Chapters IV, V and VI of this document present a detailed discussion of all impacts and mitigation measures.

6.1 Short-Term Construction Period Impacts

IMPACT:	The project area's soils will be impacted during grading and construction.
MITIGATION MEASURE:	The use of sediment basins, filter beams, erosion barriers and silting ponds will be implemented throughout construction to minimize erosion potential. Grading operations will be suspended during periods of heavy rain and the maximum exposed graded area shall not exceed 20 acres at any given time during the construction phase of the project. During site construction, on-site monitoring during moving, spreading and recompacting of soils will be conducted.
IMPACT:	Fugitive dust from vehicular movement could occur during construction.
MITIGATION MEASURE:	Active work areas and temporary unpaved work roads will be

watered at least twice a day on days when rainfall does not occur.

IMPACT: Importation of soil could impact water quality of the bay in the form of uncontrolled erosion and runoff, and air quality in the form of fugitive dust.

MITIGATION MEASURE: Stockpiling of imported soil will be avoided wherever possible. An erosion control plan will be prepared and submitted to the County for approval prior to construction. Imported soils will be placed and compacted as needed to minimize the need for stockpiling. Best management practices (BMP's) recommended by the Department of Health will be utilized as a basis for managing construction activities

IMPACT: Noise from construction equipment could impact neighboring properties.

MITIGATION MEASURE: The use of properly muffled and maintained construction equipment will be required on the job site during the project's construction period. In addition, State Department of Health construction noise limits shall be implemented. Properly muffled and maintained tractor equipment will be utilized within the entire golf course project area as a means of mitigating noise impacts associated with its operation. If necessary, a maintenance shed and/or a sound attenuating wall shall be used to reduce noise from maintenance activities toward the nearest neighbor to the northeast. The use of evening or nighttime curfews on operation of noisy equipment in the maintenance area may also be employed if warranted to minimize adverse noise impacts on the neighboring properties.

6.2 Long-Term Impacts

IMPACT: The general character of the existing land form will be changed by the proposed development.

MITIGATION MEASURE: Through careful design, some of the existing contours will be preserved.

IMPACT: Pesticides and fertilizers typically applied to the surface of the golf course could potentially impact groundwater and result in eventual impacts to the water quality of Kealakekua Bay.

MITIGATION MEASURES: Integrated Pest Management techniques will be employed. Use of pesticides will occur only in response to pest outbreaks.

Use of pesticides will be restricted to those listed in Table 4-5, or others found to have similar properties of low mobility, toxicity and persistence.

Runoff will be controlled to avoid ponding of irrigation water.

Use of liners as well as underdrains beneath greens will be evaluated.

Irrigation will be tied to soil moisture and will be scheduled based on this parameter. Soil moisture may be measured via soil moisture probes. Irrigation rates will be monitored closely. If, due to salt build-up, a leaching requirement is foreseen, the amount of excess irrigation to achieve this requirement will be closely monitored. Foliar application of fertilizers will be implemented.

Soils will be moved and compacted only when relatively dry. Tests on soils will be conducted to ensure that they may meet specifications for turf grass soils.

A fertilizer and management plan has been prepared for the proposed project and will be implemented.

Best Management Practices (BMP's) will be used, especially involving storm water management.

A certified golf course superintendent will be employed and all pesticide application staff will be certified by the Hawaii Department of Agriculture to apply restricted use pesticides.

IMPACT: Spray equipment utilized to apply pesticides could result in drift of chemical vapors.

MITIGATION MEASURE: Low pressure, coarse nozzle spray equipment less than three feet above the ground will be used. Spray equipment will only be used during light wind conditions. A 100-foot buffer distance from populated areas will be observed.

IMPACT: Existing vegetation will be lost due to construction of the golf course and related facilities.

MITIGATION MEASURE: To offset the loss of existing vegetaton, the use of native plant material for landscaping in and around the golf course will be considered wherever practicable. The buffer area at the top of the pali will be recultivated with native plants. The property owner has entered into an agreement with Bishop Museum to research and recommend native plants for cultivation in the buffer zone and for landscaping. The category 2 caper will be planted as part of the landscaping wherever possible.

IMPACT: Construction and operation of the golf course could impact water quality and various forms of marine life within Kealakekua bay.

MITIGATION MEASURE: Drainage and storm runoff will be accommodated on the project site through the use of drywells and retention basins so that none

impacts the bay. Irrigation will be closely monitored to prevent runoff. The use of pesticides and fertilizers will be strictly monitored and controlled to prevent potential contamination of the groundwater.

IMPACT: Potential loss of archaeological sites.

MITIGATION MEASURE: The general significance of archaeological sites identified on site has been determined and those determined to be of scientific, historical or cultural value will be preserved. A detailed Mitigation Plan will be prepared and implemented (subject to approval by the State's Historic Sites Office) prior to any ground moving activities.

IMPACT: Open space character of the project may be lost.

MITIGATION MEASURE: Development of the golf course will ensure that the general open space character of the project area is preserved. Buildings developed on-site will be designed to have minimal visual impact upon the area.

IMPACT: Vehicular traffic will increase as a result of the project.

MITIGATION MEASURE: Mitigation measures to alleviate the problem at the intersection can involve three alternatives; signalization of the intersection, redesign of the existing intersection, or closure of the intersection and replacement with a new access road.

IMPACT: Development of the property may constrain public access to historic Ka'awaloa Road (trail).

MITIGATION MEASURE: The provision of a public parking area with pedestrian paths linking it to a scenic overlook at the summit of Pali Kapu-O-Keoua, as well as the development of new trails, including lateral accesses on the property will provide access to Ka'awaloa Road and facilitate greater public access to the property as well as to the Ka'awaloa-Captain Cook area at the base of the pali.

7. SUMMARY OF ALTERNATIVES CONSIDERED

None of the four development alternatives considered for the project area are capable of fulfilling the objectives of the proposed project. The alternatives are either not cost-effective or have greater potential environmental impacts than the proposed development.

The "no-action" or "no-project" alternative would retain the property in its present use. Because approximately 100 acres of the property, representing the mauka portion, is presently zoned RA-2, retaining the property as vacant land will represent a continued loss of income for the applicant, who is essentially paying residential property taxes on vacant land with no opportunity for a reasonable return on their investment.

Although the property could support at least 36 residential units consistent with a 1987 preliminary subdivision approval and its present zoning of RA-2, and has been allocated sufficient potable water by the County system to serve these units, this use is not viewed by the property owners as being in the best interest of the property or the community.

The property has been historically utilized for agricultural-related activities. However, according to an Analysis for Agricultural Potential prepared for this project and presented as an appendix to this document, the quality of the land is considered to be inadequate for successful agricultural development.

A scaled down alternative would result in a development similar to that which is proposed with the exception of either a smaller Members' Lodge or no Members' Lodge. The proposed golf course cannot, in itself, be scaled down because it would result in short narrow fairways which could be hazardous to play and would likely not be of sufficient quality to attract persons to join the golf club or play the course. A smaller Members' Lodge would not be feasible because the memberships it might attract would not be of a number sufficient to assist in the offsetting of development costs associated with the golf course. The elimination of the Members' Lodge from the plan is not desirable for the same reason.

8. SUMMARY OF UNRESOLVED ISSUES

Three general issues cannot be resolved at this point in the land use permitting and development process: the source of approximately 1,300 gallons per day of potable water beyond approximately 22,000 gpd which is presently allocated to the project by the County; the specific location and design of traffic improvements to mitigate potential negative traffic impacts; and the specific design, construction, and day-to-day operation and maintenance of the scenic overlook.

9. SUMMARY OF COMPATIBILITY WITH LAND USE PLANS AND POLICIES

With exception of the proposed Members' Lodge, the proposed project is generally consistent with the applicable Hawaii State Plan, various State Functional Plans, and the County General Plan goals and objectives. The Members' Lodge will require an amendment to the General Plan and rezoning. The project is also consistent and supportive of the Special Management Area Guidelines.

10. NECESSARY APPROVALS AND PERMITS

Following is a list of major approvals and permits required for implementation of the proposed project. Additional permits and approvals may be necessary.

Permit or Approval	Authority
Special Management Area Permit	County Planning Commission
Conservation District Use Permit	Board of Land & Natural Resources
General Plan Amendment for Members' Lodge	County Council/Mayor
Zoning Amendment for Members' Lodge	County Council/Mayor
Use Permit for Golf Course	County Planning Commission
Well Construction Permit	State Commission on Water Resource Management
Pump Installation Permit	State Commission on Water Resource Management
Potable Water System Approval	State Department of Health
Wastewater Treatment Works Approval	State Department of Health
Underground Injection Control Line Approval	State Department of Health
Water Master Plan Approval	Hawaii County Department of Water Supply
Drainage Master Plan Approval	Hawaii County Department of Public Works
Subdivision Approval	Hawaii County Planning Department
Building and Grading Permits	Hawaii County Department of Public Works
Plan Approval	Hawaii County Planning Department

Chapter II:
DESCRIPTION OF THE PROPOSED PROJECT

CHAPTER II - DESCRIPTION OF THE PROPOSED PROJECT

1. REGIONAL SETTING

The site of the proposed project consists of a privately owned property approximately 262 acres in size. It is located in the South Kona district of the Island of Hawaii, as depicted in Figure 2-1. The nearest urban settlements are Captain Cook, approximately one quarter mile east of the property, and Napoopoo, about one half mile south of the property. Captain Cook is accessible from the property by taking Napoopoo Road to Mamalahoa Highway and proceeding south a quarter mile. Because there is no direct access between the property and the town of Napoopoo, a circuitous route of about three and a quarter miles must be taken to reach Napoopoo. The property is approximately eleven and a half miles south of Kailua-Kona, the largest urban area on the leeward side of Hawaii, and about eighteen miles south of Keahole airport. Access to Kailua-Kona is via Mamalahoa Highway.

The property contains three distinct parcels of record, identified as Tax Map Key 8-2-02: portion of 2, 8-2-02:39, and 8-1-10: 3 (see Figure 2-2, 2-3 and 2-4). The latter parcel is owned by the Royal Coast Development Corporation and the former are owned by Pac Inv Hawaii, Inc..

2. EXISTING AND SURROUNDING USES

A large portion (192 acres) of the property consists of lands formerly owned by the Greenwell Ranch. With the exception of four single-family dwellings, the former Greenwell Ranch portion of the project area is vacant and undeveloped. Three of the four dwellings are abandoned and not used as residences. The fourth house is situated on a separate, subdivided lot that is not part of the development area. The remainder of the property (70 acres) consists of an undeveloped portion of the ahupua'a of Ka'awaloa. The project area is generally unused except for occasional cattle grazing associated with the Greenwell Ranch. The bulk of the property is moderately to heavily vegetated prehistoric a'a lava, while the northern extension of the property consists of barren to sparsely vegetated prehistoric a'a lava.

The property is situated on a moderate slope rising in a northeastern direction from the top of a steep cliff known as Pali Kapu-O-Keoua (hereinafter 'the pali') up to Napoopoo Road (formerly the Lower Government Main Road). The cliff stands directly behind Kealakekua Bay. Although the property overlooks Kealakekua Bay and the Kealakekua Bay Historic Park, views of the bay are limited by the existing vegetation, the topography of the property, and the steepness and height of the pali. As a point of fact, the makai boundary of the property is about 600 feet above the bay and about 300 feet inland from the water's edge. The ocean and western horizon are visible from virtually anywhere on the property.

The property is generally square in shape except for a long rectangular piece extending northwest, parallel to the coastline. Along the project area's mauka boundary, two small portions of the property abut Napoopoo Road. With the exception of these two pieces, the mauka edge of the property is buffered from Napoopoo Road by the privately owned single-family dwellings discussed above. The remainder of the northern, eastern and southern property boundaries abut lands that may be described as rural in character; ranging from barren lava and open pasture to moderately forested areas interspersed with single family homes on lots from 1.2 acres to 6 acres in size. The 600 foot high pali forms the northwestern or makai boundary of the property.

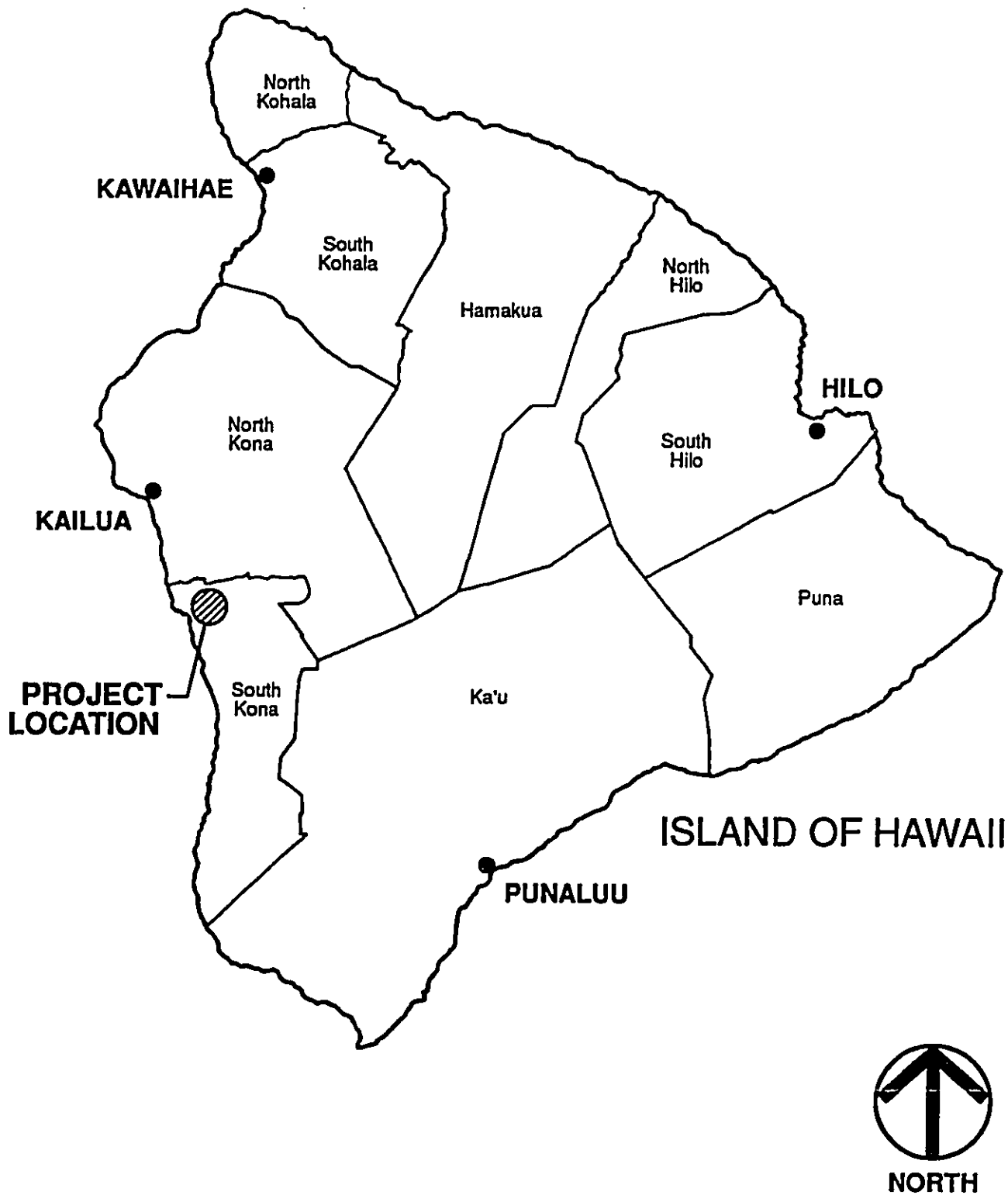
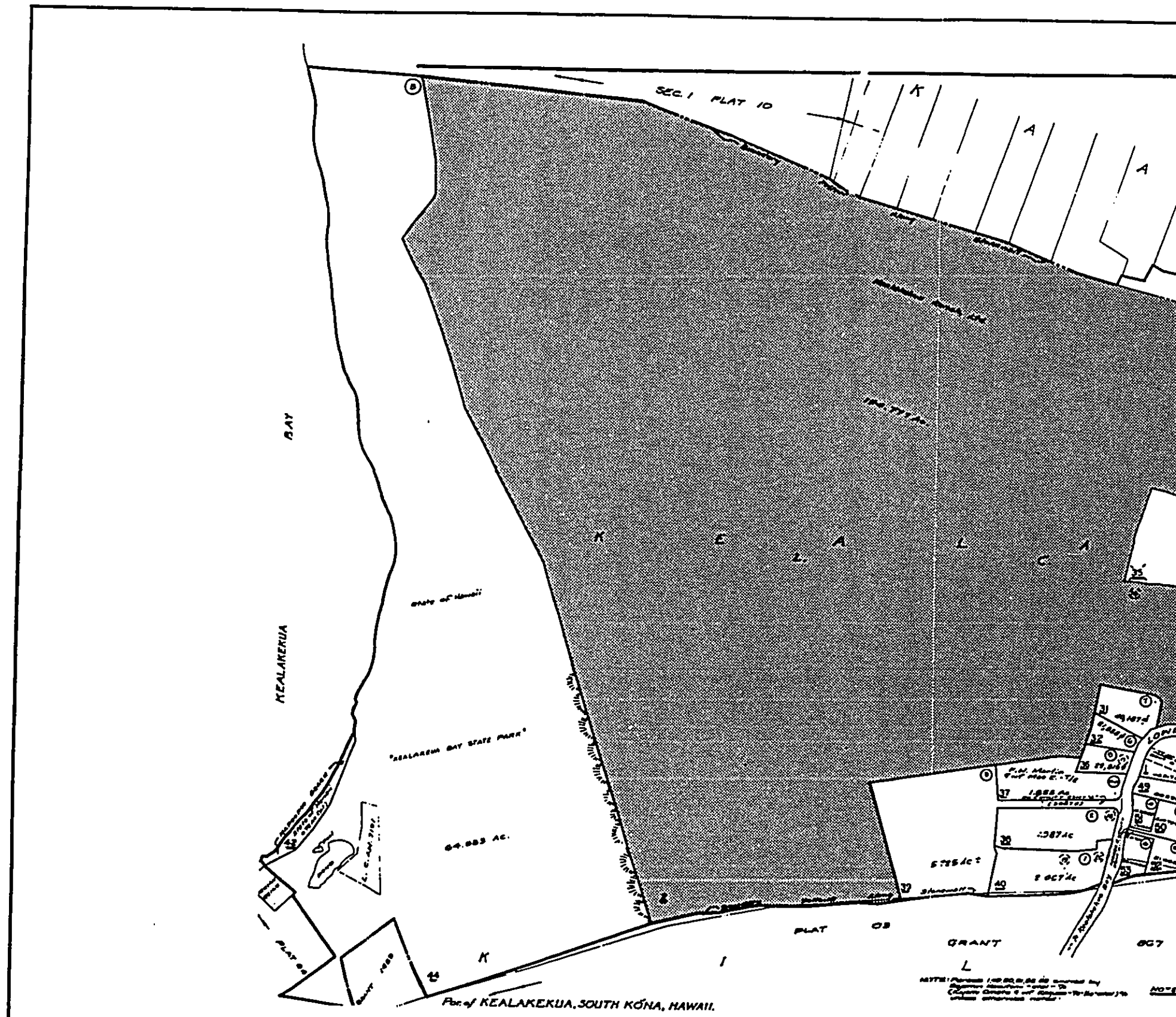


Figure 2-1
LOCATION MAP
Kealakekua Bay Club
South Kona, Hawaii

Prepared by: Belt Collins & Associates



Prepared by: Belt Collins & Associates

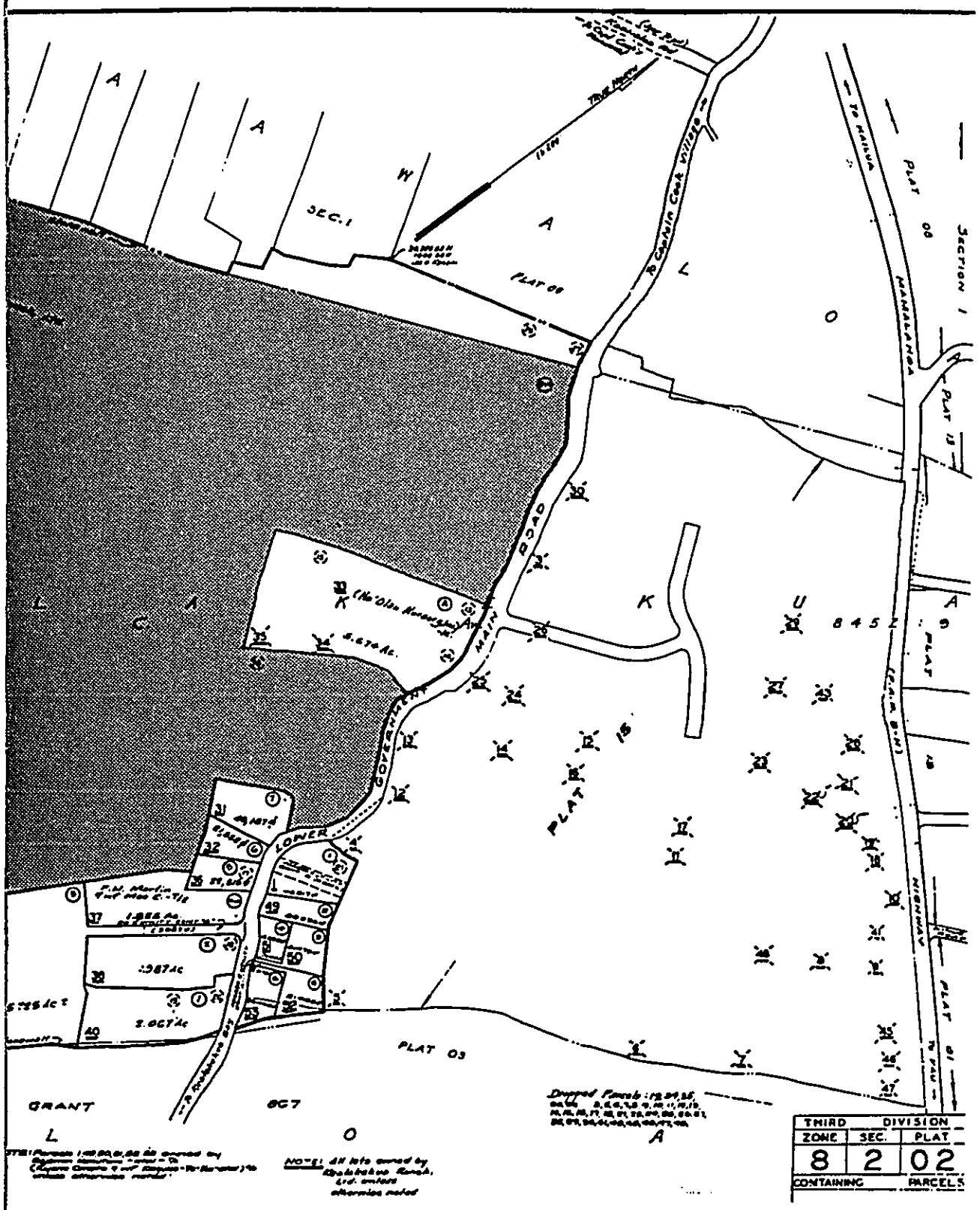
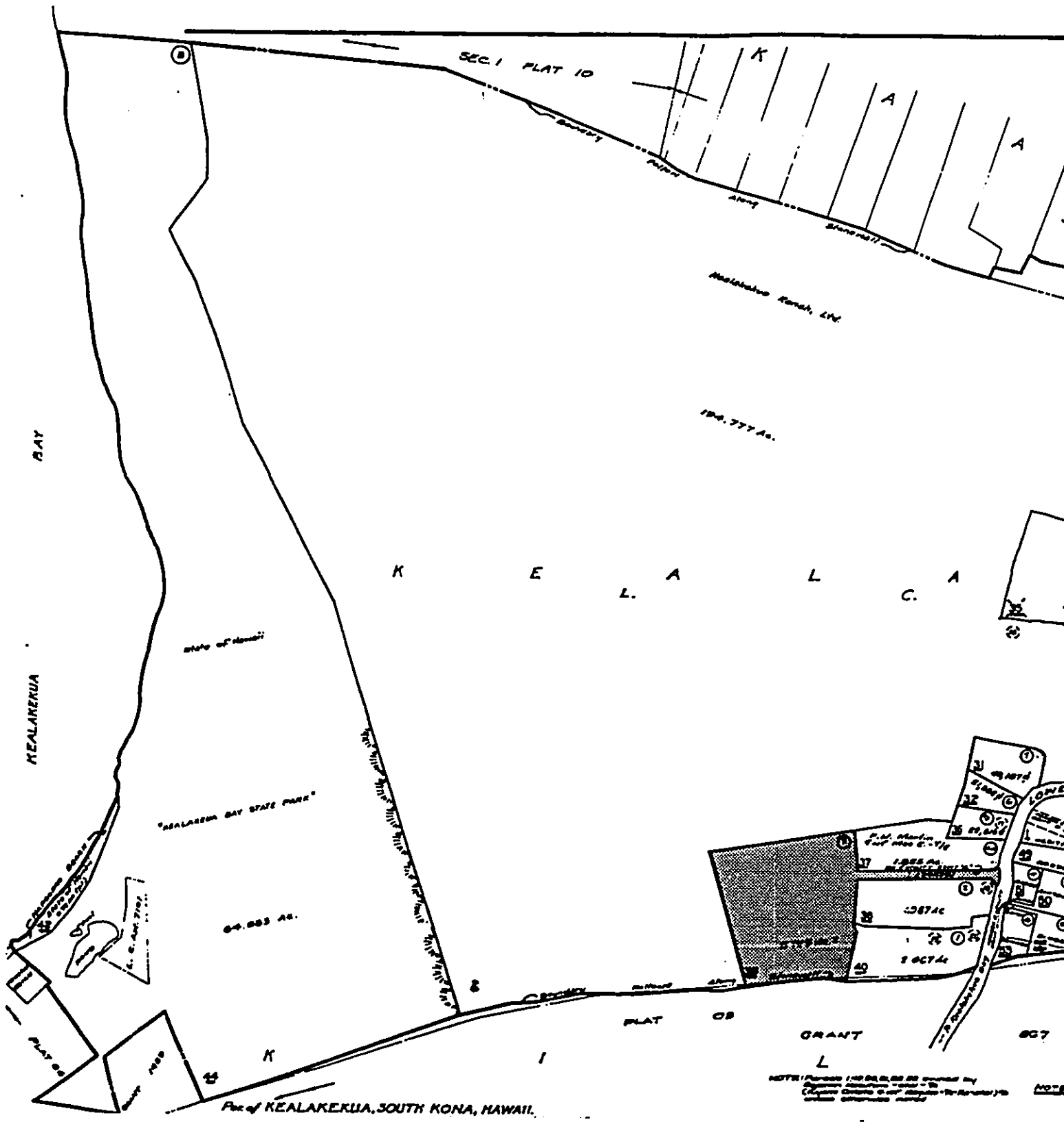


Figure 2-2
TAX MAP KEY
8-2-02: PORTION OF 2
Kealakekua Bay Club
South Kona, Hawaii



Prepared by: Belt Collins & Associates

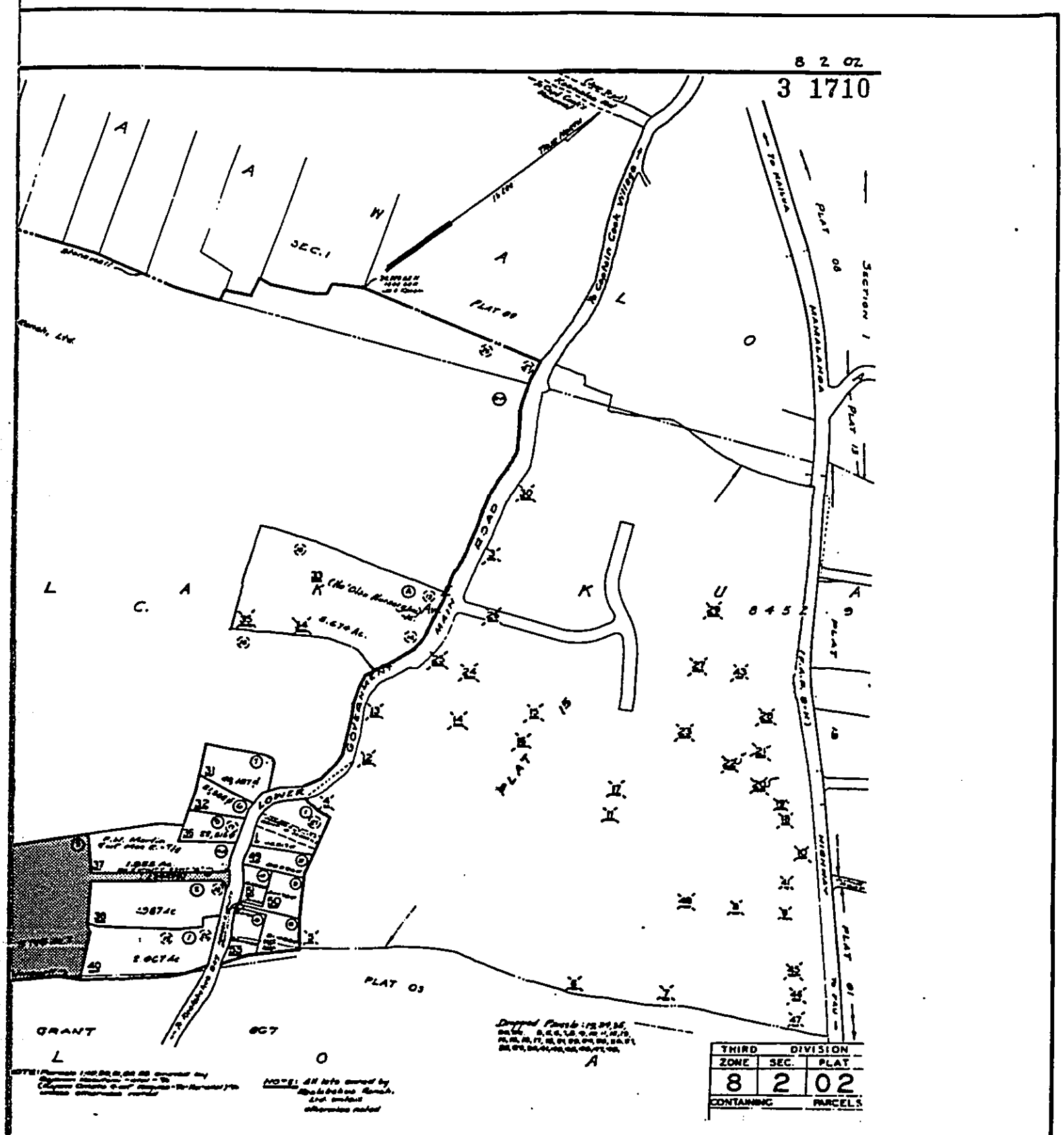
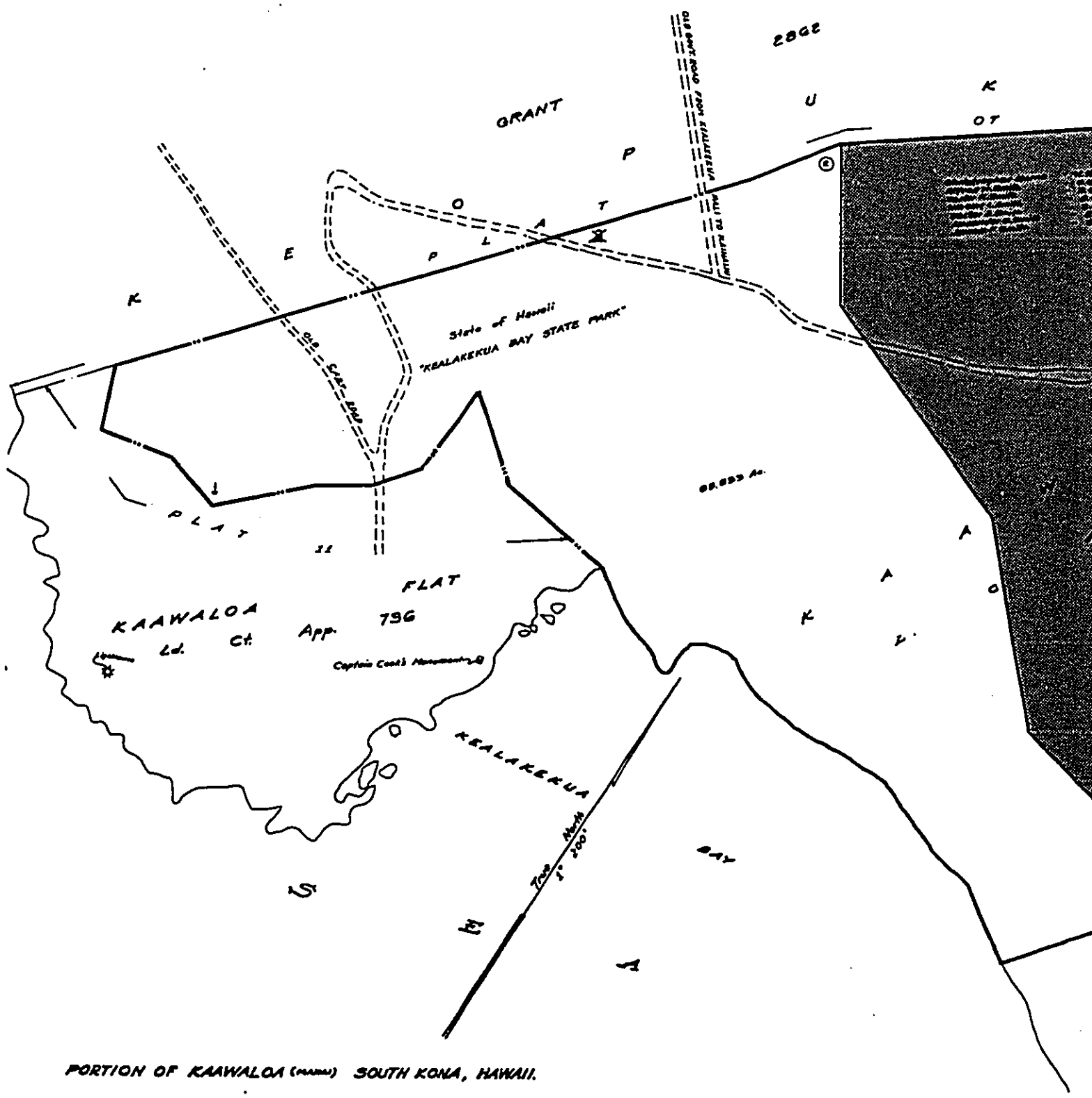


Figure 2-3
TAX MAP KEY 8-2-02: 39

Kealakekua Bay Club
South Kona, Hawaii



PORTION OF KAAWALOA (MAUKA) SOUTH KONA, HAWAII.

Prepared by: Belt Collins & Associates

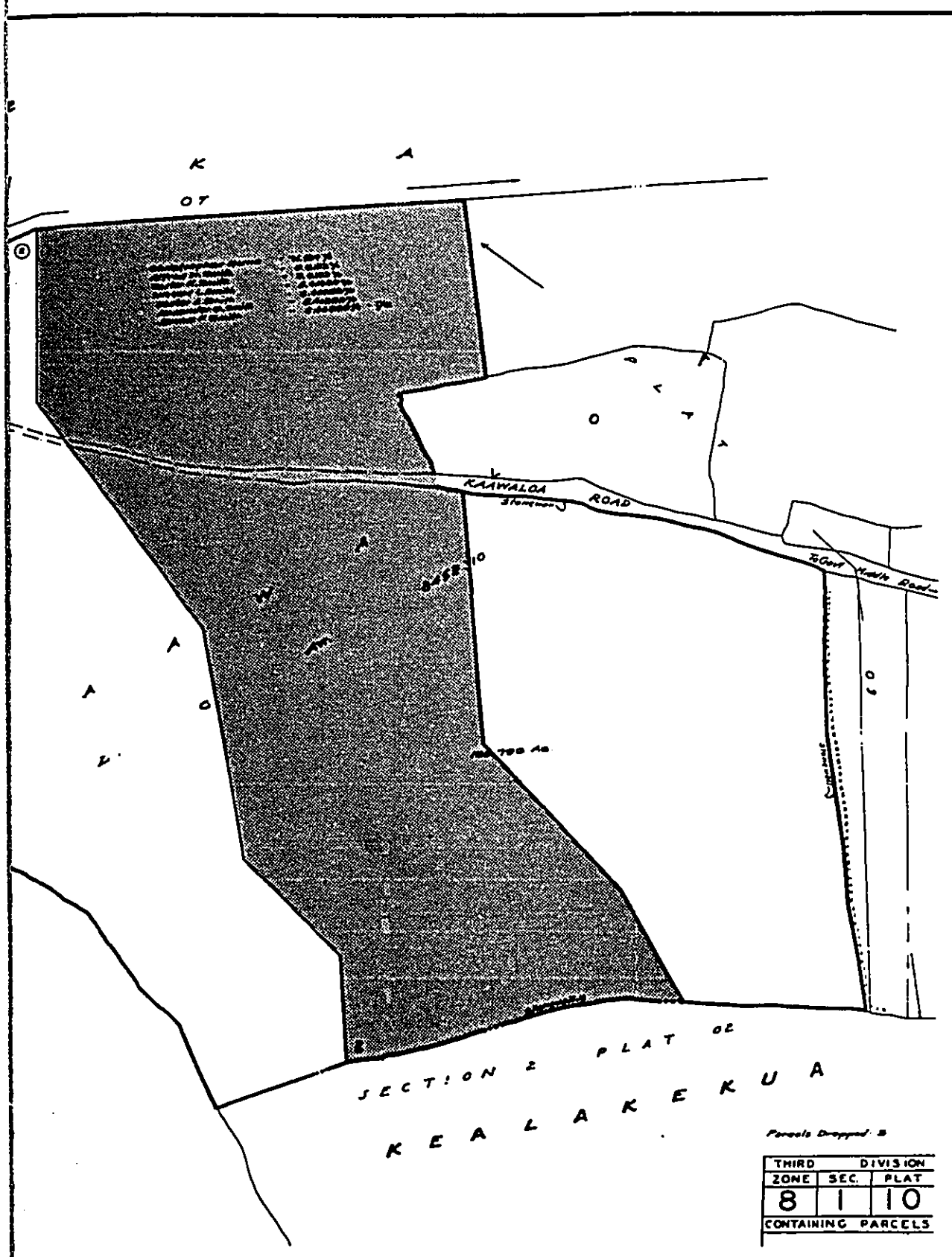


Figure 2-4
TAX MAP KEY 8-1-10: 3

Kealakekua Bay Club
South Kona, Hawaii

3. IDENTIFICATION OF THE APPLICANT AND THE PROPOSED ACTION

The applicants for the proposed project are Royal Coast Development Corporation and Pac Inv Hawaii, Inc. (hereinafter, 'the applicant'), together representing the general partnership, Kealakekua Bay Club Partners.

The applicant proposes the development of a world class championship golf course with clubhouse and restaurant, and a low profile, low density 36-room Members' Lodge, to be collectively known as the Kealakekua Bay Club. In addition, the applicant proposes that the two small areas abutting Napoopoo Road be subdivided into a total of five two-acre lots consistent with the current zoning. The Kealakekua Bay Club, appurtenant uses, supportive infrastructure and subdivided lots are hereinafter referred to as 'the project'.

A portion of the project is located within the Conservation District, established by the State Land Use Commission and administered by the State's Department of Land and Natural Resources (DLNR). The entire project area is situated within the Special Management Area (SMA) which is administered by the Hawaii County Planning Department. The project site is also located within the Kealakekua Bay Historic District, which is on the National Register of Historic Places. Development of the proposed project will require a Conservation District Use (CDU) permit from the Board of Land and Natural Resources, an SMA permit from the County Planning Commission, General Plan and zoning amendments for the Members' Lodge, as well as other related development permits.

4. INTENDED USE OF THIS DOCUMENT

This environmental impact statement (EIS) contains a comprehensive description of the proposed action, an analysis of the impacts of that action upon the physical, natural, social and economic environment, recommendations for the mitigation of any potential adverse impacts resulting from the action, comments from public agencies, elected officials, private business persons, and the general public, and responses to those comments from the applicant. This EIS is intended to fulfill the requirements of Chapter 343, HRS and is also presented as a supportive informational document to accompany the applicant's CDU and SMA permit applications, and General Plan and zoning amendments for the proposed Members' Lodge.

5. ACCEPTING AUTHORITY

Because the proposed project is located within the Kealakekua Bay Historic District, a portion of it is located on lands classified Conservation, and a portion of it will require a General Plan amendment, the project is subject to a Chapter 343, Hawaii Revised Statutes, EIS review. A conservation district use permit will be required from the State's Department of Land and Natural Resources. The entire project area is also located within the County's Special Management Area. Because an SMA permit is required for the processing of a CDU permit, the accepting authority for this EIS is the first agency with discretionary permitting authority for the project, in this case the County of Hawaii Planning Department.

6. DEVELOPMENT CONCEPT

It is the applicant's intent to develop the property in a manner that is compatible with the existing character of the region, benefits the community and provides an economic means of

protecting an historic area. Rather than encourage or participate in the construction of up to 36 homes, which would be permitted on the property under its current zoning classification, the applicant is seeking an economic return from the property that does not compromise its historic character and the beauty of its location. The pristine quality of Kealakekua Bay and its historic and cultural importance establish a unique value and attraction to the property, as well as a significant burden of responsibility to its owner. Mindful of this, the applicant is proposing a land use plan which preserves the vast majority of the property in open space, protects the quality of Kealakekua Bay, improves public access to the area, preserves the property's historical and archaeological resources, and prevents future development of the property and any increases in development density.

7. STATEMENT OF OBJECTIVES

As the applicant, Royal Coast Development Corporation and Pac Inv, Inc. wishes to generate a viable economic return on its investment in the subject property while ensuring that its development proposal is sensitive to the environment and the surrounding community. Development of the proposed project will accomplish the following objectives.

- to provide a world-class golf course in the South Kona area;
- to operate a private club with overnight facilities for its members;
- to provide times of play for State residents at kamaaina rates;
- to develop an economically viable low-density use for the project site;
- to contribute to the region's economic diversification;
- to provide public access to the pali together with a public parking area;
- to design and operate the project to avoid or mitigate potentially negative project impacts;
- to participate in the improvement of vehicular access from Napoopoo Road onto Mamalahoa Highway.

8. PROJECT DESCRIPTION

Following is a detailed description of each of the major components of the proposed development. A Preliminary Concept Plan of the overall project is presented in Figure 2-5. The environmental and social impacts generated by the development and operation of each of these components are addressed in Chapters 4, 5 and 6, together with specific recommendations to mitigate any potentially negative impacts. Although the design of these components may be altered or revised during the course of the permit review process in response to requirements or conditions established by regulatory agencies, the following descriptions represent the applicant's intentions for the ultimate development of the subject property. The property owner will place a deed restriction on the golf course land which will prohibit any alternate development once it is established as a golf course.

8.1 Golf Course

The principal element of the proposed project is an 18-hole, par 72 championship golf course. The golf course will be situated on that portion of the property situated below the 1,100 foot elevation and will be set back from the makai property edge from 350 to 600 feet. A buffer area between the golf course and the edge of the pali will be permanently protected from development and dedication to a public agency or public trust will be considered. The buffer area

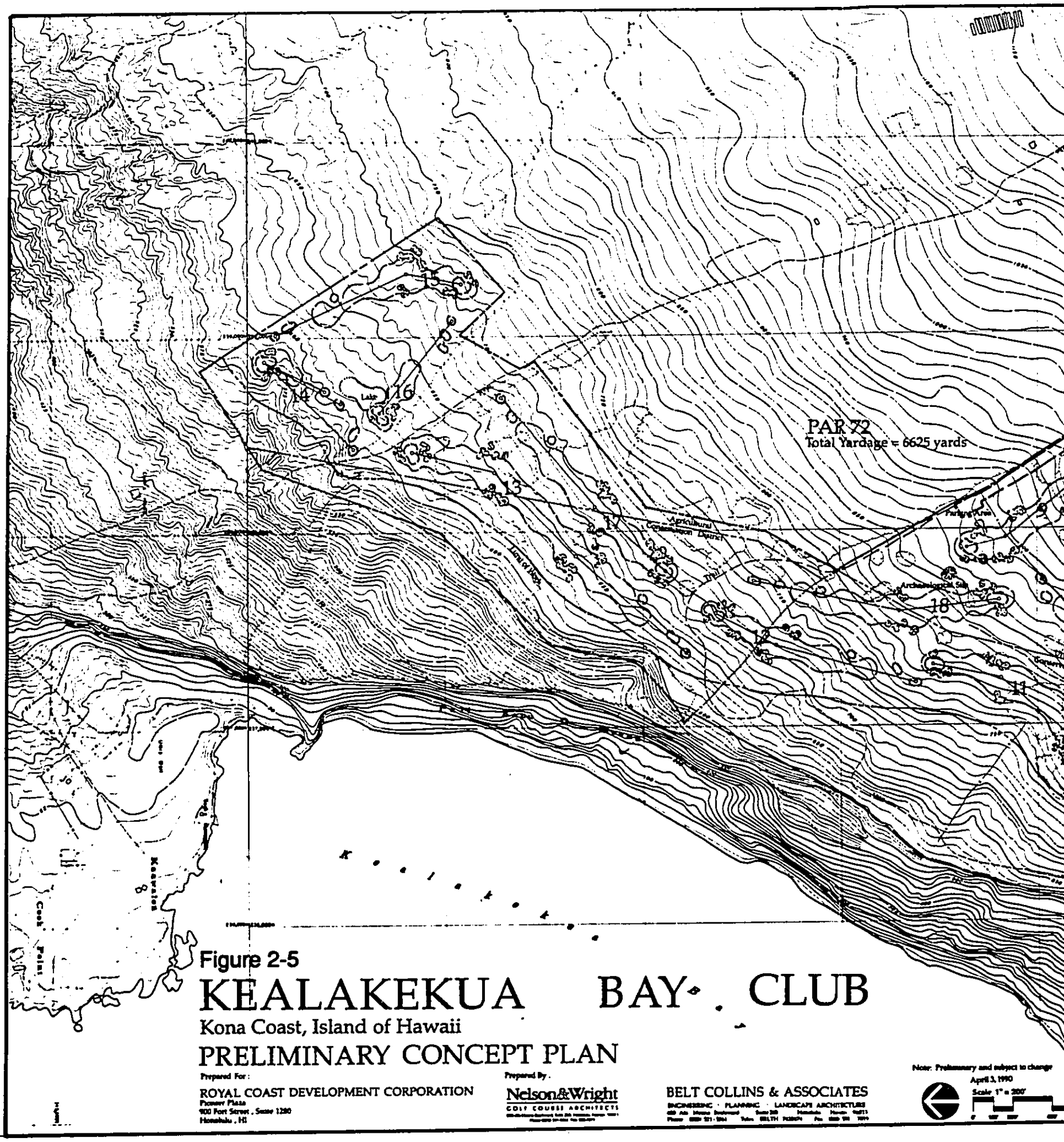


Figure 2-5

KEALAKEKUA BAY CLUB

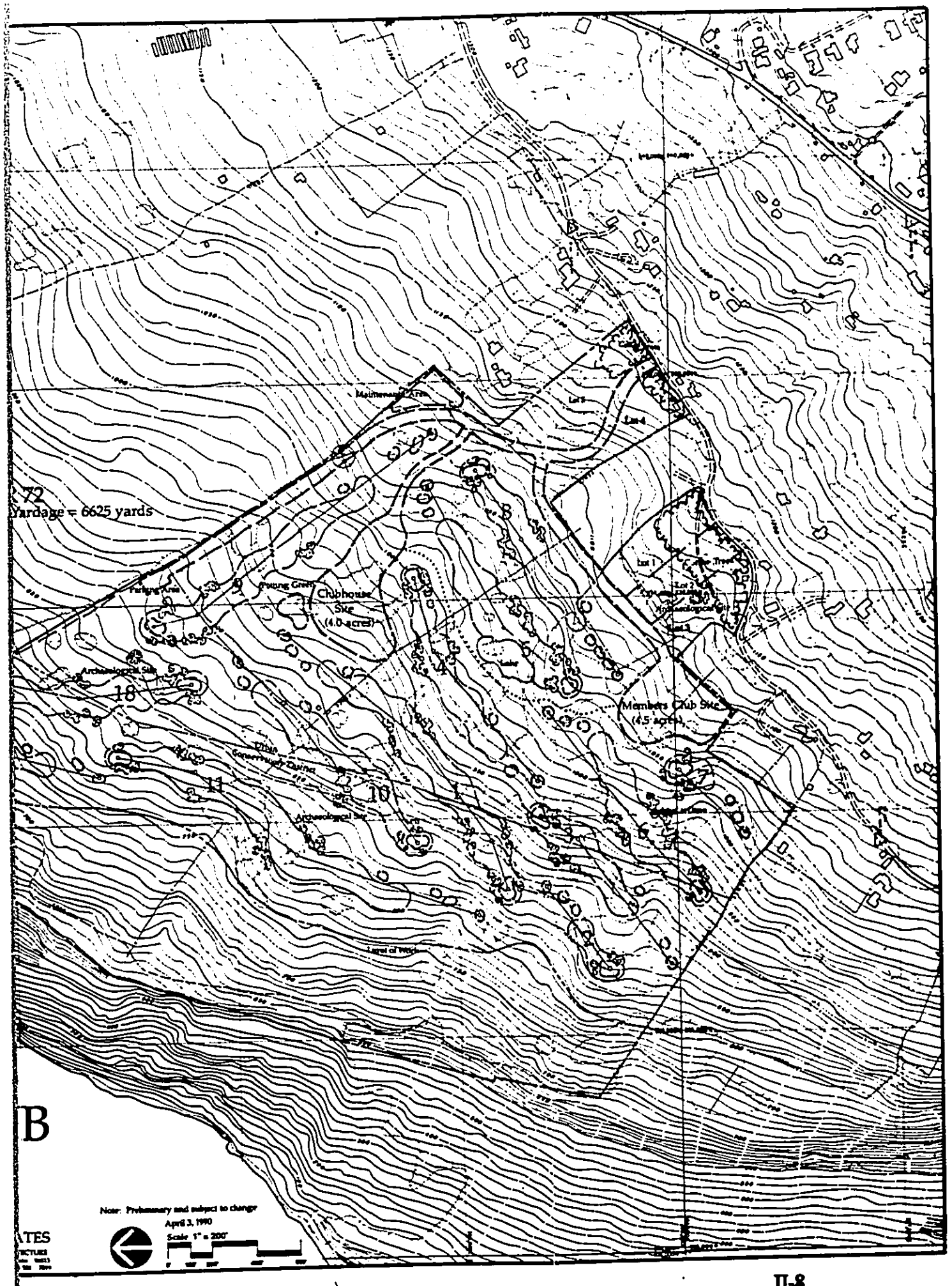
Kona Coast, Island of Hawaii

PRELIMINARY CONCEPT PLAN

Prepared For:
ROYAL COAST DEVELOPMENT CORPORATION
Pioneer Plaza
900 Fort Street, Suite 1280
Honolulu, HI

Prepared By:
Nelson&Wright
GOLF COURSE ARCHITECTS

BELT COLLINS & ASSOCIATES
ENGINEERING · PLANNING · LANDSCAPE ARCHITECTURE



72
Yardage = 6625 yards
Maintenance Area
Parking Area
Putting Green
Clubhouse Site (4.0 acres)
Archaeological Site
18
Urban Conservatory District
11
10
Archaeological Site
Members Club Site (4.5 acres)
Lot 1
Lot 2
Lot 3
Lot 4
Lot 5
Level of Work
B
Note: Preliminary and subject to change
April 3, 1990
Scale 1" = 200'

will be planted with native Hawaiian endemic plants as a means of helping to reestablish native vegetation in the area.

Fifteen of the eighteen fairways will be aligned generally parallel to the existing contours of the property, creating a series of terraces or steps extending down from the proposed Members' Lodge. The ninth and sixteenth holes will be aligned downslope and will provide dramatic views of the ocean and the distant coastline. The proposed design will include a water feature located generally between the golf club house and the members' lodge which will serve as the principal irrigation reservoir for brackish water wells to be drilled on site, as well as a water hazard for at least one of the fairways on the front nine. A second water feature may be developed on the back nine near the northern boundary of the Ka'awaloa parcel. The total yardage for the proposed course is about 6,625 yards. Public play will be permitted with regular times and rates established for kama'ainas.

A full-serviced golf club house will be located on a 4-acre parcel of land near the eastern mauka corner of the project area. The 4-acre parcel will include an access road with a circular turn-around, the club house with a landscaped entry feature, a swimming pool, four tennis courts and two parking lots separated by an existing grove of trees (see Figure 2-6). The smaller lot nearest the clubhouse will contain 32 stalls and the larger lot will contain about 73 stalls. The club house will include a pro shop, dining facilities, cart storage, and related amenities in approximately 17,000 square feet of interior space in a two-story structure. In addition, approximately 6,700 square feet of lanai and other outdoor space are planned around the club house facility. The architectural character of the two-story clubhouse will be of the Hawaiian plantation style and landscaping will incorporate many existing mature trees as well as the cultivation of native Hawaiian endemic plants. Exterior views of the clubhouse are presented in Figure 2-7.

The golf course facility also includes a maintenance facility of about one acre in size at the eastern mauka corner of the property. The maintenance facility will consist of a main storage building, a separate area for pesticide storage (see building plan at the end of Appendix 6), a bulk storage area and a 16-stall parking area for maintenance vehicles and employee vehicles (see Figures 2-8 and 2-9). All buildings within the maintenance facility will be limited to one story in height. The maintenance facility will be screened from the access roadway by a landscape buffer.

8.2 Members' Lodge

A unique component of the proposed project is the Members' Lodge, a lodging facility that will be available to club members only. The lodge is located on a 4.5 acre parcel near the south eastern corner of the project area.

8.3 Facilities

The Members' Lodge will accommodate members in 36 units in a two-story structure, centered around an inner courtyard (see Figure 2-10). The lodge complex will also include an oval-shaped porte cochere with a 20-stall parking lot on either side. Other than an indoor lounge and recreation area, no other recreational amenities such as a pool or tennis courts are included at the lodge. Nor will the lodge include dining facilities. Members are expected to focus most of their activities at the golf clubhouse complex and on the golf course. Rooms at the lodge will range from 780 square feet to 823 square feet, including lanai areas from 102 square feet to 168 square feet. The Members' Lodge will be a two-story structure as presented in Figure 2-11.

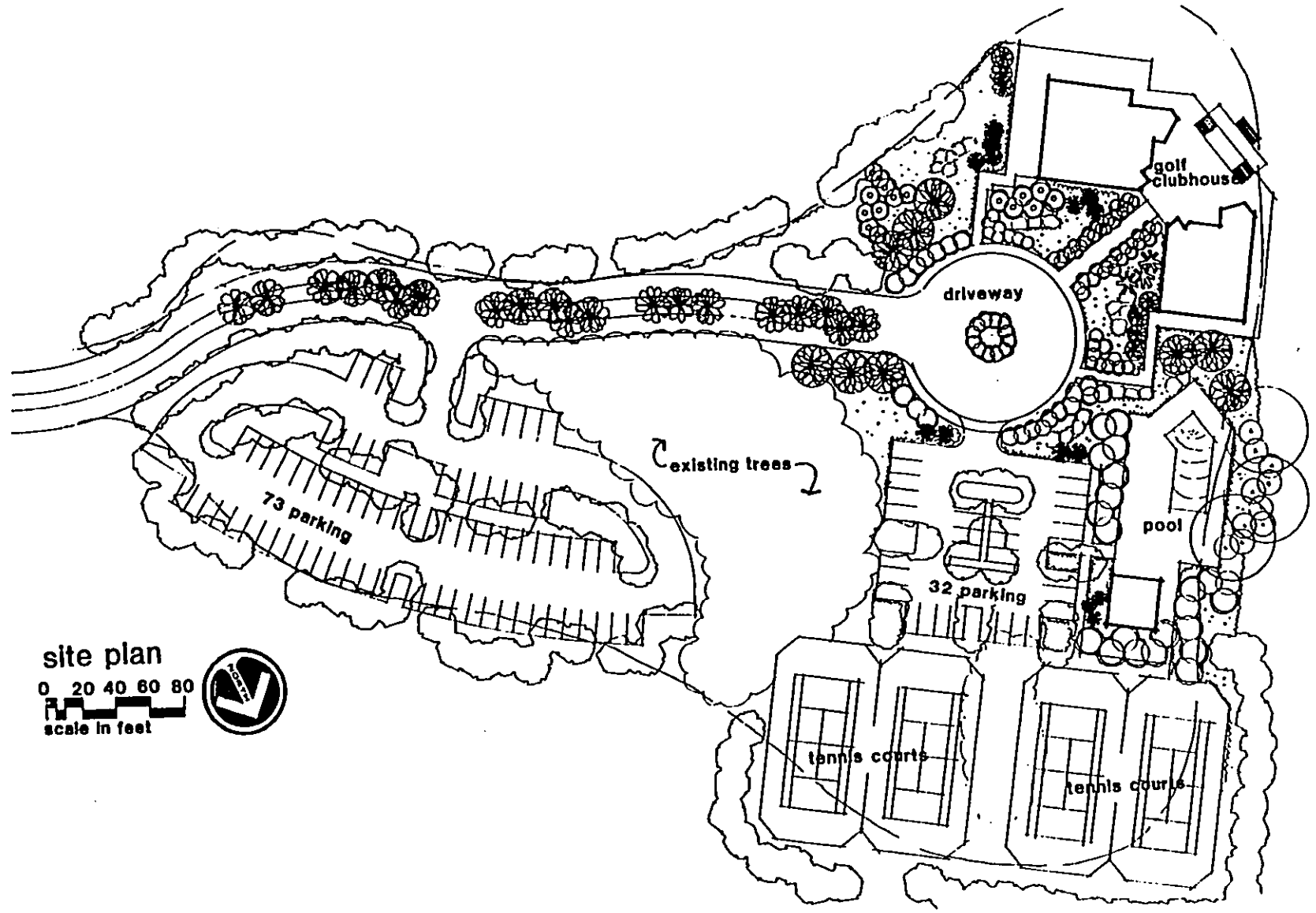
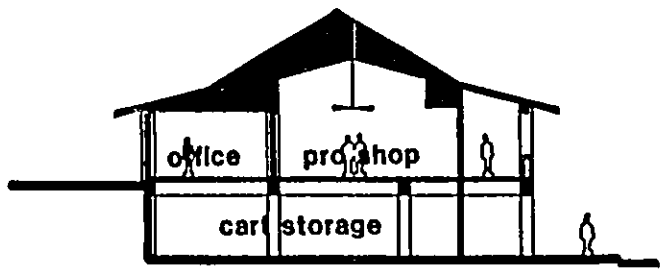
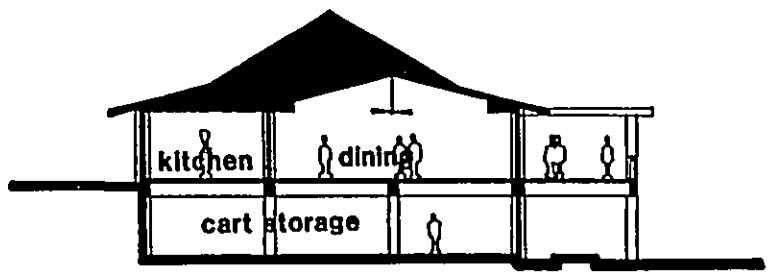


Figure 2-6
GOLF CLUBHOUSE PLAN
Kealakekua Bay Club
South Kona, Hawaii

exterior elevation /
view from the west

0 5 10 20 30
scale in feet





section thru building

0 5 10 20 30
scale in feet

Figure 2-7
CLUBHOUSE EXTERIOR VIEWS
Kealakekua Bay Club
South Kona, Hawaii

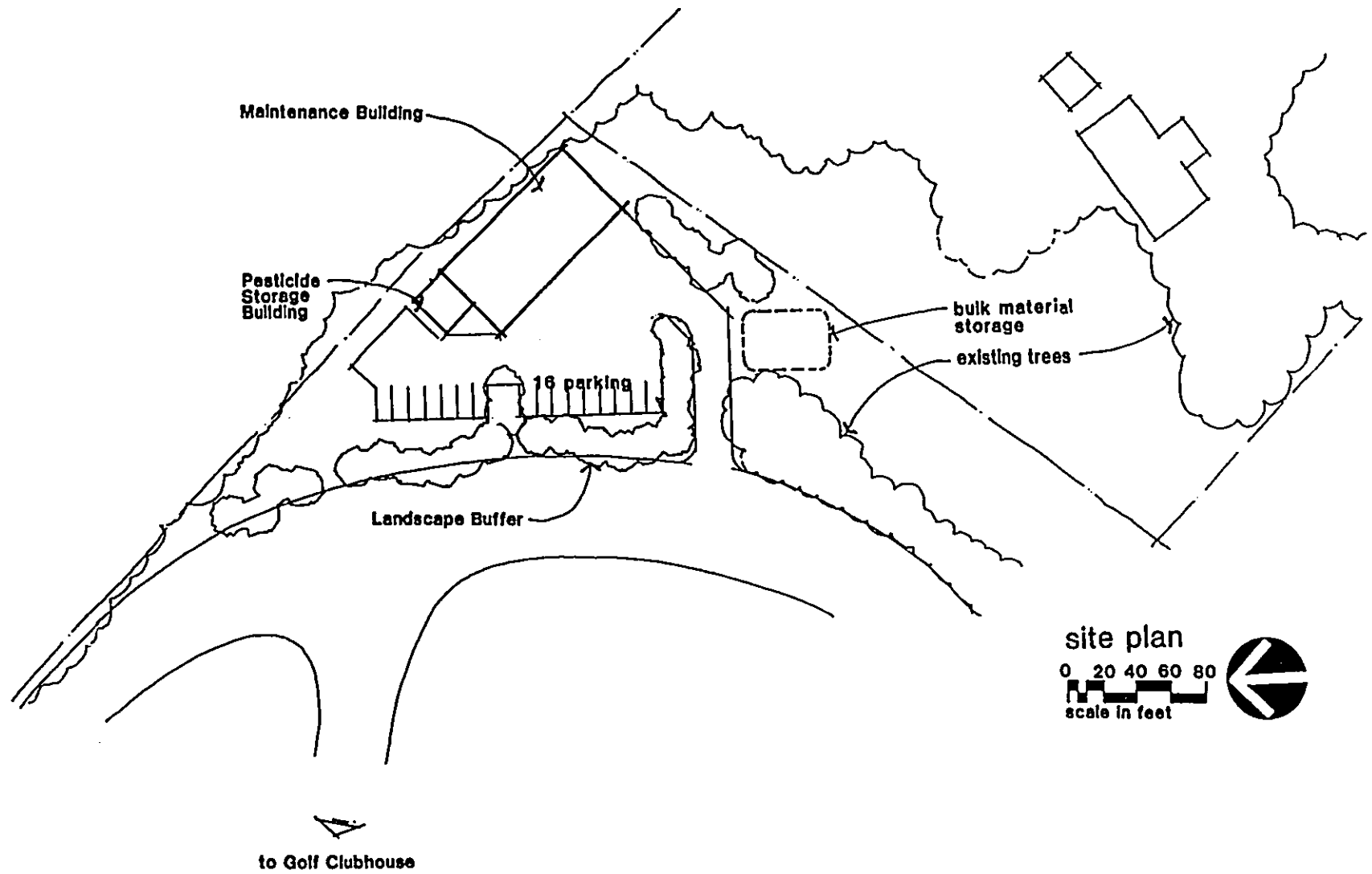
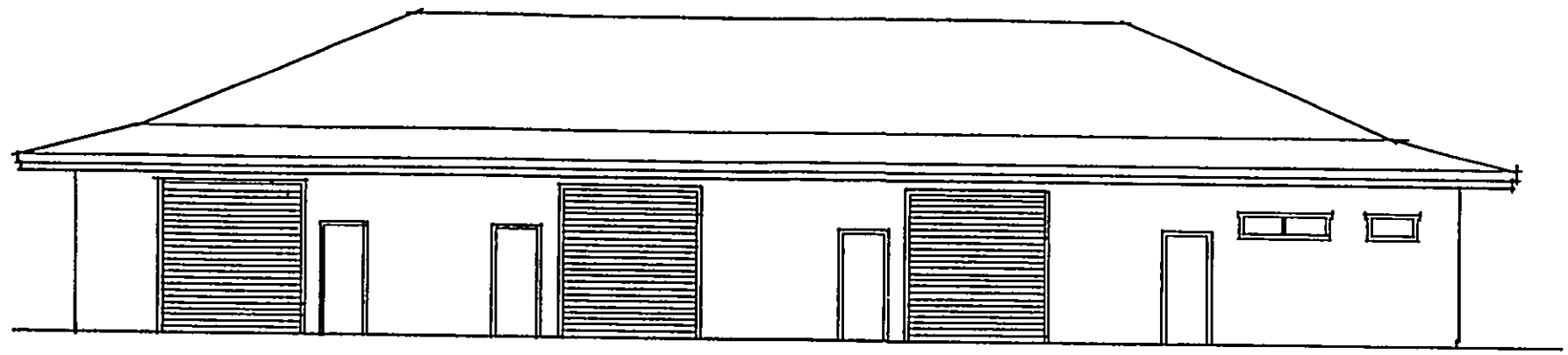
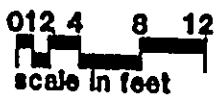


Figure 2-8
MAINTENANCE FACILITY PLAN
Kealakekua Bay Club
South Kona, Hawaii



exterior elevation / view from front



section thru building

Figure 2-9
MAINTENANCE FACILITY
EXTERIOR VIEWS
Kealakekua Bay Club
South Kona, Hawaii

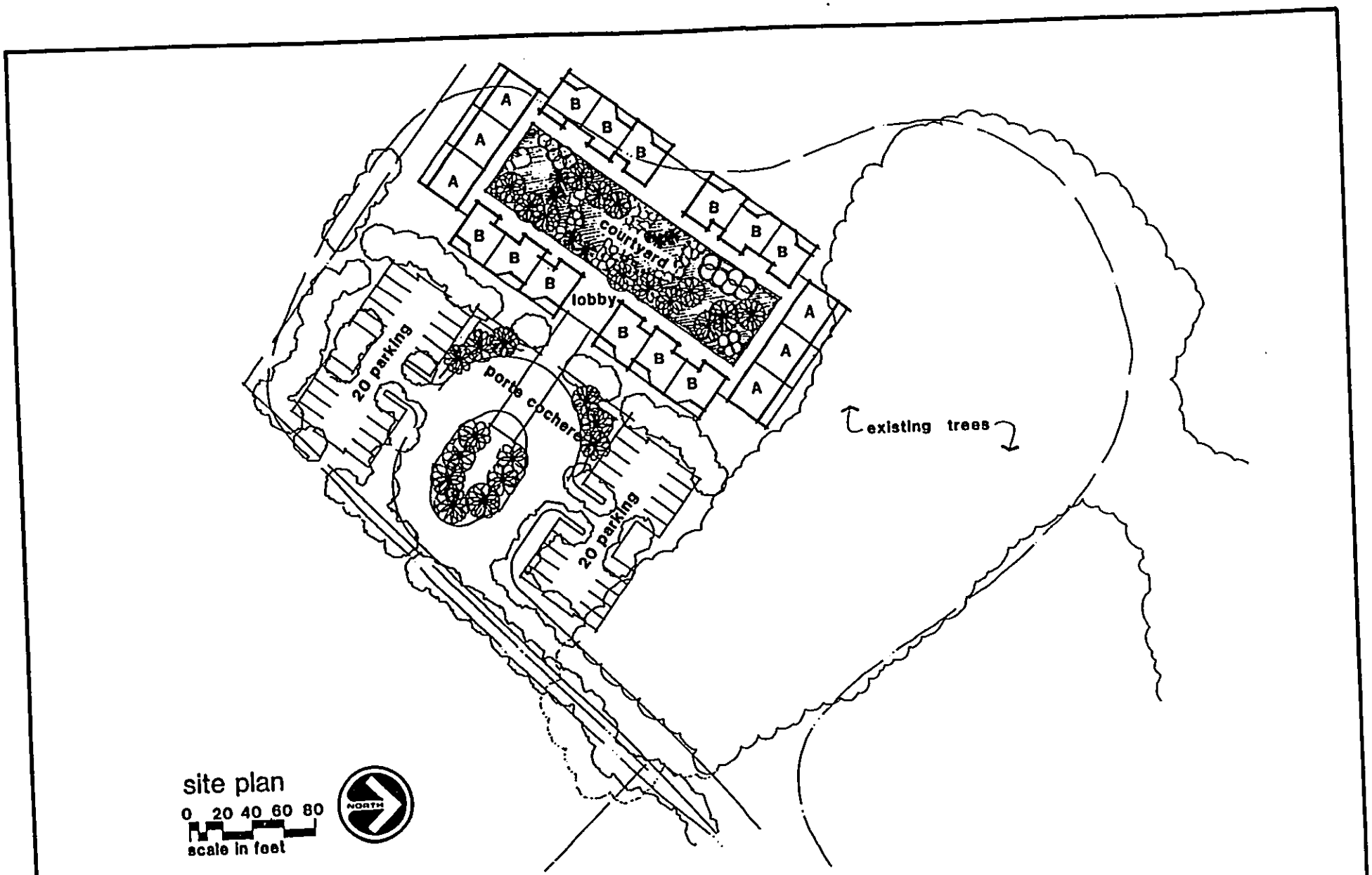
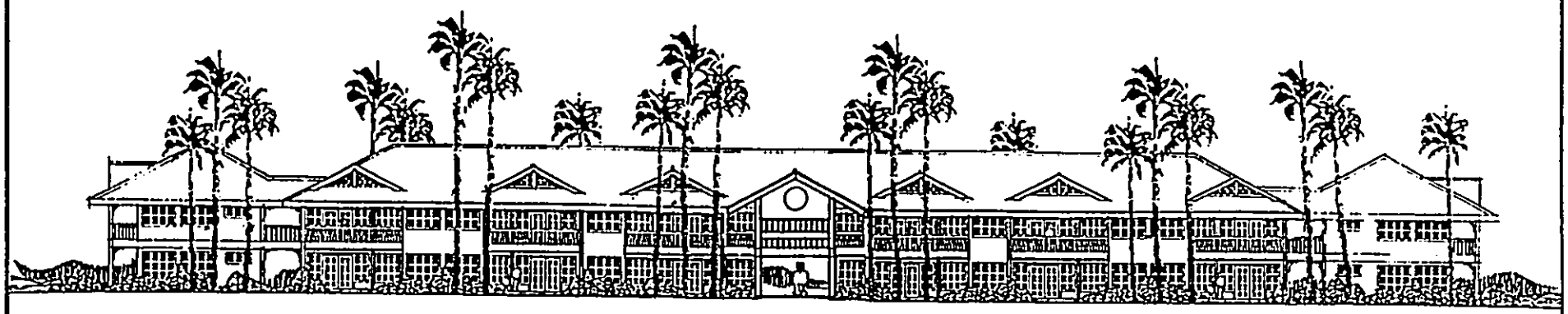
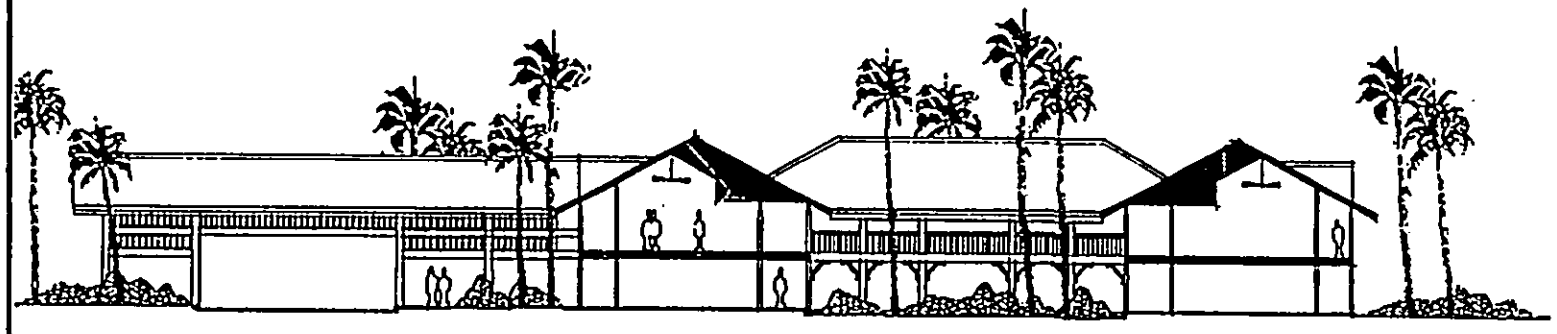


Figure 2-10
MEMBERS' LODGE PLAN
Kealakekua Bay Club
South Kona, Hawaii



exterior elevation / view from entry

0 5 10 20 30
scale in feet



section thru building

0 5 10 20 30
scale in feet

Figure 2-11
MEMBERS' LODGE
EXTERIOR VIEWS
Kealakekua Bay Club
South Kona, Hawaii

8.4 Agricultural Lots

In addition to the golf course facilities and lodge, the project includes 5 lots fronting Napoopoo Road. A portion of the land to be subdivided into the lots is currently occupied by three termite damaged single family dwelling. One of these dwellings has been nominated for inclusion on the National Register of Historic Places. Unfortunately, this house was remodeled extensively prior to the current property owner's acquisition of the parcel, reducing its historic value significantly. Nevertheless, the house will be preserved if required by the State Historic Sites Office. Once subdivided, the five lots will be available for diversified agriculture activities and residential use consistent with the current zoning. A buffer of coffee trees along Napoopoo Road will be maintained in the 60-foot building exclusion setback and will shield the 2-acre lots from traffic and the passerby from a direct golf course view.

8.5 Infrastructure

8.5.1 Water

The proposed project will require the development of an on-site potable water distribution system as well as a non-potable irrigation system. This potable system will consist of the appropriate transmission lines and valves linking it to the County's municipal water line. All on-site water infrastructure (potable and non-potable) will be developed and funded by the applicant.

Potable water demand generated by the proposed development is about 23,500 gallons per day. Projected demand exceeds existing allocation by approximately 1,300 gallons per day (gpd). To address the potable water deficit, the applicant will either seek an additional allocation from the County, negotiate with surrounding property owners for the acquisition of additional water, or if no other recourse exists, construct a new well at a location upslope from the project area. It should be noted that the potable water deficit will not materialize until such time as the proposed Members' Lodge is certified for occupancy. Under the current development schedule, the lodge will be opened in 1997, subject to approval by the County of General Plan and zoning amendments to permit its development. The applicant believes that this time frame provides ample time to obtain additional potable water to serve the property should it be determined that it will be necessary.

Anticipated golf course irrigation (non-potable) at the Kealakekua Bay Club is estimated at 3,100 gallons per acre per day to maintain turf and landscaping for 150 acres of golf course fairways, tees and greens. This amount is equal to about .465 mgd on an average daily basis. A well constructed on-site providing between 0.7 million gallons per day (mgd) and 1.2 mgd will be sufficient to address the project's irrigation requirements and ensure sufficient reserve for extended periods of dry weather.

8.5.2 Wastewater

In order to protect the surrounding environment from the impacts of sewage disposal resulting from the proposed project, an onsite wastewater management system is proposed. It is anticipated that between 11,500 and 12,000 gallons per day of wastewater will be generated at full development of the site. Of the total wastestream, roughly 42% will originate from the proposed golf clubhouse, while 47% will be contributed from the proposed Members' Lodge and 11% will be generated by the maintenance facility. The five agricultural lots will each be served by individual septic tanks. The design, construction and operation of the proposed system will conform to Hawaii County and State health and sanitation standards.

The proposed wastewater treatment plant will be constructed to accommodate a total capacity of about 20,000 gallons of wastewater per day. It will be located at the proposed maintenance area situated mauka of the golf course's ninth tee. The facility will be funded, constructed and operated by the applicant.

After treatment in the facility, the disinfected secondary effluent will be used to supplement irrigation of the golf course. It would be blended with non-potable irrigation water. Due to the relatively small volume of effluent that might be used, its overall impact upon the golf course in terms of a potential health concern is minimal. Assuming an average daily volume of wastewater totaling about 12,000 gallons, effluent will constitute less than 3% of the total daily volume of irrigation water required. The applicant will work with the State Department of Health and the County Public Works Department to ensure that treated effluent disposal is conducted in a manner which minimizes environmental impacts.

8.5.3 Drainage

The watershed for the proposed development has no natural drainage ways or streams crossing the project site. There is some drainage runoff that reaches the site from the mauka side of Napoopoo Road; however, all rainwater falling on and reaching the site appears to percolate through the soil. Runoff over the pali at the makai boundary of the subject property has never been documented, although one area resident remembers it occurring during a particularly heavy storm.

The County's Department of Public Works (DPW) has indicated a concern about the excess runoff from the Cook's Landing subdivision, mauka of the proposed project. This excess runoff is due to the blockage of grate inlets with rock and debris. In addition, some of the drywells in the subdivision were plugged with rock and debris at the time of inspection.

The proposed development will result in about 9.3 acres of land being converted from its natural state to built-on land. This area includes parking lots, sidewalks, buildings and maintenance facilities. Because over 97% of the project's total land area will remain as open space in the form of a golf course, landscaped areas around development sites, and the undisturbed 50-acre Conservation District area, the impact upon the existing runoff pattern is minimal.

To address runoff across the site, the use of drywells at specified locations as well as the development of retention basins within the golf course area is recommended. These facilities will enable stormwater to percolate through the ground and will prevent runoff from reaching the pali.

If the runoff problem from the Cook's Landing Subdivision is not rectified by the responsible parties, the applicant may need to address this offsite runoff. This may result in larger culverts or added drywells to the project's drainage system.

8.5.4 Solid Waste Disposal

At full buildout, the proposed project is anticipated to generate approximately 723 pounds of solid waste per day, or about 132 tons per year. Solid waste will be collected by a private refuse disposal service and disposed of at the nearest landfill. To mitigate potential impacts resulting from the volume of solid waste generated by the proposed project, all activities will be encouraged to practice recycling measures to the maximum extent possible.

8.5.5 Power and Communications

The proposed project will not require additional sources of electrical energy for its development or operation. The project will utilize electrical energy provided by the existing 69 kv transmission line. Therefore, it will have no significant impact upon regional electrical energy resources.

Increased telephone service to the project area will not significantly impact the capabilities of the Hawaiian Telephone service to provide service to its existing or future customers.

The CATV system would be expanded as requested and required to serve the project area.

8.5.6 Traffic Circulation

For the purposes of analysis, a worst-case scenario was assumed with full build-out of the project occurring in 1994.

The project will add about 50 vehicle trips on Napoopoo Road with the majority in the northern direction during the afternoon peak hour. The north bound trips at total build-out will have a significant impact upon the intersection of Napoopoo Road with Mamalahoa Highway. A traffic impact analysis prepared for the project demonstrates that without the project, conditions involving left turns at the intersection of Napoopoo Road and Mamalahoa Highway will continue to worsen from the present Level-of-Service (LOS) D; high density traffic flow with severe maneuvering ability, to LOS F; extreme delays, by the time the entire project is completed. The proposed project will, therefore, exacerbate the problem. Even without the project, improvements are needed at the intersection to provide better sight distances and adequate storage lanes.

Three alternatives are presently being considered to resolve not only the project's impacts, but to help alleviate the existing situation. The first alternative is to signalize the Napoopoo Road intersection with Mamalahoa Highway. The second alternative is to make substantial improvements to the intersections including improving sight distances along Mamalahoa Highway and constructing a left turn storage lane on Napoopoo Road. A third alternative is to construct a new access road linking the project area to Mamalahoa Highway. If this third alternative were to be implemented, it would result in the eventual closure of the existing intersection at Napoopoo Road and Mamalahoa Highway. The applicant is presently working with the County Public Works Department and surrounding landowners to determine the most appropriate alternative to solve the continuing traffic problem.

8.6 Public Access

Napoopoo Road provides vehicular access to the subject property. New access roadways from Napoopoo Road to the golf clubhouse and the members' lodge will be constructed on site. The northern branch of the internal access road will terminate at the 900 foot elevation where a public parking area will be provided. This parking area will be situated approximately 1,600 feet upslope from the top of the cliff. It will provide about 20 public parking stalls for persons wishing to visit a new scenic lookout at the top of the Pali Kapu O Keoua. A new pedestrian access trail will be provided from the parking area to the scenic overlook. Although there are no specific plans for the development of the overlook at this time, it is anticipated that it will be administered by a

public agency such as the Department of Land and Natural Resources. No specific development proposal for the scenic lookout is included as part of the proposed Kealakekua Bay Club golf course project. However, public access improvements will include improvements to existing trails in the area as well as the development of new trails in coordination with the Department of Land and Natural Resources, including a lateral trail along the the top of the pali. Historic Ka'awaloa Road will be preserved in its current alignment. Although it may be crossed by golf cart paths or infrastructure easements, no other improvements are planned for it. Pedestrian trails on-site will provide new access to Ka'awaloa Road, enabling people visiting the proposed scenic lookout to walk down to the Ka'awaloa-Cook's Point area. The applicant will work closely with the DLNR's Division of Parks and Recreation, Historic Sites Office and the Na Ala Hele organization to integrate the project public access improvements with planned State improvements.

8.7 Development Schedule

If all appropriate land use approvals are granted, construction of the proposed project will begin in 1993. The golf course will likely open for play in 1995 and construction of all support facilities should be completed by 1997.

8.8 Project Costs

The cost of planning and constructing the golf course and clubhouse will exceed $25 million.

Chapter III:
ALTERNATIVES CONSIDERED

CHAPTER III - ALTERNATIVES CONSIDERED

1. INTRODUCTION

In compliance with the provisions of Title 11, Department of Health, Chapter 200, Environmental Impact Statement Rules, Section 11-200-17(f), the "known feasible" alternatives to the proposed project are discussed in this chapter. Those alternatives which could "feasibly" attain the objectives of the project are described and evaluated.

2. DESCRIPTION OF ALTERNATIVES

2.1 "No Action" Alternative

The "no-action" or "no-project" alternative would retain the property in its present use; the vacant dilapidated plantation houses would remain and the remainder of the property would continue as vacant, part-time pasture land. Because approximately 100 acres of the property, representing the mauka portion, is presently zoned RA-2, retaining the property as vacant land will represent a continued loss of income for the applicant, who is essentially paying residential property taxes on vacant land with no opportunity for a reasonable return on their investment. The "no-action" alternative will also deny the general public of the potential public benefits associated with the current development proposal, including enhanced public access, roadway improvements and a scenic overlook above Kealakekua Bay.

2.2 Residential Development

In 1987, the subject property was granted a preliminary subdivision approval which provided for its subdivision into 37 residential lots; 36 lots suitable for residential and agricultural development plus a 37th lot consisting of the Conservation District that occupies the makai portion of the subject property. Although the property could support at least 36 residential units consistent with this subdivision approval and its present zoning of RA-2, and has been allocated sufficient potable water by the County system to serve these units, this use is not viewed by the property owners as being in the best interest of the property or the community. The development of a subdivision will result in the creation of impermeable surfaces such as roadways, rooftops, driveways, and sidewalks which could generate storm runoff in far greater quantities than that of less intrusive development and would be very costly to mitigate. In addition, the traffic generated by a 36 unit subdivision is expected to have a significant impact upon Napoopoo Road, especially during peak morning and afternoon peak hours.

2.3 Agricultural Development

Although the property has been historically utilized for agricultural-related activities, according to an Analysis for Agricultural Potential prepared for this project and presented as an appendix to this document, the quality of the land is considered to be inadequate for agricultural development. Therefore, utilization of the property exclusively for agricultural development is not considered to be a feasible or viable alternative. In the long-term, continued use of the property for grazing is viewed as having a potentially detrimental impact on native species of plants.

2.4 Scaled Down Alternative

A scaled down alternative would result in a development similar to that which is proposed with the exception of either a smaller Members' Lodge or no Members' Lodge. The proposed golf course can =not, in itself, be scaled down because it would result in short narrow fairways which could be hazardous to play and would likely not be of sufficient quality to attract persons to join the golf club or play the course. A smaller Members' Lodge would not be feasible because the memberships it might attract would not be of a number sufficient to assist in the offsetting of development costs associated with the golf course. The elimination of the Members' Lodge from the plan is not desirable for the same reason.

3. COMPARATIVE EVALUATION

None of the development alternatives considered for the project area are capable of fulfilling the objectives of the proposed project as presented in Section 7 of Chapter II of this document. The alternatives are either not cost-effective or have greater potential environmental impacts than the proposed development. The development of the proposed project will enable the applicant to ensure the preservation of open space while creating community benefits such as public access and a scenic overlook which would otherwise not be possible or too costly. Furthermore, development of the property as proposed in this environmental impact statement affords greater opportunity to protect and preserve important archaeological sites than do other development proposals considered above.

Chapter IV:
DESCRIPTION OF THE ENVIRONMENTAL SETTING

CHAPTER IV - DESCRIPTION OF THE ENVIRONMENTAL SETTING

1. INTRODUCTION

This chapter describes the environment affected by the proposed development and discusses potential impacts related to the construction and operation of the project's components. The discussion is based upon the assumption of full development of the proposed project.

A review of mitigation measures that would be required to minimize potential adverse impacts generated by the project is also presented in this chapter. The information contained in this chapter is based upon three sources:

- Detailed studies, including field studies, conducted by staff planners and engineers as well as consultants contracted specifically for this environmental impact statement.[1]
- Comments received from public agencies, private groups, organizations and residents from the affected region, and elected and appointed officials, based upon their review of the environmental assessment and the concept plans for the project.
- Comparisons and evaluations made by consultants relative to similar planned or existing projects.

2. PHYSICAL ENVIRONMENT

2.1 Geology and Topography

2.1.1 Existing Conditions

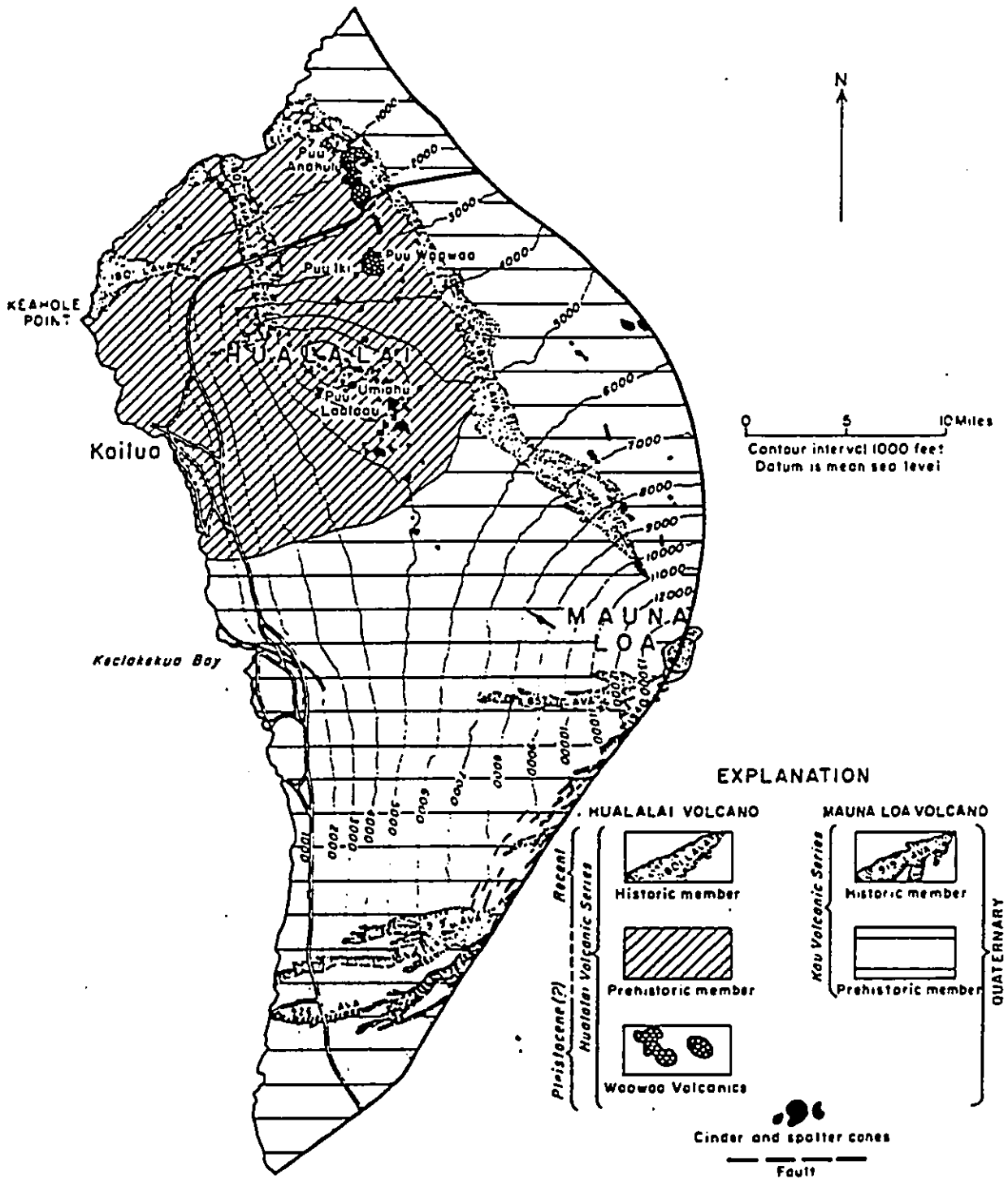
2.1.1.1 Geology

As shown in Figure 4-1, the project area is located on the western slope of Mauna Loa, approximately 20 miles due west of the summit. The entire site is composed of lava estimated to be from 10,000 to 50,000 years old. The subject property lies directly above and abuts the Kealakekua Fault which curves north from Hookena and is evidenced in the vicinity of the project area by the 600 foot high sea cliff behind Kealakekua Bay. The fault extends into the ocean a distance of about 22 miles. The sea cliff itself is believed to be the remnant of a landslide which occurred between 13,000 and 31,000 years ago.

2.1.1.2 Topography

The project area consists of approximately 262 acres of land situated above Kealakekua Bay between Napoopoo Road (Lower Government Main Road) and Pali Kapu O Keoua, the 600 foot high sea cliff at the rear of the bay. The property's topography is characterized by a continuous upward slope from an elevation of 550 feet at the top of the cliff to an elevation of 1,250 feet at the upper most portion of the project area bordering Napoopoo Road (Figure 4-2). The site area ranges in grade from 10 to over 20 percent in some of the lower portions and from 10

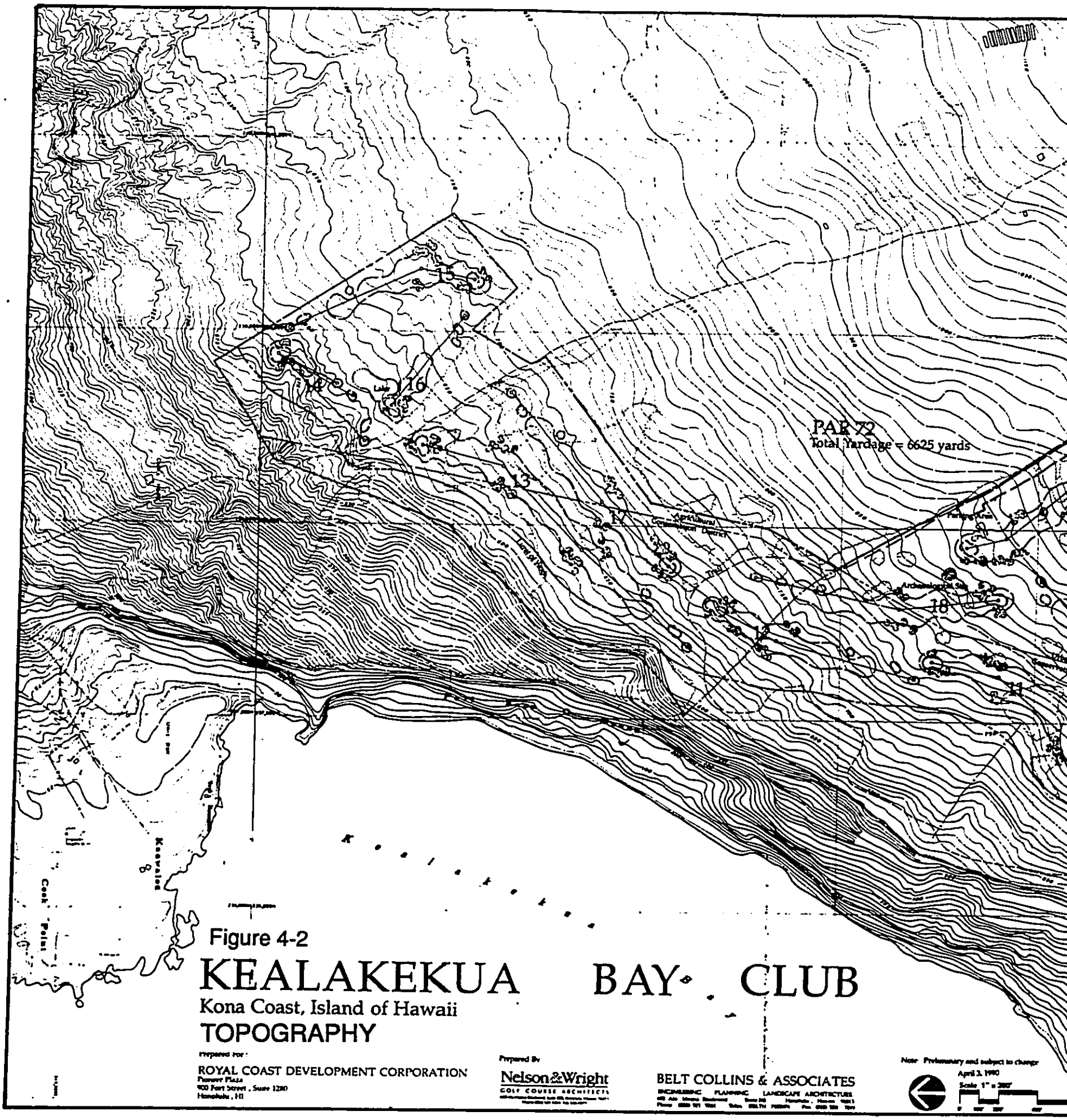
[1] All subconsultant studies are included in their complete and final form as appendices to this document

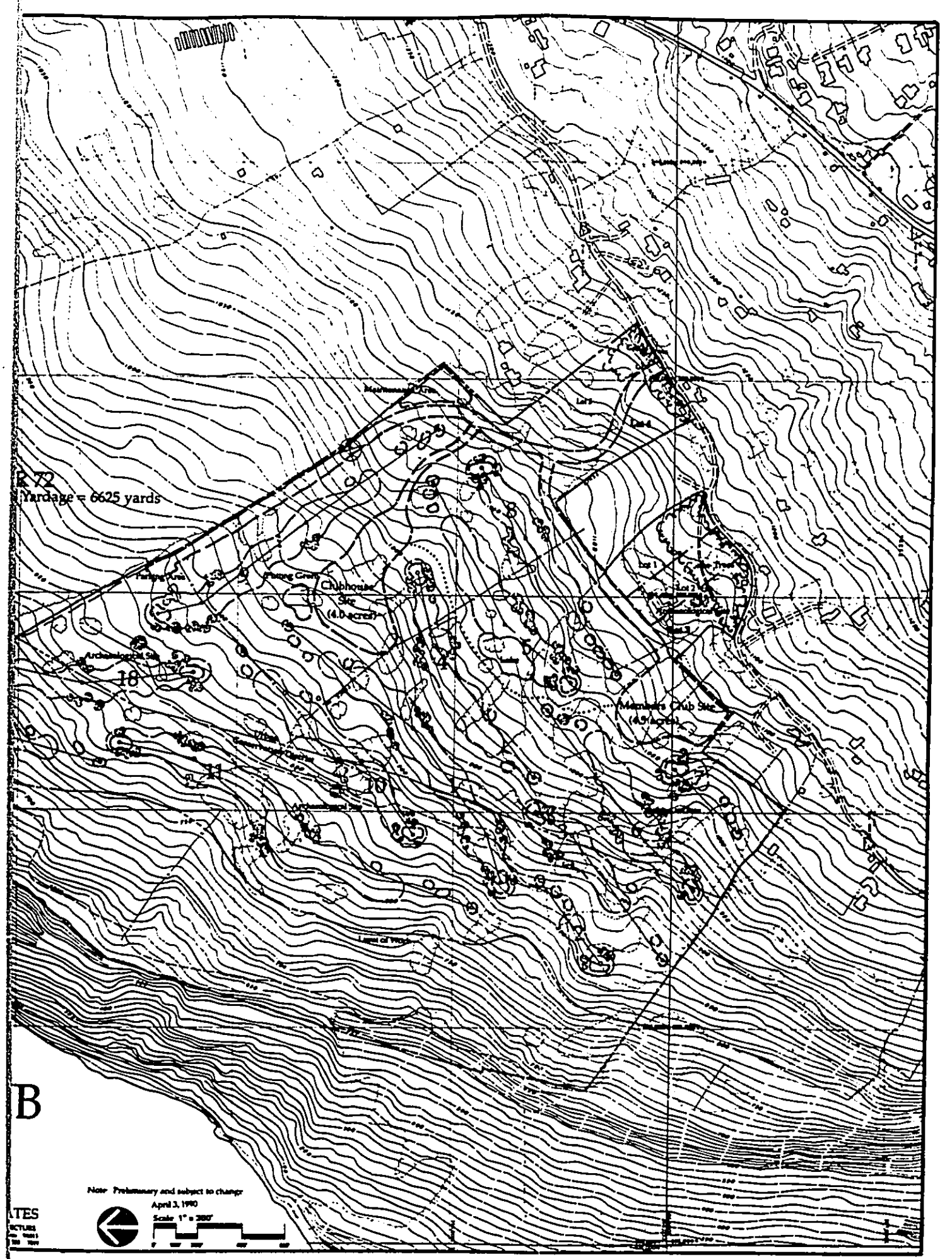


NOTE: Map modified from Stearns and MacDonald, 1946.

Figure 4-1
GEOLOGY
Kealakekua Bay Club
South Kona, Hawaii

Prepared by: Belt Collins & Associates


PAR 72
Total Yardage = 6625 yards
Figure 4-2
KEALAKEKUA BAY CLUB
Kona Coast, Island of Hawaii
TOPOGRAPHY
Prepared for:
ROYAL COAST DEVELOPMENT CORPORATION
Prepared By
Nelson&Wright
GOLF COURSE ARCHITECTS
BELT COLLINS & ASSOCIATES
ENGINEERING PLANNING LANDSCAPE ARCHITECTURE
Note: Preliminary and subject to change
April 3, 1990


R 72
Yardage = 6625 yards
Parking Area
Parking Area
Clubhouse Site (4.0 acres)
Archaeological Site
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11
10
Archaeological Site
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Note: Preliminary and subject to change
April 3, 1990
Scale 1" = 200'

to 15 percent in the upper portions. The general topography of the site is best characterized as a continuous slope with intermittent areas of relatively level terraces or small plateaus.

2.1.2 Probable Impacts

The proposed project will have no impact upon the regional geology of the area, including the Kealakekua Fault. The topography of the project area will be substantially impacted by the development of the proposed golf course and its related facilities. Extensive grading will be conducted in most areas to reshape the land surface to provide a playable surface and to minimize offsite drainage. The portion of the proposed project to be subdivided for residential-agricultural lots will not change the topography of the individual lots beyond some landscaping.

The general character of the property will be changed by the proposed development. Its appearance will be permanently altered by the construction and landscaping of golf course fairways and the addition of access roads, golf cart paths, and related physical amenities. Upon completion of the proposed project, the land area occupied by the golf course will appear as a series of relatively broad terraces running parallel to the edge of the cliff and extending upslope to the mauka edge of the project area. However, the overall character of the five agriculture lots will not have significantly changed, due to the fact that no substantive new development is proposed for the lots.

2.1.3 Mitigation Measures

Impacts to the geology and physiography of the project site can be mitigated to some degree through careful design of the project in an attempt to preserve some existing contours. However, the overall topography must be altered to allow construction of golf course fairways and access roads. Construction activities will be conducted in accordance with applicable air and noise quality regulations to minimize potential fugitive dust and noise impacts on adjacent developed areas.

2.2. Soils and Agricultural Potential

2.2.1 Existing Conditions

2.2.1.1 Soils

The project area consists of five soil types as classified by the United States Department of Agriculture Soil Conservation Service (December, 1973). Following is a description of the soil types as presented in the Soil Conservation Services 1973 publication. A map of the distribution of these soil types on the project site is presented in Figure 4-3.

rLV <u>A'a Lava Flows</u>. This lava has practically no soil covering and is bare of vegetation, except for mosses, lichens, ferns. It is at an elevation ranging from near sea level to 13,000 feet and receives from 10 to 250 inches of rainfall annually. It is associated with pahoehoe lava flows and many soils. This lava is rough and broken. It is a mass of clinkery, hard, glassy, sharp pieces piled in tumbled heaps. In areas of high rainfall, it contributes substantially to the underground water supply and is used for watershed.

rKED <u>Kaimu extremely stony peat, 6 to 20 percent slopes</u>. This soil is at low elevations on Mauna Loa. In a representative profile the surface layer is very dark brown extremely stony peat about 3 inches thick. It is underlain by fragmental A'a lava.

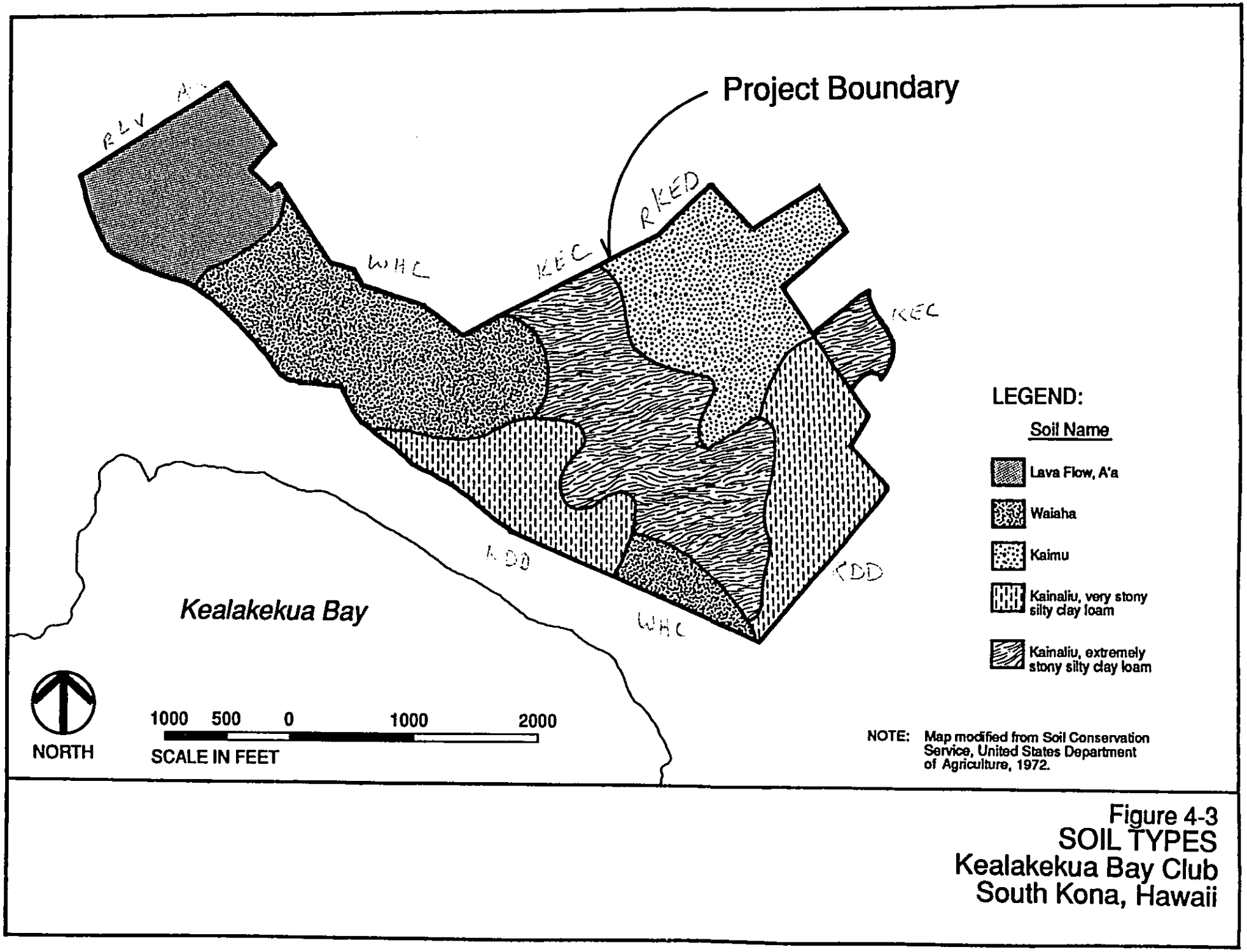


Figure 4-3
SOIL TYPES
Kealakekua Bay Club
South Kona, Hawaii

This soil is neutral in reaction. Permeability is rapid, runoff is slow, and the erosion hazard is slight. This soil is not suitable for cultivation. Most of it is in native woodland. Small areas are used for pasture, macadamia nuts, papaya, and citrus fruits.

KEC Kainaliu extremely stony silty clay loam, 12 to 20 percent slopes. This soil is at low elevations on Mauna Loa and Hualalai. In a representative profile the surface layer is very dark brown extremely stony silty clay loam about 10 inches thick. The subsoil consists of dark-brown very stony silty clay loam and silt loam. It is about 16 inches thick and is underlain by fragmental A'a lava. The surface layer is medium acid, and the subsoil is neutral. Permeability is rapid, runoff is slow, and the erosion hazard is slight. Roots penetrate to a depth of about 26 inches or more. This soil is used for coffee, macadamia nuts, and pasture.

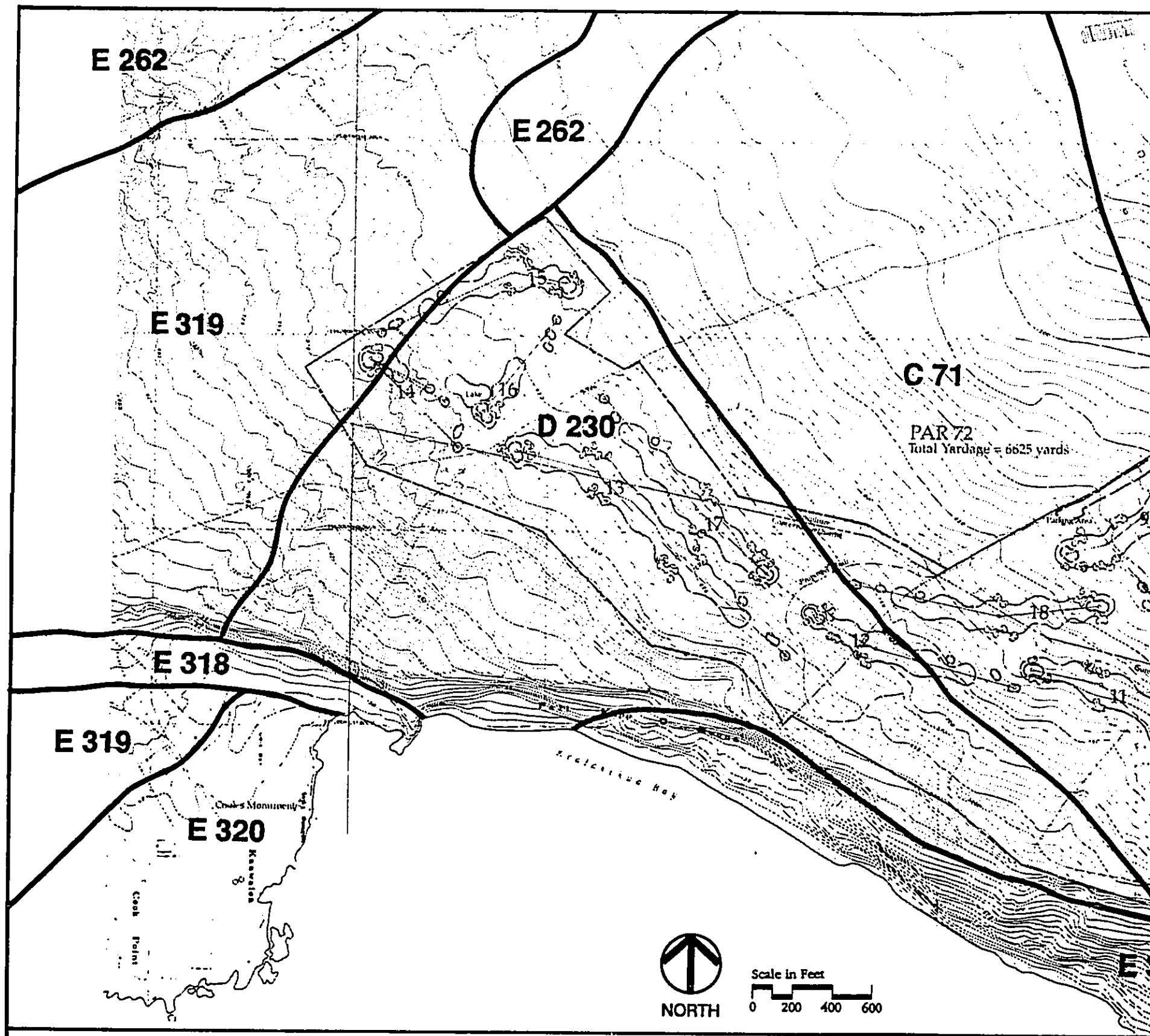
KDD Kainaliu very stony silty clay loam, 12 to 20 percent slopes. This soil is similar to Kainaliu extremely stony silty clay loam, 12 to 20 percent slopes, except that it is less stony. Most areas of this soil follow the pattern of the lava flows and are long and narrow, but some are isolated and are surrounded by recent lava flows. Most of the acreage is used for coffee, macadamia nuts, and pasture. A small acreage is used for truck crops.

WHC Waiaha extremely stony silt loam, 6 to 12 percent slopes. This soil is low on the leeward side of Hualalai and Mauna Loa. In a representative profile the surface layer is very dark brown extremely stony silt loam about 4 inches thick. The subsoil is dark-brown very stony silt loam about 14 inches thick. The substratum is pahoehoe lava bedrock. The surface layer is slightly acid. The subsoil is neutral to mildly alkaline. In places the surface layer is nonstony. Permeability is moderately rapid, runoff is slow, and the erosion hazard is slight. Roots can penetrate to bedrock.

Soils identified as rLV make up about 13 acres of the total project area. About 21 acres consist of rKED soils. Just over 51 acres consist of WHC soils. Approximately 92 acres consist of KEC soils. Finally, about 84 acres consist of KDD soils.

2.2.1.2 Agricultural Potential

According to the Detailed Land Classification, Island of Hawaii, a soil analysis published by the University of Hawaii's Land Study Bureau in 1972, 172 acres of the total project area are classified as C lands (Fair), 71 acres as D lands (Poor), and 15 acres as E lands (Very Poor). This study presents a detailed analysis of soil types identifying a total of seven variations of soil in the project area. The agricultural potential of the various soils (identified by a numbering system) is presented in Figure 4-4. Following is a summary of the analysis.



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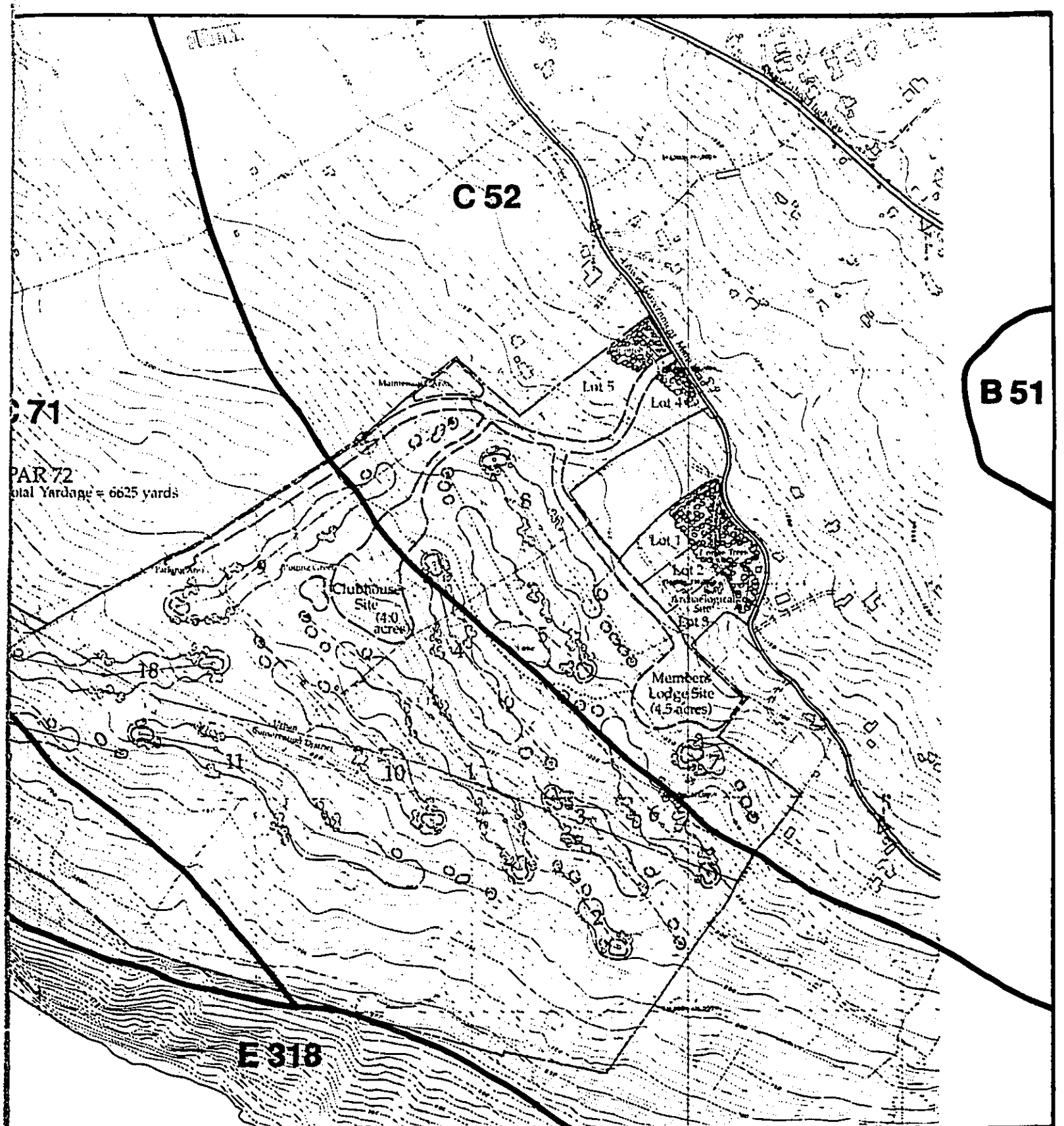


Figure 4-4
AGRICULTURAL CLASSIFICATIONS

Kealakekua Bay Club
South Kona, Hawaii

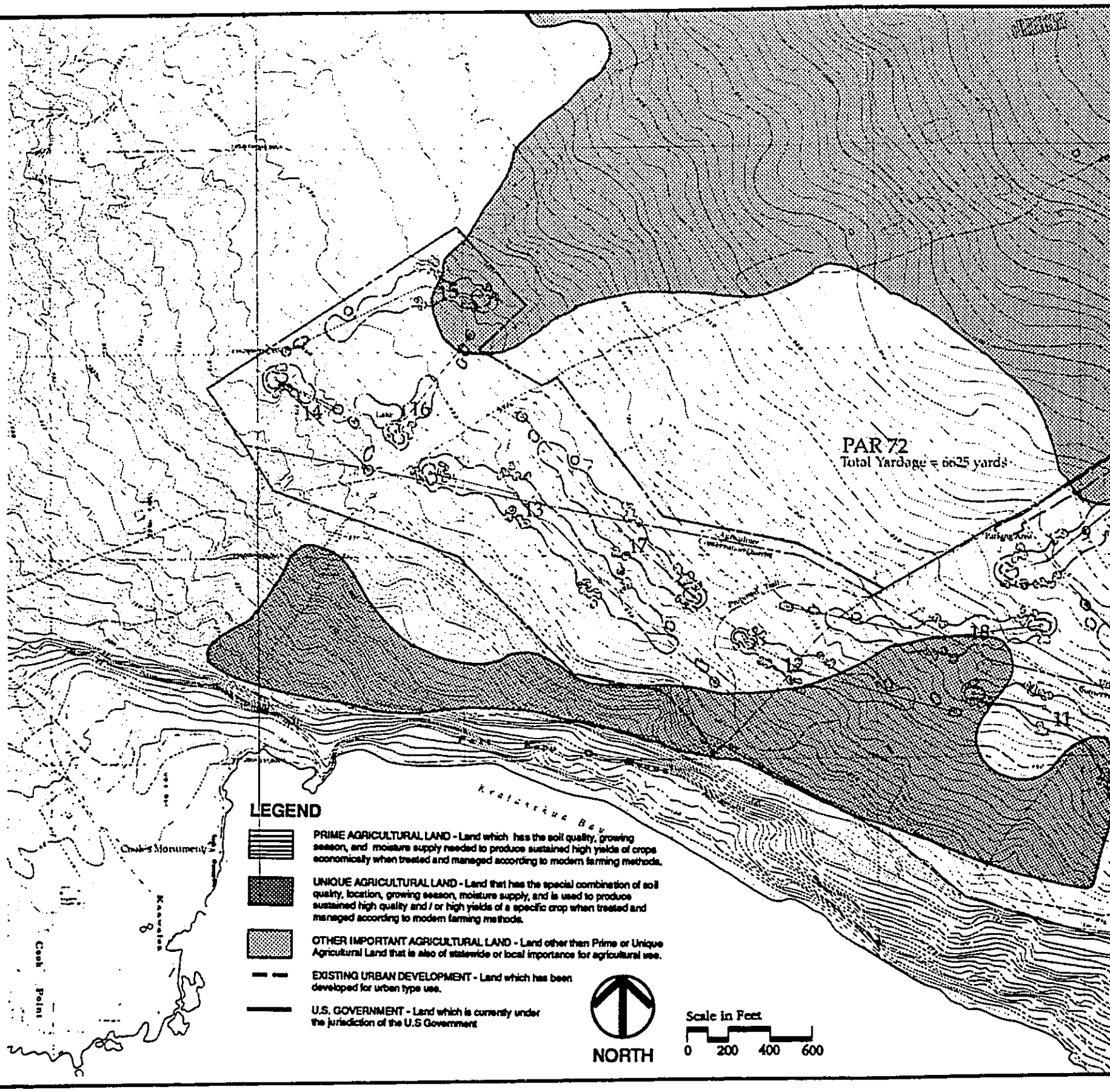
Table 4-1: Detailed Land Classification

Soil	Parent Material	Stoniness	Drainage	% Slope	Machine Tillability
C52	Volcanic Ash	Rocky	Well drained	11 to 20 with undulating terrain	Unsuited
C71	Volcanic Ash	Rocky	Well drained	11 to 20 uniform	Unsuited
D230	Volcanic Ash	Rocky	Well drained	0 to 20	Unsuited
E319	A'a	Sharp A'a clinkers	Excessively drained	0 to 20	Unsuited
E320	Pahoehoe	----------	Well drained	0 to 20	Unsuited

A total of approximately 108 acres within the project area, or roughly 40 percent is identified as Other Important Agricultural Land under the State's ALISH system (Agricultural Land of Importance to the State of Hawaii). These lands are located generally in the mauka portion of the property adjacent to Napoopoo Road and extending midway down the length of the property, and in a narrow band along the top of the pali. They are identified in Figure 4-5. The remainder of the property has no agricultural value as determined by the State's ALISH system.

The Land Evaluation and Site Assessment (LESA) Commission was established in 1983 to identify "important agricultural lands" in the State of Hawaii and to recommend the adoption by the State Legislature of a classification system to be developed by the Commission. The LESA report has been submitted to the Legislature, but has, as of the date of this writing, not been adopted. Soil types by island were evaluated in the LESA report; those on the island of Hawaii had ratings of 88 to 14. The ratings of soil types at the project site range from 58 to 43, making it relatively unlikely that the project site lands would be classified as "important agricultural lands".

None of the land identified as Other Important Agricultural is presently utilized for the cultivation of crops. Some areas within the upper region of the project site have been historically used by the Greenwell Ranch for cattle grazing. However, the seasonal character of the climate and the quality of the grazing land results in a ratio of one grazing animal for every two acres of pasture land.



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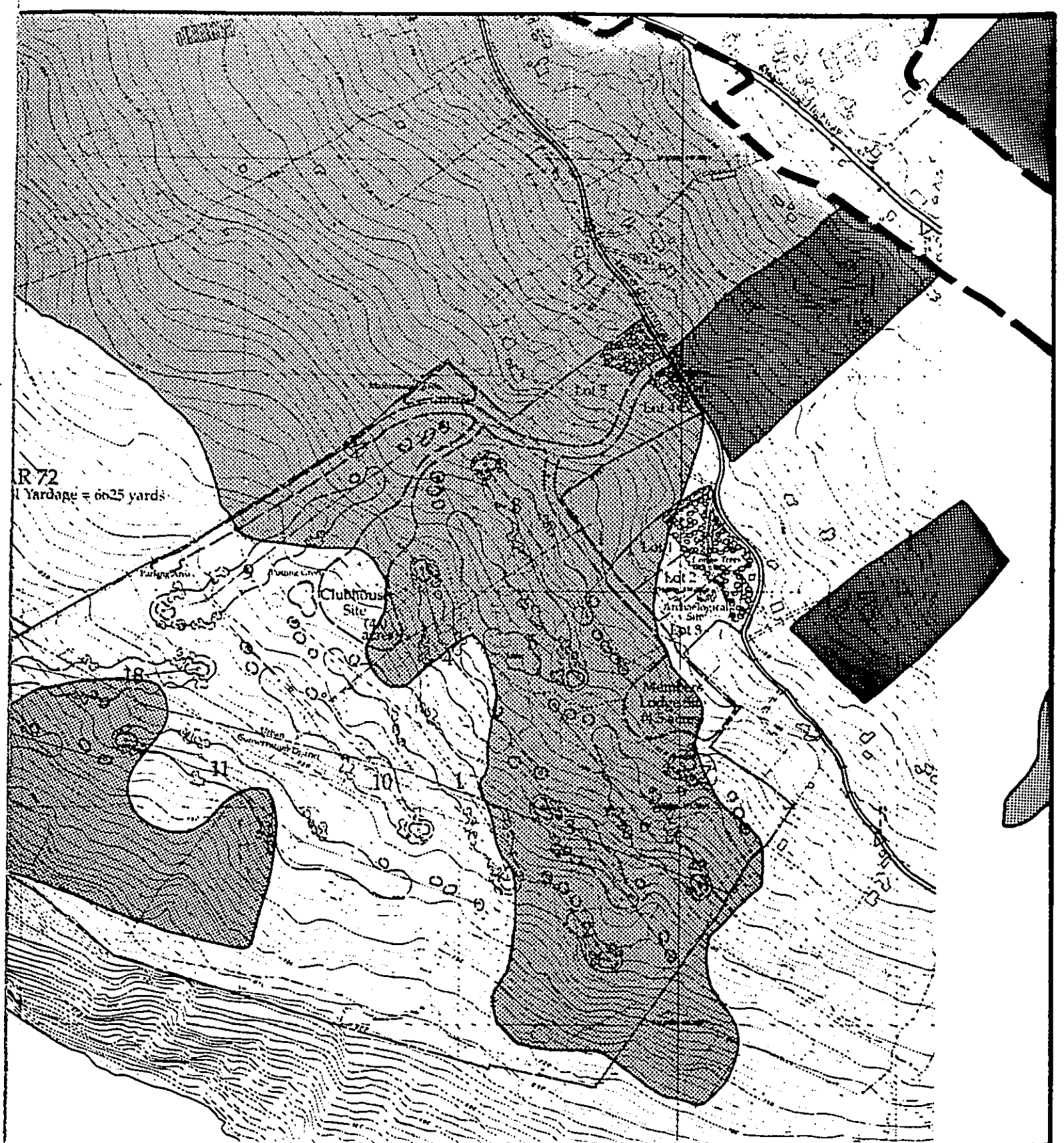


Figure 4-5
ALISH CLASSIFICATIONS

Kealakekua Bay Club
South Kona, Hawaii

Between 1904 and 1908, the project area was leased to the Hala Kanning Company which tried to grow pineapple on it. The venture proved to be unprofitable. Coffee has also been grown on the property but efforts were abandoned in 1924 due primarily to the pronounced differences in the dry and wet seasons in the area. Today, a few coffee trees are maintained on the mauka residential lots within the subject property.

2.2.2 Probable Impacts

Although soil depths exceed 14 inches in some portions of the project area, additional soils will need to be imported from other areas of the island to the project site to enable construction of the golf course. Imported soils pose a potential siltation or runoff problem if they are stockpiled without adequate precautions. They also may impact air quality in the form of dust generated during off-loading from trucks and if not properly stockpiled.

Impact upon the project's soils will occur during the construction phase of the project and, to a lesser degree, during the upkeep of landscaped areas. The erosion hazard is considered to be slight because of the terraced character of the property which compensates for the relative steepness of the slope.

The project will impact the limited agricultural activity (cattle grazing) existing on the property. Development of the property as a golf course will preclude its use for cattle grazing. Given the relatively poor quality of the soil and the scrub nature of its vegetation, the loss of these lands for grazing is not considered to be a significant adverse impact.

However, the development of the proposed golf course and its related amenities will effectively eliminate the agricultural potential of those lands identified as Other Important Lands of agricultural importance to the State of Hawaii. Given the State and County's policies to protect agricultural land, this loss is recognized as a negative impact of the proposed project. But this negative impact is offset to some degree by three considerations. First, the current zoning of the subject property would allow up to 36 residential lots to be developed, resulting in the same loss of agricultural potential. Second, while it is understood that the LESA Commission was established to replace the State's ALISH system and clarify the identity of important agricultural lands, it is unclear at this time whether lands deemed as Other Important Lands under the ALISH system will "make the cut", so to speak, under the LESA system. In other words, lands identified under the ALISH system may, in fact, be considered to be marginal under the LESA system. Third, historical use of the subject property for agricultural purposes has been limited to cattle grazing and unsuccessful attempts at coffee and pineapple cultivation. Together, these three considerations raise some question about the value of the subject property as an agricultural area. Surrounding properties are devoted largely to residential development with some small nurseries or orchards. The proposed project will have no impact upon the value of these surrounding agricultural uses or lands. It will, however, have a positive economic impact upon the surrounding area in terms of providing new employment opportunities for part-time farmers.

An Agricultural Impact Study prepared by Marutani & Associates in May, 1991 for the project is included as an appendix to this environmental impact statement. The report concluded,

> "...the total impact this project might have on agriculture on the Island of Hawaii will be minor, at best, or to the point of being irrelevant...the soil condition is poor, and the lack of an even distribution of rainfall is counter productive to agriculture.

The State's policy toward its primary land objective is the achievement of productive agricultural use of lands most suitable and needed for agriculture. It is also to 'encourage productive use of the most suitable agricultural lands'. The project site is not suitable for conventional productive agricultural use..."

The Marutani study concluded that extensive irrigation and land clearing would be necessary to make the land productive.

2.2.3 Mitigation Measures

Imported soils will be placed and compacted as needed in an effort to avoid stockpiling. Thus, the importation of soil will be timed to correlate with the phased grading and sculpting of the golf course. For projects greater than one acre in size, an erosion control plan is required for approval prior to the issuance of a grading permit. A detailed erosion control plan will be prepared and submitted to the County Public Works Department for approval. Stockpiling of soils will be avoided wherever possible. However, if necessary, stockpiling requires a separate permit and will conform to County requirements to prevent erosion, run-off, and fugitive dust.

Due to the relatively sparse use of the subject property for cattle grazing, the loss is not considered to be significant and is therefore not worthy of mitigation. Once subdivided, the five mauka lots will be available for diversified agriculture activities.

While the development of the golf course will permanently impact the agricultural potential of those lands identified as Other Important Agricultural, the actual productivity of those lands is questionable. The golf course development will, however, ensure that the lands are retained in open space and will not be lost to more intensive urban use. The Marutani report suggests, "Utilization of the land for recreation, such as a golf course, which might be considered an alternative form of agriculture, would provide substantially more economic benefit than conventional crop production in the agricultural sense. A golf course on the site would provide improved open space and be able to take advantage of the beauty of the general area."

An additional consideration is the positive benefits of the proposed golf course upon the creation of employment opportunities in the area for the part-time farmer. It is estimated that well over half of all the coffee grown in the Kona region is produced by part-time farmers who hold other jobs in addition to their farming endeavors. While the proposed project reduces to some degree the net available agricultural land, it actually benefits existing and future part-time farmers by offering potential employment opportunities in South Kona which might help to augment the part-time farmer's income.

2.3 Natural Hazards

2.3.1 Existing Conditions

Aside from storms and strong winds, the natural hazards which could have the greatest potential impact upon the physical character of the subject property are volcanic eruptions and earthquakes. Tsunamis are not a potential threat to the property because of its elevation.

The proposed project is located on the western slope of Mauna Loa volcano, which rises to a height of 13,679 feet above sea level. The project site is located about 20 miles due west of Mokuaweoweo Crater, the volcano's summit, on a prehistoric lava flow estimated to be more than

4,000 years old. According to the United States Geological Survey, Mauna Loa has erupted thirty-two times since 1832. Seven of these eruptions have occurred in the southwest rift zone; that area of the volcano with the greatest potential exposure to the South Kona area. Of those seven eruptions, the closest to Kealakekua Bay occurred in 1950 when a lava flow from the southwest rift zone reached the sea about eight miles to the south.

Hazards associated with eruptions can be categorized in four types; lava flows, tephra falls, pyroclastic surges and volcanic gases. Volcanic hazard zones have been established for the entire island of Hawaii, including the South Kona region (Mulleneaux, et.al., 1987). The area surrounding Kealakekua Bay is designated as lava flow Hazard Zone 3 (with zone 1 being the highest and zone 9 being the lowest risk), and is characterized by lava coverage of about 5 percent in the past 40 years, and 20 percent during historic times.

Tephra consists of volcanic ash and coarser fragments produced by lava fountaining or explosive eruptions. Kealakekua is located in Tephra Hazard Zone 2. Hazard zones for volcanic gases are the same as for tephra. Kealakekua is located in Volcanic Gas Hazard Zone 2. No threat from pyroclastic surges, which are clouds of ash, rock fragments and gas which move at high speed outward from a source vent, has been identified for Kealakekua. Pyroclastic surges are presently associated only adjacent to Kilauea caldera, although they could conceivably be initiated at other places where ground water or sea water can interact with magma.

The Island of Hawaii experiences thousands of earthquakes every year, usually associated with volcanic activity or the movement of magma at shallow depths. Earthquakes endanger people and property by shaking structures and generating ground fractures, settling and landslides. Sudden subsidence along the shoreline associated with an earthquake can also generate a tsunami. The two most severe earthquakes during historical times occurred in 1868 and 1975. The magnitudes of both quakes exceeded 7 on the open-ended Richter scale and resulted in locally major damage in the Kau and Kilauea areas respectively. Both events generated a tsunami.

The most likely threat would result from a large earthquake (magnitude 6 or greater) occurring at Mauna Loa or Kilauea and impacting the South Kona region. In 1951, an earthquake occurred about one mile off-shore and was caused by movement on the fault. In 1983, a landslide at Kealakekua Bay occurred shortly after a magnitude 6.6 earthquake occurred at a depth of seven miles, approximately mid-way between Mauna Loa and Kilauea.

2.3.2 Probable Impacts

The proposed project is not likely to have any impact on natural hazards to which the land might be subjected. However, natural hazards such as lava flows and earthquakes could have a direct impact upon the proposed project. Based upon information developed by the United States Geological Survey (USGS) and published in its Professional Paper 1350 (1987), the likelihood of volcanic eruption at Mauna Loa is remote; only one to three percent of the land surface in Lava Flow Hazard Zone 3 has been covered by lava during historic times. An eruption at Mauna Loa could also result in thin layers of tephra impacting the project site. Volcanic gases from an eruption might also impact the project site. However, both of these latter occurrences would depend in great part upon the size of the eruption, associated fountaining of lava, and wind direction.

Buildings, including residential structures, as well as roadways, sewer and water lines could be damaged by an earthquake of sufficient magnitude. Landslides triggered by earthquakes

are a possibility in the project area, although they would likely occur on the face of Pali O Kapu Keoua rather than on the property above it. However, construction upon areas of substantial fill could be expected to be impacted by earthquakes at a higher degree than areas with no fill. Thus, certain fairways on the golf course might be subjected to higher degrees of risk than others, depending on the use of fill in their design.

2.3.3 Mitigation Measures

The impact of lava flows upon the project site can only be mitigated with the intention of protecting life. The protection of property from lava inundation has proven to be relatively ineffective on a regional scale. Therefore, mitigation of lava flow hazards is limited to the provision of adequate evacuation routes and a civil defense warning system designed to provide area residents with as much advance notice of a threatening lava flow as possible.

Mitigation of hazards associated with earthquakes include adherence to County building codes and standards in order to minimize potential damage to structures. It is recommended that all buildings and structures within the proposed project be designed and constructed in compliance with applicable building codes and standards. It is further recommended that the use of large volumes of fill to establish level development sites be discouraged. Because the proposed golf course is set back approximately 350 to 600 feet from the top of the pali, the likelihood of the course being impacted by landslides associated with the pali is remote.

2.4 Groundwater, Hydrology, Surface Water and Drainage

To better understand the area's existing hydrology and the potential impact of golf course pesticides and fertilizers upon Kealakekua Bay, detailed studies of the project were prepared by Tom Nance Water Resources Engineering, Harding Lawson Associates, Marine Research Consultants, and Environmental Impact Consultants. Following are excerpts from those reports, which are presented in their entirety as appendices to this environmental impact statement. Further recommendations on methods for reducing the amount and type of pesticides and fertilizers were offered by Faust Bio-Ag Consultants.

2.4.1 Existing Conditions

2.4.1.1 Groundwater and Hydrology

The occurrence of groundwater in the Kona coastal aquifer is illustrated in Figure 4-6. The basal lens of fresh water floats on top of the heavier salt water due to the density differential between fresh water and saline water. The fresh water characteristically forms a lens-shaped body floating over the saline water known as the Ghyben-Herzberg lens. This lens is dynamic due to variations in water discharge from pumpage, tidal action, and recharge.

The actual character of groundwater beneath the project site cannot be fully understood until a well is drilled and its results are analyzed. Until that time, the best knowledge of the area's hydrology is derived from two sources: experience gained from the drilling of nearby wells, and, time derived electromagnetic (TDEM) resistivity surveys conducted within and above the project site. TDEM surveys utilize electromagnetic energy to measure variations in resistivity among underlying geologic layers or strata. These variations help to characterize strata from which the lens may be interpreted. The strong contrast in resistivity of lava saturated with freshwater in the basal lens in comparison to the underlying lava saturated with seawater enables the interface of

these two groundwater bodies to be located. The depth of this occurrence below sea level can be converted to the calculation of the freshwater head above sea level, and subsequently, the thickness of the lens.

The only drilled wells in the near vicinity of the project are the County's Department of Water Supply (DWS) wells at Keei, approximately two and a half to three miles south of the project site. Tables 4-2 and 4-3 below present summaries of data gathered from these wells. Groundwater at the Keei wells occurs as a basal lens, which is presumably the same condition which exists beneath the project site. This means that it exists as a lens of fresh (or brackish) water floating on and in hydraulic contact with seawater which saturates the lavas at depth. The stability of the basal lens configuration is due to a number of factors: the density difference between fresh water and seawater; the very slow movement of groundwater generally; and the fact that the horizontal movement of groundwater toward the shoreline is several orders of magnitude greater than vertical movement of water (which would tend to mix the fresh and saltwater) and the effect of upward diffusion and dispersion of salts from the saline water at depth.

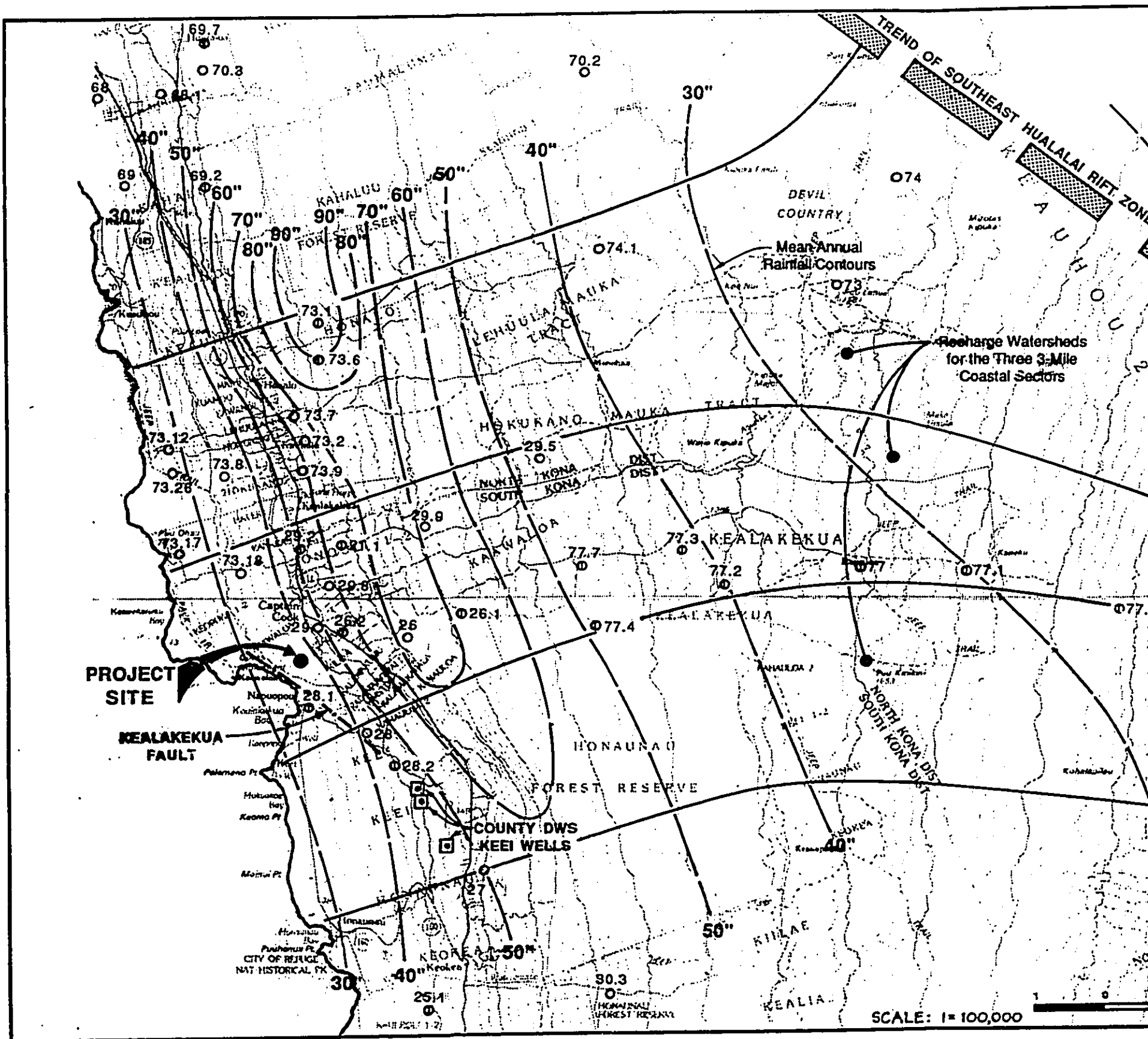
The natural and continuous movement of freshwater from its inland sources of recharge toward its shoreline discharge drives the groundwater system. The contact of fresh and saline groundwater actually occurs as a transition zone rather than as an abrupt change in salinity. The interface is generally assumed as the location within the transition zone where the salinity is 50% of seawater. The Ghyben-Herzberg principle provides a useful mathematical characterization of a basal lens. It states that based on the density differences of fresh and saltwater, for every foot that the freshwater lens extends above sea level, the depth to the fresh-saltwater interface below sea level will be 40 times as great. "Head" is a term that is often used to indicate the height that the top of the basal lens extends above sea level. For example, for the 2.3 and 4.2 foot heads which are reported for DWS' Keei wells, the Ghyben-Herzberg principle indicates that basal lens thicknesses are 92 to 168 feet.

This basal lens is particularly vulnerable to seawater intrusion which can occur when its dynamic equilibrium is disturbed by overpumping. Two of the DWS' Keei wells have experienced significant salinity increases, for example, even though they penetrate just 25 to 30 feet into the lens, amounting to less than a quarter of the lens' thickness. DWS has reduced its pumping rates at the Keei wells to keep their salinity within acceptable limits.

To estimate the groundwater flowrate and its safe yield, the portion of rainfall which percolates to become groundwater recharge must be estimated. Based upon an analysis of annual rainfall in the area, it has been determined that the potential recharge rate in the area above the project site is approximately 5 million gallons per day (MGD) per coastal mile.

For a basal lens in highly permeable flow lavas, the maximum draft rate which can be sustained from wells without adverse effects, according to Nance, is about one-third to one-half of the recharge rate. Since the project site spans 1.2 miles of the shoreline, this would amount to a maximum draft rate of 2.0 to 3.0 MGD.

A time domain electromagnetic (TDEM) survey of the project site indicated that the thickness of the fresh/brackish water lens beneath the site ranges from 46 to 127 feet, and flows southwesterly to its discharge area in Kealakekua Bay. Although the majority of the groundwater flow occurs with the fractures, lava tubes, and bedding surfaces of the basaltic bedrock, it is assumed that flow occurs in a porous media with equivalent hydraulic properties. Groundwater



Prepared by: Belt Collins & Associates

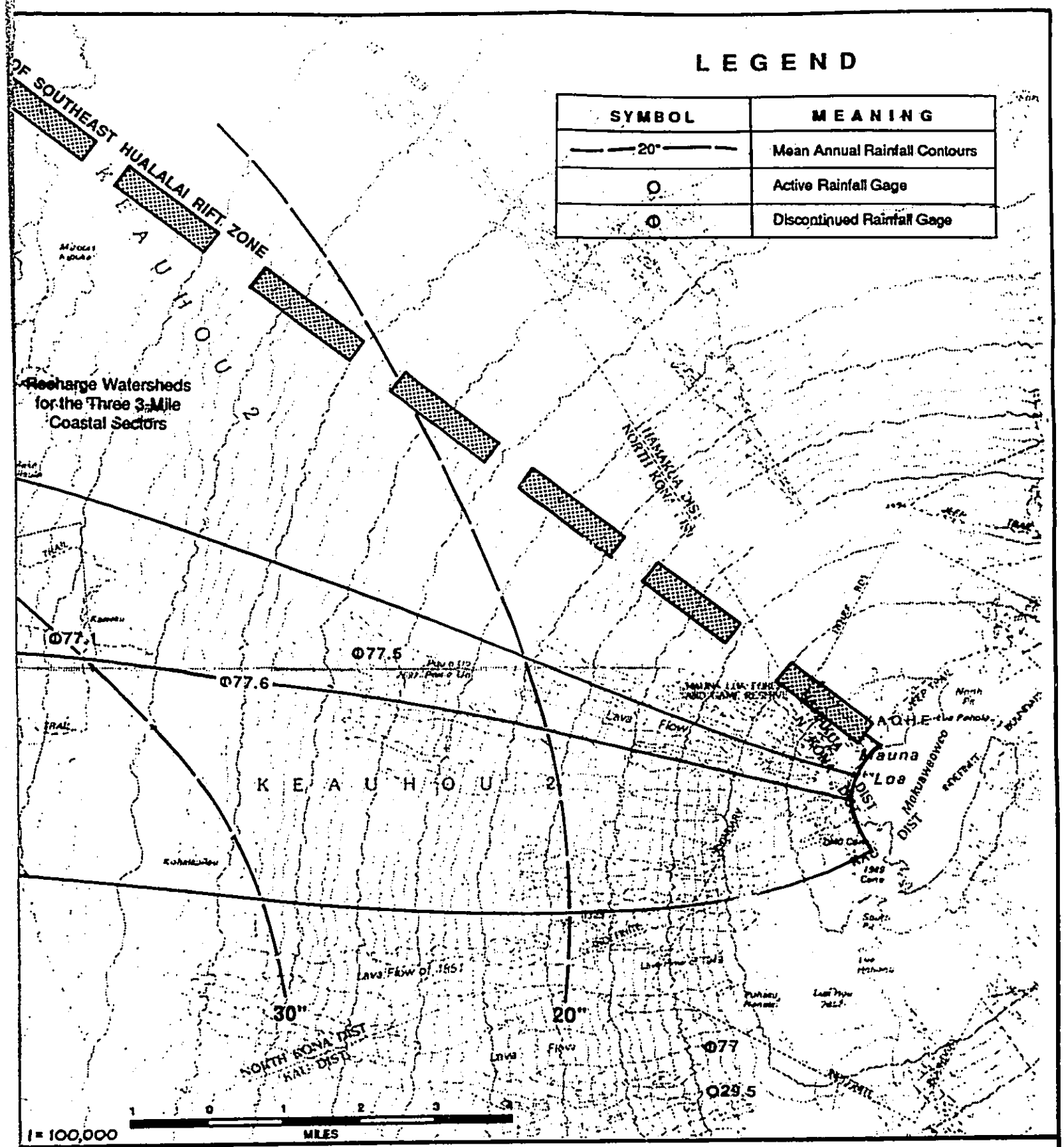


Figure 4-6
GROUNDWATER
IN THE KONA AQUIFER
Kealakekua Bay Club
South Kona, Hawaii

flow will generally converge at concave-shaped coastal features such as bays and diverge at convex-shaped coastal features such as points.

Figure 4-7 shows the location of fresh-water springs near the project site (Fisher et al., 1967). One of these fresh water springs is located at the bottom of Kealakekua Bay near Napoopoo but is not directly downgradient of the proposed golf course. A second spring located at Ka'awaloa and is called "Haliilua O Ka'awaloa".

Average groundwater elevations in wells in the vicinity of the project site are shown in Table 4-2 for measurements between 1980 and 1990. The average hydraulic gradient based on this groundwater data is approximately 2 feet per mile.

The TDEM study commissioned for the proposed project concluded that a basal lens with heads from 1.1 to 3.2 feet above sea level occur within the project site with the best results indicated from measurements taken just makai of Lots 4 and 5 which are identified on the Preliminary Concept Plan. Based primarily on the experience of the DWS' Keei wells, the basal head of up to 3.2 feet at this location should translate into an adequate supply of slightly brackish water at the rates of pumping required for the golf course. This location is also consistent with the logical location of the golf course's irrigation lake.

2.4.1.2 *Inventory of Supply and Disposal Wells*

Figure 4-7 also shows the locations of water wells in the vicinity of the project site, and Table 4-2 lists these water wells. The information about water wells was obtained from the State of Hawaii, Department of Land and Natural Resources, and the U.S. Geological Survey (USGS), who maintain inventories of water wells in the state.

The closest water well to the project site is Well 2753-01, which is approximately 9,000 feet east and 5,500 feet south of the project site. This well is used for drinking water supply by the County of Hawaii. The County Department of Water Supply will soon be drilling a new well directly above the project at about the 1,600-foot to 1,700-foot elevation.

The Underground Injection Control (UIC) line is located near the coastal boundary of the proposed golf course (see Figure 4-7). The UIC line was established in 1977 by the state of Hawaii as part of the Federal Safe Drinking Water Act to protect the quality of the State's underground sources of drinking water (USDW) from pollution by subsurface disposal of waste fluids. The UIC line separates, in plan view, aquifers (or portions of aquifers) that supply public or private drinking water from exempt aquifers (those aquifers or portions of aquifers that do not supply drinking water and that can accept spent fluids).

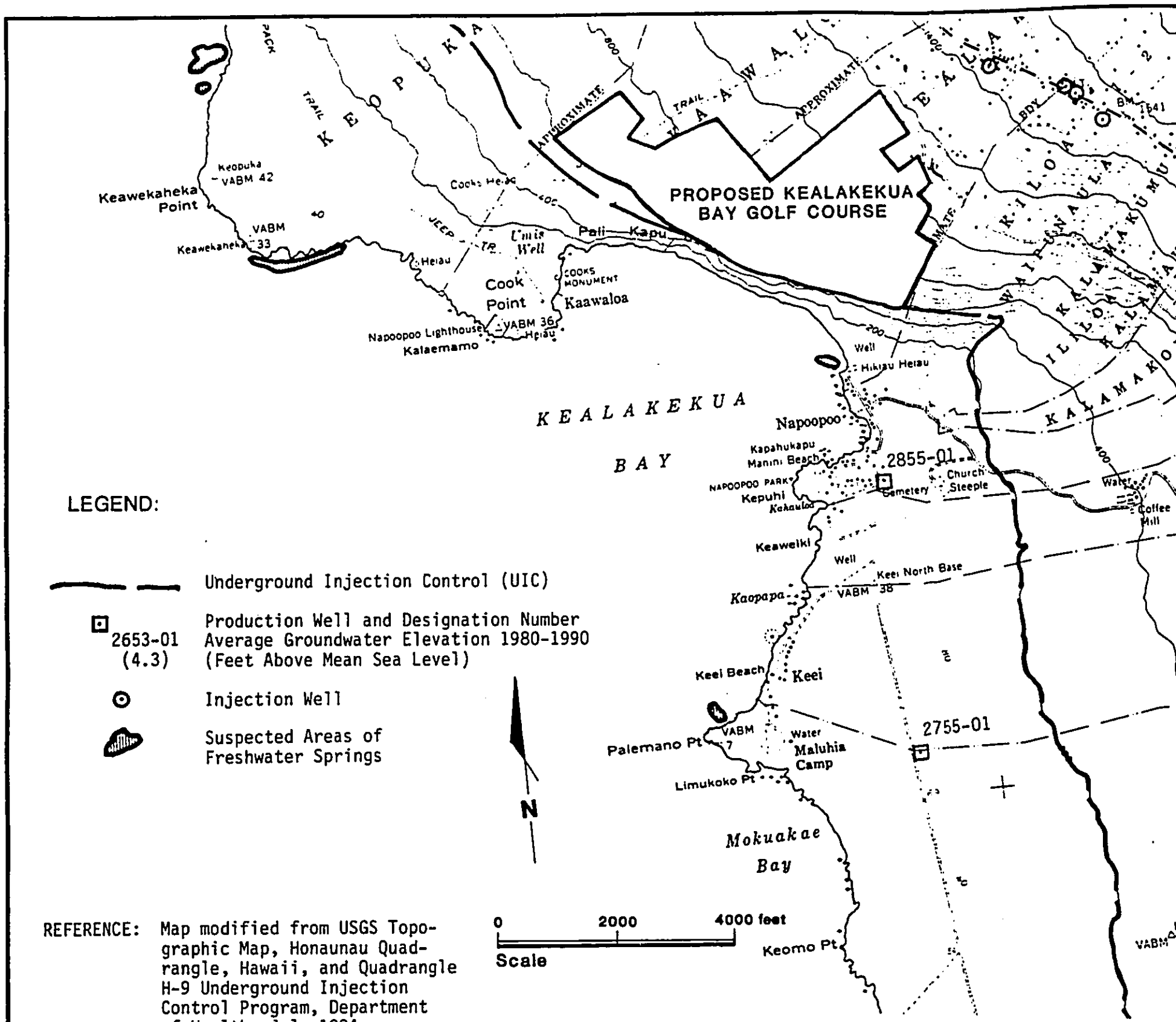
No injection wells are located seaward of the UIC line in the vicinity of the project site (Figure 4-7). However, five injection well systems are located inland of the UIC line. These five injection well systems are located approximately half a mile upgradient of the southern half of the project site and were installed prior to the establishment of the UIC program.

Table 4-2: Water Wells in the Vicinity of the Proposed Project

water

Well No.	Owner or User	Year Drilled	Ground Surface Elevation (ft. MSL)	Bottom of Hole Elevation (ft. MSL)
2653-01	Hawaii DWS	1978	882	-31
2753-01	Hawaii DWS	1958	744	-36
2753-02	Hawaii DWS	1963	737	-37
2753-03	New Well - No Further Information Available			
2755-01	W. Thompson	1955	45	5
2855-01	W. Thompson	1939	20	0

Well No.	Pump Rate (gpm)	Draw Down (ft)	Site Capacity (gpm/ft)	Major Use & Year Reported
2653-01	770	1.3	592	Municipal, 1984
2753-01	100	.7	143	Municipal, 1972
2753-02	270	.3	900	Municipal, 1972
2753-03	New Well - No Further Information Available			
2755-01	Unknown	Unknown	Unknown	Other, 1974
2855-01	Unknown	Unknown	Unknown	Other, 1974



LEGEND:

- Underground Injection Control (UIC)
- 2653-01 (4.3) — Production Well and Designation Number Average Groundwater Elevation 1980-1990 (Feet Above Mean Sea Level)
- Injection Well
- Suspected Areas of Freshwater Springs

REFERENCE: Map modified from USGS Topographic Map, Honaunau Quadrangle, Hawaii, and Quadrangle H-9 Underground Injection Control Program, Department of Health, July 1984.

GROUNDWATER

Prepared by: Belt Collins & Associates

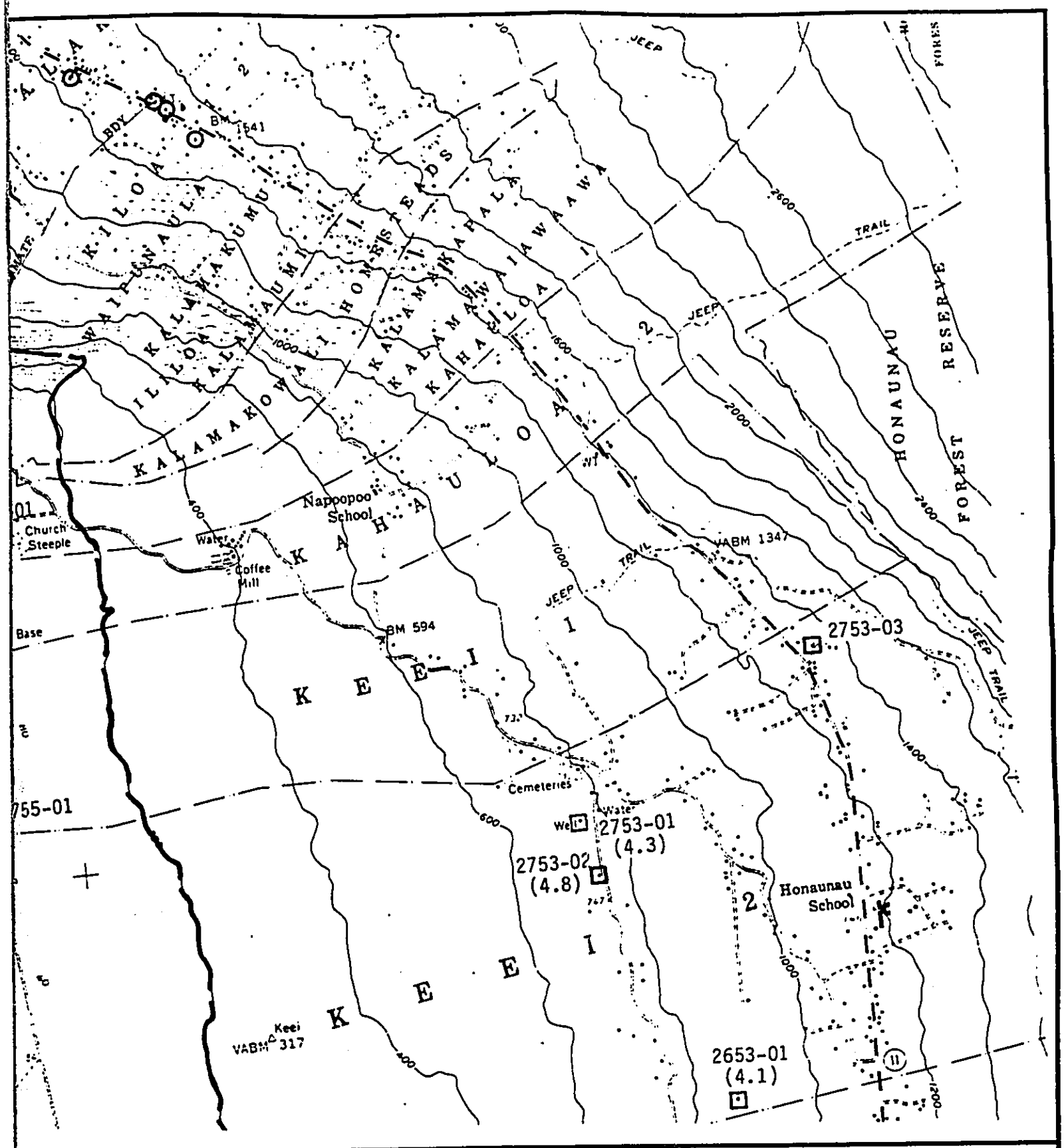


Figure 4-7

GROUNDWATER FEATURES AND WELLS IN GENERAL PROJECT AREA

Kealakekua Bay Club
South Kona, Hawaii

2.4.1.3 Groundwater Quality

A chloride concentration of 1,500 milligrams per liter (mg/l) was measured from a dug well (Well 2855-01) located 800 feet inland from Kealakekua Bay at Napoopoo in 1974. The high permeability of the basalt allows seawater intrusion and mixing of fresh and saline water near the coast. Groundwater may be brackish for more than half a mile inland from the coast. As the report of Marine Research Consultants indicates, NO3 is a normal constituent of groundwater and the concentrations found in surface waters at Kealakekua Bay appear to be the result of groundwater discharge at the shoreline.

The chemical composition of fresh water in the basal lens results from the composition of rainfall and its interaction with the soil mantle. Table 4-3 presents the chemical analysis of water samples from Wells 2753-01 and 2753-02. These wells are located two miles inland of Mokuakae Bay (Figure 4-7). The chemical composition of this water indicates that groundwater is not influenced by seawater intrusion as the concentrations of chloride and dissolved solids are low. The concentration of nitrate, an indicator of fertilizer nutrient, is approximately 1 mg/l NO3-N. The average concentration of nitrate in rain and native fresh water is typically less than 0.25 mg/l NO3-N.

2.4.1.4 Rainfall, Surface Water and Drainage

The distribution of average annual rainfall for the island of Hawaii is shown in Figure 4-8. The area surrounding Kealakekua Bay is one of the wetter coastal areas on the leeward side of the island receiving an average annual rainfall of approximately 50 inches.

The Kona coast experiences a seasonal rainfall regime unique to the Hawaiian islands. Summers on the Kona coast are wetter than winters. For all other parts of the Hawaiian islands, winter receives the highest average rainfall.

Table 4-4 lists the average monthly rainfall for two rain gauge stations located near Kealakekua Bay; Napoopoo Station, State Key Number 28.00 and Kealakekua Station, State Key Number 26.2. These rain gauge stations are located less than one half mile from the project site. Napoopoo Station is located at an elevation of 480 feet above MSL and Kealakekua Station is located at an elevation of 1,440 feet above MSL. The ground surface elevation of the golf course ranges between 575 to 1,100 feet above MSL. Consequently, mean annual rainfall at the golf course is expected to range between 40 (Napoopoo Station) to 60 (Kealakekua Station) inches.

There are no streams or natural drainage ways crossing the project site. Some runoff does reach the site from the mauka side of Napoopoo Road. All rainwater falling on and reaching the site appears to percolate through the soil.

2.4.2 Probable Impacts

2.4.2.1 Construction and Irrigation

Construction activities related to the proposed project, including the grading, shaping and landscaping of the proposed golf course, are not expected to have a direct or indirect impact upon the groundwater. Operation of the golf course, and specifically, maintenance procedures related to the application of pesticides and fertilizers may, however, impact the groundwater.

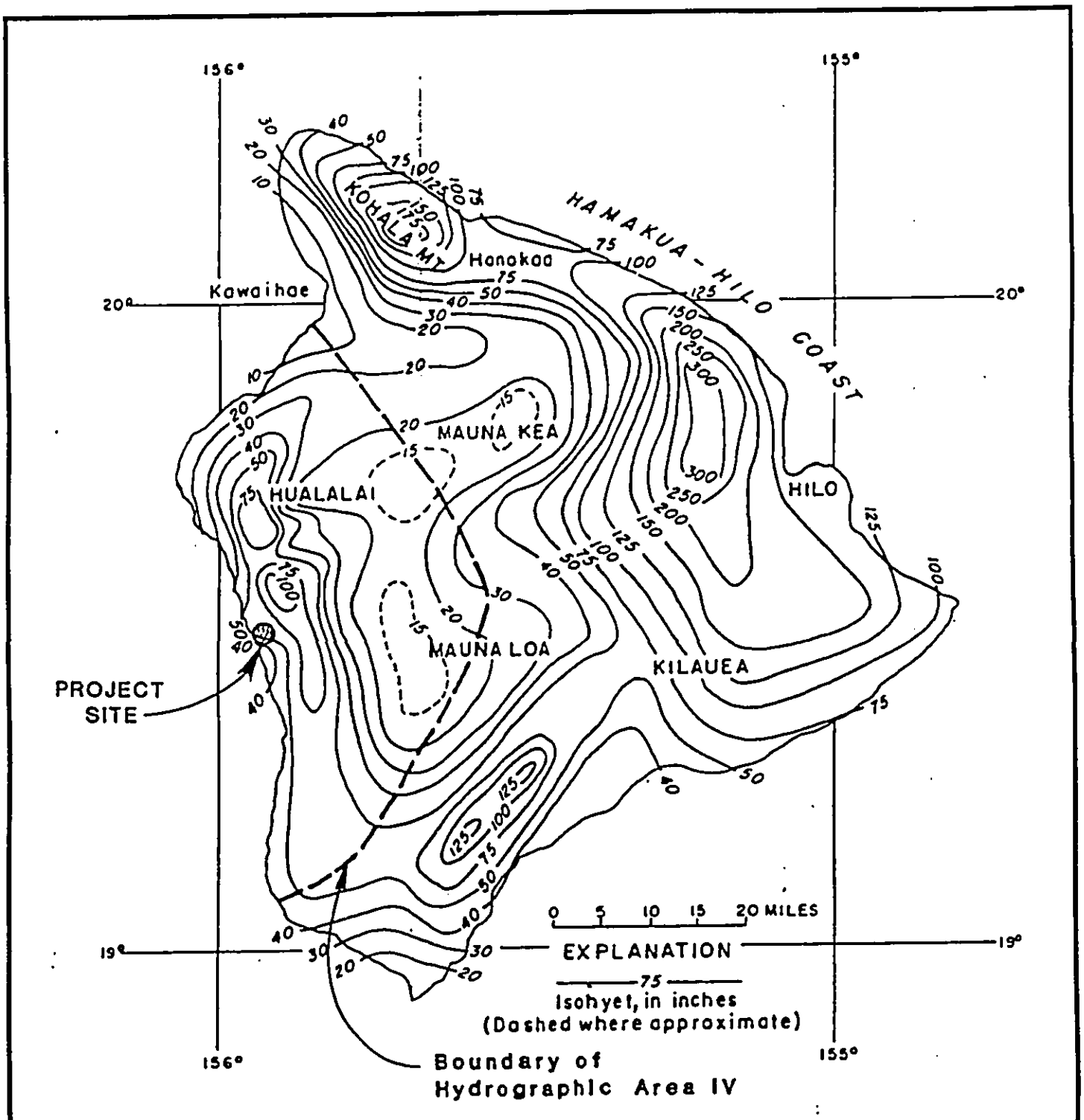
Table 4-3: Water Chemistry for Wells 2753-01 & 2753-02

	Well 2753-01 (*)	Well 2753-02 (**)
Total Dissolved Solids (mg/l)	310	333
Total Nitrate as N (mg/l)	0.94	1.3
Total Hardness as $CaCO_3$ (mg/l)	66	74
Silica (mg/l)	42.3	52
Calcium (mg/l)	10	9.6
Magnesium (mg/l)	11	12
Sulfate (mg/l)	25	25
Sodium (mg/l)	72	77
Chlorides (mg/l)	116	129
Potassium (mg/l)	4.0	4.8
Fluoride (mg/l)	0.3	0.38

Notes:
* Data from USGS. Sample collected 7/31/73.
** Data from USGS. Sample collected 3/16/72.

Table 4-4: Average Monthly Rainfall for Napoopoo & Kealakekua Stations

	---------Mean Rainfall (inches)---------	
Month	Napoopoo (elevation 480 ft)	Kealakekua (elevation 1,440 ft)
January	3.0	3.9
February	2.1	2.9
March	3.2	4.1
April	3.4	4.8
May	3.6	6.2
June	3.8	6.1
July	3.9	6.6
August	4.1	6.9
September	4.3	7.0
October	3.7	5.6
November	2.5	3.6
December	2.4	3.3



NOTE: Map adapted from Davis and Yamanaga (1968)

Figure 4-8
RAINFALL
Kealakekua Bay Club
South Kona, Hawaii

Prepared by: Belt Collins & Associates

Anticipated golf course irrigation at Kealakekua Bay Club is estimated at 3,100 gallons per acre per day on average (.465 mgd for about 150 acres of fairway, tees and greens), based on the irrigation requirements at Kona Country Club and the mean annual irrigation rate for golf courses in the state (Hollyer, 1990). Both the Kealakekua Bay Club and the Kona Country Club have similar annual rainfall (Department of Land and Natural Resources, 1982) and evaporation totals (Ekern and Chang, 1985). The estimated irrigation rate is equal to about 42 inches of water annually. Actual irrigation scheduling will be determined based on turf grass needs. These requirements are well within the calculated capacity of the basal lens discussed above. In addition, brackish irrigation water obtained from the on-site wells may be augmented by effluent generated by the on-site sewage treatment plant. After treatment in the facility, the disinfected secondary effluent will be blended with non-potable irrigation water. The property owner will work with the State Department of Health and the County Department of Public Works to ensure that treated effluent disposal is conducted in a manner which minimizes environmental impacts. The use of effluent will not substantially reduce the calculated amount of non-potable well water necessary for irrigation. Assuming an average daily volume of wastewater totaling about 12,000 gallons (see discussion on page VI-13), effluent will constitute less than 3% of the total daily volume of irrigation water required.

2.4.2.2 Pesticides and Fertilizers

Pesticides and fertilizers are typically applied to the surface of the golf course in liquid or granular powdered form. They are introduced into the soil dissolved in the irrigation and rainfall water. Upon entry into the soil, the dissolved concentration of pesticides and fertilizers is dependent on many factors, including pesticide solubility, antecedent moisture condition, previous and current application, irrigation and rainfall rates. The transport and fate of pesticides and fertilizers dissolved in soil water follows a complicated path, dependent on plant-water uptake, evaporation, timing and quantity of rainfall and irrigation, and chemical and biologic reactions.

Pesticide Use Integrated pest management (IPM) concepts will be used to control turf diseases and pests. IPM programs rely on proper identification and monitoring of pest life cycle and biology in order to select and apply effective management practices. Careful monitoring can effectively reduce pesticide application, thereby reducing costs and adverse effects to beneficial organisms. Table 4-5 lists the proposed pesticide program. The leaching potentials for the two herbicides listed in Table 5, MSMA and glyphosate, are presented in Table 4-6.

The leaching potential of a chemical refers to its mobility and persistence in the subsurface environment and, to a lesser degree, its solubility. Mobility is characterized by the soil sorption index or organic carbon partition coefficient (KOC). A large KOC indicates that the chemical would tend to be adsorbed onto soil particles and is less likely to migrate with water. Persistence is characterized by its biochemical half life. Chemicals with large KOC values and low biochemical half lives have low leaching potentials and are less likely to cause environmental pollution. The insecticide Pyrellin (see Table 4-6) contains two synergistic chemicals, rotenone and pyrethrins. Combined, these make up approximately one percent of Pyrellin. Annual usage of the two chemicals at the golf course is estimated to be 0.06 gallons for pyrethrins and 0.05 gallons for rotenone (Table 4-5).

Table 4-5: Proposed Pesticide Use at Kealakekua Bay Club

Turfgrass Area	Product	Application Rate	Annual Total
HERBICIDES			
Greens	glyphosate MSMA	0.75 lb ai/acre 2 lb ai/acre	20 lb 36 lb
Tees	glyphosate MSMA	0.75 lb ai/acre 2 lb ai/acre	20 lb 36 lb
Fairways	glyphosate	0.75 lb ai/acre	50 lb
Perimeter	glyphosate	0.75 lb ai/acre	56 lb
INSECTICIDES			
Greens	Bacillus Thuringensis Insecticidal Soap Pyrellin*	1 lb/acre 2 gal/acre 2 pts/acre	36 lb 25 gal 10 gal (0.5 gal rotenone, 0.06 gal pyrethrins)
Tees	Bacillus Thuringensis Insecticidal Soap	1 lb/acre 2 gal/acre	36 lb 25 gal
Fairways	Bacillus Thuringensis	1 lb/acre	36 lb
Perimeter	Insecticidal Soap	2 pts/acre	10 gal (0.5 gal rotenone, 0.06 gal pyrethrins)
FUNGICIDES			
Greens	Wettable Sulfur	5 lb/acre	80 lb
Tees	Ringer Corp Greens Super 10-2-6**		

* Pyrellin consists of pyrethrins (0.60%), rotenone (0.50%), other cube resins (0.50%) and inert ingredients (98.40%)

** Ringer Corp Greens Super 10-2-6 is an organic-based turf fertilizer with disease suppressive effects and will be used for greens and tees instead of fungicides and nitrate fertilizers.

Reference: Harding Lawson Associates, July 1991

The environmental fate information for rotenone and pyrethrins is limited. Estimates of the properties of the two chemicals are, therefore, based upon contacts with other members of the project consultant team, the State Department of Agriculture, the United States Environmental Protection Agency, and the distributor of Pyrellin (CCT Corporation). The chemicals' properties are presented in Table 4-6.

A pollution potential classification system developed by Jury et al. (1987) and presented in the Harding Lawson Associates report (Appendix 15, Plate 7) can be used to rapidly screen pollution risks of pesticides according to their organic carbon coefficients and biochemical half lives. Based on this classification system, the pesticides proposed for use at the Kealakekua Bay Club golf course would pose very low pollution risks.

Fertilizers Fertilizers are normally applied to only the greens, tees, fairways, and part of the roughs of a golf course. Turfgrass fertilization includes nitrogen (N), phosphorous (P), and potassium (K), with nitrogen and phosphorus the primary fertilizer elements of concern for contamination of ground and surface waters (Murdoch and Green, 1989). Phosphorous bonds well with iron and aluminum hydroxides, which are commonly found in abundance in volcanic-derived soils. This bonding minimizes the potential for phosphorous contamination of drainage water (Murdoch and Green, 1989). Ammonium nitrogen (NH4), the most common form of nitrogen in fertilizer applications, moves only slowly through the soil, but is rapidly converted to nitrate (NO3), which is soluble. Nitrate will usually be used rapidly after application in the production of new turfgrass. However, over-fertilization, over-irrigation, or excessive rainfall could result in nitrates migrating below the root zone. The highly organic soils beneath the site presently contain excess nitrogen.

As presently envisioned, nitrogen will be applied to the golf course as a foliar spray. Approximately 10 pounds per acre per month (lbs/ac-mo) may be applied to fairways, and twice that amount may be applied to greens and tees, for an average of about 12 lbs/ac-mo over the entire golf course, according to Faust. Because of the high natural levels of nutrients in soils, the planned nitrogen application rate is less than half of that used on average for golf courses in Hawaii (Murdoch and Green, 1989). According to estimates by Faust, at an efficiency of 90 percent foliar application of nitrogen provides the least opportunity for excess nitrogen to migrate beneath the root zone and become a potential groundwater contaminant. Excess nitrogen, based on expected application rates and efficiency, is 1.2 lbs/ac-mo. The calculated volume of post-development deep infiltration (past the soil zone) from the water budget analysis (Appendix B of the Harding Lawson report) is approximately 61,000 gallons/ac-mo. The increase in nitrogen (as N) concentration for excess applied nitrogen is 2.35 milligrams per liter. The predicted increase in concentration of nitrogen in the groundwater beneath the project site is discussed below.

Modeling Subsurface Flow and Transport. Computer modeling was conducted to gain a better understanding of the potential impact of pesticides and fertilizers upon the groundwater beneath the proposed project (for a complete description of the modeling assumptions, equations, and simulations, see Appendix 15). Modeling was used as a tool: 1) to predict concentrations of pesticides at the point of groundwater discharge in Kealakekua Bay; and 2) to evaluate the sensitivity of the model predictions to uncertainties in transport and hydrological conditions. The objective of the sensitivity analysis was to identify and prioritize critical soil, pesticide and climatological properties that require better definition in order to more accurately predict pesticide movement.

Table 4-6: Properties of Pesticides Proposed for Use at Kealakekua Bay Club

Pesticide Common Name	Trade Name(s)	Soil Sorption Index (Koc)	Water Solubility (mg/l)	Half Life in Soil (days)
HERBICIDES				
MSMA	Weedhoe, etc.	2,000-10,000	1,000,000	100
glyphosate	Roundup, Kleenup	2,000-10,000	1,000,000	30
INSECTICIDES				
rotenone	Pyrellin	900	17	<30
pyrethrin	Pyrellin	>4,300	>1	<50
insecticidal soap	----------	NA	NA	NA

Pesticide Common Name	Decay Factor (1/day)	Retardation Coefficient, K	Leaching Potential
HERBICIDES			
MSMA	6.9×10^{-3}	300-1,700	Small
glyphosate	2.3×10^{-2}	300-1,700	Small
INSECTICIDES			
rotenone	2.3×10^{-2}	720	----
pyrethrin	1.4×10^{-2}	150	----
insecticidal soap	----------	----	----

From: Wauchope, R.D., 1988. U.S.D.A.-ARS Interim Pesticide Properties Database Version 1.0, from Environmental Impact Consultants (1990)

Estimates based on information from other members of project consultant team, U.S.EPA, State Department of Agriculture, and Pyrellin distributor.

Based on: Bulk density = 1.5 g/cm^3, porosity = 0.45, organic content = 0.05

Modeling Results. Two numerical models were used to simulate the subsurface migration of pesticides applied to the golf course. The soil (1-D) model was used to predict the concentration in the soil layers beneath the golf course by accounting for biochemical decay, retardation, and adsorption. The basalt (2-D) model was used to predict the concentration in the groundwater discharging to the bay resulting from advection and dispersion in the unsaturated and groundwater zones.

Results of the soil model indicated that pesticide degradation is extremely effective in the soil zone, accounting for a decrease in concentration of 4 to 5 orders of magnitude. For typical application rates (see Table 4-5), this would result in concentrations of pesticide in the single part per trillion range, or less, at the base of the root zone. These concentrations are far below common limits of detection, or health concerns. Further reduction by approximately 97 percent would occur through dispersion and dilution in the underlying groundwater system.

The least amount of decay occurred in simulated soils making up the greens. This is expected because the sandier soils would drain quickly and contain less organic carbon than the native soils on site. The simulated amount of pesticide reduction at the base of the greens was about a factor of 20, or 95 percent. Depending on the application rate, concentrations of pesticide may be detectable at the base of the greens.

Results of the basalt model indicate that dispersion and dilution would cause concentrations of solutes entering the basalt from the soil to be reduced by an average of 97 percent. This reduction is caused primarily by dilution in the groundwater. The additional dilution would cause proposed pesticides, if migration to the groundwater occurred, to be rendered far below detection. Nitrogen, however, may show a detectable increase over ambient groundwater concentrations. Nitrogen (as nitrate) is considered a conservative solute and, below the root zone, will be reduced in concentration only by dispersion and dilution. Using the 97 percent simulated dispersion/ dilution in the basalt, the increase in nitrogen as nitrate is calculated to be about 70 parts per billion. The average groundwater nitrogen content is 1,300 to 1,500 parts per billion (ppb). This concentration increase may be detectable in the groundwater beneath the site. The amount of the increase, however, given the volume of groundwater discharge, ambient bay concentrations, and the mixing characteristics of the bay, is not anticipated to cause a noticeable increase in bay nitrogen concentration, and is less than the average daily fluctuation in nitrogen measurements. To appreciate the significance of the average content of nitrogen in groundwater, it should be noted that the Environmental Protection Agency establishes a maximum for potable wells at 10,000 ppb.

2.4.3 Mitigation Measures

The character of the project area's soils and its general hydrology suggest that the possibility of leaching chemical fertilizers or pesticides used on the golf course into the ground water is slight. The proper application and management of pesticides and fertilizers will result in no significant impact to the groundwater or the ocean.

The following practices will be implemented to ensure that pesticides are not transported beneath the root zone:

1. Integrated Pest Control Management (IPM) techniques will be employed. Use of pesticides will occur only in response to pest outbreak.

2. Use of pesticides will be restricted to those listed in Table 4-5, or others found to have similar properties of low mobility, toxicity and persistence.

3. Positive runoff controls will be implemented to avoid ponding of irrigation water.

4. Use of liners as well as underdrains beneath greens will be evaluated.

Results of a water budget analysis indicate that normal precipitation combined with planned irrigation rates may result in surplus water, with increased infiltration and runoff. Because some leaching of fertilizers may occur under these conditions, efforts will be made to mitigate this effect. The following practices will be implemented:

1. Irrigation will be tied to soil moisture and will be scheduled based on this parameter. Soil moisture may be measured via soil moisture probes. Irrigation rates will be monitored closely. If, due to salt build-up, a leaching requirement is foreseen, the amount of excess irrigation to achieve this requirement will be closely monitored.

2. Foliar application of fertilizers will be implemented.

Several test plot experiments are being planned and are designed to further refine pesticide, fertilizer, and irrigation requirements on turf grasses. These experiments will assist in answering many of the questions regarding pesticide and fertilizer migration beneath the root zone, leaching requirements, and whether liners and underdrains will be appropriate or effective. The following will be implemented in regard to soils, test plots, and monitoring.

1. Native soils on site are subject to permanent loss of structure and permeability unless properly handled during site construction. Therefore, soils will be moved and compacted only when relatively dry. Tests on native soils will be conducted to ensure that they may meet specifications for turf grass soils. During site construction, on-site monitoring during moving, spreading and recompacting native soils will be conducted.

2. A site meteorological station may be appropriate to be installed during the test plot experiments. At a minimum, the station should measure and record rainfall and temperature. Other useful measurements are wind speed, humidity, solar insolation, and soil moisture.

3. Various soil lysimeters will also be tested during the test plot experiments. If effective at allowing leachate samples to be collected for determination of pesticide and fertilizer concentrations, lysimeters may be equally effective as vadoze zone monitoring instruments.

A fertilizer and management plan has been prepared for the proposed project and is included in Appendix 6. It includes the following recommendations which have been or will be implemented:

1. Use minimum amounts of pesticides by observing integrated pest management (IPM) practices and select pest and drought resistant plant species.

2. Use the groundwater monitoring plan in concert with Hawaii Department of Health recommendations to manage water and chemicals on the golf course site.

3. Obtain an environmental assessment of the proposed site and adjacent areas to document chemical contamination which may have resulted from previous agricultural activity.

4. Store pesticides and fertilizers in a facility constructed to minimize chemical movement resulting from spills, floods, and equipment maintenance.

5. Observe Best Management Practices (BMP's), especially those concerning storm water management.

   a. Critical area planting. Critical area planting is the practice of planting vegetation such as trees, shrubs, vines, grasses or legumes on highly erodible or critically eroding areas.

   b. Diversion, accumulation and evaporation. This process addresses the use of washdown water, spills and rinsates on the hardstand so that they can be used again as makeup water.

   c. Drift control agents. Drift control agents are substances that when added to a biocide mixture in a spray tank reduce drift from the target area.

   d. Drip irrigation. Drip irrigation serves to distribute water in an even pattern which avoids excess watering and reduces leaching of nutrients and biocides.

   e. Irrigation systems. An irrigation system is a water application system that includes all necessary water control structures for the efficient distribution and application of irrigation water.

   f. Irrigation water management. Irrigation water management is the practice of determining and controlling the rate, amount, and timing of irrigation water application to soils to supply plant water needs in a planned and efficient manner.

   g. Mulching. Mulching involves the application of plant residues or other suitable materials not produced on the site to the soil surface in order to conserve moisture, prevent surface compaction, reduce runoff and erosion, control weeds, and help establish plant cover.

   h. Pond. Ponds can be fed by diversions which channel excess water from low lying areas subject to temporary flooding.

   i. Underground outlet. An underground outlet is a conduit installed beneath

the surface of the ground to collect surface water and convey it to a suitable outlet such as a pond.

j. Sedimentation basin. A sedimentation basin is a water impoundment used to collect sediments that result from runoff.

k. Waste management system. Waste management systems are used to manage waste in a manner which prevents or minimizes degradation of air, soil, and water resources and protects public health and safety.

6. Use a modern irrigation system that includes computerized environmental monitoring instruments or equivalent to measure evapotranspiration and schedule irrigation application.

7. Employ a certified golf course superintendent and have all pesticide application staff certified by the Hawaii Department of Agriculture to apply restricted use pesticides.

In addition, the project developer has engaged the services of Faust Bio-Agricultural Services to review the proposed development and provide recommendations for methods to further mitigate the impacts of the proposed development upon potential groundwater and ocean water contamination. Faust concludes that the soil at the project site is high in nutrients and superior to soils at other local golf courses[2]. Grass is well established on the site and fertilizer use will be focused on the greens. Faust recommends that Zeolite be used to retain and reduce nitrogen leaching. Also recommended is leaf analysis and irrigation monitoring by soil moisture sensors to reduce leaching to a minimum on the greens. Foliar applications of nitrogen would be the preferred method.

Faust believes that insect pests can be controlled with biological, cultural and non-toxic elements. Recommended methods include biotechnology and use of turf pest destroying nematodes. Turf fungal diseases can be prevented and controlled biologically with reduced fungicide applications. Other methods for reducing fertilizer and pesticide use on the golf course include leaf testing for fertilizer needs and fungus diseases before symptoms occur, biological controls for insects and diseases, training of personnel in IPM methods, supervision of a professional pest control advisor, and minimizing over-watering through the use of moisture sensors and computer analysis of the flow in irrigation systems. Organic fertilizers are recommended since they provide nutrients slowly as plants need them, thus producing better turf quality and reducing overall costs.

Although Faust's recommendations represent somewhat of a departure from traditional management and operational techniques, they are worthy of consideration and shall be implemented to every extent practicable. These recommendations are also carried in a publication by the Golf Superintendents of America who advocate reduced usage of both pesticides and fertilizers and the use of alternate means for controlling both insect pests as well as disease organisms.

[2] This assessment is contrary to the conclusion of Marutani & Associates' Agricultural Impact Study which states, "The study found that the project site's soil condition is of marginal quality..." (page 2, Appendix 10)

3. NATURAL ENVIRONMENT
3.1 Climate, Meteorology and Air Quality
3.1.1 Existing Conditions

The project site's location and low-level elevation result in a relatively moderate temperature profile. Measurements taken at Kainaliu, a few miles to the north of the project site at an elevation of 1,500 feet above MSL reveal average daily minimum and maximum temperatures of 61 degrees (F) and 79 degrees (F) respectively. Temperatures at the project site are probably a few degrees warmer due to its lower elevation.

Much of the western coast of the island of Hawaii is sheltered by high mountains from the prevailing northeasterly trade winds. Due to wind shadow effects caused by Mauna Loa, winds in the Kealakekua area are often light and variable. When trade winds are strong, a large eddy tends to form near the southern tip of the island causing a weak return flow from the west in the Kealakekua area. The passage of Kona storms during Hawaii's "winter" season can bring very strong "Kona" winds for brief periods from the south or southwest. When trade winds or Kona winds are absent or weak, local winds such as land-sea breezes and/or upslope-downslope winds tend to dominate the wind pattern for the area. During the daytime, winds typically move onshore because of seabreeze and/or upslope effects. At night, winds generally are land breezes and/or drainage winds which move downslope and out to sea. Calms occur about 29% of the time, as measured at Keahole Point, several miles to the north.

Present air quality in the project area is mostly affected by air pollutants from natural, agricultural and/or vehicular sources. The principal natural source of air pollutants is volcanic emissions from Kilauea Volcano which began in 1983. These emissions take the form of volcanic haze which persistently hangs over the Kona area. The American Lung Association is currently studying the character and concentrations of volcanic air pollution in the Kona area, but to date no results of the study are available.

Vehicular emissions from Napoopoo Road and Mamalahoa Highway tend to be carried away from the site by prevailing onshore winds. Any high levels of air pollution presently occurring in the area due to motor vehicle emissions are likely confined to limited areas near intersections where and when traffic congestion occurs during poor dispersion conditions. At this time, there are no reported measurements of lead, ozone, nitrogen dioxide or carbon monoxide in the project vicinity.

3.1.2 Probable Short-Term Impacts

Short-term direct and indirect impacts on air quality could occur during construction in the form of fugitive dust from vehicular movement and site excavation and exhaust emissions from on-site construction equipment. Indirectly, slow-moving construction equipment traveling to and from the project site as well as a temporary increase in vehicular traffic generated by commuting construction workers could also generate impacts.

3.1.3 Probable Long-Term Impacts

Long-term direct and indirect impacts on air quality could occur as a result of increases in vehicular traffic generated by the project. However, air quality modeling conducted for the project reveals that increases in vehicular emissions under a worst-case scenario still fall within both state

and national ambient air quality standards.

Long-term impacts could also occur as a result of drift of chemical vapors from spray equipment utilized to apply pesticides to the golf course fairways or greens. However, due to the types of pesticides proposed for use and the management practices proposed for implementation at the golf course, vapor drift is not considered to be a potential problem.

Similarly, indirect emissions resulting from increased demand for electrical energy utilized at the project are considered to be a potential problem. Calculations indicate that the project's power demand will increase emissions from the electric utility by only 0.25 percent if all project power is derived from fuel oil.

3.1.4 Mitigation Measures

To control fugitive dust, active work areas and temporary unpaved work roads will be watered at least twice a day on days when rainfall does not occur. Dirt-hauling trucks will be covered when traveling to prevent windage. Wind screens may also be used to contain fugitive dust emissions. The movement of equipment and personnel during off-peak hours will provide a means of mitigating potential short-term increases in vehicular emissions.

Although vehicular emissions generated by the project are expected to be within state and national standards for air quality, improvements to the intersection of Napoopoo Road and Mamalahoa Highway will help to improve traffic flow, thereby reducing vehicular idling time. No further mitigation measures are deemed necessary.

The application of pesticides according to industry standards and safety guidelines will help to ensure that potential air quality impacts are minimized. Mitigation measures include the use of low-pressure, coarse-nozzle spray equipment less than 3 feet above the ground and only during light wind conditions. Maintaining a 100 foot buffer distance from populated areas and the planting of trees and shrubs along golf course perimeters will provide further practical mitigation measures. The proposed use of a specialized, less-toxic pesticide management program should also reduce the potential for contamination of adjacent areas by airborne drift.

The use of energy saving features at the project will help to reduce the project's demand for electrical energy, thereby reducing the amount of emissions generated by fuel oil burning electrical power generating facilities.

3.2 Noise Quality

3.2.1 Existing Conditions

The existing background ambient noise levels in the project area result from traffic on Mamalahoa Highway and Napoopoo Road, local traffic, birds, dogs, wind, and foliage. At the residences situated on the subject property fronting Napoopoo Road, existing average background ambient noise levels range from 40 to 45 Ldn, which is the "Minimal Exposure, Unconditionally Acceptable" noise exposure category. These low levels of background noise are due to the rural character of the area.

3.2.2 Probable Impacts

A detailed study of noise impacts was conducted for the proposed project and is included as an appendix to this environmental impact statement. The study concludes that the increases in traffic noise levels attributable to the project are predicted to be approximately 0.1 to 0.2 dB (or Ldn) along Mamalahoa Highway, and 0.1 to 0.9 dB (or Ldn) along Napoopoo Road. An increase in traffic noise of 0.2 dB or less should not be perceptible and is not considered to be significant. For this reason, traffic noise are not expected along Mamalahoa Highway and the south section of Napoopoo Road. Moderate increases in project generated traffic noise of 0.9 dB are predicted to occur along the section of Napoopoo Road between Mamalahoa Highway and the project's entrance road. This increase is low, however, when compared to the larger increase of 3.4 dB expected from non-project traffic along Napoopoo Road by calendar year 1994.

Adverse noise impacts from the planned clubhouse activities are not anticipated due to the relatively large buffer distance (approximately 1,300 to 2,200 feet) between the facility and its nearest noise sensitive neighbors, residences along Napoopoo Road.

Audible construction noise will probably be unavoidable during the project's construction period, and noise from golf course maintenance equipment may be audible at neighboring residences and at the proposed members' lodge.

3.2.3 Mitigation Measures

Noise mitigation measures along public roadways, such as Mamalahoa Highway and Napoopoo Road, are usually undertaken by private landowners along the roadway. These noise mitigation measures may take the form of large setback distances from the roadway, sound attenuating walls or berms, or sound attenuation windows which allow for the use of natural ventilation. Noise mitigation measures are also implemented in conjunction with roadway improvement projects which are intended to increase capacity of these roadways or the intersections along these roadways.

The use of properly muffled and maintained construction equipment will be required on the job site during the project's construction period. In addition, State Department of Health construction noise limits shall be implemented. Properly muffled and maintained tractor equipment will be utilized within the entire golf course project area as a means of mitigating noise impacts associated with its operation. If necessary, a maintenance shed and/or a sound attenuating wall shall be used to reduce noise from maintenance activities toward the nearest neighbor to the northeast. The use of evening or nighttime curfews on operation of noisy equipment in the maintenance area may also be employed if warranted to minimize adverse noise impacts on the neighboring properties.

3.3 Visual Attributes

3.3.1 Existing Conditions

The property is situated on a moderate slope rising in a northeastern direction from the top of the pali up to Napoopoo Road. The cliff stands directly behind Kealakekua Bay. Although the property overlooks Kealakekua Bay, views of the bay are limited by the existing vegetation, the

Prepared by: Belt Collins & Associates

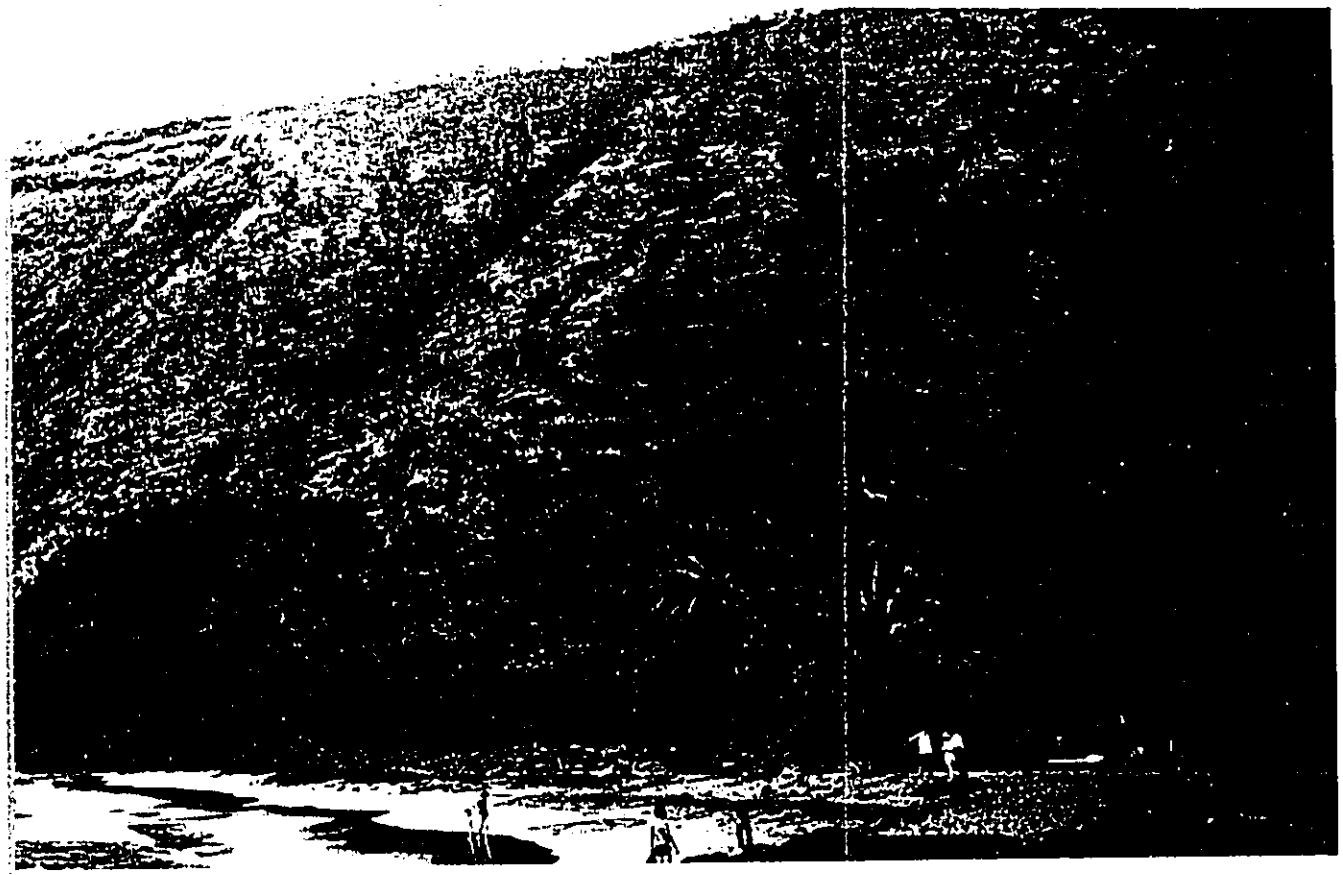
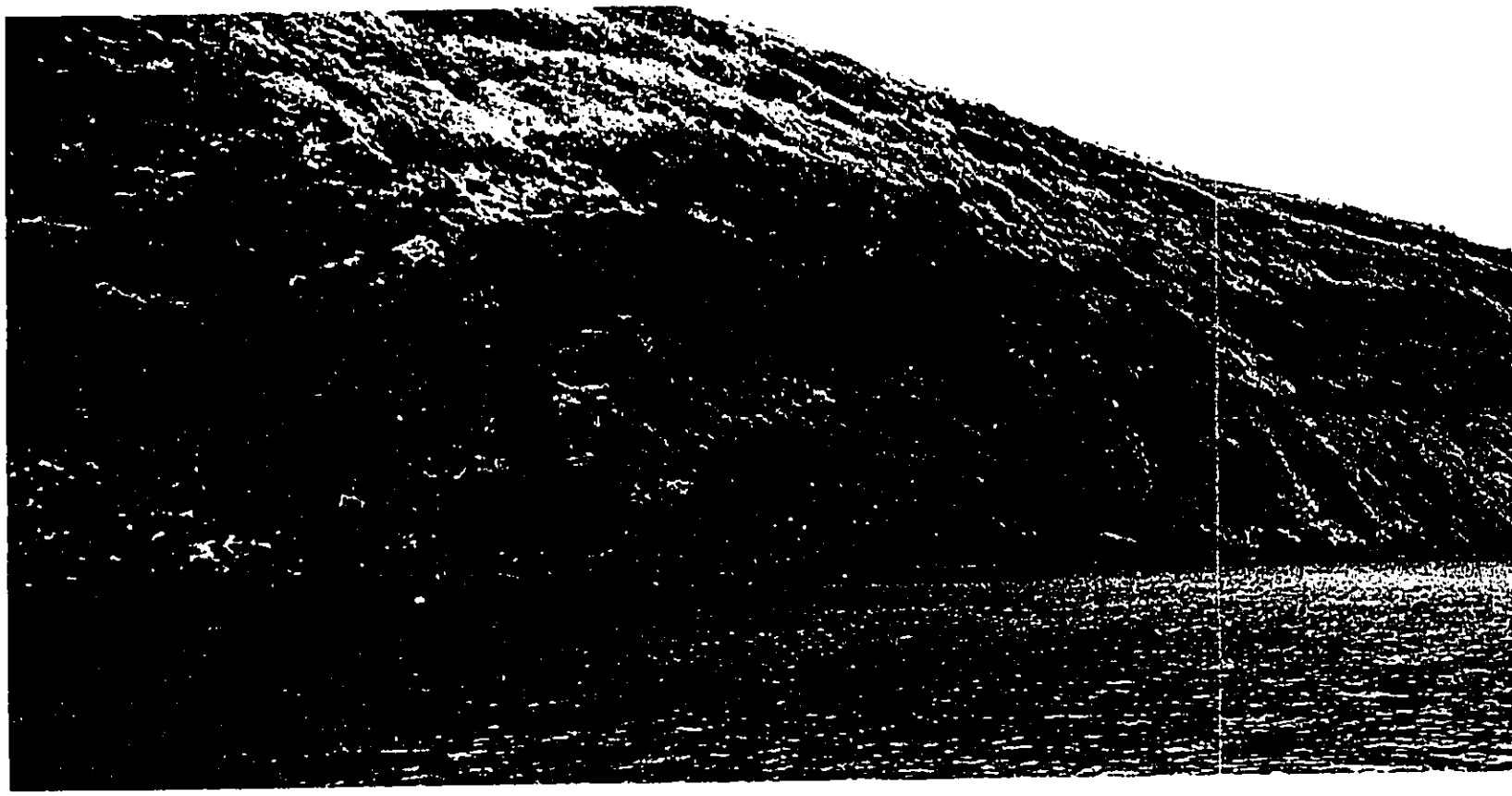


Figure 4-9 A
NORTHERN FACE OF PALI KAPU-O-KEOUA

Kealakekua Bay Club
South Kona, Hawaii



Prepared by: Belt Collins & Associates

Figure 4-9 B
SOUTHERN FACE OF PALI KAPU-O-KEOUA

Kealakekua Bay Club
South Kona, Hawaii

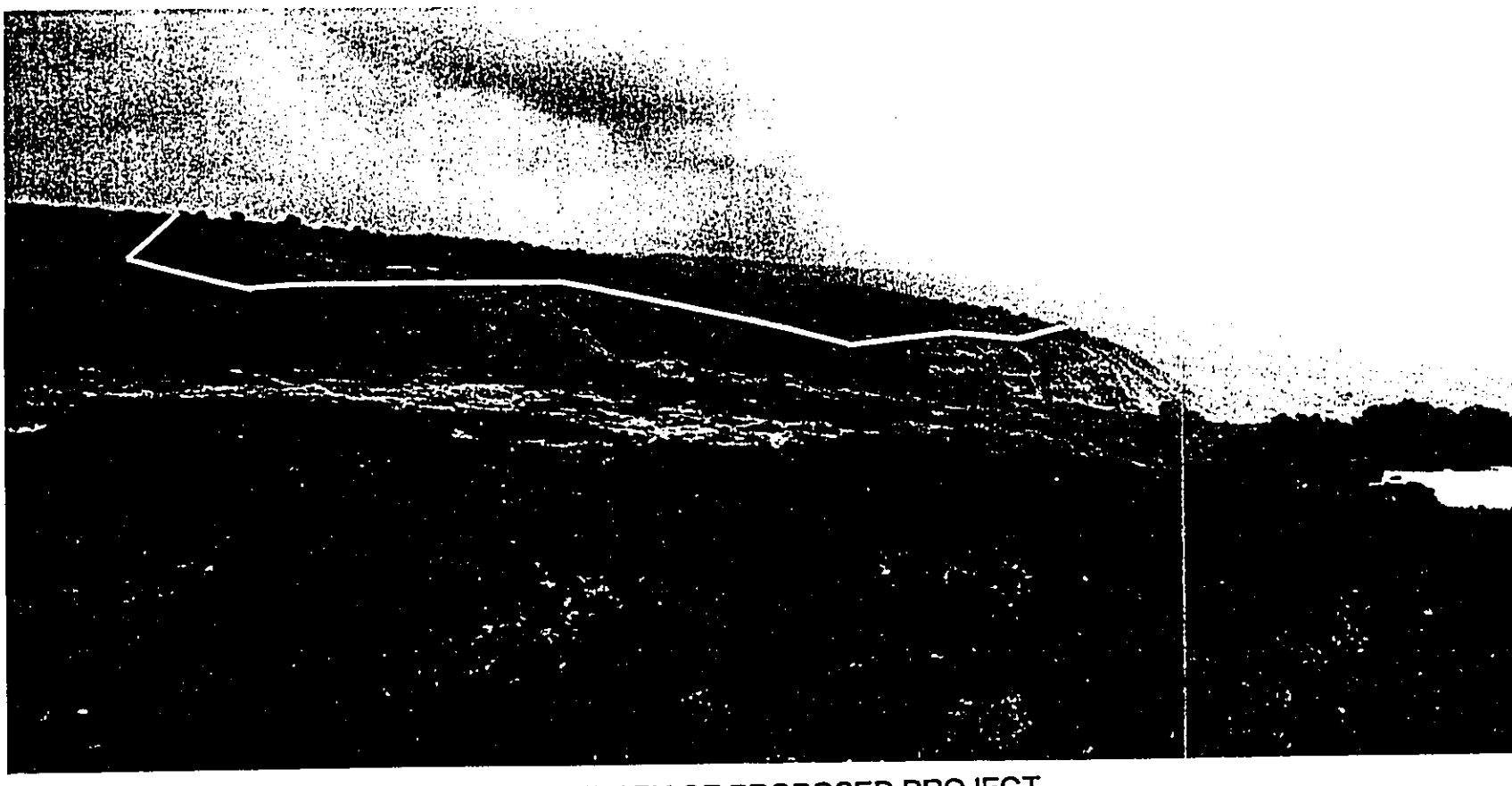
WHITE LINE DENOTES PROPERTY BOUNDARY OF PROPOSED PROJECT
A - CLUBHOUSE SITE
B - MEMBERS' LODGE SITE

VIEW O

Prepared by: Belt Collins & Associates

Figure 4-9 C
VIEW OF PALI KAPU-O-KEOUA FROM KEEI/PALIMANO POINT

Kealakekua Bay Club
South Kona, Hawaii



WHITE LINE DENOTES PROPERTY BOUNDARY OF PROPOSED PROJECT

VIE

Prepared by: Belt Collins & Associates

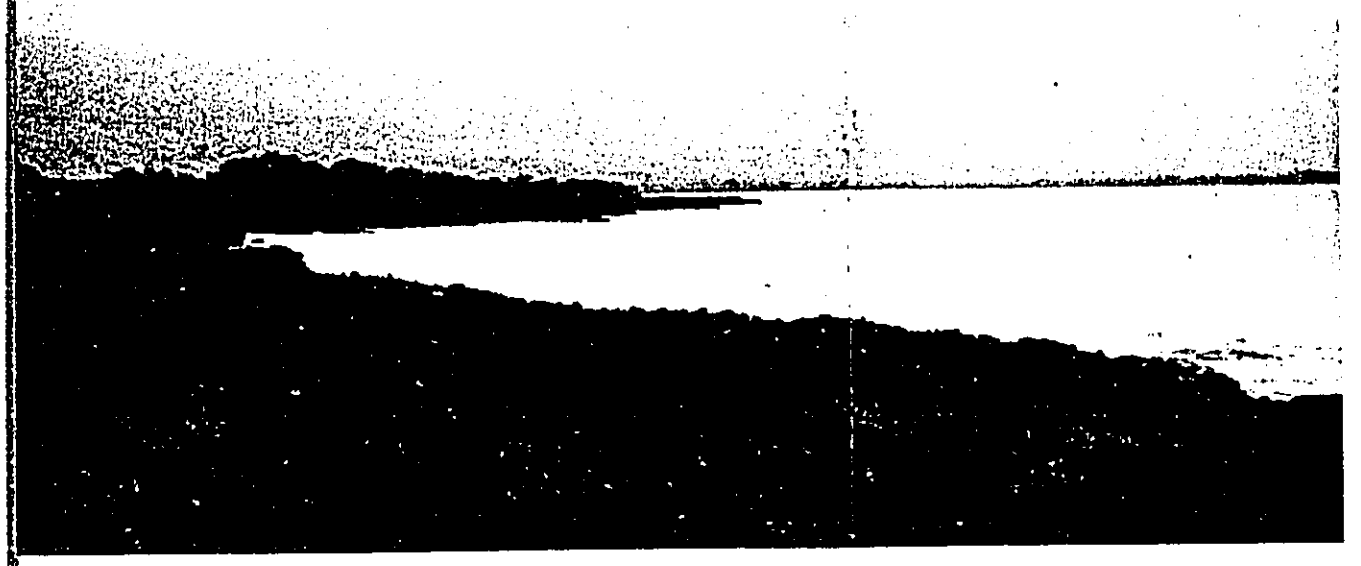


Figure 4-9 D
VIEW OF KA'AWALUA POINT FROM KEAWEKAHEKA POINT

Kealakekua Bay Club
South Kona, Hawaii

WHITE LINE DENOTES PROPERTY BOUNDARY OF PROPOSED PROJECT

VIE

Prepared by: Belt Collins & Associates

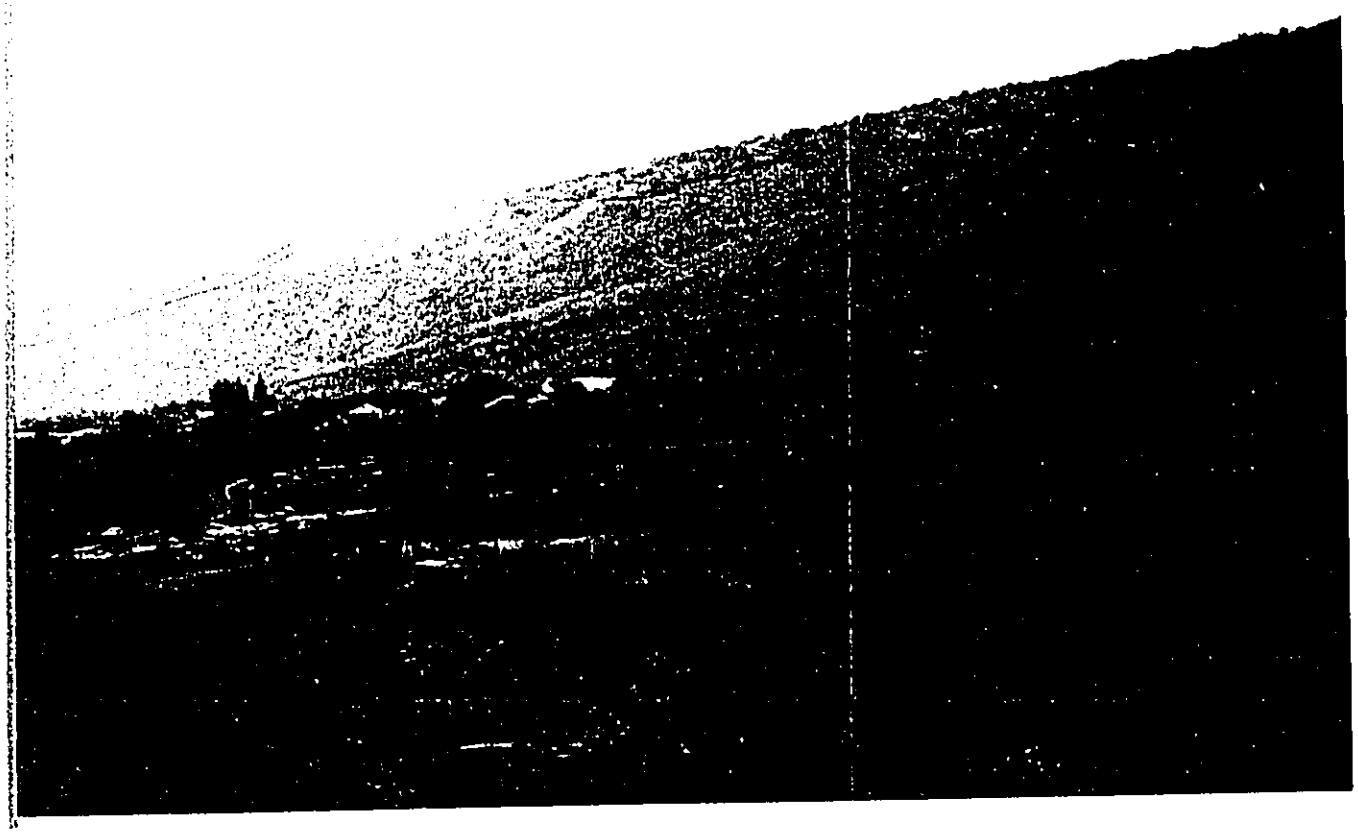


Figure 4-9 E
VIEW OF KEALAKEKUA BAY FROM KEALAKEKUA ESTATES

Kealakekua Bay Club
South Kona, Hawaii

WHITE LINE DENOTES PROPERTY BOUNDARY OF PROPOSED PROJECT

VIEW OF PALI KAPU-O-KEO

Prepared by: Belt Collins & Associates

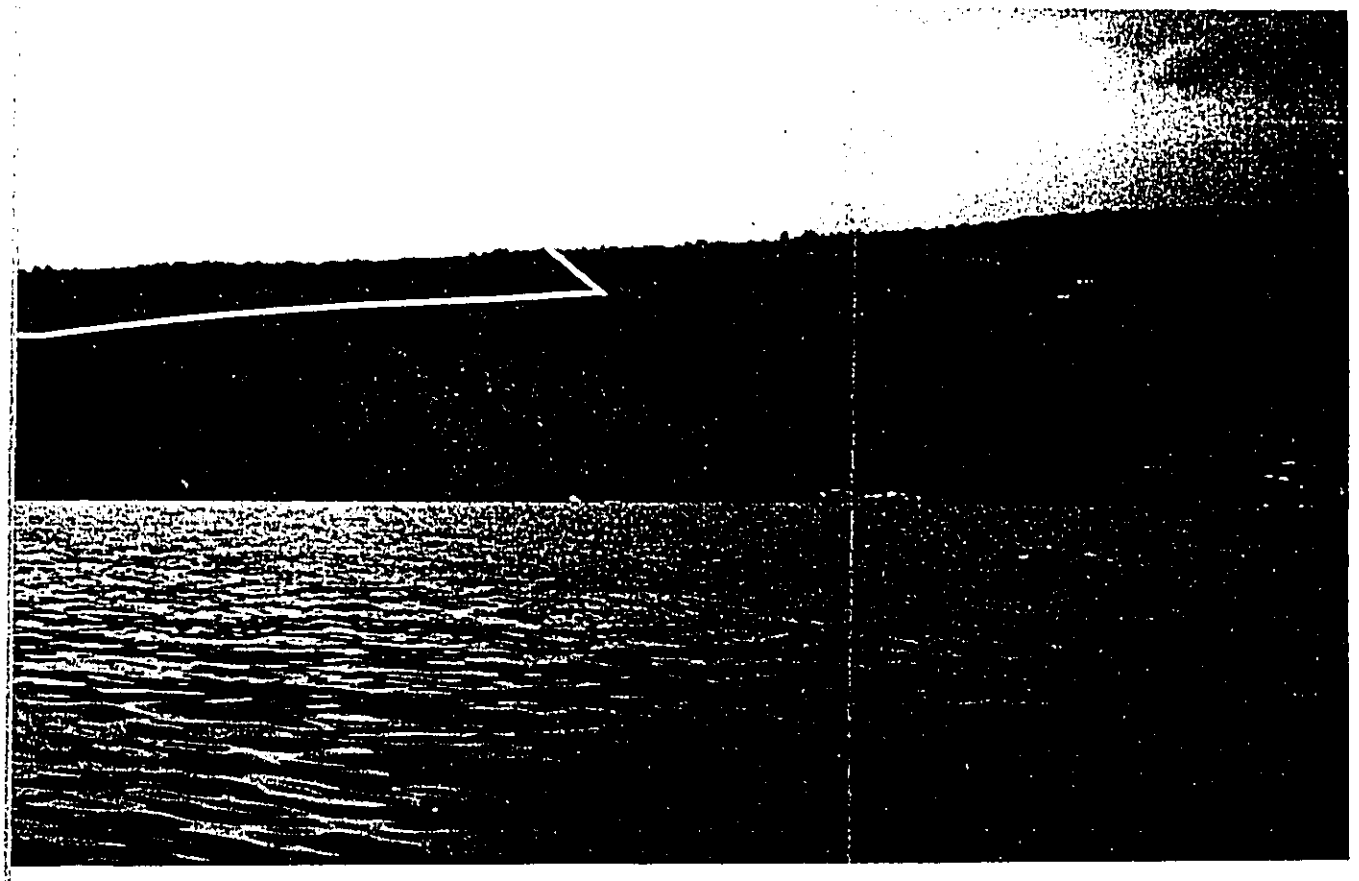
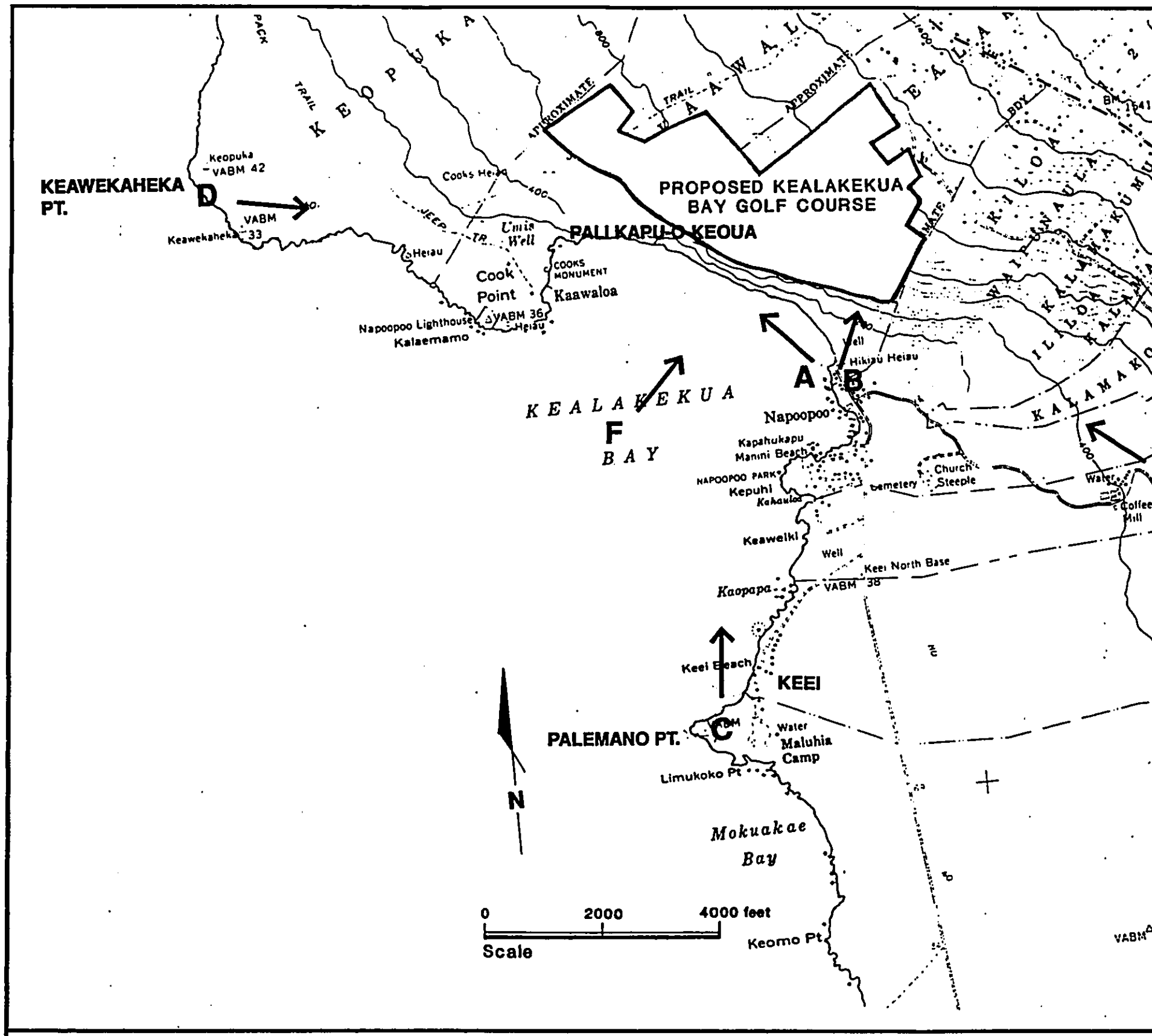


Figure 4-9 F
PALI KAPU-O-KEOUA FROM OCEAN (APPROX. 3,000 FEET FROM SHORE)

Kealakekua Bay Club
South Kona, Hawaii



Prepared by: Belt Collins & Associates

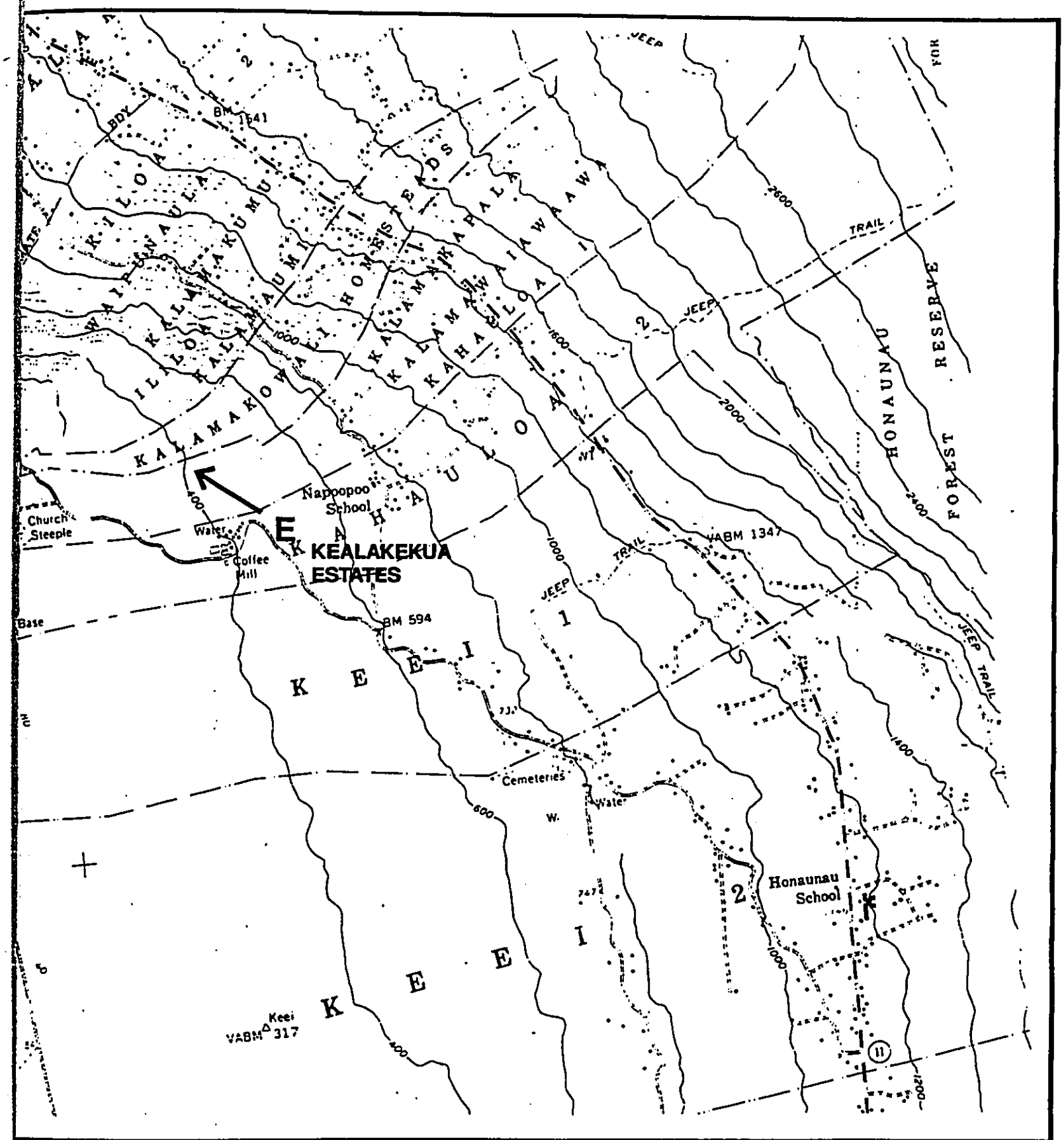


Figure 4-9 G
LOCATION OF VIEWS ANALYSIS
OBSERVATION POINTS
Kealakekua Bay Club
South Kona, Hawaii

topography of the property, and the steepness and height of the pali. As a point of fact, the makai boundary of the property is about 600 feet above the bay and about 300 feet inland from the water's edge. The ocean and western horizon are visible from virtually anywhere on the property.

Due to the topography of the project area and the fact that the pasture land on its mauka slopes is interspersed with mature landscape trees, the vast majority of the project area is not visible from Napoopoo Road. No portion of the project area is visible from Mamalahoa Highway. From the confines of Kealakekua Bay, the project area is not visible due to the height of the cliff face (see Figures 4-9 A & B). Portions of the project area are presently visible to abutting properties on the north and south, from Keawekaheka Point, Keei/Palemano Point and from Kealakekua Estates (see Figures 4-9 C, D, E & F).

3.3.2 Probable Impacts

Visual impacts associated with the construction and operation of the proposed project are considered to be minimal due to the fact that views of the area from above and below are extremely limited. A visual impact analysis was conducted to determine potential impacts. As depicted in Figures 4-9 A thru F, the property boundaries are not visible from the area within Kealakekua Bay. Outside of the bay, views are generally limited to portions of the proposed golf course. Figure 4-9G presents the location of the View Analysis observation points.

The proposed golf clubhouse and Members' Lodge are planned not to exceed two stories in height. Only limited views of these structures will occur from Napoopoo Road. The most direct view of these structures will be from Keei/Palimano Point, as depicted in Figure 4-9 C.

3.3.3 Mitigation Measures

Retention of some of the existing forest area on the mauka slopes will help to screen the project site during both construction and operation of the proposed project. The small portions of the site that are visible from Napoopoo Road will be buffered by trees. A buffer of natural vegetation will be use as a screen for the far view from south of the bay. Structures built on site will be designed to be compatible with the rural character of the area and will be generously landscaped to further mitigate potential visual impacts. Views of the golf course do not need to be mitigated due to its open space character and its general visual compatibility with the surrounding area.

3.4 Terrestrial Flora

3.4.1 Existing Conditions

A botanical survey of the subject property was conducted in May, 1990 to assess the botanical resources present. A total of 108 plant species were inventoried on the project site during the field survey. Of these, 92 (85% are introduced or alien species), 10 (10%) are native, and 5 (5%) are of Polynesian origin. Among the species of native plants, 8 species are indigenous (native to the Hawaiian islands and also elsewhere) while 3 are endemic (native only to the Hawaiian islands). The complete botanical survey is included as an appendix to this environmental impact statement. It contains a detailed explanation of survey methods, as well as the scientific names and listings of all plants inventoried. Four major vegetation types were identified on the project site: Open Mixed Forest, 'Opiuma Savanna, Ekoa Shrubland, and Lava Flow Scrub.

Figure 4-10 presents the distribution of these vegetation types. Vegetation associated with homes and other maintained areas was not surveyed.

The Open Mixed Forest is found on the mauka half of the subject property from about the 900-foot elevation. Due to slightly higher annual rainfall than the makai half, the mauka area supports denser vegetation and many more tree species. The canopy of the forest is open with tree cover from about 30% to 60% and in most places the crowns of the trees do not interlock. Guinea grass forms a dense cover in between the shrubs and trees.

The 'Opiuma Savanna is named after the widely spaced 'Opiuma trees which occur below the 900-foot elevation. Tree cover in this area ranges from 5% to 30%. Again, Guinea grass is the dominant ground cover, although in places, Bermuda grass or manienie may be more common. Where the savanna adjoins the coastal cliff, rocky areas support a few native species.

The Ekoa Shrubland occupies a relatively small area, roughly less than 10 acres, situated between the 'Opiuma savanna and the lava flow scrub discussed below. Ekoa shrubs, 10 to 15 feet tall, form a dense thicket on very stony soil. Again, guinea grass is the dominant ground cover although it may be less dense in this shrubland.

The Lava Flow Scrub coincides with the portion of an a'a lava flow which is included in the subject property. Plants occur as scattered patches over the rough surface of the flow, usually in depressions or in crevices. Plant cover is about 20%. Most of the native species found on the project site occur within this plant community.

3.4.2 Threatened and Endangered Plants

None of the native species identified on the property are considered officially listed, threatened, or endangered species protected by endangered species laws, nor are any currently being proposed for such status. The native caper or puapilo (Capparis sandwichiana), which is found on the lava flow area, is considered a Category 2, candidate species (U.S. Fish and Wildlife Service 1990). Category 2 plants are those for which there is some evidence of vulnerability, but for which there are not enough data to support listing proposals at this time.

3.4.3 Probable Impacts

Impacts to the existing flora would result from preparation of the project site for the development of residential units and supporting infrastructure. Grading, cut and fill work, and similar construction activities will destroy existing plant cover. Impacts would also occur from the introduction of alien or exotic plant species which might out-compete existing species. The significance of potential impact has been evaluated on the basis of the extent of loss of existing vegetation, the potential for introduction of competitive exotic species, and the potential for loss of endangered or threatened species.

The impact to existing vegetation is considered to be significant due to the need for extensive grading and clearing associated with site preparation. However, the loss of existing vegetation will be offset, to some degree, by the introduction of extensive landscaping. Virtually all of the areas designated for golf course fairway development will need to be cleared. Roughs boarding the fairways will be left intact wherever possible. The remaining property will also be cleared for the development of infrastructure and support facilities.

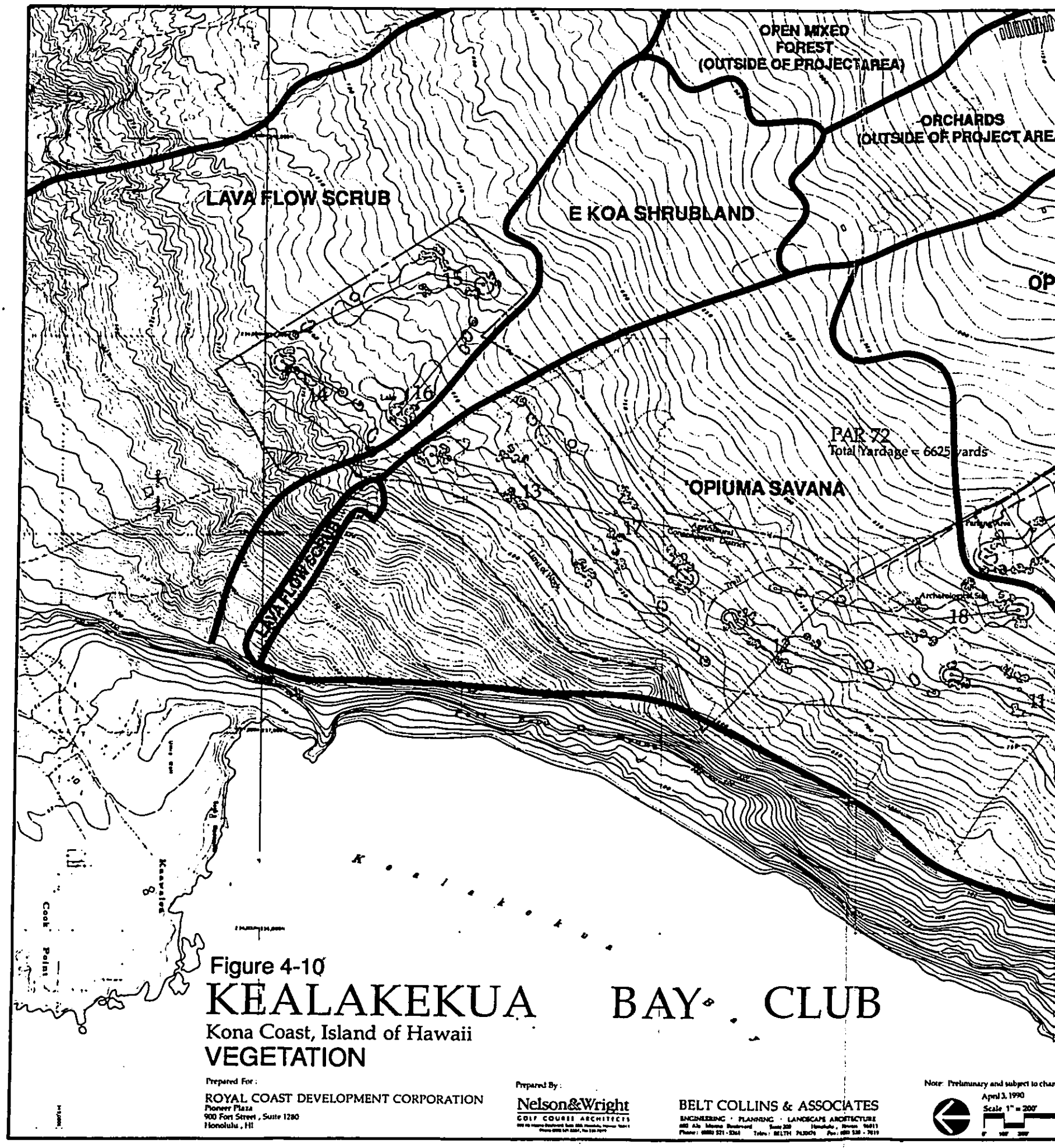


Figure 4-10

KEALAKEKUA BAY CLUB

Kona Coast, Island of Hawaii

VEGETATION

Prepared For:

ROYAL COAST DEVELOPMENT CORPORATION
Pioneer Plaza
900 Fort Street, Suite 1280
Honolulu, HI

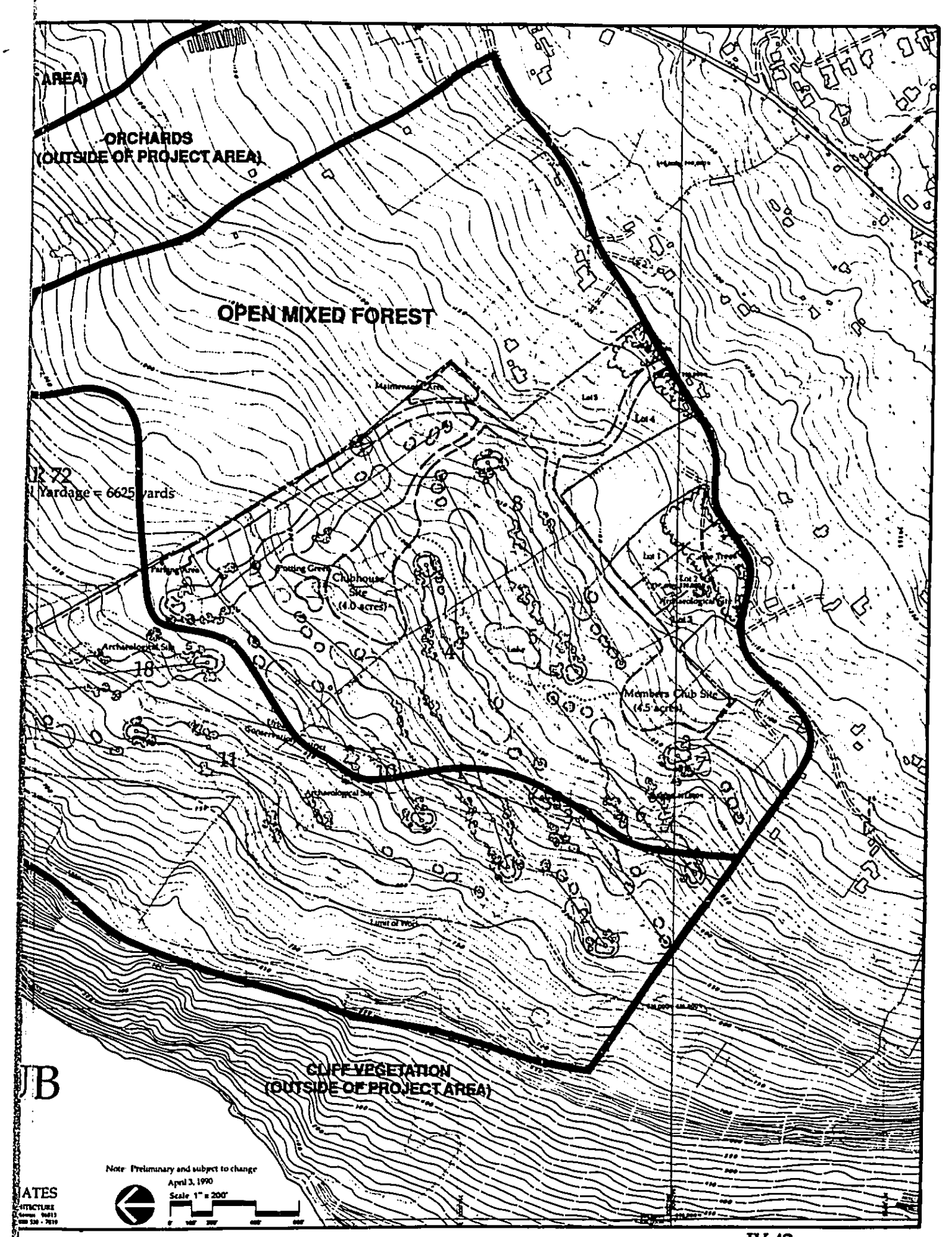
Prepared By:

Nelson&Wright
GOLF COURSE ARCHITECTS

BELT COLLINS & ASSOCIATES
ENGINEERING · PLANNING · LANDSCAPE ARCHITECTURE

Note: Preliminary and subject to chan

April 3, 1990
Scale 1" = 200'


AREA)
ORCHARDS
(OUTSIDE OF PROJECT AREA)
OPEN MIXED FOREST
Yardage = 6625 yards
Clubhouse Site
(4.0 acres)
Archaeological Site
Members Club Site
(4.5 acres)
Archaeological Site
CLIFF VEGETATION
(OUTSIDE OF PROJECT AREA)
Note: Preliminary and subject to change
April 3, 1990
Scale 1" = 200'

The majority of the property is vegetated with introduced species and the proposed development is not expected to have a significant negative impact on these areas. The lava flow area is considered to be somewhat sensitive due to the presence of the Category 2 species.

3.4.4 Mitigation Measures

To offset the loss of existing vegetation, the use of native plant material for landscaping in and around the golf course will be considered wherever practicable. Also, the buffer area between the lower portion of the golf course and the top of the cliff will be recultivated with native plants. The property owner has entered into an agreement with Bishop Museum to research and recommend native plants for cultivation in the buffer zone and for landscaping. The category 2 caper will be planted as part of the landscaping wherever possible.

3.5 Terrestrial Fauna

Following is a summary of the survey of avifauna and feral mammals conducted for the proposed project by Phillip L. Bruner. The survey is based upon field work conducted in November , 1989, and is included in its entirety in the appendix to this environmental impact statement.

3.5.1 Avifauna

Only one endemic (native) species of land or water birds was recorded during the course of the field survey. An adult dark phase Hawaiian Hawk (Io) (Buteo solitarius) was observed flying over the eastern sector of the property. This hawk is endemic to the island of Hawaii and is also listed as an endangered species. Io are widespread over agricultural lands and forests. The Short-eared Owl or Pueo (Asio flammeus sandwichensis) is the only species which might occur at this site because it is relatively common on Hawaii, particularly at higher elevations. No other endemic birds would be expected at the site given the elevation and location of the site and nature of the habitats available. No waterbirds should be found on the property as there are no wetlands.

Of all migratory indigenous (native) shorebirds that winter in Hawaii, the Pacific Golden Plover (Pluvialis fulva) is the most abundant. Plover prefer open areas such as mud flats, lawns, pastures and plowed fields. They arrive in Hawaii in early August and depart to their arctic breeding grounds during the last week of April. Plover are also recognized as being extremely site-faithful on their wintering grounds and many establish foraging territories which they defend vigorously. However, only two plover were recorded during the field survey. This result was not unexpected due to the type of habitat present at the site. In its present state the property is unsuitable for migrating shorebirds because the grass is too tall and there are very few barren areas.

No indigenous species of resident native birds were recorded nor would any be expected at the site. No seabirds were observed on the actual property, although one White-tailed Tropicbird (Phaethon lepturus) was seen along the sea cliff face makai of the property line.

A total of 12 species of exotic birds were recorded during the field survey. The most abundant species at the property were Japanese White-eye (Zosterops japonicus), Common Myna (Acridotheres tristis), House Finch (Carpodacus mexicanus), Zebra Dove (Geopelia striata), and Nutmeg Mannikin (Lonchura punctulata). Given the range of habitats found on the property as

well as from survey elsewhere in West Hawaii, the following exotic bird species might also be expected to occur on or near the property: Common Barn Owl (Tyto alba), Northern Mockingbird (Mimus polyglottos), Black Francolin (Francolinus francolinus), Lavender Waxbill (Estrilda caerulescens) and Yellow-fronted Canary (Serinus mozambicus).

3.5.2 Mammals

Small Indian Mongoose (Herpestes auropunctatus) were seen or heard during the survey. Feral cats were also observed. Cattle were concentrated on the lower (makai) section of the property. No evidence of rats and mice were found but these ubiquitous mammals undoubtedly occur in the area. The area is also inhabited by feral pigs and domestic pigs "gone wild", according to neighboring residents.

Records of the endemic and endangered Hawaiian Hoary Bat (Lasiurus cinerus semotus) are sketchy, but the species has been reported in West Hawaii. None were observed during the field survey despite two nights of observations. This species roosts primarily in trees. Much remains to be known about the natural history of this bat and its ecological requirements in Hawaii.

3.5.3 Endangered and Threatened Species

As previously mentioned, a single member of the endangered species of Hawaiian Hawk was seen during the survey. However, the single sighting was not entirely unexpected. This species ranges widely over ranch and farm lands as well as forested areas on the island of Hawaii, but is somewhat less common in West Hawaii.

3.5.4 General Conclusions

General conclusions regarding bird populations include the following: 1) All representative types of habitat found on the property were identified. The more densely vegetated mauka section contained many more birds than the open habitat on the lower slope. 2) The present habitats provide a limited range of living spaces which are utilized by the typical array of exotic species of birds one would expect at this elevation and in this type of environment. However, some species normally found in this habitat were not recorded. This could have been due to the fact that the survey was too brief or that their numbers are so low that they went undetected or a combination of these and other factors. 3) The low numbers of migratory birds at this site is due entirely to the absence of suitable habitat. If large lawn areas are developed, the number of Pacific Golden Plover utilizing the area will undoubtedly increase.

With regard to the mammal populations, in order to obtain more definitive data on mammals, a trapping program would be required. No endangered mammal species were observed.

3.5.5 Probable Impacts

The proposed development will create an environment which will result in a significant change over the existing conditions. The present habitat provides a limited range of living spaces that are utilized by exotic species of birds expected to occur at the project site. The open space character of the project will probably result in an increase in the variety of bird species and their relative abundance. It is likely that the Pacific Golden Plover would be attracted to the open spaces

created by golf course fairways. Other species such as the Japanese White-eye, House Finch and game birds like the Black Francolin will decline in abundance once the forested area is eliminated. This can be interpreted as an adverse impact. However, given the vast amounts of undeveloped land around the project site, it is evident that other habitat opportunities are available and that development will not threaten the existence of these birds. Thus, the impact is not viewed as significant.

Changes resulting from the proposed development will impact the habitat of mammals identified on site. However, the impact is viewed as insignificant because there are abundant alternative habitats for the mammals around the project site, and the species identified, particularly rats, mice, mongooses and feral cats can easily adapt to changes in settings.

3.5.6 Mitigation Measures

The majority of bird and mammal species identified on site area exotic. The value of these species is somewhat subjective, in that birds such as the Common Myna and House Sparrow, as well as rats and mice, are considered to be pests and nuisances by some. However, in general impacts to existing exotic species are considered to be insignificant. Therefore, no mitigation measures are necessary.

Similarly, no mitigation measures are deemed necessary regarding the Hawaiian Hawk sighted over the property. There is no evidence to suggest that the individual sighted nests on the property. Changes to the property brought on by the development proposal should not impact the ranging pattern of the Hawaiian Hawk.

4. NEARSHORE AND MARINE ENVIRONMENT

Kealakekua Bay is designated as a State of Hawaii Marine Life Conservation District that serves as both a protected sanctuary for marine species and a prime recreational area for residents and visitors. The proposed project's location overlooking the bay has focused concern upon the project's potential impacts upon the bay. To address this concern, a baseline marine survey and potential impact analysis was conducted in November 1989 by Marine Research Consultants. The final report of the survey is included as an appendix to this environmental impact statement. A primary recommendation of the survey called for the implementation of a monitoring program in the bay to ensure that the dynamics of groundwater extrusion into the bay are fully understood and documented, and that the potential impacts of the project's development and operation can be readily assessed and mitigated if negative impacts occur. Copies of two subsequent monitoring program reports are also presented as appendices to this document. Following is a non-technical summary of all three reports. The reader is urged to review the appendices for technical data, methodology, sampling methods, and a detailed description of the study design and monitoring program parameters.

4.1 Coastal Morphology and Underwater Topography

4.1.1 Existing Conditions

The shoreline area of Kealakekua Bay downslope of the proposed project is composed of a nearly vertical cliff approximately 600 feet in height containing layered rock of volcanic origins. In some areas, the cliff face continues uninterrupted into the water; in the remaining areas, narrow rocky and cobble ledges separate the emergent cliff face from an underwater cliff. At intermittent

intervals along the underwater cliff face, small freshwater springs were observed discharging cool, low salinity groundwater into the ocean.

Underwater physiographic structure offshore of the cliffed shoreline is composed of three zones. Nearest to the shoreline is an area characterized by large basaltic boulders that appear to have broken off of the cliff face (0 - 10 feet in depth). Seaward of the boulder zone is a flat to gently sloping terrace that forms the main area of coral reef growth (10 - 40 feet in depth). Further seaward, bottom slope steepens and grades into an area completely covered with calcareous sand (greater than 40 feet in depth).

4.1.2 Probable Impacts

The proposed project is set back a distance of some 350 to 600 feet from the top of the cliff. The project will have no impact upon the cliff, the narrow rocky ledges at the shoreline, or the underwater physiographic structure of Kealakekua Bay.

4.1.3 Mitigation Measures

Because of a lack of impacts upon the physiographic character of the bay, no mitigation measures are necessary.

4.2 Water Chemistry

The salinity of Kealakekua Bay is relatively uniform and its waters may be characterized as pristine open ocean waters. There is no indication of vertical stratification in any of the salinity samples; surface samples do not exhibit a pattern relative to deep water samples. Lack of such stratification indicates that there is near total homogeneous mixing of the small volume of groundwater that enters the ocean in Kealakekua Bay, and that there is no effect from groundwater intrusion on salinity beyond 5 meters from the shoreline. These data indicate that groundwater discharge into the area of Kealakekua Bay downslope of the proposed golf course is relatively small, and does not influence the composition of nearshore waters. However, it was noted in the subsequent sampling of the bay's waters pursuant to the aforementioned monitoring program, that there is a temporal component to groundwater discharge. A comparison of June 1990 data to December 1989 data reveals substantially higher groundwater inputs in June relative to December. Further sampling in October 1990 confirm that there is a natural variability in groundwater discharge. Groundwater discharge appears to be greatest at the northern end of the bay.

Additional water quality measurements (nitrogen, phosphorous and silica) indicate that the mixing of groundwater results in a low salinity surface layer with high concentrations of nutrients (N, P and Si) that are normal components of groundwater. Beyond a distance of about 500 meters from the back shoreline of the bay, water chemistry reflects oceanic conditions with little indication of groundwater characteristics.

Water chemistry parameters not directly associated with groundwater input exhibit various trends. Chlorophyll a and turbidity exhibit increases at nearshore samples off Napoopoo, but are consistently low at the sampling site in the northern bay where groundwater input was most evident. Temperature shows a cooling trend moving south to north in the bay that is more pronounced than can be explained by either solar warming or groundwater input. Application of a hydrographic mixing model to the water chemistry data was used to verify that the cause of

increased nutrient concentrations in the inner bay is mixing of groundwater with oceanic water. The slight variance of the line created by the data points and a theoretical mixing line suggest that groundwater reaching the bay is slightly different in character than potable water collected at Napoopoo. Nevertheless, the model indicates that there is presently no substantial input of external sources of nutrient materials, particularly nitrogen, into Kealakekua Bay. There is a suggestion of a slight increase in phosphorous, although the levels are far too low to result in alteration of water quality or biological community structure.

Finally, during the July 1990 sampling survey, many of the nearshore measurements of nitrate and two measurements of chlorophyll a taken during the monitoring program exceeded State Department of Health water quality standards. It is evident, however, that nitrate levels are solely a function of natural groundwater input. Under the present conditions of shoreline, it is not unexpected that natural processes cause some water quality parameters to exceed specified DOH limits.

4.3 Biological Resources

4.3.1 Benthic Community

Coral community zonation pattern reflects the physical structure of the reef habitats described above. Owing to factors related to the shallow depth (primarily wave surge), living corals are least abundant in the boulder zone, comprising from 11 % to 40% of bottom cover. While cover is lowest, coral species diversity is highest in the nearshore region, as no single species is able to gain a competitive advantage and monopolize the community. Major species that occur in the boulder zone are Porites lobata, Pocillopora spp., and Pavona varians.

Owing to the protected nature of the bay, the effects of wave stress are primarily limited to the shallow nearshore boulder zone. As a result, the deeper reef terrace provides a stable habitat for coral reef development, in that corals are accreting a calcium carbonate substrate that comprises the physical character of the benthic surface. Living coral cover in this zone is substantially higher than in the shallower areas, ranging from 63% to 68% on the two transects located at the 25-foot depth. Dominant coral structures were large colonies of Porites lobata (up to 10 feet in diameter). P. lobata generally is found to be the most abundant species in Hawaiian coral communities, and occurs in various growth forms in different reef environments.

Beyond the edge of the reef terrace, bottom topography grades into a sloping bottom. Dominant coral cover on the reef slope down to a depth of approximately 60 feet consists of interconnected mats of Porites compressa. This species is capable of growing rapidly in areas that are either sloping, or are composed of nonconsolidated substrata. Coral cover in the P. compressa zone (50 feet) is the highest encountered on the Kealakekua Bay transects (95%). Owing to the domination by a single species, however, diversity is among the lowest of all areas.

Several species of motile invertebrates were observed through the reef zonation pattern. The major taxa of benthic organisms occurring within the survey area were sea urchins (Echinoidea). The most abundant urchins in the reef terrace zone were the two species that bore into limestone surfaces, Echinometra matheai and Echinostrephus aciculatus. Several individuals of larger species of urchins, particularly Heterocentrotus mammillatus, but also Tripneustes gratilla and Echinothrix diadema were also observed. Several large crown-of-thorns starfish (Acanthaster plancii) were observed through the study area. The entire reef surface not inhabited by coral colonies is covered with a short mixed-species algal turf. Frondose benthic algae are rare in

occurrence in all zones of the surveyed reef.

4.3.2 Aquatic Community

A rich and diverse fish community, typical of West Hawaii, was found in reef areas off the proposed project. The total number of species observed on transects was 65; on a single transect the species number ranged from 28 to 40, while individual fish encountered on transects ranged from 330 to 407. The most diverse fish community was observed in water greater than 20 feet deep, while the greatest abundance of fishes was found in shallow water along the shoreline.

Algal-feeding acanthurids were the most numerous single group of fishes observed. Common species observed during the survey included yellow tang, goldring surgeonfish, whitebar surgeonfish, brown surgeonfish, and convict tang. Other common species included damselfishes, black durgon, pinktail durgon, reef triggerfish, manybar goatfish, and the multiband butterflyfish.

Juvenile reef fishes were most abundant at the deeper transect sites in areas covered with Porites compessa. Several species of "food fishes" were observed during the survey. These included parrotfishes, goatfishes, jacks, emperorfish, surgeonfish, and the introduced grouper. Many of these fishes were quite tame and not disturbed by the presence of divers. Many of the small reef fishes were also quite familiar with divers; their tendency to approach divers suggested that they had been fed by humans in the past.

Overall, the fish community is fairly typical of assemblages found in Hawaiian reef environments. The number of species, total number of individuals, and overall composition indicate a healthy and diverse fish community. The abundance of some food fishes and their tendency not to avoid divers speaks well of the protection offered to fish by the status of the bay as a Marine Life Conservation District.

4.3.3 Threatened and Endangered Species

Three species of marine animals that occur in Hawaiian waters have been declared threatened or endangered by Federal jurisdiction. The threatened green sea turtle (Chelonia mydas) occurs commonly along the shoreline of the major Hawaiian Islands and is known to feed on selected species of macroalgae. Resting habitats of green sea turtles are commonly deeper reef areas characterized by undercut ledges and other topographic features. The endangered hawksbill turtle (Eretmochelys imbricata) is found infrequently in waters off Hawaii. Only one small green sea turtle was observed during the course of the present survey, although it is likely that larger populations of turtles frequent the area on occasion.

Populations of the endangered humpback whale (Megaptera novaeangliae) spend the winter months in the Hawaiian Islands, and are especially abundant off the West Coast of Hawaii. Although neither endangered nor threatened, spinner dolphins are known to frequent the bay area which is considered by some to be an important resting area for them.

4.4 Probable Impacts

The main objective of the baseline survey is to estimate the potential for impact to the marine environment from construction and operation of a golf course above Kealakekua Bay. Because the project does not entail any shoreline modification, potential problems could arise only

from changes in input to the marine environment from erosion of soils or chemical subsidies from fertilizers and pest control agents.

The potential for increased sedimentation (soil erosion runoff) is greatest during the period of construction. During the construction process, proper planning to minimize exposed acreage at any one point in time is essential to minimize the potential for increased erosion. Temporary increases to sediment loading in the nearshore environment of the bay could pose the potential for temporary negative impacts, as the area is not a high wave energy regime. As a result, water movement in the receiving environment would not cause rapid dispersal of any particulate material that might enter the bay as a result of construction.

Reef corals, generally considered to be the "keystone species" on reefs must deal with sediment in the environment under natural conditions. While the effects of sediment stress to corals can be deleterious, especially when the corals are buried, sedimentation can also result in no negative impacts. Because sediments are suspended by natural processes in many reef environments, most corals can withstand a certain level of sediment supply to the living surface. Many species have the ability to remove sediment from their tissues.

It appears that there is presently no surface runoff from the property proposed for development into the bay. Because of the highly pristine character of the bay, inputs of erosional sediment would result in obvious impacts to water quality. Preventing sediment input to the marine environment should also insure that the proposed project will have no effects to endangered or protected species.

The findings of a recent literature review by the Golf Course Superintendents Association of America (GCSAA) in November 1988 indicate that golf courses do not pose a significant pollution threat to the nation's water supplies. With respect to the impacts from erosion, golf courses actually help reduce sedimentation pollution by increasing soil stability through thick layers of grass thatch. Carefully managed golf course turf grasses have been found to have 15 times less runoff than does a lower quality lawn. Golf courses can also greatly reduce erosion and runoff effects compared to other land uses, such as roadways,. buildings and parking lots.

The development and operation of the proposed golf course will require application of fertilizers and pesticides. Under some conditions, these chemicals may be subject to movement from the site of application, principally by leaching to the groundwater aquifer. The potential impacts of these chemicals to the groundwater aquifer is addressed in Section 2 above.

A survey of the effects of existing golf course irrigation and fertilization on nearshore marine waters off the West Coast of the Island of Hawaii showed that existing courses (Mauna Lani, Waikoloa, Mauna Kea) are not causing alteration in water quality or biological community function and structure. Courses located upslope from open coastline, such as Kealakekua Bay and Kauna'oa Bay at the Mauna Kea Beach Hotel, showed no measurable effects whatsoever on nutrient concentrations in the nearshore ocean. These results indicated that normal fertilization does not result in any undesirable nutrient enrichment in nearshore waters. An exception, however, appeared in a semi-enclosed inlet (Keauhou Bay) located directly downslope from a 27-hole golf course. Owing to a residence time in the bay that is substantially longer than in an equivalent area of open coastline, and to the 'focusing' of groundwater efflux, increases in dissolved nitrogen measured in Keauhou Bay appear to be attributable to golf course fertilization (Dollar and Smith, 1988).

The results of the present survey indicate that the amount of groundwater input to the area of Kealakekua Bay directly downslope from the proposed golf course varies during the course of the year. The potential level of impacts on nutrient subsidies will therefore vary according to the amounts of groundwater entering the bay. It should be noted, however, that naturally occurring groundwater contains extremely high concentrations of NO3- in relation to marine waters. As such efflux is a natural phenomenon, it must be assumed that the nearshore communities are adapted to such concentrations, and these areas cannot be considered 'polluted'. It therefore follows that subsidies of NO3- to groundwater, should they occur as a result of golf course operation, do not change the qualitative nature of the groundwater, and do not necessarily represent a potential pollutant to receiving environments.

4.5 Mitigation Measures

Mitigation measures addressing the potential negative impact of chemicals entering the groundwater are discussed in detail in section 2.4.3 above. That discussion is equally relevant for impacts upon the waters of Kealakekua Bay. While all indications are that the planned golf course will have no negative impacts to Kealakekua Bay, it is nevertheless recognized that a monitoring program establishing a baseline set of conditions before construction, with which to compare conditions during and after construction will provide the best means of detecting potential problems and mitigating them in a timely manner.

5. HISTORICAL AND ARCHAEOLOGICAL RESOURCES

5.1 Introduction

Kealakekua Bay area's historical significance as the site of the landing and death of Captain James Cook in 1779 is well known. This location is also the area in which the first lengthy contacts occurred between Europeans and native Hawaiians, and much information has been recorded on this subject (including the earliest substantial observations on intensive aboriginal agricultural practices). The majority of the 262-acre survey area, excluding only the most inland section adjacent to Napoopoo Road, is situated within the limits established for the Kealakekua Bay Historic District (HRHP Site No. 50-10-47-7000), an important historical site complex area placed on the National Register of Historic Places in December 1974. The entire project area is also located within the southern part of the Kona Field System (HRHP Site No. 50-10-37-6601), a large complex (about 3 by 18 miles in extent) of aboriginal Hawaiian dryland cultivation and habitation features declared eligible for inclusion on the National Register of Historic Places in January 1977.

The proposed project area has been the subject of four separate archaeological surveys: Full Archaeological Reconnaissance Survey - Kealakekua Ranch Makai Land Subdivision, by Paul H. Rosendahl, Ph.D., Inc. (PHRI), April 1987; Kealakekua Ranch Makai: Interim Archaeological Investigations, by William Barrera, Jr. (d.b.a. CHINIAGO INC.), July 1989; Archaeological Inventory Survey, Kealakekua Ranch Development - Ka'awaloa Parcel, PHRI, February 1991; and Archaeological Inventory Survey - Kealakekua Bay Club Parcel 39, PHRI, May 1991. The first two studies focused on the 195 acre parcel identified as TMK 3-8-2-02:2, 33. The third study focused on the 70 acre parcel as TMK 3-8-1-10: Portion 2 (note: this area has subsequently been granted a new TMK parcel number; 3-8-1-10:3). The fourth study concentrated on a 5.725 acre parcel identified as TMK 3-8-2-2: 39. Together these three land areas comprise the entire proposed project area. For the sake of clarity and understanding, the 195-acre parcel (hereinafter,

Kealakekua Ranch Makai Lands or 'Makai Lands'), the 70-acre parcel (hereinafter, the 'Ka'awaloa Parcel'), and the 5.75-acre parcel (hereinafter 'parcel 39') will be treated separately in the discussion below. The four reports are included in their entirety as appendices to this environmental impact statement. The reader is directed to these reports for a full discussion of the scope of work, methodology, and field procedures utilized during the course of the archaeological survey work.

PHRI's full reconnaissance survey for the makai lands was carried out in compliance with the requirements of the County of Hawaii and in accordance with the minimum requirements for a reconnaissance level survey, as recommended by the Society for Hawaiian Archaeology (SHA). These standards were utilized by the Hawaii County Planning Department, in 1987, as guidelines for the review and evaluation of archaeological reconnaissance survey reports submitted in conjunction with various development permit applications. At that time, the County determined that the full reconnaissance survey was necessary for an environmental impact statement. It should be noted that the reconnaissance survey is a pedestrian survey, extensive rather than intensive in scope, and conducted to determine the presence or absence of surface remains within a specified project area. It permits a preliminary evaluation of cultural resources, and facilitates formulation of realistic recommendations and estimates for such further archaeological work as might be necessary or appropriate. Such further work could include an intensive survey -- detailed recording of sites and features, and selected test excavations; and possibly subsequent mitigation -- data recovery research excavations, interpretive planning and development, monitoring, and/or preservation of sites and features with significant scientific research, interpretive, or cultural values.

Barrera's report represents a follow-up to PHRI's reconnaissance survey of the makai lands and was prepared to represent an interim step in "a potentially multi-part mitigation program". It concluded that the project area sites represent a valuable archaeological resource and evaluated them as being significant solely for their informational content. However, the Barrera report limited its focus on the those lands within the 195 acre makai land area that are designated as Urban by the State Land Use Commission, and specifically excluded sites identified by PHRI as being located in the Conservation District. Due to differences in report methodologies and presentation styles, no attempt is made here to integrate the findings of the Barrera and PHRI reports. The PHRI format is utilized here as a standardized format and the reader is directed to the appendix for the findings, conclusions of the Barrera report, and conversion of PHRI site numbers to DLNR-HPP/SHPO site numbers.

PHRI's inventory surveys of the Ka'awaloa parcel and parcel 39 were similar in scope and methodology to the reconnaissance survey of the makai lands. The inventory surveys were carried out in accordance with the standards for inventory-level survey recommended by the State's Department of Land and Natural Resources, Historic Preservation Program/State Historic Preservation Office (DLNR-HPP/SHPO). The significance of all archaeological remains identified within the project areas were assessed in terms of the National Register criteria contained in the Code of Federal Regulations (36 CFR Part 60) and the criteria for evaluation of traditional cultural values prepared by the national Advisory Council on Historic Preservation (ACHP). These criteria are currently used by the DLNR-HSS/SHPO and the County of Hawaii for the evaluation of cultural resources. Following is a summary of the PHRI findings.

5.2 Existing Condition of Makai Lands

The makai lands are located in the ahupua'a of Kealakekua, South Kona District, Island of Hawaii. Most of the makai land area have been used for more than 100 years primarily for cattle grazing, and some of the area has been modified in recent times by bulldozing of vegetation to provide improved pasture. The most inland portion (adjacent to Napoopoo Road) has been affected more extensively by alterations related to residential use, ranching activities, and small-scale intensive agricultural development (primarily coffee). In general, the inland half of the property (above a 4-wheel drive road known as the Old Pineapple Road) seems to have been the subject of more historic and recent disturbances than has the seaward area.

A total of 49 designated sites, many containing multiple component features, were identified in the project area (see Figure 4-11). The range of formal feature types encountered in designated sites and complexes includes walls (free-standing and retaining), terraces, raised stone platforms, walled shelters, enclosures, cave shelters, alignments, modified bedrock outcrops, and stone piles and mounds. While the function of many of these features appears to be agricultural, many also suggest residential habitation and burials. The overall condition of structural remains ranges from poor to very good, and integrity is generally fair to very good.

The 85 identified features consist of agricultural features (22), habitation structures (25), possible agricultural and/or habitation features (12), possible burial structures (21), and transportation features (4). Most of the agricultural features are components of the larger Kona Field System which were recorded individually because they are situated within or in close proximity to non-agricultural features. Habitation features include probably temporary and permanent prehistoric habitations and historic-era residential structures. A wooden frame house, Site 7324, represents a residential architectural type unique to the historic period. Possible burial features include twelve stone mounds and nine platforms. Test excavations would be necessary to verify the functions of these features (several of the mounds may potentially be agricultural features). Transportation features include a trail, two historic roads, and a historic loading platform.

In terms of overall distribution, agricultural features are relatively evenly distributed, compared to non-agricultural ones. Most of the probable permanent habitation structures, transportation-related features, and possible burials are concentrated between the 650-750 and 1000-foot elevation. Temporary habitation features are concentrated in the inland portions of the makai lands; the majority are situated above 1,000 feet in elevation. These patterns, however, should be viewed as very tentative because of the small sample size and the evidence of disturbance.

5.3 Probable Impacts

Impacts to the features found within the project area would primarily be a loss of the features due to excavation and/or construction of the proposed project. Most of the potential direct impacts have been avoided through modification of the project design following the initial archaeological inventory. For those sites identified for possible preservation, impacts could also include increased human activity around and exposure to the sites. This is especially important for sites that might be preserved with interpretive development in park-like or educational setting. If any of the sites recommended for preservation cannot be incorporated into the project design (and fully protected), a data recovery plan and proper mitigation will be required. Indirect impacts could

occur on many features from the increased access to the area generated by the proposed development. However, for those sites incorporated into the project design, indirect impacts will be to a great degree mitigated by access control related to the operation of the golf course.

5.4 Mitigation Measures

The significance of individual sites and features have been evaluated based on the definitions derived from the National Register of Historic Places criteria for evaluation (Table 4-7). The Hawaii State Historic Preservation Office also employs these criteria for evaluating cultural resources.

Of the 49 identified sites, 33 are assessed as significant solely for information content. Thirty of these sites still contain significant information and further data collection is recommended. Sufficient data have already been collected from the remaining three sites, and no further work is needed. Nine sites have been determined to be significant for their information content and may also have cultural significance as burial sites, pending the findings of further investigations. Five sites have been determined to be significant for their information content as well as for being good examples of specific site types. Two sites have been determined to be significant for information content, as site type examples, and for cultural value. Table 4-7 summarizes the general significance assessments and recommended general treatments for all sites identified in the current survey.

To ensure that the archaeological and historical sites identified within the project site are not adversely impacted, the treatments recommended by the consulting archaeologist and presented in Table 4-7 will be implemented subject to the concurrence of the State's Historic Preservation Office. In those instances where skeletal remains are confirmed, the burial will be preserved "as is" or will be reinterred within the proposed archaeological preserve to ensure that the remains are not removed from the Kealakekua ahupua'a. Additional sites proposed for preservation will be integrated into the proposed development through the use of landscaping or similar design treatments.

Finally, should any additional site be uncovered during construction, work will stop and the appropriate State and County officials notified. Work will resume upon approval of the State Preservation Officer and the Hawaii County Planning Department.

5.5 Existing Condition of the Ka'awaloa Parcel

The Ka'awaloa Parcel consists of an area approximately 70 acres in size situated inland of Pali-Kapu-O-Keoua, the 600-foot high seacliff behind Kealakekua Bay. The Ka'awaloa Parcel is bounded on the south by the Land of Kealakekua, a 195-acre portion of which is contained in the total project area and is discussed immediately above (the boundary is marked by an old stone wall), on the north by the Land of Keopuka, and to the east and west by lands within Ka'awaloa. The Ka'awaloa Parcel consists of rough a'a lava on the northern third of the property and dense vegetation consisting of thick ground cover and shrubs on the remaining property area.

During the survey, 44 sites containing 85+ component features were identified within or immediately adjacent to the project area (Figure 4-12). Although two of these sites (14184 and

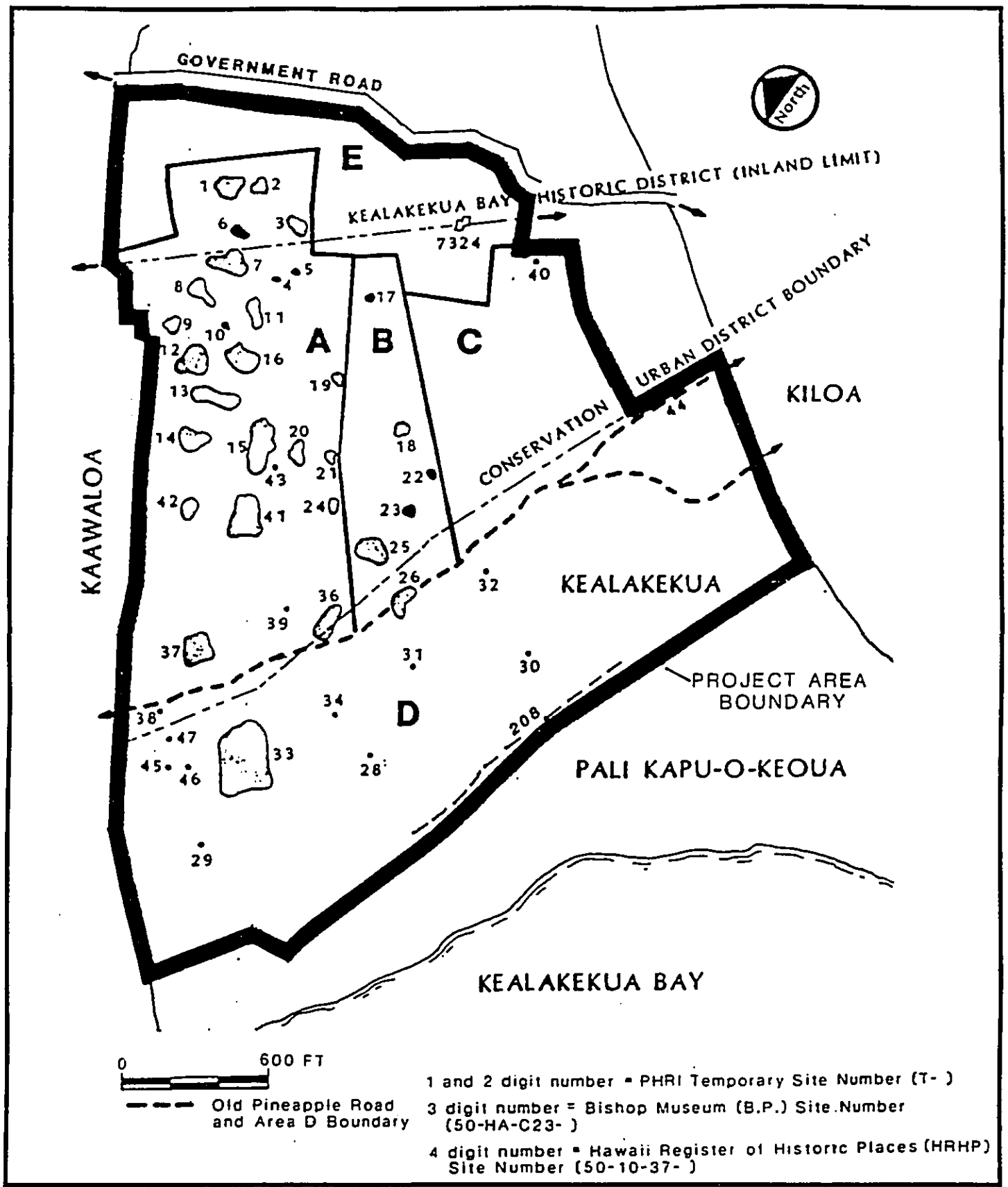


Figure 4-11
ARCHAEOLOGICAL SITES
ON MAKAI LANDS
Kealakekua Bay Club
South Kona, Hawaii

Prepared by: Belt Collins & Associates

TABLE 4-7:
SUMMARY OF GENERAL SIGNIFICANCE ASSESSMENTS AND RECOMMENDED GENERAL TREATMENTS

Site Number	Significance Category				Recommended Treatment			
	A	X	B	C	FDC	NFW	PID	PAI
1	+	-	-	-	+	-	-	-
2	+	-	-	-	+	-	-	-
3	+	-	-	-	+	-	-	-
4	+	-	-	-	+	-	-	-
5	+	-	-	-	+	-	-	-
6	+	-	-	-	+	-	-	-
7	+	-	-	-	+	-	-	-
8	+	-	-	-	+	-	-	-
Subtotal	**8**	**0**	**0**	**0**	**8**	**0**	**0**	**0**

General Significance Categories:

A = Important for information content, further data collection necessary (PHRI = research value)

X = Important for information content, no further data collection necessary (PHRI = research value, SHPO = not significant)

B = Excellent example of site type at local, regional, island, State, or National level (PHRI = interpretive value); and

C = Culturally significant (PHRI = cultural value).

Recommended General Treatments:

FDC = Further data collection necessary (intensive survey and testing, and possibly subsequent data recovery/mitigation excavations)

NFW = No further work of any kind necessary, sufficient data collected, archaeological clearance recommended, no preservation potential

PID = Preservation with some level of interpretive development recommended (including appropriate related data recovery work); and

PAI = Preservation "as is", with no further work (and possible inclusion into landscaping), or minimal further data collection necessary.

(Table 4-7 continued)

Site Number	Significance Category A	X	B	C	Recommended Treatment FDC	NFW	PID	PAI
9	+	-	-	-	+	-	-	-
10	+	-	-	-	+	-	-	-
11	+	-	-	-	+	-	-	-
14	+	-	-	-	+	-	-	-
15	+	-	-	-	+	-	-	-
16	+	-	-	-	+	-	-	-
17	+	-	-	-	+	-	-	-
18	+	-	-	-	+	-	-	-
19	+	-	-	-	+	-	-	-
20	+	-	-	-	+	-	-	-
21	+	-	-	-	+	-	-	-
22	+	-	-	-	+	-	-	-
24	+	-	-	-	+	-	-	-
28	+	-	-	-	+	-	-	-
29	+	-	-	-	+	-	-	-
30	+	-	-	-	+	-	-	-
32	+	-	-	-	+	-	-	-
34	+	-	-	-	+	-	-	-
38	+	-	-	-	+	-	-	-
42	+	-	-	-	+	-	-	-
43	+	-	-	-	+	-	-	-
45	+	-	-	-	+	-	-	-
Subtotal	**22**	**0**	**0**	**0**	**23**	**0**	**0**	**0**
12	+	-	-	*	+	-	-	*
13	+	-	-	*	+	-	-	*
25	+	-	-	*	+	-	-	*
31	+	-	-	*	+	-	-	*
36	+	-	-	*	+	-	-	*
39	+	-	-	*	+	-	-	*
41	+	-	-	*	+	-	-	*
46	+	-	-	*	+	-	-	*
47	+	-	-	*	+	-	-	*
Subtotal	**9**	**0**	**0**	**9**	**9**	**0**	**0**	**9**

*Provisional assessment, definite assessment pending further data collections (i.e., testing features for presence/absence of skeletal remains.

(Table 4-7 continued)

Site Number	Significance Category A	X	B	C	Recommended Treatment FDC	NFW	PID	PAI
26	+	-	+	-	+	-	?	?
37	+	-	+	-	+	-	?	?
44	+	-	+	-	+	-	-	+
208	+	-	+	-	+	-	?	?
209	+	-	+	-	+	-	?	?
Subtotal	**5**	**0**	**5**	**0**	**5**	**0**	**0**	**1**
33	+	-	+	+	+	-	+	-
7324#	+	-	+	*	+	-	?	?
Subtotal	**2**	**0**	**2**	**2**	**2**	**0**	**1**	**0**
23	-	+	-	-	-	+	-	-
40	-	+	-	-	-	+	-	-
205	-	+	-	-	-	+	-	-
Subtotal	**0**	**3**	**0**	**0**	**0**	**3**	**0**	**0**
Total	**46**	**3**	**7**	**11**	**46**	**3**	**1**	**1**

? Recommendation with regard to possible preservation deferred until completion of recommended further data collection

HRHP Site No. 50-10-37-7324

14189) are outside of the project area, they are included in this discussion for purposes of consistency with the report included in the appendix to this document. Of the 44 sites, 10 represent site complexes and 34 are identified as single-feature sites. The sites and complexes comprise a variety of formal feature types. The most common feature types are terraces (29). Other types included enclosures (9), walls (9), caves (7), modified sinkholes (1), mounds (6), linear alignments (4), modified outcrops (4), walled pavements (3), pahoehoe excavations (2), roads (2), foot trails (2), a platform, a rectangular boulder alignment, and an upright consisting of a pahoehoe slab placed in an upright position with its base supported by several cobbles. The overall physical condition and integrity of the sites varies from poor to good.

The most common functional feature type encountered was habitation (28 features), which are distributed throughout the project area, however, a greater number are located in a'a lava terrain

than in the larger vegetated area. The majority are thought to be prehistoric. Additional functional feature types include agriculture (19 features), agriculture/habitation (8 features), boundary (6 features), transportation (4 features), burial (3 features), possible burial (1), and other (6 features including two agricultural boundary features, two quarries-possible quarries, one indeterminate-possible marker, and one feature of indeterminate function. No features of an agricultural or agriculture/habitation are located in the lava terrain. All three of the burial features are caves located in the a'a lava, and contain a collective total of 22 identified burials.

Based on subsurface testing, the most likely age ranges of the two samples collected are 1380-1510 AD and 1470-1680 AD. This suggests that the Ka'awaloa Parcel was occupied as early as 1380 AD at Site 14158 and 1470 AD at site 14192. Occupation of both sites was apparently limited in duration as evidenced by the shallowness of the samples within the cultural deposits at each site.

5.6 Probable Impacts

As discussed in section 5.3, impacts to the features found within the project area would primarily be a loss of the features due to excavation and/or construction of the proposed project. Most of the potential direct impacts have been avoided through modification of the project design following the initial archaeological inventory. For those sites identified for possible preservation, impacts could also include increased human activity around and exposure to the sites. If any of the sites recommended for preservation cannot be incorporated into the project design (and fully protected), a data recovery plan and proper mitigation will be required.

Indirect impacts could occur on many features from the increased access to the area generated by the proposed development. However, for those sites incorporated into the project design, indirect impacts will be to a great degree mitigated by access control related to the operation of the golf course.

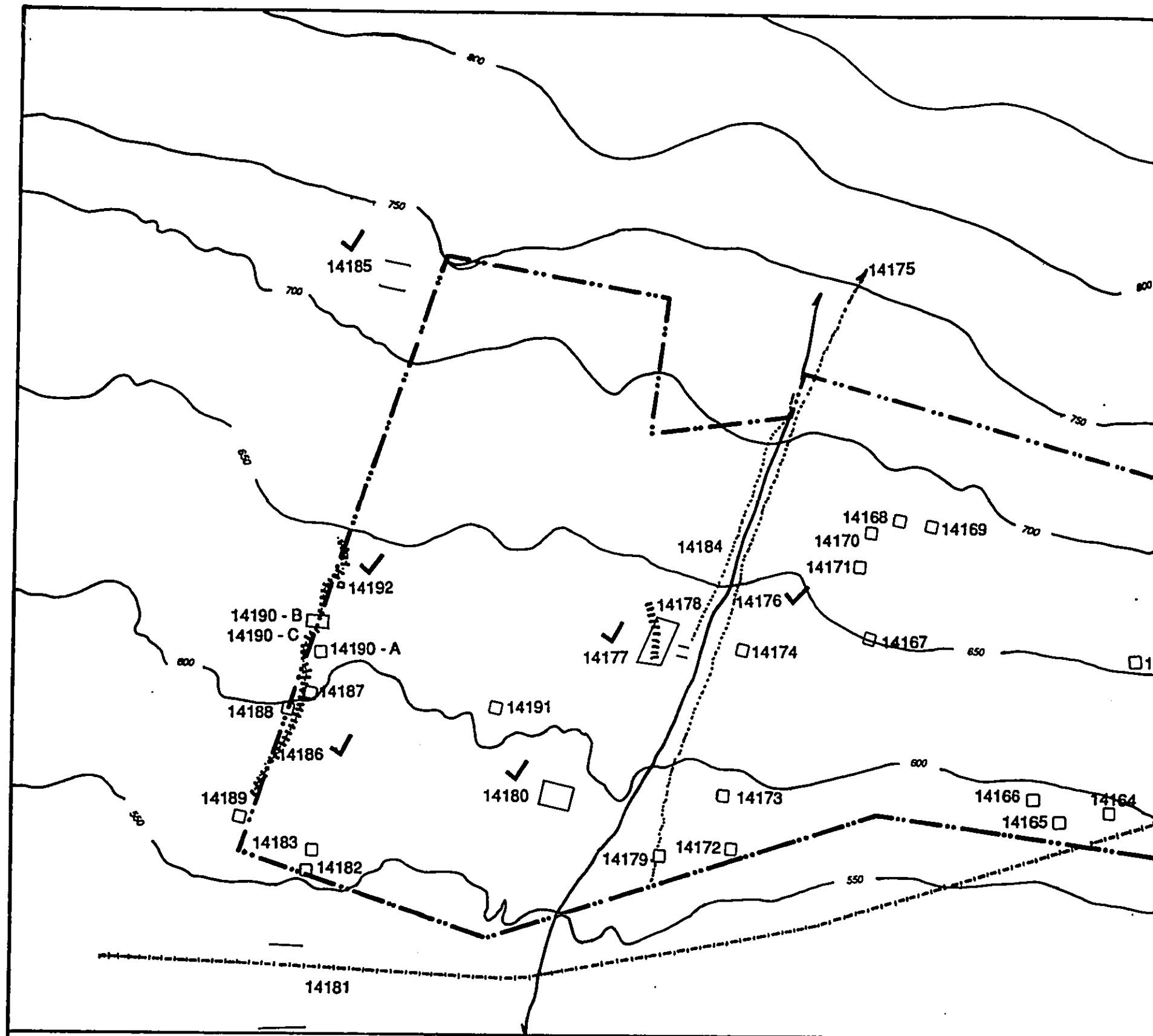
5.7 Mitigation Measures

5.7.1 Ka'awaloa Parcel

The significance of individual sites and features have been evaluated based on the definitions derived from the National Register of Historic Places criteria for evaluation (Table 4-8). The Hawaii State Historic Preservation Office also employs these criteria for evaluating cultural resources. Sites with potential cultural significance are evaluated under guidelines prepared by the Advisory Council on Historic Preservation (ACHP).

Of the 44 sites in the project area, 36 (81.8%) are assessed as significant solely for information content. Further data collection (detailed recording of sites and features, surface collection, and excavation) is recommended for 27 of these sites. After further data collection is completed, if further work is warranted, a data recovery plan for the work will be prepared and implemented for sites not recommended for preservation or interpretation. No further work is recommended for the remaining 9 of these 36 sites. Data collection from them during the present survey is considered sufficient; their preservation is not essential, although some sites could perhaps be considered for inclusion into development landscaping.

For the remaining 8 sites (18.2%), 5 are assessed as significant for scientific information content, are excellent examples of site types, and are culturally significant. For these five sites,



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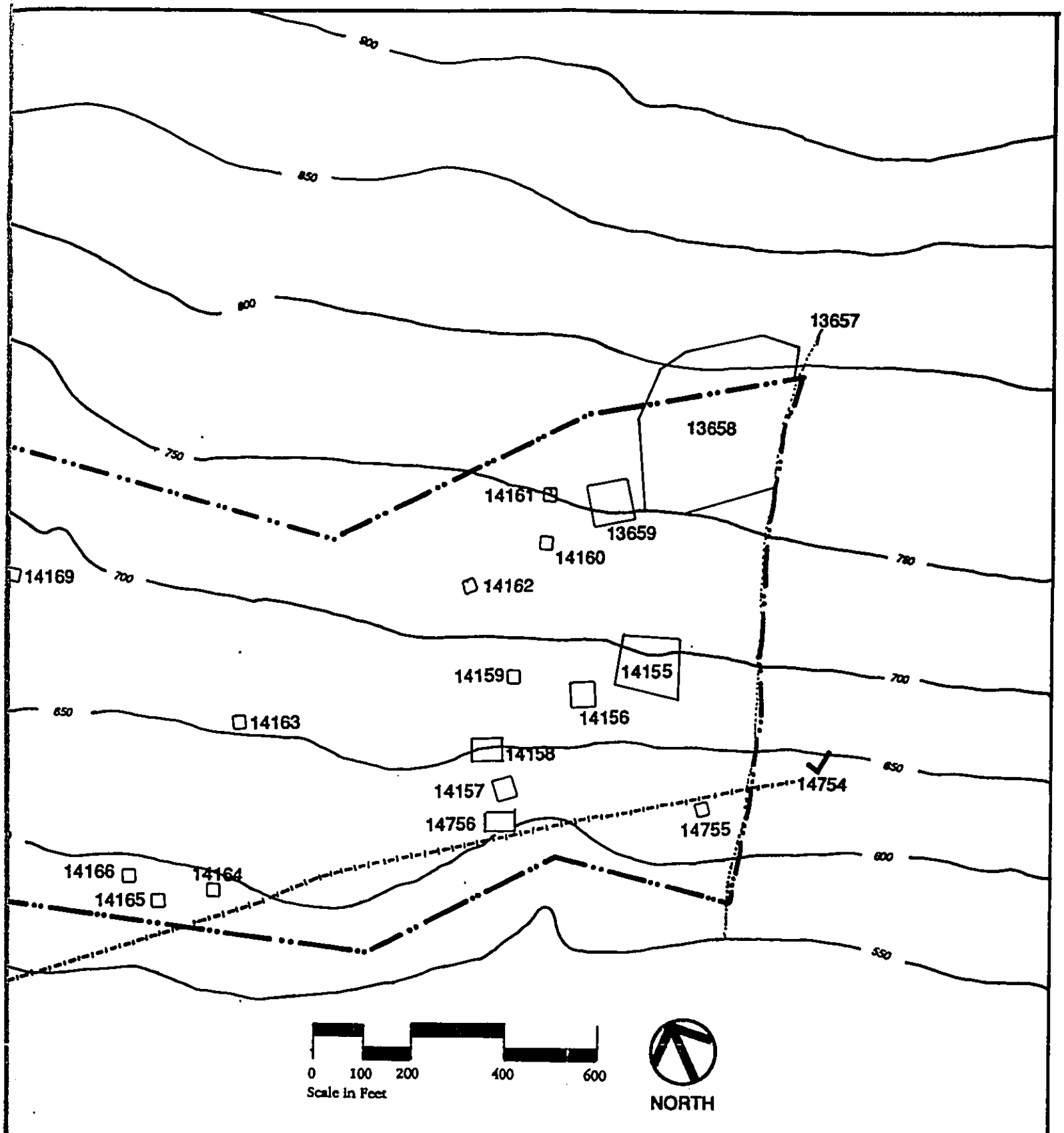


Figure 4-12
ARCHAEOLOGICAL SITES
ON KA'AWALOA PARCEL
Kealakekua Bay Club
South Kona, Hawaii

further data collection followed by preservation with some level of interpretive development is recommended. Because one of these sites contains a burial feature (Site 14180-E), it is recommended that the feature be preserved "as is" and not be interpreted or displayed. Two sites are assessed as significant for scientific information content and as culturally significant. For these two sites, further data collection is recommended. Because one of these two sites contains burials, following further data collection, preservation "as is" is recommended.

The final site is assessed as significant for information content and is tentatively evaluated as culturally significant. For this site, further data collection is recommended and preservation "as is" is tentatively recommended, pending further data collection results. This site may contain a burial. The sites recommended above for preservation area summarized in Table 4-8.

5.7.2 Kona Field System

Previous studies have recommended that portions of the Kona Field System in the general Kealakekua area be preserved, but they do not specify which areas. Undoubtedly, portions should be preserved, as the system was central to the social and economic development of North Kona. The portions to be preserved should be determined by the DLNR-HPP/SHPO. In the case of the present study, the Kona Field System as represented by the approximately 50 acres below the line of work will be preserved. However, because land-disturbing activities in the area are generally prohibited by its Conservation District classification, restoration of the area for traditional Hawaiian cultivation practices is not believed to be possible.

The golf course design and layout reflects the property owner's efforts to minimize impact upon those sites recommended for preservation. In general, the developer intends to maximize preservation of the garden complexes wherever practicable. If burials are determined to be present at any of the sites identified as possible burial sites, a treatment plan will be prepared and submitted to appropriate State agencies for approval prior to final disposition of the burials.

5.8 Existing Condition of Parcel 39

Parcel 39 consists of an area approximately 5.75 acres in size situated approximately 500 feet south of Napoopoo Road leading to Napoopoo and is bounded by stone walls on the north and east (see Figure 4-13). The east wall marks the boundary between Kiloa and Kealakekua ahupua'a. The west boundary adjoins the Kealakekua Ranch Makai Land Subdivision property; the Urban/Conservation District boundary adjoins the south boundary. The parcel has recently been used for cattle grazing and shows evidence of historic land alteration and disturbance. Although the overall aspect is of undulating, rocky, grass-covered terrain sloping seaward, ridges along the east and west boundaries of the property rise above the central area. There is a steep, sloping pile of boulders and dozer-push in the northwest corner of the parcel. The terrain near the northeastern corner consists of a number of high knolls sloping south and west from the boundary wall. Divisions within the parcel are marked by several historic stone walls.

During the survey, 15 sites containing 20 component features were identified. Of the 15 sites, three are multiple feature complexes, and the remaining 12 sites are single features. The twenty identified features comprise five formal feature types and four functional categories. The most common feature types are terraces (8). Other types included walls (6), mounds (3), roads (2), and a single platform.

TABLE 4-8:
SUMMARY OF GENERAL SIGNIFICANCE ASSESSMENTS AND RECOMMENDED GENERAL TREATMENTS

Site Number	Significance Category				Recommended Treatment			
	A	X	B	C	FDC	NFW	PID	PAI
13657	-	+	-	-	-	+	-	-
14159	-	+	-	-	-	+	-	-
14162	-	+	-	-	-	+	-	-
14165	-	+	-	-	-	+	-	-
14166	-	+	-	-	-	+	-	-
14172	-	+	-	-	-	+	-	-
14182	-	+	-	-	-	+	-	-
14187	-	+	-	-	-	+	-	-
14191	-	+	-	-	-	+	-	-
Subtotal	**0**	**9**	**0**	**0**	**0**	**9**	**0**	**0**

General Significance Categories:

A = Important for information content, further data collection necessary (PHRI = research value)

X = Important for information content, no further data collection necessary (PHRI = research value, SHPO = not significant)

B = Excellent example of site type at local, regional, island, State, or National level (PHRI = interpretive value); and

C = Culturally significant (PHRI = cultural value).

Recommended General Treatments:

FDC = Further data collection necessary (intensive survey and testing, and possibly subsequent data recovery/mitigation excavations)

NFW = No further work of any kind necessary, sufficient data collected, archaeological clearance recommended, no preservation potential

PID = Preservation with some level of interpretive development recommended (including appropriate related data recovery work); and

PAI = Preservation "as is", with no further work (and possible inclusion into landscaping), or minimal further data collection necessary.

(Table 4-8 continued)

Site Number	Significance Category A	X	B	C	Recommended Treatment FDC	NFW	PID	PAI
13658	+	-	-	-	+	-	-	-
13659	+	-	-	-	+	-	-	-
14155	+	-	-	-	+	-	-	-
14156	+	-	-	-	+	-	-	-
14157	+	-	-	-	+	-	-	-
14158	+	-	-	-	+	-	-	-
14160	+	-	-	-	+	-	-	-
14161	+	-	-	-	+	-	-	-
14163	+	-	-	-	+	-	-	-
14164	+	-	-	-	+	-	-	-
14167	+	-	-	-	+	-	-	-
14168	+	-	-	-	+	-	-	-
14169	+	-	-	-	+	-	-	-
14170	+	-	-	-	+	-	-	-
14171	+	-	-	-	+	-	-	-
14173	+	-	-	-	+	-	-	-
14174	+	-	-	-	+	-	-	-
14175	+	-	-	-	+	-	-	-
14178	+	-	-	-	+	-	-	-
14179	+	-	-	-	+	-	-	-
14181	+	-	-	-	+	-	-	-
14183	+	-	-	-	+	-	-	-
14184	+	-	-	-	+	-	-	-
14188	+	-	-	-	+	-	-	-
14189	+	-	-	-	+	-	-	-
14190	+	-	-	-	+	-	-	-
14756	+	-	-	-	+	-	-	-
Subtotal	**27**	**0**	**0**	**0**	**27**	**0**	**0**	**0**
14176	+	-	+	+	+	-	+	-
14177	+	-	+	+	+	-	+	-
14180	+	-	+	+	+	-	+	-
14186	+	-	+	+	+	-	+	-
14754	+	-	+	+	+	-	+	-
Subtotal	**5**	**0**	**5**	**5**	**5**	**0**	**5**	**0**

(Table 4-8 continued)

Site Number	Significance Category A	X	B	C	Recommended Treatment FDC	NFW	PID	PAI
14185	+	-	-	+	+	-	-	+
14192	+	-	-	+	+	-	-	+
Subtotal	**2**	**0**	**0**	**2**	**2**	**0**	**0**	**2**
14755	+	-	-	*	+	-	-	*
Subtotal	**1**	**0**	**0**	**1**	**1**	**0**	**0**	**1**
Total	**35**	**9**	**5**	**8**	**35**	**9**	**5**	**3**

* Provisional assessment; definite assessment pending further data collection.

The most common functional feature type encountered was agriculture (9 features). Additional functional feature types include land division/boundary (6 features), possible habitation (3 features), and transportation (2 features).

The eight terraces identified represent 40% of the features identified during the survey. Six of the terraces are small agricultural features; the two larger terraces (Site 14972 A and D) have been assigned possible habitation functions. The six historic walls comprise 30% of the identified features. All are double-faced, have core-filling, and range in condition from excellent to poor. Four of the walls appear to have functioned as dividers within the project area. Sites 14967 and 14970 are mauka-makai walls that may have extended northeast-southwest across the length of the project area at one time. All stones from the northeast ends of the walls appear to have been removed. The southwest wall ends near Site 14973, a wall that begins at the west boundary and spans the project area c. east-west. Site 14965 extends 35.0 meters east from wall 14967 and stops about 15 meters from the west boundary line. Site 14968 abuts the ahupua'a wall at the east boundary and extends west along approximately two-thirds of the northern project boundary.

Three of the remaining six sites ware boulder and cobble mounds (Sites 14966, 14971 and 14972 B) that were identified as probable agricultural features. These mounds of loosely piled boulders and cobbles have no aligned perimeter stones, paving, or facings. No coral or waterworn stones were present at any of the three features.Sites 11481 and 14977 are elevated roadways associated with pineapple cultivation in the area during the early part of the century. Both roads cross the southern boundary and intrude a short distance into the project area.

Site 14969, a possible habitation, is the only platform identified during the survey. One piece of weathered branch coral, at Site 14972 feature D, was the only manuport identified with the survey area. No surface midden was noted at any location during the survey and no substantial cultural deposits were identified during test excavations. Three sites located south of the project boundary (877-18, 877-19, 877-20) were recorded but are not included as part of this report and

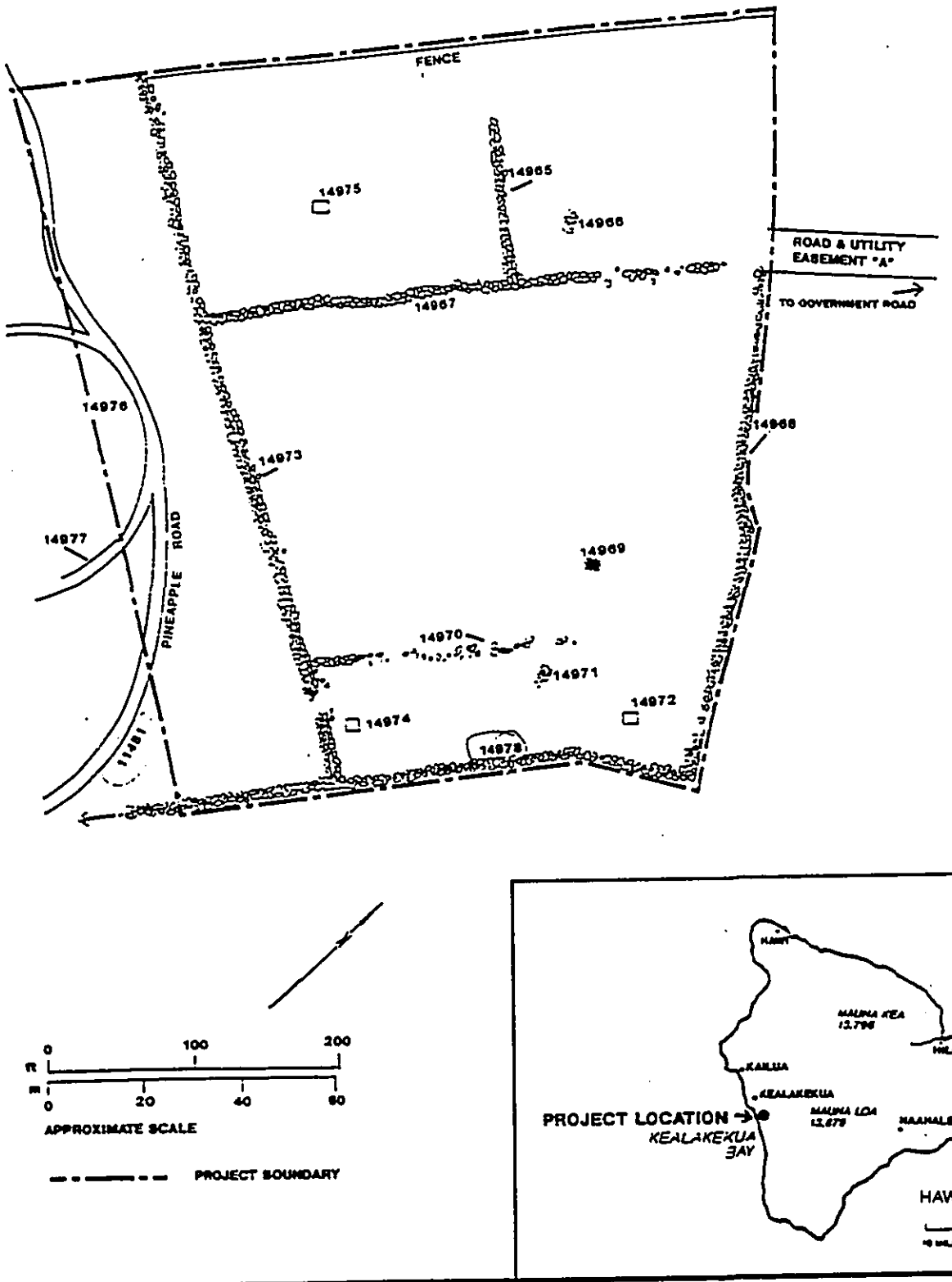


Figure 4-13
ARCHAEOLOGICAL SITES
ON PARCEL 39
Kealakekua Bay Club
South Kona, Hawaii

Prepared by: Belt Collins & Associates

were not assigned SIHP site numbers. The sites were not identified during an earlier survey of the property adjoining the south and west boundaries of parcel 39 (Kaschko and Rosendahl 1987).

The results of an age determination analysis indicate that the project area was occupied during prehistoric times, possibly as early as AD 1390 at Site 14972. While no charcoal samples were recovered from Sites 14969 and 877-18, the presence of volcanic glass flakes at these sites suggest that they were occupied during the prehistoric period, because volcanic glass flakes ceased in the Hawaiian islands after approximately 1790 AD.

5.9 Probable Impacts

As discussed earlier, impacts to the features found within the project area would primarily be a loss of the features due to excavation and/or construction of the proposed project. Most of the potential direct impacts have been avoided through modification of the project design following the initial archaeological inventory. For those sites identified for possible preservation, impacts could also include increased human activity around and exposure to the sites. If any of the sites recommended for preservation cannot be incorporated into the project design (and fully protected), a data recovery plan and proper mitigation will be required. Indirect impacts could occur on many features from the increased access to the area generated by the proposed development. However, for those sites incorporated into the project design, indirect impacts will be to a great degree mitigated by access control related to the operation of the golf course.

5.10 Mitigation Measures

The significance of individual sites and features have been evaluated based on the definitions derived from the National Register of Historic Places criteria for evaluation (Table 4-9). The Hawaii State Historic Preservation Office also employs these criteria for evaluating cultural resources. Sites with potential cultural significance are evaluated under guidelines prepared by the Advisory Council on Historic Preservation (ACHP).

Eleven of the 15 sites in the project area (73.3%) are assessed as significant solely for information content. Further data collection is recommended for these sites. After further data collection is completed, it is expected that no additional work will be necessary for these sites.

Two of the four the remaining sites (11481 and 14978) are assessed as significant for information content and are excellent examples of site types. For these two sites, further data collection followed by preservation "as is" is recommended. No further work is recommended for the remaining two sites (14966 and 14969). Information recorded during the present survey is considered sufficient to have fully documented these sites.

TABLE 4-9:
SUMMARY OF GENERAL SIGNIFICANCE ASSESSMENTS AND RECOMMENDED GENERAL TREATMENTS

Site Number	Significance Category				Recommended Treatment			
	A	X	B	C	FDC	NFW	PID	PAI
14965	+	-	-	-	+	-	-	-
14967	+	-	-	-	+	-	-	-
14868	+	-	-	-	+	-	-	-
14971	+	-	-	-	+	-	-	-
14970	+	-	-	-	+	-	-	-
14972	+	-	-	-	+	-	-	-
14973	+	-	-	-	+	-	-	-
14974	+	-	-	-	+	-	-	-
14975	+	-	-	-	+	-	-	-
14976	+	-	-	-	+	-	-	-
14977	+	-	-	-	+	-	-	-
Subtotal	**11**	**0**	**0**	**0**	**11**	**0**	**0**	**0**
14966	-	+	-	-	-	+	-	-
14969	-	+	-	-	-	+	-	-
Subtotal	**0**	**2**	**0**	**0**	**0**	**2**	**0**	**0**
11481	-	+	-	-	+	-	-	+
14978	-	+	-	-	+	-	-	+
Subtotal	**0**	**2**	**0**	**0**	**2**	**0**	**0**	**2**
Total	**11**	**4**	**0**	**0**	**13**	**2**	**0**	**2**

General Significance Categories:

A = Important for information content, further data collection necessary (PHRI = research value)

X = Important for information content, no further data collection necessary (PHRI = research value, SHPO = not significant)

B = Excellent example of site type at local, regional, island, State, or National level (PHRI = interpretive value); and

C = Culturally significant (PHRI = cultural value).

Recommended General Treatments:

FDC	=	Further data collection necessary (intensive survey and testing, and possibly subsequent data recovery/mitigation excavations)
NFW	=	No further work of any kind necessary, sufficient data collected, archaeological clearance recommended, no preservation potential
PID	=	Preservation with some level of interpretive development recommended (including appropriate related data recovery work); and
PAI	=	Preservation "as is", with no further work (and possible inclusion into landscaping), or minimal further data collection necessary.

Chapter V:
SOCIOECONOMIC FACTORS

CHAPTER V - SOCIOECONOMIC FACTORS

1. SOCIAL IMPACTS

1.1 Existing Population

The project area lies just south of the boundary between North and South Kona and immediately makai of the community of Captain Cook. Between 1970 and 1980, South Kona's population grew from 4,004 to 5,914 with an annual average change of about 4.0 percent. Between 1980 and 1990, the district's population growth slowed to an average annual rate of about 2.9 percent resulting in a 1990 population of 7,658. This trend appears to have remained constant through 1990, when the population of South Kona was calculated to be 7,658 persons. In 1970, the community of Captain Cook constituted 31.5 percent of South Kona's total population. In 1980, Captain Cook's population represented 33.9 percent of the district's total. By 1990, the community's population was 33.8 percent of the total district's, essentially unchanged from 1980.

1.2 Existing Employment

In 1970, the potential labor force (age 16+) for South Kona was 2,629 and the actual civilian labor force was 1,535. This reflects a weighted average for labor force participation of about 57 percent, according to the U.S. Bureau of the Census. Data for the community of Captain Cook is unavailable for 1970 and 1980. Between 1970 and 1980, the potential labor force of South Kona grew to 4,265, an increase of about 62 percent. During the same period, the civilian work force, or the actual number of workers, grew by 1,288 persons, an increase of nearly 84 percent. The weighted average labor force participation rate increased to 76.5 percent. This increase is due to a number of potential factors. The most likely is that fact that labor force participation among females increased by nearly 11 percent (from 44.7 percent to 55.3 percent). For men the increase was smaller, just under 7 percent.

Unemployment figures for Hawaii county indicated an average rate of 3.8 for 1990, less than two-thirds of the 1980 County unemployment rate. Within the South Kona district, unpublished average 1990 estimates provided by the Department of Labor and Industrial Relations show a 3.2 percent unemployment rate, .6 percent less than the county as a whole.

County job losses between 1980 and 1990 occurred only in the manufacturing sector, while significant increases in jobs were noted in the areas of retail trade, services, finance, insurance and real estate. Since 1986, construction employment in the county has also increased greatly. The Hyatt Regency Waikoloa Hotel spurred construction employment, which has been sustained through increases in residential, commercial and industrial development elsewhere in the West Hawaii region. In addition, several other major developments to be built in the west Hawaii region should further strengthen the county's construction labor pool in the years ahead.

1.3 Issues and Concerns

Since June, 1990 project representatives have met with community leaders, organizations and neighbors to discuss the project and provide a forum for comments. Major concerns and issues related to the project during these meetings and from other sources can be grouped into five topics:

- drainage and pesticide or fertilizer runoff and its impact on Kealakekua Bay
- increased traffic and its impact upon the intersection of Napoopoo Road and Mamalahoa Highway
- public access to the overlook above Kealakekua Bay
- the potential for future development on site (hotel or residential subdivision)
- views of the project from adjacent areas

The most significant concern expressed about the project is speculation about its impact upon the fragile environment of Kealakekua Bay. Concerns have been voiced that pesticides and fertilizers used on the propose golf course will leach into the groundwater and eventually find their way into the bay. This same concern has been also expressed as a fear that development of the project area will increase the likelihood of runoff from the project, as well as the Ke Nui subdivision upslope, impacting the bay.

Of almost equal concern, especially among residents of the Napoopoo area, is the hazardous condition of the existing intersection of Napoopoo Road with Mamalahoa Highway. As designed, Napoopoo Road takes a sharp right-hand curve uphill immediately before terminating at Mamalahoa Highway. Because the intersection is located on a curve, sight distance in both directions of Mamalahoa Highway is limited. In addition, there are no deceleration lanes or stacking lanes on the highway to separate vehicles desiring to enter Napoopoo Road from the general traffic stream. The result is that a single vehicle making a left hand turn from the highway on to Napoopoo Road can result in a queue of up to 20 or more vehicles forming within minutes. In addition, medium sized delivery vehicles making this left hand turn have been observed making two or more attempts at turning on to Napoopoo Road due to the severity of its downhill curve. It is feared that the development of the project site will contribute to traffic congestion on Napoopoo Road which will result in even a greater number of vehicles utilizing the intersection and an increase in an already hazardous condition.

Ka'awaloa Road connects Napoopoo Road to the large peninsula (Cook Point) adjacent to Kealakekua Bay and represents the only mauka-makai access to the Captain Cook monument. Although it the road is restricted to 4-wheel drive vehicles it is used regularly by residents and visitors as an access to Cook Point. Because the road crosses a portion of the project area, concerns have been raised that access to the point and use of the road may be impacted.

Because the existing zoning for the subject property would permit up to 36 single family residences, many area residents view the proposed golf course and lodge as far more acceptable development alternative. However, concerns have been expressed that the proposed golf course might eventually be replaced by a residential subdivision, or that the lodge might eventually become a full-sized hotel.

Concerns have also been raised about the potential impact of the project upon coastal views, especially from adjoining properties. Some neighboring property owners are concerned that once the existing vegetation is cleared and the golf course is constructed, the proposed lodge may block views to the ocean.

Additional concerns raised include the loss of agricultural land resulting from development of the project, the desire to preserve the existing rural character of South Kona by restricting development in general, and the belief that improvement or development of one parcel will open the door to future subdivision and/or development of surrounding parcels.

1.4 Probable Social Impacts
1.4.1 Quantitative Impacts
1.4.1.1 Population

The County of Hawaii projects that population in the South Kona district will increase by about 6,000 persons over the next ten years to a total of 13,671. This represents a 78 percent increase. A review of residential projects currently planned for the general region of South Kona indicates that approximately 375 new housing units are presently planned for construction. Assuming all 375 units are developed before the year 2010, an additional 1,076 persons would be added to the population solely on the basis of existing development proposals. The actual future population is likely some figure between the county's projection and the result of development proposals.

The on-site population impacts of the proposed project can be considered to be the result of three sources:

- Visitors - Daytime visitors to the Club would be those using the golf course, non-golfing guests of the members, and visitors and residents who dine at the restaurant. Based on assumptions involving the projected number of rounds and the number of non-golfing quests, the average daily on-site visitor population is projected to be about 120 persons by 1995, increasing to 125 persons by project stabilization in 1996.

- Residents - Resident population at Kealakekua resulting from the development of a two homes by 1995 is 6 persons, with a total of 14 persons resulting from by assumed build-out of all five homes by 1997.

- Employees - Operational and construction employees would add to the on-site population on a daily basis and most are expected to commute from other parts of the island. The on-site operational employee impact could amount to 80 persons in 1995 and a total of 95 persons in 1997.

Direct construction workers will also impact the daily on-site population. This impact is expected to increase to about 186 employees during peak periods of construction activity and to decrease significantly over the development period as the majority of construction is completed.

In summary, facility development at Kealakekua is projected to generate a de facto (daytime population consisting of permanent residents + visitors) population increase of about 51 persons in 1993, increasing to about 240 persons by 1997. These impacts would be initially a result of construction activity on-site, and later due principally to daytime visitor use of the Club.

The project's impacts on the island's population may also be considered in terms of visitor and resident populations. In contrast to on-site effects, impacts of the development on the population of the island of Hawaii are expected to be driven principally by resident population changes. The majority of daytime visitors to the site are anticipated to be persons who would have been on the island whether or not the Kealakekua Bay Club had been established. An exception to this might be international Club members who are attracted to or aware of the island of Hawaii principally because of the Kealakekua Bay Club. Thus, from the island perspective, the project's visitor population impacts are assumed to consist of visiting international Club members and their

golfing and non-golfing guests. This is estimated to represent about 25 persons on an average day, once Club operations are established.

On-site residents of the five lots are assumed to be prior residents of the island. Thus, the resident population impacts of the development for Hawaii island would consist of construction and operational employees who move to the island because of employment opportunities at the Club.

It is estimated that about 30% of the direct construction employment will be filled by off-island workers, and each worker is anticipated to bring approximately .5 dependents. Thus, the in-migrant construction population could represent about 22 persons in 1993, peak at 84 persons in 1994 and decrease to about 32 persons in 1997 as construction is completed.

In total, the projected population impacts of the development for the island of Hawaii are expected to amount to about 23 persons in 1993, peaking at about 93 in 1995, and then stabilizing at about 84 persons by 1997.

Population impacts to the state would be less than those for the island, because many of those employees moving to the island of Hawaii may be assumed to have been prior residents of other parts of the state. Even those visitors who were new to the island could be likely to have been already familiar with the state, and to have visited even without development of the project.

About 25% of those international members assumed to visit the island of Hawaii because of the development could be estimated to be visitors who might not have come to the state if the Kealakekua project were not established. Including their guests, this could represent fewer than 10 persons on an average day.

Residents of the project's five home sites were assumed to be prior island and thus state residents, and the construction labor force required for the project is assumed to be satisfied from within the state's labor pool. Thus, the Club's impacts on the resident population of the state would consist of those operational employees who move from out-of-state because of the employment opportunities at the development. Based on the skills required to operate a golf club catering to international and local members, it is assumed that this could represent about 20% of projected operational employment requirements of the Club, or about 11 persons by 1997.

1.4.1.2 Employment

Planned development will generate short-term employment during the construction of new facilities and long-term employment in the operation and support of those facilities. Employment effects may also be classified as being direct, indirect or induced. Direct employment is that supported by expenditures at the Club, such as those at the golf course and restaurant. Most of the direct employment effects would occur at Kealakekua. As for expenditures, however, indirect and induced employment resulting from the project may be supported supported throughout the state's economy.

<u>Direct Construction Employment</u>

Direct construction employment is that which would be supported directly by the construction of the planned facilities. Such employment includes on-site laborers, operatives and

craftsmen, as well as the professional, managerial, sales and clerical workers whose usual places of employment may be elsewhere on the island or in the state.

Construction employment would be highest during 1994, before facilities are operational, when the major portion of the infrastructure, golf course and residential lots are being graded and/or constructed. Direct construction employment is estimated to range from about 50 person-years in 1993 and peak at just under 200 person-years in 1994.

Indirect and Induced Construction Employment

The direct employment of construction workers at the development will stimulate additional employment on the island and elsewhere in the state. Based upon data from DBED, it is estimated that 2.03 full-time jobs are created in the state for every full-time job in the construction industry. This multiplier is used to project the indirect and induced employment to be supported by the direct construction employment. As with direct construction employment, the greatest employment would occur in 1994, when indirect and induced construction employment effects are expected to provide employment opportunities for nearly 400 person-years. Indirect and induced construction employment would then decline to about 10 person-years in 1997.

Total Construction Employment

Total direct, indirect and induced operational employment is estimated to represent over 140 positions in the initial stages of development and peak to well over 550 employees by 1995. As construction is completed, the construction employee population will decrease to an estimated 17 employees by 1997.

Direct Operational Employment

The majority of direct operational employment at the development would occur at the golf course which, based on comparable golf courses in Hawaii, is estimated to employ between 40 to 50 full-time equivalent direct employees. The clubhouse is projected to employ between 25 and 30 people. Employment at the proposed lodge is estimated to average about 13 direct employees. Two full-time equivalent positions have been allocated to administration, marketing and public relations. Thus, the project could be expected to have generated about 80 full-time equivalent direct operational positions by 1995 and about 95 full-time equivalent positions at stabilization in 1997.

Indirect and Induced Operational Employment

Facility operations at Kealakekua would also indirectly generate employment elsewhere in the state. Recent studies on the total economic impacts of direct, indirect and induced employment multipliers in the hotel and other services industries by the DBED suggest that the activities at the Bay Club could be expected to support .68 indirect and induced full-time equivalent positions elsewhere in the state for each direct job created at the golf course and clubhouse and .93 indirect and inducted full-time equivalent positions as a result of the lodge employment. Thus, the indirect and induced operational employment could be expected to amount to about 55 full-time equivalent positions by 1995 and about 65 full-time positions by 1997.

Total Operational Employment

Total direct, indirect and induced operational employment is estimated to represent over 130 full-time equivalent positions by 1995, increasing to slightly over 160 positions by 1997.

1.4.1.3 Housing

Development of the Kealakekua Bay Club could affect West Hawaii's housing situation in several ways. Temporary housing could be needed to house workers brought to the island during project construction. Operational employment at the community could also trigger additional housing demand, to accommodate in-migrant employees and their dependents.

Construction employment is temporary, and therefore does not generate the long-term housing demands associated with Club operational employment. In-migrating construction workers could be expected to seek short to medium term rental units in the general market. It is assumed that an average of 30% of construction workers would have to be attracted from off-island, and that construction workers would share housing at a ratio of 1.25 people per household. Thus, the average daily unit requirements for construction workers could range from about 18 units when the project begins in 1993 to 67 units at maximum development activity in 1994. Thereafter, these temporary housing needs could decline to become almost negligible, as the project is built-out. The majority of this demand could be expected to be for rental units. Because of the nature of labor needs during development of real estate projects, construction employment could fluctuate significantly from month-to-month and even week-to-week within any year. Thus, considering the anticipated timing of individual construction projects within the Kealakekua golf course development, the associated temporary housing needs could represent up to about 120 units during peak activity weeks in the 1993 to 1996 period.

Kealakekua Bay Club operational employees and their dependents who come from off-island would require long-term housing on the island. Also, new household formation among prior island residents who work at the project could create demands for new housing units. About 30% of permanent positions at the project could generate in-migration to the island. Based on employment needs, it is anticipated that about 28 new units will be required for in-migrant operational employees and their dependents by 1995 and grow to about 33 units as the Club becomes fully operational in 1997. This assumes that operational employees have one dependent per worker and housing demand is assessed at 1.7 people per household. It is assumed that the majority of these in-migrant operational employees will also seek rental units.

1.4.2 Qualitative Impacts

Full development of the project by 1997 will impact the social character of the area, largely through the provision of new employment opportunities in the Kealakekua area. Residents of the area who now must commute north to Keauhou, Kailua-Kona, or resort developments in North Kona and South Kohala, will have the opportunity to seek employment in Kealakekua. Because the proposed golf course will require many operational positions which would benefit from agricultural experience, the project is seen as a viable source of employment for the agricultural-oriented community. It is expected that the quality of life will improve for Kealakekua area residents who are employed at the project because potential commuting times will be reduced and more time will be available to spend in the immediate vicinity of their home and community.

On a community wide scale, although the project will result in an increase in traffic volumes on Napoopoo Road, improvements proposed for the road's intersection with Mamalahoa Highway will render access to the project much safer than present conditions. The result will be a general improvement to the character of the community in terms of traffic circulation.

1.4.3 Impacts on Nearby Areas and Activities

1.4.3.1 Residential Areas

Negative impacts related to day-to-day operations of the Kealakekua Bay Club upon surrounding residential properties are not anticipated. Surrounding residences will be virtually unaware of activities occurring on the golf course, in the lodge, or at the project's various support facilities. The arrival and departure of members and guests, as well as delivery and service vehicles, from the project area will not be generally discernible from the existing traffic stream, especially in light of the fact that traffic flow is dispersed throughout the day rather than concentrated at a particular time. Construction activity at the golf course will impact surrounding residences with increased noise levels related to the operation of construction equipment. However, these noise levels are considered to be within acceptable limits established by the Department of Health and are, therefore, not considered to be significant. The result will be that the project's general impact upon surrounding residences will be negligible.

1.4.3.2 Commercial Areas

The proposed project is expected to have a positive impact upon the commercial activities in the area, especially Captain Cook. Operation of the lodge and its food and the golf club will require support from local businesses, in the way of increased purchases of wholesale and retail goods. International club members represent a new source of revenue to local merchants. During construction of the project, construction workers on-site also represent increased sources of revenue for the community's commercial establishments. Because the project is relatively different for the community, it will not compete with existing businesses in the area. Thus, its impacts are viewed as positive.

1.4.3.3 Other Nearby Property and Activities

Properties and activities not immediately abutting the project site will not be impacted by the project due to its location and relative small size. The activities of visitors to the Kealakekua Bay State Historical Park will not be impacted by the project because it is located far above the park at the top of the pali. Hikers and similar outdoor enthusiasts will be positively impacted by the proposed development through its provision of hiking trails and an overlook at the top of the pali.

2. FISCAL IMPACTS

The following information is derived from an Economic and Fiscal Impact Assessment for the Kealakekua Bay Club, prepared by the firm of KPMG Peat Marwick, which appears as an appendix to this environmental impact statement.

The proposed project is expected to generate significant positive fiscal benefits for the county of Hawaii and for the state of Hawaii. These fiscal impacts have been evaluated by comparing tax revenues and operating expenditures that are projected to be incurred by the state and county governments.

2.1 Government Revenues

County government revenues would be principally in the form of real property taxes on the new facilities. Revenues to the state government would be composed principally of general and specific excise taxes, personal income taxes paid by new state residents, general excise tax on sales revenues attributable to visitors to the community and transient accommodations tax on lodge room sales. This section projects the additional revenues that could be generated for the county and state governments as a result of the recreational-oriented development.

2.1.1 County Revenues

Real property in the county is currently taxed from $8.50 to $10.00 per $1,000 of assessed value depending on the land use class. Golf courses are currently taxed at the agricultural-zone rate of $10.00 per $1,000 assessed value, while commercial tax rates of $8.50 per $1,000 assessed value are applied to golf clubhouses, their surrounding lands and their related facilities.

Net additional real property taxes were projected according to assessed values for other comparable golf club facilities in the state, projected sales prices of the residential components, and estimated land value, less the current property taxes generated by the undeveloped site. Based on these tax rates and estimated assessed values, the proposed private club, golf course, lodge, lots, homes and other land could be expected to generate net new property tax revenues for the county of Hawaii of about $250,000 per year by 1995, and $270,000 per year at stabilization, in 1991 dollars.

2.1.2 State Revenues

Net revenues to the state government would be generated by the 4.167% general excise tax on direct expenditures by consumers at Kealakekua Bay Club. Also, those staying at the lodge could generate an additional 5.25% revenue from room rentals. In addition, new residents attracted to the state by the employment opportunities of the project would be associated with additional excise tax sales taxes, individual income taxes and other state taxes such as liquor, tobacco, fuel, inheritance, estate and conveyance taxes.

Using state tax receipts in fiscal 1989 and adjusting for inflation to 1991 dollars, individual income and other taxes mentioned above averaged $3,950 per state resident. As a result, total new tax revenues to the state government attributable to the project's development are expected to increase from $90,000 in 1993 to about $310,000 per year at stabilization by 1997, in 1991 dollars.

2.2 Government Operating Expenditures

New visitors and residents attracted by the project would also necessitate additional expenditures of state and county public resources. In-migrant residents would incur public costs in terms of public safety, maintenance of highways, recreational facilities and natural resources, health and sanitation measures, special cash capital improvements, education, retirement and pension funds, public welfare and other government functions.

Visitors attracted to the island by the Club may be expected to be principally the international members and their guests. Domestic club members, their guests and other visitors

who golf at the Club, are anticipated to be prior island residents or visitors who would be on the island even without the Kealakekua Bay Club. Therefore, the international Club members and their guests would increase the average daily population of the island and in some cases the state, requiring public expenditures in terms of public safety, maintenance of highways, health and sanitation, recreation and special cash capital improvements.

2.2.1 County Expenditures

The various county government operating expenditures for fiscal year 1989 were analyzed with respect to the relevant population served by each of the government functions. This analysis indicates that the county of Hawaii government expenditures in 1989 totaled about $614 per resident and $399 per visitor. When adjusted for inflation and presented in terms of 1991 dollars, the equivalent expenditures are about $682 per capita for residents and $443 for visitors. Based on these county government outlays, public expenditures by the county on behalf of the service population for the Kealakekua Bay Club could be expected to total about $20,000 in 1993, rise to about $60,000 in 1994 when the peak number of construction workers is expected to temporarily relocate to the island, and then stabilize at about $50,000 per year by 1997, in 1991 dollars.

2.2.2. State Expenditures

A similar analysis of state government operating expenditures and the relevant populations for the various government services indicate that expenditures in 1989 totaled about $2,887 per resident and $837 per visitor. This is equivalent to about $3,206 per resident and $930 per full-time equivalent visitor when adjusted upwards to bring the amounts to 1991 dollars.

Many of the persons expected to move to the island because of the project would be expected to be prior state residents, such as those moving from Oahu. Thus, the net additional population impact to the state would be less than that to the island. This analysis assumes that all construction workers come from within the state's labor pool, 80% of operational employees who move to the island of Hawaii move from elsewhere within the state, and 25% of international Club members and their guests would not have visited the state if the project were not developed.

Based on these operating costs, state government expenditures attributed to the project's population impacts are projected to total approximately $40,000 per year by 1995 and to increase to about $50,000 per year by 1997.

2.3 Revenue and Expenditure Analysis

The net fiscal impacts of the planned development to the county and state operating budgets are estimated by comparison of the projected revenues and expenditures.

2.3.1 County Cost/Benefit

Comparison of projected public revenues and expenditures attributable to the project's development indicates that the county government could expect to net an additional $190,000 per year by 1995 and $220,000 per year by 1997 and thereafter, in 1991 dollars. The analysis also indicates that additional county government revenues generated by the proposed project at completion could be over five times the operating expenditures incurred by the county government.

2.3.2 State Cost/Benefit

Based on a similar analysis, net fiscal benefits to the state government are projected to be about $290,000 per year by 1995, and stabilizing at $260,000 per year by 1997. In addition, at project completion, state government revenues generated by the development could represent over six times the additional expenditures.

Chapter VI:
INFRASTRUCTURE AND PUBLIC FACILITIES

CHAPTER VI - INFRASTRUCTURE AND PUBLIC FACILITIES

1 TRAFFIC CIRCULATION

The following analysis of traffic impacts is derived from a study conducted by Pacific Planning and Engineering in July 1990. The complete study is presented as an appendix to this environmental impact statement.

1.1 Existing Roadway Conditions

The project area is served by Napoopoo Road (FASC 160), a Federal Aid Secondary County road, which is maintained by Hawaii County. Napoopoo Road has a pavement width of 20 feet with two 10-foot wide lanes and a posted speed limit of 25 miles per hour. It is a winding road bordered by private residences and two subdivisions which have direct access to it via private roads or driveways. Approximately a quarter mile north of the project site, Napoopoo Road intersects Mamalahoa Highway. Napoopoo Road runs parallel to and makai of Mamalahoa Highway. It intersects with the highway near Captain Cook Village.

Mamalahoa Highway (FAP 11) is a Federal Aid Primary roadway providing access to the population centers along the coast of Hawaii in the vicinity of Kealakekua. The portion fronting Napoopoo Road is a County maintained highway with two 12-foot wide lanes. Near the intersection of Mamalahoa Highway with Napoopoo Road, the highway has a 2-foot wide shoulder on the mauka side and 5-foot wide shoulder on the makai side. The posted speed limit for this section of highway is 35 miles per hour.

At the intersection of Mamalahoa Highway with Napoopoo Road, vehicles turning left from the highway have limited sight distance due to the curve of the highway near at the north side of the intersection. On Napoopoo Road, there is a lack of storage space for vehicles exiting the road because of a sharp, almost 90 degree bend in the road near the intersection. Poor geometry inhibits the left turn movement from Napoopoo Road onto the highway. In addition, Napoopoo Road intersects Mamalahoa Highway in an adverse grade connection.

Ka'awaloa Road is an historic road which crosses the northern portion of the property in the form of a 4-wheel drive roadway. There is some question concerning the ownership of Ka'awaloa Road. Neither the County nor the State claim ownership. However, private property owners mauka of the project area believe the road is owned by the County of Hawaii. The road is identified in the applicant's property deeds as a 50-foot right of way. Mauka of the project, however, the roadway is bordered by rock walls on either side considerably less than 50 feet apart. Access to the roadway from the properties mauka of the project area will not be impacted by the project. In the vicinity of the project area, pedestrian paths, easements, and golf carts may cross the road's alignment. A pedestrian path crossing the subject property is proposed to connect the scenic lookout to Ka'awaloa Road, thereby providing pedestrian access to the historic roadway and the lands of Ka'awaloa and Cook's Point.

1.2 Existing Traffic Conditions

Traffic volume data from the State Department of Transportation (DOT) were used to determine traffic volumes on Mamalahoa Highway near the project site. Figure 6-1 summarizes

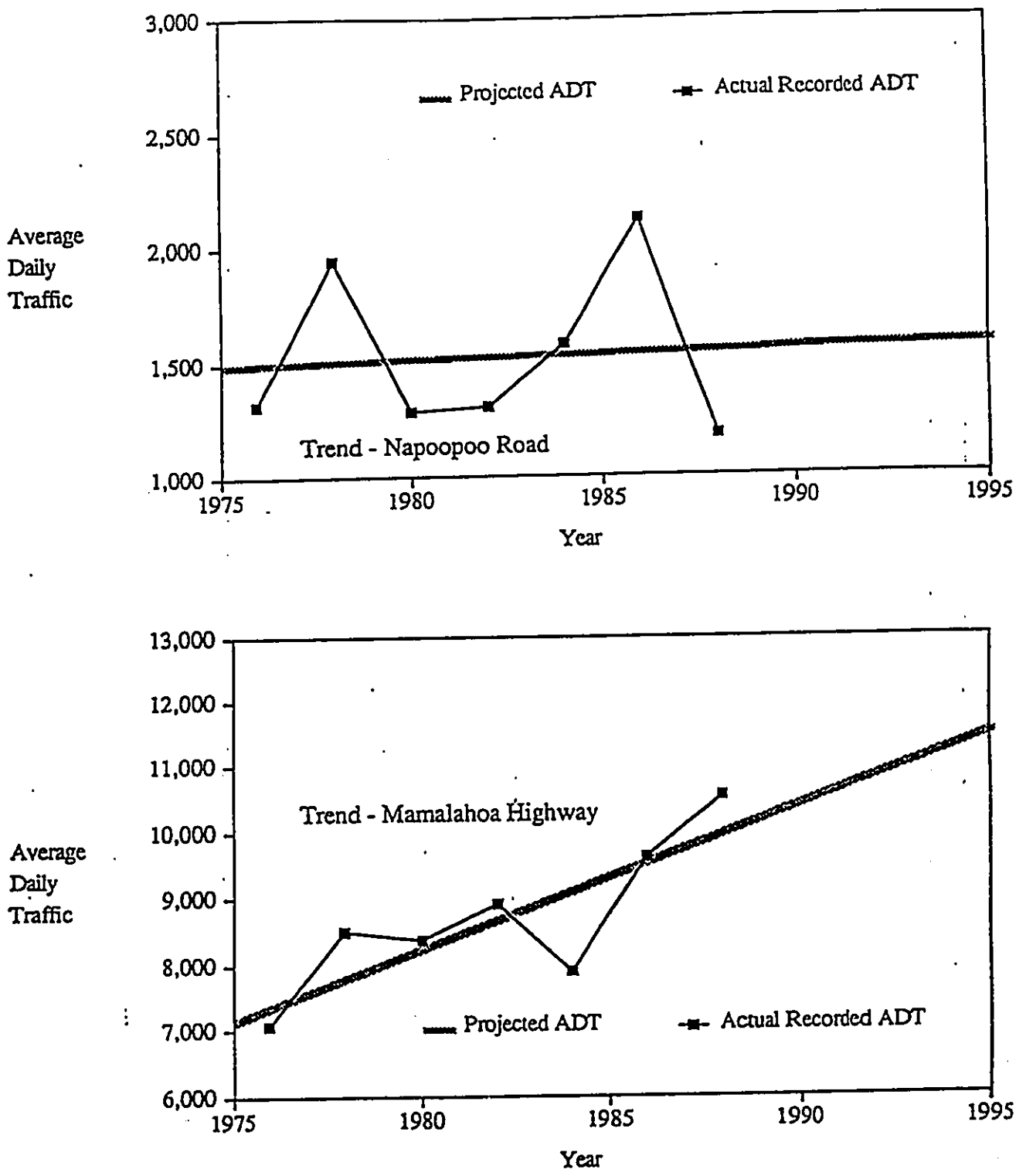


Figure 6-1
ANNUAL AVERAGE DAILY TRAFFIC

Kealakekua Bay Club
South Kona, Hawaii

Prepared by: Belt Collins & Associates

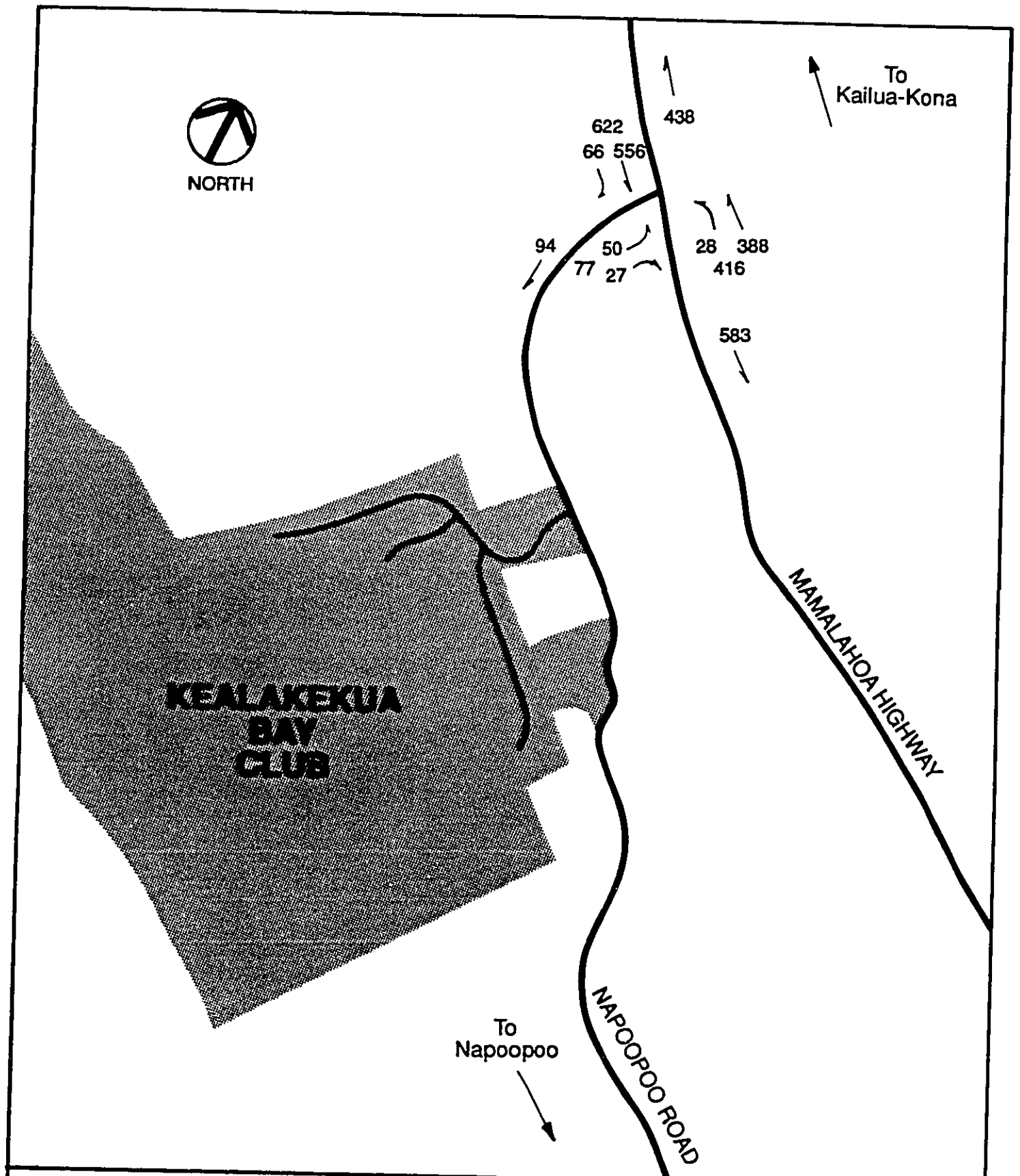


Figure 6-2
EXISTING PEAK
AFTERNOON TRAFFIC
Kealakekua Bay Club
South Kona, Hawaii

Prepared by: Belt Collins & Associates

the Annual Average Daily Traffic (AADT) along the highway at its intersection with Napoopoo Road (Station 7). Traffic volume projections show an increase in traffic growth on the highway on the order of 2 percent per year. The analysis (using linear regression) of Napoopoo Road indicates an increase in traffic growth on the order of 1 percent per year.

A review of the 1988 DOT traffic count data for the intersection of Mamalahoa Highway with Napoopoo Road indicated that the weekday afternoon commuter peak hour occurs between 4:00 and 5:00 pm. This peak hour was used to determine traffic impacts since the project would have its greater impact than the morning peak period. Manual traffic counts were taken for the intersection on December 21, 1989. These counts were used as the baseline condition upon which future estimated traffic volumes were added. Figure 6-2 shows the present volumes and movements of traffic at the study intersection of the observed peak hour. Conditions were sunny and dry at the time the counts presented in Figure 6-2 were taken.

1.3 Probable Impacts

Future traffic forecasts without and with the project were estimated for the year 2010, based upon the Draft County of Hawaii Long-Range Transportation Plan.

1.3.1 Future Traffic Without the Project

Ambient traffic is the traffic which would occur in the Kealakekua area even if the proposed project was not built. It is forecasted by increasing the existing traffic through traffic volumes by the traffic growth trend along Mamalahoa Highway and Napoopoo Road and by adding traffic generated by developments within the immediate area.

Based on research of land use data and other development information sources, there are two known future major developments in the immediate area that would generate additional traffic by 1994. One of the developments, known as Cook's Landing Subdivision, is a 60-unit single family residential subdivision that is currently under construction and is located mauka of Napoopoo Road, and north of the future project site. Six homes will access through Napoopoo Road, and the remaining 54 homes will access through Mamalahoa Highway. The other known development is also a single family residential subdivision which will be under construction in 1994. It is projected that by then, approximately 15 homes will be completed. This development will be located northwest of the intersection of Napoopoo Road with Middle Keei Road. Access to this development will be through Napoopoo Road.

Traffic counts by the State Department of Transportation indicate that traffic along Mamalahoa Highway and Napoopoo Road has been increasing by about 2% and 1%, respectively, as discussed above. The growth rate generally reflects traffic increase from developments outside the immediate study area and tourist related traffic. For these reasons, the existing peak hour through traffic volumes on Mamalahoa Highway and Napoopoo Road were increased by 8% and 4% respectively, to obtain the ambient traffic forcast volumes for 1994. Table 6-1 presents trip generation rates and number of trips generated by the sum of proposed land uses and potential future development during the afternoon peak hour.

Table 6-1: Trip Generation for Proposed Land Use (Without Project) by 1994

Weekday Afternoon

Land Use	Quantity	Trip Rates Enter	Trip Rates Exit	Trips Enter	Trips Exit
Single Family Unit	6	0.62	0.38	5	3
Single Family Unit	54	0.62	0.38	38	23
Single Family Unit	15	0.62	0.38	11	7

Trip generation and traffic assignment allocates the generated trips to different directions of travel and specific turning movements on the roadway. Since most of the attractions such as shopping centers and employment are located in the direction of Kailua-Kona, 90 percent of the trips exiting Cook's Landing onto Napoopoo Road were assigned northbound and 10 percent of the trips were assumed to travel southbound, in the direction of South Kona.

Of the vehicles turning onto Mamalahoa Highway from the future developments, 90 percent of the trips were assigned to travel north, in the direction of Kailua, and 10 percent of the trips were assigned to travel south. Of the vehicles entering and exiting development south of the project site, 90 percent were assumed to travel north and 10 percent were assumed to travel south on Napoopoo Road. Figure 6-3 shows the future traffic volumes for the weekday afternoon peak hour without the project for 2010.

1.3.2 Future Traffic With Proposed Development Project

The same procedure utilized for determining future traffic without the proposed project was used to estimate future traffic with the proposed development. For the purposes of this analysis, all development components were assumed to be completed and operating in 1994.

Trip generation data for the peak hour of adjacent street traffic for golf courses was used to generate the traffic impact of the proposed golf course for the weekday afternoon peak hour. Since the proposed restaurant may also attract visitors, trips were generated using the peak hour of adjacent traffic for quality restaurants for the weekday afternoon peak hour. For the proposed lodge, trips were generated using the peak hour of adjacent street traffic for resort trips, and trips for the five agriculture lots were generated by using the peak hour of adjacent street traffic for single family detached housing. Table 6-2 shows the number of trips generated during the weekday afternoon peak hour.

Table 6-2: Trip Generation for Proposed Project

Weekday Afternoon

Land Use	Quantity	Type	Trips Enter	Trips Exit
Golf Course	100	parking stalls	8	32
Lodge	36	rooms	7	9
Restaurant	1	2,800 sq. ft.	13	6
Agricultural Lots	5	dwelling units	4	3

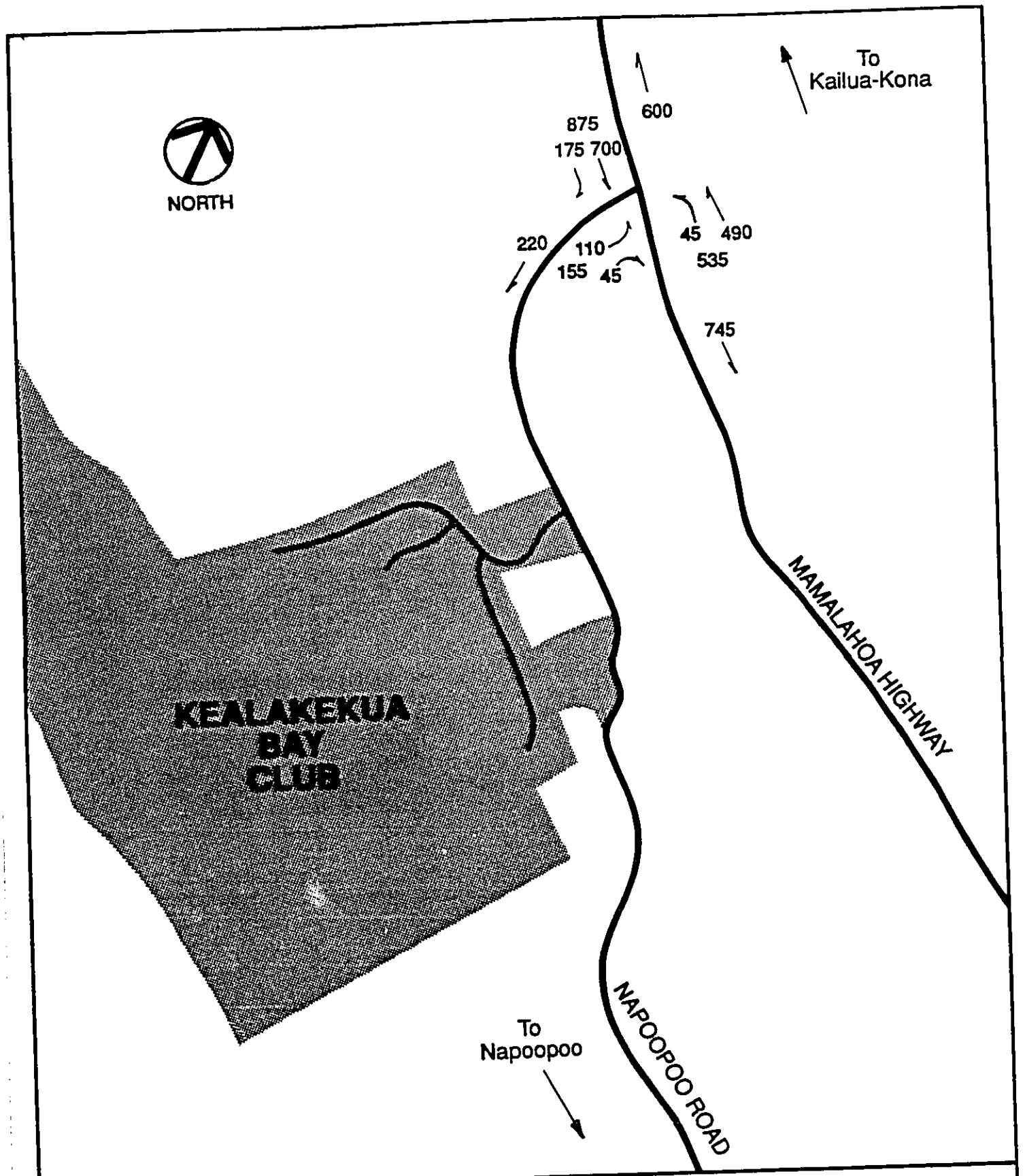


Figure 6-3
PROJECTED PEAK AFTERNOON TRAFFIC
IN 1994 WITHOUT PROJECT
Kealakekua Bay Club
South Kona, Hawaii

Prepared by: Belt Collins & Associates

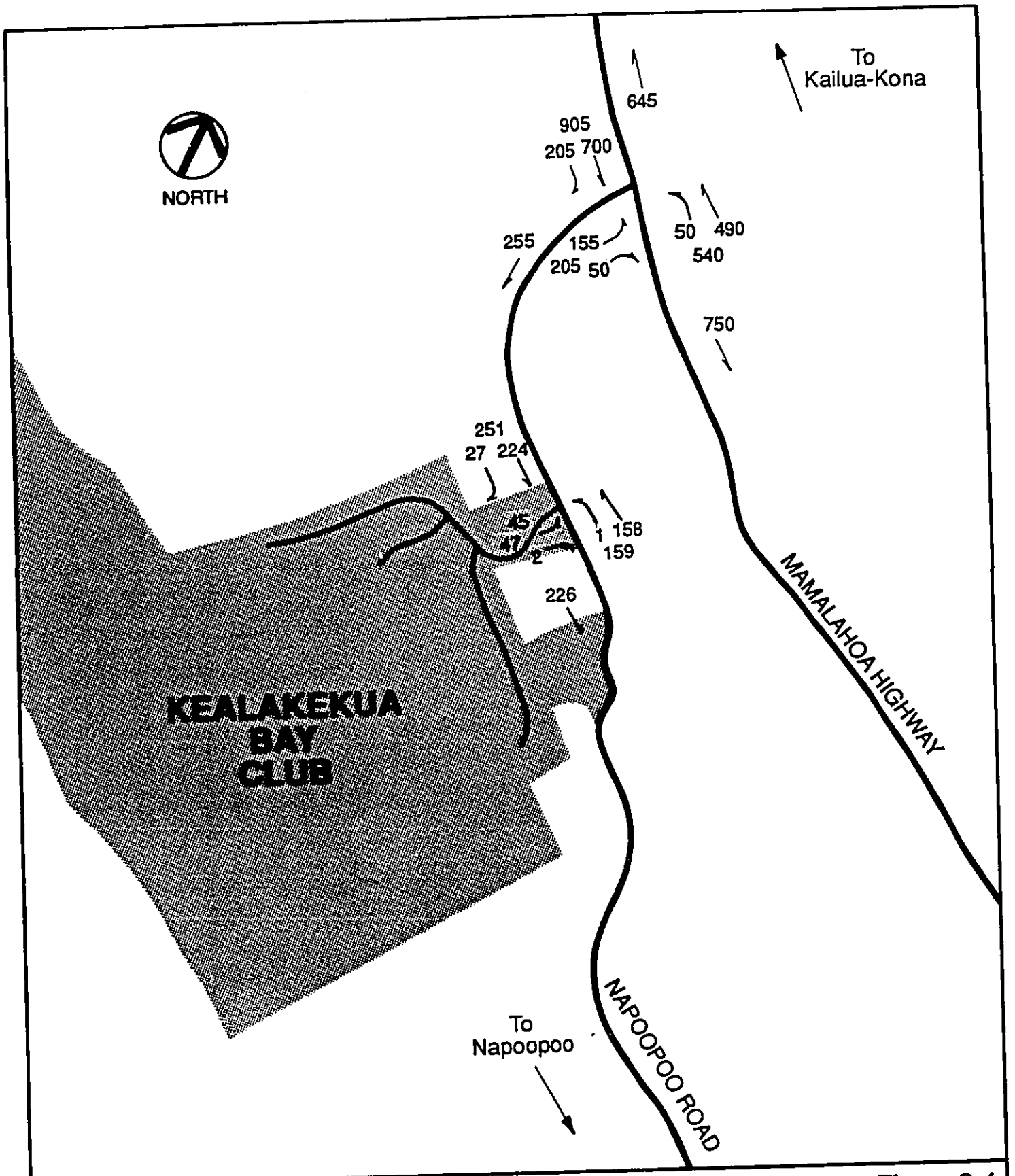


Figure 6-4
PROJECTED PEAK AFTERNOON TRAFFIC
IN 1994 WITH PROJECT
Kealakekua Bay Club
South Kona, Hawaii

Prepared by: Belt Collins & Associates

The trip distribution and traffic assignment steps allocate the project generated trips to the different directions of travel and specific turning movements on the roadway. The trips were distributed based on the locations of attractions such as hotels, residences, and airports. Approximately 90 percent of the trips were assumed to travel to/from the northern direction and 20 percent to/from the southern direction. Figure 6-4 presents the ambient traffic volumes for 2010 with the proposed project's traffic added.

To assess the impacts of the proposed project, it is assumed that a new access road connecting the property to Mamalahoa Highway could be constructed. It is further assumed that if this road is constructed, the existing intersection of Napoopoo Road with Mamalahoa Highway can be closed.

1.3.3 Analysis of Impacts

Impacts on traffic resulting from the project were measured by comparing existing traffic conditions, future traffic conditions without the project and future traffic conditions with the project.

These conditions were analyzed using the Unsignalized Intersection analysis from the Highway Capacity Manual (Special Report 209, 1985 Edition, Transportation Research Board). This analysis method determines level-of-service (LOS) which is classified into six categories ranging from LOS A to LOS F (see appendix to Traffic Impact Assessment Report). The results of the analysis are summarized in Table 6-3 below. (Note: Reserve Capacity refers to the calculated difference between the total capacity of a roadway and the actual volume of traffic. If a roadway is designed for a capacity of 500 vehicles and the actual use is 200, the Reserve Capacity is 300)

Table 6-3: Level-of-Service for the Study Intersection

Weekday Afternoon	Existing 1990	Reserve Capacity	Without Project 1994	Reserve Capacity	With Project 1994	Reserve Capacity
Mamalahoa Hwy w/ Napoopoo Rd						
Mamalahoa Highway						
Left Turn	A	537	A	401	B	374
Napoopoo Road						
Left Turn	D	117	F	-102	F	-198
Right Turn	A	486	B	318	B	300
Napoopoo Rd w/ Project Access Rd						
Napoopoo Road						
Left Turn	-	-	-	-	A	931
Project Access Road	-	-	-	-	A	489

Presently, vehicles turning left from Mamalahoa Highway into Napoopoo Road experience LOS A (little or no delays) during the weekday afternoon peak hour. Vehicles turning right from Napoopoo Road experience LOS A while vehicles turning left from Napoopoo Road experience LOS D (long traffic delays). Vehicles turning left from Napoopoo Road have long delays since drivers must wait for both directions of Mamalahoa Highway to clear before they are able to complete their maneuver.

Without the project, in 1994, vehicles turning left from Mamalahoa Highway will continue to experience LOS A. Vehicles turning right from Napoopoo Road will experience LOS B. Vehicles turning left from Napoopoo Road will continue to experience LOS F (extreme delays), a decrease in level-of-service.

With the project, in 1994, vehicles turning left from Mamalahoa Highway into Napoopoo Road will experience LOS B (slight decline in ability to maneuver but traffic flow unaffected) as well as vehicles turning right from Napoopoo Road into Mamalahoa Highway. Vehicles turning left from Napoopoo Road will experience LOS F (extreme delays), a decrease of level-of-service from the without-project condition. Table 6-3 indicates that the reserve capacity for the vehicles turning left from Napoopoo Road is negative. This indicates that the demand volume exceeds the capacity of the lane.

For the existing and without-project conditions, the intersection of Napoopoo Road and a Project Access Road does not exist, therefore, Napoopoo Road was not analyzed for these conditions.

Table 6-3 shows that with the project, in 1994, vehicles turning left from Napoopoo Road onto the proposed Project Access Road as well as vehicles exiting the Project Access Road will experience little or no delays (LOS A).

The County of Hawaii includes in its Long-Range Transportation Plan, a South Kona By-Pass Highway. The alignment of this proposed bypass road crosses the mauka portion of the subject property and would, therefore impact the proposed project.

1.4 Mitigation Measures

The traffic impact analysis demonstrates that without the project conditions involving left turns at the intersection of Napoopoo Road and Mamalahoa Highway will continue to worsen (LOS F) and that the proposed project will contribute to further deterioration of traffic conditions that even without the project would be characterized as 'extreme delays'. With the project in 1994, drivers turning left from Napoopoo Road into Mamalahoa Highway will continue to experience LOS F. Other turning movements at this intersection will continue to operate with little delay (LOS B). Thus, traffic along Mamalahoa Highway will also experience little or no delay. Mitigation measures to alleviate the problem at the intersection can involve three alternatives; signalization of the intersection, redesign of the existing intersection, or closure of the intersection and replacement with a new access road.

The intersection of Mamalahoa Highway with Napoopoo Road was analyzed using the Planning Application Worksheet for Signalized Intersections for the with-project condition. This analysis indicates that if signalized, the intersection would operate under capacity. Afternoon peak hour traffic would have a critical volume of 1,110 and maximum critical volume of 1,200.

To improve traffic flow, the intersection of Mamalahoa Highway with Napoopoo Road could be improved (in lieu of signalization) as follows:

1) Construct a left turn storage lane on Napoopoo Road.
2) Improve the sight distance on Mamalahoa Highway and Napoopoo Road.

The applicant will contribute funds for the improvement of the existing intersection if that is determined to be the most appropriate solution. Alternate mitigation measures can include a new project access road, funded by the applicnt, linking the project area to Mamalahoa Highway. At present, alternate alignments of such an access road are being reviewed. However, the access road design and alignment cannot be finalized until negotiations with surrounding landowners have been completed. Thus, it is premature to commit to a single preferred alignment. If a new access road were implemented, it is likely that the existing intersection of Napoopoo Road with Mamalahoa Highway would be closed.

To minimize the impacts of the project, the intersection ofNapoopoo Road with the Project Access Road could be improved such that a short deceleration lane (right turn lane) be provided for vehicles entering the project access road from the north or mauka direction.

Implementation of the County's proposed South Kona bypass roadway in the foreseeable future is not seen as likely. The bypass roadway is presented as priority #28 in the Long-Range Plan's list of 32 priorities and is projected to cost about $27 million to construct. To implement the bypass roadway, however, the County would first have to fund and construct the 27 improvement projects presented above it in the long range plan's priority list, at a cost of over $521 million. Thus, the bypass roadway is not considered to be an available mitigation measure due to its priority ranking and the unlikelihood of its implementation within the foreseeable future.

2 WATER SUPPLY

2.1 Existing Conditions

The five agricultural lots along Napoopoo Road are presently connected to an 8 inch municipal water line located along Napoopoo Road. The line is supplied by the County wells discussed in section 2.4.1.2 of this document and depicted in Figure 4-7. The remainder of the property is not served by the County's water system. As the result of a previous subdivision request approved by the County in the mid-1980's and the subsequent acquisition of additional parcels, the project area has been granted a total water allocation by the County of 22,200 gpd.

2.2 Probable Impacts

The proposed project will require the development of an on-site potable water distribution system as well as a non-potable irrigation system. This potable system will consist of the appropriate transmission lines and valves linking it to the County's municipal water line.

Potable water demand generated by the proposed development is presented in Table 6-4. As is demonstrated, projected demand exceeds existing allocation by approximately 1,300 gallons per day (gpd).

Table 6-4: Projected Potable Water Demand

Proposed Use	Projected Demand
Golf Clubhouse (including clubhouse, restaurant, lockers, etc.)	15,000 gpd
Members' Lodge - 36 suites (@ 125 gpd each)	4,500 gpd
Agriculture Lots - 5 (@ 600 gpd each)	3,000 gpd
Maintenance Area	1,000 gpd
TOTAL:	23,500 gpd
Existing Allocation:	22,200 gpd
Shortfall:	1,300 gpd

As discussed in section 2.4.2.1 of this document, anticipated golf course irrigation (non-potable) at the Kealakekua Bay Club is estimated at 3,100 gallons per acre per day to maintain turf and landscaping for 150 acres of golf course fairways, tees and greens. This amount is equal to about .465 mgd on an average daily basis.

2.3 Mitigation Measures

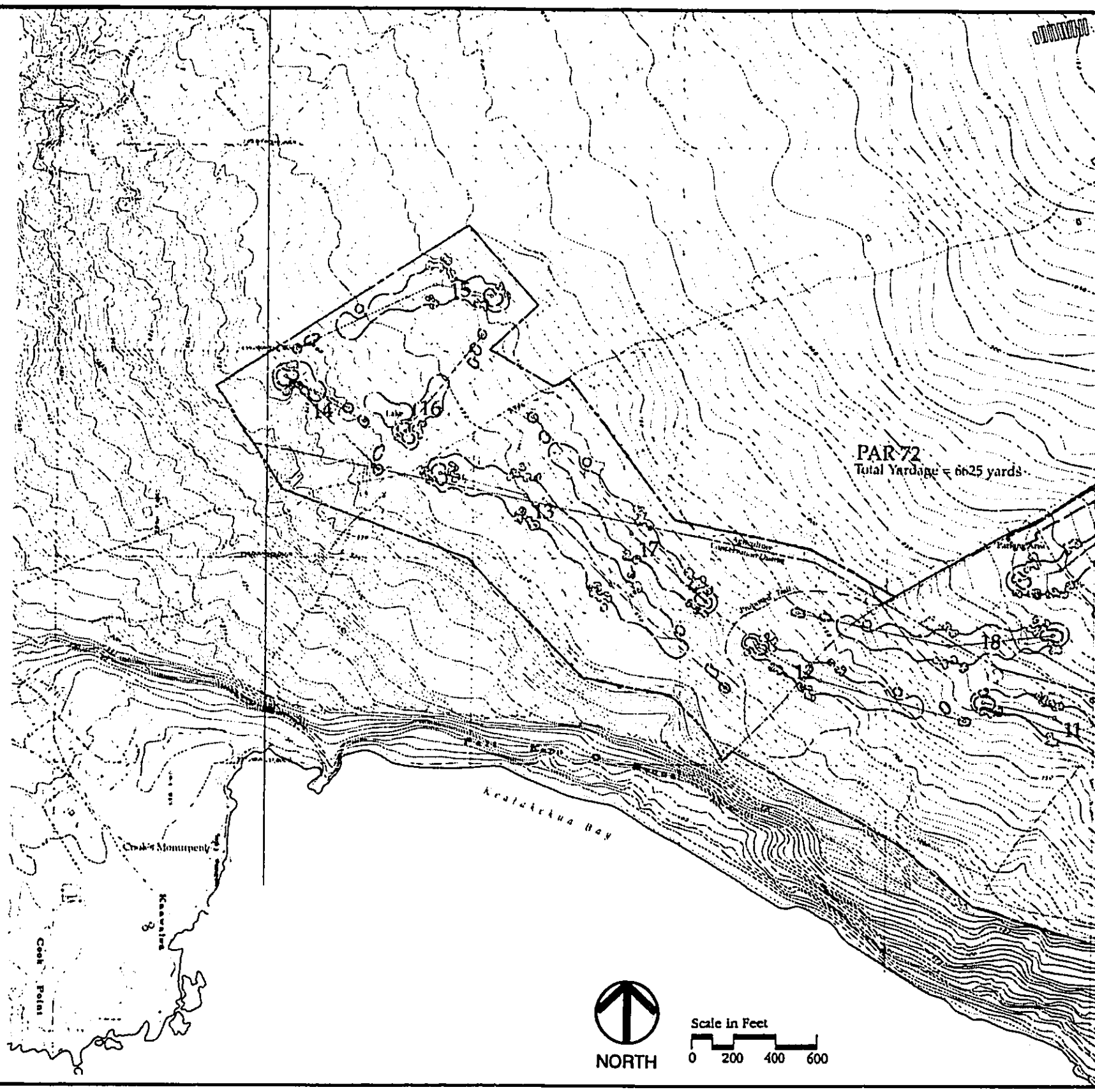
All on-site water infrastructure (potable and non-potable) will be developed and funded by the applicant. To address the potable water deficit of about 1,300 gpd, the applicant will either seek an additional allocation from the County, negotiate with surrounding property owners for the acquisition of additional water, or if no other recourse exists, construct a new well at a location upslope from the project area. It should be noted that the potable water deficit will not materialize until such time as the proposed Members' Lodge is certified for occupancy. Under the current development schedule, the lodge will be opened in 1997 subject to approval by the County of a General Plan and zoning amendment to permit its development. The applicant believes that this time frame provides ample time to obtain additional potable water to serve the property should it be determined that it will be necessary.

The Nance report included as an appendix to this document identifies potential locations for an on-site non-potable well to supply water for irrigation purposes. As discussed in the report, a well providing between 0.7 million gallons per day (mgd) and 1.2 mgd will be sufficient to address the project's irrigation requirements and ensure sufficient reserve for extended periods of dry weather. Figure 6-6 presents the recommended location for a non-potable well and demonstrates how the well and its accompanying irrigation lake will be situated in relation to the proposed golf course.

3. WASTEWATER AND DISPOSAL

3.1 Existing Conditions

At the present time the site of the proposed Kealakekua Bay Club is not serviced by a municipal wastewater treatment system. Because the majority of the 262 acre property is vacant and was historically used for grazing and agriculture, it has no private sewage disposal system such as cesspools or septic tanks. However, each of the existing dwellings on the portion of the property along Napoopoo Road is served by its own cesspool. The potential for connecting the project area into a central municipal treatment facility is judged to be minimal. There are no known plans at this time to extend the municipal system serving the Kailua-Kona area to provide



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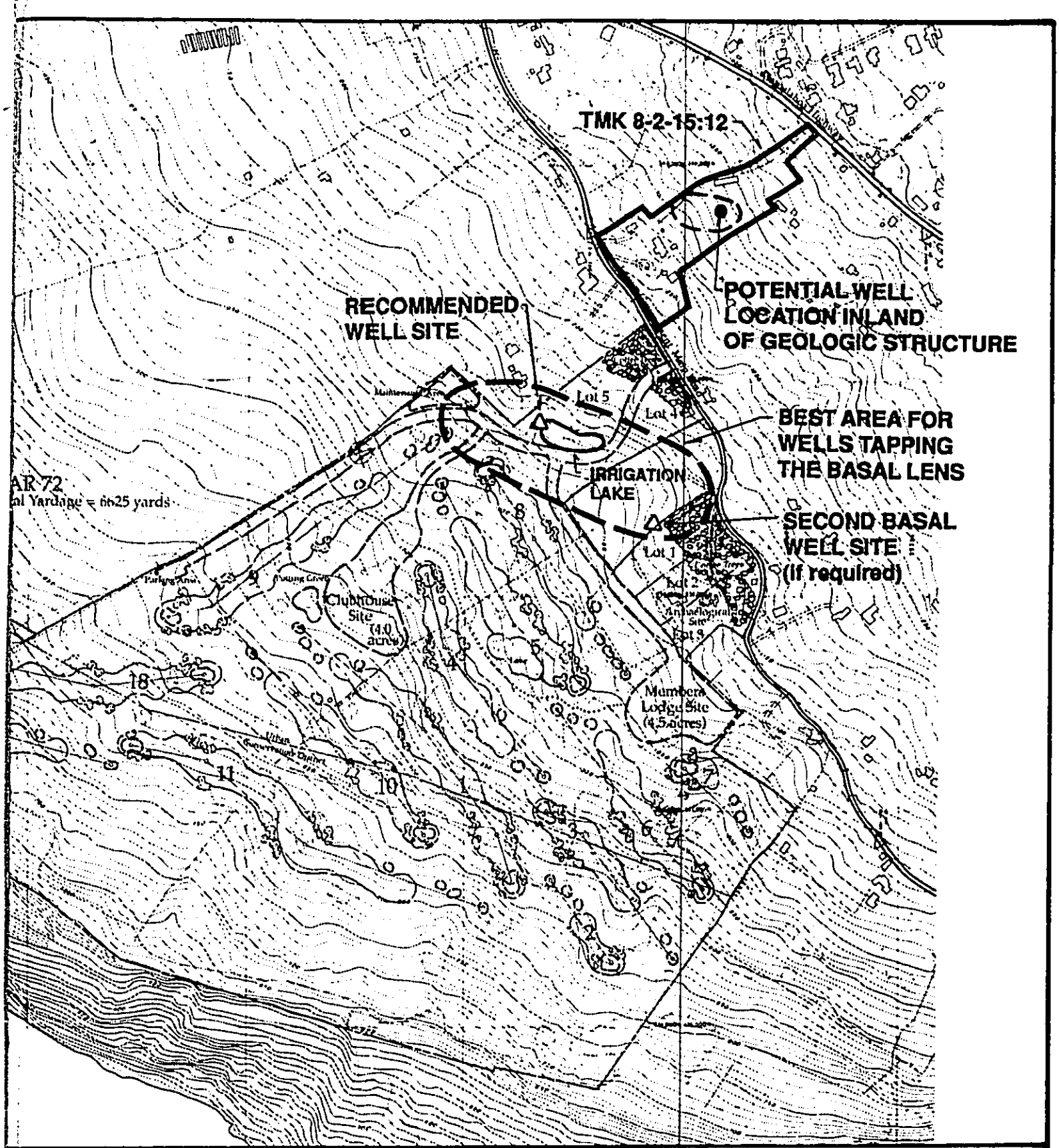


Figure 6-5
POTENTIAL NON-POTABLE WELL LOCATIONS

Kealakekua Bay Club
South Kona, Hawaii

service to Captain Cook or the Kealakekua area.

In order to protect the surrounding environment from the impacts of sewage disposal resulting from the proposed project, an onsite wastewater management system is proposed.

3.2 Probable Impacts

Based upon the development plan for the Kealakekua Bay Club, it is anticipated that between 11,500 and 12,000 gallons per day of wastewater will be generated at full development of the site. The wastewater will have characteristics similar to those of domestic wastewater (biochemical oxygen demand = 350 milligrams/liter; total suspended solids = 200 milligrams/liter). Of the total wastestream, roughly 42% will originate from the proposed golf clubhouse, while 47% will be contributed from the proposed Members' Lodge and 11% will be generated by the maintenance facility. The five agricultural lots will each be served individual septic tanks. The design, construction and operation of the proposed system will conform to Hawaii County and State health and sanitation standards.

The proposed wastewater treatment plant will be constructed to a total capacity of about 20,000 gallons of wastewater per day. It will be located at the proposed maintenance area situated mauka of the golf course's ninth tee. Construction of an engineered wastewater treatment facility is not anticipated to result in adverse impacts on the environment, provided that the facility is properly operated.

3.3 Mitigation Measures

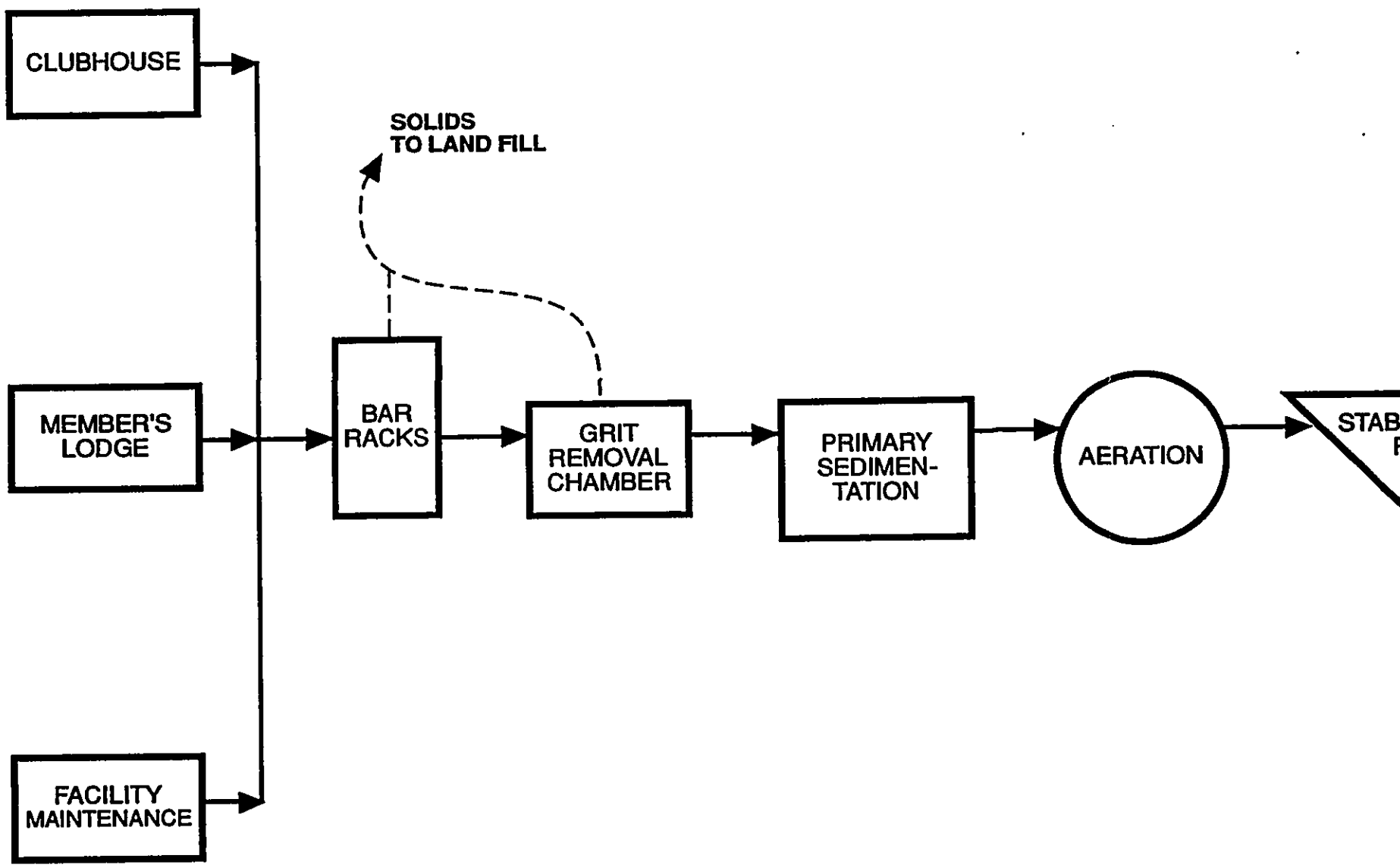
A secondary level of treatment is proposed for the wastewater facility. It will likely include the following treatment processes: grit removal; primary settling; aeration; settling pond; chlorination; and land application. The proposed process will reduce the raw BOD by 90% to 30mg/l and the TSS by 85% to 30mg/l. The facility will be funded, constructed and operated by the applicant.

After treatment in the facility, the disinfected secondary effluent will be used to supplement irrigation of the golf course. It would be blended with non-potable irrigation water. Due to the relatively small volume of effluent that might be used, its overall impact upon the golf course in terms of a potential health concern is minimal. Assuming an average daily volume of wastewater totaling about 12,000 gallons, effluent will constitute less than 3% of the total daily volume of irrigation water required. The applicant will work with the State Department of Health and the County Public Works Department to ensure that treated effluent disposal is conducted in a manner which minimizes environmental impacts. Figure 6-7 presents the preliminary design for the wastewater collection system to be developed on the subject property.

4. STORM DRAINAGE

4.1 Existing Conditions

The drainage basin for Kealakekua Bay consists of two large drainage areas extending downslope from Hualalai (see Figure 6-8). The larger area, Basin "A", is calculated to begin at the 4,600-foot elevation and contains a total of about 1,780 acres. The smaller area, Basin "B", abuts Basin A on the southern side and begins at the 3,400-foot elevation. Basin B contains about 900 acres. Runoff quantities were estimated by the process of determining the volume or peak rate of



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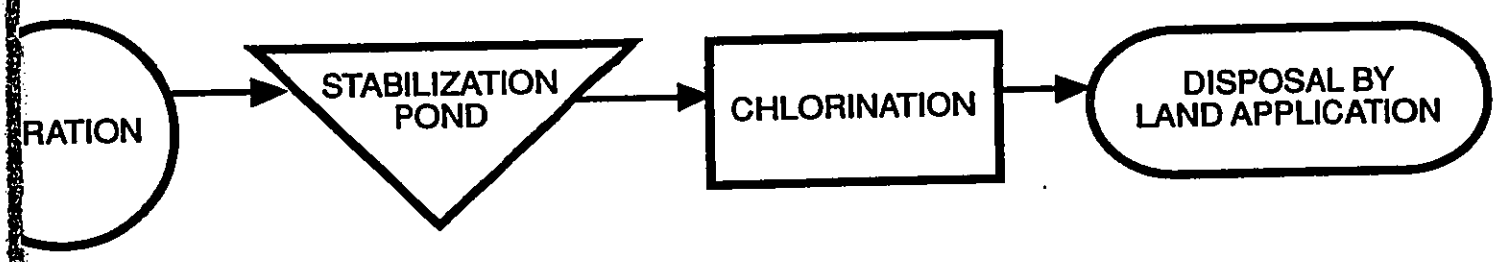
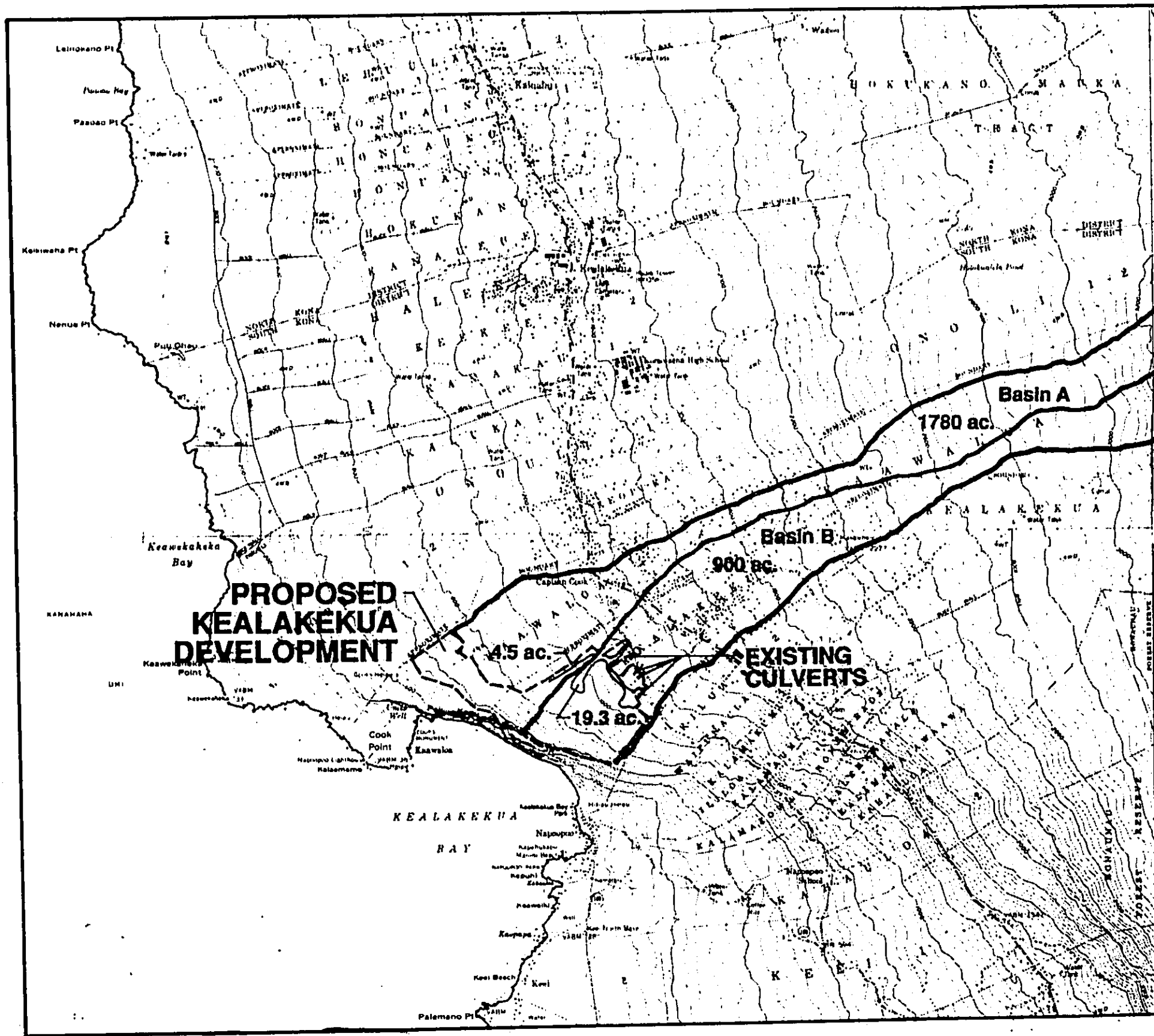


Figure 6-6
PROPOSED WASTEWATER INFRASTRUCTURE (SCHEMATIC)
Kealakekua Bay Club
South Kona, Hawaii



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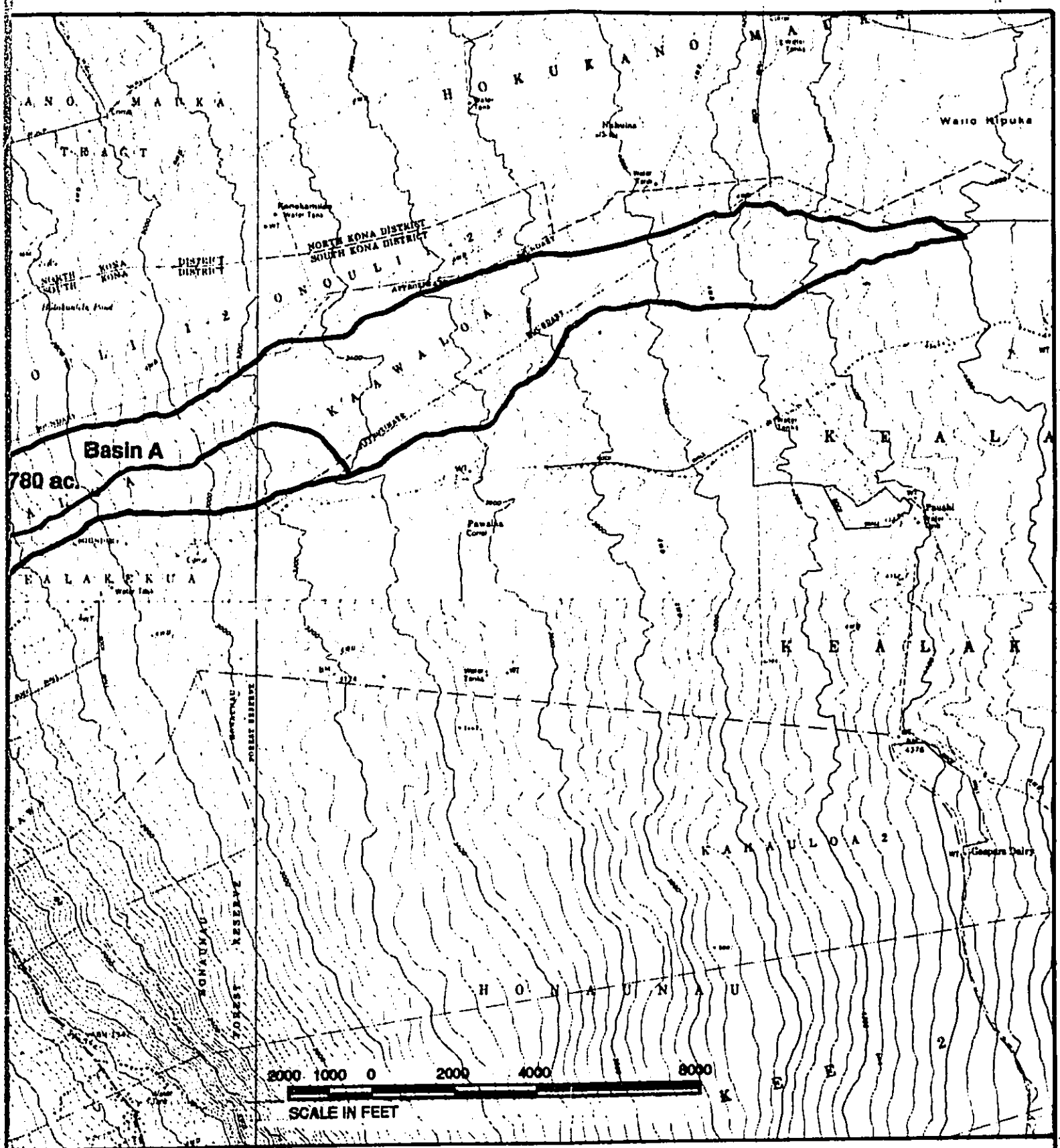
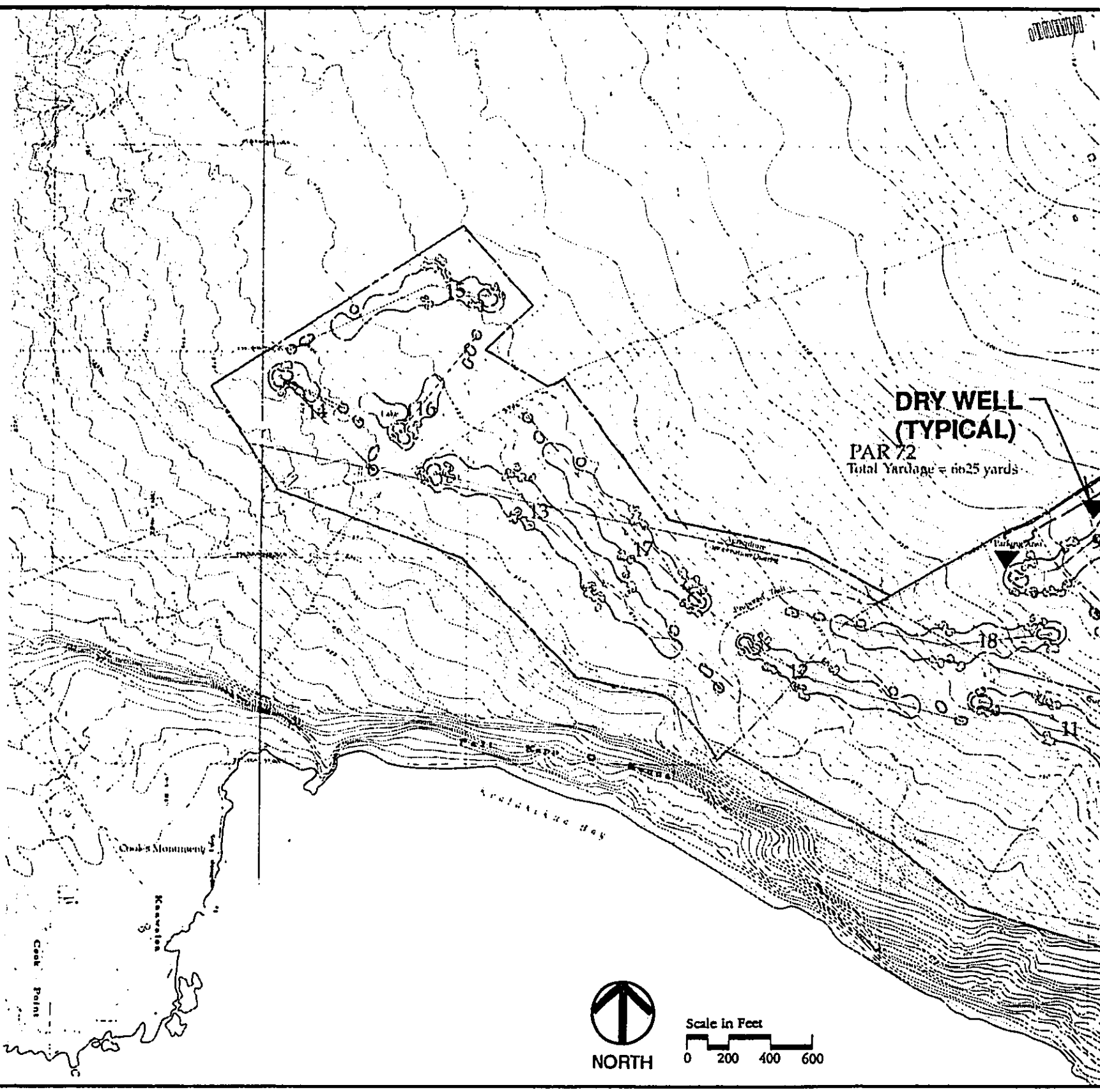


Figure 6-7
STORM DRAINAGE

Kealakekua Bay Club
South Kona, Hawaii



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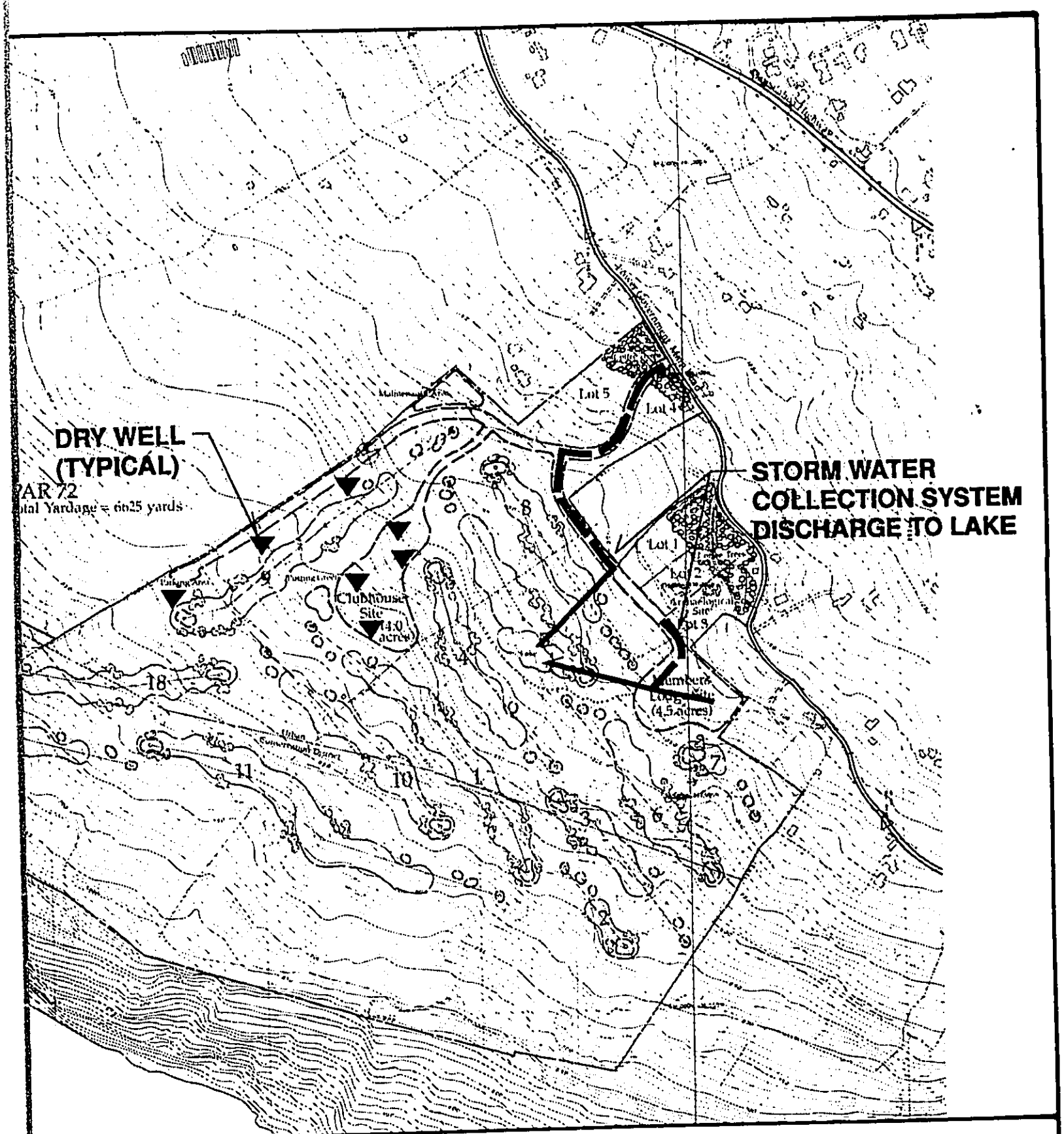


Figure 6-8
DRY WELL SITES AND WATER COLLECTION

Kealakekua Bay Club
South Kona, Hawaii

runoff from a given watershed for the design 50-year 24-hour storm. For Basin A, runoff depth (the average depth of water moving downslope in a natural drainage channel during a 50-year storm event) is calculated at about 3 inches with a peak discharge per inch of runoff at about 300 cubic feet per second. For Basin B, runoff depth is estimated to be 2.6 inches with a peak discharge rate per inch of runoff at about 175 cubic feet per second. Rainfall for a 50-year 24-hour storm is estimated at about 7 inches for Basins A and B. The computed discharge for a 50-year storm is about 888 cubic feet per second in Basin A and about 410 cubic feet per second for Basin B.

The watershed for the proposed development has no natural drainage ways or streams crossing the project site. There is some drainage runoff that reaches the site from the mauka side of Napoopoo Road; however, all rainwater falling on and reaching the site appears to percolate through the soil. There is no documented runoff over the pali at the makai boundary of the subject property, although an area resident remembers such an occurrence in the past during a particularly heavy storm. A culvert under Napoopoo Road near its intersection with Mamalahoa Highway deposits runoff from the mauka area onto private property adjacent to the proposed project much to the concern and frustration of the property owner.

The County's Department of Public Works (DPW) has indicated a concern about the excess runoff from the Cook's Landing subdivision, mauka of the proposed project. This excess runoff is due to the blockage of grate inlets with rock and debris. In addition, some of the drywells in the subdivision were plugged with rock and debris at the time of inspection.

4.2 Probable Impacts

The proposed development will result in about 9.3 acres of land being converted from its natural state to built-on land. This area includes parking lots, sidewalks, buildings and maintenance facilities. No significant increase in runoff is expected to occur due to the proposed development project. Because over 97% of the project's total land area will remain as open space, vegetated land in the form of a golf course, landscaped areas around development sites, and the undisturbed 50-acre Conservation District area, the impact upon the existing runoff pattern is minimal. Any possible improvements to the existing intersection of Napoopoo Road with Mamalahoa Highway will likely impact the drainage in that area.

6.3 Mitigation Measures

To address runoff across the site, the use of drywells at specified locations as well as the possible need for retention basins within the golf course area is recommended. These facilities will enable stormwater to percolate through the ground and will prevent runoff from reaching the pali. Potential dry well sites are presented in Figure 6-8.

The possible improvement of the Napoopoo Road intersection with Mamalahoa Highway will provide an opportunity to address existing drainage problems caused by the culvert discussed above. The siting of a drywell at the base of the culvert would help to mitigate the impacts of existing and future drainage from the mauka area and the intersection.

If the runoff problem from the Cook's Landing Subdivision is not rectified by the responsible parties, the applicant may need to address this offsite runoff. This may result in larger culverts or added drywells to the project's drainage system.

7. SOLID WASTE COLLECTION AND DISPOSAL

7.1 Existing Conditions

Solid waste from the community of Captain Cook and the surrounding area, including the project site, is collected by the County from the Napoopoo waste transfer station, and transported by truck to the County landfill at Kealakehe just north of Kailua-Kona.

7.2 Probable Impacts

At full build out in 1997, the proposed project is anticipated to generate approximately 723 pounds of solid waste per day, or about 132 tons per year. The determination of this projection is presented in Table 6-5 below.

Table 6-5: Solid Waste Impacts at Buildout

Average Daily Census (1997)	Rate	Projected Volume
Golf Course - 125 persons	1.33 lbs/person/day	166.25 lbs per day
Members' Lodge - 72 guests	5 lbs/person/day	360.00 lbs per day
Agriculture Lots - 14 residents	5 lbs/person/day	70.00 lbs per day
Employees - 95	1.33 lbs/person/day	126.35 lbs per day
TOTAL:		722.60 lbs per day

7.3 Mitigation Measures

Solid waste will be collected by a private refuse disposal service and disposed of at the County landfill. To mitigate potential impacts resulting from the volume of solid waste generated by the proposed project, all activities will be encouraged to practice recycling measures to the maximum extent possible.

8. ELECTRICAL POWER AND COMMUNICATIONS

8.1 Existing Conditions

Electrical power for the project area is provided by Hawaii Electric Light Company (HELCO) facilities. A 69 kv transmission line is located along Mamalahoa Highway and links the Captain Cook Substation to the electrical generating facility near Keahole Airport.

Telephone service to the project area is provided by Hawaiian Telephone Company via their Kailua-Kona facilities.

Cable television (CATV) is provided to the project area via a private cable company's system serving the Kona area.

8.2 Probable Impacts

The proposed project will not require additional sources of electrical energy for its development or operation. The project will utilize electrical energy provided by the existing 69 kv transmission line. Therefore, it will have no significant impact upon regional electrical energy resources.

Increased telephone service to the project area will not significantly impact the capacity of the Hawaiian Telephone service to provide service to its existing or future customers.

The CATV system would be expanded as requested and required to serve the project area.

8.3 Mitigation Measures

Because the project is not expected to result in significant impacts to either the electrical or communications systems of the project area, measures to mitigate potential adverse effects are not warranted. The applicant will provide, if necessary, an onsite location for an electrical transformer or unit to contain telephone switching gear.

9. POLICE AND FIRE PROTECTION SYSTEMS

9.1 Existing Conditions

The project area police and fire services are provided by facilities located in Captain Cook, less than a mile from the project area. At present, these facilities are adequate to serve existing requirements. The police station is a sub-station of the main facility located just north of Kailua-Kona at Kealakehe. The fire station is staffed by 18 men divided into three shifts providing 24 hour coverage. Equipment consists of a 1,500 gallons per minute (gpm) pumper carrying 1,000 gallons of water, a mini-pumper 4x4 carrying 300 gallons of water, and an ambulance.

9.2 Probable Impacts

The proposed project's impact upon the provision of police and fire services in the general area is relatively insignificant. No expansion of existing services will be required to service the proposed project in the event of a police or fire emergency.

9.3 Mitigation Measures

Because the project will have no significant adverse impacts on the provision of police and fire services, mitigation measures are not warranted. However, all developments within the project area will be constructed and operated in conformance with County fire codes and building safety codes. Non-potable irrigation water will be available onsite for fire emergencies and infrastructure will be designed to ensure its availability at the Members' Lodge and Golf Clubhouse.

10. HEALTH CARE FACILITIES

10.1 Existing Conditions

The nearest available health facility is the state operated Kona Hospital in Kealakekua, about three and a half miles north of the project site. Although the hospital is licensed for 54 acute care beds, because of staffing and other limitations only about 40 beds are normally available for

acute care. However, according to the West Hawaii Regional Health Center Taskforce Report of October, 1989, the State Department of Health is committed to renovate the Kona Hospital "without delay" at the cost of $6 million.

An emergency ambulance service is located in Captain Cook in conjunction with the Captain Cook fire station. Current response time to the project site is estimated to be less than 10 minutes.

10.2 Probable Impacts

As discussed in Section 1.4.1.1 of Chapter V, the projected population impact of the proposed project in 1997 will be about 240 persons. This growth is relatively consistent with annual average population growth in the South Kona district. Therefore, it is not believed that the proposed development will have a significant adverse impact upon the provision of health services in the Kona region, especially in light of the state's commitment to upgrade the existing facility.

10.3 Mitigation Measures

Because the project will have no significant adverse impacts on the provision of health services, mitigation measures are not warranted.

11. SCHOOLS AND EDUCATIONAL FACILITIES

11.1 Existing Conditions

The South Kona district, which includes the project area, is served by the Konawaena Elementary School and High School, both in Kealakekua. A new elementary school is also planned for the general area, although specific details about it are unknown at the time of this document's publication.

11.2 Probable Impacts

In terms of residential impacts of the proposed development, by 1997 approximately 14 people will be residing within the project area (assuming permitted development under the RA-2 zoning of the five agricultural lots). These persons will have a negligible impact upon the public school system. The number of employees working at the proposed project is projected to be about 95 persons by 1997. Included direct, induced and operational employment, the total employment impact will be about 160 persons by 1997. In view of the Department of Education's plans to provide a new elementary school to the South Kona area, the increased population associated with residents and employees of the project is not viewed as having a significant adverse impact upon the provision of educational services.

11.3 Mitigation Measures

Because the project will have no significant adverse impacts on the provision of educational services, mitigation measures are not warranted.

12. RECREATIONAL FACILITIES

12.1 Existing Conditions

Existing public park facilities in the general region include a public park in Captain Cook and the Kona Scenic Park in Kealakekua. In addition, as discussed earlier in this document, the project site overlooks the Kealakekua Bay Historic Park, which is operated by the state. Recreational activities at the bay park include snorkeling, swimming, hiking and sightseeing.

12.2 Probable Impacts

Population growth associated with the proposed project is not expected to have a significant adverse impact upon the existing public recreational facilities in the region. The recreational resources associated with the project; the golf course and tennis courts, will be private in nature and will not have a direct impact upon the general public. However, limited public play will be permitted at the golf course.

The provision of a scenic overlook above Kealakekua Bay and the development of new public access trails and a parking area will have a positive impact upon the availability of new recreational resources for the Captain Cook area. Public access improvements will include improvements to existing trails in the area as well as the development of new trails in coordination with the Department of Land and Natural Resources, including a lateral trail along the the top of the pali. Historic Ka'awaloa Road will be preserved in its current alignment. Although it may be crossed by golf cart paths or infrastructure easements, no other improvements are planned for it. Pedestrian trails on-site will provide new access to Ka'awaloa Road, enabling people visiting the proposed scenic lookout to walk down to the Ka'awaloa-Cook's Point area. The applicant will work closely with the DLNR's Division of Parks and Recreation, Historic Sites Office and the Na Ala Hele organization to integrate the project public access improvements with planned State improvements.

12.3 Mitigation Measures

Because the project will have no significant adverse impacts on the provision of recreational services, mitigation measures are not warranted.

Chapter VII:

RELATIONSHIP OF THE PROPOSED ACTION TO LAND USE PLANS, POLICIES, AND CONTROLS FOR THE AFFECTED AREA

CHAPTER VII - RELATIONSHIP OF THE PROPOSED ACTION TO LAND USE PLANS, POLICIES, AND CONTROLS FOR THE AFFECTED AREA

1. HAWAII STATE PLANS AND CONTROLS

1.1 State Land Use District Boundaries

All lands in the State have been placed in one of four land use districts (Urban, Agriculture, Conservation, or Rural) by the State Land Use Commission (SLUC). The site of the proposed golf course and lodge is presently designated by the State Land Use Commission as Urban (100 acres), Agriculture (34 acres), and Conservation (118 acres). Figure 7-1 depicts these designations. The proposed activities will not require amendments to the current State Land Use designations.

1.2 Conservation District Rules

The administrative rules of the Hawaii State Department of Land and Natural Resources, Title 13, Chapter 2, govern land use within the conservation district and provide for four categories, or subzones. Royal Coast Development Corporation proposes to use the State-controlled conservation district land contained within the subject property. The actions for which it seeks approval from the Board of Land and Natural Resources are summarized below followed by a discussion of the relationship of the proposed project to the conservation district rules.

1.2.1 Proposal for the Conservation District

The subject property contained within the Conservation district will have two principal uses; golf course and passive recreational. A total of three entire golf course fairways and portions of seven additional fairways will be located within the Conservation district, together with related golf course facilities such as cart paths, maintenance vehicle access roads and signage. The passive recreational uses involve the development of a public access to the top of the cliff and a scenic overlook for pedestrians. Although public parking will be provided in conjunction with the public access, it is not anticipated that it will be located within the conservation district. It is also proposed that the approximate 50 acre area of Conservation district outside of the proposed project area will be replanted with native plants as a means of mitigating the loss of plant material in that portion of the Conservation district being impacted by development of the golf course.

1.2.2 Existing Subzones

The portion of the subject property designated Conservation is divided into two subzones as depicted in Figure 7-1. The southern portion of the Conservation district is identified as a General Use (G) subzone and the northern portion is designated as Limited Use (L). The objective of the General subzone "is to designate open space where specific conservation uses may not be defined, but where urban use would be premature." The objective of the Limited subzone "is to limit uses where natural conditions suggest constraints on human activites." The proposed uses within the Conservation District are consistent with these subzones. With respect to the General subzone, neighboring properties are already designated urban and agriculture. With respect to the Limited subzone, the property is no susceptible to floods, soil erosion, or tsunami, and susceptibility to volcanic activity is minimal. An application for a Conservation District Use Permit for the golf course and passive recreational uses described above will be filed with the Board of

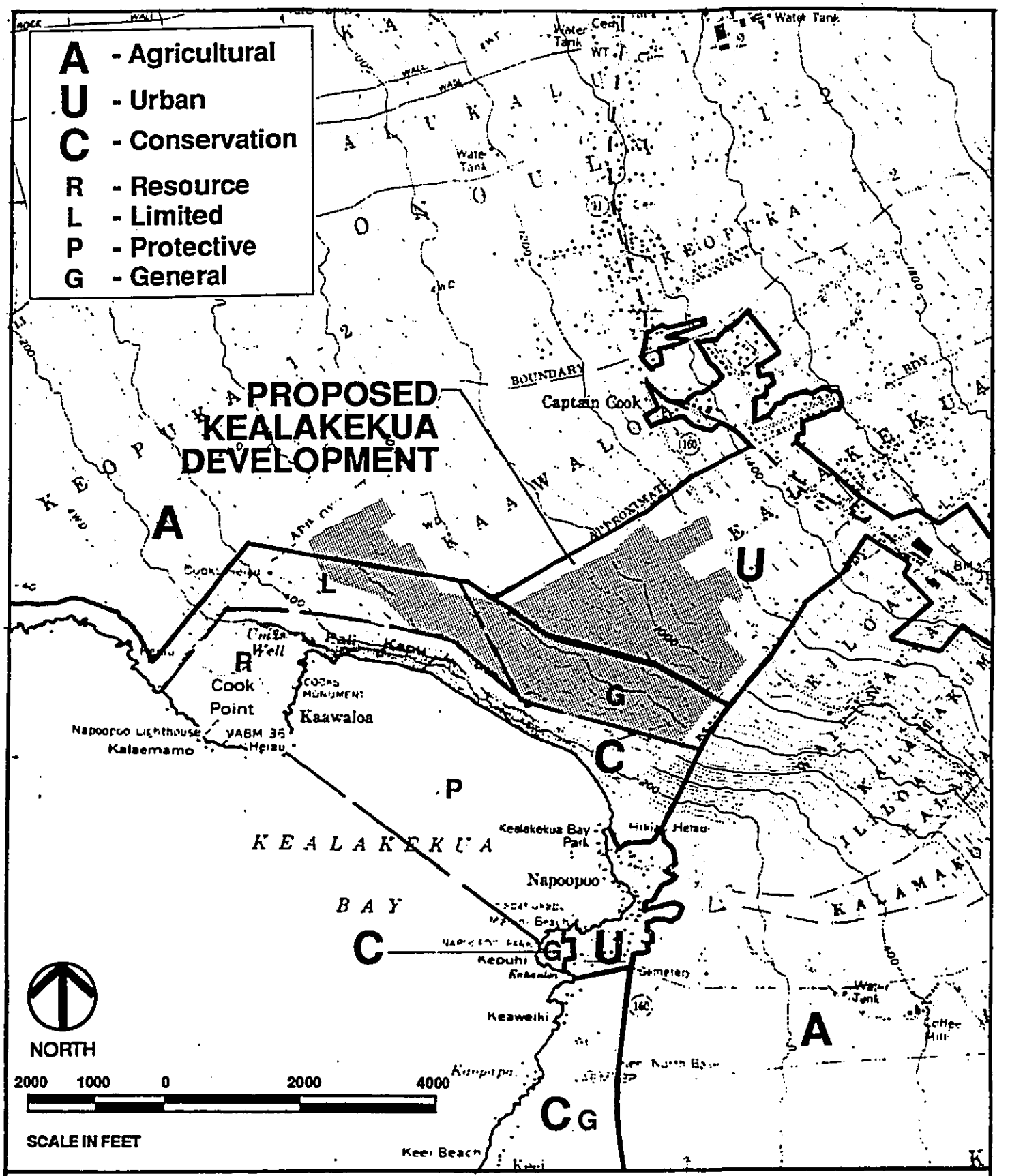


Figure 7-1
STATE LAND USE
CLASSIFICATIONS AND SUBZONES
Kealakekua Bay Club
South Kona, Hawaii

Prepared by: Belt Collins & Associates

Land and Natural Resources. This environmental impact statement will be included as part of the application. All other portions of the proposed development are outside of the Conservation District and are, therefore, exempt from these particular permit requirements.

1.2.3 Conditions of Conservation District Use

All allowed uses in the conservation district are subject to the conditions outlined in Section 13-2-21 of the rules. The conditions relevant to the proposed project are presented below together with a discussion of the proposed actions' compliance with them.

(1) The use shall be compatible with the locality and surrounding areas, and appropriate to the physical conditions and capabilities of the specific parcel or parcels of land.

Discussion: Usage of the Conservation district lands for development as a golf course and for passive recreational activities related to the proposed public access and scenic overlook is compatible with the locality and surrounding area, which consists entirely of vacant, open space. The uses are also compatible with the physical conditions and capabilities of the parcel.

(2) The existing physical and environmental aspects of the subject areas, such as natural beauty and open space characteristics, shall be preserved, or improved upon, whichever is applicable.

Discussion: Although the character of the vegetation will change with the proposed use, the resulting development will consist mainly of vast expanses of open space in the form of golf course fairways, tees and greens. The development will optimize the natural slope of the property by taking advantage of the existing grade. Some cut and fill will be necessary, however, the ultimate design of the golf course facility will result in a development that is similar to the existing character of the property. The natural beauty of the area will be maintained, if not improved. Development of the golf course and public access will improve the overall landscaping of the property and will permit greater public access than currently available.

(3) All buildings, structures, and facilities shall harmonize with physical and environmental conditions stated in this rule.

Discussion: There are no buildings proposed within the Conservation District. Buildings proposed for construction as part of the project outside of the Conservation District include the golf course clubhouse, the members' lodge and the maintenance facility. The clubhouse and members' lodge will feature a Hawaiian plantation style architecture that will be compatible with the rural character of the area. These buildings will not exceed two stories in height. The maintenance facility will include small buildings of not more than one story in height which will be screened from view by the use of a landscaped buffer.

(4) Use of the area shall conform with the program of the appropriate soil and water conservation district or plan approved by and on file with the department.

Discussion: The provisions of this condition shall be complied with.

(5) When provided or required, potable water supply and sanitation facilities shall have the approval of the department of health and the board/department of water supply.

Discussion: The provisions of this condition shall be complied with.

(7) The construction, alteration, moving, demolition and repair of any building or other improvement on lands within the conservation district shall be subject to the building codes of the respective counties in which the lands are located; provided that prior to the commencement of any construction, alteration or repair of any building or other improvement, four copies each of the final location map, plans, and specifications shall be submitted to the chairperson or an authorized representative, for approval; provided, further that any alteration or repair which does not change or expand on the existing land use shall not be subject to the above.

Discussion: The provisions of this condition shall be complied with.

(8) Provisions for access, parking, drainage, fire protection, safety, signs, lighting, and changes in the landscape shall have the approval of the chairperson or an authorized representative.

Discussion: The provisions of this condition shall be complied with.

(9) Where any interference, nuisance, or harm may be caused, or hazard established by the use, the applicant shall be required to take measures to minimize or eliminate the interference, nuisance, harm or hazard.

Discussion: The provisions of this condition shall be complied with. The only potential harm generated by the proposed project might be associated with the project's potential impact upon the groundwater. However, as has been discussed in Chapter 4 of this document, no significant impacts are anticipated.

(10) Obstruction of public roads, trails, and pathways shall be minimized. If obstruction is unavoidable, the applicant shall provide roads, trails, or pathways acceptable to the department.

Discussion: The applicant shall work closely with the DLNR to ensure that the golf course design minimizes impact on known trails and that proposed public access pathways and the scenic overlook are acceptable to the DLNR.

(11) Except in the case of public highways, access roads shall be limited to a maximum of two lanes.

Discussion: There is no access road proposed within the Conservation District. Access to the scenic overlook will be via a path from the public access parking area located well outside of the Conservation District.

(12) Overloading of off-site roadways, utilities, and public facilities shall be minimized.

Discussion: The proposed project will not result in an overloading of off-site public facilities or utilities, including roadways.

(13) Clearing areas for construction purposes shall require prior approval by the chairperson, ground cover of slopes over 40% shall not be removed unless specifically authorized by the chairperson.

Discussion: Detailed grading and landscaping plans will be submitted to the chairperson for approval prior to any construction activities, including clearing.

(14) Cleared areas shall be revegetated within thirty days unless otherwise provided for in a plan on file with and approved by the department.

Discussion: The provisions of this condition shall be complied with.

(15) Upon approval of a particular use by the board, any work or construction to be done on the land shall be initiated within one year of the approval of the use and all work and construction shall be completed within three years of the approval of the use.

Discussion: The provisions of this condition shall be complied with.

1.3 Hawaii State Plan

The Hawaii State Plan (Office of the Governor, Office of State Planning, 1989) consists of a series of broad goals, objectives and policies which serve as the guidelines for the growth and development of the State. The Plan is divided into three parts; Part I (Overall Theme, Goals, Objectives and Policies), Part II (Planning, Coordination and Implementation), and Part III (Priority Guidelines). Part II pertains to the administrative structure and implementation process for the State Plan, and is, therefore, not relevant to the proposed action. Discussed below are the specific goals, objectives, policies, and priority actions contained in Part I and Part III of the State Plan which are thought to be most directly related to the proposed project.

1.3.1 Part I. Overall Theme, Goals, Objectives and Policies

The Hawaii State Plan lists three "Overall Themes": (1) Individual and family self-sufficiency; (2) Social and economic mobility; and (3) Community or social well being. These themes are considered to be "basic functions of society" and goals towards which government must strive. To guarantee the elements of choice and mobility embodied in the three themes, three goals are presented in the Plan. Following is a discussion of these goals and their relationship to the proposed project:

SEC. 226-4 State goals. In order to guarantee, for present and future generations, those elements of choice and mobility that insure that individuals and groups may approach their desired levels of self-reliance and self-determination, it shall be the goals of the State to achieve:

(1) A strong, viable economy, characterized by stability, diversity, and growth, that enables the fulfillment of the needs and expectations of Hawaii's present and future generations.

Discussion: The proposed project will contribute to the economic diversification of the region by providing new employment opportunities which will promote a stable and diverse economy. These jobs will help to provide a base income for individuals and families who derive a least a portion of their income from part-time farming. It should be noted that the applicant estimates, based on direct experience, that nearly 50% of all the coffee grown in Kona is cultivated by part-time farmers. The provision of golf course related employment opportunities that are compatible with the skills of farmers will help to provide additional income for part-time farmers to pay for their properties and school for their children.

(2) A desired physical environment, characterized by beauty, cleanliness, quiet, stable natural systems, and uniqueness, that enhances the mental and physical well-being of the people.

Discussion: Development of the proposed project will ensure that the project area will remain in open space and will contribute to the region's recreational resource inventory. It will be constructed and operated in a manner that preserves the natural beauty and cleanliness of the environment. It should be noted that the County General Plan provides for open space above the cliffs at Kealakekua Bay and that the present development proposal will insure this in perpetuity. The Conservation District area below the project line at the top of the cliff will be considered for dedication to the State or a public trust to further guarantee its preservation.

(3) Physical, social, economic well-being, for individuals and families in Hawaii, that nourishes a sense of community responsibility, of caring, and of participation in community life.

Discussion: As a recreational amenity that is compatible with the rural character of the surrounding area, the proposed project will enhance the existing community in terms of scenic and economic impacts. This will, in turn, contribute to the physical, social and economic well-being of the area residents.

The proposed project will also promote the following State Plan objectives, policies and priority guidelines:

SEC. 226-6 Objectives and policies for the economy--in general.

Objectives: (1) Increased and diversified employment opportunities to achieve full employment, increased income and job choice, and improved living standards for Hawaii's people.

(2) A steadily growing and diversified economic base that is not overly dependent on a few industries.

Policies: (10) Stimulate the development and expansion of economic activities which will benefit areas with substantial or expected employment problems.

Discussion: The proposed project will contribute to the diversification of the economy of South Kona and provide new employment opportunities that are not now available within the existing community. It will help to strengthen agriculture in the area by providing a stable, alternate means of income for farmers who are willing to farm part time and work full time. As with most golf

courses, the starting time for the workers will be quite early thus allowing many part time farmers the afternoon and early evening hours to care for their coffee and macadamia nut farms that are located in the South Kona region.

SEC. 226-11 Objectives and policies for the physical environment--land-based, shoreline, and marine resources.

Objectives: (1) Prudent use of Hawaii's land-based, shoreline, and marine resources.

(2) Effective protection of Hawaii's unique and fragile environmental resources.

Policies: (2) Ensure compatibility between land-based and water-based activities and natural resources and ecological systems.

(3) Take into account the physical attributes of areas when planning and designing activities and facilities.

(4) Manage natural resources and environs to encourage their beneficial and multiple use without generating costly or irreparable environmental damage.

(8) Pursue compatible relationships among activities, facilities, and natural resources.

(9) Promote increased accessibility and prudent use of inland and shoreline areas for public recreational, educational, and scientific purposes.

Discussion: Although the proposed project does not include any shoreline areas, it is situated immediately above Pali Kapu O Keoua, the sea cliff behind Kealakekua Bay. Because of its location, its potential impact upon the bay is a concern which is fully accommodated in its proposed design and development plan. The natural resources of the area will be protected. The project will be developed in a manner which will minimize impacts upon the bay. Development of the project will be sensitive to existing environmental conditions. The use of fertilizers and pesticides will be strictly controlled to prevent infiltration into the groundwater. Runoff into the bay will be avoided wherever possible. Endemic plants will be used for landscape material wherever possible, and the applicant has committed to replanting the 50 acres above the Pali Kapu O Keoua to native plant material. This commitment is made in an effort to re-establish native plants in an area where they have completely disappeared. The subject property will be developed in a prudent manner consistent with the master plan resulting in orderly and timely development of necessary infrastructure. Public access to a new overlook will be provided.

SEC. 226-12 Objective and policies for the physical environment--scenic, natural beauty, and historic resources.

Objective: Planning for the State's physical environment shall be directed towards achievement of the objective of enhancement of Hawaii's scenic assets, natural beauty, and multi-cultural/historical resources.

Policies: (1) Promote the preservation and restoration of significant natural and historic resources.

(3) Promote the preservation of views and vistas to enhance the visual and aesthetic enjoyment of mountains, ocean, scenic landscapes, and other natural features.

(5) Encourage the design of developments and activities that complement the natural beauty of the islands.

Discussion: Numerous historic sites, many consisting of multiple features, have been identified on the subject property. A detailed archaeological study of these sites has been conducted and treatment ranging from data collection to preservation has been recommended, depending upon the cultural and scientific value of individual sites. Scenic views of the ocean and the South Kona coastline will be preserved wherever possible. The golf course will create a large open space area which will significantly contribute to preserving coastal views from the subject property. The open space character of the development will be compatible with the surrounding area and will contribute to the preservation of South Kona's natural beauty. The architectural design of the proposed lodge and clubhouse will be compatible with the character of the surrounding rural area.

SEC. 226-13 Objectives and policies for the physical environment--land, air, and water quality.

Objective: (1) Maintenance and pursuit of improved quality in Hawaii's land, air, and water resources.

Policies: (2) Promote the proper management of Hawaii's land and water resources.

(3) Promote effective measures to achieve desired quality in Hawaii's surface, ground, and coastal waters.

(4) Encourage actions to maintain or improve aural and air quality levels, to enhance the health and well-being of Hawaii's people.

(5) Reduce the threat to life and property from erosion, flooding, tsunamis, hurricanes, earthquakes, volcanic eruptions, and other natural or man-induced hazards and disasters.

(6) Encourage design and construction practices that enhance the physical qualities of Hawaii's communities.

(7) Encourage urban developments in close proximity to existing services and facilities.

Discussion: The proposed project is located near the community of Captain Cook and will be designed in a manner consistent with the character of the existing rural community. Development of the project will ensure that threats to life, property, and natural resources from erosion and flooding are minimized through the proper engineering methods to accommodate surface runoff. No portion of the property is located within a tsunami inundation zone. With regard to seismic activity, buildings will be constructed according to accepted engineering methods to minimize the potential damage from earthquakes. While air quality will be impacted to some degree during construction, construction activities will be in full compliance with State and Federal air quality standards and procedures. Improvements to Napoopoo Road and the access road's intersection

with Mamalahoa Highway will help to minimize the impact of automobile emissions upon air quality by reducing vehicle idling times. Impact upon ground waters will be minimized by adherence to accepted construction techniques and standards and careful management of the golf course maintenance program. Environmentally safe soil fertilization and pest control programs will be implemented to ensure that impacts to the groundwaters are minimized.

SEC. 226-23 Objective and policies for socio-cultural advancement--leisure.

Objective: Planning for the State's socio-cultural advancement with regard to leisure shall be directed towards the achievement of the objective of the adequate provision of resources to accommodate diverse cultural, artistic, and recreational needs for present and future generations.

Policies:

(4) Promote the recreational and educational potential of natural resources having scenic, open space, cultural, historical, geological, or biological values while ensuring that their inherent values are preserved.

(6) Assure the availability of sufficient resources to provide for future cultural, artistic, and recreational needs.

Discussion: The proposed golf course, public access and scenic overlook included in the proposed development contribute to the goals and objectives of providing recreational and leisure activities to the existing and growing population of the area. The property's location in proximity to Kealakekua Bay and the increased public access afforded by the project will greatly enhance the public's enjoyment of the bay as a natural and historic resource. Existing recreational activities at the bay including swimming, snorkeling and sightseeing. These will all be enhanced by improved access to the bay park.

1.3.2. Part III. Priority Guidelines

The purpose of this part of the State Plan is to establish overall priority guidelines to address areas of statewide concern. Section 226-102 of the Plan notes that the State shall strive to improve the quality of life for Hawaii's present and future population through the pursuit of desirable courses of action in five major areas of statewide concern which merit priority attention: economic development, population growth and land resource management, affordable housing, crime and criminal justice, and quality education. The priority guidelines applicable to the proposed project are discussed below.

SEC. 226-104 Population growth and land resources priority guidelines.

(b) Priority guidelines for regional growth distribution and land resource utilization:

(1) Encourage urban growth primarily to existing urban areas where adequate public facilities are already available or can be provided with reasonable public expenditures and away from areas where other important benefits are present, such as protection of important agricultural land or preservation of lifestyles.

(2) Make available marginal or non-essential agricultural lands for appropriate

urban uses while maintaining agricultural lands of importance in the agricultural district.

(9) Direct future urban development away from critical environmental areas or impose mitigating measures so that negative impacts on the environment would be minimized.

(12) Utilize Hawaii's limited land resources wisely, providing adequate land to accommodate projected population and economic growth needs while ensuring the protection of the environment and the availability of the shoreline, conservation lands, and other limited resources for future generations.

Discussion: The proposed project is situated upon marginal agricultural land, near an existing urban area and contains a substantial amount of Urban-designated property. It's development will result in the productive use of land in a manner that will have considerably less impact than the residential development permitted under its present zoning. The proposed property is intended to be developed in a way that is sensitive to the environment and protect valuable resources including Kealakekua Bay, archaeological sites and endemic plants. In this manner, the project will aid in the attainment of the above land resource related guidelines.

1.4 State Functional Plans

As set forth in Section 2 of the Hawaii State Plan, functional plans shall include "the policies, programs and projects designed to implement the objectives of a specific field of activity when such activity or program is proposed, administered, or funded by any agency of the State". The twelve functional plans were examined to determine the relationship of the proposed project to each of their administrative areas of responsibility.

1.4.1 State Agricultural Functional Plan (1985)

Historically, portions of the property have been leased to the neighboring Greenwell Ranch for cattle grazing. In addition, mauka portions of the project area have been utilized to cultivate coffee trees and pineapple on a limited basis. The proposed project provides for five lots along Napoopoo Road which can be continue to be used for agricultural purposes such as coffee cultivation. However, because the general quality of the overall property as an agricultural resource is best described as marginal and has limited potential for agricultural activities, the objectives, policies and implementing actions of the Agricultural Functional Plan are not relevant to the proposed project.

1.4.2 State Conservation Functional Plan (1984)

There are several objectives and policies in the State Conservation Functional Plan which pertain to the proposed project. These are identified below and followed by a discussion of how the proposed may assist in their implementation.

Objective: Effective protection and prudent use of Hawaii's unique, fragile, and significant environmental and natural resources.

Policy: (A1) Exercise an overall conservation ethic in the use of Hawaii's resources by protecting, preserving, and conserving the critical and significant natural resources of the State of Hawaii and controlling use of hazardous areas.

Objective: Effective protection and management of open space, watersheds, and natural areas.

Policy: (C3) Protect and manage the lands with historic or natural resources value.

Objective: Promote sound management and development of Hawaii land and marine resources for potential economic benefit.

Discussion: Development of the proposed project in strict adherence to environmentally sound practices will result in a minimal amount of negative impact upon the environment. Management of the proposed golf course will include the prudent use of fertilizers and pesticides to ensure the least possible amount of impact upon the environment, especially the groundwater and the pristine waters of Kealakekua Bay. Culturally significant historic and archaeological resources identified on the subject property will be preserved.

1.4.3 State Educational Functional Plan (1989)

The State Education Functional Plan reflects the Department of Education's strategies to address the goals, policies and priority guidelines of the Hawaii State Plan and the goals of the State Board of Education. All of the actions are to be undertaken by the State Department of Education. The specific objectives and policies of the functional plan are not directly applicable to the proposed development.

1.4.4 State Higher Educational Functional Plan (1984)

There are no objectives, policies or implementing actions in this functional plan that are directly applicable to the proposed project.

1.4.5 State Employment Functional Plan (1989)

The State Employment Function Plan contains objectives, policies and implementing actions directed four major areas: Education and Preparation Services for Employment; Job Placement; Quality of Work Life; and Employment Planning Information and Employment Coordination. The proposed project will provide new employment opportunities in the construction trades, service industry and in golf course operation and management to the existing and future residents of the region which will, in turn, have a direct impact upon improving the quality of life in the region. The proposed project complies with the State Employment Functional Plan in providing alternative sources of employment to the region.

1.4.6 State Energy Functional Plan (1984)

The State Energy Functional Plan's objective to promote energy efficiency through land use and support facility systems planning relates directly to the overall master planning of the proposed project as well as its implementation. The project will be master planned to promote energy efficiency through the general siting of facilities to maximize access and minimize energy consumption. The proposed project will adhere to energy conservation standards whenever

possible. Specific elements of energy conservation such as the utilization of solar energy in building design for the purposes of water heating will be encouraged wherever practicable. Consistent with Policy D(1), the proposed project is an "easily serviceable," and "compact development", which promotes energy-efficient land use. The natural ambient air temperature of the area is such that air conditioning will not be needed.

1.4.7 State Health Functional Plan (1989)

The State Health Functional Plan includes objectives and policies that relate directly to the proposed development. These are presented below followed by a discussion how the project will support their implementation.

Objective: To prevent degradation and enhance the quality of Hawaii's air, land and water.

Policy: (A1) Prevent and control the pollution of air, water and land through long-range planning, environmental impact assessments, interagency coordination, programs, regulations, and financial assistance to local governments.

Objective: Minimize the threat to public health from insanitary conditions by ensuring that facilities are built and maintained so that products and services are provided in a healthful manner.

Discussion: The proposed project intends to comply with all applicable Department of Health rules and regulations as well as those established by Hawaii County. Environmental impacts on air quality are fully addressed within this EIS document. Drainage and runoff from the project, both during construction and long-term maintenance of planned facilities will be minimized to ensure the protection of ground water quality and offshore ocean water quality. The impacts of drainage and runoff, as well as impacts upon groundwater and the water quality of Kealakekua Bay are fully addressed within this environmental impact statement. Infrastructure intended to accommodate the sewage generated by the project will be master planned to ensure its timely development and thereby minimize environmental impacts.

1.4.8 State Historic Preservation Functional Plan (1984)

Objectives, policies and implementing actions in the Historic Preservation Functional Plan are intended for implementation by the Department of Land and Natural Resources and affiliated State agencies. The project area has been extensively surveyed and a description of identified historic and archaeological sites is included in this EIS document. Recommendations are included for the disposition of the sites, including preservation of those sites identified as significant for cultural, scientific or educational value. Implementation of the proposed project will include the preparation of an Historic Sites Mitigation Plan to ensure conformance with all applicable state, county and federal regulations concerning historic sites. In view of the project's location within the Kealakekua Bay Historic District as well as the Kona Field System, the development is particularly sensitive to full compliance with all regulations and policies pertaining to Historic Preservation.

1.4.9 State Housing Functional Plan (1989)

Because the project contains no proposed housing development, the objectives and policies

of the State Housing Functional Plan are not directly applicable to the proposed development.

1.4.10 State Human Services Functional Plan (1989)

Objectives and polices of the Human Services Functional Plan are directed specifically to administration and implementation by State agencies including the Department of Human Services, the Department of Health, the Department of Education, the Department of Labor and Industrial Relations, and the State Office of Children and Youth and Executive Office on Aging. The functional plan does not relate directly to the proposed project.

1.4.11 State Recreation Functional Plan (1984)

A number of objectives and policies of the Recreation Functional Plan are applicable to the proposed project. These are presented below and followed by a discussion of how the project will assist in their implementation.

Objective: Achieve a pattern of land and water resource usage which is compatible with community values, physical resources, recreation potential, and recreation uses which support comprehensive public land use policies.

Policies: (A2) Ensure that intended uses for a site respect community values and are compatible with the area's physical resources and recreation potential.

(A3) Emphasize the scenic and open space qualities of physical resources and recreational areas.

Discussion: The development of a new recreational resource in the South Kona region will greatly enhance the public's access to the property, especially the proposed scenic view area overlooking historic Kealakekua Bay. The development will utilize the natural character of the property and will preserve its existing open space character. New public access trails will be developed to allow public access to a scenic overlook above the bay. A new trail extending laterally across the property will conncet to Ka'awaloa Road, providing improved pedestrian access to the Ka'awaloa portion of the Kealakekua Bay park.

Objective: Establish a system of maintaining natural and cultural resources for present and future generations, and of managing recreation and other uses in accordance with sound conservation practices.

Policy: (B1) Exercise an overall conservation ethic in the use of Hawaii's resources.

Discussion: Natural and cultural resources within the project area will be maintained and managed in accordance with sound conservation practices. A detailed archaeological inventory survey has been conducted to identify all archaeological and historic sites worthy of preservation. The project's design accommodates those sites identified for preservation. In addition, the provision of a public access way and scenic overlook will ensure the availability of the property as a natural and cultural resource for future generations.

1.4.12 State Tourism Functional Plan (1984)

The objectives and policies of the Tourism Functional Plan directly relate to the proposed development.

Objective: Maintenance and enhancement of Hawaii's share of existing and potential visitor markets.

Policy: (B4) Ensure that visitor facilities and destination areas are carefully planned and sensitive to existing neighboring communities and activities.

Discussion: Limiting the size of the proposed lodge to 36 units will ensure that it is compatible with the surrounding community. Although it is proposed as a private lodge and is therefore not available to the general visitor, the golf course as a visitor facility will provide an attraction to the area. However, its use as a private lodge should have no influence upon surrounding property owners decision to develop transient accommodations due to existing zoning restrictions.

1.4.13 State Transportation Functional Plan (1984)

The objectives and policies of the Transportation Functional Plan relate primarily to the administration and implementation of transportation policy by the State Department of Transportation. For this reason, the functional plan does not directly relate to the proposed project. Nonetheless, specific mitigation measures have been proposed to improve traffic circulation in the Captain Cook region and access to the project site. These improvements will assist in the functional plan's intent to promote the timely development of infrastructure to serve new development and to improve the quality of life for residents of the area.

1.4.14 State Water Resources Development Functional Plan (1984)

Objectives and policies of the Water Resources Development Functional Plan are directed primarily to State and County agencies responsible for the management of water resources and are not directly applicable to the proposed project. Implementation of water infrastructure will be done in cooperation with the appropriate State and County agencies.

1.5 Coastal Zone Management Act (Chapter 205-A, HRS)

The objectives of the Hawaii Coastal Zone Management (CZM) Program, as set forth in Chapter 205A, Hawaii Revised Statutes, include the protection and maintenance of valuable coastal resources. The proposed project conforms to applicable objectives. Because the State CZM authority has been delegated to the county level through the Special Management Area controls, the specific objectives of the CZM program are addressed below under the section pertaining to the SMA regulations.

1.6 Hawaii Water Code

Chapter 174C, Hawaii Revised Statutes, The State Water Code, was adopted by the State Legislature in 1987 to "protect, control, and regulate the use of Hawaii's water resources for the benefit of its people." The Water Code is administered by the Commission on Water Resources Management, Department of Land and Natural Resources. The codes' policies include protection of water resources, maintenance of ecological balance and scenic quality, improvement of water

quality, and establishment of comprehensive water planning statewide. A major element of the State Water Code is the development of the Hawaii Water Plan discussed below.

Discussion: Preparation of this environmental impact statement and the recommended mitigation measures contained herein represent the means for compliance with Water Code policies.

1.7 State of Hawaii Water Plan

As adopted by the Commission on Water Resource Management in July, 1990, the State Water Plan contains five elements; A Water Quality Plan prepared by the Department of Health, a Water Projects Plan prepared by the DLNR, a Water Resource Protection Plan prepared by the DLNR, and two County Water Use and Development Plans (Hawaii and Kauai). The overall purpose of the Water Plan is set forth in section 174 C-31(d): the plan "shall be directed toward the achievement of the following objectives: The attainment of maximum reasonable-beneficial use of water; the proper conservation and development of the waters of the State and the implementation of the water resources polices as expressed in section 174 C-2". This section, in turn, calls for "a program of comprehensive water resources planning" and "maximum beneficial use of the waters of the State" with adequate provision for the protection of "traditional and customary Hawaiian rights", fish and wildlife, and the maintenance of "proper ecological balance and scenic beauty" among others.

The proposed project will acquire potable water from the existing municipal system and is expected to have very little impact on that system due to its limited size. The non-potable water required for irrigation purposes will be supplied by wells to be drilled within the project area. The following objective and strategies are pertinent to the proposed action.

Objective	(2)	Maximize the utility of the State's water resources for all uses of water by both mankind and nature.
Strategy	(2)(A)	Maximize the efficient use of water and limit quantities of water use to the minimum required for efficient and economic utilization.
Strategy	(2)(B)	Maximize the efficient use of water and limit the quality of water used to the minimum required for efficient and economic utilization.

Discussion: As discussed in other sections of this environmental impact statement, the efficient use of water is a particular concern at the proposed project. In order to maximize the use of irrigation waters while ensuring the minimal amount of impact upon the groundwater in terms of infiltration and upon the bay in terms of runoff, the careful regulation and control of irrigation is vital to success. Therefore, irrigation waters will be utilized in a prudent manner to minimize impacts. This translates as an extremely conservative approach to the application of irrigation waters. Development of non-potable sources of water to meet irrigation needs at the project complies with the above objective and strategies. In addition, brackish irrigation water obtained from the on-site wells may be augmented by effluent generated by the on-site sewage treatment plant. The use of effluent to supplement irrigation will have a minimal impact due to the total volume of effluent available (less than 3% of daily irrigation needs). Ultimately, the applicant will work with the State Department of Health and the County Department of Public Works to determine the most appropriate method of disposal.

1.8 Kealakekua Bay Historic District and Kona Field System

The project area is located within both the Kealakekua Bay Historic District (Site 50-10-47-7000) and the Kona Field System (Site 50-10-37-6601). Both of the above referenced sites are included on the National Register of Historic Places. As such, they fall under the jurisdiction of the Department of Land and Natural Resources' Historic Preservation Program/State Historic Preservation Office and the County of Hawaii's Planning Department. Pursuant to Chapter 343, Hawaii Revised Statutes, as amended, any development within lands identified on the National Register of Historic Places requires an environmental impact statement to assess potential impacts and recommend mitigation measures to address negative impacts.

2. HAWAII COUNTY PLANS AND CONTROLS

2.1 Hawaii County General Plan

The Hawaii County General Plan is the policy document for the long-range comprehensive development of the island of Hawaii. The General Plan provides direction for balanced growth of the County. The Plan contains goal, policies, and standards concerning twelve functional areas as well as a series of land use maps referred to as General Plan Land Use Pattern Allocation Guide (LUPAG) Maps. The LUPAG map designations for the subject property identify it generally as Low Density Urban, Orchard and Extensive Agriculture. The proposed project is consistent with the County General Plan with the exception of the proposed Members' Lodge, which will require an amendment to the General Plan. With the exception of the Lodge, the proposed project is consistent with the following policy elements of the General Plan.

Economic Element

Economic goals for the County of Hawaii include the need to "strive for diversity and stability in its economic system" and to "provide an economic environment which allows new, expanded, or improved economic opportunities that are compatible with the County's natural and social environment." Policies include an intent to "strive for an economic climate which provides its residents an opportunity for choice of occupation."

Discussion: The General Plan identifies agriculture as the primary economic activity of the South Kona District. The proposed makai lots adjacent to Napoopoo Road will allow lot owners to engage in agricultural activities as either a full-time or part-time economic pursuit. The proposed golf course and lodge facilities will generate new jobs in the area and increase business to local suppliers. This will contribute to the economic health of the South Kona region by stimulating economic growth through the sale of goods and services. It will also help to strengthen agriculture in the area by providing a stable, alternate means of income for farmers who are willing to farm part time and work full time. As with most golf courses, the starting time for the workers will be quite early thus allowing many part time farmers the afternoon and early evening hours to care for their coffee and macadamia nut farms that are located in the South Kona region. The overall character of the proposed development is compatible with the surrounding rural area.

Environmental Quality

A key attribute of the proposed project is its compliance with the County's policy to maintain the quality of the environment for residents and future residents.

Discussion: The golf course project will be constructed and operated in a manner that will ensure that adverse impacts to the environment are minimized. The property owners recognize their responsibility in providing the utmost protection to the environment, especially in terms of the project's compatibility with Kealakekua Bay. Extensive studies of the project have resulted in a series of management recommendations, included in this document, that will provide for the environmentally safe management of the golf course facility. As a result, the proposed development will not diminish the valuable natural resources of the surrounding area.

Flood Control and Drainage

The General Plan includes goals to conserve scenic and natural resources, prevent damage to man-made improvements, and to reduce surface water and sediment runoff. Policies include the intent that all development-generated runoff be disposed of in a manner that is acceptable to the County's Department of Public Works. The private sector is seen as a partner to the government in maintaining and improving drainage systems and in building new drainage facilities.

Discussion: The project area is not subject to flooding. The property owners will work closely with the Department of Public Works to ensure that the ultimate design of the golf course and lodge will include a drainage plan that will cause minimal impact to Kealakekua Bay.

Historic Sites

The General Plan includes a goal to "protect and enhance the sites, buildings and objects of historic and cultural importance to Hawaii" and a policy that the County require "both public and private developers of land to provide a historic survey prior to the clearing and development of land when there are indications that the land under consideration has historic significance."

Discussion: An exhaustive survey of the project area has been completed and nearly 100 sites have been identified. This environmental impact statement includes evaluations of the historic, scientific and cultural significance of each site and recommendations for further work and/or preservation. The applicant will work closely with the Hawaii County Planning Department and State Historic Sites Division to prepare an acceptable mitigation and preservation plan. The golf course will be designed to accommodate those sites identified for eventual preservation. In addition, a 50-acre portion of the Kona Field System is being preserved in its entirety and will be replanted with native plants. This will help to restore the area to its original historical character and preserve it in perpetuity for future generations.

Housing Element

General Plan goals for housing include a desire to have a diverse housing mix throughout the island, maintaining a housing supply that allows choice and a policy to accommodate the housing requirements of special need groups, including those residents living in rural areas.
Discussion: The proposed two-acre lots will provide an alternative to smaller residential lots for rural residents to accommodate both residential use and agricultural pursuits. A portion of the project area is designated as Urban and zoned RA-2. Although this area could be used to accommodate 36 new housing units, development is being limited to only five lots to be subdivided. Clearly there is a trade-off that must be considered. The full development of the property for residential use will help to provide new housing in the South Kona district. However, that alternative is not viewed as acceptable to the surrounding community. The applicant has

carefully weighed the alternatives and has concluded that the development of the property as a golf course with limited residential lots will provide a better opportunity to control environmental impacts upon the surrounding area. In effect the golf course will serve as a buffer between residential development inland from the property and Kealakekua Bay. As a natural, open space area, the golf course will be able to accommodate runoff and drainage and retain it on-site. It will enhance the rural character of the surrounding community and provide a scenic and recreational amenity to current and future residents. With these considerations in mind, the provision of a limited number of subdivided RA-2 zoned lots is seen as a means of fulfilling the County's housing goals without causing undue impact to the environment in this particularly sensitive area.

Natural Beauty

Goals concerning the scenic and natural beauty of Hawaii include the desire to preserve the quality of coastal scenic resources and to protect scenic vistas and view planes from becoming obstructed. The vast expanse of Kona's landscape is identified as the area's most striking feature. Kealakekua Bay is listed as an example of a site of natural beauty.

Discussion: The low-density and low-rise character of the project will result in the preservation of views from the property to adjoining areas and from surrounding properties to the coast. Scenic views will not be substantially adversely affected. The site location at the top of the cliff assures that visual impacts of the site from the bay will be only from a considerable distance.

Natural Resources and Shoreline

A primary goal of the General Plan is to "protect and conserve the natural resources of the County of Hawaii from undue exploitation, encroachment and damage". It is the County's policy that the shoreline be protected from the encroachment of man-made improvements and structures. It is also the County's policy to encourage the protection of unique habitats, wildlife species, and agricultural use of the land.

Discussion: Alterations to the area's existing landforms will be mitigated by compliance with accepted construction and design standards and will result in minimal impact to the water resources, scenic and recreational amenities of the area. The golf course will be designed to compliment the existing topography wherever possible. Because the project is located at the top of Pali O Kapu Keoua, it does not directly impact the shoreline, but will enhance the public enjoyment of the shoreline view by creation of an open, scenic point and trail system allowing access to the shoreline at Ka'awaloa. Sensitive design, good golf course management practices, and a comprehensive ocean water monitoring program will result in minimal indirect or secondary impact to the shoreline, scenic and recreational resources. To further enhance the area, the applicant intends to improve the cliff edge by reestablishing native plants. Development of the golf course will provide a new open area habitat of migratory birds. By these actions, the applicant hopes to improve the area's function as a natural habitat and its visual appearance.

Public Facilities

The General Plan identifies public facilities as schools, libraries, fire stations, police stations, detention and correction facilities, and refuse disposal areas. The County's overall goal is to improve public service through better facilities that are in keeping with the environmental and aesthetic concerns of the community.

Discussion: The proposed project will have a very limited impact upon public facilities due to its small size and relative lack of population impacts. Nevertheless, public revenues in the form of property and excise taxes that will be generated by the proposed development are expected to more than offset the governmental cost of providing public services and facilities.

Public Utilities

The General Plan declares that public utilities, including water, telephone, electricity, gas, sewage treatment and disposal should complement adjacent land uses and be operated to avoid pollution or disturbance. The improvement of existing utility services is linked to demand for such services.

Discussion: The proposed project would acquire its electrical power from the Hawaii Electric Light Company (HELCO) system. It is anticipated that HELCO has sufficient generating capacity to meet the electrical demands of the proposed project. Power transmission to the project area will be via an existing transmission line from the HELCO Captain Cook substation, and the project will be supplied lower voltage through overhead lines. The five agricultural lots proposed in the overall concept plan for the project will be connected to various utility systems. Existing water commitments will provide potable water to the proposed project. An on-site privately financed and operated wastewater treatment facility will be installed.

Recreation

As resident population on the Big Island continues to grow and the visitor industry continues to expand, demand for additional recreational resources is expected to increase. County polices include the intent to improve existing facilities, provide a broad range of recreational opportunities, and provide public access to the shoreline and shoreline resources. The General Plan identifies the South Kona district as having inadequate neighborhood recreational facilities.

Discussion: The proposed project will not have a substantial impact upon existing or proposed County recreation facilities due to the limited size of actual population growth generated by the five RA-2 zoned lots proposed. The proposed golf course will contribute to the inventory of golf courses in the greater Kona area and will provide a new recreational opportunity for Kona residents and visitors alike. Because the project is located at the top of Pali O Kapu Keoua, it does not directly impact the shoreline, but will enhance the public enjoyment of the shoreline view by creation of an open, scenic point and trail system allowing access to the shoreline at Ka'awaloa. This will result in an increase in recreational opportunities in the area such as hiking. New access trails and public parking stalls will also be provided.

Transportation

The General Plan includes transportation policies to provide transportation facilities that promote the desired land use, improve transportation service, and plan for future needs. A course of proposed action near the project area is the construction of a scenic drive from Keauhou above the Kealakekua cliffs to Napoopoo.

Discussion: The development of the proposed project will not interfere with the County's planned scenic route discussed above. The project's impacts upon traffic conditions in the area will be mitigated by the applicant working closely with County and State transportation agencies to

improve roadway conditions in the immediate vicinity of the project.

Land Use

The General Plan recommends courses of action for the future land use of Kona which include the protection of important agricultural lands and the encouragement of buffer zones between important agricultural land and incompatible land uses. As an area that is facing the pressures of urbanization in the face of traditional agricultural activity, the compatibility of new development is of particular importance.

Discussion: As discussed in previous sections of this environmental impact statement, the project area is considered to contain poor agricultural lands due to soil quality and overall ratings of productivity. While the area has been historically used for grazing and crop cultivation, it can not be considered to be 'important' agricultural land. The proposed development is seen as a viable alternative. The productive use of the land while retaining it as largely open space is compatible with the rural, agricultural character of the surrounding community. The proposed Members' Lodge will require an amendment to the General Plan.

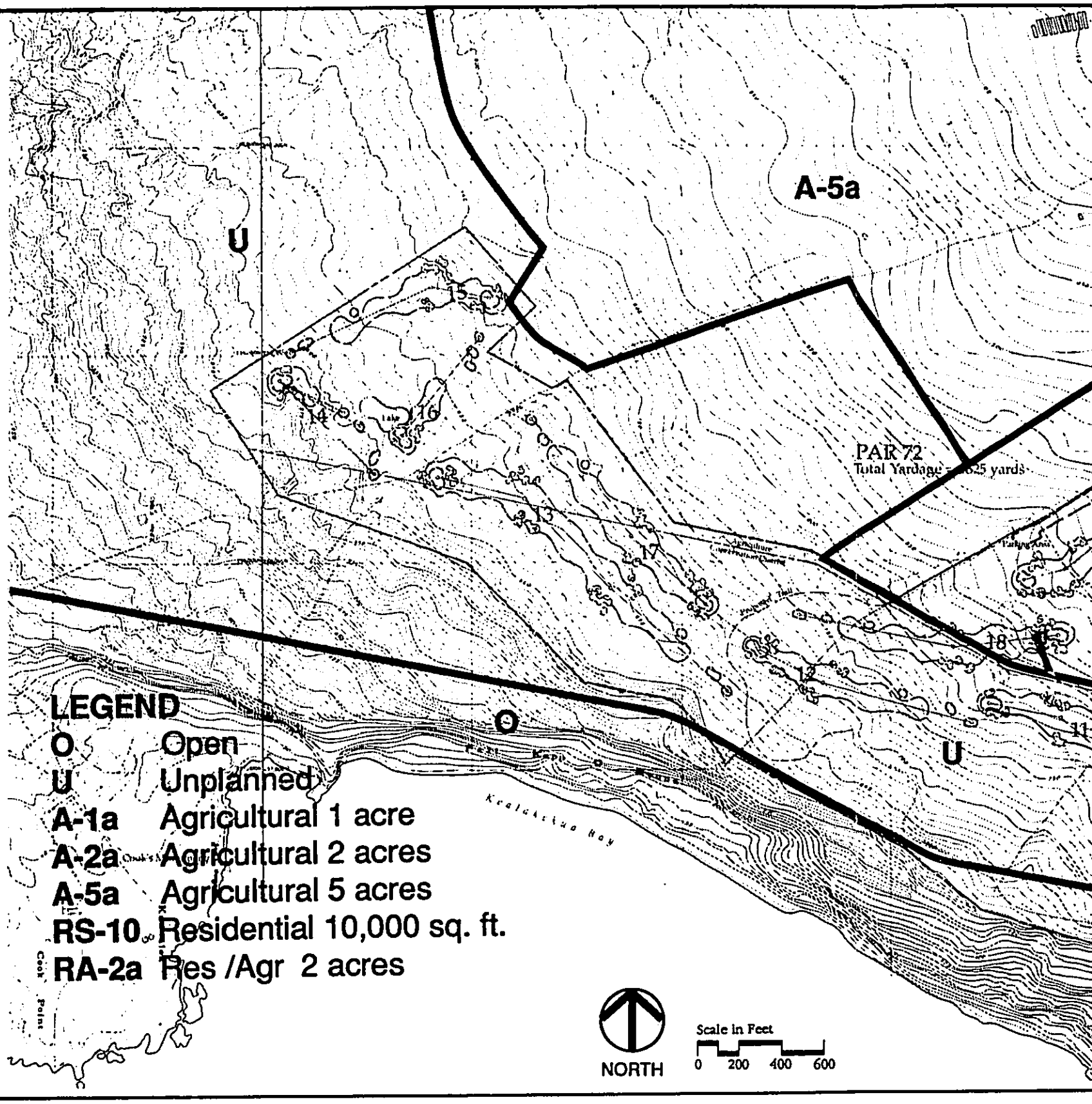
2.2 Hawaii County Zoning

Approximately 100 acres of the project area are zoned RA-2 (residential and agriculture). The remaining project area under County jurisdiction is zoned as Unplanned. The portion of the project designated as Conservation by the State Land Use Commission falls under the jurisdiction of the State. No zoning changes are required for the proposed project, with the exception of the proposed Members' Lodge which will require a General Plan amendment and rezoning. A use permit for the golf course will be necessary. The property's zoning classification is presented in Figure 7-2.

2.3 Hawaii County Special Management Area Guidelines

The proposed project is situated within the Special Management Area as shown in Figure 7-3. The proposed development is consistent with the County of Hawaii Special Management Area (SMA) guidelines. The proposed improvements will involve no adverse physical impact upon the coastal area, including recreational areas and submerged lands, and will not involve a reduction of beach size or loss of coastal resources. Public access to the coastal area will not be reduced or limited by the proposed development. There are no natural water features. The proposed development will not detract from the line of sight from the Mamalahoa Highway to the horizon due to its open space character. Although a lodge and clubhouse facility are proposed, they represent a small visual impact to the entire project area. Proper construction precautions and golf course maintenance procedures will ensure that the proposed improvements will not significantly adversely affect water quality of coastal water in the long term.

The proposed improvements will have minimal adverse environmental impact upon the project area and its surroundings. Construction of the project will not impact or impede public access. In fact, public access will be improved through the proposed provision of public parking stalls and the improvement of existing trails to a new scenic overlook at the top of the cliff. A trail will also be developed which connects with Ka'awaloa Road allowing foot access to Ka'awaloa peninsula. Solid and liquid waste will be disposed of in accordance with all applicable State and County rules and regulations, during both the construction and operation phases of the project.



Prepared by: Belt Collins & Associates

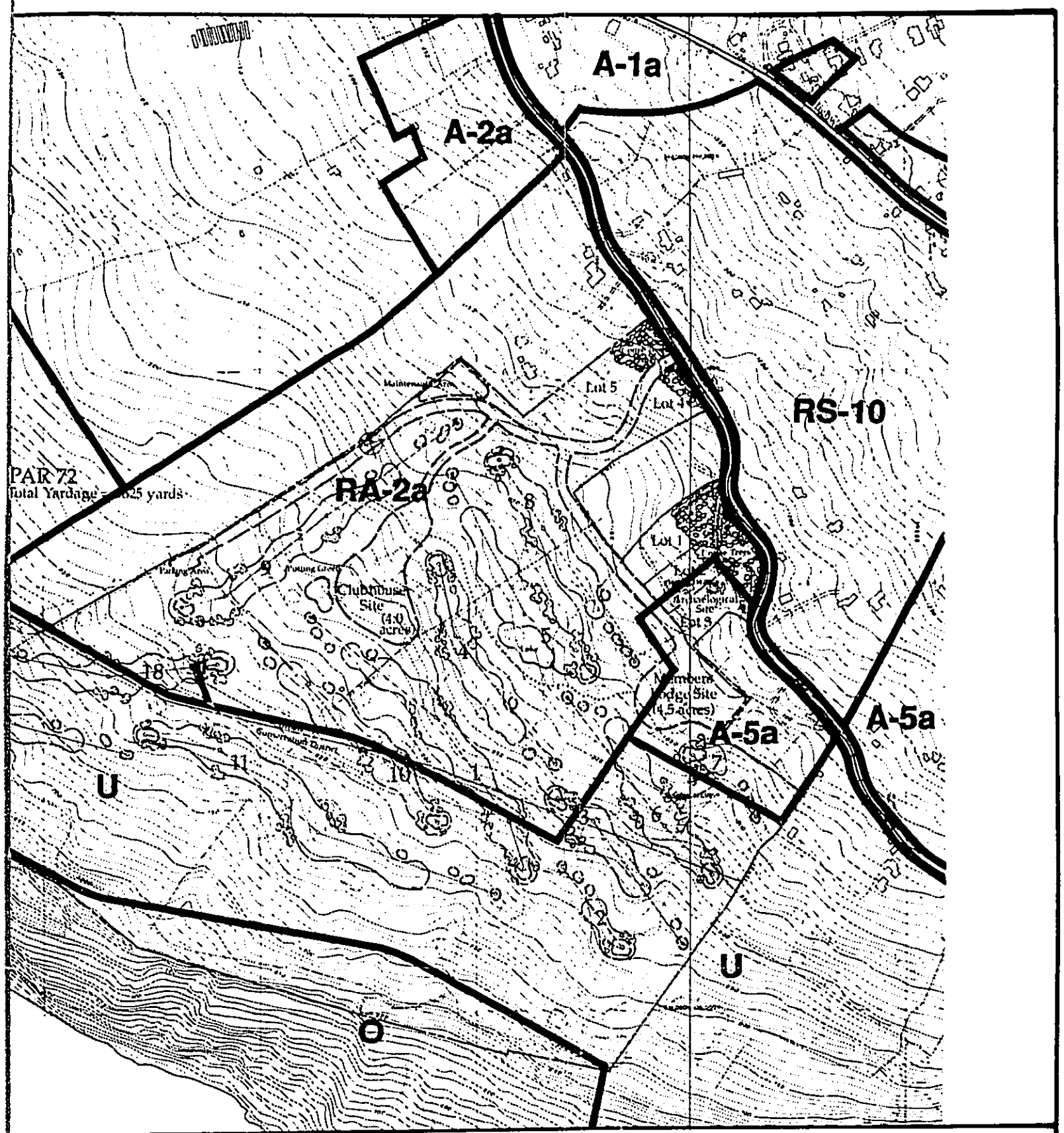


Figure 7-2
CURRENT ZONING

Kealakekua Bay Club
South Kona, Hawaii

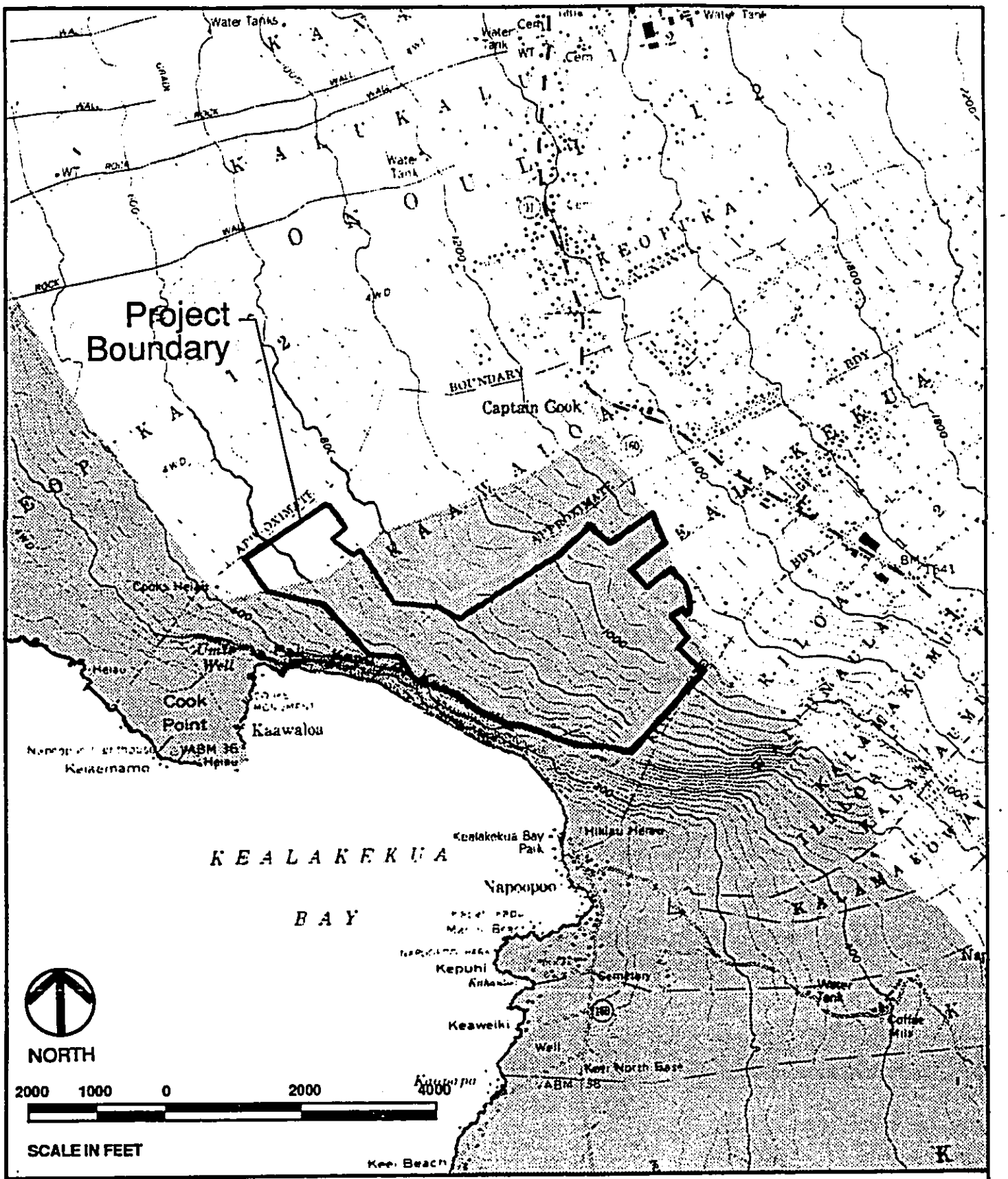


Figure 7-3
CURRENT SPECIAL MANAGEMENT AREA BOUNDARY
Kealakekua Bay Club
South Kona, Hawaii

Prepared by: Belt Collins & Associates

The proposed golf course will be designed to take advantage of the existing topography wherever possible and impact to existing landforms will be minimized. Finally, water resources and scenic and recreational amenities will not be adversely impacted. Flooding from surface runoff, erosion, and siltation will be minimized and are not expected to result in any noticeable impact to the property or to coastal resources or water quality. Following is a discussion of the specific objectives and policies of the Chapter 205A, Hawaii Revised Statutes.

Recreational Resources

Objective: Provide coastal recreational opportunities accessible to the public.

Discussion: Due to the location of the property, the coastal area is not directly accessible from the project site. However, the proposed project will provide new recreational opportunities not presently available to the public.

Historic Resources

Objective: Protect, preserve, and where desirable, restore those natural and man made historic and prehistoric resources in the coastal zone management area that are significant in Hawaiian and American history and culture.

Discussion: As previously discussed, a detailed archaeological inventory of the entire property has been prepared and includes recommended treatments for the sites identified. These recommendations include the preservation of significant sites.

Scenic and Open Space Resources

Objective: Protect, preserve, and where desirable, restore or improve the quality of coastal scenic and open space resources.

Discussion: The property does not front the shoreline. Therefore, the shoreline area will not be directly affected. Open space and lateral view corridors along the coastal area will be maintained. Mauka-makai view corridors will not be significantly impacted. No structures are planned in the immediate vicinity of the coastline which would detract from its scenic beauty.

Coastal Ecosystems

Objective: Protect valuable coastal ecosystems from disruption and minimize adverse impacts on coastal ecosystems.

Discussion: No development is proposed along the coastline of the subject property. However, a detailed study of the coastal ecosystem has been conducted and includes specific recommendations for the protection of the coastal ecosystem from the potential impacts of runoff and drainage from the project site. These recommendations will be implemented.

Economic Uses

Objective: Provide public or private facilities and improvements important to the State's economy in suitable locations.

Discussion: The subject property is considered to be a suitable location for a golf course to serve the recreational needs the region. Although the golf course is to be privately developed, it will be open to the public on a limited basis. The proposed improvements to the property will not preclude the development of coastal dependent public and private facilities necessary to the State's economy in suitable areas.

Coastal Hazards

Objective: Reduce hazard to life and property from tsunami, storm waves, stream flooding, erosion, and subsidence.

Discussion: The property is located within the C zone (areas of minimal flooding), as designated by the Flood Insurance Rate Map (FIRM) for the subject area. The proposed improvements will not result in significantly increased surface runoff and coastal flooding, nor are there expected to be any major erosion and sedimentation problems. The subject property is not affected by tsunami or storm waves.

Managing Development

Objective: Improve the development review process, communication and public participation in the management of coastal resources and hazards.

Discussion: This Environmental Impact Statement has been prepared in compliance with with existing state and county environmental rules (Chapter 343, HRS and Chapter 200, Department of Health Environmental Impact Rules). In addition, in fulfilling the requirements of the County's Special Management Area Permit requirements and Use Permit requirements, the applicant has been and will continue to meet with all appropriate federal, state and county personnel, as well as affected and interested community groups and individuals to ensure that the plans for the proposed project are fully communicated and reviewed. An amendment of the General Plan and current zoning will be required for the proposed Members' Lodge.

3. STATE ENVIRONMENTAL IMPACT STATEMENT REQUIREMENTS

Section 343-5(a) of Chapter 343, HRS (revised) states that except as otherwise provided, an environmental assessment shall be required for actions that propose any use within any land classified as conservation district by the state land use commission under Chapter 205, as well as for projects located within sites included on the National Register of Historic Places. Accordingly, this environmental impact statement for the proposed project has been prepared and is submitted pursuant to the provisions of Chapter 343. It is also required due to the need to amend the General Plan to permit development of the proposed Members' Lodge.

Upon acceptance of this EIS and approval of the requested State and County permits, the proposed project would conform with relevant state and county land use regulations.

Chapter VIII:
CONTEXTUAL ISSUES

CHAPTER VIII - TOPICAL ISSUES

1. RELATIONSHIP BETWEEN SHORT-TERM USES AND MAINTENANCE OF LONG-TERM PRODUCTIVITY

The subject property is identified as having physical attributes that are desirable as amenities as a golf club and for their own sake. These include the elevation of the property, its views of the Kona coast, and its climate. The studies performed for and included in this environmental impact statement demonstrate that the project is compatible with the existing natural environment and will both preserve it and enhance it. The specific measures that will be employed to mitigate potential adverse environmental impacts are discussed in Chapter IV of this document and will be adhered to during the design, construction and operations phases of the project.

Current short-term uses of the subject property relate principally to the occasional grazing of cattle. No short-term exploitation of resources that will have negative long-term consequences, beyond the effects of cattle grazing, have been identified. Current long-term uses relate to the occupied and abandoned single family dwelling units located just makai of Napoopoo Road. The proposed benefits of the proposed project include the productive use of the property and the preservation of open space in the area. Increased economic opportunities for all socioeconomic levels will be provided and the agricultural economy of the region will enhance through the provision of employment opportunities for part-time farmers of the area.

As discussed in Chapter III of this document, alternatives to the proposed project include retaining the project area as a vacant property. This would be a less than optimum use of the property. The economic benefits of the project include increased employment opportunities and tax revenues. Public revenues from the project will offset any expenses associated with the expansion of public services to meet the requirements of the proposed project and indirect population growth, as discussed in Chapter V.

2. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

The development of the proposed project and resultant construction of the golf course, golf course club house, members' lodge, appurtenant facilities and single family dwellings on the five agricultural lots will result in the irreversible and irretrievable commitment of certain natural and fiscal resources. Major resource commitments include the land on which the project is located and on which the facilities would be constructed, as well as money, construction materials, manpower and energy. The impacts of using these resources should be weighted against the expected positive economic benefits to be derived from the project versus the consequence of taking no action or adopting another less beneficial use of the property.

Under the project's design proposal, the vast majority of the project will remain in open space. This includes the entire golf course, as well as the conservation district between the golf course and the summit of the pali.

The commitment of resources required to accomplish the project includes building materials and labor, both of which are generally non-renewable and irretrievable. The consumption of petroleum products for the project's electrical generation needs, as well as for transportation to and from the project site for construction vehicles and equipment, employees, visitors, club members

and guests, and recreational enthusiasts also represents an irretrievable commitment of resources.

The proposed project does not call for a substantial commitment of government supplied services or facilities that would not be required without the proposed project. The project will add to the recreational facilities available to residents of the region. Similarly, the project will add to the tax revenues of the county and the state.

3. OFFSETTING CONSIDERATIONS OF GOVERNMENTAL POLICIES

As indicated in Chapter VII, the proposed project is generally consistent with the applicable Hawaii State Plan and various Functional Plans, the County General Plan, County zoning and Special Management Area guidelines, with the exception of the proposed Members' Lodge which will require an amendment to the General Plan and rezoning. The use of a great majority of the property represents a permitted use of considerably less potential impact than that for which the subject property is zoned. The analysis of public revenues versus public expenditures indicates an extremely favorable ratio of revenues to expenditures.

4. UNRESOLVED ISSUES

Three general issues cannot be resolved at this point in the land use permitting and development process; the source of potable water, the specific location and design of traffic improvements to mitigate potential negative traffic impacts, and the specific design, construction, the day-to-day operation and maintenance of the scenic overlook.

As is discussed in Chapter VI, an additional allocation of potable water in the amount of approximately 1,300 gallons per day will be required by project build-out in 1997. This additional water is generally related to the demand generated by the proposed Members' Lodge. At the time that this document is being published it has yet to be determined if this allocation can be purchased from a neighboring property owner, obtained from the county, or whether a potable well will need to be developed on the subject property or upslope from it. It is recognized that negotiations concerning the ultimate source of the additional potable water resources necessary for the project must be completed before any building permits related to construction of the Members' Lodge can be obtained. The Members' Lodge will require an amendment of the General Plan and zoning ordinance.

Two types of general traffic improvements are discussed in Chapter VI; improvements to Napoopoo Road's intersection with Mamalahoa Highway, and the development of a new access road to the project site. The specific design of intersection improvements must be approved by the County's Department of Public Works. Such an approval will likely not be obtained from the County prior to the completion of this EIS process, largely due to normal administrative process requirements and design review procedures employed by the County. While preliminary discussions with the County have occurred, a final design will not be agreed upon for many more months. The public and agency review phase of this EIS process will provide an additional level of review and input that will be beneficial to the design and review process concerning the proposed intersection improvements.

Similarly, the design of a new access road to the project site cannot be completed within the time frame of the EIS process. While alternative alignments can be considered, negotiations with surrounding property owners must be completed before County approvals can be obtained. Thus,

a commitment to a particular access roadway design is not possible at this stage of the land use permitting process.

Although preliminary discussions concerning the development and operation of a scenic overlook on the subject property at the summit of the pali have been held with the State Department of Land and Natural Resources, a final determination about design and operation has not yet been reached. It is still unclear at the time of this writing whether such a facility would be dedicated to the State or some other agency, and whether such dedication may include the proposed access road to the public parking lot located upslope and well inland from the proposed overlook. Again, the final determination will likely not occur before the conclusion of this EIS process. However, the review and comments received during the EIS process will be valuable in making a final determination.

Chapter IX:

PARTIES CONSULTED AND THOSE WHO PARTICIPATED IN THE PREPARATION OF THE EIS

CHAPTER IX - PARTIES CONSULTED AND THOSE WHO PARTICIPATED IN THE PREPARATION OF THE EIS

1. CONSULTED PARTIES

The notice of availability of the EIS Preparation Notice and Environmental Assessment for the Kealakekua Bay Club was published in the OEQC Bulletin by the Office of Environmental Quality Control on June 8, 1991. Representatives of the applicant have personally met with a wide variety of public agencies, community organizations, elected officials and private citizens. The agencies, organizations and individuals consulted about the project are listed below. Those who commented on the environmental assessment in writing or requested status as a Consulted Party are identified with an asterisk (*) next to their names. Copies of the correspondence with them are reproduced in this chapter.

Federal Agencies

Soil Conservation Service, U.S. Department of Agriculture
Fish and Wildlife Service, U.S. Department of the Interior
National Park Service, U.S. Department of the Interior
Geological Survey, Water Resources Division, U.S. Department of the Interior
National Marine Fisheries Service, U.S. Department of Commerce

State Agencies

* Department of Agriculture
* Board of Agriculture
* Department of Business, Economic Development and Tourism
Department of Health
* Department of Land and Natural Resources
* Department of Transportation
* Office of Environmental Quality Control
* Department of Hawaiian Home Lands
Office of Hawaiian Affairs
* Office of State Planning
Environmental Center, University of Hawaii at Manoa
Water Resources Research Center, University of Hawaii at Manoa

State Legislators

Senator Andrew Levin
Senator Malama Solomon
Representative Harvey S. Tajiri
Representative Dwight Takamine
* Representative Mike O'Kieffe
Senator Richard M. Matsuura
Representative Jerry L. Chang
* Representative Wayne Metcalf
Representative Virginia Isbell

Hawaii County Agencies

* Office of the Mayor
  Department of Public Works
* Police Department
  Office of Housing and Community Development
* Department of Parks and Recreation
* Fire Department
* Department of Water Supply
  Civil Defense Agency
* Planning Department

Hawaii County Council

Councilman Russel Kokubun, Chairman
Councilman Takashi Domingo
Councilman Brian De Lima
Councilman Robert Makuakane
Councilman Spenser Schutte
Councilwoman Helene Hale
Councilwoman Merle Lai
Councilman Harry Ruddle
Councilman James Arakaki

Public Utilities

Hawaiian Telephone Company
Hawaii Electric Light Company, Inc.
The Gas Company, Hawaii Division

Community Organizations

Alu Like, Inc.
American Lung Association
Big Island Business Council
Hawaii Audubon Society
Hawaii Conference Foundation
Hawaii Island Contractors Association
Hawaii Island Board of Realtors
Hawaii Island Chamber of Commerce
Hawaii Island Economic Development Board
* Hawaii Leeward Planning Conference
Hawaii Visitor's Bureau, Big Island Chapter
Friends of Kealakekua Bay
* Greenpeace Hawaii
Kona Board of Realtors
Kona County Farm Bureau
Kona-Kohala Chamber of Commerce
Japanese Chamber of Commerce and Industry
Life of the Land, Big Island Chapter
Moku Loa Group, Sierra Club
Na Ala Hele
Native Hawaiian Legal Corporation
Public Access Shoreline Hawaii
Sierra Club Legal Defense Fund
* West Hawaii Sierra Club

2. ORGANIZATIONS AND INDIVIDUALS WHO ASSISTED IN THE PREPARATION OF THIS EIS

This Environmental Impact Statement was prepared for the Kealakekua Bay Club by Belt Collins & Associates with input provided by consultants. The following were involved:

Belt Collins & Associates

James R. Bell	-	Principal in Charge
Anne L. Mapes	-	Principal Planner
Lee William Sichter	-	Project Manager/Author of EIS
Mike Zukowski	-	Civil Engineer
Ed Iida	-	Civl Engineer
Harvey Chee	-	Civil Engineer
Pat Hayashi	-	Graphic Designer

Consultants

Archaeology	-	Paul H. Rosendahl, Ph.D. Inc.
Noise Impacts	-	Y. Ebisu & Associates
Flora	-	Char & Associates
Fauna	-	Phillip L. Bruner
Air Quality	-	Barry Neal
Ecomomic & Fiscal Impacts	-	KPMG Peat Marwick
Marine Environmental Analysis	-	Marine Research Consultants
Traffic	-	Pacific Planning & Engineering, Inc.
Subsurface Pesticide Migration	-	Harding Lawson Associates
Fertilizer & Pesticide Management	-	Environmental Impact Consultants
Agricultural Impacts	-	Marutani & Associates
Irrigation Well Analysis	-	Tom Nance Water Resources Engineering

JUN 19 1991

BELT COLLINS & ASSOCIATES

Forests

The West Hawaii Sierra Club

Seas

Monday, June 17, 1991

Royal Coast Development Corp.
c/o Belt Collins and Associates
Attn: Ann Mapes
680 Ala Moana Blvd, Suite 200
Honolulu, HI 96813

Dear Ms. Mapes,

This is to confirm our conversation concerning the proposed Kealakekua Bay Club. The West Hawaii Sierra Club requests participation in the EIS process.

The Executive Committee of the West Hawaii Sierra Club has passed a resolution asking that developers subscribe to the "Valdez Principles". Enclosed is a copy of the Valdez Principles for reference. Should you have any questions concerning the Valdez Principles, please contact us.

Finally, we expect to have additional comments as the EIS process unfolds; please put us on your mailing list.

Thank you for your attention in this matter,

Jay Hanson Phone 322-7268 or 329-6645 Fax 322-7869
Program Chair, West Hawaii Sierra Club,
78-6622 Alii Drive
Kailua-Kona, HI 96740

XEROX COPY

The Valdez Principles

By adopting these Principles, we publicly affirm our belief that corporations and their shareholders have a direct responsibility for the environment. We believe that corporations must conduct their business as responsible stewards of the environment and seek profits only in an manner that leaves the Earth healthy and safe. We believe that corporations must not compromise the ability of future generations to sustain their needs.

We recognize this to be a long-term commitment to update our practices continually in light of advances in technology and new understandings in health and environmental science. We intend to make consistent, measurable progress in implementing these Principles and to apply them wherever we operate throughout the world.

1. Protection of the Biosphere

We will minimize and strive to eliminate the release of any pollution that may cause environmental damage to the air, water, or earth or its inhabitants. We will safeguard habitats in rivers, lakes, wetlands, coastal zones and oceans and will minimize contributing to the greenhouse effect, depletion of ozone layer, acid rain, or smog.

2. Sustainable use of Natural Resources

We will make sustainable use of renewable natural resources, such as water, soils and forests. We will conserve nonrenewable natural resources through efficient use and careful planning. We will protect wildlife habitat, open spaces and wilderness, while preserving biodiversity.

3. Reduction and Disposal of Waste

We will minimize the creation of waste, especially hazardous waste, and wherever possible recycle materials. We will dispose of all wastes through safe and responsible methods.

4. Wise Use of Energy

We will make every effort to use environmentally safe and sustainable energy sources to meet our needs. We will invest in improved energy efficiency and conservation in our operations. We will maximize the energy efficiency of products we produce and sell.

5. Risk Reduction

We will minimize the environment, health and safety risks to our employees and the communities in which we operate by employing safe technologies and operating procedures and by being constantly prepared for emergencies.

6. Marketing of Safe Products and Services

We will sell products or services that minimize adverse environmental impacts and that are safe as consumers commonly use them. We will inform consumers of the environmental impacts of our products or services.

7. Damage Compensation

We will take responsibility for any harm we cause to the environment by making every effort to fully restore the environment and to compensate those persons who are adversely affected.

8. Disclosure

We will disclose to our employees and to the public incidents relating to our operations that cause environmental harm or pose health or safety hazards. We will disclose potential environmental, health or safety hazards posed by our operations, and we will not take any action against employees who report any condition that creates a danger to the environment or poses health and safety hazards.

9. Environmental Directors and Managers

We will commit management resources to implement the Valdez Principles, to monitor and report upon our implementation efforts, and to sustain a process to ensure that the Board of Directors and Chief Executive Officer are kept informed of and are fully responsible for all environmental matters. We will establish a Committee of the Board of Directors with responsibility for environmental affairs. At least one member of the Board of Directors will be a person qualified to represent environmental interests to come before the company.

10. Assessment and Annual Audit

We will conduct and make public an annual self-evaluation of our progress in implementing these Principles and in complying with applicable laws and regulations throughout our worldwide operations. We will work toward the timely creation of independent environmental audit procedures which we will complete annually and make available to the public.

The Valdez Principles were forged by the Coalition for Environmentally Responsible Economies (CERES), a consortium of the Social Investment Forum and 14 national environmental groups. The Social Investment Forum is a national trade association of money managers, brokers, bankers, analysts, and other socially concerned investors that control about 150 billion investment dollars.

The ten Valdez Principles are structured to reward responsible corporate actions with investment dollars, and to withdraw dollars from irresponsible corporations. For example, a state pension fund might eventually sell off stocks in companies that did not pledge to support the principles.

Investors, consumers, and employees can influence corporate behavior by supporting corporations that subscribe to the Valdez Principles. More and more corporate leaders are learning that environmental responsibility is good for business. Vigorous public participation will shorten their learning curves.

BCA
BELT COLLINS
& ASSOCIATES
Engineering • Planning
Landscape Architecture

680 Ala Moana Boulevard, Suite 200, Honolulu, Hawaii 96813
Phone: (808) 521-5361, Fax: (808) 538-7819
Hawaii • Singapore • Australia • Hong Kong • Saipan • France • Thailand

September 6, 1991
91P-283 (033.2101)

Mr. Jay Hanson
Program Chair
West Hawaii Sierra Club
78-6622 Alii Drive
Kailua-Kona, Hawaii 96740

Dear Mr. Hanson:

Environmental Impact Statement (EIS)
Kealakekua Bay Club, Island of Hawaii

Thank you for your June 17, 1991 letter. We acknowledge your request for participation in the EIS process and will send you a copy of the Draft EIS to review when it becomes available.

Thank you also for sending us a copy of the "Valdez Principles," which I have forwarded to the project owner, along with your letter.

Very truly yours,

Lee William Sichter

ALM:lf

cc: Hawaii County Planning Department
Royal Coast Development Corporation

RECEIVED
JUN 27

JOHN WAIHEE
GOVERNOR

BELT, COLLINS & ASSOCIATES

STATE OF HAWAII
OFFICE OF ENVIRONMENTAL QUALITY CONTROL
220 SOUTH KING STREET
FOURTH FLOOR
HONOLULU, HAWAII 96813

BRIAN J. J. CHOY
Director

Bell, J.
Papandrew, T.
White, P.
Mapes, A.
Ben Horn, D.
[illegible] K.
[illegible]
[illegible] E.
[illegible] M.
[illegible]
Kun[illegible] E.
Kurczewski, A.
Laughrey, S.
Nissley, [illegible]
Onuma, G.
Rutka, S.
Sichter, L.
Soloway, M.
[illegible]
Willey, M.
Fukunaga, [illegible]
Library

June 26, 1991

Ms. Anne L. Mapes
Belt Collins & Associates
680 Ala Moana Blvd., Suite 200
Honolulu, Hawaii 96813

Dear Ms. Mapes,

SUBJECT: Environmental Impact Statement (EIS) Preparation Notice
Proposed Kealakekua Bay Club, South Kona, Hawaii

We have reviewed the environmental assessment for the project listed above and have the following comment:

1. The impact of the development on puapilo, an endemic and candidate for endangered species, should be discussed.

Thank you.

Sincerely,

Cecilia N. Ornellas
for Brian J.J. Choy

BCA
BELT COLLINS
& ASSOCIATES
Engineering • Planning
Landscape Architecture

680 Ala Moana Boulevard, Suite 200, Honolulu, Hawaii 96813
Phone: (808) 521-5361 Fax: (808) 545-7519
Hawaii • Singapore • Australia • Hong Kong • Saipan • France • Thailand

September 6, 1991
91P-284 (033.2101)

Mr. Brian J.J. Choy, Director
Office of Environmental Quality Control
State of Hawaii
220 South King Street, 4th Floor
Honolulu, Hawaii 96813

Dear Mr. Choy:

Environmental Impact Statement (EIS)
Kealakekua Bay Club, Island of Hawaii

Thank you for your June 26, 1991 letter commenting on the EIS Preparation Notice for the above project.

A botanical survey of the project site has been completed and the results will be included in the EIS. The botanical report addresses the potential impact of development on puapilo, a Category 2 candidate species.

We expect the Draft EIS to be available by the end of October and you will receive a copy for review and comment.

Very truly yours,

Lee William Sichter

ALM:lf

cc: Hawaii County Planning Department
Royal Coast Development Corporation

Speaker
DANIEL J. KIHANO
Vice Speaker
PETER K. APO
Majority Leader
BRIAN T. TANIGUCHI
Majority Floor Leader
DENNIS A. ARAKAKI
Majority Whip
TOM OKAMURA

DISTRICT REPRESENTATIVES
1st — JERRY CHANG
2nd — HARVEY S. TAJIRI
3rd — WAYNE METCALF
4th — DWIGHT Y. TAKAMINE
5th — VIRGINIA ISBELL
6th — MIKE O'KIEFFE
7th — DAVID MORIHARA
8th — HERBERT J. HONDA
9th — JOSEPH M. SOUKI
10th — ROSALYN BAKER
11th — DANIEL J. KIHANO
12th — SAMUEL S. H. LEE
13th — ROBERT BUNDA
14th — ALEX SANTIAGO
15th — REB BELLINGER
16th — TERRANCE W. H. TOM
17th — MARSHALL K. IGE
18th — WHITNEY T. ANDERSON
19th — CYNTHIA THIELEN
20th — JACKIE YOUNG
21st — DAVID D. STEGMAIER
22nd — GENE R. WARD
23rd — BARBARA MARUMOTO
— JANE B. TATIBOUET
25th — CALVIN K. Y. SAY
26th — LES IHARA, JR.
27th — BRIAN T. TANIGUCHI
28th — JAMES T. SHON
29th — DAVID M. HAGINO
30th — DUKE BAINUM
31st — CAROL FUKUNAGA
32nd — MAZIE HIRONO
33rd — ROD TAM
34th — SUZANNE N. I. CHUN
35th — KENNETH T. HIRAKI
36th — DWIGHT L. YOSHIMURA
37th — DENNIS A. ARAKAKI
38th — EMILIO S. ALCON
39th — ROMY M. CACHOLA
40th — KAREN K. HORITA
41st — TOM OKAMURA
42nd — CLARICE Y. HASHIMOTO
43rd — DAVID Y. IGE
44th — NOBORU YONAMINE
45th — [illegible]
46th — PAUL T. OSHIRO
47th — ANNELLE C. AMARAL
48th — HENRY HAAKIMOTO
49th — PETER K. APO
50th — EZRA R. KANOHO
51st — [illegible]

HOUSE OF REPRESENTATIVES
THE SIXTEENTH LEGISLATURE

STATE OF HAWAII
STATE CAPITOL
HONOLULU, HAWAII 96813

June 26, 1991

Anne L. Mapes
Belt Collins & Associates
680 Ala Moana Blvd., Suite 200
Honolulu, hawaii 96813

Dear Ms. Mapes:

I acknowledge receipt of and thank you for the Environmental Impact Statement Preparation Notice for the proposed Kealakekua Bay Club. I have no comment at this time, however, please be assured that I will contact you should any concerns arise in the future.

With warm personal regards.

Sincerely,

WAYNE METCALF
Chairman
House Committee on Judiciary

BCA
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& ASSOCIATES
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Landscape Architecture

680 Ala Moana Boulevard, Suite 200, Honolulu, Hawaii 96813
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September 6, 1991
91P-285 (033.2101)

Representative Wayne Metcalf
House of Representatives
State of Hawaii
State Capitol
Honolulu, Hawaii 96813

Dear ~~Representative~~ WAYNE Metcalf:

Environmental Impact Statement (EIS)
Kealakekua Bay Club, Island of Hawaii

Thank you for your June 26, 1991 letter acknowledging receipt of the EIS Preparation Notice for the above project.

Although you have no comments at this time, we appreciate your review of the Preparation Notice. We expect the Draft EIS to be available by the end of October and look forward to any comments you may have after the document is published.

Very truly yours,

Lee William Sichter

ALM:lf

cc: Hawaii County Planning Department
Royal Coast Development Corporation

MAPES

Speaker
DANIEL J. KIHANO
Vice Speaker
PETER K. APO
Majority Leader
BRIAN T. TANIGUCHI
Majority Floor Leader
DENNIS A. ARAKAKI
Majority Whip
TOM OKAMURA

DISTRICT REPRESENTATIVES
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2nd — HARVEY S. TAJIRI
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4th — DWIGHT Y. TAKAMINE
5th — VIRGINIA ISBELL
6th — MIKE O'KIEFFE**
7th — DAVID MORIHARA
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12th — SAMUEL S. H. LEE
13th — ROBERT BUNDA
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16th — TERRANCE W. H. TOM
17th — MARSHALL K. IGE
18th — WHITNEY T. ANDERSON
19th — CYNTHIA THIELEN
20th — JACKIE YOUNG
21st — DAVID D. STEGMAIER
22nd — GENE R. WARD
23rd — BARBARA MARUMOTO
24th — JANE B. TATIBOUET
25th — CALVIN K.Y. SAY
26th — LES IHARA, JR.
27th — BRIAN T. TANIGUCHI
28th — JAMES T. SHON
29th — DAVID M. HAGINO
30th — DUKE BAINUM
31st — CAROL FUKUNAGA
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33rd — ROD TAM
34th — SUZANNE N. J. CHUN
35th — KENNETH T. HIRAKI
36th — DWIGHT L. YOSHIMURA
37th — DENNIS A. ARAKAKI
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39th — ROMY M. CACHOLA
40th — KAREN K. HORITA
41st — TOM OKAMURA
42nd — CLARICE Y. HASHIMOTO
43rd — DAVID Y. IGE
44th — NOBORU YONAMINE
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46th — PAUL T. OSHIRO
47th — ANNELLE C. AMAKAI
48th — HENRY HAALILIO PETERS
49th — PETER K. APO
50th — EZRA R. KANOHO
51st — BERTHA C. KAWAKAMI

*Minority Leader
**Minority Floor Leader

HOUSE OF REPRESENTATIVES
THE SIXTEENTH LEGISLATURE

STATE OF HAWAII
STATE CAPITOL
HONOLULU, HAWAII 96813

June 26, 1991

Anne L. Mapes
Belt Collins & Associates
680 Ala Moana Blvd., Suite 200
Hon., HI 96813

Dear Ms. Mapes.

Thank you for asking my opinion re: "proposed Kealakekua Bay Club."

Since I have very little knowledge of the area, I'm afraid I couldn't offer any pertinent information.

Since Kealakekua Bay is a marine reserve I would not want to see anything done that could jeopardize its pristine condition.

I will look through the E.I.S., but I have yet to find one that is 100% objective - and it takes time to "read between the lines".

Thanks for asking for my opinion.

Sincerely,

Mike O'Kieffe
Representative, 6th District
West Hawaii-East Maui

Mok/ho

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& ASSOCIATES
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September 6, 1991
91P-286 (033.2101)

Representative Mike O'Kieffe
House of Representatives
State of Hawaii
State Capitol
Honolulu, Hawaii 96813

Dear Representative O'Kieffe:

Environmental Impact Statement (EIS)
Kealakekua Bay Club, Island of Hawaii

Thank you for your June 26, 1991 letter acknowledging receipt of the EIS Preparation Notice for the above project.

We are cognizant of Kealakekua Bay's designation as a State of Hawaii Marine Life Conservation District. Specific studies and surveys have been performed for the EIS to address the issue of potential impact to the bay and to explore measures that would ensure the continued pristine condition of the bay.

We expect the Draft EIS to be available by the end of October and look forward to any comments you may have after the document is published.

Very truly yours,

Lee William Sichter

ALM:lf

cc: Hawaii County Planning Department
Royal Coast Development Corporation

GREENPEACE HAWAII PO BOX 10909 HILO HAWAII 96721
(808) 935-0770

July 2, 1991

Mr. Norman Hayashi
Planning Director
County of Hawaii
25 Aupuni Street
Hilo, Hawaii 96720

RE: DRAFT ENVIRONMENTAL IMPACT STATEMENT/KEALAKEKUA BAY CLUB

We have concerns regarding the negative impacts of this project on the marine environment, specifically development and maintenance of the golf course and landscaping for the clubhouse and planned 36-unit member's lodge. We are very concerned about the runoff of fertilizers and biocides (herbicides, insecticides and pesticides) into Kealakekua Bay. This area is a Marine Life Conservation District with nearly pristine waters and a diversity of marine life. MLCD's are essentially marine parks, are designed to conserve and replenish marine resources, and are necessary to protect nearshore marine populations from the adverse effects of increased human population and related developments. It would appear that developments such as the proposed Kealakekua Bay Club on adjacent, upslope parcels would be most inappropriate for a Marine Life Conservation District, particularly in light of the influx of groundwater into the Bay from the nearshore area.

Also of concern is the effect of the above on the resident pods of spinner dolphins (Stenella longirostris) who frequent the Bay on a daily basis. The Bay constitutes a critical resting habitat for this species.

The proposed use of the "five 2-acre lots fronting Napoopoo Road (Lower Government Main road) mauka of the golf course." is not included in the information provided on the project and must be specified if impacts are to be identified and addressed.

Thank you for the opportunity to comment on this project. We would appreciate your adding Greenpeace Hawaii to the list of Consulted Parties for the Draft Environmental Impact Statement.

Sincerely,

Denver A. Leaman
Executive Director

/lg

cc: Royal Coast Development Corporation & Pac Inv Hawaii, Inc.

BCA
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& ASSOCIATES
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630 Ala Moana Boulevard, Suite 201 • Honolulu, Hawaii 96813
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September 6, 1991
91P-287 (033.2101)

Mr. Denver A. Leaman
Executive Director
Greenpeace Hawaii
P.O. Box 10909
Hilo, Hawaii 96721

Dear Mr. Leaman:

Environmental Impact Statement (EIS)
Kealakekua Bay Club, Island of Hawaii

Thank you for your July 2, 1991 letter commenting on the EIS Preparation Notice for the above project.

We are cognizant of Kealakekua Bay's designation as a State of Hawaii Marine Life Conservation District and its nearly pristine condition. Several technical studies and surveys have been completed to address the potential impact on the bay due to the proposed project and these will be included in the EIS. Areas of concern which you identify will be covered in the EIS: the impact of the project on the marine environment, including the use of chemicals, the effects of runoff, and impact on marine mammal habitat.

The five 2-acre lots fronting Napoopoo Road will be residential/agricultural lots, with planned coffee plantings by the roadway. The impact analysis in the EIS will include these five lots.

We expect the Draft EIS to be available by the end of October and look forward to any comments you may have after the document is published.

Very truly yours,

Lee William Sichter

ALM:lf

cc: Hawaii County Planning Department
Royal Coast Development Corporation

Lorraine R. Inouye
Mayor
Victor V. Vierra
Chief of Police
Francis C. DeMorales
Deputy Chief of Police

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JUL 6 1991
BELT, COLLINS & ASSOCIATES

Police Department
349 Kapiolani Street • Hilo, Hawaii 96720-3998 • (808) 961-2244 • FAX (808) 961-2702

July 2, 1991

Ms. Anne L. Mapes
Belt Collins & Associates
680 Ala Moana Boulevard, Suite 200
Honolulu, HI 96813

Dear Ms. Mapes:

SUBJECT: ENVIRONMENTAL IMPACT STATEMENT (EIS) PREPARATION NOTICE
PROPOSED KEALAKEKUA BAY CLUB, SOUTH KONA, HAWAII
APPLICANT: ROYAL COAST DEVELOPMENT CORPORATION
TMK: 8-2-2:POR. 2 & 39, 8-1-10:POR.2

The proposed application has been reviewed and we foresee no adverse effect should it be granted.

Sincerely,

VICTOR V. VIERRA
CHIEF OF POLICE

JD:sk

cc: Kona Police

BELT COLLINS
& ASSOCIATES
Engineering • Planning
Landscape Architecture

680 Ala Moana Boulevard Suite 200, Honolulu, Hawaii 96813
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September 6, 1991
91P-288 (033.2101)

Mr. Victor V. Vierra, Chief of Police
Police Department
County of Hawaii
349 Kapiolani Street
Hilo, Hawaii 96720-3998

Dear Mr. Vierra:

Environmental Impact Statement (EIS)
Kealakekua Bay Club, Island of Hawaii

Thank you for your July 2, 1991 letter concerning the EIS Preparation Notice for the above project.

We appreciate your review of the Preparation Notice and your comment of no adverse effect from the project as far as your department is concerned. We expect the Draft EIS to be available by the end of October and look forward to any comments you may have after the document is published.

Very truly yours,

Lee William Sichter

ALM:lf

cc: Hawaii County Planning Department
Royal Coast Development Corporation

JUL 1 2 1991
BELT, COLLINS & ASSOCIATES

Lorraine R. Inouye
Mayor
Barry T. Mizuno
Managing Director
David Fuertes
Deputy Managing Director

Office of the Mayor

County of Hawaii • 25 Aupuni Street, Rm. 213 • Hilo, Hawaii 96720 • (808) 961-8211 • Fax (808) 961-6553

July 2, 1991

Ms. Anne L. Mapes
Belt Collins & Assoc.
680 Ala Moana Boulevard, Suite 200
Honolulu, HI 96813

Dear Ms. Mapes:

SMA Use Permit Application
Use Permit Application
Royal Coast Development Corp/Pac Inv Hawaii, Inc.
Kealakekua Bay Club
Environmental Impact Statement Preparation Notice (EISPN)

Thank you for the opportunity to provide comments on the preparation notice for the Kealakekua Bay Club EIS. We will be coordinating our response through the Planning Department at the Draft EIS stage.

Should you have any concerns in the meantime, please do not hesitate to contact my office or the Planning Department.

Aloha,

LORRAINE R. INOUYE
Mayor

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BELT COLLINS
& ASSOCIATES
Engineering • Planning
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September 6, 1991
91P-289 (033.2101)

Honorable Lorraine R. Inouye
Office of the Mayor
County of Hawaii
25 Aupuni Street, Room 213
Hilo, Hawaii 96720

Dear Mayor Inouye:

Environmental Impact Statement (EIS)
Kealakekua Bay Club, Island of Hawaii

Thank you for your July 2, 1991 letter acknowledging receipt of the EIS Preparation Notice for the above project.

We expect the Draft EIS to be available by the end of October and look forward to any comments you may have after the document is published.

Very truly yours,

Lee William Sichter

ALM:lf

cc: Hawaii County Planning Department
Royal Coast Development Corporation

RECEIVED
JUL 5 1991
BELT, COLLINS & ASSOCIATES

Lorraine R. Inouye
Mayor
Daniel Ayala
Fire Chief
Harding Fragas, Jr.
Deputy Fire Chief

Fire Department

466 Kinoole Street • Hilo, Hawaii 96720-2983 • (808) 961-8297 • Fax (808) 961-6920

July 3, 1991

Ms. Anne L. Mapes
Belt Collins & Associates
680 Ala Moana Boulevard, Suite 200
Honolulu, Hawaii 96813

Dear Ms. Mapes:

Subject: Environmental Impact Statement Preparation Notice
Proposed Kealakekua Bay Club, South Kona, Hawaii

The project site is about three to five miles from Captain Cook Fire Station which is staffed with 18 men divided into three shifts providing 24-hour coverage, which includes fire protection and advance life support services.

Equipment consist of a 1500 gpm pumper carrying 1,000 gallons of water; a mini-pumper 4x4 carrying 300 gallons of water; and an ambulance.

With the present development of a subdivision below this project, the combination of both will certainly impact the Captain Cook Fire Station's response and should be addressed.

Sincerely,

DANIEL AYALA
Fire Chief

DA/mo

cc: Norman Hayashi, Planning Director

BCA
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& ASSOCIATES
Engineering • Planning
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September 6, 1991
91P-290 (033.2101)

Mr. Daniel Ayala, Fire Chief
Fire Department
County of Hawaii
466 Kinoole Street
Hilo, Hawaii 96720-2983

Dear Chief Ayala:

Environmental Impact Statement (EIS)
Kealakekua Bay Club, Island of Hawaii

Thank you for your July 3, 1991 letter on the above project. The information provided will be included in the EIS. In it, we will address the issue of fire department response adequacy, given the proposed project.

We expect the Draft EIS to be available by the end of October and look forward to any comments you may have after the document is published.

Very truly yours,

Lee William Sichter

ALM:lf

cc: Hawaii County Planning Department
Royal Coast Development Corporation

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JUL 6 1991
BELT, COLLINS & ASSOCIATES

Lorraine R. Inouye
Mayor
Norman K. Hayashi
Director
Tad Nagasako
Deputy Director

Planning Department
25 Aupuni Street, Room 109 • Hilo, Hawaii 96720 • (808) 961-8288

Bell, J.
Papandrew, T.
White, P.
Mapes, A.
Van Horn, D.
Aoki, K.
Burke, J.
Corbett-Suzuki, F.
Goody, J.
Hutchins, M.
Koyama, G.
Kuniyoshi, E.
Kurozawa, A.
Laughrey, S.
Nissley, J.
Onuma, G.
Rutka, S.
Sichter, L.
Soloway, M.
Stephens, M.
Willey, M.
Tokunaga, L.

July 3, 1991

Ms. Anne L. Mapes
Belt Collins & Associates
680 Ala Moana Boulevard, Suite 200
Honolulu, HI 96813

Dear Ms. Mapes:

SMA Use Permit Application
Use Permit Application
Applicant: Royal Coast Development Corp/Pac Inv Hawaii, Inc.
Request: 18-Hole Golf Course, Golf Clubhouse and Related Improvements
TMK: 8-2-2:Por. of 2 & 39, 8-1-10:Por. of 2

Thank you for the opportunity to provide comments on the Environmental Impact Statement Preparation Notice (EISPN) for the Kealakekua Bay Club.

Since our Department prepared the EISPN, we shall reserve specific comments for the Draft EIS. We look forward to receiving that document.

In the meantime, should you have any questions, please feel free to contact Connie Kiriu or Alice Kawaha of this office.

Sincerely,

NORMAN K. HAYASHI
Planning Director

CRK:mra
2315D

cc: West Hawaii Office

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& ASSOCIATES
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September 6, 1991
91P-291 (033.2101)

Mr. Norman K. Hayashi, Director
Planning Department
County of Hawaii
25 Aupuni Street, Room 109
Hilo, Hawaii 96720

Dear Mr. Hayashi:

Environmental Impact Statement (EIS)
Kealakekua Bay Club, Island of Hawaii

Thank you for your July 3, 1991 letter acknowledging receipt of the EIS Preparation Notice for the above project.

We expect the Draft EIS to be available by the end of October and look forward to your comments after the document is published.

Very truly yours,

Lee William Sichter

ALM:lf

cc: Hawaii County Planning Department
Royal Coast Development Corporation

RECEIVED
JUL 1 1 1991

(9)

BELT, COLLINS & ASSOCIATES
DEPARTMENT OF WATER SUPPLY • COUNTY OF HAWAII
25 AUPUNI STREET • HILO, HAWAII 96720
TELEPHONE (808) 969-1421 • FAX (808) 969-6996

July 5, 1991

Belt Collins & Associates
ATTENTION: MS. ANNE L. MAPES
680 Ala Moana Boulevard, Suite 200
Honolulu, HI 96813

ENVIRONMENTAL IMPACT STATEMENT PREPARATION NOTICE
DEVELOPER - ROYAL COAST DEVELOPMENT CORPORATION
DEVELOPMENT - KEALAKEKUA BAY CLUB

Thank you for giving us the opportunity to comment on the subject notice.

Present water availability policies in the South Kona water system allow for development of a parcel, should the present zoning allow for it, of up to 4,200 gallons per day (7 units) maximum daily usage. The proposed golf clubhouse and related facilities together with the 36-unit members lodge will probably exceed this limit. Off-site water system improvements to provide a potable water system will include, but not be limited to, the development of a source, transmission, control and chlorination systems.

Should there be any questions, please do not hesitate to contact us.

H. William Sewake
Manager

CS

cc - Planning Department

BCA
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1680 Ala Moana Boulevard, Suite 200, Honolulu, Hawaii 96814
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September 6, 1991
91P-292 (033.2101)

Mr. H. William Sewake, Manager
Department of Water Supply
County of Hawaii
25 Aupuni Street
Hilo, Hawaii 96720

Dear Mr. Sewake:

Environmental Impact Statement (EIS)
Kealakekua Bay Club, Island of Hawaii

Thank you for your July 5, 1991 letter commenting on the EIS Preparation Notice for the above project.

The issue of water availability and use will be addressed in the EIS. The discussion will include both potable water for the site and non-potable irrigation water for the golf course and landscaping. We expect the Draft EIS to be available by the end of October and look forward to any comments you may have after the document is published.

Very truly yours,

Lee William Sichter

ALM:lf

cc: Hawaii County Planning Department
Royal Coast Development Corporation

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JUL 10 1991
BELT, COLLINS & ASSOCIATES

JOHN WAIHEE
GOVERNOR
STATE OF HAWAII

HOALIKU L. DRAKE
CHAIRMAN
HAWAIIAN HOMES COMMISSION

STATE OF HAWAII
DEPARTMENT OF HAWAIIAN HOME LANDS
P. O. BOX 1879
HONOLULU, HAWAII 96805

July 9, 1991

Ms. Anne L. Mapes
Belt Collins & Associates
680 Ala Moana Boulevard, Suite 200
Honolulu, Hawaii 96813

Dear Ms. Mapes:

Subject: EIS Preparation Notice: Proposed Kealakekua Bay Club, South Kona, Hawaii

Thank you for the environmental assessment information attached to your letter of June 22, 1991.

The proposed project will not impact the programs of the Department of Hawaiian Home Lands.

We have no other comments, except to thank you for the opportunity to review the proposal.

Warmest aloha,

Hoaliku L. Drake, Chairman
Hawaiian Homes Commission

HLD:BH:JC:asy

2179L

BCA
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& ASSOCIATES
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September 6, 1991
91P-293 (033.2101)

Ms. Hoaliku L. Drake
Department of Hawaiian Home Lands
State of Hawaii
P.O. Box 1879
Honolulu, Hawaii 96805

Dear Ms. Drake:

Environmental Impact Statement (EIS)
Kealakekua Bay Club, Island of Hawaii

Thank you for your July 9, 1991 letter on the the above project.

We expect the Draft EIS to be available by the end of October and look forward to any comments you may have after the document is published.

Very truly yours,

Lee William Sichter

ALM:lf

cc: Hawaii County Planning Department
Royal Coast Development Corporation

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JUL 15 1991
BELT COLLINS & ASSOCIATES

BANK OF HAWAII
B.P. BISHOP ESTATE
CABLEVISION
CAPT. COOK INVESTMENT CO
CHALON INTERNATIONAL
EASLEY CORP.
FIRST HAWAIIAN BANK
GENTRY PACIFIC LIMITED
HALE KEA FARMS
HASEKO (HAWAII), INC
HAWAII ELECTRIC LIGHT CO
HAWAII LAND MANAGEMENT, INC
HOLUALOA MANAGEMENT
HUEHUE RANCH
K & E ENTERPRISES
KAHUA RANCH
KAMEHAMEHA INVESTMENT CORP
KAUPULEHU DEV INC
KEALAKEKUA DEVELOPMENT CORP
KEALAKEKUA RANCH, LTD
KEHENA BEACH, INC
KIEWIT PACIFIC CO.
KOHALA RANCH

HAWAII LEEWARD PLANNING CONFERENCE

P.O. BOX 635 • KAILUA-KONA, HAWAII 96745-0635

LANIHAU PARTNERS, LP
LILIUOKALANI TRUST
LYLE ANDERSON
MAC FARMS OF HAWAII, INC
MARYL DEV., INC.
MAUNA KEA PROPERTIES
MAUNA LANI RESORT, INC.
NANSAY HAWAII
ORCHARD-MARINE
PALIKA RANCH
PARKER RANCH
POTOMAC INVESTMENT
PUAKEA BAY RANCH
QUEEN'S HEALTH SYSTEMS
R.M. JITCHAKU ENTERPRISES
R.M. TOWILL CO.
REALTY INVESTMENT
SIGNAL HAWAII, INC.
TAIYO HAWAII CO., LTD.
WAIKOLOA HEIGHTS
WAIKOLOA LAND COMPANY
WEST HAWAII CONCRETE

July 12, 1991

Anne L. Mapes
Belt Collins and Associates
680 Ala Moana Boulevard, Suite 200
Honolulu, HI 96813

Dear Anne:

I have reviewed the Environmental Impact Statement Preparation Notice for the proposed Kealakekua Bay Club in South Kona, Hawaii and have nothing to add, as I feel you have identified all of the major issues.

We wish to be a consulted party and have an opportunity to review and make comments on the Environmental Impact Statement for this project.

Sincerely,

H. Peter L'Orange
President

HPL/mg

OFFICE POTTERY TERRACE, ORCHID BLDG #226 KAILUA-KONA • PHONE 329-2334 • FAX 329-7108

BCA
BELT COLLINS
& ASSOCIATES
Engineering • Planning
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September 6, 1991
91P-294 (033.2101)

Mr. H. Peter L'Orange, President
Hawaii Leeward Planning Conference
P.O. Box 635
Kailua-Kona, Hawaii 96745-0635

Dear Mr. L'Orange:

Environmental Impact Statement (EIS)
Kealakekua Bay Club, Island of Hawaii

Thank you for your July 12, 1991 letter acknowledging receipt of the EIS Preparation Notice for the above project.

Although you have no comments at this time, we appreciate your review of the Preparation Notice. As requested, we will forward you a copy of the Draft EIS when it is available. We expect the Draft EIS to be published by the end of October and look forward to any comments you may have at that time.

Very truly yours,

Lee William Sichter

ALM:lf

cc: Hawaii County Planning Department
Royal Coast Development Corporation

RECEIVED
JUL 18 1991
BELT, COLLINS & ASSOCIATES

Lorraine R. Inouye
Mayor
Charmaine L. Kamaka
Director
Alan R. Parker
Deputy Director

Department of Parks and Recreation

25 Aupuni Street, Room 210 • Hilo, Hawaii 96720 • (808) 961-8311

July 15, 1991

Ms. Anne L. Mapes
Belt Collins & Assoc.
680 Ala Moana Blvd., Suite 200
Honolulu, Hawaii 96813

Subject: Kealakekua Bay Club, South Kona
EIS Preparation Notice
TMK: 8-1-10:por. 2
TMK: 8-2-02:por. 2 & 39

Dear Ms. Mapes:

Thank you for the opportunity to review the EIS preparation notice.

Since residential development, other than the five lots fronting Napoopoo Road, is not proposed, no significant impacts or existing County recreational facilities are anticipated.

The golfing public would welcome the use of the golf course "at regular times and at kamaaina rates" as provided for by the developer.

Sincerely,

Charmaine L. Kamaka
Director

cc: Planning Department

BCA
BELT COLLINS
& ASSOCIATES
Engineering • Planning
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September 6, 1991
91P-295 (033.2101)

Ms. Charmaine L. Kamaka, Director
Department of Parks and Recreation
County of Hawaii
25 Aupuni Street, Room 210
Hilo, Hawaii 96720

Dear Ms. Kamaka:

Environmental Impact Statement (EIS)
Kealakekua Bay Club, Island of Hawaii

Thank you for your July 15, 1991 comments on the EIS Preparation Notice for the above project.

We expect the Draft EIS to be available by the end of October and look forward to any comments you may have after the document is published.

Very truly yours,

Lee William Sichter

ALM:lf

cc: Hawaii County Planning Department
Royal Coast Development Corporation

JOHN WAIHEE
GOVERNOR

RECEIVED
JUL 17 1991
BELT, COLLINS & ASSOCIATES

EDWARD Y. HIRATA
DIRECTOR

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

IN REPLY REFER TO:

HWY-PS
2.7798

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

July 16, 1991

Ms. Anne L. Mapes
Belt Collins & Associates
680 Ala Moana Boulevard, Suite 200
Honolulu, Hawaii 96813

Dear Ms. Mapes:

Environmental Impact Statement Preparation Notice,
Kealakekua Bay Club, South Kona, Hawaii
TMK: 8-2-2: por. 2 & 39; 8-1-10: por. 2

Thank you for your letter of June 22, 1991, requesting our review of the subject proposed project's EIS preparation notice.

We have the following comments:

1. We will require the submission of a traffic impact analysis report for this project. The report should address the traffic impact on Mamalahoa Highway, Napoopoo Road (aka Lower Government Main Road), and in particular, the intersection of Mamalahoa Highway and Napoopoo Road. Traffic mitigation measures, including intersection improvements, should also be addressed.

2. Plans for construction work within the State highway right-of-way must be submitted for our review and approval. The developer shall bear the cost of required improvements.

3. Improvements along Mamalahoa Highway should be consistent with the Island of Hawaii Long-Range Highway Plan.

Very truly yours,

Al Pang

for Edward Y. Hirata
Director of Transportation

BELT COLLINS
& ASSOCIATES
Engineering • Planning
Landscape Architecture

680 Ala Moana Boulevard, Suite 200, Honolulu, Hawaii 96813
Phone: (808) 521-5361 Fax: (808) 538-7819
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September 6, 1991
91P-345 (033.2101)

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

Dear Mr. Hirata:

Environmental Impact Statement (EIS)
Kealakekua Bay Club, Island of Hawaii

Thank you for your July 2, 1991 comments on the above project.

1. A traffic impact analysis has been prepared for the project and the resulting report will an appendix of the EIS. Potential impacts on roads that you have identified will be included, as well as proposed mitgation measures to counteract any adverse effects due to the project.

2. Plans for construction work within the State highway right-of-way will be submitted for review and approval at the appropriate time. The applicant intends to contribute to the cost of improvements.

3. Project engineers will consult the Island of Hawaii Long-Range Plan when proposing improvements along Mamalahoa Highway.

We expect the Draft EIS to be available by the end of October and look forward to any comments you may have after the document is published.

Very truly yours,

Lee William Sichter

ALM:lf

cc: Hawaii County Planning Department
Royal Coast Development Corporation

JOHN WAIHEE
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
DIVISION OF FORESTRY AND WILDLIFE
1151 PUNCHBOWL STREET
HONOLULU, HAWAII 96813

WILLIAM W. PATY, CHAIRPERSON
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DAN KOCHI

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

July 19, 1991

Belt Collins and Associates
Attn: Anne L. Mapes
680 Ala Moana Boulevard, Suite 200
Honolulu, HI 96813

Re: EIS Preparation Notice: Proposed Kealakekua Bay Club, South Kona, Hawaii

Dear Ms. Mapes:

The Na Ala Hele Program would like to be informed on the progress of your project.

Page four of the preparation notice states, "...Public pedestrian access from the parking area will lead to existing trails in both the Kealakekua and Ka'awaloa parcels. The applicant intends to improve existing trails by integrating the public access improvements with planned State improvements..."

There is also a Na Ala Hele Advisory Council on Hawaii that should be kept abreast of your project. Enclosed for your information is a list of Council members and ex-officio representatives.

Sincerely,

Christina B. Meller

Christina B. Meller,
Na Ala Hele Manager

Enclosure

cc: Leilani Hino
Rodney Oshiro

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& ASSOCIATES
Engineering • Planning
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680 Ala Moana Boulevard, Suite 200, Honolulu, Hawaii 96813
Phone: (808) 521-5361, Fax: (808) 538-7819
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September 6, 1991
91P-346 (033.2101)

Ms. Christina B. Meller
Na Ala Hele Manager
Division of Forestry and Wildlife
Department of Land and Natural Resources
State of Hawaii
1151 Punchbowl Street
Honolulu, Hawaii 96813

Dear Ms. Meller:

Environmental Impact Statement (EIS)
Kealakekua Bay Club, Island of Hawaii

Thank you for your July 19, 1991 letter concerning the above project.

We certainly intend to keep the Na Ala Hele Program informed of project progress. In November 1990, the applicant gave a tour of the project to Na Ala Hele members. There was discussion on public access to the planned pali lookout as well as access to existing trails. We plan to continue the dialog with Na Ala Hele during the EIS process, and during planning and permitting.

We expect the Draft EIS to be available by the end of October and look forward to any comments you may have after the document is published.

Very truly yours,

Lee William Sichter

ALM:lf

cc: Hawaii County Planning Department
Royal Coast Development Corporation

JOHN WAIHEE
GOVERNOR

RECEIVED
JUL 22 1991
BELT COLLINS & ASSOCIATES

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 17, 1991

Ms. Anne L. Mapes
Belt Collins and Associates
680 Ala Moana Boulevard
Suite 200
Honolulu, HI 96813

Dear Ms. Mapes:

Subject: Environmental Impact Statement Preparation Notice (EISPN) for Proposed Kealakekua Bay Club Golf Course and Related Improvements
Royal Coast Development Corporation
TMK: 8-1-10: por. 2
8-2-02: por. 2 Kealakekua Bay, Hawaii
Area: 262 acres

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

According to the document, the applicant intends to develop a private golf course, five two-acre agricultural lots, and a 36-unit members' lodge (subject of a later application). The subject property is used for cattle grazing.

We have the following requests for you to consider in the Draft EIS:

- clearly identify the State Land Use District boundaries as they affect the project area;
- discuss the impact of golf course development on the land values of surrounding agricultural lands;
- specify on a map the surrounding agricultural uses.

Some of the subject area is within the climatic regime wherein Kona coffee flourishes. Our principal concern is on the adverse

impacts the golf course development may have on existing farms and the potential for new farm establishment.

Thank you for the opportunity to comment.

Sincerely,

Yukio Kitagawa

YUKIO KITAGAWA
Chairperson, Board of Agriculture

c: Office of Environmental Quality Control
Hawaii County Planning Department

BCA
BELT COLLINS
& ASSOCIATES
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680 Ala Moana Boulevard, Suite 200, Honolulu, Hawaii 96813
Phone: (808) 521-5361, Fax: (808) 538-7819
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September 6, 1991
91P-347 (033.2101)

Mr. Yukio Kitagawa
Chairman, Board of Agriculture
Department of Agriculture
State of Hawaii
1428 South King Street
Honolulu, Hawaii 96814-2512

Dear Mr. Kitagawa:

Environmental Impact Statement (EIS)
Kealakekua Bay Club, Island of Hawaii

Thank you for your July 17, 1991 comments on the above project.

The items which you have identified will be addressed in the EIS. An agricultural impact analysis has been prepared and will be included in the EIS as an appendix.

We expect the Draft EIS to be available by the end of October and look forward to any comments you may have after the document is published.

Very truly yours,

Lee William Sichter

ALM:lf

cc: Hawaii County Planning Department
Royal Coast Development Corporation

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

Ref. No. P-2182

July 25, 1991

Ms. Anne L. Mapes
Belt Collins and Associates
680 Ala Moana Boulevard, Suite 200
Honolulu, Hawaii 96813

Dear Ms. Mapes:

Subject: Environmental Impact Statement Preparation Notice for the Proposed Kealakekua Bay Club, South Kona, Hawaii

We have reviewed the Preparation Notice for the proposed project and have the following comments.

Project Location

In order to ascertain the location of the site and its resources, the draft EIS should provide additional maps showing the following information.

1. The current State Land Use District designations and proposed amendments to the land use district boundaries.
2. County zoning and LUPAG map designations.
3. The Kealakekua Bay Historic District and the Kona Field System.
4. The 9-acre Greenwell ranch parcel.
5. Any anchialine pools on-site or within the buffer area.
6. Delineation of the proposed 400-foot wide buffer of open space between the golf course and edge of the pali.
7. Surrounding land uses.

Project Description

The Draft EIS should clearly indicate which aspects of the proposed development will be involved in any permit application procedure. For land use changes, the acreages of the affected use areas should be indicated.

Page 5 of the preparation notice states, "The applicant will place a deed restriction on the golf course land which will prohibit any further development of the property as long as it is used as a golf course." This statement raises some concern about the ultimate uses of the property. Our concerns are whether the proposed uses are, in effect, a "holding action" subject to change, and the factors which may influence that change. The applicant's commitment to establishing and maintaining the proposed uses identified in the subject EIS should be disclosed.

The description of the agriculture/residential lots and member's lodge elements of the proposed project should be expanded to indicate whether the agriculture lots are intended for legitimate agriculture purposes or for other reasons which should be specified. It should also specify whether the member's lodge is a transient accommodation facility, similar to a hotel.

Coastal Ecosystems

A Coastal Zone Management (CZM) objective is to protect valuable coastal ecosystems from disruption and minimize adverse impacts on all coastal ecosystems. The Kealakekua Bay is designated as a Marine Life Conservation District. It is not clear what the existing drainage patterns are and the effect the project will have, especially on runoff over the pali. Also, the assessment indicates that existing springs along the cliff discharge fresh-water into the ocean. The effects of runoff and groundwater discharge that may carry sedimentation, herbicides and pesticides into the coastal waters, should be discussed in the EIS. Also, the quantities of sedimentation, herbicides and pesticides, during and after construction, that may run off into the nearshore waters should be discussed.

The EIS should also include descriptions of the flora and fauna in the cliff area and nearshore waters, e.g., nesting seabirds, mammals, and turtles, and their general locations on and off-site. The assessment indicates that there are native plants in the pali area and on the north side of the site. However, the document also indicates that the applicant plans to landscape in these areas. Care should be taken to ensure that landscaping is compatible with the native plants and that the rare native plant (Puapilo) will not be adversely affected. Also, the potential impacts and mitigating measures to these populations should be discussed.

Scenic and Open Space Resources

Another CZM objective is to protect and preserve the quality of coastal scenic and open space resources. The site is located on the makai side of the major coastal highway. Due to the prominence of the pali as a geologic feature and as an important scenic element to users of the Kealakekua Bay State Underwater Park and other areas along the shoreline and in the nearshore waters, it is important that the visual impact of the proposed project from surrounding land be assessed. It may be helpful to undertake a visual

simulation analysis of the project from various locations along the coastline, in the bay and surrounding property.

Economic Uses

A third relevant CZM objective is to concentrate in appropriate areas the location of coastal dependent development necessary to the State's economy. The member's lodge may be considered a transient vacation rental and similar to resort development. The draft EIS should address the effect that establishing transient accommodations at this location may have on the establishment of similar uses on other lands in the area.

Coastal Hazards

A fourth CZM objective is to reduce hazard to life and property from natural hazards. According to the U.S. Geological Survey, the Kealakekua Fault, on which the project is located, is an active fault. The susceptibility of the property to seismic activity, landslides, rockfalls and other unstable conditions should be disclosed. The effect these conditions have on the suitability of the property for the proposed uses should also be addressed.

Historic Resources

A fifth CZM objective is to protect, preserve and where desirable, restore those natural and manmade historic and prehistoric resources in the Coastal Zone Mangement area that are significant in Hawaiian and American history and culture. It is not clear in the preparation notice whether the entire area, including the pali area has been surveyed for archaeological sites. The applicant should have a complete archaeological survey of the entire site within the draft EIS, and the significance of the area, in historic terms, should be discussed in a comprehensive manner. The preparation notice states that the Kona Field System is eligible for inclusion into the National Register of Historic Sites. The draft EIS should discuss the impacts on the system and whether this proposal will render it ineligible for inclusion on the list.

Recreational Resources

Finally, a sixth relevant CZM objective is to provide coastal recreational opportunities accessible to the public. We note that on page 15 of the preparation notice, that a lookout may be provided. We also recommend that the EIS describe the recreational opportunities on-site and within the surrounding area that the public has been enjoying, for example, fishing, shorecasting, netting, sightseeing, swimming, etc. The applicant should provide public access to the recreational amenities of the site.

Thank you for allowing us to comment on this preparation notice. If you have any questions, please contact the Land Use Division at 548-2066, or the Coastal Zone Management Program at 548-3961.

Sincerely,

Harold S. Masumoto
Director

cc: Hawaii County Planning Department
Office of Environmental Quality Control

BCA
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& ASSOCIATES
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680 Ala Moana Boulevard, Suite 200 Honolulu, Hawaii 96813
Phone (808) 521-5361, Fax (808) 538-7819
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September 6, 1991
91P-348 (033.2101)

Mr. Harold S. Masumoto, Director
Office of State Planning
State Capitol
Honolulu, Hawaii 96813

Dear Mr. Masumoto:

Environmental Impact Statement (EIS)
Kealakekua Bay Club, Island of Hawaii

Thank you for your July 25, 1991 comments on the above project and EIS Preparation Notice.

Project Location

The EIS will contain maps showing State and County designations, surrounding land uses, and site specific information which you have identified. The buffer area and project site are above a steep 600-foot cliff. Being so far removed from the influence of tidal changes, neither area contains any anchialine ponds.

Project Description

The EIS will identify aspects of the project which require permitting.

The applicant's intention is to develop a golf course with golf clubhouse and related facilities and infrastructure. It also hopes to develop a 36-unit members' lodge at a later date. The statement, "The applicant will place a deed restriction on the golf course and will prohibit any further development of the property as long as it is used as a golf course" is intended to demonstrate the applicant's commitment to the proposed use as described.

The agricultural lots will be for residential/agricultural use, with coffee plantings at a minimum. The members' lodge will be for golf club members only, not operated as a hotel open to the general public.

Coastal Ecosystems

We are cognizant of Kealakekua Bay's designation as a State Marine Life Conservation District. The potential impacts of runoff and groundwater discharge into coastal waters will be discussed in the EIS.

Botanical, marine environment, bird and mammal surveys have been completed and the resulting reports will be appendices in the EIS. Discussion will include potential impacts to these resources as well as mitigation measures.

Scenic and Open Space Resources

The impact of the project on the visual character of the area will be assessed. This will include analysis of views from locations along the coastline and surrounding property.

Economic Uses

The small, 36-unit members' lodge will be for golf club members only and will not be open to the general public. As such, its use will not be similar to resort development and its impacts accordingly different. This will be addressed in the EIS.

Coastal Hazards

Natural hazards will be addressed in the EIS.

Historic Resources

The entire project site has been surveyed for historic and archaeological sites and the resulting studies will be appended to the EIS. Consultation among the applicant, the project archaeologist and the State Department of Land and Natural Resources, Historic Preservation Program Division is ongoing.

Recreational Resources

Recreational opportunities onsite and within surrounding areas will be described in the EIS. The golf course will have specified times for public play and access to trails and other natural resources will be improved.

We expect the Draft EIS to be available by the end of October and look forward to any comments you may have after the document is published.

Very truly yours,

Lee William Sichter

ALM:lf

cc Hawaii County Planning Department
Royal Coast Development Corporation

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
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FORESTRY AND WILDLIFE
HISTORIC PRESERVATION PROGRAM
LAND MANAGEMENT
STATE PARKS
WATER AND LAND DEVELOPMENT

REF:OCEA:SKK

AUG 6 1991

FILE NO.: 91-565
DOC. NO.: 1285E

The Honorable Norman K. Hayashi, Director
Planning Department
County of Hawaii
25 Aupuni Street
Hilo, Hawaii 96720

Dear Mr. Hayashi:

SUBJECT: Environmental Impact Statement (EIS) Preparation Notice
Kealakekua Bay Club
Location: South Kona, Hawaii
TMK: 8-2-2: 2&39, 8-1-10: 2

Thank you for giving our Department the opportunity to comment on this matter. We have reviewed the materials you submitted and have the following comments.

Brief Description:

The applicant plans to develop an 18-hole golf course with clubhouse and related amenities on about 260 acres above Kealakekua Bay in South Kona, Hawaii. Other improvements include a maintenance building, trails and lookout. Also proposed are five 2-acre lots fronting Napoopoo Road.

Our Department's Aquatic Resources Division suggest the forthcoming EIS discuss in detail potential short-term impacts related to golf course construction (i.e. storm runoff, erosion, etc.) and long-term effects that may impact adversely aquatic resources in the nearby Kealakekua Bay Marine Life Conservation District (i.e. nutrient loading, effects of pesticides and other potential contaminants associated with golf courses and development, etc.

The EIS should project impacts, propose specific means for averting or minimizing adverse effects, and suggest possible mitigation or compensation for unavoidable damage to natural resource values.

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
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REF:OCEA:SKK

AUG 6 1991

FILE NO.: 91-565
DOC. NO.: 1285E

The Honorable Norman K. Hayashi, Director
Planning Department
County of Hawaii
25 Aupuni Street
Hilo, Hawaii 96720

Dear Mr. Hayashi:

SUBJECT: Environmental Impact Statement (EIS) Preparation Notice
Kealakekua Bay Club
Location: South Kona, Hawaii
TMK: 8-2-2: 2&39, 8-1-10: 2

Thank you for giving our Department the opportunity to comment on this matter. We have reviewed the materials you submitted and have the following comments.

Brief Description:

The applicant plans to develop an 18-hole golf course with clubhouse and related amenities on about 260 acres above Kealakekua Bay in South Kona, Hawaii. Other improvements include a maintenance building, trails and lookout. Also proposed are five 2-acre lots fronting Napoopoo Road.

Our Department's Aquatic Resources Division suggest the forthcoming EIS discuss in detail potential short-term impacts related to golf course construction (i.e. storm runoff, erosion, etc.) and long-term effects that may impact adversely aquatic resources in the nearby Kealakekua Bay Marine Life Conservation District (i.e. nutrient loading, effects of pesticides and other potential contaminants associated with golf courses and development, etc.

The EIS should project impacts, propose specific means for averting or minimizing adverse effects, and suggest possible mitigation or compensation for unavoidable damage to natural resource values.

The Division of Water Resource Management comments that the EIS should address project water requirements and proposed water sources. New groundwater source will require well construction permits from the Commission on Water Resource Management.

The Division of State Park's two comments regarding the subject matter:

1. Further study in the EIS should also include the impacts of development on the existing and the proposed Kealakekua Bay State Historical Park and on Kealakekua Bay State Underwater Park (p. 15, no. 11).

2. It is unclear what trails or roads are being referred to in the section on "Socioeconomic and Land Use Considerations" (pp. 12-13). We do not know what trail or road is being referred to as "Kealakekua trail" and we assume that "Ka'awaloa trail" is Ka'awaloa Road.

If there are any questions regarding our comments, contact Wayne H. Souza, Planner, at x8-2627.

The Division of Forestry and Wildlife will reserve comments to the forthcoming EIS.

Thank you for your cooperation in this matter. Please feel free to call me or Sam Lemmo at our Office of Conservation and Environmental Affairs at 548-7837, should you have any quesions.

Very truly yours,

WILLIAM W. PATY

cc: BCA
OEQC

JOHN WAIHEE
GOVERNOR OF HAWAII

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

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REF:OCEA:SKK

FILE NO.: 91-565
DOC. NO.: 1321E

The Honorable Norman K. Hayashi, Director
Planning Department
County of Hawaii
25 Aupuni Street
Hilo, Hawaii 96720

Dear Mr. Hayashi:

SUBJECT: Additional Comments Regarding the Environmental Impact Statement (EIS) Preparation Notice for Kealakekua Bay Club
Location: South Kona, Hawaii
TMK: 8-2-2: 2&39, 8-1-10: 2

Thank you for giving our Department the opportunity to comment on this matter. We have reviewed the materials you submitted and have the following additional comments.

HISTORIC PRESERVATION PROGRAM CONCERNS:

We have not had the opportunity to review all the archaeological reports of inventory surveys conducted for this proposed golf course and associated facilities. Until we have reviewed and approved these reports, we cannot determine what effects the project will have on historic sites nor can we concur, with one exception, with statements presented in the Preparation Notice. This exception is that the project area lies within the Kealakekua Bay Historical District (Site # 10-47-7000) which is on the National Register of Historic Places and within the Kona Field System (Site # 10-37-6601) which has been determined eligible for the National Register. We expect to officially comment on the adequacy of the inventory surveys conducted, the significance evaluations of all identified sites and the general mitigation plan proposed for significant sites during our review of the Draft Environmental Impact Statement.

Thank you for your cooperation in this matter. Please feel free to call me or Sam Lemmo at our Office of Conservation and Environmental Affairs at 548-7837, should you have any questions.

Very truly yours,

WILLIAM W. PATY

cc: BCA
OEQC

BCA
BELT COLLINS
& ASSOCIATES
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680 Ala Moana Boulevard, Suite 200, Honolulu, Hawaii 96813
Phone: (808) 521-5361, Fax: (808) 538-7819
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September 6, 1991
91P-349 (033.2101)

Mr. William W. Paty, Chairman
Board of Land and Natural Resources
State of Hawaii
P.O. Box 621
Honolulu, Hawaii 96809

Dear Mr. Paty:

Environmental Impact Statement (EIS)
Kealakekua Bay Club, Island of Hawaii

Thank you for your August 6, 1991 comments on the above project and EIS Preparation Notice.

The areas of concern identified by your Aquatic Resources Division will be addressed in the EIS. Several studies addressing the potential impacts of drainage, erosion, chemical use, etc. on the offshore environment have been prepared and the results and mitigation measures will be included in the EIS.

Water requirements for the project, as well as water sources, will be examined in the EIS. We are aware that new groundwater source development will require well construction permits and the applicant intends to seek such permits at the appropriate time.

As requested by your Division of State Parks, we will include an analysis of potential impacts on the Kealakekua Bay State Historical Park and the Kealakekua Bay State Underwater Park. The applicant continues to consult with the Division in refining public access aspects of the proposed project as well as addressing trails issues.

In reply to your further comments in a subsequent letter (undated), archaeological reports related to the project will be forwarded to the Historic Preservation Program Division for its review and comment. The applicant, its representatives and the project archaeologist will continue to consult with Division officials and staff during the EIS and permitting process.

We expect the Draft EIS to be available by the end of October and look forward to any comments you may have after the document is published.

Very truly yours,

Lee William Sichter

ALM:lf

cc Hawaii County Planning Department
Royal Coast Development Corporation

JOHN WAIHEE
Governor
MURRAY E. TOWILL
Director
BARBARA KIM STANTON
Deputy Director
RICK EGGED
Deputy Director

DEPARTMENT OF BUSINESS, ECONOMIC DEVELOPMENT & TOURISM

MAILING ADDRESS P O BOX 2359, HONOLULU, HAWAII 96804 FAX (808) 523-8637

Augst 3, 1991

Ms. Anne L. Mapes
Belt Collins & Associates
680 Ala Moana Boulevard, Suite 200
Honolulu, Hawaii 96813

Dear Ms. Mapes:

Thank you for the opportunity to comment on the Environmental Impact Statement (EIS) Preparation Notice for the proposed Kealakekua Bay Club, an 18-hole golf course with clubhouse and related amenities on approximately 260 acres above Kealakekua Bay in South Kona.

As the State agency charged with the overall development of tourism in Hawaii, the Department of Business, Economic Development, and Tourism is responsible for the preparation of the State Tourism Functional Plan (STFP). A copy of the recently revised plan is enclosed for your information.

As you are aware, the EIS for a proposed tourism-related project normally addresses relevant STFP policies. While the current STFP does not include a specific policy regarding golf course development, it does include a policy which encourages the development of hotels and related facilities in visitor destination areas as designated by County General Plans.

Based on the information provided, we are uncertain about the extent to which this project will serve our visitor population. We do note, however, that the golf course and the 36-unit members' lodge proposed for development at a later date are located outside the designated South Kona region as illustrated on the enclosed map of visitor destination areas for Hawaii County. Accordingly, we suggest the EIS address the use of the proposed development by our transient visitor population.

If you have any questions regarding the State Tourism Functional Plan, please contact the Office of Tourism at 548-7700.

Very truly yours,

Barbara Kim Stanton
for Murray E. Towill

MET:MAA:ss

Enclosures

BCA
BELT COLLINS
& ASSOCIATES
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680 Ala Moana Boulevard, Suite 200, Honolulu, Hawaii 96813
Phone: (808) 521-5361, Fax: (808) 538-7819
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September 6, 1991
91P-350 (033.2101)

Mr. Murray E. Towill, Director
Department of Business, Economic Development & Tourism
State of Hawaii
P.O. Box 2359
Honolulu, Hawaii 96804

Dear Mr. Towill:

Environmental Impact Statement (EIS)
Kealakekua Bay Club, Island of Hawaii

Thank you for your August, 1991 comments on the EIS Preparation Notice for the above project.

We appreciate you sending us a copy of the revised State Tourism Functional Plan which we will use in the preparation of the EIS.

The small 36-unit members' lodge will not be open to the general public and will not operate as a hotel or destination resort. Membership will consist of both Hawaiian islands and international members, and the impact of overnight members will be minimal. The EIS will include an economic impact analysis and discuss the effects of the proposed development, including the future lodge.

We expect the Draft EIS to be available by the end of October and look forward to any comments you may have after the document is published.

Very truly yours,

Lee William Sichter

ALM:lf

cc: Hawaii County Planning Department
Royal Coast Development Corporation

Chapter X:
REFERENCES

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Appendix 1:
ARCHAEOLOGICAL INVENTORY SURVEY, KEALAKEKUA BAY CLUB PARCEL 39

Archaeological Inventory Survey
Kealakekua Bay Club
Parcel 39

Land of Kealakekua
South Kona District, Island of Hawaii

PHRI
Paul H. Rosendahl, Ph.D., Inc.
Archaeological • Historical • Cultural Resource Management Studies & Services
305 Mohouli Street • Hilo, Hawaii 96720 • (808) 969-1763 • FAX (808) 961-6998
P.O. Box 23305 • G. M. F., Guam 96921 • (671) 472-3117 • FAX (671) 472-3131

Report 877-052491

Archaeological Inventory Survey
Kealakekua Bay Club
Parcel 39

Land of Kealakekua
South Kona District, Island of Hawaii
(TMK:3-8-2-2:39)

by

Benkena D. Borgett, B.A.
Supervisory Archaeologist

and

Paul H. Rosendahl, Ph.D.
Principal Archaeologist

Prepared for

Mr. Clifford Temps, General Manager
Royal Coast Development Corporation
c/o Ms. Anne Mapes
Bell Collins & Associates
680 Ala Moana Blvd., Suite 200
Honolulu, Hawaii 96813

May 1991

PHRI
Paul H. Rosendahl, Ph.D., Inc.
Archaeological • Historical • Cultural Resource Management Studies & Services
305 Mohouli Street • Hilo, Hawaii 96720 • (808) 969-1763 • FAX (808) 961-6998
P.O. Box 23305 • G. M. F., Guam 96921 • (671) 472-3117 • FAX (671) 472-3131

SUMMARY

At the request of Mr. Clifford Temps, General Manager of Royal Coast Development Corporation, Paul H. Rosendahl, Ph.D., Inc. (PHRI) conducted an archaeological inventory survey of the c. 5.725 acre Kealakekua Bay Club Parcel 39 project area. The parcel is situated in the Land of Kealakekua, Island of Hawaii (TMK 3-8-2-2-39). The survey consisted of a 100% coverage surface surface survey and limited subsurface testing. The overall purpose of the survey was to provide information appropriate to and sufficient for the satisfaction of the requirements of an Environmental Impact Statement or similar level planning document.

Much of the project area had been altered during the historic period. With the exception of historic walls and roadbeds, which cross the center of the project area, sites were identified only near the eastern and western boundaries.

During the project, 15 sites consisting of 20 component features were identified. Of the 15 identified sites, six are walls that appear to be historic structures associated with ranching and/or agriculture, and three are associated with pineapple cultivation. The remaining six sites are agricultural or possible habitation features. These sites are located on and near the bases of the ridges that extend along much of the east and west project area boundaries.

Of the 15 identified sites [illegible] remaining 12 sites are single features. The [illegible] formal feature types and four functional categories. Formal feature types present are wall, terrace, mound, road, and platform. Functional feature types present are agriculture, land division/boundary, possible habitation, and transportation. The condition of the sites ranges from excellent to poor.

One site had been previously identified during a reconnaissance survey of properties adjoining the project area (The Old Pineapple Road, SIHP Site 11481).

Eleven of the fifteen identified sites are assessed as significant solely for information content. Further data collection is recommended for these sites. After further data collection is completed, it is expected that no additional work will be necessary for these sites. Two of the four remaining sites (11481 and 14978) are assessed as significant for information content and as excellent examples of site types. For these two sites, further data collection followed by preservation "as is" is recommended. No further work is recommended for the remaining two sites (14966 and 14969). Information recorded during the present survey is considered sufficient to have fully documented these sites.

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CORRECTION

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

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INTRODUCTION

BACKGROUND

At the request of Mr. Clifford Temps, General Manager of Royal Crest Development Corporation, Paul H. Rosendahl, Ph.D., Inc. (PHRI) conducted an inventory survey of the approximately 5.725 acre Kealakekua Bay Club Parcel 39 project area, situated in the Land of Kealakekua, Island of Hawaii (TMK:3-8-2-2:39) (*Figure 1*). The survey consisted of a 100%-coverage surface surface survey and limited subsurface testing. The overall purpose of the survey was to provide information appropriate to and sufficient for the requirements of an Environmental Impact Statement or similar level planning document.

Survey field work was conducted June 28 through July 3, 1990 by a crew of four to five persons under the direction of Supervisory Archaeologist Berdena D. Burgett, B.A. and under the overall supervision of Principal Archaeologist Dr. Paul H. Rosendahl. Crew members included Field Archaeologists Ed Archer, Derek Kowalchuk, Nick Kaliquka, Robert Noah, and Varda Zamier, B.A. Approximately 160 labor-hours were required for the field work.

SCOPE OF WORK

The basic purpose of an inventory survey is to identify—to discover and locate on available maps—features of potential archaeological significance present within the specified project area. An *inventory survey* is an initial level of archaeological investigation. It is extensive rather than intensive in scope, and is conducted with the primary aim of determining the presence or absence of archaeological resources within a specified project area. A survey of this type indicates both the general nature and the variety of archaeological remains present, and the distribution and density of such remains. It permits a general significance assessment of the archaeological resources, and facilitates formulation of realistic recommendations and estimates for any *mitigation* work that might be necessary or appropriate. Such work could include further data collection involving detailed recording of sites and features, and selected test excavations. It might also include subsequent data recovery research excavations, construction monitoring, interpretive planning and development, and/or preservation of sites and features with significant scientific research, interpretive, and/or cultural values.

The basic objectives of the survey were fourfold: (a) to identify (find and locate) all sites and site complexes present within the project area; (b) to evaluate the potential general significance of all identified archaeological remains; (c) to determine the possible effects of the proposed development upon the identified remains; and (d) to define the general scope of any subsequent further data collection, or other mitigation work that might be necessary or appropriate.

Based on a review of readily available background literature, PHRI's familiarity with the general project area and with the current requirements of review authorities, the following specific tasks were determined to constitute an adequate and appropriate scope of work for the inventory survey:

1. Conduct limited archaeological and historical documentary background research involving review and evaluation of readily available archaeological and historical literature, historic documents, and records, and cartographic sources relevant to the immediate project area;

2. Conduct a variable coverage (partial to 100%), variable intensity surface survey of the project area;

3. Conduct limited subsurface testing of selected sites and features identified within the project area (a) to determine the presence or absence of potentially significant buried cultural features or deposits, and (b) to obtain suitable samples for age determination analyses; and

4. Analyze background and field data, and prepare appropriate reports.

The inventory survey was carried out in accordance with guidelines provided by the Hawaii Department of Land and Natural Resources-State Historic Preservation Division (DLNR-SHPD) for the review and evaluation of archaeological inventory survey reports submitted in conjunction with various development permit applications. The significance of all archaeological remains identified within the project area was assessed in terms of the National Register criteria contained in the Code of Federal Regulations (36 CFR Part 60) and criteria for evaluation of traditional cultural values prepared by the national Advisory Council on Historic Preservation. These criteria are used by the DLNR-SHPD and the Hawaii County Planning Department for the evaluation of cultural resources and to evaluate

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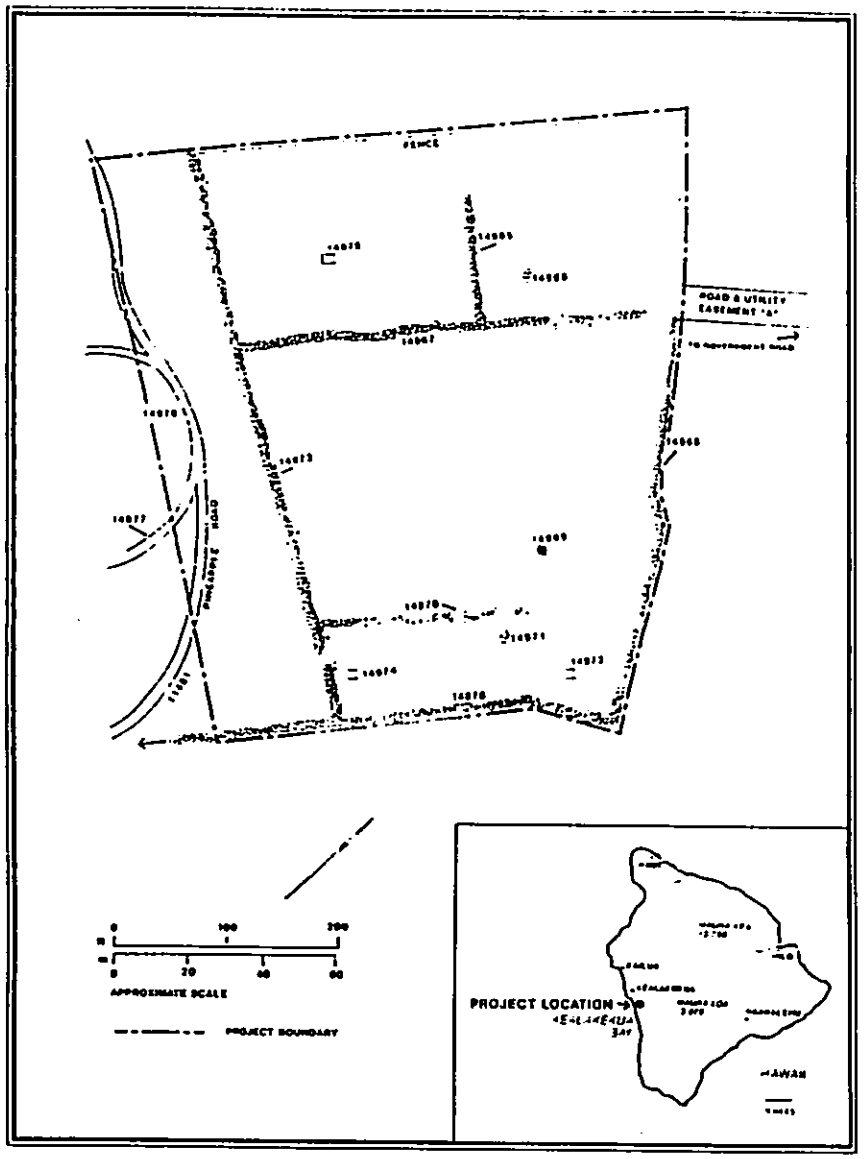

Figure 1. Project Area and Site Location Map

eligibility for the Hawaii State and National Registers of Historic Places. The significance of all remains was also assessed in terms of PIRI Cultural Resource Management (CRM) value modes. Evaluation criteria are discussed further in the Conclusion section of this report.

PROJECT AREA DESCRIPTION

The project area consists of approximately 5.725 acres located in the Land of Kealakekua, South Kona District, Island of Hawaii (TMK:3-8-2-2:39). The parcel is approximately 500 ft. south of the Government Road leading to Napo'opo'o and is bounded by stone walls on the north and east. The east wall marks the boundary between Kiloa and Kealakekua *ahupua'a*. The west boundary adjoins the Kealakekua Ranch Makai Land Subdivision property; the Urban Conservation District adjoins the south boundary.

The project area is located within the southern portion of the Kona Field System (SHIP Site No. 50-10-37-6601). This is an extensive complex of aboriginal Hawaiian habitation and dryland cultivation features that covers an area approximately three miles wide and eighteen miles long, extending from Kealakekua Bay to Kailua. The Kona Field System was declared eligible for inclusion on the National Register of Historic Places in January, 1977. The project area also lies within the Kealakekua Bay Historic District (SHIP Site No. 50-10-47-7000), an historical site complex that was placed on the National Register of Historic Places in December, 1974.

The area has recently been used for cattle grazing and shows evidence of historic land alteration and disturbance. Although the overall aspect is of undulating, rocky, grass-covered terrain sloping seaward, ridges along the east and west boundaries of the property rise above the central area. There is a steep, sloping pile of boulders and dozer-push in the northwest corner of the property. The terrain near the northeastern corner consists of a number of high knolls sloping south and west from the boundary wall. Divisions within the parcel are marked by several historic stone walls.

The soils in the project area are primarily classified as Kainaliu Series, very stony, silty clay loam. They are relatively shallow, well-drained, and used for pasture and limited agriculture (Sato et al. 1973:22). Vegetation in the area during the survey was composed primarily of a dense ground cover of grasses and weeds and introduced low trees and shrubs. The dominant tree species within the project area are *koa haole* (*Leucaena leucocephala* [Lam.] de Wit) and monkeypod (*Samanea saman* [Jacq.] Merr.). Other tree species represented by small groves and scattered individual trees include the *kukui* (*Aleurites moluccana* [L.] Willd.), guava (*Psidium guajava* L.), mango (*Mangifera indica* L.), papaya (*Carica* sp.), avocado (*Persea americana* Mill.), and *'opiuma* (*Pithecellobium dulce* [Roxb.] Benth.). Low shrubs and ground cover include lantana (*Lantana camara* L.), castor bean (*Ricinus communis* L.), and guinea grass (*Panicum maximum* Jacq.).

PREVIOUS ARCHAEOLOGICAL WORK

An early survey of the general region above Kealakekua Bay was carried out by Reinecke in 1930. Reinecke commented on the disturbance caused by pineapple cultivation in the area, but did not record any sites in the vicinity of the project area. During the late 1960s, and through the early 1980s, a number of archaeological surveys conducted in the coastal area and the lands immediately above Kealakekua Bay identified archaeological features associated with the prehistoric Kona Field System. A list of these surveys is given by Kelly (1983:15).

The area immediately above Kealakekua Bay, in the Lands of Kealakekua and Ka'awaloa, was briefly examined by Soehren and Newman (1968) as part of an inventory and evaluation study of archaeological remains in the area. An aerial survey revealed that many remaining field boundary walls of the Kona Field system were visible in aerial photographs. The photographs were then used to prepare a base map of the interconnecting walls of the field system. Limited field work was conducted to verify and check the extent of the field system boundaries represented on the map. During the 1968 field work, fifteen sites and site complexes were identified and recorded within Kealakekua and Ka'awaloa (Soehren and Newman 1968:13-15).

Newman, using information recorded by William Ellis during an 1823 journey around Hawaii Island, plotted Ellis' route on aerial photographs and established boundaries for the major agricultural areas of the island. He also described the environmental characteristics and variables of those areas (Newman 1971:336). Using Ellis's observations, aerial photographs, and modern environmental data, Newman developed three sub-zones of the Kona Field System. Those agricultural sub-zones, at elevations from 500 to 3000 feet above sea level, are delineated by elevation, rainfall, and crops produced. The zones are compared with those proposed by Holland (1969), four zones beginning at sea level and reaching an elevation of 4000 feet. Although the two studies show differences in elevation and rainfall, with the exception of Holland's Coastal Zone (0 to 750 ft. above sea level) each lists virtually the same crops growing in corresponding sub-zones (Newman n.d.:128-130).

Schilt synthesized data supplied by Holland (IN Newman n.d.:129), Newman (n.d.:128, 134) and Kelly (1983:55-68) to develop an expanded list of the Kona Field System Subzone Characteristics. Schilt's classification includes four subzones: (a) *kula*, the coastal area from sea level to 500 ft.; (b) *kalu'ulu*, seaward slopes from 500-1000 ft.; (c) *'apa'pa*, the upland slope from 1000-2500 ft.; (d) *'ama'u*, the upland jungle from 2500-4000 ft. Schilt also listed approximate amounts of annual rainfall for each subzone and crops grown in each subzone during three periods: late prehistoric, the historic period from c. AD 1778-1825, and the period from 1825-1850 (Schilt 1984:6).

Schilt's study of the Kuakini Highway Realignment Corridor revealed evidence of gardening in the southern portion of the corridor beginning in the developmental period (c. 1400-1600/1650) and continuing through the historic period, (c. AD 1779-1850) (ibid.:3, 277-281).

Clark (1983) conducted a B.P. Bishop Museum reconnaissance survey of seven residential lots north of the present project area. Thirty-four archaeological and historic features were recorded, including several that appeared to be structural remnants of the Kona Field System.

Archaeological investigations conducted in the lands adjoining the project area include a 1982 field inspection by Soehren of the Urban District to the west. Although he did not identify any new sites, he did refer to three previously identified sites and to the many visible remnants of the Kona Field System in the area. Soehren also commented on the disturbance caused to archaeological sites by vegetation grubbing (Soehren 1968).

A preliminary reconnaissance survey (field inspection) of the lands adjoining the present project area on the east and the south, was conducted by Rosendahl (1986). Approximately 35 sites were identified during the survey. Based on the findings of the preliminary survey, a full reconnaissance survey was conducted in 1987. During the 1987 fieldwork 49 sites and site complexes, including four previously identified sites, were identified. Twenty-six of the identified sites were believed to be component elements of the Kona Field System (Kaschko and Rosendahl 1987:11, 13).

After the 1987 survey by Kaschko and Rosendahl, additional field work in the same area was conducted by Barrera (1989). Forty-two test excavations were dug at 28 of the sites. Indigenous artifacts, marine midden, and vegetal remains were recovered from excavations at 19 sites. Additionally, 73 features were identified as elements of the Kona Field System (Barrera 1989:33-38).

HISTORICAL BACKGROUND AND SUMMARY OF HISTORICAL DOCUMENTARY RESEARCH

Historical overviews and summaries of the Kona District and Hawaiian lifeways in pre-contact and historic periods have been presented by Kelly (1971, 1983), Holland (1971), Barrere (1975), and Kuykendahl (1938). A general chronological sequence for expansion, settlement, and culture change in the Kona area is provided by Schilt (1984). Hommon (1986) has summarized the history of the Kealakekua region. Field investigations identifying elements of the Kona Field System in the coastal area and lands above Kealakekua Bay are listed by Kelly (1983:15). See Appendix B of this report for a discussion of the myths and legends of the area and complete historical documentary research.

Kealakekua Bay is well documented as the site of the first lengthy contacts between Europeans and natives of the Hawaiian Islands and as the scene of Captain James Cook's death in 1779 (see Appendix B). Journal entries by Cook and his officers (Clarke, King, Ledyard, Samwell, and Ellis) described the settlements and the agricultural complex above Kealakekua Bay. Ledyard described the stone walls and cultivated fields of the Kona Field System that he saw during a journey inland of Napo'opo'o (1963:118-120). Ledyard's party travelled approximately five miles inland of the coast, passing through the cultivated region to the fringe of the upper forest.

In 1793 Archibald Menzies, naturalist with Captain George Vancouver, traveled through portions of the Kona Field System inland of Kealakekua Bay, on a route north and east of the area covered by Ledyard and other members of Captain Cook's crew fourteen years earlier. Menzies provided detailed descriptions of the fields, crops, and plantations observed during his journey from the coast to the upland forest (Menzies 1920:74-77). Newman reconstructed the route traveled by Menzies and concluded that he passed north of the present town of Captain Cook and exited the field system at approximately 2500 ft above mean sea level (Newman n.d.:127).

In 1823 the William Ellis and two companions traveled through portions of the Kona Field System inland of Kailua. Ellis' description of the breadfruit plantations and garden areas show the Kona Field System to have been in full cultivation at that time. Ellis did not visit the agricultural areas near Kealakekua Bay (Ellis 1979:31).

The first coffee was planted in Kona in the early 1800s, about the time the first cattle hunters and ranchers were

starting there. The coffee and cattle industries prospered and grew until they dominated the Kona economy. In the process they significantly altered the landscape. Reverend Samuel Ruggles planted the first coffee at Naole, Onouli, during 1828 or 1829. The best coffee growing area was a strip of land, one to three miles wide, at an elevation between 800 and 1700 feet above sea level, on the leeward slopes of Hualalai and Mauna Loa. This was the former "taro belt" where the Hawaiians had grown their upland taro (Goto 1982:113-14).

A report on coffee in the 1854 Royal Hawaiian Agricultural Society Transactions mentions only two Kona coffee planters with plantations at Kealakekua. By the 1860s, disease, drought, and fluctuating prices had changed the nature of coffee production, and the industry was kept alive during difficult times by the small family farms. The collapse of the world coffee market in 1899 ended the large scale plantation industry, and coffee growing was again left to small-scale individual and family operations (Kelley:84, 87).

Before the great Mahele of 1848, the Hawaiian population in the Kealakekua region had declined significantly, and the village of Kekua was apparently nearly deserted (Hommon 1986:11). The entire *ahupua'a* of Kealakekua was awarded to Chiefess Ane Keohokalole, mother of King Kalakaua and Queen Liliuokalani (Land Commission Award 8452-Apana 9, Royal Patents 3607 and 7533 [Office of the Commissioner 1929]). She also claimed three named house lots on the coastal flats adjacent to Hikiau Heiau (Foreign Testimony 3:574) and was awarded the entire *ahupua'a* of Ka'awaloa (Land Commission Award 8452-Apana 10).

After institution of the Mahele, Hawaiian citizens, including foreigners who had sworn allegiance to the Hawaiian King, were permitted to purchase land. Lands privately owned by chiefs could be offered for sale and certain government lands were made available. When a law allowing private ownership of lands by foreigners was passed in 1850, large tracts of land were acquired and devoted to the expansion of ranching and commercial agriculture (Kelly 1983:78). It was probably during this period that the long-running stone walls in the Kealakekua area were constructed to help control livestock (ibid:75-76).

Pineapple cultivation was underway in the area by the 1840s. Wylie (1844:115) writes that pineapples "abound" in the Kealakekua area in 1844. By 1890 it was reported that "the pineapple crop is a heavy one, but there is no market for the produce, or rather the market is a very limited one" (Whitney 1890:68). Large scale pineapple cultivation began in 1905 with the incorporation of the Captain Cook Coffee Company (Hawaii State Archives 1905). Listed among the company assets were "750 fully paid up shares of the capital stock of the Hala Canning Company valued at $15,000" dissolved Corporation File).

"Hala Canning Co., pineapple cannery, Napoopoo" is first listed in the 1905-1906 issue of an annual business directory (Polk-Husted 1900-1920) and last appears in the 1911 issue. The 1910 and 1911 listings for the cannery show "Captain Cook Coffee Co., Ltd. proprs." The Captain Cook Coffee Co., Ltd. is first listed in the 1908 directory. In the 1912 through 1914 issues the listing reads:

> Captain Cook Coffee Co Ltd, L MacFarlane mgr, coffee plantation and gen store, office Kealakekua, cannery and pineapple plantation Napoopoo, Hind Rolph & Co Honolulu agts.

After 1914, no specific reference to pineapple appears in the listing. Presumably, pineapple production was phased out of the company activities.

FIELD METHODS AND PROCEDURES

The project area was surveyed by pedestrian transects. Inspection of the project area prior to the beginning of the ground survey showed that the entire survey area was covered by a dense growth of tall grass and low bushes with occasional trees. During pedestrian transects, because visibility was limited, intervals between sweeping crew members were maintained at c. 10.00 m. The five-person survey crew travelled in parallel sweeps oriented approximately east-west across the project area. Striped flagging tape marked the beginning and end of each sweep. All identified features were marked with pink and blue flags bearing a temporary PHRI site number and date. The site type, possible functional interpretation, and sweep number were recorded, and the approximate site location was plotted on a plat map of the area (scale 1"=130').

After completion of the pedestrian sweeps, all identified sites and features were recorded. Each site and feature was photographed and described on standard PHRI forms, and scaled site and feature maps were drawn using metric tape and compass. Each site was marked with a metal site tag bearing the PHRI project number, site number, and date. The sites were later assigned permanent SIHP numbers (Table 1).

Of the 21 temporary site numbers assigned during the survey, two were combined with other temporary sites during the recording phase (Table 1). One of the temporary

sites was later determined to be non cultural, and an additional three sites were found to be outside of the present project boundary and part of an adjacent, earlier, PHRI project area (Kaschko and Rosendahl 1987).

Subsurface testing was conducted at two sites within the project area. Test units measuring 1.00 m by 1.00 m were excavated at Sites 14969 and 14972. Excavated soil was screened through 1/4-inch and 1/8 inch mesh, and all identified midden and artifacts were recovered. Charcoal samples were collected for radiocarbon age determination. Excavation data was recorded on standard PHRI field forms, and test excavations were back-filled after the recording was completed.

Table 1.

CORRELATION OF SITE NUMBERS

*SIHP	PHRI (877-)	SIHP	PHRI (877-)
11481	12	14972	9
14965	1	14973	10
14966	2	14974	13
14967	3	14975	14
14968	4	14976	16
14969	5	14977	17
14970	6/8	14978	21
14971	7		

** State Historic Preservation Division (SIHP) numbers. SIHP numbers are five digit numbers prefixed by 50-10-47 (50=State of Hawaii; 10=Island of Hawaii; 47=USGS 7.5' series quad map ["Honaunau, Hawaii"]).*

FINDINGS

Much of the project area has been altered during the historic period by vegetation clearing, wall construction, and cattle grazing. With the exception of historic walls and roadbeds, which cross the center of the project area, sites were identified only near the eastern and western boundaries.

During the project, 15 sites consisting of 20 component features were identified (Table 2). Sites and features are described in Appendix A. One site had been previously identified during a reconnaissance survey of properties adjoining the project area. This site is The Old Pineapple Road, SIHP Site 11481.

Of the 15 identified sites, six are walls that appear to be historic structures associated with ranching and/or agricultural activities. Three sites are associated with pineapple cultivation: elevated roadbeds, Sites 11481, 14977; and Site 14976, a possible loading dock.

The remaining six sites are agricultural or possible habitation features. These sites are located on and near the bases of the ridges that extend along much of the east and west project area boundaries.

Of the 15 identified sites, three are multiple feature complexes, and the remaining 12 sites are single features. The twenty identified features comprise five formal feature types and four functional categories (Tables 3 and 4).

The eight terraces identified represent 40% of the features identified during the survey. Six of the terraces are small agricultural features; the two larger terraces (Site 14972 A and D) have been assigned possible habitation functions. A 1.0 by 1.0 m test excavation at Feature D, Site 14972, yielded a radiocarbon dating sample. The results of the dating analysis are discussed in the Data Analysis section.

The six historic walls comprise 30% of the identified features. All are double-faced, have core filling, and range in condition from excellent to poor. Four of the walls appear to have functioned as dividers within the project area. Sites 14967 and 14970 are *mauka-makai* walls that may have extended northeast-southwest across the length of the project area at one time. All stones from the northeast ends of the walls appear to have been removed. The southwest wall ends near Site 14973, a wall that begins at the west boundary and spans the project area e. east-west. Site 14965 extends 35.0 m east from wall 14967 and stops c. 15.00 m from the west boundary line. Site 14968 abuts the *ahupua'a* wall at the east boundary and extends west along approximately two-thirds of the northern project boundary.

Three of the remaining six sites are boulder and cobble mounds (Sites 14966, 14971, and 14972 B) that were identified as probable agricultural features. These mounds of loosely piled boulders and cobbles have no aligned perimeter stones, paving, or facings. No coral or waterworn stones were present at any of the three features.

Sites 11481 and 14977 are elevated roadways associated with pineapple cultivation in the area during the early part of the century. Both roads cross the southern boundary and intrude a short distance into the project area.

Site 14969, a possible habitation, is the only platform identified during the survey. Excavation of a 1.0 by 1.0 m test unit at the feature yielded one volcanic glass core and a small amount of charcoal. The quantity of charcoal recovered was insufficient for radiocarbon dating.

One piece of weathered branch coral, at Site 14972 Feature D, was the only manuport identified within the survey area. No surface midden was noted at any location during the survey and no substantial cultural deposits were identified during test excavations at Sites 14969 and 14972.

Three sites located south of the project boundary (877-18, 877-19, 877-20) were recorded but are not included as part of this report and were not assigned SIHP site numbers. The sites were not identified during an earlier survey of the property adjoining the south and west boundaries of the current project area (Kaschko and Rosendahl 1987). A 0.50 by 1.0 m test unit was excavated at a small enclosure, Site 877-18 Feature C. No midden or charcoal was found during the excavation. One volcanic glass flake, indicating prehistoric occupation of the site, was recovered.

Table 2.

SUMMARY OF IDENTIFIED SITES AND FEATURES

SIHP Site No.	Formal Site/Feature Type	Tentative Functional Interpretation	#CRM Value Mode Assess. R	I	C	+Field Work Tasks DR	SC	EX
11481	Road	Transportation	M	M	M	+	-	-
14965	Wall	Land division	M	L	L	+	-	-
14966	Mound	Agriculture	L	L	L	-	-	-
14967	Wall	Land division	M	L	L	+	-	-
14968	Wall	Land division	M	L	L	+	-	-
14969	Platform	Possible habitation	M	L	L	+	-	-
14970	Wall	Land Division	M	L	L	+	-	-
14971	Mound	Agriculture	L	L	L	-	-	-

 # Cultural Resource Management Value Mode Assessment
—Nature: R = scientific research value,
I = interpretive value,
C = cultural value;
—Degree: H = high,
M = moderate,
L = low.

+ Recommended Field Work Tasks:
DR = detailed recording (scaled drawings, photographs, and written descriptions),
SC = surface collections,
EX = test excavations.

Table 2. (cont.)

SIHP Site No.	Formal Site/Feature Type	Tentative Functional Interpretation	CRM Value Mode Assess. R	I	C	Field Work Tasks DR	SC	EX
14972	Complex (4**)	Agriculture/ possible habitation	M	L	L	+	-	-
A	Terrace							
B	Mound							
C	Terrace							
D	Terrace							
14973	Wall	Land Division	M	L	L	+	-	-
14974	Complex (2)	Agriculture	M	L	L	+	-	+
A	Terrace							
B	Terrace							
14975	Complex (2)	Agriculture	M	L	L	+	-	-
A	Terrace							
B	Terrace							
14976	Terrace	Agriculture	M	L	L	+	-	-
14977	Road	Transportation	M	M	M	+	-	-
14978	Wall	Boundary	M	M	M	+	-	-

***Number of component features within complex.*

Table 3.

FREQUENCIES OF FORMAL FEATURE TYPES

Formal Type	Number	%
Terrace	8	40.0
Wall	6	30.0
Mound	3	15.0
Road	2	10.0
Platform	1	5.0
TOTAL	20	100.0

Table 4.

FREQUENCIES OF FUNCTIONAL FEATURE TYPES

Functional Type	Number	%
Agriculture	9	45.0
Land division/boundary	6	30.0
Possible habitation	3	15.0
Transportation	2	10.0
TOTAL	20	100.0

DATA ANALYSES

AGE DETERMINATIONS

Objectives and Methods

Two charcoal samples from discrete cultural deposits were chosen for age determination using radiocarbon analysis. The analysis was performed by Beta Analytic, Inc., of Coral Gables, Florida. The purpose of age determination analysis is to provide initial chronological data to aid in assessing the relative significance of sites in a given project area. Using standard procedures, the samples from the current project were pretreated with an acid, alkali, acid series of soakings to remove carbonates and humic acids. After pretreatment one of the two samples, RC-904, was found to contain insufficient carbon for further analysis. The remaining sample was combusted to form carbon dioxide gas, combined with lithium to separate the carbon, and hydrolyzed for conversion to liquid form. The liquid was then catalyzed to form benzene and placed in a liquid scintillation counter to determine the amounts of carbon-13 and carbon-12. The isotope values obtained during the counting process were then used to calculate the carbon-13/carbon-12 ratio for the sample, with the final result being determined relative to international standards in order to reduce errors produced by carbon isotope fractionation. Processing of sample RC-905 proceeded normally.

Results

The results of the radiocarbon age determination are presented in Table 5. The age for each sample is reported as a range corresponding to the calendric age +/- two standard deviations. Ages were calibrated using the tables provided in Stuiver and Pearson (1986), which correct for variations in atmospheric carbon over time.

As can be seen in Table 5, sample RC-905 yielded multiple age ranges. Multiple ranges are caused by "flat" regions in the calibration curve, which correspond to periods when atmospheric carbon decreased at a rate greater than 1.2 ppm/10 years, resulting in more than one possible fit of a

Table 5.

SUMMARY OF RADIOCARBON AGE DETERMINATIONS

PHRI Lab.No. RC-	Lab. No. BETA-	Provenience	C-14 Age Yrs. B.P. (one sigma)	C-13/ C-12 Ratio	C-13 Adjusted C-14 Age Yrs. B.P.	*Calendric Range Yrs. AD
SITE 14972						
905	40935	Feature D, TU-1, Layer 1, Level 1, 0-95 cmbs	410 + 100	-26.4	390 + 100	1322-1341 1390-1670 1774-1793 1948-1953

* *Calibrated according to Stuiver and Pearson (1986). Range at two sigmas.*

sample to the calibration curve. While multiple age ranges are more difficult to interpret archaeologically, detailed examination of the sample curves, combined with evidence from artifactual material and feature stratigraphy, generally provides a means of selecting one age range as more probable than the others. Based on these criteria, the most probable age range for sample RC-905 is 1390-1670 AD.

The results of the age determination indicate that the project area was occupied during prehistoric times, possibly as early as AD 1390 at Site 14972 While no charcoal samples were recovered from Sites 14969 and 877-18, the presence of volcanic glass flakes at these sites suggest that they were occupied during the prehistoric period, because use of volcanic glass flakes ceased in the Hawaiian Islands after approximately 1790 AD.

PORTABLE ARTIFACTS

Two artifacts were recovered from the project area, both classified as indigenous artifacts. Indigenous artifacts are those fabricated using traditional Hawaiian manufacturing techniques and local raw materials. They range from tools and fishing gear to various decorative or religious items. The two indigenous artifacts from the current project area were both flaked stone artifacts composed of volcanic glass. The first derived from Level I, Test Unit 1 of Site 14969, while the second derived from Level I, Test Unit 1 of Site 877-18 (Kaschko and Rosendahl 1987 project area; no SIHP site number assigned).

All flaked stone material is evaluated with respect to flake/core type. Following established procedures for evaluating flaked stone material, diagnostic flakes are defined as those flakes having a complete or partial striking platform and a bulb of percussion. Non-diagnostic flakes are fragments that lack the platform, bulb, or both. Cores tend toward multifaceted polyhedral shapes dominated by one or more platforms, and they typically show little evidence of subsequent use as tools. Primary cores exhibit only flake scars, while secondary cores are actually flakes with a bulb from which other flakes have been removed. Based on the above criteria, the specimen from Site 877-18 is classified as a primary core, while the specimen from Site 14969 is a diagnostic flake.

The primary core measures 20 mm by 27 mm by 15 mm. The core is trapezoidal and multi-facial, with four discernible flake scars, which are oriented uni-directionally. It has a single undamaged striking platform. The diagnostic flake measures 17 mm by 11 mm and is trapezoidal in cross-section. The bulb of percussion is sheared, and the striking platform is crushed. The flake shows evidence of edge-wear on the lowermost edge.

Uses for volcanic glass artifacts have been suggested both by Barrera (1971) and Kirch (1973), who observed:

> The possible functions...are many and varied. Basaltic glass holds a fine, sharp edge and the tools make excellent cutting and scraping implements. They may have been used in food preparation, for cutting and scraping plant materials, or for delicate woodworking...[t]hese artifacts are extremely common, being found in virtually every type of [Hawaiian] site. The suggestion, then, is that the ubiquitous basaltic glass flakes functioned as a prehistoric "pocketknife", to use a modern analogy...(1973:185-6).

The artifact assemblage from the current investigation generally suggests that prehistoric activities in the project area may have included manufacture of bone or shell artifacts, as well as the production of fishing gear. Stone tool manufacture and use is suggested by the volcanic glass material at Sites 877-5 and 877-18, and may have been accompanied by food processing and craft production activities that relied on the use of flaked stone tools.

CONCLUSION

DISCUSSION

The current project area is located within the limits of two significant archaeological and historical areas: the Kealakekua Historical District (Hawaii Register of Historic Places (HRHP) Site 7000) and the extensive Kona Field System (HRHP Site 6601). Archaeological sites representing land use during both the prehistoric and historic periods were identified within the project area during the current survey.

Land modification, including vegetation clearing, has taken place over most of the project area. Extensive land alteration in portions of the Kealakekua area has resulted from early historic agricultural and ranching activities. Those activities often took place on lands once used for prehistoric gardens. The central portion of the project area, extending seaward from the north boundary, shows much evidence of land alteration and clearing, which presumably removed evidence of any early archaeological sites. With the exception of walls, no sites were identified in the central portion. Sites were located on the slopes and at the bases of the ridges that extend along much of the east and west boundaries.

The presence of the Old Pineapple Road and associated features near the southern boundary suggests that the project area may have been used for pineapple cultivation at one time. Kaschko and Rosendahl (1987:7) note that "the actual limits of the area planted in pineapple are unclear, but it seems logical that cultivation would have taken place primarily on the inland side of The Old Pineapple Road". During their survey of the lands adjoining the west and south boundaries of the present project area, Kaschko and Rosendahl found that the only site located in the area to the south was the Old Pineapple Road. Although no sites were identified within c. 900 ft. of the present west boundary, beyond that point both historic and prehistoric sites were identified. It seems safe to speculate that the areas devoid of sites could have been cleared and devoted to pineapple cultivation.

Dating results and artifacts recovered during limited testing at two possible habitation sites near the eastern boundary (14969 and 14972) indicate prehistoric occupation of the area. No evidence of substantial cultural deposits was uncovered during excavations at either site. The lack of midden deposits, artifact assemblages, or manuports suggests that the tested sites were occupied on a temporary or occasional basis. No evidence of sites or features associated with long term occupation and more extensive agricultural use was found. Given the small size of The project area, it is possible that such features may never have been present or, if present, they were located in the portions that were cleared, and have been destroyed.

GENERAL SIGNIFICANCE ASSESSMENTS AND RECOMMENDED GENERAL TREATMENTS

Tentative general significance assessments and recommended general treatments for all identified sites are summarized in Table 6. Specific field work tasks for sites requiring further work are presented in Table 2.

Significance categories used in the site evaluation process are based on the National Register criteria for evaluation, as outlined in the Code of Federal Regulations (36 CFR Part 60). The DLNR-SHPD and the Hawaii County Planning Department use these criteria for evaluating cultural resources. Sites determined to be potentially significant for information content fall under Criterion D, which defines significant resources as ones which "...have yielded, or may be likely to yield, information important in prehistory or history." Sites potentially significant as representative examples of site types are evaluated under Criterion C, which defines significant resources as those which "...embody the distinctive characteristics of a type, period, or method of construction...or that represent a significant and distinguishable entity whose components may lack individual distinction."

Sites with potential cultural significance are evaluated under guidelines prepared by the Advisory Council on Historic Preservation (ACHP) entitled "Guidelines for Consideration of Traditional Cultural Values in Historic Preservation Review" (Draft Report, August 1985). The guidelines define cultural value as "...the contribution made by an historic property to an ongoing society or cultural system. A traditional cultural value is a cultural value that has historical depth." The guidelines further specify that "[a] property need not have been in consistent use since antiquity by a cultural system in order to have traditional cultural value."

Eleven of the fifteen identified sites (73.3%) are assessed as significant solely for information content. Further data collection is recommended for these sites. After further data collection is completed, it is expected that no additional work will be necessary for these sites. Two of the four

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Table 6.

SUMMARY OF GENERAL SIGNIFICANCE ASSESSMENTS AND RECOMMENDED GENERAL TREATMENTS

SIHP Site No.	Significance Category A	X	B	C	Recommended Treatment FDC	NFW	PID	PAI
14965	+	-	-	-	+	-	-	-
14967	+	-	-	-	+	-	-	-
14868	+	-	-	-	+	-	-	-
14971	+	-	-	-	+	-	-	-
14970	+	-	-	-	+	-	-	-
14972	+	-	-	-	+	-	-	-
14973	+	-	-	-	+	-	-	-
14974	+	-	-	-	+	-	-	-
14975	+	-	-	-	+	-	-	-
14976	+	-	-	-	+	-	-	-
14977	+	-	-	-	+	-	-	-
14966	-	+	-	-	-	+	-	-
14969	-	+	-	-	-	+	-	-
11481	-	+	-	-	+	-	-	+
14978	-	+	-	-	+	-	-	+

General Significance Categories:

- *A = Important for information content, further data collection necessary (PHRI=research value);*
- *X = Important for information content, no further data collection necessary (PHRI=research value, SHPO=not significant);*
- *B = Excellent example of site type at local, region, island, state, or national level (PHRI=interpretive value); and*
- *C = Culturally significant (PHRI=cultural value).*

Recommended General Treatments:

- *FDC = Further data collection necessary (detailed recording, surface collections, and/or limited excavations);*
- *NFW = No further work of any kind necessary, sufficient data collected archaeological clearance recommended, no preservation potential; (possible inclusion into landscaping suggested for consideration);*
- *PID = Preservation with some level of interpretive development recommended (including appropriate related data recovery work);*
- *PAI = Preservation "as is", with no further work (and possible inclusion into landscaping), or possibly minimal further data collection necessary.*

remaining sites (11481 and 14978) are assessed as significant for information content and are excellent examples of site types. For these two sites, further data collection followed by preservation "as is" is recommended. No further work is recommended for the remaining two sites (14966 and 14969). Information recorded during the present survey is considered sufficient to have fully documented these sites.

To further facilitate client management decisions regarding the subsequent treatment of resources, the general significance of the archaeological resources identified during the inventory survey was also evaluated in terms of potential scientific research, interpretive, and cultural values using the PHRI Cultural Resource Management [CRM] Value Modes. The CRM value modes are derived from the above state and federal criteria. See Table 2 for individual assessment of sites. *Research value* refers to the potential of archaeological resources for producing information useful in the understanding of culture history and past lifeways. *Interpretive value* refers to the potential of archaeological resources for public education and recreation. *Cultural value*, within the framework for significance evaluation used here, refers to the potential of archaeological resources for the preservation and promotion of cultural and ethnic identity and values.

The evaluations and recommendations presented in this final report have been based on an inventory survey of the project area. It should be noted that there is always the possibility, however remote, that potentially significant, previously unidentified cultural remains will be encountered in the project area during the course of future archaeological investigations or subsequent development activities. In such situations, archaeological consultation should be sought immediately.

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APPENDIX A

SITE DESCRIPTIONS:

SITE NO.: State: 14965 **PHRI:** 877-1
SITE TYPE: Wall
TOPOGRAPHY: Sloping pahoehoe pastureland with numerous trees.
VEGETATION: Tall grass, castor bean, monkey pod, papaya, avocado and *koa-haole*
CONDITION: Poor-good
INTEGRITY: Unaltered
PROBABLE AGE: Historic
FUNCTIONAL INTERPRETATION: Land division
DIMENSIONS: 35.50 m by 0.66-0.92 m by 0.50-1.34 m (approx.)
DESCRIPTION: The wall is oriented c. east-west and is constructed of four to six courses of stacked pahoehoe boulders and cobbles. The wall is faced and core-filled. The east end of this wall abuts Site 14967 wall c. 42.50 m from the northeast end. One area of recent collapse, near the east end of the wall, appears to be the result of cattle movement in the area.

SITE NO.: State: 14966 **PHRI:** 877-2
SITE TYPE: Mound
TOPOGRAPHY: Sloping pasture land with numerous trees.
VEGETATION: Tall grass, *koa-haole*, monkey pod, papaya and lantana.
CONDITION: Poor
INTEGRITY: Altered
PROBABLE AGE: Historic
FUNCTIONAL INTERPRETATION: Agriculture
DIMENSIONS: 1.80 m by 1.80 m by 0.10-0.27 m (approx.)
DESCRIPTION: This low pile of pahoehoe boulders, cobbles and pebbles appears to be a clearing mound. The mound is located on the south slope of a knoll near the west boundary. Other cobble rubble is located to the west and downslope. A dozer push pile is located at the bottom of the knoll. The mound is c. 20.0 m at 155° to the wall intersection of PHRI Sites 14965 and 14967.

SITE NO.: State: 14967 *(Figure A-1)* **PHRI:** 877-3
SITE TYPE: Wall
TOPOGRAPHY: Seaward sloping pastureland.
VEGETATION: Dense, high buffalo grass, monkey-pod, *kukui*, *koa-haole*, mango, and lantana.
CONDITION: Fair to good
INTEGRITY: Unaltered
PROBABLE AGE: Historic
FUNCTIONAL INTERPRETATION: Land division
DIMENSIONS: 133.60 m by 0.60 m by 0.45-1.40 m (approx.)
DESCRIPTION: Oriented at c. NE-SW, it is constructed with four to six courses of stacked pahoehoe boulders and cobbles. The northeast end of the wall is 6.00 m from the northeast property boundary and is only rubble and foundation stones for approximately 5.00 m. The remainder of the wall is bi-faced and filled with cobble rubble. The southwest end abuts Site 14973.

SITE NO.: State: 14968 **PHRI:** 877-4
SITE TYPE: Wall
TOPOGRAPHY: Sloping pastureland with occasional bedrock outcrops.
VEGETATION: High grass, mango, monkey pod, avocado and castor bean.
CONDITION: Good
INTEGRITY: Unaltered
PROBABLE AGE: Historic
FUNCTIONAL INTERPRETATION: Land division
DIMENSIONS: c. 114.9 m by 0.70 m by 1.00-1.20 m
DESCRIPTION: The wall is oriented at c. 125°/305° and marks the northeast project boundary southeast of the road and utility easement. It is constructed with bi-faced walls of stacked subangular boulders and cobbles eight to nine courses high. The interior is cobble rubble filled.

SITE NO.: State: 14969 *(Figure A-2)* **PHRI:** 877-5
SITE TYPE: Platform
TOPOGRAPHY: Sloping pastureland, occasional bedrock outcrops and knolls
VEGETATION: Tall grass, avocado, monkey pod and lantana.
CONDITION: Good
INTEGRITY: Altered
PROBABLE AGE: Historic
FUNCTIONAL INTERPRETATION: Possible habitation
DIMENSIONS: 9.00 m by 4.30 m by 0.25-0.50 m.
DESCRIPTION: This platform is located at the base of a ridge extending along much of the southeast side of the

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Figure A-1. Site 14967, View to East (PHRI Neg. 1488-15)

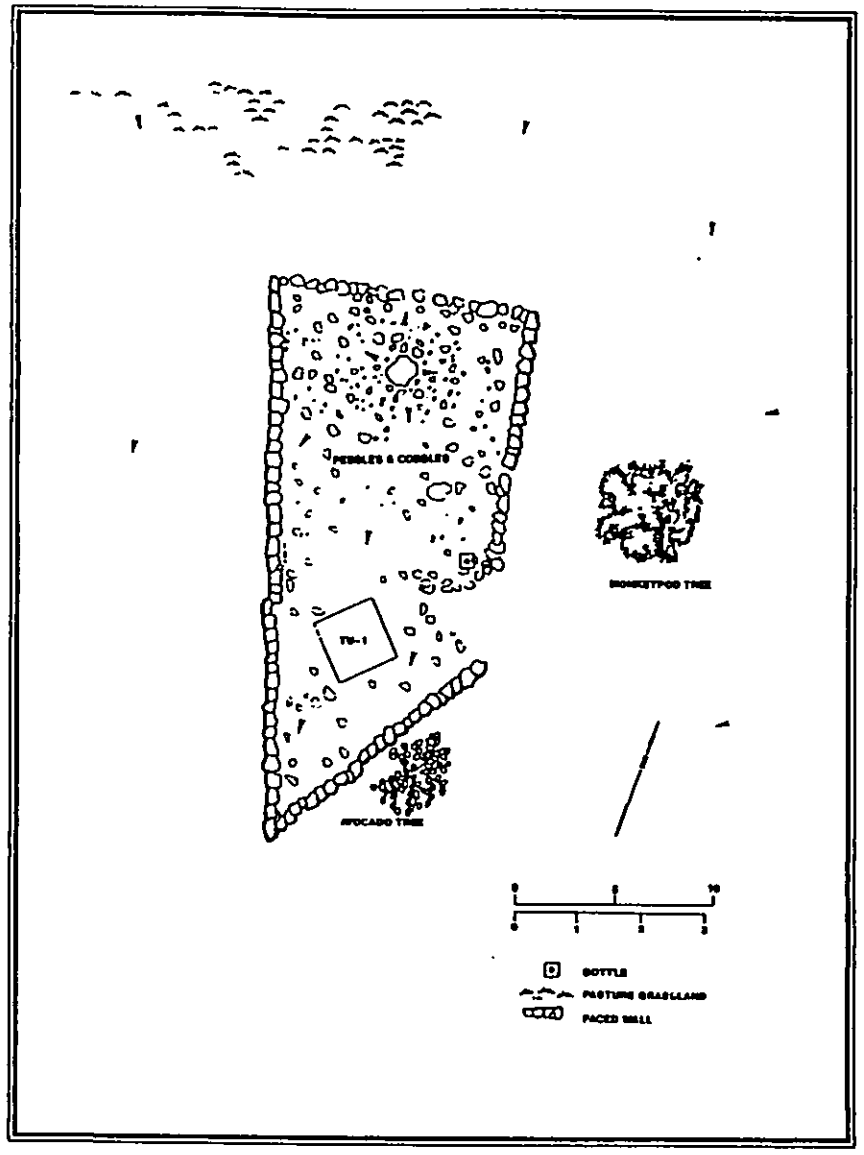

Figure A-2. Site 14969

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project area. It is constructed of pahoehoe boulders and cobbles stacked three to four courses high. The southeast end of the platform makes a 50° angle between the long east and west sides. The platform is faced on three sides and has cobble and pebble surface paving. The platform surface is slightly mounded at the NNE end. A wedge shaped portion of the east wall has collapsed or been removed. A translucent beer bottle with embossed letters was wedged in the rocks near the east side of the platform surface.

SITE NO.: State: 14970 PHRI: 877-6/8
SITE TYPE: Wall
TOPOGRAPHY: Seaward-sloping pastureland with numerous trees.
VEGETATION: Tall grass, monkey pod, *koa-haole*, lantana and avocado.
CONDITION: Poor-fair
INTEGRITY: Unaltered
PROBABLE AGE: Historic-possible prehistoric
FUNCTIONAL INTERPRETATION: Land division
DIMENSIONS: 69.40 m by 0.84 m by 0.50 m (approx.)
DESCRIPTION: The wall is constructed with one to four courses of pahoehoe boulders and cobbles and is oriented approximately inland-seaward. Evidence of facing remains on the few sections of wall that have not collapsed. The standing sections have pebble and cobble core fill. The wall is discontinuous for much of its length, and scattered rubble from the wall lies downslope. The inland extension is almost completely collapsed with only one faced section of the wall standing. This section is three to four courses high on the upslope side but has collapsed on the downslope side.

SITE NO.: State: 14971 PHRI: 877-7
SITE TYPE: Mound
TOPOGRAPHY: Sloping pastureland with numerous trees.
VEGETATION: Tall grass, monkey pod, lantana and *koa-haole*.
CONDITION: Unaltered
INTEGRITY: Poor
PROBABLE AGE: Indeterminate
FUNCTIONAL INTERPRETATION: Agriculture
DIMENSIONS: 5.25 m by 3.00 m by 0.90 m (approx.)
DESCRIPTION: This oval mound of angular and subangular boulders, cobbles, and pebbles is positioned between two monkey pod trees located near the ridge base at the eastern side of the project area. This feature, located west and downslope from Site 14972, appears to be a clearing mound.

SITE NO.: State: 14972 *(Figure A 3)* PHRI: 877-9
SITE TYPE: Complex (4 Features)
TOPOGRAPHY: Sloping pastureland with numerous trees.
VEGETATION: Tall grass, lantana, monkey pod, *koa-haole* and *'opiuma* trees.
CONDITION: Poor-fair
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Agriculture/habitation
DESCRIPTION: The site complex consists of three terraces (Features A, C and D) and a mound (Feature B), located near the southeast corner of the project area. The features are constructed on the top and north side of a ridge extending along much of the southern property boundary.

FEATURE A: Terrace
FUNCTION: Possible habitation
DIMENSIONS: c. 11.72 m NE-SW by 4.00 m NW-SE by 0.10-0.32 m.
DESCRIPTION: This rectangular terrace is constructed of one to three courses of boulders and cobbles and has a c. 3.00 m section extending at 235° from the southwest end. The feature has several areas of collapse but facing remains on portions of three sides of the rectangular terrace and on one side of the angled extension. The rough cobble surface slopes slightly seaward.

FEATURE B: Mound
FUNCTION: Agriculture
DIMENSIONS: c. 4.72 m by 2.50 m by 0.20-0.60 m.
DESCRIPTION: This oval mound consists of piled cobbles with boulders on the southern perimeter and pahoehoe pebbles at the eastern end. It is 5.50 m at 283° azimuth from the top of Feature B to the center of Feature A, Terrace wall.

FEATURE C: Terrace
FUNCTION: Agriculture
DIMENSIONS: 3.85 m by 1.40 m by 0.70 m (approx.)
DESCRIPTION: Feature C terrace is constructed of three to four courses of stacked pahoehoe boulders that confine a level, pebble-paved surface. The southeast end of the terrace, not confined by stacked boulders, is collapsing downslope.

FEATURE D: Terrace
FUNCTION: Possible habitation
DIMENSIONS: c. 7.40 m NE-SW by 5.70 NW-SE by 0.10-0.1.10 m.
DESCRIPTION: Feature D is an irregular terrace with a narrow extension curving outward from the northeast corner.

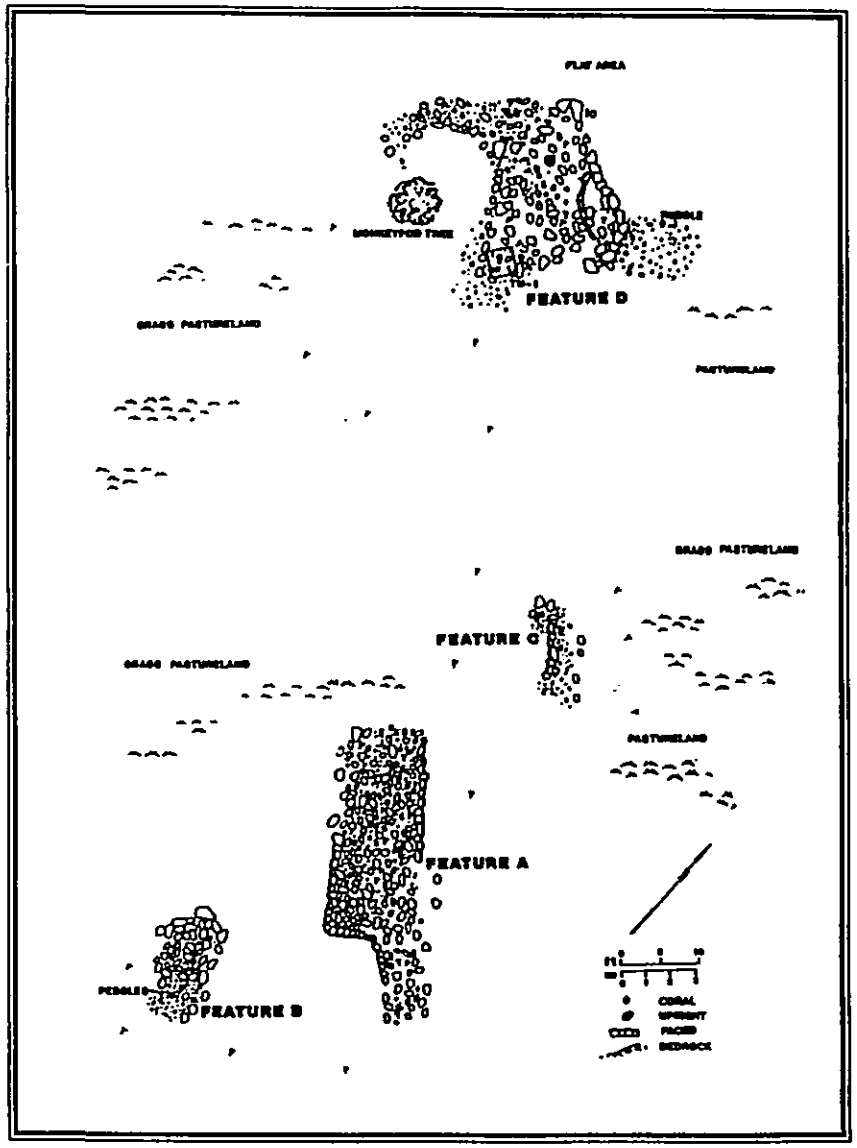

Figure A-3. Site 14972

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The terrace has a rough cobble surface with small areas of pahoehoe pebble paving. One piece of branch coral is present on the surface, near the southwest wall, and an upright stone is positioned near the center of the terrace. The feature has a slight seaward slope.

SITE NO.: State: 14973 PHRI: 877-10
SITE TYPE: Wall
TOPOGRAPHY: Sloping pastureland with numerous trees.
VEGETATION: Tall grass, monkey pod, *koa-haole*.
CONDITION: Good
INTEGRITY: Altered
PROBABLE AGE: Historic
FUNCTIONAL INTERPRETATION: Land division
DIMENSIONS: 158.6 m by 0.80 m by 1.40 m (approx.)
DESCRIPTION: This bi-faced, core-filled wall is oriented at c. 272° azimuth. The seaward height is c. 1.4 m and the inland height is c. 0.40 m. It is constructed with eight to ten courses of pahoehoe boulders and cobbles and has small, cobble rubble fill. A c. 2.0 meter-wide opening near the east end of the wall has wooden posts on either side and probably once contained a wooden gate. Wire spanning the opening continues along the top of the wall and joins the wire fence that marks the west project boundary.

SITE NO.: State: 11481 PHRI: 877-12
SITE TYPE: Road
TOPOGRAPHY: Flows and outcrops sloping seaward.
VEGETATION: Monkey pod, lantana, *koa-haole*, dense tall grass.
CONDITION: Good
INTEGRITY: Unaltered
PROBABLE AGE: Historic
FUNCTIONAL INTERPRETATION: Transportation
DIMENSIONS: 158.05 m by 5.30 m by 1.60 m (approx.)
DESCRIPTION: Previously identified as The Pineapple Road because of its association with pineapple cultivation in the area, this road enters the project area near the northwest corner and exits c. 30.00 m from the east boundary. The road curves and continues southwest, paralleling the boundary wall. Irregularly shaped a'a boulders and cobbles, stacked five to six courses high, form a causeway for the roadbed. The Pineapple Road meanders along the southern boundary of the project area at c. 315° to c. 290° azimuth at the western boundary. In addition to cattle roaming the area, vehicles appear to have been using the road; the road surface was relatively clear of grass and other vegetation on much of the portion that extends along the southern boundary.

SITE NO.: State: 14974 *(Figure A-4)* PHRI: 877-13
SITE TYPE: Complex (2 Features)
TOPOGRAPHY: Sloping pastureland with numerous trees.
VEGETATION: Tall grass, monkey pod, Christmas-berry tree, lantana and *koa-haole*.
CONDITION: Poor-fair
INTEGRITY: Altered
PROBABLE AGE: Historic
FUNCTIONAL INTERPRETATION: Agriculture
DESCRIPTION: The site complex consists of two terraces (Features A and B) located in the southeastern portion of the project area, c. 2.5 m north of wall Site 14973. The overall complex area measures c. 6.5 m by 6.5 m with heights ranging from 0.10-0.30 m. The long axis of each terrace is oriented seaward-inland rather than across the slope.

FEATURE A: Terrace
FUNCTION: Agriculture
DIMENSIONS: 2.30 m by 1.70 m by 0.30 m (approx.)
DESCRIPTION: Feature A is a rectangular cobble- and pebble-filled terrace constructed with one to two courses of stacked cobbles on the east side and confined by aligned boulders on the west. A c. 0.70 m section of the east side has collapsed; the remainder is faced.

FEATURE B: Terrace
FUNCTION: Agriculture
DIMENSIONS: 2.70 m by 1.80 m by 0.20 m (approx.)
DESCRIPTION: Feature B is a rectangular terrace constructed with one to two courses of stacked pahoehoe boulders and cobbles, faced on the east side.

SITE NO.: State: 14975 PHRI: 877-14
(Figures A-5 and A-6)
SITE TYPE: Complex (2 Features)
TOPOGRAPHY: Sloping pastureland and exposed outcrops.
VEGETATION: Tall grass, *kukui* and monkey pod.
CONDITION: Poor
INTEGRITY: Altered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Agriculture
DESCRIPTION: The overall complex area measures c. 33.0 m by 9.0 m, with heights ranging from 0.35-1.38 m. The site complex consists of two terraces (Features A and B) located within a *kukui* grove near the junction of walls, Site 14967 and Site 14973.

FEATURE A: Terrace
FUNCTION: Agriculture
DIMENSIONS: 10.00 m by 5.00 m by 1.38 m (approx.)

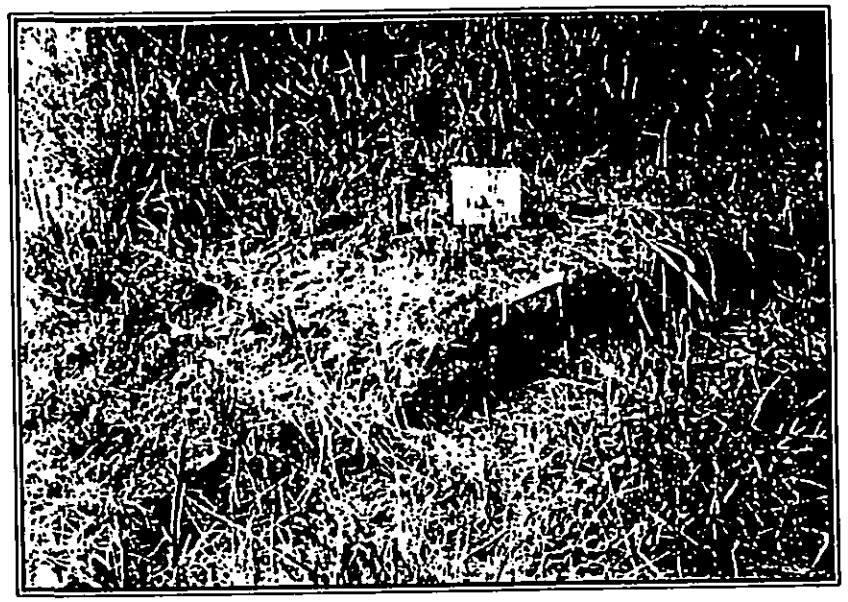

Figure 4. Site 14974 Terrace, View to West-Northwest (PHRI Neg. 1488-17)

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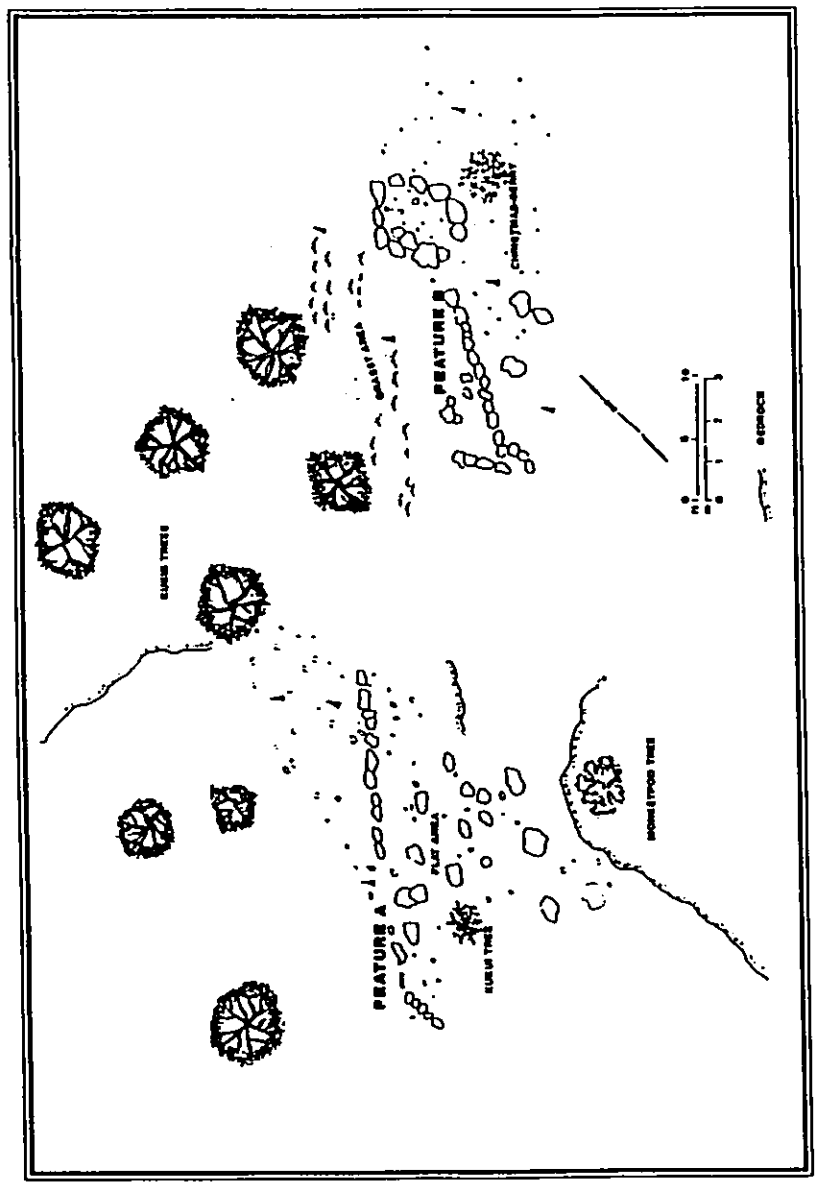

Figure A-5. Site 14975

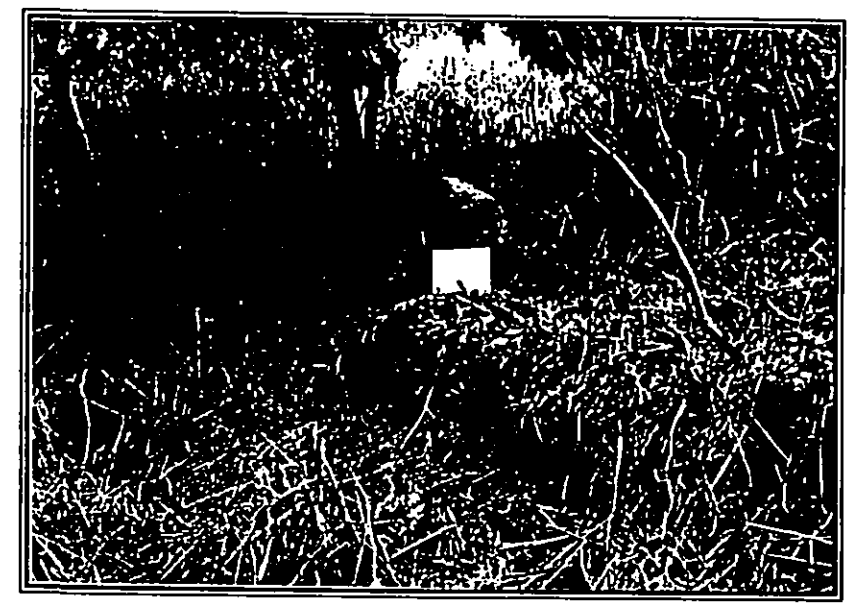

Figure A-6. Site 14975, View to Northwest (PHRI Neg. 1488-12)

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DESCRIPTION: The terrace has been constructed on a slightly sloping surface between two exposed bedrock outcrops. The level cobble-pebble fill abuts an exposed bedrock outcrop on the east and is confined by a boulder alignment on the west. Immediately west of the alignment, the terrace has an uneven, sloping, cobble surface.

FEATURE B: Terrace
FUNCTION: Agriculture
DIMENSIONS: 8.50 m by 4.00 m by 0.35-0.88 m (approx.)
DESCRIPTION: Feature B is a slightly sloping, cobble and soil terrace with boulders aligned along the west side. The north end of the terrace has been disturbed, possibly by cattle movement through the site.

SITE NO.: State: 14976 **PHRI:** 877-16
SITE TYPE: Terrace
TOPOGRAPHY: Sloping pastureland, exposed outcrops, and gullies.
VEGETATION: Tall grass, monkey pod, papaya, lantana, *'opiuma* and *koa-haole*.
CONDITION: Fair
INTEGRITY: Altered
PROBABLE AGE: Historic
FUNCTIONAL INTERPRETATION: Agriculture
DIMENSIONS: 4.00 m by 3.00 m by 0.42-1.00 m height (approx.)
DESCRIPTION: The terrace is constructed of piled pahoehoe boulders, cobbles, and pebbles. It is elevated on the south and east sides and blends into the hillside below The Pineapple Road to the north. This terrace may have been an agricultural loading dock for the pineapple operation.

SITE NO.: State: 14977 *(Figure A-7)* **PHRI:** 877-17
SITE TYPE: Road
TOPOGRAPHY: Sloping grassland with occasional bedrock outcropping.
VEGETATION: Tall grass, monkey pod and *koa-haole*.
CONDITION: Fair-good
INTEGRITY: Altered
PROBABLE AGE: Historic
FUNCTIONAL INTERPRETATION: Transportation
DIMENSIONS: 7.00+ m by 5.50 m by 0.80-1.39 m (approx.)
DESCRIPTION: This site is an elevated road bed paralleling the east boundary and crossing a small portion of the project area south of PHRI Site 14973. The road intersects the Pineapple Road, forming a U-shape with the east arm extending south beyond the project boundary for an undetermined distance. The faced roadbed retaining wall is constructed of irregularly shaped cobbles stacked five to six courses high. The roadbed is discontinuous, sloping on the west side, and has no formal facing. This section has apparently been bulldozed; bulldozer scars are visible on the pahoehoe outcrops nearby, and push-piles are located near the base of the roadbed.

SITE NO.: State: 14978 *(Figure A-8)* **PHRI:** 877-21
SITE TYPE: Wall
TOPOGRAPHY: Sloping pastureland, occasional outcrops, gullies and ridges.
VEGETATION: Tall grass, *koa-haole*, monkey pod, lantana.
CONDITION: Good
INTEGRITY: Altered
PROBABLE AGE: Historic
FUNCTIONAL INTERPRETATION: Boundary
DIMENSIONS: 107.00+ m by 0.70-1.10 m by 1.30 m (approx.)
DESCRIPTION: Oriented at c. 194° to 210°, the wall forms the east project area boundary and continues for an undetermined distance northeast and southwest of the project area. The wall is constructed of five to eight courses of stacked, angular and subangular, pahoehoe boulders and cobbles. It is formally faced and has cobble and pebble core-fill. Wooden or steel fence posts are embedded atop the wall with 1/4" metal wire (2-3 strands) extending between the wooden posts.

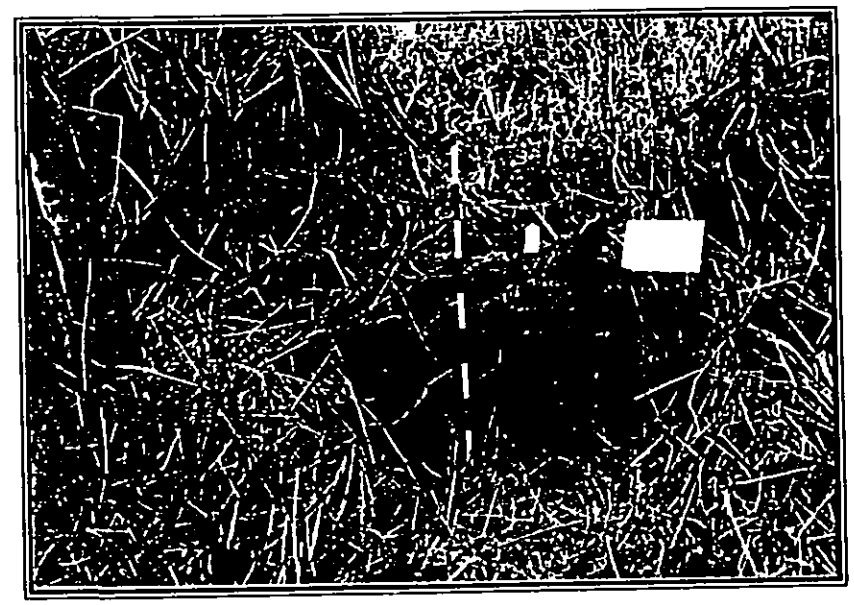

Figure A-7. Site 14977 (Roadbed), View to North (PHRI Neg. 1490-6)

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Figure A-8. Site 14978 Wall, View to East (PIIRI Neg. 1488-3)

APPENDIX B

HISTORICAL DOCUMENTARY RESEARCH
by Lehua Kalima, B.A.

The *ahupua'a* of Kealakekua in the South Kona district is bordered on the south by Kiloa and the north by Ka'awaloa. There are many historical documents from this area, because it was the site of Captain Cook's arrival in 1779 and one of the areas frequently visited by foreign ships *(Figure B-1)*. Although the project site is located above the *pali* in Kealakekua this report also includes the more well-documented coastal area of Kealakekua Bay.

In *Place Names of Hawaii*, Puku'i, Elbert and Mo'okini (1974) define the name Kealakekua as "pathway [of] the god." They explain that there were many *heiau* on the road from Kealakekua to Kailua. Thrum (1920) listed 40. It was believed that a god slid down a cliff there, leaving an imprint, and that the gods often slid there in order to cross the bay quickly.

KEALAKEKUA IN LEGEND

In the Myths and legends of Hawai'i, Kealakekua is mentioned as the home of Lono, the God of Agriculture, and the inventor of the Makahiki Festival. The Makahiki period traditionally began with the rising of the group of stars known as the Pleiades, about the middle of October, and continued until about January. This season was dedicated to the god Lono, and worship of the god Ku (the god of war) was ended. Thus no wars were allowed at this time of peace. Fishing tabus were set up and the crops being already planted, needed little tending. There were games and festivals, and the people payed taxes to their *ali'i*. Even with the taxes due, it was a happy season. Martha Beckwith, an ethnographer and translator of folklore in the Pacific and Caribbean, gives an account of the origin of the Makahiki festival:

> Lono sends out two of his brothers as messengers to find him a wife on earth. They travel from island to island and finally in the Waipi'o valley on Hawaii beside the falls of Hi'ilawe they find the beautiful Ka-iki-lani dwelling in a breadfruit grove companioned by birds. Lono descends on a rainbow and makes her his wife and she becomes a goddess under the name of Kaiki-lani-ali'i-o-Puna. They live at Ke-ala-ke-akua and delight in the sport of surfing. A chief of earth makes love to her and Lono hears him singing a wooing song. He is angry and beats her to death, but not before she has assured him of her innocence and her love for him. Lono then institutes the Makahiki games in her honor and travels about the island like a madman challenging every man he meets to a wrestling match. He builds a canoe such as mortal eyes have never seen since, with a mast of ohia wood and a sail woven of Ni'ihau matting and cordage twisted from the coconuts of Keauhou. The people bring heaps of provisions and pile them up before him. Forty men bear the canoe to the launching place, but Lono sails forth alone. His words of promise to the people are that he will return to them, not by canoe but on as island shaded by trees, covered over by coconuts, swarming with fowl and swine (Beckwith 1970:36).

Perhaps this is the reason that the people in Kealakekua mistook Captain Cook for Lono when he arrived in Kealakekua Bay. His ship, bigger than any they've seen before, and its mast, could have been interpreted as an island with large trees. Because of this error, Cook was treated like a god.

Beckwith explains another prominent figure in Hawaiian folklore:

> "The legend of 'Umi is one of the most popular of all Hawaiian prose sagas of heroes, embellished as it is with many stock episodes but still preserving the thread of historical accuracy..." (Beckwith 1970:391).

Keawe-nui-a Umi, was the son of 'Umi and in this following passage the story of Lono-i-ka-makahiki, Keawa-nui-a-Umi's son, is told, some of the incidents of which historians say belong to namesakes:

> Lono-i-ka-makahiki is a younger son of Keaw-nui-a-Umi by his wife Haokalani. Reared at Napo'opo'o near Kealakekua in Kona district by his father's two prophets Haunu and Loli, he early becomes expert in the arts of war and of wrestling and learns to respect his father's gods. The old soothsayer Ka-wa'a-maukele at Kanokapa teaches him the art of competitive word play (ho'opa'apa'a) so that he is soon able to outwit all his comrades.

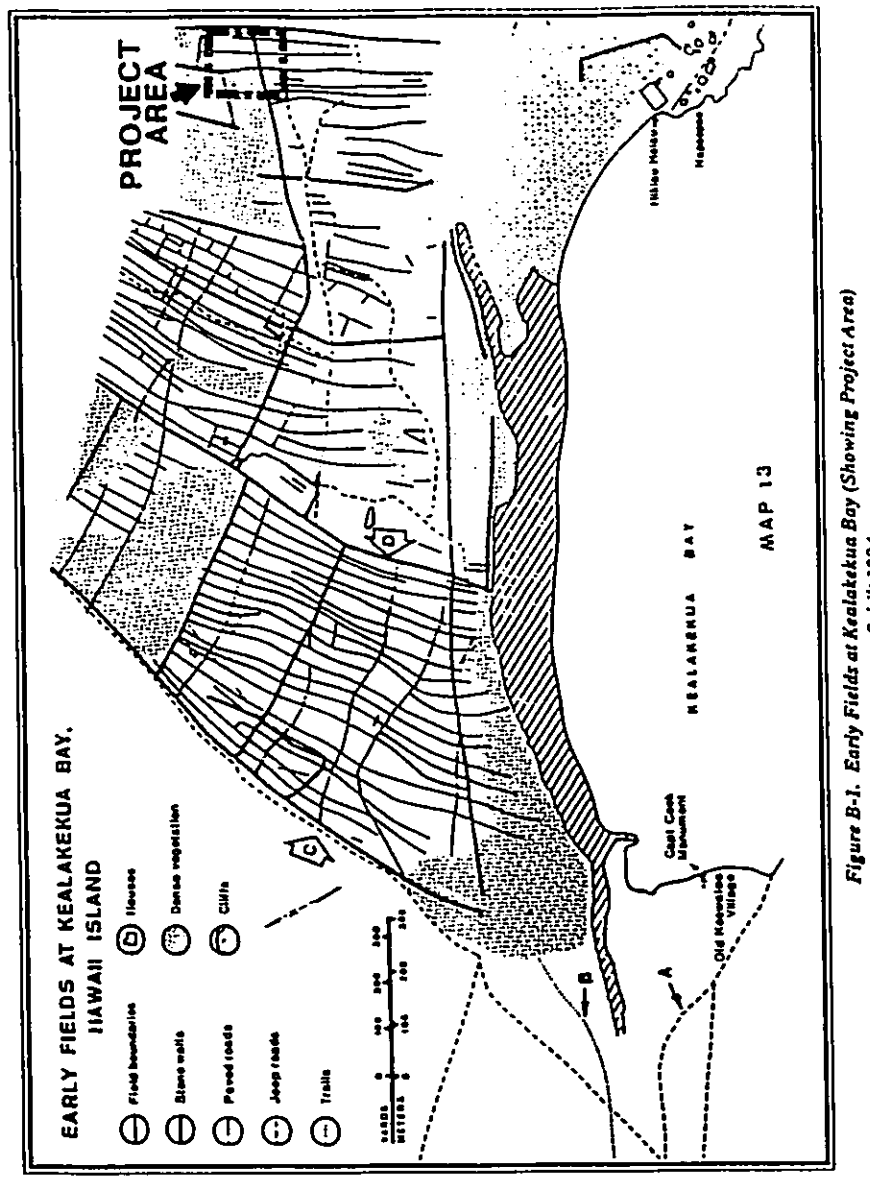

Figure B-1. Early Fields at Kealakekua Bay (Showing Project Area)
Schilt 1984

> At the death of his father, Kaiki-lani-wahine-ali'i-o-Puna (The little heavenly chiefess of Puna), daughter of Keawe-nui's older brother, becomes the legitimate heir. Lono's older half-brother Kanaloa-kuaana is her husband. He tests Lono's skill by hurling forty spears at him at once, all of which Lono dodges. He therefore gives Kaikilani to Lono and the two rule the land (Beckwith 1970:392).

This story goes on to say that Lono later accuses his wife of infidelity and kills her, he then wanders about winning a succession of contests with his skill at word play and quickness of memory. The story is very similar to the previous one, and the two may have been confused, due to the similarity in names and events, but they are from two separate eras (ibid.).

John Papa I'i, a native historian and a member of the court of Kamehameha II, refers to Kealakekua in this tale of Keaweopala, son of Alapa'i, and his battle against Kalani'opu'u. At the time of his death, Alapa'i had left the kingdom to Kamehameha, who he favored:

> Kalaniopuu, hearing of the death of Alapai, went to Waiea, South Kona. When news of his arrival reached Kawaihae, Keaweopala marched with a procession to Kona and remained at Kauluwai in upper Kealakekua, where he encamped with his multitude in warlike display. Kalaniopuu heard of this and moved on to either Honaunau or Keei. The ensuing battle, fought at Kepulu in the upland of Kahaulea at Napoopoo, was won by Keaweopala. All of the young victims of the battle were borne up to Kauluwai, where Keaweopala was staying with the young Kamehameha. When all of the dead had been transported, Keaweopala sacrificed the bodies. He did not leave this work to Kamehameha, the person to whom the kingdom properly belonged, hence Kamehameha's mother commanded Kamehameha to go to Kalaniopuu and give him the right to offer human sacrifices. Kalaniopuu had not the right to do this before (I'i 1959:4).

Kamehameha then went to see Kalani'opu'u, his uncle, and gave him the right to perform human sacrifice, which in essence was his way of giving him the kingdom, and thus Kalani'opu'u became the ruler of the island.

EARLY HISTORICAL ACCOUNTS

Kealakekua and Ka'awaloa were known to be the home of many important chiefs including Kalani'opu'u, king of the island and uncle of Kamehameha I, Kekuaokalani and Manono a chief and chiefess who were killed in the famous battle of Kuamo'o, and Chief Naihe and his wife, chiefess Kapi'olani. Of course the area is best known as the site of the arrival and death of Captain Cook in 1779:

> Nothing of special note happened until the afternoon of the thirteenth when a watering party on shore from one of the ships had some kind of altercation with the natives. At nearly the same time, a native on board the Discovery daringly seized a pair of tongs and a chisel from the blacksmith's forge and made his escape in a canoe that lay alongside the ship. Shots were fired after him and he was pursued by one of the ship's boats. The stolen goods were restored, but the thief escaped and the officer in charge of the ship's boat attempted- unwisely, it would seem— to seize the canoe. This led to a scuffle on the beach in which a chief named Palea was struck on the head with an oar and the boat's crew was rather roughly handled by the natives. As it happened, the canoe belonged to Palea, but it appears also that it was he who caused the tongs and chisel to be restored.
>
> On the following morning it was found that the Discovery's large cutter had been stolen during the night. Afterwards it was reported, on good authority, that the cutter was taken by some of Palea's people as a reprisal for the indignity he had suffered; but it is uncertain whether Palea himself was the instigator of the deed. Captain Clerke being unwell, Captain Cook assumed direction of the effort to recover the stolen cutter. He first placed a cordon of boats to guard the entrance of the bay and then went in a pinnace with Lieutenant Phillips and a squad of nine marines to the village of Kaawaloa where King Kalaniopuu was residing; he was accompanied by a launch and a small cutter, both under command of Lieutenant Williamson. Cook's plan was to get the king on board the Resolution and keep him there until the stolen boat was returned— a plan that had been effective under similar circumstances in the south Pacific...
>
> Cook landed with Lieutenant Phillips and the marines and marched to the house where the king was staying. The latter came out and after a short conversation with him Cook became satisfied that he was entirely innocent of what had happened. Kalaniopuu readily consented to go with Captain Cook and they started to walk down toward the shore. The king's youngest son, a boy of perhaps

twelve years, ran on ahead and climbed into the pinnace. Before the king reached the shore, his wife Kanekapolei and several chiefs surrounded him and begged him not to go farther; he stopped and sat down. The suspicions of the Hawaiians had evidently been aroused, as well they might be. Lono, if indeed this was Lono, had never before come to visit the king in this fashion — armed, supported by an escort of soldiers, and with a concerted and apparently hostile movement of armed boats from the two ships. In the meanwhile, a great crowd had gathered about, many of the natives being armed with daggers, clubs, spears, and stones. While the king was hesitating, news came that a chief crossing the bay in a canoe had been killed by a shot from one of the foreign boats. This caused an angry reaction among the people and some of the bolder ones began to make threatening motions toward Cook and the squad of marines.

Captain Cook gave up the attempt to take the king on board, and directed his efforts to getting the marines and himself safely into the boats. The marines withdrew to the waterside and formed in line on the rocks. One of the natives made a pass at Cook with a dagger and Cook replied by firing one barrel of his gun, either a blank or a charge of small shot, which apparently did no damage and only served to embolden the Hawaiians. The king's son became alarmed at the ominous change in the situation and was allowed to return on shore. Cook fired the other barrel of his gun, loaded with ball, and killed a man. Lieutenant Phillips also fired and the marines on shore and the sailors in the boats began firing. Cook turned, ordered the boats to cease firing and come in close, and then started toward the water. By this time a general melee was in progress; Cook was knocked down with a club and as he tried to get up was struck in the back with a dagger and fell into the water; it is uncertain whether he drowned or died of his wounds. Four of the marines were killed; the others managed to swim off to the pinnace. The Hawaiians carried away the bodies of Cook and the four marines; Cook's body was treated like that of a high chief (Kuykendall 1968:18-19).

John Ledyard, a companion of Cook aboard the Discovery, wrote a journal two years after the voyage, in which he described Ka'awaloa as a place of 300 houses and "about half as large as Kealakekua." In the days that followed Captain Cook's death, there was continuing harassment between the British and Hawaiians. The Hawaiians attacked the shore parties that tried to get water, and the shore parties retaliated by setting fire to the houses near the well, but they burned down more of the village than they intended (Silverman 1968).

Ledyard described the village of Kealakekua:

> The town of Kireekakoos is about a mile and a half in length, but narrow and of an unequal breadth, and as I have before observed contains about 1100 houses, some reckon 1300 including some detached buildings. It is situate along the shore within a few rods of the water, and is in general very compact, and as the houses in those places stand so as to create a breadth there are a number of little streets that intersect each other very happily though they do not seem to have been the effects of much design, and a very agreeable and uncommon circumstance to be found among these rude sons of nature, was, that these little avenues were generally paved. The houses here differ altogether from those to the southward in their form, though not much in other respects. They are exactly like a tent, the frame is light and for the most part lashed together, except now and then where two large posts met, and there was a kind of a mortice, both the sides and the ends are thatched with coarse grass, and sometimes palm-tree-leaves. They have but one passage which is used both as a door and window: The inside of the house is without partitions above or below, the ground within being hard and dry is covered with thick coarse grass, dryed plantain and palm-tree-leaves, over which they spread large well-wrought mats, which makes the house cleanly, and gives it an air of elegance and comfort, and as they have no chairs, tables, beds and such kind of furniture there is room enough. They are of different magnitudes, but in general they are between 30 and 40 feet square: There are cocoanut and other trees interspersed artificially among the houses all over the town, and in about the middle of it there is a level course for running and other exercises, which is very beautifully skirted with trees from end to end, and is kept very clean. There are also in different places square elevated yards for bleaching and otherwise manufacturing their cloth. The Morai stands in the northwest part of the town opposite that part of the bay where our ships lay (Ledyard 1963:129).

These large settlements noted by early visitors were connected by a trail system over the top of the *pali*. An extensive agricultural system dominated the slopes above Pali Kapu O Keoua which is where the project site is located (*Figure B-2*). This agricultural productivity and abundant marine resources supported the large population to make Kealakekua "one of the major political and religious centers in Kona and in prehistoric Hawaii" (Yent and Ota 1981:4-5).

Handy and Handy (1972) describe the native Hawaiian agricultural system of this region:

> In the time of intensive native cultivation, South Kona was planted in zones determined by rainfall and moisture. Near the dry seacoast potatoes were grown in quantity, and coconuts where sand or soil among the lava near the shore favored their growth. Up to 1000 feet grew small bananas which rarely fruited, and poor cane; from 1000 to 2000 feet, breadfruit flourished (Handy and Handy 1972:524-525).

Above Ka'awaloa some of Cook's officers saw plantations. Cook (1784, Vol.3:106-107) says that their plantations were divided from each other by thick, low walls of lava and that there they found the breadfruit trees, plantains, taro root, sweet potatoes, ginger root, and sugar canes.

Rev. William Ellis, a surgeon with Captain Cook in 1778, wrote that the country above Kealakekua was covered in every direction with plantations of sugar-cane, sweet potatoes, taro, plantains, and breadfruit trees. He also came across innumerable plantations of the paper mulberry tree, breadfruit, and plantain trees which formed an extensive garden (Handy and Handy 1972:525).

The same region is described in detail by Archibald Menzies, a surgeon and naturalist who accompanied Vancouver in 1793:

> The tract which extended along shore, if we might judge from its appearance and our knowledge of that which we had already traveled over, we were ready to pronounce a dreary naked barren waste, if we except a few groves of cocoa palms here and there near the villages. But that which stretched higher up along the verge of the woods from the manner it was industriously laid out in little fields, exhibited a more pleasing and fertile appearance...On leaving this station, we soon lost sight of the vessels, and entered their breadfruit plantations, the trees of which were a good distance apart, so as to give room to their boughs to spread out vigorously on all sides, which was not the case in the crowded groves of Tahiti, where we found them always planted on the plains along the sea side. But here the size of the trees, the luxuriancy of their crop and foliage, sufficiently show that they thrive equally well on an elevated situation. The space between these trees did not lay idle. It was chiefly planted with sweet potatoes and rows of cloth plant. As we advanced beyond the bread-fruit plantations, the country became more and more fertile, being in a high state of cultivation. For several miles round us there was not a spot that would admit of it but what was with great labor and industry cleared of the loose stones and planted with esculent roots or some useful vegetable or other. In clearing the ground, the stones are heaped up in ridges between the little fields and planted on each side, either with a row of sugar cane or the sweet [*ti*] root of these islands (Dracena...) where they afterwards continue to grow in a wild state, so that even these stony, uncultivated banks are by this means made useful to the proprietors, as well as ornamental to the fields they intersect.
>
> The produce of these plantations, besides the above mentioned, are the [*wauke*] cloth plant...taro and sweet potatoes (Menzies 1920:74-76).

These plantations were a part of what is now known as the "Kona Field System." T. Stell Newman researched these fields and concluded that the Kona Field System (*Figure B-3* and Table 4) was the most extensive and monumental work of ancient Hawaii. Newman suggested, and the data verifies, that this system continued northward from Kealakekua to include the back of Kailua town and somewhat beyond. He estimated the size of the cultivated lands as approximately 3 miles wide by 18 miles long (Kelly 1983:73). Newman's reconstruction for the 1778-1823 period and Kelly's research leave no doubt that the Kona Field System continued to function until the Great Mahele, in mid-1800's.

Additional evidence for the existence of this field system was furnished by earlier visitors to the Kona area. In addition to Menzies, an earlier visitor, John Ledyard, wrote his journal of the trip into the uplands back of Kealakekua Bay and northward toward Kailua. Heading northeast from Kealakekua Bay in 1779, Ledyard described the land as a plain of little enclosures separated from each other by low broad walls. He noticed that most of these fields were planted with sweet potatoes and suggested that these might

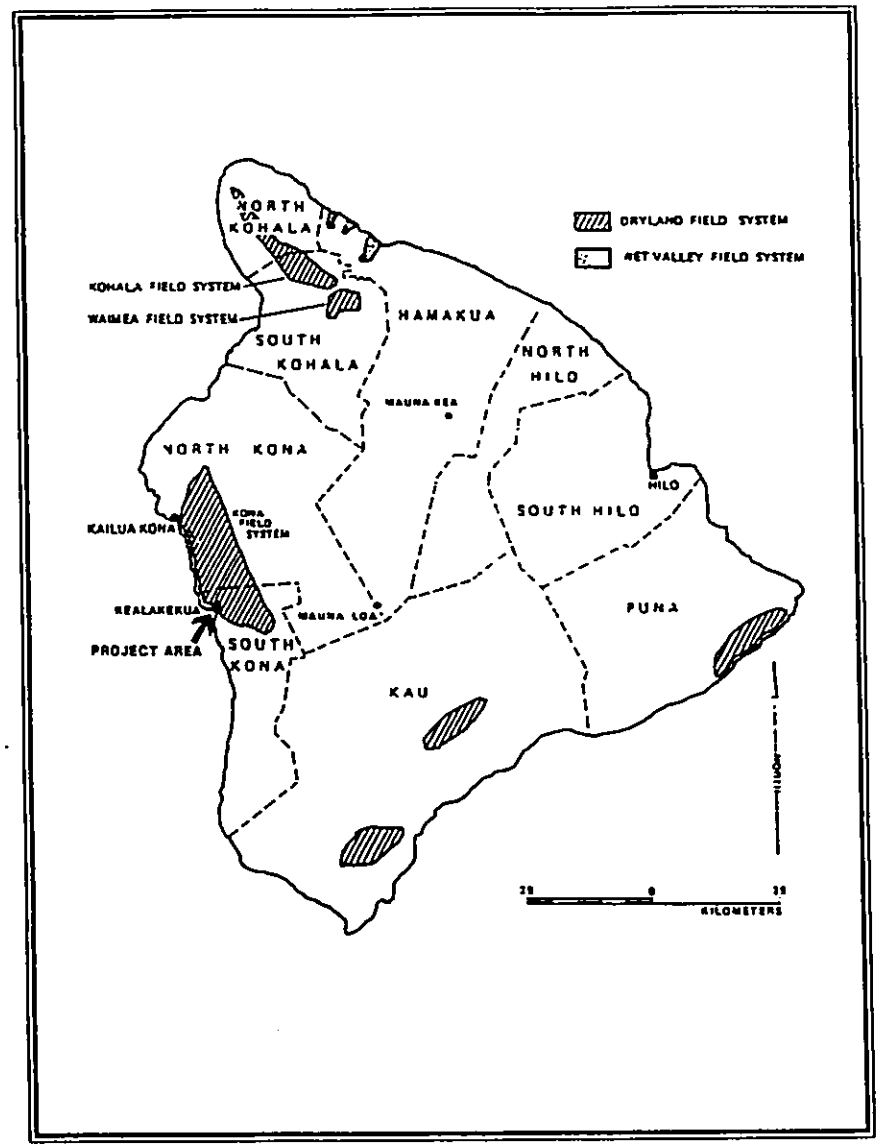

Figure B-2. Map of Hawai'i Island Showing Major Dryland Field Systems (From Schilt 1984)

Table 1-36

MAJOR FIELD SYSTEMS OF LEEWARD HAWAI'I ISLAND*

Field System/ Primary Crops	Elevation/ Rainfall/ Temperature**	Approx. Area/ Distance from Sea	Characteristics	Sources
Kohala/ sweet potatoes; taro.	c. 300-3,000 ft. (91-914 m)/ 20-50 in. (510-1,270 mm)/ 60-80°F	c. 23 mi.^{2} (60 km^2)/ c. 0.25-6.00 mi. (0.4-9.6 km) Varies from northern to southern extent.	No perennial streams; no flood problem areas. Various kinds of agricultural features, predominated by low-piled stone and soil ridges (*kuafu'*) defining rectangular fields, and including stone mounds, alignments, garden enclosures, modified outcrops, low terraces. Some gulch terracing; knoll top gardens. *Kuafu'* parallel the coast. Coastal settlement as early as c. A.D. 1300, with upland gardens beginning by c. A.D. 1400. Upland residential features date in calibrated range of c. A.D. 1420-historic times (Klein et al. 1982, applied to Rosendahl 1972:428-29).	Newman 1970b; Rosendahl 1972; Tuggle and Griffin 1973; Smith and Schilt 1973.
Waimea/ sweet potatoes; taro.	c. 2,000-2,800 ft. (609-853 m)/ 25-69 in. (600-1,750 mm)/ 50-80°F	c. 8 mi.^{2} (20.7 km^2)/ c. 8-14 mi. (5.0-8.7 km)	Two perennial streams; few flood problem areas. Widest variety of field types, including: *'ōmaa'* and pondfields; supplemental or as-needed irrigation; dryland units; retaining ridges of stone and/or soil; stone mounds; planting swales; modified outcrops. Coastal and upland settlements begin at the same time, c. past A.D. 1300. Major field developments, post A.D. 1700, with dispersed residential complexes; house sites on knolls.	Clark 1981; Clark 1983a,b; Keene 1983; HLMR 1970.
Kona/ sweet potatoes; taro; breadfruit.	c. 150-2,500 ft. (46-762 m)/ 31-79 in. (800-2,000 mm)/ 60-85°F	c. 54 mi.^{2} (140 km^2)/ c. 0.5-3.5 mi. (0.8-5.6 km)	No perennial streams; flood problem areas present. Various combinations of features probably typify the *kuafu*, *kaiuulu*, and *'āpa'a* subzones including *kuafu'*, stone mounds, retaining terraces, modified outcrops. Some preference for swales on the *kuafu*. *Kuafu'* are perpendicular to the coast. Coastal settlement, as early as c. A.D. 1050, with upland gardens beginning by c. A.D. 1400. Major field developments post A.D. 1600; Ellis mentions dispersed residences in uplands.	Ellis 1979; Newman 1970b; Kelly 1983; Yen 1978; this report.

*See Figure 1.1.
**Range of annual monthly means, minimum to maximum.

Table B-1.

Major Field Systems of Leeward Hawai'Island, Clark and Kirch 1983

be the principal object of their agriculture. He also noted many breadfruit forests, and patches of sugar cane along the plains of Kona up to about 3 miles from Kailua town (ibid:71-72).

ARCHAEOLOGICAL SITES

Numerous archaeological remains have been identified at Kealakekua. Soehren and Newman (1968) prepared a base map that showed the extent of the Kona Field System boundaries and they did field work the check the map. In the course of the field work they discovered 15 discrete sites and complexes (Rosendahl 1986:4).

Stokes identified a few *heiau* in the Kealakekua area:

> *Heiau of Paikapahu*, land of Kealakekua, South Kona; east of the upper government road and 122 feet south of the Kaawaloa boundary. Plan H.25. Tape measurements. A somewhat significant structure combining platform and enclosure, with the longer axis running north and south. No history.
>
> *Heiau of Hikiau*, land of Kealakekua, South Kona; washed by the sea; at the juncture of Kealakekua beach with the lava flow on the south: Government secondary called Hikiau on western edge of the present pile Plan H.26 *(Figure B-4)*.
>
> All that remains of this heiau that can be called ancient in fact is the east retaining wall, part of the south retaining wall, and a small platform, 3 feet higher than the surface of the large pile. The greater part of the heiau had been built on the northern edge of an aa flow traveling westward....As the present form did not correspond with the description of Captain King nor the illustration of Surgeon William Ellis, the account was credited and the measurements confined to the features said to be old. However, by a later reference to Lisiansky, it was learned that the heiau was again in operation at the time of his visit (about 1801) and had been rearranged in a manner different to the time of Cook. In 1782 Kamehameha had war services at Kealakekua; probably at Hikiau. In Cook's time the small platform supported the Lana-nuu-mamao, and the lele and idols were in front of it (to the west), in accordance with Malo's description of heiau arrangements. In 1864 W.T.R. visited the heiau, found it little disturbed, except where the road cut through the western end and saw on the platform a number of human bones, mostly femora. Again in 1890 he camped on the point opposite the landing place, and made a number of visits to the ruins. At that time no bones were seen, but a grass house was there and occupied. Since that date "restorians" have reduced it to a mere pile of stones of little antiquarian interest; a lumber yard occupies the place of Cook and Vancouver's observatory.
>
> In trying to locate the sites of Hale o Lono, priest's houses, etc. described by Captain King, only one could be found, a house platform at the north-east corner of the pool. This was said to have been the house of Hewahewa the high priest. One feature which is still in place is a heav— boundar— wall on the east and north-east. On a broadening of the wall in the middle of the east portion is the site of the Hale Pea or Hale o Papa.
>
> *The heiau of Helehelekalani*, so called, is shown on the same plan (H.26). The tradition connected with this place is that Opukahaia (one of the first company of Hawaiian youths who came to New England and proved the basis of the great Mission to the Islands) studied for the pagan priesthood here (Stokes 1919:27-29).

Of these *heiau*, Hikiau is perhaps the most famous as the site where Capt. Cook was received by the Hawaiians and honored as the god Lono.

In the cliffs next to Kealakekua several of the many burial caves for which the Pali Kapu o Keoua was famous can be seen. Many of the remains of the Kona chiefs were taken here from the Hale o Keawe *heiau* at Honaunau by Queen Kaahumanu in 1828 or 1829. Later the remains were moved to Honolulu and reinterred in the burial plot in front of Iolani Palace. When the Royal Mausoleum was completed in 1865, they were transferred there, where they remain today (Soehren 1968:7).

THE GREAT MAHELE

In 1848, during the reign of Kamehameha III, the traditional Hawaiian land ownership system was replaced with a Western-style system. This radical restructuring was called The Great Mahele (division). The Great Mahele separated and defined the undivided land interests of the King and the high-ranking chiefs, and the *konohiki*, who were originally those in charge of tracts of land on behalf of the king or a chief (Chinen 1958:vii and Chinen 1961:13). More than 240 of the highest-ranking chiefs and *konohiki* in the kingdom joined Kamehameha III in this division. The

first Mahele was signed on Jan. 27, 1848 by Kamehameha III and Princess Victoria Kamamalu, and by her guardians Matuio Kekuanaoa and Ione Ii. The last Mahele was signed by the King and E. Enoka on March 7, 1848 (Chinen 1958:16).

The Mahele did not convey title to any land. The chiefs and *konohiki* were required to present their claims to The Land Commission to receive awards for lands quitclaimed to them by Kamehameha III. They were also required to pay commutations to the government in order to receive royal patents on their awards. Until an award was issued, title remained with the government. The lands awarded to the chiefs and *konohiki* became known as Konohiki Lands. Because there were few surveyors in Hawaii at the time of the Mahele, the lands were identified by name only, with the understanding that the ancient boundaries would prevail until the land could be surveyed. This expedited the work of the Land Commission and speeded the transfers (Chinen 1961:13).

During this process all land was placed in one of three categories: Crown Lands (for the occupant of the throne), Government Lands, and Konohiki Lands. These were all "subject to the rights of native tenants," (Laws of Hawaii, 1848:22). Native tenants were the common Hawaiian people who lived on the land and worked it for their subsistence. Questions concerning the nature of their rights to the land began to arise as the King, the government, and *konohiki* began selling parcels of land. On December 21, 1849 the Privy Council attempted to clarify the situation by adopting four resolutions intended to protect the rights of native tenants referred to in the 1848 law (Chinen 1958:29).

These resolutions authorized the Land Commission to award fee simple title to all native tenants who occupied and improved any portion of Crown, Government, or Konohiki lands. These awards were to be free of commutation except for house lots located in the districts of Honolulu, Lahaina, and Hilo (ibid.).

Before receiving their awards from the Land Commission, the native tenants were required to prove that they cultivated the land for a living. They were not permitted to acquire wastelands or lands which they cultivated "with the seeming intention of enlarging their lots." Once a claim was confirmed, a survey was required before the Land Commission was authorized to issue any award. These lands became known as "Kuleana Lands" (ibid:30). Until its dissolution on March 31, 1855, the Land Commission issued thousands of awards to the native tenants for their *kuleana*; even so, less than 30,000 acres of land were awarded to the native tenants as Kuleana Lands.

In the Indices of Awards to Land Titles, the Harbor and Flat Lands of Kealakekua were listed as Government Lands (Board of Commissioners 1929). For the remaining lands there were only three awardees:

L.C.A.	AWARDEE	LAND AREA
387	*A.B.C.F.M.	30.39 Acres
7101	Ialua	0.80 Acres
8452	Keohokalole, A.	10,160.00 Acres

* *American Board of Commissioners for Foreign Missions*

The influential foreign missions were granted various parcels of land by the government and the *ali'i*.

Most of the missions were based in Honolulu, and from there they branched out to the outer islands. The Kealakekua mission was established in 1867 (Kuykendall 1953:97). When it was established, the Hawaiian people showed a great deal of interest in the services, and it was predicted that the mission would become very successful.

Foreign testimony from people of the mission describes some of the sites at Kealakekua and adjoining areas:

> at Kealakekua my dwelling house and garden is enclosed by a stone wall 72 fathoms long and 48 wide. Given by Kaniho Inauole, the owner. The church is also enclosed by a stone wall about 40 by 30 fathoms given by Kalushine the owner. The mission house at Kaawaloa is enclosed by a stone wall 60 fathoms long and 40 wide. This spot was presented by Naihe who then owned the land. There is also one land (ahupua'a) called Halekii, running from the sea back to the foot of the mountains: bounded on the north by the land called Kanaueue, on the south be the land called Keekee, this land was given by Kaahumanu to the mission at the time Mr. Ely resided at Kaawaloa. The spot where the meeting house at Kuapehua stands, was also given for that purpose by Kamakau, the owner, in exchange for the old building spot.
>
> C. Forbes

> Mission property situated at Kealakekua, now occupied by me, it lies about 3/4 of a mile from the sea shore and north of Mr. Forbes place of residence, from which it is separated by a highway. It extends to a pali or lodge of rocks on the east, to a grove of lauhalas on N.E. is enclosed by a wall on the west and partly on the north. It was given by Nihomauole the owner.
>
> M. Ives

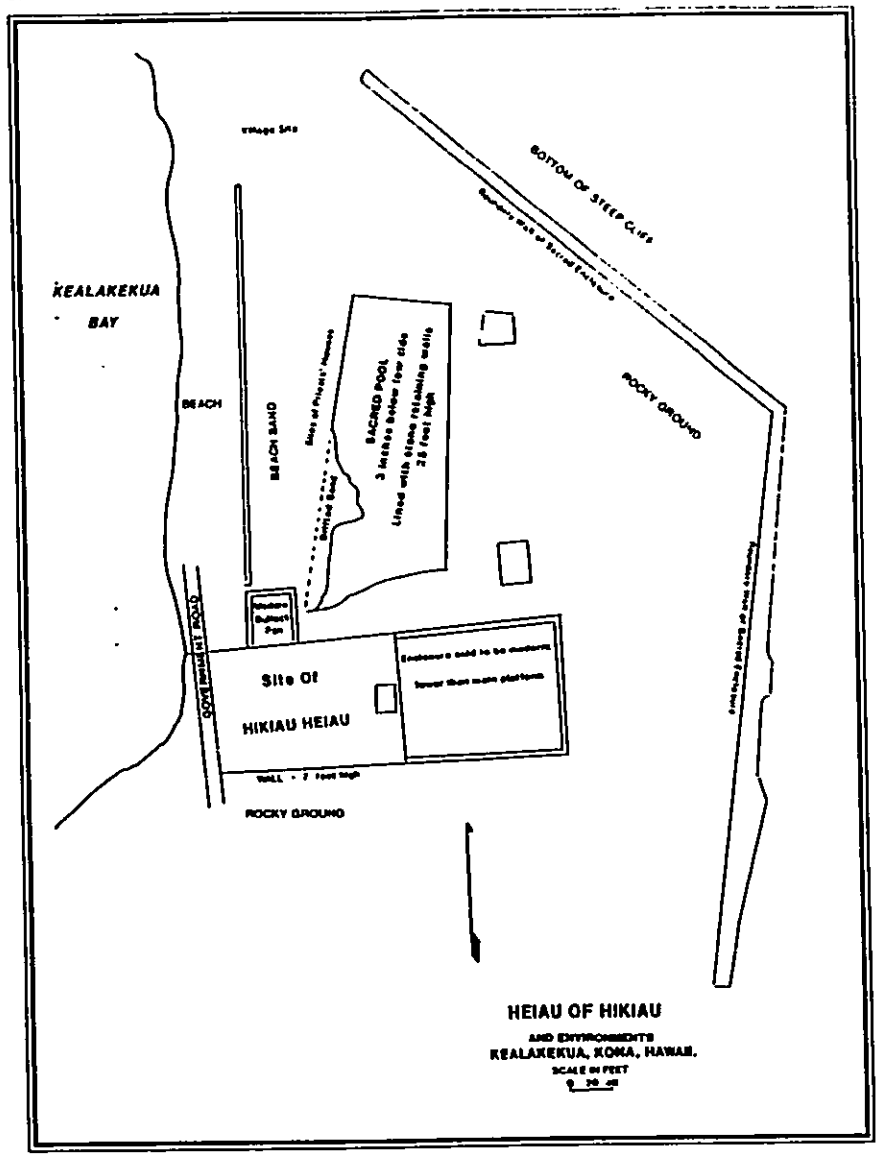

Figure B-3. Hikiau Heiau (Adapted from Stokes n.d.)

The survey of Kuapehu in Kealakekua describes a lot which was given to the mission by Kapiolani after Kaahumanus death with the consent of Gov. Adams. Kapiolani stated she got his consent with difficulty

The names given by Mr. Forbes and Mr. Ives are similar, and it is possible that they refer to the same person, Kanihoinauole or Nihomauole. The difficulties the *haoles* often had with the pronunciation of Hawaiian names occassionally led to such confusion in legal matters.

The project area consists of a portion of L.C.A. 8452, awarded to Chiefess Ane Keohokalole, the mother of King David Kalakaua and Queen Lili'uokalani. Much of the land in this area of Kealakekua and Ka'awaloa was her property. Because she was *ali'i* she did not have to give testimony for her lands, and there is no record of testimony by her for this area.

After 1850, cattle ranching increased in this area. It was probably during this time that the long stone walls in this area were built, in order to keep the cattle confined (Kashcko and Rosendahl 1987:6). Henry N. Greenwell acquired this property in 1881, and the land was returned to crops. In the early 1900s part of the land in Kealakekua was planted in pineapple. The "old pineapple road" (which is roughly where the present Urban District Boundary is) was made to transport the pineapple to the processing plant above Napo'opo'o. This plant eventually became the Captain Cook Coffee Company, and is now the Kona Farmers Cooperative coffee mill and macadamia nut factory (ibid.). The pineapple operation was given up after a few years and was eventually replaced by coffee. Records in the Real Property Tax office record coffee being grown on this particular parcel from 1956-1974. In 1974 it was listed as urban zoning and remains as such.

Records in the Real Property Tax office also indicate that the project area, identified as TMK 3-8-2-2:39, had been leased in 1983 to Polar Painting Ltd., a Canadian company. This land was acquired by the Royal Coast Development Corporation recently this year. According to Mr. Clifford Temps, of Royal Coast Development, the land was purchased to be a home site for the owners of Polar Painting, but the owner later changed his plans and sold it to Royal Coast.

This parcel being within the area designated as the "Kona Field System" is listed in the Hawaii Register of Historic Places (HRHP No. 10-37-6601). It has also been declared eligible for the National Register of Historic Places. This area also lies within the limits of the Kealakekua Bay Historic District (HRHP site No. 50-10-47-7000), which was placed on the National Register of Historic Places in December 1974 (ibid:5).

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Appendix 2:

ARCHAEOLOGICAL INVENTORY SURVEY, KEALAKEKUA BAY KAAWALOA PARCEL

Figure C-10. Site 14186, Steppingstone Trail, View to Southwest. (Neg.1475-10A)

Figure C-11. Site 14190, Feature C, TU-1, View to South. (Neg.1477-11)

Figure C-12. Site 14190, Feature C, TU-2, View to Northwest. (Neg.1477-12)

Figure C-6. Site 14180, Feature A, View to East-Southeast. (Neg.1475-11A)

Figure C-7. Site 14180, TU-1, View to Northeast. (Neg.1477-14)

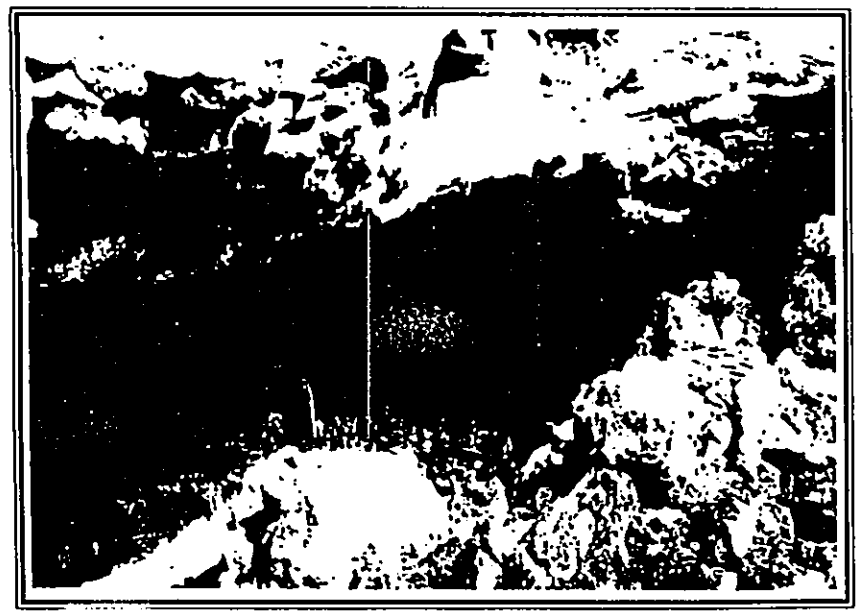

Figure C-8. Site 14181, Feature D, View to North. (Neg.1474-21)

Figure C-9. Site 14186, Trail Petroglyph, View to Southwest. (Neg.1475-9A)

Figure C-2. Site 14158, TU-1, View to North. (Neg.1478-10)

Figure C-3. Site 14160, TU-1, View to North. (Neg.1478-7)

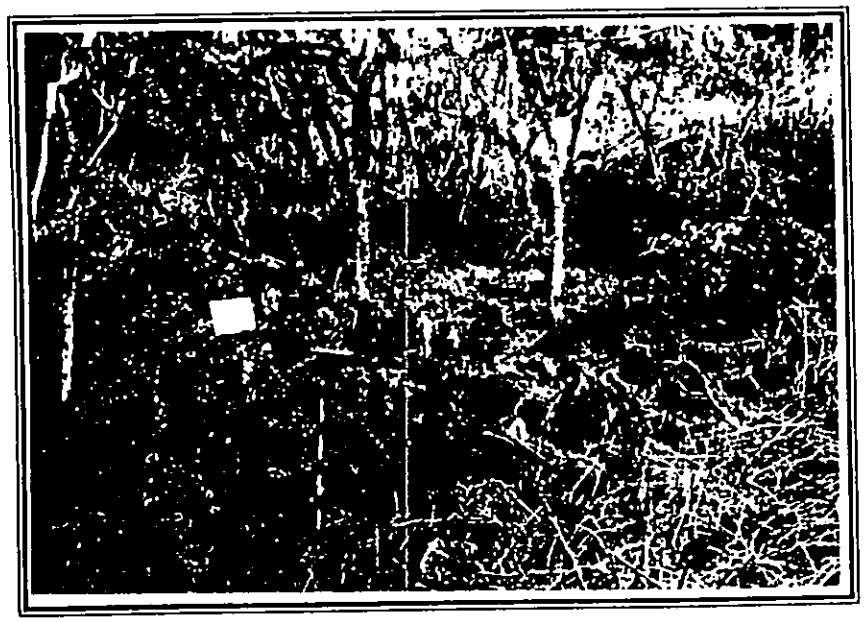

Figure C-4. Site 14167, Enclosure, View to West. (Neg.1475-28A)

Figure C-5. Site 14174, Terrace, View to North-Northwest. (Neg.1474-34)

In native testimony given by Ioba and Manoauwaa for LCA 9446 (ibid.), residents of Ka'awaloa, they swore that they had seen:

- 5 taro kihapais in section 1 of Keekeene ili of Kialaehu Kaawaloa from Naihe in 1819.

  18 taro and potato kihapais in section 2 of Haleolono Keopuka ahupuaa from Naihe in 1826.

  A lot in waipio ili in section 3 of Kaawaloa from Kapiolani in 1834.

  A house lot in Maieha in section 4 of Kaawaloa from Keohokalole in 1841.

  A house lot in section 5 of Niukukahi Kaawaloa ahupuaa from Naihe in 1820.

The project area is the property of the Paris Estate at this writing. A portion of the Paris Estate was sold to Mr. Chris Norrie, who resides in the area. He purchased his property four years ago and lives at about the 1000 ft elevation. In an interview, he noted that the area was cattle pasture and had never been used for anything else by foreign owners. He was surprised that the area had once been a highly productive agricultural area. In his opinion the absence of rain and the extreme heat would make agriculture very difficult. He speculated, however, that at one time the area may well have been highly productive, before the koa and sandalwood forests were stripped, because the forests may have captured the clouds at the higher elevations, producing more rainfall than is received today (pers. comm.).

The Kona Field System has been registered in the Hawaii Register of Historic Places (HRHP No. 10-37-6601) and has been declared eligible for the National Register of Historic Places. The project area also lies within the limits of the Kealakekua Bay Historic District (HRHP site No. 50-10-47-7000), which was placed on the National Register of Historic Places in December 1974 (ibid:5). A summary of the Kealakekua Bay Historic District states that it is "one of the most important historical and archaeological areas in Hawaii" and that "the bay offers a cultural continuity not found in other areas of the Hawaiian chain" (SHHP records, 10-47-7000 Kealakekua Bay Historic District).

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APPENDIX C

SELECTED PHOTOGRAPHS

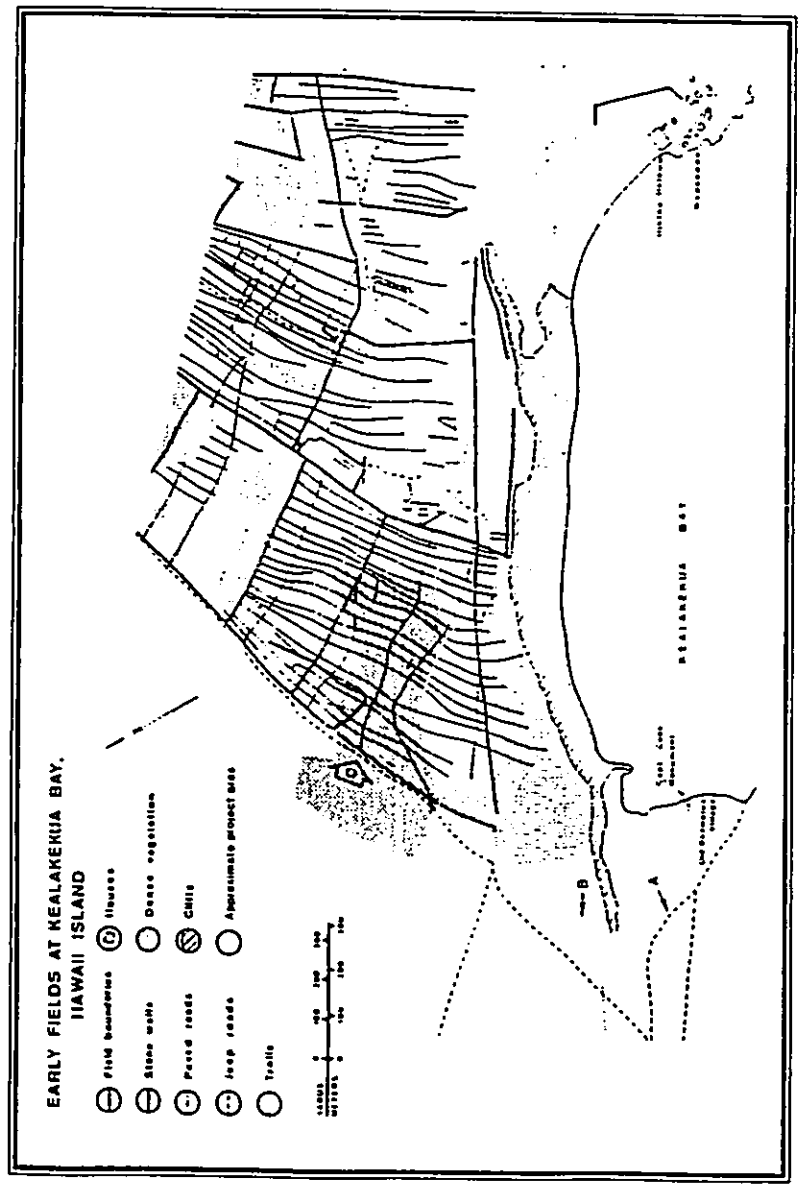

Figure B-2. Map Showing the Project Area and the Kona Field System Taken from Kelly (1983)

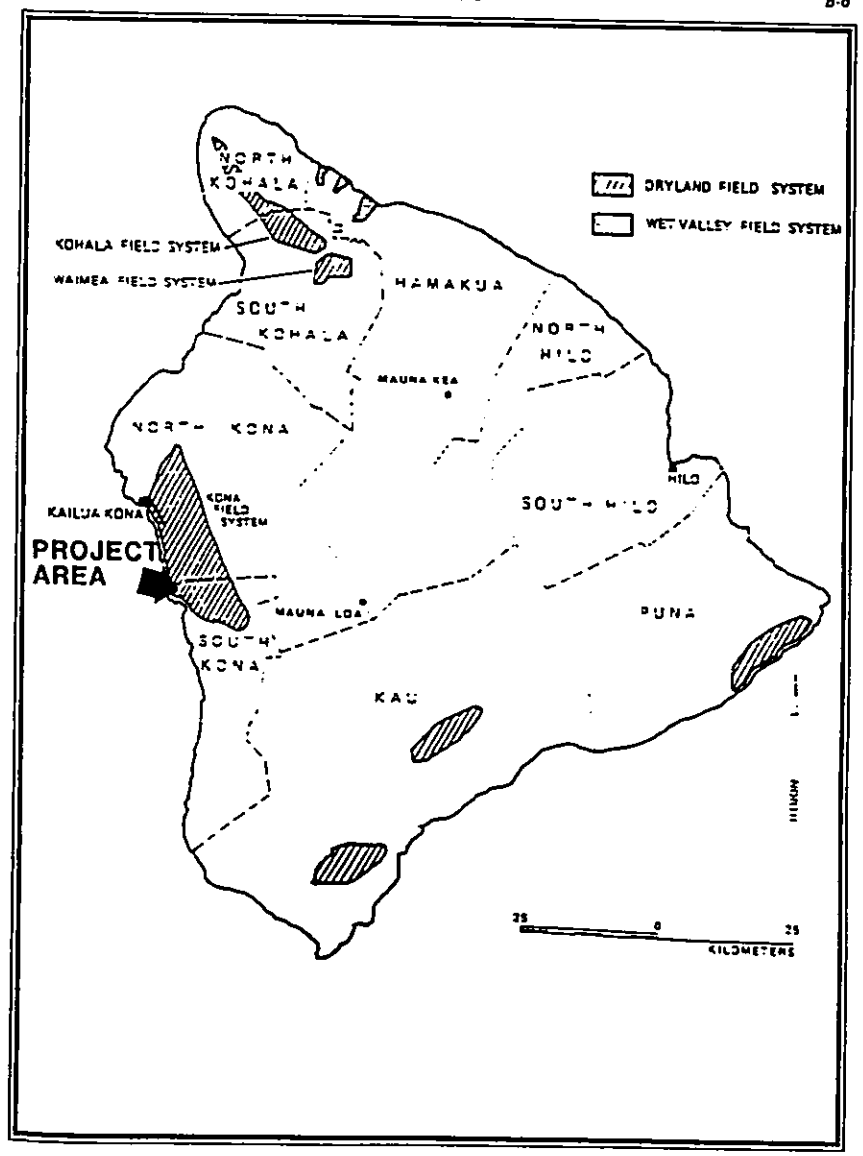

Figure B-3. Map of Hawai'i Island, Showing Project Area Location and Dryland Field Systems Taken from Schilt (1984:2)

Table 1.1a

MAJOR FIELD SYSTEMS OF LEEWARD HAWAI'I ISLAND

Field System/ Primary Crops	Elevation/ Rainfall/ Temperature**	Approx. Area/ Distance from Sea	Characteristics	Sources
Kukaio/ sweet potatoes; taro.	c. 300-5,000 ft. (91-911 m)/ 20-50 in. (510-1,270 mm)/ (in 80°F	c. 25 mi.² (60 km²)/ c. 0.25-6.00 mi. (0.4-9.6 km) Varies from southern to northern extent.	No perennial streams; one flood problem area. Various lands of agricultural features, prehistoric, natural by low pitched stone and soil ridges (kualiki) defining rectangular fields, and the lining stone mounds, alignments, gardens or terraces, modified outcrops, lava tubes. Some probably terracing, small lava gardens. Traces probably also exist.	Newman (1968); Rosendahl (1972); Ingalls and Griffin (1973, Smith and Schilt 1981)
Coastal settlement as early as c. A.D. 1400, with upland gardens beginning by c. A.D. 1500. Upland residential features date in estimated range of c. A.D. 1420 (Kaimiki, Tomo, Kikiola et al 1982, applied in Rosendahl 1972: 128-29).				
Waimea/ sweet potatoes; taro.	c. 2,000-2,900 ft. (609-853 m)/ 25-60 in. (600-1,500 mm)/ 50-80°F	c. 8 mi.² (20.7 km²)/ c. 8-11 mi. (5-10-6.7 km)	Two perennial streams; few flood problem areas. Modest variety of field types, including pondfield and pondfield; supplemented in wetland areas (Kamuela Lake), upland marsh, retaining ridges of stone and/or soil; stone mounds, planting terraces, small field outcrops.	Clark 1981, Kirch 1982a,b, Kirch 1983, Kirch et al 1986
Coastal and upland settlements begin at the same time, c. post A.D. 1500. Major field developments, post A.D. 1500, with dispersed residential complexes, house sites in fields.				
Kona/ sweet potatoes; taro; breadfruit.	c. 150-2,500 ft (46-762 m)/ 11-70 in. (280-2,000 mm)/ 80-85°F	c. 51 mi.² (130 km²)/ c. 11-5.5 mi. (18-8.8 km)	No perennial streams. Flood problem area present. Various traditional types of field systems including lava tubes, stone mounds, alignments, terraces, outcrops, some prehistoric irrigation, etc. Another site perpendicular to the coast. Coastal settlement, as early as c. A.D. 1400 with upland gardens beginning by c. A.D. 1500. Major field developments post A.D. 1500, with dispersed residences in upland.	Allen 1979, Newman 1968, Kirch 1982a, Kirch et al 1986

**Range of annual rainfall means, minimum to maximum

Table B-1. Major Field Systems of Leeward Hawai'i Island Taken from Clark and Kirch (1983:297)

More than 240 of the highest-ranking chiefs and *konohiki* in the kingdom joined Kamehameha III in this division. The first *mahele* was signed on January 27, 1848 by Kamehameha III and Princess Victoria Kamamalu, and by her guardians Mataio Kekuanaoa and Ione Ii. The last *mahele* was signed by the King and E. Enoka on March 7, 1848 (Chinen 1958:16).

The Mahele did not convey title to any land. The chiefs and *konohiki* were required to present their claims to The Land Commission to receive awards for lands quitclaimed to them by Kamehameha III. They were also required to pay commutations to the government in order to receive royal patents on their awards. Until an award was issued, title remained with the government. The lands awarded to the chiefs and *konohiki* became known as Konohiki Lands. Because there were few surveyors in Hawaii at the time of the Mahele, the lands were identified by name only, with the understanding that the ancient boundaries would prevail until the land could be surveyed. This expedited the work of the Land Commission and speeded the transfers (Chinen 1961:13).

During this process all land was placed in one of three categories: Crown Lands (for the occupant of the throne), Government Lands, and Konohiki Lands. These were all "subject to the rights of native tenants," (Laws of Hawaii, 1848:22). Native tenants were the common Hawaiian people who lived on the land and worked it for their subsistence. Questions concerning the nature of these rights began to arise as the King, the government, and *konohiki* began selling parcels of land. On December 21, 1849 the Privy Council attempted to clarify the situation by adopting four resolutions intended to protect the rights of native tenants referred to in the 1848 law (Chinen 1958:29).

These resolutions authorized the Land Commission to award fee simple title to all native tenants who occupied and improved any portion of Crown, Government, or Konohiki lands. These awards were to be free of commutation except for house lots located in the districts of Honolulu, Lahaina, and Hilo (ibid.).

Before receiving their awards from the Land Commission, the native tenants were required to prove that they cultivated the land for a living. They were not permitted to acquire wastelands or lands which they cultivated "with the seeming intention of enlarging their lots." Once a claim was confirmed, a survey was required before the Land Commission was authorized to issue any award. These lands became known as "Kuleana Lands" (ibid:30). Until its dissolution on March 31, 1855, the Land Commission issued thousands of awards to the native tenants for their *kuleana;* even so, less than 30,000 acres of land were awarded to the native tenants as Kuleana Lands.

In the Great Mahele, Ka'awaloa *ahupua'a* was listed as government land. Later, several parcels there were awarded to various people. The *konohiki* of the area was Awahua, and the land within which the project area lies was granted to Keohokalole, mother of King David Kalakaua. The grant number was LCA 8452, and it consisted of 2,100 acres (Board of Commissioners 1929).

In the following foreign testimony the surveyor spoke to Awahua, the *konohiki,* and he explains what he was told:

> L.C.A. 8452. foreign testimony—Awahua says he knows the house lots claimed by Keohokalole at Kaawaloa. The first one is fences all round with a stone wall. It is founded makai by the sea shore, on Kailua side by the government lands, mauka by the land of—haku, and Awahua, and on the other side by the road. Claimant derived this lot from her ancestors, who held it from very ancient times. There is a stone house and several grass houses in it belonging to claimant, besides a tomb. The second lot is called Awili, and is fenced all round. It is founded makai by government land. Witness knows the three house lots in Kealakekua claimed by Keohokalole. The first lot is called "Kulou" and is fenced in. It is bounded makai by the sea beach, Kaawaloa side by Government land, mauka by the road, S. Kona side by a lot belonging to T. Cummings. The second lot is called Kaahaolua it is enclosed all round and bounded on the kona hema by a lot belonging to T. Cummings. The third lot is called Wailokoalii and is bounded on the South Kona side by an old Heiau, mauka by a govt. lot and the lot of Ialua, ma kai by the sea beach on the other side of the pali (Board of Commissioners 1929).

Awahua also received a parcel of 0.633 acres in LCA 6750 (Board of Commisioners 1929). In the native register he asked for this plot of land and gave the names of these lots:

> No. 6750 Awahua, 1/25/1848
> Greetings to the Land Commissioner:
> I hereby state to you my claims for a lot and kihapais. The names of my lot claims, makai, at Kaawaloa, are Naiheha and Niukukahi. My lot mauka, at Kaawaloa, 'ili of Waipio, is named Keekeue.

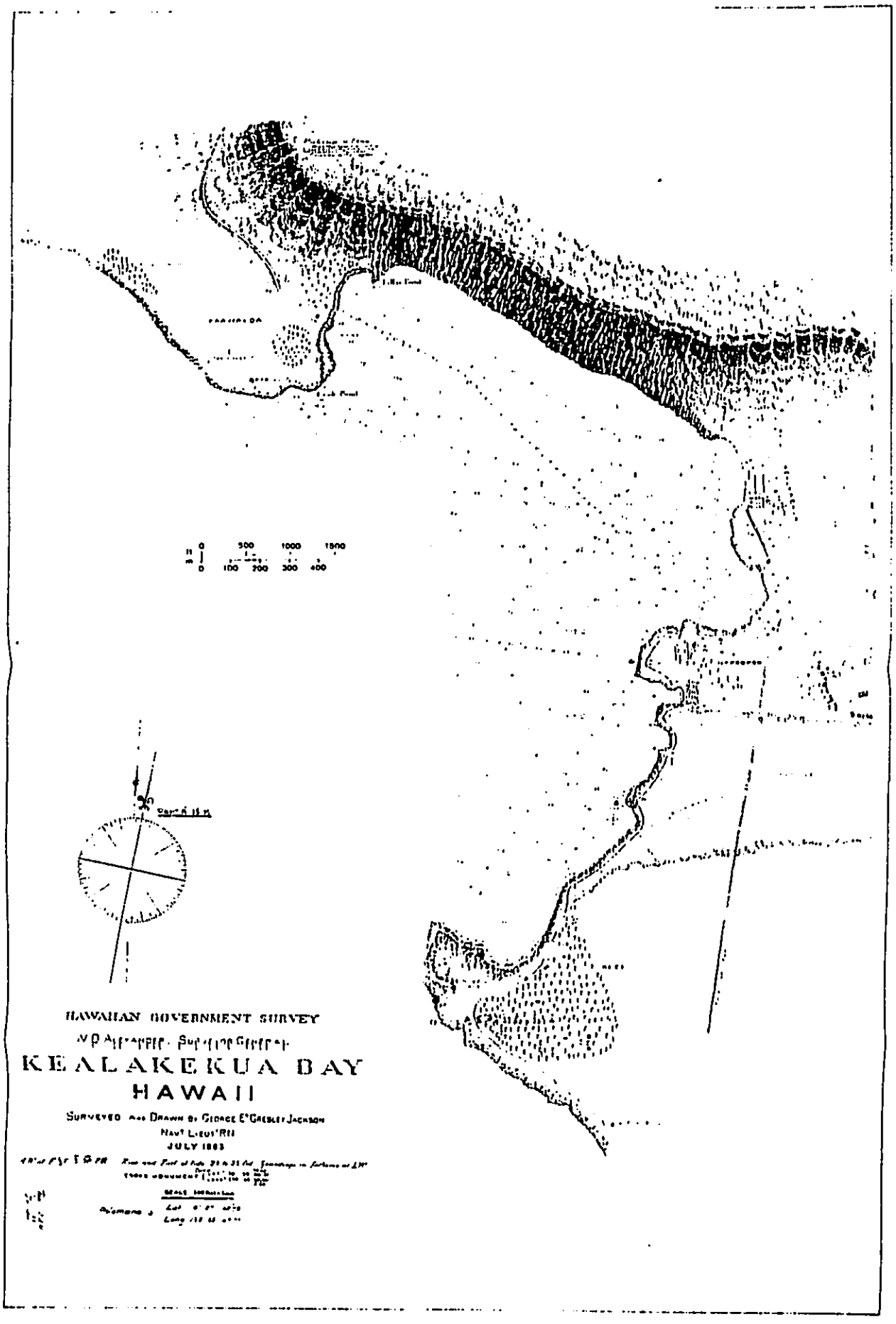

Figure B-1. 1883 Jackson Map of Ka'awaloa and Kealakekua Bay Area

that the cutter was taken by some of Palea's people as a reprisal for the indignity he had suffered; but it is uncertain whether Palea himself was the instigator of the deed. Captain Clerke being unwell, Captain Cook assumed direction of the effort to recover the stolen cutter. He first placed a cordon of boats to guard the entrance of the bay and then went in a pinnace with Lieutenant Phillips and a squad of nine marines to the village of Kaawaloa where King Kalaniopuu was residing; he was accompanied by a launch and a small cutter, both under command of Lieutenant Williamson. Cook's plan was to get the king on board the Resolution and keep him there until the stolen boat was returned—a plan that had been effective under similar circumstances in the south Pacific.

Cook landed with Lieutenant Phillips and the marines and marched to the house where the king was staying. The latter came out and after a short conversation with him Cook became satisfied that he was entirely innocent of what had happened. Kalaniopuu readily consented to go with Captain Cook and they started to walk down toward the shore. The king's youngest son, a boy of perhaps twelve years, ran on ahead and climbed into the pinnace. Before the king reached the shore, his wife Kanekapolei and several chiefs surrounded him and begged him not to go farther; he stopped and sat down. The suspicions of the Hawaiians had evidently been aroused, as well they might be. Lono, if indeed this was Lono, had never before come to visit the king in this fashion—armed, supported by an escort of soldiers, and with a concerted and apparently hostile movement of armed boats from the two ships. In the meanwhile, a great crowd had gathered about, many of the natives being armed with daggers, clubs, spears, and stones. While the king was hesitating, news came that a chief crossing the bay in a canoe had been killed by a shot from one of the foreign boats. This caused an angry reaction among the people and some of the bolder ones began to make threatening motions toward Cook and the squad of marines.

Captain Cook gave up the attempt to take the king on board, and directed his efforts to getting the marines and himself safely into the boats. The marines withdrew to the waterside and formed in line on the rocks. One of the natives made a pass at Cook with a dagger and Cook replied by firing one barrel of his gun, either a blank or a charge of small shot, which apparently did no damage and only served to embolden the Hawaiians. The king's son became alarmed at the ominous change in the situation and was allowed to return on shore. Cook fired the other barrel of his gun, loaded with ball, and killed a man. Lieutenant Phillips also fired and the marines on shore and the sailors in the boats began firing. Cook turned, ordered the boats to cease firing and come in close, and then started toward the water. By this time a general melee was in progress; Cook was knocked down with a club and as he tried to get up was struck in the back with a dagger and fell into the water; it is uncertain whether he drowned or died of his wounds. Four of the marines were killed, the others managed to swim off to the pinnace. The Hawaiians carried away the bodies of Cook and the four marines; Cook's body was treated like that of a high chief (1968:18-19).

During Cook's visit to Kealakekua Bay in 1779, he noted two large settlements with a population of as many as 2,400 (Yent and Ota, 1981). One of these settlements was Ka'awaloa, which was reported to have an estimated 300 houses. These large settlements were mostly house sites and the number of the inhabitants strained the ability of the land to support them. They were connected by a trail system over the top of the *pali*. An extensive agricultural system dominated the slopes above Pali Kapu O Keoua, which is where the project site is located (Figure B-2). This productive agricultural system and abundant marine resources supported the large population "to make Kealakekua one of the major political and religious centers in Kona and in prehistoric Hawaii" (Yent and Ota 1981:4-5).

Handy and Handy (1972) describe the native Hawaiian agricultural system of this region in the following excerpt:

> In the time of intensive native cultivation, South Kona was planted in zones determined by rainfall and moisture. Near the dry seacoast potatoes were grown in quantity, and coconuts where sand or soil among the lava near the shore favored their growth. Up to 1000 feet grew small bananas which rarely fruited, and poor cane; from 1000 to 2000 feet, breadfruit flourished (Handy and Handy 1972:524-525).

Above Ka'awaloa some of Cook's officers saw plantations. Cook (1784:Vol. 3:106-107) says that these plantations were broken into smaller parcels by thick, low walls of lava. They contained breadfruit trees, plantains, taro root, sweet potatoes, ginger root, and sugar cane.

William Ellis, a surgeon with Captain Cook in 1778, wrote that the country above Kealakekua was covered in every direction with plantations of sugar-cane, sweet potatoes, taro, plantains, and breadfruit trees. He also came across many plantations of the paper mulberry tree, breadfruit, and plantain trees, which made an extensive garden (Handy and Handy 1972:525).

The same region is described by Archibald Menzies, a surgeon and naturalist who accompanied Vancouver in 1793:

> The tract which extended along shore, if we might judge from its appearance and our knowledge of that which we had already traveled over, we were ready to pronounce a dreary naked barren waste, if we except a few groves of cocoa palms here and there near the villages. But that which stretched higher up along the verge of the woods, from the manner it was industriously laid out in little fields, exhibited a more pleasing and fertile appearance...On leaving this station, we soon lost sight of the vessels, and entered their breadfruit plantations, the trees of which were a good distance apart, so as to give room to their boughs to spread out vigorously on all sides, which was not the case in the crowded groves of Tahiti, where we found them always planted on the plains along the sea side. But here the size of the trees, the luxuriances of their crop and foliage, sufficiently show that they thrive equally well on an elevated situation. The space between these trees did not lay idle. It was chiefly planted with sweet potatoes and rows of cloth plant. As we advanced beyond the bread-fruit plantations, the country became more and more fertile, being in a high state of cultivation. For several miles round us there was not a spot that would admit of it but what was with great labor and industry cleared of the loose stones and planted with esculent roots or some useful vegetable or other. In clearing the ground, the stones are heaped up in ridges between the little fields and planted on each side, either with a row of sugar cane or the sweet *[ti]* root of these islands (Dracena...) where they afterwards continue to grow in a wild state, so that even these stony, uncultivated banks are by this means made useful to the proprietors, as well as ornamental to the fields they intersect .

> The produce of these plantations, besides the above mentioned, are the *[wauke]* cloth plant...taro and sweet potatoes (Menzies 1920:74-76).

These plantations were a part of what is now known as the Kona Field System. T. Stell Newman (n.d.) studied these fields and concluded that the Kona Field System (Fig. B-3 and Table B-1) was the most extensive and monumental work of ancient Hawaii. Newman's reconstruction for the AD 1778-1823 period and Kelly's (1983) research leave no doubt that the Kona Field System continued to function until the mid-1800s, when the Great Mahele took place.

Newman suggested that this system extended north from Kealakekua to include the area in back of Kailua and a little beyond. He estimated the overall size of the cultivated lands as approximately three miles wide by 18 miles long (IN Kelly 1983:73).

Other early visitors to the Kona area noted the Kona Field System. John Ledyard, traveling northeast from Kealakekua Bay toward Kailua in 1779, described the land as a plain of little enclosures separated from each other by low, broad walls. He noticed that most of these fields were planted with sweet potatoes, and he suggested that they were the principal crop. He also noted many breadfruit forests and patches of sugar cane along the plains of Kona up to about three miles from Kailua town (IN Kelly 1983:71-72).

Newman summarized the significance of the Kona Field System:

> The Kona Field System is without equal in Hawaii, and probably in the nation in terms of the extensiveness of a prehistoric modification of the land....It is a physical demonstration of the highly developed farming economy of ancient Hawaii and illustrates the complexity and advanced state of aboriginal Hawaiian culture....The physical remains are sufficiently well preserved and in such generally good condition that they may still be detected on the ground....In all, it is a magnificent monument to the exhaustive labors and industry of the ancient Hawaiians (Newman n.d.:126).

THE GREAT MAHELE

In 1848, during the reign of Kamehameha III, the traditional Hawaiian land ownership system was replaced with a more Western-style system. This radical restructuring was called The Great Mahele (division). The Great Mahele separated and defined the undivided land interests of the King and the high-ranking chiefs, and the *konohiki*, who were originally those in charge of tracts of land on behalf of the king or a chief (Chinen 1958:vii and Chinen 1961:13).

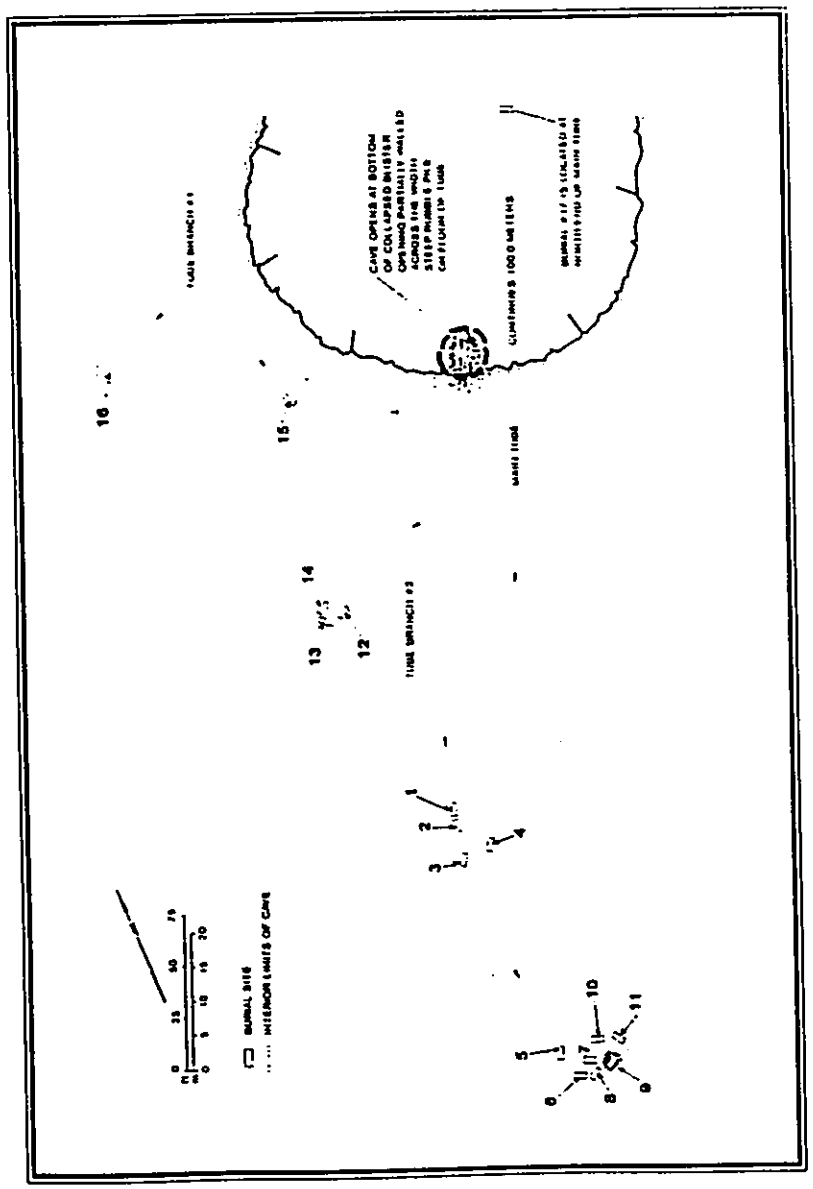

Figure A-14. Site 14192

tube. The burial appears to have been positioned with the head at the lower end, but the cranium pieces could have fallen downward. Recognizable bones include: fragment of innominate with acetabulum, pieces of a large vertebra (possible lumbar), fragment of patella, metatarsals, calcaneus, and clavicle. The foot bones are in the best condition. No large long bone pieces present. Damp bone dust/crumb deposit on a stone mashed, with fabric imprint (possibly knee imprint from a pothunter). There appears to be fabric remnants on the stones beside the burial which may possibly be burial wrapping.

Burial 3 is within a rubble floor near the northwest wall. Stones and bones tossed against the side of the tube. Calcaneus, femur piece, phalanges piled on top of boulder. Pieces of long bone shafts and small pieces of arm bones visible. No cranium pieces recognizable.

Burial 4 may not be a burial. Square excavation opposite Burial 3. Proximal end of humerus placed at edge of excavation. No other bones visible in pit; others along wall, under rubble to the west.

Burial 5 is near the end of the tube. Square excavation with pieces of long bones and foot bones. Other pieces of bone scattered outside of the excavation. No cranial bone fragments seen.

Burials 6 to 8, 10, and 11 are positioned at the end of tube. All burials are in poor state of preservation, but their preservation is better than that of Burials 1 through 5. Pieces of cranium piled against the southwest tube wall. Lower portion of frontal lobe and upper orbits of small cranium sitting on top of boulder with unidentified bone—not determined from which burial. All have been moved and disturbed.

Burial 9 is within an approximately U-shaped boulder/cobble alignment extending from the southeast wall of the tube end, sloping towards the tube floor. A waterworn stone is against the interior base of the alignment and a hand-sized piece of branch coral rests on the surface northeast of the burial. The burial is disturbed and in poor preservation. Long bone, vertebrae, and cranium fragments were identified.

Burial 12 to 14 is located at the end of Tube Branch 2. All burials are in same poor condition, with one piece of mandible recognizable.

Burial 15 is on a ledge c. 1.0 m above the floor, along the side of Tube Branch 1.

Burial 16 is at the end of Tube Branch 1. Deposit of crumbs, dust, and bone fragments indicate burial area. Burial appears disturbed. A small *'ili'ili* and one *opihi* shell near the north wall before bend in tube. Ribs (mammal) on cave floor.

Burial 17 is located at the north end of the main tube. Reported to be in same general state of poor preservation as the others.

The site is similar to SIHP Site 14185 in that the cave contains many crab shells; shells are present on the floor of all the tubes. Crab shells and bird bones are in the main N-S tube. It appears that all burials, except Burial 15, have been disturbed and uncovered, possibly by pot hunters.

SITE NO.: State: 14754 **OTHER NO:** 208
PHRI: 770-6
SITE TYPE: Road
TOPOGRAPHY: Undulating flow.
VEGETATION: Pasture grass, *koa-haole*, and *'opiuma*.
CONDITION: Poor-good
INTEGRITY: Unaltered-altered
PROBABLE AGE: Historic
FUNCTIONAL INTERPRETATION: Transportation
DIMENSIONS: 732.0 m by 1.00 m by 1.00 m (approx.)
DESCRIPTION: This site consists of two walls extending parallel to each other with a cleared area between the walls. The site is at the south corner of the project area. The roadway is oriented c. east to west and exits along the lower half of the western boundary. There is c. 365.0 m of roadway that is situated within the project area.

The walls consist of large subangular pahoehoe boulders. The cleared area between the walls is large enough to support vehicle traffic. The width of the road bed varies from c. 3.5 m to 5.0 m. The *mauka* wall is intermittent in places. A section of the road below the southwest side of the project boundary measures c. 2.0 m wide with curbstones and paving. Midden is present on the road surface.

Kaschko and Rosendahl (1987:46) record the site as follows: "208. Horse trail. This type C trail (Apple 1965) is shown on Tax Map 8-1-10 as the 'old road from Kealakekua pali to Kainaliu' but only as far south as Kaawaloa Road...(Apple 1965:52-59)". This site has also been identified as an old government road by Soehren (1980).

SITE NO.: State: 14755 **PHRI:** 770-7
SITE TYPE: Mound

TOPOGRAPHY: Undulating to a fairly steep ridge.
VEGETATION: *Koa-haole*, pasture grass, *'opiuma*.
CONDITION: Fair
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Possible burial
DESCRIPTION: The mound is fairly substantial and is constructed with basalt boulders and cobbles.

SITE NO.: State: 14756 **PHRI:** 770-8
SITE TYPE: Terrace
TOPOGRAPHY: Situated on a fairly steep ridge.
VEGETATION: *Koa-haole*, pasture grass, *'opiuma*.
CONDITION: Fair
INTEGRITY: Unaltered
PROBABLE AGE: Historic
FUNCTIONAL INTERPRETATION: Agriculture (possible loading dock)
DIMENSIONS: 8.00 m by 5.00 m by 0.78-1.00 m height (approx.)
DESCRIPTION: Situated seaward (west southwest) of SIHP Site 14157. The terrace is raised on the northwest, southwest, and southeast sides. It is constructed with boulders and cobbles. The surface interior is level and is paved with cobbles and pebbles. The terrace appears to continue to the northwest following the natural contour of the land, where it is modified slightly with boulders and cobbles. The terracing also continues c. 90.0 m seaward and beyond SIHP Site 14754, historic cart road.

APPENDIX B

HISTORICAL DOCUMENTARY RESEARCH
by Lehua Kalima, B.A.

The *ahupua'a* of Ka'awaloa in the South Kona District is bordered on the south by the *ahupua'a* of Kealakekua and on the north by the *ahupua'a* of Keopuka. There are many historical documents relating to this area, because it was the site of Captain Cook's death in 1779 and was one of the areas frequently visited by foreign ships (*Figure B-1*). Many of these documents deal with the coastal region of Ka'awaloa because this was the most populated area. Although the project site is above the *pali*, to present a fuller account of its background this report also encompasses the more well-documented areas of the Ka'awaloa coast and Kealakekua Bay.

Puku'i, Elbert and Mo'okini (1974) define the name Ka'awaloa as "the distant kava" (or *awa* as it is known in Hawaiian), explaining that runners went to Puna or Waipi'o on the eastern coast of the island to get *awa* for chiefs.

PRE-CONTACT HISTORY

Tales specifically about the Ka'awaloa *ahupua'a* are rare in the legends or mythology of Hawai'i. John Papa I'i, a native historian and a member of the court of Kamehameha II, refers to the coast of Ka'awaloa in the tale of Akalele, a canoe paddler of super-human strength who lived during the reign of Kamehameha I:

> Akalele, a man famous for his paddling strength, is said to have come from Kauai and to have lived with our first king. One night the king left Kawaihae and set forth with his double canoes. Daylight found his company outside of Kekaha, and they rested a little while at Kailua. Akalele was alone on a single canoe about 6 fathoms long and filled with baskets of sweet potatoes, fowls, dogs, and such gifts as people brought who came to see the king on the beach in Kona. When they arrived at Kahaluu, or Keauhou perhaps, the single canoe began to race with the double ones, to see which could first reach their goal, Awili in Kaawaloa. So they raced, the king with his canoe paddlers, Akalele alone. Although the single canoe was loaded with goods, the king desired this race...After they passed Keopuka and reached Kalaemamo at Kaawaloa, they again turned shoreward. Near the harbor of Awili, where there is a narrow channel only large enough for a single canoe, the king called out, "O Akalele, turn your canoe into the narrow entrance! Glide in on a wave!" Akalele did as he was told and was first to arrive at Awili. The others took the longer way around and found him there carrying the things ashore. The king helped Akalele because he was a stranger (I'i 1959:131-2).

EARLY HISTORICAL ACCOUNTS

Ka'awaloa was the home of many important chiefs including Kalani'opu'u, king of the island and uncle of Kamehameha I; Keku'aokalani and Manono, a chief and chiefess who were killed in the famous battle of Kuamo'o; and Chief Naihe and his wife, chiefess Kapi'olani, known for her defiance of Pele in the days of the missionaries. Ka'awaloa was also where a group of chiefs were residing at the time of the persecution of Catholics in Hawai'i, and it was there, in 1831, that a formal order of banishment was issued to all Catholic priests (Kuykendall 1968:142). Puku'i's explanation of the name "Ka'awaloa," mentioned above, emphasizes that chiefs once lived in that area, sending runners to the other side of the island to get *awa* for them. Of course the area is best known as the site of the death of Captain Cook in 1779. According to Kuykendall:

> Nothing of special note happened until the afternoon of the thirteenth when a watering party on shore from one of the ships had some kind of altercation with the natives. At nearly the same time, a native on board the Discovery daringly seized a pair of tongs and a chisel from the blacksmith's forge and made his escape in a canoe that lay alongside the ship. Shots were fired after him and he was pursued by one of the ship's boats. The stolen goods were restored, but the thief escaped and the officer in charge of the ship's boat attempted—unwisely, it would seem—to seize the canoe. This led to a scuffle on the beach in which a chief named Palea was struck on the head with an oar and the boat's crew was rather roughly handled by the natives. As it happened, the canoe belonged to Palea, but it appears also that it was he who caused the tongs and chisel to be restored.
>
> On the following morning it was found that the Discovery's large cutter had been stolen during the night. Afterwards it was reported, on good authority,

of the trail, a small piece of waterworn and weathered coral is present, located c. 3.4 m southeast of the trail, near the opening of a small blister. No cultural remains were present inside of the blister.

SITE NO.: State: 14187 **PHRI: 770-39**
SITE TYPE: Upright
TOPOGRAPHY: Pahoehoe flow with a seaward slope.
VEGETATION: Morning glory, ferns, and *koa-haole*.
CONDITION: Good
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Marker
DIMENSIONS: 0.65 m by 0.45 m by 0.10 m (approx.)
DESCRIPTION: The upright is at the seaward end of a sloping pahoehoe flow. It consists of a pahoehoe slab supported at the base by four pahoehoe cobbles on the east side, and wedged against low pahoehoe outcropping on the west side.

The upright appears to be a marker for SIHP Site 14188, complex. Feature E of Site 14188 is c. 18 m to the northwest, with additional features c. 50 m northwest of the upright (marker). There are no sites immediately downslope or to the south or east.

Approximately 4.5 m northwest of the marker, another upright with large cobbles at each end forms a small U-shaped enclosed space with the opening facing the west. The upright is positioned on the south side of a linear pile of boulders extending to Feature E of SIHP 14188.

SITE NO.: State: 14188 **PHRI: 770-40**
SITE TYPE: Complex (6 Features)
TOPOGRAPHY: Pahoehoe flows and aa rubble sloping seaward.
VEGETATION: *Koa-haole* and grasses.
CONDITION: Good
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Temporary habitation
DESCRIPTION: The overall complex measures at least 44.0 m (NE-SW) by 34.0 m (NW-SE). The site consists of two caves (Features A and B), two terraces (Features C and D), a walled pavement (Feature E), and a modified outcrop (Feature F).

Portable remains consists of *kukui*, coconut, bird bone, *Cellana* spp., Cypraeidae, Thaididae, fish bone, waterworn coral, and basalt. Feature A contains a *kukui* concentration.

FEATURE A: Cave
FUNCTION: Temporary habitation
DIMENSIONS: 12.20 m by 4.30 m by 1.59 m maximum (approx.)
DESCRIPTION: Feature A consists of a lava tube that angles c. 80° from the entrance. The entrance into Feature A is from a collapsed tube. The opening measures c. 2.0 m by 0.60 m and is 2.3 m high.

From the entrance the lava tube branches to two small tubes that end c. 12.2 m from the opening. Stacked pahoehoe slabs and large cobbles are at the entrance, forming rough steps in rubble, leading to the interior. Rubble is on the cave floor just inside the entrance. About 6.2 m within the entrance are five pahoehoe slabs arranged in upright positions on the south side of a natural lava pillar extending from the floor to the ceiling. A small egg-shaped waterworn is present between the two westernmost upright slabs.

Bird bone is present nearby; one piece of burned wood is against the south wall of the cave, just inside of the entrance. A soft and fragile piece of wood, measuring c. 0.12 m in length, is burned at one end. There is a very thin soil deposit inside the cave entrance; the deposit contains a *Nerita picea* and a *Planaxis labiosa*. The remainder of the cave floor is relatively clear of rubble and roof fall.

FEATURE B: Cave
FUNCTION: Temporary habitation
DIMENSIONS: 27.00 m by 1.40 m by 1.26 m (approx.)
DESCRIPTION: Feature B is at the southwest end of a section of the collapsed lava tube that also connects with Feature A. The height of the entrance into the lava tube is c. 0.70-1.26 m. The entrance has been walled cross the lower portion of the tube opening to a height of c. 0.70 m making the opening level with the rubble on the bottom of the collapsed section of the lava tube. The wall is constructed of large angular pahoehoe cobbles stacked four courses high. Interior of the wall, rubble slopes downward to the cave floor and covers the floor for c. 4.0 m, to the first overhead opening. Fish bone was present in the rubble. The remainder of the floor is relatively clear until the second skylight/opening at c. 27.0 m within the cave. The tube narrows at the second opening. There is an accumulation of rubble and roof fall that partially blocks the cave at this point; the cave is passable at this point; however, it was not explored.

FEATURE C: Terrace
FUNCTION: Temporary habitation
DIMENSIONS: 7.20 m by 5.20 m by 1.40 m (approx.)
DESCRIPTION: This terrace is roughly triangular and is constructed against a pahoehoe bedrock outcrop on two

sides. The rough aa boulder and cobble terrace is faced on the west side to a height of c. 1.4 m. The terrace surface is level and is paved with small cobbles and pebbles. The faced west side is constructed on gently sloping aa.

Two small additional areas are paved with rough pebbles and are positioned against the outcrop southwest of Feature C. Marine shells are present on or near the paved areas.

FEATURE D: Terrace
FUNCTION: Temporary habitation
DIMENSIONS: 9.00 m by 5.00 m by 0.95 m (approx.)
DESCRIPTION: This rectangular terrace is paved with small cobbles and has a slightly concave surface. The terrace is faced on the southeast and southwest sides and is level with adjoining pahoehoe outcrop on the northeast and northwest sides. Subangular boulders and cobbles are stacked five courses high on the southwest side, two to three courses high on the southeast side.

There are two areas of possible paving southwest of Feature D. The areas are amorphous in plan and have irregular surfaces consisting of medium-size cobbles; the areas have no raised or faced edges. The features are possibly natural but appear constructed because they are better leveled than surrounding rubble.

FEATURE E: Walled pavement
FUNCTION: Temporary habitation
DIMENSIONS: 6.40 m by 5.20 m by 0.47 m (approx.)
DESCRIPTION: Feature E consists of a roughly oval pavement with a low cobble wall, possibly constructed with cobbles removed from the interior. Large cobbles form the low wall; the wall surrounds the perimeter of the leveled and cleared paved area. The enclosed interior is level and is paved with rough pebbles and small cobbles.

The pavement is constructed on a pahoehoe outcrop. A small opening/cupboard in the outcrop c. 0.70 m deep is present at the south corner of the pavement. One Thaididae shell was noted at the bottom of the opening. No midden or artifacts were visible on the pavement surface.

FEATURE F: Modified outcrop
FUNCTION: Indeterminate
DIMENSIONS: 4.40 m by 1.80 m by 1.03 m (approx.)
DESCRIPTION: Feature F is an outcrop that has been modified with pahoehoe cobbles to form a rectangular shaped terrace. It is constructed on a pahoehoe outcrop over Feature A, cave. The modified outcrop has a short (1.85 m) faced section of cobbles on the northwest side consisting of two to three courses high of stacked cobbles. The surface is paved and slopes gently on three sides and is level with the outcrop on the east side.

SITE NO.: State: 14189 **PHRI: 770-41**
SITE TYPE: Mound
TOPOGRAPHY: Aa fields to the north and pahoehoe flows sloping seaward.
VEGETATION: Christmas-berry and grasses.
CONDITION: Good
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Indeterminate/possible marker
DIMENSIONS: 7.60 m by 2.80 m by 1.0-1.79 m (approx.)
DESCRIPTION: The mound consists of pahoehoe cobbles with a straight faced section measuring c. 1.40 m in length and 0.83 m in height, four courses high, on the northeast side. There appears to be some areas of collapse but the mound is constructed loosely on the north-northeast side so it is difficult to determine how much is collapse and how much is original construction.

The mound consists of pahoehoe cobbles piled atop an outcrop that has two levels and which drops on the north side. There is a small paved surface against the higher outcrop, on the south side of the mound.

A short section of collapsed lava tube is located c. 4.5 m at 105° east of the short wall section. The opening measures 3.0 m by 1.0 m. There are several *kukui* shells at the bottom of the opening; no midden or artifacts were present.

One Thaididae fragment was noted on the paved area at the east base of the mound. One large cowrie fragment c. 3.0 m was noted southwest of the mound.

SITE NO.: State: 14190 **PHRI: 770-42**
SITE TYPE: Complex (3 Features)
TOPOGRAPHY: Slopping aa and pahoehoe flows.
VEGETATION: *Koa-haole, opiuma*, lantana, morning glory, an unidentified trailing plant, grasses, and Christmas-berry.
CONDITION: Good
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Habitation
DESCRIPTION: The overall complex area measures c. 50.0 m at 133o by 16.0 m at 43°. The site complex consists of a walled pavement (Feature A), a modified outcrop (Feature B) and a cave (Feature C).

FEATURE A: Walled pavement *(Figure A-13)*
FUNCTION: Habitation
DIMENSIONS: 3.50 m by 3.00 m by 0.10-0.26 m (approx.)
DESCRIPTION: Feature A consists of a roughly square paved area consisting of pahoehoe and aa cobbles and pebbles. The pavement is walled with pahoehoe boulder alignments on top and embedded in the cobble and pebble paving. The feature sits atop a mixture of pahoehoe and aa bedrock flows. A cowrie fragment is visible between Feature A and Feature C.

FEATURE B: Modified outcrop
FUNCTION: Temporary habitation
DIMENSIONS: 12.50 m by 9.20 m by 0.62-0.78 m (approx.)
DESCRIPTION: Feature B is a modified outcrop with subangular basalt cobbles and boulders stacked on the west and northwest sides. Irregular in shape and crudely paved with cobbles, the outcrop has been leveled to resemble a terrace. The surface interior is somewhat level and meets aa rubble on the northeast end. The modified outcrop is situated on the east and west sides of SIHP Site 14186, trail. Portable remains at the outcrop consisted of three marine shell fragments.

FEATURE C: Cave *(Figure A-13)*
FUNCTION: Habitation
DIMENSIONS: 15.0 m at 83°in length by 3.2-10.0 m wide; heights range from 0.8-1.25 m (approx.)
DESCRIPTION: Feature C is a natural lava tube. It has a partially walled off entrance with pahoehoe boulders roughly stood-up or stacked at the south side of the entrance.

An area of marine shell midden and *kukui* nut, measuring c. 3.75 m by 3.0 m, is present within the entrance to the cave. Charcoal fragments, midden, and *kukui* were scattered around the back of the cave. There is c. 0.05 m of a grayish soil inside the entrance to the cave. The rear of the cave is mostly exposed bedrock.

SITE NO.: State: 14191 PHRI: 770-43
SITE TYPE: Pahoehoe excavation
TOPOGRAPHY: Decomposing pahoehoe ridge oriented inland-seaward surrounded by sloping aa flows.
VEGETATION: *Koa-haole, 'opiuma,* morning glory, and trailing plants.
CONDITION: Good
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Quarry
DIMENSIONS: 8.00 m by 5.20 m by 0.80 m overall dimensions
DESCRIPTION: Two small circular pahoehoe excavations were noted within the site depression. The northeast excavation measures c. 2.0 m (NE-SW) by 0.80 m (NW-SE). Boulders and cobbles are piled to the east southeast of the excavation. The southwest excavation measures c. 2.5 m (NE-SW) by 1.5 m (NW/-E). It contains two excavated overhang areas measuring c. 0.5-0.8 m deep. Boulders and cobbles are also piled to the east-southeast of the excavation.

SITE NO.: State: 14192 *(Figure A-14)* PHRI: 770-44
SITE TYPE: Cave
TOPOGRAPHY: Seaward sloping flows.
VEGETATION: *Koa-haole,* grass, and morning glory.
CONDITION: Poor
INTEGRITY: Altered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Burial
DIMENSIONS: 200.0 m by 2.50-10.0 m by 1.50-5.00 m (approx.)
DESCRIPTION: This site consists of a lava tube oriented north to south with two branches opening to the west. There are 17 burials located in the cave. Previous excavated square depressions are present in the rubble on the cave floor, and cobble alignments are on the rubble surface confining burial(s). Also present are waterworn basalt cobbles, bird bone, and large quantities of crab shells.

A burial is located at the north end of the main tube. Three, possibly four burials are located along the wall of the main tube and seven are present at the south end. The burials are located at the ends of the two branch tubes and one on a ledge, near the midpoint of the first branch, to the west of the opening.

All burials have been disturbed; cobble covering and bones have been removed, broken, and/or crushed. Collected bones are presently sitting on top boulders and are strewn on rubble of the cave floor. All bones are in a state of poor preservation; the bones are soft, fragile, and wet.

Burial 1 is within an excavation in the rubble floor of the cave, against the northwest wall. The burial has been disturbed; cranium pieces are positioned at the northeast end of the burial pit; pieces of the tibia and femur are near the southwest end. The bones are damp and disintegrating; few recognizable fragments, most are small pieces with damp crumbs under what appears to be a piece of roof fall.

Burial 2 is on a ledge c. 1.7 m above and 2.0 m south of Burial 1. This burial is also in a poor state of preservation. There is a layer of damp bone dust and crumbs on the ledge surface; the surface slopes slightly toward the bottom of the

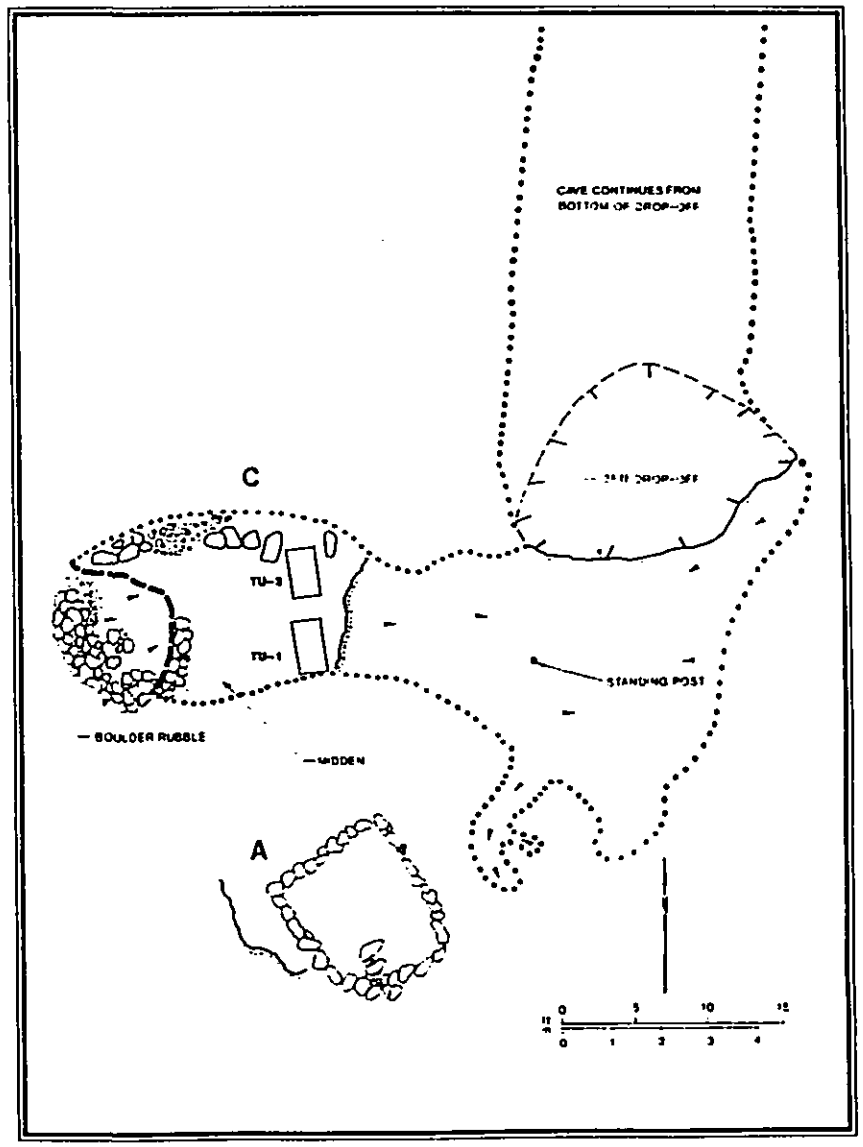

Figure A-13. Site 14190, Features A and C

FEATURE E: Cave
FUNCTION: Burial
DIMENSIONS: 15.00 m by 3.00 m by 1.80 m maximum height (approx.)
DESCRIPTION: Feature E cave opening measures c. 1.4 m by 0.90 m. The opening is in the top of a pahoehoe blister at the east edge. A small tube opening at the south end is filled with cobbles. The opening at the north end is blocked to within c. 0.30 m of the ceiling with stacked boulders. The burial is in the chamber off of the tube to the north.

Pahoehoe boulders and cobbles are stacked across the entrance reducing the opening of the north tube to c. 0.70 m wide by 0.30 m high. The original opening appears to be c. 1.2 m wide by 0.70 m high.

Portable remains consisted of waterworn coral and basalt, pencil urchin spines, and one piece each of cowrie and Tellinidae. Soil and a possible charcoal deposit measuring c. 1.0 m in diameter and 0.04-0.07 m thick is present near the west wall of the chamber.

The burial is in very poor condition. It is located in a sloping, shallow V-shape depression in the tube floor with the cranium positioned at the northwest corner of low, angular section of the tube. Water is dripping from the (tube) ceiling at the cranium area. Bone fragment c. 1.8 m down slope in depression. No intact bones visible. Many cranium fragments recognized as well as a patella, a proximal ulna, a mandible fragment, one phalange, two c. 0.15 m sections of tibiae, and rib bones. All the bones are wet and soft; most are crumbs with some splinters. The splintered bones could be the result of small animal disturbance. No roof fall in the area of the burial. The blocked opening to the tube does not appear to have been disturbed—three boulders were moved in order to gain entry.

SITE NO.: State: 14181 **PHRI:** 770-33
SITE TYPE: Complex (8 Features)
TOPOGRAPHY: Undulating pahoehoe and aa flow.
VEGETATION: *Koa-haole*, grasses, *'opiuma*, Christmas-berry, *'uhaloa*, periwinkle, and vines.
CONDITION: Good
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Habitation
DESCRIPTION: The overall complex area measures c. 90.0 m at 205° by 60.0 m at 295°. The site complex consists of a linear alignment (Feature A), three terraces (Features B, E, and F), two caves (Features C and D), an enclosure (Feature G), and a stepped terrace (Feature H). The complex is situated on newer aa and pahoehoe flows. It is constructed with large angular pahoehoe and aa boulders stacked and faced in places. Portable remains consisting of fish bone, shell midden, coral, waterworn basalt boulders, Echinoidea and historic trash are associated with the site complex. A probable cultural deposit is present within Feature C, cave, east of the cave entrance.

FEATURE A: Linear alignment
FUNCTION: Habitation
DIMENSIONS: 2.80 m by 2.50 m by 0.55 m (approx.)
DESCRIPTION: Large pahoehoe boulders are crudely stacked in a linear alignment which abuts a collapsed lava blister/overhang. The blister/overhang measures c. 2.0 m by 0.80 m deep and is open to the north. The alignment affords uphill protection from the east and continues to extend partially north to form a C-shape (enclosing the overhang) that faces to the west. The area within the alignment is filled with gravel and small cobbles. There is collapse within the area where the alignment abuts the outcrop.

FEATURE B: Terrace
FUNCTION: Habitation
DIMENSIONS: 3.00 m by 2.75 m by 0.79 m maximum height (approx.)
DESCRIPTION: Feature B is constructed with large pahoehoe boulders in a linear alignment; the boulders form a retaining wall that is raised on the south side. The north side is filled and smoothed with aa pebbles. This terrace abuts pahoehoe bedrock to the north and east and is oriented northeast to southwest.

FEATURE C: Modified sinkhole
FUNCTION: Habitation
DIMENSIONS: 16.20 m by 14.50 m by 1.5-10.00 m (approx.)
DESCRIPTION: Feature C consists of a large sinkhole. The interior of the sinkhole has terracing, paving, possible modified areas consisting of aligned boulders, and three lava tube entrances and one overhang. The westernmost lava tube entrance was designated as Feature D.

The entrance to the southernmost lava tube faces north and is oriented c. 190° azimuth. The tube contains a large waterworn boulder and a Cypraeidae shell in the entrance.

The overhang faces northwest and is located along the south-southeast side of the collapsed blister. It measures c. 6.5 m wide and c. 3.0 m deep. In the overhang is a possible firepit, marine shell midden, *kukui*, worked bone, coral abrader and a possible cultural deposit.

The third opening contains evidence of recent camp (firepit, sleeping bag); the opening faces west-southwest and is oriented at 70° azimuth. The opening measures c. 2.0 m wide and the lava tube continues inland (east) for c. 60.0 m. There is a charcoal area on a ledge c. 10.0 m from the entrance.

FEATURE D: Cave **OTHER NO:** 210
FUNCTION: Habitation
DIMENSIONS: 120.00 m by 10.00 m by 15.00 m (approx.)
DESCRIPTION: Feature D is along the west-southwest side of Feature C. The entrance faces east and the lava tube is oriented c. 270 degrees west. The entrance contains prehistoric midden, but it is badly disturbed by recent camping, and it includes trash. Four chambers were inspected. There was no cultural material beyond the first c. 20 m of the cave; the cave evidenced no structural modifications.

FEATURE E: Terrace
FUNCTION: Habitation
DIMENSIONS: 7.75 m by 3.00 m by 0.90 m (approx.)
DESCRIPTION: Feature E consists of an alignment of large angular boulders. It is stacked and faced along the southwest with a mounded area within the center c. 0.28 m high.

Feature E is c. 3.5 m northwest of Feature F, terrace. It is also situated south of Feature C.

FEATURE F: Terrace
FUNCTION: Habitation
DIMENSIONS: 12.75 m by 8.50 m by 0.46-1.14 m high (approx.)
DESCRIPTION: Feature F forms the south boundary of the site complex. It is crudely faced to the west and south with medium to large boulders, two to three courses high. The terrace is level and paved with aa cobbles; small boulders are present along the east side. The feature abuts an outcrop to the northeast.

FEATURE G: Enclosure
FUNCTION: Habitation
DIMENSIONS: 7.00 m by 5.00 m by 0.78 m (approx.)
DESCRIPTION: Feature G consists of a wall that has been constructed around a low depressed area. The wall is roughly oval in plan. It is built with aa cobbles and boulders and is crudely faced to crumbled.

FEATURE H: Stepped terrace
FUNCTION: Habitation
DIMENSIONS: 12.00 m by 5.00 m by 0.80 m (approx.)
DESCRIPTION: Feature H consists of three adjacent terraces. It is oriented roughly NE-SW and is constructed of aligned and stacked large pahoehoe boulders. The terrace platforms are fairly level and are filled with cobbles.

The northeastern most terrace measures c. 5.0 m by 5.0 m and is irregular in plan. Raised on the southwest and east sides, it ranges in height from 0.48-0.59 m. The interior is paved with aa cobbles and pebbles.

The middle terrace measures c. 4.5 m by 2.0 m maximum width and is 0.42 m high. It abuts the northeast terrace along the seaward end. The terrace is raised along the southwest side; boulders line the terrace perimeter.

The southwest terrace measures c. 7.0 m by 5.5 m. It consists of a low area that is raised with boulders along the north side, to a height of c. 0.72 m. The remaining portion is paved with aa pebbles and pahoehoe cobbles abutting smooth pahoehoe to the south.

SITE NO.: State: 14182 *(Figure A-12)* **PHRI:** 770-34
SITE TYPE: Enclosure
TOPOGRAPHY: The terrain consists of undulating aa.
VEGETATION: *'Uhaloa*, sword fern, and vines.
CONDITION: Poor
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Habitation
DIMENSIONS: 6.00 m by 5.50 m by 0.76-0.83 m (approx.)
DESCRIPTION: The enclosure consists of a natural aa outcrop to the south, and crudely stacked aa boulders and cobbles. The walls are collapsed. This structure is roughly U-shape in plan and opens to the southwest. Some rubble lies to the west of the north wall.

SITE NO.: State: 14183 **PHRI:** 770-35
SITE TYPE: Complex (2 Features)
TOPOGRAPHY: Undulating aa.
VEGETATION: *Pua-pilo, pohuehue*, and Christmas-berry.
CONDITION: Good
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Habitation possible quarry
DESCRIPTION: The overall complex area measures c. 23.85 m (NW-SE) by 6.0 to 11.0 m (NE-SW). The site complex consists of a terrace (Feature A) and a pahoehoe excavation (Feature B). Portable remains consists of shell midden, waterworn basalt, a possible hammerstone cobble, and a reworked basalt adze.

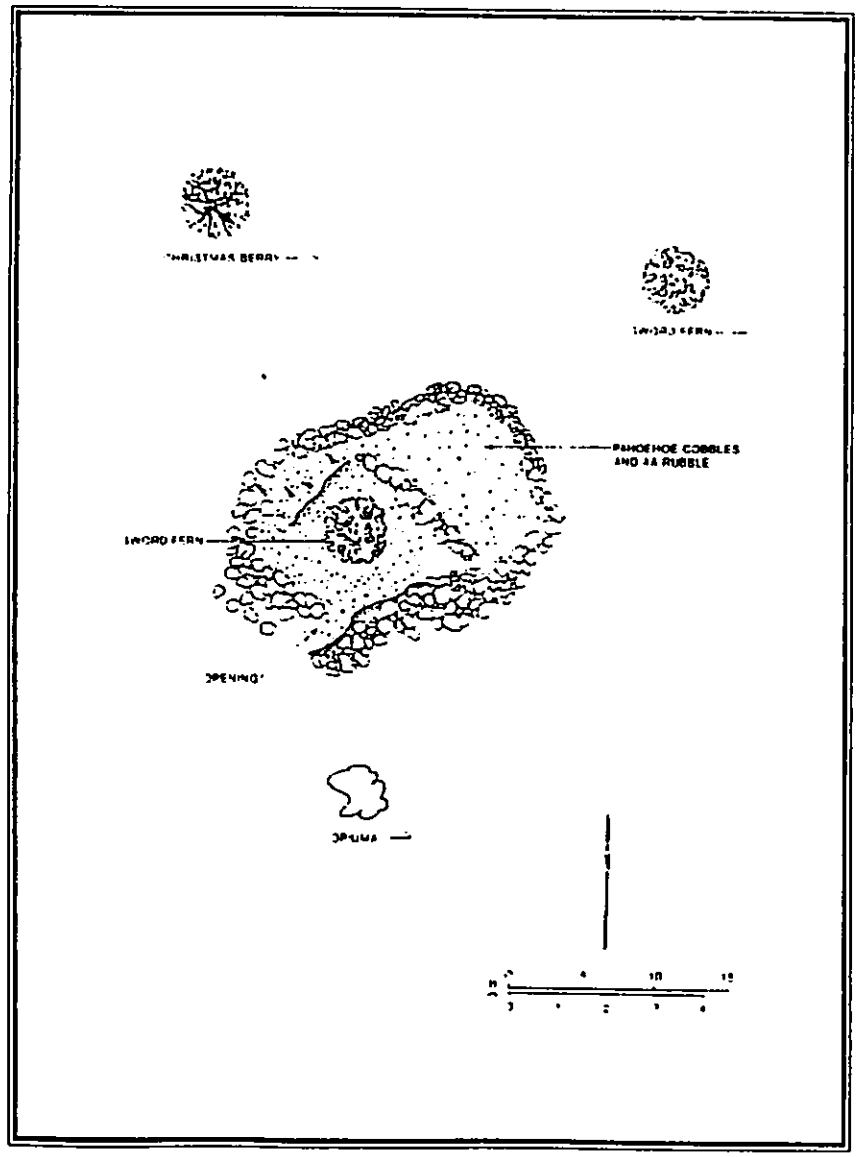

Figure A-12. Site 14182

FEATURE A: Terrace
FUNCTION: Habitation
DIMENSIONS: 23.00 m by 18.00 m by 0.76 m (approx.)
DESCRIPTION: Feature A is a large terrace constructed with aa boulders and cobbles. The boulders are in a linear alignment with cobbles and boulders used to level the terrace interior. On the terrace surface is a pahoehoe slab with a human figure petroglyph. Shell midden fragments, waterworn basalt, and a reworked adze were present on the terrace surface. Possible postholes were also noted.

FEATURE B: Pahoehoe excavation
FUNCTION: Possible quarry
DIMENSIONS: 12.00 m by 8.00 m by 0.86 m (approx.)
DESCRIPTION: Feature consists of large boulders removed and placed around a pahoehoe depresssion. The excavation measures c. 2.5 m by 2.0 m by c. 0.54 m deep. The boulders are piled to the west of the excavation. Feature B is a raised area above and overlooking Feature A, terrace.

SITE NO.: State: 14184 **PHRI:** 770-36
SITE TYPE: Wall
TOPOGRAPHY: The terrain consists of sloping lava flows and aa rubble fields.
VEGETATION: Morning glory, *'opiuma, koa-haole,* castor bean, Christmas-berry.
CONDITION: Fair
INTEGRITY: Unaltered
PROBABLE AGE: Possible prehistoric
FUNCTIONAL INTERPRETATION: Boundary
DIMENSIONS: 229.00 m by 0.72 m by 0.67 m (approx.)
DESCRIPTION: This site consists of a bifaced wall oriented c. (E-W) and enters the project area at the eastern boundary and continues west to SIHP No. 14178, a complex on the south edge of the lava flow. The wall extends c. 2.0 m to 4.0 m from SIHP No. 14176, road. The wall is constructed of four to five courses of stacked subangular pahoehoe boulders and large cobbles. It is faced on two sides and rubble filled. Sections of the wall are presently collapsed.

SITE NO.: State: 14185 **PHRI:** 770-37
SITE TYPE: Cave
TOPOGRAPHY: The terrain consists of undulating aa.
VEGETATION: Christmas-berry, lantana, *pukiawe,* and *laua'e.*
CONDITION: Good
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Burial
DIMENSIONS: 157.00 m by 4.80 m by 5.00 m (approx.)
DESCRIPTION: This site consists of a natural lava tube and shows no signs of disturbance. The overall measurements are c._157.0 m long by 1.5 m to 4.8 m wide, and 1.2 m to 5.0+ m high.

Present in the cave are the remains of four human burials. Also present are candle wax (close to the first burial), charcoal fragments, a waterworn basalt boulder, and Crustacea. The Crustacea consists of parts of a large crab; there are claws interspersed throughout the cave from the entrance to the end of the cave. It appears unlikely that the Crustacea served as food since the meatiest body parts are intact. No other marine shell, fish, bird, or mammal remains are present. No obvious fires or disturbances were noted. Some possibilities worth considering may be that the Crustacea were possibly a part of the burial interment, or perhaps land crabs may have intruded into the cave. The cave is very moist and the skeletal material is very badly deteriorated.

Charcoal chunks scattered on the cave floor were collected. These charcoal fragments were not associated with *in situ* fires.

SITE NO.: State: 14186 **PHRI:** 770-38
SITE TYPE: Trail
TOPOGRAPHY: The terrain is sloping seaward and consists of pahoehoe flows and aa fields.
VEGETATION: Cactus, *koa-haole,* grasses, lantana, Christmas-berry, and ferns.
CONDITION: Good
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Transportation
DIMENSIONS: 198.00 m by 0.50-1.80 m (approx.)
DESCRIPTION: This site consists of a steppingstone trail built with pahoehoe slabs. It is oriented c. east-west (inland-seaward), is discontinuous and disappears at the flat outcrops. One section has kerbstones on each sides for a length of c. 7.8 m. The trail meanders along the northwest project boundary and passes across SIHP No. 14190, Feature B, terrace.

A piece of broken waterworn basalt (possible hammerstone) and three pieces of marine shell are near the trail. One piece of waterworn coral is southwest of the trail. A petroglyph is on one of the steppingstones.

The trail continues west c. 45 m and stops at a flat pahoehoe outcrop. The steppingstones continue some distance west in a discontinuous manner. At c. 32 m from the east end

FEATURE D: Platform
FUNCTION: Habitation
DIMENSIONS: 4.40 m by 3.70 m by 0.78 m maximum height (approx.)
DESCRIPTION: Raised on all four sides, the platform is square in plan. It is constructed with aa boulders, cobbles, and pebbles. Portions of the northeast and southeast sides are crudely faced two to three courses high. The interior surface of the platform is relatively flat.

The central portion of the platform has a possible trench or excavation through it: this trench/excavation measures c. 2.0 m by 1.0 m. It divides the platform into a north (inland) and south (seaward) portion. In addition, a pile of rocks measuring c. 1.75 m in diameter is situated c. 2.0 m from the northwest corner of Feature D.

FEATURE E: Stepped terrace
FUNCTION: Habitation
DIMENSIONS: 6.50 m by 4.20 m by 0.60 m (approx.)
DESCRIPTION: This stepped terrace is L-shaped with two tiers. The partially paved lower tier is a well defined one-course alignment oriented N-S. It is constructed of aa boulder, cobble, and pebble alignments. The higher terrace's platform consists of crudely piled stones. There is a quarry hole immediately north of Feature E.

FEATURE F: Wall
FUNCTION: Habitation
DIMENSIONS: 11.80 m by 1.00 m by 0.80 m (approx.)
DESCRIPTION: Feature F is a crudely stacked linear alignment. It is constructed with aa boulders, cobbles, and clinkers. The wall heights range from 0.20-0.80 m.

FEATURE G: C-shape
FUNCTION: Habitation
DIMENSIONS: 11.0 m by 11.0 m by 0.4 m (approx.)
DESCRIPTION: Feature G is a paved area enclosed by a C-shape alignment. The wall is constructed of piled and stacked aa boulders and cobbles. The wall width averages c. 0.65 m and the height ranges from 0.10-0.40 m. The paved area consists of aa pebbles and cobbles. There is a possible post hole at approximately the center of the paved area with wood fragments visible at the base of the hole. Fist-size branch coral, cowrie and Thaididae fragments were noted on the paved surface.

SITE NO.: State: 14178 **PHRI:** 770-30
SITE TYPE: Complex (2 Features)
TOPOGRAPHY: Sloping pahoehoe lava flows. Exposed aa flows to the west, with dense grass and koa-haole on the east covering flows that slope seaward
VEGETATION: *Koa haole*, monkey pod, grass, vines, and low ground cover.
CONDITION: Good
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Habitation
DESCRIPTION: The site complex consists of a modified outcrop (Feature A) and a terrace (Feature B). The overall complex area measures c. 13.0 m (at 250°) by 5.0 m (at 350°). The structures are constructed of aa boulders and cobbles in rough alignments atop natural bedrock. There are scattered shell fragments and a pebble-size coral fragment associated with the complex.

Features A and B are separated by c. 20.0 m of high (c. 1.0 m +) outcropping. There is a jeep trail c. 2.5 m to the east. SIHP No. 14184, wall, abuts Feature B, terrace.

Terracing on the southeast side of the flow, within vegetation area, adjoins (in places) features of SIHP No. 14177 on exposed flow to the west. Terracing on and at base of aa rubble.

FEATURE A: Modified outcrop
FUNCTION: Habitation
DIMENSIONS: 24.50 m by 5.00-10.00 m by 0.87 m (approx.)
DESCRIPTION: Angular and subangular cobbles and boulders are stacked
at the base of the outcrop and are aligned on the upper surface, creating a series of level, cobble-paved terraces. The height of the feature from the base of the outcrop is c. 0.30-0.40 m to c. 0.87 m at the upper level surface.

The terraces are roughly rectangular and follows the contour of the flow on its east side. There is a natural opening in the outcrop, at the southwest corner. The opening has pahoehoe slabs on the southwest and southeast sides forming a small cupboard c. 0.23 m deep. The outcrop is visible along much of the feature and several short cobble alignments are present on the flat level areas.

FEATURE B: Terrace
FUNCTION: Temporary habitation
DIMENSIONS: 9.20 m by 3.50 m by 0.90 m (approx.)
DESCRIPTION: Feature B is rectangular in plan. The east edge of the feature follows the contour of the aa flow (NNE-SSW) and has aa and pahoehoe cobbles and small boulders stacked two to three courses. The northeast end of the terrace meets an outcrop; the southwest end joins the end of a wall (SIHP Site 14184).

The terrace is constructed of angular and subangular pahoehoe and aa cobbles stacked at the base and on the edge of an outcrop. The terrace creates level and slightly sloping grass-covered areas to the west. Paved surfaces of SIHP Site 14177 extend to within c. 3.0 m of the level surface of terrace.

SITE NO.: State: 14179 *(Figure A-10)* **PHRI:** 770-31
SITE TYPE: Enclosure
TOPOGRAPHY: Undulating aa flow.
VEGETATION: *Koa-haole*, *'opiuma*, and lantana.
CONDITION: Fair-good
INTEGRITY: Unaltered
PROBABLE AGE: Historic/prehistoric
FUNCTIONAL INTERPRETATION: Agriculture/habitation
DIMENSIONS: 6.50 m by 4.10 m by 0.60 m (approx.)
DESCRIPTION: This site consists of a north-south oriented enclosure. It is constructed with aa boulders stacked in a linear alignment. There is a possible entrance in the northwest wall; a portion of the east wall is collapsed. A large *'opiuma* tree is growing out of the northeast wall of the enclosure. There is a field boundary wall c. 5.0 m west of the enclosure. A large Cypracidae scraper and Conidae shell were present c. 10.0-15.0 m downhill of the site.

The possible remnant of a structure's foundation is c. 2.0 m south of the south wall of the enclosure and consists of boulder alignments. This might have been an older structure from which stone material was taken to construct this enclosure.

SITE NO.: State: 14180 *(Figure A-11)* **PHRI:** 770-32
SITE TYPE: Complex (5 Features)
TOPOGRAPHY: The terrain consists of sloping aa flows.
VEGETATION: *Koa-haole*, *'opiuma*, Christmas-berry, and fountain grass.
CONDITION: Good
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Habitation-burial
DESCRIPTION: The site complex consists of a firepit (Feature A), two terraces (Features B and D), a platform (Feature C), and a cave (Feature E). The overall complex area measures c. 28.0 m (308°) by 15.0 m (42°).

FEATURE A: Rectangular boulder alignment
FUNCTION: Habitation-firepit
DIMENSIONS: 0.53 m by 0.25 m (interior measurements) with depth of 0.12-0.24 m from top of slabs to soil surface
DESCRIPTION: This rectangular boulder alignment (firepit) consists of four pahoehoe slabs set on edge and wedged in with three smaller pahoehoe cobbles at the corners. The slabs are c. 0.10-0.12 m thick and are embedded in the aa surface of Feature B, terrace. The top edge of the slabs rise c. 0.03 m above the surrounding aa. There is c. 0.05+ m of a dark brown loam which fills the entire inside basin.

FEATURE B: Terrace
FUNCTION: Habitation
DIMENSIONS: 16.00 m by 15.00 m by 1.03 m (approx.)
DESCRIPTION: This terrace is elevated and partially faced with a flat surface. It is constructed with mostly piled aa rubble and with aa boulder and cobble fill. The northwest corner is fairly well stacked, three to four courses high. Bedrock outcropping is visible along sections of the terrace and a small bedrock overhang is present in the ESE portion of the terrace. Feature A, firepit, is embedded in the flat aa surface of the terrace; Feature C, platform, is built on top of the terrace. A possible adze flake was located on the terrace surface.

FEATURE C: Stepped platform **OTHER NO:** 211
FUNCTION: Habitation
DIMENSIONS: 4.00 m by 3.00 m by 0.40 m (approx.)
DESCRIPTION: Feature C is rectangular in plan, and stepped or two-tiered. It is elevated on all four sides and is situated on top of Feature B, terrace, and is c. 2.6 m southeast of Feature A, firepit. The feature is constructed with aa boulder and cobble alignments along the perimeter and is filled with cobbles and pebbles to create a flat surface.

The northeast level of the platform measures c. 3.0 m by 2.5 m. The height along the northeast side ranges from 0.20-0.50 m. The surface is level and well paved. The southwest platform measures c. 3.0 m by 1.5 m. It ranges from 0.15 m to 0.40 m high. The surface is not as well paved; it is full of rubble and slopes toward the center. A metal washer was found wedged in a rock along the southeast side of the stepped platform. Numbers were visible on the washer but were not clear; the numbers read either "19818" or "196\8".

FEATURE D: Walled pavement **OTHER NO:** 212
FUNCTION: Habitation
DIMENSIONS: 10.90 m by 8.80 m by 0.25-0.75 m (approx.)
DESCRIPTION: Feature D consists of a flat surface paved with aa cobbles and pebbles, with cobble and pebble alignments on three sides. A well defined aa boulder and cobble wall is along the northeast. It is constructed with one to four courses of aa.

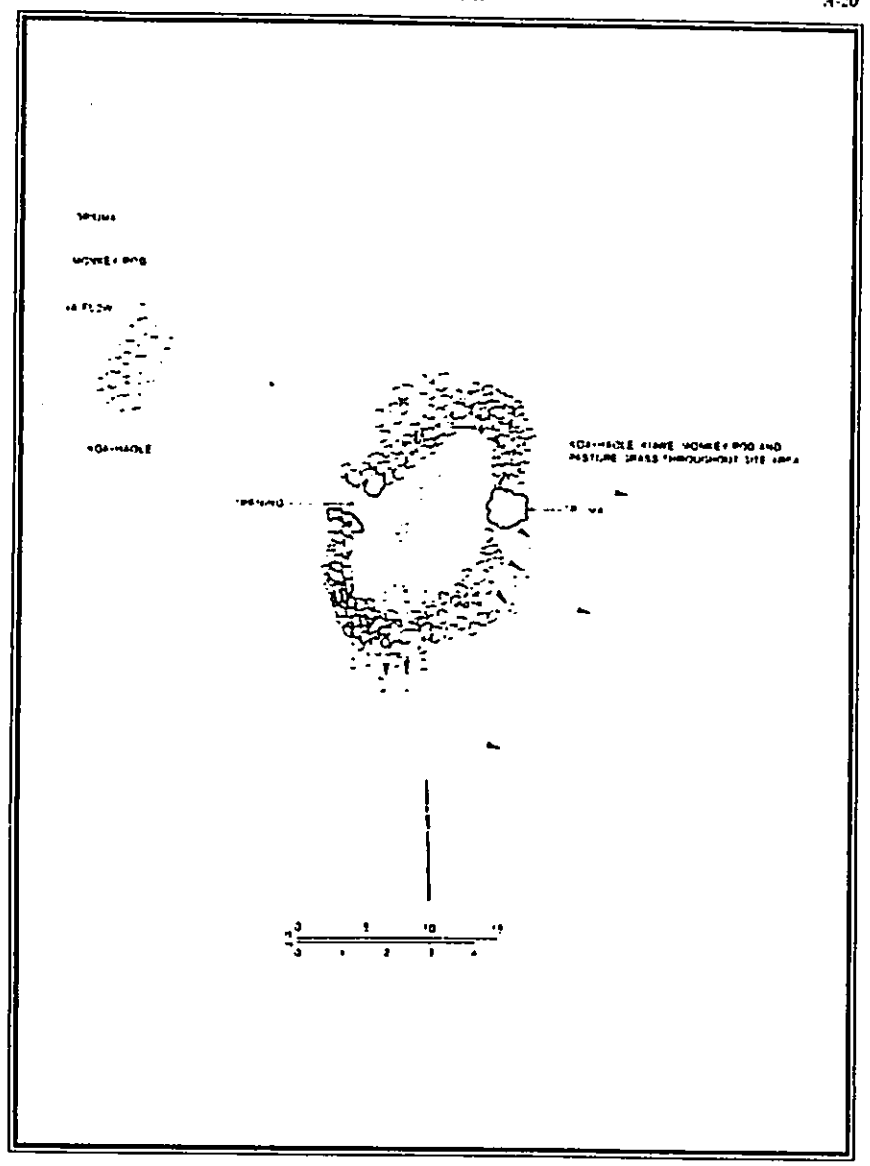

Figure A-10. Site 14179

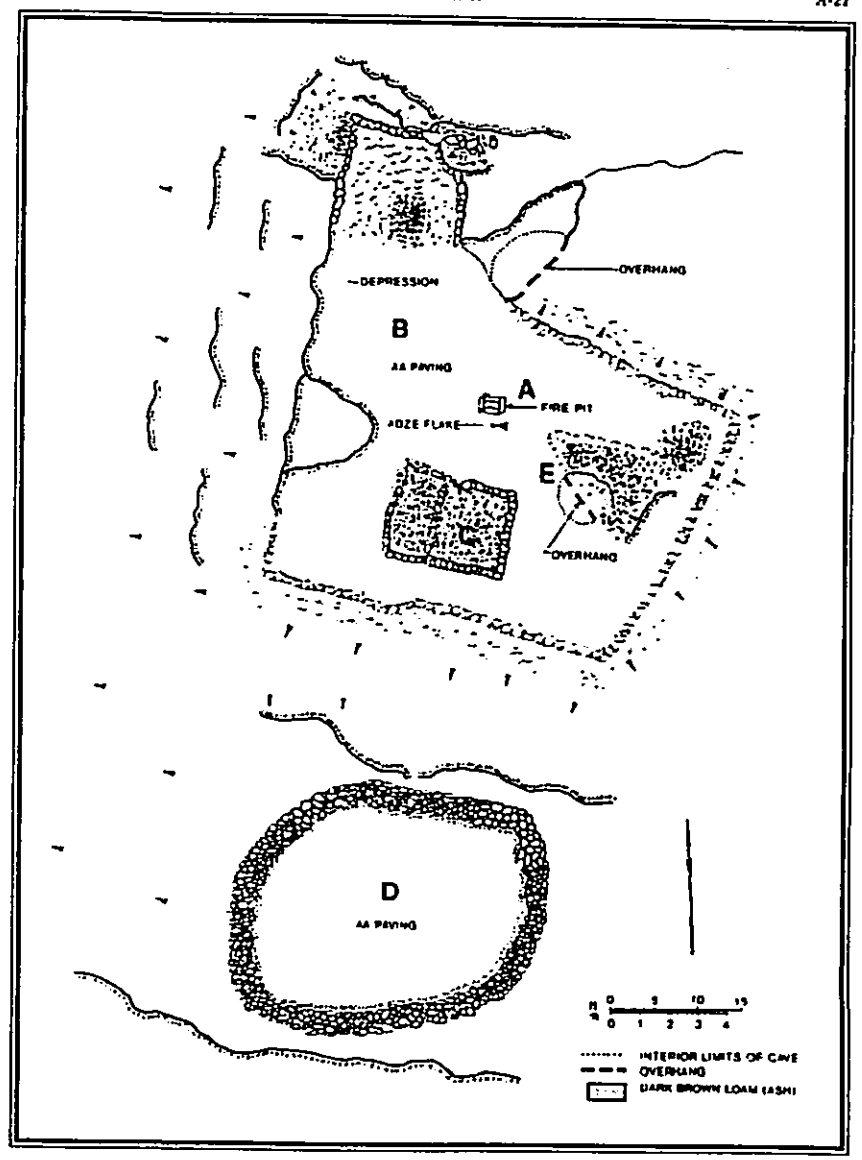

Figure A-11. Site 14180, Features A-E

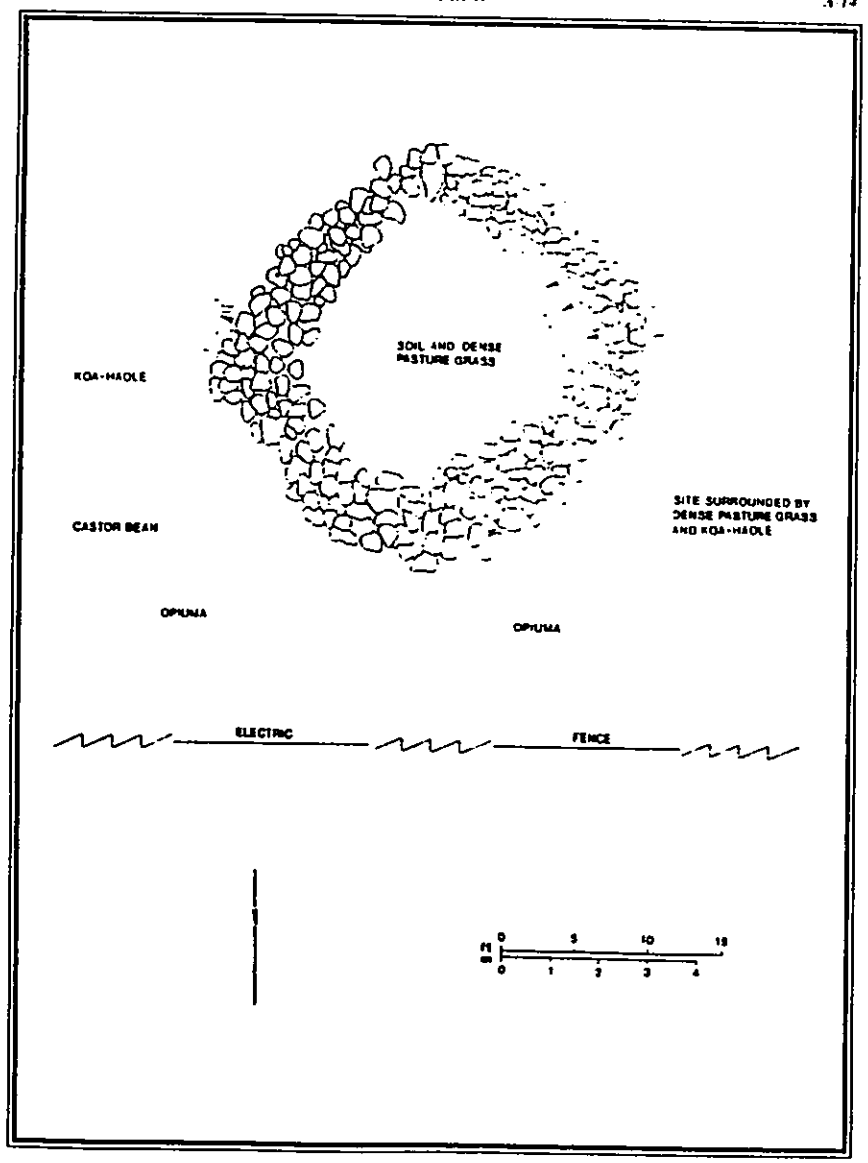

Figure A-8. Site 14170

FUNCTIONAL INTERPRETATION: Habitation/agriculture
DIMENSIONS: 8.80 m by 8.70 m by 0.83 m (approx.)
DESCRIPTION: This site consists of a somewhat oval enclosure. The long axis is oriented c. (NE-SW). The inland portion (NE) is collapsed and built up higher than the seaward (SW) end. The southwest end is somewhat more terraced than walled.

The enclosure is constructed with subangular and rounded pahoehoe boulders stacked three to five courses high. There is c. 0.2 m of soil deposit within the enclosure.

In addition, two agriculture terraces and a linear mound were visible to the northwest at c. 15.0 m from the site.

SITE NO.: State: 14171 *(Figure A-9)* PHRI: 770-23
SITE TYPE: Enclosure
TOPOGRAPHY: Undulating terrain consisting of pasture.
VEGETATION: Pasture grass, lantana, *'opiuma*, and *koa-haole*.
CONDITION: Good
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Habitation/agriculture
DIMENSIONS: 9.50 m by 7.00 m by 1.13 m (approx.)
DESCRIPTION: This site consists of an oval enclosure with the southwest *(makai)* end well faced and free standing. The height of the interior of the northeast *(mauka)* portion of the enclosure wall is c. 0.80 m high and the exterior is flushed or terraced with the uphill slope.

The enclosure is constructed with large rounded and subangular pahoehoe boulders. The stones are stacked four to six courses high and faced in places. The southwest wall is slightly collapsed possibly as a result of being trampled by cattle. The walls are well faced on the inside. They are well constructed and relatively higher; the enclosure may have functioned as an animal pen.

SITE NO.: State: 14172 PHRI: 770-24
SITE TYPE: Wall
TOPOGRAPHY: Undulating pasture terrain.
VEGETATION: Pasture grass and *koa-haole*.
CONDITION: Fair
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Boundary
DIMENSIONS: 40.00 m by 0.95 m by 1.00 m (approx.)
DESCRIPTION: This site consists of a crude but discrete free-standing wall. It is oriented c. 280° azimuth (east to west) and forms the south and southwest project boundary.

The wall is constructed of crudely stacked aa and pahoehoe, five to six courses high and partially faced in places. The wall is oriented counter to the direction of the slope. It lies c. 80 to 100 m east of an aa field.

SITE NO.: State: 14173 PHRI: 770-25
SITE TYPE: Terrace
TOPOGRAPHY: Undulating terrain consisting of pasture.
VEGETATION: Pasture grass and *koa-haole*.
CONDITION: Good
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Agriculture/habitation
DIMENSIONS: 8.0 m by 3.5-5.0 m by 0.53-1.2 m (approx.)
DESCRIPTION: This site consists of a terrace which extends across slope on a moderately steep grade; it is well faced along the seaward (SW) side and backed uphill with soil.

The terrace is constructed with large angular aa slabs and boulders crudely stacked and faced, two to three courses high along the southwest. The terrace interior is a leveled area paved with clinkers and small to medium aa cobbles. It is even with the ground surface along the north end.

SITE NO.: State: 14174 PHRI: 770-26
SITE TYPE: Terrace
TOPOGRAPHY: Undulating and improved pasture.
VEGETATION: Pasture grass and *koa-haole*.
CONDITION: Fair
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Agriculture
DIMENSIONS: 14.20 m by 13.00 m by 0.72 m (approx.)
DESCRIPTION: This site consists of a large crude boulder terrace along a southeast slope. It is situated c. 20.0 m southwest of an electric fence. There is another crude terrace c. 15.0 m to the southeast.

This site is constructed of large rounded and subangular decomposing pahoehoe boulders crudely stacked, not faced. Very crudely square, it is raised on the west, southwest, southeast, and a portion of the east side. The wall heights ranges from 0.32-0.72 m. The surface interior consists mostly of boulder and cobble rubble. Dense grass and koa-haole cover the north corner of the terrace area.

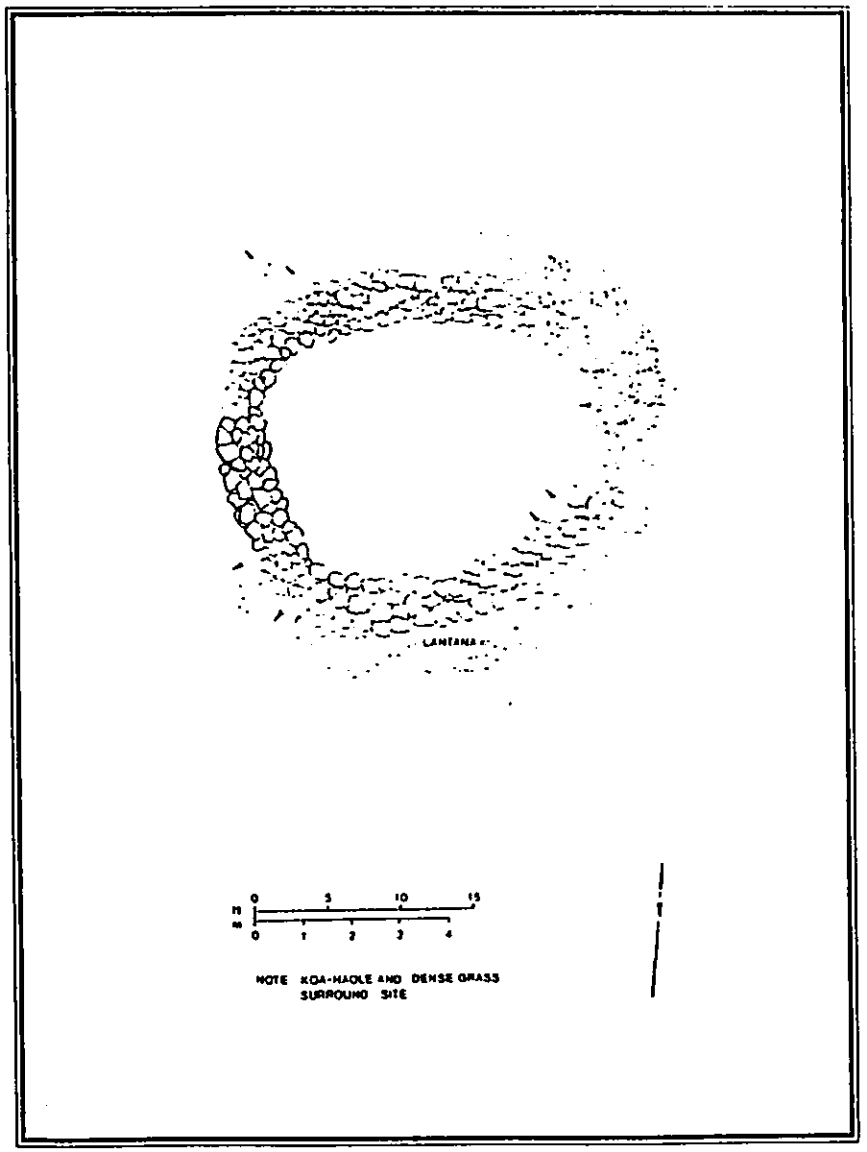

Figure A-9. Site 14171

SITE NO.: State: 14175 PHRI: 770-27
SITE TYPE: Wall
TOPOGRAPHY: Undulating terrain consisting of pahoehoe and aa flows.
VEGETATION: Pasture grass, *koa-haole*, and *'opiuma*.
CONDITION: Good
INTEGRITY: Unaltered
PROBABLE AGE: Historic
FUNCTIONAL INTERPRETATION: Boundary
DIMENSIONS: 427.0 m by 0.74-0.90 m by 1.02 m (approx.)
DESCRIPTION: The wall is oriented c. 230° azimuth and extends roughly (inland-seaward). The wall lies east of a inland-seaward jeep trail.

It is constructed of rounded and subangular pahoehoe boulders neatly stacked and well faced, four to six courses high. A section of the wall near an electrical fence was recorded. Approximately 20.0 m southwest of the electric fence, the wall has a low opening (pass through) at the base. A plank spans the opening. Cobbles are stacked on top of the plank. The wall at this point has large boulder foundation stones graduating to small medium size cobbles at the top. The wall is five to six courses and c. 1.13 m high at the opening.

SITE NO.: State: 14176 PHRI: 770-28
SITE TYPE: Road
TOPOGRAPHY: The terrain consists of pahoehoe and aa flows and has a seaward slope.
VEGETATION: Grass, *koa-haole*, *'opiuma*, morning glory, monkey pod, and grasses.
CONDITION: Fair
INTEGRITY: Indeterminate
PROBABLE AGE: Historic/possible prehistoric trail
FUNCTIONAL INTERPRETATION: Transportation
DIMENSIONS: 430.0 m by 3.50 m by 0.00 m (approx.)
DESCRIPTION: Oriented approximately NW-SE, it consists of a natural and unsurfaced road across pahoehoe outcrops and soil areas. It appears as two parallel paths worn in the soil and exposed bedrock. It extends from the upper highway and heads seaward. The road is labeled on a blueline map (1 inch=200 feet scale; prepared by Nelson & Wright) as a trail. It is presently used as a jeep road and horse riding trail. The road follows the route of an early historic cart road built prior to AD 1861 (Yent and Ota 1981:7).

SITE NO.: State: 14177 PHRI: 770-29
SITE TYPE: Complex (7 Features)
TOPOGRAPHY: Sloping aa lava flows.
VEGETATION: *Koa-haole*, *'opiuma*, Christmas-berry, fountain grass, and ground vines/creepers.
CONDITION: Good
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Habitation-transportation-boundary
DESCRIPTION: The overall complex area measures c. 33.0 m at 318° azimuth by 0.91 m at 218°. The site complex consists of two walls (Features A and F), a steppingstone trail (Feature B), an enclosure (Feature C), a platform (Feature D), a stepped terrace (Feature E), and a C-shape (Feature G).

There are numerous small agricultural features consisting of small piles of rocks; there area also single aa boulder alignments in the surrounding area.

FEATURE A: Wall
FUNCTION: Boundary
DIMENSIONS: 29.00 m by 20.0 m by 0.90 m (approx.)
DESCRIPTION: Feature A is in a U-shape configuration. The wall is constructed with stacked and piled boulders and clinkers. The wall is breached where the paved trail (Feature B) passes through. The wall turns seaward and parallels the trail. The wall width ranges from 0.90-1.0 m and the wall height ranges from 0.30-0.90 m.

FEATURE B: Steppingstone trail
FUNCTION: Transportation
DIMENSIONS: 200.00 m by 2.00 m (approx.)
DESCRIPTION: Feature B is a steppingstone trail that consists of numerous flat pahoehoe stones placed on aa flow. The trail is oriented c. north-south and extends between Feature A, wall, and Feature C, enclosure. The average size of the slabs is c. 0.30 m by 0.75 m.

FEATURE C: Enclosure
FUNCTION: Habitation
DIMENSIONS: 13.80 m by 13.00 m by 0.37 m (approx.)
DESCRIPTION: Feature C is circular to oval in plan. It is constructed with aa boulders, cobbles, and pebbles piled and stacked. The width of the wall ranges from 0.6-1.0 m and the height ranges from 0.15-0.37 m. The interior of the enclosure is a flat and level and consists of cobbles and aa pebble paving. Animal bone fragments are scattered around the interior of the enclosure.

Downslope and south of the enclosure is a flat paved surface area. This area measures c. 8.0 m by 5.0 m and is immediately adjacent to the enclosure.

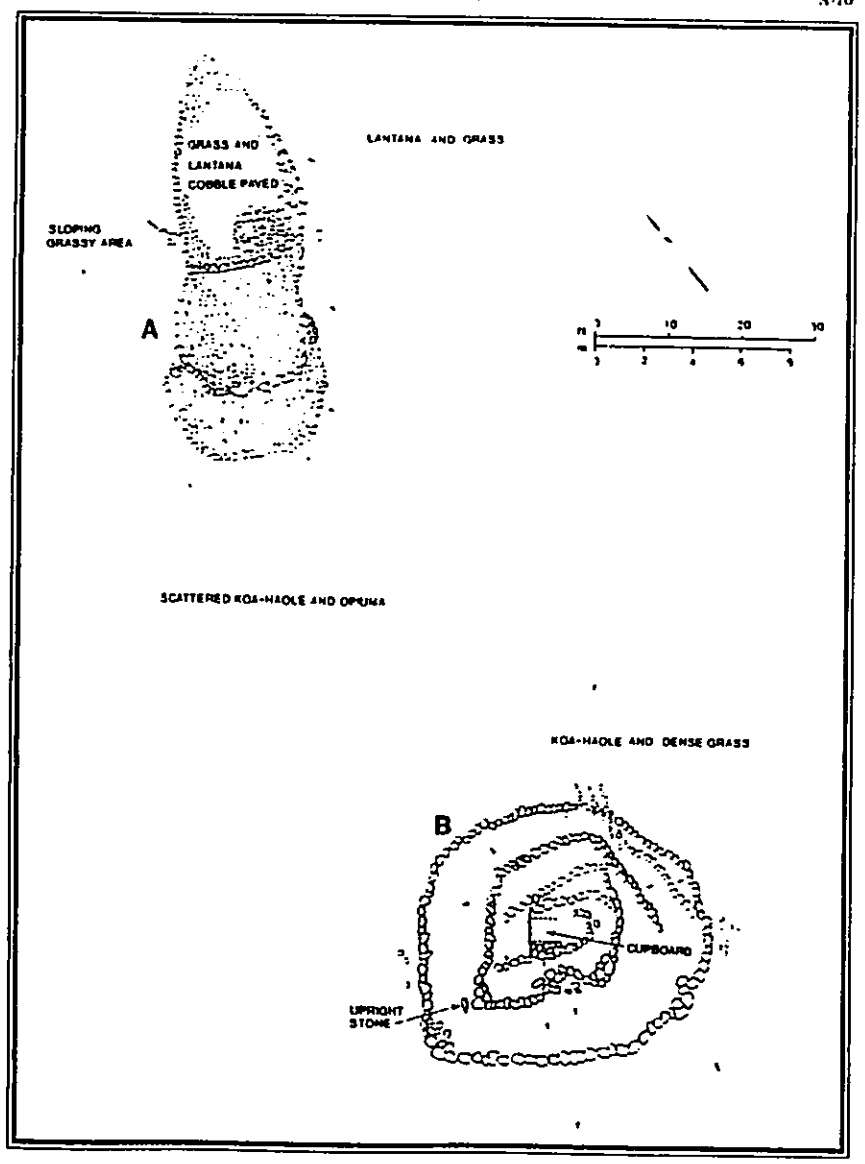

Figure A-5. Site 14164, Features A and B

wall lay on the surface. The outcrop has not been modified. At c. 30.0 m northward two roughly parallel *mauka-makai* walls are joined by a cross slope wall forming a U-shape—possibly a loading platform associated with pineapple/ranching activities outside the project area.

SITE NO.: State: 14166 **PHRI:** 770-18
SITE TYPE: Terrace
TOPOGRAPHY: The terrain is undulating and consists of improved pasture on decomposing pahoehoe bedrock outcrops.
VEGETATION: *Koa-haole*, pasture grass, and *'opiuma*.
CONDITION: Poor-fair
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Agriculture
DIMENSIONS: 17.00 m by 10.00 m by 0.62-0.82 m (approx.)
DESCRIPTION: This site consists of a large crude boulder terrace built along the east, south, and west slopes of a knoll, with a levelled area to the north. There is a crude, low free-standing wall extending off of the south portion of the terrace bearing c. 270° azimuth west, which ambles southwest then veers north and attaches to a crude rubble terrace c. 10.0 m to the northwest.

It is constructed of large rounded and subangular boulders, crudely stacked and filled (but not leveled) with medium and large cobbles. There is c. 0.10-0.15 m of an alluvial soil deposit on the north side of the terrace.

SITE NO.: State: 14167 *(Figure A-6)* **PHRI:** 770-19
SITE TYPE: Enclosure
TOPOGRAPHY: Slopping pahoehoe flow.
VEGETATION: *Koa-haole, 'opiuma*, lantana, and grass.
CONDITION: Good
INTEGRITY: Altered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Habitation
DIMENSIONS: 5.50 m by 5.50 m by 0.50-1.24 m (approx.)
DESCRIPTION: Square in plan, the enclosure is constructed with two to four courses of pahoehoe boulders and cobbles. It is well faced and appears core-filled where the wall is not crumbled.

The seaward (SSW) alignment is a possible terrace or collapsed wall. The wall has been breached c. 1.0 m near the southeast corner along the *mauka* alignment. A terrace abuts the north corner of the site and extends at c. 300° for an undetermined distance. There is soil within the interior and surrounding the structure.

SITE NO.: State: 14168 *(Figure A-7)* **PHRI:** 770-20
SITE TYPE: Terrace
TOPOGRAPHY: Undulating terrain consisting of pasture on an older decomposing pahoehoe lava flow.
VEGETATION: *Koa-haole* and *'opiuma*.
CONDITION: Good
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Agriculture/habitation
DIMENSIONS: 13.00 m by 7.0-10.00 m by 0.22-1.65 m (approx.)
DESCRIPTION: This site consists of a very well constructed terrace built along the southeast and southwest sides of a moderate slope with a low boulder alignment along the northeast and northwest sides nearly encircling a rectangular soil filled area.

The site is constructed with subangular and rounded decomposing pahoehoe boulders and large cobbles, crudely stacked. Raised along the southern half, it is almost level with the rectangular soil filled area to the north.

SITE NO.: State: 14169 **PHRI:** 770-21
SITE TYPE: Terrace
TOPOGRAPHY: Slopping pahoehoe lava flow and pasture.
VEGETATION: *Koa-haole*, lantana, and pasture grass.
CONDITION: Good
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Habitation/agriculture
DIMENSIONS: 15.00 m by 7.50 m by 0.80 m (approx.)
DESCRIPTION: The terrace is J-shaped in plan and is oriented c. NE-SW. It is constructed of pahoehoe boulders and sits atop a bedrock flow. The terrace interior consists of boulder and cobble fill. There is a depression within the southwest end of the terrace. A small pahoehoe boulder pile is located immediately north of the site and measures c. 3.5 m in length, 2.0 m in width, and is c. 0.50 m high.

SITE NO.: State: 14170 *(Figure A-8)* **PHRI:** 770-22
SITE TYPE: Enclosure
TOPOGRAPHY: Undulating terrain consisting of improved pasture.
VEGETATION: Pasture grass, *'opiuma, koa-haole, 'ilima*, pig weed, castor bean and Christmas-berry.
CONDITION: Fair-good
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric

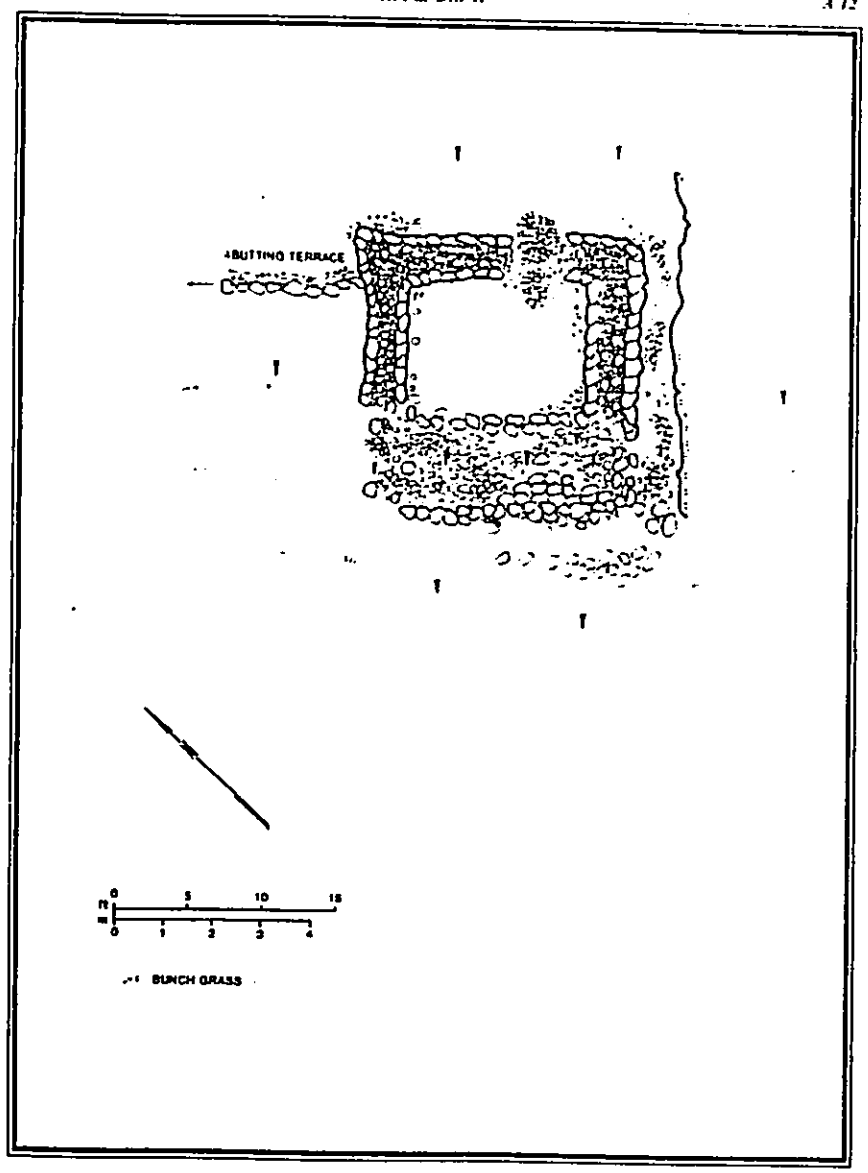

Figure A-6. Site 14167

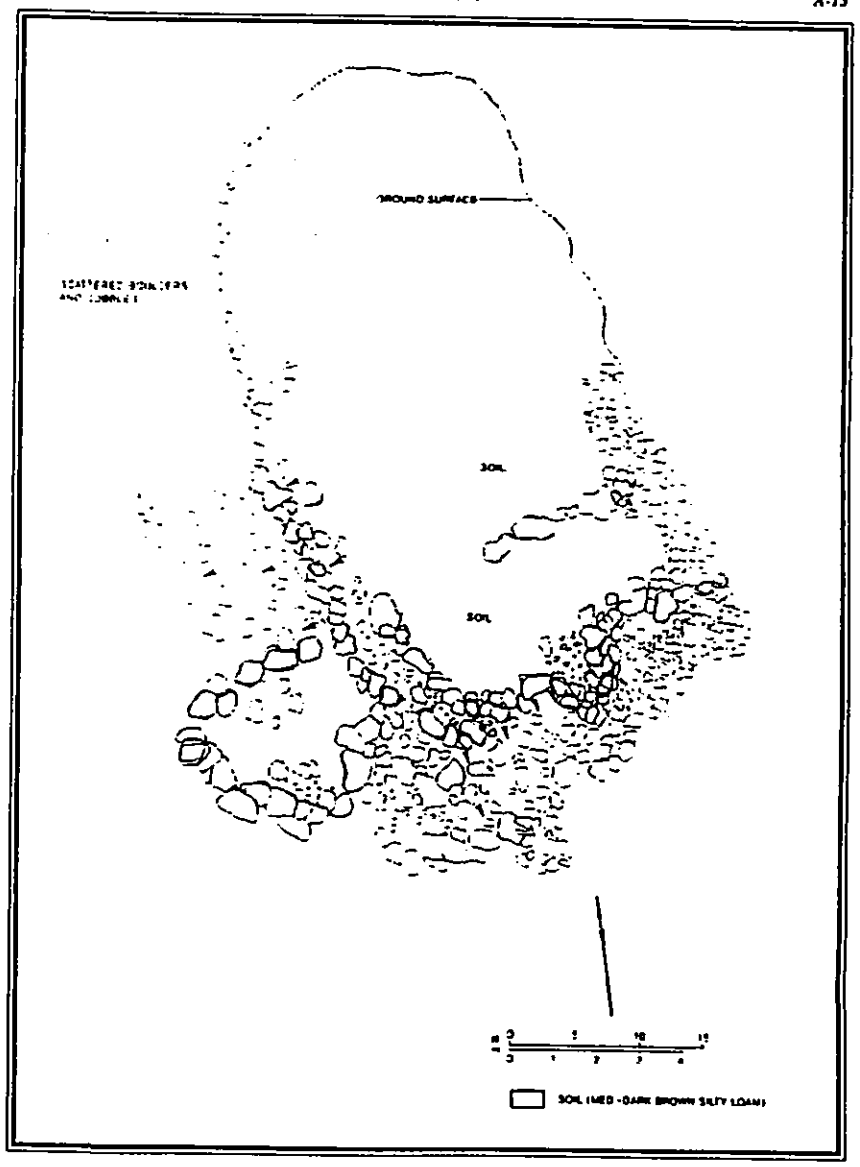

Figure A-7. Site 14168

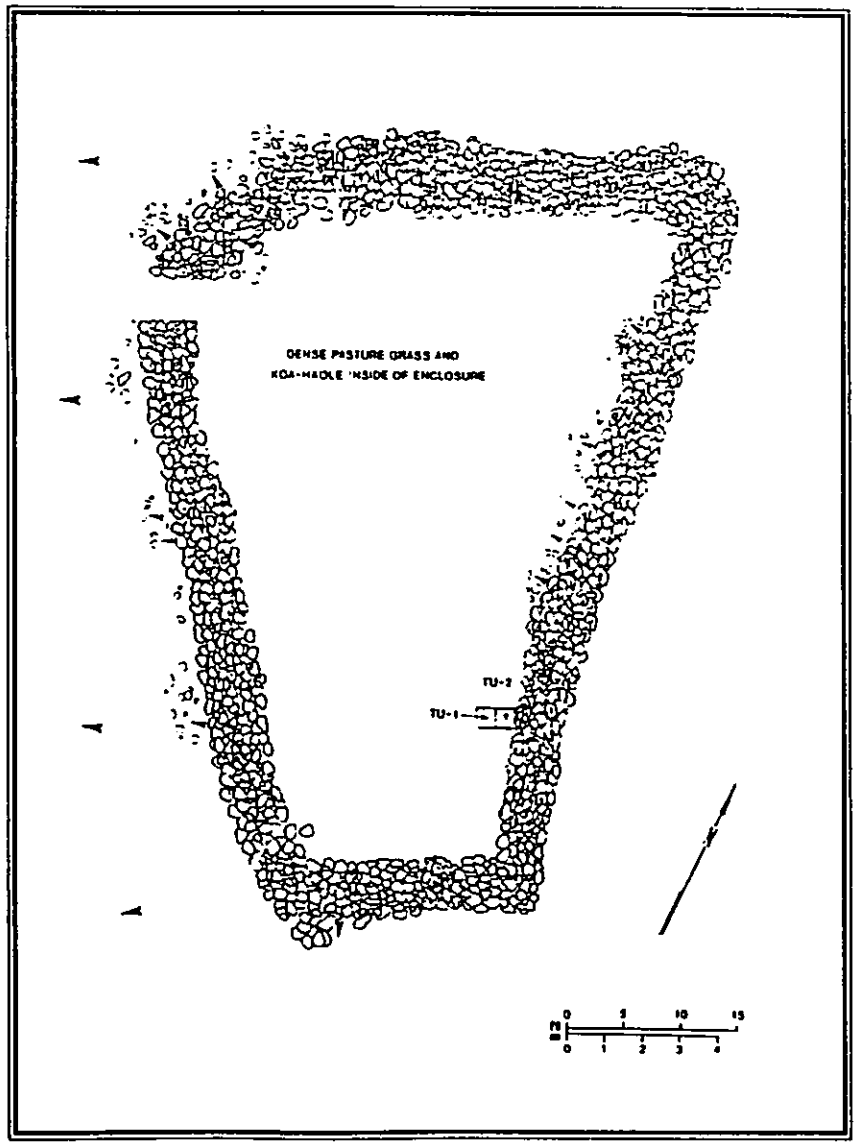

Figure A-3. Site 14158

INTEGRITY: Altered
PROBABLE AGE: Prehistoric-possibly historic
FUNCTIONAL INTERPRETATION: Boundary
DIMENSIONS: 6.50-40.0 m by 2.80 m by 0.35-0.95 m (approx.)
DESCRIPTION: This site consists of an inland-seaward oriented wall segment. It is constructed of piled pahoehoe boulders and cobbles. A portion of the south side of the wall is well faced with two to three courses of pahoehoe boulders and cobbles. In general, the wall is mostly rubble except for the faced portion. A possible terrace abuts the wall on the north side and extends at c. 300° azimuth for an undetermined distance.

The wall continues upslope and downslope for at least 40.0 m. The site is located c. 35.0 m at 280° azimuth from SIHP No. 14156 (PHRI 770-5).

SITE NO.: State: 14160 (*Figure A-4*) PHRI: 770-12
SITE TYPE: Enclosure
TOPOGRAPHY: Undulating terrain
VEGETATION: Pasture grass, *koa-haole*, and *'opiuma*.
CONDITION: Poor-fair
INTEGRITY: Altered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Habitation/agriculture
DIMENSIONS: 9.80 m by 5.25-8.25 m by 1.11 m (approx.)
DESCRIPTION: This site consists of a crude collapsing oval enclosure with the long axis oriented perpendicular to the direction of the slope. The enclosure is constructed of large subangular and rounded decomposing pahoehoe boulders, aligned and crudely stacked three to five courses high. The wall width ranges from 1.0-2.0 m and the heights range from 0.48-1.11 m. It is collapsed along the northeast wall. One coral cobble was present on the east wall.

SITE NO.: State: 14161 PHRI: 770-13
SITE TYPE: Terrace
TOPOGRAPHY: Undulating pahoehoe and pasture with a gentle to steep slope.
VEGETATION: *Koa-haole*, *'opiuma*, pasture grass, and castor bean.
CONDITION: Fair
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric-historic
FUNCTIONAL INTERPRETATION: Habitation
DIMENSIONS: 7.50 m by 7.00 m by 0.21-0.90 m (approx.)
DESCRIPTION: This site consists of a crude terrace; the terrace is raised along the south side, slopes gently on the east and west sides, and is soil-filled to the north. It is constructed of small to large boulders, crudely stacked to form a rough circle. The terrace platform is level and filled with cobbles and pebbles. A possible cupboard was noted on the south side of the terrace.

There are additional linear mounds/terraces, that appear to be land clearings, c. 15 m to 20 m to the northeast. At c. 20 m inland of the terrace is a field boundary (*kuaiwi*) wall that extends seaward into the site. There is an electric cattle fence immediately adjacent to the south.

SITE NO.: State: 14162 PHRI: 770-14
SITE TYPE: Wall
TOPOGRAPHY: Undulating terrain.
VEGETATION: *Koa-haole*, *'opiuma*, and dense pasture grass.
CONDITION: Fair-good
INTEGRITY: Unaltered-to slightly altered
PROBABLE AGE: Prehistoric-historic
FUNCTIONAL INTERPRETATION: Agriculture/boundary
DIMENSIONS: 75.00 m by 70.00 m by 1.18 m (approx.)
DESCRIPTION: This site consists of a wall that commences from the east bearing west at 300° azimuth for c. 55.0 m, where it attaches to and is intersected with a *mauka-makai* wall oriented at c. 35°/215°. The wall continues beyond the intersection at 300° (perpendicular to the direction of the slope for an undetermined distance). At the point of intersection, the wall bears seaward at c. 215° azimuth, is formally faced and continues. The inland portion of this wall (at 35°) is crude and collapsed and is built atop decomposing bedrock.

The wall is generally constructed of large subangular and rounded decomposing pahoehoe boulders. It is stacked and faced along some sections. There is a possible road bed *mauka* of and parallel to the E-W portion of the wall (probably associated with the pineapple/ranching activities outside the project area).

SITE NO.: State: 14163 PHRI: 770-15
SITE TYPE: Modified outcrop
TOPOGRAPHY: Pahoehoe and aa flows sloping seaward.
VEGETATION: *Koa-haole*, dense grass, and *'opiuma*.
CONDITION: Good
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Agriculture
DIMENSIONS: 4.50 m by 3.20 m (approx.)

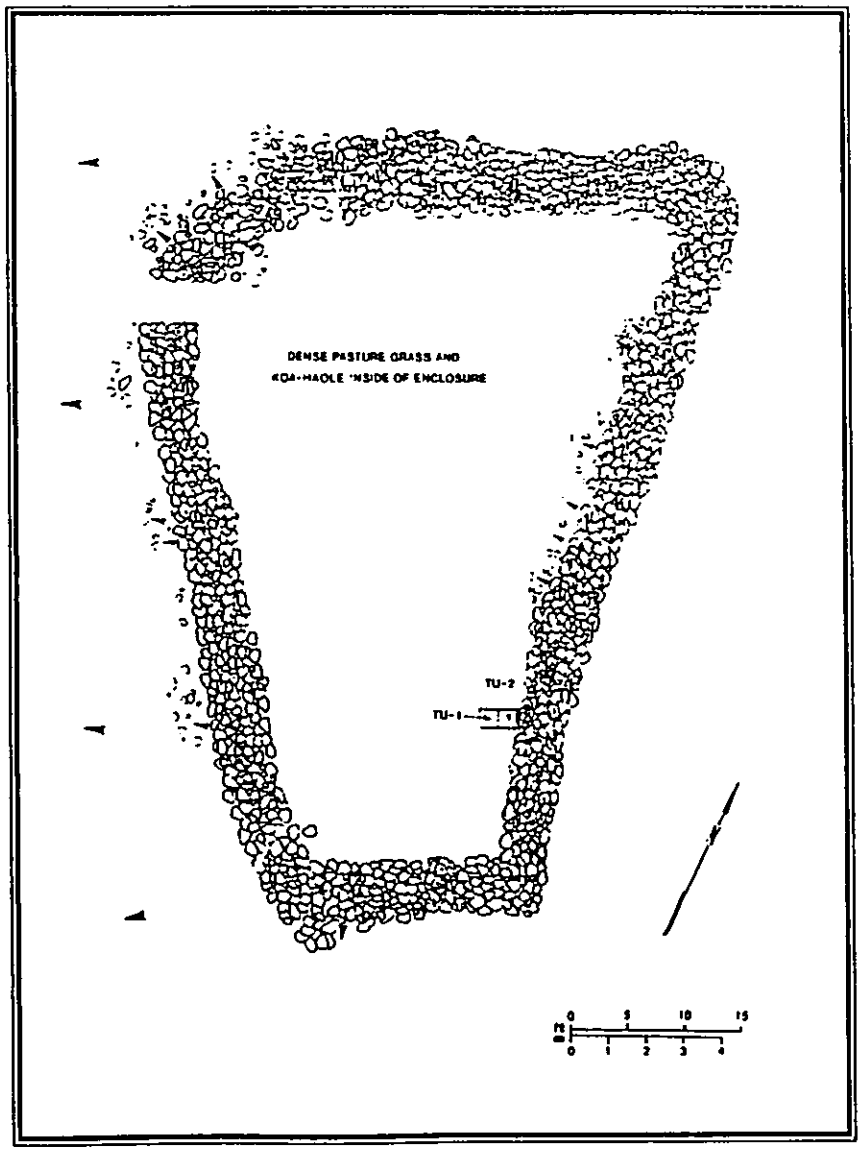

Figure A-3. Site 14158

INTEGRITY: Altered
PROBABLE AGE: Prehistoric-possibly historic
FUNCTIONAL INTERPRETATION: Boundary
DIMENSIONS: 6.50-40.0 m by 2.80 m by 0.35-0.95 m (approx.)
DESCRIPTION: This site consists of an inland-seaward oriented wall segment. It is constructed of piled pahoehoe boulders and cobbles. A portion of the south side of the wall is well faced with two to three courses of pahoehoe boulders and cobbles. In general, the wall is mostly rubble except for the faced portion. A possible terrace abuts the wall on the north side and extends at c. 300° azimuth for an undetermined distance.

The wall continues upslope and downslope for at least 40.0 m. The site is located c. 35.0 m at 280° azimuth from SIHP No. 14156 (PHRI 770-5).

SITE NO.: State: 14160 *(Figure A-4)* **PHRI: 770-12**
SITE TYPE: Enclosure
TOPOGRAPHY: Undulating terrain
VEGETATION: Pasture grass, *koa-haole*, and *'opiuma*.
CONDITION: Poor-fair
INTEGRITY: Altered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Habitation/agriculture
DIMENSIONS: 9.80 m by 5.25-8.25 m by 1.11 m (approx.)
DESCRIPTION: This site consists of a crude collapsing oval enclosure with the long axis oriented perpendicular to the direction of the slope. The enclosure is constructed of large subangular and rounded decomposing pahoehoe boulders, aligned and crudely stacked three to five courses high. The wall width ranges from 1.0-2.0 m and the heights range from 0.48-1.11 m. It is collapsed along the northeast wall. One coral cobble was present on the east wall.

SITE NO.: State: 14161 PHRI: 770-13
SITE TYPE: Terrace
TOPOGRAPHY: Undulating pahoehoe and pasture with a gentle to steep slope.
VEGETATION: *Koa-haole*, *'opiuma*, pasture grass, and castor bean.
CONDITION: Fair
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric-historic
FUNCTIONAL INTERPRETATION: Habitation
DIMENSIONS: 7.50 m by 7.00 m by 0.21-0.90 m (approx.)
DESCRIPTION: This site consists of a crude terrace; the terrace is raised along the south side, slopes gently on the east and west sides, and is soil-filled to the north. It is constructed of small to large boulders, crudely stacked to form a rough circle. The terrace platform is level and filled with cobbles and pebbles. A possible cupboard was noted on the south side of the terrace.

There are additional linear mounds/terraces, that appear to be land clearings, c. 15 m to 20 m to the northeast. At c. 20 m inland of the terrace is a field boundary (*kuaiwi*) wall that extends seaward into the site. There is an electric cattle fence immediately adjacent to the south.

SITE NO.: State: 14162 PHRI: 770-14
SITE TYPE: Wall
TOPOGRAPHY: Undulating terrain.
VEGETATION: *Koa-haole*, *'opiuma*, and dense pasture grass.
CONDITION: Fair-good
INTEGRITY: Unaltered-to slightly altered
PROBABLE AGE: Prehistoric-historic
FUNCTIONAL INTERPRETATION: Agriculture/boundary
DIMENSIONS: 75.00 m by 70.00 m by 1.18 m (approx.)
DESCRIPTION: This site consists of a wall that commences from the east bearing west at 300° azimuth for c. 55.0 m, where it attaches to and is intersected with a *mauka-makai* wall oriented at c. 35°/215°. The wall continues beyond the intersection at 300° (perpendicular to the direction of the slope for an undetermined distance). At the point of intersection, the wall bears seaward at c. 215° azimuth, is formally faced and continues. The inland portion of this wall (at 35°) is crude and collapsed and is built atop decomposing bedrock.

The wall is generally constructed of large subangular and rounded decomposing pahoehoe boulders. It is stacked and faced along some sections. There is a possible road bed *mauka* of and parallel to the E-W portion of the wall (probably associated with the pineapple/ranching activities outside the project area).

SITE NO.: State: 14163 PHRI: 770-15
SITE TYPE: Modified outcrop
TOPOGRAPHY: Pahoehoe and aa flows sloping seaward.
VEGETATION: *Koa-haole*, dense grass, and *'opiuma*.
CONDITION: Good
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Agriculture
DIMENSIONS: 4.50 m by 3.20 m (approx.)

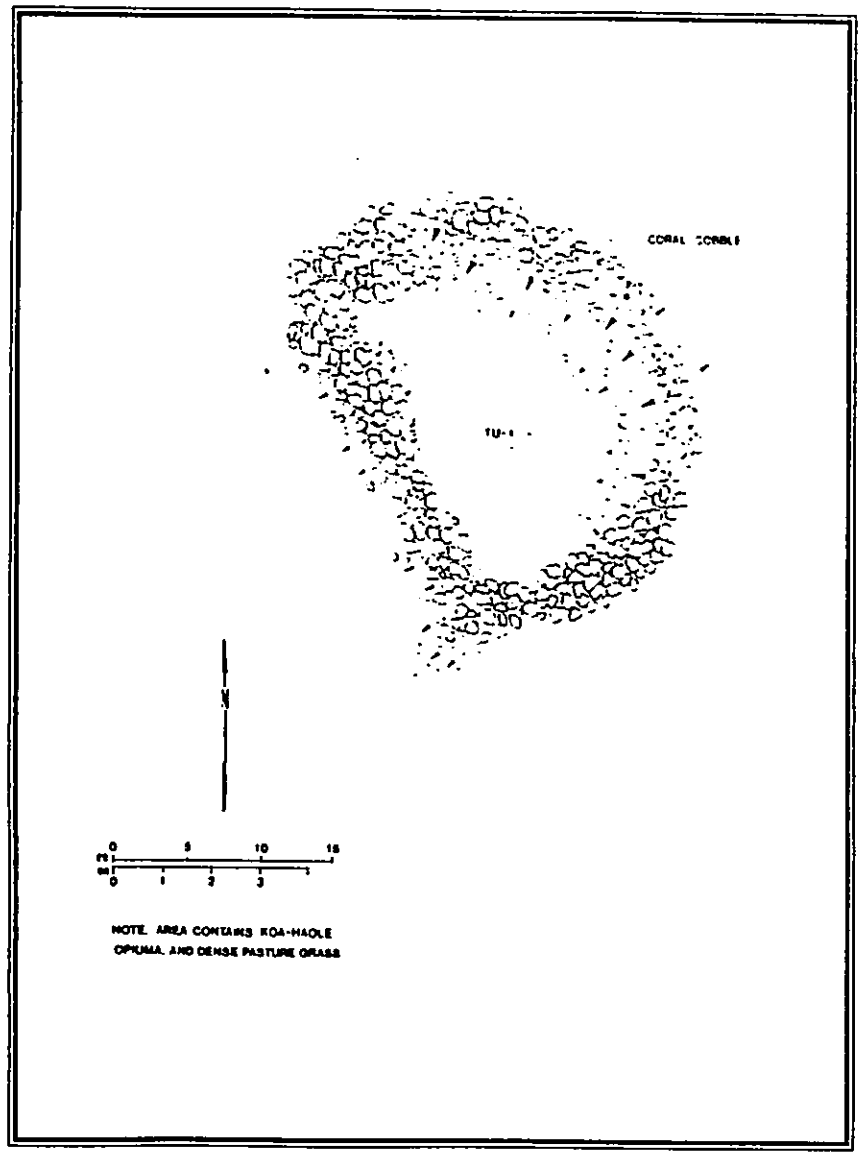

Figure A-4. Site 14160

DESCRIPTION: Somewhat rectangular in plan with no defining lines. Sloping with the terrain. The outcrop has one layer of cobbles around the edges and a pile of stones two high in the center and toward the southeast end. The surface is sloping and uneven and the northwest end is on a low sloping outcrop surface. The southeast end contains loosely piled cobbles.

SITE NO.: State: 14164 PHRI: 770-16
SITE TYPE: Complex (2 Features)
TOPOGRAPHY: Outcrops sloping seaward.
VEGETATION: *Koa-haole*, dense grass, *'opiuma*, and lantana.
CONDITION: Good
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Habitation
DESCRIPTION: The site consists of two terraces (Features A and B). The overall site complex measures c. 61 m (NE-SW) by 7-12 m (SE-NW). No definite cultural deposit visible, but possibly present subsurface of the terraces.

FEATURE A: Terrace *(Figure A-5)*
FUNCTION: Habitation
DIMENSIONS: 16.20 m by 6.70 m by 0.83 m (approx.)
DESCRIPTION: Feature A is stepped, with boulder and cobble alignments separating the terrace into three terrace levels, rising to the north. The northeast end of the feature abuts the base of a sloping rubble pile. The north end is level with the surrounding surface.

The terrace is constructed of angular and subangular basalt cobbles and boulders piled to form a sloping east side. The east side of the feature has no vertical face. Cobbles and boulders are stacked three to five courses high on the southwest and southeast sides. The terrace platforms are paved with small basalt cobbles confined at the southeast ends by larger subangular cobbles and pahoehoe slabs. The lower terrace surface slopes slightly toward the elevated southeast face.

The upper terrace measures c. 8.0 m by 5.0 m and is 0.42 - 0.85 m high. There is a depression measuring c. 0.60 m by 0.70 m near the southwest edge. The middle terrace measures c. 6.0 m by 5.0 m and 0.33 to 0.67 m high. The lower terrace measures c. 6.5 m by 2.0-4.5 m wide and with heights ranging from 0.40-0.83 m.

FEATURE B: Terrace *(Figure A-5)*
FUNCTION: Habitation
DIMENSIONS: 12.20 m by 10.40 m by 1.12 m (approx.)
DESCRIPTION: Feature B is a stepped terrace with an internal cupboard feature located in an opening of pahoehoe outcrop. The central upper terrace has a level cobble-paved upper surface constructed around the cupboard feature and the small opening in the bedrock outcrop. The irregular upper terrace is bordered by alignments of large cobbles and small boulders. A rectangular depression, sloping toward the cupboard, appears to be bordered by aligned cobbles.

The terrace is constructed of subangular boulders stacked four courses high; the boulders form the faced south and southwest edges of the lower terrace. The north and the northwest edges are level with the ground surface. The slightly sloping surface is paved with small to medium cobbles.

The terrace has been constructed around a pahoehoe outcrop with the upper terrace raised above the outcrop surface. The upper terrace has a level surface paved with small irregular cobbles. The south and southwest sides rise c. 0.65 m to 0.84 m above the lower terrace but are not formally faced along the irregular shaped terrace edge.

SITE NO.: State: 14165 PHRI: 770-17
SITE TYPE: Wall
TOPOGRAPHY: Sloping pahoehoe flows and aa fields under grass cover.
VEGETATION: Dense grasses, *'opiuma, koa-haole.*
CONDITION: Fair
INTEGRITY: Unaltered
PROBABLE AGE: Historic
FUNCTIONAL INTERPRETATION: Agriculture/boundary
DIMENSIONS: 12.50 m by 1.30 m by 0.65 m (approx.)
DESCRIPTION: This site consists of a wall, not formally faced, but with a faced section at the seaward end. The general direction of the wall is NE-SW curving to a short (c. 12 m) section extending east to west. Most of the wall is buried under dense grass; however, the wall was traced northeast for c. 10 m and continues inland.

The wall is constructed with subangular aa boulders and large cobbles. It is roughly faced on two sides with small cobble fill. The wall varies in all dimensions—it has irregular heights and widths; it is usually low and wide with loosely piled and weathered boulders. There is much collapse near the southwest end of the wall, probably from cattle, since there are cattle trails in the area.

A short seaward section of the wall extends across a pahoehoe outcrop where cobbles from the collapsed in the

APPENDIX A

SITE DESCRIPTIONS

SITE NO.: State: 13657 PHRI: 770-1
SITE TYPE: Wall
TOPOGRAPHY: Gently undulating soil and boulder terrain sloping seaward (west).
VEGETATION: Monkey pod, *'opiuma*, grasses, *koa-haole*.
CONDITION: Good
INTEGRITY: Possibly altered; the wall may be prehistoric, and rebuilt historically for ranching.
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Boundary
DIMENSIONS: 335.0 m minimum length by 1.00 m by 0.70 m (approx.)
DESCRIPTION: The wall is constructed with weathered subangular basalt boulders stacked five to six courses high. Although the wall is raised and formally faced on both sides, it does not appear to be of a bifaced, core-fill type construction. The width of the wall ranges from c. 0.6-0.7 m and the height ranges from c. 0.8-1.0 m.

The wall is not built in a straight line, but it curves and meanders along the southeast boundary. It is oriented c. 50°/ 230° azimuth. It extends the entire width of the project area's southeast boundary and continues to the northeast and southwest. The wall may be a prehistoric wall rebuilt historically.

SITE NO.: State: 13658 *(Figure A-1)* PHRI: 770-2
SITE TYPE: Complex (14 Features)
TOPOGRAPHY: Undulating pasture on older decomposing pahoehoe flow.
VEGETATION: *'Opiuma*, pasture grass, *koa-haole*, lantana.
CONDITION: Fair-good
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Agriculture
DESCRIPTION: The recorded complex area measures c. 105.0 m (N-S) by 50.0 m (E-W). The site complex consists of three linear alignments (Features A, B, and D), seven terraces (Features C, E to I, and K), and four mounds (Feature J).

This site represents a small sample of the extensive agricultural Kona Field System (SIHP No. 6601), of which the project area is a part. The linear alignments (Features A, B, and D) appear to be inland-seaward field boundary (*kuaiwi*) remnants of the Kona Field System.

FEATURE A: Linear alignment
FUNCTION: Agriculture
DIMENSIONS: 54.00 m by 2.00 m by 0.56 m (approx.)
DESCRIPTION: Feature A is oriented approximately north-south (*mauka-makai*). It is constructed of medium to large aa and pahoehoe boulders which lie on a decomposing natural pahoehoe outcrop. The width ranges from 1.0-2.0 m wide and the heights ranges from 0.10-0.56 m high. Portions of the alignment are raised. Other sections are collapsed and intermittent.

FEATURE B: Linear alignment
FUNCTION: Agriculture
DIMENSIONS: 65.00 m by 1.25 m by 1.58 m (approx.)
DESCRIPTION: Feature B is generally oriented north-south (*mauka-makai*). It is constructed of medium to large aa and pahoehoe boulders and cobbles which lie on a decomposing natural pahoehoe outcrop. The width ranges from 0.35 m to 1.25 m. The height ranges from 0.12 m to 1.58 m. Portions of the alignment are raised. Other sections are collapsed and intermittent.

FEATURE C: Terrace
FUNCTION: Agriculture
DIMENSIONS: 46.00 m by 2.00 m by 0.72 m (approx.)
DESCRIPTION: This is a cross slope terrace aligned east to west and perpendicular to the direction of the slope. The uphill (north) portion is somewhat level and is filled with an alluvial deposit of soil. The retaining wall is constructed of subangular and rounded medium to large pahoehoe and aa boulders in a crude linear alignment. The width ranges from 1.0-2.0 m wide and the height ranges from 0.33-0.72 m.

FEATURE D: Linear alignment
FUNCTION: Agriculture
DIMENSIONS: 89.00 m by 1.10 m by 0.45 m (approx.)
DESCRIPTION: This is a north to south (*mauka-makai*) oriented linear alignment. It is constructed of crudely piled medium to large aa and pahoehoe boulders and is atop a natural decomposing pahoehoe outcrop. The height of Feature D ranges from 0.10-0.45 m. There is at least 0.20 m of soil on the east and west sides.

FEATURE E: Terrace
FUNCTION: Agriculture
DIMENSIONS: 15.75 m by 1.80 m by 0.82 m (approx.)
DESCRIPTION: Feature E is a cross slope terrace aligned east to west, perpendicular to the direction of the slope. The uphill north portion is somewhat level and is filled with an alluvial deposit of soil. The retaining wall is constructed of subangular and rounded medium to large pahoehoe and aa boulders placed in a crude linear alignment. It is c. 0.6-1.8 m wide and 0.3-0.82 m high. There is at least 0.20 m of an alluvial soil deposit to the north (uphill).

FEATURE F: Terrace
FUNCTION: Agriculture
DIMENSIONS: 5.50 m by 1.50 m by 0.45 m (approx.)
DESCRIPTION: This is a cross slope terrace aligned east to west and perpendicular to the direction of the slope. The uphill (north) portion is somewhat level and is filled with an alluvial deposit of soil (c. 0.20 m). The retaining wall is constructed of subangular pahoehoe and aa boulders and cobbles placed in a crude linear alignment. The wall width is c. 1.0-1.5 m wide and the height is c. 0.17-0.45 m high.

FEATURE G: Terrace
FUNCTION: Agriculture
DIMENSIONS: 2.50 m by 1.25 m by 0.52 m (approx.)
DESCRIPTION: This is a cross slope terrace aligned east to west and perpendicular to the direction of the slope. The uphill (north) portion is somewhat level and is filled with an alluvial deposit of soil (c. 0.20 m thick). The retaining wall is constructed of subangular medium to large pahoehoe and aa boulders and cobbles which have been crudely aligned. The heights ranges from 0.11-0.52 m.

FEATURE H: Terrace
FUNCTION: Agriculture
DIMENSIONS: 9.50 m by 1.95 m by 0.78 m (approx.)
DESCRIPTION: Feature H is a cross slope terrace aligned east to west and perpendicular to the direction of the slope. The uphill (north) portion is somewhat level and is filled with an alluvial soil deposit. The width of the wall ranges from 1.20 m to 1.95 m. The heights ranges from 0.21 m to 0.78 m.

FEATURE I: Terrace
FUNCTION: Agriculture
DIMENSIONS: 9.20 m by 1.95 m by 0.52 m (approx.)
DESCRIPTION: Feature I is a cross slope terrace, aligned east towest, and perpendicular to the direction of the slope. The uphill (north) portion is somewhat level and is filled with an alluvial deposit of soil c. 0.20 m deep. The retaining wall is constructed of subangular and rounded pahoehoe and aa medium to large boulders, piled in a crude linear alignment. The wall width ranges from 0.70-1.95 m wide and the height ranges from 0.20-0.52 m high.

FEATURE J: Mounds (4)
FUNCTION: Agriculture
DIMENSIONS: 19.00 m by 7.00 m by 0.51 m (approx.)
DESCRIPTION: Feature J consists of four low informal land clearing mounds. They are located SE of Feature B and are crudely piled between an area with agriculture terraces and boundary walls. The mounds are constructed with aa and pahoehoe cobbles and boulders crudely stacked. The mounds range in diameter from c. 1.75 m to 2.0 m with heights from c. 0.22 m to 0.51 m.

FEATURE K: Terrace
FUNCTION: Agriculture
DIMENSIONS: 3.80 m by 1.05 m by 0.34 m (approx.)
DESCRIPTION: Feature K is aligned E-W and perpendicular to the slope. It is constructed with subangular and rounded pahoehoe and aa medium to large boulders crudely aligned. The uphill (north) portion is somewhat level and is filled with an alluvial deposit of soil c. 0.20 m thick. There are four additional short terrace segments in the vicinity of Feature K.

SITE NO.: State: 13659 PHRI: 770-3
SITE TYPE: Complex (2 Features)
TOPOGRAPHY: Flat gentle slope seaward with low outcrops and aa boulders and cobbles.
VEGETATION: Unidentified trees, grasses, *koa-haole*, and monkey pod.
CONDITION: Good
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Temporary habitation
DESCRIPTION: The site complex consists of two terraces (Features A and B). They are constructed of aa boulders and cobbles loosely piled. A cowrie fragment and an *opihi* shell fragment are on Feature A. No cultural deposit was visible, but one may be present subsurface.

FEATURE A: Terrace
FUNCTION: Temporary habitation
DIMENSIONS: 11.50 m by 9.00 m by 0.70 m (approx.)
DESCRIPTION: Feature A is roughly rectangular in plan. It is raised on the southwest, southeast, and northwest sides. The northeast side of the terrace abuts a raised outcrop which consists of boulder and cobble rubble. The raised sides of the terrace are constructed of crudely stacked and weathered subangular basalt boulders and cobbles. At present the sides are sloping in profile, collapsed in appearance, and are not formally faced.

In addition to being raised on the exterior, the northwest, southeast, and southwest sides of the terrace are raised on their interiors. This indicates a low wall may have enclosed the interior terrace surface. The interior terrace surface consists of flat level soil.

FEATURE B: Terrace
FUNCTION: Temporary habitation
DIMENSIONS: 7.50 m by 2.50 m by 0.50 m (approx.)
DESCRIPTION: Feature B is somewhat rectangular in plan. It is constructed of loosely piled cobbles and is located at the west end of an outcrop. No formal facing is visible. The sides slope c. 1.5 m horizontally to the flat soil surface of the terrace, which adjoins the west wall of Feature A. Single stones on top of the outcrop follow the contour eastward to Feature A, south wall.

SITE NO.: State: 14155 **PHRI:** 770-4
SITE TYPE: Terrace
TOPOGRAPHY: Slopping pahoehoe lava flow.
VEGETATION: *Koa-haole*, lantana, *'opiuma*, bunch grass.
CONDITION: Good
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Habitation
DIMENSIONS: 6.50 m by 6.00 m by 1.30 m (approx.)
DESCRIPTION: This site consists of one amorphous high terrace with a step on the seaward side. It is constructed of stacked large pahoehoe boulders and cobbles. The terrace platform is relatively flat and consists of pahoehoe cobble and pebble fill; some large flat pahoehoe slabs present on the terrace.

There is a step below the top of the terrace. This step does not extend the full length of the seaward side of the platform. The terrace may have functioned as a loading dock for cattle or agriculture products.

SITE NO.: State: 14156 **PHRI:** 770-5
SITE TYPE: Terrace
TOPOGRAPHY: Slopping pahoehoe bedrock lava flow.
VEGETATION: *Koa-haole*, *'opiuma*, bunch grass and mock orange.
CONDITION: Poor-fair
INTEGRITY: Altered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Agriculture
DIMENSIONS: 8.30 m by 3.50 m by 0.95 m (approx.)
DESCRIPTION: The terrace is constructed of crudely stacked pahoehoe boulders and cobbles that modified a bedrock outcrop. Raised along the west side, the terrace interior consists of pahoehoe pebble fill. At present, the terrace is mostly collapse, with rubble all about.

SITE NO.: State: 14157 *(Figure A-2)* **PHRI:** 770-9
SITE TYPE: Terrace
TOPOGRAPHY: Fairly steep ridge.
VEGETATION: *Koa-haole*, pasture grass, *'opiuma*.
CONDITION: Fair-good
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Habitation
DIMENSIONS: 12.00 m by 5.50 m by 0.42-1.79 height (approx.)
DESCRIPTION: The terrace is situated at the top of a ridge. The retaining wall is constructed with boulders and is raised along the exterior of the perimeter. The terrace interior surface is leveled and cobble-filled.

There are additional terraces and stepped terraces as the ridge continues downward to the southwest and southeast. The terraces are constructed of medium to large boulders on natural outcropping. Many of the terraces are natural with a minimum of cultural modifications to create somewhat level areas.

SITE NO.: State: 14158 *(Figure A-3)* **PHRI:** 770-10
SITE TYPE: Enclosure
TOPOGRAPHY: Undulating terrain with a moderate southwest slope.
VEGETATION: Dense pasture grass and *koa-haole*.
CONDITION: Fair-good
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Habitation/agriculture
DIMENSIONS: 21.40 m by 16.70 m by 1.41 m (approx.)
DESCRIPTION: This site consists of a large enclosure with the long axis oriented perpendicular to the direction of the slope. It is roughly trapezoidal in plan.

Large subangular and rounded decomposing pahoehoe boulders are aligned and then crudely stacked. The walls are c. 1.0 to 2.0 m wide. The wall heights range from 0.65 m to 1.41 m.

There is c. 0.20 m of a loamy silt soil deposit within the enclosure interior. A rusty metal can was visible on the southwest wall. Dense pasture grass and *koa-haole* are growing within the interior of the enclosure.

SITE NO.: State: 14159 **PHRI:** 770-11
SITE TYPE: Wall
TOPOGRAPHY: Slopping pahoehoe flow, pasture.
VEGETATION: *Koa-haole*, *'opiuma*, bunch grass, and lantana.
CONDITION: Poor-fair

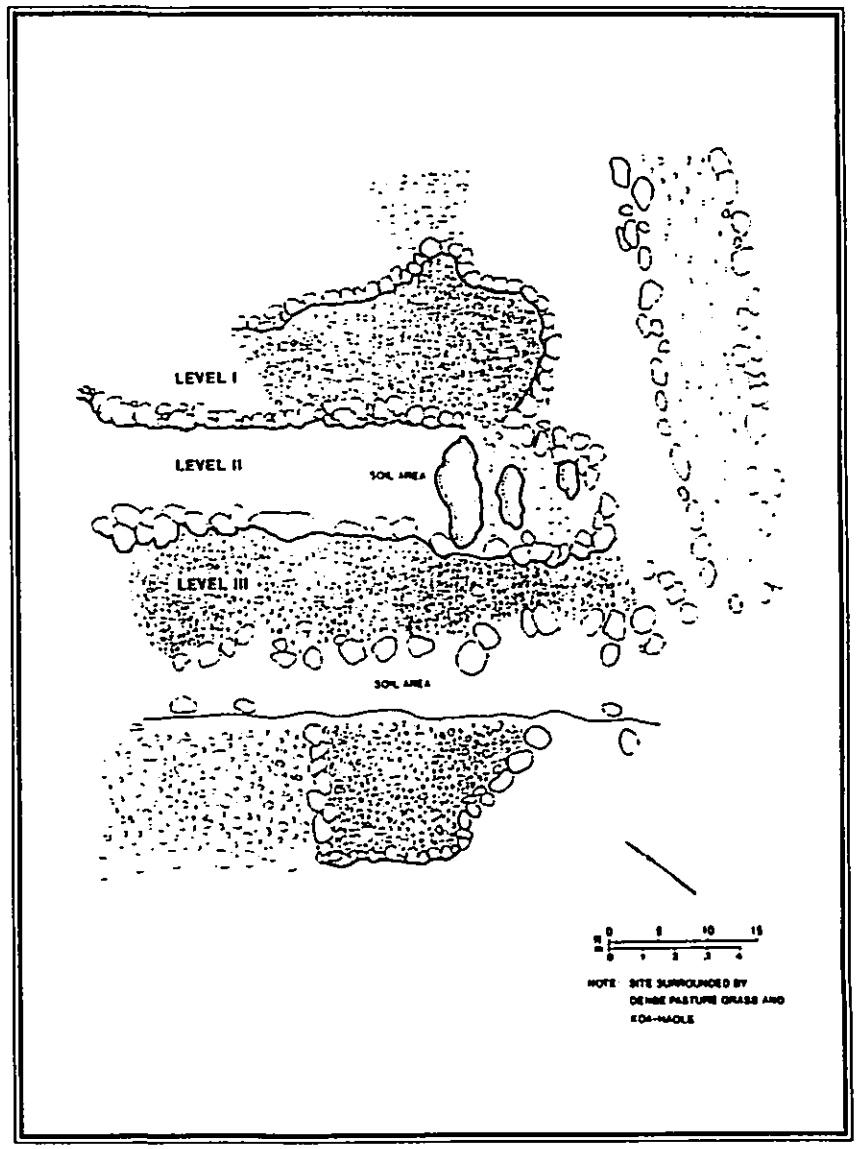

Figure A-2. Site 14157

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FEATURE B: Terrace
FUNCTION: Temporary habitation
DIMENSIONS: 7.50 m by 2.50 m by 0.50 m (approx.)
DESCRIPTION: Feature B is somewhat rectangular in plan. It is constructed of loosely piled cobbles and is located at the west end of an outcrop. No formal facing is visible. The sides slope c. 1.5 m horizontally to the flat soil surface of the terrace, which adjoins the west wall of Feature A. Single stones on top of the outcrop follow the contour eastward to Feature A, south wall.

SITE NO.: State: 14155 **PHRI:** 770-4
SITE TYPE: Terrace
TOPOGRAPHY: Slopping pahoehoe lava flow.
VEGETATION: *Koa-haole*, lantana, *'opiuma*, bunch grass.
CONDITION: Good
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Habitation
DIMENSIONS: 6.50 m by 6.00 m by 1.30 m (approx.)
DESCRIPTION: This site consists of one amorphous high terrace with a step on the seaward side. It is constructed of stacked large pahoehoe boulders and cobbles. The terrace platform is relatively flat and consists of pahoehoe cobble and pebble fill; some large flat pahoehoe slabs present on the terrace.

There is a step below the top of the terrace. This step does not extend the full length of the seaward side of the platform. The terrace may have functioned as a loading dock for cattle or agriculture products.

SITE NO.: State: 14156 **PHRI:** 770-5
SITE TYPE: Terrace
TOPOGRAPHY: Slopping pahoehoe bedrock lava flow.
VEGETATION: *Koa-haole*, *'opiuma*, bunch grass and mock orange.
CONDITION: Poor-fair
INTEGRITY: Altered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Agriculture
DIMENSIONS: 8.30 m by 3.50 m by 0.95 m (approx.)
DESCRIPTION: The terrace is constructed of crudely stacked pahoehoe boulders and cobbles that modified a bedrock outcrop. Raised along the west side, the terrace interior consists of pahoehoe pebble fill. At present, the terrace is mostly collapse, with rubble all about.

SITE NO.: State: 14157 *(Figure A-2)* **PHRI:** 770-9
SITE TYPE: Terrace
TOPOGRAPHY: Fairly steep ridge.
VEGETATION: *Koa-haole*, pasture grass, *'opiuma*
CONDITION: Fair-good
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Habitation
DIMENSIONS: 12.00 m by 5.50 m by 0.42-1.79 height (approx.)
DESCRIPTION: The terrace is situated at the top of a ridge. The retaining wall is constructed with boulders and is raised along the exterior of the perimeter. The terrace interior surface is leveled and cobble-filled.

There are additional terraces and stepped terraces as the ridge continues downward to the southwest and southeast. The terraces are constructed of medium to large boulders on natural outcropping. Many of the terraces are natural with a minimum of cultural modifications to create somewhat level areas.

SITE NO.: State: 14158 *(Figure A-3)* **PHRI:** 770-10
SITE TYPE: Enclosure
TOPOGRAPHY: Undulating terrain with a moderate southwest slope.
VEGETATION: Dense pasture grass and *koa-haole*.
CONDITION: Fair-good
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Habitation/agriculture
DIMENSIONS: 21.40 m by 16.70 m by 1.41 m (approx.)
DESCRIPTION: This site consists of a large enclosure with the long axis oriented perpendicular to the direction of the slope. It is roughly trapezoidal in plan.

Large subangular and rounded decomposing pahoehoe boulders are aligned and then crudely stacked. The walls are c. 1.0 to 2.0 m wide. The wall heights range from 0.65 m to 1.41 m.

There is c. 0.20 m of a loamy silt soil deposit within the enclosure interior. A rusty metal can was visible on the southwest wall. Dense pasture grass and *koa-haole* are growing within the interior of the enclosure.

SITE NO.: State: 14159 **PHRI:** 770-11
SITE TYPE: Wall
TOPOGRAPHY: Slopping pahoehoe flow, pasture.
VEGETATION: *Koa-haole*, *'opiuma*, bunch grass, and lantana.
CONDITION: Poor-fair

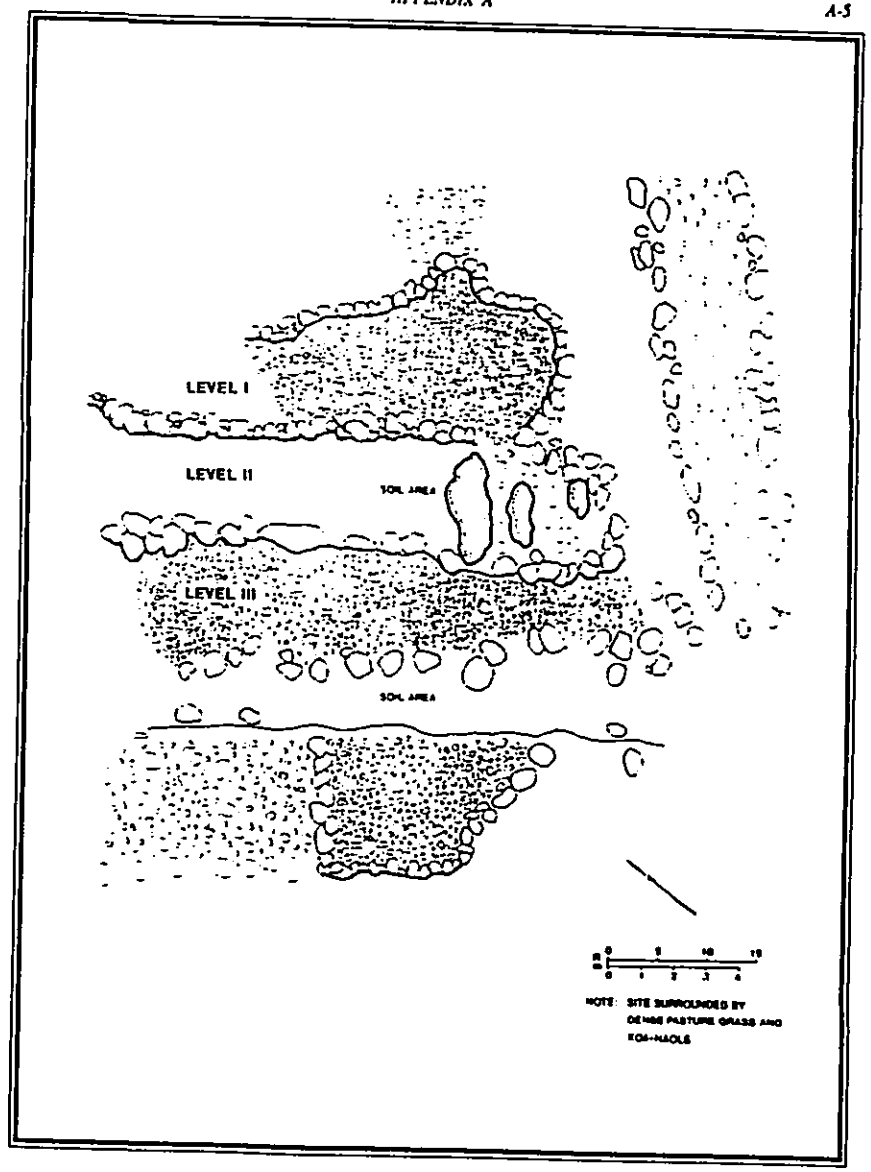

Figure A-2. Site 14157

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Table 8.

SUMMARY OF GENERAL SIGNIFICANCE ASSESSMENTS AND RECOMMENDED GENERAL TREATMENTS

#SIHP Site Number	Significance Category				Recommended Treatment			
	A	X	B	C	FDC	NFW	PID	PAI
13657	-	+	-	-	-	+	-	-
14159	-	+	-	-	-	+	-	-
14162	-	+	-	-	-	+	-	-
14165	-	+	-	-	-	+	-	-
14166	-	+	-	-	-	+	-	-
14172	-	+	-	-	-	+	-	-
14182	-	+	-	-	-	+	-	-
14187	-	+	-	-	-	+	-	-
14191	-	+	-	-	-	+	-	-
Subtotal:	0	9	0	0	0	9	0	0

General Significance Categories:

- A = Important for information content, further data collection necessary (PHRI=research value);
- X = Important for information content, no further data collection necessary (PHRI=research value, SHPO=not significant)
- B = Excellent example of site type at local, region, island, state, or national level (PHRI=interpretive value); and
- C = Culturally significant (PHRI=cultural value).

Recommended General Treatments:

- FDC = Further data collection necessary (detailed recording, surface collections, and limited excavations, and possibly subsequent data recovery/mitigation excavations);
- NFW = No further work of any kind necessary, sufficient data collected archaeological clearance recommended, no preservation potential;
- PID = Preservation with some level of interpretive development recommended (including appropriate related data recovery work);
- PAI = Preservation "as is", with no further work (and possible inclusion into landscaping), or possibly minimal further data collection necessary

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State Inventory of Historic Places (SIHP) numbers. SIHP numbers are five- digit numbers prefixed by 50-10-47 (50=State of Hawaii; 10=Island of Hawaii; 47=USGS 7.5' series quad map ["Honaunau, Hawaii"]).

* Provisional assessment pending further data collection.

Table 8. (cont.)

SIHP Site Number	Significance Category				Recommended Treatment			
	A	X	B	C	FDC	NFW	PID	PAI
13658	+	-	-	-	+	-	-	-
13659	+	-	-	-	+	-	-	-
14155	+	-	-	-	+	-	-	-
14156	+	-	-	-	+	-	-	-
14157	+	-	-	-	+	-	-	-
14158	+	-	-	-	+	-	-	-
14160	+	-	-	-	+	-	-	-
14161	+	-	-	-	+	-	-	-
14163	+	-	-	-	+	-	-	-
14164	+	-	-	-	+	-	-	-
14167	+	-	-	-	+	-	-	-
14168	+	-	-	-	+	-	-	-
14169	+	-	-	-	+	-	-	-
14170	+	-	-	-	+	-	-	-
14171	+	-	-	-	+	-	-	-
14173	+	-	-	-	+	-	-	-
14174	+	-	-	-	+	-	-	-
14175	+	-	-	-	+	-	-	-
14178	+	-	-	-	+	-	-	-
14179	+	-	-	-	+	-	-	-
14181	+	-	-	-	+	-	-	-
14183	+	-	-	-	+	-	-	-
14184	+	-	-	-	+	-	-	-
14188	+	-	-	-	+	-	-	-
14189	+	-	-	-	+	-	-	-
14190	+	-	-	-	+	-	-	-
14756	+	-	-	-	+	-	-	-
Subtotal:	27	0	0	0	27	0	0	0
14176	+	-	+	+	+	-	+	-
14177	+	-	+	+	+	-	+	-
14180	+	-	+	+	+	-	+	-
14186	+	-	+	+	+	-	+	-
14754	+	-	+	+	+	-	+	-
Subtotal:	5	0	5	5	5	0	5	0
14185	+	-	-	+	+	-	-	+
14192	+	-	-	+	+	-	-	+
Subtotal:	2	0	0	2	2	0	0	2
14755	+	-	-	*	+	-	-	*
Subtotal:	1	0	0	1	1	0	0	1
Total:	35	9	5	8	35	9	5	3

examples of a site type, and are culturally significant. For these five sites (Sites 14176, 14177, 14180, 14186, and 14754), further data collection followed by preservation with some level of interpretive development is recommended. Because one of these site contains a burial feature (Site 14180-E), it is recommended that the feature be preserved "as is" and not be interpreted or displayed.

Two of the eight sites (Sites 14185 and 14192) are assessed as significant for scientific information content and are culturally significant. For these two sites, further data collection is recommended. Because these two sites contains burials, following further data collection, preservation "as is" is recommended.

The final site (Site 14755) is assessed as significant for information content and is tentatively evaluated as culturally significant. For this site, further data collection is recommended, and preservation "as is" is tentatively recommended, pending further data collection results. This site may contain a burial. The sites recommended above for preservation are summarized in *Table 9*.

Soehren and Newman (1968:11) recommend that portions of the Kona Field System (Site 6601) in the general Kealakekua area be preserved, but they do not specify which areas. Undoubtedly, portions should be preserved, as the system was central to the social and economic development of North Kona. The portions to be preserved should be determined by the DLNR-HPP/SHPO. In the case of the present study, because the field system features are similar to the numerous field system features in nearby surrounding areas preservation is not recommended for them.

In order to facilitate client management decisions regarding the subsequent treatment of resources, the general significance of the archaeological resources identified during the inventory survey was also evaluated in terms of potential scientific research, interpretive, and cultural values (PHRI CRM [Cultural Resource Management] value modes; see *Table 2* for individual assessments of sites). *Research value* refers to the potential of archaeological resources for producing information useful in the understanding of culture history, past lifeways, and cultural processes at the local, regional, and interregional levels of organization. *Interpretive value* refers to the potential of archaeological resources for public education and recreation. *Cultural value*, within the framework for significance evaluation used here, refers to the potential of archaeological resources for the preservation and promotion of cultural and ethnic identity and values.

Recommended further data collection tasks for each site are listed in *Table 2*. Sketch maps with measured or approximate dimensions, completed site record forms, and photographs of the sites summarized above are archived at the PHRI Hilo office. The records are available for review by qualified researchers.

For project area sites containing confirmed human burials, preservation "as is" would be the preferred method of preservation. When not possible, further testing to determine more accurately the total number of burials present would be recommended. If disinterments are necessary, the procedures of Chapter 6E (Historic Preservation, Haw. Rev. Stat., as amended by Act 306 [1990 S.L.H.]) should be followed. DLNR-HPP/SHPO would be notified and would contact the local Island Burial Council. The developer, the DLNR, and the Island Burial Council would work out a burial treatment plan that would be approved by the Island Burial Council.

The evaluations and recommendations presented within this final report have been based on an inventory survey of the project area. It should be noted that there is always the possibility, however remote, that potentially significant, previously unidentified cultural remains will be encountered in the project area during the course of future archaeological investigations or subsequent development activities. In such situations, archaeological consultation should be sought immediately.

Table 9.

INVENTORY OF SITES RECOMMENDED FOR PRESERVATION

Site Number	Functional Interpretation	Comments
14176	Transportation	Site 14176 is a recent road which follows an early historic cart road built prior to AD 1861 (Yent and Ota 1981:7). According to Apple (1965), this site is a good example of a cart road and was used heavily during the historic period (Apple 1965:49). Preservation with some level of interpretive development is recommended.
14177	Habitation-boundary-transportation	Site complex consists of walls, a steppingstone trail, an enclosure, a platform, a stepped terrace, and a C-shape. Site is an excellent example of a habitation complex associated with a trail section. Trail is also culturally significant. Preservation with some level of interpretive development is recommended.
14180	Habitation-burial	Site complex consists of a rectangular boulder alignment (firepit), terrace, stepped platform, walled pavement, and cave. Site is an excellent example of a habitation complex. Because the cave contains a burial, the site is also culturally significant. Preservation with some level of interpretive development is recommended.
14185	Burial	Cave contains the remains of approximately four human burials and is evaluated as being culturally significant. Because this site contains burials and may be outside the present project area, preservation "as is" is recommended.
14186	Transportation	Foot trail is built with steppingstone slabs. Because trail appears to be a primary transportation route along an *ahupua'a* boundary, it is culturally significant and an excellent example of a site type. Preservation with some level of interpretive development is recommended.
14192	Burial	Cave contains the remains of approximately 17 human burials and is evaluated as being culturally significant. Because this site contains burials, preservation "as is" is recommended.
14754	Transportation	This transportation route has been interpreted to be a old government road (Soehren 1980) and may follow a prehistoric trail route. Because this site is evaluated as being culturally significant, preservation with some level of interpretive development is recommended.
14755	Possible burial	This site consists of a mound and may contain a human burial. Because the presence of a burial is currently indeterminate, a provisional recommendation of preservation "as is" is made here. In the event further data collection does not identify a burial, the site need not be preserved.

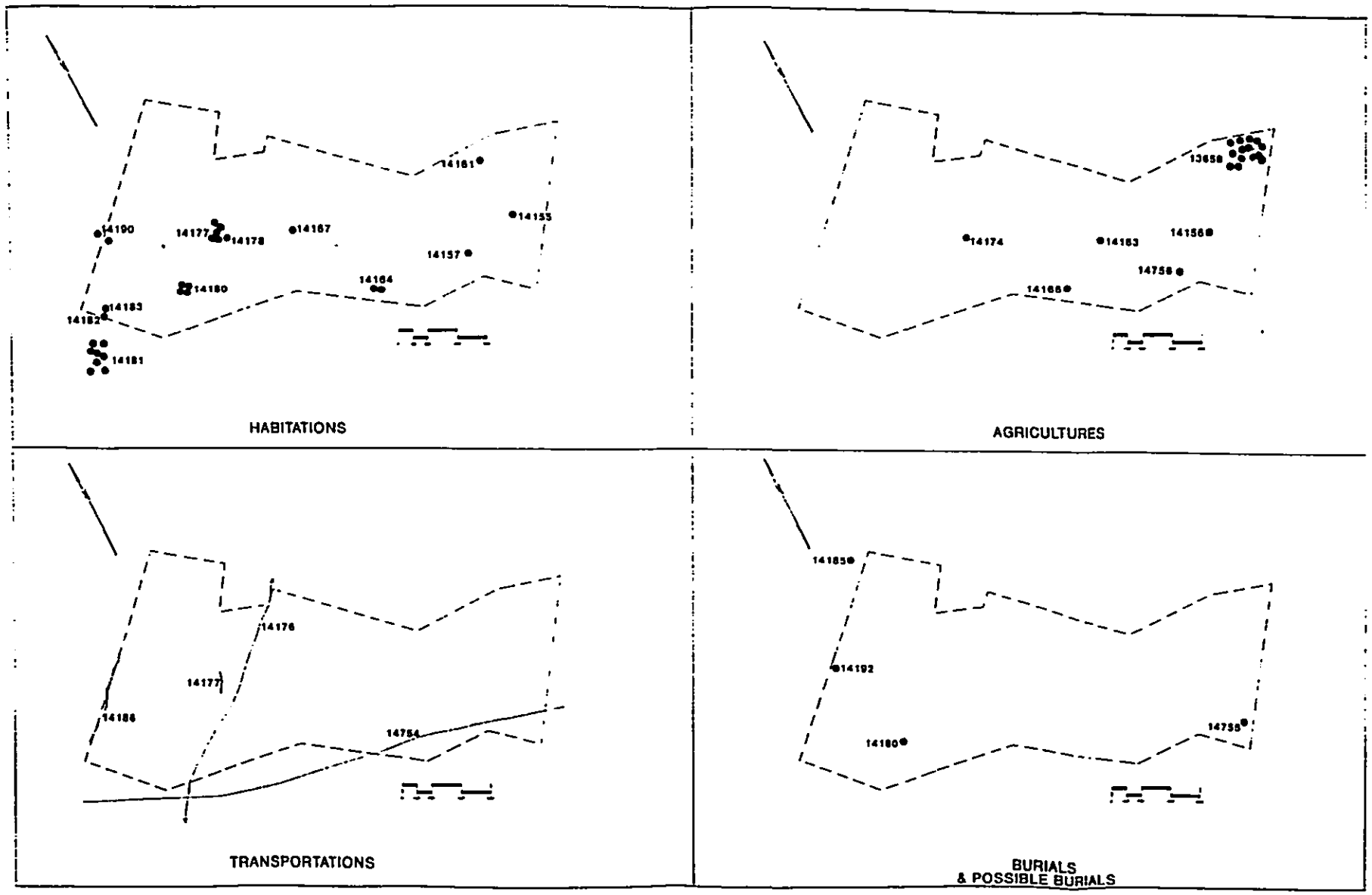


Figure 5. Distribution of Selected Functional Feature Types

zone, and the *'ama'u* (upland jungle) zone. The present project area is situated within Schilt's *kaluulu* zone. The *kaluulu* zone includes the area from c. 500-1,000 ft (150-300 m) elevation and receives c. 40-55 inches (1.0-1.35 m) of annual rainfall. According to Schilt, crops cultivated within the *kaluulu* zone during the late prehistoric period include breadfruit (*'ulu*), mountain apple (*'ohi'a-'ai*), taro (*kalo*), sweet potatoes (*'uala*), gourd (*ipu*), and paper mulberry (*wauke*). Crops cultivated during the proto-historic and early historic periods (AD 1778-1850) in this zone include cabbage, melons, onions, oranges, tobacco, beans, coffee, corn, cotton, pineapple, Irish potatoes, and pumpkins (Schilt 1984).

The agricultural fields comprising the Kona Field System were first noted by members of Cook's expedition. They likened the fields to plantations and described them as extremely extensive, extending in every direction (Cook 1784, Vol.3, pp. 106-107; Handy and Handy 1972:525 [Appendix B references]). The field system was also described similarly by Menzies, a surgeon and naturalist on Vancouver's expedition in AD 1793 (Menzies 1920:74-76; Appendix B). More recently, research by Newman (n.d.) concludes that the system was the most extensive agricultural complex in prehistoric Hawaii. Based on Newman's (n.d.) and Kelly's (1983) research, the system continued functioning until the Great Mahele (c. AD 1850).

The early historic trails in the project area may have been used prehistorically to transport produce between the Kona Field System and the immediate coast. The coastal zones immediately north (Kaawaloa Settlement) and south (Napoopoo Settlement) of Kealakekua Bay were the focus of permanent habitation, and religious and political activities. This is evidenced by the numerous residential sites (including chiefly residences), burial platforms, and *heiau* (including Puhina o Lono and Hikiau Heiau) in the zones (Reinecke n.d., Soehren 1968, Hommon and Crozier 1970, Yent and Ota 1981).

In AD 1779, Cook noted two large settlements (Kaawaloa and Napoopoo) on the shore of Kealakekua Bay. The population of these settlements was estimated to be 2,400. Kaawaloa was estimated to have c. 300 houses, while the Napoopoo (Kekua) settlement was estimated to have 1,100 houses (Yent and Ota 1981). The large population was easily supported by the Kona Field System and the marine environment. Over time, the abundance of resources allowed the Kealakekua Bay area to evolve into "one of the major political and religious centers in Kona and in prehistoric Hawaii" (Yent and Ota 1981:4-5). At the time of Cook's visit in AD 1779, Kalani'opu'u (king of Hawaii Island and uncle of Kamehameha I) resided at Kealakekua. Following the death of Kalani'opu'u, Kealakekua provided the setting for Kamehameha I's ascendancy to king of Hawaii Island and eventual control of all the Hawaiian Islands. Other important chiefs who resided at Kealakekua are Keku'iokalani, Manono, Naihe, and Kapi'olani.

Kealakekua is probably best known as the site of Captain James Cook's death. Cook was killed along the Kaawaloa coast, near the location of the existing monument, and his body was moved to Puhina o Lono Heiau where it was prepared for a traditional chiefly burial. An immediately adjacent area, reported as having been used for human burial (though not necessarily Cook's), is Pali Kapu o Keoua (Soehren 1968, Yent and Ota 1981).

Chronological phases for the Kailua area of North Kona and the Kona Field System have been presented in Schilt (1984:276-284). Based on a series of radiocarbon and volcanic glass dates, initial occupation of the general Kailua area is hypothesized to have occurred sometime during the period AD 1050-1400 (Phase I), with dryland agricultural development becoming established by AD 1400-1600/1650 (Phase II). However, two radiocarbon dates presented in Landrum et al. (1990) have indicated that initial occupation in the seaward portion of Puapuaa *ahupua'a* (and probably the general Kailua area) may have occurred as early as AD 600-890 (Landrum et al. 1990). Dates recorded in the Kahaluu area indicate that cultivation and exploitation of other portions of the Kona Field System were occurring by AD 1420-1660 (Shun and Walker 1984). By AD 1600/1650-1779 (Phase III), the Kona Field System in the Kailua-Keauhou area had undergone extensive development and was under intensive use until cultivation of fields eventually began declining during the historic period AD 1779-1850 (Phase IV). The most probable date ranges selected from radiometric samples recovered during the present project (AD 1380-1680) generally correspond with the Phase II exploitation and habitation period. Subsequent to AD 1850, agricultural use of the Kealakekua area (including the present project area) probably continued, but eventually shifted from cultivation to pasture land. Most recently, the present project area has been used as cattle pasture. Habitation along coastal Kaawaloa continued until c. AD 1929 when Reinecke (n.d.) recorded two families residing there. With the exception of transients, it is believed the coastal area was abandoned soon after this time.

The development of the Kona Field System generally coincides with a recent Hawaiian cultural-historical sequence proposed by Kirch (1985). His sequence consists of four prehistoric periods: Colonization (AD 300-1100), Developmental (AD 600-1100), Expansion (AD 1100-1650), and Proto-historic (AD 1650-1795). The initial occupation and establishment of the Kona Field System began during the Developmental period, with cultivation becoming intensified during the Expansion period and early stages of the Proto-historic period. It was during the Expansion and Proto-historic periods that new social, political, and religious forms were developed.

Construction of the miscellaneous historic features in the project area, predominately cattle and boundary walls, probably began sometime after AD 1850 and continued to the present.

GENERAL RESEARCH TOPICS

Generally, future research on the project area should concern obtaining information on the culture history and lifeways of the prehistoric Hawaiian population which occupied the area. Future archaeological research should include the following:

1. Development of a project area settlement model focusing on the distribution and functions of architectural structures, activities conducted, and their interrelationships;

2. Characterization of the Kona Field System dryland agricultural component in terms of crops, cultivation techniques, and temporal development;

3. Definition of the nature (temporary, semi-permanent, or permanent) and sequence (single or recurrent) of occupation within the specific project area to determine if the inhabitants were local residents, or were simply transiting through the area to places such as Kailua, coastal Kaawaloa, or Kealakekua;

4. Definition of the marine resource exploitation resources, methods, techniques, and technologies;

5. Examination and analyses of archaeological data with traditional and historic references;

6. Further investigation of the *ahupua'a* - wide settlement pattern in order to establish whether permanent occupation was exclusively coastal, or as suggested by the present data, or whether a dual pattern of coastal and inland permanent settlements existed; and

7. Development and formation of historic archaeological studies focusing upon acculturation during the contact period (especially the 19th and 20th centuries).

GENERAL SIGNIFICANCE ASSESSMENTS AND RECOMMENDED GENERAL TREATMENTS

General significance assessments and recommended general treatments for all identified sites are summarized in *Table 8*. Significance categories used in the site evaluation process are based on the National Register criteria for evaluation, as outlined in the Code of Federal Regulations (36 CFR Part 60). The DLNR-HPP/SHPO uses these criteria for evaluating cultural resources. Sites determined to be potentially significant for information content fall under Criterion D, which defines significant resources as ones which "...have yielded, or may be likely to yield, information important in prehistory or history." Sites potentially significant as representative examples of site types are evaluated under Criterion C, which defines significant resources as those which "...embody the distinctive characteristics of a type, period, or method of construction...or that represent a significant and distinguishable entity whose components may lack individual distinction."

Sites with potential cultural significance are evaluated under guidelines prepared by the Advisory Council on Historic Preservation (ACHP) entitled "Guidelines for Consideration of Traditional Cultural Values in Historic Preservation Review" (Draft Report, August 1985). The guidelines define cultural value as "...the contribution made by an historic property to an ongoing society or cultural system. A traditional cultural value is a cultural value that has historical depth." The guidelines further specify that "[a] property need not have been in consistent use since antiquity by a cultural system in order to have traditional cultural value."

Of the 44 sites identified, 36 (81.8%) are assessed as significant solely for scientific information content. Further data collection is recommended for 27 of these sites. After further data collection is completed, if further work is warranted, a data recovery plan for the work should be prepared and implemented for sites not recommended for preservation or interpretation. No further work is recommended for the remaining nine of the 36 sites. Data collected from them during the present survey is considered sufficient; their preservation is not essential, although some sites could perhaps be considered for inclusion into development landscaping.

Of the remaining eight sites (18.2%), five are assessed as significant for scientific information content, are excellent

Table 7.

QUALITATIVE DISTRIBUTION OF ECOFACTUAL REMAINS

MATERIAL	13659 Fea. A TU-1 I-1	14158 TU-1 I-1	14180 Feature A TU-1 I-1	II-1	III-1	Total	14190 Feature C TU-1 I-1	TU-2 I-1	Total	Grand Total
INVERTEBRATES										
GASTROPODS										
Cellana	-	-	-	-	-	0.00	24.73	22.72	47.45	47.45
Trochus intextus	-	-	-	-	-	0.00	0.04	-	0.04	0.04
Nerita picea	-	0.19	-	-	-	0.00	10.26	16.47	26.73	26.92
Littorina pintado	-	-	0.12	-	-	0.12	-	0.66	0.66	0.78
Strombus maculatus	-	-	-	-	-	0.00	-	0.07	0.07	0.07
Hipponicidae	-	-	-	-	-	0.00	0.04	-	0.04	0.04
Cypraeidae	1.27	0.46	1.15	15.88	-	17.03	58.36	65.80	124.16	142.92
Thaididae	-	0.81	-	-	0.68	0.68	44.94	40.48	85.42	86.91
Columbellidae	-	-	-	-	-	0.00	0.18	-	0.18	0.18
Anachis miser	-	-	-	-	-	0.00	0.91	-	0.91	0.91
Conidae	-	-	-	-	-	0.00	2.17	-	2.17	2.17
Melampus	-	-	-	-	-	0.00	-	0.36	0.36	0.36
SUBTOTAL GASTROPODS	1.27	1.46	1.27	15.88	0.68	17.83	141.63	146.56	288.19	308.75
BIVALVES										
Brachidontes c.	-	-	-	-	-	0.00	-	0.23	0.23	0.23
Isognomonidae	-	-	0.31	-	0.17	0.48	4.75	11.30	16.05	16.53
SUBTOTAL BIVALVES	0.00	0.00	0.31	0.00	0.17	0.48	4.75	11.53	16.28	16.76
OTHER										
Non-marine gastropods	-	-	-	-	-	0.00	0.05	-	0.05	0.05
Echinoidea	-	-	0.62	0.50	0.22	1.34	8.50	13.35	21.85	23.19
Crustacea	-	-	-	-	-	0.00	35.86	7.33	43.19	43.19
SUBTOTAL OTHER	0.00	0.00	0.62	0.50	0.22	1.34	44.41	20.68	65.09	66.43
TOTAL INVERTEBRATES	1.27	1.46	2.2	16.38	1.07	19.65	190.79	178.77	369.56	391.94
VERTEBRATES										
Bone	-	-	-	-	-	0.00	6.65	14.67	21.32	21.32
VEGETAL REMAINS										
Aleurites moluccana	-	-	-	-	-	0.00	174.50	76.16	250.66	250.66
TOTAL	1.27	1.46	2.20	16.38	1.07	19.65	371.94	269.6	641.54	663.92

CONCLUSION

DISCUSSION

The present inventory survey confirmed that numerous archaeological sites, both prehistoric and historic, are present in the project area. The overall physical condition and integrity of the sites varies from poor to good. The sites include ten complexes and 34 single-feature sites, and comprise the following functional feature types: habitation (terrace, enclosure, platform, stepped terrace, wall, C-shape, modified outcrop, rectangular boulder alignment, stepped platform, walled pavement, linear alignment, modified sinkhole, and cave), agriculture (linear alignment, terrace, mounds, and modified outcrop), agriculture/habitation (enclosure and terrace), boundary (walls), transportation (roads and trails), burial and possible burial (caves and a mound), agriculture/boundary (walls), marker (upright pahoehoe slab), quarry-possible quarry (pahoehoe excavations), indeterminate/possible marker (mound), and a feature of indeterminate function (modified outcrop).

Several patterns exist in the overall distribution of the formal and functional types: it appears the patterns are directly influenced by terrain type (*Figures 4 and 5*). Of the seven caves identified, all are in aa lava terrain; no caves are in terrain classified as Waiaha or Kainaliu series soils. The caves may be present only in aa because this terrain was formed much later than the Waiaha or Kainaliu series soil terrain and has not undergone extensive weathering and decomposition; in other words, Waiaha or Kainaliu series terrain probably included caves long ago, but these have been obliterated over time through natural processes.

Because caves were commonly used for burial, the distribution of human burials in the project area is similar to that of caves. Three of the seven caves identified contain burials. One feature, a mound, was assigned a possible burial function because a burial could not be confirmed during the present survey. The mound is in Kainaliu series soil.

Habitation features (including temporary habitation features) are distributed throughout the project area; however, a greater number are within aa lava terrain (29 of 37 features [78.4%]). It appears that aa lava was used more frequently for habitation because it was less desirable for agriculture. Waiaha and Kainaliu series soils are suitable for cultivation and were primarily used for agriculture. The habitation features within agricultural fields identified during the present project are most likely temporary field shelters used in the course of daily agricultural activities.

Other functional feature types located solely in aa terrain include an upright pahoehoe slab assigned a marker function, a mound assigned an indeterminate/possible marker function, two pahoehoe excavations assigned a quarry-possible quarry function, and a modified outcrop assigned an indeterminate function.

Six boundary features and four transportation features are not located on any particular terrain. Several of these features are associated with land units or other types of features. One trail (Site 14186) is along the Kaawaloa-Keopuka boundary and is associated with a marker and possible marker (Sites 14187 and 14189), two temporary habitation features (Sites 14188 and 14190-B), and a burial (Site 14192). One wall (Site 13657) is located on the Kaawaloa-Kealakekua boundary. One road (Site 14176) is located between two boundary walls (Sites 14175 and 14184).

The present investigation indicates that agricultural features are present exclusively on Waiaha and Kainaliu series soils. Also present exclusively on such soils are agricultural/habitation features. Past investigations have indicated the same. Other functional feature types located solely in terrain classified as Waiaha and Kainaliu series soil include two walls assigned an agricultural/boundary function.

As noted earlier in this report, agricultural features in the project area comprise components of the Kona Field System, and 19 features of the system (22.4%) were formally identified during the current project. The project area contains many other similar field system features that have not been formally identified (in other words, they have not been formally located and recorded). These features consist primarily of *kuaiwi*, low stone walls and linear embankments that define boundaries of individual rectangular field units, and ubiquitous minor agricultural features which are spread almost continuously throughout the Waiaha and Kainaliu series soils within the project area. The minor features include rubble wall alignments, stone mounds, cleared areas, modified bedrock outcrops, and small crude terraces. For the most part, the present work identified only primary structural features of the field system—obvious habitation, temporary habitation, agriculture/habitation, and agriculture/boundary features and complexes.

The Kona Field System is discussed in Schilt (1984) in terms of four zones—the *kula* (coastal area) zone, the *kaluulu* (seaward slope) zone, the *'apa'a* (upland slope)

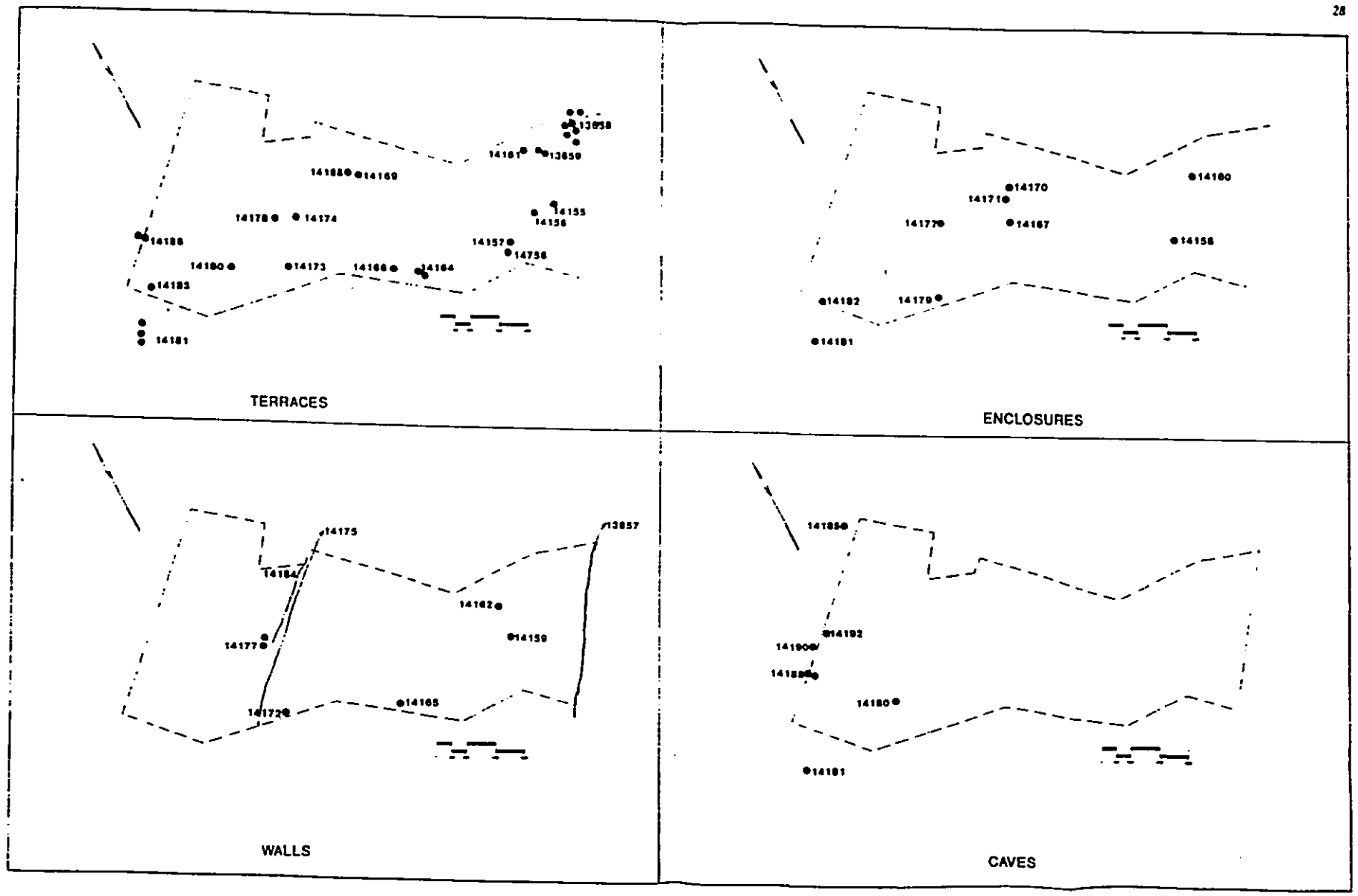


Figure 4. Distribution of Selected Formal Feature Types

II 7+ cmbs; flat pahoehoe floor

Excavation was terminated at a depth of c. 0.07 m on a relatively flat pahoehoe floor.

CHRONOLOGY

Four samples of charcoal were chosen from discrete cultural deposits for age determination using radiocarbon analysis. The purpose of age determination analysis is to provide initial chronological data to aid in assessing the relative significance of sites in the project area. The four samples were submitted for radiocarbon analysis to Beta Analytic, Inc. of Coral Gables, Florida. Using standard procedures, the samples were pretreated with an acid, alkali, acid series of soakings to remove carbonates and humic acids. After pretreatment, samples were combusted to form carbon dioxide gas, were combined with lithium to separate the carbon, and were hydrolized for conversion to liquid form. The liquid was then catalyzed to form benzene and was placed in a liquid scintillation counter to determine the amounts of carbon-13 and carbon-12. The isotope values obtained during the counting process were then used to calculate the carbon-13/carbon-12 ratio for each sample, with the final result being determined relative to international standards in order to reduce errors produced by carbon isotope fractionation. Processing for three of the samples (RC-795, RC-797, RC-798) proceeded normally, while sample RC-796 was found to contain insufficient carbon after pretreatment.

The results of the radiocarbon age determination are presented in *Table 5*. The age for each sample is reported as a range corresponding to the calendric age +/- two standard deviations. Ages were calibrated using the tables provided in Stuiver and Pearson (1986), which correct for variations in atmospheric carbon over time.

As indicated in able 5, two of the processed samples (RC-795 and RC-798) produced multiple age ranges, while sample RC-797 was essentially modern in age. Multiple ranges are caused by "flat" regions in the calibration curve, which correspond to periods when atmospheric carbon decreased at a rate greater than 1.2 ppm/ 10 years, resulting in more than one possible fit of a sample to the calibration curve. While multiple age ranges are more difficult to interpret archaeologically, detailed examination of statistical sample curves, combined with evidence from artifactual material and feature stratigraphy, generally provides a means of selecting one age range as more probable than the others.

Based on the above criteria, the most likely age ranges for the two samples are as follows: 1380-1510 AD for sample RC-795 and 1470-1680 AD for sample RC-798. The two age ranges suggest that the project area was occupied as early as 1380 AD at Site 14158, and 1470 AD at Site 14192. The age ranges of samples RC-795 and RC-798 overlap at two standard deviations, suggesting that occupation of Sites 14158 and 14192 may have been contemporaneous. Occupation of both of these sites was apparently limited in duration; this is evidenced by the shallowness of the radiocarbon samples within the cultural deposits at each site. The modern age for sample RC-797 is consistent with its stratigraphic position at Site 14180, and suggests that occupation of this site occurred after the abandonment of Sites 13658 and 14192.

PORTABLE ARTIFACTS

Indigenous Artifacts

Eight artifacts were recovered from the project area; all are classified as indigenous. Indigenous artifacts are those fabricated using traditional Hawaiian manufacturing techniques and local raw materials, and range in type from tools and fishing gear to various decorative or religious items. The inventory of indigenous artifacts from the current project area is fairly broad in content, and includes fishing gear, tools, flaked stone artifacts, and domestic implements. A detailed tabulation of artifacts by deposit area is presented in *Table 6*. The results of the artifactual analysis are discussed below.

Fishing Gear. A single fragment of a one-piece fishhook was recovered from Level I, Test Unit 2 of Site 14190. One- and two-piece fishhooks are classified according to the revised Coding System for Hawaiian Fishhooks devised by Sinoto (in Kirch 1979:231-233). The specimen, which is manufactured from pearl shell, is a fragment of a one-piece jabbing hook and includes the head, shank, and bend portions. The head has notches on both sides, just below the top (HT1b), and the bend is a diagnostic U-shape. The shank length is 19 mm. One-piece fishhooks were fashioned as either jabbing or rotating hooks depending on the fisherman's intended catch strategy (Johannes 1981:113). Jabbing hooks are those in which the point is straight or slightly outcurved or incurved, so that if extended, the point would intersect the shank between the head and upper third portion of the shank.

Tools. A single adz was recovered from the surface of Feature A of Site 14183. The adz, manufactured from black

Table 5.

SUMMARY OF RADIOCARBON AGE DETERMINATIONS

PHRI Lab.No. RC-	Lab. No. BETA-	Provenience	C-14 Age Yrs. B.P. (one sigma)	C-13/ C-12 Ratio	C-13 Adjusted C-14 Age Yrs. B.P.	*Calendric Range Yrs. AD
Site 14158						
795	38545	TU-1, Layer I, Level 2, 10-20 cmbs	470+70	-24.3	480+70	1305-1360 1380-1510 1598-1617
Site 14180						
796	38546	Fea A, TU-1, Layer III, Level 1, 8-13 cmbs	—	—	—	Insufficient carbon
797	38547	Fea A, TU-1, Layer I, Level 1, 0-5 cmbs	109.9+0.8% modern	-19.4	108.7+0.8% modern	—
Site 14192						
798	38548	Fea C, Surface	290+60	-26.0	270+60	1470-1680 1739-1805 1934-1954

* Calibrated according to Stuiver and Pearson (1986). Range at two sigmas.

aphanitic basalt, measures 67 mm by 35 mm by 20 mm. It is rectangular in cross section, formal, and has three ground surfaces. The cutting edge is straight in profile and plan view and is bevelled on the bottom surface at a 45 degree angle. The poll is pointed, while the sides are rough and flat. The adz is untanged. Adzes are generally associated with woodworking activities, such as canoe manufacture.

Flaked Stone. Five flaked stone artifacts composed of aphanitic basalt were recovered from Test Units 1 and 2, Feature C of Site 14190. All flaked stone material was evaluated with respect to flake/core type. Following established procedures for evaluating flaked stone material, diagnostic flakes were defined as those flakes having a complete or partial striking platform and a bulb of percussion. Non-diagnostic flakes were defined as fragments which lack the platform and/or bulb. Cores were defined as tending toward multifaceted polyhedral shapes dominated by one or more platforms, and typically showing little evidence of subsequent use as tools.

Based on the above criteria, the five specimens of basalt material can be separated as follows: one flake core, three diagnostic flakes, and one non-diagnostic flake. The core is a large flake with three flake scars, all of which show unidirectional flaking. One flake scar has been polished. The core has one undamaged striking platform, but no cortex. It measures 25 cm long by 7 cm wide. The three diagnostic flakes range from 15 mm to 45 mm in length, have diffuse bulbs of percussion, and are trapezoidal to lenticular in cross section. Two of the flakes show signs of retouch; the first is retouched on two edges, while the second has been sharpened into a point resembling a punch. The non-diagnostic flake measures 14 mm by 16 mm by 2 mm and is wedge-like in plan view. Two edges have been polished, while the third edge has been shaped into a curve. The front and back faces are highly polished.

Uses for basalt and volcanic glass flakes have been suggested both by Barrera (1971) and Kirch (1973); Kirch observed:

Table 6.

DETAILED DISTRIBUTION OF PORTABLE ARTIFACTS

CATEGORY	T-35, FEA.A SURFACE	TU-1 1-1	T-42, FEA.C TU-2 1-1	SITE TOTAL	GRAND TOTAL
INDIGENOUS					
FISHING GEAR					
Bone					
Fishhook (Shell frg.)	-	-	1	1	1
SUBTOTAL FISHING GEAR	0	0	1	1	1
TOOLS					
Adze (Basalt)	1	-	-	0	1
SUBTOTAL TOOLS	1	0	0	0	1
FLAKED STONE					
Basalt	-	3	2	5	5
SUBTOTAL FLAKED STONE	0	3	2	5	5
DOMESTIC IMPLEMENTS					
Pick (Bone)	-	-	1	1	1
SUBTOTAL DOMESTIC IMPLEMENTS	0	0	1	1	1
TOTAL INDIGENOUS	1	3	4	7	8

The possible functions ... are many and varied. Basaltic glass holds a fine, sharp edge and the tools make excellent cutting and scraping implements. They may have been used in food preparation, for cutting and scraping plant materials, or for delicate woodworking ... [t]hese artifacts are extremely common, being found in virtually every type of [Hawaiian] site. The suggestion, then, is that the ubiquitous basaltic glass flakes functioned as a prehistoric "pocketknife", to use a modern analogy... (1973: 185-6).

Domestic Implements. One bone pick was encountered in Level I, Test Unit 2, Feature C of Site 14190. The pick is composed of bird bone and includes the articular end of the bone. It measures 43 mm long by 6 mm in diameter at the articular end. Picks were used to get meat from shellfish, whereas awls, which have a similar shape, were used to puncture holes in various materials.

Summary

In general, the artifact assemblage encountered during the current investigation suggests that prehistoric activities in the project area probably included manufacture of bone or shell artifacts, as well as the production of fishing gear. Stone tool manufacture and use is suggested by the basalt artifacts at Site 14190 and may have been accompanied by food processing and craft production activities which relied on the use of flaked stone tools. Domestic activities are also suggested by the awl in the Site 14190 deposits. The adz, as noted above, is generally associated with woodworking activities, such as canoe manufacture.

MIDDEN

Objectives and Methods

Midden deposits are archaeologically significant on a number of levels, as the variety and content of food remains

contained within a given midden deposit provide useful information concerning prehistoric diet and resource utilization patterns. The analysis of midden remains for inventory survey projects have two primary objectives:

1. To determine midden content, in particular the variety and distribution of the remains for each cultural deposit encountered within the project area; and

2. To provide an indication of dietary and resource exploitation patterns for each site, and for the project area as a whole;

All midden recovered from the various test units underwent detailed analysis in the laboratory. Detailed analysis involved splitting the sample into two size classes by passing each sample through 1/4-in and 1/8-in screens. One hundred percent of the material retained in the 1/4-in screen was completely sorted to the lowest taxonomic level possible, while the material retained in the 1/8-in screen was inspected both for artifactual material and for taxa not encountered in the larger portion of the sample. Marine shell identifications were verified and augmented using Kay (1979).

The sampling design outlined above is adapted from Kirch (1979), based on a series of experiments measuring the relative distribution of molluscan and bone retained on each screen. Kirch concluded that use of the screening process increased the speed of the sorting process without decreasing either the accuracy or statistical validity of the overall analysis. The taxonomic distribution and weight of material retained on the 1/4-in screen should thus be considered as representative of the variety and relative percentages of each taxon present in the entire sample.

Results

The range of taxa present in the midden sample from each deposit is summarized in *Table 7*. Total weights for each taxon (in grams) are tabulated by site and feature, with subtotals indicating the combined weight per feature for each larger material class (e.g., gastropods). The total weight of each taxon in the project area is provided in the final column of the table, while the grand total represents the combined weight of all the midden for the project area.

In general, the taxa represented by the midden samples taken from the project area are common inhabitants of the shorelines, shallow-water areas, solution benches and fringing reefs of the windward islands of the Hawaiian chain. By weight, 46.5% of the 663.92 grams of midden recovered from the project area consists of marine gastropods, 2.5% consists of bivalves, and 10% consists of other invertebrates such as echinoids, crustaceans, and non-marine gastropods. Fish and mammal bone comprise 3.2% by weight of the total inventory, while vegetal material accounts for 37.7% remains. Cypraeidae, Thaididae, *Cellana*, and *Nerita picea* are the most abundant gastropod taxa by weight within the total inventory, while Isognomonidae is the most abundant taxon of bivalves. Crustacea is the most abundant other invertebrate by weight. The bone material consists of fish and mammal bone, with fish being the dominant taxon by weight. The vegetal remains consist entirely of *Aleurites moluccana* (*kukui*).

The range and relative weight percentages of taxa at each site differ from the patterns noted for the project area as a whole. The midden remains from Site 13659 are extremely limited, and consist entirely of the taxon Cypraeidae. The deposits at Site 14158 are also composed entirely of marine gastropods, but include specimens of *Nerita picea* and Thaididae as well as Cypraeidae. The deposits from Site 14180 are somewhat more varied, and include a mixture of marine gastropods (90.7%), bivalves (2.4%), and echinoids (6.8%). The deposits from Site 14190 contribute the largest amount of midden by weight to the total inventory, and are thus extremely similar in both content and relative weight percentages to the project area total discussed above.

Summary

The results of the midden analysis indicate that subsistence patterns in the project area included the collection and consumption of a variety of marine resources, ranging from several taxa of marine gastropods and bivalves to echinoids, crustaceans, and fish. All of the marine taxa represented in the midden deposits, both at the site and feature levels, were readily obtainable in the shallow-water areas immediately offshore, from tidal pools, or from the solution benches and fringing reefs near the shoreline. Exploitation of terrestrial resources formed a second component of prehistoric subsistence patterns at Site 14190, with evidence being provided by the presence of mammal bone and vegetal material in the midden at that site.

protected by a crude wall, possibly a windbreak. The three walled pavements are on terrain classified as aa lava and are thought to have functioned as habitation features. Two of the pavements (Sites 14188-E and 14190-A) are alongside Site 14186, a trail.

Other - Other formal feature types identified during the current project include two pahoehoe excavations, two roads, two foot trails, a platform, a stepped platform, a rectangular boulder alignment, and an upright. The pahoehoe excavations (Sites 14183-B and 14191) consist of areas which have been intentionally broken, the excavated material piled nearby. These features are on terrain classified as aa lava and are thought to have functioned as quarries.

The two identified roads are Kaawaloa Road (Site 14176) and an old government road (Site 14754). Although Site 14176 is now a jeep road, it follows the route of an older cart road built prior to AD 1861 (Yent and Ota 1981:7). Site 14754 is classified as a Type C trail (Apple 1965) and has been identified as the old government road (Soehren 1980).

The two foot trails (Site 14177-B and 14186) are constructed of flat pahoehoe steppingstones. One (Site 14186) is located along the boundary between the Lands of Kaawaloa and Keopuka. Both trails are built on aa lava.

Both platforms identified (Sites 14177-D and 14180-C) are square to rectangular in plan, are raised on all sides, are located on aa lava terrain, and are thought to have functioned as habitation features. One of the two platforms (Site 14180-C) has a stepped or two-tiered surface.

The rectangular boulder alignment (Site 14180-A) consists of four pahoehoe slabs set on edge to form a rectangle. This feature is thought to be rock-lined firepit.

The upright (Site 14187) consists of a pahoehoe slab placed in an upright position, its base supported by several cobbles. Because of its closeness to a trail (Site 14186), the upright is thought to have functioned as a trail marker.

Functional Feature Types

Probable functional interpretations were determined for most features. The most common functional feature type encountered was habitation (28 examples - 33.0% of total features). Other functional feature types identified include agriculture (22.4% of total features), temporary habitation (10.6%), agriculture/habitation (9.4%), boundary (7.1%), transportation (4.7%), burial (3.5%), agriculture/boundary (2.4%), indeterminate/possible marker (1.2%), marker (1.2%), possible burial (1.2%), quarry (1.2%), possible quarry (1.2%), and indeterminate (1.2%) (Table 4). Seven of the functional types (77 examples - 90.5% of total features) comprise the majority of the types, each representing more than 3.0% of the total feature inventory. The identified functional feature types are discussed below.

Habitation - A habitation function was assigned to 28 of the total number of features (Sites 14155, 14157, 14161, 14164-A, -B, 14167, 14177-C through -G, 14178-A, 14180-A through -D, 14181-A through -H, 14182, 14183-A, 14190-A, and -C). Formal feature types which were assigned a habitation function include terrace, enclosure, platform, stepped terrace, wall, C-shape, modified outcrop, rectangular boulder alignment, stepped platform, walled pavement, linear alignment, modified sinkhole, and cave.

A temporary habitation function was assigned to nine of the total number of features (Sites 13659-A, -B, 14178-B, 14188-A through -E, and 14190-B). Formal feature types which were assigned a temporary habitation function include terrace, cave, walled pavement, and modified outcrop. Criteria for determining temporary habitation is based on an assessment of quantitative differences concerning complexity and scale of the site, range and scale of activities conducted at the site, as represented by (when visible or obvious) deposit thickness and amount of midden and artifactual remains. Due to the limited excavation work done, habitation/temporary habitation designations are not absolute.

The habitation features are distributed throughout the project area, but a greater number are in terrain classified as aa lava (29 of 37 features [78.4%] assigned a habitation function). The majority of habitation features are thought to be prehistoric.

Agriculture - An agricultural function was assigned to 19 features (Sites 13658-A through -K [-J = four features], 14156, 14163, 14166, 14174, and 14756). Formal feature types assigned an agricultural function include linear alignment, terrace, mounds, and modified outcrop. The number of features assigned an agricultural function is misleading because only a sample of such features was formally designated during the survey. The features comprise dryland components of the Kona Field System (Site 6601) and are continuously present throughout portions of the project area classified as Waiaha and Kainaliu series soils. No features assigned an agricultural function are located on terrain classified as aa lava. With the exception of Site 14756, the agricultural features are thought to be prehistoric. Site 14756 is thought to be a historic period loading dock associated with Site 14754 (road).

Agriculture/Habitation - Eight features were assigned an agricultural or habitation function (Sites 14158, 14160, 14168, 14169, 14170, 14171, 14173, and 14179). The functions were assigned based on structural form. Formal feature types assigned an agriculture/habitation function include enclosure and terrace. Within the project area, agriculture/habitation features are present solely in terrain classified as Waiaha and Kainaliu series soil. Except for Site 14179, the agriculture/habitation features are thought to be prehistoric. Site 14179 may contain a historic component.

Boundary - A boundary function was assigned to six features (Sites 13657, 14159, 14172, 14175, 14177-A, and 14184), all walls. The walls form boundaries for distinguishing *ahupua'a* land units (Kaawaloa and Kealakekua), garden plots (field boundaries), or site areas. The boundary features are present on all terrain types within the project area. Both historic and prehistoric boundary walls are present. Several of the historic boundary walls may be prehistoric features which have been rebuilt during the historic period (Sites 13657, 14159, 14175, and 14184).

Transportation - A transportation function was assigned to four features (Sites 14176, 14177-B, 14186, and 14754). Formal feature types which in this category include roads and trails. Both coastal-inland (Sites 14175, 14177-B, and 14186) and parallel to the coast (Site 14754) transportation routes were identified. Three of the trails-roads (Sites 14176, 14186, and 14754) are considered primary transportation routes, and one (Site 14177-B) is a secondary route. One feature (Site 14176) is a recent historic road which follows an early historic cart road built prior to AD 1861 (Yent and Ota 1981:7); one (Site 14754) is identified as an old government road (Soehren 1980); one (Site 14186) is probably a prehistoric foot trail along an *ahupua'a* boundary; and one (Site 14177-B) is an inter-site prehistoric foot trail.

Burial - A burial function was assigned to three features (Sites 14180-E, 14185, and 14192), all caves. The caves are all in terrain classified as aa lava. Site 14180-E contains one identified burial; Site 14185 contains four burials; and Site 14192 contains 17 burials. A possible burial function was assigned to one feature (Site 14755), a mound. This possible burial is in terrain classified as Kainaliu series soil.

Other - Other functional types identified during the current project include two agriculture/boundary features, one marker, two quarries-possible quarries, one indeterminate/possible marker, and one feature of indeterminate function. Two walls (Sites 14162 and 14165) were assigned an agriculture/boundary function. The walls are located in terrain classified as Waiaha and Kainaliu series soils. The agriculture/boundary features are possibly prehistoric; they may have been rebuilt during the early historic period.

The marker function was assigned to an upright pahoehoe slab (Site 14187). This feature is located adjacent to and probably marks Site 14186 (trail). Site 14187 is probably prehistoric.

Two pahoehoe excavations (Sites 14183-B and 14191) were assigned a quarry-possible quarry function. The two features are located on terrain classified as aa lava and are probably prehistoric.

A mound (Site 14189) was assigned an indeterminate/possible marker function. This feature, because it is located adjacent to Site 14186 (trail), may comprise a prehistoric trail marker.

A modified outcrop (Site 14188-F) was assigned an indeterminate function; the outcrop is associated within several habitation features, and may have been used for temporary habitation. Site 14188-F is probably prehistoric.

SUBSURFACE TESTING

Seven test excavation units totaling 2.065 sq m in surface area were placed within the project area. The purpose of the excavations was to determine the presence or absence of cultural remains and to attempt recovery of datable material. Excavations were placed at Sites 13659-A, 14158, 14160, 14180-A, and 14190-C. The units yielded very sparse to high amounts of midden and artifacts. In addition, four radiocarbon dating samples were collected. All four dating samples were submitted for age determination analysis.

Site 13659

Test Unit 1 (TU-1) measured 0.5 by 0.5 m and was placed within Feature A, a terrace. Visible on the surface of the test area (2-3 cm) was grass, twigs, other vegetal materials, and a single piece of Cypraeidae shell. Two soil samples, one from 3-5 cmbs (centimeters below surface) and one from 10-20 cmbs, were collected from TU-1. The soil was dark reddish-brown and compact closer to the surface and became very dark grayish-brown deeper in the test unit. Fine-grained powdery silt was present under the surface of small cobbles and was mixed with small pebbles. TU-1 displayed the following stratigraphy:

LAYER	DESCRIPTION
I-1	3-5 cmbs; dark reddish-brown (5YR 3/2 moist); gravelly fine sandy loam; structureless; common fine roots; soft and weakly coherent when dry, very friable when moist, nonsticky and nonplastic when wet; lower boundary is gradual and smooth in profile;
I-2	5-25 cmbs; very dark grayish-brown (10YR 3/2 moist); cobbly fine sandy loam; structureless; loose when dry, loose when moist, nonsticky and nonplastic when wet; lower boundary is clear and irregular in profile;
II	25+ cmbs; strong brown (7.5YR 5/6 moist); cobbly clay loam; layer continues below base of excavation unit;

A few charcoal flecks were recovered from TU-1; however, it appears unlikely that they represent a fire associated with the preparation of food. Excavation was terminated at decomposing bedrock at a depth of 32 cmbs.

Site 14158

Test Unit 1 (TU-1) measured 0.5 by 0.5 m and was placed within a large enclosure. Visible on the surface of the test unit was dense pasture grass and a historic metal can. TU-1 displayed the following stratigraphy:

LAYER	DESCRIPTION
I	3-30 cmbs; very dusky red (2.5YR 2.5/2 moist); gravelly fine sandy loam; structureless; loose when dry, loose when moist, nonsticky and slightly plastic when wet; lower boundary is smooth and gradual in profile;
II	30-34 cmbs; strong brown (7.5YR 5/6 moist); cobbly silt loam; structureless; soft and weakly coherent when dry, loose when moist, nonsticky and slightly plastic when wet; lower boundary is gradual and irregular in profile;
III	34+ cmbs; decomposing bedrock

Excavation commenced by removing c. 0.03 m of humus. A few fragments of shell midden (*Nerita picea*, Cypraeidae, and Thaididae) and a coral fragment were recovered from the bottom of Layer I. Soil samples were taken from Layers I and III. A radiocarbon sample was collected from Layer I-2 (10-20 cm below surface) and was submitted for age determination analysis (Sample RC-795). The sample yielded three possible date ranges: AD 1305-1360, AD 1380-1510, and AD 1598-1617. Excavation continued through powdery orangy sterile silt and terminated at a decomposing pahoehoe cobble/bedrock floor at 34 cmbs. Since a few fragments of midden were recovered, it was decided to extend the unit 0.5 m to the east, this extension was designated TU-2.

Test Unit 2 (TU-2) measured 0.5 by 0.5 m and was opened adjacent to and east side of TU-1, abutting a rock wall at the *mauka* portion of the enclosure. Excavation commenced through a soil similar to TU-1, dense grass roots at the surface, followed by a very powdery light brown silt which quickly changed to an orangy silt. Test Unit 2 displayed the following stratigraphy:

LAYER	DESCRIPTION
I	0-20 cmbs; dark reddish- brown (2.5YR 2.5/2 moist); fine sandy loam; structureless; loose when dry, loose when moist, slightly sticky and slightly plastic when wet; lower boundary is abrupt and smooth in profile;
II	20-30 cmbs; strong brown (7.5YR 5/6 moist); fine silt loam soft and weakly coherent when dry, loose when moist, slightly sticky and slightly plastic when wet; lower boundary is gradual and irregular in profile;
III	30+ cmbs; bedrock

No shell midden or cultural material was encountered throughout the test unit. Excavation terminated at decomposing pahoehoe bedrock at a depth of 30 cmbs.

Site 14160

Test Unit 1 (TU-1) measured 0.5 by 0.5 m and was placed in an enclosure. Extremely dense pasture grass obscured most of the interior of the enclosure. Upon clearing the tall grass from the surface, excavation commenced by trowelling through a light humus of decayed vegetal material and many fine grass roots. Soil samples were taken at 0.03-0.05 m and 0.1-0.2 m below surface. The soil became darker and more crumbly at c. 0.08 m below surface. Small cobbles that were noted throughout the layer became rounded, crumbly, and decomposed easily. Test Unit 1 displayed the following stratigraphy:

LAYER	DESCRIPTION
I-1	0-8 cmbs; humus layer; lower boundary is gradual and smooth in profile;
I-2	8-21 cmbs; dark reddish-brown (5YR 2.5/2 moist); cobbly silt loam; structureless; loose when dry, loose when moist, slightly sticky and nonplastic when wet; lower boundary is clear and irregular in profile;
II	21+ cmbs; bedrock

No cultural material was encountered as excavation continued through the crumbly, medium loamy soil. Excavation terminated on bedrock at a depth of 0.21 m below surface.

Site 14180

Test Unit 1 (TU-1) measured 0.25 by 0.25 m and was placed within Feature A, a rectangular boulder alignment. Two quadrants were formed in Layer I, and they were labled SW quad and SE quad. Visible on the surface of the test unit were grass, leaves, and weeds. An ashy appearing surface was visible below the decaying organic matter, and this surface sloped toward the center of the unit. Layer I-1 (c. 0.05 m thick) in the SW quad contained bits of charcoal throughout, and had burned soil and fire-blackened pebbles present at the bottom of the layer. Layer I-1 of the SE quad contained a few marine shells. Layer II (c. 0.03 m thick) contained a pink/tan loam which appeared burned. It contained small pebbles and sparse amounts of midden. Layer III contained sparse marine shell midden. Small as pebbles were distributed across the unit at a depth of c. 0.12-0.13 m below surface. One piece of *kukui* shell was c. 0.16 m below surface. Test Unit 1 displayed the following stratigraphy:

LAYER	DESCRIPTION
I	0-5 cmbs; pinkish-gray (7.5YR 6/2 dry); ashy loam; structureless; loose when dry, loose when moist, nonsticky and slightly plastic when wet; lower boundary is abrupt and smooth in profile;
II	5-8 cmbs; brown (7.5YR 5/2 dry); gravelly very fine loam; structureless; few roots; loose when dry, loose when moist, nonsticky and slightly plastic when wet; lower boundary is abrupt and smooth in profile;
III	8-13 to 20 cmbs; black (10YR 2/1 dry); gravelly clay loam; excavation terminated on aa cobble surface (appears to be sterile matrix)

A bulk sample of charcoal-stained soil was collected from Layers I (0-0.05 m below surface) and III (0.08-0.13 m below surface), and were submitted for age determination analysis (PHRI Samples RC-797 and -796). Layer I was found to be modern in age, and Layer III did not provide sufficient carbon to be dated. No artifacts were found at this site, and excavation was terminated at c. 0.2 m below surface.

Site 14190

Test Unit 1 (TU-1) measured 1.0 by 0.5 m and was placed within Feature C, a cave. Visible on the surface were marine shell and *kukui* nut shells. Three basalt flakes were found within this test unit, as well as marine shell, fish bone, bird bone, Crustacea, and *kukui* shell. Charcoal and soil samples were taken from this test unit. Test Unit 1 displayed the following stratigraphy:

LAYER	DESCRIPTION
I	0-10+ cmbs; very dark brown (10YR 2/2 moist); silt loam; structureless; loose when dry, very friable when moist, slightly sticky and nonplastic when wet; layer continues below base of excavation unit

Excavation was terminated at a depth of 0.1 m below surface at the deepest pocket; however, most of the test unit was terminated at c. 0.05 m below surface.

Test Unit 2 (TU-2) measured 1.0 by 0.5 m and was placed within Feature C, directly opposite TU-1 (TU-1 and-2 were aligned perpendicular to the cave walls and were oriented to allow future test units or grid layouts to be placed more efficiently. Visible on the surface of the test unit was marine shell and *kukui* nut shell. Two polished basalt flakes were found within the test unit (Layer I) as well as a pearl-shell fishhook and a bird bone pick. Marine shell midden was collected along with bird bone, *kukui* shell and fish bone. Test Unit 2 displayed the following stratigraphy:

LAYER	DESCRIPTION
I	0-7 cmbs; black (10YR 2/1 moist); very fine sandy loam; structureless; loose when dry, very friable when moist; nonsticky and nonplastic when wet; lower boundary is abrupt and smooth in profile;

Table 2. (cont.)

SIHP Site No.	Formal Site/Feature Type	Tentative Functional Interpretation	CRM Value Mode Assess. R	I	C	Field Work Tasks DR	SC	EX
14178	Complex (2)	Habitation	M	L	L	+	+	+
A	Modified outcrop							
B	Terrace							
14179	Enclosure	Agriculture/ habitation	M	L	L	+	-	+
14180	Complex (5)	Habitation-burial	M	M	M/H	+	+	+
A	Rectangular boulder alignment							
B	Terrace							
C	Stepped platform							
D	Walled pavement							
E	Cave							
14181	Complex (8)	Habitation	M	L	L	+	+	+
A	Linear alignment							
B	Terrace							
C	Modified sinkhole							
D	Cave							
E	Terrace							
F	Terrace							
G	Enclosure							
H	Stepped terrace							
14182	Enclosure	Habitation	L	L	L	-	-	-
14183	Complex (2)	Habitation-possible quarry	M	L	L	+	+	+
A	Terrace							
B	Pahoehoe excavation							
14184	Wall	Boundary	M	L	L	+	-	-
14185	Cave	Burial	M	L	H	+	+	+
14186	Trail	Transportation	M	M	H	+	-	-
14187	Upright	Marker	L	L	L	-	-	-
14188	Complex (6)	Temporary habitation	M	L	L	+	+	+
A	Cave							
B	Cave							
C	Terrace							
D	Terrace							
E	Walled pavement							
F	Modified outcrop							

Table 2. (cont.)

SIHP Site No.	Formal Site/Feature Type	Tentative Functional Interpretation	CRM Value Mode Assess. R	I	C	Field Work Tasks DR	SC	EX
14189	Mound	Indeterminate/ possible marker	M	L	L	+	+	+
14190	Complex (3)	Habitation	M	L	L	+	+	+
A	Walled pavement							
B	Modified outcrop							
C	Cave							
14191	Pahoehoe excavation	Quarry	L	L	L	-	-	-
14192	Cave	Burial	M	L	H	+	+	+
14754	Road	Transportation	M	M	H	+	-	-
14755	Mound	Possible burial	M	L	L/H	+	-	+
14756	Terrace	Agriculture	M	L	L	+	-	+

Table 3.

FREQUENCIES OF FORMAL FEATURE TYPES

Formal Type	Number	%
Terrace	29	34.1
Enclosure	9	10.6
Wall	9	10.6
Cave	7	8.2
Mound	6	7.1
Linear alignment	4	4.7
Modified outcrop	4	4.7
Walled pavement	3	3.5
Pahoehoe excavation	2	2.4
Stepped terrace	2	2.4
Road	2	2.4
Trail	2	2.4
C-shape	1	1.2
Modified sinkhole	1	1.2
Platform	1	1.2
Rectangular boulder alignment	1	1.2
Stepped platform	1	1.2
Upright	1	1.2
TOTAL	85	100.3

Table 4.

FREQUENCIES OF FUNCTIONAL FEATURE TYPES

Function Type	Number	%
Habitation	28	33.0
Agriculture	19	22.4
Temporary habitation	9	10.6
Agriculture/habitation	8	9.4
Boundary	6	7.1
Transportation	4	4.7
Burial	3	3.5
Agriculture/boundary	2	2.4
Indeterminate/possible marker	1	1.2
Marker	1	1.2
Possible burial	1	1.2
Quarry	1	1.2
Possible quarry	1	1.2
Indeterminate	1	1.2
TOTAL	85	100.3

habitation) or agricultural features. Terraces assigned an agricultural function are found only in the southeastern portion of the project area in terrain containing Waiaha and Kainaliu series soils. No terraces assigned an agricultural function are found in the northwestern portion of the project area (aa lava terrain). Terraces assigned a habitation function are found throughout the project area in both Waiaha and Kainaliu series soils and aa lava terrain.

One feature identified during the current project has been classified as a stepped terrace (Site 14181-H). This feature consists of three abutting terraces built progressively higher. This feature has been assigned a habitation function.

Enclosure - Nine enclosures were identified during the current project (Sites 14158, 14160, 14167, 14170, 14171, 14177-C, 14179, 14181-G, and 14182). The enclosures vary in plan; with the exception of one example, they are generally oval-circular to square-rectangular (trapezoidal) in plan. Due to an opening in one side, one enclosure is slightly U-shape in plan (Site 14182). The functions and distribution of the enclosures are identical to that of the terraces: they are thought to function as habitation or agricultural features. Those assigned an agricultural function are found only in the southeastern portion of the project area in terrain containing soil. Enclosures assigned a habitation function are found throughout the project area.

Wall - Nine walls were identified during the current project (Sites 13657, 14159, 14162, 14165, 14172, 14175, 14177-A, -F, and 14184). With the exception of one example, the walls are linear. One wall (Site 14177-A) appears U-shaped. The walls are generally thought to function as boundary or agricultural features. One wall (Site 14177-F) was assigned a habitation function. Boundary walls (Sites 13657 and 14175) include those located between land units (Lands of Kaawaloa and Kealakekua) or adjacent to a road. Most of the walls are *kuaiwi* walls—components of the Kona Field System (Site 6601)—and are agricultural in nature. The walls appear to be both historic and prehistoric.

Cave - Seven caves were identified during the current project (Sites 14180-E, 14181-D, 14185, 14188-A, -B, 14190-C, and 14192). Three of the caves function as burial features, and four of the caves function as habitation features. All cave features are located aa lava terrain. Two of the cave features (Sites 14181-D and 14185) appear to be outside the present project area, while three (Sites 14188-A, -B, 14190-C, and 14192) are adjacent to the project area boundary.

Modified Sinkhole - One feature identified during the current project has been classified as a modified sinkhole (Site 14181-C). A sinkhole is formed when the ceiling of a lava tube or blister collapses and leaves a vertical opening. These features are similar to, and sometimes contain side tubes/caves. Site 14181-C, thought to have functioned as a habitation feature, is outside the boundary of the present project area. The sinkhole has been modified with terraces, paving, and alignments.

Mound - Six mounds were identified during the current project (Sites 13658-J [4], 14189, and 14755). Four of the mounds are thought to have functioned as agricultural features (Site 13658-J); one is thought to have functioned as a marker (Site 14189), and one is thought to have functioned as a possible burial (Site 14755). With the exception of Site 14189 (which is located on aa lava terrain), the mounds are located on Waiaha and Kainaliu series soil types. It should be noted that only a representative sample (Site 13658-J) of the total Kona Field System mounds in the project area were included in the present survey. Numerous mounds associated with the system are found throughout the project area in terrain classified as Waiaha and Kainaliu series soils.

Linear alignment - Four linear alignments were identified during the current project (Sites 13658-A, -B, -D, and 14181-A). Three of the alignments (Sites 136-A, -B, and -D) are thought to have functioned as agricultural features and are located in terrain classified as Waiaha series soil. One (Site 14181-A) is thought to have functioned as a habitation feature and is located in terrain classified as aa lava. The linear alignments assigned an agricultural function are probably collapsed remnants of *kuaiwi* walls. Like the walls noted above, only a sample of the Kona Field System alignments were formally identified during this survey. Linear alignments of the system are present throughout the project area in terrain classified as Waiaha and Kainaliu series soils.

Modified outcrop - Four modified outcrops were identified during the current project (Sites 14163, 14178-A, 14188-F, and 14190-B). Most of these features consist of exposed bedrock which has been modified with boulders and cobbles piled atop or against it. Two of the outcrops (Sites 14178-A and 14190-B) are on terrain classified as aa lava and are thought to have functioned as habitation features. One outcrop (Site 14163) is on terrain classified as Waiaha series soil and is thought to have functioned as an agricultural feature. The final modified outcrop (Site 14188-F) is on aa lava; although it is assigned an indeterminate function, its form and proximity to other habitation features, suggest it is a habitation feature.

Walled pavement - Three walled pavements were identified during the current project (Sites 14180-D, 14188-E, and 14190-A). These features consist of a paved surface

This information was also written on pieces of flagging tape, which were then wrapped around stones and placed in protected areas on the site.

Seven test excavations were placed within the project area. Test units were numbered sequentially (e.g., TU-1, -2, etc.) within sites and were excavated using hand trowel, whisk broom, and dust pan. Excavation of test units was by arbitrary 10 cm levels within natural layers. Test units were terminated either on bedrock or on large bedrock boulders below cultural matrices.

To facilitate recovery of portable remains, all excavated material was processed through 1/4- and 1/8 in mesh. All midden from the 1/4- and a 100-200 gm sample from the 1/8-in mesh from cultural layers within each test unit was retained for laboratory analysis. Material not retained was field-sorted for artifacts and diagnostic ecofactual remains. Soil samples were described in detail using standard procedures and terminology as set forth in the *Soil Survey Manual* (Soil Survey Staff 1962).

FINDINGS

ARCHAEOLOGICAL SURFACE SURVEY

During the present survey, 44 sites containing 85+ component features were identified within or immediately adjacent to the project area. Previous studies within or immediately adjacent to the project area had identified six archaeological sites (Sites 208, 210, 211, 212, 213, and 215/1980) (Soehren and Newman 1968, Yent and Ota 1981, Kaschko and Rosendahl 1987). Five of these sites (Sites 208, 210, 211, 212, and 215/1980) were relocated during the present project. One site (Site 213) was not relocated. *Figure 1* shows the locations of all identified sites. *Table 2* provides a summary of sites and their component features in terms of site numbers, formal type, functional type, CRM value mode assessments, and recommended field work tasks. *Tables 3 and 4* summarize formal feature and functional types in the project area. Appendix A provides detailed information for each site, including:

1. Site number - SIHP numbers and PHRI temporary site numbers. SIHP numbers are five-digit numbers prefixed by 50-10-47 (50=State of Hawaii; 10=Island of Hawaii; 47=USGS 7.5' series quad map ["Honaunau, Hawaii"]). PHRI temporary numbers are one- and two-digit numbers prefixed by "770-";
2. A site type designation - provides formal feature type for sites consisting of a single feature, or designates the site as a complex if site is comprised of more than one feature. Also lists total number of features present;
3. A description of site topography - a brief description of the terrain in the area of the site;
4. A listing of site vegetation - lists principal components of the vegetation within and in the vicinity of the site;
5. A statement of site condition - overall state of preservation of the site (poor, fair, good, or excellent);
6. An assessment of site integrity - degree of post-abandonment modification by human agencies (unaltered, partially altered, and completely altered) and nature of modifications, if any;
7. A probable age - indicates probable/possible age of the site (i.e., historic or prehistoric);
8. A functional interpretation - probable or possible functions for each site; or, if function cannot be determined, assigns indeterminate function. For sites with multiple functions, functions are separated by "-";
9. A site description - a brief overall description of the site, listing types of constituent features, portable remains present, if any, and other site data; and
10. Feature dimensions - maximum length, width, and height or depth. Dimensions immediately followed by a description of feature construction, associated portable remains, and other descriptive information.

Formal Feature Types

Ten site complexes (multiple-feature sites such as 13658) and 34 single-feature sites were identified in the project area. The sites and complexes comprise a variety of formal feature types. The most common feature types are terraces (29 examples - 34.1% of total features). Other types identified include enclosure (10.6% of total features), wall (10.6%), cave (8.2%), mound (7.1%), linear alignment (4.7%), modified outcrop (4.7%), walled pavement (3.5%), pahoehoe excavation (2.4%), stepped terrace (2.4%), road (2.4%), trail (2.4%), C-shape (1.2%), modified sinkhole (1.2%), platform (1.2%), rectangular boulder alignment (firepit) (1.2%), stepped platform (1.2%), and upright (1.2%) (*Table 3*). Eight of the formal feature types (71 examples - 83.5% of total features) comprise the majority of the formal types, and each are represented by more than 3.0% of the total feature inventory. The identified formal feature types are discussed below.

Terraces - Twenty-nine terraces were identified during the current project (Sites 13658-C, E-I, -K, 13659-A, -B, 14155, 14156, 14157, 14161, 14164-A, -B, 14166, 14168, 14169, 14173, 14174, 14178-B, 14180-B, 14181-B, -E, -F, 14183-A, 14188-C, -D, and 14756). The terraces are generally rectangular in plan and have either roughly level soil terraces, or basalt cobble terraces, or both. The terraces are distributed throughout the project area; they do not appear concentrated in any one area. The terraces are thought to function as habitation (including temporary

Table 2.

SUMMARY OF IDENTIFIED SITES AND FEATURES

*SIHP Site No.	Formal Site/Feature Type	Tentative Functional Interpretation	#CRM Value Mode Assess. R	I	C	*Field Work Tasks DR	SC	EX
13657	Wall	Boundary	L	L	L	-	-	-
13658	Complex (14)**	Agriculture	M	M	L/M	+	-	+
A	Linear alignment							
B	Linear alignment							
C	Terrace							
D	Linear alignment							
E-I	Terrace (5)							
J	Mounds (4)							
K	Terrace							
13659	Complex (2)	Temporary habitation	M	L	L	+	+	+
A	Terrace							
B	Terrace							
14155	Terrace	Habitation	M	L	L	+	-	+
14156	Terrace	Agriculture	M	L	L	+	-	+
14157	Terrace	Habitation	M	L	L	+	-	+
14158	Enclosure	Agriculture	M	L	L	+	-	+
14159	Wall	Boundary	L	L	L	-	-	-
14160	Enclosure	Agriculture/ habitation	M	L	L	+	+	+
14161	Terrace	Habitation	M	L	L	+	-	+

* State Inventory of Historic Places (SIHP) numbers. SIHP numbers are five-digit numbers prefixed by 50-10-47 (50=State of Hawaii; 10=Island of Hawaii; 47=USGS 7.5' series quad map ["Honaunau, Hawaii"]).

\# Cultural Resource Management Value Mode Assessment
—Nature: R = scientific research, I = interpretive, C = cultural;
—Degree: H = high, M = moderate, L = low.

\+ Field Work Tasks: DR = detailed recording (scaled drawings, photographs, and written descriptions), SC = surface collections, EX = limited excavations.

**Number of component features within complex.

Table 2. (cont.)

SIHP Site No.	Formal Site/Feature Type	Tentative Functional Interpretation	CRM Value Mode Assess. R	I	C	Field Work Tasks DR	SC	EX
14162	Wall	Agriculture/ boundary	L	L	L	-	-	-
14163	Modified outcrop	Agriculture	M	L	L	+	-	-
14164	Complex (2)	Habitation	M	L	L	+	-	+
A	Terrace							
B	Terrace							
14165	Wall	Agriculture/ boundary	L	L	L	-	-	-
14166	Terrace	Agriculture	L	L	L	-	-	-
14167	Enclosure	Habitation	M	L	L	+	-	+
14168	Terrace	Agriculture/ habitation	M	L	L	+	-	+
14169	Terrace	Agriculture/ habitation	M	L	L	+	-	+
14170	Enclosure	Agriculture/ habitation	M	L	L	+	-	+
14171	Enclosure	Agriculture/ habitation	M	M	L	+	-	+
14172	Wall	Boundary	L	L	L	-	-	-
14173	Terrace	Agriculture/ habitation	M	L	L	+	-	+
14174	Terrace	Agriculture	M	L	L	+	-	+
14175	Wall	Boundary	M	L	L	+	-	-
14176	Road	Transportation	M	L	L	+	-	-
14177	Complex (7)	Habitation-boundary-transportation	M	M	M	+	-	+
A	Wall							
B	Steppingstone trail							
C	Enclosure							
D	Platform							
E	Stepped terrace							
F	Wall							
G	C-shape							

recommendations as to which sites or site areas were best suited for preservation and possible restoration and inclusion into a proposed Kealakekua Bay historic park.

With the help of aerial photographs, Soehren and Newman (1968) identified numerous intact features of the Kona Field System and recorded 15 sites and site complexes. They also prepared a base map showing the more visible field boundaries that represent the extent of the Kona Field System remains. Soehren and Newman subsequently carried out limited field work to check and verify this map. According to their survey results, four of their identified sites (Sites 208, 211, 212, and 215) are within the present project area, and one site (Site 210) is immediately adjacent to the project area. All five sites were relocated during the present survey and were assigned permanent SIHP site numbers (Site 208 [trail] = SIHP Site 14754; Site 210 [cave] = SIHP Site 14181-D; Site 211 [stepped platform] = SIHP Site 14180-C; Site 212 [walled pavement] = Site 14180-D; Site 215 [road] = SIHP Site 14176). Soehren and Newman (1968) recorded Site 210 as being a shelter cave and petroglyphs; however, although the cave was identified during the present project, no petroglyphs were noted. Soehren and Newman (1968) note the presence of one other site in the present project area (Site 213, two slight depressions); however, the site could not be relocated due to the sketchy information provided. One other significant site recorded by Soehren and Newman (1968) is Puhina-o-Lono Heiau (Site 4). Site 4 is located seaward of the present project area. A large portion of the Soehren and Newman (1968) report is devoted to discussing the Kona Field System; they recommend that at least a portion of the systems' sites be preserved.

Newman (n.d.:123-137) summarized available information on the Kona Field System and developed four sub-zones of the system on the basis of crop types. The current project area is largely within Newman's "Breadfruit/Sweet Potato/Wauke Zone" (n.d.:128), where the crops would be breadfruit trees with sweet potatoes and *wauke* planted between them, and sugarcane and ti planted on the field borders. The most inland part of the survey parcel may be within the "Sweet Potato/Dry Land Taro Zone."

Based in part on data produced by his 1968 work, Newman (1971, 1972) further discussed the nature of the Kona Field System as compared to other prehistoric field systems on the Island of Hawaii. Kirch (1985:225-230) has recently summarized the current state of archaeological knowledge on the prehistoric Kona Field System.

Previous archaeological work *(Figure 3)* in the immediate vicinity of the present project area includes work by Soehren (1980), Yent and Ota (1981), Kaschko and Rosendahl (1987), Barrera (1989), Rosendahl and Jensen (1989), and Walker and Rosendahl (1990). In 1980, Soehren conducted an archaeological surface survey of a several hundred acre parcel located immediately north of the present project area, in the Lands of Onouli 2nd and Keopuka (Soehren 1980). No archaeological features were identified.

The Yent and Ota (1981) study was undertaken in order to estimate the type, quality, and quantity of archaeological features in two major portions of the State Historic Park at Kealakekua Bay. In their report, Yent and Ota describe important sites in their survey areas—Puhina O Lono Heiau, Hikiau Heiau, and the Great Wall enclosing Hikiau—and also discuss historic sites such as *kuleana* and cattle walls. Their survey area did not fall within the present project area but did include the coastal flats of Kaawaloa as well as other areas adjacent to the present project area. One site (Site 50-10-47-1980, Kaawaloa Road) identified by Yent and Ota (1981) had been initially identifed by Soehren and Newman (1968) as Site 215. Kaawaloa Road (Site 1980) was reidentified during the present project and was redesignated as Site 14176.

In 1987, Kaschko and Rosendahl (1987) surveyed a 195-ac parcel located alongside Kealakekua Bay, immediately south of the present project area. Numerous intact remains of the Kona Field System were identified and recorded within nearly three-fourths of the area surveyed. The remains included *kuaiwi* (raised embankments which define the boundaries of agricultural fields), walls, mounds, cleared areas, bedrock outcrops, and small crude terraces. Site 14754 (Temp. Site No. 208) was relocated during the Kaschko and Rosendahl (1987) survey and was noted to be a cart road. This road extends through the Kaschko and Rosendahl project area, into the present project area, and beyond to the north. As is expected in the Kona Field System, most of the features Kashcko and Rosendahl recorded were agricultural, and a few were habitation or burial features.

With the exception of Conservation District land, the area inspected by Kaschko and Rosendahl (1987) subsequently underwent intensive survey and testing (in 1988, by Barrera [1989]). The purpose of the Barrera study was to determine whether additional archaeological work might be needed to assure adequate and reasonable data recovery prior to development. Like Kaschko and Rosendahl (1987), Barrera's survey also identified an extensive network of habitation and agricultural features comprising the Kona Field System. Excavation recovered limited amounts of ecofactual remains (predominately marine shell, charcoal, and *kukui*) and

artifactual remains (predominately volcanic glass, basalt, and adze flakes). Based on the results of his survey, Barrera (1989) stated that the sites represent a valuable archaeological resource and evaluated them as being significant solely for their information content. Archaeological data recovery or preservation, or both, were recommended by Barrera (1989) as being appropriate mitigation. No new information concerning the present project area was included in Barrera (1989).

In late 1988-early 1989, Rosendahl and Jensen (1989) conducted an archaeological inventory survey of the c. 248 ac proposed Onouli Subdivision project area, located in the Lands of Onouli 1st and 2nd and Keopuka; this area is situated immediately north of the present project area. The Rosendahl and Jensen (1989) investigation included the area inspected earlier by Soehren (1980). During the Rosendahl and Jensen (1989) survey, 57 sites were newly identified. The sites were both historic and prehistoric, and consisted of walls, pits, terraces, mounds, alignments, enclosures, platforms, a leveled area, a modified outcrop, a steppingstone trail, a kerbstone trail, and a causeway. Functional feature types included boundary or ranching walls; agricultural complexes; agricultural enclosures; terraces, and an agricultural leveled area; habitation complexes, terrace and enclosures; a modified sink and a walled depression used for habitation; a habitation cave, a refuge cave, and a burial cave; ranch clearing features; and transportation features (trails and a railroad bed). One of the sites (Site 11305), a steppingstone trail, may extend into the present project area; this site was designated as Site 14186 during the present project.

Based on the findings of their survey, 51 of the 57 sites were assessed as being solely significant for information content. Further data collection was recommended for 50 of the 51 sites; no further work was recommended for one of the 51 sites. Of the six remaining sites, five (Sites 11291, a possible burial-agriculture-habitation complex; 11302, a refuge-burial cave; 11305, a trail; 11312, a habitation-transportation complex; and 11313, a trail) were assessed as important for information content, as excellent examples of a site type, and as culturally significant. The final site (Site 11328, a historic railroad bed) was assessed as an excellent example of a site type. Further data collection and preservation with some level of interpretive development was recommended for the six sites (Rosendahl and Jensen 1989).

In early 1990, Walker and Rosendahl (1990) conducted an archaeological field inspection of the Keopuka Lands Parcel, situated within the Lands of Onouli 2nd and Keopuka 1st and 2nd; this parcel is located immediately west of the present project area. The investigation included the area surveyed by Rosendahl and Jensen (1989). Walker and Rosendahl (1990) identified 25 sites, of which 16 had been previously identified, and background research indicated that there was an additional 60 previously identified sites in the project area (total sites: 85 consisting of numerous component features). Fifty-seven of the previously identified sites had been identified during the earlier reconnaissance survey conducted by Rosendahl and Jensen (1989). Formal feature types within this project area included C-shape, enclosure, terrace, platform, L-shape, cave, wall, walled terrace, walled overhang, boulder alignment, box C-shape, mound, double enclosure, trail, leveled area, walled depression, modified sink, railroad bed, modified outcrop, and road. Functional types encountered included habitation, ceremonial (possible *heiau*), possible burial, burial, transportation (trails and historic roads), boundary, ranching, agricultural, and refuge. Fifty-seven of the previously identified sites were assigned general significance assessments by Rosendahl and Jensen (1989). For the remaining 28 sites, because the Walker and Rosendahl (1990) survey only comprised a field inspection, only very general assessments were made.

Other studies on Kaawaloa and Kealakekua include those by Reinecke (n.d.), Silverman (1968), Soehren (1968), Hommon and Crozier (1970), Schilt (1984), Clark (1983), and Advisory Committee (1985). Reinecke (n.d.) was the first to investigate the archaeological potential of this general region. He commented on the disturbances caused by earlier cultivation of pineapple (n.d.:2) in the vicinity of the study area, but he did not record any specific sites within the present project area. Sites recorded by Reinecke (n.d.) are located along the immediate shoreline.

The Silverman study consisted of a historical documentary review of sites and events during the time of Captain Cook's arrival. Soehren's 1968 report consists of an evaluation of archaeological features between Honaunau and Kaawaloa. Soehren remarks that at Kaawaloa most of the sites have been destroyed, their stones used to build historic fences; of the sites that still exist, most are in poor condition. Soehren includes a list of sites in Kealakekua and Kaawaloa, none of which are located in the present project area. Hommon and Crozier (1970) conducted an intensive survey in the southern portion of Kaawaloa; they encountered a number of sites—*kipuka*, pavements, mounds, walls, enclosures, platforms, modern structures, pits, and long walls which corresponded to LCAs and modern property boundaries. None of the sites are within the present project area. Schilt (1982) surveyed a 1.98 acre lot of Subdivision 4798, situated in Kealakekua. Schilt did not find any archaeological resources on the lot. The study by Clark (1983) consisted of a reconnaissance

survey of seven residential lots. Clark recorded 34 features of which several appeared to consist of remnants of the Kona Field System. The study by the Advisory Council included recommendations for the development, management, and operation of Kealakekua State Historical Park on the island of Hawaii.

Previous archaeological work conducted in the general vicinity of Kaawaloa and Kealakekua and the present project area includes, but is not limited to, Hawaii Register of Historic Places (HRHP 1971), Soehren (1981), Rosendahl (1984a,b;1989), and Walker and Rosendahl (1985).

SUMMARY OF HISTORICAL DOCUMENTARY RESEARCH

Historic background studies have been conducted in conjunction with a few early archaeological studies in Kaawaloa and the Kealakekua area. These studies, as well as the historic research conducted for this project (Kalima, Appendix B), are the principal sources for the following summary.

Kaawaloa Ahupua'a is in South Kona and is bounded on the north by Keopuka Ahupua'a and on the south by Kealakekua Ahupua'a. This area is also known as Konawaena (middle Kona) because of its location generally midway between the South and North Kona Districts. The name given to this *ahupua'a*, meaning "the distant kava," is thought to be derived by the fact that many runners were sent from this area across the island to Puna to fetch kava (*awa*) for chiefs.

Kalima recounts a traditional legend that refers to Kaawaloa; the legend concerns a male visitor to Kaawaloa, named Akalele, and the canoe race between he and a king with a fully crewed canoe. In this tale, the men race to Awill, a harbor on the flat coast of Kaawaloa, and Akalele wins singlehandedly. Kalima also presents historical accounts by Handy and Handy (1972), Kuykendall (1968), and Menzies (1920) (see Appendix B references); the accounts describe the general environment of the area and the traditional Hawaiian economy in the Kealakekua Bay area. The accounts reflect on the high population of the dry coastal area and the large agricultural fields above the cliff and areas to the north. The accounts especially note the highly varied and productive fields of breadfruit, plantain, taro root, sweet potatoes, ginger root, and sugar cane. According to Menzies (1920:74), "...beyond the bread-fruit plantations, the country became more and more fertile, being in a high state of cultivation. For several miles round us there was not a spot that would admit of it but what was with great labor and industry cleared of the loose stones and planted with esculent roots or some useful vegetable or other."

The *ahupua'a* of Kaawaloa was listed as government land in the Great Mahele of 1848. Several parcels were then given to various people. The land on which the project area lies closest to was once the property of Keohokalole, mother of King David Kalakaua (L.C.A. 8452), a parcel with an area of 2,100 acres.

Renowned in ancient days as the home of several chiefs, Kaawaloa housed Hawaiian *ali'i* and served as their meeting place. Thrum, Soehren, and Stokes all list many previously located historical and cultural sites in Kaawaloa.

FIELD METHODS AND PROCEDURES

Field work for the current project was conducted May 16-June 3, 1990 under the direction of Supervisory Archaeologists Alan T. Walker and Berdena Burgett, assisted by Field Archaeologists Robert L. Noah, Steven Tachera, Edward Archer, and Ranae Ganske. A 100%-coverage surface survey was accomplished by way of a series of pedestrian transects beginning at the southeast boundary and oriented approximately northeast to southwest, perpendicular to the major axis of the project area. Intervals between sweeping crew members were 10-20 m, depending on vegetation and terrain encountered. To aid in relocating sweep areas and sites, sweeps were numbered sequentially. To ensure complete coverage, the edges of sweep areas were flagged with red or blue-stripe flagging tape. As sites were identified, they were flagged with pink-and-blue flagging tape and were assigned PHRI sequential temporary numbers prefixed by "770-", beginning with 770-1. Subsequently, all identified sites were assigned State Inventory of Historic Places (SIHP) permanent site numbers (*Table 1*).

All sites were plotted on a 1"=200' scale color aerial photo produced by Air Survey Hawaii (Photo No. 1-218 H; date 12/31/82), and were listed by sweep designations in a field notebook. Site plotting was aided by a blueline topographic map (1"=200' scale; 10-ft contours) prepared by Nelson and Wright, Golf Course Architects. The site locations plotted on the color aerial photo were done in the field and are only approximate. After plotting, sites were recorded on standard PHRI site record forms and were sketch-mapped, with orientation and site dimensions determined using metric tape and compass. A complete photographic record (35 mm black-and-white) of field work was done (PHRI Roll Nos. 1474-1478). Sites were tagged with an aluminum strip bearing the site number, PHRI project number (89-770), the letters PHRI, and the date.

Table 1.

CORRELATION OF SITE NUMBERS

*SIHP	#S&H	PHRI	SIHP	S&H	PHRI
13657	-	770- 1	14176	215	770-28
13658	-	770- 2	14177	-	770-29
13659	-	770- 3	14178	-	770-30
14155	-	770- 4	14179	-	770-31
14156	-	770- 5	14180	-	770-32
14157	-	770- 9	14180-D	212	770-32
14158	-	770-10	14180-C	211	770-32
14159	-	770-11	14181	-	770-33
14160	-	770-12	14181-D	210	770-33
14161	-	770-13	14182	-	770-34
14162	-	770-14	14183	-	770-35
14163	-	770-15	14184	-	770-36
14164	-	770-16	14185	-	770-37
14165	-	770-17	14186	-	770-38
14166	-	770-18	14187	-	770-39
14167	-	770-19	14188	-	770-40
14168	-	770-20	14189	-	770-41
14169	-	770-21	14190	-	770-42
14170	-	770-22	14191	-	770-43
14171	-	770-23	14192	-	770-44
14172	-	770-24	14754	208	770- 6
14173	-	770-25	14755	-	770- 7
14174	-	770-26	14756	-	770- 8
14175	-	770-27	-	213+	-

* State Inventory of Historic Places (SIHP) numbers. SIHP numbers are five-digit numbers prefixed by 50-10-47 (50=State of Hawaii; 10=Island of Hawaii; 47=USGS 7.5' series quad map ["Honaunau, Hawaii"]).

Soehren and Newman (1968)

+ Not located during the present project

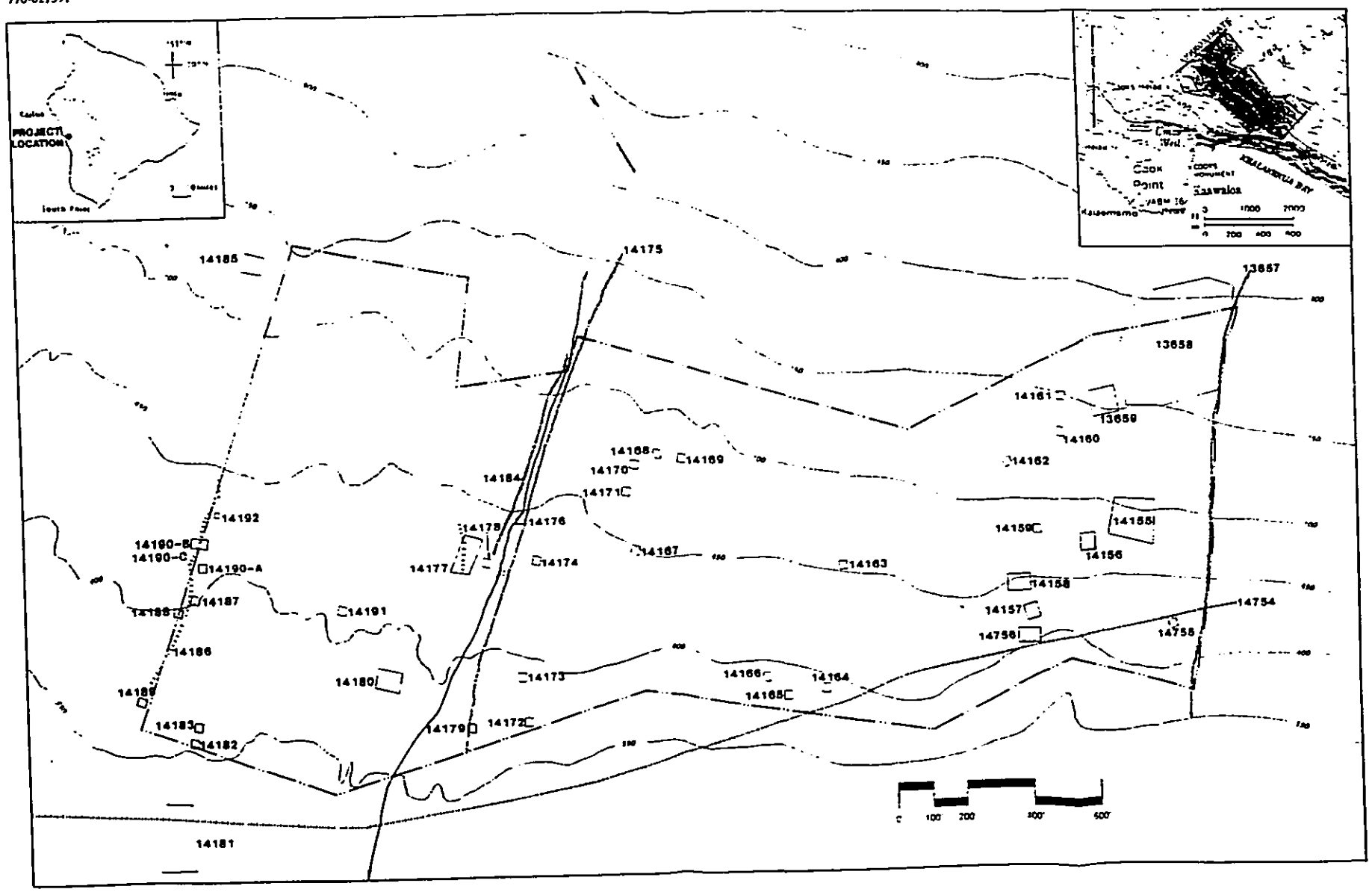


Figure 1. Project Area and Site Location Map

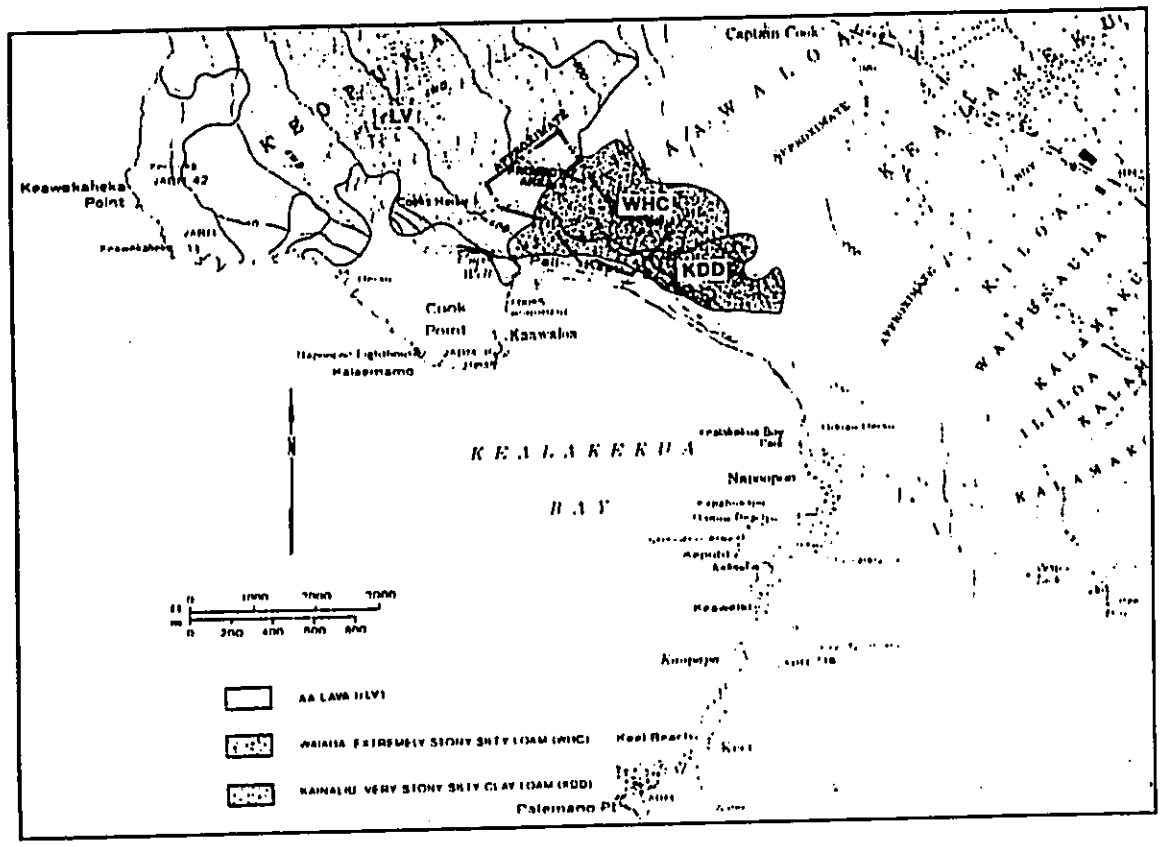
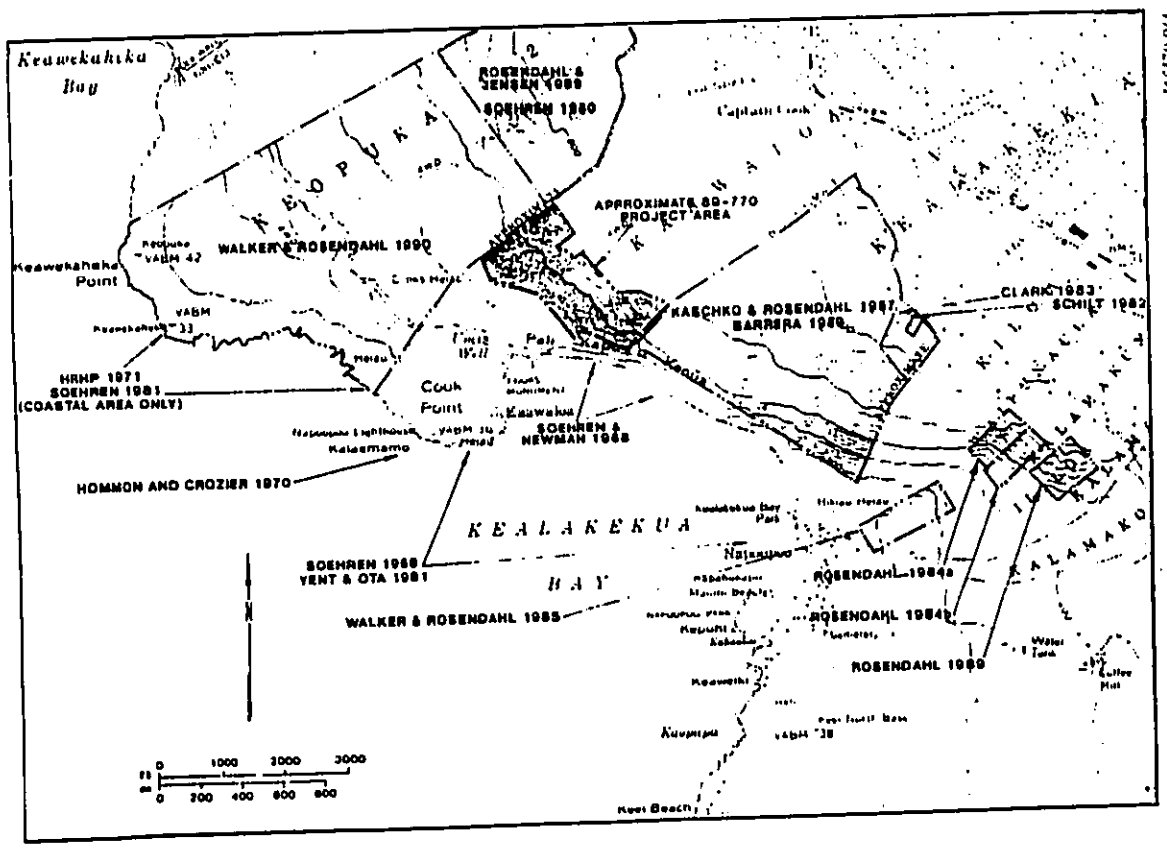


Figure 2. Terrain Map



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INTRODUCTION

BACKGROUND

This report presents the results of an archaeological inventory survey conducted at the Kealakekua Ranch Development - Kaawaloa Parcel, consisting of c. 70 acres in the Land of Kaawaloa, South Kona District, Island of Hawaii (TMK:3-8-1-10:Por.2). The survey work was conducted by Paul H. Rosendahl, Ph.D., Inc. (PHRI) at the request of Ms. Anne Mapes of Belt, Collins & Associates (BCA), for BCA client, Royal Coast Development Corporation. The overall objective of the survey was to provide information appropriate to and sufficient for the preparation of an Environmental Assessment (EA). The EA is being prepared in conjunction with (a) a Conservation District Use Application to be submitted to the Hawaii State Board of Land and Natural Resources, and (b) a Special Management Area Permit Application to be submitted to the County of Hawaii.

The survey field work was conducted May 16, 1990 through June 3, 1990. The field crew consisted of four to five persons under the direction of Supervisory Archaeologists Alan T. Walker, B.A., and Berdena Burgett, B.A. Principal Investigator Dr. Paul H. Rosendahl provided overall guidance for the project. Approximately 460 man-hours of labor were expended conducting the field work portion of the survey.

This report is the Final Report for the present project; it includes (a) background information on the environment and cultural-historical setting of the project area, (b) a summary of previous archaeological investigations relevant to the project area, (c) a description of field methodology, (d) a discussion of findings, and (e) site significance evaluations and recommended general treatments for each site.

SCOPE OF WORK

The basic purpose of an archaeological inventory survey is to identify—to discover and locate on available maps—all sites and features of potential archaeological significance present within a specified project area. An *inventory survey* comprises an initial level of archaeological investigation. It is extensive rather than intensive in scope, and is conducted basically to determine the presence or absence of archaeological resources. This level of survey indicates both the general nature and variety of archaeological remains present, and the general distribution and density of such remains. Finally, it permits a general significance assessment of the archaeological resources, and facilitates formulation of realistic recommendations and estimates for any subsequent *mitigation* work as might be necessary or appropriate. Such work could include further data collection involving detailed recording of sites and features, and selected excavations; and possibly subsequent data recovery research excavations, construction monitoring, interpretive planning and development, or preservation of sites and features with significant scientific research, interpretive, or cultural values.

The basic objectives of the current survey were fourfold: (a) to identify (find and locate) all sites and site complexes present within the project area; (b) to evaluate the potential general significance of all identified archaeological remains; (c) to determine the possible impacts of proposed development upon the identified remains; and (d) to define the general scope of any subsequent further data collection or other mitigation work that might be necessary or appropriate.

Based on a review of available background literature, basic familiarity with the general project area, extensive familiarity with the current requirements of review authorities; and based on discussions with Ms. Anne Mapes of Belt, Collins & Associates and with Mr. Clifford Temps of Royal Coast Development Corporation, the following specific tasks were determined to constitute an adequate and appropriate scope of work for the inventory survey:

1. Conduct archaeological background and historical documentary background research involving review and evaluation of readily available archaeological and historical literature, historic documents and records, and cartographic sources relevant to the immediate project area;

2. Conduct variable coverage (partial to 100%), variable intensity surface survey of the project area, with (a) relatively higher intensity coverage being given non-cultivated and otherwise minimally modified lands, and (b) relatively lower intensity coverage to areas extensively modified by historic period or recent cultivation;

3. Conduct limited subsurface reconnaissance testing of selected sites and features identified within the project area (a) to determine the presence or absence of potentially significant buried cultural features or deposits, and (b) to obtain suitable samples for age determination analyses; and

4. Analyze background research data and field data, and prepare appropriate reports.

The inventory survey was carried out in accordance with the standards for inventory-level survey recommended by the State Department of Land and Natural Resources-Historic Preservation Program/State Historic Preservation Office (DLNR-HPP/SHPO). The significance of archaeological remains identified within the project area were assessed in terms of (a) the National [illegible] contained in the Code of Federal [illegible] Part 60), and (b) the criteria for [illegible] cultural values prepared by the National Advisory Council on Historic Preservation (ACHP). DLNR-HPP/SHPO and the Hawaii County Planning Department use these criteria to evaluate eligibility for both the Hawaii State and National Register of Historic Places. In order to facilitate future client management decisions regarding archaeological sites, archaeological remains were also assessed in terms of PHRI CRM (Cultural Resource Management) value modes, which are based on the above federal criteria. Significance criteria are discussed further in the Conclusion section.

PROJECT AREA DESCRIPTION

The Kealakekua Ranch Development - Kaawaloa Parcel project area is situated inland of a steep cliff known as Pali Kapu O Keoua; this cliff overlooks Kealakekua Bay and Kalaemamo (*Figure 1*). The project area is bounded on the south by the Land of Kealakekua (the boundary is marked by an old stone wall), on the north by the Land of Keopuka, and to the east and west by lands within Kaawaloa.

Elevation within the project area ranges from c. 570 to 800 ft AMSL (above mean sea level). The terrain in the area is undulating and generally slopes downward from inland (east) to seaward (west). Rainfall within the project area is c. 45-65 inches per year. The mean annual temperature is approximately 75 degrees F (Armstrong 1983:63, 64).

Three classifications of soil are present within the project area (*Figure 2*). The northern portion exhibits a miscellaneous land type classified as aa lava. According to Sato et al. "[t]his lava has practically no soil covering and is bare of vegetation, except for mosses, lichens, ferns, and a few small *ohia* trees...[i]t is associated with pahoehoe lava flows and many soils" (Sato et al. 1973:34). During the present survey, it was noted that the aa lava terrain was also interspersed with areas of pahoehoe-like lava. The southern-inland portion consists of Waiaha [illegible] (6-12% slopes) representing the Waiaha [illegible] well-drained silt loams that formed in volcanic ash (Sato et al. 1973). According to Sato et al. "[i]n a representative profile the surface layer is very dark brown, extremely stony silt loam about 4 inches thick. The subsoil is dark-brown very stony silt loam about 14 inches thick. The substratum is pahoehoe lava bedrock" (Sato et al. 1973:52). Kainaliu very stony silty clay loam (12-20% slopes) is present along the southern-seaward section of the project area. This is a representative of Kainaliu series of well drained silty clay loams that formed in volcanic ash (Sato et al. 1973). Both the Waiaha and Kainaliu series are generally used for pasture.

Vegetation within the project area ranges from moderately sparse on the aa lava flow portion to dense on the Waiaha series and Kainaliu series soils. Vegetation on the aa lava includes scattered Christmas-berry (*Schinus terebinthifolius* Raddi.), *koa-haole* (*Leucaena leucocephala* [Lam.] de Wit), lantana (*Lantana camara* L.), *'opiuma* (*Pithecellobium dulce* [Roxb.] Benth.), *pua-pilo* (*Capparis sandwichiana* DC.), *'uhaloa* (*Waltheria americana* L.), *pukiawe* (*Styphelia tameiameiae* [Cham.] F. Muell.), and *laua'e* (*Microsorium scolopendria* [Burm.] Copel.). Vegetation on the Waiaha and Kainaliu series soils is composed primarily of a thick ground cover of introduced grasses and weeds. Also present are Christmas-berry (*Schinus terebinthifolius* Raddi.), *koa-haole* (*Leucaena leucocephala* [Lam.] de Wit), *kukui* (*Aleurites moluccana* L. Willd.), lantana (*Lantana camara* L.), monkeypod (*Samanea saman* [Jacq.] Merr.), *'opiuma* (*Pithecellobium dulce* [Roxb.] Benth.), *'uhaloa* (*Waltheria americana* L.), mock orange (*Murraya paniculata* [L.] Jack), castor bean (*Ricinus communis* L.), morning-glory (Convolvulaceae), *pa-nini* (*Opuntia megacantha* Salm-Dyck), periwinkle (*Catharanthus roseus* [L.]) G. Don, sword fern (*Nephrolepis biserrata*), and various unidentified vines.

The entire project area is within the boundaries of the Kona Field System and the Kealakekua Bay Historic District. Previously declared eligible for inclusion on the NRHP (National Register of Historic Places), the Kona Field System (Site 6601) is a complex of aboriginal Hawaiian dryland cultivation and habitation features which covers an area approximately 3 by 18 miles, extending from the Kailua area south to Hookena. The Kealakekua Bay Historic District (Site 7000) is an extremely important historical district that was placed on the NRHP in December of 1974. Kealakekua Bay is noted as the location of Captain James Cook's death in AD 1779.

PREVIOUS ARCHAEOLOGICAL WORK

[illegible] logical work conducted within the [illegible] limited to an investigation by Soehren [illegible] 3). That study consisted of an inventory and evaluation of archaeological remains situated in several parcels of land immediately above Kealakekua Bay and includes a large portion of the present project area (*Figure 3*). The purpose of the study was to provide specific

Archaeological Inventory Survey Kealakekua Ranch Development - Kaawaloa Parcel

Land of Kaawaloa, South Kona District Island of Hawaii

PHRI
Paul H. Rosendahl, Ph.D., Inc.
Archaeological • Historical • Cultural Resource Management Studies & Services
305 Mohouli Street • Hilo, Hawaii 96720 • (808) 969-1763 • FAX (808) 961-6998
P.O. Box 23305 • G.M.F., Guam 96921 • (671) 472-3117 • FAX (671) 472-3131

Report 770-021391

Archaeological Inventory Survey Kealakekua Ranch Development - Kaawaloa Parcel

Land of Kaawaloa, South Kona District
Island of Hawaii

(TMK:3-8-1-10:Por.2)

by

Alan T. Walker, B.A.
Supervisory Archaeologist

Lehua Kalima, B.A.
Historical Researcher

and

Susan T. Goodfellow, Ph.D.
Laboratory Director

Prepared for

Royal Coast Development Corporation
c/o Belt, Collins & Associates
680 Ala Moana Blvd., Suite 200
Honolulu, Hawaii 96813

February 1991

PHRI
Paul H. Rosendahl, Ph.D., Inc.
Archaeological • Historical • Cultural Resource Management Studies & Services
305 Mohouli Street • Hilo, Hawaii 96720 • (808) 969-1763 • FAX (808) 961-6998
P.O. Box 23305 • G.M.F., Guam 96921 • (671) 472-3117 • FAX (671) 472-3131

SUMMARY

At the request of Ms. Anne Mapes of Belt, Collins & Associates (BCA), for BCA client, Royal Coast Development Corporation, Paul H. Rosendahl, Ph.D. Inc. (PHRI) conducted an archaeological inventory survey of the c. 70-acre Kealakekua Ranch Development - Kaawaloa Parcel project area in the Land of Kaawaloa, South Kona District, Island of Hawaii (TMK:3-8-1-10.Por.2). The survey work was conducted May 16, 1990 through June 3, 1990 and consisted of a 100%-coverage pedestrian survey, augmented with subsurface testing. Approximately 460 man-hours of labor were expended on the survey field work.

Forty-four sites (consisting of 85 component features) were identified during the survey. The sites included 34 single- and ten multiple- component sites. Of the 44 sites, four had been initially identified by Soehren and Newman (1968). The four sites (Sites 208, 210, 211, and 212*) have been assigned State Inventory of Historic Places (SIHP) site numbers (Sites [illegible] respectively) during the present project. One site (Site 21[illegible]) could not be relocated during the present project.

Formal feature types present within the project area include terraces, enclosures, walls, caves, mounds, linear alignments, modified outcrops, walled pavements, stepped terraces, pahoehoe excavations, trails, roads, modified sinkhole, platform, stepped platform, C-shape, rectangular boulder alignment (firepit), and an upright. Functional types tentatively identified include habitation, agriculture, agriculture/habitation, temporary habitation, boundary, transportation, burial, agriculture/boundary, indeterminate/possible marker, marker, possible quarry, quarry, and indeterminate.

Of the 44 sites identified, 36 (81.8%) are assessed as significant solely for scientific information content. Further data collection is recommended for 27 of the 36 sites. After further data collection is completed, if further work is warranted, a data recovery plan for the work should be prepared and implemented for sites not recommended for preservation or interpretation. No further work is recommended for the remaining nine of the 36 sites. Data collected from them during the present survey is considered sufficient; their preservation is not essential, although some sites could perhaps be considered for inclusion into development landscaping.

Of the remaining eight sites (18.2%), five are assessed as significant for scientific information content, are excellent examples of a site type, and are culturally significant. For these five sites (Sites 14176, 14177, 14180, 14186, and 14754), further data collection followed by preservation with some level of interpretive development is recommended. One of the five sites contains a burial feature (Site 14180, Feature E). It is recommended that this feature be preserved "as is" and not be interpreted or displayed.

Two of the eight sites (Sites 14185 and 14192) are assessed as significant for scientific information content and are culturally significant. For these two sites, further data collection is recommended. Because the two sites contains burials, following further data collection, preservation "as is" is recommended.

The final site (Site 14755) is assessed as significant for information content and is tentatively evaluated as culturally significant. For this site, further data collection is recommended, and preservation "as is" is tentatively recommended, pending further data collection results. This site may contain a burial.

---

* B.P. Bishop Museum site designation system: all three-digit site numbers prefixed by HA-C23- (HA=Island of Hawaii, C=South Kona District, 23=Lands of Kaawaloa and Kealakekua [Soehren and Newman 1968])

\# State Inventory of Historic Places (SIHP) site designation system: all five- digit site numbers prefixed by 50-10-47 (50=State of Hawaii; 10=Island of Hawaii; 47=USGS 7.5' series quad map ["Honaunau, Hawaii"]).

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Appendix 3:
BOTANICAL SURVEY, KEALAKEKUA RANCH GOLF COURSE PROJECT

BOTANICAL SURVEY
KEALAKEKUA RANCH GOLF COURSE PROJECT
NORTH KONA, ISLAND OF HAWAI'I

by

Winona P. Char
CHAR & ASSOCIATES
Botanical/Environmental Consultants
Honolulu, Hawai'i

Prepared for: BELT COLLINS & ASSOCIATES

May 1990

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BOTANICAL SURVEY
KEALAKEKUA RANCH GOLF COURSE PROJECT
NORTH KONA, ISLAND OF HAWAI'I

INTRODUCTION

The proposed golf course project site consists of approximately 280 acres of land located between Captain Cook town and Kealakekua Bay. The site lies immediately above the steep cliff known as Pali Kapu-o-Keoua, overlooking Kealakekua Bay. A large part of the irregularly-shaped property, about 190 acres, is used for grazing cattle by Kealakekua Ranch; the additional ±90-acre parcel, or Norrie property, is also used for grazing except for the northern most section which contains a rough 'a'a lava flow. Past uses of the project site have included pineapple and coffee cultivation. The proposed 18-hole golf course will include a clubhouse, parking area, landscape and maintenance facilities, possibly an inn site, and other amenities.

Field studies to assess the botanical resources on the proposed golf course site were conducted on January 14-15, 1990. A total of three botanists were used to gather the technical data contained in this report. The objectives of the field studies were to (1) describe the major plant communities; (2) inventory the terrestrial, vascular flora; and (3) search for threatened and endangered species protected by federal and/or state laws.

SURVEY METHODS

Prior to the field studies, a search was made of the pertinent literature to familiarize the principal investigator with other biological studies conducted in the general area. Topographic maps as well as recent colored aerial photographs were examined to determine vegetation patterns, terrain characteristics, access, boundaries, and reference points.

Access onto the site is from the main ranch road off the lower Government Main Road to Napo'opo'o. From the main ranch road, a number of jeep roads cross the property, some more overgrown than others.

A walk through survey method was used with areas less disturbed, as the area adjacent to the cliff and the lava flow, more intensively examined. Notes were made on plant associations and distribution, substrate types, topography, exposure, etc. Species which could not be positively determined were collected for later identification in the herbarium and for comparison with the most recent taxonomic literature.

DESCRIPTION OF THE VEGETATION

On the project site, the vegetation is dominated by introduced species with Guinea grass (*Panicum maximum*) being the most abundant plant cover along with a varied mixture of tree species and ekoa (*Leucaena leucocephala*) shrubs. This, in large part, is due to past disturbances. A major portion of the Kealakekua Ranch parcel supports soils of the Kainaliu series (Sato *et al*. 1973); these sites were cultivated for pineapple and coffee at one time. Since then both the Kealakekua Ranch parcel and the Norrie property have been used for grazing cattle. Native species occur most frequently on the 'a'a lava flow on the northern portion of the proposed golf course site and near the coastal cliff area where there has been less disturbance.

Four plant communities or vegetation types can be recognized on the project site and are discussed in detail below. Vegetation associated with homes and other maintained areas was not surveyed. All those plant species inventoried during the field studies is presented in the checklist at the end of the report.

1. Open Mixed Forest

This plant community is found on the mauka half of the Kealakekua Ranch parcel from about the 900-foot elevation. Average annual rainfall is slightly higher on this portion of the property; about 50 inches/year on the mauka half and roughly 40 inches/year on the makai half. Because of this difference in rainfall, the mauka portion supports denser vegetation cover and many more tree species. The canopy of the forest is open, that is tree cover is from about 30 to 60% and in most places the crowns of the trees do not interlock.

Large trees of monkeypod (Samanea saman), from 25 to as much as 40 ft. tall, are the primary components. Scattered stands of kukui trees (Aleurites moluccana) are frequent. Jacaranda trees (Jacaranda mimosifolia), with their purplish-blue colored flowers are easy to spot in the spring, however, when they are not flowering, they tend to blend in with the rest of the canopy especially with the chinaberry trees (Melia azedarach). Two tree species which were originally experimental plantings obtained from the University of Hawai'i (pers. comm. S. Greenwell) can be found on the property; these are bella sombra (Phytolacca dioica) and Ceylon gooseberry (Dovyalis hebecarpa). The gooseberry produces numerous purplish, velvety fruits with juicy, edible, purplish pulp and several seeds. The fruits along with the seeds are eaten by birds and feral (wild) pigs, thus, it is not uncommon to find saplings or young trees scattered over the property. Two other species which have become naturalized on the site and other areas along the Kona coast are papaya (Carica papaya) and

mulberry (Morus alba). One small former planting of coffee (Coffea arabica) was found during the survey but we did not find any plants naturalized on the site; this may be because this particular site is too dry for coffee to establish itself.

Among the shrubs, koa-haole (Leucaena leucocephala), or ekoa as it is more commonly called on the big island, may form fairly large, scattered thickets in places. Other shrubs which are locally common to occasional are lantana (Lantana camara), Senna septemtrionalis, burbush (Triumfetta rhomboidea), and hairy abutilon (Abutilon grandifolium). In most places, Guinea grass (Panicum maximum) forms a dense cover in between the shrubs and trees. Areas with deeper soil or with slightly damper conditions, as along drainages and in small gullies, support very tall, 7 to 8 ft., and very dense Guinea grass, making botanizing difficult. Wild pigs also tend to favor these areas.

2. 'Opiuma Savanna

This vegetation type consists of widely spaced trees of 'opiuma (Pithecellobium dulce) and generally occurs below the 900-foot elevation; tree cover may be as little as 5% to as much as 30%. Again Guinea grass is the dominant ground cover, although, in places, Bermuda grass or manienie (Cynodon dactylon) may be more common. Scattered patches of kikuyu grass (Pennisetum clandestinum) can also be found, usually associated with somewhat more stony soils.

Other tree species associated with the savanna include kiawe (Prosopis pallida), chinaberry, and monkeypod. Large trees of monkeypod are more frequent on the Kealakekua Ranch parcel. Scattered through the savanna are shrubs of Christmas berry (Schinus terebinthifolius), up to 15 ft. tall; these tend to be rounded and tree-like with the usual tangle of lower branches absent. Ekoa shrubs form small narrow strips, usually following

along ancient lava flow ridges or sometimes in drainageways. Among the ground cover plants, two, sensitive plant or puahilahila (Mimosa pudica) and West Indian beggar's-tick (Bidens cynapiifolia), appear to be more abundant during the rainy season. A few plants occur on what appear to be former house sites; these plants are para rubber tree (Hevea brasiliensis), red hibiscus (Hibiscus rosa-sinensis), and mango (Mangifera indica).

Where the savanna adjoins the coastal cliff, rocky areas support a few natives such as the kumu niu fern (Doryopteris decora), koali (Ipomoea indica), spur flower (Plectranthus parviflorus), 'ala 'ala wai nui (Peperomia leptostachya), and 'uhaloa (Waltheria indica).

3. Ekoa Shrubland

This plant community occupies a relatively small area, roughly less than 10 acres, on the Norrie property. On the aerial photos it appears as a wedge-shaped piece, located between the 'opiuma savanna and the lava flow scrub. Ka'awaloa Road, identified as a 4-WD road on most topographic maps, runs along one side of the shrubland. Ekoa shrubs, 12 to 15 ft. tall, form a dense thicket on very stony soil. As on other portions of the project site, Guinea grass is the dominant ground cover although it may be less dense in this shrubland. Locally common on the ekoa shrubs is wild bittermelon (Momordica charantia), an annual high-climbing vine. Along the stonewall which runs parallel to Ka'awaloa Road, airplant (Kalanchoë pinnata) replaces Guinea grass as the most abundant ground cover plant. A few tamarind trees (Tamarindus indica) can also be found near Ka'awaloa Road.

4. Lava Flow Scrub

To the north of the proposed golf course is a large 'a'a lava flow, a portion of which is included within the subject property.

Plants occur as scattered patches over the rough surface of the flow, usually in depressions or in crevices. Plant cover is about 20% and is composed of low thickets of ekoa, Christmas berry, and lantana, from 3 to 6 ft. tall. A few scattered trees of 'opiuma are also found on the flow.

Most of the native species found on the project site occur within this plant community. These include a few plants of the native caper or puapilo (Capparis sandwichiana), spur flower, ilima (Sida fallax), huehue (Cocculus trilobus), 'ala 'ala wai nui, and 'uhaloa. The koali, a member of the morning-glory family, is locally common, forming a dense tangle over the shrubs. One small tree of mamane (Sophora chrysophylla), about 12 ft. tall, can also be found on the 'a'a flow.

THREATENED AND ENDANGERED PLANTS

Vegetation on the project site is dominated by introduced or alien species, which make up the major components of the four plant communities recognized on the site. Of a total of 108 species inventoried, 92 (85%) are introduced species, 5 (5%) are originally of Polynesian introduction, and 10 (10%) are native. Of the native species, 8 are indigenous, that is, they occur naturally throughout the Hawaiian Islands and the Pacific, and, 3 are endemic, that is, they occur naturally only within the islands. These 3 endemics are puapilo (Capparis sandwichiana), mamane (Sophora chrysophylla), and kumu niu (Doryopteris decora).

None of the native species are considered officially listed threatened and endangered species protected by endangered species laws nor are any currently being proposed for such status (U. S. Fish and Wildlife Service 1989, 1990). The native caper or puapilo is considered a Category 2, candidate endangered species (U. S. Fish and Wildlife Service 1990). Category 2 plants are those for

which there is some evidence of vulnerability, but for which there are not enough data to support listing proposals at this time.

Puapilo is a low, somewhat sprawling shrub with bluish-green leaves. Flowers are large, fragrant, white and open after sunset. Fruits resemble small cucumbers and contain an orange pulp. Plants can be found in leeward coastal and lowland situations on all of the main Hawaiian Islands and a few of the northwest islands -- Midway, Pearl and Hermes Atoll, Laysan.

DISCUSSION AND RECOMMENDATIONS

Four major plant communities are described from the property. These are open mixed forest, dominated by monkeypod as well as several other tree species; 'opiuma savanna; ekoa shrubland; and lava flow scrub. Guinea grass is the dominant ground cover species in the first three plant communities. Open mixed forest and 'opiuma savanna together cover roughly 75% of the property. Introduced or alien species are the dominant components in all of the plant communities. Of a total of 108 plants inventoried, 85% (92) are introduced species. Native species occur primarily on the coastal cliff adjoining the 'opiuma savanna and on the 'a'a lava flow on the northern portion of the property. One Category 2, candidate endangered species, the puapilo or native caper, occurs on the lava flow area.

The majority of the property is vegetated with introduced species and the proposed development is not expected to have a significant negative impact on these areas. Of some concern, is the lava flow area as it does contain plants of one candidate endangered species, although of low priority. It is recommended that as much of the flow be left intact and incorporated into the landscaping; this has been done for other courses such as the world-famous Mauna

Lani course. In addition, use of native plants for landscaping should be considered. Native lowland species already adapted to local environmental conditions such as low rainfall would require less water. Some natives of landscape value include the puapilo, wiliwili (Erythrina sandwicensis), naio or false sandalwood (Myoporum sandwicensis), ohe (Reynoldsia sandwicensis), mamane, kolomona (Senna gaudichaudii), 'ihi (Portulaca villosa, P. lutea, P. molokiniensis), etc.

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PLANT SPECIES LIST -- KEALAKEKUA RANCH GOLF COURSE PROJECT

Following, is a list of all those vascular plant species inventoried during the field studies. Plant families are arranged alphabetically within each of three groups: Ferns, Monocots, and Dicots. Taxonomy and nomenclature of the Ferns follow Lamoureux (1984); the flowering plants, Monocots and Dicots, are for the most case in accordance with Wagner et al. (1990). Common English and/or Hawaiian names used follow St. John (1973) or Porter (1972).

For each species, the following information is provided:

1. Scientific name with author citation.
2. Common English and/or Hawaiian name, when known.
3. Biogeographic status. The following symbols are used:
   E = endemic = native only to the Hawaiian Islands
   I = indigenous = native to the islands and also to one or more other geographic area(s)
   P = Polynesian = plants of Polynesian introduction prior to Western contact (1778); not native
   X = introduced or alien = all those plants brought to the Islands intentionally or accidentally after Western contact; not native.
4. Presence (+) or absence (-) of a particular species within each of four plant communities (or vegetation types) recognized on the project site; see text for discussion.
   1 = Open Mixed Forest
   2 = 'Opiuma Savanna
   3 = Ekoa Shrubland
   4 = Lava Flow Scrub

SPECIES LIST

SCIENTIFIC NAME	COMMON NAME	STATUS	COMMUNITY 1	2	3	4
FERNS						
Nephrolepidaceae (Sword fern family)						
Nephrolepis multiflora (Roxb.) Jarret ex Morton	sword fern	X	+	+	-	+
Polypodiaceae (Common fern family)						
Phlebodium aureum (L.) J. Sm.	laua'e haole	X	+	+	-	-
Phymatosorus scolopendria (N. E. Burm.) Pichi-Serm.	laua'e	X	-	-	-	+
Pleopeltis thunbergiana Kaulf.	pakahakaha	I	+	-	-	-
Sinopteridaceae (Cliff-brake familly)						
Doryopteris decora Brack.	kumu niu, 'iwa'iwa	E	-	+	-	-
Thelypteridaceae (Downy wood-fern family)						
Christella dentata (Forssk.) Brownsey & Jermy	oak fern	X	+	-	-	-
MONOCOTS						
Commelinaceae (Spiderwort family)						
Commelina diffusa N. L. Burm.	honohono	X	+	-	+	+
Cyperaceae (Sedge family)						
Kyllinga brevifolia Rottb.	kyllinga	X	+	-	-	-

SCIENTIFIC NAME	COMMON NAME	STATUS	COMMUNITY 1	2	3	4
Poaceae (Grass family)						
Cynodon dactylon (L.) Pers.	Bermuda grass	X	-	+	-	-
Eleusine indica (L.) Gaertn.	goose grass	X	-	+	-	-
Eragrostis tenella (L.) Beauv. ex R. & S.	love grass	X	-	+	-	-
Melinus minutiflora P. Beauv.	molasses grass	X	+	+	-	+
Panicum maximum Jacq.	Guinea grass	X	+	+	+	-
P. maximum var. *trichoglume* Eyles ex Robyns	green panic grass	X	-	+	-	-
Pennisetum clandestinum Chiov.	kikuyu grass	X	+	-	-	-
Pennisetum purpureum Schumach.	elephant grass	X	-	+	-	-
Rhynchelytrum repens (Willd.) Hubb.	Natal redtop	X	-	+	-	+
DICOTS						
Amaranthaceae (Amaranth family)						
Amaranthus spinosus L.	spiny amaranth	X	+	+	-	-
Anacardiaceae (Cashew family)						
Anacardium occidentale L.	cashew	X	+	-	-	-
Mangifera indica L.	mango	X	+	+	-	-
Schinus terebinthifolius Raddi	Christmas berry	X	+	+	-	+
Spondias dulcis Parkins.	Otaheite apple	X	+	-	-	-
Annonaceae (Custard-apple family)						
Annona muricata L.	soursop	X	+	-	-	-
Apocynaceae (Dogbane family)						
Catharanthus roseus (L.) G. Don	periwinkle	X	-	+	-	-

CORRECTION

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

SPECIES LIST

SCIENTIFIC NAME	COMMON NAME	STATUS	COMMUNITY 1	2	3	4
FERNS						
Nephrolepidaceae (Sword fern family)						
Nephrolepis multiflora (Roxb.) Jarret ex Morton	sword fern	X	+	+	-	+
Polypodiaceae (Common fern family)						
Phlebodium aureum (L.) J. Sm.	laua'e haole	X	+	+	-	-
Phymatosorus scolopendria (N. E. Burm.) Pichi-Serm.	laua'e	X	-	-	-	+
Pleopeltis thunbergiana Kaulf.	pakahakaha	I	+	-	-	-
Sinopteridaceae (Cliff-brake familly)						
Dorvopteris decora Brack.	kumu niu, 'iwa'iwa	E	-	+	-	-
Thelypteridaceae (Downy wood-fern family)						
Christella dentata (Forssk.) Brownsey & Jermy	oak fern	X	+	-	-	-
MONOCOTS						
Commelinaceae (Spiderwort family)						
Commelina diffusa N. L. Burm.	honohono	X	+	-	+	+
Cyperaceae (Sedge family)						
Kyllinga brevifolia Rottb.	kyllinga	X	+	-	-	-

SCIENTIFIC NAME	COMMON NAME	STATUS	COMMUNITY 1	2	3	4
Poaceae (Grass family)						
Cynodon dactylon (L.) Pers.	Bermuda grass	X	-	+	-	-
Eleusine indica (L.) Gaertn.	goose grass	X	-	+	-	-
Eragrostis tenella (L.) Beauv. ex R. & S.	love grass	X	-	+	-	-
Melinus minutiflora P. Beauv.	molasses grass	X	+	+	-	+
Panicum maximum Jacq.	Guinea grass	X	+	+	+	-
P. maximum var. *trichoglume* Eyles ex Robyns	green panic grass	X	-	+	-	-
Pennisetum clandestinum Chiov.	kikuyu grass	X	+	-	-	-
Pennisetum purpureum Schumach.	elephant grass	X	-	+	-	-
Rhynchelytrum repens (Willd.) Hubb.	Natal redtop	X	-	+	-	+
DICOTS						
Amaranthaceae (Amaranth family)						
Amaranthus spinosus L.	spiny amaranth	X	+	+	-	-
Anacardiaceae (Cashew family)						
Anacardium occidentale L.	cashew	X	+	-	-	-
Mangifera indica L.	mango	X	+	+	-	-
Schinus terebinthifolius Raddi	Christmas berry	X	+	+	-	+
Spondias dulcis Parkins.	Otaheite apple	X	+	-	-	-
Annonaceae (Custard-apple family)						
Annona muricata L.	soursop	X	+	-	-	-
Apocynaceae (Dogbane family)						
Catharanthus roseus (L.) G. Don	periwinkle	X	-	+	-	-

SCIENTIFIC NAME	COMMON NAME	STATUS	COMMUNITY 1	2	3	4
Plumeria rubra L.	plumeria, frangipani	X	+	-	-	-
Asclepiadaceae (Milkweed family)						
Asclepias curassavica L.	milkweed	X	-	-	-	+
Asteraceae (Sunflower family)						
Ageratum conyzoides L.	ageratum	X	-	-	-	+
Bidens cynapiifolia Kunth	West Indian beggar's-tick	X	+	+	+	+
Emilia fosbergii Nicholson	emilia	X	-	+	-	+
Pluchea symphytifolia (Mill.) Gillis	pluchea	X	-	+	-	+
Synedrella nodiflora (L.) Gaertn.	synedrella	X	+	-	-	-
Tithonia diversifolia (Hemsl.) A. Gray	tithonia	X	+	-	-	-
Begoniaceae (Begonia family)						
Begonia cf. *heracleifolia* Schlecht. & Cham.	begonia	X	+	-	-	-
Bignoniaceae (Catalpa family)						
Jacaranda mimosifolia D. Don	jacaranda	X	+	-	-	-
Spathodea campanulata P. Beauv.	African tulip tree	X	+	-	-	-
Cactaceae (Cactus family)						
Opuntia ficus-indica (L.) Mill.	panini, cactus	X	-	-	-	+
Capparaceae (Caper family)						
Capparis sandwichiana DC.	puapilo, maiapilo	E	-	-	-	+

SCIENTIFIC NAME	COMMON NAME	STATUS	COMMUNITY 1	2	3	4
Caricaceae (Papaya family)						
Carica papaya L.	papaya	X	+	+	+	+
Clusiaceae (Mangosteen family)						
Mammea americana L.	mammee apple	X	+	-	-	-
Convolvulaceae (Morning-glory family)						
Ipomoea alba L.	moon flower	X	+	-	-	-
Ipomoea indica (J. Burm.) Merr.	kowali	I	+	+	-	+
Stictocardia tiliifolia (Desr.) H. Hallier	stictocardia	X	+	-	-	-
Crassulaceae (Orpine family)						
Kalanchoë pinnata (Lam.) Pers.	air plant	X	-	+	+	-
Cucurbitaceae (Gourd family)						
Cucumis dipsaceus Ehrenb. ex Spach	wild cucumber	X	-	+	-	-
Momordica charantia L.	balsam pear	X	+	+	+	-
Euphorbiaceae (Spurge family)						
Aleurites moluccana (L.) Willd.	kukui, candlenut	P	+	+	-	-
Chamaesyce hirta (L.) Millsp.	garden spurge	X	+	+	-	-
Chamaesyce hypercifolia (L.) Millsp.	-----	X	-	+	-	+
Hevea brasiliensis (H. B. K.) Muell. Arg.	para rubber tree	X	-	+	-	-
Ricinus communis L.	castor bean	X	+	+	-	-

SCIENTIFIC NAME	COMMON NAME	STATUS	COMMUNITY 1	2	3	4
Fabaceae (Pea family)						
Acacia farnesiana (L.) Willd.	klu	X	+	+	-	+
Caesalpinia bonduc (L.) Roxb.	gray nickers, kakalaioa	I	+	+	-	-
Chamaecrista nictitans (L.) Moench	partridge pea, lauki	X	-	-	-	+
Crotalaria pallida Aiton	smooth rattlepod	X	+	+	-	+
Desmodium incanum DC.	Spanish clover	X	+	-	-	-
Desmodium tortuosum (Sw.) DC.	Florida beggarweed	X	+	-	-	-
Glycine wightii (Wight & Arn.) Verdc.	-----	X	+	-	-	-
Indigofera suffruticosa Mill.	wild indigo	X	+	+	-	+
Leucaena leucocephala (Lam.) de Wit	koa haole	X	+	+	+	+
Mimosa pudica L.	sensitive plant	X	+	+	-	-
Pithecellobium dulce (Roxb.) Benth.	'opiuma	X	+	+	+	+
Prosopis pallida (Humb. & Bonpl. ex Willd.) Kunth	kiawe, mesquite	X	-	+	-	-
Samanea saman (Jacq.) Merr.	monkeypod	X	+	+	+	-
Senna occidentalis (L.) Link	coffee senna	X	+	+	-	-
Senna septemtrionalis (Viv.) H. Irwin & Barneby	-----	X	+	+	-	+
Sophora chrysophylla (Salisb.) Seem. Seem.	mamane	E	-	-	-	+
Tamarindus indica L.	tamarind, wi 'awa'awa	X	-	+	+	-
Tephrosia purpurea (L.) Pers.	'ahuhu	P	-	-	-	+
Flacourtiaceae (Flacourtia family)						
Dovyalis hebecarpa (Gardn.) Warb.	Ceylon gooseberry	X	+	+	-	-

SCIENTIFIC NAME	COMMON NAME	STATUS	COMMUNITY 1	2	3	4
Lamiaceae (Mint family)						
Plectranthus parviflorus Willd.	spur flower	I	-	+	-	+
Salvia occidentalis Sw.	West Indian sage	X	+	-	-	-
Lauraceae (Laurel family)						
Persea americana L.	avocado	X	+	-	-	-
Malvaceae (Mallow family)						
Abutilon grandifolium (Willd.) Sweet	hairy abutilon	X	+	+	-	-
Hibiscus rosa-sinensis L.	red hibiscus	X	-	+	-	-
Malvastrum coromandelianum (L.) Garcke	false mallow	X	+	+	+	-
Sida acuta N. L. Burm.	sida	X	+	-	-	-
Sida cordifolia L.	-----	X	-	+	-	-
Sida fallax Walp.	'ilima	I	-	-	-	+
Sida rhombifolia L.	cuba jute	X	+	+	-	-
Meliaceae (Mahogany family)						
Melia azedarach L.	chinaberry	X	+	+	-	-
Menispermaceae (Moonseed family)						
Cocculus trilobus (Thunb.) DC.	huehue	I	-	-	-	+
Moraceae (Mulberry family)						
Artocarpus altilis (Parkins.) Fosb.	breadfruit	P	+	-	-	-
Ficus microcarpa L. f.	Chinese banyan	X	+	-	-	-
Morus alba L.	mulberry	X	+	+	-	+

SCIENTIFIC NAME	COMMON NAME	STATUS	COMMUNITY 1	2	3	4
Myrtaceae (Myrtle family)						
Psidium guajava L.	guava	X	+	+	-	+
Syzygium cumini (L.) Skeels	Java plum	X	+	-	-	-
Nyctaginaceae (Four-o'clock family)						
Boerhavia coccinea Mill.	-----	X	-	+	-	-
Mirabilis jalapa L.	four-o'clock	X	+	-	-	-
Oxalidaceae (Wood-sorrel family)						
Averrhoa carambola L.	star fruit	X	+	-	-	-
Oxalis corniculata L.	wood sorrel	P	+	-	-	-
Passifloraceae (Passion-flower family)						
Passiflora edulis Sims	passionfruit, yellow liliko'i	X	+	-	-	-
Passiflora foetida L.	wild passionfruit	X	+	-	-	-
Passiflora suberosa L.	huehue haole	X	+	+	-	+
Phytolaccaceae (Pokeweed family)						
Phytolacca dioica L.	bella sombra	X	+	-	-	-
Rivina humilis L.	coral berry	X	+	+	-	-
Piperaceae (Pepper family)						
Peperomia leptostachya Hook. & Arn.	'ala'ala wai nui	I	+	+	-	+
Proteaceae (Protea family)						
Grevillea robusta A. Cunn. ex R. Br.	silk oak	X	-	-	-	-
Macadamia ternifolia F. Muell.	macadamia nut	X	-	-	-	-

SCIENTIFIC NAME	COMMON NAME	STATUS	COMMUNITY 1	2	3	4
Rubiaceae (Coffee family)						
Coffea arabica L.	coffee	X	+	-	-	-
Morinda citrifolia L.	Indian mulberry, noni	P	+	+	-	+
Rutaceae (Citrus family)						
Citrus grandis (L.) Osbeck	pummelo, shaddock	X	+	-	-	-
Citrus limonia Osbeck	rough lemon	X	+	-	-	-
Solanaceae (Nightshade family)						
Capsicum frutescens L.	chili pepper	X	-	+	-	-
Solandra hartwegi N. E. Br.	cup of gold	X	+	-	-	-
Sterculiaceae (Cocoa family)						
Waltheria indica L.	'uhaloa, hi'aloa	I?	+	+	-	+
Tiliaceae (Linden family)						
Triumfetta rhomboidea Jacq.	burbush	X	+	+	-	-
Verbenaceae (Verbena family)						
Lantana camara L.	lantana	X	+	+	-	+
Stachytarpheta dichotoma (Ruiz & Pav.) Vahl	Cayenne vervain	X	+	-	-	-

STATUS: E = Endemic; I = Indigenous; P = Polynesian introduction; X = Alien.

Appendix 4:
ECONOMIC AND FISCAL IMPACT ASSESSMENT

KPMG Peat Marwick

Management Consultants

Focused experience for measurable results

Manufacturing and Technology Industries
Financial Institutions
Health Care
Government Services
Insurance
Real Estate and Hospitality
Airports
Retail and Wholesale
Energy and Utilities
Corporate Transactions
Technology and Operations
Compensation and Benefits

Belt Collins & Associates

ECONOMIC AND FISCAL IMPACT ASSESSMENT FOR THE KEALAKEKUA BAY CLUB

Report
July 1991

BELT COLLINS & ASSOCIATES

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I - EXECUTIVE SUMMARY

This chapter presents the background and objectives of this study and summarizes its findings and conclusions. More detailed findings and conclusions are presented in the following chapters.

STUDY BACKGROUND AND OBJECTIVE

The Royal Coast Development Corporation is planning the development of a golf course/lodge facility with a few residential lots to be named Kealakekua Bay Club (Club). It will be located on a 262-acre parcel at Kealakekua in the South Kona district of the island of Hawaii.

The objective of this study is to evaluate the anticipated economic and fiscal impacts of the proposed development in the state of Hawaii and county of Hawaii.

SITE DESCRIPTION AND PROJECT CONCEPT

The proposed project site is located above the steep cliff known as Pali Kapu-O-Keoua between Napoopoo Road and Kealakekua Bay in South Kona. The site is about 18 miles from the Keahole Airport and overlooks Kealakekua Bay, affording spectacular ocean and sunset views from the majority of the site.

Kealakekua Bay Club is proposed to be world-class 18-hole golf course and club with overnight facilities for members in a private lodge. The project also includes five two-acre country lots and a full-service restaurant. Kealakekua Bay Club is anticipated to primarily attract members from Japan and Hawaii and to serve island visitors and residents as well as its members at its golf course and restaurant.

ECONOMIC IMPACTS

The proposed development could be expected to impact the state and county economy by generating additional consumer expenditures, construction and operational employment, personal income and population growth.

Consumer Expenditures

Green and cart fees could be expected to range from $40 to $100 for the golf course, in 1991 dollars. Including these and other anticipated resident and visitor expenditures for other recreation-related fees, food, beverages and retail items at the facilities of the development, the Club could be expected to generate $5.4 million in direct annual consumer expenditures in Hawaii by 1995, and about $4.8 million per year by stabilization in 1997, in 1991 dollars. These figures exclude the expenditures for those memberships that would be sold in Japan.

Including their anticipated multiplier effects throughout the state's economy, these direct expenditures could be expected to support total additional spending in Hawaii of about $5.7 million by 1995, and stabilizing at $5.1 million by 1997, in 1991 dollars.

Construction and Operational Employment

Kealakekua Bay Club would generate both construction and operational employment in the state. Direct employment effects would be those supported directly by construction or by the consumer expenditures generated by the project. However, the total employment effects of the project would also include its indirect and induced effects through spending multipliers throughout the state.

The anticipated total direct, indirect and induced employment effects of the project are expected to represent about 151 to 567 average annual person-years in the 1993 to 1997 period. Permanent operational employment effects could represent about 161 full-time equivalent positions throughout the state by 1997:

Projected Employment in Hawaii
Attributable to Kealakekua Bay Club
(Average annual person-years)

	1994	1995	Stabilized (1997)
Construction:			
Direct	186	45	6
Total	565	137	17
Operational:			
Direct	2	80	95
Total	2	136	161
Total:			
Direct	188	125	101
Total	567	273	178

Personal Income

Wages and salaries paid to direct employees of the project could be anticipated to represent about $8.2 million by 1994 and after completion of all construction, the stabilized income effects could represent about $2.2 million per year in 1991 dollars, as shown below:

Projected Annual Personal Income
From Direct Employment Effects of
Kealakekua Bay Club

(Millions of 1991 dollars)

	1994	1995	Stabilized (1997)
Construction	$ 8.07	1.96	.24
Operational	.10	1.65	1.95
Total	$ 8.17	3.61	2.19

The above does not include the potential wages and salaries paid to those employed through the project's indirect and induced economic effects and does not include proprietors' or unearned income. Thus, the total household income effects of the project's development could be considerably greater than the direct personal income effects shown above.

POPULATION IMPACTS

Population impacts of the development are analyzed for three geographic regions:

- The Kealakekua Bay Club site
- The Island of Hawaii
- The state of Hawaii

Further, these population impacts are two types, defined for this report as follows:

- "De facto population" refers to the daytime population of an area, including those permanent residents who are present at the time of the projection and visitors temporarily present.
- "Resident population" refers to the overnight population of an area, excluding residents temporarily absent and visitors who do not stay overnight. Because few, if any, permanent residents of the three areas analyzed are assumed to be temporarily absent, resident population may be considered a subset of de facto population.

On-Site Population Impacts

On-site, the population impacts of the development may be considered to be of three types:

- Visitors using the project's recreational and other facilities, including Club members, their golfing guests and their nongolfing guests who stay overnight at the lodge.
- Residents of the five home sites, as the homes are constructed.
- Construction and operational employees who work at the project during the day or evenings.

The majority of this impact is expected to be composed of day visitors to, and employees of, the Club, whereas very little would be attributable to residents of the five home sites at the project:

Projected Population Impacts of the Kealakekua Bay Club On-Site

	1995	1997
Daytime population:		
Visitors(1)	120	125
Operational employees	80	95
Construction employees	45	6
Subtotal (rounded)	245	225
Resident population - residents of home sites	6	14
Total de facto impact (rounded)	250	240

(1) Including member and nonmember golfers as well as nongolfing guests of members who stay at the on-site lodge.

Island and State Population Impacts

In contrast to on-site effects, impacts of the development on the populations of the island and state of Hawaii are expected to be driven principally by resident population changes. This is because the majority of daytime visitors to, and employees at, the site are anticipated to be persons who would have been on the island (and thus in the state) whether or not the Keakakekua Bay Club had been established. However, some of the Club members who visit the site, particularly international members, could be anticipated to be golfers who may not have visited the island or state if the Club did not exist.

- Island of Hawaii - The island's population would be most impacted when construction or operational employees of the development move from off-island because of employment opportunities at Kealakekua Bay Club. These impacts would be amplified to the extent that these new residents are accompanied by dependents also moving from off-island.
- State of Hawaii - Population impacts to the state would be less than those for the island, because many of those employees moving to Hawaii Island may be assumed to have been prior residents of other parts of the state. Specifically, it is assumed that the entire construction labor force required for the project may be satisfied from within the state's labor pool.

The projected impacts of the development on the populations of the island and state of Hawaii are summarized below:

Projected Population Impacts of the Kealakekua Bay Club for the Island and State of Hawaii

	1995	1997
Island of Hawaii:		
De facto population(1)	93	84
Resident population(2)	68	59
State of Hawaii:		
De facto population(3)	16	18
Resident population(2)	10	11

(1) Including international member golfers, their golfing and nongolfing guests, and employees and dependents who move to the island because of employment at the project.

(2) A subset of projected de facto population, which excludes international member golfers and their guests.

(3) Including 25% of international member golfers and their guests, and employees and dependents who move to the state because of employment at the project.

FISCAL IMPACTS

The fiscal impacts of the proposed development are evaluated by comparing the tax revenues and operating expenditures that could be expected to be incurred by the governments of the county of Hawaii and the state of Hawaii.

Potential fiscal benefits of the project's development, in terms of additional tax revenues, are anticipated to exceed the government operating expenditures generated by additional demands for state and county services as a result of the project's development. Projected net additional revenues for the county are expected to be about $190,000 in 1995 and $220,000 by 1997, representing a benefit cost ratio of more than 5 to 1 at stabilization.

Likewise, estimated net additional revenues for the state are projected to be about $290,000 in 1995 and about $260,000 at stabilization in 1997. Thus, expected benefits would outweigh costs to the state by about 6 to 1 by stabilization.

Projected net additional revenues and the ratio of projected new government revenues to new government operating expenditures are as summarized below:

Projected County and State Revenue
and Expenditure Comparison

(Millions of 1991 dollars)

	1995	Stabilized (1997)
County government:		
Net additional revenues	$ .19	.22
Revenue/expenditure ratio	4.2	5.4
State government:		
Net additional revenues	.29	.26
Revenue/expenditure ratio	9.1	6.2

II - REGIONAL ECONOMIC AND DEMOGRAPHIC SETTING

This chapter reviews economic and demographic trends in the west Hawaii region that are pertinent to the environment for development in this area.

REGIONAL ECONOMIC BASE

The Kealakekua Bay Club site is located in the west Hawaii region on the North and South Kona district borders, but is technically in the South Kona district. The west Hawaii region also includes South Kohala, to the north of the North Kona district. Coffee production and ranching have provided Kona's economic base through much of this century, while Kohala has depended upon sugar and ranching.

However, in the 1960s and 1970s, North Kona fueled a building boom that spread to South Kohala and resulted in hundreds of new hotel and condominium units and residential dwelling. The latest growth cycle began in the late 1980s and was initiated by hotel and resort development, again concentrated in North Kona and South Kohala.

Today the region is primarily supported by its real estate and visitor industries. The Kona and Kohala districts have ideal weather conditions, a black lava coastline with scattered white sandy beaches and important historical sites. The availability of large parcels of land under single ownership and the establishment of horizontal property regime laws have further encouraged high quality development in several resort areas along this coast.

The North Kona district includes the Kailua-Kona resort area with two existing and two developing resort areas. These are:

- Keauhou Resort
- Kona Village Resort
- Kaupulehu Resort (under development)
- Kohanaiki Resort (under development)

Three master-planned resort areas currently exist in the South Kohala district and another is under development:

- Waikoloa Beach and Village Resorts
- Mauna Kea Resort
- Mauna Lani Resort
- South Kohala Resort (under development)

Both of the above districts include other proposed master-planned developments of less significance.

POPULATION

Population is considered in terms of residents, those who customarily live in an area, and de facto population, which excludes residents temporarily absent but includes visitors temporarily present.

Resident Population

The resident population of North and South Kona and South Kohala was estimated at 24,269 in 1980, as shown in Exhibit II-A. From 1970 to 1980, the resident population for the area increased at an annually-compounded rate of 8.1% per year much greater than the 3.8% rate for the county as a whole. Within the region, the North Kona district experienced the most rapid population growth at 11% per year, followed by the South Kohala district, at 7.1% per year.

Since 1980, resident population growth on the island has been more gradual in all areas except South Kohala, where the growth rate has increased slightly. Between 1980 and 1989, the population grew 7.7% per year in South Kohala, 7.1% during the previous 10 years. The county of Hawaii only grew about 2.4% for a similar period, as also shown in Exhibit II-A.

De Facto Population

Growth in the island's de facto population, including visitors present but excluding residents absent, has slowed somewhat since the 1970s. De facto population grew about 3.8% per year between 1980 and 1989, compared to 4.2% per year during the 1970s, as also shown in the exhibit.

EMPLOYMENT PATTERNS

Employment patterns of the county of Hawaii and the regions closest to Kealakekua Bay Club are evaluated in terms of historical labor force characteristics and current estimates of labor force size.

Labor Force Characteristics

Labor force participation rates increased in the North and South Kona districts between 1970 and 1980, but declined slightly in South Kohala, as shown in Exhibit II-B. Overall declines in labor force participation in the South Kohala district were due to the declining rate in male labor force participation over the period. This is attributed primarily to erosion of Kohala's traditionally male-dominated economic bases of sugar cultivation and processing and ranching, coupled with the rise of resort and tourism-related centers of employment in North and South Kona and South Kohala, which provided many new work opportunities for women. Thus, female labor force participation has increased throughout the region, with increases ranging from 10.6 percentage points over the ten year period in South Kona to 18.5 and 2.7 percentage point increases in North Kona and South Kohala, respectively.

Current Labor Force Estimates

The state of Hawaii, Department of Labor and Industrial Relations (DLIR) prepares labor force estimates for the county as a whole. The DLIR estimates that in the 1980s, the civilian labor force increased 3.5% per year to about 61,550 persons in 1990, as shown in Exhibit II-C. The county averaged a 3.8% unemployment rate in 1990, or less than two-thirds that of 1980. As of March 1991, unemployment was estimated at 3.6%, down from 4.4% in March 1990. This decrease in the unemployment rate was accomplished despite an estimated 3,900 person increase in the civilian labor force over the 12-month period.

BELT COLLINS & ASSOCIATES

Resident and De Facto Population of the
North Kohala, South Kohala and North Kona
Districts and County of Hawaii

1970 to 1989

	April 1 1970	April 1 1980	July 1, 1989	Average annual percent change 1970 to 1980	Average annual percent change 1980 to 1989
Resident population:					
South Kohala	2,310	4,607	9,000	7.1%	7.7%
North Kona	4,832	13,748	23,000	11.0	5.9
South Kona	4,004	5,914	7,900	4.0	2.9
Total region	11,146	24,269	39,900	8.1%	5.1%
County of Hawaii:					
Resident population	63,468	92,053	122,300	3.8%	2.4%
De facto population(1)	65,700	98,700	138,000	4.2	3.8

(1) Includes all persons physically present in area; includes visitors present but excludes residents who are temporarily absent.

Sources: U. S. Bureau of the Census, 1980 Census of Population, Number of Inhabitants, Hawaii, PC80-1-A13 (October 1981), Table 4; Federal-State Cooperative Program for local population estimates and Hawaii State Data Center.

Exhibit II-B

BELT COLLINS & ASSOCIATES

Labor Force Characteristics of
Selected Judicial Districts and County of Hawaii

1970 and 1980

	South Kona (census tracts 213 and 214)		North Kona (census tracts 215 and 216)		South Kohala (census tract 217)		County of Hawaii	
	1970	1980	1970	1980	1970	1980	1970	1980
Potential labor force (age 16+)	2,629	4,265	3,262	10,115	1,446	3,290	43,075	67,205
Civilian labor force	1,535	2,823	2,022	7,292	951	2,110	25,889	41,006
Percentage distribution:								
Armed services	-%	-%	-%	.1%	-%	-%	.4%	.3%
Civilian labor force	58.4	66.2	62.0	72.1	65.8	64.1	60.1	61.0
Not in labor force	41.6	33.8	38.0	27.8	34.2	35.9	39.5	38.7
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Labor force participation rates:								
Male	69.6	76.5	71.6	66.6	84.4	78.3	63.6	70.5
Female	44.7	55.3	43.5	62.0	46.3	49.0	36.4	51.3
Weighted average	57.2%	65.9%	62.0%	72.1%	65.8%	64.1%	60.1%	61.0%

Sources: U. S. Bureau of the Census, Census of Population and Housing, 1970, Census Tracts (Final Report, PHC(1)88, Honolulu, Hawaii, SMSA), 1972; and Summary Tape Files 1-A and 3-A, 1980; and State of Hawaii, Department of Planning and Economic Development, Community Profiles for Hawaii, 1973; and The Geographic Distribution of Hawaii's Racial Groups, 1970 and 1980 (SR #152), 1982.

Exhibit II-C

BELT COLLINS & ASSOCIATES

Average Annual Labor Force Estimates for the
County of Hawaii

1980 to 1990

	1980	1990	Average annual percent change 1980 to 1990
Civilian labor force	43,550	61,550	3.5%
Percent unemployed	6.2%	3.8%	
Nonagricultural wage and salary jobs by industry:			
Construction	1,950	3,250	5.2
Manufacturing	2,850	2,250	(2.3)
Transportation, communications and utilities	1,900	2,500	2.8
Trade	7,000	12,600	6.1
Finance, insurance and real estate	1,200	2,350	7.0
Hotels	3,050	6,250	7.4
Health and other services	3,900	8,000	7.4
Government	6,550	8,450	2.6
Total	28,400	45,650	4.9%

Sources: State of Hawaii, Department of Labor and Industrial Relations, Labor Force Data Book (March 1978), as revised annually through April 1991.

Thus, according to the DLIR, as of March 1991, there were 61,600 employed persons on the island, 4,200 more than in March 1990. Within the South Kona District, unpublished average 1990 estimates provided by the DLIR show a 3.2% unemployment rate, compared to 3.8% for the county as a whole.

County job losses between 1980 and 1990 occurred only in the manufacturing sector, while significant increases in jobs were noted in the areas of retail trade, services, finance, insurance and real estate, as also shown in Exhibit II-C.

Since 1986, construction employment in the county has also increased greatly. The Hyatt Regency Waikoloa Hotel spurred construction employment, which has been sustained through increases in residential, commercial and industrial development elsewhere in the region. In addition, several other major developments to be built in the west Hawaii region should further strengthen the county's construction labor pool in the years ahead.

SOCIAL CHARACTERISTICS

Exhibit II-D summarizes regional population characteristics in terms of education, ethnicity and age in 1970 and 1980. All three districts of the region have exhibited increasing levels of educational achievement over the intercensal decade, as shown in the exhibit. This change may be partly attributed to the development during the 1970s, which brought new economic opportunities. All districts also showed increases in the share of population of working force age; North Kohala and South Kohala also showed relative growth in the population aged 65 or older.

Comparison of 1970 and 1980 U. S. Census data on ethnicity, unfortunately, is not productive because of significant differences in the methods of classifying ethnicity at the two census periods.

ECONOMIC AND DEMOGRAPHIC OUTLOOK

On the island of Hawaii, much of the future economic growth is expected to occur in the west Hawaii region. Billions of dollars are committed to developing new hotels, resort areas, commercial and industrial support areas, residential communities and public works projects in this region. Hotel employment could be a major component of this growth, with the hotel work force expected to increase at an annual growth rate of 5.8% to 13,500 by the end of the century, as shown in Exhibit II-E.

The County of Hawaii employment projections reflect this overall strength with total job counts growing at a projected 4.7% annual rate from 58,000 in 1990, to 92,000 by the year 2000. Accordingly, the Hawaii General Plan projects a 60% increase in the island's resident population by 2000 from 129,000 in 1990 to a projected 212,000, as also shown in Exhibit II-E.

In summary, the west Hawaii region is expected to lead the growth that the island of Hawaii is anticipated to experience in the years ahead. The major capital investments planned for existing and new master-planned areas will help support this growth.

BELT COLLINS & ASSOCIATES

Social Characteristics of the Kona and Kohala Districts and County of Hawaii

1970 and 1980

	North Kona (census tracts 215 and 216)		South Kona (census tracts 213 and 214)		South Kohala (census tract 217)		County of Hawaii	
	1970	1980	1970	1980	1970	1980	1970	1980
Total population	4,832	13,748	4,004	5,914	2,310	4,607	63,468	92,053
Education (aged 25+)(1):								
Less than 8 years	28.8%	8.0%	48.0%	23.6%	24.1%	8.6%	37.2%	20.1%
12 years	66.0	40.9	45.7	33.8	34.2	37.0	31.6	35.5
16 or more years	8.8	18.8	6.3	12.4	13.1	20.7	7.5	15.2
Ethnicity(1):								
Hawaiian	19.3	22.1	14.7	23.5	26.5	28.5	12.3	18.8
Japanese	23.1	11.8	39.6	27.5	24.4	14.6	37.5	26.6
Caucasian	44.0	53.8	17.7	30.0	39.2	46.5	28.8	35.0
Chinese	3.7	1.6	.8	.8	1.3	1.4	2.9	1.7
Filipino	8.4	7.2	26.3	13.0	6.6	5.6	16.5	13.9
Other	1.5	3.5	.9	5.2	2.0	3.4	2.0	4.0
Age:								
Under 5 years	9.1	9.1	8.5	9.8	9.3	10.0	8.6	9.1
5 to 17 years	27.0	20.3	26.6	17.2	28.3	23.6	27.8	21.5
18 to 64 years	55.7	63.9	55.3	62.4	56.0	58.6	54.4	59.2
65 or older	8.2	6.7	9.6	10.6	6.4	7.6	9.2	10.2

(1) Estimates based on 15% sample.

Sources: U. S. Bureau of the Census, Census of Population and Housing, 1970, Census Tracts (Final Report, PHC(1)88, Honolulu, Hawaii, SMSA), 1972; Census of Population and Housing, 1980, Census Tracts (PHC 80(2)13), 1983; and Summary Tape Files 1-A and 3-A, 1980; and State of Hawaii, Department of Planning and Economic Development, Community Profiles for Hawaii, 1973; and The Geographic Distribution of Hawaii's Racial Groups, 1970 and 1980 (SR #152), 1982.

Exhibit II-E

BELT COLLINS & ASSOCIATES

Population and Employment Projections
for the County of Hawaii

1990 to 2000

	Resident population	Employment: Hotel industry	Employment: Total jobs
1990	129,000	7,700	58,000
1995	167,000	11,000	76,900
2000	212,000	13,500	92,000
Average annual percent change 1990 to 2000	5.1%	5.8%	4.7%

Source: County of Hawaii, Hawaii General Plan.

III - ECONOMIC AND POPULATION IMPACTS

The proposed Kealakekua Bay Club is expected to generate significant positive economic benefits to the county and state of Hawaii. This chapter describes the expected impacts of the planned Kealakekua Bay Club in terms of consumer expenditures, employment, resident income and population.

CONSUMER EXPENDITURES

The master-planned project would contribute to direct, indirect and induced consumer expenditures on Hawaii. Visitors and residents attracted to the island by this new development at Kealakekua would make direct expenditures to purchase the five lots at the project and for golfing and purchases of food, beverages, and other goods and services. These expenditures would, in turn, require those establishments serving direct resident and visitor demands to purchase goods and services from other establishments in the state. The latter expenditures are considered indirect expenditures. Induced expenditures are those made by employees and proprietors with income derived from establishments benefiting from these new direct and indirect expenditures.

Direct Expenditures

Direct annual expenditures at the project were estimated based on the following:

- Projected development schedule, as shown in Exhibit III-A.
- Projected golf membership absorption and facility utilization at Kealakekua, as presented in Exhibit III-B.
- Projected fees and other sales proceeds, provided by Royal Coast Development Corporation, as shown in Exhibit III-C.

Based on these factors, direct consumer expenditures in Hawaii in 1991 dollars, attributable to the project could be expected to amount to $3.45 million in 1993, as memberships are sold and stabilize at $4.81 million per year by 1997, when membership sales are completed, as shown in Exhibit III-D. Membership initiation fees are shown only for domestic memberships since international membership sales are assumed to occur overseas.

Indirect and Induced Expenditures

The Hawaii State Department of Business and Economic Development (DBED) Input/Output Model estimates the total economic activity generated in the state by various types of direct expenditures. Based on the multiplier of 1.95 for eating and drinking places, 2.15 for other retail trade sectors, 2.23 for hotel services and real estate and 2.06 for other services, an average 2.05 multiplier was derived from the most recent DBED model. The projected direct expenditures could be expected to generate indirect and induced expenditures throughout the state amounting to about $3.62 million in 1993, and stabilize at $5.06 million in 1997, as also shown in Exhibit III-D.

Exhibit III A

BELT COLLINS & ASSOCIATES

Projected Development
at the Kaslahelua Bay Club

1993 to 1997

	1993	1994	1995	1996	1997
Golf course development					
Number of holes	0	0	18	18	18
Clubhouse facility	0	0	1	1	1
Lodge rooms	0	0	36	36	36
Two acre lots					
Lot development cumulative	3	5	5	5	5
Lots sold per year	3	2	0	0	0
Home development - cumulative	0	0	2	4	5
Homes developed per year	0	0	2	2	1

Source Royal Coast Development Corporation

-- Numbers may not foot due to rounding in formulas --

Exhibit III B

BELT COLLINS & ASSOCIATES

Projected Golf Membership Absorption
and Golf and Lodge Utilization

1993 to 1997

	1993	1994	1995	1996	1997	Total
Golf membership sales						
International members	450	450	150	150	0	1,200
Local members	150	150	50	50	0	400
Total golf memberships	600	600	200	200	0	1,600
Daily rounds of golf (1)						
International members (2)	0	0	20	20	20	
Local members (2)	0	0	45	50	50	
Other visitors	0	0	30	30	30	
Nonmember residents	0	0	10	10	10	
Complimentary	0	0	10	10	10	
Total rounds	0	0	115	120	120	
Lodge occupancy percentage (3)	0%	0%	40%	40%	40%	

(1) Assumes that the golf course is completed by January 1995
(2) Includes members and their guests
(3) Estimated based upon member rounds of play

Source Royal Coast Development Corporation

-- Numbers may not foot due to rounding in formulas --

Exhibit III C

BELT COLLINS & ASSOCIATES

Assumptions Regarding Expenditures at
Kealakekua Bay Club

(1991 dollars)

Golf club initiation fees	
International	$15 000
Local	$15 000
Green and cart fees per round	
Members(1)	$9 00
Member guest fee	
International (2)	$40 00
Domestic (3)	$40 00
Nonmembers	
Hawaii residents	$45 00
Other	$100 00
Pro shop sales (4)	$30 00
Food and beverage sales	
Golf snacks (5)	$5 50
Other dining	
Lodge occupants (6)	$80 00
Public	
Number of covers per day	35
Average cover	$10 00
Lodge	
Average achieved room rate	$150 00
Two acre lots	
Lot sales price	$400 000
Average estimated home val	$400 000

(1) Cart fee only, per member
(2) Guest fee paid by international members
(3) Guest fee paid by local members
(4) Per round, including rentals, lessons, and retail sales
(5) Average per round
(6) Average per occupied room per day

Source: Royal Coast Development Corporation

-- Numbers may not foot due to rounding in formulas --

Exhibit III D

BELT COLLINS & ASSOCIATES

Projected Total Annual Consumer Expenditures in Hawaii
Attributed to Kealakekua Bay Club

1993 to 1997

(Millions of 1991 dollars)

	1993	1994	1995	1996	1997
Direct expenditures (1)					
Golf initiation fees (2)	$2 25	$2 25	$0 75	$0 75	$0 00
Green cart and visitor fees	0 00	0 00	1 98	2 03	2 03
Pro shop sales	0 00	0 00	1 26	1 31	1 31
Food and beverage	0 00	0 00	0 67	0 68	0 68
Lodge room revenues	0 00	0 00	0 79	0 79	0 79
Lot sales	1 20	0 80	0 00	0 00	0 00
Subtotal direct	3 45	3 05	5 45	5 56	4 81
Indirect and induced expenditures	3 62	3 20	5 72	5 84	5 06
Total expenditures (3)	$7 07	$6 25	$11 17	$11 41	$9 87

(1) Based on absorption and utilization shown in Exhibit III B and sales revenues assumptions shown in Exhibit III C
(2) For sales of domestic memberships only International membership sales assumed to occur overseas
(3) Projected for every $1 of direct expenditure, $2 05 spent on total direct, indirect, and induced expenditures Based on a weighted average of spending multipliers for eating and drinking, retail trade hotel services and real estate and other services Departments of Business and Economic Development Input Output Model, 1987, as reported in the "State of Hawaii Data Book" 1990, Table 208

-- Numbers may not foot due to rounding in formulas --

Total Expenditures

Direct, indirect, and induced expenditures attributable to lot and membership sales and the use of the Kealakekua Bay Club facilities are projected in 1991 dollars to total $7.07 million in 1993, and stabilize at $9.87 million per year, as summarized in Exhibit III-D.

EMPLOYMENT

Planned development will generate short-term employment during the construction of new facilities and long-term employment in the operation and support of those facilities. Employment effects may also be classified as being direct, indirect or induced. Direct employment is that supported by expenditures at the Club, such as those at its golf course and food and beverage establishments. Most of the direct employment effects would occur at Kealakekua. As for expenditures, however, indirect and induced employment resulting from the project may be supported throughout the state's economy.

Direct Construction Employment

Direct construction employment is that which would be supported directly by the construction of the planned facilities. Such employment includes on-site laborers, operatives and craftsmen, as well as the professional, managerial, sales and clerical workers whose usual places of employment may be elsewhere on the island or in the state.

Construction employment would be highest during 1994, before facilities are operational, when the major portion of the infrastructure, golf course and residential lots are being graded and/or constructed. Direct construction employment is estimated to range from about 50 person-years in 1993 and peak at just under 200 person-years in 1994, as shown in Exhibit III-E.

Indirect and Induced Construction Employment

The direct employment of construction workers at the development will stimulate additional employment on the island and elsewhere in the state. Based upon data from DBED, it is estimated that 2.03 full-time jobs are created in the state for every full-time job in the construction industry. This multiplier is used to project the indirect and induced employment to be supported by the direct construction employment, as shown in Exhibit III-E. As with direct construction, the greatest employment would occur in 1994, when indirect and induced construction employment effects are expected to provide employment opportunities for nearly 400 person-years. Indirect and induced construction employment would then decline to about 10 person-years in 1997.

Total Construction Employment

Total direct, indirect and induced operational employment is estimated to represent over 140 positions in the initial stages of development and peak to well over 550 employees by 1995. As construction is completed, the construction employee population will decrease to an estimated 17 employees by 1997.

Exhibit III E

BELT COLLINS & ASSOCIATES

Projected Facility Construction Employment
(Number of people)

1993 to 1997

	1993	1994	1995	1996	1997
Golf course(1)	25	25	0	0	0
Golf clubhouse (2)	0	51	13	0	0
Lodge (2)	0	86	21	0	0
Two acre lots					
Lot development (3)	0	0	0	0	0
Home construction (4)	0	0	11	11	6
Infrastructure (5)	24	24	0	0	0
Subtotal direct employment	49	186	45	11	6
Indirect and induced employment	100	378	92	22	11
Total employment (6)	149	565	137	33	17

(1) Estimated at 25 full time equivalent jobs per year for construction, planting and grading with a two year construction period based upon comparable golf construction projects
(2) Employment demand estimate assumes labor cost is 50% of construction cost, average union labor wages and benefits of $56,000 per worker. Cost of construction and construction periods: clubhouse - $3.0 million and five months, lodge - $5.0 million and five months. Assumes all land use approvals are obtained by beginning of 1994
(3) Estimated at 0.1 full time equivalent jobs per year per lot, and average one year construction period per lot
(4) Estimated at 5.5 full time equivalent jobs per year per home, and average one year construction period per home
(5) Based on construction costs of $6 million and 4.0 full time equivalent jobs per year per million dollars. Infrastructure includes maintenance building, well and transmission, pool, tennis courts, parking, and other infrastructure items
(6) Based on full time equivalent positions per direct position from construction employement ratios from DBED estimated at 3.03 full time equivalent positions for direct, indirect and induced employment

Source: Number of employees based on information from contractors and construction engineers and comparable projects. Construction costs and timing estimated by Royal Coast Development Corporation. Earnings and benefits of $56,000 per worker estimated based on the state of Hawaii, Department of Labor and Industrial Relations, "Labor Area News", March 1991

-- Numbers may not foot due to rounding in formulas --

Direct Operational Employment

The majority of direct operational employment at the development would occur at the golf course which, based on comparable golf courses in Hawaii, is estimated to employ between 40 and 50 full-time equivalent direct employees. The clubhouse is projected to employ between 25 and 30 people. Employment at the lodge is estimated to average about 13 direct employees. Two full-time equivalent positions have been allocated to administration, marketing and public relations.

Thus, the project could be expected to have generated about 80 full-time equivalent direct operational positions by 1995 and about 95 full-time equivalent positions at stabilization in 1997, as shown in Exhibit III-F.

Indirect and Induced Operational Employment

Facility operations at Kealakekua would also indirectly generate employment elsewhere in the state. Recent studies on the total economic impacts of direct, indirect and induced employment multipliers in the hotel and other services industries by the DBED suggest that the activities at the Bay Club could be expected to support .68 indirect and induced full-time equivalent positions elsewhere in the state for each direct job created at the golf course and clubhouse and .93 indirect and induced full-time equivalent positions as a result of the lodge employment.

Thus, indirect and induced operational employment could be expected to amount to about 55 full-time equivalent positions by 1995 and about 65 full-time by 1997, as shown in Exhibit III-F.

Total Operational Employment

Total direct, indirect and induced operational employment is estimated to represent over 130 full-time equivalent positions by 1995 increasing to slightly over 160 positions by 1997, as also shown in Exhibit III-F.

PERSONAL INCOME

Kealakekua would have an impact on personal income for residents of the island and state through employee wages, salaries and fringe benefits, as well as through revenue to its proprietors. Personal income is defined as the wages and salaries paid to the direct construction and operational employees of the development. Personal income is projected on the basis of average industry wages and salaries for the various types of employment anticipated and on the projected future employment demands.

Personal income paid to Hawaii residents could be expected to average about $2.23 million during initial construction in 1993, growing to about $8.17 million during the height of construction in 1994 and falling back to about $3.61 million per year for both construction and operational employment in 1995. In the years ensuing project development, personal income could amount to $2.19 million in 1997, in 1991 dollars, as construction activity ends and operational employment demands continue, as shown in Exhibit III-G.

Exhibit III F

BELT COLLINS & ASSOCIATES

Projected Operational Employment
(Number of people)

1993 to 1997

	1993	1994	1995	1996	1997
Golf course (1)	0	0	40	45	50
Clubhouse (2)(3)	0	0	25	28	30
Lodge and administration (3)(4)	0	0	13	13	13
Marketing/public relations	2	2	2	2	2
Subtotal direct employment	2	2	80	88	95
Indirect and induced					
Golf course and clubhouse (5)	0	0	44	50	54
Lodge and administration (6)	0	0	12	12	12
Subtotal indirect and induced employment	0	0	56	62	66
Total employment	2	2	136	149	161

(1) Operational employment based upon comparable golf courses Includes professionals such as a golf pro
(2) Includes employees of the clubhouse, restaurant, and pro shop
(3) Employment demand estimate assumes labor cost is 50% of construction cost average union labor wages and benefits of $56,000 per worker Cost of construction and construction periods clubhouse - $3.0 million and five months, lodge - $5.0 million and five months Assumes all land use approvals are obtained by beginning of 1994
(4) Employees estimated at 0.3 per room for the lodge operations plus two managerial administrative positions
(5) Estimated at 0.68 full time equivalent positions per direct position based upon the DBED Input Output model, 1987 as estimated in the "State of Hawaii Data Book" 1990, Table 208
(6) Estimated at 0.93 full time equivalent positions per direct position based upon the DBED Input Output Model, 1987 as estimated in the "State of Hawaii Data Book" 1990, Table 208

Source Based on interviews and published information of selected local and national private club and resort operations, 1990

-- Numbers may not foot due to rounding in formulas --

Exhibit III G

BELT COLLINS & ASSOCIATES

Projected Direct Annual Personal Income
from Direct Employment

1993 to 1997

	Average wages(1)	(Millions of 1991 dollars) 1993	1994	1995	1996	1997
Construction (2)	$43,300	$2.13	$6.07	$1.96	$0.48	$0.24
Operational (3)						
Golf course and clubhouse	$19,900	0.00	0.00	1.29	1.45	1.59
Lodge and administration	$20,000	0.00	0.00	0.28	0.28	0.28
Marketing/public relations	$50,000	0.10	0.10	0.10	0.10	0.10
Total		$2.23	$6.17	$3.61	$2.29	$2.18

(1) Adjusted full time equivalent 1991 salaries based on a 40 hour work week
(2) Based upon direct construction employment from Exhibit III E Assumes all land use approvals are obtained by beginning of 1994
(3) Based upon direct operational employment from Exhibit III F Assumes all land use approvals are obtained by beginning of 1994

Source State of Hawaii, Department of Labor and Industrial Relations "Labor Area News", March 1991, "Hours and Earnings of Workers in Selected Industries," February 1991 (Preliminary) and interviews of management of comparable golf courses

-- Numbers may not foot due to rounding in formulas --

POPULATION

The development of facilities will lead to population increases at the Kealakekua site, elsewhere on the island and within the state as a whole. These population impacts are of two types, defined for this report as follows:

- "De facto population" refers to the daytime population of an area, including those permanent residents expected to be present at the time of the projection and visitors temporarily present.

- "Resident population" refers to the overnight population of an area, excluding residents temporarily absent and visitors who do not stay overnight. Because few, if any, permanent residents of the three areas analyzed are assumed to be temporarily absent, resident population may be considered a subset of de facto population.

On-Site Impacts

On-site population impacts of the development can be considered to be of three types, as discussed below:

- Visitors - Daytime visitors to the Club would be those using the golf course, nongolfing guests of members, and visitors and residents who dine at the restaurant. The golfer population was estimated by using the projected number of rounds shown in Exhibit III-B and a share of international members assumed to bring nongolfing guests. With these assumptions, the average daily on-site visitor population is projected to be about 120 persons by 1995, increasing to about 125 persons by stabilization in 1996, as shown in Exhibit III-I.

- Residents - Resident population at Kealakekua was projected using the assumptions concerning home development shown previously in Exhibit III-A and assumptions about residential usage of the housing units shown in Exhibit III-H. Thus, resident population at the development is projected to be about 6 persons by 1995, increasing to 14 persons by the assumed build-out of the 5 homes in 1997.

- Employees - Operational and construction employees would add to the on-site population on a daily basis and most are expected to commute from other parts of the island. The on-site operational employee impact could amount to 80 persons in 1995 and 95 persons in 1997, as shown in Exhibit III-I.

Direct construction workers, as also shown in Exhibit III-I, will also impact the daily on-site population. This impact is expected to increase to about 186 employees during peak periods of construction activity and decrease significantly over the development period as the majority of construction is completed.

In summary, facility development at Keelakekua is projected to generate a de facto population increase of about 51 persons on the site in 1993, increasing to about 240 persons by 1997, as shown in Exhibit III-I. These impacts would be initially a result of construction activity on-site, and later due principally to daytime visitor use of the Club.

Exhibit III H

BELT COLLINS & ASSOCIATES

Assumptions for On site Overnight Population

	Number of units	Occupancy	Average household size	Average daily population
Full time residents	5	95%	3.0	14
Lodge guests	35	40%	2.0	29
Total				43

Source: Royal Coast Development Corporation

-- Numbers may not foot due to rounding in formulas --

Exhibit III I

BELT COLLINS & ASSOCIATES

Projected On site Population Impacts of the Kealakekua Bay Club

1993 to 1997

	Average daytime population				
	1993	1994	1995	1996	1997
Visitors					
Golfers (1)					
International members and guests	0	0	20	20	20
Local members and guests	0	0	45	50	50
Other visitors	0	0	30	30	30
Nonmember residents	0	0	10	10	10
Complimentary	0	0	10	10	10
Subtotal, golfers	0	0	115	120	120
Nongolfing guests(2)	0	0	5	5	5
Subtotal, visitors	0	0	120	125	125
Residents (3)	0	0	6	11	14
On site project employees					
Operational employees (4)	2	2	80	88	95
Construction employees (5)	49	186	45	11	6
Subtotal, employees	51	188	125	99	100
Total de facto impact	51	188	250	235	240

(1) Based upon number of rounds, as shown in Exhibit III B
(2) Estimated at 25% of total international members
(3) Full time resident equivalents based on home development assumptions in Exhibit III A and assumptions in Exhibit III H
(4) Direct operational employment, as shown in Exhibit III F
(5) Direct construction employment, as shown in Exhibit III E

-- Numbers may not foot due to rounding in formulas --

Island of Hawaii Impacts

The project's impacts on the island's population may also be considered in terms of visitor and resident populations. In contrast to on-site effects, impacts of the development on the population of the island of Hawaii are expected to be driven principally by resident population changes, as shown in Exhibit III-J.

- Visitors - The majority of daytime visitors to the site are anticipated to be persons who would have been on the island whether or not the Kealakekua Bay Club had been established. An exception to this might be international Club members who are attracted to or aware of the island of Hawaii principally because of the Kealakekua Bay Club. Thus, from the island perspective, the project's visitor population impacts are assumed to consist of visiting international Club members and their golfing or nongolfing guests. This is estimated to represent about 25 persons on an average day, once Club operations are established.

- Residents - On-site residents of the five lots are assumed to be prior residents of the island. Thus, the resident population impacts of the development for Hawaii island would consist of construction and operational employees who move to the island because of employment opportunities at the Club.

It is estimated that about 30% of the direct construction employment will be filled by off-island workers and each worker is anticipated to bring approximately .5 dependents. Thus, the in-migrant construction population could represent around 22 persons in 1993, peak at 84 persons in 1994 and decrease to 3 persons in 1997 as construction is completed.

In-migrant operational employees are also estimated to represent about 30% of the total operational employment requirements of the project, plus one accompanying household member per in-migrant employee. The in-migrant operational employee population impact including dependents is projected to be about 48 persons in 1995 and to stabilize at about 56 persons by 1997.

In total, the projected population impacts of the development for the Island of Hawaii are expected to amount to about 23 persons in 1993, peaking at about 93 in 1995, and then stabilizing at about 84 persons by 1997, as shown in the Exhibit III-J.

State of Hawaii Impacts

Population impacts to the state would be less than those for the island, because many of those employees moving to the island of Hawaii may be assumed to have been prior residents of other parts of the state. Even those visitors who were new to the island could be likely to have been already familiar with the state, and to have visited even without development of the project. Population impacts for the state are summarized in Exhibit III-K and discussed below:

- Visitors - About 25% of those international members assumed to visit the island of Hawaii because of the development could be estimated to be visitors who might not have come to the state if the Kealakekua project were not established. Including their guests, this could represent fewer than 10 persons on an average day.

Exhibit III J

BELT COLLINS & ASSOCIATES

Projected Population Impacts
Attributed to the Development of Kealakekua Bay Club,
Island of Hawaii

1993 to 1997

	1993	1994	1995	1996	1997
Visitors (1)					
International member golfers and guests	0	0	20	20	20
Nongolfing guests	0	0	5	5	5
Subtotal, visitors	0	0	25	25	25
Residents					
On site (2)	0	0	0	0	0
Off-site					
Construction employees (3)	15	56	14	3	2
Construction dependents (4)	7	28	7	2	1
Operational employees (5)	1	1	24	26	28
Operational dependents (6)	1	1	24	26	28
Subtotal, residents	23	85	68	58	59
Total de facto impact	23	85	93	83	84

(1) From Exhibit III I Assumes that all international members and their nongolfing guests would not have visited the island without the Club
(2) On site residents of the five planned homes are all anticipated to be existing island of Hawaii residents
(3) It is estimated that 30% of the total direct construction employment will be filled by off island workers based upon existing unemployment statistics and timing of proposed construction Refer to Exhibit III E for total direct employment
(4) Each in migrant construction employee is anticipated to have 0 5 dependents
(5) It is estimated that 30% of the total direct operational employment will be filled by off island workers based upon existing unemployment statistics and needs of the project Refer to Exhibit III F for total direct employment
(6) Each in migrant operational employee is anticipated to have one dependent

.. Numbers may not foot due to rounding in formulas ..

Exhibit III K

BELT COLLINS & ASSOCIATES

Projected Population Impacts
Attributed to the Development of Kealakekua Bay Club
State of Hawaii

1993 to 1997

	1993	1994	1995	1996	1997
Visitors					
International member golfers and guests (1)	0	0	6	6	6
Residents					
On site (2)	0	0	0	0	0
Off site (3)	0	0	10	11	11
Subtotal, residents	0	0	10	11	11
Total de facto impact	0	0	16	17	18

(1) Assumes that 25% of international members and their guests would not have come to the state of Hawaii without this facility
(2) On site residents of the five planned homes are all anticipated to be existing state of Hawaii residents
(3) It is estimated that 20% of the operational employees and their dependents who move to the island of Hawaii, as shown in Exhibit III J will be filled be new residents to the state All construction employees are projected to be from within the state

-- Numbers may not foot due to rounding in formulas --

- Residents - Residents of the project's five home sites were assumed to be prior island and thus state residents, and the construction labor force required for the project is assumed to be satisfied from within the state's labor pool. Thus, the Club's impacts on the resident population of the state would consist of those operational employees who move from out-of-state because of the employment opportunities at the development. Based on the skills required to operate a golf club catering to international and local members, it is assumed that this could represent about 20% of projected operational employment requirements of the Club, or about 11 persons by 1997, as also shown in Exhibit III-K.

HOUSING IMPACTS

Development of the Kealakekua Bay Club could affect west Hawaii's housing situation in several ways. Temporary housing could be needed to house workers brought to the island during project construction. Operational employment at the development could also trigger additional housing demand, to accommodate in-migrant employees and their dependents.

Construction Employee Housing Demand

Construction employment is temporary, and therefore does not generate the long-term housing demands associated with Club operational employment. In-migrating construction workers could be expected to seek short to medium-term rental units in the general market.

It is assumed that an average of 30% of construction workers would have to be attracted from off-island, and that construction workers would share housing at a ratio of 1.25 people per household. Thus, the average daily unit requirements for construction workers could range from about 18 units when the project begins in 1993 to 67 units at maximum development activity in 1994. Thereafter, these temporary housing needs could decline to become almost negligible, as the project is built-out, as shown in Exhibit III-L. The majority of this demand could be expected to be for rental units.

Because of the nature of labor needs during development of real estate projects, construction employment could fluctuate significantly from month-to-month and even week-to-week within any year. Thus, considering the anticipated timing of individual construction projects within Kealakekua, the associated temporary housing needs could represent up to about 120 units during peak activity weeks in the 1993 to 1996 period.

Operational Employee Housing Demand

Kealakekua Bay Club operational employees and their dependents who come from off-island would require long-term housing on the island. Also, new household formation among prior island residents who work at the development could create demands for new housing units. The projected housing demand associated with operational employees, is also shown in Exhibit III-L.

Exhibit III L

BELT COLLINS & ASSOCIATES

Projected Residential Units Required for In Migrant Employees Moving to the Island of Hawaii

1993 to 1997

	1993	1994	1995	1996	1997
Construction employees					
In migrant employees and dependants (1)	22	84	20	5	2
Construction employee households (2)	16	67	16	4	2
Operational employees					
In migrant employees and dependants (1)	1	1	44	53	57
Operational employee households (3)	1	1	29	31	33
Total units required	18	68	44	35	35

(1) From Exhibit III J Some differences may occur due to rounding
(2) Projected at 1 25 construction employees per unit
(3) Projected at 1 70 operational employees per unit

-- Numbers may not foot due to rounding in formulas --

About 30% of permanent positions at Kealakekua could generate in-migration to the Island. Based on employment needs, it is anticipated that about 28 new units will be required for in-migrant operational employees and their dependents by 1995 and and grow to about 33 units as the Club becomes fully operational in 1997. This assumes that operational employees have one dependent per worker and housing demand is assessed at 1.7 people per household. It is assumed that the majority of these in-migrant operational employees will also seek rental units.

IV - FISCAL IMPACTS

The proposed Kealakekua Bay Club is expected to generate significant positive fiscal benefits for the county of Hawaii and for the state of Hawaii. These fiscal impacts have been evaluated by comparing the tax revenues and operating expenditures that are projected to be incurred by the state and county governments.

GOVERNMENT REVENUES

County government revenues would be principally in the form of real property taxes on the new facilities. Revenues to the state government would be composed principally of general and specific excise taxes, personal income taxes paid by new state residents, general excise tax on sales revenues attributable to visitors to the development and transient accommodations tax on lodge room sales. The sections following project the additional revenues that could be generated for the county and state governments as a result of the recreation-oriented development.

County Revenues

Real property in the county is currently taxed from $8.50 to $10.00 per $1,000 of assessed value depending on the land use class. Golf courses are currently taxed at the agricultural-zone rate of $10.00 per $1,000 assessed value, while commercial tax rates of $8.50 per $1,000 assessed value are applied to golf clubhouses, their surrounding lands and their related facilities.

Net additional real property taxes were projected according to assessed values for other comparable golf club facilities in the state, projected sales prices of the residential components, and estimated land value, less the current property taxes generated by the undeveloped site.

Based on these tax rates and estimated assessed values, the proposed private club, golf course, lodge, lots, homes, and other lands could be expected to generate net new property tax revenues for the county of Hawaii of about $250,000 per year by 1995, and $270,000 per year at stabilization, in 1991 dollars, as shown in Exhibit IV-A.

State Revenues

New revenues to the state government would be generated by the 4.167% general excise tax on direct expenditures by consumers at Kealakekua Bay Club. Also, those staying at the lodge could generate an additional 5.25% revenue from room rentals. In addition, new residents attracted to the state by the employment opportunities of the project would be associated with additional excise sales taxes, individual income taxes and other state taxes such as liquor, tobacco, fuel, inheritance, estate and conveyance taxes. Using state tax receipts in fiscal 1989 and adjusting for inflation to 1991 dollars, individual income and other taxes mentioned above averaged $3,950 per state resident.

Exhibit IV A

BELT COLLINS & ASSOCIATES

Projected Real Property Tax Revenues to the County Government
Attributable to Development at the Kealakekua Bay Club

1993 to 1997

(Millions of 1991 dollars)

Source of property tax revenue	1993	1994	1995	1996	1997
Golf course (1)	$0.00	$0.00	$0.18	$0.18	$0.18
Clubhouse restaurant and pro shop (2)(3)	0.00	0.00	0.03	0.03	0.03
Lodge (3)(4)	0.00	0.04	0.04	0.04	0.04
Single family					
With homes (5)	0.00	0.00	0.01	0.02	0.02
Unbuilt lots (6)	0.00	0.00	0.00	0.00	0.00
Undeveloped land (7)	0.01	0.01	0.01	0.01	0.01
Total new property tax revenues	0.01	0.05	0.27	0.28	0.28
Less Current property tax revenues (8)	0.02	0.02	0.02	0.02	0.02
Net new property tax revenues	$0.00	$0.04	$0.25	$0.26	$0.27

(1) Based on estimated assessed value of $1 million per hole and an agricultural property tax rate of $10 per $1,000 assessed value
(2) Based on estimated cost of construction of $3.0 million and the commercial property tax rate of $8.50 per $1,000 assessed value
(3) Assumes all land use approvals are obtained by beginning of 1994
(4) Based on estimated cost of construction of $5.0 million and the commercial property tax rate of $8.50 per $1,000 assessed value
(5) Based on estimated value of $530,000 per home and lot, assuming agricultural use for a portion of the lot, a $20,000 owner occupancy deduction, and a blended land and building tax rate of $9.25 per $1,000 of assessed value
(6) Based on estimated value of $4,000 per lot, assuming agricultural use, and tax rate of $10 per $1,000 assessed value
(7) Based on estimated assessed value of $20,000 per acre for about 55 undeveloped acres at an agricultural property tax rate of $10 per $1,000 assessed value
(8) Current property taxes of $15,895 are based on the 1990-91 assessed value of $1,589,500 and agricultural property tax rate of $10 per $1,000 assessed value obtained from Royal Coast Development Corporation

Source: State of Hawaii, Department of Business, Economic Development and Tourism, "The State of Hawaii Data Book" 1990 and 1991
City and County of Honolulu, Department of Finance, Real Property Assessment Division, "Real Property Tax Valuations, Tax Rates, & Exemptions, 1990-1991 Tax Year, State of Hawaii", July 1990. 1990-91 tax rates were utilized

-- Numbers may not foot due to rounding in formulas --

As a result, total new tax revenues to the state government attributable to the project's development are expected to increase from $90,000 in 1993 to about $310,000 per year at stabilization by 1997, in 1991 dollars, as shown in Exhibit IV-B.

GOVERNMENT OPERATING EXPENDITURES

New visitors and residents attracted by the project would also necessitate additional expenditures of state and county public resources.

In-migrant residents would incur public costs in terms of public safety, maintenance of highways, recreational facilities and natural resources, health and sanitation measures, special cash capital improvements, education, retirement and pension funds, public welfare and other government functions.

Visitors attracted to the island by the Club may be expected to be principally the international members and their guests. Domestic club members, their guests and other visitors who golf at the Club, are anticipated to be prior island residents or visitors who would be on the island even without the Kealakekua Bay Club. Therefore, the international Club members and their guests would increase the average daily population of the island and in some cases the state, requiring public expenditures in terms of public safety, maintenance of highways, health and sanitation, recreation and special cash capital improvements.

County Expenditures

The various county government operating expenditures for fiscal year 1989 were analyzed with respect to the relevant population served by each of the government functions. This analysis indicates that the county of Hawaii government expenditures in 1989 totaled about $614 per resident and $399 per visitor as shown in Exhibit IV-C. A 7.3% annual increase, equal to the rise in the Honolulu Consumer Price Index between second quarter 1990, and a year earlier plus an estimated 7% additional inflation to adjust to June 1991, would be equivalent to expenditures of about $682 and $443 per capita for residents and visitors, in 1991 dollars, respectively.

Based on these county government outlays, public expenditures by the county on behalf of the service population for the Kealakekua Bay Club could be expected to total about $20,000 in 1993 rise to about 60,000 in 1994 when the peak number of construction workers is expected to temporarily relocate to the island, and then stabilize at about $50,000 per year by 1997, in 1991 dollars, as shown in Exhibit IV-D.

State Expenditures

A similar analysis of state government operating expenditures and the relevant populations for the various government services indicate that expenditures in 1989 totaled about $2,887 per resident and $837 per visitor, as shown in Exhibit IV-E. This is equivalent to about $3,206 per resident and $930 per full-time equivalent visitor when adjusted upwards to bring the amounts to 1991 dollars.

Exhibit IV B

BELT COLLINS & ASSOCIATES

Projected Annual Revenues to the State Government Attributable to Development and Operation at the Kealakekua Bay Club

1993 to 1997

(Millions of 1991 dollars)

	1993	1994	1995	1996	1997
Tax revenue source					
Visitors					
General excise tax on sales revenues (1)	$0.09	$0.09	$0.23	$0.23	$0.20
Visitor accommodations tax (2)	0.00	0.00	0.04	0.04	0.04
In-migrant population (3)	0.00	0.00	0.06	0.07	0.07
Total tax revenues	$0.09	$0.09	$0.33	$0.34	$0.31

(1) Based on 4.167% of direct consumer expenditures at the lodge and golf facilities of the Kealakekua Bay Club from Exhibit III D Does not include international membership sales nor lot sales
(2) Based on 5.25% of lodge rental revenues, as shown in Exhibit III D
(3) Based upon projected population impacts to the state, as shown in Exhibit III K and $3,950 per person for general excise, state income, employment, specific excise, and automobile taxes

Sources State of Hawaii, Department of Business, Economic Development, and Tourism, "The State of Hawaii Data Book" 1990 and Tax Foundation of Hawaii, "Government in Hawaii A Handbook of Financial Statistics, 1990"

-- Numbers may not foot due to rounding in formulas --

Exhibit IV C

BELT COLLINS & ASSOCIATES

County of Hawaii Per Capita Government Expenditures

	Expenditures FY 1989 (000s) (1)	Service population (2)	Expenditure Per resident	Expenditure Per visitor
General government	$11,045	119,900	$92	-
Public safety	30,499	132,200	231	231
Highways	5,173	132,200	39	39
Health and sanitation	4,292	132,200	32	32
Economic and urban development	3,257	119,900	27	-
Recreation	6,362	132,200	48	48
Interest	4,900	132,200	37	37
Bond redemption	2,967	119,900	25	-
Retirement and pension	6,034	119,900	50	-
Mass transit	482	132,200	4	4
Cash capital improvements	1,082	132,200	8	8
Miscellaneous	2,438	119,900	20	-
Total, 1989 dollars	$78,532		$614	$399
Estimated total, 1991 dollars (3)			$682	$443

(1) County government operating expenditures for fiscal year ended June 30, 1989 as reported by the Tax Foundation of Hawaii, "Government in Hawaii: A Handbook of Financial Statistics, 1990"
(2) Resident or de facto population estimates for the county as of January 1, 1989. Population derived from actual population figures from July 1988 and July 1989
(3) Adjusted to 1991 dollars based on a 7.3% increase in the Consumer Price Index between 2nd quarter 1990 and year earlier, as reported by Bank of Hawaii Information Center, 1990. Adjusted to June 1991 dollars based upon an estimated 7% annual inflation rate

-- Numbers may not foot due to rounding in formulas --

Exhibit IV D

BELT COLLINS & ASSOCIATES

Projected Annual County Government Operating Expenditures
Attributable to the Development of the Kealakekua Bay Club

1993 to 1997

	1993	1994	1995	1996	1997
County population impact (persons)					
Visitors (1)	0	0	25	25	25
Residents (2)	23	85	68	58	59
Total	23	85	93	83	84
Expenditures (millions of 1991 dollars)					
Visitors (3)	$0.00	$0.00	$0.01	$0.01	$0.01
Residents (4)	0.02	0.06	0.05	0.04	0.04
Total expenditures	$0.02	$0.06	$0.06	$0.05	$0.05

(1) International member golfers and their guests as shown in Exhibit III J
(2) In-migrant full time equivalent construction and operational employees and their dependents, as shown in Exhibit III J
(3) Visitors estimated to require $443 in 1991 dollars per capita per year, as shown in Exhibit IV C
(4) Residents estimated to require $682 in 1991 dollars per capita annually in county government expenditures, as shown in Exhibit IV C

-- Numbers may not foot due to rounding in formulas --

BELT COLLINS & ASSOCIATES

Exhibit IV E

State of Hawaii Per Capita Government Expenditures

	Expenditures (000's) (1)	Service population (2)	Expenditure Per resident	Expenditure Per visitor
General government	$287,802	1,105,150	$260	-
Public safety	119,981	1,240,900	97	97
Highways	78,911	1,240,900	62	62
Natural resources	38,327	1,240,900	31	31
Health and sanitation	120,440	1,240,900	97	97
Hospitals and institutions	147,452	1,105,150	133	-
Public welfare	396,944	1,105,150	359	-
Education	866,588	1,105,150	883	-
Recreation	27,025	1,240,900	22	22
Utilities and other enterprises	174,257	1,240,900	140	140
Debt service	248,062	1,105,150	224	224
Retirement and pension	85,727	1,105,150	78	-
Employees' health insurance	584	1,105,150	1	-
Unemployment compensation	48,112	1,105,150	44	-
Grants in aid to counties	42,348	1,105,150	38	38
Urban redevelopment and housing	263,908	1,105,150	239	-
Cash capital improvements	155,500	1,240,900	125	125
Miscellaneous	46,921	1,105,150	42	-
Total, 1989 dollars	$3,267,999		2,847	637
Estimated total, 1991 dollars (3)			$3,206	$930

(1) State government operating expenditures for fiscal year ended June 30, 1988 as reported by the Tax Foundation of Hawaii, "Government in Hawaii A Handbook of Financial Statistics, 1990"

(2) Resident or de facto population estimates for the county as of January 1, 1989 Population derived from actual population figures from July 1988 and July 1989

(3) Adjusted to 1991 dollars based on a 7.3% increase in the Consumer Price Index between 2nd quarter 1990 and year earlier, as reported by Bank of Hawaii Information Center, 1990 Adjusted to June 1991 dollars based upon an estimated 7% annual inflation rate

-- Numbers may not foot due to rounding in formulas --

Many of the persons expected to move to the island because of the project would be expected to be prior state residents, such as those moving from Oahu. Thus, the net additional population impact to the state would be less than that to the island. As shown previously in Exhibit III-K, this analysis assumes that:

- All construction workers come from within the state's labor pool.
- 80% of operational employees who move to the island of Hawaii move from elsewhere within the state.
- 25% of International Club members and their guests would not have visited the state if the project were not developed.

Based on these operating costs, state government expenditures attributed to the project's population impacts are projected to total approximately $40,000 per year by 1995 and to increase to about $50,000 per year by 1997, as shown in Exhibit IV-F.

REVENUE AND EXPENDITURE ANALYSIS

The net fiscal impacts of the planned development to the county and state operating budgets are estimated by comparison of the projected revenues and expenditures.

County Cost/Benefit

Comparison of projected public revenues and expenditures attributable to the project's development indicates that the county government could expect to net an additional $190,000 per year by 1995 and $220,000 per year by 1997 and thereafter, in 1991 dollars, as shown in Exhibit IV-G. The analysis also indicates that additional county government revenues generated by the proposed project at completion could be over five times the operating expenditures incurred by the county government as also shown in the exhibit.

State Cost/Benefit

Based on a similar analysis, net fiscal benefits to the state government are projected to be about $290,000 per year by 1995, and stabilizing at $260,000 per year by 1997, as shown in Exhibit IV-H. In addition, at project completion, state government revenues generated by the development could represent over six times the additional expenditures, as also shown in the exhibit.

Exhibit IV F

BELT COLLINS & ASSOCIATES

Projected Annual State Government Operating Expenditures Attributable to the Development of the Kaelakekua Bay Club

1993 to 1997

	1993	1994	1995	1996	1997
State population impact (persons)					
Visitors (1)	0	0	6	6	6
Residents (2)	0	0	10	11	11
Total	0	0	16	17	18
Expenditures (millions of 1991 dollars)					
Visitors (3)	$0.00	$0.00	$0.01	$0.01	$0.01
Residents (4)	0.00	0.00	0.03	0.03	0.04
Total expenditures	$0.00	$0.00	$0.04	$0.04	$0.05

(1) 25% of average daily international golfers and their guests as shown in Exhibit III K
(2) In-migrant operational employees and their dependents expected to move to the state, as shown in Exhibit III K
(3) Visitors estimated to require $830 in 1991 dollars per capita per annum, as shown in Exhibit IV E
(4) Residents estimated to require $3,206 in 1991 dollars per capita in state government expenditures per annum, as shown in Exhibit IV E

-- Numbers may not foot due to rounding in formulas --

Exhibit IV G

BELT COLLINS & ASSOCIATES

County Government Revenue and Expenditure Comparison

1993 to 1997

(Millions of 1991 dollars)

	1993	1994	1995	1996	1997
New revenues (1)	$0.00	$0.04	$0.25	$0.26	$0.27
New expenditures (2)	0.02	0.06	0.06	0.05	0.05
Net additional revenues	$(0.02)	$(0.02)	$0.19	$0.21	$0.22
Revenue/expenditure ratio (3)	0.0	0.7	4.2	5.2	5.4

(1) From Exhibit IV A
(2) From Exhibit IV D
(3) New revenues divided by new expenditures

-- Numbers may not foot due to rounding in formulas --

Exhibit IV H

BELT COLLINS & ASSOCIATES

State Government Revenue and Expenditure Comparison

1993 to 1997

(Millions of 1981 dollars)

	1993	1994	1995	1996	1997
New revenues (1)	$0.08	$0.08	$0.33	$0.34	$0.31
New expenditures (2)	0.00	0.00	0.04	0.04	0.05
Net additional revenues	$0.08	$0.08	$0.29	$0.30	$0.26
Revenues/expenditure ratio (3)	N/A	N/A	9.1	8.6	6.2

(1) From Exhibit IV B
(2) From Exhibit IV F
(3) New revenues divided by new expenditures

-- Numbers may not foot due to rounding in formulas --

Appendix 5:

ENVIRONMENTAL ASSESSMENT OF PROPOSED KEALAKEKUA RANCH SUBDIVISION

ENVIRONMENTAL ASSESSMENT
OF PROPOSED
KEALAKEKUA RANCH
SUBDIVISION

Prepared for: Kealakekua Ranch, Ltd.

Prepared by: Belt Collins & Associates

For Submission to: Hawaii County Planning Department

December 1986

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FOREWORD

Kealakekua Ranch, Ltd. is proposing to develop a 37-lot subdivision on approximately 198 acres of land it owns in fee in the South Kona district of the County of Hawaii. This Environmental Assessment has been prepared for Kealakekua Ranch, Ltd. to disclose information on the proposed project and to serve as supplemental application material to fulfill the requirements of governmental approval for a Special Management Area Use Permit (SMA) and a Change of Zone application for the proposed subdivision.

ENVIRONMENTAL ASSESSMENT OF PROPOSED KEALAKEKUA RANCH SUBDIVISION

I. APPLICANT

The applicant is Kealakekua Ranch, Ltd., a Hawaii Corporation. The Ranch is the fee landowner of the 198.2-acre parcel proposed to be subdivided. The parcel is identified as Tax Map Key 8-2-07-2 and 33.

II. PROPOSED ACTION

a. Description of the Proposed Project

The subject parcel is situated in Kealakekua, South Kona, Hawaii County, directly below the town of Captain Cook. The Applicant proposes to subdivide the 198 acres into 37 lots with roadways and a utility distribution system. Figure 1 shows the location of the proposed subdivision on the west Hawaii coast. The project site lies immediately above the steep cliff known as Pali Kapu-o-Keoua, overlooking Kealakekua Bay. The mauka boundary is seaward of the lower Government Main Road to Napoopoo.

The project will consist of 37 lots: 36 lots zoned RA 2.0 and one 80-acre remnant zoned Unplanned. Figure 2 shows the preliminary plat plan for the Kealakekua Ranch makai subdivision.

The project roadway and utilities improvements will start from the lower Government Main Road to Napoopoo; the major road will loop around the subdivision. Roadways will have 50-foot rights-of-way with 20-foot wide pavements to provide access to each lot. Utility service to each lot will include water, telephone service, and electrical power. Concomitant with the roadway and utility improvements will be drainage and other erosion control structures as determined to be appropriate by the project and County engineers.

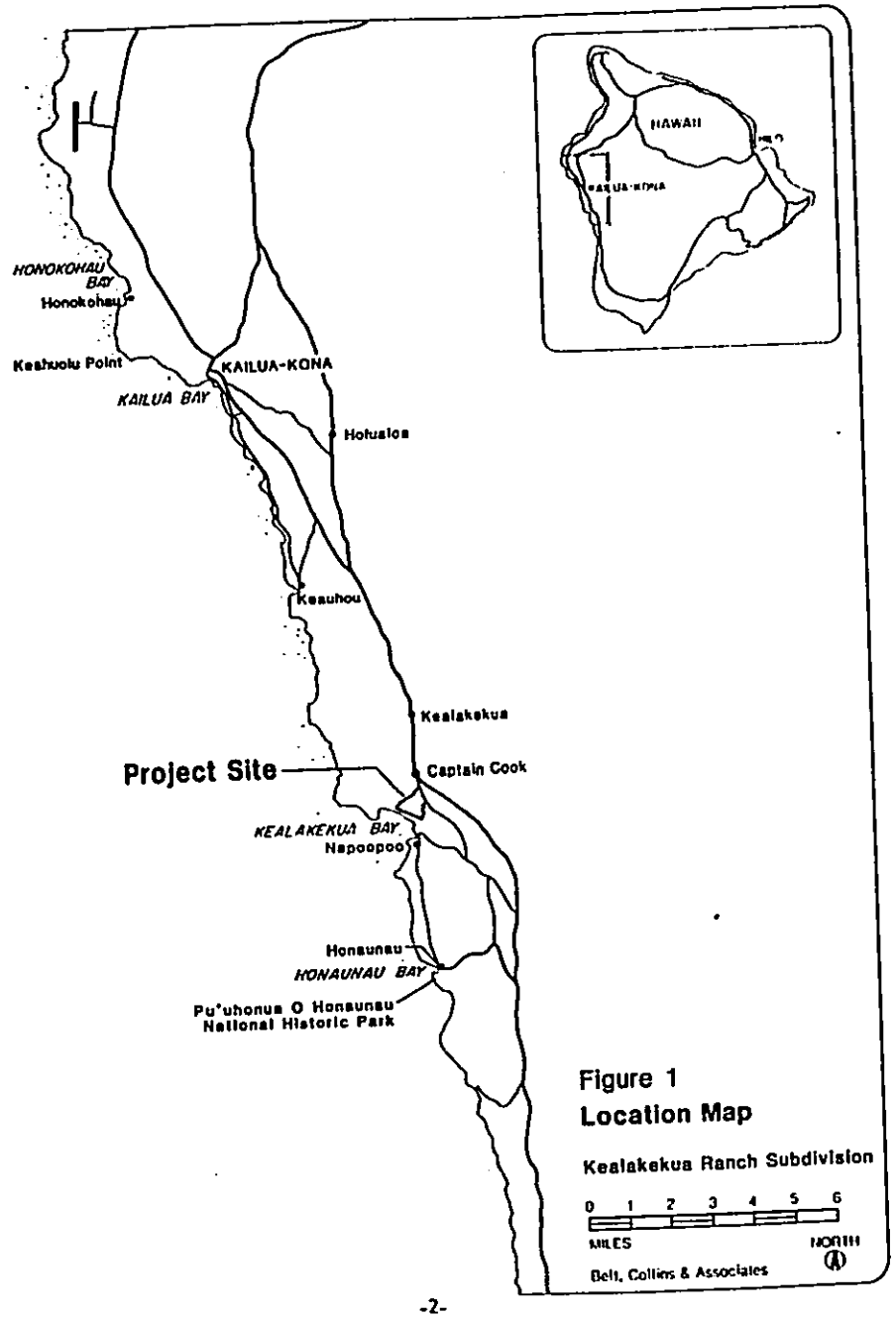


Figure 1
Location Map
Kealakekua Ranch Subdivision

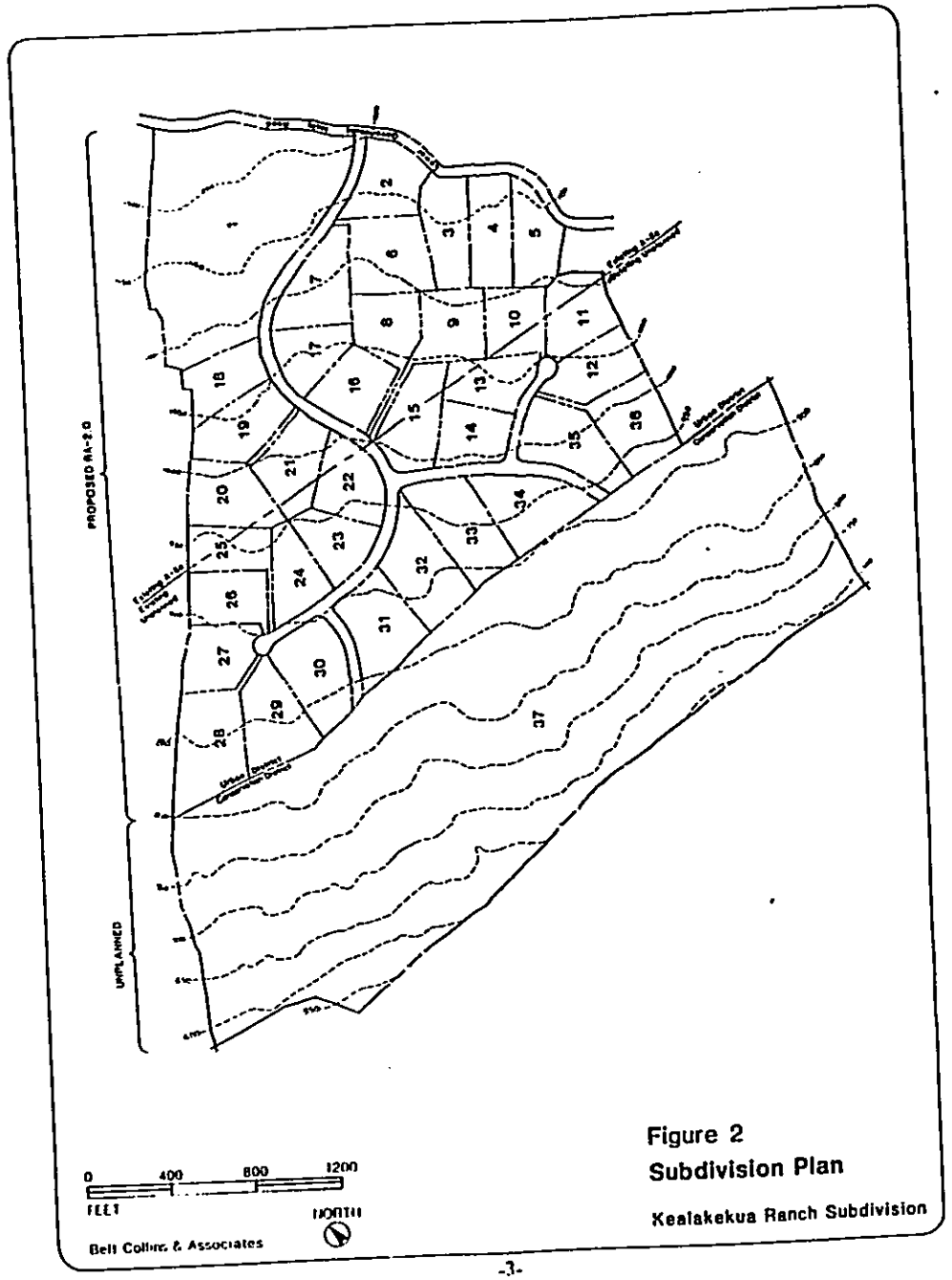


Figure 2
Subdivision Plan
Kealakekua Ranch Subdivision

Construction of the improvements is expected to begin within one year after final subdivision approval.

It is intended that the resultant lots (excluding the remnant) be sold to others and that subsequent agricultural and low-density residential development occur within the project area.

b. Statement of Objectives

Kealakekua Ranch, Ltd. (Ranch) seeks approval to subdivide its 198-acre parcel with the following objectives:

1. To cause the land to be used in a more economically productive fashion: to revitalize, broaden and stabilize the economic base of the Kealakekua-Kaawaloa community, now identified as the town of Captain Cook.

2. To make approximately 109 acres of these lands available to others, as 36 separate parcels of 2-acre minimum size, for use according to the zoning designations being sought: low density residential and agriculture.

3. To allow the Ranch to diversify from its reliance on cattle ranching and to convert its equity in this land into working capital for residential and commercial development of other Ranch-owned lands in Captain Cook which are now Urban-classified, but undeveloped.

4. To retain the "remnant parcel" of the 198-acre tract for continued active ranching, agricultural, and personal use by the Ranch and its family-stockholders, with a view toward future subdivision for residential and agricultural uses.

III. RELATIONSHIP OF PROPOSED ACTION TO STATE AND COUNTY LAND USE POLICIES

a. State Land Use Law

The State of Hawaii Land Use Commission regulations establish four different land use districts: Urban, Rural, Agricultural, and Conservation. The lower portion of the tract is in the Conservation District, and the upper portion, where the actual development is to occur, is in the Urban District. The location of the State Land Use district boundaries in relation to the proposed subdivision is shown in Figure 2.

The approximately 89 acres of the 198-acre parcel within the Conservation District would constitute a single "remnant lot" at the makai end of the parcel and separating the 36 clustered lots from the top of the cliff above Kealakekua Bay. The boundary between the Conservation District and the Urban District serves as the mauka boundary of this remnant lot and lies approximately 1,000 feet inland (mauka) from the top of the cliff.

The remaining 109 acres of the project area are all located within the Urban District and will be divided into 36 lots of 2 acres minimum each. The 9 lots fronting the Conservation District will be at least 3 acres each.

The Commission has relegated responsibility for specific land use controls within the Urban District to the County. The land to be subdivided and developed by others lies within the Urban District.

b. Hawaii County General Plan

The Hawaii County General Plan contains a set of goals, policies and courses of action as well as land use maps showing the location of desired land uses for the entire island. In May 1986, the Hawaii County Planning Department released a preliminary draft of the revised General Plan for public review and comment. The draft revised document did not include Land Use Pattern Allocation Guide (LUPAG) maps.

On the 1978 LUPAC map of the General Plan, the project area is classified low density Urban, Alternative Urban Expansion, and Orchard. The proposed subdivision fits within these classifications.

The requested change of zone which this environmental assessment supports is consistent with the goals, policies, and standards of the 1986 draft revised General Plan document. Each of the relevant elements in the Plan as it relates to the proposed subdivision is discussed below.

Economic Element

An economic goal for the County is to "strive for diversity and stability in its economic system." Another is to "provide an economic environment which allows new, expanded, or improved economic opportunities that are compatible with the County's natural and social environment." A policy is to "strive for an economic climate which provides its residents an opportunity for choice of occupation."

Agriculture is identified in the General Plan as the primary economic activity of the South Kona District. The proposed makai subdivision would allow the lot owner to engage in agricultural activities as either a full-time or part-time economic pursuit. The proposed project would also contribute indirectly to the overall South Kona economy by stimulating the sale of goods and services to such lot owners. Such agricultural and agriculture-related economic activities are in keeping with the overall character of the district and thus would have lowest impact on the existing physical and socio-economic environment while contributing to economic growth.

Environmental Quality

A County policy is to maintain the quality of the environment for residents and future residents. The proposed subdivision will not have significant impact on the environment. Its development will not diminish valuable natural or recreational resources.

Flood Control and Drainage

Problems due to flooding in the County are attributed to surface runoff, high seas, and tsunami inundation.

Goals are to conserve scenic and natural resources, prevent damage to man-made improvements, and to reduce surface water and sediment runoff. A policy is that all development-generated runoff be disposed of in a manner that is acceptable to the Department of Public Works. The private sector is seen as a partner to the government in maintaining and improving drainage systems and in building new drainage facilities.

The project site is not in an area subject to flooding. Drainageways will be designed to cause minimal impact and runoff will be disposed of in accordance with Department of Public Works standards.

Historic Sites

A County goal is to "protect and enhance the sites, buildings and objects of historical and cultural importance to Hawaii." A policy is that the County require "both public and private developers of land to provide a historical survey prior to the clearing or development of land when there are indications that the land under consideration has historical significance."

A complete reconnaissance survey has been conducted of the project site and archaeological and historical sites of potential importance located and analyzed. Recommendations have been made for further work which will occur before development.

Housing Element

Among others, County goals are to have a diverse housing mix throughout the island, maintaining a housing supply that allows choice. A policy is to accommodate the housing requirements of special need groups, including those residents living in rural areas.

In its profile of South Kona, the General Plan notes that although the district is dependent on diversified agriculture, there has been some growth reflected in new housing construction from Kealakekua through Captain Cook.

The proposed makai subdivision will provide an alternative to smaller residential lots for rural residents: 2- and 3-acre lots (or larger) to accommodate both residential use and agricultural pursuits.

Natural Beauty

The scenic and natural beauty of Hawaii is recognized as an irreplaceable asset which needs to be protected. Goals are to preserve the quality of coastal scenic resources and to protect scenic vistas and view planes from becoming obstructed.

The vast expanse of the Kona landscape is identified as the area's most striking feature. Kealakekua Bay is listed as an example of a site of natural beauty.

Due to the low density, low-rise character of the proposed makai subdivision, scenic views will not be substantially adversely affected. The subdivision's location at the top of a tall cliff assures that public views of the site will be from a distance.

Natural Resources and Shorelines

A primary goal is to "protect and conserve the natural resources of the County of Hawaii from undue exploitation, encroachment and damage." Alterations to existing landforms should cause minimal adverse impact to water resources, scenic and recreational amenities.

It is the County's policy that the shoreline be protected from the encroachment of man-made improvements and structures. It is also its policy to encourage the protection of unique habitats, wildlife species, and agricultural use of the land.

The project site is elevated and does not include the shoreline area. Development will cause minimal impact to water, scenic, and recreational resources.

Public Facilities

Public facilities identified in the General Plan are schools, libraries, fire stations, police stations, detention and correctional facilities, and refuse disposal areas. The overall goal is to improve public service through better facilities that are in keeping with the environmental and aesthetic concerns of the community.

The proposed project will result in the demand for services from public facilities as identified above. However, public revenues that will be generated by the makai subdivision development are expected to offset the governmental cost of providing these services.

Public Utilities

Public utilities facilities (water, telephone, electricity, gas, sewage treatment and disposal) should complement adjacent land uses and be operated to avoid pollution or disturbance. Improvement of utility services is linked to the demand for such services.

The proposed residential/agricultural subdivision will be connected to the utilities systems. Telephone lines will be overhead, in keeping with currently installed lines in low-density South Kona. Cesspools are identified as the accepted treatment system in the South Kona area; the proposed development will include cesspools.

Recreation

Demand for recreational resources countywide is expected to increase along with resident population and visitor growth. County policies are to improve existing facilities, provide a broad range of recreational opportunities, and provide public access to the shoreline and shoreline resources.

The South Kona district is identified in the General Plan as having inadequate neighborhood recreational facilities. The proposed 77-lot subdivision will not have a substantial impact on existing or planned facilities since the population increase due to the project is expected to be limited. The project does not front the shoreline and will not prevent public access to shoreline recreational resources.

The Hawaii County Park Dedication Ordinance uses the ratio of five acres of developed park land per 1,000 resident population as a target criterion for new developments. Kealakekua Ranch, Ltd. donated the park site and expansion area for the County-operated Arthur L. Greenwell Park in Captain Cook. The County Department of Parks and Recreation had suggested that the Hawaii County Planning Department credit Kealakekua Ranch for the donation in developing its mauka subdivision and future subdivisions. The proposed makai subdivision would be part of the Ranch's development of its lands.

Transportation

County policies are to provide transportation facilities that promote the desired land use, improve transportation service, and plan for future needs. A course of proposed action for the project area is the construction of a scenic drive from Keauhou above the Kealakekua cliffs to Napoopoo. The development of the proposed subdivision will not interfere with the construction of this scenic route.

The proposed project will lead to increased traffic on area roads. However, because of the limited extent of development, the number of increased vehicular trips is not expected to be an undue burden upon the roadway system.

Land Use

Kona is recognized as an area of agricultural activity, yet also an area where urbanization pressures are faced. The recommended courses of action for Kona include the protection of important agricultural lands and the encouragement of buffer zones between important agricultural land and non-compatible uses of land.

Soil types at the project site are extremely stony loam, peat and clay, all unsuitable for large-scale cultivation. Such soil types are actually used for pasture and, when irrigated, for growing macadamia nuts, papaya and citrus. The most recent use of the proposed makai subdivision site has been for grazing lands.

The Land Evaluation and Site Assessment (LESA) Commission was established in 1983 to identify "important agricultural lands" in the State of Hawaii and to recommend the adoption of a classification system to be developed by the Commission. The LESA report has been submitted to the Legislature, but has not been adopted. Soil types by island were evaluated in the LESA report; those on the island of Hawaii had ratings of 38 to 14. The ratings of the soil types at the project site range from 58 to 43, making it unlikely that the project site lands would be classified as "important agricultural lands." Moreover, the soils at the project site are not classified "important agricultural lands" in the State ALISH system.

The requested change of zone would allow the project site to accommodate "buffer zone" uses adjacent to important agricultural lands -- residential and small-scale agricultural uses. The low-density makai subdivision would be compatible with existing agricultural, residential and commercial land uses in the region.

c. Kona Regional Plan

The Kona Regional Plan, adopted by the Hawaii County Planning Commission as a guideline for decision making in the Kona districts, designates the project area as A-5 Agriculture and Unplanned.

d. Hawaii County Zoning

The existing County Zoning for the project area is A-5a Agriculture and Unplanned. The boundaries of these zoning districts are shown in Figure 7. To allow subdivision as described previously, a rezoning request is being submitted to the Hawaii County Planning Department as follows:

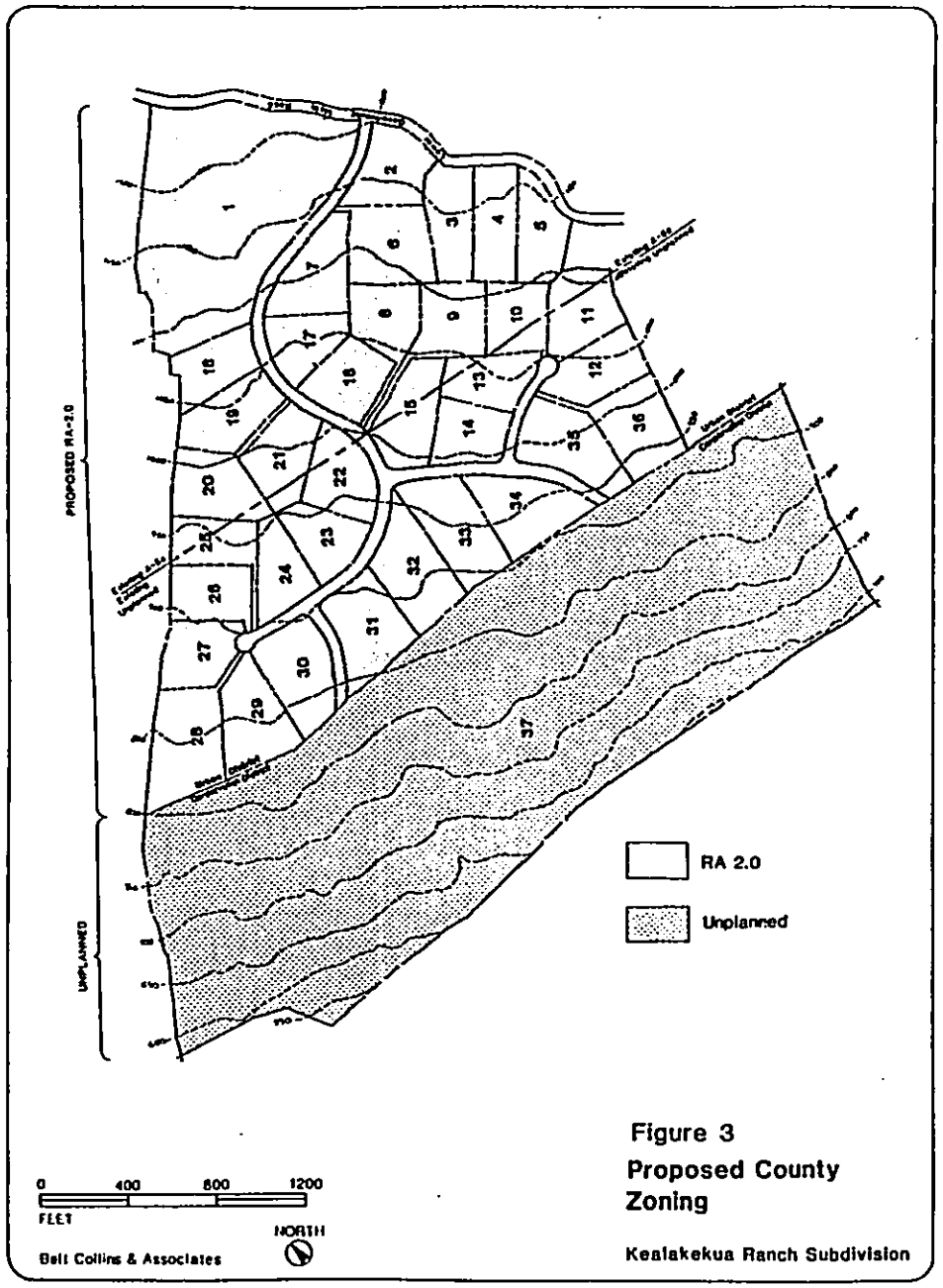


Figure 3
Proposed County Zoning

Kealakekua Ranch Subdivision

EXISTING		REQUESTED			
Zoning	Acreage	Zoning	Acreage	Zoning	Acreage
A-5a	54.6	RA 2.0	54.6		
Unplanned	143.6	RA 2.0	54.2	Unplanned	89.4
TOTAL	198.2		108.8		89.4

Although the applicant is requesting a change of zone to RA 2.0 for 36 lots, the 9 lots fronting the Unplanned remnant which is in the State Conservation District will be at least 3 acres each.

e. Special Management Area

The entire project site is located within the Shoreline Special Management Area (SMA) of Hawaii County. A discussion of the proposed project's relationship to the objectives and policies of Chapter 205A, HRS and to the SMA Guidelines in the Hawaii County Planning Commission's Rule No. 9 is presented in the sections which follow.

IV. RELATIONSHIP TO THE OBJECTIVES AND POLICIES OF CHAPTER 205A, HRS, AND THE SPECIAL MANAGEMENT AREA GUIDELINES

a. Recreational Resources

The proposed subdivision will not reduce the accessibility to the public of coastal recreation opportunities.

b. Historic Resources

Historic resources at the project site have been identified and will be analyzed. A full archaeological reconnaissance survey was performed by Paul H. Rosendahl, Ph.D., Inc. (PHRI) at the site. A total of 46 designated archaeological and historic sites were found, including intact remnants of the Kona Field System. Information retention will be maximized through further intensive survey appropriate to each site. The State goal of interpretation of historic resources will be supported.

c. Scenic and Open Space Resources

The property does not front the shoreline. Therefore, the shoreline area will not be affected. Open space and lateral view corridors along the coastal area will be maintained. Mauka-makai view corridors will not be significantly impacted. Park plans for the nearby state land will assure permanent open space along the shoreline.

d. Coastal Ecosystems

The proposed subdivision will not adversely affect valuable coastal ecosystems.

e. Economic Uses

The proposed improvements will not preclude the development of coastal dependent public and private facilities necessary to the State's economy in suitable areas.

f. Coastal Hazards

The property is located within the C Zone, areas of minimal flooding, designated by the Flood Insurance Rate Map (FIRM) for the subject area. The proposed improvements will not result in significantly increased surface runoff and coastal flooding nor will there by any major erosion and sedimentation problems. The proposed project will not be affected by tsunami or storm waves.

g. Managing Development

This environmental assessment is intended to help improve the public review process including communication and participation in the management of coastal resources.

h. Special Management Area Guidelines

The proposed improvements are consistent with the County of Hawaii Special Management Area (SMA) Guidelines. The proposed improvements will not involve dredging or fill of any natural water feature, will not reduce the size of any beach or other recreational area, will not reduce or impose restrictions upon public access to any tidal lands, beaches, river or streams, will not substantially interfere with or detract from the line of sight toward the sea from the lower Government Main Road to Napoopoo, will not adversely affect water quality of existing inland and coastal waters, and will not affect potential or existing agricultural uses of land.

The proposed improvements, because of their nature and size, will not have any significant adverse environmental or ecological effect on the project area and its surroundings. The project is consistent with the public policies of the County of Hawaii, including the General Plan, Kona Regional Plan, County zoning ordinance, subdivision codes, and objectives and policies as provided by Chapter 205A, HRS.

Construction of the proposed improvements will not interfere with any existing and planned accesses to the shoreline. Provision will be made in accordance with State and County rules and regulations for solid and liquid waste

treatment and disposition. Existing landforms and vegetation will not be significantly altered, and water resources and scenic and recreational amenities will not be adversely impacted. Finally, flooding from surface runoff, erosion, and siltation are not expected to result in any noticeable damage to the property.

V. DESCRIPTION OF THE ENVIRONMENT SETTING AND PROBABLE IMPACTS

a. Existing Land Use

The lands of the project site have most recently been used primarily for cattle grazing. Parts have been modified through bulldozing vegetation to provide improved pasture. Some ranch employee homesites line the road at the mauka boundary of the site.

b. Terrain and Soils

The site's terrain ranges in elevation from about 600 feet above sea level to about 1,250 feet and is generally uniformly sloping between the site's upper boundary and the top of the State Conservation District, ranging in grade from 10 to 15 percent. The lower portion of the site, within the Conservation District, has a slightly steeper slope gradient, ranging from 10 to over 20 percent in some areas.

The soil type varies within the site, with the lower portion comprised of Waiaha and Kainaliu series soils; the former is classified as "extremely stony silt loam", and the latter as "extremely stony or very stony silty clay loam." These soils are described as having rapid permeability and slow runoff; the erosion hazard is considered slight.

The soil in the upper portion of the site is of the Kainu series, classified as "extremely stony peat," also having rapid permeability, slow runoff, and slight erosion hazard. Representative profiles of this soil type are comprised of approximately three inches of extremely stony peat overlaying fragmented A'a lava; this soil series is described as being generally unsuitable for cultivation, with some actual use as pasture, macadamia nut and papaya orchards.

c. Hydrology and Drainage

The average annual rainfall ranges from 55 inches along the upper boundary (lower Government Main Road to Napoopoo) to 20 inches along the lower boundary (the top of the cliff).

d. Flora

The upper two-thirds of the site is currently vegetated with various pasture grasses and canopy trees, such as monkeypod and kukui. Sparse grasses, haole koa, and occasional canopy trees make up the lower third of the site. Vegetation in the upper portion of the site can be characterized as being lush during the summer rainy seasons, and rather dry in the winters. In the lower portion, summer rains bring moderate greening and vegetative growth, but winter dryness produces a parched landscape with most grasses having died back.

The species found on-site are primarily exotic species which are common throughout Hawaii.. There are no known listed or proposed endangered or threatened plant species on the project site. Further, surrounding lands are characterized by the same vegetation cover types found on the site.

e. Fauna

Wildlife in the project area include feral pig and pheasant, exotic birds, rodents and mongoose. The presence of the latter three effectively limit the success of other small animal species.

The predominant animal life within the site is cattle. For over a hundred years all of the land within this site has been used for cattle grazing, with the exception of several homesites for ranch employees in the upper portion of the site, along Napoopoo Road.

No endangered bird or mammal species are known to inhabit the project site. Suitable like habitat is available in surrounding undeveloped lands and it is expected that birds and mammals found on the site could relocate there.

f. Archaeological Sites

Paul H. Rosendahl, Ph.D., Inc. (PHRI) conducted a full reconnaissance survey of the project site in the summer of 1986. The primary purpose of the survey was to locate and evaluate all sites and features of possible archaeological or historical significance, and to determine the possible impacts of proposed

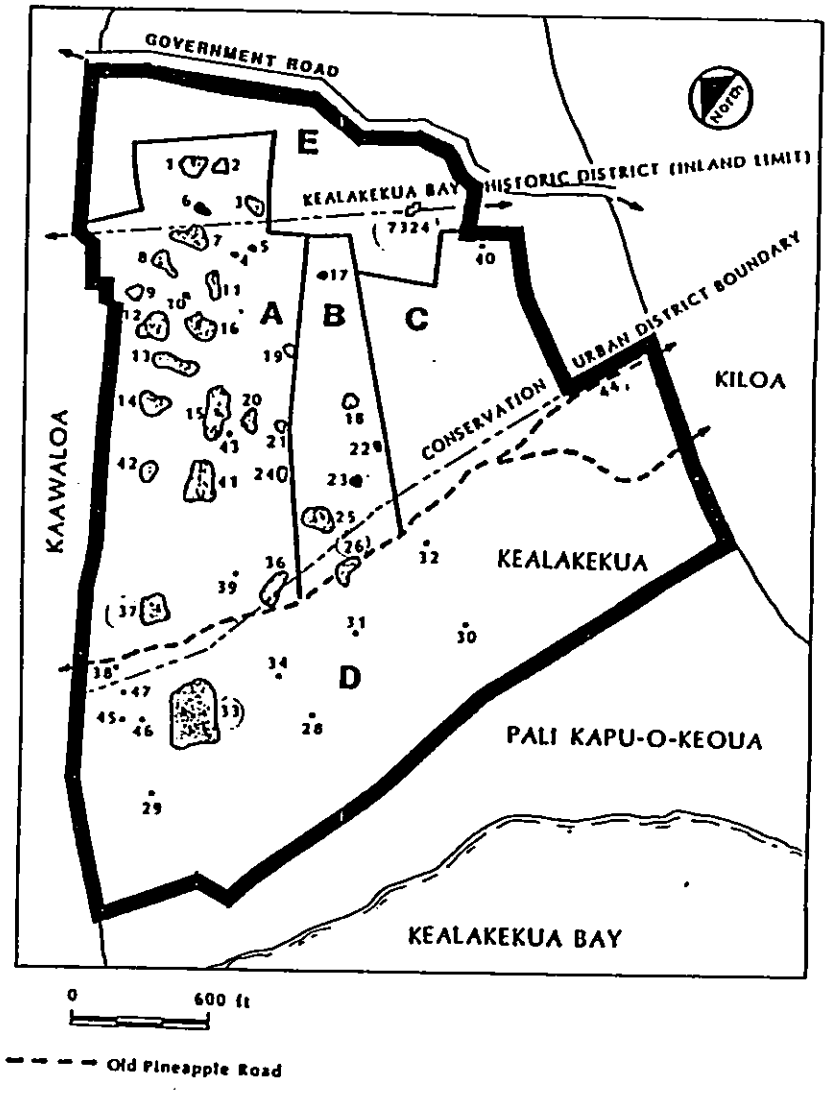
development on identified remains. Following is a summary of PHRI's report on the survey.

The majority of the survey area is within the limits of the Kealakekua Bay Historic District, an important historical site complex area which was placed on the National Register of Historic Places in December 1974. The entire area is located within the extensive 3- by 18-mile Kona (agricultural) Field System which was declared eligible for inclusion on the National Register of Historic Places in January 1977.

A total of 46 designated sites, many containing multiple component features, were identified during the 1986 reconnaissance survey. The location of the specific sites is shown in Figure 4. PHRI notes that some of these sites had been identified in earlier studies. Feature types include walls, terraces, raised stone platforms, walled shelters, enclosures, cave shelters, alignments, modified bedrock outcrops, piles and mounds. The function of many features appears to be agricultural; other features suggest residential habitation and burial functions. Sites and features at the project site are of both prehistoric and historic origin.

Based on the findings of the survey, PHRI's evaluation is that virtually all of the recorded sites are potentially significant to some degree for their scientific value, that is for the information that they may contain. Therefore, most of the sites identified appear to be sites for which continued physical preservation would not be considered essential. PHRI indicates that most of the archaeological remains could be handled adequately by carrying out the appropriate level of further archaeological work needed to recover significant data present.

Table 1 is a summary of general significance assessments and recommended general treatments. PHRI recommends some level of further data collection for all of the sites, although some sites do not require full intensive survey. Work tasks would vary considerably according to the specific site, from simple completion of recording (e.g. photographs) to detailed recording and test excavations. The PHRI report of the reconnaissance survey will be submitted separately from this environmental assessment; it will contain suggested specific tasks recommended as appropriate for each site.



1 and 2 digit number = PHRI Temporary Site Number (T-__)
4 digit number = Hawaii Register of Historic Places (HRHP) Site Number (50-10-37-__)

Figure 4
Archaeological Sites
Kealakekua Ranch Subdivision

Table 1

SUMMARY OF GENERAL SIGNIFICANCE ASSESSMENTS
AND RECOMMENDED GENERAL TREATMENTS
KEALAKEKUA RANCH MAKAI LAND SUBDIVISION PROJECT AREA

Site Number (T-)	Significance Category				Recommended Treatment			
	A	X	B	C	FDC	NFW	PID	PAI
1	+	–	–	–	+	–	–	–
2	+	–	–	–	+	–	–	–
3	+	–	–	–	+	–	–	–
4	+	–	–	–	+	–	–	–
5	+	–	–	–	+	–	–	–
6	+	–	–	–	+	–	–	–
7	+	–	–	–	+	–	–	–
8	+	–	–	–	+	–	–	–
9	+	–	–	–	+	–	–	–
10	+	–	–	–	+	–	–	–
11	+	–	–	–	+	–	–	–
14	+	–	–	–	+	–	–	–
15	+	–	–	–	+	–	–	–
16	+	–	–	–	+	–	–	–
17	+	–	–	–	+	–	–	–
18	+	–	–	–	+	–	–	–
19	+	–	–	–	+	–	–	–
20	+	–	–	–	+	–	–	–
21	+	–	–	–	+	–	–	–

General Significance Categories:

A=Important for information content, further data collection necessary (PHRI=research value);
X=Important for information content, no further data collection necessary (PHRI=research value, SHPO=not significant);
B=Excellent example of site type at local, region, island, state or national level (PHRI=interpretive value);
C=Culturally significant (PHRI=cultural value).

Recommended General Treatments:

FDC=Further data collection necessary (intensive survey and testing, and possibly subsequent data recovery/mitigation excavations);
NFW=No further work of any kind necessary, sufficient data collected, archaeological clearance recommended, no preservation potential (possible inclusion into landscaping suggested for consideration);
PID=Preservation with some level of interpretive development recommended (including appropriate related data recovery work);
PAI=Preservation "as is," with no further work (and possible inclusion into landscaping), or minimal further data collection necessary.

Table I

(Continued)

Site Number (T-)	Significance Category A	X	B	C	Recommended Treatment FDC	NEW	PID	PAI
22	+	–	–	–	+	–	–	–
23	+	–	–	–	+	–	–	–
24	+	–	–	–	+	–	–	–
28	+	–	–	–	+	–	–	–
29	+	–	–	–	+	–	–	–
30	+	–	–	–	+	–	–	–
32	+	–	–	–	+	–	–	–
34	+	–	–	–	+	–	–	–
38	+	–	–	–	+	–	–	–
40	+	–	–	–	+	–	–	–
42	+	–	–	–	+	–	–	–
43	+	–	–	–	+	–	–	–
45	+	–	–	–	+	–	–	–
Subtotal: 32	32	0	0	0	32	0	0	0
12	+	–	–	*	+	–	–	*
13	+	–	–	*	+	–	–	*
25	+	–	–	*	+	–	–	*
31	+	–	–	*	+	–	–	*
36	+	–	–	*	+	–	–	*
39	+	–	–	*	+	–	–	*
41	+	–	–	*	+	–	–	*
46	+	–	–	*	+	–	–	*
47	+	–	–	*	+	–	–	*
Subtotal: 9	9	0	0	9	9	0	0	9
33	+	–	+	+	+	–	+	–
7324#	+	–	+	+	+	–	+	–
Subtotal: 2	2	0	2	2	2	0	2	0
26	+	–	+	–	+	–	+	–
37	+	–	+	–	+	–	+	–
44	+	–	+	–	+	–	+	–
Subtotal: 3	3	0	3	0	3	0	3	0
Totals: 46	46	0	5	16	46	0	5	9

*Provisional assessment, definite assessment pending further data collections (i.e., testing features for presence/absence of skeletal remains).

#HRHP Site No. 50-10-37-7324.

Kealakekua Ranch will use the PHPI report as a guide in the development of the makai subdivision. Recommendations contained in the report will be taken into consideration, as appropriate. The Ranch is committed to further work on or preservation of significant archaeological sites. In regard to the more recent historic sites, the Ranch will decide on a case to case basis if the recommended action will be taken.

PHPI cautions that it is possible that some structural features at the project site might have been missed during the survey because of the vegetation density, but considers it very unlikely that any significant sites were missed. Should any new sites be discovered during site preparation, work will immediately stop and the appropriate governmental authorities notified. Work would not resume until approved.

g. Visual

Development of a subdivision may result in various types of visual impacts. It can change the visual character of the development site, thereby altering the visual experience of persons viewing it. It can also afford people on the site a viewpoint not generally available if the site were undeveloped. Finally, it can result in the obstruction of existing viewplanes over the site.

1. Changes in Visual Character

The site is now pastureland typical of the South Kona coastal region. Canopy trees and shrubs are scattered throughout the pastureland.

Portions of the site are visible from Napoopoo Road, but much of it is hidden from view by the large canopy trees on the site.

Much of the site will remain in its existing state. Although the development will be low in density, characterized by one home per two to three acres, landscaping around the residence sites, roadways and agricultural development means that part of the project area will exchange its present appearance for one of more manicured lushness. Little can be done to mitigate this effect, which is not seen as necessarily an adverse effect.

2. Views from the Site

The site of the proposed project is currently pasture. Hence, the beautiful vistas of the South Kona coastline that it affords currently benefit no one except the cowboys and cattle using the pastures. Consequently, no major adverse effect on these views would be caused by the proposed project.

3. Obstruction of Views Across the Site

Public land use plans, regulations and policies place emphasis on the maintenance of views from public places such as coastal highways and shoreline areas. A review of topographic maps and aerial maps of the site, as well as on-site investigation, shows that low-rise structures on the site would have limited impact on views across the site.

The lower Government Main Road to Napoopoo is the only public roadway in proximity to the project site and portions of the site will be visible from segments of this roadway. Even so, passing motorists would most likely have only a brief glimpse of the proposed structures. There will be nothing along the roadway that would call special attention to the proposed development, and it seems likely that few persons on the roadway will even be aware of its presence.

Two sections looking mauka from public places in the shoreline area are shown in Figure 5. Section 1A shows a view across the project site from Cook's Monument. Section 2A shows a view from Hikiau Heiau. Due to the distance between the public places and the subdivision, the slope of the terrain, and the low-rise character of planned development, views across the site would be minimally affected.

h. Air Quality

The major impact on ambient air quality would result from construction of the project. Grubbing and grading will be required to prepare the site for roadway and utility construction. This will involve the use of heavy construction vehicles as well as earthmoving equipment which could stir substantial amounts

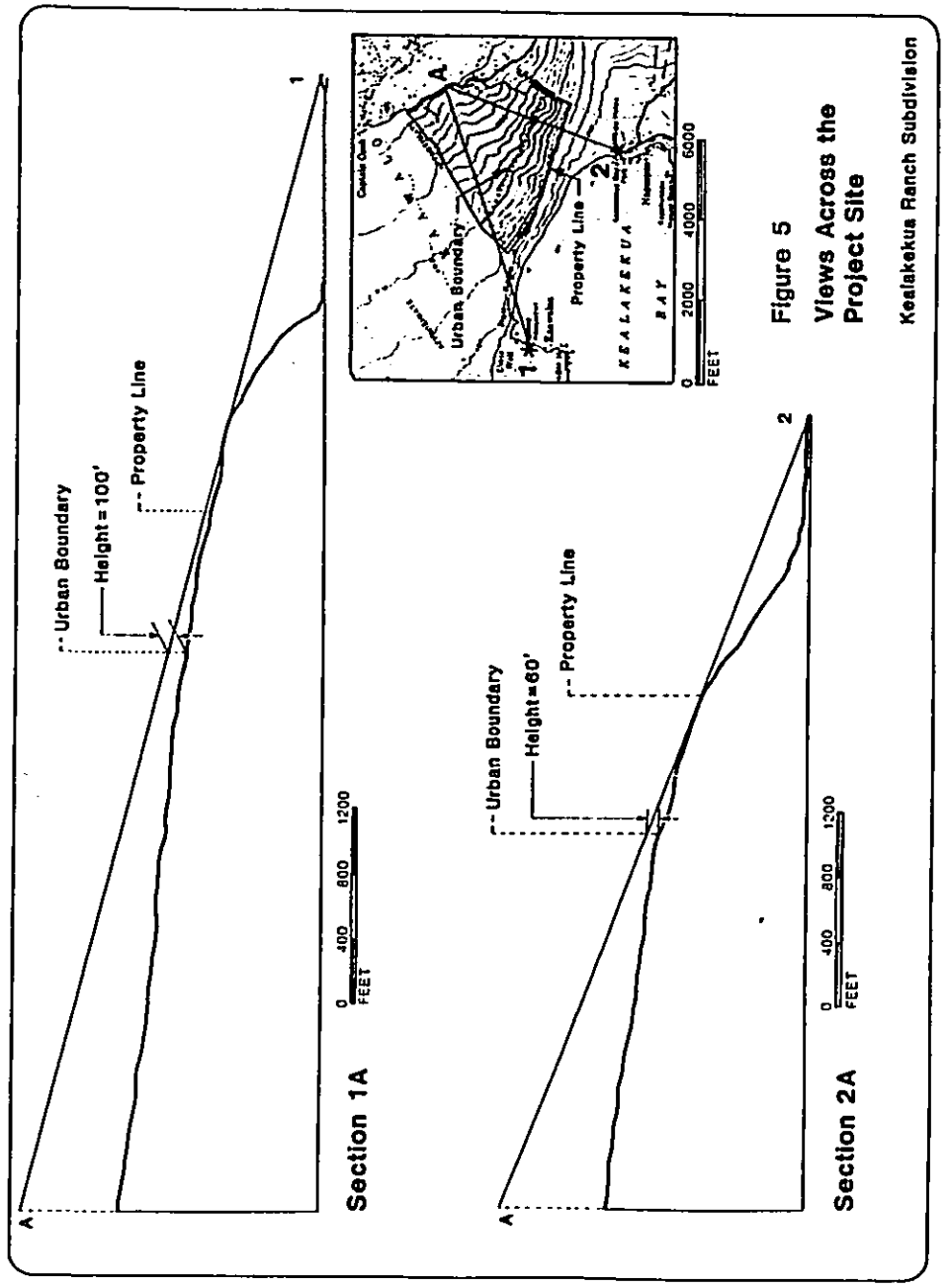


Figure 5
Views Across the Project Site
Kealakekua Ranch Subdivision

of dust. This adverse effect is considered short-term, however, being that it would be confined only to the project's construction period. It is anticipated that dust generated within the project site would dissipate and settle before reaching the outer boundary of the project site. Moreover, mitigating measures will be implemented as required by the County (in compliance with Chapter 10, Erosion and Sedimentation Control of the Hawaii County Code) to reduce or lessen the impact of dust on the surrounding land.

Long-term adverse impacts on air quality would involve primarily vehicular emissions. Considering that probably only 76 residential units will be developed and that these units would generate about 760 vehicle trips per day when homes are built on all the lots, the extent of adverse impact on the ambient air quality of the area would not be significant.

i. Noise

Traffic noise would be the major source of long-term noise generated by the proposed development. Noise from traffic which occurs on a daily basis may be of noticeable impact. However, considering the size and type of development being proposed, the anticipated noise impact appears not to be of major concern.

Construction of the project will be a source of high level noise. The impact from this activity, however, will be short-term and mitigated by noise control measures or devices such as mufflers and restricted operating hours.

j. Marine Environment

The project site is over 200 feet from the shoreline at its closest point and the Urban boundary is 1,000 feet from the shoreline. Due to the high cliff separating the site from the shoreline area and the high permeability of the soil, impact on the marine environment caused by runoff is expected to be minimal.

During construction, however, there is potential for some adverse impacts from runoff and sedimentation. The developer intends to take reasonable care during construction and such activity will be more than 1200 feet from the shoreline, thus minimizing adverse effects on the marine environment.

k. Traffic

The major project roadway will come off the Lower Government Main Road to Napoopoo. At project completion, traffic on this road and connecting roads will increase as a result of the projected 760 trips per day due to development and occupation of the project lots. This increase is not expected to place an undue burden on the roadway system and circulation.

l. Water Supply

It is expected that potable water for the proposed project will be drawn from the County of Hawaii Department of Water Supply's South Kona Water System. Water for this system is obtained from wells about five miles south of the proposed project. A water commitment for the project has been obtained from the County of Hawaii Department of Water Supply. See the letter attached to this report.

Using the County Department of Water Supply's in-house design standard of 600 gallons per unit per day, applied to a maximum of 76 units proposed, this amounts to 21,600 gallons per day for the residential units. In addition, irrigation of landscaped areas is estimated to consume about 5,800 gallons per acre per day. It is estimated that less than 10 percent of the 194-acre project site will have irrigation, or approximately 20 acres. Hence, 116,000 gallons per day might be needed for irrigation purposes. The total potable daily water need is thus projected to be approximately 137,600 gallons.

The project will tap an existing water main that runs along the Lower Government Main Road to Napoopoo. Underground waterlines will be constructed in the roadways of the project site.

m. Wastewater

Existing development in the Captain Cook area is served by cesspools, a practice which appears to be appropriate for low density developments. Cesspools are planned to be used to service the lots created by the proposed subdivision.

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The low overall density of the project (one unit per 2 acres minimum) and the successful use of cesspools in neighboring areas suggest that the use of cesspools for the proposed development will not result in any significant adverse effects. More specifically, the effluent volumes are so low, the separation between units so great, the geologic formation in which they would be dug so permeable, and the distance between the units and the nearest body of water (the Pacific Ocean) so substantial, that surface water quality should not be affected.

State Department of Health approval of the sewage disposal provisions is required under Chapter 38 of the Public Health Regulations. Final action is expected to follow a formal submittal by Kealakekua Ranch.

n. Solid Waste

Solid waste from the proposed project would be collected by private contractors or hauled by residents to the nearest County transfer station or landfill. Eventually, all of the solid waste would be disposed of in an approved County landfill. A new 300-acre public sanitary landfill area is planned for Puuanahulu and a transfer station at Captain Cook.

o. Electrical Power

The proposed project would draw its electrical power from the existing Hawaii Electric Light Company (HELCO) system.

With the use of electrically-powered air conditioning systems, the electrical energy use per unit could be 18,000 kilowatt hours per year per unit. Hence, electrical power use for the 36 units could be 648 megawatt hours per year. It is anticipated that HELCO has sufficient generating capacity to meet this demand.

Power transmission to the project will be via an existing transmission line from the HELCO substation at Hookena. This line has more than sufficient capacity to accommodate the proposed development. Distribution within the project site is at a lower voltage. The project will be supplied by overhead lines.

p. Public Services

The 36 units of the proposed project are not expected to generate substantial new population to the region, and therefore impact on existing public services will be minimal.

1. Schools

Honaunau School in Honaunau, Hookena School in Captain Cook, and Konawaena Elementary School serve area families with children in grades K to 8. Konawaena Intermediate/High School in Kealakekua serves students in grades 7 to 12. It is expected that some school-age children from the proposed project will attend private schools.

2. Recreational Facilities

There is only one neighborhood recreation center in South Kona, the County's Arthur L. Greenwell Park in Captain Cook. There are also 4 developed beach parks and two beach park reserves in the district. Recreational facilities are crowded, and the State and County have plans to provide additional facilities. Due to its limited scope, the proposed subdivision is not expected to substantially affect the use of recreational facilities in the area and region.

3. Medical Facilities

The State Department of Health administers the 93-bed Kona Hospital in Kealakekua, which includes acute care facilities. The hospital has reached capacity and it is expected that expansion will occur as funds are provided. More extensive care is available on-island at the $60-million hospital opened in Hilo in 1985. For emergency services, an advanced life support ambulance unit is located at the Captain Cook Fire Station. Kona Hospital also houses a basic life support ambulance unit.

Given the standard of 4 hospital beds needed for every 1,000 residents, the proposed project is not expected to materially affect the demand for more health care facilities.

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4. Police and Fire Protection

The Hawaii County Police Department has its regional headquarters in Captain Cook. Plans are underway to move the headquarters to a new 10-acre facility at Kealakehe in North Kona. The Captain Cook facility will be used as a substation.

A Hawaii County Fire Department station is located in Captain Cook and another station further from the project site is located in Kailua-Kona.

q. Socioeconomic Impacts

By virtue of the project's small size, the social and economic effects that would result from construction of the proposed subdivision will necessarily be fairly limited.

1. Employment Generated

Typically, large lot subdivisions do not generate much employment except during construction. The requested change of zone would reduce minimum lot sizes to 2 acres, thus allowing for a larger number of lots than would be possible under Ag 5a zoning. Because of the still limited scope of the resulting 37-lot project, the amount of additional long-term direct employment generated by the project will remain modest. However, the rezoning will encourage small lot farming as a primary, or more likely, a secondary occupation. This in turn will stimulate some indirect employment in industries that supply goods and services to small-lot farmers.

2. Short-Term Impacts

In the short term, construction of the subdivision will generate local employment and inject monies into the local economy. It is anticipated that the project will account for the employment of the equivalent of an average five full-time personnel for six to eight months. During this period, the mix of trades will fluctuate. In addition to the construction payroll generated by the proposed project, monies will be injected into the local economy in the form of payments for material and equipment and tax revenues.

3. Social Impacts

The number of future residents of the subdivision will be too low to produce a change in the social pattern of the surrounding community and thus social impacts are expected to be minimal although positive. The development of small farm lots, however, should strengthen the rural character of the community.

VI. ALTERNATIVES TO THE PROPOSED ACTION

a. "No-Project" Alternative

With no project as an alternative to the proposed large lot subdivision, no resources would be expended and the land would remain in its current pasture state. At the same time, no benefits, economic or otherwise, would accrue to Kealakekua Ranch or to the County of Hawaii. Potential economic benefits to residents of the South Kona and neighboring districts would not be realized.

b. Higher Density Use Alternative

An alternative to the proposed action is a subdivision with more lots and thus a higher density use. Because of the character of the terrain, more grading would be necessary to accommodate a greater number of units. Compared to this alternative, the proposed low density development requires a minimum of site work. With the alternate higher density development, the cost of construction would be higher.

VII. PROBABLE ADVERSE IMPACTS AND MITIGATING MEASURES

Probable adverse environmental effects which cannot be avoided are discussed in Section V of this report.

Mitigating measures to minimize impact as a result of the project will be taken. These include landscaping to minimize erosion and visibility and noise and emission abatement measures during construction. The extent to which mitigating measures are implemented will be determined by the degree of adverse impact on the surrounding area.

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VIII. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

Development of the site for the proposed subdivision will commit the land to long-term use. Monetary resources, labor, construction equipment, building materials and energy sources will be irreversibly committed to the subdivision development. In exchange, the project will benefit Kealakekua Ranch and the South Kona community.

Vegetation will be cleared to permit construction of the roadways and utilities and will be irretrievably lost.

DEPARTMENT OF WATER SUPPLY • COUNTY OF HAWAII
25 AUPUNI STREET • HILO, HAWAII 96720

September 16, 1986

Mr. Sherwood R. H. Greenwell
Kealakekua Ranch, Ltd.
P. O. Box 399
Captain Cook, HI 96704

CHANGE OF ZONE APPLICATION (R86-13)
PROPOSED 55-LOT SUBDIVISION
TAX MAP KEY 8-2-02:2 AND 33

As I discussed with you, this is to inform you that water can be made available for your proposed 55-lot change of zone application. This is based on earlier discussions between Mr. Keola Childs and Mr. Quirino Antonio of my staff in which Mr. Antonio had indicated that water was available, but shortly thereafter we changed our policy that water was not available for rezoning purposes.

We will honor our earlier commitment to you. As you are aware, in order to have a firm water commitment, you must deposit $150 per unit with the Department. Attached for your information is a copy of our "Water Commitment Guidelines Policy."

Should you be interested in pursuing this project, please deposit the necessary amount with us so that we may rescind our June 12, 1986 letter to the Planning Department.

H. William Sewake
Manager

Att.

... Water brings progress...

XEROX COPY

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

Report No. 244-082686

PRELIMINARY REPORT UPON COMPLETION OF FIELD WORK: FULL ARCHAEOLOGICAL RECONNAISSANCE SURVEY KEALAKEKUA RANCH MAKAI LAND SUBDIVISION LAND OF KEALAKEKUA, SOUTH KONA ISLAND OF HAWAII (TMK:3-8-2-02:2,37)

by

Michael W. Kaschko, M.A.
Supervisory Archaeologist

and

Paul H. Rosendahl, Ph.D.
Principal Archaeologist

Prepared for

Kealakekua Ranch, Ltd.
P.O. Box 399
Captain Cook, Hawaii 96704

September 1986

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

INTRODUCTION

BACKGROUND

At the request of Mr. Keola Childs of Kealakekua Ranch, Ltd., Paul H. Rosendahl, Ph.D., Inc. (PHRI) conducted a full archaeological reconnaissance survey of the Kealakekua Ranch Makai Land Subdivision project area situated in the Land of Kealakekua, South Kona District, Island of Hawaii (Figure 1). This preliminary report provides a summary statement of progress upon the completion of field work. PHRI had previously completed a limited (one day) preliminary reconnaissance survey (field inspection) of this parcel (Rosendahl 1986), and the results of that examination had indicated the necessity of performing the current work.

The findings of the preliminary reconnaissance survey had been discussed with Ms. Virginia Goldstein--staff planner and historic sites specialist in the Hawaii County Planning Department--who determined that a full reconnaissance survey of the entire project area would most likely be required by the Hawaii County Planning Department. Although the completed preliminary reconnaissance work was sufficient for an Environmental Impact Assessment (EIA), a full reconnaissance survey was necessary for any subsequent Environmental Impact Statement (EIS) prepared in conjunction with a Special Management Area (SMA) or Rezoning application.

The field work for the full reconnaissance survey was carried out during July 14-15 and August 5-23, 1986 by a crew of five to seven under the direction of PHRI Supervisory Archaeologist Michael W. Kaschko. PHRI Field Archaeologist Alan T. Walker supervised the first two days of field work (July 14-15). A total of approximately 88 man-days of labor was expended in the field survey.

SCOPE OF WORK

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

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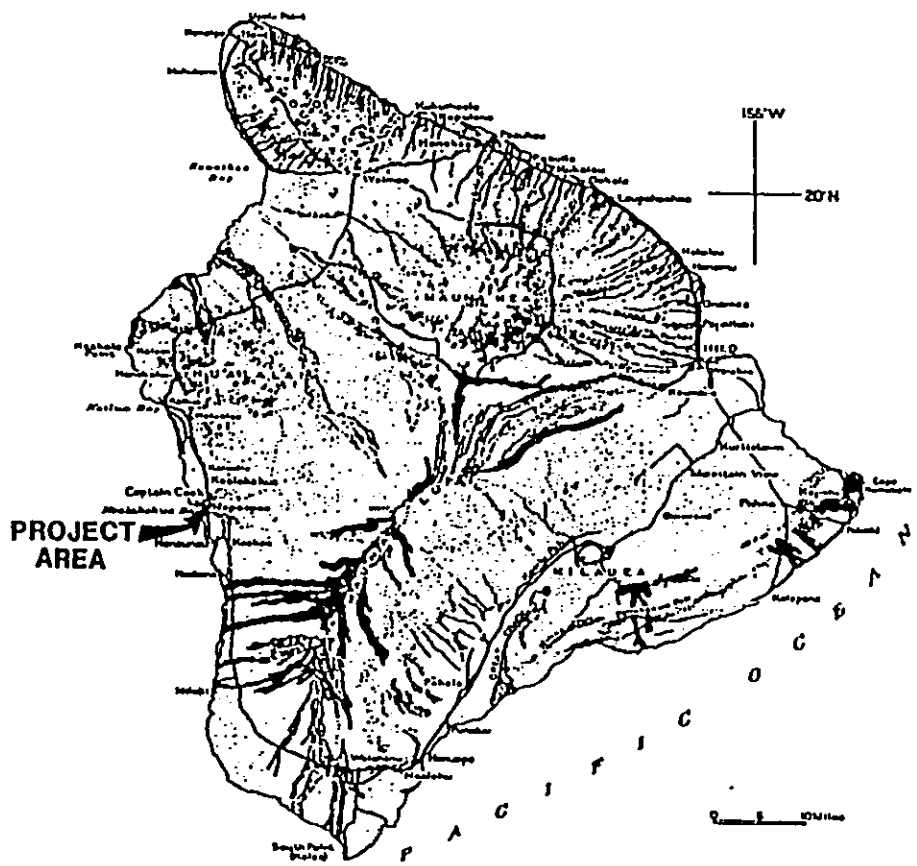

Figure 1. PROJECT LOCATION MAP

Archaeological Reconnaissance Survey
Kealakekua Ranch Makai Land Subdivision
Land of Kealakekua, South Kona
Island of Hawaii (TMK:3-8-2-02:2,37)

PHRI Project 86-244 September 1986

(Map taken from Macdonald and Abbott 1970:288.)

The four principal objectives of the full reconnaissance survey of the Kealakekua Ranch Makai Land Subdivision project area were the following:

1. To identify (find and locate) all sites and site complexes present within the project area;

2. To evaluate the potential general significance of all identified archaeological remains;

3. To determine the possible impacts of any proposed development upon the identified remains; and

4. To define the general scope of any subsequent archaeological work that might be necessary or appropriate.

Ms. Goldstein emphasized that the archaeological survey should be carried out in accordance with the minimum requirements for reconnaissance level survey recommended by the Society for Hawaiian Archaeology (SHA). These standards are currently being used by the Hawaii County Planning Department as guidelines for the review and evaluation of archaeological reconnaissance survey reports submitted in conjunction with various development permit applications.

On the basis of the preliminary reconnaissance survey findings and consultations with Ms. Goldstein and with Dr. Ross Cordy--staff archaeologist with the Hawaii State Department of Land and Natural Resources (State Historic Preservation Office), the following specific tasks were determined to constitute an adequate scope of work for the full archaeological reconnaissance survey:

1. Prepare a detailed map, based on existing aerial photographs and subsequent field work, of the relatively unaltered Kona Field System section;

2. Conduct 100% coverage variable intensity ground reconnaissance survey to identify all sites and site complexes present within the approximately 195 acre project area;

3. Complete reconnaissance level recording (written and graphic) of all identified sites and site complexes, with recording to recommended SHA standards;

4. Conduct limited historical documentary and local informant research focused on historic period land use, especially the period of pineapple cultivation; and

5. Analyze field and historical data, and prepare appropriate reports.

The possible significance of the archaeological resources identified during the reconnaissance survey was to be evaluated in terms of potential scientific research, interpretive, and/or cultural values.

PROJECT AREA DESCRIPTION

The Kealakekua Ranch Makai Land Subdivision project area (including both Urban District and Conservation District portions) consists of approximately 195 acres located in the land (ahupua'a) of Kealakekua, South Kona District, Island of Hawaii (TMK:3-8-2-02:2,37). It is situated immediately above the steep cliff known as Pali Kapu-o-Keoua, overlooking Kealakekua Bay, and lies seaward of the lower Government Main Road to Napoopoo. Adjacent to the north is the land of Kaawaloa, while to the south is that of Kiloa (both boundaries marked by old stone walls), and to the west is the boundary with Kealakekua Bay State Historic Park. The project area ranges in elevation from about 550 to 1200 ft above sea level.

Most of the project area has been used primarily for cattle grazing for more than 100 years, and some of it has been modified in recent times through the bulldozing of vegetation to provide improved pasture. The most inland portion (that adjacent to the lower Government Main Road) has been affected more extensively by alterations related to residential use, ranching activities, and small scale intensive agricultural development (primarily coffee). In general, the inland half of the property (above the old pineapple road) seems to have definitely been subject to more historic and recent disturbances than the seaward area. The terrain varies from a moderate to fairly steep slope, with a generally rolling or undulating and often rocky surface. Overall, the northern half of the parcel (especially the northeastern corner area where most of the kukui groves are located) exhibits a naturally more stoney surface than the more southern portion, which appears to have a better developed soil mantle present. At the time of the field survey, the vegetation cover ranged from moderate to very dense, and was composed primarily of a thick ground cover of introduced grasses and weeds with exotic low trees and shrubs such as koa-haole (Leucaena glauca [L.] Benth.), and lantana (Lantana camara L.). Also present are small groves of the introduced monkeypod (Samanea saman [Jacq.] Men.), pride-of-India (Melia azedarach L.), and the native kukui (Aleurites moloccana [L.] Willd.). Scattered specimens of economic plants, including papaya (Carica sp.), mango (Mangifera sp.), and breadfruit (Artocarpus sp.), were noted especially in the more inland sections of the survey area. It is clear that elevation and rainfall are responsible for some variation in the vegetation cover found within the property. Seaward of the old pineapple road (below 825 to 940 ft elevation), the vegetation is generally still quite thick but somewhat less lush and with a more restricted range of species present than in the inland zone. The most dense vegetation is found in the southern half of the project area (especially the south eastern corner portion), perhaps due to the heavier soil cover there and/or the lack of recent use for cattle grazing.

The historical significance of the Kealakekua Bay area as the site of the landing and death of Captain James Cook in 1779 is well known. This location is also the area in which the first lengthy contacts occurred between Europeans and the native Hawaiians, and such information was recorded (including the earliest substantial observations on intensive aboriginal agricultural practices). The majority of the survey area,

excluding only the most inland section adjacent to the present paved road, is situated within the limits established for the Kealakekua Bay Historic District (HRHP Site No. 50-10-47-7000), an extremely important historical site complex area which was placed on the National Register of Historic Places in December 1974. The entire project area is also located within the southern part of the Kona Field System (HRHP Site No.50-10-xx-6601), a very large complex (about 3 by 18 miles in extent) of aboriginal Hawaiian dryland cultivation and habitation features which was declared eligible for inclusion on the National Register of Historic Places in January 1977. The specific project area is composed of a portion of Land Commission Award (LCA) 8452, Apana 9 (Royal Patents 3607 and 7533, Kealakekua Ahupua'a), and a small section of LCA 8452, Apana 10 (Royal Patent 7532, Kaawaloa Ahupua'a), both awarded to the chiefess A. Keohokalole, the mother of King Kalakaua and Queen Liliuokalani.

PREVIOUS ARCHAEOLOGICAL WORK

Widespread archaeological remains had been previously reported within the Kealakekua Ranch project area. Most of the property lies within the area examined briefly in 1968 by Lloyd J. Soehren and T. Stell Newman as part of an inventory and evaluation study of the archaeological remains present immediately above Kealakekua Bay in the Lands of Kaawaloa and Kealakekua (Soehren and Newman 1968). They had utilized aerial photographs of the area to prepare a base map showing the more visible field unit boundaries which represent the extent of the Kona Field System remains, and subsequently carried out limited field work to check and verify this map. The results indicate that intact portions of the Kona Field System preserved within most of the present survey parcel. About 15 discrete sites and site complexes were also identified and recorded within Kaawaloa and Kealakekua during this field work. Eight of these (Sites 201-208) were situated within the current project area (Soehren and Newman 1968:13-15). Using the data produced by this work as a basis, Newman (1970, 1971) later discussed the nature of the Kona Field System in comparison to the other prehistoric field system areas on the Island of Hawaii.

In December 1982, Soehren (1983a) inspected the Urban District inland portion of the project area. Although not identifying any new sites, he did refer to his and Newman's 1968 study and the three previously identified sites (201-203) present within this part of the area, as well as to the many visible traces of the Kona Field System. He commented on the surface modification resulting from vegetation grubbing done since 1948, which had caused considerable disturbance to some of the archaeological remains within the survey area. He also remarked on the limited historic period disturbance occurring in the early 1900s (approx. 1907-1910), when some of this area was planted in pineapple. Based on his inspection, Soehren recommended that further reconnaissance work be done in conjunction with proposed Conservation District boundary fenceline and subdivision access road construction. In February 1983, he conducted this recommended work (Soehren 1983b), but did not identify any new sites.

The Bishop Museum (Clark 1983) has carried out a reconnaissance survey of seven residential lots situated adjacent to the southeast corner portion of the project area. A total of 34 archaeological and historic features were recorded by this survey, including several which appeared to be structural remnants of the prehistoric Kona Field System.

The most recent prior archaeological work carried out within the present project area was the preliminary reconnaissance survey (field inspection) which covered primarily the Urban District zone, conducted on February 24, 1986 by PHRI (Rosendahl 1986). Approximately 35 sites were identified during the preliminary survey. Based on the findings of that survey, it was determined that a full reconnaissance survey of the project area would be required by the Hawaii County Planning Department, and the present work is the result.

FIELD METHODS AND PROCEDURES

The complete ground reconnaissance survey of the project area was accomplished by using a series of systematic pedestrian sweeps. The distance between crew members varied from about 15.0 to 24.0 m, according to vegetation density and ground surface topography. The locations and approximate extents of individual sites and site complexes were plotted directly onto a black-and-white aerial photograph of the area (approx. scale 1"=200', R.M. Towill, 10-6-68, Photo 4743-6). Each site was described on standard PHRI site survey record forms, and selected sites and features were plan mapped to scale (tape and compass) and photographed in 35 mm black-and-white (PHRI Rolls No. 505 thru 510). Each site, or the primary feature within a site complex, was marked with pink flagging tape and an aluminum tag bearing the site number, date, and PHRI project number (86-244). All identified sites were assigned individual temporary field numbers (T-). Two temporary numbers were subsequently eliminated (T-27 and T-35), as these sites were later determined on the basis of closer examination to be natural features.

In addition, a photogrammetric map (scale 1"=100') designed to emphasize the agricultural field system features (especially the inland seaward field boundaries), was prepared using the same aerial photograph. This map was available during most of the field work period and, when checked and verified on the ground, was found to be relatively accurate and complete.

The dense vegetation cover found over the project area (especially in the southern half to two-thirds) posed difficulties, with the high grass sometimes severely reducing visibility. This presents something of a problem in assessing the survey results from these areas. It is possible that at least a few structural features that might have merited designation as specific sites were missed because of the vegetation density, particularly in areas where intact remains of the Kona Field System are present. At the same time, it is considered unlikely that any highly significant sites were missed.

SURVEY FINDINGS

KONA FIELD SYSTEM

The results of the photogrammetric mapping and the ground survey demonstrate that intact remains of the Kona Field System are present in at least three-quarters of the project area, apparently excluding only most of the southeast corner portion. There is, however, considerable variation in the nature of the physical remains visible in different parts of the remnant field system areas.

To facilitate descriptive summation of local environmental variation and the distribution of Sites, the project area has been divided into five zones (Figure 2). The northern part of the area inland of the old pineapple road (Zone A) has a naturally very rocky surface and contains the highest density of recorded site areas. Many are found in irregular distribution as "islands" of structural remains left scattered through this portion of the project area, which has been partially altered by the vegetation grubbing done over the last 35 to 40 years. Most of the sites are found associated with and beneath the canopy of small to moderate-sized clusters of kukui trees. Remnants of the prehistoric field system are fairly obvious in this area, but they have been partly disturbed by the modern vegetation grubbing.

A relatively unaltered section of the Kona Field System, containing a range of typical associated structural features, was identified in the central part of the inland portion of the project area (Zone B). It has dimensions of approximately 200 (N-S) by 500 m (E-W). Component structural features include the characteristic kuaiwi, the raised embankments or low walls that form the defining boundaries of the individual rectangular field units, and a range of internal features such as rubble wall alignments, stone mounds and piles, cleared areas, modified bedrock outcrops, and crude small terraces. The area immediately south, the southeastern portion of the survey parcel (Zone C), exhibits few traces of the prehistoric field system elements which must once have been present here. This area was reportedly the subject of heavy bulldozer clearing in about 1969 (Sherwood Greenwell, pers. comm.), and contained the thickest vegetation cover in the project area.

Most of the area seaward of the old pineapple road (Zone D) contains evident field system remains, and in general this zone appears to have been less disturbed by historic and recent activities than the inland areas. The agricultural features are still prominent, although the field boundaries are somewhat smaller or less massive when compared to the more inland zones. The south portion of this area has a heavy cover of high grass, posing serious visibility problems.

The extreme inland periphery (Zone E) has been extensively modified and altered for recent habitation and cultivation activities. This area was found to contain no archaeological remains other than a previously identified historic house site (HRHP 50-10-37-7324).

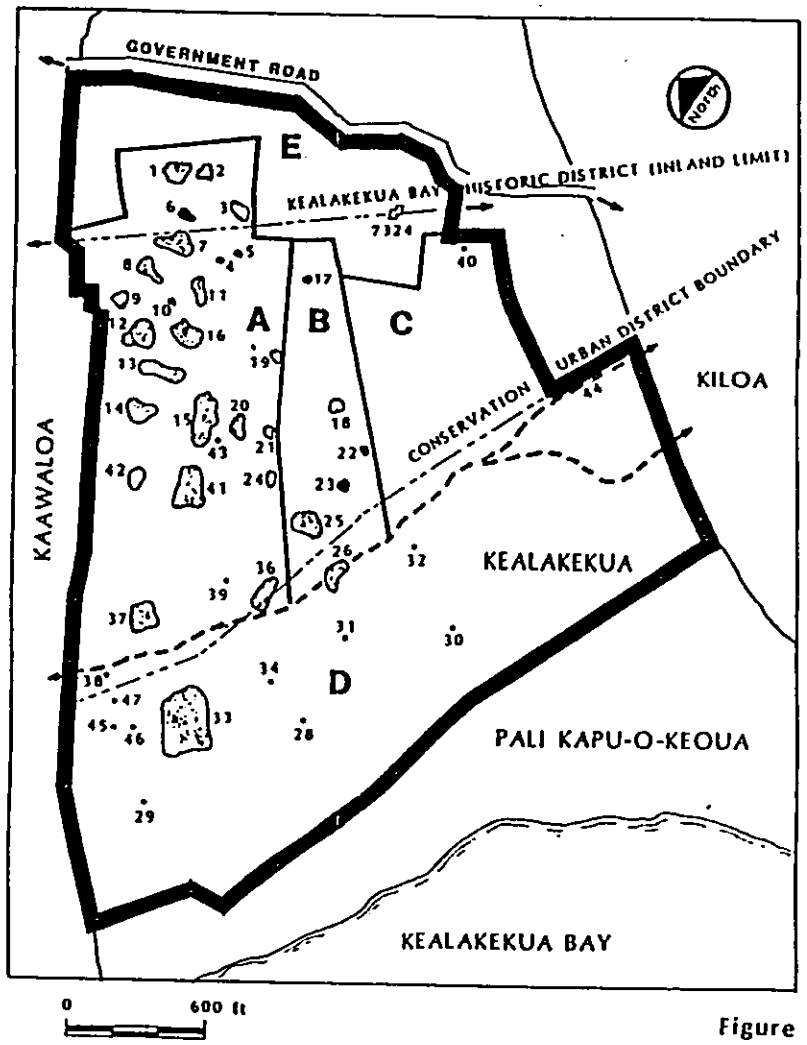

Figure 2

Old Pineapple Road

ARCHAEOLOGICAL ZONES AND SITE LOCATION MAP

1 and 2 digit number = PHRI Temporary Site Number (T-__)
4 digit number = Hawaii Register of Historic Places (HRHP) Site Number (50-10-37-__)

DESIGNATED SITES

A total of 46 designated sites, many of them containing multiple component features, were identified within the overall project area. They include Sites T-1 through T-47 (two sites, T-27 and T-35, voided), and an historic house site (Site 7324). The range of formal feature types encountered in the designated sites and complexes includes walls, terraces, raised stone platforms, walled shelters, enclosures, cave shelters, alignments, modified bedrock outcrops, piles and mounds. While the function of some of these features appears to be agricultural, many of them also suggest residential habitation and burial functions. The overall condition of the structural remains ranges from poor to very good, and the integrity is generally fair to very good. Of the eight previously identified sites situated within the project area (Soehren and Newman 1968), all were relocated except for Site 205, which may possibly have been destroyed since it was initially identified in 1968.

The sites identified within the project area can be very briefly summarized in terms of general distribution as follows:

	Zone	No. of Sites
	A	26
	B	6
	C	1
	D	12
	E	1
Total	5	46

Table 1 (at end) summarizes the identified sites and their component features in more detail with respect to formal type, tentative functional interpretation, and preliminary evaluation of site significance. Approximate site locations are indicated on Figure 2.

CONCLUSION

The full reconnaissance survey of the Kealakekua Ranch Makai Land Subdivision project area demonstrated the presence of numerous archaeological sites and features of both prehistoric and historic origin. The range of functional feature types recorded includes both temporary and most likely permanent habitation structures, probable burial features, a historic plantation roadway and associated remains, and intact remnants of an extensive prehistoric agricultural system (the Kona Field System). The distribution of identified sites, the types of features present, and related observations overall tend to confirm and amplify the assessments made earlier by Rosendahl (1986) and Soehren and Newman (1968) concerning the general pattern of aboriginal Hawaiian settlement in this area.

PRELIMINARY EVALUATIONS AND RECOMMENDATIONS

The significance of archaeological remains can be defined in terms of potential scientific research, interpretative, and/or cultural values. Research value refers to the potential of archaeological resources for producing information useful in the understanding of culture history, past lifeways, and cultural processes at the local, regional, and interregional levels of organization. Interpretive value refers to the potential of archaeological resources for public education and recreation. Cultural value, within the framework for significance evaluation used here, refers to the potential of archaeological resources for the preservation and promotion of cultural identity and values.

To attempt definitive evaluation of the significance of archaeological resources on the basis of a preliminary assessment such as a reconnaissance survey is generally premature. Occasionally it is possible, even at a preliminary level of study such as that of a reconnaissance survey, to evaluate the general significance of specific sites or features when their scientific research, interpretive, and/or cultural values are obvious; however, in most instances it is necessary first to conduct intensive survey, often including test excavations, to determine and substantiate the significance of specific archaeological remains.

Based on the findings of the completed reconnaissance survey, a preliminary evaluation of the archaeological significance of the indentified sites within the project area indicates that virtually all of the recorded sites and site complexes are potentially significant to some degree for their scientific research value; i.e., for the information they may contain. The preserved remnants of the Kona Field System (inland-seaward field boundaries, etc.), although not recorded as specific site locations, must also be regarded as holding considerable research value. Some sites and site complexes are also potentially significant for cultural and/or interpretive values as well. Possible burial features are sites of high cultural value, while a few unusual site complexes are potentially of interpretive value.

As noted earlier by Rosendahl (1986), Site T-33 is a site complex of particular interest because of the nature, size, and complexity of its constituent features. It has been suggested that this site may be a prehistoric chiefly residential complex, and thus could hold substantial interpretive value, as well as research and cultural values. The old pineapple road (Site T-44) and some of the structures associated with it (especially Sites T-26 and T-37) could also be regarded as having considerable value for historic interpretive purposes.

Most of the sites identified during the full reconnaissance survey appear to be sites for which continued physical preservation would not be considered essential. This evaluation indicates that most of the archaeological remains present within the project area could be handled adequately by carrying out the appropriate level of further archaeological work needed to recover the significant data present--thereby preserving the valuable archaeological information, rather than the physical remains themselves.

After completion of the reconnaissance survey field work, the survey findings and preliminary conclusions (including tentative general evaluations and recommendations), were reviewed (August 28, 1986) with Ms. Virginia Goldstein--staff planner and historic sites specialist in the Hawaii County Planning Department. Ms. Goldstein generally agreed with the preliminary conclusions and the tentative recommendations provided here regarding further archaeological work to be done within the Kealakekua Ranch Makai Land Subdivision project area.

Based on the findings of the reconnaissance survey, further archaeological work in the form of intensive survey (including historical documentary research, vegetation clearing, detailed mapping and recording, and controlled test excavations) is recommended for all identified sites. The basic objectives of the intensive survey and testing would be two-fold: (a) to determine and substantiate as fully as possible the significance of specific archaeological remains, and (b) to determine the scope and scale of any subsequent mitigation work, such data recovery excavations, that might be necessary or appropriate. Those sites which appear to be restricted to an agricultural function (especially T-1 through T-8) should be reexamined during intensive-level work, and only a sample of these sites would undergo standard test excavations. The following specific field tasks are believed to constitute an adequate scope of work for the intensive survey field work:

1. Selection and testing of a sample of Kona Field System agricultural features (inland-seaward field boundaries, internal features, etc.) within each of the defined zones;

2. Intensive level survey recording of designated sites--including detailed plan mapping, surface profiles, written descriptions, and photographs;

3. Surface collection of portable remains (midden and artifacts) from sites; and

4. Subsurface testing of sites with possible excavation potential.

It is important to note that any intensive survey field work should be scheduled so as to occur at a time when the vegetation cover in the project area is reduced. Ideally, it would be helpful to obtain a set of new low-level color infra-red aerial photographs, taken at a time of low vegetation, for use during the intensive survey work.

It should be noted that the evaluations and recommendations given here (see Table 1, at end) have been made on the basis of the full surface reconnaissance survey. There is always the possiblility, however remote, that previously unidentified surface structural remains of subsurface cultural features, or deposits of high significance might be encountered in the course of subsequent archaeological investigations or other development activities.

SUMMARY OF GENERAL SIGNIFICANCE ASSESSMENTS AND RECOMMENDED GENERAL TREATMENTS

To facilitate outside review of project findings, evaluations, and recommendations, general significance assessments and recommended general treatments for all archaeological sites identified within the Kealakekua Ranch Makai Land Subdivision project area are summarized in Table 2. Thirty-two of the 46 designated archaeological sites identified within the project area have been determined to be significant solely for their information content. These sites still contain significant information and additional data collection has been recommended for the sites. The same assessment and recommendation pertains to the combined but not individually designated remains collectively referred to as the "intact remains of the Kona Field System" (see page 7), and of which a representative sample should be further investigated.

Nine sites have been determined to be significant for their information content and may also have cultural significance as burial sites, pending the findings of further investigations. Two sites have been determined to be significant for information content, as a site type example, and for their cultural value. Three sites have been determined to be significant both for their information content and as good examples of specific site types.

Table 2.

SUMMARY OF GENERAL SIGNIFICANCE ASSESSMENTS
AND RECOMMENDED GENERAL TREATMENTS
KEALAKEKUA RANCH MAKAI LAND SUBDIVISION PROJECT AREA

Site Number (T-)	Significance Category				Recommended Treatment			
	A	X	B	C	FDC	NFW	PID	PAI
1	+	-	-	-	+	-	-	-
2	+	-	-	-	+	-	-	-
3	+	-	-	-	+	-	-	-
4	+	-	-	-	+	-	-	-
5	+	-	-	-	+	-	-	-
6	+	-	-	-	+	-	-	-
7	+	-	-	-	+	-	-	-
8	+	-	-	-	+	-	-	-
9	+	-	-	-	+	-	-	-
10	+	-	-	-	+	-	-	-
11	+	-	-	-	+	-	-	-
14	+	-	-	-	+	-	-	-
15	+	-	-	-	+	-	-	-
16	+	-	-	-	+	-	-	-
17	+	-	-	-	+	-	-	-
18	+	-	-	-	+	-	-	-
19	+	-	-	-	+	-	-	-
20	+	-	-	-	+	-	-	-
21	+	-	-	-	+	-	-	-

General Significance Categories:

A=Important for information content, further data collection necessary (PHRI=research value);
X=Important for information content, no further data collection necessary (PHRI=research value, SHPO=not significant);
B=Excellent example of site type at local, region, island, state or national level (PHRI=interpretive value);
C=Culturally significant (PHRI=cultural value).

Recommended General Treatments:

FDC=Further data collection necessary (intensive survey and testing, and possibly subsequent data recovery/mitigation excavations);
NFW=No further work of any kind necessary, sufficient data collected, archaeological clearance recommended, no preservation potential (possible inclusion into landscaping suggested for consideration);
PID=Preservation with some level of interpretive development recommended (including appropriate related data recovery work);
PAI=Preservation "as is," with no further work (and possible inclusion into landscaping), or minimal further data collection necessary.

Table 2. (Cont.)

Site Number (T-)	Significance Category A	X	B	C	Recommended Treatment FDC	NFW	PID	PAI
22	+	–	–	–	+	–	–	–
23	+	–	–	–	+	–	–	–
24	+	–	–	–	+	–	–	–
28	+	–	–	–	+	–	–	–
29	+	–	–	–	+	–	–	–
30	+	–	–	–	+	–	–	–
32	+	–	–	–	+	–	–	–
34	+	–	–	–	+	–	–	–
38	+	–	–	–	+	–	–	–
40	+	–	–	–	+	–	–	–
42	+	–	–	–	+	–	–	–
43	+	–	–	–	+	–	–	–
45	+	–	–	–	+	–	–	–
Subtotal: 32	32	0	0	0	32	0	0	0
12	+	–	–	*	+	–	–	*
13	+	–	–	*	+	–	–	*
25	+	–	–	*	+	–	–	*
31	+	–	–	*	+	–	–	*
36	+	–	–	*	+	–	–	*
39	+	–	–	*	+	–	–	*
41	+	–	–	*	+	–	–	*
46	+	–	–	*	+	–	–	*
47	+	–	–	*	+	–	–	*
Subtotal: 9	9	0	0	9	9	0	0	9
33	+	–	+	+	+	–	+	–
7324[f]	+	–	+	+	+	–	+	–
Subtotal: 2	2	0	2	2	2	0	2	0
26	+	–	+	–	+	–	+	–
37	+	–	+	–	+	–	+	–
44	+	–	+	–	+	–	+	–
Subtotal: 3	3	0	3	0	3	0	3	0
Totals: 46	46	0	5	16	46	0	5	9

[a]Provisional assessment, definite assessment pending further data collections (i.e., testing features for presence/absence of skeletal remains).

[f]HRHP Site No. 50-10-37-7324.

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Table 1.

SUMMARY OF IDENTIFIED SITES AND FEATURES
KEALAKEKUA RANCH HAKAI LAND SUBDIVISION

Site & Feature Number	Formal Site/Feature Type	Tentative Functional Interpretation	*Significance Evaluation R	I	C	Recommended Action	Comments
Zone A							
T-1	Terrace	Agricultural	L	L	L	Int. Sur.	Roughly shaped; coral and water-worn basalt cobble present
T-2	Terrace	Agricultural	L	L	L	Int. Sur.	Probably originally connected to T-1
T-3	Wall/Embankment (2)/ Terrace	Agricultural	H	L	L	Int. Sur.	Field boundaries; cross-slope terraces; waterworn basalt cobbles on surface
T-4	Wall/Embankment	Agricultural	L	L	L	Int. Sur.	Remnant field boundary; disturbance is evident
T-5	Wall/Embankment	Agricultural	L	L	L	Int. Sur.	Field boundary; may originally have extended from T-3
T-6	Terrace	Agricultural	L	L	L	Int. Sur.	L-shaped; one of the better constructed agricultural terraces
T-7 A B	Complex (2)# Enclosure Terrace	Agricultural	H	L	L	Int. Sur.	Located in a kukui grove; terrace has been disturbed
T-8	Wall/Embankment/Terraces	Agricultural	L	L	L	Int. Sur.	Field boundaries; cross slope terraces

*Significance Evaluation--Nature: R = scientific research, I = interpretive, C = cultural;
Degree: H = high, M = moderate, L = low.

#Number of component features within complex.

Table 1. (Cont.)

Site & Feature Number	Formal Site/Feature Type	Tentative Functional Interpretation	Significance Evaluation R	I	C	Recommended Action	Comments
T-9 A B	Complex (2) Cave shelter Wall segment	Habitation	H	L	L	Int. Sur.	Pig bones present on interior surface of Feature A
T-10	Mod. outcrop/ Terrace	Agricultural	L	L	L	Int. Sur.	Probably part of prehistoric field system
T-11	Wall/Embankment/Terrace	Agricultural	L	L	L	Int. Sur.	Field boundary and cross slope terraces
T-12	Platform	Poss. burial	H	L	L/H	Int. Sur.	Oval shaped; located in agricultural complex; waterworn basalt cobble present on surface
T-13	Platform	Habitation/ Poss. burial	H	L	L/H	Int. Sur.	Rectangular shaped
T-14	Lava bubble shelter	Habitation	H	L	L	Int. Sur.	Surface midden present; bedrock mortar, small stone cup, basalt core
T-15 A B	Complex (2) Enclosure Platform	Habitation/ Agricultural	H	M	L	Int. Sur.	Coral and waterworn basalt cobble in Feature A
T-16	C-shape	Habitation	H	L	L	Int. Sur.	Walled shelter; associated with field boundaries and cross slope terraces
T-19	Walled enclosure	Agricultural/ Habitation?	H	L	L	Int. Sur.	Structure could be the remains of a collapsed/disturbed animal pen
T-20	Walls/Embankments (2)/ Terraces	Agricultural	H	L	L	Int. Sur.	Field boundaries with associated terraces; features are components of the Kona Field System

Table 1. (Cont.)

Site & Feature Number	Formal Site/Feature Type	Tentative Functional Interpretation	Significance Evaluation R	I	C	Recommended Action	Comments
T-21	Terrace	Agricultural/ Habitation	H	L	L	Int. Sur.	Several waterworn basalt cobbles on surface
T-24	Complex (2)	Habitation	H	L	L	Int. Sur.	Dozing disturbance is evident immediately around site; prob. Site 201
A	Lava bubble shelter						
B	Walled enclosure						
T-36	Complex (3)	Poss. burials/ Habitation	H	L	L/H	Int. Sur.	Prob. Sites 202 and 203
A1	Platform						
A2	Platform						
B	Terrace						
T-37	Complex (3)	Historic habitation	H	H	L	Int. Sur.	Historic bottle, ceramics, waterworn basalt cobble, and broken basalt adze blank on Feature A
A	Terrace						
B	Walled terrace						
C	Retaining wall section						
T-39	Platform	Poss. burial	H	L	L/H	Int. Sur.	Roughly rectangular shaped; located on a small hill; appears isolated
T-41	Complex (3)	Habitation/ Poss. burial	H	L	L/H	Int. Sur.	Feature A quite large and substantial residence structure
A	Terrace						
B	Walled structure						
C	Platform						
T-42	Mod. outcrop	Agricultural	H	L	L	Int. Sur.	Located in a kukui grove
T-43	Walled terrace	Habitation	H	L	L	Int. Sur.	Heavy vegetation cover on structure
Zone B							
T-17	Walled structure	Habitation	H	L	L	Int. Sur.	Rectangular-shaped; level soil floor on the interior
T-18	Terrace	Historic habitation	H	H	L	Int. Sur.	Historic bottles and old fence wire present on surface

Table 1. (Cont.)

Site & Feature Number	Formal Site/Feature Type	Tentative Functional Interpretation	Significance Evaluation R	I	C	Recommended Action	Comments
T-22	U-shape	Poss. animal pen	H	L	L	Int. Sur.	Historic, rectangular bottle on surface
T-23	Terrace	Agricultural	L	L	L	Int. Sur.	Surface appears too sloping for habitation use
T-25	Complex (12)	Poss. burials/ Agricultural	H	L	L/H	Int. Sur.	Coral, waterworn basalt cobbles, shell midden on surface
A	Mound						
B	Mound						
C	Terrace						
D	Mound						
E	Mound						
F	Mound						
G	Mound						
H	Mound						
I	Mound						
J	Mound						
K	Mound						
L	Wall segment						
T-26	Complex (5)	Historic habitation	H	H	L	Int. Sur.	Historic bottles, ceramics, and square nail on surface
A	Enclosure						
B	Walled structure						
C	Wall section & mound						
D	Retaining wall & ramp						
E	Terrace						
Zone C							
T-40	Terraces	Agricultural	L	L	L	Int. Sur.	Roughly constructed; situated in a kukui grove
Zone D							
T-28	C-shape	Habitation	H	L	L	Int. Sur.	Surface shell midden present
T-29	Terraces (3-4)	Agricultural	H	L	L	Int. Sur.	Roughly constructed; coral cobble and a waterworn basalt boulder on surface
T-30	Terrace	Habitation	H	L	L	Int. Sur.	Rectangular shaped; a waterworn basalt cobble on surface

Table 1. (Cont.)

Site & Feature Number	Formal Site/Feature Type	Tentative Functional Interpretation	Significance Evaluation R	I	C	Recommended Action	Comments
T-31	Platform	Poss. burial/ Agricultural	M	L	L/M	Int. Sur.	Small, oval shaped; structure; may be historic
T-32 A B	Complex (2) Walled structure Terrace	Historic habitation	M	M	L	Int. Sur.	Historic bottles, ceramics, and basalt hammerstone present; prob. Site 204
T-33 A B C D E F G	Complex (7) Walled structure Terrace Terrace Terrace Enclosure Platform Mound	Habitation/ Poss. burials	M	M	M	Int. Sur.	Surface shell midden, waterworn basalt cobbles and coral
T-34	Terrace	Habitation	M	L	L	Int. Sur.	High, rectangular shaped; surface shell midden present
T-38	Terrace/ Retaining wall	Historic agricultural (?)	M	L	L	Int. Sur.	Shell midden on surface
T-44	Elevated roadway	Transportation	M	M	L	Int. Sur.	The historic "old pineapple road"
T-45	Terracing	Agricultural	L	L	L	Int. Sur.	Located while searching for Site 206
T-46	Walled terrace	Habitation/ Poss. burial	M	L	L/M	Int. Sur.	A rough basalt core on surface; prob. Site 207
T-47	Platform	Poss. burial	M	L	L/M	Int. Sur.	Prob. Site 206
Zone E							
7324	Historic house	Habitation/ Burials	M	M	M	Int. Sur.	First wood frame house in Kealakekua ahupua'a; NRHP Site

Appendix 6:
FERTILIZER AND PESTICIDE MANAGEMENT PLAN

RECEIVED
OCT 10 1990
BELT, COLLINS & ASSOCIATES

FERTILIZER AND PESTICIDE MANAGEMENT PLAN

FOR

THE PROPOSED KEALAKEKUA BAY CLUB GOLF COURSE

Prepared for

Royal Coast Development Company
P.O. Box 44394
Kawaihae, HI 96743

Prepared by

Environmental Impact Consultants
Box 266, 2440 Campus Road
Honolulu, HI 96822

October 1990

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2. Environmental Fate, Wildlife and Aquatic Studies Required for Pesticide Registration
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EXECUTIVE SUMMARY

The proposed Kealakekua Bay Club Golf Course may require the use of fertilizer and pesticides to establish and maintain the course. Public concern of environmental contamination by these chemicals mandates careful selection and control of these materials. This report identifies fertilizers and pesticides most frequently used on Hawaii golf courses and lists the environmental behavior characteristics of each including groundwater contamination potential. Environmental conditions at the proposed site that affect chemical movement are also identified.

This report describes a fertilizer and pesticide management plan for the Kealakekua Bay Club Golf Course. It is divided into three parts: (1) water quality monitoring, (2) best management practices, and (3) pesticide storage/mixing/loading facilities. These topics addresses the Hawaii State Department of Health's Eight Conditions Applicable to New Golf Course Development (April 1990) that apply to pesticides and fertilizers.

RECOMMENDATIONS

1- Use minimum amounts of pesticides by observing integrated pest management (IPM) practices and select pest and drought resistant plant species.

2- Use the proposed groundwater monitoring plan in concert with Hawaii Department of Health recommendations to manage water and chemicals on the Kealakekua Bay Club Golf Course.

3- Obtain an environmental assessment of proposed site and adjacent areas to document chemical contamination which may have resulted from previous agricultural activity.

4- Store pesticides and fertilizers in a facility constructed to minimize chemical movement resulting from spills, floods, and equipment maintenance.

5- Observe Best Management Practices (BMP's) described herein especially those concerning storm water management.

6- Use a modern irrigation system that includes computerized environmental monitoring instruments or equivalent to measure evapotranspiration and schedule irrigation application.

7- Employ a certified golf course superintendent and have all pesticide application staff certified by the Hawaii Department of Agriculture to apply restricted use pesticides.

INTRODUCTION

The proposed Kealakekua Bay Club Golf Course site is located in South Kona on the west coast of the island of Hawaii. The 260 acre golf course will be on a terrace 600 to 1100 feet above and overlooking Kealakekua Bay. Development and maintenance of the proposed golf course may require fertilizers to supply essential nutrients and pesticides to control associated weed, disease, and insect pests. These chemicals may be subject to movement from the site of application either by runoff during high intensity rainfall or by percolation towards groundwater when water infiltration exceeds evapotranspiration (ET). Because irrigation in excess of ET contributes to groundwater recharge, proper water management is essential. Careful selection and application of chemicals will mitigate potential water contamination. This report identifies the types and amounts of pesticides and fertilizers used on typical Hawaiian golf courses and lists climatic and hydrogeological factors at the Kealakekua site that can affect chemical movement. This report also describes a water monitoring program consistent with that required by the Hawaii State Department of Health's (DOH) Eight (8) Conditions Applicable to New Golf Course Development (Appendix 1). It also describes Best Management Practices which will minimize potential adverse impacts of fertilizers and pesticides.

APPROACH

This report was developed from previous reports on the proposed Kealakekua Bay Club Golf Course site including those found in Subsurface Pesticide Migration Study, Kealakekua Bay Club, South Kona, Island of Hawaii, Hawaii by Harding Lawson Associates (1) and Marine

Environmental Monitoring Program, Kealakekua Bay, South Kona, Hawaii by Marine Research Consultants (2). A site visit by EIC was completed on 30 June 1990.

This report recommends minimal pesticide usage. Estimated fertilizer and pesticide use was based on chemical usage of other Hawaii golf courses and reports by Murdoch and Green (3,4). Pesticide leaching potential was estimated using Attenuation Factors for selected pesticides derived from the USDA-ARS Pesticide Properties Database (7) and environmental factors suggested by Murdoch and Green. The water management plan described herein was made in part to comply with the Hawaii State Department of Health's (DOH) requirements (Appendix 3).

CLIMATIC AND HYDROGEOLOGICAL SITE CONDITIONS

The island of Hawaii is the most recently formed of the Hawaiian chain and is composed of five shield-type volcanoes. The proposed golf course is on the slopes of Mauna Loa which is still active. The 600 foot cliff west on the west border of the proposed site is a fault scarp. Successive lava flows produced basaltic lava layers of varying thickness under the site. These lavas slope about 12 degrees to the southwest (1). Hawaiian basaltic lavas are generally very water permeable especially horizontally. High porosity in these rocks is caused by cooling fractures, lava tubes, and other features common to lava.

Groundwater in the Kona coast aquifer occurs similar to the other Hawaiian islands. A basal lens of fresh water floats on the heavier salt water and rises about 2 feet per mile inland. Groundwater quality varies with depth and distance from the coast. Groundwater quality below the proposed site is unknown but is probably slightly brackish due to its close proximity to the coastline. Groundwater flows seaward and discharges along the coast. Fresh water effects can

be observed up to 500 m offshore (2) and there is evidence of point sources of fresh water or springs in Kealakekua Bay.

Rainfall in the Kealakekua Bay area is higher than other leeward areas on Hawaii. As opposed to most of the other Hawaiian islands, summers on the Kona coast are wetter than the winter. A nearby raingauge (State Key #26.2) shows an average rainfall of about 3-4 inches/month in the winter and 6-7 inches/month in the summer with and overall average of about 60 inches per year (5). Tradewinds from the northeast dominate the Hawaiian Islands and would blow off shore. Temperatures are moderate (ca. 80 $\pm$ 15 °F).

Soils on the proposed site are mostly Waiaha series in the western region and the Kainaliu series in the central and eastern section (6). These soils are shallow (1-3 feet) and underlain by a'a or pahoehoe lava. The dark brown silt loam soil can have a large percentage of rocky material. Infiltration is moderately rapid to rapid with permeability ranging between 2-20 inches per hour (6). The stony composition of these soils mandate importing soil for golf course construction.

An annual groundwater recharge of 25% of rainfall (about 10 - 15 inches/year) was estimated for the entire pre-development site (1). Annual averages do not adequately represent extreme weather conditions such as storms or droughts which can dramatically affect downward movement of water. Addition of a 2 ft soil layer for turf establishment would restrict groundwater recharge whereas addition of irrigation water for turf growth would contribute to recharge. Thus the post-development recharge (25%) estimate is similar to the pre-development one (1). Selection of drought resistant turf grasses and/or careful irrigation practices can

significantly affect the amount of irrigation required and therefore the amount of groundwater recharge.

FERTILIZER AND PESTICIDE USE ON GOLF COURSES

Fertilizers supply those essential nutrients which plants use in large amounts and which are deficient in most soils. Elements which are normally applied in a turfgrass fertilization program are nitrogen (N), phosphorous (P), and potassium (K). Fertilizers are generally applied to only the greens, tees, fairways, and part of the roughs of a golf course. Typical turfgrasses grown in Hawaii use about twice as much N as K and 4 times as much N as P. A typical application program for N is given in Table 1.

The primary fertilizer elements of concern for contamination of ground and surface waters are phosphorus and nitrogen. Phosphorus (as phosphate) is often attached very tightly to iron and aluminum hydroxides which are plentiful in Hawaiian soils, and any movement would be by erosion or run-off. Phosphate can adversely affect surface water by stimulating primary production (i.e. algal blooms). Ammonium nitrogen, like phosphorus, is strongly bound to most soils. Nitrogen applied in the ammonium form is rapidly converted to the nitrate form which is not bound to the soil and moves readily with water. Nitrates can adversely affect surface water by promoting primary production. Nitrates can be reduced to nitrite in the body of warm blooded animals and humans causing methemoglobinemia (impaired oxygen transport). The Maximum Contaminant Level for nitrates is 10 mg/L as nitrogen. However, because of high N uptake by turfgrasses, nitrogen will be used rapidly after application. If heavy rainfall occurs

soon after application of a soluble nitrogen source, excessive loss by surface runoff or by leaching could occur.

Table 1. Approximate nitrogen use rates for different areas of a typical golf course in Hawaii from Murdoch and Green (4).

Type of turf	Area (acres)	Fertilizer amt. (lb. N/100 sq. ft.)	Applic. freq. appl. (tons)	Total annual
Greens	3	0.5	2 weeks	0.85
Tees	3	1.0	3 weeks	1.15
Fairways	50	1.5	8 weeks	10.0
Roughs	30	1.0	3 months	2.60
Total	86			14.6

There are a number of weed, insect and disease pests of turfgrasses in Hawaii which sometimes require application of pesticides. The three general types of pesticides used on golf courses are herbicides, insecticides, and fungicides. Herbicides are used most frequently followed by insecticides and fungicides. Based on reports of pesticide usage on Hawaii golf courses, the types of chemicals and usage rates vary widely depending upon pest problems. In

general, herbicide use varies from 200 to 800 lbs of active ingredient (a.i.) per year, insecticide use varies from 100 to 800 lbs a.i./yr. and fungicide use varies from 50 to 200 lbs a.i./yr. Most herbicides used for both prevention and eradication of weeds are applied to fairways while insecticides and fungicides are applied to greens and tees or as spot treatments on fairways and then only on an "as needed" basis.

The chemistry of each pesticide is different and affects the way it behaves in the environment as well as how it affects non-target organisms. Appendix 1 contains specific information on several pesticides used on golf courses including their physical, chemical, toxicological, and environmental properties. This list of pesticides is composed of those chemicals registered for use on golf courses, those chemicals that have a history of significant use in Hawaii, and those chemicals that are potential groundwater contaminants or have significant toxicity to non-target organisms. The general environmental behavior of pesticides frequently used on Hawaii golf courses is discussed below. All of these pesticides are also registered by EPA for use on food crops. Several chemicals may be substituted for those listed in Appendix 1.

Glyphosate (tradename ROUNDUP) is very effective against all plants and is therefore only used for spot treatments. Nevertheless, it is so rapidly degraded and bound to soils that plants can be cultivated shortly after use. Because of its low toxicity to mammals, such as man, and other wildlife it is often used for right-of-way treatments (roadsides). Its strong binding to soils give it a small potential to contaminate groundwater but a relatively high potential to contaminate surface water through runoff. Glyphosate has low toxicity to fish but must be used in an aquatic weeds formulation.

Metribuzin (tradename LEXONE) is an herbicide used on a large number of grass and broadleaf weeds. It degrades fairly rapidly in soils but its moderate water solubility and moderate binding to soils can allow transport to groundwater. Moderate toxicity to birds and fish make proper management essential.

MSMA (monosodium methanearsonate; tradename WEEDHOE) is an herbicide used to control crabgrass and certain broadleaf weeds after they have sprouted. MSMA is similar to glyphosate in that its strong soil binding capacity minimizes its potential to contaminate groundwater but increases its potential to contaminate surface water with runoff. Minimal toxicity to fish limit its impact to surface water.

Chlorpyrifos (tradename LORSBAN) is an insecticide used for a wide variety of pests on numerous crops and turf. Although it is relatively toxic to mammals and wildlife, its low environmental persistence minimizes its impact on non-target organisms. Also, the chemistry of organophosphates, like chlorpyrifos, makes them susceptible to degradation in water and soil. Chlorpyrifos is especially susceptible to degradation in sunlight. Relatively strong binding to soil organic matter reduces their potential to leach to groundwater but increases chlorpyrifos' potential to contaminate surface water. Proper management of this chemical is essential to minimize adverse environmental impact.

Carbaryl (tradename SEVIN) is another insecticide used for a wide variety of pests on crops and turf. Carbamate insecticides, such as carbaryl, also degrade rapidly in the environment. While the toxicity of carbamates varies widely, carbaryl is one of the least toxic to mammals. In addition, carbamate toxicity is reversible within the body making them less hazardous than organophosphates. Relatively strong binding to soils minimizes carbaryl's

potential to leach into groundwater. Although carbaryl bound to soil can move to surface water, its rapid degradation minimizes its impact. It's toxicity to birds is low and to fish is moderate.

Chlorothalonil (tradename DACONIL) is a fungicide used on several food crops and turf. Its very high soil binding capacity reduces its potential to contaminate groundwater but increases its potential to move with surface runoff. Slow degradation coupled with high toxicity to fish make proper use imperative. Low toxicity to mammals and birds minimizes other hazards.

Pesticides in Hawaii groundwater, such as DBCP and atrazine, have raised concerns over agricultural practices. Although most of these observations are believed to be caused by non-point sources (small quantities over large fields) there are concerns that point sources contribute to the problem. Recently, the state had soils analyzed from several pesticide mixing and loading sites and found high levels of soil contamination (8). Safe storage, mixing, loading and disposal of pesticides is essential to protect the environment.

PESTICIDE LEACHING POTENTIALS

Several models are available that assess the potential for pesticide transport through soils to groundwater. One model that has received widespread attention and is currently under evaluation by the Hawaii State Department of Agriculture is the Attenuation Factor (AF) model developed by Rao and co-workers (9). Using physical and chemical properties of each pesticide and site specific environmental parameters such as groundwater recharge and soil properties, AF values can be calculated. AF is defined as the fraction of chemical remaining in the soil after a single application when the water recharge is sufficient to carry the chemical to a given depth. The AF index can have values that range from 0 (total attenuation) to 1 (no attenuation). Only

relative soil mobilities are determined. More sophisticated models require substantially more site specific environmental information to predict actual chemical concentrations in the soil profile.

AF values for selected pesticides using average environmental parameters found in Hawaii are listed in decreasing potential to contaminate groundwater (Table 2). Five of the pesticides registered for use on Hawaii golf courses have AF values that rank above atrazine, a widely used herbicide in the sugarcane industry. Since atrazine has been found in low concentrations in Hawaii groundwater, it can be assumed that the five chemicals ranked above it have potential to leach into groundwater if used under similar patterns and management. AF values for EDB and DBCP, pesticides found in Hawaii groundwater but not registered for use on golf courses, are listed for comparison.

GROUNDWATER MONITORING PLAN

Recently, the Hawaii State Department of Health issued a document (Eight Conditions Applicable to New Golf Course Development Appendix 3) which outlines a groundwater monitoring plan that must be addressed by owners and developers of new golf courses. In addition, the owner/developer must supply a monitoring schedule, a list of sampling components and mitigative measures in the event that these components are detected and/or found to increase.

Traditionally, groundwater monitoring involves periodic sampling of water supply wells or monitoring wells for the chemical, biological or physical parameters of interest. A disadvantage of this approach is that once these parameters are detected, the groundwater is contaminated. Deep groundwater monitoring often determines the average pollutant level which

Table 2. Attenuation Factors (AF) for selected pesticides.

pesticide	K_{oc}	$t_{1/2}$	AF	HAL*
EDB*	44	3650	0.90	0.0004
DBCP*	70	180	0.04	
mecoprop	3	21	1.3×10^{3}	
trichlorfon	2	27	5×10^{3}	
dicamba	2	14	7×10^{3}	200
simazine	138	75	2×10^{4}	4
metribuzin	41	30	4×10^{4}	200
atrazine*	160	60	8×10^{4}	3
ETU	3.7	2	3×10^{12}	0.2
benomyl	2100	100	5×10^{20}	
mancozeb	1000	35	3×10^{19}	
chlorthalonil	1380	20	$< 10^{19}$	2
carbaryl	229	7	$< 10^{19}$	700
chlorpyrifos	6070	30	$< 10^{19}$	
glyphosate	10000	30	$< 10^{19}$	
MSMA	10000	100	$< 10^{19}$	

Based on the following environmental conditions; soil organic carbon content = 1.5%; soil bulk density = 1.2 g/cm^3; soil water content = 35% by volume; water recharge = 0.1 cm/day; depth of penetration = 50 cm (20 in).
* indicates a pesticide found in Hawaii groundwater but not registered for use on golf courses.
* Health Advisory Levels in micrograms/Liter.

may be composed of several input events. Another disadvantage to this approach is that critical events such as the effects of heavy water application (storm event) or a change in chemical formulation cannot be readily determined. Groundwater monitoring at the proposed Kealakekua site would be very expensive due to the great depth to groundwater (>600 ft).

A more reasonable approach to groundwater monitoring that circumvents the disadvantages mentioned above is the use of soil lysimeters. A lysimeter is an area of soil (ca. 1 m^3) and associated plants confined by concrete or metal dividers with a means to collect and analyze leachate water. Usually these representative soil columns are removed to a nearby area where they are exposed to identical environmental and chemical conditions. Advantages of this approach include lower costs than deep monitoring wells, the ability to detect chemicals and alter management practices before groundwater contamination, and the ability to determine leaching losses after storm events. A disadvantage is the difficulty of simulating field conditions in lysimeters (edge effects, representative chemical application, etc.).

EIC recommends that lysimeters be constructed that simulate each of the different chemical application regimes (tees, greens, and fairways). If possible, the lysimeters should be constructed on the actual golf course. Design and location of these lysimeters are subject to approval by the DOH. EIC also recommends that Kealakekua Bay be monitored in at least three sites near shore and that the golf course irrigation wells be monitored.

Standard parameters required by DOH and/or the U.S. Environmental Protection Agency to be monitored include total dissolved solids, pH, chloride, nitrate, total Kjeldahl nitrogen, total phosphorous, and orthophosphate. Kealakekua Bay samples should also include the parameters recommended by Marine Research Consultants (2).

The pesticides metribuzin and chlorpyrifos should be monitored in the lysimeters. Metribuzin is commonly used on golf courses and is relatively mobile (see Table 2). Chlorpyrifos, an organophosphate insecticide also commonly used on golf courses, has a relatively high mammalian and aquatic toxicity. Lastly, pesticides with an AF value higher than that of atrazine should be included in the monitoring. These parameters are subject to approval by the DOH. If these chemicals are found to leach through the lysimeters under standard irrigation conditions or a simulated storm event, then these parameters should be included in the irrigation wells and Kealakekua Bay samples.

Because previous agriculture activity in the area may have impacted the water resources, it is essential to have background data to assess this impact if any. EIC recommends that the developer have an environmental assessment or chemical inventory performed on the proposed site as well as on off-site areas that may affect the proposed golf course site. The results of this assessment may require additional sampling.

The following sampling schedule is proposed for the irrigation wells, Kealakekua Bay, and lysimeters:

Before development-------	preferably two times at least one month apart.
During development------	quarterly and increased to monthly during landscape and turfgrass establishment.
Post development--------	first year-- quarterly following years-- semi annually

This sampling frequency schedule is subject to approval by the DOH. Monitoring of lysimeter leachate should begin after they are constructed and stabilized. Samples should be taken just prior to and after chemical applications begin. Sampling frequency will depend upon avaliablity of leachate water. They should be taken often (ca. weekly) during turf development. Lysimeters should be sampled within 24 hours after a major storm event.

Once the sampling sites, parameters, and schedule have been approved, the DOH requires that the owner/developer contract an independent third party professional (approved by the DOH) to have the groundwater sampled and the data reported to the DOH. The DOH further requires that water testing be done by a certified laboratory.

MITIGATIVE MEASURES IN THE EVENT CONTAMINATION OCCURS

If any of the pesticides used on the golf course is reported in the irrigation well or Kealakekua Bay water samples, careful evaluation of the laboratory report should be performed. This includes but is not limited to duplicate analyses or mass spectral confirmation. If contamination is confirmed, use of that chemical should be stopped immediately and the departments of health and agriculture notified. Monitoring efforts should be increased to once a month or a frequency as requested by the DOH. Efforts should be made to determine the cause of water contamination since this will influence subsequent management practices.

Lysimeter leachates have more probability of containing pesticides because of the shallow depths monitored. Also, the ability of laboratories to determine very low concentrations of pesticides increases the chance of detection. If any of the pesticides used on the golf course is measured in the lysimeter leachate, that chemical should be monitored frequently to determine

if concentrations are changing with time. If concentrations increase over time, pesticide management practices should be altered. Reducing amounts or frequency of applications, modifying application methods or equipment, or changing formulations of active ingredients are mitigative measures which the golf course supervisor should consider. Increases in other chemical parameters can reflect improper chemical and/or water management and should be included in subsequent management practices. Guidelines suggested by the departments of health and agriculture for mitigative measures should also be observed.

PEST CONTROL FACILITY

A pest control facility (PCF) is that area on a golf course where pesticides are stored, mixed, and loaded. A properly designed and managed pest control facility can greatly minimize the possibility of point source environmental contamination (8). Plumes of pesticide contaminated soil detected at some mixing/loading facilities are a potential threat to groundwater. Proper design and management can greatly reduce the possibility of personal injuries and unauthorized access to chemicals. Improperly stored pesticides are more hazardous to handle and violate state and federal regulations.

Recommended procedures and criteria for storage of pesticides and pesticide containers are addressed in 40 CFR 165.10 (10). Procedures and criteria were developed primarily for pesticides and containers whose uncontrolled release into the environment would cause unreasonable adverse effects on the environment.

PCF's contain toxic pesticides and related chemicals and may be required for interim storage of pesticides classified as hazardous materials. Excess pesticides and other chemicals are

considered hazardous wastes if they possess certain physical characteristics or are listed under 40 CFR 261 (11), the Resource Conservation and Recovery Act (RCRA). The PCF should be properly secured either by enclosing it in a climb resistant fence or by installing security devices on the windows, e.g., heavy gauge wire mesh or bars, and standard exit locking hardware on the doors.

A PCF should be large enough to provide adequate space for personnel and equipment necessary to address anticipated pest management activities. It should include a pesticide and equipment storage area, a change area, mixing area, and a deluge shower and eyewash as a minimum. A telephone is essential for emergencies. An office, laundry and toilet can be located elsewhere depending on the distance from the PCF.

The change area should include storage closets for personnel protective equipment (respirators, goggles, gloves, etc.) and work clothing. The pesticide handling area should include both storage and mixing/loading areas.

Pesticides should be stored off the floor so that all labels are visible, with lanes (at least three feet wide) to provide effective access and inspection, and stored no more than eight feet high. Shelving should be located against the walls. The room should be dry and equipped with a fire detection device. Pesticide concentrates should not be stored in rooms containing floor drains. Open shelving of non-absorptive material is recommended. A workbench made of non-absorptive material for equipment maintenance is also recommended.

Insecticides should be separated from herbicides due to the potential for contamination of the insecticides with herbicides (not the reverse). Additionally, phenoxy and urea herbicides should be physically separated from all insecticides. The pesticides should be arranged so that

clean air flows continuously from the insecticides past the herbicides and fungicides out the facility. Good practices also dictate that liquid materials be stored below dry materials to prevent contamination if leaks or spills occur. Leakage and spillage should be cleaned up immediately. Drip trays containing absorbent material should be placed under pesticide containers fitted with spigots. Ammonium nitrate fertilizers should not be stored in the same structure as pesticides for fire safety purposes. All fumigants should be stored outside of occupied buildings in hazardous chemical lockers. A Type ABC fire extinguisher of 10 pound capacity should be located near each door.

The pesticide mixing area should be equipped with electricity and hot and cold water. Metal or plastic pallets should be used to hold the containers off the floor. Steel stands to keep drums off the floor are recommended. The sink should be deep enough to wash and fill small equipment items. It should be pesticide resistant with a self-draining drip-proof counter top at least five feet long. Sideboards, a splash panel on back and an adjacent shelf for holding measuring devices and concentrates should be included. Swing-type spigots for the hot and cold water faucets should allow an air gap of at least two inches between their outlet and the top of the sink. The sink should be connected to the sanitary sewer.

Both the storage and interior pesticide mixing areas should be well ventilated to minimize toxic or flammable vapor and dust buildup. The light and exhaust switch (one switch) with a pilot light should be located outside the door and marked with a sign reading "VENTILATE DURING OCCUPANCY".

The use of windows should be minimized as sunlight will promote degradation of some chemicals. Reducing or eliminating windows will also enhance security. Ceiling hung light

fixtures should provided at least 50 lux in all work areas. Outdoor lighting should be provided for night time operations.

Walls and roof should be made of noncombustible material resistant to liquid and chemical attack. Drop ceilings should not be used because they may trap vapors. Foundations should be slab-on-grade with flat (flush) door sills at interior and exterior doors. The thickness of the slab should be designed to accept live loads equal to the weight of a 55 gallon drum in the interior storage area. Concrete floors should be finished with a nonabsorbent nonskid finish. Floors should be sloped from sills to the center or to one side of the room to facilitate spill cleanup. Additionally, a four inch concrete curb may be used to contain spills.

Exterior work areas where equipment is filled or washed should slope away from door sills. This area should have a continuous concrete curb to contain spills. It should be equipped with a closable drain connected to a storm sewer to dispose of accumulated precipitation. (This drain should be closed during pesticide application equipment filling operations.) State water quality control regulations should be consulted before connecting the drain system. Emergency eyewash and deluge shower (30 gpm shower head) with manually operated, delayed-closing valves should be accessible within 10 seconds from any mixing site. Spigots, fill pipes and other pressurized water sources should be fitted with reduced pressure backflow prevention devices if used for pesticide mixing.

The PCF should be isolated from congested areas for reasons of health and safety, fire protection, environmental protection and security. Fire safety is the most important consideration in selecting the PCF site. PCF's fully involved in fire are generally allowed to burn in order to minimize the spread of pesticides with runoff from fire-fighting. A list of the types of materials

stored in the PCF should be made available to the local fire department. A prefire and fire plan should be developed with their assistance.

The PCF should be sited a minimum of 200 feet from surface waters, existing wells, or 100 year flood plains. They should be downhill from such sensitive areas. Alternatively, diking may be used where space is limited. Consideration should be given to prevailing winds and the location of populated areas. The PCF should not be located uphill from potable water sources or continuously occupied structures. Actual siting should be approved by an industrial hygienist, sanitary engineer or fire protection engineer. A soil analysis of the site should be conducted to determine hazardous chemical background levels.

No concentrated or diluted pesticides (including rinsates) should be discarded to the sanitary sewer or storm drain. Neither should they be poured on the ground. Containers should be triple rinsed or otherwise disposed according to their label. Pressurized rinsing devices are recommended. Closed systems which utilize returnable containers should be used to the extent possible.

The PCF should not be designed with holding tanks as they could bring the facility under additional regulation and could result in considerable unnecessary expense. Procedures to preclude the need for holding tanks include (1) the practice of washing application equipment at the application site and applying the wash water to the area treated, (2) using water from rinsing containers to make up finish sprays, (3) saving wash water from the exterior for reuse, and (4) substituting the more hazardous or toxic pesticides with safer, less persistent materials. Prudent use of pesticides can greatly reduce disposal requirements.

The PCF should be properly identified and marked "PESTICIDE STORAGE AREA" to advise personnel of its contents. A "DANGER - PESTICIDES. KEEP OUT" sign should be posted on each door. "NO SMOKING" signs should be posted in all work areas. A "DO NOT DISCHARGE PESTICIDES INTO THE SINK" sign should be posted above the sink. The employees toilet should be posted with a reminder to wash their hands BEFORE they use the toilet. Lastly, the exterior mixing/loading area (hardstand) should have a sign to remind users to "CLOSE DRAIN WHILE HANDLING PESTICIDES ON HARDSTAND". If non-English speaking personnel handle pesticides consider posting the signs in their language also.

The US Department of Agriculture has developed a general plan for a pesticide storage building (Appendix 4) which takes into account many of the recommendations discussed above. Other plans and additional recommendations are available (12-15).

MANAGEMENT PRACTICES FOR FERTILIZERS AND BIOCIDES

This report addresses fertilizer and biocide management from two perspectives. The first considers how fertilizers and biocides, i.e., pesticides, act on the environment. The second considers how the environment acts on fertilizers and biocides. The DOH requires that this later perspective be addressed as one of the conditions applicable to development of new golf courses (see Appendix 3).

A. Chemical Management Factors Considered

1. Fertilizer use

Runoff or leaching of fertilizers in established turf will be minimal under most weather conditions. During periods of heavy rainfall, fertilizers should be applied only in a slow release form, such as sulfur coated urea and organic forms of nitrogen. Soluble formulations should be avoided during rainy periods. Movement of nitrates to groundwater ca be minimized by using a slow-release nitrogen fertilizer or reducing application rates 75% and increasing the frequency of application. High application rates of nitrogen fertilizers should be avoided at all times. High application rates overstimulate shoot growth at the expense of root development. Overly fertilized plants are more susceptible to many turf diseases. High application rates increase the potential for adverse environmental impacts associated with runoff and leaching. Since heavy rainfalls may occur on occasion, runoff should be managed through environmental modification (see below).

2. Pesticide use

The Environmental Protection Agency (EPA) is responsible for registration of pesticides. The registration process requires submission of extensive environmental fate studies (see Appendix 2). Pesticides which can, in EPA's assessment, cause unreasonable risk to either man or the environment are classified as Restricted Use Pesticides (RUP's). In Hawaii, RUP's can only be applied by or under the direct supervision of an applicator certified by the Hawaii Department of Agriculture (DOA).

Generally, individuals who wish to become certified complete a pesticide applicator training course conducted by the University of Hawaii Cooperative Extension Service. This course includes a discussion of factors and practices which contribute to groundwater contamination, runoff and drift. Approximately half of the 17 hour course deals with proper pesticide mixing, loading, application, storage and disposal and equipment calibration. (Appendix 5 describes a training course which meets both state and federal certification/training requirements.) Certified applicators are required to maintain their certification by attending recertification courses approved by the DOA. Suggested changes to the current state regulations would require all applicators to complete a technician level training course. EIC strongly recommends that the use of all pesticides be under the direct supervision of a golf course superintendent certified by the DOA to purchase, apply or supervise the use of RUP's. Furthermore, EIC recommends that all individuals handling pesticides complete a course in pesticide applicator safety. Refresher training should be given on an annual basis and should involve hands-on training utilizing application and safety equipment used for golf course maintenance or specified on product labels.

Pesticides enter the environment as either a point or a non-point source. They become contaminants when they move off target or are concentrated at a single point. Point source contaminants are found primarily at pesticide storage or mixing/loading sites. The importance of a properly constructed and managed pest control facility is discussed elsewhere in this report.

It is not always necessary to use pesticides to control pests. Pest control measures should be integrated to maximize their effectiveness without causing negative impacts to the environment. These integrated pest management (IPM) programs require a thorough knowledge of each pests life cycle and biology. IPM programs depend on proper identification and monitoring in order to select and apply suitable management practices at the most effective time. Careful monitoring can effectively reduce the number of pesticide applications which in tern reduces pest management costs and adverse effects to beneficial organisms.

Although EIC does not advocate the use of pesticides we recognize that at times the judicious use of pesticides can be the most effective means of minimizing both pest damage and the adverse environmental effects caused by pests.

The efficacy of pesticide applications can be maximized by carefully calibrating application equipment and following basic application principles. Applicators should use low pressure nozzles, low application pressures, (20-40 psi), drift control agents or shrouded boom applicators, keep the boom close to the target and avoid applications when winds exceed 10 mph. To the extent possible, applications should be restricted to periods of minimal wind conditions (late afternoon or early morning) and minimal golfer activity. Night applications to greens and tees may be considered. Drift can be further minimized by selecting formulations with low

volatility or using granular formulations. Buffer zones and high vegetation will also minimize exposure to aquatic environments, clubhouse facilities and nearby farms and homes.

Golf courses are managed much more carefully than most agricultural crops. While greens and tees are the most frequently treated areas, their total area constitutes less than 10 percent of the total golf course. This situation tends to mitigate the potential problems associated with pesticides that are known to move on or through soils. Pesticides such as glyphosate, MSMA, chlorpyrifos and chlorothalonil have been determined by USDA to have large surface loss potential because they bind with soil particles which may move with storm runoff. Conversely, metribuzin and nitrates have large leaching potentials because of their water solubility. Soils which will receive fertilizers and biocides should be at least two feet deep and contain at least 2% organic matter. This much organic matter is also needed for turf establishment.

The presence of turfgrass will reduce surface runoff and leaching. Studies by Watschke et al. (16) indicate that dense, high quality turfgrass stands affect the overland flow process to such a degree that fertilizer and pesticide runoff is insignificant. Dense turfgrass permits water to infiltrate and thereby promotes metabolism of solutes. Pesticides generally do not penetrate more than 2 to 3 centimeters in the soil, most being confined to the thatch. Microbial degradation occurs most rapidly in the root zone.

Conventional insecticides such as chlorpyrifos and carbaryl are toxic to fish. Therefore, extreme care must be taken to see that they do not get carried with runoff into Kealakekua Bay. In some areas and against some pests it may be advisable to use insecticides which are more environmentally compatible, for example, microbial insecticides, attractants and pheromones.

Herbicides and fungicides used on a typical golf course are of relatively low toxicity to fish and other aquatic organisms. The active ingredient of the herbicide most commonly used for spot treatments (glyphosate) is also registered for use in estuaries, ponds, lakes and similar sites.

Birds are sensitive to some organophosphates and carbamates. However, the most commonly used organophosphate, chlorpyrifos, is tightly bound to thatch and soil, thus reducing its availability to birds. The majority of bird kills associated with insecticides result from birds consuming granule formulations left exposed on the soil surface. Granule formulations of chlorpyrifos should be avoided. Carbaryl is not available in a granule formulation. When spray applications are made they should be timed to avoid normal feeding periods of birds, that is, they should be applied in late evening or even at night.

In support of the Endangered Species Act, the DOA identified areas where threatened or endangered plant and animal species may be adversely affected by pesticides. Insecticides used in areas known to be occupied by threatened or endangered species can be restricted or banned. Bruner (17) surveyed the proposed site for both birds and feral mammals. No waterbirds were found on the property. Several endemic and migratory birds were observed. Although the endangered Hawaiian Hoary Bat was not observed, Bruner stated that it is known to occur in West Hawaii. EIC is unaware of any bird kills associated with the use of chlorpyrifos or carbaryl on Hawaii's golf courses. However, applicators should be made aware of their potential for doing so.

B. Environmental Management Factors Considered

The DOH listed eight conditions applicable to the development of all golf courses including the proposed Kealakekua Bay Club Golf Course. The final condition was the establishment of a maintenance plan and program which addresses "Best Management Practices (BMP)" for the "utilization of fertilizers and biocides as well as the irrigation schedule." This maintenance plan is to be reviewed by the Department of Health prior to implementation.

The DOH is the agency designated by the Governor as the State Water Quality Management Agency. As such, the DOH is responsible for developing water quality standards, monitoring water quality and protecting the State's water resources. Under this broad mandate, the DOH developed the State's Nonpoint Source Water Pollution Management Plan (18). The development of this plan was in accordance with Section 319(b) of the 1987 Water Quality Act which requires that each state submit a management plan to the Environmental Protection Agency which includes (a) best management practices and measures which reduce nonpoint source pollution impacting state water, and (b) identification of programs to be used to achieve the implementation of the best management practices identified.

Best management practices (BMP's) are methods, measures, or practices which are used to prevent or reduce the pollution of water. They may be structural or nonstructural. Structural BMP's involve construction of facilities or measures which reduce or prevent erosion and transport of pollutants such as fertilizers and biocides. Nonstructural BMP's involve the installation of vegetative controls or the use of land management to prevent or mitigate circumstances which produce runoff or groundwater contamination. Maximum effectiveness is achieved by combining various BMP's. The selection of BMP's is influenced by the land use,

the condition of the resource, climatic conditions and the practicality and feasibility of the proposed installations.

A number of federal, state, county and private agencies and organizations are available to help administer the state's Nonpoint Source Water Pollution Management Plan. These include: the Soil Conservation Service, the US Geological Survey (Water Resources Division), the State of Hawaii Department of Health (Environmental Management Division), State of Hawaii Department of Land and Natural Resources (Divisions of Aquatic Resources, Forestry and Wildlife, Land Management, Water and Land Development), College of Tropical Agriculture and Human Resources, and county Soil and Water Conservation Districts.

EIC conducted a site visit to the proposed Kealakekua Bay Club Golf Course on June 30, 1990. Each of the 60 BMP's identified by the Department of Health in Hawaii's Nonpoint Source Water Pollution Management Plan were evaluated as they relate to this site. EIC's recommendations are based on the site visit and our knowledge of pest management, fertilizer and pesticide use practices and the environmental fate of fertilizers and pesticides. EIC believes that the following BMP's are applicable to the proposed Kealakekua Bay Club Golf Course.

1. Critical area planting

Critical area planting is the practice of planting vegetation such as trees, shrubs, vines, grasses or legumes on highly erodible or critically eroding areas. This practice is used to stabilize the soil, reduce damage from sediment and runoff to downstream areas, improve wildlife habitat and enhance natural beauty. Critical area planting must be an essential component of this

golf course in order to help prevent soil, fertilizer and biocide movement from the site to Kealakekua Bay.

2. Diversion, accumulation and evaporation

This process addresses the use of washdown water, spills and rinsates on the hardstand so that they can be used again as makeup water. (See related discussion in "Pest Control Facility".)

3. Drift control agents

Drift control agents are substances that when added to a biocide mixture in a spray tank reduce drift from the target area. They stabilize sprays by increasing droplet size or reducing evaporation of chemicals while increasing coverage and adherence on the target area. They are most often used in areas subject to windy conditions. (The use of shrouded boom applicators should also be considered.)

4. Drip irrigation

Drip irrigation serves to distribute water in an even pattern. Avoiding excess water reduces leaching of nutrients and biocides. Drip irrigation will be especially important in those areas with the least amount of rainfall.

5. Irrigation systems

An irrigation system is a water application system that includes all necessary water control structures for the efficient distribution and application of irrigation water. Each irrigation system is designed as part of an overall plan for conservation consistent with land use. It includes, surface flow, sprinkler systems, and drip or trickle application through tubes. Computerized

irrigation systems can measure ET rates in critical areas and adjust irrigation timing and rates automatically.

6. Irrigation water management

Irrigation water management is the practice of determining and controlling the rate, amount and timing of irrigation water application to soils to supply plant water needs in a planned and efficient manner. Irrigation water management is used to control soil moisture; to promote the desired plant response; to minimize soil erosion and loss of plant nutrients; to control undesirable water loss; and to protect water quality.

Irrigation practices can have a large influence on the movement of water soluble chemicals in soils. If excessive irrigation water is applied soon after application of soluble nitrogen sources, the chance of runoff or leaching of nitrogen below the root zone is increased. Because of the high cost of irrigation water, there is little incentive to over-water golf courses.

Watering should promote deep root growth. The amount of irrigation needed to establish and maintain turf will depend on the variety of turf selected, temperature, relative humidity, wind speed and the amount of water available in the soil. Soils store different amounts of water depending on their texture; sands hold less water, clays hold more. Well watered turf in Hawaii requires 0.1 to 0.3 inches of water per day. Watering should be adjusted to the needs of the plants. On slopes or in other hard-to-wet sites a short irrigation to wet the thatch followed 20 minutes later by the main watering will increase penetration of water to the root zone. Watering should be conducted early in the morning. As temperatures rise, leaf blades dry and leaf diseases are reduced. Early morning watering also reduces evaporation loses and conserves water.

7. Mulching

Mulching involves the application of plant residues or other suitable materials not produced on the site to the soil surface. Mulching is used to conserve moisture, prevent surface compaction, reduce runoff and erosion, control weeds and help establish plant cover. Hydro-mulching is appropriate to critical areas particularly during turfgrass establishment. Hydro-mulchers can plant, seed, sprig, fertilize, spray and much simultaneously.

8. Pond

A pond is a water impoundment made by constructing a dam or embankment or by excavating a pit. They are constructed to provide water for fish, wildlife, recreation and other related uses. Ponds can be fed by diversions which channel excess water from low lying areas subject to temporary flooding.

9. Underground outlet

An underground outlet is a conduit installed beneath the surface of the ground to collect surface water and convey it to a suitable outlet such as a pond. It is used to dispose of excess water and applies to areas where excess surface water needs to be disposed, e.g., low lying areas.

10. Sedimentation basin

A sedimentation basin is a water impoundment used to collect sediments that result from runoff. The use of such basins during construction and turf establishment will reduce the possibility of movement of runoff to Kealakekua Bay.

11. Waste management system

Waste management systems are used to manage waste in a manner which prevents or minimizes degradation of air, soil, and water resources and protects public health and safety.

Such systems are designed to preclude discharge or pollutants to surface or ground water and, to the fullest practicable extent, recycle waste through soil and plants. A waste management system is feasible when waste generated has all the elements necessary to make a complete system and when soil, water and plant resources are available to treat and recycle the waste.

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Appendix 1

These pesticide information sheets were prepared using information from the USDA Soil Conservation Service (7), U.S. Environmental Protection Agency documents and the Agrochemicals Handbook (2nd Ed.).

Soil half lives vary by a factor of 3 or more depending upon soil moisture, temperature, oxygen status, soil microbial population and other factors. The numbers given are only relative indicators of persistence. "E" indicates that the value is estimated and is probably in error by a factor of 2 or more. "G" indicates that the value is a guess and could be off by a factor of 3 or more.

Soil sorption index is measured by Koc values. Higher Koc values indicates a stronger attachment to soil organic matter and less tendency to move with water except with eroded materials. The "E" indicates a probable error of 3 to 5 times while "G" indicates a probable error of 10-100 times.

Surface loss potential indicates the tendency of the pesticide to move with sediment in runoff. Leaching potential indicates the tendency of a pesticide to move in solution with water and leach below the root zone into ground water. Both of these movement potentials need to be used in conjunction with the individual soil ranking in relation to surface runoff and leaching properties. The Waiaha and Kainaliu series soils on the proposed site would be classified as large for leaching potential. Thus, pesticides with LARGE leaching loss potentials would have large overall pesticides losses through leaching loss.

PESTICIDE INFORMATION SHEETS

Pesticide common name: Bensulide
Trade names: Prefar, Betasan, Betamec
Manufacturers: ICI Americas, Stauffer
Use: Herbicide
Formulation types: Emulsifiable concentrate, granules
Application methods: Soil spray: watered in or soil incorp.
LD-50 mg/kg (rat, oral): 770
Toxicity to wildlife: Moderate to fish
Water solubility (mg/L): 25
Soil half-life (days): 60
Soil sorption index (Koc): 10,000
Surface loss potential: Large
Leaching potential: Small

Pesticide common name: Dicamba
Trade name(s): Banvel, Trooper
Manufacturer: Sandoz
Use: Herbicide
Formulation types: Aqueous concentrate
Application methods: Soil surface spray, rope wick, target plant foliar spray
LD-50 mg/kg (rat, oral): 1707
Toxicity to wildlife: Low to birds, moderate to fish
Water solubility (mg/L): 6500
Soil half-life (days): 14
Soil sorption index (Koc): 2
Surface loss potential: Small
Leaching potential: Large

Pesticide common name: Glyphosate
Trade names: Roundup, Rodeo
Manufacturer: Monsanto
Use: Herbicide (terrestrial and aquatic)
Formulation type: Aqueous concentrate
Application methods: Target plant foliar spray, wiper application
LD-50 mg/kg (rat, oral): 5600
Toxicity to wildlife: Low to birds and fish
Water solubility (mg/L): 12,000
Soil half-life (days): 30
Soil sorption index (Koc): 10,000 E
Surface loss potential: Large
Leaching potential: Small

Pesticide common name: Mecoprop (MCPP)
Trade names: 2 Plus (MCPP ad 2,4-D amine), Chipco
Manufacturers: Fermenta, Rhone-Poulenc
Use: Herbicide
Formulation type: Aqueous solution
Application method: Target weed foliar spray
LD-50 mg?kg (rat, oral): 930
Toxicity to wildlife: low to fish
Water solubility (mg/L): 620
Soil half-life (days): 21
Soil sorption index (Koc): 3
Surface loss potential: Small
Leaching potential: Large

Pesticide common name: Metribuzin
Trade names: Sencor, Lexone
Manufacturers: Mobay, DuPont
Use: Herbicide
Formulation types: Dispersable liquid or granules
Application methods: soil surface, chemigation
LD-50 mg/kg (rat, oral): 2200
Toxicity to wildlife: Moderate for birds and fish
Water solubility (mg/L): 1220
Soil half-life (days): 30
Soil sorption index (Koc): 41
Surface loss potential: Medium
Leaching potential: Large

Pesticide common name: MSMA (monosodium methanearsonate)
Trade names: Weed-Hoe, Calar
Manufacturers: Vineland, Fermenta
Use: Herbicide
Formulation type: Aqueous concentrate
Application method: Target weed foliar spray
LD-50 mg/kg (rat, oral): 900
Toxicity to wildlife: Low to fish
Water solubility (mg/L): 1,400,000
Soil half-life (day): 100
Soil sorption index (Koc): 10,000 E
Surface loss potential: Large
Leaching potential: Small

Pesticide common name: Carbaryl
Trade name: Sevin
Manufacturer: Rhone Poulenc
Use: Insecticide
Formulation types: Wettable powder, oil suspensions
Application methods: Crop foliar spray, chemigation
LD-50 mg/kg (rat, oral): 850
Toxicity to wildlife: low to birds, moderate to fish
Water solubility (mg/L): 120
Soil half-life (days): 7
Soil sorption index (Koc): 229
Surface loss potential: Medium
Leaching potential: Small

Pesticide common name: Chlorpyrifos
Trade name: Lorsban
Manufacturer: DOW-Elanco
Use: Insecticide
Formulation types: Emulsifiable concentrate, wettable powder, granules
Application methods: Soil incorporation, crop foliar spray, chemigation
LD-50 mg/kg (rat, oral): 135-163
Toxicity to wildlife: High to birds and fish
Water solubility (mg/L): 2
Soil half-life (days): 30-60
Soil sorption index (Koc): 6070
Surface loss potential Large
Leaching potential: Small

Pesticide common name: Ethoprop
Trade neame: Mocap
Manufacturer: Rhone-Poulenc
Use: Insecticide, nematicide
Formulation types: Emulsifiable concentrate, granules
Application methods: Watered in or soil incorporated
LD-50 mg/kg (rat, oral): 62
Toxicity to wildlife: High to birds, moderate to fish
Water solubility (mg/L): 700
Soil half-life (days): 30
Soil sorption index (Koc): 120
Surface loss potential: Medium
Leaching potential: Large

Pesticide common name: Trichlorfon
Trade name: Dylox
Manufacturer: Mobay
Use: Insecticide
Formulation type: Soluble powder
Application methods: Crop foliar spray
LD-50 mg/kg (rat, oral): 560
Toxicity to wildlife: High for birds and fish
Water solubility (mg/L): 154,000
Soil half-life (days): 27
Soil sorption index (Koc): 2
Surface loss potential: Small
Leaching potential: Large

Pesticide common name: Chlorothalonil
Trade names: Bravo, Daconil
Manufacturer: Fermenta
Use: Fungicide
Formulation types: Wettable powder, dispersible granules and liquid
Application methods: Crop foliar spray, chemigation
LD-50 mg/kg (rat, oral): >10,000
Toxicity to wildlife: Low to birds, high for fish
Water solubility (mg/L): 0.6
Soil half-life (days): 20-60
Soil sorption index (Koc): 1380
Surface loss potential: Large
Leaching potential: Small

Appendix 2

ENVIRONMENTAL FATE, WILDLIFE AND AQUATIC STUDIES REQUIRED FOR PESTICIDE REGISTRATION

The data generated by environmental fate studies are used to: assess the toxicity to man through exposure of humans to pesticide residues remaining after application, either upon reentering treated areas or from consuming inadvertently-contaminated food; assess the presence of widely distributed and persistent pesticides in the environment which may result in loss of usable land, surface water, ground water, and wildlife resources; and, assess the potential environmental exposure of other nontarget organisms, such as fish and wildlife, to pesticides. Additionally, this data requirement is to help estimate expected environmental concentrations of pesticides in specific habitats where threatened or endangered species or other wildlife populations at risk are found.

Degradation studies*
Mobility studies***
Accumulation studies
Subchronic studies
Teratogenicity and Reproduction studies
Hazard to humans and domestic animals
Mutagenicity studies
Reentry Protection
Hazard to nontarget organisms****
Metabolism studies**
Dissipation studies
Acute studies
Chronic studies
Metabolism studies
Spray drift evaluation
Product performance

*hydrolysis, photodegradation in soil, air and water
**aerobic and anaerobic soil and aquatic studies
***leaching, absorption, desorption
****toxicity, reproduction

STATE OF HAWAII
DEPARTMENT OF HEALTH

April, 1990 (Version 3)

EIGHT (8) CONDITIONS APPLICABLE TO THIS NEW GOLF COURSE DEVELOPMENT

1. The owner/developer and all subsequent owners shall establish a groundwater monitoring plan and system which shall be presented to the State Department of Health for its approval. The groundwater monitoring plan and system shall minimally describe the following components:

   a. A monitoring system tailored to fit site conditions and circumstances. The system shall include, and not be limited to, the use of monitoring wells, lysimeters and vadose zone monitoring technologies. If monitoring wells are used, the monitoring wells shall generally extend 10 to 15 feet below the water table.

   b. A routine groundwater monitoring schedule of at least once every six (6) months and more frequently, as required by the State Department of Health, in the event that the monitoring data indicates a need for more frequent monitoring.

   c. A list of compounds which shall be tested for as agreed to by the State Department of Health. This list may include, but not be limited to the following: total dissolved solids; chlorides; PH; nitrogen; phosphorus; or any other compounds associated with fertilizers, biocides or effluent irrigation.

2. Baseline groundwater/vadose zone water data shall be established as described in this paragraph. Once the monitoring system and list of compounds to be monitored for have been determined and approved by the State Department of Health, the owner/developer shall contract with an independent third-party professional (approved by the State Department of Health) to establish the baseline groundwater/vadose zone water quality and report the findings to the State Department of Health. Testing of the analyses of the groundwater shall be done by a certified laboratory.

3. If the data from the monitoring system indicate the presence of the measured compound and/or the increased level of such compound, the State Department of Health can require the owner/developer or subsequent owner to take immediate mitigating action to stop the cause of the contamination. Subsequently, the developer/owner or subsequent owner shall mitigate any adverse effects caused by the contamination.

4. Owner/developer shall provide sewage disposal by means of connection to the public sewer system; or by means of a wastewater treatment works providing treatment to a secondary level with chlorination. Effluent from this wastewater treatment works may be used for golf course irrigation, subject to Condition #3. The entire system shall be approved by the State Department of Health in conformance with Administrative Rules Title 11, Chapter 62, Wastewater Treatment Systems, effective December 10, 1988.

5. If a wastewater treatment works with effluent reuse becomes the choice of wastewater disposal, then the owner/developer and all subsequent owners shall develop and adhere to a Wastewater Reuse Plan which shall address as a minimum, the following items:

   a. Management Responsibility. The managers of the irrigation system using reclaiming wastewater shall be aware of the possible hazards and shall evaluate their system for public health, safety, and efficiency. They must recognize that contact with the reclaimed wastewater from treated domestic sewage poses potential exposure to pathogenic organisms which commonly cause infections diseases (bacteria, viruses, protozoa, and helminths or worms).

   b. General Recommendations

      1) Irrigated areas should be no closer than 500 feet from potable water wells and reservoirs.

      2) Irrigated areas should be no closer than 200 feet from any private residence.

      3) Application rates should be controlled to minimize ponding. Excess irrigation tailwater in the reclaimed wastewater irrigation area shall be contained and properly disposed. An assessment should be made of the acceptable time and rate of application based on factors such as type of vegetation, soil, topography, climate and seasonal variations.

      4) Effluent holding/mixing ponds shall be designed to prevent the infiltration of the wastewater into the subsurface. The holding/mixing ponds shall be made impervious.

      5) Irrigation shall be scheduled such that the public is not in the vicinity and the soil is sufficiently dry to accept the irrigation water.

      6) Permanent fencing or barriers shall be erected around polishing or holding ponds to prevent public entry or stray feral and tame animals from gaining access to the ponds.

7) Adequate irrigation records shall be maintained. Records should include dates when the fields are irrigated, rate of application, total application and climatic conditions. Records should also include any operational problems, diversions to emergency storage or safe disposal and corrective or preventive action taken.

8) The holding/mixing ponds shall be periodically monitored for the purpose of detecting leakage into the subsurface. If leakage is detected, corrective action shall be immediately taken.

c. Adequate Notice. Appropriate means of notification shall be provided to inform the employees and public that reclaimed wastewater is being used for irrigation on the site.

1) Posting of conspicuous signs with sufficient letter size for clear visibility with proper wording should be distributed around the use areas.

2) Signs shall be securely fastened. Periodic surveillance shall be conducted to assure permanent posting at all times. Immediate replacements shall be made when necessitated by deterioration, vandalism or misuse.

d. Adequate Employee Education. Employees or users should be cautioned and warned of the potential health hazards associated with the ingestion of reclaimed wastewater being used at the site.

1) Employees should be warned that the ingestion of reclaimed wastewater is unsafe.

2) Employees should be protected from direct contact of the reclaimed wastewater. If necessary, protective clothing should be provided.

3) Employees should be informed of the following:

- The irrigation water is unsafe for drinking or washing.
- Avoid contact of the water or soil with any open cuts or wounds.
- Avoid touching the mouth, nose, ear or eyes with soiled hands, clothes or any other contaminated objects.
- Be aware that inanimate objects such as clothes or tools can transport pathogenic organisms.
- Always wear shoes or boots to protect feet from the pathogenic organisms in the soil or irrigation water.

6. Releases from underground storage tanks (USTs) used to store petroleum products for fueling golf carts, maintenance vehicles, and emergency power generators pose potential risks to groundwater.

Should the owner/developer/operator plan to install USTs that contain petroleum or other regulated substances, the owner/developer/operator must comply with the federal UST technical and financial responsibility requirements set forth in Title 40 of the Code of Federal Regulations Part 280. These federal rules require, among other things, owners and operators of USTs to meet specific requirements in the detection, release response and corrective action. Also, the owner/developer/operator must comply with all State UST rules and regulations pursuant to Chapter 342-L 'Underground Storage Tanks' of the Hawaii Revised Statutes.

In consideration of the above-mentioned remarks, the Department of Health recommends that the owner/developer/operator implement facility plan alternatives that exclude the installation and operation of UST systems (e.g., the preferential use of electric golf carts, use of above-ground storage of fuel oil for emergency power generators, etc.), or, if USTs are utilized, that secondary containment be considered.

7. Buildings designated to house the fertilizer and biocides shall be bermed to a height sufficient to contain a catastrophic leak of all fluid containers. It is also recommended that the floor of this room be made waterproof so that all leaks can be contained within the structure for cleanup.

8. A golf course maintenance plan and program will be established based on "Best Management Practices (BMP)" in regards to utilization of fertilizers and biocides as well as the irrigation schedule. BMP's will be revised as an ongoing measure. The golf course maintenance plan will be reviewed by the State Department of Health prior to implementation.

If there are any questions regarding the eight (8) conditions mentioned here, please contact Mr. James K. Ikeda at 543-8304. We ask you cooperation in the protection of Hawaii's valuable groundwater resource.

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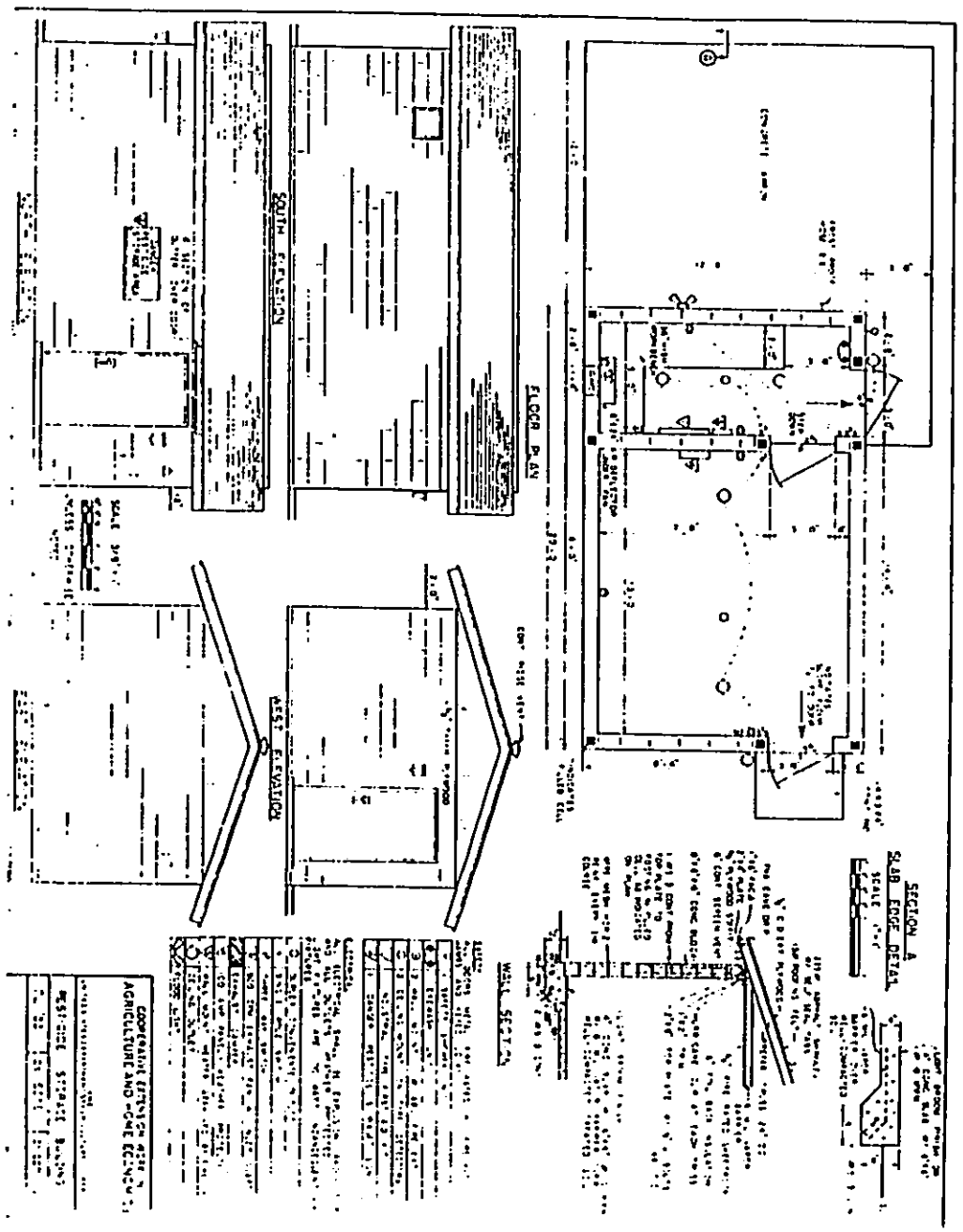

Appendix 5 PESTICIDE APPLICATOR TRAINING FOR TURFGRASS MANAGERS

Course Outline

I. Laws and Regulations

A. State and federal laws and regulations
Emphasis on core and category specific pesticide applicator training requirements. Overview of pesticide laws and regulations. Discussion of "direct supervision".

B. Labels and labeling
Discussion of each section of the label and what constitutes labeling. Importance of the label as an enforcement tool.

C. Liability and record keeping
Discussion of applicator and supervisor liability and the need to keep accurate records of all applications. How to fill out DOA forms.

II. Pest Identification and Control

A. Common weeds, diseases and insects
Discussion of proper identification, life cycles and importance of timing control measures. Should involve a field trip or similar lab experience.

B. Pesticides
Discussion of classification, chemical characteristics, compatibility, formulations and proper selection.

C. Pest management practices
Discussion of how to minimize the need for pesticides with an emphasis on importance of early problem detection. Discussion of those practices identified by the Hawaii Department of Health as being appropriate to the development and maintenance of golf courses.

III. Application

A. Methods of application
Emphasis on equipment (small boom sprays and back pack applicators) and techniques (spot sprays, broadcast application) appropriate to golf courses.

B. Selection and care of equipment
Discussion of application equipment maintenance and selection of pumps, hoses and nozzles.

C. Determining how much chemical to use
How to determine areas, particularly irregularly shaped areas such as greens. Interpretation of use directions on labels. Working with ratios.

D. Calibration
Hands on methods of calibration. Importance of routine calibration. Recognizing and correcting problems related to poor calibration (e.g., worn nozzles).

IV. Environmental Considerations

A. Chemical leaching and run-off
Discussion of factors (climate, soil and chemical) that contribute to leaching and run-off. How to mitigate potential problems.

B. Drift and drift control
Discussion of factors (weather, chemical, application method) which contribute to drift. Symptoms of drift and how to mitigate impacts.

C. Protecting non-target organisms
Discussion of importance of selecting pesticides with low potential for negatively impacting the environment and humans. Discussion of application methods, timing, environmental considerations, barriers, Endangered Species Act.

V. Using and Handling Chemicals

A. Personal protective clothing and equipment
Demonstration of what the "well dressed applicator" should be wearing. Considerations in selecting safety equipment. Care and maintenance of clothing and safety equipment.

B. Transportation, storage and disposal
How to transport pesticides to minimize accidental spills. Storage and product management to avoid future problems. Reportable quantities. Disposal options.

C. Spills and fires
Procedures for handling spills. Community Right to Know laws. Planning for a fire.

D. Safe handling (mixing and loading)
Discussion of how to work with concentrates without exposing yourself or others. Emphasis on procedures and protective clothing.

E. First aid
Contents of a first aid kit. Recognition and management of pesticide poisoning.

Appendix 7:

FULL ARCHAEOLOGICAL RECONNAISSANCE SURVEY, KEALAKEKUA RANCH MAKAI LAND SUBDIVISION

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

Report 244-100186

FULL ARCHAEOLOGICAL RECONNAISSANCE SURVEY
KEALAKEKUA RANCH MAKAI LAND SUBDIVISION

Land of Kealakekua
South Kona, Island of Hawaii
(TMK:3-8-2-02:2,33)

by

Michael W. Kaschko, M.A.
Supervisory Archaeologist

and

Paul H. Rosendahl, Ph.D.
Principal Archaeologist

Prepared for

Kealakekua Ranch, Ltd.
P.O. Box 399
Captain Cook, Hawaii 96704

April 1987

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

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INTRODUCTION

BACKGROUND

At the request of Mr. Keola Childs of Kealakekua Ranch, Ltd., Paul H. Rosendahl, Ph.D., Inc. (PHRI) conducted a full archaeological reconnaissance survey of the Kealakekua Ranch Makai Land Subdivision project area situated in the Land of Kealakekua, South Kona District, Island of Hawaii. This document is the final report on the findings of the reconnaissance survey in the subject parcel. PHRI had previously completed a limited (one day) preliminary reconnaissance survey (field inspection) of this parcel (Rosendahl 1986), and the results of that examination indicated the necessity of performing the current work.

Findings of the preliminary reconnaissance survey were discussed with Virginia Goldstein--staff planner and historic sites specialist in the Hawaii County Planning Department--who determined that a full reconnaissance survey of the entire project area would most likely be required by the Hawaii County Planning Department. Although the completed preliminary reconnaissance work was sufficient for an Environmental Impact Assessment (EIA), a full reconnaissance survey was necessary for any subsequent Environmental Impact Statement (EIS) prepared in conjunction with a Special Management Area (SMA) or Rezoning application.

Field work for the full reconnaissance survey was carried out during July 14-15 and August 5-23, 1986, by a crew of five to seven persons under the direction of PHRI Supervisory Archaeologist Michael W. Kaschko. PHRI Supervisory Archaeologist Alan T. Walker directed the first two days of field work (July 14-15). Approximately 88 man-days of labor were expended in the field survey.

SCOPE OF WORK

The basic purpose of an archaeological reconnaissance survey is to identify--to discover and locate on available maps--sites or features of possible archaeological or historical significance. A reconnaissance survey is a pedestrian survey, extensive rather than intensive in scope, conducted to determine the presence or absence of surface remains within a specified project area. A reconnaissance survey indicates both the general nature and variety of archaeological remains present, and the general distribution and density of such remains. A reconnaissance survey permits a preliminary evaluation of cultural resources, and facilitates formulation of realistic recommendations and estimates for such further archaeological work as might be necessary or appropriate. Such further work could include intensive survey--detailed recording of sites and features, and selected test excavations; and possibly subsequent mitigation--data recovery research excavations, interpretive planning and development, monitoring, and/or preservation of sites and features with significant scientific research, interpretive, or cultural values.

The four principal objectives of the full reconnaissance survey of the Kealakekua Ranch Makai Land Subdivision project area were:

1. To identify (find and locate) all sites and site complexes present within the project area;

2. To evaluate the potential significance of all identified archaeological remains;

3. To determine the possible impacts of any proposed development upon the identified remains; and

4. To define the scope of any subsequent archaeological work that might be necessary or appropriate.

Ms. Goldstein emphasized that the archaeological survey should be carried out in accordance with the minimum requirements for a reconnaissance level survey, as recommended by the Society for Hawaiian Archaeology (SHA). These standards are currently being used by the Hawaii County Planning Department as guidelines for the review and evaluation of archaeological reconnaissance survey reports submitted in conjunction with various development permit applications.

Based on the preliminary reconnaissance survey findings and on consultations with Ms. Goldstein and with Dr. Ross Cordy--staff archaeologist with the Hawaii State Department of Land and Natural Resources (State Historic Preservation Office)--the following specific tasks were determined to constitute an adequate scope of work for the full archaeological reconnaissance survey:

1. Prepare a detailed map, based on existing aerial photographs and subsequent field work, of the relatively unaltered Kona Field System section;

2. Conduct 100% coverage variable intensity reconnaissance survey to identify all sites and site complexes present within the approximately 195 acre project area;

3. Complete reconnaissance level recording (written and graphic) of all identified sites and site complexes, with recording to recommended SHA standards;

4. Conduct limited historical documentary and local informant research focused on historic period land use, especially the period of pineapple cultivation; and

5. Analyze field and historical data, and prepare appropriate reports.

The possible significance of archaeological resources identified during the reconnaissance survey was to be evaluated in terms of potential scientific research, interpretive, and/or cultural values.

PROJECT AREA DESCRIPTION

The Kealakekua Ranch Makai Land Subdivision project area (including Urban District and Conservation District portions) consists of c. 195 ac located in the Land (ahupua'a) of Kealakekua, South Kona District, Island of Hawaii (TMK:3-8-2-02:2,33) (Figure 1). It is situated immediately above the steep cliff known as Pali Kapu-o-Keoua, overlooking Kealakekua Bay, and it lies seaward of the lower Government Main Road to Napoopoo. Adjacent and to the north is the Land of Kaawaloa, while to the south is the Land of Kiloa (both boundaries marked by old stone walls), and to the west is the boundary with Kealakekua Bay State Historical Park. The seaward part of the property includes (north to south) the "Awahua" and the "cotton field" (called "paddocks"), defined by long, historic stone walls, while the inland portion is composed of the "cow," "Sonoda," and "ohsi" paddocks.

Most of the project area has been used for more than 100 years primarily for cattle grazing, and some of it has been modified in recent times by bulldozing of vegetation to provide improved pasture. The sort inland portion (adjacent to the lower Government Main Road) has been affected more extensively by alterations related to residential use, ranching activities, and small-scale intensive agricultural development (primarily coffee). In general, the inland half of the property (above the Old Pineapple Road) seems definitely to have been subject to more historic and recent disturbances than has the seaward area. The terrain varies from a moderate to fairly steep slope, with a generally rolling or undulating and often rocky surface. Overall, the northern half of the parcel (especially the northeastern corner area where most of the kukui groves are located) exhibits a naturally more stony surface than does the more southerly portion, which appears to have a better-developed soil mantle. The soils in the survey area are classified primarily as Kainaliu series (very stony, silty clay loam) and are well-drained and fairly well-suited for agriculture (Sato et al. 1973:22).

At the time of the field survey, vegetation cover ranged from moderate to very dense and was composed primarily of a thick ground cover of introduced grasses and weeds, with exotic low trees and shrubs such as koa-haole (Leucaena glauca [L.] Benth.), and lantana (Lantana camara L.). Also present were small groves of the introduced monkeypod (Samanea saman [Jacq.] Merr.), Pride-of-India (Melia azedarach L.), and the native kukui (Aleurites moluccana [L.] Willd.). Scattered specimens of economic plants, including papaya (Carica sp.), mango (Mangifera sp.), breadfruit (Artocarpus sp.), coffee (Coffea sp.), red chili pepper (Capsicum sp.), guava (Psidium guajava L.), and noni (Morinda citrifolia) were noted, especially in the more inland sections of the survey area. Other less abundant species observed were 'opiuma (Pithecellobium dulce [Roxb.] Benth.), kiawe (Prosopis pallida [Humb. and Bonpl. ex Willd.] HBK.), Christmas-berry (Schinus terebinthifolius Raddi), octopus tree (Brassaia actinophylla Endl.), hau (Hibiscus tiliaceus L.), and an unidentified fern. Sherwood Greenwell (pers. comm.) identified the dominant introduced grasses in the area as Guinea grass (both Colonial Guinea and Common Guinea, Panicum spp.), kikuyu (P. clandestinum Hochst.), panic grass (P. antidotale Retz.), and buffalo grass (Stenotaphrum secundatum [Walt.] Ktze.).

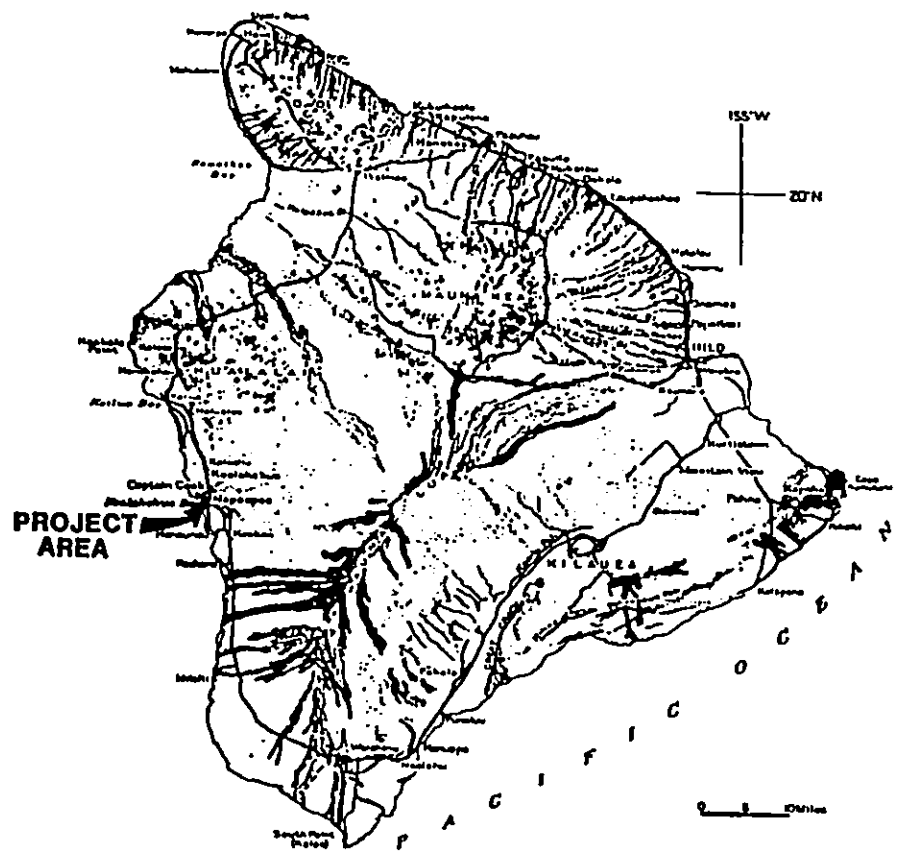


Figure 1. PROJECT LOCATION MAP

Archaeological Reconnaissance Survey
Kealakekua Ranch Makai Land Subdivision
Land of Kealakekua, South Kona
Island of Hawaii (TMK:3-8-2-02:2,33)

PHRI Project 86-244 September 1986

(Map taken from Macdonald and Abbott 1970:288.)

Clearly, elevation and rainfall are responsible for some variation in vegetation cover found within the property. Seaward of the Old Pineapple Road (below 825 to 940 ft elevation), vegetation is generally still quite thick, but it is somewhat less lush than that in the inland zone, and it has a more restricted range of species. The densest vegetation is found in the southern half of the project area (especially the southeastern corner), perhaps due to the heavier soil cover and/or the lack of recent cattle grazing.

Kealakekua Bay area's historical significance as the site of the landing and death of Captain James Cook in 1779 is well known. This location is also the area in which the first lengthy contacts occurred between Europeans and native Hawaiians, and much information has been recorded on this subject (including the earliest substantial observations on intensive aboriginal agricultural practices). The majority of the survey area, excluding only the most inland section adjacent to the present paved road, is situated within the limits established for the Kealakekua Bay Historic District (HRHP Site No.50-10-47-7000), an important historical site complex area placed on the National Register of Historic Places in December 1974. The entire project area is also located within the southern part of the Kona Field System (HRHP Site No.50-10-37-6601), a large complex (about 3 by 18 miles in extent) of aboriginal Hawaiian dryland cultivation and habitation features declared eligible for inclusion on the National Register of Historic Places in January 1977. The specific project area is composed of a portion of Land Commission Award (LCA) 8452, Apana 9 (Royal Patents 3607 and 7533, Kealakekua Ahupua'a), and a small section of LCA 8452, Apana 10 (Royal Patent 7532, Kaawaloa Ahupua'a), both awarded to Chiefess Ane Keohokalole, mother of King Kalakaua and Queen Liliuokalani.

HISTORICAL SUMMARY

General histories of the Kealakekua Bay vicinity (Hommon 1986, Advisory Committee 1985, HRHP Site No.50-10-47-7000) and the larger Kona District region (Kelly 1983, Holland 1971, HRHP Site No.50-10-37-6601) have been reviewed elsewhere. Hommon (1986:9-11) summarized the history of the Kealakekua region by dividing it into several major periods: Pre-Contact, before 1779; Western Contact, early 1779; Early Post-Contact, 1779 to 1819; Middle Post-Contact, 1819 to 1848; Late Post-Contact, 1848 to 1929; and recent, 1929 to present. The discussion presented here is restricted to information relevant to the project area.

As the site of the landing and violent death of Captain James Cook in 1779, the historical significance of the area around Kealakekua Bay is well known. This area is also the place where the first lengthy contacts occurred between Europeans and native Hawaiians, and much cultural information was recorded in journals by Cook and his officers (Clarke, King, Ledyard, Samwell, and Ellis). One of the subjects of interest was the intensive agricultural practices employed by the Hawaiians in areas inland of the bay, and some of these observations almost certainly pertain

directly to the present study area. For example, Ledyard (1963:118-120) described a trip inland from the Napoopoo area, probably on a route near the south side of the project area. He observed the inland-seaward stone boundaries of the field system and saw cultivated sweet potatoes, patches of sugarcane and plantain trees, and breadfruit trees at a slightly higher elevation. A sketch of Kealakekua Bay done in 1779 (King 1784:1) shows five houses associated with more than a dozen rectangular, cultivated fields located within and/or immediately adjacent to the survey area and just inland of the steep bluff.

Archibald Menzies, a naturalist with Captain George Vancouver between 1792 and 1794, provides the most substantial description of the Kona Field System, from a trip behind Kealakekua Bay apparently following a route (Newman n.d.:127) very close to the north boundary of the survey area. Menzies (1920:77) observed breadfruit "plantations" also planted with sweet potatoes, and rows of cultivated wauke, taro, and sweet potatoes.

In 1823 Reverend William Ellis (1963) travelled through portions of the Kona Field System and described it as apparently being still in full cultivation, though he did not specifically examine the agricultural areas near Kealakekua Bay.

Before the time of the Great Mahele in 1848, the Hawaiian population in the Kealakekua region had significantly declined, and the village of Kekua was apparently nearly deserted (Hommon 1986:11). The entire ahupua'a of Kealakekua, including the study parcel, more than 10,000 ac in area, was awarded to Chiefess Ane Keohokalole (Land Commission Award 8452-Apana 9, Royal Patents 3607 and 7533), mother of King Kalakaua and Queen Liliuokalani (Office of the Commissioner 1929). She also claimed three, named house lots on the coastal flat adjacent to Hikiau Heiau (Foreign Testimony 3:574) and was awarded the whole of Kaawaloa Ahupua'a (LCA 8452-Apana 10).

After 1850, attempts at large-scale cattle ranching expanded rapidly in this area (Kelly 1983:78-81). It was probably during this period that the long-running stone walls found in the project area were constructed to help control livestock (Kelly 1983:75-76). Indeed, the first on-ground survey description of the Kealakekua award (Commission on Boundaries 1873) refers to at least the north boundary wall as being present at that time. Henry N. Greenwell acquired this property in 1881 (Sherwood Greenwell, pers. comm.).

"Manuel's house" (Manuel De Gouvia) is reported to be the first frame house in Kealakekua Ahupua'a (Sherwood Greenwell, pers. comm.) and is recorded as HRHP Site 7324. It appears on an 1891 government map (Registered Map No. 1281) and is also referenced in field notes from an 1884 survey (Registered Field Book No. 256). Clearly this structure is now something more than 100 years old.

As early as 1844 (Wyllie 1844:115), pineapples were said to "abound" in the Kealakekua area, and by 1890 (Whitney 1890:68), it was reported that "the pineapple crop is a heavy one, but there is no market for the

produce, or rather the market is a very limited one." Apparently no serious attempt was made to raise pineapples commercially on a large scale until 1905. In July of that year, the Captain Cook Coffee Company, Limited, was incorporated (dissolved 1935), and listed among its assets were "750 fully paid up shares of the capital stock of the Hala Canning Company (a Californian corporation) valued at $15,000" (Dissolved Corporation File). President of the new company was William W. Bruner of Kealakekua. The pineapple company operation that affected part of the study area appears to have been some manner of subsidiary of the Captain Cook Coffee Company.

"Hala Canning Co., pineapple cannery, Napoopoo" is first listed in an annual business directory (Polk-Husted) in the 1905-6 issue and last appears in 1911, but the 1910 and 1911 listings indicate "Captain Cook Coffee Co. Ltd. proprs." "Captain Cook Coffee Co. Ltd." is first listed in 1908, and from 1912 through 1914 it appears as follows:

> Captain Cook Coffee Co Ltd, L Macfarlane mngr, coffee plantation and gen store, office Kealakekua, cannery and pineapple plantation Napoopoo, Hind Rolph & Co Honolulu agts.

From 1915 onwards, no specific reference to pineapple is made. Although in 1912 it was observed that "the pineapple cannery at Napoopoo is prosperous" (Sheridan:245), apparently the pineapple did not do well enough and was eventually replaced by the emphasis on coffee (State Historic Preservation Office 1977:41).

The original pineapple cannery was located on the site of the present Sunset Coffee Company Mill (HRHP Site 7343). Within the area of the survey parcel are some remains of the pineapple roadway (Site T-44). Sherwood Greenwell (pers. comm., based on information from his father, Arthur L. Greenwell) also identified the pineapple loading platform or ramp where large freight wagons were loaded (Site T-26, Feature D), and the location of an old pineapple workers' house (Site T-37, Feature A). The actual limits of the area planted in pineapple are unclear, but it seems logical that cultivation would have taken place primarily on the inland side of the Old Pineapple Road.

PREVIOUS ARCHAEOLOGICAL WORK

Reinecke (1930) was the first to investigate the archaeological potential of this general region. In the vicinity of the study area, he commented on the disturbance caused by earlier cultivation of pineapple (1930:2), but did not record any specific sites.

Widespread archaeological remains have been reported previously within the Kealakekua Ranch project area. Most of the property lies within the area examined briefly in 1968 by Lloyd J. Soehren and T. Stell Newman as part of an inventory and evaluation study of archaeological remains present immediately above Kealakekua Bay, in the Lands of Kaawaloa and

Kealakekua (Soehren and Newman 1968). They utilized aerial photographs of the area to prepare a base map showing the more visible field unit boundaries which represent the extent of the Kona Field System remains, and subsequently carried out limited field work to check and verify this map. The results indicate that intact portions of the Kona Field System are preserved within most of the present survey parcel. About 15 discrete sites and site complexes were also identified and recorded within Kaawaloa and Kealakekua during this field work. Eight of these (Sites 201-208) are situated within the current project area (Soehren and Newman 1968:13-15). Using data produced by this work, Newman (1971, 1972) later discussed the nature of the Kona Field System compared to other prehistoric field system areas on the Island of Hawaii.

Newman (n.d.:123-137) summarized available information on the Kona Field System and developed four sub-zones on the basis of crop types. Prehistoric fields located in the project area are largely within the "Breadfruit/Sweet Potato/Wauke Zone" (n.d.:128), where the crops would be breadfruit trees with sweet potatos and wauke planted between them, and with sugarcane and ti planted on the field borders. The most inland part of the survey parcel may be within the "Sweet Potato/Dry Land Taro Zone."

Based in part on data produced by his 1968 work, Newman (1971, 1972) further discussed the nature of the Kona Field System compared to other prehistoric field system areas on the Island of Hawaii. Kirch (1985: 225-230) recently summarized the current state of archaeological knowledge on the prehistoric Kona Field System.

In December 1982, Soehren (1983a) inspected the Urban District (or inland portion) of the project area. Although not identifying any new sites, he did refer to his and Newman's 1968 study and to the three previously identified sites (201-203) present within this part of the area, as well as to the many visible traces of the Kona Field System. He commented on the surface modification resulting from vegetation grubbing done since 1948, which had caused considerable disturbance to some of the archaeological remains within the survey area. He also remarked on the limited historic-period disturbance occurring in the early 1900s (c. 1907-1910), when some of this area was planted in pineapple. Based on his inspection, Soehren recommended that further reconnaissance work be done in conjunction with proposed Conservation District boundary fenceline and subdivision access road construction. In February 1983, he conducted this recommended work (Soehren 1983b), but did not identify any new sites.

B.P. Bishop Museum (Clark 1983) carried out a reconnaissance survey of seven residential lots situated adjacent to the southeast corner portion of the project area. A total of 34 archaeological and historic features was recorded, including several which appeared to be structural remnants of the prehistoric Kona Field System.

The most recent prior archaeological work carried out within the present project area is a preliminary reconnaissance survey (field inspection) which covered primarily the Urban District zone, conducted on February 24, 1986, by PHRI (Rosendahl 1986). Approximately 35 sites were

identified during the preliminary survey. Based on the findings of that survey, it was determined that a full reconnaissance survey of the project area would be required by the Hawaii County Planning Department, and the present work is the result.

FIELD METHODS AND PROCEDURES

Before and after conducting the field work, records describing known archaeological sites in or near the survey area were obtained from the Historic Sites Section of the Department of Land and Natural Resources in Honolulu. In addition, documentary materials and other sources relevant to the history of the Kealakekua Bay region were consulted at the Hawaii State Archives, the State Survey Office, and the Hawaiian Collection in Hamilton Library at the University of Hawaii.

The complete ground reconnaissance survey of the project area was accomplished using a series of systematic pedestrian sweeps (total of 24 individual sweeps required). The distance between crew members varied from about 15.0 to 25.0 m, according to vegetation density and ground surface topography. After the survey sweeps were completed, the field crew divided into two teams to return to discovered sites and conduct detailed recording. Prominent long historic walls found in the study area were not recorded as specific sites or features. Locations and approximate extents of individual sites and site complexes were plotted directly onto a black-and-white aerial photograph of the area (approx. scale 1"=200', R.M. Towill, 10-6-68, Photo No.4743-6). Each site was described on standard PHRI survey record forms, and selected sites and features were plan-mapped to scale (tape and compass) and photographed in 35 mm black-and-white (PHRI Rolls No.505 thru 510). Each site, or the primary feature within a site complex, was marked with pink flagging tape and an aluminum tag bearing the site number, date, and PHRI project number (86-244). All identified sites were assigned individual temporary field numbers (T-). Two temporary numbers were subsequently eliminated (T-27 and T-35), as these locations were later determined, on the basis of closer examination, to be minor agricultural features similar to others in their immediate vicinity. Several surface artifacts were collected after their locations were noted on feature maps.

Descriptive information recorded on site and feature forms included: structural type, location references, horizontal and vertical dimensions, general condition, vegetation cover, adjacent topography and terrain, construction method and materials, surface midden and artifacts, probability of cultural deposit, and possible age and function.

In addition, a photogrammetric map (scale 1"=100') designed to emphasize agricultural field system features (especially the inland-seaward field boundaries) was prepared using the same aerial photograph mentioned above. This map was available during most of the field work and, when checked and verified on the ground, was found to be relatively accurate and complete (see Figure 2, at end).

Dense vegetation cover found over the project area (especially in the southern half to two-thirds) posed difficulties, with high grass sometimes severely reducing visibility. This situation presents a problem in assessing the survey results from these areas. It is possible at least a few structural features that might have merited designation as specific sites were missed because of vegetation density, particularly in areas where intact remains of the Kona Field System are present. At the same time, it is considered unlikely that any large significant sites were missed. In regard to limitations posed by the vegetation cover, it is interesting to note Soehren's (1983a:2) recent observation that "the pasture is now so thickly overgrown with guinea grass, ekoa and other vegetation that a thorough search for small features is impractical."

SURVEY FINDINGS

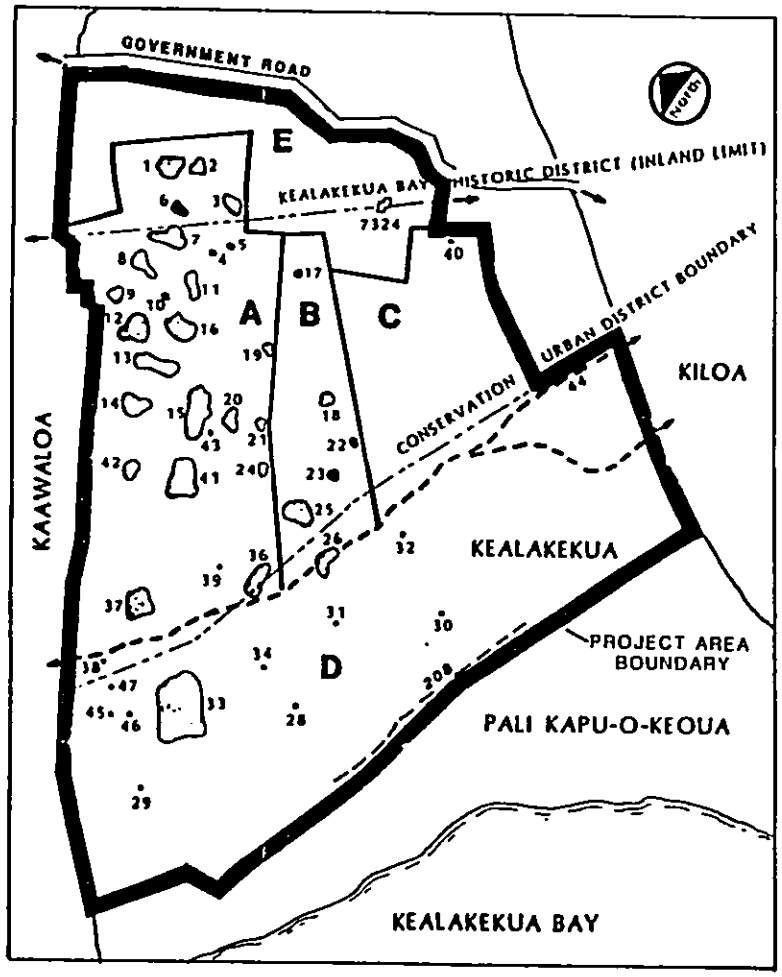
KONA FIELD SYSTEM

The results of photogrammetric mapping and of ground surveying demonstrate that intact remains of the Kona Field System are present in at least three-quarters of the project area (see Figure 2, at end), perhaps over most of the southeast corner portion. There is, however, considerable variation in the nature of physical remains visible in different parts of the remnant field system area. To facilitate descriptive summation of local environmental variation and to show the distribution of sites, the project area has been divided into five zones (Figure 3).

The northern part of the area inland of the Old Pineapple Road (Zone A) has a naturally very rocky surface and contains the highest density of recorded site areas. Many sites are found in irregular distribution as "islands" of structural remains left scattered through this portion of the project area, which has been partially altered by vegetation grubbing over the last 35 to 40 years. Most sites are associated with and are beneath the canopy of small- to moderate-sized clusters of kukui trees. Remnants of the prehistoric field system are fairly obvious in this area, but they have been partly disturbed by modern vegetation grubbing.

A relatively unaltered section of the Kona Field System, containing a range of typical associated structural features, was identified in the central part of the project area's inland portion (Zone B). This section has dimensions of c. 200 (N-S) by 500 m (E-W). Component structural features include the characteristic kuaiwi (raised embankments or low walls that form defining boundaries of the individual rectangular field units) and a range of internal features such as rubble wall alignments, stone mounds and piles, cleared areas, modified bedrock outcrops, and crude small terraces. The area immediately south (the southeastern portion of the survey parcel) (Zone C) exhibits few traces of the prehistoric field system elements that must once have been present. This area was reportedly the subject of heavy bulldozer clearing in about 1969 (Sherwood Greenwell, pers. comm.) and contains the thickest vegetation cover in the project area.

Most of the area seaward of the Old Pineapple Road (Zone D) contains evident field system remains, and in general this zone appears to have been less disturbed by historic and recent activities than have the inland areas. Agricultural features are still prominent, although the field boundaries are somewhat smaller or less massive compared to the more inland zones. The south portion of this area has a heavy cover of high grass, posing serious visibility problems.



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Old Pineapple Road and Area D Boundary

1 and 2 digit number = PHRI Temporary Site Number (1-)

3 digit number = Bishop Museum (B.P.) Site Number (50-HA-C23-)

4 digit number = Hawaii Register of Historic Places (HRHP) Site Number (50-10-37-)

FIGURE 3. Archaeological Zones and Site Location Map

DESIGNATED SITES

A total of 49 designated sites, many containing multiple component features, has been identified within the overall project area. They include Sites T-1 through T-47, identified during the present project (two sites, T-27 and T-35, voided); previously identified Sites 205, 208, and 209 (Soehren and Newman 1968); and a historic house site (Site 7324). The range of formal feature types encountered in designated sites and complexes includes walls (free-standing and retaining), terraces, raised stone platforms, walled shelters, enclosures, cave shelters, alignments, modified bedrock outcrops, and stone piles and mounds. While the function of many of these features appears to be agricultural, many also suggest residential habitation and burials. The overall condition of structural remains ranges from poor to very good, and integrity is generally fair to very good. Of the nine previously identified sites situated within the project area (Soehren and Newman 1968), all but two were tentatively relocated; Site 205 may possibly have been destroyed since its initial identification in 1968. Sites 208 and 209 were not specifically re-examined during the field work.

Sites identified within the project area can be briefly summarized in terms of general distribution as follows:

	Zone	No. of Sites
	A	26
	B	6
	C	1
	D	15
	E	1
Total	5	49

The relatively large number of sites recorded in Zone A is somewhat misleading, in that many are restricted to a likely agricultural function and apparently are component elements of the prehistoric Kona Field System.

Table 1 (at end) summarizes identified sites and their component features, with respect to formal type, tentative functional interpretation, and preliminary evaluation of site significance. Site locations are indicated on Figure 2 (at end). Detailed individual descriptions of recorded archaeological sites and features follow in the next section, Site Descriptions.

SITE DESCRIPTIONS

T-1 Terrace — Zone A

Site T-1, located in a grove of kukui trees, features one prominent terrace (5.0 m long, up to 90 cm high) situated in a rocky area (c. 40.0 by 20.0 m) among rough terraces formed by boulders stacked on natural bedrock outcrops. A large piece of coral and a waterworn basalt cobble are visible on the surface. Surface modification may have once been more obvious, as the site area appears to have been disturbed and collapsed by cattle.

This site is most likely an area of heavy surface rock modification related to prehistoric agricultural practices.

T-2 Terrace — Zone A

This large, sloping rubble terrace (12.0 m long, up to 130 cm high) is partially collapsed and appears to have a few stones set in alignment on its upper surface.

The structure apparently is a prehistoric agricultural feature. Although now separated by a dirt road, it is likely this site was originally connected to Site T-1.

T-3 Walls, Embankments, Terrace — Zone A

Two inland-seaward field boundaries (c. 3.0 m wide, 60 cm high) and a cross-slope terrace (20.0-25.0 m long, up to 90 cm high) are located in an area (c. 50.0 by 20.0 m) covered by a kukui grove. The field boundaries are composed primarily of stone rubble, while portions of the cross-slope terrace have a stacked boulder face with cobble fill behind it. Many waterworn basalt cobbles (at least 20) are present near the south end of the cross-slope terrace. Other surface rock modification is visible in the immediate area, and bulldozing disturbance is evident seaward of the site area.

These features appear to be agricultural in function and probably are remnants of the prehistoric Kona Field System.

T-4 Wall, Embankment — Zone A

This feature (c. 3.0 by 6.0 m, up to 50 cm high) is probably the remnant portion of a disturbed inland-seaward field boundary. It appears as a rubble mound composed of piled boulders and cobbles.

With an apparent agricultural function, the structure is very likely to have been a component part of the prehistoric field system.

T-5 Wall, Embankment — Zone A

Site T-5, an inland-seaward field boundary (3.0 to 6.0 m wide, up to 60 cm high), is constructed of stacked boulders with rubble fill, and it may have extended from Site T-3. About 10.0 to 15.0 m seaward of the site marker is a cross-slope terrace (40 cm high).

As a rather typical field boundary, this feature represents one of the fundamental structural elements of the prehistoric agricultural field system.

T-6 Terrace — Zone A

Site T-6, an L-shaped terrace (5.0 by 8.0 m, up to 140 cm high), is composed of a stacked boulder retaining wall with a level soil surface. Although partially collapsed, this structure is still one of the better-constructed agricultural terraces and apparently is prehistoric.

T-7 Complex — Zone A

This site complex (at least 11.0 by 13.0 m in area) is located in a grove of kukui trees and includes two specific features. Also in the site area are two, large inland-seaward rubble walls with three or four large boulder rubble terraces.

The complex appears to be primarily agricultural and could be associated with the prehistoric field system.

Feature A is a small, round, walled structure (2.9 by 3.4 m, up to 65 cm high) constructed on a steep slope. It is composed of stacked basalt boulders and rocks and has an interior soil floor.

The structure possibly is a planting enclosure with a specialized function, or it could have been used for storage.

Feature B, a much-disturbed terrace (c. 6.0 by 11.0 m, up to 110 cm high) with one definite corner and face, is composed of stacked boulders and rocks forming a retaining wall with rubble fill behind it. It is situated just inland of Feature A, and a bulldozed road is just behind it.

The function of this feature is difficult to determine because it has been disturbed, but it could possibly have been a habitation terrace or part of the prehistoric agricultural system.

T-8 Wall, Embankment, Terraces Zone A

This site area (25.0 by 15.0 m) includes an inland-seaward field boundary (1.0-2.0 m wide, up to 80 cm high) and two attached cross-slope terraces (3.0 m wide, up to 100 cm high) located in a grove of kukui trees. The stone construction is generally rubble, although the field boundary is stacked in some parts.

These features appear to be agricultural and probably are small components of the prehistoric field system.

T-9 Complex Zone A

This site complex, including two designated features, is situated in a kukui tree grove just north of a dirt road. The south and west portions of the site area also contain three or four rough terraces and two rubble mounds.

The complex appears to consist of a temporary habitation shelter (Feature A) and wall segment (Feature B) with some associated agricultural terraces, and it apparently is prehistoric (Figure 4).

Feature A, an overhang cave shelter (4.5 by 3.0 m interior area, up to 85 cm high), contains a possible small, low, terrace wall just inside the drip line. It has a soil floor with a natural deposit of kukui nut shells covering the entire surface, but with pig bones (skull, humerus, scapula, etc.) also present.

The feature is a possible prehistoric temporary shelter probably associated with agricultural activities in the area.

Feature B, a crudely built wall segment (2.0 by 1.1 m, up to 60 cm high), has been disturbed by a kukui tree. It is composed of stacked and piled basalt rocks and is located south of the Feature A cave shelter.

The function of this structure remains undetermined; the kukui has disturbed the wall so much that it is difficult to tell its original extent.

T-10 Modified Outcrop Zone A

Site T-10, a modified bedrock outcrop, has the appearance of a rough terrace (5.0 by 4.0 m, up to 80 cm high). It is constructed of piled boulder rubble and is located just inland of a bulldozed dirt road.

This feature appears to be agricultural and is probably a component of the prehistoric field system.

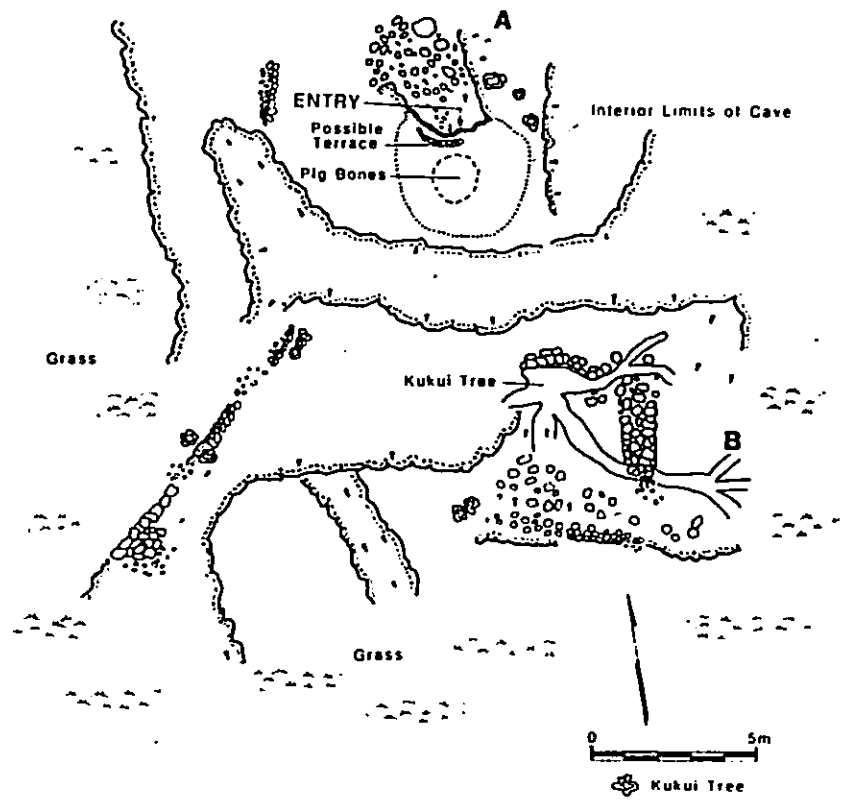

FIGURE 4. Site T-9, Features A and B

T-11 Wall, Embankment, Terrace Zone A

This site area (45.0 by 30.0 m) is located in a kukui grove and consists of a cross-slope terrace (8.0 m long, up to 70 cm high) attached to an inland-seaward field boundary (2.0-6.0 m wide, up to 100 cm high), with a large rubble mound (7.0 by 3.0 m, up to 100 cm high) adjacent. The construction is generally unfaced rubble.

These features appear to be agricultural and were probably associated with the prehistoric field system.

T-12 Platform Zone A

The oval or roughly rectangular, faced platform (10.0 by 6.0 m, up to 135 cm high) is partially collapsed and has a large bedrock outcrop in the middle of the surface. It is constructed of stacked boulders, while the other features generally are composed of piled rubble. A broken waterworn basalt cobble is visible on the surface. The areas immediately adjacent to the site include three large inland-seaward rubble wall alignments (possible field boundaries), three modified bedrock outcrop terraces, and a cross-slope terrace.

The platform's function is not definitely determined, although it may be a burial structure or a type of agricultural mound. The other features apparently are agricultural and most likely are parts of the prehistoric field system.

T-13 Platform Zone A

The rectangular platform (4.5 by 5.0 m, up to 80 cm high) is constructed on a bedrock outcrop and consists of large basalt boulders serving as a foundation for boulders and cobbles stacked on top. The platform has a relatively level soil-filled surface. A kukui grove (30.0 by 20.0 m in area) is associated with the site and contains two or three modified outcrop mounds and at least four rough terraces (Figure 5).

The rectangular platform possibly is a burial structure or perhaps is habitation-related, while the adjacent features probably have prehistoric agricultural functions.

T-14 Shelter Zone A

This natural shelter (6.0 by 3.0 m, up to 100 cm high) is formed by a possible collapsed lava tube or large bubble, and a large mango tree grows in the entranceway (Figure 6). The shelter has a soil floor, and a subsurface cultural deposit is quite possible. Cultural materials visible on the surface included Cypraea sp. shells, a bedrock mortar in a large boulder near the entranceway, a waterworn basalt cobble which is ground at one end, a boulder with a smoothly worn surface, a basalt core, and a

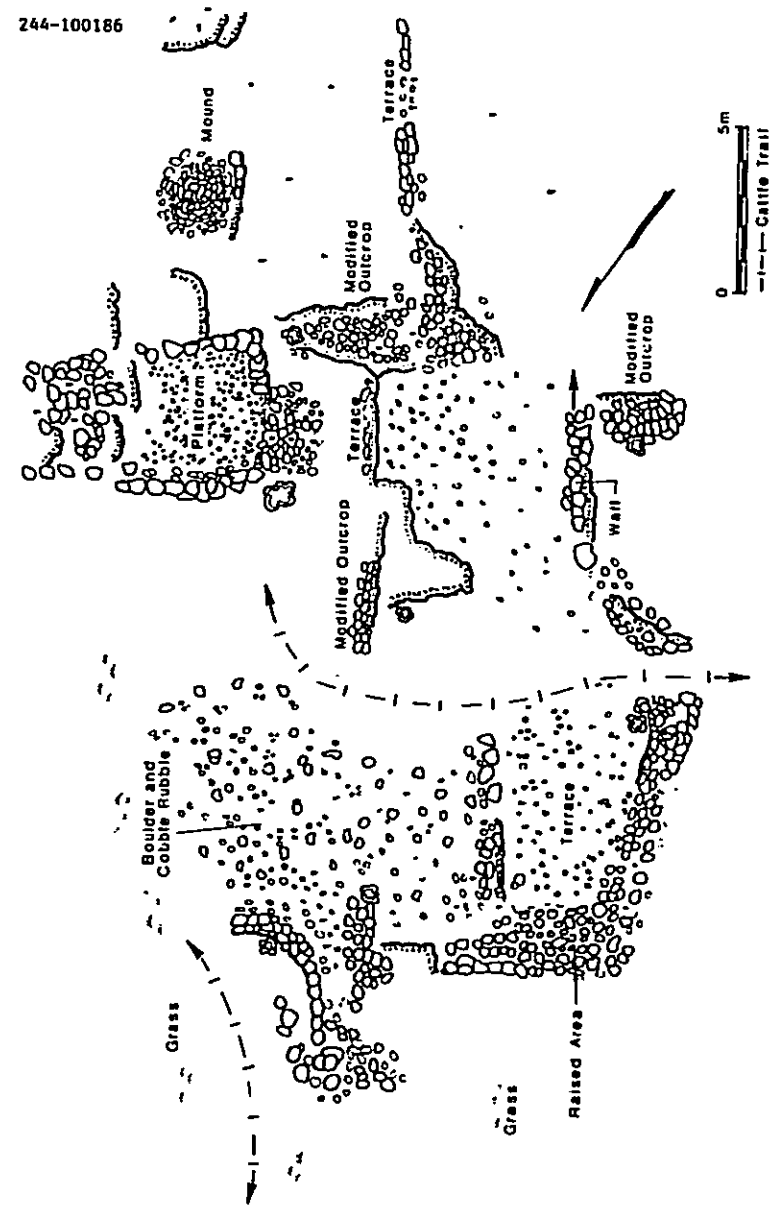

FIGURE 5. Site T-13

Figure 6. SITE T-14, ENTRANCE TO LAVA BUBBLE SHELTER. View to east. (PHRI Neg.505-11)

small basalt bowl or cup (collected). (Collected surface artifact No.4 is a small basalt mortar or kukui nut lamp [70.9 by 47.1 mm, 271.3 g].) The area associated with Site T-14 includes several rough terraces. Two terrace walls forming a "T" are found near the shelter, and four or five smaller terraces (with both stacked and rubble walls) are located northwest.

This probable temporary habitation shelter may have been associated with prehistoric agricultural acitivites in the immediate area, or could possibly have been a special-purpose site.

T-15 Complex — Zone A

The T-15 site complex consists of two designated features. Feature A, a partially collapsed, rectangular, walled enclosure (17.0 by 15.0 m, up to 140 cm high), is situated just south of a dirt road (Figure 7). It is constructed of stacked basalt boulders and rocks and has an interior soil surface with considerable exposed bedrock. A coral fragment and a broken waterworn basalt cobble were found on the surface.

This structure is probably a historic animal enclosure; the large size and the presence of bedrock outcrop inside would make it seem to be unlikely as a habitation feature.

Feature B, a rectangular platform (6.5 by 5.5 m, up to 70 cm high), is located 187 ft (27.1 m) from Feature A. It has four stacked basalt boulder faces with a level cobble- and rubble-filled floor area (Figure 8). An entrance in the middle of the southwest side includes flat basalt slabs which form a stepway.

The feature is apparently a prehistoric or perhaps early historic habitation platform (a possible house foundation).

A number of minor features, including rough terraces and three or four inland-seaward rubble walls (possible field boundaries), are located in the western part of the complex. The site appears to be a habitation and agricultural complex of prehistoric to historic age.

T-16 C-shape — Zone A

The C-shape (3.0 by 5.0 m, up to 80 cm high) is constructed of stacked boulders on exposed bedrock and has an interior soil surface. Two inland-seaward field boundaries, composed largely of rubble (c. 3.0 m wide, 70 cm high), are located within the area (40.0 by 50.0 m) associated with the site.

This structure possibly is a temporary habitation shelter associated with prehistoric agricultural features.

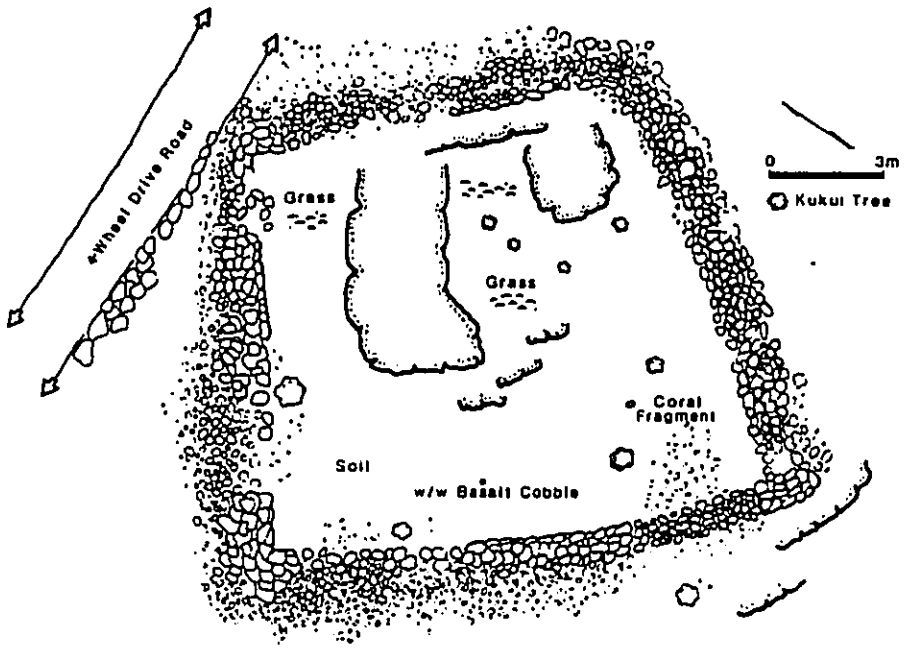

FIGURE 7. Site T-15, Feature A

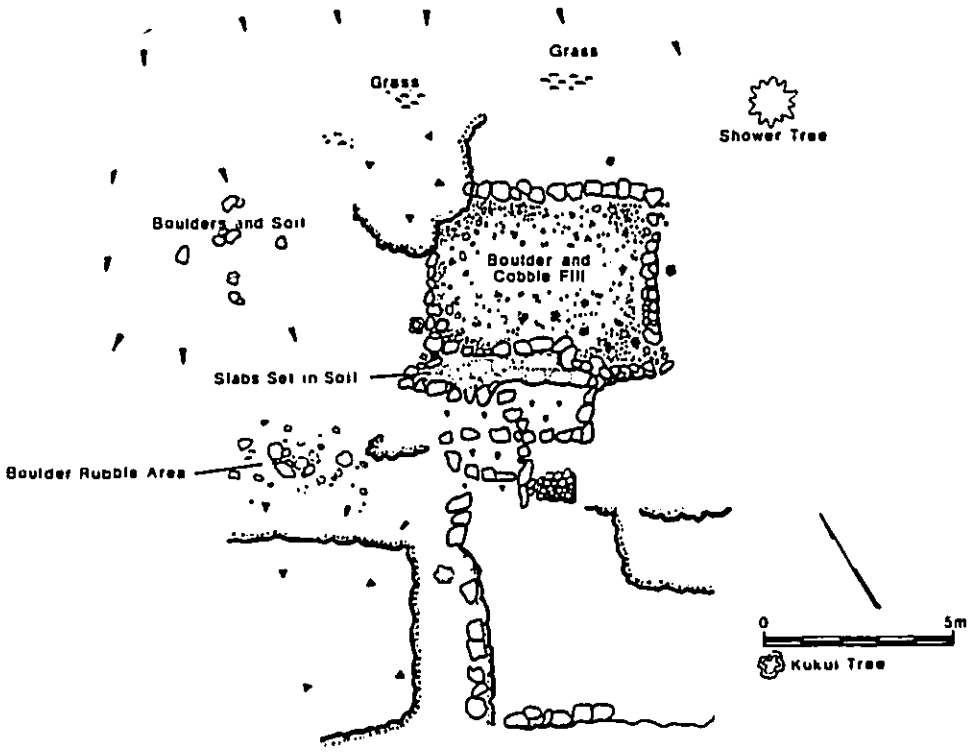

FIGURE 8. Site T-15, Feature B

T-17 Walled structure Zone B

Site T-17 is a partly collapsed, rectangular walled structure (11.0 by 12.5 m, up to 80 cm high) located between two inland-seaward field boundaries. It has a level interior soil surface and faced walls composed of stacked basalt boulders. The inland side is formed by a faced retaining wall.

The flat soil floor and standing walls indicate this structure may be a fairly substantial prehistoric habitation feature.

T-18 Terrace Zone B

Site T-18 is an irregularly shaped but angular large terrace (7.0 by 17.0 m, up to 130 cm high) with a high, stacked boulder face and a level interior soil surface. It is constructed of stacked boulders faced on the exterior and is built partly on bedrock. Artifacts present on the surface included thick round fence wire, three bottles (one collected), part of an iron door lock plate with keyhole (collected), and an old shoe heel. (Collected surface artifact No.2 is a broken iron door lock plate with keyhole, marked "ORBU" [76.5 by 83.0 by 4.2 mm, 92.0 g]; collected surface artifact No.3 is a clear, rectangular, historic bottle embossed "GIFFORD & CO., H.H.H. LINIMENT, CHICAGO" [223 by 74.6 by 46.8 mm, 194.1 g].)

This structure is apparently a historic (early 1900s) habitation feature perhaps associated with the pineapple cultivation period or with ranching activities.

T-19 Walled enclosure Zone A

This roughly rectangular, walled enclosure (11.0 by 12.0 m, up to 80 cm high) has a flat soil surface and has been disturbed on both sides by inland-seaward bulldozer cuts. Only portions of the stacked boulder walls are standing, while the remainder are rubble.

This rather large structure has been affected by bulldozing: it is unclear whether it may have been a prehistoric or early historic habitation site, an animal pen, or whether it could have been used agriculturally.

T-20 Walls, Embankments Zone A

Site T-20 exhibits two inland-seaward field boundaries (30.0 m long, 2.0-3.0 m wide, up to 100 cm high) associated with about five, small cross-slope terraces. The features are composed of stacked boulders and/or piled rubble. A bulldozer cut runs just south of the site area.

These rough structures appear to be agricultural features associated with the prehistoric field system.

T-21 Terrace Zone A

Site T-21, a terrace, is constructed primarily of basalt boulder and rock rubble with an occasional stacked face. At least six waterworn basalt cobbles are present on the surface. The northwest portion has a level soil surface with an alignment of upright boulders. Although the site may be some type of remnant habitation terrace, extensive bulldozer disturbance makes this determination indefinite.

Site T-21 is located in an area of large, rubble terraces (38.0 by 12.0 m) in a kukui grove. The area is divided into three sections by a bulldozer cut and an inland-seaward historic wall. Most of the rough terraces in the area apparently are agricultural and probably are related to the prehistoric field system.

T-22 U-shape Zone B

Site T-22 exhibits a small, U-shaped, walled enclosure (5.0 by 7.0 m, up to 120 cm high) with an opening in the seaward end and a relatively level soil floor. The somewhat collapsed wall is composed of stacked boulders filled with cobble and larger rock; the inland end is formed by exposed bedrock. The only artifact visible on the surface was a rectangular sarsaparilla bottle (collected). (Collected surface artifact No.1 is a complete rectangular historic bottle embossed "HOOD'S COMPOUND EXTRACT SARSAPARILLA, C.I. HOOD & CO., LOWELL, MASS." [220 by 73 by 46 mm, 453.2 g].)

This small structure appears most likely to be a historic animal pen, but it could have been used as a temporary habitation shelter as well.

Also found at Site T-22, but not assigned a feature designation, is a rough terrace (15.5 by 6.0 m, up to 115 cm high) defined by retaining walls on the seaward and south sides. The partially collapsed walls consist of stacked boulders with cobble fill behind, and the soil surface is moderately sloping.

The structure is probably a prehistoric agricultural terrace, as its surface seems to slope too steeply for habitation use.

T-23 Terrace Zone B

The south and west walls of Site T-23, an L-shaped terrace, are constructed of stacked boulders forming the faces and are cobble filled. The terrace measures 15.5 m long by 6.0 m wide. The upper surface of the terrace is moderately sloping and soil covered. The sloping upper surface and the absence of habitation debris suggest an agricultural function for the terrace.

T-24 Complex Zone A

The Site T-24 (prob. Soehren's Site 201) complex, located in a small grove of kukui trees, consists of a cave shelter within a walled enclosure (18.0 by 14.0 m). This two-feature complex could possibly have been used for storage, or it may have been a temporary habitation shelter associated with prehistoric agricultural activities in the area.

Feature A, a small, V-shaped lava bubble shelter (5.5 by 1.7 m, up to 70 cm high) with an interior soil floor, is situated at the inland end of the walled enclosure (Feature B). A large kukui tree is growing from the entranceway.

The feature may be a temporary habitation shelter or possibly a storage site.

Feature B, a roughly rectangular walled enclosure (14.0 by 13.0 m, up to 100 cm high), surrounds an area including the cave shelter (Feature A) and a bedrock outcrop surface. It is constructed of stacked basalt boulders with some faced sections, but the wall has been disturbed by bulldozing on almost all sides.

The enclosure wall may be a historic attempt to keep animals out of the lava bubble. It is located just 5.0 m northwest of a major inland-seaward historic wall.

This site appears to correspond to Site 201, originally described as follows:

> 201. Shelter cave. A small "bubble cave" in a pahoehoe outcrop was probably used as a sleeping shelter by travelers or farmers passing the night in the area. The outcrop is surrounded by an old stone fence, low and tumbled down, which encloses an area about 30 by 40 feet. There is some evidence that blocks of stone have been quarried from the outcrop. A small grove of kukui trees covers the site (Soehren and Newman 1968:13).

T-25 Complex Zone B

The T-25 site complex (prob. Soehren's Site 202) (15.0 by 37.0 m) consists of 11 stone mounds and a wall section (Figure 9). Coral fragments and waterworn basalt cobbles are present on the surface. More mounds may possibly be located in the site area which were missed because of thick vegetation.

The site is considered a possible prehistoric or early historic complex of burial structures, although some mounds could also be the result of agricultural surface modification.

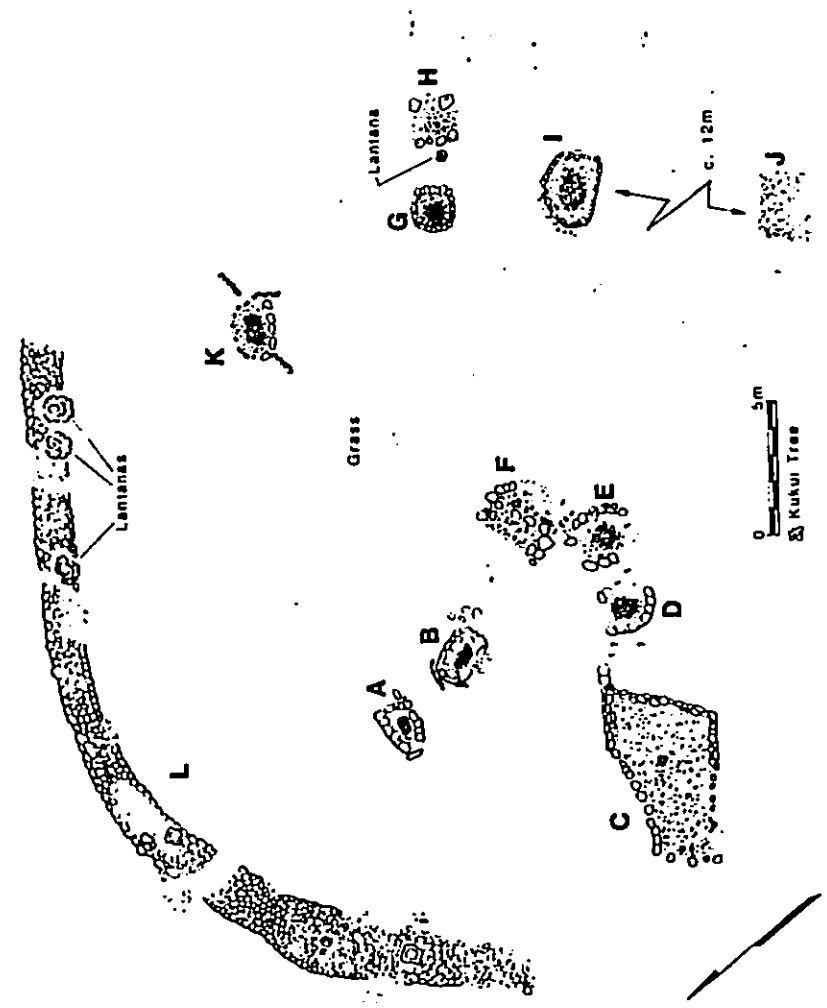

FIGURE 9. Site T-25, Features A-L

Feature A, a rock mound (1.5 by 2.0 m, up to 55 cm high), is composed of stacked basalt boulders with rock and cobble fill. One large displaced slab may have been an upright.

Feature B, a mound (2.2 by 1.9 m, up to 70 cm high), has a perimeter face of large basalt boulders with interior cobble fill and appears to be built on bedrock.

Feature C, a roughly rectangular terrace with three, faced sides (4.0 by 6.0 m, up to 60 cm high), is constructed of stacked basalt boulders and rocks with a rubble-filled floor. Coral is present on the surface.

Feature D, a semicircular mound (2.0 by 2.0 m, and up to 70 cm high), consists of stacked boulders and rocks with rubble and boulder fill. Coral is visible on the surface.

Feature E, a mound (2.0 by 2.5 m, up to 30 cm high), is composed of large boulders at the base. Rubble, cobble, and boulder fill form a level floor, and waterworn basalt is present on the surface.

Feature F is a partly collapsed, semicircular rubble mound (3.0 by 2.5 m, up to 60 cm high) with a rubble-filled surface. Waterworn basalt is visible on the surface.

Feature G, a low rubble mound (1.7 by 1.7 m, up to 25 cm high), is composed of small cobble fill with some larger rocks on the outside edges. Three coral fragments and two waterworn basalt cobbles are present on the surface.

Feature H, a low rubble mound (1.9 by 2.0 m, up to 35 cm high), consists of large basalt boulders with small cobble fill.

Feature I is a somewhat rectangular, faced mound (2.0 by 3.2 m, up to 60 cm high) constructed of stacked boulders with rubble and cobble fill, but it is collapsing. Two waterworn basalt cobbles are visible on the surface.

Feature J, a low rubble mound (1.5 by 2.5 m), is composed of some larger boulders on the outer edges and has cobble and rubble fill.

Feature K, a low rubble mound (2.2 by 1.8 m, up to 45 cm high), appears to be built on bedrock and has rubble fill. A waterworn basalt cobble is present on the surface.

Feature L is a wide, faced, standing wall (c. 35.0 m long and 2.0 m wide, up to 85 cm high) constructed of stacked basalt boulders with cobble fill. It forms a wide curve over a fairly large area. A broken waterworn basalt cobble and a Cypraea sp. shell are visible on the surface. The wall seems to mark one side of the area containing the possible burial structures.

T-26 Complex — Zone B

The T-26 historic site complex (40.0 by 20.0 m) includes five individually designated features (Figure 10). Specific functions of most of these structures are not known, but they are apparently associated with the period of pineapple cultivation.

Feature A consists of a somewhat collapsed, semicircular walled structure (8.0 by 8.0 m, up to 110 cm high) with a circular platform of large boulders (2.0 by 2.5 m, up to 100 cm high). The wall is constructed of large, upright basalt boulders with cobble fill, and the interior surface is boulder fill. A broken ceramic bowl, with blue markings representing a crane and a tree, is present on the surface.

Feature B, a rectangular walled structure with three standing walls (5.5 by 3.3 m, up to 80 cm high), is composed of stacked boulders and rubble. An alignment of rocks seems to connect Features A and B.

Feature C includes a faced, standing, wall section (23.5 by 1.0 m, up to 80 cm high) with an attached semicircular rubble mound (2.0 by 2.2 m, up to 55 cm high). The wall is cobble filled and is faced on the downslope side like a retaining wall. A slight jog in the wall, with three faced stones set to fill the gap, suggests a stepped entranceway. Surface artifacts consisted of a broken, square pink gin bottle (collected); fragments of a white ceramic vase with a flower design; a complete clear bottle; and two pieces of white, glazed ceramic (possibly a bowl). (Collected surface artifact No.7 is a lavendar, broken, rectangular case bottle [274 by 102 by 102 mm, 1061 g].)

Feature D, located just inland side of the Old Pineapple Road, is a large, faced, retaining wall (21.0 m long, up to 210 cm high) with a ramp (3.7 m long, up to 110 cm high) leading up from the road (Figure 11). The retaining wall is constructed of well-stacked boulders with smaller rocks and cobbles behind it. Blue bottle glass and a square iron nail (collected) were visible on the surface. This structure is apparently the old pineapple loading platform (Sherwood Greenwell, pers. comm.). (Collected surface artifact No.6 is a square iron nail [98.6 by 8.2 by 2.8 mm, 12.7 g].)

Feature E, a rectangular terrace (6.5 m by 5.0 m, up to 130 cm high) adjacent to the seaward side of the pineapple road, has a faced retaining wall and a soil floor (Figure 12). It consists of stacked boulders with rock and soil fill and has rubble and boulder side alignments.

T-27 Void

Site T-27 is a large, modified bedrock outcrop forming a rough terrace similar to a number of agricultural features in the area.

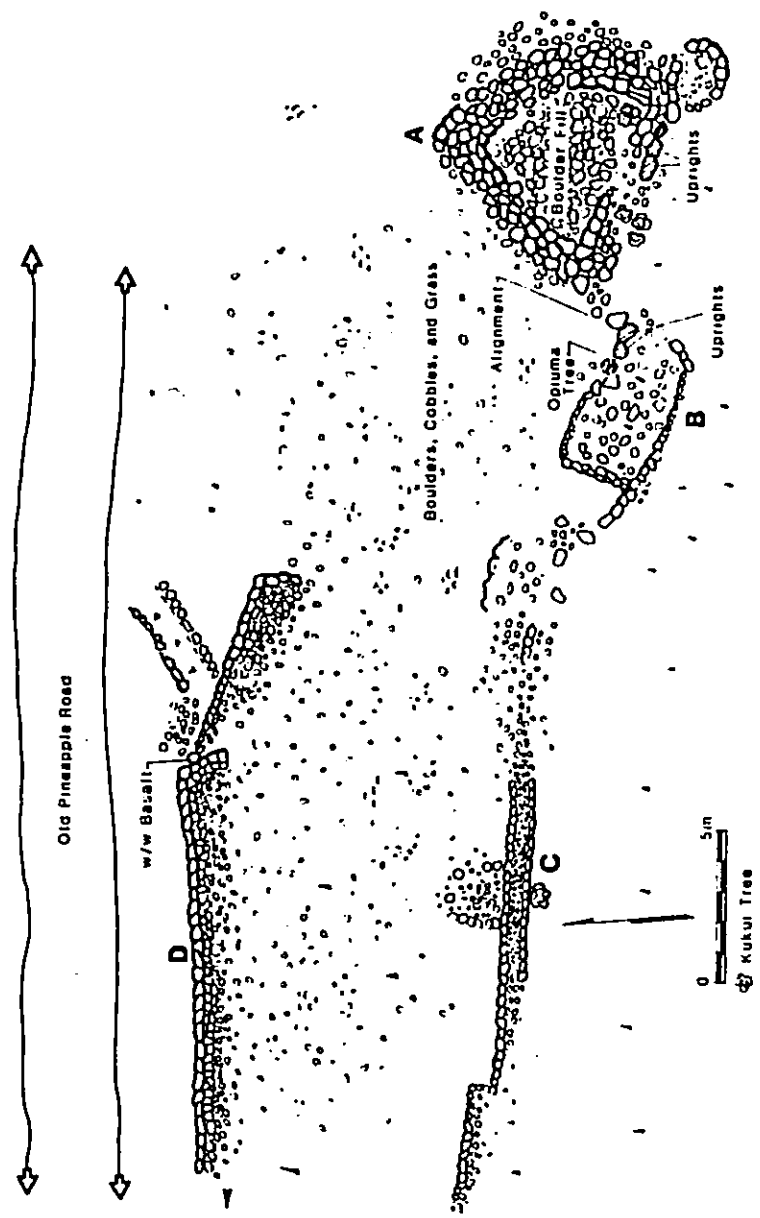

FIGURE 10. Site T-26, Features A-D

Figure 11. SITE T-26, FEATURE D, RETAINING WALL. View to northeast. (PHRI Neg.508-3)

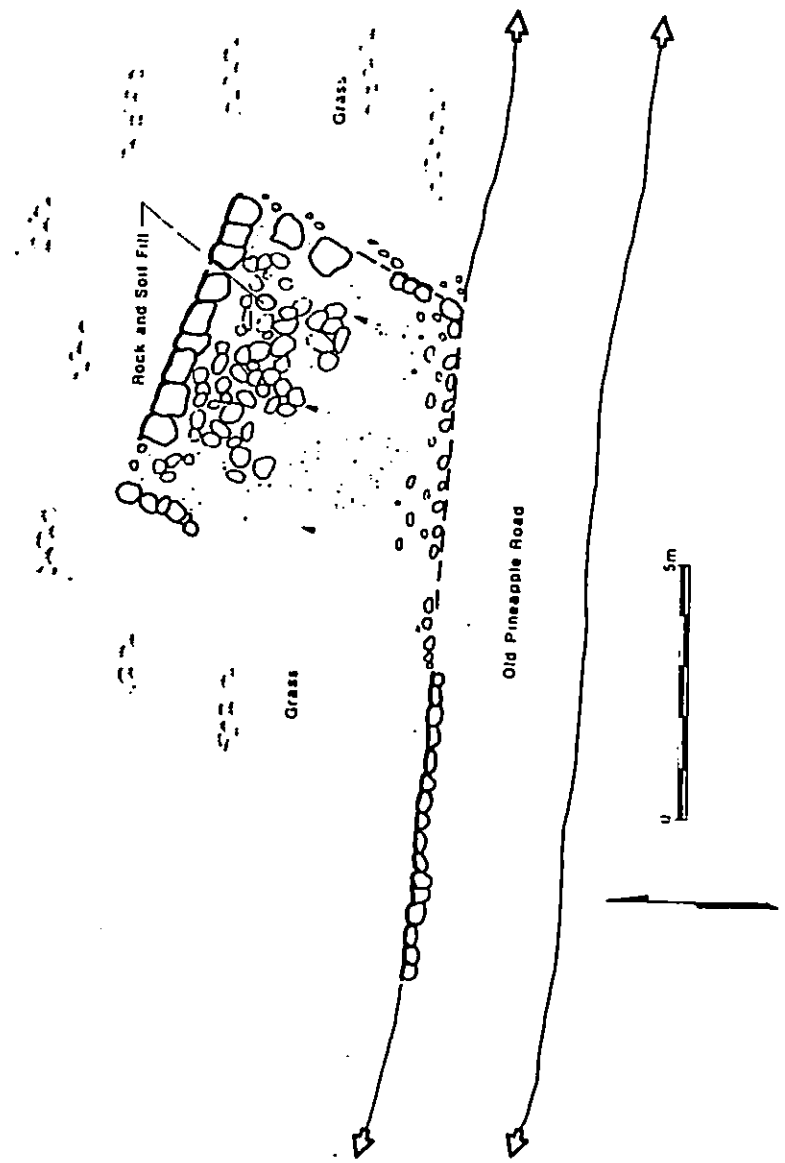

FIGURE 12. Site T-28, Feature E

T-28 C-shape Zone D

Located on a small rise c. 10.0 m north of an inland-seaward stone wall, Site T-28 is a large C-shaped walled shelter (12.0 by 10.0 m, up to 120 cm high) with a fairly flat interior soil surface and a small, roughly rectangular terrace attached to its seaward side. This rather collapsed structure is composed of roughly stacked basalt boulders and cobbles and appears to be constructed partly on bedrock. Surface midden remains consist of a single large Cellana sp. shell. The surrounding area exhibits considerable agricultural rock piling and some inland-seaward field boundaries.

This feature is probably a prehistoric, temporary habitation field shelter associated with cultivation activities in the surrounding agriculturally modified area.

T-29 Terraces Zone D

A set of two or three fairly large, but rough and irregular, linear terraces (30.0 by 10.0 m, up to 160 cm high). Site T-29 is situated across the base of a rocky slope. The terraces are roughly constructed of piled basalt boulders and cobbles and apparently use some exposed bedrock boulders. One broken, waterworn basalt boulder and a small coral cobble are visible on the surface.

This rough, rocky slope terracing is probably the result of prehistoric dryland agriculture. Similar agricultural terracing and rock piling are found in this general area, but the features here are more prominent.

T-30 Terrace Zone D

Site T-30, a partially collapsed, roughly rectangular, three-sided terrace (10.5 by 10.0 m, up to 80 cm high), has a level soil surface interior and is located just seaward of an old dirt road. It is constructed of roughly stacked boulders and cobbles, with some intact faces remaining. Cultural materials present on the surface include a broken waterworn basalt cobble and a few possible fire-cracked vesicular cobbles. An upright basalt slab in the surface of the terrace floor may indicate a slab-outlined firepit. Fairly prominent agricultural rock piling and inland-seaward field boundaries are present in the surrounding area, especially in areas inland of this site location. There is a good view from here to Napoopoo and Kealakekua Bay to the southwest. (A small broken adze was collected from a cow path at 277°, 44.5 m from the site marker on this feature.) (Collected surface artifact No.5 is the tang portion of a broken polished basalt adze [53.3 by 30.2 by 12.8 mm, 37.1 g]. It was found in a cow path at 277°, 44.5 m from the T-30 site marker.)

This structure may be a long-term, temporary-use habitation feature (possible garden house) associated with prehistoric agricultural activities in this area.

T-31 Platform Zone D

Site T-31, a small, oval platform or large cairn (2.2 by 2.0 m, up to 90 cm high), is somewhat collapsed and could possibly be regarded as roughly rectangular. It is composed of a stacked basalt boulder facing, with cobbles and some boulders as interior fill.

The feature could be a prehistoric or early historic burial structure or possibly just a well-constructed agricultural rock pile.

T-32 Complex Zone D

The T-32 site complex (prob. Soehren's Site 204) consists of two designated features and is situated just seaward of the Old Pineapple Road.

Feature A, located on a rise with some exposed bedrock boulders, is a long, inland-seaward oriented, roughly rectangular, walled structure (21.0 by 7.5 m, up to 125 cm high). It includes a four-sided square section at its inland end. The somewhat collapsed structure has a fairly flat interior soil surface, and is constructed of stacked boulders and cobbles, with some wall segments appearing to be roughly core-filled. Artifacts noted on the surface were a dense basalt hammerstone, blue-on-white oriental ceramics, a "Kona Bottling Works Co. Ltd." bottle, and a large broken bottle.

The feature is probably a historic habitation structure, either temporary or longer term, or possibly a historic animal pen; it could be associated with the period of pineapple cultivation. This feature probably corresponds to Site 204, which was originally described as follows:

> 204. Enclosure. Perhaps a pen, this irregular enclosure has walls about three feet wide and high, and encompasses an area roughly 25 by 70 feet. No features were observed which might suggest any other function, but the site is much overgrown. It may well pertain to pineapple plantation days (Soehren and Newman 1968:14).

Feature B, possibly a collapsed, roughly rectangular, rock-filled terrace (c. 8.0 by 5.0 m, up to about 100 cm high) is located north of Feature A and is well-covered by high grass and other vegetation.

The structure could be associated with Feature A and is perhaps a collapsed burial platform or possibly just agricultural rock piling. (Feature B is located 100° and 30.0 m of Feature A.)

T-33 Complex Zone D

Site T-33 is a large, site complex (c. 115 by 80.0 m) located primarily on a rocky ridge-top area with a very good view toward the sea

(Figure 13). The complex contains seven recorded features as well as rough cross-slope terracing, modified bedrock boulder outcrops, and generalized agricultural rock piling. Much of the site area (including Features A, B, C and D) seems to be surrounded by a large, but quite collapsed, enclosure wall, roughly rectangular in form. The north and south walls of this main enclosed area could be built on the lines of two inland-seaward field boundaries. Most of the stone construction consists of stacked or piled basalt boulders and cobbles that appear generally rather rough and/or collapsed, probably due to the many years of cattle grazing in the area. Visible on the surface of the general site area are some scattered waterworn basalt cobbles, coral fragments and occasional pieces of marine shell midden. The presence of a subsurface cultural deposit, potentially quite substantial, must be considered very likely within this site complex. If further detailed work were done on this site, it is likely a few more structures would be recognized that could merit designation as individual features.

The site is most likely a prehistoric to early historic habitation complex (possibly permanent) and associated agricultural use area. The size and complexity of the structural elements may suggest a high-status, chiefly residential compound.

Feature A, a roughly rectangular, walled structure (9.0 by 7.0 m, up to 120 cm high) with a fairly flat interior soil surface, is constructed of stacked basalt boulders and some cobbles. A mammal rib (possibly pig) and cow long-bones are visible on the surface.

This structure could be a historic animal pen or possibly of habitation use; its function actually is unclear, and the feature may not be contemporary with the rest of the site complex.

Feature B, a partly collapsed, roughly rectangular terrace (7.0 by 5.0 m, up to 130 cm high) with an uneven stone-filled surface, includes remnant boulder facings in the seaward retaining wall that suggest two parallel faces or stages. It is composed of stacked boulders and cobbles and appears to be built on a long, cross-slope, rough terrace alignment.

This feature is probably a prehistoric habitation, although it could be a burial or other special-purpose structure.

Feature C, a large three-sided, roughly rectangular terrace (10.0 by 8.0 m, up to 120 cm high) with a level soil interior surface, is constructed of roughly stacked basalt boulders and cobbles. Cultural materials present on the surface include broken waterworn basalt cobbles, coral fragments, a fragment of an unidentified large shell, Nerita sp., and large Cypraea sp.

This feature is a probable prehistoric habitation structure (possible house foundation), perhaps for long-term use, and it could be functionally related to Feature B, located just downslope.

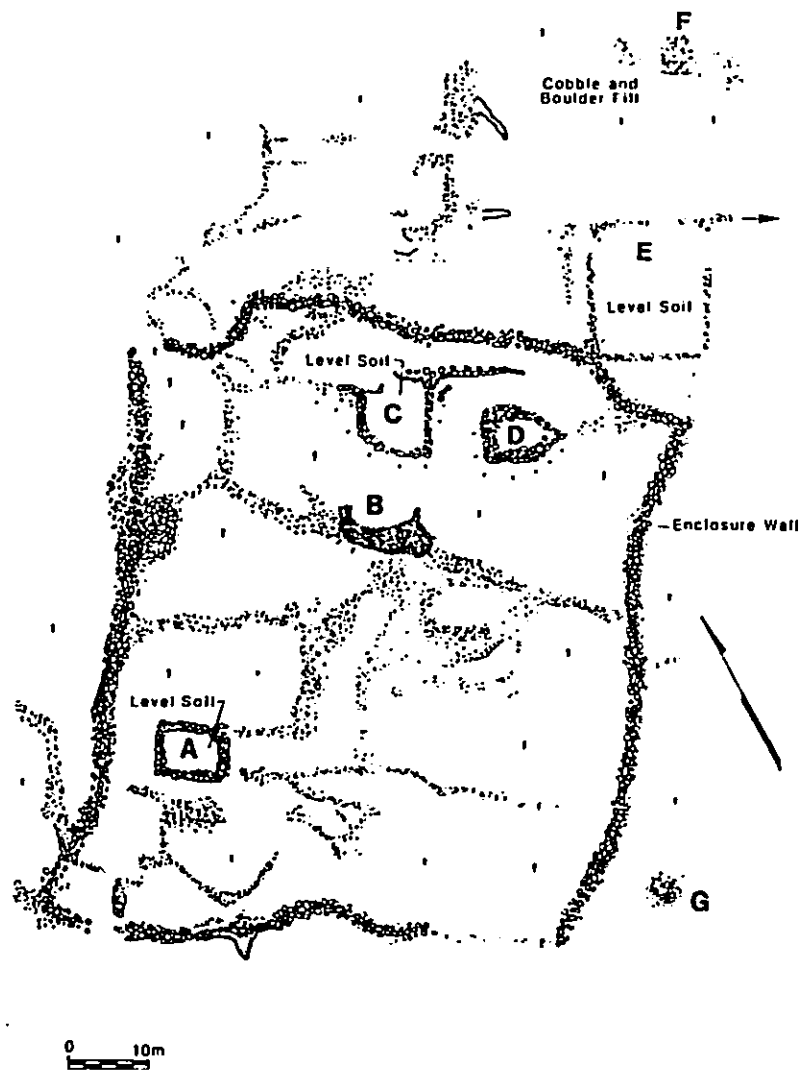

FIGURE 13. Site T-33, Features A-G

Feature D, a roughly rectangular terrace (9.0 by 5.0 m, up to 130 cm high), is rather collapsed but has a fairly level soil surface. It consists of roughly stacked basalt boulders and cobbles, with the inland side formed by exposed bedrock boulder outcrops. Visible cultural materials scattered on the surface include a basalt core from a ground adze fragment, broken waterworn basalt cobbles (possible fire-cracked rocks), a flaked small waterworn boulder, a ground Cassis sp. fragment, coral fragments, Cypraea sp., Cellana sp., Conus sp., Drupa sp., and Nerita sp. The surface midden present on and around this feature is the heaviest found in the area.

The structure is a probable prehistoric habitation terrace and may be functionally related to Features B and C.

Feature E, a long, roughly rectangular, walled enclosure (c. 25.0 by 12.0 m, up to 110 cm high), contains a smaller, roughly triangular, walled compartment (c. 10.0 by 8.0 m) in the seaward end. The much-collapsed walls are constructed of roughly stacked basalt boulders and cobbles. The interior is a sloping but fairly smooth soil surface, and midden remains are restricted to a Cypraea sp. shell and some coral fragments.

Considering the standing walls, this feature may be an early historic, walled garden area or an animal pen associated with the habitation complex.

Feature F is a rectangular, raised platform (5.0 by 5.0 m, up to 130 cm high) located on a slight rise overlooking the rest of the site complex. It consists of a roughly stacked boulder exterior facing, with cobbles and boulders as inside fill, and has a fairly flat upper surface. A few meters to the south and seaward, some brush covers rock piling that could be one or two more rough platforms.

The structure is possibly an early historic burial monument associated with a long-term or permanent habitation area.

Feature G, a roughly rectangular, raised, rubble mound (5.7 by 4.6 m, up to 75 cm high), is composed of large boulders at the base and along the perimeter, with smaller boulders and cobbles used as fill. A dense basalt core and a round basalt cobble are present on the surface. This feature is possibly a collapsed burial platform.

T-34 Terrace Zone D

Located just north of an old inland-seaward dirt road, Site T-34 is a high, stone-filled, rectangular terrace (6.0 by 7.5 m, up to 155 cm high) that is rather collapsed. It is constructed of stacked boulders and cobbles, with some standing faces remaining, and may originally have had a two-step seaward retaining wall. One fragment of small Cypraea sp. shell is visible on the surface.

This structure appears to be a prehistoric rectangular habitation terrace of temporary to long-term use, and it was probably associated with agricultural activities in the surrounding area. It is less likely, but possible, that the feature could be a rectangular burial platform on a slope.

T-35 VOID

Site T-35 is a somewhat large, rough terrace that falls within the general range of agricultural rock piling and rough terracing found in this immediate area.

T-36 Complex Zone A

The T-36 site complex (prob. Soehren's Sites 202 and 203) (c. 60.0 by 20.0 m) includes three designated features, two stone platforms and a rectangular terrace, and is located 20.0 to 25.0 m north of a major inland-seaward stone wall. An inland-seaward dirt road runs between the A and B sections of the site area.

Feature A1, an oval and somewhat angular, raised stone platform (3.0 by 3.5 m, up to 75 cm high), is partially collapsed and consists of a stacked boulder exterior facing with cobble and boulder fill on the inside.

The structure is a possible early historic, rectangular burial platform or perhaps an agricultural rock pile from the period of pineapple cultivation. (The site marker was placed on top of this structure; from Feature A1 to Feature A2 is 21.5 m at 47°.)

Feature A2, a roughly rectangular, raised platform (3.0 by 2.5 m, up to 50 cm high) has an exterior boulder facing with cobbles filling the interior. About 5.0 m to the southwest is another more rough and collapsed rock mound.

This feature is also a possible early historic rectangular burial platform or possibly an agricultural rock pile of the pineapple cultivation period.

Features A1 and A2 are probably parts of Site 202, originally recorded as follows:

> 202. Grave sites. In a small paddock just above the old "pineapple road" and between the jeep trail and a stone fence to the south are six stone cairns of various sizes which appear to be grave sites. All are in poor condition, and small waterworn stones were seen in several, two factors suggestive of antiquity. The cairns range in size from four by six feet to 12 feet square, and from one and one-half feet to four feet high (Soehren and Newman 1968:14).

Feature B, a fairly large, rock-filled, high rectangular terrace (16.5 by 7.5 m, up to c. 115 cm high), is constructed primarily of stacked boulders with some internal divisions or wall alignments. It is quite heavily covered by vegetation, making detailed visual inspection difficult.

The structure appears to be a habitation feature (a possible house foundation) and is perhaps prehistoric or more likely historic and related to the time of pineapple cultivation. (From Feature A1 to Feature B is 30.0 m at 275°.)

Feature B apparently correlates with Site 203 which was originally described as follows:

> 203. Modern house site. The stone foundations of a house said to have been built at the time of pineapple cultivation, prior to World War 1 (Soehren and Newman 1968:14).

T-37 Complex Zone A

Located a short distance inland of the pineapple road, Site T-37 is a historic habitation site complex (about 50.0 by 50.0 m) that includes three recorded features and some large, prominent agricultural rock pilings in and around the site area, especially to the inland side. It is possible that additional features would be found in the complex area if it were more intensely examined and if the heavy vegetation cover were partly cleared.

Feature A is a high, roughly rectangular, partially walled terrace (12.0 by 8.0 m, up to 165 cm high) with a large stone mound to the north side. It consists of a well-stacked boulder retaining wall with cobble and boulder fill behind; the interior surface is a fairly level soil and stone fill floor. Cultural materials visible on the surface include a probable broken basalt adze blank, a waterworn basalt cobble, a broken bottle, part of a large square metal can, and pieces of blue-on-white ceramic. The feature is situated under an old dead kukui tree and a live mango tree.

This structure is believed to be the remains of the old pineapple workers' house (Sherwood Greenwell, pers. comm.) (Figure 14).

Feature B, a quite collapsed, walled rectangular terrace (9.0 by 7.0 m, up to 120 cm high), is constructed of stacked boulders and cobbles and has a fairly level soil surface interior. An old north-south road seems to run between Features A and B.

The terrace is a likely house structure of perhaps somewhat earlier historic age than Feature A. (From Feature A to Feature B is 26.5 m at 190°.)

Feature C, a section of north-south retaining wall (c. 10.0 m long, up to 120 cm high), is located just off the south side of an inland-seaward

Figure 14. SITE T-37, FEATURE A, OLD PINEAPPLE WORKERS' HOUSE PLATFORM. View to west. (PHRI Neg.509-13)

dirt road. It is composed of well-stacked boulders and looks to be historic.

This retaining wall segment may have had an agricultural function and is probably related to Feature A. (From Feature A to Feature C is 28.0 m at 292°.)

T-38 Retaining wall

Zone D

Located c. 20.0 m seaward of the Old Pineapple Road, Site T-38 is a long, high north-south terrace retaining wall that forms a corner with an inland-seaward wall at its north end (c. 40.0 by 20.0 m, up to 145 cm high).

The faced retaining wall is constructed of well-stacked boulders and has a fairly flat, rock-filled and soil surface behind it. The north end of the retaining wall runs into an exposed bedrock rise, with several rough rubble wall alignments and rock pilings on and around it. A single piece of Cypraea sp. shell was noted on the surface in the north end area.

The retaining wall is apparently historic and possibly is related to the pineapple road which runs just inland, but the bedrock rise area to the north may have had a habitation function.

T-39 Platform

Zone A

Site T-39 is a somewhat collapsed, roughly rectangular, raised platform (5.0 by 3.5 m, up to 75 cm high) located under a small monkeypod grove on top of a small hill. It consists of a stacked boulder exterior face with cobbles and soil interior fill, and the inside surface has a slight depression below the top of the outside wall face.

This structure may be an early historic, rectangular burial platform or possibly just a well-built agricultural rock pile perhaps related to the pineapple cultivation period.

T-40 Walled terrace

Zone C

Located in a kukui grove, Site T-40 is a small, roughly rectangular, walled terrace (4.0 by 5.0 m, up to 60 cm high) associated with a long, cross-slope, rough terrace. The small, walled terrace is composed of stacked large boulders and has a soil and rubble interior surface.

This feature may be a prehistoric temporary shelter structure associated with an agriculturally modified area.

T-41 Complex Zone A

A probable prehistoric/early historic habitation and agricultural site complex (c. 45.0 by 55.0 m). Site T-41 is composed of three designated features along with various sorts of agricultural rock pilings found within the site area.

Features A and C are located under separate kukui groves, while Feature B is under mango and octopus trees.

Feature A is a large, roughly rectangular, walled terrace (16.5 by 11.0 m, up to 160 cm high), quite collapsed but still fairly distinct. Its thick walls are constructed of roughly stacked boulders and cobbles; there is a level soil surface on the interior.

This feature is probably a large habitation structure and indicates long-term temporary or possibly permanent residence.

Feature B, a much collapsed, roughly rectangular, walled structure (8.5 by 8.5 m, up to 95 cm high), is composed of stacked boulders with some cobbles and is built partially on exposed bedrock. Much agricultural surface modification on the slope just to the south includes a large, linear rock pile.

The structure is possibly a small habitation feature or collapsed animal pen. (From Feature A to Feature B is 15.0 m at 120°.)

Feature C is a small, but high and roughly rectangular, raised platform (4.0 by 3.5 m, up to 140 cm high). Built against an exposed bedrock outcrop, it consists of a stacked boulder face with interior cobble fill. A possible similar structure is located about 8.0 m inland, while 6.0 m to the south runs a possible inland-seaward field boundary with prominent agricultural rock piles adjacent.

This feature may be a burial platform or possibly just a prominent agricultural rock pile on bedrock. (From Feature A to Feature C is 26.0 m at 56°.)

T-42 Modified outcrop Zone A

Located in a grove of kukui trees somewhat on the south side of an inland-seaward dirt road, the T-42 site area (c. 35.0 by 30.0 m) consists of assorted rock pilings and other surface modifications on and around a large, natural bedrock boulder outcrop rise. Construction is generally of roughly stacked boulders and some cobbles, often on or against bedrock boulders. The seaward part of the site area seems to have been roughly cleared of rocks to the soil surface, and a large, rough rubble terrace line (up to 120 cm high) is present on the inland side of the clearing (c. 8.0 by 13.0 m cleared area).

The site is an agriculturally modified kukui grove surface rock concentration area and is probably prehistoric in origin.

T-43 Walled terrace Zone A

Site T-43, a rather collapsed, large high rectangular walled terrace (c. 14.0 by 10.0 m, up to 150 cm high) with a level soil surface on the interior, is located just north of an old inland-seaward dirt road. It is constructed of stacked boulders and some cobbles and is heavily overgrown with vegetation.

This possibly prehistoric structure is most likely a rather substantial rectangular habitation terrace, perhaps for relatively long-term use. Poor visibility due to heavy vegetation cover makes it difficult to give a definite assessment.

T-44 Elevated roadway Zone D

A raised and faced roadway (3.5 to 5.0 m wide), Site T-44 is braced on the seaward side by a stone retaining wall (often more than 1.0 m high) (Figure 15). The wall is constructed of stacked large boulders as a foundation, with smaller boulders and cobbles used as fill, and has a level soil surface.

This feature is an elevated causeway for the historic Old Pineapple Road, built sometime between about AD 1905 and 1910. It appears to be associated with a number of the historic-era sites (e.g., Site T-26).

T-45 Terrace Zone D

Site T-45 features prominent rock piling on and around outcropping bedrock boulders (8.0 by 13.0 m, up to 125 cm high). The mostly collapsed feature is composed of stacked boulders with boulder and rubble fill and includes a possible small sheltered surface area.

The feature appears to represent some large-scale prehistoric agricultural surface modification. This site was recorded while searching for Site 206.

T-46 Walled terrace Zone D

A rough and much-collapsed rectangular walled terrace (prob. Soehren's Site 207) (6.8 by 7.4 m, up to 70 cm high), Site T-46 includes a fairly flat, rock-filled interior surface. Large basalt boulders are stacked along the perimeter, with smaller boulders and cobbles used as fill. A rough, dense basalt core is visible on the surface.

The feature is probably a prehistoric habitation structure or possibly a collapsed burial platform.

This site apparently corresponds to Site 207, which was originally described as follows:

Figure 15. SITE T-44, OLD PINEAPPLE ROAD RETAINING WALL. View to east. (PHRI Neg.509-29)

207. Grave sites. A rough, greatly disturbed platform about 18 feet square, built on a slope, seems to have been built as an enclosure then filled in with rubble so that the floor is about one foot lower than the top of the walls. In front the structure stands about four feet high, and in back about two feet. The floor is paved with small stones, among which was seen one piece of coral, and slopes seaward. The center has been disrupted by a small tree, now dead (Soehren and Newman 1968:15).

T-47 Platform

Zone D

A large, roughly rectangular raised platform with a smaller extension on the south side (6.0 by 10.0 m, up to 80.0 cm high) (prob. Soehren's Site 206). Site T-47 is located just north of an inland-seaward dirt road. It is composed of a stacked boulder exterior facing with mostly cobble interior fill and has a fairly level upper surface. The areas north and west of this location, over to the north boundary wall, contain much agricultural surface modification, including rock piling and linear mounds, etc.

This fairly large and substantial structure is a probable prehistoric/early historic burial platform, most likely multiple.

The feature appears to correlate with Site 206, which was previously recorded as follows:

206. Grave sites. A double burial platform, probably built in two phases. The main platform is built on a slope, stands three feet high in front but only one foot high in back, and measures 15 by 18 feet. A smaller platform is attached to the south side and measures about six feet square. The surface of both is generally well paved with small stones but slopes slightly downhill to the west (Soehren and Newman 1968:14).

205 Enclosure

Zone D

Although searched for, this site was not relocated. Bulldozing is evident in the area where it should be situated, and the structure may have been destroyed since originally being described:

205. Pen. This much disturbed stone wall enclosure has walls four feet high on the inside and measures about 12 by 13 feet on the inside. No entrance was seen. It was probably used as an animal pen (Soehren and Newman 1968:14).

208 Cart road — Zone D

Site 208 was not specifically examined in the field except, where it is visible at the top of a steep slope entering the seaward side of the project area. It was recorded as follows:

> 208. Horse trail. This type C trail (Apple 1965) is shown on Tax Map 8-1-10 as the "old road from Kealakekua pali to Kainaliu" but only as far south as Kaswaloa Road. From that point the trail is generally lost in the soil and vegetation found above the cliffs, but its alignment is indicated by a stone wall paralleling it on the seaward side. The trail descends the Pali-o-Hanuahi, behind Hikiau heiau, and terminates at Napoopoo, although the location of the lower portion is uncertain. From there it probably continued southward to Honaunau and the City of Refuge National Historic Park, where it has been identified as having been built about 1871 (Apple 1965:52-59). The trail was an important link in the transport system of the nineteenth century (Soehren and Newman 1968:15).

209 Foot trail — Zone D

This site was not inspected in the field but was previously described as follows:

> 209. Foot trail. A portion of what is undoubtedly the ancient Hawaii foot trail from Kaswaloa to Kealakekua can be traced on vertical aerial photographs and, to some extent, on the ground where it crosses the barren lava flows above Kaswaloa flat. Above the high sea cliffs the trail is lost in the soil and dense vegetation. Its descent at Kealakekua is similarly lost. That such a trail was used is attested by Bloxam (1925:72):
>
> > Between (Kealakekua and Kaswaloa) is a high and perpendicular cliff six hundred feet in altitude which prevents any path along the shore. The natives are therefore obliged to go over, if they wish to proceed from one village to the other.
>
> The trail crosses the Kaswaloa road perhaps two hundred yards below Puhina-o-Lono heiau. The northern portion is marked by stones placed alongside the trail, sometimes two or three stacked up, a usual way of marking trails. A short distance north the trail crosses a broken-in lava tube on a natural arch. This tube is probably the same one described under site number 210. No signs of occupation were noted, but without lights careful examination could not be made. The presence of rusted cans and glass bottles, together with the trail markers, indicates that the trail has been in recent use.

> The southern portion of the trail has no surviving markers, and can be detected most readily on aerial photographs by a distinct line of vegetation. Some portions have been built up or paved with flat lava slabs to facilitate passage, but other parts are virtually untraceable on the ground. Although it is now lost in the soil and vegetation south of the lava flows, the trail probably passed near the top of the cliffs, below the Type C trail (Site 208) (Soehren and Newman 1968:15-16).

7324 Historic house — Zone E

This historic structure is the first frame house in the Kealakekua Ahupua'a (Sherwood Greenwell, pers. comm.) (Figure 16, 17). Information provided by Willie Henriques (pers. comm.) indicates there are two graves near a large old avocado tree just south of the house and across an old rock wall. In the late 1930s, Henriques was told by the old Hawaiian "Naha" (about in his eighties at the time) that his wife and daughter were buried there. Known as the Dennis Henriques House, this site was previously recorded by the state as follows:

> General Description: Set close to the old Kealakekua is the one-storey wooden house called King's Garden. This partially board and batten house built in the salt-box style of New England farm houses, is set over a large stone cistern. Remains of a stone wall and large boulders appear under the South end of the house.
>
> A front verandah porch is L-shaped and is enclosed with a diamond patterned balustrade. The variety of fenestration from double hung sashes with pedimental heads to horizontal siding windows indicates a series of alterations or remodelings. Some windows have unusually thick heads and sills.
>
> Architectual Interest and Merit: Despite alterations, the structure is a good example of early wood frame construction. The unusually thick heads and sills flanking some of the windows is notable. The site is being recommended for reserve status based on a combination of historical and architectual interest (HRHP Site-7324 file).

Architecturally the house is a good example of early wood frame construction and its salt-box profile is typical of many in the Kona area. Historically the structure is said to be the first frame house in the general Kealakekua district. The name "King's Garden" supposedly derives from the site, once a garden of an unknown Hawaii Island king. No other information about the site or structure is presently available, and no documentary evidence is known.

Because of the possibility of greater significance should additional information become known, the site is recommended for reserve status.

HRHP-4-73A 50-10-47-7324

HAWAII REGISTER OF HISTORIC PLACES

HISTORICAL SITES INFORMATION AND REVIEW FORM---CONTINUATION SHEET

Please note subject heading (Statement of Significance, etc.; use separate sheet for each heading).

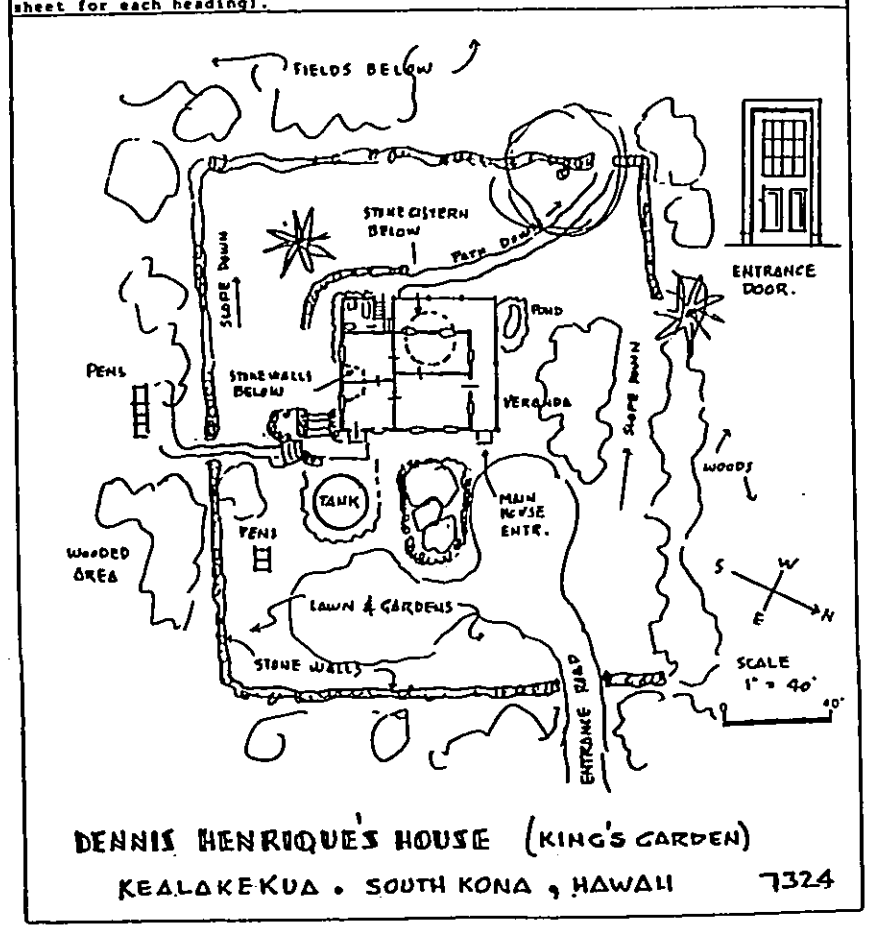

FIGURE 16. Site 7324

Figure 17. SITE 7324, HISTORIC HOUSE. View to South. (PHRI Neg.510-13A)

CONCLUSION

DISCUSSION

The vicinity of Kealakekua Bay is regarded as "one of the most important historical and archaeological areas in Hawaii" (HRHP Site-7000 file, Kealakekua Bay Historical District), and the Kona Field System (HRHP Site-6601 file) has been described as "the most extensive and monumental work of ancient Hawaii." The present survey area is located within the limits of both of these highly significant archaeological/historical districts.

Hommon (1986:1) commented that "the ancient villages of Ka'awaloa and Kekua and the other archaeological remains along the shores of Kealakekua Bay constitute the most significant unexplored historic resources known in Hawaii today." These large villages (especially Kekua in this case) were supported by extensive agricultural fields lying behind the bay, including those in the study parcel. Using an informed estimate of the amount of land required for a dryland family kuleana plot (from 6 to 12 acres, Lyons 1874:35), it appears the surveyed property area could have provided prehistoric agricultural subsistence for well over 100 people. It can be argued that the cultural and historical significance of the planned Kealakekua Bay State Historical Park would be most effectively understood in the geographical and archaeological context of the immediate surrounding area, especially the ahupua'a of Kealakekua and Kaawaloa (Hommon 1986:4). The above perspective must be borne in mind when considering the potential archaeological and historical value of the recorded sites and of this project area in general.

The full reconnaissance survey of the Kealakekua Ranch Makai Land Subdivision project area demonstrates the presence of numerous archaeological sites and features of prehistoric as well as historic origin. The distribution of identified sites, types of features present, and related observations overall tend to confirm and amplify assessments made earlier by Rosendahl (1986) and by Soehren and Newman (1968) concerning the general pattern of aboriginal Hawaiian settlement in this area.

A total of 46 sites comprised of 85 component features was identified during the full reconnaissance survey field work. Seventy-two of these features were individually recorded. These totals do not include additional elements of the Kona Field System, primarily field boundaries and walls, which were mapped as a unit, using aerial photos and field checks (see Figure 2).

The 85 identified features consist of agricultural features (N=22), habitation structures (N=25), possible agricultural and/or habitation features (N=12), possible burial structures (N=21), and transportation features (N=4). Agricultural features include modified outcrops (N=2), an animal pen, terraces (N=8), field boundaries (N=3), and eight complexes of terraces, walls, and field boundaries. Most of these agricultural

features are components of the larger Kona Field System which were recorded individually because they are situated within or in close proximity to non-agricultural features.

Habitation features include probable temporary and permanent prehistoric habitations and historic-era residential structures. Caves/rockshelters (Sites T-9, T-14, and T-24) and C-shapes (Sites T-16 and T-28) are interpreted as prehistoric temporary habitation features associated with agricultural use of the area. Probable permanent prehistoric habitations are represented by rectangular terraces (Sites T-30 and T-34, and Features B, C, and D at Site T-33), walled rectangular terraces (upper terrace surface partially enclosed by walls; Sites T-40, T-43, and T-46, and Features A and B at Site T-41), a walled enclosure (Site T-17), and possibly the Feature B platform at Site T-15. Historic habitation features include prehistorically used types such as enclosures (Site T-32 and Features A thru C at Site T-26), rectangular terraces (Sites T-18 and T-32, Feature D at Site T-26, and Feature B at Site T-36), and walled rectangular terraces (Features A and B at Site T-37). Several of these structures probably contain evidence of prior prehistoric-period occupation. The wooden frame house, Site 7324, represents a residential architectural type unique to the historic period.

Several enclosures (Site T-24, Feature A at Site T-7, and Features A and E at Site 33) and terraces (Site 21, Feature B at Site T-7, and Feature B at Site 25) may have either functioned as habitations or been used for agriculture. Determination of function for these features requires data from excavations.

Possible burial features include twelve stone mounds--eleven at Site T-25 and one at Site 33 (Feature F)--and nine platforms (Sites T-12, T-13, T-31, T-39, T-47; Feature F at Site T-33, Features A1 and A2 at Site T-36, and Feature C at Site T-41). Test excavations would be necessary to verify the functions of these features. As noted in the site descriptions, several of the mounds may potentially be agricultural features.

Transportation features include the Site 209 trail, two historic roads (Sites 208 and T-44), and a historic loading platform (Feature D at Site T-26). Several other trail segments, which were not recorded individually, are shown on Figure 2.

In terms of overall distribution, agricultural features are relatively evenly distributed, compared to non-agricultural ones. Most of the probable permanent habitation structures, transportation-related features, and possible burials are concentrated between 650-750 and 1,000 ft elevation. Temporary habitation features are concentrated in the inland portions of the project area; the majority are situated above 1,000 ft elevation. These patterns should be viewed as very tentative because of the small sample size (particularly for temporary habitation features) and the evidence of disturbance; however, they can serve as a model which could be evaluated by future work within the Kona Field System.

EVALUATIONS

The significance of archaeological remains can be defined in terms of potential scientific research, interpretative, and/or cultural values. Research value refers to the potential of archaeological resources for producing information useful in the understanding of culture history, past lifeways, and cultural processes at the local, regional, and interregional levels of organization. Interpretive value refers to the potential of archaeological resources for public education and recreation. Cultural value, within the framework for significance evaluation used here, refers to the potential of archaeological resources for the preservation and promotion of cultural identity and values.

To attempt definitive evaluation of the significance of archaeological resources, on the basis of a preliminary assessment such as a reconnaissance survey, is generally premature. Occasionally it is possible, even at a preliminary level of study, to evaluate the general significance of specific sites or features when their scientific research, interpretive, and/or cultural values are obvious. However, in most instances it is necessary first to conduct intensive survey, often including test excavations, to determine and substantiate the significance of specific archaeological remains.

Based on findings of the completed reconnaissance survey, a preliminary evaluation of the archaeological significance of identified sites within the project area indicates virtually all of the recorded sites and site complexes are to some degree potentially significant for their scientific research value; i.e., for the information they may contain. Preserved remnants of the Kona Field System (inland-seaward field boundaries and associated structural features), although not recorded as specific site locations, must also be regarded as having considerable research value. Some sites and site complexes are also potentially significant for cultural and/or interpretive values. Possible burial features are sites of high cultural value, while a few unusual site complexes are potentially of interpretive value.

As noted earlier by Rosendahl (1986), Site T-33 is of particular interest because of the nature, size, and complexity of its constituent features. It has been suggested this site may be a prehistoric chiefly residential complex and thus could hold substantial interpretive value, as well as research and cultural values. The Old Pineapple Road (Site T-44) and some of the structures associated with it (especially Sites T-26 and T-37) could also be regarded as having value for historic interpretive purposes.

Most sites identified during the full reconnaissance survey appear to be sites for which continued physical preservation would not be considered essential. This evaluation indicates most of the remains present within the project area could be handled adequately by carrying out the appropriate level of further archaeological work needed to recover any significant data, thereby preserving valuable archaeological information rather than physical remains.

These evaluations were reviewed by Dr. Ross Cordy, chief archaeologist with the Hawaii State Department of Land and Natural Resources, who generally concurred with them (letter from DLNR to Hawaii County Planning Director Lyman, dated March 6, 1987). The only question relating to these evaluations that was raised by the review concerned whether or not Sites T-44, T-26, and T-37 were sufficiently unusual or unique to warrant possible interpretive development. As indicated in Table 1 (at end), these sites were evaluated as having a moderate degree of interpretive value. This evaluation is a tentative one, based on a reconnaissance-level survey. Subsequent, more intensive levels of field and historical documentary research would provide a broader evaluative perspective, potentially leading to a downgrading of the interpretive value of these three sites.

RECOMMENDATIONS

Kirch (1985:166) recently commented that "there has been little modern archaeological work in the Kealakekua environs," and expresses the hope that in the future "they receive the full and careful attention they deserve." Archaeological sites and features recorded by the present reconnaissance survey of the Kealakekua Ranch project area are varied and significant, and most will be irretrievably damaged or destroyed as a consequence of the planned residential development. Hommon (1986:1) has even suggested that "major portions of Kealakekua's archaeological record should be 'banked' as unexcavated resources, to await more highly developed analytical techniques or as perpetually undisturbed monuments to an earlier Hawaii."

After the reconnaissance survey field work was completed, survey findings and preliminary conclusions (including tentative general evaluations and recommendations) were reviewed (August 28, 1986) with Virginia Goldstein, staff planner and historic sites specialist in the Hawaii County Planning Department. Ms. Goldstein generally agreed with preliminary conclusions and tentative recommendations provided here regarding further archaeological work to be done within the Kealakekua Ranch Makai Land Subdivision project area.

Based on the reconnaissance survey findings, further archaeological work in the form of variable-degree intensive survey (including historical documentary research, vegetation clearing, detailed mapping and recording, and controlled test excavation) is recommended for most of the identified sites. Site-specific intensive survey field work tasks are indicated in Table 1 (at end). Some level of further data collection is recommended for most sites. Work tasks vary considerably according to specific site, from completion of simple recording (e.g., photographs), to detailed recording, surface collection of associated portable remains (midden and artifacts), and test excavations.

Basic objectives of the intensive survey and testing would be two-fold: (a) to determine and substantiate as fully as possible the significance of specific archaeological remains; and (b) to determine the

scope and scale of any subsequent mitigation work, such as data recovery excavation, that might be necessary or appropriate. Sites that appear to be restricted to an agricultural function (especially T-1 thru T-8) should be reexamined during intensive-level work, and only a sample of these would undergo standard test excavations. The following specific field tasks are believed to constitute an adequate scope of work for an intensive field survey:

1. Selection and testing of a sample of Kona Field System agricultural features (inland-seaward field boundaries, internal features, etc.) within each of the defined zones;

2. Intensive-level survey recording of designated sites (including detailed plan mapping, surface profiles, written descriptions, and photographs);

3. Collection of portable surface remains (midden and artifacts) from sites; and

4. Subsurface testing of sites with excavation potential.

It is important to note that any intensive survey field work should be scheduled to occur at a time when vegetation cover in the project area is reduced. Ideally, a new set of low-level, color infrared aerial photographs, taken at a time of low vegetation, would be very helpful for use during the intensive survey work.

It should be noted that evaluations and recommendations given here (see Table 1, at end) have been made based on the surface reconnaissance survey. There is always the possiblility, however remote, that previously unidentified surface structural remains, subsurface cultural features, or deposits of high significance might be encountered in the course of subsequent archaeological investigations or other development activities.

SUMMARY OF GENERAL SIGNIFICANCE ASSESSMENTS AND RECOMMENDED GENERAL TREATMENTS

To facilitate outside review of project findings, evaluations, and recommendations, general significance assessments and recommended general treatments for all archaeological sites identified within the Kealakekua Ranch Makai Land Subdivision project area are summarized in Table 2. Thirty-three of the 49 designated archaeological sites identified within the project area have been determined to be significant solely for their information content. Thirty of these sites still contain significant information, and additional data collection is recommended. The same assessment and recommendation pertains to the combined, but not individually designated, remains collectively referred to as the "intact remains of the Kona Field System," a representative sample of which should be further investigated. Sufficient data have already been collected from the remaining three sites (significant solely for their information content), and no further work is needed.

Nine sites have been determined to be significant for their information content and may also have cultural significance as burial sites, pending the findings of further investigations. Five sites have been determined to be significant, for their information content as well as for being good examples of specific site types. Two sites have been determined to be significant for information content, as site type examples, and for cultural values.

Table 2.

SUMMARY OF GENERAL SIGNIFICANCE ASSESSMENTS
AND RECOMMENDED GENERAL TREATMENTS
KEALAKEKUA RANCH MAKAI LAND SUBDIVISION PROJECT AREA

Site Number (T-)	Significance Category				Recommended Treatment			
	A	X	B	C	FDC	NFW	PID	PAI
1	+	-	-	-	+	-	-	-
2	+	-	-	-	+	-	-	-
3	+	-	-	-	+	-	-	-
4	+	-	-	-	+	-	-	-
5	+	-	-	-	+	-	-	-
6	+	-	-	-	+	-	-	-
7	+	-	-	-	+	-	-	-
8	+	-	-	-	+	-	-	-
9	+	-	-	-	+	-	-	-
10	+	-	-	-	+	-	-	-
11	+	-	-	-	+	-	-	-
14	+	-	-	-	+	-	-	-
15	+	-	-	-	+	-	-	-
16	+	-	-	-	+	-	-	-
17	+	-	-	-	+	-	-	-
18	+	-	-	-	+	-	-	-
19	+	-	-	-	+	-	-	-
20	+	-	-	-	+	-	-	-
21	+	-	-	-	+	-	-	-

General Significance Categories:

A=Important for information content, further data collection necessary (PHRI=research value);
X=Important for information content, no further data collection necessary (PHRI=research value, SHPO=not significant);
B=Excellent example of site type at local, region, island, state or national level (PHRI=interpretive value); and
C=Culturally significant (PHRI=cultural value).

Recommended General Treatments:

FDC=Further data collection necessary (intensive survey and testing, and possibly subsequent data recovery/mitigation excavations);
NFW=No further work of any kind necessary, sufficient data collected, archaeological clearance recommended, no preservation potential (possible inclusion into landscaping suggested for consideration);
PID=Preservation with some level of interpretive development recommended (including appropriate related data recovery work); and
PAI=Preservation "as is," with no further work (and possible inclusion into landscaping), or minimal further data collection necessary.

Table 2. (Cont.)

Site Number (T-)	Significance Category				Recommended Treatment			
	A	X	B	C	FDC	NFW	PID	PAI
22	+	-	-	-	+	-	-	-
24	+	-	-	-	+	-	-	-
28	+	-	-	-	+	-	-	-
29	+	-	-	-	+	-	-	-
30	+	-	-	-	+	-	-	-
32	+	-	-	-	+	-	-	-
34	+	-	-	-	+	-	-	-
38	+	-	-	-	+	-	-	-
42	+	-	-	-	+	-	-	-
43	+	-	-	-	+	-	-	-
45	+	-	-	-	+	-	-	-
Subtotal: 30	30	0	0	0	30	0	0	0
12	+	-	-	*	+	-	-	*
13	+	-	-	*	+	-	-	*
25	+	-	-	*	+	-	-	*
31	+	-	-	*	+	-	-	*
36	+	-	-	*	+	-	-	*
39	+	-	-	*	+	-	-	*
41	+	-	-	*	+	-	-	*
46	+	-	-	*	+	-	-	*
47	+	-	-	*	+	-	-	*
Subtotal: 9	9	0	0	9	9	0	0	9
26	+	-	+	-	+	-	?	?
37	+	-	+	-	+	-	?	?
44	+	-	+	-	+	-	-	+
208	+	-	+	-	+	-	?	?
209	+	-	+	-	+	-	?	?
Subtotal: 5	5	0	5	0	5	0	0	1

*Provisional assessment, definite assessment pending further data collections (i.e., testing features for presence/absence of skeletal remains).

?Recommendation with regard to possible preservation deferred until completion of recommended further data collection (intensive survey).

Table 2. (Cont.)

Site Number (T-)	Significance Category A	X	B	C	Recommended Treatment FDC	NFW	PID	PAI
33	+	-	+	+	+	-	+	-
7324#	+	-	+	+	+	-	?	?
Subtotal: 2	2	0	2	2	2	0	1	0
23	-	+	-	-	-	+	-	-
40	-	+	-	-	-	+	-	-
205	-	+	-	-	-	+	-	-
Subtotal: 3	0	3	0	0	0	3	0	0
Total: 49	46	3	7	11	46	3	1	1

#HRHP Site No.50-10-37-7324.

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Table 1.

SUMMARY OF IDENTIFIED SITES AND FEATURES
KEALAKEKUA RANCH MAKAI LAND SUBDIVISION

Site & Feature Number	Formal Site/Feature Type	Tentative Functional Interpretation	*Significance Evaluation			#Field Work Tasks			Comments
			R	I	C	DR	SC	EX	
Zone A									
T-1	Terrace	Agricultural	L	L	L	+	-	-	Roughly shaped; coral and water-worn basalt cobbles present
T-2	Terrace	Agricultural	L	L	L	+	-	-	Prob. originally connected to T-1
T-3	Wall/Embank-ments/ Terrace	Agricultural	M	L	L	+	-	+	Field boundaries, cross-slope terraces; waterworn basalt cobbles on surface
T-4	Wall/Embank-ment	Agricultural	L	L	L	+	-	-	Remnant field boundary; disturbed
T-5	Wall/Embank-ment	Agricultural	L	L	L	+	-	-	Field boundary; may originally have extended from T-3
T-6	Terrace	Agricultural	L	L	L	+	-	+	L-shaped; one of better built agricultural terraces

*Significance Evaluation--Nature: R = scientific research, I = interpretive, C = cultural;
Degree: H = high, M = moderate, L = low.

#Recommended Action--Specific Intensive Survey Field Work Tasks:
DR = detailed recording
SC = surface collection
EX = test excavations

Table 1. (Cont.)

Site & Feature Number	Formal Site/Feature Type	Tentative Functional Interpretation	Significance Evaluation R	I	C	Field Work Tasks DR	SC	EX	Comments
T-7	Complex (2)*	Agricultural	H	L	L				Located in kukui
A	Walled structure					-	-	+	grove; terrace
B	Terrace					-	-	-	disturbed
T-8	Wall/Embank-ment/Terraces	Agricultural	L	L	L	+	-	-	Field boundary and cross-slope terraces
T-9	Complex (2)	Habitation	H	L	L				Pig bones on
A	Cave shelter					-	-	+	interior surface
B	Wall segment					-	-	-	of Feature A
T-10	Mod. outcrop/	Agricultural	L	L	L	+	-	-	-
T-11	Wall/Embank-ment/Terrace	Agricultural	L	L	L	+	-	-	Field boundary and cross-slope terraces
T-12	Platform	Poss. burial	H	L	L/H	-	-	+	Oval shaped; located in agricultural complex; waterworn basalt cobble on surface
T-13	Platform	Habitation/ Poss. burial	H	L	L/H	-	-	+	Rectangular shaped
T-14	Shelter	Habitation	H	L	L	-	+	+	Surface midden present; bedrock mortar, small stone cup, basalt core
T-15	Complex (2)	Habitation/	H	M	L				Coral, waterworn
A	Enclosure	Agricultural				-	-	+	basalt cobble in
B	Platform					-	-	+	Feature A
T-16	C-shape	Habitation	H	L	L	+	-	+	Walled shelter; associated with field boundaries and cross-slope terraces

*Number of component features within complex.

Table 1. (Cont.)

Site & Feature Number	Formal Site/Feature Type	Tentative Functional Interpretation	Significance Evaluation R	I	C	Field Work Tasks DR	SC	EX	Comments
T-19	Walled enclosure	Agricultural/ Habitation(?)	H	L	L	+	-	+	Poss. remains of collapsed/ disturbed animal pen
T-20	Walls/Embank-ments	Agricultural	H	L	L	+	-	-	Field boundaries with associated terraces
T-21	Terrace	Agricultural/ Habitation	H	L	L	-	-	+	Several waterworn basalt cobbles on surface
T-24	Complex (2)	Habitation	H	L	L				Bulldozing dis-
A	Lava bubble shelter					-	-	+	turbance evident immediately
B	Walled enclosure					-	-	-	adjacent to site; prob. Soehren's Site 201
T-36	Complex (3)	Poss. burials/ Habitation	H	L	L/H				Prob. Soehren's
A1	Platform					+	-	+	Sites 202 and 203
A2	Platform					+	-	+	
B	Terrace					+	-	+	
T-37	Complex (3)	Historic	H	M	L				Historic bottle
A	Terrace	habitation				+	+	+	ceramics, water-
B	Walled terrace					+	+	+	worn basalt
C	Retaining wall section					+	-	-	cobble, broken basalt adze blank on Feature A
T-39	Platform	Poss. burial	H	L	L/H	+	-	+	Roughly rectan-gular shaped; located on small hill; appears isolated
T-41	Complex (3)	Habitation/	H	L	L/H				Feature A quite
A	Walled terrace	Poss. burial				+	-	+	large and sub-
B	Walled structure					+	-	+	stantial resi-
C	Platform					+	-	+	dential structure
T-42	Mod. outcrop	Agricultural	H	L	L	+	-	-	Located in kukui grove

Table 1. (Cont.)

Site & Feature Number	Formal Site/Feature Type	Tentative Functional Interpretation	Significance Evaluation R	I	C	Field Work Tasks DR	SC	EX	Comments
T-43	Walled terrace	Habitation	H	L	L	+	-	+	Heavy vegetation cover
Zone B									
T-17	Walled structure	Habitation	H	L	L	- -	- -	+ +	Rectangular-shaped; level soil floor on interior
T-18	Terrace	Historic habitation	H	M	L	- -	+ +	+ +	Historic bottles and old fence wire on surface
T-22	U-shape	Poss. animal pen	H	L	L	-	+	+	Historic rectangular bottle on surface
T-23	Terrace	Agricultural	L	L	L	-	-	-	Surface appears too sloping for habitation use
T-25	Complex (12)	Poss. burials/ Agricultural/ Habitation	H	L	L/H				Coral, waterworn basalt cobbles, shell midden on surface; prob. Soehren's Site 202
A	Mound					+	-	+	
B	Mound					+	-	+	
C	Terrace					+	-	+	
D	Mound					+	-	+	
E	Mound					+	-	+	
F	Mound					+	-	+	
G	Mound					+	-	+	
H	Mound					+	-	+	
I	Mound					+	-	+	
J	Mound					+	-	+	
K	Mound					+	-	+	
L	Wall segment					+	-	+	
T-26	Complex (5)	Historic habitation	H	M	L				Historic bottles, ceramics, and square nail on surface
A	Walled structure					-	+	+	
B	Walled structure					-	-	+	
C	Wall section and mound					-	+	+	
D	Retaining wall and ramp					-	+	-	
E	Terrace					+	-	-	

Table 1. (Cont.)

Site & Feature Number	Formal Site/Feature Type	Tentative Functional Interpretation	Significance Evaluation R	I	C	Field Work Tasks DR	SC	EX	Comments
Zone C									
T-40	Walled terrace	Habitation/ Agricultural	L	L	L	-	-	-	Roughly built; situated in *kukui* grove
Zone D									
T-28	C-shape	Habitation	M	L	L	+	+	+	Surface shell midden present
T-29	Terraces (2-3)	Agricultural	M	L	L	+	-	+	Roughly built; coral cobble and waterworn basalt boulder on surface
T-30	Terrace	Habitation	H	L	L	+	-	+	Rectangular shaped; waterworn basalt cobble on surface
T-31	Platform	Poss. burial/ Agricultural	M	L	L/H	+	-	+	Small, oval shaped structure; poss. historic
T-32	Complex (2)	Historic habitation	M	M	L				Historic bottles, ceramics, basalt hammerstone present; prob. Soehren's Site 204
A	Walled structure					+	+	+	
B	Terrace					+	-	+	
T-33	Complex (7)	Habitation/ Poss. burials	H	M	H				Surface shell midden, basalt cobbles, coral present
A	Walled structure					+	+	+	
B	Terrace					+	+	+	
C	Terrace					+	+	+	
D	Terrace					+	+	+	
E	Enclosure					+	+	+	
F	Platform					+	+	+	
G	Mound					+	+	+	

Table 1. (Cont.)

Site & Feature Number	Formal Site/Feature Type	Tentative Functional Interpretation	Significance Evaluation R	I	C	Field Work Tasks DR	SC	EX	Comments
T-34	Terrace	Habitation	H	L	L	+	+	+	High, rectangular shaped; surface shell midden present
T-38	Retaining wall	Agricultural/ Habitation	H	L	L	+	-	+	Shell midden on surface
T-44	Elevated roadway	Transportation	M	H	L	+	-	-	Historic "Old Pineapple Road"
T-45	Terrace	Agricultural	L	L	L	+	-	+	-
T-46	Walled terrace	Habitation/ Poss. burial	H	L	L/H	+	-	+	Rough basalt core on surface; prob. Soehren's Site 207
T-47	Platform	Poss. burial	H	L	L/H	+	-	+	Prob. Soehren's Site 206
205	Enclosure	Animal pen	L	L	L	-	-	-	Not relocated, poss. destroyed; described in Soehren and Newman 1968
208	Cart road	Historic transportation	M	M	L	+	-	-	Not inspected in field; recorded by Soehren and Newman in 1968
209	Foot trail	Prehistoric transportation	H	H	L	+	-	-	Not identified in field; described in Soehren and Newman 1968
Zone E									
7324	Historic house	Habitation/ Poss. burials	H	H	L/H	+	-	+	First wood frame house built in Kealakekua shupua'a; HRHP site

Appendix 8:
IRRIGATION WELL ALTERNATIVES FOR THE KEALAKEKUA BAY CLUB IN SOUTH KONA, HAWAII

Irrigation Well Alternatives for the Kealakekua Bay Club in South Kona, Hawaii

Prepared by
Tom Nance Water Resources Engineering

Prepared for
Royal Coast Development Corporation

April 1991

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Introduction

This report summarizes the results of a groundwater evaluation for the proposed Kealakekua Bay Club at Kealakekua Bay in South Kona, Hawaii. An 18-hole golf course, clubhouse, and a 36-unit lodge are planned for the 262-acre project site. Potable water will be supplied by the County Department of Water Supply (DWS) system. DWS' sources are the three Keei wells located 2.7 to 3.6 miles southeast of the project site at ground elevations between 740 and 880 feet. Irrigation water is to be supplied from one or in more new wells to be developed within the project bounds or in the near vicinity. Developing recommendations for the new irrigation well or wells is the primary objective of the groundwater evaluation.

Irrigation Supply Requirement

Since only a preliminary routing plan of the golf course has been completed, the total irrigated area and its supply requirements can only be approximated. It is reasonable to assume that about 120 acres will be irrigated at a year-round average rate of 1.5 inches per week (equivalent to 5800 gallons per day per acre). This would amount to almost 0.7 million gallons per day (MGD) for the entire golf course. In dry periods and during the course's initial grow-in, water use is likely to be higher, possibly in the range of 1.0 to 1.2 MGD. It would also appropriate to use the golf course's non-potable supply to irrigate landscaping around the clubhouse and 36-unit lodge. For the purposes of this report, it has been assumed that the irrigation system's source of supply should be capable of providing at least 0.7 MGD as a year-round average and up to 1.2 MGD during peak use. This would require a well pumping capacity in the range of 800 to 850 gallons per minute (GPM).

Generalized Hydro-Geologic Conditions

The project site is located on prehistoric lava flows from Mauna Loa volcano (referred to as the Kau Volcanic Series). It is also immediately inland of the Kealakekua fault scarp (see Figure 1). The fault is actually a series of echelon faults which trend from northwest to southeast and are buried by more recent flows at its southern end. Although the fault is a dramatic topographic feature, it is not expected to have a significant influence on the occurrence or movement of groundwater. It may be significant, however, that the trend of the fault is generally parallel to the southeast rift zone of Hualalai.

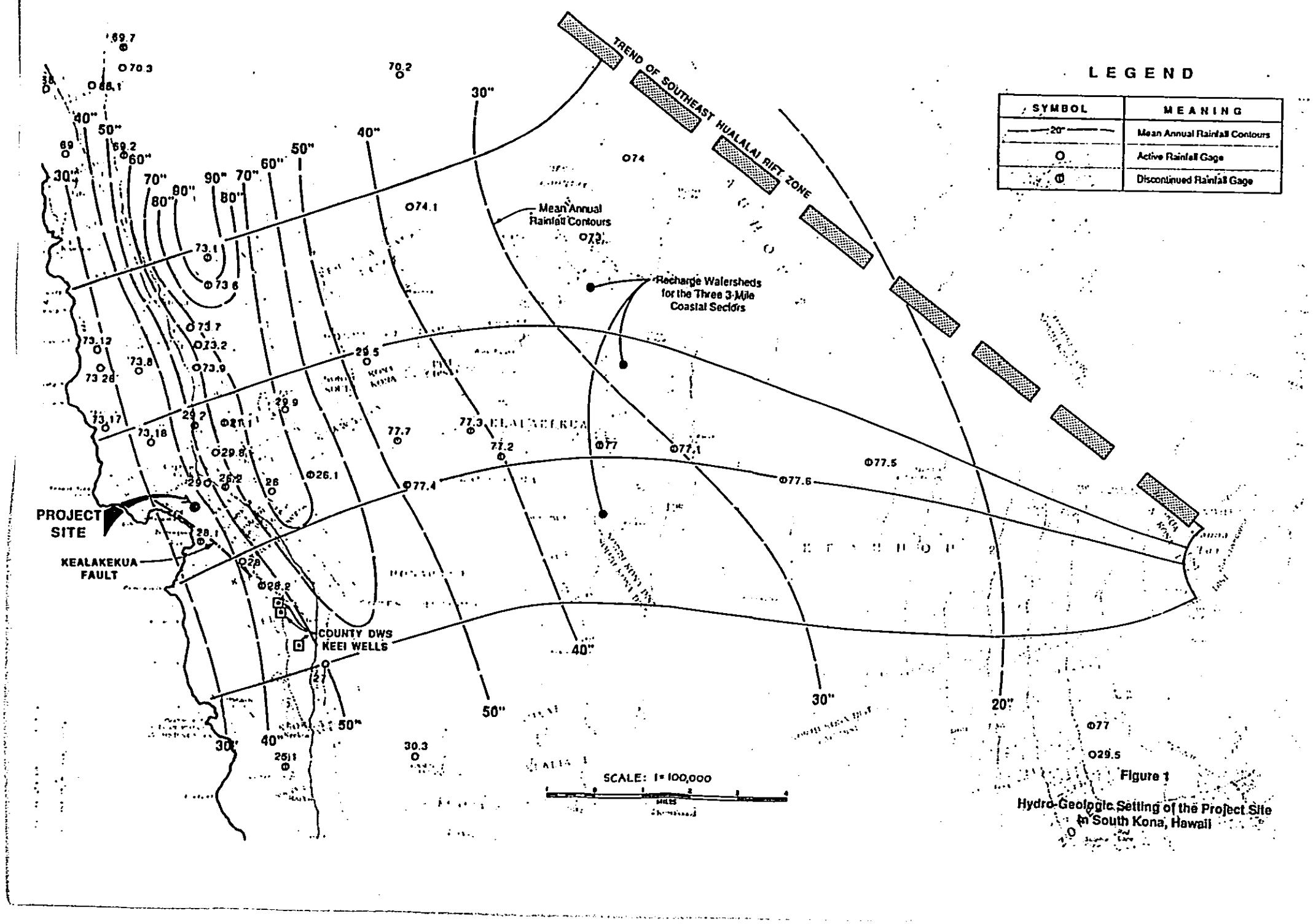

Figure 1

Hydro-Geologic Setting of the Project Site in South Kona, Hawaii

The only drilled wells in the near vicinity of the project are DWS' three Keel wells. The driller's logs of these wells indicate that the entire depth penetrated is comprised of a series of lava flows. There is no indications of the existence of an ash bed or clay horizon within the sequence of lava flows. Groundwater at the Keel wells occurs as a basal lens, which is presumably the same condition which exists beneath the project site. This means that it exists as a lens of fresh (or brackish) water floating on and in hydraulic contact with seawater which saturates the lavas at depth. The stability of the basal lens configuration is due to a number of factors: the density difference between fresh water and seawater; the very slow movement of groundwater generally; and the fact that the horizontal movement of groundwater toward the shoreline is several orders of magnitude greater than vertical movement of water (which would tend to mix the fresh and seawater) and the effect of upward diffusion and dispersion of salts from the saline water at depth. The natural and continuous movement of freshwater from its inland sources of recharge toward its shoreline discharge drives the groundwater system. The contact of fresh and saline groundwater actually occurs as a transition zone rather than as an abrupt change in salinity. The interface between these two groundwater bodies is the location within the transition zone where the salinity is 50 percent of seawater. The Ghyben-Herzberg principle provides a useful mathematical characterization of a basal lens. It states that based on the density differences of fresh and seawater, for every foot that the freshwater lens extends above sea level, the depth to the fresh-saltwater interface below sea level will be 40 times as great. "Head" is a term that is often used to indicate the height that the top of the basal lens' extends above sea level. For example, for the 2.3 to 4.2-foot heads which are reported for DWS' Keel wells, the Ghyben-Herzberg principle indicates that basal lens thicknesses are 92 to 168 feet.

A thin basal lens is particularly vulnerable to seawater intrusion which can occur when its dynamic equilibrium is disturbed by overpumping. All of DWS' Keel wells have experienced significant salinity increases, for example, even though they penetrate just 25 to 30 feet into the lens, amounting to less than one-quarter of the lens' thickness. DWS has reduced its pumping rates at the Keel wells to keep their salinity within acceptable limits.

Estimated Groundwater Flow and Safe Yield to Wells

To provide an order-of-magnitude estimate of potential groundwater flowrates, a water budget was created for the watersheds of the three, three-mile wide sectors of the coastline shown on Figure 1. The northernmost three-mile stretch includes an area of higher rainfall and extends inland to a presumed groundwater divide, an extension of Hualalai's southeast rift zone toward the peak of Mauna Loa. The middle sector includes the project site and extends 20 miles inland to the top of Mauna Loa. Its watershed is separated laterally from the other two sectors based on surface topography. The

southern three-mile sector includes DWS' three Keel wells. The total area of all three watersheds is 170 square miles. Almost half, about 80 square miles, is in the northernmost three-mile sector.

Rainfall averages about 30 inches per year along the shoreline. It increases significantly upslope to a peak band of rainfall which occurs about three miles inland. Peak rainfalls in this band are 60 to 90 inches per year. Further inland, the rainfall tapers off to about 20 inches per year at the top of the mountain (the rainfall contours shown on Figure 1 were developed from the records of the gages listed in Table 1). Rainfall over the entire 170-square mile watershed averages 35 inches per year. This is equivalent to an average of 280 MGD.

To estimate the groundwater flowrate and its safe yield, the portion of rainfall which percolates to become groundwater recharge must be estimated. Figure 2 presents the rainfall-runoff relationship that was used for this estimate. It is based on data from similar areas and is considered to be at least generally representative. For the 30 inches per year of rain which occurs along the coast, recharge amounts to 10 to 15 percent of the rainfall total. Inland where the rainfall is 60 to 70 inches per year, the recharge rate increases to 25 to 30 percent of rainfall. This rainfall-recharge relationship was applied to each area bounded by rainfall contours and watershed boundaries. The amounts of recharge within each bounded area were then added to obtain the following total recharge amounts for each three-mile wide sector:

Sector	Area (Sq. Miles)	Rainfall		Estimated Recharge	
		Inches/Year	Equivalent MGD	Inches/Year	Equivalent MGD
Northern 3 Miles	78	32	114	5.2	20
Middle 3 Miles	40	40	76	7.1	14
Southern 3 Miles	52	36	88	5.9	15
Total	170	--	278	--	49

The northern 3-mile sector has the largest potential recharge, amounting to 20 MGD or an average of almost 7 MGD per coastal mile. The other two sectors have essentially the same rate of recharge, approximately 5 MGD per mile. This rate is relatively large, but not unprecedented, in comparison to other areas along the West Hawaii coast.

For a basal lens in highly permeable flow lavas, the maximum draft rate which can be sustained from wells without adverse effects is about one-third to one-half of the recharge rate. Since the project site spans 1.2 miles of the shoreline, this would amount to a maximum draft rate of 2.0 to 3.0 MGD. This is significantly more than the irrigation requirements of the project.

Table 1

Average and Median Rainfall Amounts at Gages in the Kealakekua, South Kona Area

Gage No.	Name	Elev. (ft. msl)	Period of Record	No. of Years	Median (in./yr.)	Average (in./yr.)
25.1	Kalahiki	750	95-07	10	41.1	45.9
26	Takashiba	2100	37-79	39	78.4	77.1
28.1	Tank Field	2600	53-73	18	66.1	67.7
28.2	Kealakekua	1450	01-83	59	60.6	62.1
27	Honaunau	1090	38-83	46	49	50.8
28	Napoopoo	400	38-83	42	40.4	40.1
28.1	Napoopoo 18	15	01-38	37	34.5	35.5
28.2	Keei Middle Road	680	55-81	18	53.2	52
29	Kaawaloa	1340	42-83	41	55.5	55.2
29.1	Kealakekua	1580	91-15	24	66.1	66.5
29.2	Kalukalu	1500	20-29	10	58.6	61.4
29.5	Kanakamelai	3120	56-83	25	39.1	41.8
29.8	Onouli	1600	60-83	22	54.4	54.1
29.9	Malukalu	2560	62-83	19	68.8	64.3
30	Komokawai	6150	44-81	5	37.8	40.3
30.3	Kilae Stream	2595	60-82	7	70	56.3
68	Holualoa Beach	10	18-79	54	27.5	28.9
68.1	Middle Holualoa	42	31-78	42	39.9	46.8
69	Kahaluu Beach	40	47-78	29	30.9	31.6
69.2	Kahaluu	1080	38-64	25	55.6	57.1
69.7	Kailua-Yowell	950	80-02	20	54.8	54.8
70.2	Kaalapuuali	4500	39-83	44	36.1	36.6
70.3	Holualoa-Smith	1210	48-80	9	61.1	63.5
73	Puu Lehua	4850	22-83	59	28.1	28.9
73.1	Keauhou 73A	1890	27-81	32	91.4	101
73.12	Kainaliu Beach	15	59-83	18	30.8	30.3
73.17	Puu O Hau	10	60-83	21	30	29.4
73.18	Pineapple	800	60-83	20	35.1	35.6
73.2	Kainaliu	1500	31-83	53	66.4	68.3
73.28	Hokakano Beach	0	66-80	11	25.9	25.3
73.3	Mokuakaua Road	1980	54-62	7	93.1	94.4
73.6	Honalo 2	1800	54-72	18	85.6	85.2
73.7	Lehuula	1410	56-83	24	60.7	59.8
73.8	Hokukano Makai	500	55-80	20	34.9	32.5
73.9	Hokukano Mauka	1410	55-80	22	54.9	54.4
74	Kanahaha	5060	22-83	59	27.4	27.8
74.1	Kaukahoku	4030	56-83	21	34.8	35.1
77	Papaloa	5120	32-73	40	23.4	24.4
77.1	Papai Clark	5900	58-73	16	28.6	30.8
77.2	Paushi	4320	52-73	20	37.2	38
77.3	Pump 4	4055	53-73	19	54	51.1
77.4	J P	3550	52-73	20	47.2	47.4
77.5	Hoohui Makani	8100	58-73	13	21	22.4
77.6	Keanakini	7100	59-73	14	27.5	31.2
77.7	No. 3A Pump	3550	62-78	12	42.9	46.8

Notes: 1. The median and average rainfalls given in the table are based on records through 1983.
2. Rain gages 30, 30.3, 70.3, and 73.3 have incomplete records. The medians and averages given above are based only on the complete years of record.

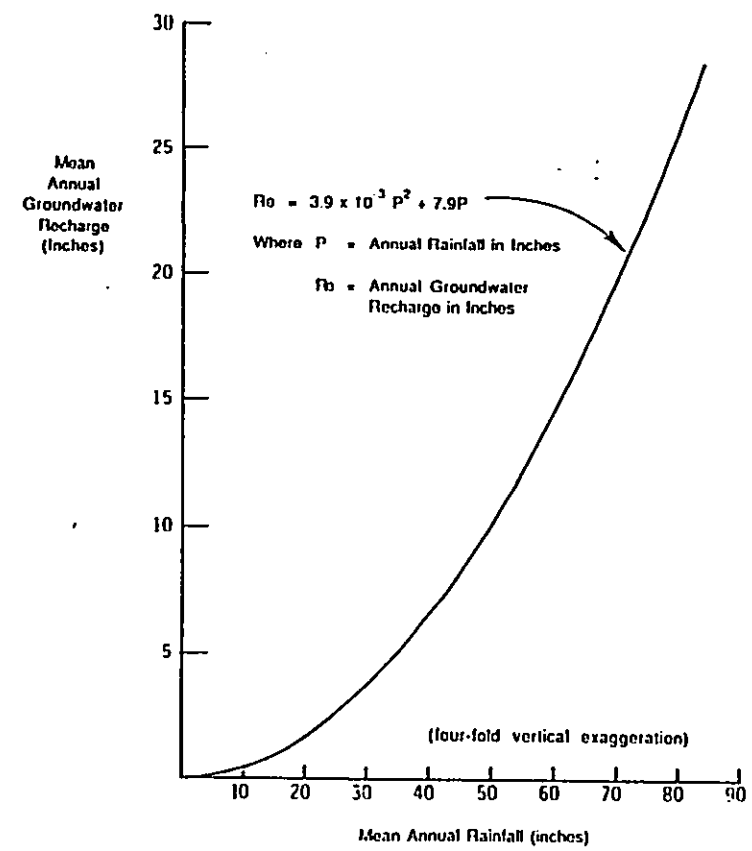

Figure 2

Basis For Estimating Groundwater Recharge From Annual Rainfall

The experience of DWS' Keel wells is instructive. They are located 1.9 to 2.2 miles from the shoreline and produce potable quality water from a relatively thin basal lens. However, they have shown significant salinity increases in response to relatively modest pumping rates. Keel wells A and B had initial chloride levels of 90 milligrams per liter (MGL). When their combined pumpage was just 0.4 MGD, chlorides occasionally exceeded 300 MGL and were often above 200 MGL. Well C, the last and best of the wells, had an initial chloride concentration of 25 MGL. At its present 0.5 MGD pumpage rate, the chlorides have stabilized in the 60 to 90 MGL range. Although the salinity response to pumping is obvious, the wells' performance is actually quite good. For similar basal heads and distances inland elsewhere along the West Hawaii coast, brackish water with chlorides in the range of 300 to 600 MGL are the norm. The experience of the Keel wells provides, at least indirectly, some confirmation that the estimated rainfall-recharge rate is of the right order of magnitude.

Geophysical Survey Methods and Results

The firm of Blackhawk Geosciences, Inc. was commissioned to do a time domain electromagnetic (TDEM) resistivity survey within and above the project site. A complete report of its methods, field work, and interpretive results can be found in the appendix. The TDEM method assumes that the underlying strata occur as horizontal, or nearly horizontal, layers. For this assumption, the method determines the thicknesses and resistivities of the layers. Where the underlying geology consists of flow lavas lying on a mild gradient and where groundwater occurs as a basal lens, the technique has proven to be accurate and useful. The strong contrast in resistivity of lava saturated with freshwater in the basal lens in comparison to the underlying lava saturated with seawater enables the interface of these two groundwater bodies to be located. Using the Ghyben-Herzberg relationship, the depth of this occurrence below sea level can be converted to a freshwater head above sea level and the thickness of the lens will have been determined. This information, along with the estimated groundwater flowrate and an assessment of the formation's permeability, allow a relatively confident prediction assessment of the potential success of a well to be made.

At locations where the underlying geology is more complicated than a simple sequence of flow lavas, particularly if it is interrupted by nearly vertical structures such as one or more intrusive dikes, the TDEM result cannot be clearly interpreted. It does not resolve the vertical structure and it does not provide information on groundwater conditions. However, this result is still useful. The fact that the geology is not simply a sequence of flow lavas and that groundwater may not occur as a basal lens is significant. Further, the presence of a geologic structure can be inferred from such a result.

Blackhawk completed six TDEM measurements at the survey loop sites shown on Figure 3. Results at the lowest three loops, numbers 1, 2, and 3, depict two layers of contrasting resistivity. The upper, more resistive layer extends from the ground surface to the bottom of the fresh, basal lens. Resistivities of the unsaturated flow lavas above the lens and that of the lavas saturated with fresh water within the lens are essentially the same. The lower, more conductive layer is interpreted as flow lavas saturated with saline water. The depths of the interface of these layers are 66, 46, and 127 feet below sea level at loops 1, 2, and 3. These results portray a basal lens with heads of 1.6, 1.1, and 3.2 feet above sea level at the respective locations. The head and lens thickness at loops 1 and 3 are generally expectable for the estimated groundwater flow through highly permeable lavas. The calculated lens thickness at loop 2 is significantly thinner than expected. There is no obvious geologic explanation for this result. Variations in resistivity among the layers within these lower three loops provides no further indication. Without additional information, however, this results depicts an area where a well is not likely to be successful.

TDEM loops 4 and 5 were located further upslope and just north of the project site. Results at both of these sites suggest that the geology there is more complex than a sequence of flow lavas containing a basal lens. At loop 4, a relatively conductive layer (but not as conductive as seawater in lavas) is depicted as occurring 400 feet above sea level. At loop 5, it is approximately 50 feet below sea level. These results suggest the presence of geologic structures that significantly influence groundwater flow. In general, such structures have a beneficial effect. They are generally of lower permeability, commonly function as hydrologic barriers which impede the movement of fresh groundwater toward the shoreline, build the head up in the groundwater body directly inland, and retard the intrusion of seawater. In other words, wells located inland of such structures are more likely to tap a thicker body of fresher groundwater which would be less vulnerable to salinity increases in response to pumping.

After the results at loops 4 and 5 were obtained, an attempt was made to verify the find with one more loop further inland. Unfortunately, problems of access and the presence of powerlines, buried pipelines, and houses limited the choice to the loop 6 site. When the results for this site were analyzed, however, it was apparent that the effect of surrounding development had rendered this TDEM result uninterpretable.

Alternative Well Locations to Consider

The choice of a well site must consider the order-of-magnitude estimate of groundwater flow, TDEM survey results, the relatively high elevation of the golf course (which translates to a deep, expensive well), and the need for a supply capacity in the range of 1.0 to 1.2 MGD. These suggest that

months to obtain and the prospects that it will be granted are good. However, if the well produces potable quality water, its use for golf course irrigation may be prohibited. The Commission has recently been requiring golf course irrigation to be done will be lesser quality (non-potable) water. To use potable water, the applicant must be able to demonstrate that non-potable alternatives do not exist or would entail prohibitive costs to develop.

The Commission's attitude toward golf course irrigation should definitely be taken into consideration in the choice of the well site. At the lower well site location (above loop 2), the basal lens occurrence of groundwater provides some flexibility. If the initial water quality is potable, the well could be deepened to produce slightly brackish water and thus be acceptable for irrigation use. If the upper well site is inland of a hydrologic barrier which gives rise to a very thick fresh groundwater body, it may not be possible to modify the well to produce more saline water. Ironically, results at the site chosen for its hydrologic potential may be too good to allow it to be used for its intended purpose.

Recommendations

The recommendations below assume that the well or wells will be used exclusively for irrigation of the golf course and landscaping around the clubhouse and 36-unit lodge. If the well might also be used for potable supply, the recommendations would be modified accordingly.

1. Locate the well at the "Recommended Site" shown on Figure 4. The site has been selected to be seaward of the geologic structure and tap into the basal lens at its most advantageous location. The ground elevation is 1130 feet. The well should be drilled to about 40 feet below sea level.

2. If, upon completion of the first well, a second well appears necessary, locate it at the second well site shown in Lot 1 on Figure 4.

3. Drill the first well using rotary or air hammer methods. Either of those methods can complete a pilot borehole in the shortest time (about six weeks) at the least cost (approximately $200 to $225 per linear foot). Results from the pilot hole can be used to modify the final well design, if appropriate. With cable tool drilling, the other method commonly used in Hawaii, it would take 10 months to a year to get any information on groundwater conditions and far more money would be at risk during this stage of the work. The cost of the cable tool borehole, which is drilled to the full diameter of the production well, is in the range of $350 to $400 per linear foot.

APPENDIX

Time Domain Electro-Magnetic Resistivity Survey

by

Blackhawk Geosciences, Inc.

GEOPHYSICAL SURVEYS FOR
GROUND WATER EVALUATION
ROYAL COAST DEVELOPMENT CORPORATION GOLF COURSE
ISLAND OF HAWAII

Prepared For:

Tom Nance Water Resources Engineering
680 Ala Moana Boulevard, Suite 200
Honolulu, HI 96813

Prepared By:

Blackhawk Geosciences, Inc.
17301 West Colfax Avenue, Suite 170
Golden, CO 80401

(BGI Project #90042)

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Appendix A - Principles of Time Domain EM

Appendix B - Sounding Results

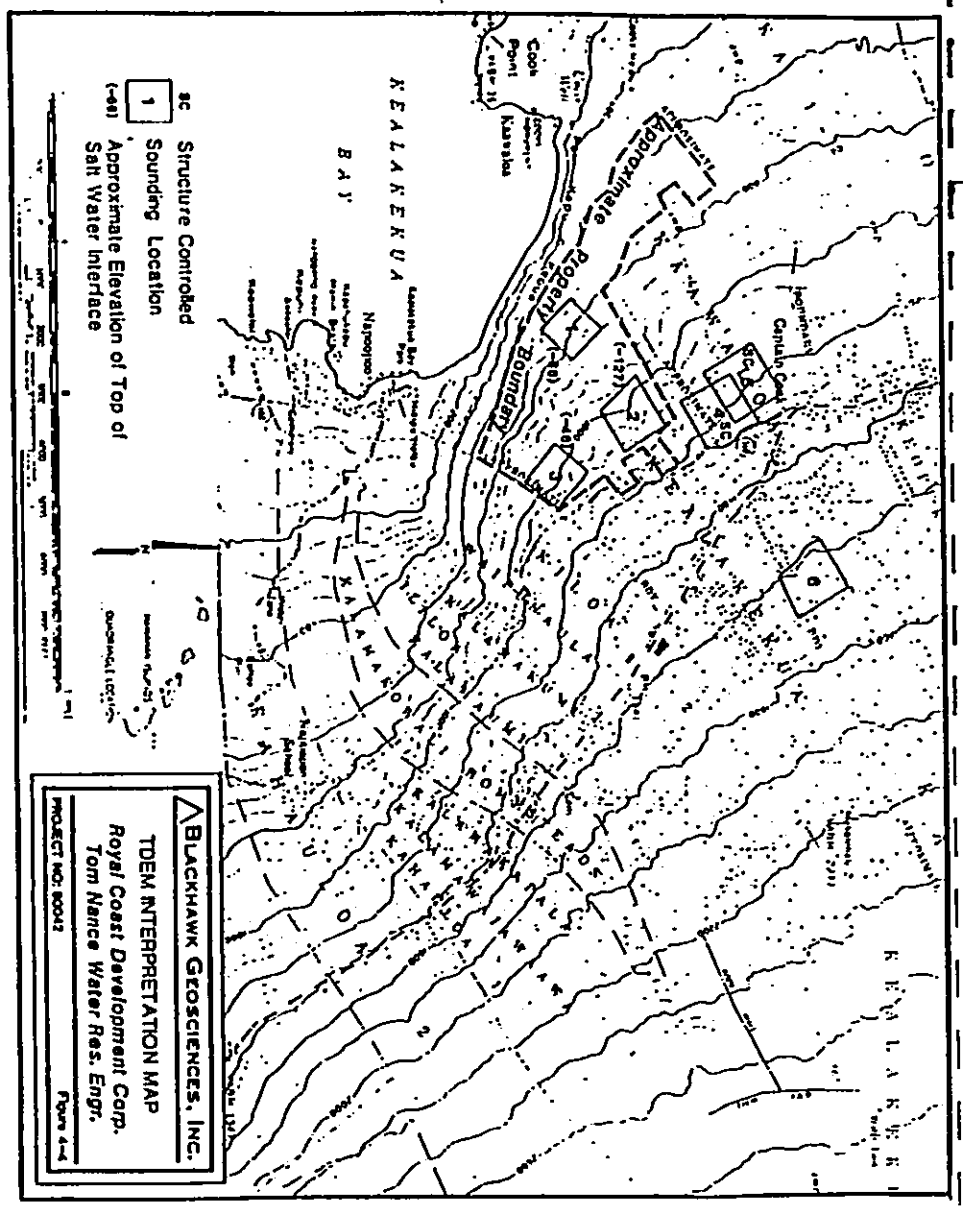

Figure 3. Location of Blackhawk's TDEM Survey Loops

there are two basic approaches toward well development to consider: (i) locate one or more wells within the project site next to or above TDEM loop 2 where the basal lens is most promising; or (ii) put the wells inland of the geologic structure identified by survey loops 4 and 5 to take advantage of the structure's probable beneficial effect. Figure 4 illustrates those alternatives.

Based primarily on the experience of DWS' Keei wells, the basal head of 3.2 feet at the TDEM loop 2 site should translate into a supply of slightly brackish water at the rates of pumping required for the golf course. The lens thickness at other locations within the site, loops 1 or 3, as well as at the northeast end of the project site where no TDEM measurements were made, is too thin to consider for a relatively high capacity well. The most significant advantages of a well or wells above the loop 2 site are that it is within the project site and very near to a logical location for the golf course's irrigation lake. Its most significant disadvantage is that two wells may be required (rather than one) to keep salinities at acceptable levels during maximum irrigation periods. For the depth of well required, 1100 to 1200 feet, a second well could increase the project cost by as much as $900,000 ($550,000 to $600,000 to develop the well itself and $250,000 to $300,000 for the pump, motor, and related works).

If the choice is made to locate the well inland of the geologic structure, land is apparently available in the TMK 8-2-15:12 parcel. The primary advantages of this site are derived from its hydrologic potential. If the well is inland of a beneficial geologic structure, that the quantity and quality of water that could be developed would be substantially greater and its vulnerability to seawater intrusion would be significantly diminished. Inland of a hydrologic boundary, it is quite likely that the well would produce potable quality water. In the event that the geologic structure identified by the TDEM measurements at loops 4 and 5 is not an effective hydrologic barrier, it is still highly likely that the basal lens would be thicker at this location than at loop 2. In other words, there still would be a high probability that the entire irrigation supply could be obtained from just one well.

The higher elevation well site would have several disadvantages, however. It would be more costly because it would be deeper (a total depth of 1350 to 1400 feet) and it would be necessary to construct a pipeline across the road. The energy costs of pumping would also be somewhat higher. This latter cost consideration may only be nominal because the higher elevation well site could potentially irrigate more of the golf course by gravity rather than from a pump station.

Potential Regulatory Constraints

Under the recently changed rules of the State Water Commission, a single permit is required to drill, case, pump test, and then install a permanent pump in the well. The permit takes two to three

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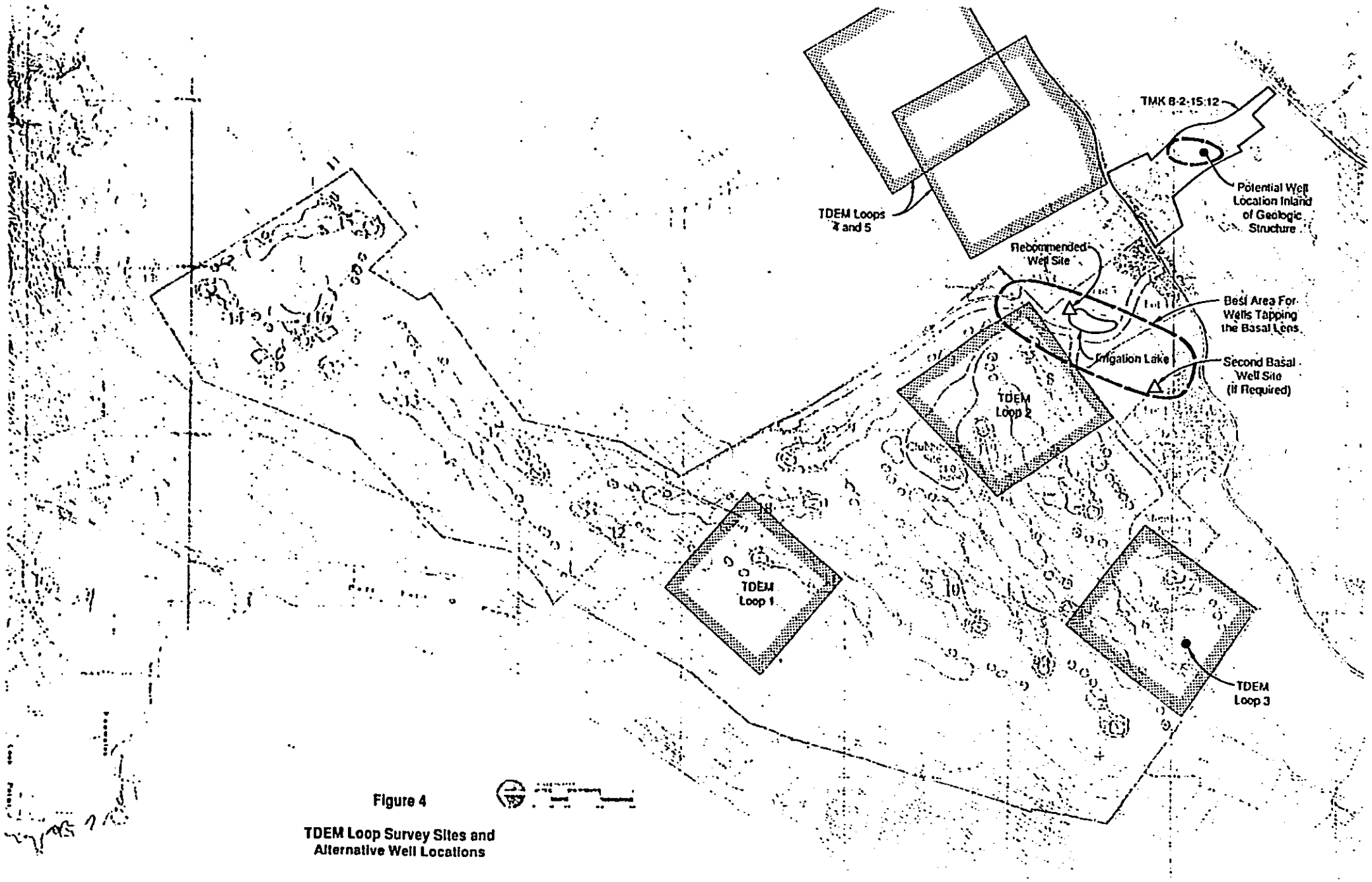


Figure 4

TDEM Loop Survey Sites and Alternative Well Locations

1.0 INTRODUCTION

Time domain electromagnetic (TDEM) geophysical surveys were performed between September 7 to September 17, 1990 on the Island of Hawaii by Blackhawk Geosciences, Inc. (BGI) for Tom Nance Water Resources Engineering. The surveys were conducted to assist in the evaluation of the ground water resources at the proposed Royal Coast Development Corporation (RCDC) Golf Course near Captain Cook.

The primary objective of the geophysical survey was to determine the elevation and thickness of the lens of fresh water floating on salt water. The generalized objectives for utilizing geophysical surveys for ground water evaluations on volcanic islands are illustrated in Figure 1-1. The volcanic rocks are generally highly permeable and this allows rainwater to percolate with little impedance directly downward through the island mass. The fresh water in these island settings is generally found in two environments:

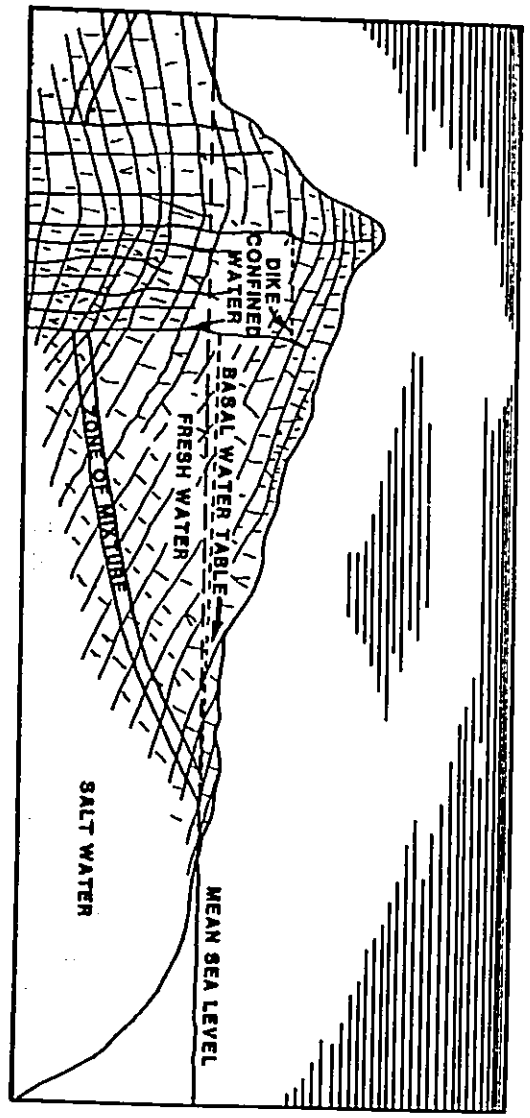
1. Dike-confined waters. Typically, above the rift zone intrusive dikes originating from a magma source below can form ground water dams, and behind these natural dams significant quantities of ground water can be stored.

2. Basal fresh water. The high permeability of the volcanic rocks allows sea water to enter freely under the island, and a delicate balance is reached where a lens of fresh water floats on sea water. In cases of hydrostatic equilibrium, the Ghyben-Herzberg relation states that for every foot of fresh water head above sea level there will be 40 ft of fresh water below sea level.

The impetus for using geophysics is that the cost of a geophysical sounding is about one-thousandth the cost of completing a well at elevations above 1,000 ft. Geophysical surveys, combined with other hydrogeologic information, are used to provide optimum locations for well placement and well completion depths.

Because the electrical resistivity of rock formations is highly dependent upon the salinity of ground water, electrical surface geophysical techniques can map the depth to salt water, and the thickness of the fresh water lens can then be estimated using the Ghyben-Herzberg principle.

The specific geophysical method employed was time domain electromagnetic (TDEM) soundings. This method was selected because it has proven effective in prior surveys in similar settings in Hawaii.



BLACKHAWK GEOSCIENCES, INC.

SCHEMATIC HYDRO-GEOLOGIC CROSS SECTION

Royal Coast Development Corp.
Tom Nance Water Res. Engr.

PROJECT NO: 90042 FIGURE 1-1

2.0 LOGISTICS AND DATA ACQUISITION PROCEDURES

2.1 GENERAL

The TDEM survey was accomplished by a three man crew consisting of two BGI personnel and one local temporary field helper. The locations of the sounding sites were determined during consultation with RCDC personnel and their consulting hydrologist. TDEM soundings were initially made at or near the 800 ft to 1,000 ft level, and several other soundings were acquired at higher elevations north and east of the RCDC property. Figure 2-1 shows the sounding locations.

Transmitter loops varied in size according to the depth of investigation needed and available property and road access. At elevations from 800 ft to 1,000 ft, transmitter loops of 750 ft by 850 ft and 1,000 ft by 1,000 ft were used to detect the salt water interface. One sounding above the 1,600 ft elevation level was acquired with a 1,000 ft by 1,000 ft transmitter loop. After site checking some additional areas (uphill of Hwy 160) were deemed not appropriate for TDEM measurements because of the excessive amount of surrounding power lines and associated culture which can deteriorate data quality.

During the four days of field work a total of 6 soundings were acquired. Sounding locations were surveyed using a compass and hip-chain from known landmarks (i.e., rock walls, roads) located on the field maps. Sounding center elevations were measured using an altimeter in the field and checked with detailed property and USGS maps. A daily log of field activities during this survey is given in Table 2-1.

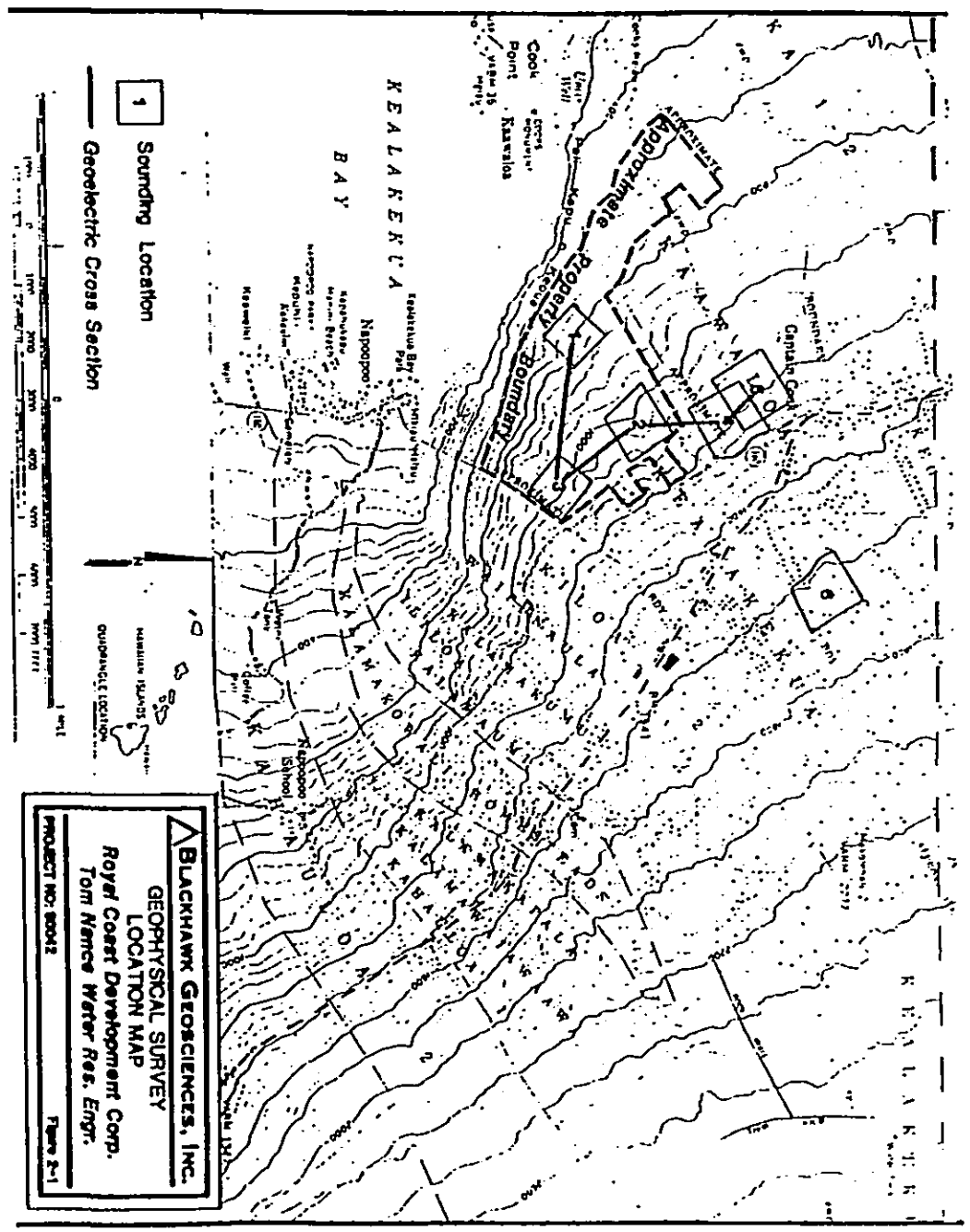
Table 2-1. Daily log of field activities

Date (1990)	Activity
September 6	Mobilize from Denver, CO to Kailua-Kona, HI in conjunction with other surveys.
September 7	Meet with RCDC field representative and conduct field reconnaissance of golf course property for sounding sites. Acquire data on sounding 1.
September 8	RCDC property data on soundings 2 and 3.
September 13	Layout transmitter loop for sounding 4 north of RCDC property in PM. One-half day of field work.
September 14	Reconnaissance with RCDC field representative for other sounding sites north and east of property. Data on sounding 4. One-half day of field work.
September 16	Data on sounding 5. One-half day of field work.
September 17	Data on sounding 6. One-half day of field work.
September 19	Demobilize equipment and BGI personnel.

(September 9 through 12, and September 15 and 18 were days of field work on other Hawaii jobs).

2.2 PROCEDURES

The Geonics EM-37 TDEM system was utilized on this survey. The system basically consists of a transmitter and a receiver. The transmitter loop is constructed of 10 to 12 gauge insulated copper wire. The wire is laid on the ground surface in a square loop varying in size, depending upon the required depth of investigation (larger loop sizes for deeper measurement). A transmitter and motor generator are connected into the non-grounded loop at one corner. A time-varying current is pulsed through the wire at two different base frequencies. The TDEM receiver measures and records the decay of the vertical magnetic field through a receiver coil placed at the center of the non-grounded transmitter loop. Receiver coils with effective areas of 100 m^2 and 1,000 m^2 were utilized at base frequencies of 3 Hz and 30 Hz. During data acquisition numerous transient decays are collected with the receiver for each sounding. Readings were acquired at several receiver gains with opposite receiver polarities for each sounding location. The readings were stored in a DAS-54 solid state data logger, and were nightly transferred to a personal computer for processing. A technical note is given in Appendix A which describes and illustrates the principles of TDEM.



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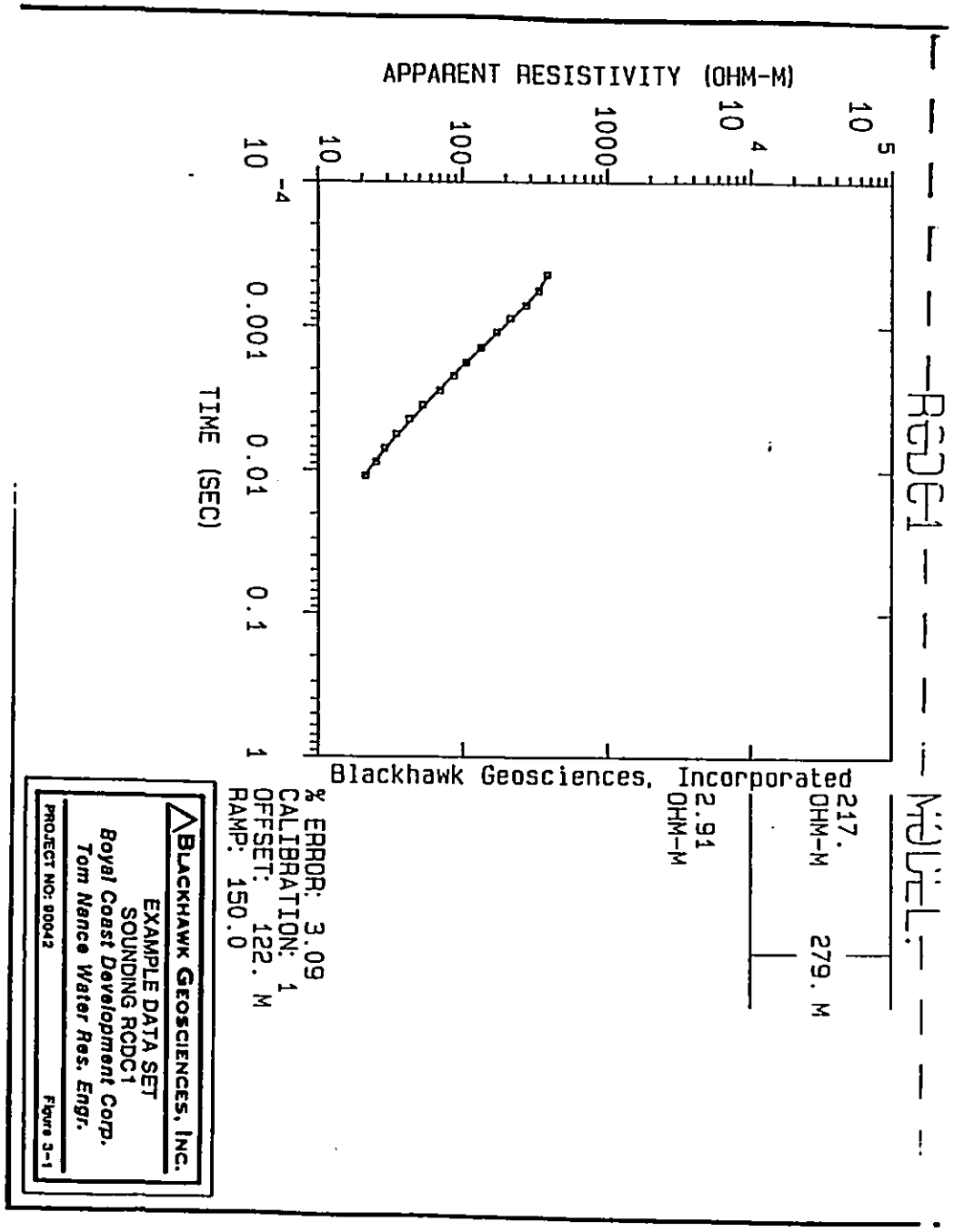
3.0 DATA PROCESSING

The field data acquired each day was transferred from the DAS-54 data logger to a personal computer. The data for each sounding location is edited and combined (both 3 Hz and 30 Hz frequencies) to produce a transient decay curve. This decay curve is transformed into an apparent resistivity curve, which is entered into an Automatic Ridge Regression Transient Inversion Program (ARRTI). From the apparent resistivity curve a one-dimensional model of resistivities and thicknesses is calculated.

The inversion program requires an initial estimate of the geoelectric section, including the number of layers, and the resistivities and thicknesses of each of the layers. The program then adjusts these parameters so that the model curve converges to best fit the curve formed by the field data set. The inversion program does not change the total number of layers within the model, but allows all other parameters to float freely.

An example data set is given in Figures 3-1 and 3-2 for sounding RCDC1. Figure 3-1 shows the measured data points (in terms of apparent resistivity) superimposed on a solid line. The solid line represents the computed behavior of the true resistivity layering shown on the right. Figure 3-2 lists in column 4 the error between measured and computed data in each time gate.

The apparent resistivity curves and data sheets for all soundings are contained in Appendix B.



XEROX COPY

RCDC1

MODEL: 2 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		259.1	850.0		
217.05	279.4	-20.3	-66.6	1.3	1.3
2.91					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	4.43E-04	3.90E+02	3.94E+02	-1.152	
2	5.64E-04	3.41E+02	3.35E+02	1.765	
3	7.13E-04	2.78E+02	2.72E+02	2.056	
4	8.81E-04	2.17E+02	2.21E+02	-1.927	
5	1.10E-03	1.74E+02	1.76E+02	-1.344	
6	1.41E-03	1.35E+02	1.35E+02	-0.493	
7	1.80E-03	1.07E+02	1.06E+02	1.030	
8	2.22E-03	8.74E+01	8.49E+01	2.907	
9	2.80E-03	6.94E+01	6.76E+01	2.718	
10	3.55E-03	5.25E+01	5.38E+01	-2.456	
11	4.43E-03	4.24E+01	4.38E+01	-3.097	
12	5.64E-03	3.45E+01	3.53E+01	-2.249	
13	7.13E-03	2.86E+01	2.89E+01	-1.226	
14	8.81E-03	2.48E+01	2.44E+01	1.712	
15	1.10E-02	2.11E+01	2.06E+01	2.287	

R: 122. X: 0. Y: 122. DL: 243. REQ: 136. CF: 1.0000
CLHZ ARRAY, 15 DATA POINTS, RAMP: 150.0 MICROSEC. DATA: RCDC1
0709 001N 001E Z OPR XTL H 4 8+100
Ch.21 = 0.15 Ch.22 = 0.089 Ch.23 = 17.5 Ch.24 =
RMS LOG ERROR: 1.32E-02, ANTILOG YIELDS 3.0872 %
LATE TIME PARAMETERS

• Blackhawk Geosciences, Incorporated •

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

	P 1	P 2	T 1
P 1	0.96		
P 2	-0.04	0.91	
T 1	0.00	0.00	1.00

BLACKHAWK GEOSCIENCES, INC.
EXAMPLE DATA SET
SOUNDING RCDC1
Royal Coast Development Corp.
Tom Nance Water Res. Engr.
PROJECT NO: 90042 Figure 3-2

4.0 INTERPRETATION RESULTS

4.1 GENERAL

From individual soundings the results of the interpretations are the resistivity layering as a function of depth. Where measurements are taken relatively close together, the results of these individual soundings can be plotted to construct a geoelectric cross-section along a line. Of the six soundings acquired over the area, five were incorporated in a geoelectric cross-section. Figure 2-1 shows the geoelectric cross-section and the individual sounding locations. Rather than projecting sounding 1 on a linear cross-section through soundings 3 through 5, a bend is incorporated on the section.

To infer from the geoelectric cross-sections geologic and geohydrologic information, characteristic ranges of resistivities are assigned to known local geologic and geohydrologic units. The assigned resistivity ranges for the various units expected in the survey area are shown in Figure 4-1. An overlap occurs between the resistivity ranges, and the most extensive overlap is found between the ash flows, weathered volcanics or intrusives, and the dry unweathered or mainly fresh water saturated volcanics. In most cases these two units can be separated by their resistivity value in ohm-m and their relative depth of occurrence in the section. Within the survey area zones of lower resistivities were detected near or above sea level in some of the TDEM soundings. These zones of lower resistivity could be caused by a combination of several factors which affect the resistivity of the hydrogeologic section. These factors are changes in lithology, porosity, and salinity which influence formation resistivity.

Where a very conductive layer (< 5 ohm-m) is detected below sea level, the layer is expected to be caused by salt water saturated volcanics. Static water levels (heads) can subsequently be calculated from these soundings by using the Ghyben-Herzberg principle. This principle states that under conditions of static equilibrium, for every foot of fresh water above sea level there will be about forty feet of fresh water below sea level. An illustration of the Ghyben-Herzberg principle is given in Figure 4-2. This principle, however, assumes static equilibrium and may not apply to TDEM soundings in close proximity to ground water damming structures (i.e., dikes, rifts, etc.).

4.2 GEOELECTRIC CROSS-SECTION

Figure 4-3 shows the results of five TDEM soundings which are presented as a roughly west-to-east-to-north trending geoelectric cross-section. Within the section layers with similar resistivities have been linked together.

Similar two layer sequences are interpreted in the geoelectric section for soundings 1, 2 and 3. The upper layer exhibits resistivities ranging from 217 to 391 ohm-m and is interpreted to represent unweathered volcanics. Where this layer occurs below sea level it is expected to be saturated with fresh-brackish water. The lower layer of these three soundings show resistivities between 2.9 to 4.6 ohm-m, this layer is interpreted to represent salt water saturated volcanics. Assuming static equilibrium exists, the elevation of the static water level (head) can be calculated using the Ghyben-Herzberg principle. The approximate thickness of the fresh-brackish water lens was found to vary below these soundings from 46 ft at sounding 3 to 127 ft at sounding 2.

In the geoelectric section below soundings 4 and 5 a layer with a resistivity of < 5 ohm-m is not observed within the effective exploration depth of the measurements (about -500 ft elevation). At depth in soundings 4 and 5 a lower layer exhibits a resistivity of 7 to 12 ohm-m, respectively, which occurs above or nearly at sea level. Where such distinct changes in geoelectric sections are observed, i.e., between soundings 2 and 4, the data are expected to be affected by lateral changes within the subsurface. This discontinuity may be the result of several geologic factors and is interpreted as ash flows, weathered volcanics, or intrusives.

Similar discontinuities have previously been observed in other areas on the island of Hawaii, and from measurements at elevations above such discontinuities, often the potential for significant fresh ground water resources was inferred. Because of the presence of culture, TDEM measurements could not be made at higher elevations than soundings 4 and 5. In fact, an attempt was made at sounding 6, but this data was distorted by culture. The structure inferred below soundings 4 and 5 can have a number of causes such as ash flows and/or intrusives. If these structures are also hydrogeologic barriers, then the potential for fresh water may exist above them.

4.3 HYDROGEOLOGIC INTERPRETATION

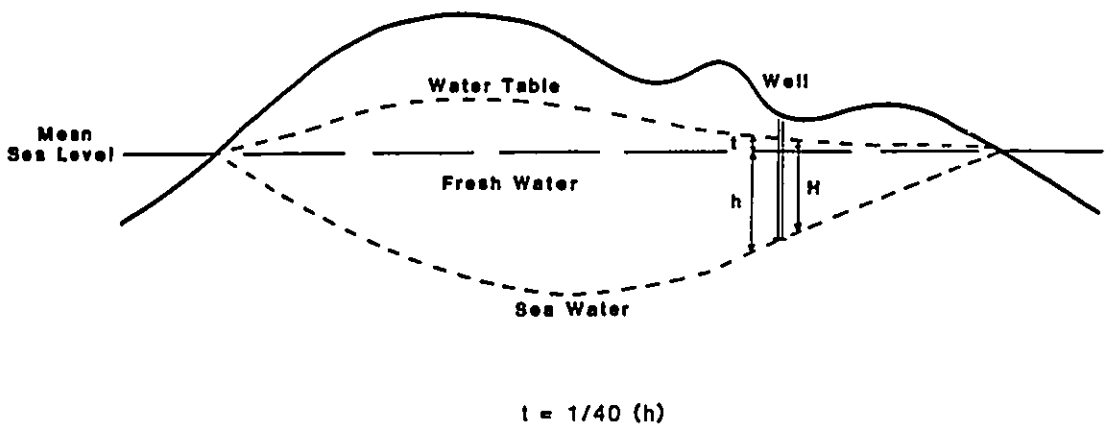
Figure 4-4 shows the geophysical interpretation map for the TDEM survey. Beneath soundings 1, 2 and 3 fresh-brackish water resources are expected to exist in the basal mode. Table 4-1 lists the thickness of the fresh-brackish water lens calculated from the elevation of the salt water interface derived from the TDEM soundings.

Below soundings 4 and 5, ground water conditions are expected to be controlled by geologic structures. Approximate thickness of fresh water resources cannot be computed from the Ghyben-Herzberg principle for these two soundings.

Because of the limited TDEM data density in the area, the boundary between basal mode ground water and structurally controlled ground water could not be determined. Unfortunately, an attempt to obtain data at elevation above soundings 4 and 5 was not successful due to culture (power lines, pipelines, buildings).

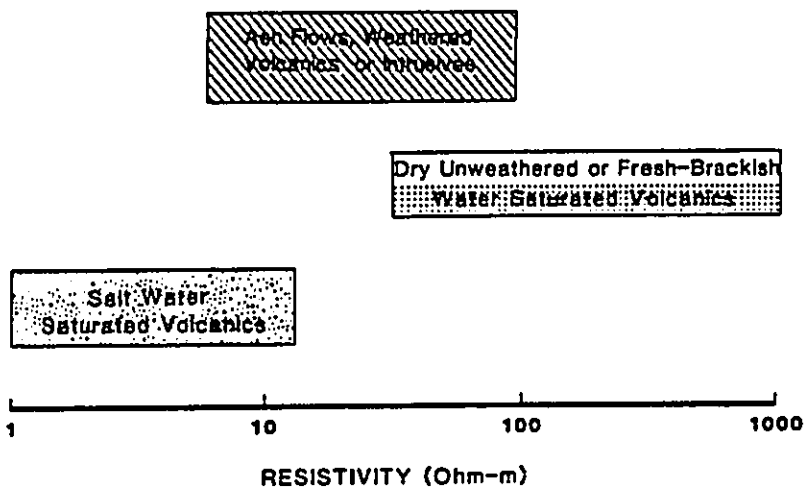
Table 4-1. Hydrogeologic information derived from TDEM soundings

Sounding #	Surface Elevation (ft)	Approximate Thickness of Fresh/Brackish Water Lens (ft)
1	850	66
2	1040	127
3	1000	46
4	1190	Structure Controlled
5	1180	Structure Controlled
6	1630	Distorted Data

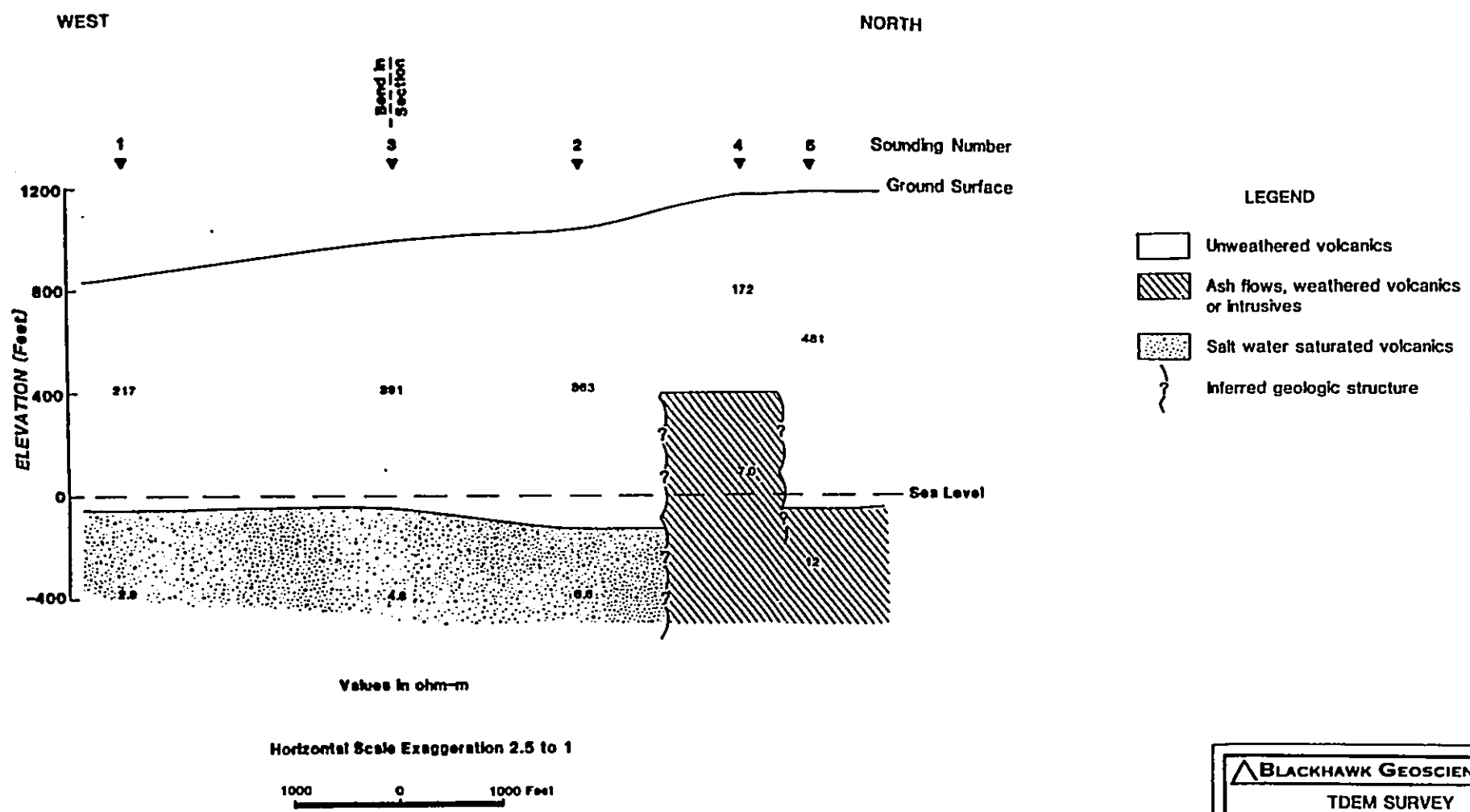


FROM: HERZBERG

BLACKHAWK GEOSCIENCES, INC.
Illustration of the
Ghyben-Herzberg Principle
Royal Coast Development Corp.
Tom Nance Water Res. Engr.
PROJECT NO: 90042 Figure 4-2



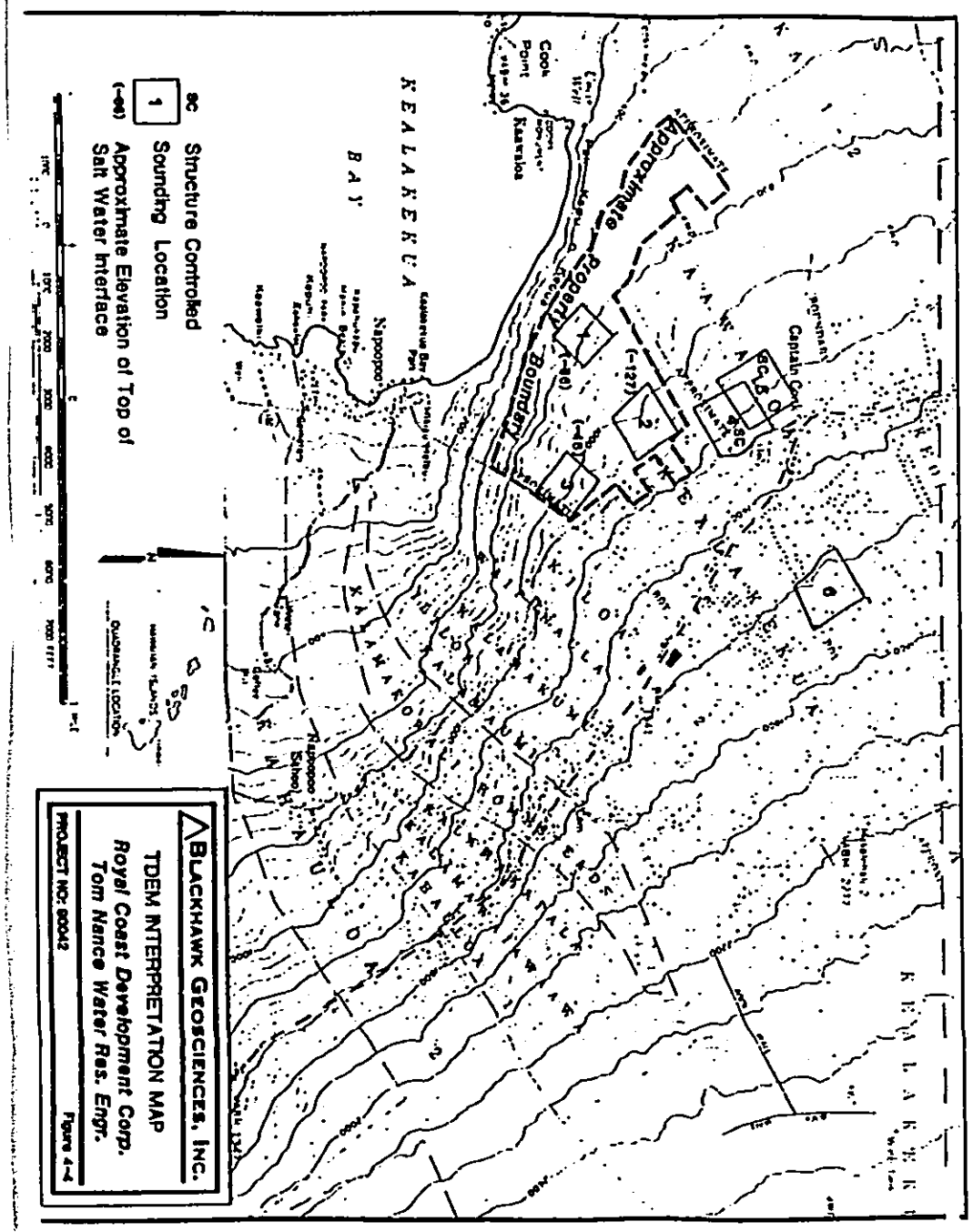
BLACKHAWK GEOSCIENCES, INC.
CHARACTERISTIC
RESISTIVITY RANGES
Royal Coast Development Corp.
Tom Nance Water Res. Engr.
PROJECT NO: 90042 Figure 4-1



BLACKHAWK GEOSCIENCES, INC.

TDEM SURVEY
GEOELECTRIC CROSS SECTION
Royal Coast Development Corp.
Tom Nance Water Res. Engr.

PROJECT NO: 80042 Figure 4-3



5.0 CONCLUSIONS AND RECOMMENDATIONS

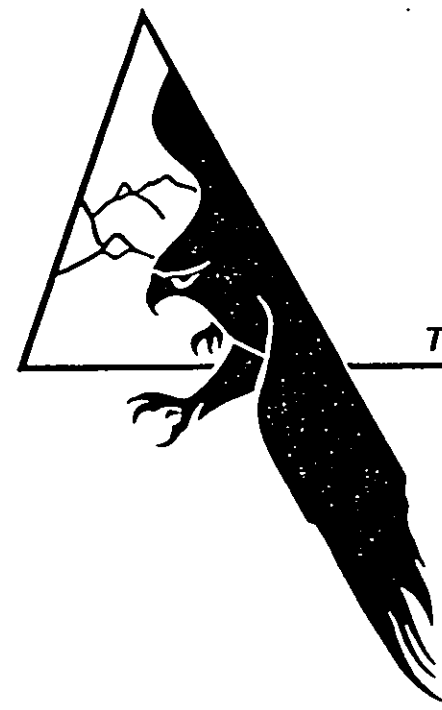
The results of the TDEM survey are summarized in Figure 4-4. In this figure, beneath soundings 1, 2 and 3, ground water resources are expected to be present in the basal mode. From the elevation of the salt water interface derived from the TDEM soundings, and assuming validity of the Ghyben-Herzberg principle, the fresh-brackish ground water resources are expected to be marginal. The thickness of the basal fresh-brackish water lens is expected to vary from about 46 ft to 127 ft in the area.

Beneath soundings 4 and 5, the geoelectric section appears to indicate the existence of a structure, and this structure might control ground water. If this is the case, the potential for dike-confined water may exist above soundings 4 and 5 at higher elevation. An attempt was made to acquire data above the 1,600 ft elevation level, but this proved unsuccessful due to limited property access and excessive cultural noise, which resulted in a distorted TDEM measurement.

The accuracy in determining the depth to the salt water saturated interface has previously been estimated to be about ± 5% of the total depth measured.

Appendix A

Principles of Time Domain EM



PRINCIPLES OF TIME DOMAIN EM

BLACKHAWK GEOSCIENCES, INC.

Question.-- What is TDEM?

Answer.-- TDEM is a surface geophysical method for determining the lateral and vertical resistivity variation (geoelectric section) in the subsurface.

Question.-- What useful information can be derived from the geoelectric section?

Answer.-- Electrical resistivity can be used as an indicator for mapping several important objectives in the subsurface, such as:

1. Presence of contaminants. Dissolved solids in ground water decrease formation resistivities, so that industrial contaminant plumes and differences in salinity (e.g., salt water intrusion) can often be delineated from geoelectric sections.

2. Soil and rock types. Clays and clay shales, and formations of low hydraulic permeability, have lower resistivities than formations of high hydraulic permeability, such as sands and gravels, sandstones, basalts, and high porosity limestones. The geoelectric section can, therefore, be used to map continuity of clay and clay shale lenses.

3. Fractures and shear zones. Such zones are conduits for ground water flow and contaminant migration, and they are often characterized by zones of low resistivity. The reasons for the lower resistivities of these zones are infilling of the fracture zones by clay gouge, alteration of wall rock, and higher water contents.

Question.-- What advantages does TDEM have over other electrical and electromagnetic methods, such as resistivity (direct current) and electromagnetic conductivity profiling with the Geonics EM-31 and EM-34?

Answer.-- The advantages of TDEM over other electrical and electromagnetic methods are

- better vertical and lateral resolution
- lower sensitivity to geologic noise (see page 5)
- the ability to explore below highly conductive layers (e.g., brine saturated layers and clay lenses).

Some of the most frequently asked questions about TDEM and their answers are given below.

Question.-- Are the principles of TDEM similar to electromagnetic induction profiling, such as used in the Geonics EM-31 and EM-34?

Answer.-- Yes, the principles of electromagnetic induction profiling in the frequency domain (FDEM), used in the Geonics EM-31 and EM-34, are in many ways similar to the principles of TDEM.

An important difference between FDEM and TDEM is the current waveform driven through the transmitter loops. It is a continuous, harmonic-varying current in FDEM, and a half-duty cycle waveform in TDEM.

Question.-- Why does the current waveform of the transmitter make a large difference?

Answer.-- The large difference results from the fact that in FDEM the secondary magnetic field due to ground currents is measured when the transmitter current is on, and in TDEM when the transmitter current is off. In both cases the time-variant current driven through the transmitter causes a time-variant primary magnetic field. Associated with this primary magnetic field is an induced electromotive force (emf) that causes eddy current flow in the subsurface. The intensity of these currents is used to determine subsurface conductivities. The induced emf is a harmonic-varying function in FDEM and consists of narrow pulses in TDEM.

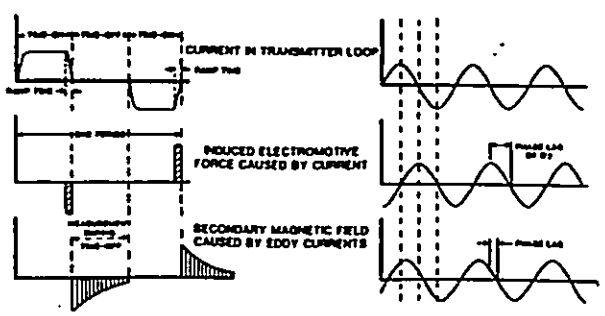


Fig. 1. System waveforms in time domain EM (TDEM) and frequency domain EM (FDEM).

The receiver measures the emf due to the secondary magnetic field of these eddy currents induced in the subsurface, and in the case of FDEM, the emf measured by the receiver is the sum of (1) the primary magnetic field (emf_p due to currents in the transmitter), and (2) the secondary magnetic field (emf_s due to eddy current flow in the ground). Thus,

$$emf_t = emf_p + emf_s$$

where subscript t, p and s refer to total, primary, and secondary magnetic field, respectively. Clearly, emf_s is the only component containing information about the subsurface. Unfortunately, in most situations, the amplitude of emf_s is only one part in 10^4 parts of emf_p. Thus, in FDEM, a small component of emf containing all the useful information about the subsurface must be measured in the presence of a large component containing no information.

In the EM-31 and EM-34 ground conductivity is determined by measuring only the component of emf_s that is in quadrature phase (90° out-of-phase) with emf_p. Unfortunately, theory shows that the in-phase component is more sensitive to ground conductivity. Measuring only the quadrature phase component limits the accuracy, exploration depth, and utility of FDEM systems.

TDEM improves the situation, because measurements are made during the time the transmitter is off. During off-time the only component of emf measured by the receiver is emf_s. Emf_s is determined in the absence of emf_p, greatly improving its accuracy of measurements.

Question.-- Briefly explain how subsurface resistivities are derived from TDEM measurements.

Answer.-- A TDEM system consists of a transmitter and a receiver. The transmitter configuration often used in ground water and environmental applications is a square loop of insulated wire laid on the ground surface (Figure 2). A multi-turn air coil receiver (about 1 m diam) is placed in the center of the loop. The sizes of the transmitter loops employed are mainly dependent upon the required exploration depth and geoelectric section. Typically, the side of a square is about one-half to two-thirds of the required exploration depth. Thus, for exploration depths to about 200 ft, 75 ft by 75 ft transmitter loops may be employed.

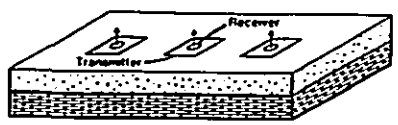


Fig. 2. Transmitter-receiver array in TDEM.

The current waveform driven through the transmitter loops is shown in Figure 1. The waveform consists of equal periods of time-on and time-off. The base frequencies employed in the Geonics instrumentation we employ can be varied from 300 hz, 30 hz, 3 hz and 0.3 hz. These frequencies result in on/off intervals of 0.833, 8.33, 83.3 and 833 msec, respectively.

The current driven through the transmitter loops creates a primary magnetic field. During the rapid current turn-off this primary magnetic field is time-variant and in accordance with Faraday's Law there will be an electromagnetic induction during this time (Figure 1b). This electromagnetic induction in turn results in eddy current flow in the subsurface. The intensity of these currents at a certain time and depth depends on ground conductivity.

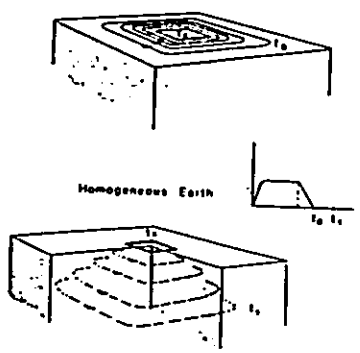


Fig. 3. Current distribution in FDEM at two times after current turn-off.

In near horizontally layered ground, the eddy currents are horizontal closed rings concentric about the center of the transmitter loop. A schematic illustration of these currents is shown in Figure 3. Immediately after turn-off (t_0) the currents are concentrated near the surface, and with increasing time currents are induced at greater depth (t_1).

The receiver measures the emf due the secondary magnetic field caused by these ground eddy currents (Figure 1c). At early time, when the currents are mainly concentrated near the surface, the emf measured will mainly reflect the electrical resistivity of near surface layers. With increasing time, as currents are induced at greater depth, the emf measured will progressively be more influenced by properties of deeper layers. Thus, in TDEM exploration, depth is mainly a function of time of measurement after turn-off.

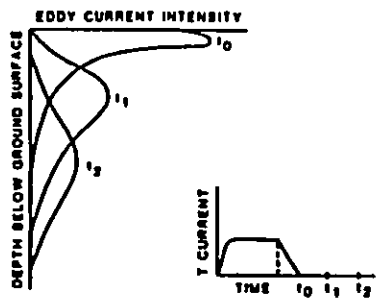


Fig. 4. Schematic illustration of eddy current distribution at different times after turn-off.

Another useful presentation of distribution of current intensity as a function of time is given in Figure 4. At early time, t_0, all currents are concentrated near the surface. At later times (e.g., t_3) the current maxima occur at increasingly greater depth. Thus, from measurements of the decay of emf at one location, the geoelectric section to a substantial depth is obtained.

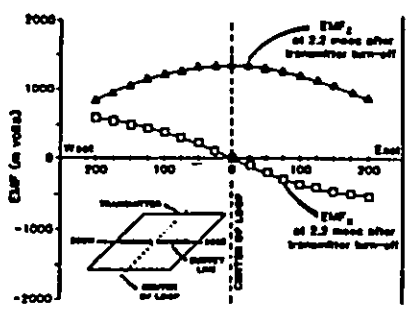


Fig. 5. Spatial behavior of emfs due to vertical (emf_z) and horizontal (emf_x) magnetic field on a profile through the center of square transmitter loop at the time (2.2 millisec) after turn-off.

The emfs caused by square transmitter loops vary with time and distance from the center. Figure 5 shows a typical measured behavior of emfs at a certain time (2.2 milliseconds) after turn-off. At other times the amplitudes will be different, but the spatial behavior is similar. The spatial behavior of the emf_z is relatively flat about the center so that measurements of emf, due to the vertical magnetic field, are relatively insensitive to errors in surveying the center of the loop, or to deviations from a square loop. This is clearly of practical value because it (1. reduces the cost of land surveys and measurement errors, and (2) allows for some flexibility in the field in positioning the measurement stations.

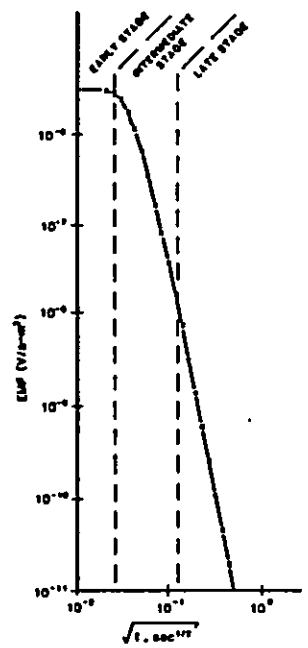


Fig. 6. Typical transient behavior of emf_z in center of square transmitter loop.

Thus, in TDEM soundings, the geoelectric section is derived from measurement of the emf due to the vertical magnetic field (emf_z) as a function of time during the period the transmitter is off. Figure 6 shows a typical behavior of emf_z as a function of time. Emf_z can be seen to decay rapidly with increasing time. One transient decay recorded over a few tens of milliseconds contains information about resistivity layering over a significant depth range.

The emfs, due to the decay of the ground eddy currents, must be measured in the presence of ambient noise sources, such as geomagnetic storms, lightning, 60 hertz powerlines, and other man-made sources. It is common to stack several hundred transient decays to improve signal to noise. Stacking of several hundred transient decays requires only a few seconds, and multiple data sets can be quickly obtained.

The processing and display of TDEM data is in many respects similar to that used in other electrical and electromagnetic methods. The objective of processing TDEM data is to obtain a solution for the resistivity stratification of the subsurface that matches the observed transient.

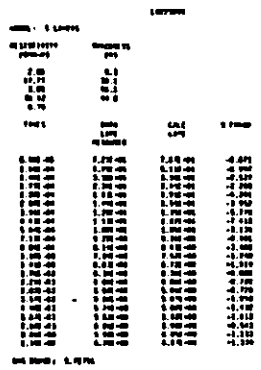


Table 1. Inversion table.

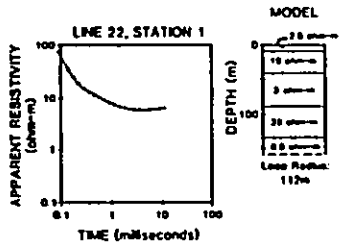


Fig. 7. Example of TDEM apparent resistivity curve and inverted geoelectric section.

The inversion of measured TDEM data into vertical resistivity stratification can be performed on a PC. An example of a data set derived for a sounding is given in Figure 7 and Table 1. In the apparent resistivity curve shown on the left (Figure 7) the measured data at each time gate is superimposed on a model curve of the geoelectric section shown on the right. This geoelectric section represents the best one-dimensional match to the experimental data. In addition to this visual display, an inversion table (Table 1) is obtained that lists (column 4) the error between measured and computed emf at each time gate, as well as an overall RMS error. The data shown on Figure 7 are typical of data quality common to TDEM soundings. Typically, 20 to 30 data points are obtained equally spaced on a logarithmic scale of time. Thus, clearly there is a major difference between TDEM soundings and profiling with the EM-31 and EM-34 (where only a few data points at different effective depths are obtained).

Question.-- If TDEM is a major improvement in electrical geophyics, why has it not been extensively used in ground water and environmental applications?

Answer.-- TDEM has been in common use in the search for base and precious metals, and for deep electrical soundings in support of hydrocarbon and geothermal exploration for about 15 years. The reason for its sparse use so far in ground water and environmental investigations was that no equipment was heretofore available for the often shallow depth (< 100 ft) requirements, common to environmental investigations.

Equipment for shallow exploration recently became available, opening a whole new range of applications for this powerful electrical measurement technique. Figure 8 shows the exploration depth range covered by various instruments.

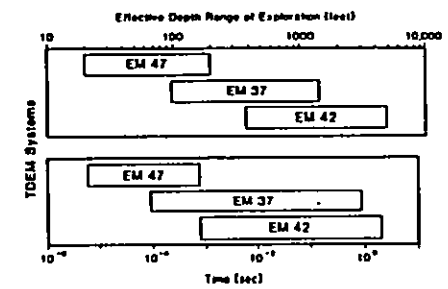


Fig. 8. Effective depth range of exploration and time range of measurement of various TDEM systems.

Question.-- What is geologic noise and why is TDEM less sensitive to such noise?

Answer.-- We define geologic noise as variation in subsurface conditions that obscures the exploration objective. Consider the schematic geologic cross section of the Floridan aquifer (Figure 9). The limestones may be overlain by overburden, likely varying laterally and vertically in soil type and thickness. At some depth in the aquifer an interface between saline and fresh water may occur, and an important exploration objective could be the mapping of this interface. Geologic noise for this objective is the change in soil type and thickness of the overburden. This noise can be very large in direct current resistivity, CSAMT and electromagnetic induction profiling.

Geologic noise is a function of the exploration objective. For example, if the objective in the setting of Figure 9 would have been the mapping of overburden thickness and type (e.g., to delineate areas of prime aquifer recharge), then what was geologic noise before becomes the exploration objective. Geologic noise is often the major cause of poor data quality in geophysical surveys for environmental and ground water applications.

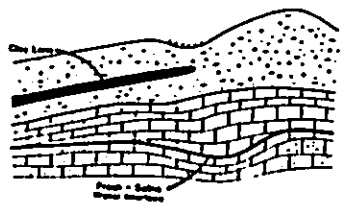


Fig. 9. Schematic geologic section of Floridan aquifer.

Question.-- How does TDEM reduce geologic noise?

Answer.-- This fact can be conceptually explained from Figure 10 where the intensity of eddy current distribution is schematically illustrated as a function of time for the FDEM and TDEM method. At early time (t_0) in TDEM all currents are concentrated near the surface, and near surface formations will largely determine the emf measured. At later time, for example, t_3, currents have largely decayed in near surface layers, and currents dominantly flow at greater depth. The emf measured at time t_3 is near transparent to near surface layers, so that their influence is greatly reduced at time t_3 and later times.

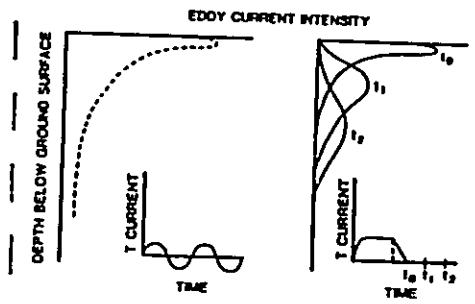


Fig. 10. Eddy current intensity in FDEM and TDEM.

In the FDEM method current intensity is always highest near the surface amplifying the influence of near surface layers.

In summary, geologic noise due to lateral and vertical resistivity variation in TDEM is reduced because:

(a) Exploration depth is mainly a function of time rather than transmitter-receiver separation. The transmitter-receiver separation need not be altered to change exploration depth as is the case in FDEM (EM-31 and EM-34), and direct current resistivity methods.

(b) Relatively small transmitter-receiver separations compared to effective exploration depth are employed.

(c) Measurements at later times are nearly transparent to near surface layers, because eddy currents at later times dominantly flow at greater depth.

Question.-- Can TDEM surveys be effective in mapping fractures and shear zones?

Answer.-- Yes, TDEM can detect contacts, fractures, and shear zones below considerable overburden thickness. The physical concepts of fracture and shear zone mapping are briefly explained.

Electrical and electromagnetic methods are often effective in mapping fractures and shear zones, because fractures and shear zones often are zones of low resistivity in more resistive host rocks. These lower resistivities are generally caused by clay gouge, higher water contents, and alteration in wall rocks. The mapping of fractures and shear zones becomes increasingly more difficult with increasing overburden thickness where outcrops are limited. It is in these situations that geophysical surveys can play an important role.

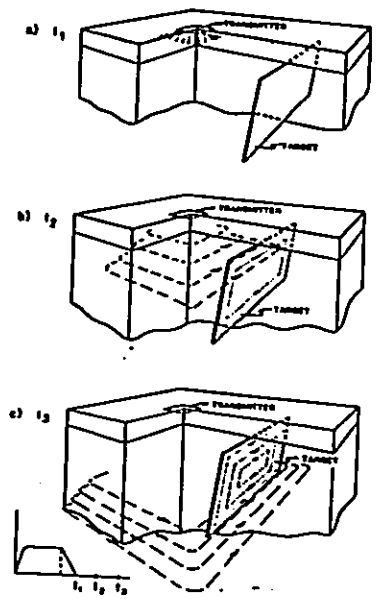


Fig. 11. Illustration of eddy current flow induced in overburden, host rock, and fracture or shear zones at different times.

Thus, in all electrical and electromagnetic methods the geoelectric section is derived by measuring resistance to current flow. We cannot selectively cause current flow in fractures and shear zones, but currents will also be induced in overburden, host rock, fractures and shear zones. The challenge is to isolate the response due to a fracture from the total response, which also contains contributions due to current flow in overburden and host rock.

TDEM is the most effective method for recognizing fractures and shear zones under overburden cover. Figure 11 conceptually explains the physical principles involved. It schematically shows a near vertical fracture zone below overburden cover, and a nearby TDEM source loop induces eddy current flow in the subsurface. At early time (t_0) eddy currents are dominantly situated in the overburden because current flow has not yet reached the fracture. Therefore, a measurement of emf at time, t_0, will not reflect the presence of a fracture zone. At later time currents are induced in the fracture, and because the fracture zone is likely less resistive than adjacent host rock, currents will be preferentially oriented in the fracture plane. In this intermediate time range the emf will contain major contributions due to currents in overburden, host rock and fractures. Currents in overburden may still dominate and fracture zones may be barely detectable. Since the fracture is less resistive than adjacent host rock, currents will decay faster in host rock than in the fracture, and there will be a time range where the fracture has maximum detectability.

To map fractures and shear zones, often different modes of surveying are employed than for determining vertical resistivity stratification (soundings). Figure 12 shows several survey modes. If the strike of the fracture is known a long transmitter loop may be laid out, and profiles are run with a receiver across the fracture zone. Also, a loop-loop array may be employed.

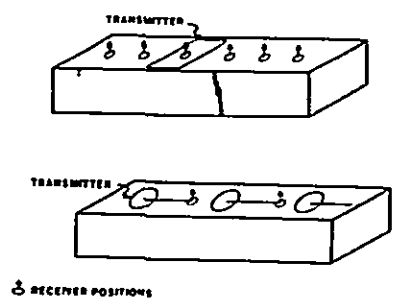


Fig. 12. Transmitter-receiver arrays useful in fracture mapping.

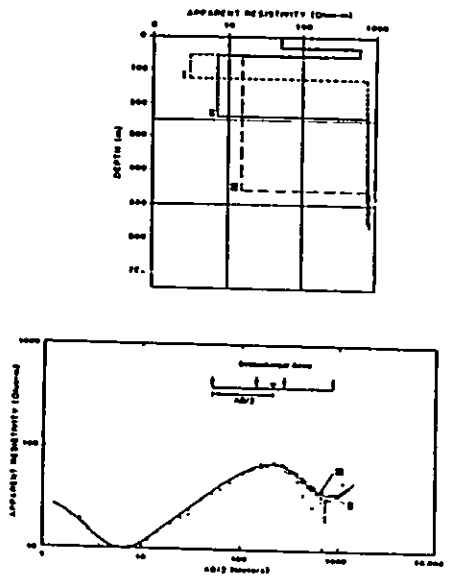


Fig. 13. Schlumberger measured apparent resistivities (a) superimposed on three one-dimensional geoelectric sections (b).

Question.-- I am from Missouri. Show me an example comparing TDEM with another electrical measurement technique next to a drill hole.

Answer.-- In a ground water survey on the coastal plain in Israel, one of the exploration objectives was to map the thickness of alluvium overlying a carbonate bedrock. A drill hole at the survey site showed depth to bedrock at about 168 m (550 ft).

The Institute of Petroleum Research and Geophysics, prior to the arrival of our TDEM crew, conducted a Schlumberger resistivity sounding near the drill hole. The results are given in Figure 13. Measurements were made to AL/2-spacing of 2,000 m (an array length of 4,000 m). The measured apparent resistivity data are superimposed on the forward models of three geoelectric sections. The three geoelectric sections are shown on the right. Clearly, the data can be fitted to any of the three models. Yet, depth to bedrock between the three sections was varied by more than 300 m. The Institute, therefore, quickly decided that Schlumberger-resistivity soundings were not a viable method, because not only was a large effort required to explore to a depth of 168 m (4,000 m of line length), but its vertical resolution was meaningless.

Measurements at the same location were made with TDEM in 200 m by 200 m transmitter loops, and the results of central-loop TDEM soundings are shown in Figure 14. Again, the measured apparent resistivity curves are superimposed on three forward model curves, and the geoelectric sections of the three model curves are shown on the right. Depth to bedrock in the models is varied by 20 m. It is evident that vertical resolution of determining depth to bedrock is now ± 10 m.

Thus, not only was the physical effort required to sound to a depth of 168 m greatly reduced - only 800 m (4 x 200 m) of wire needed to be laid out, - but the vertical resolution was greatly improved.

Question.-- Summarize for me the potential of TDEM in environmental and ground water geophysics.

Answer.--Electrical surface geophysical methods are an important tool because (1) electrical resistivity is the only readily measureable physical property highly dependent of concentration of dissolved solids (water quality), and (2) electrical resistivity often closely relates to clay content and hydraulic permeability. In the past the vertical and lateral resolution of electrical methods was poor. TDEM techniques are changing that reputation.

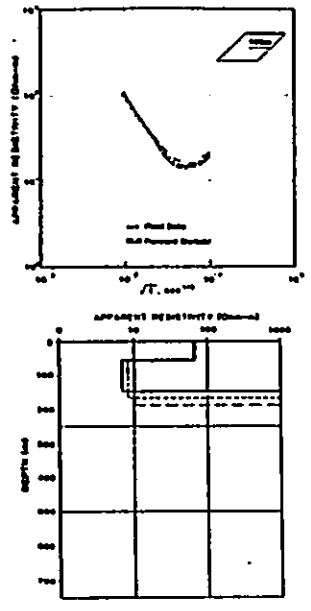


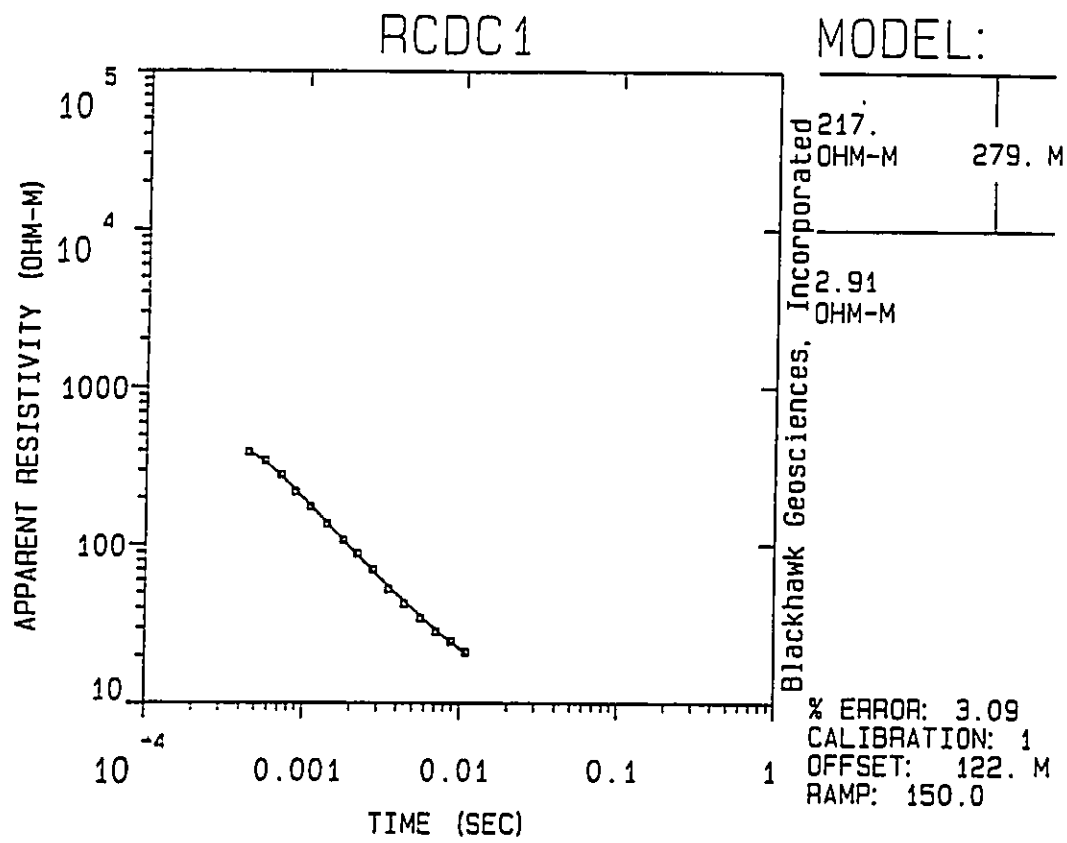
Fig. 14. TDEM measured apparent resistivities (a) superimposed on three one-dimensional geoelectric sections.

Main Office:

BLACKHAWK GEOSCIENCES, INC.
17301 WEST COLFAX AVE., SUITE 170
GOLDEN, CO 80401
(303) 278-8700
FAX (303) 278-0789

Branch Office:

BLACKHAWK GEOSCIENCES, INC.
10111 M.L. KING JR. HWY, SUITE 200-D
BOWIE, MD 20720
(301) 577-7085
FAX (301) 577-7191



Appendix B
Sounding Results

RCDC1

MODEL: 2 LAYERS

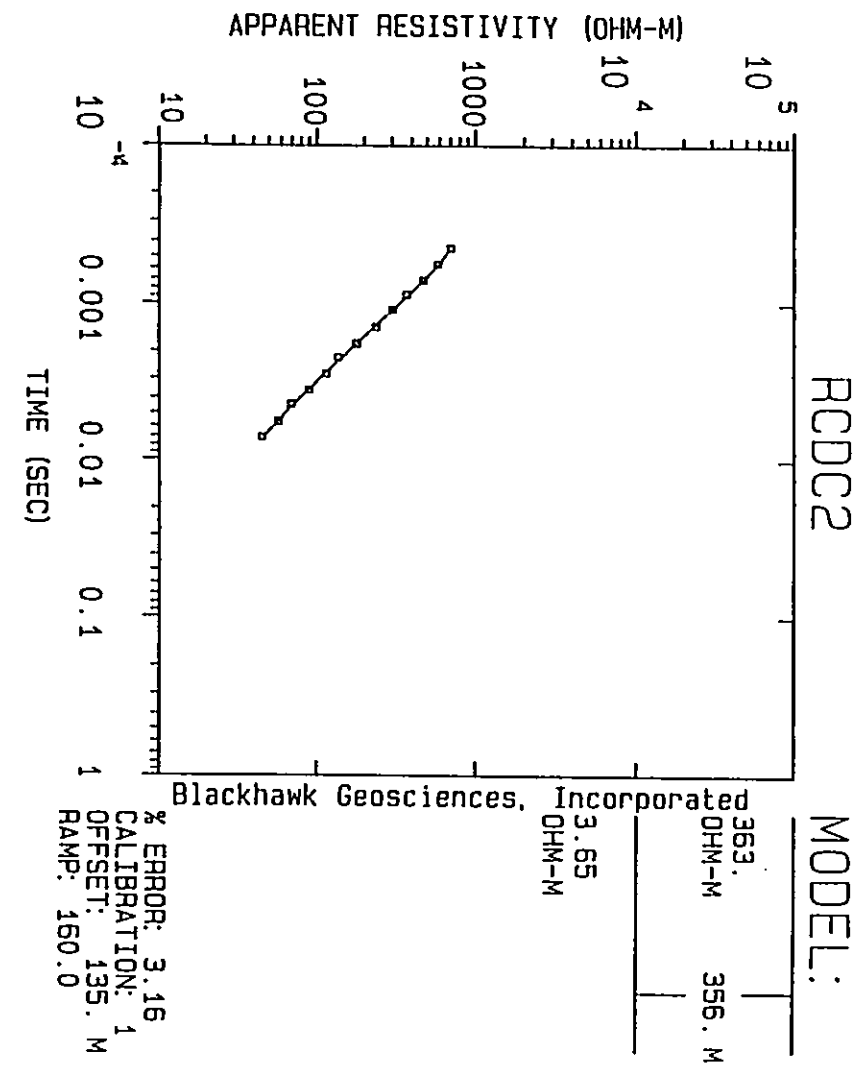
RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		259.1	850.0		
217.05	229.4	-20.3	-66.6	1.3	1.3
2.91					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	4.43E-04	3.90E+02	3.94E+02	-1.152	
2	5.64E-04	3.41E+02	3.35E+02	1.765	
3	7.13E-04	2.78E+02	2.72E+02	2.056	
4	8.81E-04	2.17E+02	2.21E+02	-1.927	
5	1.10E-03	1.74E+02	1.76E+02	-1.344	
6	1.41E-03	1.35E+02	1.35E+02	-0.493	
7	1.80E-03	1.07E+02	1.06E+02	1.030	
8	2.22E-03	8.74E+01	8.49E+01	2.907	
9	2.80E-03	6.94E+01	6.76E+01	2.718	
10	3.55E-03	5.25E+01	5.38E+01	-2.456	
11	4.43E-03	4.24E+01	4.38E+01	-3.097	
12	5.64E-03	3.45E+01	3.53E+01	-2.249	
13	7.13E-03	2.86E+01	2.89E+01	-1.226	
14	8.81E-03	2.48E+01	2.44E+01	1.712	
15	1.10E-02	2.11E+01	2.06E+01	2.287	

R: 122. X: 0. Y: 122. DL: 243. REQ: 136. CF: 1.0000
CLHZ ARRAY, 15 DATA POINTS, RAMP: 150.0 MICROSEC, DATA: RCDC1
0709 001N 001E Z OPR XTL H 4 8+100
Ch.21 = 0.15 Ch.22 = 0.089 Ch.23 = 17.5 Ch.24 =
RMS LOG ERROR: 1.32E-02, ANTILOG YIELDS 3.0872 %
LATE TIME PARAMETERS

• Blackhawk Geosciences, Incorporated •

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER
P 1 0.96
P 2 -0.04 0.91
T 1 0.00 0.00 1.00
P 1 P 2 T 1



RCDC2

MODEL: 2 LAYERS

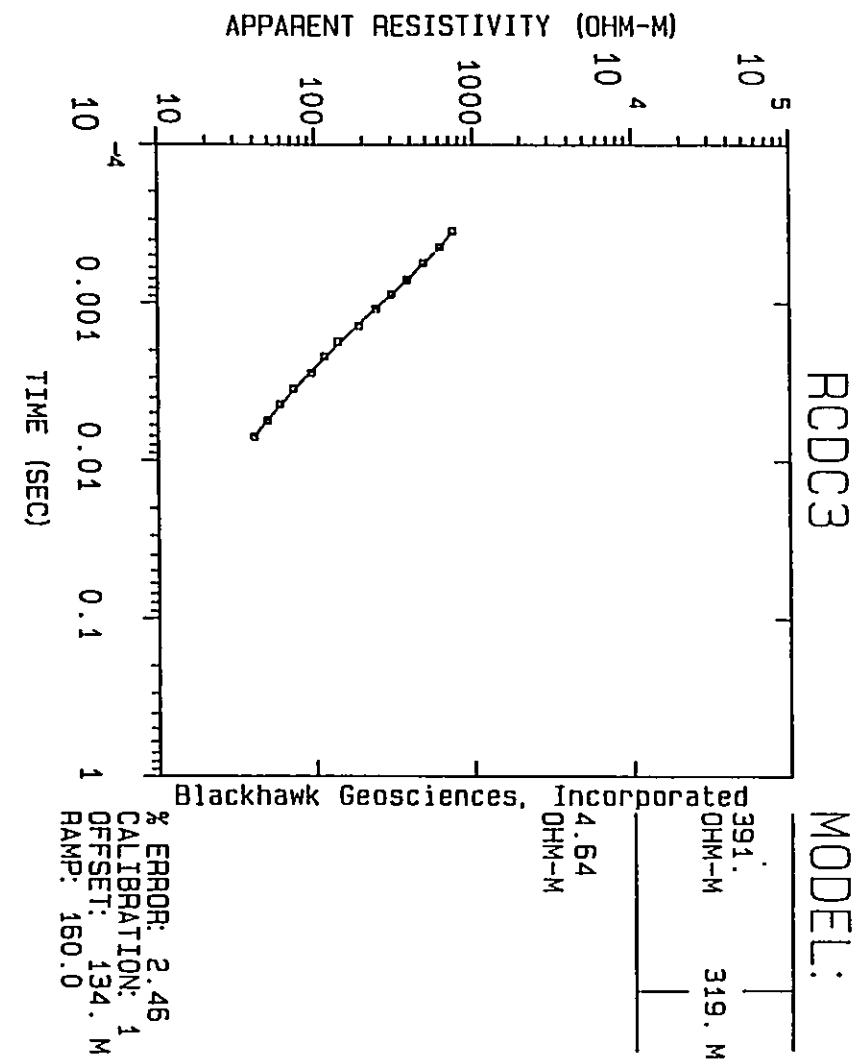
RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		317.0	1040.0		
363.45	355.8	-38.8	-127.2	1.0	1.0
3.65					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	4.43E-04	7.00E+02	6.96E+02	0.506	
2	5.64E-04	5.83E+02	5.84E+02	-0.317	
3	7.13E-04	4.70E+02	4.70E+02	0.061	
4	8.81E-04	3.68E+02	3.78E+02	-2.596	
5	1.10E-03	3.01E+02	2.99E+02	0.621	
6	1.41E-03	2.35E+02	2.28E+02	2.870	
7	1.80E-03	1.78E+02	1.76E+02	0.780	
8	2.20E-03	1.36E+02	1.42E+02	-4.267	
9	2.80E-03	1.15E+02	1.11E+02	3.246	
10	3.55E-03	8.91E+01	8.77E+01	1.578	
11	4.43E-03	6.92E+01	7.08E+01	-2.164	
12	5.64E-03	5.72E+01	5.65E+01	1.355	
13	7.13E-03	4.52E+01	4.58E+01	-1.199	

R: 135. X: 0. Y: 135. DL: 271. REQ: 150. CF: 1.0000
TDHZ ARRAY, 13 DATA POINTS, RAMP: 160.0 MICROSEC. DATA: RCDC2
0809 001N 002E 2 OPR XTL L 6 10+100
Ch.21 = 0.16 Ch.22 = 0.89 Ch.23 = 16 Ch.24 = 73
RMS LOG ERROR: 1.35E-02, ANTILOG YIELDS 3.1620 %
LATE TIME PARAMETERS

• Blackhawk Geosciences, Incorporated •

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER
P 1 0.94
P 2 -0.07 0.80
T 1 0.00 0.00 1.00
P 1 P 2 T 1



RCDC4

MODEL: 2 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		304.8	1000.0		
390.93	318.8	-14.0	-45.8	0.8	0.8
4.64					

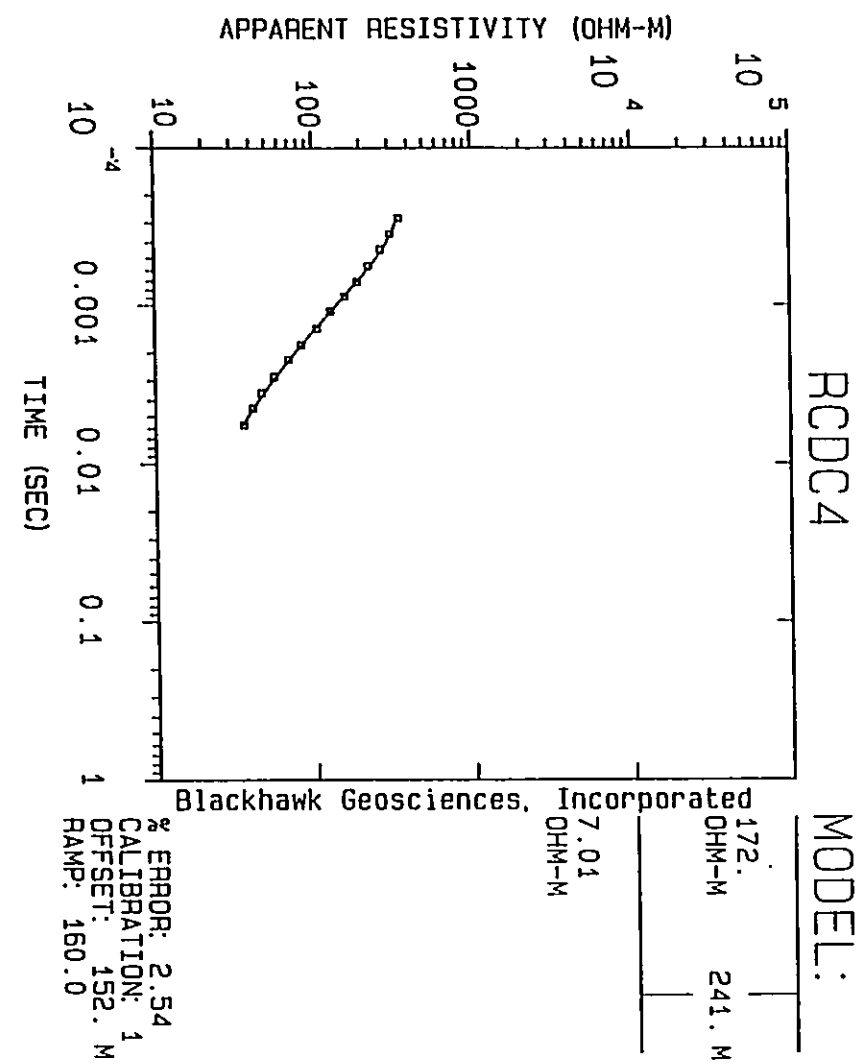
	TIMES	DATA	CALC	% ERROR	STD ERR
1	3.55E-04	7.34E+02	7.34E+02	0.035	
2	4.43E-04	6.09E+02	6.09E+02	-0.029	
3	5.64E-04	4.77E+02	4.80E+02	-0.558	
4	7.13E-04	3.76E+02	3.75E+02	0.334	
5	8.81E-04	2.98E+02	2.99E+02	-0.057	
6	1.10E-03	2.38E+02	2.36E+02	0.853	
7	1.41E-03	1.87E+02	1.81E+02	3.03[illegible]	
8	1.77E-03	1.38E+02	1.43E+02	-3.679	
9	2.20E-03	1.14E+02	1.15E+02	-1.493	
10	2.80E-03	9.36E+01	9.12E+01	2.674	
11	3.55E-03	7.21E+01	7.20E+01	-1.124	
12	4.43E-03	5.91E+01	5.98E+01	-1.101	
13	5.64E-03	4.89E+01	4.86E+01	0.767	
14	7.13E-03	4.03E+01	4.01E+01	0.466	

R: 134. X: 0. Y: 134. DL: 269. REQ: 149. CF: 1.0000
TOHZ ARRAY, 14 DATA POINTS, RAMP: 160.0 MICROSEC, DATA: RCDC3
0809 001N 003E Z DPR XTL L 6 10+100
Ch.21 = 0.16 Ch.22 = 0.89 Ch.23 = 16 Ch.24 = 72
RMS LOG ERROR: 1.05E-02, ANTILOG YIELDS 2.4563 %
LATE TIME PARAMETERS

• Blackhawk Geosciences, Incorporated •

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

	P 1	P 2	T 1
P 1	0.91		
P 2	-0.07	0.87	
T 1	0.00	0.00	1.00



RCDC4

MODEL: 2 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		362.7	1190.0		
171.96	240.5	122.2	400.9	1.4	1.4
7.01					

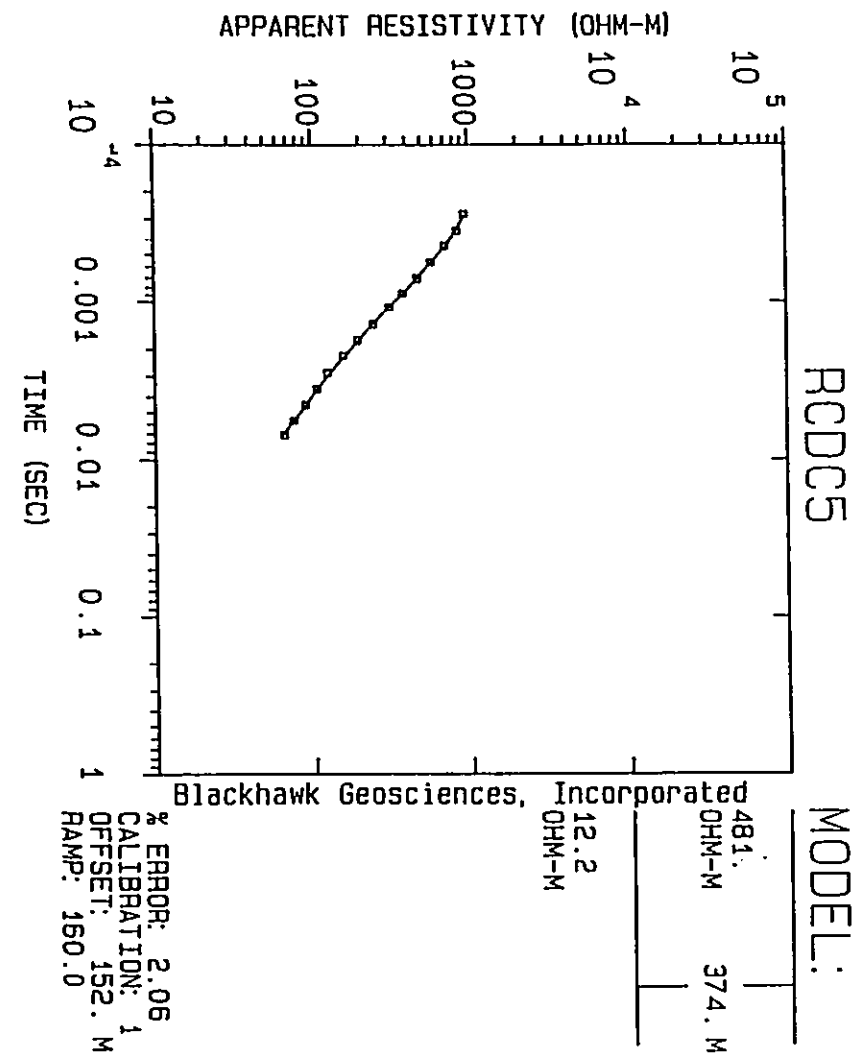
	TIMES	DATA	CALC	% ERROR	STD ERR
1	2.50E-04	3.49E+02	3.44E+02	1.567	
2	3.55E-04	3.09E+02	3.11E+02	-0.529	
3	4.43E-04	2.68E+02	2.73E+02	-1.835	
4	5.64E-04	2.24E+02	2.29E+02	-1.919	
5	7.13E-04	1.90E+02	1.88E+02	0.954	
6	8.81E-04	1.53E+02	1.56E+02	1.433	
7	1.10E-03	1.28E+02	1.28E+02	0.245	
8	1.41E-03	1.05E+02	1.02E+02	2.643	
9	1.80E-03	8.33E+01	8.29E+01	0.446	
10	2.22E-03	6.90E+01	6.94E+01	-0.576	
11	2.85E-03	5.58E+01	5.69E+01	-1.927	
12	3.60E-03	4.62E+01	4.77E+01	-3.052	
13	4.49E-03	4.08E+01	4.07E+01	0.108	
14	5.70E-03	3.56E+01	3.47E+01	2.357	

R: 152. X: 0. Y: 152. DL: 305. REQ: 169. CF: 1.0000
TDHZ ARRAY, 14 DATA POINTS, RAMP: 160.0 MICROSEC, DATA: RCDC4
1409 001N 004E Z OPR XTL L 5 8-100
Ch.21 = 0.16 Ch.22 = 0.089 Ch.23 = 15 Ch.24 = 9
RMS LOG ERROR: 1.09E-02, ANTILOG YIELDS 2.5365 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

	P 1	P 2	T 1
P 1	1.00		
P 2	0.00	1.00	
T 1	0.00	0.00	1.00



RCDC5

MODEL: 2 LAYER:

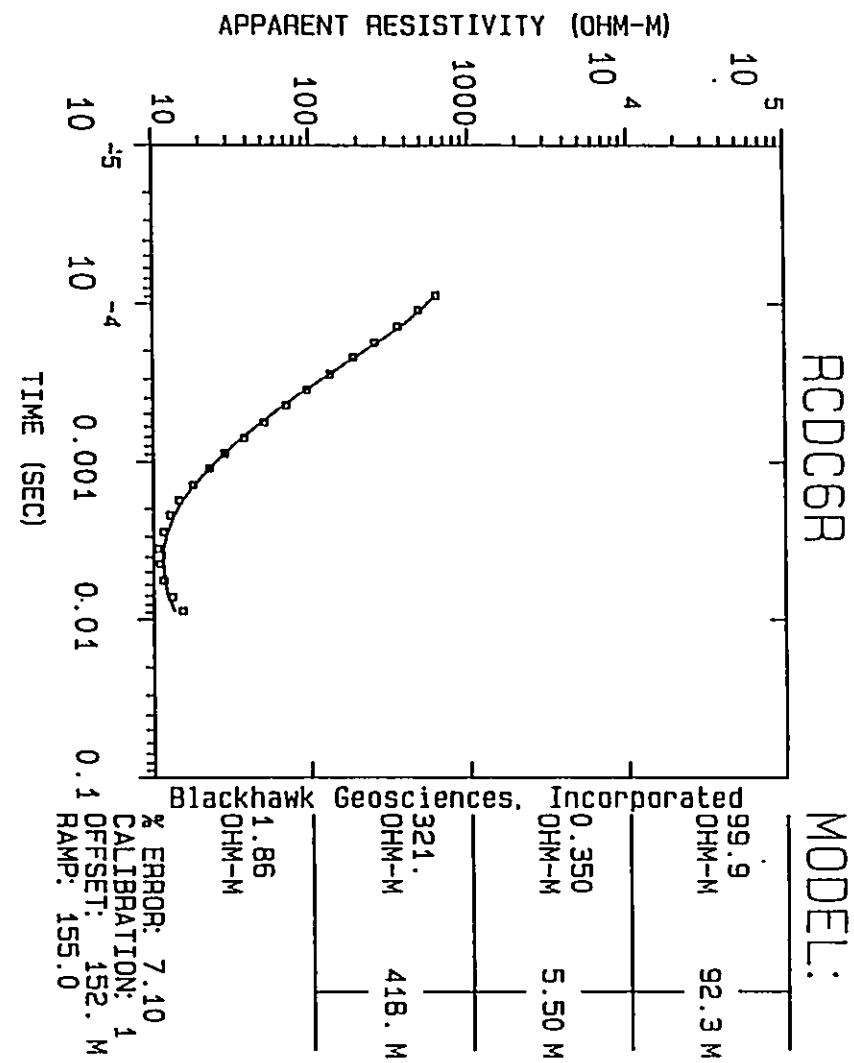
RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		359.7	1180.0		
481.27	374.0	-14.4	-47.1	0.8	0.8
12.17					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	2.80E-04	9.37E+02	9.45E+02	-0.815	
2	3.55E-04	8.42E+02	8.30E+02	1.442	
3	4.43E-04	7.01E+02	7.06E+02	-0.632	
4	5.64E-04	5.69E+02	5.72E+02	-0.540	
5	7.13E-04	4.64E+02	4.59E+02	1.217	
6	8.81E-04	3.74E+02	3.74E+02	0.039	
7	1.10E-03	3.06E+02	3.02E+02	1.225	
8	1.41E-03	2.42E+02	2.38E+02	1.564	
9	1.77E-03	1.92E+02	1.93E+02	-0.351	
10	2.20E-03	1.56E+02	1.59E+02	-2.121	
11	2.85E-03	1.23E+02	1.28E+02	-3.207	
12	3.60E-03	1.05E+02	1.06E+02	-0.125	
13	4.49E-03	8.91E+01	8.90E+01	0.106	
14	5.70E-03	7.53E+01	7.48E+01	0.574	
15	7.13E-03	6.54E+01	6.43E+01	1.810	

R: 152. X: 0. Y: 152. DL: 305. REQ: 169. CF: 1.0000
10HZ ARRAY, 15 DATA POINTS, RAMP: 160.0 MICROSEC. DATA: RCDC5
1609 001N 005F 2 OPR XTL L 5 10+100
Ch.21 = 0.16 Ch.22 = 0.89 Ch.23 = 15 Ch.24 = 92
RMS LOG ERROR: 8.85E-03, ANTILOG YIELDS 2.0587 %
LATE TIME PARAMETERS

• Blackhawk Geosciences, Incorporated •

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER
P 1 1.00
P 2 0.00 1.00
T 1 0.00 0.00 1.00
P 1 P 2 T 1



RCDC6R

MODEL: 4 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		496.8	1630.0		
99.92	92.3	404.5	1327.1	0.9	0.9
0.35	5.5	399.0	1309.0	15.7	16.6
320.75	417.7	-18.7	-61.5	1.3	17.9
1.86					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	6.14E+02	6.06E+02	1.352	
2	1.10E-04	4.76E+02	4.92E+02	-3.108	
3	1.40E-04	3.53E+02	3.64E+02	-3.217	
4	1.77E-04	2.54E+02	2.61E+02	-2.933	
5	2.20E-04	1.87E+02	1.88E+02	-0.199	
6	2.80E-04	1.33E+02	1.31E+02	1.681	
7	3.55E-04	9.57E+01	9.29E+01	2.958	
8	4.43E-04	7.08E+01	6.78E+01	4.341	
9	5.64E-04	5.12E+01	4.91E+01	4.322	
10	7.13E-04	3.82E+01	3.66E+01	4.309	
11	8.90E-04	2.86E+01	2.83E+01	1.031	
12	1.10E-03	2.30E+01	2.28E+01	0.855	
13	1.41E-03	1.79E+01	1.82E+01	-1.280	
14	1.77E-03	1.46E+01	1.53E+01	-4.592	
15	2.20E-03	1.28E+01	1.35E+01	-5.525	
16	2.80E-03	1.16E+01	1.23E+01	-5.613	
17	3.55E-03	1.07E+01	1.15E+01	-7.265	
18	4.43E-03	1.09E+01	1.15E+01	-5.389	
19	5.64E-03	1.16E+01	1.19E+01	-1.968	
20	7.13E-03	1.32E+01	1.24E+01	6.245	
21	8.81E-03	1.54E+01	1.37E+01	11.718	

R: 152. X: 0. Y: 152. DL: 305. REQ: 169. CF: 1.0000
CLHZ ARRAY, 21 DATA POINTS. RAMP: 155.0 MICROSEC. DATA: RCDC6R
1709 001N 006E Z OPR XTL L 3 10+100
Ch.21 = 0.155 Ch.22 = 0.89 Ch.23 = 15 Ch.24 = 9
RMS LOG ERROR: 2.98E-02. ANTILOG YIELDS 7.0956 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.87					
P 2	-0.01	0.53				
P 3	0.00	0.00	0.00			
P 4	-0.01	0.00	0.00	0.00		
T 1	0.00	0.03	0.00	0.00	0.99	
T 2	0.00	-0.48	-0.01	0.01	0.03	0.49
T 3	-0.02	-0.01	0.00	0.00	-0.01	0.02	0.01

Appendix 9:

KEALAKEKUA RANCH MAKAI, INTERIM ARCHAEOLOGICAL INVESTIGATION

KEALAKEKUA RANCH MAKAI:
INTERIM ARCHAEOLOGICAL INVESTIGATIONS

Prepared for

KEALAKEKUA RANCH, Ltd.
P.O. Box 399
Captain Cook, Hawaii 96704

Prepared by
William Barrera, Jr.

CHINIAGO INC.
P.O. Box 2649
Kamuela, Hawaii 96743

JULY 1989

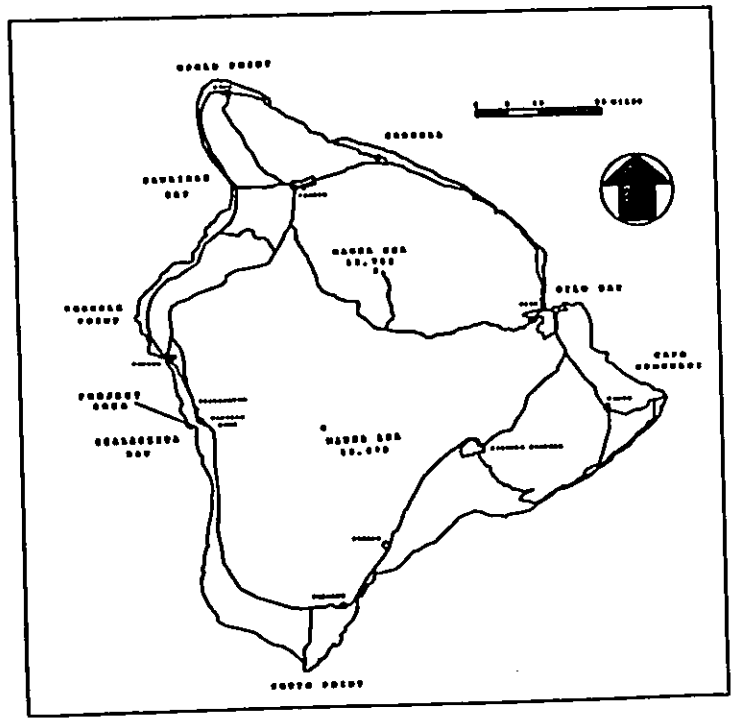
I. INTRODUCTION

An archaeological reconnaissance was conducted on 195 acres at Kealakekua Ranch Makai Subdivision in July and August of 1986 [Kaschko and Rosendahl 1987], during which 49 individual sites or site complexes were identified. In addition, it was observed that large portions of the Kona Field System were relatively intact. The purpose of this extensive effort was to identify and preliminarily evaluate the archaeological and historic resources on the property. The report recommended that an intensive survey be conducted to refine the necessarily tentative significance assessments made on the basis of the preliminary study. Chinlago Inc. was retained to perform this service, and mapping and excavations took place between April and June, 1988. The purpose of these investigations was to assess whether additional work might be needed for adequate and reasonable data recovery prior to construction. This report is seen as an interim step in a potentially multi-part mitigation program.

The project area is located in the *ahupua'a* of Kealakekua in the District of South Kona, Hawaii Island. The reconnaissance covered approximately 195 acres situated between Pali Kapu-o-Keoua immediately above Kealakekua Bay and Napoopoo Road. Approximately one-third of this area was deleted from the present investigations because it lies within the Conservation District. The project area is located in both the Kealakekua Bay Historic District [Site 50-10-47-7000] and the Kona Field System [Site 50-10-37-6601]. Historic land use has been primarily extensive pineapple cultivation and cattle grazing.

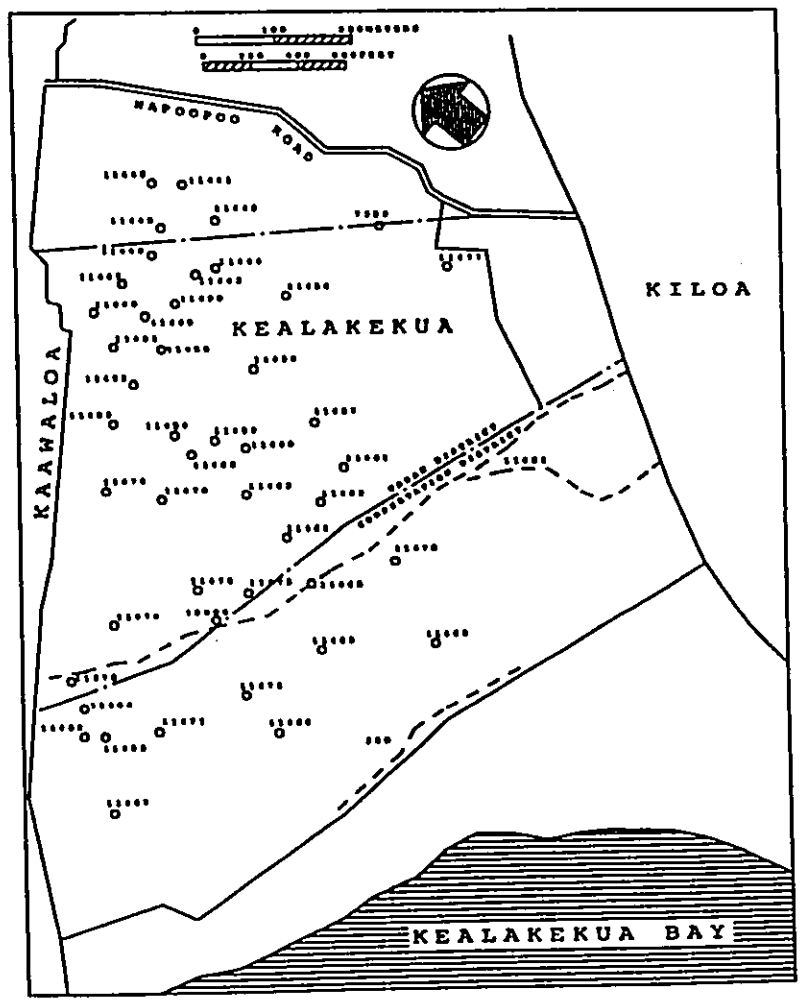
Kaschko and Rosendahl have summarized the historical and archaeological background of the project area vicinity. The reader is directed to that report or to the bibliography of the present report for this information.

The original description of each site, indicated by italics, is quoted directly from the reconnaissance report [Kaschko and Rosendahl 1986]. This is followed by any updating of the description resulting from the present investigations.



1. Hawaii Island, Showing Location of Project Area

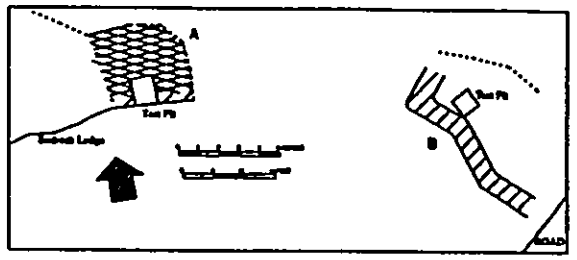
II. SURVEY RESULTS



2. Project Area, Showing Locations of Sites

PLANS		CROSS-SECTIONS
Regular Mound		Not Excavated
Irregular Mound		Leaf Litter
Platform		Cultural Layer
Bedrock Outcrop		Sterile Dirt
Retaining Wall		Bedrock
Free-Standing Wall		
Linear Mound		
Terrace.		
Cleared Area		

3. Key to Symbols

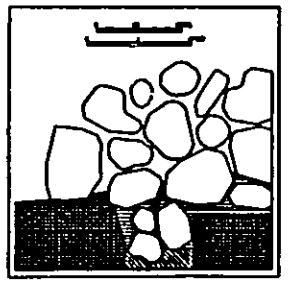


4. Plan of Site 11440

50-10-47-11440 [T-1]

Site T-1, located in a grove of kukui trees, features one prominent terrace [5.0 m long, up to 90 cm high] situated in a rocky area [c. 40.0 by 20.0 m] among rough terraces formed by boulders stacked on natural bedrock outcrops. A large piece of coral and a waterworn basalt cobble are visible on the surface. Surface modification may have once been more obvious, as the site area appears to have been disturbed and collapsed by cattle.

This site is most likely an area of heavy surface rock modification related to prehistoric agricultural practices.

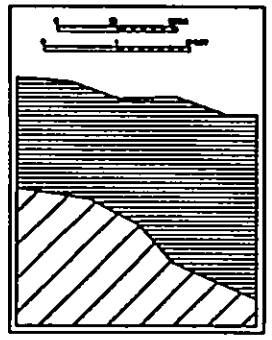


5. Site 11440A Test Pit, North Face Cross-Section

Feature A

This is a terrace measuring 3.9 by 4.1 meters [16.7 square meters] and standing to a height of 80 centimeters. It is constructed of stacked cobbles and boulders.

The only midden recovered from the single test pit that was excavated consists of 13.3 grams of charcoal and one basaltic glass flake.



6. Site 11440B Test Pit, South Face Cross-Section

Feature B

This is a retaining wall constructed of stacked boulders with an area on the northeast side cleared of rocks. The wall measures 1.0 by 8.6 meters and stands to a height of 1.3 meter. The south end of the feature has been disturbed by a road, adjacent to which at a distance of six meters from the feature was found a basalt adze fragment.

A single test pit was excavated to a depth of 75 centimeters. The only midden remains found were 1.9 grams of *Conus* sp., 10.2 grams of charcoal, a ceramic rim sherd and a basalt flake.

50-10-47-11441 [T-2]

This large, sloping rubble terrace [12.0 m long, up to 130 cm high] is partially collapsed and appears to have a few stones set in alignment on its upper surface.

The structure apparently is a prehistoric agricultural feature. Although now separated by a dirt road, it is likely this site was originally connected to Site T-1.

This is an irregular retaining wall measuring 12.0 meters in length and up to 2.0 meters in width. It stands to a height of between 60 and 120 centimeters and is constructed of stacked cobbles and boulders.

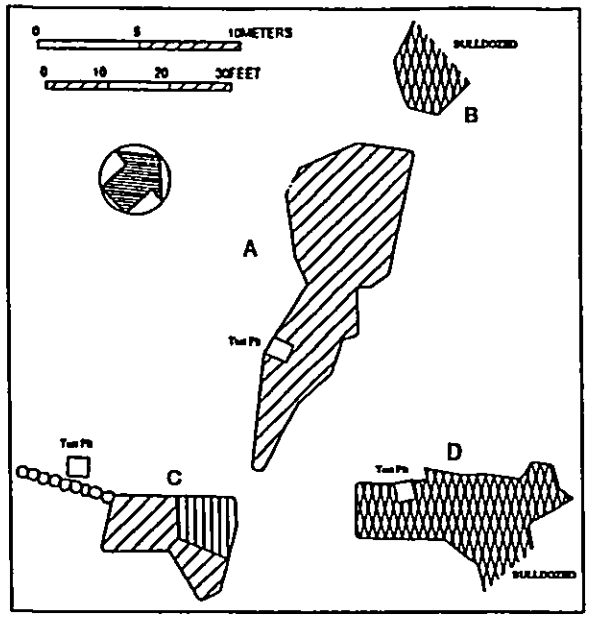
50-10-47-11442 [T-3]

Two inland-seaward field boundaries [c. 3.0 m wide, 60 cm high] and a cross-slope terrace [20.0-25.0 m long, up to 90 cm high] are located in an area [c. 50.0 by 20.0 m] covered by a kukui grove. The field boundaries are composed primarily of stone rubble, while portions of the cross-slope terrace have a stacked boulder face with cobble fill behind it. Many waterworn basalt cobbles [at least 20] are present near the south end of the cross-slope terrace. Other surface rock modification is visible in the immediate area, and bulldozing disturbance is evident seaward of the site area.

These features appear to be agricultural in function and probably are remnants of the prehistoric Kona Field System.

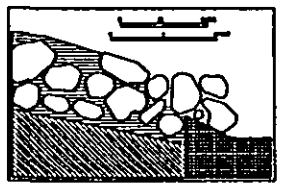
Feature A

This is a retaining wall measuring 17.6 meters in length, between 1.0 and 5.6 meters in width, and standing to a height of 90 centimeters. It is constructed of stacked cobbles and boulders and covers an area of 58.5 square meters.



7. Plan of Site 11442

One test pit was excavated. Midden remains recovered consist of 9.3 grams of charcoal, 0.1 gram of *Cypraea caputserpentis*, 0.2 grams of unidentified shell, two waterworn basalt hammerstones and five manuports [three of waterworn basalt and two of coral].



8. Site 11442A Test Pit, South Face Cross-Section

Feature B

Bulldozing has obscured this feature, but it appears to have been a linear mound. The remnant that was recorded measures 3.3 by 4.0 meters and stands to a height of 50 centimeters. It is constructed of stacked cobbles and boulders.

Feature C

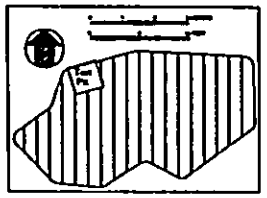
This is a retaining wall and a crude mound of stacked cobbles and boulders covering an area of 21.5 square meters. The wall measures 6.6 by 2.9 meters [14.6 square meters] and stands to a height of 1.0 meter. The mound measures 2.9 by 3.1 meters [7.1 square meters] and stands to a height of 50 centimeters. A rock alignment extends west from the corner of the retaining wall for a distance of 4.9 meters.

One test pit was excavated to a depth of between 50 and 60 centimeters, at which depth was found yellow weathered pahoehoe. Midden remains found consist of 0.3 grams of charcoal and one waterworn basalt manuport.

Feature D

This is a linear mound measuring 2.8 by 10.6 meters [32.0 square meters] and standing to a height of 1.0 meter. It is constructed of stacked cobbles and boulders. Another feature, either a linear mound or a retaining wall, apparently once extended to the southeast from the midpoint of this feature, but it has been disturbed by bulldozing.

One test pit was excavated. The upper 35 centimeters consisted of cobbles and boulders in point to point contact, the next 30 centimeters consisted of this same deposit with a cultural fill of dirt, below which was between 10 and 30 centimeters of sterile yellow dirt resting atop the weathered bedrock. The only midden found was 2.1 grams of charcoal, one waterworn basalt manuport and one basaltic glass flake.



9. Plan of Site 11443

50-10-47-11443 [T-4]

This feature [c. 3.0 by 6.0 m, up to 50 cm high] is probably the remnant portion of a disturbed inland-seaward field boundary. It appears as a rubble mound composed of piled boulders and cobbles.

With an apparent agricultural function, the structure is very likely to have been a component part of the prehistoric field system.

This is an irregular mound measuring 4.0 by 7.7 meters [22.9 square meters] and standing to a height of 60 centimeters. It is constructed of stacked cobbles and boulders.

One test pit was excavated to a depth of 60 centimeters. The upper 15 to 20

centimeters consisted of cobbles and boulders in point to point contact, followed by 30 centimeters of the same with a dirt fill. The next 20 centimeters contained fewer rocks. No midden remains were found.

50-10-47-11444 [T-5]

Site T-5, an inland-seaward field boundary [3.0 to 6.0 m wide, up to 60 cm high], is constructed of stacked boulders with rubble fill, and it may have extended from Site T-3 [50-10-47-11442]. About 10.0 to 15.0 m seaward of the site marker is a cross-slope terrace [40 cm high].

As a rather typical field boundary, this feature represents one of the fundamental structural elements of the prehistoric agricultural field system.

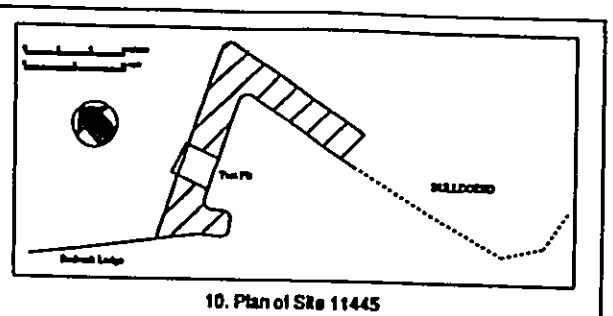
This is a section of irregular linear mound measuring 14.5 meters in length and between 1.8 and 5.9 meters in width. The feature, which stands to a height of 80 centimeters, is constructed of stacked cobbles and boulders. The collapsed appearance of the feature and the fact that about every fourth rock has a fresh face exposed indicates recent disturbance.

50-10-47-11445 [T-6]

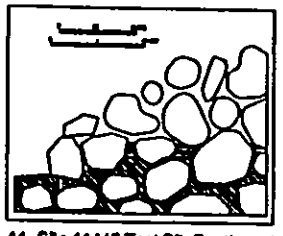
Site T-6, an L-shaped terrace [5.0 by 8.0 m, up to 140 cm high], is composed of a stacked boulder retaining wall with a level soil surface. Although partially collapsed, this structure is still one of the better-constructed agricultural terraces and apparently is prehistoric.

This is a retaining wall built of stacked cobbles and boulders. It measures 5.0 meters along one arm and 5.6 meters along the other, is 1.0 meter wide and stands to a height of 1.1 meter. The east end of the feature has been covered with bulldozed rubble.

One test pit was excavated, and the only midden found was 0.2 grams of charcoal.



10. Plan of Site 11445



11. Site 11445 Test Pit, Southwest Face Cross-Section

50-10-47-11446 [T-7]

This site complex [at least 11.0 by 13.0 m in area] is located in a grove of kukui trees and includes two specific features. Also in the site area are two, large inland-seaward rubble walls with three or four large boulder rubble terraces.

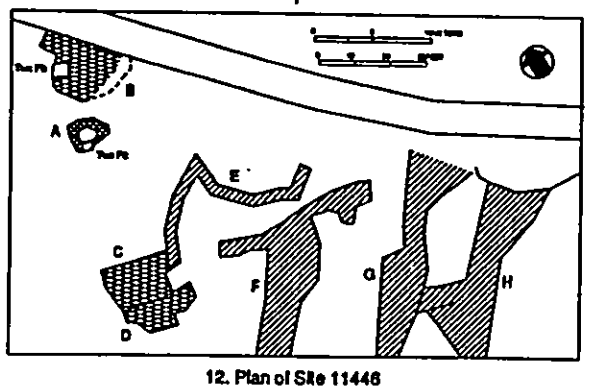
The complex appears to be primarily agricultural and could be associated with the prehistoric field system.

Feature A is a small, round, walled structure [2.9 by 3.4 m, up to 65 cm high] constructed on a steep slope. It is composed of stacked basalt boulders and rocks and has an interior soil floor.

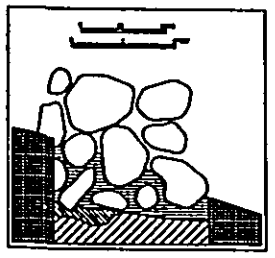
The structure possibly is a planting enclosure with a specialized function, or it could have been used for storage.

Feature B, a much-disturbed terrace [c. 6.0 by 11.0 m, up to 110 cm high] with one definite corner and face, is composed of stacked boulders and rocks forming a retaining wall with rubble fill behind it. It is situated just inland of Feature A, and a bulldozed road is just behind it.

The function of this feature is difficult to determine because it has been disturbed, but it could possibly have been a habitation terrace or part of the prehistoric agricultural system.



12. Plan of Site 11446



13. Site 11446A Test Pit, East Face Cross-Section

Feature A

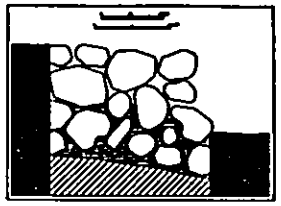
This is an oval enclosure measuring 2.7 by 3.5 meters [7.5 square meters] and standing to a height of between 60 and 80 centimeters. The wall covers an area of 5.8 square meters and encloses an area of 1.7 square meters. It is constructed of stacked cobbles and boulders.

One test pit was excavated. Midden remains recovered consist of 0.1 gram of charcoal, 1.7 gram of Thaididae, one basalt flake and three basaltic glass flakes.

Feature B

This is a terrace measuring 5.0 by 7.6 meters and standing to a height of 1.1 meter. It presently covers an area of 29.7 square meters, but construction of a dirt road has obscured the east side of the feature. It is built of stacked cobbles and boulders.

The single test pit produced a fair amount of material. This includes 27.0 grams of charcoal, 1.1 grams of *Cellana* sp., 1.8 gram of *Nerita picea*, 7.4 grams of *Cypraea caputserpentis*, 4.6 grams of *Cypraea* sp., 1.2 gram of Thaididae, 0.3 gram of Echinodermata and 1.3 grams of unidentified shell. In addition, there were eight coral manoports, five water-worn basalt manoports [three are fragmentary] and four basaltic glass flakes.



14. Site 11446B Test Pit, South Face Cross-Section

Feature C

This is a crude stone terrace measuring 3.9 by 6.9 meters [23.6 square meters] and standing to a height of 1.0 meter. It is constructed of stacked cobbles and boulders.

Feature D

This is a stone terrace measuring 2.7 by 6.6 meters [13.3 square meters] and standing to a height of 1.0 meter. It is constructed of stacked cobbles and boulders.

Feature E

This is a crude retaining wall measuring 20.4 meters in length and 1.0 meter in width. The feature is constructed of stacked cobbles and boulders and stands to a height of between 80 and 140 centimeters.

Feature F

This is a crude retaining wall that extends out of the survey area to the southwest. It is built of stacked cobbles and boulders and measures between 1.3 and 4.5 meters in width and stands to a height of 1.0 meter.

Feature G

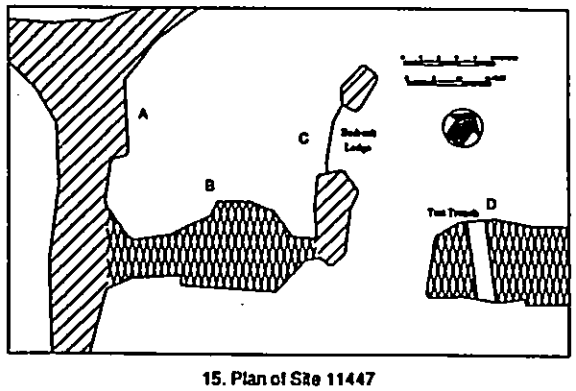
This is a crude retaining wall that continues out of the survey area to the southwest. It measures between 1.9 and 3.9 meters in width, stands to a height of 70 centimeters, and is constructed of stacked cobbles and boulders.

Feature H

This is a crude retaining wall that extends out of the survey area to the southwest. It measures between 2.7 and 4.8 meters in width and stands to a height of 1.0 meter. It is built of stacked cobbles and boulders.

50-10-47-11447 [T-8]

This site area [25.0 by 15.0 m] includes an inland-seaward field boundary [1.0-2.0 m wide, up to 80 cm high] and two attached cross-slope terraces [3.0 m wide, up to 100 cm high] located in a grove of



15. Plan of Site 11447

kukui trees. The stone construction is generally rubble, although the field boundary is stacked in some parts.

These features appear to be agricultural and probably are small components of the prehistoric field system.

Feature A

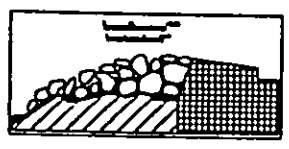
This is a retaining wall measuring between 2.1 and 3.9 meters in width and standing to a height of 1.0 meter. The feature, which extends out of the surveyed area to the north and the south, is constructed of stacked cobbles and boulders.

Feature B

This is an irregular linear mound measuring 11.7 meters in length and between 2.0 and 4.8 meters in width [38.2 square meters]. It is built of stacked cobbles and boulders and stands to a height of 80 centimeters.

Feature C

This is a retaining wall measuring 11.6 meters in length and between 1.4 and 2.4 meters in width. It stands to a height of 80 centimeters. It is constructed primarily of stacked cobbles and boulders, although the middle portion of the feature is formed by a bedrock ledge.

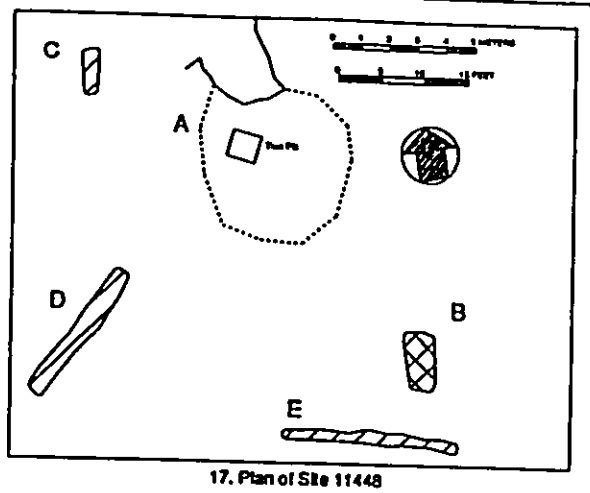


16. Site 11447D Test Pit, Southwest Face Cross-Section

Feature D

This is a linear mound measuring 4.4 meters in width and standing to a height of 1.0 meter. It is constructed of stacked cobbles and boulders and extends out of the surveyed area to the east.

The feature was sectioned with a trench which produced a waterworn basalt manoport fragment and a basalt adze flake.



17. Plan of Site 11448

50-10-47-11448 [T-9]

This site complex, including two designated features, is situated in a kukui tree grove just north of a dirt road. The south and west portions of the site area also contain three or four rough terraces and two rubble mounds.

The complex appears to consist of a temporary habitation shelter [Feature A] and wall segment [Feature B] with some associated agricultural terraces, and it apparently is prehistoric.

Feature A, an overhang cave shelter [4.5 by 3.0 m interior area, up to 85 cm high], contains a possible small, low, terrace wall just inside the drip line. It has a soil floor with a natural deposit of kukui nut shells covering the entire surface, but with pig bones [skull, humerus, scapula, etc.] also present.

The feature is a possible prehistoric temporary shelter probably associated with agricultural activities in the area.

Feature B, a crudely built wall segment [2.0 by 1.1 m, up to 60 cm high], has been disturbed by a kukui tree. It is composed of stacked and piled basalt rocks and is located south of the Feature A cave shelter.

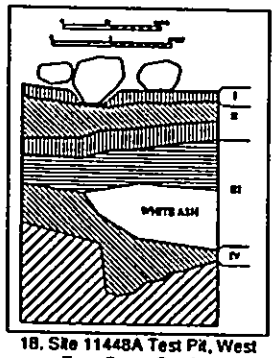
The function of this structure remains undetermined; the kukui has disturbed the wall so much that it is difficult to tell its original extent.

Feature A

This is a cave measuring 5.3 by 5.3 meters [22.7 square meters]. The possible small terrace wall is in fact the result of natural erosion.

One test pit was excavated [Tables 6-8]. It revealed four layers reaching a depth of 105 centimeters.

Layers I and II appear to be the result of recent alluviation and transportation of materials into the site. Layer I was a deposit of plant litter, primarily *Aleurites moluccana* nuts, and Layer II was composed of brown dirt and plant litter.



18. Site 11448A Test Pit, West Face Cross-Section

Layer III was a brown dirt containing a dense concentration of cultural materials, including small ash pockets and a large ash deposit.

Layer IV was a sterile brown dirt resting directly on the bedrock of the cave floor.

Feature B

This is a collapsed free-standing wall measuring 1.1 by 2.0 meters [2.0 square meters] and standing to a height of 50 centimeters. It is constructed of stacked cobbles and boulders.

Feature C

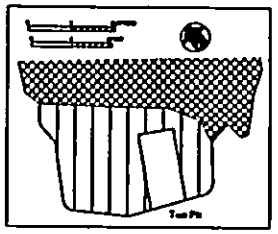
This is a retaining wall built against a bedrock outcrop measuring 0.6 by 1.7 meters [0.8 square meter] and standing to a height of 90 centimeters. It is constructed of stacked cobbles and boulders.

Feature D

This is a retaining wall constructed on a bedrock outcrop. It measures 0.6 by 5.2 meters [3.5 square meters] and stands to a height of 80 centimeters. It is constructed of stacked cobbles and boulders.

Feature E

This is a retaining wall measuring 0.5 by 6.2 meters [2.3 square meters] and standing to a height of 70 centimeters. It is constructed of stacked cobbles and boulders.



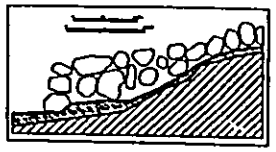
19. Plan of Site 11449

50-10-47-11449 [T-10]

Site T-10, a modified bedrock outcrop, has the appearance of a rough terrace [5.0 by 4.0 m, up to 80 cm high]. It is constructed of piled boulder rubble and is located just inland of a bulldozed dirt road.

This feature appears to be agricultural and is probably a component of the prehistoric field system.

This is an irregular mound built of cobbles and boulders stacked against a bedrock outcrop. It measures 2.5 by 3.5 meters [7.9 square meters] and stands to a height of 70 centimeters.



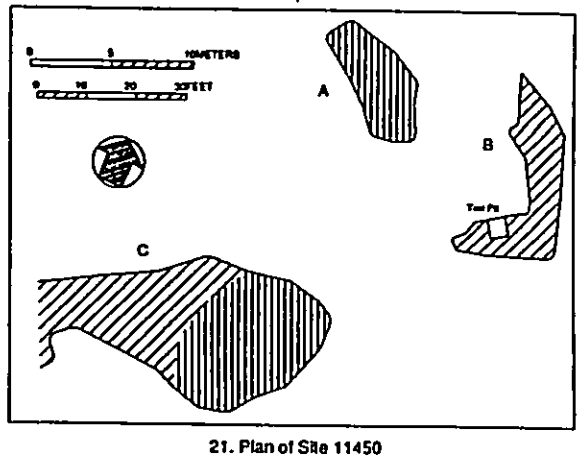
20. Site 11449 Test Pit, North Face Cross-Section

A trench was excavated into the feature, revealing that the mound had been built on sterile dirt overlying bedrock.

50-10-47-11450 [T-11]

This site area [45.0 by 30.0 m] is located in a kukui grove and consists of a cross-slope terrace [8.0 m long, up to 70 cm high] attached to an inland-seaward field boundary [2.0-6.0 m wide, up to 100 cm high], with a large rubble mound [7.0 by 3.0 m, up to 100 cm high] adjacent. The construction is generally unfaced rubble.

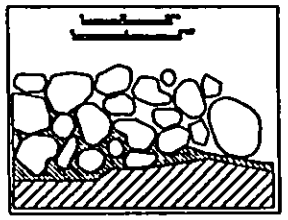
These features appear to be agricultural and were probably associated with the prehistoric field system.



21. Plan of Site 11450

Feature A

This is an irregular mound situated on a low ridge. It measures 3.8 by 7.9 meters [23.7 square meters] and stands to a height of 60 centimeters. It is constructed of stacked cobbles and boulders.



22. Site 11450B Test Pit, West Face Cross-Section

Feature B

This is an irregular retaining wall measuring 17.8 meters in total length and between 1.9 and 2.8 meters in width. It stands to a height of 80 centimeters and is built of stacked cobbles and boulders.

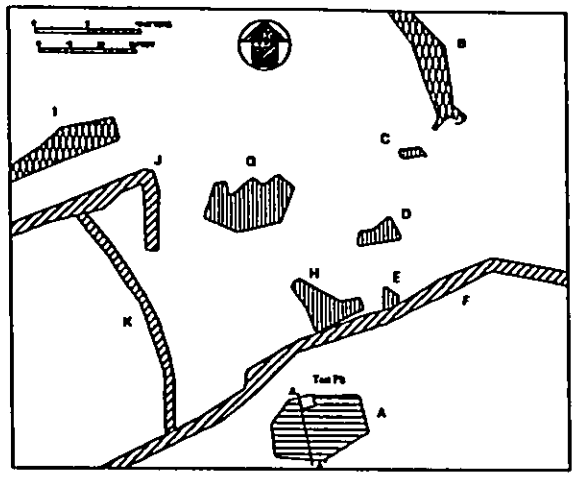
A test pit excavated into the feature produced no cultural materials.

Feature C

This feature consists of a rock mound piled on a bedrock outcrop at the east end and an irregular retaining wall at the west end. The entire feature measures 17.8 meters in length and between 3.0 and 9.5 meters in width [105.5 square meters], and stands to a height of between 50 and 100 centimeters. The west end of the feature, which is constructed of stacked cobbles and boulders, has been truncated by a bulldozer cut.

50-10-47-11451 [T-12]

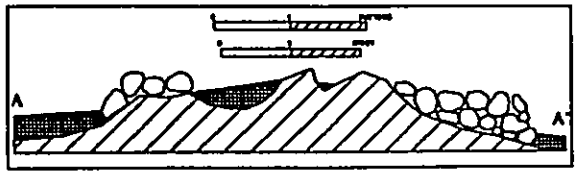
The oval or roughly rectangular, faced platform [10.0 by 6.0 m, up to 135 cm high] is partially collapsed and has a large bedrock outcrop in the middle of the surface. It is constructed of stacked boulders, while the other features generally are composed of piled rubble. A broken waterworn basalt cobble is visible on the surface.



23. Plan of Site 11451

The areas immediately adjacent to the site include three large island-seaward rubble wall alignments [possible field boundaries], three modified bedrock outcrop terraces, and a cross-slope terrace.

The platform's function is not definitely determined, although it may be a burial structure or a type of agricultural mound. The other features apparently are agricultural and most likely are parts of the prehistoric field system.



24. Site 11451A Profile

Feature A

This is a bedrock outcrop the perimeter of which has been modified by the stacking of cobbles and boulders so as to form a platform. It measures 6.4 by 9.3 meters [45.9 square meters] and stands to a height of between 90 and 130 centimeters. A basalt core was found on the surface.

A test pit excavated on the north side of the feature produced a basaltic glass flake.

Feature B

This is an irregular linear mound measuring up to 2.9 meters in width and standing to a height of 60 centimeters. The portion surveyed is 13 meters in length, and it continues out of the surveyed area to the north. It is constructed of stacked pebbles, cobbles and boulders.

Feature C

This is an irregular mound measuring 0.9 by 2.3 meters [1.9 square meters] and standing to a height of 30 to 40 centimeters. It is constructed of cobbles stacked on a 50 centimeter high bedrock outcrop.

Feature D

This is an irregular mound measuring 2.5 by 4.4 meters [6.5 square meters] and standing to a height of between 30 and 40 centimeters. It is constructed of cobbles and boulders stacked on a 50 to 70 centimeter high bedrock outcrop.

Feature E

This is an irregular mound measuring 1.5 by 2.3 meters [2.5 square meters] and standing to a height of between 50 and 70 centimeters. It is constructed of stacked cobbles and boulders.

Feature F

This is an irregular retaining wall measuring 0.9 to 1.2 meters in width and 48 meters in length. It stands to a height of between 1.0 and 1.4 meters and is constructed primarily of stacked boulders, with some cobbles.

Feature G

This is an irregular mound measuring up to 4.8 meters in width and 9.2 meters in length [30.9 square meters]. It stands to a height of between 40 and 60 centimeters, and is constructed of cobbles and boulders stacked on and against a bedrock outcrop rise.

Feature H

This is an irregular mound or retaining wall measuring 2.6 by 7.2 meters [15.6 square meters] and standing to a height of 60 centimeters. It is constructed of stacked cobbles and boulders.

Feature I

This is an irregular linear mound or collapsed free-standing wall measuring between 1.5 and 2.9 meters in width and standing to a height of 90 centimeters. The feature, which is constructed of stacked boulders and a few cobbles, continues out of the surveyed area to the west.

Feature J

This is an irregular retaining wall, possibly formed by the bulldozing of a trail situated between it and Feature I. It measures between 1.3 and 2.0 meters in width and stands to a height of between 60 and 80 centimeters. The feature is constructed of stacked cobbles and boulders and continues out of the surveyed area to the west.

Feature K

This is an irregular retaining wall measuring 1.0 meter in width and 22.7 meters in length. It stands to a height of between 60 and 80 centimeters, and is constructed of stacked cobbles and boulders.

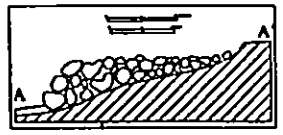
50-10-47-11452 [T-13]

The rectangular platform [4.5 by 5.0 m, up to 80 cm high] is constructed on a bedrock outcrop and consists of large basalt boulders serving as a foundation for boulders and cobbles stacked on top. The platform has a relatively level soil-filled surface. A kukui grove [30.0 by 20.0 m in area] is associated with the site and contains two or three modified outcrop mounds and at least four rough terraces.

The rectangular platform possibly is a burial structure or perhaps is habitation-related, while the adjacent features probably have prehistoric agricultural functions.

Feature A

This is a terrace measuring 4.3 by 4.9 meters and standing to a height of 1.3 meters at the south corner and 50 centimeters at the north corner. It covers an area of 19.0 square meters and is constructed of stacked cobbles and very large boulders. The middle of the southwest wall is collapsed.

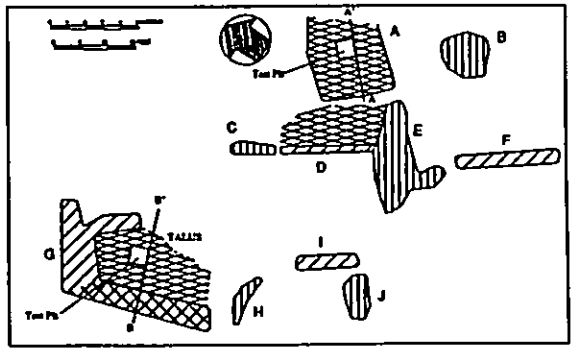


26. Site 11452A, Profile

A test pit was excavated in the center of the feature but large boulders prevented excavation down to bedrock. Cultural materials recovered include 0.4 gram of charcoal and two coral manuports.

Feature B

This is an irregular mound measuring 2.7 by 2.7 meters [5.6 square meters] and standing to a height of between 30 and 90 centimeters. It is constructed primarily of stacked cobbles, with an occasional boulder.



25. Plan of Site 11452

Feature C

This is an irregular mound measuring 0.75 by 2.7 meters [1.7 square meters] and standing to a height of between 30 and 80 centimeters. It is constructed of cobbles and boulders stacked on a bedrock exposure.

Feature D

This is a flat terraced area measuring 2.7 by 5.7 meters [13.5 square meters] located behind a boulder alignment retaining wall that stands 60 centimeters in height.

Feature E

This is an irregular mound measuring 4.0 by 6.7 meters [12.4 square meters] and standing to a height of 80 centimeters. It is constructed of cobbles and boulders stacked on a bedrock outcrop.

Feature F

This is an irregular retaining wall, the central section of which is collapsed, measuring 0.8 by 6.0 meters [4.8 square meters] and standing to a height of 1.0 meter. It is constructed of stacked cobbles and boulders.

Feature G

This is a terrace measuring 5.7 by 8.6 meters [40.7 square meters] in overall dimension enclosing an area of 3.5 by 6.7 meters [19.2 meters]. The southwest side consists of a free-standing wall measuring between 60 and 80 centimeters in height; the northwest and northeast sides are formed by an irregular retaining wall standing to a height of 80 centimeters; and the southeast side is formed by the cobbles and boulders of a talus slope. A basalt core was found on the surface.

The single test pit encountered bedrock at a depth of 30 centimeters and produced 1.0 gram of charcoal and a basalt blade.

Feature H

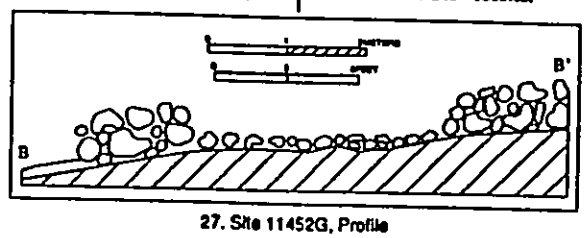
This is an irregular mound measuring 0.7 by 3.1 meters [1.7 square meters] and standing to a height of between 30 and 100 centimeters. It is built of cobbles and boulders stacked on a bedrock outcrop.

Feature I

This is an irregular retaining wall measuring 0.9 by 3.8 meters [2.9 square meters] and standing 80 centimeters high. It is constructed of stacked cobbles and boulders.

Feature J

This is an irregular mound measuring 1.4 by 2.6 meters [3.1 square meters] and standing to a height of between 50 and 130 centimeters. It is built of stacked boulders and a few cobbles.



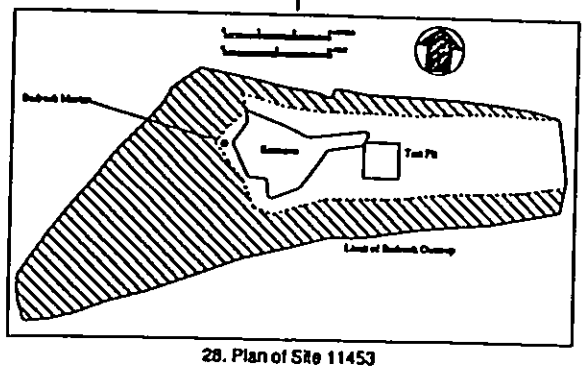
27. Site 11452G, Profile

50-10-47-11453 [T-14]

This natural shelter [6.0 by 3.0 m, up to 100 cm high] is formed by a possible collapsed lava tube or large bubble, and a large mango tree grows in the entranceway. The shelter has a soil floor, and a subsurface cultural deposit is quite possible. Cultural materials visible on the surface included Cypraea sp. shells, a bedrock mortar in a large boulder near the entranceway, a waterworn basalt cobble which is ground at one end, a boulder with a smoothly worn surface, a basalt core, and a small basalt bowl or cup [collected]. [Collected surface artifact No.4 is a small basalt mortar or kukui nut lamp [70.9 by 47.1 mm, 271.3 g].] The area associated with Site T-14 includes several rough terraces. Two terrace walls forming a "T" are found near the shelter, and four or five smaller terraces [with both stacked and rubble walls] are located northwest.

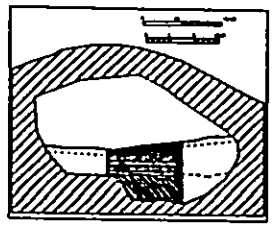
This probable temporary habitation shelter may have been associated with prehistoric agricultural activities in the immediate area, or could possibly have been a special-purpose site.

Thick vegetation prevented the location of the terraces and terrace walls.



28. Plan of Site 11453

The cave interior measures 9.8 meters in length and between 2.3 and 3.3 meters in width [23.5 square meters], with a maximum ceiling height of 1.0 meter. It is situated in a bedrock outcrop measuring 5.6 by 15.7 meters [62.0 square meters]. In the bedrock adjacent to the west end of the roof entry is a mortar measuring 20 centimeters in diameter and 5 centimeters in depth.

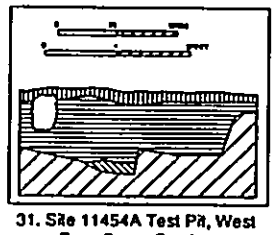


29. Site 11453 Site and Test Pit Profile

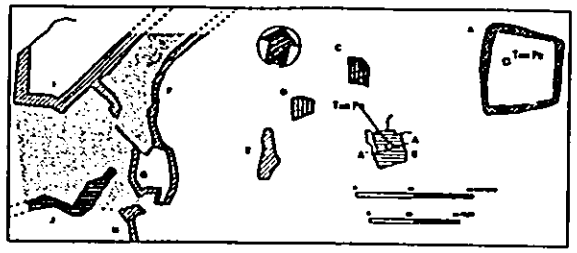
One test pit was excavated, revealing a cultural deposit between 25 and 35 centimeters thick resting atop 30 centimeters of sterile dirt [Tables 11-13].

50-10-47-11454 [T-15]

The T-15 site complex consists of two designated features. Feature A, a partially collapsed, rectangular, walled enclosure [17.0 by 15.0 m, up to 140 cm high], is situated just south of a dirt road. It is constructed of stacked basalt boulders and rocks and has an interior soil surface with considerable exposed bedrock. A coral fragment and a broken waterworn basalt cobble were found on the surface.



31. Site 11454A Test Pit, West Face Cross-Section



30. Plan of Site 11454

This structure is probably a historic animal enclosure; the large size and the presence of bedrock outcrop inside would make it seem to be unlikely as a habitation feature.

Feature B, a rectangular platform [6.5 by 5.5 m, up to 70 cm high], is located 187 ft [27.1 m] [sic] from Feature A. It has four stacked basalt boulder faces with a level cobble- and rubble-filled floor area. An entrance in the middle of the southwest side includes flat basalt slabs which form a stepway.

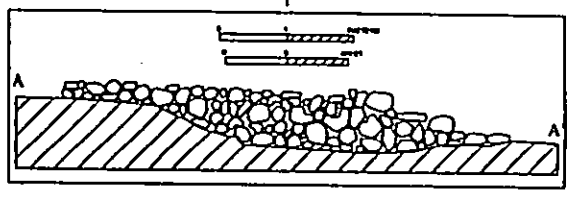
The feature is apparently a prehistoric or perhaps early historic habitation platform [a possible house foundation].

A number of minor features, including rough terraces and three or four inland-seaward rubble walls [possible field boundaries], are located in the western part of the complex. The site appears to be a habitation and agricultural complex of prehistoric to historic age.

Feature A

This is an enclosure measuring 13.9 by 16.1 meters [193.5 square meters] and standing to a height of 1.4 meter. The wall covers an area of 61.0 square meters and encloses an area of 132.4 square meters. It is constructed of stacked cobbles and boulders.

One test pit was excavated. Midden remains recovered include 12.8 grams of charcoal, 6.2 grams of *Cypraea* sp., 0.2 gram of Thaididae and 0.3 gram of unidentified shell.



32. Site 11454 B, Profile

Feature B

This is a platform measuring 5.6 by 6.4 square meters [28.9 square meters] and standing to a height of 70 centimeters. It is constructed of stacked cobbles and boulders.

One test pit was excavated. Midden found consists of 0.8 gram of charcoal, 5.3 grams of *Nerita picea*, 2.6 grams of *Cellana* sp. 17.6 grams of *Cypraea maculifera*, one basalt flake, one basaltic glass flake, and one manuport.

Feature C

This is a terrace built on a bedrock outcrop at the top of a bluff. It measures 3.6 by 4.4 meters (15.2 square meters) and stands to a height of 50 centimeters. It is constructed of cobbles and boulders stacked on a bedrock outcrop.

Feature D

This is a mound measuring 3.7 by 4.0 meters (12.0 square meters) and standing to a height of 60 centimeters. It is constructed of stacked cobbles and boulders.

Feature E

This is a retaining wall measuring 9.0 meters in length, between 2.0 and 3.3 meters in width, and up to 90 centimeters in height. It covers an area of 19.4 square meters, and is constructed of stacked cobbles and boulders.

Feature F

This is a retaining wall extending out of the surveyed area to the north. The surveyed portion measures 35.0 meters in length and 1.3 meter in width, and stands to a height of 80 centimeters. It is constructed of stacked cobbles and boulders.

Feature G

This is a retaining wall measuring 15.7 meters in length and 1.2 meters in width. It stands to a height of 90 centimeters and is constructed of stacked cobbles and boulders.

Feature H

This is a retaining wall built of stacked cobbles and boulders that extends out of the surveyed area to the south. It measures between 1.1 and 1.8 meters in width and stands to a height of 70 centimeters.

Feature I

This is a retaining wall that extends out of the surveyed area to the north. It measures 2.5 meters in width and stands to a height of between 90 and 150 centimeters. A short retaining wall measuring 1.6 by 6.5 meters abuts on the east side.

Feature J

This is a linear mound that extends out of the surveyed area to the west. It measures between 1.5 and 3.0 meters in width and stands to a height of 80 centimeters. It is built of stacked cobbles and boulders.

50-10-47-11455 [T-16]

The C-shape [3.0 by 5.0 m, up to 80 cm high] is constructed of stacked boulders on exposed bedrock and has an interior soil surface. Two inland-seaward field boundaries, composed largely of rubble [c. 3.0 m wide, 70 cm high], are located within the area [40.0 by 50.0 m] associated with the site.

This structure possibly is a temporary habitation shelter associated with prehistoric agricultural features.

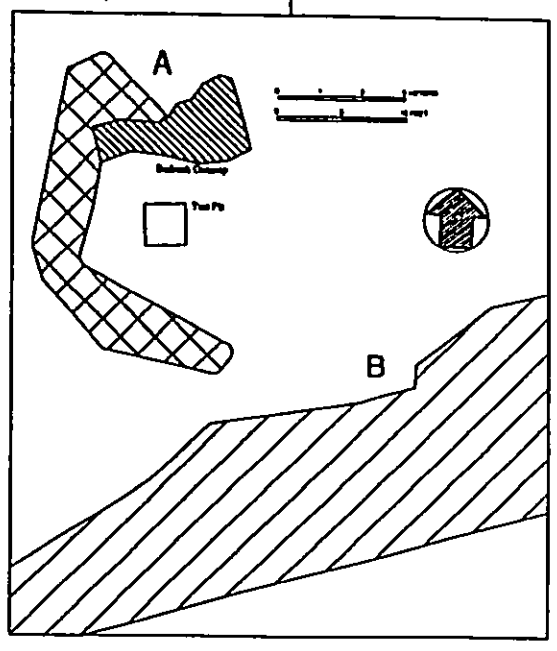
Feature A

This is a C-shaped structure covering an area of 12.3 square meters. It measures 5.0 meters along one arm and 5.2 meters along the other. The wall is up to 1.6 meters wide and stands to a height of 1.1 meter, and is constructed of cobbles and boulders stacked on a bedrock outcrop.

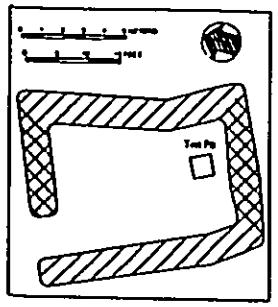
The test pit encountered sterile yellow dirt and weathered cobbles at a depth of 20 centimeters. The only midden found was 0.4 gram of charcoal.

Feature B

This is a section of retaining wall built of stacked cobbles and boulders. It measures up to 5.0 meters in width and stands to a height of between 60 and 90 centimeters. It continues out of the site area to the east and west.



33. Plan of Site 11455



50-10-47-11456 [T-17]

Site T-17 is a partly collapsed, rectangular walled structure [11.0 by 12.5 m, up to 80 cm high] located between two inland-seaward field boundaries. It has a level interior soil surface and faced walls composed of stacked basalt boulders. The inland side is formed by a faced retaining wall.

The flat soil floor and standing walls indicate this structure may be a fairly substantial prehistoric habitation feature.

This is a terrace measuring 9.5 by 11.2 meters (94.8 square meters). The wall itself, which is built of stacked cobbles and boulders, covers an area of 44.2 square meters and encloses a living area of 48.1 square meters. The east wall is level with the ground surface on the east side and stands between 50 and 100 centimeters high on the west side. The west wall stands 40 centimeters high on the east side and 80 centimeters high on the west. The side walls each stand to a height of 50 centimeters.

The single test pit went to a depth of between 30 and 40 centimeters, at which point it encountered a sterile yellow dirt and weathered cobbles. It produced 0.9 gram of charcoal, one basalt adze flake and two flakes of basaltic glass.

50-10-47-11457 [T-18]

Site T-18 is an irregularly shaped but angular large terrace [7.0 by 17.0 m, up to 130 cm high] with a high, stacked boulder face and a level interior soil surface. It is constructed of stacked boulders faced on the exterior and is built partly on bedrock. Artifacts present on the surface included thick round fence wire, three bottles [one collected], part of an iron door lock plate with keyhole [collected], and an old shoe heel. [Collected surface artifact No.2 is a broken iron door lock plate with keyhole, marked "ORBU" [76.5 by 83.0 by 4.2 mm, 92.0 g]; collected surface artifact No.3 is a clear, rectangular, historic bottle embossed "GIFFORD & CO., ILLIL. LINIMENT, CHICAGO" [223 by 74.6 by 46.8 mm, 194.1 g].]

This structure is apparently a historic [early 1900s] habitation feature perhaps associated with the pineapple cultivation period or with ranching activities.

This site could not be located in the thick vegetation.

50-10-47-11458 [T-19]

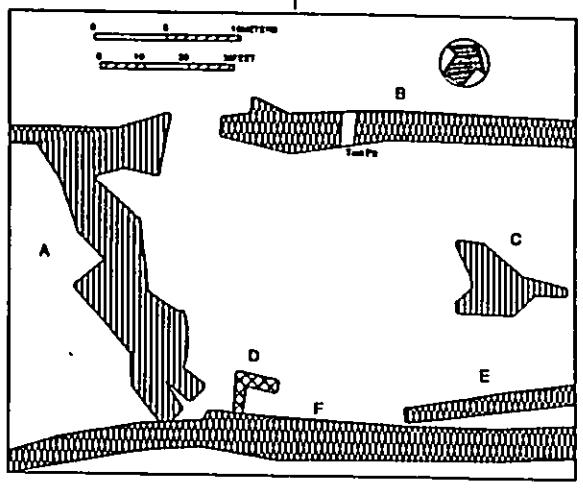
This roughly rectangular, walled enclosure [11.0 by 12.0 m, up to 80 cm high] has a flat soil surface and has been disturbed on both sides by inland-seaward bulldozer cuts. Only portions of the stacked boulder walls are standing, while the remainder are rubble.

This rather large structure has been affected by bulldozing; it is unclear whether it may have been a prehistoric or early historic habitation site, an animal pen, or whether it could have been used agriculturally.

One test pit was excavated, revealing sterile yellow dirt at a depth of 20 centimeters. Bedrock was found at a maximum depth of 30 centimeters in the southwest corner of the pit and right at the surface in the northeast corner. Midden remains found consist of 0.2 gram of charcoal, 0.5 gram of *Cypraea caputserpentis* and 0.3 gram of unidentified shell.

50-10-47-11459 [T-20]

Site T-20 exhibits two inland-seaward field boundaries [30.0 m long, 2.0-3.0 m wide, up to 100 cm



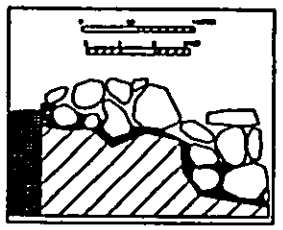
34. Plan of Site 11459

high] associated with about five, small cross-slope terraces. The features are composed of stacked boulders and/or piled rubble. A bulldozer cut runs just south of the site area.

These rough structures appear to be agricultural features associated with the prehistoric field system.

Feature A

This is an irregular mound measuring 21.2 meters in length and between 3.0 and 4.6 meters in width [94.0 square meters] and standing to a height of 80 centimeters. It is constructed of stacked cobbles and boulders.



35. Site 11459B Test Pit, East Face Cross-Section

Feature B

This is an irregular linear mound that extends out of the surveyed area to the east. It is between 1.9 and 2.7 meters in width and stands to a height of between 50 and 100 centimeters. It is of stacked construction utilizing cobbles and boulders.

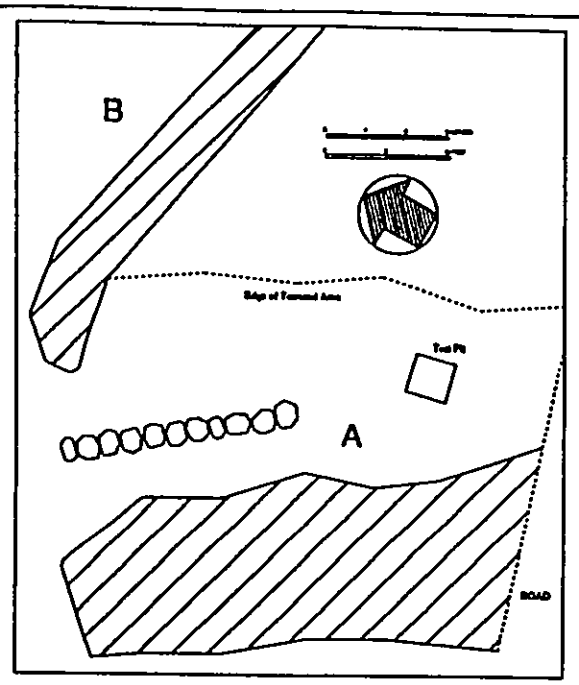
The feature was sectioned with a trench that produced no cultural materials.

Feature C

This is an irregular mound measuring 5.0 by 6.6 meters [20.7 square meters] and standing to a height of between 80 and 100 centimeters. It is constructed of cobbles and boulders stacked on a bedrock outcrop.

Feature D

This is a free-standing wall measuring 2.9 meters along one arm and 3.0 meters along the other. It measures 90 centimeters in width and stands to a height of between 30 and 40 centimeters. It is constructed of stacked cobbles and boulders.



38. Plan of Site 11460

Feature E

This is a linear mound that extends out of the survey area to the east. It measures 1.4 meter in width, stands to a height of 50 centimeters, and is constructed of stacked cobbles and boulders.

Feature F

This is a linear mound that extends out of the survey area to the east and west. It is built of stacked cobbles and boulders, measures between 1.9 and 2.8 meters in width and stands to a height of between 60 and 100 centimeters.

50-10-47-11460 [T-21]

Site T-21, a terrace, is constructed primarily of basalt boulder and rock rubble with an occasional stacked face. At least six water-worn basalt cobbles are present on the surface. The northwest portion has a level soil surface with an alignment of upright boulders. Although the site may be some type of remnant habitation terrace, extensive bulldozer disturbance makes this determination indefinite.

Site T-21 is located in an area of large, rubble terraces [38.0 by 12.0 m] in a kukui grove. The area is divided into three sections by a bulldozer cut and an inland-seaward historic wall. Most of the rough terraces in the area apparently are agricultural and probably are related to the prehistoric field system.

Feature A

This is a terrace formed by a stacked cobble and boulder retaining wall that measures 5.1 by 11.6 meters [43.3 square meters] and stands to a height of 1.2 meter. A boulder alignment measuring 6.0 meters in length and 60 centimeters in width is located on the flat terraced section, which covers an area of 58.5 square meters. The south end of the feature has been bulldozed.

The test pit encountered sterile yellow dirt at a depth of between 35 and 45 centimeters. Midden recovered consists of 2.7 grams of charcoal, 0.6 gram of *Cypraea caputserpentis* 0.7 gram of unidentified shell, one adze flake and four manuports.

Feature B

This is a retaining wall that extends out of the surveyed area to the east. It is 1.6 meters wide, stands to a height of 50 centimeters, and is constructed of stacked cobbles and boulders.

The "rubble terraces" indicated in the intensive reconnaissance report do not appear to be man-made, and are probably just lobes of talus working their way down the slope.

50-10-47-11461 [T-22]

Site T-22 exhibits a small, U-shaped, walled enclosure [5.0 by 7.0 m, up to 120 cm high] with an opening in the seaward end and a relatively level soil floor. The somewhat collapsed wall is composed of stacked boulders filled with cobble and large rock; the inland end is formed by exposed bedrock. The only artifact visible on the surface was a rectangular sarsaparilla bottle [collected]. [Collected surface artifact No.1 is a complete rectangular historic bottle embossed "HOOD'S COMPOUND EXTRACT SARSAPARILLA, C.I. HOOD & CO., LOWELL, MASS." [220 by 73 by 46 mm, 453.2 gl.]

This small structure appears most likely to be a historic animal pen, but it could have been used as a temporary habitation shelter as well.

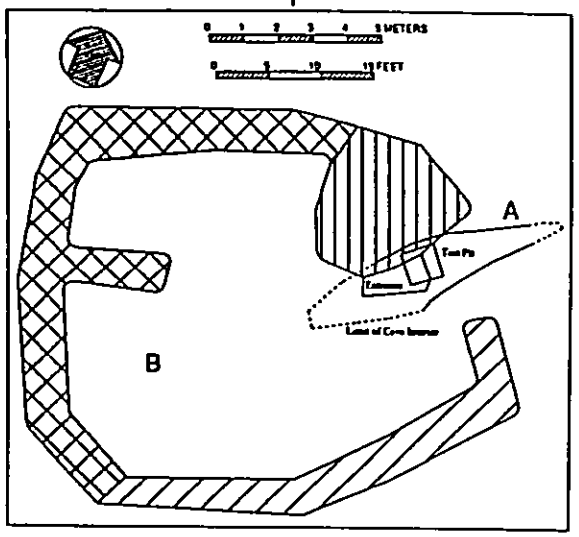
Also found at Site T-22, but not assigned a feature designation, is a rough terrace [15.5 by 6.0 m, up to 115 cm high] defined by retaining walls on the seaward and south sides. The partially collapsed walls consist of stacked boulders with cobble fill behind, and the soil surface is moderately sloping.

The structure is probably a prehistoric agricultural terrace, as its surface seems to slope too steeply for habitation use.

This site could not be located in the thick vegetation.

50-10-47-11462 [T-23]

The south and west walls of Site T-23, an L-shaped terrace, are constructed of stacked boulders forming the faces and are cobble filled. The terrace measures 15.5 m long by 6.0 m wide. The upper surface of the terrace is moderately sloping and soil covered. The sloping upper surface and the absence of habitation debris suggest an agricultural function for the terrace.



37. Plan of Site 11463

50-10-47-11463 [T-24]

The Site T-24 [prob. Soehren's Site 201] complex, located in a small grove of kukui trees, consists of a cave shelter within a walled enclosure [18.0 by 14.0 m]. This two-feature complex could possibly have been used for storage, or it may have been a temporary habitation shelter associated with prehistoric agricultural activities in the area.

Feature A, a small, V-shaped lava bubble shelter [5.5 by 1.7 m, up to 70 cm high] with an interior soil

floor, is situated at the inland end of the walled enclosure [Feature B]. A large kukui tree is growing from the entranceway.

The feature may be a temporary habitation shelter or possibly a storage site.

Feature B, a roughly rectangular walled enclosure [14.0 by 13.0 m, up to 100 cm high], surrounds an area including the cave shelter [Feature A] and a bedrock outcrop surface. It is constructed of stacked basalt boulders with some faced sections, but the wall has been disturbed by bulldozing on almost all sides.

The enclosure wall may be a historic attempt to keep animals out of the lava bubble. It is located just 5.0 m northwest of a major inland-seaward historic wall.

This site appears to correspond to Site 201, originally described as follows:

Shelter cave. A small "bubble cave" in a pahoehoe outcrop was probably used as a sleeping shelter by travelers or farmers passing the night in the area. The outcrop is surrounded by an old stone fence, low and tumbled down, which encloses an area about 30 by 40 feet. There is some evidence that blocks of stone have been quarried from the outcrop. A small grove of kukui trees covers the site [Soehren and Newman 1968:13].

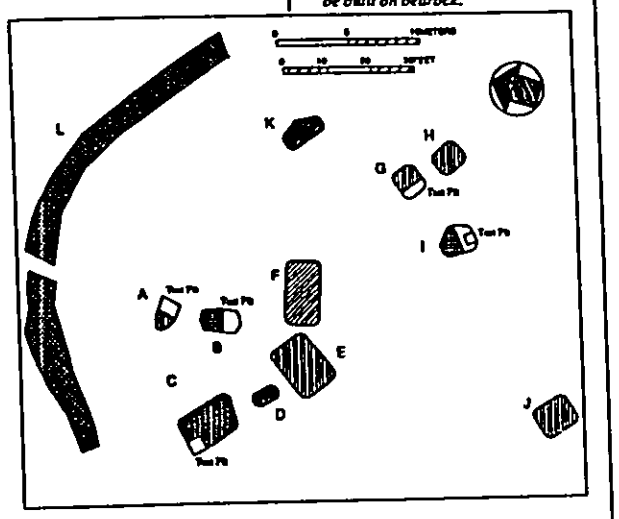
Feature A

This is a cave measuring 1.8 by 7.8 meters [9.1 square meters] with a maximum ceiling height of 60 centimeters. Details of the west end were obscured by the large tree in the entrance.

One test pit was excavated, encountering bedrock at a depth of 28 centimeters [Tables 17-19].

Feature B

This is an enclosed area measuring 11.9 by 14.0 meters [80.7 square meters] formed by a stacked cobble and boulder feature which is variously a free-standing wall, a crude retaining wall and a mound. The free-standing section of the wall stands to a height of 1.0 meter, the retaining wall stands to a height of 50 centimeters. It is unlikely that the latter section could have prevented animals from entering the site area as the reconnaissance report suggested.



38. Plan of Site 11464

50-10-47-11464 [T-25]

The T-25 site complex [prob. Soehren's Site 202] [15.0 by 37.0 m] consists of 11 stone mounds and a wall section. Coral fragments and waterworn basalt cobbles are present on the surface. More mounds may possibly be located in the site area which were missed because of thick vegetation.

The site is considered a possible prehistoric or early historic complex of burial structures, although some mounds could also be the result of agricultural surface modification.

Feature A, a rock mound [1.5 by 2.0 m, up to 55 cm high], is composed of stacked basalt boulders with rock and cobble fill. One large displaced slab may have been an upright.

Feature B, a mound, [2.2 by 1.9 m, up to 70 cm high], has a perimeter face of large basalt boulders with interior cobble fill and appears to be built on bedrock.

Feature C, a roughly rectangular terrace with three, faced sides [4.0 by 6.0 m, up to 60 cm high], is constructed of stacked basalt boulders and rocks with a rubble-filled floor. Coral is present on the surface.

Feature D, a semicircular mound [2.0 by 2.0 m and up to 70 cm high], consists of stacked boulders and rocks with rubble and boulder fill. Coral is visible on the surface.

Feature E, a mound [2.0 by 2.5 m, up to 30 cm high], is composed of large boulders at the base. Rubble, cobble, and boulder fill form a level floor, and waterworn basalt is present on the surface.

Feature F is a partly collapsed, semicircular rubble mound [3.0 by 2.5 m, up to 60 cm high] with a rubble-filled surface. Waterworn basalt is visible on the surface.

Feature G, a low rubble mound [1.7 by 1.7 m, up to 25 cm high], is composed of small cobble fill with some larger rocks on the outside edges. Three coral fragments and two waterworn basalt cobbles are present on the surface.

Feature H, a low rubble mound [1.9 by 2.0 m, up to 35 cm high], contists of large basalt boulders with small cobble fill.

Feature I is a somewhat rectangular, faced mound [2.0 by 3.2 m, up to 60 cm high] constructed of stacked boulders with rubble and cobble fill, but it is collapsing. Two waterworn basalt cobbles are visible on the surface.

Feature J, a low rubble mound [1.5 by 2.5 m], is composed of some large boulders on the outer edges and has cobble and rubble fill.

Feature K, a low rubble mound [2.2 by 1.8 m, up to 45 cm high], appears to be built on bedrock and has rubble fill. A waterworn basalt cobble is present on the surface.

Feature L is a wide, faced, standing wall [c. 35.0 m long and 2.0 m wide, up to 85 cm high] constructed of stacked basalt boulders with cobble fill. It forms a wide curve over a fairly large area. A broken waterworn basalt cobble and a Cypraea sp. shell are visible on the surface. The wall seems to mark one side of the area containing the possible burial structures.

Feature A

This is an irregular mound measuring 1.4 by 2.1 meters [2.5 square meters] and standing to a height of 50 centimeters. It is of core-fill construction utilizing cobbles and boulders.

The east end of the core-fill feature was dismantled, revealing that it had been constructed directly on a bedrock outcrop. No cultural materials were found.

Feature B

This is a regular mound measuring 1.3 by 2.8 meters [3.8 square meters] and standing to a height of 70 centimeters. Cobbles and boulders were used in the core-fill construction. The south end of the feature was dismantled, revealing that it had been built on a bedrock outcrop. One waterworn basalt manuport was found.

Feature C

This is a core-fill cobble and boulder terrace measuring 2.7 by 3.7 meters [10.8 square meters] and standing to a height of 90 centimeters.

A single test pit was excavated in the southwest corner, demonstrating that the feature had been constructed on a culturally sterile ground surface. Cultural materials were recovered from the terrace fill as well as from a 5 to 10 centimeter thick dirt deposit that rested on the basal yellow sterile deposit. Specifically, the terrace fill produced 1.9 grams of charcoal, 2.9 grams of *Cellana* sp., 3.4 grams of *Cypraea* sp., one glass vessel fragment, five ceramic vessel fragments and one waterworn basalt manuport fragment. The dirt fill produced 0.2 gram of *Nerita picea*, 0.3 gram of charcoal and a fragment of metal.

Feature D

This is a core-fill stone terrace measuring 1.1 by 1.9 meters [2.1 square meters] and standing to a height of 70 centimeters. It is of core-fill construction using cobbles and boulders.

Feature E

This is an irregular mound measuring 2.9 by 4.0 meters [11.6 square meters] and standing to a height of 30 centimeters. It is of core-fill construction utilizing cobbles and boulders. A waterworn basalt manuport fragment was found on the surface.

Feature F

This is a stone terrace measuring 2.4 by 4.6 meters [11.0 square meters] and standing to a height of 60 centimeters. It is constructed of stacked cobbles and boulders.

Feature G

This is an irregular mound constructed of stacked pebbles and cobbles. It measures 1.8 by 2.1 meters [3.5 square meters] and stands to a height of 30 centimeters.

The southwest end of the feature was excavated, demonstrating that the mound had been built on the ground surface. The rock fill that constituted the mound proper produced one coral manuport, four waterworn basalt manuports [one fragmentary] and one basalt flake. The 30 centimeter thick dirt fill below the mound produced 2.2 grams of charcoal and two basalt flakes.

Feature H

This is an irregular mound measuring 1.8 by 2.1 meters [3.5 square meters] and standing to a height of 35 centimeters. It is of crude core-fill construction utilizing pebbles, cobbles and three large boulders.

Feature I

This is a regular mound measuring 1.9 by 3.1 meters [4.4 square meters] and standing to a height of 60 centimeters. It is constructed of core-fill pebbles, cobbles and boulders.

The southeast end of the feature was dismantled, and a 70 by 70 centimeter test pit excavated into the dirt beneath. This revealed that the feature had been constructed on the ground surface, on top of a 30 centimeter thick dirt deposit containing cultural materials. This in turn rested atop a sterile yellow dirt deposit.

The rock fill of the mound produced a single shell of *Cellana* sp. weighing 14.7 grams, a basalt flake, a glass vessel fragment and a waterworn basalt manuport fragment. The dirt fill below the mound produced 10.2 grams of charcoal, 0.2 grams of *Nerita picea*, 1.7 grams of *Cellana* sp., 10.7 grams of *Cypraea mauritiana*, 0.4 gram of *Terebra* sp., a copper button, two basalt flakes, a basaltic glass flake, a flake [possibly chert], two metal fragments, one basalt adze flake and a waterworn basalt manuport fragment.

Feature J

This is an irregular mound measuring 2.3 by 2.7 meters [6.0 square meters] and standing to a height of 50 centimeters. It is of stacked construction using pebbles, cobbles and boulders.

Feature K

This is a stone terrace measuring 1.3 by 3.0 meters [4.3 square meters] and standing to a height of 50 centimeters. It is constructed of stacked cobbles and boulders.

Feature L

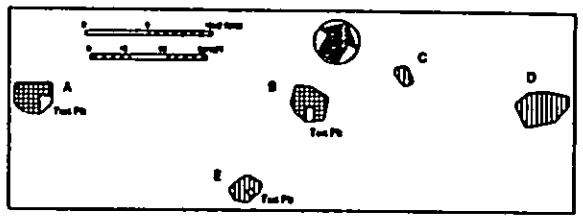
This is a free-standing stone wall measuring 35.3 meters in length, between 1.8 and 2.4 meters in width, and standing to a height of 90 centimeters. It is constructed of stacked cobbles and boulders and covers an area of 61.4 square meters.

The structure is a possible early historic, rectangular burial platform or perhaps an agricultural rock pile from the period of pineapple cultivation.

Feature A2, a roughly rectangular, raised platform [3.0 by 2.5 m, up to 50 cm high] has an exterior boulder facing with cobbles filling the interior. About 5.0 m to the southwest is another more rough and collapsed rock mound.

This feature is also a possible early historic rectangular burial platform or possibly an agricultural rock pile of the pineapple cultivation period.

Features A1 and A2 are probably parts of Site 202, originally recorded as follows:



39. Plan of Site 11473

50-10-47-11473 [T-36]

The T-36 site complex [prob. Soehren's Sites 202 and 203] [c. 60.0 by 20.0 m] includes three designated features, two stone platforms and a rectangular terrace, and is located 20.0 to 25.0 m north of a major inland-seaward stone wall. An inland-seaward dirt road runs between the A and B sections of the site area.

Feature A1, an oval and somewhat angular, raised stone platform [3.0 by 3.5 m, up to 75 cm high], is partially collapsed and consists of a stacked boulder exterior facing with cobble and boulder fill on the inside.

202. Grave sites. In a small paddock just above the old "pineapple road" and between the jeep trail and a stone fence to the south are six stone cairns of various sizes which appear to be grave sites. All are in poor condition, and small waterworn stones were seen in several, two factors suggestive of antiquity. The cairns range in size from four by six feet to 12 feet square, and from one and one-half feet to four feet high [Soehren and Newman 1968:14].

Because of its different character, Feature B has been separated from this site complex and designated as Site 12,006.

Only five of Soehren's six features were located.

Feature A

This is a regular mound measuring 2.6 by 3.0 meters [6.9 square meters and standing to a height of 60 centimeters. It is of core-fill construction utilizing an exterior retaining wall of boulders and an interior fill of cobbles and boulders.

One test pit was excavated, producing a manuport fragment.

Feature B

This is a regular mound measuring 2.8 by 3.0 meters [7.0 square meters] and standing to a height of 50 centimeters. It is of core-fill construction using a retaining wall of boulders and a fill of pebbles and cobbles.

A single test pit was excavated. Midden consists of only 0.3 gram of charcoal.

Feature C

This is a stacked irregular mound measuring 1.1 by 1.8 meters [1.6 square meters] and standing to a height of 40 centimeters. It is constructed of stacked cobbles and boulders.

Feature D

This is an irregular mound built of stacked cobbles and boulders. It measures 2.8 by 4.3 meters [9.2 square meters] and stands to a height of 40 centimeters.

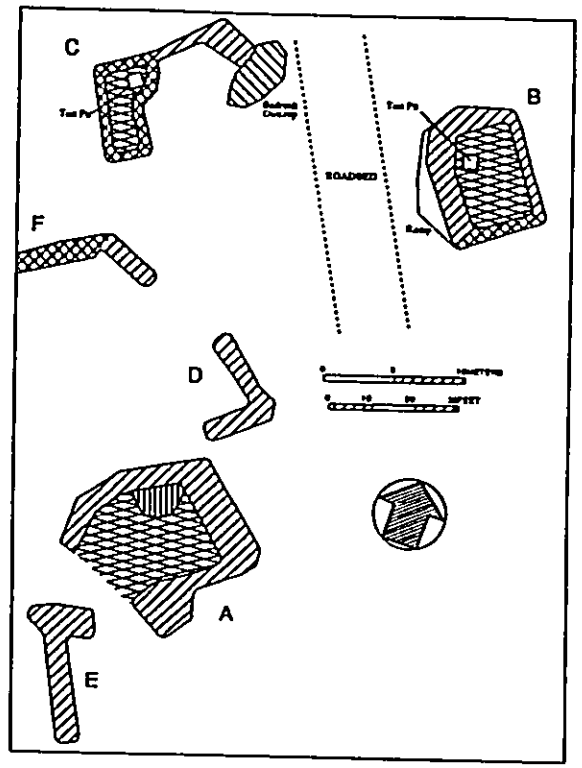
Feature E

This is an irregular mound measuring 1.9 by 2.7 meters [3.7 square meters] and standing to a height of 40 centimeters. It is constructed of stacked cobbles and boulders.

One test pit was excavated. It produced a manuport fragment and a basalt hammerstone.

50-10-47-11474 [T-37]

Located a short distance inland of the pineapple road, Site T-37 is a historic habitation site complex [about 50.0 by 50.0 m] that includes three recorded features and some large, prominent agricultural rock piling in and around the site area, especially to the in-



40. Plan of Site 11474

land side. It is possible that additional features would be found in the complex area if it were more intensely examined and if the heavy vegetation cover were partly cleared.

Feature A is a high, roughly rectangular, partially walled terrace [12.0 by 8.0 m, up to 165 cm high] with a large stone mound to the north side. It consists of a well-stacked boulder retaining wall with cobble and boulder fill behind; the interior surface is a fairly level soil and stone fill floor. Cultural materials visible on the surface include a probable broken basalt adze blank, a waterworn basalt cobble, a broken bottle, part of a large square metal can, and pieces of blue-on-white ceramic. The feature is situated under an old dead kukui tree and a live mango tree.

This structure is believed to be the remains of the old pineapple workers' house [Sherwood Greenwell, pers. comm.].

Feature B, a quite collapsed, walled rectangular terrace [9.0 by 7.0 m, up to 120 cm high], is constructed of stacked boulders and cobbles and has a fairly level soil surface interior. An old north-south road seems to run between Features A and B.

The terrace is a likely house structure of perhaps somewhat earlier historic age than Feature A.

Feature C, a section of north-south retaining wall [c. 10.0 m long, up to 120 cm high], is located just off the south side of an inland-seaward dirt road. It is composed of well-stacked boulders and looks to be historic.

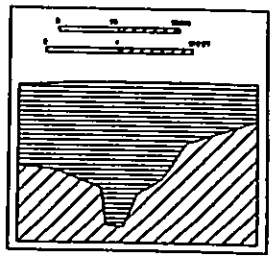
This retaining wall segment may have had an agricultural function and is probably related to Feature A.

Feature A

This is a terrace measuring 11.9 by 12.2 meters [115.6 square meters] and standing to a height of 1.3 meters. It is well constructed of boulders placed against and around a bedrock outcrop ledge.

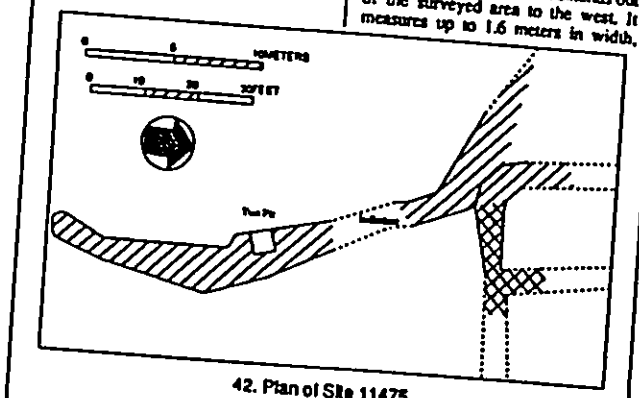
Feature B

This is a terrace measuring 7.0 by 9.7 meters [62.7 square meters] and standing to a height of 1.2 meters. If the ramp on the west side, apparently built for access, is included the overall dimensions are 8.6 by 9.7 meters [70.6 square meters]. The wall, which covers an area of 32.4 square meters and encloses a living area of 30.3 square meters, is constructed of stacked cobbles and boulders.



41. Site 11474B Test Pit, West Face Cross-Section

One test pit was excavated, reaching pahoehoe bedrock at a maximum depth of 60 centimeters. Midden recovered consists of 12.3 grams of charcoal, 0.2 gram of carbonized *Aleurites moluccana* shell and 0.5 gram of *Cypraea capuiserpentis*.



42. Plan of Site 11475

Feature C

This is a terrace measuring 4.4 by 7.0 meters [27.3 square meters] and standing to a height of 80 centimeters. The wall covers an area of 14.9 square meters and encloses an area of 12.4 square meters. A retaining wall extends between the northeast corner and a bedrock outcrop.

A single test pit was excavated mostly to a depth of 5 centimeters, although in one 20 by 25 centimeter area it reached pahoehoe bedrock at a depth of 20 centimeters. No midden was found.

Feature D

This is a collapsed L-shaped retaining wall measuring 5.3 meters along one arm and 6.9 meters along the other. It is 1.5 meters wide, stands to a height of 90 centimeters, and covers an area of 14.2 square meters. It is constructed of stacked cobbles and boulders.

Feature E

This is a retaining wall measuring 1.7 by 10.2 meters [22.5 square meters] and standing to a height of 1.2 meters. It is constructed of stacked cobbles and boulders.

Feature F

This is a wall, partly free-standing and partly a retaining wall, that extends out of the surveyed area to the west. It measures up to 1.6 meters in width, stands to a height of 80 centimeters, and is constructed of stacked cobbles and boulders.

50-10-47-11475 [T-38]

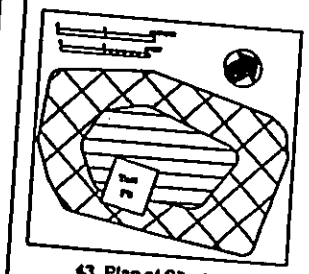
Located c. 20.0 m seaward of the Old Pineapple road, Site T-38 is a long, high north-south terrace retaining wall that forms a corner with an inland-seaward wall at its north end [c. 40.0 by 20.0 m, up to 145 cm high].

The faced retaining wall is constructed of well-stacked boulders and has a fairly flat, rock-filled and soil surface behind it. The north end of the retaining wall runs into an exposed bedrock rise, with several rough rubble wall alignments and rock pilings on and around it. A single piece of Cypraea sp. shell was noted on the surface in the north end area.

The retaining wall is apparently historic and possibly is related to the pineapple road which runs just inland, but the bedrock rise area to the north may have had a habitation function.

This is a retaining wall built of stacked boulders that measures between 1.3 and 2.5 meters in width and stands to a height of 1.5 meters. It continues out of the surveyed area to the northwest.

The test pit revealed an 85 centimeter thick fill of cobbles and boulders resting on a 5 to 20 centimeter thick deposit of dirt, which in turn was resting on pahoehoe bedrock.



43. Plan of Site 11476

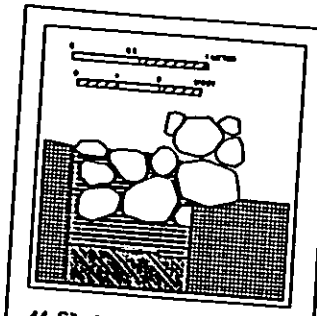
50-10-47-11476 [T-39]

Site T-39 is a somewhat collapsed, roughly rectangular, raised platform [5.0 by 3.5 m, up to 75 cm high] located under a small monkeypod grove on top of a small hill. It consists of a stacked boulder exterior face with cobbles and soil interior fill, and the inside surface has a slight depression below the top of the outside wall face.

This structure may be an early historic, rectangular burial platform or possibly just a well-built agricultural rock pile perhaps related to the pineapple cultivation period.

The site is a platform measuring 3.3 by 5.2 meters [15.0 square meters] and standing to a height of 70 centimeters. A free-standing wall up to 40 centimeters high is located on the perimeter of the platform and forms an enclosed area of 4.8 square meters.

A single test pit was excavated, demonstrating that the structure had



44. Site 11476 Test Pit, East Face Cross-Section

been built over an *in situ* cultural deposit [Tables 23-25]. The upper 50 centimeters consisted of cobbles and boulders in a matrix of ash, below which was about 20 centimeters of ash with few rocks. At this point a sterile yellow dirt was encountered, but the presence of large rocks prevented determination of whether more cultural materials were located deeper down.

50-10-47-11477 [T-40]

Located in a kukui grove, Site T-40 is a small, roughly rectangular, walled terrace [4.0 by 5.0 m, up to 60 cm high] associated with a long, cross-slope, rough terrace. The small, walled terrace is composed of stacked large boulders and has a soil and rubble interior surface.

This feature may be a prehistoric temporary shelter structure associated with an agriculturally modified area.

50-10-47-11478 [T-41]

A probably prehistoric/early historic habitation and agricultural site complex [c. 45.0 by 55.0 m]. Site T-41 is composed of three designated features along with various sorts of agricultural rock pilings found within the site area.

Features A and C are located under separate kukui groves, while Feature B is under mango and octopus trees.

Feature A is a large, roughly rectangular, walled terrace [16.5 by 11.0 m, up to 160 cm high], quite collapsed but still fairly distinct. Its thick walls are constructed of roughly stacked boulders and cobbles; there is a level soil surface on the interior.

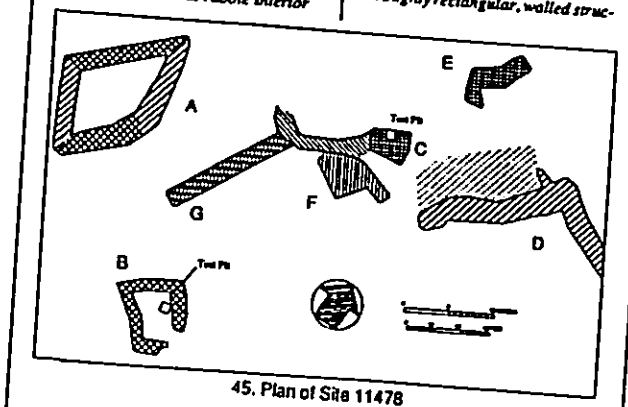
This feature is probably a large habitation structure and indicates long-term temporary or possibly permanent residence.

Feature B, a much collapsed, roughly rectangular, walled structure [8.5 by 8.5 m, up to 95 cm high], is composed of stacked boulders with some cobbles and is built partially on exposed bedrock. Much agricultural surface modification on the slope just to the south includes a large, linear rock pile.

The structure is possibly a small habitation feature or collapsed animal pen.

Feature C is a small, but high and roughly rectangular, raised platform [4.0 by 3.5 m, up to 140 cm high]. Built against an exposed bedrock outcrop, it consists of a stacked boulder face with interior cobble fill. A possible similar structure is located about 8.0 m inland, while 6.0 m to the south runs a possible inland-seaward field boundary with prominent agricultural rock piles adjacent.

This feature may be a burial platform or possibly just a prominent agricultural rock pile on bedrock.



45. Plan of Site 11478

Feature A

This is an enclosure covering an area of 11.1 by 14.3 meters [138.1 square meters]. The area enclosed by the stacked cobble and boulder wall, which itself covers 83.0 square meters, is 55.1 square meters. Two of the walls are free-standing, the other two are retaining walls and they stand to a maximum height of 1.0 meter.

Feature B

This is an enclosure covering an area of 6.5 by 8.6 meters [47.7 square meters]. The stacked cobble and boulder wall covers an area of 27.3 square meters, encloses an area of 19.0 square meters, and stands to a height of 80 centimeters.

One test pit was excavated. Midden recovered includes 0.1 gram of charcoal, 0.6 gram of *Cypraea capuiserpentis*, one manuport and six specimens of basaltic glass.

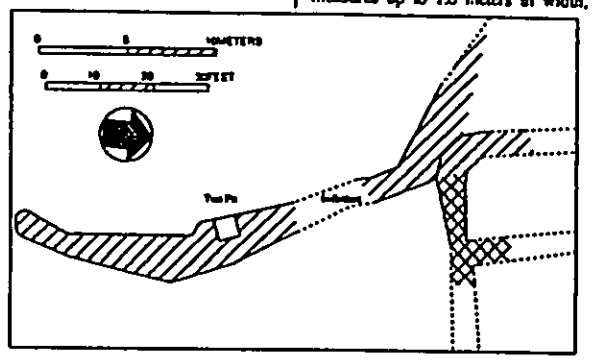
Feature C

This is a regular mound measuring 3.5 by 4.5 meters [13.3 square meters] and

CORRECTION

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

One test pit was excavated, reaching pahoehoe bedrock at a maximum depth of 60 centimeters.. Midden recovered consists of 12.3 grams of charcoal, 0.2 gram of carbonized *Aleurites moluccana* shell and 0.5 gram of *Cypraea caputserpentis*.



42. Plan of Site 11475

Feature C

This is a terrace measuring 4.4 by 7.0 meters [27.3 square meters] and standing to a height of 80 centimeters. The wall covers an area of 14.9 square meters and encloses an area of 12.4 square meters. A retaining wall extends between the northeast corner and a bedrock outcrop.

A single test pit was excavated mostly to a depth of 5 centimeters, although in one 20 by 25 centimeter area it reached pahoehoe bedrock at a depth of 20 centimeters. No midden was found.

Feature D

This is a collapsed L-shaped retaining wall measuring 5.3 meters along one arm and 6.9 meters along the other. It is 1.5 meters wide, stands to a height of 90 centimeters, and covers an area of 14.2 square meters. It is constructed of stacked cobbles and boulders.

Feature E

This is a retaining wall measuring 1.7 by 10.2 meters [22.5 square meters] and standing to a height of 1.2 meters. It is constructed of stacked cobbles and boulders.

Feature F

This is a wall, partly free-standing and partly a retaining wall, that extends out of the surveyed area to the west. It measures up to 1.6 meters in width, stands to a height of 80 centimeters, and is constructed of stacked cobbles and boulders.

50-10-47-11475 [T-38]

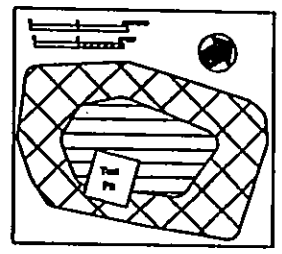
Located c. 20.0 m seaward of the Old Pineapple road, Site T-38 is a long, high north-south terrace retaining wall that forms a corner with an inland-seaward wall at its north end [c. 40.0 by 20.0 m, up to 145 cm high].

The faced retaining wall is constructed of well-stacked boulders and has a fairly flat, rock-filled and soil surface behind it. The north end of the retaining wall runs into an exposed bedrock rise, with several rough rubble wall alignments and rock piling on and around it. A single piece of Cypraea sp. shell was noted on the surface in the north end area.

The retaining wall is apparently historic and possibly is related to the pineapple road which runs just inland, but the bedrock rise area to the north may have had a habitation function.

This is a retaining wall built of stacked boulders that measures between 1.3 and 2.5 meters in width and stands to a height of 1.5 meters. It continues out of the surveyed area to the northwest.

The test pit revealed an 85 centimeter thick fill of cobbles and boulders resting on a 5 to 20 centimeter thick deposit of dirt, which in turn was resting on pahoehoe bedrock.



43. Plan of Site 11476

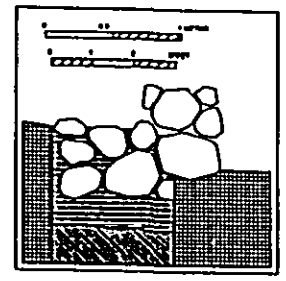
50-10-47-11476 [T-39]

Site T-39 is a somewhat collapsed, roughly rectangular, raised platform [5.0 by 3.5 m, up to 75 cm high] located under a small monkeypod grove on top of a small hill. It consists of a stacked boulder exterior face with cobbles and soil interior fill, and the inside surface has a slight depression below the top of the outside wall face.

This structure may be an early historic, rectangular burial platform or possibly just a well-built agricultural rock pile perhaps related to the pineapple cultivation period.

The site is a platform measuring 3.3 by 5.2 meters [15.0 square meters] and standing to a height of 70 centimeters. A free-standing wall up to 40 centimeters high is located on the perimeter of the platform and forms an enclosed area of 4.8 square meters.

A single test pit was excavated, demonstrating that the structure had been built over an *in situ* cultural deposit [Tables 23-25]. The upper 50 centimeters consisted of cobbles and boulders in a matrix of ash, below which was about 20 centimeters of ash with few rocks. At this point a sterile yellow dirt was encountered, but the presence of large rocks prevented determination of whether more cultural materials were located deeper down.



44. Site 11476 Test Pit, East Face Cross-Section

50-10-47-11477 [T-40]

Located in a kukui grove, Site T-40 is a small, roughly rectangular, walled terrace [4.0 by 5.0 m, up to 60 cm high] associated with a long, cross-slope, rough terrace. The small, walled terrace is composed of stacked large boulders and has a soil and rubble interior surface.

This feature may be a prehistoric temporary shelter structure associated with an agriculturally modified area.

50-10-47-11478 [T-41]

A probably prehistoric/early historic habitation and agricultural site complex [c. 45.0 by 55.0 m], Site T-41 is composed of three designated features along with various sorts of agricultural rock pilings found within the site area.

Features A and C are located under separate kukui groves, while Feature B is under mango and octopus trees.

Feature A is a large, roughly rectangular, walled terrace [16.5 by 11.0 m, up to 160 cm high], quite collapsed but still fairly distinct. Its thick walls are constructed of roughly stacked boulders and cobbles; there is a level soil surface on the interior.

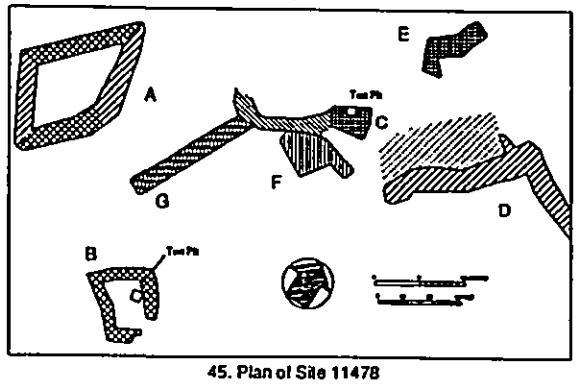
This feature is probably a large habitation structure and indicates long-term temporary or possibly permanent residence.

Feature B, a much collapsed, roughly rectangular, walled structure [8.5 by 8.5 m, up to 95 cm high], is composed of stacked boulders with some cobbles and is built partially on exposed bedrock. Much agricultural surface modification on the slope just to the south includes a large, linear rock pile.

The structure is possibly a small habitation feature or collapsed animal pen.

Feature C is a small, but high and roughly rectangular, raised platform [4.0 by 3.5 m, up to 140 cm high]. Built against an exposed bedrock outcrop, it consists of a stacked boulder face with interior cobble fill. A possible similar structure is located about 8.0 m inland, while 6.0 m to the south runs a possible inland-seaward field boundary with prominent agricultural rock piles adjacent.

This feature may be a burial platform or possibly just a prominent agricultural rock pile on bedrock.



45. Plan of Site 11478

Feature A

This is an enclosure covering an area of 11.1 by 14.3 meters [138.1 square meters]. The area enclosed by the stacked cobble and boulder wall, which itself covers 83.0 square meters, is 55.1 square meters. Two of the walls are free-standing, the other two are retaining walls and they stand to a maximum height of 1.0 meter.

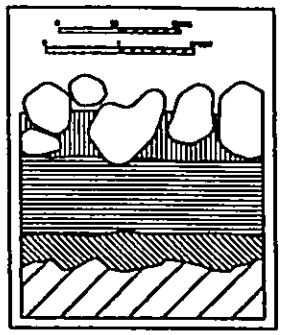
Feature B

This is an enclosure covering an area of 6.5 by 8.6 meters [47.7 square meters]. The stacked cobble and boulder wall covers an area of 27.3 square meters, encloses an area of 19.0 square meters, and stands to a height of 80 centimeters.

One test pit was excavated. Midden recovered includes 0.1 gram of charcoal, 0.6 gram of *Cypraea caputserpentis*, one manuport and six specimens of basaltic glass.

Feature C

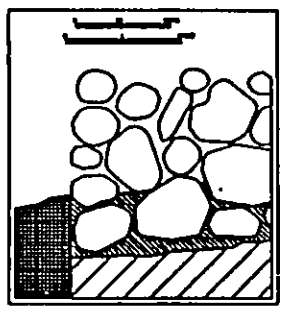
This is a regular mound measuring 3.5 by 4.5 meters [13.3 square meters] and



48. Site 11478B Test Pit, West Face Cross-Section

standing to a height of 1.0 meter. It is constructed of stacked cobbles and boulders.

One test pit was excavated.



47. Site 11478C Test Pit, Northeast Face Cross-Section

Feature D

This is a retaining wall measuring up to 2.6 meters in width and 1.1 meter in height that continues out of the surveyed area to the east. An area of 65.6 square meters on the northwest side of the wall has been cleared of rocks.

Feature E

This is a regular mound measuring 2.3 by 8.1 meters [18.6 square meters] and standing to a height of 1.0 meter. It is built of stacked cobbles and boulders.

Feature F

This is an irregular mound measuring 5.0 by 8.4 meters [24.2 square meters] and standing to a height of 80 centimeters. It is built of cobbles and boulders stacked against a bedrock outcrop.

Feature G

This is a linear mound measuring 2.0 by 14.3 meters [29.0 square meters] and standing to a height of between 80 and 100 centimeters. It is constructed of stacked cobbles and boulders.

50-10-47-11479 [T-42]

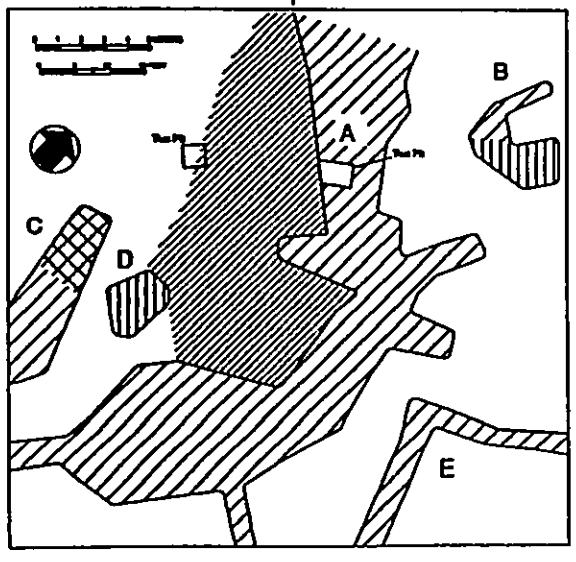
Located in a grove of kukui trees somewhat on the south side of an inland-seaward dirt road, the T-42 site area [c. 35.0 by 30.0 m] consists of assorted rock piling and other surface modifications on and around a large, natural bedrock boulder outcrop rise. Construction is generally of roughly stacked boulders and some cobbles, often on or against bedrock boulders. The seaward part of the site area seems to have been roughly cleared of rocks to the soil surface, and a large, rough rubble terrace line [up to 120 cm high] is present on the inland side of the clearing [c. 8.0 by 13.0 m cleared area].

The site is an agriculturally modified kukui grove surface rock concentration area and is probably prehistoric in origin.

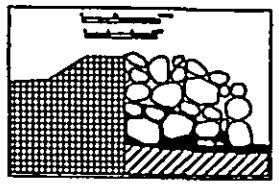
Feature A

This is a cobble and boulder retaining wall built on a bedrock outcrop. It measures between 2.4 and 6.0 meters in width and stands to a height of between 0.6 and 1.0 meter. It continues out of the surveyed area to the southeast and southwest.

One test pit was excavated, producing two manuports.



48. Plan of Site 11479



49. Site 11479A Test Pit, Southeast Face Cross-Section

Feature B

This is a pile of rocks on a bedrock outcrop that takes the form of a retaining wall on the north side and a mound on the south. It measures 4.0 by 4.6 meters [9.6 square meters] and stands to a height of 60 centimeters. It is constructed of stacked cobbles.

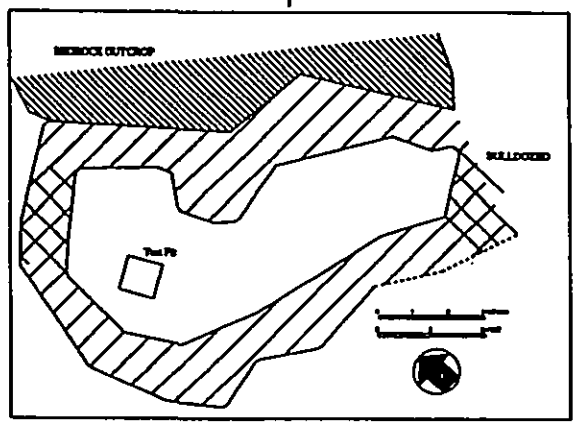
Feature D

This is an irregular mound measuring 2.3 by 3.2 meters [7.7 square meters] and standing to a height of between 40 and 100 centimeters. It is constructed of stacked cobbles with a few boulders.

Feature E

This is a stacked boulder retaining wall measuring 1.2 meters in width and standing to a height of between 50 and 90 centimeters. It continues out of the surveyed area to the east and to the south.

A 30 centimeter deep pit in the open area west of Feature A produced 1.6 gram of unidentified shell.



50. Plan of Site 11480

Feature C

This is a wall, partly free-standing and partly a retaining wall, that measures between 1.5 and 2.6 meters in width. The free-standing section stands 70 centimeters high, the retaining wall part stands 40 centimeters high. It continues out of the surveyed area to the south, where it joins with Feature A. It is constructed of stacked cobbles and boulders.

50-10-47-11480 [T-43]

Site T-43, a rather collapsed, large high rectangular walled terrace [c. 14.0 by 10.0 m, up to 150 cm high] with a level soil surface on the interior, is located just north of an old inland-seaward dirt road. It is constructed of stacked boulders and some cobbles and is heavily overgrown with vegetation.

This possibly prehistoric structure is most likely a rather substantial rectangular habitation terrace, perhaps for relatively long-term use. Poor visibility due to heavy vegetation cover makes it difficult to give a definite assessment.

This is a stacked cobble and boulder terrace measuring 7.2 by 13.8 meters [84.3 square meters] and standing to a height of 1.5 meter on the west and 1.7 meter on the east. The living area enclosed by the wall covers 37.2 square meters. The east end of the structure has been bulldozed, revealing one shell of a cowrie (*Cypraea capulserpentis*).

A single test pit was excavated to a depth of between 40 and 50 centimeters, at which point weathered bedrock was encountered [Tables 28-30].

50-10-47-12006 [T-36]

This site consists of Feature B of Site T-36 [Site 11473] of the intensive reconnaissance report:

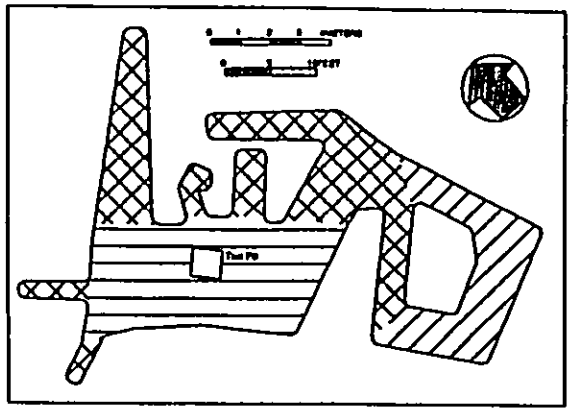
Feature B, a fairly large, rock-filled, high rectangular terrace [16.5 by 7.5 m, up to c. 115 cm high], is constructed primarily of stacked boulders with some internal divisions or wall alignments. It is quite heavily covered by vegetation, making detailed visual inspection difficult.

The structure appears to be a habitation feature [a possible house foundation] and is perhaps prehistoric or more likely historic and related to the time of pineapple cultivation.

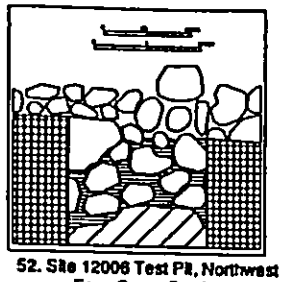
Feature B apparently correlates with Site 203 which was originally described as follows:

Modern house site. The stone foundations of a house said to have been built at the time of pineapple cultivation, prior to World War I [Soehren and Newman 1968:14].

This site was separated from the other features of Site 11473 because of its clearly different formal characteristics. It was apparent upon clearing of the vegetation that its interpretation as a historic structure associated with the



51. Plan of Site 12006



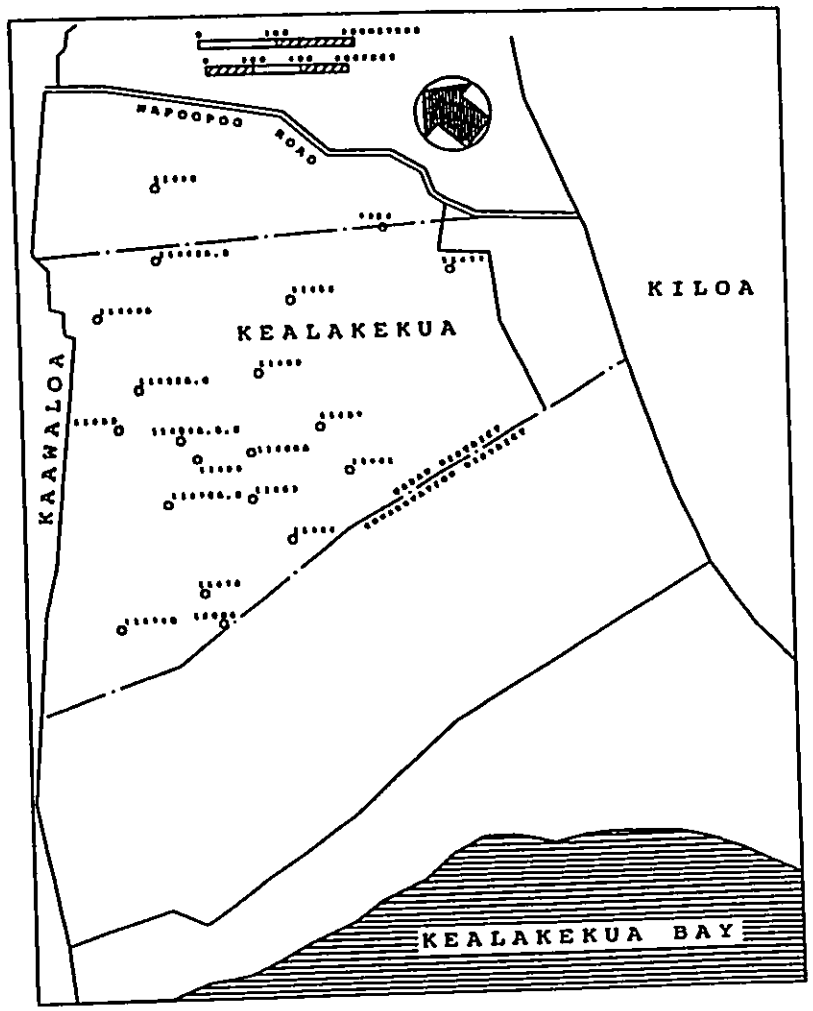
52. Site 12006 Test Pit, Northwest Face Cross-Section

pineapple plantation was incorrect. Its construction technique and materials are different from the known plantation structures, there is no historic trash at the site and debris from construction of the supposedly contemporary "pineapple road" is piled against the west side of the structure.

The structure is composed of several connected features covering an area of 10.4 by 17.6 meters [85.9 square meters]. It is constructed of stacked cobbles and boulders and stands to a height of 1.2 meter. On the southwest side of the site there is a platform measuring 3.7 by 8.5 meters [29.7 square meters]. It appears that a second building phase may have added a meter to this feature on the southwest and southeast sides. A basalt hammerstone was found on the surface. On the southeast side there is an enclosure measuring 4.9 by 5.7 meters [28.3 square meters] that is formed by a free-standing wall and three retaining walls which enclose an area of 6.9 square meters. Six crude free-standing walls abut the site on three sides.

Excavation of the single test pit was stopped at a depth of between 65 and 80 centimeters by either bedrock or a very large boulder that prevented further digging. Midden consists of 12.2 grams of charcoal, 1.1 gram of *Cypraea caputserpentis*, 1.5 gram of Thaididae and 3.7 grams of unidentified shell. Artifacts recovered include five coral manuports, one basalt flake, one basaltic glass flake and a piece of worked bone.

III. SIGNIFICANCE ASSESSMENTS



53. Locations of Significant Sites

50-10-47-11440

Both Feature A and B were tested and each produced cultural materials indicative of prehistoric occupation. In addition, Feature B produced a ceramic sherd, suggesting historic utilization. The site is significant for information it might provide relevant to the study of history or prehistory, and if either feature is in the way of construction a data recovery plan should be implemented for each.

50-10-47-11441

This feature is a component of the Kona Field System, and is discussed under that heading.

50-10-47-11442

All four features of this site are components of the Kona Field System, and are discussed under that heading.

50-10-47-11443

This feature is a component of the Kona Field System, and is discussed under that heading.

50-10-47-11444

This feature is a component of the Kona Field System, and is discussed under that heading.

50-10-47-11445

This feature is a component of the Kona Field System, and is discussed under that heading.

50-10-47-11446

Although the function and age of Feature A itself has not been determined, the presence of midden and artifacts in the dirt beneath it demonstrates the presence of information important to prehistory. A data recovery plan should be implemented if development entails an adverse impact to the feature.

The relatively large amounts of midden and artifacts from Feature B indicate that it was a habitation in use during the prehistoric period, and its significance lies in the fact that it contains information important to the prehistory of Hawaii. If this feature lies in the way of development, a data recovery plan should be implemented.

Features C through H are components of the Kona Field System, and are discussed under that heading.

50-10-47-11447

These features are components of the Kona Field System, and are discussed under that heading.

50-10-47-11448

The large amounts of ash, midden and artifacts from Feature A indicate that it was probably a habitation feature, and that its significance lies in the important information about prehistory that it contains. If the cave is to be disturbed, a data recovery plan should be implemented.

Features B through E are components of the Kona Field System, and are discussed under that heading.

50-10-47-11449

This feature is a component of the Kona Field System, and is discussed under that heading.

50-10-47-11450

All of the features of this site are components of the Kona Field System, and are discussed under that heading.

50-10-47-11451

All of the features of this site are components of the Kona Field System, and are discussed under that heading.

50-10-47-11452

Although midden and artifactual remains from Features A and G were rather scarce, their form and size alone suggest that they were habitation features. They are significant because they contain information important to Hawaiian prehistory and if development is to involve either feature, a data recovery plan should be implemented.

The remaining features of this site are components of the Kona Field System, and are discussed under that heading.

50-10-47-11453

The extensive midden and artifactual remains recovered from this site indicate that it was a habitation feature, and that it contains information important to Hawaii prehistory. If the site is to be disturbed by development, a data recovery program should be implemented.

50-10-47-11454

Although the exact nature of its utilization has not been determined, the presence of midden remains at Feature A indicates the presence of information important to the prehistory of Hawaii. A data recovery plan should be implemented if development represents an adverse impact to the feature.

The formal characteristics and midden assemblage at Feature B indicate that it was a habitation during the prehistoric period, and therefore contains information important to Hawaii prehistory. If development involves this feature a data recovery plan should be excavated.

The significance of Feature C, a possible habitation terrace, has not been determined. It should be tested, and if it contains information important to Hawaiian history or prehistory a data recovery plan should be implemented.

All of the remaining features of this site are components of the Kona Field System, and are discussed under that heading.

50-10-47-11455

The virtual absence of midden or artifacts at Feature A demonstrate that it is not a habitation feature, as might have been surmised from its form. It, along with Feature B, are components of the Kona Field System and their significance is discussed under that heading.

50-10-47-11456

The paucity of midden remains at this site was unexpected, but its form and the nature of the artifacts recovered indicate that it was a prehistoric habitation feature. It is therefore significant because of its importance to Hawaii prehistory, and if it is to be disturbed during

SITE	TYPE	Length	Width	Height	A	B	C	D	E	F	KFS	NLS	NS
11,440A	Terrace	4.1	3.9	0.8				■					
11,440B	Retaining Wall	8.6	1.0	1.3				■					
11,441	Retaining Wall	12.0	2.0	1.2							■		
11,442A	Retaining Wall	17.6	1.0-5.6	0.9							■		
11,442B	Linear Mound	4.0	3.3	0.5							■		
11442C	Retaining Wall & Mound	6.6	2.9	1.0							■		
11442D	Linear Mound	10.6	2.3	1.0							■		
11,443	Irregular Mound	7.7	4.0	0.6							■		
11,444	Linear Mound	14.5	1.2-5.9	0.8							■		
11,445	Retaining Wall	5.0,5.6	1.0	1.1							■		
11,446A	Enclosure	3.5	2.7	0.8				■					
11,446B	Terrace	7.6	5.0	1.1				■					
11,446C	Terrace	6.9	3.9	1.0							■		
11,446D	Terrace	6.6	2.7	1.0							■		
11,446E	Retaining Wall	20.4	1.0	1.4							■		
11,446F	Retaining Wall		1.3-4.5	1.0							■		
11,446G	Retaining Wall		1.9-3.9	0.7							■		
11,446H	Retaining Wall		2.7-4.8	1.0							■		
11,447A	Retaining Wall		2.1-3.9	1.0							■		
11,447B	Linear Mound	11.7	2.0-4.8	0.8							■		
11,447C	Retaining Wall	11.6	1.4-2.4	0.8							■		
11447D	Irregular Linear Mound		4.4	1.0							■		
11,448A	Cave	5.3	5.3	0.9				■					
11,448B	Free-Standing Wall	2.0	1.1	0.5							■		
11,448C	Retaining Wall	1.7	0.6	0.9							■		
11,448D	Retaining Wall	5.2	0.6	0.8							■		
11,448E	Retaining Wall	6.2	0.5	0.7							■		
11,449	Irregular Mound	3.5	2.5	0.7							■		
11,450A	Irregular Mound	7.9	3.8	0.6							■		
11,450B	Retaining Wall	17.8	1.9-2.8	0.8							■		
11,450C	Retaining Wall & Mound	17.0	3.0-9.5	1.0							■		
11,451A	Platform	9.3	6.4	1.3							■		
11,451B	Linear Mound		2.9	0.6							■		
11,451C	Irregular Mound	2.3	0.9	0.4							■		
11,451D	Irregular Mound	4.4	2.5	0.4							■		
11,451E	Irregular Mound	2.3	1.3	0.7							■		
11,451F	Retaining Wall	42.0	0.9-1.2	1.4							■		
11,451G	Irregular Mound	9.2	4.8	0.6							■		
11,451H	Mound/Retaining Wall	7.2	2.6	0.6							■		
11,451I	Linear Mound/Wall		1.5-2.9	0.9							■		
11,451J	Retaining Wall		1.3-2.0	0.8							■		
11,451K	Retaining Wall	22.7	1.0	0.8							■		
11,452A	Terrace	4.9	4.3	1.3				■					
11,452B	Irregular Mound	2.7	2.7	0.9							■		
11,452C	Irregular Mound	2.7	0.7	0.8							■		
11,452D	Terraced Area	5.7	2.7	0.6							■		
11,452E	Irregular Mound	6.7	4.0	0.8							■		
11,452F	Retaining Wall	6.0	0.8	1.0							■		
11,452G	Terrace	8.6	5.7	0.8				■					
11,452H	Irregular Mound	3.1	0.7	1.0							■		
11,452I	Retaining Wall	3.8	0.9	0.8							■		
11,452J	Irregular Mound	2.6	1.0	1.3							■		

SIGNIFICANCE CRITERIA

A - Association with Broad Patterns of History
B - Association with Significant Persons
C - Excellent Example of a Site Type
D - Contains Important Information on Prehistory or History
E - Culturally Significant to an Ethnic Group
F - Provisionally Significant, Further Work Needed to Confirm Significance
KFS - Component of Knee Field System - Not Individually Significant
NLS - No longer Significant, Sufficient Information Has Been Recovered
NS - Not Significant

Table 1. Sites and Significance Assessments

SITE	TYPE	Length	Width	Height	A	B	C	D	E	F	KFS	NLS	NS
11,453	Cave	9.8	2.3-3.3	1.0				■					
11,454A	Enclosure	16.1	13.9	1.4				■					
11,454B	Platform	6.4	5.6	0.7				■					
11,454C	Terrace	4.4	3.6	0.5						■			
11,454D	Irregular Mound	4.0	3.7	0.6							■		
11,454E	Retaining Wall	9.0	2.0-3.3	0.5							■		
11,454F	Retaining Wall		1.3	0.8							■		
11,454G	Retaining Wall	15.7	1.2	0.9							■		
11,454H	Retaining Wall		1.1-1.8	0.7							■		
11,454I	Retaining Wall		2.5	1.5							■		
11,454J	Linear Mound		1.5-3.0	0.8							■		
11,455A	C-Shaped Structure	5.0,5.2	1.6	1.1							■		
11,455B	Retaining Wall		5.0	0.9							■		
11,456	Terrace	11.2	9.5	1.0				■					
11,457	NOT LOCATED									■			
11,458	Enclosure	12.0	11.0	0.8				■					
11,459A	Irregular Mound	21.2	3.0-4.6	0.8							■		
11,459B	Linear Mound		1.9-2.7	1.0							■		
11,459C	Irregular Mound	6.6	5.0	1.0							■		
11,459D	Free-Standing Wall	2.9,3.0	0.9	0.4							■		
11,459E	Linear Mound		1.4	0.5							■		
11,459F	Linear Mound		1.9-2.8	1.0							■		
11,460A	Terrace	11.6	5.4	1.2				■					
11,460B	Retaining Wall		1.6	0.5							■		
11,461	NOT LOCATED									■			
11,462	Terrace	15.5	6.0								■		
11,463A	Cave	7.8	1.8	0.6				■					
11,463B	Enclosed Area	14.0	11.9	1.0				■					
11,464A	Irregular Mound	2.1	1.4	0.5				■					
11,464B	Regular Mound	2.8	1.3	0.7				■					
11,464C	Terrace	3.7	2.7	0.9				■					
11,464D	Terrace	1.9	1.1	0.7				■					
11,464E	Irregular Mound	4.0	2.9	0.3				■					
11,464F	Terrace	4.6	2.4	0.6				■					
11,464G	Irregular Mound	2.1	1.8	0.3				■					
11,464H	Irregular Mound	2.1	1.8	0.35				■					
11,464I	Regular Mound	3.1	1.9	0.6				■					
11,464J	Irregular Mound	2.7	2.3	0.5				■					
11,464K	Terrace	3.0	1.3	0.5				■					
11,464L	Free-Standing Wall	35.3	1.8-2.4	0.9				■					
11,473A	Regular Mound	3.0	2.6	0.6								■	
11,473B	Regular Mound	3.0	2.8	0.5								■	
11,473C	Irregular Mound	1.8	1.1	0.4								■	
11,473D	Irregular Mound	4.3	2.8	0.4								■	
11,473E	Irregular Mound	2.7	1.9	0.4								■	
11,474A	Terrace	12.2	11.9	1.3								■	
11,474B	Terrace	9.7	7.0	1.2				■					
11,474C	Terrace	7.0	4.4	0.8							■		
11,474D	Retaining Wall	5.3,6.9	1.5	0.9								■	
11,474E	Retaining Wall	10.2	1.7	1.3								■	
11,474F	Wall		1.6	0.8							■		

SIGNIFICANCE CRITERIA

A - Association with Broad Patterns of History
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C - Excellent Example of a Site Type
D - Contains Important Information on Prehistory or History
E - Culturally Significant to an Ethnic Group
F - Provisionally Significant, Further Work Needed to Confirm Significance
KFS - Component of Knee Field System - Not Individually Significant
NLS - No longer Significant, Sufficient Information Has Been Recovered
NS - Not Significant

Table 1. Sites and Significance Assessments

SITE	TYPE	Length	Width	Height	A	B	C	D	E	F	KFS	NLS	NS
					SIGNIFICANCE CRITERIA								
11,475	Retaining Wall		1.3-2.5	1.5								•	
11,476	Platform	5.3	3.3	0.7				•					
11,477	Terrace	5.0	4.0	0.6				•					
11,478A	Enclosure	14.3	11.1	1.0						•			
11,478B	Enclosure	8.6	6.3	0.8				•					
11,478C	Regular Mound	4.5	3.5	1.0							•		
11,478D	Retaining Wall		2.6	1.1							•		
11,478E	Regular Mound	8.1	2.3	1.0							•		
11,478F	Irregular Mound	8.4	5.0	0.8							•		
11,478G	Linear Mound	14.3	2.0	1.0							•		
11,479A	Retaining Wall		2.4-4.0	1.0							•		
11,479B	Retaining Wall/Mound	4.6	4.0	0.6							•		
11,479C	Wall		1.5-2.6	0.7							•		
11,479D	Irregular Mound	3.2	2.3	1.0							•		
11,479E	Retaining Wall		1.2	0.9							•		
11,480	Terrace	13.8	7.3	1.7				•					
12,006	Platform & Enclosure	17.6	10.4	1.2				•					

SIGNIFICANCE CRITERIA

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NS - Not Significant

Table 1. Sites and Significance Assessments

development a data recovery plan should be implemented.

50-10-47-11457

This site could not be found because of the dense vegetation. It will have to be located and a test pit excavated in order to determine its significance.

50-10-47-11458

The form of this site and the presence of midden remains indicate that it is significant because it contains information important to the study of Hawaii prehistory. A data recovery plan should be implemented if development represents an adverse effect.

50-10-47-11459

All of the features of this site are components of the Kona Field System, and are discussed under that heading.

50-10-47-11460

Midden at Feature A suggests that it may have been a prehistoric habitation feature. A data recovery plan will be required before it can be disturbed by development.

Feature B is a component of the Kona Field System, and is discussed under that heading.

50-10-47-11461

This site could not be found because of the dense vegetation. It will have to be located and a test pit excavated in order to determine its significance.

50-10-47-11462

This site is a component of the Kona Field System, and is discussed under that heading.

50-10-47-11463

This cave and its associated enclosed area are a prehistoric habitation site. A data recovery plan should be implemented if development will be an adverse impact on the site.

50-10-47-11464

The materials in the soil beneath the features at this site probably represent late prehistoric utilization. These materials have been disturbed to some extent by what appears to be the nineteenth century construction and use of the stone structures. Because of the presence of data important to both the history and prehistory of Hawaii, a data recovery plan should be implemented if the site is to be disturbed.

50-10-47-11473

All of these features are probably historic in age, and probably date from the days of pineapple cultivation. The completed recording and excavation constitute sufficient information retrieval, and there is no need for any further archaeological work.

50-10-47-11474

Features A, D and E are relatively recent historic structures associated with the period of pineapple cultivation. The mapping and recording done during the present project represent sufficient data recovery, and they are no longer of significance. Features C and F are components of the Kona Field System, and are discussed under that heading.

Feature B was a habitation during the prehistoric period and has significance because of the data it contains pertaining to the prehistory of Hawaii. A data recovery plan should be implemented if development represents an adverse impact to this feature.

50-10-47-11475

This site is a relatively recent historic feature associated with the period of pineapple cultivation. The mapping and recording done during the present project represent sufficient data recovery, and it is no longer of significance.

50-10-47-11476

The relatively abundant artifacts and midden materials beneath this platform suggest the possibility of an extensive prehistoric cultural deposit around the site. The vicinity should be tested to delineate the extent of these remains, and a data recovery plan should be carried out if development represents an adverse impact.

50-10-47-11477

This shelter structure contains information important to Hawaii prehistory. A data recovery plan should be implemented if it lies in the path of development.

50-10-47-11478

The precise nature of Feature A has not been determined. The feature should be tested before making a final decision on its significance.

Feature B is a prehistoric habitation site and is significant because it contains information important to Hawaii prehistory. A data recovery plan should be carried out if the site is to be disturbed.

Features C through G are components of the Kona Field System, and are discussed under that heading.

50-10-47-11479

All of the features of this site are components of the Kona Field System, and are discussed under that heading.

50-10-47-11480

This site is a prehistoric habitation feature and is important because it contains information relevant to the study of Hawaii prehistory. A data recovery plan should be implemented if development represents an adverse impact.

50-10-47-12006

This site is a habitation structure occupied during the prehistoric period. A data recovery plan should be implemented if it is to be disturbed.

50-10-47-7324

This historic house site, known as the Dennis Henriques House, is the first frame house in the *ahupua'a* of Kealakekua. The developer should consult with the Historic Sites Section of the Department of Land and Natural Resources to determine the proper course of action with regard to this site.

Kona Field System

This is an extensive network of agricultural features stretching from Kealakekua to the slopes of Hualalai. In the present survey area it is mainly represented by long roughly parallel free-standing and retaining walls extending in a coastal-inland direction across the contours, and shorter crude retaining walls abutting these and extending along the contours. Interspersed throughout this grid of boundary walls are numerous crude stone mounds and cleared areas. Excavations in both the mounds and the walls during the present project revealed an almost monotonous regularity. The typical cross-section consists of a few tens of centimeters of rocks in point to point contact resting on or in a thin dirt deposit, which in turn is resting on weathered pahoehoe bedrock. The dirt deposit as often as not is sterile. When it does contain cultural materials, they are scarce and consist primarily of a few pieces of charcoal, maybe some waterworn basalt manuports and a fragment of marine shell, and perhaps a specimen of basaltic glass.

While none of these features is individually of any great significance, in the aggregate they and the open areas between them represent a valuable archaeological resource. Analyses of basaltic glass samples, pollen, charcoal and phytoliths, used in conjunction with the relatively good ethnohistorical data from the region, have the potential for providing valuable information about what crops were grown, when they were grown, how the field system developed through time, what micro-environmental changes may have accompanied the development of the field system, and so on.

A data recovery plan should begin with the preparation of a map based on aerial photographs, followed by fieldwork to verify and record pertinent details about each feature. A program of archaeological excavations should then be undertaken to gather both cultural and environmental data.

Summary

The sites recorded on the Kealakekua Ranch Makai property are primarily significant for their information content alone. Archaeological data recovery of this information and/or preservation are the recommended mitigation approaches. A mitigation/data recovery plan should be generated in consultation with the County of Hawaii Planning Department and the Historic Sites Section of the State Department of Land and Natural Resources.

APPENDIX I

MIDDEN AND ARTIFACT TABLES

CAT.#	Feat.	Square	Layer	Depth	TYPE	MATERIAL	Length	Width	Thick.
1	A	1	Dirt Fill		Flake	Basaltic Glass	1.34	0.73	0.28
2	B	1		0-10	Rim Sherd	Ceramic	1.26	0.94	0.24
3				Surface	Adze Fragment	Basalt	6.03	5.52	4.63
4	B	1		10-20	Flake	Basalt	1.47	1.37	0.20

Table 2. Site 11440A, List of Artifacts

CAT.#	Feat.	Square	Layer	Depth	TYPE	MATERIAL	Length	Width	Thick.
1	D		Dirt Fill		Flake	Basaltic Glass	0.97	0.70	0.36
2	D		Rock Fill		Manuport	Waterworn Basalt	8.18	6.65	5.33
3	A	1	Dirt Fill		Manuport Fragment	Waterworn Basalt	5.60	3.20	2.54
4	C	1		20-30	Manuport	Waterworn Basalt	4.45	3.59	3.53
5	A	1	Rock Fill		Manuport	Waterworn Basalt	6.94	5.69	3.40
6	A	1	Rock Fill		Manuport	Waterworn Basalt	7.51	6.42	4.48
7	A	1	Rock Fill		Hammerstone	Waterworn Basalt	5.93	5.54	3.60
8	A	1	Rock Fill		Hammerstone	Waterworn Basalt	6.90	4.54	4.28
9	A	1	Rock Fill		Manuport	Coral	4.41	2.53	1.23
10	A	1	Rock Fill		Manuport	Coral	4.65	2.91	1.21
11				Surface	Manuport	Waterworn Basalt	6.36	5.50	4.33
12				Surface	Hammerstone Fragment	Basalt	5.27	5.27	4.11

Table 3. Site 11442, List of Artifacts

CAT.#	Feat.	Square	Layer	Depth	TYPE	MATERIAL	Length	Width	Thickness
1	B	1	Dirt Fill		Manuport	Coral	2.16	1.05	0.91
2	B	1	Dirt Fill		Flake	Basaltic Glass	1.13	1.02	0.36
3	B	1	Dirt Fill		Flake	Basaltic Glass	2.64	1.85	0.34
4	B	1	Dirt Fill		Flake	Basaltic Glass	1.15	0.87	0.50
5	B	1	Dirt Fill		Manuport	Coral	1.58	0.74	0.62
6	B	1	Dirt Fill		Manuport	Coral	1.66	1.0	0.50
7	B	1	Dirt Fill		Manuport	Coral	1.68	1.42	1.03
8	B	1	Dirt Fill		Flake	Basaltic Glass	1.10	0.67	0.28
9	B	1	Dirt Fill		Manuport	Waterworn Basalt	5.20	3.09	2.28
10	B	1	Rock Fill		Manuport Fragment	Waterworn Basalt	7.60	6.66	4.46
11	B	1	Rock Fill		Manuport Fragment	Waterworn Basalt	6.26	4.90	2.90
12	B	1	Rock Fill		Manuport Fragment	Waterworn Basalt	3.68	2.16	1.54
13	A	1	I		Flake	Basalt	1.54	1.0	0.37
14	A	1	I		Flake	Basaltic Glass	1.51	1.25	0.30
15	A	1	I		Flake	Basaltic Glass	1.46	0.70	0.41
16	A	1	I		Flake	Basaltic Glass	1.87	1.23	0.30
17	B	1	Dirt Fill		Manuport	Coral	3.47	2.51	1.60
18	B	1	Dirt Fill		Manuport	Coral	2.38	2.08	1.33
19	B	1	Dirt Fill		Manuport	Coral	1.73	1.13	0.71
20	B	1	Dirt Fill		Manuport	Waterworn Basalt	2.91	2.38	1.15
21	B	1	Dirt Fill		Manuport	Coral	1.72	1.32	0.76

Table 4. Site 11446, List of Artifacts

CAT.#	Feat.	Square	Layer	Depth	TYPE	MATERIAL	Length	Width	Thick.
1	D	1	Dirt Fill		Adze Flake	Basalt	2.62	1.06	0.68
2	D	1	Dirt Fill		Manuport Fragment	Waterworn Basalt	3.58	3.43	2.46

Table 5. Site 11447, List of Artifacts

CAT.#	Feat.	Square	Layer	Depth	TYPE	MATERIAL	Length	Width	Thick.
1	A	1	III	25-35	Adze Flake	Basalt	2.60	1.33	0.68
2	A	1	III	55-65	Adze Fragment	Basalt	3.46	3.20	1.40
3	A	1	II	5-15	Flake	Basaltic Glass	1.64	0.68	0.37
4	A	1	III	25-35	Flake	Basaltic Glass	1.99	1.64	0.69
5	A	1	III	25-35	Flake	Basaltic Glass	1.75	1.64	0.64
6	A	1		15-25	Manuport	Coral	2.68	2.22	1.44
7	A	1	III	25-35	Flake	Basaltic Glass	1.35	0.95	0.21
8	A	1	III	25-35	Manuport	Coral	2.72	2.34	0.80
9	A	1	III	45-55	Adze Flake	Basalt	3.48	2.99	0.77
10	A	1	III	45-55	Adze Flake	Basalt	2.92	1.30	0.43
11	A	1	III	45-55	Flake	Basalt	6.30	4.35	1.19
12	A	1	III	45-55	Adze Chip	Basalt	1.98	1.40	0.55
13	A	1	III	45-55	Flake	Basaltic Glass	2.03	0.99	0.33
14	A	1	III	45-55	Flake	Basaltic Glass	2.04	1.12	0.33
15	A	1	III	45-55	Manuport	Coral	1.70	1.41	0.68

Table 6. Site 11448, List of Artifacts

LAYER	I	II	II	III	III	III	III
DEPTH (cm.):	0-5	5-15	15-25	25-35	35-45	45-55	55-65
Cellana sp.			16.8	1.8		20.9	1.4
Trochus niloticus						0.4	
Turbo marmoratus							
Nerita picea			1.2	3.7		27.3	
Nerita picea							
Nerita polata							
Thaumasta neglectus							
Thaumasta vespertinus							
Lunarena pumila						0.1	
Cypraea vespertinus			5.4	9.8		47.3	17.8
Cypraea isabella							
Cypraea mauritiana		15.3					
Cypraea moneta						14.5	
Cypraea sp.						54.7	11.3
Triton harpa							
Thaisdon sp.		0.8		1.2		10.6	2.8
Conus sp.						2.4	5.4
Terebra sp.				3.8		1.3	
Brachidontes crebrisulcatus						1.5	
Isognomon californicum						4.1	
Tellina palatam				0.1		6.4	
Unidentified Shell		0.7		7.6		23.5	1.3
Echinodermata				0.2		6.8	0.5
Crustacea						0.1	1.0
TOTAL							

Table 7. Site 11448A Test Pit, Shell Midden

LAYER:	I	II	II	III	III	III
DEPTH:	0-5	5-15	15-25	25-35	45-55	55-65
SEA TURTLE						
FISH						
Sparidae						
Monotaxis grandoculis						
Acanthuridae						
Naso cf. *hexacanthus*						
Naso unicornis						
Unidentified Acanthuridae						
Balistidae						
Unidentified Balistidae						
Diodontidae						
Diodon hystrix					1	
Unidentified Diodontidae						
Labridae						
Bodianus bilunulatus						
Unidentified Labridae						
Inoridae						
Unidentified Inoridae						
Scaridae						
Calotomus spinidens						
Scarides tonarcha						
C. spinidens/*S. tonarcha*						
Scarus sp.						
Unidentified Scaridae						
TOTAL:						
Unidentified Fish [grams]			<0.1	0.2		
PLANT MATERIAL [grams]						
Charcoal		15.9	52.6	133.8	27.0	
Aleurites moluccana shell						
A. moluccana shell [charred]	0.7	5.6	42.6	6.8		
A. moluccana kernel [charred]		0.3				
Canavalia sp. seed [charred]						
Cocos nucifera						
Ipomoea batatas [?]						
Lagenaria siceraria						
L. siceraria [charred]						
Pandanus odoratissimus						
Unidentified						
TOTAL:						
MISCELLANEOUS						
Coral [grams]						

Table 8. Site 11448A Test Pit, Marine and Vegetal Midden

CAT.#	Feat.	Square	Layer	Depth	TYPE	MATERIAL	Length	Width	Thick.
1	A			Surface	Core	Basalt	9.04	8.71	5.20
2	A	1			Flake	Basaltic Glass	1.39	0.37	0.28

Table 9. Site 11451, List of Artifacts

CAT.#	Feat.	Square	Layer	Depth	TYPE	MATERIAL	Length	Width	Thick.
1	A	1			Manoport	Coral	1.58	1.24	0.63
2	A	1			Manoport	Coral	1.45	0.92	0.64
3	G	1			Blade	Basalt	3.36	1.68	1.11
4	G			Surface	Core	Basalt	9.05	7.03	6.90

Table 10. Site 11452, List of Artifacts

CAT.#	Feat.	Square	Layer	Depth	TYPE	MATERIAL	Length	Width	Thick.
1		1		10-15	Manoport	Coral	1.58	1.22	0.74
2		1		10-15	Flake	Basaltic Glass	1.11	1.02	0.25
3		1		5-10	Flake	Basaltic Glass	2.08	1.72	0.49
4		1		5-10	Flake	Basaltic Glass	1.73	0.97	0.36
5		1		5-10	pos. Adze Preform	Basalt	6.91	3.61	2.41
6		1		20-25	Abrader	Echinoid Spine	4.28	0.59	0.68
7		1		40-45	prob. Adze fragment	Basalt	3.0	2.97	1.74
8		1		15-20	Manoport	Coral	4.19	1.97	1.32
9		1		15-20	Flake	Basaltic Glass	1.55	1.07	0.46
10		1		15-20	Manoport fragment	Waterworn Basalt	4.49	4.48	2.56
11		1		15-20	Flake	Basalt	3.35	3.25	0.78
12		1		15-20	Flake	Basalt	3.99	2.95	0.69
13		1		20-25	Flake	Basaltic Glass	1.56	0.92	0.24
14		1		20-25	Flake	Basaltic Glass	1.43	0.73	0.29
15		1		20-25	Flake	Basaltic Glass	1.50	1.05	0.46
16		1		20-25	Flake	Basaltic Glass	2.35	1.46	0.42
17		1		20-25	Flake	Basaltic Glass	2.12	1.54	0.68
18		1		20-25	Flake	Basaltic Glass	1.11	0.94	0.21
19		1		20-25	Manoport	Coral	9.10	2.77	2.14
20		1	1	25-30	Flake	Basaltic Glass	0.82	0.61	0.28
21		1	1	25-30	Flake	Basaltic Glass	1.06	0.76	0.24
22		1	1	25-30	Flake	Basaltic Glass	1.34	0.88	0.27
23		1		30-35	Flake	Basalt	1.15	1.13	0.20
24		1		30-35	Adze Chip	Basalt	1.61	1.56	0.38
25		1		35-40	Adze Chip	Basalt	1.48	0.95	0.55
26		1		35-40	Manoport	Coral	2.56	1.91	1.36
27		1	1	30-35	Flake	Basaltic Glass	2.40	1.56	0.44
28		1	1	30-35	Adze Chip	Basalt	1.65	1.40	1.10
29		1	1	30-35	Manoport	Coral	1.92	1.50	0.87

Table 11. Site 11453, List of Artifacts

DEPTH (cm.):	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55
Cellana sp.		6.6	0.1	1.8	4.7	4.3	11.5		0.1	0.5	
Trochus intextus		0.8		0.4	0.7	0.4	5.2			1.1	
Turbo intercostalis											
Nerita picea	0.2	1.7	0.6	2.1	3.4	12.8	22.0	6.2	0.1	1.0	
Nerita plicata											
Nerita polata											
Theodoxus neglectus											
Theodoxus vespertinus											
Littorina pascua											
Cypraea caputserpentis	1.7	10.3	6.3	3.7	9.6	31.9	20.5	3.8		2.3	
Cypraea umbilla											
Cypraea maculifera				14.6							
Cypraea mauritiana		15.9									
Cypraea sp.	14.0		5.5								
Thais harpa											
Thaidotoe sp.			0.9			11.7	9.6	1.0		0.2	
Conus sp.		10.3						0.8			
Turbo sp.											
Brachidontes crebristriatus							0.1				
Isognomon californicum			0.1		1.0	1.6	2.1	1.0			
Tellina palatam											
Unidentified Shell	0.5	5.1	1.3	3.0	6.6	16.8	15.9	9.7	1.7	1.7	0.7
Echinoderms		0.1	1.0	0.2	1.0	7.5	8.2	0.8	0.1		
Crustacea											
TOTAL											

Table 12. Site 11453 Test Pit, Shell Midden

DEPTH:	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55
SEA TURTLE											
FISH											
Sparidae											
Monotaxis grandoculis											
Acanthuridae											
Naso cf. *hexacanthus*											
Naso unicornis							1				
Unidentified Acanthuridae											
Balistidae											
Unidentified Balistidae						1					
Diodontidae											
Diodon hystrix											
Unidentified Diodontidae											
Labridae											
Bodianus bilunulatus											
Unidentified Labridae							1				
Lutjanidae											
Unidentified Lutjanidae			1			1					
Scaridae											
Calotomus spinidens											
Scarodon zonarcha											
C. spinidens/S. zonarcha											
Scarus sp.											
Unidentified Scaridae											
TOTAL:					0.1	1.3	1.0	0.3		0.3	
Unidentified Fish (grams)											
PLANT MATERIAL (grams)											
Charcoal		2.3	1.5	6.2	5.2	5.9	7.7	3.3			
Aleurites moluccana shell											
A. moluccana shell [charred]			0.3		0.6	0.5	0.1		0.1		
A. moluccana kernel [charred]											
Canarium sp. seed [charred]											
Cocos nucifera											
Ipomoea batatas [?]											
Lagenaria siceraria											
L. siceraria [charred]											
Pandanus odoratissimus											
Unidentified											
TOTAL:											
MISCELLANEOUS											
Coral (grams)											

Table 13. Site 11453 Test Pit, Marine and Vegetal Midden

CAT.#	Feat.	Square	Layer	Depth	TYPE	MATERIAL	Length	Width	Thick.
1	B	1			Flake	Basaltic Glass	1.51	1.12	0.33
2	B	1			Manoport	Waterworn Basalt	7.25	5.21	3.19
3	B	1			Flake	Basalt	6.37	4.48	1.88

Table 14. Site 11454, List of Artifacts

CAT.#	Feature	Square	Layer	Depth	TYPE	MATERIAL	Length	Width	Thick.
1		1		10-20	Adze Flake	Basalt	3.63	2.74	0.72
2		1		10-20	Flake	Basaltic Glass	1.31	0.71	0.22
3		1		20-30	Flake	Basaltic Glass	1.05	0.61	0.39

Table 15. Site 11456, List of Artifacts

CAT.#	Feat.	Square	Layer	Depth	TYPE	MATERIAL	Length	Width	Thick.
1				10-20	Manoport fragment	Waterworn Basalt	5.66	5.61	4.05
2				10-20	Manoport fragment	Waterworn Basalt	5.66	5.61	4.05
3				10-20	Manoport	Coral	5.62	3.97	2.80
4				20-30	Manoport	Coral	1.12	0.57	0.40
5				20-30	Adze Flake	Basalt	3.12	2.45	0.90

Table 16. Site 11460, List of Artifacts

CAT.#	Feat.	Square	Layer	Depth	TYPE	MATERIAL	Length	Width	Thick.
1	A	1		20-30	Manoport	Coral	1.08	0.86	0.53
2	A	1		10-20	Manoport	Coral	0.92	0.91	0.60
3	A	1		10-20	Manoport	Coral	1.17	1.13	0.66
4	A	1		10-20	Manoport	Coral	1.12	0.86	0.53
5	A	1		10-20	Manoport	Coral	0.76	0.62	0.42
6	A	1		10-20	Abrader	Coral	1.96	1.23	0.83

Table 17. Site 11463, List of Artifacts

DEPTH (cm.)	0-10	10-20	20-30
Cellana sp.	1.4		
Trochus intextus		1.0	
Turbo intercostalis			
Nerita picea	0.8	2.9	1.3
Nerita plicata			
Nerita polita			
Theodoxus neglectus			
Theodoxus vespertinus			
Littorina pintada			
Cypraea capitsorpentis	4.2	13.3	0.8
Cypraea isabella			
Cypraea maculifera			
Cypraea mauritiana			
Cypraea sp.			
Thais harpa			
Thaididae sp.	0.4	1.7	0.7
Conus sp.			
Terebra sp.		0.1	
Brachidontes crebristriatus			
Isognomon californicum			
Tellina palatum			
Unidentified Shell	0.8	0.5	0.2
Echinodermata	0.3	0.3	0.2
Crustacea	0.1	0.3	0.4
TOTAL			

Table 18. Site 11463A Test Pit, Shell Midden

DEPTH:	0-10	10-20	20-30
SEA TURTLE			
FISH			
Sparidae			
Monotaxis grandoculis			
Acanthuridae			
Naso cf. hexacanthus			
Naso unicornis			
Unidentified Acanthuridae			
Balistidae			
Unidentified Balistidae			
Diodontidae			
Diodon hystrix			
Unidentified Diodontidae			
Labridae			
Badianus bilunulatus			
Unidentified Labridae			
Isuridae			
Unidentified Isuridae			1
Scaridae			
Calotomus spinidens			
Scaridea sonarcha			
C. spinidens/S. sonarcha			
Scarus sp.			
Unidentified Scaridae			
TOTAL:			
Unidentified Fish (grams)	0.4		
PLANT MATERIAL (grams)			
Charcoal	0.9	3.5	4.1
Aleurites moluccana shell			
A. moluccana shell (charred)	0.1	1.5	0.3
A. moluccana kernel (charred)			
Canavalia sp. seed (charred)			
Cocos nucifera			
Ipomoea batatas (?)			
Lagenaria siceraria			
L. siceraria (charred)			
Pandanus odoratissimus			
Unidentified			
TOTAL:			
MISCELLANEOUS			
Coral (grams)			

Table 19. Site 11463A Test Pit, Marine and Vegetal Midden

CAT.#	Feat.	Square	Layer	Depth	TYPE	MATERIAL	Length	Width	Thick.
1	C		Dirt Fill		Fragment	Metal	2.98	2.00	0.29
2	I		Dirt Fill		Button	Copper	1.50 diam.		0.69
3	I		Dirt Fill		Flake	Basalt	3.43	2.14	0.40
4	I		Dirt Fill		Flake	Basalt	2.43	1.07	0.62
5	I		Dirt Fill		Flake	Basaltic Glass	2.32	1.46	0.69
6	I		Dirt Fill		Flake	Chert [?]	1.83	1.22	0.25
7	I		Dirt Fill		Fragment	Metal	7.26	1.97	0.32
8	I		Dirt Fill		Fragment	Metal	2.46	2.01	0.16
9	I		Dirt Fill		Adze Flake	Basalt	2.87	1.40	0.28
10	I		Dirt Fill		Manaport Fragment	Waterworn Basalt	6.50	6.23	4.81
11	G		Dirt Fill		Flake	Basalt	1.67	1.47	0.16
12	G		Dirt Fill		Flake	Basalt	1.80	1.69	0.20
13	C		Rock Fill		Vessel Fragment	Glass	2.91	2.25	0.24
14	C		Rock Fill		Vessel Fragment	Ceramic	3.24	1.94	0.55
15	C		Rock Fill		Vessel Fragment	Ceramic	4.95	4.77	0.71
16	C		Rock Fill		Vessel Fragment	Ceramic	4.78	3.21	0.74
17	C		Rock Fill		Vessel Fragment	Ceramic	8.07	5.70	0.80
18	C		Rock Fill		Vessel Fragment	Ceramic	5.69	4.03	0.68
19	C		Rock Fill		Manaport Fragment	Waterworn Basalt	5.41	4.03	3.78
20	G		Rock Fill		Manaport	Coral	3.32	2.99	2.59
21	G		Rock Fill		Manaport	Waterworn Basalt	7.50	4.95	2.29
22	G		Rock Fill		Manaport	Waterworn Basalt	10.57	6.24	4.15
23	G		Rock Fill		Manaport	Waterworn Basalt	8.90	7.12	5.25
24	G		Rock Fill		Manaport Fragment	Waterworn Basalt	6.48	5.29	5.10
25	G		Rock Fill		Flake	Basalt	10.41	3.75	2.75
26	I		Rock Fill		Flake	Basalt	3.96	3.10	0.50
27	I		Rock Fill		Vessel Fragment	Glass	6.84	4.32	1.15
28	I		Rock Fill		Manaport Fragment	Waterworn Basalt	6.09	5.44	2.82
29	B		Rock Fill		Manaport	Waterworn Basalt	7.32	4.41	3.72

Table 20. Site 11464, List of Artifacts

CAT.#	Feat.	Square	Layer	Depth	TYPE	MATERIAL	Length	Width	Thick.
1	E		Rock Fill		Manaport fragment	Waterworn Basalt	4.84	4.27	2.65
2	E		Rock Fill		Hammerstone	Waterworn Basalt	7.43	5.25	3.76
3	A		Dirt Fill		Manaport fragment	Waterworn Basalt	6.41	5.11	3.70

Table 21. Site 11473, List of Artifacts

CAT.#	Feat.	Square	Layer	Depth	TYPE	MATERIAL	Length	Width	Thick.
1	B	1		0-10	Manaport fragment	Waterworn Basalt	3.91	2.35	1.98
2	B	1		0-10	Board Fragment	Wood	5.76	2.25	1.43

Table 22. Site 11474, List of Artifacts

CAT.#	Feat.	Square	Layer	Depth	TYPE	MATERIAL	Length	Width	Thick.
1		1		25-35	Flake	Basaltic Glass	1.85	1.47	0.55
2		1		0-25	Adze Chip	Basalt	1.90	1.56	0.38
3		1		0-25	Adze fragment	Basalt	3.80	3.04	1.47
4		1		0-25	Flake	Basaltic Glass	1.80	1.39	0.49
5		1		0-25	Flake	Basaltic Glass	0.70	0.34	0.29
6		1		0-25	Core	Basaltic Glass	1.44	1.11	0.69
7		1		0-25	Manaport	Coral	1.88	1.26	0.80
8		1		0-25	Manaport	Coral	1.03	0.79	0.29
9		1		0-25	Manaport	Coral	1.30	0.84	0.68
10		1		0-25	Manaport	Coral	0.75	0.44	0.42
11		1		0-25	Manaport	Coral	1.28	0.70	0.34
12		1		0-25	Manaport	Coral	2.05	1.05	1.01
13		1		0-25	Manaport	Coral	1.24	0.90	0.60
14		1		45-55	Flake	Basaltic Glass	1.14	0.53	0.32
15		1		35-45	Flake	Basaltic Glass	1.81	1.04	0.28
16		1		35-45	Flake	Basaltic Glass	1.21	0.65	0.16
17		1		35-45	Abrader	Echinoid Spine	1.53	0.65	0.48
18		1		35-45	Manaport	Waterworn Basalt	3.01	2.52	1.02
19		1		35-45	Manaport	Coral	3.28	2.63	0.82
20		1		35-45	Manaport	Beachrock	3.23	2.33	1.08

Table 23. Site 11476, List of Artifacts

DEPTH (cm.):	0-15	25-35	35-45	45-55
Cellana sp.	12.7		2.5	
Trochus unistus				
Turbo intercostalis				
Nerita picea	2.5	3.1	3.0	1.0
Nerita plicata				
Nerita polita				
Theodoxus neglectus				
Theodoxus vespertinus				
Littorina pintado				
Cypraea capistrata	5.3	7.7	8.2	4.5
Cypraea isabella				
Cypraea mauritiana				
Cypraea mauritiana				
Cypraea sp.				
Thais harpa				
Thaididae sp.	3.7	3.3	3.3	0.2
Conus sp.				
Terebra sp.	0.3		0.7	
Brachidontes crebristriatus				
Isognomon californicum	0.1			
Tellina palatum	0.5			
Unidentified Shell	1.5	7.2	3.9	0.5
Echinodermata		0.3	0.9	0.3
Crustacea				
TOTAL				

Table 24. Site 11476 Test Pit, Shell Midden

DEPTH:	6-13	13-13	31-43	43-53
SEA TURTLE				
FISH				
Sparidae				
Monotaxis grandoculis				
Acanthuridae				
Naso of hexacanthus				
Naso unicornis				
Unidentified Acanthuridae				
Balistidae				
Unidentified Balistidae				
Diodontidae				
Diodon hystrix				
Unidentified Diodontidae				
Labridae				
Bodianus bilunulatus				
Unidentified Labridae				
Iuridae				
Unidentified Iuridae				
Scaridae				
Calotomus spinidens				
Scarodon zonarcha				
C. spinidens/S. zonarcha				
Scarus sp.				
Unidentified Scaridae				
TOTAL:				
Unidentified Fish [grams]		0.5		
PLANT MATERIAL [grams]				
Charcoal	3.8	1.9	0.3	0.8
Aleurites moluccana shell				
A. moluccana shell [charred]				
A. moluccana kernel [charred]				
Cocos nucifera seed [charred]				
Cocos nucifera				
Ipomoea batatas [?]				
Leucaena leucocephala				
L. leucocephala [charred]				
Pandanus odoratissimus				
Unidentified				
TOTAL:				
MISCELLANEOUS				
Coral [grams]				

Table 25. Site 11476, Marine and Vegetal Midden

CAT.#	Feat.	Square	Layer	Depth	TYPE	MATERIAL	Length	Width	Thick.
1	B	1	I	20-30	Flake	Basaltic Glass	1.16	0.89	0.31
2	B	1	II	50-60	Core	Basaltic Glass	1.41	1.28	0.5
3	B	1		40-50	Flake	Basaltic Glass	1.56	0.58	0.43
4	B	1		40-50	Flake	Basaltic Glass	1.68	1.40	0.41
5	B	1		40-50	Flake	Basaltic Glass	1.46	0.58	0.15
6	B	1		30-40	Manuport	Coral	4.52	3.04	1.28
7	B	1		30-40	Flake	Basaltic Glass	1.23	.094	0.13

Table 26. Site 11478, List of Artifacts

CAT.#	Feat.	Square	Layer	Depth	TYPE	MATERIAL	Length	Width	Thick.
1	A	1		Fill	Manuport	Waterworn Basalt	8.08	5.18	4.13
2	A	1		Fill	Manuport fragment	Waterworn Basalt	8.83	5.92	4.18

Table 27. Site 11479, List of Artifacts

CAT.#	Feat.	Square	Layer	Depth	TYPE	MATERIAL	Length	Width	Thick.
1		1		0-10	Manuport	Waterworn Basalt	6.93	5.15	3.02
2		1		0-10	Manuport	Waterworn Basalt	3.25	1.85	1.80
3		1		0-10	Manuport	Waterworn Basalt	2.21	1.84	1.45
4		1		10-20	Flake	Basalt	2.48	1.33	0.37
5		1		10-20	Flake	Basaltic Glass	1.37	0.88	0.19
6		1		10-20	Flake	Basalt	1.88	1.36	0.61

Table 28. Site 11480, List of Artifacts

DEPTH [cm.]:	0-10	10-20	20-30	30-40	40-50
Cellana sp.		0.5			
Trochus intextus					
Turbo intercostalis					
Nerita picea					
Nerita plicata					
Nerita polata					
Theodoxus neglectus					
Theodoxus verpertinus					
Littorina pulchella					
Cypraea caputserpentis		1.0	6.9	1.2	
Cypraea isabella					
Cypraea maculifera					
Cypraea mauritiana					
Cypraea sp.					
Thais harpa					
Thaididae sp.				0.6	
Conus sp.					
Terebra sp.					
Brachidontes crebristriatus					
Isognomon californicum					
Tellina palatam					
Unidentified Shell		1.0	0.2	0.4	0.1
Echinodermata					
Crustacea					
TOTAL					

Table 29. Site 11480 Test Pit, Shell Midden

DEPTH:	8-18	18-28	28-38	38-48	48-58
SEA TURTLE					
FISH					
Sparidae					
Monotaxis grandoculis					
Acanthuridae					
Naso cf. hexacanthus					
Naso unicornis					
Unidentified Acanthuridae					
Balistidae					
Unidentified Balistidae					
Diodontidae					
Diodon hystrix					
Unidentified Diodontidae					
Labridae					
Bodianus bilunulatus					
Unidentified Labridae					
Inoridae					
Unidentified Inoridae					
Scaridae					
Calotomus spinidens					
Scarodon zonarcha					
C. spinidens/S. zonarcha					
Scarus sp.					
Unidentified Scaridae					
TOTAL:					
Unidentified Fish [grams]				0.1	
PLANT MATERIAL [grams]					
Charcoal		1.0	1.1	1.9	<0.1
Aleurites moluccana shell					
A. moluccana shell [charred]					
A. moluccana kernel [charred]					
Canarium sp. seed [charred]					
Cocos nucifera					
Ipomoea batatas [?]					
Lagenaria siceraria					
L. siceraria [charred]					
Pandanus odoratissimus					
Unidentified					
TOTAL:					
MISCELLANEOUS					
Coral [grams]					

Table 30. Site 11480 Test Pit, Marine and Vegetal Midden

CAT.#	Feat.	Square	Layer	Depth	TYPE	MATERIAL	Length	Width	Thick.
1			Dirt Fill		Flake	Basaltic Glass	1.13	1.10	0.25
2			Rock Fill		Manuport	Coral	5.80	3.71	3.64
3			Rock Fill		Manuport	Coral	5.22	4.05	2.97
4			Dirt Fill		Worked Bone		2.53	0.92	0.40
5			Dirt Fill		Flake	Basalt	1.63	1.32	0.53
6			Dirt Fill		Manuport	Coral	2.05	1.74	1.51
7			Dirt Fill		Manuport	Coral	2.53	2.41	1.21
8			Dirt Fill		Manuport	Coral	2.35	2.25	2.10
9				Surface	Hammerstone	Basalt	11.50	7.64	5.28

Table 31. Site 12006, List of Artifacts

APPENDIX II

SITES IN THE CONSERVATION DISTRICT

The following descriptions, taken from the original reconnaissance report (Kaschko and Rosendahl 1987), are for sites located in the Conservation District and therefore not directly the subject of the present investigations.

50-10-47-11465 [T-26]

The T-26 historic site complex [40.0 by 20.0 m] includes five individually designated features. Specific functions of most of these structures are not known, but they are apparently associated with the period of pineapple cultivation.

Feature A consists of a somewhat collapsed, semicircular walled structure [8.0 by 8.0 m, up to 110 cm high] with a circular platform of large boulders [2.0 by 2.5 m, up to 100 cm high]. The wall is constructed of large, upright basalt boulders with cobble fill, and the interior surface is boulder fill. A broken ceramic bowl, with blue markings representing a crane and a tree, is present on the surface.

Feature B, a rectangular walled structure with three standing walls [5.5 by 3.3 m, up to 80 cm high], is composed of stacked boulders and rubble. An alignment of rocks seems to connect Features A and B.

Feature C includes a faced, standing, wall section [23.5 by 1.0 m, up to 80 cm high] with an attached semicircular rubble mound [2.0 by 2.2 m, up to 55 cm high]. The wall is cobble filled and is faced on the downslope side like a retaining wall. A slight jog in the wall, with three faced stones set to fill the gap, suggests a stepped entranceway. Surface artifacts consist of a broken, square pink gin bottle [collected]; fragments of a white ceramic vase with a flower design; a complete clear bottle; and two pieces of white, glazed ceramic [possibly a bowl]. [Collected surface artifact No.7 is a lavender [sic], broken, rectangular case bottle [274 mm by 102 by 102 mm, 1061g].]

Feature D, located just inland side of the Old Pineapple Road, is a large, faced, retaining wall [21.0 m long, up to 210 cm high] with a ramp [3.7 m long, up to 110 cm high] leading up from the road. The retaining wall is constructed of well-stacked boulders with smaller rocks and cobbles behind it. Blue bottle glass and a square iron nail [collected] were visible on the surface. This structure is apparently the old pineapple loading platform [Sherwood Greenwell, pers. comm.]. [Collected surface artifact No.6 is a square iron nail [98.6 by 8.2 by 2.8 mm, 12.7g].]

Feature E, a rectangular terrace [6.5 m by 5.0 m, up to 130 cm high] adjacent to the seaward side of the pineapple road, has a faced retaining wall and a soil floor. It consists of stacked boulders with rock and soil fill and has rubble and boulder side alignments.

The descriptions and maps of this site in the reconnaissance report are accurate, with the exception that the arrows on the maps are pointing to the south, rather than to the north.

50-10-47-11466 [T-28]

Located on a small rise c. 10.0 m. north of an inland-seaward stone wall, Site T-28 is a large C-shaped walled shelter [12.0 by 10.0 m, up to 120 cm high] with a fairly flat interior soil surface and a small, roughly rectangular terrace attached to its seaward side. This rather collapsed structure is composed of roughly stacked basalt boulders and cobbles and appears to be constructed partly on bedrock. Surface midden remains consist of a single large Cellana sp. shell. The surrounding area exhibits considerable agricultural rock piling and some inland-seaward field boundaries.

This feature is probably a prehistoric, temporary habitation field shelter associated with cultivation activities in the surrounding agriculturally modified area.

50-10-47-11467 [T-29]

A set of two or three fairly large, but rough and irregular, linear terraces [30.0 by 10.0 m, up to 160 cm high]. Site T-29 is situated across the base of a rocky slope. The terraces are roughly constructed of piled basalt boulders and cobbles and apparently use some exposed bedrock boulders. One broken, waterworn basalt boulder and a small coral cobble are visible on the surface.

This rough, rocky slope terracing is probably the result of prehistoric dryland agriculture. Similar agricultural terracing and rock piling are found in this general area, but the features here are more prominent.

50-10-47-11468 [T-30]

Site T-30, a partially collapsed, roughly rectangular, three-sided terrace [10.5 by 10.0 m, up to 80 cm high], has a level soil surface interior and is located just seaward of an old dirt road. It is constructed of roughly stacked boulders and cobbles, with some intact faces remaining. Cultural materials present on the surface include a broken waterworn basalt cobble and a few possible fire-cracked vesicular cobbles. An upright basalt slab in the surface of the terrace floor may indicate a slab-outlined firepit. Fairly prominent agricultural rock piling and inland-seaward field boundaries are present in the surrounding area, especially in areas inland of this site location. There is a good view from here to Napoopoo and Kealakekua Bay to the southwest. [A small broken adze was collected from a cow path at 277° 44.5 m from the site marker on this feature.] [Collected surface artifact No.5 is the tang portion of a broken polished basalt adze [53.3 by 30.2 by 12.8 mm, 37.1 g]. It was found in a cow path at 277° 44.5 m from the T-30 site marker.]

This structure may be a long-term, temporary-use habitation feature [possible garden house] associated with prehistoric agricultural activities in this area.

50-10-47-11469 [T-31]

Site T-31, a small, oval platform or large cairn [2.2 by 2.0 m, up to 90 cm high], is somewhat collapsed and could possibly be regarded as roughly rectangular. It is composed of a stacked basalt boulder facing, with cobbles and some boulders as interior fill.

The feature could be a prehistoric or early historic burial structure or possibly just a well-constructed agricultural rock pile.

50-10-47-11470 [T-32]

The T-32 site complex [prob. Soehren's Site 204] consists of two designated features and is situated just seaward of the Old Pineapple Road.

Feature A, located on a rise with some exposed bedrock boulders, is a long, inland-seaward oriented, roughly rectangular, walled structure [21.0 by 7.5 m, up to 125 cm high]. It includes a four-sided square section at its inland end. The somewhat collapsed structure has a fairly flat interior soil surface, and is constructed of stacked boulders and cobbles, with some wall segments appearing to be roughly core-filled. Artifacts noted on the surface were a dense basalt hammerstone, blue-on-white oriental ceramics, a "Kona Bottling Works Co. Ltd." bottle, and a large broken bottle.

The feature is probably a historic habitation structure, either temporary or longer term, or possibly a historic animal pen; it could be associated with the period of pineapple cultivation. This feature probably corresponds to Site 204, which was originally described as follows:

204. Enclosure. Perhaps a pen, this irregular enclosure has walls about three feet wide and high, and encompasses an area roughly 25 by 70 feet. No features were observed which might suggest any other function, but the site is much overgrown. It may well pertain to pineapple plantation days [Soehren and Newman 1968:14].

Feature B, possibly a collapsed, roughly rectangular, rock-filled terrace [c. 8.0 by 5.0 m, up to about 100 cm high] is located north of Feature A and is well-covered by high grass and other vegetation.

The structure could be associated with Feature A and is perhaps a collapsed burial platform or possibly just agricultural rock piling [Feature B is located 100° and 30.0 m of Feature A.]

50-10-47-11471 [T-33]

Site T-33 is a large, site complex [c. 115 by 80.0 m] located primarily on a rocky ridge-top area with a very good view toward the sea. The complex contains seven recorded features as well as rough cross-slope terracing, modified bedrock boulder outcrops, and generalized agricultural rock piling. Much of the site area [including Features A, B, C and D] seems to be surrounded by a large, but quite collapsed, enclosure wall, roughly rectangular in form. The north and south walls of this main enclosed area could be built on the lines of two inland-seaward field boundaries. Most of the stone construction consists of stacked or piled basalt boulders and cobbles that appear generally rather rough and/or collapsed, probably due to the many years of cattle grazing in the area. Visible on the surface of the general site area are some scattered waterworn basalt cobbles, coral fragments and occasional pieces of marine shell midden. The presence of a subsurface cultural deposit, potentially quite substantial, must be considered very likely within this site complex. If further detailed work were done on this site, it is likely a few more structures would be recognized that could merit designation as individual features.

The site is most likely a prehistoric to early historic habitation complex [possibly permanent] and associated agricultural use area. The size and complexity of the structural elements may suggest a high-status, chiefly residential compound.

Feature A, a roughly rectangular, walled structure [9.0 by 7.0 m, up to 120 cm high] with a fairly flat interior soil surface, is constructed of stacked basalt boulders and some cobbles. A mammal rib [possibly pig] and cow long-bones are visible on the surface.

This structure could be a historic animal pen or possibly of habitation use; its function actually is unclear, and the feature may not be contemporary with the rest of the site complex.

Feature B, a partly collapsed, roughly rectangular terrace [7.0 by 5.0 m, up to 130 cm high] with an uneven stone-filled surface, includes remnant boulder facings in the seaward retaining wall that suggest two parallel faces or stages. It is composed of stacked boulders and cobbles and appears to be built on a long, cross-slope, rough terrace alignment.

This feature is probably a prehistoric habitation, although it could be a burial or other special-purpose structure.

Feature C, a large three-sided, roughly rectangular terrace [10.0 by 8.0 m, up to 120 cm high] with a level soil interior surface, is constructed of roughly stacked basalt boulders and cobbles. Cultural

materials present on the surface include broken waterworn basalt cobbles, coral fragments, a fragment of an unidentified large shell, Nerita sp., and large Cypraea sp.

This feature is a probable prehistoric habitation structure (possible house foundation), perhaps for long-term use, and it could be functionally related to feature B, located just downslope.

Feature D, a roughly rectangular terrace (9.0 by 5.0 m, up to 130 cm high), is rather collapsed but has a fairly level soil surface. It consists of roughly stacked basalt boulders and cobbles, with the inland side formed by exposed bedrock boulder outcrops. Visible cultural materials scattered on the surface include a basalt core from a ground adze fragment, broken waterworn basalt cobbles (possibly fire-cracked rocks), a flaked small waterworn boulder, a ground Cassis sp. fragment, coral fragments, Cypraea sp., Cellana sp., Conus sp., Drupa sp., and Nerita sp. The surface midden present on and around this feature is the heaviest found in the area.

The structure is a probable prehistoric habitation terrace and may be functionally related to Features B and C.

Feature E, a long, roughly rectangular, walled enclosure (c. 25.0 by 12.0 m, up to 110 cm high), contains a smaller, roughly triangular, walled compartment (c. 10.0 by 8.0 m) in the seaward end. The much-collapsed walls are constructed of roughly stacked basalt boulders and cobbles. The interior is a sloping but fairly smooth soil surface, and midden remains are restricted to a Cypraea sp. shell and some coral fragments.

Considering the standing walls, this feature may be an early historic, walled garden area or an animal pen associated with the habitation complex.

Feature F is a rectangular, raised platform (5.0 by 3.0 m, up to 130 cm high) located on a slight rise overlooking the rest of the site complex. It consists of a roughly stacked boulder exterior facing, with cobbles and boulders as inside fill, and has a fairly flat upper surface. A few meters to the south and seaward, some brush covers rock piling that could be one or two more rough platforms.

The structure is possibly an early historic burial monument associated with a long-term or permanent habitation area.

Feature G, a roughly rectangular, raised, rubble mound (5.7 by 4.6 m, up to 75 cm high), is composed of large boulders at the base and along the perimeter, with smaller boulders and cobbles used as fill. A dense basalt core and a round basalt cobble are present on the surface. This feature is possibly a collapsed burial platform.

50-10-47-11472 [T-34]

Located just north of an old inland-seaward dirt road, Site T-34 is a high, stone-filled, rectangular terrace (6.0 by 7.5 m, up to 155 cm high) that is rather collapsed. It is constructed of stacked boulders and cobbles, with some standing faces remaining, and may originally have had a two-step seaward retaining wall. One fragment of small Cypraea sp. shell is visible on the surface.

This structure appears to be a prehistoric rectangular habitation terrace of temporary to long-term use, and it was probably associated with agricultural activities in the surrounding area. It is less likely, but possible, that the feature could be a rectangular burial platform on a slope.

50-10-47-11481 [T-44]

A raised and faced roadway (3.5 to 5.0 m wide), Site T-44 is braced on the seaward side by a stone retaining wall (often more than 1.0 m high). The wall is constructed of stacked large boulders as a foundation, with small boulders and cobbles used as fill, and has a level soil surface.

This feature is an elevated causeway for the historic Old Pineapple Road, built sometime between about AD 1905 and 1910. It appears to be associated with a number of historic-era sites (e.g., Site T-26).

50-10-47-11482 [T-45]

Site T-45 features prominent rock piling on and around outcropping bedrock boulders (8.0 by 13.0 m, up to 125 cm high). The mostly collapsed feature is composed of stacked boulders with boulder and rubble fill and includes a possible small sheltered surface area.

The feature appears to represent some large-scale prehistoric agricultural surface modification. This site was recorded while searching for Site 206.

50-10-47-11483 [T-46]

A rough and much-collapsed rectangular walled terrace (prob. Soehren's Site 207) (6.8 by 7.4 m, up to 70 cm high), Site T-46 includes a fairly flat, rock-filled interior surface. Large basalt boulders are stacked along the perimeter, with smaller boulders and cobbles used as fill. A rough, dense basalt core is visible on the surface.

The feature is probably a prehistoric habitation structure or possibly a collapsed burial platform.

This site apparently corresponds to Site 207, which was originally described as follows:

207. Grave sites. A rough, greatly disturbed platform about 18 feet square, built on a slope, seems to have been built as an enclosure then filled in with rubble so that the

floor is about one foot lower than the top of the walls. In front the structure stands about four feet high, and in back about two feet. The floor is paved with small stones, among which was seen one piece of coral, and slopes seaward. The center has been disrupted by a small tree, now dead (Soehren and Newman 1968:15).

50-10-47-11484 [T-47]

A large, roughly rectangular raised platform with a smaller extension on the south side (6.0 by 10.0 m, up to 80.0 cm high) (prob. Soehren's Site 206), Site T-47 is located just north of an inland-seaward dirt road. It is composed of a stacked boulder exterior facing with mostly cobble interior fill and has a fairly level upper surface. The areas north and west of this location, over to the north boundary wall, contain much agricultural surface modification, including rock piling and linear mounds, etc.

This fairly large and substantial structure is a probable prehistoric/clearly historic burial platform, most likely multiple.

The feature appears to correlate with Site 206, which was previously recorded as follows:

206. Grave sites. A double burial platform, probably built in two phases. The main platform is built on a slope, stands three feet high in front but only one foot high in back, and measures 15 by 18 feet. A smaller platform is attached to the south side and measures about six feet square. The surface of both is generally well paved with small stones but slopes slightly downhill to the west (Soehren and Newman 1968:14).

50-10-47-208

Site 208 was not specifically examined in the field except, where it is visible at the top of a steep slope entering the seaward side of the project area. It was recorded as follows:

208. Horse trail. This type C trail (Apple 1965) is shown on Tax Map 8-1-10 as the "old road from Kealakekua pali to Kainaliu" but only as far south as Kaawaloa Road. From that point the trail is generally lost in the soil and vegetation found above the cliffs, but its alignment is indicated by a stone wall paralleling it on the seaward side. The trail descends the Pali-o-Manuahi, behind Hikiau heiau, and terminates at Napoopoo, although the location of the lower portion is uncertain. From there it probably continued southward to Honaunau and the City of Refuge National Historic Park, where it has been identified as having been built about 1871 (Apple 1965:52-59). The trail was an important link in the transport system of the nineteenth century (Soehren and Newman 1968:15).

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Appendix 10:
KEALAKEKUA BAY CLUB: AN AGRICULTURAL IMPACT STUDY

KEALAKEKUA BAY CLUB

An Agricultural Impact Study

for

ROYAL COAST DEVELOPMENT CORPORATION

Kawaihae, Hawaii

Prepared by

MARUTANI & ASSOCIATES

24 May 1991

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Authors

Herbert K. Marutani, Ph.D.	President/Gen. Mgr., Marutani & Associates AgriBusiness Management Consultants P. O. Box 10388 Hilo, Hawaii 96721
Lawrence W. Rowland, M.S.	President, Applied Analysis Inc. P. O. Box 10631 Honolulu, Hawaii 96816
Tom Yamamoto, M.S.	Emeritus County Agent in Livestock (Cooperative Extension Service, University of Hawaii)

SUMMARY

This study examines the agricultural impact of Royal Coast Development Corporation's proposed project on the former site of the Kealakekua Ranch makai. The study addresses six issues that are deemed relevant on the impact on agriculture that this project might have:

1. Agronomic condition of the site;
2. Use of the site--historical and current;
3. Impact of the project on cattle operation;
4. Suitability of the site for crops;
5. Effect of the project on diversified agriculture; and
6. Compatibility of this project with State and County goals and policies.

The study found that the project site's soil condition is of marginal quality and generally of rocky terrain. The site shows historical evidence of prehistoric agricultural activity; a short-lived pineapple farm; and some ranching. Today the site is not in any productive use, and the impact of the project on the cattle industry is essentially nil.

The soil condition, as well as the lack of consistent rainfall on the site make this location highly unsuitable for crop production. Likewise, the use of this site for the proposed project will have a minor effect, if any, on diversified agriculture. Lastly, in reviewing the State of

Hawaii's Functional Plan and the County of Hawaii's General Plan, this project does not appear to be in conflict with the goals and policies of both Plans.

INTRODUCTION

This study critically examines the impact on agriculture the Kealakekua Bay Club might have on the proposed project site -- the Kealakekua Ranch makai. The findings of this study were the result of intensive as well as extensive search for data and information, which were obtained through literary review as well as by interviews (see references). The authors made on-site inspection as well as took photographs of representative soil type (see exhibit). The findings of the authors are described in Section I of this study entitled Assessment. Section II consists of photographs, glossary, and references.

SECTION I

ASSESSMENT

A. Agronomic Condition of the Site

Map Symbol	Mapping Unit	Acres
rLV	Lava flows, Aa	13+/-
rKED	Kaimu extremely stony muck, 6 - 20% slopes	21+/-
WHC	Waiaha extremely silt loam, 6 - 12% slopes	51.5+/-
KEC	Kainaliu extremely stony silty clay loam, 12 - 20% slopes	92.5+/-
KDD	Kainaliu very stony silty clay loam, 12 - 20% slopes	84+/-
	Total Acreages	262.00

Soil Descriptions

Lava flows, Aa

Lava flows, Aa (mapping unit rLV), has been mapped as a miscellaneous land type. (Miscellaneous land type is a mapping unit for land areas that have little or no natural soils, that are nearly inaccessible for orderly examination, or for any reason it is not feasible to classify the soil.) This lava has practically no soil covering and is bare of vegetation except for mosses, lichens, ferns and a few small ohia trees. In the Kealakekua Bay Club area, it occurs at elevations ranging from near sea level to 500 feet and receives from 20-40 inches of rainfall annually.

This lava is a mass of clinkery, hard glassy sharp pieces piled in tumbled heaps. Uses are restricted to recreation and wildlife cover.

Kaimu Series

This series occurs in the Kona and Kau districts. It consists of well-drained, thin organic soils over Aa lava. They are gently sloping to moderately steep soils occurring at elevations ranging from near sea level to 1,000 feet. They receive from 40 to 60 inches of rainfall annually, most of which falls during the summer months, except in the Kau district. The mean annual soil temperature is between 72° and 74° F. The natural vegetation consists of Christmas berry, guavas, guinea grass and lantana.

Description of Mapping Unit Representative of the Series

Kaimu extremely stony peat, 6 to 20 per cent slopes (rKED)

This soil occurs at elevations ranging from 500 to 1,250 feet in the Kealakekua Bay Club area. The surface layer is a very dark brown extremely stony peat about 3 inches thick. The underlying layer, about 20 inches thick, is composed of Aa lava fragments with very little soil material.

Permeability is rapid. Runoff is slow and the erosion hazard is slight.

Soil use -- not suitable for cultivation. Small areas are used for non-irrigated pasture, macadamia nuts, papaya and citrus. Unimproved pasture consists of natal red top, bermuda grass, lantana, Christmas berry, guava and Japanese tea. Four-fifths of the forage is produced during the summer months. Annual production is 2,000 - 3,200 pounds of air-dry forage/acre.

Profile Description of rKED:

Horizon Symbol	Depth from Surface
02	3 inches to 0, very dark brown extremely stony peat; weak, very fine granular structure; very friable, non-sticky, and non-plastic, many roots; many fine pores. Aa fragments from gravel to stone size make up to 50 to 80 per cent of the volume; natural, clear, smooth boundary.
IIC	0 to 20 inches, fragmental Aa lava; very little soil material in voids and cracks.

Waiaha Series

The Waiaha series occurs in the Kona and Kau districts. It consists of shallow, well-drained silt loams that formed in volcanic ash. These soils are nearly level to moderately steep and most areas are extremely stony. They occur at elevations ranging from near sea level to 1,000 feet. They receive from 20 to 40 inches of rainfall annually, most of which falls during the summer months, except in the Kau district. The mean

annual soil temperature is between 72° and 74° F. The natural vegetation consists of kiawe, koa haole, natal red top, lantana, guinea grass, and bermuda grass.

Waiaha soils are mostly used for pasture.

Description of Mapping Unit Representative of the Series

Waiaha extremely stony silt loam, 6 to 12 per cent slopes (WHC)

This soil occurs on the leeward side of Hualalai and Mauna Loa.

The surface layer is very dark brown extremely stony silt loam about 4 inches thick. The subsoil is dark brown very stony silt loam about 14 inches thick. The substratum is pahoehoe lava bedrock. The surface is slightly acid. The subsoil is neutral to midly alkaline. In places the surface layer is non-stony.

Permeability is moderately rapid, runoff is slow, and the erosion hazard is slight. Roots can penetrate to bedrock.

This soil is used mostly for unirrigated pasture. Four-fifths of the forage is produced during the summer. Annual production is 1,000 to 1,500 pounds of air-dry forage per acre annually.

Profile Description of WHC:

Horizon Symbol	Depth from Surface
A1	0 to 4 inches, very dark brown extremely stony silt loam; dark brown when dry; weak, fine and very fine, granular structure; soft, friable, non-sticky, and slightly plastic; many roots; many very fine and fine pores; stones make up 5 to 10 per cent of the horizon; slightly acid; clear, wavy boundary.

B21	4 to 10 inches, dark brown stony silt loam; strong brown when dry; weak, fine and very fine, subangular blocky structure; slightly hard, friable, non-sticky, and non-plastic; many roots; many very fine and fine pores; basalt fragments make up about 15 per cent of the horizon; neutral; clear, wavy boundary.
B22	10 to 18 inches, hard pahoehoe lava.

Kainaliu Series

The Kainaliu series consists of well-drained silty clay loams that formed in volcanic ash. These are moderately sloping to moderately steep soils occurring at elevations ranging from 800 to 1,200 feet. The annual rainfall is 40 to 60 inches, and most of it falls during the summer months. The mean annual soil temperature is between 71° and 73° F. The natural vegetation consists of guava, lantana, koa haole, and guinea grass.

Description of Mapping Unit Representative of the Series

Kainaliu extremely stony silty clay loam, 12 to 20 per cent slopes (KEC)

This soil occurs at low elevations on Mauna Loa and Hualalai.

The surface layer is very dark brown extremely stony silty clay loam about 10 inches thick. The subsoil consists of dark brown, very stony silty clay loam and silt loam. It is about 16 inches thick and is underlain by fragmental Aa lava. The surface layer is medium acid, and the subsoil is neutral.

Permeability is rapid, runoff is slow, and the erosion hazard is slight. Roots penetrate to a depth of 26 inches or more.

Unimproved pasture consists of natal red top, bermuda grass, lantana, Christmas berry, guava, and Japanese tea. Four-fifths of the forage is produced during the summer months. Annual production is 2,000 - 3,000 pounds of air-dry forage/acre.

Guinea grass, koa haole, kikuyu grass and Kaimi clover are adapted plants for improved pasture, and the annual production is 4,000 - 7,000 pounds of air-dry forage/acre.

Profile description of KEC:

Horizon Symbol	Depth from Surface
Ap	0 to 10 inches, very dark brown extremely stony silty clay loam; strong, medium and fine sub-angular blocky structure; hard friable, slightly sticky and plastic; many roots; many very fine pores; 10 to 15% Aa lava fragments from gravel to stone size; medium acid; abrupt, smooth boundary.
B21	10 to 18 inches, dark brown stony silty clay loam; weak, medium and fine, sub-angular blocky structure; slightly hard, friable, slightly sticky, and plastic; many roots; many medium and fine pores; 20 to 40 per cent Aa lava fragments from gravel to stone size; neutral, clear smooth boundary.
B22	18 to 26 inches, dark brown very stony silt loam; weak, medium and fine, sub-angular blocky structure; slightly hard; friable, slightly sticky, and slightly plastic; few roots; many medium and fine pores; 50 to 60 per cent Aa lava fragments from gravel to stone size; neutral; gradual, wavy boundary.
IIR	26 inches, fragmental Aa lava.

Description of Mapping Unit KDD - Kainaliu very stony silty clay loam, 12 to 20 per cent slopes

This soil is similar to Kainaliu extremely stony silty clay loam, 12 to 20 per cent slopes (KEC), except that it is less stony. Most areas of this soil follow the pattern of the lava flows and are long and narrow, but some are isolated and are surrounded by recent lava flows.

Since this soil is less stony than that of the preceding mapping unit (KEC), it requires less management impact to obtain similar productivity. A small acreage is used for truck crop where much of the stones have been removed from the soil surface.

B. Use of Site: Historical and Current

This section is a review of salient uses of this land from pre-1900 up to the present. This information was, for the most part, obtained through interviews with long-time residents who have witnessed the use change over the years.

An archeological investigation was prepared by William Barrera, Jr. (July 1989). The area that was investigated covered 195 acres between Pali Kapu-o-Keoua, immediately above Kealakekua Bay and Napoopoo Road. Field boundaries of stone rubble and stacked boulders hint the use of the area as a prehistoric agricultural field system.

Researchers have interpreted a site complex with an overhang cave shelter and with soil floor to be a possible prehistoric temporary shelter probably associated with agricultural activities. Other areas are terraced and could have been used for agricultural purposes; or even possibly as a special purpose site. An oval, raised stone platform hints of its possible past usage as a loading area for harvested pineapple. Other terraces and stacked boulders appear to have been used for habitation. There are some evidence that sweet potatoes were cultivated by ancient Hawaiians on this site.

At the turn of the century, the land was used mostly by wild cattle. However, by 1905 land use of this site was focused on pineapple production, which was under the guidance of the Hala Kanning Company. The operation proved unprofitable, and its assets were purchased by the Captain Cook Coffee Co. From 1912 on, no specific mention was made of pineapple production. This could mean that raising pineapple was not profitable, and was eclipsed by a more profitable crop--coffee. In the late 1930's, range grasses were introduced for cattle grazing; however, eventually this effort was phased out as rogue plants began to take over, i.e., lantana bush and weeds. Coffee production was attempted but abandoned due to the pronounced seasonality of the wet and dry periods, which were counter productive for the coffee plants.

C. Cattle Operation

The North and South Kona districts are composed of about 285,000 acres that are devoted to pasture and range land. Much of this acreage is marginal and is not suitable to sustain high forage production because of limitation in rainfall (or suitable irrigation) and the chemical - physical characteristics of the soils. Land used for range or pasture may vary in elevation from sea level to 7,000 feet. Rainfall on these ranges varies greatly. Forage quality is often superior on the low, dry lands but deficient in quantity; with the reverse being true in the high rainfall areas. Much of the land is not accessible and is covered with brush and weeds and/or is not planted with desirable species of grasses.

By way of the soils survey report, the 262 acre site is located along the rugged ridges of Kealakekua Bay at approximately 500 feet elevation and along the Napoopoo Road of about 1,200 feet elevation. The annual rainfall is about 20 - 40 inches during the rainy summer months and hardly any rainfall during the dry months.

An on-site inspection revealed that the only predominant pasture grass growing was the green panic and colonial quinea grass, which is grown in Hawaii from sea level to about 1,500 feet elevation under seasonally alternating wet and dry conditions with annual rainfall of more than 40 inches. Guinea grass is an excellent dryland irrigated forage plant and is readily established from seeding, voluntary growth or by cultivation.

Koa haole, Leucaena leucocephala, was the native legume found growing with the guinea grass. Koa haole is adapted to areas with annual rainfall of 20 to 60 inches and elevation up to 1,000 feet. It is a good source of crude protein for cattle production. Under good management, an irrigated, fertilized, and pest-controlled koa haole - guinea grass mixture will annually yield up to approximately 100 tons of green forage per acre. Without irrigation, fertilizer and pest control, the annual yield depends on climatic conditions and varies from 5 to 35 tons of green forage per acre.

The on-site spection also revealed that the guinea grass, some buffel grass and koa haole were invaded by brush and weed pests such as: (on the lower elevation): lantana, klu (Acacia sp.) natal red top; (on the higher elevation): pride of India, kukui, monkey pod trees and sour grass.

In view of the site inspection, i.e., (1) a very stony soil profile; (2) lack of annual rainfall during six to seven months of the year; (3) competition from noxious plant pests; and (4) lack of pasture management practices, it is believed that the carrying capacity of this pasture is approximately 3.5 acres to maintain one head of cattle weighing 1,000 lbs. (one animal unit). Therefore, about 75 heads of cattle can be maintained on ths 262 acre site annually.

The Kealakekua Ranch originally owned (11,000 acres) and leased (9,000 acres), but in recent years the owner sold the entire Ranch except 100 acres of historical ranch house site. During the years of ranch operation, 2,500 heads of cattle were maintained throughout the years.

According to the 1989 Annual Statistics of Agriculture, Hawaii County produced 85% of the State's beef needs. This is equal to 131,500 heads of cattle produced on the Big Island.

Therefore, the economic impact of Kealakekua Ranch's carrying capacity of 75 heads of cattle on 262 acres as compared with the cattle industry on the rest of Hawaii County and to the State of Hawaii is insignificant.

D. Suitability of Site for Crop Production

Kona is considered to be one of the principal agricultural production areas on the Island of Hawaii. Some of the diversified crops that are closely associated with Kona are coffee, macadamia nut, avocado, and banana. Other crops such as guava and passion fruit are also grown in Kona. The following table shows three of the many factors that are needed to grow these crops.

Crop	Soil	Annual Rainfall	Elevation
coffee	soil with good drainage	40 to 125 inches	800 to 2,500 ft.
macadamia nut	soil with good drainage	50 to 120 inches	sea level to 2,000 ft.
avocado	must have excellent drainage	50 inches	sea level to 3,500 ft.
banana	good drainage	80 - 150 inches	below 1,000 ft.
guava	good drainage	125 inches	sea level to 3,500 ft.
passion fruit	deep and fertile soil	100 inches	sea level to 2,500 ft.

Although the elevation of subject site might be suitable for the production of these crops, the soil condition and the lack of an even distribution of rainfall could be limiting factors to produce these crops. The lack of rainfall could be compensated by irrigating the field but at escalating cost, as water rates normally increase every two years. The rate, effective 1 July 1991, will be:

(a) .84/1000 gallons if under 5000 gallons;
(b) 1.14/1000 gallons for the next 20000 gallons; and
(c) 1.04/1000 gallons over 25000 gallons.

In order to qualify for these agricultural rates, one must file an annual application with the Board of Water Supply and furnish proof of engagement in agriculture.

Another basic cost that one must consider in developing a production site is the need to clear and level the land--as a start. The estimate that was received for clearing

and leveling an acre of Kona land with up to 20% slope is approximately $1,700.00. This does not include digging or ripping, which would be advisable for land with pahoehoe that is covered with shallow organic matter. Ripping the ground to enhance drainage is important to prevent root rot, which would lead to the demise of the plant itself.

Another retarding factor to consider is the lack of processing facilities for crops such as guava and passion fruit. The major processors on the Island of Hawaii are located in Hilo. This would necessitate transporting the raw product to Hilo, or ship them to Honolulu. Both destinations are not attractive alternatives because of the transportation cost.

About the only possibly suitable crop that might be considered for this site is a greenhouse nursery operation. This statement is made with reservation, as such an operation will need extensive economic analysis before it is undertaken, i.e., the cost of development; the cost of production; the climatic condition; transportation; and the market itself.

In view of the major limitations that subject site poses for crop production, this site is considered not suitable for use as a productive area for vegetable as well as orchard crops.

E. Effect on Diversified Agriculture

1. Criteria

The objective of this section is to evaluate how the loss of the subject land to agriculture would affect the availability of land for and the potential growth of diversified agriculture. Diversified agriculture is defined as crops other than sugar and pineapple, such as vegetables, melons, fruits, coffee, macadamia nut, taro, field crops, flowers, and nursery products.

The criteria are:

(a) Land use designation;
(b) Soil Conservation Service classifications;
(c) Land Study Bureau Land Capability Classifications; and
(d) State-wide acreage in crop production.

2. Site Data

2.1 Land Use Designation

Zoning	Acreage
Agriculture	34
Conservation	118
Urban	100
Total	262

Table 1. Land Use Designations

2.2 Soil Conservation Service (SCS) Classifications

The following sections describe the soil series and capability classes for the soils found on the site. The final section is a summary table (Table 2). Although SCS rates land capability with irrigation for some land types, none of the land types on the site were rated for irrigation.

2.2.1 Kainaliu Series

KEC - Kainaliu extremely stony silty clay loam, 12 to 20 per cent slopes.

In a representative profile the surface layer is very dark brown extremely stony silty clay loam about 10 inches thick. The subsoil consists of dark brown very stony silty clay loam and silt loam. It is about 16 inches thick and is underlain by fragmental Aa lava. The surface layer is medium acid, and the subsoil is neutral.

Permeability is rapid, runoff is slow, and the erosion hazard is slight. Roots penetrate to a depth of 26 inches or more.

This soil is used for coffee, macadamia nuts, and pasture.

KDD - Kainaliu very stony silty clay loam, 12 to 20 per cent slopes. This soil is similar to Kainaliu extremely stony silty clay loam. 12 to 20 per cent slopes, except that it is less stony. Most areas of this soil follow the pattern of the lava flows and are long and narrow, but some are isolated and are surrounded by recent lava flows.

Most of the acreage is used for coffee, macadamia nuts, and pasture. A small acreage is used for truck crops.

WHC - Waiaha extremely stony silt loam, 6 to 12 per cent slopes.
In a representative profile the surface layer is very dark brown extremely stony silt loam about 4 inches thick. The subsoil is dark brown very stony silt loam about 14 inches thick. The substratum is pahoehoe lava bedrock. The surface layer is slightly acid. The subsoil is neutral to mildly aklanine. In places the surface layer is non-stony.

Permeability is moderately rapid, runoff is slow, and the erosion hazard is slight. Roots can penetrate to bedrock.

About 21 acres of agriculturally zoned land is in this soil type.

2.2.2 Kaimu Series

rKED - Kaimu extremely stony peat 6 to 20 per cent slopes.
In a representative profile the surface layer is very dark brown extremely stony peat about 3 inches thick. It is underlain by fragmental Aa lava. This soil is neutral in reaction.

Permeability is rapid, runoff is slow, and the erosion hazard is slight.

This soil is not suitable for cultivation. Most of it is in native woodland. Small areas are used for pasture, macadamia nuts, papaya, and citrus fruits.

2.2.3 Lava Flows, Aa

rLV - Lava flows, Aa.
This lava has practically no soil covering and is bare of vegetation, except for mosses, lichens, ferns, and a few small ohia trees. This lava is rough and broken. It is a mass of clinkery, hard, glassy, sharp pieces piled in tumbled heaps.

About 13 acres of agriculturally zoned land is in this soil type.

2.2.4 Capability Class VIs

These soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife. The letter s shows that the soil is limited mainly because it is shallow, droughty, or stony.

2.2.5 Capability Class VIIs

These soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture or range, woodland, or wildlife. The letter s shows that the soil is limited mainly because it is shallow, droughty, or stony.

2.2.6 Capability Class VIIIs

These soils and landforms have limitations that preclude their use for commercial plants and restrict their use to recreation, wildlife, or water supply, or to esthetic purposes. The letter s shows that the soil is limited mainly because it is shallow, droughty, or stony.

2.2.7 Summary Table

Soil Type	Acreage	Capability Classification
KEC	92.5	VIIs
KDD	84	VIs
WHC	51.5	VIIs
rKED	21	VIIs
rLV	13	VIIIs
Total	262	
Class VIs	84	
Class VIIs	165	
Class VIIIs	13	

Table 2. SCS Soil Types and Classifications

2.3 Land Study Bureau (LSB) Land Capability Classifications

LSB classifies soils by land type for an overall crop productivity rating and 7 selected crop productivity ratings. LSB overall ratings for cultivated crop production and grazing range from A to E, A being the best.

A - Very good, productivity index 85 to 100
B - Good, productivity index 70 to 84
C - Fair, productivity index 55 to 69
D - Poor, productivity index 30 to 54
E - Very poor, productivity index less than 30

The overall productivity ratings evaluate each land type in its general productive capacity in agricultural use and not for the specific crop. The ratings interpret the interacting complex influence of climate, surface relief, drainage, wind velocities, and soil characteristics under modal cultural practices. Selected ratings for individual crop categories range from a to e, a being the best. Although LSB rates land capability with irrigation for some land types, none of the land types on the site were rated for irrigation. See Table 3.

C52 - This land type has a productivity index of 56. This gives an overall productivity rating of C, fair. For selected crops the land type rates b for orchard and grazing and e for vegetables, sugar cane, and forage crops.

C71 - This land type has a productivity index of 55. This gives an overall productivity rating of C, fair. For selected crops, the land type rates a for grazing, c for orchards, and e for vegetables, sugar cane, and forage crops.

D230 - This land type has a productivity index of 39. This gives an overall productivity rating of D, poor. For selected crops, the land type rates b for grazing, d for orchards, and e for vegetables, sugar cane, and forage crops.

E319 - This land type has a productivity index of 5. This gives an overall productivity rating of E, very poor. For selected crops, the land type rates e for vegetables, sugar cane, orchards, grazing, and forage crops.

Soil Type	Acreage	Capability Classification
C52	45	C
C71	131	C
D230	71	D
E319	15	E
Total	262	
Class C - Fair	176	
Class D - Poor	71	
Class E - Very Poor	15	

Table 3. LSB Land Capability Classifications

3. State-wide Acreage in Crop

In the last ten years, the number of farms across the State has increased as farm acreage and farm employment have decreased. Sugar and pineapple have accounted for this general trend with about 53,600 acres leaving production. Diversified agriculture has at the same time increased by 16,700 acres (See Table 4.). The decline of acres in crop production during the 10 year period exceeded the acres converted to uses other than agriculture, resulting in a stockpile of unused land of good quality. Some of this land offers a potential for expanded crop production with respect to ecology, but high land prices, market limitations, infeasibility of leasing the land in small parcels, and difficulty in obtaining agricultural subdivision permits have prevented its use for agriculture. This situation can be expected to continue to a greater extent on Oahu and to a lesser extent on neighbor islands.

Crop	Acreage 1979	Acreage 1989	Increase (Decrease)
Sugar	218,800	176,500	(42,300)
Pineapple	44,000	34,600	(11,300)
Diversified Ag. crops	28,000	44,700	16,700
Net			(36,900

Table 4. Acreage in Crops, 1979 - 1989

4. Evaluation

Based on the acreage-in-crop trend, productive agricultural land will be available to easily accommodate the modest growth requirements of diversified agriculture. The limiting factor for diversified agriculture will be the market, not the land supply.

Although there are additional criteria upon which the project site could be evaluated for the applicability of diversified agriculture activities, the land use and ecological criteria are sufficient in characterizing the site. See Table 5.

Agricultural land	Class VII	Class VIII	Class D Poor	Class E Very poor
Acres (SCS)	21	13		
Acres (LSB)			19	15

Table 5. Agricultural Land Classifications

About 17% of the total site area is zoned agriculture. The area is rated as poor and very poor in overall productivity. This area is the most remote part of the site and has the lowest elevation (low rainfall, about 20 inches per year). These factors combine to lessen the competitive advantage agriculturally for the site relative to other more productive sites and make it unsuitable for diversified agricultural production.

Therefore, the loss of the subject land to agriculture would not affect the availability of land for and the potential growth of diversified agriculture.

F. Compatability with State and County Plans

The Hawaii State Functional Plan for Agriculture was reviewed along with the Hawaii County General Plan. The difference between the two plans being that the Functional Plan assures that statewide problems and issues are addressed; whereas, the Hawaii County General Plan assures that unique problems and needs within the County are addressed.

The Functional Plan supports the "Vision of Hawaiian Agriculture," which envisions:

(1) growth and size of the sugar industry as determined by economic efficiency;

(2) continued growth of pineapple production; and

(3) greatest growth of diversified agriculture, which requires:

(a) understanding potential products and markets, and

(b) ensuing that factors to achieve the growth potential are established.

The plan lists issues, which are listed below, that are essential for achieving its objectives:

(1) industry research and development;

(2) agricultural pests and environment;

(3) land and water; and

(4) services and infrastructure.

The County of Hawaii General Plan points out that the structure of the County's commercial agriculture is in transition, i.e., from the present decline of sugar and pineapple, both of which at one time undisputedly dominated the agricultural scene, to the dramatic emergence of diversified agriculture. The General Plan expresses its confidence in the potential growth of diversified agriculture, but with the realization that this encouraging scenario is not without problems that must be addressed. Some of these problems include, but are not limited to:

(1) land cost,

(2) cost/availability of water,

(3) cost/availability of transportation,

(4) cost of labor,

(5) market development,

(6) quality standards, and

(7) disease and pest control.

Both policies -- the State Functional Plan and the Hawaii County General Plan -- favor agriculture where such endeavor is feasible. Furthermore, limitations of marginal lands are recognized as not putting such lands in the cultivation of crops, since farming on marginal site will not be in keeping with the land's highest and best use.

Among the policies of the County of Hawaii is to strive for diversification of its economy by strengthening existing industries and attracting new endeavors. One of the County's goal is to strive toward providing an economic environment which allows new, expanded, or improved economic opportunities that are compatible with the County's natural and social environment.

CONCLUSION

The exhaustive search for information enabled the authors to have an appreciable grasp of the impact this proposed project might have on agriculture (sugar cane, pineapple, and diversified crops). The authors feel that the total impact this project might have on agriculture on the Island of Hawaii will be minor, at best, or to the point of being irrelevant. As mentioned in the study itself, the soil condition is poor, and the lack of an even distribution of rainfall is counter productive to agriculture.

The State's policy toward its primary land objective is the achievement of productive agricultural use of lands most suitable and needed for agriculture. It is also to "encourage productive agriculture use of the most suitable agricultural lands." The project site is not suitable for conventional productive agricultural use, and thus is not needed for agriculture. Utilization of the land for recreation, such as a golf course, which might be considered an alternative form of agriculture, would provide substantially more economic benefit than conventional crop production in the agricultural sense. A golf course on the site would provide improved open space and be able to take advantage of the beauty of that general area.

The authors feel that from an agricultural perspective, the proposed project will not detract, hamper, or hinder the greater agricultural activities of the County of Hawaii.

SECTION II

GLOSSARY, PHOTOGRAPHS, REFERENCES

GLOSSARY

Capability classes - defined in terms of the use that can be made of a soil, or the management input required to sustain a desired level of production

Consistence, soil - The feel of the soil and the ease with which a lump can be crushed by the fingers. Some of the terms commonly used to describe consistency are:

(1) loose -- noncoherent when dry or moist; does not hold together in a mass

(2) friable -- when moist, crushed easily under gentle pressure between thumb and forefinger and can be pressed together into a lump

(3) firm -- when moist, crushed under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable

(4) sticky -- when wet, adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material

(5) hard -- when dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger

Horizons

A horizon - a horizon formed at or near the surface but within the mineral soil, having properties that reflect the influence of accumulating organic matter or eluviation (removal of soil material in suspension) alone or in combination

O horizon - a natural or horizon of fresh or partly decomposed plant litter on the surface of the mineral soil. It occurs above the mineral soil

01 horizon - organic horizon in which the original form of most of the vegetative matter is recognizable

02 horizon - organic horizon in which the original form of the organic matter cannot be recognized

"0" horizon - is measured from above the surface to the surface of soil profile

Ap horizon - plowed A horizon

Peat - undecomposed or slightly decomposed organic matter (mostly plant material)

B horizon - subsurface horizon(s)

C horizon - horizon that normally lies beneath B horizon; parent material of soil above it

R horizon - consolidated bedrock underlying C horizon

Peat soil - an organic soil consisting largely of undecomposed, or only slightly decomposed, organic matter accumulated under conditions of excessive moisture

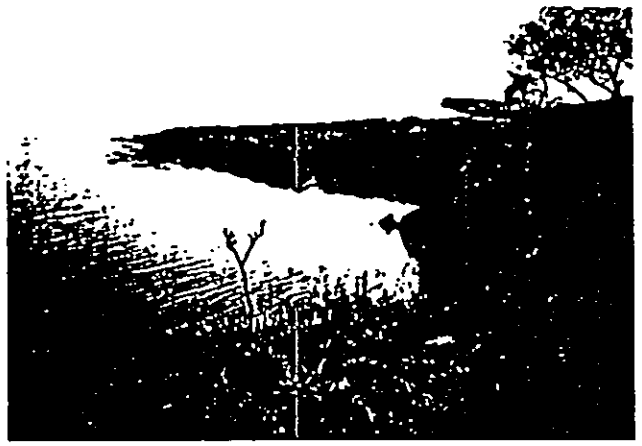
Soil permeability - the ease with which gases, liquids, or plant roots penetrate or pass through soil

Soil management - the sum total of all tillage operations, cropping practices, fertilizer, lime, and other treatments conducted on or applied to a soil for the production of plants

Soil series - the basic unit of soil classification and consisting of soils which are essentially alike in all major profile characteristics, although the texture of the A horizon may vary somewhat

Stones - rock fragments greater than 10-15" diameter

Types of Soil Condition



Escarpment

Escarpment

Kaimu rKED

Kaimu rKED

Waiaha WHC

Waiaha WHC

Kainaliu KEC

Kainaliu KDD

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Seria, Stanley, Loan Officer, Hawaii State Dept. of Ag., Kona

Takashiba, Yoshitaka, farmer, Kona

Appendix 11:

MARINE ENVIRONMENTAL MONITERING PROGRAM, REPORT 1-90

MARINE ENVIRONMENTAL MONITORING PROGRAM,

KEALAKEKUA BAY, SOUTH KONA, HAWAII

REPORT 1-90

Prepared for

Royal Coast Development Corporation
P.O. Box 44394
Kawaihae, HI 96743

by

Marine Research Consultants
217 Prospect St. F-2
Honolulu, HI 96813

July 10, 1990

PURPOSE

The proposed Kealakekua Bay Club includes construction of an 18-hole golf course, clubhouse, restaurant, low profile 36-room members's lodge and five 2-acre house lots on a 262-acre parcel of land. The project site, situated in Kealakekua, South Kona, below the town of Captain Cook, lies immediately above the steep cliff known as Pali-Kapu-o-Keoua and overlooks Kealakekua Bay.

A primary concern in the planning of the development is protection and preservation of the existing environmental quality of the area. The marine environment of Kealakekua Bay has been assessed in a preliminary baseline survey (Marine Research Consultants 1989), in order to identify and mitigate at an early stage any potential problems that may be associated with development activities. Because of the concern for maintaining the present level of environmental quality in Kealakekua Bay, and as a means of ensuring that proper procedures are set forth, it has been deemed appropriate to institute a marine monitoring program. The purpose of the monitoring program is to initially conduct a time-course evaluation of water quality and biological community structure before any construction activities take place in order to establish an "envelope" of naturally occurring variability in environmental parameters. With knowledge of the presently occurring variability, monitoring during and after construction can serve the purpose of identifying and mitigating any potential environmental problems caused by the development activities on shore. The program is also designed to meet all requirements for permit approval by government agencies, including County, State, and the U.S. Army Corps of Engineers. This report constitutes the first increment in the monitoring program, and contains data from the initial increment of water chemistry sampling conducted in June 1990. The sampling was conducted prior to any construction activities and serves as the first phase of establishing the preconstruction baseline.

METHODS

Three sites in Kealakekua Bay downslope from the proposed Kealakekua Bay Club parcel were selected as sampling stations for the monitoring program. Station 1 lies closest to the northern corner of the Bay in the area of the Captain Cook monument; Station 2 lies at the approximate center of the Bay; Site 3 lies along the southern border of the Bay near Napoopoo (see Figure 1). Water quality was evaluated at each station on transects that extended from the shoreline to the outer limits of the Bay, approximately 1000 meters (m) offshore. All transects were oriented perpendicular to the back shoreline of the Bay, and were thus somewhat parallel to the sides of the Bay. Water samples were collected at 6 locations along each transect. Such a sampling scheme was designed to span the greatest range of salinity with respect to freshwater efflux at the shoreline. Sampling was more concentrated in the nearshore zone because this area is most likely to show the effects of shoreline modification. With the exception of the stations located 1 m from the shoreline, samples were collected at two depths; a surface sample was collected within approximately 10 centimeters (cm) of the sea surface, and a bottom sample was collected within 1 m of the sea floor.

Water quality parameters evaluated included the 10 specific criteria designated for open coastal waters in Chapter 11-54, Section 06 (Open Coastal waters) of the State of Hawaii, Department of Health (DOH) Water Quality Standards. These criteria include: total nitrogen (TN), nitrate + nitrite nitrogen (NO_3^- + NO_2^-), ammonium (NH_4^+), total phosphorus (TP), chlorophyll a (Chl a), turbidity, dissolved oxygen, temperature, pH and salinity. In addition, orthophosphate phosphorus (PO_4^{-3}) and silica (Si) were also reported because these parameters are sensitive indicators of biological activity and the degree of groundwater mixing.

All fieldwork was conducted on June 1, 1990, working from a 17-foot boat. Water samples were collected by opening 1-liter polyethylene bottles at the desired depth. Subsamples for nutrient analyses were immediately placed in 125-milliliter (ml) acid-washed, triple rinsed, polyethylene bottles and stored on ice until returned to Honolulu. Analyses for NH_4^+, PO_4^{3-}, and NO_3^- + NO_2^- were performed using manual spectrophometric techniques on a Brinkman fiber-optic colorimeter. Total nitrogen (TN) and total phosphorus (TP) were analyzed in a similar fashion following digestion. Dissolved organic nitrogen (DON) and dissolved organic phosphorus (DOP) were calculated as the difference between TN and dissolved inorganic N, and TP and dissolved inorganic P, respectively. The chemistry procedures were performed according to standard methods for seawater analysis (Strickland and Parsons 1968, Grasshoff 1983).

Water for other analyses was subsampled from 1-liter polyethylene bottles and kept chilled until analysis. Turbidity was determined on 60-ml subsamples fixed with $HgCl_2$ [illegible] biological activity. Fixed samples were kept refrigerated until turbidity was measured on a Monitek Model 21 nephelometer, and reported in nephelometric turbidity units (NTU). Chl. a was measured by filtering 300 ml of water through glass fiber filters; pigments on filters were extracted in 90% acetone in the dark at -5° C for 12-24 hours, and the fluorescence before and after acidification of the extract was measured with a Turner Designs fluorometer. Salinity was determined using an AGE Model 2100 laboratory salinometer with a readability of 0.0001 °/oo.

In-situ field measurements included dissolved oxygen and water temperature (YSI Model 58 meter with a readability of 0.01 milligrams per liter (mg/l) and 0.1° C., respectively). pH was determined in the field with a Cole-Parmer Digisense millivolt meter with a readability of 0.001 pH units.

RESULTS

Table 1 shows results of all marine water chemistry analyses for samples collected on June 1, 1990. Concentrations of ten chemical parameters as functions of distance from the shoreline are plotted for each station in Figures 2 and 3. It can be seen that moving offshore from the back shoreline of the Bay to a distance of approximately 500 m offshore, dissolved nutrient concentrations exhibit a decreasing trend (Figure 2). Salinity shows the opposite trend, with increasing values with increasing distance from the shoreline (Figure 3). These patterns are a result of mixing of low salinity groundwater with oceanic water. Low salinity groundwater, which contains high concentrations of Si, NO_3^-, and PO_4^{3-} (see values for well water in Table 1), percolates to the ocean at the shoreline, resulting in a mixing zone within inner Kealakekua Bay. The apparent highest input of groundwater occurs at Station 1 in the northern corner of the Bay. Samples located 50 and 250 m from the back wall of the Bay, in the vicinity of the Cook Monument, reflect substantially higher freshwater input that at the other stations. Comparison of the pattern of groundwater efflux measured in the present monitoring survey with data collected in the preliminary baseline survey of Kealakekua Bay (December 1989) reveal substantially higher inputs in June relative to December. Such results suggest that there is a temporal component to groundwater discharge.

Water chemistry parameters that are not associated with groundwater input do not show the same strong pattern with respect to distance from the back Bay. Chl. a and turbidity exhibit increases at the nearshore samples from Station 3, but are consistently low in value at the Station 1 sites where groundwater input is evident. Temperature values are coolest at Station 1, and become increasingly warm at Stations 2 and 3. Oxygen concentration shows little pattern with respect to Station or distance from the shoreline. pH tends to increase at all Stations with distance from the shoreline.

Figures 4 and 5 show concentrations of water chemistry parameters as functions of distance from the back of the Bay with respect to vertical stratification. It can be seen in Figure 4 that all of the samples

which exhibit high concentrations of groundwater nutrients (Si, N, and P) occur at the surface, while corresponding salinities are low (Figure 5). Mixing of low salinity groundwater with oceanic water creates a distinct low-density surface lens which is evident to distances of at least 250 m from shore. The anomalous high values of turbidity and Chl. a at Station 3 also occur in the surface layer. Temperature, on the other hand, does not display a distinct surface layer thermal structure throughout the Bay. Temperature differences at each station are more pronounced than differences between depths throughout the Bay. Such a pattern suggests that there are other factors, probably related to residence time of water in the Bay, that are responsible for the observed temperature structure.

Also shown in Table 1 are samples that exceed DOH water quality standards for open coastal waters under "wet" conditions. The criteria for wet conditions are applied to Kealakekua Bay as this area receives at least 3 million gallons of groundwater input per mile per day (T. Nance, personal communication). Comparing water chemistry results from the Kealakekua Bay samples to DOH standards reveals 13 measurements of NO_3^- and 2 measurements of Chl. a exceeded the 10% standards, while 7 measurements of NO_3^- exceeded the 2% standards. As discussed above NO_3^- is a normal constituent of groundwater, and the concentrations found in surface waters of Kealakekua Bay appear to be the result of groundwater discharge at the shoreline. The comparative results with DOH criteria indicate that under the present undisturbed (with respect to construction activity on the shoreline) conditions, natural processes can result in water quality that exceeds specified DOH limits. The situation for the two Chl. a samples that exceed the DOH limit is somewhat different. These two samples, collected at nearshore sites at Station 3, also had the highest turbidity of the survey set. From this limited information, it appears that there may be some areas in the southern end of the Bay where relatively restricted water circulation results in higher concentrations of phytoplankton.

A useful treatment of water chemistry data for interpreting the extent of material input from land is application of a hydrographic mixing model. In the simplest form, such a model consists of plotting the concentration of a dissolved chemical species as a function of salinity. Comparison of the curves produced by such plots with conservative mixing lines provides an indication of the origin and fate of the material in question. Figure 6 shows plots of concentrations of four chemical parameters (Si, NO_3^-, NH_4^+, PO_4^{3-}) as functions of salinity. Each graph also shows conservative mixing lines that are constructed by connecting the endpoint concentrations of open ocean water and groundwater from the potable wells located upslope of Kealakekua Bay.

If the parameter in question displays purely conservative behavior (no input or removal from any process other than physical mixing), data points should fall on, or near, the conservative mixing line. If, however, external material is added to the system through processes such as leaching of fertilizer nutrients to groundwater, data points will fall above the mixing line. If material is being removed from the system by processes such as biological uptake, data points will fall below the mixing line.

Dissolved Si represents a check on the model as this material is present in high concentration in groundwater, but is not a component of fertilizer, and is not utilized rapidly within the nearshore environment by biological processes. It can be seen in Figure 6 that when Si concentrations are plotted versus salinity, data points fall in a straight line indicating groundwater is mixing with seawater in a conservative fashion. The line created by the data points, however, falls above the conservative mixing line, suggesting that the groundwater entering Kealakekua Bay is somewhat different in composition than the well water used to construct the line. While the agreement of the measured mixing line with the theoretical conservative mixing line is not perfect, the relationship can still be used to provide a valid representation of the system under investigation.

The plots of NO_3^- versus salinity (Figure 6) shows a pattern very similar to dissolved Si, with most NO_3^- data points falling very close to the conservative mixing line. As NO_3^- is the form of nitrogen most common in fertilizer mixes, and is the most mobile form of nitrogen, the agreement of the

theoretical mixing line and the data line is evidence that presently there does not appear to be an external input of NO_3^- to the ocean from activities on land

The other form of dissolved inorganic nitrogen, NH_4^+, shows a scattered pattern of distribution with respect to salinity (Figure 6). As some of the higher salinity samples have the highest NH_4^+ concentrations, it does not appear that this form of nitrogen is present in the marine environment as a result of mixing from groundwater sources. Typical groundwater also contains less NH_4^+ than nearshore oceanic waters. Inspection of the data in Table 1 indicates that groundwater from the Kealakekua area has less NH_4^+ than some of the offshore samples. Rather, the plot of NH_4^+ versus salinity suggests that this material is generated by biological activity in the Bay waters.

PO_4^{3-} is also a component of fertilizer but is usually not found to leach to groundwater to the extent of nitrate nitrogen, owing to a high absorptive affinity of phosphorus in soils. It can be seen, however, in Figure 6 that many of the data points for the Kealakekua Bay PO_4^{3-} concentrations fall above the mixing line, suggesting an external source from groundwater leaching. Repetitive sampling during the next monitoring increment will indicate if the apparent phosphorus input is a continuing phenomenon, or was an isolated event.

The density of data points from the first monitoring survey is not yet sufficient to indicate if there is distinct curvature of the PO_4^{3-} data line. Such curvature would indicate if there is measurable biotic uptake of the apparent nutrient subsidies, while lack of curvature would suggest that the added materials are mixed out of the Bay by physical dispersive processes.

While there appears to be a subsidy of phosphorus to Kealakekua Bay from activities on land, it should be noted that at the present level the additional material does not appear to present the potential for substantial ecosystem alteration. PO_4^{3-} was measured at a concentration of 4.04 µM in potable well water that is used for human consumption. The highest concentration measured in Kealakekua Bay was 0.68 µM, only 17% of groundwater concentration. In terms of effects to reef communities from such concentration, field experiments where patch reefs were subjected to PO_4^{3-} levels of 2 µM continuously for eight months showed no effects to coral community structure (Kinsey and Domm 1974, Kinsey and Davies 1979). In addition, the areas where Chl. a concentrations were highest (Station 1) were the farthest removed from the area where phytoplankton were most abundant (Station 3). While the methods employed for the present monitoring program are sensitive enough to detect a potential PO_4^{3-} subsidy, it does not appear that the magnitude of the subsidy is sufficient at this point in time to be considered a potential problem with respect to water quality.

Similar consideration can be applied to the exceedance of DOH standards for NO_3^-. It can be seen by the match of the data points and the conservative mixing line in Figure 6 that there are no extraneous NO_3^- subsidies from activities on land. Yet many of the nearshore samples collected in Kealakekua Bay had concentrations exceeding 1.00 µM (the DOH "not to exceed more than 10% of the time" criterion) solely from mixing with naturally occurring groundwater. With the present level of influence from shoreline development, groundwater input into the ocean causes waters in the inner Bay to exceed DOH water quality standards with respect to NO_3^-. However, even with the detected apparent subsidy of PO_4^{3-}, none of the observed concentrations of TP exceeded the DOH criterion. These results suggest that the methods employed in this survey are sensitive enough to depict environmental changes at levels below those capable of producing negative alterations to community structure and function. Such methods optimize the utility of monitoring by providing the information necessary to instigate mitigative measures in a preventative manner.

SUMMARY

1. The first phase of the Kealakekua Bay water chemistry monitoring program was conducted on June 1, 1990. Thirty-three ocean samples from three stations spanning the length of the Bay, and directly downslope from the planned Kealakekua Bay Club Golf Course, were analyzed for 10 chemical criteria specified by DOH water quality standards.

2. Overall, water quality of Kealakekua Bay can be considered pristine, and generally unimpacted from the activities on land. A dominant feature of water chemistry is the mixing of groundwater that effluxes from the basaltic shoreline, with oceanic water in the inner Bay. This mixing results in a low salinity surface layer with high concentrations of nutrients (Si, N, and P) that are normal components of groundwater. From the results of this monitoring survey, groundwater input appears to be greatest at the northern end of the Bay. Beyond a distance of approximately 500 m from the back shoreline of the Bay, water chemistry reflects oceanic conditions with little indication of groundwater characteristics. As there was little evidence of a low salinity-high nutrient surface layer in the December 1989 baseline survey, it appears that groundwater input is temporally variable.

3. Water chemistry parameters not directly associated with groundwater input exhibit various trends. Chl. a and turbidity exhibit increases at nearshore samples off Napoopoo, but are consistently low at the sampling site in the northern Bay where groundwater input was most evident. Temperature shows a cooling trend moving from south to north in the Bay that is more pronounced than can be explained by either solar warming, or groundwater input.

4. Application of a hydrographic mixing model to the water chemistry data is used to verify that the cause of increased nutrient concentrations in the inner Bay is mixing of groundwater with oceanic water. The slight variance of the line created by the data points and a theoretical mixing line suggest that groundwater reaching the Bay is slightly different in character than potable water collected at Napoopoo. Nevertheless, the model indicates that there is presently no substantial input of external sources of nutrient materials, particularly nitrogen, into Kealakekua Bay. There is a suggestion of a slight increase in phosphorus, although the levels are far too low to result in alteration of water quality or biological community structure.

5. Many of the nearshore measurements of NO_3^-, and two measurements of Chl. a exceed State DOH water quality standards. It is evident, however, that NO_3^- levels are solely a function of natural groundwater input. Under the present conditions of shoreline, natural processes cause some water quality parameters to exceed specified DOH limits.

TABLE 1. Water chemistry measurements at Kaneohe Bay collected 6/1/90. "S" indicates surface sample, "B" indicates bottom sample. For sampling locations, see Figure 1. Boxed values indicate exceedance of DOH criteria for wet conditions of open coastal waters

STATION NO.	DISTANCE OFFSHORE (m)	PO4 (µM)	NO3 (µM)	NH4 (µM)	Si (µM)	DOP (µM)	DON (µM)	TP (µM)	TN (µM)	TURB (NTU)	SALINITY (ppt)	CHL. a (µg/L)	OXYGEN (% sat.)	TEMP (deg C)	pH
KB-1- 1	1	0.36	4.76	0.37	49.53	0.17	4.90	0.56	19.06	0.10	32.996	0.041	96.2	26.4	8.22
23	5	0.36	4.42	0.26	43.25	0.13	4.52	0.51	9.22	0.07	33.1779	0.086	96.2	26.1	8.21
23	5	0.21	1.27	0.12	10.42	0.17	4.96	0.36	6.34	0.06	34.3644	0.041	97.3	25.8	8.22
23	50	0.66	10.66	0.41	113.96	0.11	5.27	0.79	16.36	0.10	30.8825	0.078	98.8	25.7	8.25
23	50	0.30	0.53	0.19	4.17	0.06	5.53	0.36	7.23	0.06	34.5461	0.088	96.0	25.6	8.24
43	250	0.34	7.56	0.23	81.36	0.14	4.96	0.58	12.79	0.10	31.8752	0.062	91.4	25.5	8.25
43	250	0.19	0.39	0.07	0.54	0.17	7.06	0.39	7.52	0.06	34.5561	0.061	92.5	25.3	8.27
53	500	0.20	0.75	0.12	8.47	0.17	5.16	0.37	7.03	0.07	34.4301	0.062	97.9	25.4	8.24
53	500	0.14	0.12	0.09	2.22	0.19	5.14	0.33	5.86	0.06	34.6182	0.072	94.0	25.4	8.27
63	1000	0.23	1.71	0.07	18.24	0.17	4.97	0.40	6.75	0.06	34.0785	0.085	99.3	25.4	8.25
63	1000	0.14	0.25	0.00	2.61	0.19	4.72	0.33	4.87	0.07	34.6013	0.042	99.1	25.4	8.27
KB-2- 1	1	0.24	1.10	0.21	19.22	0.16	4.76	0.49	6.07	0.06	34.0147	0.139	91.0	26.8	8.24
23	5	0.40	4.61	0.41	47.86	0.17	5.50	0.57	11.42	0.12	33.1613	0.236	96.0	26.9	8.21
23	5	0.17	0.76	0.14	5.06	0.19	5.06	0.36	6.01	0.09	34.3644	0.065	99.6	27.1	8.24
23	50	0.27	2.17	0.38	23.12	0.17	5.43	0.44	7.98	0.06	33.9709	0.149	96.3	27.0	8.23
23	50	0.16	0.53	0.12	6.82	0.18	4.98	0.34	3.35	0.06	34.4867	0.075	97.9	26.8	8.24
43	250	0.23	1.52	0.19	16.54	0.19	4.98	0.41	6.21	0.10	34.0864	0.130	96.6	27.4	8.24
43	250	0.14	0.46	0.10	6.12	0.19	3.82	0.33	4.57	0.06	34.4848	0.078	96.6	27.1	8.25
53	500	0.16	0.86	0.10	6.47	0.22	7.38	0.38	6.86	0.06	34.3786	0.123	96.0	27.3	8.25
53	500	0.13	0.17	0.09	3.19	0.23	5.26	0.36	6.43	0.06	34.5787	0.085	96.9	26.8	8.27
63	1000	0.14	0.34	0.07	4.56	0.22	5.02	0.36	6.43	0.06	34.5188	0.089	97.5	27.3	8.26
63	1000	0.19	0.20	0.10	2.61	0.22	5.49	0.41	6.70	0.06	34.5888	0.082	90.0	27.1	8.27
KB-3- 1	1	0.28	1.78	0.28	22.73	0.23	5.36	0.52	8.40	0.14	33.9142	0.308	94.0	26.9	8.24
23	5	0.37	1.54	0.23	21.08	0.41	13.46	0.78	15.36	0.30	33.8431	1.963	97.7	26.9	8.21
23	5	0.19	0.80	0.18	12.86	0.25	7.30	0.44	8.76	0.11	34.3308	0.171	98.2	26.4	8.25
23	50	0.30	1.83	0.14	26.84	0.25	5.07	0.56	11.14	0.19	33.6008	1.025	98.6	26.2	8.24
43	250	0.13	0.42	0.06	5.54	0.25	5.57	0.36	6.34	0.10	34.4603	0.119	90.0	26.5	8.26
43	250	0.16	0.45	0.14	5.83	0.22	5.03	0.38	6.82	0.08	34.4702	0.386	90.0	26.1	8.27
53	500	0.12	0.17	0.07	2.81	0.22	5.55	0.34	5.79	0.07	34.5775	0.088	89.9	26.4	8.26
53	500	0.20	0.36	0.12	4.56	0.18	5.27	0.38	6.75	0.06	34.5047	0.213	94.5	26.6	8.26
63	1000	0.14	0.14	0.07	1.63	0.20	5.31	0.34	5.52	0.07	34.6111	0.033	90.3	26.1	8.28
63	1000	0.14	0.14	0.00	1.43	0.20	5.36	0.34	5.52	0.07	34.6254	0.075	87.0	27.5	8.28
WELL		0.17	0.08	0.00	1.24	0.17	5.43	0.34	8.82	0.07	34.6331	0.078	89.6	27.7	8.29
		4.04	87.21	0.14	750.01	0.00	0.18	4.04	87.54		0.2140				
DOH WATER QUAL. STDS. NOT TO EXCEED 10%			1.00	0.61				1.29	17.95	1.25		0.90			
NOT TO EXCEED 2%			1.78	1.07				1.93	25.00	2.00		1.75			

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Strickland J. D. H. and T. R. Parsons. 1968. A practical handbook of sea-water analysis. Fisheries Research Bd. of Canada, Bull. 167. 311 p.

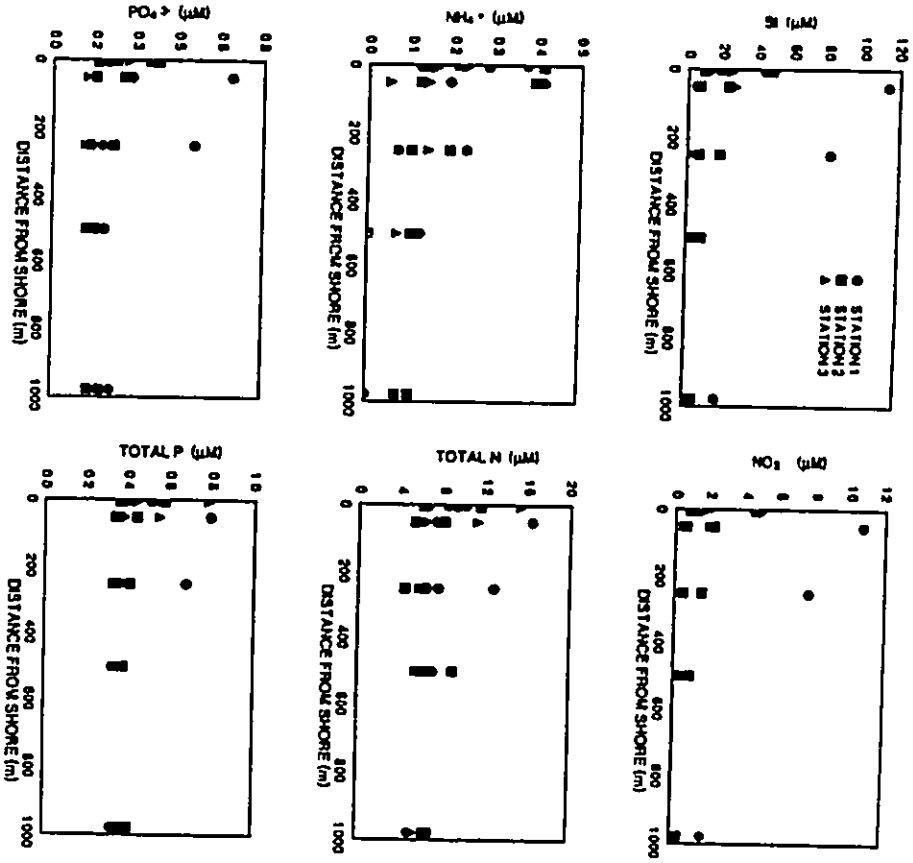

FIGURE 2. Plots of six dissolved nutrient parameters at each station as functions of distance from the back shoreline of Kealakekua Bay. For station locations, see Figure 1.

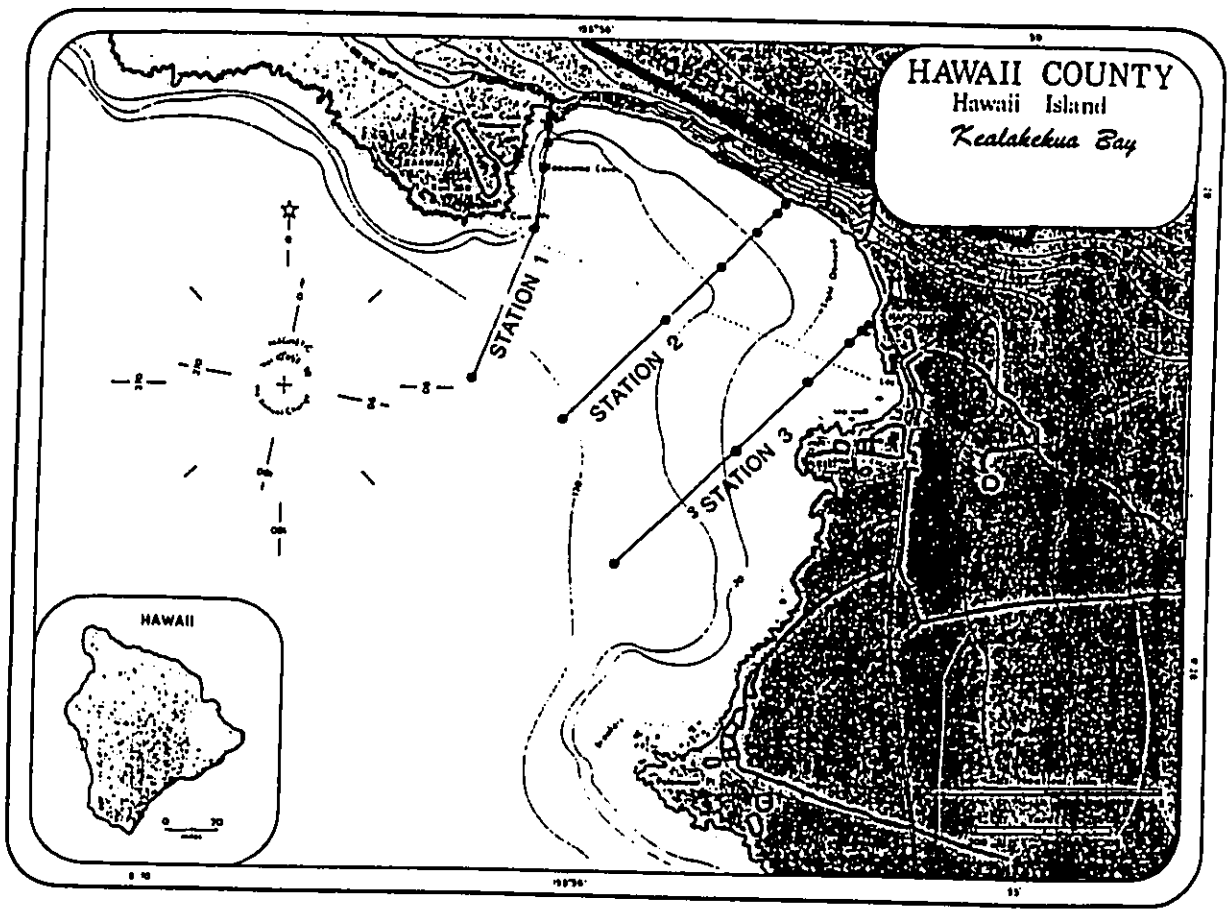

FIGURE 1. Map showing locations of water chemistry survey stations and sampling locations in Kealakekua Bay. Also shown is seaward property boundary for the planned Kealakekua Bay Club.

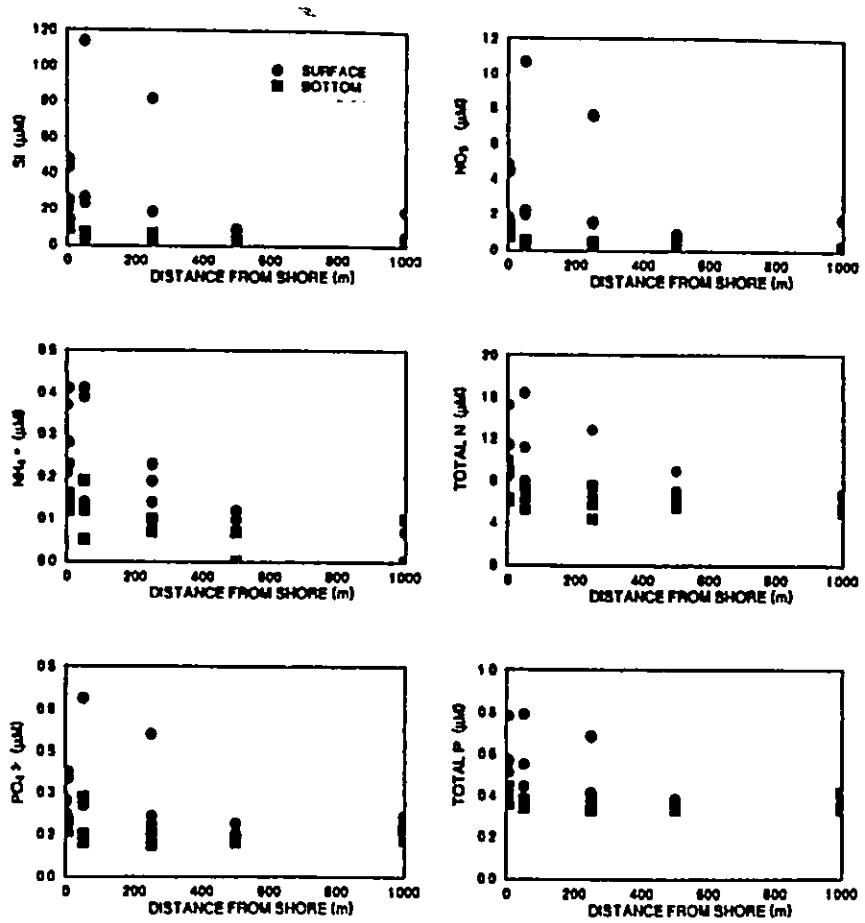

FIGURE 4 Plots of six dissolved nutrient parameters from surface and bottom samples as functions of distance from the back shoreline of Kealakekua Bay. For station locations, see Figure 1.

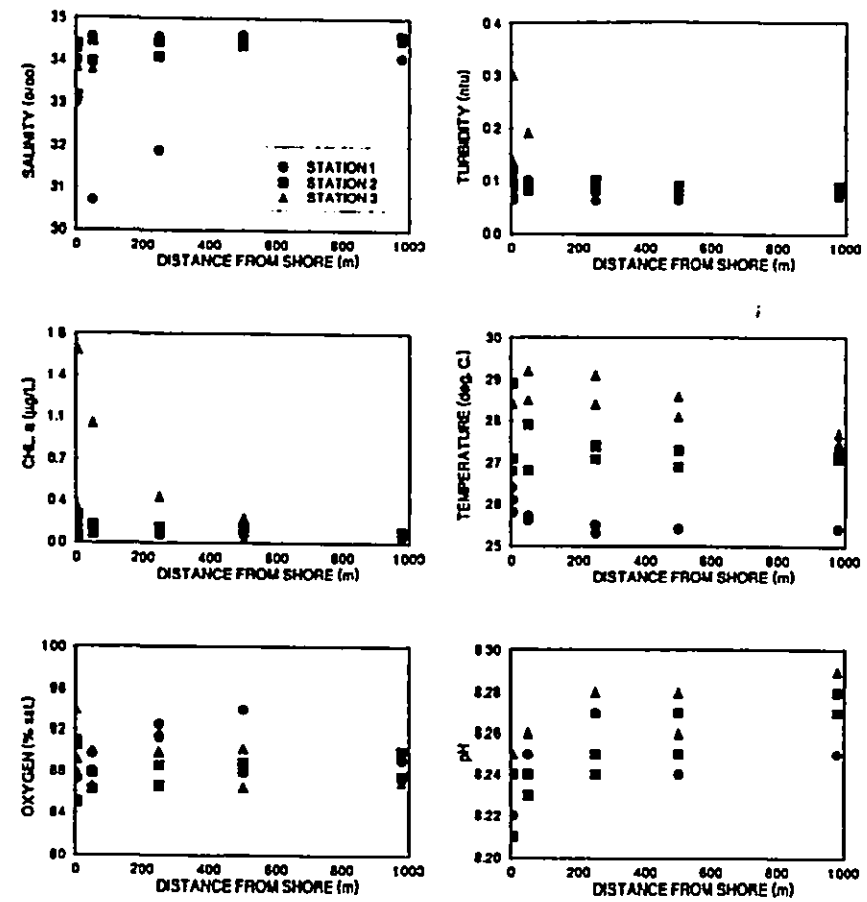

FIGURE 3. Plots of six water chemistry parameters at each station as functions of distance from the back shoreline of Kealakekua Bay. For station locations, see Figure 1.

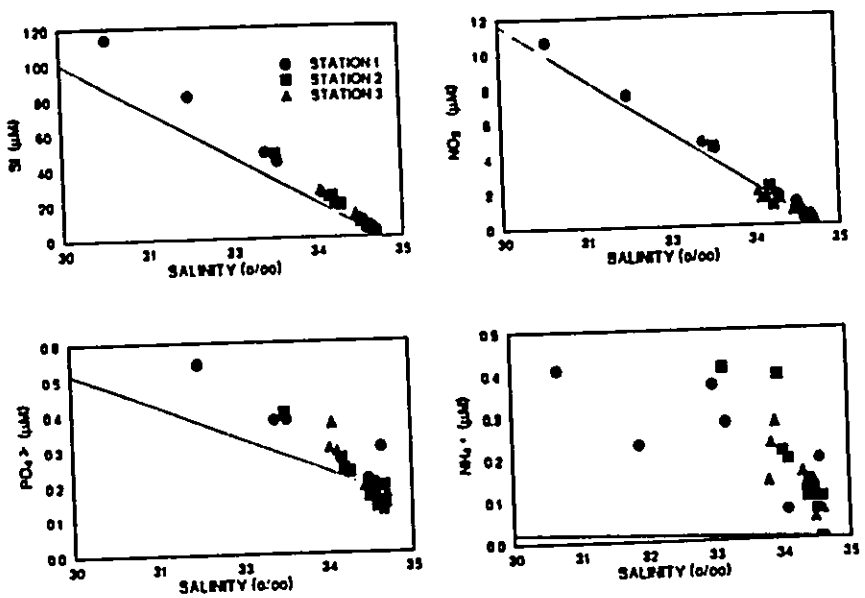

FIGURE 6 Plots of 4 dissolved nutrient parameters from Kealakekua Bay water samples as functions of salinity Straight line in each plot is conservative mixing line constructed by connecting concentrations in open ocean water and groundwater from potable wells. For station locations, see Figure 1

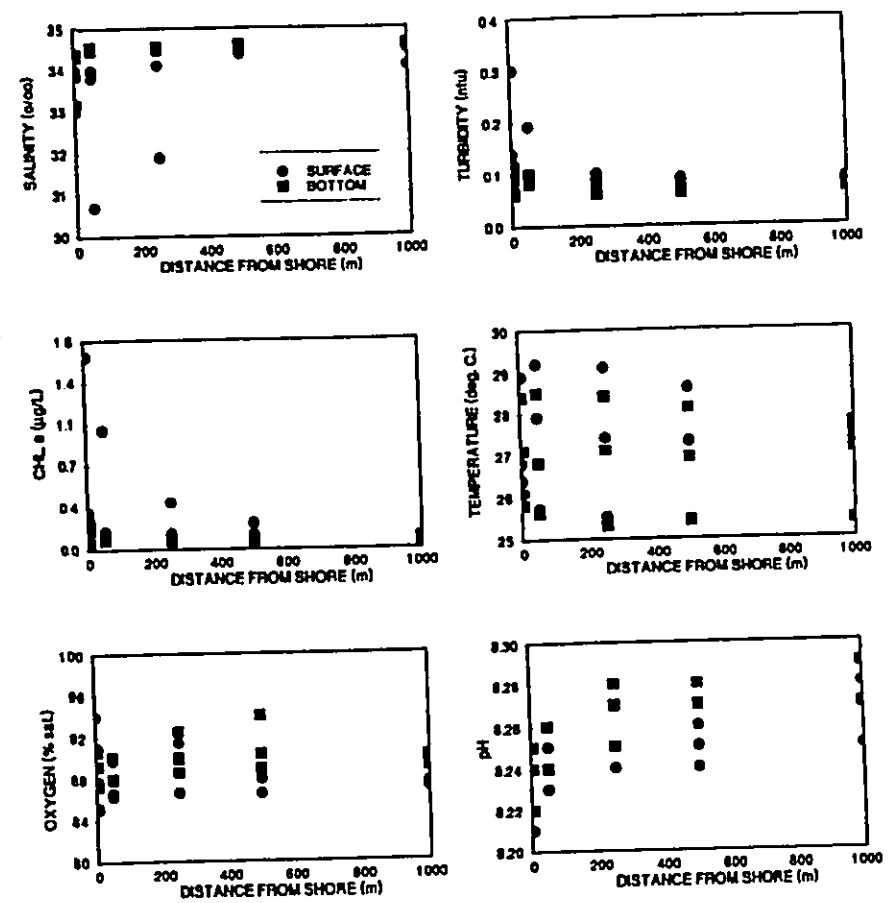

FIGURE 5. Plots of six water chemistry parameters from surface and bottom samples as functions of distance from the back shoreline of Kealakekua Bay. For station locations, see Figure 1.

Appendix 12:

MARINE ENVIRONMENTAL MONITERING PROGRAM, REPORT 2-90

MARINE ENVIRONMENTAL MONITORING PROGRAM,

KEALAKEKUA BAY, SOUTH KONA, HAWAII

REPORT 2-90

Prepared for

Royal Coast Development Corporation
P.O. Box 44394
Kawaihae, HI 96743

by

Marine Research Consultants
217 Prospect St. F-2
Honolulu, HI 96813

December 1, 1990

PURPOSE

The proposed Kealakekua Bay Club includes construction of an 18-hole golf course, clubhouse, restaurant, low profile 36-room members's lodge and five 2-acre house lots on a 262-acre parcel of land. The project site, situated in Kealakekua, South Kona, below the town of Captain Cook, lies immediately above the steep cliff known as Pali-Kapu-o-Keoua and overlooks Kealakekua Bay.

A primary concern in the planning of the development is protection and preservation of the existing environmental quality of the area. The marine environment of Kealakekua Bay has been assessed in a preliminary baseline survey (Marine Research Consultants 1989), in order to identify and mitigate at an early stage any potential problems that may be associated with development activities. Because of the concern for maintaining the present level of environmental quality in Kealakekua Bay, and as a means of ensuring that proper procedures are set forth, it has been deemed appropriate to institute a marine monitoring program. The purpose of the monitoring program is to initially conduct a time-course evaluation of water quality and biological community structure before any construction activities take place in order to establish an "envelope" of naturally occurring variability in environmental parameters. With knowledge of the presently occurring variability, monitoring during and after construction can serve the purpose of identifying and mitigating any potential environmental problems caused by the development activities on shore. The program is also designed to meet all requirements for permit approval by government agencies, including County, State, and the U.S. Army Corps of Engineers. This report constitutes the second increment in the monitoring program, and contains data from water chemistry sampling conducted in October of 1990. The sampling was conducted prior to any construction activities and serves as the first phase of establishing the preconstruction baseline.

METHODS

Three sites in Kealakekua Bay downslope from the proposed Kealakekua Bay Club parcel were selected as sampling stations for the monitoring program. Station 1 lies closest to the northern corner of the Bay in the area of the Captain Cook monument; Station 2 lies at the approximate center of the Bay; Site 3 lies along the southern border of the Bay near Napoopoo (see Figure 1). Water quality was evaluated at each station on transects that extended from the shoreline to the outer limits of the Bay, approximately 1000 meters (m) offshore. All transects were oriented perpendicular to the back shoreline of the Bay, and were thus somewhat parallel to the sides of the Bay. Water samples were collected at 6 locations along each transect. Such a sampling scheme was designed to span the greatest range of salinity with respect to freshwater efflux at the shoreline. Sampling was more concentrated in the nearshore zone because this area is most likely to show the effects of shoreline modification. With the exception of the stations located 1 m from the shoreline, samples were collected at two depths: a surface sample was collected within approximately 10 centimeters (cm) of the sea surface, and a bottom sample was collected within 1 m of the sea floor.

Water quality parameters evaluated included the 10 specific criteria designated for open coastal waters in Chapter 11-54, Section 06 (Open Coastal waters) of the State of Hawaii, Department of Health (DOH) Water Quality Standards. These criteria include: total nitrogen (TN), nitrate + nitrite nitrogen (NO_3^- + NO_2^-), ammonium (NH_4^+), total phosphorus (TP), chlorophyll a (Chl a), turbidity, dissolved oxygen, temperature, pH and salinity. In addition, orthophosphate phosphorus (PO_4^{-3}) and silica (Si) were also reported because these parameters are sensitive indicators of biological activity and the degree of groundwater mixing.

All fieldwork was conducted on October 19, 1990, working from a 17-foot boat. Water samples were collected by opening 1-liter polyethylene bottles at the desired depth. Subsamples for nutrient analyses were immediately placed in 125-milliliter (ml) acid-washed, triple rinsed, polyethylene bottles and stored on ice until returned to Honolulu. Analyses for NH_4^+, PO_4^{3-}, and NO_3^- + NO_2^- were performed using manual spectrophometric techniques on a Brinkman fiber-optic colorimeter. Total nitrogen (TN) and total phosphorus (TP) were analyzed in a similar fashion following digestion. Dissolved organic nitrogen (DON) and dissolved organic phosphorus (DOP) were calculated as the difference between TN and dissolved inorganic N, and TP and dissolved inorganic P, respectively. The chemistry procedures were performed according to standard methods for seawater analysis (Strickland and Parsons 1968, Grasshoff 1983).

Water for other analyses was subsampled from 1-liter polyethylene bottles and kept chilled until analysis. Turbidity was determined on 60-ml subsamples fixed with HgCl to terminate biological activity. Fixed samples were kept refrigerated until turbidity was measured on a Monitek Model 21 nephelometer, and reported in nephelometric turbidity units (NTU). Chl. a was measured by filtering 300 ml of water through glass fiber filters; pigments on filters were extracted in 90% acetone in the dark at -5° C for 12-24 hours, and the fluorescence before and after acidification of the extract was measured with a Turner Designs fluorometer. Salinity was determined using an AGE Model 2100 laboratory salinometer with a readability of 0.0001 °/oo.

In-situ field measurements included dissolved oxygen and water temperature (YSI Model 58 meter with a readability of 0.01 milligrams per liter (mg/l) and 0.1° C., respectively). pH was determined in the field with a Cole-Parmer Digisense millivolt meter with a readability of 0.001 pH units.

RESULTS

Horizontal and Vertical Stratification

Table 1 shows results of all marine water chemistry analyses for samples collected on October 19, 1990. Concentrations of twelve chemical constituents as functions of distance from the shoreline are plotted for each station in Figures 2 and 3. As in the initial sampling conducted in June of 1990, it can be seen that moving offshore from the back shoreline of the Bay to a distance of approximately 500 m offshore, dissolved nutrient concentrations exhibit a decreasing trend (Figure 2). Salinity shows the opposite trend, with increasing values with increasing distance from the shoreline (Figure 3).

These patterns are a result of mixing of low salinity groundwater with oceanic water. Low salinity groundwater, which contains high concentrations of Si, NO_3^-, and PO_4^{3-} (see values for well water in Table 1), percolates to the ocean near the shoreline, resulting in a mixing zone within inner Kealakekua Bay. The apparent highest input of groundwater occurs at Station 1 in the northern corner of the Bay, as was the case in the June sampling. Comparison of the pattern of groundwater efflux measured in the present monitoring survey with data collected in the June survey reveal similar inputs. As in the June survey, samples in October located within 250 m from the back wall of the bay in the vicinity of the Cook Monument, exhibited substantially higher freshwater input that at the sites located further from shore. The magnitude of nutrient concentrations between the two surveys is also similar. For instance, the peak NO_3^- concentration in June in the surface sample 50 m from shore at Station 1 was 10.68 µM in June compared to 9.00 µM in October, relative to December.

One difference between the June and October surveys is the relatively higher input of groundwater and associated nutrients at Station 3. In June, Stations 2 and 3 were essentially identical (substantially lower than Station 1) with respect to groundwater input. In October, there is a distinct groundwater signal evident in surface samples within 500 m of the shoreline at Station 3, which is not apparent at Station 2 (see Figures 2 and 3). Such results suggest that there is some natural variability in the input and mixing characteristics of groundwater efflux in Kealakekua Bay.

Water chemistry parameters that are not associated with groundwater input (total N, total P, DON, DOP) do not show the same strong pattern with respect to distance from the back Bay. NH_4^+ concentrations are somewhat randomly scattered with no apparent relationship to distance from shore. As in June, Chl. a and turbidity exhibited slight elevations at Station 3 in October. These constituents are consistently low in value at the Station 1 sites where groundwater input is evident. Temperature values are coolest at Station 1, where groundwater input is highest, but show little pattern at other locations. Oxygen concentration shows little pattern with respect to Station or distance from the shoreline. pH tends to increase at all stations with distance from the shoreline.

Figures 2 and 3 also show concentrations of water chemistry parameters as functions of distance from the back of the Bay with respect to vertical stratification. It can be seen in Figure 2 that all of the samples which exhibit high concentrations of groundwater nutrients (Si, N, and P) occur at the surface, while corresponding salinities are low (Figure 3). Mixing of low salinity groundwater with oceanic water creates a distinct low-density surface lens which is evident to distances of at least 250 m from shore. The slightly higher values of turbidity at Station 3 also occur in the surface layer. Except at the sampling sites 1 m from shore, concentrations of Chl a are consistently higher in the surface relative to deep samples throughout the bay. Temperature, on the other hand, does not display a distinct surface layer thermal structure throughout the bay.

Conservative Mixing Analysis

A useful treatment of water chemistry data for interpreting the extent of material input from land is application of a hydrographic mixing model. In the simplest form, such a model consists of plotting the concentration of a dissolved chemical species as a function of salinity. Comparison of the curves produced by such plots with conservative mixing lines provides an indication of the origin and fate of the material in question. Figure 6 shows plots of concentrations of four chemical parameters (Si, NO_3^-, PO_4^{3-}, NH_4^+) as functions of salinity. Each graph also shows conservative mixing lines that are constructed by connecting the endpoint concentrations of open ocean water and groundwater from the potable wells located upslope of Kealakekua Bay.

If the parameter in question displays purely conservative behavior (no input or removal from any process other than physical mixing), data points should fall on, or near, the conservative mixing line. If, however, external material is added to the system through processes such as leaching of fertilizer nutrients to groundwater, data points will fall above the mixing line. If material is being removed from the system by processes such as biological uptake, data points will fall below the mixing line.

Dissolved Si represents a check on the model as this material is present in high concentration in groundwater, but is not a major component of fertilizer, and is not utilized rapidly within the nearshore environment by biological processes. It can be seen in Figure 4 that when Si concentrations are plotted versus salinity, data points fall in a straight line indicating groundwater is mixing with seawater in a conservative fashion. The line created by the data points falls very close to the conservative mixing line, suggesting that the groundwater entering Kealakekua Bay is similar in composition to the well water used to construct the line. While the agreement of the measured mixing line with the theoretical conservative mixing line is not perfect, the relationship can still be used to provide a valid representation of the system under investigation.

The plots of NO_3^- versus salinity (Figure 4) shows a pattern similar to dissolved Si. Most NO_3^- data points falling very close to, or below the conservative mixing line. As NO_3^- is the form of nitrogen most common in fertilizer mixes, and is the most mobile form of nitrogen, the agreement of the theoretical mixing line and the data line is evidence that presently there does not appear to be a considerable external input of NO_3^- to the ocean from activities on land. The occurrence of most of the data points below the conservative mixing line indicates that there may be uptake, especially at Station 3, by phytoplankton populations that may persist in this region of the bay owing to increased residence time.

The other form of dissolved inorganic nitrogen, NH_4^+, shows a scattered pattern of distribution with respect to salinity (Figure 4). In both the June and October samplings, some of the higher salinity samples had the highest NH_4^+ concentrations, suggesting that this form of nitrogen is not present in the marine environment as a result of mixing from groundwater sources. Typical groundwater also contains less NH_4^+ than nearshore oceanic waters. Inspection of the data in Table 1 indicates that groundwater from the Kealakekua area has less NH_4^+ than some of the offshore samples. Rather, the

plot of NH_4^+ versus salinity suggests that this material is generated by biological activity in the Bay waters.

PO_4^{3-} is also a major component of fertilizer but is usually not found to leach to groundwater to the extent of nitrate nitrogen, owing to a high absorptive affinity of phosphorus in soils. It can be seen in Figure 4 that most of the PO_4^{3-} data points at below oceanic salinities fall on, or below, the conservative mixing line, indicating no substantial PO_4^{3-} subsidy from land. In June, many of the data points for the Kealakekua Bay PO_4^{3-} samples fell above the mixing line, suggesting an external source from groundwater leaching. The lack of recurrence of the pattern observed in June in the latest monitoring survey suggests that the apparent subsidy was either an isolated or episodic event.

Compliance with DOH Criteria

Also shown in Table 1 are samples that exceed DOH water quality standards for embayments under "wet" conditions. The criteria for wet conditions are applied to Kealakekua Bay as this area receives at least 3 million gallons of groundwater input per mile per day (T. Nance, personal communication). Comparing water chemistry results from the Kealakekua Bay samples to DOH standards reveals nine measurements of NO_3^- that exceed the 10% and 2% standards.

Table 2 shows geometric means of samples collected at the same locations in the June and October monitoring surveys. Also shown in Table 2 are the samples that exceed the DOH geometric mean limits. Fourteen samples of NO_3^-, and one sample of TN exceed the geometric mean limit.

It can be seen by the match of the data points and the conservative mixing line in Figure 4 that there do not appear to be any extraneous NO_3^- subsidies from activities on land. Yet many of the nearshore samples collected in Kealakekua Bay had concentrations exceeding 1.43 µM (the DOH "not to exceed more than 10% of the time" criterion) solely from mixing with naturally occurring groundwater. Groundwater input into the ocean causes waters in the inner bay to exceed DOH water quality standards with respect to NO_3^-. However, even with the subsidy of PO_4^{3-} from groundwater, none of the observed concentrations of TP exceeded the DOH criterion. These results suggest that the methods employed in this survey are sensitive enough to depict environmental changes at levels below those capable of producing negative alterations to community structure and function. Such methods optimize the utility of monitoring by providing the information necessary to instigate mitigative measures in a preventative manner.

SUMMARY

1. The second phase of the Kealakekua Bay water chemistry monitoring program was conducted on October 19, 1990. Thirty-three ocean samples from three stations spanning the length of the Bay, and directly downslope from the planned Kealakekua Bay Club Golf Course, were analyzed for 14 chemical criteria specified by DOH water quality standards.

2 Overall, water quality of Keelakekua Bay can be considered pristine, and generally unimpacted from the activities on land. A dominant feature of water chemistry is the mixing of groundwater that effluxes from the basaltic shoreline, with oceanic water in the inner bay. This mixing results in a low salinity surface layer with high concentrations of nutrients (Si, N, and P) that are normal components of groundwater. From the results of this monitoring survey, groundwater input appears to be greatest at the northern end of the bay, and lowest at the central region. Beyond a distance of approximately 500 m from the back shoreline of the Bay, water chemistry reflects oceanic conditions with little indication of groundwater characteristics. In general, patterns associated with distribution of water chemistry constituents were similar between the two monitoring surveys. These patterns were in contrast to results obtained in a December 1989 baseline survey, which showed very little input of groundwater at the shoreline.

3. Water chemistry parameters not directly associated with groundwater input exhibit various trends. Chl a was elevated in most surface samples relative to deep samples. Turbidity exhibited increases at nearshore samples off Napoopoo, but was consistently low at the sampling site in the northern Bay where groundwater input was most evident. Temperature shows a cooling trend in samples with a substantial groundwater component in the northern bay.

4 Application of a hydrographic mixing model to the water chemistry data is used to verify that the cause of increased nutrient concentrations in the inner Bay is mixing of groundwater with oceanic water. The general agreement of the line created by the data points and a theoretical mixing line suggest that groundwater reaching the Bay is not substantially different in character than potable water collected at Napoopoo. The model indicates that there is presently no substantial input of external sources of nutrient materials, particularly nitrogen, into Keelakekua Bay. The suggestion of a slight increase in phosphorus that was apparent in June was not evident in the latest sampling, suggesting that there is some temporal variability in inputs to the bay.

5. Several of the nearshore measurements of NO_3^- exceed State DOH water quality standards. It is evident, however, that NO_3^- levels are solely a function of natural groundwater input. Under the present conditions of shoreline, natural processes cause some water quality parameters to exceed specified DOH limits.

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Strickland J. D. H. and T. R. Parsons. 1968. A practical handbook of sea-water analysis. Fisheries Research Bd. of Canada, Bull. 167. 311 p.

TABLE 2. Geometric means of water chemistry measurements in Kealakekua Bay collected 6/1/90 and 10/19/90. "S" indicates surface sample; "B" indicates bottom sample; "DFS" = distance from shore. For sampling locations, see Figure 1. Boxed values indicate of DOH geometric mean criteria for embayments.

STATION	NO.	D.F.S. (m)	PO4 (µM)	NO3 (µM)	NH4 (µM)	SI (µM)	DOP (µM)	DON (µM)	TP (µM)	TN (µM)	TURB (ntu)	SALINITY (o/oo)	CHL a (µg/L)	OXYGEN (% sat.)	TEMP. (deg. C)	pH
KB-1-	1	1	0.32	4.49	0.38	43.08	0.14	4.73	0.46	9.61	0.10	33.290	0.04	87.18	27.2	8.22
	2S	5	0.30	5.38	0.11	53.84	0.13	5.17	0.43	10.73	0.10	32.860	0.07	86.83	26.9	8.21
	2B	5	0.18	1.45	0.31	11.89	0.17	5.96	0.35	7.82	0.11	34.401	0.06	89.81	26.8	8.22
	3S	50	0.32	9.00	0.31	106.72	0.13	5.82	0.49	15.27	0.11	31.103	0.07	91.63	26.7	8.25
	3B	50	0.21	0.52	0.09	5.71	0.06	5.81	0.30	6.44	0.08	34.607	0.09	90.22	26.8	8.24
	4S	250	0.23	1.10	0.10	20.86	0.14	4.95	0.41	8.09	0.08	33.276	0.09	92.44	26.7	8.25
	4B	250	0.14	0.31	0.03	4.89	0.16	6.23	0.31	6.57	0.06	34.660	0.07	93.10	26.6	8.27
	5S	500	0.13	0.09	0.03	5.44	0.16	5.34	0.30	5.71	0.07	34.611	0.12	89.63	26.8	8.24
	5B	500	0.12	0.08	0.01	2.43	0.18	5.18	0.30	5.27	0.07	34.719	0.08	94.80	26.8	8.27
	6S	1000	0.15	0.13	0.03	5.47	0.17	4.87	0.33	5.67	0.09	34.463	0.10	90.34	26.7	8.25
	6B	1000	0.11	0.05	0.01	2.07	0.18	4.74	0.29	4.87	0.08	34.724	0.08	92.20	26.6	8.26
KB-2-	1	1	0.18	1.44	0.33	22.58	0.18	4.89	0.37	6.80	0.09	34.003	0.10	93.17	27.3	8.24
	2S	5	0.20	1.88	0.13	27.82	0.15	5.91	0.36	8.41	0.10	33.770	0.14	88.09	28.4	8.21
	2B	5	0.13	0.67	0.11	6.26	0.18	4.98	0.31	5.77	0.08	34.589	0.06	92.58	27.5	8.24
	3S	50	0.20	0.59	0.27	9.25	0.16	5.53	0.37	6.92	0.06	34.321	0.16	90.35	28.0	8.23
	3B	50	0.14	0.38	0.07	4.63	0.15	4.10	0.29	4.56	0.07	34.645	0.10	89.63	27.4	8.24
	4S	250	0.16	0.60	0.11	11.12	0.17	4.32	0.33	5.25	0.08	34.420	0.13	89.94	27.7	8.24
	4B	250	0.09	0.19	0.29	4.89	0.20	5.69	0.30	6.40	0.07	34.645	0.09	89.94	27.5	8.25
	5S	500	0.11	0.21	0.06	4.78	0.21	7.40	0.33	7.88	0.08	34.598	0.15	90.71	27.6	8.25
	5B	500	0.10	0.04	0.02	2.69	0.30	6.09	0.41	6.21	0.07	34.707	0.06	90.09	27.4	8.27
	6S	1000	0.09	0.06	0.05	3.21	0.21	6.75	0.31	7.00	0.09	34.675	0.12	88.99	27.6	8.28
	6B	1000	0.09	0.04	0.18	2.74	0.23	7.02	0.34	7.67	0.07	34.723	0.09	90.70	27.5	8.27
KB-3-	1	1	0.28	2.78	0.11	35.92	0.22	7.03	0.50	10.13	0.12	33.316	0.18	94.85	28.4	8.24
	2S	5	0.23	2.12	0.12	29.70	0.29	9.39	0.51	12.06	0.15	33.680	0.48	89.04	28.5	8.21
	2B	5	0.12	0.25	0.08	7.12	0.21	7.50	0.33	8.02	0.09	34.541	0.18	89.90	28.1	8.25
	3S	50	0.25	2.53	0.11	32.93	0.25	8.15	0.50	10.93	0.15	33.572	0.36	88.82	28.7	8.24
	3B	50	0.09	0.14	0.04	5.12	0.23	6.59	0.33	6.89	0.09	34.637	0.13	91.19	28.3	8.26
	4S	250	0.20	1.52	0.07	16.49	0.21	6.81	0.41	9.24	0.11	33.846	0.30	91.68	28.6	8.27
	4B	250	0.10	0.12	0.05	3.19	0.21	5.96	0.31	6.15	0.08	34.682	0.08	89.70	28.2	8.28
	5S	500	0.13	0.64	0.22	7.98	0.24	7.22	0.38	9.02	0.11	34.488	0.18	88.96	28.3	8.26
	5B	500	0.09	0.14	0.16	2.71	0.21	6.14	0.31	6.48	0.07	34.713	0.05	91.34	28.1	8.28
	6S	1000	0.10	0.04	0.01	1.53	0.20	5.60	0.31	5.68	0.07	34.734	0.06	87.99	27.7	8.28
	6B	1000	0.10	0.03	0.07	1.13	0.19	6.62	0.31	7.29	0.07	34.743	0.06	90.50	27.6	8.29
DOH GEOMETRIC MEANS				0.57	0.43				0.81	14.28	1.5		1.5			

TABLE 1. Water chemistry measurements in Kealakekua Bay collected 10/19/90. "S" indicates surface sample; "B" indicates bottom sample. "DFS" = distance from shore. For sampling locations, see Figure 1. Boxed values indicate exceedance of DOH criteria for wet conditions for embayments.

STATION	NO.	D.F.S. (m)	PO4 (µM)	NO3 (µM)	NH4 (µM)	SI (µM)	DOP (µM)	DON (µM)	TP (µM)	TN (µM)	TURB (ntu)	SALINITY (o/oo)	CHL a (µg/L)	OXYGEN (% sat.)	TEMP. (deg. C)	pH
KB-1-	1	1	0.27	4.21	0.40	38.24	0.11	4.57	0.38	9.18	0.11	33.587	0.044	89.2	28.0	8.23
	2S	5	0.24	6.54	0.04	67.03	0.13	5.91	0.37	12.49	0.13	32.548	0.075	88.5	27.8	8.22
	2B	5	0.15	1.65	0.82	13.57	0.17	7.17	0.32	9.64	0.21	34.438	0.075	92.4	27.8	8.23
	3S	50	0.15	7.59	0.23	99.92	0.16	6.43	0.31	14.25	0.13	31.529	0.068	93.5	27.7	8.26
	3B	50	0.15	0.51	0.04	7.81	0.10	5.17	0.25	5.72	0.08	34.649	0.092	92.5	28.1	8.25
	4S	250	0.10	0.16	0.04	5.35	0.15	4.92	0.25	5.12	0.07	34.733	0.099	93.5	27.9	8.26
	4B	250	0.11	0.24	0.00	4.32	0.16	5.50	0.27	5.74	0.07	34.765	0.092	93.7	27.9	8.28
	5S	500	0.08	0.00	0.00	3.50	0.16	4.63	0.24	4.63	0.07	34.783	0.181	91.4	28.2	8.25
	5B	500	0.11	0.05	0.00	2.67	0.17	4.85	0.28	4.90	0.08	34.820	0.092	95.6	28.2	8.28
	6S	1000	0.10	0.00	0.00	1.84	0.17	4.77	0.27	4.77	0.11	34.853	0.126	91.4	28.1	8.26
	6B	1000	0.08	0.00	0.00	1.84	0.17	4.77	0.25	4.77	0.10	34.848	0.099	95.4	27.9	8.26
KB-2-	1	1	0.14	1.89	0.53	26.52	0.20	5.02	0.34	7.61	0.10	33.992	0.065	95.4	27.9	8.25
	2S	5	0.10	0.78	0.04	16.04	0.13	5.38	0.23	6.20	0.09	34.401	0.089	91.3	27.9	8.22
	2B	5	0.10	0.57	0.08	4.32	0.17	4.88	0.27	5.53	0.07	34.784	0.061	94.6	27.9	8.25
	3S	50	0.15	0.16	0.19	3.70	0.16	5.64	0.31	5.99	0.07	34.674	0.171	94.6	28.1	8.24
	3B	50	0.13	0.27	0.04	3.29	0.12	3.65	0.25	3.96	0.07	34.823	0.123	91.4	28.1	8.25
	4S	250	0.11	0.24	0.06	6.78	0.16	4.14	0.27	4.44	0.06	34.748	0.133	93.4	28.1	8.25
	4B	250	0.06	0.08	0.82	3.91	0.22	6.47	0.28	9.37	0.08	34.806	0.106	91.3	28.0	8.26
	5S	500	0.07	0.05	0.04	2.67	0.21	6.85	0.28	6.94	0.07	34.822	0.181	93.5	28.0	8.26
	5B	500	0.06	0.00	0.06	2.26	0.38	5.93	0.46	5.99	0.07	34.834	0.078	91.3	27.9	8.28
	6S	1000	0.06	0.00	0.04	2.26	0.21	7.57	0.27	7.61	0.10	34.834	0.171	90.5	27.9	8.28
	6B	1000	0.04	0.00	0.32	2.88	0.24	7.70	0.28	8.78	0.07	34.847	0.085	91.4	28.0	8.26
KB-3-	1	1	0.27	4.40	0.04	56.75	0.21	7.78	0.48	12.22	0.10	32.729	0.102	95.7	27.9	8.25
	2S	5	0.14	2.92	0.06	35.16	0.20	6.53	0.34	9.51	0.08	33.515	0.140	90.4	28.1	8.22
	2B	5	0.07	0.08	0.04	3.91	0.18	7.22	0.25	7.34	0.07	34.773	0.192	90.6	27.9	8.26
	3S	50	0.21	3.32	0.08	40.71	0.25	7.33	0.46	10.73	0.12	33.345	0.126	91.1	28.2	8.25
	3B	50	0.06	0.06	0.04	4.73	0.22	7.39	0.28	7.48	0.08	34.784	0.133	92.4	28.1	8.27
	4S	250	0.25	5.16	0.04	45.85	0.20	7.69	0.45	12.89	0.14	33.234	0.224	93.4	28.1	8.28
	4B	250	0.08	0.08	0.04	3.91	0.20	6.41	0.28	6.53	0.09	34.787	0.078	89.5	28.0	8.29
	5S	500	0.08	1.13	0.42	13.98	0.31	8.31	0.39	12.06	0.14	34.471	0.149	91.5	28.0	8.27
	5B	500	0.06	0.14	0.38	4.52	0.22	7.09	0.28	7.61	0.07	34.815	0.062	92.4	28.1	8.29
	6S	1000	0.07	0.00	0.00	1.64	0.21	5.85	0.28	5.85	0.07	34.843	0.075	89.0	28.0	8.29
	6B	1000	0.06	0.00	0.51	1.03	0.22	8.08	0.28	9.64	0.07	34.853	0.044	91.2	27.9	8.29
	WELL		3.81	107.13	0.13	804.51	0.08	3.84	3.89	111.10		0.351				
DOH WATER QUAL. STDS.																
NOT TO EXCEED 10%				1.43	0.93				1.81	25.00	3.00		4.50			
NOT TO EXCEED 2%				2.50	1.43				2.42	35.71	5.00		8.50			

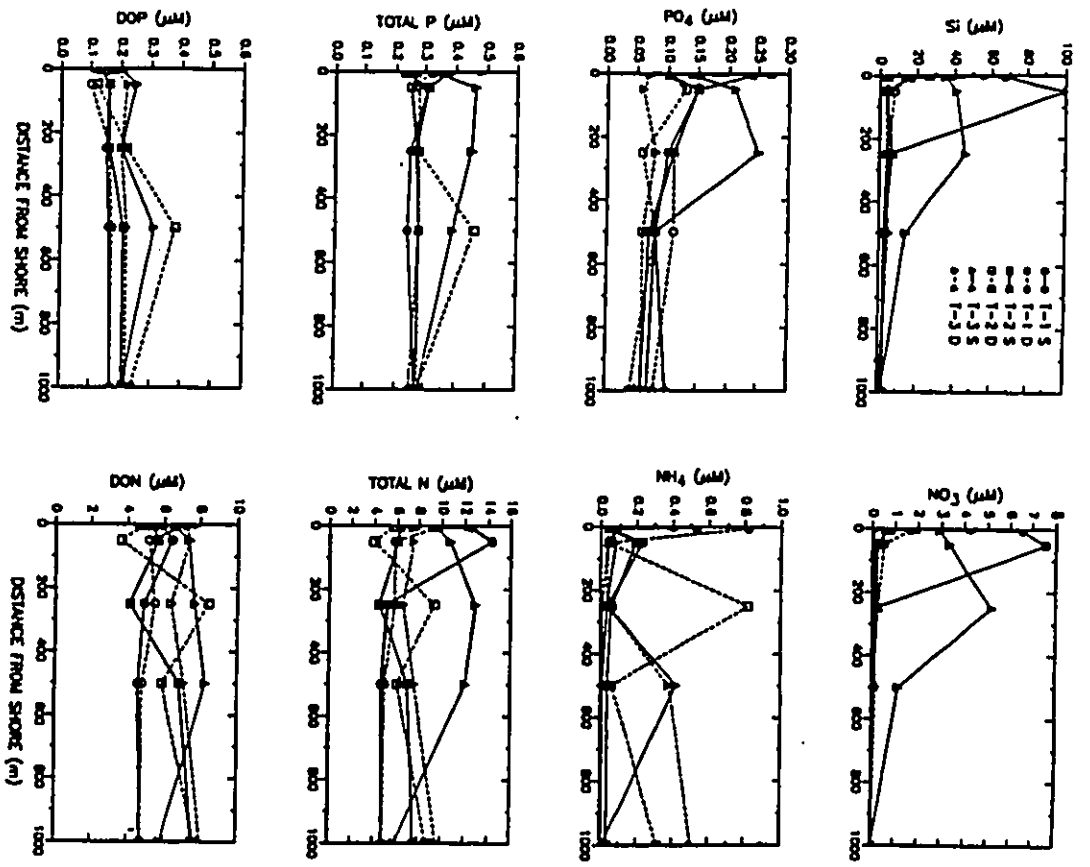

FIGURE 2. Plots of dissolved nutrient constituents at each station as functions of distance from the back shoreline of Kealakekua Bay. "S" indicates surface sample; "D" indicates deep sample. For station locations, see Figure 1.

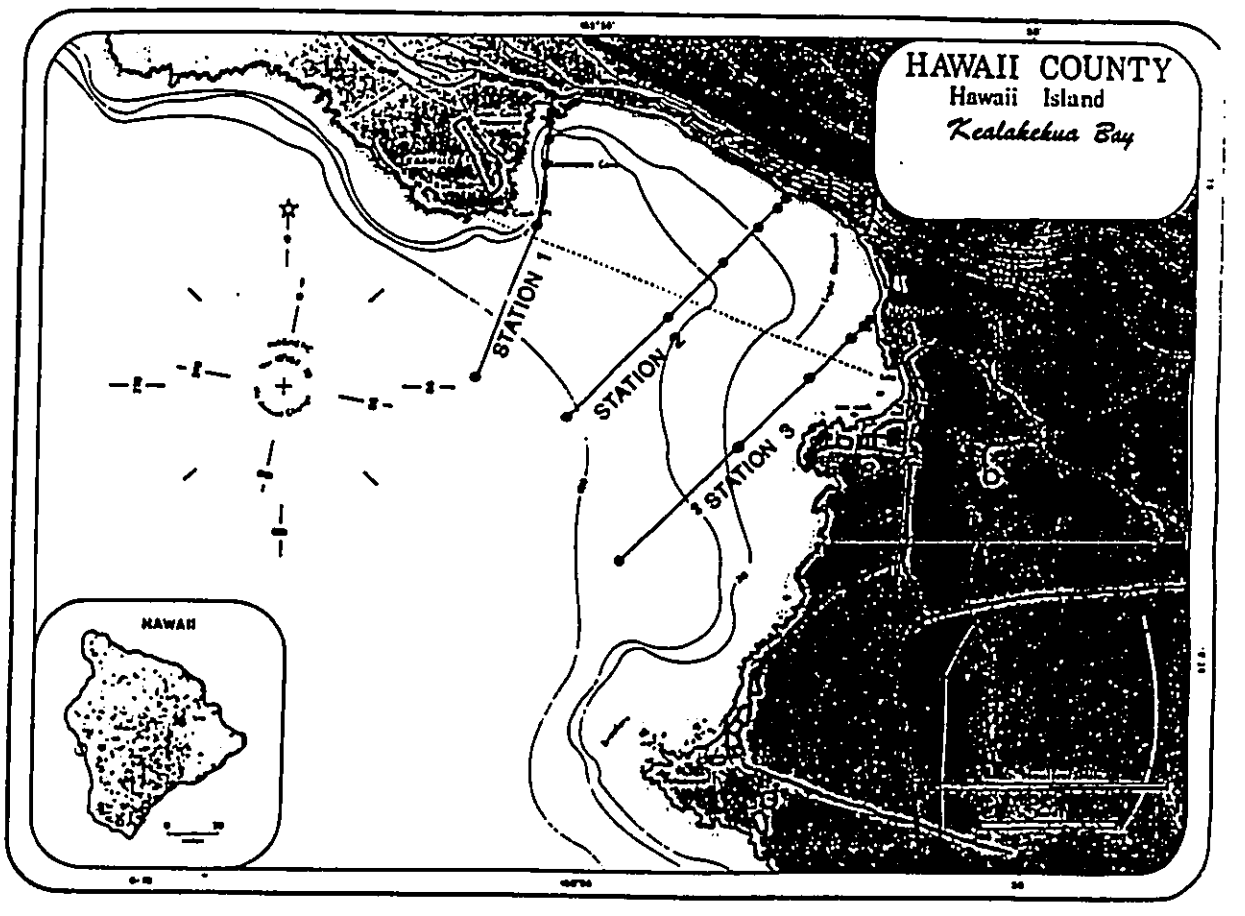

FIGURE 1 Map showing locations of water chemistry survey stations and sampling locations in Kealakekua Bay. Also shown is seaward property boundary for the planned Kealakekua Bay Club

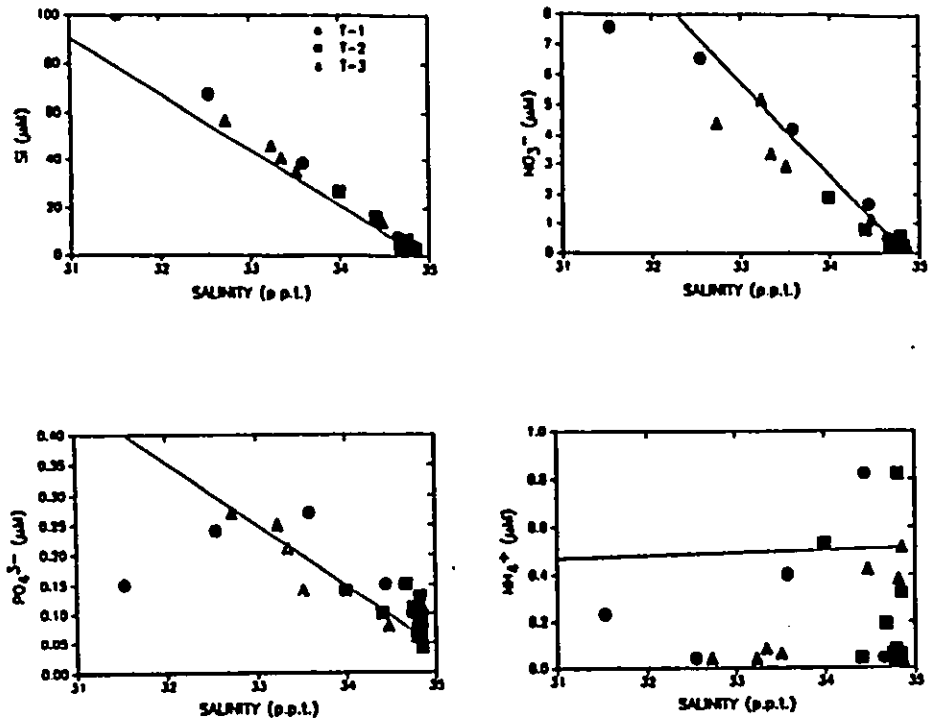

FIGURE 4. Plots of 4 dissolved nutrient parameters from Kealakekua Bay water samples as functions of salinity. Straight line in each plot is conservative mixing line constructed by connecting concentrations in open ocean water and groundwater from potable wells. For station locations, see Figure 1.

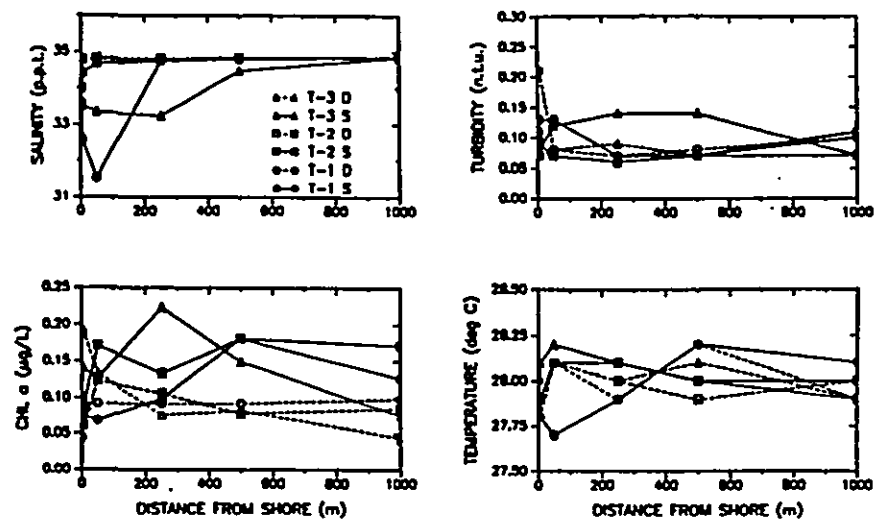

FIGURE 3. Plots of water chemistry constituents at each station as functions of distance from the back shoreline of Kealakekua Bay. "S" indicates surface sample; "D" indicates deep sample. For station locations, see Figure 1.

Appendix 13:

MARINE ENVIRONEMENTAL SURVEY TO ACCESS POTENTIAL IMPACTS FROM THE PROPOSED KEALKEKUA RANCH GOLF DEVELOPMENT, KEALAKEKUA, HAWAII

MARINE ENVIRONMENTAL SURVEY

TO ASSESS POTENTIAL IMPACTS FROM THE

PROPOSED KEALAKEKUA RANCH GOLF DEVELOPMENT,

KEALAKEKUA, HAWAII

Prepared for

Royal Coast Development Corporation
P. O. Box 44394
Kawaihae, HI 96743

by

Marine Research Consultants
1720-A Pauta Dr.
Honolulu, Hawaii 96818

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INTRODUCTION

Purpose

Royal Coast Development Corporation proposes to construct an 18-hole golf course along with associated 2-acre house lots on a 198-acre parcel of land situated in Kealakekua, South Kona, Hawaii County, below the town of Captain Cook. The project site lies immediately above the steep cliff known as Pali Kapu-o-Keoua, overlooking Kealakekua Bay. The mauka boundary is seaward of the lower Government Main road to Napoopoo.

A possible concern regarding construction and operation of the golf course from the local community as well as various regulating agencies is likely to center on the potential for environmental degradation of Kealakekua Bay resulting from the project. Of particular concern is the potential for runoff of soil, fertilizers, and other chemicals which may be used in golf course maintenance to cause alterations to water quality and marine life in Kealakekua Bay. The concerns are likely to be particularly acute owing to the status of Kealakekua Bay as a State of Hawaii Marine Life Conservation District that serves as both a protected sanctuary for marine species, and a prime recreational area for residents and visitors.

In the interest of addressing these concerns and assuring maintenance of environmental quality, it has been deemed appropriate to conduct a baseline marine survey and potential impact analysis. The purpose of the following report is to present the results of an initial baseline survey designed to evaluate the potential effects of construction and subsequent operation of the planned golf course development on the marine environment. The survey includes evaluation of water quality and marine community structure in the nearshore areas of Kealakekua Bay offshore of the planned golf course. Based on these data, as well as review of the existing literature pertaining to the effects of existing golf courses, evaluations are rendered regarding the potential for impacts from the proposed course. The design of the survey is such that the data can also serve as a baseline preliminary phase for any monitoring programs that may be required as a contingency for permit approval by government agencies, including those under the County and State of Hawaii.

Objectives

1) to establish a baseline set of water chemistry parameters that delineate the presently occurring environmental conditions of the nearshore ocean directly downslope of the site planned for golf course development. Chemical composition of the environment will be evaluated by analysis of all parameters specified by State of Hawaii, Department of Health water quality standards (Chapter 11-54 S11-54-06 (3)), as well as several other parameters that are not listed by DOH, but provide important information. This range of parameters includes those that are potentially sensitive to alteration by the effects of golf course construction and operation, particularly sediment and fertilizer input. Particular attention will be given to evaluating the influence of groundwater entering the marine environment downslope of the golf course site. As leaching of irrigation/fertilization materials to groundwater will be the major source of potential impacts from the golf course, characterization of the input of groundwater will be important.

2) to establish a descriptive baseline of biotic communities in Kealakekua Bay in the vicinity of the probable drainage of the proposed golf course. Such a characterization of biotic assemblages will provide a basis of estimating any potential for alteration of community structure as a result of altered drainage patterns.

3) to evaluate the degree of natural stresses (sedimentation, wave scour, freshwater input, etc.) that influence the nearshore marine environment in the area that could be potentially influenced by the proposed project. Typically, the composition of nearshore marine communities is intimately associated with the magnitude and frequency of these stresses, and any impacts caused by the proposed project may either be mitigated in large part, or amplified by natural environmental factors. Therefore, evaluating the range of natural stress is a prerequisite for assessing the potential for additional change to the marine environment owing to shoreline modification.

4) to utilize existing comparative sets of water chemistry parameters that delineate the presently occurring environmental conditions of the nearshore ocean off of existing golf courses in the same vicinity (West Hawaii) as the proposed course. While minor site-specific differences will undoubtedly occur between the environments, comparing water quality data will allow the best possible assessment of potential golf course effects from the proposed course.

5) to offer recommendations on scheduling and construction procedures to minimize impacts, based on the characteristics of the environment determined by the baseline.

ANALYTICAL METHODS

Water Quality

All field work was conducted on November 18-19, 1989, using a 17-foot boat. Figure 1 is a map showing the shoreline and topographical features of Kealakekua Bay, and the location of the proposed development. Survey site locations are identified as transects perpendicular to the shoreline extending across the reef shelf. Survey site 1 is located near the northern boundary of the project site; survey site 2 bisects the area off the southern end of the project.

At each of the survey sites, samples were collected at 6 distances from the shoreline, ranging from the highest wash of waves to approximately 100 meters (m) offshore. At each site, with the exception of the most shoreward, two samples were collected; a surface sample from within 10 centimeters (cm) of the air-sea interface, and a deep sample approximately 1 m from the sea floor. In addition, water samples were collected from a well directly upslope of the proposed project in order to determine the characteristics of groundwater that will reach Kealakekua Bay after traversing the region of the proposed golf course.

Water quality parameters evaluated included the 10 specific criteria designated for open coastal waters in Chapter 11-54, Section 06 (Open Coastal waters) of the Water Quality Standards, Department of Health, State of Hawaii. These criteria include: total nitrogen, nitrate + nitrite nitrogen (NO_3^- + NO_2^-), ammonium (NH_4^+), total phosphorus, chlorophyll a (Chl a), turbidity, dissolved oxygen, temperature, pH and salinity. In addition, orthophosphate phosphorus (PO_4^{-3}) and silica (Si) were also reported because these parameters are sensitive indicators of biological activity and the degree of groundwater mixing, respectively.

Water samples were collected in 1-liter polyethylene bottles. Subsamples for nutrient analyses were filtered in the field through glass-fiber filters into 125-milliliter (ml) acid-washed, triple rinsed, polyethylene bottles and immediately placed on ice. Analysis for NH_4^+, PO_4^{3-}, and NO_3^- + NO_2^- were performed using manual spectrophometric techniques on a fiber optic colorimeter. Total nitrogen and total phosphorus were analyzed in a similar fashion following ultra-violet digestion. Dissolved inorganic nitrogen (DON) and dissolved inorganic phosphorus (DOP) were calculated as

the difference between total dissolved and dissolved inorganic N and P. The chemistry procedures were according to standard methods for seawater analysis (Strickland and Parsons 1968).

Water for other analyses was subsampled from 1-liter polyethylene bottles and kept chilled until analysis. Turbidity was determined on 60-ml subsamples fixed with HgCl to terminate biological activity. Fixed samples were kept refrigerated until turbidity was measured on a Monitek Model 21 nephelometer, and reported in nephelometric turbidity units (NTU). Chl. a was measured by filtering 300 ml of water through glass fiber filters; pigments on filters were extracted and assessed fluorometrically. Salinity was determined using a AGE Model 2100 laboratory salinometer with a readability of 0.0001 °/oo.

In-situ field measurements included dissolved oxygen and water temperature (YSI Model 58 meter with a readability of 0.01 milligrams per liter (mg/l) and 0.1P° C., respectively). pH was determined in the field with a Cole-Parmer Digisense millivolt meter with a readability of 0.001 pH units.

Biological Community Structure

Several methods were employed in the collection of qualitative and quantitative data. Qualitative reconnaissance surveys covering the entire inner width of Kealakekua Bay were conducted by divers towing behind a boat from the shoreline out to the limits of coral reef formation (approximately the 50 foot depth contour). These reconnaissance surveys were useful in making relative comparisons between areas, identifying any unique or unusual biotic resources, and providing a general picture of the physiographic structure and benthic assemblages occurring throughout the region of study.

Following the preliminary survey, 5 quantitative transect sites were selected along the 2 offshore stations sampled for water chemistry. Each transect site was selected to represent the typical zonation pattern of the particular station. Transects were 165 feet (50 m) long, and were oriented parallel to the shoreline so that they bisected a cross-section of a reef zone. Ends of transects were marked by weighted floats. Quantitative benthic surveys were conducted by stretching a surveying tape over the reef surface between the marker floats. An aluminum quadrat frame, with dimensions of 3 feet by 2 feet, was sequentially placed over 10 random marks on the transect tape so that the tape bisected the long axis of the frame. At each quadrat location a color photograph recorded the segment of reef area enclosed by the quadrat frame. In addition, a diver knowledgeable in the taxonomy of resident species visually estimated the percent cover and occurrence of organisms within the quadrat frame. Only macrofaunal species greater than approximately 2 cm were noted; no attempt was made to identify and enumerate cryptic species dwelling within the reef framework. Following the period of field work, quadrat photographs were projected onto a grid and units of bottom cover for each benthic faunal species and bottom type were calculated. The photo-quadrat transect method is a modification of the technique described in Kinzie and Snider (1978), and has been employed in numerous field studies of Hawaiian reef communities (e.g. Dollar 1979, Grigg and Maragos 1974, Grigg 1983).

Quantitative assessment of reef fish community structure was conducted in conjunction with the benthic surveys. As the transect tape was being laid along the bottom, all fishes observed within a band approximately 6 feet wide along the transect path were identified by species name and enumerated. Care was taken to conduct the fish surveys so that the minimum disturbance by divers was created, ensuring the least possible dispersal of fish. Only readily visible individuals were included in the census. No attempt was made to seek out cryptic species or individuals sheltered within coral. This transect method is an adaptation of techniques described in Hobson (1974).

RESULTS

Physical Structure

The shoreline area of Kealakekua Bay downslope of the proposed project is composed of a nearly vertical cliff upwards of 200 feet in height, composed of layered rock of volcanic origins. In some areas the cliff face continues uninterrupted into the water; in the remaining areas, narrow rocky and cobble ledges separate the emergent cliff face from the underwater cliff. At intermittent intervals along the underwater cliff face, small freshwater springs were observed discharging cool, low salinity groundwater into the ocean.

Underwater physiographic structure offshore of the cliffed shoreline is composed of three zones. Nearest to the shoreline is an area characterized by large basaltic boulders that appear to have broken off of the cliff face (0-10 feet in depth). Seaward of the boulder zone is a flat to gently sloping terrace that forms the main area of coral reef growth (10-40 feet in depth). Further seaward, bottom slope steepens and grades into an area completely covered with calcareous sand (greater than 40 feet). This zonation pattern is described in detail in Dollar (1975, 1982).

Water Chemistry

Table 1 shows results of water chemistry analyses at all of the Kealakekua Bay sampling sites shown in Figure 1, as are specified limits of the measured water quality parameters set forth by the Department of Health for coastal waters. Also shown are means and standard deviations of water quality parameters collected weekly (1982-1989) from the surface water intake pipe at the Natural Energy Laboratory of Hawaii at Keahole Point. These data are considered to provide a good indication of the concentration and variability of chemical constituents in pristine open ocean surface waters along the West Hawaii coastline. As such, the long-term NELH data set provides a basis of comparison for water quality measured at Kealakekua Bay.

With respect to salinity, it can be seen by inspection of Table 1 that with one exception (sample 2-1S) values are highly uniform. On transect 1, salinity varied by 0.13 $^{o}/oo$ over the horizontal range of samples from the shoreline to a distance of 100 meters offshore. On transect 2, excluding sample 2-1S which was collected in the flow of a groundwater seep in the shoreline cliff, salinity varied by 0.3 $^{o}/oo$. Comparing these values with the mean salinity of the NELH surface waters (34.60 $\pm$ 0.17 $^{o}/oo$), shows that all of the Kealakekua samples, except 2-1S, fall within the range of pristine open ocean waters. Even at 2-1S, where the sample was intentionally collected from a groundwater spring, salinity was depressed only about 3 $^{o}/oo$ from oceanic values.

There is also no indication of vertical stratification in any of the salinity samples; surface samples do not exhibit a pattern relative to deep samples. Lack of such stratification indicates that there is near total homogeneous mixing of the small volume of groundwater that enters the ocean in Kealakekua Bay, and that there is no effect from groundwater intrusion on salinity beyond 5 meters from the shoreline.

These data indicate that groundwater discharge into the area of Kealakekua Bay downslope from the proposed golf course is relatively small, and does not influence the composition of nearshore waters. In other areas of West Hawaii, particularly in embayments such as Keauhou Bay and Pauoa Bay, groundwater discharge is substantial, and is easily recognized by distinct horizontal and vertical stratification of the nearshore water column (Dollar 1986, Dollar and Smith 1988).

Examination of nutrient concentrations shown in Table 1 reveals a pattern similar to salinity. Concentrations of all parameters are uniformly low, and show no indication of vertical stratification (other than samples 2-1S and 2-2S). Comparing water column nutrient parameters to NELH water quality values shows that in most cases the Kealakekua samples have lower concentrations than either the mean value or the mean minus the standard deviation. The notable exceptions are samples 2-1S and 2-2S, which exhibited elevated values of the nutrients typically found in groundwater, particularly PO_4^{3-}, $NO_3^- + NO_2^-$ and Si.

Turbidity and Chl. a, do not normally occur in high concentrations in groundwater. On the two transects these parameters exhibit relatively uniform patterns, and do not show elevated concentrations in the nearshore samples at Station 2. Likewise, dissolved oxygen, temperature and pH show no pattern with respect to either distance from shore or depth.

When comparing results from Table 1 with Department of Health water quality standards it can be seen that nutrient parameters (TP, TN, NH_4^+, and $NO_3^- + NO_2^-$) are typically well below the DOH standards. With the exception of the sample collected at the cliff seep (2-1S), all individual sample measurements of TN, TP and NH_4^+ are below the geometric mean concentration limits, as well as for the "not to exceed 10% and 2%" limits. $NO_3^- + NO_2^-$ concentration exceeded the geometric mean limit in 2 samples, but not the "not to exceed" limits. Turbidity values are all below the most stringent DOH limits, while several Chl. a values are above the "geometric mean" limits, but not the "not to exceed" limit.

The Department of Health also has established two sampling stations in Kealakekua Bay that are part of a state-wide monitoring system. Stations are located in water depths of 1 and 121 feet. Examination of the DOH data, however, indicates that the variability of the measured concentrations is beyond reasonable limits, probably as a result of either faulty sample collection or analytical techniques. Such variability is especially evident at the deep station (121 feet), which reports water quality measurements that deviate greatly from any known oceanic values. All means of the DOH data sets far exceed State DOH water quality mean limits.

Benthic Community Structure

Table 2 shows the distribution of reef corals on 5 benthic transects in Kealakekua Bay below the planned golf course. Coral community zonation pattern reflects the physical structure of the reef habitats described above (analyzed in detail in Dollar 1975, 1982). Transects at each station at depths of 10 feet bisected the basalt boulder zone. Owing to factors related to the shallow depth (primarily wave surge), living corals are least abundant in the boulder zone, comprising 40% of bottom cover at transect KB-1 and 11% at transect KB-2. While cover is lowest, coral species diversity is highest in the nearshore region, as no single species is able to gain a competitive advantage and monopolize the community. Major species that occur in the boulder zone are Porites lobata, Pocillopora spp. and Pavona varians.

Owing to the protected nature of Kealakekua Bay, the effects of wave stress are primarily limited to the shallow nearshore boulder zone. As a result, the deeper reef terrace provides a stable habitat for coral reef development, in that corals are accreting a calcium carbonate substrate that comprises the physical structure of benthic surface. Living coral cover in this zone is substantially higher than in the shallower areas, ranging from 63% to 68% on the two transects located at the 25-foot depth. Dominant coral structures were large colonies of Porites lobata (up to 10 feet in diameter). P. lobata generally is found to be the most abundant species in Hawaiian coral communities, and occurs in various growth forms in different reef environments.

Beyond the edge of the reef terrace, bottom topography grades into a sloping bottom. Dominant coral cover on the reef slope down to a depth of approximately 60 feet consists of interconnected mats of Porites compressa. This species is capable of growing rapidly in areas that are either sloping, or are composed of nonconsolidated substrata. Coral cover in the P. compressa zone (50 feet) is the highest encountered on the Kealakekua Bay transects (95%). Owing to the domination by a single species, however, diversity is among the lowest of all areas.

Several species of motile invertebrates were observed through the reef zonation pattern. The major taxa of benthic organisms occurring within the survey area were sea urchins (Echinoidea) (see Table 3). The most abundant urchins in the reef terrace zone were the two species that bore into limestone surfaces, Echinometra mathaei and Echinostrephus aciculatus. Several individuals of larger species of urchins, particularly Heterocentrotus mammillatus, but also Tripneustes gratilla, Echinothrix diadema, and were also observed. Several large crown-of-thorns starfish (Acanthaster planci) were observed throughout the area of study.

The entire reef surface not inhabited by coral colonies is covered with a short mixed-species algal turf. Frondose benthic algae are rare in occurrence in all zones of the surveyed reef.

Reef Fish

A rich and diverse fish community, typical of West Hawaii, was found in reef areas off the proposed project. This community has been described in detail by Hobson (1974). The total number of species observed on transects was 65; on a single transect the species number ranged from 28 to 40, while individual fish encountered on transects ranged from 330 to 407 (see Table 5). The most diverse fish community was observed in water greater than 20 feet deep, while the greatest abundance of fishes was found in shallow water along the shoreline.

Several representative groups of reef fish were especially abundant on the Kealakekua transects. Algal-feeding acanthurids were the most numerous single group of fishes observed. The yellow tang (lau'i-pala, Zebrasoma flavescens) and the goldring surgeonfish (kole, Ctenochaetus strigosus) were abundant at all sites. In shallow areas near the shoreline, these species were encountered in great numbers. Whitebar surgeonfish (Acanthurus leucopareius), brown surgeonfish (ma'i'i'i, Acanthurus nigrofuscus), and convict tang (manini, A. triostegus) were also abundant at the shallow water sites.

Planktivorous damselfishes of the genera Chromis and Abudefduf were common. Also quite prominent in the water column were the black durgon (humuhumu-'ele'ele, Melichthys niger) and the pinktail durgon (humuhumu-hi'u-kole, M. vidua). The reef triggerfish (Humuhumu-nukunuku-a-pua'a, Rhinecanthus rectangulus) was common in shallow water. Other common fishes included the manybar goatfish (moano, Parupeneus multifasciatus) and the multiband butterflyfish (kikakapu, Chaetodon multicinctus). The angelfish Centropyge potteri and several wrasses were abundant in areas dominated by coral rubble. The saddleback wrasse (Thalassoma duperrey) was common in all environments.

Juvenile reef fishes were most abundant at the deeper transect sites in areas covered with Porites compressa. The lattice structure formed by this coral provides a sheltered refuge for small fish. Juveniles belonged mostly to the family Acanthuridae (surgeonfishes), with representatives from the families Labridae (wrasses), Mullidae (goatfishes), and Chaetodontidae (butterflyfishes).

Several species of "food fishes" were observed during the survey. These included parrotfishes (Scarus spp.), goatfishes (Parupeneus and Mulloidichthys spp.), jacks (Caranx melampygus),

emperorfish (Mu, Monotaxis grandoculis), surgeonfishes (Acanthurus and Naso spp.) and the introduced grouper (Cephalophilis argus). Many of these fishes were quite tame and not disturbed by the presence of divers. Many of the smaller reef fishes were also quite familiar with divers; their tendency to approach divers suggested that they had been fed by humans in the past.

Overall, the fish community at the Kealakekua Bay site is fairly typical of assemblages found in Hawaiian reef environments. The number of species, total number of individuals, and overall composition indicate a healthy and diverse fish community. The abundance of some food fishes and their tendency not to avoid divers speaks well of the protection offered to fish by the status of Bay as a Marine Life Conservation District. Similarly, the extreme abundance of yellow tangs and the diversity of butterflyfishes suggest that the community is not affected by the commercial collection of aquarium fishes. Obviously, the prohibition of fishing within Kealakekua Bay has resulted in an attractive showcase for Hawaiian fishes.

Threatened or Endangered Species

Three species of marine animals that occur in Hawaiian waters have been declared threatened or endangered by Federal jurisdiction. The threatened green sea turtle (Chelonia mydas) occurs commonly along the shoreline of the major Hawaiian islands and is known to feed on selected species of macroalgae. Resting habitats of green sea turtles are commonly deeper reef areas characterized by undercut ledges and other topographical features. The endangered hawksbill turtle (Eretmochelys imbricata) is found infrequently in waters off Hawaii. Only one small green sea turtle was observed during the course of the present survey, although it is likely that larger populations of turtles frequent the area on occasion.

Populations of the endangered humpback whale (Megaptera novaeangliae) spend the winter months in the Hawaiian Islands, and are especially abundant off the West Coast of Hawaii. The present survey was conducted during the season when whales are not present in Hawaiian waters.

CONCLUSIONS

Golf Course Construction

The main objective of this baseline survey is to estimate the potential for impact to the marine environment from construction and operation of a golf course above Kealakekua Bay. Because the project does not entail any shoreline modification, potential problems could arise only from changes in input to the marine environment from erosion of soils, or chemical subsidies from fertilizers and pest control agents.

The potential for increased sedimentation (soil erosion runoff) is greatest during the period of construction. During the construction process, proper planning to minimize exposed acreage at any one point in time is essential to minimize the potential for increased erosion. Temporary increases to sediment loading in the nearshore environment of Kealakekua Bay could pose the potential for temporary negative impacts, as the area is not a high wave energy regime. As a result, water movement in the receiving environment would not cause rapid dispersal of any particulate material that might enter the Bay as a result from construction.

Reef corals, generally considered to be the "keystone species" on reefs must deal with sediment in the environment under natural conditions. The effects of sediment stress to corals has

been extensively reviewed by Johannes (1975), Dodge and Vaisnys (1977), Bak (1978), Brown and Howard (1985) and Grigg and Dollar (1989). In summary, these reviews indicate that while it is clear that increased sedimentation can have a deleterious effect on corals, especially when buried, sedimentation can also result in no negative impacts. Because sediments are suspended by natural processes in many reef environments, most corals can withstand a certain level of sediment supply to the living surface. Many species have the ability to remove sediment from their tissues by distension of the coenosarc with water, or ciliary action which can nullify lethal effects of sedimentation (Yonge 1931).

In case studies of the effects of sedimentation, the range of environmental effects varies through the entire spectrum of stress. Cases where effects of dredging have caused mortality have been generally limited to areas of confined circulation such as Castle Harbor, Bermuda (Dodge and Vaisnys 1977), and Kaneohe Bay, Hawaii (Banner 1974). In areas of unrestricted circulation, however, there have been instances of increased sedimentation reported that do not appear to cause any substantial effects to reefs. Sheppard (1980) reported that following dredging and blasting for a military harbor in Diego Garcia Lagoon, coral cover appeared to show no effects from increased siltation.

It appears that there is presently no surface runoff from the property proposed for development into Kealakekua Bay. While the literature clearly documents that sediment subsidies do not necessarily result in deleterious impacts to coral reefs, it is stressed that for the present project, all engineering and construction considerations should aim to completely exclude the possibility of adding sediment runoff to Kealakekua Bay. While temporary increases may not result in any substantial or permanent alteration to the biotic communities, water chemistry analyses (as well as observation) indicates that water quality and clarity in Kealakekua Bay is of the highest caliber found anywhere in Hawaii. Inputs of erosional sediment would result in obvious impacts to such water quality which, owing to the high recreational usage of the Bay, would undoubtedly result in negative input to the developers. Preventing sediment input to the marine environment should also insure that the proposed project will have no effects to endangered or protected species.

Golf Course Operation

A recent literature review compiled by the Golf Course Superintendents Association of America (GCSAA)(November 1988) summarizes the impacts of existing golf courses on environmental quality. Overall, the findings indicate that golf courses do not pose a significant pollution threat to the nation's water supplies. With respect to impacts from erosion, golf courses actually help reduce sedimentation pollution by increasing soil stability through thick layers of grass thatch. Carefully managed golf course turf grasses have been found to have 15 times less runoff than does a lower quality lawn. Studies have also shown that grasslands experience 84 to 668 times less erosion than areas planted in wheat or corn (DeBoot and Grabriels 1980). Golf courses can also greatly reduce erosion and runoff effects compared to other land uses, such as roadways, buildings, or parking lots.

The development and operation of the proposed golf course will require application of fertilizers to supply essential nutrients to turfgrasses, and pesticides to control weeds, plant diseases and insect pests. Fertilization may be accomplished either from commercial mixes, or application of treated sewage effluent. Under some conditions, these chemicals may be subject to movement from the site of application, principally by leaching to the groundwater aquifer. As groundwater efflux to the ocean is a characteristic of the entire coast of West Hawaii, consideration of the potential impacts to the marine environment from golf course operation must be considered.

The primary interest of the present report is the potential effect of fertilizer nutrients. Fertilizer nutrients of concern for contamination of groundwater are nitrogen and phosphorus. Phosphorus is attached very tightly to soil colloids and moves little, if any, from the site of application. Because of the mineralogic composition, most of the highly weathered soils in Hawaii, such as those at Kealakekua, can immobilize large amounts of phosphorus. As a result there is little potential for phosphorus to leach to groundwater owing to golf course operation.

Nitrogen is the nutrient of concern for several reasons; its use as a major component of most fertilizers, its essential solubility in the nitrate-nitrite form, and its potential role in the eutrophication of open bodies of water receiving high levels of infiltrate from land. Like phosphorus, ammonium nitrogen (NH_4^+) moves little in soils. NH_4^+, however, is converted to nitrate (NO_3^-) which is not bound tightly to soils, and moves readily with water. Normally, when golf course management matches evapotranspiration with irrigation, NO_3^- will be used rapidly after application in the production of new turfgrass. Under some conditions, however, such as overfertilization and overirrigation, or when excessive rainfall occurs soon after application of a soluble nitrogen source, there is potential for excessive loss by surface runoff or by leaching below the root zone.

Impacts from fertilization of golf courses using treated sewage effluent have been a subject of study as both an effective alternative to ocean sewage disposal and as a means of recycling fresh water. California grass (paragrass) irrigated with effluent from secondarily treated domestic sewage showed excellent results as a means of disposal of large amounts of water, and for effective removal of nitrogen. Under irrigation rates as great as 98 mm/day, the monthly effluent nitrogen content ranged from 17 to 59 mg/l with an average level of 34 mg/l. Of the applied nitrogen, an average of 69% was harvested in the grass, 3% percolated, nearly 28% was denitrified, while the soil nitrogen status remained unchanged or decreased slightly. Even with the highest effluent irrigation rates, nitrate nitrogen levels in the percolate remained less than the 10 mg/l recommended maximum for potable water (Handley and Ekern 1981).

Soil retention studies conducted on a golf course in Hawaii indicated that upwards of 90% of the applied fertilizer N and 100% of P is taken up by the thatch/soil complex (Chang and Young 1977). Data from Brown et al. (1977) and Tavares (1983) showed that for soluble N sources at high rates of application and high irrigation rates, about 10% of the total N applied was leached in the first 2 to 4 days after application, after which the leaching loss dropped to about 2% of the applied N per day for about 2 to 3 weeks. Two to three weeks after application, essentially all of the applied N is used by plants, leached, or lost as gas (denitrified). Murdoch and Green (1989) suggest that relatively porous soil with a minimum depth of 12 inches is necessary to provide adequate water and nutrient storage for healthy turf, and to retard movement of nutrients and pesticides to groundwater. As the Kealakekua site is characterized by natural soil, such criteria should be easily met for the planned golf course.

A survey of the effects of existing golf course irrigation and fertilization on nearshore marine waters off the West Coast of the Island of Hawaii showed that existing courses (Mauna Lani, Waikoloa, Mauna Kea) are not causing alteration in water quality or biological community function and structure. Courses located upslope from open coastlines, such as Kealakekua Bay, showed no measureable effects whatsoever on nutrient concentrations in the nearshore ocean. These results indicated that normal fertilization does not result in any undesirable nutrient enrichment in nearshore waters. An exception, however, appeared in a semi-enclosed inlet (Keauhou Bay) located directly downslope from a 27-hole golf course. Owing to a residence time in the Bay that is substantially longer than in an equivalent area of open coastline, and to the "focusing" of groundwater efflux, increases in dissolved nitrogen measured in Keauhou Bay appear to be attributable to golf course fertilization (Dollar and Smith 1988).

The results of the present survey indicate that the area of Kealakekua Bay directly downslope from the proposed golf course receives only a negligible amount of groundwater input, and that the chemical signal owing to the groundwater is essentially absent within a few meters of the shoreline. Alterations to groundwater characteristics underlying golf courses are not thought to affect groundwater flow rates, but rather to provide dissolved nutrient subsidies to the existing groundwater flow. Because there is presently little effect upon the marine environment from groundwater at Kealakekua, it follows that there is little potential for impacts owing to nutrient subsidies to groundwater from the proposed golf course.

It should be noted, however, that naturally occurring groundwater contains extremely high concentrations of NO_3^- in relation to marine waters. For the present sampling at Kealakekua Bay, it can be seen in Table 1 that groundwater from wells above Kealakekua contain 108 uM, compared to 8 uM in the sample collected in a shoreline spring. As discussed above, many of the nearshore areas of the Island of Hawaii are subjected to high rates of groundwater efflux, and therefore high concentrations of dissolved NO_3^-. As such efflux is a natural phenomenon, it must be assumed that the nearshore communities are adapted to such concentrations, and these areas cannot be considered "polluted". It therefore follows that subsidies of NO_3^- to groundwater, should they occur as a result of golf course operation, do not change the qualitative nature of the groundwater, and do not necessarily represent a potential pollutant to receiving environments. Brock et al. (1987) presents evidence of such nutrient subsidy in anchialine ponds downslope from the Waikoloa golf course; however the increases are within the natural range of fluctuations of nutrient content in the ponds, and native aquatic pond biota are not sensitive to the increased nutrient values.

SUMMARY AND RECOMMENDATIONS

1) The shoreline below the planned Kealakekua Golf Course is composed of a steep volcanic cliff that extends below the waterline. Configuration and orientation of the Bay protects the environment from direct exposure to long period swells from either the north or south, resulting in an extremely protected and stable physical environment ideal for the development of Hawaiian coral reef communities.

2) Water quality measurements (nitrogen, phosphorus, silica, and salinity) taken from the surface and near the bottom on transects extending from the shoreline out to 100 meters from shore show that input from the shoreline (groundwater flow) is minimal along the shoreline, and is mixed rapidly with open ocean water within a narrow zone (less than 5 meters from the shoreline). Beyond this zone, all water chemistry parameters indicate extremely clear, oligotrophic waters typical of the open ocean. By comparison, water chemistry parameters from Kealakekua Bay sampled during this study show less influence from land than samples collected in surface waters off Keahole Pt., near the Natural Energy Lab. of Hawaii.

3) Coral reef communities in the nearshore region of Kealakekua Bay occur in a zonation pattern typical of West Hawaii. Three zones, a nearshore boulder zone, a reef terrace zone, and a slope zone, are populated by corals which comprise from 11% to 95% of the bottom cover. Reef communities are well developed in Kealakekua Bay relative to other coastal areas in Hawaii as a response to infrequent episodes of storm wave stress capable of physical breakage of coral colonies. As such, the reefs in Kealakekua Bay represent "climax communities" of Hawaiian reef corals. Reef fish communities in

Kealakekua Bay are abundant in numbers of species and individuals. The marine environment in Kealakekua Bay is a rich recreational resource that is heavily utilized.

4) Condition of water quality and reef communities indicate that natural sedimentation into Kealakekua Bay is not a prevalent occurrence. All precautions possible should be taken to prevent erosion of soils into Kealakekua Bay during golf course construction. While erosion resulting from construction would not likely have a permanent impact on the marine environment, it would temporarily impact the pristine nature of the area that is utilized for recreational pursuits.

5) Operation of golf courses has the potential to add nutrients (nitrate nitrogen) to coastal waters as a result of leaching of fertilizer chemicals to groundwater. Such processes can be mitigated by ensuring that the golf course soil is porous and on the order of a foot in depth, and that fertilization and irrigation schedules are designed so that application rates do not greatly exceed uptake rates. Downslope from the planned Kealakekua golf course, chemical measurements in Kealakekua Bay indicate that there is negligible influence of groundwater on composition of the water column. If construction of the golf course does not alter the pattern of groundwater flow, there is little chance that materials from the golf course, should they percolate to the groundwater aquifer, would reach Kealakekua Bay. As a result, with proper golf course management, there is little potential for any alteration of water chemistry, and hence biological community structure, from fertilization of the golf course. Even when NO_3^- is subsidized in groundwater as a result of golf course operation, it does not necessarily indicate a "potential pollution" situation as naturally occurring groundwater contains high NO_3^- concentrations.

6) Based on the existing body of scientific literature, constructing golf courses appears to be an excellent land use in terms of minimizing erosion and preventing nutrient percolation to groundwater, compared to either agricultural crops or other land development scenarios. Use of treated sewage effluent for fertilization and irrigation appears to be without potential environmental problems as long as management practices prevent severe overirrigation.

7) Because the planned golf course does not involve any modification of the shoreline, and all indications are that with judicious planning and management there will not be alterations to water quality, there is little potential for any impacts to protected or endangered marine species that might inhabit Kealakekua Bay.

8) While all indications are that the planned golf course will have no impacts to Kealakekua Bay, it is nevertheless recommended that a monitoring program be implemented. Such a monitoring program would be designed to provide a baseline set of conditions before construction, and to compare conditions to the baseline during and after completion of construction. In this manner, unforeseen circumstances that could result in environmental impact could be identified and mitigated at an early stage.

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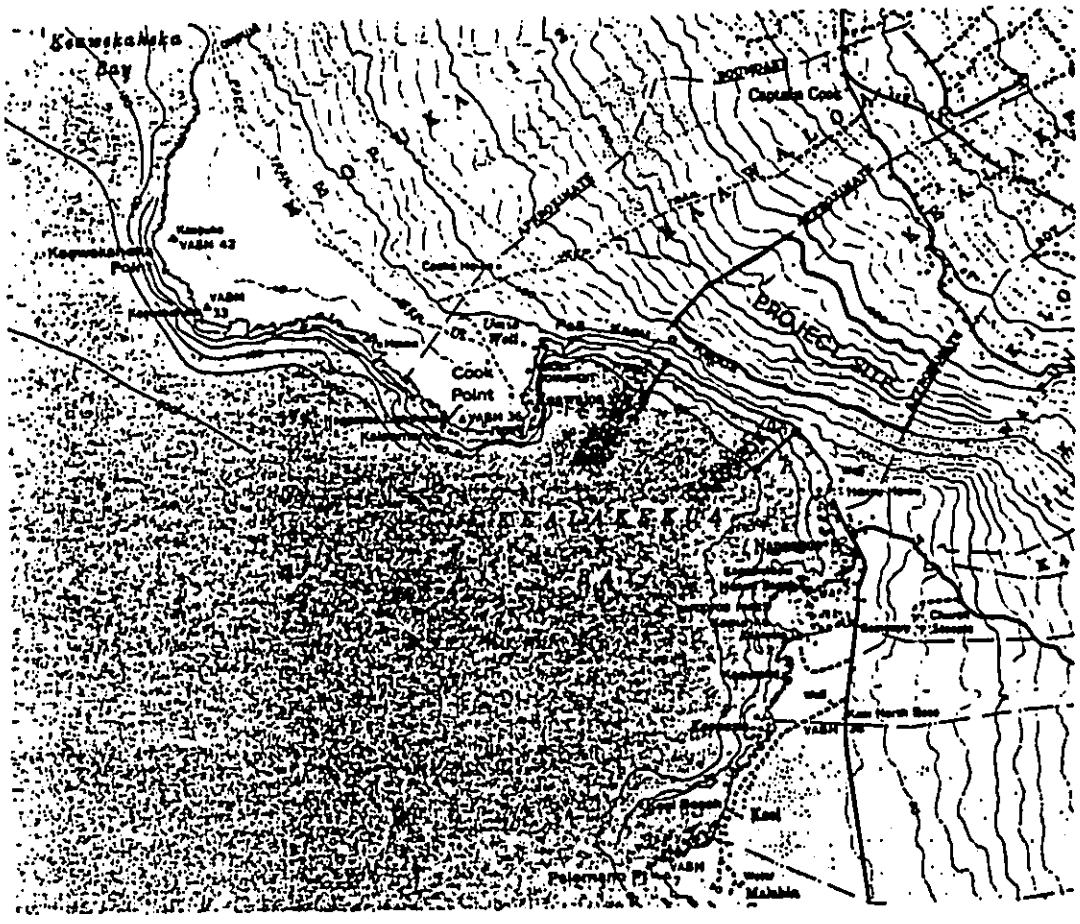

FIGURE 1. Map showing location of proposed project site and survey transect locations in Kealakekua Bay.

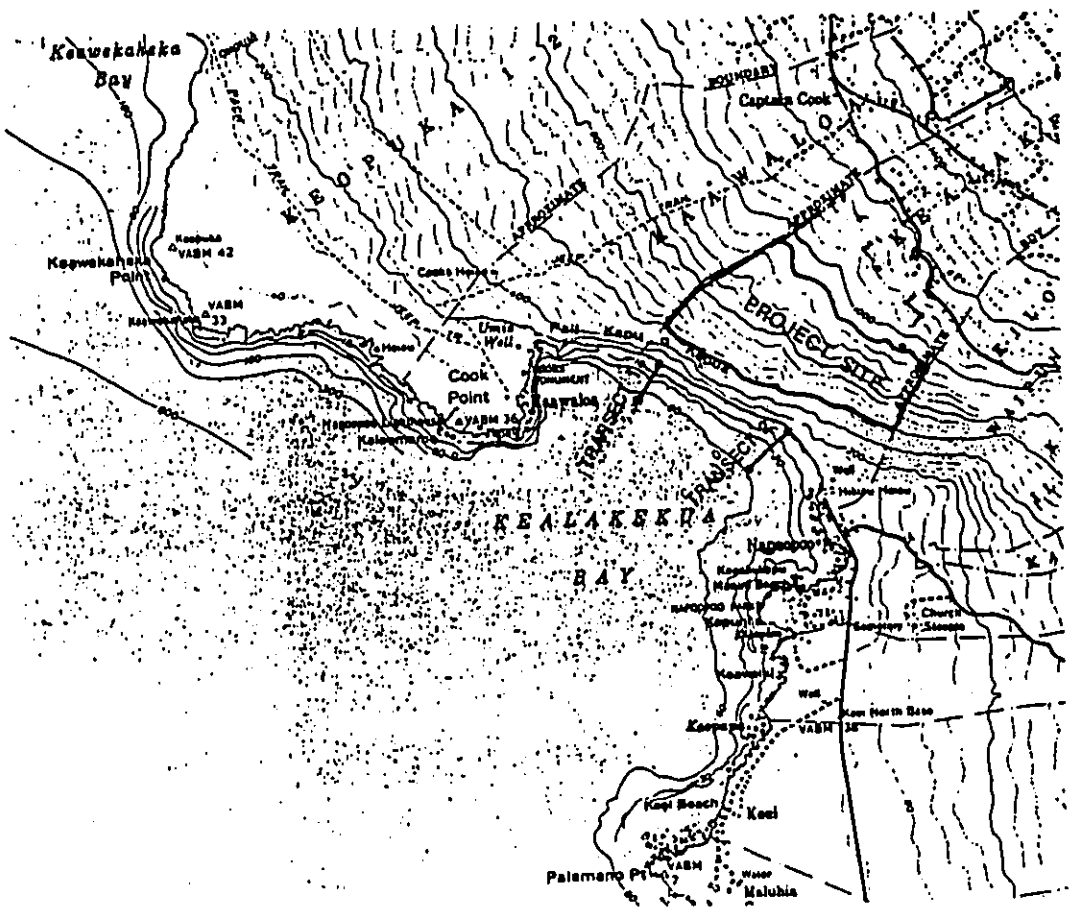

FIGURE 1. Map showing location of proposed project site and survey transect locations in Kealakekua Bay

TABLE 1. (continued)

SAMPLE NUMBER	DISTANCE FROM SHORE (m)	DISSOLVED OXYGEN (% sat.)	DISSOLVED OXYGEN (mg/L)	TEMP. (deg. C.)	pH
		PARAMETER			
KBAY-1-1S	0	86.8	5.62	27.5	8.20
1-2S	2	86.9	5.64	27.4	8.22
1-2B	2	86.8	5.63	27.2	8.22
1-3S	5	87.2	5.59	27.2	8.23
1-3B	5	88.5	5.75	27.1	8.22
1-4S	10	84.6	5.49	27.1	8.23
1-4B	10	95.8	6.05	26.8	8.21
1-5S	50	90.4	5.83	26.8	8.21
1-5B	50	91.2	5.91	26.8	8.22
1-6S	100	85.9	5.56	26.9	8.21
1-6B	100	91.1	5.85	26.9	8.21
KBAY-2-1S	0	98.5	6.29	28.1	8.19
2-2S	2	92.8	5.97	27.9	8.20
2-2B	2	92.9	5.74	28.2	8.22
2-3S	5	87.2	5.54	28.1	8.21
2-3B	5	90.5	5.81	28.2	8.21
2-4S	10	88.2	5.63	28.2	8.22
2-4B	10	85.1	5.42	28.4	8.21
2-5S	50	94.8	6.03	28.3	8.22
2-5B	50	91.0	5.78	28.2	8.23
2-6S	100	97.9	6.30	28.2	8.21
2-6B	100				

TABLE 1. Water chemistry parameters for samples in Kaneohe Bay collected November 19, 1988. For station locations, see Figure 1. Also shown are State of Hawaii Dept. of Health Water Quality Standards for open coastal waters.

SAMPLE NUMBER	DISTANCE FROM SHORE (m)	SALINITY (ppt)	PO4 (uM)	TOTAL P (uM)	DOP (uM)	NO3+NO2 (uM)	NH4 (uM)	TOTAL N (uM)	DON (uM)	SI (uM)	TURBIDITY (ntu)	CHL. a (ug/L)
		PARAMETER										
KBAY-1-1S	0	34.75	0.13	0.25	0.12	0.21	0.16	6.00	6.43	2.24	0.08	0.31
1-2S	2	34.77	0.12	0.26	0.14	0.19	0.11	5.64	5.34	1.83	0.06	0.33
1-2B	2	34.78	0.09	0.28	0.19	0.12	0.05	4.87	4.70	1.63	0.08	0.37
1-3S	5	34.79	0.09	0.28	0.19	0.10	0.21	6.24	5.93	1.42	0.12	0.47
1-3B	5	34.77	0.12	0.29	0.17	0.29	0.11	6.07	5.67	2.03	0.08	0.22
1-4S	10	34.78	0.11	0.28	0.17	0.14	0.02	5.20	5.04	1.83	0.05	0.23
1-4B	10	34.78	0.09	0.28	0.19	0.12	0.07	5.20	5.01	1.42	0.08	0.26
1-5S	50	34.78	0.09	0.28	0.19	0.12	0.07	4.87	4.68	1.42	0.07	0.21
1-5B	50	34.78	0.09	0.26	0.17	0.10	0.09	5.11	4.92	1.42	0.07	0.22
1-6S	100	34.66	0.13	0.28	0.15	0.57	0.11	5.20	4.52	5.28	0.06	0.35
1-6B	100	34.79	0.09	0.28	0.19	0.05	0.07	4.26	4.14	0.81	0.06	0.19
KBAY-2-1S	0	31.51	0.48	0.67	0.19	8.28	0.37	15.83	7.18	84.54	0.12	0.43
2-2S	2	34.50	0.15	0.29	0.14	0.81	0.23	5.13	4.09	8.54	0.08	0.73
2-2B	2	34.73	0.12	0.31	0.19	0.26	0.18	5.01	4.57	2.64	0.08	0.30
2-3S	5	34.77	0.12	0.29	0.17	0.26	0.23	5.30	4.81	1.42	0.09	0.25
2-3B	5	34.80	0.08	0.28	0.20	0.02	0.11	5.13	5.00	0.81	0.06	0.26
2-4S	10	34.79	0.09	0.30	0.21	0.02	0.09	4.99	4.88	0.81	0.05	0.27
2-4B	10	34.80	0.09	0.28	0.19	0.02	0.09	4.92	4.81	0.81	0.06	0.31
2-5S	50	34.78	0.09	0.28	0.19	0.02	0.14	4.39	4.23	0.81	0.09	0.23
2-5B	50	34.80	0.09	0.28	0.19	0.02	0.07	4.89	4.80	0.61	0.05	0.28
2-6S	100	34.79	0.09	0.28	0.19	0.02	0.09	5.23	5.12	0.81	0.08	0.32
2-6B	100											
WELL		0.02	4.18	4.18	0.00	108.60	0.07	108.65	-0.02	769.39		
DOH WATER QUAL. STDS.			-	0.64	-	0.36	0.25	10.71	-	-	0.50	0.30
GEOMETRIC MEAN				1.29		1.00	0.61	17.85			1.25	0.90
NOT TO EXCEED 10%				11.29		1.78	1.07	25.00			2.00	1.75
NOT TO EXCEED 2%												
MEAN		34.743	0.16	0.44	0.28	0.25	0.19	5.74	5.30	2.65	-	-
std. dev		0.175	0.04	0.07		0.11	0.08	0.94		2.73		

TABLE 3. Sea urchin abundance on transects in Kealakekua Bay. For transect locations, see Figure 1.

SPECIES	TRANSECT				
	KB-1 10°	KB-1 25°	KB-1 10°	KB-1 25°	KB-1 50°
Echinometra mathaei	10	18	52	18	7
Echinostrephus aciculatus	2		12	4	2
Tripneustes gratilla			1		4
Heterocentrotus mamillatus	3	16	3	17	4
Echinothrix diadema		1		1	2
TOTAL	15	35	68	40	19

TABLE 4. Fish abundance on transects in Kealakekua Bay. For transect locations, see Figure 1.

	KB1 10°	KB1 25°	KB2 10°	KB2 25°	KB2 50°
AULOSTOMIDAE					
Aulostomus chinensis		1			1
FISTULARIDAE					
Fistularia petimba	2		2		
KYPHOSIDAE					
Kyphosus bigibbus	15				
CIRRHITIDAE					
Paracirrhites arcatus		2		1	2
MULLIDAE					
Mulloides flavolineatus	18	4		15	70
M. vanicolensis	6	3			
Parupeneus multifasciatus	6	7	6	6	7
P. bifasciatus	3	1	2	2	
P. cyclostomus					2
SERRANIDAE					
Cephalopholis argus					2
CARANGIDAE					
Caranx melamphygus		1		3	
LUTJANIDAE					
Lutjanus kasmira					20
Aphareus furcatus				2	2
LETHRINIDAE					
Monotaxis grandoculis					3
CHAETODONTIDAE					
Chaetodon lunula				2	2
C. quadrimaculatus	3	3	1	3	
C. miliaris	2				
C. ornatissimus	2	6	4	3	4
C. unimaculatus	2	2		2	
C. multicinctus	4	7	4	6	9
C. fremblii	3				
C. auriga		1			
Forcipiger flavissimus		5	3	4	7
Hemtaurichthys polylepis					
POMACANTHIDAE					
Centropyge potteri				7	4
POMACENTRIDAE					
Abudefduf abdominalis	40	10		15	10
Stegastes fasciolatus	8				
Dascyllus albisella					8
Chromis agilis		59		35	45
C. hanui					3
C. vanderbilti	23	30	35	25	20

TABLE 4. (continued)

LABRIDAE					
Cheilinus unifasciatus					2
Bodianus bilunulatus				2	4
Coris gaimard			2	2	2
C. flavovittata	1				
Anampses chrysocephalus		2			
Thalassoma duperrey	16	5	16	11	9
T. trilobatum	1		2		
Bodianus varius	3	2	3	4	2
Labroides phthirophagus		2		1	1
Stethojulis balteata	3		4		
Halichoeres ornatissimus	3	1		1	2
SCARIDAE					
Scarus sordidus	3		4	4	3
S. perspicillatus	3		1		
S. psittacus	4			1	
S. rubroviolaceus	2	3			
ACANTHURIDAE					
Zebrasoma flavescens	150	36	160	90	52
Z. veliferum	3		3		
Acanthurus achilles	48	4	12	7	5
A. triostegus	8		110		
A. leucopareius	115	8	52	15	
A. dussumieri		3			
A. blochii				6	4
A. nigrofuscus	25	12	80	17	12
Ctenochaetus striguosus	130	45	105	75	45
C. hawaiiensis	3	2		2	
Naso lituratus	20	9	17	12	8
N. unicornis	1			2	
ZANCLIDAE					
Zanclus cornutus	3	2	2	9	3
BALISTIDAE					
Rhinecanthus rectangulus		1	2		
Sufflamen bursa	7	4	2	3	4
S. fraenatus	1				
Melichthys vidula		20	5	16	8
M. niger	30	25	40	27	20
TETRAODONTIDAE					
Canthigaster jactator	2	2			
NUMBER SPECIES	40	36	28	37	37
NUMBER INDIVIDUALS	722	330	673	438	407
SPECIES DIVERSITY	2.649	2.867	2.354	2.855	2.922

Appendix 14:

NOISE STUDY FOR THE KEALAKEKUA BAY GOLF COURSE PROJECT

NOISE STUDY
FOR
THE KEALAKEKUA BAY GOLF COURSE PROJECT
KEALAKEKUA, HAWAII

Prepared for:

ROYAL COAST DEVELOPMENT CORPORATION

Prepared by:

Y. EBISU & ASSOCIATES
1126 12TH Avenue, Room 305
Honolulu, Hawaii 96816

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CHAPTER I. SUMMARY

The existing and future traffic noise levels in the vicinity of the proposed Kealakekua Bay Golf Course project were evaluated for their potential impact along roadways which would service the project. The change in future traffic noise levels associated with the project traffic is anticipated to be very low.

Due to the relatively small increases in traffic anticipated to result from the project, risks of adverse noise impacts from traffic noise increases are considered to be low, and the proposed project should not cause adverse noise impacts along the roadways servicing the project. For these reasons, special traffic noise mitigation measures are not considered necessary.

Risks of adverse noise impacts from Clubhouse activities are also low due to the relatively large buffer distances (in excess of 1,000 FT) to the nearest residence. If loud entertainment activities are conducted within the interior dining and function spaces, the option of closure and air conditioning of the clubhouse is available as a standard noise mitigation measure.

Risks of adverse noise impacts from operation of the golf course's tractors are higher due to the shorter distance (approximately 200 FT) between the Maintenance Area and the nearest neighbor. However, noise levels from the tractors are not expected to be excessive and out of character with the existing area, and the use of a sound attenuating wall northeast of the Maintenance Area and/or the construction of maintenance sheds are possible means of reducing noise disturbances from the Maintenance Area. In addition, administrative controls in the form of curfews on the operation of the tractors may also be used to minimize risks of adverse noise impact.

CHAPTER II. PURPOSE

The purposes of this noise study were to predict and evaluate the traffic noise increases associated with motor vehicle traffic to and from the proposed Kealakekua Bay Golf Course. The scope of the noise study included evaluations of potential noise impacts on existing residences and noise sensitive receptors within the project environs. The proposed project will include a full-size, 18-hole golf course, a clubhouse with dining area, pool, and tennis courts, members' lodges, and supporting facilities. In addition to potential noise impacts from increased traffic noise levels, potential noise impacts from on-site activities associated with the proposed project were also evaluated.

CHAPTER III. NOISE DESCRIPTORS AND THEIR RELATIONSHIP TO LAND USE COMPATIBILITY

The noise descriptor currently used by federal agencies to assess environmental noise is the Day-Night Average Sound Level (Ldn). This descriptor incorporates a 24-hour average of instantaneous A-Weighted Sound Levels as read on a standard Sound Level Meter. The minimum averaging period for the Ldn descriptor is 24 hours (by definition). Additionally, sound levels which occur during the nighttime hours of 10:00 PM to 7:00 AM are increased by 10 decibels (dB) prior to computing the 24-hour average by the Ldn descriptor. A more complete list of noise descriptors is provided in APPENDIX B to this report.

TABLE 1, derived from Reference 1, presents current federal standards and acceptability criteria for residential land uses exposed to various levels of environmental noise. Noise levels typical of communities on Oahu are shown in FIGURE 1. As a general rule, noise levels of 55 Ldn or less occur in rural areas, or urbanized areas which are shielded from high volume streets. In urbanized areas, Ldn levels generally range from 55 to 65 Ldn, and are usually controlled by motor vehicle traffic noise. Residences which front major roadways are generally exposed to levels of 65 Ldn, and as high as 72 Ldn when the roadway is a high speed freeway. Due to noise shielding effects from intervening structures, residences which are located within interior lots are usually exposed to lower noise levels of 60 Ldn or less.

For the purposes of determining noise acceptability for funding assistance from federal agencies (FHA/HUD and VA), an exterior noise level of 65 Ldn or lower is considered acceptable. This standard is applied nationally (see Reference 2), including Hawaii. Because of our open-living conditions, the predominant use of naturally ventilated dwellings, and the relatively low exterior-to-interior sound attenuation afforded by these naturally ventilated structures, an exterior noise level of 65 Ldn does not

TABLE 1

EXTERIOR NOISE EXPOSURE CLASSIFICATION (RESIDENTIAL LAND USE)

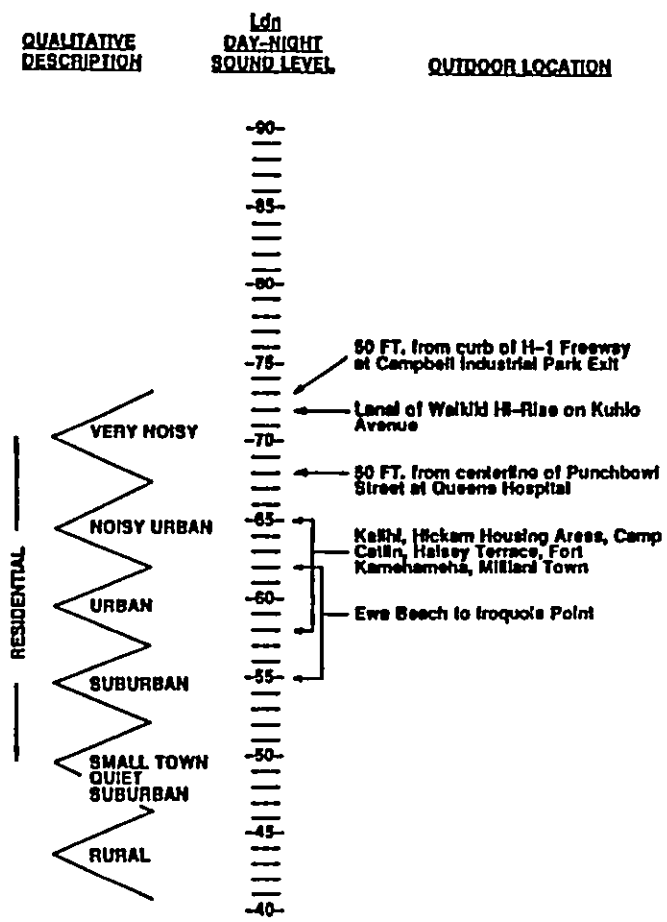
NOISE EXPOSURE CLASS	DAY-NIGHT SOUND LEVEL	EQUIVALENT SOUND LEVEL	FEDERAL[1] STANDARD
Minimal Exposure	Not Exceeding 55 L_{dn}	Not Exceeding 55 L_{eq}	Unconditionally Acceptable
Moderate Exposure	Above 55 L_{dn} But Not Above 65 L_{dn}	Above 55 L_{eq} But Not Above 65 L_{eq}	Acceptable[2]
Significant Exposure	Above 65 L_{dn} But Not Above 75 L_{dn}	Above 65 L_{eq} But Not Above 75 L_{eq}	Normally Unacceptable
Severe Exposure	Above 75 L_{dn}	Above 75 L_{eq}	Unacceptable

Notes: (1) Federal Housing Administration, Veterans Administration, Department of Defense, and Department of Transportation.

(2) FHWA uses the L_{eq} instead of the L_{dn} descriptor. For planning purposes, both are equivalent if: (a) heavy trucks do not exceed 10 percent of total traffic flow in vehicles per 24 hours, and (b) traffic between 10:00 PM and 7:00 AM does not exceed 15 percent of average daily traffic flow in vehicles per 24 hours. The noise mitigation threshold used by FHWA for residences is 67 L_{eq}.

FIGURE 1

RANGE OF EXTERIOR BACKGROUND AMBIENT NOISE LEVELS



eliminate all risks of noise impacts. For these reasons, and as recommended in Reference 3, a lower level of 55 Ldn is considered as the "Unconditionally Acceptable" (or "Near-Zero Risk") level of exterior noise. However, after considering the cost and feasibility of applying the lower level of 55 Ldn, government agencies such as FHA/HUD and VA have selected 65 Ldn as a more appropriate regulatory standard.

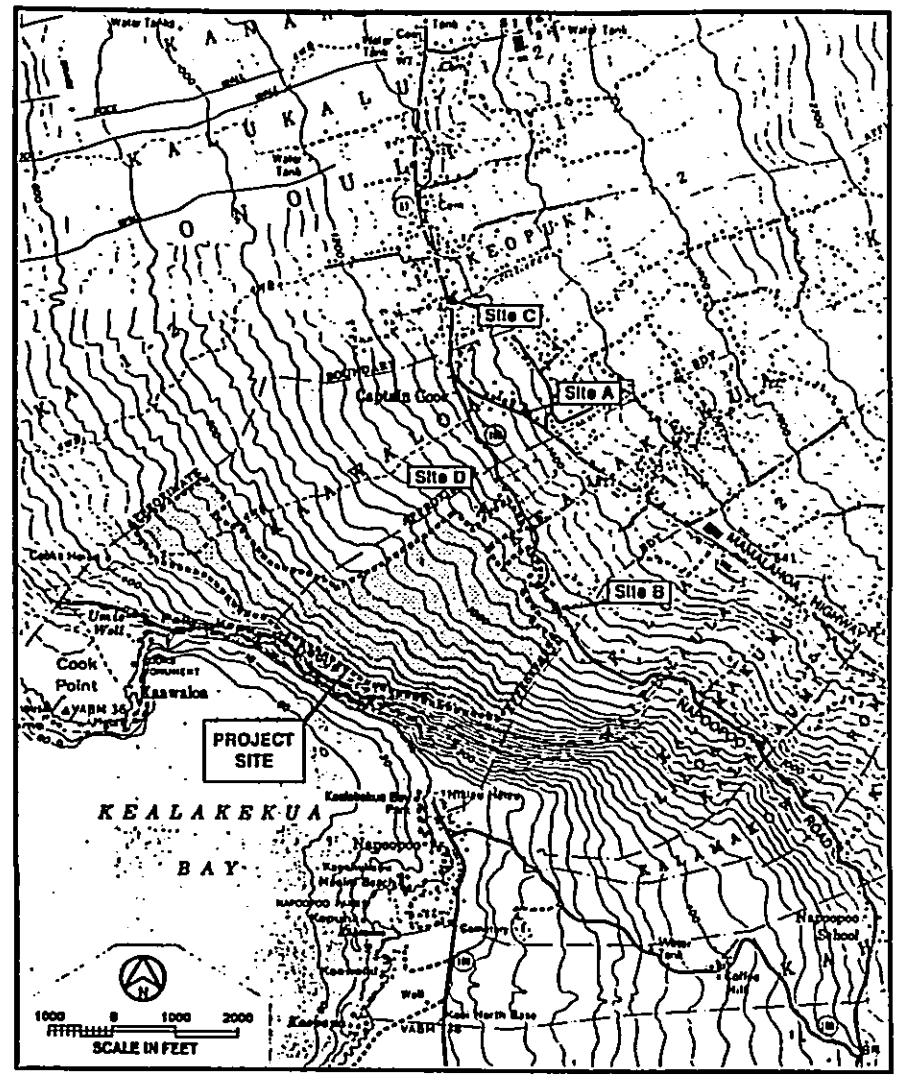
State Department of Health (DOH) noise regulations (References 4 and 5) apply on the island of Oahu, and are intended to minimize noise impacts from stationary as well as motor vehicle noise sources. At the present time, these regulations do not apply to noise sources at the project site, or to light and heavy vehicles which would travel to and from the site on public roadways (or trafficways). However, the noise limits of the DOH rules, and particularly the construction noise limits, are sometimes used as standards of reference on the outer islands of the state.

CHAPTER IV. GENERAL STUDY METHODOLOGY

Existing background ambient noise levels were measured at four locations in the project environs to provide a basis for developing the project's traffic noise contributions along Mamalahoa Highway and Napoopoo Road, as well as for describing the existing noise environment at noise sensitive locations which are removed from roadway traffic. The locations of these four measurement sites are shown in FIGURE 2. Measurements were performed in November 1990 during the off-peak traffic period as well as during the PM peak hour period. The results of the noise measurements were also compared to calculations of existing traffic noise levels to validate the traffic noise computer model used. These noise measurement results, and their comparisons with computer model predictions are summarized in TABLE 2.

Traffic noise calculations for the existing conditions as well as noise predictions for the Year 1994 following completion of the proposed development were performed using the Federal Highway Administration (FHWA) Noise Prediction Model (Reference 6). Traffic data entered into the noise prediction model were: hourly traffic volumes; average vehicle speeds; and estimates of traffic mix. The traffic study for the project (Reference 7), and Hawaii State DOT traffic counts at the intersection of Mamalahoa Highway and the road to Napoopoo (Reference 8), were the primary sources of data inputs to the model. For existing and future traffic, it was assumed that the PM peak hour Leq(h) was 0.5 dB greater than the 24-hour Ldn. This assumption was based on computations of the hourly Leq and 24-hour Ldn of traffic noise along Mamalahoa Highway at the road to Napoopoo as shown in FIGURE 3.

The projected increases in traffic noise levels attributable to project related traffic were calculated, and noise impact risks evaluated. The relative contributions of non-project and project related traffic to the total noise levels were also calculated, and an evaluation of possible traffic noise impacts was made.



LOCATIONS OF NOISE MEASUREMENT SITES

FIGURE 2

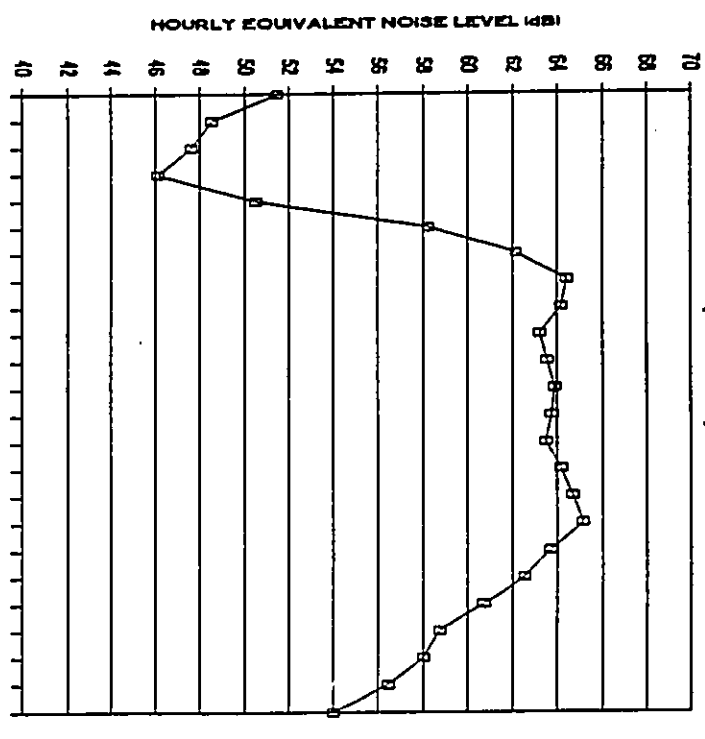
TABLE 2

TRAFFIC NOISE MEASUREMENTS

Location	Time of Day (HRS)	Ave.Speed (MPH)	Hourly Traffic Volume: Auto	Hourly Traffic Volume: Med.Truck	Hourly Traffic Volume: Heavy Truck	Measured Leq (dB)	Predicted Leq(dB)
A. 35 FT from the centerline of Mamalahoa Highway. (11/28/90)	0815 TO 0915	43	712	30	9	68.2	68.0
B. 25 FT from the centerline of Napoopoo Road. (11/28/90)	1015 TO 1115	33	114	5	5	60.9	61.0
C. 50 FT from the centerline of Mamalahoa Highway. (11/28/90)	1600 TO 1700	38	1,159	35	10	64.9	65.2
D. Residential Area, 500 FT Makai of Napoopoo Road. (11/27/90)	1700 TO 1715	N/A	N/A	N/A	N/A	40.2	N/A

FIGURE 3

HOURLY VARIATIONS OF TRAFFIC NOISE AT 50 FT SETBACK DISTANCE FROM THE CENTERLINE OF MAMALAHOA HIGHWAY NORTH OF ROAD TO NAPOOPOO (5/9-10/88)



The possibility of adverse noise impacts from on-site activities were evaluated by comparing predicted noise levels along the property lines of the project with existing background ambient noise levels in the project environs and with the existing separation distances (or buffer space) to the nearest noise sensitive neighbors.

CHAPTER V. EXISTING NOISE ENVIRONMENT

The existing background ambient noise levels in the project environs are controlled by traffic on Mamalahoa Highway and the road to Napoopoo, local traffic, birds, dogs, wind, and foliage. At residences in the immediate vicinity of the project site and which are removed from Mamalahoa Highway and the road to Napoopoo, existing average background ambient noise levels range from 40 to 45 Ldn, which is in the "Minimal Exposure, Unconditionally Acceptable" noise exposure category. Background noise levels in the project environs are relatively low due to the rural character of the area. During the quiet periods, background ambient noise levels along the roadway are controlled by the sound of dogs, birds, wind, and distant traffic.

Along Mamalahoa Highway, at approximately 50 FT setback distance from the roadway's centerline, existing traffic noise levels are approximately 65 to 67 Ldn, and are in the "Significant Exposure, Normally Unacceptable" noise exposure category. Along Napoopoo Road, at approximately 50 FT setback distance from the roadway's centerline, existing traffic noise levels are lower at approximately 57 Ldn, and are in the "Moderate Exposure, Acceptable" noise exposure category. Maximum noise levels (Lmax) associated with heavy truck and bus traffic on the two roadways are in the order of 78 to 85 dB at 50 FT setback distance. Minimum background ambient noise levels of approximately 30 to 50 dB occur between periods of traffic flow. Traffic noise levels along a roadway's Right-of-Way generally represent the worst case (or highest) levels due to the close proximity of the Right-of-Way to the noise sources. Traffic noise levels at 100 to 300 FT setback distances from the highway centerline are generally in the "Minimal Exposure, Unconditionally Acceptable" to "Moderate Exposure, Acceptable" categories, with 5 to 10 Ldn lower noise levels resulting from shielding and distance effects. An exception occurs for elevated receptor locations which are not shielded from the

roadway by intervening terrain features or man-made structures.

Results of calculations of existing traffic noise levels along Mamalahoa Highway and Napoopoo Road during the PM peak hour period are shown in TABLE 3. The traffic volumes used for the peak hour periods were obtained from Reference 7. TABLE 4 presents the calculated setback distances between the roadway centerlines and the iso-noise contours associated with the 60, 65, and 70 Ldn levels of existing traffic noise. The traffic noise levels shown in the tables only apply when unobstructed line-of-sight conditions exist to the roadways. These conditions would generally occur along the Right-of-Way, within any open space fronting the roadway, or at the upper levels of any man-made structure or natural terrain feature.

TABLE 3

COMPARISONS OF EXISTING AND CY 1994 TRAFFIC NOISE LEVELS
ALONG ACCESS ROADS TO PROJECT SITE
(PM PEAK HOUR AND 50 FT FROM ROADWAY CENTERLINES)

LOCATION	SPEED (MPH)	VPH	***** HOURLY LEQ IN dB **** AUTO	MT	HT	ALL VEH
EXISTING (CY 1990) PM PEAK HR. TRAFFIC:						
Mamalahoa Hwy. N. of Napoopoo Rd.	38	1,060	62.0	59.1	60.9	65.6
Mamalahoa Hwy. S. of Napoopoo Rd.	43	999	63.7	60.7	62.0	67.1
Napoopoo Rd. North of Project	33	171	51.6	49.1	55.7	57.8
Napoopoo Rd. South of Project	33	171	51.6	49.1	55.7	57.8
CY 1994 PM PEAK HR. TRAFFIC WITH THE PROJECT:						
Mamalahoa Hwy. N. of Napoopoo Rd.	38	1,550	63.6	60.7	62.6	67.2
Mamalahoa Hwy. S. of Napoopoo Rd.	43	1,290	64.8	61.8	63.1	68.2
Napoopoo Rd. North of Project	33	460	55.9	53.4	60.0	62.1
Napoopoo Rd. South of Project	33	388	55.1	52.7	59.3	61.3

Notes:

The following assumed traffic mixes of autos, medium trucks, and heavy vehicles were used for existing and future conditions:

(a) Mamalahoa Highway: 95.0% autos, 3.5% medium trucks, and 1.5% heavy trucks and buses.

(b) Napoopoo Road: 92.5% autos, 3.5% medium trucks, and 4% heavy trucks and buses.

TABLE 4

EXISTING AND CY 1994 DISTANCES TO 60, 65, AND 70 Ldn CONTOURS

STREET SECTION	60 Ldn SETBACK (FT) EXISTING	60 Ldn SETBACK (FT) CY 1994	65 Ldn SETBACK (FT) EXISTING	65 Ldn SETBACK (FT) CY 1994	70 Ldn SETBACK(FT) EXISTING	70 Ldn SETBACK(FT) CY 1994
Mamalahoa Hwy. N. of Napoopoo Rd.	109	140	51	65	23	30
Mamalahoa Hwy. S. of Napoopoo Rd.	137	163	64	76	30	35
Napoopoo Rd. North of Project	33	64	15	30	7	14
Napoopoo Rd. South of Project	33	57	15	26	7	12

Notes:

(1) All setback distances are from the roadways' centerlines.
(2) See TABLE 3 for traffic volume, speed, and mix assumptions.
(3) Ldn assumed to be equal to PM Peak Hour Leq minus 0.5 dB on all roadways.
(4) Setback distances are for unobstructed line-of-sight conditions.
(5) Soft ground conditions assumed along all roadways.

CHAPTER VI. FUTURE TRAFFIC NOISE ENVIRONMENT

Predictions of future traffic noise levels were made using the traffic volume assignments of Reference 7. The future projections of project plus non-project traffic on the roadway sections which would service the project are shown in TABLE 3 for the afternoon or PM peak hour of traffic in CY 1994. TABLE 4 summarizes the predicted increases in setback distances to the 60, 65, and 70 Ldn traffic noise contour lines along the roadways servicing the project and attributable to increases in project plus non-project traffic by CY 1994.

From TABLE 5, moderate project plus non-project traffic noise increases of 1.1 to 1.6 dB are predicted to occur by CY 1994 along Mamalahoa Highway, which is expected to serve as a primary access roadway to the proposed project. The increase in traffic noise along the north section of the highway, and which is attributable to project traffic is 0.2 dB, which is considered to be minimal. The proposed project is not expected to cause traffic noise increases along the south section of the Mamalahoa Highway. The future traffic noise environment along the more densely populated Mamalahoa Highway will not be significantly changed by the proposed project due to the relatively low volumes of traffic expected to be generated by the project.

Larger and significant increases in traffic noise of 3.5 to 4.3 dB are anticipated along Napoopoo Road, which will serve as the primary connector road between Mamalahoa Highway and the project site. The larger traffic noise increase of 4.3 dB is predicted to occur along the roadway section between Mamalahoa Highway and the entrance road to the project site. Project traffic contributions of 0.9 dB are also expected to be greatest along this section of Napoopoo Road. Non-project traffic will increase existing noise levels along Napoopoo Road by 3.4 dB. Existing traffic noise levels along Napoopoo Road are relatively low and significantly lower than those along Mamalahoa Highway due to the

TABLE 5

CALCULATIONS OF PROJECT AND NON-PROJECT
TRAFFIC NOISE CONTRIBUTIONS (CY 1994)

STREET SECTION	NOISE LEVEL INCREASES (Ldn) DUE TO NON-PROJECT TRAFFIC	PROJECT TRAFFIC
Mamalahoa Hwy. N. of Napoopoo Rd.	1.4	0.2
Mamalahoa Hwy. S. of Napoopoo Rd.	1.1	0.0
Napoopoo Rd. North of Project	3.4	0.9
Napoopoo Rd. South of Project	3.4	0.1

lower volume of traffic and the lower average speeds along Napoopoo Road. For this reason, total traffic noise levels along Napoopoo Road following project build-out are expected to remain in the "Moderate Exposure, Acceptable" category, and remain less than 65 Ldn at 50 FT setback distance from the roadway's centerline.

Based on the maximum of 100 parking stalls planned for the clubhouse facility, a maximum of 200 vehicle trips could occur under worst case conditions during the period immediately before and after a social function at the clubhouse. This additional volume of traffic which could occur on Napoopoo Road or Mamalahoa Highway between the hours of 10:00 AM to 10:00 PM will not affect the forecasted noise levels as measured by the Ldn descriptor due to the dominating influence of non-project traffic on total forecasted noise levels.

CHAPTER VII. DISCUSSION OF PROJECT RELATED TRAFFIC NOISE IMPACTS AND POSSIBLE NOISE MITIGATION MEASURES

The increases in traffic noise levels attributable to the project are predicted to be approximately 0 to 0.2 dB (or Ldn) along Mamalahoa Highway, and 0.1 to 0.9 dB (or Ldn) along Napoopoo Road. An increase in traffic noise of 0.2 dB or less should not be perceptible and is not considered to be significant. For this reason, traffic noise impacts are not expected along Mamalahoa Highway and the south section of Napoopoo Road. Moderate increases in project generated traffic noise of 0.9 dB are predicted to occur along the section of Napoopoo Road between Mamalahoa Highway and the project's entrance road. This increase is low when compared to the larger increase of 3.4 dB expected from non-project traffic along Napoopoo Road by CY 1994.

In absolute terms, forecasted noise levels along Napoopoo Road are not expected to exceed the 65 Ldn FHA/HUD standard at 50 FT setback distance from the roadway's centerline. Existing residences along Napoopoo Road which are not shielded from traffic noise by walls, buildings, or natural terrain features but are at setback distances greater than 30 FT from the roadway's centerline can be expected to be exposed to "Moderate, Acceptable" traffic noise levels.

Along Mamalahoa Highway, where traffic volumes, speeds, and noise levels are significantly higher, the additive noise contributions from project traffic are expected to be less significant when compared to non-project traffic contributions. Project traffic noise impacts along Mamalahoa Highway are not anticipated because of the dominating influence of non-project traffic noise over project traffic noise levels.

Noise mitigation measures along public roadways, such as Mamalahoa Highway and Napoopoo Road, are usually undertaken by private landowners along the roadway. These noise mitigation measures may take the form of large setback distances from the

roadway, sound attenuating walls or berms, sound attenuation windows which allow for the use of natural ventilation, or total closure and air conditioning. Noise mitigation measures are also implemented in conjunction with roadway improvement projects which are intended to increase the capacity of these roadways or the intersections along these roadways. The noise mitigation measures are usually designed to be effective up to the increased capacity of the improved roadway. In this way, traffic noise mitigation measures along a public roadway are customized to the desires of the landowners, or are implemented as part of an improvement project which is designed to accommodate existing and future users of the roadway.

CHAPTER VIII. OTHER NON-TRAFFIC NOISE CONSIDERATIONS

Clubhouse. Adverse noise impacts from planned activities at the Clubhouse are not anticipated due to the relatively large buffer distance of approximately 1,300 to 2,200 FT planned between the facility and its nearest noise sensitive neighbors--residences along Napoopoo Road. Additionally, loud or boisterous functions are not anticipated at the Clubhouse facility. Should sound attenuation treatment of the Clubhouse facility and its mechanical equipment be required to minimize noise emissions from the facility, available options may be implemented as required. These options include closure and air conditioning, use of silencers on mechanical equipment, and the use of sound barriers. These types of sound attenuation treatment are not unusual or extraordinary for golf course facilities, and can be implemented as required.

Maintenance Equipment. Noise from golf course maintenance equipment may be audible at neighboring residences and at the proposed members' lodges. The loudest noise sources associated with the proposed golf course are expected to be the tractors which are used for maintenance of the course. Measured noise levels from tractors used on golf courses are shown in FIGURES 4 and 5. Typical noise levels of these tractors range from 66 to 74 dB at 50 FT distance. The planned 200 FT buffer between the proposed Maintenance Area and the nearest neighbor to the northeast will attenuate the tractor noise levels shown in the figures by at least 12 to 15 dB. However, these tractors may still be audible during the quiet periods. These noise events are expected to be intermittent, and are similar to other farm equipment used within an Agricultural District. The use of properly muffled and maintained tractor equipment is recommended within the entire golf course project. If necessary, maintenance sheds and/or a sound attenuating wall may be used to reduce noise from maintenance activities toward the nearest neighbor to the northeast. In addition, the use of evening and nighttime curfews on operation of

FIGURE 4

NOISE LEVELS FROM TRACTOR/MOWER
AT 50 FT DISTANCE
(Jacobsen 535)

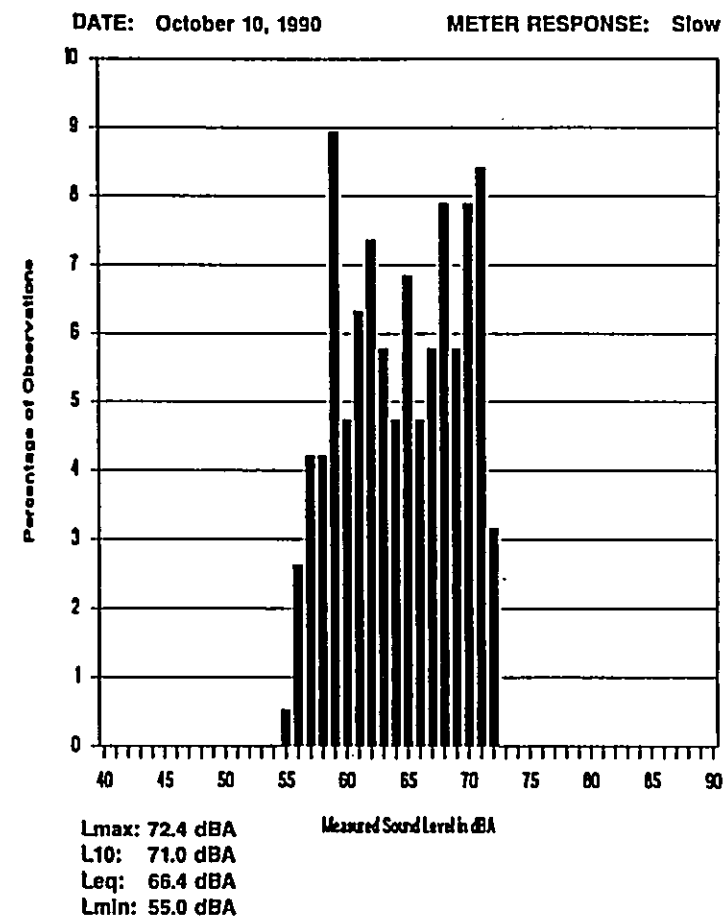
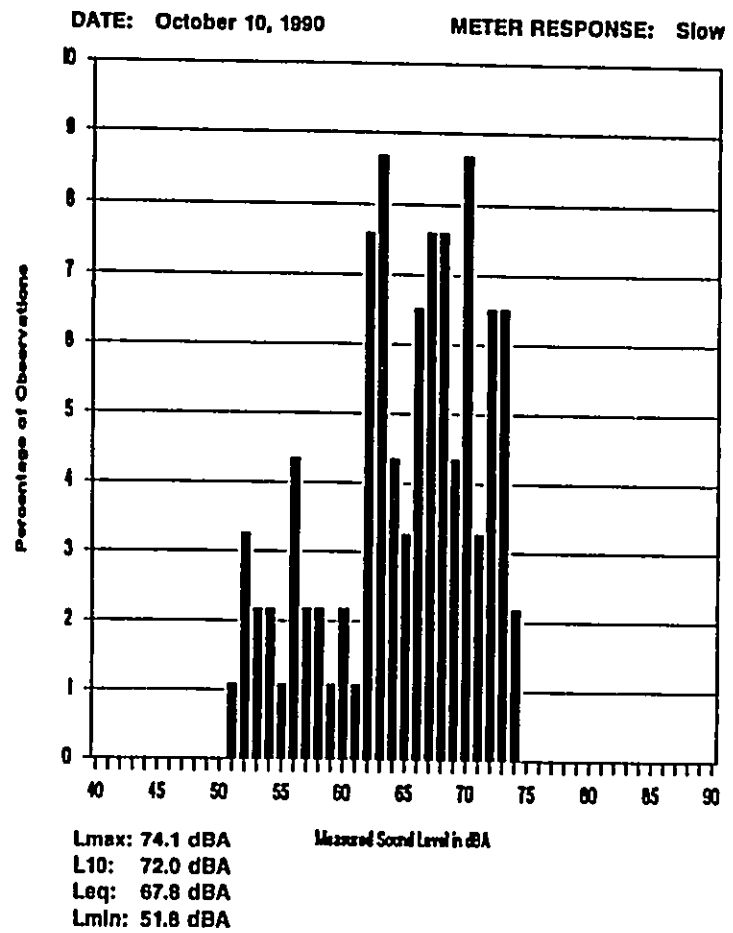


FIGURE 5

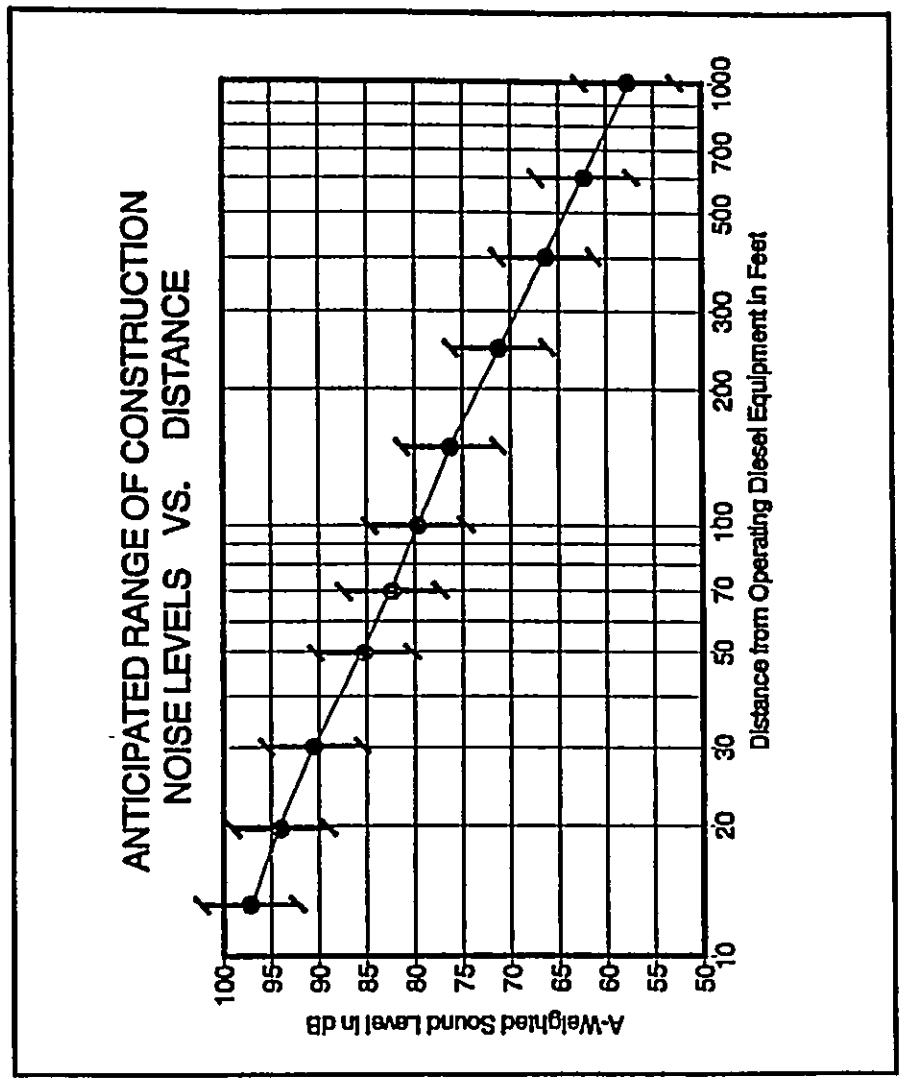
NOISE LEVELS FROM TRACTOR/MOWER AT 50 FT DISTANCE (Kubota L-3750)



noisy maintenance equipment in the Maintenance Area may also be employed to minimize adverse noise impacts on the neighboring property.

Construction Noise. Audible construction noise will probably be unavoidable during the project construction period. Short term noise impacts associated with construction of the project may occur. Typical noise levels vs. distance from construction equipment are shown in FIGURE 6. Typical noise levels at 100 FT distance from mass grading operations are shown in FIGURE 7. Because of the relatively high noise levels associated with construction activities, mitigation of construction noise to inaudible levels will not be practical in all cases. The use of properly muffled and maintained construction equipment should be required on the job site.

Permissible noise levels during construction on Oahu are regulated by the State Department of Health under the permit procedures of Reference 4. The incorporation of State Department of Health construction noise limits and curfew times, which are applicable on the island of Oahu, are other noise mitigation measures which are normally applied to construction activities. Use of these procedures by contractors has been successful in mitigating construction noise, and should also be used on this project. TABLE 6 depicts the allowed hours of construction for normal construction noise (levels which do not exceed 95 dB at the project's property line) and for construction noise which exceeds 95 dB at the project's property line. Noisy construction activities are not allowed on holidays, Saturdays, Sundays, during the early morning, and during the late evening periods under the DOH permit procedures.

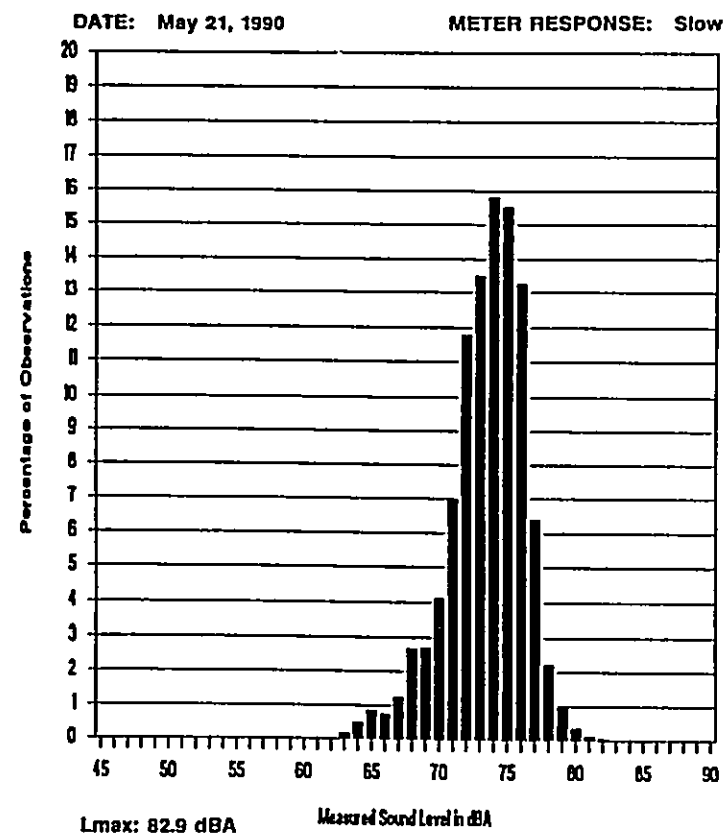


CONSTRUCTION NOISE LEVELS VS. DISTANCE

FIGURE 6

FIGURE 7

TYPICAL NOISE LEVELS FROM GRADING WORK AT 100 FT DISTANCE

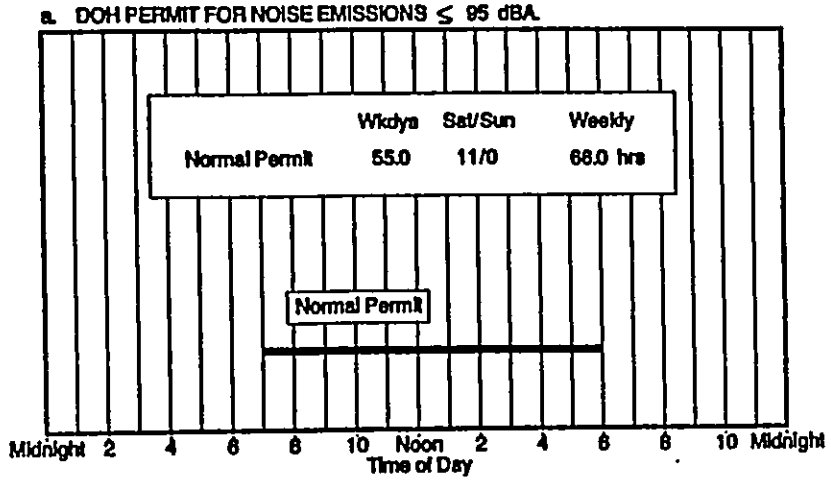


Lmax: 82.9 dBA
L10: 77.0 dBA
Leq: 74.7 dBA
Lmin: 63.0 dBA

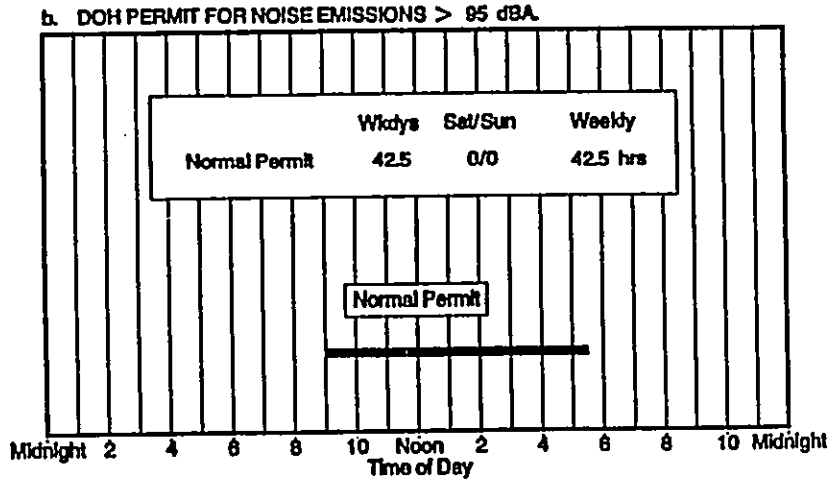
TABLE 6

AVAILABLE WORK HOURS UNDER DOH PERMIT PROCEDURES FOR CONSTRUCTION NOISE

a. DOH PERMIT FOR NOISE EMISSIONS ≤ 95 dBA



b. DOH PERMIT FOR NOISE EMISSIONS > 95 dBA



APPENDIX A. REFERENCES

(1) "Guidelines for Considering Noise in Land Use Planning and Control;" Federal Interagency Committee on Urban Noise; June 1980.

(2) "Environmental Criteria and Standards, Noise Abatement and Control, 24 CFR, Part 51, Subpart B;" U.S. Department of Housing and Urban Development; July 12, 1979.

(3) "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety;" Environmental Protection Agency (EPA 550/9-74-004); March, 1974.

(4) "Title 11, Administrative Rules, Chapter 43, Community Noise Control for Oahu;" Hawaii State Department of Health; November 6, 1981.

(5) "Title 11, Administrative Rules, Chapter 42, Vehicular Noise Control for Oahu;" Hawaii State Department of Health; October 27, 1981.

(6) Barry, T. and Reagan, J., "FHWA Highway Traffic Noise Prediction Model," FHWA-RD-77-108, Federal Highway Administration, Washington, D.C.; December 1978.

(7) "Traffic Impact Assessment Report for Kealakekua Bay Club;" Pacific Planning & Engineering, Inc.; July 1990, and updated CY 1994 assignments dated March 1991.

(8) May 9-10, 1988 24-hour Traffic Counts, Station 7, Mamalahoa Highway at Road to Napoopoo; State Department of Transportation.

APPENDIX B

EXCERPTS FROM EPA'S ACOUSTIC TERMINOLOGY GUIDE

Descriptor Symbol Usage

The recommended symbols for the commonly used acoustic descriptors based on A-weighting are contained in Table I. As most acoustic criteria and standards used by EPA are derived from the A-weighted sound level, almost all descriptor symbol usage guidance is contained in Table I.

Since acoustic nomenclature includes weighting networks other than "A" and measurements other than pressure, an expansion of Table I was developed (Table II). The group adopted the ANSI descriptor-symbol scheme which is structured into three stages. The first stage indicates that the descriptor is a level (i.e., based upon the logarithm of a ratio), the second stage indicates the type of quantity (power, pressure, or sound exposure), and the third stage indicates the weighting network (A, B, C, D, E.....). If no weighting network is specified, "A" weighting is understood. Exceptions are the A-weighted sound level and the A-weighted peak sound level which require that the "A" be specified. For convenience in those situations in which an A-weighted descriptor is being compared to that of another weighting, the alternative column in Table II permits the inclusion of the "A". For example, a report on blast noise might wish to contrast the LCdn with the LAdn.

Although not included in the tables, it is also recommended that "Lpn" and "Lepn" be used as symbols for perceived noise levels and effective perceived noise levels, respectively.

It is recommended that in their initial use within a report, such terms be written in full, rather than abbreviated. An example of preferred usage is as follows:

The A-weighted sound level (LA) was measured before and after the installation of acoustical treatment. The measured LA values were 85 and 75 dB respectively.

Descriptor Nomenclature

With regard to energy averaging over time, the term "average" should be discouraged in favor of the term "equivalent". Hence, Leq, is designated the "equivalent sound level". For Ld, Ln, and Ldn, "equivalent" need not be stated since the concept of day, night, or day-night averaging is by definition understood. Therefore, the designations are "day sound level", "night sound level", and "day-night sound level", respectively.

The peak sound level is the logarithmic ratio of peak sound pressure to a reference pressure and not the maximum root mean square pressure. While the latter is the maximum sound pressure level, it is often incorrectly labelled peak. In that sound level meters have "peak" settings, this distinction is most important.

"Background ambient" should be used in lieu of "background", "ambient", "residual", or "indigenous" to describe the level characteristics of the general background noise due to the contribution of many unidentifiable noise sources near and far.

With regard to units, it is recommended that the unit decibel (abbreviated dB) be used without modification. Hence, DBA, PNdB, and EPNdB are not to be used. Examples of this preferred usage are: the Perceived Noise Level (Lpn was found to be 75 dB. Lpn = 75 dB). This decision was based upon the recommendation of the National Bureau of Standards, and the policies of ANSI and the Acoustical Society of America, all of which disallow any modification of bel except for prefixes indicating its multiples or submultiples (e.g., decl).

Noise Impact

In discussing noise impact, it is recommended that "Level Weighted Population" (LWP) replace "Equivalent Noise Impact" (ENI). The term "Relative Change of Impact" (RCI) shall be used for comparing the relative differences in LWP between two alternatives.

Further, when appropriate, "Noise Impact Index" (NII) and "Population Weighed Loss of Hearing" (PWL) shall be used consistent with CEQ Working Group 69 Report Guidelines for Preparing Environmental Impact Statements (1977).

APPENDIX B (CONTINUED)

TABLE I

A-WEIGHTED RECOMMENDED DESCRIPTOR LIST

TERM	SYMBOL
1. A-Weighted Sound Level	L_A
2. A-Weighted Sound Power Level	L_{WA}
3. Maximum A-Weighted Sound Level	L_{max}
4. Peak A-Weighted Sound Level	L_{Apk}
5. Level Exceeded x% of the Time	L_x
6. Equivalent Sound Level	L_{eq}
7. Equivalent Sound Level over Time (T) (1)	$L_{eq(Y)}$
8. Day Sound Level	L_d
9. Night Sound Level	L_n
10. Day-Night Sound Level	L_{dn}
11. Yearly Day-Night Sound Level	$L_{dn(Y)}$
12. Sound Exposure Level	L_{SE}

(1) Unless otherwise specified, time is in hours (e.g. the hourly equivalent level is $L_{eq(1)}$). Time may be specified in non-quantitative terms (e.g., could be specified a $L_{eq(WASH)}$ to mean the washing cycle noise for a washing machine).

SOURCE: EPA ACOUSTIC TERMINOLOGY GUIDE, BNA 8-14-78, NOISE REGULATION REPORTER.

APPENDIX B (CONTINUED)

TABLE II

RECOMMENDED DESCRIPTOR LIST

TERM	A-WEIGHTING	ALTERNATIVE[1] A-WEIGHTING	OTHER[2] WEIGHTING	UNWEIGHTED
1. Sound (Pressure)[3] Level	L_A	L_{pA}	L_B, L_{pB}	L_p
2. Sound Power Level	L_{WA}		L_{WB}	L_W
3. Max. Sound Level	L_{max}	L_{Amax}	L_{Bmax}	L_{pmax}
4. Peak Sound (Pressure) Level	L_{Apk}		L_{Bpk}	L_{pk}
5. Level Exceeded x% of the time	L_x	L_{Ax}	L_{Bx}	L_{px}
6. Equivalent Sound Level	L_{eq}	L_{Aeq}	L_{Beq}	L_{peq}
7. Equivalent Sound Level[4] Over Time(T)	$L_{eq(T)}$	$L_{Aeq(T)}$	$L_{Beq(T)}$	$L_{peq(T)}$
8. Day Sound Level	L_d	L_{Ad}	L_{Bd}	L_{pd}
9. Night Sound Level	L_n	L_{An}	L_{Bn}	L_{pn}
10. Day-Night Sound Level	L_{dn}	L_{Adn}	L_{Bdn}	L_{pdn}
11. Yearly Day-Night Sound Level	$L_{dn(Y)}$	$L_{Adn(Y)}$	$L_{Bdn(Y)}$	$L_{pdn(Y)}$
12. Sound Exposure Level	L_S	L_{SA}	L_{SB}	L_{Sp}
13. Energy Average value over (non-time domain) set of observations	$L_{eq(e)}$	$L_{Aeq(e)}$	$L_{Beq(e)}$	$L_{peq(e)}$
14. Level exceeded x% of the total set of (non-time domain) observations	$L_{x(e)}$	$L_{Ax(e)}$	$L_{Bx(e)}$	$L_{px(e)}$
15. Average L_x value	L_x	L_{Ax}	L_{Bx}	L_{px}

(1) "Alternative" symbols may be used to assure clarity or consistency.

(2) Only B-weighting shown. Applies also to C,D,E,__weighting.

(3) The term "pressure" is used only for the unweighted level.

(4) Unless otherwise specified, time is in hours (e.g., the hourly equivalent level is Leq(1). Time may be specified in non-quantitative terms (e.g., could be specified as Leq(WASH) to mean the washing cycle noise for a washing machine.

Appendix 15:
SUBSURFACE PESTICIDE MIGRATION STUDY

APPENDIX B

GOLF COURSE WATER BUDGET

GOLF COURSE WATER BUDGET

A. Water Budget Components

A water balance is an accounting of hydrologic components within a system, expressed as:

$$I = O \pm \Delta s$$

Where

I	=	the rate of mass input;
O	=	the rate of mass output; and
Δs	=	rate of mass accumulation.

For the surface soils of the golf course, the mass input and mass output may be further described as:

$$I_{total} = I_p + I_{irr} + I_{rn}$$

$$O_{total} = O_{di} + O_{rf} + O_{et}$$

Where:

I_p	=	Precipitation
I_{irr}	=	Applied Irrigation
I_{rn}	=	Surface Water Runon
O_{di}	=	Deep Infiltration
O_{rf}	=	Surface Runoff
O_{et}	=	Evapotranspiration

Because the rate of mass accumulation is negligible in the long run (i.e., no net accumulation of water), we assume $\Delta s = 0$, and:

$$I_p + I_{irr} + I_{rn} = O_{di} + O_{rf} + O_{et}$$

Deep infiltration refers to the migration of water through the soil past the root zone and is the component of this equation which governs the migration of pesticides past the soil zone and potentially into the groundwater. The infiltration rate can be

calculated for a particular soil horizon and climatological conditions if the remaining components can be estimated.

B. Methodology

To calculate infiltration rate past the root zone, we used a computer program called the Hydrologic Evaluation of Landfill Performance (HELP) Model (Shroeder et al., 1983). The HELP Model, which was developed by the U.S. Environmental Protection Agenncy for assessing infiltration in landfills, utilizes both energy and water balances. This method was chosen because the limited number of required parameters can be estimated from the site. These are:

- Daily precipitation values.
- Golf course irrigation.
- Runon - A review of topographic maps, and aerial photographs and an on-site visit revealed a lack of significant gullying, stream channels or ponded water at the site. The lack of such surface flow features indicates that little surface runoff occurs during periods of precipitation, despite an average slope of about 15 percent across the site.
- Average monthly air temperatures.
- Monthly solar radiation (insolation) values.
- Soil parameters - Thickness, hydraulic conductivity, porosity, field capacity, and wilting point.
- Vegetation parameters - Root depth, leaf area and evaporative potential.

From these data, the program calculates evapotranspiration, infiltration and runoff.

1. Precipitation

The HELP model utilizes daily precipitation values; up to 5 years of precipitation data may be used for the calculations. Precipitation data are not available

for the site, so records at Napoopoo Station were used. The weekly values tabulated at that station were divided evenly into daily values.

The years 1985 to 1989 were used for this analysis. The average annual precipitation during this period was 34 inches, or about 85 percent of the long-term average. By adjusting weekly rainfall amounts upward to account for the long-term average precipitation difference between Napoopoo and the golf course, 5-year weekly rainfall and long-term average rainfall was generated for the site. A summary of these data is listed in Table B-1.

2. Irrigation

An estimate of expected irrigation rates was added to the calculations for the completed golf course. An estimate of 6,200 gallons per acre applied on alternate days was provide by Belt Collins & Associates. This volume was converted to 0.22 inches every other day per acre for 40 irrigated acres.

3. Temperature

As with precipitation, temperature measurements at Napoopoo were used to calculate site temperatures. For this calculation, Napoopoo temperatures were reduced by the wet adiabatic lapse rate of 3.2°F per 1,000 feet of elevation change (Petterrson, 1964). Table B-2 lists the estimated average monthly temperature at the project site.

4. Insolation

Available monthly solar radiation values for Honolulu were corrected for site conditions based on an overall yearly difference of approximately 12 percent (State of Hawaii, 1985). The difference is due primarily to the increased cloud cover in the

Kealakekua area during afternoon hours. Table B-3 lists Honolulu and estimated golf course insolation.

It is likely that using corrected insolation values from Honolulu may also result in seasonally higher calculated average evapotranspiration in the summer and lower evapotranspiration in the winter for the project site. Honolulu receives most of its sunshine and little precipitation during the summer months, while the project site receives more sunshine and less precipitation in the winter months. By applying the seasonally high summer insolation values from Honolulu to the seasonally high summer precipitation, there will be a resultant high summer evaportranspiration rate. The reverse will be true in the winter. It is expected that the overestimated summer evapotranspiration and underestimated winter evapotranspiration will average out in the annual evapotranspiration rate.

5. **Soil Parameters**

The soil types, presently covering the project site (Table 1) were taken from the U.S. Soil Conservation Service maps and descriptions (Soil Conservation Service, 1970; 1973). The thickness and permeability of these layers were also based on USCS estimates. The soils at the site are presently 1 to 2 feet thick underlain by basalt lava flows.

Prior to development of the golf course on site, the native soils are to be compacted or removed and covered with a layer of topsoil. The post-development soil profiles are shown on Plate 10. The soil parameters used in the HELP Model analyses for post-development soil profiles include reduced permeability of native soils due to compaction, and an additional layer of permeable top soil.

C. **Results of Analyses**

There are presently three soil types underlain by basalt at the project site (Table 1). Infiltration, evapotranspiration and runoff rates were calculated for each of these profiles using the HELP Model (Tables B-4 through B-6). The average annual precipitation at the site is approximately 54 inches. The calculated amount as lost to evapotranspiration for these soils is between 36 and 39 inches. The remaining 18 inches of precipitation infiltrate past the root zone depth. No runoff was occurred for any of the simulations.

The soil profile with the highest infiltration rate, the Kaimu series, is to be removed prior to development of the golf course and replaced with cinder soil. The remaining two soil types, along with the cinder soil, will be compacted for stability, be landscaped, seeded with grass, and irrigated to create the golf course fairways. Each of these soil layers will be capped with a one-foot layer of topsoil in the areas where greens are to be constructed.

Evapotranspiration, infiltration and runoff were calculated for each of these soil profiles as both greens and fairways. The results of these analyses are presented in Tables B-7 through B-9. With the addition of irrigation, the average mass inflow of water ($I_p + I_{irr}$) is 98 inches per year. As in the pre-development soil calculations, the evapotranspiration and infiltration rates are very similar for each of the post-development soil profiles. Approximately 68 to 74 inches are lost through evapotranspiration. The remaining 24 to 30 inches infiltrates past the route zone depth.

The greens built on each soil type have greater infiltration than the fairways soils, which is a result of the high permeability of the topsoil. The fairways on each soil type do not have a layer of topsoil and have a reduced permeability due to

CORRECTION

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

Kealakekua area during afternoon hours. Table B-3 lists Honolulu and estimated golf course insolation.

It is likely that using corrected insolation values from Honolulu may also result in seasonally higher calculated average evapotranspiration in the summer and lower evapotranspiration in the winter for the project site. Honolulu receives most of its sunshine and little precipitation during the summer months, while the project site receives more sunshine and less precipitation in the winter months. By applying the seasonally high summer insolation values from Honolulu to the seasonally high summer precipitation, there will be a resultant high summer evaportranspiration rate. The reverse will be true in the winter. It is expected that the overestimated summer evapotranspiration and underestimated winter evapotranspiration will average out in the annual evapotranspiration rate.

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Prior to development of the golf course on site, the native soils are to be compacted or removed and covered with a layer of topsoil. The post-development soil profiles are shown on Plate 10. The soil parameters used in the HELP Model analyses for post-development soil profiles include reduced permeability of native soils due to compaction, and an additional layer of permeable top soil.

C. Results of Analyses

There are presently three soil types underlain by basalt at the project site (Table 1). Infiltration, evapotranspiration and runoff rates were calculated for each of these profiles using the HELP Model (Tables B-4 through B-6). The average annual precipitation at the site is approximately 54 inches. The calculated amount as lost to evapotranspiration for these soils is between 36 and 39 inches. The remaining 18 inches of precipitation infiltrate past the root zone depth. No runoff was occurred for any of the simulations.

The soil profile with the highest infiltration rate, the Kaimu series, is to be removed prior to development of the golf course and replaced with cinder soil. The remaining two soil types, along with the cinder soil, will be compacted for stability, be landscaped, seeded with grass, and irrigated to create the golf course fairways. Each of these soil layers will be capped with a one-foot layer of topsoil in the areas where greens are to be constructed.

Evapotranspiration, infiltration and runoff were calculated for each of these soil profiles as both greens and fairways. The results of these analyses are presented in Tables B-7 through B-9. With the addition of irrigation, the average mass inflow of water ($I_p + I_{irr}$) is 98 inches per year. As in the pre-development soil calculations, the evapotranspiration and infiltration rates are very similar for each of the post-development soil profiles. Approximately 68 to 74 inches are lost through evapotranspiration. The remaining 24 to 30 inches infiltrates past the route zone depth.

The greens built on each soil type have greater infiltration than the fairways soils, which is a result of the high permeability of the topsoil. The fairways on each soil type do not have a layer of topsoil and have a reduced permeability due to

compaction. The infiltration rate in these soil types is thus slightly lower. Furthermore, using the estimated irrigation values, a small amount of runoff was generated in the fairways soils (0.04 to 0.18 inches per year) because of their relatively lower permeability.

The infiltration rate as a percentage of total precipitation and irrigation for each post-development soil profiles is lower than for pre-development soil profiles, in spite of the addition of approximately 42 inches per year of irrigation water. While one might expect infiltration to increase with additional water, the irrigation and cultivation of better grass result in an increase in evapotranspiration primarily caused by an increase in root depth and evaporativity of the planted surface.

LIST OF TABLES, APPENDIX B

Table	B-1	Estimated Average Monthly Precipitation for Kealakekua Bay Club
Table	B-2	Estimated Average Monthly Temperature for Kealakekua Bay Club
Table	B-3	Estimated Monthly Insolation Values Used in HELP Model
Table	B-4	Calculated Monthly Evapotranspiration and Infiltration for Waiaha Soils (Pre-Development)
Table	B-5	Calculated Monthly Evapotranspiration and Infiltration for Kainaliu Soils (Pre-Development)
Table	B-6	Calculated Monthly Evapotranspiration and Infiltration for Kaimu Soils (Pre-Development)
Table	B-7	Calculated Monthly Evapotranspiration and Infiltration for Waiaha Soils (Post-Development)
Table	B-8	Calculated Monthly Evapotranspiration and Infiltration for Kainaliu Soils (Post-Development)
Table	B-9	Calculated Monthly Evapotranspiration and Infiltration for Cinder Soil (Post-Development)

Table B-1. Estimated Average Monthly Precipitation for Kealakekua Bay Club

	Years 1985 - 1989	Long Term
	(inches)	(inches)
January	2.73	3.41
February	5.72	3.08
March	2.63	4.95
April	4.53	4.80
May	4.26	6.82
June	5.22	6.90
July	6.18	5.89
August	4.59	6.82
September	6.93	6.0
October	3.88	4.34
November	3.21	3.30
December	4.12	3.41
Annual	53.98	59.73

Table B-2. Estimated Average Monthly Temperature for Kealakekua Bay Club

	(°F)
January	69.7
February	69.8
March	70.2
April	71.2
May	71.7
June	72.6
July	73.5
August	74.3
September	74.0
October	73.5
November	71.9
December	70.8
Annual	71.9

Table B-3. Estimated Monthly Insolation Values Used in HELP Model

	Insolation (Langleys)	Reservoir 9 Station No. 737 on Oahu (Elev. 600 Feet)
January	343.30	348.2
February	372.32	418.9
March	423.04	457.1
April	481.88	498.6
May	533.08	511.7
June	562.90	557.4
July	563.37	578.6
August	534.35	560.4
September	483.62	516.7
October	424.78	453.2
November	373.59	381.0
December	343.77	348.3

From: Hawaii Sunshine Map. State of Hawaii, Department of Planning & Economic Development (1985).

Table B-4. Calculated Monthly Evapotranspiration and Infiltration for Waiaha Soils (Pre-Development)

	Evapotranspiration (in)	Infiltration (in)
January	2.2	0.9
February	2.6	2.9
March	2.4	0.5
April	3.6	0.9
May	3.9	0.4
June	3.7	1.4
July	5.2	0.9
August	4.0	0.8
September	4.6	2.0
October	3.4	0.8
November	2.1	1.1
December	2.0	1.9
Annual	39.5	14.6

Table B-5. Calculated Monthly Evapotranspiration and Infiltration for Kainalu Soils (Pre-Development)

	Evapotranspiration (in)	Infiltration (in)
January	2.0	1.0
February	2.3	3.4
March	2.1	0.6
April	3.4	1.1
May	3.7	0.5
June	3.5	1.7
July	5.0	1.1
August	3.7	0.9
September	4.5	2.3
October	3.1	1.0
November	1.9	1.3
December	1.9	2.1
Annual	37.1	17.0

Table B-6. Calculated Monthly Evapotranspiration and Infiltration for Kaimu Soils (Pre-Development)

	Evapotranspiration (in)	Infiltration (in)
January	1.8	1.0
February	2.2	3.5
March	2.0	0.7
April	3.4	1.1
May	3.7	0.6
June	3.5	1.8
July	5.0	1.2
August	3.7	1.0
September	4.5	2.4
October	2.9	1.0
November	1.8	1.4
December	1.9	2.1
Annual	36.3	17.8

Table B-7. Calculated Monthly Evapotranspiration and Infiltration for Waiahe Soils (Post-Development)

	GREENS		FAIRWAYS	
	Evapotranspiration (in)	Infiltration (in)	Evapotranspiration (in)	Infiltration (in)
January	4.7	2.1	4.8	1.5
February	4.7	4.1	4.9	4.2
March	5.4	1.3	5.7	1.3
April	6.0	1.8	6.3	1.4
May	6.9	1.2	7.4	0.7
June	6.5	2.3	6.9	2.2
July	7.4	2.1	7.7	1.3
August	6.9	1.9	7.2	1.9
September	6.2	3.6	6.6	2.8
October	5.8	2.4	6.1	2.3
November	4.7	2.0	5.1	1.4
December	4.4	3.4	4.8	3.3
Annual	69.5	28.4	73.6	24.3

Table B-8. Calculated Monthly Evapotranspiration and Infiltration for Kainaliu Soils (Post-Development)

	GREENS		FAIRWAYS	
	Evapotranspiration (in)	Infiltration (in)	Evapotranspiration (in)	Infiltration (in)
January	4.5	2.4	4.8	1.7
February	4.5	4.4	4.8	4.3
March	5.3	1.4	5.6	1.2
April	5.9	1.9	6.3	1.5
May	6.9	1.3	7.4	0.8
June	6.2	2.4	6.8	2.3
July	7.3	2.2	7.6	1.5
August	6.7	2.0	7.2	1.9
September	6.2	3.6	6.5	3.0
October	5.6	2.3	6.1	2.2
November	4.6	2.2	5.0	1.5
December	4.3	3.6	4.7	3.5
Annual	68.0	30.0	72.5	25.3

A Report Prepared for

Royal Coast Development Company
P.O. Box 44394
Kawaihae, Hawaii 96743

SUBSURFACE PESTICIDE MIGRATION STUDY
KEALAKEKUA BAY CLUB
SOUTH KONA, ISLAND OF HAWAII, HAWAII

HLA Job No. 19913.001.06

by

for Lane K. Masatsugu
Project Engineer

Patti A. Homan
Project Geologist

John J. Ward
Geologist - 4101 (California)

Harding Lawson Associates
803 Kamehameha Highway, Room 404
Pearl City, Hawaii 96782

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EXECUTIVE SUMMARY

This report presents the results of a study to evaluate the migration and fate of pesticides and fertilizers that may be applied to the proposed Kealakekua Bay golf course. The study was conducted to assess proposed pesticide and the soil and environmental conditions that would minimize migration beneath the root zone.

The golf course is to be located on a parcel above Kealakekua Bay between 600 and 1,100 feet elevation. Massive basalt, topped by a soil layer averaging 2 feet thick, will separate the golf course from the underlying groundwater discharging into the bay.

The impacts of pesticide use on the environment are expected to be minimal because of integrated pest management procedures and use of pesticides having very low mobility, toxicity, and persistence in the environment. Foliar application of fertilizer will provide the highest use of these fertilizers by the sod and will result in the reduction of fertilizer requirements. Of the fertilizers proposed for use, only nitrogen is likely to migrate below the root zone.

A set of mathematical models were used to provide predictions of pesticide and fertilizer migration in the soils, basalt, and groundwater. Pesticide transport, retardation, diffusion and decay were simulated, using measured and estimated pesticide properties, conditions of site soils, irrigation and precipitation, and properties of basalt. Results of the pesticide simulations showed that concentrations were reduced several thousand-fold using estimated average conditions. Under these conditions, pesticide concentrations would likely be nondetectable by the time infiltrating water penetrated the upper 24 inches of soil and entered the top of the basalt.

Additional simulations were conducted to test how variations in the input parameters affected the reduction in concentrations. Results of these simulations also

showed very high concentration reductions within the soil layer prior to reaching the top of basalt. Migration through golf greens showed less concentration reduction although the reduction was still significant.

Proposed foliar application of fertilizer should result in a 90 percent utilization of applied nitrogen by the growing plant. The remaining 10 percent has the potential of migrating below the root zone. If the remaining nitrogen migrated through the 600- to 1,000-foot-thick basalt layer to groundwater, the nitrogen content of the groundwater may increase by about 70 parts per billion. Ambient groundwater concentrations of nitrogen ranges between 1,300 and 1,500 parts per billion. Because of mixing and ambient bay concentrations, effects of this potential increase in nitrogen content are expected to be minimal.

The results of this study indicate that by having adequate soil thickness and proper soil conditioning, by using pesticides with low mobility and persistence in the environment, and by adhering to integrated pest management practices, migration of pesticides below the root zone is not likely to occur. By adhering to best management practice with regard to applications of irrigation and fertilizer, migration of nitrogen below the root zone and potentially into the groundwater may be minimized.

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I INTRODUCTION

Royal Coast Development Company plans to construct a golf course on 260 acres of land between Napoopoo Road and Kealakekua Bay in South Kona, Hawaii. The proposed Kealakekua Bay Club will include a world-class championship golf course with clubhouse and restaurant, and a low-profile, low-density 36-room members' lodge. The proposed golf course will be located approximately 13 miles south of Kailua, Hawaii (Plate 1). Most of this land is presently unused except for occasional cattle grazing.

The golf course will be situated on a terrace overlooking Kealakekua Bay. The bay has been designated as a marine conservation district by the State of Hawaii Department of Health. Recognizing the importance of preserving this state marine park, Royal Coast Development Corporation retained Harding Lawson Associates (HLA) to conduct a study using available data to simulate the subsurface migration of pesticides and fertilizers that would be applied to the proposed golf course. Computer techniques were applied to model the movement and fate of proposed pesticides and fertilizers in the subsurface environment.

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II ENVIRONMENTAL SETTING

A. Geology

The golf course site is near the west coast of the island of Hawaii. The site is between elevations of approximately 600 to 1,100 feet above mean sea level (MSL) at the top of an escarpment overlooking Kealakekua Bay.

The island of Hawaii was formed by the eruptions of basaltic lava and other volcanic ejecta from five volcanoes. Thousands of successive lava flows from each volcano dip away from the eruptive centers. Individual lava flows are usually less than 25 feet thick. The surface rocks in the vicinity of the site are from Mauna Loa Volcano (Plate 2). At depth, lavas from Hualalai may interfinger with the lavas from Mauna Loa (MacDonald et al., 1983). Mauna Loa is still active, with recent lava flows on its slopes in other areas.

The rocks underlying the site are of Recent or Late Pleistocene age and are generally fresh, unweathered basalt. A thin mantle of rocky soil has developed on the surface at the site. The cliff to the west of the site is a fault scarp; the down-thrown side is mostly below the ocean surface in Kealakekua Bay and the ocean further to the west. An earthquake in 1951 was caused by movement on the fault at a location approximately 1 mile off-shore (MacDonald et al., 1983). Approximately 600 feet of the lavas that underlie the site are exposed on the face of the cliff. The lava beds dip about 12 degrees to the southwest.

B. Soil Conditions

Four general soil types are present at Kealakekua Bay Club (Plate 3). The central section of the project site is covered by soils of the Waiaha Series on the west and the

Kainaliu Series on the east. Both soil series are silty loams derived from volcanic ash. A'a lava covers the west end of the project site, and soils of the Kaimu Series cover the north central half of the project site. The Kaimu Series consists of well-drained peat derived from organic matter and volcanic ash.

Soil samples were collected from several areas on site to evaluate their suitability for use on the golf course. Laboratory tests included saturated permeability, organic carbon content and void ratio. Both published (Soil Conservation Service, 1970; 1973) and laboratory data are listed in Table 1.

The large differences between published and laboratory-tested permeabilities listed in Table 1 are due to the test methodology. The SCS values are estimates based on infiltration rates; the laboratory tests were conducted on remolded soils, compacted to 85 percent of optimal density. The results indicate that field compaction of these soils, which contain a large ash component, should be handled carefully to ensure that the soils retain a higher permeability than the values listed in this table.

Soil samples were also collected from the project site by Faust (1990b) for evaluation of mineralogic properties. Organic carbon content of these samples ranged between 2.7 and 9.2 percent, and averaged 5.0 percent. Cation exchange capacity ranged between 19.6 and 29.4 milliequivalents per 100 grams (meq/100 gms), and averaged 23 meq/100 gms. These values indicate the soils have a high affinity (adsorptive capacity) for both organic and ionic chemicals.

C. Hydrogeology

1. Groundwater Flow

The occurrence of groundwater in the Kona coastal aquifer is shown conceptually on Plate 4. The basal lens of fresh water floats on top of the heavier salt

water due to the density difference between the fresh and salt water. The fresh water characteristically forms a lens-shaped body floating over the saline water known as the Ghyben-Herzberg lens. This lens is dynamic due to variations in water discharge, tidal action, and recharge. No wells have been drilled deep enough near the project site to directly measure the thickness of the Ghyben-Herzberg lens. However, based on groundwater elevation data, this lens is expected to be less than 80 feet thick beneath the project site. Groundwater elevations (Plate 5) beneath the project site are estimated to range up to 1.5 feet above mean sea level (MSL).

Groundwater flows seaward and discharges along the coast. At the project site, groundwater is expected to flow southwest into Kealakekua Bay. Plate 5 shows the location of suspected fresh-water springs near the project site (Fischer et al., 1967). One of these fresh-water springs is located in Kealakekua Bay near Napoopoo but is not directly downgradient of the proposed golf course.

Estimates of groundwater flow rates were reported by the Hawaii Water Resources Regional Study (1975) for five hydrographic areas on the island of Hawaii. The authors estimated infiltration to be 20 percent of rainfall and groundwater flow to be 4 million gallons per day (mgd) per coastland mile in dry areas and 10 mgd per coastland mile in rainy areas. The project site is located in one of the wetter areas of Hydrographic Area IV.

In general, Hawaiian basaltic lavas show high permeability and yield water readily to wells. Porosity in the rock is due to vesicles, joints, cooling fractures, clinker beds, lava tubes, ash and buried soil layers, tree molds and blisters. The features are more abundant in the direction of dip, and permeability is usually much higher in the horizontal than in the vertical direction.

Kanehiro and Peterson (1977) estimated the hydraulic conductivity for North Kona basalts at 3,369 feet per day by tidal analysis and 9,092 feet per day by water budget analysis. A regional value of 5,000 feet per day is commonly used in hydraulic studies on Hawaii. Effective porosity is estimated to be 0.10 (Kanehiro and Peterson, 1977; Mink, 1988).

Basalt is highly anisotropic with respect to permeability. Souza and Voss (1987) estimated that anisotropy varies between one and three orders of magnitude. In modeling the southern Oahu groundwater system, the authors found that a ratio of horizontal to vertical hydraulic conductivity of 200:1 provided the best match during model verification.

2. Groundwater Use

Locations of water wells in the vicinity of the project site are shown on Plate 5. Table 2 lists these water wells. The closest water well to the project site is Well 2753-01, approximately 9,000 feet east and 5,500 feet south of the project site. This well is used for drinking water supply by the County of Hawaii.

The Underground Injection Control (UIC) line is located near the coastal boundary of the proposed golf course (Plate 5). The UIC line separates, in plan view, aquifers (or portions of aquifers) that supply public or private drinking water from exempt aquifers (aquifers or portions or aquifers that do not supply drinking water and that can accept spent fluids).

No injection wells are located seaward of the UIC line in the vicinity of the project site. However, five injection well systems are located inland of the UIC line and approximately half a mile upgradient of the southern half of the project site. These systems were installed prior to the establishment of the UIC program.

3. Groundwater Quality

A chloride concentration of 1,500 milligrams per liter (mg/l) was measured from a dug well (Well 2855-01) located 800 feet inland from Kealakekua Bay at Napoopoo (Plate 5). The high permeability of the basalt allows seawater intrusion and mixing of fresh and saline water near the coast. Shallow groundwater may be brackish for more than half a mile inland from the coast.

The nitrogen content of groundwater from data presented in Table 3, from unpublished County of Hawaii chemical reports for South Kona District, and from measurements collected by Marine Research Consultants (1991) ranges from 940 to 1,740 parts per billion (ppb). Likely concentrations of nitrogen beneath the site ranges between 1,300 and 1,500 ppb.

D. Site Climate

1. Rainfall

The rainfall map for the Island of Hawaii is shown on Plate 6. The Kona coast experiences a seasonal rainfall regime unique to the Hawaiian Islands with summers being wetter than winters. For most other parts of the Hawaiian Islands, winter receives the highest average rainfall.

Table 4 lists the average monthly rainfall for two nearby rain gauge stations, Napoopoo (Elevation 480 ft MSL) and Kealakekua (Elevation 1,440 ft MSL). Rainfall differences between the two stations are due primarily to elevation, with an average of 2-1/4 inches of precipitation change per 100-foot elevation change between the two sites. On this basis, average annual precipitation at the proposed golf course would likely range between 50 inches near the pali to 60 inches near the mauka site boundary.

2. Temperature

Air temperature records have been kept at the Napoopoo Station for over 40 years. Temperatures range from an average monthly maximum of 84.7°F in August to an average monthly minimum of 62.5°F in February. At the proposed golf course, the elevation difference would likely result in average temperature being 1-1/2° to 3°F less than those measured at Napoopoo. The calculation of estimated average monthly temperatures on site would range between 72° to 74°F in August, and 68° to 71°F in February. The calculation of estimated site temperatures is discussed in Appendix B.

3. Evapotranspiration and Infiltration

Pan evaporation at Kealakekua Bay has been estimated at 60 inches, and for the site, 50 to 55 inches (Ekern and Chang, 1985). Pan evaporation is generally considered the limit of actual evapotranspiration where water availability is not the limiting factor. Actual evapotranspiration on site is expected to be somewhat less than pan evaporation due to seasonal variations in the availability of water.

Average annual precipitation on site likely ranges from 55 to 60 inches. Potential for infiltration past the root zone (deep infiltration) exists on a regional basis. A water budget analysis of the soil surface (Appendix B) indicates that site pre-development evapotranspiration averages 36 inches per year, or nearly 70 percent of precipitation. Deep infiltration (infiltration beyond the root zone) accounts for most of the difference, averaging 18 inches per year, or 30 percent of precipitation.

III IRRIGATION, PESTICIDE AND FERTILIZER USE

A. Irrigation

Anticipated golf course irrigation at Kealakekua Bay Club is estimated at 3,100 gallons per acre per day on average, based on the irrigation requirements at Kona Country Club (Belt Collins & Associates, 1990) and the mean annual irrigation rate for golf courses in the state of Hawaii (Hollyer, 1990). Both the Kealakekua Bay Club and the Kona Country Club have similar annual rainfall (Department of Land and Natural Resources, 1982) and evaporation totals (Ekern and Chang, 1985).

The estimated irrigation rate is equal to about 42 inches of water annually. Actual irrigation scheduling will be determined based on turfgrass needs. On the basis of the water budget presented in Appendix B, the estimated annual irrigation rate will probably not be required, except in drier-than-average years.

B. Pesticide Use

Integrated pest management (IPM) concepts will be used to control turf diseases and pests. IPM programs rely on proper identification and monitoring of pest life cycle and biology in order to select and apply effective management practices. Careful monitoring can effectively reduce pesticide application, thereby reducing costs and adverse effects to beneficial organisms (Environmental Impact Consultants, 1990). Table 5 lists the proposed pesticide program.

The leaching potentials for the two herbicides listed in Table 5, MSMA and glyphosate, are presented in Table 6. The leaching potential of a chemical refers to its mobility and persistence in the subsurface environment and, to a lesser degree, its solubility. Mobility is characterized by the soil sorption index or organic carbon partition coefficient (K_{OC}). A large K_{OC} indicates that the chemical would tend to be adsorbed

onto soil particles and is less likely to migrate with water. Persistence is characterized by its biochemical half life. Chemicals with large K_{OC} values and low biochemical half lives have low leaching potentials and are less likely to cause environmental pollution.

The insecticide Pyrellin (Table 6) contains two synergistic chemicals, rotenone and pyrethrins. Combined, these make up approximately one percent of Pyrellin. Annual usage of the two chemicals at the golf course is estimated to be 0.06 gallons for pyrethrins and 0.05 gallons for rotenone (Table 5).

A literature review showed that environmental fate information for rotenone and pyrethrins is limited. We contacted the other members of the project consultant team, state Department of Agriculture, U.S. EPA, and the distributor of Pyrellin, CCT Corporation. Estimates of the properties for the two chemicals, based on this review, are listed in Table 6.

Plate 7 shows the pollution potential classification system developed by Jury et al. (1987). This classification system can be used to rapidly screen the pollution risks of pesticides according to their organic carbon coefficients and biochemical half lives. Using this screening procedure, MSMA, glyphosate and pyrellin would pose low-pollution risks.

C. Fertilizers

Fertilizers are normally applied to only the greens, tees, fairways, and part of the roughs of a golf course. Turfgrass fertilization includes nitrogen (N), phosphorus (P), and potassium (K), with nitrogen and phosphorus the primary fertilizer elements of concern for contamination of ground and surface waters (Murdoch and Green, 1989). Phosphorus bonds well with iron and aluminum hydroxides, which are commonly found in abundance in volcanic-derived soils. This bonding minimizes the potential for

The two models and processes simulated are as follows:

Soil Model (1-D):	Advection (Unsaturated) Dispersion, Diffusion, Retardation, Decay
Basalt Model (2-D):	Advection (Saturated and Unsaturated) Dispersion, Diffusion

The construction of the two models are shown on Plates 8 and 9.

1. Saturated Flow

Groundwater occurs beneath the site at depths between about 700 and 1,100 feet, at an elevation between 0 and 1.5 feet MSL, and flows southwesterly to its discharge area in Keelakekua Bay. Based on regional groundwater conditions discussed earlier, the following values were used for modeling the saturated zone:

- Groundwater discharge is approximately 8 million gallons per day (MGD) per mile of shoreline, or approximately 202 cubic feet per day parallel to the model cross section;
- Hydraulic gradient is 2 feet per mile;
- Hydraulic conductivity is 5,000 feet per day;
- Effective porosity is 10 percent; and
- Thickness of the fresh-water lens is 70 feet at the upgradient side, and 40 feet at the point of discharge into the bay.

2. Unsaturated Flow

The unsaturated zone occurs from the land surface to the water table, a distance of between 700 and 1,100 feet beneath the proposed golf course. The unsaturated zone consists of a thin layer of surface soil underlain by volcanic basalt flows. Because of the mineralogical, hydrologic, and biologic properties of the soil, and the thickness of the basalt above the regional groundwater, the unsaturated zone is expected to provide significant protection from pesticide migration to groundwater.

a. Unsaturated Flow in Soils

The profile of soil zone will vary throughout the golf course because of the different soil types existing at the site and the different construction practices for the various golf course areas. As presently envisioned, soil profiles for fairways, greens and tees will be as shown on Plate 10. Soil properties shown on the plate are discussed below and in Appendix B.

b. Unsaturated Flow in Basalt

Unsaturated flow in fractured rocks is a poorly understood phenomena (e.g., Evans and Nicholson, 1987). Although the conduits for flow typically exhibit extremely large, saturated hydraulic conductivities, they dewater rapidly and become very resistant to flow under unsaturated conditions. Unsaturated hydraulic conductivities of fractured rocks are usually several orders of magnitude smaller than those for most soils at equivalent soil matric potentials (Hillel, 1971; Rasmussen, 1987). The relationship of hydraulic conductivity to matric potential has been estimated for the basalts underlying the site based on published information for similar rock types (Evans and Nicholson, 1987; Barnes, 1989; Preuss and Wang, 1987; Wang and Narasimhan, 1985; Stephenson and Freeze, 1974). The analysis is presented in Appendix A.

B. Pesticide and Fertilizer Transport and Fate

1. Pesticides

The pesticides proposed for use at the golf course that may have an environmental impact are glyphosate, MSMA and Pyrellin (Tables 5 and 6). The application rates and leaching properties of these chemicals were discussed earlier.

phosphorous contamination of drainage water (Murdoch and Green, 1989). Ammonium nitrogen (NH_4), the most common form of nitrogen in fertilizer applications, moves only slowly through soil, but is rapidly converted to nitrate (NO_3), which is soluble. Nitrate will usually be used rapidly after application in the production of new turfgrass. However, overfertilization, overirrigation, or excessive rainfall could result in nitrates migrating below the root zone. The highly organic soils beneath the site presently contain excess nitrogen (Faust, 1990a).

As presently envisioned, nitrogen will be applied to the golf course as a foliar spray. Approximately 10 pounds per acre per month (lbs/ac-mo) may be applied to fairways, and twice that amount may be applied to greens and tees, for an average of about 12 lbs/ac-mo over the entire golf course (Faust, 1990b). Because of the high natural levels of nutrients in soils, the planned nitrogen application rate is less than half of that used on average for golf courses in Hawaii (Murdoch and Green, 1989).

At an efficiency of 90 percent (Faust, 1990b) foliar application of nitrogen provides the least opportunity for excess nitrogen to migrate beneath the root zone and become a potential groundwater contaminant. Excess nitrogen, based on expected application rates and efficiency, is 1.2 lbs/ac-mo.

The calculated volume of post-development deep infiltration (past the soil zone) from the water budget analysis (Appendix B) is approximately 61,000 gallons/ac-mo. The increase in nitrogen (as N) concentration for excess applied nitrogen is 2.35 milligrams per liter. The predicted increase in concentration of nitrogen in the groundwater beneath the project site is discussed in a later section.

IV SIMULATION OF SUBSURFACE FLOW AND TRANSPORT

A. Conceptual Model of Saturated and Unsaturated Flow

Groundwater flow is inherently three-dimensional. Infiltration moves downward in response to gravity and upward in response to capillary pressures. Groundwater generally flows in a nearly horizontal direction. Significant local variations in flow direction may occur due to differences in infiltration rates, anisotropy and inhomogeneity of the media. It is beyond the scope of these simulations to include all of the features in the soils or basaltic bedrock that may influence horizontal groundwater flow or vertical infiltration. These features are neither known with enough certainty to justify their inclusion, nor are they of sufficient importance on the scales of these simulations.

In cross section, the subsurface beneath the developed golf course will typically consist of the following: 1) a biologically active zone (root zone) about 1 foot thick; 2) a layer of reworked native soil, between 0 and 1 foot thick; 3) massive basalt to the water table, 700 to 1,100 feet thick; and 4) the saturated zone (water table).

Within the soil layers, moisture movement is predominantly vertical. Within the basalt layers above the water table, moisture movement is primarily downward due to gravity, but with a significant horizontal component caused by partings along nearly horizontal bedding planes. Within the saturated zone, groundwater movement is nearly horizontal.

Groundwater flow and transport at the site was simulated using both one-dimensional (1-D) and two-dimensional (2-D) cross-sectional models. The location of the 2-D model cross section is shown on Plate 5. This particular section was chosen because the maximum golf course acreage lies along the section.

Pesticides are applied to the surface of the golf course in liquid or granular/powdered form. They are introduced into the soil dissolved in the irrigation and rainfall water. Upon entry into the soil, the dissolved concentration of pesticides is dependent on many factors, including pesticide solubility, antecedent moisture condition, previous and current applications, and irrigation and rainfall rates.

To simplify the numerical analysis, surface processes such as seasonality of pesticide application, rainfall and irrigation rates were not simulated. Instead, only average long-term recharge rates, and a constant pesticide input were simulated.

The following four processes were simulated in the 1-D Soil Model:

a. Advection

Advection refers to movement at the same velocity as groundwater or soil moisture. The advective velocity is equal to the recharge rate divided by the moisture content (fraction of the soil pore space that is fluid filled). The advection equation for saturated and unsaturated flow is presented in Appendix A.

b. Dispersion and Diffusion

Solutes spread as they travel due to flow-path tortuosity (dispersion) and diffusion into the rock matrix. Both of these processes cause the concentrations of the solute to decrease. The spread of a solute parallel to flow is called longitudinal dispersion; spread perpendicular to flow is called transverse dispersion. The effect of dispersion is to reduce the concentration of solutes at any point along the flow path as well as shorten their arrival time.

Constant dispersion values were used for the simulations. For the basalt (2-D) model, a longitudinal dispersion of 100 feet, a horizontal transverse dispersion of 10 feet and vertical transverse dispersion of one foot were used. For the

soil layers (1-D soil model), only longitudinal dispersion was used. A value of one foot was used.

c. Retardation

Retardation is caused by adsorption of solute from solution on soil particles. The presence of organic matter and clays in the soil enhances adsorption. Adsorbed solute will also be subject to desorption. The net effect of sorption is that the solute velocity is retarded with respect to the water velocity. The retardation coefficient, K, is a measure of retardation and is defined as:

$$K = \frac{V_w}{V_s} = 1 + |\rho \cdot K_d/M_w|$$

where:

$\frac{V_w}{V_s}$ is the water velocity divided by the solute velocity,

ρ is the bulk density of the media,

M_w is the water content as a fraction of saturation,

K_d is the partition coefficient.

From the relationship above, the larger the partition coefficient, the slower the solute migrates with respect to water. The partition coefficient for a particular organic solute is defined in terms of K_{oc} (Table 6) and the fraction of organic matter in soil, f_{oc}:

$$K_d = K_{oc} \cdot f_{oc}$$

Organic carbon content, bulk density and porosity for the soils at the site have been measured in the laboratory. Table 1 lists the measured values of these soil properties. Carbon contents listed in Table 1 are considered higher than

average. Use of these high values in the simulations would produce unrealistically low pesticide migration rates. Values of 2.5 to 5 percent were used in the simulations, based on averages from other organic carbon content determinations (Faust, 1990b). Table 6 lists retardation coefficients calculated using the above equations. For the basalt 2-D model, zero retardation was simulated.

d. Decay

The loss of pesticides from solution in soil moisture through microbial action, plant uptake, non-reversible sorption, and volatilization is treated in these simulations by using a decay factor. The decay factor is related to published half lives for pesticides by:

$$\lambda = \frac{\ln(2)}{t_{1/2}}$$

where:

λ is the decay factor,

$t_{1/2}$ is the half life.

Thus, longer half lives indicate lower rates of decay. Estimates of half lives in soil for the pesticides proposed for use at the golf course are listed in Table 6. For the basalt 2-D model, zero decay was simulated.

2. Fertilizers

Migration of fertilizers was not directly simulated. Because nitrogen is the nutrient most likely to migrate below the root zone if applied in excess of plant requirements and because retardation and decay would not likely influence its migration to the water table, only nitrogen transport in the basalt and dilution in the groundwater were calculated.

C. Numerical Simulation of Flow and Transport

1. Description of Numerical Model

Unsaturated flow and transport may be simulated numerically or calculated analytically. The use of numerical methods to evaluate the migration of contaminants in the subsurface is usually required because few analytical solutions are available, and these solutions are only for a few very simple and highly idealized conditions. The complexity inherent in real world flow systems, such as reactive solutes, heterogeneous and anisotropic soils, variable boundary and soil moisture conditions, and the inherent non-linearity of unsaturated flow problems, cannot be readily evaluated using analytical solutions.

The numerical solution chosen for simulation of fluid and transport is an HLA-developed computer code called ATLAS-Solute. ATLAS is a family of finite-element computer codes that simulate the movement of fluid, solutes, and energy in saturated and unsaturated porous media. The programs have the capability of handling a complete surface to atmospheric energy balance on the boundary. ATLAS has been used extensively to solve flow and transport problems in variably saturated media, including groundwater flow and transport at the Rocky Mountain Arsenal near Denver, Colorado, as part of a large federal remediation effort; unsaturated flow in support of siting of a low-level radioactive waste repository in California, being performed for the California Department of Health; unsaturated flow in a desert basin in Arizona, in support of siting of RCRA permitting of a Class I hazardous waste treatment and disposal facility; and freeze- and thaw-controlled heat transport from oil pipelines in the arctic tundra. The code has been extensively verified and validated through comparison of model results with analytical solutions, laboratory and field measurements, and other

numerical results. A complete description of the model, including model validation runs, are available in HLA offices.

2. Model Geometry and Boundary Conditions

To simulate pesticide transport, retardation and decay in the near-surface soils, a 1-D (vertical dimension only) soil model was developed (Plate 8). The soil model simulates vertical unsaturated advection, diffusion, decay and retardation within the soils, and was used to assess pesticide attenuation and provide estimates of pesticide flux into the underlying basalt.

To simulate both saturated and unsaturated flow, and pesticide transport within the basalt, a 2-D basalt model was also constructed (Plate 9).

a. Soil Model Boundary Conditions

The top boundary of the 1-D soil model represents the surface of the golf course. The top boundary has a unit width. On this boundary, a set recharge rate was applied, equal to the estimated average annual infiltration during operations (Appendix B). Also on this boundary, solute concentrations were set equal to one for the duration of the simulations after steady-state flow conditions were established.

The left and right boundaries are zero flux boundaries. Transverse (horizontal) migration of solute and fluid are not included in 1-D simulations.

The bottom boundary represents the water table within the basalt. The boundary was assigned a pressure of zero (water table) and was included in the soil model only to provide an appropriate lower boundary condition.

b. Basalt Model Boundary Conditions

The top boundary and the upper left boundary of the 2-D model (Plate 9) is the surface of the basalt. This boundary extends from Kealakekua Bay

inland 3,800 feet to a point at an elevation of approximately 1,220 feet above MSL, or approximately 1,200 feet upslope of the eastern edge of the proposed golf course. On this boundary, a recharge rate equal to the average annual infiltration rate (Appendix B) was set.

The bottom boundary represents the saltwater/fresh-water interface of the basal aquifer. This boundary is considered a constant flux (flux = 0) boundary. Thus, the saline water aquifer is not included in these simulations.

The lower left boundary represents the interface of the fresh-water lens with Kealakekua Bay. Simulated aquifer thickness is 40 feet at this point, and the hydraulic head is set to 0 feet above MSL. This is the point of discharge for all simulated fluid in the model.

The right boundary is also considered a constant flux boundary. The boundary length between the land surface and the water table is a zero-flux boundary. The lower right boundary, between the water table and the base of the model, is a prescribed flux boundary, where flux has been set to the average groundwater flow rate. The groundwater flow rate was varied for some simulations to assess how these groundwater flow estimates affected solute concentrations at the point of discharge.

3. Material Properties

a. Soil Zone

The important material properties for soils in these simulations are the matric potential-hydraulic conductivity relationship, the matric potential-soil moisture relationship, and solute retardation properties. The soil moisture and hydraulic conductivity relationships are developed in Appendix A based on site soils data (Soil

Conservation Service, 1973), laboratory measurements of saturated hydraulic conductivity and porosity, and from characteristics developed for similar Hawaiian soils (Plate A-1, Appendix A, after Green et al., 1982). The hydraulic conductivity and moisture retention curves are shown on Plate A-2 in Appendix A.

b. Basalt Layer

For modeling purposes, the sequence of basalt flows beneath the site has been treated as a single anisotropic material with properties as shown on Plate A-3 in Appendix A. The vertical hydraulic conductivity is assumed to be a factor of 100 smaller than the horizontal hydraulic conductivity. The saturated horizontal hydraulic conductivity is 5,000 feet per day, and the effective porosity is 10 percent. A discussion of the development of these curves is given in Appendix A.

4. Initial Conditions

The flow system (both saturated and unsaturated) was assumed to be in a steady-state moisture condition on an average annual basis. Therefore, the initial moisture conditions, matric potentials, and hydraulic conductivities of the unsaturated zone were calculated by the model on the basis of the imposed boundary conditions on the upper and lower model surfaces and on the soil moisture and hydraulic conductivity characteristics. These initial conditions were determined by the infiltration rate imposed on the top model surface, and for the basalt model, the groundwater inflow rate imposed along the lower right model boundary. Once these conditions were set, the models were run to a steady-state condition prior to simulation of pesticide migration.

5. Model Simulation Scenarios

The purposes of these model simulations are: 1) to predict concentrations of pesticides at the point of groundwater discharge to Kealakekua Bay; and 2) to evaluate the sensitivity of the model predictions to uncertainties in transport and hydrologic conditions. The objective of the sensitivity analysis was to identify and prioritize critical soil, pesticide and climatologic properties that require better definition in order to more accurately predict pesticide movement.

For a baseline prediction of concentrations, we used "average" or nominal flow and transport parameter values and our current understanding of golf course design. It is important to emphasize, however, that even though the nominal values provide a starting point from which sensitivity analyses can be performed, the nominal case itself is subject to uncertainty. Where the range of possible parameter values was large, the nominal value chosen was usually the mean value within the range.

a. 1-D Soil Model Scenarios

The average retardation and decay values, soil thickness, hydraulic conductivity and infiltration rates are listed as the Nominal Case in Table 7.

Of the four processes simulated, we tested the sensitivity of three. (Dispersion was not tested because this parameter is not expected to greatly influence the transport of pesticides in soils.) The values that each parameter was varied are listed under Cases 2 through 10 in Table 7.

b. 2-D Basalt Model Scenarios

The objectives of the basalt model simulations are to: 1) predict the concentration of pesticides in groundwater at the point of groundwater discharge using estimated average hydrologic conditions and material properties; and 2) assess

the model sensitivity to uncertainties in site hydrologic conditions and material properties.

Values of hydraulic conductivity (from Appendix A), dispersion, groundwater flow rates, and infiltration rates (Appendix B) used for the basalt model are listed in Table 8. Case 1 lists the average or nominal values used in the simulations. Cases 2 through 7 list the values that these parameters were varied in subsequent sensitivity runs.

6. Model Assumptions and Limitations

Although the numerical model may simulate both flow and transport in a complex and heterogeneous system, it must be kept in mind that this and all modeling (both numerical and analytical) require that simplifications be made in order to achieve a solution. It is not possible to simulate all the large and small scale features, even if known, that may influence flow and transport in the system being studied. It is up to the modeler, therefore, to choose a limited set of parameters that are critical to evaluation of the problem. Once accomplished, the model will then simulate the general features of the system.

The mechanisms for variably saturated flow and solute movement in fractured and cavernous basalt are presently only poorly understood (Evans and Nicholson, 1987), and comparison with experimental results is generally not possible. Despite these restrictions, however, modeling of these environments has been successfully applied (e.g., Stephenson and Freeze, 1974; Peters and Klavetter, 1988).

It is also important to keep in mind that, because the site has not been constructed, limited site-specific data are available for model calibration. Test plot

experiments will provide these site-specific data regarding moisture movement, pesticide fate, and fertilizer requirements. These test plots are currently being planned.

Assumptions used in this modeling include the following:

1. The initial distribution of moisture in the 1-D soil model is defined by the conditions of constant flux imposed on the upper boundary and constant pressure imposed along the lower boundary. This assumption means that the system is presently in steady state.

2. Moisture movement occurs only in response to gravitational and capillary forces acting on a single fluid with the density and viscosity of water. Osmotic pressures are not directly considered. This assumption would tend to cause moisture and solute movement to be slightly overestimated.

3. On the scale of these simulations, the fractured basalt behaves as an anisotropic porous media with equivalent properties of hydraulic conductivity. Unless the basalt contains extensive and continuous vertical fractures, then this assumption would tend to cause vertical flow in the basalt to be slightly overestimated.

4. Gas and vapor-phase movement are not considered.

5. Soil moisture hysteresis is not considered (i.e., hydraulic conductivity is a single-valued function, independent of whether the soil is wetting or drying). This assumption has only a small effect on soil moisture movement.

6. Only one solute is simulated, with average retardation and decay properties. Solute interactions are not considered. Given the low concentrations of the solutes of interest, solute interactions are not expected to be significant.

V RESULTS OF SIMULATIONS

The results of simulations of transport and fate of pesticides in the unsaturated soils beneath the golf course are presented on Plates 11 through 16. Each plate shows concentration, C, of a pesticide as a fraction of the applied concentration, Co, versus depth in the soil layer.

The results of pesticide transport within the basalt and groundwater are presented on Plates 17 through 19. Each plate shows relative concentrations in groundwater at the simulated point of groundwater discharge into the bay.

A. Results of Golf Course Soils Simulations

1. Average Assumed Conditions

The concentration distribution of pesticide within a 1-1/2-foot-thick soil layer is shown on Plate 11. Results indicate that pesticide concentrations are reduced in the soil to less than one in one hundred thousandth of the concentration at the surface. These results would be most applicable to the pesticide component pyrethrin, the pesticide with the highest mobility of those listed in Table 5.

If we assume that Pyrellin was applied once per year at the application listed in Table 5, and was diluted with one day's irrigation, then the initial concentration of pyrethrin would be 0.05 to 0.08 parts per million. Using results of the nominal case simulation, the concentration of this chemical would be 0.0005 to 0.0008 parts per billion (0.5 to 0.8 parts per trillion) at the base of the soil layer.

2. Sensitivity Analysis

a. Effect of Greens

An additional soil layer was added to the model to simulate migration through golf course greens. The simulated soil has high infiltration potential and half the organic carbon content of the native soils.

Because the simulated native soil is buried under 1 foot of green (Plate 10), the decay rate was reduced by a factor of 10 in the lower soil, which simulated lower microbial activity below the root zone.

Results of this simulation are shown on Plate 12. At the base of the green, concentrations have been reduced to approximately 8 percent of the initial concentration. At the base of the soil layer, concentrations have been reduced more than two orders of magnitude, to about 0.7 percent of the initial concentration.

Although these are significant reductions, they are still 2 to 3 orders of magnitude larger than results from the average conditions, Plate 11. This difference is due largely to the increased infiltration rate and lower organic carbon content of the sandy soils that comprise the greens.

b. Effects of Variability of Pesticide Decay Rate

Pesticide decay, through microbial and chemical degradation and volatilization, is the only mechanism for removal of solute mass in the model. To evaluate the sensitivity of model results to variability in this parameter, several simulations were run with a range of decay values. Results for three such runs are shown on Plate 13.

Results show moderate sensitivity to pesticide decay rates. Even at the lowest decay rate (corresponding to a half life of about 100 days), simulated

concentrations at the base of the soil layer were reduced to 1/8000 of the original concentration. For high rates of decay, concentrations were reduced to less than one millionth of the original concentration.

c. Effects of Variability of Soil Retardation

Retardation, as discussed earlier, refers to the velocity of a solute compared to the velocity of water. Retardation itself does not cause a reduction in pesticide concentration. However, retardation causes more of the pesticide to be retained in the biologically active soil layers, where pesticide decay occurs. Results of simulations where this parameter was varied are shown on Plate 14.

Results show moderate sensitivity to this parameter. However, all simulations show very high reductions in concentrations at the base of the soil layer from about 1/8000 to 1/10 million of the original concentration.

d. Effects of Variability of Soil Thickness

Average assumed simulation conditions used a soil thickness of 1.5 feet. Additional simulations were run varying this parameter between 1 and 2 feet. Results of these simulations are shown on Plate 15.

The effect of soil thickness is straightforward. Each additional 1/2 foot of soil causes a reduction in concentrations of nearly one hundred fold. The diagonal portion of the concentration lines on Plate 15 allow estimation of pesticide concentration for selected soil thicknesses.

e. Effects of Variability in Infiltration Rates

Infiltration rates depend on climatologic, soil, and irrigation factors. Rates were varied by a factor of ±2 for additional simulations. Results of these simulations are shown on Plate 16.

Over the range tested, results show fairly low sensitivity. At the highest infiltration rate, pesticide concentrations were reduced to less than one ten-thousandth of the original concentration.

B. Results of Basalt Simulations

The 2-D basalt model was used to predict steady-state concentrations in the groundwater at the coast due to advection and dispersion in the unsaturated and groundwater zones within the basalt. The pesticide was treated as a conservative solute during its migration in the basalt because chemical processes such as adsorption and biochemical decay are both assumed to be insignificant in this medium.

Six scenarios were simulated as listed in Table 8. These are discussed below.

1. Average Assumed Conditions

The average assumed conditions (Case 1, or Nominal Case) provides a concentration reduction of 97 percent from the base of the soil layer to the coast. As discussed above, the pesticide pyrethrin is expected to have a concentration of 0.5 to 0.8 parts per trillion at the base of the soil layer, or top of the basalt. With a 97 percent concentration reduction through the basaltic layer, pyrethrin concentration may be considered negligible. However, N from fertilizer is expected to have a 2.35 parts per million concentration at the base of the root zone, reducing to 70 parts per billion at the coast.

2. Sensitivity Analysis

a. Effect of Variability of Infiltration Rates

Infiltration rates were varied ±40 percent from the base case (Cases 1, 2 and 3). The effects of infiltration rate on concentration of pesticides at the

coast demonstrate low sensitivity (Plate 17). Concentrations in groundwater varied by ±1 percent over the range of values simulated.

b. Effects of Variability of Groundwater Flow Rates

Groundwater flow rates were decreased by a factor of two (Case 4) and compared to the nominal case. The effects of variability of groundwater flow on coastal concentrations are shown on Plate 18. Results show fairly high sensitivity at a rate of 1 percent decrease in concentration per 1 mgd/mi increase in groundwater flow rate.

c. Effects of Variability of Dispersion

The sensitivity of relative concentration to the range of simulated dispersion values is shown on Plate 19. The results show low sensitivity: increasing dispersion by a factor of 2 only decreases groundwater concentrations by 0.2 percent.

VI CONCLUSIONS AND RECOMMENDATIONS

A. Conclusions

Two numerical models were used to simulate the subsurface migration of pesticides applied to the golf course. The soil (1-D) model was used to predict the concentration in the soil layers beneath the golf course by accounting for biochemical decay, retardation and adsorption. The basalt (2-D) model was used to predict the concentration in the groundwater discharging to the bay resulting from advection and dispersion in the unsaturated and groundwater zones.

Results of the soil model indicate that pesticide degradation is extremely effective in the soil zone, accounting for a decrease in concentration of 4 to 5 orders of magnitude. For typical application rates (Table 5), this would result in concentrations of pesticide in the single part per trillion range, or less, at the base of the root zone. These concentrations are far below common limits of detection, or health concerns. Further reduction by approximately 97 percent would occur through dispersion and dilution in the underlying groundwater system.

The least amount of decay occurred in simulated soils making up the greens. This is expected because the sandier soils would drain quickly and contain less organic carbon than the native soils on site. The simulated amount of pesticide reduction at the base of the greens was about a factor of 20, or 95 percent. Depending on the application rate, concentrations of pesticide may be detectable at the base of the greens.

Results of the basalt model indicate that dispersion and dilution would cause concentrations of solutes entering the basalt from the soil to be reduced by an average of 97 percent. This reduction is caused primarily by dilution in the groundwater.

The additional dilution would cause proposed pesticides, if migration to the groundwater occurred, to be rendered far below detection. Nitrogen, however, may show a detectable increase over ambient groundwater concentrations. Nitrogen (as nitrate) is considered a conservative solute and, below the root zone, will be reduced in concentration only by dispersion and dilution. Using the 97 percent simulated dispersion/dilution in the basalt, the increase in nitrogen as nitrate is calculated to be about 70 parts per billion. The average groundwater nitrogen content is 1,300 to 1,500 ppb. This concentration increase may be detectable in the groundwater beneath the site. The amount of the increase, however, given the volume of groundwater discharge, ambient bay concentrations, and the mixing characteristics of the bay, is not anticipated to cause a noticeable increase in bay nitrogen concentrations.

B. Recommendations

Results of this study indicate that pesticide migration below the root zone will be negligible under the conditions assumed for the simulations. The following practices are recommended to ensure that pesticides are not transported beneath the root zone:

1. IPM techniques should be employed. Use of pesticides should occur only in response to pest outbreak (Faust, 1990b).
2. Use of pesticides should be restricted to those listed in Table 5, or others found to have similar properties of low mobility, toxicity and persistence.
3. Positive runon and runoff controls should be implemented to avoid ponding of irrigation water.
4. Use of liners as well as underdrains beneath greens should be evaluated.

Results of the water-budget analysis indicate that normal precipitation combined with planned irrigation rates may results in a surplus of water, with increased infiltration and runoff. Because some leaching of fertilizers may occur under these

conditions, efforts should be made to mitigate this effect. We recommend the following practices in regard to irrigation and fertilizer requirements:

1. Irrigation should be tied to soil moisture and should be scheduled based on this parameter. Soil moisture may be measured via soil moisture probes. Irrigation rates should be monitored closely. If, due to salt buildup, a leaching requirement is foreseen, the amount of excess irrigation to achieve this requirement should be closely monitored.
2. Foliar application of fertilizers (Faust, 1990b) is recommended because of the higher degree of utilization by this method.

Several test soil plot experiments are being planned and are designed to further refine pesticide, fertilizer and irrigation requirements on turf grasses. These experiments will assist in answering many of the questions regarding pesticide and fertilizer migration beneath the root zone, leaching requirements, and whether liners and underdrains will be appropriate or effective. We recommend the following in regard to soils, test plots, and monitoring:

1. Native soils on site are subject to permanent loss of structure and permeability unless properly handled during site construction (see remolded permeability values from native soils, Table 1). We recommend that soils be moved and compacted only when relatively dry. Tests on native soils should be conducted to ensure that they may meet specifications for turf grass soils. During site construction, on-site monitoring during moving, spreading and recompacting native soils should be conducted.
2. A site meteorological station may be appropriate to be installed during the test plot experiments. At a minimum, the station should measure and record rainfall and in temperature. Other useful measurements are wind speed, humidity, solar insolation, and soil moisture.
3. Various soil lysimeters should also be tested during the test plot experiments. If effective at allowing leachate samples to be collected for determination of pesticide and fertilizer concentrations, lysimeters may be equally effective as vadose zone monitoring instruments.

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Harding Lawson Associates

Table 1. Soil Types and Properties at Kealakekua Bay Club

Soil Type	Symbol*	SCS* Description	ASTM 2488 Soil Description	Bulk Density at 85% Relative Compaction (g/cm^3)	Porosity	Permeability (Published Value)	Laboratory Permeability at 85% Relative Compaction	Organic Content (%)
Cinder Soil	—	—	Brown Organic Silt w/Gravel (OH)	0.98	0.59	—	4×10^{-7} cm/s***	10.1
Kaimu	rKED	Extremely Stony Peat	Dark Brown Organic Silt (OH)	1.06**	—	4.4×10^{-3}-1.4×10^{-2} cm/s (6.3-20 in/hr)	—	—
Kainaku	KDD	Very Stony Silty Clay Loam	Dark Brown Organic Silt (OH)	0.96	0.66	4.4×10^{-3}-1.4×10^{-2} cm/s (6.3-20 in/hr)	1×10^{-4} cm/s	20.9
Waiaha	WHC	Extremely Stony Silt Loam	Brown Organic Silt (OH)	1.03	0.59	1.4×10^{-3}-4.4×10^{-3} (2.0-6.3 in/hr)	8×10^{-6} cm/s	11.7

* Soil Conservation Service (1973).
** 25 percent Kaimu soil and 75 percent cinder soil.
*** Hydrozorb at four pounds per cubic yard of cinder soil was added.

Table 2. Water Wells in Vicinity of Site

Well No.	Owner or User	Year Drilled	Ground Surface Elevation (ft. MSL)	Bottom Hole Elevation (ft. MSL)	Pump Rate (gpm)	Draw Down (ft)	Specific Capacity (gpm/ft)	Major Use, Year Reported
2653-01	Hawaii DWS	1978	882	-31	770	1.3	592	Municipal, 84
2753-01	Hawaii DWS	1958	744	-36	100	.7	143	Municipal, 72
2753-02	Hawaii DWS	1963	737	-37	270	.3	900	Municipal, 72
2753-03	New-No Information Available							
2755-01	W. Thompson	1955	45	5				Unknown, 74
2855-01	W. Thompson	1939	20	0				Unknown, 74

Note: Data from files of State Department of Land and Natural Resources.

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2855-01	W. Thompson	1939	20	0				Unknown, 74

Note: Data from files of State Department of Land and Natural Resources.

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Table 3. Groundwater Chemistry from Wells in Vicinity of Site

	Concentration (mg/l)	
	Well 2753 01*	Well 2753 02**
Total Dissolved Solids	310	333
Total Nitrate as N	0.94	1.3
Total Hardness as $CaCO_3$	66	74
Silica	42.3	52
Calcium	10	9.6
Magnesium	11	12
Sulfate	25	25
Sodium	72	77
Chloride	116	129
Potassium	4.0	4.8
Fluoride	0.3	0.38

Notes:

* Data from U.S. Geological Survey. Sample collected on July 31, 1973.
** Data from U.S. Geological Survey. Sample collected on March 16, 1972.

Table 4. Average Monthly and Annual Rainfall for Napoopoo Station and Kealakekua Station

Month	Mean Rainfall (inches) Napoopoo (Elev. 480)	Kealakekua (Elev. 1,440)
January	3.0	3.9
February	2.1	2.9
March	3.2	4.1
April	3.4	4.8
May	3.6	6.2
June	3.8	6.1
July	3.9	6.6
August	4.1	6.9
September	4.3	7.0
October	3.7	5.6
November	2.5	3.6
December	2.4	3.3
Annual	40.0	61.0

Reference: Giambelluca et al. (1986).

Table 5. Proposed Pesticide Use at Kealakekua Bay Club

Turfgrass Area	Product	Application Rate	Annual Total
HERBICIDES			
Greens	glyphosate MSMA	0.75 lb a/i/acre 2 lb a/i/acre	20 lb 36 lb
Tees	glyphosate MSMA	0.75 lb a/i/acre 2 lb a/i/acre	20 lb 36 lb
Fairways	glyphosate	0.75 lb a/i/acre	50 lb
Perimeter	glyphosate	0.75 lb a/i/acre	56 lb
INSECTICIDES			
Greens	Bacillus Thuringensis Insecticidal Soap Pyrellin*	1 lb/acre 2 gal/acre 2 pts/acre	36 lb 25 gal 10 gal (0.5 gal rotenone, 0.06 gal pyrethrins)
Tees	Bacillus Thuringensis Insecticidal Soap	1 lb/acre 2 gal/acre	36 lb 25 gal
Fairways	Bacillus Thuringensis	1 lb/acre	36 lb
Perimeter	Pyrellin/Soap	2 pts/acre	10 gal (0.05 gal rotenone, 0.06 gal pyrethrins)

*Pyrellin consists of pyrethrins (0.60%), rotenone (0.50%), other cube resins (0.50%) and inert ingredients (98.40%)

Table 5. (Continued)

Turfgrass Area	Product	Application Rate	Annual Total
FUNGICIDES			
Greens	Wettable Sulfur	5 lb/acre	80 lb
Tees	Ringer Corp Greens Super 10-2-6*		

*Ringer Corp Greens Super 10-2-6 is an organic based turf fertilizer with disease suppressive effects and will be used for greens and tees instead of fungicides and nitrate fertilizers.

Reference: Faust (1990b)

Table 6. Properties of Pesticides Proposed for Use at Kealakekua Bay Club

Pesticide Common Name	Trade Name(s)	Soil Sorption Index (K_{oc}) (cm^3/g)	Water Solubility (mg/l)	Half-Life in Soil (days)	Decay Factor (1/day)	Retardation Coefficient, K	Leaching Potential
HERBICIDES							
MSMA	Weedhoe, etc.	2,000-10,000	1,000,000	100	6.9×10^{-3}	300-1,700	Small
glyphosate	Roundup, Kleenup	2,000-10,000	1,000,000	30	2.3×10^{-2}	300-1,700	Small
INSECTICIDES							
rotenone	Pyrellin	900	17	<30	2.3×10^{-2}	720	--
pyrethrin	Pyrellin	>4,300	>1	<50	1.4×10^{-2}	150	--
insecticidal soap	--	NA	NA	NA	--	--	--

From: Wauchope, 1988, U.S.D.A.-ARS Interim Pesticide Properties Database, Version 1.0, from Environmental Impact Consultants (1990).

Estimates based on information from other members of project consultant team, U.S. EPA, State Department of Agriculture, and pyrellin distributor.

Based on: bulk density = 1.5 g/cm^3
porosity = 0.45
organic content = 0.05

0108R

Table 7. Simulation Scenarios for Soil (1-D) Model

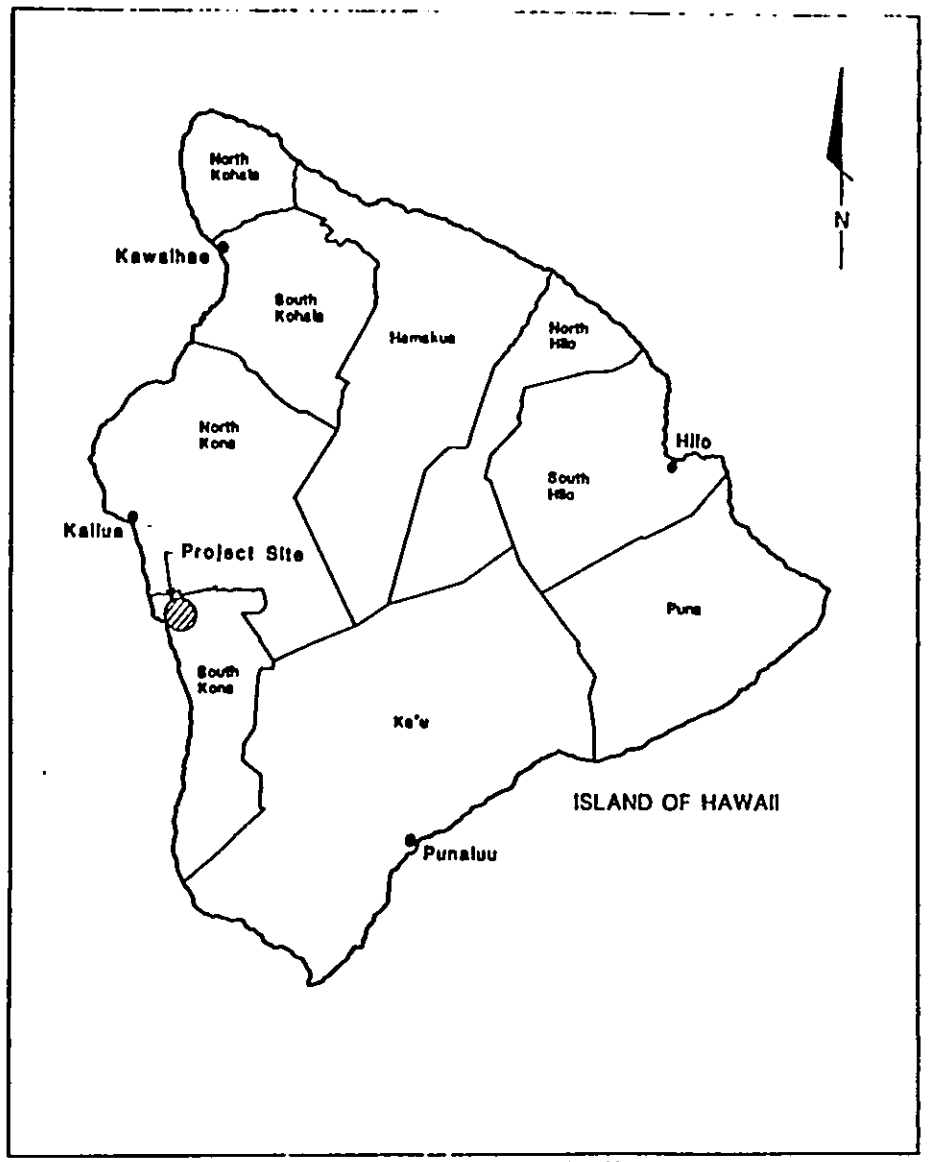
Case	File Code	Soil Thickness (ft)	Infiltration Rate (ft/day)	Pesticide Retardation Coefficient	Pesticide Decay Factor (1/day)
Nominal Case (1)	Keala 1	1.5	6.16×10^{-3}	150	2.3×10^{-2}
2	Keala 12	1 - Greens 1 - Fairways	Nominal Nominal	75 150	Nominal 2.3×10^{-3}
3	Keala 3	2	<----Nominal Values---->		
4	Keala 4	1	<----Nominal Values---->		
5	Keala 5	Nominal	9.24×10^{-3}	<----Nominal Values---->	
6	Keala 6	Nominal	3.08×10^{-3}	<----Nominal Values---->	
7	Keala 7	<----Nominal Values---->		75	Nominal
8	Keala 8	<----Nominal Values---->		300	Nominal
9	Keala 9	<----Nominal Values---->			3.45×10^{-2}
10	Keala 10	<----Nominal Values---->			1.15×10^{-2}

0108R

Table 8. Simulation Scenarios for Basalt (2-D) Model

Case	File Code	Infiltration Rate (ft/d)	Groundwater Flux (mgd/mi)	Dispersivity (ft)
Nominal Case (1)	TNPUT5	6.63×10^{3}	8	10
2	VNPUT1	4.73×10^{3}	< ..... Nominal Values ..... >	
3	XNPUT8	2.85×10^{3}	< ..... Nominal Values ..... >	
4	XNPUT2	4.73×10^{3}	4	10
5	XNPUT9	4.73×10^{3}	8	15
6	XNPUT6	4.73×10^{3}	8	20

IX ILLUSTRATIONS



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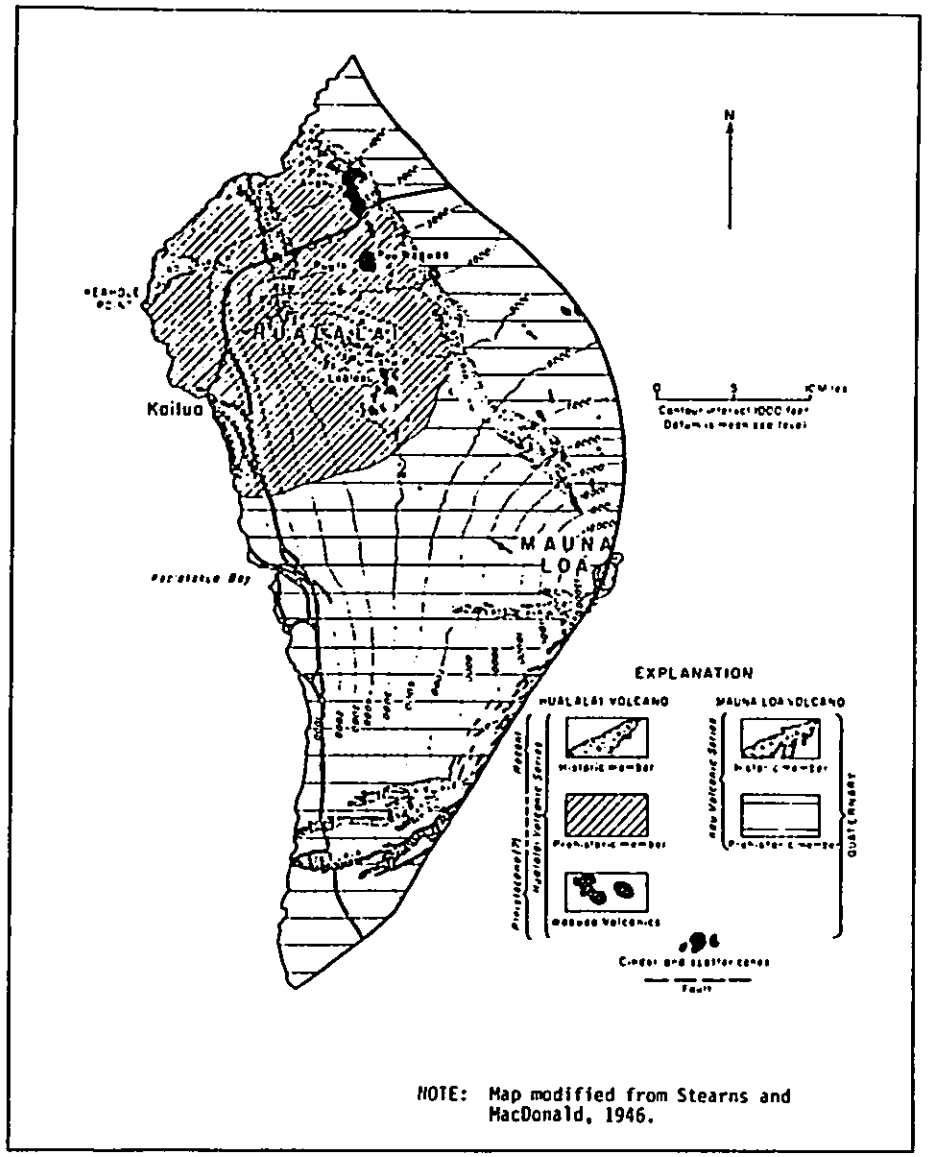
Engineers and Geoscientists

Project Location Map
Kealakekua Pesticide Migration Study
Kona, Hawaii

PLATE 1

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
hsm	19913,001.06		7/90		



NOTE: Map modified from Stearns and MacDonald, 1946.

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Engineering and Environmental Services

Geologic Map of Kona
Kealakekua Pesticide Migration Study
Kona, Hawaii

PLATE 2

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
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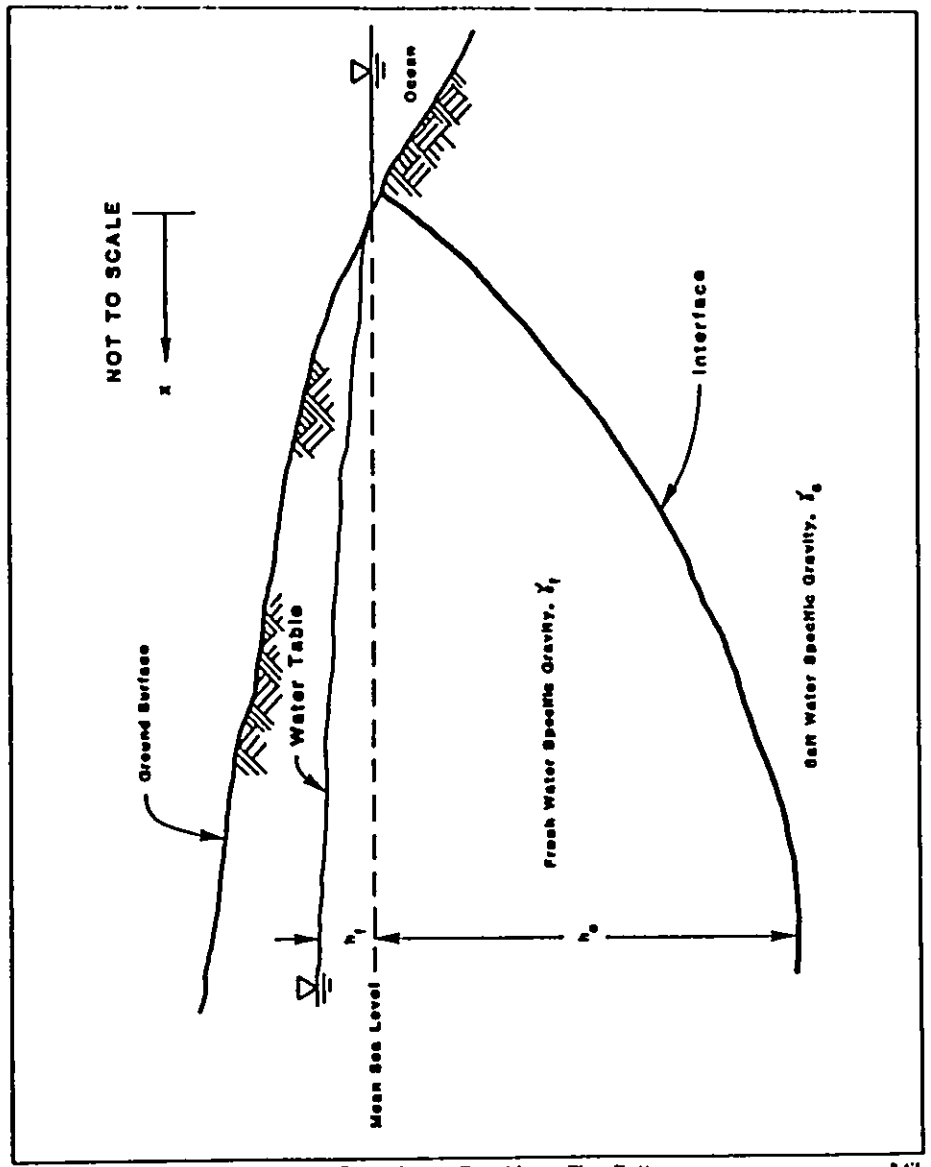

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Engineers and Geoscientists

Groundwater Basal Lens Flow Pattern
Kealakekua Pesticide Migration Study
Kona, Hawaii

PLATE 4

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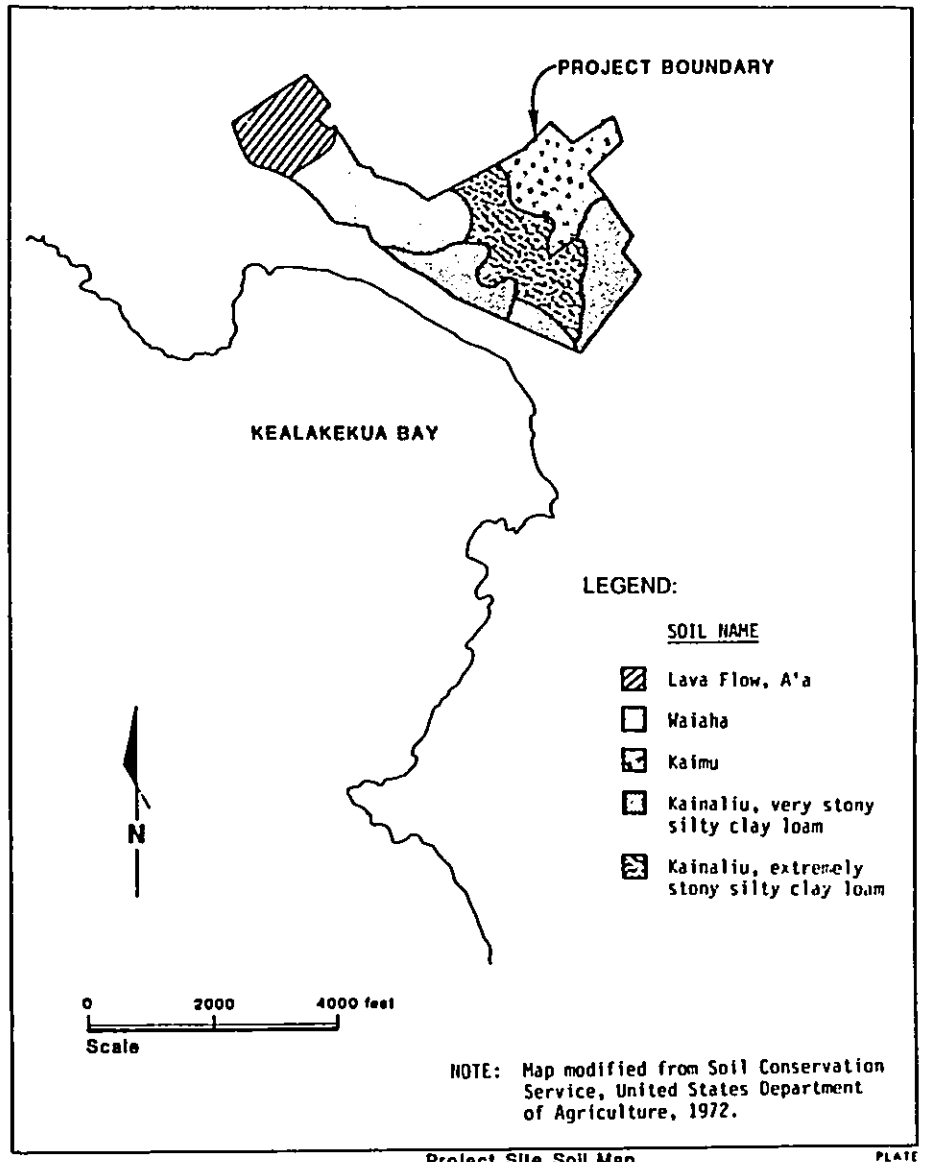

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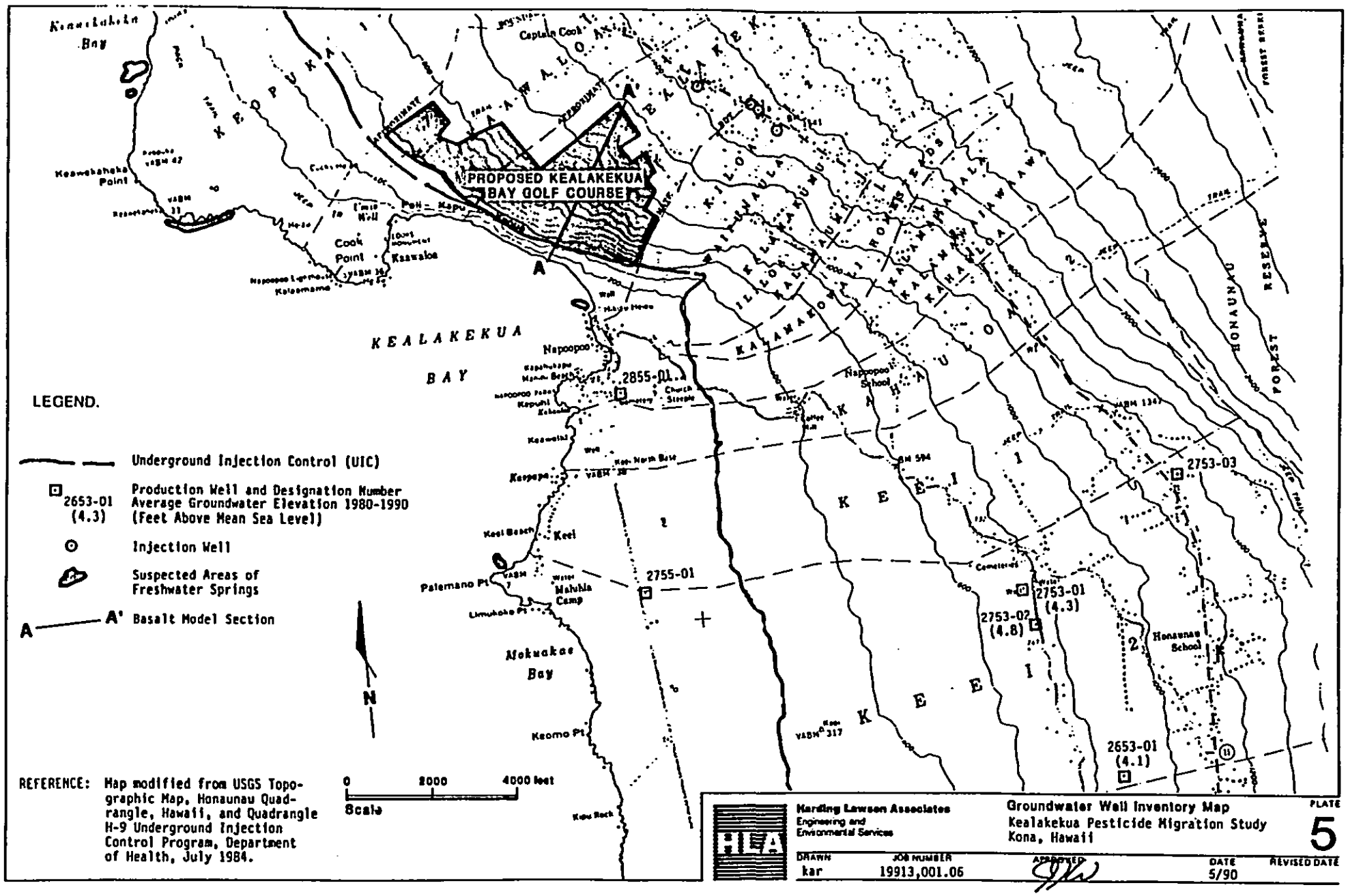
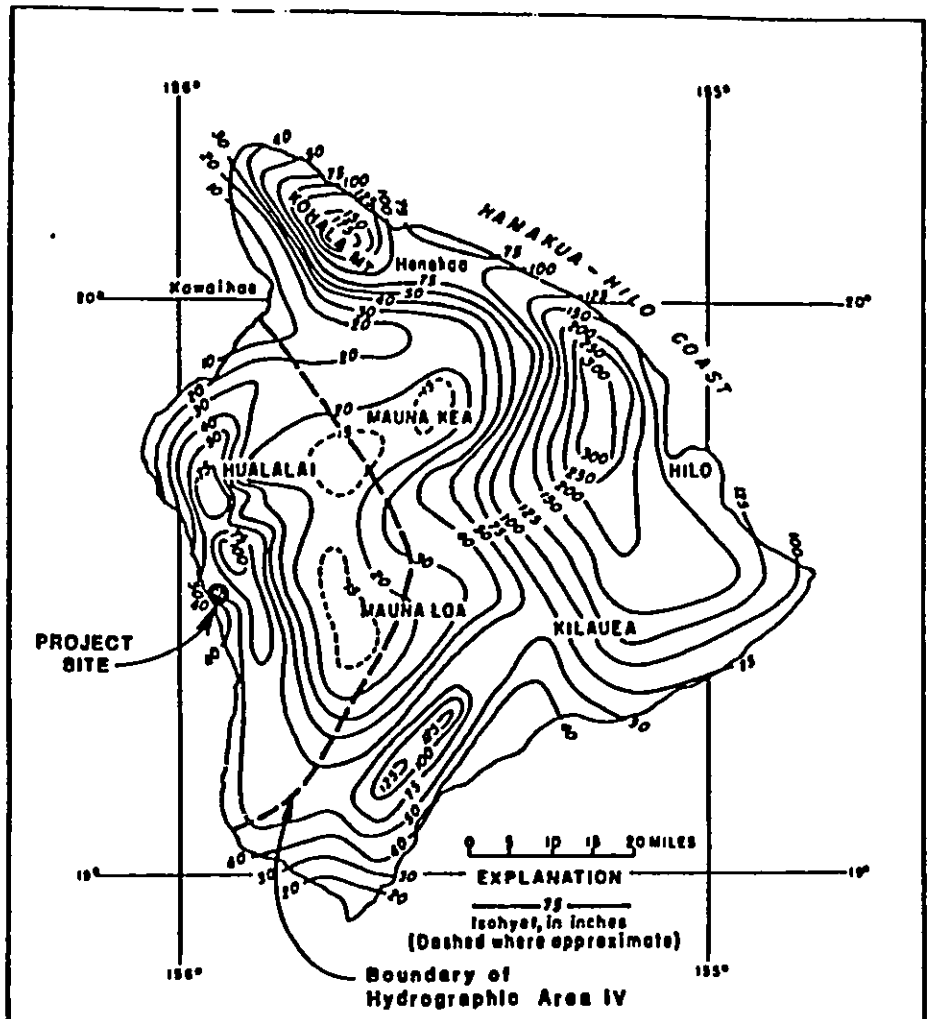
Project Site Soil Map
Kealakekua Pesticide Migration Study
Kona, Hawaii

PLATE 3

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
kar/gwl	19913,001.06		2/91	


PROPOSED KEALAKEKUA BAY GOLF COURSE
KEALAKEKUA BAY
Mokuakae Bay
Napoopoo
Keel
Palemano Pt
Keomo Pt
Cook Point
Kaawaloa
Captain Cook
Keawekaheka Point
Kaawaloa Bay
Napoopoo School
Honaunau School
HONAUNAU FOREST RESERVE
2855-01
2755-01
2753-01 (4.3)
2753-02 (4.8)
2753-03
2653-01 (4.1)
A
A'
N
0 2000 4000 feet
Scale
LEGEND.
Underground Injection Control (UIC)
2653-01 (4.3) Production Well and Designation Number Average Groundwater Elevation 1980-1990 (Feet Above Mean Sea Level)
Injection Well
Suspected Areas of Freshwater Springs
A — A' Basalt Model Section
REFERENCE: Map modified from USGS Topographic Map, Honaunau Quadrangle, Hawaii, and Quadrangle H-9 Underground Injection Control Program, Department of Health, July 1984.
Harding Lawson Associates
Engineering and Environmental Services
Groundwater Well Inventory Map
Kealakekua Pesticide Migration Study
Kona, Hawaii
PLATE 5
DRAWN kar
JOB NUMBER 19913,001.06
APPROVED
DATE 5/90
REVISED DATE



NOTE: Map adapted from Davis and Yamanaga (1968)

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Distribution Of Mean Annual Rainfall-Hawaii
Kealakekua Pesticide Migration Study
Kona, Hawaii

PLATE 6

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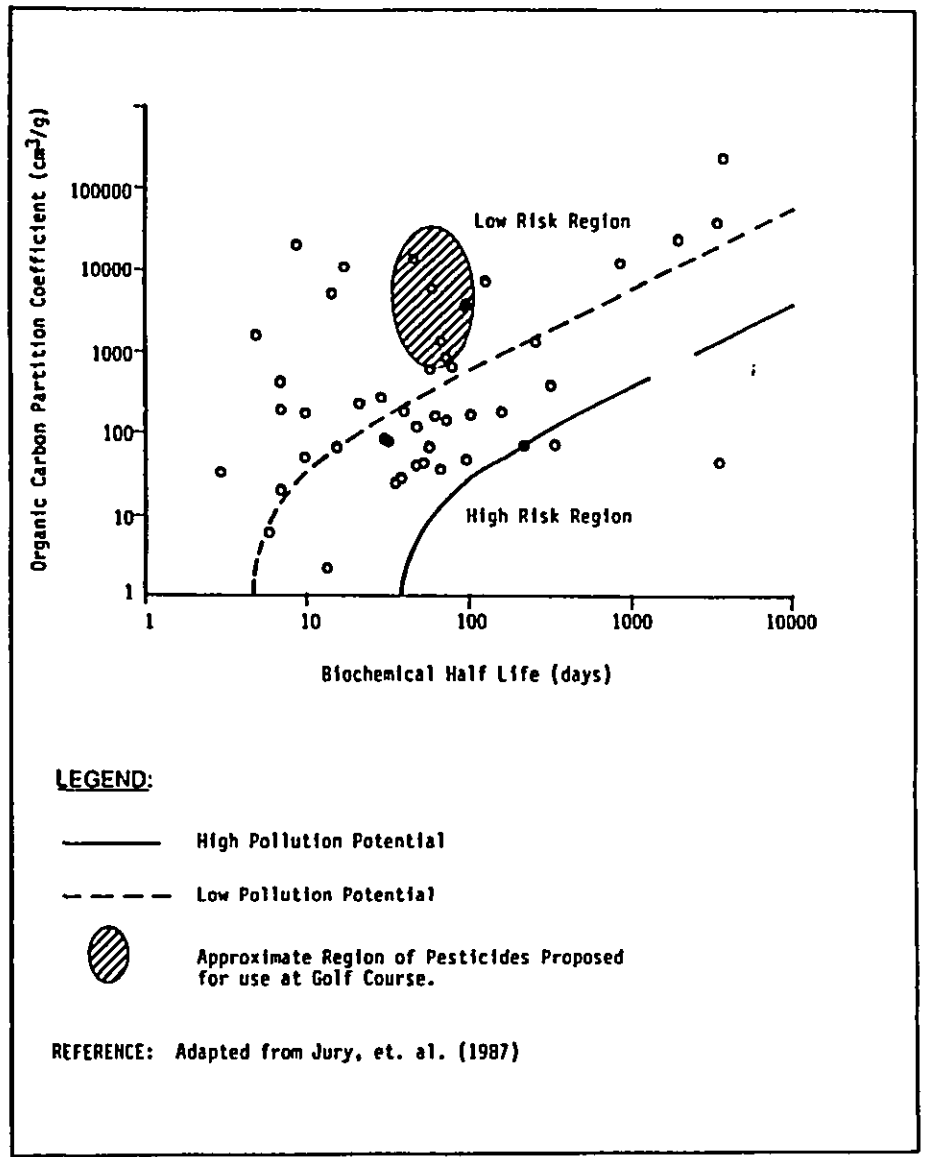

LEGEND:

High Pollution Potential

Low Pollution Potential

Approximate Region of Pesticides Proposed for use at Golf Course.

REFERENCE: Adapted from Jury, et. al. (1987)

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Engineering and Environmental Services

Pollution Potential Classification for Pesticides
Kealakekua Pesticide Migration Study
Kona, Hawaii

PLATE 7

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
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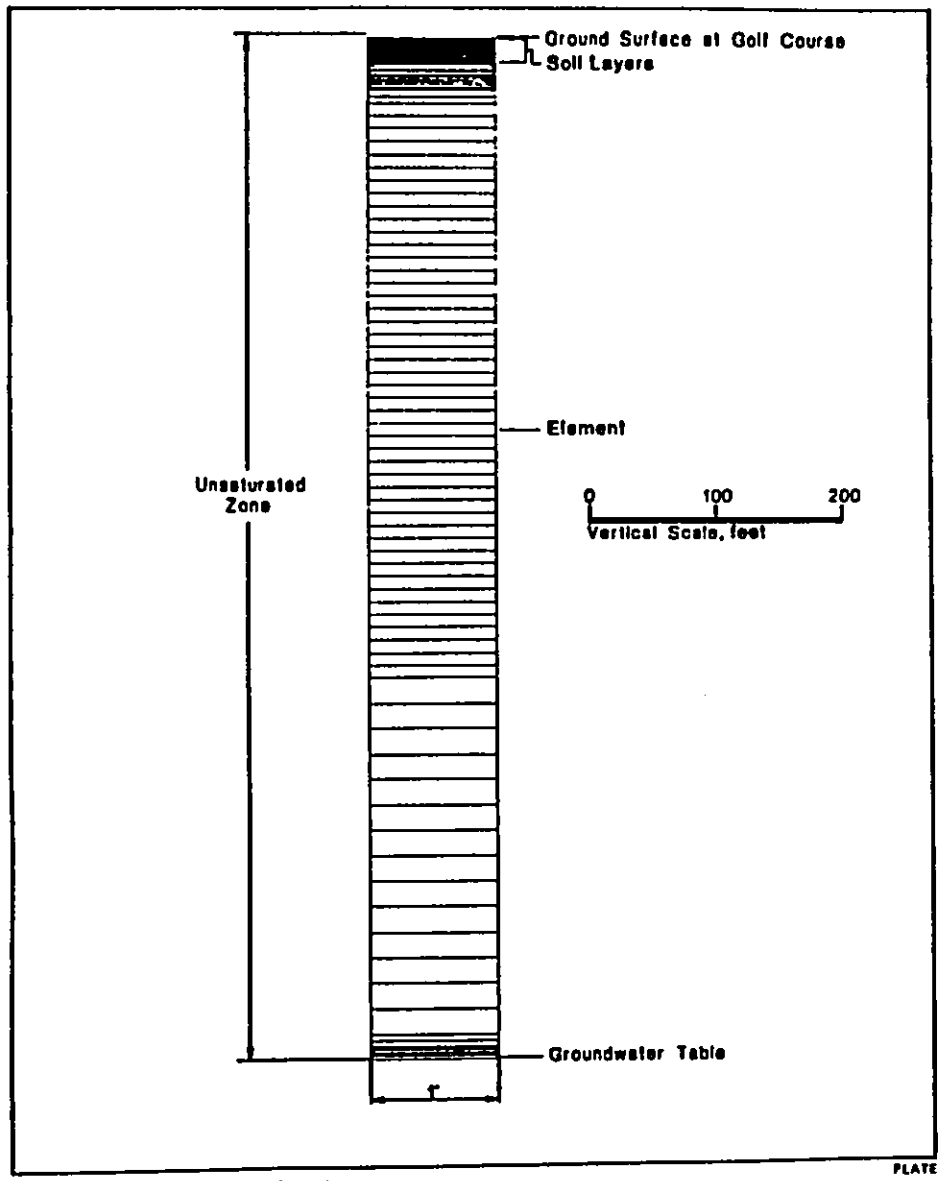

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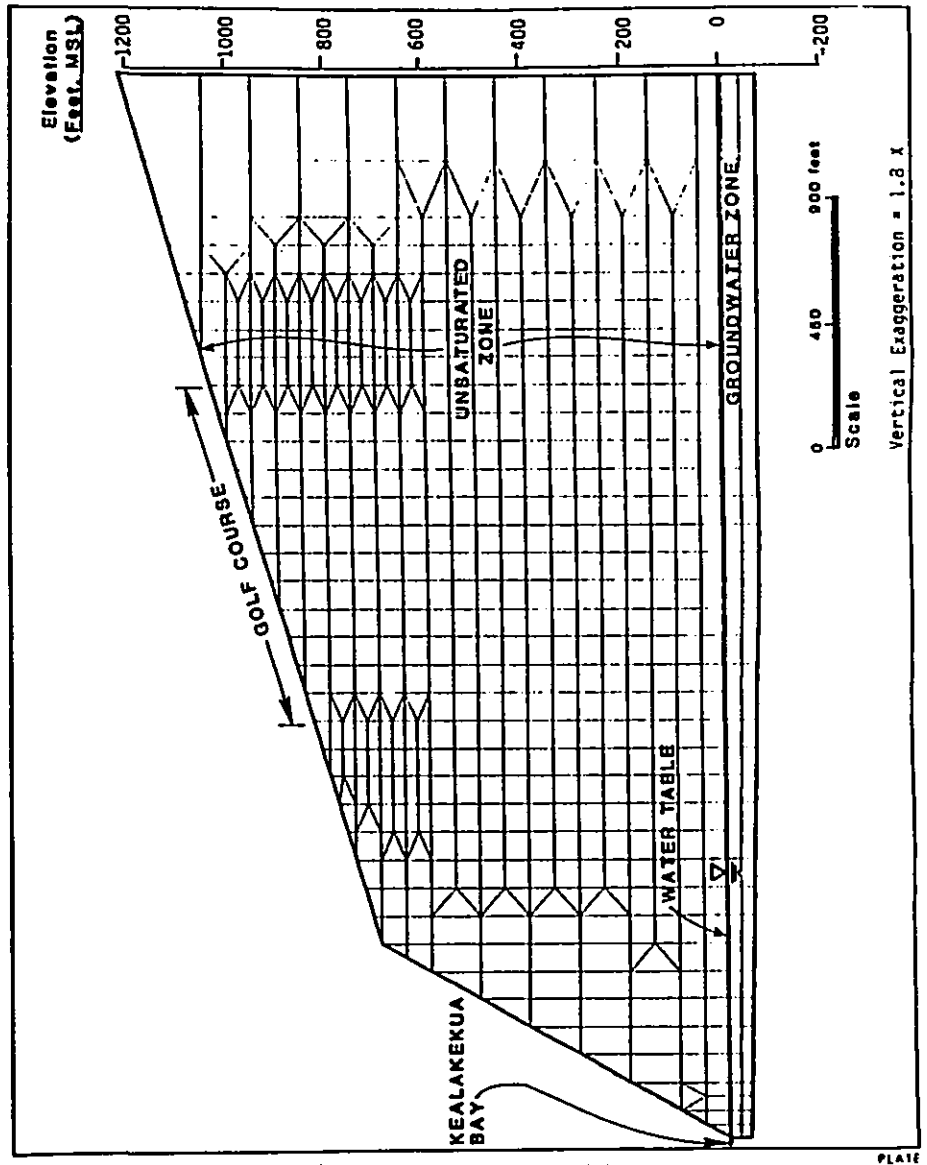
Finite Element Mesh for Soils Model
Kealakekua Pesticide Migration Study
Kona, Hawaii

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
ham	19913.001.06		7/90	

PLATE 8

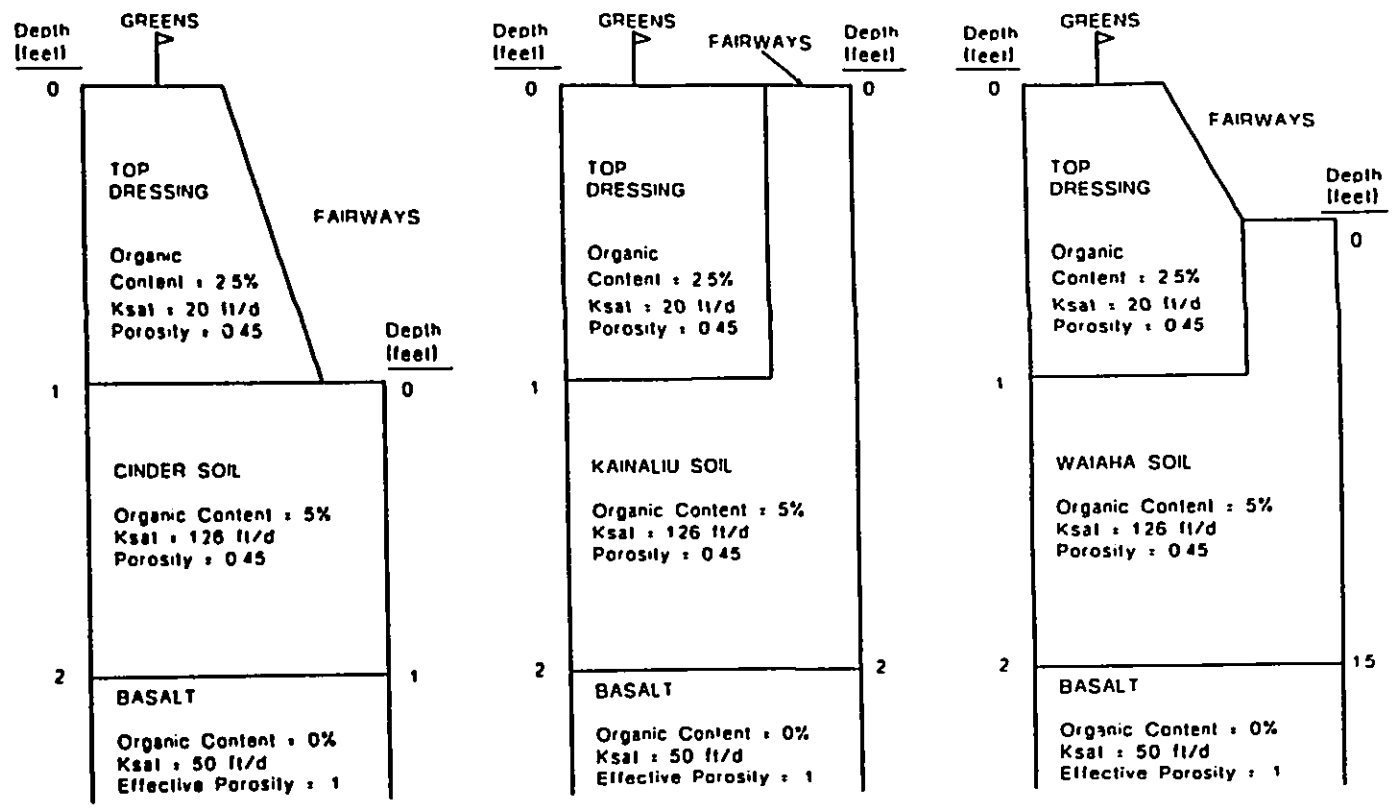


Harding Lawson Associates
Engineering and Environmental Services

Finite Element Mesh for Basalt Model
Kealakekua Pesticide Migration Study
Kona, Hawaii

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
kar	19913,001.06		6/90	

PLATE 9



Profile A: Cinder Soils

Profile B: Kainaliu Soils

Profile C: Waiaha Soils

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Soil Profiles
Kealakekua Pesticide Migration Study
Kona, Hawaii

PLATE 10

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
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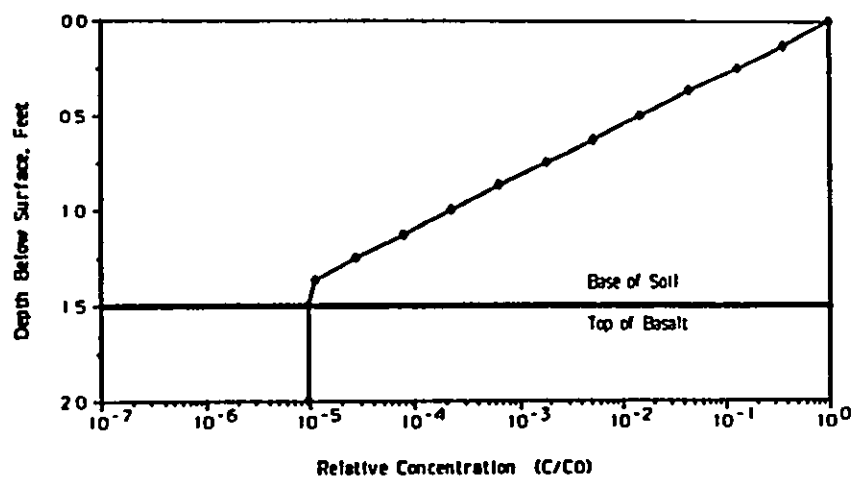

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Engineering and Environmental Services

Simulated Concentrations for Average Soil Conditions
Kealakekua Pesticide Migration Study
Kona, Hawaii

PLATE 11

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
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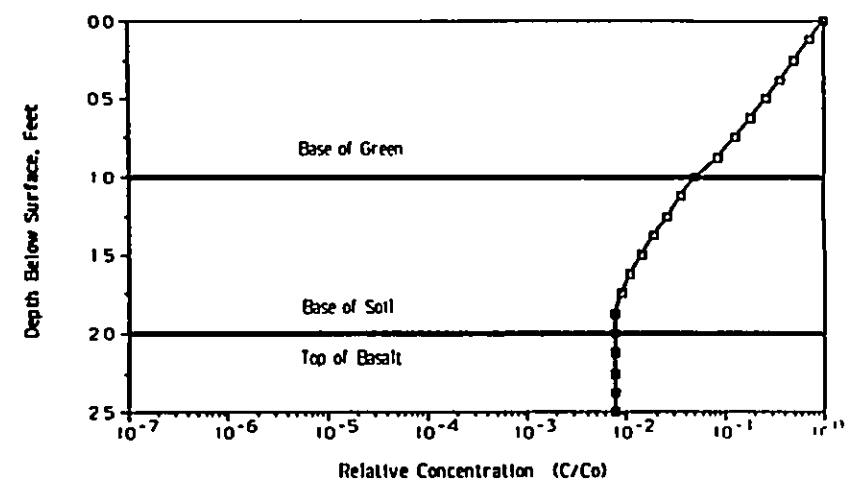

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Simulated Concentrations for Golf Green
Kealakekua Pesticide Migration Study
Kona, Hawaii

PLATE 12

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
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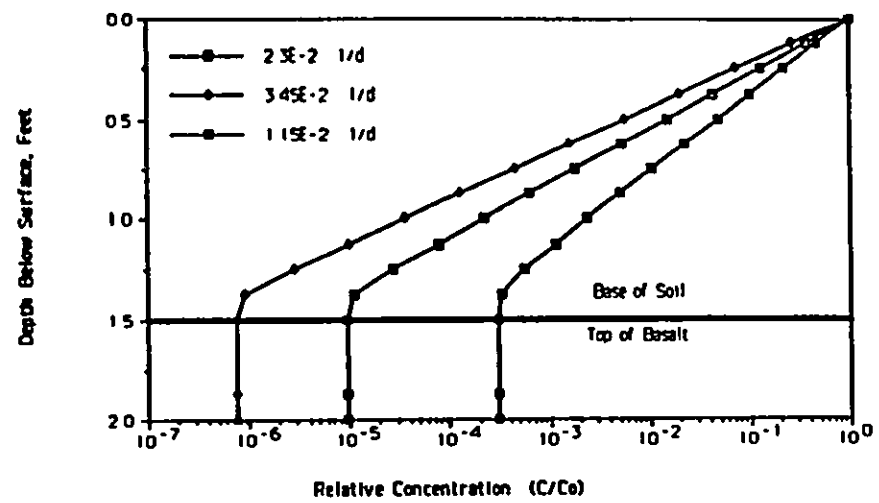

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Engineering and Environmental Services

Simulated Concentrations for Range of Pesticide Decay Rates
Kealakekua Pesticide Migration Study
Kona, Hawaii

PLATE 13

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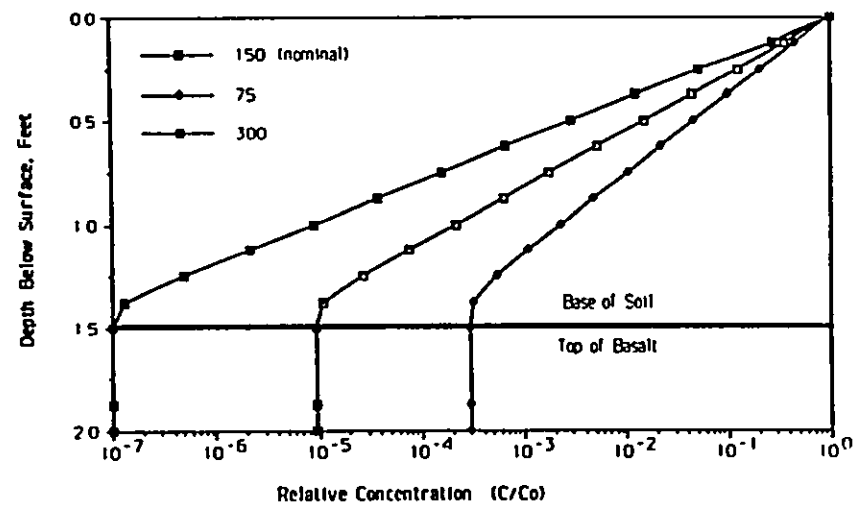

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Engineering and Environmental Services

Simulated Concentrations for Range of Retardation Coefficients
Kealakekua Pesticide Migration Study
Kona, Hawaii

PLATE 14

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
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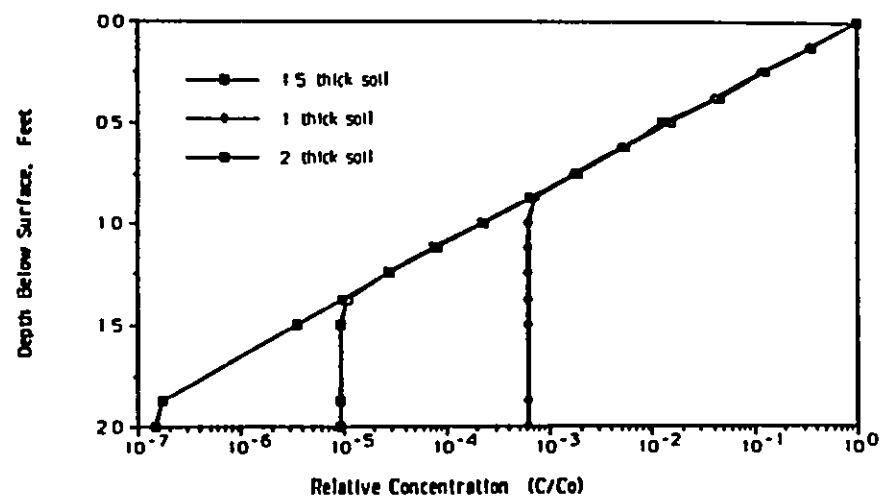

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Engineering and Environmental Services

Simulated Concentrations for Range of Soil Thicknesses
Kealakekua Pesticide Migration Study
Kona, Hawaii

PLATE 15

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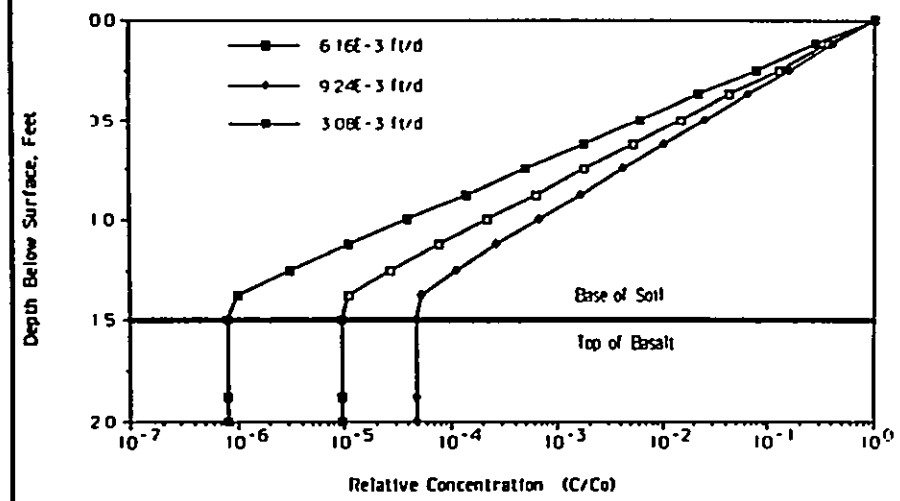

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Engineering and Environmental Services

Simulated Concentrations for Range of Infiltration Rates
Kealakekua Pesticide Migration Study
Kona, Hawaii

PLATE 16

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
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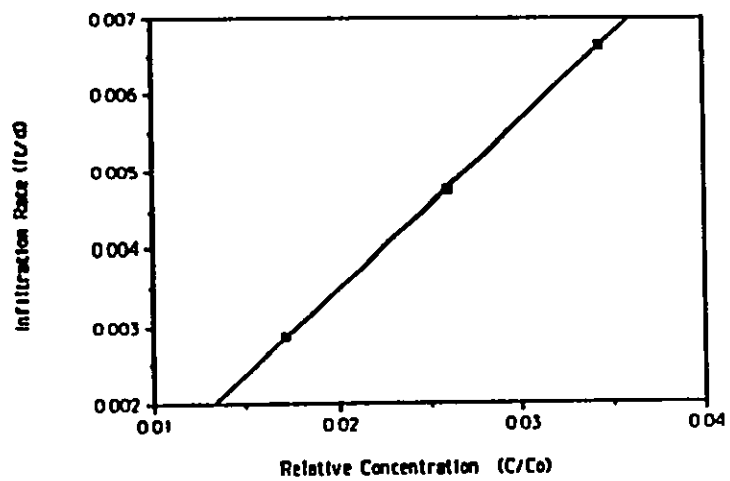

Harding Lawson Associates
Engineering and Environmental Services

Simulated Groundwater Concentrations for Range of Infiltration Rates
Kealakekua Pesticide Migration Study
Kona, Hawaii

PLATE 17

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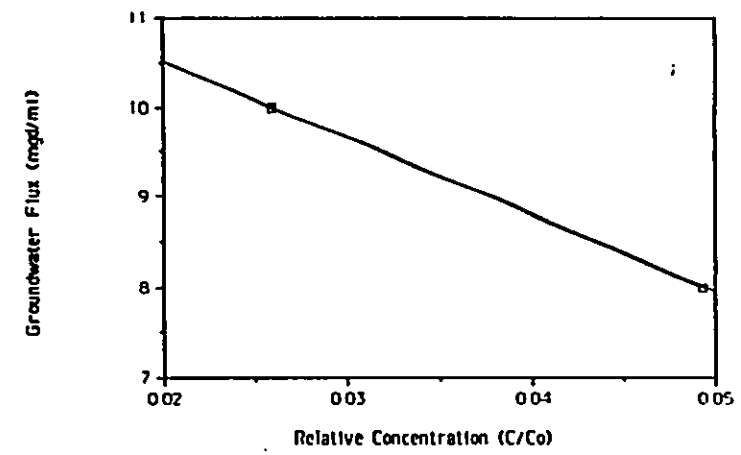

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Engineering and Environmental Services

Simulated Groundwater Concentrations for Range of Flow Rates
Kealakekua Pesticide Migration Study
Kona, Hawaii

PLATE 18

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
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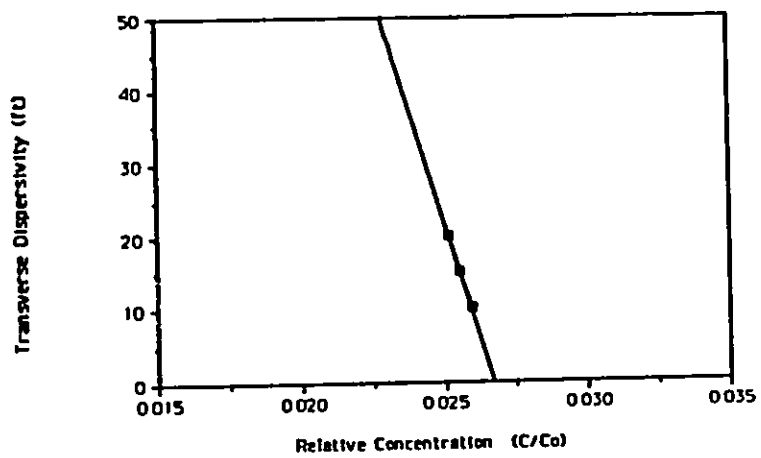

Harding Lawson Associates
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HLA

Simulated Groundwater Concentrations for Range of Dispersion Coefficients
Kealakekua Pesticide Migration Study
Kona, Hawaii

PLATE 19

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
kar	19913,001.06		4/91	

APPENDIX A

MATERIAL PROPERTIES OF UNSATURATED ZONES

MATERIAL PROPERTIES OF UNSATURATED ZONES

The unsaturated zone extends from the land surface to the water table, between 750 and 1,050 feet beneath the proposed golf course. Although this zone may contain locally perched saturated zones, the hydraulic potential is generally negative, with most of the void space being air-filled. Liquid water present is held under capillary and adsorptive forces. As water content decreases, the remaining water has progressively lower (more negative) hydraulic potentials (Evans and Nicholson, 1987). A negative hydraulic potential is termed suction head or matric potential.

Hydraulic conductivities of variably saturated media are much smaller than when fully saturated (Hillel, 1971) as the presence of air-filled voids reduces the permeability of the media to water. The reduction of hydraulic conductivity with decrease in saturation is quite dramatic, often 6 to 10 orders of magnitude over an increase in matric potential of 2 or less orders of magnitude. Consequently, the movement of water and solute through unsaturated soil is much slower than when the soil is saturated.

The dependence of groundwater flow under variably saturated conditions on both soil moisture and hydraulic conductivity must be adequately described to simulate flow of water and solute. Groundwater movement (of a single fluid) under saturated, isothermal conditions is described by:

$$q = K \nabla H$$

and

$$v = q/\epsilon$$

where:

q is the groundwater flux,

v is the seepage velocity,

K is hydraulic conductivity,

∇H is hydraulic gradient, and

ϵ is effective porosity.

Groundwater flow under variably saturated condition is described as (Hillel, 1971):

$$q = K(\theta)\nabla H$$

and

$$v = q/\epsilon(\theta)$$

where:

$K(\theta)$ is the hydraulic conductivity at matric potential θ,

$\epsilon(\theta)$ is the soil moisture at matric potential θ,

and

∇H is the hydraulic gradient, which now includes both capillary and gravitational forces. (Osmotic forces, although they may be quite large at high matric potentials, are not included in this analysis.)

From the the above relationships, it is seen that two soil hydraulic functions must be defined in order to simulate flow in variably saturated media: 1) the matric potential/soil-moisture function $\epsilon(\theta)$, also called the soil-moisture retention curve; and 2) the matric potential - hydraulic conductivity function $K(\theta)$. These characteristic curves may be calculated from laboratory measurements or estimated, based on measured or estimated soil properties and published data for similar soils. Because of limited laboratory measurements for site soils and because laboratory measurements

are not available for the underlying basalt, the latter method was used to develop material properties for simulations.

Material Properties for Soil Layers

Experimentally derived hydraulic functions for several examples of Hawaiian soils are shown on Plate A-1 (adapted from Green, 1982). From these and data presented in Table 1, simulated curves for the soil layers beneath the site were derived, as shown on Plate A-2.

Material Properties for Basalt Layer

Experimentally derived values of material properties for the basalt bedrock underlying the site do not exist. Because groundwater flow in basalts is fundamentally different than that in soils, the meaningfulness of treating flow in fractured rock the same as porous media has been the subject of much research (e.g., Khaleel, 1987; Peters and Klavetter, 1988; Stephenson and Freeze, 1974). We have assumed that the scale of the fractures, interbeds and conduits contributing to flow is small compared to the entire simulated rock mass, so that porous media flow equations and equivalent porous media hydraulic functions would, in general, apply.

The hydraulic conductivity curve was established based on a saturated hydraulic conductivity in the horizontal direction of 5,000 ft/day, as discussed in Section II,C. The slope of the curve was developed by adopting results of several previous modeling efforts, especially those of Stephenson and Freeze (1974), Wang and Narasimhan (1985), and Rasmussen (1987). Results of preliminary model runs indicated that the slope of the initial curve prevented satisfactory convergence (the problem became excessively non-linear), and so was somewhat flattened for the final simulations. This

did not affect the results of solute transport to a great degree. The hydraulic conductivity curve for the simulation of basalts is shown on Plate A-3.

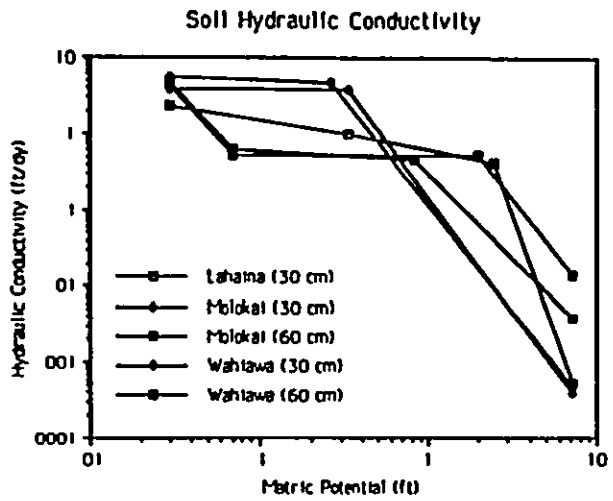
The moisture retention curve (Plate A-3) was based on a saturated water content of 10 percent. This characteristic curve was developed by adopting results of previous modeling efforts.

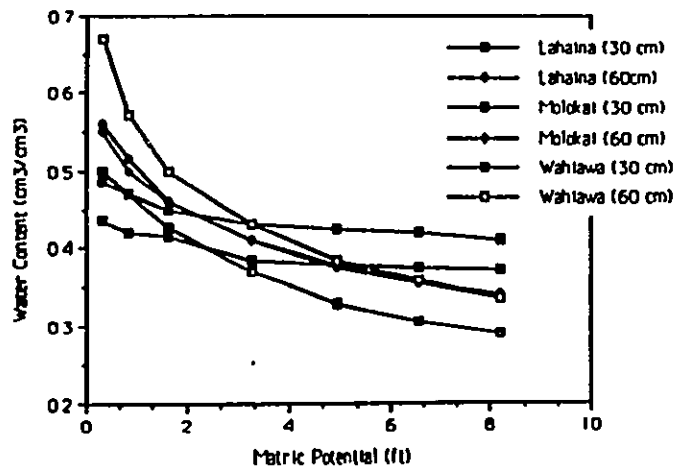
LIST OF ILLUSTRATIONS, APPENDIX A

Plate A-1 Characteristic Curves for Hawaii Soils

Plate A-2 Simulated Characteristic Curves for Soil Layers

Plate A-3 Simulated Characteristic Curves for Basalt





PLATE

Harding Lawson Associates
Engineering and Environmental Services

Characteristic Curves for Hawaii Soils
Kealakekua Pesticide Migration Study
Kona, Hawaii

A-1

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
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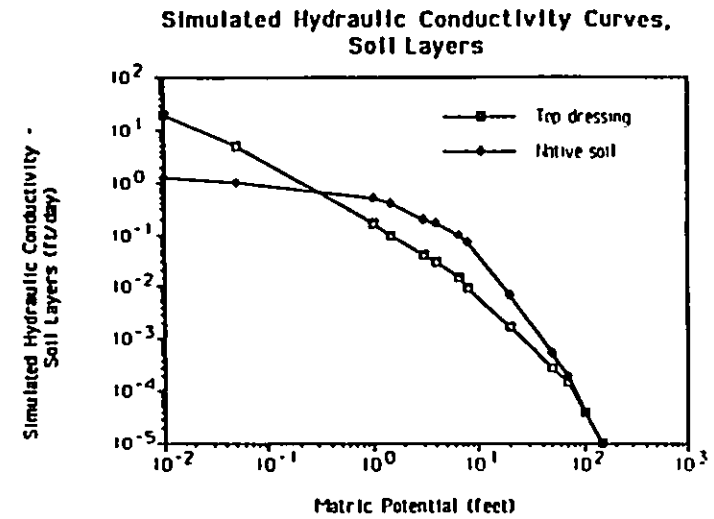

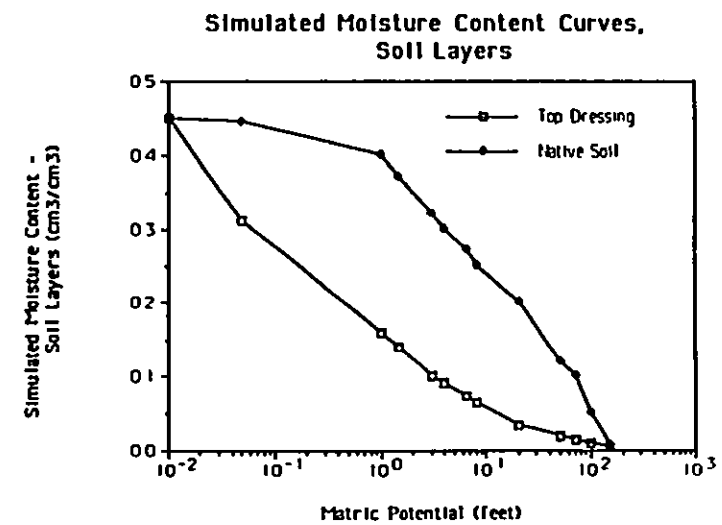

PLATE

Harding Lawson Associates
Engineering and Environmental Services

Simulated Characteristic Curves for Soil Layers
Kealakekua Pesticide Migration Study
Kona, Hawaii

A-2

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
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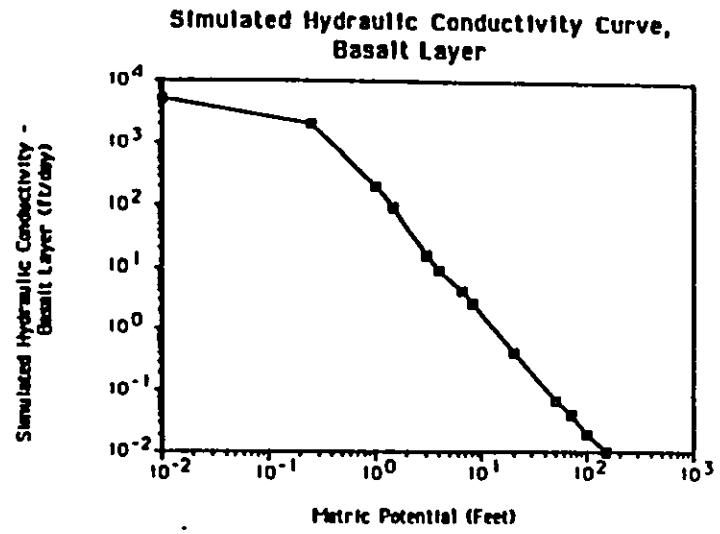

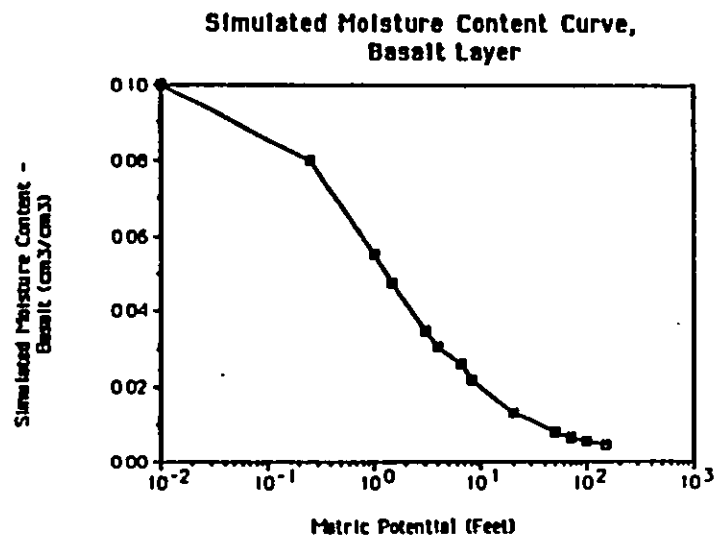

PLATE

Harding Lawson Associates
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Simulated Characteristic Curves for Basalt
Kealakekua Pesticide Migration Study
Kona, Hawaii

A-3

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
kar	19913.001.06		7/90	

Appendix 16:

SURVEY OF THE AVIFAUNAL AND FERAL MAMMALS ON THE KEALAKEKUA RANCH PROPERTY

SURVEY OF THE AVIFAUNA AND FERAL MAMMALS ON KEALAKEKUA RANCH PROPERTY, SOUTH KONA, HAWAII

Prepared for

Belt Collins & Associates

By

Phillip L. Bruner
Assistant Professor of Biology
Director, Museum of Natural History
BYU-H
Laie, Hawaii 96762

22 November 1989

SURVEY OF THE AVIFAUNA AND FERAL MAMMALS ON KEALAKEKUA RANCH PROPERTY, SOUTH KONA, HAWAII

INTRODUCTION

The purpose of this report is to summarize the findings of a two day (18-19 November 1989) bird and mammal field survey of Kealakekua Ranch Property, South Kona, Hawaii (see Fig.1). Also included are references to pertinent literature as well as unpublished reports.

The objectives of the field survey were to:

1- Document what bird and mammal species occur on the property or may likely occur given the range of habitats available.

2- Provide some baseline data on the relative abundance of each species.

3- Determine the presence or likely occurrence of any native fauna particularly any that are considered "Endangered" or "Threatened".

4- Determine if the property contains any special habitats that if lost or altered by development might result in a significant impact on the fauna in this region of the island.

GENERAL SITE DESCRIPTION

The project site is located on approximately 198 acres at Kealakekua, South Kona, Hawaii (see Fig1). The property is primarily a parkland habitat with scattered trees and grass. The mauka portion of the site contains larger trees and taller grass. The lower (makai) areas are more open and also more heavily grazed by cattle. Some of the common trees on the property are: Kukui (Aleurites moluccana), Monkeypod (Samanea saman) and Koa Haoli (Leucaena leucocephala).

Weather during the field survey had clear mornings and high overcast afternoons. Both days of the survey had NE winds.

STUDY METHODS

Field observations were made with the aid of binoculars and by listening for vocalizations. These observations were concentrated during the peak bird activity periods of early morning and late afternoon. Attention was also paid to the presence of tracks and scats as indicators of bird and mammal activity.

All existing ranch roads were walked and at various locations along these roads eight minute counts were made of all birds seen or heard (see Fig.1 for locations of count stations). Between these census stations observations of birds seen or heard were also noted. These data provide the basis for the relative abundance estimates given in this report. Published and unpublished reports

of birds known from similar habitat elsewhere in West Hawaii were also consulted in order to acquire a more complete picture of the possible species that might occur in the area (Bruner 1988, 1989a, 1989b; Pratt et al. 1987; Hawaii Audubon Society 1989). Observations of feral mammals were limited to visual sightings and evidence in the form of scats and tracks. No attemps were made to trap mammals in order to obtain data on their relative abundance and distribution. Two evenings were devoted to searching for the presence of owls and the Hawaiian Hoary Bat (Lasiurus cinerus semotus).

Scientific names used herein follow those given in the most recent American Ornithologist's Union Checklist (A.O.U. 1983), Hawaii's Birds (Hawaii Audubon Society 1989), A Field Guide to the Birds of Hawaii and the Tropical Pacific (Pratt et al. 1987), Mammal Species of the World (Honacki et al. 1982), Hawaiian Forest Plants (Merlin 1977) and Tropical Trees of the Pacific (Hardgreaves and Hargreaves 1970).

RESULTS AND DISCUSSION

Resident Endemic (Native) Land and Water Birds:

Only one endemic species was recorded during the course of the field survey. An adult dark phase Hawaiian Hawk (Io) (Buteo solitarius) was observed on 18 November flying over the eastern sector of the property. This hawk is endemic to the island of Hawaii and is also listed as an endangered species. Io are widespread over agricultural lands and forests. The Short-eared

Owl or Pueo (Asio flammeus sandwichensis) is the only other species which might occur at this site. This owl is relatively common on Hawaii particularly at higher elevations (Berger 1972, Hawaii Audubon Society 1989, Pratt et al. 1987). No other endemic birds would be expected at this site given the elevation and location of the site and the nature of the habitats that are available. No waterbirds should be found on the property as there are no wetlands.

Migratory Indigenous (Native) Birds:

Migratory shorebirds winter in Hawaii between the months of August through May. Some juveniles will stay through the summer months as well (Johnson and Johnson 1983). Of all the shorebirds species which winter in Hawaii the Pacific Golden Plover (Pluvialis fulva) is the most abundant. Plover prefer open areas such as mud flats, lawns, pastures and plowed fields. They arrive in Hawaii in early August and depart to their arctic breeding grounds during the last week of April (Johnson et al. 1981). Bruner (1983) and Johnson et al. (1989) have also shown plover are extremely site-faithful on their wintering grounds and many establish foraging territories which they defend vigorously. Such behavior makes it possible to acquire a fairly good estimate of the abundance of plover in any one area. These populations likewise remain relatively stable over many years (Johnson et al. 1989). Only two plover were recorded during this field survey. The grass is too tall and there are very few barren areas suitable for plover on this property.

Resident Indigenous (Native) Birds:

No indigenous species were recorded nor would any be expected at this site.

Resident Indigenous (Native) Seabirds:

No seabirds were observed on the actual property. One White-tailed Tropicbird (Phaethon lepturus) was seen along the sea cliff face makai of the property line.

Exotic (Introduced) Birds:

A total of 12 species of exotic birds were recorded during the field survey. Table One shows the relative abundance of each species. The most abundant species at Kealakekua were Japanese White-eye (Zosterops japonicus), House Finch (Carpodacus mexicanus), Zebra Dove (Geopelia striata) and Nutmeg Mannikin (Lonchura punctulata). Given the range of habitats found on the property as well as data from surveys elsewhere in West Hawaii (Bruner 1988, 1989a, 1989b) and information provided in Berger (1972), Hawaii Audubon Society (1989) and Pratt et al. (1987) the following exotic birds species might also be expected to occur on or near the property: Common Barn Owl (Tyto alba), Northern Mockingbird (Mimus polyglottos), Black Francolin (Francolinus francolinus), Lavender Waxbill (Estrilda caerulescens) and Yellow-fronted Canary (Serinus mozambicus).

Feral Mammals:

Small Indian Mongoose (Herpestes auropunctatus) were seen and heard during the survey. Feral cats were also observed. Cattle were concentrated on the lower (makai) section of the property. No evidence of rats and mice was discovered but these ubiquitous mammals undoubtedly occur in this area. No trapping was attempted in order to assess the relative abundance of mammals on this property.

Records of the endemic and endangered Hawaiian Hoary Bat (Lasiurus cinerus semotus) are sketchy but the species has been reported from West Hawaii (Bruner 1984, Tomich 1986). None were observed on this field survey despite two nights of observations. This species roosts solitarily in trees. Much remains to be learned about the natural history of this bat and its ecological requirements here in Hawaii.

CONCLUSIONS

A brief field survey can at best provide only a limited perspective of the wildlife present in any given area. Not all species will necessarily be observed. The number of species and the relative abundance of each species may vary throughout the year due to available resources and reproductive success. Species which are migratory will quite obviously be a part of the faunal picture only at certain times during the year. Exotic species sometimes prosper for a time only to later disappear or become a

less significant part of the ecosystem (Williams 1987). Thus only long term studies can provide a comprehensive view of the bird and mamal populations in a particular area. However, when brief field studies are coupled with data gathered from other similar habitats the value of the conclusions drawn can be significantly increased.

The following are some general conclusions relating to bird and mammal activity on the property.

1- All representative types of habitat found on the property were censused. The more densely vegetated mauka section contained many more birds than the open habitat on the lower slope.

2- The present habitats provide a limited range of living spaces which are utilized by the typical array of exotic species of birds one would expect at this elevation and in this type of environment in Hawaii. However, some species normally found in this habitat were not recorded. This could have been due to the fact that the survey was too brief or that their numbers are so low that they went undetected or a combination of these and other factors.

3- The single sighting of the endangered Hawaiian Hawk was not entirely unexpected. This species ranges widely over ranch and farm lands as well as forested areas on the island of Hawaii, but is somewhat less common in West Hawaii.

4- The low numbers of migratory birds at this site is due entirely to an absence of suitable habitat. If large lawn areas are developed on this property the number of Pacific Golden Plover

utilizing the area will undoubtedly increase.

5- The proposed development of this property will alter the existing habitats. Some exotic species of birds such as the Nutmeg Mannikin will decline in abundance as the pasture grass is replaced by more residential vegetation. The Common Myna (Acridotheres tristis) and the House Sparrow (Passer domesticus) will likely increase in abundance following urbanization of this site.

6- In order to obtain more definitive data on mammals, a trapping program would be required. No endangered species were observed.

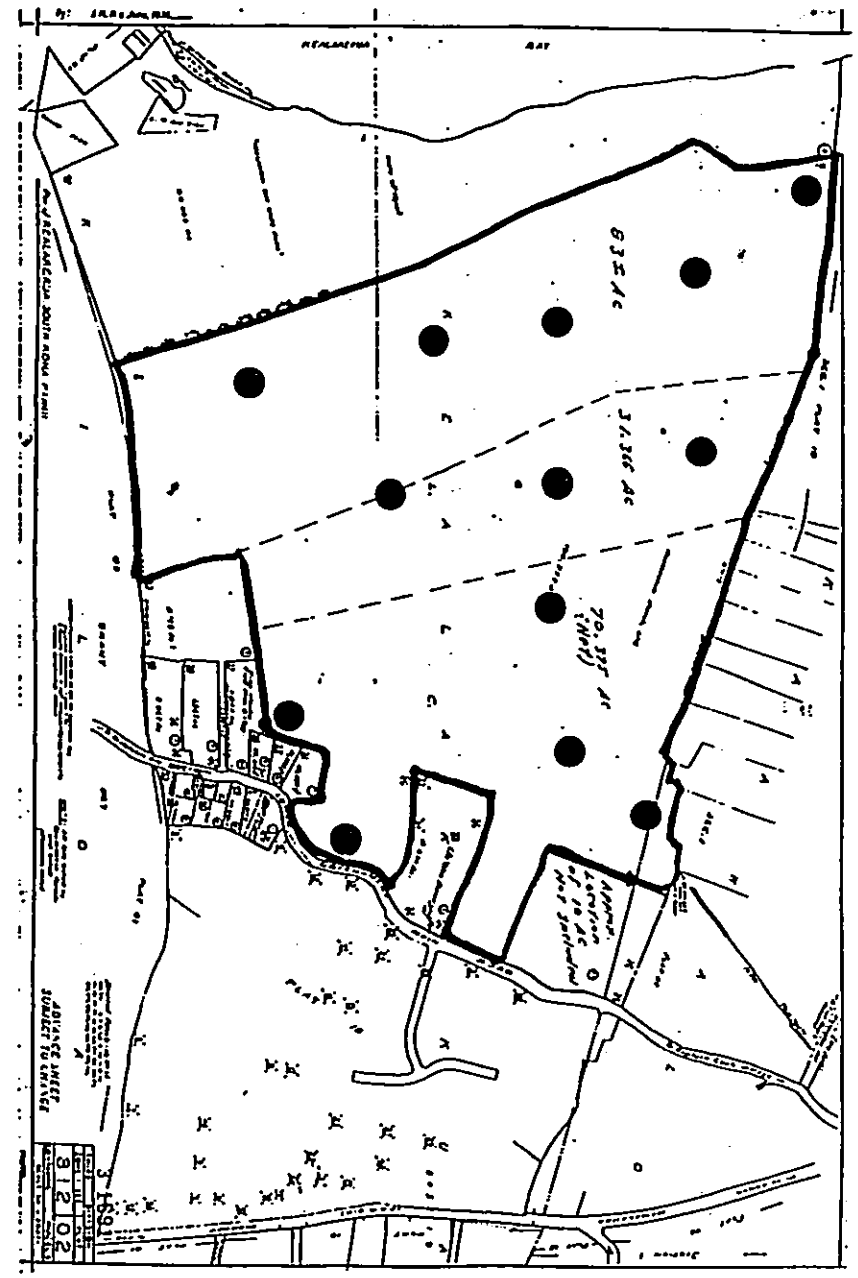

Fig. 1. Project site with eight minute count (census) stations indicated by solid circles.

KEY TO TABLE 1

Relative abundance = number of times observed during survey or average number on eight minute counts in appropriate habitat.

A = abundant (ave. 10+) number which follows is average of data from all survey days

C = common (ave. 5-10) number which follows is average of data from all survey days

U = uncommon (ave. less than 5) number which follows is average of data from all survey days

R = recorded (seen or heard at times other than on 8 min. counts. number which follows is the total number seen or heard over the duration of the survey).

TABLE

Exotic species of birds recorded on Kealakekua Ranch Property, South Kona, Hawaii

COMMON NAME	SCIENTIFIC NAME	RELATIVE ABUNDANCE *
Ring-necked Pheasant	Phasianus colchicus	R = 3
Gray Francolin	Francolinus pondicerianus	R = 2
Spotted Dove	Streptopelia chinensis	U = 3
Zebra Dove	Geopelia striata	A = 11
Common Myna	Acridotheres tristis	U = 4
Yellow-billed Cardinal	Paroaria capitata	U = 2
Northern Cardinal	Cardinalis cardinalis	C = 5
Japanese White-eye	Zosterops japonicus	A = 14
Nutmeg Mannikin	Lonchura punctulata	A = 15
Warbling Silverbill	Lonchura malabarica	R = 6
House Finch	Carpodacus mexicanus	A = 18
House Sparrow	Passer domesticus	R = 8

* (see page 11 for key to symbols)

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Appendix 17:
TRAFFIC IMPACT ASSESSMENT REPORT

TRAFFIC IMPACT ASSESSMENT REPORT

for

KEALAKEKUA BAY CLUB

Kealakekua, Hawaii
TMK: 8-2-02: 02

March 8, 1991

Prepared for:

Royal Coast Development Company

Prepared by:

Pacific Planning & Engineering, Inc.
1221 Kapiolani Boulevard, Suite 740
Honolulu, Hawaii 96814

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EXECUTIVE SUMMARY

Pacific Planning & Engineering, Inc. (PP&E) was engaged to identify and assess future traffic impacts on Napoopoo Road resulting from the proposed Kealakekua Bay Club to be built by Royal Coast Development Corporation. The report focuses on the intersections of the Project Access Road with Napoopoo Road and Mamalahoa Highway with Napoopoo Road. This report presents the findings and recommendations of the traffic study.

Project Description

The proposed project consists of a world class championship golf course with a clubhouse and restaurant, a low density 36-room member's lodge, and five 2-acre residential-agricultural lots. This project is proposed to be built by Royal Coast Development Corporation near Kealakekua Bay on the island of Hawaii. The project will be located south of Kealakekua, north of Napoopoo and west of Napoopoo Road. Figure 1 shows the project location and the roadway network in the vicinity of the project. The project will be on approximately 260 acres, 185 of which will occupy the former Greenwell Oceanside Ranch and 70 acres will lie on the lower undeveloped part of Ka'awaloa. The project will access Napoopoo Road from the Project Access Road which will be privately owned.

Conclusions & Recommendations

The proposed Kealakekua Bay Club will have some impact to the intersection of Mamalahoa Highway with Napoopoo Road in 1994 when the project is expected to be completed. Even without the proposed project, improvements are needed at the intersection of Mamalahoa Highway and Napoopoo Road to provide better sight distance and adequate storage lanes.

Currently, the intersection of Mamalahoa Highway with Napoopoo Road operates at Level-of-Service (LOS) D (long traffic delays) for vehicles turning left from Napoopoo Road onto Mamalahoa Highway. Other turning movements at this intersection operate with little or no delays (LOS A).

Without the project in 1994, the level-of-service for vehicles turning left from Napoopoo Road onto Mamalahoa Highway will worsen to LOS F (extreme traffic delays). Other turning movements at this intersection continue to operate with little delays, LOS B or better.

With the project, in 1994, drivers turning left from Napoopoo Road into Mamalahoa Highway will continue to experience LOS F. Other turning movements at this intersection will continue to operate with little delays (LOS B). Thus, traffic along Mamalahoa Highway will also experience little or no delays.

With the project, the project generated traffic turning left from Napoopoo Road will increase by 43 vehicles. This is a low volume of vehicles which indicates that the project will not create a large impact on this intersection.

Since the analysis uses the peak hour volume of vehicles entering the intersection, the extreme delays experienced by vehicles turning left from Napoopoo Road will occur only a short period during the peak hour. Other times during the day, there will be less traffic on Mamalahoa Highway, therefore vehicles exiting Napoopoo Road will experience better levels-of-service during nonpeak hours. Taking into consideration the low additional volume of vehicles the project will add to the intersection, and that the extreme delays will occur only during a short period of the peak hour, we recommend that the length of the left turn storage lane on Napoopoo Road be extended to accommodate the additional vehicles the project will generate.

To improve traffic flow, it is recommended that the intersection of Mamalahoa Highway with Napoopoo Road be improved as follows:

- Increase the length of the left turn storage lane on Napoopoo Road.
- Improve the sight distance on Mamalahoa Highway and Napoopoo Road.

To minimize the impacts of the project, we recommend that the intersection of Napoopoo Road with the Project Access Road be improved as follows:

- A short deceleration lane (right turn lane) be provided for vehicles entering the project access road from the north or mauka direction.

PROJECT DESCRIPTION

The proposed project consists of a world class championship golf course with a clubhouse and restaurant, a low density 36-room member's lodge, and five 2-acre residential-agricultural lots. This project is proposed to be built by Royal Coast Development Corporation near Kealakekua Bay on the island of Hawaii. The project site is located south of Kealakekua, north of Napoopoo and west of Napoopoo Road. Figure 1 shows the project location and the roadway network in the vicinity of the project. The project will be on approximately 260 acres, 185 of which will occupy the former Greenwell Oceanside Ranch and 70 acres will lie on the lower undeveloped part of Ka'awaloa.

Completion of construction and full operation of tee project is expected by the year 1994. The project will have one private roadway that will access onto Napoopoo Road at a T intersection. From Napoopoo Road, northbound vehicles will be able to connect with Mamalahoa Highway which leads to Kailua, Kona. Figure 2 shows the site plan of the proposed development.

The 18-hole semi-private golf course and driving range is planned to operate during the daylight hours. Public use of the golfing facilities including the clubhouse and restaurant will be allowed, however, overnight accommodations at the lodge will be for club members only. The clubhouse facilities will include a 15,000 square foot restaurant which will be open until 10 o'clock in the evenings, a pro shop, changing rooms, cart storage and maintenance, swimming pool and tennis courts.

The low density lodge is a 36-suite facility which will be available to members of the club for overnight accommodations.

The land abutting Napoopoo Road will be divided into five 2-acre lots that will be dedicated to planting coffee. At least half of each lot will be required to be used for agricultural production.

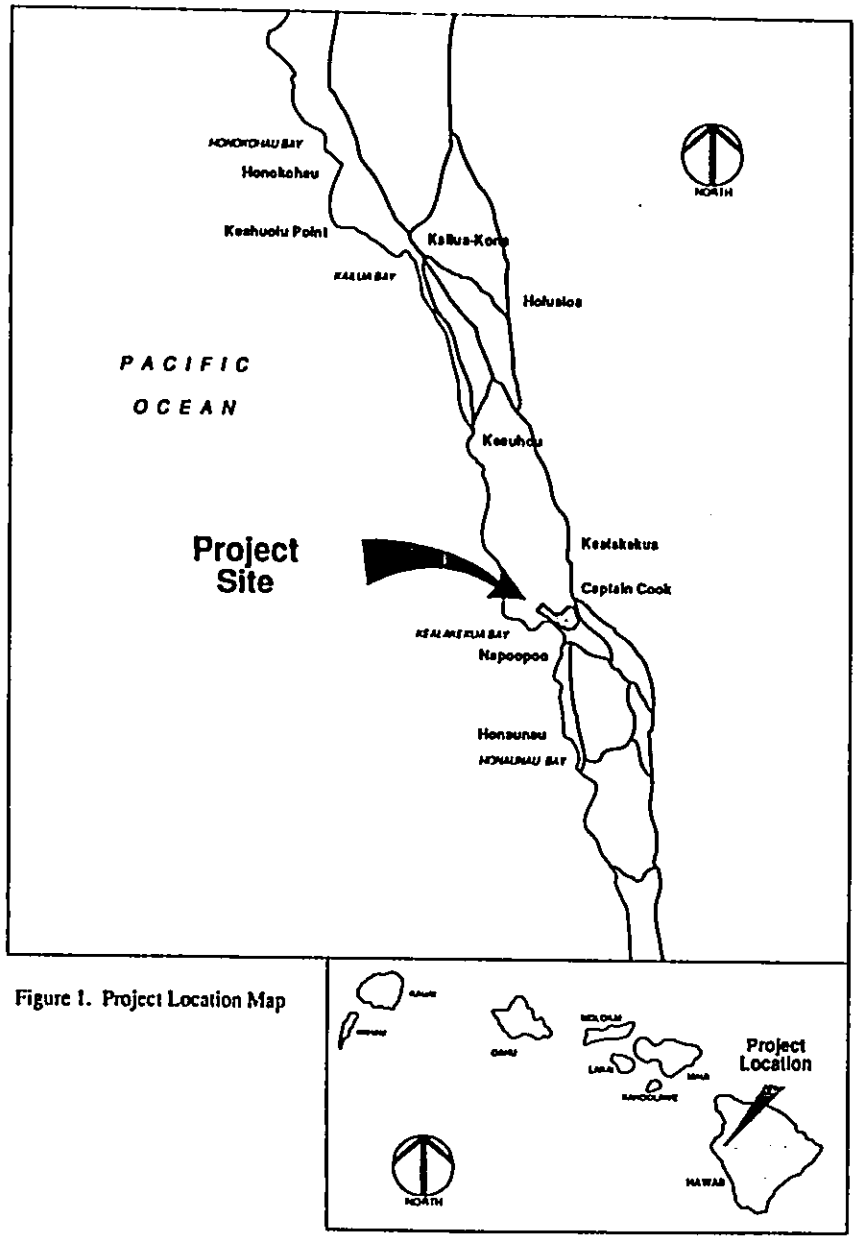

Figure 1. Project Location Map

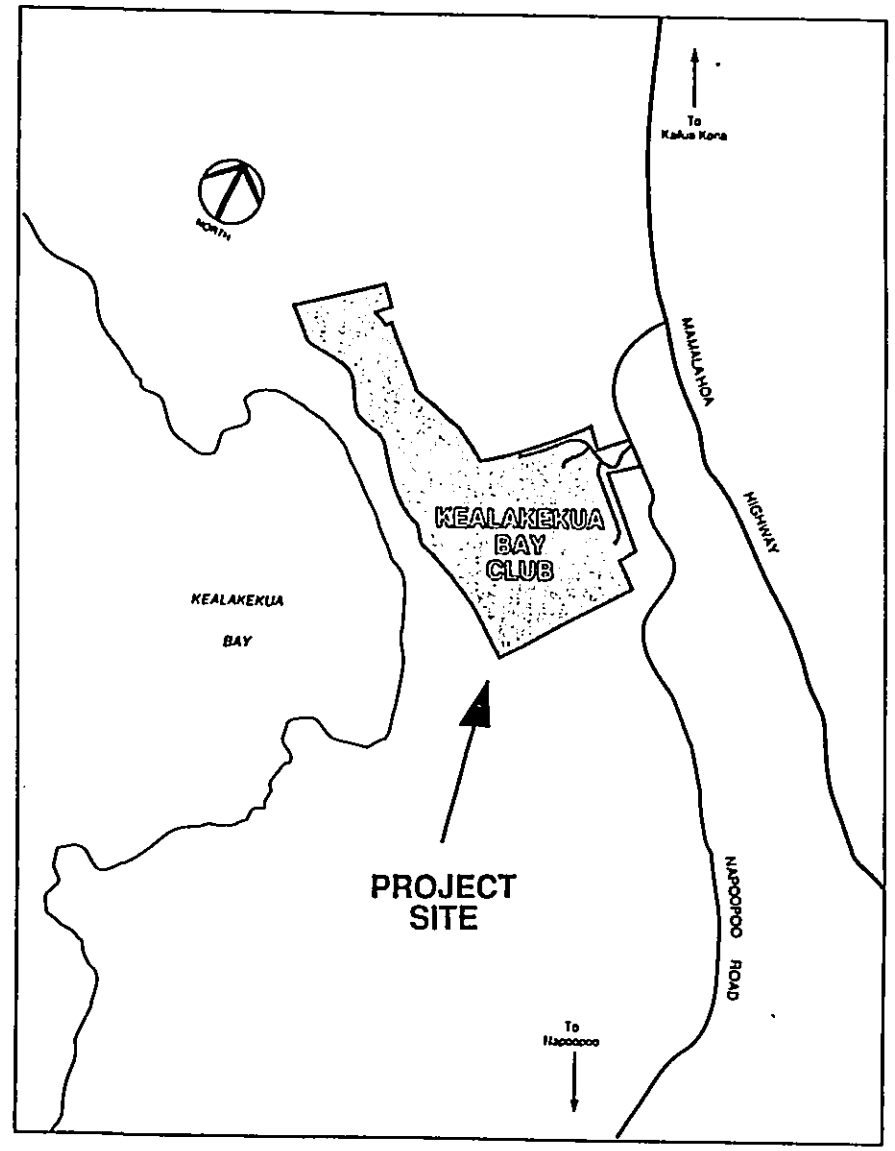

Figure 2. Project Site Plan

AREA CONDITIONS

A survey of the existing conditions was conducted to better evaluate the traffic impact of the proposed project. The survey included the land use of the area, roadway facilities, and existing traffic conditions.

Existing Land Uses

The existing land use that will be displaced by the project is grazing land for Kealakekua Ranch cattle.

The land use surrounding the project is primarily agricultural and ranch use. Some residential developments exist in the area with the closest town being Captain Cook to the north of the project site.

Future Land Uses

Based on research of land use data and other development information sources, there are two known future major development in the immediate area that would generate additional traffic by the year 1994. One of the developments, known as Cook's Landing Subdivision, is a 60 unit single family residential subdivision that is currently under construction and is located mauka of Napoopoo Road, and north of the future project site. Six homes will access through Napoopoo Road, and the remaining 54 homes will access through Mamalahoa Highway. The other development is also a single family residential subdivision which will be under construction in 1994. It is projected that by 1994 approximately 15 single family homes will be completed. This development will be located northwest of the intersection of Napoopoo Road with Middle Keei Road. Access to this development will be through Napoopoo Road.

Roadway Facilities

Mamalahoa Highway (FAP 11) is a Federal Aid Primary roadway providing access to the population centers along the coast of Hawaii in the vicinity of Kealakekua. The project has access to Mamalahoa Highway via Napoopoo Road which runs parallel to and makai of Mamalahoa Highway. Napoopoo Road intersects with Mamalahoa Highway near of Captain Cook Village and with Middle Keei Road further south.

Mamalahoa Highway is a State maintained highway with two 12-foot wide lanes. Near the intersection of Mamalahoa Highway with Napoopoo Road, Mamalahoa Highway has a 2 foot wide shoulder on the mauka side and a 5 foot wide shoulder on the makai side of the highway. Along this section of the highway, the posted speed of Mamalahoa Highway is 35 miles per hour (mph).

At the intersection of Mamalahoa Highway with Napoopoo Road, vehicles turning left from Mamalahoa Highway have limited sight distance due to the curve of the highway at the intersection. On Napoopoo Road, there is a lack of storage space for vehicles exiting the road because of the sharp, almost 90 degree bend in the road near the intersection. Also, Napoopoo Road intersects Mamalahoa Highway in an adverse grade connection.

Napoopoo Road (FASC 160) is a Federal Aid Secondary County road which connects to the project access road. Napoopoo Road is a Hawaii County maintained road that has a pavement width of 20 feet with two 10 foot wide lanes. There are a few residences along this road. The posted speed limit is 25 mph. The project access road will access Napoopoo Road at a T-intersection.

Traffic Conditions

Traffic volume data from the State Department of Transportation (DOT) were used to determine traffic trends on Mamalahoa Highway near the project site. Figure 3 summarizes the trend in Annual Average Daily Traffic (AADT) along Mamalahoa Highway at the intersection of Mamalahoa Highway with Napoopoo Road (Station 7). The plotted data shows an increase in traffic growth on Mamalahoa Highway on the order of 2% per year. The analysis on Napoopoo Road indicates an increase in traffic growth on the order of 1% per year. The trend lines were estimated using linear regression analysis.

A review of the 1988 State Department of Transportation (DOT) traffic count data for the intersection of Mamalahoa Highway with Napoopoo Road indicated that the weekday afternoon commuter peak hour along Mamalahoa Highway at the intersection of Mamalahoa Highway with Napoopoo Road occurs between 4:00-5:00 pm. This peak hour was used to determine traffic impacts since traffic count data indicates that the project traffic would impact the roadway network the most during this time period.

Manual traffic counts were taken for the intersection of Mamalahoa Highway and Napoopoo Road on December 21, 1989. These counts were used as the baseline condition upon which future estimated traffic volumes were added. Figure 4 shows the present volumes and movements of traffic at the study intersections for the observed peak hour.

The manual traffic count data are summarized in Appendix B. Manual counts were taken of passenger cars, trucks, buses, bicycles, motorcycles and pedestrians by turning movements and approaches. Any differences in the time of the manual peak hour from the peak hour found by the DOT data is due to normal variations in daily traffic.

Observed Traffic Conditions

During the field counts on December 21, 1989, the skies were sunny and the pavement was dry.

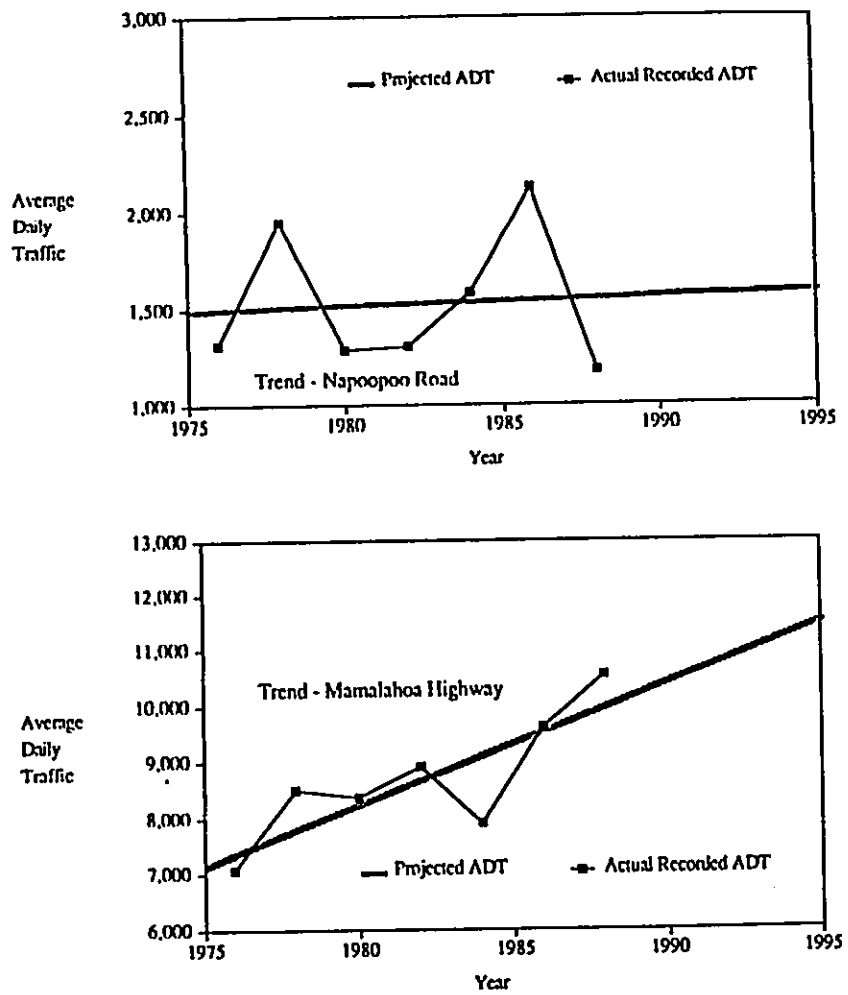

Figure 3. Traffic Growth Trend

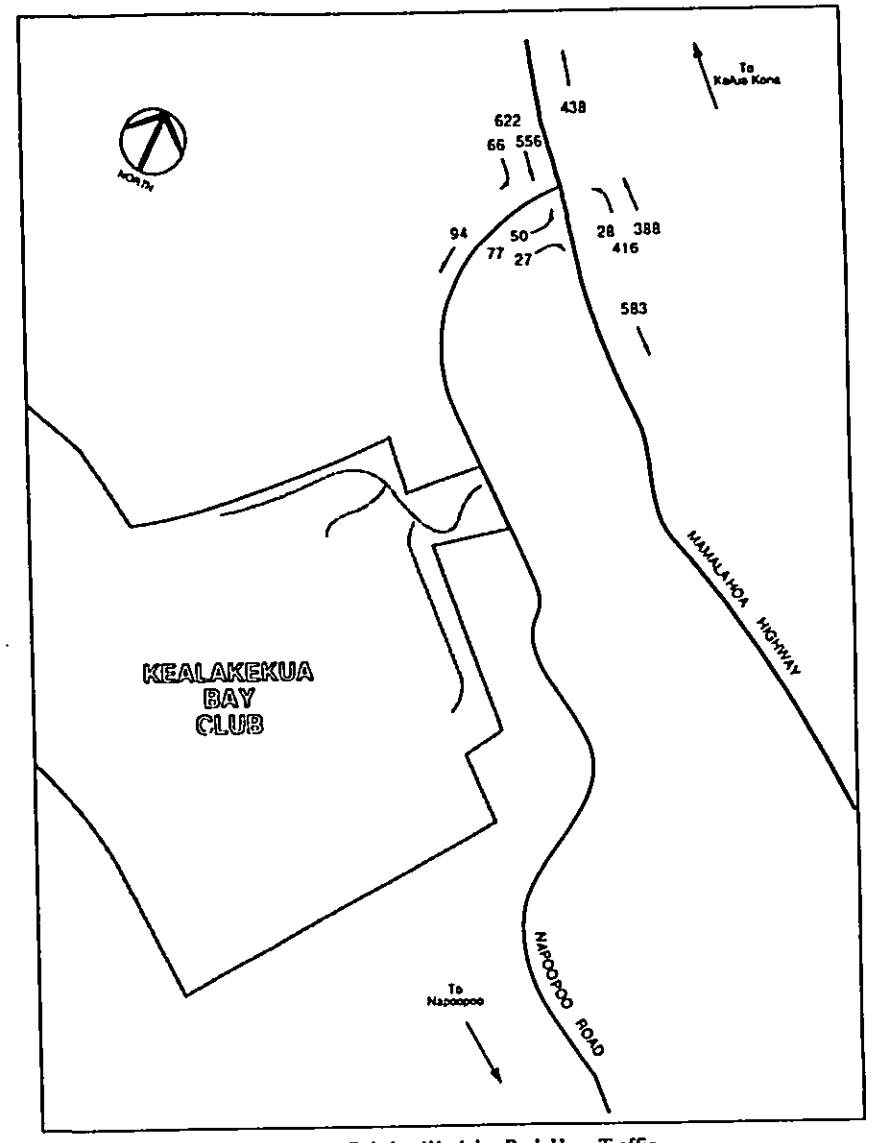

Figure 4. Existing Weekday Peak Hour Traffic

PROJECTED TRAFFIC CONDITIONS

Future traffic forecasts without and with the project were estimated for the year 1994, when the project is expected to be fully occupied.

Future Ambient Traffic

Ambient traffic is the traffic which would occur even if the proposed project was not built. Ambient traffic is forecasted by increasing the existing through traffic volumes by the traffic growth trend along Mamalahoa Highway and Napoopoo Road and by adding traffic generated by developments within the immediate area.

Traffic counts by the DOT indicates that traffic along Mamalahoa Highway and Napoopoo Road has been increasing by about 2% per year and 1% per year, respectively, as discussed in the section on "Existing Conditions." The growth rate generally reflects traffic increase from developments outside the immediate study area and tourist related traffic. For these reasons, the existing peak hour through traffic volumes on Mamalahoa Highway and Napoopoo Road were increased by 8% and 4% respectively, to obtain the ambient traffic forecast volumes for 1994.

The three-step procedure of trip generation, distribution and assignment was used to forecast future ambient traffic caused by future developments.

Trip generation estimates the number of trips that would be generated during the afternoon peak hour by the residential developments. The number of trips were calculated based on data from the ITE Trip

Generation Report (Fourth Edition, 1987) for the future additional homes expected to access Napoopoo Road and Mamalahoa Highway. Table 1 shows the ITE trip generation rates and number of trips generated by the proposed land uses during the afternoon peak hour.

Table 1. Trip Generation for Proposed Land Uses by 1994

Weekday Afternoon

			Trip Rates		Trips	
Land Use	Quantity	Units	Enter	Exit	Enter	Exit
Single Family Homes	6	homes	0.62	0.38	5	3
Single Family Homes	54	homes	0.62	0.38	38	23
Single Family Homes	15	homes	0.62	0.38	11	7

Trip distribution and traffic assignment allocates the generated trips to different directions of travel and specific turning movements on the roadway. Since most of the attractions such as shopping centers, and employment, are located in the direction of Kailua, 90% of the trips exiting Cook's Landing onto Napoopoo Road were assigned northbound and 10% of the trips were assumed to travel southbound, in the direction of South Kona.

Of the vehicles turning onto Mamalahoa from both developments, 90% of the trips were assigned to travel north, in the direction of Kailua, and 10% of the trips were assigned to travel south. Of the vehicles entering and exiting the development south of the project, 90% were assumed to travel north and 10% were assumed to travel south on Napoopoo Road. Figure 5 shows the future traffic volumes for the weekday afternoon peak hour without the project for 1994.

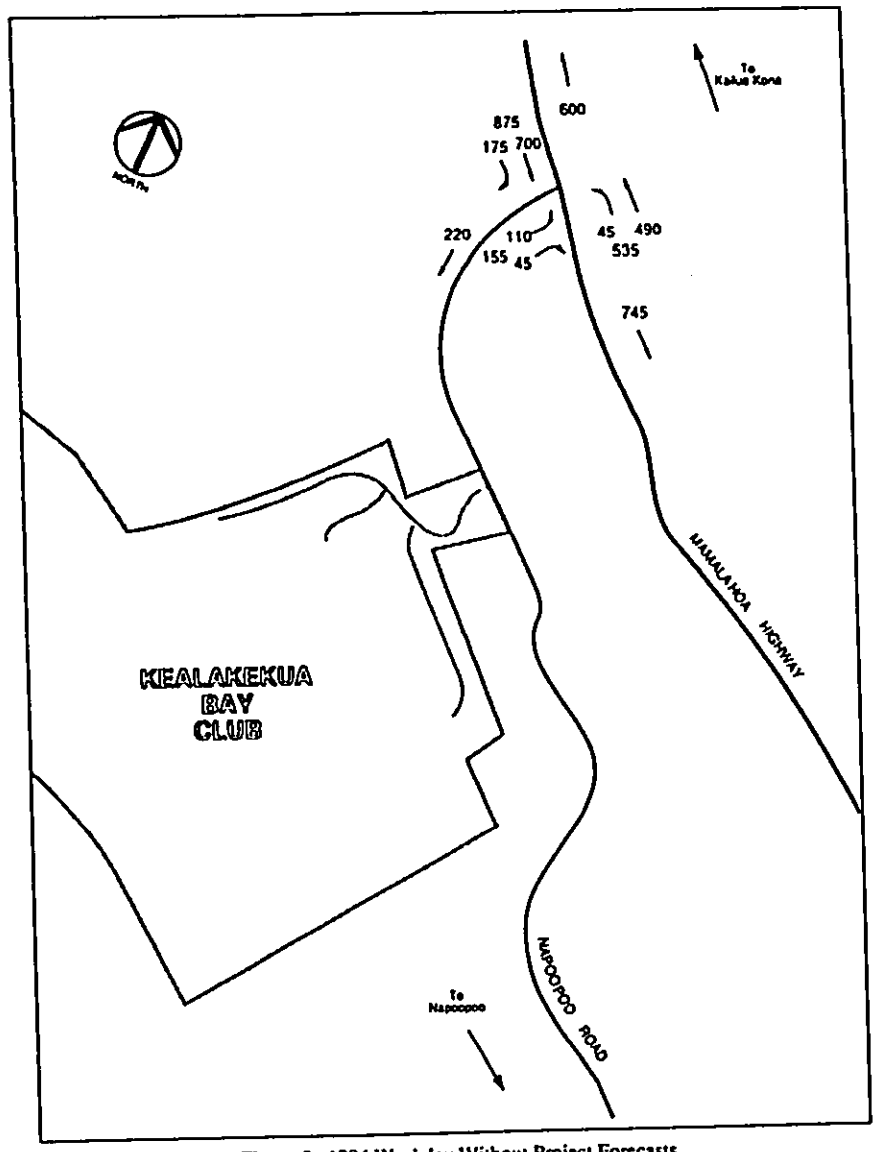

Figure 5. 1994 Weekday Without Project Forecasts

Project Generated Traffic

The three-step procedure of trip generation, distribution, and assignment was used to forecast future peak hour traffic caused by the proposed project.

Trip Generation data for the peak hour of adjacent street traffic for golf courses was used to generate the traffic cause by the proposed golf course for the weekday afternoon peak hour. Since the restaurant may attract visitors also, trips were generated using the peak hour of adjacent street traffic for quality restaurants for the weekday afternoon peak hour. For the lodge, trips were generated using the peak hour of adjacent street traffic for resort hotels, and trips for the coffee growing house lots were generated by using the peak hour of adjacent street traffic for single family detached housing. Table 2 shows the number of trips generated during the weekday afternoon peak hour using the ITE trip generation data.

Table 2. Trip Generation for Project

Weekday Afternoon

			Trip Rates		Trips	
Land Use	Quantity	Units	Enter	Exit	Enter	Exit
Golf Course	100	parking	0.20	0.80	8	32
Lodge	36	rooms	0.44	0.56	7	9
Restaurant	2.8	1000 sf	0.68	0.32	13	6
Single Family Residents	5	homes	0.57	0.43	4	3

The trip distribution and traffic assignment steps allocate the project generated trips to the different directions of travel and specific turning movements on the roadway. The trips were distributed based on the locations of attractions such as hotels, residences, and airports. Approximately 90% of the trips were assumed to travel to/from the northern direction onto Napoopoo Road and Mamalahoa Highway towards Kailua, and 10% to/from the southern direction.

Total Traffic

The ambient traffic volumes for the year 1994 were added to the project generated volumes to obtain the total forecast volumes with the project. Figure 6 shows the resulting turning movement volumes *with* the project for the weekday afternoon peak hour for 1994.

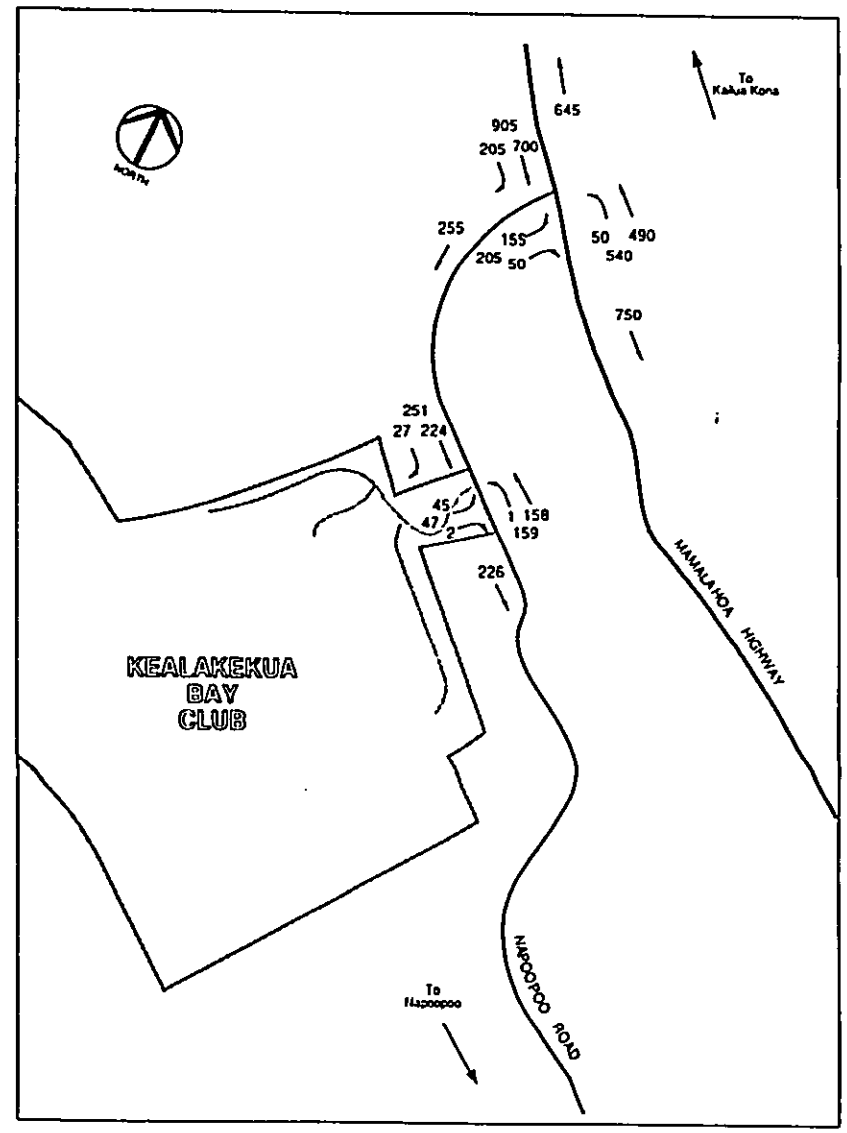

Figure 6. Weekday 1994 with Project Forecasts

TRAFFIC IMPACT ANALYSIS

Impacts on traffic resulting from the project were measured by comparing existing traffic conditions, future traffic conditions without the project and future traffic conditions with the project.

These conditions were analyzed using the Unsignalized Intersection analysis from the Highway Capacity Manual[1]. This analysis method determines level-of-service (LOS) which is classified into six categories ranging from LOS A to LOS F (summarized in Appendix A). The results of the analysis are summarized in Table 3 below.

Table 3. Level-of-Service for the Study Intersections

Weekday Afternoon	Existing 1990	Reserve Capacity	Without Project 1994	Reserve Capacity	With Project 1994	Reserve Capacity
Mamalahoa Highway with Napoopoo Road						
Mamalahoa Highway						
Left Turn	A	537	A	401	B	374
Napoopoo Road						
Left Turn	D	117	F	-102	F	-198
Right Turn	A	486	B	318	B	300
Napoopoo Road with Project Access Road						
Napoopoo Road						
Left Turn	-	-	-	-	A	931
Project Access Road						
Left & Right Turn	-	-	-	-	A	489

[1] Highway Capacity Manual, Special Report 209, 1985 Edition, by the Transportation Research Board

Presently, vehicles turning left from Mamalahoa Highway into Napoopoo Road experience LOS A (little or no delays) during the weekday afternoon peak hour. Vehicles turning right from Napoopoo Road experience LOS A while vehicles turning left from Napoopoo Road experience LOS D (long traffic delays). Vehicles turning left from Napoopoo Road have longer delays since drivers must wait for both directions of Mamalahoa Highway to clear before they are able to complete their maneuver.

Without the project, in 1994, vehicles turning left from Mamalahoa Highway will continue to experience LOS A. Vehicles turning right from Napoopoo Road will experience LOS B. Vehicles turning left from Napoopoo Road will experience LOS F (extreme delays), a decrease in level-of-service.

With the project, in 1994, vehicles turning left from Mamalahoa Highway into Napoopoo Road will experience LOS B as well as vehicles turning right from Napoopoo Road into Mamalahoa Highway. Vehicles turning left from Napoopoo Road will experience LOS F (extreme delays), a decrease of level-of-service from the without project condition (Table 3 indicates that the reserve capacity for the vehicles turning left from Napoopoo Road is negative. This indicates that the demand volume exceeds the capacity of the lane).

For the existing and without project conditions, the intersection of Napoopoo Road with the Project Access Road does not exist, therefore, Napoopoo Road was not analyzed for these conditions.

Table 3 shows that with the project, in 1994, vehicles turning left from Napoopoo Road onto the Project Access Road as well as vehicles exiting the Project Access Road will experience little or no delays (LOS A).

Signalization of Study Intersection

The intersection of Mamalahoa Highway with Napoopoo Road was analyzed using the Planning Application Worksheet for Signalized Intersections for the with-project condition. This analysis method was used since the results of the analysis indicates long delays for traffic exiting Napoopoo Road. The Planning Analysis indicates that if a signalized, the intersection would operate under capacity. Table 4 shows the results of this analysis.

Table 4. Planning Analysis for Signalized Intersection
Napoopoo Road with Project Access Road

With Project	Max Critical Volume	Critical Volume	Capacity Level
Afternoon Peak Hour	1200	1110	Under

CONCLUSIONS AND RECOMMENDATIONS

The proposed Kealakekua Bay Club will have some impact to the intersection of Mamalahoa Highway with Napoopoo Road in 1994 when the project is expected to be completed. Even without the proposed project, improvements are needed at the intersection of Mamalahoa Highway and Napoopoo Road to provide better sight distance and adequate storage lanes.

Currently, the intersection of Mamalahoa Highway with Napoopoo Road operates at Level-of-Service (LOS) D (long traffic delays) for vehicles turning left from Napoopoo Road onto Mamalahoa Highway. Other turning movements at this intersection operate with little or no delays (LOS A).

Without the project in 1994, the level-of-service for vehicles turning left from Napoopoo Road onto Mamalahoa Highway will worsen to LOS F (extreme traffic delays). Other turning movements at this intersection continue to operate with little delays, LOS B or better.

With the project, in 1994, drivers turning left from Napoopoo Road into Mamalahoa Highway will continue to experience LOS F. Other turning movements at this intersection will continue to operate with little delays (LOS B). Thus, traffic along Mamalahoa Highway will also experience little or no delays.

With the project, the project generated traffic turning left from Napoopoo Road will increase by 43 vehicles. This is a low volume of vehicles which indicates that the project will not create a large impact on this intersection.

Since the analysis uses the peak hour volume of vehicles entering the intersection, the extreme delays experienced by vehicles turning left from Napoopoo Road will occur only a short period during the peak hour. Other times during the day, there will be less traffic on Mamalahoa Highway, therefore vehicles exiting Napoopoo Road will experience better levels-of-service during nonpeak hours. Taking into consideration the low additional volume of vehicles the project will add to the intersection, and that the extreme delays will occur only during a short period of the peak hour, we recommend that the length of the left turn storage lane on Napoopoo Road be extended to accommodate the additional vehicles the project will generate.

To improve traffic flow, it is recommended that the intersection of Mamalahoa Highway with Napoopoo Road be improved as follows:

- Increase the length of the left turn storage lane on Napoopoo Road.
- Improve the sight distance on Mamalahoa Highway and Napoopoo Road.

To minimize the impacts of the project, we recommend that the intersection of Napoopoo Road with the Project Access Road be improved as follows:

- A short deceleration lane (right turn lane) be provided for vehicles entering the project access road from the north or mauka direction.

APPENDIX A

Level-of-Service for Unsignalized Intersections

APPENDIX A

LEVEL OF SERVICE FOR UNSIGNALIZED INTERSECTIONS

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

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

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

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

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

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

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

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

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

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

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

REFERENCE: Highway Capacity Manual (Special Report 209, 1985)

APPENDIX B

MANUAL TRAFFIC COUNT DATA

Location: Mamalahoa Highway @ Napoopoo Road

Date: December 21, 1989

	Mamalahoa Highway				Napoopoo Road	
	Northbound		Southbound		Eastbound	
Time (pm)	LT	TH	RT	TH	LT	RT
3:30-3:45	9	109	22	116	17	9
3:45-4:00	7	88	9	110	15	7
4:00-4:15	8	90	11	123	8	13
4:15-4:30	4	102	23	117	19	4
4:30-4:45	9	108	18	152	16	5
4:45-5:00	7	88	14	164	7	5
Peak Hour (4:00-5:00)	28	388	66	556	50	27