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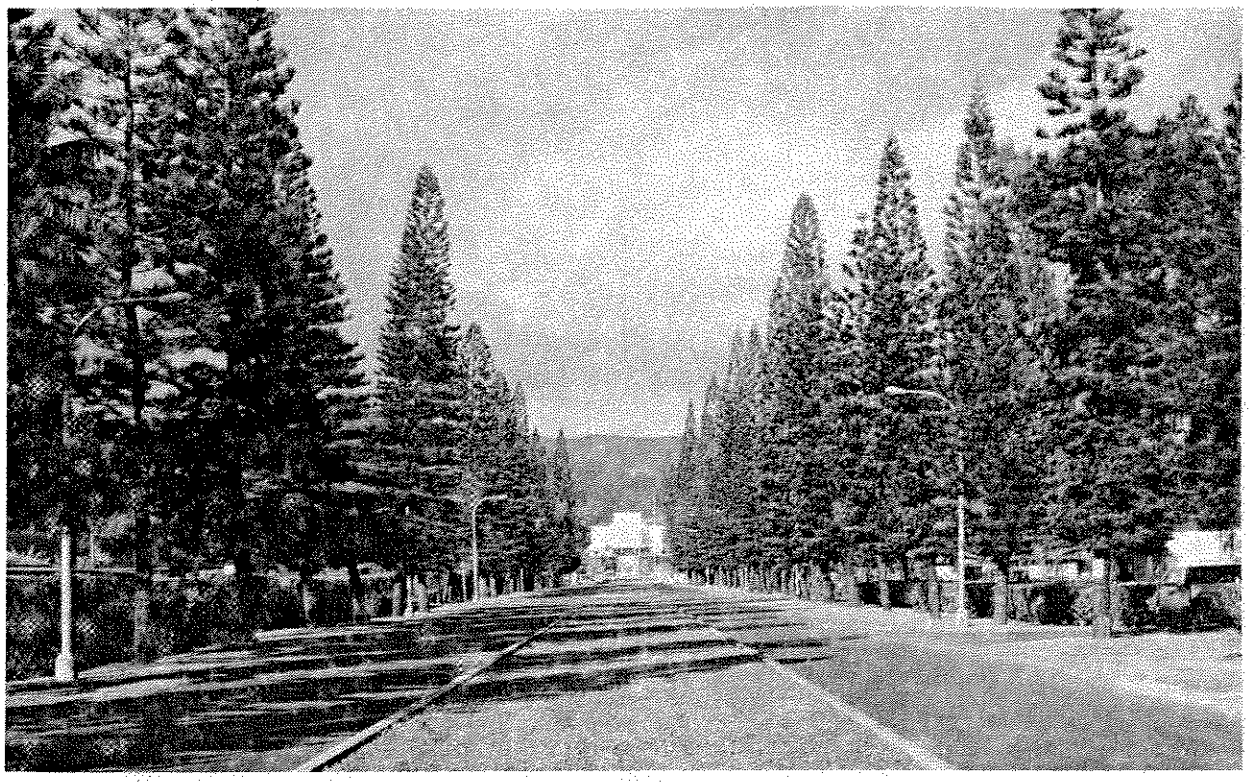
LA'IE DEVELOPMENT PLAN AMENDMENTS

LA'IE, KO'OLAULOA, O'AHU, HAWAI'I



FINAL ENVIRONMENTAL IMPACT STATEMENT

APPLICATION FOR KO'OLAULOA DEVELOPMENT PLAN AMENDMENTS

VOLUME II

ZIONS SECURITIES CORPORATION
LA'IE, HAWAI'I

APRIL 1992

LA'IE DEVELOPMENT PLAN AMENDMENTS

Ko'olauloa District, Island of O'ahu

FINAL ENVIRONMENTAL IMPACT STATEMENT

VOLUME II

Applicant:

Zions Securities Corporation
55-510 Kamehameha Highway
La'ie, Hawai'i 96762

For Submission to:

City and County of Honolulu
Department of General Planning
650 South King Street, 8th Floor
Honolulu, Hawaii 96813

Prepared by:

Group 70 International, Inc.
Architects • Planners • Interior Designers
924 Bethel Street
Honolulu, Hawai'i 96813
(808) 523-5866

Submitted by:

Ralph Portmore

Ralph Portmore, AICP
Its: Vice-President
Group 70 International, Inc.

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Appendix A: Draft La'ie Master Plan

Note: The Draft La'ie Master Plan (April 1990) included in this appendix was prepared when the Egg Farm area was under active consideration for a new residential neighborhood in La'ie. This is no longer the case. Other proposals for new land uses have also subsequently changed. This EIS and the accompanying Development Plan Amendment Application describe the current proposals for new land uses which are to be included in the La'ie Master Plan when it is finalized. Other sections of the Draft Master Plan are still current.

Draft

LAIE MASTER PLAN

2 April 1990

Group 70 Limited · Architects · Planners · Interior Designers · 924 Bethel Street · Honolulu, HI 96813 · Phone (808) 523-5866 · FAX (808) 523-5874

DRAFT

LAIE MASTER PLAN

Prepared by:

GROUP 70 LIMITED
Architects, Planners and Interior Designers
924 Bethel Street
Honolulu, Hawaii 96813

April 2, 1990

LAIE MASTER PLAN

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I. INTRODUCTION

The Laie Master Plan is intended to lay out a course for accommodating future growth and change in Laie* which has a broad base of support within the community. As described below, how that course is laid out, as well as what that course is, are given equal emphasis in the preparation of the Plan.

Objectives

There are several land use and development related issues now confronting Laie, the response to which will have a lot to do with shaping the community's future. The purpose of this Master Plan is to provide direction for an orderly and coordinated response which reflects as well as possible the collective wishes of the people who will be affected.

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*This Master Plan covers the area mauka of Kamehameha Highway which is predominantly owned by the Church of Jesus Christ of Latter Day Saints (LDS Church), and the area directly across or on the makai side of Kamehameha Highway from the LDS Church owned lands. Most of the latter area is divided into individual residential lots with separate owners. The southerly (Hauula-side) mountain-to-the-sea boundary of the Plan area crosses Kamehameha Highway at the former CYO Camp (now City & County future park site). The northerly (Malaekahana-side) boundary crosses at the roadway to the Cackle Fresh Egg Farm.

The geographic place identified as Laie on various maps is somewhat larger. Its northerly boundary -- the original Laie-Malaekahana ahupuaa boundary -- is located approximately 2,000 feet north of the above-described Plan area boundary. The southerly ahupuaa and Plan area boundaries are the same.

Specific objectives of the Master Plan are to:

1. Identify suitable areas for the provision of new homes which will meet Laie's pent-up and future housing needs.

2. Investigate alternatives for providing new housing at prices that Laie residents will be able to afford.

3. Provide sufficient land to allow for the future expansion of the Brigham Young University-Hawaii Campus, Polynesian Cultural Center, and Hawaii Temple, and/or to buffer these activities from nearby, potentially incompatible uses.

4. Determine what new support facilities (e.g., expanded parks and recreational facilities, a community center, more shops, a light industrial area) will be needed to both better serve the existing community and provide for new development, and identify suitable areas for locating them.

5. Identify major water, sewer, street and drainage improvements which will be needed to support new development, and estimate their approximate costs.

6. Estimate the overall costs of improvements to the existing private roadways and drainage systems in Laie which will have to be made if they are to be turned over to the City and County for maintenance purposes.

The Planning Process

The preparation of the Laie Master Plan focused not only on producing a final product -- namely, policies for guiding future development in Laie. Equal importance was placed on the process by which these policies were

formulated. A critical objective underlying the entire planning program was to develop a plan which has the support of a broad cross-section of Laie residents.

This approach was based on common sense as well as good intentions. Past experience in Laie and elsewhere has shown that proposals for major new development in a community usually go nowhere without broad based, active community support. The necessary government approvals simply do not come without it.

Efforts to develop this broad base of support have involved two basic processes:

1. Reaching out as far and wide as possible into the community — to people who do not normally "get involved" in community associations and other organized groups, for example — with information on the plan, so that nearly everyone has a chance to find out what is going on and offer their comments.

2. Informing people at several points during plan preparation about what has been done to that point, and giving them an opportunity to share their reactions and their ideas about what the plan should be.

Reaching Out to the Community — Attempts to inform people about the planning program went well beyond the presentations at the beginning of each phase. First of all, the Laie Community Association was very actively involved in the review of the consultants' proposals. Several public meetings were held to discuss the proposals and gather resident reactions to them. Work groups, with membership open to the public, were also formed to develop alternatives where desired and to begin gearing up to help implement the Plan's recommendations.

In addition, a major effort was made to seek comments from people who did not participate in the Laie Community Association's review. This was done with the assistance of two Laie residents who were engaged to meet informally with individuals and small groups wherever and whenever they

could to discuss the planning program. They put together block meetings, met with clubs and extended families, made themselves available for people to drop in at a storefront office in the Laie Shopping Center, and even went door-to-door to get comments from as diverse a group of people as possible.

Project Phases — To inform and involve people throughout the planning process, the preparation of the Master Plan has been broken down into several distinct phases:

1. Existing Conditions and Future Needs

2. Alternatives for Meeting the Needs

3. Draft Master Plan

4. Master Plan Finalization

The first phase began in the Spring of 1987 with a review of existing conditions in Laie (land use, steep slopes, flood hazards, etc.) which physically limit where new development could occur. In addition, a community survey was conducted to find out what kinds and how much development residents would like to see. After the results of these efforts were presented, the community was given an opportunity over a two month period to study these materials and comment on them if they wished. The idea was essentially to confirm that the survey accurately reflected peoples' wishes for the future of Laie, and to gather further opinions and insights on what kinds of development are appropriate and where it should and should not go.

Phase 2 presented choices, in the form of two alternative schemes, for meeting the needs identified in the first phase. These included alternatives locations for new housing, parks, and an industrial area. Also presented were estimates of what it would cost to provide the infrastructure (water, sewers, streets and drainage) for new development, and what it would cost to improve existing streets and drainage systems so

they could be turned over to the City and County for maintenance purposes. Here again, materials explaining the alternatives and possible costs were distributed, and both formal meetings and many informal discussions were held, to get peoples' reactions to the alternatives.

Phase 3 began with the completion by the planning consultants (Group 70 Limited) of a draft master plan, based on what was learned and the comments received during Phases 1 and 2. Also included in the draft were the results of a study of possible ways of providing housing which will truly be affordable for Laie residents needing new homes. This draft was presented to the community at a Laie Community Association (LCA) meeting in December 1987, and to the leadership of Zions Securities Corporation and the LDS Church in Salt Lake City in March 1988.

Subsequent discussion and review with the LCA Planning and Executive Committees appeared to indicate tentative support for many of the recommendations in the draft. However, any kind of formal action was withheld pending the receipt of comments from Zions Securities Corporation. After extensive review, the ZSC Board of Directors expressed serious reservations concerning the draft plan's recommendation that the area mauka of the Brigham Young University - Hawaii Campus be immediately developed with housing. This was based on two concerns:

1. The cost ($4.8 million in 1987 dollars) of building the new 1-1/2 mile long loop road that would be required to provide proper access to the proposed new residential area.

If this cost was paid entirely by the new residential area, it would probably eliminate the possibility of including a significant number of affordable units in the project. While it could be argued that the BYU-HC and PCC would benefit from the new road, and should thus pay for a portion of the cost, there was a real question as to whether this road was needed to adequately accommodate any future expansion of these facilities. Indeed, given the absence of plans for any major expansion at either facility in the near or long-term future, a sharing of costs in the very

near future, as required to build the badly needed housing, could not be justified.

2. The desire to not forclose at this time the possibility of using the area mauka of BYU-HC for some purpose other than housing.

The major advantage of this area for housing is its proximity to the existing Laie community. However, its proximity does not apply just to the existing residences; this area is also very close to the BYU-HC and PCC, as well as to the Hawaii LDS Temple. Because of this, the area could in the long-range future be needed for uses or activities related to these facilities which are not envisioned at this time, and which could not be accommodated or would not be appropriate within the expansion areas currently designated on the master plan.

The area is also among the best agricultural land in Laie, and is in active cultivation. The retention of this area in agriculture for the time being would not only permit this activity to continue. It would also allow the postponement of a decision on what type of non-agricultural use should ultimately go there (if such a change is to occur) until a better-informed choice between the many attractive options -- including housing -- can be made.

Given these reservations, it was decided to undertake a further study of the potential to accommodate additional residential development in either the Laiemalo'o area, at the Hauula end of Laie, or on and surrounding the existing Cackle Fresh Egg Farm site. Discussions with members of the Laie Community Association indicated that the latter area is likely to be more acceptable to Laie residents because of its closer proximity to the existing community. The planning consultants were then engaged to undertake a fourth phase in the plan preparation effort; namely, a study of the feasibility of accommodating the proposed 450-unit new residential area at the northerly (Malaekahana) end of Laie.

This draft master plan reflects the results of that effort.

Following review and comment on this new draft by both the Church leadership and the residents of Laie, it is hoped that the Master Plan can be finalized in a form that is jointly supported and adopted by Zions Securities Corporation and the Laie Community Association. It is intended that an adopted plan serve as a guide to both organizations — and, hopefully, the State and City and County agencies and anyone else who may be involved — in making future planning and development decisions affecting Laie.

II. THE LAIE COMMUNITY

Environmental Setting

Laie is located on the gently sloping coastal plain between the shore and the Koolau Mountains. Offshore are several small islets and scattered coral reefs. Most of the community is at an elevation of 6 to 12 feet, situated on former beach and coral deposits that were formed when the sea was at a relatively higher level. Inland from Laie, the mountains rise steeply to an elevation of 2,200 feet. The slopes of the mountains are dissected by numerous deep stream valleys, several of which contain perennial flow along much of their length (e.g. Kaipapau, Kahawainui, Malaekahana).

Laie has a nearly constant exposure to the northeast trade winds. Being the windward side of the island, the mountain crests receive as much as 200 inches of rainfall annually, while the coastal areas average 50 inches annually (Ref. 1). The mean maximum (early afternoon) temperature along the coast near Kahuku and Laie ranges from the mid 70s in the winter months, to the low 80s in the summer and fall. Mean minimum (night time) temperatures range from the low 60s in the winter to the low 70s in the summer (Ref. 2).

Laie has a healthy complement of natural resources, from clean sand beaches to mountain watersheds. Beaches form a nearly continuous strip from Hauula to Kahuku. Although much of the shoreline is difficult to reach due to private residences, there are several popular public and open private beaches.

NOTE: The bulk of the material in this chapter is excerpted from the April 1981 "Master Plan and Environmental Assessment" prepared by VTN Pacific for a proposed low income housing project. More recent data is provided when available.

Another natural resource, and a rather unique geological feature of the area, is the numerous lithified sand dunes. These are ancient coral dunes which have been cemented to a hard sandstone through a process of solution and redeposition. The dunes, most of which now appear as low hills, extend from the shore (Laie Point) to over a mile inland. They are an important local source of construction materials and have been quarried for many years.

The fertile soil of the coastal plain and low terraces of the Koolau Mountains provide a valuable agricultural resource in Laie. For many years, the Kahuku Sugar Plantation used this land and was the major economic activity of the region. When the plantation closed in 1971, much of the cane land was converted to other crops. Papaya and banana are among the most common now found in the area.

Historical Background

Laie was originally a small Hawaiian settlement with a population of around 400 in the 1830s. The estimated population in 1853 was 450 (Ref. 3 & 4). Cultivation in the area included numerous taro patches fed by streams and springs, and an inland fishpond (named Pa'eo) near Kahawainui Stream. It has been reported that there was a "place of refuge" at Laie, and two heiaus of which little remains (Ref. 5). Following the Great Mahele in the late 1840s, the ahupua'a of Laie passed through several hands and was eventually purchased by the Church of Jesus Christ of Latter Day Saints. Today, the majority of Laie residents are members of the Church, and the community has played a central role in the Church's activities in the Pacific Basin.

It is a basic tenet of Mormon belief that the Polynesian people are a scattered branch of the House of Israel. Since 1843, the Church has actively recruited new members in Polynesia (Ref. 6 and 8). The first Mormon missionaries came to Hawaii in 1850, three years after the founding of Salt Lake City.

In the early 1860s, a delegation of elders was sent from Utah to purchase a new "gathering place" for Church members. Having a common settlement is a tradition of the Mormon Church, important for the preservation of cultural values and for security (which during the early period of persecution was necessary for the protection of members). The ahupua'a of Laie, approximately 6,000 acres stretching from the shore to the crest of the Koolau Mountains, was purchased in 1865 for a total of $14,000. This price included a number of buildings and over 1,200 head of livestock. At the time, about 1,500 acres was arable ranch land while the rest was either mountainous or lacked a means of water supply (Ref. 6).

Mormon colonists for the new settlement were recruited both in Utah and Hawaii, and new arrivals were given leaseholds on which to build housing and grow crops for subsistence. Beginning in 1868, sugar cane was raised to provide employment. Since surface water was not sufficient to sustain consistent yields, Church members at Laie experienced considerable hardship, and financial aid from the Church General Authority at Salt Lake proved necessary on several occasions (Ref. 6).

In 1898, the first large pump was installed on an artesian well and Laie's water problems were ended. Additional wells and pumps made crops possible, and soon the capacity of Laie's small sugar mill was exceeded. Excess sugar acreage was leased to the Kahuku Plantation and arable land was also leased to pineapple growers. Other smaller businesses were begun, including the raising of livestock and a dairy.

For several years, the Laie Plantation was very successful, but during the 1920s, it went deeply into debt. In 1927, the plantation manager sold a large strip of beach frontage to reduce the debt. About the same time, the elementary school which Mormon missionaries had operated since 1881 was turned over to the Territory of Hawaii. Finally, in 1931, the Laie Plantation closed and all sugar acreage was leased to the Kahuku Plantation. Missionaries who had staffed the school and worked on the plantation returned to the mainland. Many Laie residents were disheartened by the economic and social decline and moved away (Ref. 6). During the 1930 census, the Laie Census Area population was only 521 (Ref. 11).

In spite of these problems, the importance of Laie in the fulfillment of Church goals did not decline. Laie had had several small chapels in the 19th century, but there was no temple in which important rites of the Church could be performed. In 1916, ground was broken for the now famous Laie Temple located on a hill overlooking the community. The Temple was dedicated in 1919, and subsequent landscaping and buildings have made it a landmark structure. Because of the importance of the Temple in Mormon doctrine, the Laie Temple became the spiritual center of the Church in the Pacific Basin.

During World War II, new jobs at nearby military installations resulted in growth of the Laie population, and an upsurge in housing construction. Heavy use of the Temple by Mormon servicemen required a large staff of workers. However, with the end of the war in 1945, the upturn in Laie's economy ended (Ref. 6). Despite the war, Laie's population increased by only 80 persons between the 1940 and 1950 census.

Laie's population more than doubled between 1950 and 1960, to a total of 1,767 in 1960. It has continued to grow ever since, reaching 4,640 in the 1980 U.S. Census. Beginning in 1953, there was new growth in employment opportunities when the lease of Mormon land to Kahuku Plantation was modified to allow more land for diversified agriculture. Then in 1955, the Church College of Hawaii was opened with 153 students housed in temporary buildings. Construction and operation of the Church College involved major expenditures and revived Laie's prosperity. In 1974, the school affiliated with Brigham Young University of Provo, Utah, and acquired its present name: Brigham Young University-Hawaii Campus (BYU-Hawaii) (Ref. 6).

By the Fall of 1981, enrollment at BYU-Hawaii had grown to about 1,880 students, the majority originating from Hawaii and other islands in the Pacific. Enrollment at the beginning of Fall 1987 was 2,079.

Approximately 80 percent of University operating costs are currently paid from the tithes of members of the Mormon Church. The remainder comes

primarily from student tuition and net revenues from admission fees of the Polynesian Cultural Center (Ref. 6 & 7).

The Polynesian Cultural Center (PCC) was established in 1963 to study and preserve Polynesian arts, crafts, and culture, and to provide work for foreign BYU-Hawaii students who needed financial aid. The PCC has been very successful and is now the single largest employer in Laie. Growth in PCC operations has more than offset the impact on Laie from the closing of Kahuku Plantation in 1971, and has made it possible for thousands of students to support themselves while attending BYU-Hawaii (Ref. 7-10).

Laie has not become the "gathering place" for all Mormons in Hawaii as originally planned, since less than 10 percent of Hawaii's Mormon population now live there (Ref. 8). However, because of the Temple, the community's importance has not diminished. With the success of BYU-Hawaii and the Polynesian Cultural Center, Laie will continue to have a central role in the lives of many Hawaii residents and visitors.

Social Characteristics

Employment -- A fall 1979 survey of Laie residents (excluding single students not living with their parents) found that 80% of all employed Laie residents had a job in Laie and that the Polynesian Cultural Center (PCC) and BYU-Hawaii together accounted for almost 70% of all jobs held by Laie residents (Ref. 12). Table 1 presents a detailed breakdown of where Laie residents reported to work at that time. While more recent information is not available, indications are that the pattern has not changed appreciably.

Since the PCC was established, in part, to provide employment for needy BYU-Hawaii students, the size of the PCC work force is as much a matter of policy as it is of economics. Students are limited to a maximum of 20 hours of work per week at the PCC. Student employees typically make up 50-60% of all PCC workers. In mid-1987, the PCC had about 550 full-time, 190 part-time and 580 student employees.

Table 1

WORKING PLACE OF LAIE RESIDENTS IN 1979

Working Place	% Of All Employed Persons
Polynesian Cultural Center	41%
BYU-Hawaii Campus	28%
Zions Securities Corporation	1%
Laie Shopping Center	2%
Laie Schools	8%
Kuilima Resort	1%
Other Kahuku or North Shore	4%
Hauula - Punaluu	1%
Kaneohe - Kailua	2%
Other Oahu	12%

Note: Data is based on a 100% sample household survey in TMK 5-5 which excluded all single BYU-Hawaii students who were not living with their parents and included all residents in married student apartments on the BYU-Hawaii campus.

Source: Ref. 12

The size of the BYU-Hawaii work force is proportional to the number of students attending BYU-Hawaii. For its Fall 1987 enrollment of 2,079 students, BYU-Hawaii employed 93 full-time and about 35 part time instructors, and 180 other staff. In general, BYU-Hawaii attempts to maintain a ratio of about 1 faculty member per 12 student credit-hours and requires about 1.8 other staff per faculty member. Historically, BYU-Hawaii students have averaged 13.5 credit-hours per semester (Ref, 7, 10 and 16).

As of 1979, only 1% of the Laie work force was employed at the Turtle Bay Resort. However, as the resort grows, it is likely that more employees will come from, or settle in, Laie.

Housing Conditions — Rapid population growth has resulted in increased crowding of resident occupied housing in Laie. Nine per cent of Laie households contained two or more families in 1979 as compared to 3% for Oahu as a whole (Ref. 12 & 13). A May 1987 community survey indicated that 21% of Laie's homes were "crowded" (1.01 to 1.5 persons/room), and an additional 20% were "very crowded" (Ref. 14). This compares to 8% and 7%, respectively, for Oahu as a whole in the 1980 census.

Another indication of overcrowding is average household size. In 1979, the average resident household size in Laie was 5.87 (Ref. 12). The 1987 community survey indicated that this had declined some, but was still very high at 5.4 persons per household (Ref. 14). By comparison, the 1980 census indicated an average resident household size of 3.25 on Oahu.

In total, Laie had 984 dwelling units in April 1980: 48 single family and duplex units on the BYU-Hawaii Campus which are exempt from property taxes, 202 tax-exempt married student apartments on-campus, and 734 taxable single family and duplex units off-campus (Ref. 15 & 16).

Because some of the shoreline houses in Laie are used as second homes or vacation rentals, it is not possible at this time to make an accurate estimate of what the "real" housing supply is in Laie. In April 1980, out of 734 taxable off-campus dwelling units, only 248 (34%) had a tax

exemption for owner-occupancy (i.e. a "home owner's exemption") (Ref. 15). Some of the 486 housing units which did not have a "home owner's exemption" are second homes, some are tourist rentals, and the remainder are available as rental housing for Laie residents.

Since the 1950s, there have been no subdivisions in Laie that have involved more than a few lots. However, the number of off-campus houses has increased by more than two thirds. Most of these new units have been built as additional structures on large lots in Laie (with or without subdividing). Also, a significant number of new homes have been built on the high-priced beachfront lots.

Population Characteristics — A 1979 survey of Laie by BYU-Hawaii (Ref. 12) compiled some very useful information on the demographics of the community. In general, it revealed that Laie households tend to be large (mean = 5.87 persons), crowded (9% contain 2 or more families), young (41% of household members are 19 years or less), and ethnically Polynesian (62% are either wholly or part Hawaiian, Samoan, or Tongan). By comparison, for Oahu as a whole, households tend to be smaller (mean = 3.25), relatively uncrowded (3% contain 2 or more families), older (34% of household members are 19 years or less), and more Oriental (40% are either Japanese, Chinese, or Filipino).

One characteristic of Laie of primary importance to the project at hand, is the large percentage of low income families. The 1979 BYU-Hawaii survey found that 43% of the Laie households had a gross annual income of $10,000 or less, and that 20% lived on less than $5,000 per year. The comparable figures for Oahu as a whole are 22% and 3%, respectively.

A 1980 survey of persons who had previously expressed a desire to lease or purchase a house in Laie, 44% of the respondents probably could not purchase a home priced above $62,500 (based on a conventional 30 year mortgage at 11.7% interest and 10% down). The income levels were fairly well distributed, but very few families had adequate assets for a down payment.

Community Resources' 1987 survey indicated a mean income of $20,500 for "doubled-up" families who indicated they would move to a new home in Laie if one was available. With conventional financing, the maximum affordable housing price for this income is about $62,000.

Existing Land Use

The use of land in Laie in 1985 is shown in Figure 1. There is relatively little idle usable land in Laie. According to the City and County Department of General Planning, 4,685 acres (57%) of the 8,208 acres in the Laie Census Tract (102.02) are vacant and unusable because of excessive slopes and other natural constraints. In 1985, of the 3,524 acres of usable land, 2,170 acres (62%) were in agricultural use, 378 acres (11%) were in private urban uses such as housing, and 542 acres (15%) were lying idle (Ref. 17). These figures are further broken down in Table 2.

There is relatively little undeveloped residential zoned land in Laie. As shown in Table 3, out of the 542 acres of unused developable land in the Laie Census Tract, only 34 acres are zoned for residential use (Ref. 17). Much of this area is either used for agriculture or occupied by private parks.

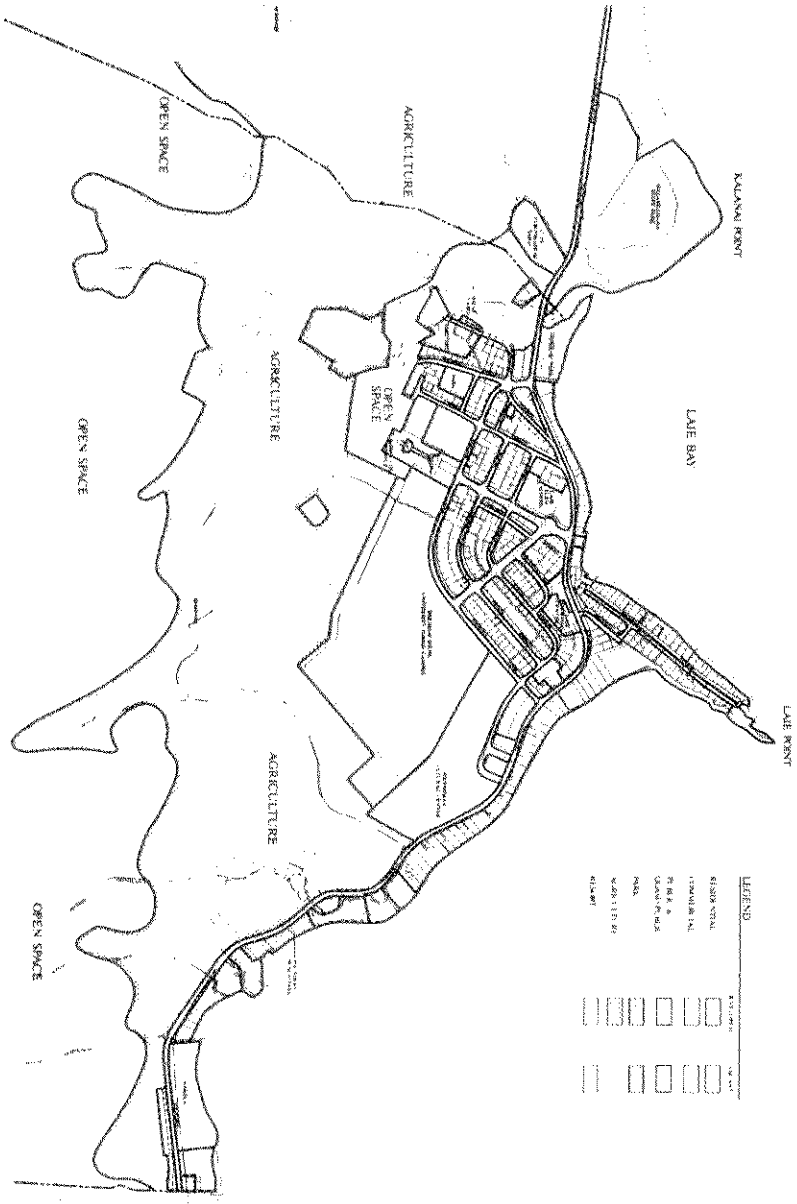

Table 2

LAND USE IN LAIE (CENSUS TRACT 102.02) IN 1985

Land Use	Acreage	% of Total
Residential	342	4.2
Industrial	16	0.2
Commercial	19	0.2
Hotel	1	0.0
Agricultural	2,170	26.4
Vacant Usable 1/	542	6.6
Other 2/	5,119	62.4
TOTAL	8,208	100.0
Total Land In Use	2,962	36.1
Vacant Usable Land	542	6.6
Vacant Unusable Land	4,685	57.1
Other Unused	19	0.2
TOTAL	8,208	100.0

Notes:

1. Includes all developable unused private land with less than 20% slope.
2. Includes all public and quasi-public uses and services and unusable open space.

Source: Ref. 17

Table 3

ZONING OF UNUSED DEVELOPABLE LAND IN LAIE
(CENSUS TRACT 102.02) IN 1985

Zoning	Acreage	% of Total
Residential	34	6.4
Apartment	0	—
Hotel	5	0.8
Business	3	0.6
Industrial	0	—
Agricultural	316	58.2
Preservation	184	34.0
TOTAL	542	100.0

Source: Ref. 17

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III. EXISTING INFRASTRUCTURE

Water

The three general components of a water system—source, storage and distribution—are dependent on usage demand (i.e., potable and irrigation usages) and fire protection requirements. The components are established based on recognized standards for any private, and certainly public, water system in Hawaii. These standards are those which were adopted by all of the County Water Supply Departments and are published as "Water System Standards, State of Hawaii, 1985".

The existing Laie Water System presently does not comply with these standards, especially in regard to source and distribution. Furthermore, full compliance is not economically feasible (e.g., water tanks must be of concrete, whereas existing tanks are of steel). Therefore, improvements to the existing system are constrained by the fact that full compliance is not achievable, but that certain basic requirements should be met. These improvements, together with recommendations for providing water service to new developments, are discussed in Chapter VI.

Most of the information on the existing water system, as presented in this section, is extracted from a previous Laie Water System study entitled "Computer Model and Master Plan Report for Zions Securities, Laie, Hawaii", dated 22 March 1985 as prepared by Community Consultants, Inc. of Provo, Utah. Two of the primary objectives of this previous study were to inventory and evaluate the deficiencies of the existing system, and to recommend improvements.

Usage Demands and Fire Protection Requirements — The average daily demands for the three basic water users - Brigham Young University Hawaii (BYUH), Polynesian Cultural Center (PCC) and Laie community (i.e., Laie other than BYUH and PCC) - were calculated from meter readings made over a seven-day period in November of 1984. The demand for the Laie community was based on

a residential equivalence basis. The demands for the other areas were based on metered and estimated usage within those areas. Table 4 indicates the average daily demands for each area in gallons per minute (gpm) and gallons per day (gpd).

Table 4

ESTIMATED WATER DEMAND FOR EXISTING CONDITIONS

November 1984

Area	Average Daily Demand (gpm)	Average Daily Demand (gpd)
Laie Community	545	785,000
BYUH	504	726,000
PCC	100	144,000
TOTAL	1,149	1,655,000

Fire protection requirements for different areas within Laie vary, based on land use; e.g., agriculture, residential and light industry. The flow requirement can be as high as 2,000 gpm for school and small shopping center areas. The requirements for spacing between fire hydrants also depend on land use. These requirements primarily impact the distribution component of the existing Laie water system.

Sources — The system is being supplied by three wells. A fourth well (quarry well) is currently non-productive, but can be redeveloped for use in the near future. Table 5 shows the average production rate for each well. The current production rate of 1,237 gpm from the three existing wells is approximately 48 percent of what is required by the applicable pumping rate standard. The standard calls for meeting the maximum day demand (one and one-half times the average daily demand) with a pump operating time of 16 hours (i.e., 1.5 x 1,149 gpm x 24 hours per day/16 operating hours per day = 2,585 gpm).

All of these wells tap into an artesian aquifer (water bearing stratum) at a depth of 100-150 feet below ground level. This aquifer is overlain by a highly impermeable basalt layer which serves to "cap" the aquifer at this depth, as well as to impede contamination from infiltrative sources (e.g., surface-applied contaminants or shallow cesspool discharges).

Table 5

WATER WELL PRODUCTION RATES

Well	Average Production (gpm)
Child's	248
Campus	696
Temple	293
Quarry	1,500 (projected)
TOTAL	2,737

Storage — Water pumped from the wells is stored within a 2,000,000 gallon reservoir (steel water tank) which was constructed in 1988. The adjacent older 300,000 gallon reservoir has been abandoned. The storage capacity of 2,000,000 gallons is approximately 80 percent of what is required by the standards. The applicable storage capacity standard for Laie is based on 1.5 times the average daily consumption (i.e., 1.5 x 1,655,000 gallons = 2,482,000 gallons).

Distribution — A majority of the distribution system was constructed over 50 years ago. Most of the system is cast iron pipe with the smaller lines in the older areas of Laie being made of galvanized steel pipe. Asbestos-cement pipe has been used in some of the newer areas. The main transmission line from the tank to developed areas is an 8-inch asbestos-cement pipe. The rest of the system within developed areas ranges from 12-inch pipe to 3/4-inch pipe.

Presently, lines are undersized throughout most of the system, especially in regard to the 8-inch pipe from the tank. Consequently, a fire in most

areas of Laie could have devastating results, as the existing system would not have adequate fire flow capacity. Furthermore, fire hydrants are inadequately spaced (i.e., too far apart) in the older areas.

The existing system has two pressure zones, one comprised of lines running parallel to the beach and highway, and the other, the balance of the system. The pressure zones are developed by pressure reducing valves (PRVs), which reduce the pressure to those lines which are suspected of having high leakage potential.

Sewerage

Most of Laie community utilize individual cesspools for sewage disposal. Only 165 of the approximately 900 residences are hooked up to an existing sewage collection system which is owned by Zions Securities Corporation and operated by BYU-HC. Most of the residences and commercial developments on cesspools utilize the services of the City's cesspool pumper trucks on an "as needed" basis. The current $38.88 per truckload charge is economically attractive to these users, most of which require infrequent pumpage.

The estimated sewage flows from those facilities serviced by the existing sewerage system are summarized in Table 6. The total flow is consistent with what is being measured at the sewage treatment plant and the percentage of total flow for each facility is consistent with the established prorated operating cost participation by the three major areas (i.e., Laie Community, BYU-HC, and PCC).

The three basic components of a sewerage system are the collection system, treatment system and disposal system.

Collection System — The Laie collection system is comprised of gravity lines (pipes conveying sewage by gravity flow), sewage pump stations (SPSs), and force mains (pipes out of SPSs conveying sewage under pressure).

Table 6

ESTIMATED SEWAGE FLOW FOR EXISTING CONDITIONS

Facility	Basis of Estimation	Sewage Flow (gpd)	% of Total
Laie Community 165 residential units	500 gpd/unit (5 residents/unit @ 100 gpd/person)	82,500	18
Laie Community Non-residential facilities	*	35,000	8
BYUH	2,000 people @ 100 gpd/person	200,000	44
PCC	*	140,000	30
	TOTAL	457,500	100

* Established prorated operating cost participation.

Sewage generated throughout sewered areas of Laie is ultimately conveyed to the Moana Street SPS, where it is pumped to the sewage treatment plant located mauka of the university campus. Conveyance of sewage to the Moana Street SPS requires two additional SPSs, one within PCC and the other along Nanilua Loop on the Hauula side of Hale Laa Boulevard.

Treatment System — The Laie Sewage Treatment Plant (STP) has a treatment capacity of 500,000 gallons per day, or 0.50 million gallons per day (MGD). This is not sufficient to accommodate the existing volume of sewage generated from all Laie facilities connected to the sewerage system. The STP is currently producing an effluent (liquid portion of sewage after treatment) that is not in compliance with standards established by the State Department of Health (DOH). To correct this deficiency, the STP is being expanded.

Disposal System — Effluent from the STP flows by gravity via a recently installed 12-inch pipe to a discharge point approximately 2,000 feet north (towards Kahuku) of the STP. The effluent is diluted with ponded rainwater in this swamp area.

Roads

The three basic components of a typical roadway in an urban area such as Laie are pavement, curb and gutter, and sidewalk. The recognized standards for type and dimensions of these components are those established by the City and County of Honolulu Department of Public Works in their "Standard Details for Pubic Works Construction, September 1984".

Most of the roads within Laie do not comply with these standards, especially in "Old Laie" (the area on the Kahuku side of Hale Laa Boulevard). The basic deficiencies are:

1. Insufficient roadway width;

2. Absence of concrete sidewalks; and

3. Absence or improper type of concrete curb and gutter.

Furthermore, it appears that the pavement section (i.e., thickness and type of roadway asphalt concrete and base material) in "Old Laie" and some other areas is substandard.

Drainage

Inadequate drainage is a major problem for Laie due to:

1. A very level topography (i.e., the ground is generally flat throughout developed areas with little variation in elevation);

2. A low ground elevation relative to sea level;

3. An average annual rainfall that is higher than most coastal areas of Oahu; and

4. A large contributing watershed (i.e., Laie is at the discharge end of a very large drainage basin which extends several miles into the mountains).

The problem is compounded in "Old" Laie by the fact that there is no storm drain system, thereby resulting in this entire area acting as a holding pond. "New" Laie (the area on the Hauula side of Hale Laa Boulevard) has a storm drain system, which includes a 12-foot wide by six-foot high box culvert from Naniloa Loop to a discharge point mauka of Kamehameha Highway on the Kahuku side of the existing shopping center. However, due to the low elevation of the box culvert and its proximity to the beach, the discharge end is plugged with sand leaving only a "visor" at the top that is less than a foot high. This "bottleneck" results in a drastic reduction in flow capacity of the box culvert and, consequently, a backup of runoff. This problem is accentuated by the fact that the system is accommodating more than just the stormwater which falls directly onto this area. Based on topographic maps of the area, approximately one-half of the runoff from BYUH also flows towards New Laie.

IV. FUTURE NEEDS

Two activities were undertaken to determine the community's views on what land use and development issues need to be addressed in the Master Plan. The results of each are summarized below.

Community Survey

First and foremost, a community-wide public opinion survey was conducted in 1987 at the suggestion of community leaders. Its purpose was to find out what residents feel are future needs in the community. A scientifically selected random sample of 225 households, or about 30% of Laie's occupied full-time residential units, was used in order to ensure that the results would accurately reflect residents' values and preferences. The sampling error is estimated to be no more than ±5%.

The survey questions focused on the major issues to be resolved in the Master Plan:

- community needs and priorities regarding:
  - — new stores or businesses for Laie
  - — new parks or recreational facilities
  - — street and highway problems
  - — employment and housing development

- sensitive locations where development proposals would generate controversy

- current housing conditions and the level of pent-up demand for additional housing

- overall level of population growth desired for Laie.

Highlights of the survey findings for each of these issue areas are:

New Stores or Businesses — A majority of residents said each of seven possible new stores and businesses represent at least "important" needs. The item receiving the most "very important" responses was a supermarket, followed by a home improvement and a drug store. Others receiving majority support were an auto repair shop, dry cleaning store, radio/TV shop, and men's barbershop. A follow-up question asked about items not on the list, and the most common type of response had to do with restaurants, particularly fast-food operations.

Parks and Recreation Needs — Items with the highest priority ratings were those oriented to youth and/or active recreation: teen recreation center, community park with sports fields, and community swimming pool. There is a less perceived need for additional passive, nature-oriented recreational experiences and facilities.

Highway and Street Problems — The only Kamehameha Highway-related item considered a problem by most Laie residents was the lack of street lighting on the road between Laie and Kahuku. There was more concern over internal street problems — lack of sidewalks on busy streets, street maintenance, and (particularly for older people) speeding on the streets.

Willingness to Pay for Improvements — It was assumed for the survey that, if Laie residents must bear the full cost of either (1) improving internal streets or (2) sewer line hook-ups, the average assessment would amount to $150/month (with interest) for each of these projects. But 82% of respondents said they would be unable or unwilling to pay this much for either project.

New Employment and Housing Development — The majority of Laie residents care more about having jobs and affordable housing than about keeping Laie "like it is now." A majority would like to see a light industrial area in Laie. There is substantial support for housing aimed at senior citizens or low-income residents, including low-rise apartments or townhouses.

Changes in Land Use — There is substantial opposition to high-rise apartments or more expensive housing and to any development of beaches, parks, or Church-owned facilities, such as areas around the Temple of BYU. Laie residents' desire for new development appears to be contingent on assurance of direct benefit for current residents and, at most, a modest change in the existing character of the community.

Pent-up Housing Demand — Laie households are much more crowded than is the case for Oahu as a whole, and 36 per cent have someone who would move out if more affordable homes were available. The people moving out would require 1.4 homes apiece, suggesting a "pent-up demand" in Laie for some 365 units. However, given the low household incomes of those needing new units (median $20,500 per year), the realistic need for most would appear to be rental rather than fee-simple units.

Overall Desired Level of Growth — Given a benchmark of about 900 housing units currently in Laie (including vacation rentals, vacancies, etc.), residents were asked how many total housing units they would like to see in Laie 20 years from now.

The median response was "about 1,200 homes," which is roughly consistent with the current level of pent-up demand for new affordable homes. A majority of residents answered either 1,200 homes or higher. However, a substantial minority either wanted to keep Laie at roughly its present size or else said their answers would depend on the type of people or type of housing unit. Thus, it cannot be said that there is a total community consensus on the growth issue.

Demographics — Overall, demographic variables measured in this survey (primarily age, sex, length of residence, and location of residence within Laie) were not important predictors of attitudes. For example, beach area residents were somewhat more likely than others to want to keep Laie like it is now, but not dramatically so (since there is substantial crowding even among beach area households).

Perhaps the major demographic difference which emerged was that young people and/or relative newcomers to Laie have to bear more of the burden of the present housing shortage, as indicated by household crowding. In addition to grown children living with parents, the survey data imply that many families of adults in their 30's and 40's are sharing homes in order to make ends meet.

Interviews

The second process used to help determine the community's views on future needs was to meet with the heads of the major institutions in Laie in order to learn of their plans and projections for the future. Interviews were conducted with the presidents of Brigham Young University-Hawaii Campus, the Polynesian Cultural Center, the Hawaii Temple, and the Laie and Laie North Stakes, and with the principal of the Laie Elementary School. The main points brought out in the interviews are summarized below.

Brigham Young University-Hawaii Campus — The total area within the BYUH campus boundary is 210± acres. A little more than half of this space is currently occupied by university-related facilities, with the remainder in agriculture, quarry use, or open space.

Existing campus facilities are fully used under the current 2,000 student enrollment ceiling. Any major expansion of the ceiling would require a corresponding major expansion of the physical plant.

No increase in the enrollment ceiling is planned or being contemplated. A new dormitory and cafeteria are the only new facilities being planned at this time. The new dorm is needed to allow for extensive remodeling of the six existing dorms without requiring a reduction in enrollment. Remodeling will be done one building at a time, with each building taking approximately one year.

While there are no immediate plans for a major University expansion, the current campus boundaries should be retained in the event that, at some

time in the future, such an expansion is found to be desirable. This area will also serve as a buffer between university facilities and other nearby, potentially incompatible uses.

A pressing concern within the University community is the need for a new residential subdivision within which faculty and staff could purchase or build homes at prices they could afford. There is a possibility of using part of the undeveloped campus area for this purpose, but no decisions in this regard have been made.

Another potential issue is the possibility that the open areas on each side of the campus entrance drive will eventually be needed for new University facilities. (These areas are now frequently used by the community for sporting events and other activities.) An alternative location for these activities - possibly within the planned new park - may need to be found.

Polynesian Cultural Center — It is anticipated that the PCC will continue to expand at approximately the same rate as the visitor industry as a whole. Recent additions include a new theater and restaurant within the existing exhibit area.

While it is not expected that a major expansion beyond the existing built-up exhibit area will be necessary for several years to come, additional area would be needed in the long term if expansion keeps pace with visitor growth. The existing PCC plantation area should be retained, both for new exhibits and relocated or expanded parking (generally in the makai area along Kamehameha Highway) and for a new plantation tour of the mauka farm areas which exhibit various Polynesian farming practices. Major new exhibits should preferably border the existing site, without any intervening roads or other uses to interfere with free movement between the various activities.

Hawaii Temple — There are no current plans to expand the Temple itself. Primary attention will be focused on making improvements to the existing building and surrounding grounds. However, there is a need to provide overnight accommodations for Church members and their families who come

from the neighbor islands to attend Temple meetings and other functions. The vacant area adjoining the Temple parking lot would be a highly suitable location for this facility.

The possibility that abutting lands could be developed with incompatible uses is also a concern. (The land which is very close to the Temple on the Hauula and mauka sides is not part of the grounds.) In particular, no development should be allowed on the prominent hilltop immediately behind the Temple. In addition to its physical prominence, burial sites from the 19th and early 20th century are located there. Many people attach a sacred value to the area.

Laie Elementary School — The capacity of the existing school facilities is 1,000 students. This compares to a generally preferred elementary school enrollment of 500 to 600 students. Fourteen portable classrooms are currently located on the site, and space for outdoor activities is very limited.

Enrollment at the school at the beginning of the 1987-88 school year was 940. Since there is no additional room on the school site for further expansion, any significant construction of new housing in Laie will almost certainly generate the need for a new school.

V. LAND USE PLAN

The survey described in Chapter IV indicated that Laie residents support new development in the community, provided it will be of benefit to them. Developments which people favored included affordable homes, more shopping facilities, a small light industrial area, active recreational facilities, and a community center with programs for teens and senior citizens.

Interviews with the heads of BYUH and PCC indicated that, while there are no immediate plans for new facilities which will require additional land, there will be a long-term need which should be provided for in the Master Plan. In the case of the Hawaii Temple, it will be important to avoid locating uses nearby which would visually or in other ways detract from its setting. With Laie Elementary School filled to capacity, any major new housing construction will generate the need for a new elementary school.

Altogether, about 100 acres will be required to accommodate the new uses desired by the community. Provisions for possible future expansion of BYUH and PCC, and for the protection of the Hawaii Temple, will require at least another 100 acres. Where should these activities be located? Recommendations have been developed based upon analysis of development constraints and review by the community of possible alternatives.

Development Constraints

A survey of existing land uses in Laie indicated that there are no developed areas which would be appropriate for major redevelopment. Therefore, the review of potential alternative sites for locating new developments was limited to lands which are either vacant or currently in agricultural use.

Within these areas, the ability to accommodate new development is further constrained by natural conditions. Three conditions — slopes, soils, and flood hazards — were analyzed to determine which undeveloped areas in Laie

are, at least from the standpoint of physical characteristics, potentially suitable for development.

The slope analysis for Laie is depicted in Figure 2. Generally, lands which exceed 20 percent in slope are too steep for development - i.e., the extensive regrading required to accommodate roads, house sites, etc. is too costly and/or would create unstable soils and hazardous slide conditions. As seen in Figure 2, the foothills of the Koolaus, which begin anywhere from 1,000 feet to 3,000 feet mauka of existing development in Laie, are for the most part steeply sloping and unsuited for development. However, the land between the base of the foothills and existing development has gradual to moderate slopes and could, from this standpoint, be developed.

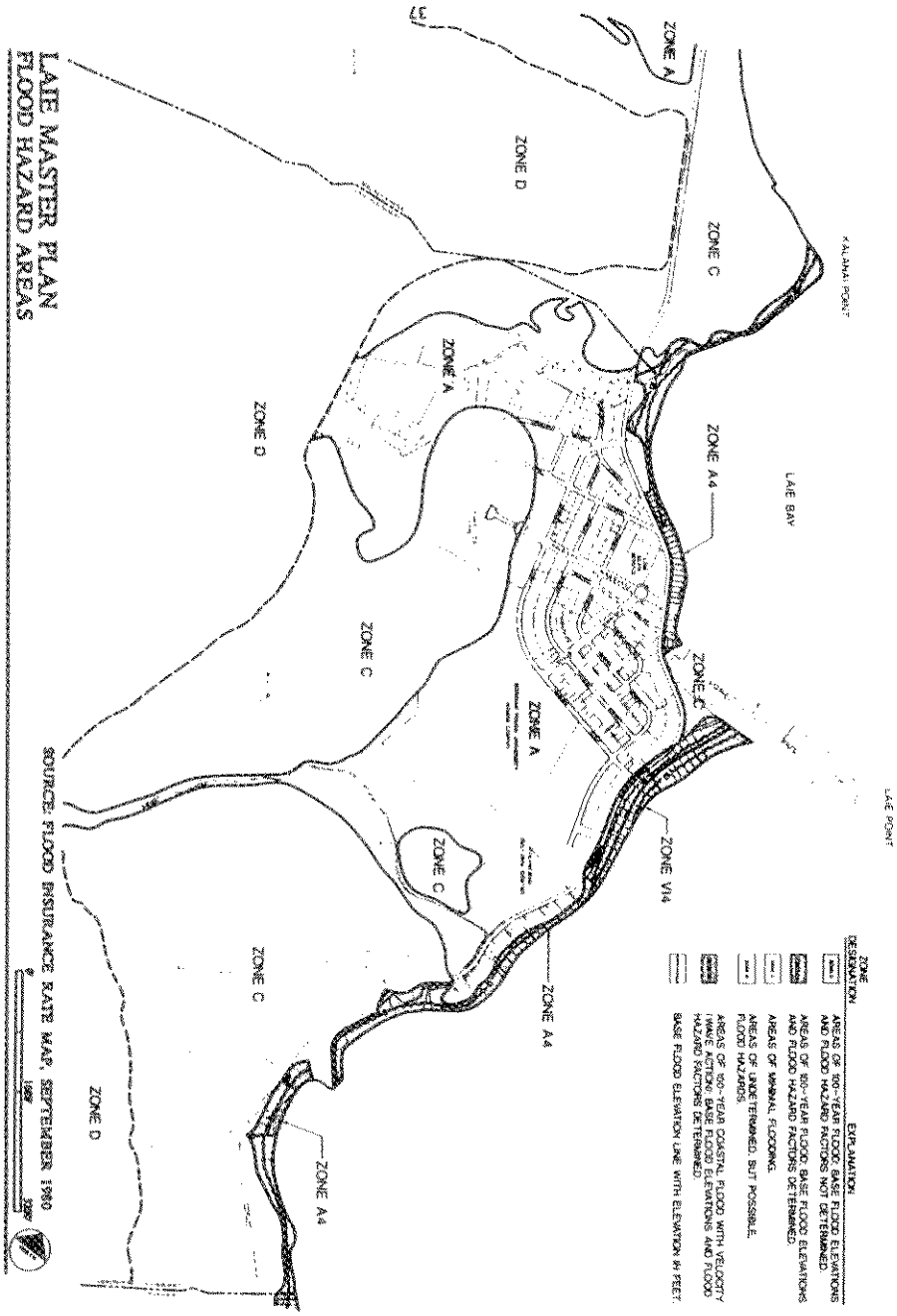
Soil conditions were found to closely reflect slope conditions - i.e., soils which present problems for new development are mostly located where the land is also steeply sloping. However, marshy areas, such as where the existing aquaculture ponds are located, also contain unsuitable soils for building foundations. Except for the marshy lands, soils found in slight to moderately sloping areas do not present any serious problems for development.

Flood hazard zones, as established on the 1980 Flood Insurance Rate Map (FIRM) for the Laie area, are shown on Figure 3. Virtually all of the existing Laie community, as well as the BYUH and PCC expansion areas, are subject to flooding. As a result, building permit applications for any new development in these areas must be accompanied by a flood study, and all habitable floors must be located above the determined flood level.

The low lying lands on both sides of Kahawainui Stream are also shown on the map as prone to flooding. Much of this area is occupied by aquaculture ponds. The Corps of Engineers' Kahawainui Flood Control Project calls for using this area as a temporary retention basin during heavy storms. Any extensive filling on this area, as would be required to accommodate development, would both be very expensive and seriously jeopardize its function as part of the flood control project. Therefore, it has been treated as unsuitable for development in this Master Plan.

LAIE MASTER PLAN
SLOPE ANALYSIS

FIGURE 2



LAIE MASTER PLAN
FLOOD HAZARD AREAS

SOURCE: FLOOD INSURANCE RATE MAP, SEPTEMBER 1980

FIGURE 3

Alternatives

Two alternative schemes for accommodating new housing and other desired uses on the remaining developable lands were prepared in 1987 for review and discussion within the community. One scheme (hereafter referred to as Scheme A) split the new housing into two areas, one along the Kahuku side of Laie at the Cackle Fresh Egg Farm site, and the other on agricultural lands mauka of BYU-HC. The alternative scheme (Scheme B) located a single, large new housing area mauka of Kakela Park, in the area known as Laiemalo'o at the Hauula end of Laie.

The principal advantage of Scheme A was that it located new housing as close as possible to the existing community. Disadvantages were that the housing was still somewhat removed, was split between two areas, and due to the need to bridge a floodplain area, involved infrastructure costs that were somewhat higher than Scheme B.

Scheme B had the advantage of locating virtually all new housing in one area which has direct access to Kamehameha Highway. Infrastructure costs were also a little lower for Scheme B, although they were still quite high. Disadvantages were its distance from the existing community and the lack of a direct roadway connection other than Kamehameha Highway to the existing community, with the resultant possibility that the area would become more of a distinct neighborhood than an integral part of the Laie community.

Both schemes provided for 600± new housing units. Also included were sites for other new uses - a new community park, expanded shopping, a 6-10 acre light industrial park, and expansion areas for Laniloa Lodge, PCC and BYU-HC, etc. - with slight variations between the schemes for site size and/or location.

In both schemes, a majority (500± acres) of the existing productive agricultural lands would remain available for such uses.

1987 Draft Master Plan

The draft plan prepared by the consultants at the end of 1987 attempted to combine the advantage of providing all of the new housing in a single area, as provided in Scheme B, with Scheme A's advantage of (and community preferences for) locating the new housing as close as possible to the existing community. An area of approximately 76 acres bordering the mauka boundary of the BYU-HC site was recommended to accommodate about 450 new homes and a new school site. While still somewhat removed from the existing community, this area was the closest of the alternatives studied.

As previously described in Chapter I, this draft was presented to the community at a Laie Community Association (LCA) meeting in December 1987, and to the leadership of Zions Securities Corporation and the LDS Church in Salt Lake City in March 1988. After extensive review, the ZSC Board of Directors expressed serious reservations concerning the draft plan's recommendation that the area mauka of the BYU-HC be immediately committed to development with housing. This was based on two concerns:

1. The cost ($4.8 million in 1987 dollars) of building the new 1-1/2 mile long loop road that would be required to provide proper access to the proposed new residential area.

2. The desire to not forclose at this time the possibility of using the area mauka of BYU-HC for some purpose other than housing.

(Further detail on the basis for these concerns in provided in Chapter I.)

Given these reservations, it was decided to take another look at the potential to accommodate additional residential development in either the Laiemalo'o area, at the Hauula end of Laie, or on and surrounding the existing Cackle Fresh Egg Farm site. Based on community preferences that the new housing be as close as possible to the existing community, the northerly (Malaekahana) end of Laie was selected for further study. This draft master plan reflects the results of that effort.

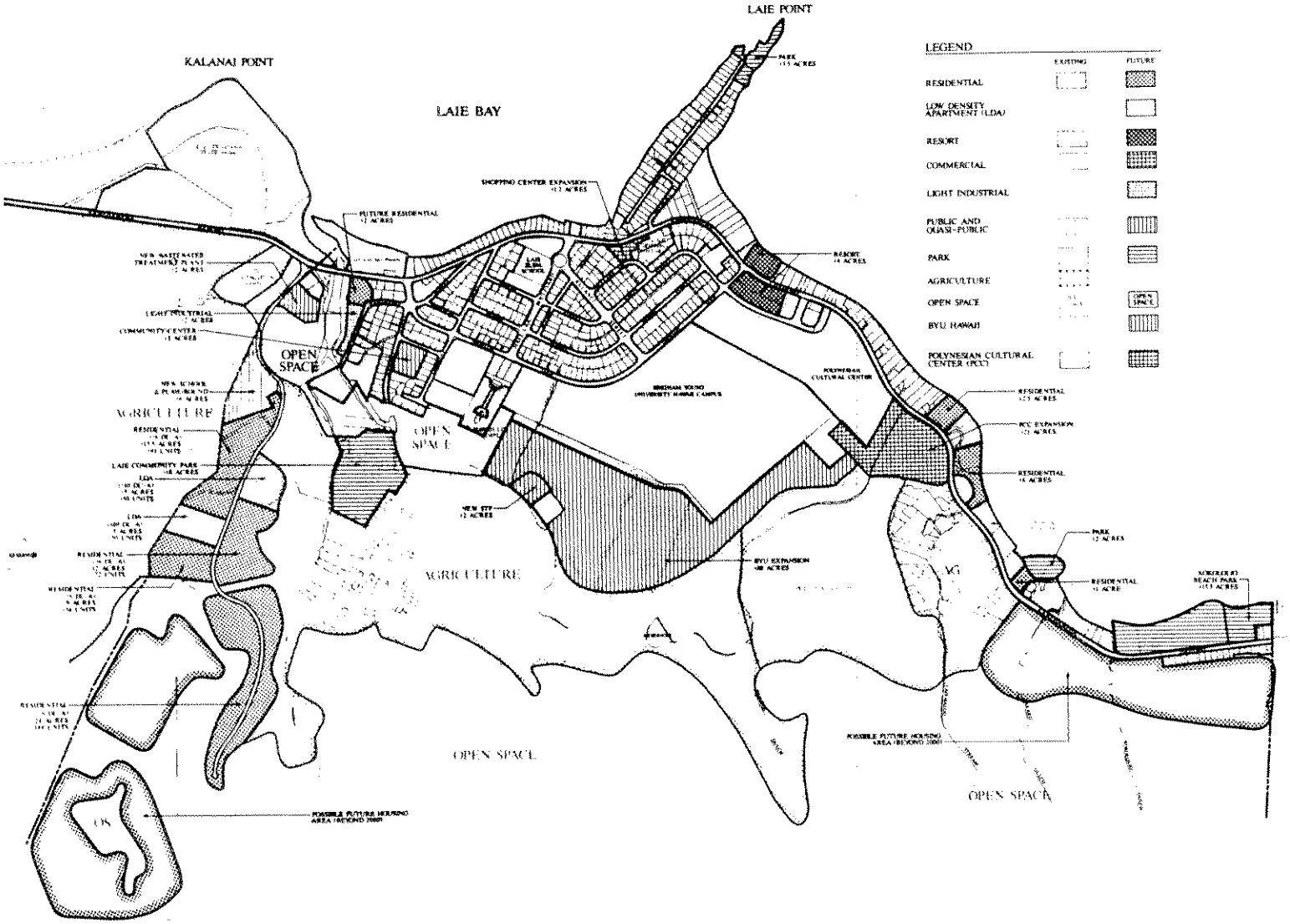
Current Proposal

Two alternative land use plans are proposed for consideration, as shown on Figure 4A (Scheme A) and Figure 4B (Scheme B). Scheme A includes the proposed plan for the entire town of Laie. Scheme B is identical in all respects to Scheme A except for the plan for developing the new housing area. Consequently, Figure 4B shows only the alternative housing area plan.

In both schemes, new housing areas are at a single location, reasonably close to the existing community, in keeping with the community's preference expressed during the review of the earlier schemes. Their principal disadvantage is the absence of a direct roadway link to existing Laie. This proved to be infeasible due to the cost ($5+ million) of constructing a bridge or viaduct over the Kahawainui Stream floodplain area.

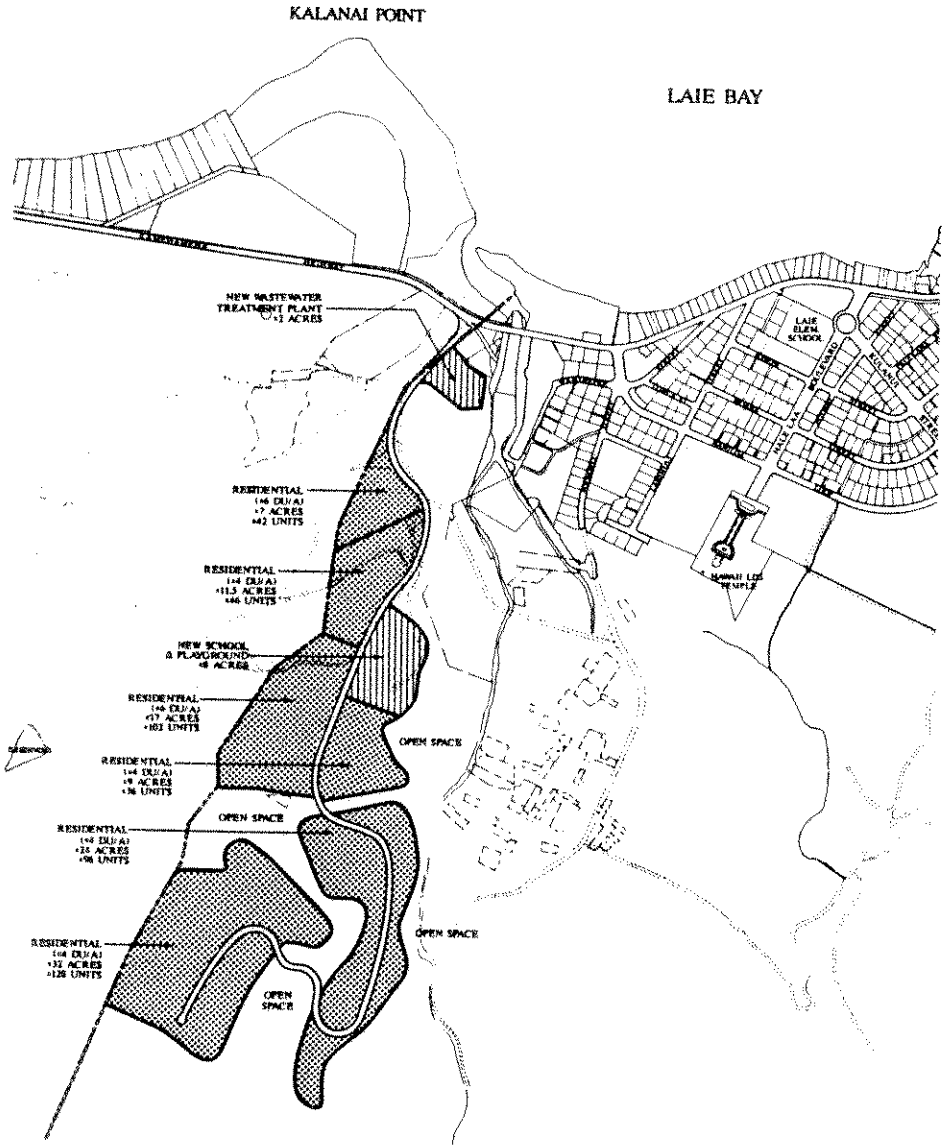
However, the expense of such a connection, and ultimately the inability to justify the sharing of this expense, proved to also render infeasible the plan proposed in 1987. Thus, while requiring vehicular traffic to travel over a section of Kamehameha Highway in order to reach the existing community is not desirable, a feasible alternative for avoiding this is not really available. For the newly proposed residential area, pedestrians and bicyclists will be able to travel over the floodplain area to the existing community at all times except during flooding, and thus will have a relatively short trip and be able to avoid the traffic on the highway.

An advantage of these new proposed schemes is their reduced impact on agriculture. Compared to the area mauka of BYU-HC, only portions of the housing areas proposed in both Schemes A and B are of agricultural value. Also, the existing egg farm operation, because of its proximity to the existing community, presents a serious odor problem whenever wind are blowing in the "wrong" direction. This would be eliminated if the egg farm was moved to a more remote location.



LAIE MASTER PLAN
LAND USE PLAN • SCHEME A

FIGURE 4A



LAIE MASTER PLAN
LAND USE PLAN • SCHEME B

FIGURE 4B

New Housing Area — Scheme A and Scheme B differ slightly in their approaches to accommodating approximately 450 new housing units. Scheme A uses less land area and develops housing at an overall higher average density, combining single family residential units with low density multi-family housing. Scheme B uses more land and provides for only single family units, with a considerable number at a lower density than provided in Scheme A.

In Scheme A, approximately 68.5 acres of land would be developed with housing, ten acres of which are proposed for townhouses or garden apartments at ten dwelling units per acre. The single family residential units would be at a density of six dwelling units per acre. Scheme B makes use of about 32 acres of additional land located at a higher elevation overlooking the community; the total land area used for housing in this scheme is approximately 100.5 acres. A mixture of two different densities of single family housing is proposed in Scheme B, with approximately 24 acres for residences at six dwelling units per acre, and the remaining 76.5 acres for homes at four dwelling units per acre.

Scheme A attempts to present a "minimum cost" alternative to providing the new housing. Single family residential lots would average about 5,000 square feet in size, which is relatively small for a rural area like Laie. Also, 20 to 25 percent (±100) of the 450 units would be in more affordable low-rise multi-family structures, either in the form of townhouses or garden apartments.

Scheme B offers a lower density scenario which is more similar to the housing densities in existing Laie, and is probably more in keeping with the desires of prospective homeowners. However, as shown in the analysis of infrastructure improvement costs contained in Chapter VI, the lowering of densities would add significantly to the average cost of each home.

The location in Scheme B of ±128 of the 450 lots on a ridge, where many will have scenic views of Laie, Malaekahana and the ocean, offers a possible way of offsetting at least part of these added costs. This is because these lots could probably be marketed at higher prices than the

lower area units. If the added infrastructure costs are "carried" by the view lots, the lower area homes could be priced in the same range as in Scheme A.

Although not designated on the Land Use Plan, it is anticipated that one or, more likely, two chapel sites will be provided in the new residential area. Their most suitable locations will to some degree depend on the subdivision layout and design of specific housing projects. Thus, the selection of a specific sites is best done at a later time.

In addition to either of these new residential areas, there are also several residentially zoned parcels in the existing Laie community which are not fully developed and could accommodate more homes. The larger ones, all along Kamehameha Highway, are designated on the Land Use Plan. Other smaller parcels could also accommodate one or more additional homes. It is estimated that, altogether, about 100 new residences could be built in the existing community.

A new, small (±2 acres) residential area is proposed within the existing community, adjacent to and protected by the flood control project levee presently under construction. Future use of this site for housing is dependent on filling this land to increase its elevation, and finding an alternative means of drainage for Laie properties presently directing their surface runoff to this low basin.

Shopping Facilities — About one-third (1.2± acres) of the existing Laie Shopping Center site is available for the construction of a new supermarket, and possibly other retail uses as well. Plans for expansion and renovation of the Laie Shopping Center have already been prepared and completion of the project is expected by the end of 1990. A major supermarket chain is locating a 25,000 square foot facility on the site.

Although no plans are presently under consideration, an existing automobile service station might be replaced with a two or three story professional building at some time in the future. Services such as a home improvement

center might also be located in the Laie Shopping Center, or in the proposed light industrial area (discussed in the next section).

While it may be desirable to provide space for further expansion of shopping facilities in Laie, it is not recommended that a new shopping center site be established. The expansion of the existing center as described above, together with the nearby Hauula Kai Shopping Center and the shopping facilities planned for Kahuku, should be sufficient to serve the residents of Laie and the surrounding communities. Establishing a fourth shopping center in the area could spread the available business between too many centers, adversely affecting the viability of all of them.

Light Industrial Area — A ±2 acre site located between the Laie Cemetery and the flood control project levee is proposed for light industrial use on the Land Use Plan. Included on the site are buildings presently housing the ZSC maintenance equipment and staff. Space would be available in this area for such uses as an auto repair shop, local crafts or dance studios, and possibly a small home improvement center. The area would provide a location for locally run small businesses and for needed community services that do not need to locate in a retail shopping center. A limited number of additional job opportunities should also be available to Laie residents.

A portion of the proposed area is presently low and poorly drained as a result of catching surface runoff from adjacent properties. The flood control project presently under construction will protect this area from flooding; however, an alternative means for diverting surface runoff from the community must be found before this area can be developed.

Resort — The 4± acre area between the Laniloa Lodge and Naniloa Loop, now used as a park, has long been planned and zoned for expansion of the lodge into a larger resort hotel. This designation is retained on the Land Use Plan in recognition of the benefits that an improved resort operation can offer. Specifically, it will provide more suitable accommodations for PCC visitors who wish to stay overnight or longer in Laie, as well as for those from out of town who are participating in church and university related

functions. As with the light industrial area, it will also provide additional job opportunities for Laie residents.

To enhance the attractiveness of the hotel and help to ensure its long-term operational success, it is proposed that the 2.6 acre Church-owned ocean front property located across Kamehameha Highway from the Resort be used to provide amenities and recreational facilities for hotel guests. Uses on the site would be limited to leisure, recreational, and similar amenities normally found in a resort. No lodging units would be provided. At least some of the facilities would be available for use by Laie residents, and a public accessway to the beach would be provided.

Brigham Young University - Hawaii Campus — Approximately 88 acres are provided for the future expansion of BYU-HC. The outer boundaries of the existing campus already encompass this expansion area. This area should enable the university to expand in an orderly and efficient manner, and be sufficiently buffered from other uses to avoid any adverse impacts.

BYU-HC lists the following capital improvement projects in its June 1989 Five-Year Master Plan:

1. Remodeling and contruuction of a ±2,100 square foot addition to the Technology Building.

2. Construction of a new 104-unit single student dormitory (Hale 7).

3. Expansion of the existing sewage treatment plant from a capacity of 500,000 gallons per day to one million gallons per day.

4. Construction of 48 units of married student housing at Temple View Apartments.

5. Renovation of Hale 6 student dormitory.

6. Construction of a new auxiliary services building to house such activities as a printing shop, security and housing offices, and maintenance and book storage facilities.

7. Construction of a new Student Chapel.

8. Renovation of Hale 3 student dormitory.

The first project listed, the addition and renovation of the Technology Building, is complete. Highest priority is now being placed on starting the expansion of the sewage treatment plant and building the Hale 7 Dormitory.

Although the projects listed above include new housing for single and married students, no increase in BYUH enrollment is planned at least within the next five years. The new units are intended only to help satisfy existing housing needs.

Polynesian Cultural Center -- For the PCC, 20-25 acres out of the existing ±115-acre plantation area is designated for expansion of cultural exhibits and parking. This area is located along Kamehameha Highway, between the existing PCC facilities and the privately owned Laiemalo'o lots. The remaining 90-95 acres in the plantation area would remain predominantly in agricultural use. As with the BYU-HC, these areas should enable the PCC to expand in an orderly and efficient manner, and be sufficiently buffered from other uses to avoid any adverse impacts.

PCC currently has plans for the completion of the following capital improvement projects over the next five years:

1. Construction of new bathroom facilities in an area adjacent to the School House and IMAX Theatre

2. Construction of a new luau facility in the area adjacent to the maintenance building

3. Redevelopment of the front parking lot for cultural exhibits, and the plumeria garden area (on the Hauula side of the existing parking area) for additional parking spaces.

4. Remodeling, new plantings, and redirection of traffic at the front entrance.

5. Development of a plantation drive tour through the farms and to a mountain view point in the existing plantation area mauka of the Center and BYU-HC.

Hawaii Temple — The provision of overnight accommodations for Church members attending Temple meetings and other functions is planned for the vacant area adjacent to the Temple parking lot. In addition, to maintain an appropriate setting for the Temple, it is proposed that the hill behind the Temple and the vacant land on the Hauula side be kept as open space. This area is approximately 15 acres.

Schools and Parks — As mentioned in the earlier discussion of future needs, the existing Laie Elementary School is already filled to capacity. Therefore, an 8± acre site for a school/playground complex is provided in the new residential area. Once built, some of the students from the existing community could also be transferred to the new school, thereby reducing the enrollment at Laie Elementary to a more desirable level.

A major new community park is planned a short distance mauka of the existing park. This 18± acre site is six times the size of the existing park, and should have ample space for several playfields and a recreation building.

Laie now has five oceanfront parks - Hukilau, Temple (opposite Hale Laa Boulevard), Laie Point, Pounders, and Kakela. All are retained as parks or planned for park expansion on the Land Use Plan.

Retention of the existing Hukilau and Temple Park boundaries, without further expansion, is recommended. At Laie Point, it is recommended that

the existing park be expanded to include the four adjoining vacant lots. This is especially important for the half-acre parcel that constitutes the Kahuku side of the Point. The 0.9 acre area encompassed by the three adjoining lots on the Hauula side would also be a valuable addition to the park.

Pounders Beach Park is also recommended for expansion to include the bluff overlooking the existing park area. This is an excellent viewpoint and would be an attractive picnic area for park users.

Kakela is retained on the Plan in beach park use. Although the City and County of Honolulu is presently considering condemning this land for public use, in this Master Plan it is assumed that it will continue to be operated by the Mormon Church as a recreation and gathering place for community and church groups. The adjoining land, formerly the Catholic Church's CYO Camp, is also designated as a beach park in reflection of its purchase by the City and County for park use.

Community Center — The community survey indicated strong support for providing a community center in Laie. Strongly favored activities for such a facility are a teen center and a meeting place for senior citizens and other groups.

The alternative schemes presented in 1987 placed the community center in the new residential area. However, many people expressed a preference for locating the center in the existing community, where most residents will continue to live. Therefore, the existing park site has been selected as the location for the community center, which could be built once the new community park is established. A play area could also be retained on the site for smaller children.

Laie Cemetery -- Although the only cemetery in Laie is nearly full, no plan for expansion is recommended. This is because the only possible area -- the land mauka of the cemetery -- is low in elevation and subject to frequent flooding. This area is not suitable for underground burials and should remain as open space.

Agricultural Areas -- With the development of the new residential area and expansion of the BYUH campus and the Polynesian Cultural Center, roughly 60 acres which is now used by the egg farm or under cultivation will no longer be available for agricultural use. However, more than 500 acres of usable (i.e., not steeply sloping) land is still designated for agricultural use on the Plan.

Significant portions of this area are not now used and could provide relocation sites for at least some of the operations that will be displaced. There are also pockets of slight to moderately sloping land a short distance into the foothills behind Laie which were once cultivated with sugar cane and could again be used for crops or for relocation of the egg farm.

Open Space -- Two areas within the Laie community, and the steeply sloping lands that form the base of the Koolau Mountains behind Laie, are designated as open space on the Plan. The value of keeping in open space the area surrounding the Hawaii Temple has already been discussed. The open space area bordering the Kahuku side of the existing community is so designated because it is a flood plain and part of the Kahawainui Flood Control Project.

Kuleanas -- There are many kuleanas (small land holdings granted to Hawaiian families in the 19th century) which still remain in Laie. A few are in scattered locations, but most are clustered in the vicinity of the aquaculture ponds beyond the end of Poohaili Street. For the most part, the Plan retains their existing agriculture and open space designations.

Long-Term Housing Needs

As indicated by the 1987 community survey, there was at that time an extensive pent-up demand for housing among existing Laie residents. Nothing has occurred in the three years since the survey which would have alleviated even part of this demand. It is also known that there are many people with strong ties to Laie who would like to live in the community,

but live elsewhere on Oahu because of the housing shortage in Laie. Given these conditions, it is anticipated that (once the required government approvals are obtained) the 450± units in the new residential area would be built and occupied in as little as five years, and at most ten years.

A question that immediately comes to mind is what should happen after ten years. Will there be no need for additional housing in Laie once the 450 units are built? Even if there is an additional need, will Laie then be getting "too big" or "too crowded" so that people wanting to live in Laie should be forced to live elsewhere in order to preserve the community lifestyle?

While it is difficult to predict exactly what the demand for housing in Laie will be five or ten years from now, it seems fairly certain there will still be significant demand. First, it is not at all clear that the 450 planned units will be sufficient to meet all of the pent-up demand. Secondly, any significant expansion of facilities at BYU-HC or PCC will generate additional jobs, and with it a need for additional housiing. The planned construction of a Foodland Supermarket at the Laie Shopping Center, any other new businesses which may be added at the center, and the construction of a hotel on the resort area next to the Laniloa Lodge will also generate additional employment in Laie.

There are two potentially suitable areas where additional housing could be located once the proposed 450-unit residential area is built out (Figure 4A):

1. On the ridge mauka of the currently proposed residential area. Analysis of a topographic survey of the Malaekahana side of Laie indicates there are sufficient buildable site on the ridge to accommodate an additional 300 to 400 residences.

2. In the Laiemalo'o area mauka of Kakela Park, at the Hauula end of Laie. This area was recommended for the development of approximately 250 affordable and 130 market housing units in a study done in 1981, and was also one of two areas considered for housing as part of the initial

alternatives analysis done in connection with the preparation of this master plan.

Either of these areas would be well suited for the provision of housing. It also appears likely that they could be developed without adversely affecting the living environment or "lifestyle" in Laie. However, their relative advantages and disadvantages depend on factors such as community preferences and the costs of providing infrastructure -- water supply, sewage treatment and disposal, and roadways and drainage -- which would be costly to determine at this time. In any case, attitudes and conditions are likely to change over the next five years, making any current detailed analysis of questionable value when the time comes to decide where to provide additional housing.

Therefore, while recognizing the likely continued need for additional housing in Laie once the proposed 450-unit residential area is completed, the selection of a specific site should be deferred until that need is closer at hand.

VI. INFRASTRUCTURE IMPROVEMENT PLAN

Improvements to the infrastructures for Laie can be viewed as a process involving both upgrading and expansion. Although most of the upgrading effort is associated with improving service for existing development, and the expansion effort with providing service for new development, these two phases are not mutually exclusive. There is an overlapping of benefits which precludes clear cut segregation and assignment of costs to specific existing, or new, areas of development. Therefore, this chapter of the Master Plan presents this two-phase concept of upgrading and expansion jointly under the headings of the three infrastructures of water, sewerage, and roads and drainage.

Since the total number of units (450) for the new residential areas in Schemes A and B are the same, the overall water demands and sewage flows are likewise the same for these two schemes. However, the 32-acre, 128-unit residential area provided on the mauka ridge in Scheme B requires not only additional lengths of waterlines, sewerlines, and roadways, but also a significant pumping and storage additions to the water system. The details and costs of these additional requirements are explained below.

Water

Improvements to upgrade the existing water system basically involve:

1. Redevelopment of the quarry well.

2. Installation of a 16-inch transmission main from the existing water reservoir to Old Laie.

3. Installation of 6, 8, and 10-inch waterlines within Old Laie.

4. Installation of fire hydrants within Old Laie.

These improvements, together with the recommended improvements to accommodate future development for Schemes A and B, are incorporated into the plans for the Proposed Water and Fire Protection System, as shown in Figures 5A and 5B. The improvements for the two schemes are similar except for the incorporation of a higher service level in Scheme B to accommodate the uppermost 128 residential unit area. This area is too high to be serviced by the existing water system. Therefore, a booster pump system and 200,000 gallon storage tank, as shown in Figure 5B, would be required.

The estimated water demands for future conditions are summarized in Table 7. These quantities are based on the following assumed future conditions:

1. Residential units to increase by up to 100 units in the existing community, and 450 units in the new residential area, over the existing 900 units.

2. Non-residential demand (shopping center, resort, community center, industrial park, etc.) to increase by 100 percent.

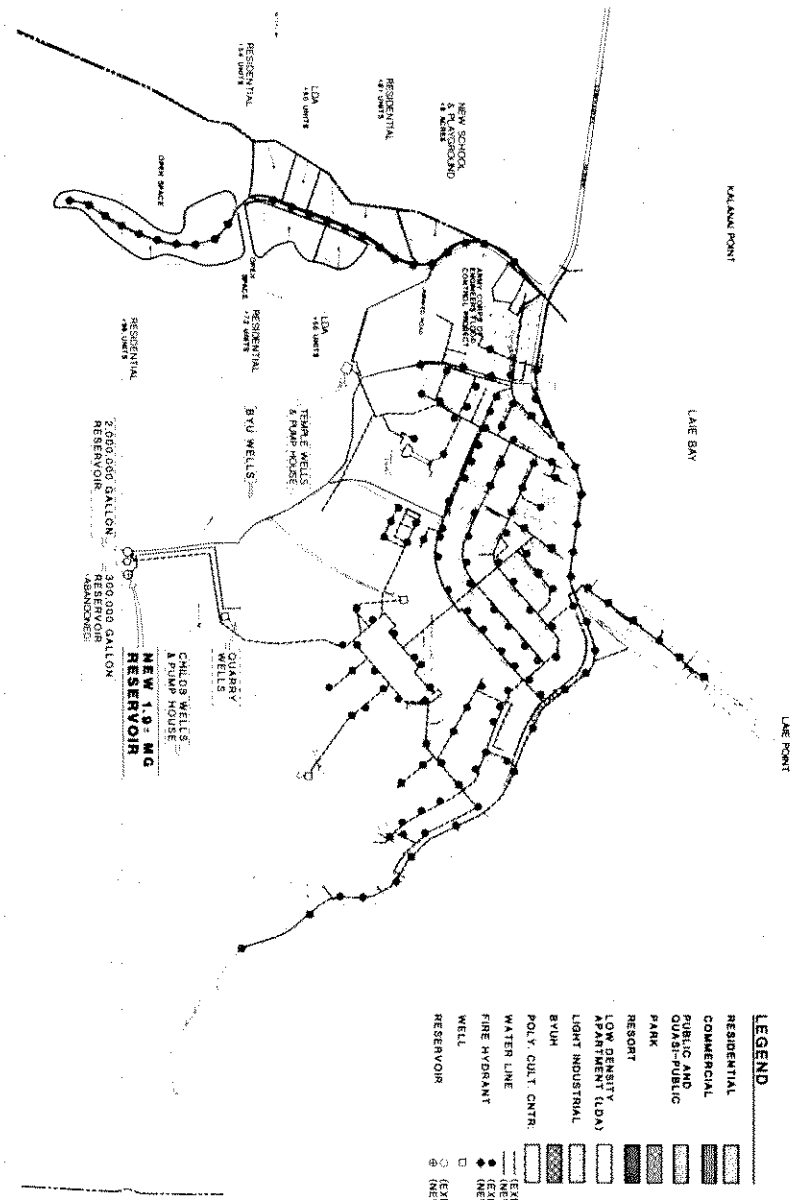
3. BYUH enrollment to ultimately expand by 50 percent.

4. PCC facilities to ultimately expand by 50 percent.

Table 7

FUTURE AVERAGE DAILY WATER DEMAND

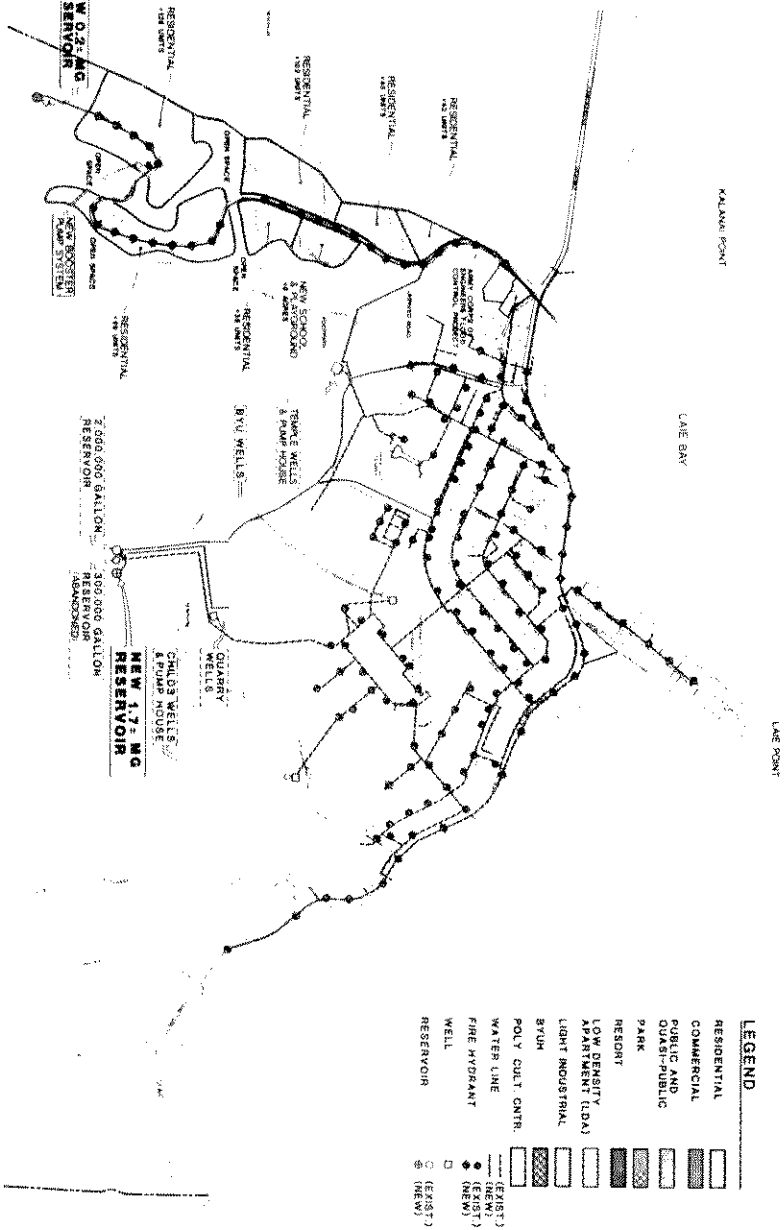
Area	Water Demand (1,000 Gallons Per Day) Present	Additional Future	Total Future
Existing Laie Community			
Residential	720	80	800
Non-Residential	65	65	130
New Residential Area	—	360	360
BYUH	726	363	1,089
PCC	144	72	216
TOTAL	1,655	940	2,595



LAIE MASTER PLAN
PROPOSED WATER AND FIRE PROTECTION SYSTEM • SCHEME A

SOURCE: AUSTIN, TSUTSUMI & ASSOCIATES, INC.

FIGURE 5A



The water source requirement (water well production rate) for the ultimate demand will be 4,055 gallons per minute (gpm) (1.5 x average daily demand of 2,595,000 gallons and pumps operating 16 hours per day). Based on a projected production rate of 2,737 gpm upon redevelopment of the quarry well, an additional 1,318 gpm of production rate will be required.

The water reservoir storage requirements for the ultimate demand will be 3.9 million gallons (MG) (1.5 x average daily demand of 2,595,000 gallons). Based on a current storage capacity of 2.0 MG, an additional 1.9 MG of storage will be required.

The 16-inch transmission main from the existing reservoir to Old Laie, planned as part of the upgrading improvements, would be insufficient for the ultimate demand. Another 12-inch main would be required from a new reservoir to the BYUH/PCC expansion area. This main should be installed in conjunction with redevelopment of the quarry well. Consideration was given to increasing the upper 1,100± lineal feet of the 16-inch main -- from the reservoir to the juncture with the 12-inch main -- to a larger 20-inch main to accommodate the ultimate demand. However, based on the immediate need to install this main and the present uncertainty of the ultimate water system, it would be prudent to install a parallel 12-inch main in the future, at such time as it is needed.

The estimated construction costs for Scheme A for both upgrading and expansion improvements are presented in Table 8-A. Item No. 1 lists the upgrading improvement costs, while Item Nos. 2 through 5 are costs for expanding the existing system. The existing system would be upgraded and expanded only as necessary to serve the BYUH and PCC expansion, and the new development within the existing Laie community. These improvements, except for new waterlines and hydrants within the BYUH/PCC expansion area (i.e., the internal distribution system), are as shown on Figure 5A.

Table 8-A

INTEGRATED WATER SYSTEM COSTS
FOR SCHEME A

Item No.	Description	Cost
1.	Existing System Upgrading for Present Development (Redevelopment of Quarry Wells, Distribution Lines, Valves and Appurtenances, Fire Hydrants)*	$1,700,000
2.	Existing System Expansion for BYU-HC and PCC Expansion, and for Other New Development in Existing Laie, Including Internal Distribution Systems	2,300,000
3.	Additional 1,320 gpm Water Well	700,000
4.	New 1.9 Million Gallon Steel Reservoir	1,600,000
5.	New Residential Area Waterlines	1,000,000
	TOTAL	$7,300,000

* As recommended in Community Consultants' 3/22/85 Study.

The estimated construction costs for Scheme B for both upgrading and expansion improvements are presented in Table 8-B. Item No. 1 lists the upgrading improvement costs, while Item Nos. 2 through 7 are costs for expanding the existing system. As with Scheme A, the existing system would be upgraded and expanded only as necessary to serve the BYUH and PCC expansion, and the new development within the existing Laie community. These improvements, except for new waterlines and hydrants within each new development (i.e., the internal distribution system), are shown on Figure 5B.

The total cost of improvements for Scheme B is $1,300,000 greater than that for Scheme A. This is primarily due to the requirement for a higher service level incorporating a new booster pump system and reservoir.

Table 8-B

INTEGRATED WATER SYSTEM COSTS
FOR SCHEME B

Item No.	Description	Cost
1.	Existing System Upgrading for Present Development (Redevelopment of Quarry Wells, Distribution Lines, Valves and Appurtenances, Fire Hydrants)*	$1,700,000
2.	Existing System Expansion for BYU-HC and PCC Expansion, and for Other New Development in Existing Laie, Including Internal Distribution Systems	2,300,000
3.	Additional 1,320 gpm Water Well	700,000
4.	New 1.7 Million Gallon Steel Reservoir	1,500,000
5.	New Residential Area Waterline	1,300,000
6.	New Booster Pump System	500,000
7.	New 0.2 Million Gallon Steel Reservoir	600,000
	TOTAL	$8,600,000

* As recommended in Community Consultants' 3/22/85 Study.

The information presented thus far is based on an integrated water system for each scheme which would serve both existing and future developments. An alternative to this scenario would be to establish a new and totally independent system to service only the future residential units. This system would be constructed in full compliance with the Board of Water Supply (BWS) standards, with the intent of dedicating the systems to BWS. The existing system would be upgraded and expanded only as necessary to serve BYU-HC and PCC expansion, and the new development within the existing Laie community.

Based on an average daily water demand for the 450 residential units of 360,000 gallons per day (see Table 7), the following water system components would probably be required for a separate system:

1. A water well with a minimum average production rate of 570 gallons per minute.

2. A concrete reservoir with minimum capacity of 550,000 gallons.

3. Transmission waterlines between the source, reservoir, and residential development.

4. An internal distribution system within the residential development comprised of waterlines, fire hydrants, and appurtenances.

Tables 9-A and 9-B present the estimated construction costs of such a separate water system to serve the 450 residential units for Schemes A and B, respectively. Also presented are the costs for improvements to the existing system which would still be needed to upgrade and expand it to serve the BYU-HC and PCC expansions and other developments in the existing Laie community.

As can be seen by comparing the cost figures in Tables 8A and 9A, the advantages gained by building a separate water system for the new 450-unit residential area in Scheme A, and dedicating it to the BWS for maintenance purposes, would require an $800,000 increase in the total costs as compared to the Scheme A improvements for an integrated system. Tables 8B and 9B indicate, however, that the total costs for a separate water systems under Scheme B would be the same as the cost of an integrated system. (This is primarily due to the exclusion from the separate water system of a booster pump system required for the integrated system. The concept for separate water systems for Scheme B is to have the well at the reservoir site.) Still, separate water systems for Scheme B would cost $500,000 more than separate systems for Scheme A.

Table 9-A

SEPARATE WATER SYSTEM COSTS
FOR SCHEME A

Item No.	Description	Cost
	Existing Water System	
1.	Existing System Upgrading for Present Development (Redevelopment of Quarry Wells, Distribution Lines, Valves and Appurtenances, Fire Hydrants)	$1,700,000
2.	Existing System Expansion for BYU-HC and PCC Expansion, and for Other New Development in Existing Laie, Including Internal Distribution Systems	2,300,000
3.	Additional 750 gpm Water Well	500,000
4.	New 1.35 Million Gallon Steel Reservoir	1,000,000
	TOTAL	$5,500,000
	New Residential Area Water System	
5.	New 570 gpm Water Well	$500,000
6.	New 550,000 Gallon Concrete Reservoir	1,000,000
7.	Transmission Waterline from Reservoir to Residential Area, Including Access Road	400,000
8.	Residential Area Waterline	700,000
	TOTAL	$2,600,000
	TOTAL SEPARATE WATER SYSTEM COSTS FOR SCHEME A:	$8,100,000

Table 9-B

SEPARATE WATER SYSTEM COSTS
FOR SCHEME B

Item No.	Description	Cost
	Existing Water System	
1.	Existing System Upgrading for Present Development (Redevelopment of Quarry Wells, Distribution Lines, Valves and Appurtenances, Fire Hydrants)	$1,700,000
2.	Existing System Expansion for BYU-HC and PCC Expansion, and for Other New Development in Existing Laie, Including Internal Distribution Systems	2,300,000
3.	Additional 750 gpm Water Well	500,000
4.	New 1.35 Million Gallon Steel Reservoir	1,000,000
	TOTAL	$5,500,000
	New Residential Area Water System	
5.	New 570 gpm Water Well	600,000
6.	New 550,000 Gallon Concrete Reservoir	1,100,000
7.	Transmission Waterline from Reservoir to Residential Area, Including Access Road	400,000
8.	Residential Area Waterline	1,000,000
	TOTAL	$3,100,000
	TOTAL SEPARATE WATER SYSTEM COSTS FOR SCHEME B:	$8,600,000

Sewerage

The estimated sewage flows for future conditions are summarized in Table 10. These quantities are based on the following assumed future conditions:

1. 35 additional existing residential units to hook up to sewers for a total of 200 hookups from existing residential areas. The other 700 ± residential units to remain on cesspools.

2. Non-residential flow to increase to 115,000 gpd.

3. BYU-HC enrollment to increase 50 percent from 2,000 to 3,000. (1.50 x 2,000 people x 100 gpd per person = 300,000 gpd).

4. 50 percent increase in PCC flow (1.50 x 140,000 gpd = 210,000 gpd).

5. 450± units in the new residential area to be sewered.

Table 10

FUTURE AVERAGE DAILY SEWAGE FLOW

Area	Sewage Flow (1,000 Gallons Per Day) Present	Additional Future	Total Future
Existing Community			
Residential	83	17	100
Non-Residential	35	80	115
BYU-HC	200	100	300
PCC	140	70	210
New Residential Area	0	225	225
TOTAL	458	492	950

Assuming an additional five to ten percent capacity to accommodate normal infiltration of groundwater into the sewage collection system, the future

total capacity of the sewage treatment works should be at least 1.00 million gallons per day (MGD). In addition to expansion of the treatment works, installation of several thousand feet of sewer lines and construction of at least three new sewage pump stations (SPSs) would be required.

Based on discussions with Zions Securities and the Director of Physical Plant at Brigham Young University-Hawaii Campus, the desired scenario is to expand the existing sewage treatment plant (STP), with present capacity of 0.50 MGD, to 1.00 MGD (i.e., 0.50 MGD expansion) to service BYU-HC and PCC and any other new development within the existing community that would have to be sewered. A second, new 0.25 MGD STP would be constructed to service the new residential area. The new residential area's system would be built to City and County standards so it can be dedicated to the City for maintenance purposes. The costs for expansion of the existing system, and construction of a new system for the new residential area, are shown in Table 11.

Implementation of the above-described collection and treatment system improvements is possible within economic limitations -- i.e., the costs, while high, will not be so prohibitive as to threaten the economic viability of the users who will have to pay for them. Disposal of the sewage effluent, however, faces a non-economic factor which poses a potential problem. This factor is the State Department of Health's (DOH's) Underground Injection Control (UIC) Regulations and its impact in terms of geographically limiting potential effluent disposal sites.

As part of these regulations, adopted in 1984, a UIC Line was established around the island of Oahu. Subsurface disposal of any contaminant mauka (mountainside) of this line (e.g., disposal of sewage into cesspools or injection wells) is not allowed. Fortunately, almost all existing cesspools in Laie are makai (oceanside) of this UIC line. However, almost all of the proposed future development will be mauka of this line. Therefore, most new developments will have to hook up to the existing or new sewerage system.

Table 11

SEWERAGE SYSTEM COSTS

Item No.	Description	Cost
	Improvements to Existing Sewerage System	
1.	0.50 MGD Expansion of Existing Sewage Treatment Plant (STP)	$2,500,000
2.	New Sewage Pump Station	600,000
3.	New Transmission Sewer Mains, Including Effluent Line from STP to Quarry Disposal Site	1,100,000
4.	Expansion of Internal Sewer Lines	1,100,000
	TOTAL (Existing System)	$5,300,000
	New Residential Area Sewerage System	
5.	New 0.25 MGD STP	3,000,000
6.	New Sewage Pump Stations	1,500,000
7.	Sewer Lines Including Effluent Line from STP to Quarry Disposal Site	1,000,000
	TOTAL (Scheme A New Residentail Area)	$5,500,000
8.	Additional Sewer Lines to Mauka 128 Residential Units for Scheme B	200,000
	TOTAL (Scheme B New Residential Area)	$5,700,000

Presently, the only potential subsurface disposal site for the STP effluent makai of the UIC Line is at the old gravel pit site behind the BYU-HC rugby field and the PCC maintenance building. The disposal capacity of this site, however, has not yet been determined. A previously considered disposal site at the end of the paved road leading to the egg farm along the Kahuku side of Laie has been closed by DOH.

Two alternatives to subsurface disposal of effluent to the area behind BYU-HC are: effluent irrigation and ocean disposal of the effluent via an outfall. The alternative of effluent irrigation within developed areas (present or proposed) of Laie is not feasible due to a lack of sufficient irrigation area for the volume of effluent expected, as well as the potential health hazards associated with effluent irrigation within a populated area. However, irrigation of areas remote from developed areas is feasible. Such areas could include a golf course, as proposed on the Kahuku side of Laie, or pastureland within the mauka areas of Laie.

In addition to the UIC Line, the Board of Water Supply (BWS) established has a line (referred to as "No-Pass Line") around the island of Oahu mauka of which subsurface disposal of any contaminant is not allowed. This line coincides with the UIC line in the Laie area. Irrigation with treated effluent mauka of BWS's No-Pass Line, however, may be allowed. Although resistance from BWS is expected, DOH is supportive of treated effluent reuse for irrigation. Since DOH is the regulatory agency on such matters, irrigation with effluent is an option.

The alternative of ocean disposal is not feasible. The cost of an ocean outfall is expected to be in the range of $5 - $10 million. Although this high a construction cost is the primary negative factor, preconstruction requirements alone (e.g., preparation of an Environmental Impact Statement, Special Management Area Use Permit application, etc.) would be a major obstacle with no assurance of approval by regulatory agencies.

Consequently, subsurface disposal behind BYU-HC at the old gravel pit site, and golf course (or pastureland) irrigation are currently the only feasible alternatives. A disadvantage of irrigation with treated effluent, however, is dependence on a lack of substantial rainfall. Consequently, a backup method of disposal is required when rainfall is heavy. Therefore, some degree of subsurface disposal, probably behind BYU-HC, would be required regardless of whether an effluent irrigation program is implemented.

Based on the information presented in this section, the concept for the proposed sewerage system is to:

1. Collect sewage from each new development area by gravity sewer lines leading to either SPSs, or directly to an STP;

2. For areas where gravity flow to the SPS is not possible, pump the sewage to the STPs from the SPSs;

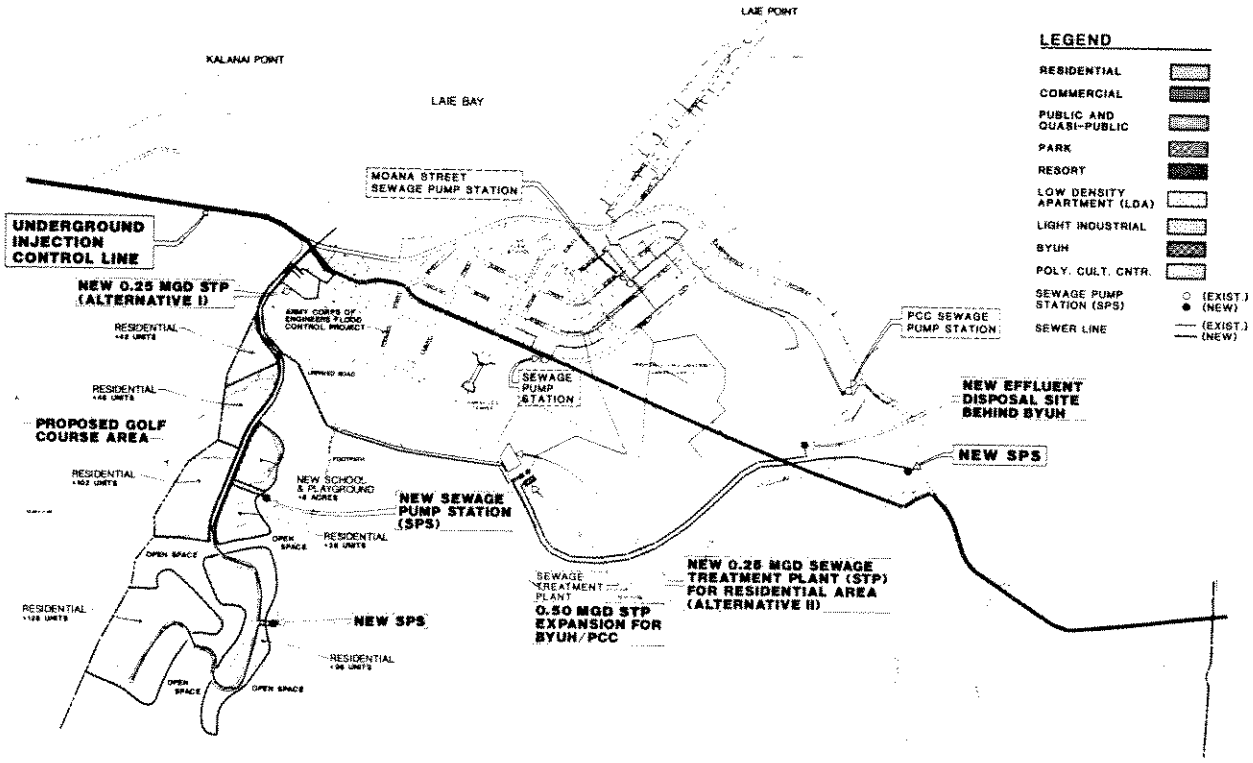
3. Treat the sewage at the STPs; and

4. Utilize the effluent for irrigation and/or convey the effluent to the site behind BYUH for subsurface disposal.

This concept is incorporated into the layouts for the Proposed Sewer System shown in Figures 6A and 6B for Schemes A and B, respectively. Two alternative sites for the new residential area STP are shown in these exhibits: next to the existing STP (Alternative I), and at the makai end of the new residential area (Alternative II).

The primary disadvantage of locating the new STP next to the existing STP (Alternative I) is the presumption that the old gravel pit site will be able to accommodate the additional effluent, even though the disposal site's capacity has not yet been determined. The additional constant flow - as compared to the occasional flow if this is a backup disposal method - may not be within its disposal capacity.

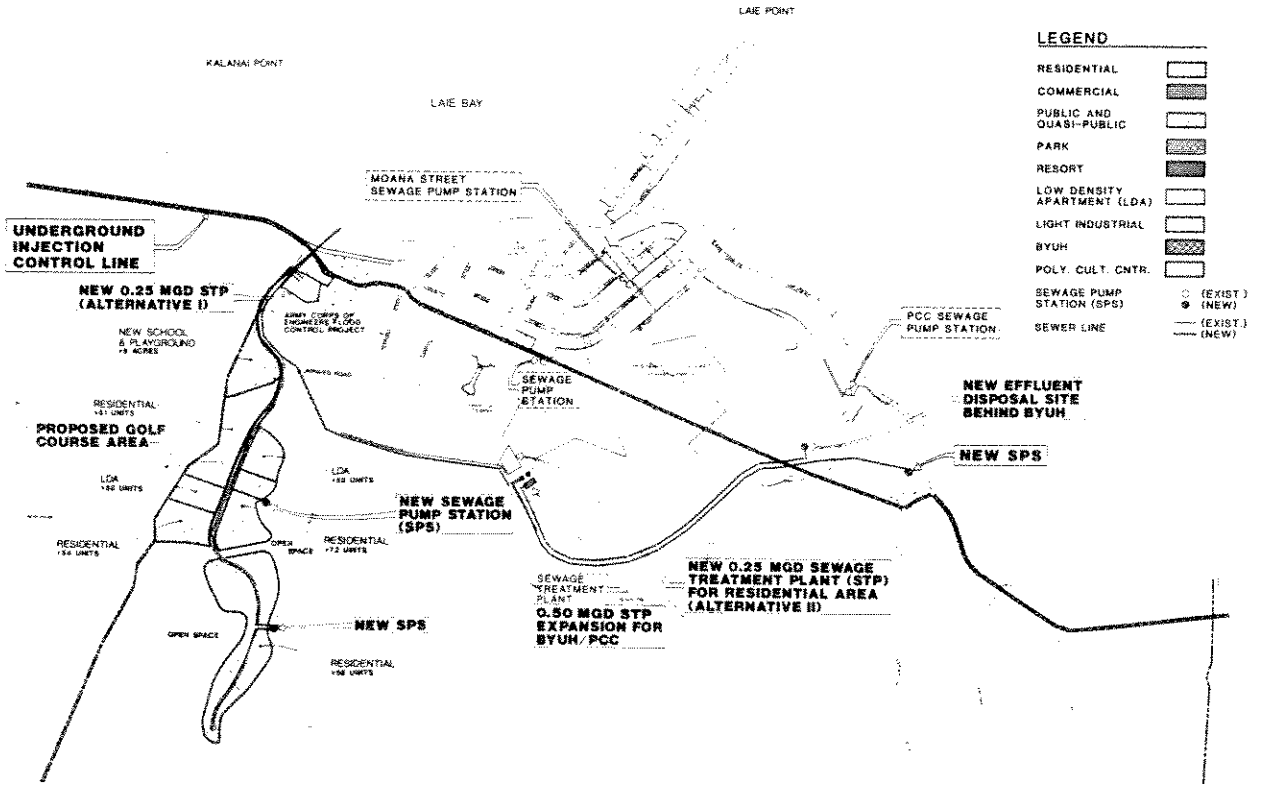
The feasibility of locating the new STP at the makai end of the new residential area is contingent upon the approval and construction of at least one of the two golf courses which are proposed for the adjacent Malaekahana area, and the utilization of the effluent for irrigation of the golf course. Regardless of the implementation of such an irrigation program, however, a pump/force main system would probably be required as a backup, to pump the treated effluent to the old gravel pit disposal site when the rainfall is heavy and the effluent cannot be used for irrigation. The need for this pump/force main system could be avoided only if a suitable injection well field site can be found makai of the UIC Line in the Malaekahana area.



LAIE MASTER PLAN
PROPOSED SEWER SYSTEM • SCHEME B

SOURCE: AUSTIN, TSUTSUMI & ASSOCIATES, INC.

FIGURE 6B



LAIE MASTER PLAN
PROPOSED SEWER SYSTEM • SCHEME A

SOURCE: AUSTIN, TSUTSUMI & ASSOCIATES, INC.

FIGURE 6A

Construction of the new STP at the makai end of the residential area (Alternative II) will require dewatering to install the 15+ foot deep treatment tanks, and possibly extensive earthwork to prevent flooding. The additional cost associated with these two factors would be substantial. There are also potential logistical disadvantages in terms of operating and maintaining geographically separated STPs.

The total estimated cost for the residential area sewerage system, as indicated in Table 11, would be about the same whether the new STP is built next to the existing one (Alternative I) or is built at the makai end of the new residential area (Alternative II). This is because the additional earthwork and dewatering costs incurred under Alternative II would probably be offset by lower pump station costs. Alternative I would require a pump station which is built to regularly pump untreated sewage to a new STP next to the existing STP, whereas Alternative II requires a less costly pump station built to only occasionally pump treated effluent to the disposal site behind BYU-HC.

Roads and Drainage

New roadway construction can be placed into two categories:

1. New off-site roads (new roadways connecting new development areas to existing major roadways); and

2. New on-site roadways (new roadways within each proposed development area).

There are no major off-site roads required or proposed to implement the Master Plan. However, a major on-site road through the proposed new residential area is required. This road woould extend from Kamehameha Highway to the uppermost residential lot, and serve as a collector road for the development.

The estimated roadway construction costs for the new residential area are summarized in Table 12. All costs are based on full compliance with City and County of Honolulu Department of Public Works Standards. The costs of drainage improvements and street lighting along the roadways are incorporated into the roadway costs in Table 12.

Table 12

ON-SITE ROADWAY COSTS
FOR NEW RESIDENTIAL AREA

Item No.	Description	Cost*
1.	Major Road from Kamehameha Highway to uppermost residential lot	$3,100,000
2.	Minor Roads	10,000,000
	TOTAL (SCHEME A)	$13,100,000
3.	Additional Major and Minor Roads for 128 residential units for Scheme B	1,000,000
	TOTAL (SCHEME B)	$14,100,000
	Cost Per Unit for Scheme A (450 homes)	$29,100
	Cost Per Unit for Scheme B (450 homes)	$31,300

* Includes cost of drainage system and street lighting along roads.

An off-site drainage project, the Kahawainui Stream Flood Control Project, is located immediately adjacent to the proposed residential area. It is being implemented and mostly funded by the U.S. Army Corps of Engineers. The City and County of Honolulu is also contributing to the funding, and Zions Securities Corporation is contributing both funds and land. None of these costs are included in the drainage system costs for the proposed residential area.

VII. IMPLEMENTATION

The value of a master plan can be measured in two ways. The first is the degree to which future development activities follow the plan. Benefits of this are the efficiency and relatively low level of disruption that results when several independent activities are coordinated and move in the same direction.

A second value is the extent to which the plan serves as a catalyst for desired activities. Many times things which people want do not happen because there is no agreed-upon plan for making them happen. By setting a direction, a plan can often lead to action.

Three of the major issues being addressed on the Laie Master Plan are concerned specifically with implementation. One is to find out what alternatives are available for building homes that will be affordable to Laie residents. The others relate the costs of water, sewer, road, and drainage improvements needed to upgrade services in the existing community and provide new services to new development.

Presented below is a profile of the demand for "below market" or affordable housing in Laie, and of available options for meeting that need. The costs of infrastructure improvements were described in the previous chapter. In this chapter they are "prorated" or distributed among the different generators of demand. Alternative ways to pay for upgrading existing roads and drainage, so the City and County will be willing to take them over and maintain them, are also discussed.

A. Providing Affordable Housing

Variables Involved in Housing Costs

The major elements, and potential variables, involved in the cost of building new homes are (1) the cost of raw land, (2) the cost of

infrastructure (water, sewers, roads, etc.), (3) the cost of building materials, (4) the cost of labor, and (5) the cost of borrowing money. Making housing affordable to people who cannot pay the full cost means that it must be supplied at "below market," or at less than the sum of all normal costs.

The difference between the desired price and the normal costs must be made up somewhere. For most housing in the United States, this difference has been made up by the federal government in the form of tax credits for mortgage interest. In essence, the tax system subsidizes the true cost of housing in this country by significantly reducing the cost of borrowing money. The owners of rental housing are also subsidized by the government for not only mortgage interest but also for depreciation and other business expenses. These subsidies, which are inherent in all housing, have brought decent housing within the grasp of most Americans.

However, in high cost areas such as Honolulu, this subsidy is not enough to make housing affordable for many working people.* Other variables in the cost of providing housing need to be reduced to below market levels, and/or the cost of borrowing money needs to be further reduced. Available options for accomplishing this are described following a discussion of the estimated demand in Laie for below market housing.

Laie Housing Demand and Pricing Requirements

The 1987 community survey found that there was a "pent-up" demand for approximately 365 affordable housing units in Laie. Pent-up demand means people who would move out of an existing home to form a new household if there were affordable housing available in Laie. The large average household size in Laie - 5.4 versus 3.25 for all of Oahu - is a further indication of a significant pent up demand.

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* As a rule of thumb, housing is considered affordable when the cost does not exceed 30 percent of the household's gross income.

A breakdown of this demand by income levels is provided in Table 13. Assuming conventional financing at 10.5 percent interest rate, housing would have to be available for purchase at less than $59,000 (maximum $450 monthly rent) for nearly 40 percent of the 365 households. For another 25 percent, housing would have to be priced at no more than $68,000 ($525 monthly rent) for it to be affordable. Only 19 percent of the 365 households could afford homes costing more than $88,000 ($675 monthly rent).

(NOTE: As the income data is from a 1987 survey, the affordable housing prices presented above and elsewhere in this section are in 1987 dollars. Income eligibility requirements are also in 1987 dollars. It can be reasonably presumed that incomes, and consequently affordable housing costs, are somewhat higher in 1990. However, data pinpointing the extent of the income rise experienced by Laie residents over the last three years is not available.)

Housing Development Options

For-Purchase Housing -- The only developer-built housing production program viable for Laie is the State Act 105 (also known as Section 359G, HRS) program. The basic thrust of the program is to provide for-purchase housing to "gap group" families. These are families making between $27,500 (80 percent) and $40,700 (120 percent) of the county median income of $34,000 for a family of four. This represents the upper end of the Laie need group and may be appropriate for development of up to 80 units.

Various approaches are available under Act 105 to reduce the cost of homes. These include low interest construction loans, exemptions from zoning and building code requirements, waiver of the general excise tax on materials and services, and assumption by HHA of marketing risks and carrying costs. In return, developer profit will be limited to six percent. Homes will be subject to a buy-back provision if the home owner wishes to sell within ten years, and the gain to the seller will be limited.

Table 13

PROFILE OF LAIE HOUSING DEMAND

Household Income (1)	Percent of Demand (1)	Number of Units (2)	Approximate Maximum Price (3)	Approximate Maximum Rent (4)
<$18,000	39.6%	145	$58,565	$450
$18,000 to $24,000	25.4%	93	$68,325	$525
$24,001 to $30,000	15.9%	58	$87,847	$675
>$30,000	19.1%	70	$97,608	$750

Loan Assumptions

Interest Rate: 10.5%
Loan Term 30

NOTES:
(1) As per CRI Laie Community Survey.
(2) Based on CRI Survey demand of 365 units.
(3) Based on Conventional Financing with above loan assumptions.
(4) Based on 30 percent of gross income.

The major advantage to using Act 105 in housing development is the ability to expedite land use processing and waive various subdivision regulations to reduce cost. A second advantage for some developers is access to the relatively low interest money for construction loans.

Major disadvantages involve the political nature of the process and the lack of control over who may purchase the homes. Under Act 105, the State Land Use Commission, if boundary changes are involved, and the City Council must approve the project and the requested exemptions. While few projects have ever been denied, the negotiations have caused some developers to question the desirability of using Act 105. Additionally, Act 105 requires that applications be accepted from any qualified resident on the island. This could mean that a number of non-Laie residents could benefit from the project.

Rental Housing — As with for-purchase housing, rental housing has undergone a dramatic decrease in production since the enactment of the Tax Reform Act of 1986. This is true for both private and government projects. Today, tax exempt financing, the prime cause of rental construction in the last few years, is not available. Both the City and the State have plans to recreate their own programs, but this is at least a year away and very uncertain. Private developers cannot develop rental housing without the tax incentives which previously existed. Also, there is no new money for rent subsidies, with waiting lines over a year in length.

In spite of this gloomy picture, there is one rental housing program which has remained untouched by budget cuts. That is the Farmers Home Administration's (FmHA) Section 515 Rural Rental Housing Program.

Loans for rental housing in rural areas (Laie qualifies according to a preliminary review by FmHA) are available to provide living units for persons with low and moderate incomes and for those age 62 and older. Loans are primarily made to build, purchase or repair apartment-style housing, usually consisting of duplexes or similar multi-unit dwellings.

Rents are set by household income, but may not exceed 30 percent of adjusted gross income. There is no lower limit to rent. The loan interest rate is subsidized by FmHA so as to assure affordability.

The major advantage of this program is the very favorable terms of the loan which make rental housing possible. Additionally, FmHA is the only rental construction program available.

The major disadvantage is the processing time and cumbersome requirements of FmHA. It may be expected to take up to two years to receive funding. FmHA also has rigid standards which must be met for all phases of the project.

Owner-Built Housing — Often referred to as self-help or sweat equity, owner-built housing derives its primary subsidy from labor savings. In an owner-built development, the intended occupants of the housing do the house construction themselves under the supervision of a licensed contractor. The land improvements are done professionally, as is the foundation.

The house construction price is approximately $25 to $35 per interior square foot, or $25,000 to $35,000 for a 1,000 square foot house. This price is exclusive of land and infrastructure.

Owner-built housing programs are offered by both the Oahu Self-Help Housing Corporation and by Savio Development Company. Oahu Self-Help Housing currently uses stick built construction (pre-cut lumber sold as a package and assembled), while Savio Development uses a panelized construction method (the house is factory built on the mainland and shipped in large panels which are owner assembled). Construction of the house by the stick built method takes approximately ten months, while the panelized method takes about one month.

The primary advantage with owner-built housing is that, coupled with Farmers Home Administration financing, it brings home ownership within the range of even the lowest income family. A $65,000 home with FmHA financing

would yield monthly payments of only $192 per month for families eligible for the most subsidized interest rate, and not require any down payment.

A second advantage to owner-built housing is the sense of community participation and empowerment inherent in building ones own home. Communities which have participated in owner-built programs report increased community cohesion and pride.

A disadvantage to the program is the image people have of it taking too much time and effort. Indeed, the ten months for stick built housing does have drawbacks in terms of loss of enthusiasm toward the end of the program.

A second disadvantage is that, to take full advantage of the benefits, FmHA financing must be used. This form of financing is time consuming to obtain and heavy with requirements.

Financing Options

Another significant way of reducing the cost of housing is to reduce the cost of borrowing money even more than already provided by the income tax deduction for interest. Essentially, this means reducing the interest rate with a subsidy. Table 14 illustrates the impact of reducing the interest rate on the maximum price of a house that is affordable for someone at a given income level.

Conventional and FHA — Most home financing in Hawaii is done either with what is known as conventional financing or with a mortgage insured by the Federal Housing Administration (FHA). Both of these methods have relatively high interest rates and contain no subsidies. The major difference between the two is that with FHA insurance it is possible to finance up to 97 percent of the house price. It is unlikely that either of these programs will be of great benefit to Lale residents in need of below market housing.

Table 14

APPROXIMATE MAXIMUM PURCHASE PRICE WITH VARIOUS FORMS OF FINANCING

Form of Financing	Interest Rate	Term	Income/ Payment Ratio	Down Payment	Approximate Maximum Price With Household Income of: $15,000	$18,000	$21,000	$27,000	$30,000	$33,000
Conventional	10.50%	30	3.5:1	20%	$48,804	$58,565	$68,325	$87,847	$97,608	$107,369
FHA Insured	10.00%	30	3.5:1	3%	$41,955	$50,346	$58,738	$75,520	$83,911	$92,302
Farmers Home	1.00%	33	N/A	0%	NO MAXIMUM PRICE (UP TO $65,000 LOAN)					
Hula Mae	8.00%	30	2.8:1	10%	$67,601	$81,121	$94,641	$121,682	$135,202	$148,722
ARM	7.50%	30	3.5:1	20%	$63,847	$76,617	$89,386	$114,925	$127,694	$140,464

APPROXIMATE MAXIMUM LOAN AMOUNT WITH VARIOUS FORMS OF FINANCING

Form of Financing	Interest Rate	Term	Income/ Payment Ratio	Down Payment	Approximate Maximum Loan Amount With Household Income of: $15,000	$18,000	$21,000	$27,000	$30,000	$33,000
Conventional	10.50%	30	3.5:1	20%	$39,043	$46,852	$54,660	$70,276	$78,086	$85,895
FHA Insured	10.00%	30	3.5:1	3%	$40,697	$48,836	$56,975	$73,254	$81,393	$89,533
Farmers Home	1.00%	33	N/A	0%	UP TO $65,000 LOAN (NO MAXIMUM PRICE)					
Hula Mae	8.00%	30	2.8:1	10%	$60,841	$73,009	$85,177	$109,514	$121,682	$133,850
ARM	7.50%	30	3.5:1	20%	$51,078	$61,293	$71,509	$91,940	$102,155	$112,371

Adjustable Rate Mortgages — Often called ARMs, adjustable rate mortgages come in various forms. The basic principle is to lower the interest rate below conventional mortgages but to allow the rate to change over time given changes in the prime rate. Usually the rate changes annually after a set period of one to three years. The increases, or decreases, are capped in any one year and throughout the life of the loan. Some are convertible to fixed rate after a certain holding period. These loans have become popular as conventional rates have increased. The August 1987 ARM was about 7.5 percent.

Hula Mae — Hula Mae is administrated by the Hawaii Housing Authority (HHA). Through the use of tax-exempt revenue bonds, the Hula Mae Program provides first-time home buyers with mortgage loans at interest rates below those available on conventional loans. Program eligibility is limited to Hawaii residents who:

1. Have not received a previous Hula Mae loan.

2. Have not owned a home in the past three years.

3. Have a maximum income of between $36,154 for a one person household and $47,404 for a household of eight or more.

The current (1987) interest rate is eight percent. The loan term is 30 years. Generally, a 10 percent down payment is required, but this may be reduced to five percent under some circumstances. The loan value on new construction cannot exceed $143,500, with house price not to exceed $151,000.

Farmers Home — The FmHA loan program is similar to Hula Mae but is restricted to rural areas. Existing homes purchased under this program must meet strict building standards, and new construction must be pre-approved. This process is lengthy and may take up to one year. The entire subdivision is subject to FmHA building standards. This includes water, sewers, and roads. Income limits range from $19,100 for a one person household up to $34,150 for a family of eight or more.

The current (1987) interest rate is nine percent. However, this rate can be lowered to as low as one percent, and often is, to make the housing affordable to very low income families. This is accomplished using a fairly complex formula based on the principle that the household shall not pay more than 20 percent of their income for mortgage payments.

There is no required down payment. The loan amount cannot exceed $65,000, but there is no limit on price. It is unlikely, however, that eligible families will have access to a down payment. This form of financing was used in the Oahu Self-Help Housing Corporation's Maili Project. Several families there are paying the minimum $192 per month.

It should be stressed that this program is not a grant. The subsidy must be repaid when the owner ceases to occupy the home or after the 33 year loan period, whichever occurs first. Should the family leave before the 33 years, the amount is due at the time they cease to occupy the house. Should the family stay for the entire mortgage period, the repayment may be made in payments arranged by FmHA.

Elements of a Successful Housing Program

A program to provide affordable housing for all Laie residents will need to utilize a combination of the above described programs. There are also important operational concerns which will affect the outcome of such an effort.

Below Market Housing — Below market generally refers to households in the low and moderate income groups (those making less than 80 percent of the 1987 median income of $30,400). For Oahu this would be those households with incomes less than $24,320 per year. This represents the bulk of the Laie pent-up demand.

An extensive owner-built housing program, used in conjunction with FmHA loan financing, is certainly the most and perhaps the only viable means of

providing the number and price range of housing most in demand in Laie. To the extent that there remain families who cannot participate in an owner-built program and do not have sufficient incomes to afford gap group housing, and FmHA rental housing program should be considered.

Gap Group Housing -- The gap group is generally defined as being between 80 and 120 percent of the county median income. For Oahu, the median income was pegged at $30,400 for a family of four in 1987. The gap group would therefore range from $24,320 to $36,480. This would represent the top portion of the Laie pent-up demand.

To provide this housing, Act 105 should be used to expedite the processing of the entire development and reduce infrastructure construction standards. Hula Mae financing can be obtained for home mortgages for the gap group families. The construction of these homes should blend with the below market units. Indeed, if the panelized option is selected, the entire development could be of the same construction with different models providing aesthetic variation.

Project Coordination -- Due to complexity and close coordination of programs and activities required to develop the housing, it is advisable that a project coordinator be retained to operate the Laie program. Such a coordinator will need to be familiar with the various private sector and government parties which may be involved in the development, as well as be sensitive to the community and its needs. He or she should be interested in spending time explaining the various aspects of the development to the community and assisting the community in understanding real estate development. The coordinator would be responsible for assuring the appropriate interfacing of government activities, many of which must be accomplished at established times. This is especially true of interactions with Farmers Home Administration.

Lead Developer -- It would be most efficient and effective for one developer to be retained to produce both gap group and below market housing, especially if the developments are to be in the same location. The developer should have experience with limited income housing and have

the resources to accomplish a development of this size. He or she should have a good reputation and be familiar with FmHA and HHA.

B. Funding Infrastructure Improvements

Providing water, sewers, roads and drainage for new development is very expensive. Major upgrading of the systems serving existing developments will be similarly costly. Important to the feasibility as well as the equity of paying for these improvements will be a fair distribution of the costs among the beneficiaries.

Presented in this section is a distribution, or proration, of infrastructure improvement costs among the existing and new developments which will benefit. They are derived from the total estimated costs for construction of the various infrastructures presented in Chapter VI.

These prorated costs are not offered as firm recommendations for funding the improvements. Rather, they are intended to provide a starting point for discussion aimed at working out more specific funding strategies. Final decisions on who pays for what will require more detailed analysis of both costs and the distribution of benefits.

New and Expanded Infrastructure Systems

Water System -- The prorated costs (in 1990 dollars) for an integrated water system and for separate water systems (i.e., improvements to the existing system and an independent system for the new residential area) for Scheme A are presented in Tables 15-A and 16-A, respectively. The prorated costs for integrated and separate water systems for Scheme B are presented in Tables 15-B and 16-B.

Table 15-A

PRORATED COSTS FOR INTEGRATED WATER SYSTEM IMPROVEMENTS
SCHEME A

Beneficiary	Prorated Cost
BYU-HC	$2,910,000
PCC	570,000
Other Existing Laie Community	
Existing Development	1,220,000
New Development	860,000
New Residential Area (450 Homes)	1,960,000
TOTAL	$7,300,000
Cost Per Unit in New Residential Area	$4,400

Table 16-A

PRORATED COSTS FOR SEPARATE WATER SYSTEM IMPROVEMENTS
SCHEME A

Beneficiary	Prorated Cost
BYU-HC	$3,030,000
PCC	590,000
Other Existing Laie Community	
Existing Development	980,000
New Development	900,000
TOTAL	$5,500,000

New Residential Area Water System

New Residential Area (450 Homes)	$2,600,000
Cost Per Unit in New Residential Area	$5,800

Table 15-B

PRORATED COSTS FOR INTEGRATED WATER SYSTEM IMPROVEMENTS
SCHEME B

Beneficiary	Prorated Cost
BYU-HC	$2,910,000
PCC	570,000
Other Existing Laie Community	
Existing Development	1,220,000
New Development	860,000
New Residential Area (450 Homes)	3,040,000
TOTAL	$8,600,000
Cost Per Unit in New Residential Area	$7,200

Table 16-B

PRORATED COSTS FOR SEPARATE WATER SYSTEM IMPROVEMENTS
SCHEME B

Beneficiary	Prorated Cost
BYU-HC	$3,030,000
PCC	590,000
Other Existing Laie Community	
Existing Development	980,000
New Development	900,000
TOTAL	5,500,000

New Residential Area Water System

New Residential Area (450 Homes)	$3,100,000
Cost Per Unit in New Residential Area	$6,900

Sewerage System -- Table 17 presents the prorated costs for upgrading the existing sewerage system as required to meet the needs of existing and anticipated new users. The percentages used to prorate the water and sewerage system costs are based on the future average daily demand for water and the average daily flow of sewage from the different users. Cost per unit figures for the separate sewerage system required to service the proposed new residential area are also presented for both Scheme A and Scheme B.

Table 17

PRORATED COSTS FOR SEWERAGE SYSTEM IMPROVEMENTS

Beneficiary	Prorated Cost
Existing Sewerage System	
BYU-HC	$2,390,000
PCC	1,640,000
Other Existing Laie Community	
Existing Development	850,000
New Development	420,000
TOTAL	$5,300,000
New Residential Area Sewerage System	
New Residential Area for - Scheme A (450 Homes)	$5,500,000
Cost Per Unit for Scheme A	$12,200
New Residential Area for - Scheme B (450 Homes)	$5,700,000
Cost Per Unit for Scheme B	$12,700

NOTE: As discussed in Chapter VI, the costs of the new residential area sewerage system are estimated to be the same whether the new sewage treatment plant is located adjacent to the existing plant or at the makai end of the new residential area.

Roadway and Drainage Systems -- As indicated in Table 12, roadway and drainage system costs for the proposed new residential area are $29,100 per unit for Scheme A and $31,300 per unit for Scheme B. The costs of upgrading the roads and drainage in the existing Laie community are discussed in the last section of this chapter.

All Infrastructure Systems -- Summaries of the costs for all infrastructure improvements, as prorated to the various benefitting developments, are presented in Tables 18-A (Scheme A) and 18-B (Scheme B) for the integrated water system alternative, and similarly in Tables 19-A and 19-B for the separate water systems alternative. All costs are in 1990 dollars.

Table 18-A

SUMMARY OF PRORATED COSTS FOR ALL INFRASTRUCTURE IMPROVEMENTS
INTEGRATED WATER SYSTEM ALTERNATIVE
SCHEME A

Beneficiary	Prorated Cost
Existing Systems[1]	
BYU-HC	$5,300,000
PCC	2,210,000
Other Existing Laie Community	
Existing Development	2,070,000
New Development	1,280,000
TOTAL	$10,860,000
New Residential Area Systems[2]	
New Residential Area (450 Homes)	$20,340,000
Cost Per Unit for Scheme A	$45,200

1 Excludes cost of internal roads, drainage and street lighting.

2 Includes cost of internal roads, drainage, and street lighting

Table 18-B

SUMMARY OF PRORATED COSTS FOR ALL INFRASTRUCTURE IMPROVEMENTS
INTEGRATED WATER SYSTEMS ALTERNATIVE
SCHEME B

Beneficiary	Prorated Cost
Existing Systems[1]	
BYU-HC	$5,300,000
PCC	2,220,000
Other Existing Laie Community	
Existing Development	2,070,000
New Development	1,280,000
TOTAL	$10,860,000
New Residential Area Systems[2]	
New Residential Area (450 Homes)	$22,840,000
Cost Per Unit for Scheme B	$50,800

1 Excludes cost of internal roads, drainage and street lighting.

2 Includes cost of internal roads, drainage, and street lighting

Table 19-A

SUMMARY OF PRORATED COSTS FOR ALL INFRASTRUCTURE IMPROVEMENTS
SEPARATE WATER SYSTEM ALTERNATIVE
SCHEME A

Beneficiary	Prorated Cost
Existing Systems[1]	
BYU-HC	$5,420,000
PCC	2,230,000
Other Existing Laie Community	
Existing Development	1,830,000
New Development	1,320,000
TOTAL	$10,800,000
New Residential Area Systems[2]	
New Residential Area (450 Homes)	$21,200,000
Cost Per Unit for Scheme A	$47,100

1 Excludes cost of internal roads, drainage and street lighting.

2 Includes cost of internal roads, drainage, and street lighting

Table 19-B

SUMMARY OF PRORATED COSTS FOR ALL INFRASTRUCTURE IMPROVEMENTS
SEPARATE WATER SYSTEMS ALTERNATIVE
SCHEME B

Beneficiary	Prorated Cost
Existing Systems[1]	
BYU-HC	$5,420,000
PCC	2,230,000
Other Existing Laie Community	
Existing Development	1,830,000
New Development	1,320,000
TOTAL	$10,800,000
New Residential Area Systems[2]	
New Residential Area (450 Homes)	$22,900,000
Cost Per Unit for Scheme B	$50,900

1 Excludes cost of internal roads, drainage and street lighting.

2 Includes cost of internal roads, drainage, and street lighting

Comparison of 1987 and 1990 Draft Master Plan Infrastructure Costs -- The infrastructure costs per unit for Scheme A of the proposed new residential area are $45,200 with an integrated water system and $47,100 for separate water systems. (For Scheme B, the per unit costs are $50,800 and $50,900, respectively.) By comparison, per unit infrastructure costs for the new residential area proposed in the 1987 draft Master Plan, *expressed in 1990 dollars (assuming a 15% increase in costs over 2-1/2 years)*, are $39,700 with an integrated water system and $41,100 with separate water systems.

A major portion of this cost (about 65 percent) in the 1987 Draft Plan, as well as for Schemes A and B presently under consideration, is for new roadways and drainage. However, significantly different approaches to the allocation of these costs were used in the 1987 Draft Plan and in this current draft. If the same approach is used for both draft plans, the new residential area infrastructure costs proposed in the current draft are actually less.

In the 1987 Draft Plan, new roadway and drainage construction costs related to the new residential area amounted to $15.9 million (in 1990 dollars). However, 75 percent ($4.15 million) of the $5.5 million cost (1990 dollars) of the major loop road required to provide access to the new residential area was charged to BYU-HC and PCC. (This was based on the comparative amounts of frontage that each facility and the residential area would have on the loop road.) Only $11.75 million (1990 dollars) of the total roadway costs was charged to the new residential area.

New roadway construction costs for Schemes A and B amount to only $13.1 million and $14.1 million respectively, or considerably less than the $15.9 million in the 1987 Draft Plan's roadway costs. If the costs of the new loop road proposed in the 1987 Draft Plan were attributed entirely to the new residential area, per unit costs would be $48,900 with an integrated water system, and $50,300 with separate water systems. This is over $3,000 per unit higher than for the current Scheme A. (Per unit infrastructure costs for the residential area proposed in the 1987 Draft Plan, on the other hand, are as much as $2,000 lower than for the current Scheme B.)

Perhaps more significantly, the prorated costs of upgrading and expanding the infrastructure for existing Laie would be signifantly less under either the current Scheme A or Scheme B, as compared to the 1987 Draft Plan. The savings would be on the order of $2+ million for BYU-HC, $1+ million for PCC, and $500,000 for other existing and new development within the existing Laie community.

Upgrading Existing Roads and Drainage

Discussed below is the concept of utilizing an Improvement District (I.D.) to pay for upgrading the roadways and drainage in the existing residential area of Laie. An I.D. is a defined, developed area that is to be upgraded to City and County requirements, with part of the cost of the improvements (usually 50+ percent) paid by the City and County. The balance of the cost would be paid by property owners within the I.D., either as a lump sum payment or in 20 annual installments. More specific information is available in a City and County brochure entitled "The Improvement District Process", dated May 1987.

The purpose of an I.D. for Laie would be to upgrade existing private roads and drainage to the degree necessary to dedicate them to the City and County for maintenance. The district would cover the portion of the existing community mauka of Kamehameha Highway, where all roads except Wahinepee Street are currently owned and maintained by Zions Securities Corporation.

Two alternative ways of allocating the costs of improvements were investigated: the creation of a single I.D. covering the entire area mauka of Kamehameha Highway, and the division of this area into two I.D.s, one on the Kahuku side of Hale Laa Boulevard (referred to as "Old" Laie), and the other on the Hauula side (called "New" Laie).

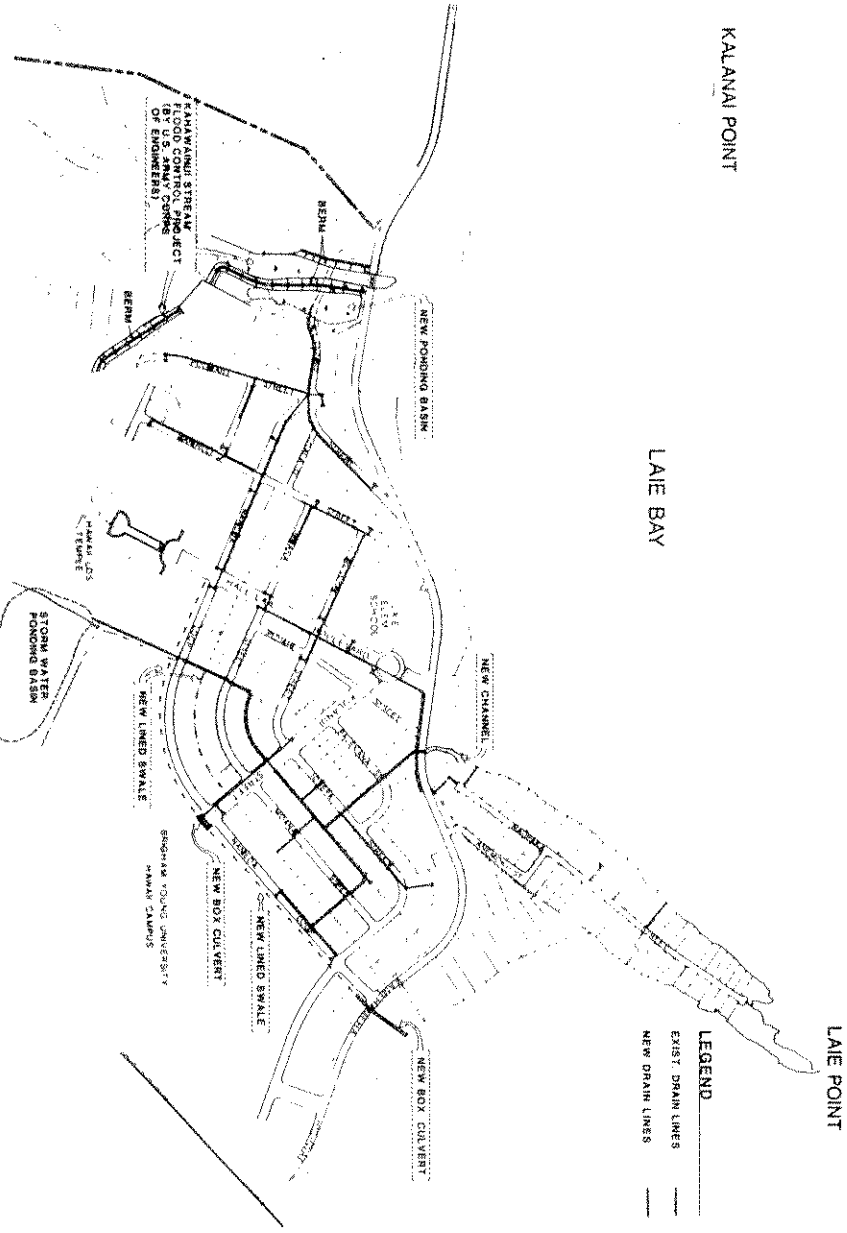
A primary factor which may warrant separating the area into two districts is the difference in condition of existing improvements. Most of the roads in New Laie comply with City and County standards in existence at the time

they were built. A drainage system also exists, although it is not up to standard. The roadways in Old Laie, however, are not up to standard, and a drainage system is virtually non-existent. Consequently, there is a significant disparity in improvement costs between the two areas.

A major factor which tends to offset this, however, is the need to construct a major drainage course to intercept storm water runoff from BYU-HC which presently flows into New Laie. This interceptor drain, which would run along the mauka-Hauula side of Naniloa Loop from Hale Laa Boulevard to the ocean, would primarily be a concrete-lined open channel with fencing on both sides. Concrete box culverts would be used where it crosses under the Kulanui Street entrance to BYUH, and under Kamehameha Highway.

Although most of the infrastructure improvements for the I.D. are for the exclusive benefit of property owners in the I.D., the proposed major interceptor drain along Naniloa Loop would benefit both the I.D. and BYUH. Therefore, consideration should be given to having at least a portion of the construction cost for this interceptor drain borne by BYUH.

The I.D. areas, and the drainage improvements required to bring the existing system up the City and County standards, are shown on Figure 7. Tables 19 and 20 present estimated total construction costs and prorated costs per lot, respectively, for the two scenarios of one combined I.D. and two separate I.D.s, all in 1990 dollars. Both assume improvements would be made to full City and County standards. Prorated costs in Table 20 are also given with and without the inclusion of the BYUH interceptor drain in the improvement district.



LAIE MASTER PLAN
DRAINAGE SYSTEM

SOURCE: AUSTIN, TSUTSUMI & ASSOCIATES, INC.

FIGURE 7

Table 20

ESTIMATED IMPROVEMENT DISTRICT COSTS
FOR THE EXISTING LAIE COMMUNITY

Item No.	Description	Cost: One Improvement District	Cost: Two Separate Improvement Districts "New" Laie	Cost: Two Separate Improvement Districts "Old" Laie
1.	Roadway Improvements	$5,370,000	$1,830,000	$3,540,000
2.	Drainage System	2,870,000	910,000	1,960,000
3.	Street Lighting Addition	265,000	105,000	160,000
	SUB-TOTAL	$8,505,000	$2,845,000	$5,660,000
4.	BYUH Interceptor Drain	4,715,000	4,715,000	—
	TOTAL	$13,220,000	$7,560,000	$5,660,000

Table 21

ESTIMATED IMPROVEMENT DISTRICT COSTS PER LOT
FOR THE EXISTING LAIE COMMUNITY

Item No.	Description	Cost: One Improvement District	Cost: Two Separate Improvement Districts "New" Laie	Cost: Two Separate Improvement Districts "Old" Laie
1.	Roadway Improvements	$11,380	$6,560	$18,400
2.	Drainage System	6,100	3,220	10,240
3.	Street Lighting Addition	580	340	800
4.	BYUH Interceptor Drain	10,000	16,900	-0-
TOTAL COST Per Average Lot, Assuming 100 percent Payment of I.D. Costs by Lot Owners:				
	With BYUH Interceptor Drain	$28,060	$27,020	$29,440
	Without BYUH Interceptor Drain	$18,060	$10,120	$29,440
TOTAL COST Per Average Lot, Assuming 50 percent City and County Contribution:				
	With BYUH Interceptor Drain	$14,030	$13,570	$14,720
	Without BYUH Interceptor Drain	$9,080	$5,060	$14,720

APPENDIX B

AN EVALUATION OF BELOW MARKET HOUSING PROGRAMS AND FINANCING OPTIONS FOR THE DEVELOPMENT OF AFFORDABLE HOUSING IN LAIE

Prepared By:

David W. Rae and Associates.

Prepared For:

Group 70

August 1987

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1 Introduction

1.1 Background and Purpose

Zions Securities Corporation has retained the architectural and planning firm of Group 70 to prepare a Master Plan for the Laie Community. The plan addresses the future need of the community with regard to community services, infrastructure, employment, and housing. As part of the broader housing assessment, Group 70 retained David W. Rae and Associates to compile and assess available means of providing below market housing.

As inputs to the community needs assessment, Zions Securities retained the firm of Community Resources Inc. (CRI) to survey the community on a broad range of topics. Several questions assessing below market housing need and ability to pay were included in the survey. The results of these questions form the basis for assumptions regarding affordability and demand and are discussed in Section 2.

1.2 Scope

It is understood that this report represents a step in the planning process and not a single recommendation but rather a menu of reasonable options from which Zions Securities and the community with the assistance of Group 70 may develop a definite affordable housing plan. As such, the report discusses those options which are both available and minimally appropriate to the goals of the Master Plan. It should be remembered that many options which existed several years ago are no longer viable due to lack of federal funds and/or changes to the tax code. They are not discussed in this report.

2 Definition of Below Market Housing

In general, the cost of for-purchase housing to the consumer is the sum of all building material costs, land costs, labor costs, developer profits, and financing costs. In order for housing to be supplied at below market, or less than the sum of all costs, the difference between the desired price and the normal costs must be made up somewhere. For most housing in the United States, this difference has been made up by the Federal government in the form of tax credits for mortgage interest. In essence, the tax system subsidizes the true cost of housing in this country. The owners of rental housing are also subsidized by the government for not only mortgage interest but also for depreciation and other business expenses. These subsidies which are inherent in all housing have brought decent housing within the grasp of most Americans.

However, people living in high cost areas such as Honolulu do have difficulty either purchasing or renting housing and not exceeding the "rule of thumb" of paying more than 30 percent of their gross income for housing. This report will discuss those programs and financing options which can provide both rental and for purchase housing to the Laie community at prices appropriate to the income categories discussed in the Laie survey.

2.1 Variables Involved in Affordability

The major variables involved in affordability are 1) the cost of raw land, 2) the cost of infrastructure (water, sewers, roads, etc.), 3) the cost of building materials, 4) the cost of labor, and 5) the cost of money. Each of these costs will be address by at least one of the programs or financing options discussed in the report. The ultimate program used in Laie will most appropriately be a combination of several options.

2.2 Units Demanded and Pricing Requirements

Based on the CRI survey of Laie residents, a 365 unit "pent up" demand may be predicted. Survey question 22 asked if respondents knew of anyone who would move out of an existing home to form a new household if there were more affordable housing in Laie. Thirty six percent said they knew of someone who would form a new household. Question 23 followed by asking how may new housing units would be required by those moving out to form new households. The mean was that 1.4 housing units would be required for each current household saying that people would move out of that house into a new home. Due to phrasing of questions 22 and 23, it is reasonable to assume that 365 represents an upper range. The average household size in the survey was 5.4 persons per household. This is considerably higher than the Oahu average of 3.25 and is reflected in the "pent up" demand number of 365.

Question 24 of the survey attempted to assess the income of those who would be demanding the new homes. Four broad income categories were used. It was found that: 39.6 percent (145 units) of the demand would be from families making less than $18,000 per year; 25.4 percent (93 units) of the demand would be from families in the $18,000 to $24,000 per year income range; 15.9 percent (58 units) of the demand would be from families in the $24,001 to $30,000 per year range; and that 19.1 percent (70 units) of the demand would be from families making more than $30,000 per year.

Data on the number of people within families or households wanting new homes was not collected during the survey. For conventional financing, household size is not a factor in loan qualification. For some forms of assistance, however, household size will determine maximum allowable incomes or subsidy levels. This will be discussed under the relevant programs.

If conventional financing were used by Laie residents to purchase the projected housing, those making less than $18,000 per year would not be able to buy units in excess of approximately $58,000. For those in the $18,000 to $24,000 range, the maximum purchase price would be approximately $68,000. For families making between $24,001 and $30,000 the maximum purchase price could not exceed approximately $87,000 while those making more than $30,000 would be able to afford conventionally financed homes in excess of approximately $97,000.

Maximum rental rates, assuming not more than 30 percent of income for rent would be as follows: for families making less than $18,000 per year, $450 per month, for families making between $18,000 and $24,000, $525 per month, for families making between $24,001 and $30,000 $675 per month, and families making more than $30,000 would be able to spend more than $750 per month in rent.

The foregoing information is presented in Table 1.

Table 1

PROFILE OF LAIE HOUSING DEMAND

Household Income (1)	Percent of Demand (1)	Number of Units (2)	Approximate Maximum Price (3)	Approximate Maximum Rent (4)
<$18,000	39.6%	145	$58,565	$450
$18,000 to $24,000	25.4%	93	$68,325	$525
$24,001 to $30,000	15.9%	58	$87,847	$675
>$30,000	19.1%	70	$97,608	$750

Loan Assumptions

Interest Rate:	10.5%
Loan Term	30

NOTES:
(1) As per CRI Laie Community Survey.
(2) Based on CRI Survey demand of 365 units.
(3) Based on Conventional Financing with above loan assumptions.
(4) Based on 30 percent of gross income.

3 Housing Development Programs and Options

Due to the low incomes indicated in the CRI survey, below market housing development can only be achieved through deeply subsidized means. Even with subsidized construction, discounted mortgage financing will be required. This section will discuss the few remaining development programs and options for actual unit production. For all intents and purposes, government supplied housing no longer exists. The programs and options discussed in this section require a partnership between government and the private sector.

3.1 For Purchase Housing

Several years ago there was a concentration of government sponsored single family production programs, most of which derived their support from the federal government. Today the only production program viable enough for consideration in this discussion is the State enabled Act 105 program (also known as Section 359G HRS). Under this legislation, both the City and County of Honolulu as well as the Hawaii Housing Authority (HHA) have many of the same powers. The City has, however, decided to concentrate on multi-family housing and is not involved in single family production unless it acts as the developer of large scale projects such as Waiola or West Loch. Therefore, this description will focus on Act 105 projects as performed by HHA.

3.1.1 Description of Program

The basic thrust of the program is to provide for purchase housing to "gap-group" families. These are families making between 80 and 120 percent of the county median income of $34,000 for a family of four. This produces a qualifying family of four income range of $27,300 to $40,920. This represents the upper end of the Laie need group and may be appropriate for development of approximately 80 units.

Within the Act 105 program, developments are built under one of several approaches. HHA may act as a developer, retaining contractors to actually build units. This is the approach the City is now taking. HHA may form a partnership with a private developer, usually a land owner, under a joint venture or development agreement. A private developer may work independently but use HHA's exemption powers (discussed later) or low cost financing. The last two options seem most appropriate for Laie.

Various approaches are used under Act 105 to reduce the cost of homes. The State has the dwelling unit revolving fund (DURF) available for low interest construction loans. HHA encourages the use of this fund on all Act 105 projects. The HHA has the power to request of the Land Use Commission and/or the county that all land use controls from boundary change through building permit be waived or modified so long as public safety is not compromised. Such a waver may include all planning, zoning, subdivision requirements, and building standards. It is important to note, however, that if exemptions are contemplated and

if Farmers Home programs are to be involved, that Farmers Home standards must not be violated even though permitted by the County. This is explained further under Farmers Home programs. By law, such a request must be acted upon within 45 days. HHA also has the power to waive the general excise tax on materials and services used in the project. HHA may assume marketing risks and carrying costs. Developer profit will be limited to 6 percent. Homes will be subject to a buy-back provision if the home owner wishes to sell within 10 years. The gain to the seller will be limited. Purchasers will be selected from an island-wide sign-up.

3.1.2 Agencies Involved

For the State the lead agency is the:
Hawaii Housing Authority
1002 North School Street
Honolulu, Hawaii 96817
Contact:
Richard Hirata 848-3226

For the City and County of Honolulu the lead agency is:
Department of Housing and Community Development
650 South King Street
Honolulu, Hawaii 96813
Contact:
Robert Miyasato 523-4360

3.1.3 Type and Cost of Housing

Both multi-family and single-family for purchase housing are developed under Act 105. Units may be fee simple or lease hold. While rental housing has in the past been developed under the program, its future availability is uncertain due to changes in the tax law.

Maximum purchase price is set by household income. At least 60 percent of the units in the development must be made available to families making less than $40,900 per year (assuming a family of four). Assuming conventional financing, the average price of a unit for a family of four could not exceed $133,137. If Hula Mae financing is used, as is usually the case in HHA projects, the maximum price could not exceed $151,030.

Typical projects have ranged in sales price from approximately $90,000 to $120,000 for a single-family unit on a 4,000 square foot lot. This is clearly the upper end of the Laie market. However, land and infrastructure costs are important variables and may be different for Laie.

3.1.4 Advantages and Disadvantages

The single major advantage to using Act 105 in housing development is the ability to expedite land use processing and waive

various subdivision regulations to reduce cost. A second advantage for some developers is access to the relatively low interest DURF money for construction.

The major disadvantages involve the political nature of the process and the lack of control over who may purchase the homes. Under Act 105, the State Land Use Commission, if boundary changes are involved, or the City Council must approve the project and the requested exemptions. While few projects have ever been denied, the negotiations have caused some developers to question the desirability of using Act 105. Additionally, Act 105 requires that applications be accepted from any qualified resident on the island. This could mean that a number of non-Laie residents could benefit from the project.

3.2 Rental Housing

As with for purchase housing, rental housing has undergone a dramatic decrease in production since the enactment of the Tax Reform Act of 1986. This is true for both private and government projects. Today, tax exempt financing, the prime cause of rental construction in the last few years, is not available in Hawaii. Both the City and the State have plans to recreate their own program but this is at least a year away and very uncertain. Private developer can not develop rental housing without the tax incentives which used to exist. Also, there is no new money for rent subsidies with waiting lines over a year in length.

In spite of this gloomy picture for rental housing, one program has remained untouched by budget cuts. That is the Farmers Home Administration's (FmHA) Section 515 Rural Rental Housing Program.

3.2.1 Description of Program

Loans for rental housing in rural areas (Laie qualifies according to a preliminary review by FmHA) are available to provide living units for persons with low and moderate incomes and for those age 62 and older. Loans are primarily made to build, purchase or repair apartment-style housing, usually consisting of duplexes, or similar multi-unit dwellings. The housing must be modest in size, design, and cost, but adequate to meet the tenants needs. Funds may be used to: buy and improve land; provide streets, water, and waste disposal systems; supply appropriate recreation and service facilities; install laundry facilities and equipment; and landscape the development. Funds may not be used for nursing, special care or other institutional types of housing.

Loans can be made to individuals, trusts, associations, partnerships, limited-partnerships, State or local governments, consumer cooperatives, and profit and nonprofit corporations.

Borrowers must agree to provide rental units for occupancy by eligible individuals or families. They must be unable to finance the housing with personal resources and be unable to obtain credit from other sources with terms which would permit them to rent units to eligible families.

Borrowers are required to deposit rental income into special accounts and establish reserve funds to meet long-term capital replacement needs. Profit is limited to 8 percent of equity. Loans are limited to 95 percent of cost. The loan period may not exceed 50 years. Interest rates may be as low as 1 percent.

Applicants must provide detailed plans, specifications, and cost estimates and well as a market study. FmHA has standards for all phases of development. All infrastructure must meet applicable standards. It is important to coordinate FmHA requirements with any exemptions sought under Act 105. The application for funds must contain the following: complete financial information; preliminary plans, specifications, and cost estimates; a budget of anticipated income and expenses; and survey information supporting the need for the housing in the area.

3.2.2 Agencies Involved

The lead agency is:
United States Department of Agriculture
Farmers Home Administration
P. O. Box 50224
Honolulu, Hawaii 96850
Contact person:
Mary Curill 524-2584

3.2.3 Type and Cost of Housing

Housing units are multi-family in nature usually in duplex or apartment like configuration. Rents are set by household income but may not exceed 30 percent of adjusted gross income. Typical units are 600 to 800 square feet in size. There is no lower limit to rent. The loan interest rate is subsidized by FmHA so as to assure affordability.

3.2.4 Advantages and Disadvantages

The major advantage is the vary favorable terms of the loan which make rental housing possible. Additional, FmHA is the only rental construction program available.

The major disadvantage is the processing time and cumbersome requirements of FmHA. It may be expected to take up to two years to receive funding. FmHA will also have standards for all phases of the project.

3.3 Owner Built Housing

Often referred to as self help or sweat equity, owner built housing derives its primary subsidy from labor savings. There are several options for owner built housing which will be discussed in this section.

3.3.1 Description of Program

Owner built housing programs are offered by both the Oahu Self Help Corporation and by Savio Development Company. Except where noted, items discussed in this section will apply to both programs.

In an owner built development, the intended occupants of the housing do the house construction themselves under the supervision of a licensed contractor. The land improvements are done professionally as is the foundation. The Oahu Self Help Corporation currently uses stick built construction (pre-cut lumber sold as a package and assembled) while Savio Development uses a panelized construction method (the house is factory built on the mainland and shipped in large panels which are owner assembled). The panelized process would allow a custom design home to be packaged into components and assembled on the site. This would allow for integration of the below market housing into the broader development. Construction of the house by the stick built method takes approximately 10 months while the panelized method takes about one month.

In an owner built program, groups of residents are organized into working teams and perform work on all of the homes in the group. The Oahu Self Help program establishes working groups of 15 families at a time. Both Oahu Self Help and Savio Development believe that several hundred units in Laie is feasible given the close knit nature of the community.

3.3.2 Parties Involved

The Oahu Self Help Corporation
200 North Vineyard Blvd.
Honolulu, Hawaii 96817
Contact Person:
Claudia Shay 545-4133

Savio Development Company
931 University Ave.
Honolulu, Hawaii 96826
Contact Person:
Sally Winter 924-7701

3.3.3 Types and Cost of Housing

The most common type of unit is single-family detached housing. Some locations have done multi-family housing but none has been attempted in Hawaii thus far. The typical size of home is 1,000 to 1,500 square feet on a 5,000 square foot lot.

The house price for each is approximately $25 to $35 per interior square foot or $25,000 to $35,000 for a 1,000 square foot house. This price is exclusive of land and infrastructure. The land and infrastructure should be kept to $25,000to $30,000 per 5,000 square foot lot in order to deliver a house and lot for approximately $65,000. This is a goal because a Farmers Home loan (see financing Section) has a maximum loan amount of $65,000.

3.3.4 Advantages and Disadvantages

The primary advantage with owner built housing is that, coupled with Farmers Home financing, it brings home ownership with in the range of even the lowest income family. A $65,000 home with FmHA financing would yield monthly payments of only $192 per month depending on family eligibility for the most subsidized interest rate (See Section 4.1.1 for an explanation of FmHA financing).

A second advantage to owner built housing is the sense of community participation and empowerment inherent in building ones own home. Communities which have participated in owner built programs report increased community cohesion and pride.

A third advantage is that the land owner may be able to realize some return on the land due to the savings on house price.

A disadvantage to the program is the image people have of it taking too much time and effort. Indeed the 10 months for stick built housing does have draw-backs in terms of loss of enthusiasm toward the end of the program.

A second disadvantage is that to take full advantage of the benefits, FmHA financing must be used. This form of financing is time consuming to obtain and heavy with requirements.

4 Financing Options

Most home financing in Hawaii is done either by what is known as Conventional Financing or by an insured mortgage by the Federal Housing Administration (FHA). Both of these methods have relatively high interest rates and contain no subsidies. The major difference between the two is that with FHA insurance it is possible to finance up to 97 percent of the house price. It is unlikely that either will be of great benefit to Laie residents but they are included in Table 2 for comparisons.

4.1 Hula Mae Financing

Hula Mae is administrated by the Hawaii Housing Authority (HHA). Through the use of tax-exempt revenue bonds, the Hula Mae Program provides first-time home buyers with mortgage loans at interest rates below those available on conventional loans. The program is run through participating loan institutions which accept applications and screen them for eligibility. The amount of the loan write-down will vary over time due to changes in the bond rates which fund Hula Mae.

Program eligibility is limited to any person or family who:

- -- is a bonafide resident of Hawaii.
- -- is a citizen of the United States or a declarent alien.
- -- is 18 years of age or older.
- -- has not received a previous Hula Mae loan.
- -- has not owned a home in the past three years.
- -- does not have an adjusted household income that exceeds the maximum income limit by applicable family size:

1 member	$36,154	5 members	$43,654
2 members	$39,904	6 members	$44,904
3 members	$41,154	7 members	$46,154
4 members	$42,404	8 members	$47,404

The current interest rate is 8.00 percent. The loan term is 30 years. Generally a 10 percent down payment is required but may be reduced to 5 percent under some circumstances. The loan value on new construction can not exceed $143,479 with house price not to exceed $151,030. The impact of Hula Mae financing on Laie households can be seen in Table 2.

4.2 Farmers Home Financing

FmHA administers a loan program similar to Hula Mae but it is restricted to rural areas. Homes purchased under this program must meet strict building standards and it is required that new construction be pre approved. This process is lengthy and may take up to one year. The entire subdivision is subject to FmHA building standards. This includes water, sewers, and roads. Income limits are as follows:

1 member	$19,100	5 members	$29,000
2 members	$21,850	6 members	$30,700
3 members	$24,550	7 members	$32,400
4 members	$27,300	8 members	$34,150

The current interest rate is 9 percent. However, this rate can be lowered to as low as 1 percent, and often is, to make the housing affordable to very low income families. This is accomplished using a fairly complex formula based on the principal that the household shall not pay more than 20 percent of their income for mortgage payments. The loan term is 33 years. There is no required down payment. The loan amount can not exceed $65,000 but there is no limit on price. It is unlikely, however, that eligible families will have access to a down payment. This form of financing was used in the Oahu Self Help Corporation's Maili project. Several families there are paying the minimum $192 per month.

It should be stressed that this program is not a grant. The subside must be repaid when the owner ceases to occupy the home or after the 33 year loan period, whichever occurs first. Should the family leave before the 33 years, the amount is due at the time they cease to occupy the house. Should the family stay for the entire mortgage period, the repayment may be made in payments arranged by FmHA.

4.3 Adjustable Rate Mortgages

Often called ARMs, adjustable rate mortgages come in various forms. The basic principle of which is to lower the interest rate below conventional mortgages but to allow the rate to change over time given changes in the prime rate. Usually the rate changes annually after a set period of one to three years. The increases, or decreases, are capped in any one year and through out the life of the loan. Some are convertible to fixed rate after a certain holding period. These loans have become popular again as conventional rates have increased. The current ARM is about 7.5 percent. This is even lower than Hula Mae and has caused that program competition. The impact of ARMs on Laie household incomes is depicted in Table 2.

Table 2

APPROXIMATE MAXIMUM PURCHASE PRICE WITH VARIOUS FORMS OF FINANCING

Form of Financing	Interest Rate	Term	Income/ Payment Ratio	Down Payment	Approximate Maximum Price With Household Income of: $15,000	$18,000	$21,000	$27,000	$30,000	$33,000
Conventional	10.50%	30	3.5:1	20%	$48,804	$58,565	$68,325	$87,847	$97,608	$107,369
FHA Insured	10.00%	30	3.5:1	3%	$41,955	$50,346	$58,738	$75,520	$83,911	$92,302
Farmers Home	1.00%	33	N/A	0%	NO MAXIMUM PRICE (UP TO $65,000 LOAN)					
Hula Mae	8.00%	30	2.8:1	10%	$67,601	$81,121	$94,641	$121,682	$135,202	$148,722
ARM	7.50%	30	3.5:1	20%	$63,847	$76,617	$89,386	$114,925	$127,694	$140,464

APPROXIMATE MAXIMUM LOAN AMOUNT WITH VARIOUS FORMS OF FINANCING

Form of Financing	Interest Rate	Term	Income/ Payment Ratio	Down Payment	Approximate Maximum Loan Amount With Household Income of: $15,000	$18,000	$21,000	$27,000	$30,000	$33,000
Conventional	10.50%	30	3.5:1	20%	$39,043	$46,852	$54,660	$70,278	$78,086	$85,895
FHA Insured	10.00%	30	3.5:1	3%	$40,697	$48,836	$56,975	$73,254	$81,393	$89,533
Farmers Home	1.00%	33	N/A	0%	UP TO $65,000 LOAN (NO MAXIMUM PRICE)					
Hula Mae	8.00%	30	2.8:1	10%	$60,841	$73,009	$85,177	$109,514	$121,682	$133,850
ARM	7.50%	30	3.5:1	20%	$51,078	$61,293	$71,509	$91,940	$102,155	$112,371

5 Recommendations

The following recommendations are aimed at creating housing units in Laie for Laie residents at prices they can afford. The recommendations are also aimed at assuring some return on land for the land owner and minimizing procedural difficulties.

5.1 Project Coordination

Due to complexity and interrelationship of programs and activities to develop the housing, it is recommended that a project coordinator be retained either directly in-house or as a consultant by Zions Securities. The coordinator should be familiar with the various private sector and government parties which may be involved in the entire development as well as being sensitive to the community and its needs. The coordinator should be interested in spending time explaining the various aspects of the development to the community and assisting the community in understanding real estate development. The coordinator would be responsible for assuring the appropriate interfacing of government activities. Many of which must be accomplished at established times. This is especially true of interactions with Farmers Home Administration.

5.2 Lead Developer

It is recommended that one developer be retained to produce both gap group and below market housing, especially if the developments are to be in the same location. The developer should have experience with limited income housing and have the resources to accomplish a development of this size. The developer should have a good reputation and be familiar with FmHA and HHA.

5.3 Gap Group Housing

The gap group is generally defined as being between 80 and 120 percent of the county median income. For Oahu, the median income is now pegged at $30,400 for a family of four. The gap group would therefore range from $24,320 to $36,480. This would represent the top portion of the Laie pent-up demand.

It is recommended that Act 105 be used to expedite the processing of the entire development and reduce infrastructure as appropriate. Hula Mae financing should be obtained for home mortgages for the gap group families. The construction of these homes should blend with the below market units. Indeed, if the panelized option is selected, the entire development could be of the same construction with different models providing aesthetic variation.

5.4 Below Market Housing

Below market generally refers to households in the low and moderate income groups (those making less than 80 percent of the

median income of $30,400). For Oahu this would be those households with incomes less than $24,320 per year. This represents the bulk of the Laie pent-up demand.

It is recommended that an extensive owner builder program using panelized construction be used in conjunction with FmHA loan financing to produce the bulk of below market financing. To the extent that there remain families who can not participate in owner built and do not have sufficient incomes to afford gap group housing, the FmHA rental housing program should be considered.

APPENDIX C

Laie Master Plan EIS

WASTEWATER MANAGEMENT PLAN

Laie, Oahu, Hawaii

January 8, 1992

Aqua/Waste Engineers
P.O. Box 1686, Kailua Kona, HI 96745
(808) 329-8266 Fax (808) 326-7767

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1 EXISTING WASTEWATER SYSTEM

INTRODUCTION

The community of Laie is preparing a Master Plan intended to lay out a course for accommodating future growth and change in Laie that will have a broad base of support in the community. For planning purposes various land uses have been identified including: residential, commercial, resort, public, schools, and industrial. The infrastructure upgrades to support the development include the necessary roads, drainage structures, water and sewer lines, electrical distribution lines and secondary roads.

Housing is a primary element of the plan and three Alternative Land Use Schemes to provide additional residential housing and a school are being studied for inclusion in the overall Master Plan. This report provides an evaluation of the wastewater system to support the future development plans.

BACKGROUND

Proposed Project

The Laie Master Plan addresses the needs of the people and outlines the improvements necessary for growth in the community. This proposed development will result in the expansion of existing commercial areas, including the shopping center and the Polynesian Cultural Center. Light industry is being considered mauka of Hukilau Park. A new resort will be located makai of the Laniloa Lodge area providing leisure and recreational facilities for hotel guests. Among areas that will benefit the public are a community center near the Temple and another community center in a residential area. Three new or improved city parks will enhance the town at Laie Point, Kokololio Park and the Pounders area site. Several areas are being evaluated for much needed affordable housing which will include single family residences and apartments. A new school convenient to the chosen residential site and the expansion of BYU complete the Laie development plan.

Topographic Features

Elevations within the Laie community and adjacent agricultural lands range from sea level along the Laie Bay shoreline to roughly 120 feet above mean sea level at the mauka side of existing agricultural cultivation. Ground contours in the urbanized portion of Laie range from 0 to 10 percent while upslope agricultural lands contain a greater proportion of lands having 10 to 30 percent slopes. However, a significant portion of the mauka agricultural lands is also characterized by slopes of less than 10 percent.

Climate

The community of Laie is exposed to a warm, tropical environment. Ambient temperatures throughout the year have historically ranged from a low of approximately 50 degrees Fahrenheit to a record high temperature of 92 degrees Fahrenheit. However, a more normal ambient range typically averages from 71 to 79 degrees (State Department of Land and Natural Resources, Division of Water and Land Development, 1976).

Annual rainfall patterns are more variable and more indicative of the nominal seasonal changes which occur throughout the year. The variation of rainfall throughout the year suggests a 5-month "summer" season and a 7-month "winter" season. The summer season, from May through September, is a higher sun period that includes slightly warmer temperatures and more consistent northeasterly tradewinds. In contrast, the winter season is characterized by somewhat cooler temperatures, greater storm-generated rainfall, and less frequent tradewinds (Giambelluca, Nullet, and Schroeder, 1986). Total average annual rainfall is 58.4 inches.

EXISTING WASTEWATER INFRASTRUCTURE

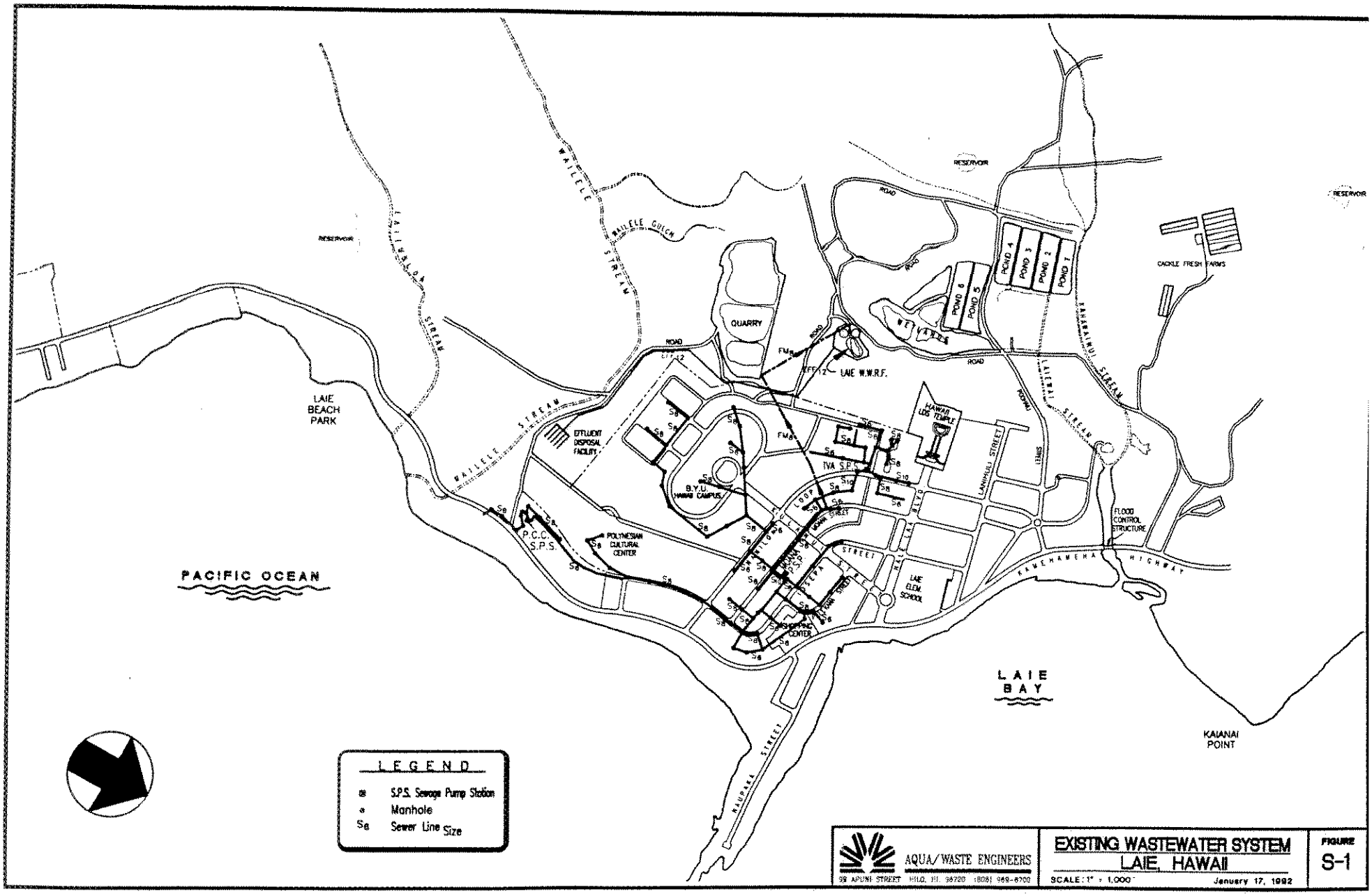
The Laie community wastewater system is owned and operated by Zion's Securities Corporation.

Collection System

The existing collection system (Figure 1) presently serves the Hawaii Temple, the entire BYUH campus, Polynesian Cultural Center, Laniloa Lodge, Chevron, McDonalds, and other commercial facilities in the Laie Shopping Center. Residential connections to the collection system include on-campus housing at BYUH campus and portions of the New Laie residential area. More specifically, residential connections include the following:

26 on-campus homes for faculty and administrative personnel at BYUH;
250 on-campus apartments at the Temple View Apartments complex;
6 on-campus dormitories for unmarried students;
55 off-campus faculty residences owned by BYUH; and
128 privately-owned homes in the New Laie residential area
(Stone, 1989; Whetten, 1991; and Au, 1991).

Old Laie, Laniloa, and other residential areas makai (seaward) of Kamehameha Highway are presently not incorporated within the existing service area. Available information indicates that roughly 800 housing units in Laie are not connected to the existing collection system. Unsewered commercial facilities in Laie include Cackle Fresh Farms poultry



PACIFIC OCEAN
LAIE BEACH PARK
LAIE BAY
KAIANAI POINT
KAMEHAMEHA HIGHWAY
LAIEWAI STREAM
KAHAWAINUI STREAM
WAILELE STREAM
WAILELE GULCH
LAIIWALOA STREAM
RESERVOIR
QUARRY
LAIE W.W.R.F.
EFFLUENT DISPOSAL FACILITY
B.Y.U. HAWAII CAMPUS
P.C.C. S.P.S.
POLYNESIAN CULTURAL CENTER
IVA S.P.S.
HAWAII LDS TEMPLE
LAIE ELEM. SCHOOL
SHOPPING CENTER
FLOOD CONTROL STRUCTURE
CACKLE FRESH FARMS
POND 1
POND 2
POND 3
POND 4
POND 5
POND 6
WETLANDS
LANIHULI STREET
KAUPAKA STREET
LEGEND
S.P.S. Sewage Pump Station
Manhole
Sewer Line Size
AQUA/WASTE ENGINEERS
99 APUNI STREET HILO, HI. 96720 (808) 969-6700
EXISTING WASTEWATER SYSTEM
LAIE, HAWAII
SCALE: 1" = 1,000'
January 17, 1992
FIGURE
S-1

production facilities and its smaller retail sales facility along Kamehameha Highway.

Roughly 28,500 lineal feet of sewer line collect existing wastewater flows from sewered institutional, commercial and residential areas (Figure 1). Existing collection lines are, for the most part, the original sewer pipe installed in the late 1950's and early 1960's. Sewer laterals are typically four-inch cast iron pipe (Gray, Hong, Bill & Associates, 1989). The larger, gravity sewer lines ranging from six to eight inches in diameter, are primarily transite pipe (Austin Smith and Associates, 1976). Manholes are located at intervals of approximately 300 feet along the entire course of the collection system.

Since the topography of New Laie is relatively flat, existing flows are transported to the Moana pump station via two pump stations. One pump station is situated in the vicinity of Temple View Apartments; the second pump station is located southeast of the Polynesian Cultural Center. The Moana pump station carries cumulative flows to the Laie treatment plant which is upslope of Temple View Apartments complex at about 60 feet above mean sea level.

Treatment Plant

The existing treatment plant is an extended aeration facility that is designed to treat average wastewater flows of approximately 0.5 mgd. The treatment process installed for the plant is capable of achieving an effluent quality of "30-30" BOD and suspended solids.

This facility consists of headworks equipment that uses a Chicago pump barminutor in one channel and a bypass channel with a bar trash rack. Wastewater flows split to two separate treatment units which include an aeration chamber, settling tank, aerobic digester and a chlorine contact tank (Gray, Hong, Bills and Associates, 1989).

Treated effluent from the treatment plant is initially discharged to a 1.0 mgd effluent "polishing" pond. Theoretically, this added detention of the effluent provides additional time for solids to settle which, ultimately, provides a more advanced level of secondary treatment. During the higher flow conditions, the "polishing pond" is actually being used to temporarily hold incoming influent until the plant is capable of treating the higher volumes of flow.

The existing treatment plant is, at the time of this report, undergoing interim modifications that are aimed at eliminating the present effluent discharge to the marsh mauka of the existing plant. The interim plant modifications are to include installation or construction of the following:

- influent rotary fine screen at the existing headworks structure that will replace an older bar screen;
- an effluent junction box control structure that will permit bypass of the pond for rehabilitation;

- an effluent tertiary filtration complex;
- an effluent transmission line;
- an effluent subsurface drain field;
- a Somat solids dewatering unit;
- rebuilt sludge drying beds;
- a replacement emergency generator capable of carrying the electrical load of 1.5 mgd plant;

- upgraded chlorination facilities;
- an access road and security fencing; and
- related site preparation.

Effluent Disposal

Treated effluent from the "polishing" pond is discharged to a 12-inch line which carries effluent to an open wetland pond mauka of the present wastewater treatment plant complex.

However, the ongoing installation of tertiary filters and a subsurface effluent disposal facility southeast of the existing plant will soon eliminate all effluent discharges into the open wetland pond and adjoining stream areas.

PROJECTED WASTEWATER QUANTITY AND CHARACTERISTICS

Wastewater Quantity

An important aspect of future wastewater planning for Laie is the forecasting of anticipated resident population. The use of estimated resident population and per capita waste generation rate information is frequently used as a basis for determining an estimated average daily flow from domestic wastewater sources. The use of these forecasts, and their relationship to estimates of future wastewater flow from other sources, is discussed more fully in section 4.1 of the Laie Wastewater Facilities Plan/EIS.

In the preparation of resident population forecasts, various assumptions were made concerning future population characteristics and potential land use development in Laie on the basis of available information. Subsequently, these assumptions were used in order to formulate three longer-term population growth scenarios, i.e., "low", "moderate", and "high", for the Laie community. Each of the growth/development scenarios, is presented in Tables 2-19 through Table 2-21 of the Laie Wastewater Facilities Plan/EIS , and represents a combination of assumptions concerning future population growth and land use development during the next 20 years.

The three alternate forecasts of future community population to the year 2010, and their related growth/development scenarios, ultimately suggest a very conservative range of future population growth in Laie, and the type of land use development that might occur. The lands mauka of the existing urbanized area of Laie could accommodate a significant expansion in residential development, e.g. 1,500 single family homes and/or townhouses. However, the present attitudes and preferences of the Laie community and Zion Securities Corporation diminish the likelihood of a "high" development scenario which would encourage increased land development to this extent.

For this reason, a more realistic variable level in future community growth is expected to be derived from the gradual growth in the BYUH campus where their is considerable demand for increased student enrollment and on-campus housing. Concurrently, there is also is a clear demand for more affordable housing that can meet the needs of both young and incoming families, as well as over-crowded households, in Laie.

With this perspective, the anticipated population in Laie is expected to range from roughly 8,900 to 12,200 persons by the year 2010 based on the information developed in the Laie Wastewater Facilities Plan/EIS and presented here in Table 1 on page 6. However, the "moderate" growth/development scenario assumptions, Table 2 on page 8, are believed to represent the more realistic forecast in light of the existing residential development plans of Zion Securities Corporation and BYUH. Further, it is believed that the majority of the community may eventually demonstrate support for increased residential development, particularly if homes are priced at more affordable level.

'LE 1
ALTERNATE FO ..CASTS OF RE POPULATION GROWTH IN LAIE
-2010
(NUMBER OF PERSONS)

	Base Year	Low Growth Scenario	Moderate Growth Scenario	High Growth Scenario
1990				
Laie Residents/BYUH Faculty	4,096			
Single Students	1,075			
Married Students & Dependents	792			
Total	5,963			
1995				
Laie Residents/BYUH Faculty		4,567	6,381	6,381
Single Students		1,187	1,187	1,187
Married Students & Dependents		1,090	1,090	1,090
Total		6,844	8,658	8,658
2000				
Laie Residents/BYUH Faculty		5,043	7,045	7,045
Single Students		1,310	1,310	1,444
Married Students & Dependents		1,204	1,204	1,327
Total		7,557	9,559	
9,816				
2005				
Laie Residents/BYUH Faculty		5,568	7,779	7,779
Single Students		1,447	1,447	1,757
Married Students & Dependents		1,329	1,329	1,614
Total		8,344	10,555	11,150
2010				
Laie Residents/BYUH Faculty		6,147	8,588	8,588
Single Students		1,597	1,597	1,940
Married Students & Dependents		1,468	1,468	1,782
Total		9,212	11,653	12,310

Notes:

1. Laie refers to Laie residents, BYUH faculty and their dependents.

2. Base year estimates of population based upon U.S. Census of 1990 block statistics and 1991 married student housing information.

Source: James Pedersen, Planning Consultant, 1991

'BLE 2

MODERATE GROWTH/DE\ 'MENT SCENARIO ASSUMPTIONS

LAI ·MMUNITY

)-2010

Resident Population:

1. A significant increase will occur in the year 1995 with the addition of 450 new families. The existing population will increase at a rate of 2% over the entire forecast period. This growth rate parallels the annual rate of growth in the Laie area from 1980 to 1990.

2. Average household size will continue at the present rate of 4.03 persons per household.

3. The enrollment at BYUH will increase to roughly 3,600 students in the year 2000 and grow to an enrollment of 4,400 students by the year 2010. 70 percent of the future student population will live on-campus; the remaining students will reside in homes situated in the Laie area or other locations outside of Laie.

Land Use Development:

1. No significant residential development expansion will occur within existing residential areas. Some limited rezoning and home remodeling will occur which will generate a nominal increase in overall residential densities.

2. Additional housing will be constructed adjacent to the Hawaii Temple to provide accommodations for additional missionary support and visiting church members from neighboring Hawaiian Islands.

3. 450 single family homes will be constructed and fully occupied by the year 1995. The homes will be located on undeveloped lands presently owned by Zion Securities Corporation.

4. In terms of commercial development, the Laie Village Shopping Center expansion will be completed. The annual number of visitors at PCC will not exceed 1.5 million even though a greater number of attractions will be developed.

5. Resort expansion will include the expansion of the Laniloa Lodge to become a 150-room facility.

6. The BYUH campus area will be expanded within its existing property to accommodate more on-campus housing for both married students, faculty and their dependents. This expansion will include the construction and occupancy of 36 3-bedroom apartments for larger married student families, and nine more townhouses for faculty members and their dependents, by 1995. Other on-campus development will include construction of a new auxiliary services building and a new fine arts/museum/classroom building, as well as expansion of the existing library.

7. Water and sewer systems will be expanded to meet the flow requirements generated by anticipated residential, institutional, commercial, and resort development.

Source: James Pedersen, Planning Consultant, 1991

Data obtained for 1990 suggests that average wastewater flows to the plant range from roughly 0.365 mgd during the month of August to about 0.465 mgd in the March. Wastewater flows in Laie are clearly influenced by the presence of more students during the school year between September and May.

However, the variability appears to be more driven by potentially higher rates of inflow to the collection system during the wet season. Following a February 5, 1987 inspection of the Laie WWTP, the State Department of Health representatives cited the plant operator for exceeding its design flow of 0.5 mgd and having a higher infiltration rate of 10,000 to 140,000 gallons per day (Gray, Hong, Bills and Associates, 1989). In its own subsequent 1989 study of inflow and infiltration, Gray, Hong, Bill & Associates concluded that: ***"Inflow (to the system) is directly caused by rainfall events over 100 mm (over four inches) and increases the average daily flows (to the plant) from 50 to 70%".***

Anticipated wastewater flows to the year 2010 have been prepared for the Facilities Plan. A range of anticipated wastewater flows was calculated. Forecasts were developed for three sets of anticipated design average flows for three possible population growth/land development scenarios, as well as a modified "moderate" growth scenario combined with aggressive water conservation efforts. The assumptions used for the "low", "moderate" and "high" growth scenarios are identical to the population and land development assumptions used for the population forecasts. Anticipated population and land development trends made for this plan were subsequently applied to other local design flow standards relating to per capita and facility waste generation rates. In addition, local standards for residential waste generation rates were correlated with water consumption in selected residential areas in New Laie.

The assumptions used for the forecasts of average design flows is based upon estimates of existing wastewater generation from residential, institutional, commercial and resort sources.

The calculation of anticipated average design flows to the year 2010 suggests a total influent to the proposed treatment plant ranging from 1.119 to 1.356 million gallons per day. While there is always uncertainty regarding future population growth and the level of related land development, it is believed that the "moderate" growth scenario represents the most probable set of assumptions relating to future population growth and land development in Laie. In addition, the assumptions used in the moderate growth/development scenario are felt to most closely reflect the combined desires of the general community and corporate land interests.

Table 3 on the following page presents the average design flows for the moderate growth scenario which exceeds the growth of the DP amendments.

TABLE 3
ANTICIPATED AVERAGE DESIGN FLOWS
LAIE WASTEWATER SYSTEM
1990 TO 2010
MODERATE GROWTH DEVELOPMENT SCENARIO
(Million Gallons Per Day)

	1990	1995	2000	2005	2010
RESIDENTIAL					
Laie Residents/ BYUH Faculty	0.328	0.511	0.564	0.622	0.687
INSTITUTIONAL					
BYUH Single Students	0.086	0.095	0.105	0.116	0.128
BYUH Married Students & Dependents	0.063	0.087	0.096	0.106	0.117
Hawaii Temple	0.040	0.057	0.057	0.057	0.057
Stake Houses	0.004	0.004	0.004	0.004	0.004
COMMERCIAL					
PCC	0.100	0.110	0.120	0.140	0.160
Other Commercial	0.018	0.018	0.018	0.018	0.018
RESORT					
Laniloa Lodge	0.003	0.009	0.009	0.009	0.009
SUBTOTAL	0.642	0.891	0.973	1.072	1.180
INFILTRATION @ 10%	0.064	0.089	0.097	0.107	0.118
TOTAL	0.706	0.980	1.070	1.179	1.298

Sources: James Pedersen, Planning Consultant, 1991; and Aqua/Waste Engineers, Inc., 1991.

Wastewater Characteristics

Wastewater flows incoming to the plant are from institutional, commercial, and residential sources. The nature of activities associated with these types of facilities and land uses generates, almost exclusively, domestic sewage. This is generally supported by available measurements of the monthly average biological oxygen demand (BOD) ranging from 226-365 mg/l and suspended solids (SS) levels ranging from 124-204 mg/l for the plant influent in 1990.

It should be noted, however, that plant influent is occasionally characterized by the influx of a more toxic sewage effluent for shorter periods of time. These temporary "shocks" to the plant influent can sometimes not be adequately treated by the extended aeration process. Consequently, maximum effluent limitations are temporarily exceeded.

PROPOSED WASTEWATER MANAGEMENT PLAN

Wastewater Collection System

The Laie community, is only partly sewered now and will require a significant expansion of the existing gravity collection system, pump stations, and force mains to provide service to the entire community. These capital improvements are estimated at $ 4.2 million to expand the collection system to serve the presently developed areas. The proposed housing scheme alternatives would require a gravity collection system, pump station, and force main to connect to the upgraded collection system to serve present development. Costs for a collection system for the proposed housing area and school are estimated at $ 2.9 million.

Wastewater Treatment Plant

The Laie Wastewater Facilities Plan/EIS is currently in preparation and a draft is circulating for review. This plan offers six alternative treatment plant schemes at 1.5 MGD each which the community are reviewing for a final selection. From engineering evaluations done to date, it appears that one central treatment plant expanded and upgraded utilizing a Sequential Batch Reactor process, located at the existing 6.2 Acre plant site will be more cost effective and beneficial to the community than adding a second "satellite" plant near the proposed housing areas.

Effluent Characteristics

The treatment process must meet the following requirements for discharge effluent shown in Table 4.

TABLE 4
EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

Monitoring Requirements	DISCHARGE LIMITATIONS				
	kg/day (lbs/day)		Other Units (Specify)		
Effluent Characteristic	Average 30-day	Average 7-day	Average 30-day	Average 7-day	Measurement Frequency
Same Type					
Flow m^3/day (MGD)	--	--	--	--	Continuous
Biochemical Oxygen Demand (5 day) Once/Month Composite	56.8 (125)	85 (187.4)	30 mg/l	45 mg/l	
Suspended Solids Once/Month Composite	56.8 (125)	85 (187.4)	30 mg/l	45 mg/l	
Total Coliform Bacteria* Discrete	--	--	--	--	Weekly
Total Residual Chlorine Discrete	--	--	--	--	Once/Month
pH	Not less than 6.0 standard units nor greater than 9.0 standard units.				Once/Month Discrete
Phosphates Composite	--	--	--	--	Once/Month
Kjeldahl Nitrogen Composite	--	--	--	--	Once/Month

period.
** The median number shall be based on no less than 5 discrete samples.b)
The arithmetic mean values for the effluents samples of BOD and suspended solids collected in a period of 30 consecutive days shall not exceed 15 percent of the arithmetic mean of the values for the influent samples collected at approximately the same times during the same period (85 percent removal).

c) The discharge shall not cause objectionable odors at the surface of the receiving water.

d) There shall be no discharge of floating solids or visible foam in other than trace amounts.

e) Samples taken in compliance with the monitoring requirements specified above shall be taken at the following location(s): Effluent samples shall be taken downstream from the treatment works and prior to discharge to the irrigation system.

A tertiary treatment process is proposed which will normally produce a high quality effluent of 10-10 mg/l BOD and SS using sand filtration and ultraviolet disinfection. This level of treatment is acceptable for disposal above the UIC line as well as irrigation re-use.

Wastewater Collection and Treatment Safeguards

Certain special measures will be taken to safeguard public health in case of malfunctions in equipment or power failures.

Safeguards proposed for the wastewater reclamation facility (WWRF) and sewage pumping stations (SPS) are:

1. Generators Standby power will be provided to each SPS and the WWRF to provide emergency power in case of electrical power outage. Thus, pumping operations and disinfection can continue uninterrupted, therefore preventing sewage spills.

2. Wet Well Extra storage capacity will be designed into wet wells at each SPS to insure against a backup resulting in wastewater overflow, in the event of equipment failure.

3. Redundancy Parallel sets of process basins, equal in capacity, will be constructed to provide operational redundancy during periodic instances of basin/equipment maintenance. Pump stations will be equipped with dual pumps, each capable of handling the entire flow entering the station.

4. Odor Abatement The treatment processes are designed to promptly handle raw wastewater without a holding period thus minimizing the emission of odors. Also, the treatment plant site sits on a knoll facing the prevailing tradewinds and is surrounded by agricultural lands and not near any current or planned residential areas.

5. Alarms and Telemetering Alarms indicating high/low liquid level conditions, equipment malfunction, and other emergency conditions will be installed at each SPS. Visual and audio alarms will be mounted in areas routinely accessed by maintenance personnel. As far as practicable, signals will also be transferred through telephone lines by telemetry to the homes of key maintenance personnel as an additional safety measure during nonworking hours.

5. Restricted Public Access Pump stations and the treatment plant will be fenced to restrict public access. Additionally, these facilities will be landscaped of otherwise shielded from direct view.

7. Warning Signs and special Precautions Effluent reuse facilities, including piping and appurtenances, in areas subject to public access will have warning signs that irrigation water is not fit for consumption. Piping and appurtenances will be labeled to distinguish the product as reclaimed sewage effluent.

PROPOSED METHOD OF EFFLUENT DISPOSAL

Part of the interim improvements for the treatment plant include a tertiary filtration complex and subsurface drainfield for effluent disposal which have been completed and approved by the State Dept. of Health to begin effluent disposal. The drainfield has not been put into operation yet pending review and approval under the Consent Decree. The drainfield will discharge to groundwater able to percolate to the coastal surface aquifer used for agricultural irrigation. The deeper potable artesian aquifer is separated from the surface aquifer by a dense basalt cap confining the potable aquifer so that surface water contamination is highly unlikely.

The Laie Wastewater Facilities Plan/EIS proposes studying an effluent re-use plan using agricultural irrigation with the subsurface drainfield as an emergency or "back up" system. There is a considerable amount of agricultural land suitable for suitable for such use in the area. An ultra-violet disinfection system is being installed for treating effluent before re-use

or disposal.

Agricultural irrigation represents a potential use of reclaimed water if it can be delivered at a cost not exceeding its value. The feasibility of water reuse for agricultural irrigation also will depend on effluent quality and the particular type of crops growth in the area. Health regulations prohibit using wastewater on food crops that are normally consumed in a raw state, because coliform bacteria may be present.

Wastewater irrigation is generally considered to be a more appropriate source of irrigation water for crops such as sugarcane which is heat processed and kills bacteria. In recent history, however, secondary effluent in Laie was applied directly to taro plants with notable success in terms of increased growth.

Nitrogen, phosphorus, and organic carbon are present in secondary wastewater and represent good nutrient sources that are beneficial to plant growth. However, chlorides and sulfates remaining after treatment may be harmful to plants. For this reason, analysis of reclaimed wastewater is necessary.

Any analysis related to possible reclamation of water for agricultural irrigation must include a comparison of the quality of reclaimed water with standards applicable to irrigation use. Requirements for agricultural irrigation are primarily concerned with the minerals contained in the water supply, while criteria generally used to evaluate water quality include chloride, total dissolved solids, boron, and sodium. Based on the comparison of irrigation water standards with an analysis of minerals in the wastewater effluent, the reclaimed water could be classified as a good quality irrigation source.

If the quality of the reclaimed wastewater is sufficient, it can be applied directly to crops either by spraying, flooding, or use of a ridge and furrow method. The wastewater is accounted for in plant uptake, evaporation, evapotranspiration, and soil percolation.

IMPACTS OF EFFLUENT DISPOSAL

The interim proposal to dispose of effluent is by a subsurface drainfield makai of the UIC line that will percolate tertiary effluent into the groundwater of the coastal surface aquifer above the basalt cap on the potable artesian aquifer. Monitoring wells are in place and background water quality measurements have been done. A water and groundwater management plan should be developed using the monitoring results as input.

The Laie Wastewater Reclamation Facility has the first of its kind, unique drainfield filtration technology that exceeds the requirements of advanced tertiary treatment of wastewater and leaves the water even cleaner than the tertiary filtered and ultraviolet disinfected water that will be delivered to it. This $500,000 infiltration field allows the water

to be absorbed naturally back into the ground. After this field filtration, the water is of the same quality as when it was pumped out of the ground water as drinking water. However, Zions has chosen to locate the infiltration field makai of the Board of Water Supply's Drinking Water Line away from Laie's drinking water supply.

Also twelve groundwater monitoring wells have been installed and tested in key areas in and around the Laie community. These monitoring wells, which were required by the State Department of Health in order to gain valuable data from the infiltration field, will be sampled twice a month to ensure that the water going into the infiltration field is performing as expected. The cost of the wells and first six months of monitoring is over $100,000.

For re-use, drip and row irrigation are proposed to minimize aerosol concerns on non-contact crops such as coconuts and sugar cane. An ongoing program will sample the monitoring wells and surface waters.

PROPOSED METHOD OF SLUDGE DISPOSAL

The domestic nature of Laie sewage sludge from the wastewater treatment process is such that composting with green waste collected from the community has been identified in the Laie Wastewater Facilities Plan/EIS as a viable method of sludge re-use. Somat dewatering units have recently begun operation and produce an ideal sludge cake for composting.

Aerated static pile composting facilities under roof are planned along with open storage, mixing, and curing areas. Green waste will be collected from the community, shredded, and stored for mixing with primary screenings and dewatered sludge. The mixture will be placed in static aerated piles for two weeks under roof where air will be drawn into the piles via a blower suction and discharged by filtering thru aged compost to remove possible odors. After two weeks of aeration, the piles will be moved to an open slab for two weeks of curing before end use as a soil amendment.

The refurbished sand drying beds would be roofed to provide backup sludge drying capacity for abnormal conditions.

IMPACTS OF SLUDGE DISPOSAL

The goal of sludge re-use is to minimize the potential for contamination of surface waters and subsurface drinking water sources, and to prevent the creation of any public health hazards or nuisances. Beneficial utilization of sludge, such as composting, is considered secondary to public health and environmental protection. Agricultural fields using sludge compost would be closely monitored and periodic soil samples would be taken for analysis.

The Laie Wastewater Reclamation Facility has also embarked on a program to reclaim not only it's wastewater, but also it's wastewater sludge. A new mechanical sludge dewatering unit removes excess water from the sludge to make handling easier and a just delivered tub grinder shreds organic and greenwaste that is mixed with the sludge and composted. The sewage sludge composting process is still undergoing initial trials and when put fully into operation will be the first of its kind in Hawaii.

COSTS FOR ALTERNATIVE HOUSING SCHEMES

Estimated construction cost comparisons for the three alternative housing schemes are presented below. These costs include on site collection system, and pump station plus the cost of force mains to connect to the WWRF via the existing collection system.

A. Egg Farm	$ 1,700,000
B. BYU Mauka	$ 1,100,000
C. Laiemalo'o	$ 1,300,000

APPENDIX D

Laie Master Plan EIS

WATER SUPPLY REPORT

Laie, Oahu, Hawaii

January 8, 1992

Aqua/Waste Engineers
P.O. Box 1686, Kailua Kona, HI 96745
(808) 329-8266 Fax (808) 326-7767

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1 EXISTING WATER SYSTEM

INTRODUCTION

The community of Laie is preparing a Master Plan intended to lay out a course for accommodating future growth and change in Laie that will have a broad base of support in the community. For planning purposes various land uses have been identified including: residential, commercial, resort, public, schools, and industrial. The infrastructure upgrades to support the development include the necessary roads, drainage structures, water and sewer lines, electrical distribution lines and secondary roads.

Housing is a primary element of the plan and three Alternative Land Use Schemes to provide additional residential housing and a school are being studied for inclusion in the overall Master Plan. This report provides an evaluation of the water system to support the future development plans.

BACKGROUND

Proposed Project

The Laie Master Plan addresses the needs of the people and outlines the improvements necessary for growth in the community. This proposed development will result in the expansion of existing commercial areas, including the shopping center and the Polynesian Cultural Center. Light industry is being considered mauka of Hukilau Park. A new resort will be located makai of the Laniloa Lodge area providing leisure and recreational facilities for hotel guests. Among areas that will benefit the public are a community center near the Temple and another community center in a residential area. Three new or improved city parks will enhance the town at Laie Point, Kokololio Park and the Pounders area site. Several areas are being evaluated for much needed affordable housing which will include single family residences and apartments. A new school convenient to the chosen residential site and the expansion of BYU complete the Laie development plan.

Topographic Features

Elevations within the Laie community and adjacent agricultural lands range from sea level along the Laie Bay shoreline to roughly 120 feet above mean sea level at the mauka side of existing agricultural cultivation. Ground contours in the urbanized portion of Laie range from 0 to 10 percent while upslope agricultural lands contain a greater proportion of lands having 10 to 30 percent slopes. However, a significant portion of the mauka agricultural lands is also characterized by slopes of less than 10 percent.

Climate

The community of Laie is exposed to a warm, tropical environment. Ambient temperatures throughout the year have historically ranged from a low of approximately 50 degrees Fahrenheit to a record high temperature of 92 degrees Fahrenheit. However, a more normal ambient range typically averages from 71 to 79 degrees (State Department of Land and Natural Resources, Division of Water and Land Development, 1976).

Annual rainfall patterns are more variable and more indicative of the nominal seasonal changes which occur throughout the year. The variation of rainfall throughout the year suggests a 5-month "summer" dry season and a 7-month "winter" wet season. The summer season, from May through September, is a higher sun period that includes slightly warmer temperatures and more consistent northeasterly tradewinds. In contrast, the winter season is characterized by somewhat cooler temperatures, greater storm-generated rainfall, and less frequent tradewinds (Giambelluca, Nullet, and Schroeder, 1986). Total average annual rainfall is 58.4 inches.

Water Resources

A U.S. Geological Survey - Water Supply Paper 1874 by Takasaki and Valenciano dated 1969 and titled Water in the Kahuku Area, Oahu, Hawaii identifies the Laie groundwater recharge at 17 MGD. Based on a conservative estimate that at least 50% of the groundwater recharge can be developed, the estimated sustainable yield would be 8.5 MGD.

EXISTING WATER INFRASTRUCTURE

The Laie community water system is owned and operated by Zion's Securities Corporation. This system is not connected into the County Board of Water Supply (BWS). The BWS evaluated the Laie water system according to their own assessment criteria for possible operation in the future. The BWS assessment is used for relative comparison purposes in this planning document, recognizing that the BWS standards such as maximum day flow, peak hour flow, and fire flow requirements may not be the most appropriate measures for smaller communities such as Laie. Community Consultants, Inc. prepared a five year master plan dated March 1985 using the BWS standards for storage and maximum day demand. This report also looked at alternative water mains, wells, and fire hydrants similar to the BWS. Also a study by Austin-Tsutsumi updated as-builts in 1990 showing 1988 and 1990 installations of new water mains in Old Laie. A water facilities master plan should be considered for Laie that would develop suitable measures for evaluation as part of a comprehensive plan for water resource management, supply, storage, distribution, and fire protection for the existing community and a plan for future growth.

Source

The Laie potable water system is now supplied by water from two well stations: Temple well and Campus wells (Figure 1). Earlier the Child's well was also used but in recent years, water quality measurements of the Child's well have indicated levels of bacterial contamination which did not meet the State of Hawaii's Safe Drinking Water Standards and use of this well was restricted.

Some non-potable uses, mostly for irrigation are supplied by a number of wells drawing mostly from the shallow coastal aquifer.

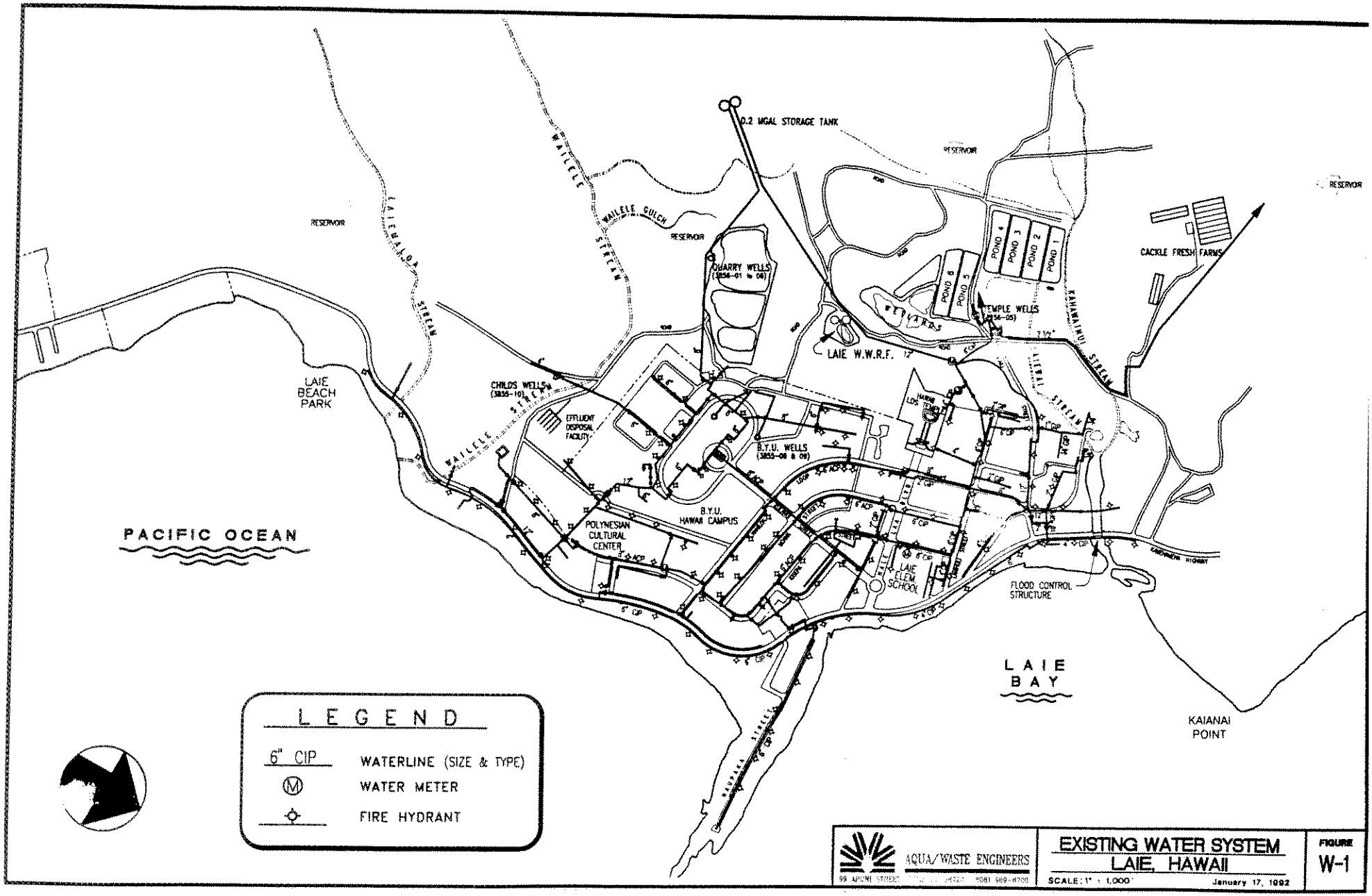
Available data (Table 1) suggests that the Temple and Campus wells presently provide a combined average daily pumpage rate of over 1,000 gallons per minute (Community Consultants, 1985; Honolulu Board of Water Supply, 1988 and 1989).

TABLE 1
AVERAGE DAILY PUMPAGE
LAIE WELL STATIONS
IN GALLONS PER MINUTE (GPM)

Well Station	Mar. 22, 1985	Dec. 28, 1988	Jan. 18, 1989
Temple	293	280	325
Campus	696	750	700

Notes: March 22, 1985 flow measurements made by Community Consultants, Inc. Flow measurements made in 1988 and 1989 were made by the Honolulu Board of Water Supply.

Source: Honolulu Board of Water Supply, 1990.



0.2 MGAL STORAGE TANK
RESERVOIR
RESERVOIR
RESERVOIR
RESERVOIR
WAILELE GULCH
WAILELE STREAM
LAIEMALOA STREAM
QUARRY WELLS
POND 6
POND 5
POND 4
POND 3
POND 2
POND 1
TEMPLE WELLS
CACKLE FRESH FARMS
KAHAWAINUI STREAM
LAIE W.W.R.F.
LAIE BEACH PARK
CHILDS WELLS
EFFLUENT DISPOSAL FACILITY
B.Y.U. WELLS
B.Y.U. HAWAII CAMPUS
POLYNESIAN CULTURAL CENTER
LAIE ELEM. SCHOOL
FLOOD CONTROL STRUCTURE
PACIFIC OCEAN
LAIE BAY
KAIANAI POINT
LEGEND
6" CIP WATERLINE (SIZE & TYPE)
WATER METER
FIRE HYDRANT
AQUA/WASTE ENGINEERS
EXISTING WATER SYSTEM
LAIE, HAWAII
SCALE: 1" = 1,000'
January 17, 1992
FIGURE
W-1

Storage

Storage of the pumped water supply is accomplished through the use of a 2.0 million gallon reservoir. This storage facility is situated mauka of the BYUH campus at approximately the 230 feet elevation (Figure 1). The current reservoir is a welded steel tank that was moved to the site and reconstructed in 1987, and replaces the original smaller tank. The floor elevation of the reservoir is approximately 229.5 feet and the overflow is at 268 feet. (Austin Smith and Associates, 1976; Honolulu Board of Water Supply, 1990).

In its Preliminary Engineering Evaluation of the Laie Water System, the Honolulu Board of Water Supply evaluated, in part, the capacity and condition of existing water storage facilities to meet their standards in the event that the system were transferred to the BWS. In this context, the Board of Water Supply concluded the following:

1. In order to meet Board of Water Supply standards, the capacity of the reservoir must meet two criteria:

   a. Meet maximum day consumption (assuming the reservoir is full at the beginning of a 24-hour period with no input to the reservoir).

   b. Meet maximum day rate plus fire flow for the duration of a fire. This criteria assumes that the reservoir is 75 percent full at the beginning of a fire, with credit given for incoming flow from pumps, and one maximum size pump is out of service.

2. "The existing 2.0 mg reservoir does not provide enough storage for the existing Laie water system. At least an additional 0.5 mg of storage capacity is needed to meet BWS (Board of Water Supply) standards for the existing water system."

3. The existing reservoir is considered substandard because no cathodic protection has been installed to protect the steel tank from corrosion. Surface rusting of the existing tank is already evident.

4. No grounding system has been installed to protect the tank from strikes by lightning.

5. There is no electrical power distribution to the reservoir site which constrains the installation of telemetry equipment and pump controls.

6. The 8-inch influent-effluent line of the reservoir should be increased to a 24-inch line.

7. All-weather vehicular access is needed to the reservoir site. In addition, a perimeter road around the reservoir should be constructed.

8. Construct a new concrete reservoir at about the 228-foot elevation. This reservoir would be in addition to the smaller proposed Laie Reservoir that the Honolulu Board of Water Supply intends to build at the 180-foot elevation. A second development option would be to build a larger 2.5 mg concrete reservoir at the 228-foot elevation.

Transmission

Installation of the present system began in 1927. This system included Old Laie and Laniloa residential areas, as well as the Hawaii Temple. Expansion of the system occurred with the development of New Laie in 1958, the development of Polynesian Cultural Center in 1962, the construction of the Laie Shopping Center in 1972, and the expansion of Polynesian Cultural Center in 1975. Today, all of urbanized Laie is served by the Laie water system (Figure 1).

The Laie system presently services the entire Laie population of almost 6,000 people; 5,963 residents were counted by the U.S. Census of 1990. Housing data obtained from the U.S. Census of 1990 indicates that the system includes roughly 1,212 residential connections that comprise single family homes and apartment units. Six dormitory units at BYUH are also part of the water distribution system. The exact number of residential connections cannot be accurately confirmed with residential meter records for 1990 since 15 percent of the residential meters are connected to two or more housing units.

All institutional, resort and commercial facilities are also connected to Laie's water system. These connections include the Polynesian Cultural Center, BYUH, the Hawaii Temple, Laniloa Lodge, McDonald's, and several commercial enterprises in Laie Shopping Center.

The present distribution system includes almost 63,000 lineal feet of transmission pipe. Because of the age of the distribution system and its related incremental development, the size and type of transmission pipe used in the system varies considerably (Table 2).

TABLE 2
SIZE OF WATER DISTRIBUTION MAINS
LAIE WATER SYSTEM

Diameter (inches)	Lineal Feet
4 or less	13,960
6	32,285
8	13,524
12	2,967
Total	62,737

Source: Honolulu Board of Water Supply, 1990

Old Laie area contains a combination of galvanized iron pipe, cast iron pipe and some recently installed ductile iron pipe. Cast iron pipe has been used exclusively for the Laniloa residential area and adjacent residential areas makai of Kamehameha Highway. In contrast, the distribution system in New Laie is comprised almost entirely with asbestos cement pipe.

In order to evaluate the size of existing distribution lines and the capacity of the existing distribution system according to their standards, the Honolulu Board of Water Supply used a computer simulation model of the present distribution network. One of the assumptions used was that the distribution system serves a population of 5,000 residents (present population is about 6,000 residents).

Information gained from the modeling study included the following conclusions, based upon the BWS standards which may not be appropriate depending upon standards developed for Laie in a water facilities master plan:

1. The present system accommodates average day demand fairly well.

2. The reservoir's spillway elevation at 268 feet above mean sea level causes distribution system pressures to be about 100 psi.

3. "Maximum day conditions (1.5 x average day) are handled marginally by the existing system. Low pressure problems are becoming evident in the areas along Kam Highway and Laie Point."

4. The existing system cannot accommodate peak hour conditions (3.0 x average day) as numerous portions of the system experience negative system pressures. However, peak hour conditions are infrequent.

5. Fire flows cannot be adequately provided by the existing system. "The lack of fire protection is due to small distribution main sizes (major distribution main is a 6-inch pipe) and a small reservoir influent-effluent main. It is also due to the lack of a grid of larger distribution mains, such as 12 or 16-inch pipelines."

6. The distribution system improvements needed to meet the Board of Water Supply standards for maximum day, peak hour and maximum day with fire flow are summarized in Table 3 for comparison. A water facilities master plan should be developed for Laie using appropriate standards for the community to identify distribution improvements.

TABLE 3
PROPOSED WATER DISTRIBUTION SYSTEM IMPROVEMENTS
LAIE WATER SYSTEM
BY HONOLULU BOARD OF WATER SUPPLY

MAJOR TRANSMISSION AND DISTRIBUTION SYSTEM PROJECTS

Poohaili Street 24-inch Main (from proposed Laie 228 reservoir to Temple Well)
Poohaili Street 16-inch Main (Temple Well to Kam Highway)
Kam Highway 16-inch Main (Poohaili Street to Wailele Stream)
Kam Highway 16 inch Main (Wailele Stream to Hauula 180 reservoir)
Kulanui Street 12-inch Main (replaces 8-inch, Naniloa Loop to BYUH campus)
Anemoku Street 8-inch Main (Kam Highway to Naupaka Street)
Naupaka Street 8-inch Main (replaces 6-inch, end to Laie Point)
Fire Hydrant Installations: Approximately 65 additional fire hydrants are needed at various locations in Laie.

SUBSTANDARD MAIN REPLACEMENT PROJECTS

Kam Highway 8-inch Main (City and County Yard to Poohaili Street)
Cul-de-sac 8-inch Main (off Kam Highway near Anemoku Street)
Naniloa Loop 8-inch Main (Kam Highway to Puuahi Street)
Iosepa Street 8-inch Main (Lanihuli Street to Naniloa Loop)
Moana Street 8-inch Main (Iosepa Street to Lanihuli Street)
Palekana Street 8-inch Main (Kulanui Street to Iosepa Street)
Puuahi Street 8-inch Main (Kam Highway to Naniloa Loop)
Kulanui Street 8-inch Main (Puuahi Street to Iosepa Street)
Lanihuli Street 8-inch Main (Kam Highway to 6-inch CIP)
Loala Street 8-inch Main (Wahinepee Street to Lanihuli Street)
Wahinepee Street 8-inch Main (Kam Highway to 2-inch GIP)

OTHER

1. Remove all pressure relief valves along Kam Highway.
2. Transfer service connections along Poohaili Street, Kam Highway and Naupaka Street to the new mains.
3. The Laie WWTP should be placed on its own booster and hydropneumatic tank system with an appropriate backflow prevention device.
4. Install additional distribution system valves at various locations.

Source: Honolulu Board of Water Supply, 1990

PROJECTED WATER DEMAND

Potable Water

An important aspect of future water planning for Laie is the forecasting of anticipated resident population. The use of estimated resident population and water consumption information is used as the basis for determining an estimated average daily water consumption.

In the preparation of resident population forecasts, various assumptions were made concerning future population characteristics and potential land use development in Laie on the basis of available information. Subsequently, these assumptions were used in order to formulate three longer-term population growth scenarios, i.e., "low", "moderate", and "high", for the Laie community. Each of the growth/development scenarios, is presented in Tables 2-19 through Table 2-21 of the Laie Wastewater Facilities Plan/EIS , and represents a combination of assumptions concerning future population growth and land use development during the next 20 years.

The three alternate forecasts of future community population to the year 2010, and their related growth/development scenarios, ultimately suggest a very conservative range of future population growth in Laie, and the type of land use development that might occur. The lands mauka of the existing urbanized area of Laie could accommodate a significant expansion in residential development, e.g. 1,500 single family homes and/or townhouses. However, the present attitudes and preferences of the Laie community and Zion Securities Corporation diminish the likelihood of a "high" development scenario which would encourage increased land development to this extent.

For this reason, a more realistic variable level in future community growth is expected to be derived from the gradual growth in the BYUH campus where their is considerable demand for increased student enrollment and on-campus housing. Concurrently, there is also is a clear demand for more affordable housing that can meet the needs of both young and incoming families, as well as over-crowded households, in Laie.

With this perspective, the anticipated population in Laie is expected to range from roughly 8,900 to 12,200 persons by the year 2010 based on the information developed in the Laie Wastewater Facilities Plan/EIS and presented here in Table 4 on page 9. However, the "moderate" growth/development scenario assumptions, Table 5 on page 11, are believed to represent the more realistic forecast in light of the existing residential development plans of Zion Securities Corporation and BYUH. Further, it is believed that the majority of the community may eventually demonstrate support for increased residential development, particularly if homes are priced at more affordable level.

TABLE 4
ALTERNATE FORECASTS OF FUTURE POPULATION GROWTH IN LAIE
1990-2010
(NUMBER OF PERSONS)

	Base Year	Low Growth Scenario	Moderate Growth Scenario	High Growth Scenario
1990				
Laie Residents/BYUH Faculty	4,096			
Single Students	1,075			
Married Students & Dependents	792			
Total	5,963			
1995				
Laie Residents/BYUH Faculty		4,567	6,381	6,381
Single Students		1,187	1,187	1,187
Married Students & Dependents		1,090	1,090	1,090
Total		6,844	8,658	8,658
2000				
Laie Residents/BYUH Faculty		5,043	7,045	7,045
Single Students		1,310	1,310	1,444
Married Students & Dependents		1,204	1,204	1,327
Total		7,557	9,559	
9,816				
2005				
Laie Residents/BYUH Faculty		5,568	7,779	7,779
Single Students		1,447	1,447	1,757
Married Students & Dependents		1,329	1,329	1,614
Total		8,344	10,555	11,150
2010				
Laie Residents/BYUH Faculty		6,147	8,588	8,588
Single Students		1,597	1,597	1,940
Married Students & Dependents		1,468	1,468	1,782
Total		9,212	11,653	12,310

Notes:

1. Laie refers to Laie residents, BYUH faculty and their dependents.

2. Base year estimates of population based upon U.S. Census of 1990 block statistics and 1991 married student housing information.

Source: James Pedersen, Planning Consultant, 1991

TABLE 5
MODERATE GROWTH/DEVELOPMENT SCENARIO ASSUMPTIONS
LAIE COMMUNITY
1990-2010

Resident Population:

1. A significant increase will occur in the year 1995 with the addition of 450 new families. The existing population will increase at a rate of 2% over the entire forecast period. This growth rate parallels the annual rate of growth in the Laie area from 1980 to 1990.

2. Average household size will continue at the present rate of 4.03 persons per household.

3. The enrollment at BYUH will increase to roughly 3,600 students in the year 2000 and grow to an enrollment of 4,400 students by the year 2010. 70 percent of the future student population will live on-campus; the remaining students will reside in homes situated in the Laie area or other locations outside of Laie.

Land Use Development:

1. No significant residential development expansion will occur within existing residential areas. Some limited rezoning and home remodeling will occur which will generate a nominal increase in overall residential densities.

2. Additional housing will be constructed adjacent to the Hawaii Temple to provide accommodations for additional missionary support and visiting church members from neighboring Hawaiian Islands.

3. 450 single family homes will be constructed and fully occupied by the year 1995. The homes will be located on undeveloped lands presently owned by Zion Securities Corporation.

4. In terms of commercial development, the Laie Village Shopping Center expansion will be completed. The annual number of visitors at PCC will not exceed 1.5 million even though a greater number of attractions will be developed.

5. Resort expansion will include the expansion of the Laniloa Lodge to become a 150-room facility.

6. The BYUH campus area will be expanded within its existing property to accommodate more on-campus housing for both married students, faculty and their dependents. This expansion will include the construction and occupancy of 36 3-bedroom apartments for larger married student families, and nine more townhouses for faculty members and their dependents, by 1995. Other on-campus development will include construction of a new auxiliary services building and a new fine arts/museum/classroom building, as well as expansion of the existing library.

7. Water and sewer systems will be expanded to meet the flow requirements generated by anticipated residential, institutional, commercial, and resort development.

Source: James Pedersen, Planning Consultant, 1991

Using the Moderate Growth scenario thru 2010 (Table 4) anticipated by the Facility Plan for residential, institutional, and commercial usage at 100 gpd/capita and resort and public usage based upon the acreage projections of the Moderate Growth scenario would add approximately 690,000 gpd of water consumption to the current system demand. The DP Amendments would be 300,000 gpd of the 690,000 gpd total. Because the Moderate Growth scenario involves land use changes that do not affect water usage, there is no change or additional water usage for the Institutional, Resort, or Public areas. The DP Amendment for Rsidential assumes 500 gpd for the 450 residential units.

	Moderate Growth		DP Amendments	
Residential	448,750	gpd	225,000	gpd
Commercial & Industrial	75,000	gpd	75,000	gpd
Institutional	141,250	gpd	0	gpd
Resort	20,000	gpd	0	gpd
Public	5,000	gpd	0	gpd
Total	690,000	gpd	300,000	gpd

Current residential water consumption is estimated at 600,000 gpd and combined commercial, resort, and public use is estimated at 330,000 gpd. BYUH water is unmetered so a good estimate of institutional usage is based on wastewater flows. However, indications that the system can only marginally handle the current maximum day demand suggest that total current consumption on the Laie water system is about 1.5 mgd. This agrees with the pumping records of Table 1. Agricultural figures from Zions Securities indicate a usage of approximately 2.4 mgd.

Therefore, projected total water supply needs for the Laie system under this growth plan would be approximately 4.6 mgd based on an average water demand.

Fire Demand

The BWS Water System Standards require the following fire flow rate for the various land uses:

	flow rate(gpm)	duration(hours)
Non-residential: (commercial, resort, institutional, public)	2000	2
Residential:	1000	1

The water distribution system and the storage reservoir would have to be upgraded to deliver the fire flow rates prescribed by the BWS Water System Standards. A water facilities master plan should be developed for Laie and include an evaluation of fire protection based upon appropriate standards for the size and nature of the community.

PROPOSED DEVELOPMENT

Potable Water System

The proposed DP amendments anticipated thru 2010 will have to expand on the presently marginal water system regardless of the alternative housing scheme chosen. A water facilities master plan should be undertaken to plan and refine in detail the following facilities improvements:

Supply: An additional source capable of delivering 300,000 gpd and pumping at least 240 gpm will be needed to adequately meet the potable water requirements of the proposed DP Amendments. (Based on pumping rates from the existing well sources, additional well source locations would be required - 1 duty and 1 standby.)

For the additional wells, application to construct the wells must be made before the Commission on Water Resource Management of the State Department of Land and Natural Resources. No adjudications or entitlements have been established for this water source since the extent of the reserve (i.e. safeyield) has never been determined.

Storage: To meet growth plus the current 0.5 MG storage deficit, additional storage capacity, totaling 1.5 MG and transmission mains should be provided. Storage tank siting and line sizing should be determined by computer analysis as part of a water master plan.

Distribution:

1. New distribution lines will be needed for each proposed housing/school area.

2. The transmission capacity from the current 2.0 MG reservoir will have to be increased to handle peak demands plus fire flow as previously discussed. There is a well south of the Childs well site that could be fitted with a pump to provide 300 gpm for standby or emergency use.

3. The main distribution arterials within the current distribution system will have to be upgraded to handle peak demands plus fire flow as identified in Table 3.

4. Approximately 65 additional fire hydrants are needed in the Laie area to meet fire protection guidelines.

POTENTIAL IMPACTS AND MITIGATION

Short-Term Impacts

Short term impacts are construction related and may include dust, noise, and traffic disturbances in the community due to installation of water lines. Mitigation of these nuisances can be accomplished by limiting construction to weekdays during working hours when many residents are not at home; use of watering to reduce dust; and observance of approved traffic control plans.

Long-Term Impacts

Impact on the Aquifer

The sustainable yield on this aquifer as discussed earlier is estimated at 8.5 MGD. Actual potable water use for the Laie water system is about 1.5 MGD, however there may be other private users. The BWS is constructing a 1 MGD well at Laie for their system that is not on line yet. The Polynesian Cultural Center utilizes a well to supply water to its ponds and canals. It is believed that they use in excess of 1 MGD based on the overflow from the canals to the storm drain. Based on available information, it appears that the Laie area aquifers have available capacity for extensive additional development in Laie or for water export to other areas of Oahu. In addition, to preserve future potable water resources, Zions Securities Corp. will be conducting a water reuse study to determine the economics of utilizing the tertiary treated wastewater effluent for irrigation and other uses.

Impact on Existing Water Users

Existing water consumers on the Laie system currently experience low pressure problems during peak demand periods due to inadequately sized lines. Additional users will exacerbate this problem unless upgrading is done. Also, fire flows are restricted in some areas due to undersized lines. Guidelines for upgrading the water system have been discussed in this report and should be followed up with an in depth engineering study and water master plan to guide development.

COSTS FOR ALTERNATIVE HOUSING SCHEMES

Estimated construction cost comparisons for the three alternative housing schemes are presented below. These costs include additional supply, storage, and transmission costs to the housing area as well as the on site distribution system and fire protection.

A. Egg Farm	$ 1,600,000
B. BYU Mauka	$ 950,000
C. Laiemalo'o	$ 1,300,000

APPENDIX E

GROUNDWATER RESOURCES SUMMARY
Laie Master Plan
Koolauloa, Oahu

Prepared for
Group 70 International, Inc.

Prepared by
Water Resource Associates

Honolulu, Hawaii
February 1992

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GROUNDWATER RESOURCES SUMMARY

INTRODUCTION

Zion Securities Corporation is proposing various land use changes for its land at Laie in the Koolauloa District in northeast Oahu. These changes are embraced in the Laie Development Plan covering 214 to 220 acres. Affordable housing is a major part of the development plan.

The purpose of this report is to summarize the occurrence and availability of ground water in the area and relate them to the project's water needs and potential impact on groundwater resources in the area.

REGIONAL HYDROLOGY

Koolauloa Aquifer System

The project site lies within the Koolauloa Aquifer System (Water Resources Protection Plan, 1990) which comprises the windward section of northeast Oahu from Punaluu Stream to Kahuku Point and bounded on the interior by the crest of the Koolau Range. The Aquifer System covers an area of 32.5 square miles and includes an interior high-level, dike-confined aquifer (Koolauloa High-Level Aquifer) situated beneath the Koolau crest within the northwest-trending dike zone of Koolau volcano and a coastal basal aquifer (Koolauloa Basal Aquifer) which lies seaward of the high-level aquifer. The Koolau crest serves as the interior boundary of the Aquifer System because the crest is a topographic divide which approximates an undetermined hydrologic divide in the central portion of the dike zone.

Rainfall and Streamflow

The greatest rainfall on all of Oahu occurs in the southern part of the aquifer system above the Koolau crest. Due largely to its orographic origin, rainfall is most abundant in the interior areas and more or less coincident with the topography. It decreases from a high of about 250 inches a year at Punaluu to about 40 inches a year in the coastal area from Laie to Kahuku Point. In rainfall areas greater than 100 inches, streams in their upper reaches have perennial low flows fed by high-level, dike-confined aquifers. Within and down-gradient of the dike zone, these streams gradually lose their flow in permeable basalts and flow intermittently during stormy periods.

Groundwater Occurrence

Groundwater occurrence and recharge are greatly influenced by three major geologic features in the region--the semi-permeable dike-intruded basalts of the northwest-trending zone; the impermeable coastal plain deposits, collectively called the "caprock" and the permeable dike-free basalts located between the two (see Figure 1).

Ground water (sometimes referred to as "dike water") in the dike zone which is roughly 2½ miles wide and 10 miles long occur at high levels in the southern part of the Koolauloa aquifer system due to a high rainfall of 80 to 250 inches a year. The elevations of the dike water reflect the amount of rainfall and, in turn, the amount of groundwater recharge. Consequently, water levels in the dike zone probably diminishes from about 1000 feet at Kaluanui to about 10 feet along the north coast at Kawela, indicating a gradient of about 100 feet per mile. Ground water on either side of the dike zone occurs as basal water in dike-free basalts. Based upon other similar areas, the dike water levels probably drop rapidly in step-like fashion, perpendicular to the dike trend and drops sharply to a water or piezometric surface elevation in the basal aquifer 20 feet or more above sea level.

Ground water moves from areas of high rainfall beneath the Koolau crest, toward the windward coast between Punaluu and Kahuku and northerly toward the coast between Kawela and Kahuku. Dike water also moves parallel to the dike trend

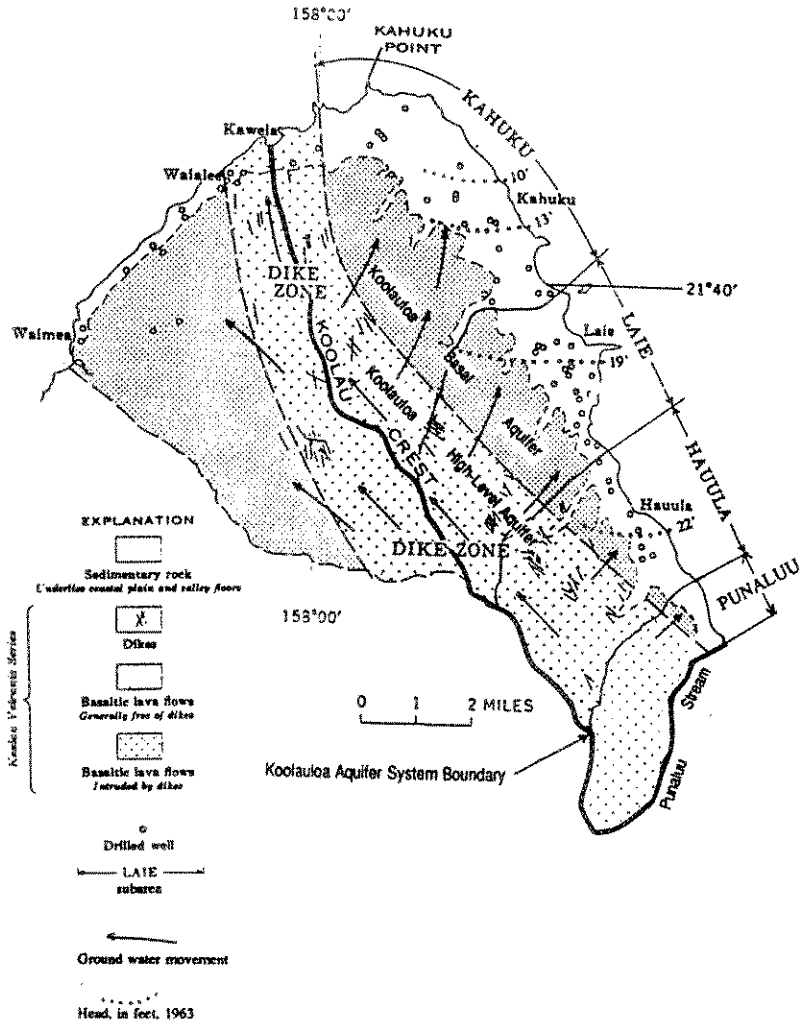

Figure 1. Generalized Geohydrology of the Koolauloa Aquifer System (Modified after Takasaki and Valenciano, 1969)

within the dike zone toward Kawela. Plausibly, the bulk of dike water moves into the basal aquifers on either side of the zone where less rainfall occurs. In the Koolauloa basal aquifer, the coastal caprock protects the basal aquifer from salt water intrusion and enhances the movement of ground water along the coast toward Kahuku, rather than directly to the sea underneath the offshore portion of the caprock.

Basal water occurs under water table conditions, except in the coastal plain where the overlying caprock consisting of marine and alluvial sediments creates (confined) artesian conditions. Shallow ground water also occurs in the caprock but is generally brackish to saline near the coast.

The regional hydrology of the Koolauloa Aquifer System has been well studied by Stearns and Vaksvik (1935), Takasaki and Valenciano (1969), and Mink (1982).

KOOLAULOA BASAL AQUIFER

Boundaries

The principal groundwater resource in the Koolauloa District is the Koolauloa Basal Aquifer in permeable dike-free basalts. The aquifer is about 11 miles long from Punaluu Stream to the north shore of Kahuku. Its landward portion extends from the dike zone and is about a half mile wide at Punaluu and widens to about 3 miles at Kahuku. However, the seaward boundary is formed by the seaward slope of the basalts overlain by a thick wedge of caprock. The boundary probably extends a distance of one to two miles offshore.

Groundwater Flow

As dike water spills unseen into the dike-free basal aquifer, groundwater flow in the southern part of the basal aquifer probably is predominantly toward the sea, more or less transverse to the dike zone boundary. Based upon water level measurements in 1963, the gradient between Hauula and Laie is a low one ft./mile and increases to two ft./mile between Laie and Kahuku, suggesting that groundwater flow

becomes more predominantly northerly toward Kahaluu. Thus, north of Laie ground water moves predominantly northward rather than eastward to the sea. The hydrologic sink is located in the vicinity of the old Kahuku airport, where basal ground water discharges naturally at the surface through reef limestone deposits and other caprock sediments under an artesian head of 10 feet, forming swampy wetlands.

Groundwater Recharge

One of the methods used to determine the availability of ground water in an area is to calculate its hydrologic water budget based upon reasonable geologic and hydrologic assumptions of the recharge area, and also based upon using long-term averages of rainfall, evapotranspiration, and runoff. Groundwater recharge is the net amount of rainfall that is able to percolate deep enough to become ground water. Groundwater recharge is calculated by using the following equation:

$$I = R - ET - RO$$

Where, I = Recharge, R = Rainfall, ET = Evapotranspiration, and RO = Runoff

However, because most of the recharge to the Koolauloa basal aquifer originates in the dike zone beneath the Koolau range and because the hydrologic divide within the dike zone is unknown, water budget estimates for the Koolauloa basal aquifer are difficult and, at best, approximate.

The estimated groundwater recharge for the Koolauloa Basal Aquifer ranges between 65 mgd and 70 mgd (million gallons per day) as shown in Table 1.

Table 1. Water Budget Estimates for Koolauloa Basal Aquifer

Subarea	Recharge Estimate By Takasaki and Valenciano (1969)	Recharge Estimate By Mink (1982)
Punaluu	9	9
Hauula	27	24
Laie	17	17
Kahuku	12	20
Total	65 mgd	70 mgd

Takasaki and Valenciano used pumping test data and the flow equation, Q = TIL, to corroborate their recharge estimate for the Hauula area. Mink also used the equation to confirm his water budget estimate of 70 mgd.

Sustainable Yield

Of the estimated 70 mgd recharge, only a fraction can be developed on a sustained or long-term basis. This fractional amount is called the sustainable yield of an aquifer. In other words, sustainable yield is commonly used to describe the amount of ground water that can be developed from a basal aquifer without adversely affecting the long-term ability of the aquifer to produce acceptable quality water from existing and new sources. Adverse effects may relate to localized upconing of salt water caused by drilling wells too deep, by excessive pumping rates, or by shrinkage of the basal lens due to excessive total pumpage over the long term. Sustainable yield is always less than recharge. It also refers to total withdrawal from the aquifer and does not take into account well spacing, well depth, or pumping capacities of individual wells.

Sustainable yield has been estimated by analyzing the behavior of heads and pumpage in the Koolauloa Basal Aquifer, for which reasonably good records were kept by the former Kahuku Plantation during the 40-year period from 1931 to 1970. Mink (1982), page 50, indicates that average annual pumpage in the aquifer reached an equilibrium of about 35 mgd. Assuming that heads in the aquifer had also reached

equilibrium during that period, a sustainable yield of 35 mgd was indicated. The salinity of wells in all areas of the basal aquifer has remained consistent throughout its development. The stable salinity indicates the sustainable yield was not exceeded and that a higher sustainable yield may be possible.

Using the historical records of head and pumpage and a recharge of 65 mgd, Mink utilized a robust analytical model to estimate different values of sustainable yield for different equilibrium conditions. For an equilibrium head at Hauula (Well 396) of 18 feet and 12 feet at Kahuku (Well 356), the overall sustainable yield of the aquifer would be 35 mgd.

In a 1983 report, the Division of Water and Development, now the Division of Water Resource Management (DWRM), of the Department of Land and Natural Resources also estimated a sustainable yield of 35 mgd for the Koolauloa Basal Aquifer and arbitrarily allocated the 35 mgd among the subareas as shown in Table 2. Table 2 also shows Mink's arbitrary allocations. On October 16, 1991, the State Commission on Water Resource Management (CWRM) accepted staff's recommendation of 35 mgd as the sustainable yield of the Koolauloa Aquifer System to be used for planning purposes. The Commission is expected to hold public hearings prior to adoption of the 35 mgd sustainable yield.

Table 2. Sustainable Yield of Koolauloa Basal Aquifer

Subarea	Sustainable Yield By Mink (1982)	Sustainable Yield By CWRM (1991)
Punaluu	7	8
Hauula	7	6
Laie	7	6
Kahuku	15	15
Total	36 mgd (say 35 mgd)	35 mgd

In its October 1991 presentation to the Commission, DWRM estimated the 1990 existing water use at 13.67 mgd (not including perched or alluvial aquifers). Therefore, groundwater availability for planning purposes is 21.33 mgd.

LAIE SUBAREA

Sustainable Yield

Although a sustainable yield of 6 to 7 mgd has been arbitrarily allocated for the Laie Subarea as shown in Table 2, it is possible to calculate the sustainable yield using the steady state equation (Mink, 1980) for predicting the behavior of a basal aquifer:

$$\frac{S.Y.}{I} = 1 - \left[\frac{h_e}{h_o}\right]^2$$

where,

S.Y. = sustainable yield
I = groundwater recharge
h_o = original head of the aquifer
h_e = established equilibrium head of the aquifer

For the Laie Subarea, groundwater recharge, I, has been estimated by Takasaki and Valenciano (1969) and Mink (1982) at 17 mgd. The original head of the aquifer at Laie has been estimated at 24 feet based largely upon a reported head of 25 feet at Hauula in 1918 and a head of 17 feet at Kahuku in 1916. Based upon experience with the thick basal aquifers of southern Oahu, establishing an equilibrium head of 15 feet at Laie is considered reasonable. Based upon the above, the calculated sustainable yield for the Laie subarea would be 10 mgd, as follows:

$$S.Y. = I\left[1 - \left(\frac{h_e}{h_o}\right)^2\right] = 17\left[1 - \left(\frac{15}{24}\right)^2\right] = 10.36, \textit{say } 10 \textit{ mgd}$$

Thus, the sustainable yield for the Laie Subarea may eventually prove to be more than 7 mgd, especially if existing wells which are too deep are modified, replaced, or abandoned and future withdrawals in the aquifer are carefully monitored. Consequently, records of pumpage, head, and salinity in the Laie subarea as well as throughout the aquifer should be maintained. Zion Securities Corporation for its own benefit should also survey all of its wells and take any action necessary to manage the groundwater resources and enhance its sources of supply.

Current Water Use

Water use at Laie is not metered and, consequently, historical records of water use are not available. However, Zion Securities Corporation has installed meters on their two domestic well sources. During the period June 16, 1991 to January 13, 1992, their potable water usage has averaged 1.45 mgd (Kari Kilstrom, personal communication, February 1992). On January 18, 1989, the Honolulu Board of Water Supply measured the average-day pumpage from Zion Securities' two potable well sources at 1.48 mgd. Also, based upon a survey conducted in 1985, the current agricultural water use at Laie is estimated at 2.35 mgd. Thus, the current (1991) water use by Zion Securities is estimated to be 3.85 mgd.

Potable Water Requirements

The projected additional potable water requirements for the Laie Development Plan through the year 2010 has been estimated by others as follows:

Residential	359,000
Commercial	60,000
Institutional	113,000
Resort	20,000
Public	5,000
Total	557,000 gpd

Groundwater Availability

In addition to the existing water needs of Zion Securities Corporation (ZSC), the Honolulu Board of Water Supply (BWS) has drilled two wells in the Laie subarea and plans to develop each well with a pump capacity of 1.0 mgd. Thus, a surplus of 1.0 mgd is estimated for the Laie Subarea as follows:

Sustainable Yield	7.0
Existing ZSC Water Use	-3.8
Projected ZSC Water Use	-0.6
Projected BWS Use	-1.6
Surplus	1.0 mgd

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APPENDIX F

Laie Master Plan EIS

STORM DRAINAGE PLAN

Laie, Oahu, Hawaii

January 8, 1992

Aqua/Waste Engineers
P.O. Box 1686, Kailua Kona, HI 96745
(808) 329-8266 Fax (808) 326-7767

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INTRODUCTION

The community of Laie is preparing a Master Plan intended to lay out a course for accommodating future growth and change in Laie that will have a broad base of support in the community. For planning purposes various land uses have been identified including: residential, commercial, resort, public, schools, and industrial. The infrastructure upgrades to support the development include the necessary roads, drainage structures, water and sewer lines, electrical distribution lines and secondary roads.

Housing is a primary element of the plan and three Alternative Land Use Schemes to provide additional residential housing and a school are being studied for inclusion in the overall Master Plan. This report provides an evaluation of the storm drainage system to support the future development plans.

PROJECT BACKGROUND

Proposed Project

The Laie Master Plan addresses the needs of the people and outlines the improvements necessary for growth in the community. This proposed development will result in the expansion of existing commercial areas, including the shopping center and the Polynesian Cultural Center. Light industry is being considered mauka of Hukilau Park. A new resort will be located makai of the Laniloa Lodge area providing leisure and recreational facilities for hotel guests. Among areas that will benefit the public are a community center near the Temple and another community center in a residential area. Three new or improved city parks will enhance the town at Laie Point, Kokololio Park and the Pounders area site. Several areas are being evaluated for much needed affordable housing which will include single family residences and apartments. A new school convenient to the chosen residential site and the expansion of BYU complete the Laie development plan.

Topographic Features

Elevations within the Laie community and adjacent agricultural lands range from sea level along the Laie Bay shoreline to roughly 120 feet above mean sea level at the mauka side of existing agricultural cultivation. Ground contours in the urbanized portion of Laie range from 0 to 10 percent while upslope agricultural lands contain a greater proportion of lands having 10 to 30 percent slopes. However, a significant portion of the mauka agricultural lands is also characterized by slopes of less than 10 percent.

The greater Laie area including this proposed development with the alternate housing schemes spans three major drainage basins plus parts of the two basins on the north and south ends of the project area. The drainage basins run from the low lying relatively flat, poorly drained coastal areas westward to the peaks of the Koolau Range. Beginning on the north side of the community, alternative housing scheme "A" would set on the south side of Malaekahana Stream. The drainage basin on the south side of Malaekahana Stream comprises a long narrow roughly pie shaped basin of approximately 1,039 acres stretching over 5.3 miles from the coastal wetlands at sea level to the peaks of the Koolau Range at 2000 feet above mean sea level. The coastal area is roughly 3,000 feet wide on the south side of the mouth of the stream and the basin narrows to a steep inland valley of 500 feet wide at the headwaters.

Moving south toward the community and including Old Laie is the Kahawainui Stream drainage basin encompassing approximately 3,398 acres. The low lying coastal area is approximately 6,000 feet wide along the highway with typical elevations of 5 to 10 feet above mean sea level. The drainage basin is a wide pie shape strip stretching inland approximately 4.9 miles to a headwaters strip less than 3,000 wide in the peaks of the Koolau Range at 2240 feet msl.

Wailele Gulch, a long narrow drainage basin covering approximately 1,359 acres lies south and parallel to the above basins. The low lying coastal area typical of these basins is approximately 4,500 feet wide along the shoreline and includes New Laie and the BYUH campus. Elevations range from sea level to approximately 20 feet msl at the rear of the campus housing area. The basin stretches inland over 4.5 miles and narrows to less than 1,500 feet in width to headwaters in the peaks of the Koolau Range at over 2300 feet msl.

The Koloa Gulch system covering approximately 1,613 acres including Aakakii and Kokololia Gulches is the southern most drainage system of the Laie Ahupuua and forms the boundary with Kaipapau. The low lying coastal area typical of these basins is approximately 4,500 feet wide along the shoreline and south of the PCC complex. Elevations range from sea level to approximately 20 feet msl inland of the present housing near Kam Highway. The basin stretches inland over 4 miles, is more uniform in width, and narrows to approximately 3,500 feet in width at the headwaters in the peaks of the Koolau Range at over 2400 feet msl.

One of the housing schemes would also partially overlap into a fifth drainage basin south of Koloa. Alternative "C" would have approximately 30 acres of the 70 acre Laiemalo'o development falling outside the Laie Ahupuua in the next drainage basin of Kaipapau.

Climate

The community of Laie is exposed to a warm, tropical environment. Ambient temperatures throughout the year have historically ranged from a low of approximately 50 degrees Fahrenheit to a record high temperature of 92 degrees Fahrenheit. However, a more normal ambient range typically averages from 71 to 79 degrees (State Department of Land and Natural Resources, Division of Water and Land Development, 1976).

Annual rainfall patterns are more variable and more indicative of the nominal seasonal changes which occur throughout the year. The variation of rainfall throughout the year suggests a 5-month "summer" season and a 7-month "winter" season. The summer season, from May through September, is a higher sun period that includes slightly warmer temperatures and more consistent northeasterly tradewinds. In contrast, the winter season is characterized by somewhat cooler temperatures, greater storm-generated rainfall, and less frequent tradewinds (Giambelluca, Nullet, and Schroeder, 1986). Total average annual rainfall is 58.4 inches.

EXISTING DRAINAGE CONDITIONS

Existing storm drainage facilities in Laie include the Kahawainui flood control channel on the north side of Laie, Wailele Stream on the south, as well as a lined 15-foot wide drainage ditch that flows through the New Laie residential area from a natural drainage course mauka and north of the Temple View Apartment complex (Figure D-1).

The construction of the Kahawainui flood control channel in 1989 has helped to alleviate storm flows from overtopping former natural drainage courses along Kahawainui and Laiewai streams. However, the lower elevations within the Laie community, the presence of many slab on-grade housing units, and limited drainage facilities still pose an imminent flood potential to homes located within portions of urbanized Laie. In addition, inadequate drainage also has a potential adverse effect upon Laie's wastewater system.

"***Because it is situated in a low-lying coastal area, rainfall events exceeding 100 mm tend to cause ponding of water in the streets and yards. If this ponding occurs during high tides, storm water is unable to drain for many hours further increasing the potential for inflow into the wastewater collection system***" (Gray, Hong, Bills and Associates, 1989).

The draft Laie Master Plan offers various proposals for improving drainage within urbanized Laie. The Master Plan, which was never adopted by Zions Securities Corporation or the Laie Community Association, indicated a primary need to "***....construct a major drainage course to intercept storm water runoff from BYU-HC which presently flows into New Laie***". The proposed interceptor drain would be built along the mauka-Hauula side of Naniloa Loop from Hale Laa Boulevard to the ocean.

More recently, representatives of BYUH, PCC, and Zions Securities met following the storm of March 19-20, 1991 to identify and coordinate the implementation of various potential measures that are aimed at improving drainage within the community. For example, a significant effort has already been accomplished by the Church of Jesus Christ of Latter Day Saints with the clearing of vegetation and debris within and along the natural drainage course of Wailele Stream.

The limited capacity of the lined 15-wide channel through New Laie is not adequate to support additional development without expansion, or a direction of flows to other natural drainage courses having greater capacity, e.g. Wailele Stream.

A related consideration is a decision regarding whether the storm drainage system can be transferred and dedicated to the City and County of Honolulu for its operation and maintenance. Such a transfer would not be accomplished until such time that existing drainage facilities are improved. The Laie Community Association has suggested the establishment of an improvement district would be a desirable approach for financing the cost of making improvements to the existing drainage system (McKenzie, 1991).

PROPOSED DEVELOPMENT

The proposed DP amendments total approximately 220 acres of which approximately 112 acres by the change in usage from agricultural to residential or commercial would contribute to additional runoff and reduced times of concentration in the developed low lying residential areas of the drainage basins near the coast but mauka of the highway.

The northern most housing scheme (egg farm area) would develop approximately 68 acres or about 2 % of the Kahawainui drainage basin encompassing approximately 3,398 acres. The additional runoff contribution generated in the drainage basin by this housing development scheme would be about 1/2 of 1 % of the total basin flow.

The BYU mauka housing scheme would develop approximately 68 acres or about 5 % of the Wailele drainage basin encompassing approximately 1,359 acres. The additional runoff contribution generated in the drainage basin by this housing development scheme would be about 1 % of the total basin flow.

The Laiemalo'o housing scheme would develop approximately 72 acres lying within two adjoining drainage basins. Approximately 42 acres of the development (representing about 2.6 % of the basin) drains toward the Kaloa drainage basin encompassing approximately 1,613 acres. The additional runoff contribution generated in the Kaloa basin by this housing development scheme would be about 1/2 of 1 % of the total basin flow. The remaining 30 acres of the development (representing about 1.6 % of the basin) drains toward the Kaipapau drainage basin encompassing approximately 1,850 acres. The additional runoff contribution generated in the

Kaipapau basin by this housing development scheme would be about 1/3 of 1 % of the total basin flow.

POTENTIAL IMPACTS AND MITIGATION

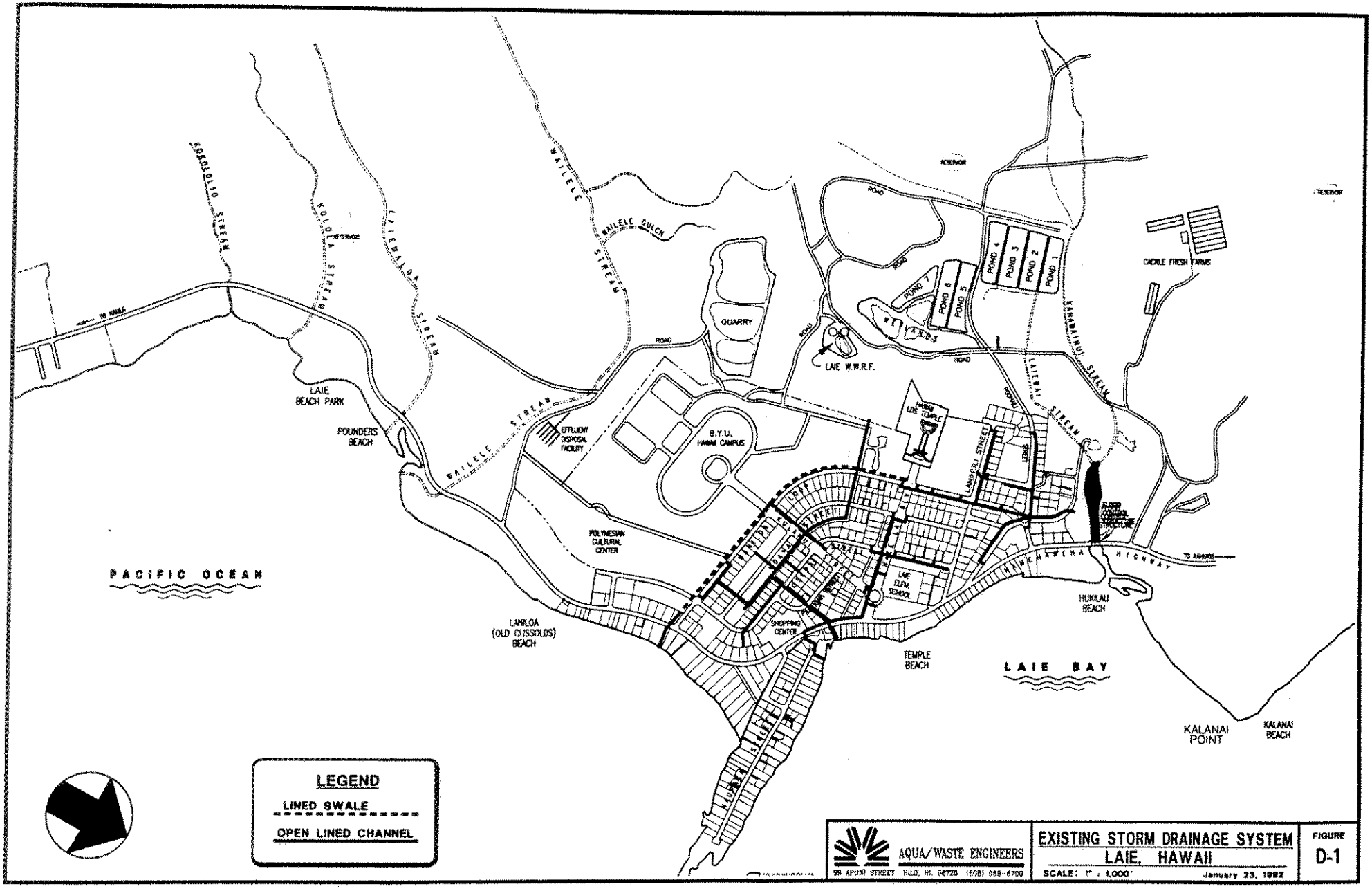
The existing community has no comprehensive drainage plan. Some improvements have been made as discussed earlier but ponding of water still occurs in the streets and yards of urbanized Laie with rainfall events exceeding 100 mm.

The proposed development will increase the quantity of peak runoff and would contribute to flooding problems in the residential areas. Mitigation in the existing community should include residential area drainage improvements identified in the master plan to eliminate current flooding. Additional storm drainage and dry wells for the proposed development would prevent exacerbating drainage problems in the existing community. Drywells are not normally used on Oahu, however Laie seems to have favorable conditions for drywell stormwater disposal in an underlying porous coral limestone strata identified in the Final Detailed Project Report and EIS, dated November 1985 by the Corps of Engineers and also reflected in the Soil Conversation Service maps of Laie. Recent construction activity for treatment plant improvements has also confirmed locations of the favorable strata for drywell disposal which could be more cost effective than a storm sewer piping system, especially in existing developed areas.

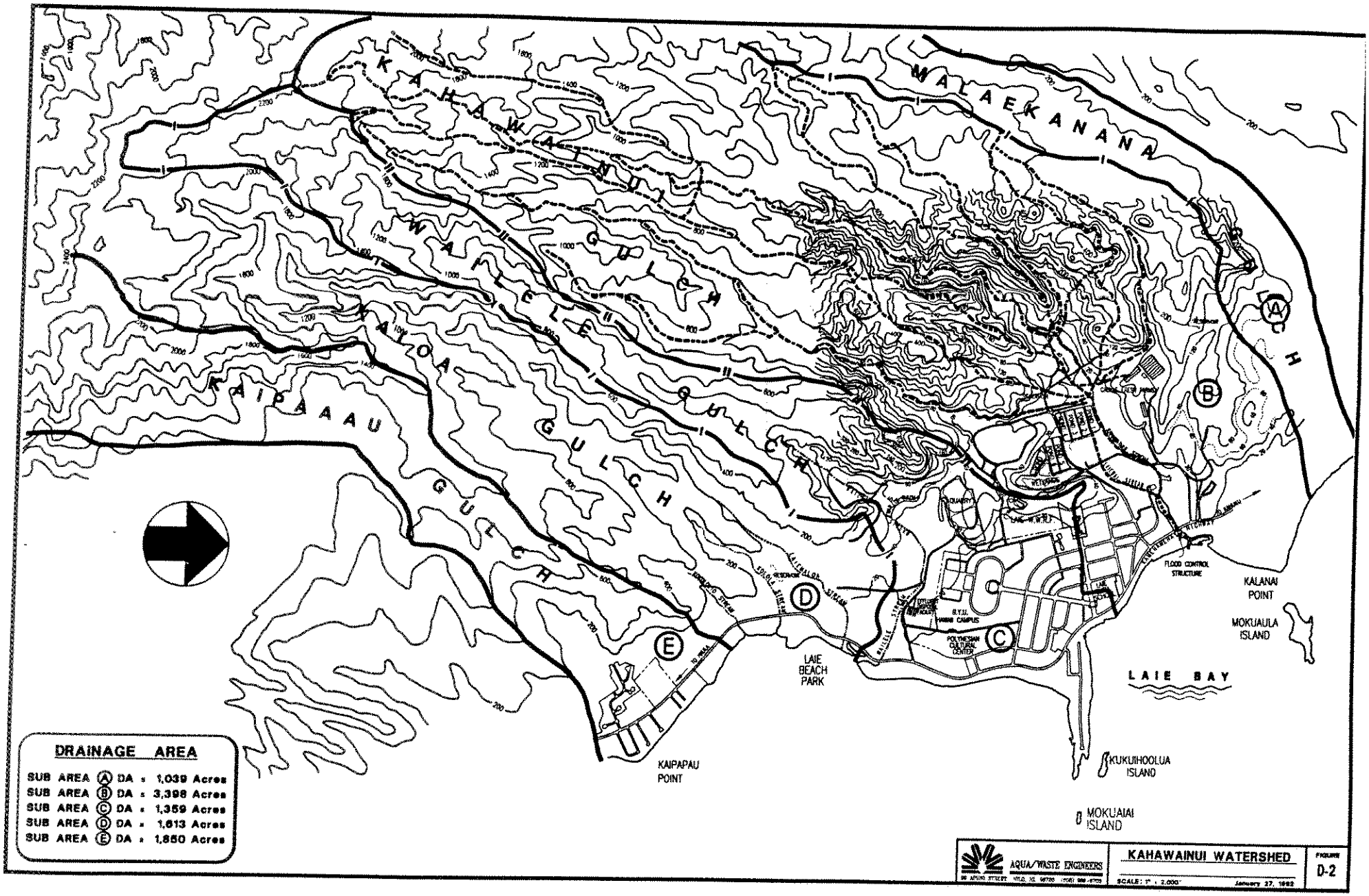
COSTS FOR ALTERNATIVE HOUSING SCHEMES

Estimated construction cost comparisons for the three alternative housing schemes are presented below. These costs include on site drainage plus the cost of channeling to the existing drainage system.

A. Egg Farm	$ 200,000
B. BYU Mauka	$ 200,000
C. Laiemalo'o	$ 2,000,000



KOKOLOLIO STREAM
KOLOLA STREAM
LAIEMALOA STREAM
WAILELE STREAM
WAILELE GULCH
RESERVOIR
ROAD
QUARRY
LAIE W.W.R.F.
WETLANDS
POND 7
POND 6
POND 5
POND 4
POND 3
POND 2
POND 1
CACKLE FRESH FARMS
KAHAWAINUI STREAM
LAIEWAI STREAM
LAIE BEACH PARK
POUNDERS BEACH
EFFLUENT DISPOSAL FACILITY
B.Y.U. HAWAII CAMPUS
HAWAII LDS TEMPLE
LANIHULI STREET
POLYNESIAN CULTURAL CENTER
LAIE ELEM SCHOOL
SHOPPING CENTER
HAMEHAMEHA HIGHWAY
TO KAHUKU
HUKILAU BEACH
TEMPLE BEACH
LANILOA (OLD CLISSOLDS) BEACH
PACIFIC OCEAN
LAIE BAY
KALANAI POINT
KALANAI BEACH
LEGEND
LINED SWALE
OPEN LINED CHANNEL
AQUA/WASTE ENGINEERS
99 APUNI STREET HILO, HI. 96720 (808) 969-6700
EXISTING STORM DRAINAGE SYSTEM
LAIE, HAWAII
SCALE: 1" = 1,000'
January 23, 1992
FIGURE
D-1


KAHAWAINUI
WALAEKANANA
WAILELE GULCH
ALOA GULCH
KAIPAAU GULCH
A
B
C
D
E
LAIE BEACH PARK
KAIPAPAU POINT
FLOOD CONTROL STRUCTURE
KALANAI POINT
MOKUAULA ISLAND
LAIE BAY
KUKUIHOOLUA ISLAND
MOKUAIAI ISLAND
B.Y.U. LAIE CAMPUS
POLYNESIAN CULTURAL CENTER
QUARRY
DRAINAGE AREA
SUB AREA (A) DA = 1,039 Acres
SUB AREA (B) DA = 3,398 Acres
SUB AREA (C) DA = 1,359 Acres
SUB AREA (D) DA = 1,613 Acres
SUB AREA (E) DA = 1,850 Acres
AQUA/WASTE ENGINEERS
KAHAWAINUI WATERSHED
SCALE: 1" = 2,000'
January 27, 1992
FIGURE
D-2

APPENDIX G

BOTANICAL SURVEY

LA'IE MASTER PLAN PROJECT

LA'IE, KO'OLAU LOA DISTRICT, O'AHU

by

Winona P. Char

CHAR & ASSOCIATES
Botanical/Environmental Consultants
Honolulu, Hawai'i

Prepared for: GROUP 70 INTERNATIONAL

November 1991

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BOTANICAL SURVEY
LA'IE MASTER PLAN PROJECT
LA'IE, KO'OLAU LOA DISTRICT, O'AHU

INTRODUCTION

The La'ie Master Plan project consists of several separate parcels totaling approximately 387 acres. The majority of the property is agricultural lands which support small vegetable and banana farms. Mixed forest and scrub vegetation are generally found on the uncultivated areas, steeper slopes, and rocky outcroppings. A few small wetlands occur along the Kahawainui Stream area. Also within the project area are smaller residential parcels.

Field studies to assess the botanical resources found within the La'ie Master Plan project site were conducted in November 1991. The primary objectives of the survey were to: (1) describe the major vegetation types; (2) inventory the vascular flora; and (3) search for threatened and endangered species protected by Federal and/or State endangered species' laws.

SURVEY METHODS

Prior to undertaking the field studies, a search was made of the pertinent literature to familiarize the principal investigator with other botanical studies conducted in the general area. Topographic maps and a recent colored aerial photograph (1" = 400') were examined to determine vegetation type cover patterns, terrain characteristics, access, boundaries, and reference points. A number of unpaved, farm roads can be found on the various parcels; these provided the major access and also served as reference points during the field studies.

Areas most likely to harbor native plants and sensitive native plant communities, such as the mixed forest and scrub vegetation, were more intensively surveyed. Also wetland areas were surveyed in more detail as development on such sites will require approval from the U. S. Army Corps of Engineers (COE). Not surveyed in detail were agricultural lands, residential parcels, and other disturbed places; these are highly unlikely to support rare native plants or sensitive native plant communities.

A walk-through survey method was used. Notes were made on plant associations and distribution, substrate types, topography, exposure, drainage, etc. Plant identifications were made in the field; plants which could not be positively identified were collected for later determination in the herbarium and for comparison with the most recent taxonomic literature.

The species recorded are indicative of the season ("rainy" vs. "dry") and the environmental conditions at the time of the survey. A survey taken at a different time of the year and under varying environmental conditions would no doubt yield slight variations in the species list, especially of the weedy annual plants.

DESCRIPTION OF THE VEGETATION

There have been other botanical surveys which have covered a portion of the project site or adjacent lands. The most pertinent of these is the report by Char (1990) which covered the existing La'ie Wastewater Treatment Plant and the adjoining lands since the use of future wastewater effluent for the irrigation of nearby agricultural lands was being proposed as one of the more viable options. Two botanical studies (Nagata 1989; Char 1989) were conducted for golf courses on lands bordering the north (Kahuku side) boundary of the project site.

In the botanical survey report prepared for the wastewater treatment plant (Char 1990), three major vegetation types were recognized: agricultural lands and other disturbed areas, mixed forest and scrub vegetation, and California grass dominated areas. Two subtypes of the California grass vegetation type were described; these were wetland and nonwetland areas.

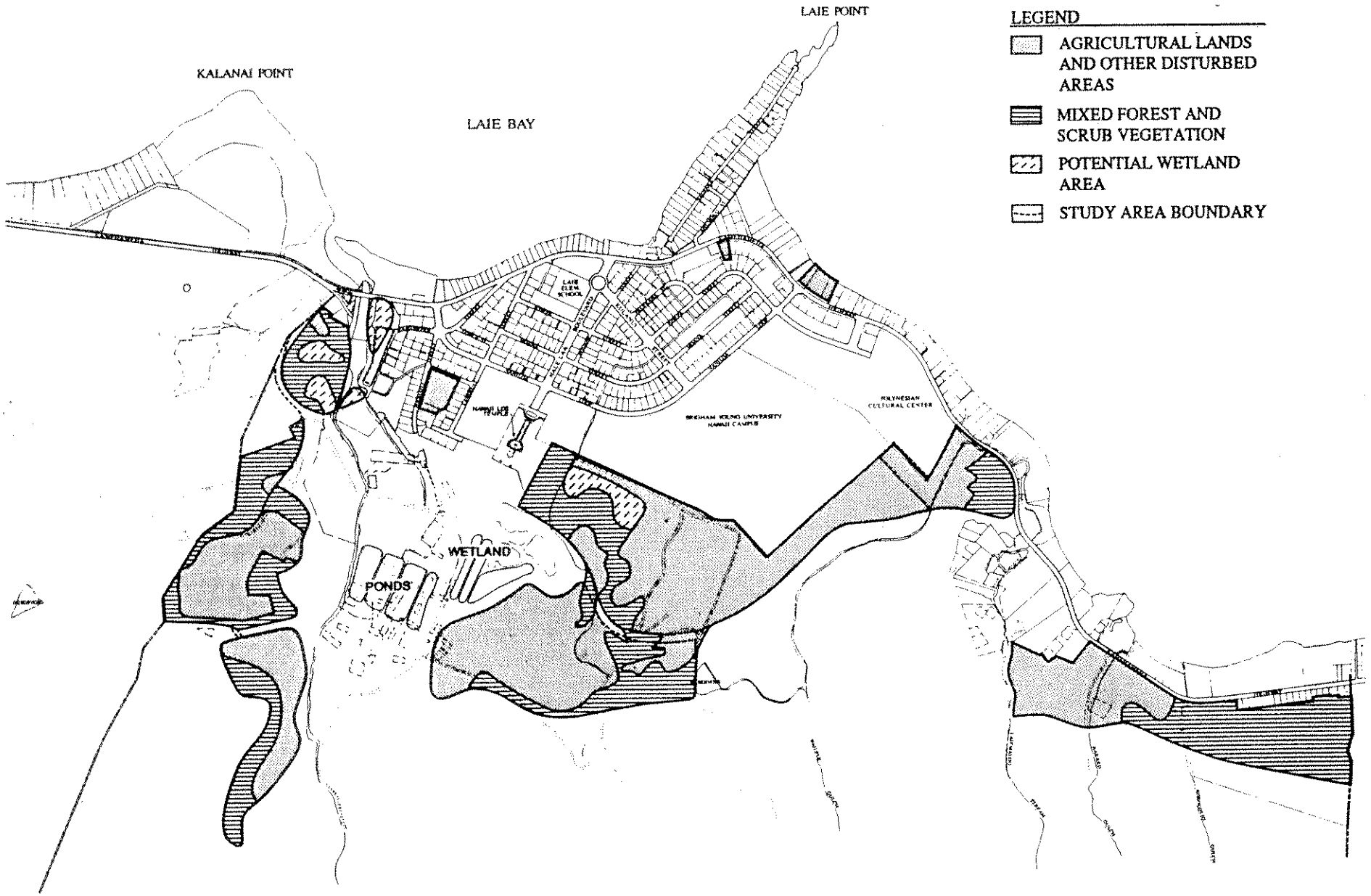
In this report, the vegetation discussion largely follows Char's 1990 treatment. The California grass dominated areas on the project site support wetlands. The distribution of the three vegetation types on the subject property is presented in Figure 1. A list of all those vascular plants found during the field studies is given in the plant checklist at the end of this report.

Agricultural Lands and Other Disturbed Areas

Included in this vegetation type are farmlands and homes, the existing wastewater treatment plant, a quarry, the Cackle Fresh egg farm, roadsides, and other frequently disturbed areas. Also included are the three smaller residential parcels (3.6 acres Po'ohaili St.; 2.6 acres along Kamehameha Highway; ±0.5 acres adjacent to the shopping center). These parcels have been urbanized and greatly modified.

Vegetable farms and banana fields cover most of the agricultural lands. A number of banana cultivars are grown including several types of cooking bananas. Other crops include bittermelon, winged bean, yard long bean, string beans, watermelon, 'ape, cassava, taro, several varieties of squashes, papaya, etc. Small stands of citrus, avocado, and breadfruit trees are also frequently encountered. A weedy mixture of species commonly associated with such agricultural lands occurs primarily along the margins of fields, along drainages, and roadways.

The quarry site is actively mined and large mounds of sand and



Source: Derived from Char & Associates, February 1992

VEGETATION COVER TYPES

LA'IE DEVELOPMENT PLAN AMENDMENTS

NOTE: FIGURE DERIVED FROM CHAR FIELD SURVEY MAP

crushed coral are piled on the site. The margins of the quarry are less frequently disturbed and support an association of grasses, weedy herbs, and a few scattered shrubs. The wastewater treatment plant is landscaped around the main facilities; common lawn components are Hilo grass (Paspalum conjugatum), puahilahila (Mimosa pudica), three-flowered beggarweed (Desmodium triflorum), and hierba del cabello (Calyptocarpus vialis). As on most disturbed areas, weedy species become more numerous around the perimeter of the site. Common weedy species include white-flowered beggar's tick (Bidens alba), spiny amaranth (Amaranthus spinosus), koa-haole seedlings (Leucaena leucocephala), borreria (Spermococe mauritiana), sour grass (Digitaria insularis), maile-hohono (Ageratum houstonianum), three species of spurge (Chamaesyce spp.), nettle-leaved vervain (Stachytarpheta urticifolia), and Jamaica vervain (Stachytarpheta jamaicensis).

Mixed Forest and Scrub Vegetation

This vegetation type is present on the more steeply sloping parcels, on areas with old coralline reef (produced during higher stands of the sea) around the quarry and wastewater treatment plant, and on fallowed fields in a late stage of succession. Generally, this mixed forest and scrub association consists of several tree species with no one species dominant. Among the more frequently observed trees are ironwood (Casuarina equisetifolia), Java plum (Syzygium cumini), macaranga (Macaranga tanarius), hau (Hibiscus tiliaceus), and Chinese banyan (Ficus microcarpa). The trees may form open to closed canopied stands and vary in height from 20 to as much as 50 ft. tall. On the foothills mauka of the egg farm ironwood forests become extensive and the other tree species become minor components. On the Hau'ula side of the project site, Java plum trees form a rather dense forest.

Filling in the matrix between the scattered stands of mixed forest are shrubs of Christmas berry (Schinus terebinthifolius)

and koa-haole, from 6 to 12 ft. tall. These shrubs form dense thickets on the slopes around the egg farm and on the parcels on the Hau'ula side of the project site. In some areas, guava may become a common component of the mixed scrub.

Ground cover in this vegetation type is highly variable, depending in part on substrate type, topography, and density of the tree and shrub layers. On areas with karst (coralline substrate), ground cover is sparse and consists primarily of the saplings of tree and shrub species mentioned above. Rouge plant (Rivina humilis) may be locally abundant in these areas. On level areas with soil, California grass (Brachiaria mutica) may form a dense mat especially if the canopy is open. Where the canopy is closed, ground cover tends to be sparse with only the more shade-tolerant species such as Chinese violet (Asystasia gangetica), hairy sword fern (Nephrolepis multiflora), and Hilo grass (Paspalum conjugatum) forming localized clumps of plants. In most places, leaf litter and fallen branches are more typical. On steeply sloping areas such as the area mauka of the egg farm, open grassy patches, primarily Guinea grass (Panicum maximum), and some small patches of exposed red soil can be found.

Wetland Areas

Wetlands occur along Kahawainui Stream and in a low-lying area behind the Curch College apartment complex. Alien or introduced plants are the dominant components on these sites and the wetlands on the project site do not contain anything of botanical significance (i.e. threatened and endangered plants, sensitive native plant communities). However, wetlands are of particular interest to regulatory agencies such as the U.S. Army Corps of Engineers (COE) and the U.S. Fish and Wildlife Service (USFWS).

Two small wetlands can be found on the 16-acre parcel located near the highway. Soils on this site are classified as "Kfb"

Kaloko clay, noncalcareous variant (Foote et al. 1972). This soil type has small included areas that meet the criteria for hydric soils. Although no standing water was observed at the time of the survey, the colored aerial photograph of the site taken in February 1989 shows open water in these two areas. California grass, a facultative wetland (FACW) indicator species, and Indian pluchea (Pluchea indica), a facultative (FAC) indicator species (Reed 1988) are the dominant plants on the two wetlands. The construction of the new flood control channel may have affected the previous drainage patterns and these wetlands now appear to be only seasonally floooded.

On the 2-acre parcel by Wahinepe'e Street, the wetland is highly disturbed probably due to construction activities from the flood control project. Wetland indicator species include California grass, false daisy (Eclipta alba), Leptochloa uninervia, spike rush (Eleocharis geniculata), barnyard rice (Echinochloa crusgalli), and water hyssop (Bacopa monnieri). Two Koloa or Hawaiian Duck (Anas wyvilliana) were observed in this wetland. Bruner (1991) noted the occurrence of Kolea in wetlands on and adjacent to the project site, but did not specifically mention this location.

Immediately mauka of the Church College apartments is a small California grass dominated area which appears to be a wetland as portions of it also support plants of cattail (Typha latifolia), an obligate wetland (OBL) indicator species. Parts of this wetland may be seasonally flooded while smaller sections may be more or less wet throughout the year.

A narrow strip of Keaau clay, "KmA", can be found on the Hau'ula parcels bordering Kamehameha Highway. This soil type may also have small included areas which meet the hydric soils criteria. However, the general physiognomy of the vegetation does not

indicate the presence of a wetland; for now, the vegetation has been mapped as mixed forest and scrub.

DISCUSSION AND RECOMMENDATIONS

The vegetation on the project site is composed primarily of alien or introduced plant species. Large portions of the project site are under cultivation. Uncultivated areas support a mixed forest and scrub association while smaller, low-lying areas may contain wetlands. Of a total of 163 plant species inventoried during the field studies, 141 (87%) are introduced or alien species; 12 (7%) represent plants originally of early Polynesian introduction; and 10 (6%) are indigenous, that is, native to the Hawaiian Islands and elsewhere throughout the Pacific. No endemic species, i.e. plants native only to the Hawaiian islands, were found. None of the plants inventoried are officially listed threatened or endangered species (U.S. Fish and Wildlife Service 1989); nor are any proposed or candidate for such status (U.S. Fish and Wildlife Service 1990). Similar findings were recorded in three recent botanical surveys (Char 1989, 1991; Nagata 1989) conducted on or adjacent to the project site.

The proposed developments for the various parcels within the project site are not expected to have a significant negative impact on the botanical resources. Of some concern, is soil loss and discharge of sediments into the nearby streams especially on portions of the steeper sloping areas on the 24-acre parcel mauka of the egg farm. It is recommended that these areas (slopes and streamsides) be revegetated and landscaped as soon as possible.

Wetland areas pose some regulatory problems. A wetlands determination and delineation will need to conducted by the COE. In addition, the USFWS should be consulted if any of the wetland areas are to be filled or modified. The area with the "KmA" soil type may require a more detailed study for the presence of any wetlands especially along streams and low-lying sections.

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PLANT SPECIES LIST -- La'ie Master Plan Project

A checklist of all the vascular plant species found during the course of the field studies is presented below. The plants are divided into three groups: Ferns and Fern Allies, Monocots, and Dicots. The taxonomy of the Ferns and Fern Allies follow Lamoureux (1984); the flowering plants, Monocots and Dicots, are in accordance with the most recent treatment of the flora by Wagner et al. (1990).

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:
   - I = indigenous = plants native to the Hawaiian Islands and elsewhere throughout the Pacific
   - P = Polynesian = plants of Polynesian introduction prior to Western contact (1778); not native
   - X = introduced or alien = all those plants introduced intentionally or accidentally after Western contact; not native.
4. Presence (+) or absence (-) of a particular species within each of three vegetation types recognized within the project area (see text for discussion):
   - Ag = Agricultural Lands and Other Disturbed Areas
   - F/S = Mixed Forest and Scrub Vegetation
   - W = Wetland Areas

Scientific name	Common name	Status	Vegetation type Ag	F/S	W
FERNS AND FERN ALLIES					
NEPHROLEPIDACEAE (Sword Fern Family)					
Nephrolepis multiflora (Roxb.) Jarrett ex Morton	hairy sword fern	X	-	+	-
POLYPODIACEAE (Common Fern Family)					
Phymatosorus scolopendria (Burm.) Pic.-Serm.	laua'e, lauwa'e	X	+	+	-
PSILOTACEAE (Whisk Fern Family)					
Psilotum nudum (L.) Beauv.	moa, pipi	I	-	+	-
FLOWERING PLANTS					
MONOCOTS					
AGAVACEAE (Sisal Family)					
Cordyline fruticosa (L.) A. Chev.	ti, ki	P	+	+	-
Furcraea foetida (L.) Haw.	Mauritius hemp	X	-	+	-
ARACEAE (Taro Family)					
Alocasia macrorrhiza (L.) Schott	'ape	P	+	-	+
Colocasia esculenta (L.) Schott	taro, kalo	P	+	-	+
Epipremnum pinnatum (L.) Engl.	pothos vine, taro vine	X	-	+	-
ARECACEAE (Palm Family)					
Cocos nucifera L.	coconut, niu	P	+	+	+
Phoenix sp.	date palm	X	-	+	-
CANNACEAE (Canna Family)					
Canna indica L.	Indian shot, poloke	X	+	+	-

Scientific name	Common name	Status	Vegetation type Ag	F/S	W
COMMELINACEAE (Spiderwort Family)					
Commelina diffusa N. L. Burm.	honohono	X	+	+	+
CYPERACEAE (Sedge Family)					
Cyperus rotundus L.	nut grass, nutsedge	X	+	+	+
Eleocharis geniculata (L.) Roem. & Schult.	spike rush	X	-	-	+
Pycreus polystachyos (Rottb.) P. Beauv.		I	+	-	-
MUSACEAE (Banana Family)					
Musa X paradisiaca L.	banana, ma'ia	P	+	+	+
ORCHIDACEAE (Orchid Family)					
Spathoglottis plicata Blume	Malayan or Philippine ground orchid	X	-	+	-
POACEAE (Grass Family)					
Andropogon virginicus L.	broomsedge	X	-	+	-
Axonopus fissifolius (Raddi) Kuhlm.	carpet grass	X	-	+	-
Brachiaria mutica (Forssk.) Stapf	California grass, paragrass	X	+	+	+
Brachiaria sp.		X	+	-	-
Cenchrus echinatus L.	common sandbur, 'ume-'alu, kuku	X	+	+	-
Chloris barbata (L.) Sw.	swollen finger grass, mau'ulei	X	+	+	+
Chloris radiata (L.) Sw.	radiate finger grass	X	+	-	-
Coix lachryma-jobi L.	Job's tears, pupu-kolea	X	+	-	+
Cynodon dactylon (L.) Pers.	Bermuda grass, manienie	X	+	-	+
Digitaria ciliaris (Retz.) Koeler	hairy crabgrass	X	+	+	-
Digitaria insularis (L.) Mez ex Ekman	sour grass	X	+	+	-
Digitaria sp.	crab grass	X	+	-	-
Echinochloa colona (L.) Link	jungle rice	X	+	-	+
Echinochloa crusgalli (L.) Beauv.	barnyard rice	X	-	-	+

Scientific name	Common name	Status	Vegetation type Ag	F/S	W
Eleusine indica (L.) Gaertn.	wire grass	X	+	-	-
Eragrostis tenella (L.) P. Beauv. ex Roem. & Schult.	lovegrass	X	+	+	-
Leptochloa uninervia (K. Presl) Hitchc.	leptochloa	X	-	-	+
Melinis minutiflora P. Beauv.	molasses grass	X	+	+	-
Oplismenus hirtellus (L.) Beauv.	basket grass	X	-	+	-
Panicum maximum Jacq.	Guinea grass	X	+	+	+
Paspalum conjugatum Bergius	Hilo grass, mau'u Hilo	X	+	+	+
Paspalum fimbriatum Kunth	fimbriate paspalum	X	+	+	-
Paspalum scrobiculatum L.	ricegrass, mau'u laiki	X	-	+	-
Paspalum urvillei Steud.	Vasey grass	X	+	+	+
Pennisetum purpureum Schumach.	elephant grass, Napier grass	X	+	-	+
Saccharum officinarum L.	sugar cane, ko	P	+	+	-
Setaria verticillata (L.) P. Beauv.	bristly foxtail	X	+	-	-
Sorghum halpense (L.) Pers.	Johnson grass	X	+	-	-
Sporobolus indicus (L.) R. Br.	Indian dropseed	X	+	-	-
PONTEDERIACEAE (Pickerel Weed Family)					
Eichornia crassipes (Mart.) Solms	water hyacinth	X	-	-	+
Monochoria sp.	pickerel weed	X	-	-	+
TYPHACEAE (Cattail Family)					
Typha latifolia L.	cattail	X	-	-	+
DICOTS					
ACANTHACEAE (Acanthus Family)					
Asystasia gangetica (L.) T. Anderson	Chinese violet	X	-	+	-
AMARANTHACEAE (Amaranth Family)					
Achyranthes aspera L.		X	-	+	-
Amaranthus spinosus L.	spiny amaranth, pakai kuku	X	+	-	-
Amaranthus viridis L.	slender amaranth, pakai	X	+	-	-

Scientific name	Common name	Status	Vegetation type Ag	F/S	W
ANACARDIACEAE (Mango Family)					
Mangifera indica L.	mango, manako	X	+	+	-
Schinus terebinthifolius Raddi	Christmas berry	X	+	+	+
APIACEAE (Carrot Family)					
Centella asiatica (L.) Urb.	Asiatic pennywort, pohe-kula	X	+	-	-
Ciclospermum leptophyllum (Pers.) Sprague	fir-leaved celery, apium	X	+	-	-
APOCYNACEAE (Dogbane Family)					
Plumeria rubra L.	plumeria, frangipani	X	+	-	-
ARALIACEAE (Ginseng Family)					
Schefflera actinophylla (Endl.) Harms	octopus tree	X	+	+	-
ASTERACEAE (Sunflower Family)					
Ageratum conyzoides L.	maile-hohono	X	+	-	-
Ageratum houstonianum Mill.	maile-hohono	X	+	-	-
Bidens alba var. radiata (Schultz-Bip.) Ballard ex Melchart	white-flowered beggar's tick	X	+	+	+
Bidens pilosa L.	Spanish needle, beggar's tick	X	+	-	-
Calyptocarpus vialis Less.	hierba del cabello	X	+	-	-
Conyza bonariensis (L.) Cronq.	hairy horseweed	X	+	-	-
Crassocephalum crepidioides (Benth.) S. Moore	crassocephalum	X	+	+	+
Eclipta alba (L.) Hassk.	false daisy	X	+	-	+
Emilia coccinea (Sims) G. Don		X	+	-	-
Emilia fosbergii Nicolson	red pualele	X	+	+	-
Pluchea indica (L.) Less.	Indian pluchea	X	+	-	+
Pluchea symphytifolia (Mill.) Gillis	pluchea	X	+	+	-

Scientific name	Common name	Status	Vegetation type Ag	F/S	W
Sonchus oleraceus L.	milkweed, pualele	X	+	+	+
Synedrella nodiflora (L.) Gaertn.	synedrella	X	+	-	-
Tridax procumbens L.	coat buttons	X	+	-	-
Verbesina encelioides (Cav.) Benth. & Hook.	golden crownbeard	X	+	-	-
Vernonia cinerea var. parviflora (Reinw.) DC.	ironweed	X	+	-	-
Wedelia trilobata (L.) Hitchc.	wedelia	X	+	+	+
Xanthium strumarium var. canadense (Mill.) Torr. & A. Gray	cocklebur	X	+	+	-
Youngia japonica (L.) DC.	Oriental hawksbeard	X	+	+	-
BALSAMINACEAE (Balsam Family)					
Impatiens wallerana J.D. Hook.	impatiens	X	+	-	-
BIGNONIACEAE (Bignonia Family)					
Spathodea campanulata P. Beauv.	African tulip	X	+	+	-
BORAGINACEAE (Borage Family)					
Heliotropium procumbens var. depressum (Cham.) Fosb.		X	+	-	-
BRASSICACEAE (Mustard Family)					
Coronopus didymus (L.) Sm.	swine cress	X	+	-	-
CARICACEAE (Papaya Family)					
Carica papaya L.	papaya, mikana	X	+	+	-
CARYOPHYLLACEAE (Carnation Family)					
Drymaria cordata var. pacifica Mizush.	drymaria	X	+	-	-
CASUARINACEAE (Ironwood Family)					
Casuarina equisetifolia L.	ironwood	X	+	+	-
CLUSIACEAE (Mangosteen Family)					
Calophyllum inophyllum L.	kamani	P	+	-	-

Scientific name	Common name	Status	Vegetation type Ag	F/S	W
COMBRETACEAE (Terminalia Family)					
Terminalia catappa L.	Chinese almond, false kamani	X	+	+	-
CONVOLVULACEAE (Morning-glory Family)					
Ipomoea alba L.	moon flower, koali pehu	X	-	-	+
Ipomoea indica (J. Burm.) Merr.	koali-'awania	I	+	+	-
Ipomoea obscura (L.) Ker-Gawl.	field bindweed	X	-	+	-
Ipomoea pes-caprae ssp. brasiliensis (L.) Ooststr.	beach morning glory, pohuehue	I	-	-	+
Ipomoea triloba L.	little bell, pink bindweed	X	+	+	-
CUCURBITACEAE (Squash Family)					
Momordica charantia L.	wild bittermelon	X	+	+	-
EUPHORBIACEAE (Spurge Family)					
Aleurites moluccana (L.) Willd.	kukui, tutui	P	-	+	-
Chamaesyce hirta (L.) Millsp.	hairy spurge	X	+	+	-
Chamaesyce hypericifolia (L.) Millsp.	graceful spurge	X	+	-	-
Chamaesyce prostrata (Aiton) Small	prostrate spurge	X	+	-	-
Macaranga tanarius (L.) Mull. Arg.	macaranga	X	+	+	-
Manihot esculenta Crantz	cassava, tapioca	X	+	+	-
Phyllanthus debilis Klein ex Willd.	phyllanthus weed	X	+	-	-
Ricinus communis L.	castor bean, koli	X	+	+	+
FABACEAE (Pea Family)					
Acacia confusa Merr.	Formosan koa	X	-	+	-
Alysicarpus vaginalis (L.) DC.	alysicarpus	X	+	-	-
Canavalia cathartica Thouars.	mauna-loa vine	X	+	+	-
Chamaecrista nictitans (L.) Moench	partridge pea, lauki	X	+	-	-
Crotalaria incana L.	fuzzy rattlepod, kukae hoki	X	+	-	-
Crotalaria pallida Aiton	smooth rattlepod, pikakani	X	+	+	-

Scientific name	Common name	Status	Vegetation type Ag	F/S	W
Desmanthus virgatus (L.) Willd.	virgate mimosa	X	+	-	-
Desmodium incanum DC.	Spanish clover, ka'imi	X	+	+	-
Desmodium tortuosum (Sw.) Dc.	Florida beggarweed	X	+	+	-
Desmodium triflorum (L.) DC.	three-flowered beggar-weed	X	+	-	-
Indigofera suffruticosa Mill.	indigo, 'iniko	X	+	-	-
Leucaena leucocephala (Lam.) de Wit	koa-haole	X	+	+	+
Macroptilium lathyroides (L.) Urb.	wild bean, cow pea	X	+	+	-
Mimosa pudica var. unijuga Duchass. & walp.) Griseb.	sensitive plant, pua-hilahila	X	+	+	-
Senna alata (L.) Roxb.	candle bush	X	-	+	+
Senna surratensis (N.L. Burm.) H. Irwin & Barneby	kolomona	X	-	+	-
LAMIACEAE (Mint Family)					
Hyptis pectinata (L.) Poit.	comb hyptis	X	+	-	-
Leonotis nepetifolia (L.) R. Br.	lion's ear	X	+	+	-
Stachys arvensis L.	stachys	X	+	-	-
LAURACEAE (Laurel Family)					
Cassytha filiformis L.	kauna'oa pehu	I	-	+	-
Persea americana Mill.	avocado, pear	X	+	+	-
LYTHRACEAE (Loosestrife Family)					
Cuphea carthagenensis (Jacq.) Macbr.	cuphea, kamole	X	-	-	+
MALVACEAE (Mallow Family)					
Abutilon grandifolium (Willd.) Sweet	hairy abutilon, mao	X	-	+	-
Hibiscus rosa-sinensis L.	hibiscus	X	+	+	-
Hibiscus tiliaceus L.	hau	I?	-	+	+
Malvastrum coromandelianum (L.) Garcke	cheeseweed, hauuoi	X	+	+	-
Sida rhombifolia L.	Cuba jute	X	+	+	-
MENISPERMACEAE (Moonseed Family)					
Cocculus trilobus (Thunb.) DC.	huehue	I	-	+	-

Scientific name	Common name	Status	Vegetation type Ag	F/S	W
MORACEAE (Mulberry Family)					
Artocarpus altilis (Parkins. ex Z) Fosb.	breadfruit, ulu	P	+	+	-
Ficus elastica Roxb. ex Hornem.	India rubber tree	X	+	+	-
Ficus microcarpa L. f.	Chinese banyan	X	+	+	-
Ficus sp.	banyan	X	+	-	-
MYRTACEAE (Myrtle Family)					
Eucalyptus sp.	eucalyptus, gum tree	X	+	+	-
Psidium cattleianum Sabine	strawberry guava	X	-	+	-
Psidium guajava L.	guava, kuawa	X	+	+	+
Syzygium cumini (L.) Skeels	Java plum	X	+	+	+
NYCTAGINACEAE (Four-o'clock Family)					
Mirabilis jalapa L.	four-o'clock, pua-ahiahi	X	-	+	-
ONAGRACEAE (Evening Primrose Family)					
Ludwigia octovalvis (Jacq.) Raven	primrose willow, kamole	P?	-	-	+
OXALIDACEAE (Wood Sorrel Family)					
Oxalis corniculata L.	yellow wood sorrel, 'ihi	P?	+	-	-
Oxalis corymbosa DC.	pink wood sorrel	X	+	+	-
PASSIFLORACEAE (Passion Fruit Family)					
Passiflora edulis forma flavicarpa Deg.	passion fruit, liliko'i	X	+	+	-
Passiflora foetida L.	running pop, pohapoha	X	+	+	-
Passiflora suberosa L.	huehue haole	X	+	+	-
PHYTOLACCACEAE (Pokeweed Family)					
Rivina humilis L.	rouge plant	X	-	+	-
PLANTAGINACEAE (Plantain Family)					
Plantago lanceolata L.	narrow-leaved plantain	X	+	-	+
Plantago major L.	broad-leaved plantain, laukahi	X	+	-	+

Scientific name	Common name	Status	Vegetation type Ag	F/S	W
PORTULACACEAE (Purslane Family)					
Portulaca oleracea L.	common purslane, pigweed	X	+	+	-
PRIMULACEAE (Primrose Family)					
Anagallis arvensis L.	scarlet pimpernel	X	+	-	-
RUBIACEAE (Coffee Family)					
Morinda citrifolia L.	noni	P	+	+	-
Spermococe mauritiana Gideon	borreria	X	+	-	-
SCROPHULARIACEAE (Snapdragon Family)					
Bacopa monnieri (L.) Wettst.	water hyssop	I	-	-	+
SOLANACEAE (Tomato Family)					
Lycopersicon esculentum Mill.	tomato	X	+	-	-
Solanum americanum Mill.	popolo	I?	+	+	-
Solanum torvum Sw.		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, lakana	X	+	+	-
Stachytarpheta dichotoma (Ruiz & Pav.) Vahl	owi, oi	X	-	+	-
Stachytarpheta jamaicensis (L.) Vahl	Jamaica vervain, owi, oi	X	+	+	-
Stachytarpheta urticifolia (Salisb.) Sims	nettle-leaved vervain	X	+	+	-
Verbena litoralis Kunth	weed verbena	X	+	-	-

APPENDIX H

SURVEY OF THE AVIFAUNA AND FERAL MAMMALS AT

LAIE, OAHU FOR THE LAIE MASTER PLAN

Prepared for

Group 70

by

Phillip L. Bruner
Assistant Professor of Biology
Director, Museum of Natural History
Environmental Consultant - Faunal (Bird & Mammal) Surveys

4 November 1991

INTRODUCTION

The purpose of this report is to summarize the findings of a three day (15,17,24 October 1991) bird and mammal field survey of approximately 389 acres of property located at Laie, Oahu (Fig.1). Also included are references to pertinent literature as well as unpublished faunal reports from similar habitat.

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 type of habitats available.

2- Provide some baseline data on the relative (estimated) abundance of each species.

3- Determine the presence or likely occurrence of any native fauna particularly any that are considered "Endangered" or "Threatened".

4- If any special or unique wildlife habitat occurs on the property locate such sites and note their possible value for birds and mammals in this region of the island.

GENERAL SITE DESCRIPTION

Figure One indicates the various locations surveyed for birds and mammals. Most of the property is covered in a variety of introduced plants. Some sections are under active cultivation while others are overgrown with brush and grass. Wetland habitat can be found in several localities. These wetlands include aquaculture ponds, natural ponds, streams and flooded grasslands.

Weather during the field survey was overcast and warm. Heavy rains occurred on 16 October.

STUDY METHODS

Field observations were made with 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. At various locations, along roads and trails, eight minute counts were made of all birds seen or heard (Fig.1). Between these count (census) stations any unusual observations of birds were also noted. These data provide the basis for the relative (estimated) abundance figures given in this report (Table 1). Published and unpublished reports of birds

known from similar habitat were also consulted in order to acquire a more complete picture of the possible species that might occur in the area (DLNR 1986, 1987, 1988; Bruner 1989a, 1989b, 1989c, 1991a, 1991b; 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 attempts were made to trap mammals in order to obtain data on their relative (estimated) abundance and distribution.

Scientific names used herein follow those given in Hawaii's Birds (Hawaii Audubon Society 1989); Field Guide to the Birds of Hawaii and the Tropical Pacific (Pratt et al. 1987) and Mammal Species of the World (Honacki et al. 1982).

RESULTS AND DISCUSSION

Resident Endemic (Native) Land Birds:

No endemic birds were recorded on the survey. The Short-eared Owl or Pueo (*Asio flammeus sandwichensis*) is the only endemic land bird that would likely occur in this area (Pratt et al. 1987). Other endemic land birds can be found in native forest at highier elevation (Pratt et al. 1987; Hawaii Audubon Society 1989).

Resident Endemic (Native) Waterbirds:

The following four endemic waterbirds were recorded on the

survey: Black-necked Stilt (Himantopus mexicanus knudseni); Hawaiian Duck or Koloa (Anas wyvilliana); American Coot (Fulica americana alai) and Common Moorhen (Gallinula chloropus sandvicensis). These four endangered species were observed throughout the various wetlands associated with this site. The total recorded number of each species for the three day survey were: Black-necked Stilt = 18; Koloa = 11; American Coot = 21 and Common Moorhen = 10. Quarterly surveys conducted by the State of Hawaii DLNR Division of Forestry and Wildlife provide additional data from which to evaluate the importance of these wetlands for waterbirds (DLNR 1986, 1987, 1988).

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 exposed intertidal reef, rocky shorelines, mud flats, lawns, plowed fields and pastures. 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 the 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). Forty eight plover were recorded over the duration of the survey. In addition 16 Ruddy Turnstone (Arenaria interpres) another common migrant which forages in fields, lawns and intertidal habitat, was recorded on the survey. Migratory ducks such as Northern Pintail (Anas acuta) and Northern Shoveler (Anas clypeata) are also known to occur in the Laie wetlands (DLNR 1986, 1987, 1988). No migratory waterfowl were found on this survey.

Resident Indigenous (Native) Birds:

A total of 29 Black-crowned Night Heron (Nycticorax nycticorax) were tallied on the survey. This species is the only native waterbird that is not listed as endangered. Night heron have probably increased in abundance in recent years as a result of the statewide development of the aquaculture industry (Hawaii Audubon Society 1989).

Resident Indigenous (Native) Seabirds:

No seabirds were observed on the property. The presence of predators renders this site unsuitable for nesting or roosting seabirds.

Exotic (Introduced) Birds:

A total of 20 species of exotic birds were recorded during the field survey (Table 1). The most abundant birds were: Japanese White-eye (Zosterops japonicus); Zebra Dove (Geopelia striata);

Spotted Dove (Streptopelia chinensis); Common Myna (Acridotheres tristis); Red-vented Bulbul (Pycnonotus cafer); Nutmeg Mannikin (Lonchura punctulata) and House Finch (Carpodacus mexicanus).

Based on the location and type of habitats found on the property as well as from data gathered elsewhere (Bruner 1989a, 1989b, 1989c, 1991a, 1991b; information provided in Pratt et al. 1987 and Hawaii Audubon Society 1989) the only expected exotic bird species not recorded on the survey was the Red Avadavat (Amandava amandava).

Feral Mammals:

Small Indian Mongoose (Herpestes auropunctatus) and feral cats were commonly observed. Evidence of feral pigs and dogs were also found. No trapping was conducted in order to assess the relative abundance of mammals.

Records of the endemic and endangered Hawaiian Hoary bat are sketchy, however, the species has been reported from Oahu (Tomich 1986; Kepler and Scott 1990). No bats were found on this survey.

CONCLUSION

A brief field survey such as this one can provide only a limited perspective of the wildlife which utilize the area. The

number and relative abundance of each species may vary throughout the year due to available food resources and reproductive success. Species which are migratory will quite obviously be found only at certain times during the year. Exotic species sometimes prosper only to later disappear or become a less significant part of the ecosystem (Williams 1987; Moulton et al. 1990). Thus only long term studies can provide a comprehensive view of the bird and mammal populations in a particular area. Nevertheless some general conclusions related to bird and mammal activity at this site can be drawn. The following comments summarize the findings of this survey:

1- All major habitats were visited and census stations were distributed along roads and trails so as to provide a reasonable sample from which relative estimates of bird populations could be derived.

2- The endemic waterbirds found on the survey have long been known to occur in this region (DLNR 1986, 1987, 1988). The Laie wetlands are censused for waterbirds on a quarterly basis by DLNR Division of Forestry and Wildlife. The Oahu population of the endemic Hawaiian Owl or Pueo is listed by the State of Hawaii as an endangered species. This species was not recorded on this survey. Pueo, however, are seen regularly, in the Kahuku area and likely do occur at Laie.

3- The number of migratory shorebirds recorded on the survey was comparable with data gathered on other surveys in this general

area (Bruner 1989a, 1989b, 1989c, 1991a, 1991b).

4- The property supports the typical array of exotic birds one would expect in this type of environment in Hawaii. Species such as Common Myna (Acridotheres tristis) and House Sparrow (Passer domesticus) should become even more abundant following urbanization.

5- In order to obtain more definitive data on mammals a trapping program would be required. The Hawaiian Hoary Bat was not recorded at this site.

6- The most important wildlife habitat at this site are the wetlands. These ponds, streams and flooded grasslands provide important habitat for endemic (Native) birds as well as migratory and introduced species.

Recommendations

1- All wetland habitat must be protected from any harmful effects of development. Degrading or destroying these wetlands is unacceptable.

2- Any specific development plans that might negatively impact on the wetlands should be discussed in advance with the USFWS.

3- I would recommend that no industrial or residential types of development be located near the wetlands. The potential for pollution and disturbance of the wildlife would be increased

by such developments. Parks and agricultural types of activity may be more compatible. Any development, however, should be separated from the wetland by a buffer of tall trees and brush. Wetlands should also be fenced to exclude predators.

4- Finally, the land owner of these wetlands should consider the possibility of either leasing or selling in fee these wetlands to the USFWS or to private groups like The Nature Conservancy. These organizations have the experience and ability to properly care for and manage wetlands.

TABLE 1

Exotic (introduced) birds recorded at Laie, Oahu

COMMON NAME	SCIENTIFIC NAME	RELATIVE ABUNDANCE*
Barn Owl	Tyto alba	R = 1
Cattle Egret	Bubulcus ibis	C = 9
Ring-necked Pheasant	Phasianus colchicus	R = 3
Rock Dove	Columba livia	R = 47
Spotted Dove	Streptopelia chinensis	A = 10
Zebra Dove	Geopelia striata	A = 14
Common Myna	Acridotheres tristis	A = 10
Red-vented Bulbul	Pycnonotus cafer	A = 15
Hwamei	Garrulax canorus	R = 2
White-rumped Shama	Copsychus malabaricus	C = 8
Northern Cardinal	Cardinalis cardinalis	C = 6
Red-crested Cardinal	Paroaria coronata	C = 7
Japanese Bush-warbler	Cettia diphone	C = 6
Japanese White-eye	Zosterops japonicus	A = 18
Chestnut Mannikin	Lonchura malacca	R = 14
Nutmeg Mannikin	Lonchura punctulata	A = 10
Common Waxbill	Estrilda astrild	R = 20
House Finch	Carpodacus mexicanus	A = 11
House Sparrow	Passer domesticus	R = 12
Java Sparrow	Padda oryzivora	R = 6

*(see page 12 for key to symbols)

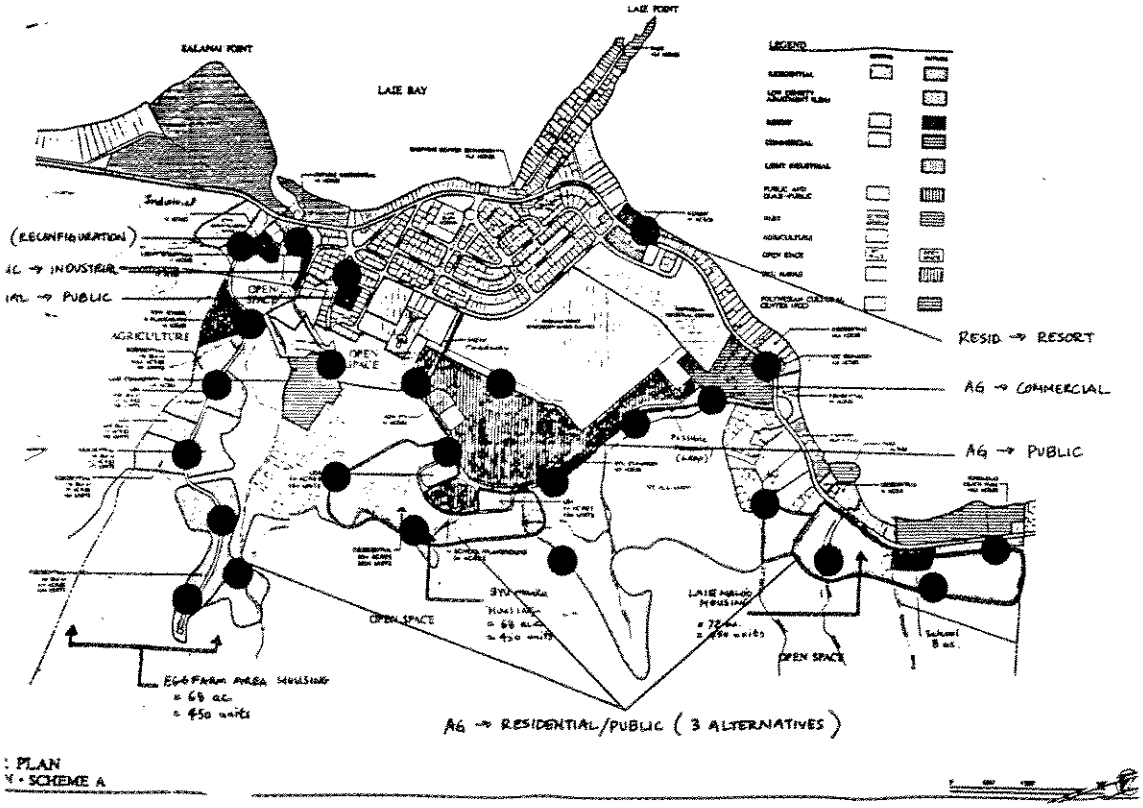

Fig. 1. Location of faunal survey with census stations shown as solid circles.

KEY TO TABLE 1

Relative (estimate) 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 or on one count only) number which follows is the total number seen or heard over the duration of the survey

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APPENDIX I

BIOLOGICAL STREAM RECONNAISSANCE

FOR THE KAHAWAINUI STREAM

LAIE, OAHU, HAWAII

Prepared For

Group 70
924 Bethel Street
Honolulu, Hawaii 96813-4398

BHP

Environmental Technologies International
P.O. Box 3379
Honolulu, Hawaii USA 96842

February 3, 1992
ETI Job No. 00406

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4 Riffle and pool habitat in reach 3.

5 Dry streambed with large boulders in reach 4.

6 Intermittent pool surrounded by long stretches of dry streambed in reach 4.

7 'O'opu nakea collected in reach 3.

I. INTRODUCTION

Environmental Technologies International was retained by Group 70 to perform a biological stream reconnaissance in the Kahawainui Stream, Oahu. The objective of this biological survey was to qualitatively describe aquatic organisms found in the Kahawainui Stream from its origin to the ocean. This survey separated the stream into four reaches and identified aquatic vertebrates and invertebrates found within Kahawainui Stream. Personnel conducting this survey were Ron Englund and Lisa Cody.

II. STUDY SITE

Kahawainui Stream originates in the Koolau mountain range in northern Oahu, near the town of Laie. The Kahawainui Stream was separated into four major reaches based on stream gradient, channel morphology, and elevation (Figure 1). Reach 1 ran the length of the concrete flood control structure beginning at the ocean and continuing upstream to the cemetery (Figure 2). Reach 2 began where the concrete flood control structure ended and the confluence of Laiewai Stream with Kahawainui Stream (Figure 3). Reach 2 continued upstream past the aquaculture ponds. Reach 3 began where the channelization was not as apparent, and continued until water flow in the stream ceased (Figure 4). Reach 4 was mostly dry stream bed with large 2-4 ft. boulders, and contained occasional pools in the streambed (Figures 5 and 6). The highest elevation surveyed in reach 4 was approximately 400 feet above sea level, and the stream appeared to be dry except during freshets at this elevation. Reach 1 flowed through Laie, reaches 2 and 3 drained agricultural land, and reach 4 drained undeveloped land.

III. METHODS

Visual observations were made along the Kahawainui Stream for the entire length of all four reaches. Snorkel observations and netting verified visual fish species identification. Aquatic invertebrates were collected in riffles with one person holding a fine meshed net while another person upstream disturbed the stream bottom. Invertebrates were preserved in alcohol after removal from nets while all captured fish were released. Adult damselflies were captured with nets and placed in ziploc bags. Damselflies were later taken to the Bishop Museum and identified by Dan Polhemus, aquatic entomologist.

IV. RESULTS

The Kahawainui Stream reconnaissance survey was conducted on January 24 and 28, 1992. Stream flow conditions were low, with an estimated stream flow of 1-2 cfs. Due to low stream flow and good water clarity the entire stream could be visually

surveyed. The following are results of the different aquatic organisms observed in Kahawainui Stream, and are summarized in Table 1.

A. FISH:

Three of the five native 'o'opu fish species were observed in the Kahawainui Stream: 'o'opu 'akupa (*Eleotris sandwicensis*), 'o'opu nakea (*Awaous stamineus*), and 'o'opu naniha (*Stenogobius genivittatus*) (Table 1). A healthy 'o'opu nakea collected in the Kahawainui Stream is shown in Figure 7. Additionally, hinana (post-larval 'o'opu) were abundant in the Kahawainui stream, indicating successful recruitment. The hinana appeared to be 'o'opu nakea and ranged in size from < 1/2 to 3/4 inches long. 'O'opu were common in reaches 1-3, with 'o'opu nakea being the most abundant native species. Alien fish species such as tilapia (*Tilapia mossambica*), mosquitofish (*Gambusia affinis*), and the green swordtail (*Xiphophorus helleri*) were also common throughout Kahawainui Stream.

Continuous stream flow ceased at the beginning of reach 4, and intermittent pools up to three feet deep contained only *Macrobrachium lar* and mosquitofish. Approximately 1/4 mile upstream of the beginning of reach 4, the deep intermittent pools ceased. Further upstream occasional small puddles 3-6 inches deep were observed, as well as intermittent wetting of the streambed, and no fish or macroinvertebrates were observed. By the end of reach 4 the streambed was 1-2 feet wide and water appears to flow only during heavy freshets.

B. AQUATIC INSECTS:

Aquatic insect numbers appear to be low in the Kahawainui Stream. Ten benthic kick samples in riffles collected only one caddisfly larva (*Cheumatopsyche analis*), and no other aquatic insects. Damselfly populations of the endemic genus *Megalagrion* are currently low and concern exists about their continued survival in Oahu (Howarth and Polhemus, In Press). During this survey, no species of this genus were either captured or visually sighted in the area of the Kahawainui stream. No larval damselflies in the family Coenagrionidae were collected, but three adult *Ischnura ramburi* were collected (Polhemus, 1992). *I. ramburi* is an introduced damselfly species from western North America (Howarth and Polhemus, In Press).

C. CRUSTACEA:

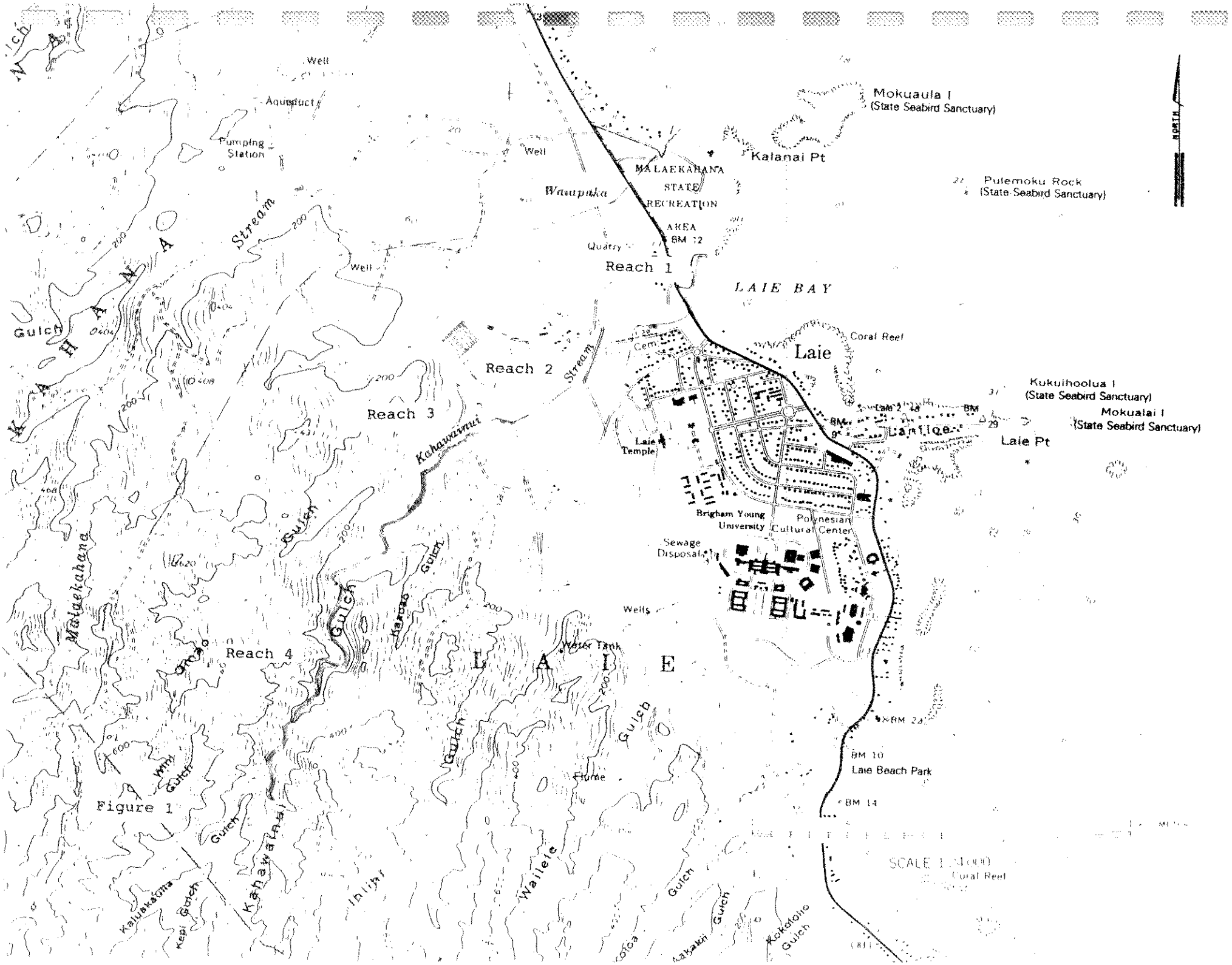
Macrobrachium lar, or the Tahitian prawn was common throughout Kahawainui Stream. *M. lar* juveniles (< 1 inch) were also collected in almost all kick net samples.

D. GASTROPODA:

Two species of snails were collected in the Kahawainui Stream riparian zone, the apple or taro snail (*Pomacea canaliculata*) and the carnivorous land snail (*Euglandina rosea*). The specimen of *P. canaliculata* was deposited in the Bishop Museum collection. Native neritids and the alien *Corbicula* were not observed.

CONCLUSIONS

A biological reconnaissance of the Kahawainui Stream from the ocean to its origin found three of the five indigenous Hawaiian 'o'opu fish species. Native fish species inhabiting the Kahawainui Stream are 'o'opu nakea, 'o'opu naniha, and 'o'opu akupa. The 'o'opu nakea appears to be successfully recruiting to this stream as post-larval hinana were also abundant. Introduced fish species observed were mosquitofish, tilapia, and green swordtail. No endemic damselflies were captured or visually sighted. Aquatic insect diversity and numbers were extremely low throughout the entire Kahawainui Stream.



Mokuaula I
(State Seabird Sanctuary)
Kalanai Pt
Pulemoku Rock
(State Seabird Sanctuary)
MALAEKAHANA
STATE
RECREATION
AREA
BM 12
Quarry
Reach 1
LAIE BAY
Coral Reef
Laie
Kukuihoolua I
(State Seabird Sanctuary)
Mokualai I
(State Seabird Sanctuary)
Laie Pt
Laie Temple
Brigham Young
University
Polynesian
Cultural Center
Sewage
Disposal
Wells
Water Tank
Reach 2
Reach 3
Reach 4
Kahawainui
Stream
Gulch
Malaekahana
Kahawainui
Ihiihi
Wailele
Flume
Kokololio
Gulch
Kepi Gulch
Kaluakauna
Wini Gulch
Aqueduct
Pumping
Station
Well
Figure 1
BM 10
Laie Beach Park
BM 14
NORTH

Figure 2. Concrete flood control structure in reach 1.

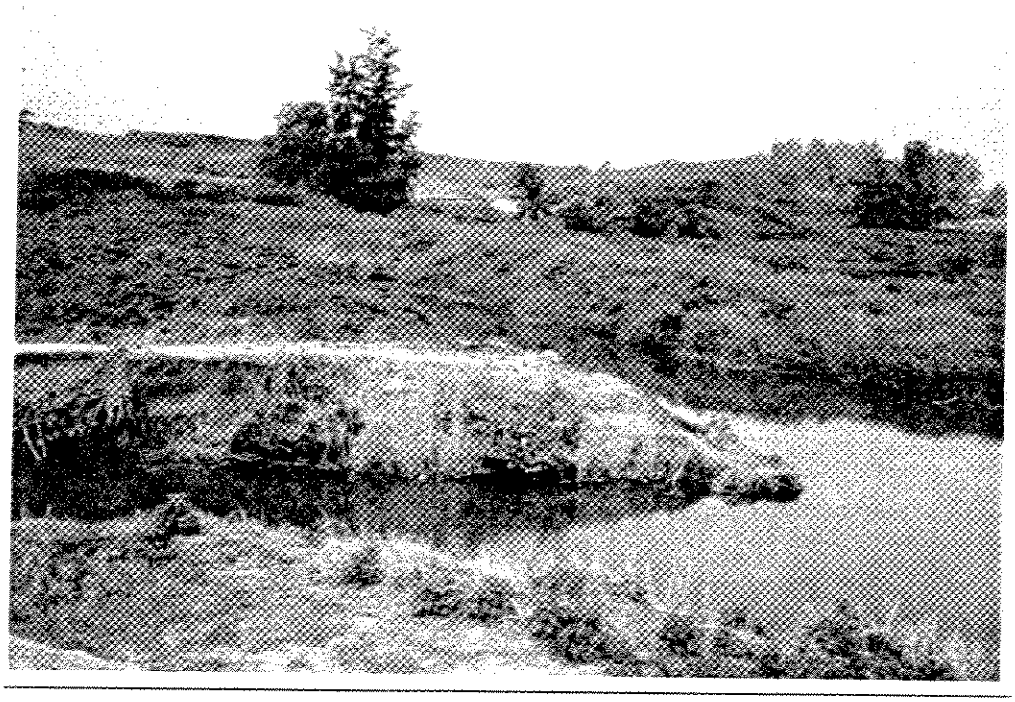


Figure 3. The confluence of Laiewai Stream and Kahawainui Stream showing channelized stream banks in reach 2

Figure 4. Riffle and pool habitat in reach 3.

Figure 5. Dry streambed with large boulders in reach 4.

A450F4 5 406

Figure 6. Intermittent pool surrounded by long stretches of dry streambed in reach 4.

Figure 7. 'O'opu nakea collected in reach 3.
A450F6 7 406

Table 1. Macrofauna observed in the Kahawainui Stream, January 24 and 28, 1992.

Scientific Name	Common Name	Biogeographical Status[1]
Fish		
Eleotris sandwicensis	'o'opu 'akupa	Endemic
Stenogobius genivittatus	'o'opu naniha	Indigenous
Awaous stamineus	'o'opu nakea	Endemic
Tilapia mossambica	tilapia	Introduced
Gambusia affinis	mosquitofish	Introduced
Xiphophorus helleri	green swordtail	Introduced
Crustacea		
Macrobrachium lar	Tahitian prawn	Introduced
Gastropoda		
Pomacea canaliculata	apple snail	Introduced
Euglandina rosea	carnivorous land snail	Introduced

[1](Kinzie 1990)

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ADDENDUM

STATUS OF NATIVE FISHES FOUND WITHIN THE KAHAWAINUI STREAM

None of the native endemic 'o'opu found within the Kahawainui Stream are currently listed as threatened or endangered by the Federal Government. One 'o'opu species that is under consideration for being listed as an endangered species by the U.S. Fish & Wildlife Service is *Lentipes concolor*. *L. concolor* is listed as threatened by the American Fisheries Society (Deacon et al. 1979), and is currently a Category One endangered species candidate (Dodd et al. 1985). However, this fish was not found in the Kahawainui Stream, and usually is found in streams at higher elevations and with with steeper gradients than those occurring in the Kahawainui Stream. It is unlikely that *L. concolor* would inhabit the Kahawainui Stream due to unsuitable habitat, poor water quality, and its preference for undisturbed and higher elevation streams (Kinzie, 1990).

BIOLOGY OF THE NATIVE HAWAIIAN FRESHWATER STREAM FISH

Five species of native freshwater 'o'opu (gobies) inhabit Hawaiian freshwater streams. Four of the five 'o'opu species are endemic, or only found in the Hawaiian islands (Kinzie, 1990). 'O'opu have an amphidromous life cycle which means that these fish migrate to and from the sea but do not use the ocean for reproduction (Meyers, 1949). Amphidromous fish spend their entire adult lives in freshwater streams and migrate downstream to spawn close to estuaries. Spawning runs downstream are believed to be triggered by the first large rainstorm in the fall. Eggs are laid in freshwater on the upper surfaces of rocks and a large female 'o'opu nakea (*Awaous stamineus*) can lay up to 1.5 million eggs (Ego, 1956). Eggs hatch within 48 hours and the fry drift out to the ocean, spending up to 160 days as planktonic larvae. Returning postlarval 'o'opu are called hinana and may ascend freshwater streams in great numbers. Some 'o'opu are also able to climb waterfalls and areas of rapids in streams. *L. concolor* is a strong climber and uses a modified pectoral fin to ascend waterfalls as high 300 feet, or a series of falls 1000 feet high (Maciolek, 1977).
Only streams having a perennial (permanent) flow regime or seasonal (intermittent, i.e. flows during rainy season) will be inhabited by 'o'opu. Streams having the lower elevations severely modified by channel alterations, water diversions, and poor water quality are generally unsuitable for the more sensitive 'o'opu species (Kinzie, 1990). Most likely the sensitive species such as 'o'opu alamo'o (*L. concolor*) or 'o'opu nopili (*Sicyopterus stimpsoni*) were not found in the Kahawainui Stream due to human disturbance in the watershed. Both of these 'o'opu species are currently extirpated or rare on Oahu (Kinzie, 1990).

PRECAUTIONS/RECOMMENDATION

The major ecological requirements for the 'o'opu species found in the Kahawainui Stream are the necessity of a marine planktonic larval stage and the need to pass through a stream mouth two times in each individuals life (Kinzie, 1990). Obstructions or obstacles blocking fish access to and from the ocean would be detrimental to the fish population. Any reduction in stream flow in the Kahawainui Stream would most likely be detrimental to the 'o'opu populations as agricultural diversions appear to have already reduced streamflow. Further requirements are areas in the stream containing rocks close to the estuary. Increases in sedimentation due to further development would also impair 'o'opu reproductive success as large rocks or stones are required for spawning (Ego, 1956).

Increased urban development in the Kahawainui Stream watershed will have the effect of decreasing rainwater infiltration, lowering the baseflow and increasing water temperature in the stream. Due to the increased area of sealed surfaces in a development, the flooding potential will increase. A net effect of increased flooding and decreased low stream flow could occur, and reductions in flow are generally believed to be harmful to native Hawaiian fishes. Tolerances of the different 'o'opu species to specific water quality parameters (i.e. temperature, dissolved oxygen, heavy metals, oil, ammonia) are presently not well known.

The initial clearing of land during development has the potential to increase sedimentation to a point to render a stream unsuitable for native fish. Precautions could be taken to reduce sedimentation during construction. Keeping heavy equipment away from the stream area, maintaining a buffer zone around the stream, and sediment catch-basins or berms will reduce sedimentation during construction. Revegetation of the riparian zone (streamside area) with native Hawaiian plants immediately after construction would also reduce sedimentation, lower stream water temperatures, and increase cover for native fishes. Revegetation of the riparian zone with certain alien plants such as bamboo, ironwood and other alien species can be detrimental and actually increase sedimentation (Julie Ishiki, Hawaii DLNR personal comm.).

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APPENDIX J

Report 878-012292

Archaeological Inventory Survey
Laie Master Plan Project

Lands of Malaekahana and Laie
Koolauloa District, Island of Oahu

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 878-012292

Archaeological Inventory Survey
Laie Master Plan Project

Lands of Malaekahana and Laie
Koolauloa District, Island of Oahu

by

Amy E. Dunn
Project Supervisor

and

Paul H. Rosendahl, Ph.D.
Principal Archaeologist

Prepared for

Group 70 International, Inc.
924 Bethel Street
Honolulu, Hawaii 96813

April 1992

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. Jeffrey H. Overton of Group 70 International, Inc., for their client, Zion Securities Corporation, Paul H. Rosendahl, Ph.D., Inc. (PHRI) recently carried out an archaeological inventory survey of the approximately 393-acre Laie Master Plan Project site, located in the Lands of Malaekahana and Laie, Koolauloa District, Island of Oahu. The overall objective of the survey was to provide information sufficient for the preparation of an Environmental Impact Statement (EIS).

The field work for the project was conducted December 10, 1991 through January 17, 1992, under the supervision of Supervisory Archaeologist Amy E. Dunn and Crew Chief Jeffrey Putzi. Assisting on the project were Matt Steinkamp, Steve Duncan, Joe Farrugia, Gemma Mahalchick, and Karl Kleinbach. Hawaii Projects Director Alan T. Walker, B.A., and Principal Archaeologist Dr. Paul H. Rosendahl provided overall direction for the project.

During the field work, 23 sites consisting of 121+ features were identified. Of the 23 sites, 17 consisting of 109+ features were identified within the project area boundaries, and the remaining six sites, consisting of 12 features, were identified outside and adjacent to the boundaries. The sites were in poor to good condition and consisted of both single and multiple features. The sites comprised the following formal types: cave, cemetery, circular alignment, cupboard, ditch, ditch-tunnel, enclosure, foundation, modified bedrock, modified crevice, mound, overhang, paved area, platform, pond field, retaining wall, rubble concentration, soil berm, soil mound, subsurface deposit, terrace, terrace-wall, upright stone, wall, wall remnant, and wall segment. The feature types comprised the following functional types: agriculture, boundary, burial, dozer push, erosion control, erosion control-fenceline, habitation, indeterminate, irrigation, marker, possible agriculture, possible burial, possible habitation, possible storage area, storage, temporary habitation, temporary habitation-possible burial, and temporary habitation-burial.

As part of the field work, 13 test units and six shovel tests, together totaling 9.0 square meters, were excavated at 14 features within eight sites. These excavations were placed in order to ascertain whether the features contained cultural deposits, and in order to collect dating samples. In addition to the test units and shovel tests, 27 backhoe trenches were placed within or close to Land Commission Award (LCA) plots, and throughout the project area, where subsurface deposits were suspect. The trenches were placed in order to obtain pollen samples and to test for cultural deposits.

During the current testing, 244 artifacts were collected, of which 15 were indigenous. The artifacts included basalt flakes, a basalt core, an *'ulu-maika* stone, adze preforms, and various historic items. Also collected were 17 samples of charcoal, of which seven were submitted for age determination analysis, and 12 pollen samples, of which eight were submitted for sediment, pollen, and dating analyses.

Based on the findings of the inventory survey, 16 sites are assessed as significant solely for information content (one other site, 277-Paeo Fishpond, is assessed as significant for information content even though it was not relocated during the current survey). No further work is recommended for eight of the 16 sites. The data collected from them during the present survey is considered sufficient recovery of significant information. Further data collection is recommended for the remaining eight sites. After further data collection is completed, data recovery excavations at specific sites—if warranted by the data collection findings—would be implemented for the sites not recommended for preservation or interpretation. Because they are not good examples of site types, preservation of these sites subsequent to mitigation would not be essential.

Three sites (4465, 4468, 4472) are assessed as significant for information content and cultural value. Further data collection followed by preservation "as is" is recommended for these sites.

Two sites are assessed as significant for information content and are provisionally assessed as being excellent site types. Further data collection followed by provisional preservation with interpretive development is recommended.

One site is assessed as significant for information content and as possibly significant for cultural value (pending additional historical documentary research). Further data collection is recommended, and preservation with interpretive development is provisionally recommended pending the results of further data collection.

One site is assessed as significant for information content and as possibly significant for cultural value. Further data collection is recommended, and preservation "as is" is provisionally recommended pending the results of further data collection.

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INTRODUCTION

BACKGROUND

At the request of Mr. Jeffrey H. Overton of Group 70, for their client, Zion Securities Corporation, Paul H. Rosendahl, Ph.D., Inc. (PHRI) recently carried out an archaeological inventory survey of the approximately 393-acre Laie Master Plan Project site, located in the Lands of Malaekahana and Laie, Koolauloa District, Island of Oahu. The overall objective of the survey was to provide information sufficient for the preparation of an Environmental Impact Statement (EIS).

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SCOPE OF WORK

The basic purpose of an inventory survey is to identify all sites and features of potential archaeological significance within a specified project area. An inventory survey comprises an initial level of archaeological investigation. It is conducted basically to determine the presence or absence of archaeological resources. It 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 such further work as might be necessary. Such work could include further data collection—additional data collection involving detailed recording of sites and features, and selected limited excavations; and possibly subsequent mitigation—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 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 proposed development upon the identified remains; and (d) to define the general scope of any subsequent further data collection and/or other mitigation work that might be necessary.

Based on a review of readily available background literature, extensive familiarity with both the general project area and current requirements of review authorities, and based on discussions with Mr. Overton of Group 70, the following specific tasks were determined to constitute an adequate scope of work for the inventory survey:

1. Review archaeological and historical literature relevant to the project area, and conduct limited historical documentary research (emphasis on readily available literature and documentary sources); also, interview local informants;

2. Conduct 100%-coverage, variable-intensity ground survey of the project area, with (a) greater emphasis given to undisturbed lands, and (b) lesser emphasis given to lands disturbed by earth moving;

3. Conduct limited subsurface testing of selected sites and features in 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 field and historical research data, and prepare appropriate reports.

The inventory survey was carried out in accordance with the standards for inventory-level survey recommended by DLNR-SHPD. The significance of all archaeological remains identified within the project area were assessed in terms of (a) the National Register criteria contained in the Code of Federal Regulations (36 CFR Part 60), and (b) the criteria for evaluation of traditional cultural values prepared by the national Advisory Council on Historic Preservation. DLNR-SHPD and HCPD both use these criteria to evaluate eligibility for both the Hawaii State and National Register of Historic Places.

To further facilitate client management decisions regarding the subsequent treatment of resources, the general significance of all archaeological remains identified during the survey were also evaluated in terms of three cultural resource management value modes which are derived from the previously mentioned federal evaluation criteria. These value modes and the federal criteria are discussed in detail in the Conclusion section.

PROJECT AREA DESCRIPTION

The project area consists of 11 parcels scattered throughout Laie town (Parcels A-K, Figure 1). The parcels total c. 393 acres and are located on the coast to 6,600 ft inland of the coast. Elevations of the parcels range from 5-200 ft AMSL (above mean sea level).

Parcel A is triangular and consists of c. 0.3 acres. At the time of the survey the parcel was the site of TT's Surf Shop and Cackle Fresh Farm's egg store. The parcel is bounded on the east by Kamehameha Highway, on the west by Wahinepe'e Street, on the north by the junction of Kamehameha Highway and Wahinepe'e Street, and on the south by a row of palm trees extending west off of Kamehameha Highway, located just north of the Flood Control Structure.

Parcel B, a c. 16-acre parcel, is west of Parcel A and is separated from Parcel A by private property held by Walter Tashiro. The parcel is bounded on the north and west by a dirt road leading back to Cackle Fresh Farm and private residences, and on the south by the Flood Control Structure and Kahawainui Stream.

Parcel C consists of c. 52 acres. At the time of the survey the parcel was the site for Cackle Fresh Farm, and included pasture land, the farm employee's housing, and farm fields cultivated in cucumber and papaya. The parcel is bounded on the northwest by the *ahupua'a* boundary between Laie and Malaekahana, on the southwest by a limestone escarpment immediately southwest of the Cackle Fresh Farm chicken barns, and on the northeast by a western tributary of Kahawainui Stream. On the northeast boundary of this parcel is a dirt road leading back to Cackle Fresh Farm. The southeast boundary of the parcel is c. 600 ft northwest of Kahawainui Stream and c. 400 ft southeast of the Cackle Fresh Farm chicken barns.

Parcel D is roughly triangular and consists of c. 24 acres. The northeast side of the parcel is bounded by a western tributary of Kahawainui Stream and is across from the limestone escarpment which defines the southwest boundary of Parcel C. The southeast boundary is defined by Kawainui Stream and Omao Gulch. The northwest boundary is c. 450 ft northwest of Omao Gulch and c. 400-1,100 ft northwest of Kawainui Stream. At the time of the current survey the parcel had been altered by mass erosion at higher elevations, and by agricultural activities at the lower elevations.

Parcel E consists of c. 2 acres, and at the time of the current survey it was occupied by buildings. The parcel is bounded on the north by the Flood Control Structure, on the west by Laiewai Stream, and on the south by Wahinepe'e Street. The parcel's east boundary is c. 300 ft southwest of Kamehameha Highway.

Parcel F consists of c. 3.6 acres and is within the residential area of Laie. At the time of the current survey the parcel consisted of a park with a basketball court and a baseball field. The parcel is bounded on the north by Poohaili Street, and on the east, west, and south by residential housing (on the south specifically by houses facing Lanihuli Street).

Parcel G consists of c. 71 acres. At the time of the current survey almost the entire parcel was planted in papaya and banana. The parcel is generally bounded on the north by wet lands and aquaculture ponds, on the east by the Laie Sewer Treatment Plant and Quarry, on the south by a reservoir and sloping foothills of the Koolau Mountains, and on the west by the sloping foothills of the Koolau Mountains.

Parcel H consists of c. 119 acres and at the time of the current survey was occupied by Brigham Young University (BYU) housing, a junkyard, a baseball field, a quarry, the Laie Sewer Treatment Plant, and cultivated papaya and banana fields. In general, the north and east boundaries are defined by the Polynesian Culture Center, the BYU Campus, and Kamehameha Highway. The south is generally bounded by Wailele Stream, and the west is bounded by wetlands and Parcel G.

Parcel I consists of c. 0.5 acres and is within the residential area of Laie. At the time of the current survey the parcel was occupied by a resident. The parcel is bounded on the northeast by Kamehameha Highway, on the northwest by Laie Shopping Center, and on the southeast and southwest by residences.

Parcel J consists of c. 2.6 acres and is within the residential area of Laie. At the time of the current survey it was occupied by several residences. To the north and south of the parcel are adjacent, occupied residences. On the east the parcel is bounded by the coastline, and on the west it is bounded by Kamehameha Highway and Naniloa Loop.

Parcel K consists of c. 70 acres, and in general is located at the southeast of Laie between Laiemaloa Stream and Hauula Shopping Center. The parcel is bounded on the northeast by Kamehameha Highway, on the northwest by Laiemaloa Stream and *kuleana* land, on the southwest by the foothills of the Koolau Mountains, and on the southeast by open pasture land adjacent to Hauula Shopping Center.

The project area is on the north shore of Oahu and as such is exposed to the prevailing northeasterly winds, which blow

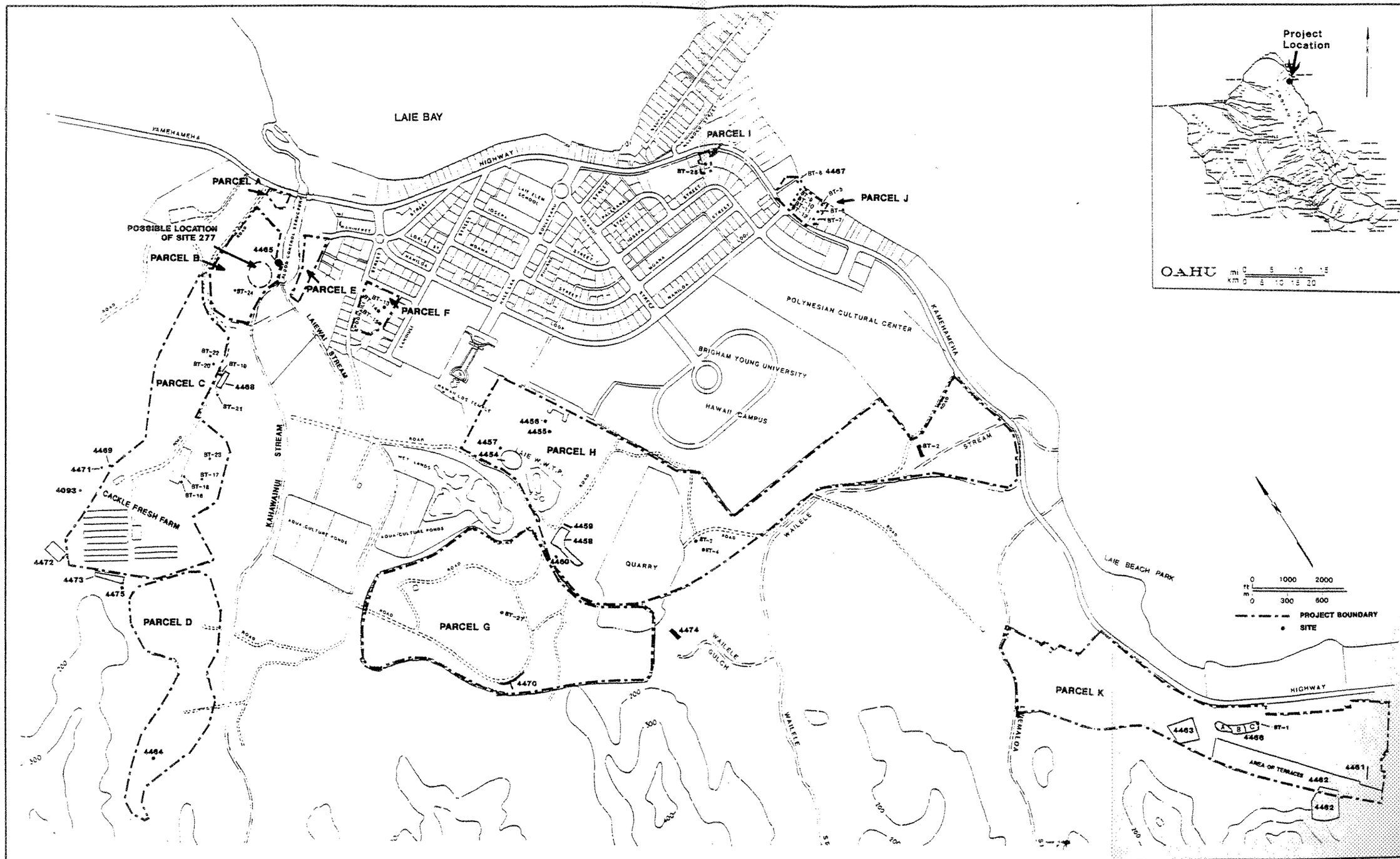

Figure 1. PROJECT AREA AND SITE LOCATION MAP

at an average 18 knots. Temperature in the area is 65-85 degrees F., and the average annual rainfall is approximately 45-50 inches (Armstrong 1973:63-65). Numerous streams and gulches run through or are close to the various parcels. At the time of the current survey there was running or standing water within Kahawainui Stream and Kokololio Gulch. An important source of fresh water for the area are underground springs located beneath the northwest portion of the project area.

Most of the parcels have been historically cleared of natural vegetation and planted in sugar cane (*Saccharum officinarum*). Soils in these areas are dominated by silty clays from the Paumalu, Haleiwa, and Lahaina series, with isolated areas of stony clay from the Kaena series. In various areas are exposed coral reef escarpments capped with silty clays or a thin layer of friable, red soil concentrated in cracks, crevices, and depressions (Foote et al. 1972). At the time of the current survey, the fields previously planted in sugar cane had been replaced primarily by fields of banana (*Musa* sp.), papaya (*Carica papaya* L.), and cucumber. In those areas previously planted in sugar cane but more recently abandoned, a variety of vegetation thrived. Most noticeable were dense stands of immature *koa-haole* (*Leucaena glauca* [L.] Benth.), *lilikoi* (*Passiflora* sp.), morning glory (*Ipomoea congesta* R.Br.), tree heliotrope (*Messerchimidia argentea* [L.f.] Johnston), Christmas-berry (*Schinus terebinthifolus* Raddi), dense thickets of lantana (*Lantana camera* L.), a variety of small shrubs, various grasses, and occasional stands of fallow sugar cane. Large mango trees (*Manifera indica* L.), Java plum (*Eugenia cuminii* [L.] Druce.), Chinese banyan (*Ficus microcarpa* L. F.), octopus tree (*Brassia actinophylla* Endl.), *hau* (*Hibiscus tiliaceus* L.), *ti* (*Cordyline terminalus* [L.] Kunth), *'ape* (*Alocasia macrorrhiza* [L.]), ironwood tree (*Casuarina equestifolia* L.), guava (*Psidium guajava* L.), strawberry guava (*Psidium cattleianum* Sabine), and *Kukui* (*Aleurites moluccana*) were present along the gulches and in those areas which do not appear to have been heavily affected by more recent agricultural activity.

PREVIOUS ARCHAEOLOGICAL WORK

Previous archaeological work within and in the vicinity of the project area consists of reconnaissance surveys, subsurface testing, and data recovery work.

The earliest documented research is the 1930 survey of Oahu by McAllister (1933), at which time McAllister identified 12 sites within the Ahupua`a of Laie. Of these 12 sites, three (274, 277, and 281) are designated as Archaeological Sites, one (5) is designated as a Building, and six (276, 278, 279, 282, 283, and 285) are designated as Destroyed or Non-Archaeological Sites. In addition to the above sites McAllister describes two sites—280 and 284. The description of Site 280 states that the Land of Laie was formally a place of refuge, based on information gathered from the local residents of Laie. Site 284 is described as a narrow strip of land extending into the ocean from Laie, often mentioned in Hawaiian tradition (McAllister 1933;156-158).

Sites 274 and 285 (Kaikukuuna) are designated as fishing shrines. Sites 281 (Nioi) and 283 (Moohekili) are designated as *heiau*. Site 5 is designated as a building, the Mormon Temple. Site 276 (Waikuukuu) is described as a cave containing water affected by the tide. Site 277 is designated as Paeo fishpond, associated with Hawaiian legend. Site 278 (Hanapepe) is described as a sacred place where a female fish god, Kamehaikana, was worshiped. Site 279 is described as a tunnel through which Manonihokahi once passed through in going to the sea, and is associated with Hawaiian legend. Site 282 is described as a famous taro land.

Of the above sites, Site 277, Paeo fishpond, appears to have been within the current project area. McAllister described this site as being a fishpond on the mountain side of the old bridge, on the Kahuku side of Laie. Associated with the pond, on the Kahuku bank, is a chalice-shaped stone about three feet high where *Hauwahine*, the goddess (*Mo'o*) of the pond is said to have been. The exact former location of the site is not known. During the current project the general area of the site was surveyed, but no evidence of the site was found. In the future, systematic subsurface testing should be conducted to locate the pond and recover information from it.

A substantial archaeological excavation program was undertaken during the late 1970s at Malaekahana State Recreation Area (Yent and Estioko-Griffin 1980). The research involved reconnaissance, testing, and mitigative-level excavations at several sites in the extensive dune formation fronting Malaekahana and Laie Bays. The excavations revealed three major cultural occupations dating to the late prehistoric period (between c.AD 1600 and 1780). Each of the three occupations were stratigraphically and temporally distinct, and suggested an increase in the local population and expansion in the subsistence base over time. In addition, the presence of terrestrial products coupled with certain changes in settlement pattern indicated greater reliance on inland products concomitantly with increased sedentism through time. Preservation of the archaeological resources and the natural coastal environment was recommended (Yent and Estioko-Griffin 1980:430)

Additional archaeological field work was conducted at Malaekahana State Recreation Area in 1981 (Yent and Ota 1982). The field work was done as part of the Phase II (TMK:5-6-01:24,45-47,49,51,53,55-65) portion of the overall project area, and was seen as a continuation of the previous work conducted by Yent and Estioko-Griffin (Phase I; completed in 1980). The additional field work was conducted in anticipation of the removal and demolition of the houses that were present within the project area. Twenty-two auger cores were placed around the houses, in areas suspected to contain buried cultural deposits. Cultural deposits were found at the coastal portion of the project area near Malaekahana Stream, but were absent elsewhere. Based on the findings, and in comparison to the findings during Phase I, it was judged that the Phase II portion was not occupied extensively or intensively. Archaeological monitoring was recommended during the house demolition and removal precess.

An intensive subsurface reconnaissance survey was conducted at Laie Beach Park (Connolly 1980) as a follow-up to a prior archaeological reconnaissance survey completed by Clark in 1979. During the Clark (1979) survey two features were identified, a mound and a faced terrace. Connolly's work included the excavation of 13 test pits and c. 81 auger holes throughout the park. The excavations revealed 15 features, primarily firepits and undistinguished pits, and three possible postmolds. The findings of the excavations suggested that the area was used for temporary rather than permanent habitation, and that the habitation, in several cases, was historic. Preservation "as is" was recommended for the above project area.

An archaeological reconnaissance survey of the Flood Control Study Area, Kahawainui Stream in Laie was conducted by Ahlo and Hommon (1981). Their project area was divided into three study areas (A, B, and C), of which Area B is partially within the current project area (designated as Parcel B). During the study, two sites were identified, both within Area B. The first was a concrete *torii* determined to be a remnant of a Shinto temple. The second site was a small fenced enclosure containing at least six and possibly more grave sites and an historic trash dump. Reference was made to Paeo fishpond, McAllister Site 277; the pond was determined to have been filled in, the surface evidence destroyed by municipal, military, and other refuse dumping. Ahlo and Hommon concluded that "No archaeological evidence or material of any significance was found in the project area.

In response to the work conducted by Ahlo and Hommon (1981), Earl Neller (DLNR Staff Archaeologist) and David Cox (U.S. Army Corps of Engineers, Archaeology Technician) conducted an informal inspection of the project area (Neller 1984), based on Neller's review and differences of opinion with Ahlo in regard to the two sites. In addition to those sites identified by Ahlo and Hommon, Neller identified a late 19th century house ruin, the remains of a Japanese plantation camp and an unmarked Japanese cemetery, a portion of the 19th century railroad bed of the Oahu Railway and Land Company, which is on the National Register in other areas, and a possible prehistoric *auwai*.

Relevant to the current project area is Neller's inspection of the grave sites and historic trash dump, and his comments on Paeo fishpond. The first site was found to contain features additional to those identified by Ahlo and Hommon. The fenced area was found to contain at least 16 graves. In addition to the fenced area of graves, Neller identified two concrete crypts located on the remnants of a house platform or foundation and possibly associated with the nearby historic trash deposit where he recovered 19th century bowl fragments. The headstone inscription on one of the concrete crypts was translated by Neller as follows (1984:10):

> Mr. Kuliamokuiki
> Hanauiama Kohala [born in Kohala]
> Hawaii Nov. 17 1880
> Make Makahuku [died at Kahuku]
> Mar 25 1920

Neller suggested that if the deceased was the occupant of the former house site, then the site was more likely occupied by Hawaiians who had been converted to Christianity.

Neller stated that the exact location of Paeo pond was unknown, so therefore the reference by Ahlo and Hommon that the site was destroyed and had no significance was unfounded. Neller suggested the site area required further data collection in the way of extensive archaeological excavations. (It is also recommended in this report that further testing be conducted to identify the location, condition, and integrity of the site; the site will be discussed later in this report.) Neller also concluded that the project area contained archaeological sites significant for their information content, as well as significant cultural resources.

Dale L. Berge, Professor of Anthropology at Brigham Young University in Provo, Utah, mentions in correspondence that in 1984 he "partially excavated the remains of the Laie Plantation sugar mill and discovered an ancient Hawaiian site nearby. In addition to the mill and site, Berge mentions he found *heiau* walls and a fishpond located "just north of the sugar mill site." The area described as a fishpond by Berge is presently a low, swampy area directly inland of BYU married student housing. This area may have been modified during development of the university. To date, Berge has not prepared a final report of his findings. Mr. Ken Baldrich, a

professor at Brigham Young University in Laie, who is familiar with Dr. Berge's work, described the location and components of Berge's work via the telephone. According to Mr. Baldrich, Berge uncovered the subsurface remains of the Laie Plantation sugar mill, located in a currently cultivated banana field, c. 60-80 yards west of the ceramic studio on the BYU campus.

The sugar mill site excavations were apparently back filled; during the current survey no evidence of the site was visible in the area indicated by Baldrich. In regards to the "ancient Hawaiian site," Berge describes it thus: "on the surface were hundreds of sea shells, plus a few small adzes, fish hooks, and other artifact fragments." Upon discussing this particular site with Mr. Baldrich, it appears to be the site identified during the current survey as Site 4458, but the artifacts were not observed at the site. As for the "rock walls of a heiau and a fishpond" identified by Berge, no positive correlations can be made between those sites and the current sites until more detailed information is received. The only wall identified during the current survey near the supposed location of Berge's wall is Site 4454. It should be noted that Berge has submitted a proposal for preservation to BYU, in regards to the mill, heiau rock walls, fishpond, and ancient Hawaiian sites. It should also be noted that a 1951 aerial photograph of the area that Berge identified as containing the walls and fishpond, is shown as planted in sugar cane.

Also of particular relevance to the present project area is Bath's 1985 testing and mapping at Kahawainui Stream in Laie (TMK:5-5-05 and -09). During the field work six test units and 12 auger holes were excavated. Also, two graveyards, a limestone escarpment face, and all surface features were mapped. A total of five surface features were identified—two graveyards, an alignment, a solution cave, and a small mound. The excavations revealed a prehistoric subsurface layer dating to AD 1415-1645; the layer was partially disturbed and was overlain by a historic deposit. The historic component seemed to be one of Hawaiian occupation, and not white Mormon missionaries or Chinese rice farmers. Preservation was recommended for the graveyards, while further data collection by means of excavation was recommended for the remaining features and deposits. Coring in the general, suspected area of Paeo fishpond was recommended to identify the pond's location.

In late 1988 through early 1989 PHRI conducted an inventory survey of c. 866 acres in the Koolauloa District of Oahu (Jensen 1989). The project area consisted of two parcels—one at Punamano near Kuilima Resort in the Lands of Ulupehupehu, Punalau, and Kahuku, and another near Laie town, in the Lands of Malaekahana and Laie. This second parcel is adjacent to the far northwest boundary of the current project area. During the 1988-1989 survey 26 sites containing 45 component features were identified within the overall project area. Formal feature types included caves, overhangs, walls, terraces and platforms, enclosures, isolated midden deposits, and historic components, including WWII emplacements, historic dumps, roads, and agricultural ditches. Functional types included habitation, burial, historic agriculture, and WWII activities. During the current survey one of the sites, 4093, was reidentified.

As part of the field work, three test units were excavated within three features at three sites to determine the presence/absence of cultural deposits, and to obtain dating samples for age determination analyses. Four dating samples were submitted for radiocarbon age determination analyses, two were contaminated with bomb C-14, but the remaining two samples yielded ranges of AD 1010-1375 and AD 1327-1617. In addition to the test units, 32 backhoe test trenches were excavated at the north-central portion of the Punamano project area. The objective of the trenching was to evaluate the subsurface deposits in the area for evidence of buried agricultural field deposits, field walls, other cultural features, and evidence that would confirm a *kuleana* holding that had been tentatively identified during the pre-field work research (LCA 4422:2). The data from the test trenches are still pending analyses.

Based on the above findings it was concluded that the overall project area was utilized both prehistorically and historically. The prehistoric sites appear to have been utilized primarily for habitation and burial, and from the two dates obtained, the overall occupation period was at least AD 1000-1600. The sites which were evaluated as historic comprised three distinct types—WWII coastal defenses, early ranching sites, and late 19th and early to mid-20th century sugar cane operation sites. Of the 26 sites identified, 23 were assessed as significant solely for information content, and for 13 of the 23 sites no further work was recommended. For the remaining 10 of the 23 sites, further data collection was recommended. Of the remaining three of the total 26 sites, two were assessed as significant for information content and cultural value, and further data collection was recommended. The remaining one site was assessed as significant for information content and as an excellent example of a site type, and for the site, further data collection followed by preservation "as is" was recommended.

An archaeological reconnaissance survey of a 2.8 acre parcel (TMK:5-5-01:51) at Laie was conducted in January 1989 (Hammatt 1989). The parcel is immediately south of Laie Beach Park and east of Kamehameha Highway and

consists of a sandstone bluff and low-lying consolidated sandstone covered with clay alluvium. Four auger holes were excavated in the parcel, and these yielded only modern trash. Surface survey of the bluff resulted in the discovery of a cave with an overhang at the entrance. Fragmented human skeletal remains were found in the cave. A 50 cm square test unit was placed within the overhang area; the unit had scattered cultural material in the top 30 cm possibly indicating the overhang was used for temporary shelter. It was recommended that the cave entrance be sealed and preserved, and no further work was recommended for the overhang area.

A survey of the Laie Sewer Plant was done by Cultural Surveys Hawaii in September 1991, for Mr. James Pederson (Hammatt 1991). The project area comprised six acres surrounding the sewer plant. During the survey no archaeological sites were identified. During the current survey one site (4454) was identified c. 17.00 m north of the Sewer Plant fenceline, and three sites (4458, 4459, and 4460) were identified within or immediately adjacent to the south southeast portion of the six acre parcel, within the limits of a coral outcrop.

SUMMARY OF HISTORICAL DOCUMENTARY RESEARCH

The following is a summary of Appendix B, Historical Documentary Research by Lehua Kalima, B.A.

The project area lies in the *ahupua'a* of Laie (lit. 'ie leaf) (Pukui et al. 1974). This district is often mentioned in Hawaiian legends and myths as the home of various supernatural beings.

The legend of the Princess Laieikawai is most frequently associated with Laie, as it was here that the princess was born and was hidden in a cavern by her grandmother. The cavern where she was hidden, named Waiapuka, is in the neighboring *ahupua'a* of Malaekahana, and still can be seen.

Another legend deals with a shark-man of the area named Mano-niho-kahi. He lived in Laie and as people passed his house he would ask them where they were going fishing. He would then go to the ocean via an underground stream which led from a pool in his yard. Once at the ocean he would attack them. He finally was discovered and put to death (Rice IN Sterling and Summers 1978:157).

Another legend mentions Laniloa Point, where a giant man-eating lizard once lived. This lizard was eventually killed and his body was thrown out to sea and became the five small islands which lie off Malaekahana (ibid.).

A story is also told of a chief named Kahalaiu whom Kamehameha sent out to conquer the chief of Malaekahana named Manuwahi. Apparently Manuwahi was never defeated as he was aided by the gods, a source of great pride for those from Malaekahana. Eventually Kahalaiu joined forces with Manuwahi and was known as the chief who revolted against Kamehameha (McAllister IN Sterling and Summers 1978).

McAllister lists many previously discovered archaeological and historical sites within Laie Ahupua'a. These include a house site, fishing shrines, ponds and pools, *heiau*, taro lands, and a *puuhonua* (ibid.).

Due to the frequent rains and numerous streams in the area, native cultivation within Laie Ahupua'a consisted mainly of irrigated taro. Handy and Handy (1972) mention the various streams and the many terraces which existed along these streams along with the different types of land areas lying within the *ahupua'a*.

Various maps depict Laie in the 1800s, indicating the taro lands, and the locations of the sites mentioned by McAllister (see Appendix B, Figures B-1 through B-5).

One of the earliest mentions of Laie is in a missionary journal. One journal (Chamberlain 1956) tells of two schools in Laie and Malaekahana. Mormon missionaries settled in Laie in the mid-1800s and recorded that Laie was a small primitive village which had the reputation of being a city of refuge until King Kamehameha II rescinded the sanctuary. The population in 1831 was recorded at 452, with a population loss of 210 between 1831-1835 (Bath 1985).

Kamehameha I gave both Laiemalo'o and Laiekawai (which make up Laie Ahupua'a) to his half-brother Kalaimamahu after he had established control on Oahu. From Kalaimamahu control passed to his daughter, Kekauluohi, and finally to his grandson Lunalilo. It remained under Lunalilo's control until the Great Mahele of 1848.

When the Great Mahele took place numerous *kuleana* awards were granted within Laie Ahupua'a. Kalima lists the testimony for those awards within the project area. The testimonies indicate the majority of the awardees were cultivating taro, along with small crops of tobacco and sweet potato. A map in Appendix B shows the locations of the awards within the project area (see Figure B-6).

In 1861 the entire lands of Laiewai and Laimaloo, excluding the personal *kuleana*, were sold to Henry H. Howland by guardians of Lunalilo's estate. In 1863 Howland

sold 298 1/2 acres of land in Laiewai to Robert Moffitt of Kahuku. Five months later Moffitt sold that property to Charles Hopkins of Honolulu. At that time the Malaekahana and Kahuku ranches were probably extended to Laie (Bath 1985).

The Church of Jesus Christ of Latter Day Saints began their influence in Laie in 1850 when ten Mormon missionaries settled there. By 1865 the Church had bought 6,000 acres in the area for agricultural use (Ahlo and Hommon 1981). Initially, a variety of small crops were cultivated there, but by the end of the 19th century the predominant crops were sugar cane and pineapple. Sugar cane produced by Laie Plantation and later by Kahuku Plantation was the main crop in the area until the plantation closed down in 1970. Land in the area is currently used mostly for pasture and truck farming. Most of the Laie population still consists of Mormons. The BYU-Hawaii campus, along with the Mormon temple and the Polynesian Cultural Center provide activities and jobs for the Mormon students and attract many visitors to the area.

Ms. Kalima interviewed several Laie residents. Mr. Walter Tashiro and Mr. Walter Wong, who have resided all their lives in the area, provided much information on the area (see end of Appendix B).

POSTULATED SETTLEMENT PATTERN

In summary, the previous archaeological work indicates that the Laie area was occupied as early as AD 1000. This date was obtained during the 1988-1989 PHRI survey at Punamano and Malaekahana (Jensen 1989), recovered from a cave site (4089) c. 4,000 ft inland of the coast in Malaekahana. Additional samples obtained by Bath in 1985, and by Yent and Estioko-Griffin in the late 1970s, yielded date ranges between AD 1415-1780 for coastal Malaekahana and Laie.

Subsistence in the area apparently consisted of both marine exploitation and agricultural activities. Previously identified sites represent a variety of formal types. There are both permanent and temporary prehistoric habitation sites, as well as major and minor ceremonial sites. Agricultural sites indicate extensive and intensive use of the land for agriculture.

Based on the evidence, it can be concluded that the population of Laie settled along coastal areas in order to exploit the marine environment and the fertile floodplains. Therefore, during the current project, it was expected that sites would be found near the coast. Agricultural sites were expected within the areas previously identified as agricultural areas, and in areas of similar topography, and in areas less modified by recent activity.

FIELD METHODS AND PROCEDURES

The portions of the project area which appeared undisturbed by current cultivation, or other obvious land modification, and/or had a cover of dense vegetation, was surveyed by way of a series of pedestrian sweeps. Intervals between sweeping crew members varied from 30-60 ft, depending on vegetation density and terrain. The sweeps were flagged with red-striped flagging tape, and as sites were identified they were flagged with pink flagging. Areas under cultivation were inspected for isolated unmodified areas where archaeological sites could have been present, such as small drainages or the fringes of agricultural fields. Sample sweeps were conducted in dense banana fields when visibility was poor from the field roads.

All sites were plotted on a map (1" = 400 ft scale) provided by the client. The locations of sites were determined by way of tape and hand-held compass. Sites were recorded on standard PHRI site record forms, scaled sketch maps were drawn, and sites were photographed with 35mm black-and-white film. To aid in future reidentification, all features were tagged with an aluminum strip bearing the temporary site number and feature letter, PHRI project number (90-878), the letters "PHRI", and the date.

As part of the inventory survey subsurface testing was conducted at (a) various sites/features, (b) those LCA (Land Commission Awards) plots which were accessible by backhoe, and (c) selected areas which were currently under agricultural cultivation. The purpose of the excavations was to gather information on cultural deposits in the area and to collect pollen and carbon samples for radiocarbon dating. The excavations conducted at the surface sites/features, consisted of both test units and shovel tests. Formal test units were excavated at features which displayed an obvious surface cultural deposit. Shovel tests were informal units excavated at potential features to determine if a subsurface cultural deposit was present; for example, a test would be placed in an overhang lacking any modification or surface midden scatter, but containing a soil deposit. All excavations conducted within test units and shovel tests were excavated using arbitrary levels within layers; selected cross sections were drawn; and all fill was processed through 1/8-inch mesh to facilitate recovery of portable artifacts and midden.

The trenches placed in the areas of LCAs and lands currently under cultivation were excavated using a backhoe.

The areas were selected for trenching based on historical documentary research (locations of LCAs) and past findings. Areas excavated included: sites with potential agricultural deposits (such as Site 4466), areas suspected to contain subsurface deposits (such as Parcel J); sand dune areas with potential to contain subsurface deposits and human skeletal remains, and parcels under current cultivation (areas at various elevations were tested for possible subsurface deposits). All trenches were recorded on standard PHRI stratigraphy forms. Trench locations were plotted on a site location map, and trenches were photographed using black-and-white 35mm film. Selected profiles of trenches were drawn. All soil samples encountered during the excavations were described following the format used in the Soil Survey Manual (Soil Survey Staff 1962).

All recovered samples were returned to the Hilo laboratory for systematic sorting. Laboratory analyses of the remains included cataloging the artifacts, analysis of the ecofactual remains, and preparation of carbon and pollen samples. Two carbon samples from Site 4458, one from Site 4460, two from Site 4467, one sample from BT-17, and one sample from BT-19, for a total of seven samples, were processed and submitted to Beta Analytic, Coral Gables, Florida for radiometric age determination. One pollen sample from BT-1, two samples from BT-3, three samples from BT-17, one sample from BT-22, and one sample from BT-26, for a total of eight samples, were prepared and submitted to Paleo Research Laboratories, Golden, Colorado, for sediment, pollen, and dating analyses.

FINDINGS

SURFACE SURVEY

During the present survey 17 sites consisting of 109+ component features were identified within the project area. In addition, six sites consisting of 12 component features were identified in areas adjacent to the project area. These six sites were also recorded because they may be affected by development activities. Figure 1 shows the locations of the total 23 sites, and Table 1 summarizes the sites and their component features in terms of formal type, functional type, PHRI Cultural Resource Management (CRM) value mode assessments, and recommended further field tasks.

Of the total 23 sites, two had been previously identified. The site identified as 4093 (T-5) during the current survey was identified and designated SIHP Site 4093 during PHRI Project 483, Archaeological Inventory Survey, Punamano and Malaekahana Golf Courses (Jensen 1989). The site identified and designated 4465 (T-28) during the current survey was previously identified by Ahlo and Hommon (1981), Neller (1984), and was identified and excavated by Bath (1985), but apparently was never assigned a state number.

During the current survey, Site 277 (Paeo Fishpond), previously identified by McAllister, could not be relocated. One backhoe trench was excavated in the supposed vicinity of the site; the trench yielded only recent trash. Since the site was not relocated it is not included in Table 1, but because the site or portions of it may still exist, its supposed location is recommended for further data collection in the Conclusion section.

The 23 identified sites include 11 complexes (multiple-feature sites), and 12 single-feature sites. The sites are both altered and unaltered and range in physical condition from poor to good. All the identified sites were assigned functional interpretations. Seventeen sites were designated as having single functions and six sites were assigned multiple functions (Table 1).

Archaeological sites were identified within or immediately adjacent to all parcels of the project area except Parcels A, E, F, and I. The identified sites are generally in areas less altered by development and recent agriculture.

Appendix A provides a detailed description for each site, including:

1. Site number - SIHP numbers and PHRI temporary site numbers. SIHP are four-digit numbers prefixed by 50-80-02 (50=State of Hawaii; 80=Island of Oahu; 02=USGS 7.5" series quad map ["Kahuku, Hawaii"]). PHRI temporary numbers are one- or two-digit numbers prefixed by "T";
2. A site type designation - provides formal feature type for sites consisting of a single feature, or designates the site as a complex if the site is comprised of more than one feature. Also lists total number of features present;
3. A description of site topography - a brief description of the terrain in the area of the site;
4. A list 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, or 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 a hyphen;
9. A site description - a brief overall description of the site, listing types of constituent features, portable remains, 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 information.

Twenty-six formal feature types were identified among the 121 features recorded. These include: terrace (N=21,17.4%), circular alignment (N=18,14.9%), retaining wall (N=12,9.9%), wall (N=9, 7.4%), overhang (N=8, 6.6%), soil mound (N=8, 6.6%), ditch (N=7, 5.8%), enclosure (N=4, 3.3%), cave (N=3, 2.5), modified bedrock (N=3, 2.5%),

Table 1.

SUMMARY OF IDENTIFIED SITES AND FEATURES

Site/Feature Number	Formal Site/Feature Type	Tentative Functional Interpretation	CRM Value Mode Assess. R	I	C	Field Work Tasks DR	SC	EX
4454 (T-10)	Complex (32)**	Agriculture	M	L	L	-	-	-
A	Wall							
B	Terrace							
C	Wall Segment							
D	Enclosure							
E	Wall Remnant							
F	Terrace							
G	Enclosure							
H	Wall Remnant (2)							
I	Circular Alignment							
J	Circular Alignments (16)							
K	Rubble Concentration							
L	Mound							
M	Circular Alignment							
N	Terrace							
O	Paved Area							
P	Modified Bedrock							
4455 (T-12)	Foundation	Possible Habitation	M	L/H	L/H	+	-	+
4456 (T-13)	Modified Bedrock	Dozer Push	L	L	L	-	-	-
4457 (T-14)	Ditch	Irrigation	L	L	L	+	-	-
4458 (T-17)	Complex (19)	Multiple	H	L/H	L/H	+	+	+
A	Overhang	Temporary Habitation						
B	Modified Crevice	Temporary Habitation						
C-E1	Overhang	Temporary Habitation						
E2	Cave	Possible Burial						
E3	Cupboard	Storage						
F	Modified Crevice	Temporary Habitation						
G1	Retaining Wall	Possible Agriculture						
G2	Wall	Possible Agriculture						
H	Wall	Boundary						
I	Wall	Boundary						
J	Overhang	Possible burial						
K	Overhang	Temp. Hab. - Poss. Burial						
K2	Modified Crevice	Temporary Habitation						
L	Cave	Possible Storage Area						
M	Wall	Possible Habitation						
N	Overhang	Temporary Habitation						
O	Paved Area	Indeterminate						

SIHP (State Inventory of Historic Places). SIHP numbers are five-digit numbers prefixed by 50-80-02 (50=State of Hawaii; 80=Island of Oahu; 02=USGS 7.5' series quad map ["Kahuku, Hawaii"]. SIHP numbers are immediately followed by PHRI temporary site numbers, (T-).

CRM (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 1. (cont.)

Site/Feature Number	Formal Site/Feature Type	Tentative Functional Interpretation	CRM Value Mode Assess. R	I	C	Field Work Tasks DR	SC	EX
4459 (T-18)	Ditch	Irrigation	M	L	L	-	-	-
4460 (T-19)	Complex (5+) Terraces & Paved Areas	Habitation	H	L	L	+	+	+
4461 (T-20)	Terrace-Wall	Erosion Control-Fenceline	M	L	L	-	-	-
4462 (T-21)	Complex (21+)	Multiple	H	M	L	+	+	+
A	Retaining Wall	Agriculture						
B	Terrace	Agriculture						
C	Retaining Wall	Agriculture						
D-F	Ditch	Irrigation						
G	Terrace	Possible Habitation						
H-J	Terrace	Agriculture						
K	Terrace	Habitation						
L	Terrace	Agriculture						
M	Wall	Erosion Control						
N	Terrace-Wall	Agriculture						
O	Terrace(2)	Agriculture						
P	Terrace(3)	Agriculture						
Q	Enclosure	Indeterminate						
R	Overhang	Temporary Habitation						
4463 (T-22)	Complex (8)	Multiple	M	L	L	+	-	+
A	Wall	Agriculture						
B	Retaining Wall	Agriculture						
C	Retaining Wall	Agriculture						
D	Ditch	Irrigation						
E	Soil Berm	Erosion Control-Fenceline						
F	Retainingwall	Erosion Control						
G	Ditch	Irrigation						
H	Retaining Wall	Agriculture						
4464 (T-26)	Complex (2)	Habitation	M	L	L	+	-	+
A	Terrace							
B	Modified Bedrock							
4465 (T-28)	Complex (19)	Burial	H	H	H	+	-	-
A	Platform (2)							
B	Mound (17)							
4466 (T-29)	Complex (3)	Agriculture	M	L/H	L/H	+	-	+
A-C	Pond Field							
4467 (T-30)	Subsurface Deposit	Possible Habitation	M	L	L	-	-	+
4468 (T-31)	Cemetery	Burial	H	H	H	+	-	-
4469 (T-32)	Upright Stone	Marker	M	L	L	-	-	-
4470 (T-33)	Ditch-Tunnel	Irrigation	M	L	L	-	-	-

Table 1. (cont.)

Site/Feature Number	Formal Site/Feature Type	Tentative Functional Interpretation	CRM Value Mode Assess. R	I	C	Field Work Tasks DR	SC	EX
SITES LOCATED OUTSIDE OF PROJECT AREA								
4471 (T-04)	Complex (2)	Agriculture	M	L	L	+	-	+
A	Mound							
B	Paved Area							
4472 (T-07)	Cave	Temporary Habitation-Burial	H	M	H	+	+	+
4473 (T-15)	Complex (4)	Multiple	M	L	L	+	-	+
A	Retaining Wall	Possible Agriculture						
B	Enclosure	Possible Agriculture						
C	Wall	Indeterminate						
D	Wall	Indeterminate						
4474 (T-16)	Complex (3)	Erosion Control	M	L	L	+	-	-
A-C	Retaining Wall							
4475 (T-27)	Retaining Wall	Agriculture	L	L	L	-	-	-
4093 (T-05)	Ditch-Tunnel	Irrigation	M	L	L	+	-	+

modified crevice (N=3, 2.5%), paved area (N=3, 2.5%), pond field (N=3, 2.5%), wall remnant (N=3, 2.5%), ditch-tunnel (N=2, 1.7%), mound (N=2, 1.7%), platform (N=2, 1.7%), terrace-wall (N=2, 1.7%), cemetery (N=1. 0.8%), cupboard (N=1, 0.8%), foundation (N=1, 0.8%), rubble concentration (N=1, 0.8%), soil berm (N=1, 0.8%), subsurface deposit (N=1, 0.8%), upright stone (N=1, 0.8%), and wall segment (N=1, 0.8%). The various formal types are summarized in Table 2. The majority of the features, almost half (42.2%), represent three types, terraces, circular alignments, and retaining walls. In addition to the 121 features recorded, an additional 100+ features exist at Site 4462, consisting of retaining walls, terraces, and ditches. During the present survey only a sample of this site was recorded and mapped in detail due to the size of the site and extremely thick vegetation.

Probable functional interpretations were determined for all identified sites (Table 3). Individual features were also assigned functional interpretations (Table 4). Functional types include agriculture, boundary, burial, dozer push, erosion control, erosion control-fenceline, habitation, indeterminate, irrigation, marker, possible agriculture, possible burial, possible habitation, possible storage area, storage, temporary habitation, temporary habitation-possible burial, and temporary habitation-burial.

The features are constructed of three types of materials (limestone, basalt, and concrete) using three methods. Those features constructed of limestone are **(a)** simply placed or stacked cobbles, boulders and/or slabs, or **(b)** dressed blocks, either formally stacked or block and mortar. Basalt features consist of stacked cobbles and boulders. The concrete features include historic irrigation ditches which are constructed of what appear to be pre-fabricated concrete sections placed end to end.

Terraces (N=21, 17.4%), are the prevalent formal type encountered. These features are constructed with at least one side flush with the ground surface, with one or more of the remaining sides raised above the ground surface. The perimeters of the features range from being stacked and well-faced to being haphazardly stacked. The terrace platforms range from being irregular with remnant paving, or evenly paved with slabs or small cobbles, to partially or exclusively consisting of soil. There are terraces at only four of the identified sites, with the majority being at Site 4462. The terraces are assessed as having the following functions: agriculture, habitation, and possible habitation.

Table 2.

FREQUENCIES OF FORMAL FEATURE TYPES

Formal Type	Number	%	SIHP
Terrace	21	17.4	4454(B,F,N),4460, 4462(B,G,H,I,J,K,L,O,P),4464(A)
Circular Alignment	18	14.9	4454(I,J,M)
Retaining Wall	12	9.9	4458(G1),4462(A,C),4463(B,C,F,H),4473(A),4474,4475
Wall	9	7.4	4454(A),4458(G2,H,J,M),4462(M),4463(A),4473(C,D)
Overhang	8	6.6	4458(A,C,D,E1,J,K,N),4462(R)
Soil Mounds	8	6.6	4465(B)
Ditch	7	5.8	4457,4459,4462(D,E,F),4463(D,G)
Enclosure	4	3.3	4454(D,G),4462(Q),4473(B)
Cave	3	2.5	4458(E2,L),4472
Modified Bedrock	3	2.5	4454(P),4456,4464(B)
Modified Crevice	3	2.5	4458(B,F,K2)
Paved Area	3	2.5	4454(O),4458(O),4471(B)
Pond Field	3	2.5	4466(A,B,C)
Wall Remnant	3	2.5	4454(E,H)
Ditch-Tunnel	2	1.7	4093,4470
Mound	2	1.7	4454(L),4471(A)
Platform	2	1.7	4465(A)
Terrace-Wall	2	1.7	4461,4462(N)
Cemetery	1	0.8	4468
Cupboard	1	0.8	4458(E3)
Foundation	1	0.8	4455
Rubble Concentration	1	0.8	4454(K)
Soil Berm	1	0.8	4463(E)
Subsurface Deposit	1	0.8	4467
Upright Stone	1	0.8	4469
Wall Segment	1	0.8	4454(C)
TOTAL	**121**	**100.1**	

The circular alignments (N=18, 14.9%) all are at Site 4454. These features are of similar size and construction, consisting of limestone cobbles and an occasional piece of limestone bedrock outcropping arranged in a circular alignment. Most of the interiors consist of soil and are raised above the surrounding ground surface, being c. 1.00 m to 2.50 m in diameter. All these features were assigned agricultural functions, and appear to be the result of recent agricultural activity.

The retaining walls (N=12, 9.9%) consist of a linear walls constructed of limestone and/or basalt cobbles stacked on the downhill side, with the top, or uphill side flush with the soil surface. These feature types are found throughout the inland portion of the project area, but predominantly in Parcel K, at Sites 4462 and 4463. The walls function for possible agriculture, erosion control, and agriculture.

Eight overhangs were identified, seven of which are at Site 4458 in Parcel H. Overhangs, similar to caves, are defined as having a greater overall width than depth. These features were assigned the following functions: temporary habitation, possible burial, or in the case of one overhang, temporary habitation-possible burial.

Eight soil mounds were identified within Parcel B, at Site 4465. The features are slightly raised areas of soil, contained within a fenced area, and are very similar to each other. In the northeast ends of four of the mounds are single glass jars partially embedded in the ground. The mounds are interpreted as burials, based on their appearance, the presence of the fence, and previous archaeological work by Neller (1984), and Bath (1985).

Table 3.

FREQUENCIES OF FUNCTIONAL SITE TYPES

Functional Type	Number	%
Agriculture	4	17.4
Irrigation	4	17.4
Multiple	4	17.4
Burial	2	8.7
Habitation	2	8.7
Possible Habitation	2	8.7
Dozer Push	1	4.3
Erosion Control	1	4.3
Erosion Control-Fenceline	1	4.3
Marker	1	4.3
Temporary Habitation-Burial	1	4.3
TOTAL	**23**	**99.8**

Table 4.

FREQUENCIES OF FUNCTIONAL FEATURE TYPES

Functional Type	Number	%	SIHP NO.
Agriculture	55	45.5	4454,4462(A,B,C,H,I,J,L,N,O,P),4463 (A,B,C,H), 4466, 4471,4475
Burial	11	9.1	4465,4468
Irrigation	9	7.4	4093,4457,4459,4462(D,E,F),4463(D,G),4470
Temporary Habitation	9	7.4	4458(A,B,C,D,E1,F,K2,N),4462(R)
Habitation	8	6.6	4460,4462(K),4464
Erosion Control	5	4.1	4462(M),4463(F),4474
Indeterminate	4	3.3	4458(O),4462(Q),4473(C,D)
Possible Agriculture	4	3.3	4458(G1,G2),4473(A,B)
Possible Habitation	4	3.3	4455,4458(M),4462(G),4467
Boundary	2	1.7	4458(H,I)
Erosion Control-Fenceline	2	1.7	4461,4463(E)
Possible Burial	2	1.7	4458(E2,J)
Dozer Push	1	0.8	4456
Marker	1	0.8	4469
Possible Storage Area	1	0.8	4458(L)
Temporary Habitation-Burial	1	0.8	4472
Temp. Habitation - Poss. Burial	1	0.8	4458(K)
Storage	1	0.8	4458(E3)
TOTAL	**121**	**99.9**	

Seven ditches were identified, two within Parcel H at Sites 4457 and 4459, and five within Parcel K at Sites 4462 and 4463. Two distinct methods were used in constructing the ditches. Some ditches appear to be constructed of prefabricated concrete sections placed end to end (as at Site 4459), and other ditches—simple, but effective—are made of soil, in some cases with associated basalt cobble retaining walls. The ditches are interpreted as for historic and prehistoric irrigation.

Four enclosures were identified; these were scattered across the inland portion of the project area, within or near Parcels C, H, and K. The two enclosures identified at Site 4454 are roughly rectangular, are fairly small, incorporate the surrounding bedrock, and appear to be sheltered agricultural planting areas. The remaining two features, at Sites 4462 and 4473, both appear to be the remnants of structures, and were assigned functional interpretations of indeterminate, and possible agriculture, respectively.

Three caves were identified, two of which are located at Site 4458 within Parcel H. These two caves are relatively small, and are classified as caves because their overall depths are greater than their widths. One cave was assigned the function of possible burial based on the presence of human skeletal remains discovered on the floor surface. The other cave was assigned the function of possible storage area, based on its small size, and the level smooth paved interior floor. The remaining cave, Site 4472, located near the west boundary of Parcel C, consists of a large tube, existing at the base of a large, exposed bluff of coral outcrop. Due to the presence of a scattered human individual burial, and the presence of a buried cultural deposit, the cave was given a dual function, temporary habitation and burial.

Modified bedrock features were identified at Sites 4454, 4456, and 4464. In the case of Site 4454, Feature P, rocks have been stacked among the outcrops, and a cleared soil area is present. The feature was determined to be agricultural in function. Site 4456 also consisted of an area of exposed outcrop with a scattering of cobbles, but after excavating a test unit and upon closer inspection of the feature it was determined that the feature was created by bulldozing, thus the feature was assigned the function of dozer push. Site 4464 is a large exposed bedrock boulder with a worn depression on its surface. This depression appears to be the result of grinding, or pulverizing action using a small basalt cobble (which was found *in situ* within the depression). The feature was assigned a habitation function.

Three modified crevices were identified at Site 4458. These features are similar to modified outcrops in that the primary component of the feature is bedrock. More specifically, the features consist of large fissures within limestone bluff outcroppings, with modifications to the floor areas of the fissures. All of the modified crevices are interpreted as temporary habitation features, based on the type of interior modification, portable remains, and presence of subsurface cultural deposits.

The paved areas identified are areas smoothed out with small to medium cobbles. Three such features were identified, two within Parcel H at Sites 4454 and 4458, and one at Site 4471, near the northwest boundary of Parcel C. The paved areas are interpreted to function for agriculture or are determined to have an indeterminate function.

Three pondfields were identified, all at Site 4466. These features consist of sunken, level areas which terrace each other. The features were assigned an agricultural function. The presence of a concrete water control gate at the end of one of the features indicates the site has a historic component; the site may also be prehistoric, as it is very similar in appearance and construction to the prehistoric *lo'i*.

Three wall remnants were identified at Site 4454 and were interpreted to function for agriculture.

There are additional feature types in the project area, but they are not as common as the above-mentioned ones. The remaining features include ditch-tunnel, mound, platform, terrace-wall, cemetery, cupboard, foundation, rubble concentration, soil berm, subsurface deposit, upright stone, and wall segment. The ditch-tunnel features consist of the above described ditches, consisting of either concrete troughs or lined with dressed limestone blocks, with man-made tunnels directly associated with them. The mounds are informal piles of cobbles and have been assigned agricultural functions. The platforms are concrete and are raised; they have been interpreted as burials. The cemetery consists of numerous marked grave plots. The cupboard is a niche in bedrock which has been paved and smoothed. The foundation is a structural base of stone and mortar. Rubble concentration is a pile of stones which lacks formal construction. A soil berm is a linear mound of placed soil. Subsurface deposit, as the name implies, is a cultural deposit entirely below the ground surface. Upright stone is a vertically placed piece of granite.

In terms of distribution, both historic and prehistoric sites are scattered throughout the project area. Prehistoric sites appear to be primarily in areas not heavily affected by recent agriculture, ranching, and development work. For example, the areas of Sites 4458 and 4462—exposed limestone bluffs and sloping foothills of a larger ridge system—seem to have

escaped the recent modifications surrounding them. Site function and distribution is discussed in more detail in the Conclusion section of this report.

SUBSURFACE TESTING

Thirteen test units and six shovel tests, totaling 9.0 square meters in surface area, were excavated at 14 features within eight sites. The findings of the excavations are summarized in Table 5, and a detailed description of each unit is presented in Appendix A. The excavations were placed to determine the presence or absence of potentially significant buried cultural deposits, to substantiate functional interpretations, and to obtain suitable samples for age determination analyses.

The excavations yielded 244 artifacts, of which 15 were indigenous. The artifacts included basalt flakes, a basalt core, an *'ulu-maika* stone, and adze preforms. The non-indigenous artifacts included glass, ceramic, metal, and plastic fragments. The artifacts are discussed in detail in the Data Analyses section.

Seventeen radiocarbon samples were collected from the test units, backhoe trenches, and shovel tests. Seven of the samples were submitted for radiocarbon age determination analysis.

In addition to the above excavations, 27 backhoe trenches were placed in the project area (in the Interim Report for this project [Dunn and Rosendahl 1992] it was erroneously stated that 28 trenches were excavated). Eight trenches were excavated within or close to LCA plots, while the remaining 19 trenches were excavated throughout the project area where subsurface deposits were suspected. Eight of the 27 trenches excavated appeared to contain agricultural deposits, and pollen samples were collected from them. Trench findings are summarized in Table 6, and an analysis of the pollen samples is presented in Appendix C.

Table 6.

SUMMARY OF BACKHOE TRENCH EXCAVATIONS

BT-		
		EAST FACE
1	I	0-47 cmbs; black (5YR 2.5/1 moist); silty clay; structureless; slightly hard, friable, slightly sticky, plastic consistence; abrupt, smooth boundary; Possible agricultural deposit.
	II	47-66 cmbs; dark brown (10YR 4/3 moist); sand; strong, medium single grain structure; loose, loose, non-sticky, non-plastic consistence; clear, wavy boundary;
	III	66-90+ cmbs; grayish brown (2.5Y 5/2 moist); sand; strong, medium single grain structure; loose, loose, non-sticky, non-plastic consistence; layer continues below base of unit.
		WEST FACE
2	I	0-105 cmbs; dark brown (7.5YR 3/4 moist); silty clay; structureless; slightly hard, firm; sticky, plastic consistence; clear, wavy boundary;
	II	105-130 cmbs; dark brown (7.5YR 3/4 moist); silt loam; loose, very friable, sticky, slightly plastic consistence; clear, irregular boundary;
	III	130+ cmbs; limestone bedrock.
		SOUTHWEST FACE
3	I	0-48 cmbs, dark reddish brown (5YR 2.5/2 moist); loam; weak, medium crumb structure; soft, firm, sticky, plastic consistence; abrupt, smooth boundary;
	II	48-68 cmbs; dark yellowish brown (10YR 4/6 moist); sandy loam; dark brown (7.5YR 3/2 dry); weak fine single grain structure; soft, very friable, sticky, non-plastic consistence; abrupt, smooth boundary;
	III	68-96 cmbs; dark brown (7.5YR 3/2 moist); clay loam; weak, fine granular structure; hard, firm, sticky, plastic consistence; clear, wavy boundary;
	IV	96-137 cmbs; dark brown (10YR 3/3 moist); clay loam; weak, fine crumb structure; soft, very friable, sticky, non-plastic consistence; possible agricultural deposit.
	V	137-144 cmbs; black (10YR 2/1 moist); cobbly clay loam; weak, fine crumb structure; slightly hard, firm, slightly sticky, slightly plastic consistence; clear, wavy boundary;
	VI	144-183+ cmbs; dark brown (10YR 3/3 moist); cobbly silty clay; weak, fine crumb structure; soft, very friable, sticky, slightly plastic consistence; layer continues below base of unit.
		SOUTHEAST FACE
4	I	0-30 cmbs; dark brown (7.5YR 3/2 moist); gravelly silty clay; moderate medium crumb structure; soft, friable, slightly sticky, plastic consistence; common roots; abrupt, smooth boundary;
	II	30-180+ cmbs; dark brown (7.5YR 3/4 moist); cobbly silty clay; strong, very fine massive structure; soft, friable, non-sticky, plastic consistence; layer continues below base of unit.

Table 5.

SUMMARY OF TEST EXCAVATIONS

Site/ Feature	Formal Site Type	Tentative Functional Interpretation	No. of Test Units	Excav. Area (sq m)	Immed. Action Recom.	Comments
4454	Complex (32)	Agriculture			None	No substantial cultural deposit, only recent historic deposit due to previous bulldozing.
L	Mound		1	0.25		
O	PavedAreen		1	0.25		
4456	Modified Bedrock	Dozer Push	1	0.25	None	No cultural deposit. Plastic found subsurface.
4458	Complex (19)	Multiple			FDC	Feat.A contained 33 cm of cultural deposit, marine shell, charcoal, bone, *kukui* nut shell, a possible *'ulu-maika* stone, & a hearth. Feat C contained 5+ cm of cultural deposit, charcoal, marine shell, *kukui* nut shell, and fire-cracked rock. Feat. D contained 10+ cm of cultural deposit, charcoal, marine shell, and *kukui* nut shell.Feat F had at least 30 cm cultural deposit in ST-2, basalt flake and marine shell. Feat K had 30 cm of cultural deposit, marine shell, charcoal, bone, and *kukui* nut shell. Feat. K contained 14 cm of cultural deposit, charcoal, marine shell bone, and *kukui* nut shell.
A	Overhang	Temporary Habitation	1	0.25		
C	Overhang	Temporary Habitation	1*	0.25		
D	Overhang	Temporary Habitation	1*	0.25		
F	Modified Crevice	Temporary Habitation	2*	0.50		
K	Overhang	Temporary Habitation	1	0.25		
K-2	Modified Crevice	Temporary Habitation	1*	0.25		
4460	Complex (5+)	Habitation	2	1.50	FDC	TU-1 had 25 cm of cultural deposit, charcoal and marine shell.TU-2 contained at least 30 cm of cultural deposit, marine shell, bone, *kukui* nut shell, waterworn basalt cobble and fire-cracked rock.
4463	Complex (8)	Multiple				No cultural deposit, besides possible agricultural deposit.
B	Retaining Wall	Agriculture	2	1.50		
4467	Subsurf. Deposit	Possible Habitation	2	2.00	FDC	Had at least 14 cm cultural deposit, charcoal and marine shell.
4469	Upright Stone	Marker	1	1.00	None	No cultural deposit.
4472	Cave	Temporary Habitation-Burial	2*	0.50	FDC	Shovel Test #1 consisted of 50 cm of cultural deposit, marine shell, charcoal, *kukui* nut shell, and basaltflakes. Shovel Test #2 contained sparse crab shell.

**Differentiates shovel test from formal test unit*
FDC = Further Data Collection

Table 6.(cont.)

		WEST FACE
5	I	0-43 cmbs; dark brown (7.5YR 4/2 moist); fine sand; dark brown (7.5YR 4/2 dry); weak, fine single grain structure; loose, loose, non-sticky, non-plastic consistence; clear, wavy boundary;
	II	43-205+ cmbs; pink (7.5YR 7/4 moist); loamy fine sand; pink (7.5YR 7/4 dry); weak, fine single grain structure; loose, loose, non-sticky, non-plastic consistence; layer continues below base of unit.
		SOUTHEAST FACE
6	I	0-34 cmbs; dark brown (7.5YR 4/2 moist); fine sand; dark brown (7.5YR 4/2 dry); weak, fine single grain structure; loose, loose, non-sticky, non-plastic consistence; clear, wavy boundary;
	II	34-230+ cmbs; pink (7.5YR 7/4 moist); loamy fine sand; pink (7.5YR 7/4 dry); weak, fine single grain structure; loose, loose, non-sticky, non-plastic consistence; layer continues below base of unit.
		NORTH FACE
7	I	0-13 cmbs; brown (7.5YR 5/4 moist); sand; brown (7.5YR 5/4 dry); weak, fine granular structure; loose, loose, non-sticky, non-plastic consistence; many roots; clear, wavy boundary;
	II	13-64 cmbs; brown (7.5YR 5/4 moist); very fine sand; brown (7.5YR 5/4 dry); weak, very fine single grain structure; loose, loose, non-sticky, non-plastic consistence; diffuse, wavy boundary;
	III	64-190 cmbs; brownish yellow (10YR 6/6 moist); sand; brownish yellow (10YR 6/6 dry); weak, fine granular structure; loose, loose, non-sticky, non-plastic consistence; abrupt, wavy boundary;
	IV	190-206 cmbs; gray (5Y 5/1 moist); very fine sand; gray (5Y 5/1 dry); weak, very fine single grain structure; loose, loose, non-sticky, non-plastic consistence; abrupt, wavy boundary;
	V	206-230+ cmbs; very pale brown (10YR 7/3 moist); very fine sand; very pale brown (10YR 7/3 dry); weak, very fine single grain structure; loose, loose, non-sticky, non-plastic consistence; layer continues below base of unit.
		NORTHEAST FACE
8	I	0-25 cmbs; (see TU-2)
	II	25-44 cmbs; (see TU-2)
	III	44-49 cmbs; (see TU-2)
	IV	49-60 cmbs; very dark grayish brown (10YR 3/2 moist); very fine sandy loam; very dark grayish brown (10YR 3/2 dry); weak, very fine single grain structure; loose, loose, slightly sticky, non-plastic consistence; abrupt, smooth boundary; possible habitation deposit, correlates with Stratum III in TU-2, Site 4467.
	V	60-215 cmbs; brownish yellow (10YR 6/6 moist); sand; brownish yellow (10YR 6/6 dry); weak, fine granular structure; loose, loose, non-sticky, non-plastic consistence; abrupt, wavy boundary;
	VI	215-245+ cmbs; very pale brown (10YR 7/3 moist); very fine sand; very pale brown (10YR 7/3 dry); weak, very fine single grain structure; loose, loose, non-sticky, non-plastic consistence; layer continues below base of unit.

Table 6.(cont.)

		WEST FACE
9	I	0-18 cmbs; very dark brown (10YR 2/2 moist); very fine sandy loam; very dark brown (10YR 2/2 dry); weak, very fine single grain structure; soft, very friable, slightly sticky, non-plastic consistence; abrupt, smooth boundary;
	II	18-164 cmbs; brownish yellow (10YR 6/6 moist); sand; brownish yellow (10YR 6/6 dry); weak, fine granular structure; loose, loose, non-sticky, non-plastic consistence; clear, wavy boundary;
	III	164-180+ cmbs; very pale brown (10YR 7/3 moist); very fine sand; very pale brown (10YR 7/3 dry); weak, very fine single grain structure; loose, loose, non-sticky, non-plastic consistence; layer continues below base of unit.
		EAST FACE
10	I	0-25 cmbs; brown (7.5YR 5/4 moist); sand; brown (7.5YR 5/4 dry); weak, fine granular structure; loose, loose, non-sticky, non-plastic consistence; many roots; abrupt, smooth boundary;
	II	25-130 cmbs; brownish yellow (10YR 6/6 moist); sand; brownish yellow (10YR 6/6 dry); weak, fine granular structure; loose, loose, non-sticky, non-plastic consistence; clear, wavy boundary;
	III	130-140+ cmbs; very pale brown (10YR 7/3 moist); very fine sand; very pale brown (10YR 7/3 dry); weak, very fine single grain structure; loose, loose, non-sticky, non-plastic consistence; layer continues below base of unit.
		EAST FACE
11	I	0-20 cmbs; very dark brown (10YR 2/2 moist); very fine sandy loam; very dark brown (10YR 2/2 dry); weak, very fine single grain structure; soft, very friable, slightly sticky, non-plastic consistence; abrupt, smooth boundary;
	II	20-140 cmbs; brownish yellow (10YR 6/6 moist); sand; brownish yellow (10YR 6/6 dry); weak, fine granular structure; loose, loose, non-sticky, non-plastic consistence; clear, wavy boundary;
	III	140-155+ cmbs; very pale brown (10YR 7/3 moist); very fine sand; very pale brown (10YR 7/3 dry); weak, very fine single grain structure; loose, loose, non-sticky, non-plastic consistence; layer continues below base of unit.
		EAST FACE
12	I	0-20 cmbs; very dark brown (10YR 2/2 moist); very fine sandy loam; very dark brown (10YR 2/2 dry); weak, very fine single grain structure; soft, very friable, slightly sticky, non-plastic consistence; abrupt, smooth boundary;
	II	20-160 cmbs; brownish yellow (10YR 6/6 moist); sand; brownish yellow (10YR 6/6 dry); weak, fine granular structure; loose, loose, non-sticky, non-plastic consistence; clear, wavy boundary;
	III	160-170+ cmbs; very pale brown (10YR 7/3 moist); very fine sand; very pale brown (10YR 7/3 dry); weak, very fine single grain structure; loose, loose, non-sticky, non-plastic consistence; layer continues below base of unit.

Table 6.(cont.)

		WEST FACE
13	I	0-38 cmbs, dark brown (7.5YR 3/2 moist); loam; dark brown (7.5YR 3/2 dry); weak, fine crumb structure; soft, very friable, slightly sticky, slightly plastic consistence; common roots; abrupt, smooth boundary;
	II	38-105 cmbs; light brown (7.5YR 6/4 moist); sand; light brown (7.5YR 6/4 dry); moderate, fine granular structure; loose, loose, non-sticky, non-plastic consistence; clear, wavy boundary;
	III	105-135+ cmbs; very pale brown (10YR 8/3 moist); sand; very pale brown (10YR 8/3 dry); moderate fine granular structure; loose, loose, non-sticky, non-plastic consistence; layer continues below base of unit.
		EAST FACE
14	I	0-43 cmbs; dark brown (7.5YR 3/2 moist); loam; dark brown (7.5YR 3/2 dry); weak, fine crumb structure; soft, very friable, slightly sticky, slightly plastic consistence; common roots; abrupt, smooth boundary;
	II	43-130 cmbs; light brown (7.5YR 6/4 moist); sand; light brown (7.5YR 6/4 dry); moderate, fine granular structure; loose, loose, non-sticky, non-plastic consistence; clear, wavy boundary;
	III	130-165+ cmbs; very pale brown (10YR 8/3 moist); sand; very pale brown (10YR 8/3 dry); moderate fine granular structure; loose, loose, non-sticky, non-plastic consistence; layer continues below base of unit.
		EAST FACE
15	I	0-27 cmbs; dark brown (7.5YR 3/2 moist); loam; dark brown (7.5YR 3/2 dry); weak, fine crumb structure; soft, very friable, slightly sticky, slightly plastic consistence; common roots; abrupt, smooth boundary;
	IIA	27-57 cmbs; strong brown (7.5YR 5/6 moist); fine sand; strong brown (7.5YR 5/6 dry); weak, fine single grain structure; loose, loose, non-sticky, non-plastic consistence; gradual, wavy boundary;
	IIB	57-123 cmbs; light brown (7.5YR 6/4 moist); sand; light brown (7.5YR 6/4 dry); moderate, fine granular structure; loose, loose, non-sticky, non-plastic consistence; clear, wavy boundary;
	III	123-145+ cmbs; very pale brown (10YR 8/3 moist); sand; very pale brown (10YR 8/3 dry); moderate fine granular structure; loose, loose, non-sticky, non-plastic consistence; layer continues below base of unit.
		EAST FACE
16	I	0-12 cmbs; very dark brown (10YR 2/2 moist); silt loam; very dark brown (10YR 2/2 dry); soft, very friable, slightly sticky, non-plastic consistence; abrupt, wavy boundary;
	II	12-160 cmbs; very dusky red (2.5YR 2.5/2 moist); silty clay; very dusky red (2.5YR 2.5/2 dry); weak, fine crumb structure; soft, friable, slightly sticky, non-plastic consistence; gradual, wavy boundary;
	III	160-280+ cmbs; very dusky red (2.5YR 2.5/2 moist); silty clay; very dusky red (2.5YR 2.5/2 dry); weak, fine crumb structure; soft, friable, slightly sticky, slightly plastic consistence; layer continues below base of unit.

Table 6.(cont.)

		WEST FACE
17	I	0-26 cmbs; very dusky red (2.5YR 2.5/2 moist); clay loam; weak, fine crumb structure; soft, friable, slightly sticky, plastic consistence; clear, wavy boundary; possible agricultural deposit.
	II	26-230 cmbs; very dusky red (2.5YR 2.5/2 moist); silty clay; weak, fine crumb structure; soft, very friable, sticky, slightly plastic consistence; gradual, wavy boundary; possible agricultural deposit.
	III	230-270+ cmbs; very dusky red (7.5R 2.5/2 moist); silty clay; weak, fine crumb structure; soft, very friable, slightly sticky, slightly plastic consistence; layer continues below base of unit.
		NORTH FACE
18	I	0-40 cmbs; very dusky red (2.5YR 2.5/2 moist); clay loam; weak, fine crumb structure; soft, friable, slightly sticky, plastic consistence; clear, wavy boundary; possible agricultural deposit.
	II	40-80 cmbs; very dusky red (2.5YR 2.5/2 moist); silty clay; weak, fine crumb structure; soft, very friable, sticky, slightly plastic consistence; gradual, wavy boundary; possible agricultural deposit.
	III	80-195 cmbs; very dusky red (7.5R 2.5/2 moist); silty clay; weak, fine crumb structure; soft, very friable, slightly sticky, slightly plastic consistence; clear, wavy boundary;
	IV	195-280 cmbs; dark reddish brown (5YR 3/4 moist); silty clay; dark brown (7.5YR 3/4 dry); weak, fine crumb structure; soft, firm, slightly sticky, slightly plastic consistence; abrupt, irregular boundary;
	V	280+ cmbs; limestone bedrock.
		SOUTH FACE
19	I	0-107 cmbs; dark reddish brown (5YR 3/3 moist); silty clay; weak, fine crumb structure; slightly hard, firm, very sticky, plastic consistence; abrupt, irregular boundary;
	II	107+ cmbs; limestone bedrock.
		EAST FACE
20	I	0-15 cmbs; dark reddish brown (5YR 3/3 moist); silty clay; weak, fine crumb structure; slightly hard, firm, very sticky, plastic consistence; abrupt, wavy boundary;
	II	15-20 cmbs; yellowish brown (10YR 5/4 moist); loamy sand; light yellowish brown (10YR 6/4 dry); weak, fine single grain structure; loose, loose, non-sticky, non-plastic consistence; clear, wavy boundary;
	III	20-30 cmbs; dark reddish brown (5YR 3/2 moist); clay loam; dark brown (7.5YR 3/4 dry); moderate very fine crumb structure; hard, firm, slightly sticky, non-plastic consistence; clear, smooth boundary;
	IV	30-50 cmbs; dark brown (7.5YR 3/4 moist); silty clay; dark reddish brown (5YR 3/4 dry); moderate very fine crumb structure; soft, very friable, slightly sticky, non-plastic structure; abrupt, wavy boundary;
	V	50+ cmbs; limestone bedrock.

Table 6.(cont.)

		NORTHEAST FACE
21	I	0-142 cmbs; very dusky red (10R 2.5/2 moist); silty clay; weak, fine crumb structure; slightly hard, firm, sticky, slightly plastic consistence; clear, wavy boundary;
	II	142-180 cmbs; dark brown (7.5YR 3/4 moist); silty clay; weak, fine crumb structure; soft, friable, sticky, slightly plastic consistence; abrupt, wavy boundary;
	III	180+ cmbs; limestone bedrock.
		WEST FACE
22	I	0-140 cmbs, ranges from 54-140 cm in thickness; dark reddish brown (5YR 3/2 moist); silty clay; weak, fine crumb structure; soft, very friable, slightly sticky, slightly plastic consistence; diffuse, irregular boundary; possible agricultural deposit.
	II	54-156 cmbs; dark reddish brown (5YR 3/3 moist); silt loam; weak, fine granular structure; soft, very friable, slightly sticky, non-plastic consistence; abrupt, wavy boundary;
	III	156+ cmbs; limestone bedrock.
		WEST FACE
23	I	0-20 cmbs; very dusky red (2.5YR 2.5/2 moist); clay loam; weak, fine crumb structure; soft, friable, slightly sticky, plastic consistence; clear, wavy boundary;
	II	20-200 cmbs; very dusky red (2.5YR 2.5/2 moist); silty clay; weak, fine crumb structure; soft, very friable, sticky, slightly plastic consistence; gradual, wavy boundary; possible agricultural deposit.
	III	200-240+ cmbs; very dusky red (7.5R 2.5/2 moist); silty clay; weak, fine crumb structure; soft, very friable, slightly sticky, slightly plastic consistence; layer continues below base of unit.
		WEST FACE
24	I	0-15 cmbs; dark reddish brown (5YR 3/2 moist); loamy clay; weak, fine prismatic structure; soft, very friable, slightly sticky, slightly plastic consistence; clear, wavy boundary;
	II	15-190 cmbs; dark olive brown (2.5Y 3/2 moist); sandy clay; weak, fine to medium granular structure; soft, very friable, slightly sticky, slightly plastic consistence; clear, wavy boundary;
	III	190-250+ cmbs; black (5Y 2.5/2 moist); sandy clay; weak, fine to medium granular structure; soft, very friable, slightly sticky, slightly plastic consistence; layer continues below base of unit.
		SOUTH FACE
25	I	0-10 cmbs; dark brown (7.5YR 3/2 moist); loam; dark brown (7.5YR 3/2 dry); weak, fine crumb structure; soft, very friable, slightly sticky, slightly plastic consistence; common roots; abrupt, smooth boundary;
	II	10-27 cmbs; dark brown (7.5YR 3/2 moist); loam; dark brown (7.5YR 3/2 dry); weak, fine crumb structure; soft, very friable, slightly sticky, slightly plastic consistence; few roots; abrupt, smooth boundary;
	III	27-130 cmbs; pink (7.5YR 7/4 moist); loamy fine sand; pink (7.5YR 7/4 dry); weak, fine single grain structure; loose, loose, non-sticky, non-plastic consistence; abrupt, wavy boundary;
	IV	130-152+ cmbs; gray (5Y 5/1 moist); very fine sand; gray (5Y 5/1 dry); weak, very fine single grain structure; loose, loose, non-sticky, non-plastic consistence; layer continues below base of unit.

Table 6.(cont.)

		NORTH FACE
26	IA	0-46 cmbs, ranges from 0-46 cm in thickness; dark reddish brown (5YR 2.5/2 moist); cobbly clay loam; dark reddish brown (5YR 3/2 dry); weak, fine crumb structure; soft, friable, slightly sticky, plastic consistence; abrupt, smooth boundary;
	IB	0-127 cmbs; ranges from 64-81 cm in thickness; dark reddish brown (5YR 2.5/2 moist); clay loam; dark reddish brown (5YR 3/2 dry); weak, fine crumb structure; soft, friable, slightly sticky, plastic consistence; abrupt, smooth boundary; possible agricultural deposit.
	II	64-170 cmbs, ranges from 43-46 cm in thickness; dark brown (10YR 4/3 moist); sand; strong, medium single grain structure; loose, loose, non-sticky, non-plastic consistence; clear, wavy boundary;
	III	110-180+ cmbs, ranges from 10-15 cm in thickness; grayish brown (2.5Y 5/2 moist); sand; strong, medium single grain structure; loose, loose, non-sticky, non-plastic consistence; layer continues below base of unit.
		EAST FACE
27	I	0-20 cmbs; dark brown (7.5YR 3/2 moist); gravelly silty clay; moderate medium crumb structure; soft, friable, slightly sticky, plastic consistence; common roots; abrupt, smooth boundary;
	IIA	20-70 cmbs; dark brown (7.5YR 3/2 moist); silty clay; weak, fine crumb structure; soft, friable, slightly sticky, slightly plastic consistence; clear, wavy boundary;
	IIB	70-190 cmbs; dark reddish brown (5YR 3/3 moist); silty clay; weak, fine crumb structure; soft, friable, slightly sticky, slightly plastic consistence; clear, wavy boundary;
	III	190-240+ cmbs; very dusky red (2.5YR 2.5/2 moist); silty clay; weak, fine crumb structure; soft, very friable, slightly sticky, slightly plastic consistence; layer continues below base of unit.

DATA ANALYSES

by Susan T. Goodfellow, Ph.D.

AGE DETERMINATIONS

Objectives and Methods

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. Seven samples of charcoal were chosen from discrete cultural deposits within Sites 4458, 4460, and 4467, and BT-17 and -19 for age determination using radiocarbon analysis. Samples were selected based on the amount and nature of datable material present, stratigraphic context, and overall distribution within the project area. The 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 of the seven samples proceeded normally.

Results

The results of the radiocarbon age determination are summarized in Table 7. 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 shown in Table 7, Samples RC-1280, -1283, -1284, and -1285 yielded definitive age ranges after calibration, while Samples RC-1279, -1281, and -1282 produced 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 sample to the calibration curve. While multiple age ranges are more difficult to interpret archaeologically, detailed examination of the statistical curves, combined with evidence from feature stratigraphy, generally provides a means of selecting one age range as more probable than the others. Based on these criteria, the most likely age ranges for Samples RC-1279, -1281 and -1282 are AD 1390-1640, BC 3370-2870 and BC 5420-4890, respectively.

The results of the age determination analysis span a 28,670-year period extending from BC 26,655 to the present (present = AD 1955). Within this period, the results from specific features can be grouped into three clusters. The first cluster consists of samples with age ranges predating human occupation of the Hawaiian Islands (BC 26,655-100) and includes samples RC-1281 from BT-17, RC-1282 from BT-19, and RC-1285 and -1285 from Feature J of Site 4467. In all four cases, sample age ranges are apparently inconsistent with known stratigraphic relationships, and may have been affected by localized contamination or disturbance. Given that none of the samples were associated with artifactual or ecofactual material, however, the possibility exists that the strata from which they were derived represent entirely natural deposits and that the age ranges are correct.

The second cluster consists of those samples which are prehistoric in age (AD 1260-1640) and includes Sample RC-1279 from Feature A of Site 4458 and Sample RC-1283 from Site 4460. In contrast to the samples in the first cluster, both age ranges are consistent with known stratigraphic relationships and artifact data.

The third cluster consists of the remaining sample, RC-1280, which has an age range spanning both the prehistoric and historic periods. Examination of the two sigma values for the sample indicates that there is a higher probability (> than 56%) that the sample is historic, with a revised age range of AD 1790-1955. Again, the sample age range is consistent with stratigraphic relationships and associated cultural materials.

Based on the results of the age determination analysis, initial occupation of the project area occurred during the prehistoric period, beginning potentially as early as AD 1260 at Site 4460. Feature A of Site 4458 appears to have been utilized slightly later in the prehistoric period, but given the overlap of the age ranges from Samples RC-1279 and -1283, may have been occupied contemporaneously with Site 4460. Both locations have been interpreted as habitations, with Site 4460 being a collection of five terraces and Feature A an overhang. Evidence for late prehistoric/early historic occu-

Table 7.

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/BC
Site 4458						
1279	51231	Feature A,TU-1, HF-1, Layer II, 23-38 cmbd	460±70	-26.2	440±70	1327-1334 AD 1390-1640 AD
1280	51232	Feature C,ST-1, Layer I, Level 1, 0-5 cmbs	140±70	-25.4	130±70	1640-1955# AD
Site Other						
1281	51233	BT-17, Layer II,44-56 cmbd	4,360±120	-22.5	4400±120	3370-2870 BC 2806-2774 BC 2721-2701 BC
1282	51234	BT-19, Layer II,159-169 cmbd	6,210±130	-25.2	6210±130	5469-5445 BC 5420-4890 BC 4883-4842 BC
Site 4460						
1283	51235	TU-2, Layer II,30-40 cmbs	620±80	-26.0	600±80	1260-1440 AD
Site 4467						
1284	51236	Feature J,TU-2, Layer II, Level 1, 2, 30-40 cmbs	2,240±70	-26.8	2210±70	400-100 BC
1285	51237	Feature J, TU-2, Layer III, 44-52 cmbs	26,680±970	-25.8	26670±97	26655-22775 BC

** Calibrated according to Stuiver and Pearson (1986). Range at two sigmas.*
 # Denotes bomb C-14

pation is derived solely from Feature C (overhang) of Site 4458 which, like the features above, is interpreted to have functioned as a temporary habitation.

PORTABLE ARTIFACTS

A total of 244 artifacts were recovered from the project area, 15 of which were classified as indigenous. Indigenous artifacts are those fabricated using traditional Hawaiian manufacturing techniques and local raw materials, and range in type from fishing gear and tools to various decorative or religious items. The inventory of indigenous artifacts from the current project area is fairly narrow in content, and consists of flaked stone artifacts, recreational items, tools and a number of artifacts of uncertain function. The inventory of non-indigenous items, in contrast, is fairly broad and includes construction materials, domestic items, clothing, and several miscellaneous items. A detailed tabulation of the artifacts by provenience is presented in Table 8. The results of the artifactual analysis are discussed below.

Indigenous Artifacts

Flaked Stone - Ten of the indigenous artifacts recovered from the project area are flaked stone artifacts (derived from Sites 4472, 4458, 4463, and Area J). The assemblage includes one core and nine flakes, all of which are manufactured from basalt.

All flaked stone material was evaluated with respect to flake/core type following established procedures. The definitions used to classify the material are as follows. Cores tend toward multifaceted polyhedral shapes dominated by one or more platforms, and 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. Diagnostic flakes are defined as those flakes having a complete or partial striking platform and a bulb of percussion. Non-diagnostic flakes are fragments which lack the platform or bulb, while debitage represents the debris associated with flake manufacture. Polished flakes are restricted to the basalt assemblage, and represent flakes which have one or more highly polished surfaces. Polished flakes are generally interpreted as deriving from flaking or retouch done on polished stone tools such as adzes. Based on the above criteria, the ten specimens comprise one secondary core, four diagnostic flakes, four non-diagnostic flakes, and one piece of debitage. None of the flakes are polished.

Cores - Cores are further described by the number and condition of platforms, the number and direction of flake scars, and the presence or absence of cortex. The core specimen is a secondary core measuring 5.6 cm by 7.9 cm by 2.5 cm. It has a single intact platform with three associated flake scars, and is distally contracted in plan view. Cortex is retained on approximately 30% of the dorsal face, indicating that the specimen was discarded prior to extensive use.

Flakes - Compositionally, one of the diagnostic and one of the non-diagnostic flakes are manufactured from vesicular basalt, while the remaining three diagnostic and three non-diagnostic flakes are manufactured from aphanitic basalt. The diagnostic flakes are 20-61 mm in length and 24-30 in width, and the non-diagnostic flakes are 9-23 mm in length and 13-23 mm in width. The vesicular basalt flakes are generally larger than the aphanitic basalt flakes due to lesser quality as a flaking medium.

Uses for flaked stone 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).

Recreation - One *'ulu-maika* stone was encountered in the project area. The specimen is manufactured from vesicular basalt and derives from the surface of Feature F-1 at Site 4458. It measures 7.5 cm in diameter and 4.7 cm in thickness. According to Buck (1957:372-3), the game of *'ulu maika* was played on a prepared course (*kahua*) with stone disks. Two sticks were placed in the ground at the end of the 30-40 ft. course, and the disks would be rolled between them. In another variant, the stones would be thrown as far as possible along the course, with the longest throw being counted as the winner (Ellis 1839:198). The disks were generally manufactured with two convex edges so that the disk would roll in a straight line; however, Emerson (1951:221) has noted that a few were rounded on a single side so as to run along a curved course.

Tools - Two tools were encountered in the project area during the current investigation. The assemblage derives from Feature F of Site 4454 and the surface of Site 4464, and includes two adze preforms. Adzes are described according to a system developed by PHRI, based on work done by Craib

Table 8.

DETAILED DISTRIBUTION OF ARTIFACTUAL REMAINS

Category	4454 Fea.A Surf.	4454 Fea.F & O TU-1 Surf.	4454 Fea.F & O TU-1 II 2	4454 Fea.F & O TU-1 II 3	4454 Fea.F & O TU-1 II 4	(Fea.O) Sub Total	(4454) Site Total	4458 Fea.C ST-1 I 1	4458 Fea.F-1 ST-2 Surf.	4458 Fea.F-1 ST-2 I 1	(Fea.F-1) Sub Total	(4458) Site Total	4460 TU-1 II	4460 TU-2 II	(4460) Site Total	4463 Fea.B TU-1 I	4463 Fea.B TU-2 I	(4463) Site Total	4464 Surf.	4467 TU-2 I 1	4467 TU-2 I 2	4467 TU-2 I 3	4467 TU-2 II 1	4467 TU-2 II 2	4467 TU-2 III 1	(4467) Site Total	4472 Cave ST-1 I	Other BT-4	Area J TU-1 I/II 1	Area J TU-1 II 2-3	(Area J) Sub Total	(Other) Site Total	Grand Total
Indigenous																																	
Flaked Stone																																	
Basalt																																	
Core	-	-	-	-	-	0	0	-	-	-	0	0	-	-	0	-	-	0	-	-	-	-	-	-	-	0	-	1	-	-	0	1	1
Flake	-	-	-	-	-	0	0	2	-	1	1	3	-	-	0	2	-	2	-	-	-	-	-	-	-	0	3	-	1	-	1	1	9
Subtotal Flaked Stone	0	0	0	0	0	0	0	2	0	1	1	3	0	0	0	2	0	2	0	0	0	0	0	0	0	0	3	1	1	0	1	2	10
Recreation																																	
Basalt																																	
Ulu Maika	-	-	-	-	-	0	0	-	1	-	1	1	-	-	0	-	-	0	-	-	-	-	-	-	-	0	-	-	-	-	0	0	1
Subtotal Recreation	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Tools																																	
Basalt																																	
Adze Preform	-	1	-	-	-	0	1	-	-	-	0	0	-	-	0	-	-	0	1	-	-	-	-	-	-	0	-	-	-	-	0	0	2
Subtotal Tools	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Total Indigenous	0	1	0	0	0	0	1	2	1	1	2	4	0	0	0	2	0	2	1	0	0	0	0	0	0	0	3	1	1	0	1	2	13
Non-Indigenous																																	
Construction Materials																																	
Glass																																	
Light Bulb	-	-	-	-	-	0	0	-	-	-	0	0	-	-	0	-	-	0	-	2	-	-	-	-	-	2	-	-	-	-	0	0	2
Metal																																	
Bolt	-	-	-	-	-	0	0	-	-	-	0	0	-	-	0	-	1	1	-	-	-	-	-	-	-	0	-	-	-	-	0	0	1
Fluorescent Tube Pins	-	-	-	-	-	0	0	-	-	-	0	0	-	-	0	-	-	0	-	1	-	-	-	-	-	1	-	-	-	-	0	0	1
Subtotal Const. Materials	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	3	0	0	0	0	0	3	0	0	0	0	0	0	4
Domestic Items																																	
Ceramic																																	
Fragments	-	-	-	-	-	0	0	-	-	-	0	0	-	-	0	-	-	0	-	-	-	-	-	-	-	0	-	-	1	-	1	1	1
Glass																																	
Bottle	-	-	-	-	-	0	0	-	-	-	0	0	-	-	0	-	-	0	-	2	-	-	-	-	-	2	-	-	2	-	2	2	4
Fragments	-	-	1	1	-	2	2	-	-	-	0	0	1	-	1	-	3	3	-	4	2	-	-	-	-	6	-	-	53	1	54	54	66
Jar	-	-	-	-	-	0	0	-	-	-	0	0	-	-	0	-	-	0	-	-	-	-	-	-	-	0	-	-	1	-	1	1	1
Subtotal Domestic Items	0	0	1	1	0	2	2	0	0	0	0	0	1	0	1	0	3	3	0	6	2	0	0	0	0	8	0	0	57	1	58	58	72
Miscellaneous																																	
Fiber																																	
Cordage	1	-	-	-	-	0	1	-	-	-	0	0	-	-	0	-	-	0	-	-	-	-	-	-	-	0	-	-	-	-	0	0	1
Metal																																	
Barbed Wire	-	-	-	-	-	0	0	-	-	-	0	0	-	-	0	38	1	39	-	-	-	-	-	-	-	0	-	-	-	-	0	0	39
Fragments	-	-	-	-	1	1	1	-	-	-	0	0	-	-	0	1	-	1	-	-	-	99	3	2	2	106	-	-	-	1	1	1	109
Plastic																																	
Fragments	-	-	-	-	-	0	0	-	-	-	0	0	-	-	0	-	-	0	-	1	-	-	-	-	-	1	-	-	-	-	0	0	1
Subtotal Miscellaneous	1	0	0	0	1	1	2	0	0	0	0	0	0	0	0	39	1	40	0	1	0	99	3	2	2	107	0	0	0	1	1	1	150
Total Non-Indigenous	1	0	1	1	1	3	4	0	0	0	0	0	1	0	1	39	5	44	0	10	2	99	3	2	2	118	0	0	57	2	59	59	226
Total	1	1	1	1	1	3	5	2	1	1	2	4	1	0	1	41	5	46	1	10	2	99	3	2	2	118	3	1	58	2	60	61	239

(1971), which records attributes such as cross-sectional shape, shape in plan view, poll shape, cutting edge morphology, number and placement of ground surfaces, bevel type and angle, nature of side surfaces, and presence or absence of tangs. Terminology follows Buck, Emory, Skinner, and Stokes (1930), except that "face" and "base" are substituted for front and back.

Both adze preforms are complete specimens, manufactured from aphanitic basalt, and are formal in description. The first preform (#1) has been completely roughed out in the shape of a gouge or chisel, but has not been ground on any surface. It is triangular in cross section and measures 14.3 cm by 2.4 cm by 2.6 cm. The cutting edge is pointed in plan view, V-shaped in profile, and has a single bevel. The poll is triangular and untanged, and the sides are flat. The second preform (#10) is completely roughed out and has been partially ground on the face and sides. It is rectangular in cross-section and measures 23.7 cm by 5.5 cm by 5.7 cm. The cutting edge is straight in plan view and profile, and has a single bevel. The poll is angled and untanged, and the sides are slightly convex. Basalt adzes were used for a variety of woodworking or butchering tasks; the size and shape of a particular adze being directly correlated with the task for which it was designed. The chisel, or gouge, shape of the first preform would have been useful for puncturing wood or bone; while the second preform was most likely used in a manner similar to a modern hatchet.

Non-indigenous Artifacts

Two hundred twenty-nine non-indigenous recent historic artifacts were recovered from the project area. The assemblage, which includes construction materials, domestic items, items of personal adornment, and miscellaneous items, derives from Sites 4454, 4460, 4463, 4467 and Area J. The artifacts are discussed by function below.

Construction Materials - Four items identified as hardware were encountered in the deposits associated with Sites 4463 and 4467. The inventory includes portions of two lightbulbs, a metal bolt, and the pin section of a fluorescent light. The metal items are badly corroded due to exposure to salt air and ground water, but are otherwise intact. The glass items are fragmentary. No diagnostic attributes which could be used to date the items were noted.

Domestic Items - Seventy-two household items were encountered in the deposits associated with Sites 4454, 4463, 4467, and Area J. The inventory includes one non-diagnostic ceramic fragment, one complete bottle and three bottle fragments, a jar fragment, and 66 non-diagnostic glass fragments. The ceramic fragment is a body fragment from an earthenware vessel; it is too small and eroded for further description. The complete bottle is manufactured of clear glass and most likely contained some type of household cleanser. It measures 15 cm in height by 4.5 cm in diameter, has a round base which is slightly convex, and a small mouth external thread neck finish. The bottle is embossed on the base with "180-8/Ball/H-3" and has mold-lines extending from base to mouth, indicating that the bottle was manufactured after AD 1903.

The bottle fragments are all portions of bottle bases. The first is an entire base (diameter = 6.3 cm) manufactured of amber glass. It is round in plan view, slightly convex in profile, and is embossed with the number "57". The second and third fragments each represent approximately 30% of their respective bottle bases and are manufactured of amber glass. Like the first fragment, both are round in plan view, convex in profile. One is embossed with a "5" while the other has a "27" on the base and a "NO" on the side. The third fragment is a complete base manufactured of clear glass. The fragment has a diameter of 6.5 cm. It is round in plan view, flat in profile, and is embossed with "United Vintner's Inc./ @ H-3-25/ Refilling Prohibited". The notation "Refilling Prohibited" suggests that the bottle was manufactured after federal laws prohibiting sale of reuse of glass bottles went into effect (1933). The jar fragment is a portion of a mouth and is manufactured of clear glass. It appears to be finished with a large mouth external thread, but is otherwise non-diagnostic. The non-diagnostic glass fragments include 16 specimens of clear glass, two specimens of green glass, and 47 specimens of amber glass.

Miscellaneous Items - One hundred fifty recent historic miscellaneous items were encountered in the deposits associated with Site 4454, 4463, 4467 and Area J. The inventory includes a length of cord, 148 corroded fragments of barbed wire and unidentified metal items, and one fragment of blue plastic. No diagnostic attributes were noted for the artifacts in this category.

Summary

In general, the artifact assemblage encountered during the current investigation suggests that a fairly narrow range of prehistoric activities were carried out within the project area. Stone tool manufacture and use is suggested by the flaked stone assemblage, and may have been accompanied by food processing and craft production that relied on the use of flaked stone tools. Woodworking may be indicated by the adze preforms, while recreation is suggested by the *'ulu-maika* stone. The lack of prehistoric artifacts in the deposits

associated with Site 4467 suggests that the site was unoccupied during prehistoric times; but given the general scarcity of prehistoric remains at all of the sites may not be of particular note. Most of the artifacts are recent historic (post 1903). Based on the limited range of non-indigenous artifacts present in the assemblage and their poor condition, it is thought the artifacts are more likely the result of periodic dumping rather than debris associated with previous occupation.

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 mesh. One hundred percent of the material retained in the 1/4-in mesh was completely sorted to the lowest taxonomic level possible, while the material retained in the 1/8-in mesh 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) and is based on a series of experiments measuring the relative distribution of molluscan and bone material 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

Midden was encountered in the deposits at 20 sites. The range of taxa in the midden is summarized in Table 9. 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 derived from the project area.

In general, the invertebrate taxa included in the midden assemblage from the current project area are common inhabitants of the shorelines, shallow-water areas, solution benches and fringing reefs of the windward islands of the Hawaiian chain. The vegetal material includes the "native" taxa *Aleurites moluccana* (*kukui*) and *Pandanus odoratissimus*, and three historically introduced taxa—*Caesalpinia crista* (gray nicker), *Mucuna gigantea* (sea bean), and *Psidium guajava* (guava). By weight, 14% of the 577.35 grams of midden material recovered from the project area is contributed by marine gastropods, 1.4% by bivalves, 15.7% by other invertebrates such as echinoids, crustaceans and non-marine gastropods and 68.9% by vegetal material. Vertebrate faunal remains were also present in the assemblage, and are analyzed in detail below. *Turbinidae*, *Strombidae*, *Trochidae* and *Patellidae* are the most abundant marine gastropods by weight, while *Mytillidae* and *Tellinidae* are the most common bivalves. *Crustacea* and barnacles are the most common taxa within the other invertebrates category. Vegetal material consists primarily of *Aluerites moluccana* (*kukui*), with lesser amounts of carbonized vegetal remains in the form of charcoal.

The midden assemblages, when examined by site and feature, are fairly distinct in content and relative distribution when compared to the project area totals. The deposits associated with Sites 4458 and 4467 contribute the largest relative proportion of midden remains to the current assemblage, and consequently mirror the content and relative distribution noted for the total assemblage above. Within Site 4458, however, the deposits associated with individual features are more diverse. The Feature A and F deposits are dominated by other invertebrates and lack gastropods and bivalves. The Features C, D, K and K-2 deposits are similar to the total site assemblage, but Features C and D contain higher relative percentages of gastropods and comparatively fewer other invertebrates; while K and K-2 contain lower percentages of gastropods and higher percentages of other invertebrates.

Table 9.

DETAILED DISTRIBUTION OF ECOFACTUAL REMAINS

Material	4454 Fea O TU-1 II 2	4458 Fea A TU-1 I 2	II 1	II 2	III 1	III 2	IV 1	(Fea A) Sub Total	Fea C ST-1 I 1	Fea D ST-1 I 1	Fea F-1 ST-2 I 1	II 1	(Fea F-1) Sub Total	Fea K TU-1 I 1	I 2	I 3	(Fea K) Sub Total	Fea K-2 ST-1 I 1	I 2	(Fea K-2) Sub Total
Mollusca																				
Gastropoda																				
Patellidae																				
Cellana sp.	-	-	-	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	0.00	-	-	0.00
Trochidae																				
Trochus intextus	-	-	-	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	0.00	-	-	0.00
Turbinidae	-	-	-	-	-	-	-	0.00	2.93	9.61	-	-	0.00	-	-	-	0.00	-	-	0.00
Turbo sanwicensis	-	-	-	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	0.00	0.26	-	0.26
Neritidae																				
Nerita picea	-	-	-	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	0.00	-	-	0.00
Theodoxus neglectus	-	-	-	-	-	-	-	0.00	-	0.18	-	-	0.00	-	-	-	0.00	-	-	0.00
Littorinidae																				
Littorina pintado	-	-	-	-	-	-	-	0.00	-	-	-	-	0.00	0.16	-	-	0.16	-	-	0.00
Vermetidae	-	-	-	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	0.00	-	-	0.00
Strombidae																				
Strombus maculatus	-	-	-	-	-	-	-	0.00	2.09	5.29	-	-	0.00	-	-	-	0.00	0.70	-	0.70
Hipponicidae	-	-	-	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	0.00	-	-	0.00
Calyptraeidae	-	-	-	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	0.00	-	-	0.00
Cypraeidae	-	-	-	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	0.00	-	-	0.00
Thaididae	-	-	-	-	-	-	-	0.00	2.53	-	-	-	0.00	-	-	-	0.00	-	-	0.00
Subtotal Gastropoda	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**7.55**	**15.08**	**0.00**	**0.00**	**0.00**	**0.16**	**0.00**	**0.00**	**0.16**	**0.96**	**0.00**	**0.96**
Bivalvia																				
Mytilidae																				
Brachidontes c.	-	-	-	-	-	-	-	0.00	0.30	2.45	-	-	0.00	-	-	-	0.00	-	-	0.00
Isognomonidae	-	-	-	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	0.00	-	-	0.00
Tellinidae	-	-	-	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	0.00	-	-	0.00
Subtotal Bivalvia	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.30**	**2.45**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Other Invertebrates																				
Barnacle	-	-	-	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	0.00	-	-	0.00
Crustacea	-	0.45	-	0.74	7.53	19.45	5.57	33.74	-	-	0.11	1.38	1.49	1.47	-	4.08	5.55	0.66	1.59	2.25
Echinoidea	-	-	-	-	-	-	-	0.00	-	0.35	-	-	0.00	-	-	-	0.00	-	-	0.00
Non-Marine Gastropods	-	-	-	-	-	-	-	0.00	0.09	0.85	-	-	0.00	-	-	-	0.00	0.11	-	0.11
Subtotal Other Invertebrates	**0.00**	**0.45**	**0.00**	**0.74**	**7.53**	**19.45**	**5.57**	**33.74**	**0.09**	**1.20**	**0.11**	**1.38**	**1.49**	**1.47**	**0.00**	**4.08**	**5.55**	**0.77**	**1.59**	**2.36**
Total Invertebrates	**0.00**	**0.45**	**0.00**	**0.74**	**7.53**	**19.45**	**5.57**	**33.74**	**7.94**	**18.73**	**0.11**	**1.38**	**1.49**	**1.63**	**0.00**	**4.08**	**5.71**	**1.73**	**1.59**	**3.32**
Vegetal Remains																				
Pandanaceae																				
Pandanus odoratissimus	-	-	-	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	0.00	-	-	0.00
Caesalpinioideae																				
Caesalpinia crista	-	-	-	-	-	-	-	0.00	-	-	-	-	0.00	-	2.19	-	2.19	3.36	-	3.36
Papilionatae																				
Mucuna gigantea	-	-	-	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	0.00	-	-	0.00
Euphorbiaceae																				
Aleurites moluccana	-	-	-	-	-	-	-	0.00	10.37	18.93	-	-	0.00	1.99	1.30	8.13	11.42	-	0.67	0.67
Myrtaceae																				
Psidium guajava	-	-	-	-	-	-	-	0.00	-	-	-	-	0.00	0.46	0.68	-	1.14	-	-	0.00
Other																				
Charcoal	-	1.95	1.62	-	-	-	-	3.57	1.89	3.14	-	-	0.00	1.81	0.20	0.20	2.21	2.68	0.91	3.59
Unidentified	46.38	-	-	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	0.00	-	-	0.00
Subtotal Vegetal Remains	**46.38**	**1.95**	**1.62**	**0.00**	**0.00**	**0.00**	**0.00**	**3.57**	**12.26**	**22.07**	**0.00**	**0.00**	**0.00**	**4.26**	**4.37**	**8.33**	**16.96**	**6.04**	**1.58**	**7.62**
Total	**46.38**	**2.40**	**1.62**	**0.74**	**7.53**	**19.45**	**5.57**	**37.31**	**20.20**	**40.80**	**0.11**	**1.38**	**1.49**	**5.89**	**4.37**	**12.41**	**22.67**	**7.77**	**3.17**	**10.94**

Table 9. (cont.)

Material	(4458) Site Total	4460 TU-1 II	4460 TU-2 II	(4460) Site Total	4467 TU-2 I 1	I 2	I 3	II 1	II 2	III 1	IV 1	V 1	(4467) Site Total	4472 Cave ST-1 1	ST-2 1	(4472) Site Total	Grand Total
Mollusca																	
Gastropoda																	
Patellidae																	
Cellana sp.	0.00	-	-	0.00	-	-	-	5.40	-	-	-	2.76	8.16	-	-	0.00	8.16
Trochidae																	
Trochus intextus	0.00	-	-	0.00	-	-	-	-	-	-	4.20	4.38	8.58	-	-	0.00	8.58
Turbinidae	12.54	-	-	0.00	-	-	4.34	-	-	-	-	10.08	14.42	0.30	-	0.30	27.26
Turbo sanwicensis	0.26	-	-	0.00	-	-	-	-	-	-	-	-	0.00	-	-	0.00	0.26
Neritidae																	
Nerita picea	0.00	-	-	0.00	-	-	-	-	-	-	0.30	0.46	0.76	-	-	0.00	0.76
Theodoxus neglectus	0.18	-	-	0.00	-	-	-	-	-	-	0.54	3.86	4.40	-	-	0.00	4.58
Littorinidae																	
Littorina pintado	0.16	-	-	0.00	-	-	-	-	-	-	-	-	0.00	-	-	0.00	0.16
Vermetidae	0.00	-	-	0.00	-	-	-	-	-	-	0.48	-	0.48	-	-	0.00	0.48
Strombidae																	
Strombus maculatus	8.08	-	-	0.00	-	-	-	-	-	-	-	-	0.00	6.22	-	6.22	14.30
Hipponicidae	0.00	-	-	0.00	-	-	0.03	-	-	-	3.09	0.81	3.93	-	-	0.00	3.93
Calyptraeidae	0.00	-	-	0.00	-	-	-	-	-	-	-	0.07	0.07	-	-	0.00	0.07
Cypraeidae	0.00	-	-	0.00	-	-	-	-	-	-	-	-	0.00	5.01	-	5.01	5.01
Thaididae	2.53	-	-	0.00	-	-	-	-	-	-	-	-	0.00	1.35	-	1.35	3.88
Subtotal Gastropoda	**23.75**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**4.37**	**5.40**	**0.00**	**0.00**	**8.61**	**22.42**	**40.80**	**12.88**	**0.00**	**12.88**	**77.43**
Bivalvia																	
Mytilidae																	
Brachidontes c.	2.75	-	-	0.00	-	-	-	-	-	-	-	-	0.00	2.79	-	2.79	5.54
Isognomonidae	0.00	-	-	0.00	-	-	0.08	-	-	-	0.73	-	0.81	-	-	0.00	0.81
Tellinidae	0.00	1.69	-	1.69	-	-	-	-	-	-	-	-	0.00	-	-	0.00	1.69
Subtotal Bivalvia	**2.75**	**1.69**	**0.00**	**1.69**	**0.00**	**0.00**	**0.08**	**0.00**	**0.00**	**0.00**	**0.73**	**0.00**	**0.81**	**2.79**	**0.00**	**2.79**	**8.04**
Other Invertebrates																	
Barnacle	0.00	-	-	0.00	-	-	1.62	6.77	4.24	3.17	-	-	15.80	-	-	0.00	15.80
Crustacea	43.03	-	-	0.00	-	-	0.04	1.26	-	-	-	-	1.30	1.31	22.28	23.59	67.92
Echinoidea	0.35	-	-	0.00	-	-	-	-	-	-	-	-	0.00	0.11	-	0.11	0.46
Non-Marine Gastropods	1.05	-	0.34	0.34	-	-	-	-	-	-	-	-	0.00	-	-	0.00	1.39
Subtotal Other Invertebrates	**44.43**	**0.00**	**0.34**	**0.34**	**0.00**	**0.00**	**1.66**	**8.03**	**4.24**	**3.17**	**0.00**	**0.00**	**17.10**	**1.42**	**22.28**	**23.70**	**85.57**
Total Invertebrates	**70.93**	**1.69**	**0.34**	**2.03**	**0.00**	**0.00**	**6.11**	**13.43**	**4.24**	**3.17**	**9.34**	**22.42**	**58.71**	**17.09**	**22.28**	**39.37**	**171.04**
Vegetal Remains																	
Pandanaceae																	
Pandanus odoratissimus	0.00	-	-	0.00	1.62	-	-	-	-	-	-	-	1.62	-	-	0.00	1.62
Caesalpinioideae																	
Caesalpinia crista	5.55	-	-	0.00	-	-	-	-	-	-	-	-	0.00	-	-	0.00	5.55
Papilionatae																	
Mucuna gigantea	0.00	-	-	0.00	0.81	-	0.42	-	-	-	-	-	1.23	-	-	0.00	1.23
Euphorbiaceae																	
Aleurites moluccana	41.39	-	4.02	4.02	203.26	74.48	-	-	0.22	-	0.13	-	278.09	0.51	-	0.51	324.01
Myrtaceae																	
Psidium guajava	1.14	-	-	0.00	-	-	-	-	-	-	-	-	0.00	-	-	0.00	1.14
Other																	
Charcoal	14.40	-	-	0.00	-	-	1.24	-	-	-	-	-	1.24	2.01	-	2.01	17.65
Unidentified	0.00	-	-	0.00	-	-	-	-	-	-	-	-	0.00	-	-	0.00	46.38
Subtotal Vegetal Remains	**62.48**	**0.00**	**4.02**	**4.02**	**205.69**	**74.48**	**1.66**	**0.00**	**0.22**	**0.00**	**0.13**	**0.00**	**282.18**	**2.52**	**0.00**	**2.52**	**397.58**
Total	**133.41**	**1.69**	**4.36**	**6.05**	**205.69**	**74.48**	**7.77**	**13.43**	**4.46**	**3.17**	**9.47**	**22.42**	**340.89**	**19.61**	**22.28**	**41.89**	**568.62**

The deposits associated with Site 4472 are also similar to the project area assemblage in that all of the major taxonomic categories are present. The deposits are marked by a lower relative percentage of vegetal remains and a comparatively higher percentage of other invertebrates when compared with the Site 4458 and 4467 deposits. In contrast, the deposits associated with Sites 4454, 4460 and Area J are fairly restricted in content. The Site 4460 deposits are dominated by vegetal material and have a high relative percentage of bivalves, but lack gastropods. The Area J deposits lack bivalves and vegetal material, and have high percentages of gastropods and other invertebrates. The Site 4454 deposits are composed entirely of vegetal material.

Turbinidae is the most common gastropod in the deposits associated with Sites 4458 and 4467 and Area J, while Stromblidae dominates the gastropod material in the Site 4454 deposits. Mytillidae are the most common bivalves in the Site 4454 and Site 4458 deposits, while Tellinidae and Isognomonidae dominate the bivalves at Sites 4460 and 4467 respectively. Crustacea dominates the deposits at Sites 4454, 4458, and Area J; non-marine gastropods dominate the deposits at Site 4460, and barnacles dominate the deposits at Site 4467. Finally, *Aleurites moluccana* (*kukui*) is the most common vegetal remains in the deposits associated with Sites 4458, 4460 and 4467; while charcoal and unidentified vegetal remains are most abundant at Sites 4472 and 4454, respectively.

The results of the midden analysis indicate that subsistence in the project area included the collection and consumption of a variety of shell fish, ranging from several taxa of marine gastropods and bivalves to echinoids and crustaceans. Unfortunately, however, the majority of the marine taxa identified in the assemblage are not unique to a single habitat, making identification of more specific exploitation patterns difficult. The remains of non-marine gastropods and vegetal material in the midden assemblage indicates that terrestrial resources were also utilized by local populations, although the non-marine gastropods may have been contributed by natural post-depositional disturbance of the deposits rather than by cultural activity. Unlike the invertebrate material, however, not all of the vegetal taxa present in the midden assemblage would have contributed to the diet. *A. moluccana* (*kukui*), for example, has several additional uses documented in the ethnological records of the Bernice P. Bishop Museum, including the manufacture of *kukui* nut candles and torches, *kukui* leis, and as a raw material in tapa manufacture. Pandanus provided edible fruit, leaves for weaving baskets and mats, and brushes for painting designs on tapa. *Caesalpinia crista* (gray nicker) most commonly functioned as a barrier against cattle, but also provided seeds for *leis*. The seeds of *Mucuna gigantea* (sea bean) were used for *leis* as well, but when powdered was used as a purgative. Finally, the bud leaves of *Psidium guajava* (guava) were used to relieve diarrhea, while small branches have more recently been used in the manufacture of *lomi-lomi* (massage) sticks.

VERTEBRATE FAUNAL REMAINS

Objectives and Methods

Vertebrate faunal remains are archaeologically significant on a number of levels, as the variety and abundance of vertebrate faunal material contained within a deposit provide useful information concerning prehistoric diet, environment, and resource utilization patterns. Vertebrate faunal remains encountered in a deposit may also have paleontological significance, and so are collected and analyzed to determine whether rare or extinct taxa are present in the deposits of a particular area. The analysis of faunal remains for the current project thus has three primary objectives:

1. To determine faunal deposit content, in particular the variety and distribution of the remains for each cultural deposit encountered within the project area;

2. To provide an indication of dietary and resource exploitation patterns for each unit type, and for the project area as a whole; and

3. To assess the paleontological significance of the faunal material recovered from each unit type and preserve specimens of extinct or rare taxa where encountered.

Analysis of the faunal remains from the project area was completed by Dr. Alan Ziegler, a zoological consultant who currently resides in Hawaii. Faunal samples were separated by site, feature, test unit and stratum prior to submission to Dr. Ziegler. Identification information and bone counts were attached to the separated samples as they were analyzed in order to prevent mixing of contexts during analysis or repacking of the samples upon their return to the PHRI lab. All faunal remains were identified to the lowest taxonomic level possible. Use of common names for certain taxa is meant to convey the general size of the animal represented, rather than to definitively indicate that any specific taxon mentioned is present in the deposit. The results of Dr. Ziegler's analysis are summarized in Table 10. These results are discussed in detail below.

Results

A total of 182 faunal specimens were encountered in the deposits associated with Sites 4458, 4460, 4467, and 4472.

Table 10.

DETAILED DISTRIBUTION OF FAUNAL REMAINS

Category	4458 Feature A TU-1 I 1	I 2	II 1	(Feat.A) Total	Feat.K TU-1 I 1	I 2	I 3	(Feat.K) Total	Feat.K-2 ST-1 I 1	I 2	(Feat.K-2) Total	(4458) Site Total	4460 TU-1 II	TU-2 II	(4460) Site Total	4467 Feat.J TU-2 I 3	II 2	(4467) Site Total	4472 Cave ST-1 I	Grand Total
Osteichthyes																				
Unidentified Fish	-	-	-	0	1	-	-	1	-	-	0	1	-	-	0	-	-	0	2	3
Subtotal Osteichthyes	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	2	3
Amphibia																				
Bufonidae																				
Bufo Marinus	-	-	-	0	-	-	-	0	-	-	0	0	-	-	0	1	-	1	-	1
Subtotal Amphibia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1
Aves																				
Indeterminate																				
Small Passeriform	-	-	-	0	1	1	-	2	-	-	0	2	-	-	0	-	-	0	-	2
Order And Family Indeterminate																				
Medium Bird	-	1	-	1	1	-	1	2	-	-	0	3	-	-	0	-	-	0	-	3
Subtotal Aves	0	1	0	1	2	1	1	4	0	0	0	5	0	0	0	0	0	0	0	5
Mammalia																				
Muridae																				
Rattus Exulans	7	11	5	23	8	6	23	37	3	-	3	63	-	-	0	-	-	0	5	68
Rattus Norvegicus	-	-	2	2	6	1	-	7	6	-	6	15	-	-	0	-	-	0	-	15
Felis Catus	-	-	-	0	46	1	1	48	-	-	0	48	-	-	0	-	-	0	-	48
Bovidae																				
Bos Taurus	-	-	-	0	-	-	-	0	-	-	0	0	-	2	2	-	-	0	-	2
Order And Family Indeterminate																				
Small-To Medium Mammal	-	-	-	0	5	-	-	5	1	-	1	6	15	-	15	1	-	1	1	23
Medium Mammal	-	1	3	4	-	-	-	0	-	-	0	4	-	-	0	-	-	0	-	4
Large Mammal	10	-	-	10	-	-	-	0	-	1	1	11	-	-	0	-	1	1	-	12
Subtotal Mammalia	17	12	10	39	65	8	24	97	10	1	11	147	15	2	17	1	1	2	6	172
Indeterminate																				
Order And Family Indeterminate																				
Medium Vertebrate	-	-	-	0	-	1	-	1	-	-	0	1	-	-	0	-	-	0	-	1
Subtotal Indeterminate	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	1
Total	17	13	10	40	68	10	25	103	10	1	11	154	15	2	17	2	1	3	8	182

Based on actual counts, the total assemblage contains 1.65% Osteichthyes, 0.55% Amphibia, 2.75% Aves, 94.5% Mammalia, and 0.55% Indeterminate Vertebrates. The Osteichthyes remains are comprised entirely of non-diagnostic bone from small fish, and the Amphibia remains are contributed entirely by bones of Giant Neotropical Toad (*Bufo marinus*). The Aves remains are dominated by small passeriforms and medium birds. Polynesian Rat (*Rattus exulans*), cat (*Felis catus*) and small to medium mammals are the most common taxa of mammals in the assemblage. The remainder of the inventory is comprised of highly fragmented specimens of indeterminate medium vertebrates.

The faunal deposits, when examined by site, vary considerably in content and relative abundance, although Mammalia remains dominate each deposit. The deposits at Site 4458 contribute the largest proportion of vertebrate faunal remains to the current assemblage, and consequently mirror the content and relative distribution noted for the total assemblage above. In contrast, the deposits associated with the remaining three sites are extremely limited in content. The remains at Site 4467 contain 33.3% Amphibia and 66.7% Mammalia, while the remains from Site 4472 contain 25% Osteichthyes and 75% Mammalia. The vertebrate faunal remains from Site 4460 are comprised entirely of Mammalia. At those sites where faunal remains were encountered in more than one feature, the faunal deposits associated with each feature generally mirror the total site deposits in content and relative distribution.

In addition to the more general observations above, several more specific observations can be made concerning the distribution of faunal material in the project area. First, Dr. Ziegler notes that Site 4458 seems to have formerly served as the home of a mammalian and/or avian predator. Historically introduced species in the form of one or both larger *Rattus* species, as well as house cat are present. The presence of small passeriform bird bones along with a number of bones of rats, in conjunction with the fact that much of this material is fairly well fragmented, suggests that these small animals may well have been predator prey (Ziegler, personal communication). The remains associated with Site 4467 also contain historic material in the form of toad (*Bufo marinus*) and a metal-sawed mammal rib section. The remains associated with Sites 4472 and 4460 were largely fragmentary and reveal little concerning past activity at each site.

Discussion

The faunal analysis indicates that subsistence patterns in the project area included the collection and consumption of fish, although the general scarcity of Osteichthyes remains argues against this resource being a major component of local diets. The presence of amphibian, bird and mammal remains in several of the site deposits indicates that, consistent with the results of the midden analysis above, terrestrial resources were also included as part of the subsistence in the project area. Again, it should be noted that the relative importance of marine versus terrestrial resources in prehistoric diets cannot be accurately determined given the differential preservation of the two types of remains.

SUMMARY OF POLLEN ANALYSIS

Eight pollen samples from five backhoe trenches excavated in the project area (BT-1, 3, 17, 22 and 26) were submitted to Dr. Linda Scott Cummings of PaleoResearch Laboratories, Colorado (see Appendix C) for palynological analysis. Using a chemical extraction technique based on flotation, pollen grains were extracted from the soil matrix of each sample. The grains were then mixed with glycerol and were placed on microscope slides. The slides were examined using a light microscope at a magnification of 500x to determine the abundance of pollen grains present in each sample and the degree of preservation. Finally, identification of specific taxa and a general estimate of the taxonomic variability present in each sample were based on comparison to materials from the Bishop Museum Herbarium.

The analysis indicates that vegetation varied across the project area. In the eastern portion (BT-1, 26) wetter conditions are suggested by large amounts of Graminae and Cyperaceae pollen, as well as small percentages of Urticaceae. Fragmentary grains of Pandanus (*hala*) or Colocasia (taro) pollen were also noted in the eastern samples, suggesting that the area was utilized for cultivation of wetland crops. In the western portion of the project area (BT-3, 17, 22) the pollen record is dominated by shrubby Chenopodium, indicating drier conditions. Pollen from agricultural crops is absent from the samples, suggesting that the area sampled was not used for agriculture during the periods represented by the pollen record.

CONCLUSION

SUMMARY AND DISCUSSION

During the present survey 17 sites consisting of 109+ component features were identified within the project area. In addition, six sites consisting of 12 component features were identified in areas adjacent to the project area. These six sites were also recorded because they may be affected by development activities. Of the total 23 sites identified, two had been previously identified. The sites comprise 11 complexes and 12 single-feature sites, and range in physical condition from poor to good. The sites comprise the following formal types: terrace, circular alignment, retaining wall, wall, overhang, soil mounds, ditch, enclosure, cave, modified bedrock, modified crevice, paved area, pond field, wall remnant, ditch-tunnel, mound, platform, terrace-wall, cemetery, cupboard, foundation, rubble concentration, soil berm, subsurface deposit, upright stone, and wall segment. Probable functional interpretations for the features include agriculture, burial, irrigation, temporary habitation, habitation, erosion control, indeterminate, possible agriculture, possible habitation, boundary, erosion control-fenceline, possible burial, dozer push, marker, possible storage area, temporary habitation-burial, temporary habitation-possible burial, and storage. In all, the features comprise 18 functional types. Only 17% of the sites have multiple functions, and nearly half of the total identified features are agricultural in function.

The project area has been heavily affected by historic agriculture, ranching, and other development activities. There are isolated areas which seem to have escaped the effects of these activities, and within these areas are examples of the types of prehistoric sites which surely existed throughout the Laie area. In addition to sites identified as prehistoric, there are also sites identified as historic, and in some cases prehistoric sites were found in conjunction with historic features.

Four sites (4454, 4466, 4471, and 4475) consisting of a total of 38 component features were assigned exclusively agricultural functions. Site 4454 reflects relatively more recent agricultural activities, as evidenced by the overall construction methods used, the presence of post holes with associated posts, and the presence of a recent irrigation system (sprinkler heads set above the ground surface on pipes). An aerial photograph of the project area taken in 1951 shows the area of the site was cultivated in sugar cane. Site 4466 contains a historic element—one of the features has a concrete water control gate present at one end, and local residents remember the fields being planted in taro. The site may also contain a prehistoric element in that the overall site is very similar to a prehistoric irrigated pondfield system. As such it would reflect one of few such sites in the immediate area. Sites 4471 and 4475 appear to be remnants of prehistoric agricultural features; these sites have been negatively affected by relatively recent land modifications.

Four single component sites (4093, 4457, 4459, and 4470) are assigned irrigation functions; all appear historic. All four sites consist of ditches, consisting either of concrete troughs, or excavated soil ditches with stone-lined sides. Two of the sites have associated tunnels, one consisting of small openings lined with corrugated metal, and the other larger in size and appearing to have been drilled through limestone substrate. In all cases the sites appear to be parts of an overall, larger irrigation system supplying water for agricultural or ranching needs.

Two sites (4465 and 4468) were assigned burial functions. The sites appear historic—they are marked with a variety of headstones, some have associated jars. Site 4465 has undergone previous archaeological work by Bath (1985).

Two sites (4460 and 4464) are assigned habitation functions, based on portable remains, construction methods, and associated features. A charcoal sample recovered from TU-2 at Site 4460 yielded a calibrated range of AD 1260-1440.

Two sites (4455 and 4467) were assigned the function of possible habitation. Site 4455, a dressed limestone block and mortar structure, may be a historic habitation structure. Site 4467, identified during the backhoe trenching phase of the current field work, may be a subsurface deposit. During the excavation of BT-8 at the site a possible subsurface cultural layer was identified. A subsequent test unit was excavated to isolate and identify the deposit. Two charcoal samples from the unit were submitted for radiocarbon age determination analyses, one collected from Stratum II, and one from Stratum III. Stratum II yielded a calibrated range of 400-100 BC, and Stratum III yielded a range of 26,655-22,775 BC. These ranges predate human occupation in the Hawaiian Islands, and appear to be the result of contamination or disturbance. Further data collection is recommended at the site in order to substantiate the date ranges. There is a remote possibility that the laboratory that conducted the dating analyses, Beta Analytic, Inc., may have accidentally switched the samples with those from a location other than Hawaii.

One site (4456, dozer push) was determined to be the result of bulldozing associated with historic sugar cane cultivation. This was based on excavations conducted at the site, and examination of the structure of the feature.

One site (4474) appears to be historic and to function for erosion control. This is based on location of the site, at the base of a road, and the presence of a drainage pipe incorporated into the stabilization structure.

One site (4461) is assigned a dual function, erosion control and fenceline. This site appears to stabilize the bank of a stream, and in places also serves as a fenceline boundary. The site has been determined to be historic, but it may actually comprise a prehistoric structure that has been historically modified.

One site (4469) is assigned a historic marker function. This site consists of an upright piece of granite generally rectangular with an arched top. There is an "X" on the top of the stone, and two small notches at the base, one on each side. Upon the excavation of a test unit at the base of the stone it was revealed that the stone extended c. 1.0 m below the surface, to bedrock. No subsurface deposit was found in the unit. Based on the evidence, the stone is thought to be a marker of some kind, perhaps a property marker, like similar markers found on the mainland.

One site (4472) is assigned a dual function of temporary habitation and burial, and appears prehistoric. This is based on the results of subsurface testing.

In addition to the sites mentioned above, four sites (4458, 4462, 4463, and 4473) were assigned multiple functions. During the current survey only a representative sample of Site 4462 was recorded and mapped because of the largeness of the site and the site's extremely thick vegetation. This site represents extensive and intensive prehistoric and/or early historic agriculture. Formal feature types at the site include retaining wall, terrace, ditch, wall, terrace-wall, enclosure, and overhang. Most of the features at the site are agricultural; other functions represented include irrigation, possible habitation, erosion control, indeterminate, and temporary habitation. Two dates ranges were recovered from Site 4458, Features A and C (calibrated ranges of AD 1390-1640 and AD 1640-1955, respectively).

Laie is much different today than in the past. Land along the coast has been modified to make way for residential areas. Alluvial floodplains and lower foothills have been cleared for historic agriculture, ranching, and housing developments. These modifications have destroyed much of the evidence necessary for a comprehensive understanding of prehistoric settlement patterns in Laie.

The previous archaeological work conducted in the general Laie area shows that the area was occupied as early as AD 1000. This date was obtained from a sample recovered during the 1988-1989 PHRI inventory survey at Punamano and Malaekahana (Jensen 1989). The sample was recovered from a cave site (4089) in Malaekahana, c. 4,000 ft inland of the coast. Additional dates obtained by Bath in 1985, and by Yent and Estioko-Griffin in the late 1970s indicated coastal Malaekahana and Laie were occupied from AD 1415-1780.

When comparing the sites identified during the current survey with known sites in the vicinity, no new patterns are discernible. The earliest date range obtained from the current field work, from Site 4460, located c. 4,800 feet inland of the coast, is AD 1260-1440, which fits into the previously identified range for occupation. The types of sites identified, their apparent functions and ages, in conjunction with the results of radiocarbon age determination analyses, all point to occupation occurring as early as AD 1000. Sites dated during the current survey and sites dated during previous archaeological work in the vicinity fall within Kirch's Expansion Period (AD 1100-1650). During this period there was a rapid increase in population, and intensified agriculture (large-scale irrigation, dryland cultivation, and aquaculture systems), which resulted in the creation of new social, political, and religious forms (Kirch 1985 :303-306).

Past archaeological work in the Laie and Malaekahana coastal and floodplain areas indicates occupation occurred throughout the Expansion Period, with one range from Site 4089 representing the late Developmental Period. Additional work at the sites identified during the current project and during the Jensen survey of the Malaekahana portion of the project area in 1988-1989 (Jensen 1989), may shed light on Developmental Period sites. Specifically, further work at Site 4467 may substantiate the date of 400-100 BC, and thus provide a better overview of initial settlement for the Laie area.

GENERAL SIGNIFICANCE ASSESSMENTS AND RECOMMENDED GENERAL TREATMENTS

General significance assessments and recommended general treatments for all identified sites are summarized in Table 11. Specific field tasks for individual sites are summarized in Table 1. 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 uses these criteria for evaluating cultural resources. Sites determined to be potentially significant for information content fall under Criterion

Table 11.

SUMMARY OF GENERAL SIGNIFICANCE ASSESSMENTS AND RECOMMENDED GENERAL TREATMENTS

SHIP Site Number	Significance Category A	X	B	C	Recommended Treatment FDC	NFW	PID	PAI
4454	-	+	-	-	-	+	-	-
4456	-	+	-	-	-	+	-	-
4457	-	+	-	-	-	+	-	-
4459	-	+	-	-	-	+	-	-
4461	-	+	-	-	-	+	-	-
4469	-	+	-	-	-	+	-	-
4470	-	+	-	-	-	+	-	-
4475	-	+	-	-	-	+	-	-
Subtotal: 8	0	8	0	0	0	8	0	0
277	+	-	-	-	+	-	-	-
4093	+	-	-	-	+	-	-	-
4460	+	-	-	-	+	-	-	-
4463	+	-	-	-	+	-	-	-
4464	+	-	-	-	+	-	-	-
4467	+	-	-	-	+	-	-	-
4471	+	-	-	-	+	-	-	-
4473	+	-	-	-	+	-	-	-
4474	+	-	-	-	+	-	-	-
Subtotal: 9	9	0	0	0	9	0	0	0
4465	+	-	-	+	+	-	-	+
4468	+	-	-	+	+	-	-	+
4472	+	-	-	+	+	-	-	+
Subtotal: 3	3	0	0	3	3	0	0	3
4462	+	-	*	-	+	-	*	-
4466	+	-	*	-	+	-	*	-
Subtotal: 2	2	0	2	0	2	0	2	0
4455	+	-	-	*	+	-	*	-
Subtotal: 1	1	0	0	1	1	0	1	0
4458	+	-	-	*	+	-	-	*
Subtotal: 1	1	0	0	1	1	0	0	1
Total: 23	15	8	2	5	16	8	3	4

General Significance Categories:

A = Important for information content, further data collection necessary (CRM value mode assessment = scientific research value);
X = Important for information content, no further data collection necessary (CRM value mode assessment = scientific research value);
B = Excellent example of site type at local, regional, island, State, or National level (CRM value mode assessment = interpretive value);
C = Culturally significant (CRM value mode assessment = cultural value).

Recommended General Treatments:

FDC = Further data collection necessary (further 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.

**Provisional assessment; definite assessment pending results of further data collection.*

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

To further facilitate management decisions regarding the subsequent treatment of resources, the general significance of the archaeological resources identified during the inventory survey were also evaluated in terms of potential scientific research, interpretive, and/or cultural values (PHRI Cultural Resource Management [CRM] Value Modes; see Table 1 for individual assessments of sites). These three value modes are derived from the above state and federal evaluation criteria. *Research value* refers to the potential of archaeological resources for producing information useful in understanding the cultural history, past lifeways, 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 significant evaluation used here, refers to the potential of archaeological resources for the preservation and promotion of cultural and ethnic identity and values.

Based on the above federal/state criteria, of the 23 sites formally identified, 16 are assessed as significant solely for information content (one other site, 277 - Paeo Fishpond, is also assessed as significant solely for information content even though it was not relocated during the current survey. No further work is recommended for eight of the 16 sites. These eight sites have been measured, described, photographed, and plotted. The data collected from them during the present survey is considered sufficient recovery of significant information. Further data collection is recommended for the remaining eight sites and for 277-Paeo Fishpond. Further data collection field tasks for individual sites are summarized in Table 1. After further data collection is completed, data recovery excavations at specific sites—if warranted by the data collection findings—would be implemented for the sites not recommended for preservation or interpretation. Because they are not good examples of site types, preservation of these sites subsequent to mitigation would not be essential.

Three sites (4472,4465,4468) are assessed as significant for information content and cultural value because the sites contain burials. Further data collection followed by preservation "as is" is recommended.

Two sites which include possible prehistoric agricultural features (Sites 4462 and 4466) are assessed as significant for information content and are provisionally assessed as excellent examples of site types. Further data collection followed by provisional preservation with interpretive development is recommended.

One site (4455, a possible habitation foundation) is assessed as significant for information content and as possibly significant for cultural value (pending additional historical documentary research). Further data collection is recommended, and preservation with interpretive development is provisionally recommended pending the results of further data collection.

One site (4458) is assessed as significant for information content and as possibly significant for cultural value. Further data collection is recommended, and preservation "as is" is provisionally recommended pending the results of further data collection.

As an important initial step, it is recommended that all identified sites be accurately located and plotted by professional surveyors, with the aid of an archaeologist, on an appropriate scale topographic map of the project area. This locational plotting would greatly aid development planning by allowing further archaeological work determinations (further data collection, data recovery and/or preservation) to be more accurately considered on a site-by-site basis.

The assessments and recommendations presented here have been based on the findings of the recently completed inventory survey and test excavations. There is always the possibility, however remote, that potentially significant, unidentified subsurface cultural remains could be encountered in the course of further 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: 4093 **PHRI:** T-05
SITE TYPE: Ditch
TOPOGRAPHY: Hillside
VEGETATION: Dense *koa-haole* saplings, vines, and various ground cover.
CONDITION: Fair
INTEGRITY: Altered
PROBABLE AGE: Historic
FUNCTIONAL INTERPRETATION: Irrigation
DIMENSIONS: 46.50 m by 1.75 m by 1.50 m (approx.)
DESCRIPTION: This is a fairly substantial irrigation ditch which proceeds at approx. 198° Az. and runs through a tunnel in a hill. The tunnel is c. 46.50 m long and averages c. 1.50 m in diameter by c. 1.75 m high. The tunnel runs through sandstone substrate. To prevent erosion of the floor and sides of the tunnel, the tunnel portion of the ditch was concrete-lined. The concrete portion of the ditch is c. 0.60 m wide and 0.35 m deep. Past the tunnel, the ditch continues on a new bearing (260° Az.) for c. 21.40 m, at which point it ends under a dirt access road. Apparently the ditch was destroyed sometime during cultivation of sugar cane; perhaps the ditch was replaced with pipe. Except for chunks of concrete and some of the concrete forms used in constructing the tunnel, no portable artifacts were found at the site. This site probably dates to around the turn of the century. It does not appear that the ditch has been utilized for a considerable time, as the dirt access road blocks the ditch outlet.

SITE NO.: State: 4454 **PHRI:** T-10
SITE TYPE: Complex (32 Features)
TOPOGRAPHY: Fairly flat ridge top overlooking BYU campus to the NE. Area appears bulldozed from previous cane cultivation.
VEGETATION: Thick grass, morning glory, vines, papaya, *koa-haole*, guava.
CONDITION: Good
INTEGRITY: Unaltered
PROBABLE AGE: Historic
FUNCTIONAL INTERPRETATION: Agriculture
DESCRIPTION: This site has a total of 32 individual features, but in some cases similar feature types were tallied and designated one feature letter designation. The site consists of one wall (Fea. A), three terraces (Fea. B, F, N), one wall segment at (Fea. C), two enclosures at (Fea. D, G), three wall remnants at (Fea. E, H), 18 circular alignments at (Fea.I, J, M), one rubble concentration at (Fea. K), one mound at (Fea. L), one paved area at (Fea. O), and an area of modified bedrock (Fea. P). The overall dimensions are c. 80.0 m NW-SE by 45.0 m NE-SW.

FEATURE A: Wall
FUNCTION: Agriculture
DIMENSIONS: 96.4 m by 1.0 m by 1.8 m
DESCRIPTION: This free-standing wall appears to serve as a boundary marker for agricultural purposes. The limestone is formally stacked and is faced in certain areas. Rocks are stacked two-three courses wide and two-five courses high. Rock size is c. 0.4 m in diameter and bedrock outcrops are incorporated into the wall construction. Bedrock size averages c. 1.0 by 0.8 m. Rocks are stacked between and on top of outcrops. The wall has numerous bends in it and various orientations. From the west end the wall is oriented SE for c. 10.5 m, then east for c. 16.3 m, then SE for c. 0.7 m, then NE for c. 15.5 m, then SE for c. 2.6 m, then S-SE for c. 0.17 m, and finally NE for c. 27.5 m. A bulldozer berm is at the west end of the south side of the wall.

FEATURE B: Terrace
FUNCTION: Agriculture
DIMENSIONS: 7.5 m N/S by 1.5 m by 0.4 m
DESCRIPTION: This feature consists of loosely stacked limestone cobbles, small to medium boulders, and slabs that abut a natural bedrock outcrop. The outcrop is on the eastern edge of the feature, is c. 1.0 m high, and runs the entire feature length. More outcropping is visible to the southeast. Adjacent to the southwest corner of the feature is a bulldozer push pile of mounded dirt and limestone. Recent historic material is scattered throughout the feature. Limestone cobbles and slabs are placed within the surface area of the terrace. Along the west edge, limestone is two courses high. Interior stacking is not discernible. Rock dimensions are c. 0.18 by 0.13 m with some larger rocks at c. 0.35 by 0.40 m also stacked.

FEATURE C: Wall segment
FUNCTION: Agriculture
DIMENSIONS: 3.5 m N/S by 1.5 m by 0.7 m
DESCRIPTION: This wall segment is approx. 1.5 m west of Feature D and c. 2.0 m southeast of Feature K. It is constructed of formally stacked limestone cobbles and boulders with a bedrock outcrop incorporated into its construction. Limestone cobbles and boulders are stacked two-three courses high. Smaller rocks, c. 0.16 by 0.18 m, are stacked near the middle and larger rocks, c. 0.7 by 0.6 m, placed on smaller rocks. Very large rocks c. 1.0 by 0.6 m and larger are at either end of the feature, and appear to be part of natural outcrops. This feature may have been part of a wall based on construction and barbed wire found within the rocks.

FEATURE D: Enclosure
FUNCTION: Agriculture
DIMENSIONS: 6.5 m N/S by 4.0 m by 1.2 m
DESCRIPTION: This rectangular enclosure incorporates a limestone outcrop. The south wall is built of rock outcropping and limestone stacked three courses high. The west wall is outcropping with stacked rocks. The east wall is all outcropping with no apparent stacking. The rocks furthest north in this wall are only c. 0.4 - 0.5 m high whereas all other areas are c. 1.0 - 1.2 m high. The NE corner abuts Feature A. The north wall is all outcrop except the northwest corner which is stacked. A very large rock, c. 1.0 by 1.0 m, is stacked on smaller rocks in this corner. The NW corner also abuts Feature A. Few large rocks (i.e. natural outcrop) occurred within the feature's interior. No stacking occurs here. There is a gap c. 0.8 - 0.9 m wide where the southwest and southeast corners of the wall should meet. This may be an entrance or exit of the enclosure.

FEATURE E: Wall remnant
FUNCTION: Agriculture
DIMENSIONS: 3.5 m N/S by 1.5 m by 1.2 m
DESCRIPTION: This wall remnant is c. 10.0 m southwest of Feature A and may have been part of an enclosure similar to Feature D. It is c. 1.0 m north of Feature F and c. 1.0 m southeast of Feature D's south wall. Constructed of formal stacked rocks, it is approx. four-five courses high. A few pieces of the natural outcrop have been incorporated into the structure. The outcrop rocks are c. 0.75 m in diameter while the remaining rocks are from c. 0.1 m to c. 0.4 m in diameter. At the southern edge of the N/S oriented wall is another wall remnant oriented E/W and adjacent to the N/S wall. It is c. 1.0 m E/W by 0.9 m N/S. This appears to be a corner of the wall. Feature E construction is similar to Feature A in the formal stacking of rock and average height of the walls, c. 1.2 m.

FEATURE F: Terrace
FUNCTION: Agriculture
DIMENSIONS: 7.0 m N/S by 6.5 m by 0.5 m
DESCRIPTION: This terrace, c. 0.5 m south of Feature E and c. 0.5 m north of Feature G, was built incorporating a large amount of limestone outcrops, with limestone cobbles and boulders making up the remaining portion of the feature. The largest rocks are between c. 0.8 m and 1.3 m in diameter. Loosely stacked rocks, one-two courses high, are along the south and east edges of a natural outcrop. A posthole is visible adjacent to the southern outcrop. Two wooden posts have also fallen within the feature interior. The feature interior seems to be prepared, being c. 0.3 m higher than the surrounding area, and it is relatively flat. Some outcropping does occur along the western edge of the interior and other small rocks, c. 0.1 m in diameter, are scattered throughout.

FEATURE G: Enclosure
FUNCTION: Agriculture
DIMENSIONS: 8.0 m E/W by 4.0 m by 1.2 m
DESCRIPTION: This rectangular enclosure area, c. 0.5 m south of Feature F, is delineated by edges of limestone outcropping. Very little stacking occurs between or on top of outcrops. Rocks are between c. 0.5 m and 1.0 m in diameter. The southeast corner has loosely placed rocks among the outcrop. The height here is c. 0.7 m. The northeast corner has an outcrop with rocks formally stacked five courses high to c. 1.2 m. Other than the two aforementioned areas, the height is c. 0.4 - 0.5 m.

FEATURE H: Wall remnant (2)
FUNCTION: Agriculture
DIMENSIONS: 4.0 m N/S by 1.5 m by 1.1 m (approx.)
DESCRIPTION: Feature H consists of two linear wall remnants c. 3.0 m WNW of Feature I and c. 1.0 m ENE of Feature F. The east wall is c. 2.0 (N/S) by 0.8 by 0.5 m (E/W), and the west wall is c. 2.0 by 1.5 by c. 1.1 m. The furthest west wall incorporates one large rock outcrop (c. 1.3 by 0.8 m) that has rock stacked on top of it three courses high and extending northward. The north extension is piled four courses high. Stacked rocks measure from c. 0.1 by 0.1 m in diameter to c. 0.8 by 0.4 m. About 0.4 m north of this wall remnant is a large naturally occurring boulder. No rocks are stacked on top or around it. The east wall is c. 0.6 m west of the aforementioned alignment. The northern edge of the east wall begins where the southern edge of the west wall ends. The north and south ends of the east wall are a natural outcrop with rocks stacked between them. Outcrop rocks are c. 0.92 by 0.70 m. The stacked rocks are c. 0.6 by 0.4 m and smaller, two courses high, and cover an area c. 0.7 m N/S between the outcrops.

FEATURE I: Circular Alignment
FUNCTION: Agriculture
DIMENSIONS: 3.0 m E/W by 2.3 m by 0.75 m (approx.)
DESCRIPTION: This feature is a circular alignment c. 4.0 m east of Feature H (east wall). It is constructed of limestone cobbles with two outcropped boulders (c. 1.0 m in diameter) incorporated into the construction and opposite each other east to west. Rocks have been formally stacked on the southern edge of both outcrops. Stacked rocks are c. 0.25 by 0.2 m, two courses high, and extend for c. 0.7 m. All other rocks are singularly placed and average c. 0.45 by 0.3 m. The exterior dimensions of the feature are wider E/W due to the size of the outcrops, however the interior is symmetrical. The interior contains placed soil c. 0.2 m higher than the surrounding ground surface. A few small rocks (c. 0.1 by 0.1 m) are scattered about the interior, particularly towards the center. The height of the outcrop is c. 0.75 m, to c. 0.40 m (stacked rocks), to c. 0.25 m (single rock placement).

FEATURE J: Circular Alignments (16)
FUNCTION: Agriculture
DIMENSIONS: 21.0 m E/W by 14.6 m by 0.6 m
DESCRIPTION: The feature is a total of 16 individual circular alignments which were grouped under the designation of "Feature J" because of their similarity. They skirt the southeast, south, and southwest border of Site 4454. These circular alignments appear to form a staggered semicircular line in overall placement and relationship to one another. All 16 features are constructed with stacked or aligned retaining perimeters of limestone cobbles with soil interiors, which are elevated c. 0.2 m to 0.6 m above the surrounding ground surface. The features vary in diameter from 2.5 m to 1.0 m. In overall appearance, the features appear to be agricultural planting areas. Two of the features incorporate massive boulders as part of their perimeters. The individual features were labeled J-1 through J-16 in the field.

FEATURE K: Rubble Concentration
FUNCTION: Agriculture
DIMENSIONS: 4.6 m NNW/SSE by 2.4 m by 1.3 m (approx.)
DESCRIPTION: This feature is roughly linear in shape, oriented NNW/SSE, and consists of large limestone slabs and chunks ranging in size from c. 0.5 by 0.35 by 0.27 m to c. 1.20 by 1.04 by 0.30 m. The slabs are arranged two courses wide and one-two courses high. The NNW end has a large piece of limestone outcrop which has been disturbed by tree root activity. No formalized stacking appears to be associated with the feature. It seems to be a concentration of limestone slabs resulting from agricultural clearing. A small dozer push area is to the west c. 0.6 m of the NNW end of the feature. Note: The area to the immediate WSW appears to be bulldozed, thus this feature may have been associated with additional features which are now gone.

FEATURE L: Mound
FUNCTION: Agriculture
DIMENSIONS: 3.5 m N/S by 3.0 m by 0.6 m
DESCRIPTION: This feature is a low agricultural mound, with possible cleared planting areas on the surface and around its base. It is on the SSW end of Site 4454. It is constructed of limestone cobbles and small boulders piled atop a low rise. The crest and surface of the mound has large boulders, as well as soil within the cleared areas.

A test unit (TU-1), measuring 0.5 m by 0.5 m was excavated in the center of the feature. The following stratigraphy was revealed:

North Face Layer	Description
I	0-30 cmbs; dark brown (7.5YR 3/2 moist); silt loam; dark brown (7.5YR 3/2 dry); structureless; soft, very friable, slightly sticky, slightly plastic consistence;Stratum I (0-30 cmbs) was excavated in three arbitrary 10 cm levels, and was terminated on bedrock. The only cultural material noted was a piece of recent plastic in level 2 (20-30 cmbs), which was not collected.

FEATURE M: Circular Alignment
FUNCTION: Agriculture
DIMENSIONS: 2.20 m N/S by 1.60 m by 0.45 m
DESCRIPTION: This feature is a circular alignment similar to those features within Feature J, except that the interior appears to be sunken. Aligned limestone cobbles form the perimeter of the feature, with the ENE side abutting Feature L. The interior of the feature is a soil-filled depression c. 0.45 m below ground surface.

FEATURE N: Terrace
FUNCTION: Agriculture
DIMENSIONS: 2.2 m N/S by 2.2 m by 0.3 m
DESCRIPTION: This terrace wall is oriented N/S, with a small portion extending W off the N end. The terrace is c. 0.5 m W of Feature M, c. 1.5 m S of the west end of Feature O, and the SW corner of Site 4454. The terrace wall is constructed of limestone cobbles stacked two courses high.

FEATURE O: Paved area
FUNCTION: Agriculture
DIMENSIONS: 9.0 m N/S by 6.0 m by 0.5 m
DESCRIPTION: This feature is a large, low paved area. It is amorphous in shape, with a surface of several cleared and possibly excavated planting areas. It is constructed of limestone cobbles and boulders which appear piled. Large boulders form the eastern perimeter, and the southern perimeter abuts Features L, M, and N. The NE quad of Feature O is higher than the others, and the west border lies at the base of a very slight rise with a large boulder. Feature A (main wall) is c. 0.10 m to 0.15 m due north.

A test unit (TU-1), measuring c. 0.5 m by 0.5 m, and oriented magnetic north, was excavated on the central north side of the feature surface. Approximately 0.15 m of angular limestone cobble fill was removed, then the unit was excavated in arbitrary 0.10 m levels within the underlying soil deposits. The following stratigraphy was revealed:

North Face Layer	Description
I	Consisted of angular limestone cobble fill, above fill layers.
II	0-28 cmbs; very dusky red (2.5YR 2.5/2 moist); silt loam; very dusky red (2.5YR 2.5/2 dry); slightly hard, friable, non sticky, non-plastic consistence;
III	28-38 cmbs; dark reddish brown (2.5YR 2.5/4 moist); silt loam; dark reddish brown (2.5YR 2.5/4 dry); structureless; soft, friable, non-sticky, non-plastic consistence; Stratum II contained glass shards and some charcoal flecking. Stratum III was sterile.

FEATURE P: Modified Bedrock
FUNCTION: Agriculture
DIMENSIONS: 3.0 m NW/SE by 2.5 m by 0.7 m
DESCRIPTION: This feature is 0.3 m west of Feature J-2. The feature consists of limestone bedrock and limestone boulders and cobbles. The boulders are c. 0.7 m in diameter and the cobbles are c. 0.45 m in diameter and smaller. The boulders and cobbles are stacked two courses high. In the southern half of the feature is a soil mound. It is c. 0.20 m higher than the surrounding ground surface. In the northern half of the feature is a depression c. 0.5 m in diameter. It is not known whether this is natural or not.

SITE NO.: State: 4455 PHRI: T-12
SITE TYPE: Foundation
TOPOGRAPHY: Large limestone bedrock outcrop to immediate south and west. Flat swampy area to the northeast.
VEGETATION: Banyan, *hau* bush, *koa-haole*, and large mango.
CONDITION: Good
INTEGRITY: Unaltered
PROBABLE AGE: Historic
FUNCTIONAL INTERPRETATION: Possible habitation
DIMENSIONS: 10.25 m E/W by 5.70 m by 1.60 m
DESCRIPTION: An historic building foundation consisting of one room. The entrance is at the northwest corner of the structure, and has three steps which proceed from ground surface down to the structure floor. The floor is covered with soil, but portions of a concrete slab can be seen. The walls are c. 0.30 - 0.40 m wide. There is a hole in the east wall measuring c. 0.70 by 0.70 m which appears to have been punched through because block and mortar chunks are apparent inside the structure and adjacent to the hole. Soil has washed around the exterior west side of structure, practically burying the wall. This structure may be one of the early buildings associated with the Mormon missionaries.

SITE NO.: State: 4456 PHRI: T-13
SITE TYPE: Modified outcrop
TOPOGRAPHY: At base of a hill just off a swampy, grass covered lowland area.
VEGETATION: *Koa-haole*, passion fruit, *hau*, vines, Christmas-berry, and grass.
CONDITION: Fair
INTEGRITY: Altered
PROBABLE AGE: Recent
FUNCTIONAL INTERPRETATION: Dozer push
DIMENSIONS: 4.0 m N/S by 4.0 m by 0.6 m
DESCRIPTION: This site is a small circular piled rock area on a limestone outcrop. Upon closer inspection and excavation, the feature appears to be the result of bulldozer activity.

A test unit (TU-1), measuring 0.5 m by 0.5 m was excavated in the central west portion of the feature surface. The following stratigraphy was revealed:

Layer	Description
I	Subangular limestone cobble fill on the top 0.15 m.
II	15-32 cmbs; dark reddish brown (5YR 2.5/2 moist); silty clay; dark reddish brown (5YR 2.5/2 dry); moderate medium crumb structure; loose, friable, slightly sticky, slightly plastic consistence; Stratum I consisted of 0.15 m of rock fill. Upon removing the rock, a soil layer, Stratum II was present, c. 0.17 m thick and terminated on bedrock. A piece of recent plastic was found within the top 10 cm of Stratum II.

SITE NO.: State: 4457 **PHRI:** T-14
SITE TYPE: Ditch
TOPOGRAPHY: 5% slope just below ridge top.
VEGETATION: High density of *koa-haole* saplings, passion fruit, vines, and small shrubs.
CONDITION: Poor
INTEGRITY: Altered
PROBABLE AGE: Historic
FUNCTIONAL INTERPRETATION: Irrigation
DIMENSIONS: 65.0 m NW/SE by 1.0 m
DESCRIPTION: This feature is one shallow drainage ditch, c. 15.0 m of which is rock lined. This ditch is most likely an historic ditch, probably used to slow runoff as it contours the slope. Within this area, broken-up cement trough pieces, the type that were frequently used for sugar cane irrigation, were noted while conducting pedestrian sweeps. The entire area has also been bulldozed and is now covered with a low, secondary growth of *koa-haole* and grass.

SITE NO.: State: 4458 **PHRI:** T-17
SITE TYPE: Complex (19 Features)
TOPOGRAPHY: Large outcrop/ridge of limestone bedrock with many natural fissures and crevices.
VEGETATION: Thick *koa-haole*, banyan, *lilikoi*, *hau*, Christmas-berry, ferns, banana, papaya, and small shrubs.
CONDITION: Fair-good
INTEGRITY: Altered
PROBABLE AGE: Prehistoric-early historic
FUNCTIONAL INTERPRETATION: Agriculture-Poss. habitation
DESCRIPTION: The overall dimensions for this site are c. 100.0 m N/S by 90.0 m E/W. This site consists of seven overhangs at (Fea. A, C, D, E1, J, K, N), three modified crevices at (Fea. B, F, K2), two caves at (Fea. E2, L), one cupboard at (Fea. E3), one retaining wall at (Fea. G1), four walls at (Fea. G2, H, I, M), and a paved area at (Fea. O). The site area is within and around a large outcrop of limestone bedrock, consisting of many large crevices, overhangs, and a few caves.

FEATURE A: Overhang (Figure A-1)
FUNCTION: Temporary habitation
DIMENSIONS: 12.0 m N/S by 3.0 m by 3.0 m
DESCRIPTION: This feature is a long, broad, deep soil deposit contained on a shelf along the base of an outcropped limestone cliff, resulting in an overhang area. The cliff is oriented north/south, with the overhang opening facing east. The shelf is partially sheltered on the east by a massive boulder, which appears to have broken off the cliff and lies c. 2.0 m from the overhang. The soil deposit on the shelf has a vertical east bank, and is c. 1.0 m from the back of the overhang. The terrain is a vertical cliff face on the west with overhangs, boulders, ledges, and notches allowing access to the ridge top. The soil shelf and its exposed vertical bank have no retaining features, although there appears to be possible stacking of limestone cobbles in the shelf c. 3.0 m from the north end. An ash deposit was noted in the exposed vertical (east facing) bank. A worked basalt and half of a glass bottle bottom were found in the bank face.

A test unit (TU-1), measuring 0.5 m by 0.5 m, was excavated within the south end of the overhang (Figure A-2). A unit datum was set at 0.1 m above the ground surface in the southwest corner of the unit. The following stratigraphy was revealed:

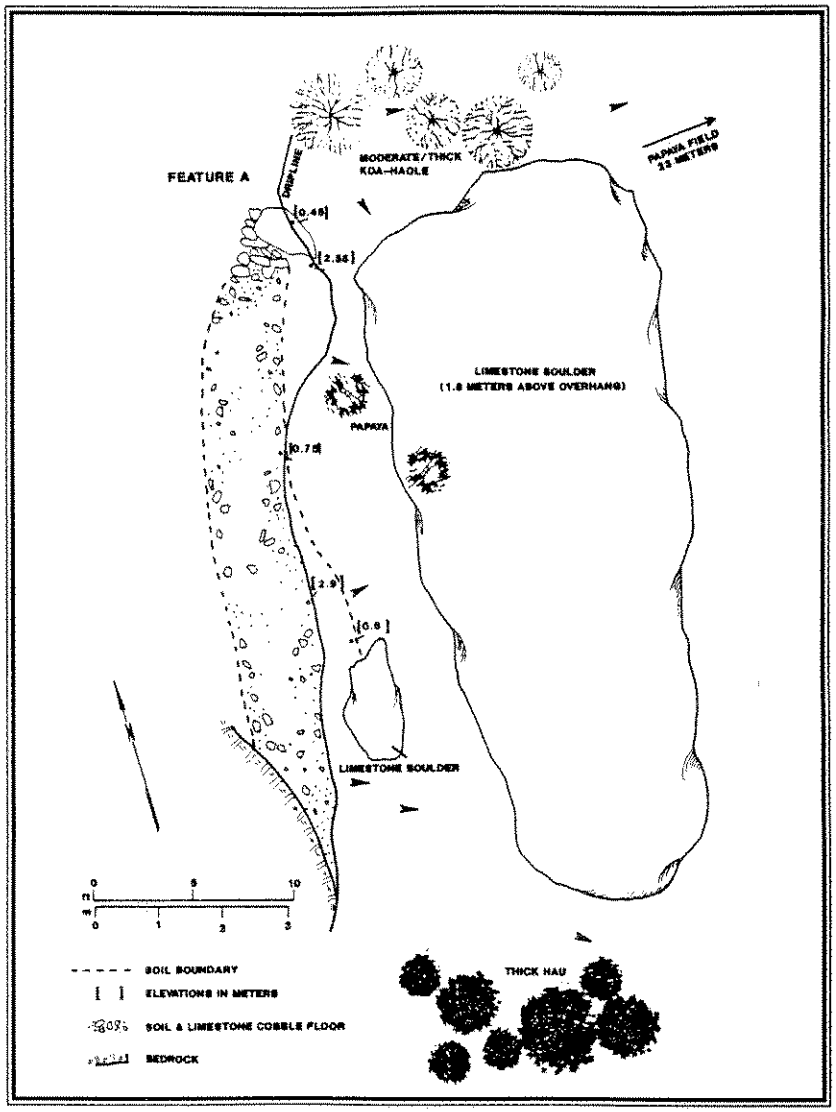


Figure A-1. SITE 4458, FEATURE A

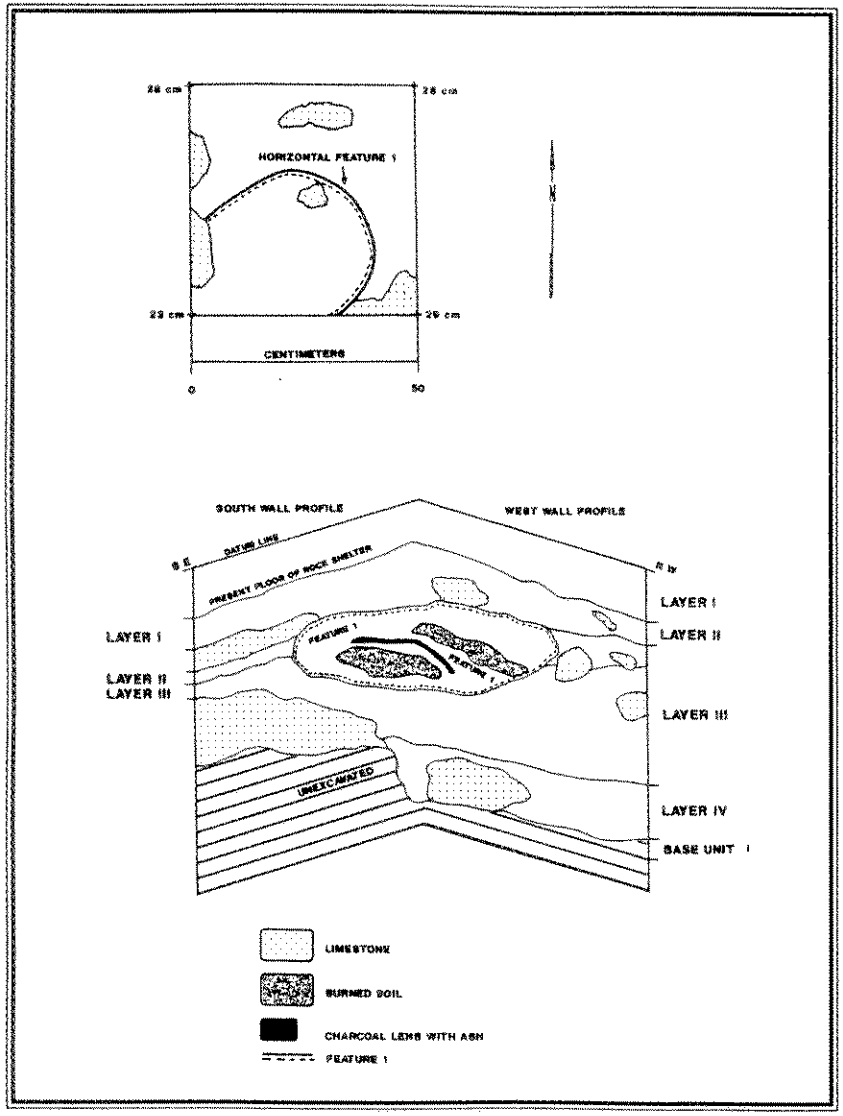


Figure A-2. SITE 4458, FEATURE A, TU-1, SOUTH & WEST FACES

West Face Layer	Description
I	10-23 cmbs; very dark grayish brown (10YR 3/2 moist); silt; dark reddish brown (5YR 3/3 dry); structureless; soft, very friable, slightly sticky, non-plastic consistence;
II-1	23-30 cmbs; dark reddish brown (5YR 2.5/2 moist); silt; dark reddish brown (5YR 3/2 dry); structureless; loose, very friable, non-sticky, slightly plastic consistence;
II-2	30-33 cmbs; dark reddish brown (5YR 2.5/2 moist); silt; dark brown (10YR 3/3 dry); structureless; soft, very friable, slightly sticky, slightly plastic consistence;
III	33-50 cmbs; dark brown (7.5YR 3/4 moist); silt; brown (7.5YR 5/4 dry); structureless; loose, very friable, non-sticky, non-plastic consistence.
IV	50-60 cmbs; dark brown (7.5YR 3/4 moist); silt; dark brown (7.5YR 4/4 dry); loose, very friable, non-sticky, slightly plastic consistence.

Stratum I (10-23 cmbd) was excavated in two arbitrary 10 cm levels, and contained non-human bone, charcoal, and crab shell. At 23 cmbd a soil change was encountered, Stratum II, as well as an ash deposit, designated Horizontal Feature #1 (HF-1), in the southwest portion of the unit. HF-1 was excavated separately in 10 cm levels, and terminated at a maximum depth of 38 cmbd, at which time the feature appeared basin-shaped in overall appearance.

Stratum II (23-33 cmbd) was excavated in two levels, II-1 (23-30 cmbd) and II-2 (30-33 cmbd) due to a very subtle difference in soil. Stratum II contained sparse rodent bone, crab shell, and charcoal.

Stratum III (33-50 cmbd) was excavated in two levels, III-1 (33-40 cmbd), and III-2 (40-50 cmbd), and contained crab shell.

Stratum IV (50-60 cmbd) contained crab shell, and terminated on bedrock at a maximum depth of 60 cm below unit datum.

FEATURE B: Modified crevice (Figure A-3)
FUNCTION: Temporary habitation
DIMENSIONS: 24.0 m N/S by 13.0 m by 10.0 m
DESCRIPTION: This feature is a crevice in an exposed limestone formation. There are large boulders scattered throughout the floor area, apparently from side wall collapse and natural weathering. The crevice has two entrances, one on the southeast, c. 7.8 m north of Feature A, and the other at the north end of the crevice. The crevice proceeds c. 14.0 m at 316°, then turns and proceeds c. 8.0 m at 15° where it terminates at the north entrance. The northern 8.0 m of the crevice is covered by several large boulders and slabs.

A terrace is inside the crevice, c. 12.0 m from the southeast entrance. The terrace is built of stacked limestone cobbles with one large boulder incorporated into the construction. The rock is stacked two-three courses high, and is faced in places. The terrace measures c. 1.40 (L) by 0.08 (W) by 0.50 m (H). Rubble at the base of the terrace may have once been stacked. A soil deposit was noted on the north northwest side of the terrace, and a trowel probe placed in the deposit yielded a crab claw and fishbone.

Another terrace is c. 5.0 m from the southeast entrance, and also incorporates natural rock fall and stacked rocks. The rocks are stacked two courses high and are c. 0.2 by 0.1 m in size. Overall, the terrace measures c. 1.5 (L) by 0.6 (W) by 0.2 m (H).

FEATURE C: Overhang (Figure A-4)
FUNCTION: Temporary habitation
DIMENSIONS: 7.0 m N/S by 2.4 m by 2.4 m
DESCRIPTION: This feature is a natural overhang along the base of an exposed limestone cliff. No modification is apparent within the overhang area, but based on a machete probe, the soil deposit is c. 0.4 m deep.

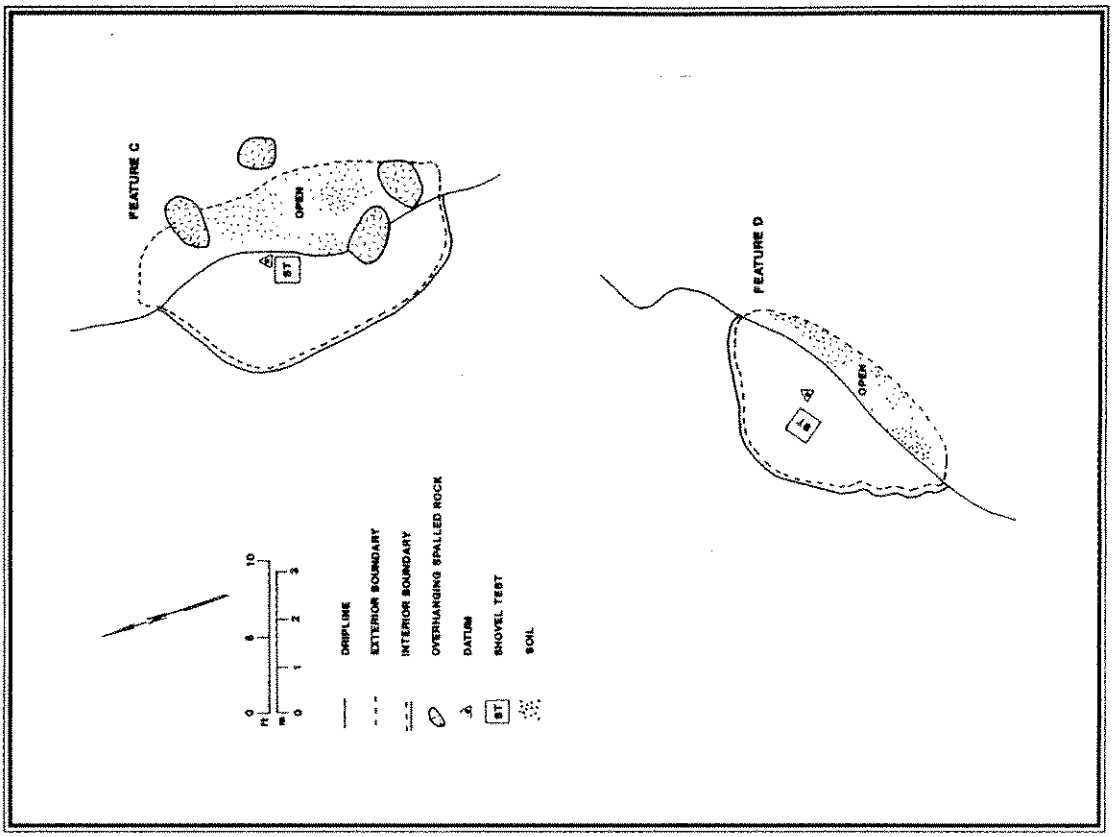


Figure A-4. SITE 4458, FEATURES C AND D.

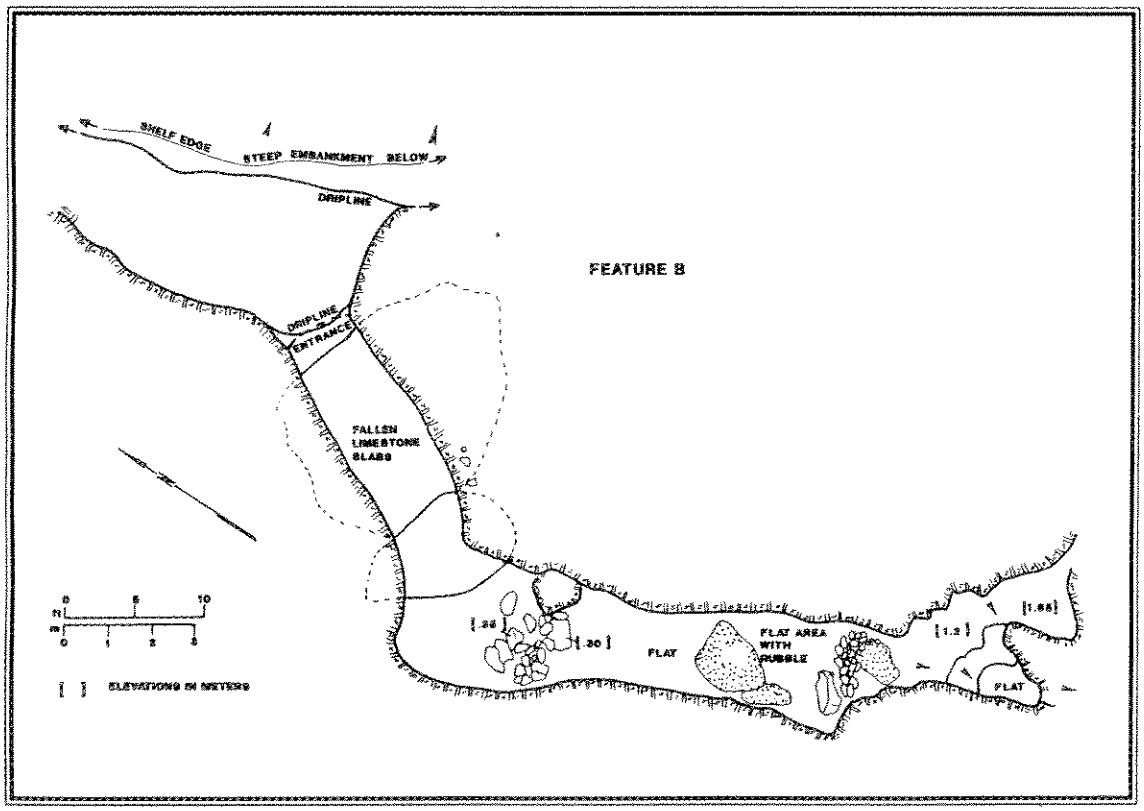


Figure A-3. SITE 4458, FEATURE B

A shovel test (ST-1), measuring c. 0.5 m by 0.5 m, was excavated in the soil deposit contained within the overhang. The following stratigraphy was revealed:

Layer	Description
I	0-5 cmbs; black (10YR 2/1 moist); silt loam; black (10YR 2/1 dry); structureless; loose, very friable, slightly sticky, slightly plastic consistence;

Excavation was terminated at c. 0.05 mbs when a cultural deposit was reached, containing burned *kukui* nutshells, marine shell, and charcoal.

FEATURE D: Overhang (Figure A-4)
FUNCTION: Temporary habitation
DIMENSIONS: 5.5 m N/S by 3.0 m by 1.8 m
DESCRIPTION: This feature is an overhang at the base of an exposed limestone cliff. The interior of the overhang has no modifications. A few large limestone cobbles are in front of the dripline. However, basalt flakes and a substantial soil deposit were noticed on the surface. Due to the portable remains and the soil deposit, a shovel test was excavated.

A shovel test excavated within the soil deposit beneath the overhang uncovered *kukui* nutshells, marine shells, and charcoal. The shovel test measured c. 0.5 m in diameter and was excavated c. 0.1 m, to locate cultural deposits. Upon reaching a cultural deposit, excavation was terminated. The following stratigraphy was revealed:

Layer	Description
I-1	0-10 cmbs; black (5YR 2.5/1 moist); silt; black (5YR 2.5/1 dry); structureless; loose, very friable, non-sticky, slightly plastic consistence.

FEATURE E1: Overhang (Figure A-5)
FUNCTION: Temporary habitation
DIMENSIONS: 5.4 m NE/SW by 2.6 m by 2.3 m
DESCRIPTION: The feature is an overhang at the base of an exposed limestone cliff. The overhang faces SE at 130°. From the back of the overhang area, roof fall extends c. 1.0 m outward. The floor slopes to the northeast. Besides heavy rockfall, a fair amount of rock and soil lies subsurface, based on a trowel probe. Approx. 4.0 m downslope from the overhang, waterworn and fire cracked vesicular basalt were observed. A shovel probe was excavated to c. 0.15 m and recovered crab shell and *kukui* nut from a brown sandy silt matrix. The extent of the deposit is probably from the edge of the roof fall to the edge of the exposed bedrock.

FEATURE E2: Cave (Figure A-5)
FUNCTION: Possible burial
DIMENSIONS: 3.6 m N/S by 3.2 m by 2.5 m
DESCRIPTION: This feature is a cave chamber opening to the southeast, at the base of an exposed limestone cliff, c. 3.2 m northeast of the eastern edge of Feature E1. There are loosely stacked limestone cobbles at the entrance, with one layer placed on bedrock. Rock size averages c. 0.20 by 0.15 m. Within the cave chamber, c. 2.0 m from the entrance, two small human bones were noticed, mapped *in situ*, and collected. A small probe was placed here but rock fall encountered subsurface did not allow for any excavation.

From immediately inside the cave entrance, a side chamber extends perpendicular to the aforementioned chamber, and is oriented at c. 40°. A heavy amount of roof fall occurs in this chamber, prohibiting any exploration.

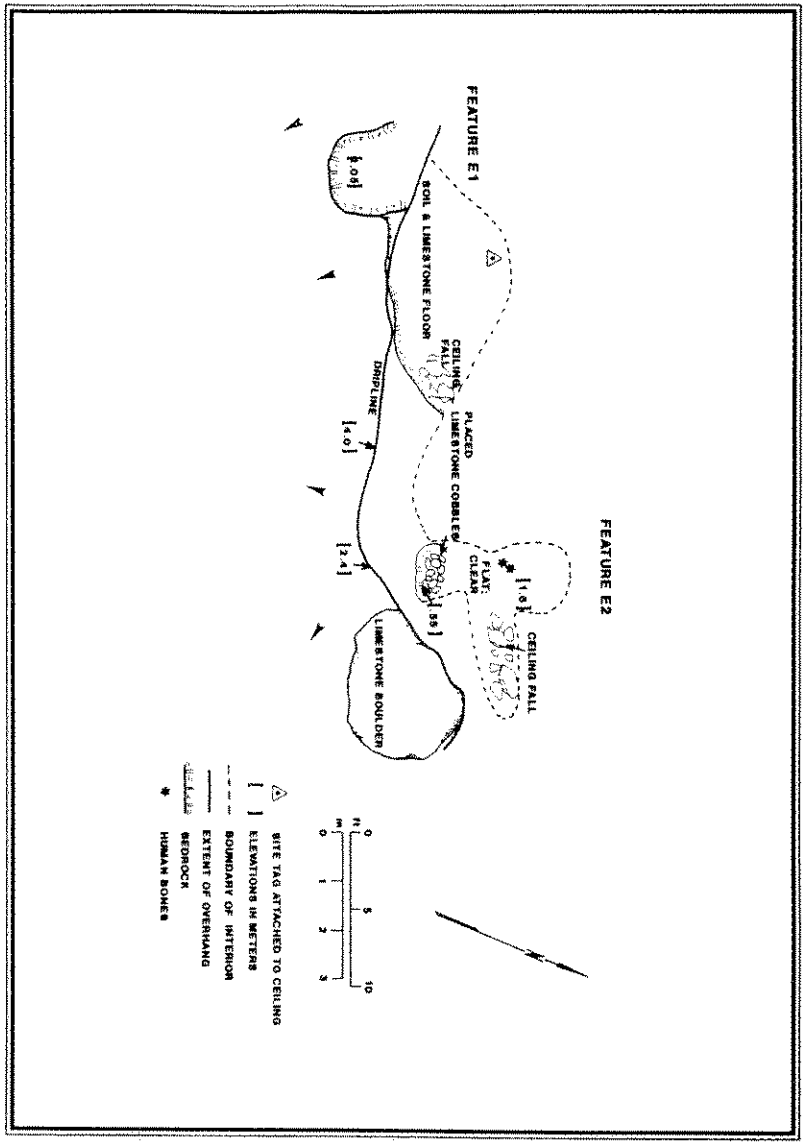


Figure A-5. SITE 4458, FEATURES E1 AND E2

FEATURE E3: Cupboard (Figure A-6)
FUNCTION: Storage
DIMENSIONS: 1.50 m E/W by 1.20 m by 0.55 m
DESCRIPTION: The feature is c. 5.50 m northeast of the entrance to Feature E2. It is a nook on a shelf-like area occupying a large piece of limestone bedrock with rocks formally placed on the surface. The feature area is roughly square and the interior surface paved flat with limestone cobbles measuring c. 0.30 m by 0.30 m. No material was observed on or within the placed rocks.

FEATURE F: Modified crevice (Figure A-7)
FUNCTION: Temporary habitation
DIMENSIONS: 46.0 m NNE/SSW by 20.0 m
DESCRIPTION: This is a crevice in a limestone bedrock outcrop. It is between Features B and E1, and takes up most of the area between them. Scattered basalt cobbles, worked basalt, and a cultural deposit reflecting temporary habitation were observed at the feature. Waterworn basalt cobbles, an *ulu-maika* stone, and flaked basalt were found at the feature. A subsurface deposit is just outside of the overhang, in an area of c. 5.0 by 5.0 m. Functional interpretation was based on associated features at the site, and the portable remains observed on the surface and within Shovel Test 2.

Shovel Test No. 1 (ST-1), measuring c. 0.5 m in diameter, was excavated within an overhang area containing an aeolian soil deposit. The soil was sterile and terminated on bedrock at 0.1 m below the surface.

Shovel Test No. 2 (ST-2) also measured c. 0.5 m in diameter, and was excavated in a soil deposit outside the overhang area. Excavation was terminated at 0.5 mbs based on the presence of cultural material, crab shell and a basalt flake.

The following stratigraphy from ST-1 was revealed:

Layer	
1	0-10 cmbs; very dusky red (2.5YR 2.5/2 moist); silt loam; very dusky red (2.5YR 2.5/2 dry); structureless; soft, very friable, slightly sticky, non-plastic consistence.

The following stratigraphy from ST-2 was revealed:

Layer	
1	0-50 cmbs; dark reddish brown (2.5YR 2.5/4 moist); silt loam; dark reddish brown (2.5YR 2.5/4 dry); structureless; soft, friable, non-sticky, non-plastic consistence.

FEATURE G1: Retaining wall (Figure A-8)
FUNCTION: Possible agriculture
DIMENSIONS: 1.04 m NNW/SSE by 0.90 m by 1.80 m
DESCRIPTION: This feature is oriented NNW/SSE and constructed across a narrow crevice near the base of a limestone cliff. It is c. 80.50 m at 110° from the edge of a banana/papaya patch, and on the west side of an active quarry. There are natural terraces occurring throughout the limestone outcrop, but no modification is apparent. Above the retaining wall (to the west), is the possible remnant of a limestone cobble terrace c. 2.00 m from the wall, and c. 0.15 m high. A papaya tree is growing between the edge of the terrace remnant and the retaining wall. The area behind the retaining wall is covered with small-medium sized limestone cobbles and a thick duff layer, so visibility is poor. The construction is limestone slabs and large cobbles stacked up to five courses high and one-two courses wide between the crevice, on the east northeast side. On the west southwest side of the retaining wall only two courses (c. 0.75 m high) of stones are visible due to the accumulated soil deposit. The retaining wall appears to be an erosion control structure.

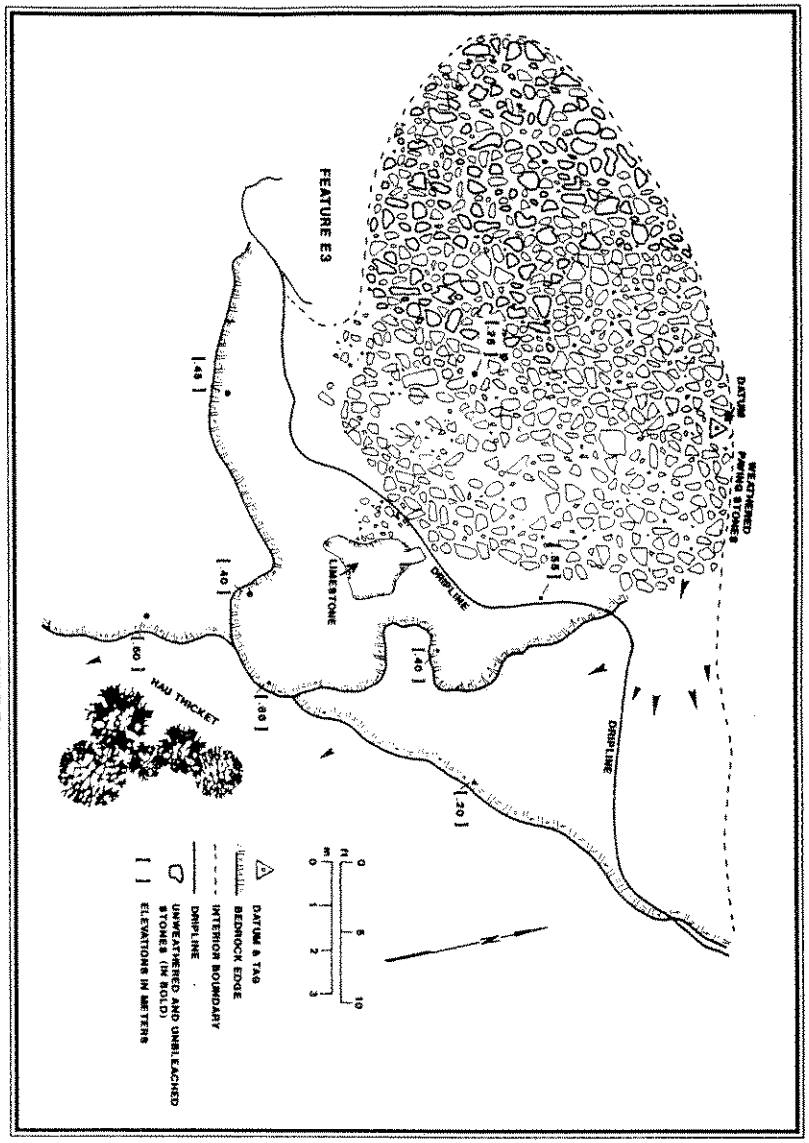


Figure A-6. SITE 4458, FEATURE E3

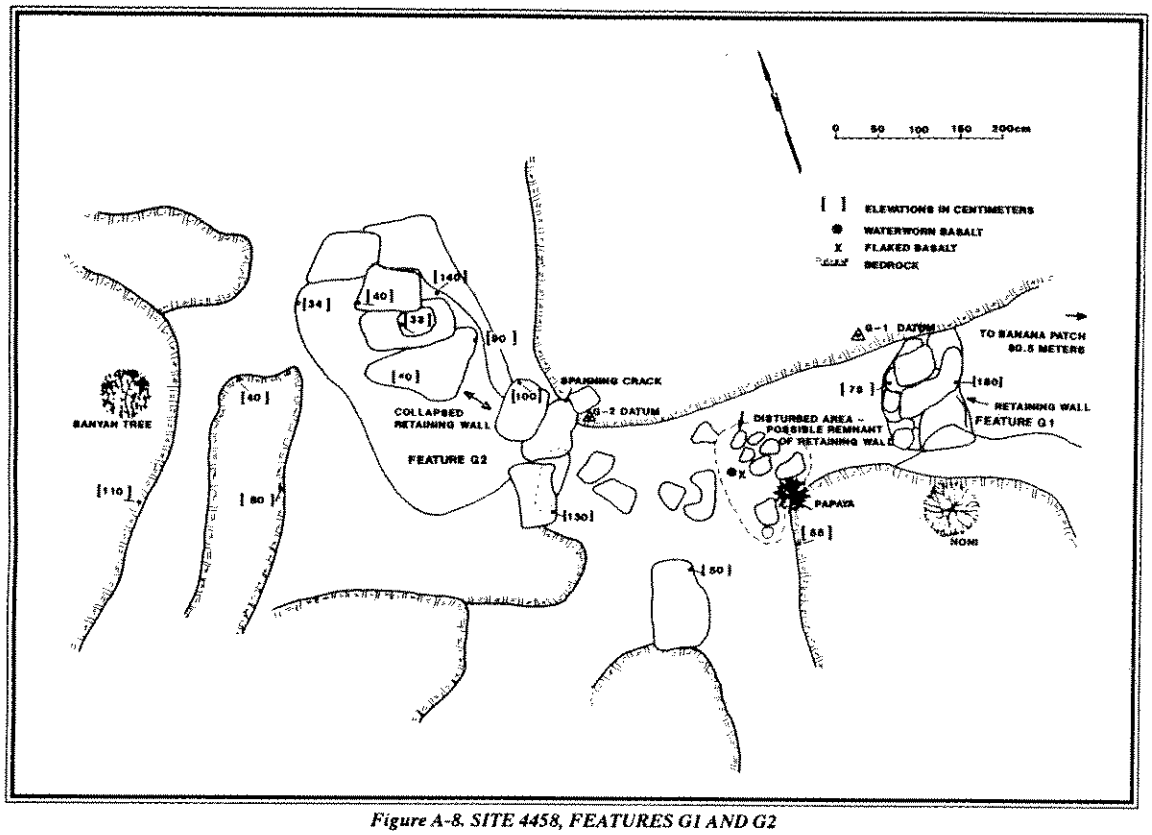


Figure A-8. SITE 4458, FEATURES G1 AND G2

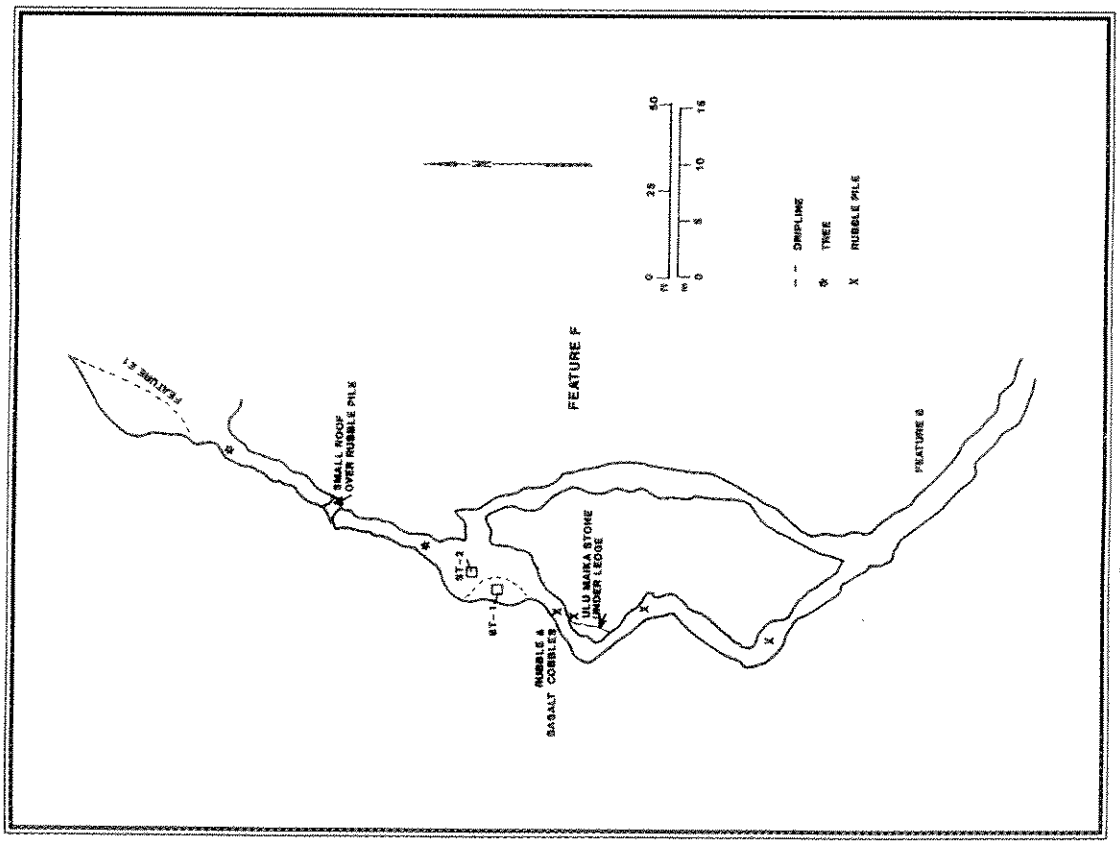


Figure A-7. SITE 4458, FEATURE F

FEATURE G2: Wall (Figure A-8)
FUNCTION: Possible agriculture
DIMENSIONS: 6.5 m NW/SE by 2.0 m by 1.4 m
DESCRIPTION: This feature is a roughly "L" or "T" shaped wall. The short section of wall is c. 4.0 m and 260° from the Fea. G1 wall. This section is constructed on limestone bedrock across the top and the northwest end of the crevice that the Fea. G1 retaining wall is constructed across. This short section is oriented NE/SW. The longer portion of the wall runs perpendicular to the short section and also runs across the top or the SW end of an adjacent crevice in the limestone outcrop. This section of wall is on a limestone outcrop and constructed of medium to large limestone slabs and boulders stacked one course high and one course wide. The adjacent terrain is natural limestone bedrock outcrop at the base of a ridge.

FEATURE H: Wall (Figure A-9)
FUNCTION: Boundary
DIMENSIONS: 5.3 m NE/SW by 1.5 m by 1.0 m
DESCRIPTION: This feature is a small, stacked limestone cobble wall at the north end of a natural limestone crevice. It is c. 7.5 m south of Site 4459 (cement irrigation trough). The limestone crevice measures c. 3.5 m wide and up to c. 4.0 m high. It is constructed of stacked limestone cobbles atop bedrock and soil. The southwest portion of the wall appears to have been partially dismantled for the placement of a recent PVC pipe, but because of the lack of stones in the immediate area of the feature, it appears that the wall has not suffered much collapse. The adjacent terrain is on the NE side of a moderately sloping ridge (10%).

FEATURE I: Wall (Figure A-9)
FUNCTION: Boundary
DIMENSIONS: 2.20 m NE/SW by 1.00 m by 0.65 m
DESCRIPTION: This feature is a small, stacked limestone wall constructed across the north end of a limestone crevice. The feature is at the base of the northeast side of an exposed limestone ridge, with a moderate slope of c. 10%. The lack of small rocks in the immediate area, except those from apparent collapse, indicates that the wall was likely little higher than its present state.

FEATURE J: Overhang (Figure A-10)
FUNCTION: Possible burial
DIMENSIONS: 3.50 m E/W by 1.60 m by 1.02 m
DESCRIPTION: This feature is a small overhang within and on the southeast of a crevice in the surrounding exposed limestone outcrop. The overhang is deeper than it is high. The roof is flat and gradually slopes west. One human long bone fragment was noted at the back of the overhang on top of piled rocks. Small limestone rocks appear to have been placed in the overhang. This feature appears to be directly associated with Features K and K1, just outside of this feature, where skeletal remains were found.

FEATURE K: Overhang (Figure A-10)
FUNCTION: Temporary habitation
DIMENSIONS: 4.00 m E/W by 2.60 m by 2.65 m
DESCRIPTION: This is a small overhang within and on the north side of a crevice in the surrounding limestone bedrock, across and to the north of Feature J. A large rock has fallen at the east side of the feature. A few flat rocks may have been placed on this rock to create a level surface to provide easier access into the overhang area from the above exposed limestone. A limestone outcrop with banyan trees and *noni* was noted above the overhang. The interior of the overhang is fairly level and covered with a soil deposit.

A 0.50 m by 0.50 m shovel test was excavated in the center of the overhang, revealing the following stratigraphy:

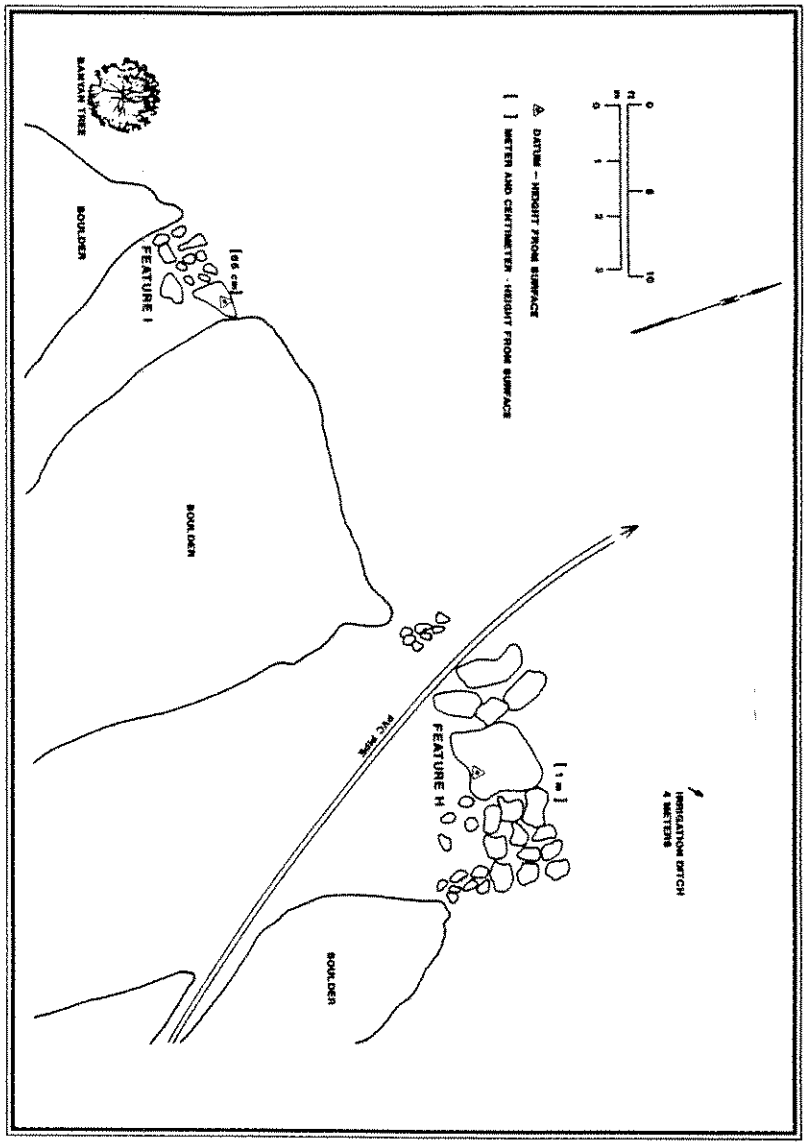


Figure A-9. SITE 4458, FEATURES H AND I

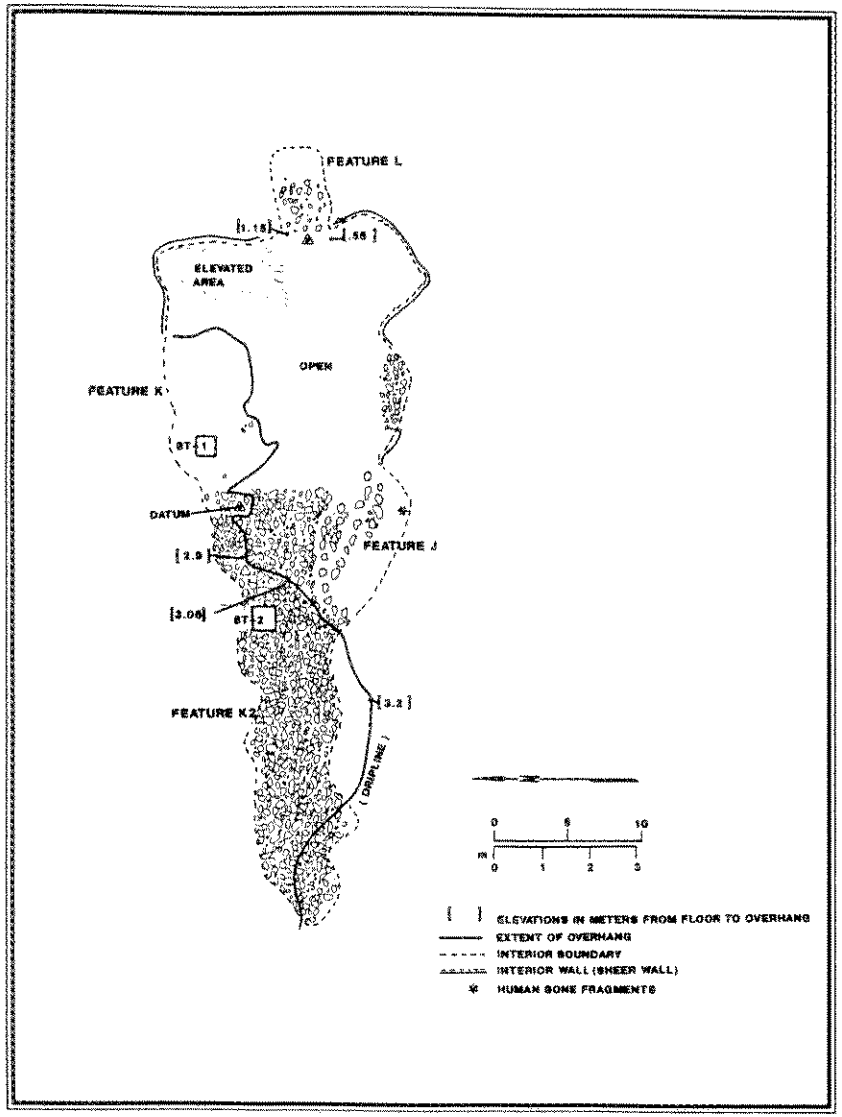


Figure A-10. SITE 4458, FEATURES J, K, K2, L.

Layer	Description
I	0-30 cmbs; dark reddish brown (5YR 3/2 moist); silt loam; dark brown (10YR 4/3 dry); loose, very friable, non-sticky, slightly plastic consistence.

Stratum I (0-30 cmbs) was excavated in three levels, all containing human skeletal remains, marine shell, charcoal, *kukui* nutshell, and non-human bone. No burial pit or skeletal articulation was apparent throughout the excavation. Excavation terminated at a maximum depth of 30 cmbs on bedrock.

FEATURE K2: Modified crevice (Figure A-10)
FUNCTION: Temporary habitation
DIMENSIONS: 9.0 m NE/SW by 3.0 m by 3.0 m
DESCRIPTION: This feature is a crevice in the surrounding exposed limestone bedrock. The crevice sides cover c. 70% of the ground surface, which is covered with a moderate deposit of soil. The adjacent terrain is near the crest of large limestone outcrop.

A shovel test (ST-1) measuring c. 0.5 m in diameter was excavated within the soil deposit covering the floor of the crevice. The following stratigraphy was revealed:

Layer	Description
I	0-14 cmbs; dark brown (10YR 3/3 moist); silt loam; dark brown (10YR 3/3 dry); structureless; loose, very friable, slightly sticky, non-plastic consistence.

Stratum I yielded non-bone, marine shell, scattered, human skeletal remains, and *kukui* nut fragments. Excavation was terminated at c. 0.30 m upon revealing cultural material, but the soil deposit extends another 0.15 m.

FEATURE L: Cave (Figure A-10)
FUNCTION: Possible storage
DIMENSIONS: 1.80 m NNE/SSW by 1.00 m by 1.15 m
DESCRIPTION: This is a small cave opening to the south southwest, at the northeast end of the same limestone crevice that Features J, K, and K2 are in. The interior appears to be roughly paved with small limestone cobbles. The adjacent terrain is a NE sloping hillside of c. 10% slope.

FEATURE M: Wall (Figure A-11)
FUNCTION: Possible habitation
DIMENSIONS: 7.90 m NW/SE by 0.55 m by 0.85 m
DESCRIPTION: This feature is a bi-faced wall between two large outcrops. The wall is constructed of limestone cobbles and slabs, averaging 0.25 m by 0.15 m, stacked six-seven courses high and three courses wide. The wall parallels the east edge of a relatively flat, soil covered area that measures c. 3.00 m E/W by 4.50 m N/S. Bedrock outcrops delineate the other three boundaries. A crevice is east and southeast of the wall's south edge. The crevice contains Feature F. From the north edge of the flat area is a runoff area, oriented at c. 350°, which continues down the ridge slope. The furthest north section of the wall (c. 2.50 m in length) parallels the southern edge of the runoff area. From the north edge of the wall to c. 4.00 m south, there is a rubble pile abutting the west side of the wall. This may have naturally fallen off the wall, or it may have been purposely placed to help brace this section of wall.

FEATURE N: Overhang (Figure A-12)
FUNCTION: Temporary habitation
DIMENSIONS: 2.50 m E/W by 1.40 m by 0.84 m
DESCRIPTION: This feature is an overhang shelter opening to the north. The entrance is higher in the center and slopes down to ground level on either side. The interior ceiling is convex. The floor area is soil covered and flat, and may have been cleared of ceiling collapse. *Kukui* nutshell, human humerus fragment, and crab shell were portable remains found. There is a low density culture deposit throughout the soil area (c. 2 .00 by 1.00 m). A natural shelf extends to the north, c. 5.00 m of the opening, where a bedrock lip occurs. Tiers of limestone bedrock exist on both sides of the overhang. The overhang is west of Feature O near the top of the north northeast side of a ridge. The surrounding terrain is exposed limestone bedrock.

FEATURE O: Paved area (Figure A-12)
FUNCTION: Indeterminate
DIMENSIONS: 2.6 m E/W by 1.8 m
DESCRIPTION: This feature is a small, flat paved area on a tier of exposed limestone bedrock. Feature N is immediately west of this feature, and may be associated. The surface paving is constructed of small angular limestone cobbles. The feature area has been slightly disturbed by tree roots and some erosion. Very little underbrush occurs around the feature due to the presence of a large banyan tree to the east.

SITE NO.: State: 4459 **PHRI:** T-18
SITE TYPE: Ditch
TOPOGRAPHY: This ditch runs along a slope. The base of the slope is at the north end of a large limestone ridge.
VEGETATION: *Hau*, *koa-haole*, *noni*, papaya, banana, vines, and grass.
CONDITION: Fair
INTEGRITY: Altered
PROBABLE AGE: Historic
FUNCTIONAL INTERPRETATION: Irrigation
DIMENSIONS: 61.00 m NW/SE by 0.48 m by 0.28 m
DESCRIPTION: The ditch is constructed of preformed sections of concrete forming the walls and base of the channel. The sections are placed end to end. The NW end has poured concrete about it, possibly part of an old flood gate. The southeast end has been destroyed by road construction, presumably bulldozing.

SITE NO.: State: 4460 **PHRI:** T-19
SITE TYPE: Terrace (5)
TOPOGRAPHY: Ridge running to the SE from site. Ridge sloping down to road to the immediate west and SW.
VEGETATION: Thick *koa-haole*, banyan, papaya, thick ferns and vines, two ti plants, various ground cover and grass.
CONDITION: Fair
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Habitation
DIMENSIONS: 57.0 m N/S by 30.0 m
DESCRIPTION: The overall dimension is c. 57.0 m N/S by 30.0 m E/W. The site is on the west end of a ridge which runs back to a recent, active quarry. The slope and ridge top have been terraced with limestone cobbles, incorporating bedrock and paved with limestone cobbles and waterworn basalt. At least five terraces were noted on the top and along the slope of the ridge. The site area is heavily vegetated, and extensive clearing is needed to define all the interior characteristics of the site.

Two test units (TU-1, -2), each measuring 1.0 m square, were excavated within the site area.

TU-1 was excavated on the surface of the uppermost southern terrace. The following stratigraphy was revealed:

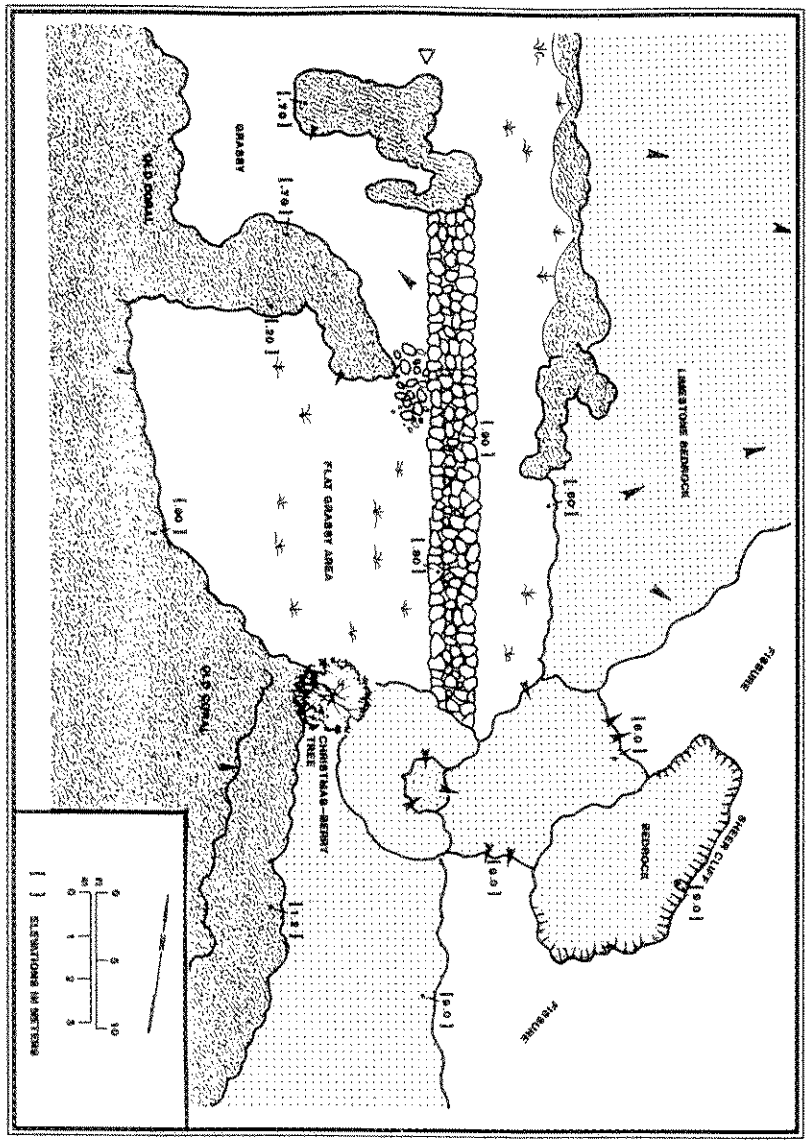


Figure A-11, SITE 4458, FEATURE M

West Face Layer	Description
I	0-35 cmbs consisted of angular cobble fill.
II	20-40 cmbs; dark reddish brown (5YR 2.5/2 moist); silt loam; dark reddish brown (5YR 2.5/2 dry); structureless; soft, very friable, non-sticky, slightly plastic consistence;

After removing the cobble fill (Strat I), bedrock was encountered along the east side of the unit. Stratum II was excavated in three arbitrary 0.1 m levels. Level II-1 (20-30 cmbs) contained one piece of historic glass. Level II-2 (30-40 cmbs) contained a marine shell. Level II-3 (40-55 cmbs) contained non-human bone. Excavation was terminated at 0.55 mbs on bedrock.

TU-2 was excavated on the surface of the uppermost northern terrace. The following stratigraphy was revealed:

South Face Layer	Description
I	0-15 cmbs consisted of subangular limestone cobble fill.
II	15-40 cmbs; dark reddish brown (5YR 2.5/2 moist); silt loam; dark reddish brown (5YR 2.5/2 dry); structureless; slightly hard, very friable, slightly sticky, slightly plastic consistence.

After removing the cobble fill, Stratum I, Stratum II commenced at c. 15 cmbs and terminated at 40 cmbs on bedrock. Stratum II contained two non-human bones, scattered charcoal flecking, and *kukui* nutshell.

SITE NO.: State: 4461 **PHRI:** T-20
SITE TYPE: Retaining wall
TOPOGRAPHY: Naturally occurring drainage oriented northeast/southwest, and dry at the time of the current survey.
VEGETATION: Christmas-berry, Java plum, *hau*, and grass.
CONDITION: Poor-Fair
INTEGRITY: Altered
PROBABLE AGE: Possibly prehistoric with later historic alterations.
FUNCTIONAL INTERPRETATION: Erosion control
DIMENSIONS: 40.5 m NE/SW by 7.0 m by 0.5 m (approx.)
DESCRIPTION: The feature exists along an apparent natural drainage with modifications along the stream banks. The wall is constructed of stacked limestone cobbles and boulders two-three courses high and one-two course wide and c. 0.3 - 0.5 m in height, with bedrock incorporated where outcrops occur. A metal drainage pipe is present in the center of the streambed, with a barbed-wire fence running parallel on the northwest bank. The placed stones appear to serve as erosion control, and support for the fence line.

At the northeast end of the feature a second fence line crosses roughly perpendicular to the drainage. From the point where the second fence line crosses the drainage, the modification along the stream banks continues to the southwest for c. 110.0 m, at which point the drainage turns more northward but the fence line continues at a bearing of 240°.

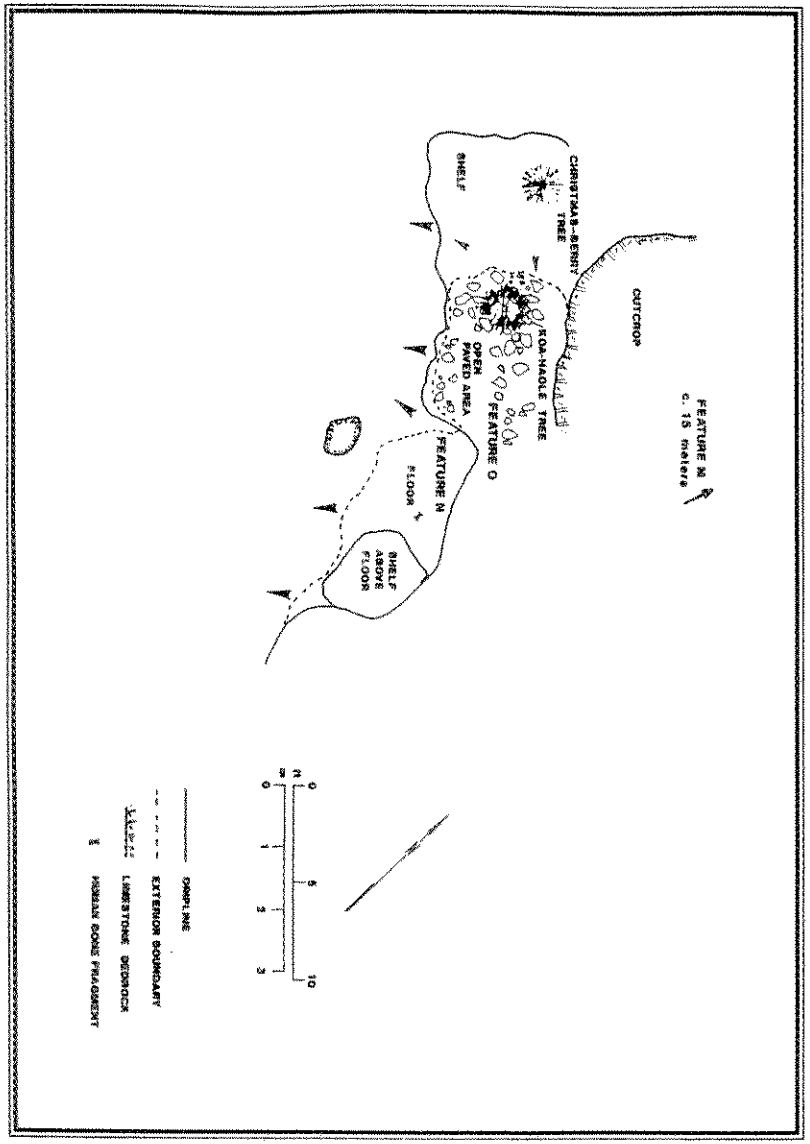


Figure A-12. SITE 4458, FEATURES N AND O.

SITE NO.: State: 4462 (Figure A-13) **PHRI:** T-21
SITE TYPE: Complex (21 Features)
TOPOGRAPHY: Sloping foothills at the base of a large ridge system to the southwest of Kamehameha Highway.
VEGETATION: Very dense Christmas-berry, ferns, large mango, *hau*, ti, *koa-haole*, *noni*, *lilikoi*, papaya, and various ground cover.
CONDITION: Good
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Agriculture-Poss. Habitation
DESCRIPTION: The overall site dimensions are c. 580.0 m NW/SE by 61.0 m, but at the time of the current survey a sample area was recorded, measuring c. 120.0 m N/S by 111.0 m. The sample area of recorded features consists of two retaining walls (Fea. A, C), 12 terraces (Fea. B, G, H, I, J, K, L, O, P), three ditches (Fea. D, E, F), one wall (Fea. M), one terrace-wall (Fea. N), an enclosure (Fea. Q), and an overhang (Fea. R).

FEATURE A: Retaining wall
FUNCTION: Agriculture
DIMENSIONS: 31.5 m NW/SE by 2.0 m by 1.5 m
DESCRIPTION: This retaining wall is oriented northwest/southeast, and is faced along the northeast side. It is constructed of basalt boulders, up to c. 1.0 m in diameter, and large cobbles up to c. 0.5 m in diameter stacked three-six courses high and three-five courses wide. The wall appears to be constructed at the base of a series of terraces descending from the west and the south. The feature follows the contour of the slope and alternates between a SW/NE and a SE/NW bearing. At the northwest end of the feature is a drainage (part of field system) oriented east/west, at which point the retaining wall veers to the west. The feature extends upslope to the west for an indeterminate distance (but for at least 75.0 m).

FEATURE B: Terrace
FUNCTION: Agriculture
DIMENSIONS: 12.0 m N/S by 9.0 m by 1.1 m
DESCRIPTION: This terrace extends from the base of Fea. A and is bordered by the same drainage which parallels a portion of Fea. A. on the west northwest. The terrace is constructed of basalt cobbles up to c. 0.5 m in diameter and basalt boulders c. 1.0 - 0.5 m in diameter stacked to form a retaining wall four-five courses high. On the east side of the terrace is a stacked retaining wall oriented at 10°, perpendicular to Fea. A. The north boundary is an alignment of basalt cobbles which parallels Fea. A, c. 12.0 m from it, completing the roughly rectangular terrace. The interior of the terrace was probably terraced at one time (terrace within a terrace within a terrace) as is evidenced by retaining alignment remnants and a lot of cobbles strewn about. A flat area is to the east with a large mango tree and *noni* trees. It is possible that Feature B served as a sort of water gate, or flood control.

FEATURE C: Retaining wall
FUNCTION: Agriculture
DIMENSIONS: 45.0 m N/S by 1.0 m by 1.0 m
DESCRIPTION: This feature is at the SE edge of the recorded sample area. It is constructed of basalt boulders stacked three-four courses high and two courses wide. The north half of the wall retains an agriculture terrace. The south half parallels an irrigation ditch, Fea. D, and provides retainment for it. Terrain is an east slope of a high hill.

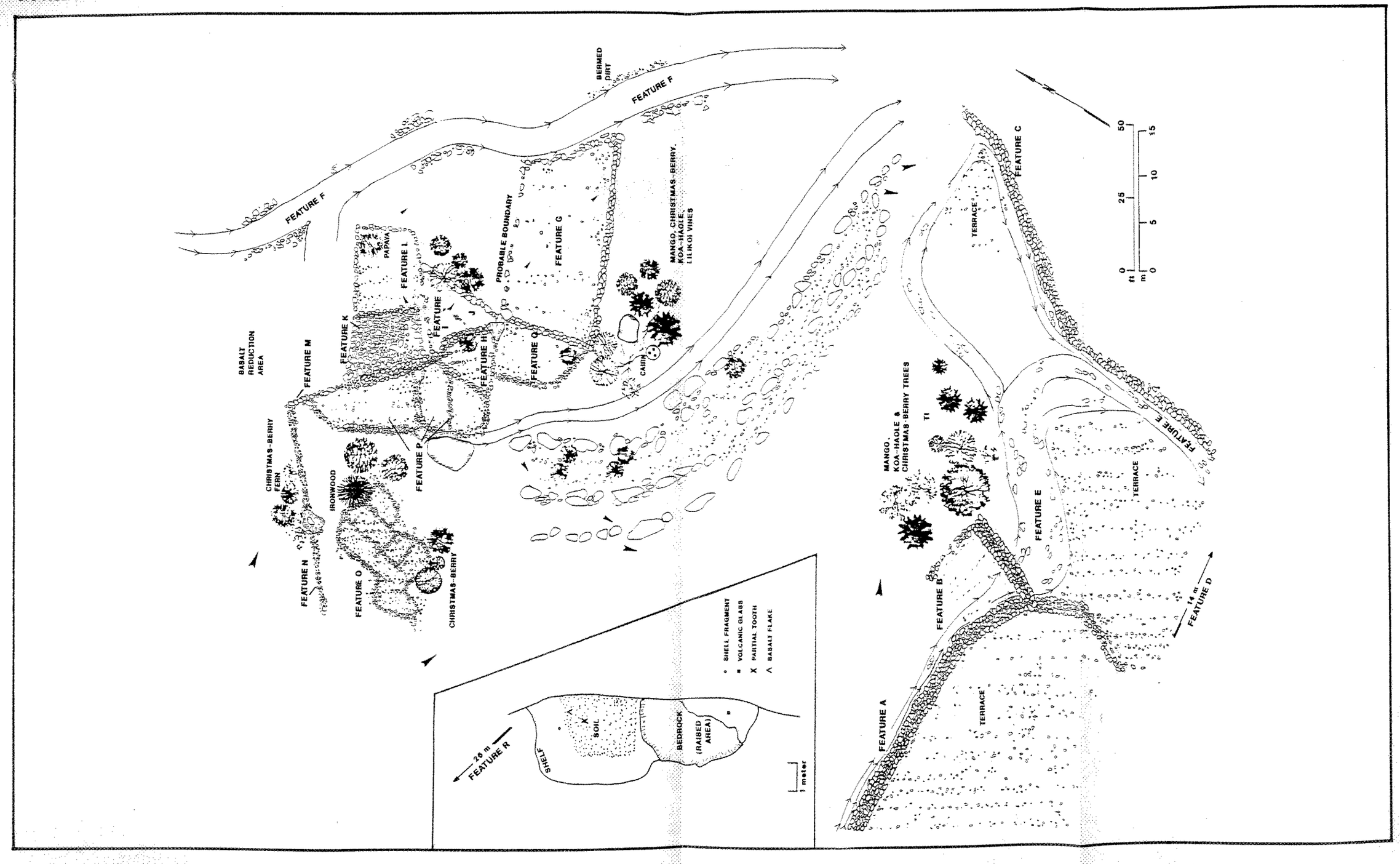


Figure A-13
SITE 4462, FEATURES A THROUGH R

FEATURE D: Ditch
FUNCTION: Irrigation
DIMENSIONS: 68.0 m N/S by 1.5 m by 0.5 m
DESCRIPTION: This feature is a soil ditch, apparently designed to catch slope wash south of the sample area. The feature runs along the SE edge of the sample area. The ditch is constructed of soil berms with rock retaining walls on both sides. The walls are three-four courses high and two courses wide, and built of basalt cobbles and small boulders. This ditch mainly flows S to N but winds at several points. Fea. C's southern portion provides a retaining wall for Fea. D.

FEATURE E: Ditch
FUNCTION: Irrigation
DIMENSIONS: 25.0 m by 1.5 m by 0.8 m
DESCRIPTION: This feature is a boulder-lined, flat-bottomed ditch which runs downhill on a 55° bearing. It is perpendicular to Fea. C and flows through the terraces behind Fea. C. The ditch has straight walls and a flat bottom. Basalt boulders and cobbles line the walls in some places and have fallen to the floor in others. In places it is steep walled, in others, it is broad and shallow. Adjacent terrain is a large flat area with a giant mango to the SW and gradual terraced slopes descending eastward. The west end of the feature is a large flat area with giant mango trees east of Features A and B. It is probable that Fea. E connected with the drainage cutting through Fea. B at one time.

FEATURE F: Ditch
FUNCTION: Irrigation
DIMENSIONS: 28.0 m E/W by 2.0 m by 1.0 m
DESCRIPTION: This long, broad, deep irrigation ditch runs perpendicular to a generally E/NE slope. It runs along the east edge of Fea. G. It is at the base of several terraces and heads downhill at its NW end after being joined by a channel off the terrace to the west. The west side of the ditch is supported by a retaining wall, constructed of basalt cobbles stacked three-five courses high, along the c. 23.0 m 270° portion of the ditch. The sides of the ditch are steep to gradually sloped. Adjacent terrain consists of terraced slopes descending to the east, and from the west.

FEATURE G: Terrace
FUNCTION: Possible habitation
DIMENSIONS: 22.50 m ENE/WSW by 10.00 m by 0.45 m
DESCRIPTION: This feature is roughly rectangular in overall shape, located between Fea. Q and Fea. F, and oriented NE/SW. The NE boundary is a remnant retaining wall, the west side of Fea. F irrigation ditch. The SE and SW boundaries consist of a two course wide alignment. The wall is constructed of basalt boulders, slabs, and cobbles placed one-two courses wide with smaller cobble fill. Along the interior of this L-shaped wall the stones have been placed to give a faced appearance. The NW boundary has been disturbed by tree roots but a few large basalt cobbles can be seen. The floor of the terrace has two large basalt boulders in it, but the remainder consists of soil with a few strewn cobbles, and gently slopes to the NE. There are large mango trees immediately SW of the NW boundary. Adjacent terrain is a gentle NE slope with basalt outcrops.

FEATURE H: Terrace
FUNCTION: Agriculture
DIMENSIONS: 6.0 m by NE/SW 4.5 m by 1.0 m
DESCRIPTION: This feature is constructed of basalt boulders with smaller basalt cobbles stacked between them. It is triangular in shape and raised on three sides. The northeastern retaining wall is the best preserved, consisting of basalt outcropping augmented by boulders and cobbles stacked several courses high and wide. Large basalt boulders one course high and one course wide form the southwest boundary. The southeast boundary is vestigial. The terrace surface is cluttered with basalt, trees, and other vegetation.

FEATURE I: Terrace
FUNCTION: Agriculture
DIMENSIONS: 10.5 m ESE/WNW by 5.2 m by 1.5 m
DESCRIPTION: This is a triangular-shaped terrace with a broad base on the NW end. This terrace is between Fea. H (to the west, upslope) and Fea. J (downslope to the east). Basalt boulders (c.1.0 m in diameter) were aligned to form the east retaining wall of this feature. The terrace surface has large basalt boulders and cobbles scattered throughout. Fea. G borders the SE end and Fea. K borders the NW. This feature is bordered on the SW by the base of a well-constructed retaining wall, which retains a terrace designated Fea. H. On the NE is the retaining wall supporting Fea. I, and at its base is Fea. J, another terrace. Features H, I, and J, descending eastward, are bounded on the south by the perimeter wall of Fea. G and on the north by Fea. K. This gives these three stepped terraces very definite boundaries.

FEATURE J: Terrace
FUNCTION: Agriculture
DIMENSIONS: 7.0 m N/S by 3.0 m by 1.0 m
DESCRIPTION: This feature is a rectangular terrace bounded by large basalt boulders with some smaller boulder and cobble stacking. Basalt boulders are incorporated into the construction. A large boulder defines the entire south southeast boundary. Fea. L is the western boundary and acts as a retaining wall for soil within Fea. I (Fea. J is c. 0.5 m lower than Fea. I). The northern boundary is also shared by Fea. L and acts as a retaining wall for soil within it, which is 0.5 m higher. No terrace abuts the southern wall. There may be smaller walls within the retaining/boundary walls, partitioning possible agricultural plots.

FEATURE K: Terrace
FUNCTION: Habitation
DIMENSIONS: 6.5 m NW/SE by 6.0 m by 1.0 m
DESCRIPTION: This feature is a probable habitation terrace. It has very defined, if somewhat slumped edges, and its surface is roughly level, sloping to the NE (35°). It is constructed of basalt cobbles and boulders stacked, piled, and aligned to form retaining walls with more basalt cobbles (some worked) and boulders forming the body and surface of the terrace. The south side of the terrace forms the north boundaries of Features H, I, and J. Adjacent terrain is gradually eastward descending terraced slopes. The slopes descending from the west are likewise terraced.

FEATURE L: Terrace
FUNCTION: Agriculture
DIMENSIONS: 8.0 m N/S by 7.5 m by 0.5 m
DESCRIPTION: This feature is a series of placed boulders, one course high and wide, with cleared areas in between. The south boundary is Fea. J's north boundary and the west boundary is Fea. K's east boundary. The southern edge of the feature has boulders placed in alignment. The remainder of the feature has loosely placed boulders. A large papaya tree has grown in the cleared areas at the northern edge of the feature. Adjacent terrain is an east slope of hill.

FEATURE M: Wall
FUNCTION: Erosion control
DIMENSIONS: 8.0 m NW/SE by 1.0 m by 0.6 m
DESCRIPTION: This wall begins at Fea. N and ends at Fea. K. From Fea. N the wall is constructed of one row of large boulders one course high that extends two-thirds of the way to Fea. K. At this point, the wall is built of smaller limestone rocks three courses high and three courses wide and continues to Fea. K. Where the wall intersects Fea. K, many rocks are scattered. These rocks are most likely part of Fea. K but some could have been eroded from this feature. The adjacent terrain is the eastern slope of hill.

FEATURE N: Terrace
FUNCTION: Agriculture
DIMENSIONS: 20.00+ m N/S by 0.85 m by 1.90 m (approx.)
DESCRIPTION: This feature is a SW/NE oriented wall starting at the base of a ridge and continuing upslope. At the N/NE end of the wall is Fea. M. Basalt cobbles are stacked between and on top of outcrops. Rock is stacked three-four courses high on the southwest side. Size of the rock varies from c. 0.50 m in diameter to c. 0.25 by 0.20 m. In some areas, the size of the natural outcrop measures c. 2.90 by 1.50 by 1.50 m, but averages c. 1.00 m by 0.70 m by 0.80 m. Further upslope, it appears that this feature is a retaining wall for erosion control, or a boundary marker. The wall has a northeast face and upslope this face measures c. 1.90 m in height, while the opposite side measures c. 0.85 m in height. Rock is stacked three-four courses wide and nine courses high. Rock size is similar to aforementioned measurements. As it proceeds downslope, the NE face is stacked six-seven courses high and measures c. 1.40 m in height. At the base of the slope, the NE face is four courses high and measures c. 0.85 m in height. Vesicular and fine-grained basalt cobbles were observed c. 1.00 to 2.00 m northwest of datum along the base of the slope.

FEATURE O: Terrace (2)
FUNCTION: Agriculture
DIMENSIONS: 17.0 m SW/NE by 10.0 m by 0.0 m (approx.)
DESCRIPTION: This feature consists of retaining walls forming enclosed areas for planting. One area, generally flat, is enclosed by a north wall c. 3.70 by 1.00 by 0.65 m. This wall is built of rock stacked on top of and between outcrops. Stacking is two courses high and three courses wide. Average outcrop measurement is c. 0.60 by 0.55 m and average rock measurement is c. 0.30 by 0.35 m. The east wall is c. 4.20 by 0.85 by 0.70 m. The construction method is the same as the north wall. Both medium grained basalt and vesicular basalt were used. The wall is three courses high and three courses wide. Outcrop measurements are c. 0.60 by 0.55 m and rocks vary from 0.10 to 0.40 m in diameter. The southern one-third of the east wall has been heavily disturbed by Christmas-berry trees. What remains of the wall is one or two courses of stacked rocks. The wall is about c. 0.20 m high. The south wall is c. 3.0 by 0.9 by 0.8 m high. The wall is three courses high by two courses wide. Cobbles range in size from c. 0.13 to 0.62 m in diameter. The west wall is very well constructed. The majority of rock is well stacked. The north face of the west wall is sloped from top to bottom approx. 45°. It is stacked approximately two courses high at the base and six-seven courses high at top. The wall measures c. 4.30 m long and forms a corner with the north wall; however, the west wall extends c. 2.75 m past the NW corner and eventually abuts another wall. The west wall from base to top measures c. 1.55 m and the slope measures c. 2.15 m across. Rock sizes vary from c. 0.10 to 0.70 m in diameter.

The other planting area is c. 4.0 m at 200° away from the first and is oriented at approx. 320/140°. It measures c. 3.80 m N/S by 3.20 m E/W (outside wall to outside wall). The interior is c. 2.75 m by 1.10 m. The walls are constructed of rocks stacked on the ground and on outcrops. The north and south walls are one to two courses high and one course wide with a height of c. 0.20 to 0.50 m. The east wall is four courses high by three courses wide. The average height is c. 0.90 m. The west wall is four courses high and two courses wide. The height ranges from c. 0.50 m (southern end) to c. 1.05 m (northern end). Outcrop size averages c. 0.60 by 0.30 m and stacked limestone size averages c. 0.30 by 0.20 m.

FEATURE P: Terrace (3)
FUNCTION: Agriculture
DIMENSIONS: 8.0 m NW/SE by 7.5 m (approx.)
DESCRIPTION: This feature is a series of retaining walls forming terraces and planting areas. Three walls will be described as part of Fea. P. The first wall, oriented c. 160-340°, is mainly bedrock outcropping with cobbles stacked two courses high and two-three courses wide between outcrops. The wall measures c. 4.90 by 0.65 by 0.60 m (average height). Height varies from c. 0.35-0.65 m. The outcrop ranges in size from c. 0.55 by 0.65 m to 0.30 by 0.30 m. Stacked rocks average c. 0.20 by 0.15 m. The second wall, c. 3.90 by 0.60 m, forms a corner with the first. The second wall is oriented c. 45-225° and is built of loosely stacked rocks (average c. 0.15 by 0.10 m) placed on bedrock in some areas. The wall is two courses high and five courses wide. Average height is c. 0.25 m. The third wall, oriented c. 174-354°, forms a corner with the second wall. This wall is stacked cobbles placed on bedrock outcropping. It is four courses wide by four-five courses high. The northern end is c. 0.90 m high and the southern end is c. 1.10 m high. The bedrock measures c. 0.55 by 0.35 m. The stacked rock ranges in size from c. 0.40 by 0.30 m to 0.15 by 0.10 m. Other terraces with retaining walls are partially visible upslope and adjacent to Fea. P. Only a representative sample of the walls at this site are described here. The three walls recorded here abut the edge of a relatively flat area.

FEATURE Q: Enclosure
FUNCTION: Indeterminate
DIMENSIONS: 10.0 m NW/SE by 6.0 m by 1.30 m (approx.)
DESCRIPTION: This rough enclosure is built of basalt cobbles and small boulder alignments on the SW, SE, and a portion of the NW side. The NE boundary is the Fea. G SW boundary. The interior is fairly flat with a few cobbles scattered. The adjacent terrain is fairly flat, sloping from the SW.

FEATURE R: Overhang
FUNCTION: Temporary habitation
DIMENSIONS: 7.7 m by 2.8 m by 1.9 m
DESCRIPTION: This feature is a rock shelter. No apparent modification is within or immediately outside the overhang. However, a series of rock-edged terraces and walls are downslope toward Fea. N, which lies c. 26.0 m 80° from the opening. There appears to be some cultural deposit, as noted by artifacts and possibly by a darkened soil area. Depth is undetermined. Volcanic glass, basalt flake, a non-human tooth fragment, and several small pieces of marine shell were observed on the interior surface.

SITE NO.: STATE: 4463 **PHRI:** T-22
SITE TYPE: Complex (8 Features)
TOPOGRAPHY: Fairly flat terrain in the immediate area of the site, gently sloping to the north, Kokololio Stream/Gulch to the east with a ridge line heading up to the SE across streambed. A fallow cane field is immediately south of the site. The area north of the site to Kamehameha Highway appears dozed.
VEGETATION: Thick grasses, *koa-haole*, banyan, large mango, ti, banana, sugar cane, papaya, *kukui*, Java plum, Christmas-berry, and ferns.
CONDITION: Fair-Good
INTEGRITY: Altered
PROBABLE AGE: Prehistoric-historic
FUNCTIONAL INTERPRETATION: Agriculture
DESCRIPTION: This site consists of a wall (Fea. A), two ditches (Fea. D, G), a soil berm (Fea. E), and four retaining walls (Fea. B, C, F, H). The overall dimensions are c. 58.0 m E/W by 36.0 m N/S. Basalt cobbles and small boulders are stacked to create retaining wall terraces. Soil berms and an irrigation ditch (soil) are within the site. A few pieces of limestone are present.

FEATURE A: Wall (Figure A-14)
FUNCTION: Agriculture
DIMENSIONS: 17.0 m N/S by 1.5 m by 0.5 m
DESCRIPTION: This wall is two courses high as well as wide. It is constructed of aligned and stacked basalt boulders. The central and southern parts are loosely aligned boulders one course high as well as wide. The south edge of wall abuts the Fea. B wall, and the northernmost edge appears to have been bulldozed away. The adjacent terrain is c. 19.5 m west of Kokololio Stream, where it comes offslope into the flat agriculture fields.

FEATURE B: Retaining wall (Figure A-14)
FUNCTION: Agriculture
DIMENSIONS: 28.00 m E/W by 1.05 m by 0.70 m
DESCRIPTION: This retaining wall is faced along the north side and abuts a relatively flat area to the south. It is constructed of stacked basalt cobbles incorporating some bedrock. Rocks are stacked four-five courses high and four-five courses wide. Rock size varies from c. 0.10 m to c. 0.90 m (c. 0.35 by 0.30 m average). Bedrock size averages c. 0.50 by 0.50 m. The wall is disturbed by vegetation, particularly tree roots. This is especially true along the western half. Kokololio Stream is c. 11.5 m east of the east wall edge. The south edge of Fea. A abuts the north face of Fea. B. The adjacent terrain is a relatively flat area with a gentle slope to the north.

Two test units (TU-1, -2) were excavated, one on either side, across the retaining wall.

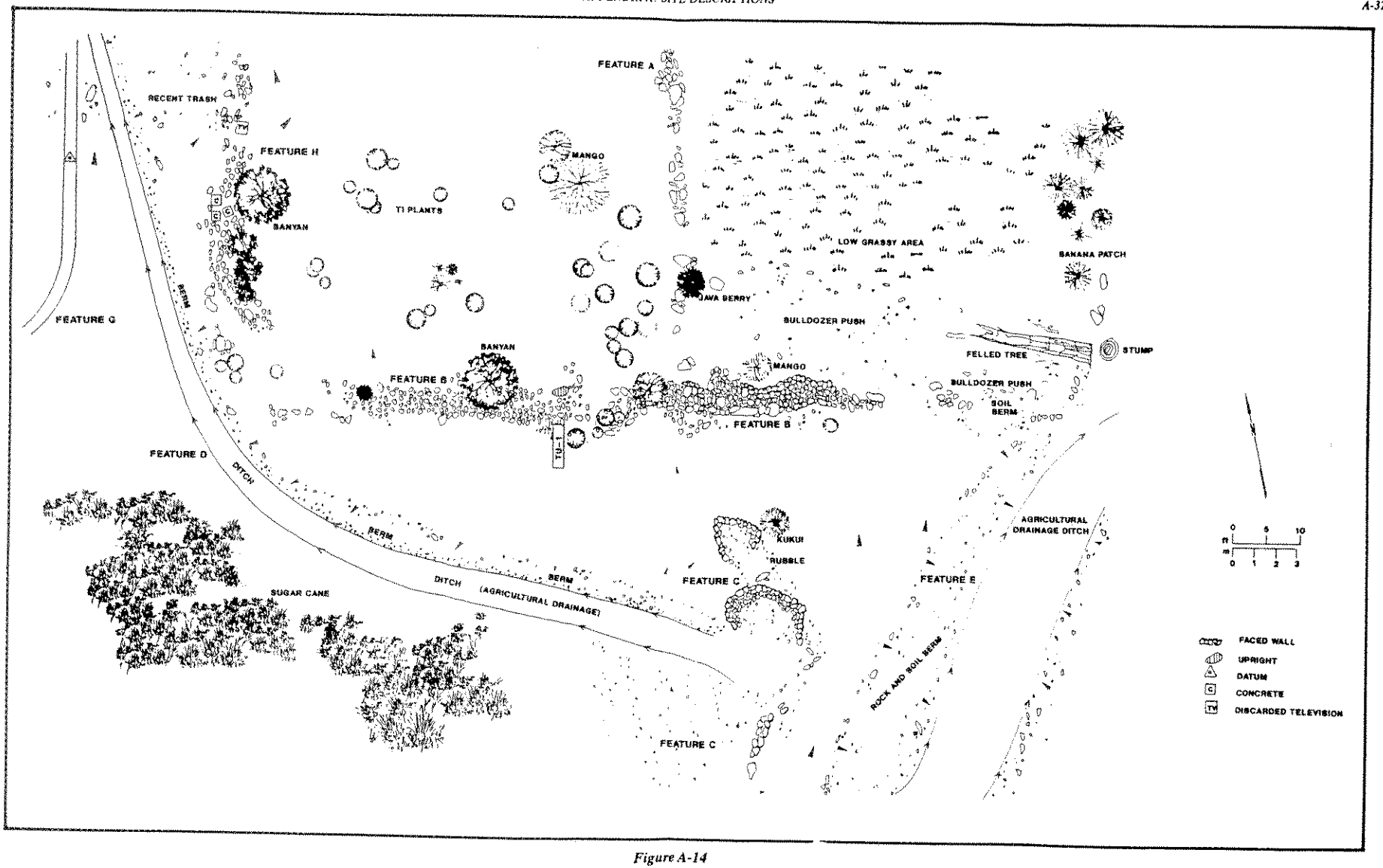


Figure A-14
SITE 4463, FEATURES A, B, C, D, E, G

TU-1, measuring 1.5 m by 0.50 m, was excavated on the south side of the retaining wall. The following stratigraphy was revealed:

East Face Layer	Description
I	0-25 cmbs; black (5YR 2.5/1 moist); silty clay; structureless; soft, very friable, slightly sticky, slightly plastic consistence.

Metal fragments and two basalt flakes were recovered from Stratum I. Excavation was terminated at c. 0.30 cmbs due to the presence of very large basalt boulders.

Tu-2 was measured c. 1.50 m by 0.50 m, and was excavated on the north side of the feature directly across from TU-1. The following stratigraphy was revealed:

East Face Layer	Description
I	0-30 cmbs; black (10YR 2/1 moist); silty clay; structureless; soft, very friable, slightly sticky, slightly plastic consistence;
II	30-40 cmbs; dark reddish brown (5YR 2.5/2 moist); silty clay; structureless; soft, very friable, slightly sticky, plastic consistence.

Stratum I was the same as Stratum I in test unit 1, with Stratum II uncovered at c. 0.30 cmbs. Historic material was recovered from Stratum I.

FEATURE C: Retaining wall (Figure A-14)
FUNCTION: Agriculture
DIMENSIONS: 14.3 m N/S by 4.8 m by 0.7 m
DESCRIPTION: The feature is a retaining wall remnant, faced on the northeast side, with a remnant paved area to the south southwest. The wall is c. 3.5 m south of Fea. B and c. 4.0 m west of Fea. E. It is four courses high and generally four courses wide, with a few pieces of bedrock incorporated into construction. Rock size ranges from c. 0.50 by 0.43 m to c. 0.15 by 0.15 m for the retaining wall. Average rock size for the paved area is c. 0.25 by 0.15 m. There is a moderate upward slope northeast to southwest. The adjacent terrain is a relatively flat area with a gentle slope to the north.

FEATURE D: Ditch (Figure A-14)
FUNCTION: Irrigation
DIMENSIONS 43.0 m SE/NW by 15.0 m by 0.4 m (overall)
DESCRIPTION: This feature is a ditch channel c. 0.7 m wide and 0.4 m deep. The north and east sides consist of a soil berm, measuring c. 2.5 m wide. The eastern edge of the ditch begins at Fea. C and arcs west for c. 20.0 m. It then turns north for c. 15.0 m. An occasional small rock is on the berm. The ditch empties into an historic agriculture field. Two abandoned cars are also located at that point. The ditch appears to have been used to divert slope wash runoff away from the prehistoric agriculture plot downslope (N) which now has dense ti leaf plants growing on it. The west bank of Kokololio Stream is adjacent.

FEATURE E: Soil berm (Figure A-14)
FUNCTION: Erosion control-fence line
DIMENSIONS: 20.0+ m NE/SW by 3.0 m by 1.7 m
DESCRIPTION: This feature is a soil berm c. 2.0 m west of Kokololio Stream. The east and west sides of the berm are lined with rocks, and some rocks are atop the berm. Rocks are stacked four-six courses high. Average rock size is c. 0.3 by 0.2 m. Loosely placed rocks are also along the east and west banks of the berm to retard soil erosion, but in general the feature consists of soil. At the north end of the berm is a SW/NE oriented drainage ditch. This has loosely placed rocks along the interior walls and is c. 3.00 m by 0.70 m by 0.45 m (depth). At this point, water would drain into Kokololio Stream. The feature appears to have been originally used for erosion and water control, but at some point, part of the berm was incorporated into a fence line. Adjacent terrain is a relatively flat area adjacent to the stream.

FEATURE F: Retaining wall (Figure A-15)
FUNCTION: Erosion control
DIMENSIONS: 6.0 m E/W by 0.7 m by 1.2 m
DESCRIPTION: This feature is a well constructed, four-six course high retaining wall built into the south bank of Kokololio Gulch at c. 60.0 west of its intersection with the Kamehameha Highway and c. 14.0 m 70° from datum of the main site map. Large basalt cobbles are stacked one course wide and four-six courses high, set within the stream bank, resting on the streambed. The wall is the remnant of what probably lined the gulch. The adjacent terrain is flat, with a very gradual eastward slope descending from the west.

FEATURE G: Ditch (Figure A-14)
FUNCTION: Irrigation
DIMENSIONS: 38.00 m N/S by 0.48 m by 0.25 m
DESCRIPTION: This ditch begins upslope in a fallow sugar cane field and runs at 75° for c. 30.00 m downslope. At this point a c. 8.00 m section is missing. It turns 7° for c. 18.00 m, paralleling Fea. D, and ends at the agriculture field and abandoned cars. The ditch is pre-fabricated concrete with metal slats to control water release. The adjacent terrain is the north slope of a hill and an agriculture field c. 56.00 m west of Kokololio Stream.

FEATURE H: Retaining wall
FUNCTION: Agriculture
DIMENSIONS: 16.00 m N/S by 1.05 m by 0.40 m
DESCRIPTION: This remnant retaining wall is partially faced on the east side and has been heavily disturbed by vegetation and trash dumping. It is c. 1.5 m east of Fea. D and c. 3.00 m east of Fea. G. The rock is stacked two courses high and loosely placed two-three courses wide. Rock size ranges from c. 0.40 by 0.35 m to c. 0.12 by 0.12 m. The adjacent terrain is a relatively flat area with a gentle downward slope south to north.

SITE NO.: State: 4464 **PHRI:** T-26
SITE TYPE: Complex (2 Features)
TOPOGRAPHY: East slope near crest of a N/S running ridge. Slope falls away to E/NE and SE from the flat.
VEGETATION: Christmas-berry, ti, mango, *koa-haole*.
CONDITION: Good
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Habitation
DESCRIPTION: This site consists of a habitation terrace at (Fea. A) and a mortar and pestle boulder at (Fea. B). The overall site dimensions are c. 15.5 m (at 340°) by 10.0 m (230°). Large basalt cobbles and small basalt boulders form a three-sided, paved terrace off a descending slope. A large boulder with a hole pounded in the top and a pounder are also present.

FEATURE A: Terrace
FUNCTION: Habitation
DIMENSIONS: 5.50 m by 5.50 m by 0.65 m
DESCRIPTION: The feature is a paved terraced area, retained on three sides, with the fourth side coming off a descending slope. The feature is c. 5.00 m north of the fence line at c. 200.00 m from the gate and c. 10.00 m NW of Fea. B. The site rests on a flat area perpendicular to the slope before descending eastward. The terrace is constructed of large boulders and small cobbles of basalt stacked two-three courses and piled to form the three retaining walls of this terrace. The body and surface of the terrace is paved with basalt cobbles, and in good condition. A possible grinding stone is c. 1.50 m off the feature's SW corner. The adjacent terrain slopes from W/NW.

FEATURE B: Modified outcrop
FUNCTION: Habitation
DIMENSIONS: 1.2 m N/S by 1.0 m by 0.8 m
DESCRIPTION: This feature is a large bedrock boulder with a depression apparently formed by pounding or grinding activity by a pestle stone (which is still in the hole). It is c. 10.0 m south of Fea. A at c. 200.0 m uphill along a fence line. An adze was found and collected c. 5.0 m downslope from the feature.

SITE NO.: State: 4465 **PHRI:** T-28
SITE TYPE: Complex (19 Features)
TOPOGRAPHY: Flat with an exposed area of limestone bedrock oriented E/W on the north side of the site area, and Kahawainui Stream forming the east boundary of the site.
VEGETATION: Thick grasses, ironwood, banyan, palm trees, sisal, and *koa-haole*.
CONDITION: Good
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric/Early historic
FUNCTIONAL INTERPRETATION: Burial
DESCRIPTION: The site measures c. 38.0 m N/S by 28.0 m overall, and is a large elevated soil area containing two capped grave plots, one with a headstone. Adjacent to this area is a fenced area with several soil mounds which appear to be grave plots.

FEATURE A: Platform (2) (Figure A-16)
FUNCTION: Burial
DIMENSIONS: 12.00 m by 12.00 m by 0.65 m
DESCRIPTION: Two capped graves occupy a square, raised area atop a low rise. The graves are c. 120.00 m upstream of the Kamehameha Highway bridge crossing Kahawainui Stream. One cap appears to be marble with a worn inscription on its west end. The date on the cap is January 25, 1920. The other cap is possibly granite with a raised headstone. Coral blocks and cobbles are scattered across the surface of the square, and are aligned on the east boundary of the elevated area. The overall area slopes gently east, west, and north to the foot of a large limestone bedrock outcrop. The elevated area with the coral cobble alignment appears to be a remnant house platform boundary referred to by Neller (1984), and the site where Bath conducted excavations in 1985.

FEATURE B: Mound (17) (Figure A-16)
FUNCTION: Burial
DIMENSIONS: 12.0 m by 8.0 m by 1.0 m
DESCRIPTION: This is a fenced area that has been cleared of all vegetation except recent grass growth. It is c. 120.0 m at 230° from the Kamehameha Highway bridge that crosses over Kahawainui Stream and is adjacent to Fea. A. Fifteen linear soil mounds, four of which have glass jars placed at the northeast ends, and two roughly square elevated soil areas partially bounded by cobble alignments are present. Wooden posts with barbed wire supported by ironwood trees surround the soil mounds.

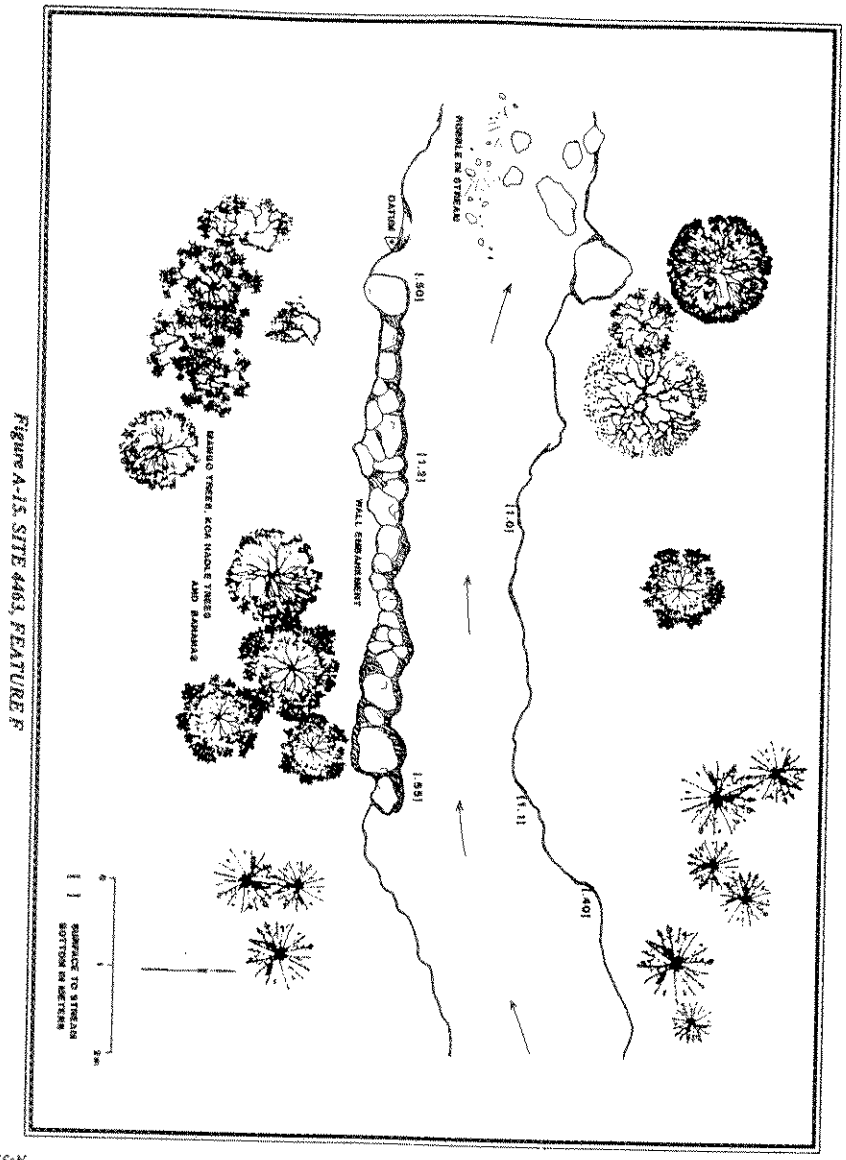


Figure A-15. SITE 4463, FEATURE F

SITE NO.: State: 4466 **PHRI:** T-29
SITE TYPE: Complex (3 Features)
TOPOGRAPHY: Fairly flat from the site area to the ocean (ENE). Sloping foothills and large ridge system to the WSW of site.
VEGETATION: Thick grass, guava, banana, mango, Christmas-berry, and heliotrope bushes.
CONDITION: Good
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric-historic
FUNCTIONAL INTERPRETATION: Agriculture
DESCRIPTION: Overall dimension is c. 122.0 m NW/SE by 48.0 m. This site consists of three pond fields (Features A, B, and C). Leveled soil fields are surrounded by soil berms with associated soil lined irrigation ditches. One cement channel gate is present for the purpose of draining fields. The site appears to be historic, based on the presence of the cement flood gate in the NE corner of Fea. A, and the lack of vegetation in the field areas, but the site may contain a prehistoric element.

FEATURE A: Pond field
FUNCTION: Agriculture
DIMENSIONS: 68.0 m by 48.0 m by 0.6 m
DESCRIPTION: This feature is a grass covered field at the base of the foothills. A large ridge system is to the WSW. The WSW field is bounded by a fence line and the base of the foothills. The SSE boundary is a soil berm, c. 5.0 m wide, which separates field "A" from field "B". The NNW field boundary is a retained soil area, which may be from a dozer cut, or a stacked cobble or cement retaining wall. Only soil and thick vegetation covers this boundary. The ENE boundary is a soil berm (c. 2.0-2.5 m wide) which extends from the SSE boundary. There is also a drainage ditch which parallels this soil berm. The ditch extends to the SSE, along the sides of Fea. B and C, also to the NNW towards Kokololio Stream and Kamehameha Highway. In the far NE corner of the field is a water control gate. It is constructed of poured cement, is "L" shaped, and cuts across the soil berm then turns parallel to the ditch and spills out into it. It is c. 30.0 m SW of Kamehameha Highway and c. 60.0 m east of Site 4463. The adjacent terrain consists of sloping foothills to the immediate SW, otherwise it is fairly flat. The construction consists of a sunken, levelled field area with soil berms and remnant terrace. The retaining wall running along the fence line is constructed of basalt and limestone cobbles.

FEATURE B: Pond field
FUNCTION: Agriculture
DIMENSIONS: 33.0 m by 20.0 m by 0.5 m
DESCRIPTION: This feature is similar to Fea. A, a sunken, levelled field area with boundaries of soil berms and a rough remnant terrace retaining wall. It is adjacent to Fea. A's SE boundary soil berm. The NW, NE, and SE boundaries are soil berms, and measure c. 2.0 to 5.0 m wide and c. 0.5 m above the field area. A soil ditch runs along the NE side of the field, which is the same ditch that runs along the ENE side of Fea. A. The SW boundary is a remnant terrace wall, retaining the sloping foothills behind it. There is also a fence line and old road running directly above this retained area. Sloping foothills are to the SW, otherwise the area is flat with thick grass.

FEATURE C: Pond field
FUNCTION: Agriculture
DIMENSIONS: 45.0 m by 30.0 m by 0.5 m
DESCRIPTION: This feature is similar to Fea. B in appearance, construction, and definition of boundaries. It is adjacent to Fea. B's SE boundary. The NW, NE, and SE boundaries are soil berms, and the SW boundary is the rough remnant retaining wall at the base of the foothills. Sloping foothills are to the SW, otherwise the area is flat with thick grass.

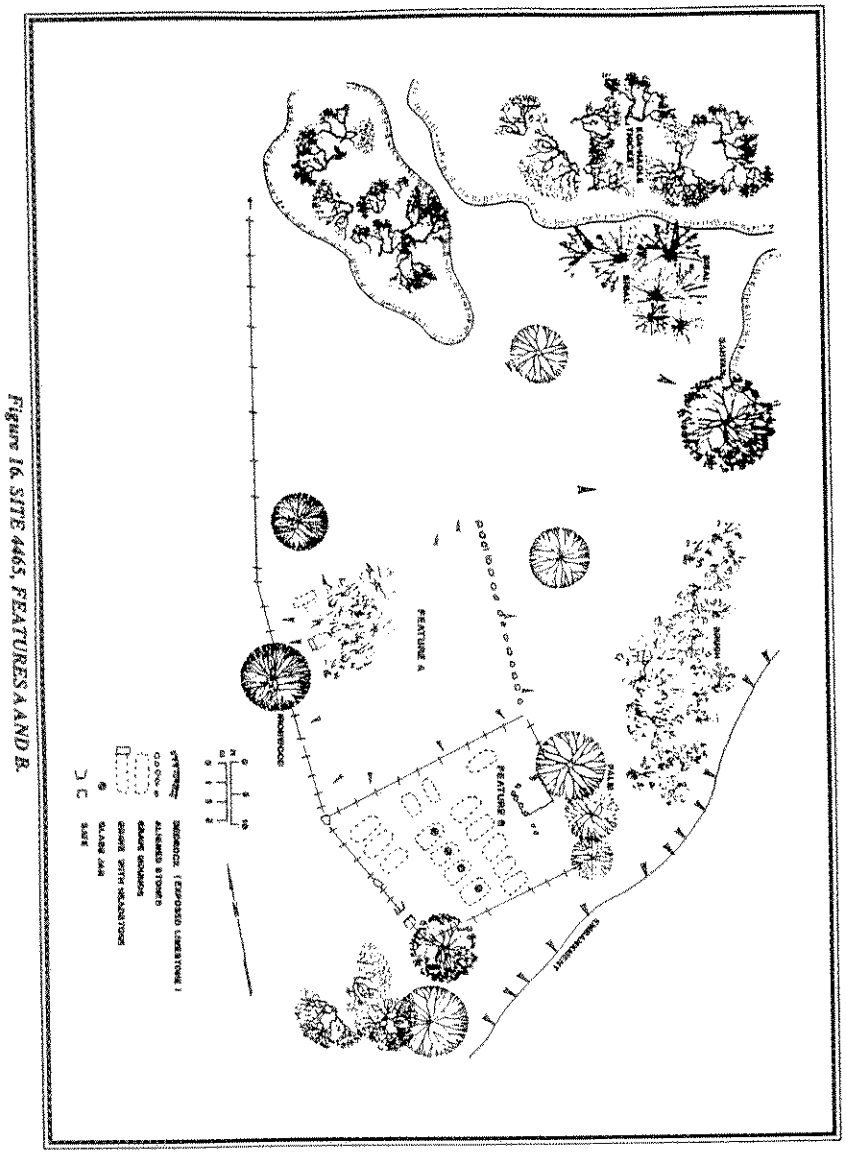


Figure 16. SITE 4465, FEATURES A AND B.

SITE NO.: State: 4467 PHRI: T-30
SITE TYPE: Possible habitation
TOPOGRAPHY: Flat, sandy residential area on the coast.
VEGETATION: False *kamani*, grass, and shrubs.
CONDITION: Fair
INTEGRITY: Altered
PROBABLE AGE: Prehistoric-early historic
FUNCTIONAL INTERPRETATION: Possible habitation
DIMENSIONS: 15.0 m by 15.0 m (approx.)
DESCRIPTION: This feature is a subsurface deposit which was discovered while conducting the backhoe testing, and appears to be a very dark brown sandy loam with fire-cracked rock and possible ash or fine charcoal content. The layer appeared in BT-8 at c. 0.49-0.60 m, but not in BT-9. The total extent of this deposit is unknown. A test unit, (TU-2), was excavated NW of BT-8. This layer was encountered in the test unit and is being processed in the lab. The location is in the far NW corner of parcel J.

During the excavation of backhoe trench #8 (BT-8), a possible cultural deposit was observed c. 49.0 cm below the surface, but due to the overall depth and unstable sidewalls of the trench the possible deposit could not be approached. Further investigation was accomplished through the excavation of a test unit (TU-2). TU-2 measured 1.0 m by 1.0 m, and was excavated immediately beyond the northeast end of BT-8. The following stratigraphy was revealed:

North Face Layer	
I	0-24 cmbs; brown (10YR 5/3 moist); very fine sand; brown (10YR 5/3 dry); structureless; loose, loose, non-sticky, non-plastic consistence;
II	24-44 cmbs; very dark grayish brown (10YR 3/2 moist); very fine sand; very dark grayish brown (10YR 3/2 dry); structureless; loose, loose, non-sticky, non-plastic consistence;
HF1	40-44 cmbs; very dark grayish brown (10YR 3/2 moist); very fine sandy loam; very dark grayish brown (10YR 3/2 dry); structureless; loose, loose, non-sticky, non-plastic consistence;
III	44-54 cmbs; light yellowish brown (10YR 6/4 moist); very fine sand; light yellowish brown (10YR 6/4 dry); structureless; loose, loose, non-sticky, non-plastic consistence;
IV	54-68 cmbs; black (5YR 2.5/1 moist); very fine sandy loam; black (5YR 2.5/1 dry); structureless; loose, loose, non-sticky, non-plastic consistence;
V	68-84 cmbs; light yellowish brown (10YR 6/4 moist); very fine sand; light yellowish brown (10YR 6/4 dry); structureless; loose, loose, non-sticky, non-plastic consistence.

A unit datum was set at the ground surface in the northeast corner of the test unit, and the test unit was excavated in 10.0 cm levels within layers. Stratum I (0-30 cmbd) seemed to be fairly disturbed and contained historic materials including, a shoe fragment, glass, and metal fragments. Stratum II (30-44 cmbd) contained a few metal fragments, sparse marine shell, *kukui* nutshell, and charcoal. Stratum II-2 (40-44 cmbd) was darker in color at first thought to be a horizontal feature, upon excavation appeared to be a stain. Charcoal collected from Stratum II yielded a date of 400-100 BC. Stratum III (44-52 cmbd) contained two fragments of metal, marine shell, and charcoal. The charcoal sample yielded a date of 26,655-22,775 BC. Stratum IV (52-68 cmbd) contained some charcoal flecking, *kukui* nutshell, and marine shell. Stratum V (68-84 cmbd) contained marine shell. The marine shell recovered in the test unit may be natural, considering the close proximity of the test unit to the ocean. As for the recovered dates, Stratum II may indeed be a very early occupation layer, but the layer directly underlying this deposit obviously predates human occupation in the Hawaiian Islands. Stratum III, as with Stratum II, may represent a localized area of contamination.

SITE NO.: State: 4468 (Figure A-17) **PHRI:** T-31
SITE TYPE: Cemetery
TOPOGRAPHY: The cemetery is on a flat area, on a gradually northward descending ridge.
VEGETATION: High dense grass, papaya, various saplings, and sisal. The cemetery is extremely overgrown.
CONDITION: Fair
INTEGRITY: Altered
PROBABLE AGE: Historic
FUNCTIONAL INTERPRETATION: Burial
DIMENSIONS: 30.0 m E/W by 20.0 m
DESCRIPTION: There are at least five different types of headstones/grave markers in the cemetery: (a) graves marked with limestone coral cobbles aligned to form a rectangle; (b) graves marked in the same manner as in (a), but with a carved marble headstone; (c) graves with perimeters of poured or pre-formed concrete (perimeters form rectangles); (d) pre-formed concrete gravestones that lie flat on the ground; and (e) headstones carved from coral/limestone.

Cobbles used in Type (a) markers are c. 0.2 m in diameter. The rectangles measure c. 2.0 m NE-SW by c. 1.0 m NW-SE by c. 0.2 m high. Some of the graves abut one another and share a perimeter wall.

There is only one Type (b) marker in the cemetery. It is at the southwest end of a grave. Its base is broad and rectangular and measures (c. 0.4 m NW/SE by 0.2 m NE/SW by 0.6 m high). The headstone inscription reads "Grandfather Kamauoha Kakahoolae, born 1850, died July 2, 1921". There is a potted plant near the headstone.

Type (c) perimeters are about 0.15 m wide by c. 0.3 m high. There are no Type (c) graves that share perimeter walls.

There are three types of Type (d) markers; all, however, are c. 2.0 m by 1.0 m by 0.2 to 0.7 m high. Subtype one actually consists of two flat, rectangular headstones, the slightly smaller one atop the larger. Subtype two comprises a large rectangular concrete slab, a much smaller rectangular slab centered atop the larger, and an arched headstone centered atop the smaller slab. Subtype three consists of an arched marker measuring about 2.0 by 1.0 by 0.7 m high.

Type (e) coral/limestone slabs are circular and are set on end. On the NE faces of the slabs are illegible carved inscriptions. There are no perimeters to these plots.

SITE NO.: State: 4469 **PHRI:** T-32
SITE TYPE: Upright Stone
TOPOGRAPHY: NW-SE running ridge with steep sloped sides.
VEGETATION: *Koa-haole* and thick vines.
CONDITION: Good
INTEGRITY: Unaltered
PROBABLE AGE: Historic
FUNCTIONAL INTERPRETATION: Marker
DIMENSIONS: 0.2 m wide by 0.6 m high
DESCRIPTION: This feature is an upright piece of granite, worked on all four sides, and arched on the top. A cross is carved in the top surface, and at the base of the northwest and southeast sides there are two carved circular depressions. The feature appears to be a property marker, similar to old property line markers. Inspection of the surrounding area yielded no other like features.

A test unit (TU-1), measuring c. 1.0 m by 1.0 m was excavated along the southeast side of the feature. One stratum, with a few cm of duff overlying, was revealed, and excavated to c. 1.00 m where it terminated on bedrock. No cultural material or deposit was uncovered, and the granite stone extended to the bedrock.

SITE NO.: State: 4470 (Figure A-18) **PHRI:** T-33
SITE TYPE: Ditch-tunnel
TOPOGRAPHY: Ridge sloping to the northeast, with currently cultivated banana plantation in low lying area to the northeast.
VEGETATION: *Hau*, large mango, thick grass, ferns, and *koa-haole*.
CONDITION: Good
INTEGRITY: Unaltered
PROBABLE AGE: Historic

FUNCTIONAL INTERPRETATION: Irrigation
DIMENSIONS: 72.5 m E/W by 17.0 m
DESCRIPTION: This site consists of three ditch segments. Two of the segments are oriented c. E/W and separated by a gap of c. 28.0 m. These two segments run along the south side of an old overgrown dirt road (oriented E/W). The third segment extends to the south from the east end of the first segment. Only the first c. 9.0 m of the third ditch is lined with stones, beyond that it is a soil ditch.

There are three tunnels at the easternmost end of the second segment. The tunnels appear to be corrugated metal pipes. The ditches are lined with dressed limestone and basalt blocks stacked one-five courses high, creating nicely faced interior sides.

SITE NO.: State: 4471 **PHRI:** T-04
SITE TYPE: Complex (2 Features)
TOPOGRAPHY: The south crest of a low, broad NW/SE running ridge. Slope to the south is gradual.
VEGETATION: *Koa-haole*, vines, and various ground covering shrubs.
CONDITION: Fair
INTEGRITY: Altered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Agriculture
DESCRIPTION: This site, a mound (Fea. A) and a paved area (Fea. B), measures c. 20.0 m E/W by 8.0 m overall.

The area around the features appears to have been dozed, most likely associated with sugar cane cultivation. The two features that comprise the site appear to be remnants of earlier agricultural activity, which has been negatively impacted by the later agricultural activity.

FEATURE A: Mound
FUNCTION: Agriculture
DIMENSIONS: 3.50 m N/S by 2.00 m by 0.45 m
DESCRIPTION: The roughly circular mound is constructed of limestone cobbles with a fairly flat surface. It is off the SE corner of a fenced lot containing an abandoned truck, and c. 0.25 m NW of Site 4469. Dozer push has impacted the feature with a piece of cement abutting the north end.

FEATURE B: Paved area
FUNCTION: Agriculture
DIMENSIONS: 9.0 m NW/SE by 7.0 m by 0.3 m (approx.)
DESCRIPTION: This feature is a large, amorphous, relatively flat area paved with limestone clinkers and cobbles, and disturbed by dozer push. This feature is very scattered. It appears to be a clearing area associated with agricultural activity.

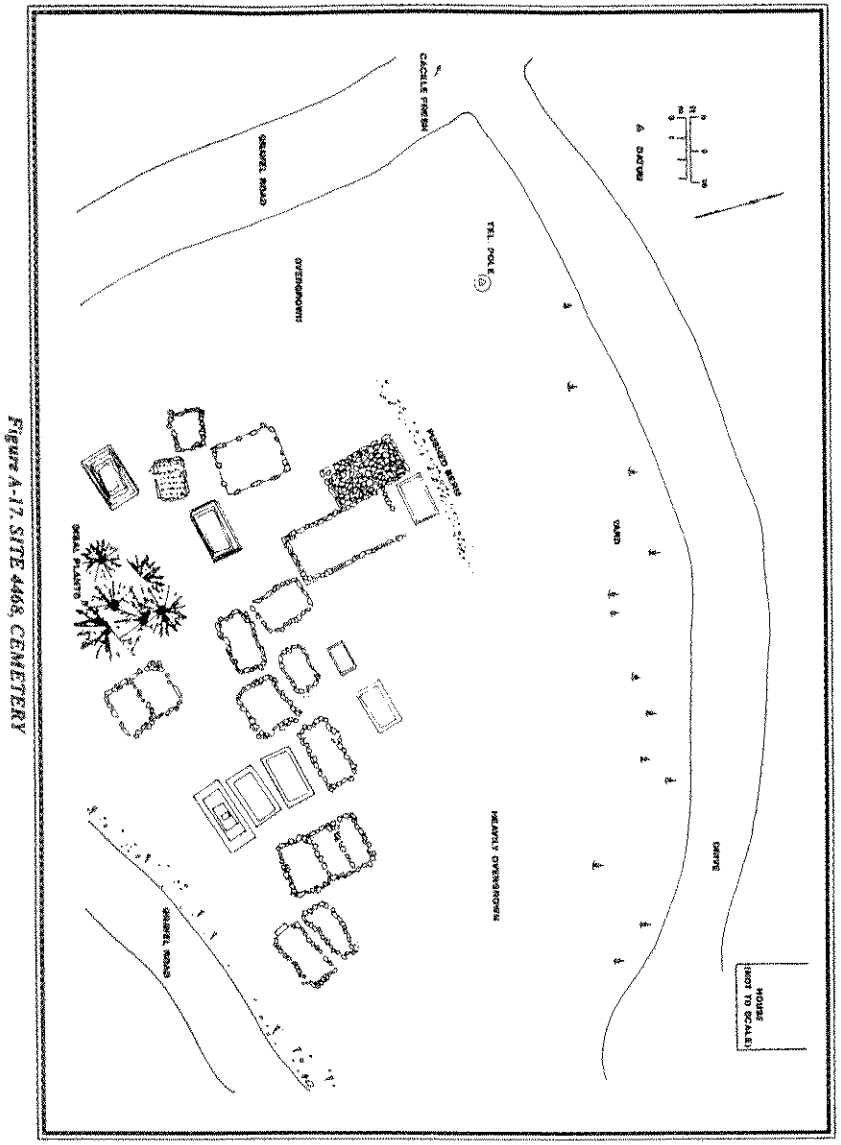


Figure A-17. SITE 4468, CEMETERY

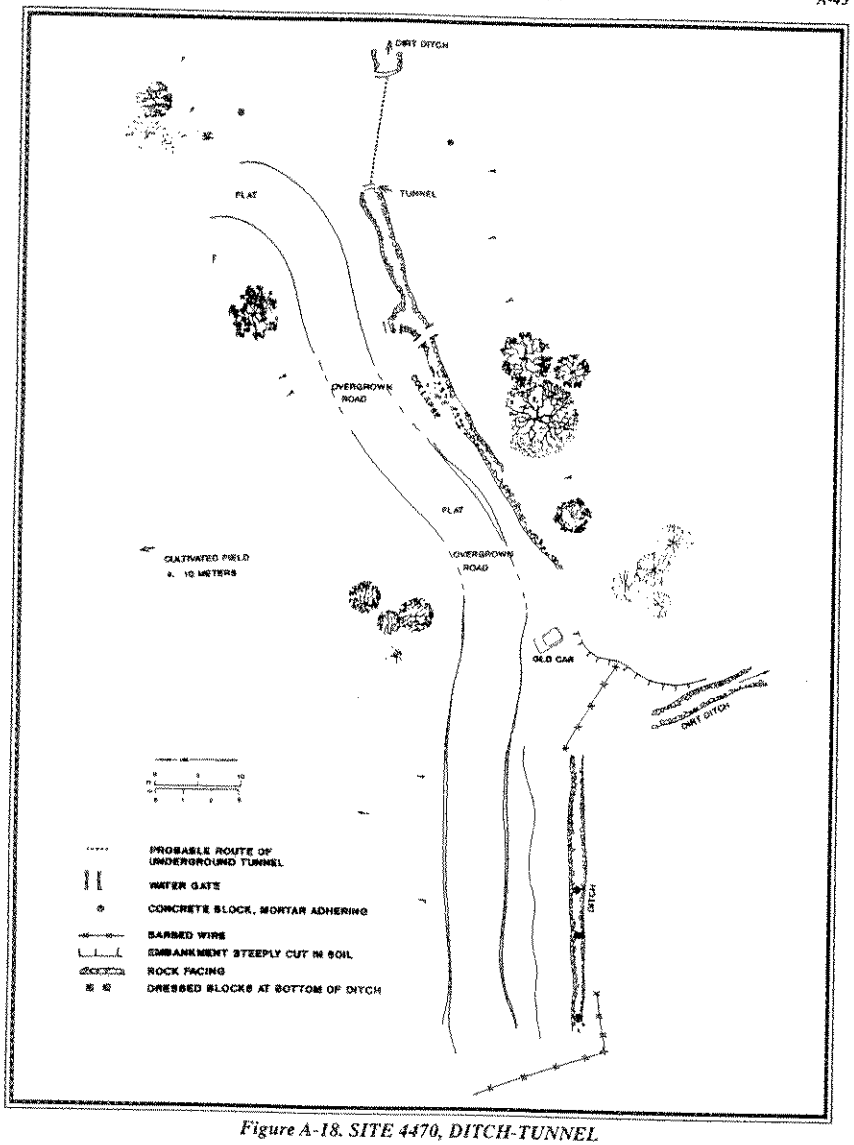


Figure A-18. SITE 4470, DITCH-TUNNEL

SITE NO.: State: 4472 **PHRI:** T-07
SITE TYPE: Cave
TOPOGRAPHY: Limestone bluff/cliff overlooking the west branch of Kahawainui Stream, and gently sloping to the northeast to Cackle Fresh Farms.
VEGETATION: *Koa-haole*, ferns, and papaya outside of cave.
CONDITION: Fair-Good
INTEGRITY: Altered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Temporary habitation-burial
DIMENSIONS: 68.0 m N/S by 37.0 m
DESCRIPTION: The site is a large, single chambered cave with two entrances. The NE entrance measures c. 14.0 m long by c. 10.0 m wide, and is an almost vertical drop into the cave. This entrance is in a large, partially sunken area with exposed limestone bedrock, c. 100.0 m NE of the Cackle Fresh chicken barns within the dense *koa-haole*. This cave has a second entrance which opens to the south, measures c. 8.5 m long (E/W) by 5.0 m wide and is also a near vertical drop into the cave. This entrance is at the base of a large limestone bluff. Both entrances are choked with garbage, as the area has been apparently used as a recent refuse dump. The interior of the cave is fairly clear of garbage and covered with aeolian silt and slabs of limestone from ceiling fall. Disturbed human skeletal remains were noted against the central NW wall of the cave. Two shovel tests were excavated at the north. One-third of the cave showed a habitation deposit present.

Two shovel tests (ST-1 and 2), each measuring c. 0.5 m by 0.5 m were excavated at the base of the slope extending into the cave from the northeast entrance. The following stratigraphy was revealed:

ST-1 Layer	Description
I	0-50 cmbs; very dusky red (2.5YR 2.5/2 moist); silt loam; very dusky red (2.5YR 2.5/2 dry); structureless; soft, very friable, slightly sticky, non-plastic consistence.

ST-2 Layer	Description
I	0-50 cmbs: very dusky red (2.5YR 2.5/2 moist); loam; very dusky red (2.5YR 2.5/2 dry); structureless; loose, very friable, slightly sticky, non-plastic consistence.

Shovel test 1 contained c. 50.0 cm of cultural deposit of marine shell, charcoal, *kukui* nutshell fragments, and basalt flakes. Excavation was terminated at c. 50.0 cm below the surface on limestone bedrock.
Shovel test 2 was excavated at the apex of soil mound c. 15.0 m south of shovel test 1, and contained a few crustacean shells. Excavation terminated at c. 50.0 cm below the surface on limestone, but it was not determined if the limestone was bedrock or a large slab.

SITE NO.: State: 4473 **PHRI:** T-15
SITE TYPE: Complex (4 Features)
TOPOGRAPHY: A drainage or western branch of Kahawainui Stream at the base of a limestone cliff.
VEGETATION: A large canopy of *hau* and mango, *koa-haole*, thick ferns and vines, and banyan trees.
CONDITION: Good
INTEGRITY: Partially Altered
PROBABLE AGE: Prehistoric-early historic
FUNCTIONAL INTERPRETATION: Multiple
DESCRIPTION: The overall site dimension is c. 93.5 m NW/SE by 20.0 m, consisting of a retaining wall (Feature A), one enclosure (Fea. B), and two walls (Fea. C, and D).

FEATURE A: Retaining wall
FUNCTION: Possible agriculture
DIMENSIONS: 7.1 m E/W by 1.7 m by 0.7 m (approx.)
DESCRIPTION: This feature is a retaining wall at the base of a large limestone cliff south of the Cackle Fresh Farms barns, and c. 4.0 m north of the northwest corner of Fea. B. The wall has two separate sections. The first runs east to west and is built of limestone cobbles stacked two-four courses high. The second is c. 1.5 m west of the first along the cliff. This portion of wall is formed by large limestone boulders and limestone slabs that are placed on their edges. Overall the limestone cobbles average c. 0.3 m in diameter, are stacked two-four courses, and are anchored at both ends by bedrock outcrops.

FEATURE B: Enclosure
FUNCTION: Possible agriculture
DIMENSIONS: 12.0 m E/W by 10.0 m by 0.6 m (approx.)
DESCRIPTION: This is a stacked and aligned U-shaped enclosure constructed off the base of a limestone cliff face. The location is from the datum or site tag of B to the datum of Feature C at 100°, c. 0.35 m. The enclosure is constructed of limestone cobbles and boulders stacked two-three courses in places, aligned in others, and missing in other areas, forming three walls with the cliff face forming the fourth. The interior surface is fairly flat and covered with soil.

FEATURE C: Wall
FUNCTION: Indeterminate
DIMENSIONS: 24.00 m NNW/SSE by 17.00 m by 0.83 m
DESCRIPTION: This is an L-shaped wall NNE of a western branch of Kahawainui Stream, at the base of a large limestone cliff immediately southwest of the Cackle Fresh Farms barns. It is c. 30.0 m at 100° from Fea. B and c. 27.5 m at 149° to Fea. D. The shorter segment extends from the base of the limestone cliff at c. 240°, then turns and heads at c. 150°. The longer wall portion roughly parallels the limestone cliff and is about half way between the cliff and streambed.

The area contained within the wall is fairly flat and clear of rock, with only a couple of isolated waterworn basalt cobbles noted. The soil within this area is reddish-brown clay loam. At places along the exterior side of the wall are upright limestone slabs that appear to be braced by waterworn basalts along the interior. The wall width varies from c. 0.5 m to 1.1 m. The wall abruptly ends at the SE end of the longer portion, with three aligned limestone boulders (medium sized). At this termination point the streambed appears to have cut the pre-existing bank back, washing out any wall portion. Limestone slabs and cobbles are along and at the base of the streambed bank. The shorter section extending from the cliff has been altered by a roughly parallel barbed wire fence line. There is a line of 12 large mango trees running parallel to the longer section of the wall and just inside the feature. The adjacent terrain consists of a flat gulch bottom with a limestone cliff NE and streambed (oriented at ESE/WNW) to the SSW c. 10.0 m. A flat open field, currently cultivated in papaya, is c. 20.0 m to the SE.

FEATURE D: Wall
FUNCTION: Indeterminate
DIMENSIONS: 28.0 m by 1.0 m by 1.0 m
DESCRIPTION: This wall, built of stacked limestone boulders, connects the northeast side of a culvert with a drainage area to the southwest, effectively blocking all easy access into the culvert through the flood terrace. The feature is c. 27.5 m at 329° away from Fea. C (datum to datum). The wall is constructed at the point where the culvert opens out onto a wide flood terrace. This wall provides a boundary/defense wall for all features in the culvert. At one time it probably connected with Fea. C (a stacked limestone wall running N/S), but the connecting portion may have been washed away by floods.

SITE NO.: State: 4474 **PHRI:** T-16
SITE TYPE: Complex (3 Features)
TOPOGRAPHY: Relatively flat with a slight N/NE slope. High road embankment on NE side (c. 10° slope).
VEGETATION: *Koa-haole* and Christmas-berry.
CONDITION: Good
INTEGRITY: Unaltered
PROBABLE AGE: Historic
FUNCTIONAL INTERPRETATION: Erosion control
DESCRIPTION: This site is a series of retaining walls built of basalt cobbles and boulders. The walls retain the west embankment along an old cane road. The walls were probably once connected.

FEATURE A: Retaining wall
FUNCTION: Erosion control
DIMENSIONS: 9.3 m N/S by 2.4 m by 0.4 m
DESCRIPTION: This is a long wall at the base of the cane road embankment. The wall is c. 2.0 m south of Feature B. It is constructed of stacked basalt cobbles.

FEATURE B: Retaining wall
FUNCTION: Erosion control
DIMENSIONS: 2.00 m N/S by 0.85 m by 0.40 m
DESCRIPTION: This feature is c. 5.0 m SSW of Fea. C. The wall is semi-circular and built of stacked basalt cobbles; it supports the eastern portion of the old road embankment. Near the center of the feature is an old culvert.

FEATURE C: Retaining wall
FUNCTION: Erosion control
DIMENSIONS: 1.5 m N/S by 0.9 m by 0.8 m
DESCRIPTION: This is a short wall which retains roadbanks to the north and east. The wall is built of basalt stones stacked three-four courses high, from the base to about half way up the embankment.

SITE NO.: State: 4475 **PHRI:** T-27
SITE TYPE: Retaining wall
TOPOGRAPHY: A more than gradual descent to the NW, N, and NE from the SW, S, and SE. Series of hills, ridges, and hollows.
VEGETATION: Christmas-berry, *koa-haole*, and mango.
CONDITION: Fair
INTEGRITY: Unaltered
PROBABLE AGE: Prehistoric
FUNCTIONAL INTERPRETATION: Agriculture
DIMENSIONS: 2.6 m E/W by 1.0 m by 0.6 m
DESCRIPTION: This is an L-shaped retaining wall that runs downslope to the east, and then turns south. The wall is two courses high and is constructed of limestone boulders c. 1.0 m in diameter and limestone cobbles c. 0.25 in diameter.

APPENDIX B

HISTORICAL DOCUMENTARY RESEARCH

by Lehua Kalima, B.A.

The project area lies in the *ahupua'a* of La'ie, in the Ko'olauloa District of the Island of O'ahu. The neighboring *ahupua'a* of Malaekahana borders the project area on the western side. Due to its proximity and frequent ties with La'ie in historical literature, information on this land will also be included in this report. La'ie translates literally as "'ie leaf" (Pukui et al. 1974:128), and is perhaps best known as the birthplace of the legendary princess La'ieikawai. Malaekahana was the name of La'ieikawai's mother, and also the name of an image in the Halemano legend (ibid:143). Many Hawaiian legends and stories of supernatural beings are placed within these lands of the Ko'olauloa District.

LEGENDS AND MYTHS

Perhaps the legend most frequently associated with this area is that of the Princess La'ieikawai. This is a lengthy story which covers different islands, but which originates in La'ie. La'ieikawai and Laielohelohe were twin daughters of Malekahana. While she was still pregnant, Malaekahana's husband Kahauokapaka, chief of the two Koolau districts, vowed to destroy any girl children they may have prior to having a boy, since he wanted only sons. In accordance with his wishes, the first four children of Malaekahana, all girls, were killed. When she was ready to give birth again, Malaekahana sent her husband to the coast to get her a type of fish she craved. While he was away, Malaekahana gave birth to twin girls who were exceptionally beautiful. She quickly arranged for them to be raised by others so that Kahauokapaka would not kill them. La'ieikawai was given to her grandmother Waka who hid her in a cavern near a pool named Waiapuka until she was a teenager. It is said a rainbow appeared over Waiapuka the moment La'ieikawai entered the cavern, and could be seen there even when the sun was hidden. Laielohelohe went to live with a priest named Kapukaihaoa and neither sister knew the other existed. The legend is complex and covers the lives of La'ieikawai and Laielohelohe as they grow up and have adventures throughout the islands (Kalakaua 1972:455). The pond where La'ieikawai is said to have been hidden still exists and is described in greater detail later in this report.

Another legend deals with a shark-man of the area named Mano-niho-kahi. The following tells the story of his activities in Malaekahana and his final capture:

> **Legend of Manonihokahi**
> Near the water hole in Malae-kahana, between Laie and Kahuku, lived a man called Mano-niho-kahi, who was possessed of the power to turn himself into a shark. Mano-niho-kahi appeared as other men except that he always wore a tapa cloth which concealed the shark's mouth in his back.
>
> Whenever he saw women going to the sea to fish or to get limu he would call out, "Are you going into the sea to fish?"
>
> Upon hearing that they were, he would hasten in a roundabout way to reach the sea, where he would come upon them, and biting them with his one shark's tooth, kill them.
>
> This happened many times. Many women were killed by Mano-niho-kahi. At last the chief of the region became alarmed and ordered all the people to gather together on the plain. Standing with his kahuna, the chief commanded all the people to disrobe. All obeyed but Mano-niho-kahi, Shark-with-one-Tooth, so his tapa was dragged off and there on his back was seen the shark's mouth. He was put to death at once and there were no more deaths among the women. (Rice IN Sterling and Summers 1978:157).

Laniloa is the name given to a point of land which extends into the ocean from La'ie. In ancient times this point was said to be a *moo* (lizard), standing upright, ready to kill any passersby. A myth tells the story of a young man named Kana and his brother who eventually destroy the lizard:

> After Kana and his brother had rescued their mother from Molokai and had taken her back to Hawaii, Kana set out on a journey around the islands to kill all the mo-o. In due time he reached Laie, where the mo-o was killing many people. Kana had no difficulty in destroying this monster. Taking its head, he cut it into five pieces and threw them into the sea, where they can be seen today as the five small islands lying off Malae-kahana; Malualai, Keanuakaluapaaa, Pulemoku, Mokuaaniwa and Kihewamoku.
>
> At the spot where Kana severed the head of the mo-o is a deep hole which even to this day has never been fathomed (Rice IN Sterling and Summers 1978:157).

One legend collected by Rice (IN Sterling and Summers 1978:158) tells the story of Kamehameha sending out Kahalaiu, a chief under his control, who was unable to subdue Manuwahi, a *kahuna* of Malaekahana, because this powerful *kahuna* was aided in battle by the gods. After the battle, Kahalaiu joined forces with Manuwahi and is still spoken of by the older natives as the chief who revolted against Kamehameha. Many skeletons were unearthed in plowing the cane fields of Malaekahana and in digging the foundations for the beach houses, indicative, some think, of many battles in the region (McAllister IN Sterling and Summers 1978:156).

PREVIOUSLY DOCUMENTED ARCHAEOLOGICAL AND HISTORICAL SITES

The following sites have been previously documented by Sterling and Summers (1978) and can be located according to their site number on Figure B-1. Many of these sites lie within or close to the present project area and are discussed in detail in the following descriptions:

Malaekahana - Site 272. A few rocks at Makahoa, all that remain of a fishing shrine which was on the point. The fish brought here were the oio.

Formerly a fishpond was located near the point and was known as Waipunaea. There are traditions about the mullet coming to this point from Pearl Harbor....To this day schools of mullet come around the island to this northern point of Malaekahana. They go no farther, and their apparent disappearance still mystifies the Hawaiians (McAllister IN Sterling and Summers 1978:157).

House Site of Manuwahi - Site 273. Foundation of the house (kahuahale) of Manuwahi, keeper of the god of Malaekahana. Only a few large rocks remain by the site of the railroad track, but the site has great importance in the eyes of natives because of the prominence of the kahuna Manuwahi. About this area is said to have been a rather large Hawaiian settlement, which formerly was level land, but which owing to the removal of flora has formed into dunes. The site was pointed out by a descendant of Manuwahi, Kahiona Apuakehau, a very old Hawaiian living in Laie. The Hawaiians are still proud that the district of Malaekahana was never conquered by Kamehameha I...(ibid:154).

Waiapuka - Site 275. Waiapuka, a pool on the Kahuku side of Laie in Malaekahana, inland from the road in the midst of a cane field.

Waiapuka is made famous by the legend of Laieikawai. Without guidance it is difficult to find, for it is hidden from sight even from the surrounding elevations or from the tops of the highest pines which line the road. The pool is oval in shape, measuring about 30 ft. by 60 ft. with the water about 10 ft. below the level of the surrounding plain. Tides are said to affect the pool. On the Laie side is a small crevice in the rock, which is said to open into the cavern in which Laieikawai was hidden. Natives of the region remember when it was possible to swim through an underwater entrance, and it is said that the chamber could accommodate three of four people. Within the last 25 years silt has filled the pool, and it is no longer possible to enter the hidden chamber. The pool is significant in the minds of the Hawaiians because it was here that Waka hid Laieikawai until she reached maturity (ibid.).

Waiapuka is located two tenths of a mile N.W. of Malaekahana R.R. Station, and about 300 feet inland from electric powerline pole No. 60 (Jan. 1933). (Stokes IN Sterling and Summers 1978:154).

Laie - Puuhonua - Site 280. Land of Laie which several of the Hawaiians of Laie told me had formerly been a puuhonua (place of refuge). This statement is partially verified by Pogue (Moolelo of Hawaii, Manuscript at Bishop Museum), who says: "At Laie on Oahu was an old city of refuge. They called the boundary on the Kahana side 'Pa-paa-koko' or 'Fence that held the blood'." (McAllister IN Sterling and Summers 1978:155).

Ko'a - Site 274. Site known to Hawaiians as a fishing shrine on the land known as Kalanai, which is now included in the division of Laie but formerly belonged to Malaekahana.

The fish brought to this shrine were the kala and enenue. Several flat rocks have been placed on end; one is placed flat. Innumerable remains of fish were found about the stones and on the west side of the rocks. Skeletal remains were found on the northwest side at an average depth of 2 feet. The body was partially flexed. The upper portion of the body was lying on its back, with the head thrown back so that the mandible was uppermost. The legs had been flexed. The entire length of the burial, from head to knee, was 4 feet. The maximum length of the right femur was 17 inches. The head was lying toward the south, and the lower portion was toward the sea (ibid.).

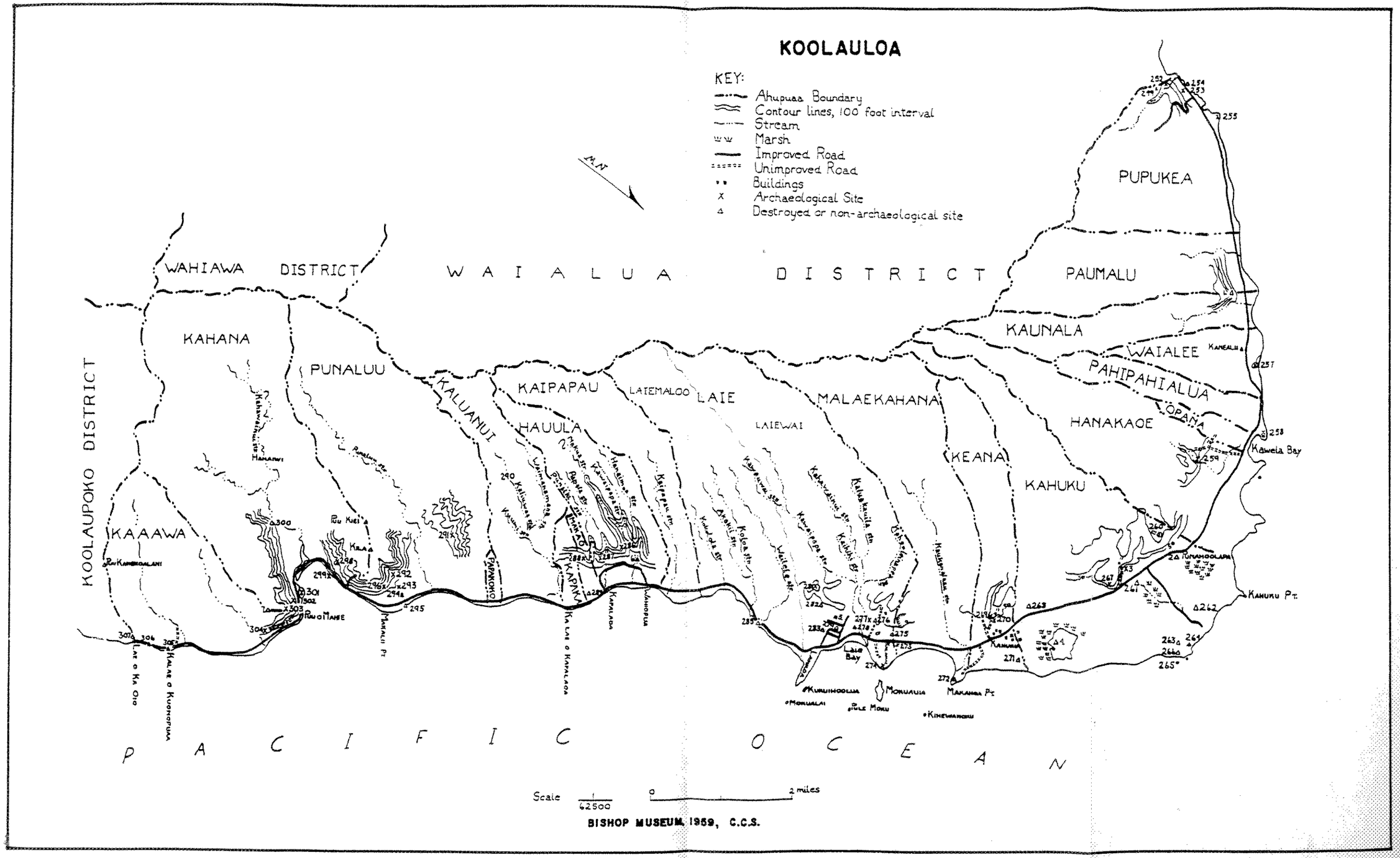


Figure B-1. MAP OF LA'IE SHOWING LOCATIONS OF VARIOUS SITES (FROM STERLING AND SUMMERS 1978)

Waikuukuu - Site 276. Waikuukuu, Kahuku side of the old Paeo fishpond, about 100 ft. up on the low ridge. A narrow but deep crevice in the ground with water at the bottom. This is affected by the tides and the depth of the water in Waiapuka may be judged by the height of the water in this opening. The place is now being used for dumping garbage (ibid.).

Paeo Fishpond - Site 277. Paeo fishpond, mountain side of the old bridge on the Kahuku side of Laie (ibid:156). This was a large horseshoe-shaped pond that was famous for the size of its fish. It is now dry and overgrown with weeds. On the Kahuku bank is a chalice-shaped stone about 3 ft. high, where Hauwahine, the goddess (moo) of the pond, is said to have been frequently seen combing her long black hair. This was a very sacred stone and could not be approached, nor would the old Hawaiians use the pond when a blanket of leaves and other refuse (aamoo) covered the water, for it was believed that then Hauwahine was present. When the water was clear, Hauwahine had departed to Kailua...(ibid.).

Hanapepe - Site 278. Hanapepe, elevation near the first bridge on the Kahuku side of Laie. A portion of this elevation was once a very sacred place where the akua stone, Kamehaikana, was worshipped. This is said to have been a female fish god, and the first fish were brought as an offering (ibid.).

Mormon Temple - Site 5. Ten Mormon Missionaries arrive Dec. 12, 1850. Finally, by 1865, a plantation of six thousand acres was purchased, and the elders organized so that the land could become self-sustaining and help support them. Many of the early missionaries had difficulty in maintaining themselves. (Josephson IN Sterling and Summers 1978:156).

Site 279 - Tunnel through which Manonihokahi once passed in going to the sea, until a few years ago in evidence in the settlement of Laie... McAllister IN Sterling and Summers 1978:156).

Moohekili Heiau (destroyed) - Site 283. Moohekili heiau, the site of which is pointed out in the taro patches on the sea side of the Mormon Temple. The slight elevation of ground, the occasional sound of the drums, and the name, are all the traces that remain, according to the oldest Hawaiians of the district. (ibid.).

Taro Land - Site 282. Taro land, Hauula side of the Mormon temple. A flat lowland, now drained and planted in cane, formerly a famous taro land. The old Hawaiian name for the region is now lost and it is known as Kanaana, an adaptation of Canaan, the Land of Promise of the Israelites. In with the taro were extremely large fish. One of the old Hawaiians remembers that one day in her childhood, while her parents were gathering taro, as she swam and played in the water she was knocked senseless by a fish. About this taro land the old Hawaiian settlement was located and on the mountain side of the site are the only foundations of a heiau (Nioi heiau) in Laie (ibid.).

Nioi Heiau - Site 281. Nioi heiau, on a small ridge on the mountain side of the Mormon temple, Laie. Disturbed coral platforms are all that remain to mark the place where the heiau once stood. The site is heavily covered with lantana and it is impossible to define the limits of the platforms. There are no walls which may be followed. Native tradition holds that the only wall which surrounded the platforms was removed by the plantation authorities. It is built on the Kahuku side of a coral outcrop; the coral from the ridge has been used for construction. The heiau is said to have been one at which human sacrifices were offered. The results of clearing would probably not justify the expense of such an undertaking. On the Kahana side of the ridge are several rock shelters which were probably used as the abodes of the kahunas (ibid.).

Pool at Laniloa Point - The small water hole next to the road, which is said never to have been fathomed, is of modern origin. During the quarrying of rock this underground cavern was accidentally opened. It is said that no amount of rock thrown into the pool would fill it (ibid:158). [This pool was filled in 1969]

Kaihukuuna, Ko'a - Site 285. Kaihukuuna, on the Hauula side of Laniloa Point. A few stones on the beach are all that remain of the fishing shrine at which mullet were once offered to the fish god (ibid.).

A story by Thrum (1916) tells of the establishment of many *ko'a* on O'ahu. The following passage confirms the presence of a *ko'a* at La'ie:

> Shortly afterwards Aiai arranged with Puniaiki for the establishing of Ku-ulas, ko'as, and fish stones around the island of Oahu, which were as follows: ...ko'a Kaihukuuna for Laiemaloo, Koolau (Thrum 1916:249).

Fornander (1918-1919) also mentions Kaihukuuna *ko'a* in the Legend of Maikoha:

> ...When Ihukoko decided to remain in Waialua, the sister that was left, Kahukuuna (Kaihukuuna?), continued on her way until she came to Laie where she met Laniloa, a goodly man, and they lived together as husband and wife. The fish that came with her was the mullet and it too remained there to this day. (Fornander 1920:272 vol. V).

CULTIVATION

The La'ie area, located on the windward side of O'ahu, is a very wet area, with many streams. Even today the area is frequently flooded when heavy rains fall on this part of the island. The streams provided an abundant water supply for irrigated taro cultivation. Handy and Handy (1972) give descriptions of the many streams in La'ie Ahupua'a, along with the type of native cultivation that took place in the various land sections.

> There are many streams in this ahupua'a. Kahooleinapea is the first stream reached after leaving the ahupua'a of Malekahana. Here terraces are still in use. The old terrace area named Waieli, along the lower reaches of Kahawainui Stream, is now under cane cultivation; it was once watered from a spring. Farther up Kahawainui Stream there were formerly many terraces, according to Kakela Kalua. About 2.5 miles up Wailele Stream there are evidences of old taro terraces (155).
>
> Along Koloa Stream, beginning at a point about 2 miles inland on its twisting course, there are abandoned groups of terraces at intervals, many of them now half hidden in the jungle growth. Just below the old water gates, on the south side of the stream, there is a group of about 15 small terraces, all with stone facings, and nearer the gates, on the north side, a smaller group of five or six. Immediately beyond a sharp curve in the stream bed, and evenly spaced at intervals on either side of the stream, are 15 or more very old mango trees planted in lines. At this point, on the left bank, going upstream, the valley widens into a beautiful flat area which was evidently an extensive dwelling site. There are about eight old breadfruit trees on the hillside and more huge old mangos. This flat area, extending upstream to the sheer cliff wall at the next stream bend, is terraced with low stone lines. Here there are 11 terraces, from 15 to 40 ft. wide and from 20 to 30 ft. long, now partly overgrown but very distinctly outlined. They could not be replanted unless the mangos were destroyed, as the whole surface of the soil is webbed with a network of tree roots. The stream makes a horseshoe bend at this point, and beyond are more mangos planted in lines for a distance of several hundred yards; and at the upper end of the site is a small house platform. Around the next curve is an area of three small lo'i; beyond this there is no further evidence of planting, the stream becoming more and more winding and the valley more and more narrow. Kakela Kalua of Laie says that this was formerly konohiki land, and now belongs to the Mormons.
>
> **Kapuna** - The comparatively flat land between the hills and the seacoast in Laie was divided into many clearly named small districts in the old days - a considerable portion of it, back from the beach strip, having been planted in wet taro. Kekuku, 75-year old kamaaina of the place, says that one of the largest single areas formerly under taro cultivation was the land, over 60 acres in extent, lying back of the present Mormon Temple, and known as Kapuna (the spring) because it was watered by one large and several lesser springs (Figure B-1: Site 282) (ibid.).
>
> According to Kekuku, there was another terrace area in the flatland named Kaholi, seaward of Kapuna, now abandoned. There is also a large area farther seaward known as Kuamoo, which is now planted in wet taro. Naueluli, more seaward still, had terraces formerly, as did Makalii to the west. Inland and west of Kapuna, the largest old terrace plantation is Poohaili, a mound where mango trees stand, surrounded by terraces, eight of which are still cultivated. Mahanu, inland from the Mormon Temple is marked by old coconut trees and is the upper end of the terrace area; here the kula begins (Handy 1940:89-90).

Figures B-2 to -5 show various areas within La'ie, most of which fall within the project area. Figure B-2 is an 1884 map of La'ie by Jackson, identifying many areas in taro cultivation. Figure B-3 shows La'ie Town in 1927 in taro cultivation. Figure B-4 is a portion of a 1922 U.S.G.S. map of La'ie. Paeo Fishpond is shown as a marsh area. Figure B-5 is from a previous archaeological survey done by Ahlo and Hommon (1981) showing the northern part of the present project area.

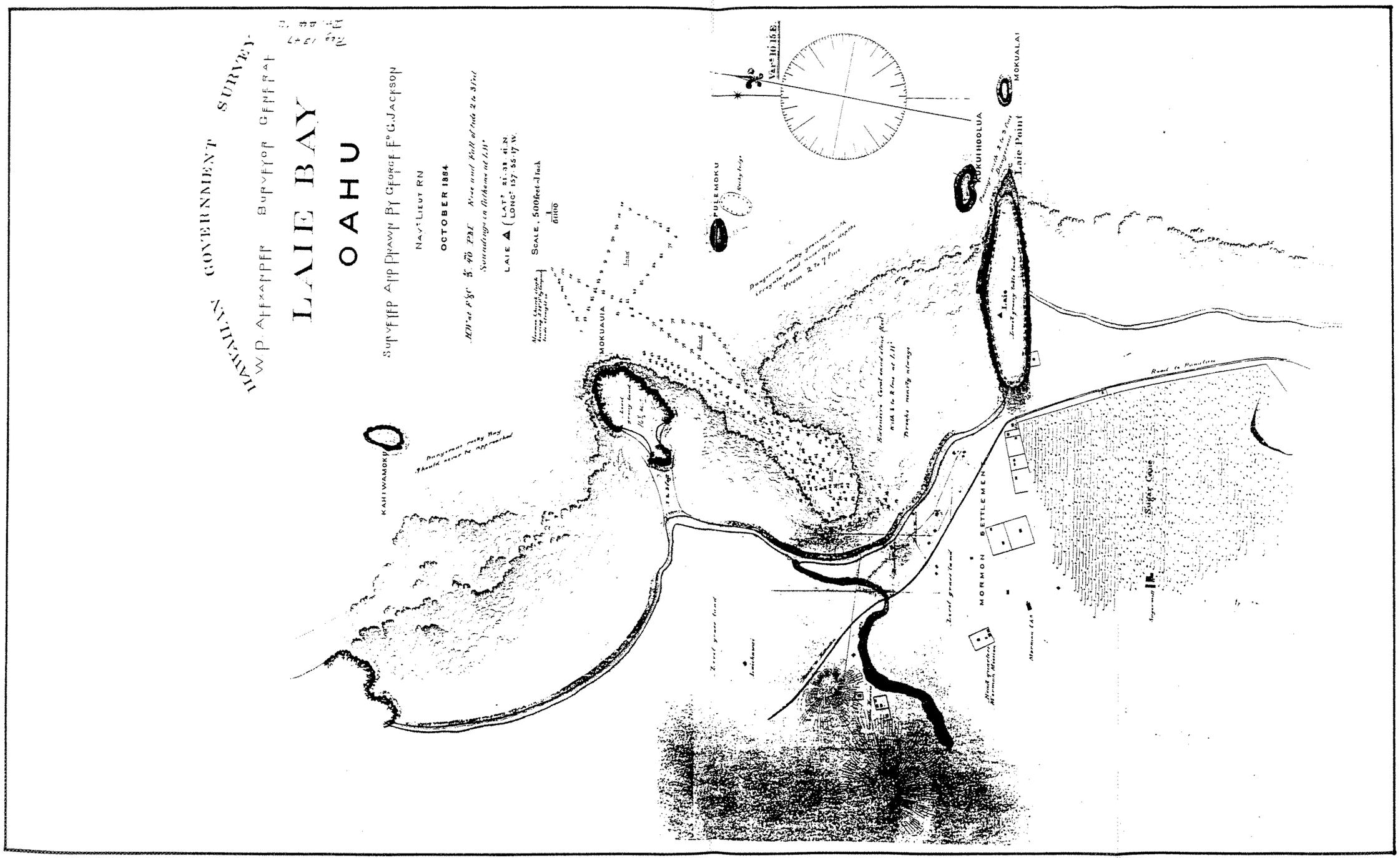


Figure B-2. 1884 MAP OF LA'IE BY JACKSON (STATE SURVEY OFFICE MAP)

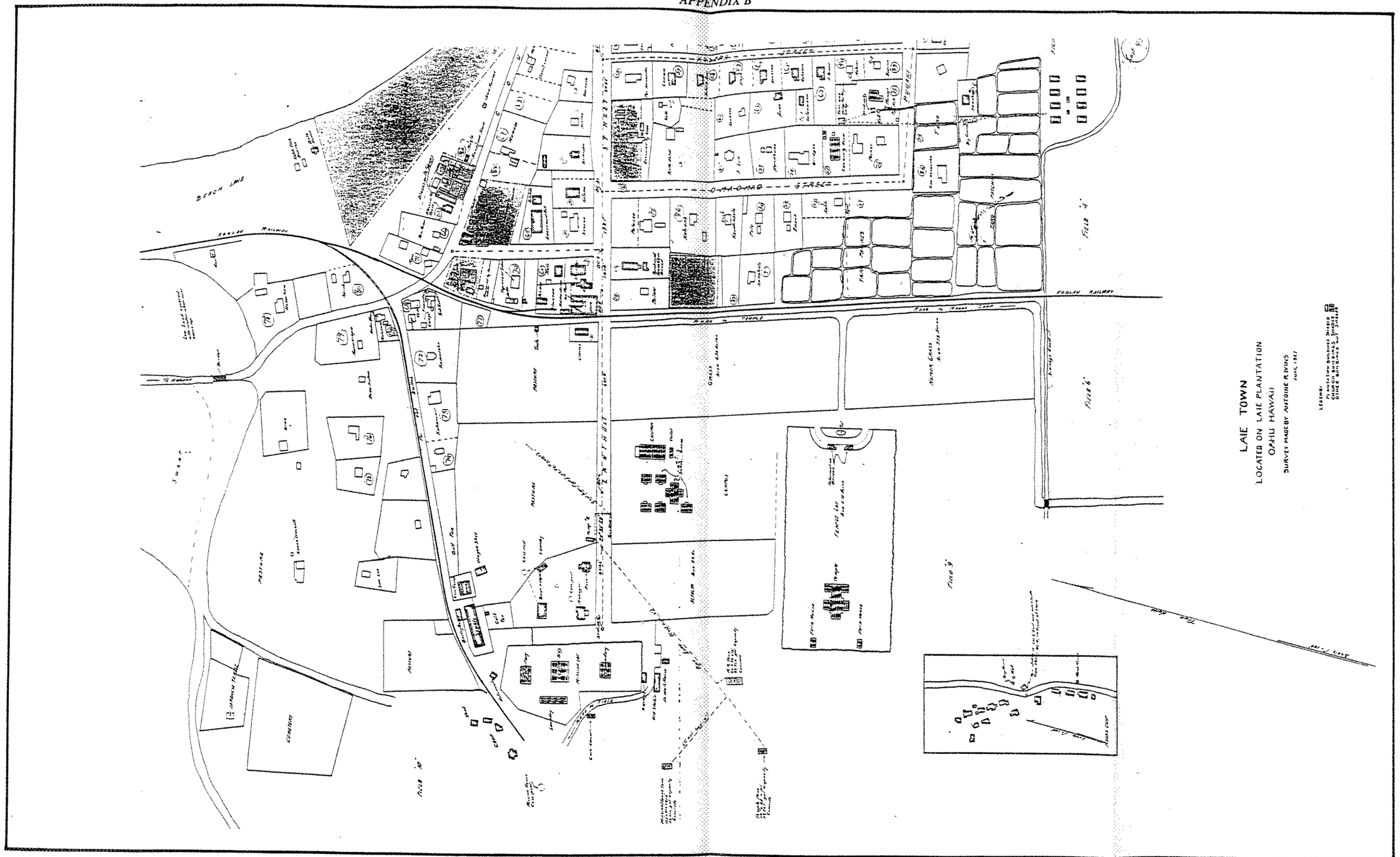


Figure B-3. 1927 MAP OF LA'IE TOWN BY AL IVINS

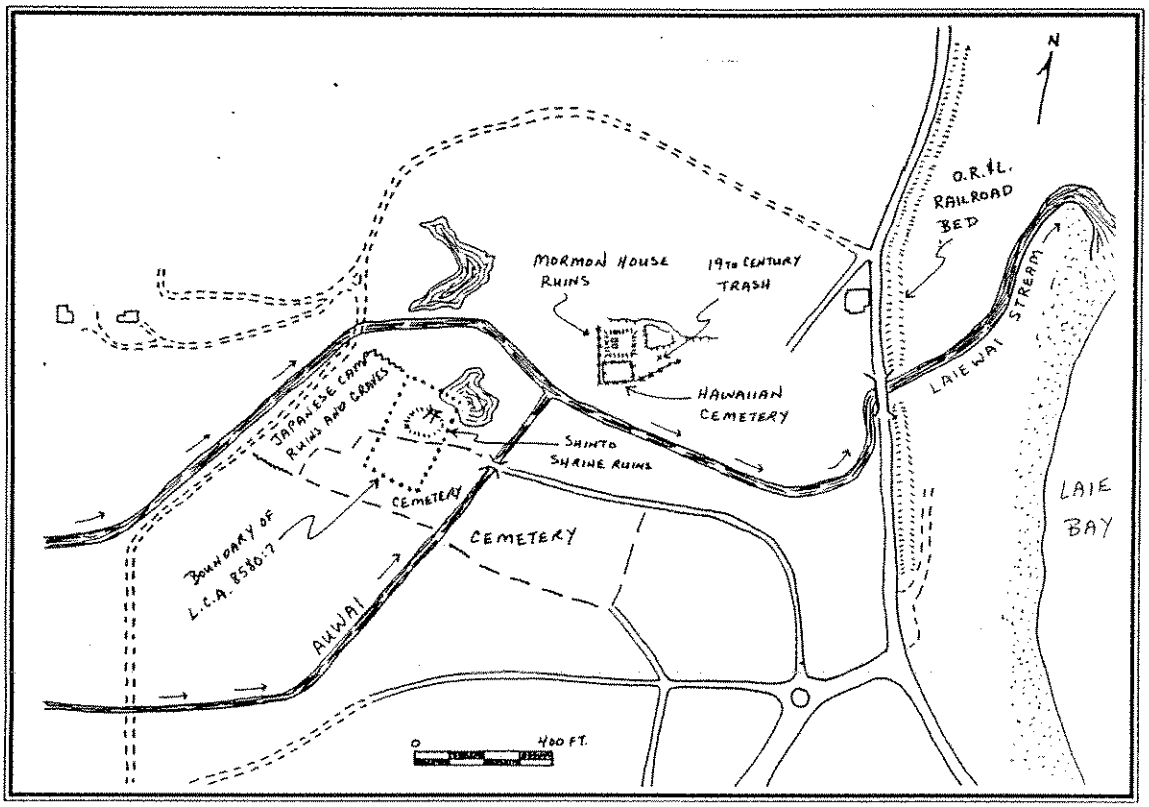
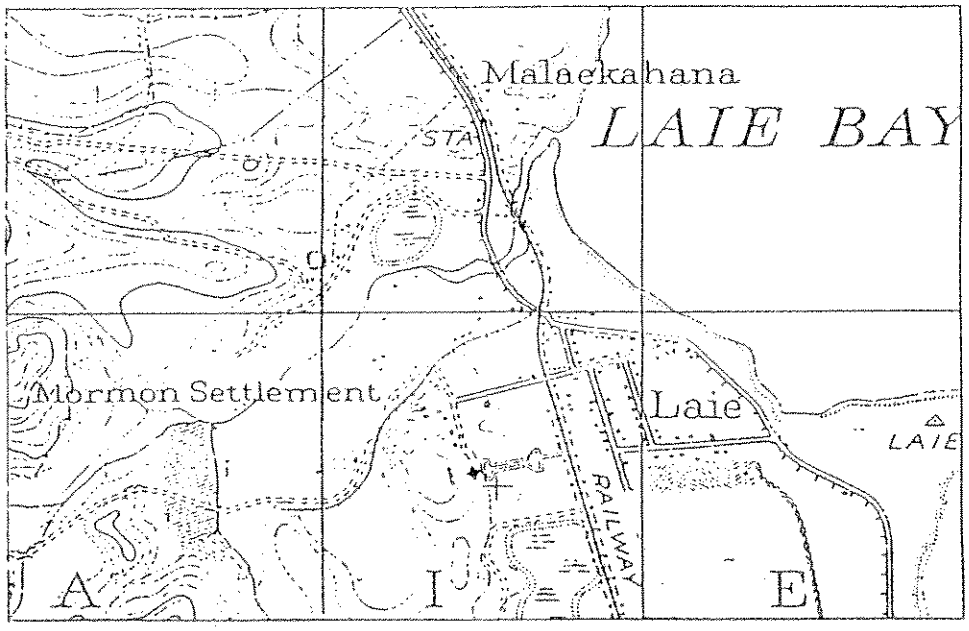


Figure B-5. PREVIOUSLY SURVEYED AREA (FROM AHLO AND HOMMON 1981)



U.S.G.S. Map of La'ie, 1922

Figure B-4. PORTION OF 1922 U.S.G.S. MAP OF LA'IE (FROM AHLO AND HOMMON 1981)

EARLY HISTORICAL ACCOUNTS

Missionary journals include a few observations relative to the native population in La'ie in the period between 1780 and 1850. One of these is in Chamberlain's 1828 journal (Chamberlain 1956) in which he mentions examining two schools in La'ie and Malaekahana. At this time, the "head man" of La'ie was Peka. An earlier diary insert adds that La'ie school had 60 pupils, from both 'Laiewai' and 'Laimoro'.

Mormon missionaries who settled in La'ie in the mid-1800's recorded that La'ie was a small primitive village which had the reputation of being a city of refuge until the sanctuary was rescinded by King Kamehameha II. Missionary censuses show a La'ie population of 452 in 1831, out of a total Koolauloa population of 2891. It is noted that a population loss of 210 for the entire district occurred between 1831 and 1835 (Bath 1985:7).

One early description of Waiapuka Pond is given as it was seen by a group of travelers in 1885:

> Entering the district of Koolauloa, and approaching the coast over a broad stretch of grassy meadow but slightly above the level of the ocean, our party was suddenly brought to a halt beside a pool of clear water, nearly round, and perhaps a hundred feet in diameter. The surface of the pool was ten or twelve feet below the level of the surrounding plain, and its even banks of solid rock dropped almost perpendicularly into water of unknown depth. The volume of the pool is affected neither by rain nor drought, and the native belief is that it is fed by springs at the bottom, and has a subterranean drainage to the ocean, some two or three miles distant.
>
> All of them (the legends) speak of a cavern somewhere beyond the walls of the pool, and to be reached only by diving into the water and finding the narrow passage leading up into it.
>
> An old native plunged into the pool. Swimming to the northern wall, he clung for a moment to a slight projection, and then disappeared. Three or four minutes elapsed when the salutation of aloha greeted us from the opposite wall, and the next moment a pair of black eyes were seen glistening through a small opening into the cavern about four feet above the surface of the water. The swimmer then returned to the pool by the passage through which he had left it.
>
> To the many questions with which he was asked the old man returned but brief answers on his return, and when importuned to explain the method of his entrance to the cavern, that the secret might not be lost, he pointed significantly to the sea, and declared that there would be found the bodies of those who sought to solve the mystery of the passage and failed (Kalakaua 1972:453).

Another story involves the island named Moku Auia, presently known as Goat Island, which lies just off the coast of Malaekahana Beach Park. The island is now a bird sanctuary.

> **Moku Auia** - Kauahi lived on this island with two mistresses. He was a native lawyer who was known for his smartness and quickness in matching wits. It was in the days of fame that Kauahi took the two women for mates, thus opposing the marriage law of Hawaii nei. When Kamehameha V and his counsellors heard of it, Kauahi and the two women were ordered arrested. When the soldiers arrived with the warrant to arrest him, Kauahi declared, "I am king of this island. Twelve of the islands are on the map, but this one is not" (McAllister IN Sterling and Summers 1978:159).

The Hawaiian historian John I'i (1959) recorded the succession of chiefly control in La'ie after the battle of Nu'uanu in the last decade of the 18th century. Kamehameha I gave both La'ie *ahupua'a* to his half-brother Kalaimamahu. From Kalaimamahu, control passed to his daughter, Kekauluohi o Mano, and finally to his grandson, Lunalilo. The property remained Lunalilo's under this traditional authority until the Great Mahele of 1848 (Bath 1985:7).

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). 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 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.

Numerous land commission awards are located within or adjacent to the project area boundaries. The register information and testimony for these LCA's is presented here. The testimonies indicate the majority of *kuleana* awardees were cultivating taro, with small crops of tobacco and sweet potato also being mentioned. The locations of these LCA were transferred to a map showing the present project area and presented as Figure B-6.

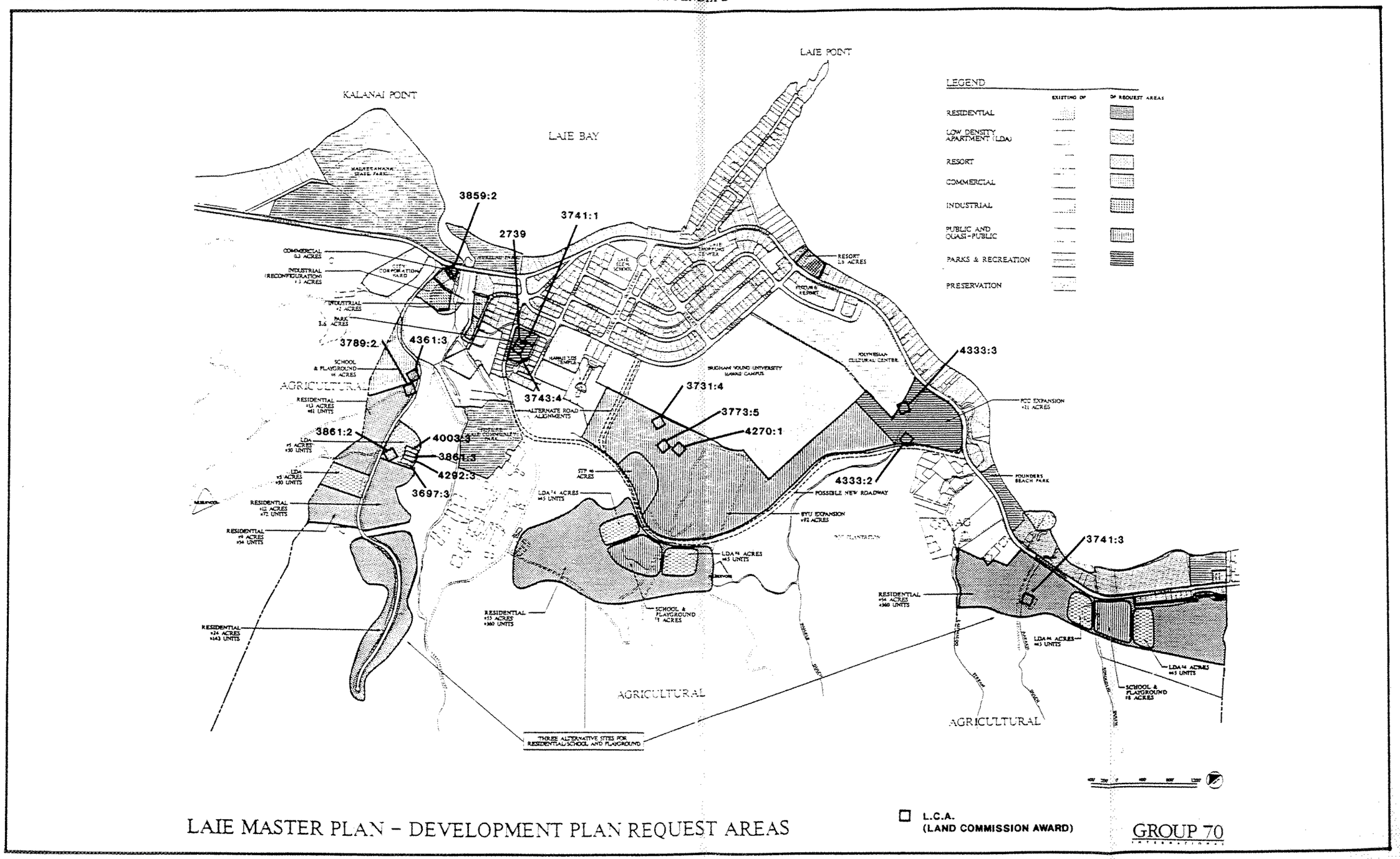
LCA 4333:2 to Kahoukua

Native Register V. 4:262
January 7, 1848
To the Land Commissioner, Greetings: I, Kahoukua, am a claimant at La'ie in the *'ili* of Paakea. There are 5 lo'i, no kula. The boundaries are North, Land of Lakee, east, Kaula's land, south, land of Kanakanui, West, land of Kanaikaua....My right of occupancy of these claims is from the time of my kupunas until the present.

Foreign Testimony V. 11:292
No. 4333. Kahoukua
Papaiakea sworn says, he knows the land of clt in Laie. It consists of 5 patches (kalo), 2 pieces of kula land and a house site. The 5 patches form 2 pieces. The first piece of 4 patches is bounded on Hauula side by Kanakanui's land - Mauka by Puhilaka's land. The second piece of one patch is bounded on Hauula side by Makaiki's land - Mauka and Waialua side by Hoopau's land - Makai by Laielolohe's land. The first piece of kula land is surrounded by the Konohiki's land. It is planted with potatoes. The second piece of kula land is planted with tobacco. It is bounded on all sides by the Konohiki. The House site is makai. It is enclosed with a wooden fence. Claimant derived the land from his father. Length of occupancy uncertain. The agent of the Konohiki had no other objections to this claim....

LCA 3741:1 & 3 to Waha

Native Register V. 4:160
January 5, 1848
To the Land Commissioner, Greetings: I hereby state my claim at Kohelepo. Two taro *lo'i* are at Kohelepo. One kula with *milo* trees and one steep planting of sweet potatoes is at Aakakii. One *mala* of 'awa is at Aakakii. One *mala* of noni is at Aaakakii. Two *moku weuweu* are at Poohina. Four taro *lo'i* are at Kokololio. Two *'ili* of sweet potatoes are at Kokololio. One *ko'a* canoe tree is at Kokololio. At Aakakiii is one houselot. My right of occupancy was from the *makuas*. Kamehameha I was the ruler at that time.



LAIE MASTER PLAN – DEVELOPMENT PLAN REQUEST AREAS

Figure B-6. MAP OF PROJECT AREA WITH LCA LOCATIONS

Foreign Testimony V. 11:263
No. 3741 Waha
Makea sworn says, he knows the land claimed by Waha in Laie. It consists of 4 kalo patches, a piece of kula land and a house site. The 4 patches form 2 pieces. The first piece of 3 patches is bounded on all sides by the konohiki. The second piece of one patch is bounded on Hauula side by the konohiki, - Mauka by Mahakea's land - Waialua side by Nawai's land - Makai by Napahu's land. The kula land is bounded on Hauula side by Mahakea's land, - Mauka by the konohiki, - Waialua side by Puaokahala's land, - Makai by Paiakea's land. The house site is makai - it is not enclosed - there are two houses on it. Claimant derived the land from his ancestors who held it from the time of Kamehameha I. The Konohiki's agent consented to this claim.

LCA 3731:4 to Ihupuu

Foreign Testimony V. 11:247
No. 3731 Ihupuu
Paakahi, sworn says, he knows the land claimed by Ihupu in Laie. It consists of 6 kalo patches, planted, and a house site. The 6 kalo patches form 3 pieces. The first piece of 3 patches is bounded on Hauula side by Kauhane's land, - Mauka by Paakahi's land, - Waialua side by the Konohiki, - Makai by Mahoe's land. The second piece, of 2 patches, is bounded on Hauula side by Koula's land, - Mauka by Kalua's land, - Waialua side by Hoopau's land, - Makai by Keliiwaiwaiole's land. The third piece of one patch, is bounded on Hauula side by Kalua's land, Mauka by Aaamakaiki's land, - Waialua side the same, - Makai by Laielolohi's land. The House Lot is makai. It is not enclosed. There is one house on it. Claimant has held the land for ten years. Claimant has also a piece of kula land planted at present in Tobacco. It is bounded on Hauula side by Kaohu's land, - Mauka by Nakahili's land, - Waialua side by Kalua's land, - Makai by Akuina's land.

LCA 3773:5 to Amaka

Native Register V. 4:165
January 4, 1848
To the Land Commissioners, Greetings: I, Amaka am a claimant of land at Laie in the *'ili* of Kamapuna. There are five *lo'i*, and one *kula*, no *kula* houselot. Following are the boundaries: north, Land of Kaleo, east, Puni's land, west, Moanauli's land, south, the Land of Pupuka. Here are the scattered claims: In the *'ili* of Kumupali, three *lo'i*, no *kula*. In the *'ili* of Paakea, two *kula*, no *lo'i*. In the *'ili* of Kahikale, nine *kula*, no *lo'i*. In the *'ili* of Aakakii four *kula*. In the *'ili* of Nahelehele one *kula*. Because these claims of mine are so very scattered it is not practical to tell you their boundaries. My right of occupancy of these claims is from my *kupunas* to the present reign of Kamehameha III.

Foreign Testimony V. 11:245
Laie 21st Sept. 1850
No. 3773 Aamaka
Maii, sworn says, he knows the land claimed by Aamaka in Laie. It consists of 8 kalo patches, a piece of kula land and a house site. The 8 kalo patches form 4 pieces. The first piece of 3 patches, is bounded on Hauula side by Kuku's land, - Mauka by Moanauli's land, - Waialua side by Maii's land, - Makai by Pupuka's land. The second piece of 3 patches is bounded on Hauula side by Ihupu's land, - Mauka by Koula's land, - Waialua side by Keliiwaiwaiole's land, - Makai by Kamanio's land. The third piece of one patch, is bounded on Hauula side by the Konohiki, - Mauka by Hakailani's land, - Waialua side by Mahoe's land, - Makai by Puaokahala's land. The fourth piece of 1 patch is bounded on Hauula side by Kauhane's land, - Mauka by Kuku's land, - Waialua side by Kaleo's land, - Makai by the Konohiki. The kula land is bounded on all sides by the Konohiki. It is planted in tobacco. Clts house site is near the sea side. It is enclosed with a wooden fence. There is one house in it. Claimant derived the land from his father. Keliiwaiwaiole, agent of the Konohiki, consented to this claim.

LCA 3861:2 & 3 to Pulehu

Native Register V. 4:179
Laie, January 5, 1848
To the Land Commissioners, Greetings: I hereby state the claim for my land. Kahikiea is the *mo'o*. There are five taro *lo'i* at Kahikiea. One *lo'i* is at Kahofo, one *lo'i* is at Paakea. One *'ili weuweu* /grass or herbage/, one *mo'o* is at Malaekahana. One *'ili* of sweet potatoes is at Omao. The right of my *makuas* was from Liholiho.

Foreign Testimony V. 11:263
No. 3861 Pulehu
Kauaikaua, sworn says, he knows the land claimed by Pulehu in Laie. It consists of 6 kalo patches, a piece of kula land and a House site. The 6 patches are

bounded on Hauula side by Kahalelaau's land, - Mauka and Waialua side by the Konohiki, - Makai by Kii's land. The kula land is planted with wauke - contains about half an acre - surrounded by the Konohiki. The house site is not enclosed, there is one house on it. Claimant has held the land for 30 years. The Konohiki's agent consented to this claim.

LCA 4292:3 to Kaumeheniho (not awarded)

Native Register V. 4:240
To the Land Commissioners, Greetings: I hereby state my claim for one taro *lo'i* and one *'ili* of sweet potatoes.

Laie, January 5, 1848
Kaumeheniho
Foreign Testimony V. 11:289
No 4292 Kaumeheniho
Paakahi, sworn says, the land claimed by Kaumeheniho consisted of one kalo patch and a piece of kula land which belonged to the konohiki. The land was given to Kaumeheniho to take care of only for the konohiki. Claimant died in 1848, and the land reverted to the Konohiki, whose agent now claims it for C. Kanaaina.

LCA 4003:3 to Hano

Native Register V. 4:208
January 5, 1848
To the Land Commissioners, Greetings: I, Hano am a claimant of land at Laie. In the *'ili* of Paoo are three *lo'i*, one *kula*, one *kai* /fishery/ one mountain area. The boundaries are: on the north, *muliwai* land of Poouahi, on the east, land of Kaaipuaa, on the south, land of Kauwaiawa, on the west, land of Palii. Here are the scattered claims: In the *'ili* of the *ahupua'a*, six *lo'i*, ten *kula*. Seaward of the mountain, one houselot. In the *'ili* of Kapuna, one *lo'i*, two *kula*. Because these claims are so very scattered, therefore it is not practical to describe their boundaries to you, the Land Commissioners. My right of occupancy at these places is from the time of Kamehameha I until the reign of Kamehameha III at this time.

Foreign Testimony V. 11:277
No. 4003 Hano
Kauaiamanu, sworn says, he knows the land claimed by Hano in Laie. It consists of 3 kalo patches, a piece of kula land, - and a House lot. The 3 patches are bounded on Hauula side by Maii's land, - Mauka by Hoanauli's land, - Waialua side by Kaluaiawa's land, - Makai by Kauaiamanu's land. The kula land is planted with tobacco & bananas. It is bounded on Hauula side by Kauaiamanu's land, - Mauka by Napahu's land, - Waialua and Makai by the Konohiki. The house lot is in another place. It is not enclosed. Claimant has held the land for 9 years. The konohiki's agent had no other objection to the claim....

LCA 4343:2 to Kauaiomano

Native Register V. 4:267
Laie, January 3, 1848
To the Land Commissioners, Greetings: I, Kauaiomano, am a claimant at Laie for four *lo'i* and one *kula*. The boundaries are: north, the land of Pupuka, east, Kalakee's /land/, south, the land of Napaeko, west, the land of Hano. The scattered *lo'is* and *kulas* are as follows:

Kalawa, one *lo'i*, no *kula*. Kapaakea, four *lo'i*, three *kula*. Kaholi, one *lo'i*, no *kula*. Kahikiea, no *lo'i*, two *kula*. Kumupali, no *lo'i*, one *kula*. My right of occupancy is from my *kupunas* until the present.

Foreign Testimony V. 11:298
No. 4343 Kauaiomano
Kauaikaua, sworn says, he knows the land of claimant in Laie. It consists of 12 kalo patches, 7 of which are planted, a piece of kula land and a house site. 5 of the patches have not been planted for two years. The 7 kalo patches which are planted are bounded on Hauula side by Kaleo's land, - Mauka by Elemakule's land, - Waialua side by the Konohiki, - Makai by Kamamai's land. The kula land is bounded on Hauula side by Pulehu's land, - Mauka by Kaleo's land, - Waialua side by the land of Malaekahana, - Makai by Kamamai's land. It is planted with wauke. The house site is separate - not enclosed. Clt derived the land from his ancestors. The Konohiki's agent had no other objection to this claim....

LCA 4361:3 to Kii

Native Register Vo. 4:271 Laie wai, Oahu
January 3, 1848
To the Land Commissioners, Greetings: I, Kii, am a claimant of land in the *'ili* of Kahikea. There are two taro *lo'i*, a *kula* and a wooded upland named Omao. The boundaries are: north, Napilipili, east, Kaiwikole, west, a stream, south, Kapaakea. Here are the scat-

tered claims: At Puhahaka is one *'ili* of *wauke*. At Namahana is one *'ili* of *wauke* and a *pali uala* /steep planting of sweet potatoes/. At Keanahale is one *'ili* of *wauke* and an *apuapu'uala*. At Noholua are two /*lo'i*/ and a watercourse. At Paakea is one *'ili* of *wauke*, two *'ili* of sweet potatoes, and an *'ili* of watermelon. At Malaekahana is one *'ili* of sweet potatoes. Malaekahana is a separate *ahupua'a*. Also, my house is at Paakea. My occupancy has been from the reign of Kamehameha 3. /*'apuapu* appears to be a local term. The dictionaries define it as cup-like/

Foreign Testimony V. 11:309
No. 4361 Kii
Kupehia, sworn says, he knows the land claimed by Kii in Laie. It consists of 2 kalo patches, a piece of kula land and a house site. The 3 patches are bounded on Hauula side by Kahalelaau's land, - Mauka by Pulehua's, - Waialua side by the Konohiki, - Makai by Mahoe'a land. The kula land is bounded on Hauula side by Kauaiomano's, - Mauka and Makai by the Konohiki, - Waialua side by Kauaikaua's land. The house site is distinct from the land - not enclosed. Claimant has held this land for over ten years. The land claimed in Malaekahana is naheleheie. The agent of the Konohiki of Laie had no objections to this claim.

LCA 3789:2 to Opala and Kalimakuhi

Native Register V. 4:168
Laie, Jan. 4, 1848
To the Land Commissioners, Greetings: I hereby state my claim. Naueloli is the *mo'o*, with one taro *lo'i* and a portion of a *lo'i*. Two taro *lo'i* are at Kaholi and one *'ili* of *wauke* is at Kaholii. One *'ili* of *weuweu* /grass or herbage/ is at Lilimano. One *'ili* of *weuweu* is at Kauamopuu /and/? one house lot. The occupancy has been from the time of Kamehameha I.

I, Opala, hereby state my claim for one taro *lo'i* at Kaholi. My right was from my *makuas*.

Foreign Testimony V. 11:287
No. 3789 Opala
Kalimakuhi, sworn says he knows the kalo patch claimed by Opala in Laie. It has not been cultivated for 2 years. (This was confirmed by others present). The agent of the Konohiki claimed this land for C.

Foreign Testimony V. 11:294
No. 3789 B Kalimakuhi
Kua sworn says, he knows the land claimed by Kalimakuhi in Laie. It consists of one kalo patch, a piece of kula land, and a house site. This kalo patch is bounded Makai by Mahiole's land, - on all the other sides by the Konohiki. The kula land is bounded on Hauula side by a stream, - Mauka by the Konohiki, - Waialua side by Napahu's land, - Makai by a watercourse. It is planted with wauke. The house site is near the river - not enclosed. Claimant has held the land for ten years. The agent of the konohiki had no other objection to this....

LCA 3743:4 to Wi

Native Register V. 4:161
Laie, January 5, 1848
To the Land Commissioners. At Laie in the *'ili* of Naueloli are two *lo'i* and one *kula*. I, Wi, the one who makes this claim, give the boundaries as follows: on the north, the land of Kaualewa, on the east, the land of Palii, on the south, the Land of Lakee, on the west, Kanaikawa's land. Here are the scattered claims: In the *'ili* of Kapuna, one and a half *lo'i*, and three *kula*. In the *'ili* of Kamapuna, one *lo'i*, one *kula*, one mountain *kula*. In the *'ili* of Keahupuaa, two *lo'i*, four *kula*, four fallen *ko'a* trees, one mountain *kula*, two *hala* clumps, one *kula* planted in gourd. In the *'ili* of Lakee, one *kula* house lot. In the *'ili* of Kalua, one mountain *kula*. Because these claims of mine are so scattered, O Land Commissioners, it is not possible to describe their boundaries. My right of occupancy of these claims is from my *kupunas* to the present reign of Kamehameha III. One *ko'a* tree is in Pia's place.

Foreign Testimony V. 11:305
No. 3743 Wi (deceased)
Poouahi, sworn says, he knows the land claimed by Wi in Laie. It consists of 4 kalo patches in 2 pieces, 2 pieces of kula land and a house site. The first piece, of 3 patches, is bounded on Hauula side by Mahakea's, - mauka by Poouahi's, - Waialua side the same, - Makai by Kalimakuhi's. The second piece, of one patch, is bounded on Hauula side by Ihupu's, - Mauka and Waialua side by the Konohiki, - Makai by Pupuka's land. The first and second pieces of kula land are bounded on all sides by the Konohiki, - and planted with wauke, bananas & c. The house site is

distinct from the land - not enclosed. Claimant held the land for about 20 years. The Konohiki's agent had no other objections to this claim....

LCA 2739 to Pia

Native Register V. 3:614
December 29, 1847
To the Land Commissioners, Greetings: I have 4 lands in Laie in Koolauloa. The first is named Kapuna, there are ten lo'i, bounded on the North by the lo'is of Nahulu and Kanakanui, on the east by the lo'is of Maii, on the south by *kula*, on the west by Kihewa. 2. The name is Puhau on the east, Kionaole, south, Naholua, west, Naueloli. The third is a houselot, surrounded by a fence by myself. It was from my *makuas*, from the time of Kamehameha I to us. The fourth is a *kula* planted in *wauke* from Kamaikahulipu *ma*. I wish for an award of documentation for myself.

Native Testimony V. 10:60
No. 2739 Pia Vs. C. Kanaina - 8559
21 Oct. 1851
Kamaikahulipu sworn I have seen this place over which there is a dispute, it is a pond, Kapuna in Laie, Koolaupoko (?), Oahu. "I do not know the boundary - I give this taro patch to him under the konohiki, because this pond is the springs water of Laie". Land given at the time S. Kuluwailehua was tax assessor in 1840, probably and Pia has lived there to the present time. I have not known who had planted the taro, but I have known that C. Kanaina had opposed Pia in 1847 and had given the patch to Kaioe, the wife of Keaka Makapoula, however, Kaioe has never worked in the patch. Pia objected to this and as a result, I have not seen him cultivate this patch.
Pulehu sworn I have seen this pond, Kapuna in Laie. It is surrounded by pastureland except for Kanikaua's land, on the Waialua side. I have known this patch had been for the konohiki since the time of Kam. I to the time Kamaikahulipu had given this pond to Pia, but I do no know the time of this action, however, Pia had continuously attended prisoners day for the konohiki and he had made his contributions in taxes until his death. I have never known the oppositions to him, nor the reason for his dismissal. Kaaulani, the wife of Pia has had the patch to the present. The taro from the patch is for Kaaulani and the patch has always been cultivated. I have seen the tenants of that ili working in that patch during the time Pia had it until his death, but they have not done any work in it since 1848, to the present time.
Keliiwaiwaiole sworn I have known about this pond just as Kamakahulipu has related here. He had given it to Pia in 1839, and I have heard this pond has had poalima service altho(sic) I am not quite sure about this and I have seen Pia working in the pond to the present day, (until his death.) *Kanaikaua* (for Pia) sworn I have seen this pond, Pia started to work with it at the time Kaahumanu I had died in 1832, probably, it was given by Kamaikahulipu and Pia had always lived there to the time of his death in 1848, I have not known of any objections to Pia during his occupation here, I have not known also after Pia's death, the reason for the konohiki's objections. I have not seen the tenants do poalima work at this time in the pond, Pia's wife does the cultivation of the patch and yield there from is for her.

C. Kanaina
Question: "Did you know the konohiki's claim for this pond?"
Answer: "The konohiki has no claim."
Question: "Did you see Koolua and Keelualani, his wife cultivating in that pond?"
Answer: "No."
Question: "Did you know this is a spring for Laie?"
Answer: "I have known it as a spring for all of Laie."
Nakeu sworn I have known that this was Pia's pond from 1838 to the present time. I had not known until Oct. 1850 about the konohiki's opposition in 1838 and I do not known the reason for the objection, but I have heard this patch had been given to him (Pia) as a husbandman.

Foreign Testimony V. 11:259
No. 2739 Pia (Deceased)
Keliiwaiwaiole sworn says Pia died in 1848, leaving his property to his wife. Witness knows the land claimed by Pia in Laie. It consists of one kalo patch, bounded on Hauula side and Mauka by the Konohiki, - Waialua side by Kauaikaua's land, - Makai by Maii's land.

Kamaikahulipu, a former konohiki, gave this patch in charge to Pia to take care of as an Under Luna. It has always been considered the property of the Konohiki from the time of Kamehameha I. In it is the spring which supplies all the kalo land with water. The house lot of claimant is near the sea side. It is not enclosed. The Konohiki agent claimed the

water spring and kalo patch above mentioned, is the property of the Konohiki. He consented to the claim for a house lot.

LCA 3859:2 to Pahumoa

Native Register V. 4:179
Laie, January 5, 1848
To the Land Commissioners, Greetings: I hereby state my claim for the *mo'o* of Kapuni, with six taro *lo'i*. One *'ili* is at Keaewa of the large *kula* of Hopuni. One *'ili* of sweet potatoes is at Keokilehelehe. One *'ili* of sweet potatoes is at Puhahaka. One *mala* of *'awa* is at Kaluakauila. One *lo'i* is at Paakia. My right of occupancy is from the time of Kamehameha I.

Foreign Testimony V. 11:261
No. 3859 Pahumoa (Deceased)
Keliiwaiwaiole, sworn says, Pahumoa died in 1848, leaving the land to Koaa. Witness knows the land claimed by Pahumoa in Laie. It consists of 8 kalo patches & a house site. The 8 patches form one piece, bounded on Hauula side by Namakaokaia's land, - Mauka by Mahiole's land, - Waialua side by Keliiwaiwaiole's, - Makai by Hakaialania's land. The house site is makai, it is not enclosed. Claimant lived on the land from his youth. The Konohiki's agent consented to this claim.

Land records at the Hawaii State Archives revealed the following note on La'ie Ahupua'a, indicating its ownership:

Interior Department Doc. May 17, 1852

In letter from C. Kanaina to Minister of the Interior, that he is owner of above land (Laie), and Hee [octopus] is the tabu fish.

In 1861, upon petition of Charles Kanaina and James Austin, the appointed guardians of the estate of Lunalilo, the entire lands of Laiewai and Laiemaloo were sold to Henry H. Howland (Bureau of Conveyances, Liber 14:405). On March 17, 1863, Howland sold 298 1/2 acres of land in Laiewai to Robert Moffitt of Kahuku for $597.00. On August 3 of that same year and for the same amount, the same property was conveyed by R. Moffitt to Charles Hopkins of Honolulu (Bureau of Conveyances, Liber 17:116, 130-131). When Hopkins purchased Laiewai from Moffitt in 1863, the Malaekahana and Kahuku ranches were probably extended to this land (Bath 1985:8).

The influence of the Church of Jesus Christ of Latter Day Saints in La'ie began in 1850 when ten Mormon missionaries first settled there. By 1865 the Church had purchased 6,000 acres in the area for agricultural use (Ahlo and Hommon 1981:10). Approximately 1,500 of these acres were arable land. Initially a variety of crops were cultivated on the land purchased, but by the end of the 19th century pineapple and sugar cane were the predominant crops. Agricultural utilization of the lands purchased was greatly increased by the addition of a large pump in 1898 which made possible cultivation of fields which were previously barren (ibid.). Sugar cane, produced by La'ie Plantation and later by Kahuku Plantation, was the dominant crop in the area until about 1970, when the plantation closed down.

The Mormon Temple at La'ie, O'ahu, which cost $200,000 to build and was said to resemble in plan and design the famous Salt Lake edifice, was dedicated Nov. 27-30th, 1920 (Thrum 1920:155). The Mormon temple is now a popular tourist attraction along with the Polynesian Cultural Center, which is staffed mainly by students attending the Brigham Young University. The population of the La'ie area still consists almost exclusively of Mormons. Evidence of this can be found at most of the stores in the area which do not sell alcoholic beverages.

Currently the major land use for the area is pasturage for a few cattle and for aquacultural activities (owned and operated by BYU-Hawaii) (Ahlo and Hommon 1981:10-11).

INFORMANT INTERVIEWS

A few residents of the area, known to have some historical information, were contacted regarding the project area and its vicinity. Thanks to Ms. Gladys Pualoa who helped us contact people in the community, Mr. Walter Wong, Mr. Water Tashiro, and Mr. Ken Baldrich for their helpful information and assistance.

Mr. Wong is a lifelong resident of La'ie, an avid hunter, and very familiar with the mountain and forest area in La'ie. He also was a scoutmaster for 29 years and used to take the troops hiking into the back hills of La'ie often.

Mr. Wong mentioned an old village and foundations along the Koolau Stream near an old mango grove, about 1 mile inland from La'ie. He also said that there were many old caves that have been covered up due to the rushing water and debris that gets brought down from the mountain area whenever there is flooding in the area. He knows of some caves that

go deep into the mountain, one of which he states you can still go about 30 ft. down into, even though it has been filled in a lot. He believes Waiapuka still has water in it, and says that it is just one of a number of caves and pools that were interconnected by lava tubes, and which led down to the ocean. He said that the old people say some of these underground courses connect all the way to Makaha and Waianae, under the Koolau mountains.

Mr. Wong also mentioned that night marchers were sometimes heard marching on the ridge behind the Mormon temple marching into the mountain.

He also said that there were many human bones found along Kahawainui Stream. He remembers getting sand from that area to mix into concrete. While they were sifting and cleaning the debris they found a human skull. He recalls seeing more bones on other occasions.

Regarding legends, Mr. Wong recalled the tale of the sharkman of La'ie who lived in an area which he knew recently as the "Kanahele Place" (where the Kanahele family lived). He said there was a legend which says that an underwater cave which led to the ocean was located in this area where the sharkman lived. Occasionally the sharkman, seeing fishermen and women walking along the road past his house, would greet the people and ask where they were going fishing. Once they had told him, he would enter the cave in his yard, swim out to the ocean and attack the unassuming victims. The story says that the man was finally caught when there was a contest at La'ie Pond inland of La'ie, in which they were trying to determine who could hold his breath the longest. Apparently a man already suspicious of the sharkman knocked him into the water, and he didn't come up for air but instead transformed into the shark. They then caught him and threw him into a fire.

Mr. Walter Tashiro is a 69 year old who has also lived in La'ie all of his life. He was very familiar with La'ie and provided a map he had drawn showing the Cackle Egg Farm side of the project area (Figure B-7). Mr. Tashiro remembers that the road which leads to the Cackle Egg Farm once was part of a graveyard, but the tombstones were bulldozed over when they cleared the road. He also remembered as a young child of about seven, going to the area behind the present egg farm to get mangos. Most of the area was planted in sugar cane at that time. When Mr. Tashiro and his friends went to get mangos one day they noticed a cavern leading into the ground which contained fresh running water. He recalled a friend, who has since passed away, going into the tube which led from the cave into a larger tube approximately 13 feet high, 40 feet long and 50 feet wide. This is shown on Figure B-7. The lava tube then continued on, with the fresh water running through it, but became increasingly smaller so that his friend could not venture more than 20 feet beyond the large chamber. This lava tube led to a junction shown on the map as a sewage pit. This was used to dump sewage in for a while, but before that the fresh water would split into three separate lines. One line led to Waiapuka Pond, another straight out to the ocean, and the third to Kahawainui Stream, prior to its alteration. The old stream used to run differently as shown on Figure B-7, however it was partially filled and altered and the present canal was built to aid in flood prevention. Mr. Tashiro said he used to bathe in what he calls the "bath-tub pond" which was fed by this line of the fresh water flow. The Paeo fishpond was once in this area, but Mr. Tashiro does not remember seeing it as a fishpond in his lifetime. It was dry and already filled in with dirt and debris from prior floods by the time he remembers seeing it. However, he does remember seeing the outline of the pond and the sloping walls that a pond would have had. He heard that when the kings of Hawaii lived in Honolulu they would send relay runners to La'ie to get mullet from this pond. The caretaker of the pond (approximate location of that residence shown on Figure B-7) would catch the fish, wrap it up, and send various relay runners back to Honolulu with the fish for the king.

Mr. Tashiro also mentioned a story about *okole hao*, a liquor made from the ti plant, being made in the area by the cave he remembers as a child. Since this lava tube led all the way to the area where the sewage pit is, a watchman would stay at that area and upon seeing a policeman coming up the road, he would hit the lava with a large iron pipe, therefore letting those up the tube know trouble was coming. They would then hide all the evidence and equipment in the lava tube and by the time the policeman reached them, there would be no incriminating evidence left to find.

Regarding the Torii and alleged Japanese Camp area near the cemetery (as shown on Figure B-5), Mr. Tashiro said the information stating this area as a Japanese camp is incorrect. He said that only a few Japanese families had their houses here and the camp was located behind the area where the present BYU campus is. He said that the area shown on Figure B-5 also incorrectly identifies the area shown as Mormon house ruins. He said he remembers an old Hawaiian house here. He recalls many *lauhala* trees in the area, and said the house area was where some people would meet to treat and prepare the *lauhala* for weaving. He remembers them making hats both from the *lauhala* and the tassels of sugar cane.

Mr. Baldrich is a professor at the BYU campus and very interested in La'ie history. He accompanied PHRI's Historical Researcher into the area behind the egg farm, pointing out

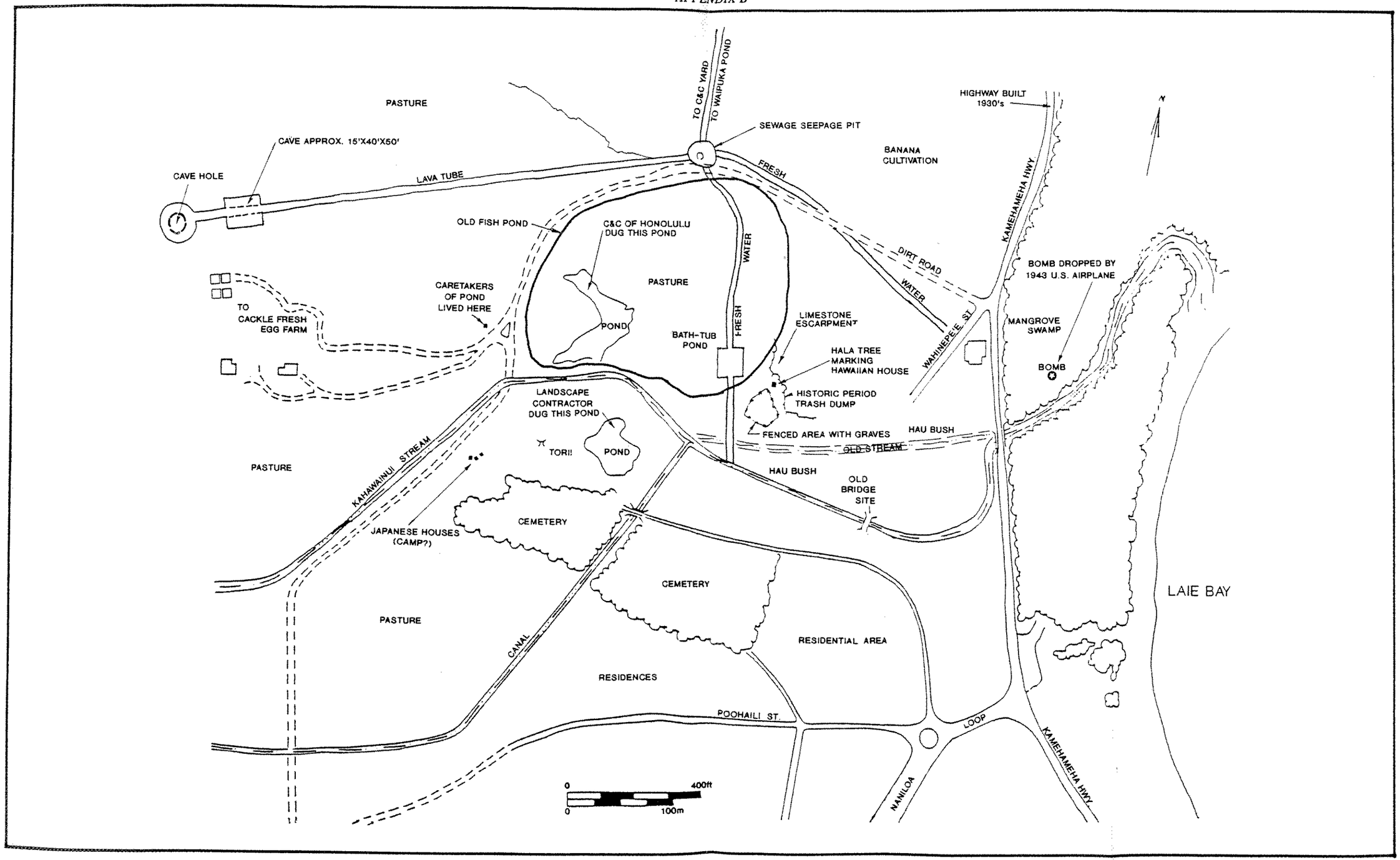


Figure B-7. TASHIRO MAP OF CACKLE FRESH EGG FARM VICINITY

areas which Mr. Tashiro mentioned. Most of this land is now in pasture and some varied agriculture crops. Mr. Baldrich has in his office a copy of a report done by BYU-Provo Professor Dale Berge. Dr. Berge preliminarily surveyed archaeological features in and around the BYU-Hawaii campus a few years ago. In his report he noted the location of the old La'ie Plantation Sugar Mill. He also noted various Hawaiian archaeological features near the mill. According to Berge's report, the first sugar mill was built in 1868 and was run by steam. In 1873 a new steam boiler was installed, but by 1875 the mill was shut down for repairs. A second mill was built on the same site and completed in 1881. In 1890 the Kahuku Plantation began. After the Kahuku mill was built, all of the La'ie cane was sent there to be processed. By 1891 the entire La'ie crop was sold to Kahuku for seed and use of the La'ie mill was discontinued at that time. Mr. Baldrich visited the site of the mill with Mr. Berge when he did his study. Mr. Baldrich describes the mill site as being approximately 60-80 yards west of a gate next to the ceramic studio on the BYU campus. Mr. Berge's report makes note of some Hawaiian archaeological sites near the mill. These consisted of an area where seashells, adzes, and basalt flakes were found and an area containing a stone wall which Mr. Berge described as a *heiau* wall. The adze site was described by Mr. Berge as being about 200 feet southwest of the mill site. The wall site was described by him as being about 250 feet north-northwest of the mill site (pers. comm., Dale Berge). Mr. Baldrich also visited the Hawaiian sites and felt that the wall may not be a *heiau* wall, as it was not high. No maps were made for this report as Mr. Berge expected to return to Hawaii in the summer of 1993 to complete his survey and at that time finalize all the maps.

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APPENDIX C

POLLEN ANALYSIS

by Linda Scott Cummings, Ph.D.

INTRODUCTION

Eight pollen samples from backhoe trenches located in Laie, Oahu were examined in conjunction with archaeological investigations. This analysis was undertaken to establish a record of general prehistoric vegetation that may have been related to agriculture and/or habitation in this area.

METHODS

A chemical extraction technique based on flotation is the standard preparation technique used in this laboratory for the removal of the pollen from the large volume of sand, silt, and clay with which they are mixed. This particular process was developed for extraction of pollen from soils where preservation has been less than ideal and pollen density is low.

Relatively large quantities of sediment (50 ml) were processed for each of these samples. This sediment was added to a 0.1 molar solution of sodium pyrophosphate, diluted, then sieved through 150 micron mesh. The sample was allowed to settle for four hours, then the supernatant, which contained clay, was poured off. This settling time allowed pollen to settle to the base of the beaker. The samples were mixed with water, allowed to settle for four hours, and the supernatant discarded several times, until the supernatant was clear.

At this time, hydrochloric acid (10%) was used to remove any calcium carbonates present in the soil. Zinc bromide (density 2.0) was used for the flotation process. The samples were mixed with zinc bromide while still moist, immediately after centrifugation to remove the dilute hydrochloric acid and water. All samples received a short (10 minute) treatment in hot hydrofluoric acid to remove any remaining inorganic particles. The samples were then acetolated for 5 minutes to remove any extraneous organic matter.

A light microscope was used to count the pollen to a total of 100 to 200 pollen grains at a magnification of 500x. Pollen preservation in these samples varied from good to poor. Comparative reference material collected at the Bishop Museum Herbarium was used to identify the pollen to the family, genus, and species level, where possible.

Pollen aggregates were recorded during identification of the pollen. Aggregates are clumps of a single type of pollen, and may be interpreted to represent pollen dispersal over short distances, or the actual introduction of portions of the plant represented into an archaeological setting. Aggregates were included in the pollen counts as single grains, as is customary. The presence of aggregates is noted by an "A" next to the pollen frequency on the pollen diagram. Indeterminate pollen includes pollen grains that are folded, mutilated, and otherwise distorted beyond recognition. These grains are included in the total pollen count, as they are part of the pollen record.

DISCUSSION

Eight pollen samples were collected from five backhoe trenches to examine the pollen record representing prehistoric vegetation in this area (Table C-1, at end). Modern vegetation in this area includes banana (*Musa*), cucumber (*Cucumis*), mango (*Mangifera*), Christmasberry (*Schinus*), morning-glory (*Ipomoea*), papaya (*Carica*), passionfruit (*Passiflora*), koa haole (*Leuceana glauca*), guava (*Psidium guajara*), hau (*Hibiscus filiaceus*), watermelon (*Citrillus vulgaris*), sugarcane (*Saccharum*), and unidentified grasses (Gramineae). Historic crops in this area include sugarcane, pineapple, taro, and pasturelands (Figure C-1 and Table C-2, at end).

Very small quantities of arboreal or tree pollen were noted throughout these samples, indicating that throughout the period represented by these samples the area appears to have been cleared and supported a variety of shrubs or small trees, herbs, as well as grasses and sedges. The pollen grains reported as *Pandanus* are always fragments. *Pandanus* and *Colocasia* (taro) are not distinguishable as fragments. While the pollen has been assigned to the genus *Pandanus* on the basis of probability, there is a possiblity that it could represent *Colocasia*. *Pandanus* produces large quantities of pollen that is transported by wind, while *Colocasia* produces small quantities of pollen. Most taro farmers do not allow taro to flower, and some believe that it does not flower. Therefore, *Pandanus* is considered to be the more likely identification.

Sample 61 represents Stratum I in Backhoe Trench 1. This area was formerly a swamp and a cultivated field for taro. Sample 61 exhibits a large quantity of Gramineae pollen, as well as a moderate quantity of Cyperaceae pollen. The few trees that are present include Araliaceae, *Artocarpus*, *Casuarina*, *Pandanus*, and *Pritchardia*. The small quantities of pollen recovered indicate that these trees, with the possible exception of *Artocarpus*, were not locally abundant. *Artocarpus* contributed the largest quantity of tree pollen to this record, and is frequently not observed in large quantity in areas where these trees grow. A very small quantity of starch granules were

recovered from this sample, indicating that a starchy crop, such as taro was grown in this area. Indeed, the area is noted to have been formerly cultivated for taro. The large quantity of Gramineae and Cyperaceae pollen indicates that these plants were abundant either in these wet fields or adjacent to them.

Sample 124, representing Backhoe Trench 26, is located to the west of Backhoe Trench 1. This sample exhibits similar quantities of Gramineae and Cyperaceae pollen to those noted in sample 61. This sample exhibited a small quantity of *Azolla* spores, representing small aquatic plants. This sample exhibited a small quantity of Solanaceae pollen, which was absent from sample 61. *Casuarina* pollen was noted in a larger frequency in this sample, suggesting that this field's location, formerly cultivated for taro, was located closer to *Casuarina* than was Backhoe Trench 1.

Backhoe Trench 3 is located farther to the west of both Backhoe Trenches 1 and 26. This area is described as near the edge of a cultivated banana patch. Cheno-am pollen frequencies are higher in the upper sample (sample 56) collected from Stratum III. Liguliflorae pollen was also recovered from this sample, indicating that it probably represents a historic component, or that it is contaminated with historic materials. *Artocarpus* pollen was also recorded in this sample. In sample 72, representing Stratum IV, Cheno-ams decline, while Gramineae is noted in slightly larger quantity. Urticaceae pollen is present, and probably represents *Pipturis*. Spores representing *Cibotium* and *Lycopodium cernuum* are present in this sample but not in the sample above. Both samples from Backhoe Trench 3 exhibit very little arboreal pollen, indicating that this area was farther removed from local stands of trees than were Backhoe Trenches 1 and 26.

Three samples were examined from Backhoe Trench 17, collected from Stratum III, and lower and upper portions of Stratum II. The lowest two samples did not yield sufficient pollen for analysis. The uppermost sample (84), however, exhibited a very large frequency of Cheno-am pollen. This area appears to have been covered with local shrubby *Chenopodium*. No probable crops are identified in the pollen record. A single starch granule was recovered from sample 84, suggesting growth of a plant with a starchy root in this area.

Backhoe Trench 22, located northwest of Backhoe Trench 17, exhibits a similarly high frequency of *Chenopodium* pollen. Trees appear to be lacking in this general vicinity, as small quantities of pollen representing only a few trees were noted. Again, this area appears to have supported a relatively dense stand of local shrubby *Chenopodium*. Grasses are slightly more abundant in this area than they are in Backhoe Trench 17.

SUMMARY AND CONCLUSIONS

The pollen record near Laie represents diverse local vegetation. In the eastern area, wetter conditions are noted, supporting much larger populations of Gramineae and Cyperaceae. *Chenopodium* populations were low, and *Chenopodium* pollen might be present through wind-transport of this pollen from surrounding areas. Urticaceae are noted in Backhoe Trenches 1, 26, and 3, but not farther west. This area is the most probable to have been cultivated for crops needing wet conditions, such as taro.

Pandanus (hala) pollen is noted only in samples from the wetter areas. Since the cf. *Pandanus* pollen grains were fragmentary, it is not possible to accurately distinguish between *Pandanus* and *Colocasia* (taro) pollen. There is a possibility that the pollen reported as *Pandanus* is, in actuality *Colocasia*. It is, however, not possible to make this distinction in this material, due to the fragmentary nature of the pollen grains.

Liguliflorae-type Compositae pollen is noted in Backhoe Trenches 26, 3, 17, and 22. *Taraxacum* (dandelion), the most common member of this morphological group of pollen, is noted to have been naturalized in Hawaii. It is native to Eurasia and was first collected on Oahu in 1909 (Wagner *et al.* 1990:361). Presence of this pollen type suggests historic origin or historic contamination for these levels. Other plants producing Liguliflorae-type pollen include *Lactuca* (prickly lettuce), also naturalized in Hawaii and first collected in 1928 (Wagner *et al.* 1990:327). The presence of Liguliflorae-type pollen probably reflects the presence of weedy composites.

Backhoe Trenches 17 and 22 are located farthest to the west and with Backhoe Trench 3 are the drier areas represented. *Chenopodium* pollen is highest in Backhoe Trenches 17 and 22, indicating that shrubby *Chenopodium* probably grew in abundance in this area. No possible agricultural crops are identified for this area, as it appears that for the time periods represented, the areas sampled supported shrubby *Chenopodium*, rather than having been used as agricultural plots.

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Table C-1.

PROVENIENCE FOR SAMPLES FROM LAIE, OAHU

Sample No.	Unit	Stratum	Depth in cm	Provenience	Pollen Counted
61	BT-1	I	15-28	Swamp area, former taro cultivated field	100
124	BT-26	I	20-35	Former taro cultivated field	200
56	BT-3	III	75-87	Near edge of cultivated banana patch	200
72	BT-3	IV	109-128	Near edge of cultivated banana patch	100
84	BT-17	Upper II	36-46	Cultivated cucumber field	100
86	BT-17	Lower II	99-114	Cultivated cucumber field	Insuff
87	BT-17	III	230	Cultivated cucumber field	Insuff
126	BT-22	I	75-90	Pasture	200

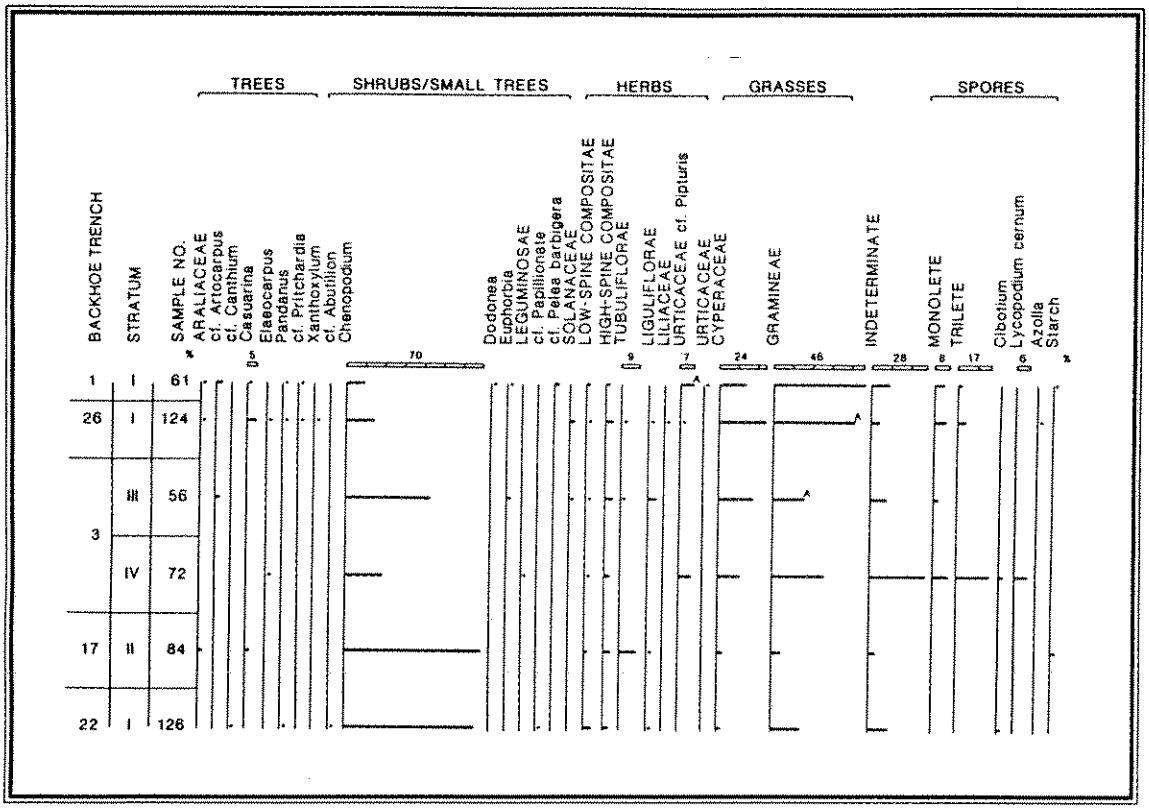

Figure C-1. POLLEN DIAGRAM FROM NEAR LAIE, OAHU.

Table C-2.

POLLEN TYPES RECOVERED

Scientific Name	Common Name	Nat	Pol	End	Ind
Trees:					
Anacardiaceae	Mango family	x	—	x	—
Araliaceae	Binseng family	x	—	x	—
cf. *Artocarpus*	Breadfruit	—	x	—	—
Canthium	*Alahe'e, 'ohe'e, walahe'e*	—	—	—	x
Casuarina	Australian pine	x	—	—	—
Elaeocarpus	*Kalia*	—	—	x	—
Erythrina	*Wiliwili*	—	—	x	—
cf. *Pandanus tectorius*	*Hala, pu hala*	—	—	—	x?
Pritchardia	Loulu palm	—	—	x	—
Xanthoxylum	*A'e, manele, hea'e, kawa'u, kawa'u kua kuku kapa*, prickly ash	—	—	x	—
Shrubs/Small Trees:					
Cheno-am	Goosefoot family and pigweed (amaranth)	—	—	—	—
Dodonea viscosa	*A'ali'i, 'a'ali'i ku makani, 'a'ali'i ku ma kua, kumakani*	—	—	—	x
Euphorbia	Spurge, *kaliko*, Mexican fireplant, wild poinsettia	x	—	x	—
Fabaceae	Pea family	x	x	x	x
Fabaceae cf. Papillionate	Pea family	x	x	x	x
Malvacese cf. *Abutilion*	Mallow family	x	—	x	x
Pelea barbigera	*Uahiapele*	—	—	x	—
Solanaceaae	Nightshade family	x	x?	x	x
Herbs:					
Low-spine Compositae	Sunflower family, includes ragweed, and others	x	—	x	x
High-Spine Compositae	Sunflower family, includes Bidens	x	—	x	x
Tubuliflorae	Includes eroded Low- and High-spine Compositae	x	—	x	x
Liguliflorae	Sunflower family, Lactuceae tribe	x	—	—	—
Liliaceae	Lily family	x	—	x	x
Urticaceae cf. *Pipturis*		—	—	x	—
Urticaceae		—	—	—	—
Grasses:					
Cyperaceae	Sedge family	—	—	—	—
Gramineae	Grass family	—	—	—	—
INDETERMINATE					
Spores:					
Monolete smooth		—	—	—	—
Lycopodium cernuum		—	—	x	—
Cibotium	Tree fern	—	—	—	—
Trilete smooth		—	—	—	—
Azolle		—	—	—	—
Starch	Starch granules	—	—	—	—

Wagner et al. 1990

APPENDIX K

TRAFFIC IMPACT ANALYSIS REPORT FOR THE PROPOSED

LAIE DEVELOPMENT PLAN AMENDMENTS

PREPARED FOR

GROUP 70 INTERNATIONAL

April 7, 1992

PREPARED BY

THE TRAFFIC MANAGEMENT CONSULTANT

RANDALL S. OKANEKU, P. E., PRINCIPAL • 1188 BISHOP STREET, SUITE 1907 • HONOLULU, HAWAII 96813

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TRAFFIC IMPACT ANALYSIS REPORT FOR THE PROPOSED

LAIE DEVELOPMENT PLAN AMENDMENTS

I. INTRODUCTION

A. Purpose of Study

The purpose of this study is to identify and analyze the traffic impacts resulting from the proposed Laie Development Plan Amendments on the island of Oahu. This report presents the findings and recommendations of this study.

B. Scope of Study

The scope of this study includes:

1. Description of the proposed Development Plan Amendments.
2. Evaluation of existing roadway and traffic conditions.
3. Estimating future traffic without the proposed Development Plan Amendment projects.
4. Development of trip generation characteristics for various elements of the proposed Development Plan Amendment projects.
5. Analyzing three alternative locations for the residential component of the Development Plan Amendment projects.
6. Identification and analysis of traffic impacts resulting from the proposed Development Plan Amendment projects.
7. Recommendation of road improvements that would mitigate the traffic impacts identified in this study.

II. DESCRIPTION OF THE PROPOSED DEVELOPMENT PLAN AMENDMENTS

A. Location and Access

The Laie Development Plan Amendments area is located on the windward coast of Oahu, near the northernmost point of the island. Access off Kamehameha Highway to the Laie area is provided by a number of access roadways and driveways between the Polynesian Cultural Center (PCC) and the north end of Naniloa Loop. Exhibit 1 shows the Laie vicinity

B. Laie Master Plan

1. Approved Future Use in the Laie Master Plan

Under existing land use designations, the Laie Master Plan includes approximately 100 single family dwelling units and a 250 room hotel. The 100 dwelling units are primarily infilling within the existing developed area. The 250 room hotel is an expansion of the existing Laniloa Lodge. The traffic generated from these developments are included in the background traffic forecast for this study.

2. Proposed Land Uses

a. Residential

This study is conducted in support of the proposed amendments to the Koolauloa Development Plan (DP) Land Use Map. The amendments include the redesignation of 62 to 68 acres from agricultural to residential for the development of approximately 450 dwelling units. Three alternative sites are analyzed for the residential development.

The "Egg Farm" site is the northernmost location with access off a roadway, which will be referred to as the "Egg Farm Road". The Egg Farm Road is located approximately 1,200 feet north of the north junction of Naniloa Loop and Kamehameha Highway.

The "BYU Mauka" site is located mauka of the BYU campus. The BYU Mauka alternative includes a new loop road circling the BYU campus, beginning on Kamehameha Highway, south of PCC and connecting to either Poohaili Street or Naniloa Loop.

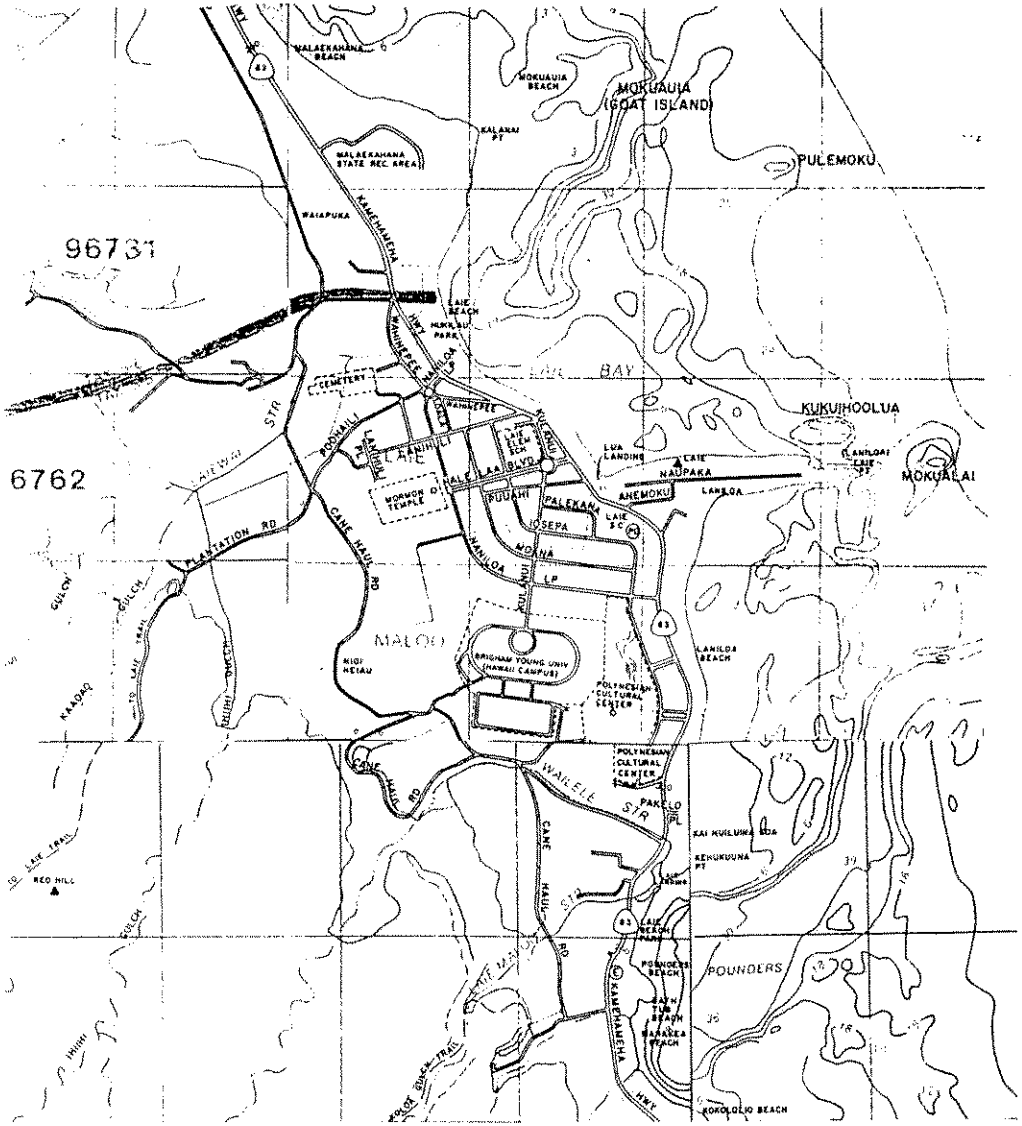


EXHIBIT 1 - LOCATION MAP

The "Laiemalo'o" site is the southernmost alternative, located on the mauka side of Kamehameha Highway, south of Laiemalo'o Stream. Access to the Laiemalo'o site would be provided directly on Kamehameha Highway.

Included in each alternative site is an 8 acre parcel designated for elementary school and park facilities. The student enrollment is projected at 140 students. Except for the Laiemalo'o alternative, the proposed elementary school is not expected impact traffic on Kamehameha Highway, since its enrollment is drawn from the new 450 dwelling units and from additional 100 dwelling units within the Development Plan Amendments area.

b. Brigham Young University

Approximately 98 acres is proposed to be redesignated from agricultural to public and quasi-public for the expansion of the Brigham Young University-Hawaii (BYU) campus and for a sewage treatment plant facility. The BYU student enrollment is not expected to accompany the campus expansion, therefore the BYU campus expansion is not expected to significantly impact traffic. The sewage treatment plant is also not expected to affect traffic operations in the study area.

c. Commercial

Approximately 21 acres are proposed to be redesignated from agricultural to commercial primarily for the purpose of the expansion of the Polynesian Cultural Center. The remainder of the 21 acres is located immediately south of the PCC site, mauka of Kamehameha Highway. Although the increase in visitor attendance is expected to increase with or without the PCC expansion, it is assumed that the growth in traffic is associated with the PCC expansion for the purpose of this analysis.

The redesignation of a 0.3 acre site at the corner of Kamehameha Highway and Wahinepee Street to commercial would bring into conformity an existing commercial operation. Another 0.5 acre site, next to the Laie Shopping Center, is proposed for commercial designation to provide additional parking and is not expected to increase overall traffic from the shopping center.

d. Resort

About 2.6 acres is proposed for redesignation from residential to resort located to the north of Laniloa Lodge, on the makai side of Kamehameha Highway. The site will not include hotel rooms. It would be used to provide resort amenities associated with a future hotel to be developed on a resort- designated property, across Kamehameha Highway and next to the Laniloa Lodge.

e. Industrial

The proposed Laie Development Plan Amendment projects include the redesignation of a 2 acre parcel on Wahinepee Street (herein referred to as the "Wahinepee Industrial" site) and about 16 acres on the Egg Farm Road to light industrial use, i.e., auto repair, home improvement, and similar activities (herein referred to as the "Egg Farm Industrial" site).

3. Phasing and Timing

Exhibit 2 shows the location of the proposed projects. Table 1 shows the land use activities proposed for the Laie Development Plan Amendments projects. The target years for the start and completion of the projects are also shown. The Year 2004 is used as the planning horizon for the traffic impact analysis.

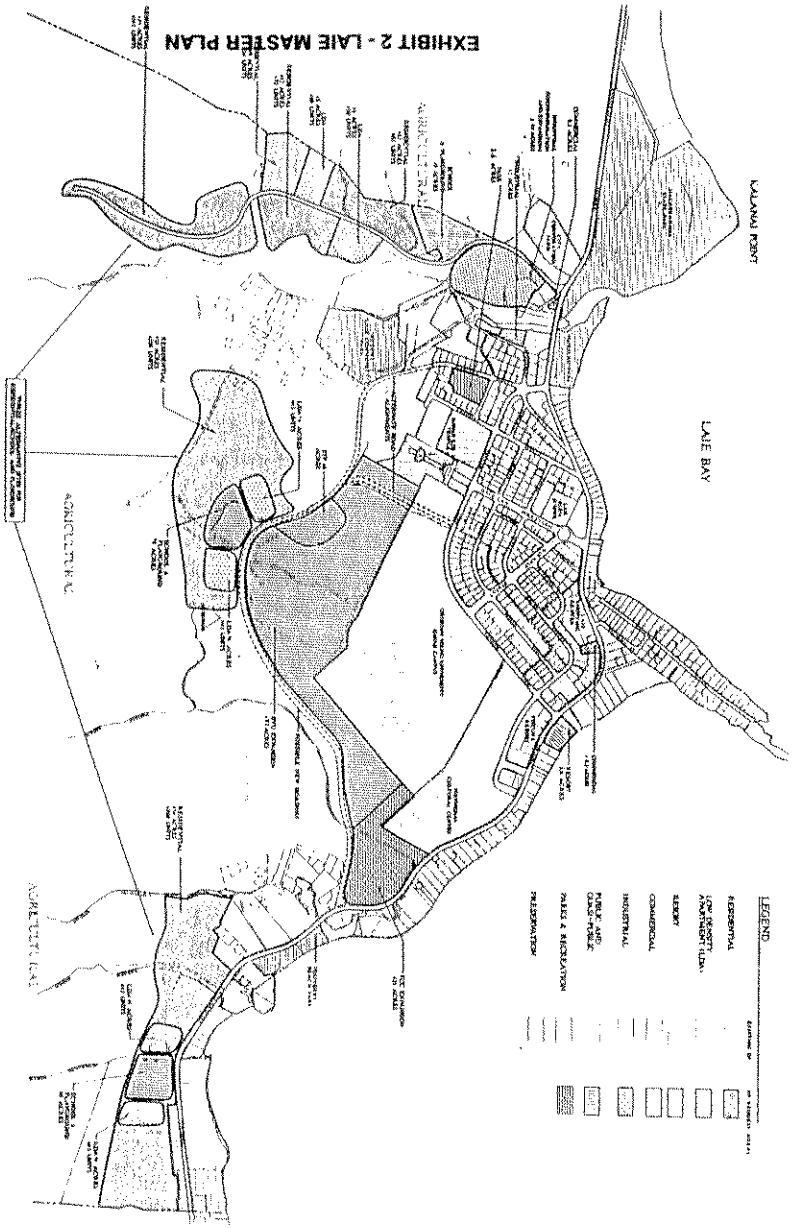


EXHIBIT 2 - LAIE MASTER PLAN

TABLE I. LAIE DEVELOPMENT PLAN AMENDMENTS				
Development Plan Amendment Projects		**Proposed Land Use**	**Year of Implementation**	**Land Use Intensity/Area**
Residential Alternatives	Egg Farm Alternative	Single - Family Dwellings	1994 - 1998	350 DU
		Apartment Dwellings	1994 - 1998	100 DU
		Elementary School	1994 - 1998	140 Students
	BYU Mauka Alternative	Single - Family Dwellings	1994 - 1998	360 DU
		Apartment Dwellings	1994 - 1998	90 DU
		Elementary School	1994 - 1998	140 Students
	Laiemalo'o Alternative	Single - Family Dwellings	1994 - 1998	360 DU
		Apartment Dwellings	1994 - 1998	90 DU
		Elementary School	1994 - 1998	140 Students
Common Elements	Egg Farm Road Industrial	Light Industrial	1994 - 1997	209,000 SF GFA
	Wahinepee Industrial	Light Industrial	1994 - 1997	26,140 SF GFA
	PCC Expansion	Visitor Attraction	1995 - 2000	21 Acres
	BYU Expansion	University	1993 - 2000	92 Acres
	Corner Commercial	Commercial	N/A	0.3 Acre
	Laie Shopping Center	Commercial	N/A	0.5 Acre
	Future Resort	Resort	2000 - 2001	2.6Acres
	Park	Recreational	N/A	3.6 Acres

III. STUDY AREA CONDITIONS

A. Study Area

The study area is located along Kamehameha Highway between the Egg Farm Road and the vicinity of the Laiemalo'o site. The existing intersections on Kamehameha Highway, analyzed in this study, include the Egg Farm Road, Naniloa Loop (north and south junctions), Hale Laa Boulevard, and the three access driveways to PCC.

B. Study Area Land Use

1. Existing Land Uses

The Laie Development Plan area is an integrated community comprised of various land use activities. These include the Polynesian Cultural Center (PCC), Laniloa Lodge, Brigham Young University-Hawaii (BYU), the Mormon Temple, residential community, and commercial developments. Many of the BYU students live in the Development Plan area. About one half the employees of PCC are BYU students. Most of the Laniloa Lodge employees are BYU students. Both PCC and the Mormon Temple are major visitor attractions on Oahu.

2. Anticipated Future Development Outside the Development Plan Area

The most significant future development in the region is the Kuilima Resort expansion. Ultimately, the Kuilima Resort would contain 4,000 hotel rooms, 1,368 resort condominiums, and a variety of recreation activities. The traffic impact analysis for the Kuilima Resort expansion was presented in the "Draft Traffic Impact Analysis Report for the Proposed Kuilima Resort Expansion", prepared by The Traffic Management Consultant, dated July 25, 1991.

Other future developments in the region include two golf courses, the 18-hole Malaekahana Golf Course and the 54 hole (three 18-hole golf courses) Punamano Golf Course. The traffic impact analysis for these projects was presented in "Country Courses at Kahuku, Traffic Impact Assessment Report", prepared by Pacific Planning & Engineering, Inc. (PPE) and dated February, 1989. Although these golf courses have not received Development Plan approval, they are included in the background traffic forecast because of

their proximity to the Laie area, especially the Malaekahana Golf Course, which would share access with the Egg Farm Industrial site and the Egg Farm residential alternative.

IV. EXISTING TRAFFIC CONDITIONS

A. Site Accessibility

1. Area Roadway System

Kamehameha Highway is a two lane, two way arterial highway, which provides the only access to the study area. Kamehameha Highway begins at the Trans-Koolau corridors of Pali Highway and Likelike Highway, circles the windward and north coasts of Oahu, and continues southward through Central Oahu to the primary urban center in Honolulu.

The Egg Farm Road is a narrow unimproved roadway intersecting Kamehameha Highway. The mauka portion of the Egg Farm Road is unpaved.

Naniloa Loop is a loop roadway intersecting Kamehameha Highway at the north and south limits of the BYU-Laie area. The south intersection is the primary access to the BYU campus and residential area. The north intersection provides access to Laie Elementary School and nearby residential areas. Naniloa Loop is stop-controlled at both intersections, without provisions for exclusive left turn lanes on Kamehameha Highway.

Hale Laa Boulevard is a divided roadway, which provides access to the Mormon Temple, as well as the surrounding residential area. Hale Laa Boulevard is stop-controlled at Kamehameha Highway. There are no provisions for an exclusive left turn lane on Kamehameha Highway at Hale Laa Boulevard.

PCC has three access driveways leading to its main parking lot, located between Kamehameha Highway and the PCC grounds. All three access driveways on Kamehameha Highway are unsignalized. The main access driveway (middle) has provisions for exclusive left and right turn lanes on Kamehameha Highway in the north bound and south bound directions, respectively.

2. **Transit Service**

Public transit service is available on Kamehameha Highway. Several bus stops are located on Kamehameha Highway through the study area.

B. Traffic Volumes and Conditions

1. General

a. Field Investigation

The field investigation was conducted in November, 1991 and January, 1992. Traffic count surveys were conducted during the weekday AM peak period between the hours of 6:30 AM and 8:30 AM, during the weekday PM peak period between the hours of 3:30 PM and 5:30 PM, and during the Saturday peak period between the hours of 1:00 PM and 3:00 PM.

b. State Department of Transportation Traffic Data

State Department of Transportation (DOT) 1990 data were obtained on Kamehameha Highway and used in the analysis.

c. Capacity Analysis Methodology

The highway capacity analysis performed for this study is based upon procedures presented in the "Highway Capacity Manual", Special Report 209, Transportation Research Board, 1985 and the "Highway Capacity Software", Federal Highways Administration. Level of Service (LOS) is a quantitative and qualitative assessment of traffic operation, "A" being the highest or best condition and "F" being the lowest or worst condition.

"Volume-to-capacity" (v/c) ratio is another measure indicating the relative traffic demand to the road's traffic carrying ability. A v/c ratio of 1.00 indicates that the roadway is operating at its capacity.

2. Existing Weekday AM Peak Hour Traffic Analysis

The AM peak hour of traffic during the weekday occurs between 7:15 AM and 8:15 AM. Exhibits 3 and 4 show the existing weekday AM peak hour traffic and the results of the capacity analysis.

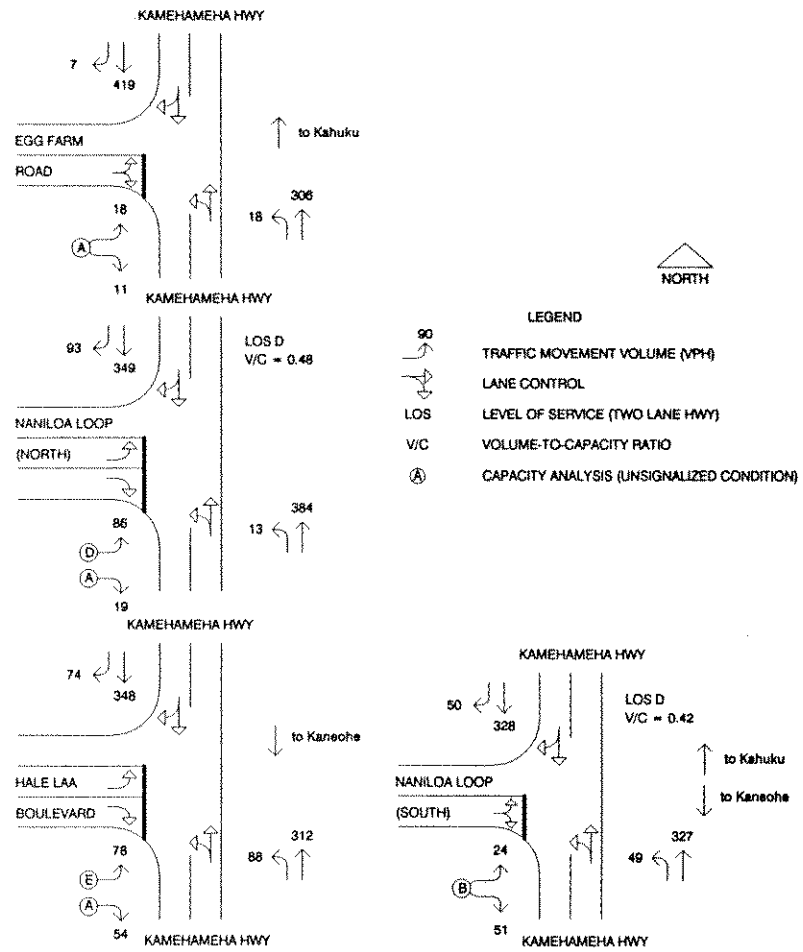


EXHIBIT 3 - EXISTING AM PEAK HOUR TRAFFIC (BYU VICINITY)

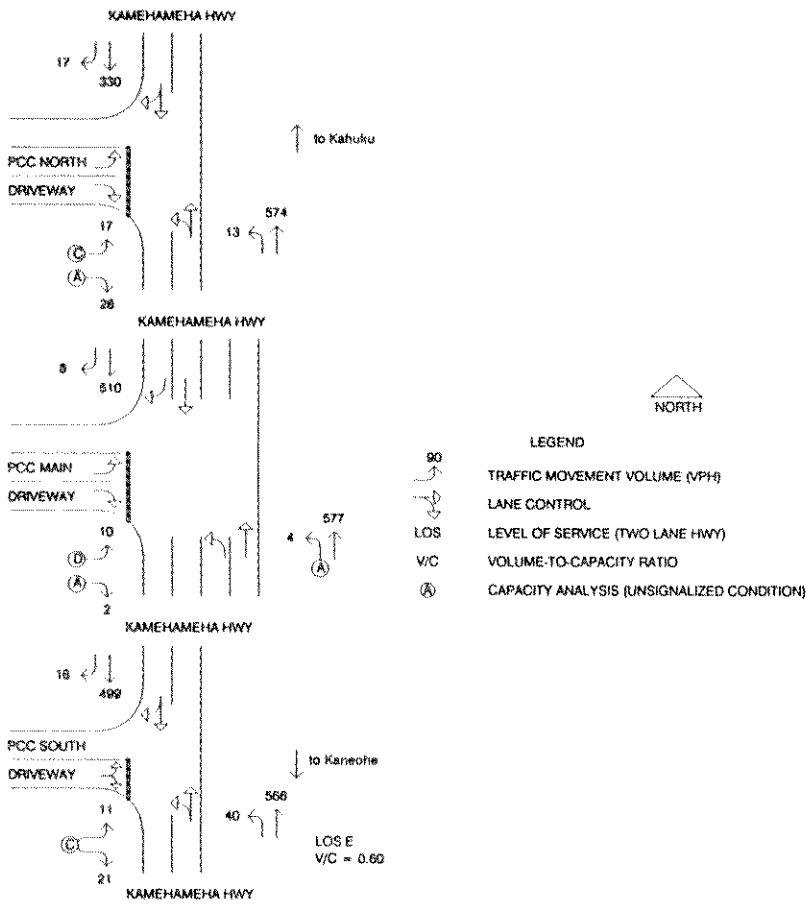


EXHIBIT 4 - EXISTING AM PEAK HOUR TRAFFIC (PCC VICINITY)

Kamehameha Highway, between the north junction of Naniloa Loop and the Egg Farm Road, operates at LOS "D" and a v/c ratio of 0.48 during the AM peak hour. Kamehameha Highway, in the vicinity of the BYU-Laie area, operates at LOS "D" and a v/c ratio of 0.42. South of PCC, Kamehameha Highway operates at LOS "E" and a v/c ratio of 0.60.

The left turn movement from Naniloa Loop to north bound Kamehameha Highway at the north junction operates at LOS "D" during the AM peak hour. The left turn movement from Hale Laa Boulevard to Kamehameha Highway operates at LOS "E".

The left turn movement from the PCC main access driveway to north bound Kamehameha Highway operates at LOS "D" during the AM peak hour. A left turn lane on north bound Kamehameha Highway at the south driveway to PCC is warranted, based upon traffic volumes during the existing AM peak hour. The remaining movements at the main driveways and the other driveways operate at satisfactory LOS, i.e., LOS "C" or better.

3. Existing Weekday PM Peak Hour Traffic Analysis

The PM peak hour of traffic during the weekday generally occurs between 3:45 PM and 4:45 PM. Exhibits 5 and 6 show the existing weekday PM peak hour traffic and the results of the capacity analysis.

Kamehameha Highway, between the north junction of Naniloa Loop and the Egg Farm Road, operates at LOS "D" and a v/c ratio of 0.40 during the PM peak hour. Kamehameha Highway in the vicinity of the BYU-Laie area operates at LOS "D" and a v/c ratio of 0.49. South of PCC, Kamehameha Highway operates at LOS "D" and a v/c ratio of 0.53.

The left turn movement from Hale Laa Boulevard to Kamehameha Highway operates at LOS "D". Naniloa Loop at its south junction with Kamehameha Highway operates at LOS "D". Left turn lanes on north bound Kamehameha Highway are warranted, based upon existing traffic volumes during the PM peak hour, at the north and south junctions of Naniloa Loop and at Hale Laa Boulevard.

The left turn movement from the PCC main driveway to Kamehameha Highway operates at LOS "C" during the PM peak hour. A left turn lane on north bound Kamehameha Highway at the PCC south driveway is warranted,

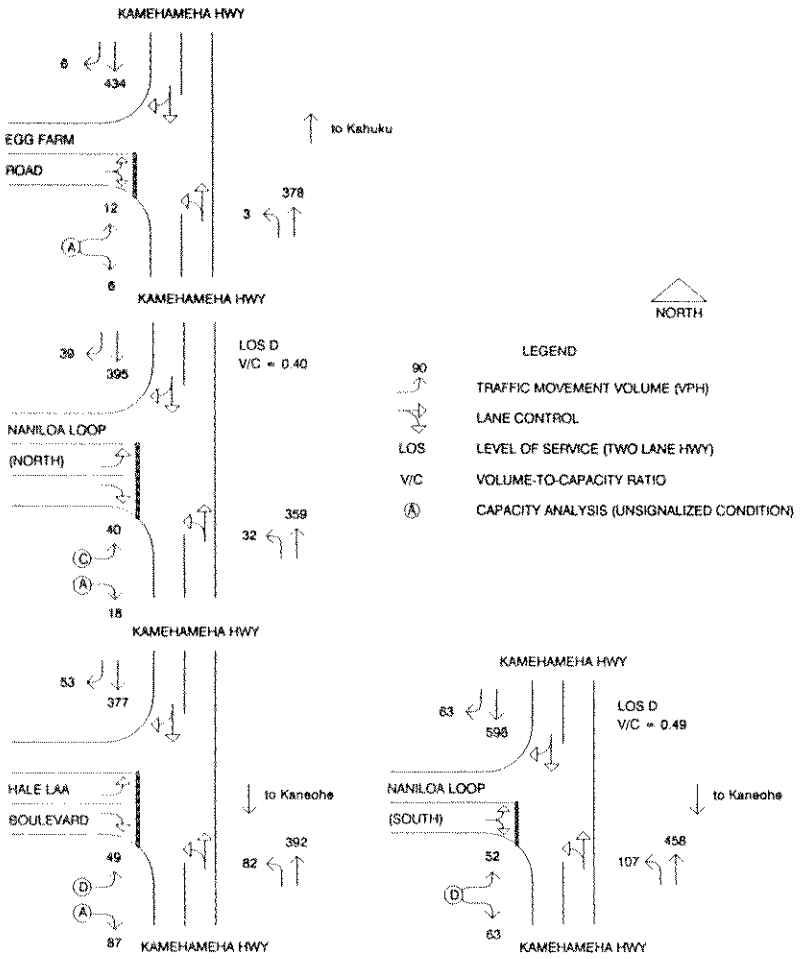


EXHIBIT 5 - EXISTING PM PEAK HOUR TRAFFIC (BYU VICINITY)

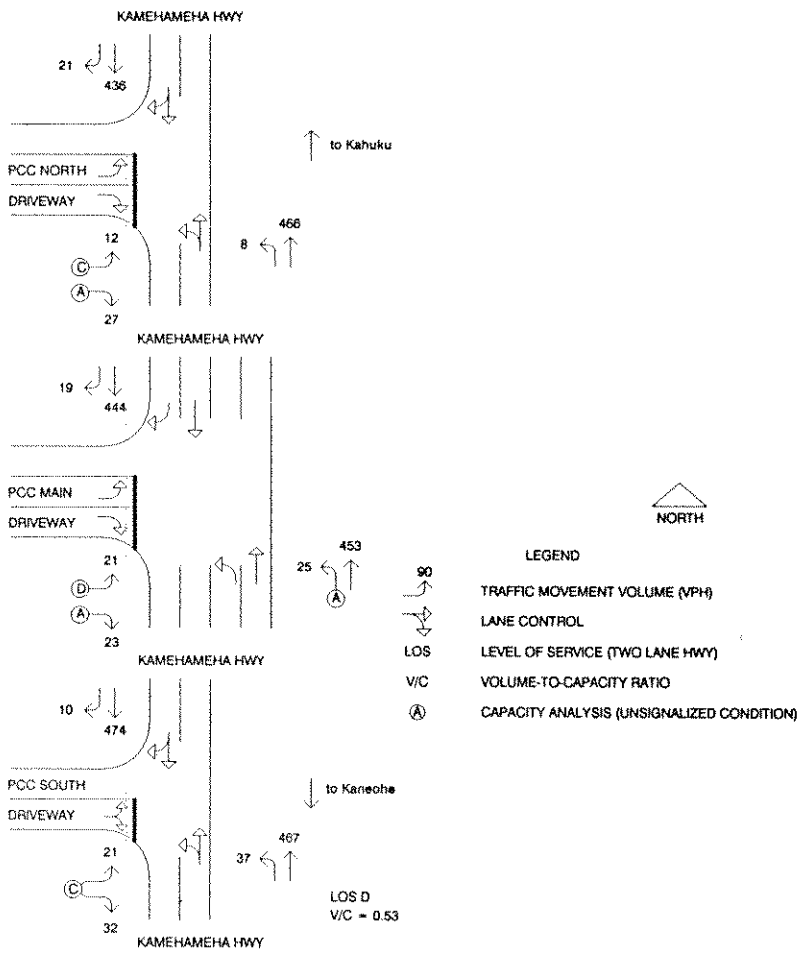


EXHIBIT 6 - EXISTING PM PEAK HOUR TRAFFIC (PCC VICINITY)

based upon existing traffic volumes during the PM peak hour. The remaining movements at the main driveway and the other driveways operate at satisfactory LOS.

4. Existing Saturday Peak Hour Traffic Analysis

The Saturday peak hour of traffic during the weekday generally occurs between 1:15 PM and 2:15 PM. Exhibits 7 and 8 show the existing Saturday peak hour traffic and the results of the capacity analysis.

Kamehameha Highway, between the north junction of Naniloa Loop and the Egg Farm Road, operates at LOS "D" and a v/c ratio of 0.52 during the Saturday peak hour. Kamehameha Highway in the vicinity of the BYU-Laie area operates at LOS "D" and a v/c ratio of 0.52. South of PCC, Kamehameha Highway operates at LOS "E" and a v/c ratio of 0.62.

The left turn movement from Naniloa Loop (north junction) and from Hale Laa Boulevard to north bound Kamehameha Highway at operate at LOS "E" during the Saturday peak hour. Left turn lanes on north bound Kamehameha Highway are warranted at Hale Laa Boulevard and at the south junction of Naniloa Loop, based upon existing traffic volumes during the Saturday peak hour.

The left turn movement from the PCC main driveway to north bound Kamehameha Highway operates at LOS "D" during the Saturday peak hour. The left turn movement from the PCC north driveway to north bound Kamehameha Highway operates at LOS "D". A left turn lane on north bound Kamehameha Highway at the PCC south driveway is warranted, based upon existing traffic volumes during Saturday peak hour. The remaining movements at the main driveway and the other intersections in the study area operate at satisfactory LOS.

V. PROJECTED TRAFFIC

A. Site-Generated Traffic

1. Trip Generation Methodology

The trip generation methodology used in this study is based upon generally accepted techniques developed by the Institute of Transportation Engineers (ITE) and published in "Trip Generation", 5th Edition, 1991.

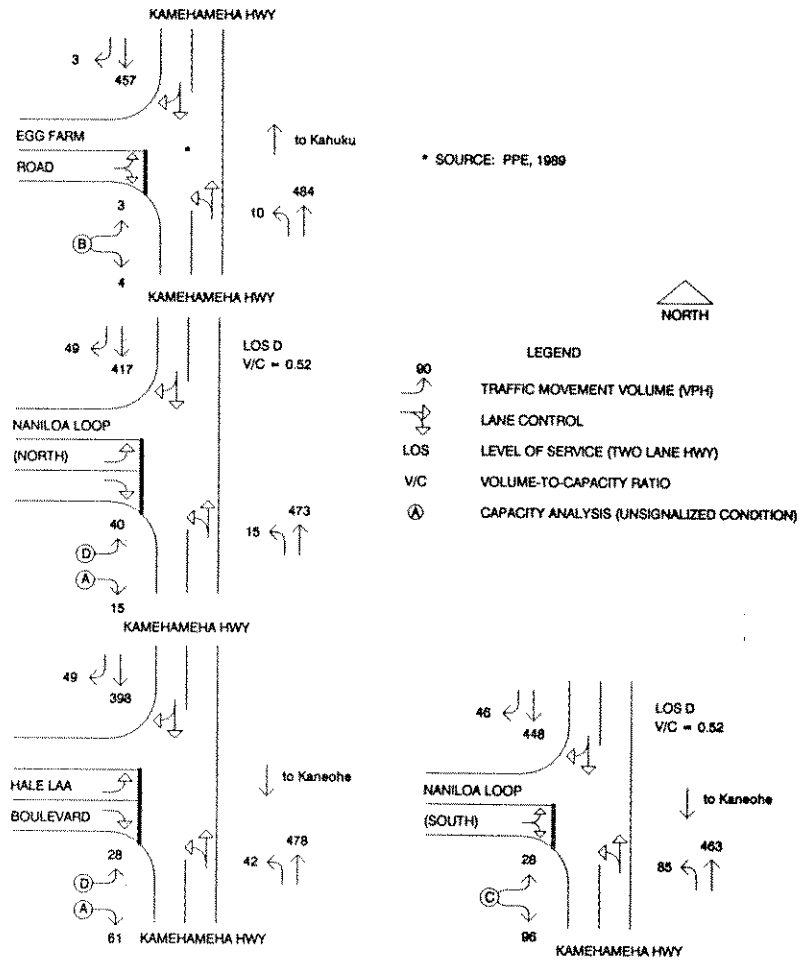


EXHIBIT 7 - EXISTING SAT PEAK HOUR TRAFFIC (BYU VICINITY)

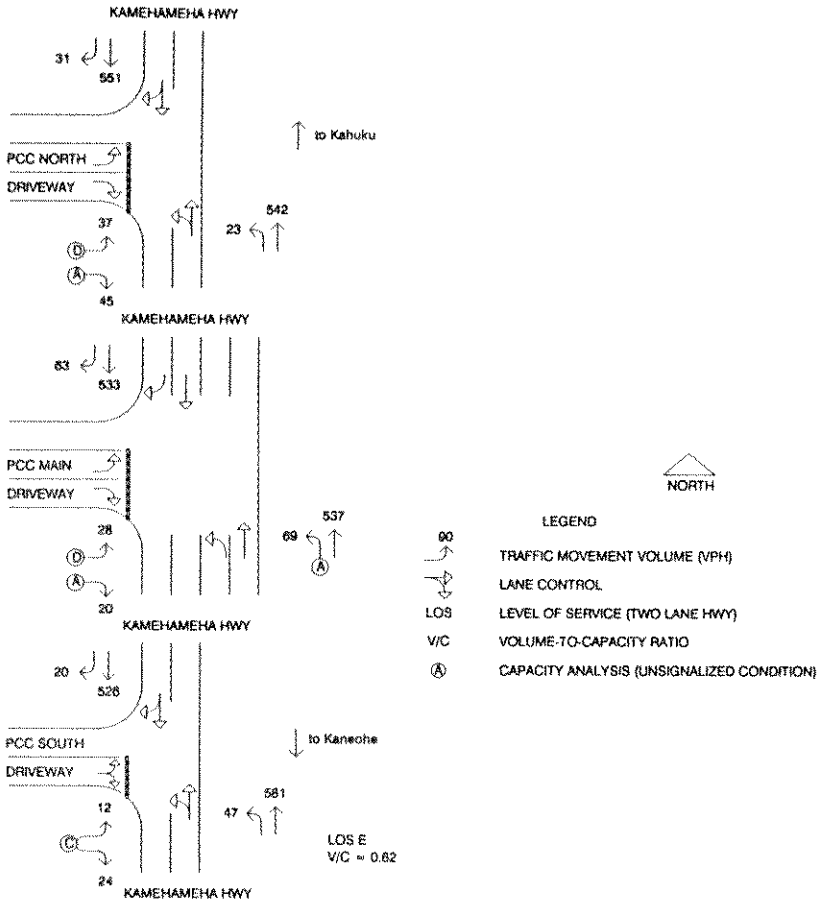


EXHIBIT 8 - EXISTING SAT PEAK HOUR TRAFFIC (PCC VICINITY)

The ITE trip rates for residential project are developed by correlating vehicle trip generation data with various land use characteristics, such as vehicle trips per dwelling unit. The trip generation rates for the industrial activities are based upon ITE light industrial rates for the approximate gross floor area planned for each development.

The trip generation for PCC is developed empirically, by correlating the observed traffic volumes during the peak hours of analysis with the daily attendance during the field investigation period. Projected attendance figures were obtained from PCC administration. Table 2 shows the trip generation characteristics for each of the Development Plan elements being analyzed.

TABLE 2. TRIP GENERATION SUMMARY

Analysis Period	Vph	Land Use					Traffic Generation Totals
		Single-Family Residential	Residential Apartment	Egg Farm Industrial	Wahinepee Industrial	PCC Expansion	
		Independent Variable					
		350 - 360 DU	90 - 100 DU	209,000 SF GFA	26,140 SF GFA	21 Acres	
Wkday AM Peak Hour	Enter	62 - 62	8 - 9	131	20	36	257 - 260
	Exit	177 - 181	39 - 44	27	4	28	275 - 284
	Total	239 - 245	47 - 53	158	24	64	532 - 544
Wkday PM Peak Hour	Enter	217 - 223	39 - 43	16	3	48	323 - 333
	Exit	117 - 120	19 - 20	120	23	58	337 - 341
	Total	334 - 343	58 - 63	136	26	106	660 - 674
Saturday Peak Hour	Enter	176 - 181	26 - 28	14	2	107	324 - 332
	Exit	150 - 154	26 - 28	16	2	56	250 - 256
	Total	326 - 335	52 - 56	30	4	163	575 - 588

2. **Trip Generation Characteristics**

a. **Residential**

The trip generation rates for the residential component of the Development Plan Amendment is based upon the dwelling unit count, which varies among the three alternatives sites. The Egg Farm alternative consists of 350 single family dwelling units and 100 apartment dwelling units. The BYU Mauka and Laiemalo'o consist of 360 single family dwelling units and 90 apartment units. The Egg Farm alternative would generate a total of 292 vehicles per hour (vph) during the AM peak hour of weekday traffic, 397 vph during the PM peak hour of weekday traffic, and 382 vph during the Saturday peak hour of traffic. The BYU Mauka and Laiemalo'o alternatives are each expected to generate a total of 292 vph during the AM peak hour of weekday traffic, 401 vph during the PM peak hour of weekday traffic, and 387 vph during the Saturday peak hour of traffic.

b. **Industrial**

The trip generation rates for industrial activities is based upon ITE light industrial rates for approximate gross floor area planned for the development. The Egg Farm Road industrial development would consist of 209,000 square feet of gross floor area (GFA) and the Wahinepee Street industrial site would contain 26,140 square feet GFA. The Egg Farm Road industrial site is expected to generate a total of 158 vph during the AM peak hour of weekday traffic, 136 vph during the PM peak hour of weekday traffic, and 30 vph during the Saturday peak hour of traffic. The Wahinepee site is expected to generate a total of 24 vph during the AM peak hour of weekday traffic, 26 vph during the PM peak hour of weekday traffic, and 4 vph during the Saturday peak hour of traffic.

c. **Polynesian Cultural Center Expansion**

The trip generation for PCC is developed empirically, by correlating the observed traffic volumes during the peak hours of analysis with the daily attendance during the field investigation period. According to PCC provided attendance figures, the average daily attendance is currently 2,842 persons per day. Based upon a six day week operation (closed Sunday), the average

weekly attendance is about 17,000 persons. During the field investigation period the weekly attendance was approximately 14,500, i.e., 85% of the annual average. The PCC attendance is expected to increase by 28% to the Year 2004. The observed traffic volumes during the peak hours of traffic were adjusted to reflect the increase in average visitor attendance and the seasonal variation between the investigation period and the annual average to reflect projected traffic conditions for PCC in the Year 2004. PCC traffic is expected to increase by 64 vph during the AM peak hour of weekday traffic, 106 vph during the PM peak hour of weekday traffic, and 163 vph during the Saturday peak hour of traffic. The total peak hour traffic generated by PCC in the Year 2004 is shown on Table 2.

3. **Traffic Assignment**

The traffic assignment is generally based upon existing conditions, however some adjustment was made to reflect the development of the Kuilima Resort as a visitor origin and employment opportunity.

The traffic assigment also reflects the assumption that one half of the future residents of the proposed residential development will work within the Laie area, e.g., PCC or BYU. Therefore these trips will remain within the Laie area.

B. **External Traffic**

1. **Future Traffic In Laie Area**

The traffic generation, resulting from the development of the 250 room hotel next to the existing Laniloa Lodge, is based upon ITE trip generation rates for a hotel. The future 250 room hotel is expected to generate a total of 165 vph during the AM peak hour of weekday traffic, 184 vph during the PM peak hour of weekday traffic, and 218 vph during the Saturday peak hour of traffic. The Laniloa Lodge expansion is expected to be built out and occupied by the traffic study's planning horizon of the Year 2004.

The traffic generation resulting from the development of the 100 dwelling units within the Laie area is based upon ITE rates for single family dwelling units. The 100 dwelling units are expected to generate a total of 81 vph during the AM peak hour of weekday traffic, 108 vph during the PM peak hour of

weekday traffic, and 108 vph during the Saturday peak hour of traffic. The residential infilling is expected to be built out and occupied by the traffic study's planning horizon of the Year 2004.

2. **Future Off-site Traffic in the Region**

The traffic generation resulting from the development of the Malaekahana and Punamano Golf Courses were adapted from the "Country Courses at Kahuku, Traffic Impact Assessment Report" prepared by Pacific Planning & Engineering, Inc., February 1989. The Malaekahana and Punamano Golf Courses are assumed to be built by the traffic study's planning horizon of the Year 2004.

The traffic generation resulting from the development of the Kuilima Resort expansion is taken from the "Draft Traffic Impact Analysis Report for the Proposed Kuilima Resort Expansion" prepared by The Traffic Management Consultant, dated July 25, 1991. The Kuilima study is based upon full build out and occupancy by the Year 2005. For the purpose of the traffic analysis, it is assumed that the completion of the Kuilima Resort expansion will coincide with this study's planning horizon of Year 2004.

3. **Through Traffic**

In addition to the future projects discussed above, a "background" traffic forecast was developed to establish the base line Year 2004 traffic conditions without the proposed the Development Plan amendment projects. The traffic forecast is based upon historical traffic data obtained from the State DOT at the Kii Bridge traffic count station on Kamehameha Highway in Kahuku. Linear regression techniques were performed on the historical data to obtain the growth rate of traffic in the vicinity. Based upon this analysis, it was determined that traffic on Kamehameha Highway increased at a rate of 2.9% per year using 1991 as the base year. Through traffic on Kamehameha Highway is expected to increase by 37.7% by the Year 2004.

4. **Total Traffic Volumes Without the Development Plan Amendment Projects**

a. **General**

The traffic generated by the Kuilima Resort expansion, the Malaekahana and Puamano Golf Courses, and the approved developments contained within the Laie Master Plan are added to the traffic forecast of 2.9% per year to arrive at the total traffic volumes without the proposed Development Plan Amendment projects.

The projected Year 2004 AM and PM peak hour traffic conditions are analyzed under existing roadway conditions and under recommended highway improvements without the proposed Development Plan amendments, for comparison purposes. It is assumed that future highway deficiencies without the project would be mitigated with the following improvements:

i. Upgrading of Kamehameha Highway to provide a 24 foot wide travel way and 6 foot wide paved shoulders on both sides of the highway.

ii. Installing traffic signals on Kamehameha Highway at its intersections with both junctions of Naniloa Loop and at Hale Laa Boulevard.

iii. Constructing exclusive left turn lanes on Kamehameha Highway at its intersections with the Egg Farm Road, both junctions of Naniloa Loop, Hale Laa Boulevard, and the north and south access driveways to PCC.

iv. Constructing separate left turn and right turn lanes on Naniloa Loop at its south junction with Kamehameha Highway.

Exhibits 9 and 10 show the year 2004 weekday AM peak hour traffic without the Development Plan Amendment projects and the results of the capacity analysis under existing roadway geometrics and under improved conditions.

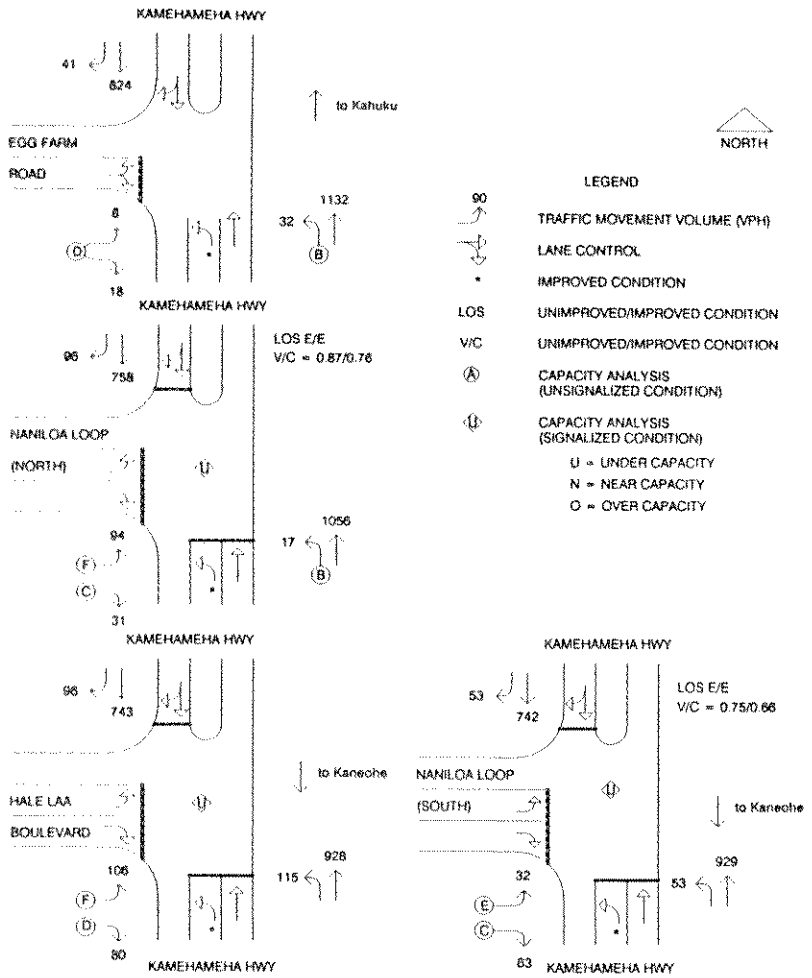


EXHIBIT 9 - YEAR 2004 AM PEAK HOUR TRAFFIC (BYU VICINITY)

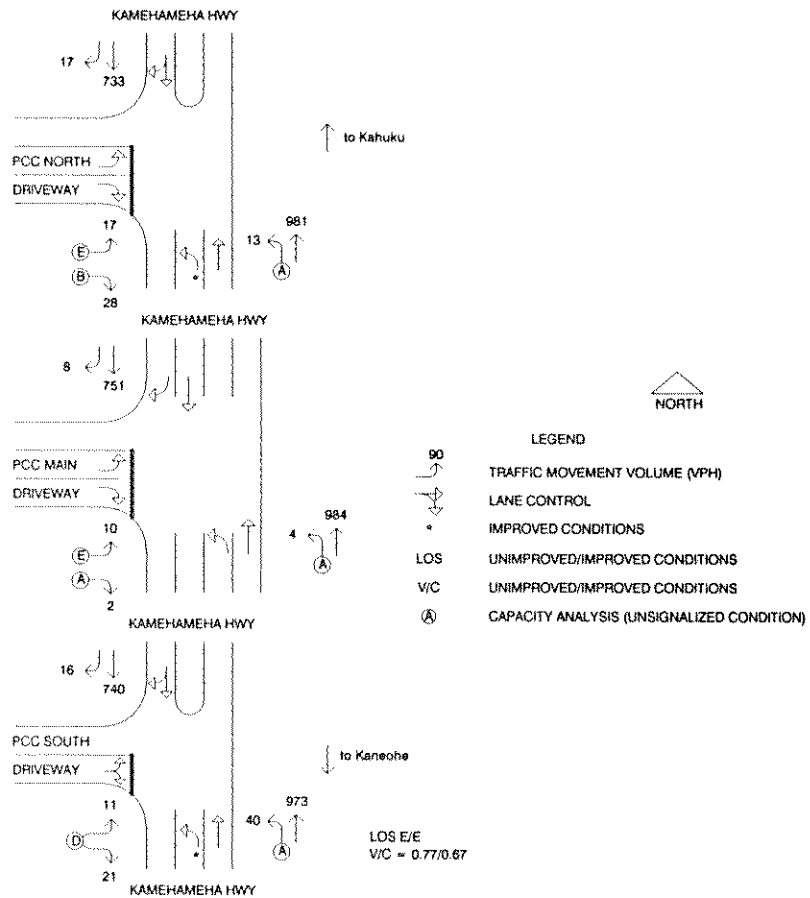


EXHIBIT 10 - YEAR 2004 AM PEAK HOUR TRAFFIC (PCC VICINITY)

b. Year 2004 Weekday AM Peak Hour Traffic Analysis W/O The Development Plan Amendment Projects

Kamehameha Highway, north of the Development Plan area, operates at LOS "E" and a v/c ratio of 0.87 during the AM peak hour under existing road geometrics. With the proposed upgrading, Kamehameha Highway is expected to continue to operate at LOS "E" conditions, however the improved capacity would lower the v/c ratio to 0.76.

Kamehameha Highway in the vicinity of the BYU-Laie area operates at LOS "E" and a v/c ratio of 0.75 under existing roadway conditions. Under the improved roadway conditions, Kamehameha Highway would operate at LOS "E" with a v/c ratio of 0.66.

South of PCC, Kamehameha Highway operates at LOS "E" and a v/c ratio of 0.77. The proposed highway upgrade would improve the v/c ratio to 0.67.

The Egg Farm Road operates at LOS "D" at Kamehameha Highway during the AM peak hour without the Development Plan Amendment projects. The left turn movements from Naniloa Loop at the north junction and from Hale Laa Boulevard to north bound Kamehameha Highway operate at LOS "F" under unsignalized conditions. Naniloa Loop, at its south junction with Kamehameha Highway, operates at LOS "E" under unsignalized conditions. Traffic signals at both Naniloa Loop intersections and at Hale Laa Boulevard intersection on Kamehameha Highway would operate at under capacity conditions.

The left turn movements from the north and main PCC access driveways to north bound Kamehameha Highway operate at LOS "E" during the AM peak hour without the Development Plan Amendment projects. The PCC south driveway operate at LOS "D". The remaining movements at the other intersections analyzed in this study operate at satisfactory LOS. Left turn lanes area warranted at the north and south PCC access driveways under projected AM peak hour volumes without the proposed Development Plan Amendment projects.

c. Year 2004 Weekday PM Peak Hour Traffic Analysis W/O The Development Plan Amendment Projects

Kamehameha Highway, between the north Naniloa Loop and the Egg Farm Road, operates at LOS "E" and a v/c ratio of 0.79 during the PM peak hour under existing roadway conditions. The proposed highway upgrade should increase the roadway capacity and improve the v/c ratio to 0.69.

Kamehameha Highway in the vicinity of the BYU-Laie area operates at LOS "E" and a v/c ratio of 0.83 under existing road geometrics. Under improved conditions, Kamehameha Highway would continue to operate under at LOS "E" conditions, however the v/c ratio would be reduced to 0.73.

South of PCC, Kamehameha Highway operates at LOS "E" and a v/c ratio of 0.83 under existing road conditions. The proposed improvements would improve the v/c ratio to 0.73.

The Egg Farm Road operates at LOS "E" at Kamehameha Highway during the PM peak hour without the Development Plan Amendment projects. The left turn movements from the north junction of Naniloa Loop and from Hale Laa Boulevard to north bound Kamehameha Highway would operate at LOS "E" under unsignalized conditions. The south junction of Naniloa Loop at Kamehameha Highway would operate at LOS "F" under unsignalized conditions. Under the proposed signalization, all three intersections would operate under capacity.

The left turn movements from the PCC north and main driveways to north bound Kamehameha Highway operates at LOS "E" during the PM peak hour without the Development Plan amendments. The PCC south driveway operates at LOS "E". The remaining movements at the other intersections analyzed in this study operate at satisfactory LOS. Exhibits 11 and 12 show the Year 2004 weekday PM peak hour traffic without the Development Plan Amendment projects and the results of the capacity analysis.

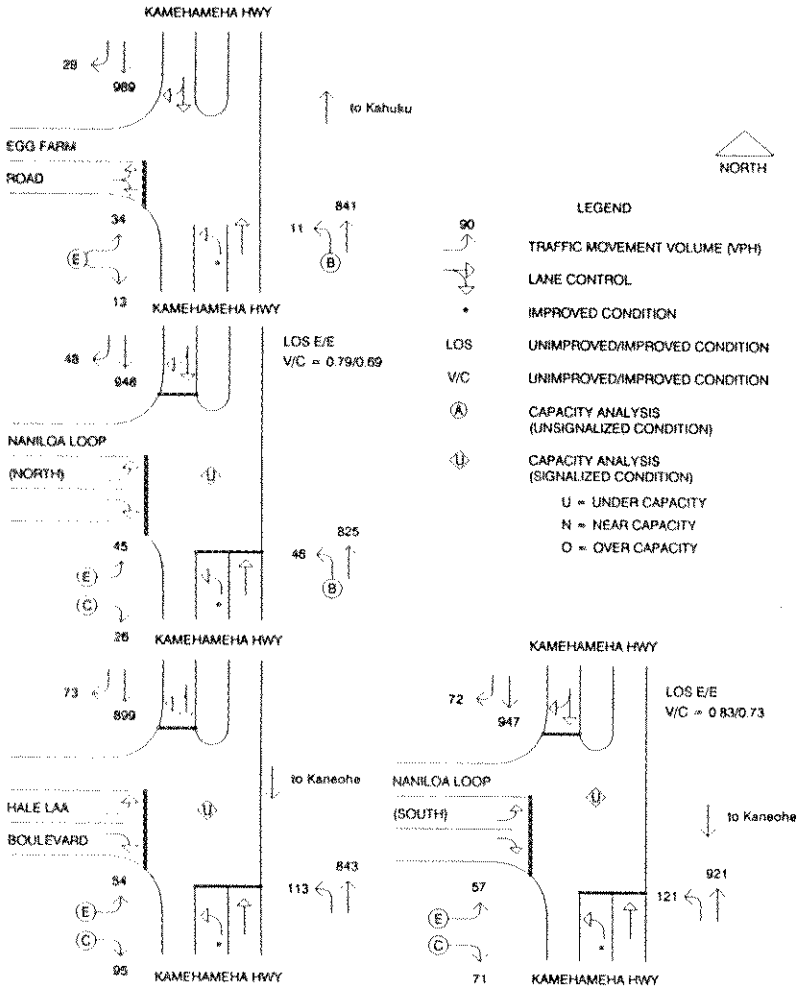


EXHIBIT 11 - YEAR 2004 PM PEAK HOUR TRAFFIC (BYU VICINITY)

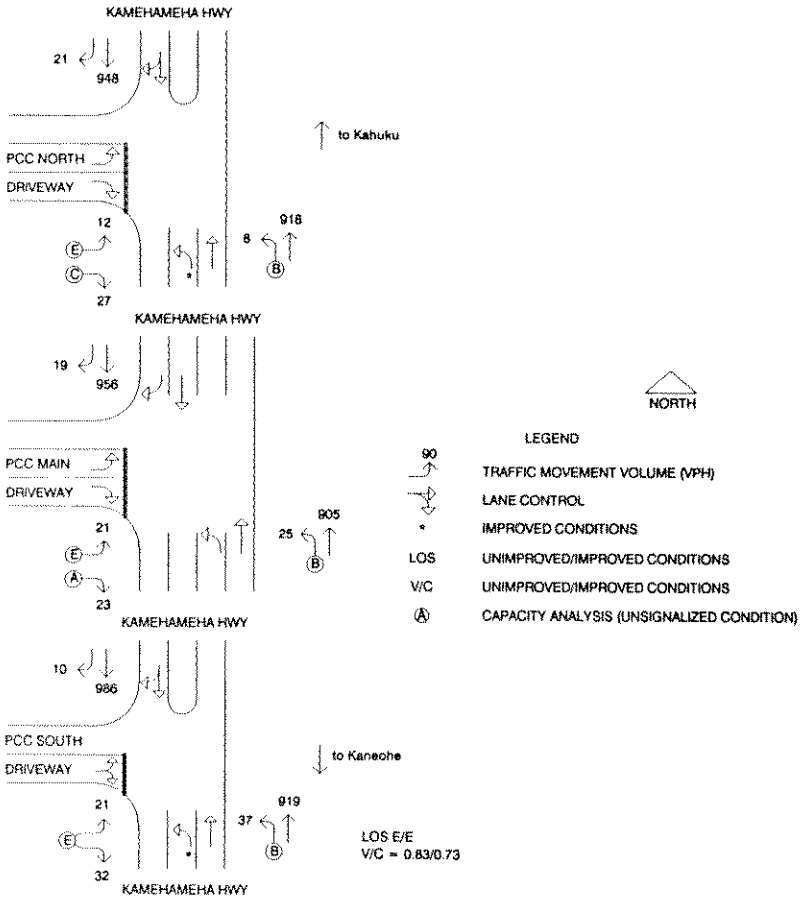


EXHIBIT 12 - YEAR 2004 PM PEAK HOUR TRAFFIC (PCC VICINITY)

d. Year 2004 Saturday Peak Hour Traffic Analysis W/O The Development Plan Amendment Projects

Kamehameha Highway, between the north Naniloa Loop junction and the Egg Farm Road, operates at LOS "E" and a v/c ratio of 0.85 during the Saturday peak hour under existing roadway conditions. Under improved conditions, Kamehameha Highway would continue to operate at LOS "E" conditions, however the increase in capacity would lower the v/c ratio to 0.74.

Kamehameha Highway in the vicinity of the BYU-Laie area operates at LOS "E" and a v/c ratio of 0.85 under existing roadway conditions. The proposed highway upgrade would improve the v/c ratio to 0.74.

South of PCC, Kamehameha Highway operates at LOS "E" and a v/c ratio of 0.90 under existing road conditions. The proposed highway upgrade would lower the v/c ratio to 0.80.

The Egg Farm Road operates at LOS "E" at Kamehameha Highway during the Saturday peak hour without the Development Plan Amendment projects. The left turn movement from Naniloa Loop (north junction) and from Hale Laa Boulevard to north bound Kamehameha Highway at the north junction operate at LOS "E" under existing traffic controls. Naniloa Loop, at its south junction with Kamehameha Highway, operates at LOS "E" under unsignalized conditions. With traffic signalization, all three intersections would operate at under capacity conditions.

The left turn movements from the PCC north and main driveways to north bound Kamehameha Highway operate at LOS "E" during the Saturday peak hour without the Development Plan Amendment Projects. The PCC south driveway operates at LOS "D". The remaining movements at the other intersection within the study area operate at satisfactory LOS. Exhibits 13 and 14 show the Year 2004 Saturday peak hour traffic without the Development Plan Amendment projects and the results of the capacity analysis.

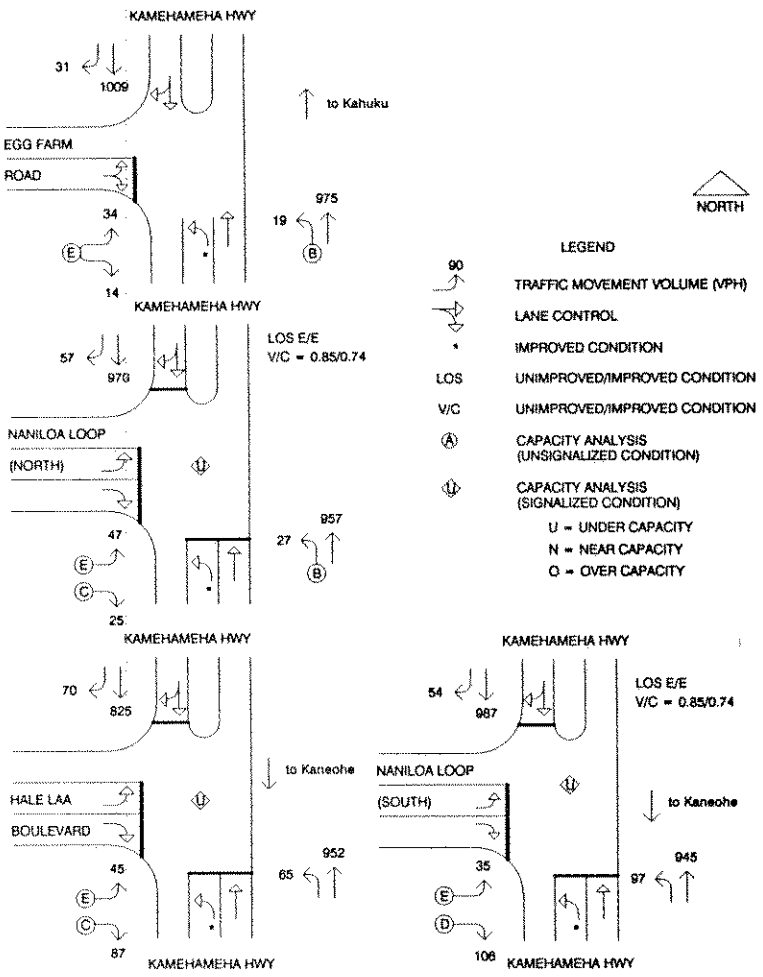


EXHIBIT 13 - YEAR 2004 SAT PEAK HR TRAFFIC (BYU VICINITY)

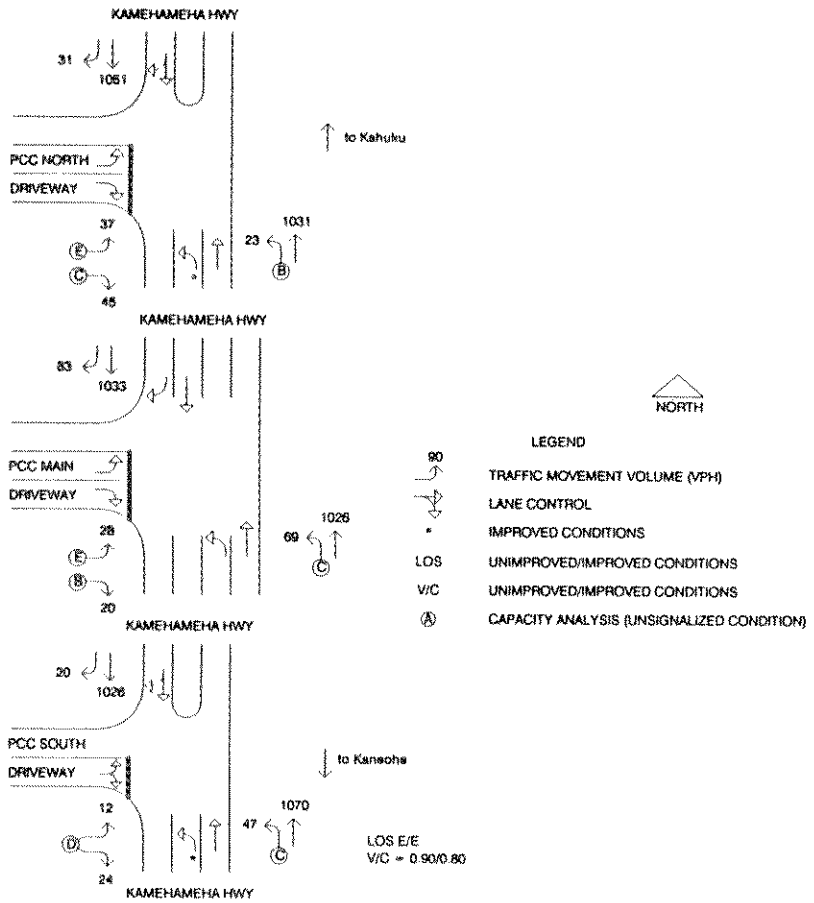


EXHIBIT 14 - YEAR 2004 SAT PEAK HR TRAFFIC (PCC VICINITY)

C. Total Traffic With The Development Plan Amendment Projects

The traffic generated by the proposed Development Plan Amendment projects is superimposed over the Year 2004 conditions to assess the traffic impacts of the projects associated with the proposed Development Plan Amendments.

The two lane Kamehameha Highway is analyzed, assuming that the Highway has been upgraded to provide a 12 foot wide lane in each direction and 6 foot wide paved shoulders on both sides of the highway. Furthermore, the Kamehameha Highway intersections at both junctions of Naniloa Loop and at Hale Laa Boulevard are analyzed under signalized conditions, necessary to mitigate the unsatisfactory LOS under projected conditions without the proposed Development Plan Amendment projects. The LOS analysis for unsignalized conditions is shown for comparison purposes. The traffic impacts of the proposed Development Plan Amendment projects are analyzed for the weekday AM and PM peak hours and the Saturday peak hour for each of the alternative residential locations and are discussed in the next section.

VI. TRAFFIC IMPACT ANALYSIS

A. General

The traffic generated by the Development Plan Amendment residential proposals are analyzed without taking into account trips taken within the region. For example, the residents of the proposed housing project can be expected to work at the new hotels proposed at Kuilima. A portion of the visitor traffic generated by the PCC expansion is expected to originate from the Kuilima Resort expansion and the Laniloa Lodge expansion. However, the traffic generated by each of these developments are analyzed independently, therefore part of the projected traffic may be "double counted". This study has taken a conservative approach, i.e., overstating the traffic projections by analyzing the cumulative traffic impacts resulting from the proposed projects, as well as other proposed projects in the region.

Assumptions were made regarding the internal trips generated by the proposed Development Plan Amendment projects. It is assumed that the elementary school trip generation would consist of trips originating primarily from the proposed residential area. Another assumption, made on the profile of

the future residents of the proposed housing project, is that one half of the future residents would be working within the study area, i.e. BYU or PCC. This assumption is supported by the profile of the existing residents in Laie.

The traffic impact analysis is based upon three scenarios, representing the alternative locations of the proposed residential projects.

B. Egg Farm Alternative

1. Weekday AM Peak Hour With the Development Plan Amendment Projects

Kamehameha Highway, between the north Naniloa Loop junction and the Egg Farm Road, operates at LOS "E" and v/c ratio of 0.86 during the AM peak hour with the Development Plan Amendment projects. Kamehameha Highway, in the vicinity of BYU-Laie area operates at LOS "E" and a v/c ratio of 0.80. South of PCC, Kamehameha Highway operates at LOS "E" and a v/c ratio of 0.77.

The left turn movement from the Egg Farm Road to north bound Kamehameha Highway would operate at LOS "F" during the projected AM peak hour. The right turn movement from the Egg Farm Road to south bound Kamehameha Highway would operate at LOS "D". The Kamehameha Highway intersection at the north junction of Naniloa Loop operate at near capacity conditions.

The left turn movements from the PCC north and main driveways to north bound Kamehameha Highway operate at LOS "E" during the projected AM peak hour. The PCC south driveway at Kamehameha Highway operates at LOS "D". Exhibits 15 and 16 show the cumulative AM peak hour traffic with the Development Plan Amendment projects and results of the capacity analysis.

2. Weekday PM Peak Hour With the Development Plan Amendment Projects

Kamehameha Highway, between the north Naniloa Loop junction and the Egg Farm Road, operates at LOS "E" and v/c ratio of 0.82 during the PM peak hour with the Development Plan Amendment projects. Kamehameha Highway in the vicinity of the BYU-Laie area operates at LOS "E" and a v/c ratio of 0.84. South of PCC, Kamehameha Highway also operates at LOS "E" and v/c ratio of 0.84.

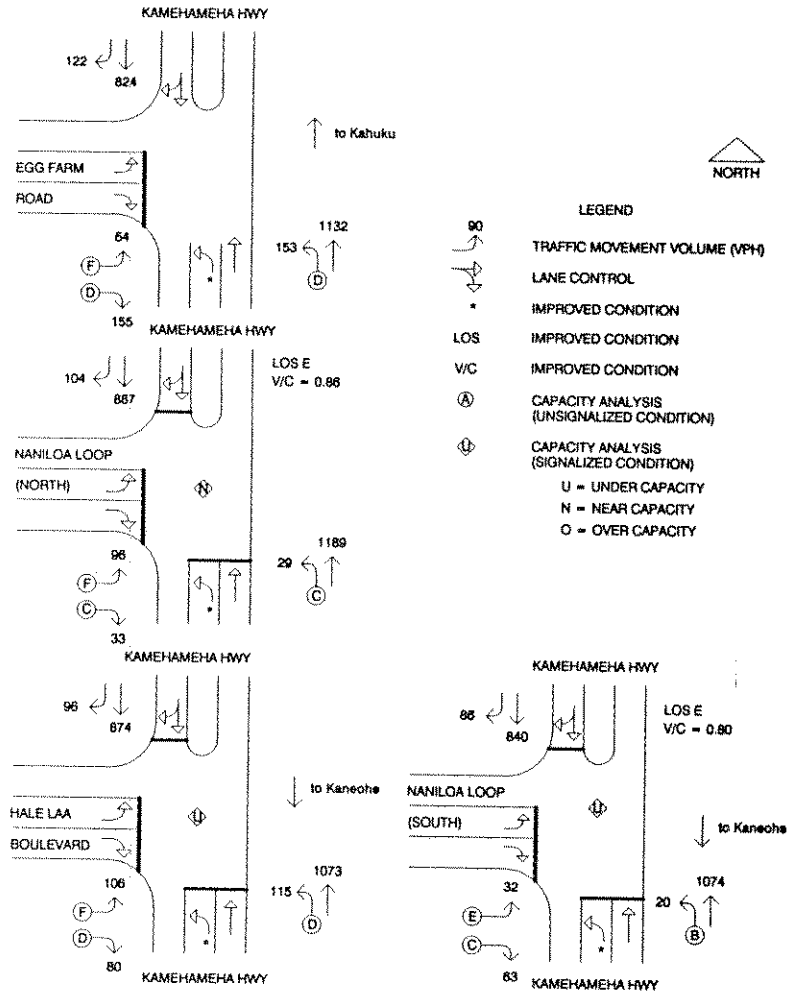


EXHIBIT 15 - EGG FARM CUMULATIVE AM PEAK HR (BYU VICINITY)

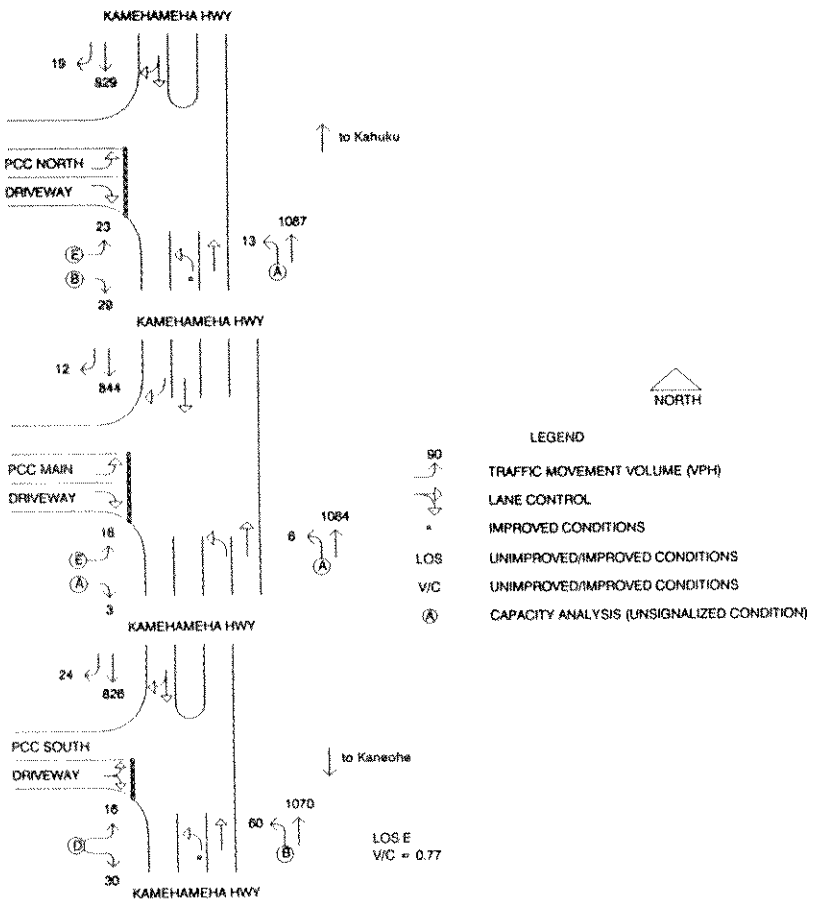


EXHIBIT 16 - EGG FARM CUMULATIVE AM PEAK HR (PCC VICINITY)

The left turn movement from the Egg Farm Road to north bound Kamehameha Highway operates at LOS "F" during the projected PM peak hour. The Kamehameha Highway intersections at the north junction of Naniloa Loop and at Hale Laa Boulevard operate at near capacity conditions. The south junction of Naniloa Loop and Kamehameha Highway operates at over capacity conditions.

The left turn movements from all the PCC Driveways to north bound Kamehameha Highway operate at LOS "E" during the projected PM peak hour. Exhibits 17 and 18 show the cumulative PM peak hour traffic with the Development Plan Amendment projects and the results of the capacity analysis.

3. Saturday Peak Hour With the Development Plan Amendment Projects

Kamehameha Highway, between the north junction of Naniloa Loop and Egg Farm Road, operates at LOS "E" and v/c ratio of 0.86 during the Saturday peak hour with the Development Plan Amendment projects. Kamehameha Highway, in the vicinity of the BYU-Laie area, operates at LOS "E" and v/c ratio of 0.85. South of PCC, Kamehameha Highway operates at LOS "E" and v/c ratio of 0.93.

The left turn movement from the Egg Farm Road to north bound Kamehameha Highway operates at LOS "F" during the projected Saturday peak hour. The Kamehameha Highway intersections at the north and south junctions of Naniloa Loop and at Hale Laa Boulevard operate at near capacity conditions.

The left turn movements form all the PCC driveways to north bound Kamehameha Highway operate at LOS "E" during the projected PM peak hour. The left turn movement from north bound Kamehameha Highway to the PCC main driveway operates at LOS "D". Exhibits 19 and 20 show the cumulative Saturday peak hour traffic with the Development Plan Amendment projects and the results of the capacity analysis.

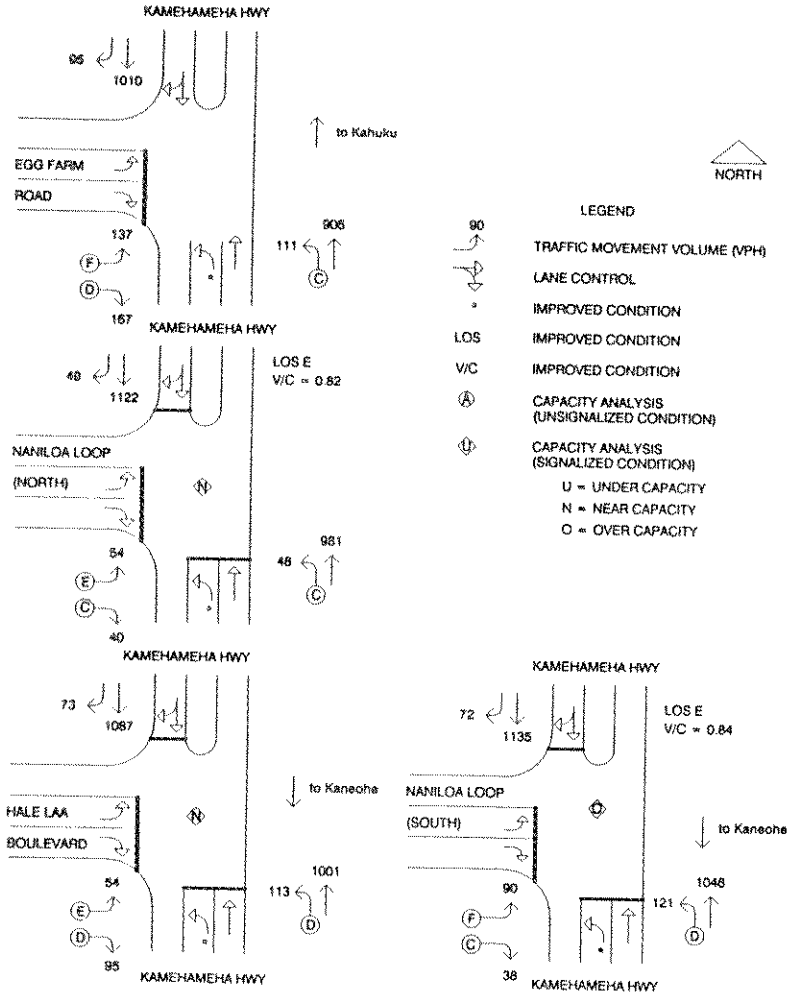


EXHIBIT 17 - EGG FARM CUMULATIVE PM PEAK HR (BYU VICINITY)

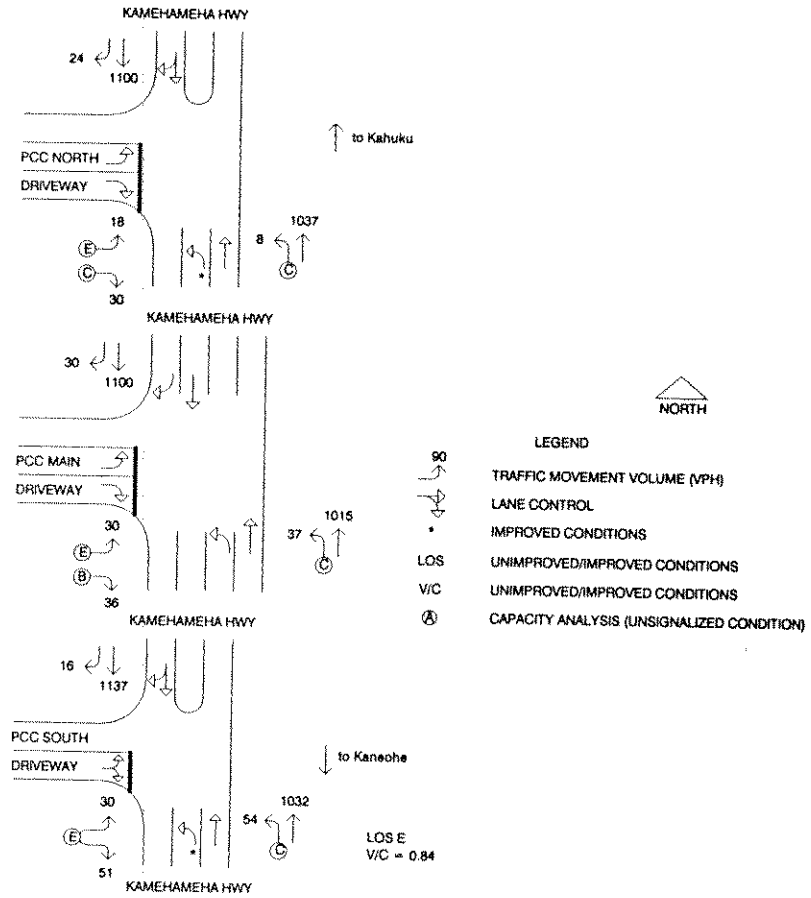


EXHIBIT 18 - EGG FARM CUMULATIVE PM PEAK HR (PCC VICINITY)

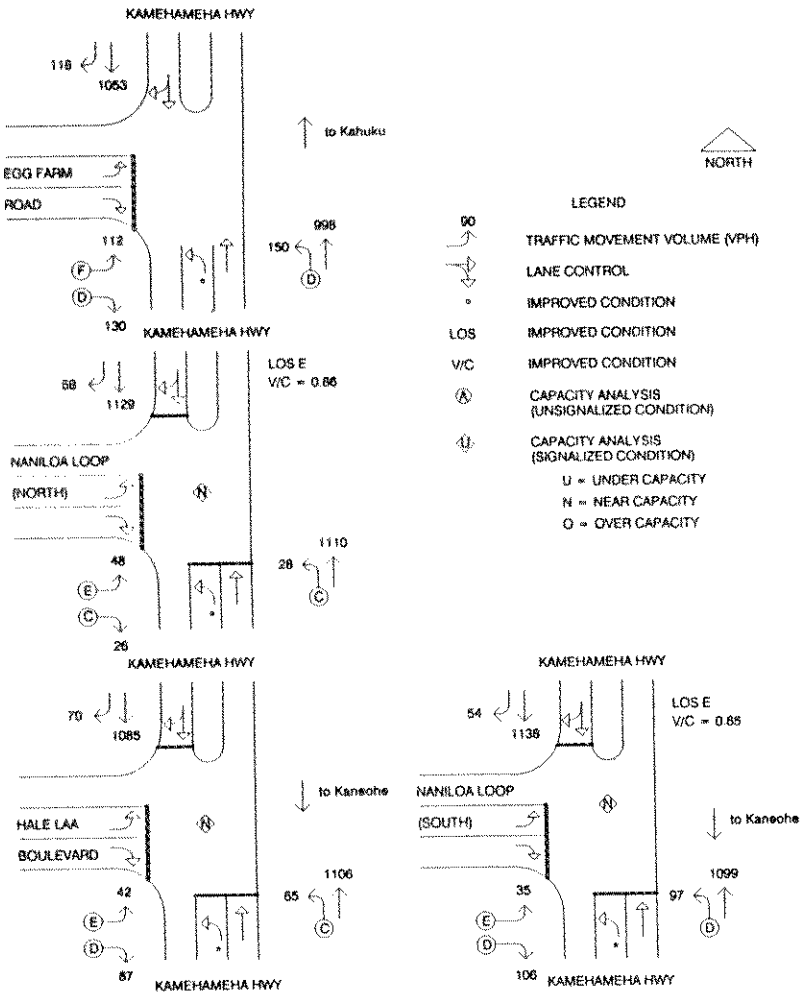


EXHIBIT 19-EGG FARM CUMULATIVE SAT PEAK HR (BYU VICINITY)

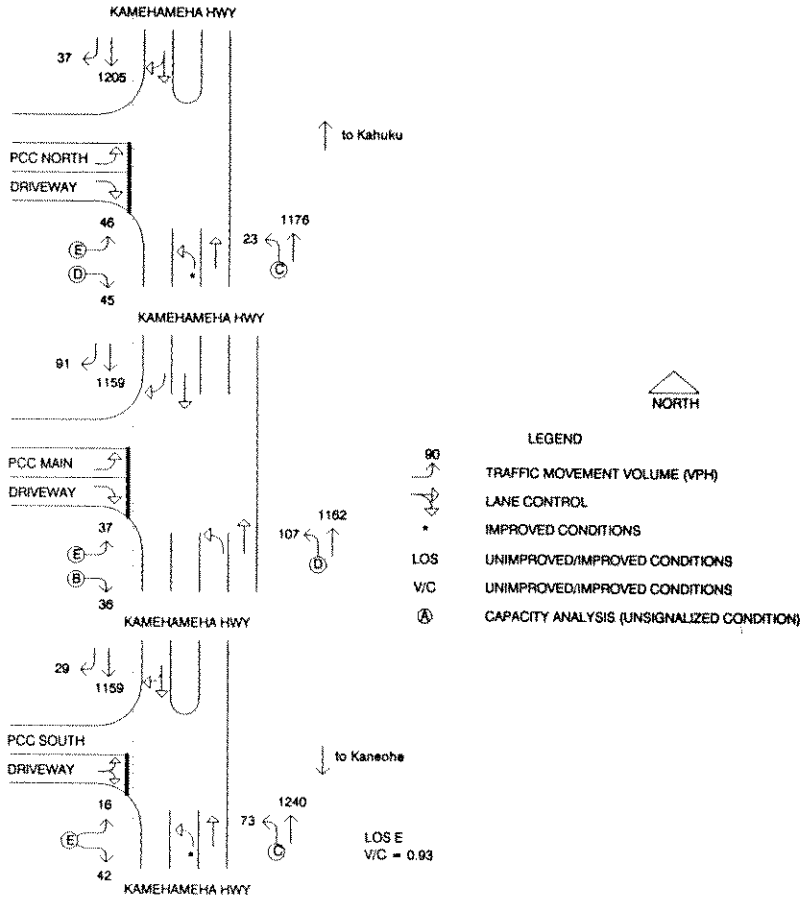


EXHIBIT 20-EGG FARM CUMULATIVE SAT PEAK HR (PCC VICINITY)

C. BYU Mauka Alternative

1. Weekday AM Peak Hour With the Development Plan Amendment Projects

Kamehameha Highway, between the north Naniloa Loop junction and the Egg Farm Road, operates at LOS "E" and v/c ratio of 0.84 during the AM peak hour with the Development Plan Amendment projects. Kamehameha Highway in the vicinity of the BYU-Laie area operates at LOS "E"and a v/c ratio of 0.72. South of PCC, Kamehameha Highway operates at LOS "E" and a v/c ratio of 0.72.

The left turn movement from the Egg Farm Road to north bound Kamehameha Highway operate at LOS "E". The north junction of Naniloa Loop and Kamehameha Highway operates at near capacity conditions.

The left turn movements from the PCC north and main driveways to north bound Kamehameha Highway operate at LOS "E" during the projected AM peak hour. The PCC south driveway at Kamehameha Highway operates at LOS "D".

The proposed access road for BYU Mauka Alternative is expected to operate at LOS "B" at Kamehameha Highway, during the projected AM peak hour. A left turn lane on north bound Kamehameha Highway at the proposed project access road is warranted, based upon the cumulative AM peak hour traffic volumes. Exhibits 21 and 22 show the cumulative AM peak hour traffic volumes with the Development Plan Amendment projects and results of the capacity analysis.

2. Weekday PM Peak Hour With the Development Plan Amendment Projects

Kamehameha Highway, between the north Naniloa Loop junction and the Egg Farm Road, operates at LOS "E" and v/c ratio of 0.78 during the PM peak hour with the Development Plan Amendment projects. Kamehameha Highway, in the vicinity of the BYU-Laie area operates at LOS "E" and a v/c ratio of 0.77. South of PCC, Kamehameha Highway operates at LOS "E" and a v/c ratio of 0.77.

The left turn movement from the Egg Farm Road to north bound Kamehameha Highway operate at LOS "E" during the projected PM peak hour. The Kamehameha Highway intersections at the north and south

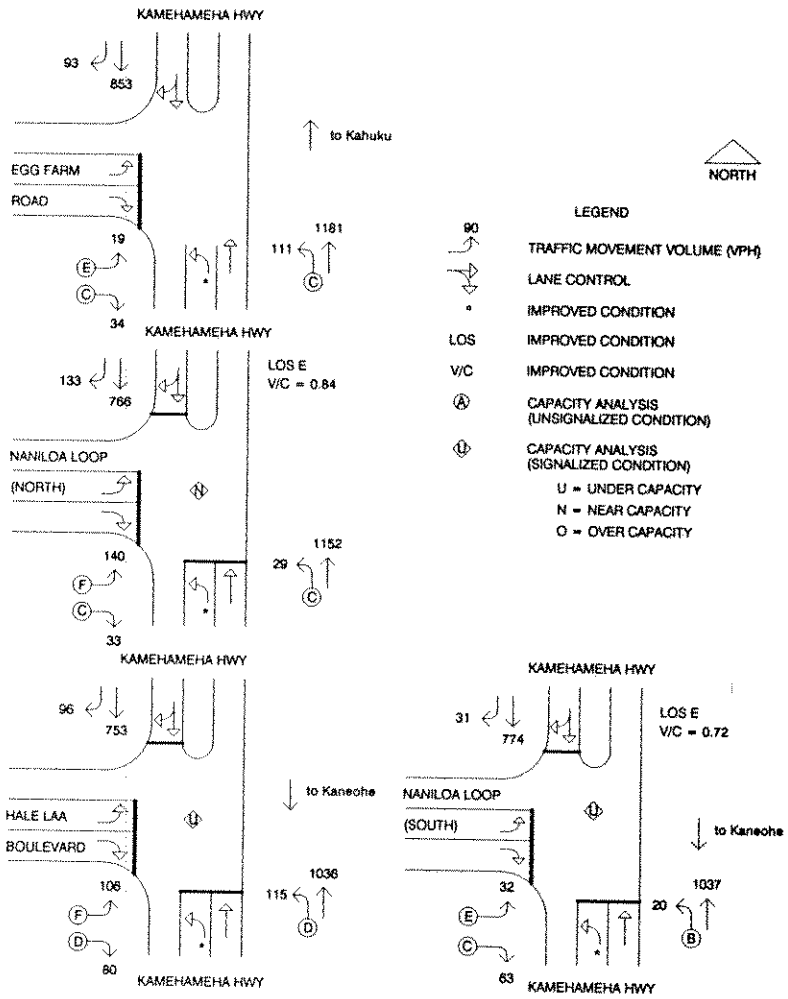


EXHIBIT 21-BYU MAUKA CUMULATIVE AM PEAK HR (BYU VICINITY)

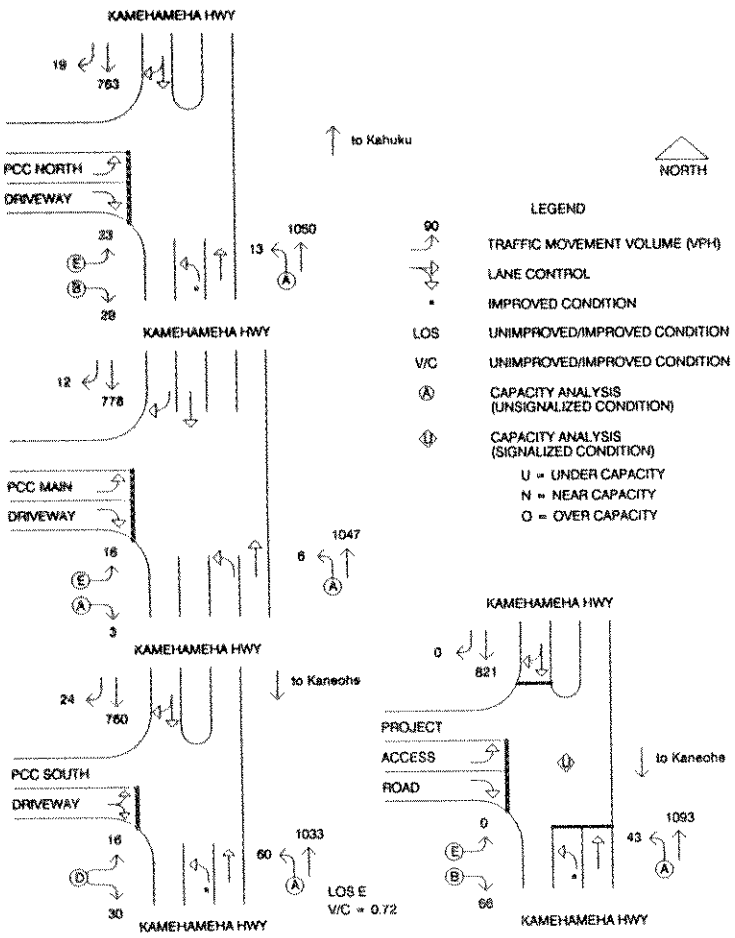


EXHIBIT 22-BYU MAUKA CUMULATIVE AM PEAK HR (PCC VICINITY)

junctions of Naniloa Loop and at Hale Laa Boulevard operate at near capacity conditions. The left turn movements from all the PCC driveway to north bound Kamehameha Highway operate at LOS "E" during the projected PM peak hour.

The proposed access road for BYU Mauka Alternative is expected to operate at LOS "D" at Kamehameha Highway, during the projected PM peak hour. A left turn lane on north bound Kamehameha Highway is warranted at the project access road, based upon the traffic volumes during the projected PM peak hour. Exhibits 23 and 24 show the cumulative PM peak hour traffic with the Development Plan Amendment projects and the results of the capacity analysis.

3. Saturday Peak Hour With the Development Plan Amendment Projects

Kamehameha Highway, between the north Naniloa Loop junction and the Egg Farm Road, operates at LOS "E" and v/c ratio of 0.83 during the Saturday peak hour with the Development Plan Amendment projects. Kamehameha Highway, in the vicinity of the BYU-Laie area operates at LOS "E" and a v/c ratio of 0.77. South of PCC, Kamehameha Highway operates at LOS "E" and a v/c ratio of 0.84.

The left turn movement from the Egg Farm Road to north bound Kamehameha Highway operate at LOS "E" during the projected Saturday peak hour. The north and south junctions of Naniloa Loop and Kamehameha Highway operate at near capacity conditions.

The left turn movements from the north and main PCC driveways to north bound Kamehameha Highway operate at LOS "E" during the projected Saturday peak hour. The PCC south driveway at Kamehameha Highway operates at LOS "D".

The proposed access road for BYU Mauka Alternative is expected to operate at LOS "D" at Kamehameha Highway, during the projected Saturday peak hour. A left turn lane on north bound Kamehameha Highway is warranted at the project access road, based upon the traffic volumes during the projected Saturday peak hour. Exhibits 25 and 26 show the cumulative Saturday peak hour traffic with the Development Plan Amendment projects and the results of the capacity analysis.

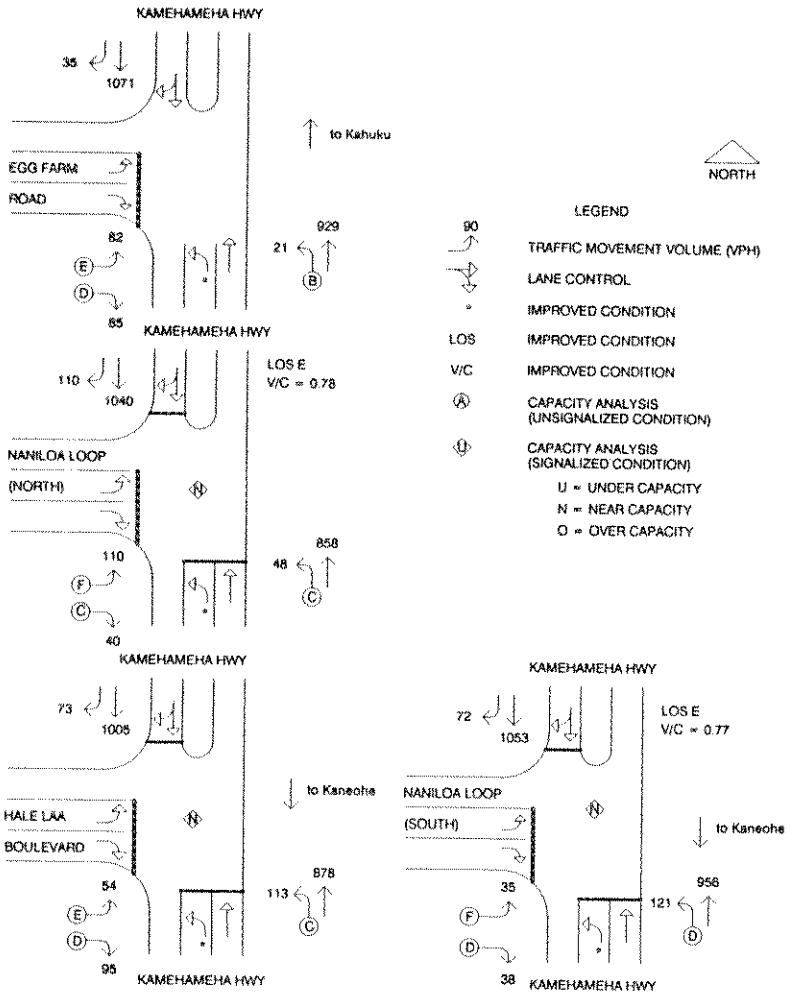


EXHIBIT 23-BYU MAUKA CUMULATIVE PM PEAK HR (BYU VICINITY)

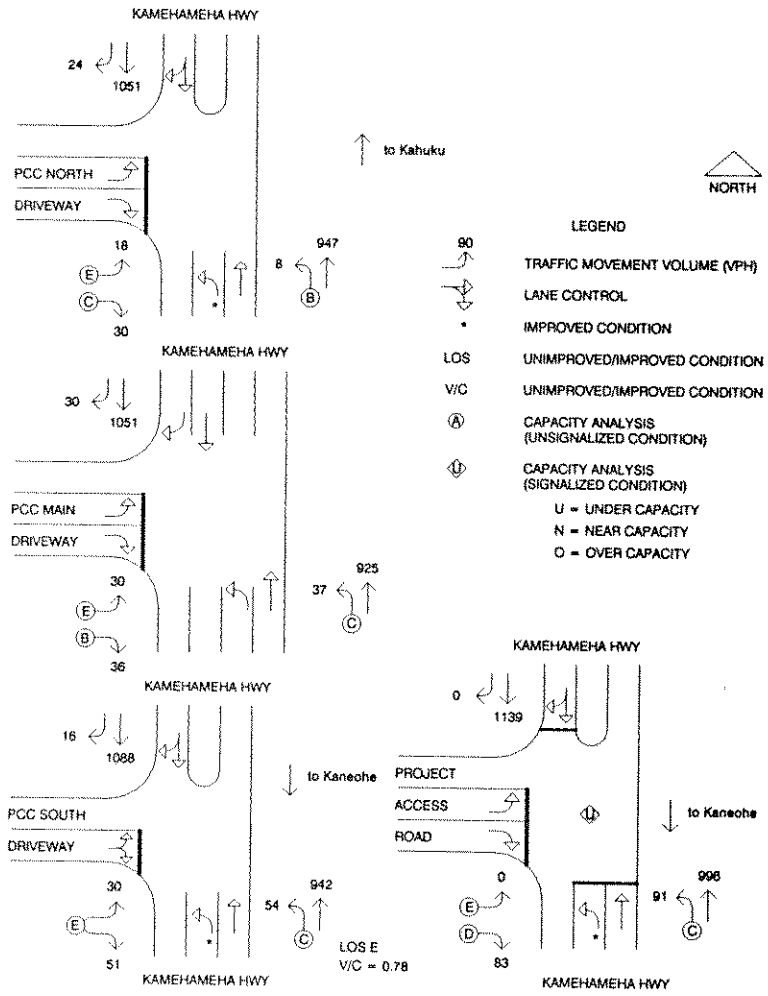


EXHIBIT 24-BYU MAUKA CUMULATIVE PM PEAK HR (PCC VICINITY)

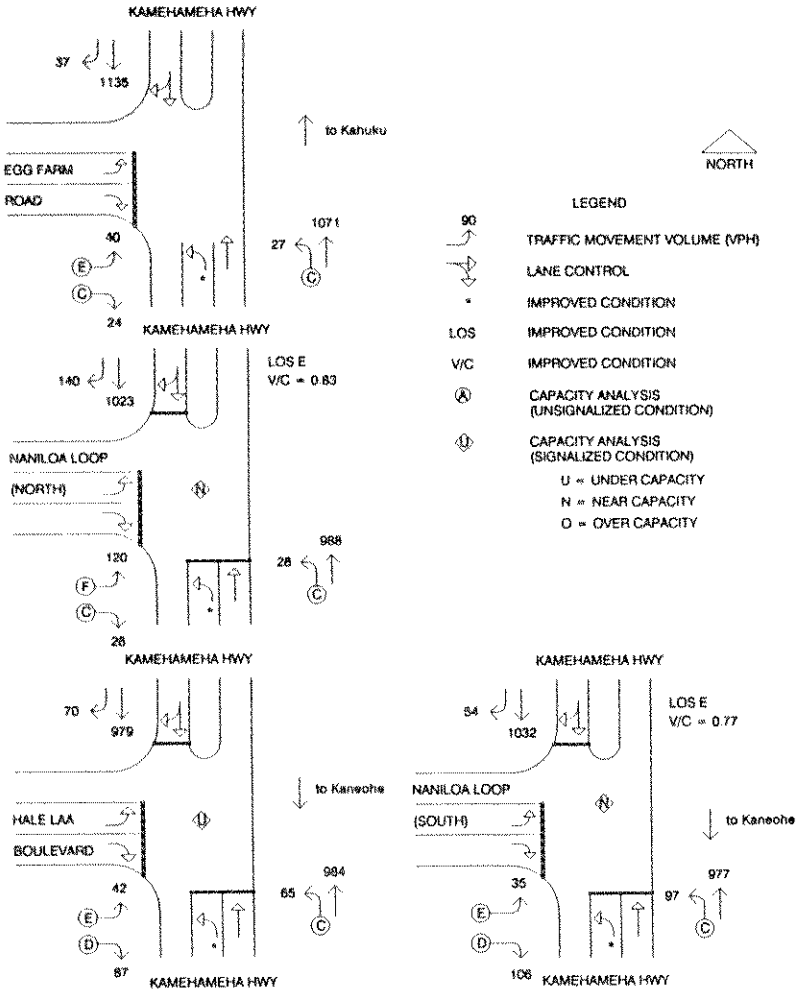


EXHIBIT 25-BYU MAUKA CUMULATIVE SAT PEAK HR (BYU VICINITY)

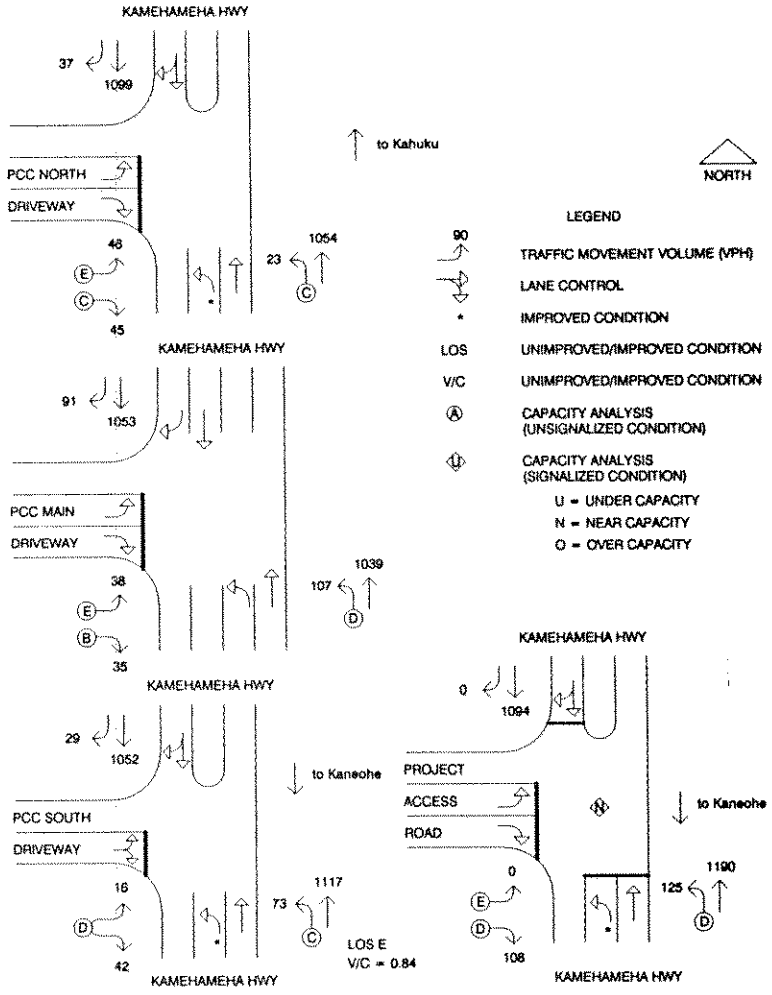


EXHIBIT 26-BYU MAUKA CUMULATIVE SAT PEAK HR (PCC VICINITY)

D. Laiemalo'o Alternative

1. Weekday AM Peak Hour With the Development Plan Amendment Projects

Kamehameha Highway, between the north Naniloa Loop junction and the Egg Farm Road, operates at LOS "E" and v/c ratio of 0.84 during the AM peak hour with the Development Plan Amendment projects. Kamehameha Highway in the vicinity of the BYU-Laie area operates at LOS "E"and a v/c ratio of 0.79. South of PCC, Kamehameha Highway operates at LOS "E" and a v/c ratio of 0.77.

The north junction of Naniloa Loop and Kamehameha Highway operates at near capacity conditions during the projected AM peak hour. The left turn movement from the Egg Farm Road operate at LOS "E".

The left turn movements from the PCC north and main driveways to north bound Kamehameha Highway operate at LOS "E" during the projected AM peak hour. The PCC south driveway at Kamehameha Highway operates at LOS "D".

The left turn movement from proposed access road for Laiemalo'o Alternative to north bound Kamehameha Highway is expected to operate at LOS "F", during the projected AM peak hour. A left turn lane on north bound Kamehameha Highway at the proposed project access road is warranted, based upon the cumulative AM peak hour traffic volumes. Exhibits 27 and 28 show the cumulative AM peak hour traffic volumes with the Development Plan Amendment projects and results of the capacity analysis.

2. Weekday PM Peak Hour With the Development Plan Amendment Projects

Kamehameha Highway, between the north Naniloa Loop junction and the Egg Farm Road, operates at LOS "E" and v/c ratio of 0.78 during the PM peak hour with the Development Plan Amendment projects. Kamehameha Highway, in the vicinity of the BYU-Laie area operates at LOS "E" and a v/c ratio of 0.81. South of PCC, Kamehameha Highway operates at LOS "E" and a v/c ratio of 0.85.

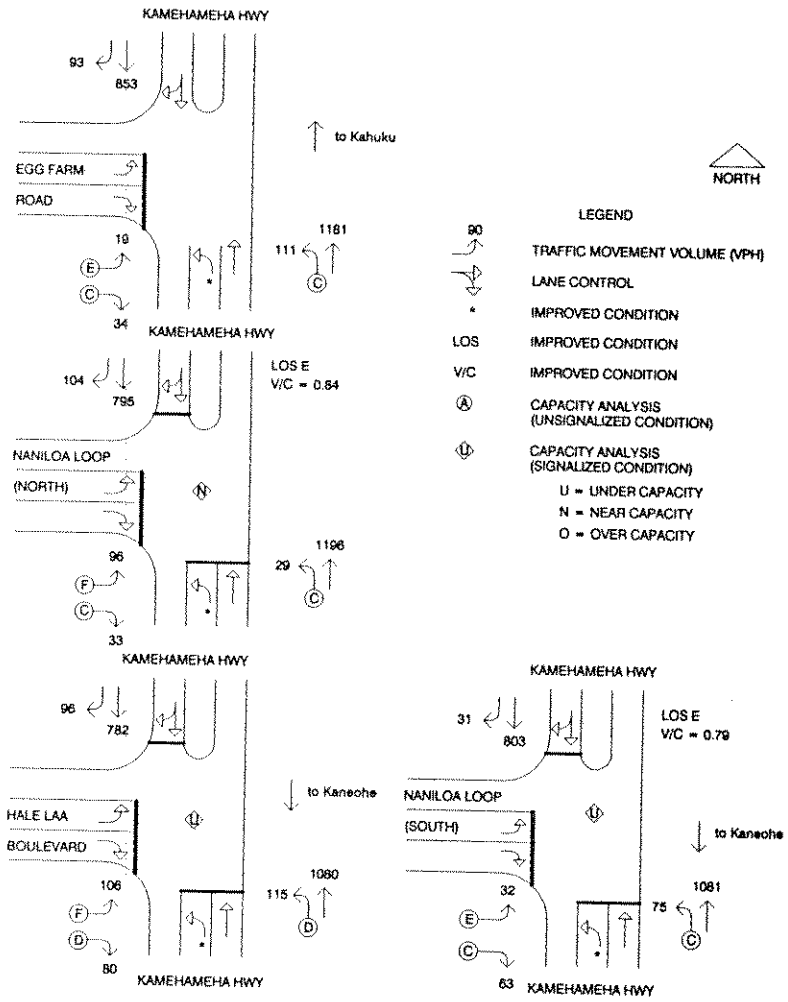


EXHIBIT 27-LAIEMALO'O CUMULATIVE AM PEAK HR (BYU VICINITY)

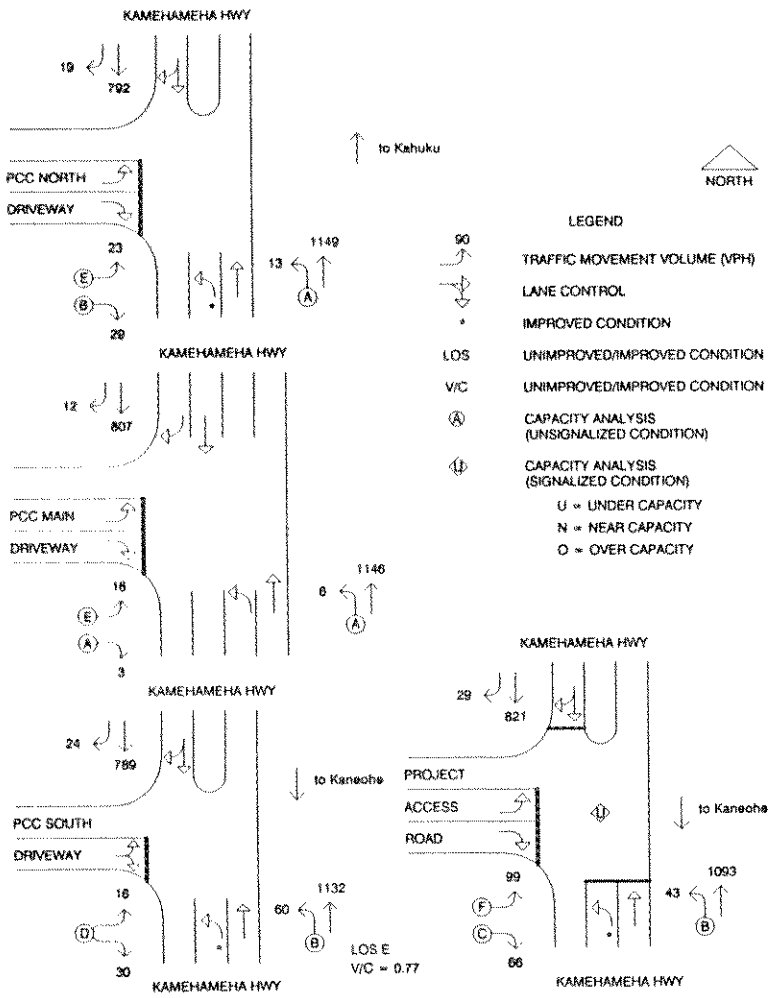


EXHIBIT 28-LAIEMALO'O CUMULATIVE AM PEAK HR (PCC VICINITY)

The left turn movement from the Egg Farm Road to north bound Kamehameha Highway operate at LOS "E" during the projected PM peak hour. The Kamehameha Highway intersections at the north and south junctions of Naniloa Loop and at Hale Laa Boulevard operate at near capacity conditions.

The left turn movements from all PCC Driveway to north bound Kamehameha Highway operate at LOS "E" during the projected PM peak hour. The left turn movement from proposed access road for Laiemalo'o Alternative to north bound Kamehameha Highway is expected to operate at LOS "E", during the projected PM peak hour. A left turn lane on north bound Kamehameha Highway is warranted at the project access road, based upon the traffic volumes during the projected PM peak hour. Exhibits 29 and 30 show the cumulative PM peak hour traffic with the Development Plan Amendment projects and the results of the capacity analysis.

3. **Saturday Peak Hour With the Development Plan Amendment Projects**

Kamehameha Highway, between the north Naniloa Loop junction and the Egg Farm Road, operates at LOS "E" and v/c ratio of 0.83 during the Saturday peak hour with the Development Plan Amendment projects. Kamehameha Highway, in the vicinity of the BYU-Laie area operates at LOS "E" and a v/c ratio of 0.83. South of PCC, Kamehameha Highway operates at LOS "E" and a v/c ratio of 0.90.

The left turn movement from the Egg Farm Road to north bound Kamehameha Highway operate at LOS "E" during the projected Saturday peak hour. The Kamehameha Highway intersections at the north and south junctions of Naniloa Loop operate at near capacity conditions during the PM peak hour.

The left turn movements from all PCC driveways to north bound Kamehameha Highway operate at LOS "E" during the projected Saturday peak hour. The left turn movement from north bound Kamehameha Highway to the PCC main driveway operates at LOS "D".

The left turn movement from the proposed access road for Laiemalo'o Alternative to north bound Kamehameha Highway is expected to operate at LOS "F", during the projected Saturday peak hour. The left turn movement

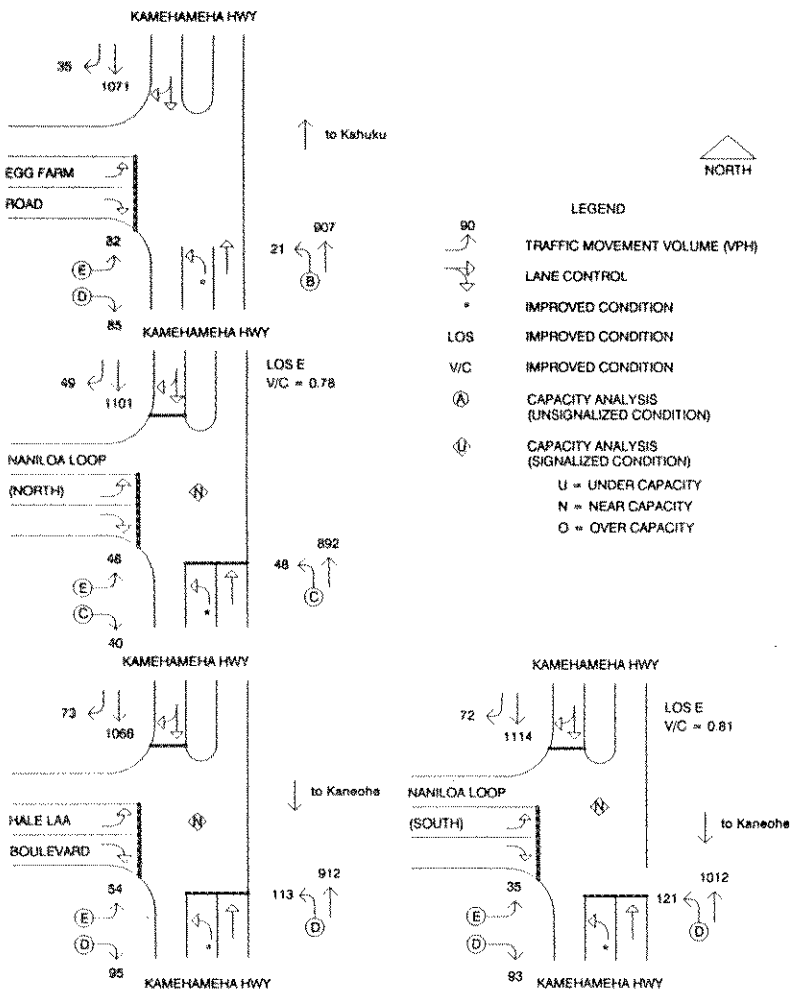


EXHIBIT 29-LAIEMALO'O CUMULATIVE PM PEAK HR (BYU VICINITY)

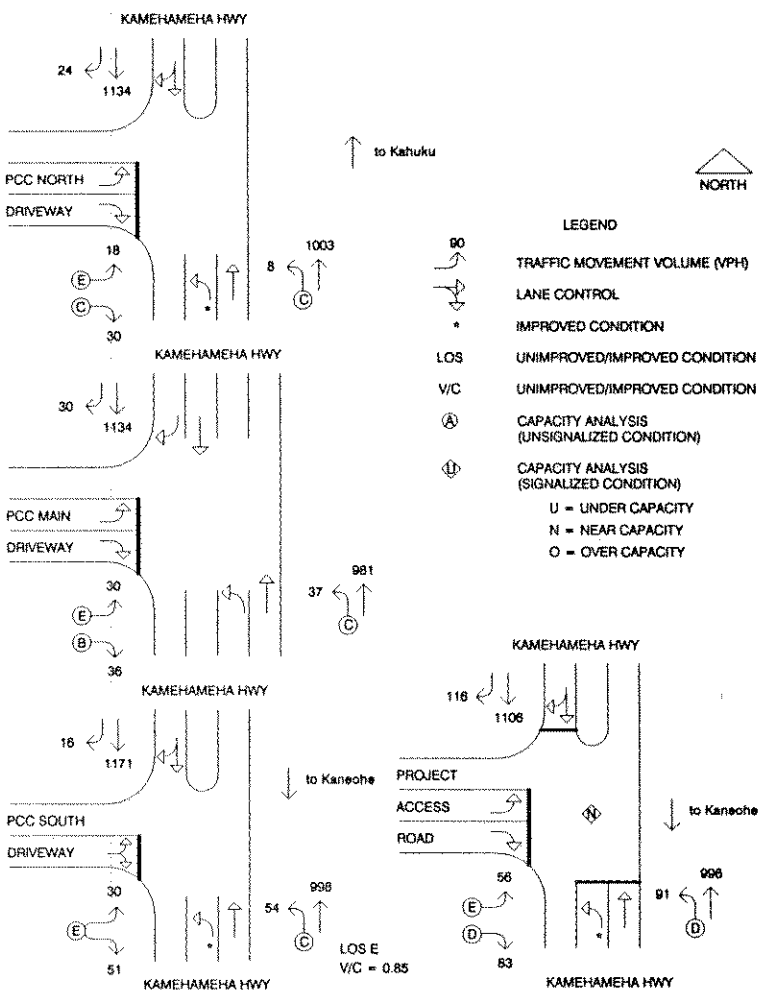


EXHIBIT 30-LAIEMALO'O CUMULATIVE PM PEAK HR (PCC VICINITY)

on north bound Kamehameha Highway to the project access road and the right turn movement from the project access road to south bound Kamehameha Highway would operate at LOS "D". A left turn lane on north bound Kamehameha Highway is warranted at the project access road, based upon the traffic volumes during the projected Saturday peak hour. Exhibits 31 and 32 show the cumulative Saturday peak hour traffic with the Development Plan Amendment projects and the results of the capacity analysis.

VII. ALTERNATIVES ANALYSIS

A. Highway Improvements Recommended to Mitigate Highway Deficiencies Expected Without the Proposed Development Plan Amendment Projects

1. Kamehameha Highway should be widened to provide 24 foot wide travel way and 6 foot wide paved shoulders on both sides of the road where right-of-way is available.
2. Consideration should be given to construct bus turnouts at bus stops on both sides of Kamehameha Highway where right-of-way is available.
3. Exclusive left turn lanes on north bound Kamehameha Highway should be constructed at the Egg Farm Road, the north and south junctions of Naniloa Loop, Hale Laa Boulevard, and the north and south driveways to PCC.
4. Traffic signals should be considered on Kamehameha Highway at its intersections with Hale Laa Boulevard and both the north and south junctions of Naniloa Loop, when they become warranted.
5. Naniloa Loop, at its south junction with Kamehameha Highway, should be widened to provide separate left and right turn lanes.

B. Highway Improvements Associated With the Egg Farm Alternative

1. Traffic signals should be constructed at the intersection of Kamehameha Highway and the Egg Farm Road, when warranted.
2. Consideration should be given to providing a secondary access to the Egg Farm residential site by extending a road from the Egg Farm Road to the existing roadway network in the BYU-Laie area.
3. An exclusive right turn lane should be constructed on south bound Kamehameha Highway at the south leg of Naniloa Loop.

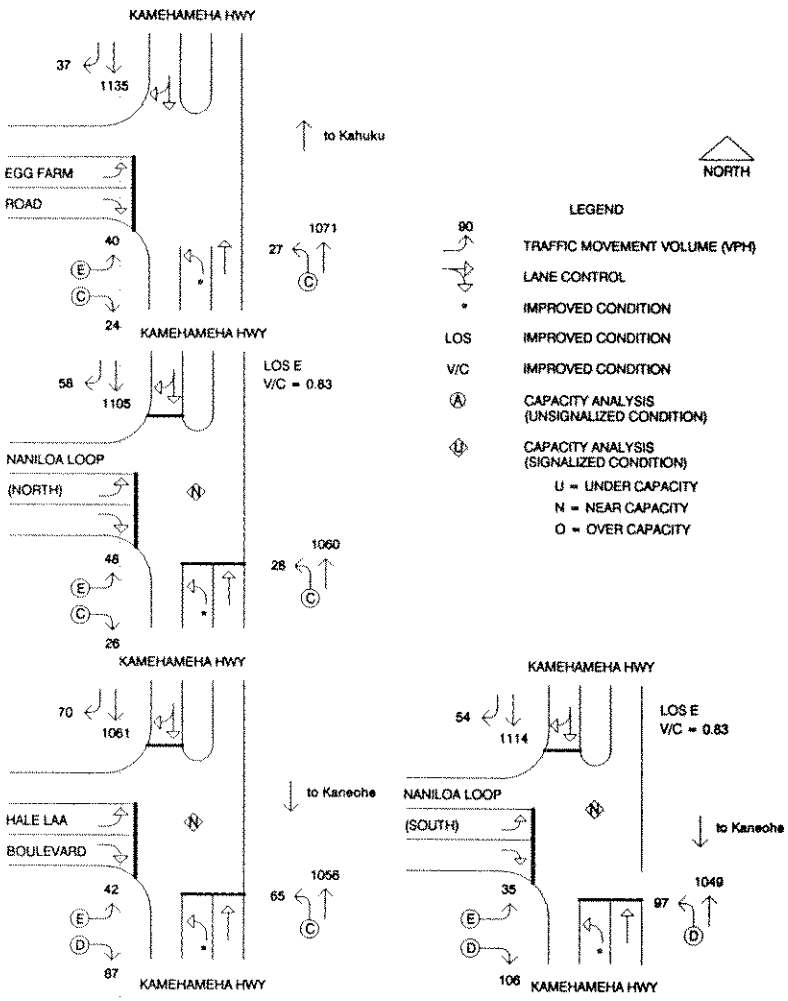


EXHIBIT 31-LAIEMALO'O CUMULATIVE SAT PEAK HR(BYU VICINITY)

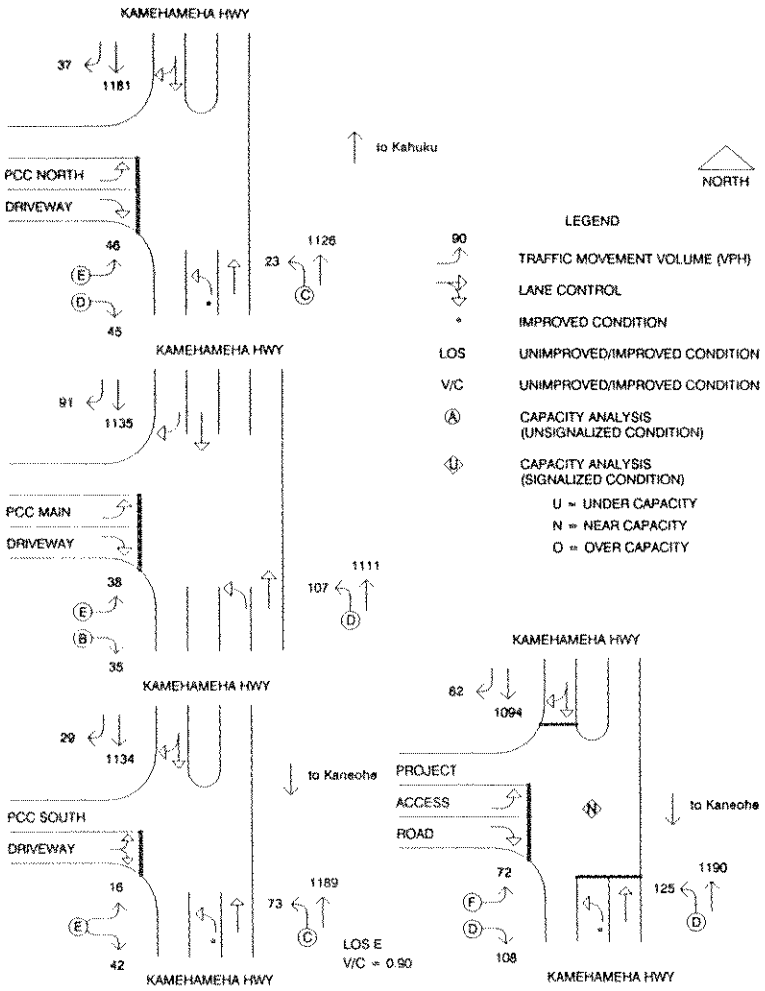


EXHIBIT 32-LAIEMALO'O CUMULATIVE SAT PEAK HR(PCC VICINITY)

C. Highway Improvements Associated With the BYU Mauka Alternative

1. Traffic signals should be constructed at the intersection between the project access road and Kamehameha Highway, when warranted.
2. A left turn lane on north bound Kamehameha Highway should be constructed at the project access road.

D. Highway Improvements Associated With the Laiemalo'o Alternative

1. Traffic signals should be constructed at the intersection between the project access road and Kamehameha Highway, when warranted.
2. A left turn lane on north bound Kamehameha Highway should be constructed at the project access road.
3. Consideration should be given to providing a secondary access to the Laiemalo'o site.
4. The proposed school should be developed to provide adequate traffic circulation, parking, and drop off/pick up areas within the site, so as not to disrupt traffic flow on Kamehameha Highway.

E. Traffic Management Alternatives

1. A shuttle bus service between the study area and Kuilima Resort should be considered. The shuttle bus could transport employees during the commuter periods and visitors during the rest of the day. During the peak visitor season, the visitor shuttle bus service could be expanded to Haleiwa Town and possibly to Waikiki.
2. An employee van pool should be encouraged between the Kuilima Resort and the residential areas of Laie.
3. TheBus routes should be extended to provide service to the Egg Farm and BYU Mauka alternative residential sites.

VIII. CONCLUSIONS

A. General

This study has taken a conservative approach throughout the analysis. The proposed projects in the region were assumed to be built out and occupied by the planning horizon year for this study. Some of the trips originating from the

Kuilima Resort would be destined for PCC. Similarly, the traffic originating from the proposed residential development can be expected to be the same employee trips generated by Kuilima. However in this analysis, the traffic generated from these developments are analyzed independently.

The recommended highway improvements proposed herein are expected to mitigate the traffic impacts resulting from the development of the proposed Laie Development Plan Amendment projects. The traffic management alternatives could mitigate the traffic impacts identified in this study and should be pursued aggressively through a joint effort between government and the private sector.

B. Alternative Residential Locations

Among the three residential alternatives, the BYU Mauka Alternative is the least disruptive to traffic on Kamehameha Highway within the study area. Traffic generated by the BYU Mauka residential project is diverted around PCC and BYU via the proposed loop road.

The Laiemalo'o Alternative probably would be the most disruptive to Kamehameha Highway traffic, because of its proximity to Kamehameha Highway. The traffic and pedestrian impacts resulting from the elementary school are expected to cause short term slow downs on Kamehameha Highway before and after school.

The Kamehameha Highway access for the Egg Farm Alternative would concentrate the traffic generated by the 450 dwelling units, a school, a light industrial development, and a golf course along a single access road on Kamehameha Highway. This limited access also raises a concern during an emergency, when the Egg Farm Road is closed.

C. Regional Traffic

The most significant regional traffic impact is expected to result from the development of the Kuilima Resort. According to the Kuilima Resort developer, the master plan expansion is about two years behind schedule at this writing. The near term economic outlook could result in further delay in the development of the Kuilima Resort Master Plan. The pace of development would have a significant effect on determining when future highway deficiencies can be expected. The proposed Puamano and Malaekahana Golf Courses have not progressed beyond the submittal of an environmental impact statement.

THE TRAFFIC MANAGEMENT CONSULTANT
Randall S. Okaneku, P. E., Principal • 1188 Bishop Street • Suite 1907 • Honolulu, Hawaii 96813
Telephone: (808) 536-0223 • Facsimile: (808) 537-2985

April 7, 1992
Job No. 9130

Group 70 International
924 Bethel Street
Honolulu, Hawaii 96813

Attention: Ms. Kari Kilstrom

Ladies and Gentlemen:

Subject: Laie Development Plan Amendments

Per your request, I have revised the traffic impact analysis for the BYU Mauka Alternative without the proposed Puamano and Malaekahana Golf Courses. Exhibits S-1 through S-6 show the results of the analysis. The information contained herein is intended to supplement the "Traffic Impact Analysis Report on the Proposed Laie Development Plan Amendments" (TIAR), dated April 7, 1992.

During the AM peak hour the v/c ratios on Kamehameha Highway are improved (lowered) by about 2% to 3% over the analysis contained in TIAR. During the PM peak hour the v/c ratios on Kamehameha Highway improve by about 1%. During the Saturday peak hour the v/c ratios on Kamehameha Highway are about 2% lower. The intersection of Kamehameha Highway and the project access road is improved from "near capacity" to "under capacity" for signalized conditions.

If you require clarification on any of the above matters or have any other questions, please do not hesitate to call me.

Very Truly Yours,

The Traffic Management Consultant

By

Randall S. Okaneku, P. E.
Principal

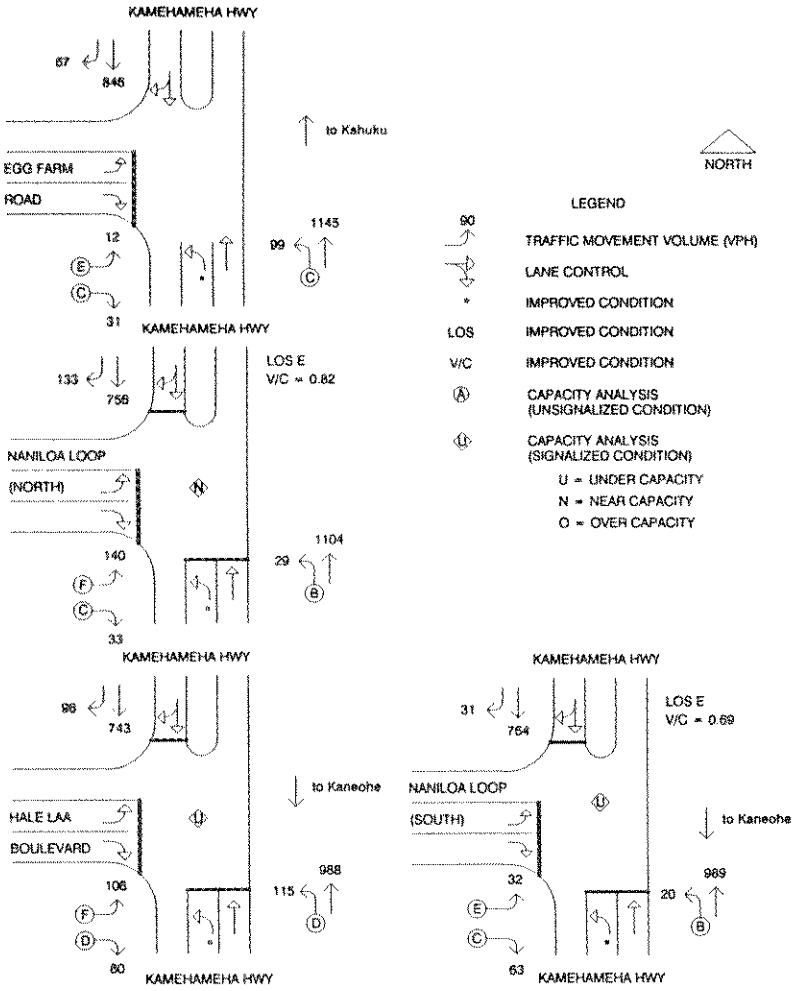
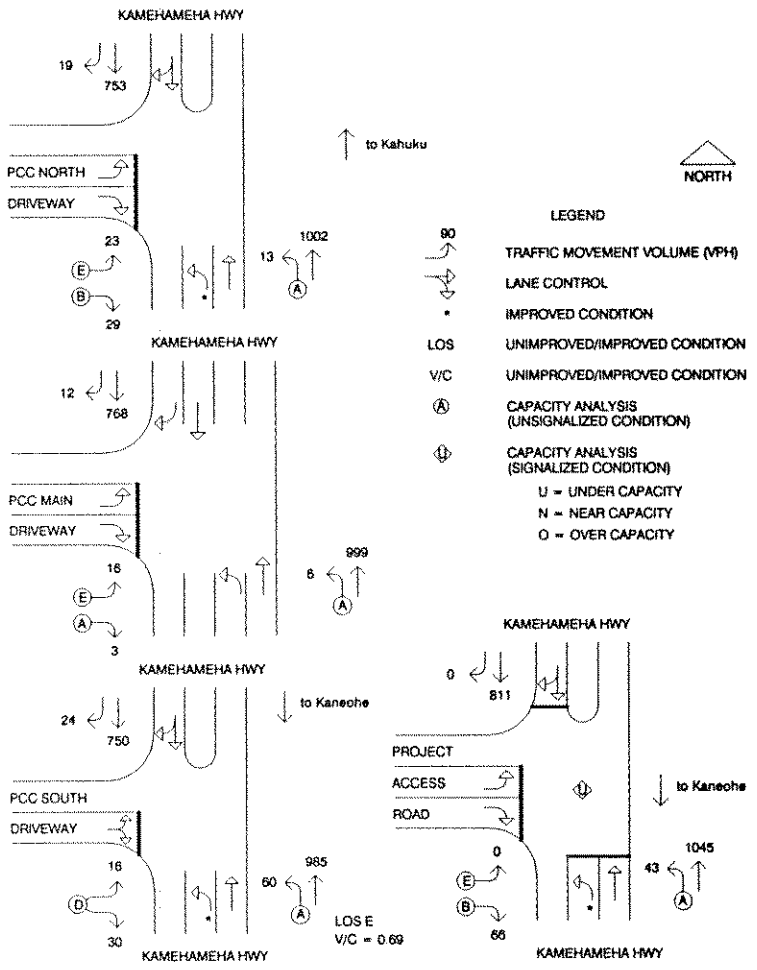


EXHIBIT S-1 BYU MAUKA AM PEAK HOUR TRAFFIC (BYU VICINITY)



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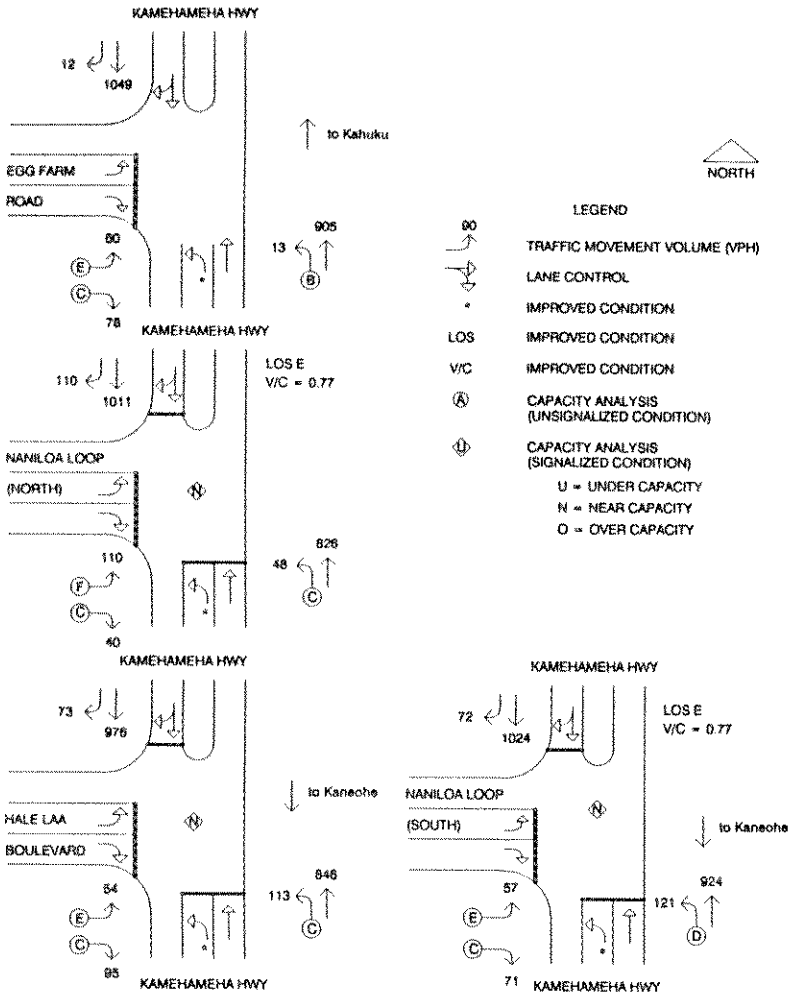

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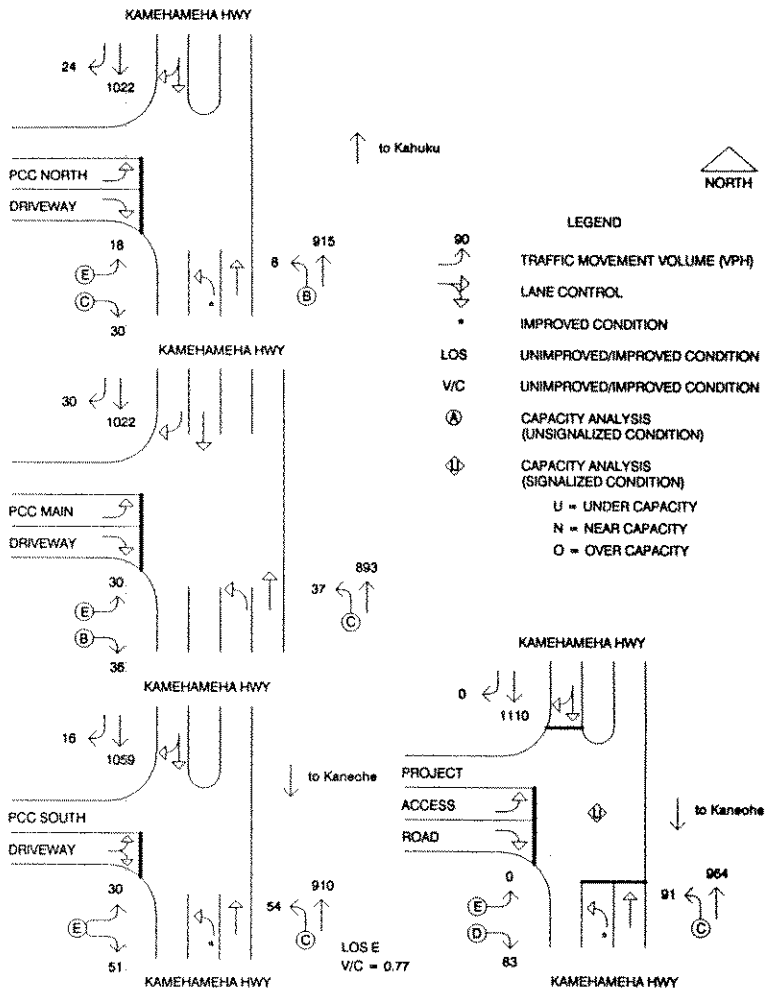

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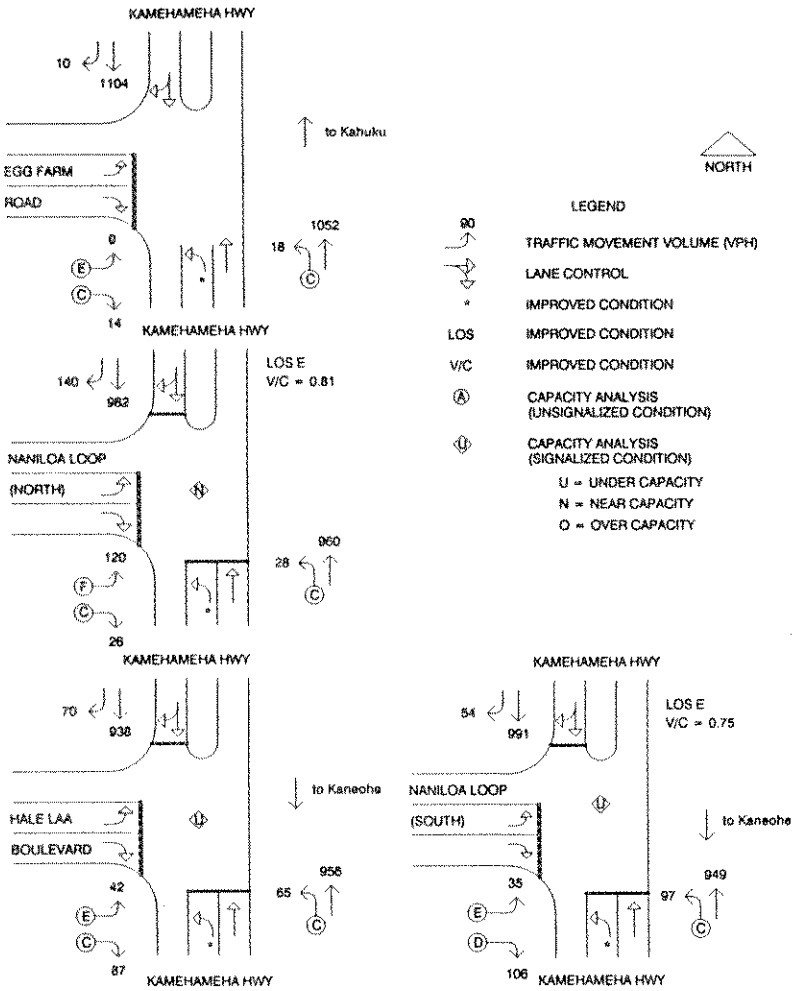

EXHIBIT S-5 BYU MAUKA SAT PEAK HR TRAFFIC (BYU VICINITY)

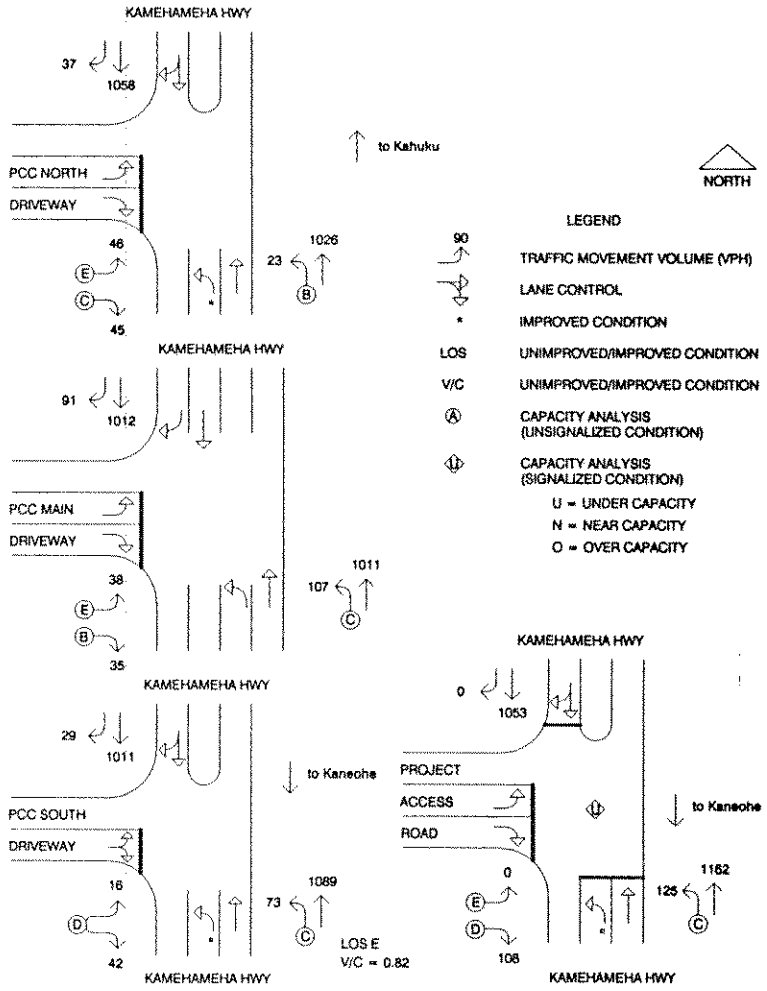

EXHIBIT S-6 BYU MAUKA SAT PEAK HR TRAFFIC (PCC VICINITY)

APPENDIX L

A SURVEY OF LAIE COMMUNITY NEEDS

Volume I: Results

-- May 1987

Prepared for:

Zions Securities, Inc.

Prepared by:

Community Resources, Inc.

SURVEY HIGHLIGHTS

- **Sample and Purpose:** This report contains results of a door-to-door survey of 225 Laie households (approximately 30 percent of all occupied residential homes, excluding student dormitories). The survey's purpose was to gather resident input on issues important for the new Laie Master Plan being prepared by Zions Securities and its consultant, Group 70.

- **New Stores or Businesses Desired for Laie:** A majority of residents said each of seven possible new stores/businesses represent at least "important" needs. However, the item receiving the most "very important" responses was a supermarket, followed by a home improvement and a drug store. A follow-up question asked about items not on the list, and the most common type of response had to do with restaurants, particularly fast-food operations.

- **Parks and Recreation Needs:** Items with the highest priority ratings were those oriented to youth and/or active recreation: teen recreation center; community park with sports fields; and community swimming pool.

- **Highway and Street Problems:** The only highway item considered a problem by most Laie residents was the lack of street lighting on the road between Laie and Kahuku. There was a higher level of concern over internal street problems -- lack of sidewalks on busy streets, street maintenance, and (particularly for older people) speeding on the streets.

- **Willingness to Pay for Improvements:** If Laie residents must bear the full cost of either (1) improving internal streets or (2) sewer line hook-ups, the average assessment with interest would amount to $150/month for each of these projects. But 82 percent of respondents said they would be unable or unwilling to pay this much for either project.

- **Attitudes Toward Zions' Rates/Services -- Sewer and Water:** Majorities or pluralities said fees are reasonable and Zions has been doing a good job in terms of service. However, satisfaction is higher in regard to water than sewer service.

- **Land Use, Employment, and Housing Development:** Majorities of Laie residents care more about both jobs and affordable housing than about keeping Laie "like it is now," and they would support a light industrial area. There is substantial support for housing aimed at senior citizens or low-income residents (including low-rise apartments or townhouses.)

  However, there is substantial opposition to high-rise apartments or more expensive housing and to any development of beaches, parks, or Church-owned facilities such as areas around the Temple or BYU. Thus, Laie residents desire for new development would appear to be contingent on assurance of direct benefit for current residents.

(Continued)

SURVEY HIGHLIGHTS
(Continued)

- **Housing:** Laie households are much more crowded than is the case for Oahu as a whole, and 36 percent have someone who would move out if more affordable homes were available. The people moving out would require 1.4 homes apiece, suggesting a "pent-up demand" in Laie for some 360 units. However, given the low household incomes of those needing new units (median $20,500/year), the realistic need for most would appear to be rental rather than fee-simple units.

- **Overall Desired Level of Growth in Laie Housing Units:** Given a benchmark of about 900 housing units currently in Laie (including vacation rentals, vacancies, etc.), residents were asked how many housing units they would like to see in Laie 20 years from now.

  The median response was "about 1,200 homes," which is roughly consistent with the current level of pent-up demand for new affordable homes. A majority of residents answered either 1,200 homes or higher. However, a substantial minority either wanted to keep Laie at roughly its present size or else said their answers would depend on the type of people or type of housing unit. Thus, it cannot be said that there is a total community consensus on the growth issue.

- **Demographics:** Overall, demographic variables measured in this survey (primarily age, sex, length of residence, and location of residence within Laie) were not important predictors of attitudes. For example, Beach area residents were somewhat more likely than others to want to keep Laie like it is now, but not dramatically so (since there is substantial crowding even among Beach area households).

  Perhaps the major demographic difference which emerged was that young people and/or relative newcomers to Laie have to bear more of the burden of the present housing shortage, as indicated by household crowding. In addition to grown children living with parents, the survey data imply what Community Association members also report, which is that many families of adults in their 30's and 40's are sharing homes in order to make ends meet.

ACKNOWLEDGMENTS

While Community Resources, Inc. was solely responsible for the final survey questionnaire, we are grateful to numerous individuals for helping to shape and review the instrument:

Laie Community Association -- Junior Ah You, Joe Bruey, Lucky Foanimoana, and Roger McKenzie.

Group 70 -- Ralph Portmore and Vincent Shigekuni.

Zions Securities -- Marvin Stone.

We are particularly grateful to the interviewers, all from BYU-Hawaii, without whom the project could not have been completed:

David Chase
Janet Feinga
Mele Funaki
Craig Jones
Michael Nielson
Halaevalu Ofahengaue
Frank Pueringer
Lose Uluave

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(Note: Part IV of Vol. I consists entirely of tables of overall results. Also, Appendix B in Vol. II consists entirely of tables of cross-tabulations.)

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II. METHODOLOGY

COMMUNITY RESOURCES, INC. was retained by Zions Securities to consult with community members, design the instrument, and analyze results in this report. Community Resources subcontracted with DATAMETRIC RESEARCH for data collection and computerized analysis. The following methodology was adapted by the two firms working in conjunction with one another, the client, and the community.

A. Survey Instrument

Community Resources designed the survey instrument (attached as Appendix C) in the course of a series of meetings with, and reviews by, Laie Community Association members, Group 70 planners, Datametric, and Zions Securities.

The procedure began with an initial meeting in Laie during which all parties listed possible questions. Community Resources returned with an initial draft encompassing all the suggested topics, and the subsequent task was to select the most important and/or feasible questions for the final instrument.

B. Interviewer Selection and Training

At the suggestion of the Laie Community Association, interviewers were hired from the community itself. Community association members helped post ads throughout the area, and nine students of the Brigham Young University at Hawaii (BUY-Hawaii) responded and actually participated in this study.

The nine student interviewers (see "Acknowledgments" page for names) represented a multi-ethnic team -- including persons of Tongan and Samoan ancestry with capability to speak those languages.

There were three training sessions conducted at the student activities center (Aloha Center) on the BYU-Hawaii campus. The first session was conducted at 7 p.m. Tuesday, April 28, 1987, and the second and third sessions were held the afternoon and evening of the following day.

Each training session lasted approximately 90 minutes and covered door-to-door interviewing techniques, sampling procedures, and the survey instrument on a question by question basis.

C. Data Collection

Door-to-door in-person interviews were conducted between the hours of 9 a.m. to 9 p.m. on weekdays and weekends. These hours were selected to accommodate the significant numbers of Laie residents employed at the Polynesian Cultural Center (PCC) between the hours of 2 p.m. and 10 p.m., Monday to Saturday.

All interviews were conducted between April 29 and May 7, 1987.

Interviewers were supervised by Datametric Research staff throughout the fielding phase. Each interviewer's work was reviewed periodically to assure proper study administration. Upon completion of the study, at least 20 percent of each interviewer's work was verified by contacting original respondents by telephone.

(NOTE: All respondents were assured that their names and comments would be totally confidential. To permit verification of interviewers' work, first names only and phone numbers were recorded, but even these have not been passed along to the client, the Laie Community Association, or anyone else.)

In general, this survey was one of the smoothest ever administered by either Community Resources or Datametric Research. Laie residents were extremely friendly and cooperative. Only two households declined to participate, an abnormally low refusal rate. Language problems were minimal. Four interviews were conducted in Tongan. In all other households, interviews were conducted with (or with the aid of) some English-speaking member.

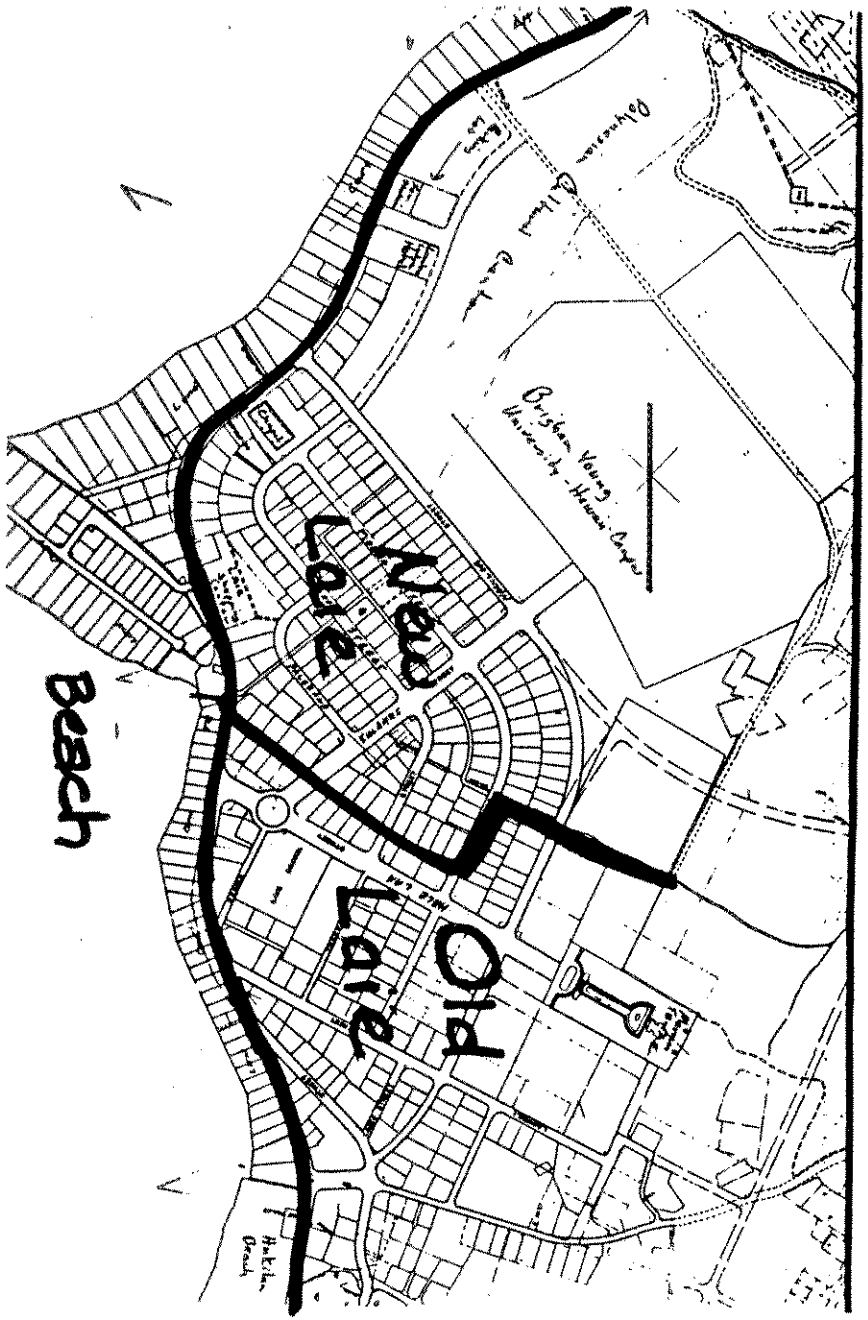
D. Sample Size, Procedures, and Accuracy

A sample size of 225 households was selected. The study employed a simple cluster sample drawn by Datametric Research. A City and County of Honolulu Department of General Planning "Existing Land Use Map" for Kahuku-Laie -- along with corresponding Tax Map Key plat maps -- served as the initial base for drawing the sample.

The area selected for sampling comprised the entire town of Laie, including married student housing, the beach areas, and a few scattered homes in the valley. Excluded, however, were BYU-Hawaii on-campus dormitories. Interviewers recorded the area of Laie in which each interview was taken -- "Old Laie," "New Laie," or "Beach area" -- according to the attached map.

Field verification of the sample revealed that many vacation retnals, abandoned/vacant dwellings, and demolished units were included in the original sample maps. Furthermore, newly constructed and occupied homes were <u>not</u> included in the original sample. Adjusting for these discrepancies, the final sample was drawn and recorded on plat maps so that interviewers would have a relatively easy time locating the correct house.

The fieldwork indicated Laie has approximately 725 occupied full-time residential units qualifying for this study. Therefore, the sample of 225 included about 30 percent of Laie units, resulting in a sampling error of only about ± five percent. (Surveys also contain unmeasurable "non-sampling error," and errors would be higher for particular groups, such as Beach area residents alone.)



E. Data Processing

All completed interviews were edited and coded by Datametric professional staff. Community Resources and Datametric determined appropriate codes for responses to the survey's two open-ended questions. Data were then computer-entered and verified.

Frequency distributions were generated for all items, and each of the substantive survey questions was cross-tabulated by each of the five demographic items. Results of these computations form the basis for the following analysis.

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III. RESULTS -- DISCUSSION

Part IV of this report contains complete tables of results for each question posed in the survey questionnaire (which is reproduced at the end of this report, in Appendix C). Additionally, Appendix B contains results of cross-tabulating each substantive question by five demographic variables (length of residency in Laie, age, sex, status in household, and area in Laie).

The following discussion presents highlights of results, as well as some interpretive comments.

A. New Stores or Businesses Desired for Laie

The survey began with two questions about possible additional stores or businesses desired for Laie. The first question asked respondents to rate the importance of eight different categories of potential new retail activities -- "not important," "important," or "very important."

While all eight items were rated at least as "important," clearly the most important of these eight items was a supermarket, ranked "very important" by almost half the respondents and "not important" by only 19 percent:

	"Very Important" %	"Important OR "Very Important" %
SUPERMARKET	45	81
HOME IMPROVEMENT STORE, LIKE CITY MILL	27	78
DRUG STORE	22	65
AUTO REPAIR SHOP	19	61
DRY CLEANING STORE	16	56
RADIO / TV SHOP	12	57
MEN'S BARBERSHOP	11	55

A follow-up question asked if respondents could think of any other stores or businesses not on the above list which would be useful for Laie. People answered this question in their own words, and responses were later coded into categories.

One-half the respondents could think of no additional type of business needed in Laie. Of those who did volunteer some answer, nearly one-third mentioned either "restaurants" or some type of fast-food operation such as McDonald's. Clothing or fabric stores were the next most-often named:

	PERCENT MENTIONING %
RESTAURANTS / FAST FOODS	30
CLOTHING STORES / FABRIC STORES	21
SHOPPING MALLS / DEPARTMENT STORES	17

(Base = 112 people who gave some response. See Part IV for complete percentage results and Appendix A for verbatim listing of responses to this question, Question #2.)

Comments: Overall results for these two questions suggest that the major need for new Laie retail operations involves operations with a variety of merchandise (supermarkets, home improvement stores) as opposed to specialty stores. However, even businesses as specialized as men's barbershops are acknowledged by a majority as at least fairly important.

In terms of specific products, food (supermarkets, eating places) is clearly the most important item, followed by everyday household needs (home improvement, clothing, drug store).

In the case of food, cost is likely a major consideration. Food prices are high throughout Hawaii, but particularly so in rural areas such as Laie. Many of the respondents asking for eating places specifically mentioned inexpensive fast-food operations rather than fine-dining opportunities. (At present, there is only one fast-food operation in Laie, a McDonald's, following the recent closure of an A & W chain outlet.)

For everyday household or garden needs, there is also the dimension of convenience, since it is frustrating to drive 15 or 30 miles for simple purchases such as tools or clothing.

Demographics: As indicated in Appendix B, people who lived in Laie for just 2 - 5 years were usually a little more likely than other respondents to say all suggested stores or businesses represent a "very important" need. To a slightly lesser extent, this was also true of people living in Laie 6 - 10 years. Newcomers and very longtime residents of Laie were less likely to feel strongly concerned about the proposed stores or businesses.

There was also a fairly consistent (and perhaps related) age pattern: respondents in their 30's were more likely than others to say almost all the listed stores would be "very important," while people aged more than 65 were generally least concerned (although senior citizens did want a supermarket as much or more than other age groups).

Females were generally a little less concerned about getting new stores or businesses of any type in Laie. The gender gap was greatest for a radio/TV shop, considered "not important" by 49 percent of females but just 29 percent of males.

There was little strong or consistent patterns to distinguish among people according to household status or where they lived in Laie.

B. Laie Parks and Recreation Needs

The third survey question asked about residents' evaluations (again in terms of "not important," "important," or "very important") of seven possible parks or recreation needs for Laie.

Results again fell into a fairly clear pattern:

	"Very Important" %	"Important OR "Very Important" %
A COMMUNITY RECREATION CENTER FOR TEEN-AGERS	49	89
A COMMUNITY PARK FOR PLAYING GAMES LIKE SOCCER OR BASEBALL	38	81
A COMMUNITY SWIMMING POOL	33	72
A MOUNTAIN PARK FOR CAMPING AND PICNICS	25	75
A COMMUNITY CENTER FOR MEETINGS AND PARTIES	24	73
MORE RIGHTS-OF-WAY TO THE OCEAN IN PLACES WHERE THERE ARE NO PARKS	22	58
MORE BEACH CAMPING AND PICNIC AREAS	16	48

While a majority of respondents said all the recreational needs (with the exception of additional beach camping/picnic areas) were at least "important," it may be noted that only the first three of the foregoing items elicited the stronger response of "very important" from a third or more of the respondents, with the teen recreation center by far the most important.

Comments: The pattern of responses makes it clear that Laie's priorities are for improved facilities relating to active and/or youth-oriented recreation -- teen center, sports playing fields, and community swimming pool.

There is less perceived need for additional passive, nature-oriented recreational experiences and facilities. However, the apparent low priority given to shoreline access and beach parks should not be misinterpreted as lack of concern for these resources, since a later question on where not to permit development was most frequently answered in terms of beach areas. Rather, there is simply not a strong desire for more ocean or shoreline-oriented recreational facilities than currently exist.

Demographics: As detailed in the figures of Appendix B, there is some tendency for people to become more and more concerned about the need for a teen-oriented recreation center as they live in Laie for more years.

Overall, however, the demographic figures do not indicate different priorities for different groups. Rather, such patterns as exist have more to do with tendency to consider all items "very important." The strongest such pattern was that people aged 31 - 40 were generally more likely than other groups to say all seven items were "very important." (One exception was, again, the teen-oriented recreation center, where there was even more interest among people in their 40's, who are perhaps the most likely group in Laie to have teen-aged children.)

C. Highway and Street Problems in Laie

Survey questions #4 and #5 asked about the importance of a number of possible problems relating to, respectively, the Kamehameha Highway through Laie and internal Laie town streets. For each question, the possible response categories were "no problem," a "problem," or a "big problem."

Local government has recently repaired some longstanding Kamehameha Highway problems in Laie (e.g., potholes), and there is apparently now a general satisfaction with highway conditions. Of the four possible highway "problems" listed, a majority of residents said three were "not a problem" at all.

The only highway issue of major concern was the lack of street lighting on the highway between Laie and Kahuku. One-third said this is a "problem," and another third said "big problem."

	"Big Problem" %	"Problem" OR "Big Problem" %
NO STREET LIGHTING ON HIGHWAY BETWEEN LAIE AND KAHUKU	33	66
BEING ABLE TO GET ON AND OFF THE HIGHWAY	15	43
HIGHWAY TRAFFIC GOES TOO FAST	12	32
HIGHWAY TRAFFIC GOES TOO SLOW	10	38

By contrast, street lighting was the least important of the listed problems for Laie's internal streets, and it was the only item for which half the respondents said "no problem." For the off-highway streets, the key concerns were lack of sidewalks on the major streets and need for repairs and maintenance.

	"Big Problem" %	"Problem" OR "Big Problem" %
NO SIDEWALKS ON BUSY STREETS	38	76
FIXING THINGS LIKE POTHOLES, FADED STRIPES, AND OLD PAVING	28	83
SPEEDING	24	65
STREETS NOT WIDE ENOUGH	23	56
STREET LIGHTS	17	46

Comments: Laie residents appear relatively more concerned about problems in their internal street system than on the highway through town. For the four highway problems, all but one were rated "not a problem" by the majority. But only one of the five internal street problems was considered "not a problem" by the majority.

Highway congestion -- sometimes perceived as a problem by non-Laie residents due to tour bus caravans to or from the Polynesian Cultural Center -- is apparently not a major concern in Laie itself, as evidenced by the small number of people saying that slow traffic or being able to get on/off the highway represents a "big problem." In fact, fast traffic was a little more often seen as a big problem than slow traffic, and groups which were more likely to complain about getting on/off the highway were also more likely to complain about fast, not slow, traffic.

Demographics: Beach area residents (and, to a lesser extent, females) were somewhat more likely than other residents to be concerned about both getting on/off the highway and also fast traffic. Additionally, females were more likely than males (40 percent vs. 20 percent) to say lack of lighting between Laie and Kahuku represents a "big problem."

For the internal street problems, age and area of residence within Laie had some effect on answers. Residents of "Old Laie" were the most concerned about narrow streets and streets in need of repair. Beach area residents were least concerned about these problems, and beach residents were also unconcerned with street lighting on the internal streets. Speeding on internal streets was the dominant concern for people in their 50's and 60's, while the lack of sidewalks on busy streets was a particularly strong issue for people in their 30's. (See detailed figures in Appendix B.)

D. Willingness to Pay for Improvements

The next several questions dealt with residents' willingness to participate in improvement district financing of street improvements or sewer line hook-ups. The question about street improvements was posed to all respondents who did not live on the highway (since such residents would not be assessed), and the question about sewer line hook-ups was asked only of residents who said they were currently on cesspool (since about a third of Laie residents -- predominantly in the "New Laie" area -- currently pay Zions Securities for sewer line services).

Preliminary calculations by Group 70 indicated that the probable maximum cost of assessments for either street improvements or sewer line hook-ups would be approximately $150 a month over a 20-year period. (This figure would include interest on loans.) The $150/month figure for each of the two projects reflects the City's current position that each project could be undertaken only if full standards are met, and it also reflects an assumption that the entire participant cost would be borne by residents. In a sense, therefore, it is a maximum figure. However, it was decided to utilize the $150/month number in the questions to give a reading of community support for the "worst-case" assessment scenario.

WILLING TO PAY $150/MONTH FOR...

	Street Improvements %	Sewer Hook-Up %
YES	8	11
NO	82	82
DON'T KNOW / REFUSED	10	7
(Base:)	(171)*	(116)**

* Remainder of 225 sample not asked because home was located on highway.

** Remainder of sample not asked because they were already hooked up to sewer or because respondent was uncertain. Results of screening question on this issue:

Cesspool -	52% (the 116 above)
Sewer Line -	36%
Don't Know / Refused -	12%

Only five respondents in the entire survey answered "yes" to both questions. These people were asked a follow-up question to determine if they would actually be willing to pay $300 a month for both sets of improvements. Three of the five said they would be willing, but two said they could afford only one $150/month assessment (of these, one gave priority to the street improvements and the other could not choose).

Comments: Results were essentially as expected, given the community's overall low-income status.

Demographics: Willingness to pay for street improvements was slightly greater, although still essentially negligible, in the Beach area (14 percent) as compared to Old Laie (nine percent) or New Laie (five percent). The New Laie people were also even less likely than other residents to be willing to pay for sewer hook-ups.

E. Attitudes Toward Zions' Rates/Services -- Sewer and Water

People who knew for certain that they currently were hooked up to a sewer line were asked whether they felt Zions Securities'

rates for this services are "reasonable" and whether they thought Zions has been doing a "good job." Additionally, all respondents were asked the same two questions about drinking water provided by Zions, as well as a lead-in question about the taste of the water. Results were:

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Satisfaction with FEE for...

	Sewer %	Water %
REASONABLE	41	55
TOO HIGH	31	20
REFUSED / RATHER NOT SAY	0	3
DON'T KNOW WHAT FEE IS	28	22

Satisfaction with SERVICE QUALITY For...

	Sewer %	Water %
ZIONS DOING GOOD JOB	64	80
TOO MANY PROBLEMS	27	13
DON'T KNOW / REFUSED	9	6
(Bases for each question:)	(81)*	(225)

* Questions asked only of respondents who knew or believed they were already hooked up to sewer lines.

==========

On the question about water quality, 92 percent of the respondents believed Laie's water tastes at least as good as water elsewhere on the island (and half of these believe it tastes better), and only three percent feel it tastes worse.

Comments: It should be noted that these questions were requested by Zions for purposes of self-evaluation rather than as part of the Master Plan effort. The evaluation turns out very positive indeed in regard to water. For sewer lines, results were essentially positive, but not quite to the same degree.

Demographics: The figures in Appendix B indicate that residents of "New Laie" were considerably more likely than others to feel rates (for both sewer and water services) are too high. There was also a tendency to hear proportionately more complaints about rates from females and from people in either the very youngest age group or the oldest group (21 to 30, or 66 and older).

Women and/or elderly residents were also somewhat more likely to complain about quality of service for both sewer and water, but the geographical variable did not show up as important for this question as it was for the question about cost.

The people most likely to say Laie's water is "better" than (not just the same as) water elsewhere were people who lived in Old Laie and/or were older and/or who had lived in Laie longer. This suggests that community loyalty may be a factor.

F. Land Use, Employment, and Housing Development

Particularly important to the Master Plan effort were a number of questions dealing with possible new economic or housing development in Laie:

(1) Attitudes toward a light industrial area for Laie;

(2) Importance of keeping Laie "pretty much like it is now" vs. providing (a) more jobs, and (b) more "homes which local families could afford to buy or rent";

(3) Attitudes toward various types of new housing;

(4) Places where new houses or businesses should not be developed.

(A fifth question -- desires for overall growth in Laie housing units -- was placed after some subsequent questions on housing conditions and pent-up demand for new housing. Therefore, results for that question will be reported after results for these housing questions.)

Development of a Light Industrial Area: This was favored by 52 percent of all respondents and opposed by 36 percent (with ten percent giving some sort of qualified answer and three percent giving no answer). While the concept is thus technically endorsed by a majority, the fact that a significant minority would not like such a development or hold questions about it indicates that any light industrial park proposal is a source of potential community controversy.

Keeping Laie "Like It Is" Vs. New Jobs, Homes: Both jobs and -- even more so -- affordable housing represent higher priorities than preservation for a clear majority of Laie residents:

	JOBS Question %	Affordable HOMES Question %	
LIKE IT IS NOW	25	20	LIKE IT IS NOW
MORE JOBS	64	71	MORE HOMES
DEPENDS	6	6	DEPENDS
DON'T KNOW	5	4	DON'T KNOW

Preferred Types of New Housing for Laie: Asked for reactions to a six-item list on possible housing types, residents clearly said they would "like" housing that was (1) aimed at a less affluent market (particularly senior citizens) and/or (2) of a low-rise nature. The majority said they would "not like" taller or more expensive housing units. For each of the choices, only four to ten percent said they had no particular feeling one way or the other.

	Would Like %	Would NOT Like %
SENIOR CITIZEN HOUSING, LIKE IN KAHUKU	74	19
SMALL APARTMENT BUILDINGS OR TOWNHOUSES, TWO STORIES OR LESS	65	30
AFFORDABLE HOUSES ON SMALL LOTS	64	26
MORE EXPENSIVE HOUSES ON LARGER LOTS	28	62
APARTMENT BUILDINGS WITH THREE OR FOUR STORIES	22	72
VERY EXPENSIVE HOMES	10	82

Place NOT to Develop in Laie: Respondents were asked to name places in Laie which should "never" be developed, "places which should always just be left like they are now." (The reason for framing the question in negative terms was that people are often more vehement in resisting development of a particular site than they are in urging that some other place <u>be</u> developed.) Respondents answered in their own words, and responses were then coded into categories. Nearly half the respondents (46 percent) offered no reply, but those who did answer had definite opinions. Grouping these replies into very broad categories:

	Percentages Based on Total Sample %	Percentages Based Only On People Giving Definite Reply %
BEACHES / PARKS*	47	87
CHURCH-RELATED PROPERTY (Temple, BYU, PCC)*	22	40
OTHER	15	29
CAN'T THINK OF ANY	46	N/A
(Bases:)	(225)	(122)**

* NOTE: Within these broad categories, beach areas were more important than non-beach parks, and Temple areas were mentioned more than BYU or PCC.

** Number of people giving at least one reply. Percentages based on responses rather than respondents. See Part IV for complete percentage results <u>and</u> Appendix A for verbatim listing of responses to this question, Question 19.

Comments: While the results clearly indicate that most Laie residents care much less about keeping Laie "like it is now" than about jobs or affordable housing, they also indicate that residents have some sense of what they want to keep and what they would <u>not</u> want to happen in Laie.

The results suggest that at least two aspects of present-day Laie are particularly valued: (1) the sense of space and openness, as indicated by concern for protecting beach areas and Church-related facilities with large open areas, and (2) the types of people who are there now, as indicated by the focus on housing which would meet the needs of low-income residents and rejection of more expensive and/or high-rise dwellings.

Clearly, these two values could sometimes be in conflict. It may be hard to build affordable housing unless it is subsidized by more expensive homes. An industrial area will provide jobs and services, but a motivated minority of residents can be expected to ask numerous questions about the exact types of businesses which would locate there. And affordable housing is often incompatible with a sense of space (although in this case it is clear that residents seem willing to accept clustered housing on small lots so long as important common areas remain open).

Based both on these survey results and our familiarity with the overall North Shore area, Community Resources believes that Zions and its planning consultants should always be ready to address two questions in regard to any proposed major change for Laie:

- "How will this benefit the people who live here now?" is likely to be the most frequent question from the community as a whole.
- "How will this change the feeling of what it is like to live in Laie?" will probably be asked by a smaller number of people, but with more intensity.

Finally, it may be noted that many Laie residents would like to see housing provided which is less "rural" in nature -- i.e., low-rise apartment buildings and/or affordable homes on smaller lots. However, it should be stressed that this question was about respondents' willingness to see such housing in Laie, not willingness to live in such units themselves.

Demographics: Percentage comparisons found in Appendix B indicate no radical differences in attitudes among various types of Laie residents, although there are differences in degree. For example, on most of the foregoing questions, males were a little more likely than females to favor various forms of job or housing development.

Longtime Laie residents (particularly those living there for 20 years or more) were, like females, a little more likely to be opposed or uncertain about proposed changes. Again, this was primarily a matter of degree rather than totally different answers, although residents living there 20 years or more did happen to comprise the only group with a majority against a light industrial area.

Since all respondents were at least 21 years old, length of residence does not necessarily translate into age. For example, the age group most opposed to a light industrial area was comprised of people in their 20's, not in their 50's or 60's. The age group most opposed to apartment buildings (short or tall) consisted of people in their 40's. People aged 66 or more were, not surprisingly, the most enthusiastic about senior citizen housing -- 100 percent in favor.

Area of residence within Laie made little strong or consistent difference in type of response. Beach area residents were a little more inclined to keep Laie "pretty much like it is now," but even in the Beach area 60 percent majorities placed higher priority on more jobs or more affordable homes.

In terms of Laie areas NOT to develop, there were a few groups for whom Church-related areas (Temple, BYU, PCC) appear equal (but still not necessarily greater) in priority as compared to beaches or parks. These include longtime Laie residents, and/or people in their 40's and 60's, and/or females. Beach area residents were a little less concerned about Church-related areas than other residents, but not dramatically so.

G. Housing Conditions

Survey Question #20 asked about number of people living in the housing unit, and Question #21 asked about number of rooms in the unit (excluding, as per U.S. Census definitions, bathrooms and hallways). During the computerized analysis, "Question #21a" was created through dividing Question #20 by #21 to derive number of people per room -- i.e., a crowding factor.

The average household size in this survey was 5.4 persons -- down somewhat from the 5.9 figure in the 1979 Laie survey by BYU-Hawaii, but still considerably higher than the Oahu figure of 3.25 determined by the 1980 U.S. Census. Although Oahu's average household size is generally assumed also to have declined since 1980, the following comparison illustrates how high Laie's household sizes are in comparison to the island as a whole:

	NUMBER PEOPLE IN HOUSEHOLD:	
	LAIE (Survey) 1987 %	OAHU (Census) 1980 %
1 - 2 PEOPLE	11	43
3 PEOPLE	13	19
4 PEOPLE	17	18
5 PEOPLE	13	10
6 PEOPLE	16	--¦
7 - 8 PEOPLE	16	--¦-- 10
9 - 13 PEOPLE	13	--¦

The average number of rooms per Laie unit in this survey (5.3) was almost identical to the average average household size (5.4), suggesting substantial household crowding. This inference was borne out by the computer-calculated crowding factor, which also indicates that Laie homes are considerably more crowded than those of Oahu as a whole, even relying on 1980 base data:

CROWDING FACTORS:

Category/Definition*	LAIE (Survey) 1987 %	OAHU (Census) 1980 %
"NOT CROWDED" (Less than 1.01 persons/room)	59	85
"CROWDED" (1.01 - 1.50 persons/room)	21	8
"VERY CROWDED" (More than 1.50 persons/room)	20	7

* Based on U.S. Census definitions.

Comments: Arguably, national standards for household "crowding" may not apply to Laie, where large families and intimate living conditions may be more culturally acceptable. However, this argument is somewhat suspect in light of the finding to follow that more than one-third of the household contain people who would move out and start new households if there were more affordable homes within the Laie area.

Demographics: While Old Laie households are the most likely to be either "crowded" or "very crowded" (48 percent), even in the Beach area of Laie 39 percent of households meet the criteria for being "crowded" or "very crowded."

However, the data summarized on the following page indicate that the groups most clearly living in crowded conditions are newcomers and/or younger people. It is difficult to say to what extent these figures might be influenced by groups of BYU-Hawaii students living together off-campus. However, given both the number of respondents in their 30's or 40's who report crowded conditions and also the school's strict housing policies for students, it would appear that student households would be only a marginal aspect. In general, it appears that young people seeking to form their own households and/or recent arrivals are now bearing much of the burden of Laie's housing shortage.

Length of Residence	"Very Crowded" %	"Crowded" OR "Very Crowded" %
Less than 2 years	32	51
2 - 5 years	16	45
6 - 10 years	26	52
11 - 20 years	18	28
20+ years / lifetime	13	34
Age of Respondent		
21 - 30 years	27	55
31 - 40 years	25	45
41 - 50 years	13	32
51 - 65 years	7	24
66 years or older	15	15

H. Pent-Up Housing Demand

"Pent-up housing demand" refers to potential market demand for new housing units which is being suppressed (or "pent-up") by high housing cost relative to ability to pay. That is, the term refers to the number of people who would like housing but cannot afford it. Within Laie, this translates into people involuntarily sharing housing units -- often crowded units -- with other family or non-family members.

The level of this demand within Laie was measured in direct fashion by asking: "If Laie had more houses or apartments that people could afford, would anyone quickly move out of this household and into one of the new homes?" People who answered "yes" were then asked two follow-up questions: (1) how many new homes would be needed for these people, and (2) what is the gross income of all the people who would form one of the new households (an indicator of ability to afford various levels of housing).

Percentage of households where someone would move out:	36%
Average number of homes required for these people: (based on 1 home = 61%; 2 homes = 28%; 3+ homes = 8%)	1.4*
Median pre-tax income of people forming new households:	$20,500*

* based on responses of the 36% only.

Comments: In the course of drawing a sample for this survey, Datametric Research found that the number of occupied housing units in Laie (excluding student dormitories, vacation rentals, and vacant homes) was about 725 at the time of the survey. Multiplying 725 time 0.36 times 1.4 yields a pent-up demand for approximately 365 units.

This estimate is subject to two caveats: (1) It may be somewhat liberal, in the sense that it is easier to say "I'd move into a new house" in a survey situation than it is actually to do it in a real-life situation; and (2) Given the indicated household incomes, the pent-up demand is for very inexpensive units -- probably rentals. As reported to Community Resources by several local market survey research firms, the average Oahu household income is now approximately $30,000 per year. But less than 20 percent of the "pent-up" Laie households are making more than that amount, according to results of this survey.

Demographics: While crowded household conditions were much more frequently encountered among younger residents than older ones, pent-up demand is only somewhat higher for younger residents and/or newcomers, and there is a more pronounced geographical difference:

	Households Where Someone Would Move to Affordable New Home	Proportion of These Needing Two or More Homes
Length of Residence	%	%
Less than 2 years	42	23
2 - 5 years	42	34
6 - 10 years	37	43
11 - 20 years	25	30
20+ years / lifetime	33	40
Age of Respondent		
21 - 30 years	27	45
31 - 40 years	25	17
41 - 50 years	13	36
51 - 65 years	7	57
66 years or older	15	0
Area of Residence in Laie		
Old Laie	44	44
New Laie	35	26
Beach Area	28	40

Additionally, incomes among those needing housing were reportedly somewhat higher when respondents were in their 30's or 40's. The overall pattern suggests two types of households in which pent-up demand exists: (1) grown young people still living with their parents, and (2) several families (with adults primarily in their 30's and 40's) sharing a home in order to make ends meet. The demand for fee-simple market housing would presumably be somewhat stronger among the latter group, where about 30 percent of the reported pent-up households earn in excess of $30,000 per year. For the former group, however, rentals would clearly be the required solution.

In addition to the standard demographics, the "crowding factor" was cross-tabulated by pent-up demand. As expected, a definite relationship was found: Among "very crowded" households, 59 percent said someone would move out if possible; among "crowded" households, it was 45 percent; and among "not crowded" households, only 24 percent.

I. Overall Preference for Laie Housing Unit Growth

The final substantive survey question asked: "Right now there are about 900 homes and apartment units in Laie. How many homes and apartment units would you like to see in Laie 20 years from now?" [NOTE: The 900 figure would include vacancies, vacation rentals, student housing, etc.]

Respondents were asked to choose from five numerical categories, although some other types of responses (e.g., "it depends...") were recorded if volunteered. Results were:

	%
STILL JUST 900	17
ABOUT 1,000	14
ABOUT 1,200	23
ABOUT 1,500	12
1,800 OR MORE	20
(DEPENDS ON TYPE OF NEW UNITS)	8
(DEPENDS ON TYPE OF NEW PEOPLE)	2
(DON'T KNOW / REFUSED)	5

Comments: Based on the foregoing figures, the median answer would be "about 1,200 homes" over the next 20 years. Arguably, Laie residents <u>might</u> be willing to see even faster growth, since (1) the 1,200 figure is roughly consistent with the pent-up demand figure of 365 <u>today</u>, and (2) some people may have stated their ideal community size without regard to a timeframe, since it is difficult to think 20 years into the future.

Although a majority of respondents favored growth to levels of 1,200 units or more, it is worth noting that nearly one-third wished to keep Laie's size at or near the current level (i.e., 900 or 1,000 units). And another 15 percent qualified their answers or declined to state an opinion. Thus, while moderate to substantial growth in Laie's affordable housing stock would probably be welcomed by a majority, it cannot be said that there is total community consensus on the issue.

Demographics: Residence within Laie had no relationship with attitudes toward overall growth. However, in line with the patterns observed in the earlier questions regarding housing and land use (Section III.F), males were somewhat more pro-growth than females; longtime Laie residents were somewhat more cautious about change; and the age factor showed a complex relationship, with more pro-growth attitudes among both young adults and senior citizens than those in their middle years:

	Willing to See 1,500 OR 1,800+ Units in 20 Yrs
<u>Sex</u>	%
Male	40
Female	26
<u>Length of Residence</u>	
Less than 2 years	45
2 - 5 years	42
6 - 10 years	29
11 - 20 years	20
20+ years / lifetime	24
<u>Age of Respondent</u>	
21 - 30 years	36
31 - 40 years	28
41 - 50 years	23
51 - 65 years	37
66 years or older	46

IV. RESULTS -- TABLES OF FREQUENCIES FOR EACH ITEM

QUESTION 1

First, I'm going to read you a list of some possible stores and businesses for Laie. For each one, please tell me whether it is not important, important, or very important that we get this type of store someday.

	NOT IMPORTANT %	IMPORTANT %	VERY IMPORTANT %	DON'T WANT IT %	DONT' KN REFUSED %
SUPERMARKET	19	36	45	0	0
MEN'S BARBER	43	44	11	0	2
AUTO REPAIR	34	45	19	0	1
DRUG STORE	34	43	22	0	1
DRY CLEANING	44	40	16	0	0
HOME IMPROVEMT	20	51	27	0	1
RADIO/TV SHOP	42	45	12	0	1
BASE	225				

NOTE: Percentages on this table add horizontally. On all other tables, unless so noted, percentages add vertically.

QUESTION 2

Are there any other types of stores or businesses not on this list (LIST FOR QUESTION 1) which you'd want for Laie?

	ALL RESPONSES %	RESPONSES LESS "CAN'T THINK OF ANY" %
RESTAURANTS/FAST FOODS	15	30
SHOPPING MALLS/DEPARTMENT STORES	8	17
CLOTHING STORES/ FABRIC STORES	11	21
OTHER RETAIL STORES	4	7
GROCERY STORES	4	9
MISC. RECREATION	2	4
OTHER	6	13
NO/CAN'T THINK OF ANY	50	N/A
BASE	225	112

NOTE: A VERBATIM LISTING OF ALL RESPONSES MAY BE FOUND IN THE APPENDIX OF THIS REPORT.

QUESTION 3

Thank you! Now I'd like to go over a list of possible parks or recreation needs for Laie. For each one, please tell me how important this would be for Laie.

	NOT IMPORTANT %	IMPORTANT %	VERY IMPORTANT %	DON'T WANT IT %	DONT' KN REFUSED %
MORE BEACH CAMPING & PICNIC AREAS	51	32	16	0	1
MOUNTAIN PARK	24	50	25	0	0
RIGHT-OF-WAY TO OCEAN	40	36	22	0	1
COMMUNITY PARK	18	43	38	0	1
COMMUNITY POOL	28	39	33	0	1
RECREATION CENTER	9	40	49	0	2
COMMUNITY CENTER	25	49	24	0	1
BASE	225				

NOTE: Percentages on this table add horizontally. On all other tables, unless so noted, percentages add vertically.

QUESTION 4

Here are things which some people feel are problems with the highway in and around Laie. For each one, please tell me whether you feel it is no problem, a problem, or a big problem in Laie.

	NO PROBLEM %	PROBLEM %	BIG PROBLEM %	EXPRESSED OPP VIEW %	DONT' KN REFUSED %
GET ON/OFF HIGHWAY	56	28	15	0	2
NO STREET LIGHTS LAIE-KAHUKU	33	33	33	0	1
TRAFFIC GOES TOO FAST	65	20	12	2	2
TRAFFIC GOES TOO SLOW	60	28	10	0	1
BASE	225				

NOTE: Percentages on this table add horizontally. On all other tables, unless so noted, percentages add vertically.

QUESTION 5

Now let me ask about the streets inside Laie, off the highway. Again, for each thing I say, please tell me if you think it's no problem, a problem, or a big problem.

	NO PROBLEM %	PROBLEM %	BIG PROBLEM %	EXPRESSED OPP VIEW %	DONT' KN REFUSED %
STREET LIGHTS	50	29	17	0	4
SPEEDING	34	41	24	0	1
FIXING THINGS	24	45	28	0	2
NO SIDEWALKS ON BUSY STREETS	23	38	38	0	1
STREETS NOT WIDE ENOUGH	42	33	23	0	3
BASE	225				

NOTE: Percentages on this table add horizontally. On all other tables, unless so noted, percentages add vertically.

QUESTION 6

(ASKED ONLY IF RESPONDENT DOES NOT LIVE ON HIGHWAY)
This is a just-pretend question. The County government will sometimes improve people's streets if they will share the cost. The improvements would be things like sidewalks, curbs and gutters, better drainage of rain water, better pavement, and widening some streets.
Pretend the share for this house is $150 a month for 20 years. Would you pay this much for street improvements?

	%
YES	8
NO	82
DON'T KNOW/REFUSED	10
BASE	171

QUESTION 7

Is this home connected to a cesspool, or is it connected to a sewer line instead?

	%
CESSPOOL	52
SEWER LINE	36
DON'T KNOW/REFUSED	12
BASE	225

QUESTION 8

(ASKED ONLY IF RESPONDENT HAS A CESSPOOL)
This is a just-pretend question. The County will sometimes put in a sewer line if everybody who hooks up to it will share the cost. Pretend the share for this house is $150 a month for 20 years. Would you pay this much to have your house hooked up to a sewer line?

	%
YES	11
NO	82
DON'T KNOW/REFUSED	7
BASE	116

QUESTION 9

(ASKED ONLY IF RESPONDENT SAID "YES" TO BOTH Q6 AND Q8)
You have said "yes" to paying $150 for street improvements and also to paying $150 for a sewer line hook-up. Does that mean you would be willing to pay $300 a month to get both? (IF "NO":) If you could afford just $150 a month, which would you rather spend it for-street improvements or sewer line hook-up?

	%
YES, PAY $300	60
NO-STREET IMPRV ONLY	20
NO-SEWER ONLY	0
NO-CAN'T CHOOSE	20
DON'T KNOW/REFUSED	0
BASE	5

QUESTION 10

Do you think your monthly payment to Zions Securities for sewer-line service is reasonable, or is it too high?

	%
REASONABLE	41
TOO HIGH	31
REFUSED/RATHER NOT SAY	0
DON'T KNOW WHAT FEE IS	28
BASE	81

QUESTION 11

Is Zions doing a good job keeping the sewer lines working, or are there too many problems?

	%
GOOD JOB	64
TOO MANY PROBLEMS	27
DON'T KNOW/REFUSED	9
BASE	81

QUESTION 12

Do you think the drinking water in Laie tastes better than it does elsewhere on the island, the same, or worse?

	%
BETTER	46
SAME	46
WORSE	3
DON'T KNOW/REFUSED	5
BASE	225

QUESTION 13

Do you think your monthly payment to Zions Securities for water is reasonable, or is it too high?

	%
REASONABLE	55
TOO HIGH	20
REFUSED/RATHER NOT SAY	3
DON'T KNOW WHAT FEE IS	22
BASE	225

QUESTION 14

Is Zions doing a good job getting water to people's homes, or are there too many problems?

	%
GOOD JOB	80
TOO MANY PROBLEMS	13
DON'T KNOW/REFUSED	6
BASE	225

QUESTION 15

A "light industrial area" is a place which mixes offices and businesses. These businesses could be anything from auto shops or warehouses to hula studios. Would you like to see a light industrial area in Laie, or not?

	%
WOULD LIKE	52
WOULD NOT	36
DEPENDS/MIXED FEELINGS	10
DON'T KNOW/REFUSED	3
BASE	225

QUESTION 16

In general, which is more important to you-keeping Laie pretty much like it is now, or providing more jobs here?

	%
LIKE IT IS NOW	25
PROVIDE MORE JOBS	64
DEPENDS ON TYPE OF JOBS	6
BOTH/CAN'T CHOOSE/DON'T KNOW	5
BASE	225

QUESTION 17

In general, which is more important to you-keeping Laie pretty much like it is now, or building more homes which local families could afford to buy or rent?

	%
LIKE IT IS NOW	20
MORE HOMES	71
DEPENDS ON TYPE/NO. OF HOMES	6
BOTH/CAN'T CHOOSE/DON'T KNOW	4
BASE	225

QUESTION 18

There are different types of homes. If new housing does get built in Laie, please tell me if you would like or not like to see each of the following types-or if you have no feeling one way or the other.

	LIKE %	NOT LIKE %	NO FEELING %
AFFORDABLE HOUSES ON SMALL LOTS	64	26	9
MORE EXPENSIVE HOUSES ON LARGER LOTS	28	62	9
VERY EXPENSIVE HOUSES	10	82	8
APT BUILDINGS WITH 3-4 STORIES	22	72	6
SMALL APT BUILDINGS OR TOWNHOUSES	65	30	4
SENIOR CITIZEN HOUSING	74	19	7
BASE 225			

NOTE: Percentages on this table add horizontally. On all other tables, unless so noted, percentages add vertically.

QUESTION 19

Are there any particular places in or around Laie which should never have any new houses or businesses built there, places which should always just be left like they are now?

	ALL RESPONSES	RESPONSES LESS "CAN'T THINK OF ANY"
	%	%
TEMPLE AREA/CHURCH OWNED PROPERTY	14	26
POLYNESIAN CULTURAL CENTER	4	7
BRIGHAM YOUNG UNIVERSITY CAMPUS	4	7
BEACHES--GENERAL/MISC.	16	30
TEMPLE BEACH	4	7
KAKELA BEACH	8	15
HUKILAU BEACH	10	18
PARKS--GENERAL/MISC.	6	11
LAIE PARK	3	6
MOUNTAIN AREAS	4	7
LAIE	4	8
CEMETERY	2	4
OTHER	5	10
NO/CAN'T THINK OF ANY	46	N/A
BASE	225	122

NOTE: ADD'S TO MORE THAN 100% DUE TO MULTIPLE RESPONSES.

QUESTION 20

Finally, I'd like to ask some questions about you and the other people living in this house. First, how many people live here?

NUMBER OF PEOPLE	ALL RESPONSES
	%
ONE	2
TWO	9
THREE	13
FOUR	17
FIVE	13
SIX	16
SEVEN	9
EIGHT	7
NINE	6
TEN	4
ELEVEN	1
TWELVE	1
THIRTEEN	1
BASE	225
MEAN	5.4
MEDIAN	5

QUESTION 21

Not counting bathrooms and hallways, how many rooms are there in this house?

NUMBER OF ROOMS	ALL RESPONSES
	%
ONE	3
TWO	2
THREE	15
FOUR	13
FIVE	29
SIX	18
SEVEN	8
EIGHT	5
NINE	3
TEN	1
ELEVEN	1
TWELVE	*
THIRTEEN	1
FOURTEEN	*
BASE	225
MEAN	5.3
MEDIAN	5

* LESS THAN 1%.

QUESTION 21A

CROWDING FACTOR

	%
NOT CROWDED	59
CROWDED	22
VERY CROWDED	20
BASE	225

NOTE: THE CROWDING FACTOR WAS CALCULATED BY DIVIDING THE TOTAL NUMBER OF PEOPLE IN THE HOUSEHOLD (QUESTION 20) BY THE NUMBER OF ROOMS IN THE HOUSEHOLD (QUESTION 21). THE RESULTING PRODUCT WAS THEN COMPARED TO THE FOLLOWING DEFINITION FOR CROWDING AND CODED.

NOT CROWDED	A VALUE LESS THAN 1.01
CROWDED	A VALUE BETWEEN 1.01 AND 1.51
VERY CROWDED	A VALUE GREATER THAN 1.51

QUESTION 22

If Laie had more houses or apartments that people could afford, would anyone quickly move out of this household and into one of the new homes?

	%
YES	36
NO	62
DON'T KNOW/REFUSED	3
BASE	225

QUESTION 23

How many new Laie homes would be needed for the people moving out of this household?

	%
ONE	61
TWO	28
THREE OR MORE	8
DON'T KNOW/REFUSED	4
BASE	80
MEAN	1.4

QUESTION 24

We'd like to figure out what sort of place these people can afford, so we'd like to ask: All together, how much do these people make in a year before taxes are taken out? If you're not sure, please give your best guess.

	%
LESS THAN $18,000	32
$18,001 TO $24,000	21
$24,001 TO $30,000	13
MORE THAN $30,000	16
DON'T KNOW/REFUSED	18
BASE	77
MEDIAN	$20,460.50

QUESTION 25

Right now there are about 900 homes and apartment units in Laie. How many homes and apartment units would you like to see in Laie 20 years from now?

	%
STILL JUST 900	17
ABOUT 1,000	14
ABOUT 1,200	23
ABOUT 1,500	12
1,800 OR MORE	20
DEPENDS ON TYPE OF NEW UNITS	8
DEPENDS ON TYPE OF NEW PEOPLE	2
DON'T KNOW/REFUSED	5
BASE	225

QUESTION 26

How long have you lived in Laie?

	%
LESS THAN 2 YEARS	14
2 - 5 YEARS	24
6 - 10 YEARS	17
11 - 20 YEARS	18
MORE THAN 20 YEARS/LIFETIME	27
DON'T KNOW/REFUSED	0
BASE	225

QUESTION 27

And how old are you now?

	%
21 to 30 YEARS	36
31 to 40 YEARS	23
41 to 50 YEARS	21
51 to 65 YEARS	13
66 OR OLDER	6
REFUSED	0
BASE	225

QUESTION 28

(SEX OF RESPONDENT)

	%
MALE	35
FEMALE	65
BASE	225

QUESTION 29

(STATUS IN HOUSEHOLD)

	%
HOUSEHOLD HEAD	31
SPOUSE	46
OTHER ADULT MEMBER	23
BASE	225

QUESTION 30

(LOCATION OF HOME WITHIN LAIE)

	%
OLD LAIE TOWN	28
NEW LAIE TOWN	48
BEACH AREA	24
BASE	225

APPENDIX M

ECONOMIC AND DEMOGRAPHIC IMPACT ASSESSMENT OF PROPOSED LAIE DEVELOPMENT PLAN AMENDMENTS

February 1992

Prepared for:
Zions Securities
Group 70 International

Prepared by:
Community Resources, Inc.

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1.0 INTRODUCTION

1.1 PROJECT DESCRIPTION

Zions Securities, the land management arm of the Church of Jesus Christ of Latter-Day Saints, proposes to implement a master plan for the town of Laie on Oahu's North Shore. Drafts of the Laie Master Plan were prepared by Group 70 in December 1987 and April 1990.

The present form of the plan results from an analysis of Laie's infrastructural requirements and a thorough consideration of the needs of Laie residents. The Laie Community Association (LCA) has played a crucial role in reviewing preliminary consultant proposals, and several public forums and workshops have also been held over the past few years in order to air community concerns. Additional community input stems from information gathered by two Laie residents whose task was to informally appraise town people about the plan and record relevant feedback.

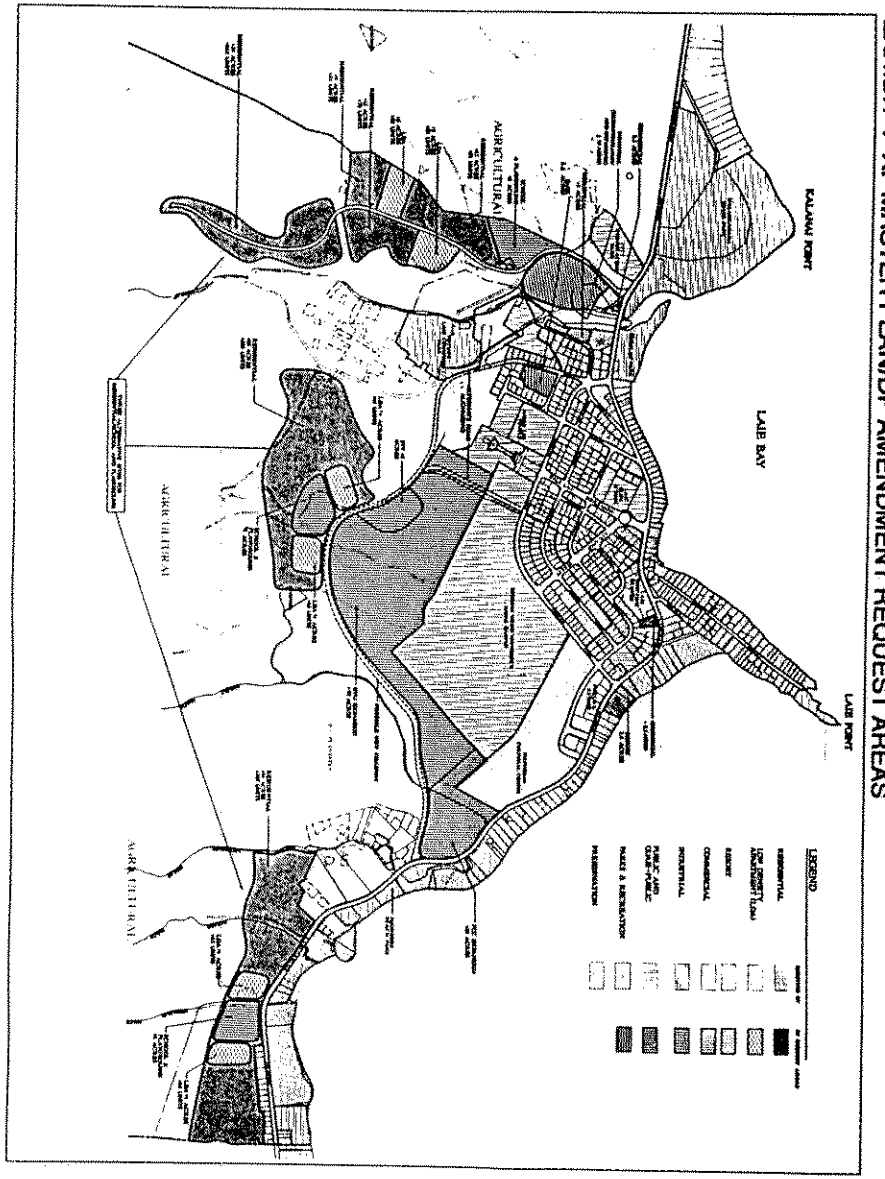
While the Laie Master Plan covers the entire town, only 214 to 220 acres require Development Plan (DP) amendments (see Exhibit 1-A). The largest element of the plan that requires a DP amendment is the proposed housing area, which could accommodate some 450 new units, provisionally apportioned as follows:

- 210 affordable single-family units;
- 90 affordable apartment units; and
- 150 market single-family units.

Construction for the housing units is slated between 1994 and 1998. Other facilities envisioned by the master plan include:

- An eight-acre school/playground complex accompanying the residential development;
- A 92-acre expansion of the Hawaii campus of Brigham Young University;
- A 21-acre Polynesian Cultural Center expansion;
- Major improvements on 6.5 acres of the present sewage treatment plant;
- Addition of a 2.6-acre parcel makai of Kamehameha Highway to the Resort-designated area of the Laniloa Lodge, giving the Lodge its own beach access;

EXHIBIT 1-A: MASTER PLAN/DP AMENDMENT REQUEST AREAS



- A reconfiguration of some two acres adjacent to the cemetery to light industrial use, and a 16-acre light industrial park on the Kahuku side of the flood control;
- A 0.5-acre parking lot addition to the Laie Shopping Center;
- A 0.3-acre redesignation of the present "corner commercial" site of the Cackle Fresh Egg Farm sales outlet to commercial use; and
- Dedication to the City and County of the old 3.5-acre Laie park.

All the above components of the master plan have definite locations except for the residential area. A final site for the housing units will be determined from the three existing alternatives currently under scrutiny:

- The area in the vicinity of Cackle Fresh Egg Farm on Laie's western edge (approximately 68 acres);
- The area mauka of Brigham Young University (approximately 68 acres); and
- The Laiemalo`o area on the eastern extreme of Laie (approximately 72 acres).

1.2 DEFINITION OF STUDY AREA

As shown in Exhibit 1-B, Laie itself is located on the northeastern shore of Oahu. The Laie area is bounded by Malaekahana Stream to the west and Kapapau Stream to the east. This area comprises Census Tract 102.02. Together with neighboring Census Tracts 101 and 102.01, Laie is part of the Koolauloa Census Division, a region stretching from Waimea Bay to Kaaawa (see Exhibit 1-C).

Census Tract 102.02 includes the entire area possibly subject to DP amendment. Laie is often defined more narrowly, in terms of the built-up area within the Laie Census Designated Place (CDP). In 1990, the CDP included 80.5% of the population and 74.0% of the housing units in the census tract. (The higher population percentage results from the presence in Laie CDP of over 1,000 students in dormitories.)

The Koolauloa Census Division and its component tracts will be considered the study area for this report, since data from the 1990 U.S. Census are readily available for these areas. However, occasional mention will be given to the City's Koolauloa Development Plan (DP) Area, which is somewhat smaller than the Koolauloa Census Division.

EXHIBIT 1-B: LOCATION MAP

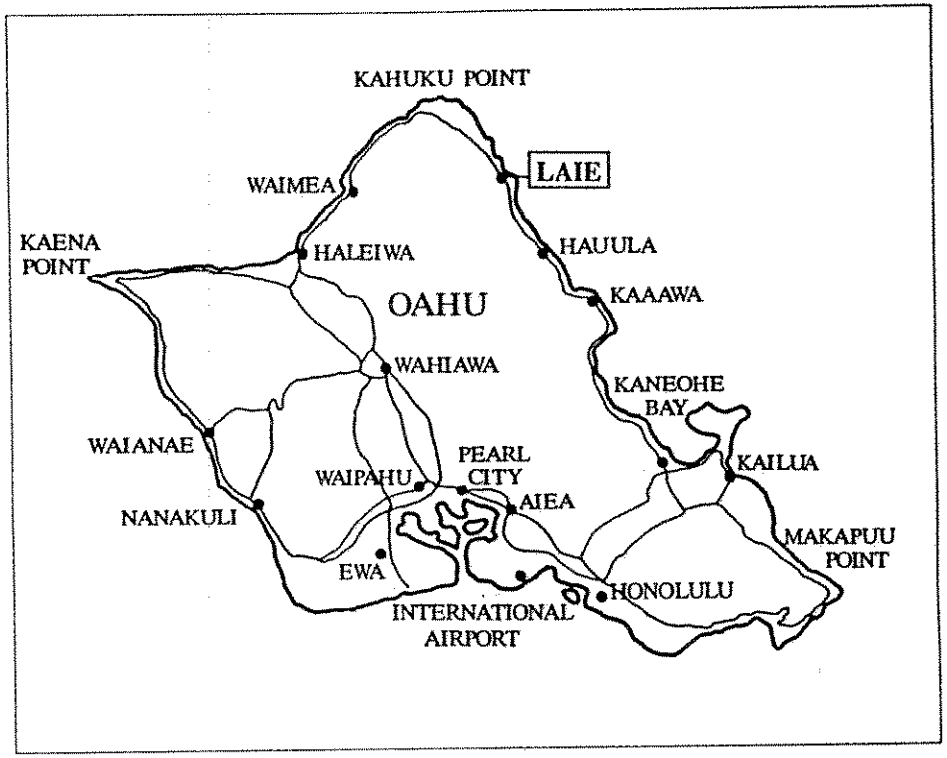
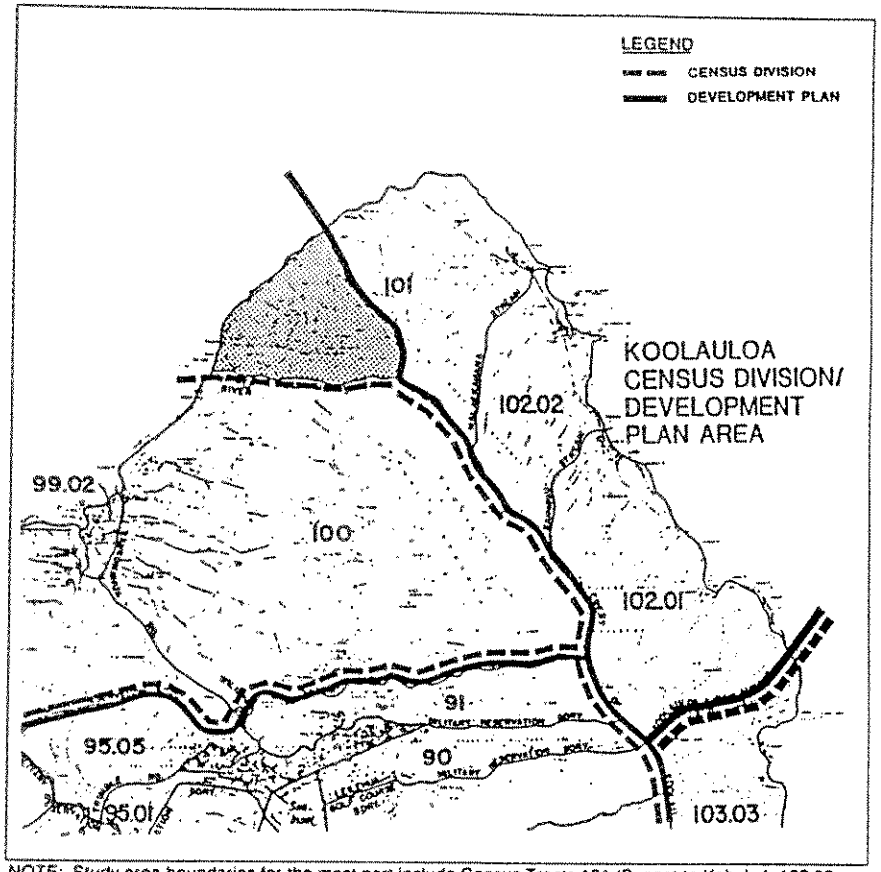


EXHIBIT 1-C: STUDY AREA BOUNDARIES



NOTE: Study area boundaries for the most part include Census Tracts 101 (Sunset to Kahuku), 102.02 (Laie), and 102.01 (Hauula to Kaaawa), which together comprise the Koolauloa Census Division. The shaded region is that portion of the Koolauloa Census Division that is not part of the Koolauloa Development Plan area.

2.0 EXISTING CONDITIONS

2.1 OVERVIEW OF KOOLAULOA DIVISION COMMUNITIES

The Koolauloa Census Division consists mainly of a narrow coastal strip bounded by the Koolau Mountains and the Pacific. A series of residential communities -- Sunset Beach, Kuilima, Kahuku, Laie, Hauula, Punaluu, and Kaaawa -- abut Kamehameha Highway. At the northern tip of Oahu, between Kuilima and Laie, the coastal strip pans out to a broad plain. Each community is geographically distinct, due mainly to mountain ridges and valleys. This relative isolation has led to the emergence of communities that differ in shape and character.

Earlier this century, sugar production constituted the major economic base. The last mill in the region finally shut down in 1971. Major sources of employment and revenue now include tourism, aquaculture, and specialized agriculture. The most important regional employers are the Polynesian Cultural Center in Laie and the Kuilima Resort near Kahuku. Although fundamentally considered rural by its inhabitants, some 18,443 persons lived in the Koolauloa Division in 1990.

A recurring theme in the Koolauloa Division is the desire to maintain a rural atmosphere. However, the communities in the region are composed of so many diverse peoples and cultures that the notion of country living may vary considerably.

A "country" lifestyle involves a close-knit community for some residents, but a fairly independent mode of living for others. Nearly two-thirds of the population in 1990 lived in small towns with business centers and well-defined neighborhoods, such as Laie, Kahuku, and Hauula. The remainder lived in more isolated settings or in strip-development neighborhoods such as Sunset Beach, Waimea, Punaluu, and Kaaawa.

Town-dwellers generally differ from the more rural country residents in that their homes are less isolated and they are more subject to small-town pressures for cooperation and social unity. Additionally, many of the communities are or were company towns, resulting in a number of distinct social boundaries.

Ethnicity appears to contribute to the country/community differences. According to the 1990 Census, the majority of Caucasians in the Koolauloa Division live in more isolated locales (such as Sunset Beach, Kuilima, Punaluu, and Kaaawa) while Filipinos tend to be concentrated in Kahuku, and Pacific Islanders other than Hawaiians in Laie. Hawaiians are more numerous in Hauula than elsewhere in the Division.

The country/community distinction is not absolute. Community residents value their country surroundings, and people living in the country areas report a sense of community, too. However, communities in the study area were founded on various economic activities, and there is a history of third- and fourth-generation families seeking preservation of their particular community as a home for the next generation. The more rural areas, by contrast, have a higher proportion of first-generation residents attracted by recreational opportunities and/or the absence of nearby large-scale economic activity.

Thus, large-scale economic activity and centralized employment centers are to a point historically compatible with the lifestyles and values of community dwellers, but less so for the country residents of the region. Community members seeking job opportunities band together to spur controlled economic development while country residents tend to view new projects as encroachments on the region's character.

2.1.1 Laie

Early in the nineteenth century, Laie was inhabited by a Hawaiian population of barely 400 persons. The principal agricultural activities conducted by the people of Laie at the time included taro cultivation and aquaculture. The settlement was also a center of refuge and the site of at least two heiau.

The entire ahupuaa of Laie -- almost 6,000 acres -- was purchased in 1865 by the Church of Jesus Christ of Latter-Day Saints (the LDS Church). The church planned to create in Laie a central settlement for members of the church in Hawaii and elsewhere in Polynesia.

Sugar cultivation began in 1868 as a means of supporting the growing LDS population, but an inadequate water supply made the task unproductive. Finally, towards the turn of the century, improved irrigation allowed Laie's sugar lands to flourish -- so much so that the local mill could not process the increased cane yield. The plantation leased land to the neighboring Kahuku Plantation as a countermeasure.

By 1931, debts forced the plantation's closure, and Laie's population declined drastically. Despite the exodus, the Hawaii Temple (dedicated in 1919) ensured the town's survival as a spiritual center for the LDS Church.

Modern-day Laie has only partly achieved its original aim of becoming the gathering place of Pacific Rim church members. The town boasted a 1990 population of 6,926, making it Koolauloa's largest settlement. It remains an important religious and educational center: not only is Laie home to the Temple but it is also the site of the Hawaii campus of Brigham Young University (BYU-H), which began operations as the Church College of Hawaii in 1955.

Laie's economic importance to the region is further enhanced by the Polynesian Cultural Center (PCC), which opened in 1963. The workings of the PCC are closely related to BYU-H, as the Center provides both income for the university and employment for the school's students. The PCC is largely responsible for Laie's substantial Polynesian community, with far higher concentrations of Hawaiians, Samoans, and Tongans than elsewhere on Oahu. While the town's proportion of Caucasian residents closely reflect island averages, Laie has very few Japanese or Filipinos.

The typical Laie lifestyle is still largely centered on the activities of the LDS Church. The church owns and operates the Temple, the PCC, BYU-H, and Laniloa Lodge (a low-key hotel fronting the PCC). The church also owns the lots that house the town's shopping center (including the only cinema on the North Shore), as well as the bulk of residential lots throughout Laie. People from neighboring communities tend to view Laie as being self-contained and as having scant contact with other towns.

Although LDS involvement brings many Laie residents together, people in the town recognize cross-cultural and socio-economic differences between the predominantly Mainland-born college faculty and the other, largely Polynesian, residents. Furthermore, Laie residents have become increasingly more vocal on land/economic issues while also becoming more involved with nearby communities.

Census Tract 102.02 includes the town of Laie, beach homes in Malaekahana (to the north) and towards Hauula (to the south), along with scattered farm houses. The beach houses tend to be relatively luxurious compared to town units. Many of the Malaekahana homes are held for occasional use.

2.1.2 Sunset Beach to Kahuku

SUNSET BEACH. The Sunset Beach residential area -- a strip of homes along and mostly below the Kamehameha Highway -- begins about a mile southeast of Kuilima Resort and continues for approximately three miles. The southerly portion of this strip is also known as Waimea, and the hills above Waimea contain the rural one-acre lots comprising the Pupukea Highlands.

Waimea Valley had a large Hawaiian population until 1894, when many residents left the valley after a disastrous flood. The valley is now occupied by Waimea Falls Park, a commercial botanical and cultural attraction.

The area became known to a few surfers in the 1950s, although it was then not as prominent as Makaha. Today, Waimea Bay and the Pipeline rate among the most famous surf spots in the world. In December, when winter swells can produce waves of over 25

feet, international surf meets are held at various beach parks. This increase in surfers and tourists during the winter months creates a respectable short-term vacation rental market.

Sunset Beach is heavily Caucasian and strongly ocean-oriented in lifestyle. Given the lack of nearby professional jobs, the more affluent are either retired or willing to commute long distances to Honolulu. Thus, values and lifestyles in this semi-rural area are often characterized by a self-sufficient, pioneer ethic.

KUILIMA. The Kuilima Resort opened in 1972. It was originally developed as a joint venture by Prudential Insurance and the Del E. Webb Corporation. Asahi Jyuken took over ownership in 1988. The hotel currently offers 486 hotel and cabana units.

Prudential developed plans for expansion of the Kuilima Resort in the late 1970s. Land use permits had already been granted by the time Asahi Jyuken acquired the property. Phase One of the expansion had been underway until September of 1991 when financing for the project was adversely affected by the banking climate in Japan. A temporary cessation of all construction work save that on the new golf course is currently in effect.

In addition to the hotel, the facilities at Kuilima include a low-rise condominium complex totaling 366 units, a golf course and clubhouse, a riding stable, and tennis courts. The profile of the condominium occupants has varied over time. In early 1989, property managers estimated that about 60% of the units were held by full-time owner-occupants, with the great majority of the remainder being in the rental pool or held for part-time use by owners.

KAHUKU. Kahuku maintains strong roots to its plantation past. Even though the Campbell Estate-owned sugar plantation covered much of northern Koolauloa and employed residents of other towns, the mill and company headquarters were in Kahuku itself. Consequently, Kahuku remains the site of many crucial regional services, with its police station, high school, and hospital, despite a relatively small current population.

When the plantation shut down in 1971, community leaders aided by the ILWU and Campbell Estate fought to keep the community alive. They supported the new Kuilima hotel and a series of commercial ventures in and around the mill, which area residents view as a prized symbol of the town's origin. The mill itself was extensively renovated during the 1980s and is the current site of a shopping center which caters mainly to tourists.

Another commercial activity important to Kahuku is aquaculture. On the makai side of Kamehameha Highway on the way to Kuilima, shrimp and prawns are grown and sold. A small side-of-the-road restaurant operated by the farm does a brisk trade in cooking and serving the produce.

2.1.3 Hauula to Kaaawa

HAUULA. Hauula is predominantly a Hawaiian Homesteads community with high poverty rates and reported shortages of affordable housing. Housing tends to be fairly dense, and many units are dilapidated. Public amenities include a small shopping center, a satellite City Hall, and a fire station. Hauula residents have historically been interested in new employment opportunities.

PUNALUU. Punaluu is a generally rural, lightly-populated area in which beachfront homes tend to be second residences for affluent Honolulu people. However, some actual pastoral and aquacultural activities take place in the valley. An oceanfront condominium complex -- the combined Pat's at Punaluu and Hanohano Hale -- is the only commercial activity of note in the town.

KAAAWA. Kaaawa was historically a Hawaiian agricultural area. Besides a few small restaurants and a fire station, it contains few urban amenities or employment opportunities. Many residents commute to more urban Oahu areas. Homes in the settlement tend to be relatively more expensive than in neighboring towns.

2.2 SOCIO-ECONOMIC CONDITIONS

The analysis in this section stems mainly from 1990 U.S. Census data and a 1990 household Koolauloa/North Shore survey conducted by Community Resources, Inc. The geographic areas studied in the survey are loosely comparable with census tracts. (Hence, "Laie" here is equivalent to Census Tract 102.02, "Sunset Beach-Kahuku" is equivalent to C.T. 101, and Hauula-Kaaawa" is equivalent to C.T. 102.01).

2.2.1 Demographic Characteristics

LAIE. As seen in Exhibit 2-A, Laie had a 1990 population of 6,926 persons. Laie's annual average growth rate, which was in earlier years quite phenomenal, has decreased over the last decade. This decline could be attributable to Laie's infrastructural limitations, which have prevented new housing in recent years. Despite this trend, Laie's 1980-90 growth of 1.9% is still almost twice that of the County's.

Although Laie is akin to the County in that Caucasians form the largest single group, the town differs greatly from the rest the island in that it has great numbers of Polynesians -- particularly Hawaiians and Samoans (see Exhibit 2-B). As with other Koolauloa communities, Laie has few Asians compared to islandwide averages. The population is slightly younger than in the rest of Koolauloa and the County, presumably due to Polynesian and/or LDS families having a greater number of children.

EXHIBIT 2-B: CENSUS DEMOGRAPHIC CHARACTERISTICS, 1990 AND 1980

	CITY AND COUNTY OF HONOLULU		KOOLAULOA DIVISION		C.T. 102.02 LAIE		C.T. 101 SUNSET-KAHUKU		C.T. 102.01 HAUULA-KAAAWA	
	1990	1980	1990	1980	1990	1980	1990	1980	1990	1980
TOTAL POPULATION	836,231	762,565	18,443	14,195	6,926	5,752	6,909	4,491	4,608	3,952
ETHNICITY										
Caucasian	31.6%	33.1%	38.5%	35.9%	31.6%	27.2%	47.4%	50.8%	35.6%	31.6%
Japanese	23.3%	24.9%	5.8%	6.1%	4.6%	4.7%	7.2%	9.1%	5.4%	4.8%
Filipino	14.4%	12.8%	8.1%	8.2%	2.8%	2.1%	16.9%	21.0%	2.9%	2.8%
Chinese	7.6%	6.9%	3.2%	2.5%	4.8%	3.6%	1.5%	1.4%	3.2%	2.0%
Hawaiian	11.0%	10.5%	24.7%	24.0%	22.8%	19.7%	15.8%	12.0%	40.8%	43.9%
Samoan	1.7%	1.8%	8.4%	10.4%	15.9%	20.6%	3.3%	0.6%	4.9%	6.9%
Other	10.4%	10.0%	11.3%	12.9%	17.6%	22.3%	7.8%	5.1%	7.1%	8.0%
AGE										
Less than 5 years	7.4%	7.9%	9.8%	11.6%	10.8%	14.6%	8.8%	8.1%	10.1%	11.1%
5-9 years	7.0%	7.4%	9.2%	9.0%	8.5%	9.9%	9.9%	7.0%	9.1%	10.0%
10-15 years	7.6%	9.3%	10.0%	10.2%	10.7%	10.4%	9.0%	8.0%	10.2%	12.5%
16-64 years	67.0%	68.1%	63.7%	62.9%	65.5%	61.8%	63.6%	66.7%	61.2%	60.2%
65 years & over	11.0%	7.3%	7.3%	6.3%	4.5%	3.3%	8.7%	10.2%	9.4%	6.2%

SOURCES: U.S. Bureau of the Census, 1991, 1981.

EXHIBIT 2-A: POPULATION TRENDS, 1950-1990

	1950	1960	1970	1980	1990
AREA POPULATION					
CITY AND COUNTY OF HONOLULU	353,020	500,409	630,528	762,565	836,231
KOOLAULOA DIVISION	5,223	8,043	10,562	14,195	18,443
C.T. 102.02 (Laie) *	1,478	2,639	3,810	5,752	6,926
C.T. 101 (Sunset-Kahuku) **	2,482	3,150	3,497	4,491	6,909
C.T. 102.01 (Hauula-Kaaawa) *	1,263	2,254	3,255	3,952	4,608
KOOLAULOA DP AREA	N/A	N/A	N/A	11,123	14,263

	1950-60	1960-70	1970-80	1980-1990
AVERAGE ANNUAL GROWTH RATE				
CITY AND COUNTY OF HONOLULU	3.6%	2.3%	1.9%	1.0%
KOOLAULOA DIVISION	4.4%	2.8%	3.0%	2.9%
C.T. 102.02 (Laie) *	6.0%	3.7%	4.2%	1.9%
C.T. 101 (Sunset-Kahuku) **	2.4%	1.1%	2.5%	4.4%
C.T. 102.01 (Hauula-Kaaawa) *	6.0%	3.7%	2.0%	1.5%
KOOLAULOA DP AREA	N/A	N/A	N/A	2.5%

NOTES: * Census Tract (C.T.) 102.02 and C.T. 102.01 comprised only one tract in 1960 and 1950 (C.T. 102 in 1960 and C.T. 32 in 1950). Thus, C.T. 102.01 for 1960 and 1950 is approximated by applying the 1970 ratio of C.T. 102.01 to C.T. 102.02.

** C.T. 101 was termed C.T. 33 for Census year 1950.

SOURCES: U.S. Bureau of the Census, 1991, 1981, 1972, 1962, 1952; DPED, 1973.

Survey results in Exhibit 2-C indicate that roughly a fifth of Laie residents were born in the Pacific Islands, and only about 70% were born in the United States, compared to 84% for Koolauloa as a whole.

SUNSET BEACH TO KAHUKU. While the town of Kahuku is smaller than Laie, the Sunset to Kahuku area combined (C.T. 101) has nearly as many inhabitants as Laie (C.T. 102.02). This region also experienced the highest growth rate of the Koolauloa communities over the last decade.

Caucasians form almost half the population of the tract, and are present in particularly large numbers in Sunset Beach. Filipinos and Hawaiians are well-represented in Kahuku Town but both these groups have experienced a proportional decrease from 1980 as a wider ethnic mix of newcomers has settled in Kahuku.

Although the Sunset Beach to Kahuku population is slightly younger than islandwide, it tends to be somewhat older than for Koolauloa as a whole. A decline in the average age since 1980, however, suggests that the population is becoming increasingly younger.

HAUULA TO KAAAWA. This area, comprising C.T. 102.01, is the least populous of the Koolauloa Division, with only 4,608 residents. It has also exhibited the lowest growth rate for the last 10 years.

As with most of Oahu, the area has a sizable Caucasian group that comprises more than a third of the total population. Most Caucasians are located in the communities of Punaluu and Kaaawa. Unlike islandwide or even the rest of Koolauloa, however, a significant proportion (41%) of the residents from Hauula to Kaaawa are Hawaiian. Most Hawaiians in this tract reside in the town of Hauula.

The population is fairly young overall, but a good tenth are 65 years or over. Since this same group only composed 6% of the population a decade ago, it appears that the average age is increasing (in part due to Kaaawa having a number of retirees).

Not unexpectedly considering the many Hawaiians in C.T. 102.01, more than half of the residents were born locally. This tract also has the least percentage of foreign-born residents.

EXHIBIT 2-C: SURVEY DEMOGRAPHIC CHARACTERISTICS, 1990

	KOOLAULOA REGION (1)	LAIE	SUNSET-KAHUKU	HAUULA-KAAAWA
SAMPLE POPULATION	569	153	235	181
ETHNICITY				
Caucasian	45.5%	30.1%	58.3%	42.0%
Filipino	4.7%	2.6%	9.4%	0.6%
Hawaiian	24.8%	24.8%	13.6%	39.2%
Other Polynesian	10.7%	28.1%	2.1%	7.2%
Japanese	6.0%	5.2%	9.4%	2.2%
Mixed/Other	8.3%	9.2%	7.2%	8.8%
AGE				
Less than 25 years	9.8%	18.3%	6.0%	7.7%
25 to 34 years	27.2%	31.4%	24.3%	27.6%
35 to 44 years	25.0%	22.2%	27.7%	23.8%
45 to 54 years	15.1%	13.1%	11.5%	21.5%
55 or over years	22.5%	15.0%	29.8%	19.3%
Refused	0.4%	0.0%	0.9%	0.0%
PLACE OF BIRTH				
Hawaii	40.2%	35.9%	35.3%	50.3%
Mainland United States	43.6%	34.6%	52.8%	39.2%
Pacific Islands	8.6%	20.9%	2.6%	6.1%
Philippines	2.5%	2.0%	4.7%	0.0%
Other Asian Countries	2.3%	2.6%	2.1%	2.2%
Elsewhere	2.8%	3.9%	2.6%	2.2%

NOTE: (1) Region is sum of Laie, Sunset to Kahuku, & Hauula to Kaaawa. It approximates the Koolauloa Census Division rather than the County DP area.

SOURCE: Community Resources, Inc., 1990.

2.2.2 Housing and Income Characteristics

Housing has long been widely recognized as a concern for many North Shore and Koolauloa residents. While Koolauloa is distant from Honolulu, where Oahu's housing prices are highest, study area prices for single-family properties have climbed along with islandwide averages. High prices and a lack of available units contribute significantly to widespread overcrowding and housesharing in the area.

LAIE. Exhibit 2-D shows housing characteristics for the Koolauloa Division. Of all Koolauloa communities, Laie faces the most serious housing shortage. Laie has more people but fewer housing units than the other census tracts in Koolauloa. (The high average population per household in C.T. 102.02 does not include students in dormitories.) Of Laie's total 1,517 units in 1990, around 11% were vacant, compared to 17% for Koolauloa. Even so, the census tract has almost double the vacancy rate of the County. In large part this is because of beach houses in Malaekahana being held for occasional use.

Most Laie residents rent. Only around a third of the occupied units are owner-occupied compared to almost half for Koolauloa and just over half for the County.

Close to a sixth of Laie residents -- some 1,075 persons -- live in group quarters (that is, in the BYU-H dormitories).

Housing costs in Laie were low by islandwide standards in 1990. The town's median home value of $179,500 and median monthly rent of $509 were easily the lowest in Koolauloa.

The median number of rooms per unit in Laie was five, compared to four for the rest of Koolauloa. Despite having relatively more spacious homes, Laie is the most crowded community in the Koolauloa Division, with almost a fifth of its residents in crowded units (1.0 to 1.5 persons per room) and another fifth in very crowded units (more than 1.5 persons per room). Not surprisingly, the Laie area has 4.33 persons per unit compared to the much lower 3.02 and 3.50 persons per unit for the County and Koolauloa, respectively. (In the Laie CDP, the average household size reached 4.42 in 1990.)

Despite the large number of college students who reside in the town, Laie is a fairly stable community. The housing survey data in Exhibit 2-E indicates that over a third of Laie householders have resided in the same home for more than 10 years, compared to only about a fifth for the entire Koolauloa Division.

EXHIBIT 2-D: CENSUS HOUSING CHARACTERISTICS, 1990

	HONOLULU COUNTY	KOOLAULOA DIVISION	C.T. 102.02 LAIE	C.T. 101 SUNSET-KAHUKU	C.T. 102.01 HAUULA-KAAAWA
TOTAL HOUSING UNITS	281,683	5,939	1,517	2,596	1,826
TOTAL VACANT UNITS	5.8%	16.9%	11.0%	18.1%	20.2%
Seasonal/recreational/occasional	1.6%	9.4%	4.4%	11.6%	10.5%
For sale only	0.3%	0.4%	0.2%	0.4%	0.6%
For rent	2.0%	2.4%	2.9%	1.6%	3.0%
Other vacant	1.9%	4.7%	3.5%	4.5%	6.1%
ROOMS PER UNIT					
One to three	36.5%	39.3%	33.2%	40.7%	42.3%
Four to five	34.6%	39.6%	38.7%	40.9%	38.3%
Six or more	28.9%	21.2%	28.1%	18.4%	19.4%
Median rooms	4	4	5	4	4
TOTAL OCCUPIED UNITS	265,304	4,935	1,350	2,127	1,458
TENURE					
Owner-occupied	52.0%	46.5%	37.0%	51.9%	47.3%
Renter-occupied	48.0%	53.5%	63.0%	48.1%	52.7%
PERSONS PER ROOM					
1.00 to 1.50 (1)	8.2%	13.8%	19.9%	12.1%	10.6%
1.51 or more (2)	8.2%	13.9%	21.9%	9.3%	13.2%
PERSONS PER UNIT	3.02	3.50	4.33	3.21	3.16
PERSONS IN OCCUPIED UNITS	802,338	17,291	5,851	6,832	4,608
As % of total population	95.9%	93.8%	84.5%	98.9%	100.0%
MEDIAN VALUE (3) (owner-occupied)	$283,600	$197,000	$179,500	$202,700	$212,800
MEDIAN CASH RENT (renter-occupied)	$615	$563	$509	$631	$563

NOTES: (1) Indicates "mildly crowded" conditions.
(2) Indicates "very crowded" conditions.
(3) Median values are for non-condominium housing units.

SOURCE: U.S. Bureau of the Census, 1991.

EXHIBIT 2-E: SURVEY HOUSING CHARACTERISTICS, 1990

	KOOLAULOA REGION (1)	LAIE	SUNSET-KAHUKU	HAUULA-KAAAWA
SAMPLE HOUSEHOLDS	569	153	235	181
FAMILY HOUSEHOLDS	90.5%	90.8%	87.7%	93.9%
TYPE OF UNIT				
Multi-family	8.8%	5.9%	8.1%	12.2%
Townhouse	17.2%	17.0%	21.7%	11.6%
Single-family	74.0%	77.1%	70.2%	76.2%
ROOMS PER UNIT				
One	1.9%	2.0%	1.7%	2.2%
Two	6.3%	8.5%	6.8%	3.9%
Three	14.6%	21.6%	14.0%	9.4%
Four	21.1%	16.3%	22.1%	23.8%
Five or more	56.1%	51.6%	55.3%	60.8%
CROWDING				
Not crowded (2)	74.5%	54.2%	84.3%	79.0%
Crowded (3)	16.0%	22.2%	11.9%	16.0%
Very crowded (4)	9.5%	23.5%	3.8%	5.0%
TENURE				
Owner-occupied	50.3%	48.4%	50.6%	51.4%
Renter-occupied	46.4%	49.0%	47.2%	43.1%
Occupied without rent	2.6%	2.0%	1.7%	4.4%
Not sure/refused	0.7%	0.7%	0.4%	1.1%
LENGTH OF RESIDENCE IN SAME HOUSE				
Under 1 year	20.4%	19.0%	19.1%	23.2%
1-3 years	22.3%	18.3%	26.0%	21.0%
4-10 years	26.2%	24.8%	30.6%	21.5%
11-17 years	12.0%	15.7%	9.8%	11.6%
18 or more years	19.2%	22.2%	14.5%	22.7%

NOTES: (1) Region is sum of Laie, Sunset to Kahuku, & Hauula to Kaaawa. It approximates the Koolauloa Census Division rather than the County DP area.
(2) One person per room or less.
(3) From 1.0 to 1.5 persons per room.
(4) More than 1.5 persons per room.

SOURCE: Community Resources, Inc., 1990.

Reported household incomes, as shown in Exhibit 2-F, are very similar to those of other towns, with the majority of Laie households (42%) garnering incomes between $2,000 and $4,000. Given that Laie households on average have more people, however, such household incomes may be inadequate. Nevertheless, only 4% of Laie households receive food stamps -- this is the lowest level of public assistance in Koolauloa, and barely half the County average. This is probably attributable to the relief afforded by the LDS church's welfare program.

SUNSET BEACH TO KAHUKU. This area is comparable to Laie in population size, but has almost a thousand more housing units. Of a 1990 total of 2,596 units, 18% were vacant. A significant portion of the vacancies (mainly in Sunset Beach and Kuilima) are rental units held for short-term use. Many of these short-term rentals are occupied by surfers during the high surf season. Consequently, fewer rentals are available in the winter months than at other times of the year.

Despite its strong short-term rental market, this area has the lowest proportion of renters in Koolauloa (less than half). Rental prices, however, tend to be higher in this tract than elsewhere in Koolauloa, and even higher than the islandwide averages.

The survey indicates that this tract as a whole has the lowest proportion of single-family units, perhaps due to the emphasis on the vacation rental market. Much of the Kahuku housing stock, however, is comprised of old single-family plantation homes. C.T. 101 also tends to be a fairly mobile community: only a quarter of the population has lived in the same house for more than a decade.

HAUULA TO KAAAWA. Total units in this tract amounted to 1,826 in 1990. The area's vacancy rate of 20% is the highest in Koolauloa and far above the County's 6%. Additionally, this tract had the fewest persons per unit for Koolauloa.

While the survey suggests monthly housing costs and household incomes are close to the Koolauloa average, C.T. 102.01 has the highest proportion of households receiving food stamps.

2.2.3 Employment

Although the Koolauloa Division is "country" in atmosphere, more than half the workforce commutes outside the region for work (as shown in Exhibit 2-G). The survey also indicates that residents who commute further for work generally earn more. Survey results further suggest that the labor force includes high proportions of both professionals and general laborers.

EXHIBIT 2-F: SURVEY INCOME CHARACTERISTICS, 1990

	KOOLAULOA REGION (1)	LAIE	SUNSET-KAHUKU	HAUULA-KAAAWA
SAMPLE HOUSEHOLDS	569	153	235	181
MONTHLY HOUSING COST				
$500 or less	26.7%	27.5%	27.2%	25.4%
$501 to $750	22.0%	22.9%	21.3%	22.1%
$751 to $1,000	19.5%	17.6%	19.1%	21.5%
$1,000 to $1,500	19.2%	22.2%	16.6%	19.9%
Over $1,500	9.3%	5.2%	11.9%	9.4%
Not Sure/Refused	3.3%	4.6%	3.8%	1.7%
HOUSEHOLD INCOME				
$1,000 or less	8.6%	8.5%	9.8%	7.2%
$1,001-$2,000	13.2%	14.4%	11.1%	14.9%
$2,001-$3,000	24.3%	24.8%	26.8%	20.4%
$3,001-$4,000	17.9%	17.0%	16.6%	20.4%
$4,001-$5,000	11.2%	9.8%	11.9%	11.6%
Over $5,000	17.4%	13.7%	18.3%	19.3%
Not Sure/Refused	7.4%	11.8%	5.5%	6.1%
HOUSEHOLDS RECEIVING FOOD STAMPS	8.6%	3.9%	8.1%	13.3%

NOTE: (1) Region is sum of Laie, Sunset to Kahuku, & Hauula to Kaaawa. It approximates the Koolauloa Census Division rather than the County DP area.

SOURCE: Community Resources, Inc., 1990.

EXHIBIT 2-G: SURVEY EMPLOYMENT CHARACTERISTICS, 1990

	KOOLAULOA REGION (1)	LAIE	SUNSET-KAHUKU	HAUULA-KAAAWA
SAMPLE POPULATION	569	153	235	181
LABOR FORCE STATUS				
Civilian jobs	57.3%	60.1%	54.0%	59.1%
Military jobs	0.7%	0.0%	0.9%	1.1%
Active unemployed	4.4%	5.9%	4.7%	2.8%
Hidden unemployed	5.1%	5.9%	4.3%	5.5%
Prefer not working	32.3%	28.1%	36.2%	30.9%
Unknown	0.2%	0.0%	0.0%	0.6%
CIVILIAN LABOR FORCE PARTICIPATION RATE (2)	66.8%	71.9%	63.0%	67.4%
CIVILIAN JOBS	326	92	127	107
TYPE OF JOB				
Single full-time	73.0%	69.6%	74.8%	73.8%
Single part-time	15.3%	22.8%	14.2%	10.3%
Several part-time	3.4%	2.2%	3.1%	4.7%
Full-time & others	8.3%	5.4%	7.9%	11.2%
OCCUPATION				
Sales	11.3%	9.8%	11.8%	12.1%
Office/clerical	10.4%	8.7%	10.2%	12.1%
Farm/plantation	1.8%	1.1%	2.4%	1.9%
Restaurant/cocktail	4.6%	5.4%	3.9%	4.7%
Housekeeping	1.8%	2.2%	0.8%	2.8%
General labor	22.4%	23.9%	25.2%	17.8%
Professional/managerial	42.0%	38.0%	43.3%	43.9%
Other/Refused	5.5%	10.9%	2.4%	4.7%
JOB LOCATION				
Kuilima	6.1%	5.4%	10.2%	1.9%
Kaaawa to Waialua	46.3%	63.0%	38.6%	41.1%
Kahaluu to Kaneohe	7.1%	7.6%	3.9%	10.3%
Wahiawa	3.4%	1.1%	7.1%	0.9%
Elsewhere in Hawaii	36.5%	22.8%	39.4%	44.9%
Refused	0.6%	0.0%	0.8%	0.9%

NOTES: (1) Region is sum of Laie, Sunset to Kahuku, & Hauula to Kaaawa. It approximates the Koolauloa Census Division rather than the County DP area.
(2) Includes hidden unemployed (i.e. persons without jobs who are not actively seeking work but who still want work).

SOURCE: Community Resources, Inc., 1990.

LAIE. Laie has the highest civilian labor force participation rate in Koolauloa. However, a quarter of Laie's workforce only works one part-time job compared to 12% for the entire region. According to DLIR estimates, Laie's 1990 unemployment rate of 2.0% was the lowest in Koolauloa.

Proportionally, more Laie workers remain in the Koolauloa/North Shore region for employment than any other community. This is in due part to many Laie residents' working at the PCC and Kuilima.

SUNSET BEACH TO KAHUKU. This area has the lowest civilian labor force participation rate. Not unexpectedly with retirees and short-term residents (such as surfers) over a third of the residents prefer not to work. Not surprisingly, C.T. 101 had the highest 1990 unemployment rate in Koolauloa, with a rate almost double that of Laie. Despite the higher unemployment rate, the survey indicates that this tract has the highest proportion of workers with single full-time jobs.

As with other Koolauloa communities, most of the workers are either in professional/managerial positions or are general laborers. Slightly more workers in the area were employed in agriculture, reflecting the fairly rural nature of the tract. A higher proportion of C.T. 101 workers traveled out of the Koolauloa/North Shore districts for work than did other regional workers.

HAUULA TO KAAAWA. This area has substantially fewer general laborers than the rest of Koolauloa and slightly more sales and clerical workers. As with other Koolauloa communities except Laie, well over half of the workers from this area worked outside the Koolauloa Division. Unemployment in 1990 was relatively low at 2.3%

3.0 FORCES FOR CHANGE INDEPENDENT OF THE PROJECT

This section addresses developments and trends, apart from the project, that are likely to contribute to future changes in Koolauloa.

According to official State projections, the City and County's resident and visitor populations will continue to increase over the next two decades:

	1995	2000	2005	2010
Resident Population	910,400	932,800	961,100	999,500
Average Visitor Census	89,300	96,800	104,900	113,400

Continuing growth of the economy will have impacts down to the regional level. Koolauloa, which has had population growth rates exceeding the County average, will continue to experience an economic surge.

In particular, expansion of the Kuilima Resort will bring thousands of additional jobs to the region. With new economic opportunities, the resident population could grow along with the visitor population. Traffic congestion will increase, and the need to improve limited infrastructure will become pressing.

Resident opinion and City policy support growth control measures in the region. However, if controls are exercised in the form of housing stock restrictions, the likely result will be severe crowding, higher housing costs, and more long-distance commuting.

3.1 PLANNED AND PROPOSED DEVELOPMENTS

3.1.1 Resident Housing

WEINBERG VILLAGES MALAEKAHANA. A joint effort by the State Department of Human Services and the Weinberg Foundation to provide temporary housing for 55 families will begin in January or February of 1992. Completion of the project is set for June 1992. The housing will be erected between Malaekahana State Park and Kahuku on land leased from the State (personal communication, Ron Critser, Project Coordinator for Homeless Villages, Department of Human Services, December 11, 1991).

KUILIMA RESORT. Kuilima Resort is committed by its Unilateral Agreement to erect 200 affordable units outside the resort when new visitor units are built. All Kuilima projects save the new golf course, however, are on hold.

KAHUKU. An important residential development is ongoing in Kahuku. The Kahuku Housing Corporation began construction of 289 units in 1987. Current construction is now overseen by the Kahuku Village Association. Approximately 177 units remain to be built by 1993, all of which have been allotted to families in the town (personal communication, Joanne Eugenio, Kahuku Village Association, December 10, 1991).

LIHI LANI. Obayashi's Lihi Lani Recreational Community on 1,143 acres of the Pupukea plateau includes several components:

- 180 affordable housing units;
- 120 market residential lots; along with
- An 18-hole golf course and other recreational facilities, including a tennis center, a ranch, camp grounds, and trails.

Construction is scheduled to start in 1994, with all but the market residential lots completed by 1997. The City Council recently voted in favor of Obayashi's request for a Development Plan amendment. However, further land use and construction permits are required.

HAUULA. A proposal to build 114 housing units and an autistic school on an 18.5-acre parcel in Hauula is on hold until infrastructural needs can be adequately addressed.

3.1.2 Additional Projects

GOLF COURSES. A new 18-hole golf course is under construction at the Kuilima Resort. It is due to begin operations in 1992. When the new course is completed, the existing Kuilima course will close down for extensive renovation. The new Kuilima facility is the only course that is currently under construction; all other golf courses are proposals, for which no land use permits have been obtained. Proposals include:

- **Campbell Estate.** Campbell Estate proposes four courses: three at Punamano (near Kuilima) and one at Malaekahana (near Laie). All would be 18-hole courses open for public play. Two clubhouses would service the Punamano courses, while the Malaekahana course, being much further away, would require its own clubhouse and support facilities. Although an Environmental Impact Statement has been accepted, no public announcement to seek permits has yet been made. Campbell Estate hopes to have construction underway within three years, with completion anywhere from four to six years after initial work begins (personal communication, Chuck Ehrhorn, Development Manager, Campbell Estate, December 10, 1991).
- **Asahi Jyuken.** Asahi Jyuken possesses 225 acres of land at Malaekahana, currently used to graze cattle, on which it plans to develop an 18-hole course. No date for development is scheduled.

KAHUKU LIGHT INDUSTRIAL PARK. In 1989, the City and County approved a Development Plan amendment for a light industrial park of 28 lots (on 14.9 acres) adjacent to the Kahuku Sugar Mill. The timetable for this project, however, is presently on hold (personal communication, Chuck Ehrhorn, Development Manager, Campbell Estate, December 10, 1991).

3.2 ANTICIPATED CHANGES IN REGIONAL EMPLOYMENT

3.2.1 Kuilima Resort Expansion

The expansion planned by Kuilima Resort constitutes the most extensive alteration in Koolauloa's employment base. The hope is to create a critical mass of visitor facilities -- a resort area offering diverse attractions that will draw a larger volume of visitors.

The most recent expansion plans call for four new hotels, and two additional towers to the present hotel (making a total of 2,599 new hotel units); 1,000 resort condominium units; and a 112,000 square foot shopping village.

Phase I began in 1989 and was originally scheduled for completion by 1995. Virtually all Phase I construction stopped in 1991, and while no new schedule has been announced, delays of more than two years are likely. Timing of the next two phases is yet to be determined.

Besides the new golf course mentioned earlier, planned recreational facilities include stables, a clubhouse, tennis club, beach club, and visitor center.

Operations at the completed Kuilima Resort facilities are expected to generate approximately 3,360 direct on-site jobs, and a further 1,210 direct, indirect, and induced jobs throughout the region. Phase I operations alone could provide 3,000 or more direct on-site jobs in the region.

3.2.2 Other Potential Employers

Other major employers indicated in 1990 interviews with Community Resources that their actions could lead to an approximate 2,500 new jobs over the next decade. This estimate includes new jobs created at light industrial and commercial areas. Many of these jobs could also be the indirect and induced jobs estimated as impacts of the Kuilima expansion. Other jobs depend on timetables that are highly indefinite. If the region's visitor plant expands to the levels planned, the total number of new jobs in the combined Koolauloa/North Shore areas by 2000 would range from 4,000 to 6,000 jobs.

Due to the large number of union jobs that the resort expansion will bring to the region, many study area employers expect to have difficulty in finding and retaining staff. Wage levels will increase throughout the region. Consequently, jobs will become somewhat more attractive to workers living either in the region or nearby.

The PCC and BYU-H, in particular, could be affected by a migration of employees lured to the resort expansion by substantially higher wages. Such a trend would initiate a demand for more inexpensive student labor from BYU-H.

3.3 CHANGES IN AGRICULTURAL OPERATIONS

Zions Securities has notified farm tenants that current agricultural leases will not be renewed except on a month-to-month basis. The LDS Church has announced that, as a matter of policy, it will establish an organizational arm to farm its land. Also, the cessation of leases responds to concerns that Zions or its tenants are liable due to violations of government statutes and regulations. The decision to end agricultural leases was independent of the master plan expansion.

The area now under agricultural lease covers thousands of acres, of which approximately 154 acres lie within the project site. Most of the project site leases expire well before construction is expected to start. However, one lease in the Egg Farm area, and one in the area mauka of BYU-H, run until August 31, 1996.

With the establishment of a separate organization to farm LDS land in the Laie/Hauula area, new agricultural jobs will be created. Hence persons now farming as lessees may be able to continue farming as employees.

Zions Securities recognizes that a few dwellings have existed on land under farm leases. Hence the change in policy could lead to displacement of some persons from their current homes.

4.0 IMPACTS

This chapter provides projections of the employment, income, population, and housing demand associated with development in Laie on areas subject to change in Development Plan Map designation. An initial discussion places changes in Laie in the context of the notion of "impact" used in environmental impact studies.

4.1 RELATION OF ON-SITE ACTIONS TO "IMPACTS"

In socio-economic impact assessment, an "impact" is usually defined as the difference between the future with a project and the future without that project. The future with the project is not properly compared to existing conditions, since that comparison does not separate ongoing regional or statewide trends from the likely impacts of the specific project.

The Koolauloa region currently has relatively few people and jobs, compared to urban areas to the south. Still, housing is crowded, especially in Laie. Unemployment is somewhat above the island average, and wages have historically been low. Crowding and rising real estate prices signal the involvement of the region in the islandwide economy. Future growth in that economy, especially growth of the visitor industry in Koolauloa, will likely lead to the following local trends:

- Increased demand for housing in the Koolauloa and North Shore regions;
- Lower unemployment in these regions;
- New economic opportunities in the region to support both operations at Kuilima and the needs of the new workforce; and
- A general trend towards higher wage levels (with union wages at Kuilima setting regional standards).

Whether or not new jobs will attract new residents or encourage existing residents to stay in the area depends largely on City and County policy. Government constraints on new housing could mean that many Kuilima workers will commute to work from outside the region, while others add to crowded conditions in existing housing.

In this context, the proposed Laie Development Plan Amendments and development expected on the land covered by those amendments (hereinafter "the DP Amendments") must be seen as largely responsive to economic and demographic

changes in progress. The "impact" of the DP Amendments is a matter of where anticipated development occurs, not whether it occurs.

Notably, activities at the proposed Laie industrial park would likely support the expanded Kuilima Resort and its workforce. Hence these would be ones which have been counted for EIS purposes as indirect and induced impacts of the Kuilima Resort expansion (Community Resources, Inc. and A. Lono Lyman, 1984).

Similarly, the expansion of the Polynesian Cultural Center responds to projected growth in the island visitor census (Department of Business and Economic Development, 1988). Resort EISs have already forecast increases in off-site visitor spending that would presumably account for the PCC expansion.

New housing in the DP Amendments area is intended to alleviate existing housing pressure, rather than to attract new residents to the island or area. Hence it is responsive to existing conditions. (The numbers of new residents and visitors likely to be in Laie with or without the DP Amendments will be discussed in more detail in Section 4.3.)

At the island level, economic impacts follow from the importation of capital, creating new jobs and income. At the regional level, the impact of the DP Amendments has to do with local community character and planning goals.

A further factor affecting the DP Amendments is the **timing** of regional development. In the current climate of economic uncertainty, proposed new developments cannot be viewed as likely to be built on schedule. When and if major new regional economic activities -- above all, the Kuilima Resort expansion -- occur, the regional economy and housing market will be drastically changed.

In recognition of current uncertainty about the timing and extent of regional growth, low and high estimates of future economic and demographic impacts are provided here.

In this chapter, information will be provided about activities and operations on-site. The implications of such on-site activities for employment, population, and housing will be analyzed. As discussed above, these should largely not be counted as new economic impacts, but as locational ones. Exhibit 4-A provides a general account of the relation between on-site activities and impacts for the various elements of the DP Amendments.

EXHIBIT 4-A: OVERVIEW OF ON-SITE CHANGES AND ASSOCIATED IMPACTS

PROJECT ELEMENT	MAJOR CHANGES ON-SITE	ECONOMIC ACTIVITY ON SITE *	POPULATION ON SITE *	IMPETUS FOR CHANGE	MAJOR IMPACTS
RESIDENTIAL AREA (one of three alternatives)	Construction of 450 units by 1998	Construction employment	About 1,450 to 1,700 residents	Existing crowding	Relocation of Laie residents; relieves some crowding; could allow renewed crowding if demand for housing stays high
BYU-HAWAII EXPANSION	Construction of Auxiliary Services Bldg. and 48-unit married students' housing	Construction; a few operational jobs	About 200 in apartments	Long-term planning	Locational: relieves some crowding in the area
PCC EXPANSION	About 3 new exhibits by 2004	Const. and operational jobs	Increased de facto population	Expected growth of island visitor census	Expansion avoids crowding throughout PCC exhibits. Locational: helps to attract more visitors to region
INDUSTRIAL AREA	Lot development by 1997; eventual buildout	Const. and operational jobs (incl. proprietors)	None	Growth in regional economy	Locational
STP UPGRADE	Increased capacity by 1994	About 4 on-site jobs	None	Existing and anticipated needs	Allows new housing in Laie (hence locational impact); improves on facilities.

NOTE: * Economic and population analysis provides quantitative estimates later in this chapter.

4.2 EMPLOYMENT

Employment effects associated with a development include direct, indirect, and induced jobs:

- "Direct" jobs are involved in the actual construction and operation of the development. Some, such as jobs in construction firms' offices and loading yards, may be off-site.
- "Indirect" jobs are created by demand for goods and services to support a development. These include jobs in suppliers' firms.
- "Induced" jobs are supported by the wages of workers in direct and indirect jobs. These include, for example, jobs in retail stores patronized by workers.

The number of indirect and induced jobs associated with work on a development can be estimated using the State's Input-Output Model of the Hawaii economy.

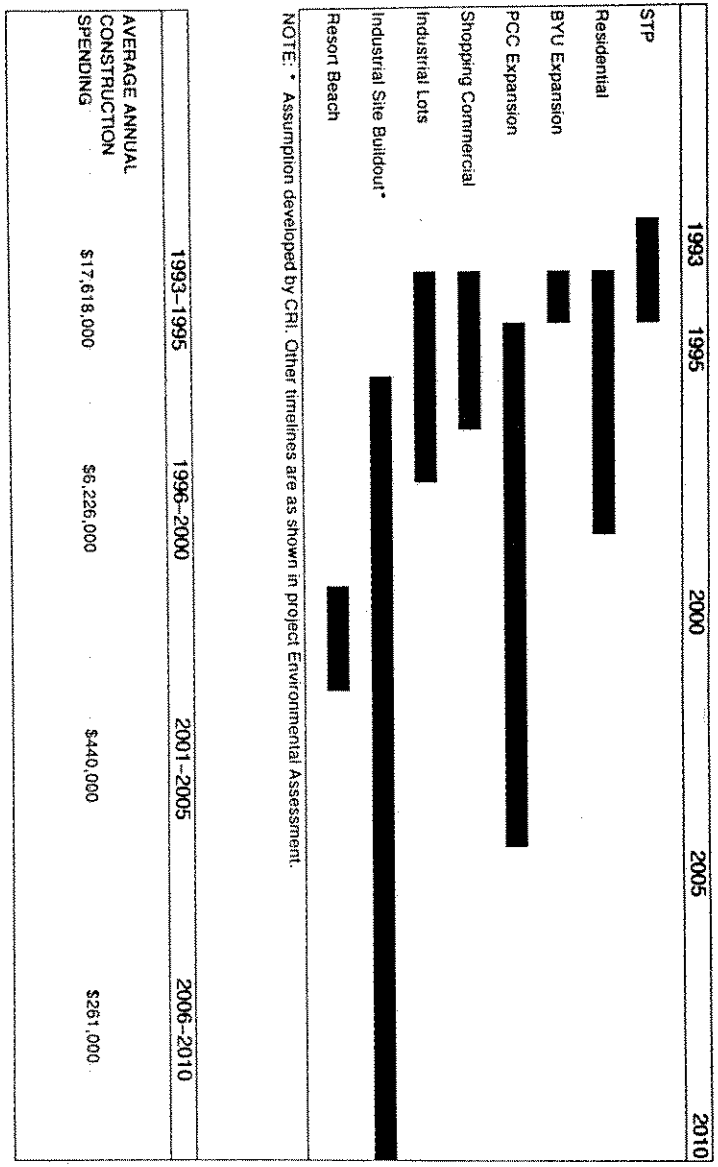
4.2.1 Construction Employment

Exhibit 4-B shows on-site developments involving construction:

- The sewage treatment plant and infrastructure for the residential development;
- The 450 housing units;
- The PCC expansion;
- An auxiliary service building and a 48-unit student housing complex at BYU-H;
- A small expansion of the Laie Shopping Center commercial area (for parking);
- Creation of industrial lots, which will be eventually built out; and
- Eventually, some recreational facilities on the beachfront Resort land.

The cumulative value of construction (including estimates for residential and industrial buildings) is projected as about $87.5 million (1991 dollars). Most construction work is scheduled for the first few years of the proposed development. The jobs created by construction are shown in Exhibit 4-C.

EXHIBIT 4-B: CONSTRUCTION SCHEDULE



NOTE: * Assumption developed by CRI. Other timelines are as shown in project Environmental Assessment.

	1993–1995	1996–2000	2001–2005	2006–2010
AVERAGE ANNUAL CONSTRUCTION SPENDING	$17,618,000	$6,226,000	$440,000	$261,000

EXHIBIT 4-C: CONSTRUCTION EMPLOYMENT

	AVERAGE ANNUAL EMPLOYMENT (FTE JOBS)			
	1993-1995	1996-2000	2001-2005	2006-2010
DIRECT EMPLOYMENT (1)	100	40	0	0
INDIRECT AND INDUCED EMPLOYMENT (2)	200	100	0	0
TOTAL	300	140	10	0

NOTES: All figures rounded to nearest ten.

(1) Based on ratio of construction jobs to construction spending. 1990 ratio: $137,500 spent on construction per construction job. Ratio adjusted for different levels of labor-intensity of single-family, multi-family, and other types of construction. Direct jobs include both on- and off-site jobs. Typically, 20% of direct construction jobs are off-site. Those jobs would nearly all be located on Oahu, outside the Koolauloa region.

(2) Indirect and induced jobs statewide are calculated from Type II multipliers in the State Input-Output model. Multipliers -- single-family construction (3.29); multi-family (3.17); other construction (2.97).

SOURCES: DBED, 1991, 1990, State 1982 Input-Output Model (unpublished tables).

(The regional impact of construction is likely small, since construction workers come from all over Oahu and travel to job sites on the island. Nearly all indirect and induced jobs associated with construction are likely to be located on Oahu, but not necessarily in the Koolauloa region.)

4.2.2 Operational Employment

New jobs will be created in several parts of Laie after construction. The most important job sites are the Polynesian Cultural Center and the industrial area, as shown in Exhibit 4-D. The total on-site employment is estimated as about 180 to 240 full-time or full-time-equivalent (FTE) jobs by 2005. (As noted earlier, operational employment, and its indirect and induced effects, are not "impacts" since such employment is itself caused by off-site capital-importing projects.)

At the PCC, new exhibits and operations will come to employ about 50 full-time employees and 70 students by 2005. (Student employees are counted as half-time workers, so the total number of jobs created by 2005 is 85.)

The mix of tenants in the new Laie industrial sites will depend on the level of activity in the regional economy. The industrial park tenants will largely provide services supporting other regional businesses and consumers. If the regional economy does not include major new sources of employment, it is likely that the industrial sites' tenants will nearly all be small proprietors with no paid employees. If local demand is stronger, the industrial area could include operations with larger staffs, including some wholesale enterprises.

Exhibit 4-D includes both low and high estimates of employment in the industrial area, reflecting different assumptions about tenant mix. Over time, it will be increasingly likely that the high range is the best estimate of jobs on-site, as the regional economy is expected to grow.

Indirect and induced jobs associated with on-site employment are shown in Exhibit 4-E. The direct jobs created by the year 2005 are estimated as creating some 140 to 190 indirect and induced jobs in the state. (The jobs shown in Exhibit 4-D are assigned in Exhibit 4-E to various industries, in order to use State estimates of the indirect and induced effects of different types of jobs.) Some of the indirect and induced jobs may be in the Koolauloa region. These nearby jobs are likely to comprise well under half the indirect and induced jobs shown in Exhibit 4-D.

EXHIBIT 4-D: NEW DIRECT OPERATIONAL EMPLOYMENT CREATED ON-SITE

	1995	2000	2005	2010
BRIGHAM YOUNG UNIVERSITY				
Full-Time Staff	5	5	5	5
Students (FTE)	5	5	5	5
Total FTE:	5	5	5	5
POLYNESIAN CULTURAL CENTER				
Full-Time Staff	5	25	50	65
Students (FTE)	5	20	35	50
Total FTE:	10	45	85	115
INDUSTRIAL AREA				
Low Range	0	40	80	115
High Range	0	70	140	200
SEWAGE TREATMENT PLANT	5	5	5	5
RESORT BEACHFRONT	0	0	5	5
TOTAL JOBS (FTE)				
Low Range	20	100	180	250
High Range	20	130	240	330
Student Job Total	10	20	40	50
Full-Time Employees Job Total				
Low Range	10	70	140	190
High Range	10	100	200	280

NOTES: Figures for areas rounded to nearest five; figures for total jobs rounded to nearest ten. Estimates based on discussions with affected organizations and research by CRI. BYU-H students are projected as working half-time. Hence, a student FTE of 10 indicates jobs for 20 students. Industrial area jobs vary according to the mix of industries likely to be in the area:

	LOW	HIGH
Service, no payroll	80%	60%
Service, with payroll	15%	30%
Wholesale	5%	10%

Estimates of employment derive from the 1987 economic censuses, using (where possible) data for areas relatively distant from airports, harbors, and urban centers.

SOURCES: U.S. Bureau of the Census, 1989a, 1989b.

EXHIBIT 4-E: DIRECT, INDIRECT, AND INDUCED EMPLOYMENT

	1995	2000	2005	2010
DIRECT EMPLOYMENT (BY INDUSTRY)				
Maintenance and Repair				
Low	10	20	40	60
High	10	30	60	90
Water and Sanitary Services	0	0	0	0
Wholesale Trade				
Low	0	0	0	10
High	0	10	10	20
Retail Trade	0	0	10	10
Eating and Drinking	0	0	10	10
Auto and Misc Repair				
Low	0	20	40	60
High	0	30	70	100
Amusement Services	10	40	70	100
TOTAL DIRECT JOBS				
Low	20	100	180	250
High	20	130	240	330
INDIRECT AND INDUCED EMPLOYMENT (BY TYPE OF DIRECT JOB)				
Maintenance and Repair				
Low	10	30	60	80
High	10	50	80	110
Water and Sanitary Services	20	20	20	20
Wholesale Trade				
Low	0	0	0	10
High	0	10	10	20
Retail Trade	0	0	0	10
Eating and Drinking	0	0	10	10
Auto and Misc Repair				
Low	0	10	20	30
High	0	20	30	50
Amusement Services	0	20	30	50
TOTAL INDIRECT AND INDUCED JOBS				
Low	30	80	140	190
High	30	110	190	260
TOTAL DIRECT, INDIRECT, AND INDUCED EMPLOYMENT				
Low	50	180	320	440
High	50	230	430	590

NOTES: All figures rounded to nearest ten. In this exhibit, direct jobs from Exhibit 4-D are assigned to industry categories as listed in Hawaii State Input-Output job estimate model.

4.2.3 Personal Income

The wages and salaries paid to direct employees -- including both construction and operational workers -- counts as the personal income associated with the DP Amendments. This is estimated in Exhibit 4-F. Personal income is highest during the early years, when most construction is under way. By 2005, nearly $3 to $4 million in income will derive from on-site operations. Eventually, operational income would stabilize at about $4 to $5 million.

Personal income is calculated on the basis of average industry wages and salaries for different industries. In the case of service operations without payrolls, the proprietor's share is estimated as, on average, 50% of receipts. (Receipts are estimated from the 1987 Census of Service Industries, using data for locations on Oahu at some distance from Honolulu and its airport as comparable to the future Laie industrial area.)

4.2.4 Projected Employment in Relation to Labor Supply

Potential workers on the developments on the DP Amendments area and on related jobs will come from several sources:

- Both BYU-H and PCC count on students to fill many jobs. The estimated additional student jobs -- about 35 FTE jobs, or part-time work for some 70 students by 2005 -- would employ less than 5% of the student body. (BYU-H and the PCC now employ about 1,580 students, some 70% of the total enrollment.)

- Both recent and future high school graduates of the Koolauloa/North Shore area. Recent graduates are disproportionately represented among the unemployed and underemployed in the region (Community Resources, Inc., 1990).

- Currently, labor force participation is lower than the Oahu average in Laie and surrounding communities. With new employment opportunities, members of the community who now view themselves as outside the workforce could join it.

- About half the employed persons living in the Koolauloa Division commuted to work elsewhere on Oahu in 1990 (as shown in Exhibit 2-G). Many workers on-site, especially in the industrial area, could be existing area residents who are now commuting long distances.

EXHIBIT 4-F: PERSONAL INCOME ASSOCIATED WITH DIRECT JOBS

	AVERAGE ANNUAL INCOME			
	1993-1995	1996-2000	2001-2005	2006-2010
CONSTRUCTION (1)	$7,822,000	$3,741,000	$171,000	$101,000
OPERATIONAL (2)				
Low	$181,000	$1,213,000	$2,654,000	$3,954,000
High	$181,000	$1,548,000	$3,550,000	$5,355,000
TOTAL INCOME				
Low	$8,002,000	$4,954,000	$2,824,000	$4,055,000
High	$8,002,000	$5,289,000	$3,720,000	$5,456,000

NOTES: All figures rounded to nearest thousand.
(1) Estimates generated from average 1990 industry wages.
(2) Estimates generated from: current BYU-H and PCC wages; proprietors' income and wages averaged in 1987 economic censuses and adjusted to 1990 dollars by using the Honolulu CPI; and average 1990 industry wages for STP operators.

SOURCES: U.S. Bureau of the Census, 1989a, 1989b; DLIR, 1991; DBED, 1991.

- Consequently, direct operational jobs will likely be filled mostly by residents of Laie and the surrounding area. However, ex-commuters will leave jobs elsewhere to be filled. Similarly, indirect and induced jobs, mostly located on Oahu outside the Koolauloa region, would remain to be filled.

  New entrants to the labor force could well fill many of the positions in question. In Hawaii's tight labor market, however, it must be assumed that a substantial number of the jobs outside Koolauloa associated with the DP Amendments would be taken by in-migrants.

The likelihood that jobs in Koolauloa associated with the DP Amendments will be filled by residents depends on competition for their labor. Many new job openings are projected (as discussed in Chapter 3). Strong regional economic growth would likely provide jobs for available residents and further attract in-migrants (or commuters) to the region. Without a major regional job center (such as the Kuilima resort expansion is expected to be), the developments in the Laie DP Amendment are could find most of their direct workforce among residents. (However, operations in the proposed Laie industrial area, highly dependent on residents' available income, would be small in scale if less regional growth is projected.)

In sum, local labor sources could most provide on-site labor, but the proposed industrial park would most likely prosper in a context of regional growth, and hence strong off-site demand for labor.

4.3 POPULATION AND HOUSING

Two distinct types of population associated with the DP Amendments are estimated in different ways. The population living on or visiting the site can be estimated. Again, the population supported by activities on-site -- the people in households supported by on-site workers, for example -- can be estimated. Since the families of on-site workers may well live in the residential area to be developed, these figures could well refer to the same persons.

4.3.1 On-Site Population

DISPLACEMENT. Currently, agricultural operations are present on all three of the possible residential areas, along with some of the land identified as sites for expansion of the PCC and BYU-H. Group 70 and Zions Securities have identified structures on the three residential alternative sites and three other areas in the DP Amendments which now could have occupants. (Some are clearly farm houses; others possibly are used for

shelter.) Also, the resort expansion site includes two houses and several apartments leased on a month-to-month basis.

Private tenants now on Zions Security and BYU-H farm land have been notified that, as a matter of policy not connected with the DP Amendments, their leases will not be renewed. Consequently, all but two leases in the alternative residential areas will have ended before construction begins. Construction can take place without displacing tenants from either of those remaining two sites before lease expiration.

The shopping center expansion would involve the removal of one house, the lease on which will expire before the proposed construction date. Part of the back yard in an adjoining property would also be used. Zions Securities expects to negotiate a settlement with the tenant, who holds a long-term lease and would presumably remain in his house.

Current plans include the creation of a new agricultural organization, which would farm land near Hauula. It would offer new agricultural jobs. As for the population displaced from the agricultural lands, help for them would likely be forthcoming from friends and relatives in the community, and from LDS church organizations.

FUTURE ON-SITE RESIDENTIAL POPULATION. Residential development in the proposed DP Amendment area is intended to respond to community needs, relieving crowding in the town. Hence the population living on-site could well be largely composed of people now living in Laie and the surrounding area. Consequently, the immediate increase in Laie's population at the time the residential subdivision is built could be small. Over time, however, Laie housing could again become crowded, with existing and new households much larger than the island average.

The likelihood that on-site residents will largely be current Koolauloa residents could be affected by (a) policies encouraging such residents to apply for and get housing on-site and/or (b) the development timetable. It is not clear whether policies discouraging in-migration to the region would be developed for the new Laie housing, since public financing of part of the housing area, if used, may rule out any preferential practices. Still, the timing of the development could result in an on-site population with few in-migrants to the region, if the residential area is created before any major new demand for housing in the area arises.

In other words, if Laie housing is developed before many new jobs are created in the region, many on-site residents are likely to be persons with longstanding social and economic ties. In the short run, Laie could experience much less crowding and only slight population growth. In the longer run, however, this significant increase in housing for workforce households will allow further population growth. This scenario, in which population increases in Laie occur gradually, is quite likely assuming that Phase I of the

proposed Kuilima Expansion is not completed until after 1998, when buildout of the residential units is scheduled.

The area subject to the DP Amendments includes areas now slated for four different types of housing: affordable multi-family and single-family units, market single-family units, and married student housing.

The population impact of the development has been estimated by City and County Department of General Planning personnel using the following approach:

1. The DP Amendment area includes land now designated as Residential that would be converted to other uses if the petition is approved. This land is estimated as capable of supporting 53 units, which are currently counted in the Department of General Planning's estimate of development capacity for the Koolauloa DP area.

2. The housing impact of the residential subdivision is hence 397 units (450 - 53).

3. The population impact is estimated as 1,294 persons, based on an estimated 3.26 persons per household.

The married students' units would, by this approach, have an additional impact of 156 persons.

4.3.2 Housing Demand Associated with Employment On-Site

Strictly speaking, housing demand is not an economic impact of the DP Amendments, since on-site jobs must be considered as indirect and induced employment impacts of approved visitor industry developments. Consequently, this section focuses on the local housing demand of on-site workers.

The economic factors shaping future crowding in Laie also affect the housing demand of persons holding jobs created in the areas affected by the proposed Development Plan changes:

- In a slowly growing economy (associated with the Low job estimates), jobs on-site would all (or nearly all) be filled by existing area residents.

- In a more active regional economy (associated with the High job estimates, many jobs off-site would attract potential workers among residents. Consequently, fewer on-site jobs would be taken by existing residents, and in-migrants to the area would form much of the on-site labor force.

For the purpose of estimating maximal impacts, it is assumed here that in-migrant workers would account for 75% of the on-site full-time workforce, and would be new to Hawaii, not just to the Koolauloa region.

- If few housing starts are allowed in Koolauloa, on-site workers in the area will live in crowded households and be less likely to form new households. Few on-site workers from outside the area would be able to find homes nearby, so most would commute to Laie from other regions.

- With more new housing allowed in the region, crowding could diminish, but local households would probably remain larger than the City and County average. Workers from the region would tend to form new households at rates found in areas of Hawaii with much available residential land.

Exhibit 4-G summarizes the housing demand associated with on-site jobs. It shows that a population of 290 to 410 persons would, by 2005, be supported by the on-site workforce. Under different conditions, that population could form from 70 to 140 households.

Under Low economic growth assumptions, the islandwide housing demand associated with on-site jobs would amount to at most 20 new households by 2005. Under High growth conditions, the islandwide demand would be much larger (from 90 to 110 new households). The difference between the High and Low ranges follows from the likelihood, under High growth conditions, that few existing residents would be available to fill on-site jobs. Hence the need to house in-migrants would arise.

Under either scenario, new demand for housing in the relatively rural areas of Koolauloa and the North Shore is projected (in Exhibit 4-G) as modest. (Both Development Plan Areas are included in the analysis, since developable land is available in both areas at a short distance from Laie.)

Under High growth conditions, many of the in-migrant workers on-site would expectably seek housing in more urbanized areas, so the net impact on rural districts is limited.

The islandwide new housing demand associated with the DP Amendments amounts to half or less of the new affordable units to be built in the Laie DP Amendments area. The regional share of that demand amounts by 2005 to less than 15% of the proposed new affordable units.

EXHIBIT 4-G: POPULATION AND HOUSING IMPACTS OF ON-SITE EMPLOYMENT

	1995	2000	2005	2010
FULL-TIME JOBS ON-SITE, NON-STUDENT (1)				
Low	10	70	140	190
High	10	100	200	280
POPULATION SUPPORTED BY WORKFORCE, INCLUDING WORKERS (2)				
Low	20	150	290	400
High	20	210	410	580
WORKFORCE HOUSEHOLDS				
Low: Limited Housing Allowed (3)	10	40	70	90
New Housing Encouraged (4)	10	40	80	120
High: Limited Housing Allowed (4)	10	80	120	170
New Housing Encouraged (5)	10	70	140	190
ESTIMATED NEW ISLANDWIDE HOUSING DEMAND				
Low: Limited Housing Allowed (6)	0	10	10	10
New Housing Encouraged (7)	0	10	20	30
High: Limited Housing Allowed (8)	10	50	90	130
New Housing Encouraged (9)	10	60	110	160
ESTIMATED NEW KOOLAULOA/NORTH SHORE HOUSING DEMAND				
Low: Limited Housing Allowed (10)	0	0	10	10
New Housing Encouraged (11)	0	10	20	30
High: Limited Housing Allowed (12)	0	10	20	20
New Housing Encouraged (13)	0	20	40	60

NOTES: All figures rounded to nearest ten.
(1) Assumes students are housed in dormitories.
(2) Using 2.1 household members per worker, based on 1990 averages for both Laie and Honolulu City and County.
(3) Based on Laie's average worker household size of 4.33.
(4) Based on Koolauloa's average worker household size of 3.50.
(5) Based on City and County's average worker household size of 3.02.
(6) Based on resident household formation rate of 15%; no in-migrants.
(7) Based on resident household formation rate of 25%; no in-migrants.
(8) Based on resident household formation rate of 20%, and a 75% in-migrant workforce. Assumes in-migrants require housing.
(9) Based on resident household formation rate of 30%, and a 75% in-migrant workforce. Assumes in-migrants require housing.
(10) Assumes 75% of new housing demand is met in the Koolauloa/North Shore region.
(11) Assumes 100% of new housing demand is met in the Koolauloa/North Shore region.
(12) Assumes 75% of new housing demand from existing Koolauloa/North Shore residents is met in the region, and 15% of demand for housing for in-migrants in met in the region.
(13) Assumes 100% of new housing demand from existing Koolauloa/North Shore residents, and 50% of the demand from in-migrants, is met in the Koolauloa/North Shore region.

SOURCES: Community Resources, Inc., 1990, 1987; Hawaii County, 1989.

4.3.3 Visitor Population Associated with the DP Amendments

The only aspect of the proposed development affecting visitor activities is the PCC expansion. That expansion is planned to accommodate the growth in visitor numbers expected as a consequence of predicted growth in visitors to Oahu.

As Exhibit 4-H indicates, the number of PCC visitors is expected to reach an average of about 3,600 daily by 2005. Of that number, some 360 would be attributable to the DP Amendments, since the PCC expansion would account for about 10% of PCC operations by that time.

The visitor population associated with the DP Amendments should not simply be treated as an increase in the regional visitor population. Many of the visitors could be staying nearby at the expanded Kuilima Resort, and would hence already be in Koolauloa. The one clear impact of the DP Amendments would be their location at the PCC for a few hours in the afternoon or evening.

EXHIBIT 4-H: VISITOR POPULATION ASSOCIATED WITH PROJECT

	HISTORICAL	PROJECTED				
	1990	1990	1995	2000	2005	2010
OAHU RESIDENTS	836,231	861,600	910,400	932,800	961,100	999,500
Average Annual Rate of Growth (1)			1.7%	1.6%	1.6%	1.6%
OAHU AVC (2)	87,400	82,100	89,300	96,800	104,900	113,400
Average Annual Rate of Growth			1.1%	0.5%	0.6%	0.8%
PCC AVC (3)	2,850		3,100	3,350	3,620	3,910
PCC EXPANSION SHARE OF OPERATIONS			1%	6%	10%	13%
PCC EXPANSION SHARE OF AVC			30	190	360	510
Hawaii Residents			0	10	20	30
Westbound Visitors			20	110	220	310
Eastbound Visitors			10	70	130	180

NOTES: All figures rounded to nearest ten.

(1) Until corrected postcensal projections are issued, growth rates must be calculated from the official "M-K Series" projections for 1990 rather than from actual population counts.

(2) AVC (average visitor census) based on published admissions data, with facilities open 310 days per year.

(3) The PCC visitor census is, according to the operator, expected to increase along with the island visitor count. This projection is quantified here, using official State projections and a breakdown of future visitors to the PCC (5% residents, 60% Westbound, and 35% Eastbound) adapted from recent levels and expected trends in Hawaii visitor counts.

SOURCES: DBED, 1991 State Data Book Update (unpublished) 1991, 1988.

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COMMUNITY RESOURCES, INC.

April 16, 1992

Kari Kilstrom
Group 70 International
924 Bethel Street
Honolulu, HI 96813

Dear Ms. Kilstrom,

We have re-analyzed our model of the impacts of the proposed changes in Laie in response to your indication that one of the proposed industrial sites would be about 5 acres in size, with 10 lots, in contrast to the earlier assumption that it would have 16 acres, and include 32 lots.

Specific quantitative changes are identified here in relation to the exhibits in the Community Resources, Inc. report included as an appendix to the Draft Environmental Impact Statement (DEIS) for the Laie Development Plan Amendments. We have not attempted to reproduce every table in the report, only to identify important changes.

Brief notes on the implications of the re-analysis for your EIS are also included in this letter.

Exhibit 4-C

	1993-1995	1996-2000	2001-2005
Construction jobs			
Direct Employment	no change.....		
Indir. and Induced Employment	no change.....		
Total DII	no change ..... 0 (not 10)		

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Exhibit 4-D

	95	2000	2005
Industrial Area			
Low	0	25	45
High	0	45	75
Total Jobs (FTE)			
Low	20	85	140
High	20	100	175
Full-Time Employees Job Total			
Low	10	60	100
High	10	80	130

Exhibit 4-E: Direct, Indirect, and Induced Employment (Operations)

	95	2000	2005
Direct -- as shown above			
Indirect and Induced			
Total			
Low	30	70	110
High	30	90	140
Total Direct, Indirect, and Induced			
Low	50	155	250
High	50	190	310

NOTE: The DEIS Table 10 adapts these calculations, showing permanent operational jobs that could be held long-term, i.e., excluding direct student jobs. The operational job totals for Table 10 then would be:

Direct Employment			
Low	10	60	100
High	10	80	130
Indirect and Induced Employment			
Low	30	70	110
High	30	90	140

Exhibit 4-F: Workforce Personal Income

	Average Annual Income (in $1,000s)		
	93-95	96-2000	2001-2005
Total			
Low	7,974	4,759	2,409
High	7,974	4,970	2,960

NOTE: The change in the industrial area lowers construction income very little. Operational workers' income changes markedly. In 2005, operational workers would earn $2.6 million to $3.2 million. Eventually, operational wages would stabilize at about $3.3 to $3.8 million.

Exhibit 4-G: Population and Housing Impacts

	year 2005
TOTAL POPULATION SUPPORTED	
Low	210
High	280
WORKFORCE HOUSEHOLDS	
Low /limited housing allowed	50
Low /new housing encouraged	60
High /lim.	80
High /new	90
NEW ISLANDWIDE DEMAND	
Low /lim.	10
Low /new	20
High /lim.	60
High /new	80
NEW KOOLAULOA/N.S. DEMAND	
Low /lim.	10
Low /new	20
High /lim.	10
High /new	30

NOTE: The islandwide change in the impacts associated with the project due to the change in the industrial area involves about 130 persons (up to 50 households). In the immediate area (Koolauloa/North Shore), the difference in demand is smaller (up to 10 households in 2005).

Community Resources, Inc. supplied Group 70 International with fiscal calculations used in the DEIS (but not in our separate report). With the changed project description, the following new revenue projections are appropriate:

County: Real property taxes, increase in annual tax revenues after buildout of project -- i.e., 2005 and afterwards:
$278,000 (assuming that the BYU-mauka site is chosen for residential development -- the annual tax revenues would amount to over $275,000 for any of the three residential alternatives);

State: Revenues are shown in the accompanying table (correcting DEIS Table 11).

In sum, the reduction in size of the industrial park will reduce the employment and employment-related impacts of the project considerably. (However, the argument made in our analysis was that these impacts were locational: the impact was a matter of locating jobs in Laie that respond to regional economic growth, rather than creating that growth. So this doesn't mean that there will be fewer jobs on Oahu, just that Laie won't be home to them. They could be in the industrial area proposed for Kahuku, or outside Koolauloa.)

The impact on local population and housing differs a little; but the size of the impact is small in any event (difference of about 10 new households in the local area, with local demand in the range of 10-30 new households).

The fiscal impacts are a fair share of the total revenues estimated. However, the basic point made in the analysis, that the project does bring in new revenues (while the costs to government should have already been attributed to a primary revenue generator), still stands.

Specific changes warranted in the EIS include:

4.16.2.B.1: Fewer jobs, as shown above (Exhibits 4-C and 4-D);

4.16.2.B.2: Changes in estimated construction workers' income are too small to affect the statement in the text. Estimated direct operational workers' incomes will be smaller than shown in the DEIS -- see Exhibit 4-F, above.

4.16.3.B: The islandwide demand for new housing associated with the Laie jobs would range from 10 to 20 new households (under low economic growth assumptions, and 60 to 80 new households (under high economic

growth assumptions) by 2005. The share of this new demand located in the Koolauloa/North Shore region would amount to up to 30 households.

4.16.4.B: Changes in estimated new revenues, and hence overall fiscal benefits, as shown on the preceding page and the attached revision of Table 11.

With the changes indicated, our report can stand as an assessment of the economic and population impacts of the Laie Development Plan Amendments (as amended).

Sincerely yours,

John Kirkpatrick
Vice President

TABLE 11: PROJECTED REVENUES AND STATE TAXES ASSOCIATED WITH DEVELOPMENT OF THE DP AMENDMENT AREAS

	ANNUAL AVERAGE ($1,000s) FOR:			CUMULATIVE
	1993–1995	1996–2000	2001–2005	1993–2005
CONSTRUCTION SPENDING				
Affordable Residential	1,770	2,322	0	16,920
Other Construction	15,775	3,751	331	67,732
OPERATIONAL RECEIPTS				
Polynesian Cultural Center (1)	458	2,343	4,830	37,242
Industrial Park				
Low	0	726	1,902	13,144
High	0	1,347	3,528	24,377
SELECTED POTENTIAL TAX REVENUES ASSOCIATED WITH OPERATIONS AND CONSTRUCTION				
Excise Tax (2)				
Low	326	196	280	3,361
High	326	221	345	3,810
Income Taxes (3)				
Low	266	123	88	1,852
High	267	132	108	2,003
TOTAL				
Low (4)	593	319	368	5,213
High (5)	593	354	453	5,813

NOTES: All values are in thousands of dollars.

(1) Based on estimated average visitor spending of $48, estimated as covering both PCC receipts and off-site travel costs.

(2) Excludes affordable housing construction.

(3) At a rate of 3.41% (based on income tax receipts as a percentage of personal income in Hawaii).

(4) 1993–2005 average: $454,000

(5) 1993–2005 average: $493,000