INTRODUCTION
THE PROCESS
THE PROGRAM
THE PLAN
BACKGROUND DATA
APPENDIX

ADDITIONAL INFORMATION

CLIMATE (Refer to Figure 6)

The climate of Hawaii results from the interaction of many physical parameters of different scales (Blumestock, 1967). In the Central North Pacific, the trade winds blow from the northeast quadrant and represent the outflow of air from the Pacific anticyclone. The Pacific high pressure system and the trade wind zone moves north and south with the sun, so that it reaches its northernmost position in the summer half-year. This brings the heart of the trade winds across Hawaii during the period May through September, when the trades are prevalent 80 to 95 percent of the time. During the winter half year, Hawaii often comes under the influence of mid-latitude weather systems. This is the time of the year when most of the precipitation falls in many areas of Hawaii. Large scale precipitation is usually associated with the synoptic scale weather systems, such as cold fronts, Kona storms and upper level low pressure systems.

Hurricanes and tropical storms are very rare in Hawaii. Only four hurricanes have affected the islands during the past 73 years. Tropical storms, with winds below 74 miles per hour, are more frequent. Unlike cold fronts and Kona storms, hurricanes and tropical storms are not limited to the winter season. They are most likely to occur between July and November.

Most islands in the Hawaiian chain show dramatic differences in climate over short distances. This is a consequence of the strong orographic relief of most of the Hawaiian islands. Frequent and often heavy rains will usually occur at the windward coast of most islands under trade wind conditions, a result of the interplay of the mountain barriers with the steady stream of the trade winds. By contrast, the leeward coasts are much drier.

The configuration of the islands produce large variation in climatic conditions from one place to another. Air, passing through Hawaii as part of a large circulation system such as trade winds or synoptic scale low pressure systems, undergoes a complex three-dimensional flow, resulting in striking differences in wind speed, cloudiness and rainfall from place to place. Together with variations in the elevation of the land, this results in differences in air temperature. The climatic pattern, therefore, reflects not only such dynam elements as the trade wind flow, large sca storms, and the seasonal rhythm of solar heatir but also static elements like topography.

Long-term climatic data for the Kaena region quite limited. The only weather station in tl area with substantial records is the U.S. Air For Kaena Point Satellite Tracking Station, which located at the top of the ridge at an elevation 1,240 feet.

Temperature

In Hawaii, the difference between the coldest an the warmest months averages only about 6.5°I This is the smallest difference of any State in th United States. At Miami, the difference is slightl over 13°F and at Salt Lake City, New York an Boston it is over 40°F. The steady temperature result from the small variation in energy receive from the sun from season to season. The surfac waters of the open ocean around Hawaii have a average temperature that ranges from a min mum of 73 to 74°F during late February and ea ly April to a maximum of 79 to 80°F during lat September and early October. The mild tempera tures of the ocean water give rise to mild tempe atures in the lower layers of the atmospher around Hawaii.

At most locations below 5,000 feet elevation i Hawaii, the average daily range in temperatur is greater than the range of mean temperature throughout the year. Ranges of 15° to 20°F ar common on the Leeward coast. The nearest sta tion with long-term temperature records is lc cated at Waianae. The temperature extremes c that station have ranged from 96° to 50°F. Dail mean January temperatures range from 62.5° t 81.1° and daily August temperatures from 71.1 t 89.5°F. The temperature climate at Waianae ca be taken as fairly representative of conditions i the coastal sections of Kaena Point. The averag decrease in mean monthly temperatures with ele vation is about 3°F per thousand feet, but ther are large differences due to local changes i cloudiness, effects of local winds and differenc in exposure to the trades. At the Kaena Poir Satellite Tracking Station for the period Januar 1962 through June, 1966, the daily temperatur means ranged from 63° to 70°F in January to 67 to 78° in August.

Winds

As in all mountainous areas, the wind conditior in Hawaii are quite complex. Although the trad winds are fairly constant in speed and directio

the trade wind flow is distorted and disrupted by local topography. There also are local wind regimes along many of the coasts and on the mountain slopes which either reinforce or oppose the general flow of air, depending on local circumstances. In some weather situations the trade winds are replaced by other general winds, some of which are not as uniform in direction or speed. The usual regime is to have upslope winds by day and downslope winds by night.

Over Oahu, the trade winds prevail during the summer and predominate during the remainder of the year. As they move over and around Oahu, the trade winds are subject to a variety of interacting influences. Three of the island corners are exposed to the trade winds which are "squeezed" as they sweep around them. Also, as the winds rise over the hilly terrain, they are further constricted and accelerated between the land surface and the trade wind temperature inversion. Speeds are somewhat greater around Kahuku than around Kaena Point. Local funneling often occurs through a notch in the mountain chain, the most notable example being the Pali lookout in the Koolaus. Kolekole Pass in the Waianaes is another such location.

Complex diurnal effects also operate in the wind pattern (Ramage *et al,* 1977). On terrains less than 2,000 feet, night cooling reduces the turbulence of the wind. During the day, turbulence increases and so does the wind. The sea breeze effect on Oahu is relatively minor. Over most of the islands, the diurnal variation of turbulent mixing overpowers the land breeze-sea breeze cycle. Only leeward of the Waianae Range is this cycle detectable.

As part of a preliminary wind power survey conducted by the University of Hawaii's Department of Meteorology (Ramage *et al,* 1977), wind measurements were taken at Kaena Point at three different elevations: 30 feet, 90 feet and 180 feet above sea level. The data period for Kaena Point was 18 months and the mean wind speeds recorded were as follows: 12.5 mph at the 30 foot elevation, 13.7 mph at the 90 foot elevation and 16.8 mph at the 180 foot elevation. There was a clearly defined diurnal pattern to the wind at Kaena Point. Minimum wind speeds averaging about 12 mph were recorded on the average between 3:00 and 9:00 A.M. Wind speeds picked up rapidly during the day and averaged about 16 to 17 mph in the early afternoon hours, gradually dying down in the late evening and at night. The wind rose for the Kaena Point station is shown in Figure 6. Numbers represent the percentage of the time the wind blows from the designated direction and speed.

Kaena Point's north coast is directly exposed to the trade winds. The south shoreline is protected from the trade winds by the Waianae mountains. Along most of the protected Leeward coast, the diurnal heating and cooling of the land mass causes local land-sea breezes. These breezes are independent of the trade wind system and have much lower average velocities of about 5–6 mph. This is a typical on-shore velocity at Lahaina, one of the few locations in Hawaii where the convective breezes have been measured.

Humidity and Cloudiness

In the lowland area and along the lower mountains, the relative humidity on Oahu commonly averages between 70 and 80 percent in windward areas and 60 to 70 percent in leeward areas. The winter relative humidities are somewhat higher than summer ones, maximum values usually occurring with minimum temperatures on a daily basis.

Leeward locations that are well sheltered from the trade winds experience clear daylight conditions 30 to 60 percent of the time, and cloudy conditions less than 20 percent of the time. Unfortunately, there are no stations at the Kaena Point area that measure relative humidity or cloudiness.

Rainfall

Rainfall on Oahu is highly variable. Annual totals vary from under 20 inches along the Waianae Coast to over 300 inches at the highest elevations of the Koolau range. This large variability mainly is due to the interaction of the trade winds with local orographic features.

In the Kaena region, rainfalls vary from less than 20 inches along the semi-arid coastal areas to 75 inches in the higher altitudes near Mt. Kaala (Figure 6). During an average year, almost 90 percent of the days in the lower regions have no rain. In the lowlands at all times of the year, rainfall is more likely to occur during the night or morning hours, and is least likely to occur during mid-afternoon. The more pronounced diurnal variations in the summer exist because most summer rainfall consists of trade wind showers, and these showers are most apt to occur at night. In winter, most of the rainfall in the lowlands occurs in large scale storm situations and these are as likely during the day as at night. Rainfall is highly variable between similar periods of the

year and from year to year.

GEOLOGY (Refer to Figure 7)

The geologic formations found within the study area consist of rugged lava structures, extensive calcareous sand deposits, towering cliffs, deep gorges, alluvial sands, dikes, mud flows, accumulations of basaltic outcroppings and benchrock, consisting of rounded basalt boulders, some of which may have lithified in calcareous materials.

Due to the melting of polar ice caps and glaciers hundreds of thousands of years ago, much of the study area was inundated, evidenced by fossils of marine life found along the mountain slope. Fossiliferous conglomerate is found 89 feet above sea level at Kaena Point, and there are loose coral cobbles up to 100 feet elevation. These outcrops indicate a stand of the sea, the Kaena stand, about 95 feet above present sea level. A stand of the sea is the elevation at which former sea levels have been identified.

The Waianae Range is the older of two mountain ranges forming the island of Oahu, dating back about ten million years. Rainfall on the youthful Waianae was heavy. The Koolaus did not exist at that time so moisture from trade wind clouds was not taken up. For a while lava flows were so frequent that erosion could make little progress. The rain penetrated the porous lava instead of running off the surface. Ensuing lava flows poured down the eastern "Schofield" side of the range. High crater walls prevented flows to the west. Streams carrying runoff water down the western side carved the present deep valleys.

The Waianae shield volcano was built up by repeated fissure eruptions within three rift zones, which met at the central vent near the summit of the original dome. A rift zone of an active volcano is characterized by parallel to sub-parallel fissures and a line of cinder and splatter cones.

These features are absent or scarce in extinct volcanoes, such as the Waianae, where erosion has cut deeply into the dome and the rift zones are marked by exposed dikes. Dikes are major controls in the movement and storage of groundwater because they are less permeable than the rocks they intrude. Where dikes are few and mostly parallel, groundwater is channeled along their trend. Where they are numerous and intersect, compartments form which reduce lateral movement of groundwater. The height at which water is stored depends on the dike pattern and the ability of the dikes to retain water.

Dikes intrude most of the volcanic rocks in t
Waianae district. They are sparse in the poo
permeable, massive, thick-bedded flows of t
upper member, and are numerous in the high
permeable, thin-bedded flows of the lower a
middle members of the Waianae volcanic serie
A large portion of the ridge bisecting Kaena Poi
consists of lava flows of the upper members
the Waianae volcanic series. Lava flows in low
and middle members of the Waianae Volcan
Series are conspicuous in the Makua area, b
coming less evident approaching Kaena Poi
from both directions. Coastal areas along bo
sides of the point are comprised of broad strip
of non-calcareous sedimentary materials. Th
shoreline along the Mokuleia side is composed
calcareous sedimentary materials.

HYDROLOGY (Refer to Figure 6)

Most of the fresh groundwater supply in the Wa
anae district occurs in flows of the lower and mic
dle members of the Waianae Volcanic Serie
Flows of the upper member are mostly above th
water table and contain only a small perenni
supply. Some fresh groundwater occurs in sed
mentary materials, but development of this sup
ply is generally limited by the low permeabilit
of alluvium, the restricted storage available i
talus or by sea water intrusion in coral or cora
rubble.

The groundwater reservoir in the volcanic rock i
large. The top of the reservoir extends from a
altitude of a few feet near the coast to more tha
1,800 feet near the crest of the range at Kaala
Although the reservoir seems to be continuous, i
is far from being homogeneous (having a uniform
water level gradient). Instead, the gradient i
steplike, reflecting the damming effects of loca
changes in permeability, caused by variations i
dike density and in number of dike intersections
Groundwater also occurs in highly permeable
coral and coral rubble near sea level.

Water obtained from well sources is found along
the coastline fronting Makua Valley and Moku
leia. Aqueducts serving installations atop the
Waianae range are presently drawing water from
the Mokuleia area. An abandoned aqueduct is
also located within the military impact area of
Makua Valley.

The quality of water from wells tapping the volcanic aquifer is generally good except in nearshore areas and areas abutting landward edges of the coralline aquifer, where the major contaminant is sea water. Other contaminants result

from leaching of hydrothermally altered volcanic rock above or adjacent to the volcanic aquifer. Most of the coralline aquifer is intruded by sea water, so the volcanic aquifer is highly susceptible to sea water intrusion where it is in conflict with the coralline aquifer. The low overall lateral permeability of volcanic rocks, which is mostly caused by dike intrusion, is the principal deterrent to sea water encroachment.

SOILS

The topography and soils found within the study area are a result of gradual weathering of the geological formations of the island. The U.S. Soil Conservation Service completed a survey of Hawaii in 1972. Forty-three different soil types were identified within the study area (Table 14). Rock land makes up the majority of the southern slopes of the Waianae range and ridge itself, while only a few fertile soil types are found within Makua Valley and the plateau of Kuaokala. However, in areas adjacent to the study area, particularly in the low valleys to the north, the soils are well suited for agriculture and have been cultivated in the past.

Soil Suitability for Cultivated Agriculture (Refer to Figure 9)

The ability of the land to support agriculture is dependent upon the character of the soil, the availability of water, and climatic conditions. Although almost any soil can be modified to grow many crops, certain questions regarding the specific conditions found at the study area exist:

1. What crop could be grown within the study area that could be grown elsewhere with different soils, climate, yield, markets, etc.?
2. From the standpoint of agronomy, are those crops which could be grown an economically viable crop in that particular situation?
3. Where will irrigation water be drawn from and at what cost?

Soils use ratings here were based upon simplified interpretations of the "capability groupings" and "description of the soils" in the soil survey provided by the Soil Conservation Service. Criteria used in the ratings were slope, soil texture, depth, stoniness, salinity, water retention capacity and climate. Because the combination of little available water and the high cost of providing irrigation systems in the study area limit irrigation feasibility, the non-irrigated classification was used to determine suitability for cultivated agriculture.

Based on the criteria developed by the Soil Conservation Service, soils are classified as well suited (Class I and II), moderately suited (Class III and IV), poorly suited (Class V and VI), unsuited (Class VII and VIII) and unclassified. Soils classified as unsuited for agriculture comprise more than 85% of the study area. The soils moderately suited, poorly suited and best suited for agriculture comprises a remaining 15% of the study area (Figure 9). There are no soils located within the proposed park boundary classified by the State Department of Agriculture as being "prime" or "unique" for agriculture. Lands having the best ratings for agriculture are found within Makua Valley and at the plateau of Kuaokala. Usage of the study area presently is agronomically limited and economically unsound.

Soil Limitation Ratings for Development (Refer to Figure 10)

Developing the land to support structures: roads, buildings, septic tanks, parking lots and recreational uses depends upon the capability and compatibility of the soil for each use.

Soil limitation ratings for community development and recreational use, developed by the Soil Conservation Service in May 1974, were used to identify soil limitations for certain uses. Criteria to establish soil limitation ratings for specific uses vary with each use.

Based on these criteria, soils located within the study area were rated according to the degree of limitations on development. Each soil was given the rating of severe, moderate or slight. By examining these ratings, critical soil areas can be determined. If they are located in areas where specific use is planned, detailed studies of the specific locale are necessary. Ratings of moderate to severe do not necessarily prohibit specific use of the land, for with proper design, engineering and technology, many of the soil limitations may be overcome.

Since this study is concerned with recreational pursuits, the major concern is the presence of soil limitations for the development of paths and trails, campsites, playgrounds and picnic areas. Beach areas are also included. As shown in Figure 10, the location of major soils classified suitable for development occur along the windward coast, Kuaokala plateau, Keawaula, Makua beach and valley. Other major areas are the fingers of land along the northern boundary which were included as possible access points to the upland area.

TABLE 14. SOIL TYPES

slight ○
moderate ◒
severe ●

SYMBOL	SOIL SERIES & SUBGROUPS		% OF SLOPE	SOIL SUITABILITY FOR CULTIVATED AGRICULTURE: IRRIGATED	SOIL SUITABILITY FOR CULTIVATED AGRICULTURE: NON IRRIGATED	SOIL LIMITATION RATING FOR COMMUNITY DEVELOPMENT AND RECREATIONAL USES: SEPTIC TANKS	DWELLINGS	ROADS ETC.	PARKING LOTS	LAWNS & GOLF	PATHS TRAILS	CAMP.	PLAY-GROUND	PICNIC
BS	BEACHES				VIIIw	●	●	●	●	●	●	●	●	●
CR	CORAL OUTCROP				VIIIs	●	◒	●	●	●	●	●	●	●
EaB	EWA	Silty Clay Loam	3- 6	IIe	IVc	○	○	○	◒	○	○	○	◒	○
EaC		Silty Clay Loam	6-12	IIIe	IVe	◒	◒	◒	●	◒	○	◒	●	◒
EmA		Silty Clay Loam	0- 2	IIs	IVs	●	○	○	○	○	○	○	○	○
EwC		Stony Silty Clay	6-12	IIIe	IVe	◒	◒	◒	●	◒	◒	◒	●	◒
FL	FILL LAND, MIXED		—	—	—	VAR.	VAR.	VAR.	VAR.	VAR.	VAR.	VAR.	VAR.	VAR.
HJE	HALAWA	Silt Loam	20-35		VIe	●	●	●	●	●	●	●	●	●
HJF2		Silt Loam	35-70		VIIe	●	●	●	●	●	●	●	●	●
HLMG	HELEMANO	Silty Clay	30-90		VIIe	●	●	●	●	●	●	●	●	●
JaC	JAUCAS	Sand	0-15	IVs	VIe	◒	◒	◒	◒	●	●	◒	●	◒
KaB	KAENA	Clay	2- 6	IIIw	IVw	●	●	●	●	●	●	●	●	●
KaeB		Stony Clay	2- 6	IIIw	IVw	●	●	●	●	●	●	●	●	●
KanE		Very Stony Clay	10-35		VIs	●	●	●	●	●	●	●	●	●
KlaA	KAWAIHAPA	Stony Clay Loam	0- 2	IIs	IIs	○	○	○	○	◒	○	◒	◒	○
KlaB		Stony Clay Loam	2- 6	IIe	IIe	○	○	○	◒	◒	○	◒	◒	○
KlbC		Very Stony Clay Loam	0-15		VIs	◒	◒	◒	◒	●	◒	◒	●	◒
KmA	KEAAU	Clay	0- 2	IIIw	Vw	●	●	●	●	●	●	●	●	●
KpD	KEMOO	Silty Clay	12-20		IVe	●	●	●	●	●	◒	●	●	●
KpE		Silty Clay	20-35		VIe	●	●	●	●	●	●	●	●	●
KpF		Silty Clay	35-70		VIIe	●	●	●	●	●	●	●	●	●
LoB	LOLEKAA	Clay	3- 8		IIe	○	○	○	◒	○	○	◒	◒	◒
LoC		Silty Clay	8-15		IIIe	◒	◒	◒	●	◒	◒	◒	●	◒
LoE		Silty Clay	25-40		VIe	●	●	●	●	●	●	●	●	●
LuA	LUALUALEI	Clay	0- 2	IIIs	VIs	●	●	●	●	●	◒	◒	●	◒
LvB		Stony Clay	2- 6	IIIe	VIs	●	●	●	●	●	◒	◒	●	◒
LPE		Extremely Stony Clay	3-35		VIIs	●	●	●	●	●	●	●	●	●
McC2	MAHANA	Silty Clay Loam	6-12	IIIe	IVe	◒	◒	◒	●	◒	○	◒	●	◒
McD2		Silty Clay Loam	12-20	IVe	IVe	●	●	●	●	●	●	●	●	●
McE2		Silty Clay Loam	20-35		VIe	●	●	●	●	●	●	●	●	●
MBL	MAHANA—BADLAND COMPLEX				VIIIe	●	●	●	●	●	◒	●	●	●
MnC	MAMALA	Stony Silty Clay Loam	0-12	IIIs	VIs	●	○	◒	◒	◒	○	○	●	○
Mt	MOKULEIA	Clay Loam		IIs	VIs	○	○	○	○	○	○	○	○	○
PsA	PULEHU	Clay Loam	0- 3	I	IVc	○	○	○	○	○	○	○	○	○
PuB		Stony Clay Loam	2- 6	IIe	IVs	○	○	○	○	◒	○	○	○	○
PvC		Very Stony Clay Loam	0-12		IVs	◒	◒	◒	◒	●	◒	◒	◒	◒
rAAE	ALAKAI MUCKY PEAT		0-30		VIIw	●	●	●	●	●	●	●	●	●
rRK	ROCK LAND				VIIs	●	●	●	●	●	●	●	●	●
rRO	ROCK OUTCROP				VIIIs	●	●	●	●	●	●	●	●	●
rST	STONY LAND				VIIs	●	●	●	●	●	●	●	●	●

Although the majority of soils within the study area have been classified as not being suitable for cultivated agriculture and development, they are suitable for forest, pasture, wildlife habitat, beach and mountain-recreational pursuits.

FLORA AND FAUNA (Refer to Figure 11)

The biological study of the Makua-Kaena State Park encompasses the general areas delineated in Figure 11. The information contained in this study is based on literature reviews, general area surveys and personal communications with people familiar with the project area. The following descriptions are brief summaries of various areas included within the upland, coastal and valley areas. A more detailed species list for terrestrial flora and fauna is provided in the Appendix.

Flora

Uplands—This region can be subdivided into grassland, dry upland forest, wet upland forest and montane bog. The grasslands are located at Kuaokala and are composed of grasses and shrubs with isolated pockets of native and exotic dryland species. Major grass species are molasses grass (*Melinis minutiflora*), lovegrass (*Eragrostis* sp.), broomsedge (*Andropogon virginicus)* and guinea grass *(Panicum maximum).* Dominant shrubs include koa-haole (*Leucaena leucocephala*), guava (*Psidium guajava*) and lantana (*Lantana camara*). Eastward, the grasses and shrubs change to a dry upland forest.

The dry upland forest is located primarily within the Mokuleia Forest Reserve. The upper two-thirds of the dry upland forest parallel to the Waianae Range is predominantly native with pockets of exotic species established throughout the forest. Koa (*Acacia koa*), 'ohi'a-lehua (*Metrosideros collina* subsp. *polymorpha*), olopua (*Osmanthus sandwicensis*), 'ohi'a-ha (*Eugenia sandwicensis*), lama (*Diospyros ferrea*) and papala kepau (*Pisonia sandwicensis*) are some of the endemic trees found here. Undergrowth species include maile (*Alyxia olivaeformis*), and awikiwiki (*Canavalia galeata*). Endangered species recorded from the dry upland forest include *Ochrosia compta, Cyanea superba,* and *Pleomele forbesii.* The lower third of the project area is still considered a dry forest, however, these areas contain more exotic species because they are less isolated. Ranchlands are located nearby and accessibility is not as restricted as at the higher areas.

The State Division of Forestry has reforested areas located in portions of the grassland and dry upland forest. Plantings on Oahu are designed to provide erosion control, timber resources, watershed protection, recreation habitats and wildlife habitats. Common species used in forestry plantings include species of *Eucalyptus,* silk oak (*Grevillea robusta*) and Norfolk Island pine (*Araucaria heterophylla*).

The wet upland forest receives more than seventy inches of rain per year and is located high in the Waianae Mountains below the Mt. Kaala bog. The dominant tree is the 'ohi'a-lehua. It is commonly accompanied by 'ohi'a-ha and kalia (*Elaeocarpus bifidus*). Other common species are the kolea-lau-nui (*Myrsine lessertiana*), pelea (*Pelea sanwicensis*) and hame (*Antidesma platyphyllum*). In deep gulches the kukui (*Aleurites moluccana*) and strawberry guava (*Psidium cattleianum*) are abundant. *Alsinodendron trinerve* and *Dubautia plantaginea* var. *plantaginea* are examples of species usually found in wet forests that are on the proposed federal list of endangered species.

The montane bog is located at the summit of Mt. Kaala, the highest point on Oahu. Climatic conditions permit runoff to be exceeded by rainfall, thus creating conditions permitting the bog to form. The Mt. Kaala bog is characterized by extremely damp conditions, mud and small pockets of standing water. Bright sunshine alternates with misty showers and the nights are cold. Common species include 'ohi'a-lehua, pukiawe (*Styphelia tameiameiae*) and *Cheirodendron platyphyllum. Gunnera kaalensis, Gunnera makahaensis, Astelia veratroides* and *Schiedea kaala* var. *kaalae* are some of the species listed on the proposed *Federal Register* of endangered species.

Valleys—The major valley in the study area is Makua Valley which is part of the Makua Military Reservation. The Makua Military Reservation is actually comprised of Makua Valley, Kahanahaiki Valley and Koiahi Gulch. Makua Valley is presently used as a firing range and training area. Fires have been common occurrences and grasses have established themselves as the dominant species after the natural vegetation was destroyed. The valley floor of Makua is predominantly grassland with dominant species including molasses grass and guinea grass. Large koa-haole stands cover portions of the valley floor with fingers of lush vegetation most noticeable along the streambeds. Vegetation along the streambeds include Christmas berry (*Schinus terebinthifolius*), pride of India (*Melia azeda-*

rach) kukui, Java plum (*Eugenia cuminii*), and guava.

Portions of the rim and sides of Makua Valley are dominated by dry forest species. The dominant cover consists of 'ohi'a-lehua, lama, 'ohi'a-ha, kukui, koa and papala kepau. Shrub cover in the understory include maile, a'ali'i (*Dodonaea eriocarpa*), 'akia (*Wikstroemia* sp.) and 'ilima (*Sida fallax*). The northern side of the valley has been burnt by fires and molasses grass is the dominant vegetative cover.

Coastal Areas—Much of the coastal area can be subdivided into four major vegetation zones influenced primarily by the geological make-up and climatic conditions of the area. The major vegetation zones are the windward talus slopes and gulches, the windward coastal zone, the sand dunes, and the leeward slopes and coastline.

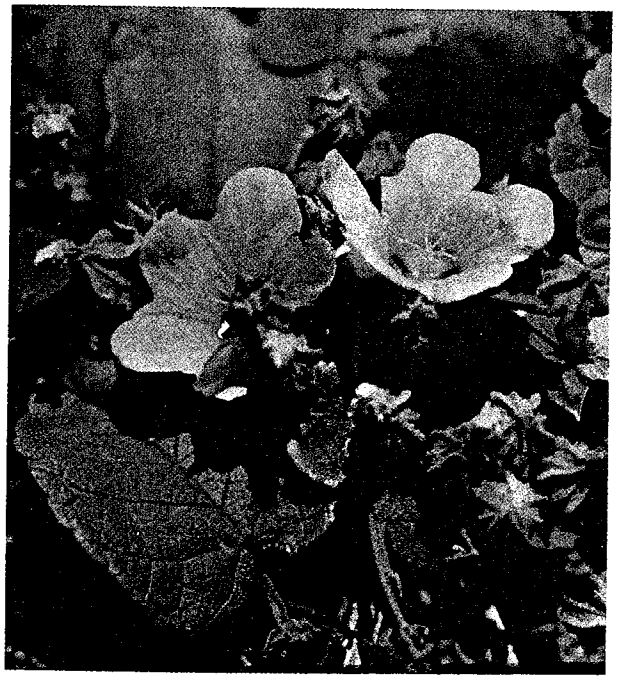
The windward talus slopes, cliffs and gulches are located at the northern base of the Waianae Mountain Range. The slopes are formed from an accumulation of rock debris from the steep cliffs above. A significant number of endemic species are found on the talus slopes and cliffs probably because of the rough terrain which minimizes any man-induced impacts. Some of the endemic species found on the talus slopes, cliffs and gulches are: 'aheahea (*Chenopodium oahuense*), kūpala (*Sicyos microcarpus*), aulu (*Sapindus oahuensis*) and naio (*Myoporum sandwicense*). Representative indigenous species include alahe'e (*Canthium odoratum*), pili (*Heteropogon contortus*) and hilie'e (*Plumbago zeylanica*). Examples of common exotic species are koa-haole, *Achyranthes indica* and Java plum.

Endemic species that are on the proposed endangered species list include ili-ahi-a-lo'e *(Santalum ellipticum* var. *littorale),* ma'o *(Gossypium tomentosum),* pua-pilo *(Capparis sandwichiana* var. *sandwichiana),* 'akoko *(Euphorbia celastroides* var. *kaenana)* and *Nototrichium humile* var. *subrhomboideum.* Four varieties of nehe are also on the proposed endangered list and include *Lipochaeta integrifolia* var. *megacephala, Lipochaeta lobata* var. *hastulata, Lipochaeta lobata* var. *leptophylla,* and *Lipochaeta remyi.*

The windward coastal zone is located below the talus slopes and extends down to the ocean. Included in this area are pasture and beach sites. Endemic species include Pa'u-o-hi'i-'aka *(Jacquemontia sandwicensis),* kakonakona *(Panicum torridum),* naio and 'ihi *(Portulaca cyanosperma).* The ma'o (Hawaiian cotton), listed on the proposed list of endangered and threatened plants, also can be found in this zone. Common indigenous plants include akulikuli *(Sesuvium portulacastrum),* koali-'awania *(Ipomoea congesta),* and naupaka kahakai *(Scaevola taccada).* Prevalent exotic species are sourgrass *(Trichachne insularis),* ironwood *(Casuarina equisetifolia),* swollen fingergrass *(Chloris inflata),* koa haole, kiawe *(Prosopis pallida),* bristly foxtail *(Setaria verticillata)* and klu *(Acacia farnesiana).*

At Kaena Point, large sand dunes and rock outcroppings are the predominant geological feature of the area. Representative endemic species include pa'u-o-hi'i-a'ka, nehe *(Lipochaeta integrifolia* var. *integrifolia)* and 'akoko *(Euphorbia degeneri).* Endemic species listed as rare and endangered include 'ohai *(Sesbania tomentosa* var. *tomentosa),* pua-pilo *(Capparis sandwichiana* var. *sandwichiana)* and ili-ahi-a-lo'e. Indigenous species include alena *(Boerhavia diffusa),* and 'ilima *(Sida fallax).* Exotic plant species such as koa-haole, Australian saltbush *(Atriplex semibaccata),* and radiate fingergrass *(Chloris radiata)* are common in this area.

The leeward slopes are formed from rock outcrops and rock debris. Most of the land is fairly steep with traces of coral and shells, indicating a much higher sea level in the past. In contrast, the windward portion of Kaena consists of talus slopes and flat coastal areas. The leeward area slopes sharply to the sea. Some of the rare and endangered species recorded from the leeward



slopes include 'akoko *(Euphorbia celastroides* var. *kaenana),* ma'o, ili-ahi-a-lo'e, *(Achyranthes splendens* var. *rotundata* and *Lipochaeta lobata* var. *lobata).* Major indigenous plant species include the beach morning glory *(Ipomoea brasiliensis),* 'ohelo kai *(Lycium sandwicense),* and hi-'aloa *(Waltheria americana).* Dominant exotic species found on the leeward slopes include kiawe, koa-haole, prostrate spurge *(Euphorbia prostrata),* and swollen fingergrass *(Chloris inflata).*

Fauna

At the lower elevations major avifauna include the barred dove *(Geopelia striata),* lace-necked dove *(Streptopelia chinensis),* Kentucky cardinal *(Richmondena cardinalis),* Brazilian cardinal *(Paroaria coronata),* house sparrow *(Passer domesticus),* house finch *(Carpodacus mexicanus frontalis),* ricebird *(Lonchura punctulata),* Japanese white-eye *(Zosterops japonica),* mynah *(Acridotheres tristis)* and mockingbird *(Mimus polyglottos).* As the elevation increases, the barred dove is partially replaced by the lace-necked dove, and the Brazilian cardinal, house sparrow, ricebird and mynah become uncommon.

Migratory seabirds and waterfowl may include plover *(Pluvialis dominica fulva),* 'ulili *(Heteroscelus incanus),* 'akekeke *(Arenaria interpres),* huna kai *(Calidris alba),* wedge-tailed shearwater *(Puffinus pacificus chlororhynchus),* white-tailed tropicbird *(Phaethon lepturus dorotheae),* red-footed booby *(Sula sula rubripes)* and great frigatebird *(Fregata minor palmerstoni).*

The pueo or Hawaiian owl *(Asio flammeus sandwichensis)* is an endangered species that possibly could be found within the study area. It inhabits dry forests and wet forests but prefers grasslands.

In areas associated with dry forests, numerous endemic bird species have been recorded. These include the 'elepaio *(Chasiempis sandwichensis gayi),* 'apapane *(Himatione sanguinea)* and 'amakihi *(Loxops virens chloris).* Japanese white-eye, bush warbler *(Horeites cantans)* and shama thrush *(Copsychus malabaricus)* are some of the exotic species found in the dry forest. The peafowl *(Pavo cristatas)* is found in the Mokuleia Forest Reserve.

Game birds commonly found along the grass slopes and grasslands include Erckel's francolin *(Francolinus erckelii),* ring-necked pheasant *(Phasianus colchicus torquatus),* barred dove, lace-necked dove, Japanese quail *(Coturnix japonica)* and chukar *(Alectoris chukar).*

The major avifauna in Makua Valley are the barred dove, lace-necked dove, ricebird, Erckel's francolin, ring-necked pheasant, Japanese white-eye, Kentucky cardinal, Brazilian cardinal, bush warbler and mockingbird. The side gulches and dry forests on the rim of the valley probably contain most of the dry forest species previously mentioned.

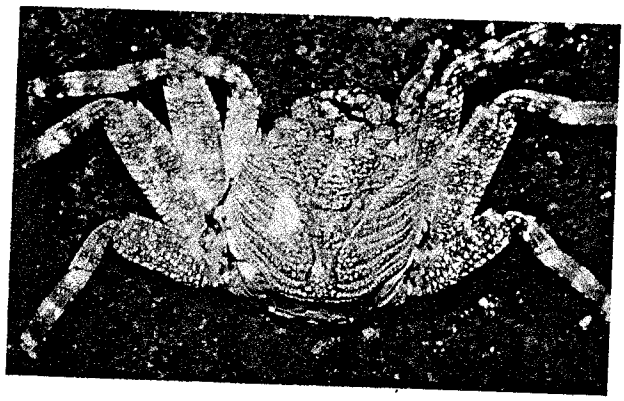
Endemic avifauna are dominant along the Waianae summit at the wetter parts of the study area, where native vegetation is predominant. Introduced species are generally restricted to the lower elevations, however, some species have adapted to high elevation areas. Exotic bird species that have been recorded previously along the Waianae ridgeline include house finch, Kentucky cardinal, Japanese white-eye, bush warbler, red-billed leiothrix *(Leiothrix lutea)* and melodious laughing thrush *(Garrulax canorus).* Endemic species include 'elepaio, 'amakihi, 'apapane, 'i'iwi *(Vestiaria coccinea)* and Oahu creeper *(Loxops maculata maculata).* The 'i'iwi and Oahu creeper are rare and endangered species.

Mammalian wildlife in the mountainous regions include pig *(Sus scrofa)* and goat *(Capra hircus).* In some areas dogs *(Canis familiaris)* were seen which were probably lost hunting dogs. Rats *(Rattus* spp.) are present in all sections of the project area. In the coastal areas and lower elevations mongoose *(Herpestes auropunctatus),* mouse *(Mus musculus),* rat, cat *(Felis catus),* dog and cattle *(Bos taurus)* are the major species present. The Hawaiian bat *(Lasiurus cinereus semotus),* an endangered species, has been observed in the study area on occasion.

Hawaiian land-snails are found in the project area and geographical isolation as well as preferences for particular host trees have made them increasingly rare. Two pairs of families *(Achatinellidae-Tornitellinidae* and *Amastridae-Cochlicopidae)* contain the majority of Hawaiian land snails. The major genera that may be found in the project area include *Achatinella* and *Amastra. Achatinella* is a genus nearly limited to Oahu and variability within species is considerable. Species such as *Achatinella lymanina, A. mustelina., A. concavospira* and *A. sordida* can be found in the Waianae Mountains. Species of *Amastra* found in the Waianaes include *Amastra rubens* and *A. cornea.*

Endemic Hawaiian insects have not been studied and documented in detail as much as the Hawai-

ian flora. Native Hawaiian fruit flies *(Drosophilidae)* seem to be the best known species. More than two hundred and fifty species of *Drosophila* have been described for the Hawaiian Islands but the total number is expected to double as further studies are conducted. Hawaiian drosophilas live on decaying leaves of araliads such as *Cheirodendron* and *Tetraplasandra,* and also on lobeloids such as *Clermontia* and *Cyanea.* Plants greatly influence native insects because many insect species are host specific. The distribution and large number of species of fruit flies and Hawaiian insects make surveying difficult. Many species are distributed over a small range and in some cases, in a single valley. Color pattern and food sources are the prime reasons why Hawaiian insect groups are so diverse. The presence of certain species of plants indicates that *Drosophila* and other native Hawaiian insects can be found in the project area.



Marine Life

In 1976, marine biological observations were carried out at several locations along the northern and southern coastlines of Kaena Point.

Keawaula (Yokohama) and Makua Beach Areas

The first area observed consisted of the region located between Keawaula (Yokohama) Beach and Makua Beach. The substrate was dominantly sand with periodic rocky areas that were usually flat although some small ledges were seen. Coral heads of the species *Pocillopora meandrina* were observed on some of the rock areas but it was not in abundance. Dead coral of the same species was also observed in a few areas, those corals showing evidence of sand abrasion.

Other benthic organisms seen in the area were sea urchins *(Tripneustes gratilla)* and fish, the dominant family being *Acanthuridae.* Few urchins were observed and they were normally on or near rocky regions of the substratum. The fish also were concentrated in the rock and coral areas although some fish of the family *Mullidae* were observed in the sand areas. Also seen were fish of the families *Scaridae, Labridae, Pomacentridae, Chaetodontidae, Cirrhitidae, Monacanthidae, Scombridae,* and *Tetradontidae.*

Checks at different stations along the north-facing coast showed gradual changes in the substratum. The rock ledge type of bottom flattened out to a smoother rock bottom. Fish were noticeably absent. The only benthic organism observed along the western half of this sector was algae.

The eastern half of this sector showed no change in the bottom topography but the coral *Porites lobata* was observed, abundance increasing eastward. Visibility was also poor and it would be premature to conclude that none existed in the area. Fish of a few families were seen, the dominant one being *Acanthuridae.* Also observed were fish of the families *Scaridae, Labridae, Balistidae,* and *Mullidae.*

Checks at different stations along the north-facing coast showed gradual changes in the substratum. The rock ledge type of bottom flattened out to a smoother rock bottom. Fish were noticeably absent. The only benthic organism observed along the western half of this sector was algae.

Keawaula (Yokohama) to Kaena Point

The shoreline from Keawaula (Yokohama) to Kaena Point is predominantly rocky. The substratum at the 30-foot depth is irregular with large blocks of basalt rising to within 10–15 feet of the surface. The blocks support varied coral fauna, dominant species being *Porites lobata* and *Pocillopora meandrina.* Other corals include *Leptastrea purpurea, Pavona varians, Cyphastrea ocelli, Montipora flabellata, Montipora verrucosa,* and *Palythoa tuberculosa.* In some areas, the substratum consisted of eroded coral blocks (old reef areas) that protruded 3–5 feet above the bottom. Both the basalt and coral blocks provide habitat space for many organisms. The hard surfaces are occupied by sessile (corals, algae, sponges, tunicates, bryozoans, etc.) and sedentary (sea cucumbers, sea urchins, mollusca, etc.) organisms. The many holes, ledges, and crevices offer protection for the more active organisms such as fish, crabs, and lobster.

Near Kaena Point, the bottom is strewn with basalt and coral boulders up to 5 feet in diameter. More sand and fewer corals are present here, suggesting sand abrasion during periods of strong wave surges.

Kaena Point to Dillingham Military Reservation
The Kaena Point area consisted primarily of basalt rock with many cracks and ledges. Neither coral nor sand was observed in the area, but visibility was poor and it would be premature to conclude that none existed in the area. Fish of a few families were seen, the dominant one being *Acanthuridae.* Also observed were fish of the families *Scaridae, Labridae, Balistidae,* and *Mullidae.*

The eastern half of this sector showed no change in the bottom topography but the coral *Porites lobata* was observed, abundance increasing eastward. Also present were algae of different types including the coralline algae *Porolithon.* A few fish of the families *Labridae, Monacanthidae,* and the *Myliobatidae* were observed.

A station at the eastern boundary consisted of a flat rocky substratum with abundant patches of *Porites lobata* and a few very small heads of the coral *Pocillopora meandrina.* Sand was found in small pockets and channels and then the bottom changed abruptly to all sand. Algae was also observed and very few fish, the only families being *Labridae* and *Monacanthidae.* Along the entire coast the water was very choppy with medium swells. Visibility was poor in all areas.

TSUNAMI/FLOOD ZONES (Refer to Figure 12)

The Hawaiian Islands are affected by tsunamis generated in the Pacific, especially those from the northwest rim of the basin (Kamchatka-Aleutian) and the South American coast. Since 1820 eight tsunamis have caused moderate to severe damage on Hawaiian shores.

Tsunamis take one of two forms when entering shallow water: 1) oscillation of the water level, much like rapid tidal cycles; or 2) bores which are breaking walls of water.

There have been five tsunamis in recent years occurring in 1946, 1952, 1957, 1960 and 1964. The 1946 tsunami was the most destructive, in terms of loss of life and property, ever to hit Hawaii. Recorded runups within the project area during the tsunamis mentioned above varied from 8 to 34 feet, the high value of 34 feet being observed at the Point and at Makua during the 1946 tsunami.

Tsunami inundation zones for the project area are shown in Figure 12. This zone extends to the 50 foot contour, generally covering a narrow strip of land along the leeward coast and a much wider area along Kaena Point and the windward coast.

The areas subject to flooding are generally found near the mouths of streams that drain the area, especially in the leeward coastline. The largest such area covers Makua Beach and some distance inland from it.

NEAR SHORE & OFFSHORE CONDITIONS (Refer to Figure 12)

The windward (Mokuleia) coast from Dillingham Military Reservation to Kaena Point is approximately 20,000 feet long. The eastern sector consists of an 8,000 foot long beach in the vicinity of Camp Erdman. The beach is partially protected by a fringing reef but is still exposed to wave action. The remainder of the windward coast is rugged coralline rock. In this region, access to the water is difficult due to the irregular rock, offshore benches and frequent severe wave action. At Kaena Point, the shoreline changes abruptly to basalt boulders and shallow interconnected tide pools.

The windward coastline is exposed to large winter waves and tradewind generated waves resulting in significant wave action most of the time. This severe wave action limits water recreation of the windward shoreline by making access into the water difficult and often dangerous. Prevalent wave action also suspends fine sediments, making water turbid in the nearshore areas, further limiting the recreational possibilities.

The dominant characteristic of the leeward (Waianae) coast from Kaena Point to Kaneana Cave is the presence of two long beaches, Makua Beach and Keawaula Beach. These beaches provide easy access to the water and are popular for swimming, snorkeling, surfing and other ocean activities. Wave action is much less intense on this side, being sheltered from the persistent tradewinds. However, long swells approach from the south and southwest during the summer months and from the northwest during the winter months. The water is generally much clearer along this coast than on the north side. The remainder of the leeward coast consists of basalt and coralline rock projections forming numerous small coves. Offshore from the beaches the bottom is primarily scoured rock and sand. The remaining offshore area is characterized by irregular bottom with rock and coral ledges which provide excellent diving and snorkeling.

WATER QUALITY

(Refer to Figure 12)
Near-shore waters found along the coastlines of the project area are classified as either Class AA or Class A. Class AA waters include the near-shore waters along Kaena Point for a distance of 3.5 miles towards Mokuleia and 3.5 miles towards Makua. The remainder of the coastal waters along the project area are classified as Class A.

Class AA waters

The uses to be protected in this class of waters are oceanographic research, the support and propagation of shellfish and other marine life, conservation of coral reefs and wilderness areas, compatible recreation, and aesthetic enjoyment.

It is the objective of this class of waters that they remain in as nearly their natural, pristine state as possible with an absolute minimum of pollution from any source. To the extent possible, the wilderness character of such areas shall be protected. No zones of mixing will be permitted in these waters.

The classification of any water area as Class AA shall not preclude other uses of such waters compatible with these objectives and in conformance with the standards applicable to them.

Class A waters

The uses to be protected in this class of waters are recreational (including fishing, swimming, bathing, and other water-contact sports), aesthetic enjoyment, and the support and propagation of aquatic life.

It is the objective for this class of waters that their use for recreational purposes and aesthetic enjoyment not be limited in any way. Such waters shall be kept clean of any trash, solid materials or oils, and shall not act as receiving waters for any effluent which has not received the best degree of treatment or control practicable under existing technology and compatible with the standards established for this class.

Existing Water Quality

Near-shore water quality of the study area was monitored by the State Department of Health until 1975. The monitoring program was discontinued because of the excellence of the waters.

ARCHAEOLOGY (Refer to Figure 13)

General

Kaena Point is a region rich in old Hawaiian legend and myth about both gods and men. Its stark, desolate beauty, its geographical location as the westernmost point of the island of Oahu, and its rich fishing grounds, have contributed to numerous descriptions of the area, stories of exploits along its shore, and after-death beliefs.

Although legends and chants concerning Kaena Point have survived, little remains to indicate the area played a part in the lives of the old-Hawaiians. This is due, in part, to both natural and man-made actions: tsunamis may have destroyed many heiaus or fishing shrines that were once located along the shoreline. Some archaeological sites have been destroyed by recent activities, including the railroad construction around the Point in the late nineteenth century and the construction of cattle fences during the mid-nineteenth and early twentieth centuries, which may have used heiau and fishing shrine rock materials.

Thorough archaeological surveys have not been conducted within the region, except for a study conducted along a portion of the Waianae coast shoreline (Boucher, 1970). McAllister charted all the known sites in the area in 1933, relying primarily on informants living in the area. He was not able to definitely locate several of these sites, as their existence was based solely on tales passed down through generations. In 1962, Sterling and Summers provided an updated listing of all sites known to exist or thought to have existed and had been destroyed.

The following account used the above sources and other literature on the subject to describe the historical and cultural significance of the Kaena Point region and to delineate known archaeological sites or remnants.

Ahupua'a Divisions

The project site, was divided into the old Hawaiian ahupua'a of Makua, Kahanahaiki and Keawaula on the Waianae coast. The site also encompasses the inland ahupua'a of Kuaokala. Under the ancient form of land holdings, all land on an island was held by a supreme chief or mo'i, who was trustee for the lands for the gods, Kane and Lono, the nature gods who caused the land to be fruitful. The supreme chief partitioned the land into districts and appointed high chiefs (ali'i) to supervise each district. The ali'i, in turn, subdivided the districts into ahupua'a for the purposes of taxation, and appointed an administrator, or konohiki, to supervise the ahupua'as. The ahupua'a ideally were parcels of land running from the mountains to the sea, and were meant to provide all materials necessary for the

self-sufficiency of the inhabitants. Each ahupua'a had defined boundaries: the seaward boundary of each district was marked by an altar in which were placed the yearly taxes of the ahupua'a for the ali'i and mo'i; inland boundaries usually consisted of natural demarcations, such as ridges, rock outcroppings, or a stream channel. By ancient custom, each ahupu'a that extended to the coast included fishing rights for a distance of a mile outward from that coast.

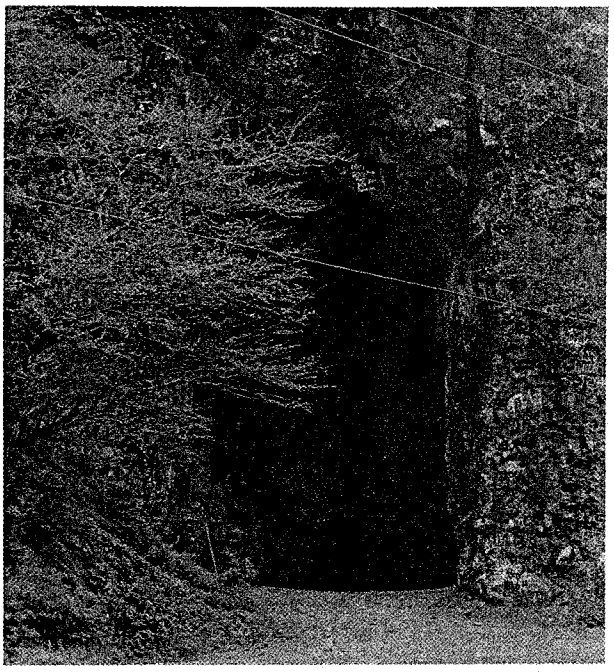
The ahupua'a was divided into ili (strips) which were allotted to commoner families (maka 'ainana) who lived on them and cultivated them. Each ili was farmed by an 'ohana, or extended family, that had permanent dwelling rights on the land, although the proprietorship of the ahupua'a could change from generation to generation, depending on the accession of a new mo'i, who could redistribute land rights among the ali'i.

The ahupua'a of the Kaena Point region were generally among the poorest in land resources on the island of Oahu, possessing little water, poor soil, and hot, dry climate. This was particularly true of the ahupua'a on the Waianae coast, which were subject to periodic drought conditions (Handy and Handy, 1972). It is likely that the Hawaiians did not consider these ahupua'a to be very desirable, as water (wai) was a prime determinant in a "rich" ahupua'a, and was equated with wealth (waiwai). With abundant water, taro, the dietary staple of the Hawaiians, could be irrigated and cultivated. Sweet potato was the poor man's taro, and grown only when taro cultivation was not possible.

What the ahupua'a of the Kaena Point region lacked in agricultural potential was compensated for in marine resources, the area possessing exceptional deep-sea fishing off and beyond Kaena Point. Because of these conditions, and following general settlement patterns, the ancient Hawaiians who inhabited the Kaena Point area made their livelihood in fishing, settling in small coastal communities and scattered homesteads along the shoreline. When the English Captain Vancouver sailed up the Waianae coast in 1793, he described the region as follows:

> ...From the commencement of the high land to the westward of Opooroah (Puuloa) was... one barren rocky waste, nearly destitute of verdure, cultivation or inhabitants, with little variation all the way to the west point of the Island. Not far from the southwest point is a small grove of shabby cocoanut trees, and along these shores are a few straggling fishermen's huts (Handy, 1940).

Vancouver observed only one village along the entire Waianae coast, which was located in the vicinity of the present town of Waianae. Behind the village, he noted areas of cultivation within the Waianae Valley, which were the most fertile and possessed the best water resources of the west coast.



Makua

Of the Waianae district ahupua'a encompassed by the project site, Makua may have possessed the largest population, a result from more favorable terrain, water, and soils that provided agricultural potential. Settlements in Makua may have been similar to those in the neighboring Makaha Valley, where extensive archaeological research has been conducted. Such research indicates that the valley supported an extensive agricultural community. According to a study (Hommon, 1969), three-quarters of the inhabitants of Makaha Valley may have lived and worked more than a kilometer from the seashore at the time when Vancouver sighted just a few houses along the coastal section of Makaha. Makua may also have supported an inland community of some type, although it was probably much less extensive than that of Makaha, due to the lack of constant streams (Handy and Handy, 1972). It is likely these Makua settlements sub-

sisted primarily on sweet potato, supplemented by fish, abundant off the coast. In his journals (1822-1849), Levi Chamberlain noted that there were no trees in Makua, "a few clusters of sugarcane here and there" and potatoes were cultivated but not taro (Sterling and Summers, 1962). Makua was known, however, for its maile (maile laulii), a small-leafed type grown in Koiahi, and considered to be the finest of any on Oahu. Makua was also known as a pleasant way station where travellers could spend the night before passing on through to Kaena.

In legend, Makua was famous for its olohe, professional robbers and cannibals who would prey on the unwary traveler. They were skilled in wrestling and bone-breaking and were said to have removed all the hair from their bodies and oiled their skins so no hold was given to their opponents (Beckwith, 1940).

McAllister, in his 1933 island-wide survey of archaeological sites, listed several sites along the shore of Makua. As shown in Figure 13, these sites consisted of Kumuakuopio Heiau (Site 178) and a fishing shrine (Site 179). Kaneana Cave also was reported by McAllister to be "the dwelling place of a shark goddess who held sway from Kaena Point to Kepuhi Point."

Fishing shrines were prevalent along both the Waianae and Waialua coasts, indicating the prominence of fishing during the times of the old Hawaiians. Fishing shrines were usually dedicated to the fish god Ku-ula, and the first such shrine was said to have been built by Ai-ai, the son of Ku-ula. It was Ai-ai who taught the art of fishing to the people, how to make various lines and nets. He established ko'a ia, or fishing grounds or stations, where abundant fishing could be had. He also left the Hawaiians ku-ula, or fish stones named after the god, which had the power to draw fish to its spot and thereby provide good fishing (Beckwith, 1970).

Kahanahaiki

The ahupua'a of Kahanahaiki shared many characteristics with Makua. The inhabitants of Kahanahaiki subsisted on fish and sweet potato, as did those who lived in the neighboring ahupua'as. It is probable that fishermen located close to shore exchanged seafood with their kin for cultivated crops grown inland. Some fisherman may also have been farmers cultivating both sweet potato during the growing season, and fishing during other periods. Water for Kahanahaiki was obtained from intermittent streams that flowed during the rainy season, and from hillside springs.

McAllister listed three archaeological sites for Kahanahaiki. Site 181, Ukanipo Heiau, apparently was the principal heiau for Kahanahaiki. The heiau was used as a place of burial, but not in the sense of a cemetery. The bodies of ali'i were said to have been placed on the lele or flat stone, until the kahuna-nui was informed by the gods to remove the bodies to their final resting place in some designated cave. They were actually "buried" in the cave, that is, placed with the appropriate ceremonies and offerings. Site 182 was said to have been a swimming pool on the makai side of the Ukanipo heiau, which was used exclusively by the ali'i. Site 183 was the Puaakanoahoa fishing shrine, a platform that was "10 feet square and built up from 3 to 4 feet of large rough stone" (McAllister, 1933).

Keawaula

Keawaula ahupua'a was given its name meaning "red harbor" because of the great schools of muhe e (cattle fish) that came into the bay, giving the water a reddish appearance. The Hawaiians living at Keawaula were primarily fishermen, but they also cultivated both sweet potato and small sections of wet taro beneath the upper slopes of the region (Handy, 1940). Water for the area came from springs, gullies that channeled water during the wet season, and from a pool within Poha Cave (Site 184). According to McAllister, the cave was said to contain nine courses of water, usually fresh, which were carried through the ground to the middle of Kaieiewaho channel, between Oahu and Kauai.

> . . . when out fishing, the Hawaiians would obtain drinking water by diving down a certain distance with empty calabashes, and then, turning them over, would fill them with fresh water by letting the air escape.
>
> An opening or exit to Poha Cave, called Kilawea, is located under the water at the end of the reef off Keawaula. The cave is also said to be connected with the cave in Kaaawa . . . (McAllister, 1933).

In historic times, Keawaula was used as grazing land for cattle. An archaeological study of a portion of Keawaula (Boucher, 1970) found many high coral walls, probably used as cattle pens. The report noted that koa-haole trees, which densely covered the study area, were introduced to the islands around 1888, and was grown for cattle fodder. The presence of dense koa-haole

growth and cattle pens indicates that cattle grazing may have been prevalent in the area. The study also uncovered historic house foundations, and numerous C-shaped structures and mounds. The uses of such structures are not known, though Hommon (Hommon, 1969) has suggested that the mounds were used as platforms on which vines with an affinity for sunlight, such as gourds were grown. Since the Waianae coast was known for the quality of its gourds and as a prime sweet potato area, this conclusion seems reasonable.

Other archaeological surveys have not been conducted at Keawaula, although McAllister listed several other archaeological sites. These include the Puaakanoahoa Fishing Shrine (Site 183) which no longer exists and Poha Cave (Site 184).

Kaena

The ahupua'a of Kaena means "red-hot", and according to various legends, was named either after one of the relatives of Pele who came with her from Kahiki or after a young chief named Kaena. According to the story, Kaena was out fishing with his followers one night and the noise and lights from the canoes awakened a chief sleeping on the shores of Kauai. This chief (Haupu) was so angered at the disturbance that he threw over a large boulder, killing Kaena and his followers. The impact of the falling boulder caused huge waves which " . . . swept sand upon the shore until in time a long point of land was formed" (Sterling and Summers, 1962). This point was named after the dead chief, and the boulder which caused his death, the Pohaku o Kauai.

The Kaena ahupua'a according to Handy, (Handy, 1940) was probably the poorest ahupua'a in terms of arable land resources on Oahu. It is likely that Kaena was devoted exclusively to sweet potato, except for about 20 taro patches, terraced with rock facings, on the slopes below Uluhulu Gulch. These were irrigated from a spring on the hillside west of the gulch. Between these terraces and Kaena Point no taro was grown, although there were clearings presumably used for sweet potato.

Water was scarce in Kaena, as at other Waianae coast ahupua'a, although there were several springs perched among the pali cliffs. Legend says that when Hiiaka passed through Kaena on her way to Kauai, the natives of the region refused to tell her the location of highly treasured water:

> I drink of the water distilled by the dripping pali walls, led forth in a hollowed log. The rustic denies it and hides it: Four waterstreams has Kaena; And the summer sun is ardent. (Emerson, 1915).

In other arid areas of Hawaii, there were springs whose existence was kept secret by the area's inhabitants to conserve an important resource (Handy and Handy, 1972). This was evidently the situation in this chant of Hiiaka, although the "Hidden Waters" referred to may be located in the ahupua'a of Kawaihapai, rather than in Kaena.

Although very poor in terms of land, Kaena faced out onto very rich deep sea fishing grounds. Family groups fished along the shore for sustenance, and Chamberlain, in his journals written between 1822-1849, noted one such group:

> . . . we passed Nenelea, a settlement of fishermen and a convenient place for hauling up their canoes . . . (Sterling and Summers, 1962).

Little is left of these scattered habitations along the shore, except, according to the State Historic Preservation Office, the remains of a fishing camp located at Kaena Point beneath the lighthouse. This fishing camp site is listed on the Hawaii Register of Historic Places, and is one of three open dune midden sites known for Oahu. The site is considered valuable, due to the scarcity of such sites and to the research potential it contains. It is dated back to pre-contact days, before the European visitors arrived, and existed in some form up to and including the nineteenth century.

McAllister listed several other sites in Kaena, including a few old house foundations, inland from the old railroad, and Ponuahua, "a fishing shrine near the point, though it is not known which group of rocks was so designated," (McAllister, 1933), Alauiki fishing shrine (Site 187), "a group of stones near the edge of the water, no different from other stones in the vicinity," *(Ibid),* and Ulehulu Heiau (Site 189):

> "Many scattered piles of stone give little indication of the extent or features of the structures. Stones from the heiau were probably used to construct the modern stone walls in the vicinity" *(Ibid).*

The abundance of fishing ko'a along the shoreline testifies to the rich fishing available off the coastline, and because of this, Kaena was the

scene of famous legendary fishing exploits. It was at Kaena Point that the hero Maui attempted to unite Kauai and Oahu by casting:

> . . . his wonderful hook, Mana-ia-ka-lani, far out into the ocean that it might engage itself in the foundations of Kauai. When he felt that it had taken a good hold, he gave a mightly tug at the line. A huge boulder, the Pohaku o Kaua'i, fell at his feet. *(Ibid).*

The Pohaku o Kaua'i may be found today, and is thought to be one of two large boulders found at the Point: the Pohaku o Kaua'i is said to be the boulder nearest Kauai, the Pohaku Oahu the boulder nearest the Point (Sterling and Summers, 1962). Maui is also said to have caught a huge red fish here which he dragged up the point, leaving a trail from Pohaku o Kaua'i to the Mokaena Heiau (Site 188), which formerly could be followed (McAllister, 1933). He placed this fish, a kumu, on the heiau where menehunes found it and cut it into small bits. When the sea covered the land, the pieces of fish went back to the ocean, and since then, the kumu have been small.

The Mokaena (Kuaokala) Heiau, where Maui dragged his fish, was said to have been built by Kauaians who settled Oahu *(Ibid).* Situated on a ridge above Kaena Point, it was the highest heiau on the island, and may have been one of the two temples on Oahu built by sun-worshippers and dedicated to the sun (Sterling and Summers, 1962). It is said to have been destroyed by the army during World War II *(Ibid).*

Kaena is best known, however, for the part it played in the after-death beliefs of the Hawaiians.

Hookala tells that when an individual lay on the deathbed, his soul left the body and wandered about, first going to a fishing shrine (ko'a) named Hauone (Site 189). If all earthly obligations had been fulfilled, the soul continued wandering, otherwise it was returned to the body. In its continued wandering it then approached Leina Kauhane (Soul's Leap) at Kaena Point. Here it was taken by two minor gods . . . and thrown into a pit . . . It was at the time that the soul was thrown into this pit that death actually came upon the body. The soul then went to Na ake o le'i walo . . . on the boundary between Ewa and Honolulu districts. Here the road divided, the clean, good soul went to the right, and the other to the left (McAllister, 1933).

According to Kamakau *(Ibid),* Leina Kauhane (Soul's Leap) on Oahu is located:

> . . . close to Kaena Point on the Waialua side near the dividing road descending to Keaokuukuu, which is said to be its boundary . . . the Soul's Leap is a sea furrow, a leaping place into endless night.

The exact location of the rock is not known, though many speculate that it is a large white rock, near Kumakau's described location. The Kaena Point leaping place, however, was not unique, and other Leina Kauhane are named at different points about the island coasts (Beckwith, 1970).

Kealia

The ahupua'a of Kealia was named after the shallow depressions found in the shoreline lava in which salt collected. Kealia means "salt pan", and was an area that was good for little else. The arable land area in Kealia was exceedingly narrow, between elevated coral and sheer cliff. According to Handy and Handy (1972), there was some ground where sweet potatoes would have flourished, and near the cliff, sugar-cane, bananas, and awa. Terraces from the neighboring ahupua'a of Kawaihapai extended into Kealia, and in these taro was grown. Little is known about Kealia, because according to literature surveys there are no significant legends or archaeological sites associated with the area.

Kawaihapai

The ahupua'a of Kawaihapai was named after several perched springs located among the pali cliffs of the area, as Kawaihapai means "lifted water." The portion of Kawaihapai located within the project site is restricted to the mountain area, of which little is known either about legend and mythology or about archaeology and cultural history. Lowland areas, however, were known to support extensive terraces of taro, surrounded by

sugarcane, and watered by Kawaihapai Stream. The area was known to be rich, as it was said that there existed a life of plenty until trouble came and all the water of the region disappeared. Then an omen was perceived by the people and water started pouring out of the cliffs. The spring in the cliff gave the name to the district and as no one knew the source of the water, it was called Ka-wai-kumu-ole-i-ka-pali (Sterling and Summers, 1962).

Several archaeological sites in the lowland area of Kawaihapai, north of the study area boundary, were listed by McAllister. These included the Puu o Hekiki (Site 190), a fishing shrine, Kawailoa Heiau (Site 191), "Hidden Waters" (Site 192) from which Hiiaka is said to have drank, and Kuakea Fishing Shrine (Site 194). None of these sites exist except for "Hidden Waters" spring *(Ibid).*

Mokuleia and Waialua

The project site also encompasses parts of the mountain regions of the ahupua'a of Mokuleia and Waialua. Mokuleia and Waialua were rich ahupua'a possessing fertile soil and abundant water, which supported taro, sweet potatoes, bananas, and awa (Handy, 1940). McAllister listed several archaeological sites within this area, including a possible heiau site (Site 194), the Kolea fishing shrine (Site 195), and a village site (Site 196) which is listed on the Hawaii Register of Historic Places. The Kalakiki Heiau (Site 197) is also listed on the Hawaii Register of Historic Places.

Located within the study area according to McAllister are a burial cave (Site 198), piles of stones (Site 199) and a cave (Site 200). The burial cave was one in which skeletal material had been found:

Powdered skeletal material was noticed on the side of a cliff beneath several very small caves. Upon examination portions of two skeletons were found in a lava tube whose entrance was so cleverly sealed that the material would not have been discovered had there not been a hole into a lower cave larger than a man's head. From the inside, light was noticed through the cracks of the rocks, and the entrance then discovered. No mortar had been used, but sharp-edged rocks had been carefully fitted together. There were no artifacts with the burial. The bones had probably been bundled together, but had evidently been disturbed by animals, as several had been recently gnawed. There was one skull but no mandible, one humerus, one radius, two ulnas, four femurs, three tibiae, and many fragments (McAllister, 1933).

The piles of stones (Site 199) were probably random piles created when the land was cleared for agricultural purposes *(Ibid).* Of Site 200, a cave located in Kaumoku Gulch, McAllister wrote the following:

At present one can squirm about 200 feet into the interior but comes in contact with large stones which obstruct the passage. It is believed that in the construction of the water tunnel just above, the blasting dislocated these stones. Water also constantly drips from the roof making shallow pools in the passageway. Twenty years or more ago the cave is said to have contained skeletal material, though there is no evidence now of such remains, which undoubtedly would have decayed with so much moisture.

Summary

Of all the ahupua'a encompassed by the project site, that of Kaena is dominant because of the place it occupies in the legends and religion of old Hawaii. It is probable that Makua Valley may have been the most populated ahupua'a, possessing an inland community that may have been similar to the extensive agricultural community that lived in Makaha Valley. Little is known of the mountain ahupua'a of Kuaokala, or of the other mountain sections encompassed by the project site. However, the prevalence of caves within the mountainous regions makes it likely that many burials may have been conducted in these areas.

INFRASTRUCTURE (Refer to Figure 14)

Roads

Farrington Highway

Farrington Highway is the major roadway which circumvents Kaena Point, approximately 5 miles of which, beginning just beyond Keawaula (Yokohama) Bay and continuing around the point, is virtually impassable by conventional vehicular traffic (Figure 5). Oahu Railway and Land Company operated trains along this general route from around the turn of the century, until 1948. After the railroad system was abandoned, a vestigial dirt maintenance road which went along the tracks, provided the only access to private landholdings in this area. Repeated washouts by storm waves and floods, and the absence of upkeep over the past 20-plus years have rendered this road extremely hazardous.

The following description of the existing roadway conditions commences from the Makaha

extremity.

Farrington Highway approaches Kaena Point along the Waianae Coast, allowing access to this region from Honolulu. The improved 2-lane A.C. paved highway terminates at the U.S. Air Force Satellite Tracking Station Access Road.

A short, approximately 3/4 mile, section of BST (Bituminous Surface Treatment) continues from this point, to a point just past the sand beach, commonly referred to as Yokohama Bay. Vehicular traffic beyond this section is discouraged by signs posting warning of hazardous road conditions and advising motorists to proceed at their own risk.

This marks the start of the 5 mile segment which is extremely rugged, narrow, winding, full of depressions, protruding rocks, soft sand, and washouts, generally regarded as hazardous.

A short section of recently improved, A.C. (asphaltic concrete) paved road (22' wide), approximately 1.12 miles long, extends past Camp Erdman from the terminus of the dirt road to the Quarry.

Farrington Highway reverts at this juncture once again to a rugged, unimproved road filled with potholes, and classified by the Department of Transportation as a dirt road for the next mile.

The stretch of road fronting the Dillingham Military Reservation, approximately 2 miles, is described by the Department of Transportation as BST, though in need of improvement, poses no great difficulty for motorists.

An improved 2-lane, A.C. paved road is resumed for Farrington Highway. This corridor continues either around the North Shore of Oahu, or through Central Oahu, ultimately arriving in Honolulu.

Actual traffic counts for June 1975, prepared by the Department of Transportation, Planning Section, indicates the following flow levels at specific points.

Farrington Highway at Makua Cave	ADT = 1572
Farrington Highway at Kapalaau Bridge (near Waialua)	ADT = 1889
1998 Projection	ADT = 3900

Satellite Tracking Station Road

The U.S. Air Force Satellite Tracking Station Access Road which is operated and maintained by the U.S. Air Force diverges from Farrington Highway at the end of the improved length, on the Waianae side. Because of the classified missions and operations of the facilities it serves, the use of this road is restricted to the general public, except for those with a valid hunting license or those belonging to a recognized organization such as the Sierra Club, Boy Scouts, Girl Scouts, etc. All others are prohibited from entry according to the terms of the existing lease. The Canadian Overseas Tele-communication Corporation offices and ground facilities are situated approximately a quarter of a mile up this road from Farrington Highway.

FAA Road

Entry is through a private ranch located approximately 1 mile west of Waialua town. This is a single laned, A.C. paved road characterized by steep grades, and sharp turns enroute to the summit of Mt. Kaala.

Use of this road is restricted to official business for security and safety reasons. The FAA, Hawaii Air National Guard, Hawaiian Telephone Co., and City and State public safety agencies have facilities requiring use of this road. The State Department of Land and Natural Resources is also allowed access for routine checks of the Forest Reserve areas.

A permanent FAA work crew maintains this hazardous road year-round.

Nike Road

The entrance to the Nike road is located roughly a mile west of the FAA road entrance, along Farrington Highway. This road was developed to provide access to an Army Nike Station atop the ridge, which is presently abandoned. The lower portion of the road passes through Mokuleia Ranch lands, and the remainder is within the State Forest Reserve boundaries.

The road is used primarily by hunters, and campers wishing to utilize the Peacock Flats campsites. Public access is allowed only on agreement with Mokuleia Ranch, and the State Division of Forestry. A permit must be obtained from the Division of Forestry, in order to use the campsite.

Sewage

A sewage treatment plant exists in Waianae and serves the urbanized areas between Nanakuli and Makaha. Construction is presently underway to extend the interceptor line along Farrington Highway to Kili Drive in Makaha Valley. The City and County Sewer Division's master plan envisions only a short extension (less than 1 mile), to Kepuhi Point, to complete future service to this

area. The Waialua region depends on cesspools and septic tanks to accommodate sewage disposal. A sewage treatment plant is planned for Waialua, pending availability of construction funds. When this occurs, the City and County Sewers Division master plan shows the extent of service to terminate at Camp Erdman.

Water

The City and County Board of Water Supply provides service along the Waianae Coast as far north as Kepuhi Point, just past Makaha Valley. Along the Waialua Coast, the Board of Water Supply extends service as far as Mokuleia Beach Park, across from the Dillingham Military Reservation.

Three private water systems presently serve specific areas in the Mokuleia vicinity:

- The Mokuleia Water System owned by Mokuleia Properties, Ltd., services a residential area (88 consumers) along Crozier Drive and Crozier Loop.
- The Mokuleia Ranch and Land Company Water System—Kawaihapai serves a limited area along Farrington Highway (52 consumers) including the polo field.
- The source of the Camp Erdman Water System is the U.S. Army well at the nearby Dillingham Military Reservation.

The Department of Land and Natural Resources, Division of Water and Land Development is presently planning to refurbish an existing well above Keawaula Beach to provide water for irrigation and restroom facilities.

Electricity

The existing overhead electric line around Kaena Point was originally installed before World War II and is still used. It connects the Waialua and Makaha substations and insures the necessary overall system reliability along the North Shore (Mokuleia) and the Waianae Coast. In the event of a failure in the power line from Makaha, this segment provides Hawaiian Electric Company power to the Canadian Overseas Telecommunication Facility via the Waialua feeder. Presently energized at 12kv, this line will eventually be a combined 56kv/12kv circuit. This line is covered by several perpetual grants of easement, including State Land Board approval within TMK 6-8-02: 17 on June 10, 1971, and the grant within TMK 8-1-01 dated February 11, 1966.

Other major lines which exist in the area include the two overhead 12kv feeders to the Air Force Kaena Point Tracking Site—one from the Mokuleia side, and the other from the Waianae side over former McCandless lands pursuant to CDUA (Conservation District Use Application) approval by the Land Board (OA—1/29/73—406) on July 27, 1973.

The Hawaiian Electric Company, with the cooperation of the State Department of Planning and Economic Development and the City and County of Honolulu, has been selected to sponsor one of 17 sites for the possible test of a large one megawatt wind turbine. If Hawaii is selected for the actual test of this large wind turbine, it may be erected within the Kaena Point State Park study area boundaries. The site is on the ridge line about 250 yards above the Satellite Tracking Station in the Kuaokala Forest Reserve.

Communication

Canadian Overseas Telecommunication Corp.

The Canadian Overseas Telecommunication Cable, located in the (Keawaula) Yokohama Bay area, occupies a 10 ft. wide easement extending roughly a quarter of a mile inland. A steel pipe buried approximately 3 feet underground presently houses the cable and crosses the existing coastal road enroute to the terminal facility located on the access road to the Satellite Tracking Station.

Hawaiian Telephone Company

Hawaiian Telephone Company operates and maintains two underground communication cable systems within the study region.

Transpacific Cable—This cable approaches Kaena Point from both the Makaha and the Waialua directions, buried at depths varying from 4-6 feet along the improved length of Farrington Highway. These underground cables continue up the mountainsides, and both terminate atop the ridge at the U.S. Air Force Satellite Tracking Station.

Hilo Cable—The Hilo cable, buried at a depth of approximately 30 inches along the Waianae length of Farrington Highway, terminates at the Kaena end of Makua Valley.

The U.S. Signal Corps Cable extends north along the Waianae Coast following the Farrington Highway alignment. Hawaiian Telephone Company is presently under contract to maintain this cable which branches just about midway past Makua Valley. One segment continues along Farrington Highway to the Tracking Station Access Road, and the other extends up through Makua Valley, over the Waianae Range, past Pea-

cock Flats above Mokuleia, and terminates at the Dillingham Military Reservation.

The recently abandoned U.S. Signal Corps Cable, below the natural ground, still occupies the old railroad right-of-way around Kaena Point.

Presently, the furthest extent of Hawaiian Telephone Company's service is to Camp Erdman along the Mokuleia Coast, and to the Canadian Overseas Telecommunication Corporation on the Waianae side. All the facilities of various agencies situated atop the Kaena Point Ridge (Kuaokala) are serviced by Hawaiian Telephone Company's cables. An emergency telephone is located at Mokuleia Beach Park, and on the Waianae side at the Tracking Station Access Road along Farrington Highway.

Public Safety Radio Communication
A microwave radio relay station, referred to as the Mokuleia Station, is located atop the Kaena Point ridge and is utilized by the State Civil Defense Unit, City and County Police Department and the City and County Fire Department.

Federal Aviation Administration
The FAA maintains and operates the Satellite Tracking Station located on the ridge. The area is restricted to the general public.

Hawaii Air National Guard
Communication facilities are also maintained and operated by the Hawaii Air National Guard atop the ridge near Mt. Kaala.

Public Services

Police
Law enforcement in the Waialua-Haleiwa area is provided by the Wahiawa Police Station. Their jurisdictional area encompasses the area on the Waialua side of the Waianae Mountain Range to Wailee Stream near Sunset Beach (District II). Patrolmen from the Wahiawa Station have eleven beats in this area with four beats located between Mokuleia and Sunset Beach. The boundaries of Kaena Point State Park fall within beat 227 of District II on the windward side. One motor patrolman is assigned to each beat. The most prevalent type of crime in the Waialua-Haleiwa area has been burglary and theft (auto and from parked cars). Beat 227 reported 72 instances of burglaries and 37 auto thefts in 1976 (1976 Statistical Report, HPD).

Most crime involves beachgoing visitors who park their vehicle along the road, venture to the beach, and return to find their valuables missing. Theft from parked cars occurs primarily at Mokuleia Beach Park and the area between Mokulei Beach Park and Kaena Point.

The Waianae area is serviced by the Waiana Police Station whose jurisdiction extends fror the Kaena Point lighthouse to Kahe Point (Dis trict III). The Waianae Mountain Range als(serves as a jurisdictional border. One officer i: assigned to each of the six beats in the Waiana(area. The leeward side of Kaena Point State Par falls within beat 319 of District III.

The most prevalent type of crime in beat 319 has been burglary, vandalism, and theft from parkec cars. As in the Waialua-Haleiwa area, beach-going visitors are the victims of theft from parkec cars. High incidents of theft have been reportec at Keawaula (Yokohama) Bay and Makaha Beach areas. There were 145 burglaries, 29 car thefts and 103 vandalisms reported in beat 319 in 1976.

Assaults (1st and 2nd degree) and other assaults numbered 50 for beat 319 and 29 for beat 227 in 1976. These figures placed these beats 7th out of 10 and 4th out of 11 among all beats in their respective districts in the assault category.

Fire
Waialua-Haleiwa is served by the Waialua Fire Station. Fifteen men are assigned to the station with five men on duty at all times. Their primary equipment is a 1,250 gallon per minute pumper. Sea-rescue equipment consists of a 17-foot Boston Whaler, surfboards, fins, and goggles. A City and County ambulance is stationed there during the day on weekends only. On weekdays an ambulance must be dispatched from Wahiawa or Kahuku.

Response time from the Waialua Fire Station to Kaena Point is approximately 10 minutes. If the truck is unable to proceed, firefighting or rescue must be done on foot. The estimated time varies according to traffic, weather and time of day. Back-up help comes from Engine Company 11 (Sunset Beach) and Engine Company 16 (Wahiawa). The fire department also receives assistance from the military and the Waialua Sugar Company in the event of large uncontrollable brush fires.

The Waianae area is serviced by the Waianae Fire Station at Maili Point and the Nanakuli Fire Station in Nanakuli. Fifteen men are assigned to each station with five men on duty at all times. The stations are equipped with a 1,250 gallon per minute pumper and the Waianae Fire Station has an additional 400 gallon tanker and Nanakuli has a 1,500 gallon water tanker.

Sea rescue equipment consists of surfboards, fins, and goggles. The nearest sea rescue unit is located across Pier 39 in Honolulu. A City and County ambulance is stationed at the Waianae Station.

Response time from the Waianae Fire Station to the end of Farrington Highway near Kaena Point is 7-12 minutes, varying according to traffic, weather, and time of day. Back-up assistance is provided by the Nanakuli Fire Station.

Medical Evacuation
Medical evacuation assistance is available to the City and County of Honolulu from the military. If necessary, ambulance units may call helicopter assistance from Wheeler Air Force Base in transporting emergency cases to hospitals. Military personnel are transported to Tripler Army Medical Center and civilian evacuees are generally taken to Queen's Medical Center or to other outlying hospitals.

Health Services
Health facilities located near the Kaena Point area include Kaiser-Maili Clinic and Waianae Comprehensive Health Clinic in Waianae, and Waialua Outpatient Clinic in Waialua. Hospitals and clinics close to the project area include Fronk Clinic (formerly Leeward Hospital), Wahiawa General Hospital and Kahuku Community Hospital. Two public health nurses in Waialua-Haleiwa and seven nurses in the Waianae area provide field services to the public. These nurses stress preventive medicine and public education. Some of the services provided include immunizations, nutrition guidance, well baby clinics, vision testing and tuberculin testing.

PAST PROPOSALS

Highway
Development of a road around Kaena Point (remaining link in the island's belt highway), originated in 1929 when Territorial Senator Francis H.I. Brown proposed that $25,000.00 be appropriated to build an improved road using prison labor. Construction of this two-lane unimproved road from Makua did not commence until late 1954. However, from the start, the Territory encountered many difficulties. Inability to obtain necessary rights-of-way through private landholdings, escalations in construction costs, lack of funding, and a low priority based on need prevented the project from being completed.

In 1965, the first official proposal to include the Kaena Point Road as a scenic road was advanced, and in 1967, the State Department of Transportation qualified the Kaena Point Road project for Federal aid status by inclusion of the road in the State Highway System as a secondary route.

In 1971, a report was completed covering preliminary planning and development of design criteria for a two-lane road section extending from the end of the Kaena Point Tracking Station Access Road at Keawaula Bay to the Point. However, as a result of protests by special interest groups, organizations, and private individuals, completion of further transportation plans were halted until a recreational master plan could be prepared.

Peacock Flats
In 1961, a report was prepared for the First Legislature in regards to the development of cabin facilities, together with firm prices of the necessary lands to be acquired, at two separate sites on Oahu. One of the sites studied was at Peacock Flats, located in the Waianae Mountains.

The 1961 study envisioned provisions for necessary utilities, road access, park headquarters, sixteen duplex cabins with a capacity of one hundred ninety two persons, one hundred fifty person capacity picnic area, seventy five overnite tent campsites, a campfire circle, view point, a group use camp area, trail improvements and related facilities. At that time, the total estimated costs for all improvements was $846,700.00.

Recommendations made upon completion of the study were that the development of Kahana Bay and Valley would provide greater benefits due to its wide diversity of available uses and large land areas suitable for intensity development. With this in mind the development of Peacock Flats and Waialee Beach were deferred.

Wind-Powered Electric Generation
Because of the strong directionally stable winds found within the region, the Energy Research and Development Administration selected the Kaena area in June 1970, as one of seventeen most promising sites in the United States to locate windmills. If selected as one of the four final test sites by the ERDA, an experimental windmill could be placed atop the Waianae Ridgeline or at Kahuku in the early 1980's.

The first stage of development would involve placement of anemometers at the selected test sites to determine the suitability of the wind speed, direction and frequency. After completion of these studies, which would require several

years, a decision would be made as to the feasibility of the site for further development. If it is determined that the project would be feasible, a prototype windmill with blades measuring between 150'-200' in diameter would be constructed with Federal funding and operated by Hawaiian Electric Co. Power generated would be transmitted by existing electrical distribution lines located within the area.

KAENA POINT STATE PARK

CONCEPTUAL PLAN

EXISTING ACCESS

- Major Highway
- Improved Road
- Unimproved Road
- Major Trail
- Secondary Trail
- Existing Facilities

Windward Coastline

Camp Erdman

Mokuleia Beach

Farrington Highway

Puu Pueo

Kuaokala

Kealia Trail

Peacock Flats Trail

Nike Road

FAA Road

Leeward Coastline

Satellite Tracking Station Road

Kuaokala Trail

Keawaula (Yokohama) Bay

Nike Facilities

Peacock Flats

Mokuleia Trail

Dupont Trail

Kahanahaiki Valley

Makua Beach

Makua Valley

Farrington Highway

Puu Pane

Mt. Kaala

1 mile

.5 mile

2 miles

80 acres

10

20

40

5

5

KAENA POINT STATE PARK

CONCEPTUAL PLAN

HYDROLOGY & CLIMATOLOGY

- Watershed Boundary
- Perennial Stream
- Intermittent Stream
- Aqueduct
- Well
- Spring
- Boundary Between Basal Water & High Level Water Bodies
- Average Annual Rainfall Isohyet

Windward Coastline

Leeward Coastline

Keawaula (Yokohama) Bay

Kaena Point

Camp Erdman

Kuaokala

Nike Facilities

Peacock Flats

Kahanahaiki Valley

Makua Beach

Makua Valley

Puu Pane

Mt. Kaala

Waialua

Haleiwa

All Weather

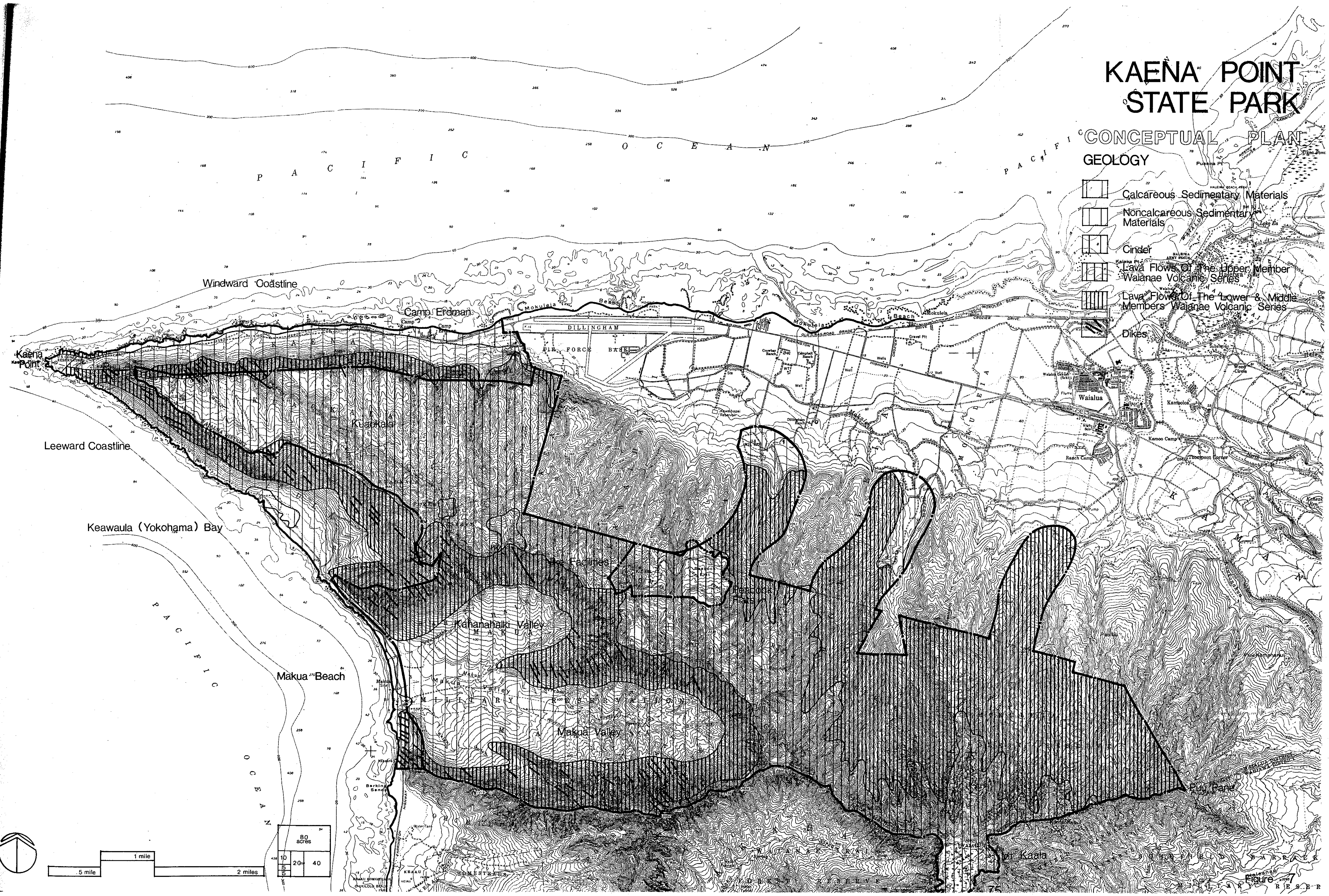
Winds 10 Knots or Less 45.2

Annual Wind Rose
(Percentage of time)

.5 mile 1 mile 2 miles

80 acres

Figure 6



KAENA POINT
STATE PARK
CONCEPTUAL PLAN
GEOLOGY
Calcareous Sedimentary Materials
Noncalcareous Sedimentary Materials
Cinder
Lava Flows Of The Upper Member Waianae Volcanic Series
Lava Flows Of The Lower & Middle Members Waianae Volcanic Series
Dikes
PACIFIC OCEAN
Windward Coastline
Camp Erdman
Kaena Point
Leeward Coastline
Kuaokala
Keawaula (Yokohama) Bay
Kahanahaiki Valley
Makua Beach
Makua Valley
Peacock Flats
Dillingham Air Force Base
Mokuleia
Waialua
Puu Pane
Mt. Kaala
80 acres
10
20
40
1 mile
.5 mile
2 miles
Figure 7

KAENA POINT STATE PARK

CONCEPTUAL PLAN

SLOPE ANALYSIS

0 – 10%

10 – 20%

20 – 30%

30% +

Windward Coastline

Leeward Coastline

Keawaula (Yokohama) Bay

Makua Beach

Camp Erdman

Kuaokala

Kaena Point

Mokuleia Beach

DILLINGHAM AIR FORCE BASE

Waialua

Haleiwa

Kamooloa

Kemoo Camp

Thompson Corner

Radio Camp

Kahanahaiki Valley

Makua Valley

Puu Kanehoa

Mt. Kaala

PACIFIC OCEAN

1 mile

.5 mile

2 miles

80 acres

10

20

40

KAENA POINT STATE PARK

CONCEPTUAL PLAN

SOIL SUITABILITY FOR CULTIVATED AGRICULTURE

- Well Suited
- Moderately Suited
- Poorly Suited
- Unsuited
- Unclassified

Windward Coastline

Leeward Coastline

Kaena Point

Camp Erdman

Dillingham Air Force Base

Mokuleia Beach

Waialua

Haleiwa

Kuaokala

Keawaula (Yokohama) Bay

Nike Facilities

Peacock Flats

Kahanahaiki Valley

Makua Beach

Makua Valley

Puu Pane

Mt. Kaala

Pacific Ocean

80 acres

.5 mile 1 mile 2 miles

Figure 9

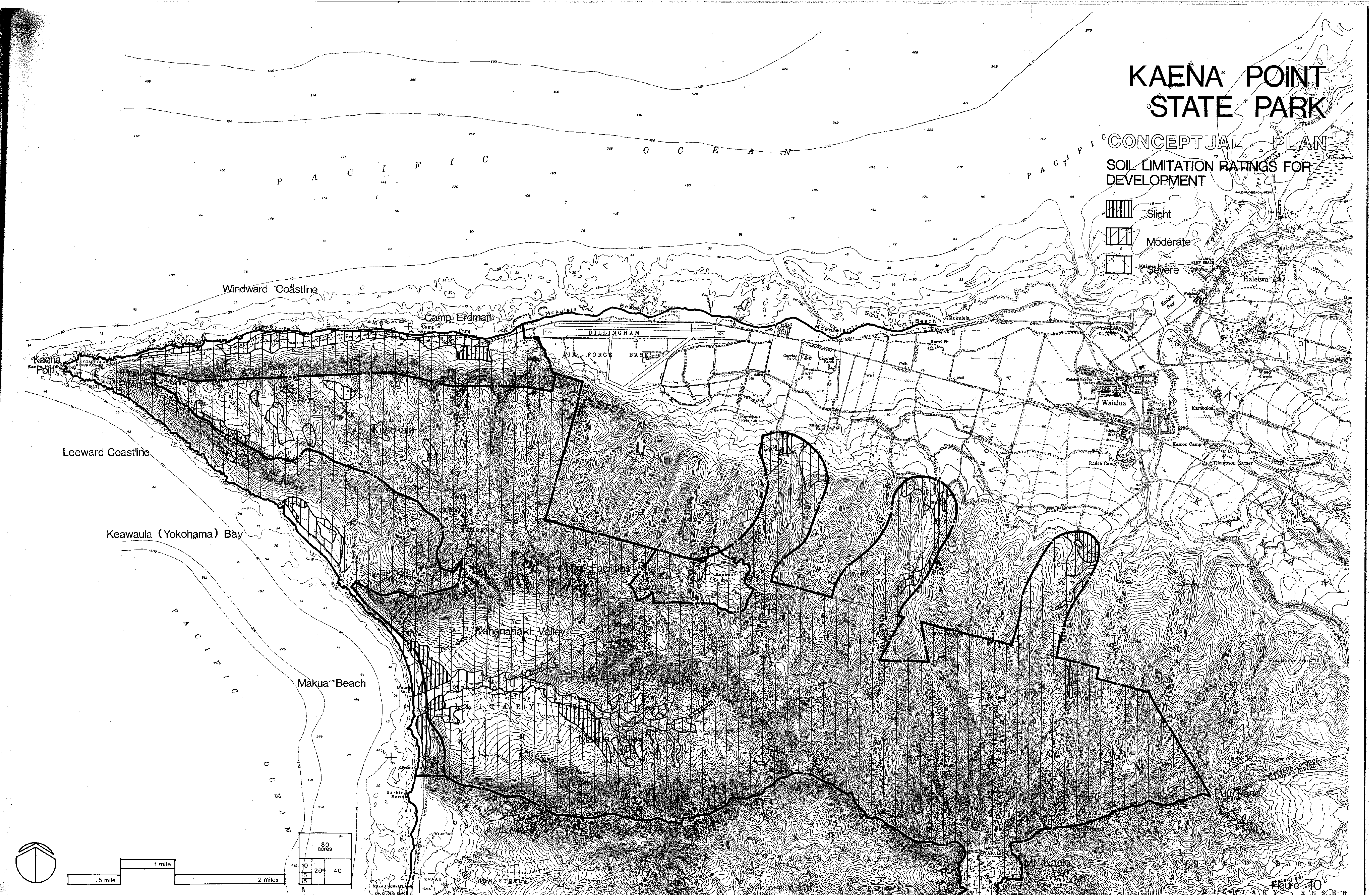

KAENA POINT
STATE PARK
CONCEPTUAL PLAN
SOIL LIMITATION RATINGS FOR DEVELOPMENT
Slight
Moderate
Severe
PACIFIC OCEAN
Windward Coastline
Camp Erdman
DILLINGHAM
AIR FORCE BASE
Mokuleia
Waialua
Haleiwa
Kaena Point
Puu Pueo
Kuaokala
Leeward Coastline
Keawaula (Yokohama) Bay
Nike Facilities
Peacock Flats
Kahanahaiki Valley
Makua Beach
Makua Valley
Puu Pane
Mt. Kaala
80 acres
10
20
40
5
5
.5 mile
1 mile
2 miles

Figure 10

KAENA POINT STATE PARK
CONCEPTUAL PLAN
FLORA / FAUNA AREAS
1 Grassland
2 Dry Forest
3 Wet Forest
4 Montane Bog
5 Kaena Dunes
6 Windward Talus Slopes & Gulches
7 Windward Coastline
8 Leeward Slopes & Coastline
9 Makua Valley Floor
10 Makua Slopes & Rim
Proposed Natural Area Reserve
Outstanding Native Flora/ Fauna Habitats
PACIFIC OCEAN
Windward Coastline
Camp Erdman
Kaena Point
Puu Pueo
Kuaokala
Leeward Coastline
Keawaula (Yokohama) Bay
Nike Facilities
Peacock Flats
Kahanahaiki Valley
Makua Beach
Makua Valley
Puu Pane
Mt. Kaala
DILLINGHAM AIR FORCE BASE
Haleiwa
Waialua
1 mile
.5 mile
2 miles
80 acres
10
20
40
5

Figure 11

KAENA POINT STATE PARK

CONCEPTUAL PLAN

NEAR SHORE WATERS & AREAS SUBJECT TO TSUNAMI & FLOODS

- Class AA Waters
- Class A Waters
- Areas Subject To Tsunami Inundation
- Areas Subject To Flooding

Windward Coastline

Leeward Coastline

Kaena Point

Pua Pueo

Kuaokala

Camp Erdman

AA

A

Mokuleia Beach

DILLINGHAM AIR FORCE BASE

Gravel Pit

Waialua

Kamploca

Kemoo Camp

Rader Camp

Thompson Corner

Keawaula (Yokohama) Bay

Nike Facilities

Peacock Flats

Kahanahaiki Valley

Makua Beach

Makua Valley

MILITARY RESERVATION

Puu Pane

Mt. Kaala

KEAAU HOMESTEADS

PACIFIC OCEAN

5 mile 1 mile 2 miles

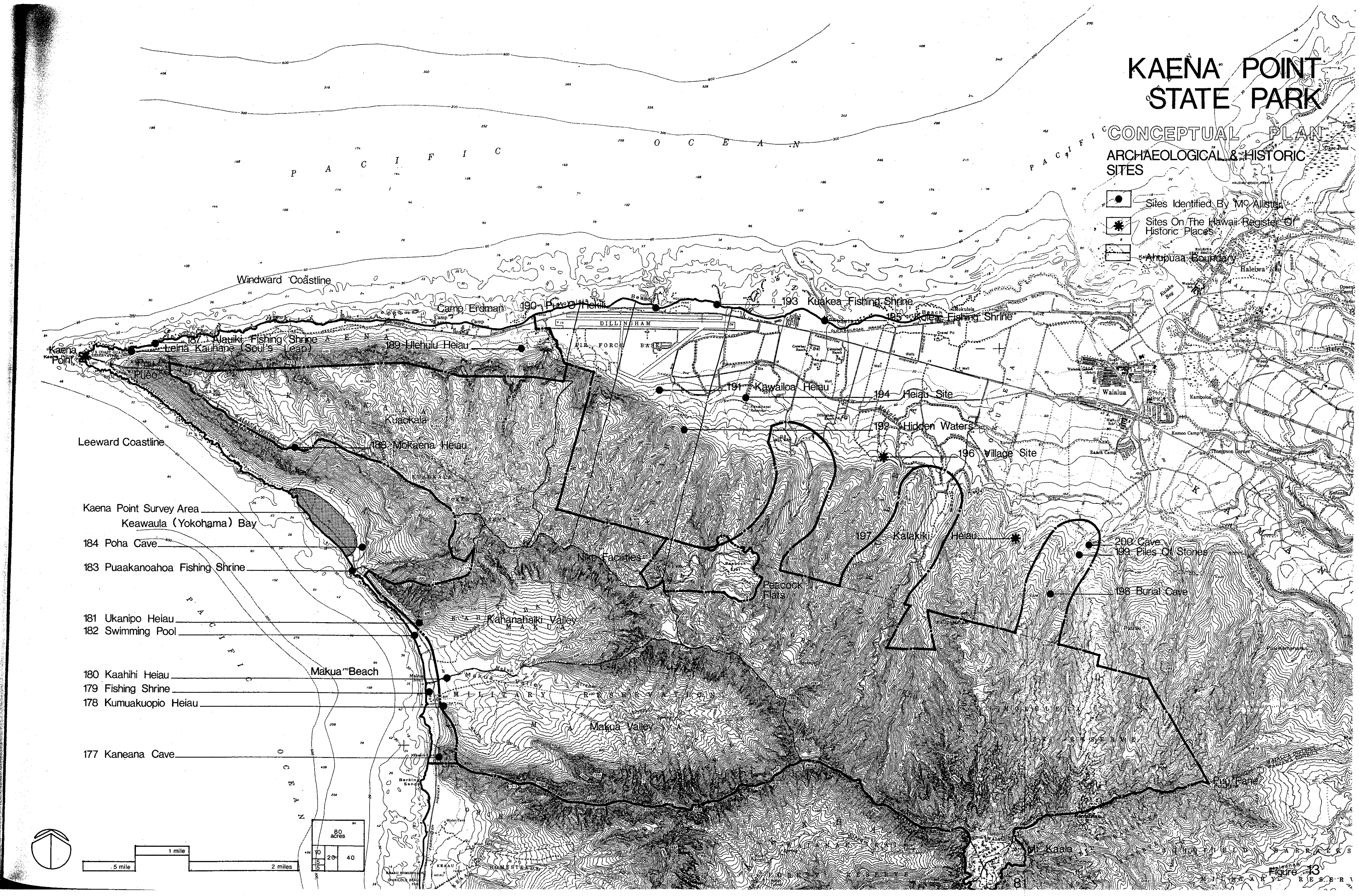
80 acres

10 20 40

5

6

Figure 12



KAENA POINT STATE PARK
CONCEPTUAL PLAN
ARCHAEOLOGICAL & HISTORIC SITES
Sites Identified By Mc Allister
Sites On The Hawaii Register Of Historic Places
Ahupuaa Boundary
PACIFIC OCEAN
PACIFIC
PACIFIC OCEAN
Windward Coastline
Leeward Coastline
Kaena Point
Camp Erdman
190 Puu O Hekili
193 Kuakea Fishing Shrine
195 Kolea Fishing Shrine
187 Alauiki Fishing Shrine
Leina Kauhane (Soul's Leap)
189 Ulehulu Heiau
Puu Pueo
DILLINGHAM AIR FORCE BASE
191 Kawailoa Heiau
194 Heiau Site
Kuaokala
192 Hidden Waters
188 Mokaena Heiau
196 Village Site
Waialua
Haleiwa
Kaena Point Survey Area
Keawaula (Yokohama) Bay
184 Poha Cave
183 Puaakanoahoa Fishing Shrine
Nike Facilities
Peacock Flats
197 Kalakiki Heiau
200 Cave
199 Piles Of Stones
198 Burial Cave
181 Ukanipo Heiau
182 Swimming Pool
Kahanahaiki Valley
180 Kaahihi Heiau
179 Fishing Shrine
178 Kumuakuopio Heiau
Makua Beach
Makua Valley
MILITARY RESERVATION
177 Kaneana Cave
Puu Pane
Mt. Kaala
80 acres
10
20
40
5
5
.5 mile
1 mile
2 miles
Figure 13

KAENA POINT
STATE PARK
CONCEPTUAL PLAN
INFRASTRUCTURE
Hawaiian Electric Overhead Power Line
Canadian Overseas Telecommunication Corp. Cable
Transpacific Cable
Hilo Cable
U.S. Signal Corps Cable
Abandoned U.S. Signal Corp. Cable
Aqueduct
PACIFIC OCEAN
Windward Coastline
Camp Erdman
DILLINGHAM
AIR FORCE BASE
Kaena Point
Puu Pueo
Kuaokala
Leeward Coastline
Keawaula (Yokohama) Bay
Nike Facilities
Peacock Flats
Kahanahaiki Valley
Makua Beach
Makua Valley
Puu Pane
Mt. Kaala
Waialua
Haleiwa
80 acres
10
20
40
1 mile
.5 mile
2 miles

82

KAENA POINT STATE PARK

CONCEPTUAL PLAN

LAND OWNERSHIP / TENURE

- State of Hawaii
- United States Of America
- Mokuleia Ranch & Land Co.
- Castle & Cooke, Inc.
- Other Privately Owned
- State Lands Leased Or Under Permit To The United States Of America
- State Lands Leased Or Under Permit To Mokuleia Ranch & Land Co.
- Other State Lands Privately Leased
- Lands Condemned But Not Yet Purchased
- Lands To Be Condemned

Windward Coastline

Camp Erdman

Kaena Point

Kuaokala

Leeward Coastline

Keawaula (Yokohama) Bay

Facilities

Peacock Flats

Kahanahaiki Valley

Makua Beach

Yokua Valley

Puu Pane

Mt. Kaala

PACIFIC OCEAN

DILLINGHAM AIR FORCE BASE

Mokuleia Beach

Waialua

Haleiwa

1 mile

.5 mile

2 miles

80 acres

10 | 20 | 40

5

Figure 15

KAENA POINT STATE PARK

CONCEPTUAL PLAN

STATE LAND USE DISTRICTS & COUNTY GENERAL PLAN

- C — Conservation — State
- A — Agriculture — State
- Preservation — County
- Park — County
- Agriculture — County
- Military — County
- Residential — County
- Major Streets & Highways

Windward Coastline

Leeward Coastline

Keawaula (Yokohama) Bay

Makua Beach

Camp Erdman

DILLINGHAM AIR FORCE BASE

Nike Facilities

Headrock Flats

Kahanahaiki Valley

Makua Valley

Kaala

Mt. Kaala

Puu Kanehili

Puu Kanehili

Kemoo Camp

Thompson Corner

Ranch Camp

Kaena Point

Kaena Point State Park

PACIFIC OCEAN

1 mile

.5 mile

2 miles

80 acres

10 20 40

5

5

Figure 16

KAENA POINT STATE PARK

CONCEPTUAL PLAN

CITY & COUNTY OF HONOLULU
ZONING & SPECIAL MGT. AREA

P-1 Preservation

AG-1 Agriculture

Special Shoreline Management Area

Windward Coastline

Leeward Coastline

Kaena Point

Camp Erdman

Mokuleia Beach

DILLINGHAM AIR FORCE BASE

Kuaokala

Keawaula (Yokohama) Bay

Nike Facilities

Peacock Flats

Waianae Kai Valley

Makua Beach

Makua Valley

Waialua

Haleiwa

Kemoo Camp

Puu Pane

Mt. Kaala

SCHOFIELD BARRACKS

PACIFIC OCEAN

0 .5 mile 1 mile 2 miles

80 acres

10 20 40

5

15

Figure 17