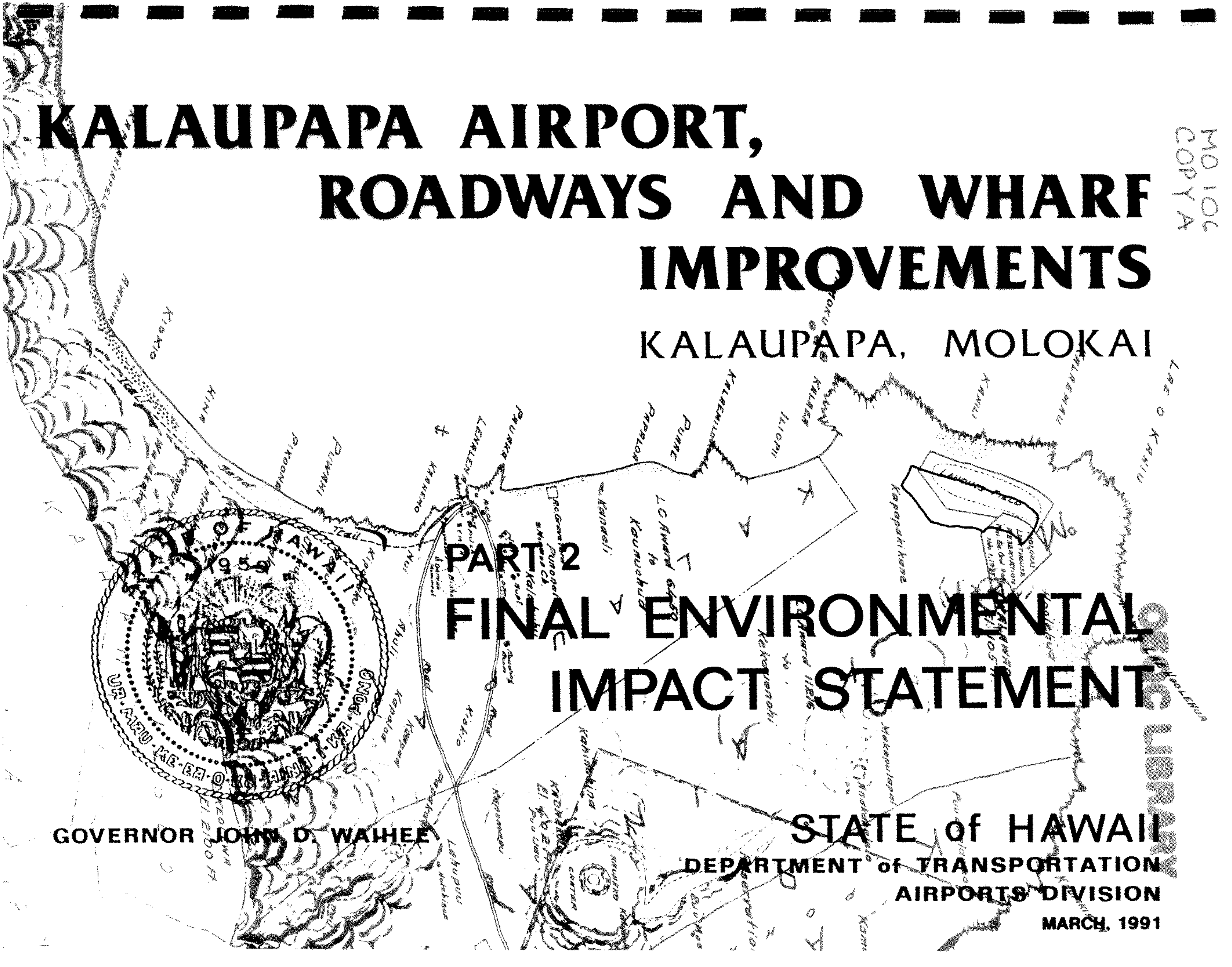
KALAUPAPA AIRPORT, ROADWAYS AND WHARF IMPROVEMENTS

KALAUPAPA, MOLOKAI



PART 2

FINAL ENVIRONMENTAL IMPACT STATEMENT

GOVERNOR JOHN D. WAIHEE

STATE of HAWAII
DEPARTMENT of TRANSPORTATION
AIRPORTS DIVISION
MARCH, 1991

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

FINAL

ENVIRONMENTAL IMPACT STATEMENT
PART 2 OF 2

KALAUPAPA AIRPORT, ROADWAYS AND WHARF IMPROVEMENTS
KALAUPAPA, MOLOKAI, HAWAII

Submitted by:

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
AIRPORTS DIVISION

This Statement is submitted for review pursuant to the following public law requirements: National Environmental Policy Act of 1969; Section 4(f) of the Department of Transportation Act of 1966; Section 505 of the Airport and Airway Improvement Act as amended by the Airport and Airways Safety Expansion Act of 1987; Sections 106 and 110 of the National Historic Preservation Act of 1966.

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APPENDIX A

APPENDIX A

AVIFAUNA AND FERAL MAMMAL SURVEY REPORTS, KALAUPAPA AIRPORT

FIELD SURVEY OF THE AVIFAUNA AND FERAL MAMMALS AT KALAUPAPA, MOLOKAI: PHASE I REPORT

Prepared for

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4 May 1989

FIELD SURVEY OF THE AVIFAUNA AND FERAL MAMMALS AT KALAUPAPA, MOLOKAI: PHASE I REPORT

INTRODUCTION

The purpose of this Phase I report is to summarize the findings of the first of two separate three day bird and mammal field surveys conducted on 17-19 March 1989 for the Kalaupapa Airport Master Plan at Kalaupapa, Molokai (Fig.1). Also included are references to pertinent literature and unpublished observations of faunal activity at this site. Finally, the report discusses some possible changes that might occur in the faunal community given the scope of the proposed development. A second shorter report will be made of the observations obtained on the second field survey to be conducted in late May 1989. This latter report will help to provide a more complete picture of bird activity at this site.

The objectives of the field survey were to:

1- Document what bird and mammal species occur on the property or may likely occur given the type of habitats available.

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

3- Assess the possible changes in the faunal communities that might occur as a result of habitat alteration following the proposed development. In the event that special or critical habitat resources exist on the property identify these sites and make recommendations regarding their protection or what mitigating measures should be considered.

GENERAL SITE DESCRIPTION

The project site is located at Kalaupapa, Molokai (see Fig.1). The area surveyed included not only the present Kalaupapa Airport but the surrounding lands and the Access Road to Kalaupapa town. The dominant trees in the area include: Kiawe (Prosopis pallida), Iron Wood (Casuarina spp.), Cook Pine (Araucaria columnaris) and Tree Heliotrope (Messerschmidia argentea). The lands immediately surrounding the airport are covered by Beach Naupaka (Scaevola taccada) and a variety of grasses and native coastal plants.

Weather during the field survey was variable with cool cloudy mornings and afternoons and clear mid-day periods. Winds were unusually light and from the west rather than the typically strong NE trades that normally prevail along this coastal section of Molokai.

STUDY METHODS

Field observations were made with the aid of binoculars and by listening for vocalizations. Attention was also paid to the presence of tracks and scats as indicators of bird and mammal activity. A total of eleven census stations (Fig. 1) were established and eight minute counts were made during early morning and late afternoon periods of all birds seen or heard at these stations. These counts provide the basis for the population estimates given in this report. Between these count stations additional observations of birds were also kept. Literature resources and reports of bird observations made at Kalaupapa by other competent ornithologists were consulted in order to acquire a more complete picture of the faunal community at this site (Berger 1972, Hawaii Audubon Society 1984, Pratt et al. 1987, Robert Pyle - ornithologist with the Bishop Museum, Honolulu).

Observations of feral mammals were limited to visual sightings and evidence in the form of scats and tracks. No attempts were made to trap mammals in order to obtain data on their relative abundance and distribution.

Scientific names used herein follow those given in the most recent American Ornithologist's Union Checklist (A.O.U. 1983), Hawaii's Birds (Hawaii Audubon Society 1984), A Field Guide to the Birds of Hawaii and the Tropical Pacific (Pratt et al. 1987) and Mammal Species of the World (Honacki et al. 1982).

RESULTS AND DISCUSSION

Resident Endemic (Native) Birds:

No endemic birds were recorded during the actual survey. The Short-eared Owl (*Asio flammeus sandwichensis*) might occasionally be found at this site as they forage over open lowlands as well as at higher elevation (Pratt et al. 1987). No other endemic species would be expected given the present condition of the habitat. The wetlands located on the town side of the airport are almost completely overgrown. If open water spaces were available then native endemic wetland birds such as Black-necked Stilt (*Himantopus mexicanus knudseni*), and American Coot (*Fulica americana alai*) as well as migratory waterfowl might be expected to take advantage of this wetland.

Migratory Indigenous (Native) Birds:

Pacific Golden Plover (*Pluvialis fulva*) - Plovers prefer open areas for foraging such as mud flats, lawns and fields with short grasses. Prey items primarily include insects, crustaceans, and a wide variety of other small invertebrates. An average of 82 plover were recorded for each day of this first field survey. These birds were observed along the roadside, on the grassy margins of the airstrip and on other small lawns and open spaces scattered throughout the area surveyed. Johnson et al. (1981), Bruner (1983). and Johnson et al. (1989) have shown plover are extremely site-faithful on their wintering grounds (returning each day to the same spot and maintaining this behavior throughout their life time). Plover also establish foraging territories which they defend vigorously. Such behavior makes it possible to acquire a fairly good estimate of the abundance of plover in any one area. These populations likewise remain relatively stable over many years. (Johnson et al. 1989).

Ruddy Turnstone (Arenaria interpres) - Ruddy Turnstone forage on lawns as well as in the intertidal zone. They typically occur in small flocks and are not known to be territorial but may exhibit some site-faithfulness tendencies (Fleisher 1985). Turnstone also compete with plover for many of the same types of prey. An average of 32 Ruddy Turnstone were recorded for each day of this first field survey.

Wandering Tattler (Heteroscelus incanus) - Wandering Tattler spend their non breeding season in Hawaii foraging along rocky coastlines, in mudflats and intertidal habitats as well as beside mountain streams. No site-faithful or territorial studies have been conducted on tattler in Hawaii. Typically they forage alone rather than in flocks like Ruddy Turnstone. An average of two Wandering Tattler were seen on each day of this first survey. The Siberian Tattler (Heteroscelus brevipes) has been recorded only rarely in Hawaii, the most recent record is from Kona, Hawaii (Pratt pers. comm.). This species is much more common in the western Pacific (Pratt et al. 1987). No Siberian Tattler were recorded on this survey.

Two other species of migratory shorebirds Sanderling (Calidris alba) and Bristle-thighed Curlew (Numenius tahitiensis) may at times occur on the property although they were not recorded on this first survey. Sanderling commonly forage along wave swept beaches but will also utilize lawns and intertidal habitats. Bristle-thighed Curlew are usually seen only when they pass through Hawaii in the early fall as they migrate further south to the central and southeastern Pacific. There they forage along exposed reefs on atolls and in high elevation grasslands on the volvanic high islands of the Society and Marquesas archipelagos (Bruner 1972, Pratt et al. 1987).

Seabirds:

No seabirds were observed on the ground but three species: Great Frigatebird (Fregata minor), Red-footed Booby (Sula sula) and Wedge-tailed Shearwater(Puffinus pacificus) were seen flying overhead or off shore. R. Pyle (pers. comm.) reports Laysan Albatross (Diomedea immutabilis), White-tailed Tropicbird (Phaethon lepturus) as well as Great Frigatebird from Kalaupapa. Laysan Albatross have only in the last ten years begun to visit the main Hawaiian Islands. This may be due to space limitations on the breeding sites within the NW Hawaiian Island National Wildlife Refuge.

Resident Indigenous (Native) Birds:

No resident indigenous species were recorded. Black-crowned Night Heron (Nycticorax nycticorax) might occasionally forage in and around the wetland habitat, however, none were observed on this first survey.

Exotic (Introduced) Birds:

A total of 16 species of exotic birds were recorded during the field survey. Table One shows the relative abundance of these species. The most numerous during the three day survey were Common Myna (Acridotheres tristis), Japanese White-eye (Zosterops japonicus), House Finch (Carpodacus mexicanus) and Zebra Dove (Geopelia striata). R. Pyle (pers. comm., an Ornithologist with the Bishop Museum) visited Kalaupapa on 5 March 1989 and found House Finch to be the most common species in the eastern sector of the peninsula.

Four species recorded in similar habitat elsewhere on Molokai (Hawaii Audubon Society 1984, Pratt et al. 1987). were not recorded on this survey but potentially could occur on the property or adjacent lands. They include: Common Barn-Owl (Tyto alba), Melodious Laughing-Thrush (Garrulax canorus), Eurasian Skylark (Alauda arvensis), and Northern Mockingbird (Mimus polyglottos).

Feral Mammals:

Feral cats and dogs were seen during all days of the survey. Rats and mice were not observed but undoubtedly occur on the property. A total of seven Small Indian Mongoose (Herpestes auropunctatus) were also recorded. Feral goats were both seen and heard as well as feral pigs. Axis Deer (Axis axis) are reported from Kalaupapa but none were found on this survey. Without a trapping program it is difficult to conclude much about the relative abundance of rats, mice, cats and mongoose, however, their numbers are probably not dramatically different from what one would find elsewhere on Molokai in similar habitats.

Records of the endemic and endangered Hawaiian Hoary Bat (Lasiurus cinerus semotus) are sketchy but the species likely occurs on Molokai (Tomich 1986). Little is known of their natural history, distribution and ecological requirements. No bats were recorded on this project site despite two nights of observation.

CONCLUSION AND RECOMMENDATIONS

A brief survey can at best provide a limited perspective of the wildlife present in any given area. Not all species will necessarily be observed and information on their use of the site must be sketched together from brief observations and the available literature. The number of species and the relative abundance of each species may vary throughout the year due to available resources and reproductive success. Species which are migratory will quite obviously be a part of the faunal community only at certain times during the year. Exotic species sometimes prosper for a time only to later disappear or become a less significant part of the ecosystem (Williams 1987). Thus long term studies can provide the insights necessary to acquire both a broad view as well as a more definitive perspective of the bird and mammal populations in a particular area. However, when brief studies are coupled with data gathered from other similar habitats the value of the conclusions which are drawn is significantly increased.

In terms of broad conclusions related to bird and mammal activity on the project site the following are offered:

1- The present environment in the area surveyed provides a diverse range of habitats which are utilized by the typical array of exotic birds one would expect in these types of environments on Molokai. The proposed development will reduce habitat for species which rely on brush covered habitats for foraging and shelter, such species include: Northern Cardinal (Cardinalis cardinalis), and game bird species such as Gray Francolin (Francolinus pondicerianus). Black Francolin (Francolinus francolinus) and Ring-necked Pheasant (Phasianus colchicus).

2- Migrant species particularly Pacific Golden Plover and to a lesser degree Ruddy Turnstone are usually benefited by the kind of development that creates open spaces such as lawns. The proposed development should add more habitat for plover while at the same time it reduces living spaces for species which require brush or trees.

3- Laysan Albatross are not necessarily overly attracted to airstrips but they do frequent open habitat which affords access to prevailing winds. Because of their large body size they must run into the wind in order to get enough lift to become airborne. It remains to be seen what will become of recent attempts at reinvasion of the main islands by this species. Predators such as dogs and man may severely limit the success of this venture. Although no albatross were observed on the survey they never-the-less have been recorded at Kalaupapa. If albatross begin to make greater use of the airstrip there may be some reason for concern about possible airstrikes between aircraft and albatross. This situation should be watched carefully.

4- No significant changes in the feral mammal population should occur as a result of the proposed development.

5- The wetland habitat that lies on the town side of the present airfield could become a valuable resource for resident and migratory waterbirds. What is needed is some clearing to make open water habitat and the creation of some small islands which would reduce the effects predators would have on nesting birds. Fencing of the wetland to restrict dogs from entering would also be a positive step towards improvement. Eventually this site could become again a useful wetland as well as an added attraction to the beauty of the Kalaupapa peninsula.

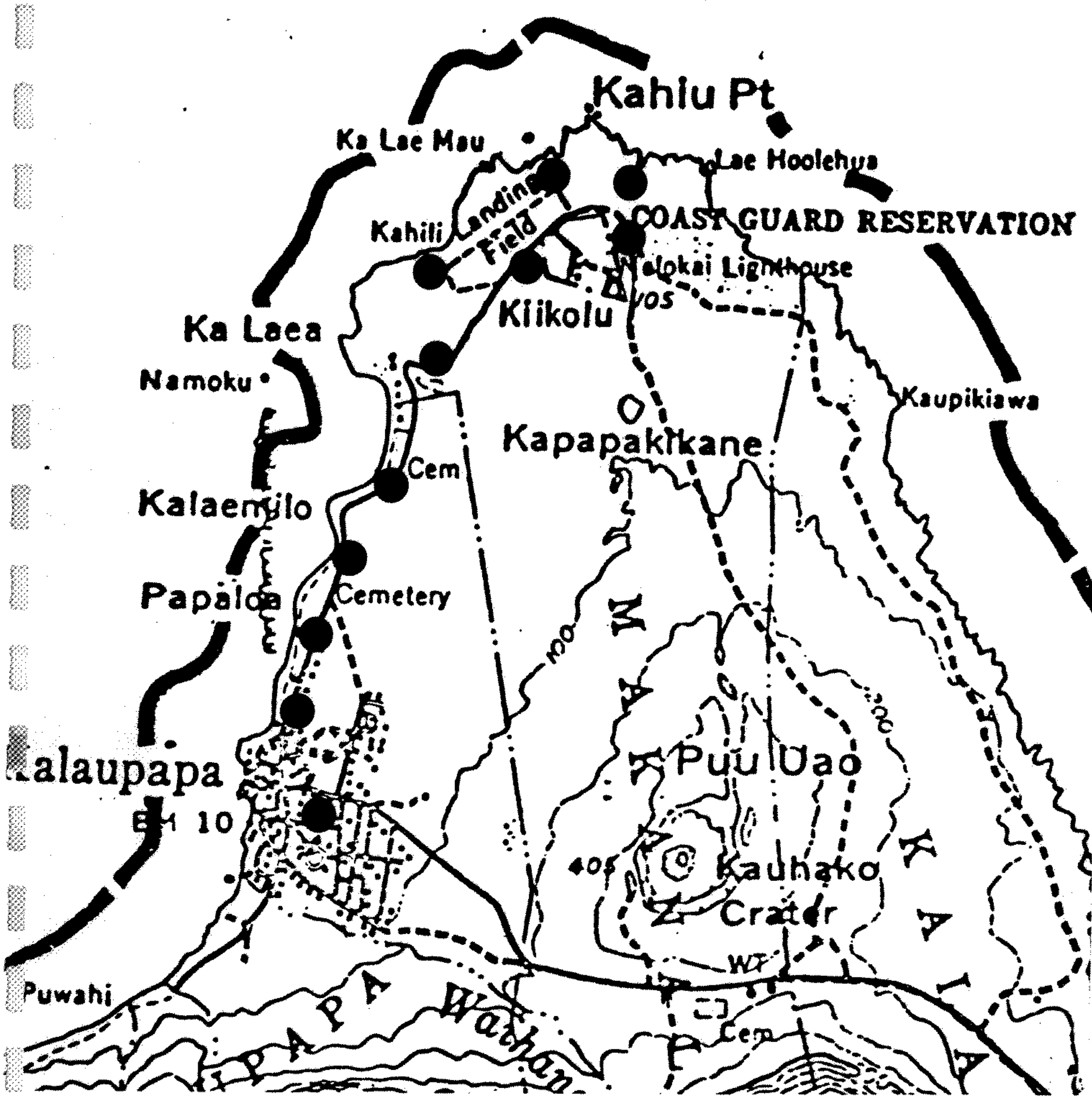

Fig. 1. Project site with locations of eight minute count stations indicated by solid circles.

TABLE 1

Relative abundance of exotic birds recorded in the region of the airport and the access road to town at Kalaupapa, Molokai

COMMON NAME	SCIENTIFIC NAME	RELATIVE ABUNDANCE*
Cattle Egret	*Bubulcus ibis*	R = 3
Ring-necked Pheasant	*Phasianus colchicus*	R = 2
Gray Francolin	*Francolinus pondicerianus*	R = 8
Black Francolin	*Francolinus francolinus*	U = 2.4
Spotted Dove	*Streptopelia chinensis*	U = 4.8
Zebra Dove	*Geopelia striata*	A = 12.6
Rock Dove	*Columba livia*	R = 1
Common Myna	*Acridotheres tristis*	A = 18.7
Japanese White-eye	*Zosterops japonicus*	C = 8.1
Northern Cardinal	*Cardinalis cardinalis*	U = 4.5
Red-Crested Cardinal	*Paroaria coronata*	U = 4.1
Japanese Bush-Warbler	*Cettia diphone*	R = 4
House Sparrow	*Passer domesticus*	C = 7.5
House Finch	*Carpodacus mexicanus*	A = 15.3
Nutmeg Mannikin	*Lonchura punctulata*	C = 6.2
Warbling Silverbill	*Lonchura malabarica*	R = 2

* (see page 13 for key to symbols)

KEY TO TABLE 1

Relative Abundance = Determined by frequency on eight minute counts in appropriate habitat. Number which follows is average of all counts for that species in appropriate habitat.

A = Abundant (ave. 10+)

C = Common (ave. 5-10)

U = Uncommon (ave. less than 5)

R = Rare or recorded only once (number which follow is total individuals recorded during the field survey)

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FIELD SURVEY OF THE AVIFAUNA AND FERAL MAMMALS AT KALAUPAPA, MOLOKAI: PHASE II REPORT

Prepared for

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26 May 1989

FIELD SURVEY OF THE AVIFAUNA AND FERAL MAMMALS AT KALAUPAPA, MOLOKAI: PHASE II REPORT

INTRODUCTION

The purpose of this Phase II report is to summarize the findings of the second bird and mammal field survey conducted on 22-24 May 1989 for the Kalaupapa Airport Master Plan at Kalaupapa, Molokai. Also included are additional personal communications regarding wildlife observations at Kalaupapa which were not recorded in the Phase I report.

The objectives of this second field survey were to:

1- Document what species occur on the property during the summer months.

2- Provide some additional baseline data on the relative abundance of each species.

3- Assess the importance and quality of the wetland habitat in the Ka Laea area.

4- Conduct a brief faunal survey of Kauhako Crater and Puu Uao.

GENERAL SITE DESCRIPTION

Two abundant plants inadvertently left of the original list in the first report were: Christmas Berry (*Schinus terebinthifolius*) and 'Ilima (*Sida fallax*).

Weather during this second field survey was variable with clear periods and occasional passing showers. Winds were strong (20-30 mph) from the east.

METHODS

This second field survey followed the same methods that were used in the 17-19 March survey. The identical census stations shown in Figure One of the Phase I Report were also sampled in this survey. In addition a walk through of the wetland at Ka Laea was made to evaluate this resource for waterbirds as well as two visits to the interior and surrounding lands of Kauhako Crater and Puu Uao.

RESULTS AND DISCUSSION

Endemic (Native) Birds:

No endemic birds were recorded during this second survey. The wetlands located on the town side of the airport contain sufficient water and food resources to support a small number of waterbirds. This wetland could be used by Black-necked

Stilt (Himantopus mexicanus knudseni), American Coot (Fulica americana alai) and Common Moorhen (Gallinula chloropus sandvicensis).

Migratory Indigenous (Native) Birds:

Pacific Golden Plover (Pluvialis fulva) - Only one plover was seen during the course of this second survey. The bird was a juvenile with no signs of breeding plumage.

Ruddy Turnstone (Arenaria interpres) - Several flocks of turnstone were recorded along the grassy margins of the airstrip and in the region of the lighthouse on all three days of the survey. The largest flock contained 16 birds about half of which had some breeding plumage. These turnstone are over-summering birds which did not migrate. This phenomenon is typical of many juvenile shorebirds (Johnson, O.W. M.L. Morton, P.L. Bruner and P.M. Johnson. 1989..Fat cyclicity, predicted migratory flight ranges, and features of wintering behavior in Pacific Golden-Plovers. Condor 91:156-177). No other species of migratory shorebirds were recorded on this survey.

Seabirds:

Two additional seabird species were recorded on this survey: Red-tailed Tropicbird (Phaethon rubricauda) and the White-tailed Tropicbird (Phaethon lepturus). Both species were observed flying over the peninsula.

Resident Indigenous (Native) Birds:

No resident indigenous species were recorded.

Exotic (Introduced) Birds:

A total of 12 species of exotic birds were recorded during this second field survey. Table One shows the relative abundance of these species. The most numerous during the three day survey were Common Myna (*Acridotheres tristis*), House Finch (*Carpodacus mexicanus*) and Nutmeg Mannikin (*Lonchura punctulata*). The decrease in counts of Japanese White-eye (*Zosterops japonicus*) may have been in part the result of the high wind conditions which made detection difficult. The lower numbers of Zebra Dove (*Geopelia striata*) is less clear. Several residents of Kalaupapa reported the presence of California Quail (*Callipepla californica*) along the road between Kalawao and Kalaupapa. Other species of gamebirds were less vocal on this summer survey than in March. Four species recorded on the March survey were not found on this census they include: Japanese Bush-Warbler (*Cettia diphone*), Cattle Egret (*Bubulcus ibis*), Warbling-Silver-bill (*Lonchura malabarica*) and Rock Dove (*Columba livia*). Bush-Warbler were not singing and thus were impossible to detect.

The other three unaccounted for species were rare on the first survey and hence easily missed on this census.

A survey of Kauhako Crater and the Puu Uao area did not add any new species to the list in Table One. Table Two shows the relative abundance of each species. Japanese White-eye was abundant in the crater. The protection from the wind afforded by the crater walls made for calmer conditions and a better ability to hear and see this species. The dense lush vegetation of the crater is in stark contrast to the barren wind swept habitat which characterizes the majority of the unhabitated portions of the peninsula. The lake in the crater might be capable of supporting some waterbirds such as coot or moorhen. However, the lake's depth and poor water quality may be a drawback to extensive use of this site. No waterbirds were found on this body of water during either survey.

Feral Mammals:

Feral cats were seen during all days of the survey. Rats and mice were not observed but undoubtedly occur on the property. A total of eleven Small Indian Mongoose (*Herpestes auropunctatus*) were also recorded. Feral pigs and Axis Deer (*Axis axis*) were abundant on the peninsula. Tracks and scats attest to their numbers. These two species do great damage to the habitat by eating and up-rooting native plants and creating erosion. The Ka Laea wetland and Kauhako Crater showed abundant signs of deer and pig activity.

CONCLUSIONS AND RECOMMENDATIONS

The conclusions for this second faunal survey are as follows:

1- Activity and numbers of exotic birds were typical of the summer months.

2- The increased seabird activity over the peninsula was probably due to the high wind conditions.

3- Feral mammals on the peninsula are numerous, particularly pigs and deer.

4- The wetland habitat at Ka Laea and the Kauhako Crater area are two locations that either are or could become important sites for wildlife.

5- The proposed development at the airstrip will have little impact on the populations of wildlife at Kalaupapa.

RECOMMENDATIONS

1- The Ka Laea wetland although relatively small in size could be made useful to waterbirds if water levels could be controlled and intruders such as man, deer, dogs and pigs could be kept out by fencing. The creation of small islands would discourage predation on nesting birds by cats and mongoose.

2- The Kauhako Crater is one of the best forested areas on the peninsula and should be protected. Feral pigs and Axis Deer destroy the understory vegetation and should be removed from this site.

TABLE 1

Relative abundance of exotic birds recorded in the region of the airport and the access road to town at Kalaupapa, Molokai (22-24 May 1989).

COMMON NAME	SCIENTIFIC NAME	RELATIVE ABUNDANCE*
Ring-necked Pheasant	*Phasianus colchicus*	R = 3
Gray Francolin	*Francolinus pondicerianus*	U = 2
Black Francolin	*Francolinus francolinus*	U = 2.2
Spotted Dove	*Streptopelia chinensis*	U = 4.9
Zebra Dove	*Geopelia striata*	C = 8.6
Common Myna	*Acridotheres tristis*	A = 16.2
Japanese White-eye	*Zosterops japonicus*	U = 4
Northern Cardinal	*Cardinalis cardinalis*	U = 3.5
Red-Crested Cardinal	*Paroaria coronata*	U = 4.4
House Sparrow	*Passer domesticus*	C = 11.7
Nutmeg Mannikin	*Lonchura punctulata*	A = 18.9
House Finch	*Carpodacus mexicanus*	A = 11.7

* (see page 10 for key to Relative Abundance Symbols)

TABLE II

Relative abundance of exotic birds in Kauhako Crater and the Puu Uao area, Kalaupapa, Molokai (22-29 May 1989).

COMMON NAME	SCIENTIFIC NAME	RELATIVE ABUNDANCE*
Black Francolin	*Francolinus francolinus*	R = 2
Spotted Dove	*Streptopelia chinensis*	C = 6.5
Zebra Dove	*Geopelia striata*	C = 7.8
Common Myna	*Acridotheres tristis*	A = 12.4
Northern Cardinal	*Cardinalis cardinalis*	C = 5.6
Red-Crested Cardinal	*Paroaria coronata*	U = 2.1
Japanese White-eye	*Zosterops japonicus*	A = 14.0
House Finch	*Carpodacus mexicanus*	A = 17.5

* (see page 10 for key to Relative Abundance Symbols)

KEY TO TABLE 1

Relative Abundance = Determined by frequency on eight minute counts in appropriate habitat.

Number which follows is average of all counts for that species in appropriate habitat.

A = Abundant (ave. 10+)

C = Common (ave. 5-10)

U = Uncommon (ave. less than 5)

R = Rare or recorded only once (number which follows is the total number of individuals recorded during the survey)

APPENDIX B

APPENDIX B

MARINE ENVIRONMENTAL BASELINE SURVEY TO ASSESS THE EFFECTS OF EXTENSIONS OF THE RUNWAY AT KALAUPAPA AIRPORT, KALAUPAPA, MOLOKAI, HAWAII

MARINE ENVIRONMENTAL BASELINE SURVEY TO ASSESS THE EFFECTS OF EXTENSION OF THE RUNWAY AT KALAUPAPA AIRPORT, KALAUPAPA, MOLOKAI, HAWAII

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INTRODUCTION

Purpose

Part of the planned Kalaupapa Airport Master Plan calls for a 1000 foot extension off the southwestern end of the existing runway. Location of the airport is at mean sea level on the most seaward part of the Kalaupapa peninsula. Runway construction may result in modification of the shoreline in a manner that may cause effects to the marine environment (primarily by increased runoff and siltation). In order to evaluate the potential effects on water quality and marine biological community structure resulting from construction of the runway extension, a baseline marine environmental survey of the area was conducted in July of 1989. The purpose of this report is to present the results and conclusions of the baseline survey. The evaluation includes qualitative and quantitative descriptions of the environments that are directly offshore of the existing and expanded runway, as well as neighboring areas that may be influenced by water quality changes caused by construction. The baseline survey can also serve as the preliminary phase of any monitoring programs that may be required to meet all requirements for permit approval by county, state and federal government agencies.

Specific Objectives

1) to characterize, in both qualitative and quantitative terms, the existing water quality in the vicinity of the existing runway, and at a control station that will not be affected by the construction of the project. Chemical composition of the environment will be evaluated by analysis of all parameters specified by State of Hawaii, Department of Health water quality standards (Chapter 11-54 S11-54-06 (3)), as well as several other parameters that are not listed by DOH, but provide important information. Of particular importance will be potential changes that may result from sediment created by construction and its related short term impact on turbidity;

2) to establish a comprehensive quantitative and descriptive baseline of biotic communities in the vicinity of the existing and proposed runway and at the control site. All methods used to assemble the baseline will incorporate criteria listed in DOH water quality standards (S11-54-07 (3)(D));

3) to evaluate the degree of natural stresses (sedimentation, wave scour, freshwater input, etc.) that influence the nearshore marine environment in the vicinity of the proposed project. Typically, the composition of reef communities is intimately associated with the magnitude and frequency of these stresses, and any impacts caused by the proposed project may be mitigated in large part by natural environmental factors. Therefore, evaluating the range of natural stress is a prerequisite for assessing the potential for additional change to the marine environment owing to shoreline modification;

4) based on results of objectives 1-3, to evaluate the potential impacts to the marine environment owing to runway expansion, and to offer recommendations or mitigating measures that will lessen, or eliminate, such impacts.

METHODS

Water Quality

Figure 1 is a map showing the Kalaupapa Peninsula and Airport along with the locations of 3 survey sites. Sites are located off the center of the existing runway (#1), off the southwestern end of the runway directly offshore of the extension location (#2), and approximately 1 kilometer south of the airport (#3). Site #3 serves as a control site, and should delineate if any observed environmental changes are caused by inherent natural variability or construction related activities. It was originally planned to include a fourth site off the northeastern end of the runway. During the period of field survey, however, extremely rough sea conditions prevented access to this area. All site locations were recorded by compass bearings on prominent landmarks.

All field work was conducted on July 21-22, 1989 using a 30 foot boat. At each of the three ocean sampling sites a series of chemical sampling transects were established. On each transect samples were collected at two distances, 10 meters (m) and 100 m from the shoreline. At each sampling site two samples were collected; a surface sample from within 10 centimeters (cm) of the air-sea interface, and a deep sample approximately 1 m from the sea floor.

Water quality parameters that were evaluated included the 10 specific criteria designated for open coastal waters in Chapter 11-54, Section 06 (Open Coastal waters) of the Water Quality Standards, Department of Health, State of Hawaii. These criteria include: total nitrogen, nitrate + nitrite nitrogen ($NO_3^- + NO_2^-$), ammonia (NH_4^+), total phosphorus, Chlorophyll a (Chl a), turbidity, dissolved oxygen, temperature, pH and salinity. In addition, orthophosphate phosphorus (PO_4^{-3}) and silica (Si) were also reported because these parameters are sensitive indicators of biological activity and degree of groundwater mixing, respectively.

Water samples were collected in 1-liter polyethylene bottles. Subsamples for nutrient analyses were filtered through glass-fiber filters into 125 milliliter (ml) acid-washed, triple rinsed, polyethylene bottles in the field and immediately placed on ice. Analysis for NH_4^+, PO_4^{3-}, and $NO_3^- + NO_2^-$ and Si were performed using manual techniques on a Brinkman colorimeter. Total nitrogen and total phosphorus were analyzed in a similar fashion following ultra-violet digestion. Dissolved inorganic nitrogen (DON) and dissolved inorganic phosphorus (DOP) were calculated as the difference between total dissolved and dissolved inorganic N and P.

Water for other analyses was subsampled from 1-liter polyethylene bottles and kept chilled until analysis. Turbidity was determined on 60-ml subsamples fixed with HgCl to terminate biological activity. Fixed samples were kept refrigerated until turbidity was measured using a Monitek Model 21 nephelometer, and reported in nephelometric turbidity units (NTU) . Chlorophyll a was measured by filtering 300 ml of water through glass fiber filters; pigments on filters were extracted and assessed fluorometrically. Salinity was determined using a AGE Model 2100 laboratory salinometer with a readability of 0.0001 $^{o}/oo$.

In-situ field measurements included dissolved oxygen and water temperature (YSI Model 58 meter with a readability of 0.01 milligrams per liter (mg/l) and 0.1 0 c. , respectively). pH was determined in the field with a Cole-Parmer Digisense millivolt meter with a readability of 0.01 pH units.

Biological Community Structure

Prior to quantitative transect sampling, qualitative reconnaissance surveys were conducted throughout the area fronting the existing runway. These surveys were useful in making relative comparisons between areas, identifying any unique or unusual biotic resources, and providing a general picture of the physiographic structure and benthic assemblages occurring throughout the region of study.

Following the preliminary survey, 6 quantitative transect sites were selected along the 3 offshore stations sampled for water chemistry. Each transect site was selected to represent the typical zonation pattern of the particular station. Transects were 50 m long, and were oriented parallel to the shoreline so that they bisected a cross-section of a reef zone. Ends of transects were marked by weighted floats. Quantitative benthic surveys were conducted by stretching a surveying tape over the reef surface between the marker floats. An aluminum quadrat frame, with dimensions of 1 m by 0.66 m, was sequentially placed over 10 random marks on the transect tape so that the tape bisected the long axis of the frame. At each quadrat location a color photograph recorded the segment of reef area enclosed by the quadrat frame. In addition, a diver knowledgeable of the taxonomy of resident species visually estimated the percent cover and occurrence of organisms and substrata types within the quadrat frame. Only macrofaunal species greater than approximately 2 cm were noted; no attempt was made to identify and enumerate cryptic species dwelling within the reef framework. Following the period of field work, quadrat photographs were projected onto a grid and units of bottom cover for each benthic faunal species were calculated. The photo-quadrat transect method is a modification of the technique described in Kinzie and Snider (1978), and has been employed in numerous field studies of Hawaiian reef communities (e.g. Dollar 1979, Grigg and Maragos 1974, Grigg 1983).

Quantitative assessment of reef fish community structure was conducted in conjunction with the benthic surveys. As the transect tape was being laid along the bottom, all fishes observed within a band approximately 2 m wide along the transect path were identified to species and enumerated. Care was taken to conduct the fish surveys so that the minimum disturbance by divers was created, ensuring the least possible dispersal of fish. Only readily visible individuals were included in the census. No attempt was made to seek out cryptic species or individuals sheltered within coral. This transect method is an adaptation of techniques described in Hobson (1974).

RESULTS

Physical Structure

The entire area off the existing Kalaupapa airport runway is homogeneous. A basaltic shoreline drops sharply from the shoreline in a vertical cliff face down to depths of 5-15 m. At the foot of the cliff, and extending offshore for distances of at least 500 m, and to water depths of at least 30 m, bottom topography is composed of large basaltic boulders. Interspersed in the boulders are areas of flat basaltic pavement. Surfaces of the boulders, as well as the shoreline cliff face, are relatively devoid of attached benthic organisms, owing to extreme turbulence during the months when winter shore impacts the north shores of the Hawaiian Islands. The boulders do form, however, a complex of interstitial spaces that provide shelter for fish.

Off transect 3, located to the south of the runway, physical structure of the marine environment is somewhat different. The shoreline is composed of narrow white sand beaches, and the shoreline cliff is absent. Rather, seaward of the shoreline, there is a relatively flat basaltic platform approximately 3-5 m deep that extends approximately 200 m offshore. The platform is devoid of relief other than a scattering of small rocks. Seaward of 200 m, water depth extends to approximately 10 m and bottom topography consists of large boulders, similar to off the runway.

Water Quality

Table 1 shows results of water quality sampling off the Kalaupapa Airport. Also shown in Table 1 are geometric means of all samples for each parameter, as well as the most stringent State of Hawaii Water Quality Standard limits. In addition, the mean values of weekly measurements collected for the past 3 years from the warm seawater intake at the National Energy Laboratory of Hawaii (NELH) at Keahole Pt. on the Island of Hawaii, are also listed. As the waters off NELH are considered to represent pristine coastal oceanic condition, these data provide a good basis of comparison.

It can be seen that in all cases, the geometric mean of the Kalaupapa samples is below the most stringent of the Hawaii Water Quality Standards. With the exception of total dissolved nitrogen and dissolved organic nitrogen, means of parameters from the Kalaupapa samples are also below the means of NELH measurements. These comparisons indicate that at present the waters off Kalaupapa can be considered unimpacted by any extraneous inputs, and represent pristine oceanic conditions.

Examination of the data in Table 1 indicates that there is a very slight indication of vertical stratification with respect to salinity; surface samples were slightly less saline than deep samples. Dissolved silica, a constituent of groundwater was slightly higher at station 3 compared to stations 1 and 2, and also was elevated in surface relative to deep samples. This pattern for silica concentration appears to indicate a slight input of groundwater off station 3.

Concentrations of PO_3^{3-} and NO_3^-, showed slightly higher concentrations in the nearshore samples relative to the offshore samples, but did not display any indications of vertical stratification. NH_4^+, DON, DOP and Chl. a did not display any pattern of distribution, and were uniformly low. Oxygen, pH and temperature were essentially uniform throughout the sampling scheme.

Benthic Community Structure

Table 2 shows percent coral cover, number of coral species, and species diversity for corals encountered on transects. Coral cover on all transects is extremely low, ranging from 3% to 6%. While 7 species of corals were encountered, species per transect ranged from 2 to 4, and two species (Porites lobata and Pocillopora meandrina) comprised 89% of all coral cover.

Coral cover is uniformly low throughout the offshore area of Kalaupapa owing to the intense forces associated with breaking waves that impact the coastline every winter season. Such wave action is sufficient in magnitude to prevent planular settlement, and growth of adult colonies. The corals that were encountered were all small flat encrustations that presented no exposed surfaces above the boulder substratum. Pocillopora meandrina, considered a "pioneering species" in that it is normally found in areas that are physically too harsh for other species, occurred predominantly as small colonies that can be considered new recruits, less than a year in age.

Other forms of benthos were extremely rare off the entire Kalaupapa area. The only sea urchins that were observed were Echinometra matheai and Echinostrephus aciculatus. These urchins bore into rock surfaces, and were observed in small numbers on boulder surfaces. Other urchins that are normally found on the reef surface were not present, likely owing to the inability to withstand the turbulent motion associated with high surf conditions.

No benthic macroalgae were observed, except at transect KAR3-10'. At this locale, mats of the spiny seaweed Turbinaria ornata were abundant.

Reef Fish Community Structure

In contrast with the poorly developed coral community noted off the Kalaupapa Airport, the fish community was observed to be both diverse and abundant. A total of 64 species representing 17 families was observed on the 6 transects (Table 3). On individual transects, the number of species noted ranged from 24 to 39 and the number of individuals ranged from 208 to 436. Species diversity values ranged from 2.3 to 3.2.

Herbivorous surgeonfishes were the single largest component of the fish community. The predominant species were the goldring surgeonfish (kole, Ctenochaetus strigosus), the brown surgeonfish (ma'i'i'i, Acanthurus nigrofuscus), the whitebar surgeonfish (maikoiko, A. leucopareius), the convict tang (manini, A. triostegus), and the orangespine unicornfish (umaumalei, Naso lituratus).

Other other common herbivorous fishes included the brown chub (nenue, Kyphosus bigibbus) and two parrotfish species (uhu, Scarus perspicillatus and S. rubroviolaceus). Planktivorous damselfishes were also an important constituent of the fish community. In particular, large aggregations of the oval chromis (Chromis ovalis) and the smaller blackfin chromis (C. vanderbilti) were seen feeding several meters off the bottom. Also noted were the hawaiian sargeant (mamo, Abudefduf abdominalis) and the threespot chromis (C. verator). In addition to the fishes cited above, numerous other species were observed. Principle representatives came from the wrasse family (Labridae), the butterflyfish family (Chaetodontidae), and the goatfish family (Mullidae).

Both the behavior and composition of the fish community indicated that relatively little fishing pressure has been exerted on this site. Large nenue swarmed about divers in apparent curiosity, and large parrotfish were very easily approached. Cursory inspection of holes under boulders revealed large numbers of squirrelfish (u'u, menpachi, Myripristis spp.). Further, large male yellowstripe coris (hilu, Coris flavovitta) such as those observed during the study are usually absent from well-fished sites. The apparent scarcity of fishing activity is a result of the remote location and rough sea conditions associated with the site.

Threatened or Endangered Species

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

Populations of the endangered humpback whale (Megaptera novaeangliae) spend the winter months in the Hawaiian Islands. No whales were sighted during the course of the present survey in July, yet it is likely that whales frequent the offshore area between November and April.

DISCUSSION AND CONCLUSIONS

Project Construction

Implementing the proposed project will require the removal of solid material from behind the shoreline; it is not anticipated that there will be modification of the intertidal zone or any regions of the coastal zone. Thus, there is no potential for direct impacts from construction (i.e. removal) of organisms that inhabit the reef zones described in the previous sections of this report.

Potential alteration to water quality and biotic structure during construction could occur as a result of increased sedimentation and turbidity generated by on-land activities. These parameters may increase temporarily during the construction process, and the length of time of decreased water quality will depend on the length of the construction period. Following completion of the runway expansion, it is likely that there will be no permanent or residual effects to the marine environment as a result of airport expansion.

A substantial literature exists on the effects of sediments to coral reefs, as well as numerous case studies that report effects owing to construction-generated sediment on marine environments. The effects of sediment stress to corals has been extensively reviewed by Johannes (1975), Dodge and Vaisnys (1977), Bak (1978), Brown and Howard (1985) and Grigg and Dollar (1989). In summary, while it is clear that increased sedimentation can have deleterious effects on corals, especially when buried, increased sedimentation does not necessarily result in negative impacts. Because sediments are suspended by natural processes in many reef environments (including Hawaii), most corals can withstand a certain level of sediment supply to the living surface, especially when the level of increase is for a short duration. Many species have the ability to remove sediment from their tissues by distension of the coenosarc with water, or ciliary action which can nullify lethal effects of sedimentation (Yonge 1931, Marshall and Orr 1931, Hubbard and Pocock 1972).

In case studies of the effects of sedimentation, the range of environmental effects varies through the entire spectrum of stress. In general, situations where sediment stress causes negative impacts are characterized by chronic input, rather than episodic sediment addition. Cases where effects of dredging have caused mortality have been generally limited to areas of confined circulation such as Castle Harbor, Bermuda (Dodge and Vaisnys 1977), and Kaneohe Bay, Hawaii (Banner, 1974).

In areas of unrestricted circulation such as off Kalaupapa, however, there have been instances of increased sedimentation reported that have not caused negative effects to neighboring reefs. Sheppard (1980) reported that following dredging and blasting a military Harbor in Diego Garcia Lagoon, coral cover appeared to show no effects from increased siltation. Based on observations following construction of Honokohau Harbor in North Kona, Hawaii, there was also no indication that increased suspended sediment levels remained elevated beyond the period of construction (U.S. Army Corps of Engineers 1983).

While the Kawaihae Deep Draft Harbor located in South Kohala, Hawaii, was created by extensive blasting (Day et al. 1975) surveys of coral communities located just outside the harbor breakwater, as well as inside the harbor, indicated that coral and reef fish communities are flourishing (ORCA 1978). Before-and-after monitoring of the marine benthic communities in the vicinity of the Barbers Point Deep Draft Harbor on the leeward coast of Oahu indicated no impacts to corals beyond the edge of the dredged channel (AECOS 1985, 1986).

Monitoring of beach construction at the shoreline of a shallow, semi-enclosed inlet on the west coast of the Island of Hawaii (Makaiwa Bay), characterized by very high coral cover and fish population densities, showed that while substantial sediment plumes were created by excavation of the shoreline, there were no temporary or permanent negative effects to benthos and fish communities. Rapid flushing of the bay by normal current exchange, and the ability of live corals to exercise sediment removal behavior appeared to prevent measurable changes in community structure parameters. The monitoring survey also showed that water quality parameters were not permanently affected by temporary sediment loads, and quickly returned to preconstruction levels after the new beach was completed (Dollar 1987, Daxboeck 1987).

Several other scenarios around the Hawaiian Islands can also be drawn upon to substantiate that increased sedimentation does not necessarily result in substantial, or irreversible damage to neighboring marine environments. Studies conducted at Princeville, Kauai (Grigg and Dollar, 1980), French Frigate Shoals (Dollar and Grigg 1981), and Hilo Bay (Dollar 1985), all investigated the impacts to reef coral communities subjected to high levels of sediment stress. Results of these studies indicate that Hawaiian reef communities possess the adaptive ability to maintain community integrity under conditions of substantial, but temporary, sediment stress. The common theme in all of these case studies is that as long as construction (sediment generating) activities occur in environments with unrestricted circulation, and that the sediment stress is episodic, rather than chronic in nature, there appears to be no negative impact (either temporary or permanent) to coral reef communities. At the Kalaupapa site, it is expected that sediment suspension and removal by current action will prevent build-up of material on the sea floor, and allow organisms to maintain functional cleaning mechanisms.

The literature review presented above provides good documentation that impacts associated with short-term sediment producing events can be minimal or non-existent. At Kalaupapa, it is expected that activities on the shoreline associated with runway expansion will have no impacts to water quality or biota. Results of the present survey indicate that water quality presently shows very little effects from land. Mixing forces are so intense owing to wind and sea conditions that materials are rapidly dispersed in the nearshore zone. Airborne sediment created by excavation would have little or no chance of accumulating in the water column or on the sea floor during the period of construction.

As benthic communities must either tolerate the surrounding environmental conditions (as opposed to motile species which can leave an area with undesirable characteristics), they represent a good indicator for stress. Results of the survey indicate that the benthic communities off Kalaupapa are severely restricted owing to natural stresses associated with rough wind, sea and swell conditions. As such, if any small increases in environmental rigor associated with the airport expansion occur, it would likely be indistinguishable from the natural conditions that characterize the region.

Potential Impact from Ciguatera

A concern associated with excavation of the shoreline is a potential increase in incidence of toxic fish poisoning, termed ciguatera. Ciguatera is a circumtropical disease caused by the ingestion of a wide variety of coral reef fishes that contain toxins accumulated via the marine food chain. The microscopic organism implicated as the source of the ciguatera toxin is a photosynthetic benthic dinoflagellate, <u>Gambierdiscus toxicus</u>. Ciguatera poisoning is not a recent phenomenon; reports of the poisoning in the Pacific date back to 1606, when Spanish sailors suffered from ciguatera in the New Hebrides (Withers 1982).

Toxic outbreaks of ciguatera are sporadic and unpredictable, with patchy distribution in both space and time. When a benthic dinoflagellate was identified as the source, an early hypothesis was developed that any disruption of the marine environment which caused new surfaces to be exposed would trigger ciguatera outbreaks. While there is circumstantial evidence that there may be a connection is a relationship between dredging and ciguatera, definitive cause and effect relationships between environmental alteration and toxic outbreaks have not been verified. In fact, if the theory holds that newly cleared substratum triggers outbreaks, substantially increased incidences following hurricanes or severe storms would be expected. These events result in massive removal of live coral and clearing of substrata on a far greater areal extent than localized dredging (Dollar 1982).

As the Kalaupapa Airport Runway expansion will not involve any clearing of substrata below the water line, there is virtually no potential for increased incidences of ciguatera stemming from the project.

SUMMARY AND RECOMMENDATIONS

1) The marine environment offshore of the existing Kalaupapa Airport is characterized by a single bio-geomorphological zone. A steep basaltic shoreline cliff drops from the shoreline to depths of 5-15 m. From the base of the shoreline cliff to approximately to 500 m offshore, the bottom consists of a relatively flat reef terrace that is predominantly covered with basaltic boulders. Interspersed between the boulders are areas of flat basalt. No pockets of loose sediment are present.

2) Water quality off Kalaupapa can be considered typical of class AA, open coastal areas. Geometric means of all water quality parameters were below the most stringent DOH limits, and most concentrations of dissolved materials was lower than in waters off the Natural Energy Laboratory of Hawaii--a site where ocean waters are considered pristine. Off the Kalaupapa runway, there is very little, if any, influence from land on water quality, and only a very slight vertical stratification of salinity.

3) Corals, and associated coral reef organisms are very rare in abundance anywhere in the offshore area, comprising only 3%-6% of bottom cover on transects. Low coral cover is a result of predictable seasonal stress from winter surf which focuses energy on the north-facing side of Kalaupapa peninsula. Coral colonies that were observed were all small, flat encrustations that are best able to withstand the rigors of wave-induced turbulence. Motile macrobenthic invertebrates were extremely rare throughout the area.

4) Reef fish communities off the Kalaupapa airport were observed to be both diverse and abundant. Optimal shelter from the interstitial spaces created by the boulder substratum, and lack of substantial fishing pressure appear to be the predominant factors accounting for the robust fish communities.

5) None of the biotic assemblages observed in and near the area of the runway expansion constitutes rare, endangered or commercially valuable resources. Because the excavated area will not impinge on the shoreline, or areas seaward of the shoreline, there is no potential for directly altering, or removing, any components of the marine ecosystem.

6) Expansion of the runway may cause temporary increases in suspended sediment that reaches the nearshore zone. Turbulent mixing conditions resulting from wind, seas and waves that impact the Kalaupapa Peninsula will likely disperse these material with no impacts to the marine ecosystem.

Shoreline modification projects in other areas characterized by unrestricted circulation in the Hawaiian Islands have illustrated that suspended material generated by excavation can be dispersed by normal circulation before substantial settlement on the bottom. Marine communities appear to be able to withstand sediment stress by employing natural mechanisms such as cleaning behaviors. In addition, benthic marine communities off the Kalaupapa Airport are extremely scanty owing to the natural rigors of the area--thus there is very little potential for additional impact. Reef fish inhabiting the area are transients and are capable of leaving the area if environmental conditions become temporarily unfavorable.

7) Shoreline construction of the expanded airport does not appear to have the potential for impacts to protected and endangered marine species.

8) While outbreaks of ciguatera poisoning have been circumstantially linked to shoreline construction, there is no verifiable proof of such a connection. No underwater areas will be cleared during runway expansion, so there is no potential for shoreline construction at Kalaupapa to result in ciguatera outbreaks.

9) The present survey serves as a baseline for any required monitoring programs that might be required to meet county, state or federal permit requirements. Monitoring programs could identify any impacts to the environment resulting from the project, as well as mitigating measures to eliminate such impacts.

10) All of the conclusions presented above are predicated on utilizing the best and most relevant planning procedures, that place environmental considerations at the forefront of the project. If such planning practices are utilized, it appears from all available information that construction and operation of the expanded Kalaupapa Airport runway should not result in any degradation of the marine environment.

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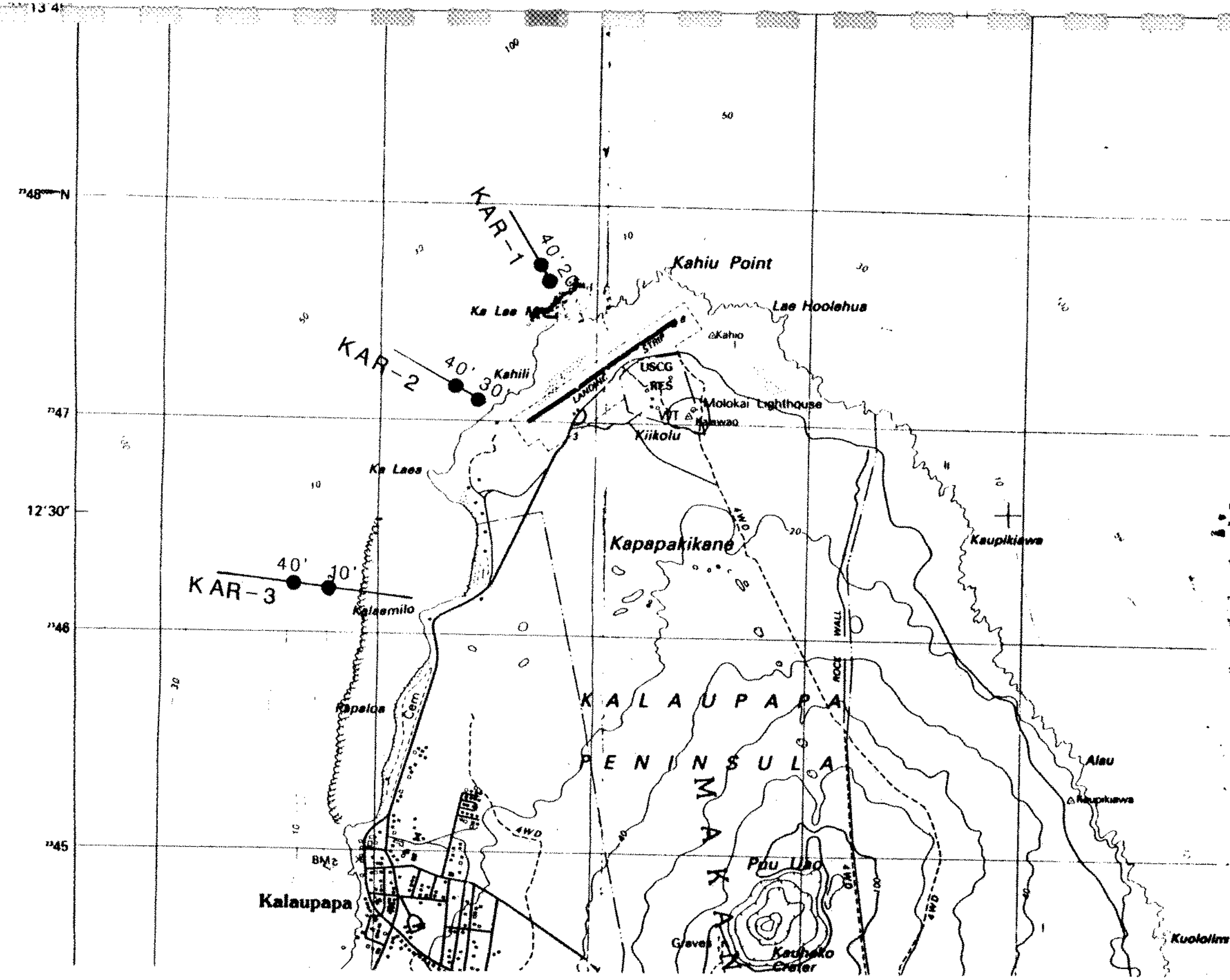

FIGURE 1. Map of Kalaupapa Peninsula showing location of existing runway. Locations of 3 marine environmental survey sites (KAR1-3) are also shown; locations of survey transects are shown as solid circles along with transect depth (feet).

TABLE 1. Water chemistry measurements taken off the Kalaupapa Airport.
"S" refers to surface samples; "D" refers to deep samples. Also included are DOH water quality standards (mean values not to exceed), and NELH 5 year means for surface ocean water.

SAMPLE STATION	PO4 (uM)	NO3 (uM)	NH4 (uM)	SI (uM)	DOP (uM)	DON (uM)	TDP (uM)	TDN (uM)	TURB (NTU)	SALINITY (0/00)	CHL. a (ug/L)	Oxygen (% sat.)	pH	TEMP. (deg. C.)
1-1S	0.15	0.13	0.06	0.99	0.21	5.54	0.36	5.73	0.09	34.99	0.24	100	8.10	25.4
1-1D	0.15	0.13	0.03	0.79	0.24	6.03	0.39	6.19	0.07	35.27	0.25	102	8.09	25.4
1-2S	0.13	0.06	0.03	0.79	0.19	6.00	0.32	6.09	0.08	34.98	0.32	99	8.13	25.5
1-2D	0.14	0.06	0.06	1.58	0.22	7.83	0.36	7.95	0.10	35.21	0.25	101	8.08	25.4
2-1S	0.17	0.17	0.10	0.79	0.22	5.50	0.39	5.77	0.09	34.98	0.25	103	8.12	25.4
2-1D	0.17	0.17	0.19	0.99	0.19	7.08	0.36	7.44	0.08	35.00	0.23	101	8.11	25.3
2-2S	0.15	0.11	0.10	0.79	0.23	5.89	0.38	6.10	0.11	35.15	0.15	102	8.13	25.4
2-2D	0.14	0.11	0.06	0.59	0.20	6.46	0.34	6.63	0.09	35.09	0.21	100	8.09	25.4
3-1S	0.14	0.11	0.12	6.52	0.25	6.44	0.39	6.67	0.25	34.68	0.13	98	8.12	25.6
3-1D	0.14	0.11	0.13	2.77	0.24	6.62	0.38	6.86	0.09	35.02	0.15	99	8.13	25.4
3-2S	0.15	0.09	0.13	2.08	0.14	5.86	0.29	6.08	0.07	35.03	0.32	100	8.09	25.4
3-2D	0.13	0.06	0.19	1.38	0.18	6.28	0.31	6.53	0.10	35.03	0.50	99	8.08	25.4
GEOMETRIC MEAN	0.15	0.10	0.08	1.27	0.21	6.26	0.35	6.47	0.09	35.03	0.23	100	8.1	25.4
DOH WQS		0.25	0.14				0.52	7.85	0.20		0.30			
NELH	0.16	0.20	0.36	2.98	0.24	4.34	0.40	4.90						

TABLE 2. Percent cover of reef corals on transects in the vicinity of the Kalaupa Airport Runway. For transect locations, see Figure 1.

CORAL SPECIES	TRANSECT KAR-1 20'	KAR-1 40'	KAR-2 30'	KAR-2 40'	KAR-3 10'	KAR-3 40'
PORITES LOBATA	0.7	2.2	1.5	5.4	5.6	3.1
POCILLOPORA MEANDRINA	1.5	0.5	0.9	0.2	0.3	0.6
LEPTASTREA PURPUREA	1					
MONTIPORA VERRUCOSA			0.1	0.2		
CYPHASTREA OCELLINA					0.2	
PAVONA VARIANS					0.4	
PALYTHOA TUBERCULOSA		0.8				
TOTAL CORAL COVER	3.2	3.5	2.5	5.8	6.5	3.7
SPECIES COVER DIVERSITY	1.05	0.91	0.83	0.29	0.62	0.43
SPECIES NUMBER	3	3	3	3	4	2

TABLE 3. Reef fish community stucture on transects in vicinity of Kalaupapa Airport Runway. For station locations, see Figure 1.

	KAR-1 20'	KAR-1 40'	KAR-2 30'	KAR-2 40'	KAR-3 10'	KAR-3 40'
AULOSTOMIDAE						
Aulostomus chinensis	1					
KYPHOSIDAE						
Kyphosus bigibbus	22	7		6		12
CIRRHITIDAE						
Cirrhitus pinnulatus					1	
Paracirrhites arcatus		1		1		1
P. forsteri					1	
MULLIDAE						
Mulloides flavolineatus			5	2		
M. vanicolensis	8					
Parupeneus multifasciatus	4	1	6	2	3	7
P. bifasciatus		5		1		
P. cyclostomus		2		1		
CARANGIDAE						
Caranx melamphygus	1					
LUTJANIDAE						
Lutjanus kasmira		1		2		
Aphareus furcatus	7			2		
LETHRINIDAE						
Monotaxis grandoculis	2					
CHAETODONTIDAE						
Chaetodon lunula					1	
C. quadrimaculatus		3	1		1	1
C. miliaris				7		
C. ornatissimus	2				2	
C. ephippium	2					
C. multicinctus	7	5	4	5	6	4
Forcipiger flavissimus		2	6		2	6
POMACENTRIDAE						
Abudefduf abdominalis	15	2		28		
A. sordidus	3					
Plectro. johnstonianus					3	
P. imparipennis					1	
Stegastes fasciolatus	3			3	10	
Dascyllus albisella						2
Chromis vanderbilti	25	24	40	20	70	40
C. ovalis	25	18	70	18		180
C. verater						25

TABLE 3. continued

	KAR-1 20'	KAR-1 40'	KAR-2 30'	KAR-2 40'	KAR-3 10'	KAR-3 40'
LABRIDAE						
Cheilinus unifasciatus						2
Bodianus bilunulatus	2	2	1	1	1	3
Coris gaimard		1			2	
C. flavovittata	1	2		2	2	2
Anampses cuvier	3		2			
Thalassoma duperrey	7	15	17	8	28	12
T. trilobatum	2				1	
T. ballieui				2	1	
Gomphosus varius	3					
Halichoeres ornatissimus	4				2	
SCARIDAE						
Calotomus sp.	1					2
Scarus perspicillatus	7	3		2		4
S. psittacus	2					
S. rubroviolaceus	8	4	2	8		
juvenile *Scarus*				2	12	3
ACANTHURIDAE						
Zebrasoma veliferum			3			
Acanthurus achilles	12	12	11	3		
A. triostegus	17	17	8	8	12	11
A. leucopareius	12	24	12	13	14	28
A. olivaceus	3	3		3		9
A. dussumieri	6		2	4		
A. blochii	6	2	2	3		3
A. nigrofuscus	11	18	23	16	38	30
Ctenochaetus strigosus	34	26	16	22	6	28
Naso lituratus	22	12	11	8		12
N. unicornis	3	4	10			5
ZANCLIDAE						
Zanclus cornutus	2		2	3		
MONOCANTHIDAE						
Pervagor spilosoma					1	
P. aspricaudus			1		1	
BALISTIDAE						
Rhinecanthus rectangulus					1	
Sufflamen bursa			1			2
Melichthys vidula	3			1		
OSTRACIONTIDAE						
Ostracion meleagris	1			1		
TETRADONTIDAE						
Canthigaster jactator						2
NUMBER SPECIES	39	27	24	33	27	27
NUMBER INDIVIDUALS	299	216	256	208	223	436
SPECIES DIVERSITY	3.21	2.83	2.51	3.02	2.34	2.30

APPENDIX C

APPENDIX C

ARCHAEOLOGICAL INVENTORY SURVEY AND HISTORIC PRESERVATION MITIGATION PLAN, AIRPORT IMPROVEMENT PROJECT, KALAUPAPA, MOLOKA'I

A DRYLAND AGRICULTURAL SYSTEM AT KALAUPAPA, MOLOKA'I:

ARCHAEOLOGICAL INVENTORY SURVEY,

AIRPORT IMPROVEMENT PROJECT

by

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SYNOPSIS

Archaeological Inventory Survey, Kalaupapa Airport Improvement Project

Surface Features: 38 in west parcel
11 in east parcel

Sites: 29 in west parcel
11 in east parcel

Mitigation Phase: mapping, detailed description, and subsurface testing

Subsurface test units and sq. meters: 23 units in 21 features, 11 square meters

Volume of excavated sediment: 2.4406079 cubic meters

Volume of sorted sediment: 2.0753474 cubic meters

Radiocarbon dates (adjusted for isotopic fractionation; not cal.):
510 ± 80 B.P. (Feature 8)
170 ± 120 B.P. (Feature 12)
170 ± 50 B.P. (Feature 13)
100.4 ± 0.6% modern (Feature 18)
100.4 ± 0.9% modern (Feature 23)
70 ± 50 B.P. (Feature 28)
60 ± 50 B.P. (Feature 31)

Interpretive comments:

The archaeological features in the west parcel are the remains of a residential and agricultural complex. Within the functional classification of residential features there is morphological diversity. The west parcel contains a high density of shelters and agricultural alignments. Excavations revealed at least two subsurface agricultural alignments. Most of the features contain a single-component cultural deposit. Several lines of evidence suggest that the majority of the features were used during the historic era. The archaeological features in the east parcel are not nearly as well preserved, and are probably the remains of an agricultural complex.

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INTRODUCTION

This report concerns an intensive archaeological survey of two parcels adjacent to the Kalaupapa airport on the Kalaupapa peninsula of Moloka'i (Figs. 1, 2, and 3). Edward K. Noda & Associates of Honolulu contracted International Archaeological Research Institute, Inc. (IARII) to conduct the survey as part of the Kalaupapa Airport Improvement Project. The study area includes one parcel of land at the west end of the runway, and a second parcel at the east end.

This project is the second phase of an inventory-level archaeological survey. The first phase involved a reconnaissance survey of the west end of the study area conducted on November 9 and 10, 1988 by two IARII archaeologists (Athens 1989). The objectives of Phase I were to systematically locate all or most archaeological features and obtain information useful for planning more detailed investigations. The researchers conducted no subsurface testing, and prepared no site or feature maps.

Four IARII archaeologists conducted the second phase of field work from July 11 to August 12, 1989. The objectives of the field work included 1) locating and inventorying all the archaeological remains in the study area, 2) clearing the features of vegetation, 3) obtaining accurate written descriptions, photographs, and maps of the features, and 4) conducting limited subsurface testing to further evaluate the archaeological significance of a sample of the features. During the 100 man days the archaeological crew spent in the field, 49 archaeological features containing 126 architectural components were recorded. Plan maps of 33 features were drawn, and 23 test pits totalling 11 square meters were excavated in 21 features.

The data from the fieldwork addresses research questions focusing on agricultural intensification in the region. The archaeological features in the west end of the study area are the remains of a residential and agricultural complex. The morphology of the features exhibits a range of diversity within a functional classification. This diversity in conjunction with the results of the limited subsurface testing suggests that while people have lived and farmed the area for at least five centuries, their mode of existence has changed. Furthermore the results of the project exemplify the diversity of archaeological features found throughout the peninsula.

Fieldwork for the first phase of the project was conducted by J. Stephen Athens, Ph.D., and Michael W. Kaschko, M.A.. Project personnel for the second phase included J. Stephen Athens, Ph.D., as principal investigator, Thegn N. Ladefoged, M.A., as project director, and Sarina R. Pearson, B.A., James Adams, B.A., and Pennie Moblo, M.A., as assistant archaeologists. Other project personnel included Sarina R. Pearson, B.A., Steve Wickler, M.A., and Tove Wickler, B.A., for midden analysis; Sarina R. Pearson, B.A., Mark Smith, and Judy McNeill, M.A. for drafting; Alan Ziegler, Ph.D., for faunal identification; Gail Murakami, M.A., for wood species identification of charcoal; Christopher Stevenson, Ph.D., for volcanic glass analysis; Marshall Weisler, M.A., for basalt analysis; and Beta Analytic Inc. for radiocarbon dating.

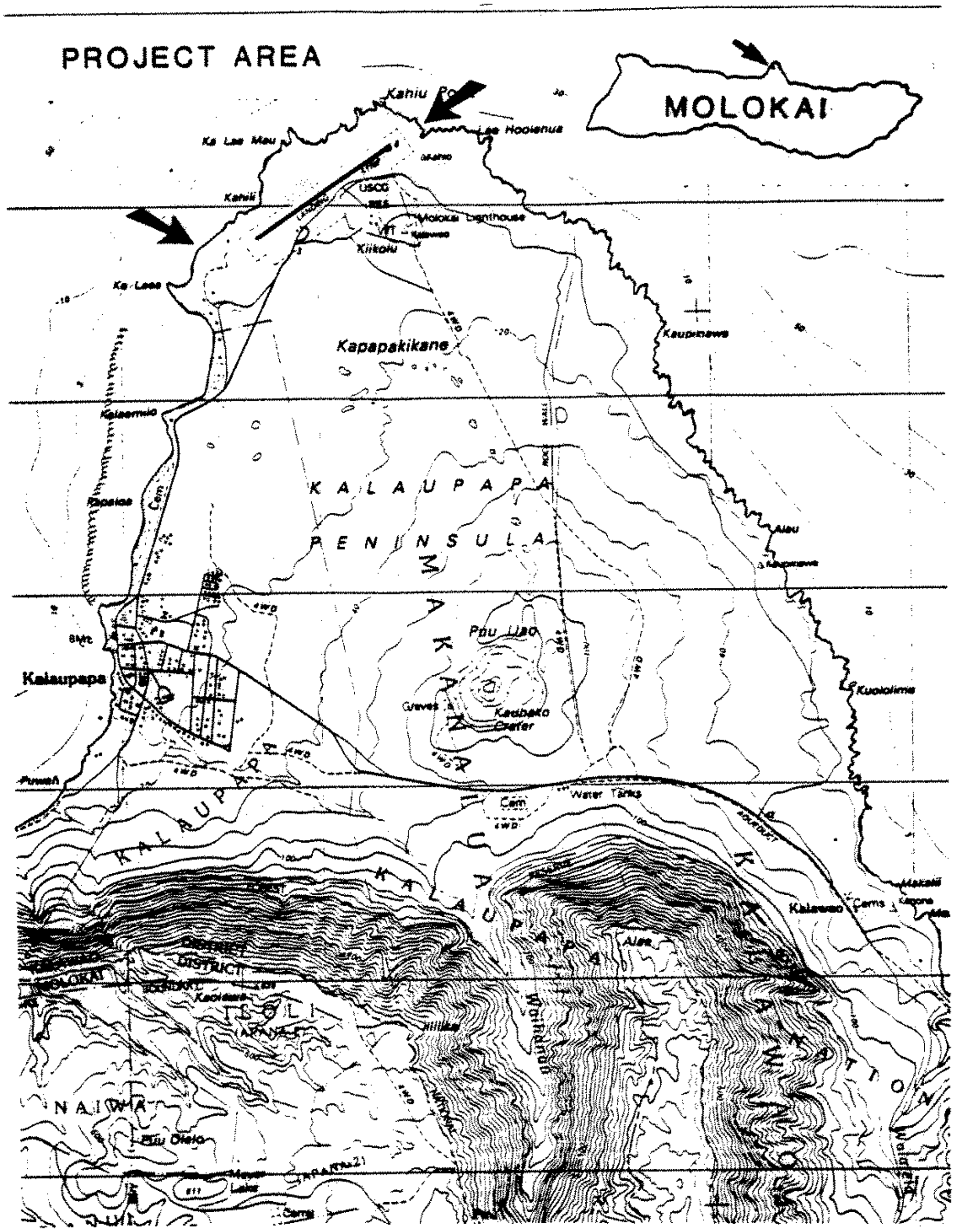


Figure 1. U.S.G.S. map of Kalaupapa peninsula showing location of airfield and project area. Grid squares are 1 kilometer.

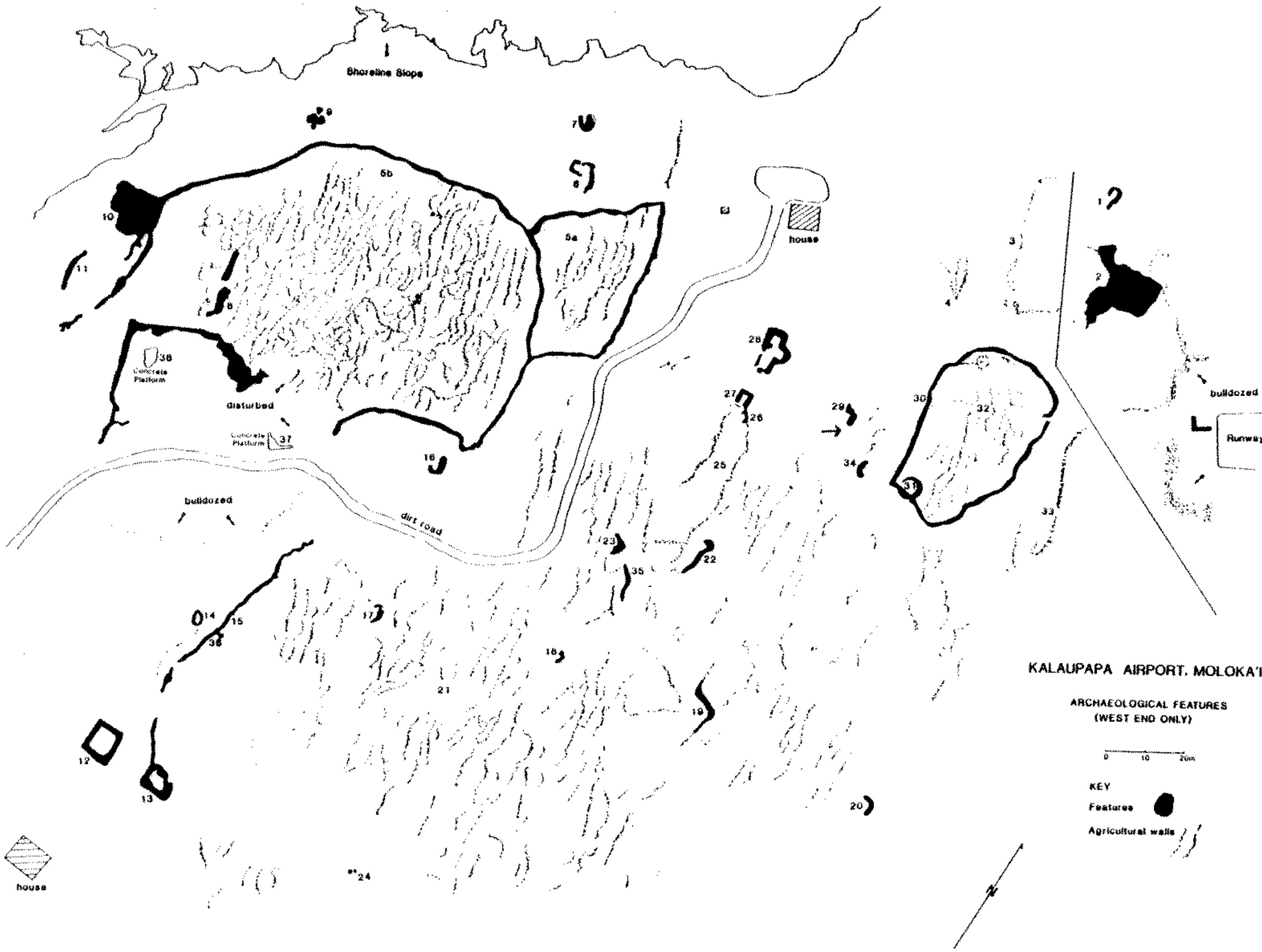


Figure 2. Map of west end of project area showing the spatial distribution of the archaeological features.

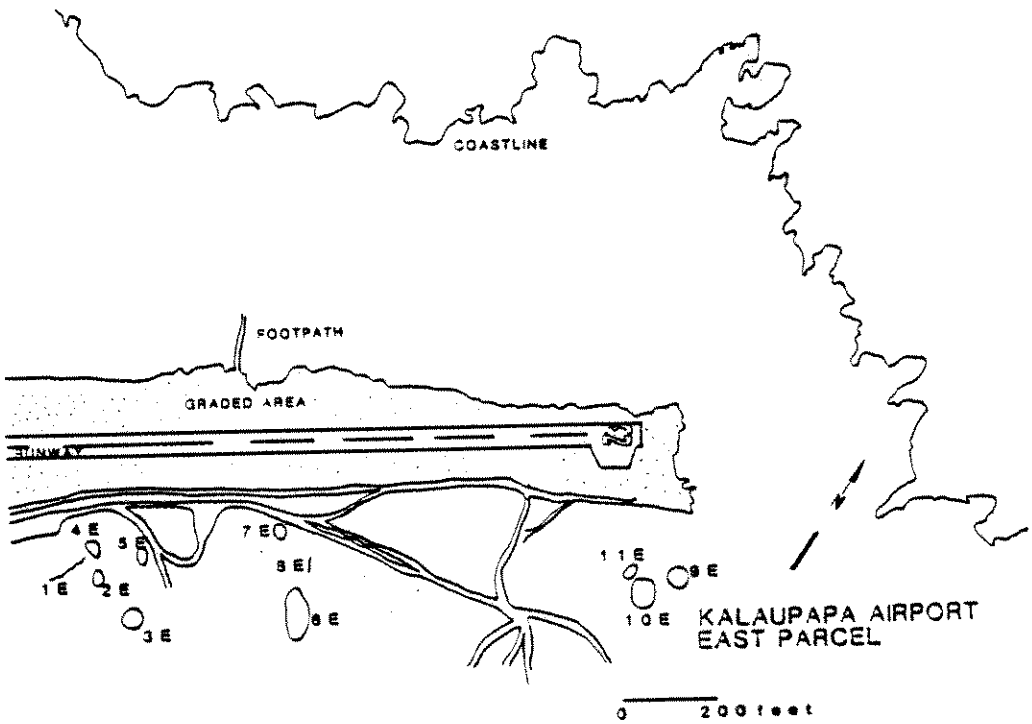


Figure 3. Map of east end of project area showing the spatial distribution of the archaeological features.

Environment

The project area is located on the northeast corner of the Kalaupapa peninsula of Moloka'i. The peninsula itself was formed during the late Pleistocene when Kauhako Crater was volcanically active. Athens (1989:4) provides the following description:

> The towering cliffs on the south side of the peninsula, which extend along much of the north shore of Moloka'i were probably formed as a result of wave erosion, though another theory suggests that the cause was a giant landslide (Simon 1983:327). They were clearly formed at a much earlier time. The cliffs provide a dramatic geographical boundary to the south end of the peninsula, effectively restricting land access to the hardier and more intrepid individuals capable of the foot or mule-back journey over the 2,000 ft pali or cliff.

The project area includes two parcels. The west parcel is bounded by the shoreline slope on the north and west sides. The terrain in the north half of the west parcel is relatively flat in contrast to the terrain in the south half which is relatively broken and dissected. The flatness of the northern half of the west parcel is probably due to the impact of occasional high surf. The large waves apparently level the area and deposit large amounts of water worn shell and coral. The sediment of Features 2, 5B, 6, 8 and 10 were composed solely of this matrix. The examination of a set of aerial photographs indicates that the area north of an imaginary line connecting Features 2 and 8 is subjected to the occasional action of waves. In the areas south of this line, the sediment does not include water worn shell and coral and the ground surface consists of soil with areas of exposed and eroded pahoehoe outcrops. The east parcel of the project area consists of soil with areas of exposed and eroded pahoehoe outcrops with small amounts of wave washed sediments. The project area as a whole is classified as "Rock Land" on a soil map of the peninsula (Foote et al. 1972).

Murakami (1989:10) describes the vegetation within the project area:

> The area is dominated by Lantana camara (lantana) with scattered Schinus terebinthifolius (christmas berry) and Leucaena leucocephala (koa haole) shrubs. This assemblage of alien species or recent introductions contrasts with the vegetation of the eastern side of the Kalaupapa Peninsula.
>
> Canfield (1989) describes the vegetation near the northeastern end of the Kalaupapa Airport runway as a strand community composed of localized plant associations including the following woody native species: Scaevola taccada (naupaka), Sida fallax ('ilima), and Chamaesyce degeneri ('akoko) which was referred to as Eurphorbia degeneri in the report. Other woody species in the coastal portion of the nearby Kalaupapa National Park include another 'akoko (Chamaesyce celastroides = Euphorbia celastroides var. amplectans), Acacia farnesiana (klu), Lantana camara (lantana), Schinus terebinthifolius (christmas berry), and Prosopis pallida (kiawe). Except for the kiawe which was rare in the interior grassland, the woody vegetation consisted of scattered shrubs.

The climate on Kalaupapa is determined primarily by direct exposure to the prevailing northeasterly tradewinds. The mean wind speed at Kalaupapa is 20.7 mph (Armstrong 1983). More persistent winds occur during the summer months (Armstrong 1983). Annual rainfall at the Kalaupapa settlement is 1,152 mm (Giambelluca et al. 1986:220). The rainy season is between November and April. Temperature is fairly constant, varying from an average of 22 degrees celsius in January to 25 degrees celsius in July (Armstrong 1983).

Land Units and Ownership

In 1980 the Kalaupapa peninsula and adjacent valleys to the east were established as a National Historical Park. Land ownership of the peninsula is divided between the State of Hawai'i, the Hawaiian Homes Commission, the Coast Guard, and the National Park Service. It is administrated by the National Park Service in conjunction with the State Department of Health. The airport is under the control of the Department of Transportation. The Coast Guard owns 0.75 acres around the lighthouse, and the National Park Service owns 22.13 acres around the lighthouse. The west parcel of the project area is State of Hawai'i land. Portions of the east parcel are State of Hawai'i land, and other sections belong to the National Park Service.

The Kalaupapa peninsula is divided into three traditional land units or ahupua'a: Kalawao, Makanalua, and Kalaupapa (see Figure 1). All of these belong to the Ko'olau district or moku, one of the two traditional polities or chiefdoms of Moloka'i.

The project area is situated within Makanalua ahupua'a, which contains a large mid-19th century Land Commission Award. The award is listed as no. 11216 to Kekauonohi, a granddaughter of Kamehameha I, and one of the wives of Kamehameha II. Apparently the award never received a Royal Patent and was never surveyed. The Tax Map and a 1905 survey map by Wall (in Greene 1985:253) do not show the boundaries of it.

Historical Background

Although Kalaupapa is best known for the Hansen's disease (i.e. leprosy) colony established in 1866, the peninsula has an extensive prehistory and history. Somers (1985), Greene (1985), and Fortunato de Loach (1975) review the pertinent literature and their findings are not reiterated here in toto. This section focuses on the written records that mention the immediate project area, and the accounts which discuss the agricultural intensification and subsequent agricultural demise of the Kalaupapa peninsula. The review is chronological, spanning from the 1830's to the 1940's.

In 1839 the missionary Hitchcock estimated that 1,000 people lived on the peninsula and in 1841 the population was estimated to be 700 persons (American Board of Commissioners for Foreign Missions 1937, p. 4-6). Jules Remy visited Kalaupapa in 1854 and noted that the fields surrounding the villages were primarily planted in sweet potatoes (Remy 1893:20,22). In 1857 M.L. Napihelua wrote the following description of the agricultural practices at Kalaupapa:

> These sweet potatoes from ancient times....There are nineteen varieties....The likolehua and halonaipu [sweet potato

> varieties] when ready to be sold are heaped at the seaport like bruised mountain apples on the beach, their purplish color lying against the pahoehoe lava. The eyes scan them up and down with desire for the tubers raised by the farmers....
>
> Kalaupapa is a good land because the crops planted are successful and the gain is large...
>
> Many sweet potatoes are being planted now, four or five patches to each man. Most of the crops are watermelons, and some small and big beans and onions. Be on the watch you traders, for Kalaupapa is the best in all the islands for good prices and fast work. All the California ships come to Kalaupapa. (Ka Hae Hawaii, March 4, 1857, quoted in Handy and Handy 1972:518).

King Kamehameha IV visited Kalaupapa sometime during his reign from 1855 to 1863 (Somers 1985:22). When he tried to buy sweet potatoes from the natives they insisted on giving them to him. He said "I was glad that those men, by their hard work, had plenty of potatoes, and I was glad that from their abundance they wanted to give (Curtis 1966:174 quoted in Somers 1985:22).

By the 1850's it appears that the residents of Kalaupapa were producing a surplus of sweet potatoes. Most of this surplus was probably grown for exportation to California. Fortunato de Loach (1975:77) mentions that occasionally ships would come directly to Kalaupapa from California and that the trade in sweet potatoes lasted until 1867 when the Hansen's disease colony was established.

In 1865 Kalawao and Makanalua ahupua'a were purchased by the Hawaiian government to establish the Hansen's disease colony, and in 1873 Kalaupapa ahupua'a was acquired (Fortunato de Loach 1975:82). When Kalawao and Makanalua ahupua'a were purchased residents were given an option to "dispose of their birthright if they chose to do so, or they could remain; for there was abundant room for all..." (Stoddard 1893:21, quoted in Fortunato de Loach 1975:82). According to Fortunato de Loach (1975:82) "about forty persons chose to remain and formed a community that lasted about twenty-nine years." Not until 1895 were all non-patients evicted from the peninsula.

By the 1870's, the superintendent of the Hansen's disease settlement, R. W. Meyer, noted that the majority of the food consumed by the settlement came from the neighboring valleys of Wailau, Pelekunu and Halawa (Hawai'i Board of Health 1886, p. cxxviii, quoted in Fortunato de Loach 1975:84). Meyer maintained that most of the residents were not interested in growing their own food. He stated that "It was often difficult to supply the settlement with food, especially during the winter season, when the landings are bad" (Hawai'i Board of Health 1886, p. cxxv - cxxvi, quoted in Fortunato de Loach 1975:84).

In a 1873 letter to Queen Emma, Peter Kaeo mentioned the numerous abandoned sweet potato patches at Kalaupapa (Korn 1976:7, 17, 35, quoted in Somers 1985:16). Similarly, Charles Nordoff who visited Kalaupapa in the 1870's reported:

> here lived, not very many years ago, a considerable population, who have left the marks of an almost incredible industry in numerous fields enclosed between walls of lava rock well laid up; and in what is yet stranger, long rows of stone, like the windrows of hay in a grass field at home,

> evidently piled there in order to secure room in the long, narrow beds thus partly cleared of lava which lay between, to plant sweet-potatoes. Yet on this apparently desert space, within a quarter of a century more than a thousand people lived contentedly and prosperously...(Nordoff 1974:100, quoted in Somers 1985:16-17).

These passages are significant because they imply that the agricultural productivity of Kalaupapa peaked in the 1850's or 60's, and by the 1870's, many of the fields were lying fallow and food supplies were imported from other parts of Moloka'i. This inference has important implications for interpreting the archaeological remains of the project area.

The occupation of Kalaupapa from the late nineteenth century to the early twentieth century is well documented by Greene (1985). During this time there appear to be no specific references to the project area. A map drawn in 1895 by Monsarrat depicts no structures or roads in the area. Similarly, no structures or roads are shown on a map drawn by Wall in 1905. A 1921-1922 U.S.G.S. topographic survey map shows at least four structures (presumably houses) and a road in the general vicinity, but when this map was compared with the modern U.S.G.S. map it was clear that none were within the project area (Athens 1989:7). Therefore, it appears that the abandoned house and the cement foundations (Features 37 and 38) found in the study area were not occupied until after the early 1920's.

Harry Franck who visited Kalaupapa in the 1930's wrote "The beach beyond it (the lighthouse) is fringed with little houses belonging to and in some cases built by the lepers" (Franck 1937:191, quoted in Dean 1989:149). Franck was returning to Kalaupapa from Kalawao and thus "the beach beyond" might refer to the west parcel of the study area, and the "little houses" to the abandoned house and cement foundations in the project area. A final description of the area comes from Fred Robins who was the lighthouse keeper from 1940 to 1964. He witnessed the April 1, 1946 tsunami from the safety of the lighthouse and wrote "One minute the houses were there, and the next they were washing away in the wave" (Robins 1948, quoted in Dean 1989:153). Obviously it is unclear which houses Robins was referring to, but it is entirely possible that they were the structures in the study area.

Previous Archaeological Investigations

Recent reports by Somers (1985) and Athens (1989) review the previous archaeological investigations conducted at Kalaupapa peninsula. Somers (1985:27) notes:

> In 1909 John F. G. Stokes (1909a) made a site survey of heiau on the island of Moloka'i, including Kalaupapa peninsula. In 1966 and 1967 Richard Pearson led a small crew of students from the University of Hawaii in test excavations in Kaupikiwa Cave (Site 312, Figure 2) near the northern coast of the peninsula (Pearson et al. 1974, in addition see Hirata and Potts 1967). Catherine C. Summers 1971 publication, Molokai: A Site Survey, was an overview of the recorded archaeological sites of the island of Moloka'i and included a discussion of previously recorded archaeological sites of Kalaupapa. A Bishop Museum survey team, as part of the State-wide inventory

of historic places, attempted in 1974 to relocate previously recorded archaeological sites on Kalaupapa peninsula. In 1978 William Barrera, Jr., conducted archaeological excavations at Site 50-60-03-515 in the settlement of Kalaupapa prior to the construction of a new hospital facility (Barrera n.d.).

These studies documented a wide range of archaeological sites including several heiau, a holua slide, a cave site, numerous residential features, and a plethora of agricultural walls.

Other archaeological studies include reconnaissance surveys of portions of the peninsula done in the 1930's by Southwick Phelps (1937) and H. L. McHenry (n.d.a, n.d.b, n.d.c). McHenry's work is especially pertinent, since he recorded an archaeological site which might be Features 10 and 11 which are discussed in a later section of this report. Unfortunately, McHenry's manuscript (n.d.b,), notes (n.d.c), and map (n.d.a) are incomplete and it is impossible to determine the precise archaeological sites and features that he recorded. His map of the peninsula clearly shows unnumbered archaeological sites in what would be the west parcel of the project area (Fig. 4). Several sketch maps of sites are included in his notes and one of these maps is labeled "Site 8a at Kahili, Makanalua Peninsula, Moloka'i" (Fig. 5). It can be inferred that "Site 8a" is the archaeological site depicted on his overall peninsula map that is in the project area. The sketch map of the site looks remarkably like Features 10 and 11. The site in the sketch map has an additional wall, but this could easily have been disturbed at a later date, perhaps during the 1946 tsunami.

To further complicate the matter, a map in Summers' (1971) report indicates that Site 298 should be in the project area. It seems that Summers' Site 298 should be McHenry's Site 8a. Unfortunately the descriptions do not match up. Summers (1971:194) writes:

> Site 298. Ko'a at Ka Laea, Makanalua.
> This is an enclosure measuring 30 by 40 ft; the walls are 6 to 8 ft wide. McHenry, who recorded and measured the site, called this place Kahili (McHenry, n.d.a,b).

There are two possibilities. The first is that Summers had a complete copy of McHenry's notes, manuscript, and map, and is describing a different site. The second alternative is that she consulted HcHenry's sketch map, which does not contain a scale or key, and derived an erroneous written description.

Somers (1985) systematically surveyed and mapped the archaeological features found in a 142 hectare study area located in the south part of the peninsula. The project area was densely packed with features, and in places there was virtually a solid cover of stone structures. The features consisted of terraces, flat areas, cleared areas, circular enclosures, modified boulder fields, and artificial pits in boulder areas. They were functionally classified as religious, residential and agricultural features.

Athens (1989:12) noted significant differences between the archaeological resources found in the south part of the peninsula and those found in the northern Airport Improvement Project study area. The northern features appear more or less spatially distinct whereas the features in the south are often continuous. Furthermore, shelter features are common in the north part of the peninsula and relatively rare in the south. Finally, the

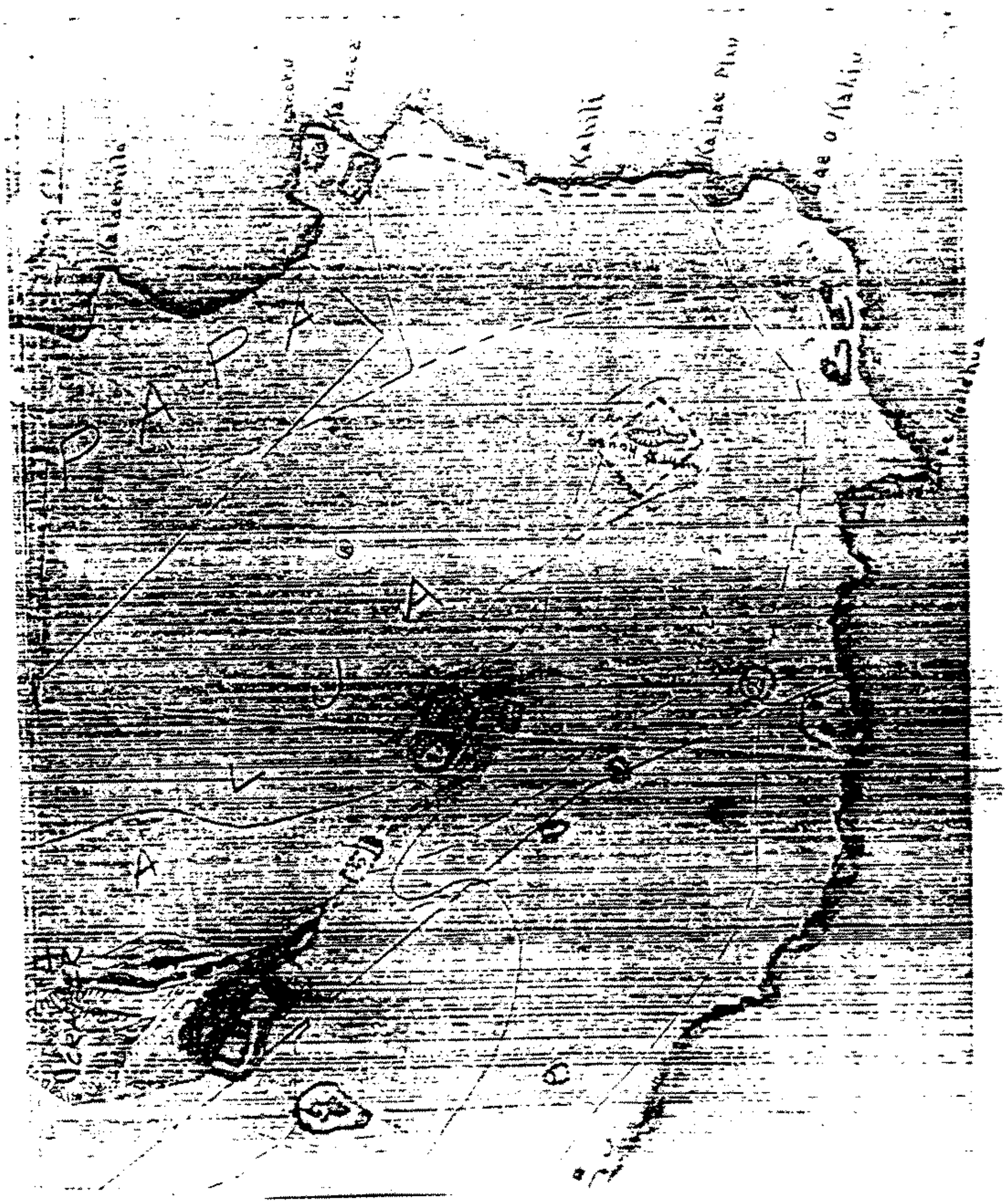


Figure 4. McHenry's map of Kalaupapa Peninsula, Moloka'i.

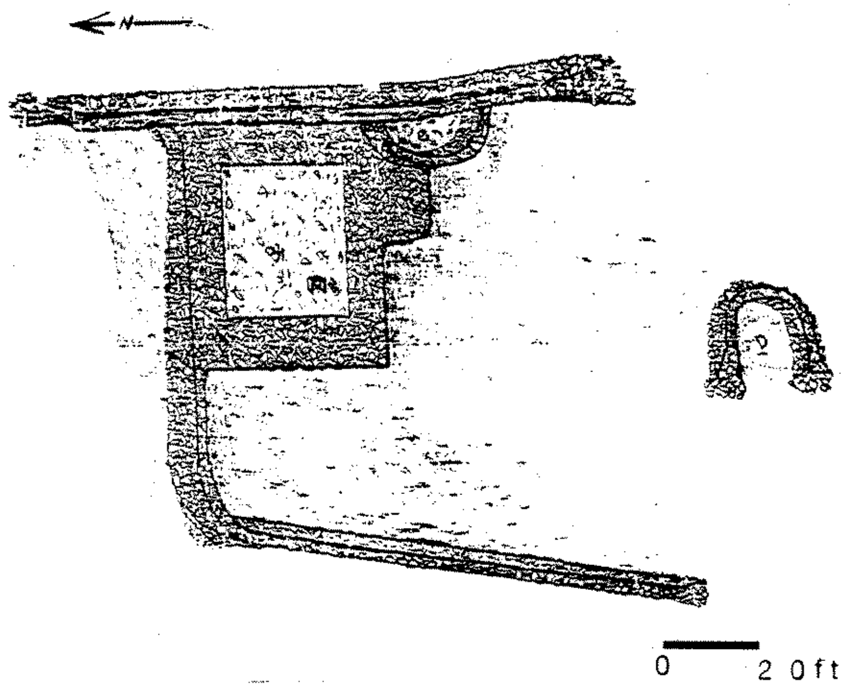


Figure 5. McHenry's map of Site 8a at Kahili, Makanalua Peninsula, Moloka'i.

agricultural features in the north are predominately parallel alignments which are virtually absent on the south side of peninsula. These differences probably reflect adaptations to specific microenvironments and perhaps different periods of occupation.

Additional archaeological research includes Somers' (1987) intensive survey of a portion of Waihanau Valley, and the excavation of two human burials from the sandy beach that is northeast of Moloka'i Lighthouse and southeast of Kahi'u Point (Somers in press).

Before the Airport Improvement Project, only two sites on the peninsula had been dated (see Weisler 1989:137). Charcoal samples from Pearson's excavations at Kaupikiawa Cave yielded radiocarbon dates of 880 ± 70 years B.P. (Beta-9276), 490 ± 180 years B.P. (Beta-9962, small sample with extended counting), and less than 120 years B.P. (Beta-9275), (dates are calibrated according to Stuiver and Reimer 1986). The samples were from 9-12, 12-15, and 14 inches below the surface and were separated by over 4 meters horizontally. Athens (1989:7) notes that despite the wide range of the dates in the shallow deposits, which implies some degree of disturbance or mixing, the results are significant in that they indicate a time depth since at least A.D. 1000 for occupation of the Kalaupapa peninsula. Weisler (1989:137) notes that the Beta-9276 date is the second oldest from Moloka'i. Barrera (n.d.:29) reports the following basaltic glass hydration-rind dates: 1850 ± 50; 1772 ± 15; 1755 ± 26; 1753± 27; 1773 ± 34.

Field Methodology

The intensive survey of the archaeological resources was conducted in several distinct phases. Initially the archaeological features were identified and cleared of vegetation. Next, a sample of the resources were accurately mapped, and an even more exclusive sample were tested for subsurface deposits. Materials recovered during the excavations were analyzed in the laboratory. The inventory of archaeological remains included both written descriptions and photographs.

The archaeological resources were inventoried according to an explicit classification system. Feature numbers were assigned to spatially distinct architectural structures. Any contiguous or subsurface components were classified as part of the numbered feature. There were two exceptions to this system. The numerous agricultural walls in the study area were not assigned individual numbers. On the basis of their spatial distribution, these walls were grouped together and then each group was assigned a feature number. The majority of these walls were inventoried off of an aerial photograph. The second exception pertains to large enclosures and alignments emanating off of other features. These were assigned their own feature number. The features at the east end of the runway were assigned numbers suffixed with "E." Features were grouped into sites for managerial purposes. These site designations are discussed in the last section of this report.

The map shown in Figure 2 is based on field observations and a set of aerial photographs taken July 1, 1983. Cattle were grazing throughout the project area in 1983 and therefore the vegetation was extremely sparse. This made it possible to identify the archaeological features on the aerial photograph and draw an accurate map.

In order to determine the precise morphology of the features, vegetation had to be cleared. Cane knives, clippers, and a chain saw were used to remove dense lantana, grass and koa-haole growth. Once cleared, tape and compass maps were drawn of all of the architectural features except for agricultural walls and large agricultural complexes.

Standard archaeological recording and excavation procedures were employed throughout the subsurface testing phase. Excavations were conducted according to the natural stratigraphy of a unit. Within a unit, a layer was designated as a homogeneous deposit. If layers were thicker than 10 cm, they were divided into levels. The depths of layers and levels were recorded as the minimum and maximum depth below datum at the top of a level, and the minimum and maximum depth at the bottom of the level. Thus the vertical distribution of a level reported as 12/16 to 18/21 cm BD had a minimum top depth of 12 cm BD, a maximum top depth of 16 cm BD, a minimum bottom depth of 18 cm BD, and a maximum bottom depth of 21 cm BD. At each of the features a vertical datum was established 10 cm above ground surface.

The entire volume of excavated material was sifted through 1/8 inch mesh screen with two exceptions. Only a sample of some layers in Feature 5B test pit 1 and Feature 8 test pit 1 were screened. The other exception was that some unscreened bulk samples were kept for further analysis. All deposits were screened and bulk residues were bagged in their entirety for laboratory sorting. Prior to screening, the volume of excavated sediments was recorded in buckets. This was done to accurately determine the artifact and midden densities. Because of the exceptions just mentioned, the total volume of the excavated sediment does not necessarily equal the total volume of the processed sediment.

Sediments were described using Munsell soil color charts and in accordance with the Soil Conservation Service format. The Munsell color was taken on dry sediment samples under field conditions. The term "boundary" in the profile descriptions refers to the distinctiveness and topography of the lower boundary of a layer. The distinctiveness of the boundary is described by the first term, and the topography by the term in parentheses. A field catalogue was maintained for all collected archaeological samples. Each layer/level within an excavation unit was recorded on standardized forms, and at least one face of all excavation units was profiled. At the end of the excavation phase all test pits were backfilled with sterile sand.

During laboratory analysis all bulk residue samples were sorted into general midden categories, artifacts, and other samples. Botanical samples from 6 units, shell from 5 units, and bone from all units were identified. A total of 7 radiocarbon dating determinations were made, and 10 samples of volcanic glass underwent specialized analysis. Results of these various investigations are presented in later sections of this report.

FEATURE DESCRIPTIONS

There are 38 archaeological features in the west end of the study area, and 11 features in the east end (see Figures 2 and 3). Table 1 is a listing of the functional classification of each archaeological feature, and a morphological classification of each feature's individual architectural components. Table 2 presents a summary of the types of features found in each section of the study area, and Table 3 is a summary of the architectural components in each section of the study area. The 49 archaeological features contain 559 architectural components.

Most of the terms used in the functional and morphological classification are self-explanatory. However, the following guide should dispel any potential ambiguity. Terms with semicolons in the descriptions include both types of features. Therefore, a "shelter; boundary alignment" feature is a small shelter connected to a boundary alignment. An additional more serious problem pertains to the classification and quantification of agricultural alignments and mounds. There are so many small walls that it is impractical to assign individual feature numbers to each. Therefore, walls have been classified according to their spatial distribution and assigned numbers as groups. Feature 5 and Feature 30 are large enclosures containing agricultural alignments. Feature 4 is a group of 3 alignments, and Feature 25 consists of 2 large alignments. Feature 21 contains all the other alignments in the study area.

In the following sections archaeological features are individually described. Attention is given to the feature's dimensions, its construction style and technique, the presence of surface midden, and its possible function. Figure 6 is the symbol key for the feature maps and profiles.

Feature 1

Feature 1 is a well preserved C-shape with a small contiguous platform (Fig. 7). It is located ca. 10 meters northeast of Feature 2 (see Figure 8). The large enclosure (Feature 3) which surrounds Feature 2, also incorporates Feature 1. Feature 1 is a small shelter associated with the main residential area (Feature 2).

The overall dimensions of Feature 1 are 9 by 5.5 m. The ends of the C-shape are rounded, so as to almost form an enclosure. The windward east wall of the C-shape is 6 courses of stacked stone and faced on the interior. It is 1.28 m high and 1.75 m wide. The west lee wall is also faced on the interior is 30 cm high and 1.8 m wide and consists of a single course of rock. The north and south walls are each 3 courses high. The interior of the C-shape is 2.25 by 1.5 m and is paved with rough cobbles. No surface artifacts were observed, however small amounts of pipipi and opihi shell were present. The small platform adjacent to the C-shape is 2.5 by 2.25 m, is faced with large boulders and filled in with smaller rocks. Its maximum height is 72 cm. The surface of the platform is not evenly paved, rather it is quite rough. There is a concentration of small rocks (3-8 cm) just to the south of the platform. Subsurface testing was not conducted at this feature.

Table 1. Archaeological features and components in the study area.

FEATURE NUMBER	FUNCTIONAL CLASSIFICATION OF FEATURE	QUANTITY AND MORPHOLOGICAL CLASSIFICATION OF ARCHITECTURAL COMPONENTS
1	shelter	1 C-shape 1 platform
2	residential	6 pavings 2 platforms 2 alignments 1 enclosure
3	boundary enclosure	1 enclosure
4	agricultural	3 alignments
5A	agricultural	1 enclosures 17 alignments
5B	agricultural	1 enclosure 178 alignments
6	residential	1 enclosure 1 alignment 1 slablined hearth
7	shelter	1 C-shape 1 cupboard
8	shelter	1 alignment
9	cupboards	4 cupboards
10	residential	1 platform 3 pavings 1 enclosure 1 slablined hearth 1 slablined pit
11	shelter	1 L-shape 1 paving 1 slablined hearth
12	animal enclosure	1 enclosure
13	possible shrine	1 enclosure 2 terrace
14	shelter	1 enclosure
15	boundary alignment	1 alignment
16	shelter	1 U-shape
17	shelter; agricultural	1 C-shape 1 cupboard
18	shelter	1 C-shape 1 slablined hearth

Table 1. (cont.)

FEATURE NUMBER	FUNCTIONAL CLASSIFICATION OF FEATURE	QUANTITY AND MORPHOLOGICAL CLASSIFICATION OF ARCHITECTURAL COMPONENTS
19	shelter; agricultural	3 C-shapes 2 terraces 2 alignments
20	shelter	1 C-shape 1 slablined hearth
21	agricultural	204 alignments
22	shelter	1 C-shape
23	shelter	2 C-shape 1 terrace
24	shelter	1 C-shape
25	agricultural	2 alignments
26	shelter	1 C-shape
27	shelter	1 U-shape 1 terrace
28	residential	1 enclosure 2 terraces 1 slablined hearth 1 alignment
29	shelter	1 C-shape 1 paving 1 slablined hearth
30	agricultural	1 enclosure 34 alignments
31	shelter	1 C-shape 1 paving 1 slablined hearth
32	shelter	1 C-shape
33	shelter; boundary alignment	1 C-shape 1 alignment
34	shelter	1 enclosure
35	shelter	2 C-shape 1 terrace 1 alignment 1 slablined hearth
36	shelter	1 C-shape 1 crypt
37	residential	1 concrete foundation

Table 1. (cont.)

FEATURE NUMBER	FUNCTIONAL CLASSIFICATION OF FEATURE	QUANTITY AND MORPHOLOGICAL CLASSIFICATION OF ARCHITECTURAL COMPONENTS
38	residential	1 concrete foundation
1E	agricultural	1 alignment
2E	agricultural	1 mound
3E	shelter	1 C-shape 1 platform
4E	agricultural	1 mound multiple alignments
5E	shelter	2 C-shapes
6E	shelter; agricultural	2 enclosures 1 terrace 1 alignment
7E	foundation	1 platform
8E	agricultural	1 alignment
9E	shelter	2 C-shapes 1 platform 2 alignments
10E	shelter; agricultural	11 C-shapes 2 enclosures 2 alignments
11E	cupboard	1 cupboard

Table 2. Summary of archaeological features in study area.

WEST SIDE OF STUDY AREA

Functional classification of feature	
Animal enclosure	1
Agricultural	5
Boundary enclosure	1
Boundary alignment	1
Cupboards	1
Possible shrine	1
Residential	6
Shelter	19
Shelter; boundary alignment	1
Shelter; agricultural	2
TOTAL	38

EAST SIDE OF STUDY AREA

Functional classification of feature	
Agricultural	4
Cupboards	1
Foundation	1
Shelter	3
Shelter; agricultural	2
TOTAL	11

Table 3. Summary of archaeological components in study area.

WEST SIDE OF STUDY AREA

Morphological classification of architectural components

Alignment	446
C-shape	20
Concrete foundation	2
Crypt	1
Cupboard	6
Enclosure	12
L-shape	1
Paving	12
Platform	4
Slablined pit	1
Slablined hearth	9
Terrace	9
U-shape	2
Total	525

EAST SIDE OF STUDY AREA

Morphological classification of architectural components

Alignment	7
C-shape	16
Cupboard	1
Enclosure	4
Mounds	2
Platform	3
Terrace	1
Total	34

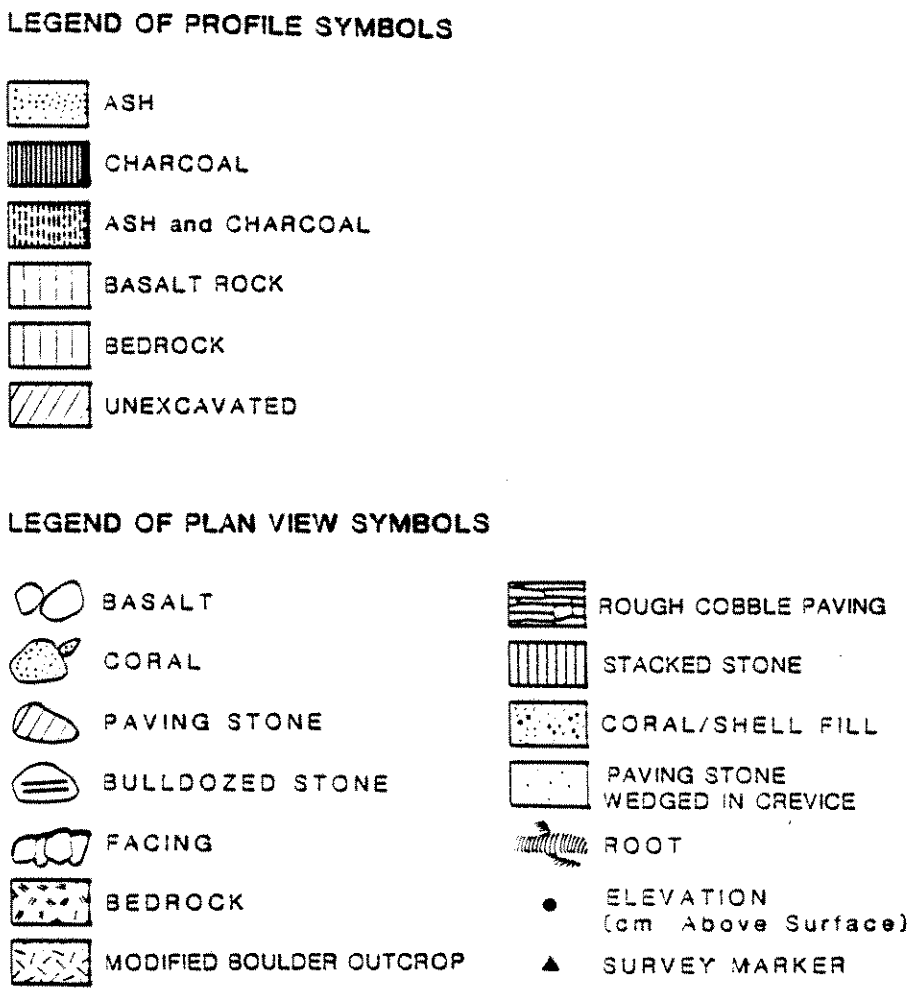


Figure 6. Symbol key to feature maps and profiles.

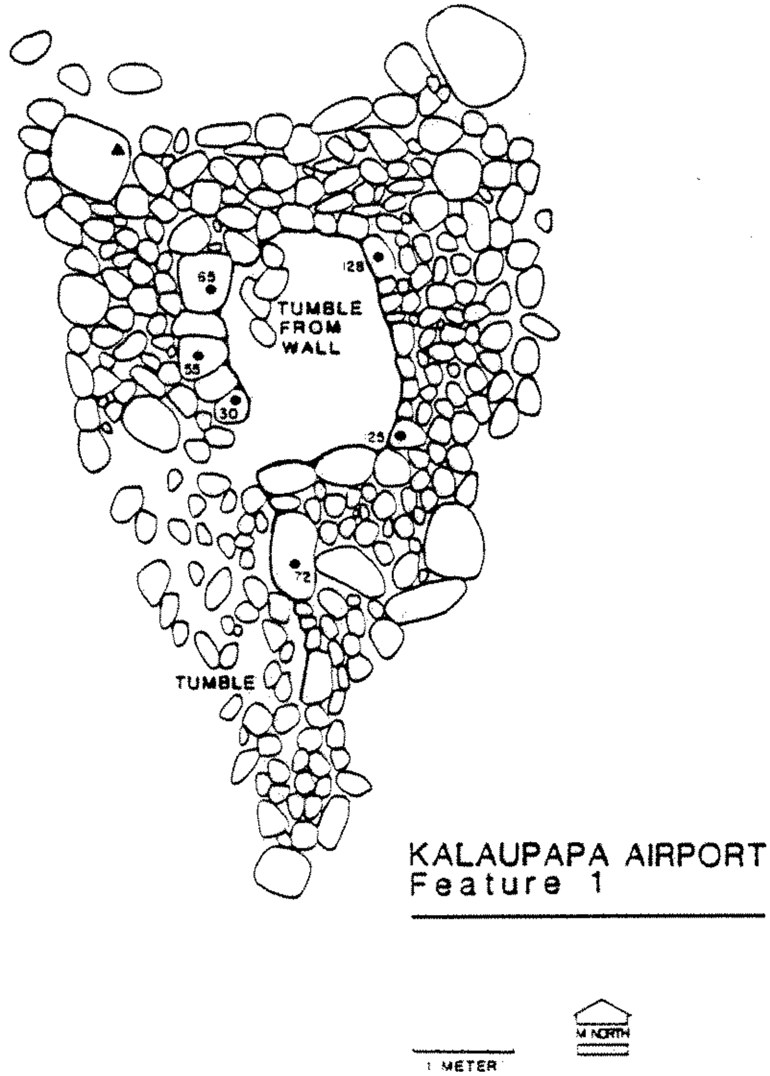


Figure 7. Map of Feature 1.

Feature 2

Feature 2 is a large residential platform with a number of internal architectural components (see Figure 8). It is located near the west end of the current airport runway, and has been partially disturbed by bulldozing. The overall dimensions of Feature 2 are 22 by 20 m. The main platform contains at least 6 pavings, 1 platform, 2 alignments, and 1 enclosure. There might be additional architectural components to the north of the feature between Feature 1 and Feature 2. Many of the pavings of Feature 2 were probably used as activity areas within the household. The pavings near the center of the platform might have been the main residential area, and the 2 pavings on the east side, an open lanai. Similarly, the paving adjacent to the small enclosure in the southeast corner of the platform might also have been a lanai. On the surface of a low platform near the southwest corner of the main platform there was a concentration of coral. Because this low platform might have been a burial, a 1 by 1 m test pit was excavated. Unfortunately, as discussed in the excavation section of this report, the results of the excavation were inconclusive. Another test pit to the west of the main platform yielded a number of historic artifacts, strongly suggesting that the feature was occupied during the historic era. Additional pieces of historic bottle glass and small amounts of shell midden are spread liberally throughout the surface of the platform and the adjacent area.

Feature 3

Feature 3 is a low enclosure surrounding Feature 2 and incorporating Feature 1 (see Figure 2). It is the enclosing wall of the residential complex. In comparison to the other features in the study area it is not as well made or preserved. Currently, a barbed wire fence which is not part of the original enclosure cuts across the feature. The wall is ca. 83.5 m long and 80 cm wide, and encloses an area of ca. 78 square meters. The construction of the wall varies between core-filled, stacked stone, and upright boulders. It is 1 to 3 courses high, and varies in height between 15 and 70 cm. The maximum width of the wall is ca. 80 cm. Subsurface testing was not conducted at this feature.

Feature 4

Feature 4 is a series of 3 roughly linear alignments (Fig. 9). They were probably used for agricultural purposes. The eastern alignment is 10.5 m long and 2 m wide, the middle alignment is 13.9 m long and 2 m wide, and the west alignment is 7.8 m long and 3.5 m wide. All of the alignments are single course, with a maximum height of ca. 50 cm. The alignments are made out of porous basalt boulders that range in size from a few centimeters up to 70 cm. There are two concentrations of coral and small cobbles at the south end of the alignments. The first concentration has ca. 12 pieces of 10 to 15 cm coral, and the second concentration ca. 5 pieces. There is wave washed shell and coral spread throughout the feature. Subsurface testing was not conducted at this feature.

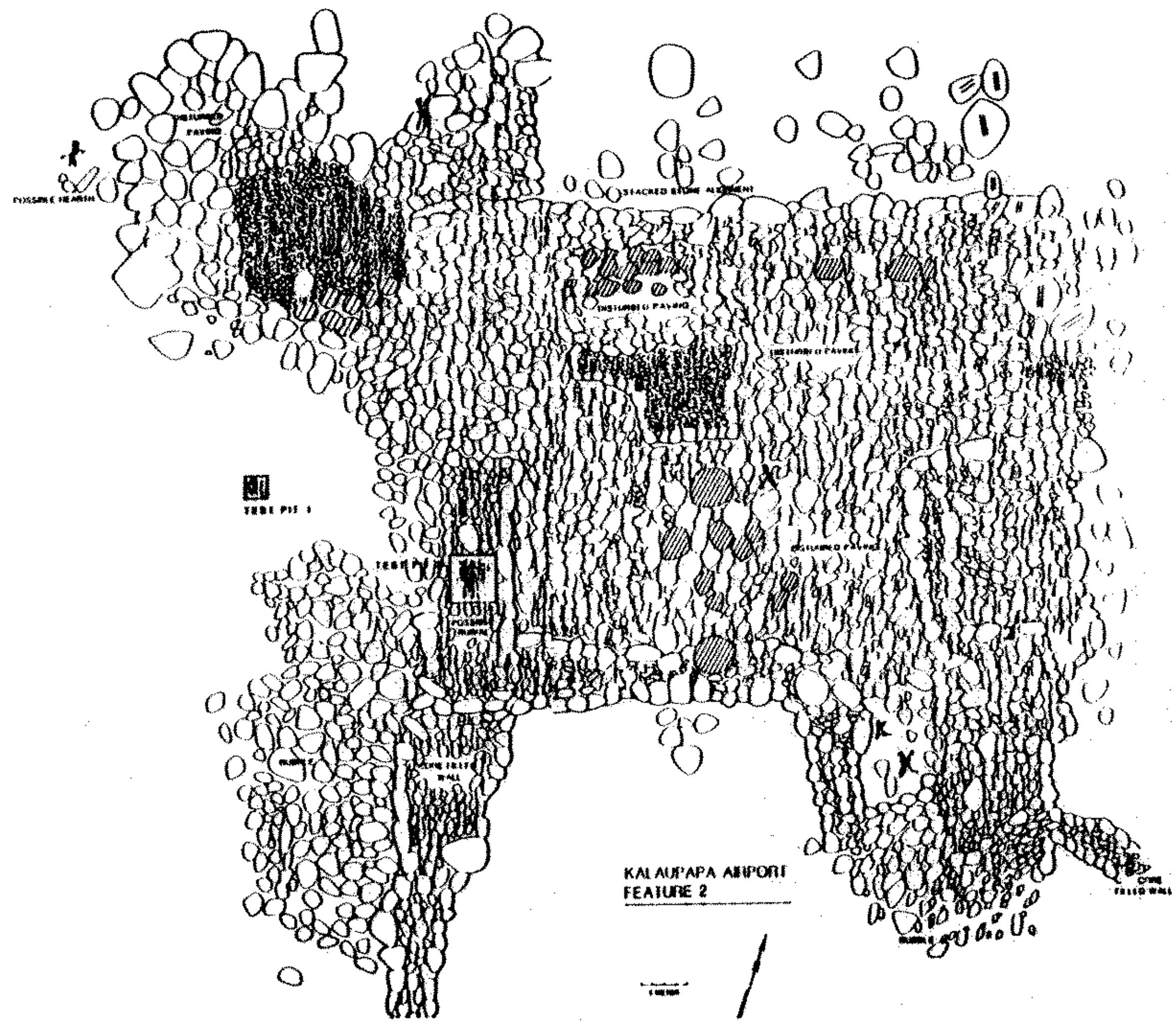


Figure 8. Map of Feature 2.

Figure 9. Map of Feature 4.

Feature 5

Features 5A and 5B are two connected agricultural complexes (see Figure 2 and Photo 3). The eastern enclosure is designated 5A, while the western is 5B. 5A is roughly rectangular in shape, measuring 33 by 27 m. The massive enclosure wall is constructed of up-right boulders and stacked stones to a height of 1.15 m. Inside of the enclosure there are numerous walls aligned perpendicular to the northeast trade winds. Approximately 17 of these were inventoried from an aerial photograph. The linear alignments are ca. 2 m apart, have a maximum height of 90 cm, and an average height of 50 cm.

Although the Feature 5B enclosure is much larger than Feature 5A, it appears to have had an essentially similar agricultural function. It measures approximately 93 by 59 m. The enclosure wall averages over 1 m in height. As with 5A, linear alignments are present in the interior. These are 50 to 80 cm high and separated from one another by 1.5 to 3 m. Toward the south and west side of the enclosure, the alignments become less well defined, appearing to have a less orderly arrangement and increased interspersion with planting mounds. Approximately 178 interior alignments were inventoried from an aerial photograph.

Feature 8 is a small shelter located within the Feature 5B enclosure. Feature 10 is a large historic residential platform connected to the western wall of the enclosure. The morphology and construction method of the two features suggests that the platform might be contemporaneous with Feature 5B. Furthermore, the southern enclosure wall of 5B connects with a concrete foundation of what was probably a modern house (Feature 37). As with Features 5B and 10, this suggests that the enclosure may have been used during the same time period as the house. However, there is a difference in the way that the enclosure connects with Feature 10 and the way it connects with Feature 37. The wall of 5B neatly abuts feature 10, whereas it looks as if it has been heavily disturbed around Feature 37. This might suggest that the enclosure was built first, possibly at the same time as Feature 10, and then at a later date when Feature 37 was built Feature 5B was disturbed. Another concrete foundation (Feature 38) is located near the southwest corner of the enclosure. A 3/4 inch metal pipe runs from the abandoned house at the end of the two-track road through enclosures 5A and 5B to the concrete foundation (feature 37), and then continues south.

The chronology of the use of Features 5A, 5B, 8, 10, 37, 38, and the abandoned house at the end of the two-track road is unclear. It seems likely that portions of agricultural enclosures Feature 5A and 5B were used when residential Feature 10 was occupied. The agricultural enclosures might also have been used during a later period when Features 37, 38, and the abandoned house were occupied. Further excavation and a detailed inspection of the construction phases of the walls and features is required to clarify the matter.

Feature 6

Feature 6 consists of a rectangular enclosure, an open area behind a windbreak, and a circular slablined hearth (Fig. 10 and Photo 5). It was probably built and used in several stages. The feature's eastern windward wall is the most massive. It is a 6.7 m

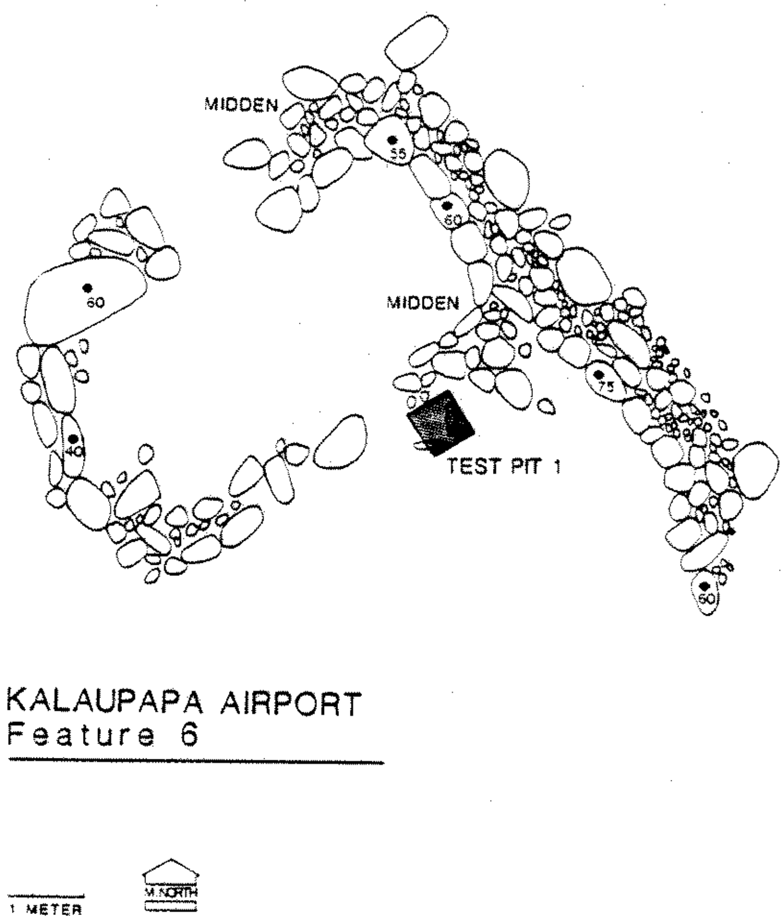


Figure 10. Map of Feature 6.

long, 1.1 m wide, 75 cm high, core-filled wall. This wall serves as the windbreak of the rectangular enclosure. The overall size of the enclosure is 6 by 3.75 m, and its interior measures 4.5 by 2 m. The other 3 walls of the enclosure are core-filled and range in width between ca. 60 cm and 1 m, and are ca. 60 cm high. These walls are not as massive as the windward wall. Some stones appear to have been removed from the walls. Currently only the larger foundation stones are present. The south wall which is aligned SW-NE abuts the more massive windward wall. This indicates that the enclosure may have been built during a later construction phase. The break in the enclosure's north wall was probably the entrance of the structure. A circular slablined hearth was built close to the south wall of the enclosure. The construction chronology of these two components is unclear, but it is assumed that they are not contemporaneous. It is possible that the hearth is associated with the open area behind the massive windward wall, and the enclosure was built at a later date. Wave action has dispersed waterworn shell and coral throughout the feature. A 50 by 50 cm test pit was excavated at the feature.

Feature 7

Feature 7 is an ca. 5 by 3 m C-shape shelter (Fig. 11). The core-filled wall of the C-shape incorporates large 45 cm boulders. The wall has a maximum width of 1.5 m and height of 1.2 m. The interior of the C-shape measures ca. 2.3 by 2 m and is filled with 20 to 30 loose stones. The stones do not appear to be a paving. They probably originated from the wall. In the south wall of the C-shape there is a small circular alignment. This might be a cupboard, but its location on the exterior, exposed, side of the structure is not an ideal location for storage. Subsurface testing was not conducted at this feature.

Feature 8

Feature 8 is a section of a core-filled wall ca. 9 m long, 1.5 m wide and 80 cm high (Fig. 12). It is part of the field system surrounded by Feature 5B. Smaller stacked stone agricultural walls and enclosures extend off of the feature. Feature 8 is distinguished from these alignments by its core-filled construction style, its relatively massive height and width, and the presence of shell and bone midden in its lee. The feature may have functioned as a temporary shelter. A 100 by 50 cm test pit was excavated at the feature.

Feature 9

Feature 9 is a series of 4 free standing cupboards (Fig. 13 and Photo 7). They are located near the edge of the beach berm. Three of the cupboards have cap stones, the fourth has collapsed. The exact dimensions of the cupboards vary, but their interior diameters are ca. 1 m with interior heights of 50 cm. The sides of the cupboards are either a single course of large boulders or smaller stones stacked 2 courses high. Large flat stones have been placed on top of the walls to form the roof of the cupboard. Wave action has deposited a considerable amount of waterworn shell and coral throughout the area. The cupboards were void of material other than water worn shell. Subsurface testing was not conducted at this feature.

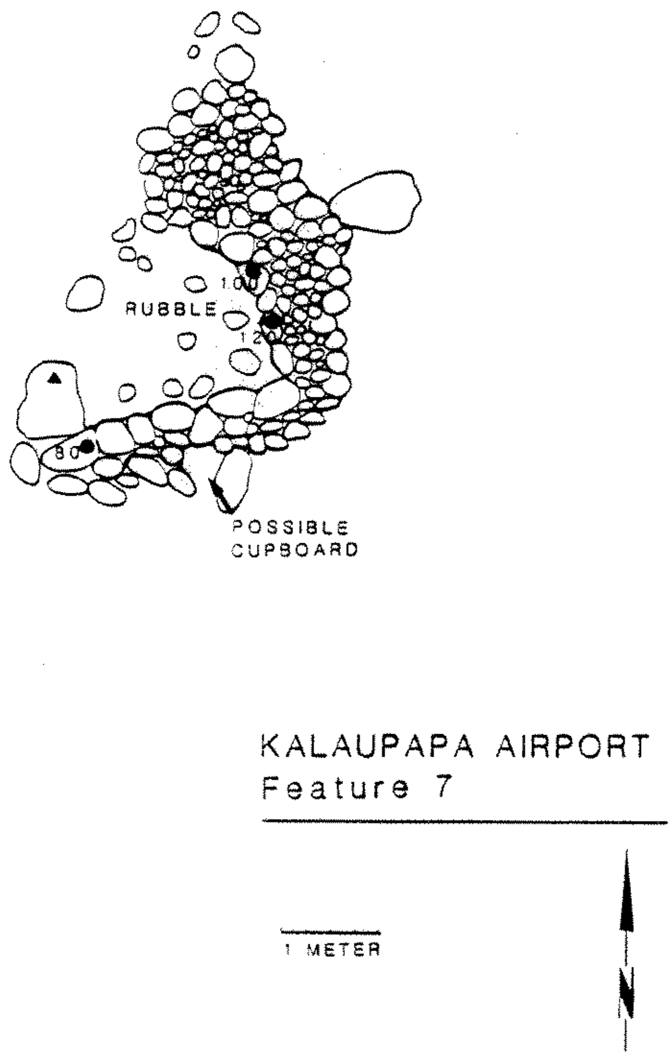


Figure 11. Map of Feature 7.

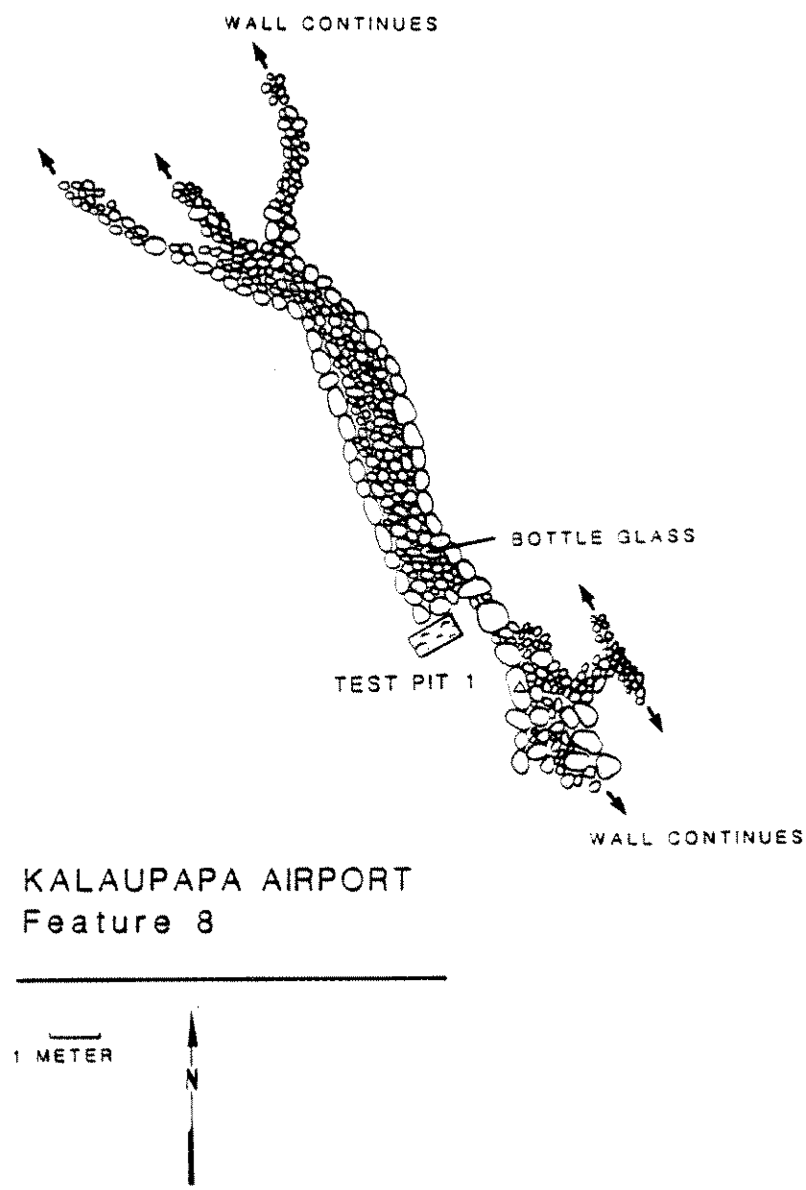


Figure 12. Map of Feature 8.

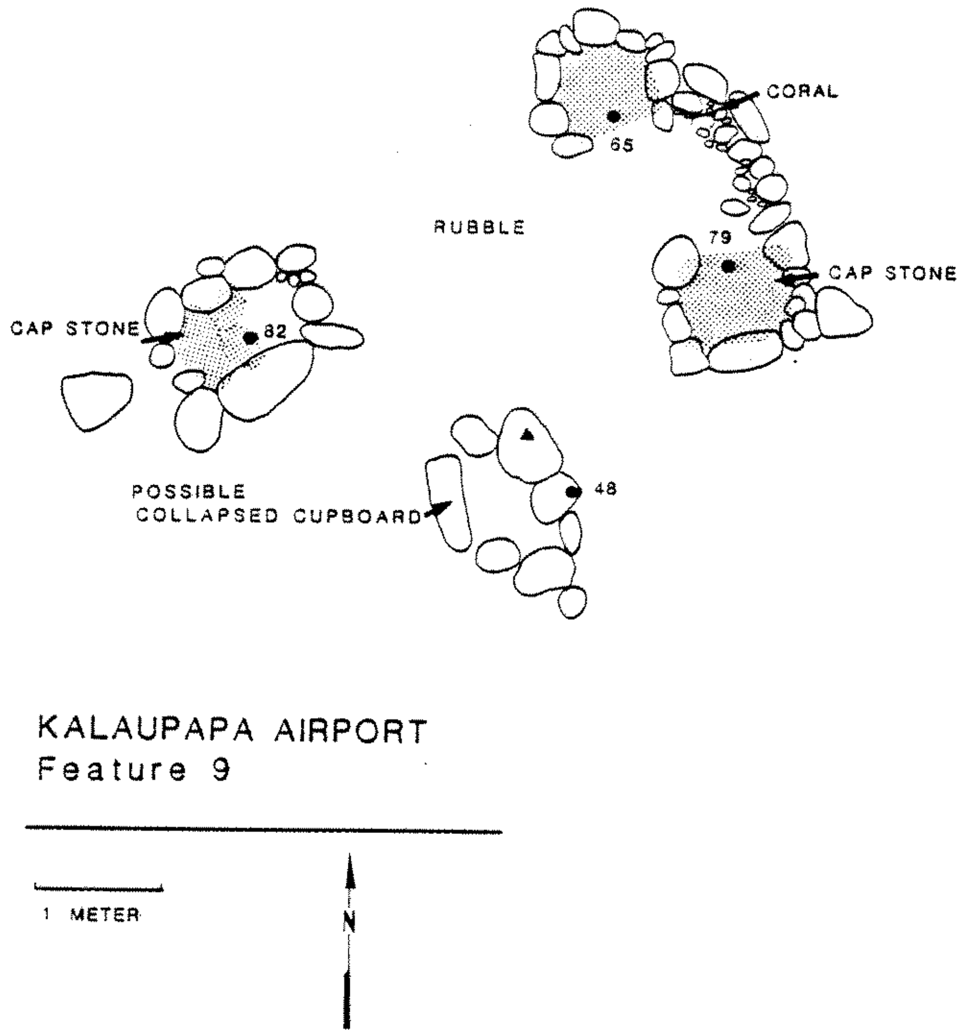


Figure 13. Map of Feature 9.

Feature 10

Feature 10 is a large residential platform with a number of internal architectural components (Fig. 14 and Photo 8). The overall dimensions of the feature are 17 by 14.5 m. The main platform contains 3 pavings, 1 slablined hearth, and 1 slablined pit. One of the pavings is an ili ili paving of coral and basalt pebbles. It is 6 by 3 m, and is more or less level at a height of 70 cm above ground surface. On its north side there are steps leading up to the paving. Contained in the ili ili paving is a slablined hearth and a slablined pit. This paving appears to be the main residential activity area of the feature. A considerable amount of lithic material and a few pieces of historic glass are on the surface of the paving. At the northwest end of the ili ili paving there is a smaller paving of basalt stones. A third paving is made out of large flat inter-locking boulders, forming a lanai off to the west of the main paving. The south side of the platform is heavily disturbed and might have been a continuation of the third paving at one time.

The walls of Feature 5B connect with the northeast and southeast corners of the platform. The wall extending to the south is massive. A small enclosure is formed by it and the side of the platform. A 50 by 50 cm test pit was dug in the middle of the enclosure. Concentrations of bottle glass and ceramic sherds were observed on the surface and on the walls of the enclosure.

The feature appears to be a historic house site. As indicated in the section concerning previous archaeological studies at Kalaupapa, Feature 10 might have been recorded by Mchenry (n.d.a) in 1937. The feature is currently used as a shrine, indicated by the offerings wrapped in ti leaves that are located on various parts of the platform. Since the platform is integrated into the agricultural enclosure wall of Feature 5B, it is probable that the two features are contemporaneous and functionally interrelated.

Feature 11

Feature 11 is a disturbed L-shape with an interior paving (Fig. 15). The windward wall of the L-shape is ca. 8.7 m long, 1 m high, and has a maximum height of 1.1 m. A portion of the wall is core-filled and the rest of it is stacked stone. The currently disturbed portion that is stacked stone might have been core-filled at one time. The side wall is stacked stone. The interior of the feature consists of 30 to 70 cm boulders intermixed with coral paving and ili ili stones. There is a possible slablined hearth in the paving. Two fragments of historic dark green glass, 2 fragments of violet glass, and several pottery sherds are on the surface of the paving. The violet glass is similar to pieces found in the enclosure next to Feature 10. Feature 11 probably functioned as a shelter or residence. Subsurface testing was not conducted at this feature.

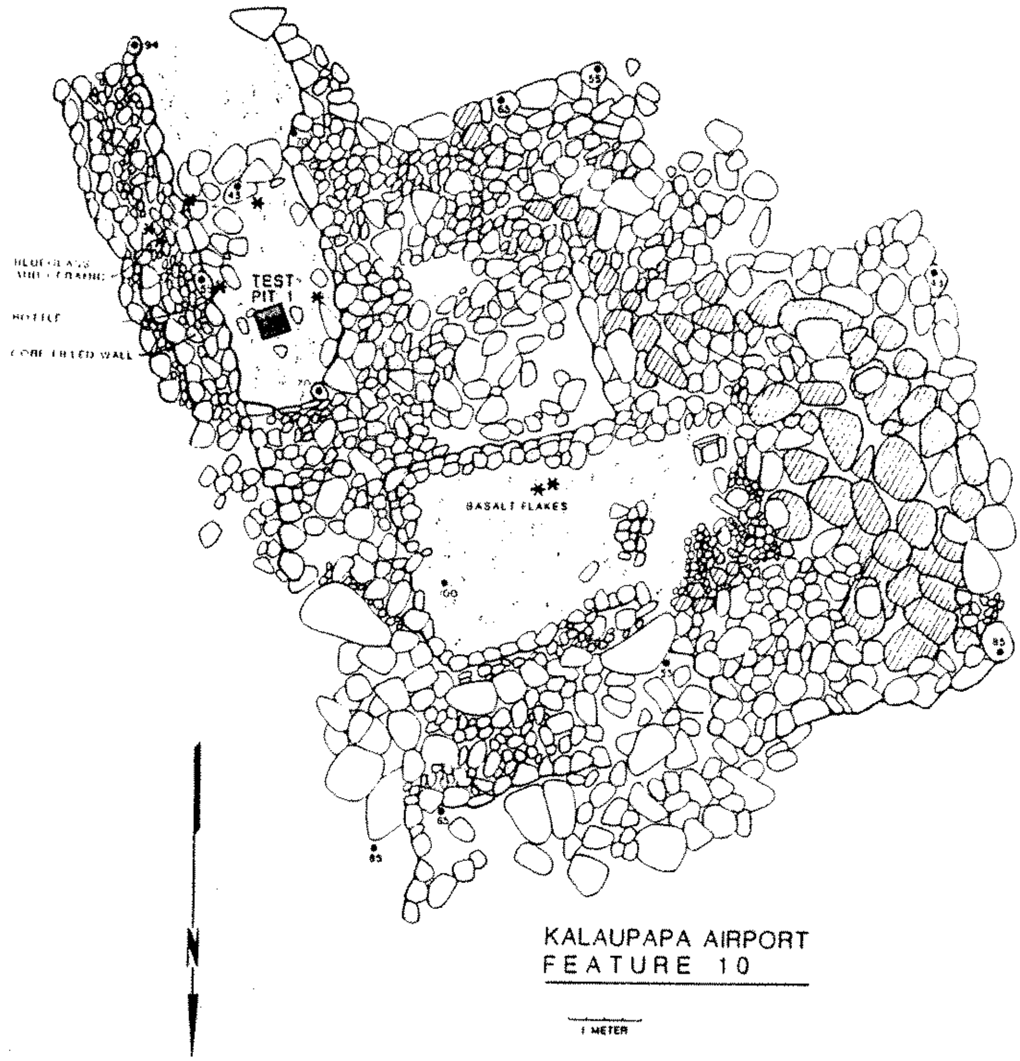


Figure 14. Map of Feature 10.

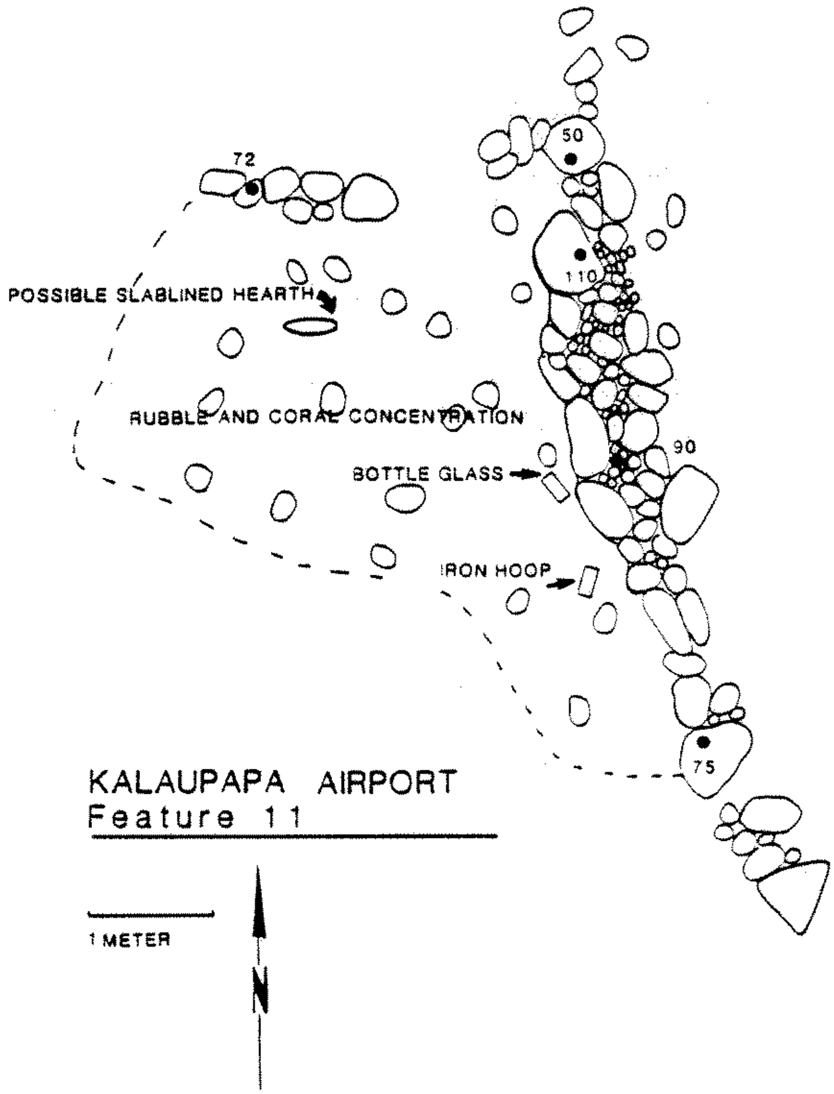


Figure 15. Map of Feature 11.

Feature 12

Feature 12 is a rectangular enclosure 13 by 8.5 m on the exterior and 6.5 by 6 m on the interior (Fig. 16 and Photo 11). There appear to be steps into the enclosure in the northwest corner. The massive walls of the enclosure look as if they might have been built in several phases. The maximum exterior height of the walls is 1 m, and the maximum interior height is 1.85 m. All four walls are core-filled, but the north, east, and south walls are much more massive than the west. The maximum width of any of the walls is 2.20 m, and the minimum width is 80 cm. The northeast corner of the enclosure has been built up to such an extent, that it virtually forms a terrace with the protruding bedrock. The foundation stones of the north, east, and south walls are large 110 by 80 cm rocks. The upper stones are much smaller, being 30 to 40 cm long. The north, east, and south walls are two tiered. It appears that the original wall was core-filled, and that the upper section of stacked stone was a later addition. Furthermore, the west wall appears to have been built after the other three walls. Although all the walls are core-filled, the west wall is significantly thinner and appears to be of a different construction style than the others. The west wall also appears to abut both the north and south walls, covering their respective faces. Thick vegetation obscured the interior of the enclosure, but a few pieces of shell midden, and 1 piece of bottle glass were noted. An discoidal ula maika or pecking stone was recovered from the interior of the southern wall approximately 70 cm above the ground surface. It is made out of porous basalt and has a diameter of 6.7 cm and a width of 4.3 cm. The precise function of Feature 12 is unknown, but several hypotheses are presented in the excavation section of this report. A 100 by 50 cm test pit was excavated at the feature.

Feature 13

Feature 13 is a hill-top enclosure with 2 interior terraces and a small, faced depression (Figs. 17 and 18, and Photos 12 and 13). From the floor of the feature to the base of the outcrop is ca. 5 m. The south wall is 8 m long and the west wall 6.1 m long. The east wall is approximately 4.25 m, and the north wall is somewhat irregular in shape. An entrance step approximately 80 cm high is located in the northeast corner. The interior wall height is 90 to 140 cm and the exterior has a vertical drop of 1 to 3 m. The enclosure wall is stacked stone and incorporates a number of bedrock outcrops. There is a roughly paved terrace in the southwest corner of the unit. It is 4.2 by 2.6 m, and the height of the terrace face is 30 cm. The paving cobbles range in size from 10 to 40 cm. A 1 by 1 m test pit was excavated at the northeast corner of this terrace. The test pit uncovered a cultural deposit containing quantities of Sus scrofa (Pig), other mammal, fish, and bird bone. A second terrace is located in the southeast corner. It is not nearly as well constructed. A small, walled depression was incorporated into the north wall of the enclosure. It may have functioned as a storage area. Just outside of the enclosure there was a small man-made depression built into the bedrock outcrop. In between Feature 13 and Feature 12 there was a small terrace. It is 6 m long, 2.6 m wide, and the height of the terrace face is 1.6 m. The precise function of feature 13 is unknown, but several hypotheses are presented in the excavation section of this report.

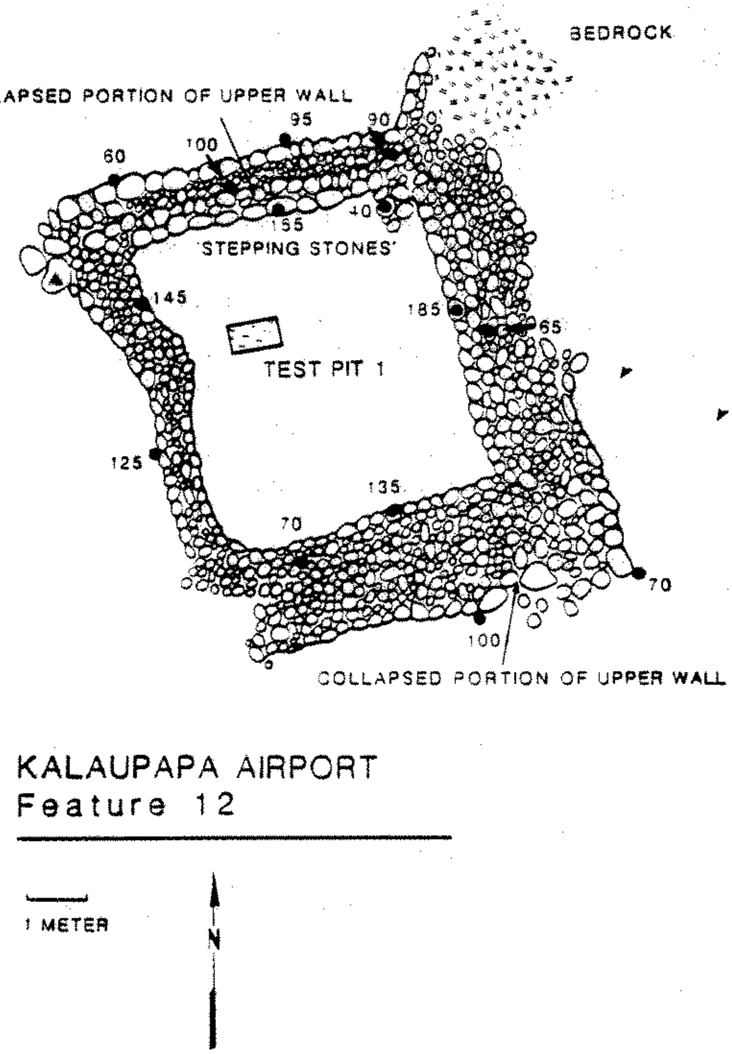


Figure 16. Map of Feature 12.

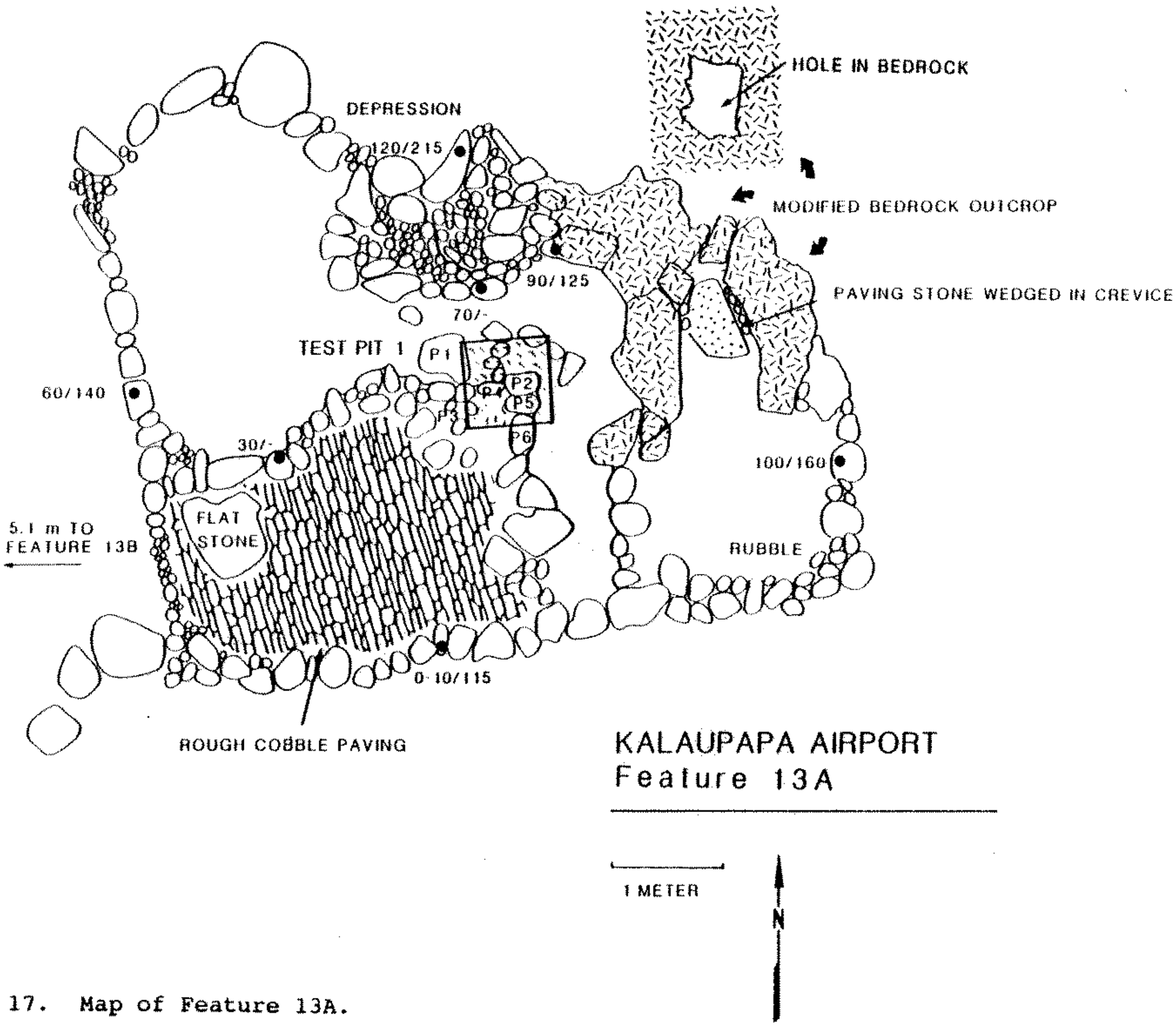


Figure 17. Map of Feature 13A.

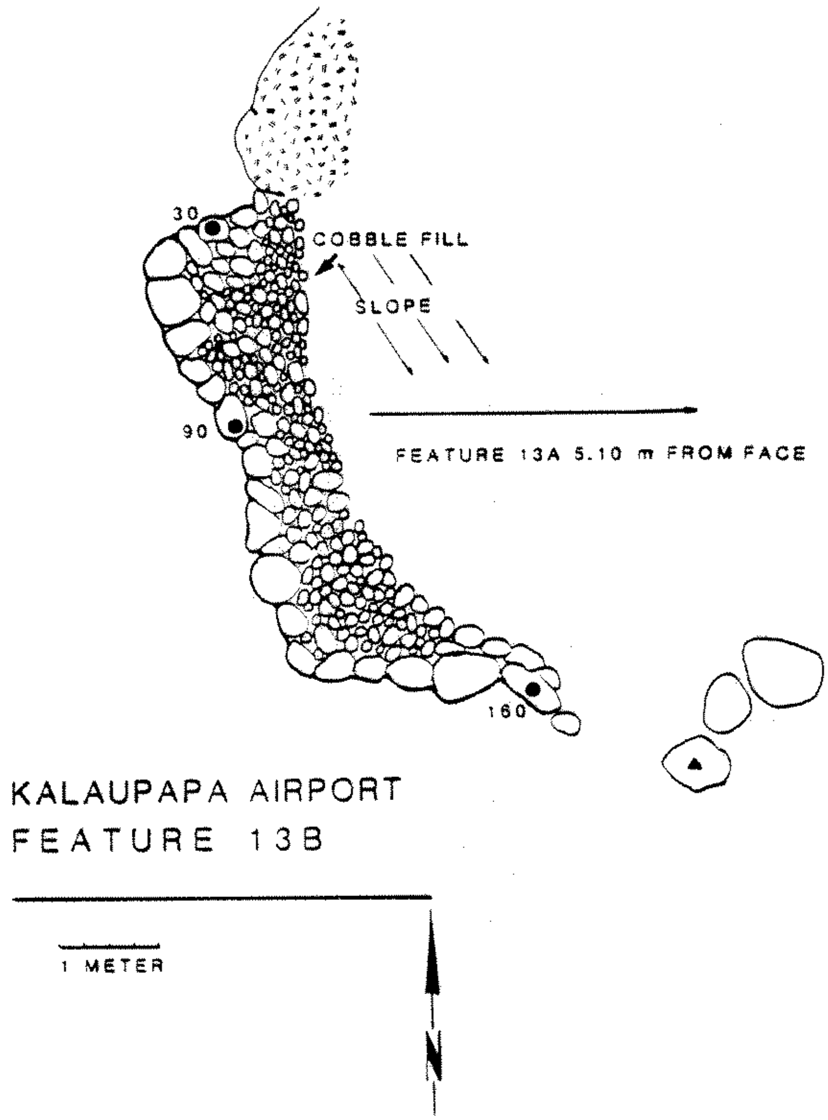


Figure 18. Map of Feature 13B.

Feature 14

Feature 14 is an elliptical enclosure ca. 4.45 m long and 3.5 m wide (Fig. 19). It has a maximum height of 1.2 m and a minimum of 75 cm. Portions of the enclosure are core-filled while others are stacked stone. The rocks used to construct the enclosure range in size from 10 to 35 cm and are stacked 6 courses high. The enclosure has no open entry, however the leeward northwest corner is significantly lower. There are several pieces of branch coral and some small pieces of unidentified shell in the interior of the enclosure. A 50 by 50 cm test pit was excavated at the feature.

Feature 15

Feature 15 is a 65 m long wall that runs along a ridge between Feature 13 and Feature 16 (see Figure 2). Portions of the wall consist of large, 60 cm to 1 m, boulders placed upright adjacent to each other, while others are constructed of stacked stone. The height of the wall ranges between 40 cm to 1.1 m. In segments the bedrock which is about 2 m away from the wall has been modified to form a narrow passage. It is possible that the modified bedrock and the wall are borders of a trail. Subsurface testing was not conducted at this feature.

Feature 16

Feature 16 is a 7.53 m long, 5.25 m wide U-shape (Fig. 20). It is located on top of a knoll which is part of the ridge upon which Feature 15 runs along. The interior of the feature is ca. 4.25 by 2.1 m. The walls of Feature 16 are core-filled with the larger facing boulders measuring ca. 70 cm and the fill cobbles measuring ca. 5 to 15 cm. The windward wall is relatively massive with a maximum width of 2.1 m. The height of the walls range between 35 cm and 1.45 m. A 100 by 50 cm test pit was excavated at the feature.

Feature 17

Feature 17 is a 5 by 3.1 m C-shape (Fig. 21). The interior of the feature is 2.5 by 1 m. The core-filled walls are faced on the interior. They have a maximum width of 1.5 m and range in height between 37 cm to 1.12 m. A cupboard is built into the interior of the windward wall. It is open on both ends and is ca. 30 cm long, 25 cm wide, and 37 cm high. Surrounding Feature 17 are ca. 7 rough C-shapes and enclosures, and numerous walls. These features are disturbed and are morphologically similar to the agricultural walls and enclosures surrounding Feature 8. Subsurface testing was not conducted at this feature.

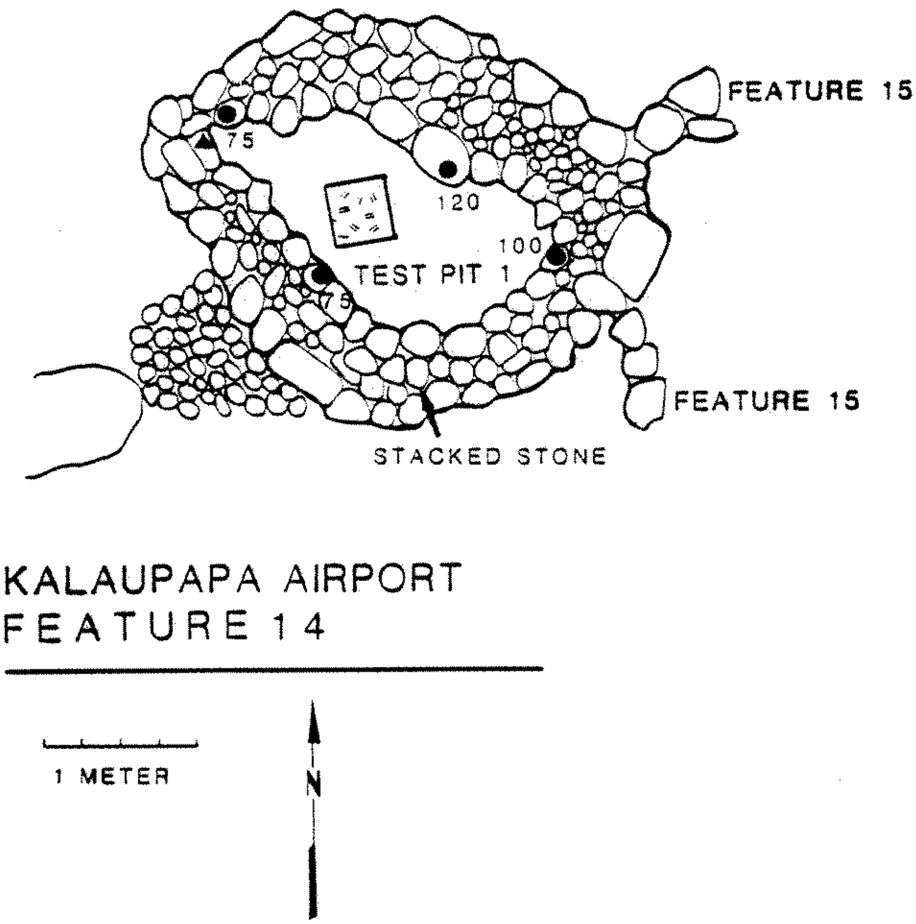


Figure 19. Map of Feature 14.

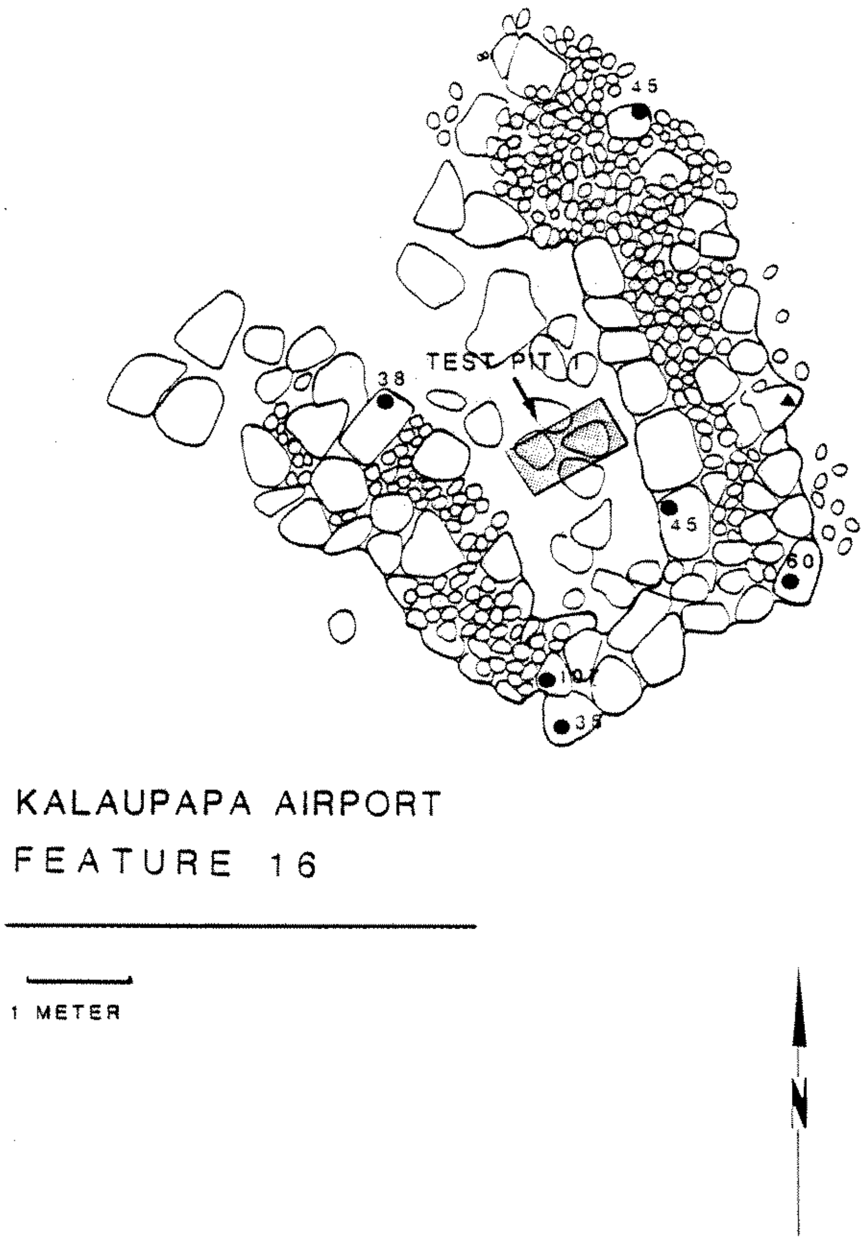


Figure 20. Map of Feature 16.

Figure 21. Map of Feature 17.

Feature 18

Feature 18 is a 4.75 by 4.3 m C-shape shelter built against a low bedrock outcrop (Fig. 22). The interior of the feature is 3.35 by 1.75 m. Interior and exterior portions of the wall are faced. It is core-filled with facing stones ranging in size from 30 to 25 cm, and fill stones ranging in size from 15 to 10 cm. The height of the wall ranges between 1 m and 20 cm. It has a maximum width of 2.1 m. A small amount of surface shell midden was noted. There is a circular slab-lined hearth in the lee of the C-shape. A 1 by 1 m test pit was excavated at the feature.

Feature 19

Feature 19 includes a series of 3 C-shapes, 2 terraces, and 2 walls (Fig. 23). There are also 3 small platforms located to the northwest of the feature. Subsurface testing was not conducted at any of these structures. The C-shapes of Feature 19 are part of a single wall which extends along the side of a small knoll. The elevation difference between the floor of the northern upper C-shape and the base of the southern lower terrace is ca. 3 m. The northern C-shape is the most substantial. Its overall dimensions are 4.5 by 3 m, and its interior measures 2.5 by 2 m. It is core-filled and faced. It has a maximum wall width of 1.2 m and a height of ca. 1.1 m There is a low single course alignment extending across the interior of the C-shape.

The other two C-shapes extend off of the northern C-shape and are not as substantial. The amount of their curvature is less. The middle C-shape is ca. 3 m long, has a maximum width of 80 cm and a maximum height of 95 cm. The southern C-shape is 2.7 m long, has a maximum width of 60 cm, and maximum height of 1.2 m.

The northern terrace extends along the edge of a bedrock outcrop. It is faced with large 30 to 60 cm boulders and filled in behind with smaller 5 to 15 cm rocks. It has a maximum height of 1.05 m. Extending off of the western end of the terrace is a low wall. This wall follows the edge of the outcrop all the way to Feature 35. Another wall extends off of the terrace to the northwest. This is one of the many low agricultural walls in the area. The southern terrace of Feature 19 connects with the end of the southern C-shape. It is faced with large boulders and has a maximum height of 80 cm.

Approximately 10 m to the northwest of Feature 19 are 3 small core-filled platforms. They are ca. 1.5 by 1 m, and 40 cm tall. The facing stones of these features are 50 to 40 cm long, and the fill rocks are 10 to 15 cm long. The function of these features has not been determined. It is possible that they are clearing mounds, but their construction seems too formalized. It is possible that they are burials, but this should be determined through excavation.

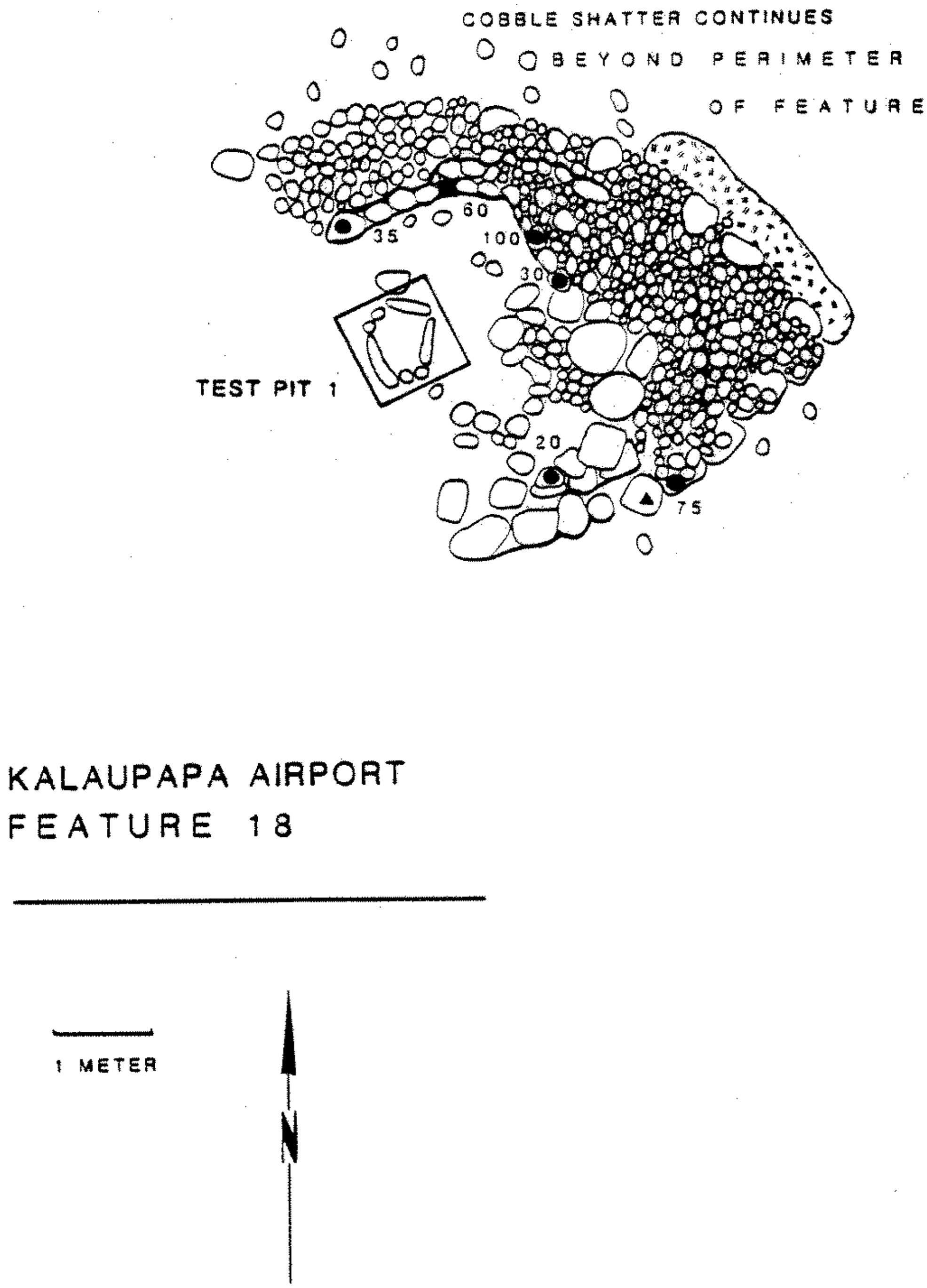


Figure 22. Map of Feature 18.

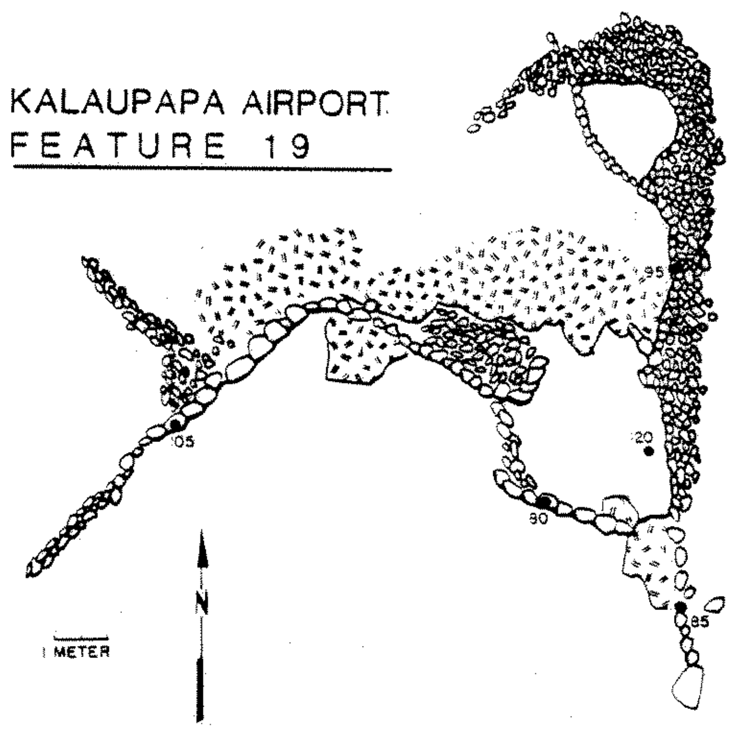


Figure 23. Map of Feature 19.

Feature 20

Feature 20 is a 10 by 2 m C-shape situated on the leeward edge of a small knoll (Fig. 24). The interior dimensions of the C-shape are 2 by 1.5 m. The wall is core filled and portions of it are well faced on both the interior and exterior. The height of the wall ranges between 30 and 105 cm, and has maximum width of 2.5 m. There is a low wall extending off of the north edge of the C-shape. There are many similar walls in the area, which were probably used for agricultural purposes. A 50 by 50 cm test pit was excavated at the feature.

Feature 21

Feature 21 consists of all the small agricultural alignments and mounds in the study area that are not contained in the agricultural enclosures, and that are not part of Features 4 and 25 (see Figure 2). This is a blanket designation for the walls spread throughout the study area. These walls were undoubtedly part of an agricultural complex. They generally range in height from 20 to 40 cm, and are made up of 1 or 2 courses of rock. Some of the walls are slightly larger. Subsurface testing was not conducted at this feature.

Feature 22

Feature 22 is a 10.9 m by 3 m C-shape situated on top of a small knoll (Fig. 25). The windward wall is core-filled with a maximum width of 1.6 m, and height ranging between 95 and 70 cm. Portions of the interior and exterior of the wall are well faced. In the south side of the feature there is a rubble area. This could be the remains of a low dividing wall or possibly the remains of a rough paving. Further excavation is needed to determine its shape and function. At the north end of the feature is a small 30 by 95 cm area delineated by a single course alignment. There was midden and basalt flakes inside of the area, perhaps indicating a storage function. A 100 by 50 cm test pit was excavated at the feature.

Feature 23

Feature 23 includes 2 C-shapes, and a terrace (Figs. 26 and 27, and Photo 16). The components of the feature were used as a shelter. The larger C-shape is to the east of the terrace, and to the north of the smaller C-shape. The overall dimensions of the larger C-shape are 5.5 by 1 m, and its interior measures 4.75 by 60 m. It is core-filled with a maximum wall width of 1.75 m. Its interior wall is faced by 25 to 40 cm stones and the fill stones are 10 to 15 cm. A large boulder has been incorporated into the interior face. This divides the C-shape in half, almost forming 2 joined C-shapes. Two agricultural walls join the C-shape on the north side. There was an extensive scatter of shell midden, coral, and lithics on the interior surface of the shelter.

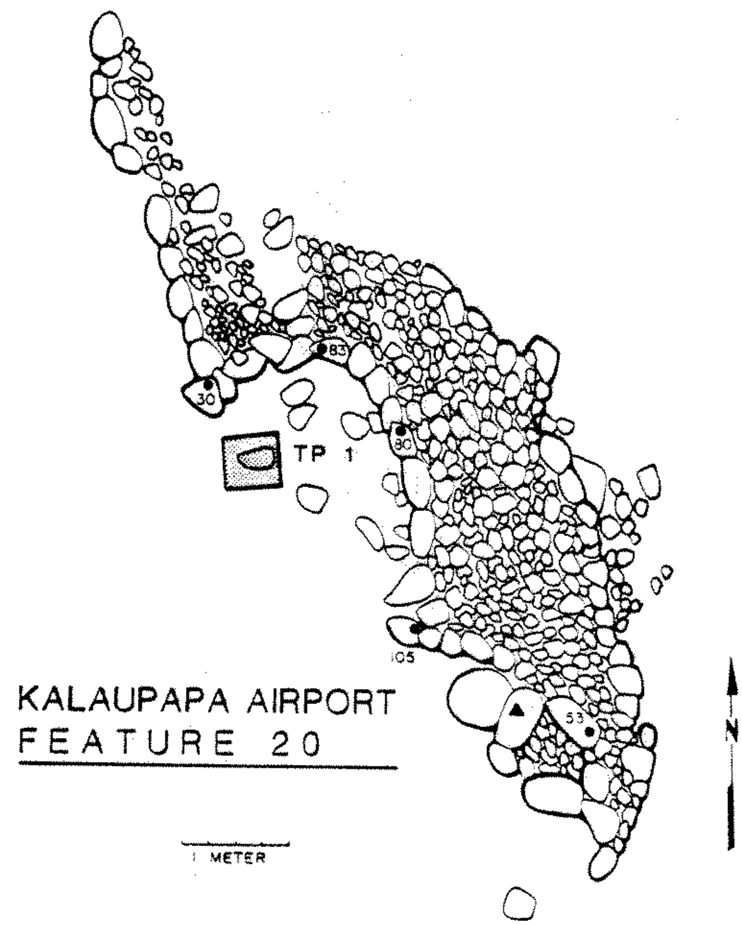


Figure 24. Map of Feature 20.

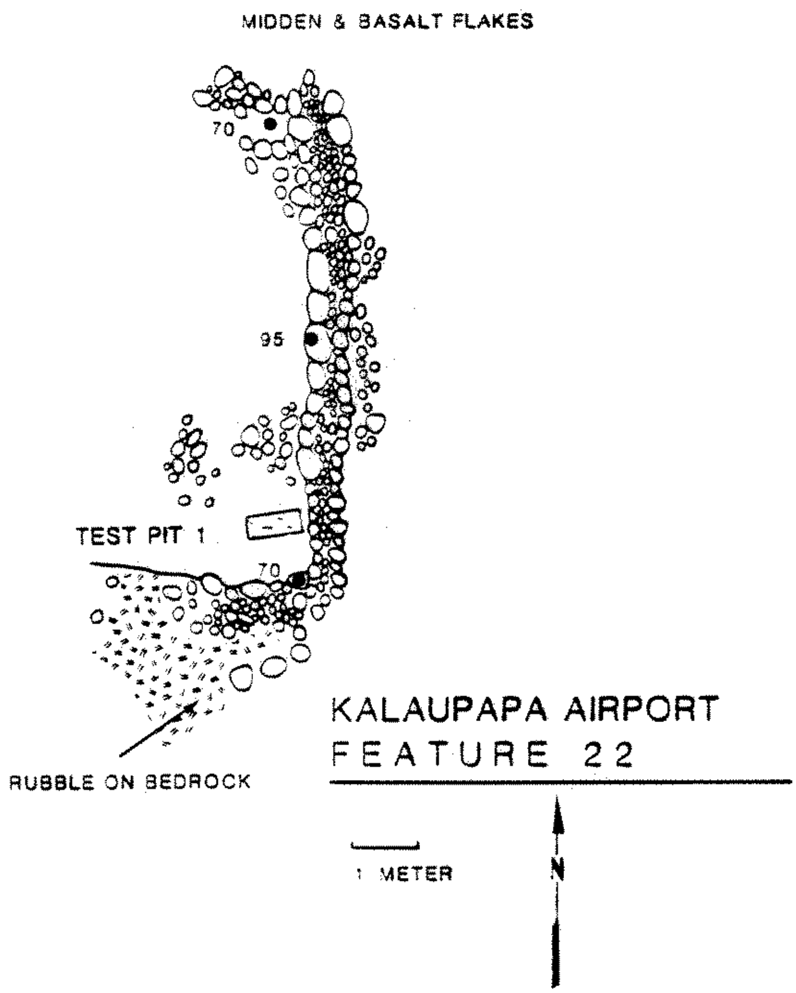


Figure 25. Map of Feature 22.

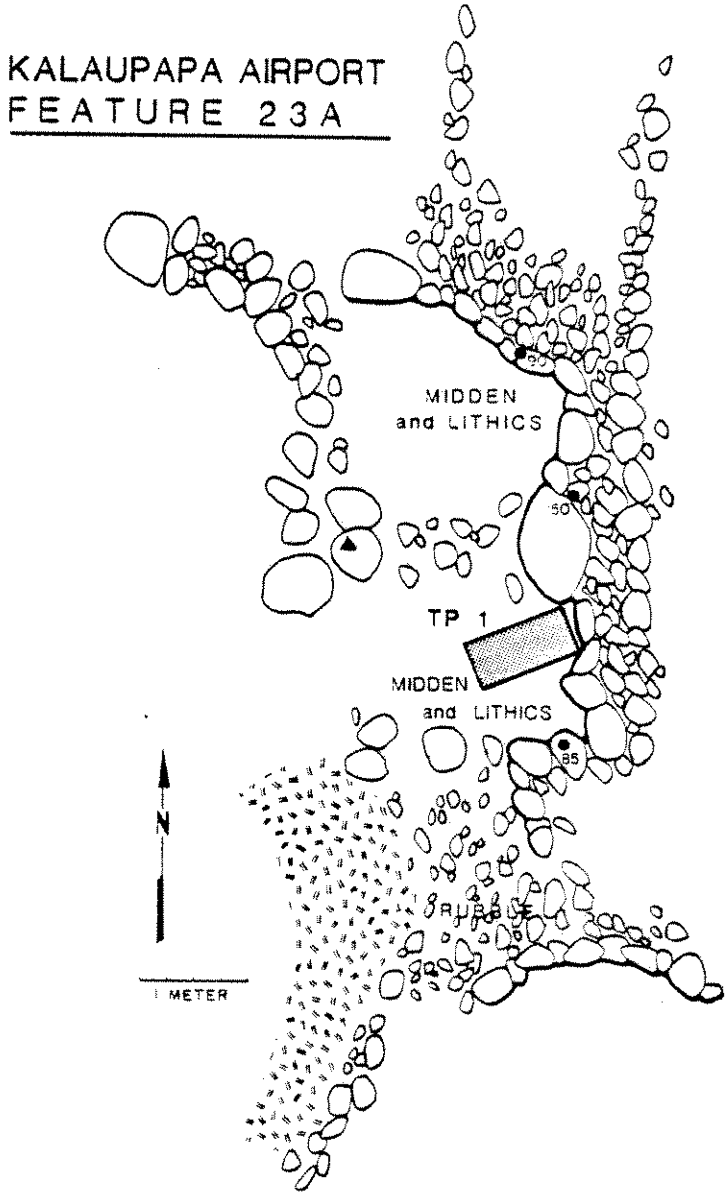


Figure 26. Map of Feature 23A.

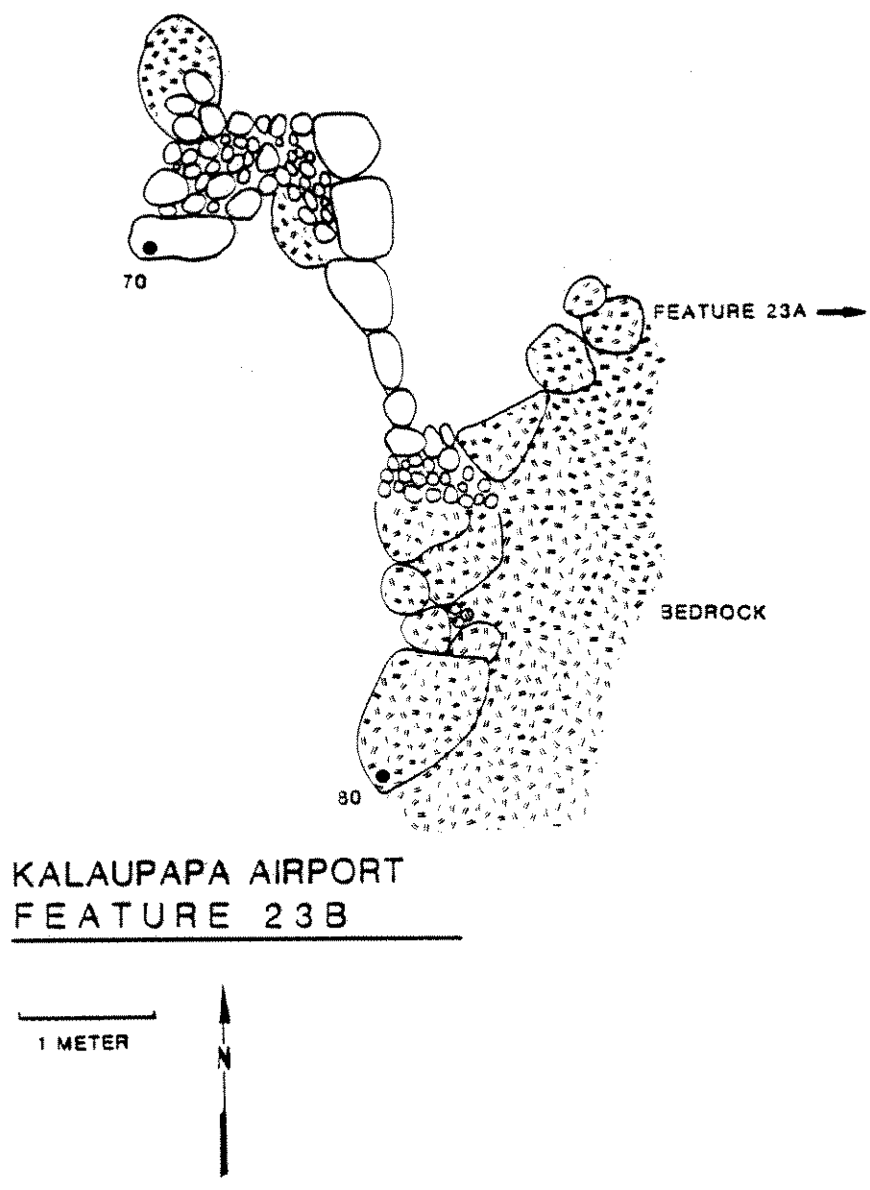


Figure 27. Map of Feature 23B.

The second C-shape is ca. 1 m south of the first, and is connected to the larger C-shape by a pile of rubble. The overall dimensions of the smaller C-shape are 2.38 by 0.5 m, and its interior measures 2.25 by 0.5 m. The smaller C-shape is not nearly as substantial as the larger structure.

The down slope face of the terrace is ca. 5 m west of the larger C-shape. Because of the terrace, the flat area behind the C-shape is larger. The terrace is 8.25 m long, and has a maximum height of 80 cm. It was formed by stacking large 50 to 100 cm rocks next to each other, and chinking them with small rocks. At the north end of the terrace there is a concentration of smaller rocks. A 100 by 50 cm test pit was excavated at the feature.

Feature 24

Feature 24 is a small C-shape located 12 to 15 m east of the downed airplane (Fig. 28). It is built upon a boulder-lava outcrop. Its overall dimensions are 4.25 by 0.7 m, and its interior measures 1.75 by 0.75 m. The wall abuts a large 1.5 m^3 boulder. The wall is poorly constructed and consists of stacked 10 to 35 cm boulders. The upper part of the wall consists of small cobbles precariously stacked in a single row. The height of the wall ranges between 20 and 89 cm. Because of the relatively flimsy construction it is possible that the feature dates to a later time period and/or had a different function than the other C-shapes in the study area. A 50 by 50 cm test pit was excavated at the feature.

Feature 25

Feature 25 is a series of 2 parallel core-filled walls located in a small swale (see Figure 2). They are perpendicular to the prevailing wind and are part of the field system located throughout the study area. Their size and formal construction distinguish them from many of the less substantial walls in the study area. The longest wall is 39 m. The walls are faced on both sides, but the eastern side is generally higher. The maximum height of the walls is ca. 1 m, although many portions of the walls are much lower. They have a maximum width of 90 cm. The eastern most wall of the series runs between, and almost abuts Feature 26 and Feature 22. Subsurface testing was not conducted at this feature.

Feature 26

Feature 26 is a C-shape shelter built at the base of a knoll and into the side of the hill slope (Fig. 29). Its overall dimensions are 8 by 3 m, and its interior dimensions are 2.5 by 1.5 m. Much of the feature is stacked stone. The interior leeward portion of the C-shape is core-filled. The stacked stone cobbles range in size from 3 to 15 cm. The rocks that make up the core-filled section are considerably larger, ranging up to 70 cm. The maximum width of the feature is 1.8 cm, and its height ranges between 30 and 90 cm. The windward wall is 3 courses high and the side walls are 1 to 2 courses high. Feature 25, an agricultural wall, begins ca. 75 cm from the south side of Feature 26. A 100 by 50 cm test pit was excavated at the feature.

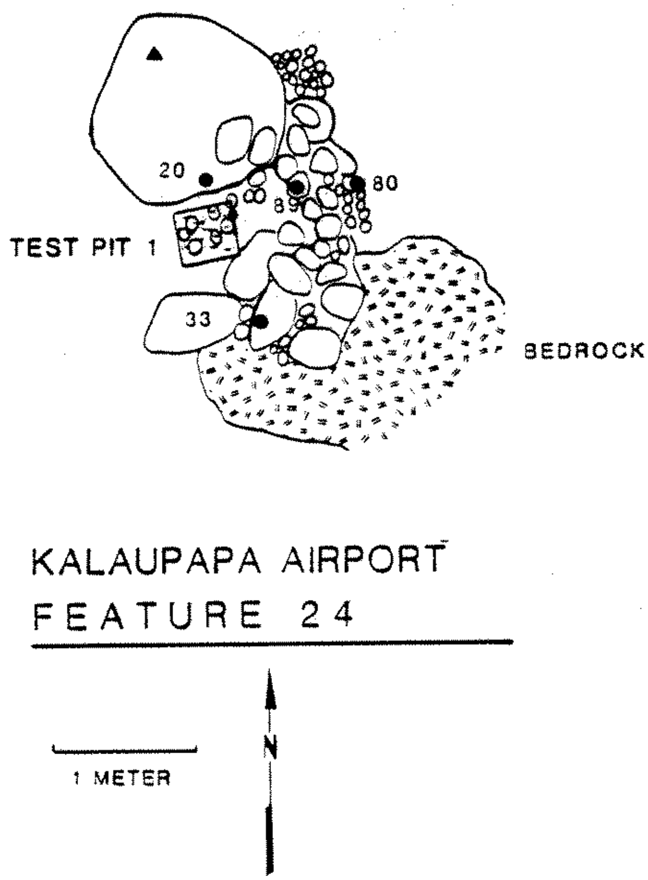


Figure 28. Map of Feature 24.

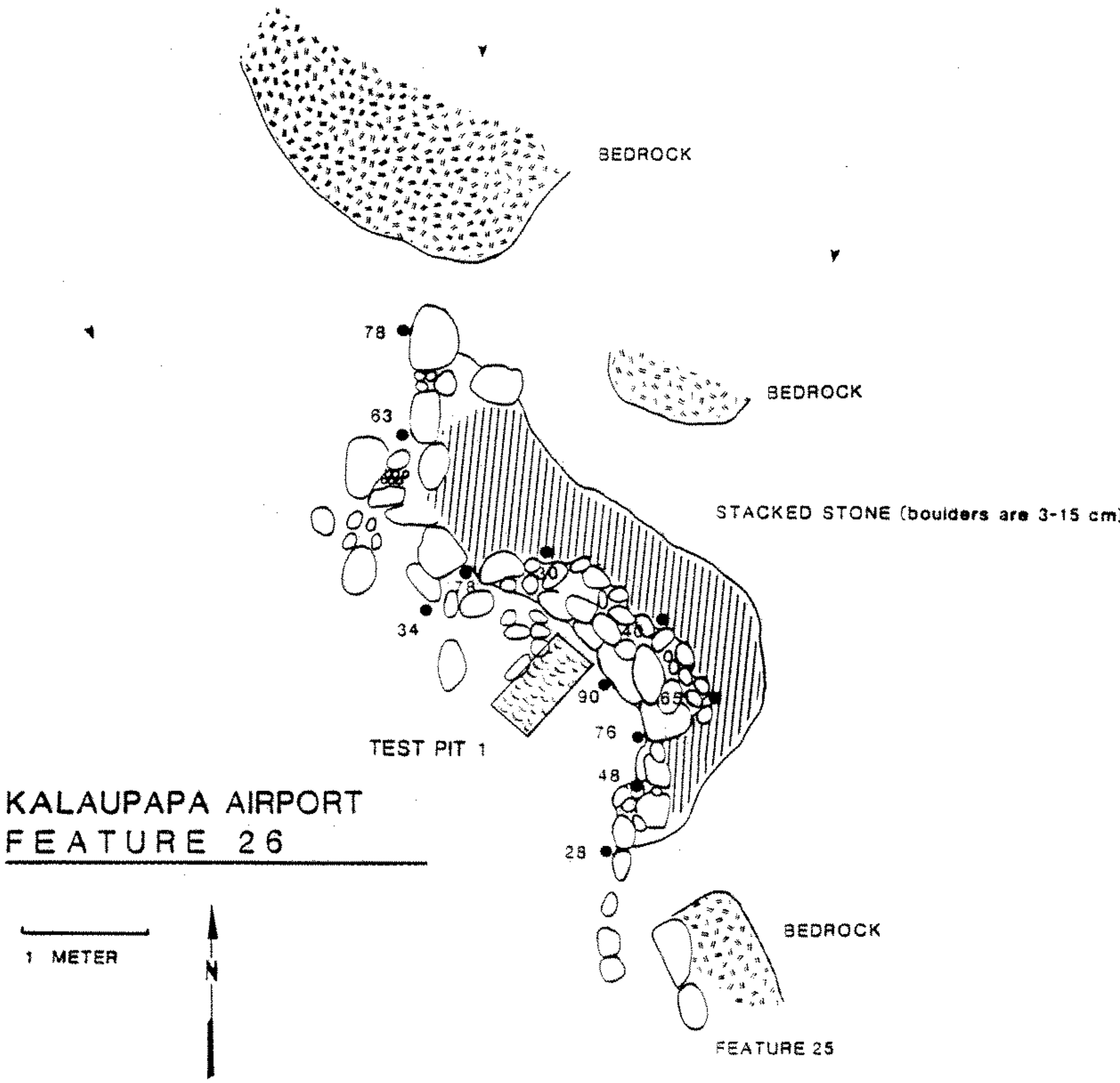


Figure 29. Map of Feature 26.

Feature 27

Feature 27 is a massive U-shaped shelter built into the side of a hill-slope just below the top of a knoll (Fig. 30, and Photo 18). Below the U-shape to the south, is a roughly paved terrace connected to one of the (Feature 25) walls. The U-shape is 6 by 4.2 m, and its interior measures 5 by 2 m. The walls are well constructed. They are core-filled and double faced. The maximum width of the wall is 1.6 m, its interior height ranges between 25 and 145 cm, and its exterior height ranges between 60 and 70 cm. The interior face is ca. 6 courses high and the exterior face ranges between 2 and 6 courses high. The south edge of the U-shape is a low terrace. Below the terrace there is a 4 by 3 m rubble pile. It is roughly paved. The rubble pile has a maximum height of ca. 50 cm. It is the beginning of a wall which is part of Feature 25. A 100 by 50 cm test pit was excavated at the feature.

Feature 28

Feature 28 is a large irregularly shaped residential enclosure situated on top of a knoll (Fig. 31). Its overall dimensions are 13 by 4.5 m. The enclosure wall is relatively massive on both the windward side and part of the leeward side. However on the southwest leeward side, the enclosure wall is a single course alignment which forms two interior spaces or "rooms", and a more exposed interior lanai. The massive segment of the enclosure is a double faced core-filled wall with a maximum height of 83 cm and a width of 2.2 m. The two interior rooms contain terraces. A 100 x 50 cm test pit was excavated in the eastern terrace. The results of the excavation indicate that the terrace was probably paved. The northern terrace evidence of a rough paving on the surface. The lanai is formed by the core-filled wall to its windward side and the single course alignment to its leeward side. It does not appear to be paved, but there is a substantial amount of rubble on the surface indicating that a paving is a possibility. There is a small circular alignment in the middle of the lanai that might be a slablined hearth. It was not excavated. An alignment extending off of the southeast end of the feature parallels the edge of the knoll. There was shell midden and lithic material dispersed throughout the surface of the feature. A 100 by 50 cm test pit was excavated at the feature.

Feature 29

Feature 29 is a 8.5 by 3.5 m C-shape located near the top of a small knoll (Fig. 32). It is located on the windward side of the knoll and part of the feature extends down slope. The interior of the C-shape measures 3 by 3 m. Portions of the feature are core-filled. There are, however, several additional faces throughout the feature. The maximum width of the main wall is 3.5 m. Heights of the feature range between 70 and 90 m. In the interior of the C-shape there is a rough paving made out of 20 to 40 cm cobbles. A 100 by 50 cm test pit was excavated at the feature.

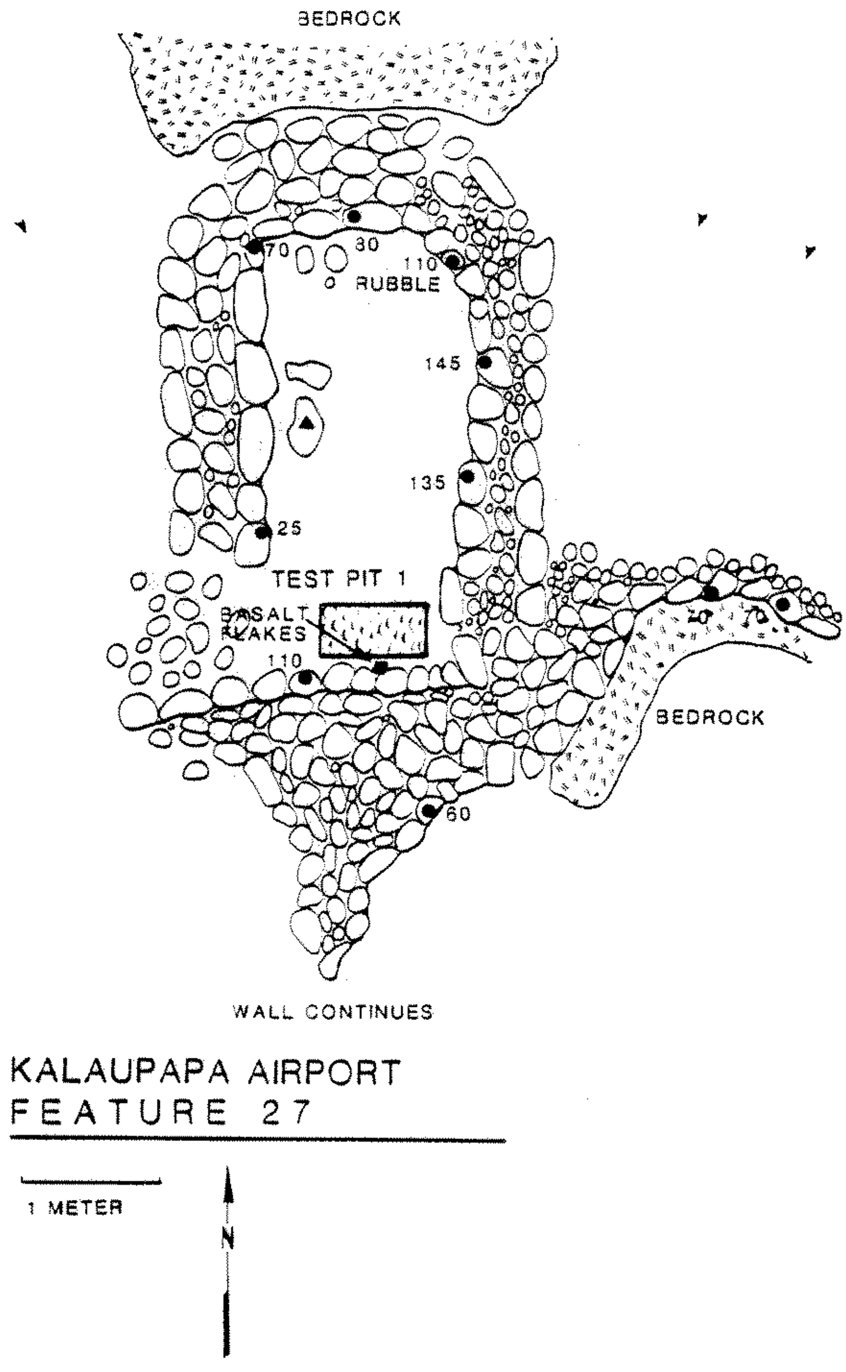


Figure 30. Map of Feature 27.

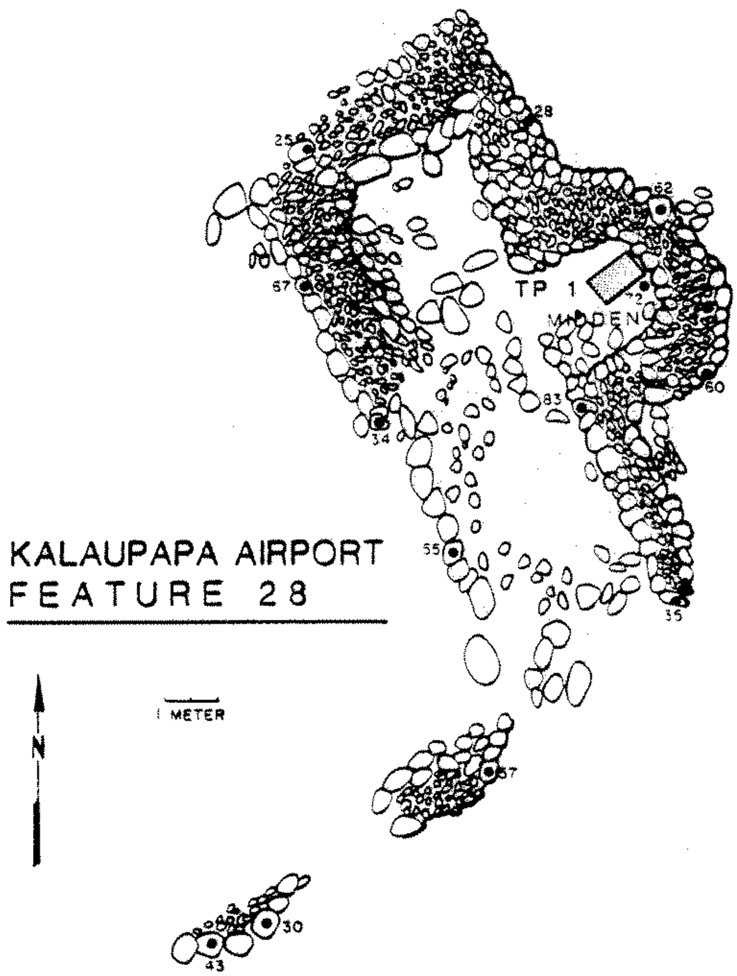


Figure 31. Map of Feature 28.

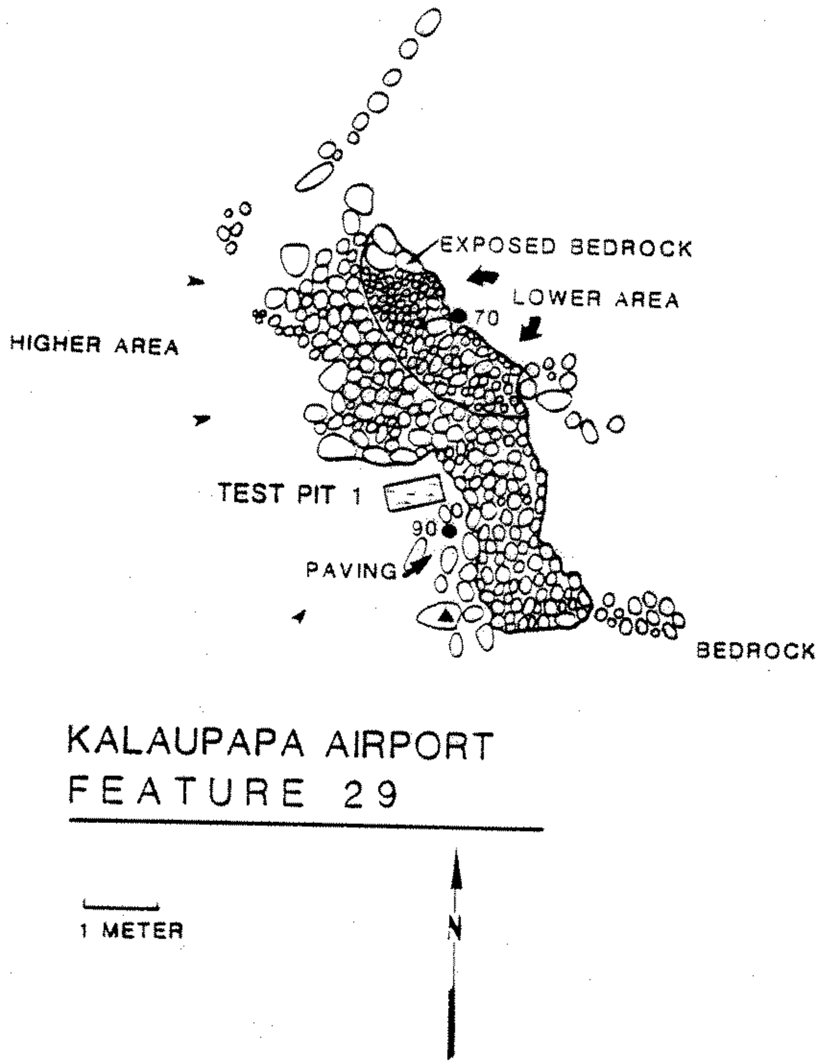


Figure 32. Map of Feature 29.

Feature 30

Feature 30 consists of a large enclosure built around a swale or low lying area (see Figure 2). The majority of the wall is core-filled, although there are sections of stacked stone. Its height reaches 2 m above the interior base, while the exterior wall height is 60 to 70 cm. It has a maximum width of ca. 80 cm. The interior of the wall is relatively flat. A C-shape shelter is located inside the enclosure at its southwest corner (Feature 31), and a large rock pile and C-shape are situated near the center of the enclosure (Feature 32). Thirty-four additional interior walls were inventoried from the aerial photograph. Subsurface testing was not conducted at this feature.

Feature 31

Feature 31 is a C-shape that is almost the shape of an enclosure (Fig. 33). It is integrated into Feature 30, a large agricultural enclosure. Both the agricultural feature, and Feature 31, are located in a small swale. The C-shape is 5.5 by 1.5 m, with an interior of 3.25 by 2.75 m. The interior of the feature is paved with cobbles. The walls of the feature are core-filled. They have a maximum width of 1.5 cm, and range in height from 23 to 100 cm. The facing boulders of the wall measure 40 to 75 cm, and the fill cobbles measure 5 to 15 cm. There are several small pieces of coral and basalt flakes on top of the wall. It is possible that the enclosure wall of Feature 30 abuts Feature 31. This would indicate that Feature 31 was built before the agricultural enclosure. However, this is a tentative interpretation that could be tested through excavation of the relevant wall segments. A 50 by 50 cm test pit was excavated at the feature.

Feature 32

Feature 32 includes a small C-shape, a large rubble mound, and several low walls (Fig. 34). The feature is situated inside of Feature 30, an agricultural enclosure. The C-shape is ca. 3.1 by 2.5 m, with an interior measuring 2.6 by 0.9 m. It is a stacked stone C-shape with a maximum wall width of 30 cm and height of 100 cm. The C-shape probably functioned as an agricultural windbreak. The rubble mound attached to the north end of the C-shape is core-filled. The rocks on the edge of the mound are ca 50 by 60 cm, whereas the fill is smaller 5 to 40 cm cobbles. It is irregularly shaped and has no formal facing. It is possible that it is a clearing mound. There are at least 4 other walls that connect with the mound. These are part of the agricultural system inside of the large agricultural enclosure. Several small pieces of coral were noted throughout the feature. Subsurface testing was not conducted at this feature.

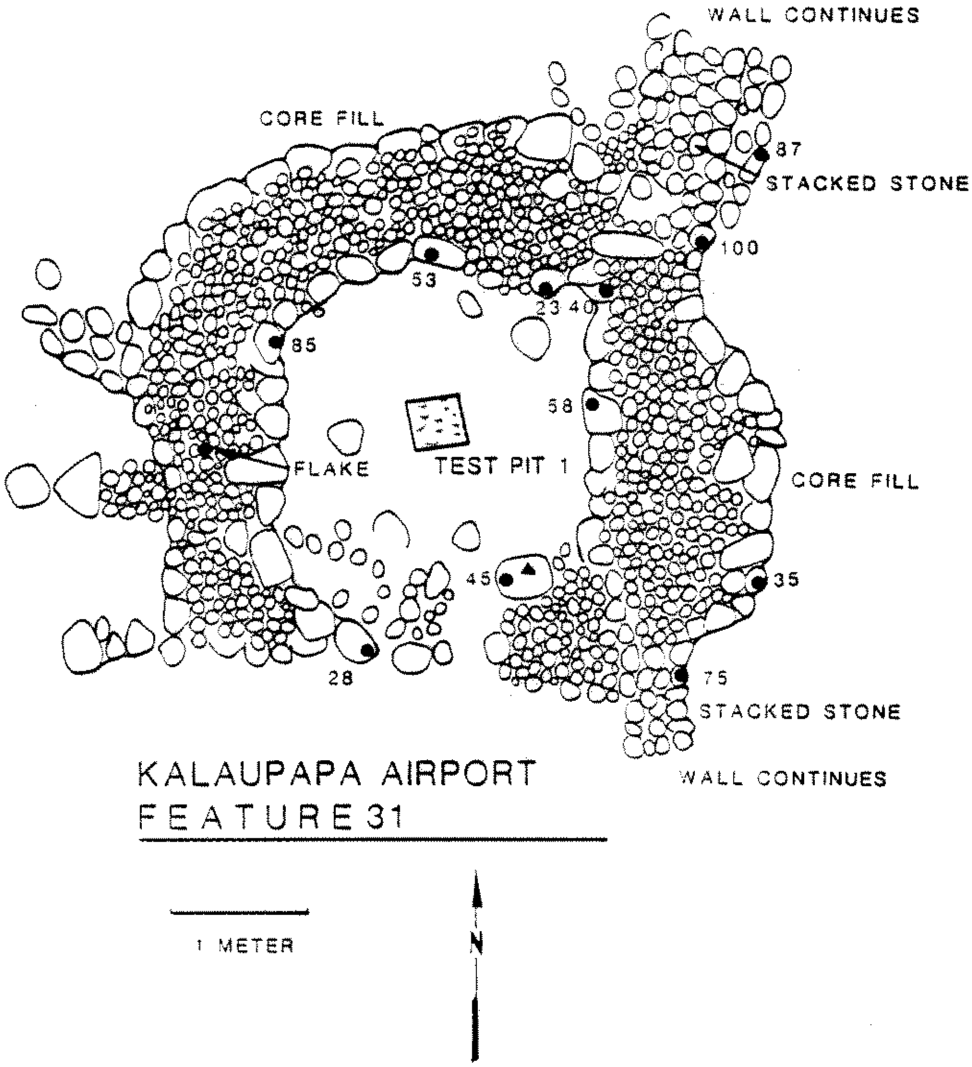


Figure 33. Map of Feature 31.

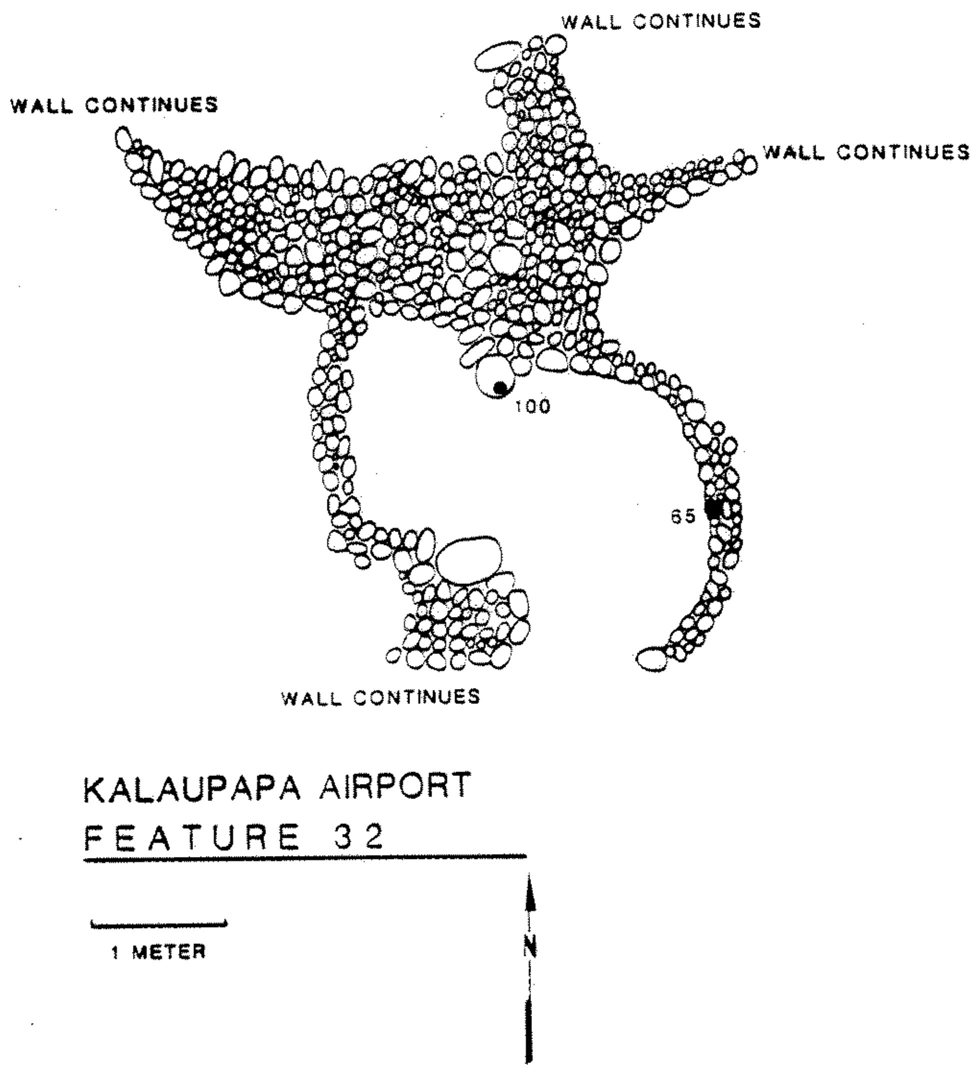


Figure 34. Map of Feature 32.

Feature 33

Feature 33 is a curved core-filled wall remnant with a small C-shape built into it (see Figure 2). The wall extends underneath the fill used to construct the airfield. The wall might have formed part of an enclosure that was destroyed when the airfield was built. The wall surrounds a small swale and incorporates portions of the bedrock outcrop. It is ca. 34 m long, has a maximum width of 1 m, and a height ranging between 60 to 130 cm. The facing stones of the wall range between 20 and 55 cm, and the fill stones between 7 and 20 cm. The swale area to the southeast of the wall was examined for additional archaeological Features but none were noted. A small 2 by 2 m C-shape is incorporated into a portion of the wall. It is ca. 80 cm wide and 70 cm high. Subsurface testing was not conducted at this feature. In the future the surrounding area should be intensively surveyed to make sure that all archaeological components have been recorded.

Feature 34

Feature 34 is a small oblong enclosure (Fig. 35). It is built near the base, up against the windward side of a small knoll. The feature's overall size is 4.5 by 1.8 m, and its interior dimensions are 1.5 by 0.9 m. The windward, east portion of the enclosure is core-filled with large (50 cm) boulders forming the exterior and interior facing, and small (5 to 20 cm) rocks forming the fill. The leeward west wall is a single course of large boulders. The maximum wall width is 50 cm. Several pieces of coral were noted on the surface of the feature. Subsurface testing was not conducted at this feature.

Feature 35

Feature 35 contains two C-shapes, a terrace, and a low wall (Fig. 36). All of the structures are located on the leeward side of a small knoll. The northern most C-shape is 5.3 by 3 m, with an interior dimension of 1.7 by 1.4 m. It is stacked stone with an interior face. It has a maximum wall width of 2 m, and it ranges in height between 95 cm to 35 cm. A subsurface slablined hearth was uncovered during the test excavations.

The terrace is ca. 1 m to the south of the northern most C-shape. The terrace is 4 by 1 m. The maximum height of the face is 65 cm. The terrace is roughly paved with small rocks.

The southern C-shape consists of roughly stacked rocks. It is ca. 4.4 by 1 m, with an interior measurement of 3 by 1.4 m. It does not contain any formal facings. Extending off of the east side of the feature is a low stacked stone wall, ca. 60 cm wide and 40 cm high. It extends around the edge of the outcrop to Feature 19. The feature was probably used for agricultural purposes.

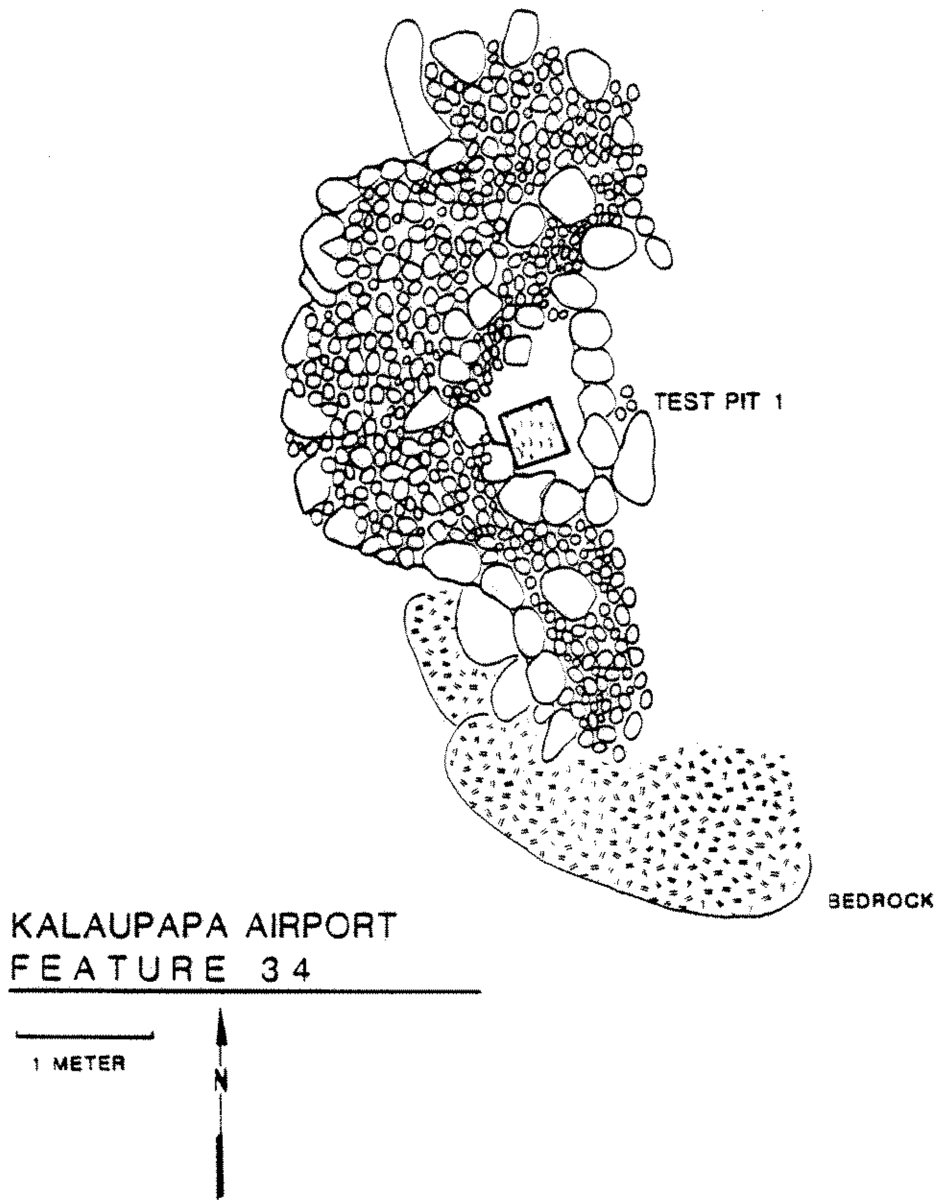


Figure 35. Map of Feature 34.

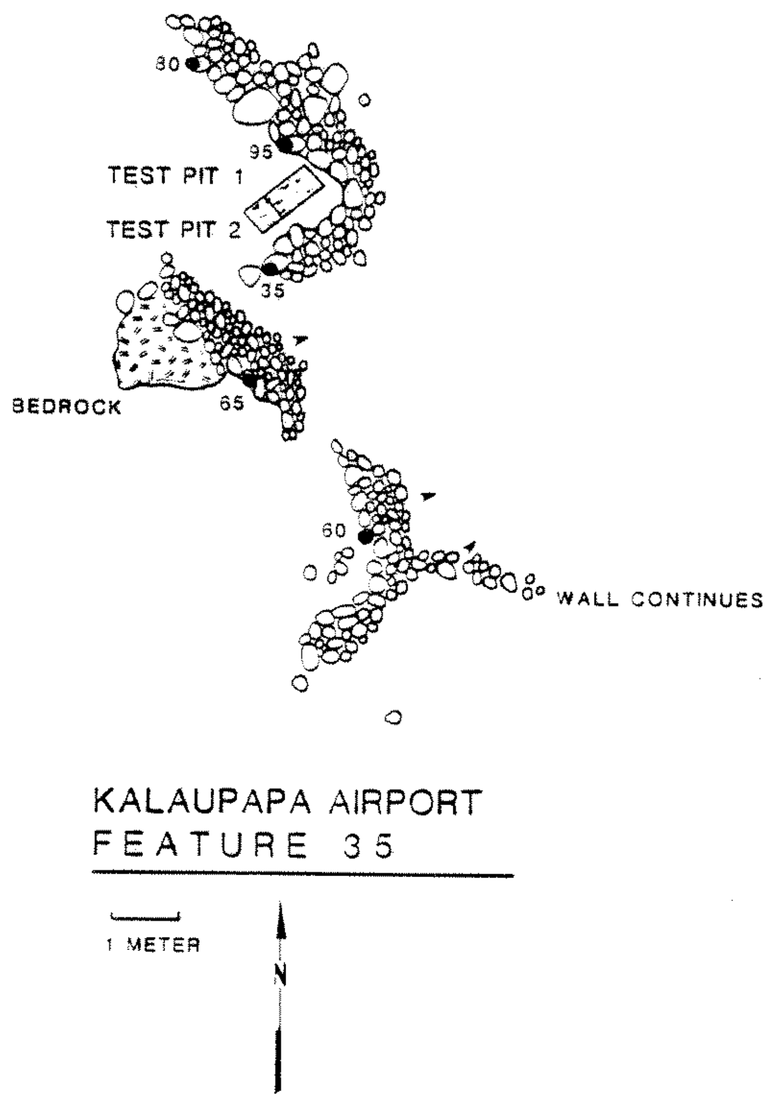


Figure 36. Map of Feature 35.

Feature 36

Feature 36 is a C-shape with an interior crypt (Fig. 37). It is located on the same ridge as Feature 15. Feature 15 extends along the ridge and connects with Feature 36. Feature 36 is 4 by 3.5 m, with an interior measuring 2.3 by 1.2 m. For most of its length and especially the northern wall, it is a double faced core-filled wall. The northern wall is the most formal portion. The windward eastern wall is somewhat disturbed. The southern portion of the wall is stacked stone. The feature has a maximum width of 3.5 m, and heights that range between 26 and 140 cm. Three 5 to 10 cm pieces of coral are on top of the wall.

The interior of the C-shape is a crypt. It is 1 by 0.5 m, and is defined on the east side by the windward wall and on the west by its edge. The top of the crypt is ca. 50 cm above ground surface. It was formed by laying large rocks on top of other rocks to form a cavity. At the south end of the crypt is a cupboard, made by implanting large boulders upright and covering them with capstones. It is ca. 1 m deep, 40 cm wide, and 60 cm high and incorporates part of the eastern wall of the C-shape. The function of the feature has not been determined. There is a possibility that it is a burial, but alternatively it could just be a storage area. The feature would have to be dismantled to determine if it is a burial. Subsurface testing was not conducted at this feature.

Feature 37

Feature 37 is a 5.5 by 4.4 m concrete foundation. It is surrounded by a large amount of historic debris including pieces of metal and lumber. The feature is probably the foundation of a historic house. The enclosure walls of Feature 5B appear to run into the disturbed area suggesting that the two features might be contemporaneous. However, a large amount of rock rubble near the west side of the break in the enclosure might indicate that the enclosure was built first and later modified to incorporate the new house. This is in contrast to Feature 10, where the enclosure wall neatly abuts the feature. Subsurface testing was not conducted at this feature.

Feature 38

Feature 38 is another concrete foundation near the west entrance of enclosure Feature 5B. It is 4.4 by 3.3 m. In comparison to Feature 37, there is less associated historic material, however there are a few pieces of metal and wood. The feature appears to be the foundation of a historic structure associated with the historic house site designated Feature 37. Subsurface testing was not conducted at this feature.

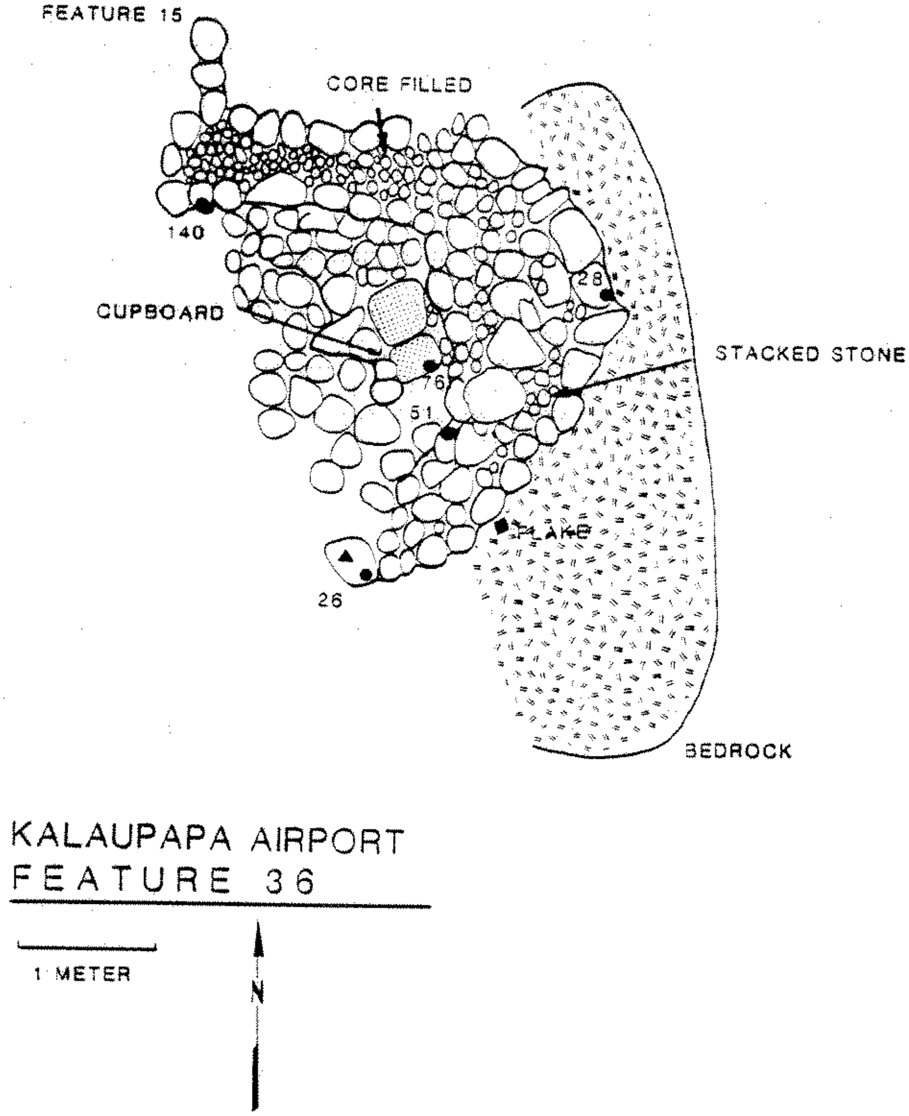


Figure 37. Map of Feature 36.

Feature 1 East

Feature 1E is a rough linear alignment situated on a level plane south of the runway. This area might have been bulldozed at one time. The alignment is ca. 45 m long, 50 cm wide, and 5 to 20 cm high. It is made out of small 10 to 15 cm cobbles stacked 1 to 2 courses high. There do not appear to be any other walls in the immediate area. The function of the wall is unclear, but it was possibly used for agricultural purposes or is of modern origin. Subsurface testing was not conducted at this feature.

Feature 2 East

Feature 2E is a 2 by 1.7 m rubble mound. Its height ranges between 14 and 40 cm. The feature is not well constructed. Constituent rocks appear to be piled up in a random manner. About 50 cm from the feature there is a 3 inch metal pipe. The pipe runs along a southwest to northeast axis. It is unclear weather the rubble mound is associated with the metal pipe, or served some other unrelated function. Subsurface testing was not conducted at this feature.

Feature 3 East

Feature 3E is a C-shape with an adjacent platform. It is probable that the feature is located outside of the study area. It is a stacked stone feature which incorporates part of a bedrock outcrop. The overall dimensions of the feature are 3.6 by 2.7 m. Its height ranges between 25 to 50 cm. The wall is 1 to 2 courses high. A possible slablined hearth is located in the middle of the C-shape. Subsurface testing was not conducted at this feature.

Feature 4 East

Feature 4E consists of a low rubble mound and several low walls located in a small swale just to the south of the road. The mound is 3.2 by 1.8 m, and ranges in height between 15 to 20 cm. It has no facings, rather is constructed out of stacked stone. The walls are also stacked stone. They are ca. 40 cm wide and 30 cm high. It is probable that the features throughout the swale are part of an agricultural complex. Subsurface testing was not conducted at this feature.

Feature 5 East

Feature 5E consists of two adjoined C-shapes near the east end of the swale that contains Feature 4E. Their overall dimensions are 3.2 by 1.8 m and 4.5 by 2 m, and their height ranges between 15 and 40 cm. They are not formally constructed. The walls are low stacked stone rubble alignments. It is probable that they are part of the same agricultural complex as Feature 4E. Subsurface testing was not conducted at this feature.

Feature 6 East

Feature 6E includes 2 enclosures, a wall and a terrace. They are situated on the lee side of the relatively large hill upon which the lighthouse is located. The structures are probably located just outside (south) of the study area. They are covered by extensive vegetation making a precise description impossible at this time. The wall is quite massive. It is ca. 25 m long, up to 3 m wide, 2 m high, and is constructed out of boulders up to 1.5 m in diameter. Some of the boulders are part of a bedrock outcrop. The terrace and the enclosures extend off of the wall. They are somewhat disturbed. Subsurface testing was not conducted at this feature.

Feature 7 East

Feature 7E is a heavily disturbed platform situated 1 m south of the road that parallels the runway (Fig. 38 and Photo 20). It is 5.25 by 4 m, with a maximum height of 50 cm. All four sides of the platform are faced with rocks ranging in size from 10 to 60 cm. The fill of the platform is small 10 to 30 cm rocks. A limited amount of marine shell was noted in the area. Its precise function is unknown. At one time it could have been the foundation for a small structure or water tank, or alternatively it could be a historic grave. Subsurface testing would be required to determine its function. Subsurface testing was not conducted at this feature.

Feature 8 East

Feature 8E is a 8.5 m long, 50 cm wide, 15 to 30 cm high, wall. It is situated on the lee slope of the lighthouse hill. It is a 1 to 2 course high stacked stone wall, with rocks ranging in size from 10 to 25 cm. It was probably used for agricultural purposes. Subsurface testing was not conducted at this feature.

Feature 9 East

Feature 9E consists of 2 C-shapes, a platform, and 2 alignments (Fig. 39 and Photo 22). All of the structures are situated on a gentle slope ca. 20 m from the coastal berm. The eastern most C-shape is disturbed and might have been an enclosure at one time. Presently the "opening" of the structure is on the windward side, and the most massive wall is on the lee side. This might suggest that the northern portion of the feature has been disturbed. Its overall dimensions are 5.2 by 1.5 m, with the interior measuring 1.5 by 0.75 m. The maximum wall width is 80 cm, and the maximum height is 70 cm. A few pieces of modern looking metal were noted on the surface. This feature might have been used for residential or agricultural purposes.

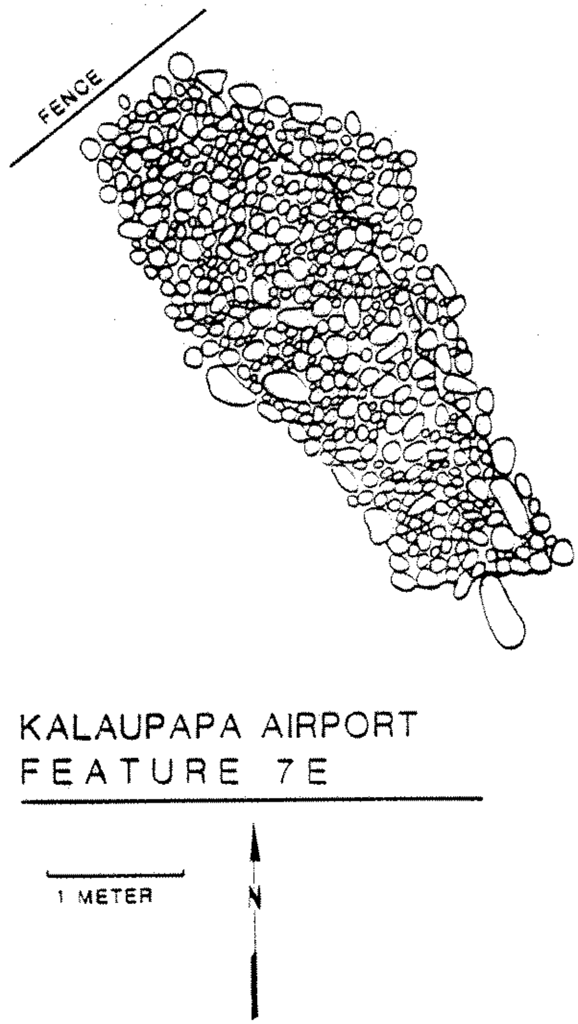


Figure 38. Map of Feature 7E.

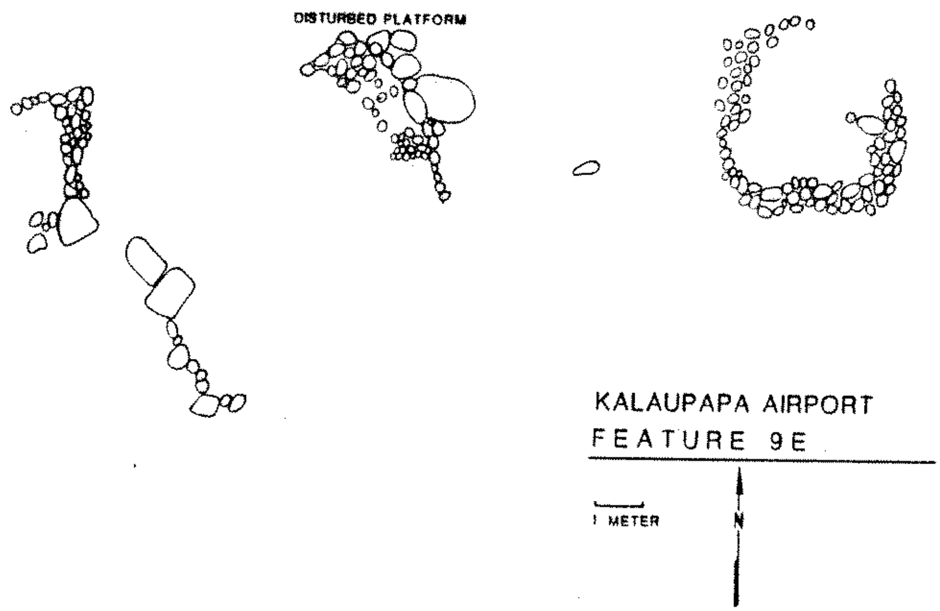


Figure 39. Map of Feature 9E.

The middle C-shape is 5.3 by 5 m, with an interior measuring 3 by 1.5 m. It is made out of stacked stone, with the interior facing. At the north end of the feature there is a rough 1.25 by 1 m platform. This feature might have been some sort of field shelter. The western most alignments are made out of stacked stone and incorporate some large boulders which might be part of a bedrock outcrop. The northern most of these alignments is faced on its eastern side. These two alignments were probably used for agricultural purposes. Subsurface testing was not conducted at this feature.

Feature 10 East

Feature 10E is a complex of at least 11 C-shapes, 2 walls, and 2 enclosures (Fig. 40 and Photo 21). More intensive clearing and mapping of the area might reveal additional structures. The structures are not well constructed, and some of them look disturbed. Most of them are stacked stone with interior faces. The walls of the structures are ca. 50 to 70 cm wide and their maximum height is ca. 90 cm. There are a few fragments of ceramics, glass, and metal, on the surface of one of the enclosures. Despite these artifacts, the features were probably used as a agricultural complex. Subsurface testing was not conducted at this feature.

Feature 11 East

Feature 11E is a cupboard formed by two large boulders and several stacked stones (Fig. 41). Its overall dimensions are 2.27 by 1.9 m, with the interior measuring 1.6 by 1 m. Its maximum interior height is 90 cm. Several small rocks have been placed on top of two large adjacent boulders to form the cupboard. There is a low stacked stone wall extending between the leeward ends of the boulders. Several lithic flakes were noted inside of the cupboard. Subsurface testing was not conducted at this feature.

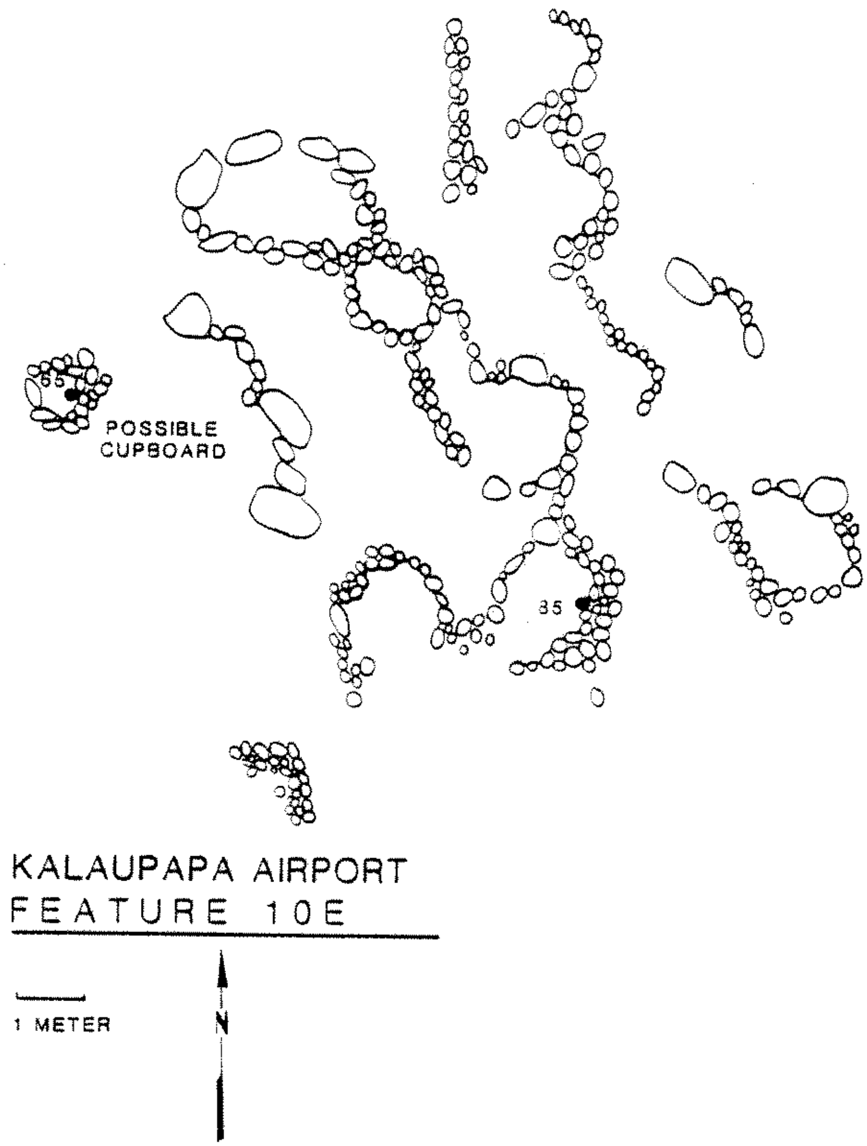


Figure 40. Map of Feature 10E.

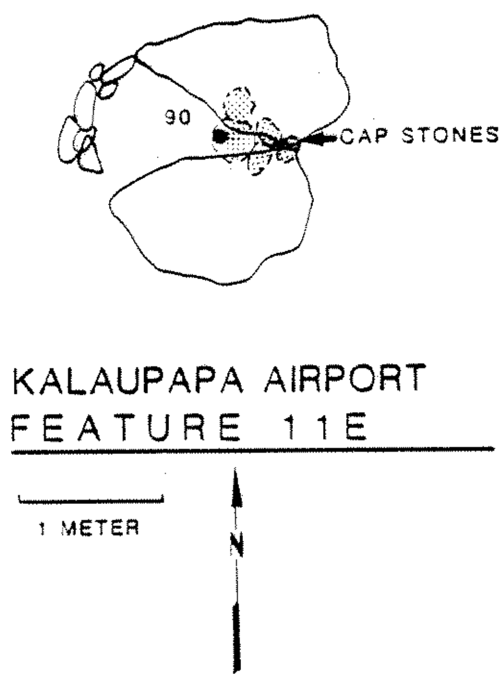


Figure 41. Map of Feature 11E.

EXCAVATIONS

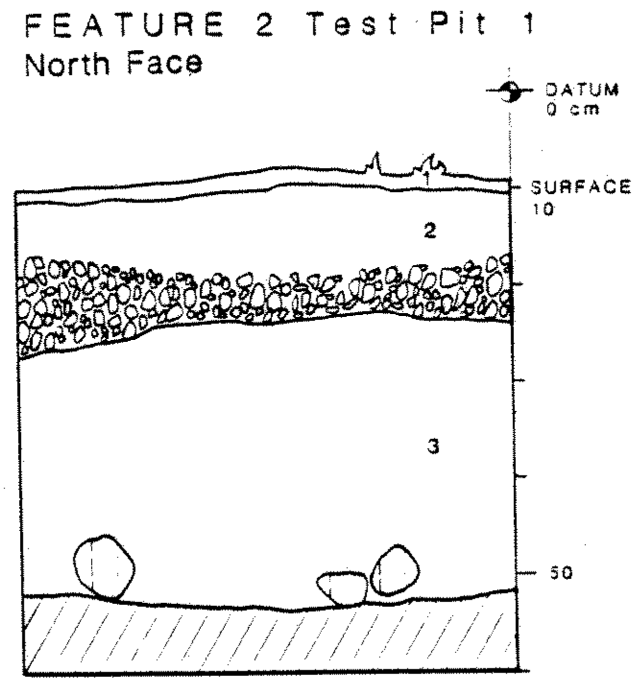
A total of 23 controlled test pits (TP) totalling 11.0 square meters were excavated at 21 different features. In the following sections, the subsurface testing of each feature is discussed separately. Primary attention is given to 1) the midden and artifact contents of each layer and level, 2) the number of cultural deposits and subsurface components found within the test unit, 3) the relative and absolute chronology of the archaeological remains, and 4) the possible function or use of the feature. The test units are discussed in the numerical order of their associated feature. The concentration indices reported in the tables were calculated by dividing the total weight or count of a material by the total volume of the processed deposit. Concentration indices are thus cited as the amount of a unit (whether it be grams or a count) per cubic meter.

Feature 2, TP-1

Feature 2 TP-1 is a 50 x 50 cm unit located ca. 1.5 m down wind of a residential structure (see Figure 8). The test pit was placed away from the actual rock feature so that the sediment deposits surrounding the feature could be tested. The purpose of the test pit was to investigate the existence of any subsurface cultural deposits and to determine the function and chronology of the associated residential feature. Table 4 is a list of the layers and levels in the test pit, their volume, and their depth below datum. Figure 42 is a stratigraphic profile of TP-1. Table 5 is a list of the materials recovered during the excavation, and the concentration indices for those materials. Table 6 is a list of the shell midden from the feature. The entire deposit of the unit contained wave washed shell and coral. This undoubtedly skews the quantity of crab, sea urchin, and shell midden reported in Tables 5 and 6.

There was lantana, grass, decomposing vegetation, and wave washed shell on the surface of the test pit. Layer 1 was a loose deposit of wave washed shell and decomposing vegetation containing some pieces of shell midden. Layer 2 was a cultural deposit with a pebble paving. The paving was ca. 10 cm thick and made out of small 2 to 5 cm pebbles. The layer yielded small amounts of charcoal and kukui nut, 1 piece of basalt, 1 piece of volcanic glass, and 8 historic artifacts. The artifacts included 2 pieces of clear glass, 2 small (3 to 4 mm) glass beads, 3 pieces of chert, and 1 small piece of metal (1 cm by 5 mm). Also faunal material from Scarid and some other unidentified fish were recovered.

Layer 3 was a dark brown deposit containing far fewer pebbles. The layer yielded small amounts of charcoal, 1 small piece of fish bone, and 1 small piece of indeterminate bone. In Layer 3, Levels 2 and 3, 30% of the unit was filled by loose cobbles ranging in size from 15 to 25 cm. The cultural association of the cobbles is unclear, but they do not appear to be part of a paving. Beneath Layer 3 Level 3 the deposit appeared sterile.



Layer	Munsell Color	Boundary	Description
1	-	abrupt (smooth)	silt loam, with wave washed shell and coral, lots of roots and vegetation
2	10YR 2/2 (very dark brown)	abrupt (smooth)	silt loam, with wave washed shell and coral; basalt pebbles
3	10YR 3/3 (dark brown)	-	silt loam, with wave washed shell and coral

Figure 42. Profile and sediment description of Feature 2, TP-1.

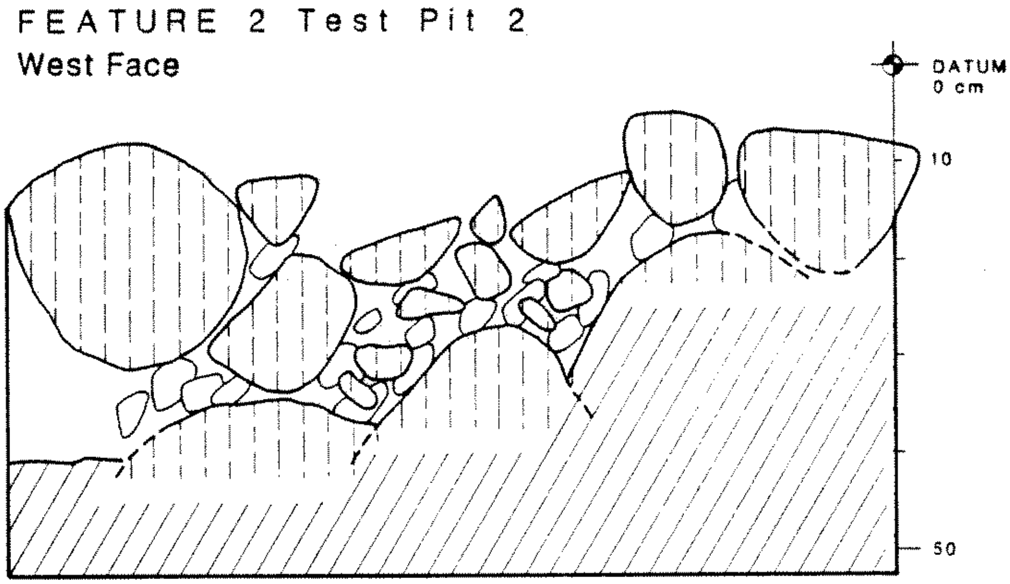
Table 4. The depth and volume of excavated materials of each layer and level from Feature 2, TP-1.

Layer	Level	Depth (cm below datum)	Volume Excavated (cubic meters)
surf.		8/9	0.0000000
1	1	8/9 to 8/10	0.0028274
2	1	8/10 to 18	0.0340650
2	2	18 to 23	0.0125000
3	1	23 to 33	0.0255487
3	2	33 to 43	0.0127744
3	3	43 to 53	0.0250000
*** Total ***			0.1127155

The results of the excavation indicate that the area immediately adjacent to Feature 2 was occupied during the historic era. Since a subsurface paving was contained in the cultural deposit, further excavations should focus on clearly defining the subsurface architectural components and the existence of further buried deposits.

Feature 2, TP-2

Feature 2 TP-2 is a 1 x 1 m unit in a low platform which is one of the internal architectural components of Feature 2 (see Figure 8, and Photos 1, 2). There was a 50 by 45 cm concentration of coral on top of the platform. The purpose of the test pit was to determine if the platform was a burial. Unfortunately, the results of the excavation were inconclusive. A vertical datum was established 10 cm above the surface of the platform, which was ca. 60 cm above the ground surface. Table 7 is a list of the layers and levels in the test pit, their volume, and their depth below datum. Figure 43 is a stratigraphic profile of TP-2. Tables 8 and 9 are lists of the materials recovered during the excavation, and the concentration indices for those materials.



Layer	Munsell Color	Boundary	Description
1	-	-	pebble, cobble, boulder fill

Figure 43. Profile and sediment description of Feature 2, TP-2.

Table 5. List of materials from Feature 2, TP-1. CI refers to concentration index for the previous column in unit per cubic meter.

Layer	Level	Charcoal (gm)	Charcoal (CI)	Kukui (gm)	Kukui (CI)	Urchin (gm)	Urchin (CI)	Shell (gm)	Shell (CI)	Historic Artifact Count	Historic Artifact Count (CI)
surf.		-	-	-	-	-	-	-	-	-	-
1	1	-	-	-	-	1.0	353.7	25.0	8842.0	-	-
2	1	0.4	11.7	0.6	14.7	5.0	146.8	447.0	13122.0	7	205.5
2	2	0.1	8.0	-	-	2.0	160.0	109.0	8720.0	1	80.0
3	1	0.8	31.3	-	-	4.0	156.6	455.0	17809.1	-	-
3	2	0.1	7.8	-	-	2.0	156.6	163.0	12759.9	-	-
3	3	-	-	-	-	1.0	40.0	88.0	3520.0	-	-
*** Total ***		1.4		0.6		15.0		1287.0		8	285.5

Layer	Level	Flake Count	Flake Count (CI)	Flake Weight (gm)	Flake Weight (CI)	Shatter Count	Shatter Count (CI)	Shatter Weight gms.	Shatter Weight (CI)	Polished Flake Count	Polished Flake (CI)	Polished Flake Weight (gm)	Polished Flake Weight (CI)
surf.		-	-	-	-	-	-	-	-	-	-	-	-
1	1	-	-	-	-	-	-	-	-	-	-	-	-
2	1	-	-	-	-	1	29.4	0.3	8.8	1	29.4	2.0	58.7
2	2	2.0	160.0	54.0	4320.0	-	-	-	-	-	-	-	-
3	1	-	-	-	-	-	-	-	-	-	-	-	-
3	2	-	-	-	-	-	-	-	-	-	-	-	-
3	3	-	-	-	-	-	-	-	-	-	-	-	-
*** Total ***		2.0		54.0		1		0.3		1		2.0	

Table 6. List of shell midden from Feature 2, TP-1. CI refers to concentration index for the previous column in grams per cubic meter.

Layer	Level	Trochus (gm)	Trochus (CI)	Turbo (gm)	Turbo (CI)	Oper-culae (gm)	Oper-culae (CI)	Nerita (gm)	Nerita (CI)	Theo-doxus (gm)	Theo-doxus (CI)	Cellana (gm)	Cellana (CI)	Hip-ponix (gm)	Hip-ponix (CI)
surf.		-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	1	-	-	-	-	-	-	2.0	707.4	-	-	27.0	9549.4	1.0	353.7
2	1	-	-	3.0	88.1	1.0	1.0	23.0	675.2	1.0	29.4	62.0	1820.0	8.0	234.8
2	2	-	-	-	-	1.0	1.0	7.0	560.0	-	-	6.0	480.0	5.0	400.0
3	1	1.0	39.1	2.0	78.3	1.0	1.0	32.0	1252.5	-	-	38.0	1487.4	15.0	587.1
3	2	-	-	2.0	156.6	1.0	1.0	9.0	704.5	-	-	17.0	1330.8	4.0	313.1
3	3	1.0	40.0	-	-	-	-	4.0	160.0	1.0	40.0	6.0	240.0	1.0	40.0
*** Total ***		2.0		7.0		4.0		77.0		2.0		156.0		34.0	

Layer	Level	Cypraea (gm)	Cypraea (CI)	Conus (gm)	Conus (CI)	Strombus (gm)	Strom-bus (CI)	Cymatium (gm)	Cymatium (CI)	Drupa (gm)	Drupa (CI)	Morula (gm)	Morula (CI)
surf.		-	-	-	-	-	-	-	-	-	-	-	-
1	1	-	-	-	-	-	-	-	-	-	-	-	-
2	1	80.0	2348.5	9.0	264.2	1.0	29.4	3.0	88.1	10.0	293.6	-	-
2	2	9.0	720.0	-	-	-	-	-	-	6.0	480.0	-	-
3	1	40.0	1565.6	7.0	274.0	4.0	156.6	-	-	4.0	156.6	-	-
3	2	11.0	861.1	1.0	78.3	-	-	-	-	-	-	2.0	156.6
3	3	7.0	280.0	1.0	40.0	-	-	-	-	1.0	40.0	1.0	40.0
*** Total ***		147.0		18.0		5.0		3.0		21.0		3.0	

Table 6 (cont.). List of shell midden from Feature 2, TP-1. CI refers to concentration index for the previous column in grams per cubic meter.

Layer	Level	Lit-torina (gm)	Lit-torina (CI)	Tel-lina (gm)	Tel-lina (CI)	Peri-glypta (gm)	Peri-glypta (CI)	Isong-omon (gm)	Isong-omon (CI)	Unident-ified (gm)	Unident-ified (CI)
surf.		-	-	-	-	-	-	-	-	-	-
1	1	-	-	-	-	-	-	-	-	5.0	1768.4
2	1	4.0	117.4	-	-	8.0	234.8	4.0	117.4	227.0	6663.4
2	2	2.0	160.0	-	-	-	-	-	-	72.0	5760.0
3	1	11.0	430.6	1.0	39.1	-	-	6.0	234.8	292.0	11429.2
3	2	4.0	313.1	-	-	2.0	156.6	1.0	78.3	104.0	8141.3
3	3	3.0	120.0	-	-	-	-	1.0	40.0	61.0	2440.0
*** Total ***		24.0		1.0		10.0		12.0		761.0	

Table 7. The depth and volume of excavated materials of each layer and level from Feature 2, TP-2.

Layer	Level	Depth (cm below datum)	Volume Excavated (cubic meters)
surf.		1/34	0.0000000
1	1	1 to 63	0.0170325
*** Total ***			0.0170325

Rocks and a small amounts of vegetation covered the surface of the platform. Rocks ranging in size from 5 cm to 50 cm were neatly chinked into a paving. Layer 1 extends from 1 to 63 cm BD. Because there was very little sediment, Layer 1 consists primarily of the rocks removed from the unit. The layer yielded small amounts of kukui nut, sea urchin, and shell, as well as 1 piece of basalt and 3 pieces of green bottle glass. The bottle glass came from depths of 35, 40, and 47 cm BD. At 36 cm BD a 40 by 40 cm rock was encountered in the center of the test pit. Other rocks extending in from the side walls made it impossible to remove the 40 cm rock. In places it was possible to excavate down to 63 cm BD, but without expanding the test pit it became impossible to remove the lower rocks. This is unfortunate since the ground surface was estimated to be ca. 70 cm BD, thus the excavation did not really extend into any subsurface deposits.

The results of the excavation indicate that the platform was used during the historic era. However, the platform does not appear to be a crypt, and no skeletal remains were encountered. Unfortunately the inability to excavate into the subsurface deposit renders the test pit inconclusive. Further excavation is needed to determine the presence or absence of skeletal material.

Feature 5B, TP-1

Feature 5B TP-1 is a 100 x 50 cm unit located on the lee side of an agricultural wall. The purpose of the test pit was to investigate the existence of any subsurface cultural deposits or buried walls within the agricultural field system. Table 10 is a list of the layers and levels in the test pit, their volume, and their depth below datum. Figure 44 is a stratigraphic profile of TP-1. The entire deposit of the unit contained wave washed shell and coral. The test pit yielded no cultural material, but 2 buried walls were discovered (Photo 4).

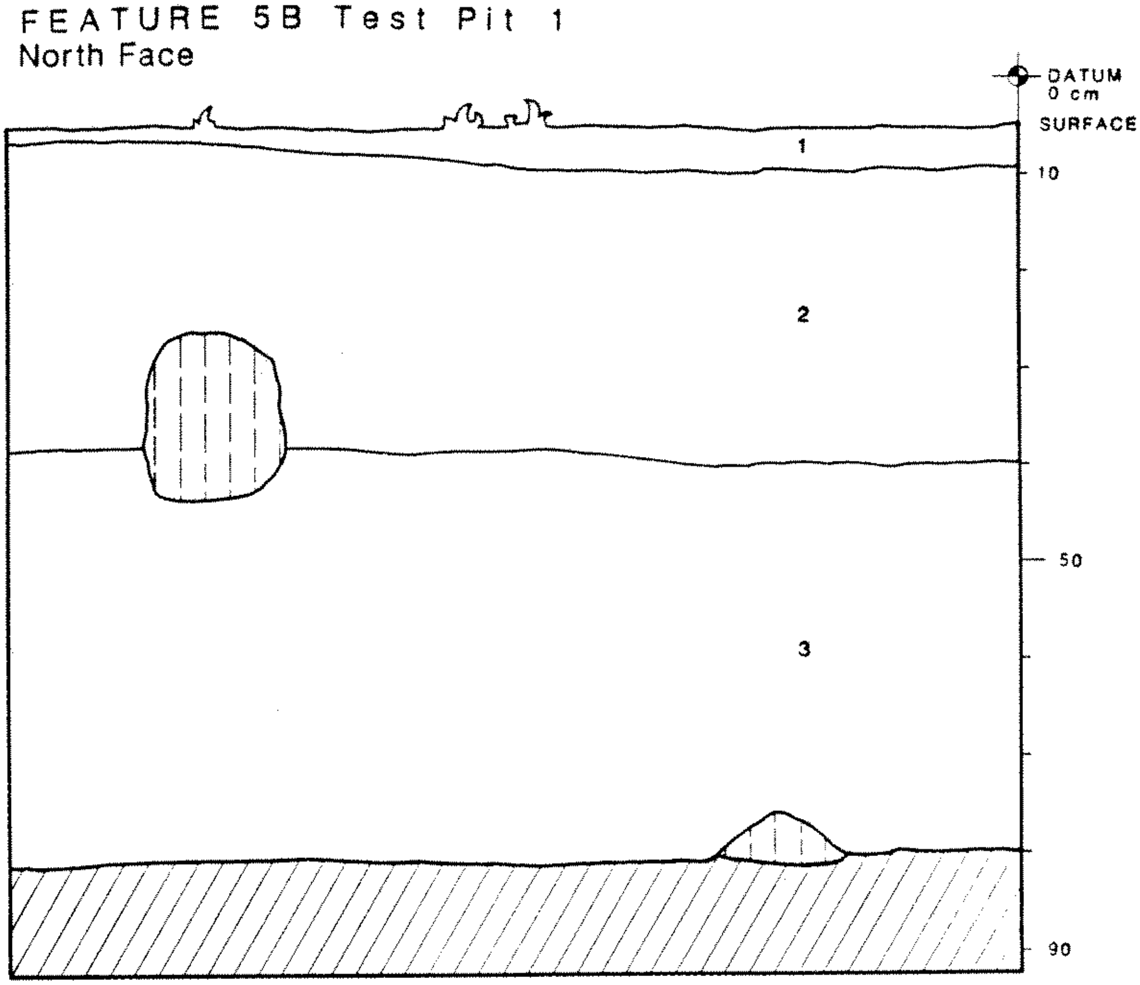
Table 8. List of materials from Feature 2, TP-2. CI refers to concentration index for the previous column in unit per cubic meter.

Layer	Level	Kukui (gm)	Kukui (CI)	Urchin (gm)	Urchin (CI)	Shell (gm)	Shell (CI)
surf.		-	-	-	-	-	-
1	1	9.4	551.9	1.0	58.7	46.0	2700.7
*** Total ***							
		9.4		1.0		46.0	

Layer	Level	Flake Count	Flake Count (CI)	Flake Weight (gm)	Flake Weight (CI)	Historic Artifact Count	Historic Artifact Count (CI)
surf.		-	-	-	-	-	-
1	1	1.0	58.7	7.0	411.0	3	176.1
*** Total ***							
		1.0		7.0		3	

Table 9. List of shell midden from Feature 2, TP-2. CI refers to concentration index for the previous column in grams per cubic meter.

Layer	Level	Nerita (gm)	Nerita (CI)	Cellana (gm)	Cellana (CI)	Conus (gm)	Conus (CI)	Isogn-omon (gm)	Isogn-omon (CI)	Unident-ified (gm)	Unident-ified (CI)
surf.		-	-	-	-	-	-	-	-	-	-
1	1	1.0	58.7	5.0	293.6	26.0	1526.5	13.0	763.2	1.0	58.7
*** Total ***											
		1.0		5.0		26.0		13.0		1.0	



Layer	Munsell Color	Boundary	Description
1	10YR 2/2 (very dark brown)	abrupt (smooth)	sandy loam with wave washed shell and coral
2	10YR 3/3 (dark brown)	abrupt (smooth)	loam with wave washed shell and coral
3	10YR 3/3 (dark brown)	-	loam with wave washed shell and coral

Figure 44. Profile and sediment description of Feature 5B, TP-1.

There was grass, decomposing vegetation, and wave washed shell and coral on the surface of the test pit. No large rocks or sections of wall were evident on the surface. Layer 1 Level 1 was the culturally sterile relatively loose deposit of decomposing vegetation and wave washed shell and coral. Layer 2 was a slightly more compact deposit of wave washed shell and coral. Only 0.0170325 m^3 of sediment was screened from each level of Layer 2. Layer 3 was very similar too Layer 2, but it appeared slightly browner. Only 0.0085162 m^3 of each level from this layer were screened.

In the west end of the unit an alignment of ca. twelve rocks ranging in size from 10 to 30 cm in diameter was found between 15 and 85 cm BD. The alignment appears to extend even deeper into the unexcavated deposit. At the east end of the unit there was a similar alignment of 5 rocks found between 29 and 65 cm BD. It is possible that these 2 distinct subsurface alignments are part of a buried field system. The subsurface alignment at the east end of the unit might be a buried segment of the surface alignment. The excavation, however, was inconclusive on this matter since the unit was placed to far away from the surface alignment. Because the test pit was so narrow it was impossible to reach the bottom of the deposit. Further excavation is needed to complete this task and to clearly define the extent of the subsurface alignments.

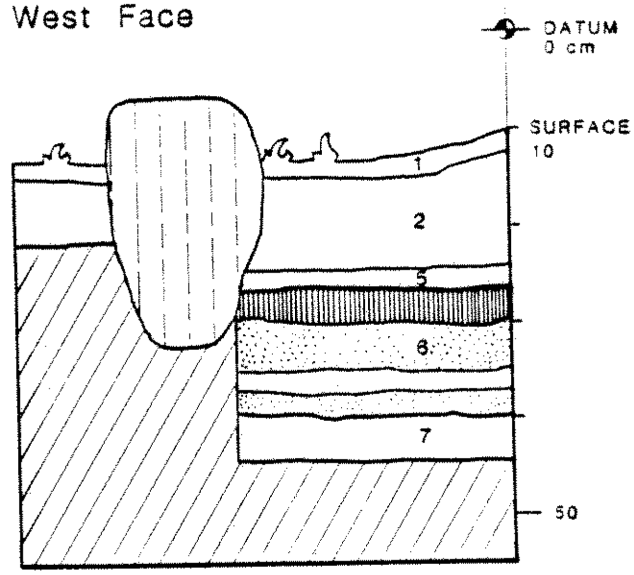
Feature 6, TP-1

Feature 6 TP-1 is a 50 x 50 cm unit encompassing a circular slablined hearth. The test pit is located behind a windbreak and next to an enclosure (see Figure 10). The purpose of the test pit was to gather cultural material from the hearth for analysis and dating. Table 11 is a list of the layers and levels in the test pit, their volume, and their depth below datum. Figure 45 is a stratigraphic profile of TP-1. Table 12 is a list of the materials recovered during the excavation, and the concentration indices for those materials. Wave washed shell and coral was present throughout the deposit. This undoubtedly skews the quantity of crab, urchin, and shell midden reported in Table 12.

There was grass, decomposing vegetation, and wave washed shell and coral on the surface of the test pit. Two surface slabs defined a hearth. Layer 1 Level 1 was the loose deposit of wave washed shell and vegetation removed from the entire test pit. Layer 2 Level 1 was a slightly harder deposit with charcoal flecking excavated from the interior of the hearth. It contained small amounts of kukui nut and 3 small pieces of polished basalt. Layer 2 Level 2 was a similar deposit, but the bottom 2 cm of the level was mottled and contained more charcoal.

Layer 3 Level 1 was a relatively sterile deposit excavated from the exterior of the hearth. It contained only small amounts of kukui nut, and no charcoal. Layer 4 Level 1 was underneath Layer 3. It was excavated from the exterior of the hearth and had slightly more charcoal than Layer 3. No further excavation took place outside of the hearth.

FEATURE 6 Test Pit 1
West Face



Layer	Munsell Color	Boundary	Description
1	-	abrupt (smooth)	loam with wave washed shell and coral
2	10YR 3/1 (very dark gray)	abrupt (smooth)	silt loam with wave washed shell and coral, slight charcoal flecking
3	5YR 2.5/1 (black	abrupt (smooth)	silt loam with wave washed shell and coral, slight charcoal flecking
4	5YR 3/1 (very dark gray)	abrupt (smooth)	silt loam with wave washed shell and coral, slight charcoal flecking
5	10YR 5/1 (gray)	gradual (irregular)	silt ash loam with charcoal
6	10YR 5/1 (ash: gray) 2.5YR 2/0 (charcoal: black)	abrupt (smooth)	silt ash loam with charcoal
7	7.5YR 5/2 (brown)	-	sandy silt with wave washed shell and coral

Figure 45. Profile and sediment description of Feature 6, TP-1.

Table 10. The depth and volume of excavated materials of each layer and level from Feature 5, TP-1.

Layer	Level	Depth (cm below datum)	Volume Excavated (cubic meters)
surf.		3/7	0.0000000
1	1	3/7 to 4/8	0.0127744
2	1	4/8 to 14	0.0340650
2	2	14 to 24	0.0681300
2	3	24 to 34	0.0553556
2	4	34 to 44	0.0396857
2	5	44 to 50	0.0425813
3	1	50 to 60	0.0510975
3	2	60 to 70	0.0681300
3	3	70 to 85	0.0681300
*** Total ***			
			0.4399495

Table 11. The depth and volume of excavated materials of each layer and level from Feature 6, TP-1.

Layer	Level	Depth (cm below datum)	Volume Excavated (cubic meters)
surf.		9/13	0.0000000
1	1	9/13 to 9/14	0.0042581
2	1	9/14 to 19	0.0127744
2	2	19 to 29	0.0212906
3	1	9/14 to 14/18	0.0030000
4	1	14/18 to 24	0.0034065
5	1	29 to 36	0.0127744
6	1	36 to 41	0.0085162
7	1	36 to 43	0.0100000
*** Total ***			
			0.0760202

Table 12. List of materials from Feature 6, TP-1. CI refers to concentration index for the previous column in unit per cubic meter.

Layer	Level	Charcoal (gm)	Charcoal (CI)	Kukui (gm)	Kukui (CI)	Urchin (gm)	Urchin (CI)	Shell (gm)	Shell (CI)	Polished Flake Count	Polished Flake Count (CI)	Polished Flake Weight (gm)	Polished Flake Weight (CI)
surf.		-	-	-	-	-	-	-	-	-	-	-	-
1	1	-	-	-	-	-	-	57.0	13386.3	-	-	-	-
2	1	0.1	7.8	0.1	7.8	4.0	313.1	111.0	8689.3	3	234.8	4.0	313.1
2	2	11.7	549.5	-	-	20.0	939.4	392.0	18411.9	-	-	-	-
3	1	-	-	0.4	133.3	-	-	32.0	10666.7	-	-	-	-
4	1	1.8	528.4	-	-	7.0	2054.9	74.0	21723.2	-	-	-	-
5	1	15.7	1229.0	0.1	7.8	7.0	548.0	117.0	9158.9	-	-	-	-
6	1	0.2	280.0	-	-	1.0	1400.2	15.0	21002.5	-	-	-	-
7	1	-	-	-	-	-	-	-	-	-	-	-	-
*** Total ***		29.5		0.6		39.0		798.0		3		4.0	

Layer 5 Level 1 was the next stratum excavated from the interior of the hearth. It was a mottled sediment of ash and charcoal with small amounts of kukui nut and 1 piece of fish bone. Layer 6 Level 1 was the main ash and charcoal deposit of the hearth. It was a small deposit and only 0.0007142 m^3 of it was processed. The remaining 0.001 m^3 of the deposit has been saved for future analysis. Layer 7 Level 1 was a sterile deposit under Layer 6.

The excavation confirmed the presence of a slablined hearth with a single ash and charcoal deposit bordered by mottled deposits. Despite this single cultural deposit, the location of the hearth so close to a wall of the enclosure suggests that the feature was occupied in several phases. The feature was apparently used as a shelter.

Feature 8, TP-1

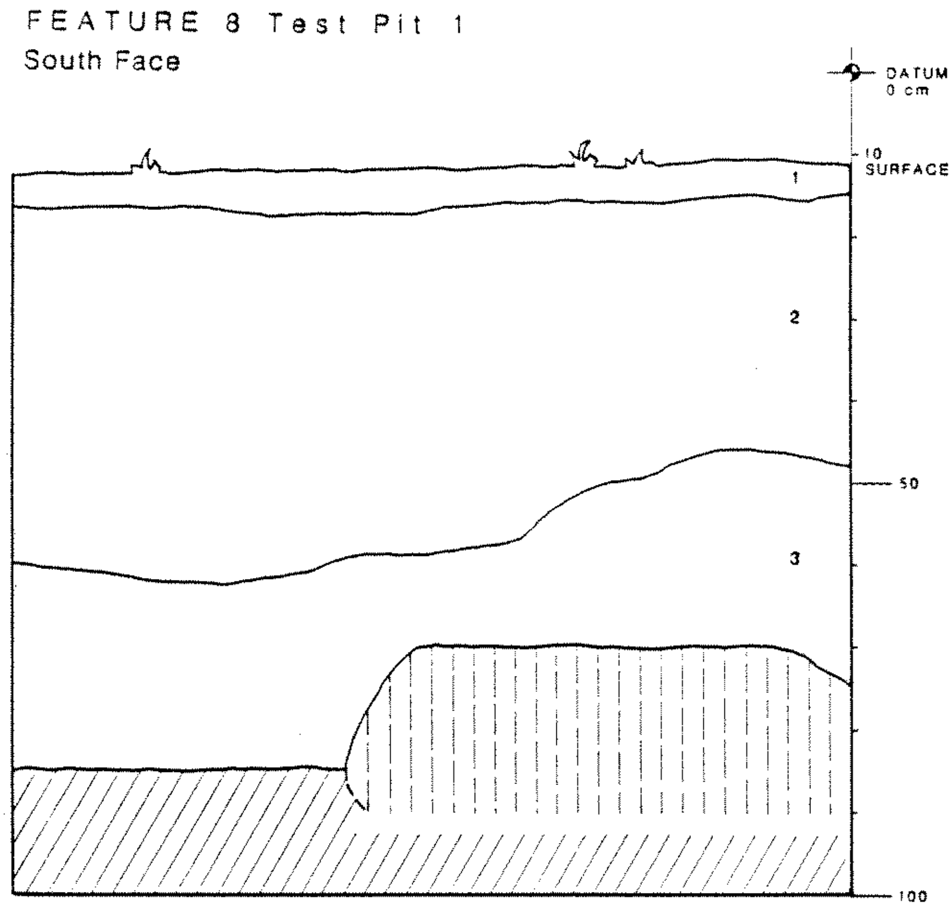
Feature 8 TP-1 is a 100 x 50 cm unit located behind a shelter alignment in the middle of agricultural complex 5B (see Figure 12). The purpose of the test pit was to determine if the area had been used as a shelter. Also we wanted to determine if there were any subsurface alignments within the agricultural field system. Table 13 is a list of the layers and levels in the test pit, their volume, and their depth below datum. Figures 46 and 47 are stratigraphic profiles of TP-1. Table 14 is a list of the materials recovered during the excavation, and the concentration indices for those materials. Table 15 is a list of the shell midden from the feature. The entire deposit of the unit contained wave washed shell and coral. This undoubtedly skews the quantity of crab, urchin, and shell midden reported in Tables 14 and 15.

There was lantana, low grass, and decomposing vegetation on the surface of the test pit. In addition there was wave washed shell, shell midden, faunal midden, and a few pieces of basalt. Layer 1 Level 1 was the thin loose deposit just below the surface. It contained small amounts of charcoal, kukui, and crab, moderate amounts of sea urchin, 6 pieces of basalt, and 25 pieces of volcanic glass. The faunal material from the level includes 1 piece of Scarid, 10 pieces of undetermined fish, and 1 piece of Rattus exulans (Polynesian Rat).

Layer 2 Level 1 was a grayish deposit of wave washed shell and coral. It contained a similar assemblage of cultural material as Layer 1 Level 1, with the notable exceptions of an increase in volcanic glass, and 1 small piece of material that is probably historically introduced chert. This lithic flake is grey with black speckles. It is 1 cm by 5 mm, and has ca. 6 small flake scars on it. The faunal material from the level includes several types of fish, 4 pieces of Rattus exulans (Polynesian Rat), and 1 piece of Bufo marinus (Giant Neotropical Toad). The Bufo marinus was introduced to the Hawaiian Islands in 1932. The chert and the faunal material from a historically introduced species clearly indicate that the layer was deposited relatively recently. The very bottom of the level contained the top of a rock which was part of a buried alignment. This alignment will be discussed at the end of this excavation description.

Table 13. The depth and volume of excavated materials of each layer and level from Feature 8, TP-1.

Layer	Level	Depth (cm below datum)	Volume Excavated (cubic meters)
surf.		8/13	0.0000000
1	1	8/13 to 13/16	0.0255487
2	1	13/16 to 23	0.0510975
2	2	23 to 33	0.0510975
2	3	33 to 43	0.0425813
2	4	43 to 53	0.0425813
2	5	53 to 55/64	0.0255487
3	1	55/64 to 65	0.0340650
3	2	65 to 75	0.0298069
3	3	75 to 85	0.0255487
*** Total ***			0.3278756



Layer	Munsell Color	Boundary	Description
1	10YR 8/2 (white)	abrupt (wavy)	silt loam with wave washed shell and coral
2	5YR 3/1 (very dark gray)	abrupt (wavy)	sandy loam with wave washed shell and coral, charcoal and ash flecking
3	10YR 3/3 (dark brown)	-	silt loam with wave washed shell and coral

Figure 46. Profile and sediment description of Feature 8, TP-1.

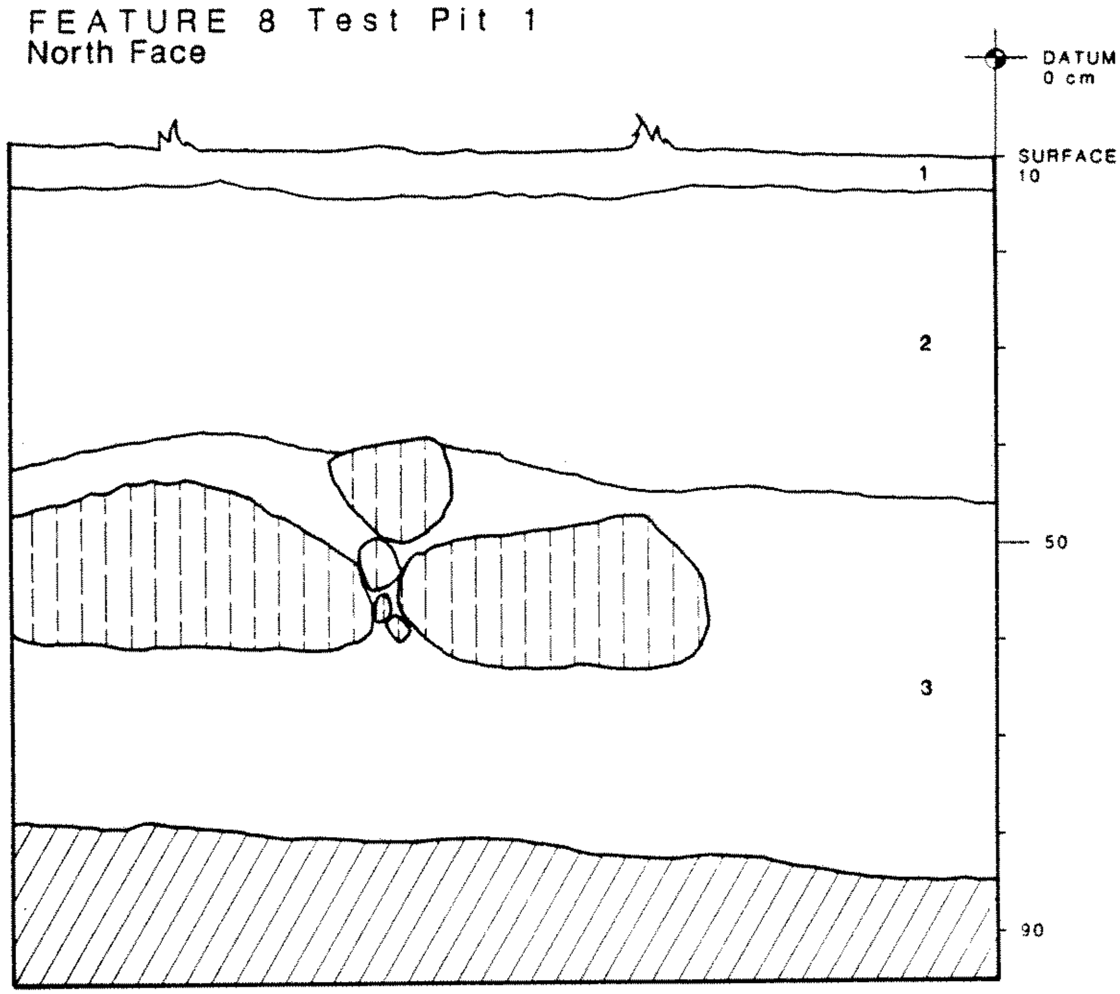


Figure 47. Profile of Feature 8, TP-1.

Table 14. List of materials from Feature 8, TP-1. CI refers to concentration index for the previous column in unit per cubic meter.

Layer	Level	Charcoal (gm)	Charcoal (CI)	Kukui (gm)	Kukui (CI)	Crab (gm)	Crab (CI)	Urchin (gm)	Urchin (CI)	Shell (gm)	Shell (CI)	Historic Artifact Count	Historic Artifact Count (CI)
surf.		-	-	-	-	-	-	-	-	-	-	-	-
1	1	0.1	3.9	1.0	39.1	0.1	3.9	16.0	626.3	760.0	29747.1	-	-
2	1	0.5	9.8	-	-	-	-	55.0	1076.4	1673.0	32741.3	1	19.6
2	2	12.0	234.8	0.1	-	-	-	55.0	1076.4	1700.0	33269.7	-	-
2	3	27.5	645.8	0.4	-	-	-	71.0	1667.4	1520.0	35696.4	-	-
2	4	18.6	436.8	-	-	-	-	62.0	1456.0	1522.0	35743.4	-	-
2	5	-	-	-	-	-	-	25.0	978.5	620.0	24267.4	-	-
3	1	0.1	5.9	0.1	-	-	-	4.0	234.8	234.0	13738.4	-	-
3	2	0.1	11.8	-	-	-	-	2.0	235.0	187.0	21973.6	-	-
3	3	0.1	11.8	-	-	-	-	1.0	117.5	155.0	18213.4	-	-
*** Total ***													
		59.0		1.6		0.1		291.0		8371.0		1	19.6

Layer	Level	Flake Count	Flake Count (CI)	Flake Weight (gm)	Flake Weight (CI)	Shatter Count	Shatter Count (CI)	Shatter Weight gms.	Shatter Weight (CI)	Polished Flake Count	Polished Flake (CI)
surf.		-	-	-	-	-	-	-	-	-	-
1	1	2.0	78.3	26.0	1017.7	4	156.6	1.0	39.1	-	-
2	1	-	-	-	-	22	430.5	19.7	385.5	-	-
2	2	2.0	39.1	2.0	39.1	8	156.6	3.0	58.7	-	-
2	3	-	-	-	-	12	281.8	3.1	72.8	1	23.5
2	4	8.0	187.9	33.0	775.0	3	70.5	3.5	82.2	-	-
2	5	2.0	78.3	3.0	117.4	3	117.4	0.5	19.6	-	-
3	1	-	-	-	-	-	-	-	-	-	-
3	2	-	-	-	-	-	-	-	-	-	-
3	3	-	-	-	-	-	-	-	-	-	-
*** Total ***											
		14.0		64.0		52		30.8		1	

Table 14 (cont.). List of materials from Feature 8, TP-1. CI refers to concentration index for the previous column in unit per cubic meter.

Layer	Level	Polished Flake Weight (gm)	Polished Flake Weight (CI)	Volcanic Glass Count	Volcanic Glass Count (CI)	Volcanic Glass Weight (gm)	Volcanic Glass Weight (CI)	Volcanic Glass Core Ct.	Volcanic Glass Core Ct. (CI)	Volcanic Glass Core Wt. (gm)	Volcanic Glass Core Wt. (CI)
surf.		-	-	-	-	-	-	-	-	-	-
1	1	-	-	25	978.5	3.8	148.7	-	-	-	-
2	1	-	-	80	1565.6	10.0	195.7	1	19.6	2.0	39.1
2	2	-	-	73	1428.6	10.3	201.6	1	19.6	1.0	19.6
2	3	1.0	23.5	28	657.6	4.4	103.3	1	23.5	7.0	164.4
2	4	-	-	18	422.7	3.9	91.6	-	-	-	-
2	5	-	-	4	156.6	0.3	11.7	-	-	-	-
3	1	-	-	-	-	-	-	-	-	-	-
3	2	-	-	1	117.5	0.4	47.0	-	-	-	-
3	3	-	-	-	-	-	-	-	-	-	-
*** Total ***											
		1.0		229		33.1		3		10.0	

Table 15. List of shell midden from Feature 8, TP-1. CI refers to concentration index for the previous column in grams per cubic meter.

Layer	Level	Trochus (gm)	Trochus (CI)	Turbo (gm)	Turbo (CI)	Oper-culae (gm)	Oper-culae (CI)	Nerita (gm)	Nerita (CI)	Theo-doxus (gm)	Theo-doxus (CI)	Cellana (gm)	Cellana (CI)	Hip-ponix (gm)	Hip-ponix (CI)
surf.		-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	1	2.0	78.3	52.0	2035.3	12.0	12.0	111.0	4344.6	3.0	117.4	15.0	587.1	4.0	156.6
2	1	4.0	78.3	75.0	1467.8	35.0	35.0	308.0	6027.7	11.0	215.3	21.0	411.0	12.0	234.8
2	2	1.0	19.6	109.0	2133.2	39.0	39.0	283.0	5538.4	9.0	176.1	18.0	352.3	13.0	254.4
2	3	2.0	47.0	167.0	3921.9	19.0	19.0	226.0	5307.5	-	-	42.0	986.3	19.0	446.2
2	4	3.0	70.5	148.0	3475.7	20.0	20.0	191.0	4485.5	2.0	47.0	65.0	1526.5	25.0	587.1
2	5	1.0	39.1	42.0	1643.9	6.0	6.0	72.0	2818.1	2.0	78.3	8.0	313.1	19.0	743.7
3	1	2.0	117.4	1.0	58.7	2.0	2.0	7.0	411.0	1.0	58.7	2.0	117.4	9.0	528.4
3	2	1.0	117.5	3.0	352.5	1.0	1.0	4.0	470.0	1.0	117.5	4.0	470.0	8.0	940.0
3	3	1.0	117.5	1.0	117.5	1.0	1.0	3.0	352.5	1.0	117.5	1.0	117.5	5.0	587.5
*** Total ***															
		17.0		598.0		135.0		1205.0		30.0		176.0		114.0	

Layer	Level	Cypraea (gm)	Cypraea (CI)	Conus (gm)	Conus (CI)	Strombus (gm)	Strom-bus (CI)	Cymatium (gm)	Cymatium (CI)	Bursa (gm)	Bursa (CI)	Drupa (gm)	Drupa (CI)	Morula (gm)	Morula (CI)
surf.		-	-	-	-	-	-	-	-	-	-	-	-	-	
1	1	146.0	5714.6	9.0	352.3	22.0	861.1	-	-	-	-	61.0	2387.6	1.0	39.1
2	1	193.0	3777.1	17.0	332.7	35.0	685.0	3.0	58.7	-	-	87.0	1702.6	7.0	137.0
2	2	202.0	3953.2	28.0	548.0	27.0	528.4	6.0	117.4	-	-	111.0	2172.3	-	-
2	3	228.0	5354.5	25.0	587.1	42.0	986.3	1.0	23.5	-	-	102.0	2395.4	1.0	23.5
2	4	174.0	4086.3	48.0	1127.3	46.0	1080.3	-	-	-	-	119.0	2794.7	2.0	47.0
2	5	78.0	3053.0	13.0	508.8	17.0	665.4	-	-	4.0	156.6	35.0	1369.9	1.0	39.1
3	1	43.0	2524.6	9.0	528.4	4.0	234.8	-	-	-	-	6.0	352.3	1.0	58.7
3	2	16.0	1880.1	10.0	1175.1	5.0	587.5	-	-	-	-	5.0	587.5	1.0	117.5
3	3	25.0	2937.7	3.0	352.5	2.0	235.0	4.0	470.0	-	-	-	-	-	-
*** Total ***															
		1105.0		162.0		200.0		14.0		4.0		526.0		14.0	

Table 15 (cont.). List of shell midden from Feature 8, TP-1. CI refers to concentration index for the previous column in grams per cubic meter.

Layer	Level	Littorina (gm)	Littorina (CI)	Mitra (gm)	Mitra (CI)	Tellina (gm)	Tellina (CI)	Periglypta (gm)	Periglypta (CI)	Braciodon (gm)	Braciodon (CI)	Isongomon (gm)	Isongomon (CI)	Barnacle (gm)	Barnacle (CI)
surf.		-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	1	6.0	234.8	-	-	-	-	-	-	1.0	39.1	1.0	39.1	-	-
2	1	13.0	254.4	2.0	39.1	-	-	-	-	2.0	39.1	5.0	97.9	-	-
2	2	16.0	313.1	-	-	-	-	-	-	-	-	5.0	97.9	-	-
2	3	18.0	422.7	-	-	2.0	47.0	1.0	23.5	-	-	8.0	187.9	7.0	164.4
2	4	15.0	352.3	-	-	-	-	2.0	47.0	-	-	2.0	47.0	5.0	117.4
2	5	16.0	626.3	-	-	1.0	39.1	2.0	78.3	-	-	1.0	39.1	3.0	117.4
3	1	4.0	234.8	-	-	-	-	1.0	58.7	-	-	1.0	58.7	-	-
3	2	3.0	352.5	-	-	-	-	3.0	352.5	-	-	1.0	117.5	-	-
3	3	3.0	352.5	-	-	2.0	235.0	-	-	-	-	-	-	-	-
*** Total ***															
		94.0		2.0		5.0		9.0		3.0		24.0		15.0	

Layer	Level	Unidentified (gm)	Unidentified (CI)
surf.		0.0	0.0
1	1	299.0	11703.1
2	1	810.0	15852.0
2	2	800.0	15656.3
2	3	619.0	14536.9
2	4	658.0	15452.8
2	5	299.0	11703.1
3	1	145.0	8513.1
3	2	121.0	14218.2
3	3	98.0	11515.6
*** Total ***			
		3849.0	

Layer 2 Level 2 yielded far more charcoal than the previous layers, less basalt, and about the same amount of volcanic glass. It also contained considerable amounts of several different types of fish, 1 piece of <u>Rattus</u> <u>exulans</u> (Polynesian Rat), and 2 pieces of medium sized mammal. Layer 2 Level 3 yielded even more charcoal, but less basalt and volcanic glass. It also included several types of fish, 3 pieces of indeterminate vertebrate bone, and 3 pieces of <u>Rattus</u> <u>exulans</u> (Polynesian Rat). The amount of charcoal decreased in Layer 2 Level 4, as did the amount of volcanic glass. The amount of basalt, however, was at a maximum for the test pit. The level contained considerable amounts of fish bone. Layer 2 Level 5 had even less charcoal and volcanic glass, and the amount of basalt and fish bone also decreased.

A 6.6 gram charcoal sample from Layer 2 Level 5 yielded a C13/C12 adjusted date of 510 ± 80 B.P. (Beta-33172). The calibrated age ranges of this sample (95% confidence interval), based on the computer program of Stuiver and Reimer (1986) are as follows

A.D. 1281-1520 (97%)
A.D. 1592-1622 (3%)

The statistical probabilities for these ranges, given in parentheses above, suggest that the A.D. 1281-1520 range is the most likely of the two.

Layer 3 was a relatively sterile brown deposit of wave washed shell and coral. It was excavated because the rocks of the subsurface alignment were found throughout the layer. Only 0.0170325 m^3 of the material excavated from Layer 3 Level 1 was screened and analyzed. It contained a trace of charcoal and kukui nut, 1 piece of fish bone, and no basalt or volcanic glass. Layer 3 Level 2 contained a trace of charcoal and 1 small piece of volcanic glass. Only 0.0085102 m^3 of the material excavated from this level was screened and analyzed. Layer 3 Level 3 also contained a trace of charcoal, but no other cultural material. Only 0.0085102 m^3 of the material excavated from this level was screened and analyzed. Because of the limited dimensions of the test pit, it was impossible to excavate further, even though the bottom of the deposit was not reached.

One of the most interesting aspects of Feature 8 TP-1 was the discovery of a buried alignment (Photo 6). The very top of the alignment was first visible in Layer 2 Level 1 at 20 cm BD, and portions of the alignment extended down through Layer 3 Level 3 to a depth of 85 cm BD. The alignment consisted of seven relatively large, 20 to 50 cm long, rocks stacked on top of each other. There were numerous smaller 5 to 15 cm cobbles in between these rocks.

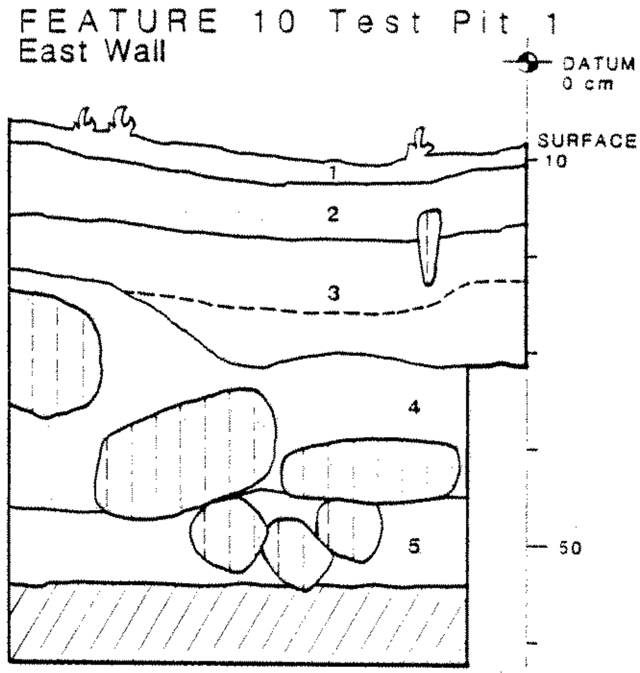
The top of the subsurface alignment corresponds with the stratigraphic level where the density of charcoal increases. The radiocarbon date is from the bottom level of Layer 2, the last stratum that has a relatively high density of charcoal. The alignment, however, extends into Layer 3 and therefore might have been built even earlier than the radiocarbon date suggests. Given the high concentration of wave washed material, it is possible that a lower layer has been disturbed. This might be one explanation for the sharp decrease in the density of charcoal in the lower layer.

Feature 10, TP-1

Feature 10 TP-1 is a 50 x 50 cm unit located in the middle of a small enclosure associated with the main residential feature (see Figure 14 and Photos 9, 10). The purpose of the test pit was to determine the function and chronology of the enclosure, and to determine its relationship with other features in the area. Table 16 is a list of the layers and levels in the test pit, their volume, and their depth below datum. Figure 48 is a stratigraphic profile of TP-1. Table 17 is a list of the materials recovered during the excavation, and the concentration indices for those materials. The entire deposit of the unit contained wave washed shell and coral. This undoubtedly skews the quantity of crab, urchin, and shell midden reported in Table 17.

Table 16. The depth and volume of excavated materials of each layer and level from Feature 10, TP-1.

Layer	Level	Depth (cm below datum)	Volume Excavated (cubic meters)
surf.		9/11	0.0000000
1	1	9/11 to 10.5/12	0.0085162
2	1	10.5/12 to 14/19	0.0170325
3	1	14/19 to 22/24	0.0255487
3	2	24 to 34	0.0060000
4	1	23/24 to 34	0.0425813
4	2	34 to 44	0.0170325
5	1	44 to 54	0.0125000
*** Total ***			0.1292112



Layer	Munsell Color	Boundary	Description
1	-	clear	loam with wave washed shell and coral
2	10YR 2/2 (very dark brown)	clear	silt loam with wave washed shell and coral
3	10YR 3/2 (very dark grayish brown)	clear	loam with wave washed shell and coral, with charcoal flecking
4	10YR 2/1 (black)	clear	loam with wave washed shell and coral
5	10YR 3/3 (dark brown)	-	loam with wave washed shell and coral

Figure 48. Profile and sediment description of Feature 10, TP-1.

Table 17. List of materials from Feature 10, TP-1. CI refers to concentration index for the previous column in unit per cubic meter.

Layer	Level	Charcoal (gm)	Charcoal (CI)	Kukui (gm)	Kukui (CI)	Urchin (gm)	Urchin (CI)	Shell (gm)	Shell (CI)	Historic Artifact Count	Historic Artifact Count (CI)
surf.		-	-	-	-	-	-	-	-	4	-
1	1	0.5	58.7	0.9	105.7	8.0	939.4	114.0	13386.3	3	352.3
2	1	0.6	35.2	0.6	29.4	32.0	1878.8	501.0	29414.4	11	645.8
3	1	1.6	62.6	-	-	26.0	1017.7	665.0	26028.7	-	-
3	2	1.2	200.0	1.9	316.7	9.0	1500.0	350.0	58333.3	-	-
4	1	0.6	14.1	-	-	3.0	70.5	250.0	5871.1	-	-
4	2	0.4	23.5	-	-	3.0	176.1	152.0	8924.1	-	-
5	1	-	-	-	-	3.0	240.0	350.0	28000.0	-	-
*** Total ***		4.9		3.4		84.0		2382.0		18	

Layer	Level	Flake Count	Flake Count (CI)	Flake Weight (gm)	Flake Weight (CI)	Shatter Count	Shatter Count (CI)	Shatter Weight (gm)	Shatter Weight (CI)	Volcanic Glass Flake Count	Volcanic Glass Flake Ct. (CI)	Volcanic Glass Flake Wt. (gm)	Volcanic Glass Flake (CI)
surf.		1.0	-	38.0	-	-	-	-	-	-	-	-	-
1	1	-	-	-	-	-	-	-	-	1	117.4	0.1	11.7
2	1	-	-	-	-	2	117.4	1.0	58.7	4	234.8	0.6	35.2
3	1	-	-	-	-	4	156.6	5.4	211.4	8	313.1	1.2	47.0
3	2	2.0	333.3	55.0	9166.7	-	-	-	-	9	1500.0	2.7	450.0
4	1	-	-	-	-	2	47.0	2.3	54.0	12	281.8	1.4	32.9
4	2	-	-	-	-	-	-	-	-	1	58.7	0.2	11.7
5	1	-	-	-	-	-	-	-	-	-	-	-	-
*** Total ***		3.0		93.0		8		8.7		35		6.2	

There was lantana, grass, and decomposing vegetation on the surface of the test pit. There was also 1 basalt flake, 1 piece of clear glass, and 3 pieces of violet colored bottle glass. Layer 1 Level 1 was a loose deposit of wave washed material. It contained small amounts of charcoal and kukui nut, 1 piece of volcanic glass, and 3 pieces of violet bottle glass.

Layer 2 Level 1 was a similar but harder deposit containing small amounts of charcoal and kukui nut, 2 pieces of basalt shatter, and 4 pieces of volcanic glass. The faunal remains from the layer include several types of fish, 1 piece of a medium sized bird, 1 piece of _Sus scrofa_ (pig), and 18 pieces of medium to large sized mammal. The material from the medium to large sized mammal could be a number of prehistoric or historically introduced species. The layer also contained 11 historic artifacts, including 3 metal square nail fragments (ca. 3.2 cm long by 3 mm wide), 4 pieces of metal that might be nail fragments (ranging in size from 4 mm to 1 cm), 1 piece of violet bottle glass, and 3 pieces of clear bottle glass. This was the lowest layer and level that contained historic material.

Although Layer 3 Level 1 contained only a small amount of charcoal, it was the most for any layer within the feature. The layer yielded 2 basalt flakes and 8 pieces of volcanic glass. Layer 3 Level 2 was excavated exclusively from the southeast quadrant of the test pit. It contained small amounts of charcoal and kukui nut, 2 pieces of basalt, and 9 pieces of volcanic glass. It also contained small amounts of fish bone and large amounts of medium or large sized mammal bone.

Layer 4 Level 1 was a slightly more compact deposit with less gravel. It was excavated from all areas of the test pit except for the southeast quadrant. The level contained a very small amount of charcoal, 2 pieces of basalt, and 12 small pieces of volcanic glass. The faunal material from the level included fish and medium to large mammal. During the excavation of the layer, several large rocks and cobbles were encountered. The test pit was to small to determine if the rocks were part of an alignment, but they did appear to be cultural.

Layer 4 Level 2 was excavated from the entire test pit. It yielded a trace of charcoal, 1 small volcanic glass flake, and small amounts of fish and medium or large sized mammal bone. Layer 5 Level 1 was lighter in color and yielded no cultural material. Excavation was terminated at the bottom of Layer 5 Level 1. It is possible that there are further buried deposits below this, but the size of the test pit prevented further excavation.

The results of the excavation indicate that the upper layers of the test pit were occupied during the historic era. The cultural material found in the test pit is probably the rubbish of the occupants of the house site immediately adjacent to the enclosure. Layer 4 might represent an earlier occupation, and the possible alignment a part of an earlier building phase. Further excavation is needed for clarification.

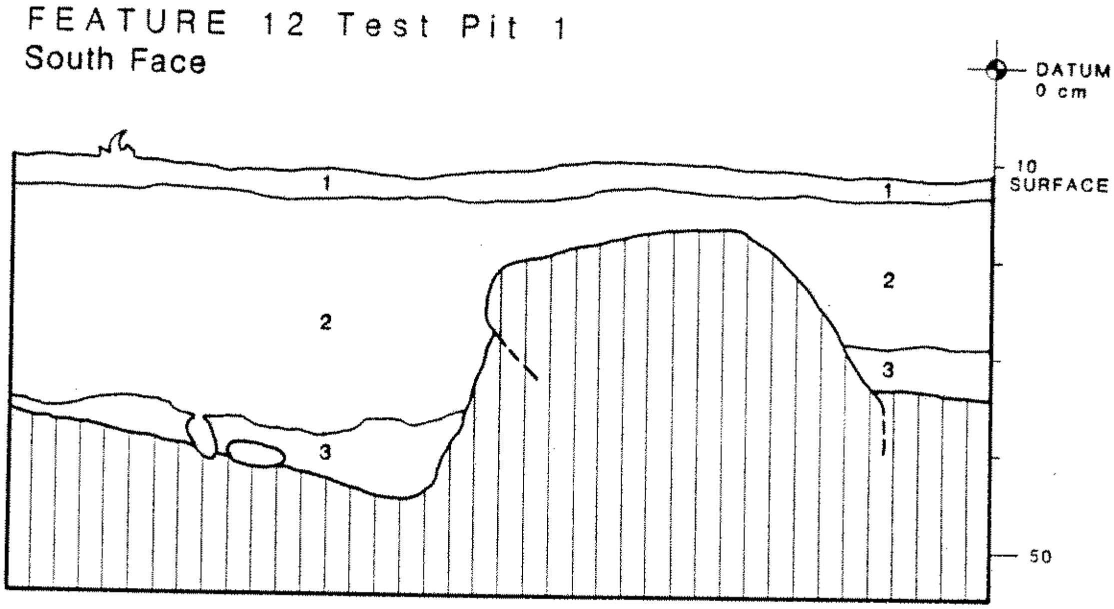
Feature 12, TP-1

Feature 12 TP-1 is a 100 x 50 cm unit located in the middle of a large enclosure (see Figure 16). The purpose of the test pit was to determine the function and chronology of the enclosure, and to try and determine its relationship with Feature 13. Table 18 is a list of the layers and levels in the test pit, their volume, and their depth below datum. Figure 49 is a stratigraphic profile of TP-1. Table 19 is a list of the materials recovered during the excavation, and the concentration indices for those materials. Table 20 is a list of the shell midden from the feature.

Table 18. The depth and volume of excavated materials of each layer and level from Feature 12, TP-1.

Layer	Level	Depth (cm below datum)	Volume Excavated (cubic meters)
surf.		9/11	0.0000000
1	1	9/11 to 14	0.0255487
2	1	14 to 24	0.0596138
2	2	24 to 34	0.0212906
2	3	34 to 43	0.0042581
3	1	26/43 to 32/44	0.0015000
*** Total ***			0.1122112

There was grass, decomposing vegetation, and a few pieces of shell on the surface of the test pit. Layer 1 Level 1 was a thin loose sandy deposit with an abundance of pebble sized gravel. It yielded a fair amount of shell, small amounts of sea urchin, 10 pieces of basalt, but only a trace of charcoal. The faunal material from the level included small amounts of Bufo marinus (Giant Neotropical Toad), labrid, shark undetermined fish, Rattus exulans (Polynesian Rat), and 1 piece of small to medium sized mammal.



Layer	Munsell Color	Boundary	Description
1	10YR 4/2 (dark grayish brown)	abrupt (smooth)	sandy loam
2	10YR 3/3 (dark brown)	clear (irregular)	sandy loam
3	10YR 3/4 (dark yellowish brown)	-	silt loam

Figure 49. Profile and sediment description of Feature 12, TP-1.

Table 19. List of materials from Feature 12, TP-1. CI refers to concentration index for the previous column in unit per cubic meter.

Layer	Level	Charcoal (gm)	Charcoal (CI)	Crab (gm)	Crab (CI)	Urchin (gm)	Urchin (CI)	Shell (gm)	Shell (CI)	Volcanic Glass Flake Count	Volcanic Glass Flake Ct. (CI)	Volcanic Glass Flake Wt. (gm)	Volcanic Glass Flake Wt. (CI)
surf.		-	-	-	-	-	-	-	-	-	-	-	-
1	1	0.2	7.8	-	-	11.0	430.6	200.0	7828.2	2	78.3	0.5	19.6
2	1	0.3	5.0	1.0	16.8	43.0	721.3	509.0	8538.3	2	33.5	0.4	6.7
2	2	-	-	0.2	9.4	11.0	516.7	132.0	6199.9	-	-	-	-
2	3	0.4	93.9	-	-	3.0	704.5	28.0	6575.7	-	-	-	-
3	1	0.2	133.3	-	-	1.0	666.7	11.0	7333.3	-	-	-	-
*** Total ***		1.1		1.2		69.0		880.0		4		0.9	

Layer	Level	Flake Count	Flake Count (CI)	Flake Weight (gm)	Flake Weight (CI)	Shatter Count	Shatter Count (CI)	Shatter Weight (gm)	Shatter Weight (CI)	Misc. Basalt Count	Misc. Basalt (CI)	Historic Artifact Count	Historic Artifact Count (CI)
surf.		-	-	-	-	-	-	-	-	-	-	-	-
1	1	3.0	117.4	20.0	782.8	7	274.0	30.0	1174.2	1	39.1	-	-
2	1	1.0	16.8	5.0	83.9	6	100.6	6.0	100.6	-	-	5	84
2	2	-	-	-	-	-	-	-	-	-	-	-	-
2	3	-	-	-	-	-	-	-	-	-	-	-	-
3	1	-	-	-	-	-	-	-	-	-	-	-	-
*** Total ***		4.0		25.0		13		36.0		1		5	84

Table 20. List of shell midden from Feature 12, TP-1. CI refers to concentration index for the previous column in grams per cubic meter.

Layer	Level	Trochus (gm)	Trochus (CI)	Turbo (gm)	Turbo (CI)	Oper-culae (gm)	Oper-culae (CI)	Nerita (gm)	Nerita (CI)	Theo-doxus (gm)	Theo-doxus (CI)	Cellana (gm)	Cellana (CI)	Hip-ponix (gm)	Hip-ponix (CI)
surf.		-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	1	-	-	49.0	1917.9	32.0	32.0	12.0	469.7	4.0	156.6	1.0	39.1	3.0	117.4
2	1	1.0	16.8	70.0	1174.2	60.0	60.0	38.0	637.4	-	-	10.0	167.7	2.0	33.5
2	2	1.0	47.0	36.0	1690.9	20.0	20.0	11.0	516.7	-	-	1.0	47.0	3.0	140.9
2	3	1.0	234.8	12.0	2818.2	1.0	1.0	2.0	469.7	-	-	-	-	2.0	469.7
3	1	-	-	1.0	666.7	3.0	3.0	1.0	666.7	-	-	-	-	1.0	666.7
*** Total ***		3.0		168.0		116.0		64.0		4.0		12.0		11.0	

Layer	Level	Cypraea (gm)	Cypraea (CI)	Conus (gm)	Conus (CI)	Strombus (gm)	Strom-bus (CI)	Cymatium (gm)	Cymatium (CI)	Bursa (gm)	Bursa (CI)	Drupa (gm)	Drupa (CI)	Unident-ified (gm)	Unident-ified (gm)
surf.		-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	1	8.0	313.1	2.0	78.3	3.0	117.4	7.0	274.0	-	-	7.0	274.0	62.0	2426.7
2	1	12.0	201.3	4.0	67.1	6.0	100.6	-	-	1.0	16.8	23.0	385.8	268.0	4495.6
2	2	5.0	234.8	1.0	47.0	1.0	47.0	2.0	93.9	-	-	7.0	328.8	36.0	1690.9
2	3	1.0	234.8	-	-	1.0	234.8	-	-	-	-	2.0	469.7	5.0	1174.2
3	1	-	-	-	-	1.0	666.7	-	-	-	-	1.0	666.7	4.0	2666.7
*** Total ***		26.0		7.0		12.0		9.0		1.0		40.0		375.0	

Layer	Level	Lit-torina (gm)	Lit-torina (CI)	Mitra (gm)	Mitra (CI)	Tel-lina (gm)	Tel-lina (CI)	Peri-glypta (gm)	Peri-glypta (CI)	Isong-omon (gm)	Isong-omon (CI)	Barn-acle (gm)	Barn-acle (CI)
surf.		-	-	-	-	-	-	-	-	-	-	-	-
1	1	-	-	-	-	-	-	2.0	78.3	1.0	39.1	-	-
2	1	1.0	16.8	1.0	16.8	1.0	16.8	1.0	16.8	1.0	16.8	6.0	100.6
2	2	1.0	47.0	-	-	-	-	-	-	2.0	93.9	1.0	47.0
2	3	-	-	-	-	-	-	-	-	-	-	1.0	234.8
3	1	-	-	-	-	-	-	-	-	-	-	-	-
*** Total ***		2.0		1.0		1.0		3.0		4.0		8.0	

Layer 2 Level 1 was slightly more compact, and contained significantly more shell and sea urchin, but a similar density of charcoal. The level also yielded 7 pieces of basalt, 2 pieces of volcanic glass, and 5 rusty fragments of metal. The metal fragments range in size from 5 mm by 5 mm up to 1 cm by 1 cm. These were the only historic artifacts found in the test pit. The faunal material from the level included small amounts of several types of fish, 1 piece of medium sized bird, 2 pieces of small to medium or medium sized mammal, Geopelia striata (Zebra Dove), Rattus exulans (Polynesian Rat) and Rattus norvegicus and/or rattus (Norway and/or Roof Rat). The dove was introduced to the Hawaiian Islands during the early 1900's, and the Norwegian Rat is a post-contact introduction. The metal and faunal material from historically introduced species clearly indicate that the level was deposited relatively recently.

During Layer 2 Level 1 a rock 50 cm diameter and 20 cm thick, was uncovered in the west half of the test pit. It was resting on Layer 3. Because of the rock, and the presence of Layer 3 in the northeast quadrant, Layer 2 Level 2 was excavated exclusively from the southeast quadrant. It contained slightly more charcoal, but less shell and sea urchin than the previous level of the layer. Faunal material from the level included small amounts of fish and medium sized mammal. The level did not contain any lithics. The level was radiocarbon dated and this is discussed later. Layer 2 Level 3 was excavated exclusively from the southeast quadrant. It contained less charcoal, sea urchin and shell than the previous level, and 1 piece of small to medium or medium sized mammal.

Layer 3 Level 1 was a thin deposit of decomposing bedrock underneath Layer 2. The contact between Layer 2 and Layer 3 was extremely wavy. The Layer 2 deposit looked as if it had been churned up, and the lower contact reflected this. This was not a pattern observed in any of the other test pits in the study area. The 3 pieces of fish bone recovered from the level probably filtered down from the layer above. The bedrock was underneath Layer 3.

A 1.5 gram charcoal sample from Layer 2 Level 2 yielded a C13/C12 adjusted date of 170 $\pm$ 120 B.P. (Beta-33171). The calibrated age ranges of this sample (95% confidence interval), based on the computer program of Stuiver and Reimer (1986) are as follows

A.D. 1508-1603 (13%)
A.D. 1610-1955* (87%)

1955* denotes influence of bomb C-14

The statistical probabilities for these ranges, given in parentheses above, suggest that the A.D. 1610-1955* range is the most likely of the two. The presence of metal artifacts and historically introduced species in the same deposit, but at a slightly higher level, suggests that a date from the historic portion of the range might be appropriate.

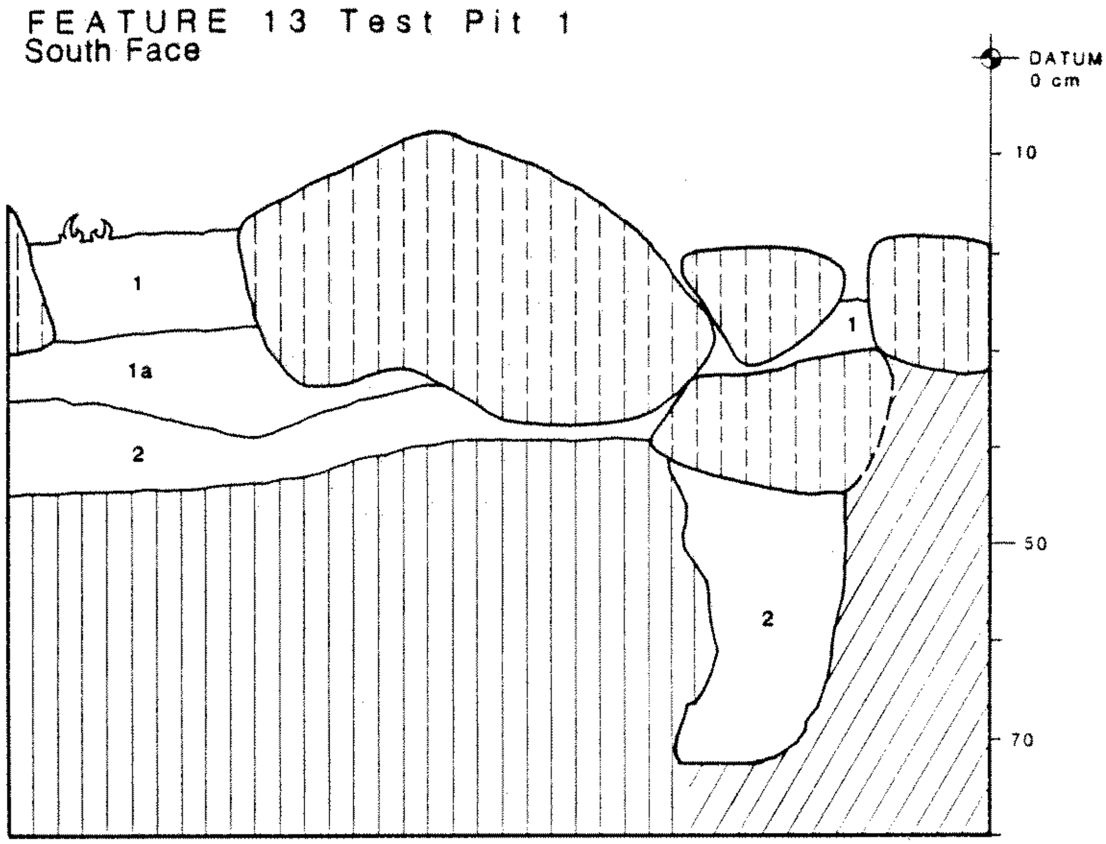
The precise function of the feature is unknown. However, it does appear to have been used during the historic period for activities which would have churned up the deposit leaving a wavy contact between the cultural deposit and the sterile substrate. One activity which might have caused this depositional pattern is pig husbandry. The feature is a large enclosure with no opening making it a suitable pig pen. The churned and wavy deposit is consistent with what would have been formed by pigs routing or walking around in a pen. This interpretation is tentative at best, and further excavation would be needed to confirm or negate the hypothesis.

Feature 13, TP-1

Feature 13 TP-1 is a 100 x 50 cm unit situated at the corner of an internal terrace of an enclosure (see Figures 17 and 18). The purpose of the test pit was to determine the function and chronology of the feature. The results of the excavation suggest the feature might be some sort of special use area, possibly a shrine. Table 21 is a list of the layers and levels in the test pit, their volume, and their depth below datum. Figures 50 and 51 is a stratigraphic profile of TP-1. Table 22 is a list of the materials recovered during the excavation, and the concentration indices for those materials. Table 23 is a list of the shell midden from the feature.

Table 21. The depth and volume of excavated materials of each layer and level from Feature 13, TP-1.

Layer	Level	Depth (cm below datum)	Volume Excavated (cubic meters)
surf.		2/8	0.0000000
1	1	2/8 to 5/14	0.0042581
1A	1	11/16 to 17/21	0.0051097
2	1	5/14 to 11/15	0.0034065
2	2	11/15 to 21	0.0127744
2	3	21 to 31	0.0596138
2	4	31 to 41	0.0298069
2	5	41 to 51	0.0170325
2	6	51 to 61	0.0056207
3	1	21 to 27	0.0034065
4	1	35-40	0.0002500
*** Total ***			0.1412791



Layer	Munsell Color	Boundary	Description
1	10YR 2/2 (very dark brown)	abrupt (wavy)	silt loam
2	10YR 3/1 (very dark gray)	abrupt (wavy)	silt loam
3	10YR 2/2 (very dark brown)	abrupt (wavy)	silt loam
4	10YR 5/1 (gray)	-	silt

Figure 50. Profile and sediment description of Feature 13, TP-1.

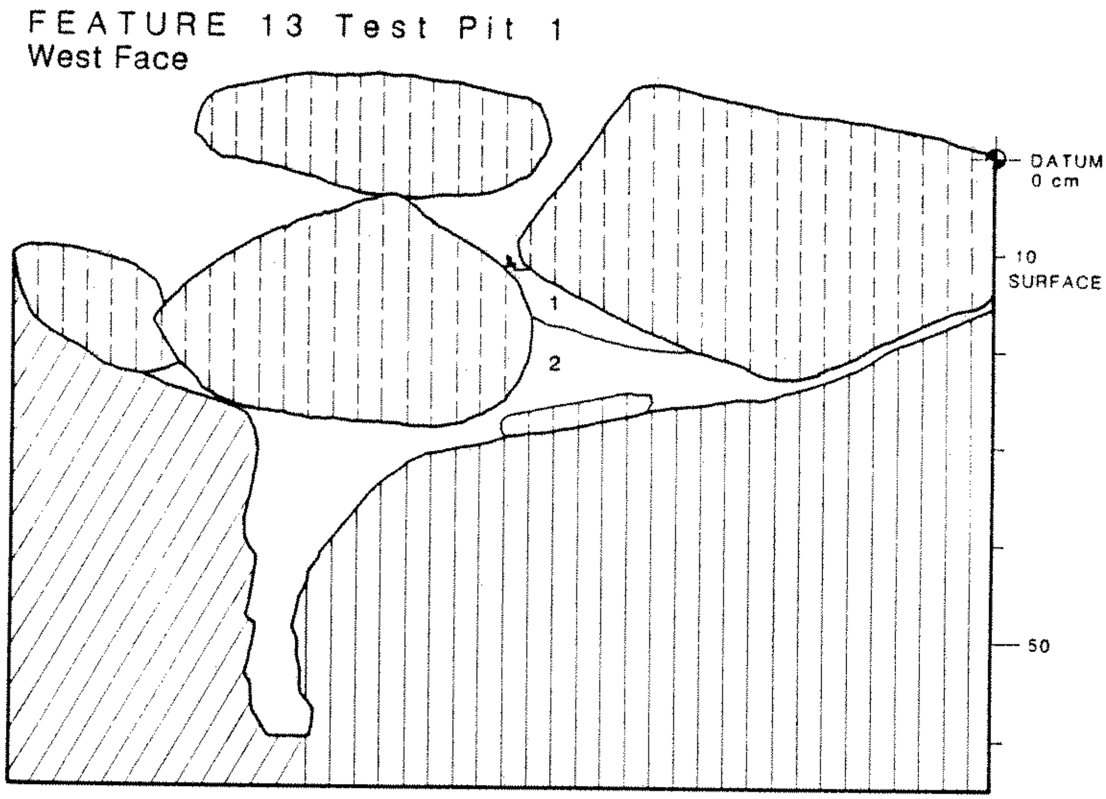


Figure 51. Profile of Feature 13, TP-1.

Table 22. List of materials from Feature 13, TP-1. CI refers to concentration index for the previous column in unit per cubic meter.

Layer	Level	Charcoal (gm)	Charcoal (CI)	Kukui (gm)	Kukui (CI)	Crab (gm)	Crab (CI)	Urchin (gm)	Urchin (CI)	Shell (gm)	Shell (CI)
surf.		-	-	-	-	-	-	-	-	-	-
1	1	-	-	-	-	-	-	-	-	2.0	469.7
1A	1	0.6	117.4	-	-	-	-	1.0	195.7	2.0	391.4
2	1	1.1	322.9	-	-	-	-	1.0	293.6	3.0	880.7
2	2	5.7	446.2	29.2	2285.8	-	-	9.0	704.5	30.0	2348.4
2	3	50.2	871.3	-	-	-	-	78.0	1353.8	1807.0	31364.0
2	4	32.9	1103.8	-	-	-	-	20.0	671.0	80.0	2683.9
2	5	52.5	3082.3	-	-	0.5	29.4	47.0	2759.4	77.0	4520.8
2	6	38.5	6849.7	-	-	0.2	35.6	12.0	2135.0	23.0	4092.0
3	1	2.1	616.5	-	-	-	-	2.0	587.1	3.0	880.7
4	1	-	-	-	-	-	-	-	-	-	-
*** Total ***		183.6		29.2		0.7		170.0		2027.0	

Layer	Level	Flake Count	Flake Count (CI)	Flake Weight (gm)	Flake Weight (CI)	Shatter Count	Shatter Count (CI)	Shatter Weight (gm)	Shatter Weight (CI)
surf.		-	-	-	-	-	-	-	-
1	1	-	-	-	-	1	234.8	1.0	234.8
1A	1	-	-	-	-	-	-	-	-
2	1	-	-	-	-	1	293.6	0.1	29.4
2	2	2.0	156.6	56.0	4383.8	2	156.6	1.2	93.9
2	3	2.0	34.7	1.0	17.4	41	711.6	52.0	902.6
2	4	4.0	134.2	12.0	402.6	2	67.1	0.9	30.2
2	5	4.0	234.8	34.0	1996.2	11	645.8	12.0	704.5
2	6	1.0	177.9	1.0	177.9	-	-	-	-
3	1	-	-	-	-	-	-	-	-
4	1	-	-	-	-	-	-	-	-
*** Total ***		13.0		104.0		58		67.2	1995.4

Table 22 (cont.). List of materials from Feature 13, TP-1. CI refers to concentration index for the previous column in unit per cubic meter.

Layer	Level	Polished Flake Count	Polished Flake (CI)	Polished Flake Weight (gm)	Polished Flake Weight (CI)	Volcanic Glass Flake Count	Volcanic Glass Flake Ct. (CI)	Volcanic Glass Flake Wt. (gm)	Volcanic Glass Flake (CI)
surf.		-	-	-	-	-	-	-	-
1	1	-	-	-	-	-	-	-	-
1A	1	-	-	-	-	-	-	-	-
2	1	-	-	-	-	-	-	-	-
2	2	-	-	-	-	-	-	-	-
2	3	2	34.7	3.0	52.1	3	52.1	17.0	295.1
2	4	-	-	-	-	-	-	-	-
2	5	-	-	-	-	-	-	-	-
2	6	-	-	-	-	-	-	-	-
3	1	-	-	-	-	-	-	-	-
4	1	-	-	-	-	-	-	-	-
*** Total ***									
		2		3.0		3		17.0	

Table 23. List of shell midden from Feature 13, TP-1. CI refers to concentration index for the previous column in grams per cubic meter.

Layer	Level	Turbo (gm)	Turbo (CI)	Oper-culae (gm)	Oper-culae (CI)	Nerita (gm)	Nerita (CI)	Theo-doxus (gm)	Theo-doxus (CI)	Cellana (gm)	Cellana (CI)	Hip-ponix (gm)	Hip-ponix (CI)	Unident-ified (gm)	Unident-ified (CI)
surf.		-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	1	1.0	234.8	-	-	-	-	-	-	-	-	-	-	-	-
1A	1	-	-	1.0	1.0	1.0	195.7	-	-	1.0	195.7	-	-	-	-
2	1	1.0	293.6	1.0	1.0	-	-	-	-	-	-	-	-	-	-
2	2	3.0	234.8	-	-	-	-	-	-	-	-	-	-	1.0	78.3
2	3	32.0	555.4	18.0	18.0	14.0	243.0	0.1	1.7	2.0	34.7	2.0	34.7	17.1	296.8
2	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	5	12.0	704.5	9.0	9.0	12.0	704.5	-	-	-	-	-	-	29.0	1702.6
2	6	3.0	533.7	4.0	4.0	2.0	355.8	-	-	1.0	177.9	1.0	177.9	8.0	1423.3
3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
*** Total ***		52.0		33.0		29.0		0.1		4.0		3.0		56.0	

Layer	Level	Cypraea (gm)	Cypraea (CI)	Conus (gm)	Conus (CI)	Strombus (gm)	Strom-bus (CI)	Drupa (gm)	Drupa (CI)	Lit-torina (gm)	Lit-torina (CI)	Tellina (gm)	Tellina (CI)	Barn-acle (gm)	Barn-acle (CI)
surf.		-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	1	-	-	-	-	1.0	234.8	-	-	-	-	-	-	-	-
1A	1	-	-	1.0	195.7	-	-	-	-	-	-	-	-	-	-
2	1	1.0	293.6	-	-	-	-	-	-	-	-	-	-	-	-
2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	3	13.0	225.6	52.0	902.6	4.0	69.4	1.0	17.4	1.0	17.4	1.0	17.4	11.0	190.9
2	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	5	5.0	293.6	2.0	117.4	-	-	1.0	58.7	-	-	-	-	-	-
2	6	2.0	355.8	1.0	177.9	-	-	1.0	177.9	-	-	-	-	-	-
3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
*** Total ***		21.0		56.0		5.0		3.0		1.0		1.0		11.0	

The surface of the test pit was covered with decomposing vegetation and a large quantity of rock. Layer 1 Level 1 was the deposit of decomposing vegetation and loose sediment which covered the rocks. It contained small amounts of shell and 1 small piece of basalt. Layer 1A Level 1 was a thick deposit of matted roots underneath Layer 1 in the east half of the unit. It contained small amounts of sea urchin and shell, a few pieces of fish bone, 1 piece of _Canis familiaris_ (Domestic Dog) bone, and 1 piece of small to medium sized or immature medium sized mammal.

Layer 2 was the main cultural deposit found in the test pit (Photo 14). It was a dark gray deposit of which the lower levels of the layer had an extremely high density of bone. Levels 1 and 2 of Layer 2 were deposited in between the terrace rocks. These levels contained a relatively small amount of bone, charcoal, shell, and 5 pieces of basalt. Layer 2 Level 3 was underneath the foundation stones of the terrace. It contained an extraordinary amount of charcoal, shell, and bone. It also contained a high density of lithics, including 2 small pieces of polished basalt, and 3 pieces of volcanic glass. A charcoal sample from this level was radiocarbon dated and is discussed below. A sediment sample from the level of 0.002 m^3 has been curated for future analysis.

There were two main concentrations of bone within Layer 2 Level 2. The results of a A. Ziegler's (1989) faunal analysis are presented in Appendices A and B. The majority of the faunal material did not appear charred, even though the general matrix contained an abundance of charcoal. It is notable that the vast majority of the faunal material is from immature _Sus scrofa_. Also included in the faunal material are several types of fish and birds, and several historically introduced species. The historically introduced species are the _Bufo marinus_ (Giant Neotropical Toad) and _Geopelia striata_ (Zebra Dove) in the lower levels of Layer 2, and _Streptopelia chinensis_ (Spotted Dove) in upper levels of Layer 2. This faunal material suggests that the feature was built after 1932. The Spotted Dove was introduced to the Hawaiian Islands sometime in the 1800's, the Zebra Dove in 1922, and the Giant Neotropical Toad in 1932 (Ziegler 1989).

Bedrock and Layer 2 Level 4 were situated beneath Layer 2 Level 3. The lower three levels of the Layer 2 contained considerable amounts of bone, charcoal, sea urchin, shell, and basalt. Layer 2 Level 4 was excavated exclusively from the center of the unit. A small ash deposit encountered during the excavation of the level was designated Layer 4. Its total volume was 0.00025 m^3 and it has been saved for future analysis. Layer 2 Level 5 was excavated from ca. 20% of the unit in the east half of the test pit. The deposit extended downwards, and Layer 2 Level 6 was excavated from the same area. Bedrock was underneath this level.

Layer 3 Level 1 was located in the southeast quadrant of the unit and had a horizontal distribution of 20 by 20 cm. It was overlaid with Layer 2 Level 2, and underlaid with Layer 2 Level 3. A large lantana root was present near the center of the deposit. This might account for its slightly darker color in relation to Layer 2. Layer 3 contained cultural material but not nearly to the same extent as Layer 2.

A 29.3 gram charcoal sample from Layer 2 Level 3 yielded a C13/C12 adjusted date of 170 $\pm$ 50 B.P. (Beta-33173). The calibrated age ranges of this sample (95% confidence interval), based on the computer program of Stuiver and Reimer (1986) are as follows:

A.D. 1652-1713 (21%)
A.D. 1715-1887 (62%)
A.D. 1913-1955* (17%)

1955* denotes influence of bomb C-14

The statistical probabilities for these ranges, given in parentheses above, suggest that the A.D. 1715-1887 range is the most likely of the two. However, the presence of faunal remains from species introduced during the early 1900's suggests that the feature was used fairly recently.

Feature 13 is somewhat anomalous. Its morphology and location on top of a knoll are unique to the study area. The test excavation uncovered large amounts of cultural material underneath the corner of a terrace foundation located inside of an enclosure. The cultural material included an extraordinary amount of faunal material, mostly immature Sus scrofa (pig), and a relatively large amount of shell and lithic material. Because of these characteristics it is tempting to interpret the feature as some sort of religious shrine. However, the late radiocarbon date, and the presence of species that were introduced to the Hawaiian Islands relatively recently, do not fully support this interpretation. An alternative interpretation is that the assemblage represents the "garbage dump" of a pig farmer (Ziegler 1989a). The faunal material could be the immature individuals who are often killed accidentally by their mothers, or who otherwise die naturally at an early age. The location of the feature next to a large enclosure (Feature 12) lends support to this interpretation. However, the location of the feature on top of a small outcrop does not make it the most accessible spot for disposing of dead piglets. Furthermore, the location of the deposit underneath the corner of a terrace means that the young pigs were disposed of and then a terrace was built over them. The energy required to construct the feature seems excessive for a piglet garbage dump. Further excavation is needed to clarify the matter.

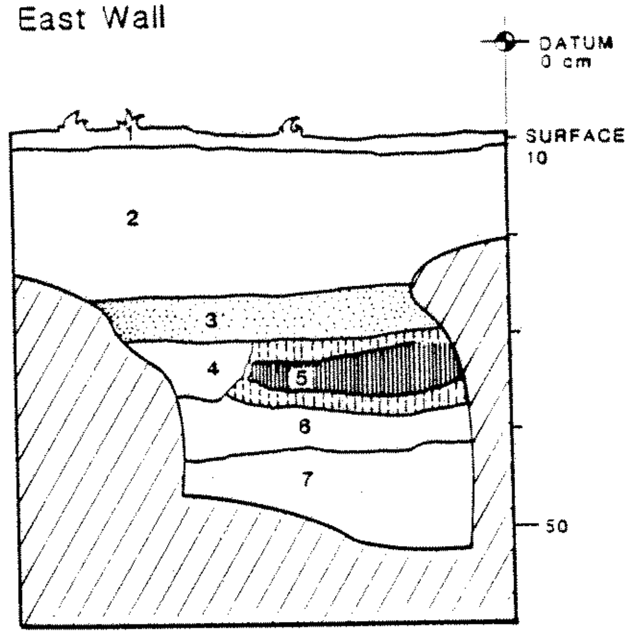
Feature 14, TP-1

Feature 14 TP-1 is a 50 x 50 cm unit located in the middle of a small enclosure (see Figure 19). The purpose of the test pit was to determine the function and chronology of the enclosure. Table 24 is a list of the layers and levels in the test pit, their volume, and their depth below datum. Figure 52 is a stratigraphic profile of TP-1. Table 25 is a list of the materials recovered during the excavation, and the concentration indices for those materials. Table 26 is a list of the shell midden from the feature.

Table 24. The depth and volume of excavated materials of each layer and level from Feature 14, TP-1.

Layer	Level	Depth (cm below datum)	Volume Excavated (cubic meters)
surf.		9/13	0.0000000
1	1	9/13 to 9/14	0.0025000
2	1	9/14 to 19	0.0340650
2	2	19 to 30/32	0.0255487
3	1	30 to 43	0.0085162
3	2	40/43 to 51	0.0008516
3	3	51 to 52.5	0.0005621
4	1	32 to 36	0.0005000
5	1	30 to 39	0.0007500
6	1	39 to 42	0.0007500
7	1	42 to 50	0.0127744
*** Total ***			0.0868180

FEATURE 14 Test Pit 1
East Wall



Layer	Munsell Color		
1	-	abrupt/ clear	loam
2	10YR 2/1 (dark brown)	clear	silt loam
3	10YR 3/2 (very dark grayish brown)	-	silt loam
4	10YR 2/1 (black)	clear	silt ash loam
5	10YR 3/2 (ash: very dark grayish brown) 2.5YR 2.5/0 (charcoal: black)	abrupt/ clear	silt ash loam with charcoal
6	2.5YR 3/2 (very dark grayish brown)	abrupt (irregular)	silt ash loam
7	10YR 4/4 (dark yellowish brown)	-	sandy loam

Figure 52. Profile and sediment description of Feature 14, TP-1.

Table 25. List of materials from Feature 14, TP-1. CI refers to concentration index for the previous column in unit per cubic meter.

Layer	Level	Charcoal (gm)	Charcoal (CI)	Kukui (gm)	Kukui (CI)	Crab (gm)	Crab (CI)	Urchin (gm)	Urchin (CI)	Shell (gm)	Shell (CI)
surf.		-	-	-	-	-	-	-	-	-	-
1	1	0.5	200.0	0.1	-	-	-	1.0	400.0	3.0	1200.0
2	1	3.4	99.8	-	-	-	-	3.0	88.1	37.0	1086.2
2	2	15.5	606.7	-	-	-	-	12.0	469.7	103.0	4031.5
3	1	3.1	364.0	-	-	0.2	23.5	5.0	587.1	23.0	2700.7
3	2	0.3	352.3	-	-	-	-	1.0	1174.3	1.0	1174.3
3	3	0.2	355.8	-	-	-	-	1.0	1779.0	-	-
4	1	-	-	-	-	-	-	-	-	-	-
5	1	0.3	1500.0	-	-	-	-	-	-	1.0	5000.0
6	1	-	-	-	-	-	-	-	-	-	-
7	1	1.1	86.1	-	-	-	-	1.0	78.3	5.0	391.4
*** Total ***											
		24.4		0.1		0.2		24.0		173.0	

Layer	Level	Flake Count	Flake Count (CI)	Flake Weight (gm)	Flake Weight (CI)	Shatter Count	Shatter Count (CI)	Shatter Weight (gm)	Shatter Weight (CI)
surf.		-	-	-	-	-	-	-	-
1	1	-	-	-	-	3	1200.0	3.2	1280.0
2	1	3.0	88.1	4.0	117.4	9	264.2	3.2	93.9
2	2	5.0	195.7	6.0	234.8	13	508.8	3.2	125.3
3	1	-	-	-	-	1	117.4	0.1	11.7
3	2	-	-	-	-	1	1174.3	0.2	234.9
3	3	-	-	-	-	-	-	-	-
4	1	-	-	-	-	-	-	-	-
5	1	-	-	-	-	-	-	-	-
6	1	-	-	-	-	-	-	-	-
7	1	-	-	-	-	1	78.3	0.1	7.8
*** Total ***									
		8.0		10.0		28		10.0	

Table 25 (cont.). List of materials from Feature 14, TP-1. CI refers to concentration index for the previous column in unit per cubic meter.

Layer	Level	Polished Flake Count	Polished Flake (CI)	Polished Flake Weight (gm)	Polished Flake Weight (CI)	Volcanic Glass Flake Count	Volcanic Glass Flake Ct. (CI)	Volcanic Glass Flake Wt. (gm)	Volcanic Glass Flake (CI)
surf.		-	-	-	-	-	-	-	-
1	1	-	-	-	-	-	-	-	-
2	1	-	-	-	-	1	29.4	0.1	2.9
2	2	1	39.1	1.0	39.1	-	-	-	-
3	1	-	-	-	-	-	-	-	-
3	2	-	-	-	-	-	-	-	-
3	3	-	-	-	-	-	-	-	-
4	1	-	-	-	-	-	-	-	-
5	1	-	-	-	-	-	-	-	-
6	1	-	-	-	-	-	-	-	-
7	1	-	-	-	-	-	-	-	-
*** Total ***		1		1.0		1		0.1	

Table 26. List of shell midden from Feature 14, TP-1. CI refers to concentration index for the previous column in grams per cubic meter.

Layer	Level	Turbo (gm)	Turbo (CI)	Oper-culae (gm)	Oper-culae (CI)	Nerita (gm)	Nerita (CI)	Cellana (gm)	Cellana (CI)	Unident-ified (gm)	Unident-ified (CI)
surf.		-	-	-	-	-	-	-	-	-	-
1	1	-	-	-	-	1.0	400.0	-	-	-	-
2	1	3.0	88.1	3.0	3.0	2.0	58.7	1.0	29.4	13.0	381.6
2	2	4.0	156.6	4.0	4.0	8.0	313.1	3.0	117.4	48.0	1878.8
3	1	6.0	704.5	1.0	1.0	2.0	234.8	-	-	9.0	1056.8
3	2	-	-	-	-	-	-	-	-	1.0	1174.3
3	3	-	-	-	-	-	-	-	-	-	-
4	1	-	-	-	-	-	-	-	-	-	-
5	1	-	-	-	-	-	-	-	-	-	-
6	1	-	-	-	-	-	-	-	-	-	-
7	1	-	-	-	-	-	-	-	-	-	-
*** Total ***		13.0		8.0		13.0		4.0		71.0	

Layer	Level	Cypraea (gm)	Cypraea (CI)	Conus (gm)	Conus (CI)	Strombus (gm)	Strom-bus (CI)	Cymatium (gm)	Cymatium (CI)	Drupa (gm)	Drupa (CI)	Tellina (gm)	Tellina (CI)	Isogn-omon (gm)	Isogn-omon (CI)
surf.		-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	1	1.0	400.0	1.0	400.0	-	-	-	-	1.0	400.0	-	-	-	-
2	1	8.0	234.8	-	-	2.0	58.7	-	-	4.0	117.4	-	-	2.0	58.7
2	2	23.0	900.2	2.0	78.3	2.0	78.3	1.0	39.1	6.0	234.8	-	-	-	-
3	1	2.0	234.8	-	-	1.0	117.4	2.0	234.8	-	-	1.0	117.4	-	-
3	2	-	-	-	-	-	-	-	-	1.0	1174.3	-	-	-	-
3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
*** Total ***		34.0		3.0		5.0		3.0		12.0		1.0		2.0	

There was grass, decomposing vegetation, and some pipipi shell on the surface of the test pit. Layer 1 Level 1 was the loose deposit of sediment and vegetation excavated from the surface of the entire unit. It contained small amounts of charcoal, kukui, shell, fish bone, indeterminate medium sized mammal, and 3 pieces of basalt.

Layer 2 was a slightly more compact cultural deposit. Level 1 of the layer contained small amounts of charcoal and sea urchin, moderate amounts of shell, 1 piece of volcanic glass, and 12 pieces of basalt. It also contained small amounts of fish and mammal bone. Included in the mammal bone where a few small pieces of Herpestes auropunctatus (Small Indian Mongoose). This animal was introduced to the Hawaiian Islands in 1883. After excavating the level, a 40 by 15 cm rock occupied the northwest quadrant of the unit. With the exception of volcanic glass, the second level of Layer 2 had a significantly higher density of all types of cultural material. It contained charcoal, sea urchin, shell, 18 pieces of basalt, 1 piece of polished basalt, 1 coral file that was 2.1 cm by 1.3 cm, 1 piece of Rattus exulans (Polynesian Rat), 1 piece of small to medium sized or medium sized mammal, and several types of fish bone. During Layer 2 Level 2, additional rocks were uncovered in all quadrants so that ca. 50% of the unit was obscured. Layer 2 was underlaid with Layer 3 Level 1 in the south west quadrant, and Layer 4 in the east.

Layer 3 was a silty deposit that extended from 30 cm BD to at least 52.5 cm BD. It contained small amounts of charcoal, sea urchin, shell, 2 pieces of basalt, 2 pieces of fish bone, 1 piece of Sus scrofa (pig), and 1 piece of undetermined mammal bone. At the lower boundary the horizontal extent of the layer was ca. 8 cm, but further excavation was limited because of the surrounding bedrock.

Layer 4 Level 1 was a thin mottled ashy deposit in the northeast quadrant. Because of its small size (0.0005 m^3) the entire deposit has been saved for future analysis. Layer 5 Level 1 was underneath Layer 4. It was a grayish black hearth deposit. Only 0.0002 m^3 of the deposit was analyzed and 0.00075 m^3 was saved for future study. Layer 6 Level 1 was the mottled deposit underneath the hearth. All 0.00075 m^3 of the deposit has been saved for future study. Layer 7 was underneath all of the other layers. It was a relatively sterile thin deposit of decomposing bedrock. The layer yielded 4 small pieces of fish bone.

The most significant strata of the test pit are the cultural deposit (Layer 2) and the hearth (Layer 5). These deposits indicate that the feature was used as a shelter. The single cultural deposit suggests that there was a solitary occupation of the feature. The presence of Herpestes auropunctatus in the upper level of the cultural deposit suggests that either the feature was used after 1883, or the historically introduced animal has somehow been incorporated into the relatively shallow upper level of the layer. Because the feature is a fairly high enclosure, it might have been used as a pen of some sort. The strata, however, do not overwhelmingly support this hypothesis.

Feature 16, TP-1

Feature 16 TP-1 is a 100 x 50 cm unit located behind the windward wall of a U-shape shelter (see Figure 20). The purpose of the test pit was to determine the function and chronology of the feature. Table 27 is a list of the layers and levels in the test pit, their volume, and their depth below datum. Figure 52 is a stratigraphic profile of TP-1. Table 28 is a list of the materials recovered during the excavation, and the concentration indices for those materials.

Prior to excavation there was a thick layer of grass and 4 large (35 to 55 cm) loose rocks on the surface of the test pit. The rocks probably fell off of the windward wall. Layer 1 was a thin culturally sterile deposit of loose vegetation and sediment.

Layer 2 was a harder packed deposit with lots of gravel and cobbles. It contained a few pieces of shell, charcoal, and mammal bone. Layer 2 was directly on top of bedrock in the western two-thirds of the unit. In the eastern third of the unit, Layer 2 overlaid Layer 3.

Layer 3 was a dark black cultural stratum with an abundance of charcoal and shell. During the excavation staining was apparent at 22 to 23 cm BD, but a clear outline was not defined until 24 cm BD. The layer did not contain a formal hearth, but a deposit of shell, ash and charcoal. It is noteworthy that the layer yielded a relatively narrow range of materials, none of which were lithic or historical. Layer 3 was directly on top of the bedrock.

The results of the excavation indicate that Feature 16 was a shelter containing a single cultural deposit. No formal hearth was found, but the amount of ash and charcoal in the cultural stratum suggests that a hearth might be present inside the feature.

Feature 18, TP-1

Feature 18 TP-1 is a 1 by 1 m unit located in the lee of a C-shape shelter (see Figure 22). The purpose of the test pit was to recover materials from a slablined hearth visible on the surface (Photo 15). Table 29 is a list of the layers and levels in the test pit, their volume, and their depth below datum. Figure 54 is a stratigraphic profile of TP-1. Table 30 is a list of the materials recovered during the excavation, and the concentration indices for those materials.

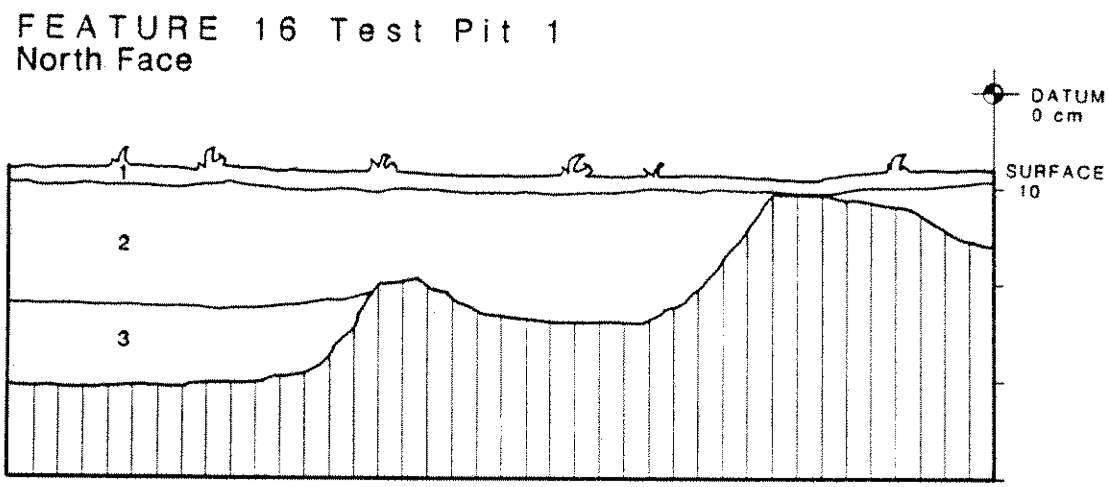
There was grass, lantana, and a few small pieces of pipipi shell on the interior surface of the C-shape. Layer 1 Level 1 was a loose dark brown deposit with lots of roots and gravel covering the entire test pit. During the excavation of Layer 1 a small amount of ash and charcoal was noted outside of the slablined hearth in the southwest corner of the unit. The boundaries of the slablined hearth were apparent after excavating Layer 1.

Table 27. The depth and volume of excavated materials of each layer and level from Feature 16, TP-1.

Layer	Level	Depth (cm below datum)	Volume Excavated (cubic meters)
surf.		9/12	0.0000000
1	1	9/12 to 11/12	0.0050000
2	1	11 to 21	0.0681300
2	2	21 to 31	0.0112415
3	1	23 to 33	0.0085162
*** Total ***			0.0928877

Table 28. List of materials from Feature 16, TP-1. CI refers to concentration index for the previous column in unit per cubic meter.

Layer	Level	Charcoal (gm)	Charcoal (CI)	Kukui (gm)	Kukui (CI)	Shell (gm)	Shell (CI)
surf.		-	-	-	-	-	-
1	1	-	-	-	-	-	-
2	1	4.1	60.2	0.1	-	20.0	293.6
2	2	2.1	186.8	-	-	1.0	89.0
3	1	40.9	4802.6	-	-	18.0	2113.6
*** Total ***		47.1		0.1		39.0	



Layer	Munsell Color	Boundary	Description
1	10YR 2/2 (very dark brown)	abrupt (wavy)	silt loam
2	10YR 3/3 (dark brown)	abrupt (wavy)	silt loam
3	10YR 2/1 (black)	abrupt (wavy)	silt ash loam

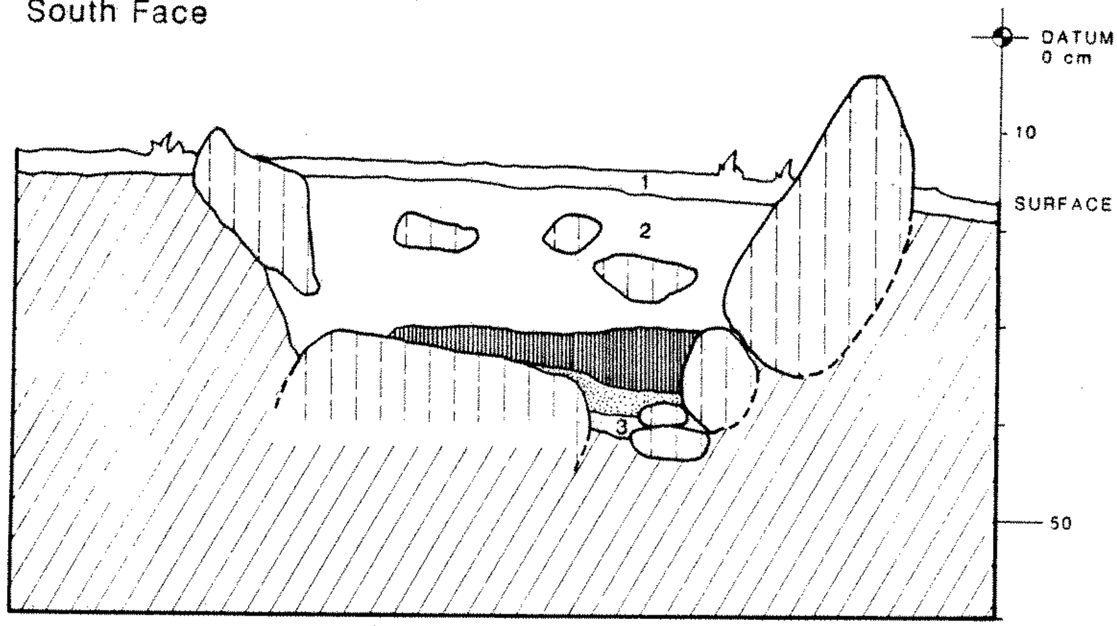
Figure 53. Profile and sediment description of Feature 16, TP-1.

Table 29. The depth and volume of excavated materials of each layer and level from Feature 18, TP-1.

Layer	Level	Depth (cm below datum)	Volume Excavated (cubic meters)
surf.		10/19	0.0000000
1	1	10/19 to 13/20	0.0255487
2	1	14/18 to 24	0.0085162
2	2	24 to 34	0.0085162
2	3	34 to 40	0.0021291
*** Total ***			0.0447102

Table 30. List of materials from Feature 18, TP-1. CI refers to concentration index for the previous column in unit per cubic meter.

Layer	Level	Charcoal (gm)	Charcoal (CI)	Urchin (gm)	Urchin (CI)	Shell (gm)	Shell (CI)	Shatter Count	Shatter Count (CI)	Shatter Weight (gm)	Shatter Weight (CI)
surf.		-	-	-	-	-	-	-	-	-	-
1	1	0.1	3.9	1.0	39.1	31.0	1213.4	1	39.1	0.1	3.9
2	1	0.1	11.7	3.0	352.3	19.0	2231.0	-	-	-	-
2	2	25.7	3017.8	7.0	822.0	22.0	2583.3	2	234.8	0.8	93.9
2	3	3.1	1456.0	1.0	469.7	4.0	1878.7	-	-	-	-
*** Total ***		29.0		12.0		76.0		3		0.9	



Layer	Munsell Color	Boundary	Description
1	5YR 2.5/2 (dark reddish brown)	abrupt (smooth)	silt loam
2	10YR 3/2 (very dark grayish brown)	abrupt (wavy)	silt loam
2 (char-coal)	7.5YR 2/0 (black)	-	silt ash loam
2 (ash)	10YR 4/1 (dark gray)	-	silt ash loam
3	10YR 4/4 (dark yellowish brown)	-	silt loam

Figure 54. Profile and sediment description of Feature 18, TP-1.

Further excavation focused exclusively on the interior north side of the hearth. The exterior of the hearth and its interior south side were left in tact. Layer 2 was a fine grained grayish brown ashy deposit. Included in the deposit were a number of fire cracked rocks. These were primarily found in Layer 2 Level 1. The largest of the rocks was ca. 20 x 8 x 5 cm, but the average size was ca. 10 x 8 x 5 cm. Layer 2 contained a charcoal stratum and an ash stratum. They should have received new layer designations, but were combined within the artificial boundaries of Layer 2 Level 2, and Layer 2 Level 3 (see Table 29 and Figure 54). The charcoal stratum was ca. 6 cm thick and the lower ash stratum ca. 4 cm thick.

Taken together, Layer 2 is the main cultural deposit of the feature. It produced a relatively large amount of charcoal and shell, a significant amount of sea urchin, and 2 small pieces of basalt. It also yielded several types of fish bone, 1 piece of Canis familiaris (Domestic Dog) bone, 2 pieces of Rattus exulans (Polynesian Rat), and 1 small piece of Mus musculus (House Mouse) bone. The house mouse was introduced to the Hawaiian Islands during the post-contact era.

A large rock extended across virtually the whole interior of the hearth and defined the lower boundary of Layer 2. Because only half of the hearth was excavated it was impossible to determine if the rock was bedrock or whether it was a loose boulder placed at the bottom of the hearth. The slabs of the hearth appeared to be resting on top of the basal rock. A 17.7 gm charcoal sample from the lower ash stratum produced a C13/C12 adjusted date of 100.4 ± 0.6 percent modern (Beta-33170). This result indicates that not enough time has pasted for the carbon to decay to produce a reliable chronometric estimate.

Layer 3 was a yellowish brown deposit found between one of the slabs and the basal rock. This stratum appeared to be sterile, but because only half of the hearth was excavated the deposit could not be removed.

Feature 18 is a shelter that was used during the historic era. The radiocarbon date and the presence of small amounts of bone from a historically introduced species support this chronological designation. The shelter appears to contain a single cultural deposit associated with a slablined hearth. Further excavation outside of the hearth is needed to determine if there are any other subsurface deposits.

Feature 20, TP-1

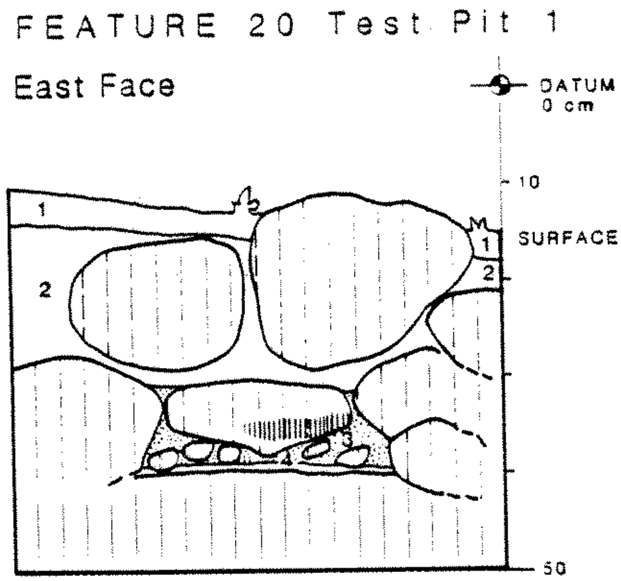
Feature 20 TP-1 is a 50 x 50 cm unit located behind the windward wall of a C-shape shelter (see Figure 24). The purpose of the test pit was to recover materials from a slablined hearth in the interior of the shelter. Table 31 is a list of the layers and levels in the test pit, their volume, and their depth below datum. Figure 55 is a stratigraphic profile of TP-1. Table 32 is a list of the materials recovered during the excavation, and the concentration indices for those materials.

Table 31. The depth and volume of excavated materials of each layer and level from Feature 20, TP-1.

Layer	Level	Depth (cm below datum)	Volume Excavated (cubic meters)
surf.		10/17	0.0000000
1	1	10/17 to 14/19	0.0042581
2	1	14/19 to 24	0.0112415
2	2	24 to 34	0.0056207
3	1	32 to 38	0.0011000
4	1	34/38 to 34/40	0.0003000
*** Total ***			
			0.0225203

Table 32. List of materials from Feature 20, TP-1. CI refers to concentration index for the previous column in unit per cubic meter.

Layer	Level	Charcoal (gm)	Charcoal (CI)	Shell (gm)	Shell (CI)
surf.		-	-	-	-
1	1	-	-	-	-
2	1	0.9	80.1	-	-
2	2	2.1	373.6	1.0	177.9
3	1	1.3	13000.0	1.0	10000.0
4	1	-	-	-	-
*** Total ***					
		4.3		2.0	



Layer	Munsell Color	Boundary	Description
1	10YR 3/2 (very dark grayish brown)	abrupt (smooth)	silt loam
2	10YR 4/3 (dark brown)	clear (smooth)	silt loam
3	10YR 2/2 (very dark brown)	abrupt (wavy)	silt ash loam
4	10YR 3/4 (dark yellowish brown)	-	silt loam

Figure 55. Profile and sediment description of Feature 20, TP-1.

There was grass and decomposing vegetation on the surface of the test pit. A circular alignment of 10 rocks was the surface manifestation of a slablined hearth. A test pit was set up to bisect the hearth. Layer 1 was a culturally sterile dark grayish brown deposit of decomposing vegetation and loose sediment.

Layer 2 Level 1 was lighter in color, contained less organic material, considerably more gravel and small rocks, and small amounts of charcoal. Layer 2 Level 2 was a similar deposit to Layer 2 Level 1 but contained slightly more charcoal.

Layer 3 was a thin ash concentration. It was a relatively small deposit and only 0.0001 m^3 of it has been processed. The remaining 0.001 m^3 has been curated for future analysis. Layer 3 was underlaid by bedrock, and Layer 4 a thin sterile yellowish brown deposit of decomposing bedrock.

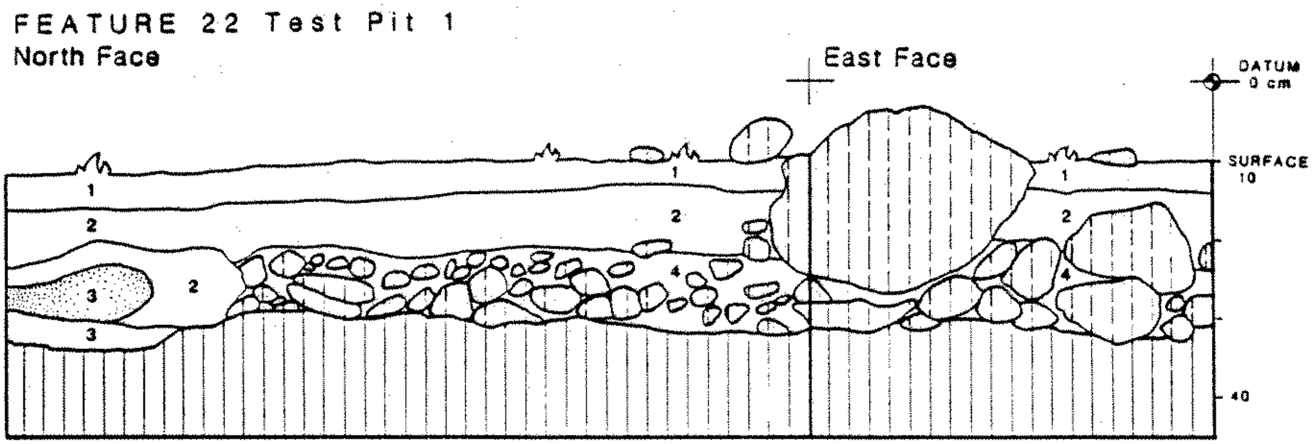
The results of the excavation indicate that Feature 20 is a shelter with a single cultural deposit associated with a slablined hearth.

Feature 22, TP-1

Feature 22 TP-1 is a 100 x 50 cm unit located behind the windward wall of a C-shape shelter (see Figure 25). The purpose of the test pit was to determine if there was a terrace in the south end of the feature. Table 33 is a list of the layers and levels in the test pit, their volume, and their depth below datum. Figure 56 is a stratigraphic profile of TP-1. Table 34 is a list of the materials recovered during the excavation, and the concentration indices for those materials.

Table 33. The depth and volume of excavated materials of each layer and level from Feature 22, TP-1.

Layer	Level	Depth (cm below datum)	Volume Excavated (cubic meters)
surf.		10/11	0.0000000
1	1	10/11 to 13/16	0.0127744
2	1	13/16 to 23	0.0170325
3	1	23 to 26/31	0.0085162
4	1	23 to 33	0.0298069
*** Total ***			0.0681300



Layer	Munsell Color	Boundary	Description
1	10YR 3/3 (dark brown)	abrupt (smooth)	silt loam
2	10YR 3/4 (dark yellowish brown)	abrupt (wavy)	silt loam
3	10YR 3/4 (dark yellowish brown)	abrupt (smooth)	silt ash loam
4	10YR 4/6 (dark yellowish brown)	abrupt (smooth)	silt loam

Figure 56. Profile and sediment description of Feature 22, TP-1.

Table 34. List of materials from Feature 22, TP-1. CI refers to concentration index for the previous column in unit per cubic meter.

Layer	Level	Charcoal (gm)	Charcoal (CI)	Kukui (gm)	Kukui (CI)	Urchin (gm)	Urchin (CI)	Shell (gm)	Shell (CI)
surf.		-	-	-	-	-	-	20.0	-
1	1	-	-	-	-	-	-	5.0	391.4
2	1	1.1	64.6	0.1	-	-	-	19.0	1115.5
3	1	4.7	551.9	-	-	1.0	117.4	9.0	1056.8
4	1	-	-	-	-	-	-	-	-
*** Total ***									
		5.8		0.1		1.0		53.0	

Layer	Level	Flake Count	Flake Count (CI)	Flake Weight (gm)	Flake Weight (CI)	Shatter Count	Shatter Count (CI)	Shatter Weight (gm)	Shatter Weight (CI)	Volcanic Glass Flake Count	Volcanic Glass Flake Ct. (CI)	Volcanic Glass Flake Wt. (gm)	Volcanic Glass Flake (CI)
surf.		-	-	-	-	-	-	-	-	-	-	-	-
1	1	-	-	-	-	1	78.3	0.6	47.0	2	156.6	0.4	31.3
2	1	6.0	352.3	10.0	587.1	1	58.7	0.3	17.6	-	-	-	-
3	1	1.0	117.4	1.0	117.4	-	-	-	-	-	-	-	-
4	1	-	-	-	-	-	-	-	-	-	-	-	-
*** Total ***													
		7.0		11.0		2		0.9		2		0.4	

The surface of the test pit was very rocky with a 1 cm thick layer of decomposing vegetation, and moderate amounts of shell midden. Layer 1 was a thin deposit of loose brown sediment containing decomposing vegetation and small amounts of shell, basalt, and volcanic glass.

Layer 2 was the main cultural deposit. It was a harder gravelly yellowish brown sediment with charcoal flecking, moderate amounts of shell, and a relatively large amount of basalt. The faunal material in the layer includes 1 piece of fish, 1 piece of Sus scrofa (Pig), and 1 piece of small to medium sized or medium sized immature mammal.

Layer 3 was a yellowish brown ash deposit found in two pockets within the test pit. It contained a relatively large amount of charcoal and moderate amounts of shell, and 1 piece of basalt. In addition to this there was a 4 cm wide dark charcoal stain in the northwest corner of the test pit. It is possible that this stain was the corner of a hearth from which the two ash pockets originated. Further excavation is necessary to confirm the existence of a formal hearth.

Layer 4 was a culturally sterile deposit of yellowish brown sediment containing an abundance of rocks ranging in size from 3 to 10 cm. It is possible that this layer represents a rough paving or the floor of a terrace. The rocks do not appear to be merely decomposing bedrock. Layer 4 was, however, underlaid with bedrock.

In sum, the feature appears to be a C-shape shelter with an interior paving or terrace. This possible terrace is overlaid with a single cultural deposit and several ash and charcoal pockets. The ash and charcoal pockets are probably associated with some unknown hearth in the immediate vicinity.

Feature 23, TP-1

Feature 23 TP-1 is a 100 x 50 cm unit located behind a C-shape shelter (see Figures 26 and 27, and Photo 17). The purpose of the test pit was to determine the function and chronology of the feature. Table 35 is a list of the layers and levels in the test pit, their volume, and their depth below datum. Figure 57 is a stratigraphic profile of TP-1. Table 36 is a list of the materials recovered during the excavation, and the concentration indices for those materials.

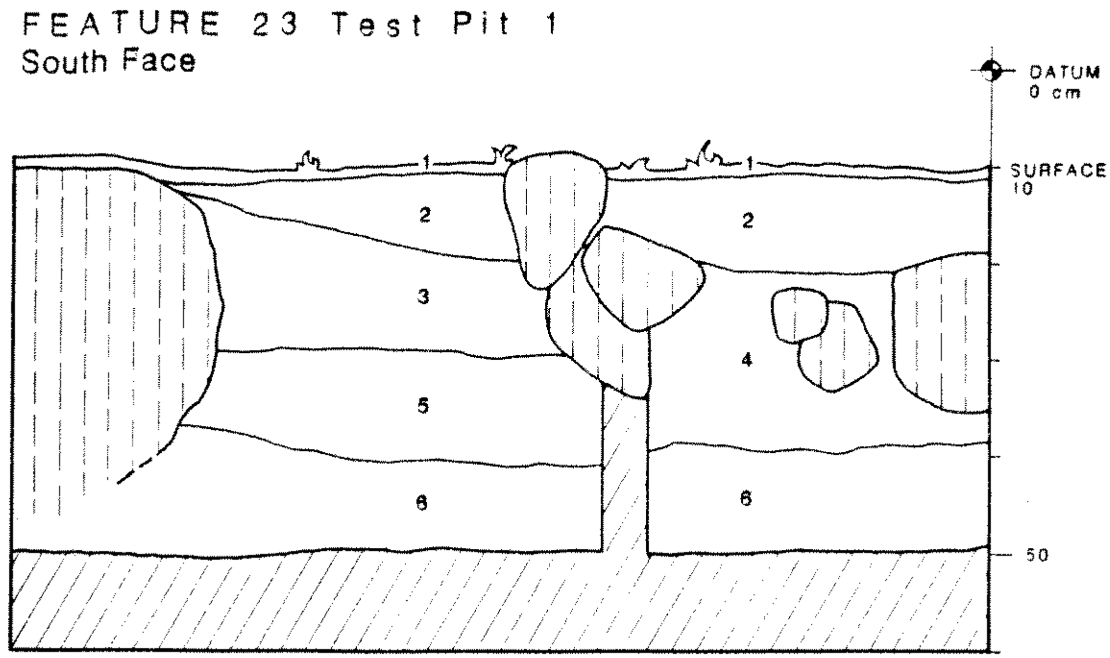
There was lantana, grass, decomposing vegetation, shell, and 1 basalt flake on the surface of the test pit. Layer 1 Level 1 was a loose deposit of decomposing vegetation and sediment extending over the entire test pit. It contained moderate amounts of shell and 1 piece of basalt.

Table 35. The depth and volume of excavated materials of each layer and level from Feature 23, TP-1.

Layer	Level	Depth (cm below datum)	Volume Excavated (cubic meters)
surf.		8/14	0.0000000
1	1	8/14 to 9/14	0.0025000
2	1	9/14 to 9.5/19	0.0298069
2	2	9.5/19 to 9.5/22.5	0.0085162
3	1	9.5/22.5 to 19/22.5	0.0127744
3	2	19/22.5 to 20/28	0.0085162
4	1	22.5 to 32.5	0.0127744
4	2	31 to 40	0.0170325
4	3	40 to 40/50	0.0170325
5	1	20 to 30	0.0350000
5	2	30 to 40	0.0298069
6	1	40/50 to 50	0.0298069
*** Total ***			0.2035669

Layer 2 Level 1 was a slightly darker, finer grained deposit that extended over the entire test pit. It contained small amounts of charcoal, several pieces of fish and mammal bone, quite a bit of shell, 9 pieces of basalt, and 1 piece of volcanic glass. The excavation of Layer 2 Level 1 uncovered an alignment that extended across the test pit. The top of the highest rock in this alignment is 5 cm BD and the bottom of the lowest rock is 40 cm BD. The alignment extends into Layers 4 and 5, but not into Layer 6. Layer 2 Level 1 was underlaid by Layer 3 to the east of the alignment, and Layer 2 Level 2 to the west. Layer 2 Level 2 contained no lithics and has less charcoal, sea urchin and shell than the previous level of the same layer. It was underlaid with Layer 4.

Layer 4 was excavated from the area west of the alignment. There was a high percentage of cobbles and small rocks in the layer, but they did not appear to be a paving. The layer contained considerable amounts of charcoal, sea urchin and shell, moderate amounts of fish and mammal bone, 8 small pieces of basalt, and 8 pieces of volcanic glass.



Layer	Munsell Color	Boundary	Description
1	-	clear	silt loam
2	10YR 2/1 (black)	abrupt (smooth)	silt loam
3	10YR 2/2 (very dark brown)	clear (smooth)	silt loam
4	10YR 2/2 (very dark brown)	clear (smooth)	silt loam
5	10YR 3/2 (very dark grayish brown)	clear (smooth)	silt loam
6	10YR 4/4 (dark yellowish brown)	-	silt loam

Figure 57. Profile and sediment description of Feature 23, TP-1.

Table 36. List of materials from Feature 23, TP-1. CI refers to concentration index for the previous column in unit per cubic meter.

Layer	Level	Charcoal (gm)	Charcoal (CI)	Kukui (gm)	Kukui (CI)	Urchin (gm)	Urchin (CI)	Shell (gm)	Shell (CI)
surf.		-	-	-	-	-	-	-	-
1	1	-	-	-	-	1.0	400.0	21.0	8400.0
2	1	2.3	77.2	-	-	15.0	503.2	84.0	2818.1
2	2	1.4	164.4	-	-	10.0	1174.2	40.0	4696.9
3	1	2.2	172.2	-	-	23.0	1800.5	88.0	6888.8
3	2	3.6	422.7	-	-	9.0	1056.8	38.0	4462.1
4	1	4.5	352.3	-	-	17.0	1330.8	60.0	4696.9
4	2	-	-	-	-	46.0	2700.7	82.0	4814.3
4	3	5.2	305.3	0.1	t	17.0	998.1	58.0	3405.3
5	1	-	-	0.2	t	31.0	885.7	113.0	3228.6
5	2	0.1	3.4	-	-	27.0	905.8	75.0	2516.2
6	1	1.2	40.3	-	-	4.0	134.2	12.0	402.6
*** Total ***									
		20.5		0.3		200.0		671.0	

Layer	Level	Flake Count	Flake Count (CI)	Flake Weight (gm)	Flake Weight (CI)	Shatter Count	Shatter Count (CI)	Shatter Weight (gm)	Shatter Weight (CI)	Volcanic Glass Flake	Volcanic Glass Flake	Volcanic Glass Flake	Volcanic Glass Flake
surf.		1.0	-	38.0	-	-	-	-	-	-	-	-	-
1	1	1.0	400.0	2.0	800.0	-	-	-	-	-	-	-	-
2	1	8.0	268.4	227.0	7615.7	1	33.5	0.1	3.4	1	33.5	0.1	3.4
2	2	-	-	-	-	-	-	-	-	-	-	-	-
3	1	-	-	-	-	-	-	-	-	-	-	-	-
3	2	-	-	-	-	1	117.4	0.1	11.7	1	117.4	0.1	11.7
4	1	-	-	-	-	1	78.3	0.2	15.7	-	-	-	-
4	2	-	-	-	-	7	411.0	3.7	217.2	5	293.6	0.4	23.5
4	3	-	-	-	-	-	-	-	-	3	176.1	0.2	11.7
5	1	1.0	28.6	2.0	57.1	3	85.7	0.5	14.3	7	200.0	0.7	20.0
5	2	-	-	-	-	6	201.3	3.0	100.6	9	301.9	0.4	13.4
6	1	-	-	-	-	2	67.1	0.1	3.4	-	-	-	-
*** Total ***													
		11.0		269.0		21		7.7		26		1.9	

Layer 3 was excavated from the area east of the alignment. It was a very fine grained silty deposit with considerable amounts of charcoal, urchin, and shell, but only 1 piece of basalt and 1 piece of volcanic glass. The layer was underlaid by Layer 5. This layer contained an abundance of charcoal, sea urchin, and shell, 9 pieces of basalt, and 16 pieces of volcanic glass. Layer 5 contained the most cultural material of any of the deposits in the unit. In addition to the usual array of charcoal, sea urchin, shell, and lithics, it contained several types of fish and mammal bone. Included in the faunal material was 1 piece of Mus musculus (House Mouse), a post-contact introduction. A 9.2 gm charcoal sample from Layer 5 Level 2 produced a C13/C12 adjusted date of 100.4 $\pm$ 0.9 percent modern (Beta-33169). This result indicates that not enough time has pasted for the carbon to decay to produce a reliable chronometric estimate.

Layer 6 was underneath both Layers 4 and 5. The contact between these layers and the distinctive yellowish brown color of Layer 6 was mottled and ambiguous. The layer yielded some cultural material, including small amounts of fish and mammal bone, but it is thought to be relatively sterile. It is possible that the material comes from the main deposit of Layer 6, but it seems more likely that it comes from the mottled zone above the layer.

Feature 23 is somewhat unique to the study area in so far as the shelter was apparently occupied on several occasions. Layers 2, 3, 4, and 5 are all relatively thick cultural deposits with distinct horizontal and vertical distributions. The radiocarbon date and the presence of bone from a historically introduced species in Layer 5 Level 2 suggests that the feature was occupied during the historic era. The piece of metal found near the bottom of the test pit confirms this. The test pit did not reach bedrock. Further excavation should determine if Layer 6 is a sterile deposit just above the bedrock, or if there are further buried cultural deposits.

Feature 24, TP-1

Feature 24 TP-1 is a 50 x 50 cm unit located behind the windward wall of a C-shape shelter (see Figure 28). The purpose of the test pit was to determine the function and chronology of the feature. Table 37 is a list of the layers and levels in the test pit, their volume, and their depth below datum. Table 38 is a list of the stratigraphic layers of TP-1.

There were three large rocks on the surface of the test pit which had probably fallen from the wall of the C-shape shelter. Layer 1 was a deposit of decomposing vegetation, and Layer 2 was the primary sediment deposit within the feature. The test pit yielded no cultural materials, but a few 10 to 15 cm rocks were encountered during the excavation. Because of the lack of materials, the precise function of the feature is unknown. The relatively flimsy construction technique suggests that it might have been built during a different time period, or perhaps served some different unknown function.

Table 37. The depth and volume of excavated materials of each layer and level from Feature 24, TP-1.

Layer	Level	Depth (cm below datum)	Volume Excavated (cubic meters)
surf.		10.5 to 16	0.0000000
1	1	10.5/16 to 11/17	0.0085162
2	1	11/17 to 18/21	0.0170325
2	2	18/21 to 32	0.0170325
*** Total ***			0.0425812

Table 38. List of stratigraphic layers in Feature 24, TP-1.

Layer	Munsell Color	Boundary	Description
1	-	clear	silt loam
2	10YR 3/6 (dark yellowish brown)		silt loam

Feature 26, TP-1

Feature 26 TP-1 is a 100 x 50 cm unit located behind the windward wall of a C-shape shelter (see Figure 29). The purpose of the test pit was to determine the function and chronology of the feature. Table 39 is a list of the layers and levels in the test pit, their volume, and their depth below datum. Figure 58 is a stratigraphic profile of TP-1. Table 40 is a list of the materials recovered during the excavation, and the concentration indices for those materials.

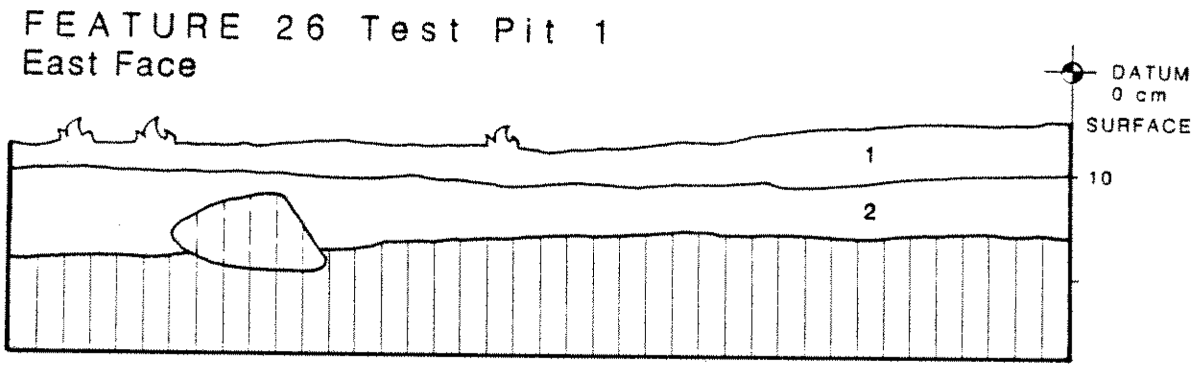
There was grass and decomposing vegetation on the surface of the test pit. Layer 1 was a deposit of loose vegetation and sediment which contained charcoal flecking but no other cultural material. Layer 2 was a harder dark brown deposit with a minimal amount of charcoal and shell. The bedrock was directly beneath Layer 2.

Because very little cultural material was recovered during the excavation, the precise function of the feature is unclear. The feature did not contain a well developed cultural deposit and thus was probably not extensively used as a shelter. It is possible that it is an agricultural feature or a minimally used shelter.

Feature 27, TP-1

Feature 27 TP-1 is a 100 x 50 cm unit located near the entrance of a U-shape shelter (see Figure 30). The purpose of the test pit was to determine the function and chronology of the feature. Table 41 is a list of the layers and levels in the test pit, their volume, and their depth below datum. Figure 59 is a stratigraphic profile of TP-1. Table 42 is a list of the materials recovered during the excavation, and the concentration indices for those materials.

There were considerable amounts of shell midden, lithics, and decomposing vegetation on the surface of the test pit. The lithics were collected, and the loose sediment and remaining materials were swept up and designated Layer 1. The layer yielded minute amounts of charcoal, small amounts of sea urchin, moderate amounts of shell, 2 small pieces of basalt shatter, and 1 small piece of worked coral. The coral artifact is 3.1 cm by 2 cm, has 3 abraded sides, and probably functioned as a small file.



Layer	Munsell Color	Boundary	Description
1	-	abrupt (smooth)	silt loam
2	10YR 3/3 (dark brown)	clear (irregular)	silt loam

Figure 58. Profile and sediment description of Feature 26, TP-1.

Table 39. The depth and volume of excavated materials of each layer and level from Feature 26, TP-1.

Layer	Level	Depth (cm below datum)	Volume Excavated (cubic meters)
surf.		6/11	0.0000000
1	1	6/11 to 7/13	0.0042581
2	1	7/13 to 10/17	0.0468394
2	2	10/17 to 10/26	0.0127744
*** Total ***			0.0638719

Table 40. List of materials from Feature 26, TP-1. CI refers to concentration index for the previous column in unit per cubic meter.

Layer	Level	Charcoal (gm)	Charcoal (CI)	Shell (gm)	Shell (CI)
surf.		-	-	-	-
1	1	-	-	-	-
2	1	0.5	10.7	9.0	192.1
2	2	-	-	-	-
*** Total ***		0.5		9.0	

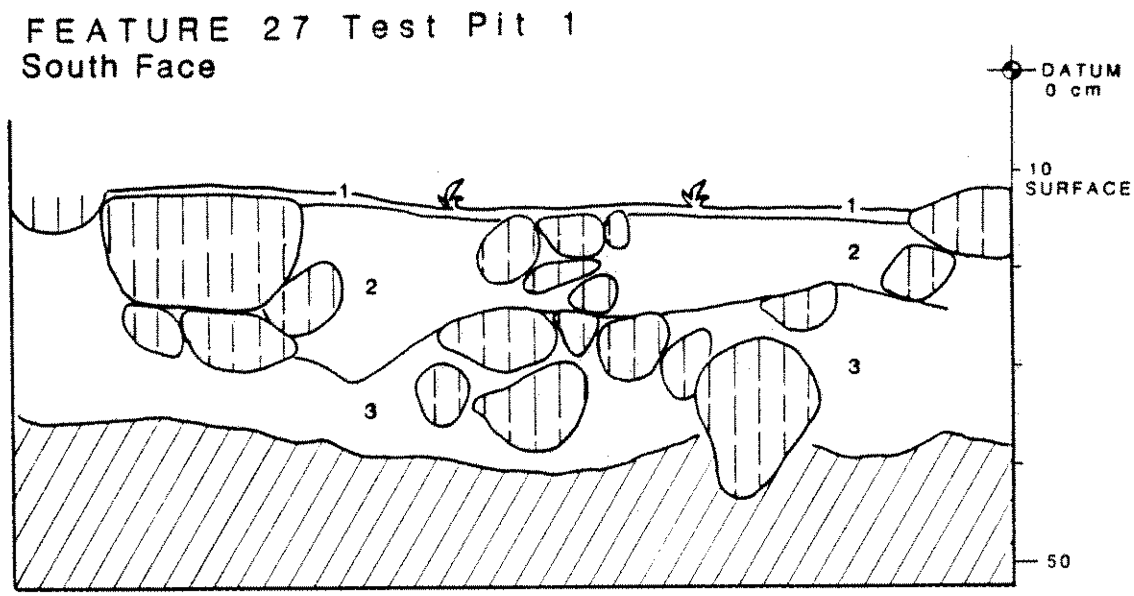
Table 41. The depth and volume of excavated materials of each layer and level from Feature 27, TP-1.

Layer	Level	Depth (cm below datum)	Volume Excavated (cubic meters)
surf.		8/14	0.0000000
1	1	8/14 to 8/15	0.0017032
2	1	8/15 to 17/19	0.0340650
3	1	17/19 to 29/35	0.0017032
*** Total ***			0.0374714

Table 42. List of materials from Feature 27, TP-1. CI refers to concentration index for the previous column in unit per cubic meter.

Layer	Level	Charcoal (gm)	Charcoal (CI)	Urchin (gm)	Urchin (CI)	Shell (gm)	Shell (CI)	Volcanic Glass Count	Volcanic Glass Count (CI)	Volcanic Glass Weight (gm)	Volcanic Glass Weight (CI)	Coral Artifact Count	Coral Artifact Count (CI)
surf.		-	-	-	-	-	-	-	-	-	-	-	-
1	1	0.1	58.7	1.0	587.1	44.0	25833.7	-	-	-	-	1	587.1
2	1	1.4	41.1	25.0	733.9	892.0	26185.2	15	440.3	4.9	143.8	1	29.4
3	1	-	-	1.0	587.1	69.0	40512.0	-	-	-	-	-	-
*** Total ***													
		1.5		27.0		1005.0		15		4.9	143.8	2	

Layer	Level	Flake Count	Flake Count (CI)	Flake Weight (gm)	Flake Weight (CI)	Shatter Count	Shatter Count (CI)	Shatter Weight (gm)	Shatter Weight (CI)	Polished Flake Count	Polished Flake (CI)	Polished Flake Weight (gm)	Polished Flake Weight (CI)
surf.		2.0	-	123.0	-	-	-	-	-	-	-	-	-
1	1	-	-	-	-	2	1174.3	1.6	939.4	-	-	-	-
2	1	20.0	587.1	157.0	4608.8	55	1614.6	24.6	722.1	1	29.4	5.0	146.8
3	1	2.0	1174.3	61.0	35814.9	-	-	-	-	-	-	-	-
*** Total ***													
		24.0		341.0		57		26.2		1		5.0	



Layer	Munsell Color	Boundary	Description
1	-	abrupt	silt loam
2	10YR 2/2 (black)	clear (irregular)	silt loam
3	-	-	pebble, cobble, boulder fill

Figure 59. Profile and sediment description of Feature 27, TP-1.

Layer 2 was the main cultural deposit. It was a loose black deposit containing large amounts of shell and lithics, moderate amounts of charcoal and sea urchin, and small amounts of bird, fish and mammal bone of different types. The lithic material was quite diverse. It included basalt flakes, basalt shatter, polished basalt flakes, and volcanic glass. The layer also yielded 1 small piece of worked coral, and 25 small pieces of branch coral. The coral artifact is another file with 2 abraded surfaces measuring 1.1 cm by 7 mm. There was also 1 small (1 cm) piece of small to medium mammal, or medium bird, bone with incision marks on it.

Layer 3 was a rough cobble paving. It was the foundation of the terrace which formed the south edge of the U-shape shelter. The paving rocks ranged in size from 5 to 40 cm in diameter. The cultural material recovered from Layer 3 probably originated in Layer 2. Because of the limited size of the test pit, it was impossible to remove the rocks any deeper than 35 cm below datum. Therefore, the excavation did not reach the bottom of Layer 3.

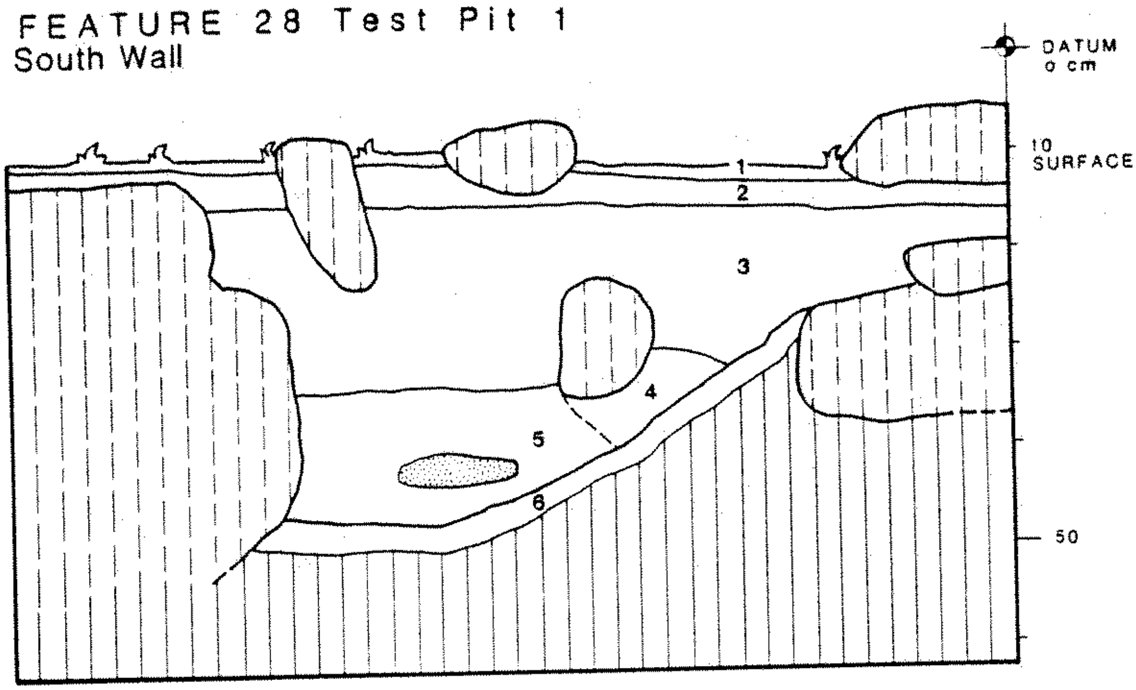
The results of the excavation indicate that Feature 27 was a U-shape shelter with an interior paving used for lithic processing. The feature contains a single cultural deposit underlaid by paving. Very little charcoal was recovered, indicating the absence of a hearth component.

Feature 28, TP-1

Feature 28 TP-1 is a 100 x 50 cm unit located behind the windward wall of a residential enclosure (see Figure 31). The purpose of the test pit was to determine the function and chronology of the feature. A slablined hearth was uncovered during the excavation. Table 43 is a list of the layers and levels in the test pit, their volume, and their depth below datum. Figure 60 is a stratigraphic profile of TP-1. Table 44 is a list of the materials recovered during the excavation, and the concentration indices for those materials.

There was lantana, grass, decomposed vegetation, and a few small pieces of coral on the surface of the test pit. In addition to this there were four rocks ranging in size from 10 to 20 cm in diameter. Two of these rocks were part of the slablined hearth. Layer 1 Level 1 was a deposit of decomposing vegetation and loose sediment. It contained ca. 12 small 2 to 3 cm pieces of coral and moderate amounts of shell. Layer 2 Level 1 was a loose dark brown deposit with lots of roots, small amounts of charcoal, considerable amounts of shell, 1 piece of medium sized bird bone, 1 piece of indeterminate vertebrate bone, and 1 piece of basalt. A third slab of the hearth was uncovered during this layer. Layer 2 Level 1 was underlaid by the sterile Layer 6 in the eastern third of the unit, and Layer 3 Level 1 in the western two thirds.

Layer 3 was excavated exclusively from the western two thirds of the unit. It was a loose dark brown deposit with small amounts of sea urchin, considerable amounts of charcoal and shell, 1 piece of fish bone, and 1 volcanic glass flake. It was the primary cultural deposit. Interspersed throughout the layer were several large rocks which might have been a rough paving or terrace. Layer 3 was underlaid with an ash deposit designated Layer 4, the slablined hearth deposit designated Layer 5, and the sterile deposit of decomposing bedrock designated Layer 6.



Layer	Munsell Color	Boundary	Description
1	10YR 2/2 (very dark brown)	abrupt (smooth)	silt loam
2	10YR 2/2 (very dark brown)	abrupt (wavy)	silt loam
3	10YR 3/3 (dark brown)	abrupt (wavy)	silt loam
4	10YR 2/2 (very dark brown)	abrupt (clear)	silt ash loam
5	10YR 2/1 (black)	abrupt (wavy)	silt ash loam
6	10YR 4/6 (dark yellowish brown)	-	silt loam

Figure 60. Profile and sediment description of Feature 28, TP-1.

Layer 4 was a fine grained ash deposit to the south of the slablined hearth. It was located outside of the hearth between one of the hearth slabs and a large rock which was part of the terrace foundation. Its horizontal dimensions were ca. 15 by 20 cm. The deposit contained considerable amounts of charcoal and shell. It is possible that the deposit was itself a formal hearth, but it did not appear to be truncated by the slablined hearth nor were its edges clearly defined. Therefore it was probably an ash deposit that had been cleared out from the hearth.

Table 43. The depth and volume of excavated materials of each layer and level from Feature 28, TP-1.

Layer	Level	Depth (cm below datum)	Volume Excavated (cubic meters)
surf.		8/11	0.0000000
1	1	8/11 to 10/13	0.0056207
2	1	10/13 to 14/20	0.0212906
3	1	17 to 24	0.0127744
3	2	24 to 30	0.0056207
4	1	24 to 34	0.0042581
4	2	34 to 40	0.0010000
5	1	30 to 47	0.0047200
6	1	14 to 24/40	0.0127744
*** Total ***			0.0680589

Table 44. List of materials from Feature 28, TP-1. CI refers to concentration index for the previous column in unit per cubic meter.

Layer	Level	Charcoal (gm)	Charcoal (CI)	Urchin (gm)	Urchin (CI)	Shell (gm)	Shell (CI)
surf.		-	-	-	-	-	-
1	1	-	-	-	-	13.0	2312.9
2	1	1.4	65.8	1.0	47.0	64.0	3006.0
3	1	2.9	227.0	1.0	78.3	59.0	4618.6
3	2	10.4	1850.3	2.0	355.8	39.0	6938.6
4	1	5.4	1268.2	1.0	234.8	34.0	7984.8
4	2	-	-	-	-	-	-
5	1	45.7	16801.5	1.0	367.6	13.0	4779.4
6	1	-	-	-	-	-	-
*** Total ***							
		65.8		6.0		222.0	

Layer	Level	Polished Flake Count	Polished Flake (CI)	Polished Flake Weight (gm)	Polished Flake Weight (CI)	Volcanic Glass Flake Count	Volcanic Glass Flake Ct. (CI)	Volcanic Glass Flake Wt. (gm)	Volcanic Glass Flake (CI)
surf.		-	-	-	-	-	-	-	-
1	1	-	-	-	-	-	-	-	-
2	1	2	93.9	1.0	47.0	-	-	-	-
3	1	-	-	-	-	-	-	-	-
3	2	-	-	-	-	1	177.9	0.7	124.5
4	1	-	-	-	-	-	-	-	-
4	2	-	-	-	-	-	-	-	-
5	1	-	-	-	-	-	-	-	-
6	1	-	-	-	-	-	-	-	-
*** Total ***									
		2		1.0		1		0.7	

The hearth deposit was Layer 5. Only 0.00272 m^3 of the deposit was analyzed, and 0.002 m^3 of it has been curated. The deposit was excavated from in between 3 slabs which defined its northern boundary. The southern half of the hearth extended into the unexcavated area adjacent to the test pit. The slabs of the hearth were resting on top of the sterile Layer 6. Inside of the hearth were ca. 9 rocks ranging in size from 10 to 15 cm. The bottom portion of the hearth contained large amounts of charcoal. Some of the charcoal pieces measured up to 5 cm long with diameters of 2 cm. The layer yielded small amounts of shell.

A 35.7 gram charcoal sample from the hearth deposit (Layer 5 Level 1) yielded a C13/C12 adjusted date of 70 $\pm$ 50 B.P. (Beta-33168). The calibrated age ranges of this sample (68% confidence interval), based on the computer program of Stuiver and Reimer (1986) are as follows

A.D. 1694-1722 (22%)
A.D. 1812-1856 (33%)
A.D. 1871-1921 (45%)

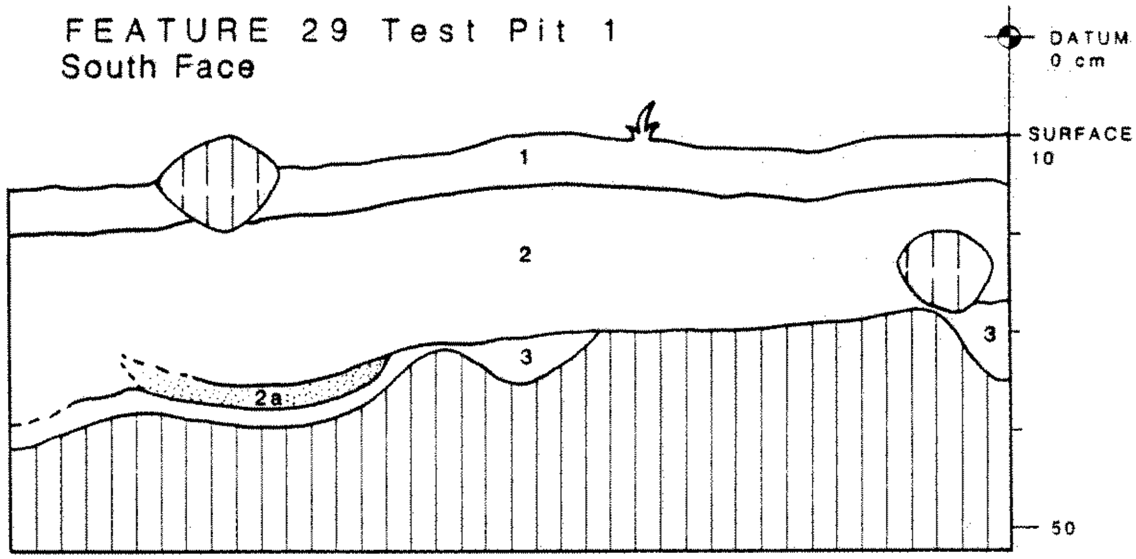
The computer program would not properly calculate the calibrated age ranges for a 95% confidence interval and thus the 68% confidence interval had to be used. Given the probabilities at the 68% confidence interval, the radiocarbon sample probably dates to the historic era.

Layer 6 Level 1 was overlaid by Layers 3, 4, and 5. It was a sterile yellowish brown deposit of decomposing bedrock. The layer was excavated until bedrock was encountered.

Based on the morphology of the feature and the limited test excavation, Feature 28 appears to be a residential feature containing at least 1 slablined hearth. The excavation indicates that a cultural deposit covered a terrace which the slablined hearth was built into. Although there was an additional ash deposit, it does not appear that there were multiple occupations of the feature.

Feature 29, TP-1

Feature 29 TP-1 is a 100 x 50 cm unit located behind the windward wall of a C-shape shelter (see Figure 32). The purpose of the test pit was to determine the function and chronology of the feature. A slablined hearth was uncovered during the excavation. Table 45 is a list of the layers and levels in the test pit, their volume, and their depth below datum. Figure 61 is a stratigraphic profile of TP-1. Table 46 is a list of the materials recovered during the excavation, and the concentration indices for those materials.



Layer	Munsell Color	Boundary	Description
1	10YR 3/6 (dark yellowish brown)	abrupt (smooth)	sandy loam
2	7.5YR 3/4 (dark brown)	clear (smooth)	silt loam
2A	10YR 3/2 (very dark grayish brown)	clear (smooth)	silt loam
3	10YR 3/4 (dark yellowish brown)	-	silt loam

Figure 61. Profile and sediment description of Feature 29, TP-1.

Table 45. The depth and volume of excavated materials of each layer and level from Feature 29, TP-1.

Layer	Level	Depth (cm below datum)	Volume Excavated (cubic meters)
surf.		10 to 16	0.0000000
1	1	10/16 to 14/20	0.0127744
2	1	14/20 to 25	0.0383231
2	2	25 to 25/35	0.0112415
2	3	25/35 to 25/42	0.0127744
3	1	25/42 to 30/42	0.0056207
*** Total ***			0.0807341

There was lantana and grass on the surface of the test pit. There were also ca. 12 rocks ranging in size from 3 to 22 cm in diameter. Layer 1 was a thin deposit of loose sediment and decomposing vegetation. The layer contained many small subangular porous basalt cobbles, 3 small (ca. 1 cm) pieces of coral, and small amounts of shell midden. It also included a few small pieces of *Herpestes auropunctatus* (Small Indian Mongoose).

Layer 2 Level 1 was a cultural stratum of dark brown sediment which contained a considerable number of porous rocks ranging in size from 2 to 8 cm. It yielded small amounts of charcoal and shell midden, 5 pieces of fish bone, and 2 pieces of indeterminate vertebrate bone. During the excavation of the layer, four rocks of a subsurface slablined hearth were uncovered in the eastern third of the unit. In the western two-thirds of the unit, Layer 2 Level 1 was underlaid with Layer 3.

Layer 2 Level 2 was excavated from the eastern third of the unit. It too contained an abundance of porous rocks, but it also had a moderate amount of charcoal, shell midden, and coral. Layer 2 Level 3 contained a relative abundance of charcoal, moderate amounts of shell, and 2 pieces of fish bone. In contrast to the other levels of Layer 2, the deposit contained relatively few rocks.

Table 46. List of materials from Feature 29, TP-1. CI refers to concentration index for the previous column in unit per cubic meter.

Layer	Level	Charcoal (gm)	Charcoal (CI)	Urchin (gm)	Urchin (CI)	Shell (gm)	Shell (CI)	Shatter Count	Shatter Count (CI)	Shatter Weight (gm)	Shatter Weight (CI)
surf.		-	-	-	-	-	-	-	-	-	-
1	1	-	-	-	-	1.0	78.3	-	-	-	-
2	1	0.9	23.5	-	-	11.0	287.0	-	-	-	-
2	2	2.3	204.6	-	-	23.0	2046.0	1	89.0	0.1	8.9
2	3	4.5	352.3	-	-	13.0	1017.7	-	-	-	-
3	1	0.8	142.3	1.0	177.9	6.0	1067.5	-	-	-	-
*** Total ***		8.5		1.0		54.0		1		0.1	

An ash deposit within Layer 2 Level 3 was designated Layer 2A. This was an error, as it should have been assigned a distinct layer designation. It was a small deposit, and the entire 0.0007 m^3 of sediment has been curated. Layer 2 Level 3 was underlaid with Layer 3. Layer 3 was a thin yellowish brown deposit of decomposing bedrock. It contained small amounts of charcoal and shell, but the excavator noted that the material probably originated from Layer 2.

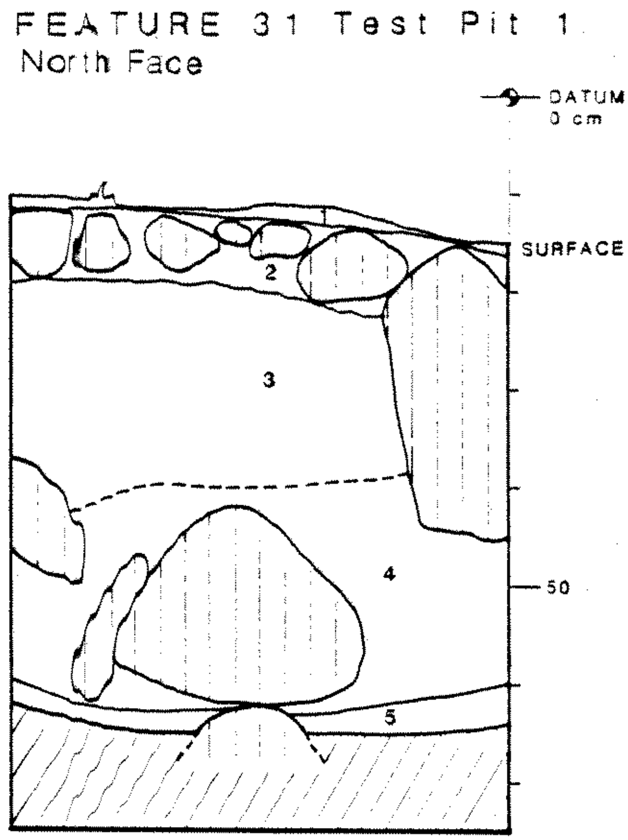
The results of the excavation indicate that Feature 29 is a C-shape shelter with a single cultural deposit and a subsurface slablined hearth.

Feature 31, TP-1

Feature 31 TP-1 is a 50 x 50 cm unit located behind the windward wall of a C-shape shelter (see Figure 33). The purpose of the test pit was to determine the function and chronology of the feature. Table 47 is a list of the layers and levels in the test pit, their volume, and their depth below datum. Figure 62 is a stratigraphic profile of TP-1. Table 48 is a list of the materials recovered during the excavation, and the concentration indices for those materials.

Table 47. The depth and volume of excavated materials of each layer and level from Feature 31, TP-1.

Layer	Level	Depth (cm below datum)	Volume Excavated (cubic meters)
surf.		10/13	0.0000000
1	1	10/13 to 12/15	0.0042581
2	1	12/15 to 17/18	0.0153292
3	1	17/18 to 27	0.0255487
3	2	27 to 37	0.0212906
3	3	37 to 43	0.0170325
4	1	55 to 60	0.0000000
5	1	40/48 to 64	0.0255487
*** Total ***			0.1090078



Layer	Munsell Color	Boundary	Description
1	5YR 2.5/2 (dark reddish brown)	abrupt (smooth)	silt loam
2	10YR 2/2 (very dark brown)	abrupt (smooth)	silt loam
3	5YR 3/3 (very dark gray)	gradual	silt loam
4	5YR 2.5/1 (black)	abrupt	silt loam
5	7.5YR 4/4 (brown)	-	silt loam

Figure 62. Profile and sediment description of Feature 31, TP-1.

Table 48. List of materials from Feature 31, TP-1. CI refers to concentration index for the previous column in unit per cubic meter.

Layer	Level	Charcoal (gm)	Charcoal (CI)	Urchin (gm)	Urchin (CI)	Shell (gm)	Shell (CI)	Volcanic Glass Count	Volcanic Glass Count (CI)	Volcanic Glass Weight (gm)	Volcanic Glass Weight (CI)
surf.		-	-	-	-	-	-	-	-	-	-
1	1	-	-	-	-	-	-	-	-	-	-
2	1	-	-	-	-	-	-	-	-	-	-
3	1	0.1	3.9	3.0	117.4	107.0	4188.1	23	900.2	3.9	152.6
3	2	4.1	192.6	6.0	281.8	110.0	5166.6	6	281.8	0.9	42.3
3	3	23.5	1379.7	10.0	587.1	92.0	5401.4	13	763.2	1.4	82.2
4	1	-	-	-	-	-	-	-	-	-	-
5	1	-	-	-	-	-	-	-	-	-	-
*** Total ***											
		27.7		19.0		309.0		42		6.2	277.1

Layer	Level	Flake Count	Flake Count (CI)	Flake Weight (gm)	Flake Weight (CI)	Shatter Count	Shatter Count (CI)	Shatter Weight (gm)	Shatter Weight (CI)	Polished Flake Count	Polished Flake (CI)	Polished Flake Weight (gm)	Polished Flake Weight (CI)
surf.		-	-	-	-	-	-	-	-	-	-	-	-
1	1	-	-	-	-	-	-	-	-	-	-	-	-
2	1	-	-	-	-	-	-	-	-	-	-	-	-
3	1	5.0	195.7	4.0	156.6	5	195.7	1.2	47.0	-	-	-	-
3	2	8.0	375.8	40.0	1878.8	4	187.9	1.4	65.8	1	47.0	2.0	93.9
3	3	5.0	293.6	3.0	176.1	-	-	-	-	-	-	-	-
4	1	-	-	-	-	-	-	-	-	-	-	-	-
5	1	-	-	-	-	-	-	-	-	-	-	-	-
*** Total ***													
		18.0		47.0		9		2.6		1		2.0	

There was lantana, grass, decomposing vegetation, and an abundance of small rocks and cobbles on the surface of the test pit. Layer 1 Level 1 was a sterile deposit of decomposing vegetation and loose sediment. After the excavation of Layer 1 Level 1, a cobble paving was visible. This paving extended across the entire unit and was excavated as Layer 2 Level 1. It was a sterile 4 cm thick deposit of dark brown sediment and rocks.

Layer 3 was a cultural deposit underneath the paving. It contained considerable amounts of charcoal and lithic material. The faunal material in the layer included a number of different types of fish bone, Rattus exulans (Polynesian Rat), and 1 piece of a small sized lizard. Underneath the cultural deposit there were two additional cultural strata, an ash pocket and a more formal hearth deposit. These two discrete deposits should have been assigned different designations from the main cultural deposit and kept distinct. Unfortunately several errors occurred during the excavation and processing of the material.

The ash pocket extended into the west wall of the test pit. Its horizontal dimensions were 5 by 10 cm, and its vertical distribution was from 38 to 43 cm BD. Even though it was labeled Layer 3 Level 3, it was excavated and inventoried as a distinct entity. The volume of the deposit was less than 0.001 m^3, and it has been saved for later analysis.

The hearth deposit was excavated from the northeast quadrant of the unit. Its horizontal dimensions were 25 by 20 cm, and its vertical distribution was from 44 to 65 cm BD. A 10 cm long, 5 cm wide, and 20 cm deep slab was located to one side of the deposit. The deposit was designated Layer 4 (as is shown in the stratigraphic profile), but the bag containing the deposit was labeled Layer 3 Level 3, and was inventoried on the Layer 3 Level 3 form. After a charcoal sample had been removed for radiocarbon dating, the deposit was combined with Layer 3 Level 3 of the main cultural deposit. Thus the materials reported in the tables for Layer 3 Level 3 include the materials excavated from Layer 4. This error is also the reason why no materials from Layer 4 are reported in the tables. Layer 5 was a yellowish brown sterile deposit.

A 22.3 gram charcoal sample from Layer 4 yielded a C13/C12 adjusted date of 60 $\pm$ 50 B.P. (Beta-33174). The calibrated age ranges of this sample (95% confidence interval), based on the computer program of Stuiver and Reimer (1986) are as follows

A.D. 1677-1743 (27%)
A.D. 1803-1939 (73%)

The statistical probabilities for these ranges, given in parentheses above, suggest that the A.D. 1803-1939 range is the most likely of the two.

The results of the excavation indicate that Feature 31 was a C-shape shelter with an interior paving. Below the paving there were several cultural deposits. One of these was an ash pocket which might have been from a second deposit, a formal hearth. Overlying these two deposits was another cultural deposit. A radiocarbon date from the lower hearth suggests that the feature was occupied during the historic era.

Feature 34, TP-1

Feature 34 TP-1 is a 50 x 50 cm unit located behind the windward wall of a C-shape shelter (see Figure 35). The purpose of the test pit was to determine the function and chronology of the feature. Table 49 is a list of the layers and levels in the test pit, their volume, and their depth below datum. Table 50 is a list of the stratigraphic layers of TP-1. Table 51 is a list of the materials recovered during the excavation, and the concentration indices for those materials.

There were sixteen 5 to 10 cm rocks and four 20 cm rocks on the surface of the test pit. Layer 1 Level 1 was a yellowish brown silty deposit with charcoal flecking and a trace of shell midden. Layer 1 Level 2 was a similar deposit, but at 30 cm BD there were ca. eleven 10 to 15 cm rocks. During the next level the size and percentage of these rocks increased. The rocks were not culturally altered, and were probably decomposing bedrock. At 42 cm BD bedrock covered the majority of the test pit.

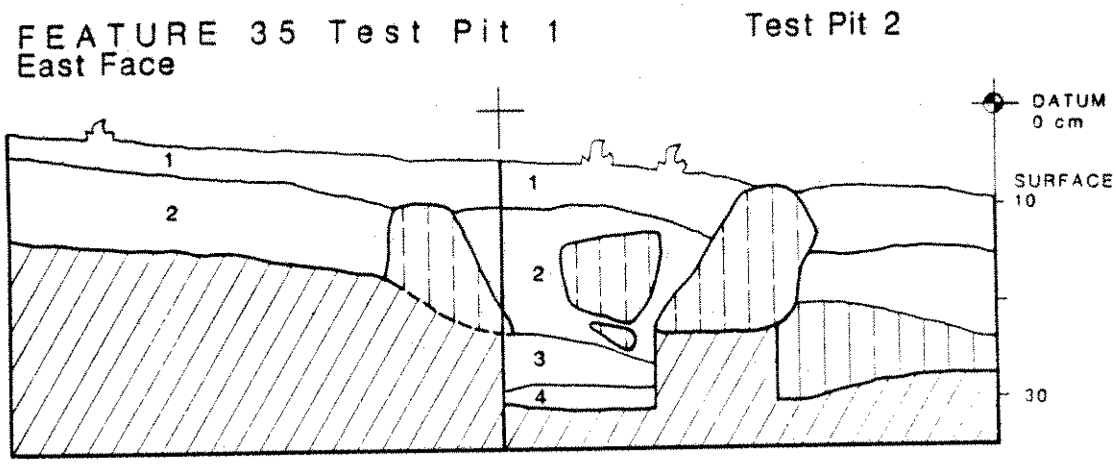
The lack of cultural material and the small interior of the C-shape suggests that the feature was not used extensively as a shelter. It is possible that it was used for agricultural purposes.

Feature 35, TP-1 and TP-2

Feature 35 TP-1 is a 100 x 50 cm unit located behind the windward wall of a C-shape shelter (see Figure 34). TP-2 is a 50 by 50 cm southern extension of TP-1. The purpose of the test pits was to determine the function and chronology of the feature, and investigate the possibility of the existence of a slablined hearth (Photo 19). Tables 52 and 53 are lists of the layers and levels in the test pits, their volume, and their depth below datum. Figure 63 is a stratigraphic profile of TP-1 and TP-2. Tables 54 and 55 are lists of the materials recovered during the excavation, and the concentration indices for those materials.

During the excavation of TP-1 it became apparent that a slablined hearth was probably located just south of the unit. Subsequent excavation of TP-2 confirmed this. The layer and level designations of the two test pits coincide with one exception. The relatively sterile thin deposit above the bedrock was labeled Layer 3 in TP-1 and Layer 6 in TP-2.

There was decomposing vegetation and a few small loose rocks on the surface of both test pits. Although they were not originally recognized, two slabs of the hearth were visible, one in each test pit. Layer 1 Level 1 of TP-1 was a culturally sterile deposit of loose vegetation and sediment. It did contain 1 piece of Rattus norvegicus (Norway Rat); a historically introduced species.



Layer	Munsell Color	Boundary	Description
1	10YR 2/2 (very dark brown)	abrupt (wavy)	silt loam
2	10YR 3/4 (dark yellowish brown)	clear (wavy)	silt loam
3	10YR 2/1 (black)	abrupt (wavy)	silt loam
4	10YR 3/2 (very dark grayish brown)	-	silt loam

Figure 63. Profile and sediment description of Feature 35, TP-1 and 2.

Table 49. The depth and volume of excavated materials of each layer and level from Feature 34, TP-1.

Layer	Level	Depth (cm below datum)	Volume Excavated (cubic meters)
surf.		12/17	0.0000000
1	1	12/17 to 22	0.0312206
1	2	22 to 32	0.0255487
1	3	32 to 42	0.0056207
*** Total ***			0.0623900

Table 50. List of stratigraphic layers in Feature 34.

Layer	Munsell Color	Boundary	Description
1	10YR 3/4 (dark yellowish brown)	-	silt loam

Table 51. List of materials from Feature 34, TP-1. CI refers to concentration index for the previous column in unit per cubic meter.

Layer	Level	Charcoal (gm)	Charcoal (CI)	Shell (gm)	Shell (CI)
surf.		-	-	-	-
1	1	0.1	3.2	1.0	32.0
1	2	0.1	3.9	1.0	39.1
1	3	-	-	-	-
*** Total ***		0.2		2.0	

Table 52. The depth and volume of excavated materials of each layer and level from Feature 35, TP-1.

Layer	Level	Depth (cm below datum)	Volume Excavated (cubic meters)
surf.		6/16	0.0000000
1	1	6/16 to 6/16	0.0085162
2	1	6/16 to 11/21	0.0298069
3	1	11/21 to 13/27	0.0212906
3	2	13/27 to 13/31	0.0042581
*** Total ***			0.0638718

Table 53. The depth and volume of excavated materials of each layer and level from Feature 35, TP-2.

Layer	Level	Depth (cm below datum)	Volume Excavated (cubic meters)
surf.		15/17	0.0000000
1	1	15/17 to 15/17	0.0021291
2	1	15/17 to 23/25	0.0170325
2	2	23/25 to 28/33	0.0034065
2	3	31/37 to 40	0.0042581
3	1	28/30 to 28/32	0.0010730
4	1	32 to 37/41	0.0021291
5	1	28 to 31/37	0.0034065
6	1	31/37 to 31/37	0.0042581
*** Total ***			0.0376929

Table 54. List of materials from Feature 35, TP-1. CI refers to concentration index for the previous column in unit per cubic meter.

Layer	Level	Charcoal (gm)	Charcoal (CI)	Urchin (gm)	Urchin (CI)	Shell (gm)	Shell (CI)
surf.		-	-	-	-	-	-
1	1	-	-	-	-	-	-
2	1	0.2	6.7	1.0	33.5	6.0	201.3
3	1	-	-	-	-	2.0	93.9
3	2	-	-	-	-	2.0	469.7
*** Total ***							
		0.2		1.0		10.0	

Layer	Level	Shatter Count	Shatter Count (CI)	Shatter Weight (gm)	Shatter Weight (CI)	Volcanic Glass Flake Count	Volcanic Glass Flake Ct. (CI)	Volcanic Glass Flake Wt. (gm)	Volcanic Glass Flake (CI)
surf.		-	-	-	-	-	-	-	-
1	1	-	-	-	-	-	-	-	-
2	1	4	134.2	1.1	36.9	6	201.3	1.5	50.3
3	1	-	-	-	-	-	-	-	-
3	2	-	-	-	-	-	-	-	-
*** Total ***									
		4		1.1		6		1.5	

Table 55. List of materials from Feature 35, TP-2. CI refers to concentration index for the previous column in unit per cubic meter.

Layer	Level	Charcoal (gm)	Charcoal (CI)	Kukui (gm)	Kukui (CI)	Shell (gm)	Shell (CI)
surf.		-	-	-	-	-	-
1	1	-	-	-	-	-	-
2	1	0.1	5.9	-	-	2.0	117.4
2	2	2.2	645.8	0.1	-	7.0	2054.9
2	3	1.1	258.3	-	-	1.0	234.8
3	1	0.1	93.2	-	-	1.0	932.0
4	1	0.3	400.0	-	-	3.0	4000.0
5	1	1.3	783.1	0.8	301.2	1.0	602.4
6	1	-	-	-	-	-	-
*** Total ***		5.1		0.9		15.0	

Layer	Level	Shatter Count	Shatter Count (CI)	Shatter Weight (gm)	Shatter Weight (CI)	Volcanic Glass Flake Count	Volcanic Glass Flake Ct. (CI)	Volcanic Glass Flake Wt. (gm)	Volcanic Glass Flake (CI)
surf.		-	-	-	-	-	-	-	-
1	1	-	-	-	-	-	-	-	-
2	1	6	352.3	1.4	82.2	4	234.8	0.1	5.9
2	2	4	1174.2	1.1	322.9	1	293.6	0.1	29.4
2	3	3	704.5	1.9	446.2	3	704.5	0.5	117.4
3	1	-	-	-	-	-	-	-	-
4	1	-	-	-	-	-	-	-	-
5	1	-	-	-	-	-	-	-	-
6	1	-	-	-	-	-	-	-	-
*** Total ***		13		4.4		8		0.7	

Layer 2 Level 1 of TP-1 was a yellowish brown deposit intermixed with 2 to 8 cm rocks which might have been a rough paving. The layer was the main cultural deposit surrounding the hearth and yielded small amounts of charcoal, shell, basalt shatter, and volcanic glass. Layer 3 Level 1 of TP-1 was a yellowish brown deposit just above the bedrock. It contained large amounts of small rocks which were decomposing off of the bedrock. The layer and level yielded small amounts of shell, but the excavator notes that it is possible the material fell in from Layer 2 Level 2. Because the bedrock sloped to the west, Layer 3 Level 2 was excavated exclusively from the west side of TP-1. The level was relatively sterile, but there was an upright slab and some charcoal staining at the extreme west end of the unit. A second unit was excavated to the west of the first to examine the possibility of a slablined hearth.

After excavating Layer 2 Level 1 of TP-2 a slablined hearth was clearly visible. Because the hearth extends into the south wall of the test pit, only half of the hearth was removed. Layer 3 Level 1 of TP-2 was the mottled deposit on the inside of the hearth. Layer 4 Level 1 was the dark grayish brown hearth fill. The layer yielded moderate amounts of charcoal and small amounts of shell, but little else. A 0.001 m^3 sample was saved for future analysis. Layer 5 Level 1 of TP-2 was an ash stain to the north of the hearth. It contained small amounts of charcoal, shell, and kukui nut. A 0.001 m^3 sample was saved for future analysis.

Layer 2 Levels 2 and 3 of TP-2 were the cultural deposit surrounding the hearth. The layer yielded small amounts of charcoal, shell, kukui nut, and several small pieces of basalt and volcanic glass. Layer 6 of TP-2 was similar to Layer 3 of TP-1. It was the loose rocky yellowish deposit above the bedrock.

To sum up, the two test pits behind the C-shape shelter revealed a slablined hearth (Layers 3 and 4 of TP-2) surrounded by a cultural deposit (Layer 2). The test excavations yielded a relatively small amount of cultural material, but it appears that some food and lithic processing was taking place at the feature.

MIDDEN ANALYSIS

This section of the report presents the results of the analysis of the faunal, wood, vegetable, marine molluscan, urchin, and crab remains. Specific details concerning the contexts of the materials are provided in the excavation section of this report. More general comments about the assemblages are presented below.

Faunal Analysis

Dr. Alan Ziegler identified the faunal material from the excavations to the lowest possible taxonomic level (Ziegler 1989a, 1989b). When common or scientific names of genera or species were used in explanations of the more generalized faunal categories--as, for example, in "Large Bird" or "Medium Mammal", Ziegler intended these names to convey only an idea of the general size of the animal represented. Table 56 is a summary listing of the material recovered from each feature. Appendix A lists the count and weight in grams of the faunal material for each layer and level within a feature, and Appendix B includes Ziegler's comments about the material from each layer and level.

Close to 90% of the total weight of faunal material is mammal bone, and nearly 80% of the material is the mammal bone from Feature 13. The vast majority of the Feature 13 mammal bone is immature Sus scrofa (pig). Fish bone comprises 10.46% of the faunal assemblage. All of the fish identified to the family taxonomic level are reef fish, and no off-shore species were noted (Ziegler 1989b). The fish were probably caught near shore by one of the usual fishing methods such as hook-and-line, trapping or netting. Bird bone comprises only 0.1% of the total bone assemblage. Ziegler (1989b) found this low percentage and the lack of sea bird bone surprising and notes that most other coastal sites in Hawai'i contain a relative abundance of procellariid bone. The few pieces of bird bone from the excavations were primarily chicken.

With the exception of the immature pig skeletons from Feature 13, the faunal assemblage is highly fragmented (Ziegler 1989b). Even sturdy elements, such as parrotfish jaws, were broken into a number of pieces. This fragmentation occurred some time during the depositional or post-depositional stages, and not during excavation. Ziegler suggests that one possible explanation is that pigs or, less likely, dogs chewed up and ate much of the material when it was still fresh.

Wood Species Identification

Charcoal samples from Features 13, 18, 23, and 28 were analyzed by Ms Gail Murakami for wood species identification (Tables 57 and 58) (Murakami 1989). Her research provides insights into the types of vegetation that were used by past inhabitants. Her results also indicate the probable nature and dynamic characteristics of the nearby vegetation community. A characterization of the utilized vegetation is presented in this section, and a short discussion of the changing diversity of vegetation types is provided in the dating section.

Table 56. Summary list of faunal material.

Feature	Amphibia	Aves	Fish	Indeter.	Mammalia	Reptilia	Total
2	-	-	0.71	0.02	-	-	0.73
6	-	-	0.23	-	-	-	0.23
8	0.07	0.05	18.43	0.76	2.01	-	21.32
10	-	0.03	2.36	-	86.92	-	89.31
12	0.02	0.03	5.65	-	1.78	-	7.48
13	0.13	0.71	63.44	0.02	824.30	0.06	888.66
14	-	0.06	4.80	0.08	0.48	-	5.42
16	-	-	0.03	-	1.34	-	1.37
18	-	-	0.46	-	0.05	-	0.51
22	-	-	0.06	-	0.37	-	0.43
23	-	-	5.40	0.29	1.08	-	6.77
27	-	0.13	1.84	0.06	0.80	-	2.83
28	-	0.06	0.41		-	-	0.47
29	-	-	0.76	0.14	1.29	-	2.19
31	-	-	3.29	-	0.23		3.62
35	-	-		-	0.16	-	0.16
TOTAL	0.22	1.07	107.87	1.37	920.81	0.06	1,031.50
PERCENT OF TOTAL	0.02	0.10	10.46	0.13	89.27	0.00	100

Murakami (1989:1) describes how the charcoal was prepared and analyzed:

> Charcoal pieces, at least 4 mm in size, from the first sample (Feature 13) were sorted into groups using the anatomical features of the freshly fractured transverse facet as seen under an American Optical Stereoscan 40x magnification dissecting microscope. The groups sorted from all subsequent samples were compared against those of the first sample. Representative charcoal pieces were selected from all groups of the first sample, in addition to the groups that appeared to differ from those of the first sample. These charcoal pieces were then trimmed and faced to facilitate orientation in the sectioning. The faced pieces were slowly infiltrated with Spurr's epoxy resin (Spurr 1969) in a procedure modified from Smith and Gannon (1973) and embedded in BEEM capsules. After polymerization the plastic embedded charcoal were sectioned with a steel microtome knife of a Reichert sliding microtome. The thin sections of the transverse, radial, and tangential facets of the charcoal were permanently mounted on microscope slides.
>
> Identifications were made by comparing the thin sections of the charcoal with those of known woods and written descriptions of Hawaiian or exotic woody genera...

Sixteen woody taxa were defined within the 25 charcoal pieces from the 4 different features. Of these 16 taxa, 11 were positively identified and 5 were unknown. The unknowns were not thought to be historic introductions (Murakami 1989:11). Most of the charcoal found in the hearths came from the nearby coastal and dryland vegetation communities although some inland taxa were represented. Murakami (1989:10) states:

> The charcoal from the four samples identified included the native shrubs, 'ilima and at least two species of 'akoko which are present in the park vegetation. However, another shrub, Chenopodium oahuense ('aheahea) and eight tree species were also identified from the charcoal. Among them were two endemic trees, Diospyros sandwicensis (lama) and Nestegis sandwicensis (olopua) which are usually found in dryland regions. Endemic trees of mesic regions identified were Acacia koa (koa), Metrosideros polymorpha ('ohia lehua), Myrsine sp. (kolea), and Psychotria sp. (kopiko). Two trees believed to have been brought to the Hawaiian Islands by the early Polynesians, Aleurites moluccana (kukui) and Artocarpus altilis ('ulu) were also represented in the charcoal.

Although the presence of specific botanical taxa in the charcoal assemblage may reflect cultural activities rather than just the surrounding vegetation, the absence of common dryland species suggests a limited resource (Murakami 1989:11). Murakami (1989:11) concludes "the taxa of greatest use as reflected in the percent composition were the coastal 'akoko and 'ilima which suggests that these shrubs were the dominant woody vegetation of the area." Probably because of its soft wood, Naupaka the other dominant shrub, was absent from the charcoal assemblage. Finally, the charcoal assemblage differs from the present day vegetation in the inclusion of some mesic trees which prior to the introduction of feral animals probably grew closer to the coast than they do today (Murakami 1989:10-11).

Vegetable Remains

No vegetable food remains were noted during the analysis of the midden. However the morphology of the features and the historic records do indicate that the past inhabitants were cultivating sweet potatoes. The dearth of sweet potato residue might be due to our methodological procedure rather than being a substantive result. Flotation was not employed during the analysis of the sediments, rather the deposits were sifted through 1/8" screen. Unfortunately the smaller seeds and vegetable matter would pass through this screen and go unnoticed. Several bulk samples from the hearths were saved, and future floatation analysis could be conducted on these sediments. This procedure would hopefully recover a few small pieces of edible vegetable remains.

Forty-six grams of kukui nut (Aleurites moluccana) were the only non-food vegetable remains recovered (Table 59). The fragments included both burnt and unburnt pieces. Features 13 and 2 had the highest density of kukui nut. In the past the oily kernel of the nut was used as a candle, and was occasionally eaten as a relish or as a strong purge (Athens 1989b). The extracted oil was also used as a medicine and as a varnish and fertilizer (Neal 1965:506 quoted in Athens 1989b:65).

Marine Molluscan, Urchin, and Crab Remains

The shell, urchin, and crab remains from each feature are summarized in the general midden tables previously presented for each test pit. The shell from Features 2, 8, 12, 13, and 14 were analyzed for shell identification. The results of this analysis were also previously presented for each test pit. Because of time constraints shell taxa were identified from only a sample of the Features. Table 60 is a summary listing of the remains from each feature.

The shell midden tables from Features 2, 8, 12, 13 and 14 indicate that a limited number of species predominate. These include Cellana (opihi), Nerita, and Cypraea. Other species such as Drupa, Turbo, and Hipponix were also found in relative abundance. Significantly, a large percentage of the shell from each feature was fragmented to the degree that it was not identifiable.

Most of the identified shell taxa are sedentary and live attached to rocks in the intertidal splash zone (Kay 1979). These would have been readily available from the coastline immediately adjacent to the project area. The shell found in Features 2 and 8 was probably deposited naturally by large storm surf. A large percentage of the shell was water worn, and thus was not culturally introduced into the deposit.

Only a small amount of crab was recovered during the excavations. It came from the late historic Features 12 and 13. Urchin was recovered from most of the features with particularly high densities found in Features 8, 13, and 23.

Table 57. Summary of Kalaupapa, Moloka'i charcoal identification (From Murakami 1989).

Feature	Layer	FPC	Lab. No.	Taxon	Sample Size No. Pcs.	Wt., gm	% Wt.
13	2.3	173	1043	Chenopodium	10	0.9	5.3
			1044	Osmanthus	5	0.5	2.7
			1045-1047	Metrosideros	21	1.8	11.0
			1049	Unknown 1	4	0.3	1.7
			1050	Unknown 2	2	0.2	1.2
			1051	Unknown 3	1	0.2	1.1
			1052	Diospyros	18	2.6	15.2
			1053	Sida	15	3.6	21.3
			1054;1060	Unknown 4	14	1.4	8.2
			1055;1059	Chamaesyce	36	4.3	25.6
			1056	Aleurites	1	0.1	0.3
			1057	Acacia	2	0.2	1.2
			1058	Artocarpus	1	0.1	0.6
18	2.2	79	sn*	Chamaesyce	35	7.1	57.2
			sn	Sida	7	0.6	5.3
			sn	Unknown 4	24	4.6	37.5
23	5.2	49	1061;1063	Sida	4	0.5	11.2
			1062;sn	Chamaesyce	40	3.2	69.8
			sn	Acacia	1	<0.1	1.1
			sn	Artocarpus	1	0.1	1.8
			sn	Chenopodium	8	0.6	13.4
			sn	Nestegis	1	<0.1	0.7
			sn	Unknown 1	1	<0.1	1.5
			sn	Unknown 4	1	<0.1	0.5
28	5.1	39	1064	Myrsine	3	0.3	1.6
			1065	Unknown 1	14	1.6	8.7
			1066	Unknown 5	2	0.1	0.7
			1067;sn	Sida	32	7.1	37.2
			sn	Chamaesyce	49	9.0	47.6
			sn	Chenopodium	5	0.8	4.2

* = no laboratory number was assigned.

Table 58. Distribution of Kalaupapa, Moloka'i charcoal taxa in percent sample weight (from Murakami 1989).

Taxon	Feature			
	13	18	23	28
Acacia koa (koa)	1.2		1.1	
Aleurites moluccana (kukui)	0.3			
Artocarpus altilis ('ulu)	0.6		1.8	
Chamaesyce spp. ('akoko)	25.6	57.2	69.8	47.6
Chenopodium oahuense ('aheahea)	5.3		13.4	4.2
Diospyros sandwicensis (lama)	15.2			
Metrosideros polymorpha ('ohi'a lehua)	11.0			
Myrsine sp. (kolea)				1.6
Nestegis sandwicensis (olopua)	2.7		0.7	
Psychotria sp. (kopiko)	1.7			
Sida fallax ('ilima)	21.3	5.3	11.2	37.2
Unknown 1	4.6		1.5	8.7
Unknown 2	1.2			
Unknown 3	1.1			
Unknown 4	8.2	37.5	0.5	
Unknown 5				0.7

Table 59 Summary list of weight of kukui.

Feature	Kukui Weight gms.
2	10.0
6	0.6
8	1.6
10	3.4
13	29.2
14	0.1
16	0.1
22	0.1
23	0.3
35	0.9
*** Total ***	46.3

Table 60. Summary list of crab, urchin, and shell.

Feature	Crab (gm)	Urchin (gm)	Shell (gm)
2	-	16	1333
5	-	-	-
6	-	39	798
8	-	291	8371
10	-	84	2382
12	1	69	880
13	1	170	2027
14	-	24	173
16	-	-	39
18	-	12	76
20	-	-	2
22	-	1	53
23	-	200	671
24	-	-	-
26	-	-	9
27	-	27	1005
28	-	6	222
29	-	1	54
31	-	19	309
34	-	-	2
35	-	1	25
*** Total ***	2	960	18431

ARTIFACTS

This section summarizes the artifacts recovered during the excavations. Specific details concerning the contexts of individual artifacts are provided in the excavation section of this report. The categories of artifacts discussed below include volcanic glass, basalt, coral, and historic materials.

Volcanic Glass

Volcanic glass is a once molten rock that solidified so quickly that minerals did not have time to form in it (Macdonald et al. 1983:124). Pieces of volcanic glass up to about a centimeter thick occur on the edges of dike formations, or as crusts on the surface of some pahoehoe lava flows (Macdonald et al. 1983:486). It has been inferred that small pieces of the material were used for cutting or scraping (Barrera and Kirch 1973, Olson 1983). In the past researchers have derived chronometric dates based on the hydration of volcanic glass. Unfortunately it is now apparent that the dates produced by this method are often skewed (Graves and Ladefoged 1990). Because of this methodological uncertainty there are currently no commercial laboratories producing hydration dates for Hawaiian samples. In addition volcanic glass can be analyzed to determine its chemical composition. If comparative data is available, the results of this analysis can be used to address questions concerning the trade and distribution of the material.

Ten volcanic glass samples were analyzed by Christopher M. Stevenson, Ph.D, of Diffusion Laboratories. The chemical composition of the samples was determined using X-ray fluorescence analysis. The results of Stevenson's analysis are presented in Table xx. Unfortunately, comparative data from Moloka'i is lacking and therefore questions concerning the trade and distribution of the volcanic glass can not be addressed at this time.

The volcanic glass recovered during the excavation was classified as either "flakes/shatter" or "cores." Flakes are identified by their laminar shape, the presence of a striking platform and a bulb of percussion. Pieces of shatter are the smaller pieces of volcanic glass that lack the more formalized attributes of flakes. In our incipient level lithic analysis these two categories were combined. Volcanic glass cores are the nodules that the flakes were removed from. They are larger than the flakes and contained numerous flake scars and usually a small amount of cortex.

The majority of the volcanic glass flakes are quite small (< 1 cm). Although all of the flakes were not systematically analyzed, the small sample that was closely examined did not exhibit signs of retouch or intentional shaping. The upper layers of Feature 8 contained the majority of the flakes and the only cores recovered. The presence of these materials leads to the inference that volcanic glass was being worked and used at the feature. The other features contain relatively smaller amounts of volcanic glass. It is possible that other areas within each of these features contain higher densities of volcanic glass and our limited subsurface testing was unable to establish this.

Table 61. The chemical composition of select volcanic glass samples (From Stevenson 1990).

Feature 8, Layer 1.1

	WEIGHT %	STD.DEV.		OXIDE %	STD.DEV.
O	44.40				
NA	1.297	0.048	NA2O	1.748	0.064
MG	5.652	0.065	MGO	9.372	0.108
AL	7.63	0.04	AL2O3	14.41	0.07
SI	22.84	0.05	SIO2	48.85	0.10
P	395	15 *	P2O5	904 *	35
S	92	4 *	SO3	230 *	9
K	0.420	0.004	K2O	0.506	0.005
CA	6.820	0.013	CAO	9.542	0.018
TI	1.241	0.010	TIO2	2.070	0.016
V	290	12 *	V2O5	518 *	21
CR	182	7 *	CR2O3	266 *	10
MN	0.131	0.002	MNO	0.170	0.002
FE	8.44	0.01	FE2O3	12.07	0.01
NI	119	4 *	NIO	151 *	5
CU	158	5 *	CUO	197 *	6
ZN	128	4 *	ZNO	159 *	5
RB	26	1 *	RB2O	29 *	1
SR	351	3 *	SRO	416 *	3
ZR	113	1 *	ZRO2	153 *	2
NB	12	0 *	NB2O5	17 *	1
BA	262	12 *	BAO	293 *	13
TOTAL	99.07				

Feature 8, Layer 2.3

	WEIGHT %	STD.DEV.		OXIDE %	STD.DEV.
O	44.97				
NA	1.052	0.043	NA2O	1.418	0.058
MG	6.09	0.07	MGO	10.10	0.11
AL	7.96	0.04	AL2O3	15.04	0.07
SI	22.58	0.05	SIO2	48.30	0.10
P	0.138	0.003	P2O5	0.316	0.007
S	168	5 *	SO3	421 *	13
K	0.374	0.004	K2O	0.450	0.005
CA	7.33	0.01	CAO	10.25	0.02
TI	1.216	0.010	TIO2	2.028	0.016
V	0.082	0.002	V2O5	0.147	0.003
MN	0.144	0.002	MNO	0.185	0.002
FE	8.47	0.01	FE2O3	12.11	0.01
NI	121	4 *	NIO	155 *	5
CU	296	6 *	CUO	370 *	8
ZN	154	4 *	ZNO	192 *	5
RB	38	1 *	RB2O	42 *	1
SR	337	3 *	SRO	399 *	3
ZR	103	1 *	ZRO2	140 *	2
NB	12	0 *	NB2O5	18 *	1
TOTAL	100.52				

Table 61 (cont).

Feature 10, Layer 3.2

	WEIGHT %	STD.DEV.		OXIDE %	STD.DEV.	
O	44.05					
NA	1.717	0.055	NA2O	2.314	0.074	
MG	5.521	0.065	MGO	9.154	0.107	
AL	7.83	0.04	AL2O3	14.79	0.07	
SI	21.65	0.04	SIO2	46.32	0.09	
P	0.206	0.003	P2O5	0.472	0.008	
S	196	5 *	SO3	490 *		14
K	0.445	0.004	K2O	0.536	0.005	
CA	6.933	0.013	CAO	9.700	0.018	
TI	1.528	0.011	TIO2	2.548	0.018	
V	276	11 *	V2O5	492 *		20
CR	109	5 *	CR2O3	159 *		8
MN	0.143	0.002	MNO	0.185	0.002	
FE	9.11	0.01	FE2O3	13.03	0.01	
NI	66	3 *	NIO	83 *		4
CU	162	5 *	CUO	203 *		6
ZN	134	4 *	ZNO	167 *		5
RB	65	2 *	RB2O	71 *		2
SR	420	3 *	SRO	497 *		3
Y	39	1 *	Y2O3	49 *		1
ZR	149	2 *	ZRO2	201 *		2
NB	35	1 *	NB2O5	49 *		1
TOTAL	99.30					

Feature 13, Layer 3.2

	WEIGHT %	STD.DEV.		OXIDE %	STD.DEV.	
O	44.40					
NA	1.574	0.053	NA2O	2.121	0.072	
MG	4.249	0.057	MGO	7.046	0.095	
AL	7.64	0.04	AL2O3	14.44	0.07	
SI	22.07	0.04	SIO2	47.22	0.09	
P	0.443	0.005	P2O5	1.015	0.012	
S	183	5 *	SO3	457 *		13
K	0.652	0.005	K2O	0.786	0.006	
CA	6.307	0.013	CAO	8.824	0.018	
TI	1.983	0.012	TIO2	3.308	0.020	
CR	100	5 *	CR2O3	146 *		7
MN	0.160	0.002	MNO	0.207	0.003	
FE	10.36	0.01	FE2O3	14.81	0.01	
NI	54	3 *	NIO	68 *		4
CU	141	5 *	CUO	176 *		6
ZN	158	4 *	ZNO	197 *		5
RB	46	1 *	RB2O	50 *		1
SR	448	3 *	SRO	529 *		4
Y	43	1 *	Y2O3	55 *		1
ZR	220	2 *	ZRO2	297 *		3
NB	22	1 *	NB2O5	32 *		1
BA	409	13 *	BAO	457 *		14
TOTAL	100.03					

Table 61 (cont.).

Feature 27, Layer 2.1

	WEIGHT %	STD.DEV.		OXIDE %	STD.DEV.
O	45.41				
NA	2.430	0.065	NA2O	3.275	0.087
MG	2.886	0.053	MGO	4.785	0.088
AL	8.48	0.04	AL2O3	16.02	0.08
SI	23.66	0.05	SIO2	50.61	0.10
P	0.569	0.006	P2O5	1.303	0.013
S	148	5 *	SO3	371 *	12
K	1.006	0.006	K2O	1.212	0.007
CA	5.021	0.011	CAO	7.025	0.015
TI	1.741	0.011	TIO2	2.903	0.019
V	362	13 *	V2O5	646 *	23
MN	0.171	0.002	MNO	0.220	0.003
FE	9.15	0.01	FE2O3	13.08	0.01
ZN	208	5 *	ZNO	260 *	6
RB	80	2 *	RB2O	88 *	2
SR	492	3 *	SRO	581 *	4
Y	72	1 *	Y2O3	91 *	1
ZR	464	2 *	ZRO2	627 *	3
NB	44	1 *	NB2O5	63 *	1
TOTAL	100.70				

Feature 31, Layer 3.1

	WEIGHT %	STD.DEV.		OXIDE %	STD.DEV.
O	44.71				
NA	1.599	0.052	NA2O	2.156	0.070
MG	7.24	0.08	MGO	12.00	0.14
AL	8.31	0.04	AL2O3	15.71	0.08
SI	21.49	0.05	SIO2	45.97	0.10
P	0.163	0.003	P2O5	0.373	0.007
S	61	3 *	SO3	153 *	8
K	0.273	0.003	K2O	0.329	0.004
CA	6.640	0.012	CAO	9.290	0.017
TI	1.266	0.010	TIO2	2.112	0.016
V	552	16 *	V2O5	985 *	28
MN	0.148	0.002	MNO	0.191	0.002
FE	8.44	0.01	FE2O3	12.06	0.01
NI	154	5 *	NIO	196 *	6
CU	309	6 *	CUO	387 *	8
ZN	144	4 *	ZNO	180 *	5
RB	46	1 *	RB2O	51 *	1
SR	287	2 *	SRO	340 *	3
ZR	101	1 *	ZRO2	137 *	2
NB	13	0 *	NB2O5	18 *	1
TOTAL	100.44				

Three hundred and seventy five pieces of volcanic glass were recovered from 11 separate features (Table 61). Of the 11 features, 7 (Features 8 upper layer, 10, 12, 13, 14, 23, 35) have been dated to the historic period (see dating section). Two additional features (Features 28, 31) have radiocarbon date ranges that overlap the prehistoric and historic eras, 1 feature (Feature 8 lower layer) was occupied prehistorically, and 2 features (Feature 22, 27) have not been dated. The high percentage of historic features containing volcanic glass is somewhat surprising as other archaeological projects in Hawai'i have noted an inverse correlation between volcanic glass and historic materials (Graves and Ladefoged 1990).

Table 62. Listing of volcanic glass.

Feature	Flake Count	Flake Weight gms.	Core Count	Core Weight gms.
8	229	33.1	3	10.0
10	35	6.2	-	-
12	4	0.9	-	-
13	3	17.0	-	-
14	1	0.1	-	-
22	2	0.4	-	-
23	26	1.9	-	-
27	15	4.9	-	-
28	1	0.7	-	-
31	42	6.2	-	-
35	14	2.2	-	-
*** Total ***	372	73.6	3	10.0

Basalt Artifacts

Three hundred and eighty-eight basalt artifacts with a total weight of 1.24 kg were recovered from 15 features. The basalt artifacts were classified as polished flakes, flakes, shatter, and miscellaneous basalt (Table 62). The flake category consists of basalt artifacts with a striking platform and a bulb of percussion. Polished flakes contain at least one smooth and polished surface. Shatter consists of small pieces of debitage that lack a bulb of percussion. The miscellaneous basalt artifact is a discoidal porous basalt pecking stone or ula maika.

Marshall Weisler (1990:1) of the University of California, Berkeley, analyzed two basalt flakes from Feature 6, Layer 2.1 and reports:

> The oxides of titanium, magnesium and iron and trace elements of Rb, Sr, Y, Zr, and Nb were assayed by non-destructive, energy dispersive XRF (X-ray fluorescence). The two flakes are similar in their ratios of trace elements and both are undoubtedly from the same source (same lava flow, rock, or tool, for that matter; they do have very similar macroscopic qualities). Geochemical values were compared against all known sources of fine-grained, adze quality rock on Moloka'i (eight major sources and three sub-sources within Maunaloa quarry complex) and the Kapohaku quarry on Lanai. The results strongly suggest a local source (Kalaupapa peninsula) of the lithic material and compare most favorably with published geochemical data for this area.

From a visual inspection of the basalt assemblage Weisler concluded that the majority of the basalt is medium to coarse-grained and probably derives from a local source on the peninsula (Marshall Weisler, personal communication).

Several features contained a relatively high density of basalt artifacts. Feature 27 is notable for it contained a wide range of basalt flakes and shatter and a number of other artifacts including a polished flake and 2 coral file fragments. The polished flake is not an adze fragment, but a part of a grinding stone. The other polished flakes found throughout the project area are also fragments of grinding stones. Significantly, no basalt cores or adze fragments were recovered during the limited excavations. This suggests that basalt tools were being used and reworked, but adzes were not being manufactured.

Coral Artifacts

One coral file was recovered from Feature 14, and two coral files fragments from Feature 27. It is often inferred that these artifacts were used to make bone and shell fishhooks (Emory et al. 1968). The presence of lithic material, bone, and the coral files at Feature 27 suggests that the feature was a tool manufacturing area of some sort. Feature 14 did not contain the same density of bone, lithics, or coral artifacts as Feature 27 and thus might not have been as extensively occupied.

Historic Artifacts

The historic artifacts consist primarily of nails, metal fragments, bottle glass, and chert (Table 63). The nails are square, but exhibit minimal rusting. It is possible that they date to before the turn of the last century, but this has not been established. Several pieces of glass are completely clear, and thus are probably relatively recent. Further analysis to establish a tighter chronology of the historic artifacts is required.

Table 63. Summary list of basalt artifacts.

Feature	Flake Count	Flake Weight (gm)	Shatter Count	Shatter Weight (gm)	Polished Flake Count	Polished Flake Weight (gm)	Misc. Basalt Count
2	3	61.0	1	0.3	1	2.0	-
6	-	-	-	-	3	4.0	-
8	14	64.0	52	30.8	1	1.0	-
10	3	93.0	8	8.7	-	-	-
12	4	25.0	13	36.0	-	-	1
13	13	104.0	58	67.2	2	3.0	-
14	8	10.0	28	10.0	1	1.0	-
18	-	-	3	0.9	-	-	-
22	7	11.0	2	0.9	-	-	-
23	11	269.0	21	7.7	-	-	-
27	24	341.0	57	26.2	1	5.0	-
28	-	-	-	-	2	1.0	-
29	-	-	1	0.1	-	-	-
31	18	47.0	9	2.6	1	2.0	-
35	-	-	17	5.5	-	-	-
*** Total ***	105	1025.0	270	196.9	12	19.0	1

Table 64. List of historic artifacts.

Feature	Test Pit	Layer	Level	Count	Type
2	1	2	1	7	2 pieces of glass 2 glass beads 2 chert flakes 1 piece metal
2	1	2	2	1	1 chert flake
2	2	1	1	3	3 pieces of bottle glass
8	1	2	1	1	1 chert flake
10	1	surf.		4	4 pieces of bottle glass
10	1	1	1	3	3 pieces of bottle glass
10	1	2	1	11	3 metal nails 4 pieces of bottle glass 4 pieces of metal
12	1	2	1	5	5 pieces of metal
*** Total ***					35

DATING ANALYSIS

A combination of chronometric and relative dating techniques were used to determine the period of occupation for the features in the study area. Concurrence in the results of several independent dating techniques strengthens the temporal inferences derived from any one technique alone. The techniques utilized include radiocarbon dating of charcoal samples, and the use of temporally sensitive artifacts, faunal material, and botanical samples. These techniques were used to determine the period of occupation of 14 features in the west end of the study area.

Radiocarbon Samples

A total of 7 charcoal samples were submitted to Beta Analytic, Inc. for radiocarbon dating. Details concerning these samples and the dating results are summarized in Table 65. All samples were adjusted for isotopic fractionation and five of the samples were calibrated using the computer program of Stuiver and Reimer (1986). The results of this calibration program are provided in Table 66. Two samples produced modern C13 adjusted age estimates and therefore they could not be calibrated.

Of the 7 samples, only 1 had a chronometric range exclusively in the prehistoric era. This sample came from near the bottom of Feature 8, TP-1, and was associated with a buried alignment. The bottom of the deposit was not reached. Therefore this range should not be considered an estimate of the earliest occupation of the study area. It is possible that there are deeper cultural deposits dating to an early period. Furthermore, it should be noted that some of the earlier deposits could have been washed away by the periodic wave action that impacts the area. At a much higher stratigraphic level in feature 8 there was faunal material of historically introduced species and historic artifacts.

Four of the radiocarbon dates had chronometric ranges that spanned from the prehistoric to the historic era. In all four cases, the computer program calculated that the actual date had a high probability of being historic. For Features 28 and 31 there is no additional evidence indicating that the features were either prehistoric or historic. For Features 12, however, the presence of faunal material from historically introduced species as well as historic artifacts indicates that the feature is indeed historic. For Feature 13, a similar presence of faunal material indicates the feature was occupied during the historic era.

Two samples produced radiocarbon dates of "percent modern." These dates from Features 18 and 23 clearly indicate a historic occupation. The presence of faunal material from historically introduced species substantiates this.

Historic Artifacts

Six different features were either made out of historic materials or contained historical material in their deposits. This historical material has not yet been analyzed to suggest chronological estimates, rather the material merely indicates that the features were occupied during the historic era. The historical material includes introduced lithic material, bottle glass, glass beads, nails, and metal fragments. The two large residential features, Features 2 and 10, contained historic materials throughout their cultural deposits. Feature 12 an enclosure contained historic material in its lower layers. In contrast, only one of the upper levels of the shelter Feature 8 contained historic material. Features 37 and 38 are concrete foundations which were probably used as houses during the 1930's.

Table 65. Radiocarbon dates from Kalaupapa Airport Runway Expansion Study Area

Feature	Layer	Beta Analytic Number	C-14 Age B.P. ± 1 s.d	C13/C12	C13 Adjusted age B.P. ± 1 s.d
8	2.5	33172	350 ± 80	-15.2 0/00	510 ± 80
12	2.2	33171	10 ± 120	-15.4 0/00	170 ± 120
13	2.3	33173	140 ± 50	-22.8 0/00	170 ± 50
18	2.2	33170	102.8 ± 0.6% modern	-13.1 0/00	100.4 ± 0.6% modern
23	5.2	33169	102.0 ± 0.9% modern	-17.2 0/00	100.4 ± 0.9% modern
28	5.1	33168	110 ± 50	-27.8 0/00	70 ± 50
31	3.3	33174	101.3 ± 0.6% modern	-15.1 0/00	60 ± 50

Table 66. Results of calibration program.

Feature 8

```
Radiocarbon Age BP   510.0  ± 80.0+                      Reference(s)
 Calibrated age(s) cal AD  1418                       (Stuiver and Becker)
                   cal BP   532
 cal AD/BC (cal BP) age ranges obtained from intercepts (Method A):
  one Sigma**   cal AD 1327-1351( 623- 599) 1391-1442( 559- 508)
  two Sigma**   cal AD 1280-1510( 670- 440) 1602-1615( 348- 335)

  Summary of above ---
  minimum of cal age ranges (cal ages) maximum of cal age ranges:
     one sigma   cal AD 1327 ( 1418) 1442
                 cal BP  623 (  532)  508
     two sigma   cal AD 1280 ( 1418) 1615
                 cal BP  670 (  532)  335

 cal AD/BC age ranges (cal ages as above) from probability distribution
   (Method B):
  % area enclosed     cal AD (cal BP) age ranges     relative area under
                                                     probability distribution
   68.3 (one sigma)   cal AD 1314-1369( 636- 581)           .40
                             1386-1451( 564- 499)           .60
   95.4 (two sigma)   cal AD 1281-1520( 669- 430)           .97
                             1592-1622( 358- 328)           .03
```

Feature 12

```
Radiocarbon Age BP   170.0  ±120.0+                      Reference(s)
 Calibrated age(s) cal AD  1674, 1743, 1801          (Stuiver and Becker)
                           1941, 1955*
                   cal BP   276,  207,  149
                              9,    0*
 cal AD/BC (cal BP) age ranges obtained from intercepts (Method A):
  one Sigma**   cal AD 1640-1950( 310-    0)
  two Sigma**   cal AD 1450-1955*( 500-    0*)

  Summary of above ---
  minimum of cal age ranges (cal ages) maximum of cal age ranges:
     one sigma   cal AD 1640 ( 1674, 1743, 1801, 1941, 1955*) 1950
                 cal BP  310 (  276,  207,  149,    9,    0*)    0
     two sigma   cal AD 1450 ( 1674, 1743, 1801, 1941, 1955*) 1955*
                 cal BP  500 (  276,  207,  149,    9,    0*)    0*

 cal AD/BC age ranges (cal ages as above) from probability distribution
   (Method B):
  % area enclosed     cal AD (cal BP) age ranges     relative area under
                                                     probability distribution
   68.3 (one sigma)   cal AD 1654-1709( 296- 241)           .21
                             1720-1880( 230-  70)           .62
                             1914-1955*(  36-   0*)         .16
   95.4 (two sigma)   cal AD 1508-1603( 442- 347)           .13
                             1610-1955*( 340-   0*)         .87
```

Table 66 (cont.).

Feature 13

```
Radiocarbon Age BP   170.0  ± 50.0+                    Reference(s)
 Calibrated age(s) cal AD  1674, 1743, 1801          (Stuiver and Becker)
                           1941, 1955*
                   cal BP   276,  207,  149
                              9,    0*
 cal AD/BC (cal BP) age ranges obtained from intercepts (Method A):
  one Sigma**   cal AD 1658-1695( 292- 255) 1721-1812( 229- 138)
                1854-1872(  96-  78) 1920-1954(  30-   0*)
  two Sigma**   cal AD 1640-1950( 310-   0)

  Summary of above ---
  minimum of cal age ranges (cal ages) maximum of cal age ranges:
     one sigma   cal AD 1658 ( 1674, 1743, 1801, 1941, 1955*) 1955*
                 cal BP  292 (  276,  207,  149,    9,    0*)    0*
     two sigma   cal AD 1640 ( 1674, 1743, 1801, 1941, 1955*) 1950
                 cal BP  310 (  276,  207,  149,    9,    0*)    0

 cal AD/BC age ranges (cal ages as above) from probability distribution
   (Method B):
  % area enclosed     cal AD (cal BP) age ranges      relative area under
                                                      probability distribution
   68.3 (one sigma)   cal AD 1660-1693( 290- 257)             .20
                             1722-1812( 228- 138)             .57
                             1861-1867(  89-  83)             .03
                             1922-1955*(  28-   0*)           .20
   95.4 (two sigma)   cal AD 1652-1713( 298- 237)             .21
                             1715-1887( 235-  63)             .62
                             1913-1955*(  37-   0*)           .17
```

Feature 28

```
Radiocarbon Age BP    70.0  ± 50.0+                     Reference(s)
 Calibrated age(s) cal AD  1903, 1905, 1955*          (Stuiver and Becker)
                   cal BP    47,   45,    0*
 cal AD/BC (cal BP) age ranges obtained from intercepts (Method A):
  one Sigma**   cal AD 1692-1722( 258- 228) 1811-1864( 139-  86)
                1865-1922(  85-  28) 1955*
  two Sigma**   cal AD 1673-1745( 277- 205) 1763-1767( 187- 183)
                1800-1940( 150-  10) 1955*

  Summary of above ---
  minimum of cal age ranges (cal ages) maximum of cal age ranges:
     one sigma   cal AD 1692 ( 1903, 1905, 1955*) 1955*
                 cal BP  258 (   47,   45,    0*)    0*
     two sigma   cal AD 1673 ( 1903, 1905, 1955*) 1955*
                 cal BP  277 (   47,   45,    0*)    0*

 cal AD/BC age ranges (cal ages as above) from probability distribution
   (Method B):
  % area enclosed     cal AD (cal BP) age ranges      relative area under
                                                      probability distribution
   68.3 (one sigma)   cal AD 1694-1722( 256- 228)             .22
                             1812-1856( 138-  94)             .33
                             1871-1921(  79-  29)             .45
   95.4 (two sigma)   cal AD 1675-1745( 275- 205)             .28
```

Table 66 (cont.).

Feature 31

```
Radiocarbon Age BP    60.0  ± 50.0┼                          Reference(s)
 Calibrated age(s) cal AD  1955*                          (Stuiver and Becker)
                  cal BP     0*
 cal AD/BC (cal BP) age ranges obtained from intercepts (Method A):
  one Sigma**   cal AD 1694-1722( 256- 228) 1812-1857( 138-  93)
                1870-1921(  80-  29) 1955*
  two Sigma**   cal AD 1672-1746( 278- 204) 1762-1769( 188- 181)
                1800-1940( 150-  10) 1955*

  Summary of above ---
  minimum of cal age ranges (cal ages) maximum of cal age ranges:
     one sigma    cal AD 1694 ( 1955*) 1955*
                  cal BP  256 (    0*)    0*
     two sigma    cal AD 1672 ( 1955*) 1955*
                  cal BP  278 (    0*)    0*

 cal AD/BC age ranges (cal ages as above) from probability distribution
   (Method B):
  % area enclosed     cal AD (cal BP) age ranges      relative area under
                                                      probability distribution
   68.3 (one sigma)   cal AD 1696-1722( 254- 228)             .21
                             1812-1854( 138-  96)             .32
                             1873-1920(  77-  30)             .47
   95.4 (two sigma)   cal AD 1677-1743( 273- 207)             .27
                             1803-1939( 147-  11)             .73
```

References for datasets [and intervals] used:

Stuiver,M and Becker,B, 1986, Radiocarbon, 28, 863-910.

Comments:

┼This standard deviation (error) may include a lab error multiplier.
IF SO SPECIFY!
** 1 sigma = square root of (sample std. dev.^{2}+ curve std. dev.^{2})
   2 sigma = 2 x square root of (sample std. dev.^{2}+ curve std. dev.^{2})
0* represents a "negative" age BP
1955* denotes influence of bomb C-14
Calibration file(s): ATM10.14C
Listing file: kala.txt
Plot file: kala.plt

Faunal Analysis

Dr. Alan Ziegler analyzed the faunal material from the excavations (Ziegler 1989). The results of his research are presented in Table 56 and Appendices A and B. A complete discussion of the faunal material is presented in another section of this report. Only the faunal results with implications for dating the features are discussed here. These results are intriguing, because they offer a relative dating technique that occasionally has extremely tight temporal control.

Ziegler identified 6 species of animals in the archaeological remains that are historic introductions. Two of the most interesting are the Geopelia striata (Zebra Dove) and the Bufo marinus (Giant Neotropical Toad). According to Ziegler (1989) the dove was introduced to the Hawaiian Islands in 1922, and the toad in 1932. A small amount of bone from both of these species were recovered from the lower levels of Feature 13, and Zebra Dove was recovered from Feature 12. This clearly indicates that these features were used after the early 1930's.

Another late introduction was the Herpestes auropunctatus (Small Indian Mongoose). It was introduced to the Hawaiian Islands in 1883. Bones from the mongoose were found in the upper layer of Feature 29 and a lower layer of Feature 14. The mongoose bones in Feature 29 are not associated with the cultural deposit. The mongoose bones in Feature 14 are associated with the cultural deposit and thus indicate that the feature was used after 1883.

The Streptopelia chinensis (Spotted Dove) was introduced to the Hawaiian Islands some time in the 1800's. It was found in the lower layers of Feature 13. The final 2 species were introduced to the Hawaiian Islands relatively soon after European contact in 1778. They are the Mus musculus (House Mouse), and the Rattus norvegicus and/or rattus (Norway and/or Roof Rat). Bones from these two species were found in the lower layers of Features 12, 18, and 23, and the upper layer of Feature 35.

Wood Species Identifications

The charcoal samples analyzed by Ms. Gail Murakami for wood species identification were the same samples submitted for radiocarbon dating (Murakami 1989). One of Murakami's most significant conclusions is that none of the charcoal samples contained historically introduced species. Although there are several "unknowns", Murakami is relatively confident that they are not historic introductions. This finding is somewhat remarkable given the results of the other types of chronometric and relative dating techniques. The other techniques indicate that Features 13, 18, and 23 are all historic. Of the four features analyzed for wood species identification, Feature 28 is the only one that does not have a historic occupation clearly established. This discrepancy should be addressed with further research.

Murakami (1989:11) presents additional insights. She states:

> The sample from feature 13 was the most diverse in dryland taxa and contained many of the native mesic trees. In contrast, Feature 18 contained only three taxa, among them the

currently common _'akoko_ and _'ilima_. However, the presence of the dryland _olopua_ and _aheahea_ in addition to _'akoko_ and _'ilima_ in Feature 23 suggests that the time represented by the charcoal may not be as late as Feature 18. Similarly, Feature 28 with its possible contact date is not much different from Feature 23 and does not have the same diversity as Feature 13. Obviously, the development of a chronology of vegetation change based on a few taxa is difficult even if the key taxa were present. However, if the presence of mesic trees in the charcoal is thought of as indicators of cultural activities then some change is also suggested by the charcoal from mesic taxa.

Based on the wood species diversity within the four features it would appear that Feature 13 predates Features 23 and 28, which both predate Feature 18.

Dating Summary

Using the 4 chronometric and relative dating techniques it is possible to suggest the occupation periods of 14 archaeological features (Features 2, 8, 10, 12, 13, 14, 18, 23, 28, 29, 31, 35, 37, and 38). The earliest known period of occupation could be as early as the late thirteenth century. This is based on the radiocarbon date from a lower layer of Feature 8. Using the results of the radiocarbon dates, it is possible to conclude that Features 28 and 31 were occupied exclusively during the prehistoric period. Probabilities provided by a computer program, however, suggest that they were occupied during the historic era. On the basis of historic artifacts and/or faunal material from historic introductions, Features 2, 8, 10, 12, 13, 14, 18, 23, and 35 were occupied during the historic period. Based on faunal material, Feature 14 was probably not occupied until after 1883. Similarly, Features 12, 13, and the upper layers of Feature 8 were probably not occupied until after the 1930's. The upper layer of Feature 29 contains faunal material from a historic introduction, but its main cultural deposit could be earlier. Features 37 and 38 are concrete foundations which clearly date to the historic era, probably the 1930's.

In sum, 1 feature (Feature 8) has a prehistoric component, 2 features (Features 28 and 31) could be prehistoric, 6 features (Features 2, 8, 10, 18, 23, 35) were occupied after 1778, 1 feature (Feature 14) was occupied after 1883, and 4 features were probably occupied in the twentieth century (Features 12, 13, 37, 38). The occupation period of Feature 29 and all the other features in the study area is uncertain. While the results of the tree species identification do not logically negate these conclusions, they do not overwhelmingly support them.

DISCUSSION AND CONCLUSIONS

The intensive survey of the study area located 49 features containing 559 components. A total of 23 controlled test pits totalling 11.0 square meters were excavated at 21 features. The archaeological features in the east end of the study area are primarily low C-shapes that were probably used for agricultural purposes. In contrast, the archaeological features in the west end are the remains of a residential and agricultural complex. This complex contains a variety of features including residential features, shelters, and agricultural enclosures and alignments. Each of these types of features is discussed in turn, a summary of the excavations is presented, and then the evidence for a period of historic agricultural intensification at Kalaupapa is reviewed.

Residential Features

The six main residential features in the area can be divided into three chronological types. The criteria for this classification are the morphology of the feature, its associated faunal and artifactual material, the radiocarbon dates, and the testimony of informants. Features 37 and 38 are probably concrete foundations of houses occupied during the early twentieth century. The abandoned house at the end of the dirt road might be a similar structure. Topographic maps drawn in 1921-1922 do not show these structures and therefore it is assumed that they were built sometime thereafter. Contemporary residents of Kalaupapa informed us that these houses were first occupied in the 1930's.

Features 2 and 10 are morphologically different than Features 37 and 38. Features 2 and 10 are constructed out of dry stone masonry, and include no concrete or bonding materials. They have several internal pavings which were probably distinct activity areas within the household. This is a morphological characteristic that is associated with historic residential features in other parts of Hawai'i (Ladefoged et al. 1987). Furthermore, the associated faunal material and artifacts from these features clearly suggest that they were occupied during the historic era.

The final type of residential feature is represented by Features 6 and 28. These are smaller structures that include enclosures surrounding internal living areas. Feature 28 contains 3 activity areas and Feature 6 contains 2. Based on the morphology of Feature 6, it might have been occupied during 2 phases. No historical material was found at either of these residential features, and the range of the radiocarbon date for Feature 28 spans from the prehistoric to the historic era. Although these two features are morphologically distinct from the 4 residential features that are known to be historic, they cannot be clearly defined as either prehistoric or historic.

Shelters

Of the 38 archaeological features in the west end of the study area, 19 were shelters of some sort or another. Test excavations took place at 14 of these features. These excavations indicated that 3 of the shelters had multiple cultural deposits, 8 had a single cultural deposit, and 3 lacked a cultural deposit. Furthermore, 6 of the shelters contained slablined hearths. These results suggest that the study area contained a relatively large number of shelters in comparison to the other major types of features. Of the 12 shelters that are known to contain cultural deposits, 66.6% had only one cultural deposit and 33.3% had multiple deposits. This suggests that the majority of shelters were built and used during a relatively narrow time period.

Agricultural Features

There are two main types of agricultural complexes in the west end of the study area. These include alignments with enclosures around them, and alignments without enclosures. The agricultural complexes with enclosures are Features 5A, 5B, and 30. The density of alignments is much higher within the enclosures than the areas outside of the enclosures (see Figure 2). It is possible that the agricultural enclosures are a later intensification of an earlier field system. The test excavations in the two agricultural contexts support this notion. The two test units were excavated behind agricultural walls contained in enclosure 5B. In both instances buried alignments were encountered. A radiocarbon date associated with one of these alignments indicates that the area could have been used for agricultural purposes as early as the late thirteenth century. In addition to these agricultural alignment complexes, there are several agricultural mounds throughout the study area.

Comparison of the Archaeological Features in the Study Area with Other Features Throughout the Peninsula

The archaeological features recorded in the project area differ from those recorded in other parts of the Kalaupapa peninsula. In contrast to Pearson et al. (1974), no lava tubes were recorded in the project area. In comparison to the features found in the south part of the peninsula (Somers 1985), the features in the project area were spatially distinct with a high percentage of shelters. Furthermore the agricultural features were parallel alignments and not pits and terraces as in the south. One reason for these distinctions could be that the two areas were occupied during different time periods. The majority of the surface remains in the project area are historic whereas the southern area might have more of a prehistoric component to it. An additional factor might be the distinctiveness of the two microenvironments.

Excavations

Test excavations were conducted in 4 residential features (Features 2, 6, 10, 28), 14 shelters (Features 8, 14, 16, 18, 20, 22, 23, 24, 26, 27, 29, 31, 34, 35), 1 possible shrine or special use area (Feature 13), 1 animal pen (Feature 12), and 2 agricultural areas (Features 5B, 8). The excavation at Feature 8 is classified as both a shelter because of the findings in an upper level, and an agricultural area because of the findings in a lower level. The test excavations in the 21 features revealed 3 features with multiple cultural deposits, 2 features with a single cultural deposit and what appears to be a rebuilding phase of the architectural structure on the surface, 12 features with a single cultural deposit, and 4 features lacking a developed cultural deposit. These results suggest that 57% of the archaeological features tested were occupied during a single time period, 23.8% were occupied more than once, and 19% show little or no sign of occupation. It should be noted that not all cultural activities produce deposits.

The material recovered during the test excavations provide insights into the behaviors and activities of the past occupants. The faunal analysis indicates that near shore reef fish were exploited. The lack of faunal material from off-shore species and the near total lack of bird bone is also significant. The vast majority of the faunal material comes from mammals, especially immature Sus scrofa (pig). The faunal assemblage as a whole is fragmented and broken. The wood species identification of charcoal samples suggests that people were predominately burning the coastal 'akoko and 'ilima shrubs. Furthermore, the charcoal assemblage differs from the present day vegetation in the inclusion of mesic trees which might suggest that these trees grew closer to the coast at one time. Kukui nut was the only vegetable remains recovered. The identified shell taxa were sedentary species who live attached to rocks in the intertidal splash zone. The lithic artifacts indicate that the past occupants were utilizing local materials to manufacture a number of different types of tools. Feature 27 was notable for the range of lithic and coral artifacts. The glass and metal artifacts clearly indicate the historic occupation of a number of the features.

Historic Agricultural Intensification

The results of the intensive survey indicate that the study area has been used for residential and agricultural purposes over the last seven centuries. It is likely that occupation of the area has an even greater antiquity. However, the vast majority of features in the study area appear to date to the historic era. The tendency of the features to contain a single cultural deposit suggests that they were built and used within a relatively short time frame. This does not, however, mean that all of the features are contemporaneous. The chronometric and relative dating techniques suggest that the features were occupied during several different time periods within the historic era. It is possible that the two large residential features (2 and 10), the agricultural enclosures (5 and 30), and a number of shelters were occupied during the early historic period. Then, at a later date, the concrete foundations, a number of other shelters, the animal enclosure (Feature 12), and the shrine or special use area (Feature 13) were occupied.

The chronology of events specified by the historical accounts provide a framework for interpreting when individual features in the project were occupied. Missionary accounts estimate that the population of Kalaupapa during the 1830's and 40's was approximately 1,000 persons. By the 1850's the inhabitants of the area were producing large quantities of sweet potatoes for exportation to California. By the 1870's, produce exportation from Kalaupapa had ceased and inhabitants were actually importing food from other parts of Moloka'i. The population of the area had declined dramatically, and Fortunato de Loach (1975:82) suggests that there were only 40 non-patients in the area. These accounts suggest the occupation of Features 2 and 10, and the intensification of the associated agricultural system (Feature 5) took place during the 1840's or 50's. Of course it is possible that the occupation and agricultural intensification took place during an earlier phase of the historic era, but the historical accounts indicate that the mid-nineteenth century is the most likely period. The 1921-1922 U.S.G.S. topographic maps do not depict any houses in the project area. Therefore it seems likely the concrete foundations (Features 37 and 38) and the features with the faunal material from late historic introductions (Features 12 and 13) were not occupied until the 1930's.

SITE SIGNIFICANCE EVALUATIONS

The archaeological features in the study area are part of an exceptionally well preserved residential and agricultural system that appears to be distributed throughout the Kalaupapa peninsula. Because very little archaeological work has been done on the peninsula, it is difficult to determine how representative the features in the study area are of the features found throughout the peninsula. If the features in the study area were unique, their significance would obviously be greater. However, it appears that the types of features found in the study area are found elsewhere on the peninsula. In any case, it is desirable to preserve as many of the archaeological features as possible.

The archaeological features in the project area can be grouped into archaeological "sites" for managerial purposes. This grouping is somewhat arbitrary as many of the features are spatially continuous and do not form distinct clusters or sites. Site groupings were made to facilitate the management of the archaeological resources in the project area. Site designations with the site's significance and recommended mitigation procedures are presented in Table 67. The site numbers are State of Hawai'i Department of Land and Natural Resources numbers and should be prefixed by 50-60-03.

The preliminary significance assessments for the sites in the study area are given in Table 67. The evaluations are based on the National Register and State Register criteria for determining potential site significance. Some of the determinations are somewhat tentative or provisional since they are derived entirely from surface observations. These evaluations are made with the consideration that while the vast majority of the sites in the study area are extremely interesting and well preserved, some sacrifices for infrastructure improvements are necessary.

All 40 sites are regarded as potentially significant due to the important archaeological information which they may contain (Criterion D). A total of 32 of these sites appear to be significant only for their scientific information content and possible research value. Eight sites are deemed as excellent examples of a site type, and three of these also have cultural significance as possible prehistoric or historic shrines, or sites that are currently being used as a shrine.

Recommended Mitigation

Recommendations for archaeological mitigation of adverse impacts are presented in Table 67. It is probable that the airport improvements will be somewhat limited and therefore only those sites directly impacted by the development will have to have the impact of the development mitigated. The three sites that are recommended for preservation will probably not be impacted by the development. The sites that will be impacted need to be intensively investigated.

The basic mitigation strategy should include extensive excavations to locate all subsurface deposits, including hearths, post holes, and subsurface architectural structures. Midden and artifacts recovered from the excavations will provide insights into the function and chronology of the sites. A detailed mitigation strategy should be written in consultation with the appropriate agencies.

Table 67. Archaeological sites in the project area, with a summary of their significance and the recommended mitigation procedures.

SITE NUMBER	FEATURE NUMBER	FUNCTIONAL CLASSIFICATION OF FEATURE	QUANTITY AND MORPHOLOGICAL CLASSIFICATION OF ARCHITECTURAL COMPONENTS WITHIN FEATURES	SIGNIFICANCE CRITERIA[1]	MITIGATION PROCEDURE[2]
1801	1	shelter	1 C-shape 1 platform	D	2
	2	residential	6 pavings 2 platforms 2 alignments 1 enclosure		
	3	boundary enclosure	1 enclosure		
1802	4	agricultural	3 alignments	D	2
1803	5a	agricultural agricultural	1 enclosure 17 alignments	C D E	2 and/or
	5b	agricultural agricultural	1 enclosure 178 alignments		
	8	shelter	1 alignment		
	10	residential	1 platform 3 pavings 1 enclosure 1 slablined hearth 1 slablined pit		
1804	6	residential	1 enclosure 1 alignment 1 slablined hearth	D	2
1805	7	shelter	1 C-shape 1 cupboard	D	2
1806	9	cupboards	4 cupboards	D	2

Table 67 (cont.).

SITE NUMBER	FEATURE NUMBER	FUNCTIONAL CLASSIFICATION OF FEATURE	QUANTITY AND MORPHOLOGICAL CLASSIFICATION OF ARCHITECTURAL COMPONENTS WITHIN FEATURES	SIGNIFICANCE CRITERIA[1]	MITIGATION PROCEDURE[2]
1807	11	shelter	1 L-shape 1 paving 1 slablined hearth	D	2
1808	37	residential	1 concrete foundation	D	2
1809	38	residential	1 concrete foundation	D	2
1810	16	shelter	1 U-shape	D	2
1811	12	animal enclosure	1 enclosure	C D E	2 and/or 3
1812	13	possible shrine	1 enclosure 2 terrace	C D E	2 and/or 3
1813	14	shelter	1 enclosure	C D	2
1814	15 36	boundary alignment shelter	1 alignment 1 C-shape 1 crypt	C D	2
1815	17	shelter; agricultural	1 C-shape 1 cupboard	D	2
1816	18	shelter	1 C-shape 1 slablined hearth	D	2

Table 67 (cont.).

SITE NUMBER	FEATURE NUMBER	FUNCTIONAL CLASSIFICATION OF FEATURE	QUANTITY AND MORPHOLOGICAL CLASSIFICATION OF ARCHITECTURAL COMPONENTS WITHIN FEATURES	SIGNIFICANCE CRITERIA[1]	MITIGATION PROCEDURE[2]
1817	19	shelter; agricultural	3 C-shapes 2 terraces 2 alignments	D	2
1818	20	shelter	1 C-shape 1 slablined hearth	D	2
1819	21	agricultural	204 alignments	C D	2
1820	22	shelter	1 C-shape	D	2
1821	23	shelter	2 C-shape 1 terrace	C D	2
1822	24	shelter	1 C-shape	D	2
1823	27	shelter	1 U-shape 1 terrace	C D	2
	26 25	shelter agricultural	1 C-shape 2 alignments		
1824	28	residential	1 enclosure 2 terraces 1 slablined hearth 1 alignment	D	2
1825	29	shelter	1 C-shape 1 paving 1 slablined hearth	D	2

Table 67 (cont.).

SITE NUMBER	FEATURE NUMBER	FUNCTIONAL CLASSIFICATION OF FEATURE	QUANTITY AND MORPHOLOGICAL CLASSIFICATION OF ARCHITECTURAL COMPONENTS WITHIN FEATURES	SIGNIFICANCE CRITERIA[1]	MITIGATION PROCEDURE[2]
1826	30	agricultural	1 enclosure 34 alignments	D	2
	31	shelter	1 C-shape 1 paving 1 slablined hearth		
	32	shelter	1 C-shape		
1827	33	shelter; boundary alignment	1 C-shape 1 alignment	D	2
1828	34	shelter	1 enclosure	D	2
1829	35	shelter	2 C-shape 1 terrace 1 alignment 1 slablined hearth	D	2
1830	1E	agricultural	1 alignment	D	2
1831	2E	agricultural	1 mound	D	2
1832	3E	shelter	1 C-shape 1 platform	D	2
1833	4E	agricultural	1 mound multiple alignments	D	2
1834	5E	shelter	2 C-shapes	D	2

Table 67 (cont.).

SITE NUMBER	FEATURE NUMBER	FUNCTIONAL CLASSIFICATION OF FEATURE	QUANTITY AND MORPHOLOGICAL CLASSIFICATION OF ARCHITECTURAL COMPONENTS WITHIN FEATURES	SIGNIFICANCE CRITERIA[1]	MITIGATION PROCEDURE[2]
1835	6E	shelter; agricultural	2 enclosures 1 terrace 1 alignment	D	2
1836	7E	foundation	1 platform	D	2
1837	8E	agricultural	1 alignment	D	2
1838	9E	shelter	2 C-shapes 1 platform 2 alignments	D	2
1839	10E	shelter; agricultural	11 C-shapes 2 enclosures 2 alignments	D	2
1840	11E	cupboard	1 cupboard	D	2

1) Site significance criteria codes:

NS	Not Significant
NLS	No Longer Significant
A	Site reflects major trends or events in the history of the state and nation
B	Site is associated with the lives of persons significant in our past
C	Site is an excellent example of a site type
D	Site may be likely to yield information important in prehistory or history
E	Site has cultural significance; probable religious structures (shrines, heiau) and/or burials present

2) Mitigation procedure categories:

1	No additional work required
2	Archaeological work to mitigate development impact needed; detailed recording and data recovery excavations.
3	Preservation with appropriate interpretive data collection work.

FEATURE PHOTOGRAPHS

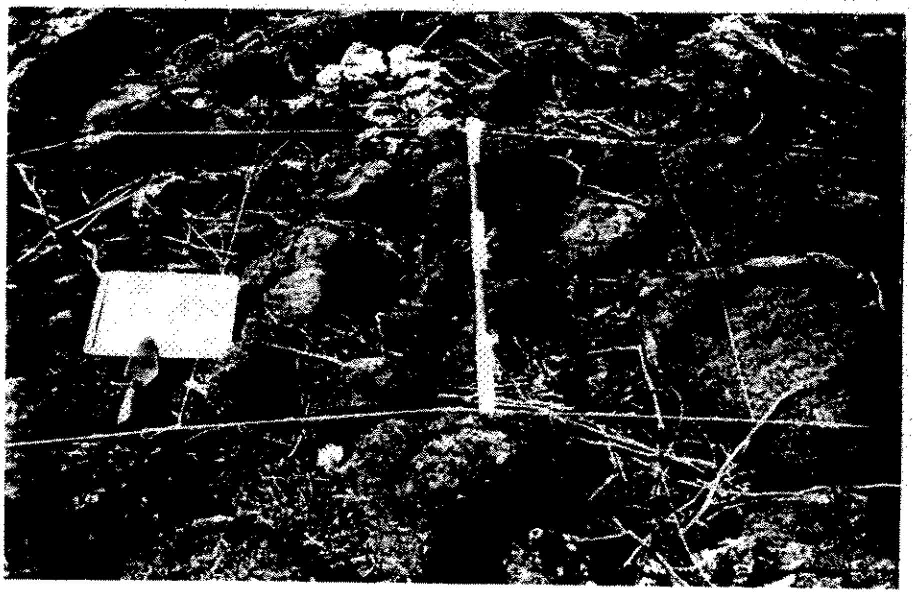


Photo 1. Feature 2, TP-2; surface of a low platform with coral concentration in background. View to north.

Photo 2. Feature 2, TP-2; bottom of excavation. View to east.

Photo 3. Feature 5B; agricultural alignments. View to south.

Photo 4. Feature 5B, TP-1; bottom of excavation with subsurface alignment. View to east.

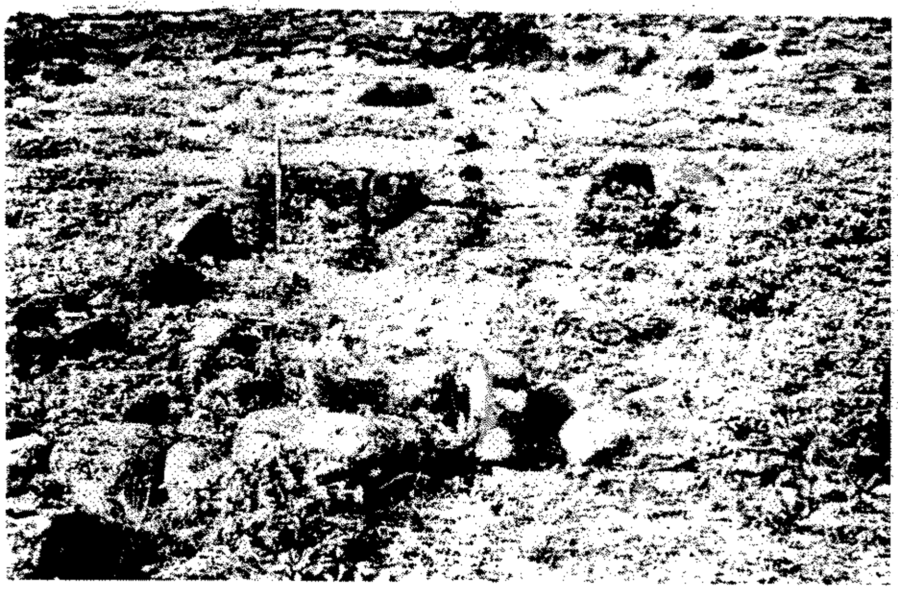


Photo 5. Feature 6; residential enclosure. Feature 7 is in the background. View to north.

Photo 6. Feature 8, TP-1; bottom of Layer 2 Level 5 showing subsurface alignment. View to north. (note: the photo board is mislabeled).

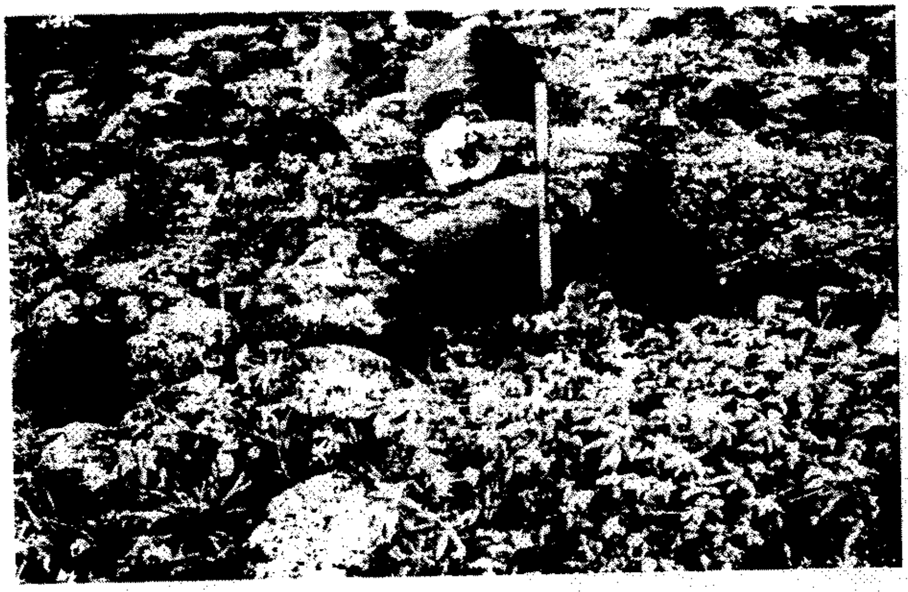


Photo 7. Feature 9; free-standing cupboard (1 of 4). View to north.

Photo 8. Feature 10; paved terrace of residential platform. View to southeast.

Photo 9. Feature 10, TP-1; bottom of excavation. View to east.

Photo 10. Feature 10, TP-1; location of test pit in eastern enclosure. View to south.

Photo 11. Feature 12; rectangular enclosure with two tiered wall. Feature 13B in foreground. View to west.

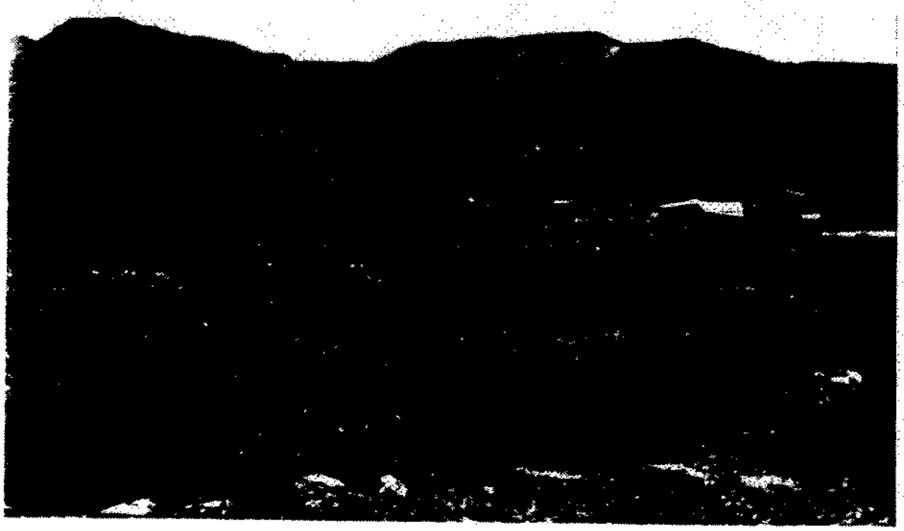


Photo 12. Feature 13; enclosure on top of knoll. View to south.

Photo 13. Feature 13; interior east side of enclosure. View to east.

Photo 14. Feature 13, TP-1; bone concentration within Layer 2.

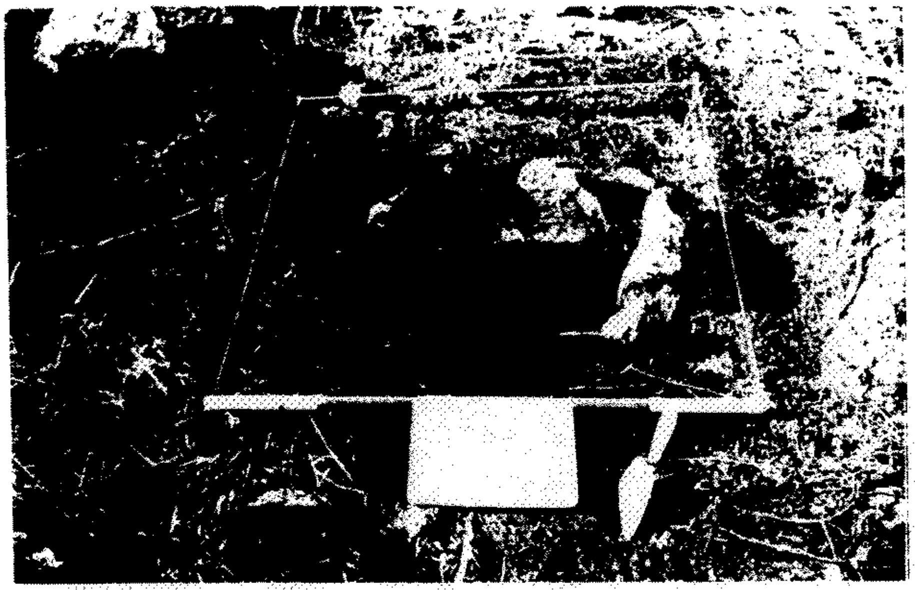


Photo 15. Feature 18; bottom of excavation of slablined hearth. (note: the photo board is mislabeled "F-22").

Photo 16. Feature 23; interior of C-shape shelter. View to north-northeast.

Photo 17. Feature 23, TP-1; bottom of excavation. View to south.

Photo 18. Feature 27; U-shape shelter and associated agricultural wall. View to north.

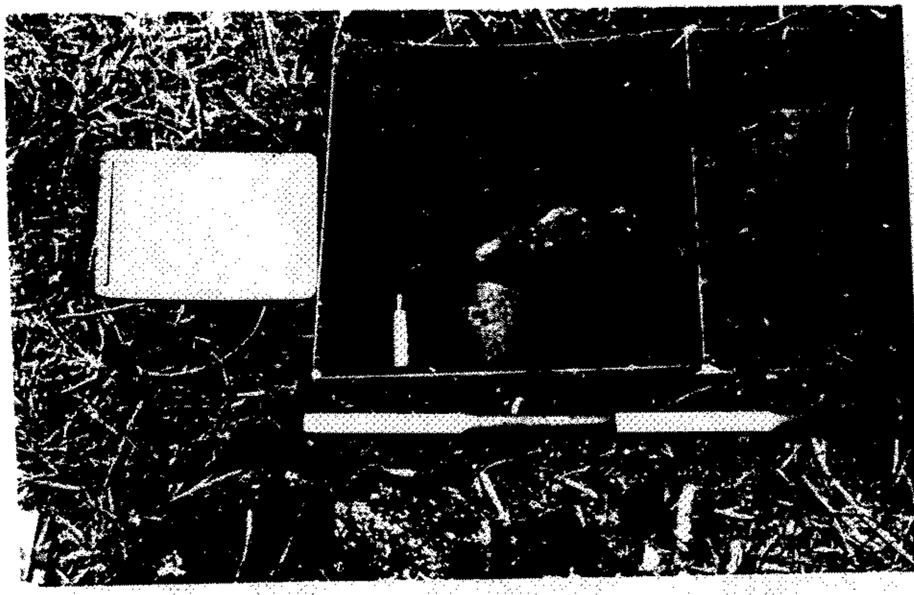


Photo 19. Feature 35, TP-1 and 2; slablined hearth. View to north.

Photo 20. Feature 7E; irregular shaped platform. View to north.

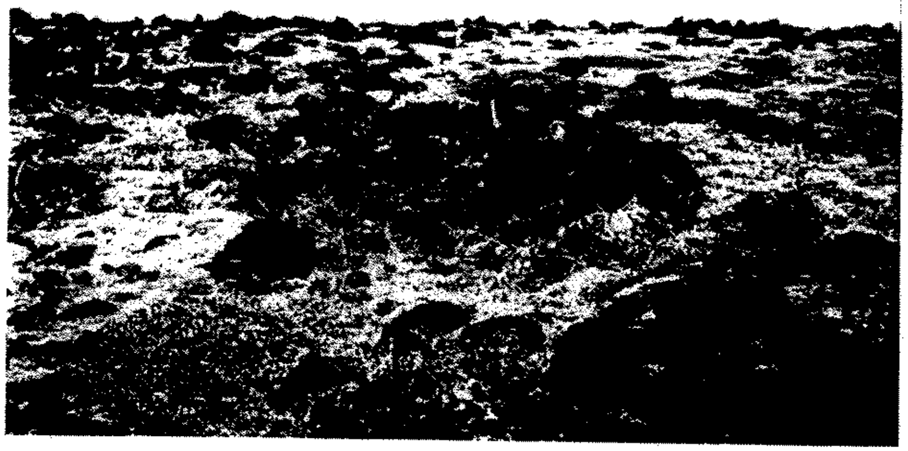


Photo 21. Feature 10E; C-shape shelter. View to northeast.

Photo 22. Features 9E and 10E; C-shape shelters. View to northeast.

APPENDIX A

SUMMARY LISTING OF FAUNAL REMAINS

Appendix A. Listing of faunal remains.

Feature	Layer	Level	Class	Type	Count	Weight
2	2	1	FISH	Scarid	2	0.39
2	2	1	FISH	undetermined	7	0.31
2	3	1	FISH	undetermined	1	0.01
2	3	1	INDETER.	undetermined	1	0.02
6	2	2	FISH	undetermined	8	0.23
6	5	1	FISH	undetermined	1	0.00
8	1	1	FISH	Scarid	1	0.11
8	1	1	FISH	undetermined	10	0.57
8	1	1	MAMMALIA	Rattus exulans	0	0.47
8	2	1	AMPHIBIA	Bufo marinus	1	0.07
8	2	1	AVES	medium bird	2	0.05
8	2	1	FISH	Labrid	1	0.25
8	2	1	FISH	Scarid	3	1.24
8	2	1	FISH	undetermined	43	1.69
8	2	1	MAMMALIA	Rattus exulans	4	0.04
8	2	2	FISH	Labrid	4	1.52
8	2	2	FISH	Scarid	7	1.93
8	2	2	FISH	undetermined	73	2.63
8	2	2	INDETER.	medium vertebrate	2	0.26
8	2	2	MAMMALIA	Rattus exulans	1	0.01
8	2	2	MAMMALIA	medium mammal	2	1.45
8	2	3	FISH	Labrid	3	1.37
8	2	3	FISH	Scarid	3	0.28
8	2	3	FISH	undetermined	88	2.54
8	2	3	INDETER.	medium vertebrate	2	0.48
8	2	3	INDETER.	small vertebrate	1	0.02
8	2	3	MAMMALIA	Rattus exulans	3	0.04
8	2	4	FISH	Labrid	2	0.00
8	2	4	FISH	Scarid	3	0.38
8	2	4	FISH	undetermined	80	2.92
8	2	5	FISH	undetermined	26	0.96
8	3	1	FISH	undetermined	1	0.04
10	2	1	AVES	medium bird	1	0.03
10	2	1	FISH	Labrid	1	1.09
10	2	1	FISH	Scarid	1	0.16
10	2	1	FISH	undetermined	17	0.51
10	2	1	MAMMALIA	Sus scrofa	1	0.04
10	2	1	MAMMALIA	medium or large mammal	18	7.11
10	3	2	FISH	undetermined	12	0.46
10	3	2	MAMMALIA	large mammal	7	9.56
10	3	2	MAMMALIA	medium or large mammal	75	61.38
10	4	1	FISH	undetermined	7	0.14
10	4	1	MAMMALIA	large mammal	1	0.29
10	4	1	MAMMALIA	medium or large mammal	10	6.60
10	4	2	FISH	undetermined	1	0.00
10	4	2	MAMMALIA	medium or large mammal	4	1.94
12	1	1	AMPHIBIA	Bufo marinus	1	0.02
12	1	1	FISH	Labrid	2	0.41
12	1	1	FISH	shark	2	0.06
12	1	1	FISH	undetermined	9	0.23
12	1	1	MAMMALIA	Rattus exulans	1	0.04
12	1	1	MAMMALIA	small to medium mammal	1	0.36
12	2	1	AVES	Geopelia striata	1	0.03
12	2	1	AVES	medium bird	1	0.00
12	2	1	FISH	Scarid	4	0.89
12	2	1	FISH	shark	1	0.00
12	2	1	FISH	undetermined	58	2.51
12	2	1	MAMMALIA	Rattus exulans	5	0.06
12	2	1	MAMMALIA	Rattus norvegicus or Rattus	1	0.09
12	2	1	MAMMALIA	small to medium or medium mammal	2	0.18
12	2	2	FISH	Labrid	1	0.03

Appendix A (cont.).

Feature	Layer	Level	Class	Type	Count	Weight
12	2	2	FISH	undetermined	25	1.21
12	2	2	MAMMALIA	medium mammal	2	0.62
12	2	3	FISH	undetermined	6	0.11
12	2	3	MAMMALIA	small-medium or medium mammal	1	0.43
12	3	1	FISH	undetermined	3	0.20
13	1a	1	AVES	Streptopelia chinensis	1	0.00
13	1a	1	FISH	Diodontid	1	0.13
13	1a	1	FISH	undetermined	2	0.00
13	1a	1	MAMMALIA	Canis familiaris	1	0.33
13	1a	1	MAMMALIA	small-medium or immature med. mammal	1	0.02
13	2	1	AMPHIBIA	Bufo marinus	1	0.08
13	2	1	AVES	Geopelia striata	1	0.04
13	2	1	AVES	medium bird	1	0.06
13	2	1	FISH	undetermined	1	0.00
13	2	1	INDETER.	medium vertebrate	1	0.02
13	2	1	MAMMALIA	Sus scrofa	21	5.55
13	2	1	MAMMALIA	medium mammal	1	2.01
13	2	2	AMPHIBIA	Bufo marinus	2	0.05
13	2	2	AVES	Streptopelia chinensis	1	0.09
13	2	2	AVES	small bird	1	0.00
13	2	2	FISH	undetermined	30	2.54
13	2	2	INDETER.	medium vertebrate (?)	1	0.00
13	2	2	INDETER.	small vertebrate	1	0.00
13	2	2	MAMMALIA	Sus scrofa	299	49.08
13	2	2	MAMMALIA	medium mammal	3	0.89
13	2	2	MAMMALIA	small-medium or medium mammal	1	0.12
13	2	2	REPTILIA	small lizard	1	0.00
13	2	3	AMPHIBIA	Bufo marinus	2	0.00
13	2	3	AVES	Gallus gallus	2	0.17
13	2	3	AVES	medium bird	6	0.18
13	2	3	FISH	Acanthurid	2	0.67
13	2	3	FISH	Cirrhitid	1	0.07
13	2	3	FISH	Labrid	3	0.22
13	2	3	FISH	Scarid	7	1.98
13	2	3	FISH	undetermined	706	27.25
13	2	3	MAMMALIA	Canis familiaris	1	0.30
13	2	3	MAMMALIA	Rattus	1	0.00
13	2	3	MAMMALIA	Rattus exulans	11	0.20
13	2	3	MAMMALIA	Sus scrofa	4424	612.33
13	2	3	MAMMALIA	medium mammal	15	12.94
13	2	3	MAMMALIA	small-medium or medium mammal	8	1.78
13	2	4	AVES	Geopelia striata	1	0.00
13	2	4	AVES	medium bird	2	0.11
13	2	4	FISH	Acanthurid	1	0.05
13	2	4	FISH	Scarid	3	0.80
13	2	4	FISH	undetermined	38	4.06
13	2	4	INDETER.	medium vertebrate	1	0.00
13	2	4	MAMMALIA	Sus scrofa	478	75.61
13	2	4	MAMMALIA	small-medium and/or medium mammal	6	2.04
13	2	5	AVES	medium bird	3	0.06
13	2	5	FISH	Kuhliid	1	0.03
13	2	5	FISH	Scarid	2	0.18
13	2	5	FISH	undetermined	486	19.46
13	2	5	MAMMALIA	Canis familiaris	1	0.04
13	2	5	MAMMALIA	Rattus exulans	1	0.01
13	2	5	MAMMALIA	Sus scrofa	223	30.31
13	2	5	MAMMALIA	medium mammal	4	2.82
13	2	6	FISH	Pomacentrid	1	0.05
13	2	6	FISH	Scarid	4	0.52
13	2	6	FISH	undetermined	233	5.08

Appendix A (cont.).

Feature	Layer	Level	Class	Type	Count	Weight
13	2	6	MAMMALIA	Sus scrofa	104	6.84
13	2	6	REPTILIA	small lizard	1	0.06
13	3	1	FISH	undetermined	10	0.35
13	3	1	MAMMALIA	Rattus exulans	3	0.00
13	3	1	MAMMALIA	Sus scrofa	125	19.28
13	3	1	MAMMALIA	medium mammal	2	1.71
13	3	1	MAMMALIA	small-medium or medium mammal	1	0.09
14	1	1	FISH	undetermined	1	0.05
14	1	1	INDETER.	medium vertebrate	1	0.08
14	2	1	FISH	undetermined	8	0.47
14	2	1	INDETER.	small vertebrate	4	0.00
14	2	1	MAMMALIA	Herpestes auropunctatus	2	0.12
14	2	1	MAMMALIA	Rattus exulans	1	0.04
14	2	2	AVES	medium bird	1	0.06
14	2	2	FISH	Labrid	1	0.28
14	2	2	FISH	Scarid	3	1.35
14	2	2	FISH	undetermined	39	1.83
14	2	2	MAMMALIA	Rattus exulans	1	0.04
14	2	2	MAMMALIA	small-medium or medium mammal	1	0.14
14	3	1	FISH	undetermined	39	0.68
14	3	1	MAMMALIA	Sus scrofa	1	0.14
14	3	2	MAMMALIA	undetermined	1	0.00
14	3	3	FISH	undetermined	2	0.04
14	7	1	FISH	undetermined	4	0.10
16	2	1	FISH	undetermined	1	0.03
16	2	1	MAMMALIA	Rattus exulans	2	0.05
16	2	1	MAMMALIA	Sus scrofa	1	0.56
16	2	1	MAMMALIA	medium mammal	1	0.69
16	2	2	MAMMALIA	Rattus exulans	1	0.04
17	2	1	FISH	Scarid	2	0.17
18	2	2	FISH	Labrid	1	0.00
18	2	2	FISH	undetermined	7	0.19
18	2	2	MAMMALIA	Canis familiaris	1	0.05
18	2	2	MAMMALIA	Mus muscola	1	0.00
18	2	2	MAMMALIA	Rattus exulans	1	0.00
18	2	3	FISH	undetermined	2	0.10
22	2	1	FISH	undetermined	1	0.06
22	2	1	MAMMALIA	Sus scrofa	1	0.28
22	2	1	MAMMALIA	small-medium or med. immature mamma	1	0.09
23	2	1	FISH	undetermined	3	0.04
23	2	1	MAMMALIA	medium mammal	1	0.32
23	2	1	MAMMALIA	small-medium or medium mammal	1	0.06
23	3	1	FISH	undetermined	5	0.40
23	3	1	MAMMALIA	small-medium or medium mammal	1	0.32
23	3	2	FISH	undetermined	4	0.24
23	3	2	MAMMALIA	Rattus exulans	1	0.07
23	4	1	FISH	undetermined	57	1.12
23	4	1	INDETER.	medium vertebrate	1	0.18
23	4	1	MAMMALIA	Canis familiaris	1	0.21
23	4	1	MAMMALIA	Rattus exulans	1	0.01
23	4	3	FISH	Labrid	1	0.10
23	4	3	FISH	scarid	1	0.04
23	4	3	FISH	undetermined	13	0.45
23	4	3	INDETER.	small vertebrate	1	0.02
23	4	3	MAMMALIA	Rattus exulans	1	0.02
23	5	1	FISH	Labrid	1	0.22
23	5	1	FISH	Scarid	1	0.46
23	5	1	FISH	undetermined	61	1.21
23	5	1	MAMMALIA	Rattus exulans	2	0.00
23	5	2	FISH	Scarid	3	0.21
23	5	2	FISH	undetermined	42	0.62

Appendix A (cont.).

Feature	Layer	Level	Class	Type	Count	Weight
23	5	2	INDETER.	medium vertebrate	2	0.09
23	5	2	MAMMALIA	Mus musculus	1	0.00
23	6	1	FISH	undetermined	13	0.29
23	6	1	MAMMALIA	small-medium or medium mammal	1	0.07
27	2	1	AVES	medium Galliform	1	0.13
27	2	1	FISH	Labrid	2	0.17
27	2	1	FISH	undetermined	20	1.30
27	2	1	INDETER.	medium vertebrate	1	0.06
27	2	1	MAMMALIA	Rattus exulans	1	0.03
27	2	1	MAMMALIA	Sus scrofa	1	0.23
27	2	1	MAMMALIA	medium mammal	2	0.54
27	2	2	FISH	undetermined	2	0.37
28	2	1	AVES	medium bird	1	0.06
28	2	1	INDETER.	small vertebrate	1	0.00
28	3	2	FISH	Scarid	1	0.41
29	1	1	MAMMALIA	Herpestes auropunctatus	5	1.29
29	2	1	FISH	Scarid	5	0.33
29	2	1	INDETER.	medium vertebrate	1	0.13
29	2	1	INDETER.	small vertebrate	1	0.01
29	2	3	FISH	Scarid	1	0.43
29	3	1	FISH	undetermined	2	0.00
31	3	1	FISH	Labrid	2	0.29
31	3	1	FISH	Monacanthid	1	0.08
31	3	1	FISH	Scarid	1	0.07
31	3	1	FISH	undetermined	6	0.21
31	3	1	MAMMALIA	Rattus exulans	2	0.14
31	3	2	FISH	Labrid	1	0.41
31	3	2	FISH	Scarid	1	0.90
31	3	2	FISH	undetermined	9	0.38
31	3	3	FISH	Labrid	1	0.86
31	3	3	FISH	undetermined	5	0.11
31	3	3	MAMMALIA	Rattus exulans	1	0.09
31	3	3	REPTILIA	small lizard	1	0.00
31	5	1	FISH	Scarid	1	0.08
35	1	1	MAMMALIA	Rattus norvegicus	1	0.16
*** Total ***						
					8401	1031.50

APPENDIX B

COMPLETE LISTING OF FAUNAL REMAINS

INCLUDING DR. ZIEGLER'S COMMENTS

Appendix B. Complete listing of Kalaupapa faunal remains.

Feature	Layer	Level	Class	Type	Body Part	Comment
2	2	1	FISH	Scarid	1 premaxillary or dentary 1 lower pharyngeal plate	
2	2	1	FISH	undetermined	4 bone fragment 3 scale	
2	3	1	FISH	undetermined	1 vertebra	Fish is only 7-8 cm long.
2	3	1	INDETER.	undetermined	undetermined	Possibly bird but I can't be certain.
6	2	2	FISH	undetermined	1 premaxillary or dentary 1 tooth 4 vertebra 2 bone fragment	The vertebrae are from 1 or more individuals 15+/- cm long.
6	5	1	FISH	undetermined	1 vertebra	About 17-20 cm long.
8	1	1	FISH	Scarid	1 premaxillary or dentary	
8	1	1	FISH	undetermined	2 vertebra 8 bone fragment	The vertebrae are from 1 or more individuals about 20-22 cm long.
8	1	1	MAMMALIA	Rattus exulans	2 cranium 4 dentary 1 tibiofibula 1 calcaveum	
8	2	1	AMPHIBIA	Bufo marinus	1 vertebra	This vertebra is almost certainly amphibian (rather than reptilian)and I have referred it to this common species although I cannot be entirely eliminate other toads and frogs that might have been introduced to the peninsula.
8	2	1	AVES	medium bird	2 limb-bone	

				fragment	
8 2	1	FISH	Labrid	1 premaxillary or dentary	
8 2	1	FISH	Scarid	1 premaxillary or dentary 2 upper pharyngeal plate	
8 2	1	FISH	undetermined	9 vertebra 34 bone fragment	The vertebrae are from at least 2 individuals: 1 about 8-10 cm long and the other 20-22 cm long.
8 2	1	MAMMALIA	Rattus exulans	1 cranium 1 dentary 1 metapodial 1 (caudal) vertebra	
8 2	2	FISH	Labrid	1 premaxillary or dentary 3 upper pharyngeal plate	At least 3 individuals are represented.
8 2	2	FISH	Scarid	6 premaxillary or dentary 1 upper pharyngeal plate	At least 2 individuals are represented.
8 2	2	FISH	undetermined	10 vertebra 63 bone fragment	The vertebrae are from 1 or more individuals, each of apparently, 3 different lengths, 8-10 cm, 10-12 cm & 15-17 cm.
8 2	2	INDETER.	medium vertebrate	2 bone fragment	
8 2	2	MAMMALIA	Rattus exulans	1 vertebra	
8 2	2	MAMMALIA	medium mammal	2 limb-bone fragment	
8 2	3	FISH	Labrid	1 dentary 2 lower pharyngeal plate	At least 2 individuals are represented.
8 2	3	FISH	Scarid	2 premaxillary or dentary 1 upper pharyngeal plate	At least 2 and possibly 3 individuals are represented.
8 2	3	FISH	undetermined	12 vertebra	The vertebrae

				65 bone fragment 11 +/- scale	are from 1 or more individuals, each of apparently 3 different lengths: 8-10cm., 15-17 cm., & 20-22 cm.
8 2	3	INDETER.	medium vertebrate	2 bone fragment	I think these are both mammal, but I can't be certain.
8 2	3	INDETER.	small vertebrate	1 bone fragment	Immature?
8 2	3	MAMMALIA	Rattus exulans	1 cranium 1 femur 1 (caudal) vertebra	
8 2	4	FISH	Labrid	1 tooth fragment 1 premaxillary or dentary	Both fragments are definitely but are only tentatively referred to this family, two individuals are represented.
8 2	4	FISH	Scarid	3 premaxillary or dentary	At least 2 and possibly 3 individuals are represented.
8 2	4	FISH	undetermined	13 vertebra 50 bone fragment 17 scale	The vertebrae are from 1 or more individuals, each of apparently 3 different lengths: 7-10 cm., 12-15 cm., & 20-15 cm.
8 2	5	FISH	undetermined	4 vertebra 19 bone fragment 3 scale	The vertebrae are from 1 or more individuals or 2 different lengths 7-10 cm. & 12-15 cm.
8 3	1	FISH	undetermined	1 bone fragment	
10 2	1	AVES	medium bird	1 limb-bone fragment	Possibly limb.
10 2	1	FISH	Labrid	1 lower	

				pharyngeal plate	
10 2	1	FISH	Scarid	1 upper pharyngeal plate	
10 2	1	FISH	undetermined	1 vertebra 13 bone fragment 3 scale	The vertebra is from an individual about 7-10 cm long.
10 2	1	MAMMALIA	Sus scrofa	1 premolar fragment	Age?
10 2	1	MAMMALIA	medium or large mammal	18 bone fragment	
10 3	2	FISH	undetermined	1 vertebra 11 bone fragment	The vertebra is from an individual about 7-10 cm long.
10 3	2	MAMMALIA	large mammal	3 metapodial fragment 7 bone fragment	
10 3	2	MAMMALIA	medium or large mammal	75 +/- bone fragment	
10 4	1	FISH	undetermined	2 vertebra 4 bone fragment 1 scale	
10 4	1	MAMMALIA	large mammal	1 bone fragment	
10 4	1	MAMMALIA	medium or large mammal	10 bone fragment	
10 4	2	FISH	undetermined	1 bone fragment	
10 4	2	MAMMALIA	medium or large mammal	4 bone fragment	
12 1	1	AMPHIBIA	Bufo marinus	1 scapula	
12 1	1	FISH	Labrid	1 dentary 1 premaxillary or dentary	
12 1	1	FISH	shark	2 tooth	
12 1	1	FISH	undetermined	4 vertebra 5 bone fragment	The vertebrae are from 1 or more individuals of 2 different lengths 5-7 cm. & perhaps 25 cm.
12 1	1	MAMMALIA	Rattus exulans	1 cranium	
12 1	1	MAMMALIA	small to medium mammal	1 limb-bone fragment	
12 2	1	AVES	Geopelia	1 ulna	

			striata		
12 2	1	AVES	medium bird	not specified	
12 2	1	FISH	Scarid	3 premaxillary or dentary 1 lower pharyngeal plate	
12 2	1	FISH	shark	1 tooth	
12 2	1	FISH	undetermined	1 tooth 8 vertebra 48 bone fragment 1 scale	The vertebrae are from 1 or more individuals, each of 3 different lengths: 7-8 cm., 9-10 cm., & 18-20 cm. The conical tooth is not shark.
12 2	1	MAMMALIA	Rattus exulans	1 dentary 1 scapula 1 innominate 2 (caudal) vertebra	
12 2	1	MAMMALIA	Rattus norvegicus or Rattus	1 innominate	
12 2	1	MAMMALIA	small to medium or medium mammal	2 bone fragment	
12 2	2	FISH	Labrid	1 upper pharyngeal plate	
12 2	2	FISH	undetermined	3 vertebra 19 bone fragment 3 scale	The vertebrae are from 1 or more individuals each of 2 different lengths, 5-7 cm., & 12-15 cm.
12 2	2	MAMMALIA	medium mammal	2 bone fragment	
12 2	3	FISH	undetermined	4 bone fragment 2 scale	
12 2	3	MAMMALIA	small-medium or medium mammal	1 bone fragment	
12 3	1	FISH	undetermined	3 bone fragment	
13 1a	1	AVES	Streptopelia chinensis	1 coracoid	Note apparent mammalian carnivore tooth punctures.

13 1a	1	FISH	Diodontid	1 dermal spine	
13 1a	1	FISH	undetermined	1 vertebra 1 bone fragment	The vertebra is from an individual about 7-10 cm long.
13 1a	1	MAMMALIA	Canis familiaris	1 ulna	Apparently adult or essentially so.
13 1a	1	MAMMALIA	small-medium or immature med. mammal	1 cranium	
13 2	1	AMPHIBIA	Bufo marinus	1 vertebra	
13 2	1	AVES	Geopelia striata	1 humerus	
13 2	1	AVES	medium bird	1 fibula	Immature possibly "medium galliform" but I can't be all that certain.
13 2	1	FISH	undetermined	1 bone fragment	
13 2	1	INDETER.	medium vertebrate	1 bone fragment	
13 2	1	MAMMALIA	Sus scrofa	2 tooth 4 cranium 1 dentary 1 humerus 3 vertebra 10+/- bone fragment	Probably only 1 individual represented, (only a few weeks old).
13 2	1	MAMMALIA	medium mammal	1 bone fragment	
13 2	2	AMPHIBIA	Bufo marinus	1 scapula 1 vertebra	
13 2	2	AVES	Streptopelia chinensis	1 humerus	
13 2	2	AVES	small bird	1 limb-bone fragment	
13 2	2	FISH	undetermined	2 vertebra 25 bone fragment 3 scale	The vertebrae are from 1 individual about 10- 15 cm. and 15-18 cm. long.
13 2	2	INDETER.	medium vertebrate (?)	1 limb-bone fragment	This could possibly be an ulna fragment of a fetal small-medium or medium mammal (as opposed to a bone of

						immature bird) but I can't be at all certain.
13 2	2	INDETER.	small vertebrate	1 bone fragment		
13 2	2	MAMMALIA	Sus scrofa	42 cranium 42 dentary 3 scapula 2 innominate 3 tibia 3 fibula 1 calcaneum 5 metapodial 75 vertebra 84 rib 74+/- bone fragment		At least 5 and possibly 6(?) individuals are represented ranging from birth to more than a month or two old.
13 2	2	MAMMALIA	medium mammal	3 bone fragment		Can't specify age but significantly older than a few weeks.
13 2	2	MAMMALIA	small-medium or medium mammal	1 rib (?)		Adult or essentially so.
13 2	2	REPTILIA	small lizard	1 cranium		
13 2	3	AMPHIBIA	Bufo marinus	1 coracoid 1 tibiofibula		
13 2	3	AVES	Gallus gallus	1 scapula 1 pedal ungal phalanx		Adult
13 2	3	AVES	medium bird	3 limb-bone fragment 2 bone fragment 1 vertebra		
13 2	3	FISH	Acanthurid	2 caudal spine		2 genera are represented: Naso and possibly Acanthurus.
13 2	3	FISH	Cirrhitid	1 dentary		
13 2	3	FISH	Labrid	1 upper pharyngeal plate 1 premaxillary 1 lower pharyngeal plate		
13 2	3	FISH	Scarid	5 premaxillary or dentary 1 premaxillary 1 lower pharyngeal plate		
13 2	3	FISH	undetermined	2 pharyngeal		A number of

					plate 1 gill raver 77 vertebra 490 bone fragment 138 scale	individuals are represented: the vertebrae are from 1 or more individuals, each of at least 6 different length-groups, 5-10 cm., 11-13 cm., 14-17 cm., 17-20 cm., 20-25 cm., & 30 or so cm.
13	2	3	MAMMALIA	Canis familiaris	1 upper right adult 2nd molar	More than 6 months old - this seems large to me so it may be an introduced breed rather than a polynesian dog.
13	2	3	MAMMALIA	Rattus	1 vertebra	
13	2	3	MAMMALIA	Rattus exulans	9 cranium 1 humerus 1 femur	
13	2	3	MAMMALIA	Sus scrofa	752 cranium and dentary 34 dentary 1 adult canine tooth 34 scapula 31 humerus 20 ulna 21 radius 46 innominate 30 femur 22 tibia 11 fibula 14 calvaceum 3 astralagus 24 podial 109 metapodial 115 phalanx 901 vertebra 653 rib 1153 bone fragment	At least 13 individuals are represented: 8 between birth and 1-2 weeks, 3 probably 3 weeks old and 1 between 1-2 years.
13	2	3	MAMMALIA	medium mammal	1 cranium 2 vertebra 4 rib 3 limb-bone fragment 5 bone fragment	2 individuals represented. One is significantly more than a few weeks old and the other is adult or essentially so.

13 2	3	MAMMALIA	small-medium or medium mammal	3 cranium 3 rib 2 limb-bone fragment	1 or more of these fragments are relatively immature but are from an individual more than several weeks old.
13 2	4	AVES	Geopelia striata	1 humerus	Seems "fresh" in comparison to other bones from this level.
13 2	4	AVES	medium bird	2 limb-bone fragment	
13 2	4	FISH	Acanthurid	1 premaxillary or dentary	
13 2	4	FISH	Scarid	2 upper pharyngeal plate 1 lower pharyngeal plate	
13 2	4	FISH	undetermined	7 vertebra 30 bone fragment 1 scale	The vertebrae are from 1 or more individuals, each of 3 different lengths: 10-12 cm., 20-22 cm., & 30-35 cm.
13 2	4	INDETER.	medium vertebrate	1 bone fragment	
13 2	4	MAMMALIA	Sus scrofa	138 cranium and dentary 22+/- cranium (2 individuals) 13 dentary (2 individuals) 2 scapula 1 sternebra 1 humerus 4 humerus (4 individuals) 1 radius 1 innominate 2 femur 2 fibula 3 calcaveum 4 podial 12 phalanx 75 vertebra 60 rib 122 bone fragment	At least 7 individuals are represented, ranging from weeks to 2-2.5 months old. 2 are about 1-3 weeks old and 1 (with very very few remains) is about 4-6 weeks old.
13 2	4	MAMMALIA	small-medium and/or medium	2 cranium and/or dentary	Not sure about the age or

			mammal	3 rib 1 bone fragment	ages but more than 6-8 weeks old.
13 2	5	AVES	medium bird	2 limb-bone fragment 1 bone fragment	
13 2	5	FISH	Kuhliid	1 dentary	
13 2	5	FISH	Scarid	1 premaxillary 1 tooth (from pharyngeal plate)	
13 2	5	FISH	undetermined	1 premaxillary 1 dentary 2 premaxillary or dentary 1 gill raver 56 vertebra 325 bone fragment 100+- scale	The vertebrae are from 1 or more individuals, each of at least the following different lengths: 5-10 cm., 10-12 cm., 15-17 cm., 18-22 cm., 25-30cm., & about 45-50 cm.
13 2	5	MAMMALIA	Canis familiaris	1 adult first premolar (probably left side)	At least 6 months old.
13 2	5	MAMMALIA	Rattus exulans	1 dentary	
13 2	5	MAMMALIA	Sus scrofa	3 scapula 4 humerus 6 ulna 4 radius 1 innominate 1 femur 1 tibia 1 astragalus 1 podial 9 metapodial 11 phalanx 46 vertebra 47 rib	At least 5 individuals are represented: 1 less than 1 week old, 1 perhaps 2-3 weeks old, 2 in the 6-8 week old range and 1 (apodial & metapodial only) probably a few months old.
13 2	5	MAMMALIA	medium mammal	3 limb-bone fragment 1 bone fragment	Probably essentially adult, probably more than several months old.
13 2	6	FISH	Pomacentrid	1 dentary	
13 2	6	FISH	Scarid	1 upper pharyngeal plate 1 lower pharyngeal plate	

				2 tooth (pharyngeal plate)	
13 2	6	FISH	undetermined	18 vertebra 155 bone fragment 60+/- scale	The vertebrae are from 1 or more individuals each of apparently, 5 different lengths: 5-8 cm, 10-12 cm, 14-16 cm, 18-20 cm, and perhaps 25-35 cm.
13 2	6	MAMMALIA	Sus scrofa	40 cranium and dentary 1 calcaveum 1 metapodial 3 phalanx 17 vertebra 7 rib 35 bone fragment	Only 1 individual seems to be represented, between birth and 1-2 weeks old.
13 2	6	REPTILIA	small lizard	1 maxillary	
13 3	1	FISH	undetermined	1 vertebra 7 bone fragment 2 bone fragments were not specified	The vertebra is from an individual about 7-10 cm long.
13 3	1	MAMMALIA	Rattus exulans	2 cranium 1 tibiofibula	
13 3	1	MAMMALIA	Sus scrofa	44 cranium and dentary 2 scapula (?) 2 humerus 2 femur 1 tibia 1 phalanx 1 metapodial 26 vertebra 20 rib 26 bone fragment	At least 3 individuals are represented: 2 between birth and 1-2 weeks old and the other (few bones present), perhaps 3 or so weeks old.
13 3	1	MAMMALIA	medium mammal	2 rib	Probably adult or essentially so.
13 3	1	MAMMALIA	small-medium or medium mammal	1 limb-bone fragment (?)	
14 1	1	FISH	undetermined	1 vertebra	
14 1	1	INDETER.	medium vertebrate	1 bone fragment	
14 2	1	FISH	undetermined	1 dentary 3 vertebra 4 bone fragment	The vertebrae are from 1 or more individuals of 2 different

					lengths, 8-10cm and 15-20 cm.
14 2	1	INDETER.	small vertebrate	4 bone fragment	
14 2	1	MAMMALIA	Herpestes auropunctatus	1 humerus 1 ilium	This humerus and ilium are either a birth-1week old mongoose or a fetal cat. Because of the relatively small size of the bones, I chose the former.
14 2	1	MAMMALIA	Rattus exulans	1 cranium	
14 2	2	AVES	medium bird	1 limb-bone fragment	
14 2	2	FISH	Labrid	1 lower pharyngeal plate	
14 2	2	FISH	Scarid	1 dentary 2 premaxillary or dentary	
14 2	2	FISH	undetermined	6 vertebra 30 bone fragment 3 scale	The vertebrae are from 1 or more individuals, each of 2 different lengths, 8-10 cm., & 15-20 cm.
14 2	2	MAMMALIA	Rattus exulans	-not specified	
14 2	2	MAMMALIA	small-medium or medium mammal	1 limb-bone fragment	Probably adult or essentially so.
14 3	1	FISH	undetermined	3 vertebra 18 bone fragment 18 scale	The vertebrae are from 3 individuals each of different lengths, 5-7 cm., 8-10 cm. & 15-17 cm.
14 3	1	MAMMALIA	Sus scrofa	1 phalanx	
14 3	2	MAMMALIA	undetermined	1 bone fragment	
14 3	3	FISH	undetermined	2 scale	
14 7	1	FISH	undetermined	2 bone fragment 2 scale	
16 2	1	FISH	undetermined	1 bone fragment	

16	2	1	MAMMALIA	Rattus exulans	1 dentary 1 tibiofibula	
16	2	1	MAMMALIA	Sus scrofa	1 milk premolar (3rd or 4th)	Age about 1 year -- this tooth could even have been shed naturally (normally at about 12 months of age), thus 1 year would be a minimum for the individual involved.
16	2	1	MAMMALIA	medium mammal	1 limb-bone fragment	Very likely not immature.
16	2	2	MAMMALIA	Rattus exulans	1 cranium	
17	2	1	FISH	Scarid	2 upper pharyngeal plate	
18	2	2	FISH	Labrid	1 lower pharyngeal plate	
18	2	2	FISH	undetermined	2 vertebra 5 bone fragment	The vertebrae are from an individual about 8-10 cm. long.
18	2	2	MAMMALIA	Canis familiaris	1 phalanx	Age? but probably at least several weeks old.
18	2	2	MAMMALIA	Mus muscola	1 tibiofibula	
18	2	2	MAMMALIA	Rattus exulans	1 cranium	
18	2	3	FISH	undetermined	2 bone fragment	
22	2	1	FISH	undetermined	1 bone fragment	
22	2	1	MAMMALIA	Sus scrofa	1 milk premolar (3rd or 4th)	Age about 1 year, this tooth could even have been shed naturally (normally at about 12 months of age), thus 1 year would be a minimum for the individual involved.
22	2	1	MAMMALIA	small-medium or med. immature mamma	1 limb-bone fragment	
23	2	1	FISH	undetermined	3 bone fragment	

23	2	1	MAMMALIA	medium mammal	1 bone fragment	Probably not immature.
23	2	1	MAMMALIA	small-medium or medium mammal	1 limb-bone fragment	Probably not immature.
23	3	1	FISH	undetermined	4 bone fragment 1 scale	
23	3	1	MAMMALIA	small-medium or medium mammal	1 limb-bone fragment	Probably not immature.
23	3	2	FISH	undetermined	4 bone fragment	
23	3	2	MAMMALIA	Rattus exulans	1 cranium	
23	4	1	FISH	undetermined	4 vertebra 29 bone fragment 24 scale	The vertebrae are from at least 3 individuals, 1 about 7-8 cm. and another perhaps 9-10 cm. long.
23	4	1	INDETER.	medium vertebrate	1 bone fragment	
23	4	1	MAMMALIA	Canis familiaris	1 adult premolar or molar	More than 6 months old.
23	4	1	MAMMALIA	Rattus exulans	1 cranium	
23	4	3	FISH	Labrid	1 tooth	This is definitely a fish tooth and very likely of this family although I can't be entirely certain.
23	4	3	FISH	scarid	1 upper pharyngeal plate	
23	4	3	FISH	undetermined	8 bone fragment 5 scale	
23	4	3	INDETER.	small vertebrate	1 bone fragment	
23	4	3	MAMMALIA	Rattus exulans	1 dentary	
23	5	1	FISH	Labrid	1 dentary	
23	5	1	FISH	Scarid	1 upper pharyngeal plate	
23	5	1	FISH	undetermined	1 tooth 2 vertebra 35 bone fragment 23 scale	The vertebrae are apparently from 2 individuals, 1 about 7-8 cm. and the other about 9-10 cm.

						long.
23	5	1	MAMMALIA	Rattus exulans	1 scapula 1 humerus	
23	5	2	FISH	Scarid	3 premaxillary or dentary	
23	5	2	FISH	undetermined	2 vertebra 20 bone fragment 20 scale	The vertebra are from 2 individuals of different lengths, 1 about 7-8 cm. and the other perhaps 15-17 cm. long.
23	5	2	INDETER.	medium vertebrate	2 bone fragment	
23	5	2	MAMMALIA	Mus musculus	1 tibiofibula	
23	6	1	FISH	undetermined	5 bone fragment 8 scale	
23	6	1	MAMMALIA	small-medium or medium mammal	1 bone fragment	Age? but at least several weeks or more old.
27	2	1	AVES	medium Galliform	1 sternum	
27	2	1	FISH	Labrid	1 premaxillary or dentary 1 upper pharyngeal plate	
27	2	1	FISH	undetermined	1 premaxillary 17 bone fragment 2 vertebra	The vertebrae from 1 or 2 individual(s) about 12-15 or so cm. long.
27	2	1	INDETER.	medium vertebrate	not specified	
27	2	1	MAMMALIA	Rattus exulans	1 dentary	
27	2	1	MAMMALIA	Sus scrofa	1 premolar or molar	Age? -but a least a few months old.
27	2	1	MAMMALIA	medium mammal	2 bone fragment	Not immature.
27	2	2	FISH	undetermined	2 bone fragment	
28	2	1	AVES	medium bird	1 tibiotarsus	
28	2	1	INDETER.	small vertebrate	1 bone fragment	
28	3	2	FISH	Scarid	1 upper pharyngeal plate	
29	1	1	MAMMALIA	Herpestes	3 cranium	Subadult

				auropunctatus	2 dentary	
29	2	1	FISH	Scarid	5 teeth (upper pharyngeal plate)	
29	2	1	INDETER.	medium vertebrate	1 bone fragment	Probably fish but I can't be certain.
29	2	1	INDETER.	small vertebrate	1 limb-bone fragment	Probably Rattus species but I can't be certain.
29	2	3	FISH	Scarid	1 premaxillary or dentary	
29	3	1	FISH	undetermined	1 vertebra 1 scale	The vertebra is from an individual about 7-8 cm. long.
31	3	1	FISH	Labrid	1 premaxillary or dentary 1 upper pharyngeal plate	
31	3	1	FISH	Monacanthid	1 dorsal spine	
31	3	1	FISH	Scarid	1 tooth (pharyngeal plate)	
31	3	1	FISH	undetermined	1 vertebra 5 bone fragment	The vertebra is from an individual about 25-30 cm long.
31	3	1	MAMMALIA	Rattus exulans	1 dentary 1 (caudal) vertebra	
31	3	2	FISH	Labrid	1 upper pharyngeal plate	
31	3	2	FISH	Scarid	1 premaxillary	Freshly broken.
31	3	2	FISH	undetermined	1 vertebra 8 bone fragment	The vertebra is from an individual about 5-7 cm. long.
31	3	3	FISH	Labrid	1 upper pharyngeal plate	
31	3	3	FISH	undetermined	2 vertebra 3 bone fragment	The vertebrae are from 1 or 2 individual(s) about 8-10 cm. long.

31	3	3	MAMMALIA	Rattus exulans	1 femur
31	3	3	REPTILIA	small lizard	1 cranium
31	5	1	FISH	Scarid	1 upper pharyngeal plate
35	1	1	MAMMALIA	Rattus norvegicus	1 dentary

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HISTORIC PRESERVATION MITIGATION PLAN

KALAUPAPA AIRPORT IMPROVEMENT PROJECT

ISLAND OF MOLOKA'I

***

Data Recovery Plan
Burial Treatment Plan
Preservation Plan

by

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I: INTRODUCTION

At the request of Edward K. Noda and Associates, Inc., International Archaeological Research Institute, Inc. (IARII) prepared the following Historic Preservation Mitigation Plan for significant historic resources that may be impacted by an improvement project for the Kalaupapa Airport on the Island of Moloka'i (Figs. 1 and 2).

The Kalaupapa Airport Improvement Project has been proposed by the Dept. of Transportation, State of Hawaii. This project, in part, includes the realignment and expansion of the airport runway at the northern end of the Kalaupapa peninsula, Island of Moloka'i, Hawaii (Sumida, letters of March 16 and May 1, 1990; see Fig. 3). The airport and the area of the proposed undertaking are located within the confines of the Kalaupapa National Historic Park.

As part of compliance with appropriate historic preservation law and regulation, an archaeological inventory survey was conducted in the project area (Ladefoged 1990). This survey identified 49 features (see Fig. 2), organized into 40 sites: 11 site at the east end of the existing airport runway and 29 sites at the west end of the runway.

The Hawaii State Historic Preservation Officer (Paty, letter of July 1, 1990) made the following determinations: (1) that five sites in the impact area at the west end of the runway are eligible for the National Register of Historic Places on the basis of their integrity and the information they may yield of importance to history or prehistory; (2) that the five sites will be adversely impacted by the undertaking; and (3) that the impact on the five sites may be mitigated by data recovery.

Subsequently, at a meeting of all involved parties (March 7, 1991) it was agreed that only three sites, rather than five, would definitely be impacted and thus subject to data recovery, while a fourth site may be impacted.

The Historic Preservation Mitigation Plan contains three elements: a data recovery plan, a burial treatment plan, and a preservation plan. The data recovery plan is a proposal to mitigate the impact of airport improvement on the three significant archaeological sites in the area of the undertaking, and also addresses the fourth site that may fall within the impact zone.

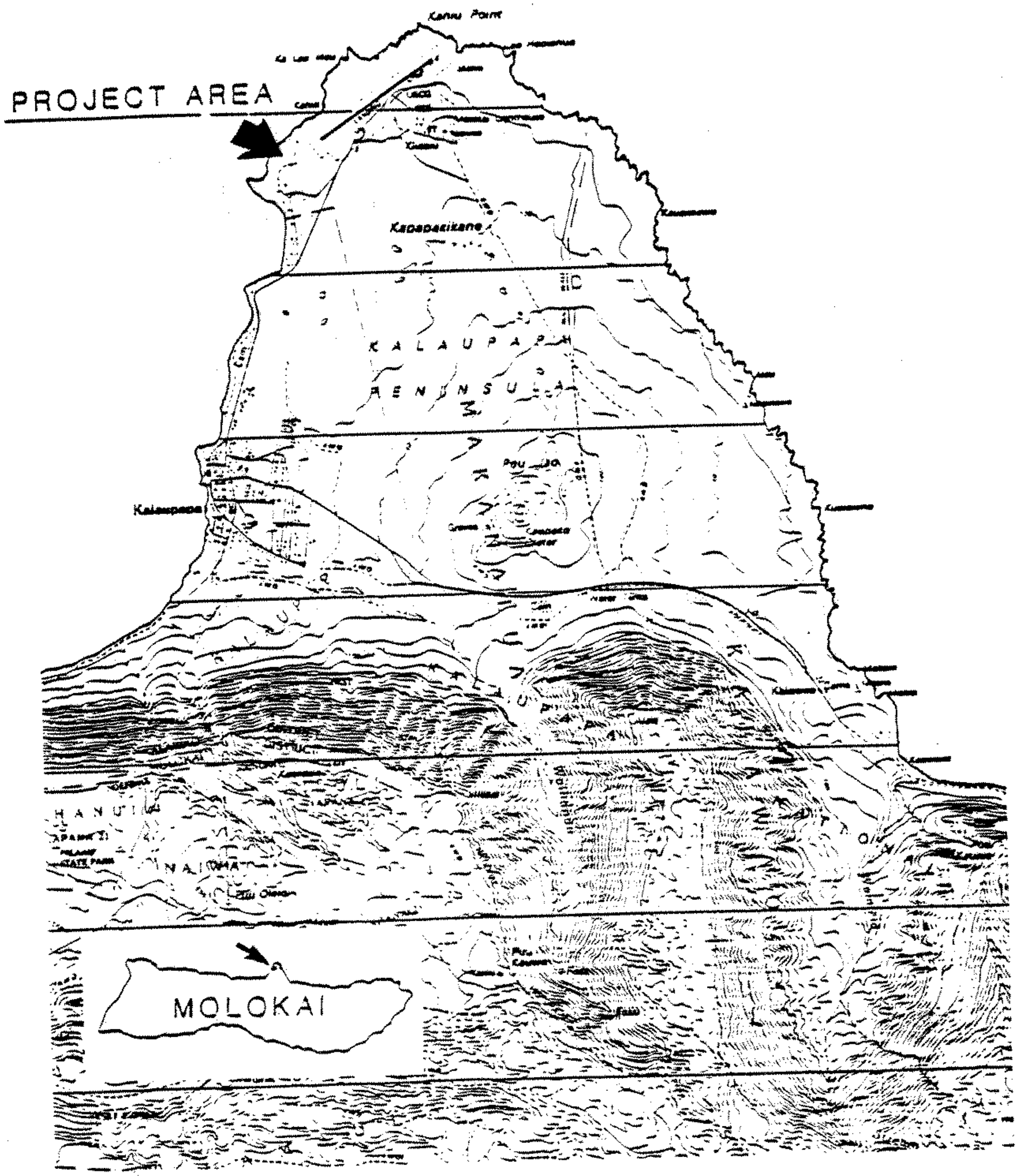

Figure 1. Kalaupapa Peninsula, Island of Moloka'i

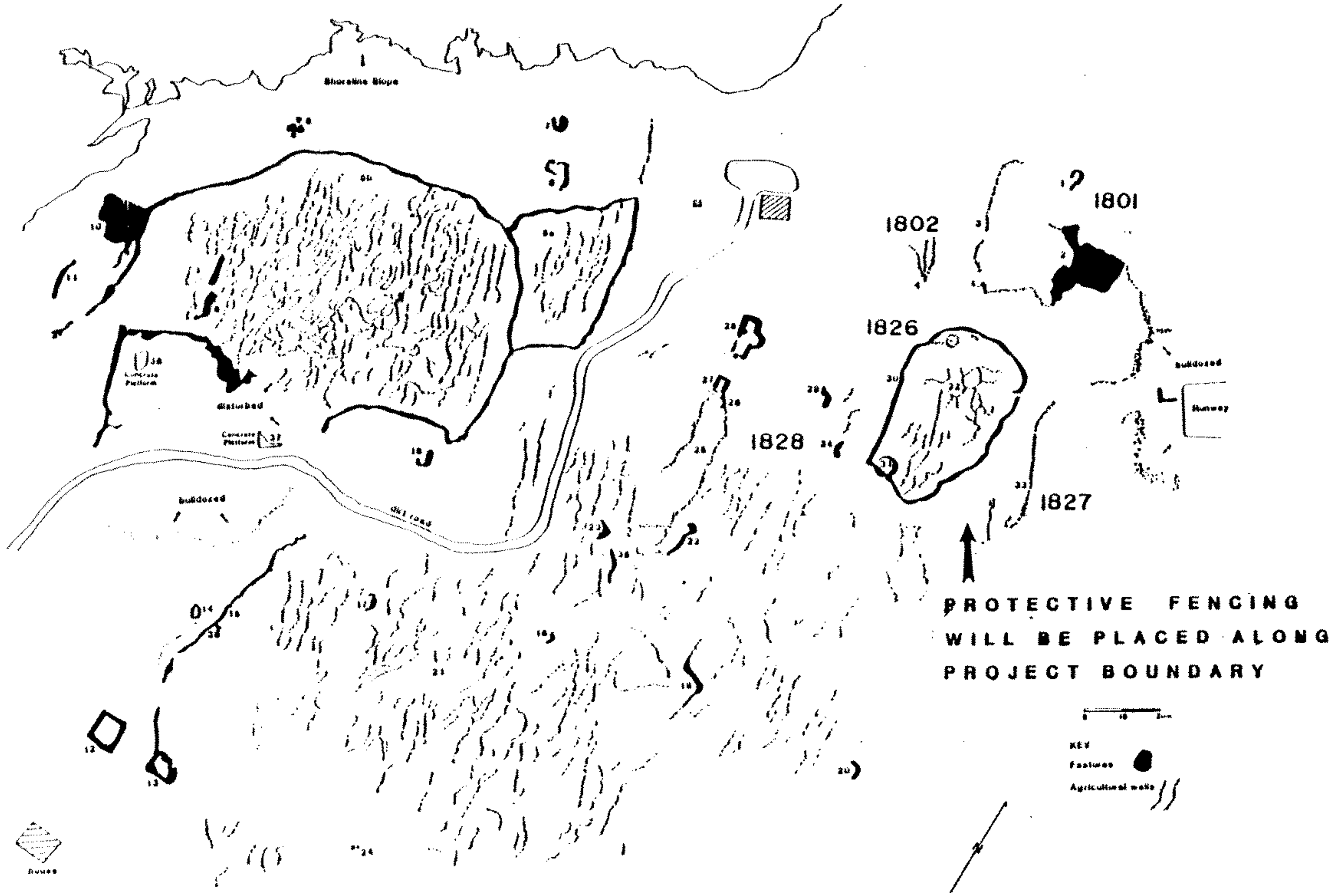

Figure 2. Sites at the West End of the Airport Runway.

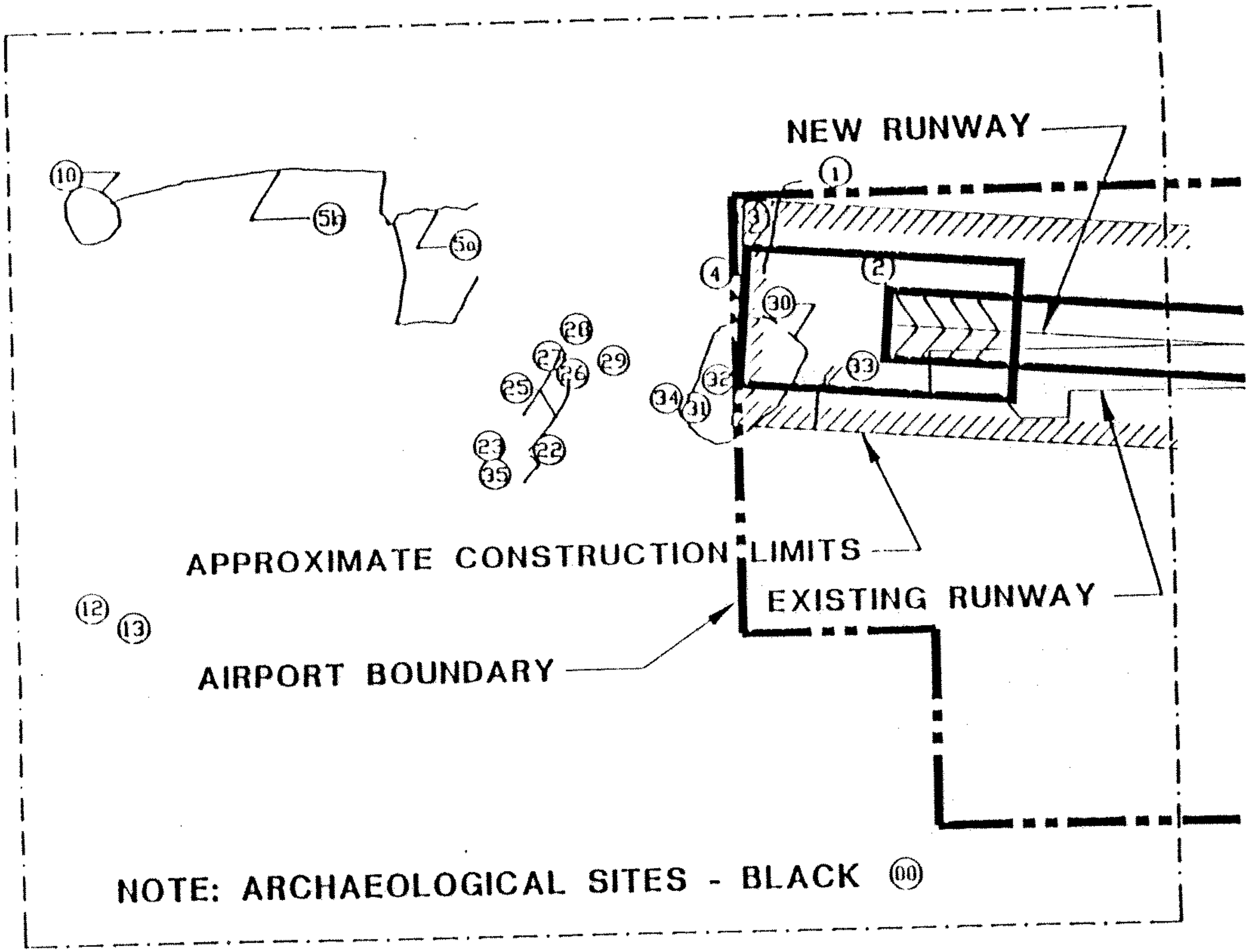

Figure 3. Kalaupapa Airport Improvement Project Area.
(Source: Sumida letter of March 16, 1990)

Although there are no known human burials in the area of the undertaking, the burial treatment plan presents the procedures to be followed in the event of inadvertent encounter of interred human remains.

The preservation plan presents the means to protect those archaeological sites that are near the project area but will not be directly impacted by airport improvement. Protective action is proposed to ensure that significant sites outside the boundaries of the undertaking will not be inadvertently affected (see Fig. 2).

The data recovery plan includes a proposal for monitoring during construction that cross-cuts the actions in the burial treatment and preservation plans.

HISTORIC PRESERVATION MITIGATION PLAN
KALAUPAPA AIRPORT IMPROVEMENT PROJECT

II. DATA RECOVERY PLAN

It has been determined that the proposed Kalaupapa Airport Improvement Project will have an adverse impact on three archaeological sites in the project area (see Figs. 2 and 3; Table 1) that are deemed eligible for the National Register of Historic Places, based on their integrity and their information content. The project may have an adverse impact on a fourth site also considered eligible for the National Register. It has been determined that the adverse impacts on these sites can be mitigated by appropriate data recovery.

This data recovery plan presents a program of data collection to mitigate the adverse impact on these four sites.

*****

Table 1. Sites to be impacted by airport improvement

SITE/ FEATURE	INFERRED FUNCTION	ARCHITECTURAL COMPONENTS
Site 50-60-03-1801		
2	residential**	6 pavings, 2 platforms, 2 alignments, 1 enclosure
3	enclosure	1 enclosure (encloses Fea. 1 and 2)
Site 50-60-03-1802		
4*	agricultural	3 alignments
Site 50-60-03-1826		
30	agricultural	34 alignments, 1 enclosure (encloses Fea. 31 and 32)
32*	shelter	1 C-shape
Site 50-60-03-1827		
33	shelter, alignment	1 C-shape, 1 alignment

*may be impacted; ** indicates test excavation

Data recovery will be conducted only on site features that will be impacted (Table 1). These features include 2, 3, 30, and 33. Features 4 and 32 are near the project boundary; it will be determined by on-site survey if these will be impacted. Features 4 and 32 are included in the present discussion, but will be excluded from actual data recovery if they are found to be outside the project area.

The Data Recovery Project Area

The data recovery plan covers four sites located at the southwest end of the existing Kalaupapa Airport runway, at the northern tip of the Kalaupapa peninsula on the island of Moloka'i (see Fig. 1). The sites cover an area that is approximately 100 by 100 m.

The project area is located on the northeast corner of the Kalaupapa peninsula, a land area of approximately 9 square km at the base of the towering, 2,000 foot high cliffs of the north shore of Moloka'i. The peninsula was formed during the late Pleistocene by lava flows from Kauhako Crater, which rises to about 100 feet above sea level at the southern end of the peninsula.

The terrain of the project area is relatively level as it extends south of the low, rocky shoreline. In his archaeological study of the project area, Ladefoged (1990:5) attributes the flatness of the shore section to occasional high surf that deposits large amounts of waterworn shell and coral. He notes that the "sediment of Features 2, 5B, 6, 8 and 10 were composed solely of this matrix." The higher ground, south of an imaginary line between Features 2 and 8 (see Fig. 2), is more broken and dissected and is characterized by soil with areas of exposed and eroded pahoehoe outcrops, with small amounts of wave washed sediments.

Vegetation is dominated by lantana (*Lantana camara*), with scattered Christmas berry (*Schinus terebinthifolia*) and koa haole *Leucaena leucocephala*) shrubs.

The existing Kalaupapa Airport runway extends in a northeast to southwest orientation. It is under the control of the State Department of Transportation. Immediately to the southeast is a lighthouse administered by the U.S. Coast Guard. Approximately 2 km to the southwest, near the base of the cliffs, is the main settlement of Kalaupapa. Land ownership of the peninsula is divided among the State of Hawaii, the National Park Service, the Hawaiian Homes Commission, and the U.S. Coast Guard.

The Kalaupapa peninsula is divided into three traditional land units: Kalawao, Makanalua, and Kalaupapa. All three ahupua'a fall within the Ko'olau District, one of the two traditional districts on the island. The project area falls within the ahupua'a of Makanalua (see Fig. 1).

Historical Background

Somers (1985), Greene (1985), and Fortunato de Loach (1975) review the historical literature concerning the Kalaupapa peninsula in general. Ladefoged (1990) discusses the written accounts that mention the immediate project area; he also discusses the agricultural history of the Kalaupapa peninsula as it pertains to the possible impacts on land use in the project area. Ladefoged's information is summarized here.

Between 1839, when a missionary census counted 1,000 people living on the peninsula, and 1867, when the Hawaiian government established a Hansen's disease colony, several accounts detail cultivation of crops, primarily sweet potato, across the peninsula. In 1854, Jules Remy noted sweet potato fields surrounding the villages. In 1857, M.L. Napihelua wrote that "Kalaupapa is a good land because the crops planted are successful and the gain is large...Many sweet potatoes are being planted now, four or five patches to each man...Be on the watch you traders, for Kalaupapa is the best in all the islands for good prices and fast work (Ka Hae Hawaii, March 4, 1857, quoted in Handy and Handy 1972:518). Occasionally, ships would come directly to Kalaupapa from California to trade for sweet potatoes (Fortunato de Loach 1975:77).

After the establishment of the Hansen's disease colony, however, it appears that cultivation fell off and accounts of visitors to the peninsula note that many of the fields were lying fallow and that food supplies were imported from other parts of the island. Greene (1985) documents the development of the colony and the occupation of the peninsula in the late 1800s and early 1900s.

For the project area itself, mapped data from this late period (Monsarrat 1895; Wall 1905; USGS 1921-22) indicate that there were no houses or structures in the area, although the USGS map shows at least four structures and a road in the general vicinity. In the 1930s, however, a visitor noted houses in the area around the lighthouse. This may refer to the abandoned house and cement foundations (Fea. 37 and 38) within the inventory survey project area (Ladefoged 1990:8).

On April 1, 1946, a tidal wave swept the seaward edges of the peninsula and the lighthouse keeper recalled "One minute the houses were there, and the next they were washing away in the wave" (Fred Robins, quoted in Dean 1989:153). Although not certain, this may refer to structures that were in the project area (Ladefoged 1990:8).

In 1980, the Kalaupapa peninsula and adjacent valleys to the east were established as a National Historical Park.

Previous Archaeological Studies

Archaeological studies have been carried out on the Kalaupapa peninsula since the early 1900s. In 1909, John Stokes visited the peninsula as part of his Moloka'i heiau survey (Stokes 1909). In the 1930s, Southwick Phelps and H.L. McHenry conducted reconnaissance surveys of portions of the peninsula (Phelps 1937; McHenry n.d.). McHenry's map clearly shows sites in the vicinity of the current project area. Ladefoged (1990:9) interprets McHenry's site 8a as Fea. 10 and 11 of the airport improvement inventory survey area (see comment, below, re: Summers 1971)

In 1966 and 1967, Richard Pearson of the University of Hawaii Anthropology Department conducted test excavations in Kaupikiawa Cave (site 312) near the northern coast of the peninsula (Pearson *et al* 1974; Hirata and Potts 1967). Charcoal samples from these excavations yielded radiocarbon dates of 880 +\- 70 years B.P., 490 +\- 180 years B.P., and less than 120 years B.P. (calibrated according to Stuiver and Reimer 1986).

In 1971, Catherine C. Summers produced an overview of recorded archaeological sites on Moloka'i, including a discussion of sites on Kalaupapa peninsula (Summers 1971). Her site 298 is identified as McHenry's site 8a, but the dimensions are different from McHenry's description.

In 1974, the State-wide inventory survey attempted to relocate previously recorded sites on the island, including Kalaupapa peninsula.

In 1978, William J. Barrera conducted excavation at site 50-60-03-515 in Kalaupapa settlement, prior to construction of a new hospital facility (Barrera n.d.).

The most extensive study to date was carried out by the National Park Service. Gary Somers (1985) systematically surveyed and mapped a large area located in the south part of the peninsula. This survey described densely packed features, in places continuous across the landscape, that include a range of religious, residential and agricultural structures.

Somers also carried out intensive survey of Waihanau Valley (Somers 1987) and excavated two human burials from the sandy beach northeast of Moloka'i Lighthouse and southeast of Kahi'u Point (Somers in press).

In 1989, a preliminary survey was conducted for the current airport improvement project (Athens 1989). Later in the same year, an inventory survey of detailed mapping and test excavations was also carried out (Ladefoged 1989; see discussion below). The current data recovery plan covers sites in a portion of the inventory survey area.

The studies of Kalaupapa peninsula have documented a wide range of archaeological sites. Sites include heiau, a holua slide, a cave site, residential structures, burials, and agricultural features. The limited chronometric efforts, while problematic, suggest an occupation possibly as early as A.D. 1000.

Archaeological Inventory Survey

In July-August 1989, an inventory survey of two parcels adjacent to the existing Kalaupapa Airport runway was carried out as part of the current airport improvement project (Ladefoged 1990). A total of 49 features were located: 38 at the west end of the runway and 11 at the east end. These features have been organized into 40 sites (Ladefoged 1990:186-190, Table 67). The well-preserved structures at the west end are interpreted as the remains of a residential and agricultural complex; the features in the east parcel, which are in poor to fair condition, are probably the remains of an agricultural complex.

As part of the inventory survey, all features were mapped in detail and 21 features were test excavated. Testing showed that most of the features were single event occupations with numbers of introduced artifacts (including bottle glass, metal, chert, and nails), but often mixed with traditional items (flakes of basalt and volcanic glass) However, there is evidence of multiple occupation phases: there are buried alignments in the enclosed agricultural field systems (Site 1803, Fea. 5a and 8) and there are overlapping features (hearth, paving, and ash deposit) in the Site 1826, Fea. 31 C-shaped shelter.

Seven samples were submitted for radiocarbon analysis: one sample (from a layer above a buried alignment, Fea. 8) had an exclusively pre-Contact age calibration; four samples (from Fea. 12, 13, 28, and 31) ranged into the historical period; and two samples (from Fea. 18 and 23) had modern calibrations (Ladefoged 1990:175).

Project Sites for Data Recovery

The sites that will be impacted by construction are located in the west parcel (see Fig. 3 and Table 1). Architectural components of these residential and agricultural structures include C-shapes, platforms, pavings, alignments, and enclosures. All features were mapped in detail. One feature (2) was test excavated.

The features to the west of the data recovery sites (see Fig. 2) are a continuation of the residential-agricultural complex in the project area and are addressed in the Preservation Plan.

<u>Site 1801</u>

Site 1801 consists of two primary features that will be subject to data recovery.

Feature 2 is a large platform, measuring 22 by 20 m, with a number of internal architectural components, including six paved areas, one platform, two alignments, and one enclosure. Bottle glass and some shell midden were observed on the surface of the platform. Two test pits were placed in this feature.

A 50 by 50 cm test pit was placed about 1.5 m to the lee (west) of the main platform to examine sediment deposits surrounding the feature. The test revealed a 10 cm thick, buried paving containing small amounts of charcoal and kukui nut, basalt, volcanic glass, and historical artifacts (clear glass, glass beads, chert, and metal). Beneath the paving was a deposit with small amounts of charcoal, a small piece of fish bone, and a piece of indeterminate bone.

The second test pit measured 1 by 1 m and was placed in a low platform, on top of which was a concentration of coral. It was thought that the platform could be a burial. The testing, however, was inconclusive short of suggesting a historical occupation.

Ladefoged (1990: 74) recommends that further excavations be conducted in the area outside the platform in order to determine the extent of "subsurface architectural components and the existence of further buried deposits."

Feature 3 is the enclosing wall of a residential complex including Fea. 1 and 2, and defines the currently understood boundaries of Site 1801. The wall is not particularly well-made or preserved; construction varies from core-filled to stacked stone to upright boulders.

Site 1802

Site 1802 may be impacted by the project. A final determination will be made following an on-site project boundary survey.

Site 1802 (Fea. 4) is a series of three roughly linear alignments, probably used for agricultural purposes, that range from 7.8 to 13.9 m long. All of the alignments are a single course high of porous basalt boulders.

Site 1826

Site 1826 has one feature (Fea.30) that will be impacted by the project, and one feature (Fea.32) that may be impacted by the project. The boundary of the site is defined by the Fea. 30 enclosing wall.

Feature 30 is a large enclosure built around a swale or low-lying area. Most of the enclosing wall is core-filled, with some sections of stacked stone. Fea. 31 and 32 are located within this enclosure; 34 additional interior alignments were mapped from aerial photographs.

Feature 32 consists of a small C-shaped structure, a large rubble mound, and several low walls, located within the larger enclosure of Fea. 30. Several pieces of coral were observed.

Site 1827

Site 1827 (Fea. 33) will be impacted by the project.

Site 1827 is a remnant of a long, curving, core-filled wall; a small, 2 by 2 m C-shaped structure is built into the south end of the wall. The wall surrounds a small swale and portions of it incorporate boulder outcrops; it might have been part of an enclosure that was destroyed when the existing airfield was constructed. The swale to the southeast of the wall was examined for additional archaeological features but none were noted.

General Research Questions

Site Formation Processes

Site formation processes are often neglected in Hawaiian research, but always need to be addressed directly in every study. The present data recovery will evaluate the surface and stratigraphic data from this standpoint, with an examination of the nature of deposition.

In this particular project, there are two elements that are of special interest for site formation studies. The first element is the effect of ocean action (high surf and tidal waves) on the sites in regard to removal and disturbance of archaeological remains, and deposition of massive wave-wash debris. Deposits will be studied carefully in regard to the effects of this natural action. This includes not only an evaluation of disturbance and deposition of ocean debris, but evaluation of the possibility of the removal of deposits as indicated by remnant or truncated deposits and scouring. Deposit loss could account for the lack of evidence for earlier occupation of the area.

The second site formation element concerns the peculiar effects that result from occupation of a stone platform, with all of the varying possibilities for vertical distribution of trash and for frequent "rebuilding" of the habitation surface. A large stone platform (site 1801, Fea. 2) is one of the major sites subject to data recovery in this project.

The study of site formation in a stone platform is complicated, but is critical to conclusions about platform construction and use. This problem will be dealt with by excavation that will emphasize platform construction on one hand and detailed provenience analysis on the other. Provenience analysis requires study of matrix as well as trash, and the field interpretation of depositional relationships.

Chronology

Chronology is of course essential to all archaeological interpretation. In this particular case, there is a great deal of evidence to suggest that several of the sites date from the late pre-Contact into the mid-1800s. This is a critical time period in Hawaiian history, incorporating as it does the "proto-historic" transition (see below). Thus, particular attention needs to be paid to the tight chronological control of the occupation events. This will be accomplished using the study of site formation processes as a base, followed by the detailed study of introduced artifacts, plants, and animals.

Comparative Settlement and Site Function Analysis

The understanding of Hawaiian community organization in the pre-Contact period is one of the primary issues in Hawaiian archaeology (cf. Kirch 1985:247 ff.); the nature of organization following Contact is a corollary concern of equal importance. The sites in the project area probably do not represent an entire community, and thus this problem cannot be addressed at this level of data recovery effort. However, the habitation structures can be studied individually for the nature of their occupation in regard to the habitation unit and the activities that took place. These data can contribute to the comparative data base that is being established in Hawaiian research.

Specific Research Questions

Models of Habitation Structures

The set of research sites includes a range of habitation structures, from C-shapes to a large platform. Site 1801, Fea. 2 is one of the two primary residential structures in the general area (the other is Site 1803, Fea. 10, outside the project area). It has clearly defined activity areas, including a buried paving to the west of the visible surface structure. Site 1826, Fea. 32, and Site 1827 (Fea. 33) are shelters.

These sites provide an opportunity to compare and contrast occupation deposits in different types of residential structures. The specific questions that will be directed toward these structures include not only the date of their occupation, but their specific functions, the number of occupational events, the duration of occupation, and the nature of the social group occupying them. Feature 2 will be intensively excavated in order to examine activity areas and features and their change through time.

These questions will be approached through stratigraphic and artifactual analyses, and through the determination of activity space and construction labor investment. This work will involve testing of models of function, duration, and social group presented in current literature (Cordy 1981; Weisler and Kirch 1985; Tuggle 1990).

The Proto-Historic Transition

Documenting the presence of a "proto-Historic" phase is important in itself, but this then sets the stage for a series of questions about the nature of this period of transition from pre-Contact Hawaiian culture to a radically altered culture. The sites under study appear to present an excellent opportunity to examine these changes in a local community.

If a pre-Contact occupation can be clearly identified, then the questions concerning the nature of the local social unit can be dealt with in regard to ranking and permanence. Then the problem of the timing and character of Contact transition can addressed; for example, what kinds of and how quickly are non-indigenous artifacts are being introduced; how are they articulated with traditional artifact use, and how is social ranking related to this process?

These problems will be addressed in all sites that have a post-Contact component. Because of the variation in settlement structures, from C-shapes to a large platform, there may be a range of ranking involved, or a range in time of occupation of the same group (as noted above).

Mid-Nineteenth Century Occupation

If a substantial portion of the occupation proves to be occupied in the mid-19th century, then problems of the relationship to the sweet potato trade become critical. The nature of access to foreign goods and the social units involved in this access are questions that can be duplicated from the problems above. However, a new question that comes into play, given cultivation for a market economy, is whether there are more people inhabiting the area than before.

It may not be possible to make this assessment based on the relatively small number of sites involved, but the nature of change in the occupational history of the sites, as well as the timing of that change, might provide some data for models that could be tested with future research. A question that can be answered is whether a major part of the post-Contact occupation is a new settlement that was established as a response to the development of potato production for the California market.

Agricultural System Variation

Within the project area there is a distinction in intensity between enclosed fields and unenclosed sets of alignments. The difference in the construction, use, and if possible age will be determined through excavation.

There is evidence of buried alignments in sites outside the project area (Site 1803) and these may have originated prior to A.D. 1300. This raises the possibility of buried, and perhaps early, agricultural features in the project area. The excavations of the various agricultural systems will investigate this possibility.

The study of the agricultural systems in the project area will also involve a comparison with those recorded by Somers (1985) in the south part of the peninsula. There, Somers recorded a continuous network of stone terraces, flat areas, cleared areas, circular enclosures, modified boulder fields, and artificial pits in boulder areas (Ladefoged 1990:9). This contrasts with the more discrete, parallel alignments in the project area.

Site Specific Data Collection Methods

Within the framework of questions identified above, site specific research will be conducted in the following manner.

Complete identification of all features around Fea. 2 in site 1801 and around site 1827 will be carried out (see Ladefoged 1990:60).

A series of stratigraphic trenches will be excavated in the open areas between structures and sites to determine the extent and nature of subsurface deposits and features (see Ladefoged 1990:74).

1. The enclosure walls of sites 1801, 1826, and 1827 will be sectioned by trenching. They will be excavated by controlled units, but these units will be tied into the system of stratigraphic trenching.

2. A sample of agricultural terraces will be excavated by stratigraphic trenches.

3. In cases where stratigraphic trenches encounter features and distinct cultural deposits, the trenching will be stopped and the unit left for detailed excavation.

The floors of the C-shapes will be excavated completely and sections of their walls will be excavated. These features include Fea. 32 of site 1826 and and Fea. 33 of site 1827.

The most intensive excavation effort will be devoted to site 1801, Fea. 2. The excavation of this structure will begin with a combination of stratigraphic and controlled trenching outside of the visible surface structure. This will determine the stratigraphic position of the main platform and the extent of related buried features and deposits.

Exterior trenching will be followed by a study of the surface of the main platform. Any necessary detailed mapping amendments will be made.

The structure itself will be excavated by a combination of controlled trenching and horizontal excavation. The specific tactics for this will be determined in the field, following the exterior trenching and detailed mapping. However, the strategy will be twofold: (1) to excavate several large horizontal areas to determine activity areas and functional change and (2) to excavate the unit as a series of integrated features (paved areas, activity areas, construction units, construction layers, etc). This means that the stratigraphic relationships between the "features" has to be determined, as well as the content of each excavated "feature".

This twofold strategy is the specific means to obtain the data critical to the research questions identified above, specifically site formation and chronological control on one hand, and occupational change on the other.

Specifications

General Methods

The stratigraphic trenching, conducted in open areas, will be qualitative in nature, emphasizing the exposure of stratigraphic profiles and the identification of cultural deposits and features.

Controlled excavation units will be quantitative in nature; all excavated materials will be screened. Excavation in critical proveniences and rich deposits will emphasize bulk collection; that is, the bagging of screened material for lab sorting, rather than collection from the screen. Controlled excavations will maintain a record of excavation volume for analysis of density of material.

Sites and excavations will be recorded through photography, field notes, and site and feature form documentation. All excavation units will be accurately located on plan maps.

Laboratory and Data Analyses

Detailed sorting and classification of artifacts and midden material will be carried out in the laboratory. Charcoal wood identification will be made for all specimens submitted for radiocarbon analyses. All bone will be identified by specialists. Detailed study of all of the historical artifacts will be conducted by a specialist. Where possible, multiple radiocarbon age determinations per provenience will be carried out.

Curation

All archaeological materials will be curated by IARII until requested to provide them to the appropriate government agency.

Copies of the inventory of archived material, a photo record, and photo contact sheets will be submitted to the Division of Historic Preservation of the State Department of Land and Natural Resources.

Reports

A draft Final Report will be submitted to the appropriate agencies for review and approval. This report will include a thorough statement on the data recovery research questions, analyses, and conclusions (including evaluation of all the appropriate historical data); detailed data description and analyses; and the identification of field methods and time. All specialized analyses will be included as appendices. All categories of the Division of Historic Preservation's guidelines for data recovery report preparation will be included. Following agency review, a final report be completed.

Project Scheduling

The field work for this project will be conducted over a period of seven weeks. The draft final report will be submitted within five months following the end of field work. A final report will be completed following review by appropriate agencies.

Monitoring

Archaeological inventory does not necessarily result in the identification of all subsurface sites. Neither inventory nor data recovery, which is a sampling process, necessarily results in the location of all buried remains. As a result, archaeological monitoring is often required as the final step in the complete historic preservation mitigation process. In this case, given that the undertaking is being conducted in a National Historical Park with extensive archaeological remains, archaeological monitoring will be carried out during all earth-moving operations. This monitoring will be carried out by a professional archaeologist.

The monitoring will have three purposes: to identify any new archaeological sites discovered in the earth-moving, to identify inadvertent encounter of human remains, and to ensure the protection of sites in the preservation area outside the area of data recovery.

In the case of discovery of a new archaeological site, the operations of the undertaking in that area will cease at the request of the archaeological monitor. The monitor will then initiate the actions required by law and policy regarding the inadvertent discovery of archaeological remains.

The actions regarding inadvertent burial discovery and those involving the preservation sites are presented under the Burial Treatment Plan and the Preservation Plan.

HISTORIC PRESERVATION MITIGATION PLAN
KALAUPAPA AIRPORT IMPROVEMENT PROJECT

III. BURIAL TREATMENT PLAN

There are no known human burials in the project area and there are no structures that appear to be for specific human interment. However, there is always the possibility of inadvertent discovery of such burials.

If human remains are encountered during data recovery, excavation in the immediate area will cease at the direction of the project director. The Division of Historic Preservation of the State Department of Land and Natural Resources will be contacted. The Division, in consultation with the undertaking agency and the project director, will follow the guidelines for action under these circumstances that are currently a matter of law, regulation, and policy.

In order to ensure appropriate action if burials should be encountered during airport improvement activities, there will be an archaeological monitor present during all earth-moving operations. If human remains are inadvertently encountered, all undertaking activity in the immediate area will cease at the monitor's request. The monitor will then contact the Division of Historic Preservation. The Division, in consultation with the undertaking agency and the monitor, will follow the guidelines for action under these circumstances that are currently a matter of law, regulation, and policy.

HISTORIC PRESERVATION MITIGATION PLAN
KALAUPAPA AIRPORT IMPROVEMENT PROJECT

IV. PRESERVATION PLAN

There are a number of archaeological sites outside the area of the undertaking that have been identified (Ladefoged 1990) and which may be eligible for the National Register of Historic Places (see Fig. 2). Consequently, action must be taken to ensure that these sites are not inadvertently damaged during airport improvement.

Such damage usually occurs when there is a misunderstanding of the boundaries of the undertaking or of protected areas. Two protective actions for these sites will be taken.

First, temporary protective fencing will be placed between the western edge of the data recovery sites and the area of preservation sites (see Fig. 2). The fencing will have signs indicating that the preservation area is closed to construction activities. This fencing will be erected under the supervision of an archaeologist who will establish a location and an installation method that will not be damaging to the preservation sites.

Second, there will be an archaeological monitor present during all earth-moving activities to ensure that the area is not intruded upon by accident during these activities, and to see that the fencing is properly maintained.

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APPENDIX D

APPENDIX D

PRELIMINARY AIR QUALITY STUDY FOR THE KALAUPAPA AIRPORT MASTER PLAN, KALAWAO COUNTY, MOLOKAI

PRELIMINARY AIR QUALITY STUDY
FOR THE KALAUPAPA AIRPORT MASTER PLAN

KALAWAO COUNTY, MOLOKAI

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Prepared by:

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September 1989

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FIGURES

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1.0 INTRODUCTION AND PROJECT DESCRIPTION

The Airports Division of the State of Hawaii Department of Transportation is proposing to upgrade facilities at the Kalaupapa Airport located on the northern peninsula of Molokai in the County of Kalawao. As indicated in Figure 1, the airport is located along the coast two miles north of the Kalaupapa Settlement. A paved, two-lane access road leads from the Airport to the Settlement. At the present time this facility serves as an interisland commuter/air taxi and general aviation airport with a few military operations. The Airport serves the residents of Kalaupapa Settlement, the various government agencies associated with the Settlement and visitors to the Kalaupapa Peninsula. The Kalaupapa Peninsula is separated from the rest of Molokai by 1600-foot cliffs.

Currently, state law limits the number of visitors to Kalaupapa to 100 per day. During 1988 daily visitors averaged about 25. Several different levels of airport development are currently being contemplated. Upgrading the facilities to accommodate 100 visitors per day is being considered, assuming that the present 100 visitor per day level is maintained. Visitor levels of 200 or 300 visitors per day are also being appraised for land use planning purposes only in the event that at some point in the long-range future the visitor level limitation is increased. Requirements to meet the 100 visitor level, as well as safety and operational needs, include lengthening and improving the runway; adding a paved taxiway and apron; installing landing aids; expanding terminal facilities; expanding and relocating support facilities; and improving the airport access road and vehicle parking facilities. All of these improvements are to be completed before the end of 1991.

The purpose of this study is to describe existing air quality in the project area and to make a preliminary assessment of the potential short- and long-term direct and indirect air quality impacts that could result from construction and use of the proposed facilities as planned. Measures to mitigate potential impacts are suggested where possible and appropriate.

2.0 AMBIENT AIR QUALITY STANDARDS

National Ambient Air Quality Standards (AAQS) are specified in Section 40, Part 50 of the Code of Federal Regulations (CFR), while State of Hawaii AAQS are defined in Chapter 11-59 of the Hawaii Administrative Rules. Table 1 summarizes both the national and the state AAQS that are specified in the cited documents. As indicated in the table, AAQS have been established for six pollutants. The pollutants for which AAQS have been established include particulate matter, sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone and lead. National AAQS are stated in terms of primary and secondary standards. National primary standards are designed to protect the public health with an "adequate margin of safety". National secondary standards, on the other hand, define levels of air quality necessary to protect the public welfare from "any known or anticipated adverse effects of a pollutant". Secondary public welfare impacts may include such effects as decreased visibility, diminished comfort levels, or other potential injury to the natural or man-made environment, e.g., soiling of materials, damage to vegetation or other economic damage. In contrast to the national AAQS, Hawaii State AAQS are given in terms of a single standard that is designed "to protect public health and welfare and to prevent the significant deterioration of air quality".

Each of the regulated pollutants has the potential to create or exacerbate some form of adverse health effect or to produce environmental degradation when present in sufficiently high concentration for prolonged periods of time. The AAQS specify a maximum allowable concentration for a given pollutant for one or more averaging times to prevent harmful effects. Averaging times vary from one hour to one year depending on the pollutant and type of exposure necessary to cause adverse effects. In the case of the short-term (i.e., 1- to 24-hour) AAQS, both national and state standards allow one exceedance per year.

State of Hawaii AAQS are in some cases considerably more stringent than comparable national AAQS. In particular, the State of Hawaii 1-hour AAQS for carbon monoxide is four times more stringent than the comparable national limit.

Under the provisions of the Federal Clean Air Act [1], the U.S. Environmental Protection Agency (EPA) is required to periodically review and re-evaluate national AAQS in light of research findings more recent than those which were available at the time the standards were originally set. Occasionally new standards are created as well. Most recently, the national standard for particulate matter has been revised to include specific limits for particulates 10 microns or less in diameter (PM-10) [2]. The State of Hawaii has not explicitly addressed the question of whether to set limits for this category of air pollutant, but national AAQS prevail where states have not set their own more stringent levels.

Hawaii AAQS for sulfur dioxide were relaxed in 1986 making the state standards essentially the same as national limits. It has been proposed in various forums that the state also relax its carbon monoxide standards to the national levels, but at present there are no indications that such a change is being considered.

3.0 PRESENT AIR QUALITY

Although there is no existing air quality data for the Kalaupapa area, present air quality in the project area can be assumed to be nearly pristine due to its remote location, the lack of air pollution sources on the peninsula, and the windward location of the project with respect to the northeast tradewinds. Occasional minor impacts may occur from natural, agricultural and/or vehicular sources. Natural sources of air pollution emissions which could affect the project area include the ocean (sea spray), plants (aero-allergens), wind-blown dust, and perhaps distant volcanoes on the Island of Hawaii. Dust and smoke from agricultural tilling and burning in the area may reduce air quality periodically, and tailpipe emissions as well as fugitive dust from the few automobiles in Kalaupapa may slightly affect air quality near roadways.

4.0 SHORT-TERM DIRECT AND INDIRECT IMPACTS OF PROJECT

Short-term direct and indirect impacts on air quality could potentially occur due to project construction. For a project of this nature, there are two potential sources of air pollution emissions which could directly result in short-term air quality impacts during project construction: (1) fugitive dust from vehicle movement and soil excavation and (2) exhaust emissions from on-site construction equipment.

Fugitive dust emissions may arise from grading and dirt-moving activities within the project site. The emission rate for fugitive dust is nearly impossible to estimate accurately because of its elusive nature and because the potential for its generation varies greatly depending upon the type of soil at the construction site, the amount and type of dirt-disturbing activity taking place, the moisture content of exposed soil in work areas, and the wind speed. The EPA [3] has provided a rough estimate for uncontrolled fugitive dust emissions from construction activity of 1.2 tons per acre per month under conditions of "medium" activity, moderate soil silt content (30%), and precipitation/evaporation (P/E) index of 50. Uncontrolled fugitive dust emissions in the project area would probably be somewhere near this level. In any case, State of Hawaii Air Pollution Control Regulations [4] require that visible emissions of fugitive dust from construction activity be essentially nil.

Adequate fugitive dust control can usually be accomplished by establishment of a frequent watering program to keep bare-dirt surfaces in work areas from becoming significant dust generators. Control regulations also require that open-bodied trucks be covered at all times when in motion if they are transporting materials likely to give rise to airborne dust. Paving of parking areas and establishment of landscaping as early in the construction process as possible can also lower the potential for fugitive dust emissions.

On-site mobile and stationary construction equipment will also emit some air pollutants in the form of engine exhausts. The largest of this equipment is usually diesel-powered. Nitrogen oxides emissions from diesel engines can be relatively high compared to gasoline-powered equipment, but the standard for nitrogen dioxide is set on an annual basis and is not likely to be violated by short-term construction equipment emissions. Carbon monoxide emissions from diesel engines, on the other hand, are very low and should be relatively insignificant.

5.0 LONG-TERM DIRECT AND INDIRECT IMPACTS OF PROJECT

In order to ascertain the significance of potential long-term direct and indirect air quality impacts of the project, estimates of air pollution emissions associated with the project and occurring in the project vicinity were prepared for comparison to the "significant" emission rates as defined by the State Department of Health [4]. If emissions are below the significant levels, it is very unlikely that any significant impacts on air quality would occur. If emissions exceed the significant levels, it does not necessarily mean that there would be significant impacts, but it does suggest that a more detailed analysis is required. Although the state significant emission rates are generally used to assess stationary point sources and not an area or volume source such as an airport, they may also be used to provide a measure of the significance of emissions from other types of sources in certain cases. In this case, where the area source is particularly well defined, the significant emission rates should be relatively applicable. Actually, emissions from area and/or volume sources are much more diluted than point source emissions, and hence ambient concentrations and impacts on air quality are less significant for a given emission rate.

In general, direct and indirect air pollution emissions from airports occur from aircraft operations, motor vehicles, fuel storage and handling and aircraft maintenance operations. At Kalaupapa, aircraft fueling and maintenance operations will not be performed. Thus, the only emissions of air pollution will come from aircraft landing, taxiing and taking off and from automobiles transporting visitors to and from the Settlement.

Based on aviation demand forecasts for various levels of development [5], both aircraft and automobile emissions in the vicinity of the airport were estimated. Aircraft emissions were estimated using U.S. EPA emissions factors [6] for civilian and military aircraft. U.S. EPA emission factors for aircraft are given in terms of pounds of air pollution emitted per landing/takeoff cycle. These were developed based on testing of several types of aircraft and the time-in-mode and engine power settings for the various modes of operation. A landing/takeoff cycle includes all of the normal flight and ground operation modes including: descent/approach from approximately 3000 feet, touchdown, landing run, taxi in, idle and shutdown, startup and idle, checkout, taxi out, takeoff, and climbout to 3000 feet. Thus, based on the number and category of aircraft operations per year given in the aviation demand forecasts, an estimate of annual emissions in the vicinity of the airport can be obtained.

The EPA computer model MOBILE3 [7] was used to estimate automobile tailpipe emission estimates for each of the levels of activity studied. Some of the key inputs to MOBILE3 include: vehicle mix, vehicle engine temperature, ambient temperature and vehicle speed. Based on the location and nature of the proposed project, a vehicle mix of 90% light-duty gasoline-powered vehicles, 4% light-duty gasoline-powered trucks and vans, 4% gasoline-powered trucks between 6000 and 8500 lbs, and 2% motorcycles was assumed. It was further assumed that the vehicle mix would include little or no diesel-powered and/or heavy duty vehicles. It was assumed that about 21 percent of all vehicles would be operating in the cold-start mode and that about 27 percent would be operating in the hot-start mode. These are typical values that are used in calculating cold/hot start emissions for most applications involving surface roadways. MOBILE3 emission estimates are inversely related to ambient temperature and to vehicle speed. An ambient temperature of 75 degrees F was used to reflect average annual conditions, while vehicle speeds were assumed to average 25 miles per hour.

Output from the MOBILE3 emission model is given in terms of composite emission factors for carbon monoxide, nitrogen oxides and hydrocarbons expressed as grams of air pollution emitted per vehicle mile of travel (VMT). These composite emission factors account for the various modes of automobile operation (i.e., deceleration, idle, acceleration and cruise). Thus, given the VMT per year for vehicles associated with the Airport, an annual estimate of automotive-related emissions can be calculated. VMT per year for each level of activity were estimated based on the forecast passenger total and the assumptions that each deplaned/enplaned passenger would travel 2 miles from/to the Airport and that each vehicle would carry two passengers on the average.

Fugitive dust emissions from automobile traffic were estimated based on U.S. EPA emission factors for paved roadways [3] and annual VMT estimates. Similar to emission factors for exhaust emissions, emission factors for fugitive dust from roadways are given in terms of grams per VMT.

Table 2 is an emission inventory for the Kalaupapa Airport Master Plan based on the emission factors and assumptions described above. Emission estimates are given for each of the major (regulated) air pollutants that would be emitted including: carbon monoxide, nitrogen oxides, hydrocarbons, sulfur oxides, total suspended particulate, and particulate matter less than 10 microns diameter. As indicated in the table, estimates are given in terms of tons of air pollution per year for each level of activity.

To assess the significance of these estimated emission rates, Table 3 shows the state-defined significant emission rates (in tons per year) for carbon monoxide, nitrogen oxides, volatile organic compounds (hydrocarbons), sulfur dioxide and particulate matter. Comparing the significant emission rates to the estimated emissions given in Table 2, it can be seen that 1988 emission levels are far below the significant emission rates. Estimated emissions for 50, 100 and 200 daily visitor levels of development would remain well within the significant emission rates. At 300 visitors per day, emissions would still be less than the significant levels if all passengers arrive/depart via commuter aircraft.

6.0 CONCLUSIONS AND RECOMMENDATIONS

Although there is no air quality data for the project area, based on the location and character of the project site and the absence of any major sources of air pollution nearby, it appears likely that all state and national air quality standards are currently being met in the project vicinity. Assuming the project is built, short-term direct and indirect air quality impacts would result

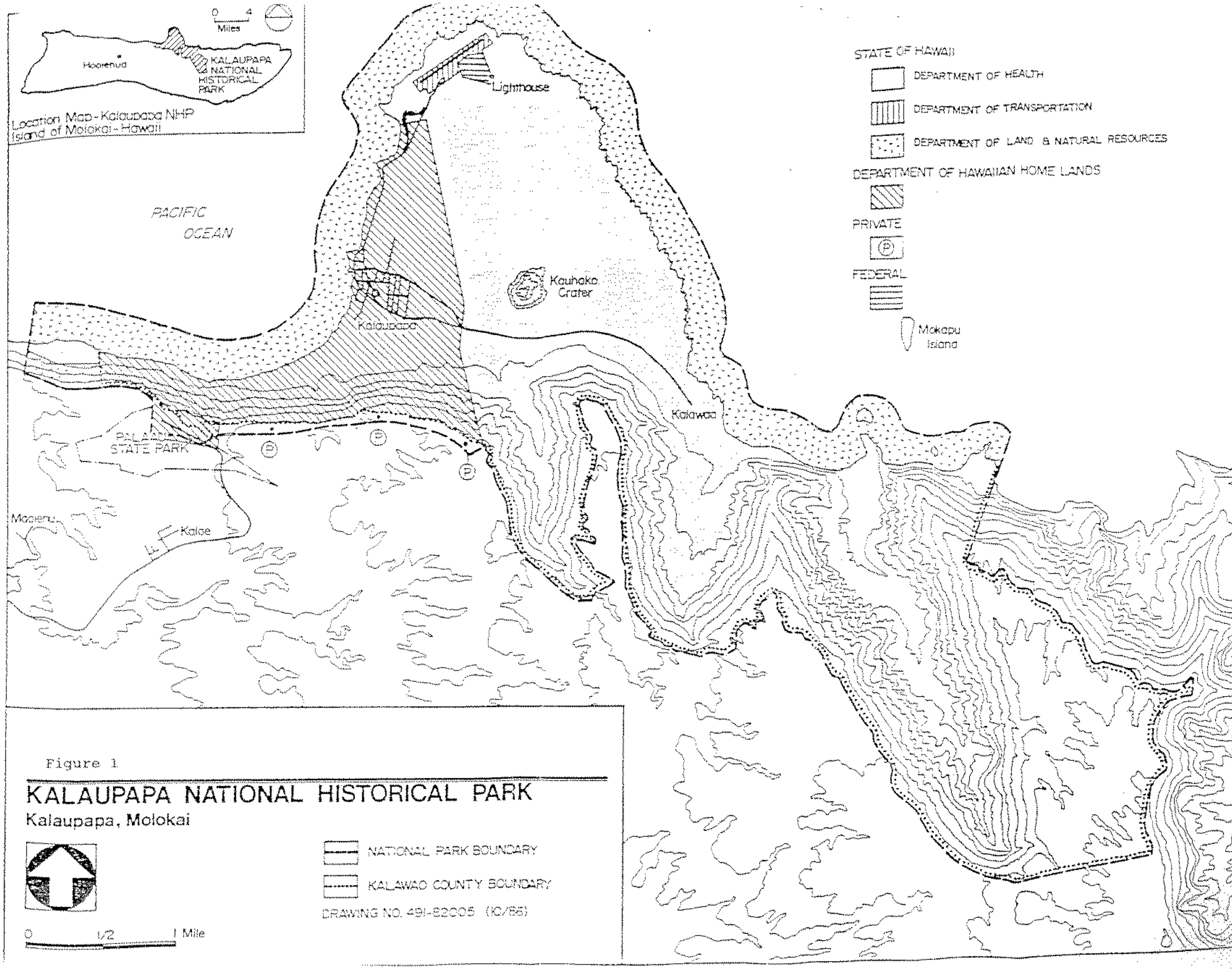

Figure 1

KALAUPAPA NATIONAL HISTORICAL PARK
Kalaupapa, Molokai

Table 1

SUMMARY OF STATE OF HAWAII AND NATIONAL AMBIENT AIR QUALITY STANDARDS (AAQS)

Pollutant (units)	Averaging Time	Maximum Allowable Concentration		
		National Primary	National Secondary	State of Hawaii
Suspended Particulate Matter (ug/m^3)	Annual	-	-	60[a]
	24 Hours	-	-	150[b]
Particulate Matter[c] (ug/m^3)	Annual	50	50	-
	24 Hours	150[b]	150[b]	-
Sulfur Dioxide (ug/m^3)	Annual	80	-	80
	24 Hours	365[b]	-	365[b]
	3 Hours	-	1300[b]	1300[b]
Nitrogen Dioxide (ug/m^3)	Annual	100	100	70
Carbon Monoxide (mg/m^3)	8 Hours	10[b]	-	5[b]
	1 Hour	40[b]	-	10[b]
Ozone (ug/m^3)	1 Hour	235[b]	235[b]	100[b]
Lead (ug/m^3)	Calendar Quarter	1.5	1.5	1.5

[a]Geometric mean
[b]Not to be exceeded more than once per year
[c]Particles less than or equal to 10 microns aerodynamic diameter

Table 2

AIR POLLUTION EMISSIONS INVENTORY FOR
KALAUPAPA AIRPORT MASTER PLAN (TONS/YR)

Pollutant / Source	1988	Average Daily Visitors by Air: 50	100	200	300[a]
Carbon Monoxide/					
Aircraft	16.7	22.1	28.5	38.6	52.2
Automobiles	0.3	1.0	1.7	3.3	4.8
Total	17.0	23.1	30.2	41.9	57.0
Nitrogen Oxides/					
Aircraft	1.9	2.5	3.1	4.1	5.5
Automobiles	nil	0.1	0.2	0.3	0.5
Total	1.9	2.6	3.3	4.4	6.0
Hydrocarbons/					
Aircraft	8.9	12.7	16.6	23.0	32.0
Automobiles	nil	0.1	0.2	0.4	0.7
Total	8.9	12.8	16.8	23.4	32.7
Sulfur Oxides/					
Aircraft	0.3	0.5	0.6	0.8	1.2
Automobiles	nil	nil	nil	nil	nil
Total	0.3	0.5	0.6	0.8	1.2
Total Suspended Particulate/					
Aircraft	nil	nil	nil	nil	nil
Automobiles[b]	0.4	1.2	2.1	4.1	5.9
Total	0.4	1.2	2.1	4.1	5.9
Particulate Matter (<10 um)/					
Aircraft	nil	nil	nil	nil	nil
Automobiles[b]	0.1	0.4	0.7	1.4	2.0
Total	0.1	0.4	0.7	1.4	2.0

[a]Assuming 100 percent of passengers on commuter aircraft (e.g., Cessna 402, DHC-6)

[b]Fugitive dust

Table 3

SIGNIFICANT AIR POLLUTION EMISSION RATES

Air Pollutant	Significant Emission Rate (tons/year)
Carbon Monoxide	100
Nitrogen Oxides	40
Volatile Organic Compounds	40
Sulfur Dioxide	40
Particulate Matter	25

Source: Hawaii Administrative Rules, Title 11, Department of Health, Chapter 60, Air Pollution Control

APPENDIX E

APPENDIX E

NOISE MEASUREMENT AND IMPACT ASSESSMENT, KALAUPAPA, MOLOKAI, HAWAII

DARBY
& ASSOCIATES
ACOUSTICAL CONSULTANTS

RECEIVED
FEB - 8 1989
EDWARD K. NODA & ASSOCIATES

Project No. 88-35
February 3, 1989

EDWARD K. NODA & ASSOCIATES
615 Piikoi Street, Suite 1000
Honolulu, Hawaii 96814

Attention: Mr. James Dittmar

Subject: Noise Measurement and Impact Assessment, Kalaupapa, Molokai, Hawaii

Dear Mr. Dittmar:

Noise measurements of aircraft operations at Kalaupapa Airport and in the vicinity on Kalaupapa Peninsula have been obtained and analyses have been performed to assess the acoustical environment at the site. The following provides the result of this study:

A. EXISTING ACOUSTICAL ENVIRONMENT (NON-AIRCRAFT NOISE) -

The residents of Kalaupapa currently experience sound primarily generated by surf, wind in foliage, and birds. Traffic movements within the town are limited with low speed and therefore do not contribute significantly to the overall noise level (Figure 1 provides an overview of Kalaupapa Peninsula.) A-weighted sound levels associated with the above activities were measured during the daytime and the results are summarized in Table 1 (page 2) [refer to Appendix I for an explanation of a A-weighted sound level.]

An ambient sound measurement for a period of twenty-four hours was obtained at Wilcox House within the town and the

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Table 1. Summary of Ambient Acoustical Environment Measurements, Kalaupapa, Molokai

POSITION NUMBER *	SOUND SOURCE	A-WEIGHTED SOUND LEVEL	WIND CONDITION
5	wind in foliage, surf, birds	50 - 64 dB(A)	NE,15-20 knots
5	wind in foliage, surf, birds	40 - 58	NE, 1-5 knots
6	wind in foliage, birds	34 - 44	NE, 1-5 knots
7	wind in foliage, birds	34 - 44	NE, 1-5 knots
8	wind in foliage, birds	34 - 46	NE, 1-5 knots
8	distant auto	48 - 56	NE, 1-5 knots
9	wind in foliage, birds	40 - 48	NE, 1-5 knots

* -- Refer to Figure 2 for the location of the measurement positions.

result indicates a Day-Night Average Sound Level (Ldn) of 64.8 dB (refer to Appendix II for a description of Ldn measure of sound exposure.) Sheet 1 of Appendix III provides a complete listing of the hourly noise level data obtained. It should be noted that during the afternoon of the twenty-four hour measurement period, a heavy wind condition was experienced with speeds ranging from 15 to 20 knots. This condition caused high wind-in-foliage and surf noise levels. Although the measured Ldn is considered high, the sound being experienced is not expected to be annoying since it is generated primarily by natural conditions. Moreover, this high Ldn level should mask types of noise that may be annoying such as aircraft operations, and therefore, it should keep the existing acoustical environment less intrusive from such sources. Ambient measurements at octave band frequencies were also obtained at the above locations. The results of these measurements are presented in Figure 3.

Noise sensitive areas located outside of the town of Kalaupapa are beach cottages along the western and the eastern coastlines, structures near the lighthouse which are possible residential, and St. Philomena (Father Damien's) Church and Siloama Church at Kalawao. The ambient acoustical environments in the vicinity of the beach cottages and the possible residences near the airport are dominated by the surf sound with A-weighted sound levels ranging from about 47 to 52 dB(A). Sound generated by wind in foliage and birds is minimal at these locations due to the lack of trees. The churches at Kalawao are currently experiencing the ambient sound dominated by wind in foliage and birds. Surf sound does not contribute significantly to the ambient due to the distances involved (about 1200 feet to the nearest coastline.)

B. AIRCRAFT NOISE -- Aircraft noise events currently being experienced at Kalaupapa Peninsula are: flight operations at Kalaupapa Airport and other aircraft flights over, or near, the peninsula. Extensive noise measurements of these activities have been performed over a three-day period, and the results are presented separately below:

1. Flight Operations at Kalaupapa -- There are currently four scheduled flights landing and departing at Kalaupapa Airport per day. Air Molokai and Aloha Island Air service the airport with two flights per day for each airline. However, it was observed that Air Molokai at times uses more than one plane for a scheduled flight. In addition, there are unscheduled flights such as air-mail, freight, and pilot training operations at the airport. These unscheduled flights averaged about 1 to 4 per day during the three day measurement period. In all, there were typically about 5 to 8 flights landing and departing at Kalaupapa Airport. Table 2 (page 5) provides the type of aircraft involved in each of the above operations.

   Sound Exposure Level (SEL) and Maximum Level (Lmax) for aircraft operation were measured at the six different positions shown in Figure 2A. A summary of the averaged and the range of these values for each type of aircraft and operation is presented in Table 3 (page 6.) Appendix III provides the complete measurement data.

Table 2. Summary of Type of Aircraft Used in Various Aircraft Operations at Kalaupapa Airport During the Measurement Period

ACTIVITY	AIRCRAFT TYPE
Air Molokai, passenger	Cessna 402
Aloha Island Air, passenger	DH-6
Air-mail	Cessna 402
Freight	Single prop.
Pilot training	Single prop.

In addition to the above, octave band frequency measurements of the Cessna 402 and DH-6 landing and departing were obtained. These data are then plotted against the ambient levels to present intrusiveness of aircraft noise at each octave band frequency. The results are shown in Figure 4.

As can be seen in Table 3 and Figure 4, the aircraft operations at Kalaupapa Airport generate significant levels of noise at locations in the vicinity

Table 3. Summary of the Results of the Noise Measurements of Aircraft Operations at Kalaupapa Airport.

AIRCRAFT TYPE	FLIGHT PATTERN	MEASMT * POS. NO.		SEL dB(A)	Lmax dB(A)	NO. OF SAMPLES
Cessna 402	takeoff	2	aver:	94.4	90.9	10
			high:	95.9	92.8	
			low :	92.1	89.0	
Cessna 402	takeoff	4	aver:	82.7	76.7	9
			high:	85.3	79.5	
			low :	77.4	71.8	
Cessna 402	takeoff	11		96.2	87.8	1
Cessna 402	landing	1		75.8	70.0	1
Cessna 402	landing	3	aver:	85.5	79.8	8
			high:	88.0	82.8	
			low :	78.3	71.8	
DH-6	takeoff	2	aver:	98.0	94.2	5
			high:	100.3	97.0	
			low :	96.1	90.5	
DH-6	takeoff	4	aver:	90.5	84.1	4
			high:	91.4	84.3	
			low :	89.4	83.5	
DH-6	landing	1		75.6	68.8	1
DH-6	landing	3	aver:	84.7	77.8	3
			high:	85.3	78.8	
			low :	84.1	77.0	
DH-6	landing	10		92.8	85.0	1
Single Prop.	takeoff	2	aver:	88.6	84.4	4
			high:	90.1	86.0	
			low :	85.0	79.8	

* -- Refer to Figure 2 for the location of the measurement positions.

of the airport with A-weighted and octave band levels increasing by as much as 40 dB(A) and 50 dB, respectively. Two aircraft landings at the airport were observed at a location within the town and they were both inaudible. No aircraft takeoffs at the airport were observed from the town.

During a conversation with residents at Kalaupapa, they indicated that military helicopters periodically conduct night-time exercises at Kalaupapa Airport during the late-night and early-morning hours. According to these residents, the exercises occur roughly one night per week and include low-level flying activities over the town. Some of the residents expressed their annoyance due to noise generated by these exercises. No such activities were observed during our stay at Kalaupapa.

2. Aircraft Flyovers Experienced in Kalaupapa Peninsula -- During the three-day measurement period, about thirty to forty audible aircraft flyovers were experienced at the Kalaupapa Peninsula. The flyovers were either directly over the peninsula or over the ocean as shown in Figure 5. Occasional commercial helicopters circling the peninsula and several military helicopter overflights were also observed. The overflights by

civilian aircraft consisted of DH-6, DH-7, Cessna 402, miscellaneous single and twin propeller general aviation aircraft, DC-9, and Boeing 737.

Attempts were made to measure SEL and Lmax of these flyovers at locations within the town and in the vicinity of the airport. However, due to low signal to noise ratio for the majority of the flyovers, only Lmax and few SEL measurements were successful. A summary of the successful SEL and Lmax measurements is presented in Table 4 (page 9.)

Overall, aircraft flyovers are not considered to have a significant impact at Kalaupapa Peninsula since majority of the flyovers generate Lmax that are no greater than the ambient levels. However, in National Parks and Forests, there are sometimes complaints about aircraft noise event intrusiveness even though the maximum dB(A) [Lmax] level associated with the event may be barely greater, or less than, the dB(A) ambient level. This situation can be visualized in Figure 4G where the octave band noise levels from a Cessna 402 flyover causing an Lmax of 55.1 dB(A) are superimposed on the ambient noise octave band levels (causing 60.6 dB[A]) obtained at Position 5. From the figure it can be seen that, though the aircraft noise event had an

Table 4. Summary of the Results of the Measurable Aircraft Flyovers at Kalaupapa Peninsula,

AIRCRAFT TYPE	FLIGHT * PATTERN	MEASMT ** POS. NO.	SEL dB(A)	Lmax dB(A)	NO. OF SAMPLES
DH-6	OVER, C	2	65.7	56.0	1
DH-6	OVER, A	5	71.6	61.3	1
DH-7	OVER, B	2	64.0	54.0	1
DH-7	OVER, B	4	72.7	63.5	1
General Aviation	CIRCLING	4	68.0	62.0	1
General Aviation	OVER, C	4	59.0	59.0	1
General Aviation	OVER, D	5	75.1	66.3	1
Helicopter	CIRCLING	3	aver: 78.4 high: 81.6 low : 65.3	66.8 68.8 55.8	3
Helicopter	CIRCLING	4	80.8	66.7	1

* -- Refer to Figure 5 for the flight pattern description
** -- Refer to Figure 2 for the location of the measurement positions

Lmax of 5 dB(A) less than the ambient, the event was clearly audible by virtue of the 125 Hz and 250 Hz octave band levels being 10 dB or greater than corresponding ambient noise octave band levels.

Noisier overflights were observed on occasion. For example, as can be seen in Table 4, commercial helicopters circling the peninsula and general aviation aircraft (single and twin propeller) flyovers with a low altitude generated Lmax ranging from about 66 to 69 dB(A). These activities occurred about two to four times per day during our stay at Kalaupapa and may be a source of annoyance to some residents and visitors to Kalaupapa.

C. **SUMMARY** -- Ambient noise measurements at various locations within Kalaupapa Peninsula indicate that the existing acoustical environment is usually dominated by natural conditions such as wind in foliage, surf and birds. Artificial noise sources such as traffic are minimal throughout the peninsula.

Noise measurements of 36 aircraft operations at Kalaupapa Airport were obtained in the vicinity of the airport. A summary of the results including SEL and Lmax is provided in Table 3. The results indicate that the aircraft operations at the airport cause significant impact at locations in the vicinity of the airport. However, the aircraft operations have no significant impact at locations within the town of Kalaupapa.

Also measured were 37 aircraft flyovers at various noise sensitive locations throughout Kalaupapa Peninsula. Except for occasional low-level flying general aviation aircraft and helicopters circling the peninsula, the aircraft flyovers are not considered to have any significant impact at Kalaupapa Peninsula. A summary of the results is provided in Table 4.

Sincerely,

Prepared by

Mike S. Lee
Senior Consultant

Approved by

Ronald A. Darby, P.E.
President

RAD;MSL:msl

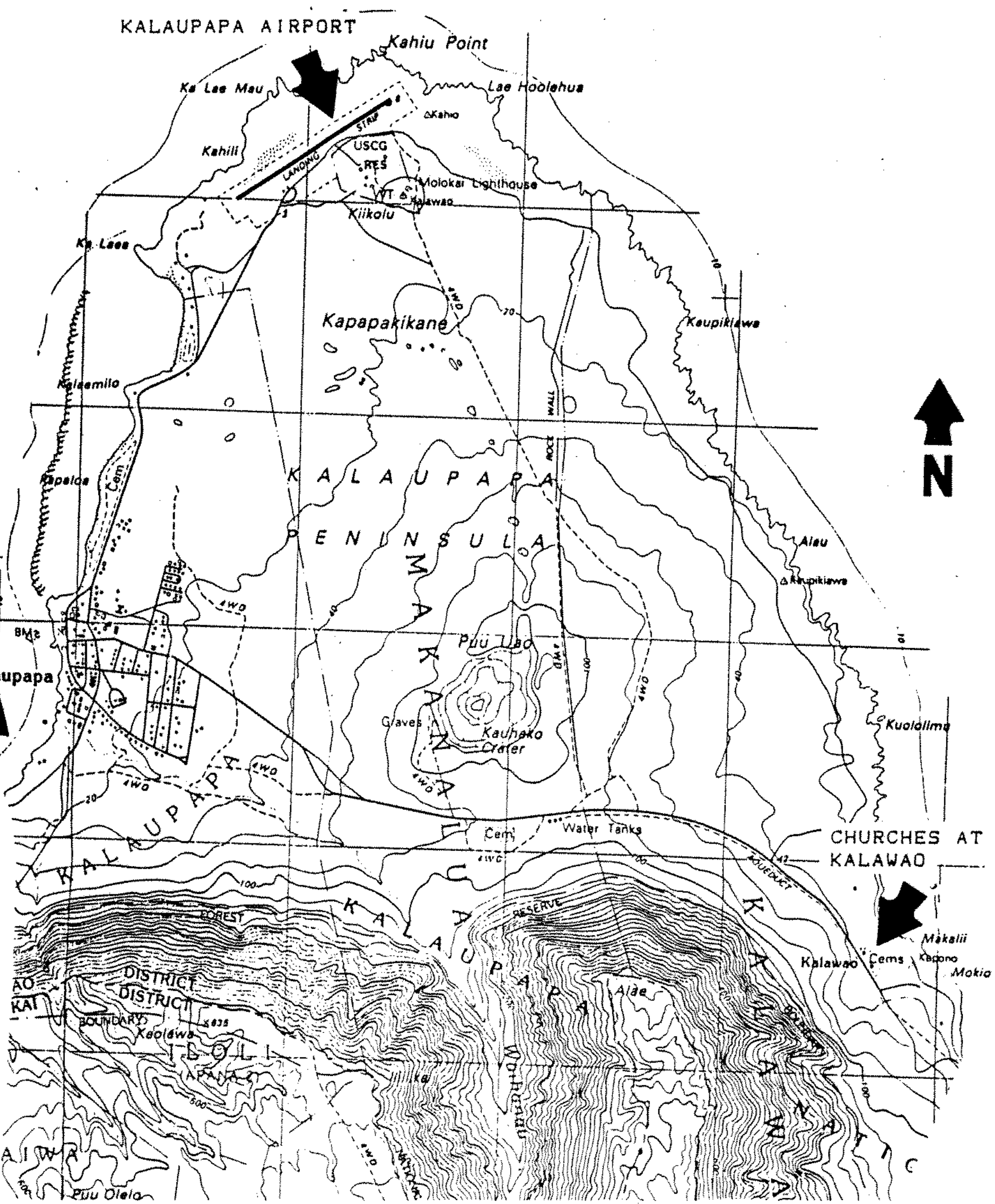

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FIGURE 1. LOCATION OF KALAUPAPA AIRPORT, TOWN OF KALAUPAPA AND KALAWAO

MAP NOT TO SCALE

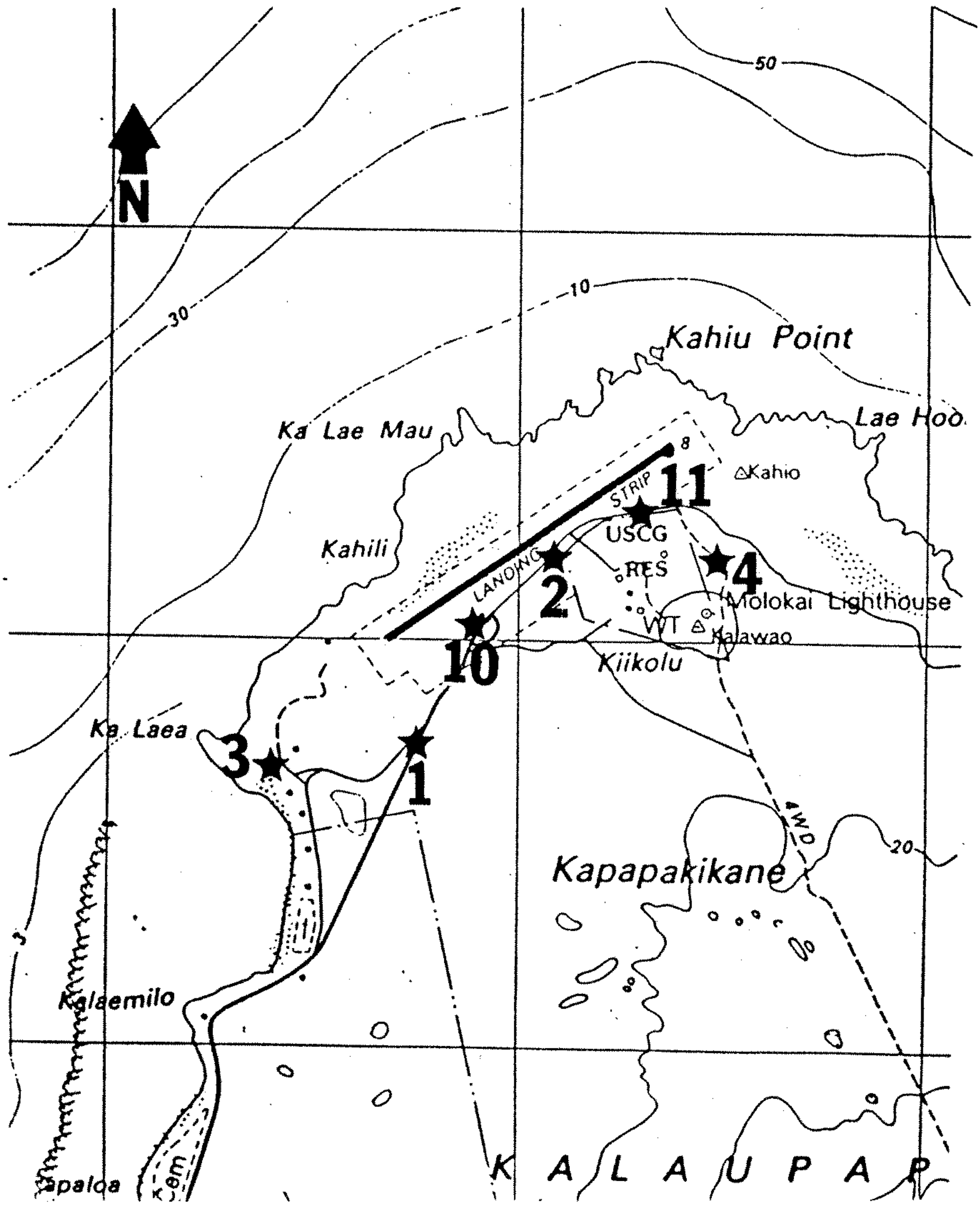

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FIGURE 2A. LOCATION OF MEASUREMENT POSITIONS IN THE VICINITY OF KALAUPAPA AIRPORT

MAP NOT TO SCALE

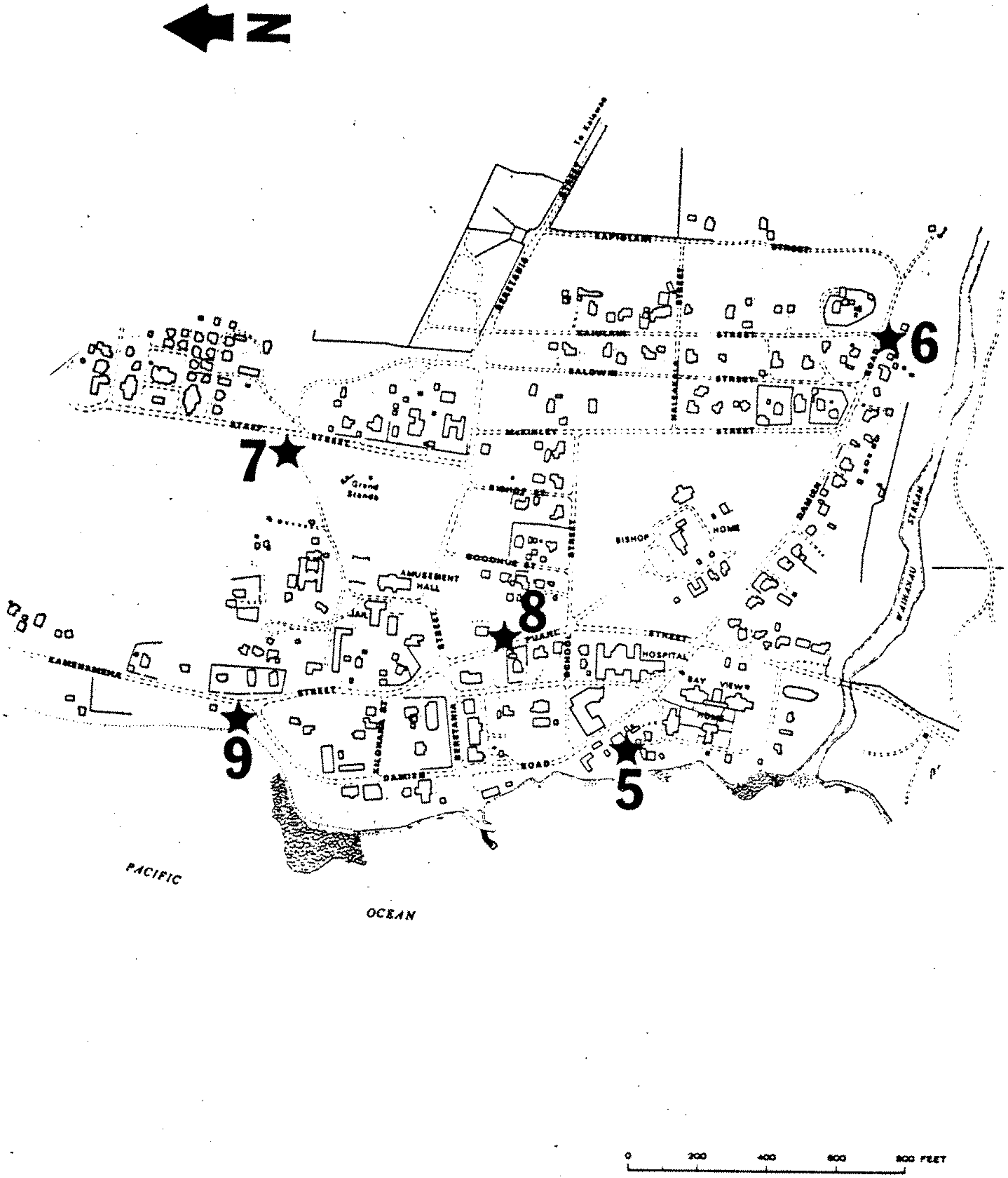

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FIGURE 2B. LOCATION OF MEASUREMENT POSITIONS WITHIN THE TOWN OF KALAUPAPA

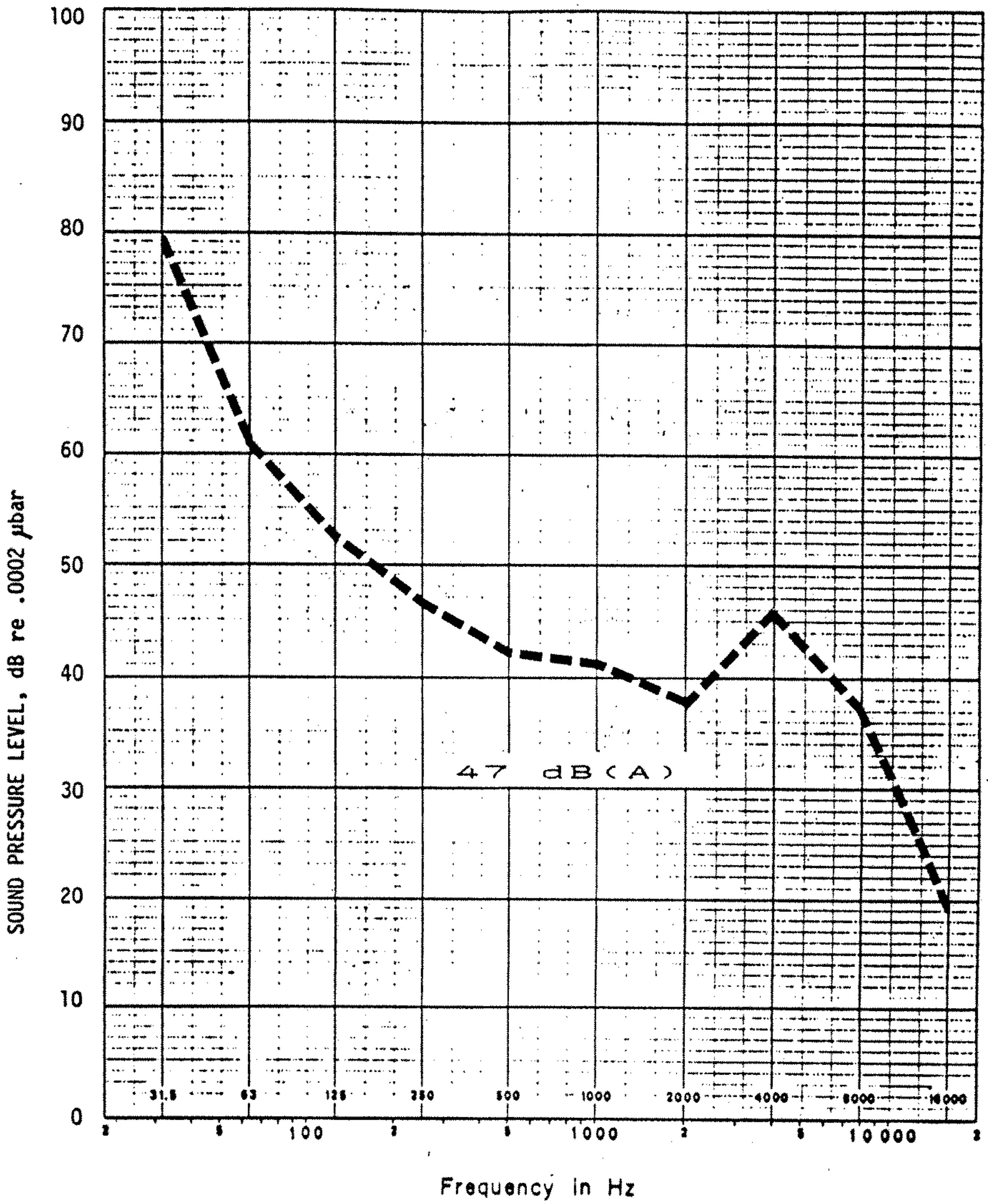

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FIGURE 3A. AMBIENT OCTAVE FREQUENCY MEASUREMENT
POSITION 5
WIND: NE, 5-10 KNOTS

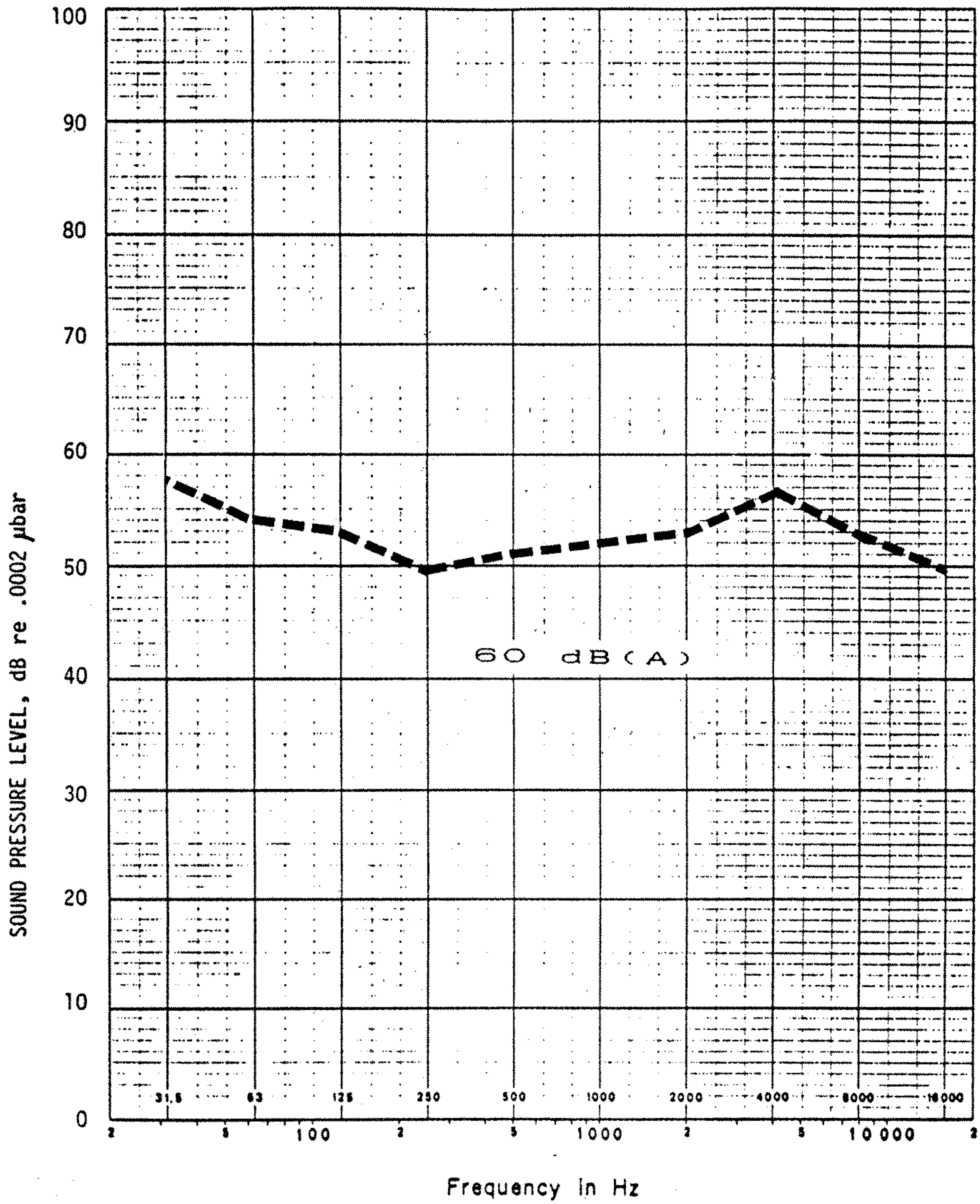

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FIGURE 3B. AMBIENT OCTAVE FREQUENCY MEASUREMENT POSITION 5 WIND: NE, 15-20 KNOTS

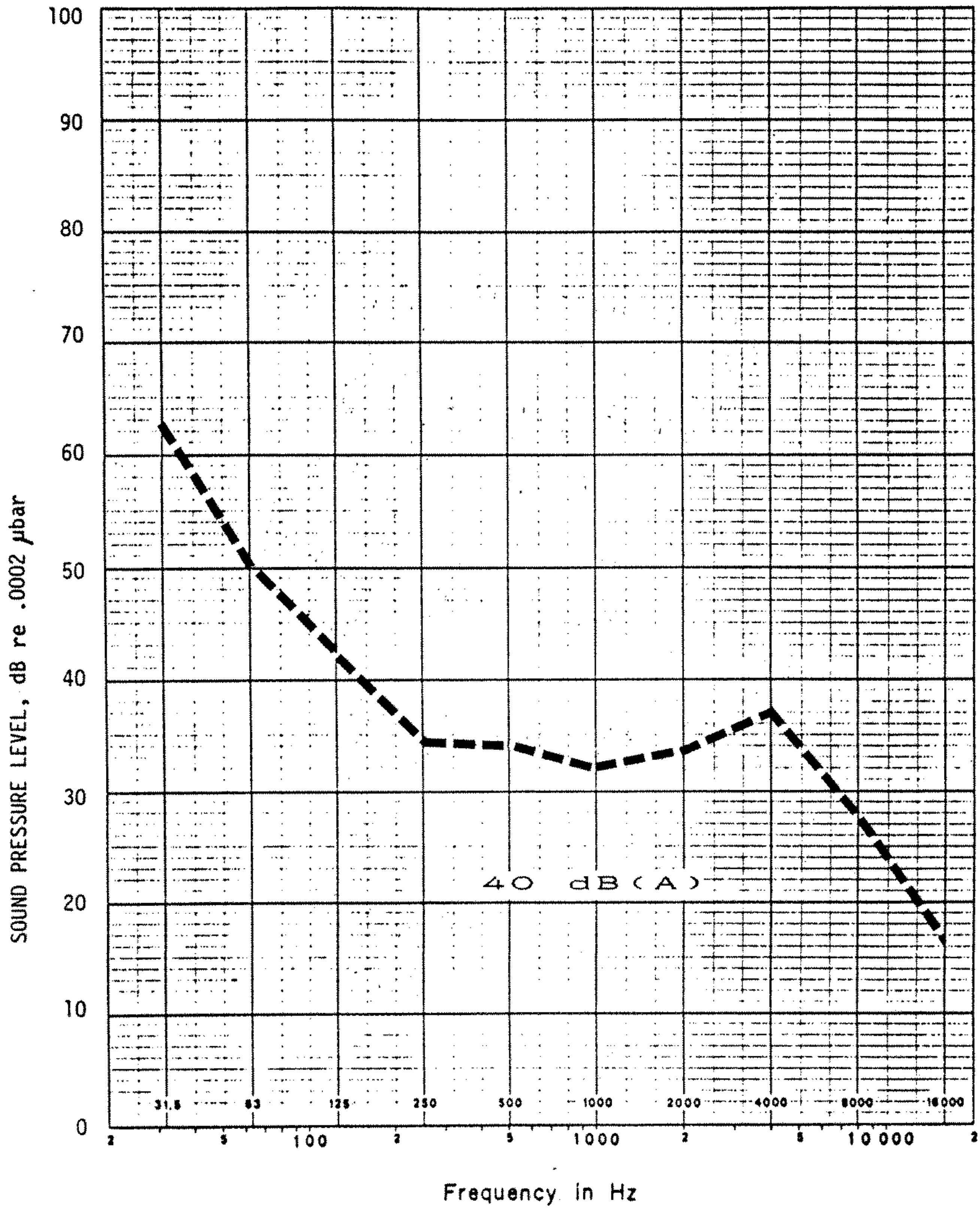

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FIGURE 3C. AMBIENT OCTAVE FREQUENCY MEASUREMENT
POSITION 6
WIND: NE, 5-10 KNOTS

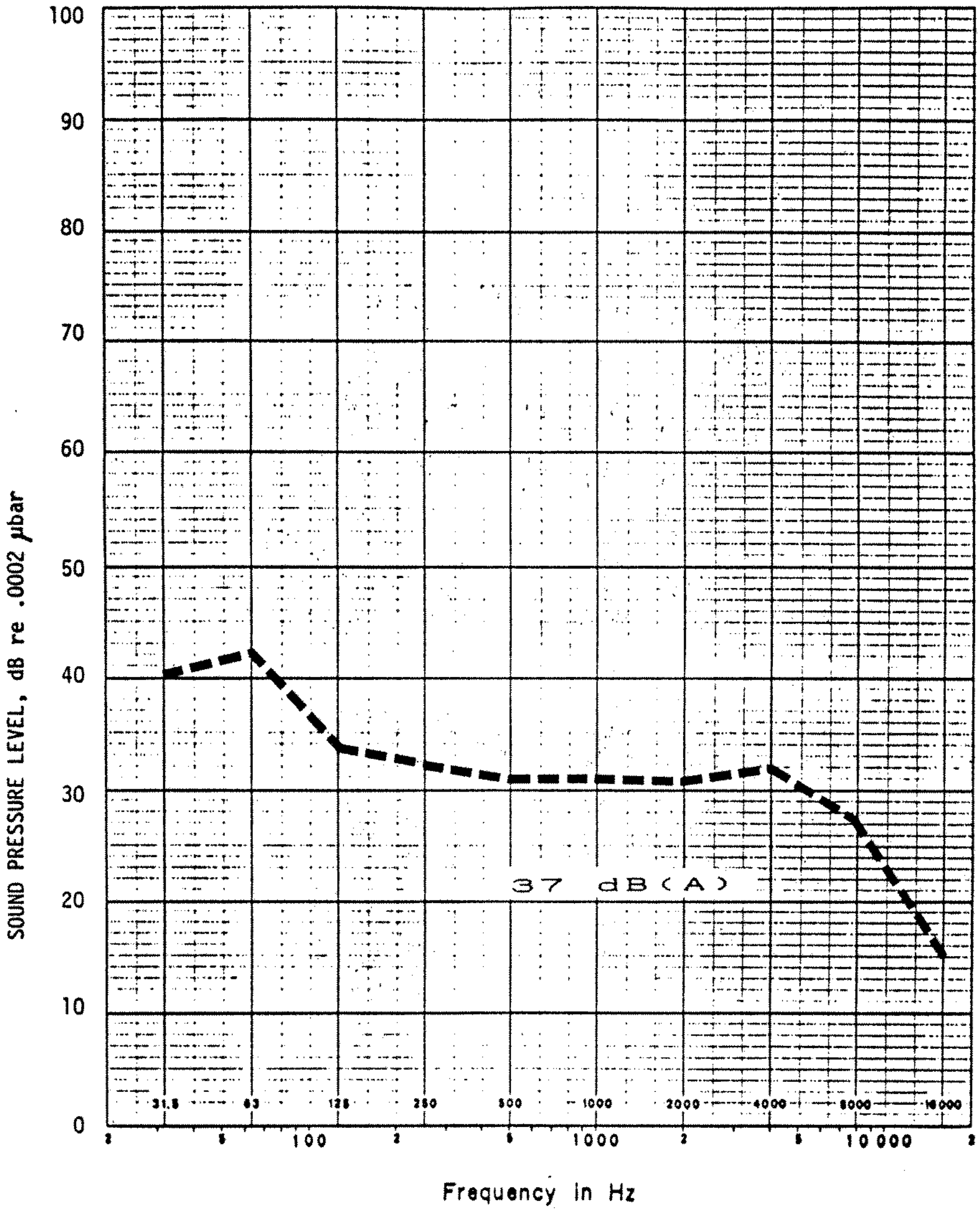

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FIGURE 3D. AMBIENT OCTAVE FREQUENCY MEASUREMENT
POSITION 7
WIND: NE, 5-10 KNOTS

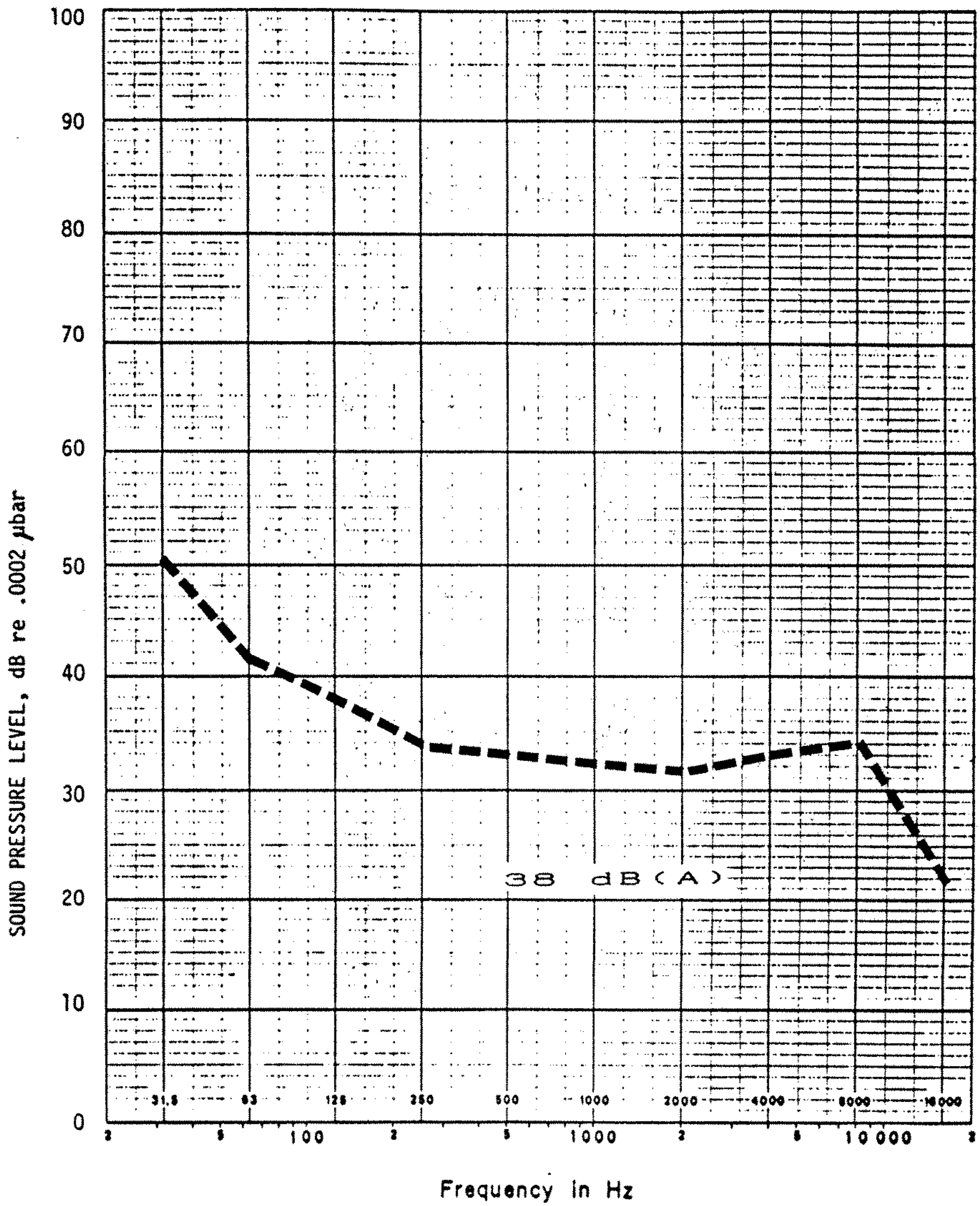

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FIGURE 3E. AMBIENT OCTAVE FREQUENCY MEASUREMENT
POSITION 8
WIND: NE, 5-10 KNOTS

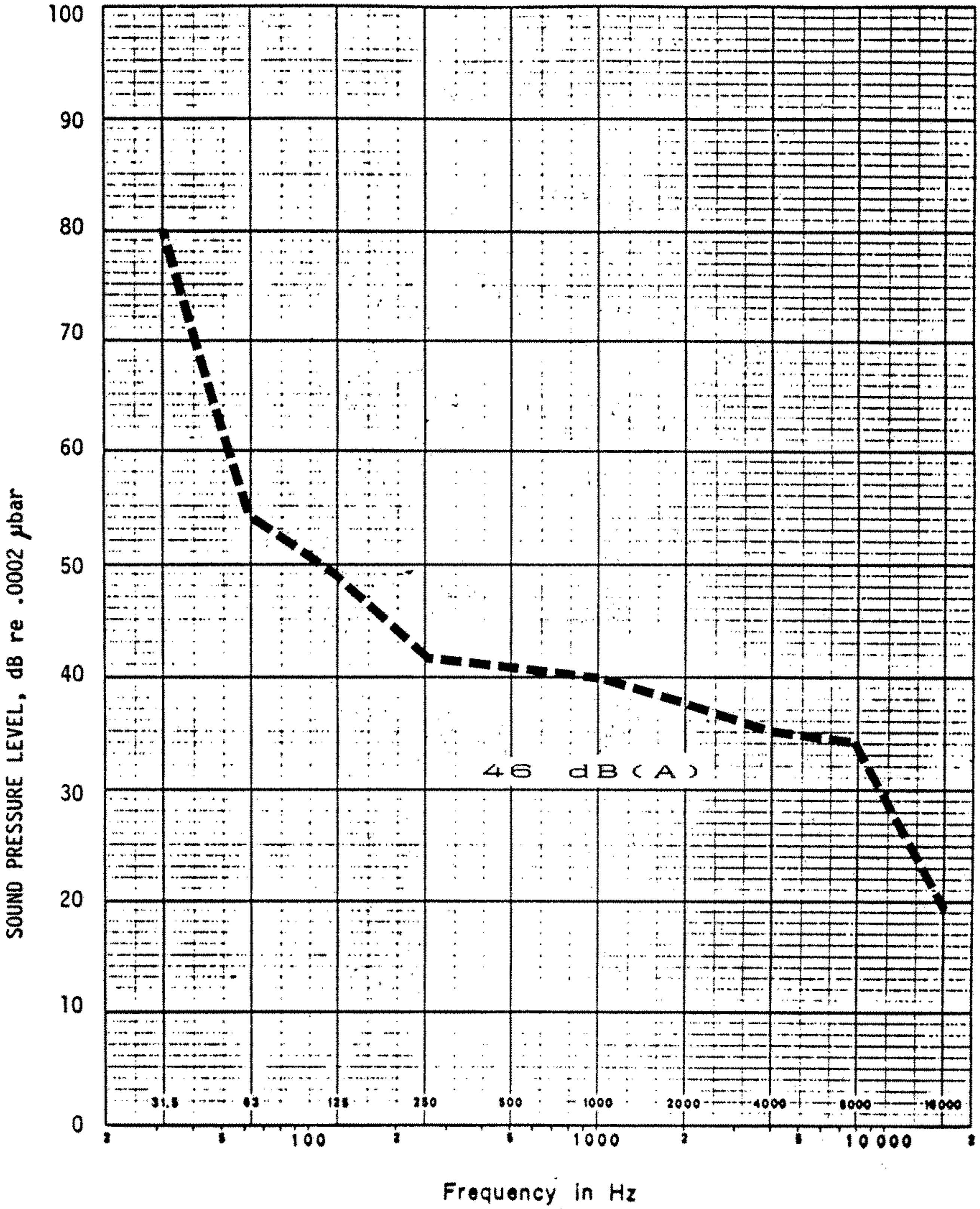

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FIGURE 3F. AMBIENT OCTAVE FREQUENCY MEASUREMENT
POSITION 9
WIND: NE, 5-10 KNOTS

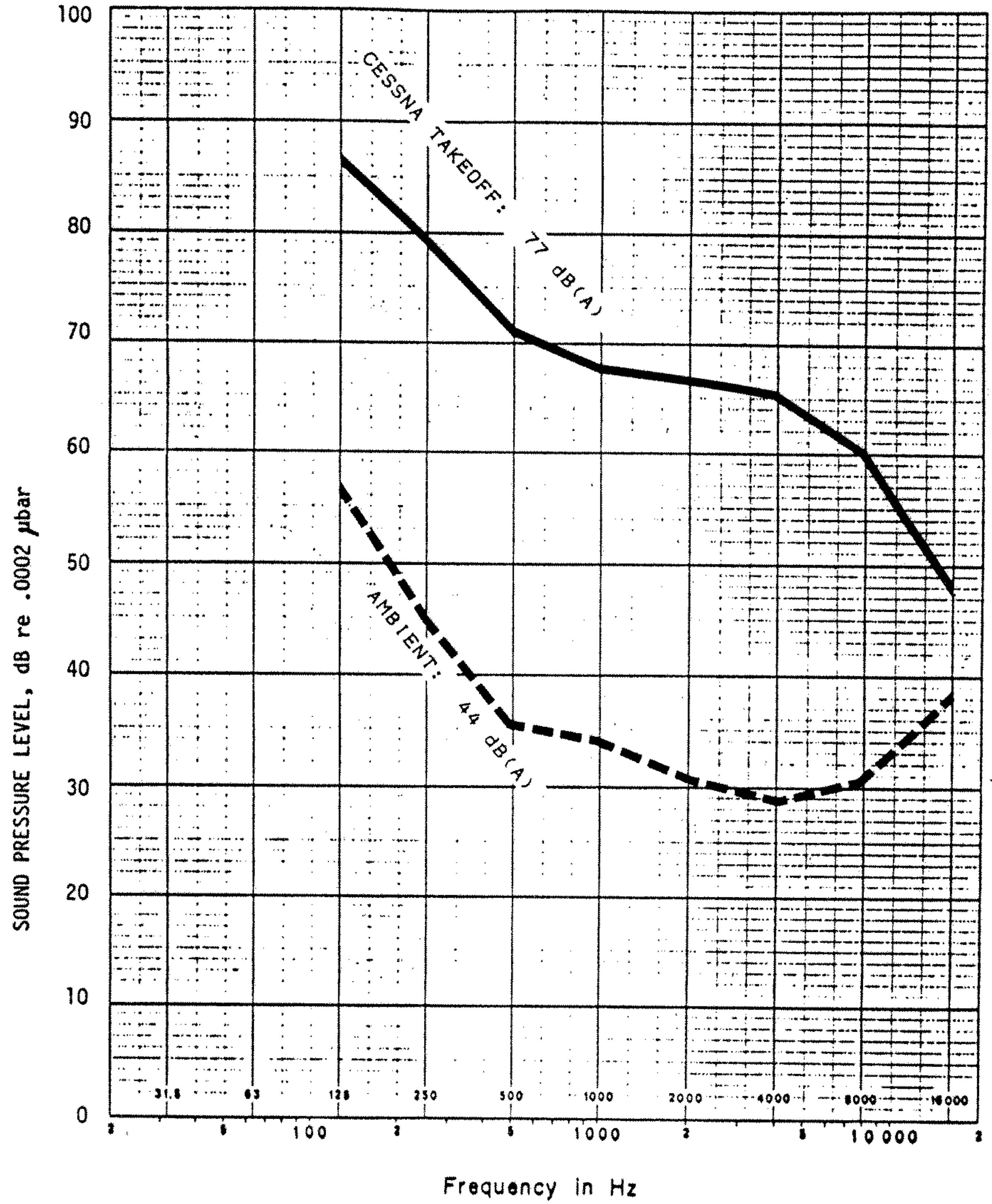

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FIGURE 4A. CESSNA 402 TAKEOFF AND AMBIENT OCTAVE FREQUENCY MEASUREMENT POSITION 2

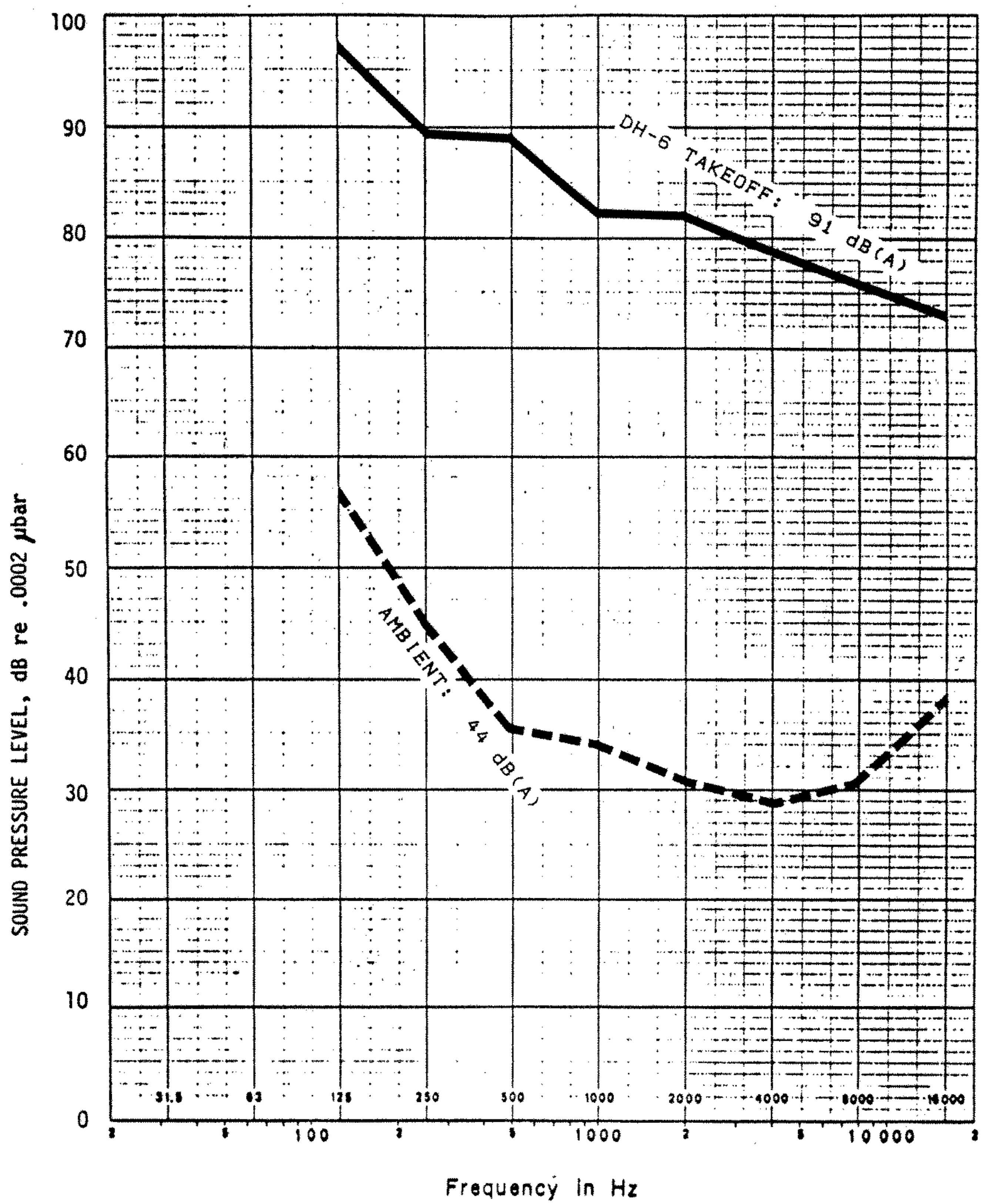

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FIGURE 4B. DH-6 TAKEOFF AND AMBIENT OCTAVE FREQUENCY MEASUREMENT POSITION 2

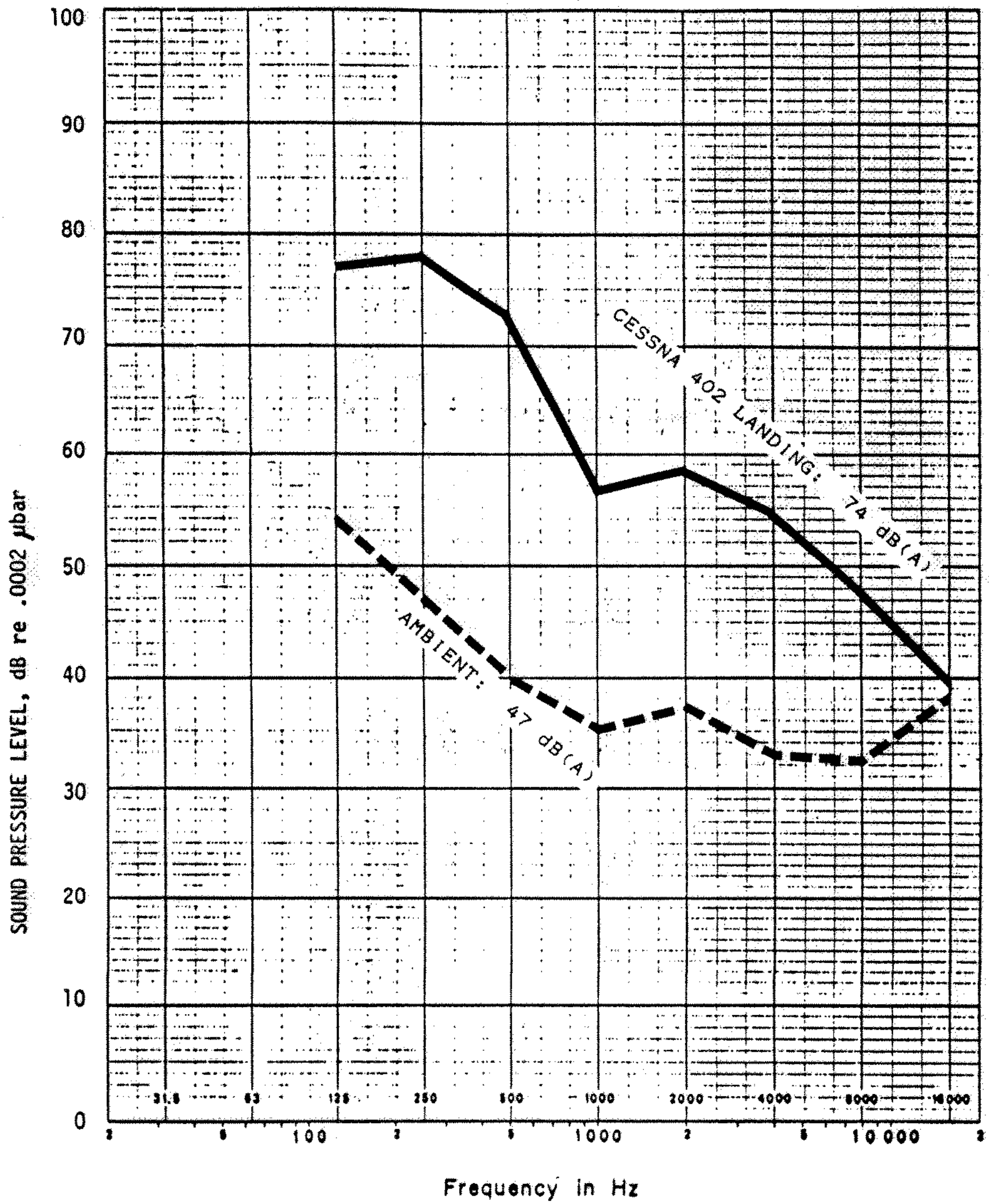

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FIGURE 4C. CESSNA 402 LANDING AND AMBIENT OCTAVE FREQUENCY MEASUREMENT POSITION 3

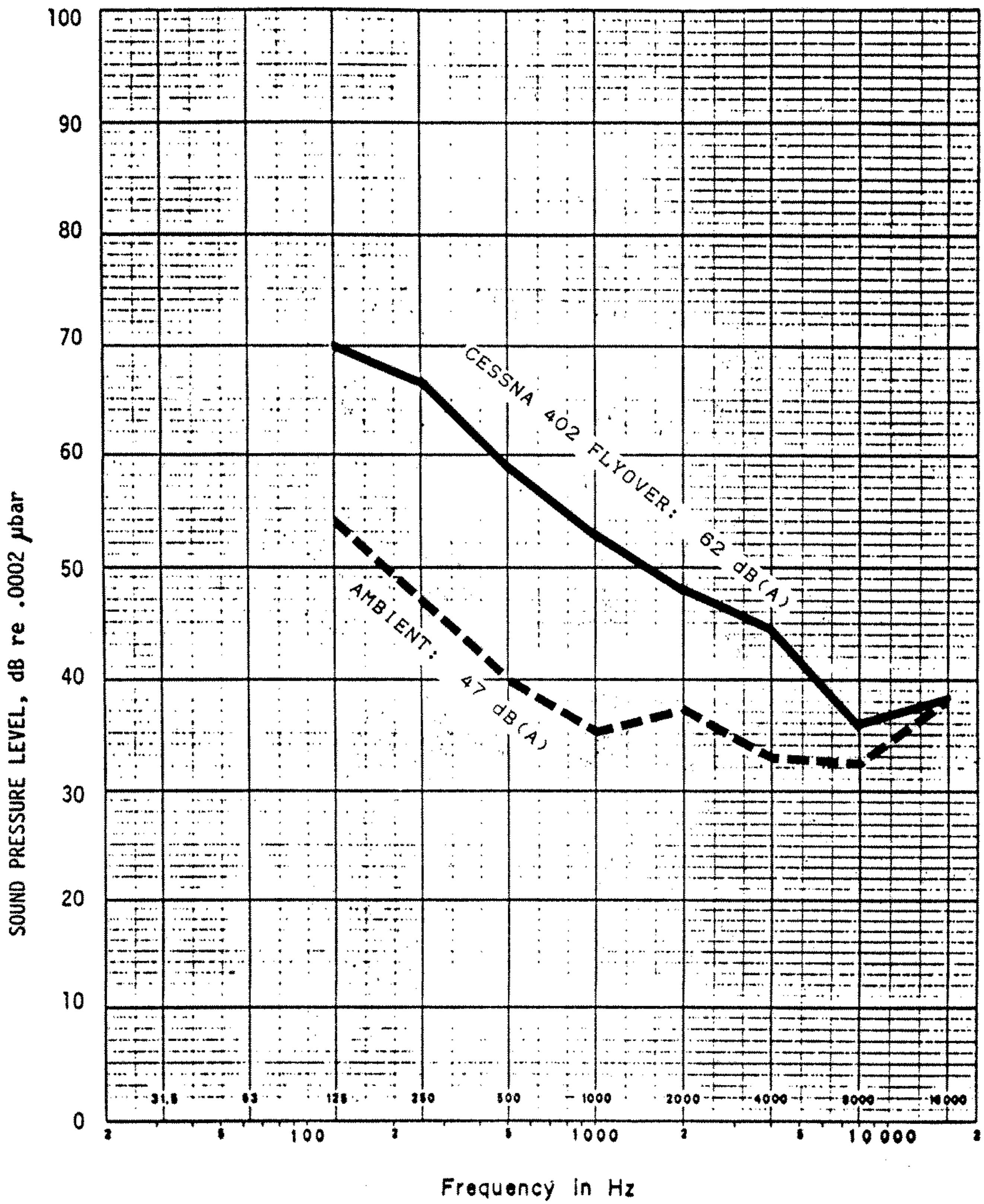

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FIGURE 4E. CESSNA 402 FLYOVER AND AMBIENT OCTAVE FREQUENCY MEASUREMENT POSITION 3

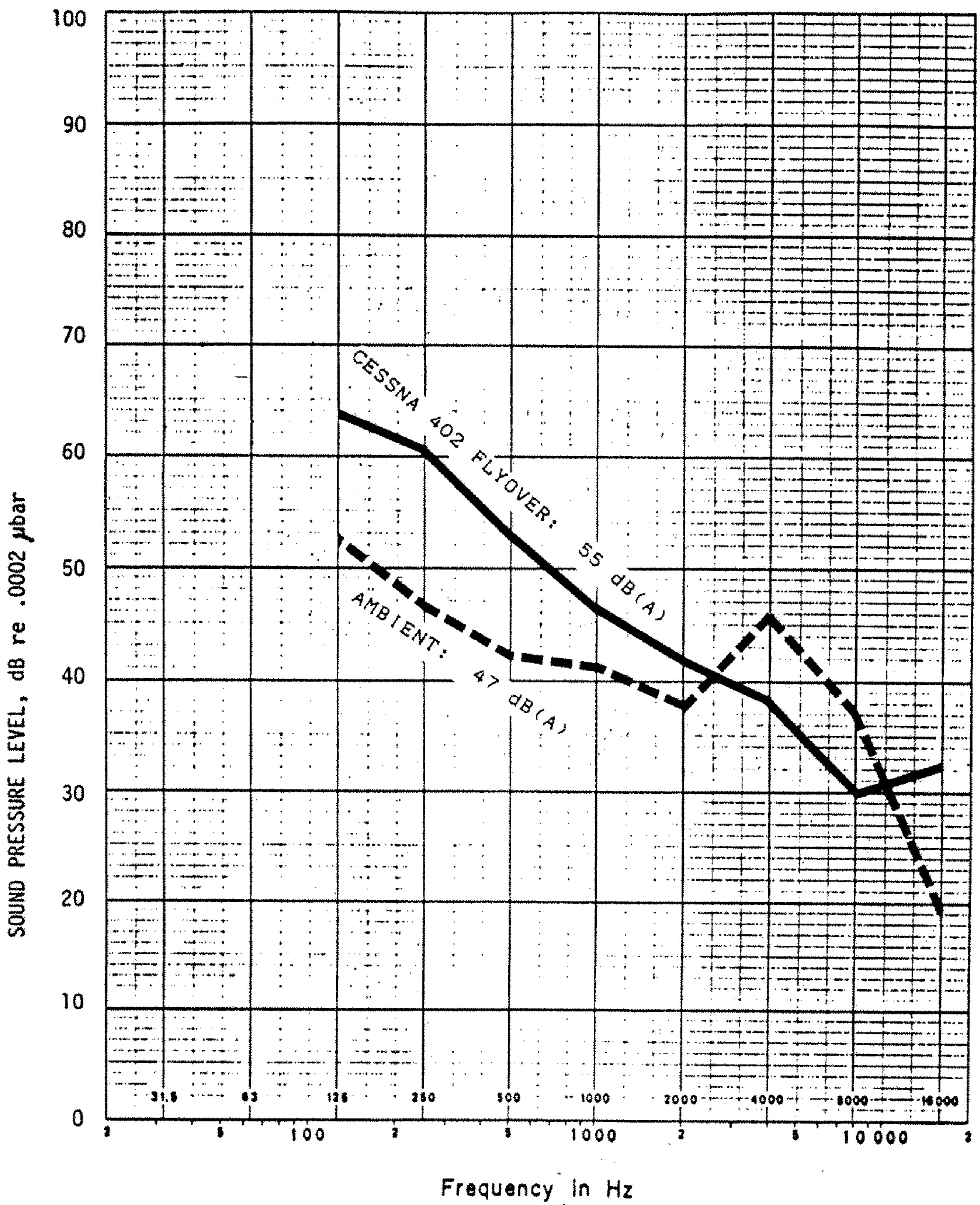

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FIGURE 4F. CESSNA 402 FLYOVER AND AMBIENT OCTAVE FREQUENCY MEASUREMENT POSITION 5, WIND 5-10 KNOTS

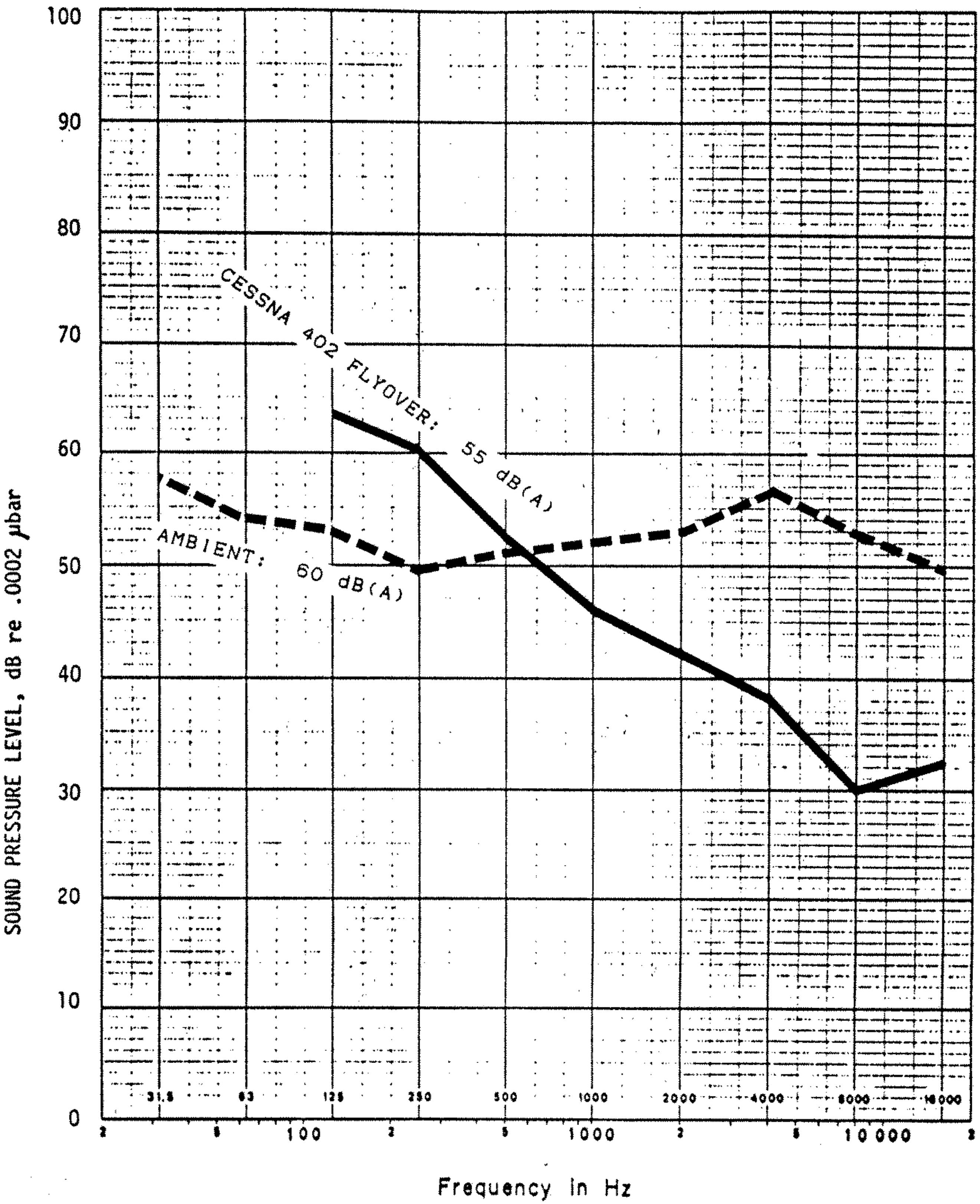

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FIGURE 4G. CESSNA 402 FLYOVER AND AMBIENT OCTAVE FREQUENCY MEASUREMENT POSITION 5, WIND 15-20 KNOTS

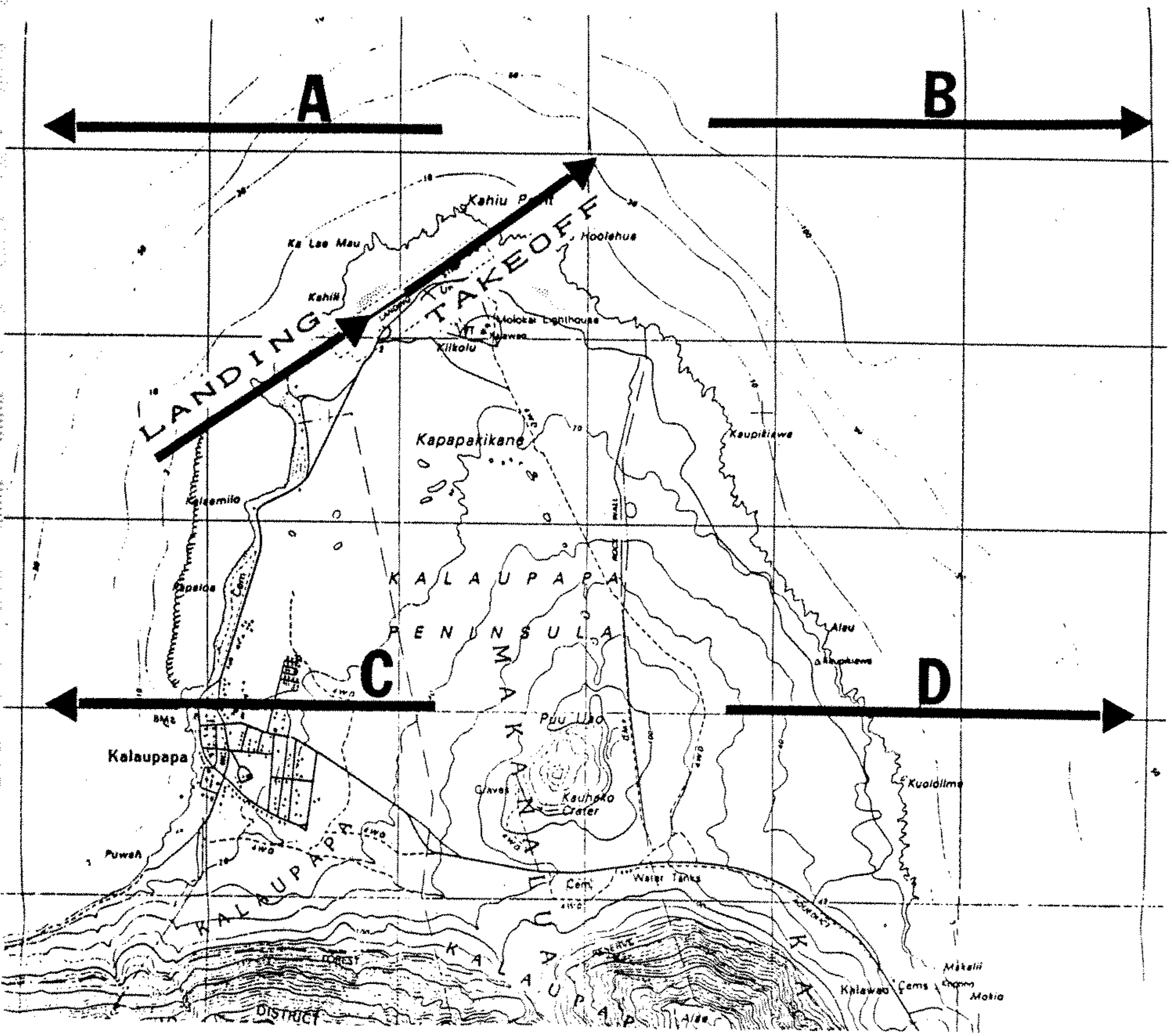

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FIGURE 5. DESCRIPTION OF AIRCRAFT LANDING AND TAKEOFF PATTERNS DURING TRADE WIND CONDITION AND OBSERVED AIRCRAFT FLYOVER PATTERNS

APPENDIX I

A-WEIGHTED SOUND LEVEL

The human ear is more sensitive to sound with frequencies above 1000 cycles per second, or Hertz (Hz), than with frequencies below 125 Hz. Due to this type of frequency response, a weighting system, namely a A-weighting , was developed to approximate the sound response of the human ear. A-weighted sound level is a single number rating of a sound signal which de-emphasizes the low frequency portion of the spectrum of a signal, and is denoted either dB(A) or dBA. The A-weighted sound pressure levels of a few typical sources are listed in Figure I-1.

The A-weighted sound levels of long term noise producing activities such as traffic movement, aircraft operations, etc. can vary considerably with time. In order to obtain a single number rating of such a signal, several special noise indices have been developed and instrumentation are available to measure them. The following are two of commonly used noise indices:

* **Leq** -- <u>The Equivalent A-weighted sound level (the energy averaged level)</u>
  A single number rating which represents the fluctuating sound signal measured over a given time period as a constant level with the same amount of the total acoustic energy during that period (refer to Figure I-2). In this report, Leq assume a measurement period of one hour. This number is widely used to assess community noise annoyance and hearing damage potential.

* **Ln** -- <u>The A-weighted exceedence level</u>
  A single number rating which represents a A-weighted sound level that is exceeded for n% of total samples taken. For example, an L10 of 60 dB(A) for a traffic noise measurement for 20 minutes would mean that 10 percent of all the noise signals measured during the 20 minute period exceeded 60 dB(A). Note that 'n' can take any values (usually integers) between 1 and 99, where L1 and L99 represent the near maximum and the near minimum sound levels, respectively. This number is primarily used to assess community noise annoyance.

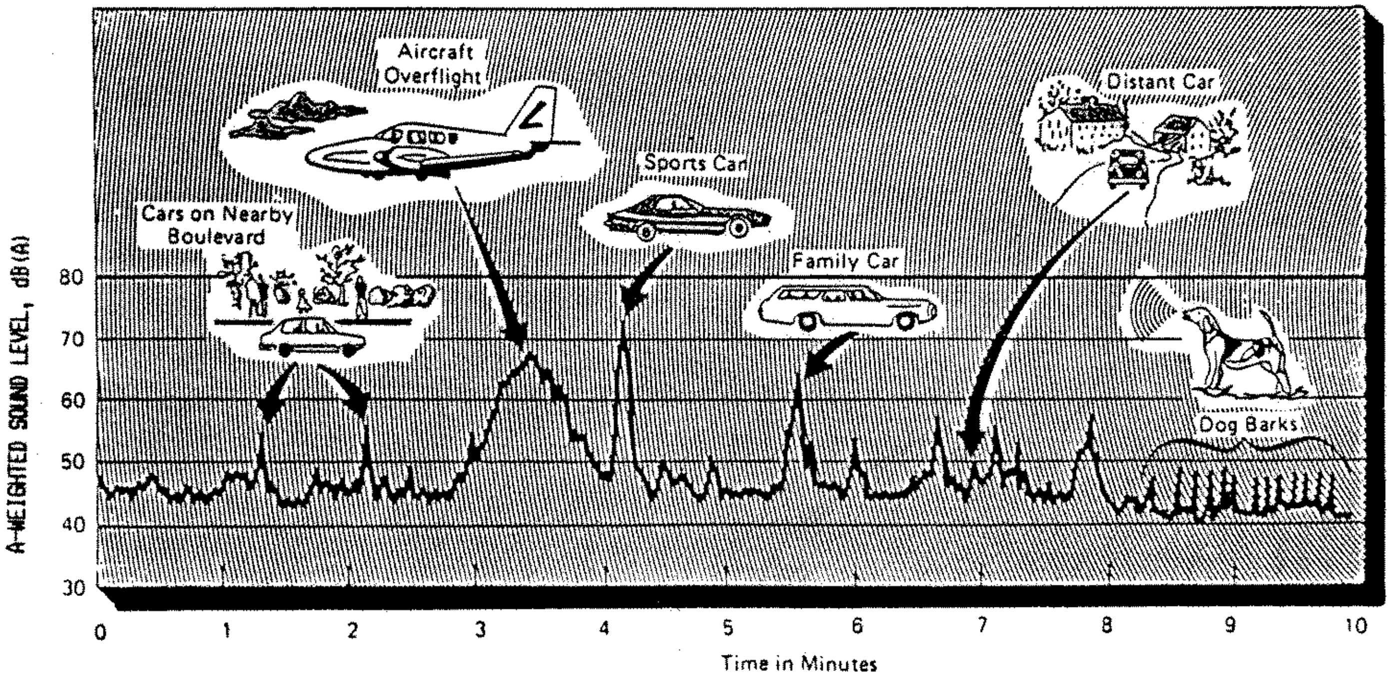

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FIGURE I-1. TYPICAL OUTDOOR A-WEIGHTED SOUND LEVELS MEASURED ON A QUIET SUBURBAN STREET

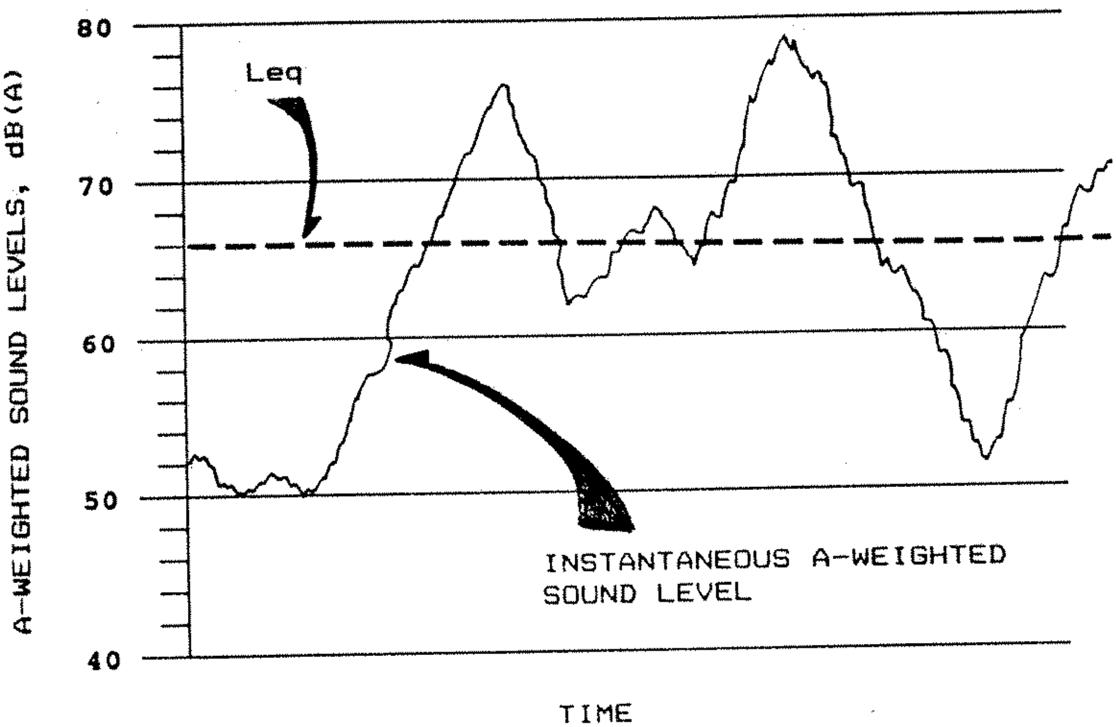

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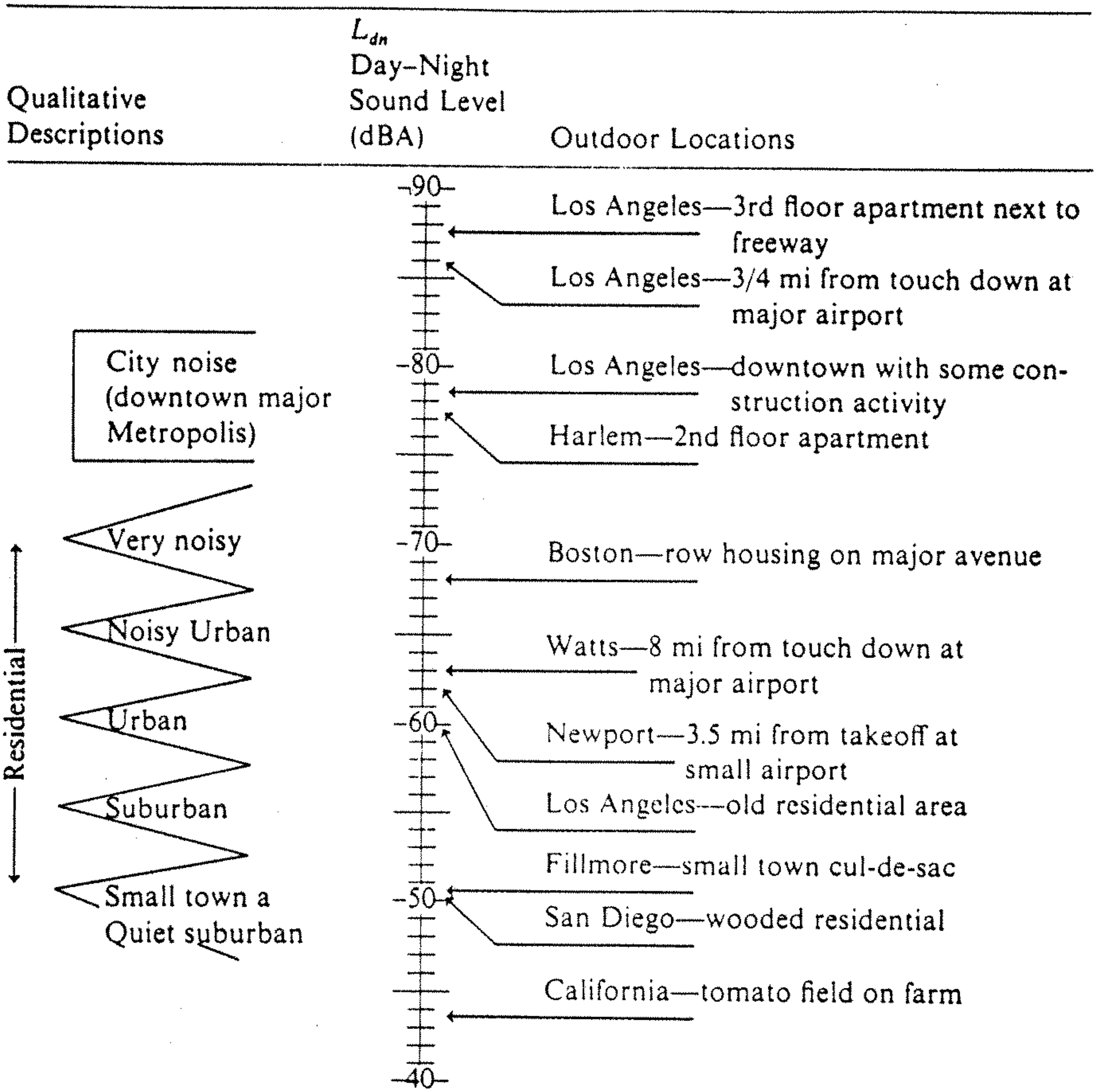
FIGURE I-2. COMPARISON OF THE INSTANTANEOUS A-WEIGHTED SOUND LEVELS AND THE Leq

APPENDIX II

DAY-NIGHT AVERAGE SOUND LEVEL

It is recognized that a given level of noise may be more or less tolerable, depending on the duration of exposure experienced by an individual. There are numerous measures of noise exposure which consider not only the A-weighted sound level variation of noise but also include the duration of the disturbance. The United States Environmental Protection Agency (EPA) has adopted a Federal Policy of noise control and acceptable levels of noise exposure. The measure of exposure used by the EPA is the day-night average noise level, Ldn. This measure is essentially an average of the A-weighted sound levels experienced for each 24-hour period. Noise levels occurring during late evening and early morning hours (10:00 pm to 7:00 am) are more annoying and, therefore, are increased by 10 dB(A) and averaged along with the daytime levels.

A comparative description of outdoor Ldn values is provided in Figure II-1.



Source. "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety," EPA, March 1974.

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Typical L_{dn} Levels in Outdoor Locations

Figure II-1

APPENDIX III

AIRCRAFT NOISE MEASUREMENT DATA

TABLE	DESCRIPTION
III-1	Equipment Listing
III-2	Data Listing - All
III-3	Data Listing - Cessna 402 Landing, Postion 3
III-4	Data Listing - DH-6 Landing, Postion 3
III-5	Data Listing - Cessna 402 Takeoff, Postion 2
III-6	Data Listing - Cessna 402 Takeoff, Postion 4
III-7	Data Listing - DH-6 Takeoff, Postion 2
III-8	Data Listing - DH-6 Takeoff, Postion 4
III-9	Data Listing - Single Prop. Takeoff, Position 2
III-10	Data Listing - Aircraft Flyovers

Sheet 1 - Data Listing of the twenty-four hour measurement and calculated Ldn

TABLE III-1 <u>INSTRUMENTATION LISTING</u>

1. Integrating Precision Type I Sound Level Meters

   - Larson Davis Laboratory (LDL) Model 800B
     S/N 0385B0276

   - LDL Model 800B
     S/N 0486B0600

   - Bolt Beranek Newman (BBN) Model 614
     S/N 790713

2. Acoustic Calibrators

   - General Radio (GR) Type 1562-A; 114 dB @ 1000 Hz.
     S/N 2280

   - GR Type 1562-A; 114 dB @ 1000 Hz.
     S/N 8605

3. Tape Recorder

   - Sony Professional Walkman
     S/N 83880

Table III-2 Summary of Noise Measurements of Aircraft Operations at Kalaupapa Airport and Aircraft Flyovers in the Vicinity of Kalaupapa Peninsula. Kalaupapa, Molokai, January 10-12, 1989

EVENT NO.	DATE	TIME	LOCATION NO. [1]	AIRCRAFT TYPE	FLIGHT PATTERN [2]	SEL dB(A)	Lmax dB(A)	DURATION (SECONDS)	WIND CONDITION	INST. USED [3]
1	1-10-89	10:05	1	DH-6	LANDING	75.6	68.8	30	NE, 15-18 KNOTS	1
2	1-10-89	10:10	2	DH-6	TAKE-OFF	96.1	90.5	15	NE, 15-18 KNOTS	1
3	1-10-89	10:15	4	2-PROP.	OVER, D	NA [4]	<60 [5]	NA	NE, 15-18 KNOTS	1
4	1-10-89	10:22	4	DH-7	OVER, A	NA	<55	NA	NE, 15-18 KNOTS	1
5	1-10-89	10:50	3	DH-6	OVER, C	NA	56	NA	NE, 15-17 KNOTS	1
6	1-10-89	11:01	3	HELICOPTER	LOOP	NA	55	NA	NE, 15-17 KNOTS	1
7	1-10-89	11:05	3	HELICOPTER	LOOP	NA	55	NA	NE, 15-17 KNOTS	1
8	1-10-89	13:17	5	2-PROP.	OVER, A	NA	<60	NA	NE, 15-20 KNOTS	2
9	1-10-89	13:18	5	2-PROP.	OVER, A	NA	<60	NA	NE, 15-20 KNOTS	2
10	1-10-89	13:18	5	2-PROP.	OVER, A	NA	<60	NA	NE, 15-20 KNOTS	2
11	1-10-89	13:20	5	1-PROP.	OVER, C	NA	66	NA	NE, 15-20 KNOTS	2
12	1-10-89	14:15	1	CESSNA 402	LANDING	75.8	70.0	NR [6]	NE, 15-20 KNOTS	2
13	1-10-89	14:22	4	2-PROP.	OVER, A	NA	<55	NA	NE, 15-20 KNOTS	2
14	1-10-89	14:43	4	CESSNA 402	TAKE-OFF	84.9	77.8	31	NE, 20-25 KNOTS	2
14	1-10-89	14:43	2	CESSNA 402	TAKE-OFF	94.1	91.3	22	NE, 15-20 KNOTS	1
15	1-10-89	14:46	4	HELICOPTER	OVER, D	NA	<65	NA	NE, 20-25 KNOTS	2
16	1-10-89	14:48	3	CESSNA 402	LANDING	87.9	82.8	19	NE, 15-18 KNOTS	1
16	1-10-89	14:48	3	CESSNA 402	LANDING	88.0	81.3	15	NE, 15-18 KNOTS	2
17	1-10-89	15:00	2	CESSNA 402	TAKE-OFF	93.0	89.8	21	NE, 15-20 KNOTS	1
17	1-10-89	15:00	11	CESSNA 402	TAKE-OFF	96.2	87.8	76	NE, 15-20 KNOTS	2

1 -- Refer to Figure 2 (text) for the location of the measurement positions
2 -- Refer to Figure 5 (text) for the description of the flight patterns
3 -- Instrument used: 1--LDL 800B S/N 0385B0276, 2--LDL 800B S/N 0486B0600, 3--BBN 614 S/N 790713
4 -- NA -- not applicable
5 -- " < " -- less than
6 -- NR -- not recorded

Table III-2. Summary of Noise Measurements of Aircraft Operations at Kalaupapa Airport and Aircraft Flyovers in the Vicinity of Kalaupapa Peninsula. Kalaupapa, Molokai, January 10-12, 1989 (continued)

EVENT NO.	DATE	TIME	LOCATION NO. [1]	AIRCRAFT TYPE	FLIGHT PATTERN [2]	SEL dB(A)	Lmax dB(A)	DURATION (SECONDS)	WIND CONDITION	INST. USED [3]
18	1-10-89	16:00	3	DH-6	LANDING	85.3	78.8	26	NE, 15-17 KNOTS	1
19	1-10-89	16:30	2	DH-6	TAKE-OFF	97.5	94.3	23	NE, 15-18 KNOTS	1
19	1-10-89	16:30	4	DH-6	TAKE-OFF	90.8	84.3	23	NE, 15-20 KNOTS	2
20	1-11-89	07:10	2	2-PROP	OVER, D	NA [4]	65	NA	NO WIND	2
21	1-11-89	NR [5]	5	2-PROP	OVER, D	75.1	66.3	19	NO WIND	
22	1-11-89	09:02	4	2-PROP	OVER, C	NA	50	NA	NE, 5 KNOTS	2
22	1-11-89	09:02	3	2-PROP	OVER, C	NA	63	NA	NE, 1-5 KNOTS	1
23	1-11-89	09:11	3	JET	OVER, B	NA	53	NA	NE, 1-5 KNOTS	1
24	1-11-89	09:29	4	HELICOPTER	OVER, C	NA	64	NA	NE, 5 KNOTS	2
24	1-11-89	09:29	3	HELICOPTER	LOOP	77.8	68.0	30	NE, 1-5 KNOTS	1
25	1-11-89	09:30	3	HELICOPTER	LOOP	65.3	55.8	19	NE, 1-5 KNOTS	1
26	1-11-89	09:36	3	CESSNA 402	OVER, D	NA	<50 [6]	NA	NE, 1-5 KNOTS	1
27	1-11-89	09:38	4	CESSNA 402	LANDING	66.1	NA	52	NE, 5 KNOTS	2
27	1-11-89	09:38	3	CESSNA 402	LANDING	82.4	75.5	19	NE, 1-5 KNOTS	1
28	1-11-89	09:53	4	CESSNA 402	LANDING	66.8	55.3	30	NE, 5 KNOTS	2
28	1-11-89	09:53	2	CESSNA 402	LANDING	75.9	68.8	28	NE, 1-5 KNOTS	1
29	1-11-89	09:58	4	CESSNA 402	TAKE-OFF	81.5	74.0	34	NE, 5 KNOTS	2
29	1-11-89	09:58	2	CESSNA 402	TAKE-OFF	95.0	90.5	17	NE, 1-5 KNOTS	1
30	1-11-89	10:02	4	CESSNA 402	TAKE-OFF	81.9	75.5	31	NE, 5 KNOTS	2
30	1-11-89	10:02	2	CESSNA 402	TAKE-OFF	93.0	89.3	18	NE, 1-5 KNOTS	1

1 -- Refer to Figure 2 (text) for the location of the measurement positions
2 -- Refer to Figure 5 (text) for the description of the flight patterns
3 -- Instrument used: 1--LDL 800B S/N 0385B0276, 2--LDL 800B S/N 0486B0600, 3--BBN 614 S/N 790713
4 -- NA -- not applicable
5 -- NR -- not recorded
6 -- " < " -- less than

Table III-2. Summary of Noise Measurements of Aircraft Operations at Kalaupapa Airport and Aircraft Flyovers in the Vicinity of Kalaupapa Peninsula. Kalaupapa, Molokai, January 10-12, 1989 (continued)

EVENT NO.	DATE	TIME	LOCATION NO. [1]	AIRCRAFT TYPE	FLIGHT PATTERN [2]	SEL dB(A)	Lmax dB(A)	DURATION (SECONDS)	WIND CONDITION	INST. USED [3]
31	1-11-89	10:05	4	DH-6	LANDING	67.5	56.3	39	NE, 5 KNOTS	2
31	1-11-89	10:05	2	DH-6	LANDING	87.7	80.9	21	NE, 1-5 KNOTS	1
32	1-11-89	10:06	4	DH-7	OVER, C	NA [4]	60	NA	NE, 5 KNOTS	2
33	1-11-89	10:10	2	DH-6	RUN-UP	NA	72	NA	NE, 1-5 KNOTS	1
34	1-11-89	10:12	4	DH-6	TAKE-OFF	91.4	83.5	26	NE, 5 KNOTS	2
34	1-11-89	10:12	2	DH-6	TAKE-OFF	98.4	95.0	21	NE, 1-5 KNOTS	1
35	1-11-89	10:19	2	DH-7	OVER, B	64.0	54.0	25	NE, 1-5 KNOTS	2
36	1-11-89	14:30	4	2-PROP	LOOP	68	62	15	NE, 5-10 KNOTS	3
37	1-11-89	14:31	4	2-PROP	OVER, C	59	59	2	NE, 5-10 KNOTS	3
38	1-11-89	14:47	4	CESSNA 402	LOOP [5]	79.4	69.7	29	NE, 5-10 KNOTS	3
39	1-11-89	14:49	3	CESSNA 402	LANDING	84.9	79.5	30	NE, 5-10 KNOTS	2
40	1-11-89	14:58	2	CESSNA 402	TAKE-OFF	95.2	90.5	33	NE, 5-10 KNOTS	2
40	1-11-89	14:58	4	CESSNA 402	TAKE-OFF	83.0	77.8	22	NE, 5-10 KNOTS	3
41	1-11-89	16:15	3	DH-6	LANDING	84.5	77.3	29	NE, 5-10 KNOTS	2
41	1-11-89	16:15	4	DH-6	LANDING	69.1	64.5	5	NE, 5-10 KNOTS	3
42	1-11-89	16:23	2	DH-6	TAKE-OFF	96.6	90.5	31	NE, 5-10 KNOTS	2
42	1-11-89	16:23	4	DH-6	TAKE-OFF	89.4	84.3	14	NE, 5-10 KNOTS	3
43	1-12-89	07:04	4	2-PROP	OVER, D	NA	60	NA	NO WIND	2
44	1-12-89	08:45	3	HELICOPTER	OVER, B	81.6	68.8	77	NO WIND	2
44	1-12-89	08:45	4	HELICOPTER	OVER, B	80.8	66.7	91	NO WIND	3
45	1-12-89	08:51	3	CESSNA 402	LOOP [5]	80.7	72.3	28	NO WIND	2

1 -- Refer to Figure 2 (text) for the location of the measurement positions
2 -- Refer to Figure 5 (text) for the description of the flight patterns
3 -- Instrument used: 1--LDL 800B S/N 0385B0276, 2--LDL 800B S/N 0486B0600, 3--BBN 614 S/N 790713
4 -- NA -- not applicable
5 -- Circling to land at Kalaupapa Airport

Table III-2. Summary of Noise Measurements of Aircraft Operations at Kalaupapa Airport and Aircraft Flyovers in the Vicinity of Kalaupapa Peninsula. Kalaupapa, Molokai, January 10-12, 1989 (continued)

EVENT NO.	DATE	TIME	LOCATION NO.[1]	AIRCRAFT TYPE	FLIGHT PATTERN[2]	SEL dB(A)	Lmax dB(A)	DURATION (SECONDS)	WIND CONDITION	INST. USED[3]
45	1-12-89	08:51	4	CESSNA 402	LOOP [4]	72.1	65.0	12	NO WIND	3
46	1-12-89	09:06	3	CESSNA 402	LANDING	81.2	75.8	10	NE, 1-5 KNOTS	2
46	1-12-89	09:06	4	CESSNA 402	LANDING	58.6	59.6	2	NE, 1-5 KNOTS	3
47	1-12-89	09:13	2	CESSNA 402	TAKE-OFF	95.1	91.5	16	NE, 1-5 KNOTS	2
47	1-12-89	09:13	4	CESSNA 402	TAKE-OFF	77.4	71.8	12	NE, 1-5 KNOTS	3
48	1-12-89	09:17	3	HELICOPTER	OVER, C	NA [5]	58	NA	NE, 1-5 KNOTS	2
49	1-12-89	09:21	3	CESSNA 402	LOOP [4]	78.0	66.8	36	NE, 1-5 KNOTS	2
49	1-12-89	09:21	4	CESSNA 402	LOOP [4]	78.5	69.5	22	NE, 5 KNOTS	3
50	1-12-89	09:23	3	CESSNA 402	LOOP [4]	NA	59	NA	NE, 1-5 KNOTS	2
51	1-12-89	09:25	3	CESSNA 402	LANDING	84.6	78.0	26	NE, 1-5 KNOTS	2
51	1-12-89	09:25	4	CESSNA 402	LANDING	71.7	61.6	34	NE, 5 KNOTS	3
52	1-12-89	09:27	3	CESSNA 402	LANDING	87.7	82.8	20	NE, 1-5 KNOTS	2
52	1-12-89	09:27	4	CESSNA 402	LANDING	75.3	65.4	20	NE, 5 KNOTS	3
53	1-12-89	09:35	2	CESSNA 402	TAKE-OFF	95.8	92.5	23	NE, 5 KNOTS	2
53	1-12-89	09:35	4	CESSNA 402	TAKE-OFF	85.3	79.5	18	NE, 5 KNOTS	3
54	1-12-89	09:37	2	CESSNA 402	TAKE-OFF	95.9	92.8	28	NE, 5 KNOTS	2
54	1-12-89	09:37	4	CESSNA 402	TAKE-OFF	79.3	73.1	14	NE, 5 KNOTS	3
55	1-12-89	09:44	3	DH-6	LOOP	66.7	53.3	38	NE, 1-5 KNOTS	2
56	1-12-89	10:12	3	DH-6	LANDING	84.1	77.0	29	NE, 5 KNOTS	2
56	1-12-89	10:12	4	DH-6	LANDING	70.1	68.0	6	NE, 5-10 KNOTS	3

1 -- Refer to Figure 2 (text) for the location of the measurement positions
2 -- Refer to Figure 5 (text) for the description of the flight patterns
3 -- Instrument used: 1--LDL 800B S/N 0385B0276, 2--LDL 800B S/N 0486B0600, 3--BBN 614 S/N 790713
4 -- Circling to land at Kalaupapa Airport
5 -- NA -- not applicable

Table III-2. Summary of Noise Measurements of Aircraft Operations at Kalaupapa Airport and Aircraft Flyovers in the Vicinity of Kalaupapa Peninsula. Kalaupapa, Molokai, January 10-12, 1989 (continued)

EVENT NO.	DATE	TIME	LOCATION NO. [1]	AIRCRAFT TYPE	FLIGHT PATTERN [2]	SEL dB(A)	Lmax dB(A)	DURATION (SECONDS)	WIND CONDITION	INST. USED [3]
57	1-12-89	10:15	2	DH-6	TAKE-OFF	100.3	97.0	21	NE, 5 KNOTS	2
57	1-12-89	10:15	4	DH-6	TAKE-OFF	90.1	84.3	18	NE, 5-10 KNOTS	3
58	1-12-89	10:19	4	DH-7	OVER, B	72.7	63.5	14	NE, 5-10 KNOTS	3
59	1-12-89	12:22	5	DH-6	OVER, A	71.6	61.3	22	NE, 5 KNOTS	2
60	1-12-89	12:35	8	1-PROP	OVER, A	59.3	49.0	23	NE, 5 KNOTS	2
61	1-12-89	13:05	2	3 1-PROP	OVER, C	NA [4]	50	NA	NE, 10-12 KNOTS	2
62	1-12-89	13:09	2	DH-6	OVER, B	NA	57	NA	NE, 10-12 KNOTS	2
63	1-12-89	13:12	2	1-PROP	TAKE-OFF	87.2	83.5	19	NE, 10-12 KNOTS	2
64	1-12-89	13:47	2	1-PROP	TAKE-OFF	90.1	86.0	21	NE, 10-12 KNOTS	2
65	1-12-89	13:50	2	DH-6	OVER, C	65.7	56.0	35	NE, 10-12 KNOTS	2
66	1-12-89	13:56	2	1-PROP	TAKE-OFF	85.0	79.8	20	NE, 10-12 KNOTS	2
67	1-12-89	14:09	2	1-PROP	TAKE-OFF	90.1	85.8	35	NE, 10-15 KNOTS	2
68	1-12-89	14:37	3	JET	OVER, D	NA	<50 [5]	NA	NE, 10-15 KNOTS	2
69	1-12-89	14:45	3	CESSNA 402	LANDING	78.3	71.8	18	NE, 10-15 KNOTS	2
69	1-12-89	14:45	4	CESSNA 402	LANDING	64.3	61.1	25	NE, 15-20 KNOTS	3
70	1-12-89	14:52	2	CESSNA 402	LANDING	64.9	58.3	15	NE, 15-20 KNOTS	2
71	1-12-89	14:58	2	CESSNA 402	TAKE-OFF	92.1	89.0	16	NE, 15-20 KNOTS	2
71	1-12-89	14:58	4	CESSNA 402	TAKE-OFF	83.4	77.4	11	NE, 15-20 KNOTS	3
72	1-12-89	15:05	2	CESSNA 402	TAKE-OFF	93.1	90.0	19	NE, 15-20 KNOTS	2
72	1-12-89	15:05	4	CESSNA 402	TAKE-OFF	81.9	77.0	13	NE, 15-20 KNOTS	3
73	1-12-89	16:34	10	DH-6	LANDING	92.8	85.0	25	NE, 15-20 KNOTS	2

1 -- Refer to Figure 2 (text) for the location of the measurement positions
2 -- Refer to Figure 5 (text) for the description of the flight patterns
3 -- Instrument used: 1--LDL 800B S/N 0385B0276, 2--LDL 800B S/N 0486B0600, 3--BBN 614 S/N 790713
4 -- NA -- not applicable
5 -- " < " -- less than

Table III-3 Summary of Noise Measurements of Cessna 402 Landings at Kalaupapa Airport
Position 3
Kalaupapa, Molokai, January 10-12, 1989

EVENT NO.	DATE	TIME	LOCATION NO. [1]	AIRCRAFT TYPE	FLIGHT PATTERN [2]	SEL dB(A)	Lmax dB(A)	DURATION (SECONDS)	WIND CONDITION	INST. USED [3]
16	1-10-89	14:48	3	CESSNA 402	LANDING	87.9	82.8	19	NE, 15-18 KNOTS	1
16	1-10-89	14:48	3	CESSNA 402	LANDING	88.0	81.3	15	NE, 15-18 KNOTS	2
27	1-11-89	09:38	3	CESSNA 402	LANDING	82.4	75.5	19	NE, 1-5 KNOTS	1
39	1-11-89	14:49	3	CESSNA 402	LANDING	84.9	79.5	30	NE, 5-10 KNOTS	2
46	1-12-89	09:06	3	CESSNA 402	LANDING	81.2	75.8	10	NE, 1-5 KNOTS	2
51	1-12-89	09:25	3	CESSNA 402	LANDING	84.6	78.0	26	NE, 1-5 KNOTS	2
52	1-12-89	09:27	3	CESSNA 402	LANDING	87.7	82.8	20	NE, 1-5 KNOTS	2
69	1-12-89	14:45	3	CESSNA 402	LANDING	78.3	71.8	18	NE, 10-15 KNOTS	2

1 -- Refer to Figure 2 (text) for the location of the measurement positions
2 -- Refer to Figure 5 (text) for the description of the flight patterns
3 -- Instrument used: 1--LDL 800B S/N 0385B0276, 2--LDL 800B S/N 0486B0600, 3--BBN 614 S/N 790713

Table III-4 Summary of Noise Measurements of DH-6 Landings at Kalaupapa Airport

Position 3

Kalaupapa, Molokai, January 10-12, 1989

EVENT NO.	DATE	TIME	LOCATION NO.[1]	AIRCRAFT TYPE	FLIGHT PATTERN[2]	SEL dB(A)	Lmax dB(A)	DURATION (SECONDS)	WIND CONDITION	INST. USED[3]
18	1-10-89	16:00	3	DH-6	LANDING	85.3	78.8	26	NE, 15-17 KNOTS	1
41	1-11-89	16:15	3	DH-6	LANDING	84.5	77.3	29	NE, 5-10 KNOTS	2
56	1-12-89	10:12	3	DH-6	LANDING	84.1	77.0	29	NE, 5 KNOTS	2

1 -- Refer to Figure 2 (text) for the location of the measurement positions

2 -- Refer to Figure 5 (text) for the description of the flight patterns

3 -- Instrument used: 1--LDL 800B S/N 038580276, 2--LDL 800B S/N 048680600, 3--BBN 614 S/N 790713

Table III-5 Summary of Noise Measurements of Cessna 402 Takeoffs at Kalaupapa Airport
Position 2
Kalaupapa, Molokai, January 10-12, 1989

EVENT NO.	DATE	TIME	LOCATION NO. [1]	AIRCRAFT TYPE	FLIGHT PATTERN [2]	SEL dB(A)	Lmax dB(A)	DURATION (SECONDS)	WIND CONDITION	INST. USED [3]
14	1-10-89	14:43	2	CESSNA 402	TAKE-OFF	94.1	91.3	22	NE, 15-20 KNOTS	1
17	1-10-89	15:00	2	CESSNA 402	TAKE-OFF	93.0	89.8	21	NE, 15-20 KNOTS	1
29	1-11-89	09:58	2	CESSNA 402	TAKE-OFF	95.0	90.5	17	NE, 1-5 KNOTS	1
30	1-11-89	10:02	2	CESSNA 402	TAKE-OFF	93.0	89.3	18	NE, 1-5 KNOTS	1
40	1-11-89	14:58	2	CESSNA 402	TAKE-OFF	95.2	90.5	33	NE, 5-10 KNOTS	2
47	1-12-89	09:13	2	CESSNA 402	TAKE-OFF	95.1	91.5	16	NE, 1-5 KNOTS	2
53	1-12-89	09:35	2	CESSNA 402	TAKE-OFF	95.8	92.5	23	NE, 5 KNOTS	2
54	1-12-89	09:37	2	CESSNA 402	TAKE-OFF	95.9	92.8	28	NE, 5 KNOTS	2
71	1-12-89	14:58	2	CESSNA 402	TAKE-OFF	92.1	89.0	16	NE, 15-20 KNOTS	2
72	1-12-89	15:05	2	CESSNA 402	TAKE-OFF	93.1	90.0	19	NE, 15-20 KNOTS	2

1 -- Refer to Figure 2 (text) for the location of the measurement positions
2 -- Refer to Figure 5 (text) for the description of the flight patterns
3 -- Instrument used: 1--LDL 800B S/N 0385B0276, 2--LDL 800B S/N 0486B0600, 3--BBN 614 S/N 790713

Table III-6 Summary of Noise Measurements of Cessna 402 Takeoffs at Kalaupapa Airport
Position 4
Kalaupapa, Molokai, January 10-12, 1989

EVENT NO.	DATE	TIME	LOCATION NO. [1]	AIRCRAFT TYPE	FLIGHT PATTERN [2]	SEL dB(A)	Lmax dB(A)	DURATION (SECONDS)	WIND CONDITION	INST. USED [3]
14	1-10-89	14:43	4	CESSNA 402	TAKE-OFF	84.9	77.8	31	NE, 20-25 KNOTS	2
29	1-11-89	09:58	4	CESSNA 402	TAKE-OFF	81.5	74.0	34	NE, 5 KNOTS	2
30	1-11-89	10:02	4	CESSNA 402	TAKE-OFF	81.9	75.5	31	NE, 5 KNOTS	2
40	1-11-89	14:58	4	CESSNA 402	TAKE-OFF	83.0	77.8	22	NE, 5-10 KNOTS	3
47	1-12-89	09:13	4	CESSNA 402	TAKE-OFF	77.4	71.8	12	NE, 1-5 KNOTS	3
53	1-12-89	09:35	4	CESSNA 402	TAKE-OFF	85.3	79.5	18	NE, 5 KNOTS	3
54	1-12-89	09:37	4	CESSNA 402	TAKE-OFF	79.3	73.1	14	NE, 5 KNOTS	3
71	1-12-89	14:58	4	CESSNA 402	TAKE-OFF	83.4	77.4	11	NE, 15-20 KNOTS	3
72	1-12-89	15:05	4	CESSNA 402	TAKE-OFF	81.9	77.0	13	NE, 15-20 KNOTS	3

1 -- Refer to Figure 2 (text) for the location of the measurement positions
2 -- Refer to Figure 5 (text) for the description of the flight patterns
3 -- Instruments used: 1--LDL 800B S/N 0385B0276, 2--LDL 800B S/N 0486B0600, 3--BBN 614 S/N 790713

Table III-7 Summary of Noise Measurements of DH-6 Takeoffs at Kalaupapa Airport
Position 2
Kalaupapa, Molokai, January 10-12, 1989

EVENT NO.	DATE	TIME	LOCATION NO. [1]	AIRCRAFT TYPE	FLIGHT PATTERN [2]	SEL dB(A)	Lmax dB(A)	DURATION (SECONDS)	WIND CONDITION	INST. USED [3]
2	1-10-89	10:10	2	DH-6	TAKE-OFF	96.1	90.5	15	NE, 15-18 KNOTS	1
19	1-10-89	16:30	2	DH-6	TAKE-OFF	97.5	94.3	23	NE, 15-18 KNOTS	1
34	1-11-89	10:12	2	DH-6	TAKE-OFF	98.4	95.0	21	NE, 1-5 KNOTS	1
42	1-11-89	16:23	2	DH-6	TAKE-OFF	96.6	90.5	31	NE, 5-10 KNOTS	2
57	1-12-89	10:15	2	DH-6	TAKE-OFF	100.3	97.0	21	NE, 5 KNOTS	2

1 -- Refer to Figure 2 (text) for the location of the measurement positions
2 -- Refer to Figure 5 (text) for the description of the flight patterns
3 -- Instrument used: 1--LDL 800B S/N 0385B0276, 2--LDL 800B S/N 0486B0600, 3--BBN 614 S/N 790713

Table III-8 Summary of Noise Measurements of DH-6 Takeoffs at Kalaupapa Airport
Position 4
Kalaupapa, Molokai, January 10-12, 1989

EVENT NO.	DATE	TIME	LOCATION NO. [1]	AIRCRAFT TYPE	FLIGHT PATTERN [2]	SEL dB(A)	Lmax dB(A)	DURATION (SECONDS)	WIND CONDITION	INST. USED [3]
19	1-10-89	16:30	4	DH-6	TAKE-OFF	90.8	84.3	23	NE, 15-20 KNOTS	2
34	1-11-89	10:12	4	DH-6	TAKE-OFF	91.4	83.5	26	NE, 5 KNOTS	2
42	1-11-89	16:23	4	DH-6	TAKE-OFF	89.4	84.3	14	NE, 5-10 KNOTS	3
57	1-12-89	10:15	4	DH-6	TAKE-OFF	90.1	84.3	18	NE, 5-10 KNOTS	3

1 -- Refer to Figure 2 (text) for the location of the measurement positions
2 -- Refer to Figure 5 (text) for the description of the flight patterns
3 -- Instrument used: 1--LDL 800B S/N 038580276, 2--LDL 800B S/N 048680600, 3--BBN 614 S/N 790713

Table III-9 Summary of Noise Measurements of Single Propeller Takeoffs at Kalaupapa Airport
Postion 2
Kalaupapa, Molokai, January 10-12, 1989

EVENT NO.	DATE	TIME	LOCATION NO. [1]	AIRCRAFT TYPE	FLIGHT PATTERN [2]	SEL dB(A)	Lmax dB(A)	DURATION (SECONDS)	WIND CONDITION	INST. USED [3]
63	1-12-89	13:12	2	1-PROP	TAKE-OFF	87.2	83.5	19	NE, 10-12 KNOTS	2
64	1-12-89	13:47	2	1-PROP	TAKE-OFF	90.1	86.0	21	NE, 10-12 KNOTS	2
66	1-12-89	13:56	2	1-PROP	TAKE-OFF	85.0	79.8	20	NE, 10-12 KNOTS	2
67	1-12-89	14:09	2	1-PROP	TAKE-OFF	90.1	85.8	35	NE, 10-15 KNOTS	2

1 -- Refer to Figure 2 (text) for the location of the measurement positions
2 -- Refer to Figure 5 (text) for the description of the flight patterns
3 -- Instrument used: 1--LDL 800B S/N 038580276, 2--LDL 800B S/N 048680600, 3--BBN 614 S/N 790713

Table III-10 Summary of Noise Measurements of Aircraft Flyovers in the Vicinity of Kalaupapa Peninsula. Kalaupapa, Molokai, January 10-12, 1989

EVENT NO.	DATE	TIME	LOCATION NO.[1]	AIRCRAFT TYPE	FLIGHT PATTERN[2]	SEL dB(A)	Lmax dB(A)	DURATION (SECONDS)	WIND CONDITION	INST. USED[3]
3	1-10-89	10:15	4	2-PROP.	OVER, D	NA[4]	<60[5]	NA	NE, 15-18 KNOTS	1
4	1-10-89	10:22	4	DH-7	OVER, A	NA	<55	NA	NE, 15-18 KNOTS	1
5	1-10-89	10:50	3	DH-6	OVER, C	NA	56	NA	NE, 15-17 KNOTS	1
6	1-10-89	11:01	3	HELICOPTER	LOOP	NA	55	NA	NE, 15-17 KNOTS	1
7	1-10-89	11:05	3	HELICOPTER	LOOP	NA	55	NA	NE, 15-17 KNOTS	1
8	1-10-89	13:17	5	2-PROP.	OVER, A	NA	<60	NA	NE, 15-20 KNOTS	2
9	1-10-89	13:18	5	2-PROP.	OVER, A	NA	<60	NA	NE, 15-20 KNOTS	2
10	1-10-89	13:18	5	2-PROP.	OVER, A	NA	<60	NA	NE, 15-20 KNOTS	2
11	1-10-89	13:20	5	1-PROP.	OVER, C	NA	66	NA	NE, 15-20 KNOTS	2
13	1-10-89	14:22	4	2-PROP.	OVER, A	NA	<55	NA	NE, 15-20 KNOTS	2
15	1-10-89	14:46	4	HELICOPTER	OVER, D	NA	<65	NA	NE, 20-25 KNOTS	2
20	1-11-89	07:10	2	2-PROP	OVER, D	NA	65	NA	NO WIND	2
21	1-11-89	NR[5]	5	2-PROP	OVER, D	75.1	66.3	19	NO WIND	
22	1-11-89	09:02	4	2-PROP	OVER, C	NA	50	NA	NE, 5 KNOTS	2
22	1-11-89	09:02	3	2-PROP	OVER, C	NA	63	NA	NE, 1-5 KNOTS	1
23	1-11-89	09:11	3	JET	OVER, B	NA	53	NA	NE, 1-5 KNOTS	1
24	1-11-89	09:29	4	HELICOPTER	OVER, C	NA	64	NA	NE, 5 KNOTS	2
24	1-11-89	09:29	3	HELICOPTER	LOOP	77.8	68.0	30	NE, 1-5 KNOTS	1
25	1-11-89	09:30	3	HELICOPTER	LOOP	65.3	55.8	19	NE, 1-5 KNOTS	1
26	1-11-89	09:36	3	CESSNA 402	OVER, D	NA	<50	NA	NE, 1-5 KNOTS	1

1 -- Refer to Figure 2 (text) for the location of the measurement positions
2 -- Refer to Figure 5 (text) for the description of the flight patterns
3 -- Instrument used: 1--LDL 800B S/N 0385B0276, 2--LDL 800B S/N 0486B0600, 3--BBN 614 S/N 790713
4 -- NA -- not applicable
5 -- " < " -- less than

Table III-10 Summary of Noise Measurements of Aircraft Flyovers in the Vicinity of Kalaupapa Peninsula. Kalaupapa, Molokai, January 10-12, 1989 (continued)

EVENT NO.	DATE	TIME	LOCATION NO. [1]	AIRCRAFT TYPE	FLIGHT PATTERN [2]	SEL dB(A)	Lmax dB(A)	DURATION (SECONDS)	WIND CONDITION	INST. USED [3]
32	1-11-89	10:06	4	DH-7	OVER, C	NA [4]	60	NA	NE, 5 KNOTS	2
35	1-11-89	10:19	2	DH-7	OVER, B	64.0	54.0	25	NE, 1-5 KNOTS	2
36	1-11-89	14:30	4	2-PROP	LOOP	68	62	15	NE, 5-10 KNOTS	3
37	1-11-89	14:31	4	2-PROP	OVER, C	59	59	2	NE, 5-10 KNOTS	3
43	1-12-89	07:04	4	2-PROP	OVER, D	NA	60	NA	NO WIND	2
44	1-12-89	08:45	3	HELICOPTER	OVER, B	81.6	68.8	77	NO WIND	2
44	1-12-89	08:45	4	HELICOPTER	OVER, B	80.8	66.7	91	NO WIND	3
48	1-12-89	09:17	3	HELICOPTER	OVER, C	NA	58	NA	NE, 1-5 KNOTS	2
55	1-12-89	09:44	3	DH-6	LOOP	66.7	53.3	38	NE, 1-5 KNOTS	2
58	1-12-89	10:19	4	DH-7	OVER, B	72.7	63.5	14	NE, 5-10 KNOTS	3
59	1-12-89	12:22	5	DH-6	OVER, A	71.6	61.3	22	NE, 5 KNOTS	2
60	1-12-89	12:35	8	1-PROP	OVER, A	59.3	49.0	23	NE, 5 KNOTS	2
61	1-12-89	13:05	2	3 1-PROP	OVER, C	NA	50	NA	NE, 10-12 KNOTS	2
62	1-12-89	13:09	2	DH-6	OVER, B	NA	57	NA	NE, 10-12 KNOTS	2
65	1-12-89	13:50	2	DH-6	OVER, C	65.7	56.0	35	NE, 10-12 KNOTS	2
68	1-12-89	14:37	3	JET	OVER, D	NA	<50 [5]	NA	NE, 10-15 KNOTS	2

1 -- Refer to Figure 2 (text) for the location of the measurement positions
2 -- Refer to Figure 5 (text) for the description of the flight patterns
3 -- Instrument used: 1--LDL 800B S/N 038580276, 2--LDL 800B S/N 048680600, 3--BBN 614 S/N 790713
4 -- NA -- not applicable
5 -- " < " -- less than

Ldn CALCULATION

LOCATION:	WILCOX HOUSE, POS. 5
PROJECT NO.:	88-35
MEAS. DATE:	JAN. 10-11, 1989
WEATHER:	MORNING: SKY: CLOUDY, WIND: NE, 1-5 KNOTS
	AFTERNOON: SKY: CLOUDY, WIND: NE, 15-20 KNOTS
	EVENING: SKY: CLOUDY, RAIN, WIND: NE, 5-10 KNOTS
	NIGHT: SKY: RAIN, WIND: NE, 5-10 KNOTS

HOUR	HNL dB(A)
07 - 08	52.0
08 - 09	50.0
09 - 10	51.7
10 - 11	49.8
11 - 12	49.5
12 - 13	50.4
13 - 14	59.0
14 - 15	58.3
15 - 16	57.9
16 - 17	57.9
17 - 18	59.4
18 - 19	60.3
19 - 20	59.0
20 - 21	58.8
21 - 22	59.4
22 - 23	58.3
23 - 00	56.2
00 - 01	57.9
01 - 02	57.5
02 - 03	58.5
03 - 04	56.0
04 - 05	51.0
05 - 06	64.1
06 - 07	56.0

DAY-NIGHT
AVERAGE SOUND
LEVEL, Ldn: 64.8 dB