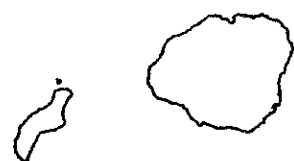


# AERIAL PHOTOGRAPHY ANALYSIS OF COASTAL EROSION ON THE ISLANDS OF KAUAI, MOLOKAI, LANAI, MAUI AND HAWAII

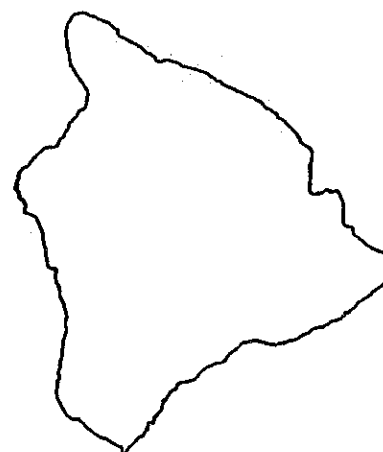


JUNE, 1991

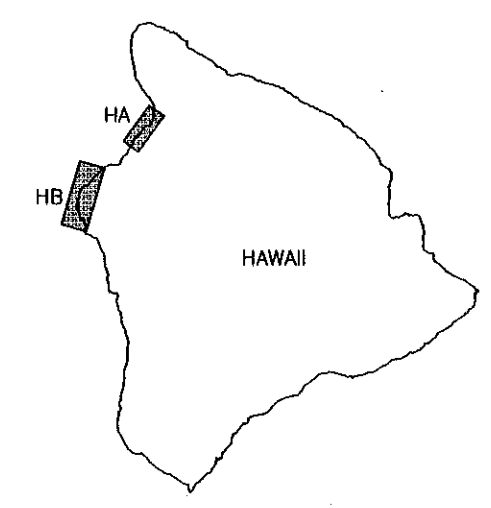
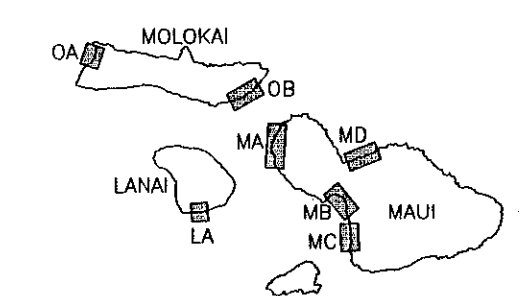
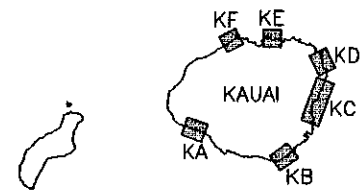


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**STATE OF HAWAII**  
**OFFICE OF STATE PLANNING**  
**COASTAL ZONE MANAGEMENT**  
**PROGRAM**



The preparation of this report was financed in part by the Coastal Zone Management Act of 1972, as amended, administered by the Office of Ocean and Coastal Resource Management, National Oceanic and Atmospheric Administration, United States Department of Commerce, through the Office of State Planning, State of Hawaii.



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# GLOSSARY

**Aeolian transport** - the transport of beach material due to the wind.

**Basemap** - Map containing HSGS coordinates used to correct the base photos and to position reference points within the HSGS.

**Base photo year** - For each sector, the photo year which is corrected to the basemap. Typically 1975 is the base photo year.

**Bench** - a nearly horizontal rock formation located along the shoreline at approximately the high water line.

**Cyclical beach** - one that undergoes alternating periods of erosion and accretion, usually with no great long term net change.

**Downdrift** - The direction of predominant movement of littoral material along a beach.

**Dynamic beach** - one that is subject to large shoreline changes over a relatively short time span.

**Groin** - a shore protection structure built (usually perpendicular to the shoreline) to trap littoral drift or retard erosion of the shore.

**HSGS coordinates** - Hawaii State Grid System coordinates (in feet).

**Lithified dune** - a sand dune that has been converted, through the processes of weathering and chemical decomposition, into rock.

**Kona storm** - a winter storm in Hawaiian waters that approaches from the south or southwest, opposite the typical tradewind direction. The steep, short period waves may result in severe beach erosion along exposed beaches.

**Perched beach** - a beach retained above the normal reach of waves by a rock ledge or bench.

**Pocket beach** - a beach, usually small and stable, located between prominent points or headlands.

**Region** - The area immediately adjacent to and represented by a transect line on the shoreline maps.

**Revetment** - a sloping structure, usually stone, built along the shoreline to protect the land behind against erosion.

**Scale** - The ratio between a distance on a basemap or photo and the same distance on land.

**Scarp** - a steep slope or cliff at the vegetation line caused by wave induced erosion.

**Seawall** - a vertical structure, usually concrete or masonry, built along the shoreline to protect the land behind from erosion.

**Sector** - A portion of shoreline in one geographic area, usually contiguous. This atlas is divided by sectors on each island.

**Shoreline** - The vegetation line.

**Shore protection** - refers to any structure built within the reach of wave action to protect a shoreline from erosion.

**Toe line** - The line offshore where beach sand and a hard seafloor meet. This line is sometimes seen through the shallow water in aerial photographs and is an indicator of beach dynamics.

**Tombolo** - a protruding reach of shoreline, formed in the lee of an offshore protective structure or natural formation.

**Updrift** - the direction opposite that of the predominant movement of littoral materials.

# INTRODUCTION

## Study Objectives

The Hawaii Coastal Zone Management (CZM) Program, Office of State Planning, is concerned with the preservation of beaches and the minimizing of adverse impacts of coastal erosion on private property. This is the third year of a multi-year statewide beach management program. The determination of erosion/accretion histories is an important step in predicting future coastal erosion trends, developing beach management plans, and enhancing regulatory decisions on shoreline area activities. This project is intended to produce quantitative data on erosion/accretion histories at specific sites on the neighbor islands.

## Study Scope

A total of 66 miles of sand shoreline was selected for study by the Office of State Planning, with input from the County planning offices and the consultant. The study includes 22.2 miles of sandy shoreline on Kauai, 7.3 miles on Molokai, 0.5 miles on Lanai, 27.3 miles on Maui, and 8.9 miles on Hawaii.

For each beach, aerial photographs were analyzed to determine historical changes in the shoreline position. Where available, five vertical aerial photographs, spanning the time period back to the first available photograph for a particular beach, were selected for detailed analysis of the shoreline position. Computer assisted digitizing was used to compare data from the various coastline data sources.

The shoreline positions determined from the aerial photographs were supplemented by recent aerial oblique color photographs, a literature review to determine beach histories, and site visits to selected areas. Finally, the digitized data and the supplemental information were used to provide commentary on the erosion and accretion trends of the areas studied, and an evaluation of the ongoing processes and potential problems.

## Other Project Deliverables

The source data used in the preparation of this atlas have also been provided to the Office of State Planning:

- All vertical aerial photographs (approximately 500) used in this study at a scale of 1"=200'
- All base maps used in locating beaches within the HSGS Coordinates
- A set of overlapping oblique aerial color photographs, 3" x 5", of all beaches included in this study (approximately 1400 photos)

In addition, the intermediate and processed data have been provided in two different formats:

- A set of large scale (22 by 34-inch) digital plots of the shoreline. These plots show shoreline features and region locations and are similar to the maps presented in this atlas for each beach.
- Digital files for each sector providing all the digitized and processed data in a format compatible with the State of Hawaii Geographic Information System.

The digital files have been created with ARC/INFO, a Geographic Information System program. The following coverages have been included in these files:

- The vegetation line from each photo.
- The beach toe lines, when observable in the aerial photo.
- Base map reference points.
- Manually edited features including houses, roads, and coastal features such as jetties, piers, and boat ramps.
- The 1988 waterline.
- The reference points used to correct the photos and the photo coverage limits.
- Each region symbol, numbered. With each region is associated database information including vegetation line positions relative to the base for each photo year together with the standard deviation for each year. A 30-year extrapolation accretion rate is also provided with its associated standard deviation. Each region is characterized with comments.

# METHODOLOGY

Shoreline erosion rates were measured by comparing aerial photographs of the same section of beach from different years. In general, shoreline aerial photographs were available from 1950 to present taken at approximately 10 to 15 year intervals.

Photographs were enlarged to a scale of 1"=200' and digitized on a digitizing tablet. Using reference points common to both the photograph and a baseline map, the photographs were corrected for distortion caused by camera tilt, location and scale, and all points were positioned in the Hawaii State Grid System (HSGS). Once all historically photographed shorelines were digitized into this common coordinate system, these past shorelines could be compared to determine the relative erosion and accretion of the beaches.

The shoreline positions determined from the aerial photographs were supplemented by oblique color photographs taken specifically for this study, by a literature review to determine beach histories, and by site visits to selected areas. All these data were used to both summarize the historical trend and to produce a 30-year forecast for the shoreline.

## Historical Photographs

The aerial photographs used typically spanned four decades. For most beaches, five different years were chosen based primarily on availability: 1988, 1987, 1975, 1960-64, and 1949-53. The 1988 photos were taken during the winter and the 1987 photos were taken during the summer. All the photos were taken specifically for aerial mapping. The 1950 and 1960 series photos were taken from a higher airplane elevation than the more recent photos and thus needed more enlargement and had less resolution.

A complete set of aerial photographs was not available for all the beaches in this study. For some remote beaches, historical aerial survey coverage was limited. All the aerial photographs that exist were reviewed and used if available and meaningful to this beach erosion analysis. The photos used were obtained from R. M. Towill, Inc. (photos prior to 1970) and from Air Survey Hawaii (after 1970). The photo years used have been listed in the section on each individual beach in this atlas. Over 500 aerial photographs were digitized for the analysis of these 66 miles of shoreline.

## Base maps

Four types of base maps were used to impose the Hawaii State Grid System onto the historical photos. The most accurate and useful maps were not available for all the beaches in this study. The maps used were based on availability and the following order of preference:

1. Photo-contour maps (PCM) at a scale of one inch equals 200 feet provided the best fit and scaling parameters for the historical photos. PCM base maps are digitally

reproduced aerial photos that are corrected for scaling distortion. Since these maps are essentially aerial photos they provide a high number of reference points (points in common between the maps and the aerial photographs) essential for accuracy in the digitization process. These maps were available only for some portions of Hawaii, Kauai and Maui.

2. The line topographic map at 1"=200' is the most accurate map but does not contain as many useful reference points as a PCM. The line topographic map is produced by land surveying crews. These maps were only used when a sufficient number of reference points could be obtained to perform a reasonable aerial photograph distortion correction. These base maps were used for the beaches on North Kauai, East Molokai, and West Maui.
3. National Ocean Survey Topographic (NOS-T) Sheets at a scale of 1:5000 (1"=417') and 1:10,000 (1"=834') are available for many of Hawaii's shorelines. NOS-T sheets are also produced by land surveyors but their surveys do not provide as high a density of survey shots as the line topographic maps. This decreases the number of useful reference points. The smaller scale also provides less accuracy in digitizing reference points. These base maps were used only for sectors on Lanai and West Molokai.
4. United States Geological Survey maps at a scale of 1:24,000 (1"=2000') were also utilized. These maps are available for all the islands but are the least accurate of the four types available. USGS maps have even fewer reference points than the NOS-T sheets. The USGS maps show lines of latitude and longitude and thus the Hawaii State Grid System must be superimposed onto these maps introducing another source of error. It was necessary to use these base maps for beaches on North-East Kauai and South Kohala, Hawaii.

## Correction of Photographs

All critical points in the photographs were digitized into a computer aided drawing (CAD) program and corrected for camera location and orientation using a computer program developed specifically for this project. The aerial photographs were distorted because of the position, rotation and tilt of the camera, the varying elevations of the land, and the wide angle of the camera lens used. Positional errors caused by distortions in the aerial photograph could easily be ten to one hundred times the resolution necessary to determine shoreline changes in this study; distortion correction was therefore a critical step.

A three dimensional process of space resection was used to correct the photos for camera tilt, scale, and location. Corrections were possible by knowing the HSGS coordinates and elevations (from the base maps) of multiple reference points on each photo to be corrected. An absolute

minimum of three reference points was required to correct for camera tilt while two reference points allowed for rotational correction only about the vertical axis. Because of uncertainties in locating reference points, a minimum of 8 reference points per photo was desired, and 15 to 20 were not uncommon. A best fit solution was used which also produced a standard deviation. This standard deviation was useful in assessing the accuracy of the digitized data.

A base photo year was selected for each beach and all photos for this year were corrected to the base map using common reference points. The base photo year was generally one of good quality with an adequate number of common reference points between it and photos from other years. In general, the base photo was from the year that most closely matched the date of the base map.

After the base year photo was corrected to the base map, other photo years were corrected to the base photo. This strategy provided more accurate erosion rates (based on shoreline variations between photographs) but slightly less accurate absolute coordinates than if all the photos had been corrected to the base map. Since the measurement of erosion rates was the goal of the study, this strategy was preferable. The idea of correcting to a base photo also offset the poor quality and small scale disadvantages of some of the base maps.

#### **Data Processing**

The following steps describe in general terms the processing of the shoreline photographic data:

- **Identify Base maps and Photos:** All base maps and photos for a particular sector were collected and uniquely identified. Photos were selected so that they overlap by a minimum amount, and base maps were selected so that all photos were covered. The base photo year for the sector was selected to most closely match the base map.
- **Locate and Mark Reference Points:** Reference points were identified, marked, and sequentially numbered on the photos and the base map. A sharp pencil was used to mark the reference points and they were circled and numbered with a colored wax pencil.
- **Trace Vegetation Line:** The vegetation line was traced on the photo with a sharp pencil.
- **Digitize Base maps:** Each base map for the sector was mounted on the digitizing tablet, calibrated, and the reference points and base map outlines digitized. The elevations of the reference points were keyed into the computer. All data was digitized into the software package AutoCAD.
- **Digitize Photos:** Beginning with the base photo year, the reference points and the shoreline of each photo were digitized. The calibration process for the photos involved knowledge of the focal length, the center of the photo, and the physical dimensions of the photograph. General features such as houses and roads were

digitized to provide key landmarks on the maps for the reader. General features were taken from the latest photo year (typically 1988).

- **Correct Photos:** The photo raw data files were corrected for tilt, rotation, and scale, and translated to HSGS coordinates. Because the correction is three-dimensional, only features with elevations were accurately corrected. Reference points and shorelines, the most important data, included elevations. Corrections for elevations were not made for the photo's general features, and therefore positional errors for these objects are proportional to their elevation above sea level. These general features are useful for display purposes but were not an integral part of the shoreline erosion analysis.
- **Create CAD drawing:** The corrected files were read into the AutoCAD drawing and plotted. The AutoCAD drawing was used for viewing, editing, and analyzing the shoreline data.
- **Smooth Overlapping Photo Data:** Where photos overlap, features and vegetation lines did not coincide exactly. A separate program created a single vegetation line from the two overlapping lines by interpolation. All features other than the vegetation line were smoothed manually.

#### **Data Interpretation**

The scope of work also included an analysis of the results of the data processing and an evaluation of the ongoing coastal processes and potential problems. The beach history was interpreted by evaluating the digitized data, by studying vertical aerial photographs and low-elevation oblique aerial photos, and by a field visit when questions remained after the initial evaluation.

The majority of the interpretative task involved examining the digitized data. The wealth of information contained in the five digitized vegetation lines and supplied in the graphical database has been summarized in this report by regions. The regions were selected at particular locations to summarize the type of beach activity representative of a stretch of shoreline; the regions have been marked on the maps with a numbered transect line. The vegetation line of the earliest year of available data (usually 1949 or the 1950's) was used as the reference datum, or zero position. Vegetation lines located seaward of the earliest vegetation line indicate an accreting beach and vegetation lines located landward of the earliest vegetation line indicate an eroding beach. Questionable areas, such as beach segments where the vegetation lines were obscured by trees, were sometimes eliminated as region locations. Similarly, questionable vegetation lines, such as those digitized from poor quality photos, were not used in the measurements of erosion and accretion for a particular region.

The low-elevation color oblique photos were an additional data source used to analyze the beach sectors. These photos provided additional detail and a qualitative feel for the nearshore and backshore environments. The oblique photos were flown in June 1991 and therefore provide an up to date picture of the most recent beach activity.

The site visits provided the final input for the study where necessary. Details were frequently observed that supplemented the partial understanding of the ongoing coastal processes provided by the vertical and oblique photographs. The final interpretive step was the re-evaluation of the raw digitized data and the erosion data for the Regions.

### Accuracy

There were three fundamentally different sources of errors, each of which contributed to uncertainty in the final computed erosion rate.

1. The first error source was digitization and was a function of the digitization tablet resolution, the scale of the photo, the repeatability of measurements, and the ability to locate precisely the reference points. The resolution of the digitizing tablet was 0.001 inch -- the distance between adjacent pixels. At the typical photo scale of 1"=200' this resulted in a resolution uncertainty of 0.2 feet.
2. The second source of uncertainty was due to inadequate correction of the base photo to the base map. If the camera tilt of the base photo was not calculated exactly then the base photo would not be perfectly horizontal (as are the base maps). Subsequent photos corrected to this tilted base photo would thus be in error. The base photo to base map uncertainty was largely a function of the quality of the base map.
3. The third, and often largest, source of uncertainty was due to the subjective location of the vegetation line itself. It was the rare case where the shoreline was distinguishable to within 3 feet. In some cases, due to blur, glare, or shadows an uncertainty of 10 to 20 feet existed (this was quite common in the old photos). The shoreline location uncertainty varied strongly between sectors, years, and even within a given year. In order to minimize subjective effects, as a matter of policy, the same person digitized all photos for a given sector.

As a measure of the total digitization uncertainty (error #1), the same photo, digitized by two different people on two different tablets, was compared and the raw digitized coordinates found to differ by no more than 3 feet.

The magnitude of the first two sources of uncertainty was estimated from the results of the photo correction program. Since, normally, many redundant reference points were used, the standard deviation of the difference between the calculated and "true" reference point coordinates gave a good indication of the uncertainty of the vegetation line. This number was typically less than 10 feet, and often less than 5 feet. This standard deviation is reported in the graphical data provided under each beach map in this atlas. This number is most valuable when at least 8 reference points were used.

A cross check of the standard deviation measurement of uncertainty was afforded by comparing overlapping features on adjacent photos. In particular, the vegetation line on one photo could be manually "moved" so as to overlap more exactly the same vegetation line in an adjacent photo. The difference between these two vegetation lines represented an upper limit on the error

since these occurred at the edges of the photos where errors due to incorrect photo tilt were largest. In general, the differences between overlapping features correlated very well with the standard deviations computed for each photograph in the correction program.

In many cases, especially with the old photos, the uncertainty in the vegetation line location dominated the uncertainty. This uncertainty was not included explicitly in the standard deviation computation, but generally the blurred images on the photos causing the shoreline uncertainty also caused a corresponding uncertainty in the reference point locations.

In summary, the uncertainty of the vegetation line location on a particular photo has been estimated as two standard deviations. The standard deviation for each photograph is provided in this atlas at the base of the Change in Vegetation Line graph associated with each shoreline map.

# HOW TO USE THIS ATLAS

This atlas presents the historical shoreline analysis results for 66 miles of beaches on five different Hawaiian islands. The islands are presented in the atlas starting from Kauai and moving down the island chain.

Each island is divided into shoreline sectors or continuous shorelines selected by the Office of State Planning for analysis. These sectors are presented in this atlas in the following order:

Island	Sectors	Nomenclature	miles
Kauai	6	KA through KF	22.2
Molokai	2	OA, OB	7.3
Lanai	1	LA	0.5
Maui	4	MA through MD	27.3
Hawaii	2	HA, HB	8.9

Each sector is introduced with an overall description of the coastal characteristics, backshore development, shoreline processes, and beach usage. With the introduction is a USGS map showing the location of the shoreline sector as well as the coverages of individual maps that document the sector on the pages following.

Each sector is further broken up into individual maps each covering approximately one mile of shoreline. Two pages of the atlas are devoted to each map which are numbered sequentially for each sector and summary tables are provided at the back of the atlas. These pages contain the following:

## Maps

A map at a scale of 1"=400' is shown that was prepared from the digitized aerial photographs. The vegetation and water lines are shown based on the most recent aerial photograph available, generally 1988. The coordinates are in the HSGS. Shoreline protection has been indicated where observed in the aerial photographs, but due to the remote nature of the process used in this study, some shoreline protection may not be indicated. The specific regions which are typical of the shoreline are shown with numbered transect lines; historical data are presented for these regions in the accompanying graph and discussion.

## Photograph

The most recent aerial photograph available, generally 1988, is provided at the same scale and orientation as the digitized map. There is not an exact correlation to the map, however, since the photographs have not been corrected for distortion.

## Graph of Shoreline Changes

The historical changes in the vegetation line for each region are presented graphically under each map. The bar graph shows the change in the vegetation line (both graphically and numerically) relative to the shoreline position taken from the earliest available photograph, designated the base year. The base year is the first year shown for each region and has a change in vegetation line value of zero. From the bar graph for each region, the relative accretion and erosion can be determined. From a comparison between regions, variations along the beach can be detected.

In some cases, shoreline protection had been added to the beach. This is shown on the bar graph as a heavy solid line along the axis in the year(s) in which the shoreline protection existed.

The digitization and distortion correction process for each photograph produced a standard deviation error discussed in the methodology and errors sections. Shoreline variations between any two years that are less than two standard deviations of the photographs involved are unlikely to be significant.

## Discussion

A discussion on each beach area is provided which gives a description of the beach, the backshore development and history of the beach, and a summary of the beach changes. This summary takes into account the digitized data from the aerial photographs as well as more recent oblique aerial photographs and site visits. Based on all this information, the level of shoreline stability, erosion or accretion was assessed.

## Accretion Rate Summary Tables

At the end of the atlas is a summary table showing the computed accretion rates between successive photographs for each region in the atlas. In addition, the net erosion or accretion is extrapolated for 30 years to the year 2018 together with the standard deviation associated with this extrapolation. Further explanation is provided with this table.



# RECOMMENDATIONS

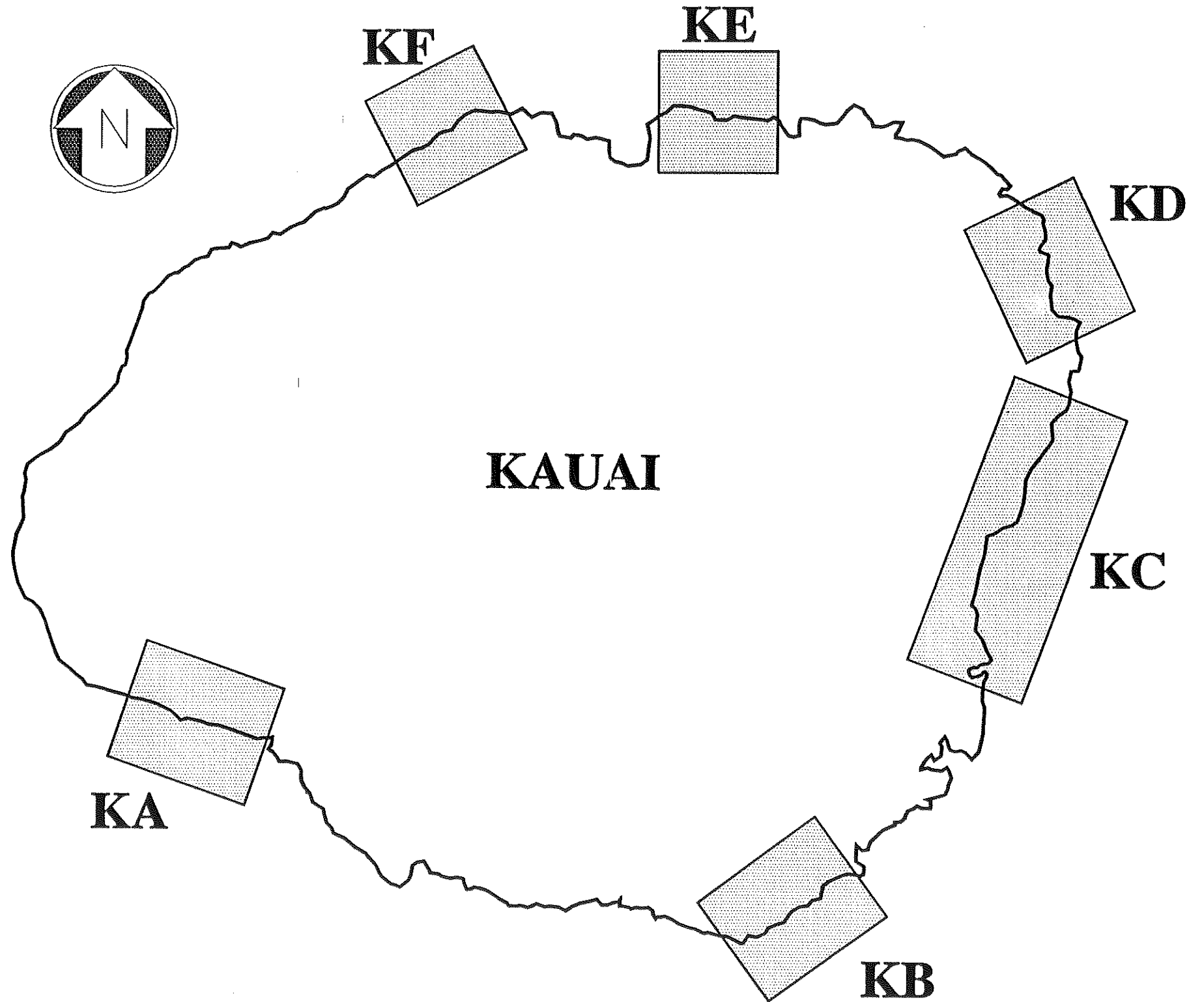
This study provides a quantitative summary of shoreline changes from the date of the earliest aerial photograph through 1988, the date of the most recent photograph. As described above, this generally provided four to five data points over the period. Continued long term monitoring is recommended for several reasons. As the base period and the number of data points increase, the confidence level of the results will increase. Long term monitoring will also supplement the development of shoreline management plans and provide an overview of the impact of the plans as they are put into effect.

Following are some specific recommendations for continued monitoring:

1. Fine tune the geographic areas to be included in the future monitoring. Those areas defined in this report as already committed to shore protection could be deleted from further standard monitoring. Likewise, small pocket beaches with one large resort covering the backshore ( for example, Mauna Kea beach) could also be deleted. In both cases, the beach is committed to a particular use and management options are limited. Available CZM resources could then be concentrated on sandy shorelines where there are either problems, potential problems, or viable management options.
2. Develop criteria for selecting beaches for more frequent and/or more detailed monitoring, and implement the monitoring program. Beaches selected should include those that are eroding, particularly if public or private facilities are threatened; slated for future development; and, any beaches where shore protection may be constructed, potentially impacting a long length of beach. The remaining sandy beaches of the Kaanapali area are an example of the latter situation.
3. Take a complete set of overlapping vertical aerial photographs of the monitored beaches every five years. With negatives at a scale of 1"=500' (typical of the more recent 9" x 9" contact aerial photographs), the resolution of the shoreline and necessary reference points are adequate for shoreline digital analysis. These photographs should be taken at a time of day along each coastline where long shadows will not obscure the vegetation line or other shoreline features. The five year period is desirable to provide a stronger database for determining trends in beach dynamics and to more easily span the gap caused by the occasional poor quality photograph.
4. Take a complete set of overlapping color aerial photographs from a low-level oblique angle every five years, at the same time as the vertical aerial photographs. These photos help in the interpretation of the vertical photographs and further document the beach dynamics.
5. Additional aerial survey shoreline data should be entered into the already existing digital database for these shorelines. The same photograph and base map reference points should be used to maintain the highest level of accuracy in determining relative changes in the shoreline. The database should be updated every ten years, with the addition of two more sets of aerial photographs.

**KAUAI**

- **Southwest Kauai**  
KA - Kekaha to Waimea
- **Southeast Kauai**  
KB - Makahuena Point to Haula Beach
- **East Kauai**  
KC - Hanamaulu to Kealia
- **Northeast Kauai**  
KD - Anahola Bay to Papaa Bay
- **North Kauai**  
KE - Kalihikai Beach to Anini Beach  
KF - Haena State Park to Ke'e Beach



## SECTOR KA: SOUTHWEST KAUAI KEKAHA TO WAIMEA

### GENERAL COASTAL CHARACTERISTICS

This sector extends from Oomano Point on the west to the Waimea River, a distance of approximately 15000 feet. The shoreline consists of a narrow sand beach, composed of black volcanic sand, mud and calcareous sand. The Waimea River is the primary source of the terrestrial material to the shoreline. The percentage of calcareous sand increases toward the west. Kikiaola Small Boat Harbor is located in the middle of the sector and divides it into two reaches. Waimea Beach extends from the Waimea River to the harbor, and Kikiaola Beach extends from the harbor to Oomano Point. The shoreline is relatively straight and featureless. The two major coastal features are man-made, the Kikiaola Small Boat Harbor and the Waimea Pier at the east end of the sector. The only fringing reef in this sector is directly off Oomano Point.

### LAND USE AND DEVELOPMENT

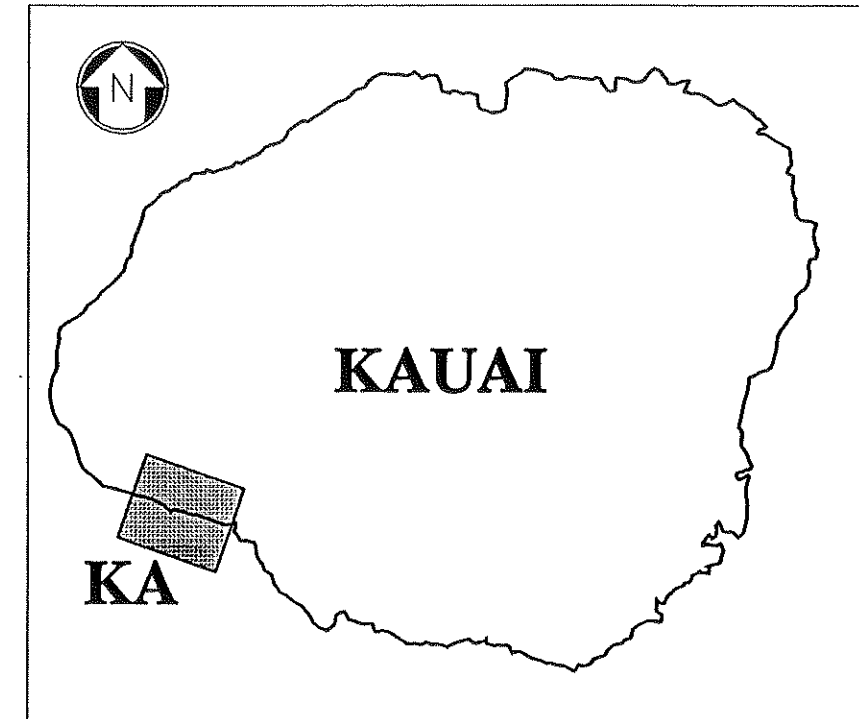
There is a small beach park just west of the river mouth. Along the backshore of Waimea Beach, the 4000 feet of shoreline west of the park is in residential use. The rest of the coast, except for a small park at the boat harbor, is either vacant or in agricultural use. The town of Kekaha is located at the west end of the sector, inland of Route 50.

### WAVE CLIMATE

This coastal sector is directly exposed to south swell and Kona storm waves. It is indirectly exposed to refracted tradewind waves from the east and to North Pacific swell from the west. As a result of the seasonal variation in waves, Waimea Beach has a steep foreshore in the winter and a moderate slope in the summer, when milder waves prevail.

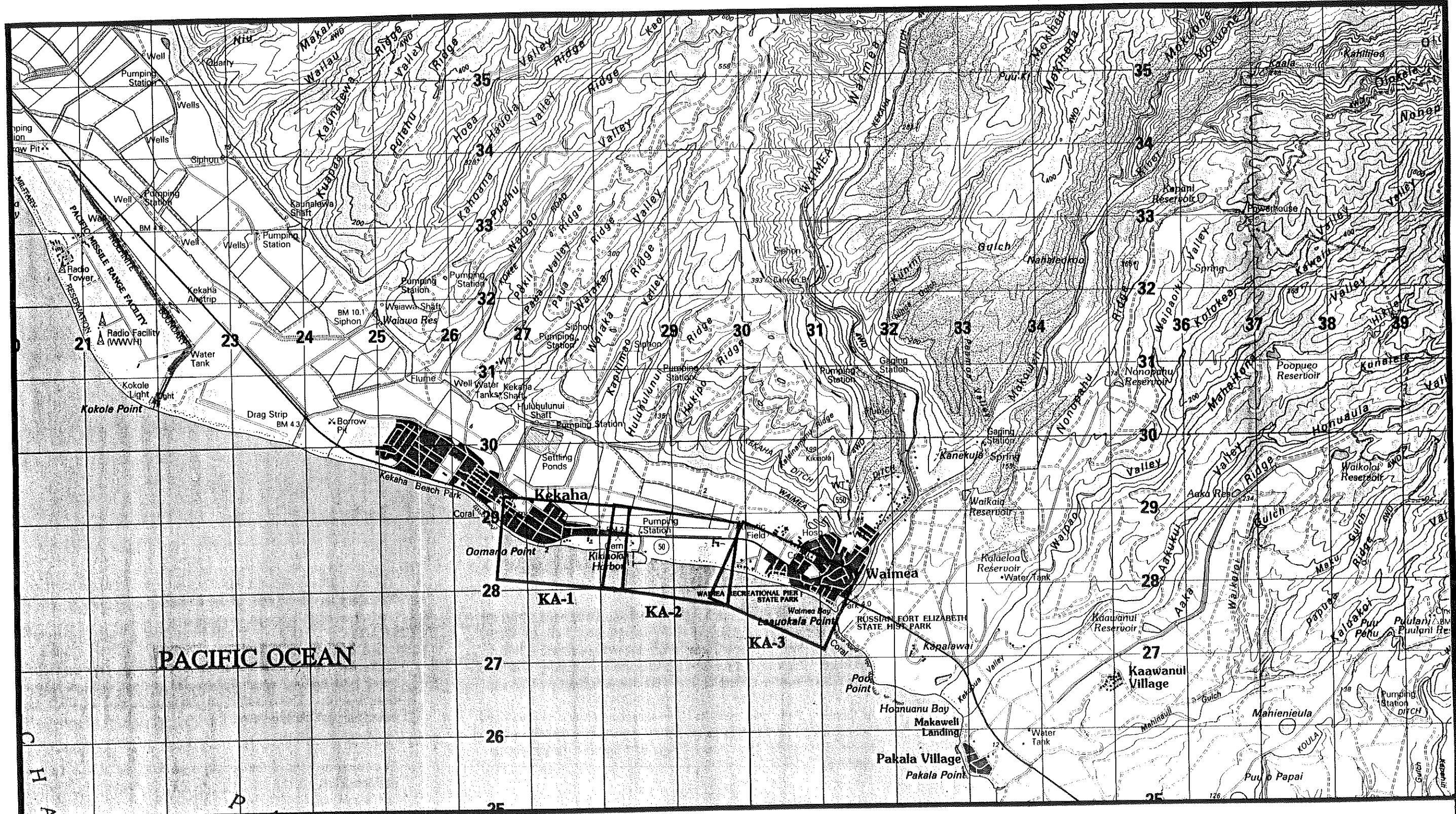
### SHORELINE PROCESSES

Severe erosion has occurred at the east end of this sector and just beyond the west boundary. According to the U.S. Army Engineer Division (1971), the 3000 feet of shoreline immediately west of the Waimea River has eroded steadily since the early 1900's. This erosion threatened the beach front road to the extent that it was relocated three times between 1940 and 1955. At one time, emergency riprap was placed along the eroding bank. On the west side of Oomano Point (west of the sector boundary), the shoreline eroded at least 100 feet between 1936 and 1966 (U.S. Army Engineer District, 1971). An extensive revetment has been constructed to protect Route 50, the coastal highway. Although the wave climate varies seasonally, the predominant direction of alongshore transport is to the west. The difference in the vegetation line positions on either side of Kikiaola Harbor illustrates the prevailing direction, with accretion on the east, or up-drift side, and erosion on the other side. Residents of Kekaha have stated that the start of the erosion coincided with the construction of the small boat harbor. Prior to the harbor, there was a wide beach at Kekaha, but by 1976, waves were breaking over the road.



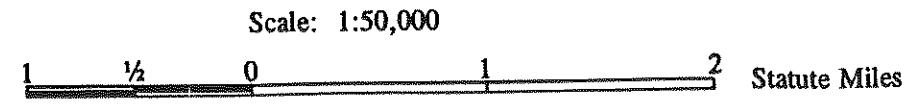
### BEACH USAGE

The inshore waters off the sector are usually dirty, due to discharge from the Waimea River and a drainage ditch that discharges into the small boat harbor, and swimming conditions are poor. The Waimea Pier, an abandoned boat landing, is now used as a recreational fishing spot. The boat ramp at the small boat harbor is used by recreational and commercial fishermen. It is the closest access point for the fishing grounds off Niihau and Kaula Rock.



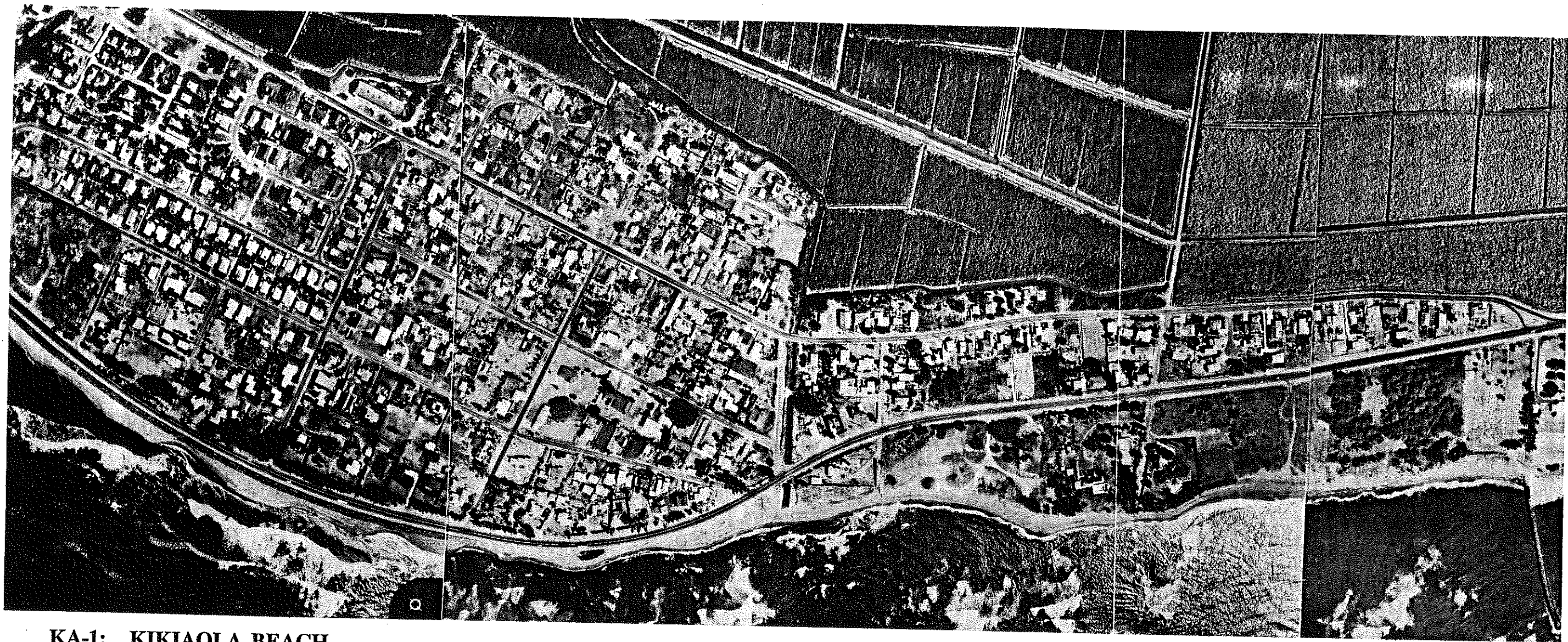
**LEGEND**  
 HYDROGRAPHIC DATUM ..... MEAN LOWER LOW WATER

Depth curve (meters)	
Foreshore flats	
Rocks awash; Reef	
Wreck: Exposed; Sunken with masts exposed	
Wharf, pier	
Seawall	
Oil/gas rig	



From U.S. Geological Survey  
 MAP INFORMATION AS OF 1983

**SOUTHWEST KAUAI**



## KA-1: KIKIAOLA BEACH

### BEACH DESCRIPTION

- Kikiaola Beach is a narrow sand beach extending from the Kikiaola Small Boat Harbor to Oomano Point.
- The beach is 4000 feet long, with an average width of 50 feet. The beach has a high percentage of terrestrial material, due to discharge from the Waimea River.

### BACKSHORE

- The backshore consists primarily of open land. Single family houses occupy approximately 1000 feet of the backshore.
- Kikiaola Beach is bounded to the east by Kikiaola Small Boat Harbor. (See KA-2).

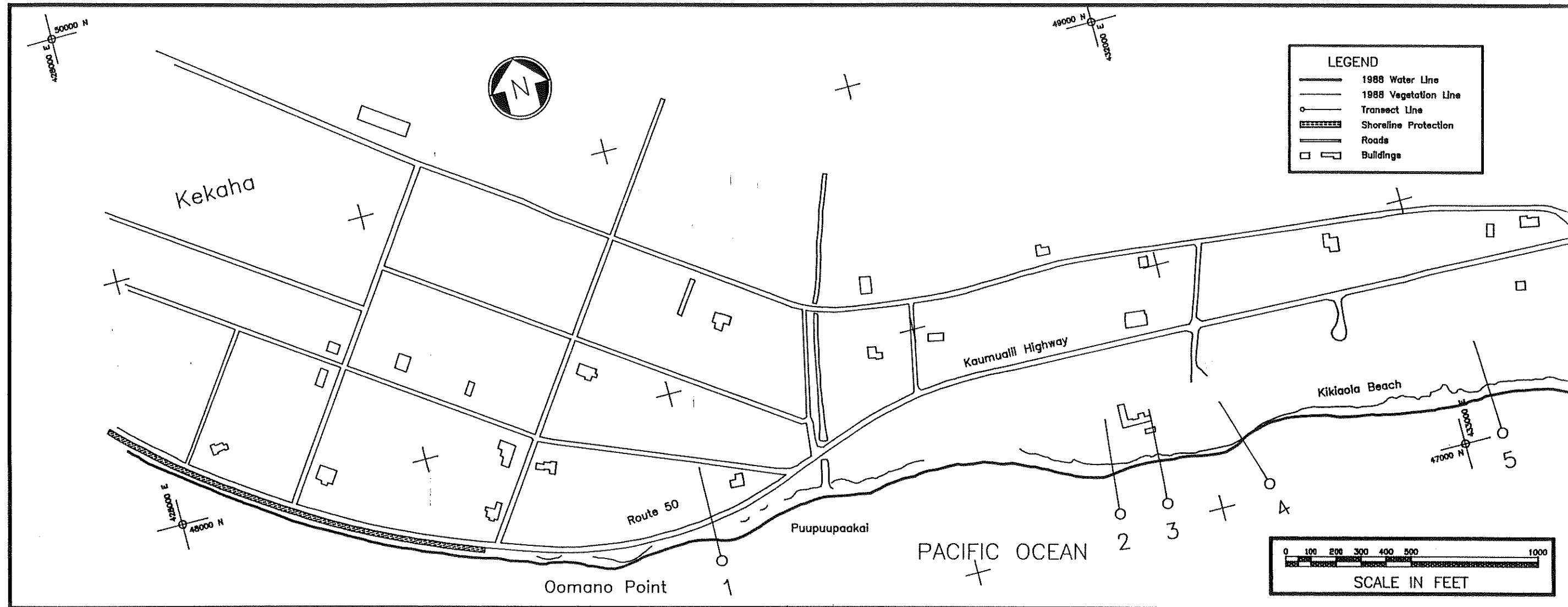
### BEACH HISTORY

- Kikiaola Beach and the beach west of Oomano Point have a history of severe erosion. Kikiaola Small Boat Harbor, built in 1959, appears to have disrupted the predominantly westward littoral transport. Regions 1 through 5 all indicate net erosion, with the most severe erosion occurring just west of the harbor.
- At Oomano Point and westward, the shoreline eroded to the point that the main highway was threatened. An extensive revetment was constructed by the U.S. Army Corps of Engineers to protect the highway.
- Regions 2 and 3 show the shoreline changes in front of the single family houses. Over 40 feet of erosion has occurred since 1960. The erosion apparently is ongoing. There is a 2 to 3 foot erosion scarp through the area and some coconut trees are threatened. The vegetation line protrudes seaward at this point, and the trees appear to have temporarily stabilized the beach.

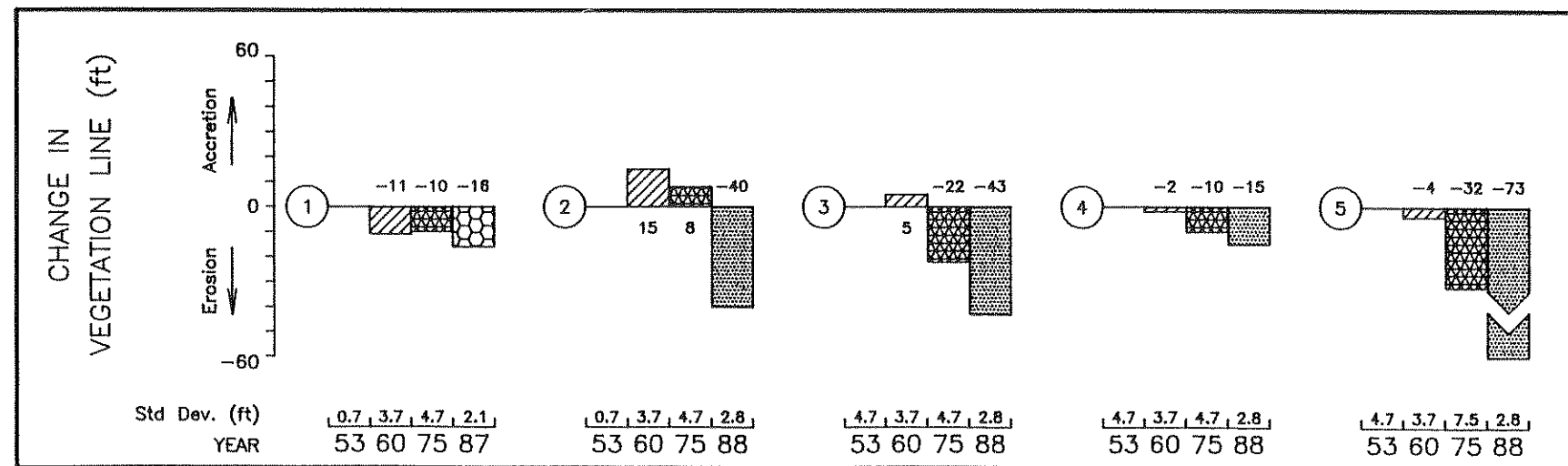
- The site visit showed that this scarp extends east to the boat harbor. The scarp tapers off west of the houses.

### SUMMARY

- Kikiaola Beach has eroded severely since the construction of the small boat harbor, which interrupted the predominant westward littoral drift. This resulted in the construction of the massive revetment at Oomano Point.
- The beach in front of the houses is eroding, and this is a potential problem area.

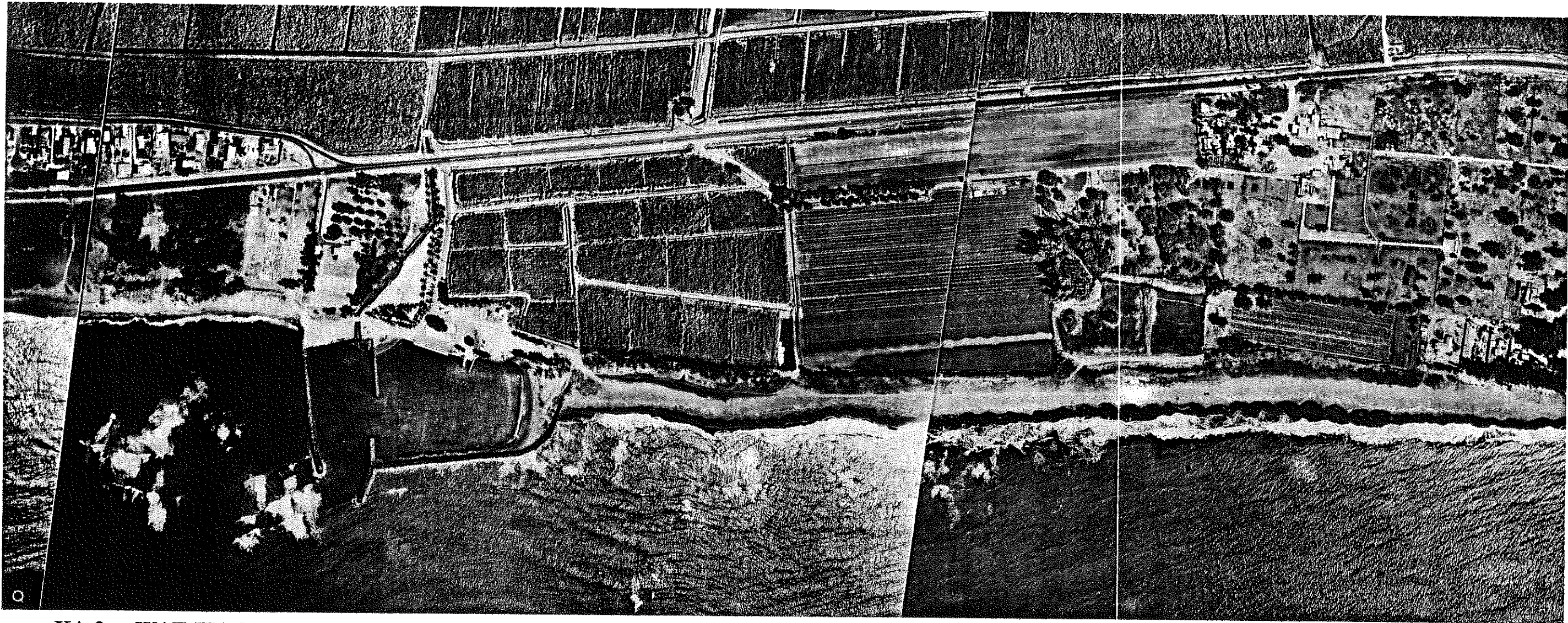


**FIGURE KA-1**



**GRAPH KA-1 Region Number vs Change in Vegetation Line**

**PHOTOS USED**  
 March 1988  
 July 1987  
 April 1975  
 January 1960  
 December 1953



**KA-2: WAIMEA BEACH (WEST END)**

**BEACH DESCRIPTION**

- Waimea Beach is an 8000 foot long beach located between Kikiaola Small Boat Harbor and Waimea River. As discussed for Sector KA-1, the brown color of the sand is due to the terrestrial material discharged by Waimea River.
- The beach is relatively wide (70 feet) at the west end and narrows to 30 feet at the east end.

**BACKSHORE**

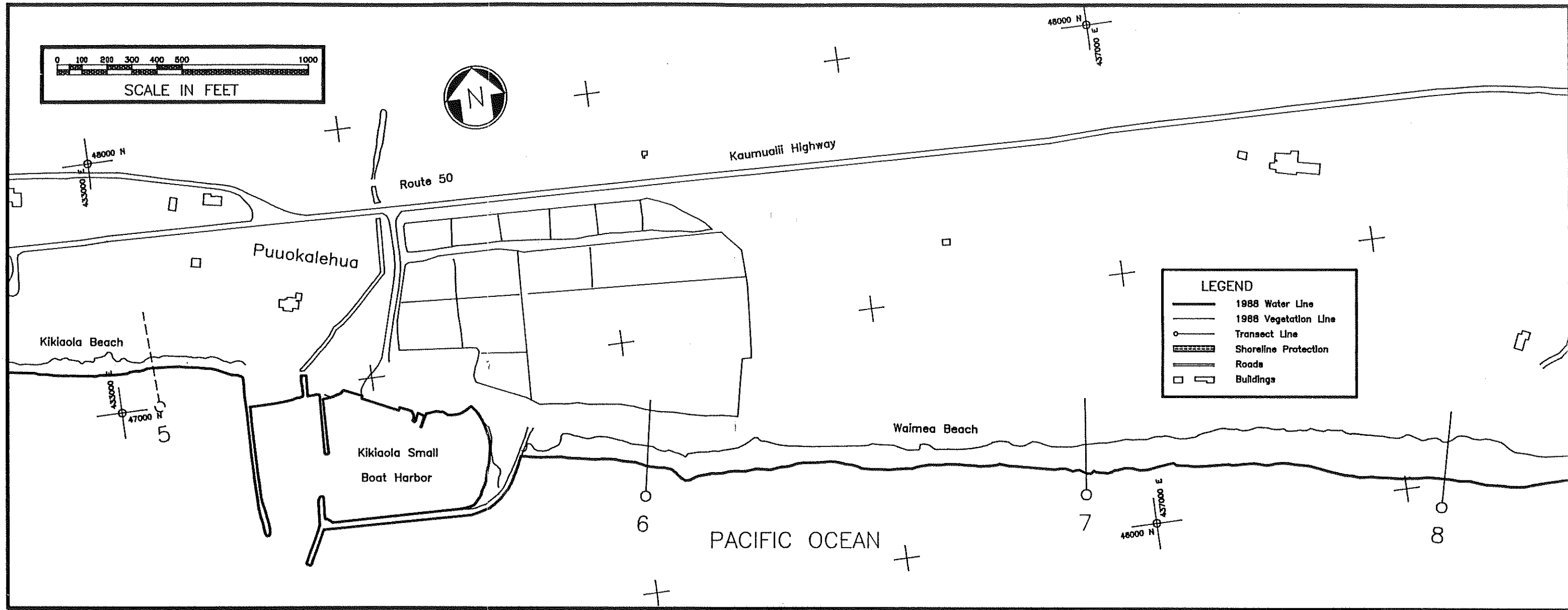
- Except for the small boat harbor, the backshore of this subsector is in agricultural use. There are no buildings near the shoreline.

**SHORELINE HISTORY**

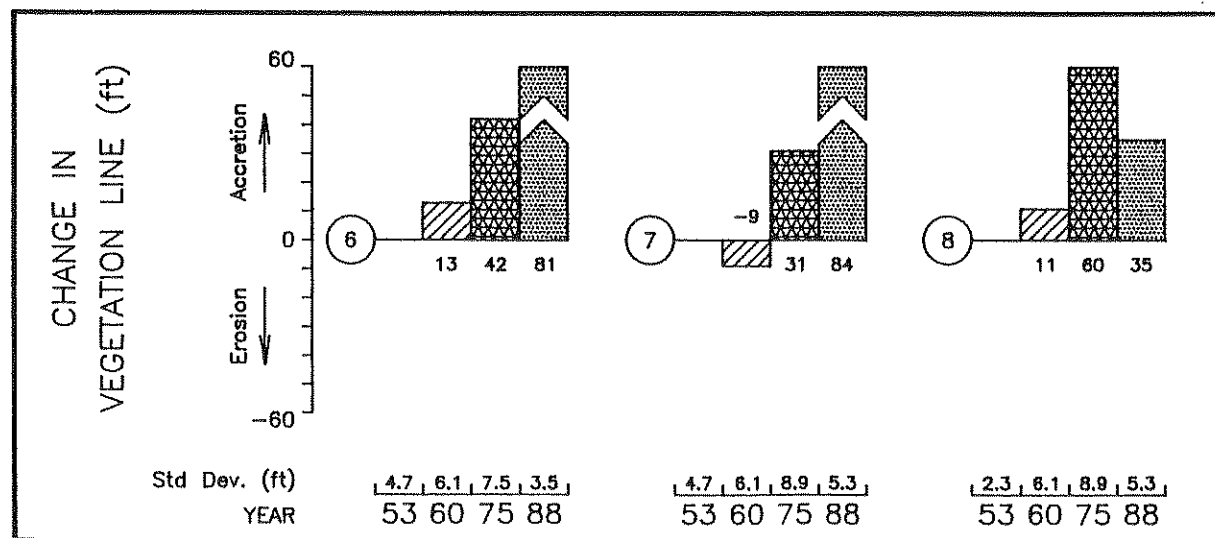
- Kikiaola Harbor has acted as a large groin by blocking predominant westward sand transport. This subsector is on the updrift side and the regions (6, 7 & 8) all indicate a net accretion.
- The beach was relatively stable from 1953 to 1960. Most of the accretion occurred after the construction of the harbor in 1959.

**SUMMARY**

- The accretion in this subsector is due to the same mechanism that caused the erosion in subsector KA-1, the blockage of the westward littoral drift by the harbor. In addition to the erosion and accretion of the adjacent downdrift and updrift shorelines, the littoral transport has resulted in chronic shoaling problems in the entrance channel of the harbor.



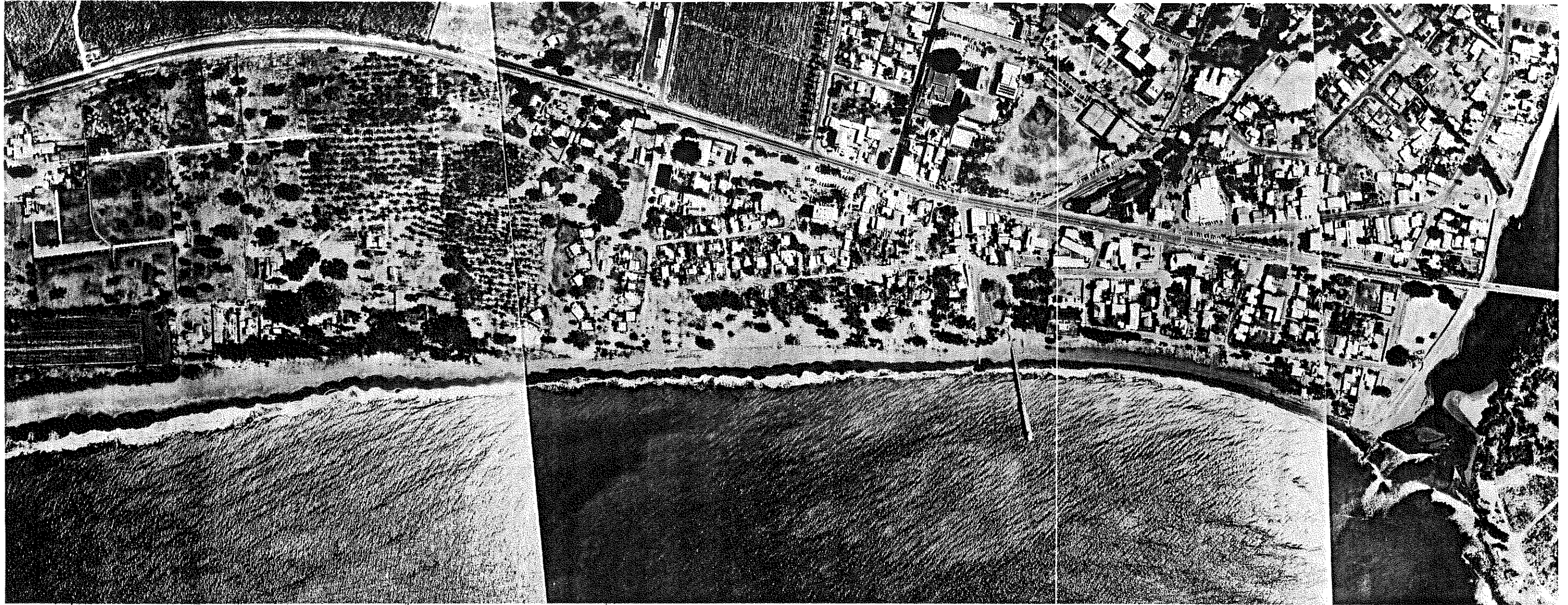
**FIGURE KA-2**



**GRAPH KA-2 Region Number vs Change in Vegetation Line**

**PHOTOS USED**  
March 1988  
July 1987  
April 1975  
January 1960  
December 1953





### KA-3: WAIMEA BEACH (EAST END)

#### BEACH DESCRIPTION

- The east end of Waimea Beach is a continuation of the beach described in subsector KA-2. The beach consists of a mixture of calcareous sand, and terrestrial and volcanic material.
- Typical beach width through this sector is 50 feet, except near the river where the beach is over 100 feet wide.

#### BACKSHORE

- The backshore is one of the residential areas of the town of Waimea, and is almost entirely developed with single family homes. The Waimea Pier, near the east end of the sector, is an old boat landing now used for recreational fishing. Lucy Wright Beach Park is located adjacent to the Waimea River.

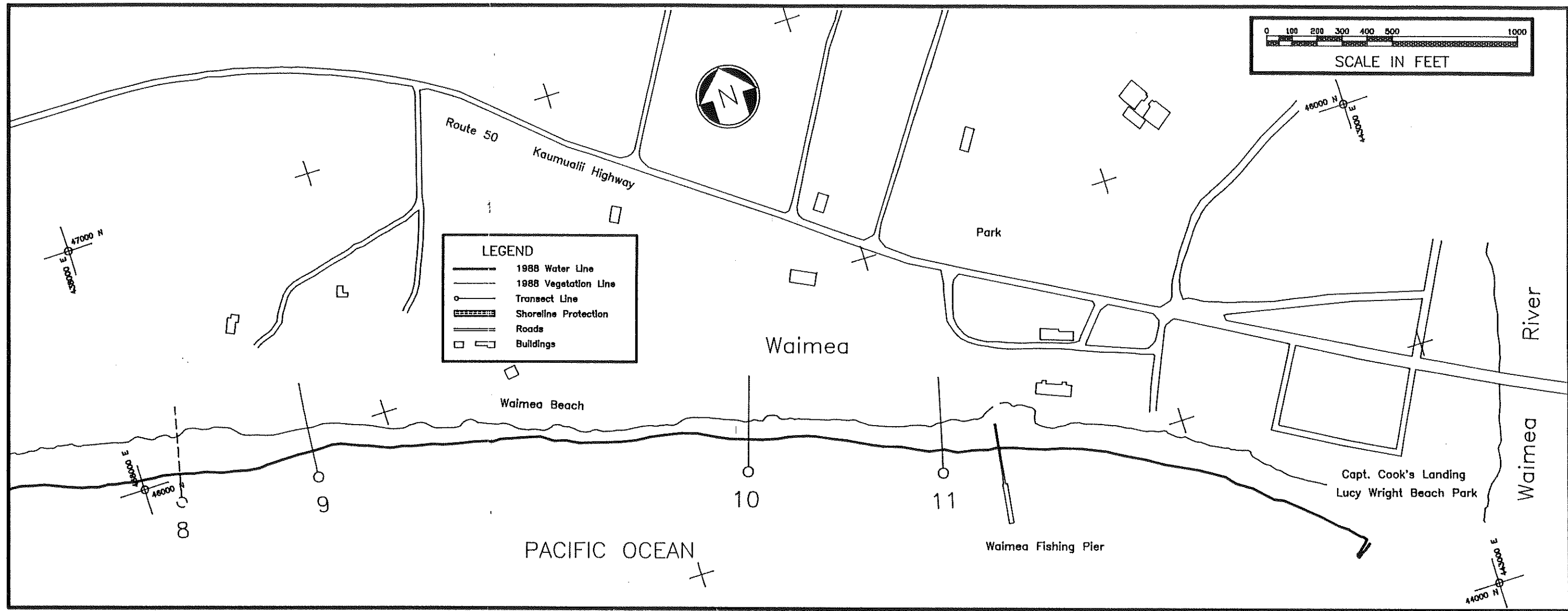
#### BEACH HISTORY

- According to the U.S. Army Engineer District (1971), the 3000 feet of shoreline west of the Waimea River eroded steadily since the early 1900's. Our 1953 aerial photographs showed several indications of ongoing erosion. There were scattered small seawalls, at least two groins across the beach, and an intermittent wave cut scarp.
- In contrast, the data for regions 9, 10 and 11 show net accretion from 1953 to 1988, and particularly from 1960 to 1988. Apparently, construction of the boat harbor reversed the previously severe erosion.

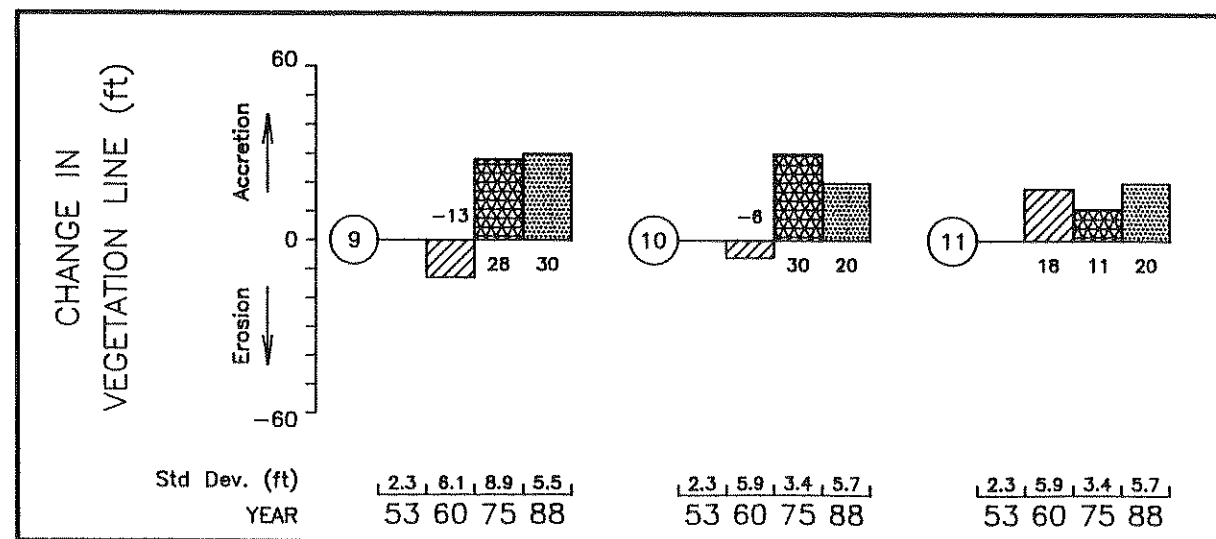
- During the site visit, it was apparent that the area east of the fishing pier was also accreting. There was evidence that 60 to 70 feet of accretion had occurred.

#### SUMMARY

- Severe erosion in this subsector was reversed by construction of the Kikiaola Small Boat Harbor in 1959.



**FIGURE KA-3**



**GRAPH KA-3 Region Number vs Change in Vegetation Line**

**PHOTOS USED**  
 March 1988  
 July 1987  
 April 19775  
 January 1960  
 December 1953

## **SECTOR KB: SOUTHEAST KAUAI MAKAHUENA POINT TO HAULA BEACH**

### **GENERAL COASTAL CHARACTERISTICS**

This 18,000 foot long sector, shown on the facing page, consists of a series of rocky basalt points, low cliffs and a few intermittent beaches. Only 28 percent of the sector, or a length of approximately 5000 feet, consists of sandy shoreline. Makahuena Point is a basalt sea cliff, 40 feet high at the point, tapering to 5 feet or less at Keoniloa Bay. The shoreline along Keoniloa Bay, known as Shipwreck Beach, is the largest sandy beach in this sector. Immediately north of Shipwreck Beach is a 9000 foot long stretch of shoreline that consists of limestone and basalt sea cliffs, up to 35 feet high. In several locations, the cliffs are backed by lithified sand dunes, a common feature throughout this sector. In the vicinity of Makawehi Point, the dunes are unvegetated, and give the appearance of a perched beach. However, the waterline is a 30 to 40 foot limestone sea cliff, and the dunes are well above normal wave influence.

Mahaulepu is the name given to the two mile long coastline from Punahoa Point to Naakea Point. The shoreline consists primarily of limestone and basalt sea cliffs up to 40 feet high, with three beach areas. The first two are known as Gillen's Beach and Kawaiiloa Bay. The two beaches are contiguous, and together are approximately 2400 feet long. The third beach is Haula Beach, a small pocket beach, 400 feet long, at the head of a narrow cove.

### **LAND USE AND DEVELOPMENT**

A large resort hotel, the Hyatt Regency, was constructed after 1988, and now occupies the backshore area of Shipwreck Beach. There is public access at the north end of the beach.

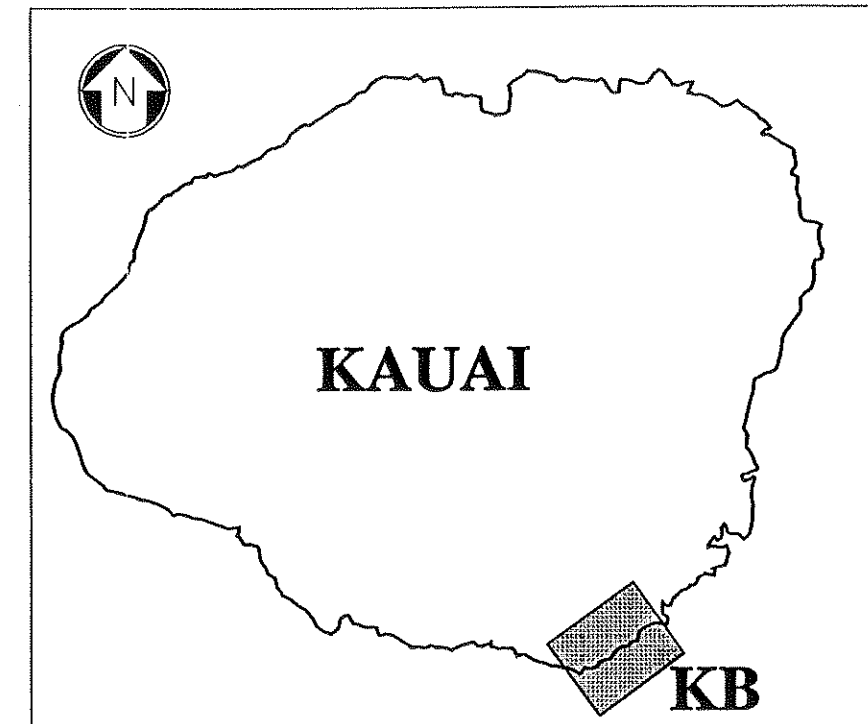
The Mahaulepu backshore is almost all open space. There is one house in the middle of Gillen's Beach, built by a former supervisor for the Grove Farm Company. A large quarry is located inland of Gillen's Beach, but is not close enough to affect the natural behavior of the beach. The rest of the shoreline in this sector is undeveloped.

### **WAVE CLIMATE**

This sector is directly exposed to tradewind generated waves and Kona storm waves. There are no fringing reefs, and with deep water close to shore, the beaches are exposed to the full force of the incoming waves.

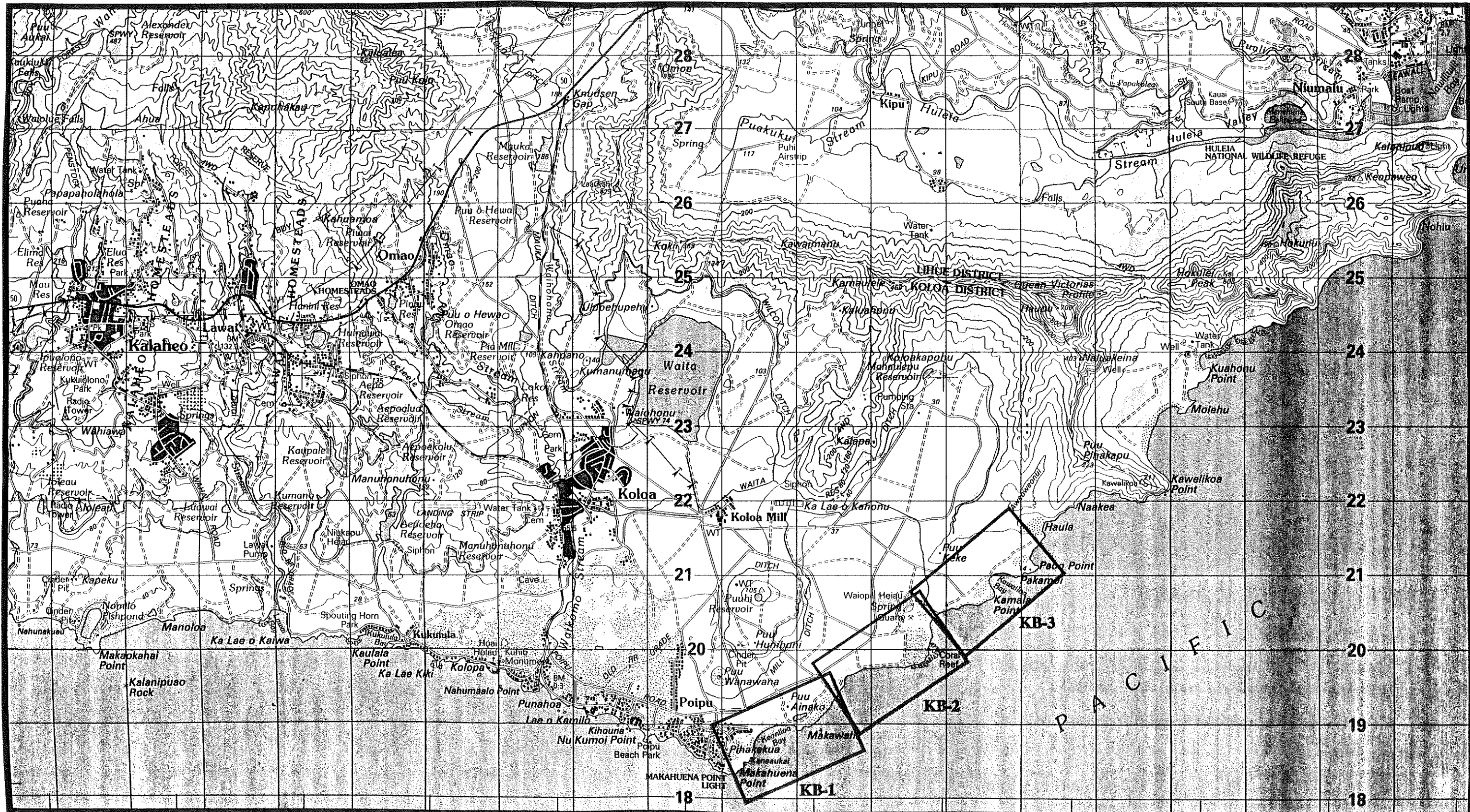
### **SHORELINE PROCESSES**

There are three separate littoral cells in this sector: Shipwreck Beach, Gillen's Beach and Kawaiiloa Bay, and Haula Beach. According to Clark (1990), all three areas are impacted by severe Kona storms. Much of the beach sand is stripped away during the storms, exposing the extensive beachrock shelves which lie below. The extensive lithified sand dunes which are common through this sector are a result of the prevailing onshore trade winds. This aeolian transport is probably a significant factor in the overall sand balance of the beaches.



### **BEACH USAGE**

With the exception of Shipwreck Beach, access is limited throughout this sector. This sector includes some of the most scenic shoreline on Kauai's south shore. The lithified sand dunes are geologically unique, and the area is of great interest to both geologists and archaeologists.

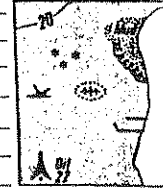


PACIFIC

**SOUTHEAST KAUI**

**LEGEND**

- HYDROGRAPHIC DATUM ..... MEAN LOWER LOW WATER
- Depth curve (meters) \_\_\_\_\_
- Foreshore flats \_\_\_\_\_
- Rocks, break, Reef \_\_\_\_\_
- Wreck: Exposed, Sunken with masts exposed \_\_\_\_\_
- Wharf, pier \_\_\_\_\_
- Seawall \_\_\_\_\_
- Oil/gas rig \_\_\_\_\_



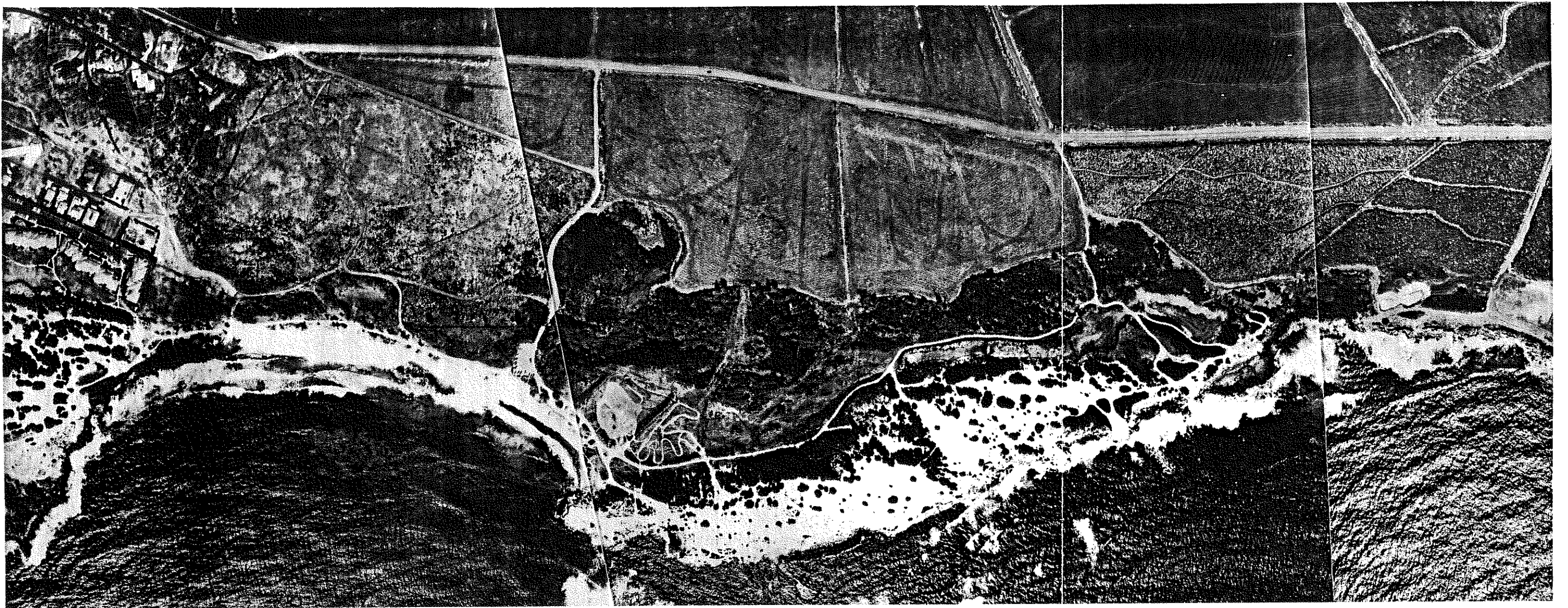
Scale: 1:50,000



Statute Miles



From U.S. Geological Survey  
MAP INFORMATION AS OF 1983



## KB-1: SHIPWRECK BEACH

### BEACH DESCRIPTION

- Shipwreck Beach is a 1600 foot long calcareous sand beach located at the head of Keoniloa Bay, a gentle coastal indentation.
- The toe of the beach is stabilized by extensive beachrock and basalt boulder outcroppings.

### BACKSHORE

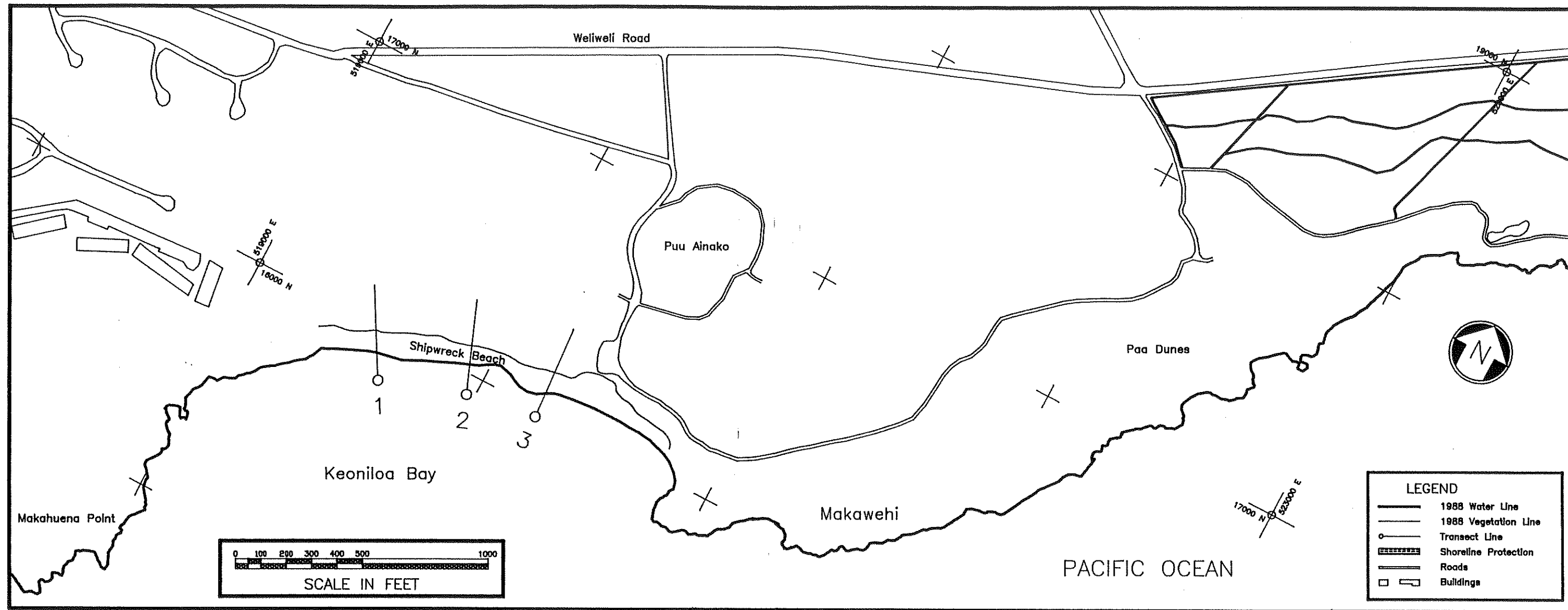
- A large resort hotel, the Hyatt Regency, was built on the backshore of the beach some time after 1988. The main hotel buildings are set well back from the beach. There is public access on the north side of the beach.

### BEACH HISTORY

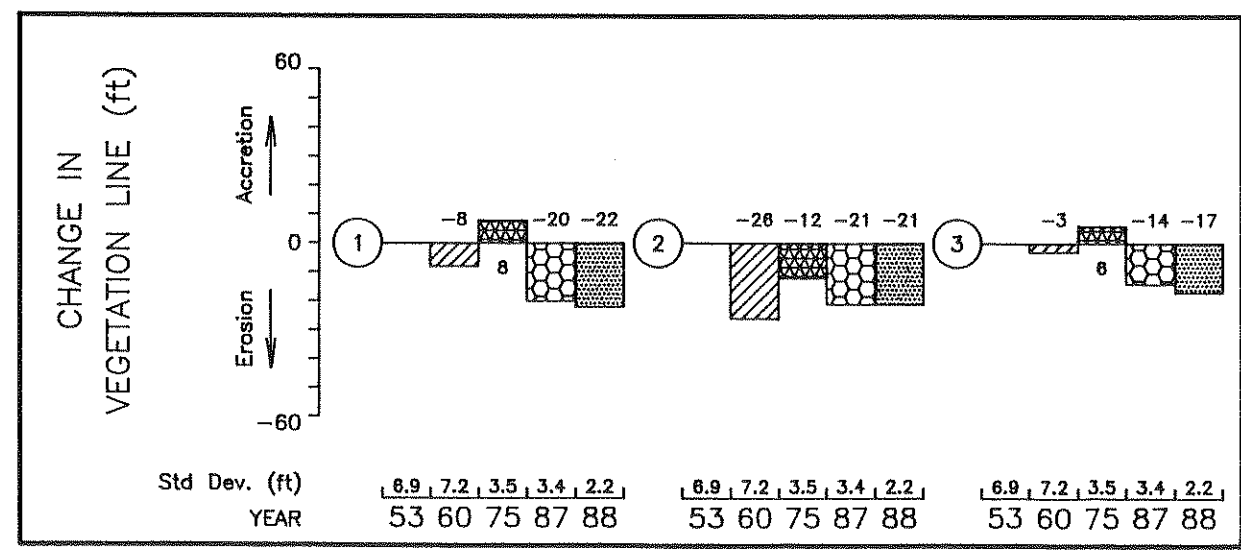
- The aerial photographs indicate that the overall trend for this beach is erosion of the vegetation line (Regions 1, 2 and 3).
- During the site visit for this study, no evidence of ongoing erosion was noted. The apparent erosion over past years may have been at least partially due to off-road vehicles affecting the vegetation or the onshore transport of wind-blown sand.

### SUMMARY

- The data for this beach are questionable due to possible changes in the vegetation line due to recreational use and onshore transport of wind-blown sand. However, from all indications, including the observed behavior of the beach over the years, it is a dynamic beach that is subject to relatively large changes, particularly during Kona storms.

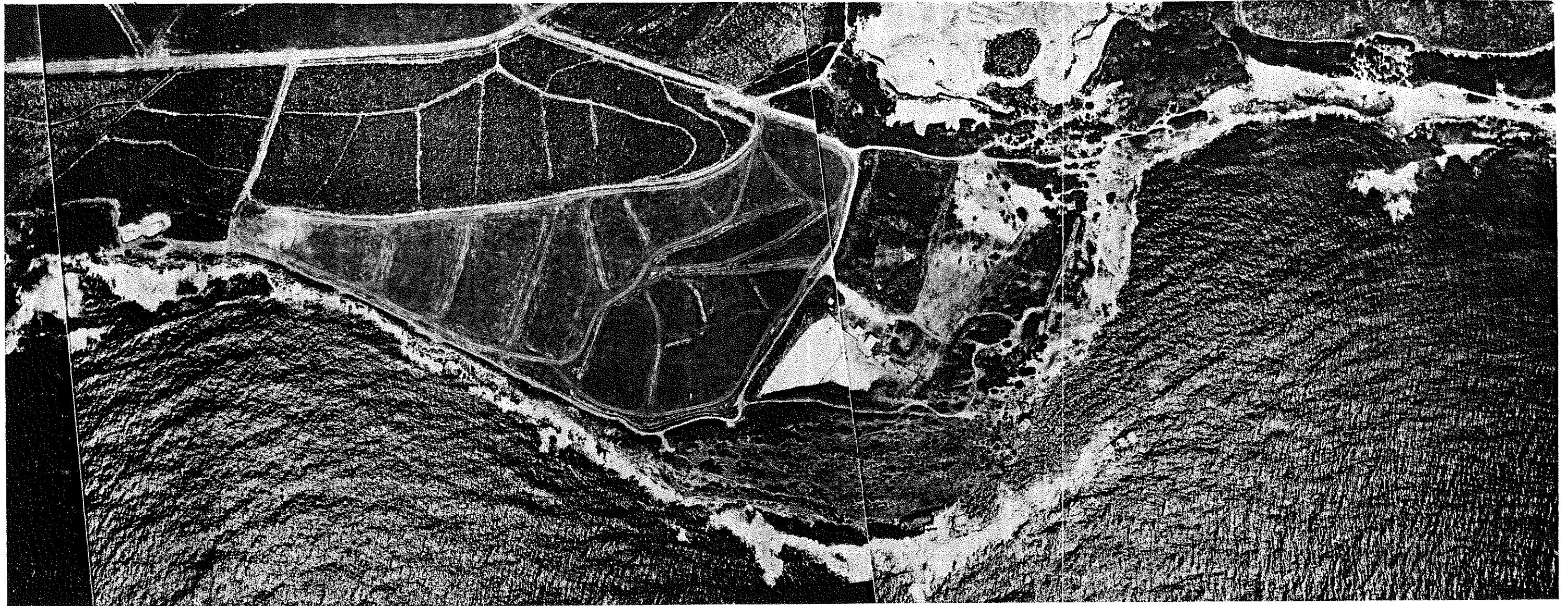


**FIGURE KB-1**



**GRAPH KB-1 Region Number vs Change in Vegetation Line**

**PHOTOS USED**  
 March 1988  
 July 1987  
 April 1975  
 March 1960  
 December 1953



## **KB-2: PUNAHOA POINT/GILLEN'S BEACH**

### **BEACH DESCRIPTION**

- The only sandy beach in this subsector is the west end of Gillen's Beach. The rest of the shoreline consists of limestone and basalt sea cliffs up to 40 feet high, and one small boulder beach.

### **BACKSHORE**

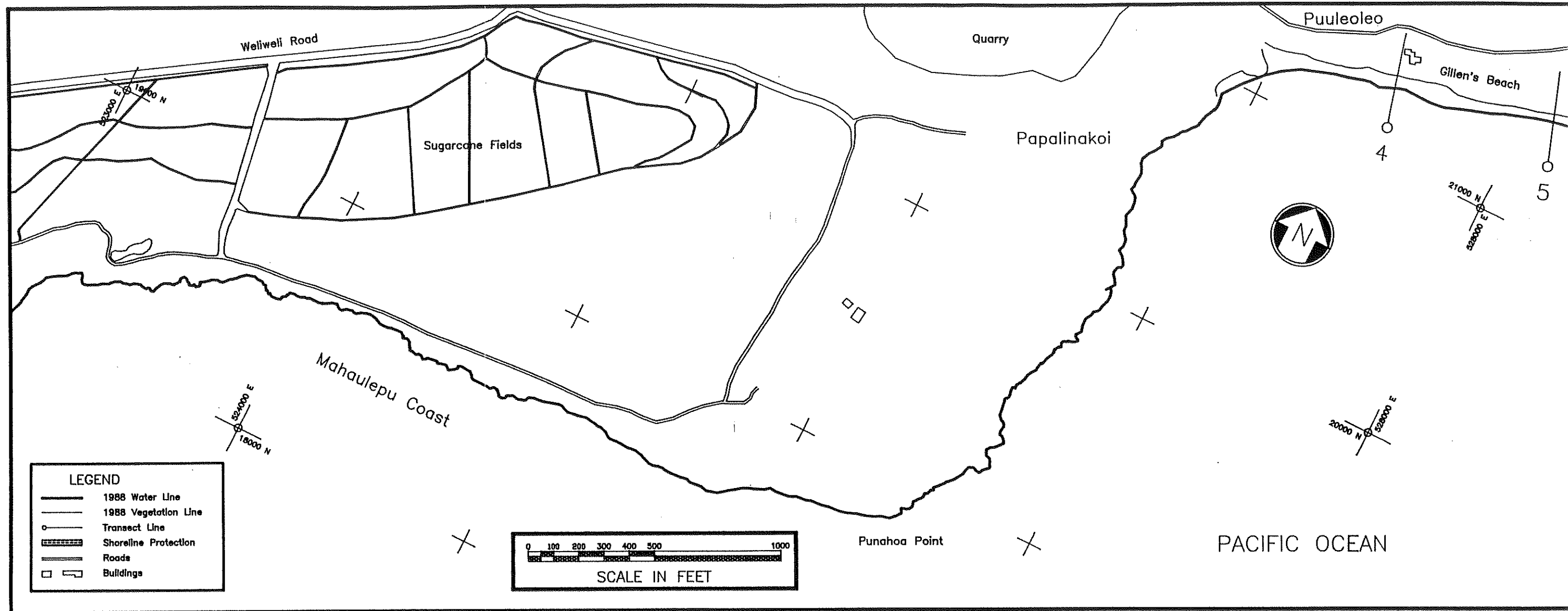
- Lithified sand dunes or sugar cane fields occupy most of the backshore area. There is one house on the backshore of Gillen's Beach. A large sand quarry is located behind the west end of Gillen's Beach.

### **BEACH HISTORY**

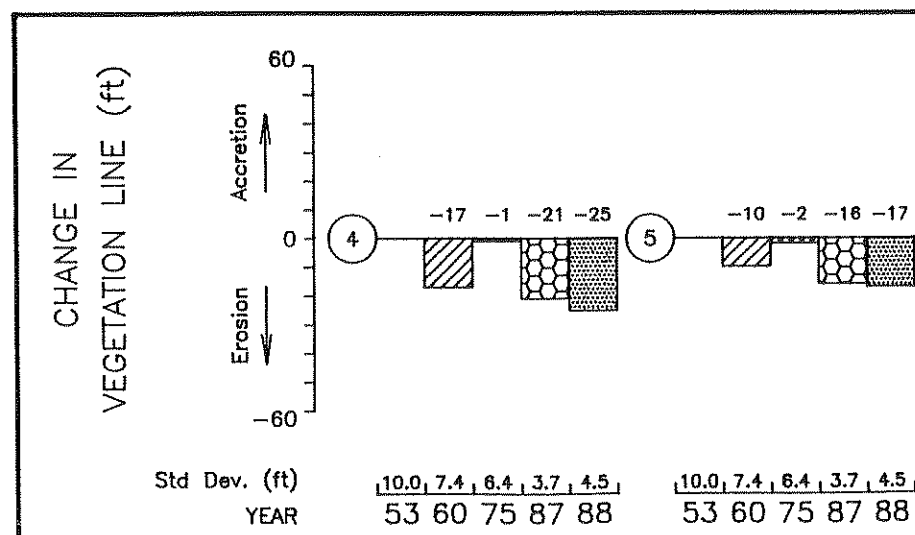
- The aerial photographs indicate that Gillen's Beach has eroded since 1963 (Regions 4 and 5). However, as at other beaches in this sector, the vegetation line changes may be due more to other processes than to wave-induced erosion.

### **SUMMARY**

- Gillen's Beach is the only sandy beach in this subsector. The beach has eroded slightly since 1963.



**FIGURE KB-2**



**GRAPH KB-2 Region Number vs Change in Vegetation Line**

**PHOTOS USED**  
 March 1988  
 July 1987  
 April 1975  
 March 1960  
 December 1953





### KB-3: GILLEN'S BEACH TO HAULA BEACH

#### BEACH DESCRIPTION

- The beach west of Kamala Point is known as Gillen's Beach; the sandy shoreline continues around Kamala Point into Kawailoa Bay, where it is known as Kawailoa Beach. The overall length of continuous sandy beach is 4000 feet.
- Haula Beach is a small, 300 foot long pocket beach located at the head of a small embayment at the north end of the subsector.
- The shoreline between the two beaches consists of limestone and basalt sea cliffs that are 5 to 35 feet high. The only reef in this subsector is located off Kamala Point.

#### BACKSHORE

- The immediate backshore is undeveloped, and cane fields are located further inland. Lithified sand dunes occur throughout the area, and as mentioned earlier, are of great geological and archaeological interest.

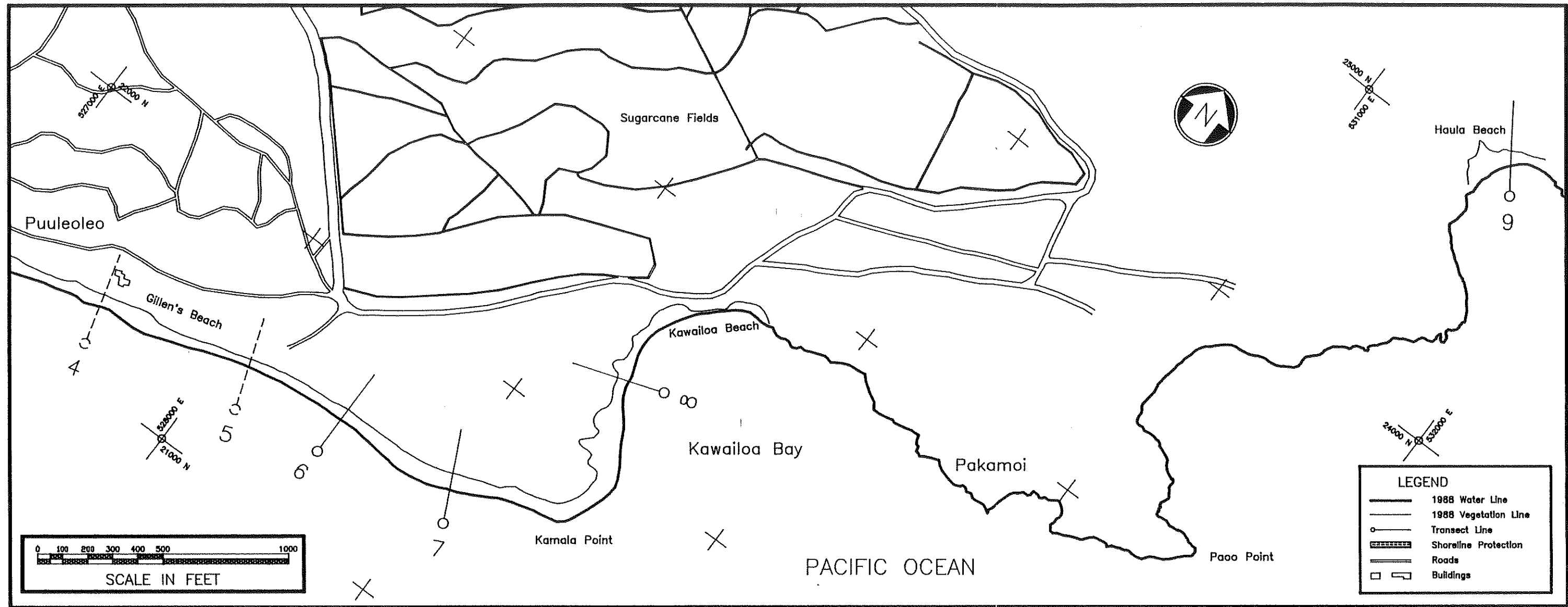
#### BEACH HISTORY

- All beach areas in this subsector appear to be relatively stable (Regions 6, 7, 8 and 9). Measured changes may be as much due to wind blown sand obscuring the vegetation line as to normal littoral processes.

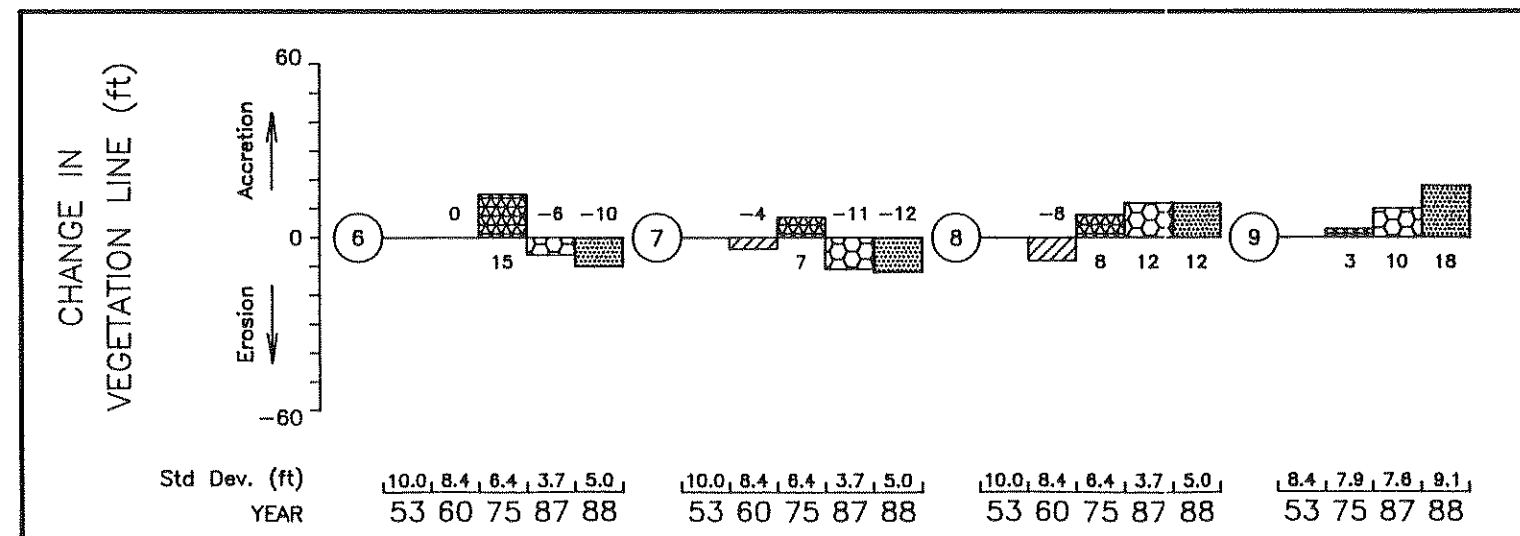
- Extensive beachrock outcrops are common through this subsector, and apparently stabilize the waterline position.

#### SUMMARY

- The backshore in this subsector is undeveloped. the beaches are stable, although they are exposed to Kona storm waves.



**FIGURE KB-3**



**GRAPH KB-3 Region Number vs Change in Vegetation Line**

**PHOTOS USED**  
 March 1988  
 July 1987  
 April 1975  
 March 1960  
 December 1953

## SECTOR KC: EAST KAUAI HANAMAULU BAY TO KEALIA

### GENERAL COASTAL CHARACTERISTICS

Except for the beaches at Hanamaulu Bay and Kealia Bay, which are both bounded by rocky shorelines, there is a continuous sandy beach along the shoreline of this 8 mile long sector. A fringing reef extends along most of the shoreline, except at Hanamaulu Bay, Wailua Bay and Kealia Bay. Relatively large streams discharge into these bays. Minor breaks in the reef occur at the Waikaea and Moikeha Canals where streams also discharge into the ocean.

### LAND USE AND DEVELOPMENT

The backshore of this sector is one of the major population centers of Kauai, and includes the towns of Wailua and Kapaa. The shoreline is almost completely developed, and uses include beach parks, major resorts, a golf course, single family houses, and condominiums and apartments.

### WAVE CLIMATE

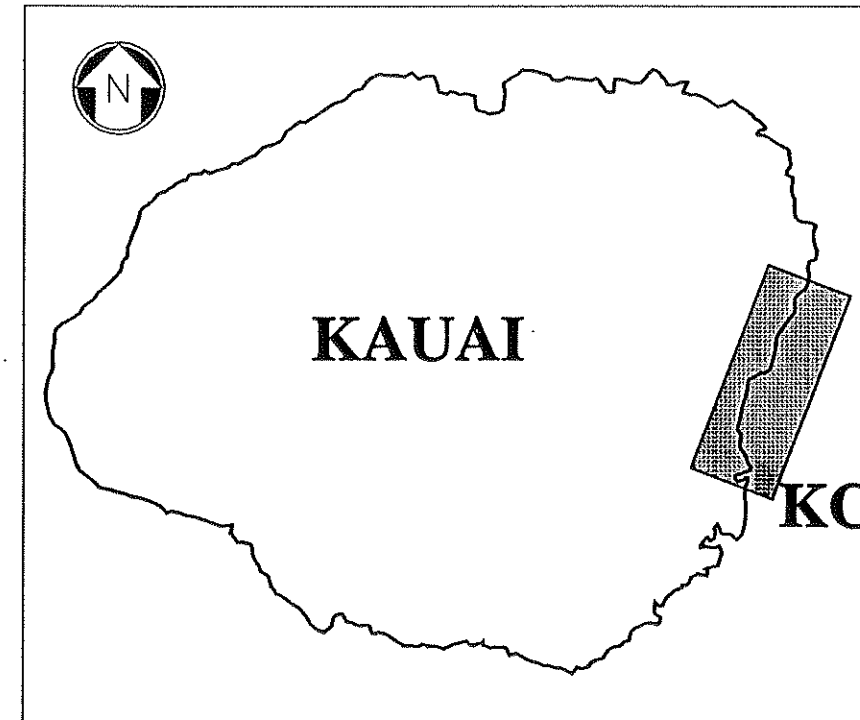
This sector is on the windward side of the island, and is directly exposed to the prevailing tradewinds and the tradewind generated waves. The tradewind waves occur throughout the year, but occur most frequently from April to September. Typical heights range from 4 to 10 feet, but during northeast gales, wave heights up to 25 feet can occur. Both south swell and north Pacific swell could refract into this area, but the tradewind waves are the predominant source of wave energy for this sector.

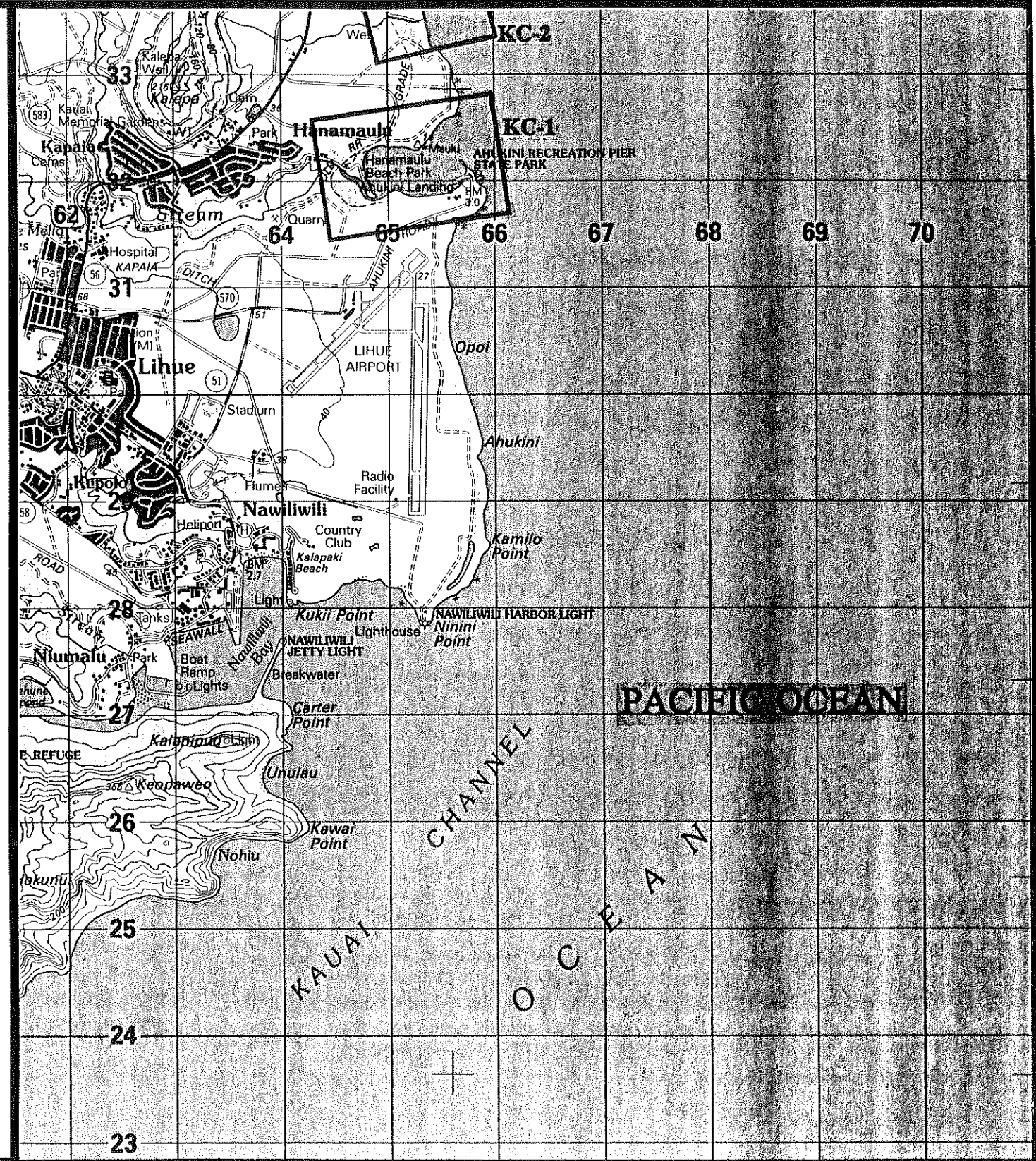
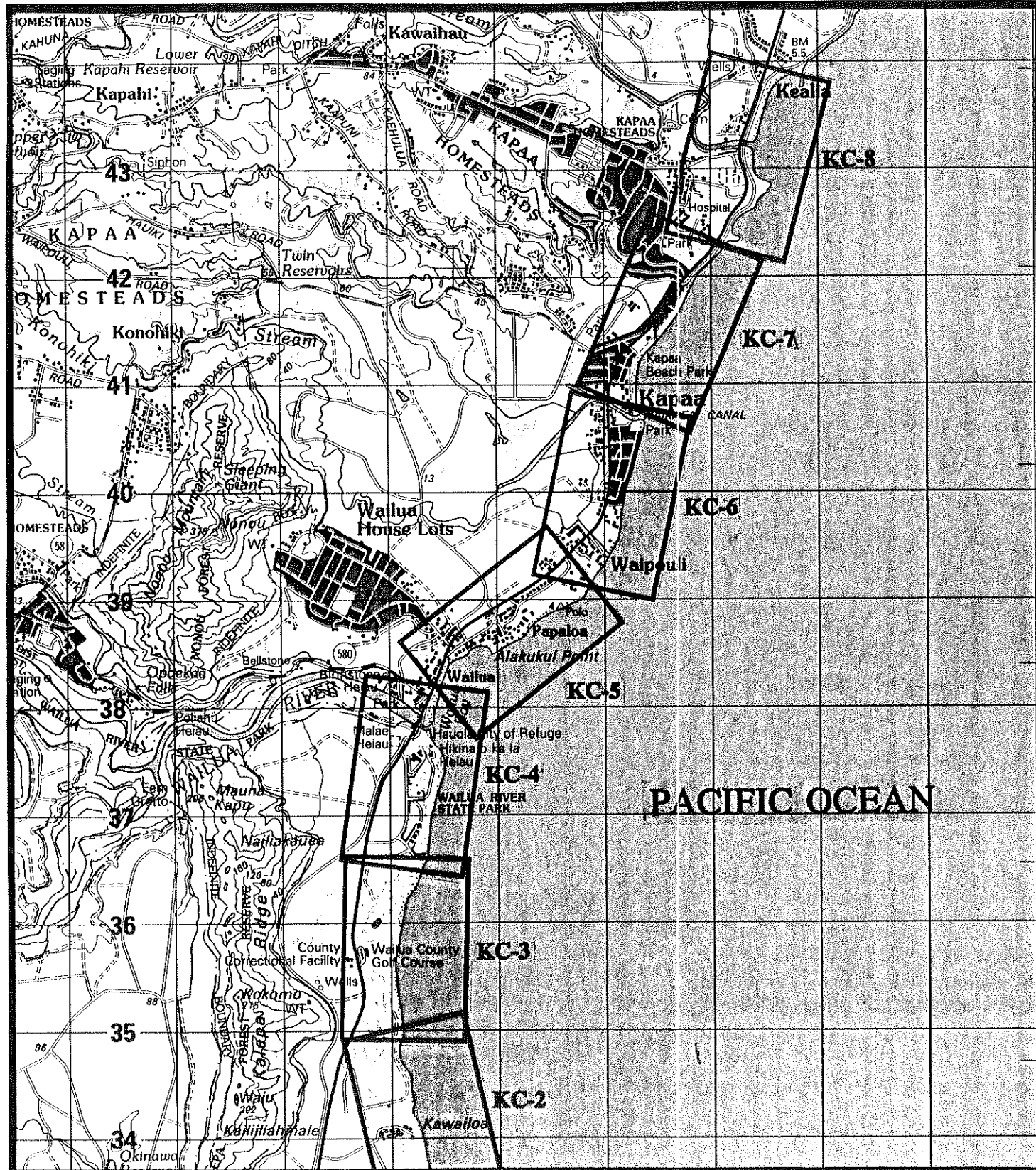
### SHORELINE PROCESSES

The natural shoreline processes in this sector have been altered by modifications of the coast associated with backshore development. These modifications include dredged channels through the fringing reef, groins across the beach, borrow pits cut into the reef flat, jetties to channelize stream flow and man made swimming holes on the reef flat, some of which are enclosed by boulder walls. Extensive, severe erosion has occurred in areas of this sector, and in many instances revetments or seawalls have been built to protect the backshore development. The shore protection, in turn, has further modified the ongoing littoral processes.

### BEACH USAGE

Although this sector is heavily used for recreation, the beaches are not of the same high quality as the north shore beaches of Kauai. Most of the beaches are narrow, and beachrock shelves at the waterline are common, making access to the water difficult. Also, the water is frequently rough and turbid due to the prevailing tradewind waves.





**LEGEND**

HYDROGRAPHIC DATUM ..... MEAN LOWER LOW WATER

Depth curve (meters) \_\_\_\_\_

Foreshore flats \_\_\_\_\_

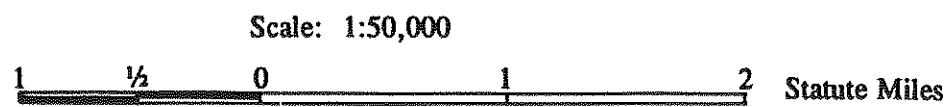
Rocks awash, Reef \_\_\_\_\_

Wreck: Exposed, Sunken with masts exposed \_\_\_\_\_

Wharf, pier \_\_\_\_\_

Seawall \_\_\_\_\_

Oil/gas rig \_\_\_\_\_



From U.S. Geological Survey  
MAP INFORMATION AS OF 1983

**EAST KAUAI**



## KC-1: HANAMAULU BAY

### BEACH DESCRIPTION

- Hanamaulu Beach is a 1500 foot long sand beach at the head of Hanamaulu Bay. The coastline along both sides of the bay is a low basalt sea cliff. Typical beach width is 35 feet. Hanamaulu Stream discharges across the south end of the beach and the nearshore water is almost always turbid, limiting the recreational potential of this area.

### BACKSHORE

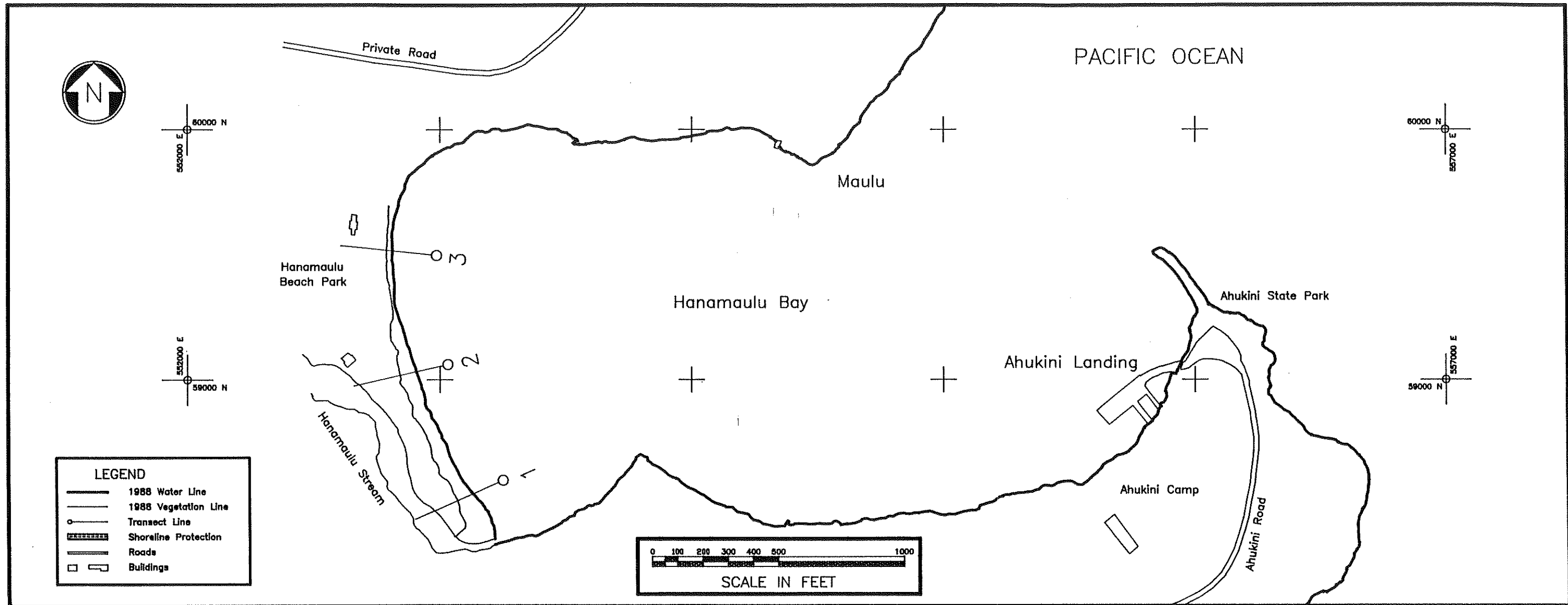
- Hanamaulu Beach Park occupies the backshore area; there are no structures close to the vegetation line.

### SHORELINE HISTORY

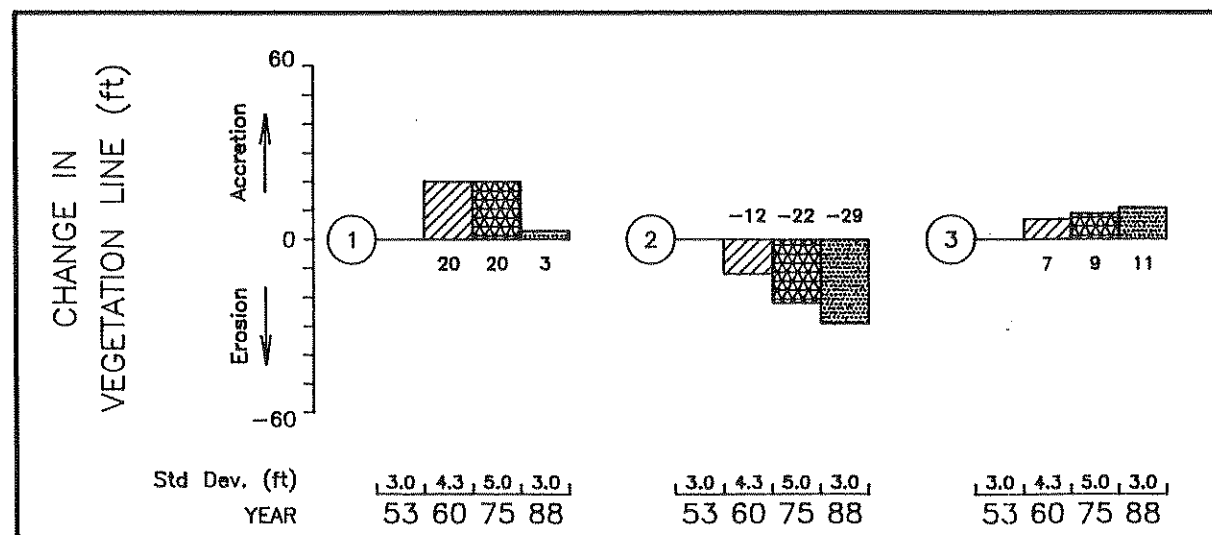
- The two ends of Hanamaulu Beach (Regions 1 and 3) have either remained stable or accreted slightly since 1953. The central portion (Region 2) has eroded steadily; net recession of the vegetation line was 29 feet.

### SUMMARY

- The south end of the beach is relatively dynamic, and probably affected by the river discharge. The erosion of the middle section of the beach, although relatively steady, does not pose a threat to structures or park facilities at this time. No significant erosion was apparent at the time of the site visit.

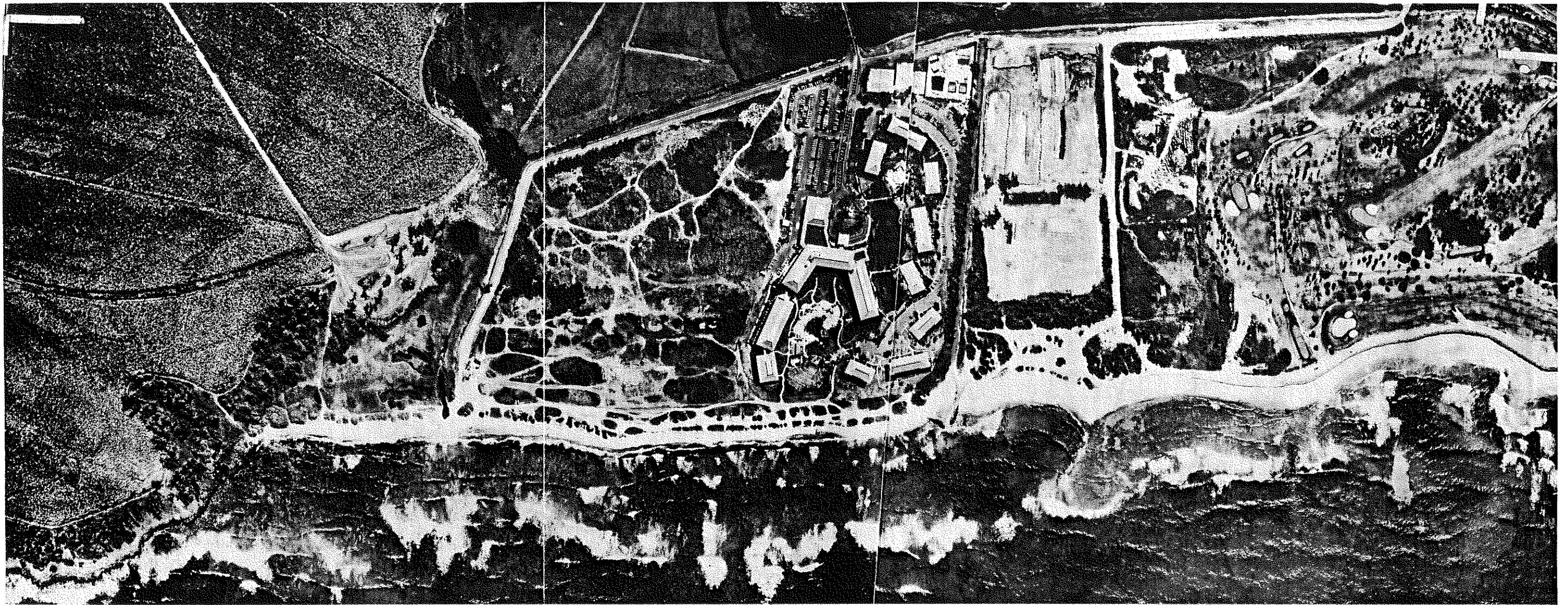


**FIGURE KC-1**



**GRAPH KC-1 Region Number vs Change in Vegetation Line**

**PHOTOS USED**  
 March 1988  
 July 1987  
 April 1975  
 January 1960  
 December 1953



## KC-2: NUKOLII TO WAILUA RIVER; SOUTH SUBSECTOR

### BEACH DESCRIPTION

- This subsector is the southern end of a 14,000 foot long, narrow beach extending from the Kauai Hilton to the Wailua River. The beach is narrow, with a typical width of 30 to 40 feet. Beach rock is exposed almost continuously at the toe of the beach along the southernmost 3000 feet of the beach. Offshore, there is a 500 foot wide fringing reef. The discharge of the drainage canal north of the hotel is protected by two man-made jetties.

### BACKSHORE

- The Kauai Hilton is located in the middle of this subsector, and the Wailua Golf Course begins at the north end. The remaining land is undeveloped.

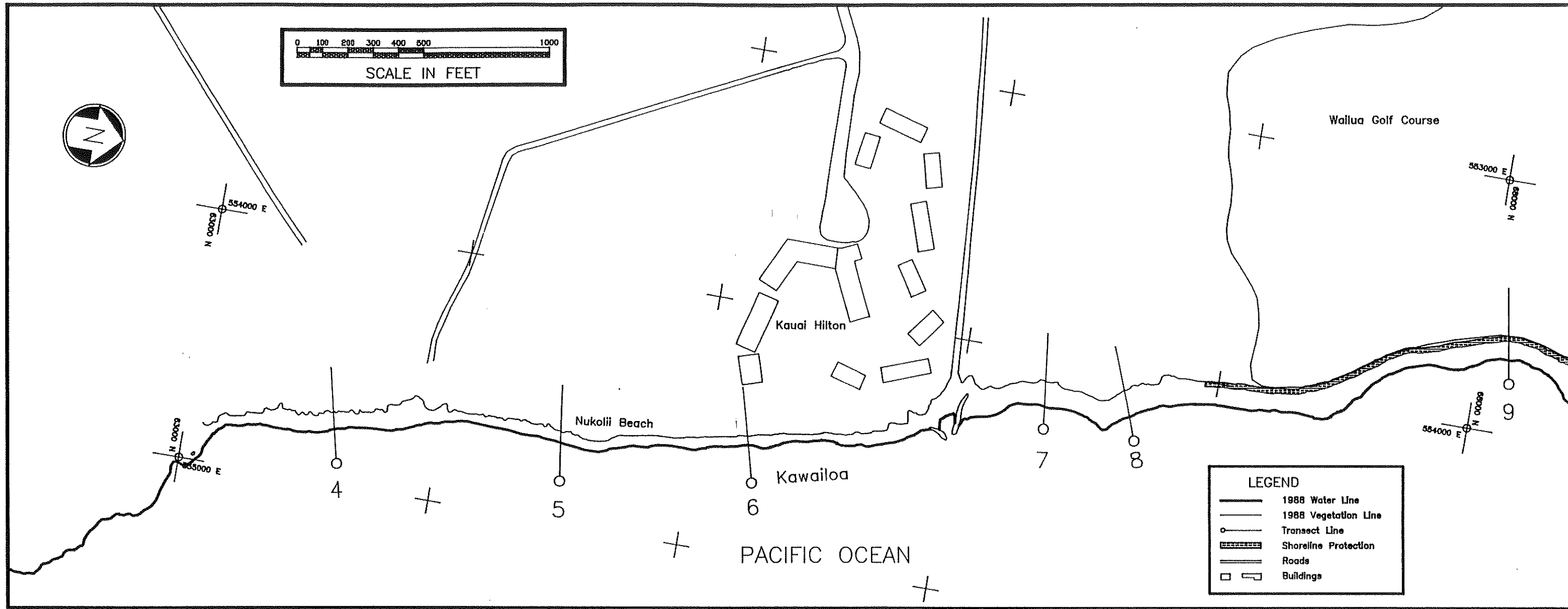
### SHORELINE HISTORY

- Although the Regions 4 and 5 indicate a dynamic vegetation line, the waterline position appears to have changed little over the years along the southern 2000 feet of the beach (from the start of the beach on the south to the drainage ditch just north of the Kauai Hilton). The exposed beachrock shelf at the beach toe has apparently stabilized the water line position.
- Localized erosion has occurred immediately south of the drainage canal, apparently due to interruption of the north to south sand transport. In front of the hotel, there is a 3 to 5 foot erosion scarp, with a steep beach foreshore. Region 6 indicates the beach eroded 24 feet between 1975 and 1988.

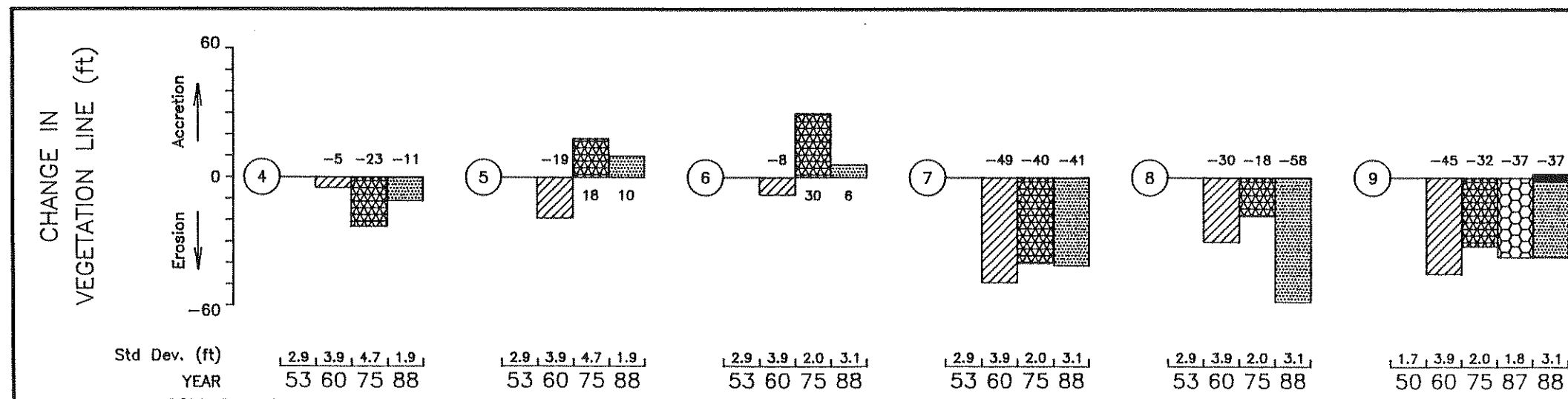
- North of the Kauai Hilton, there is little or no exposed beachrock along the beach, and significant erosion has occurred (Regions 7, 8 and 9). An extensive revetment has been constructed to protect the Wailua Golf Course. The revetment starts in the vicinity of Region 9 and extends northward.

### SUMMARY

- The southern half of this subsector is relatively stable, due to the extensive beachrock outcroppings at the waterline. Erosion is ongoing in front of the Kauai Hilton. No structures are threatened. The northern half of the subsector has been subject to severe, chronic erosion since 1950.



**FIGURE KC-2**



**GRAPH KC-2 Region Number vs Change in Vegetation Line**

PHOTOS USED  
 March 1988  
 July 1987  
 April 1975  
 January 1960  
 December 1953





### KC-3: NUKOLII TO WAILUA RIVER; CENTRAL SUBSECTOR

#### BEACH DESCRIPTION

- The beach in this subsector is a continuation of the narrow, calcareous sand beach typical of the entire sector. The fringing reef located offshore is intermittent, and there is no exposed beachrock at the waterline.

#### BACKSHORE

- The Wailua Golf Course occupies the backshore of the entire subsector. Two fairways and one green are located at or near the vegetation line; in the remaining area the golf course is set inland and there is a band of trees and shrubs between the golf course and the vegetation line.

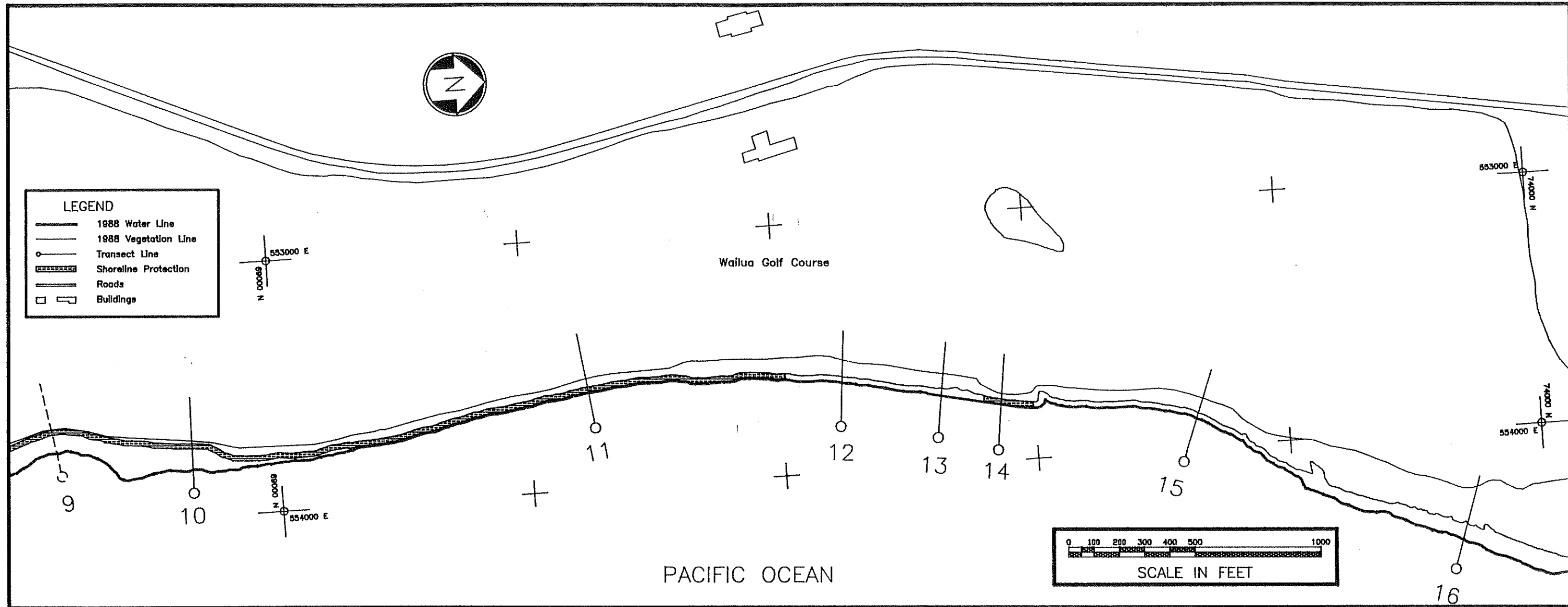
#### SHORELINE HISTORY

- A 3500 foot long revetment was constructed between 1987 and 1988 to protect two fairways of the golf course (Regions 9 to 11). The measurements indicated significant erosion (up to 53 feet) prior to construction of the revetment.
- Another revetment, approximately 250 feet long, was constructed after 1988 to protect one of the golf course greens (Region 14), despite the fact that the data show an accreting vegetation line in the area (Regions 13 and 14). The accretion was apparently due to natural beach fluctuations. The fringes of the green were extended seaward as the vegetation line accreted; the revetment was apparently built when the cycle reversed.
- Region 12 is relatively stable, and represents the transition zone between the areas that are eroding and accreting.

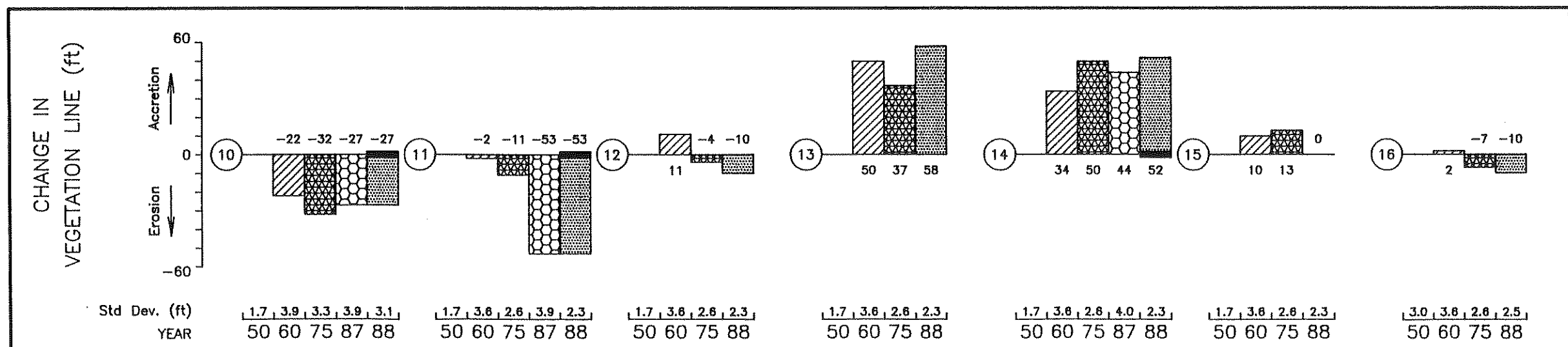
- The beach segment to the north (Regions 15 and 16) is relatively stable. The golf course is set well back from the vegetation line through this area.

#### SUMMARY

- The southern half of the beach in this subsector has been subject to chronic, long term erosion. Part of the golf course was built very close to the unstable vegetation line, and a revetment was built to protect the course. Most of Subsector KC-3 is now committed to shore protection, and the littoral processes for most of this shoreline length have probably been affected by the shore protection.

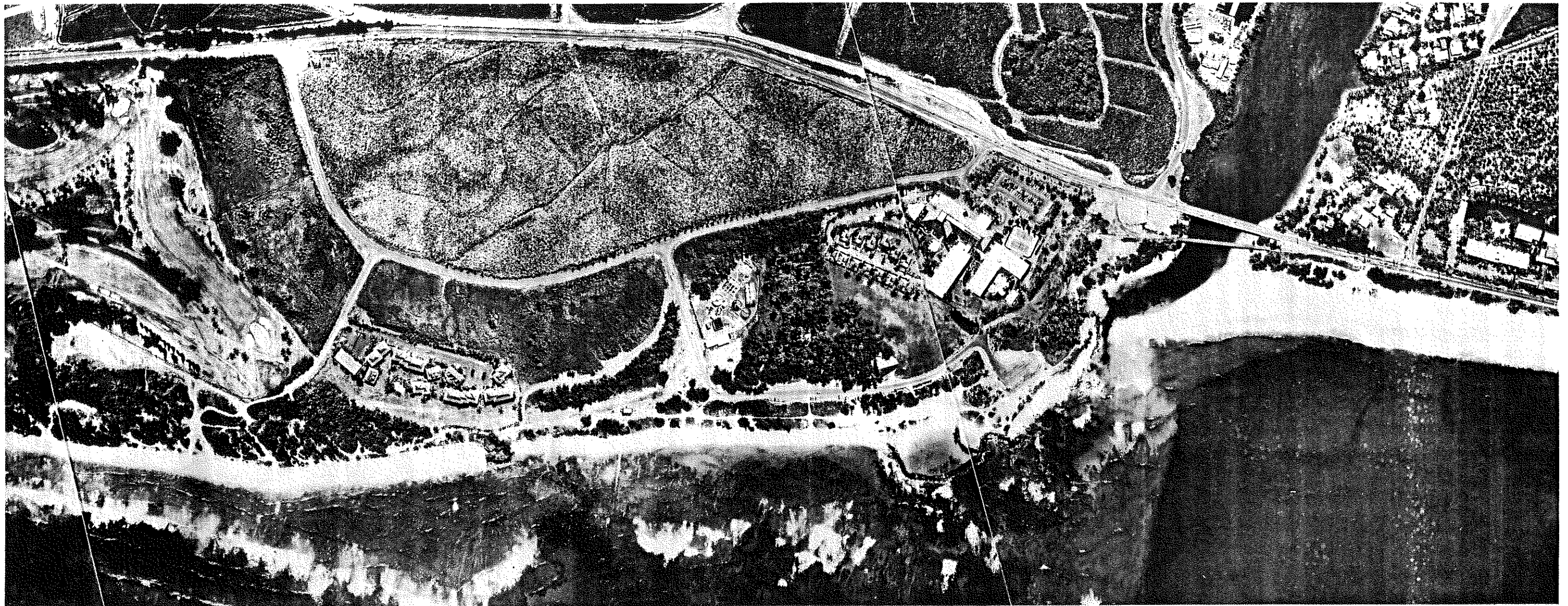


**FIGURE KC-3**



**PHOTOS USED**  
 March 1988  
 July 1987  
 April 1975  
 January 1960  
 November 1950

**GRAPH KC-3 Region Number vs Change in Vegetation Line**



**KC-4: NUKOLII TO WAILUA RIVER; NORTH SUBSECTOR**

**BEACH DESCRIPTION**

- The sand beach continues through this subsector, interrupted only by a small outcropping between Regions 17 and 18. Typical beach width is 40 feet. As in the subsector to the south, there is no beach rock at the waterline.
- Half of Wailua Beach is also shown in the northern end of the subsector.
- The fringing reef extends through this subsector, but is interrupted by small channels and sand deposits.

**BACKSHORE**

- The backshore is developed, but most of the improvements or structures are located far behind the vegetation line. Moving from south to north, the backshore is occupied by the Wailua Golf Course, a condominium complex, Lydgate State Park, and the Coco

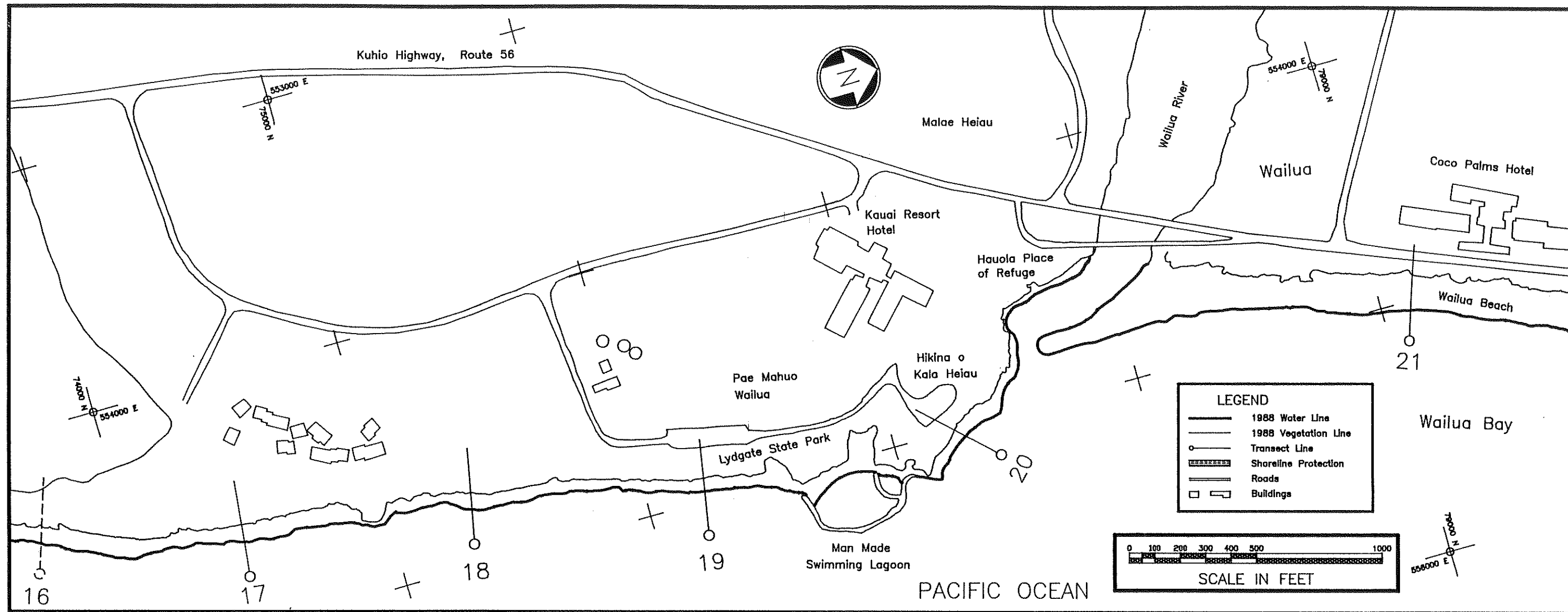
Palms Hotel. One of the notable features of the park is a large man-made swimming area, constructed in 1970 by placing large boulders in a semi-circle on the reef flat.

**SHORELINE HISTORY**

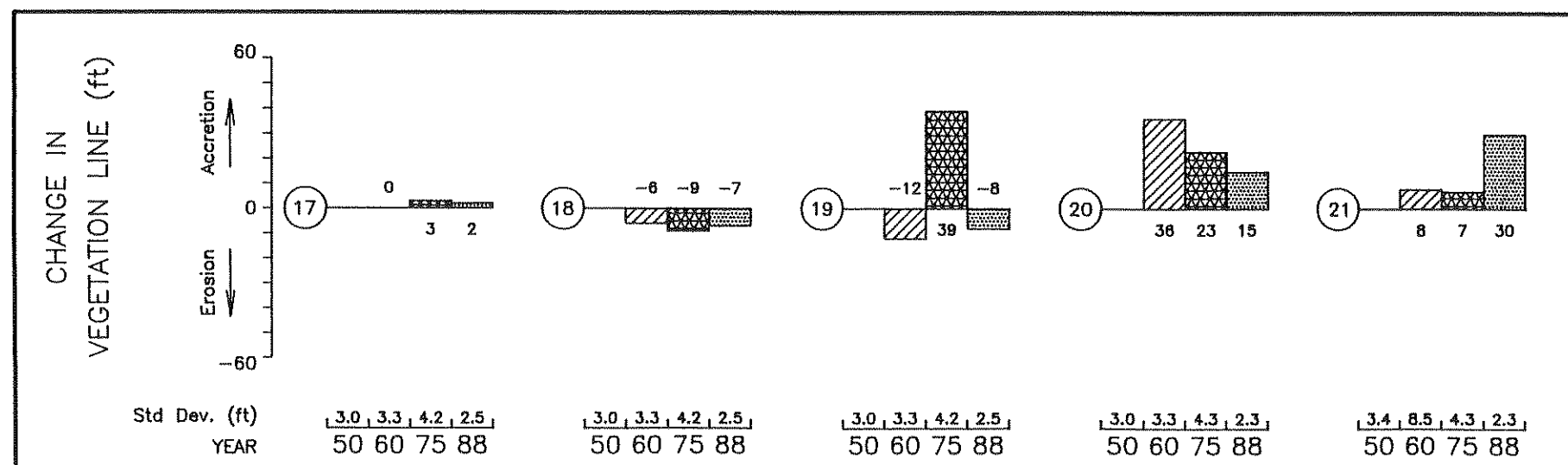
- The shoreline south of the Lydgate State Park (Regions 17 & 18) has been relatively stable. Region 19, also south of the park, appears to have been temporarily affected by the construction of swimming area. The region indicated accretion after the construction of the swimming area, but it has since eroded back to the pre-1970 range.
- The beach between the swimming area and the Wailua River is relatively unstable. Although Region 20 has a net accretion, alternating accretion and erosion has occurred between the region and the river discharge.

**SUMMARY**

- This beach subsector is relatively stable, except for the area between the Wailua River and Lydgate State Park. Except for the man-made swimming area at Lydgate State Park, all structures are set well back from the vegetation line.

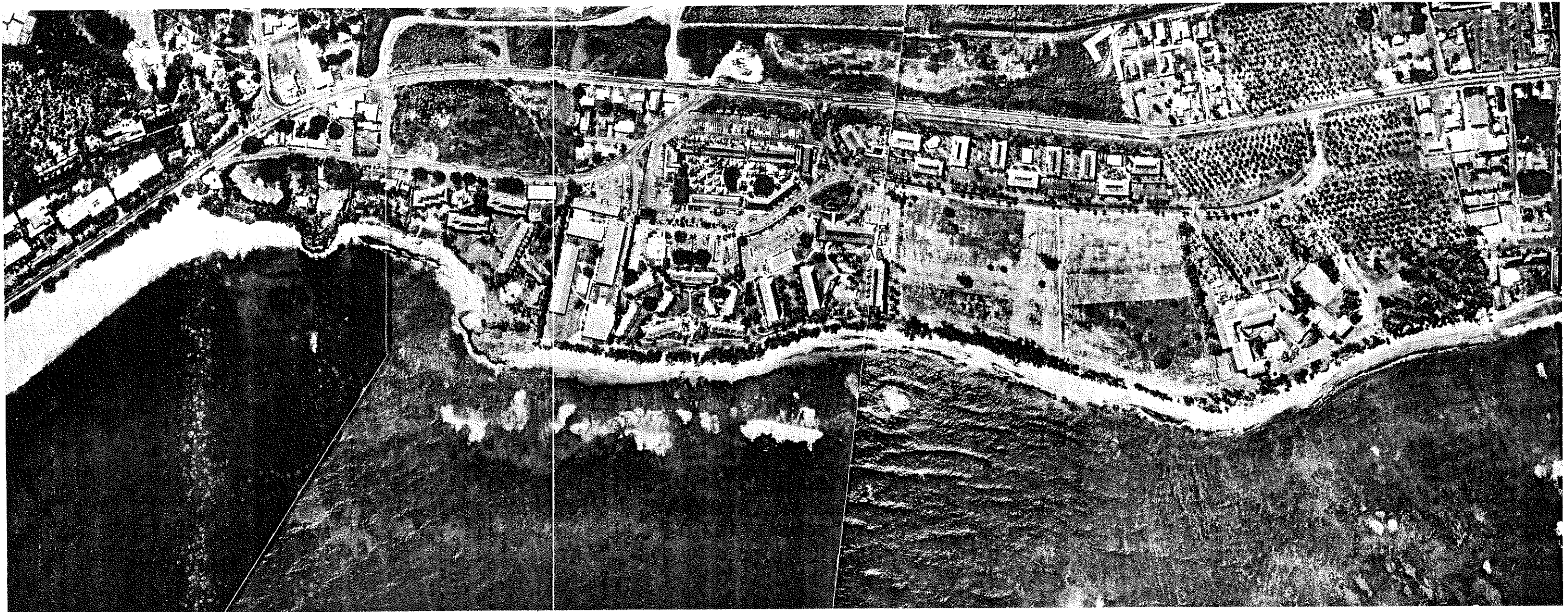


**FIGURE KC-4**



**GRAPH KC-4 Region Number vs Change in Vegetation Line**

**PHOTOS USED**  
 March 1988  
 July 1987  
 April 1975  
 January 1960  
 November 1950



## KC-5: WAILUA BAY AND THE SOUTH END OF WAIPOLI BEACH

### BEACH DESCRIPTION

- Wailua Beach is a 2000 foot long calcareous beach at the head of Wailua Bay. Typical width is 100 feet. There is no fringing reef and the tradewind waves result in frequently rough shorebreak.
- There is a small 600 foot long beach between Wailua Beach and Alakukui Point. The beach is bounded by a boulder revetment to the south and the point to the north. There is extensive beach rock outcropping along the waterline.
- This subsector also includes the southern third of Waipoli Beach, an 8500 foot long beach extending from Alakukui Point to the Waikaea Canal. The width of Waipoli Beach varies from 30 to 50 feet. Beachrock is exposed at the waterline along approximately 50-percent of the length. The fringing reef begins again off Waipoli Beach, and is 1000 feet wide at the north end of this subsector.

### BACKSHORE

- The Kuhio Highway parallels Wailua Beach, and there is a narrow band of vegetation between the highway and the vegetation line.
- Resort hotels intermixed with open space occupy the rest of the backshore of this subsector. The open space is slated for eventual development.

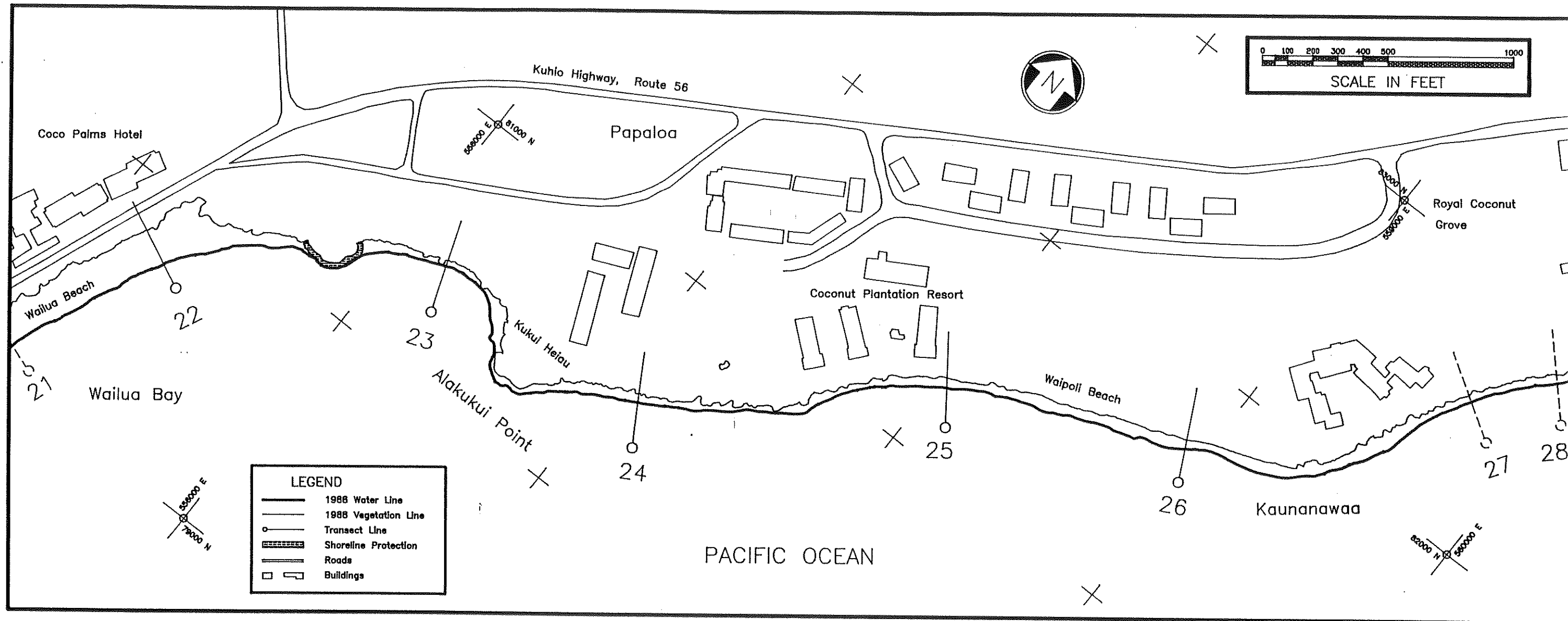
### SHORELINE HISTORY

- Regions 21 (shown in Subsector KC-4) and 22 show that Wailua Beach has accreted since 1950.
- The area near the river mouth is unstable and river flooding at times causes erosion of the south end of the beach.
- The beach south of Alakukui Point (Region 23) is stable, with only minor vegetation line changes.

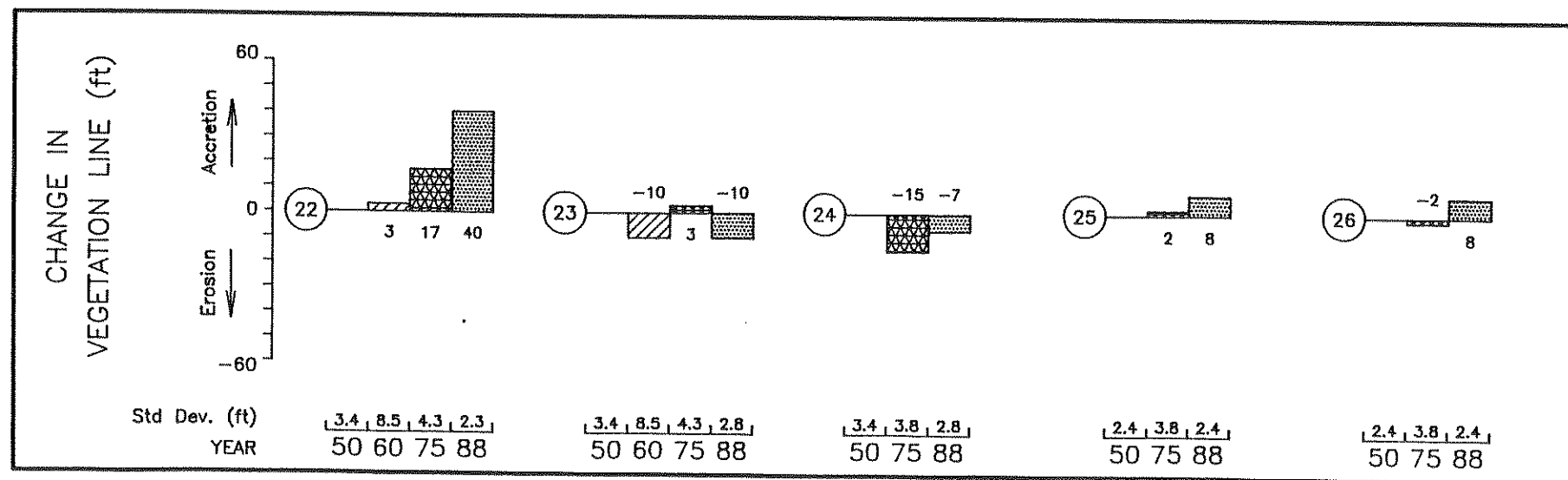
- According to the aerial photographs, the south end of Waipoli Beach (Regions 24, 25 and 26) is relatively stable; net changes in the vegetation line range from -7 to +8 feet. The site visit, however, indicated that there is at least episodic erosion. Much of the shoreline along the Coconut Beach Resort has the remnants of a small wave cut scarp. Tree roots are exposed, but the vegetation line is now seaward of the scarp in places.
- The 1960 data for this subsector were not used because the photographs were blurry, and the vegetation lines were difficult to define.

### SUMMARY

- Wailua Beach is accreting, except for the south end, which is affected by the river discharge. The other beach areas are relatively stable, but may undergo periods of erosion.

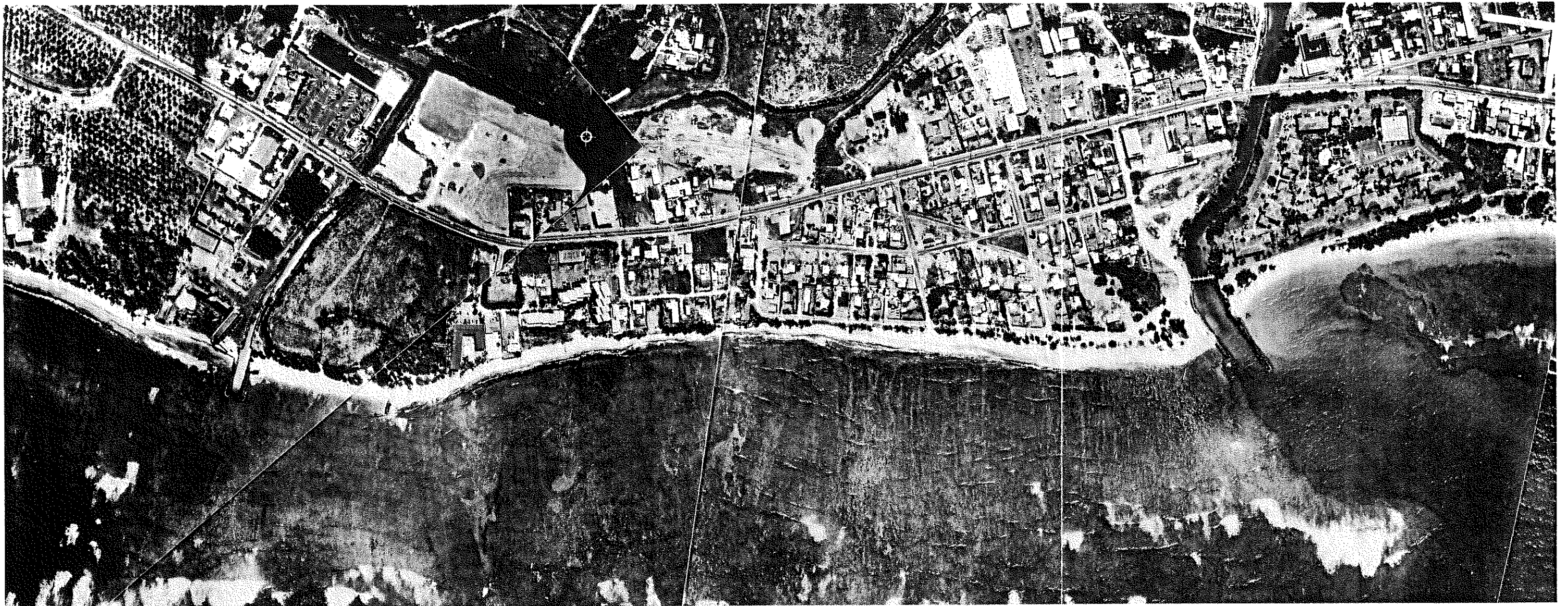


**FIGURE KC-5**



**GRAPH KC-5 Region Number vs Change in Vegetation Line**

**PHOTOS USED**  
 March 1988  
 July 1987  
 April 1975  
 January 1960  
 November 1950



## KC-6: WAIPOLI BEACH

### BEACH DESCRIPTION

- This subsector covers the northern two-thirds of Waipoli Beach, which terminates at the Waikaea Canal. The canal discharge is stabilized by two rubble mound jetties. Another small drainage canal crosses the southern end of this reach, and two jetties also stabilize the discharge point. Between 1950 and 1960, the canal was shifted 600 feet to the south. Two jetties were built to stabilize the new discharge point. One of the original jetties is still in place.
- The beach is narrow with an average width of 30 to 40 feet, and beachrock is exposed along much of the waterline. The offshore fringing reef varies in width from 800 to 1100 feet.
- A natural channel through the fringing reef is present off the Waikaea Canal, and has been improved by dredging. The improved channel services a boat ramp located in the canal.

### BACKSHORE

- The backshore is a mix of open space and park areas, resort condominiums, and single family houses. The 2000 foot long residential area south of the Waikaea Canal was constructed in 1953. A road parallels the shoreline, seaward of all the houses.

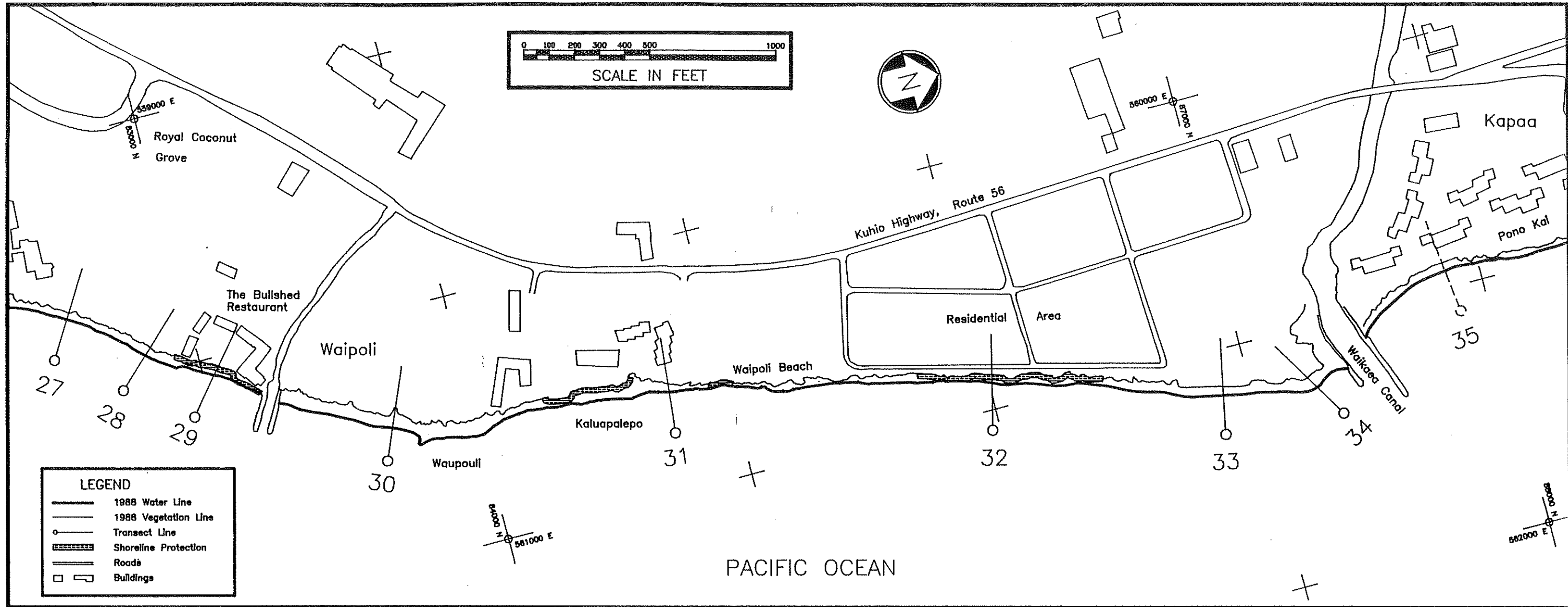
### SHORELINE HISTORY

- The beach south of the small drainage canal (Regions 28 and 29) is eroding, and a vertical seawall protects the foundation of The Bullshed, a popular restaurant.
- Along the 2000 foot long reach north of the canal (Regions 30 and 31), the data indicate an eroding beach, and there is intermittent shore protection in place.
- From and including Region 31, the rest of the beach (excluding a 600 foot reach just south of the Waikaea Canal) is undergoing severe erosion. There is a 5 foot high wave cut scarp, roots are exposed with trees ready to fall, and there is no beach at high tide. Exposed beachrock at one time stabilized the beach, but erosion has progressed to the point that there is now a channel inshore of the beachrock. At high tide, flow of water in this channel must aggravate the erosion. Large boulders have been intermittently and randomly dumped to stabilize the beach, but are doing little good. At least some of these boulders were set in place as far back as 1953. The data from the aerial photographs do not show this erosion (Regions 31 and 32) because overhanging ironwood trees block the view of the vegetation line.

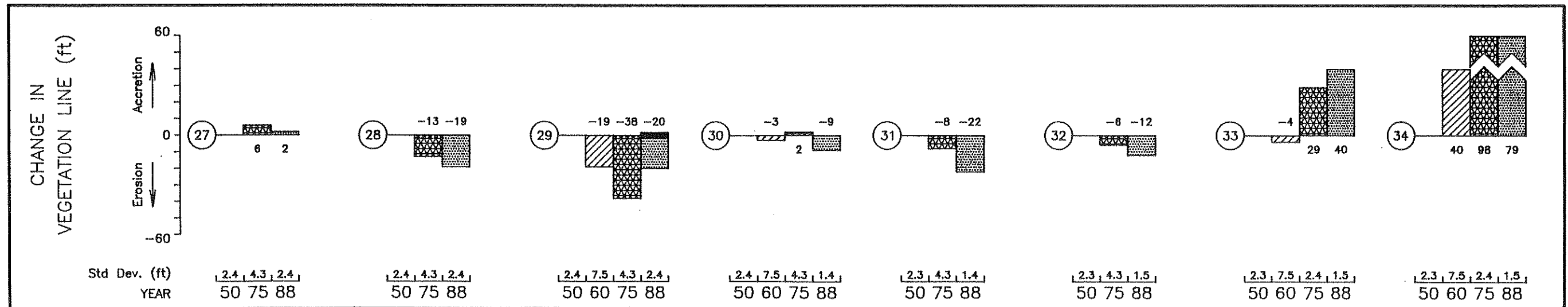
- The 600 foot length of beach just south of the canal (Regions 33 and 34) is accreting.
- The 1960 data for this subsector were not used in cases because the photographs were blurry, and the vegetation lines were difficult to define.

### SUMMARY

- Waipoli Beach has been extensively modified by the jetties, groins, revetments and seawalls that have been constructed over the past years. The developments have been placed very close to the vegetation line, and any recession of the vegetation line presents a threat to the structures; shore protection is then constructed.
- Severe erosion is occurring in front of the residential area. The houses are set back but the road along the beach crest may be threatened. This is an area where the data from the photographs do not indicate the actual erosion. Overhanging ironwood trees preclude digitizing an accurate vegetation line.



**FIGURE KC-6**



**GRAPH KC-6 Region Number vs Change in Vegetation Line**

PHOTOS USI  
 March 1988  
 July 1987  
 April 1975  
 January 1960  
 November 1950





## KC-7: KAPAA BEACH PARK

### BEACH DESCRIPTION

- This subsector consists of a 6000 foot long calcareous sand beach bounded on the south by the Waikaea Canal and on the north by a rocky shoreline. The beach is typically 30 to 40 feet wide.
- The wide fringing reef is present, but there are large channels off the Waikaea and Moikeha Canals. Both canal discharges are stabilized by rubble mound jetties extending across the beach.

### BACKSHORE

- There is a 1000 foot long resort development (Pono Kai) immediately north of the Waikaea Canal. Much of the rest of the immediate backshore is open space. A residential area seaward of the Kuhio Highway is set well back from the vegetation line. Kapaa Beach Park extends through much of this sector.

### SHORELINE HISTORY

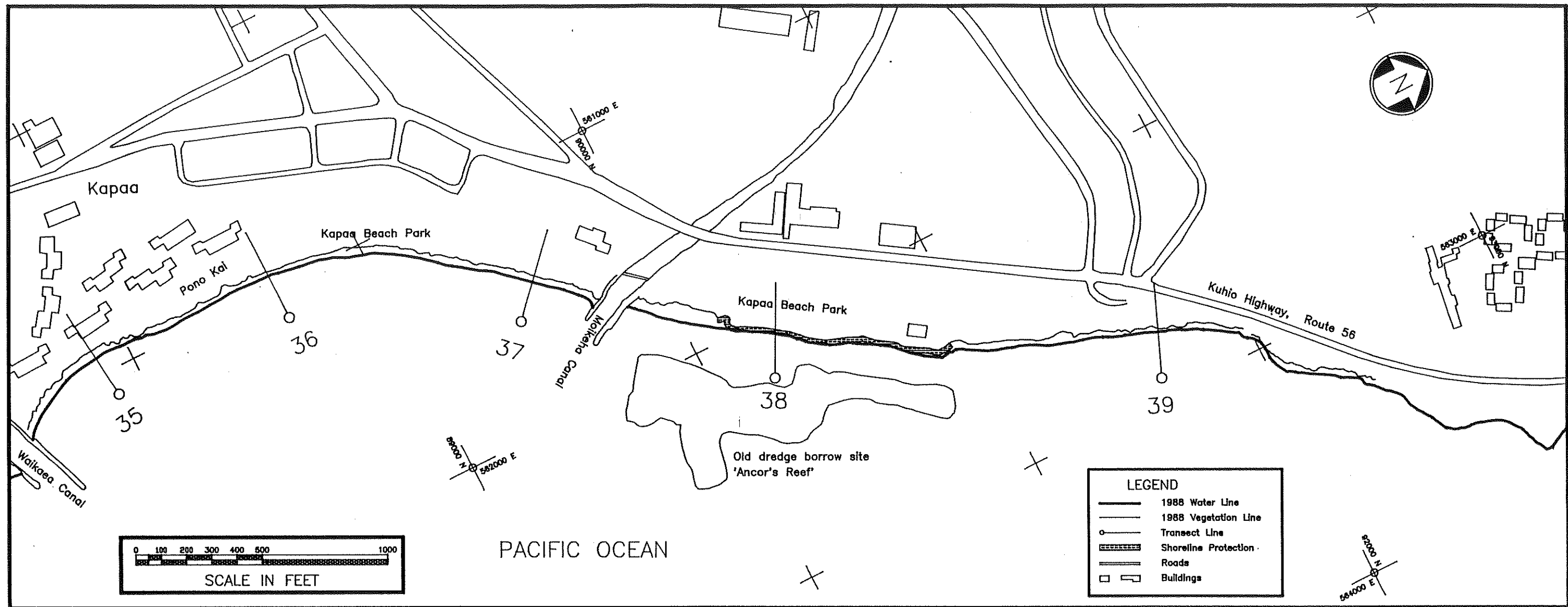
- Severe erosion has occurred along the beach just north of the Waikaea Canal (Region 35). No shore protection has yet been placed in this area. The erosion extends the length of the resort,

with the severity of erosion decreasing with distance to the north. There is a 3 to 5 foot wave cut scarp with overhanging ironwood trees, and in some areas the trees are seaward of the scarp.

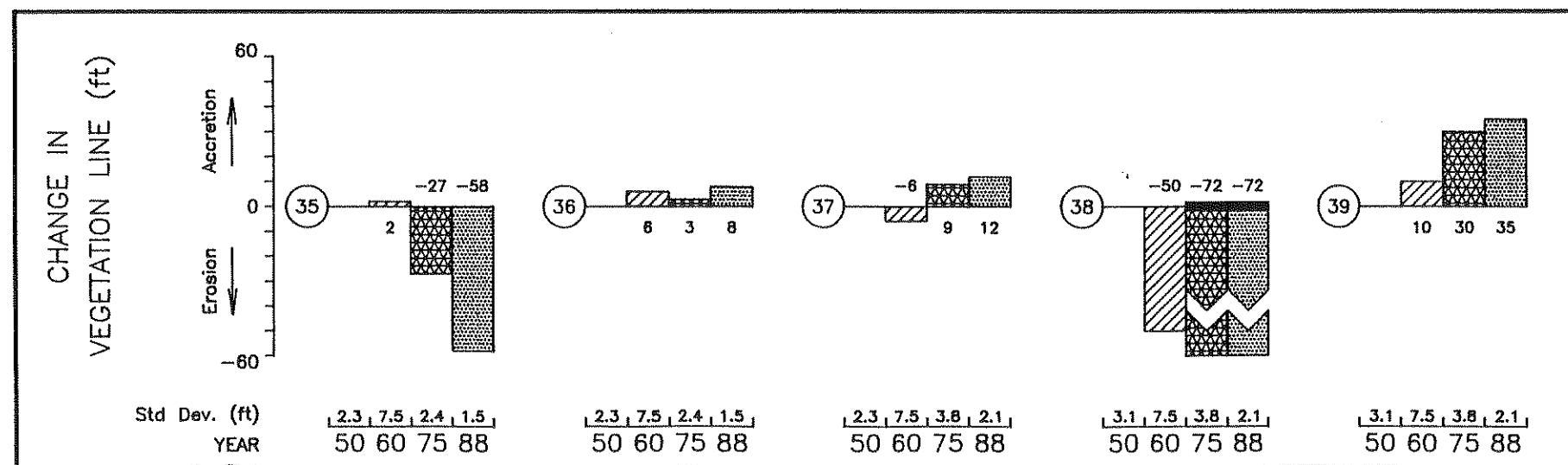
- Although the measurements indicate a stable beach (Regions 36 and 37), it appears from the site visit that there may be slow erosion along the entire length of beach to the Moikeha Canal. A small rock revetment was constructed to protect a park comfort station in this reach. There is almost no beach in this area at high tide.
- The beach north of the Moikeha Canal has a recent history of severe erosion (Region 38). In 1959, a borrow pit was dredged in the fringing reef, and 180,000 cubic yards of material were removed. The borrow pit extended along 1200 feet of the shoreline and was only 100 feet offshore. Sand transported from the reef flat or the adjacent beach into the borrow pit was lost to the littoral cell, and the immediate result was severe erosion. In 1964, the State constructed a 900 foot long revetment to prevent further loss of the land. There is no beach in front of the revetment.
- The beach north of the revetment has accreted since 1953 (Region 39).

### SUMMARY

- Kapaa Beach is similar to Waipoli Beach to the south in that it has been extensively modified by man's activities. The most notable modification was the dredging of the borrow pit on the Kapaa Reef, which resulted in severe shoreline erosion. Fortunately, most of the development in this area is set back from the vegetation line.
- Severe erosion is also occurring at the Pono Kai Resort, but the buildings are set back from the vegetation line.

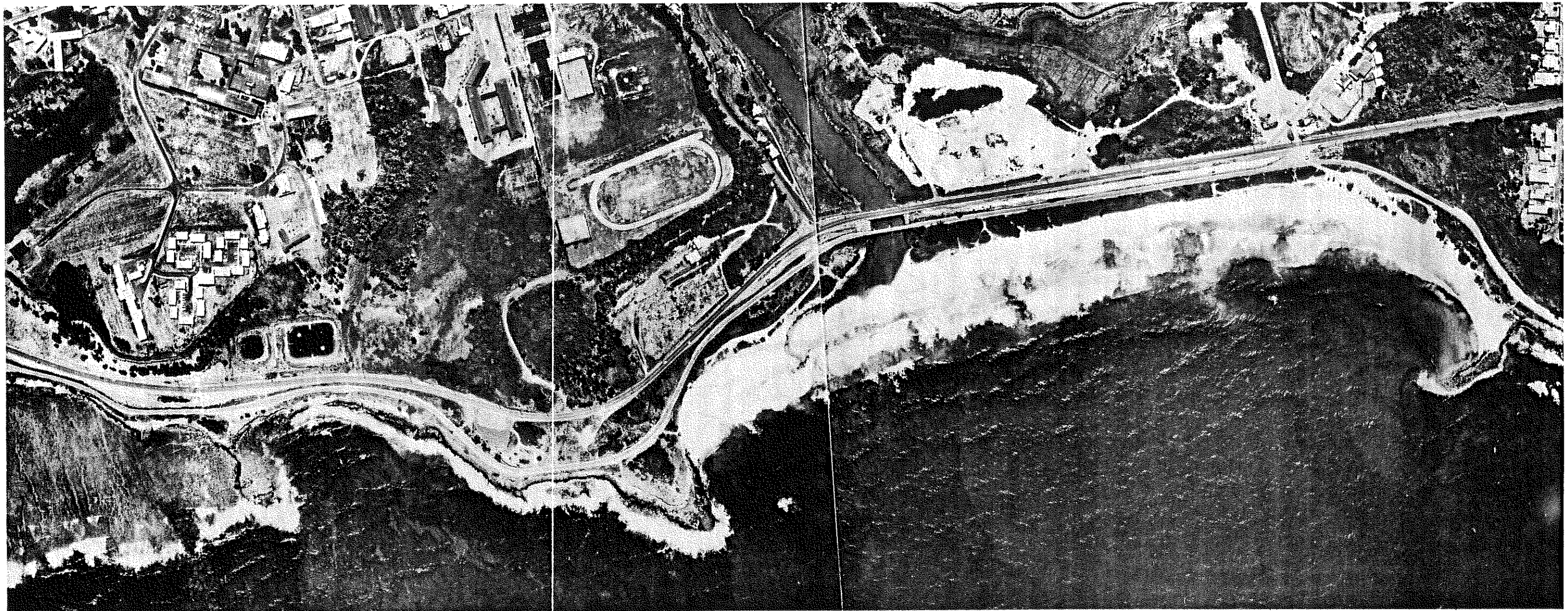


**FIGURE KC-7**



**GRAPH KC-7 Region Number vs Change in Vegetation Line**

**PHOTOS USED**  
 March 1988  
 July 1987  
 April 1975  
 January 1960  
 November 1950



## KC-8: KEALIA BEACH

### BEACH DESCRIPTION

- Kealia Beach is a 4000 foot long pocket beach, bounded on the south by a rocky point and on the north by a small jetty. This jetty is all that remains of an old inter-island steamer landing.
- Kapaa Stream crosses the center of the beach and probably causes localized, temporary erosion during floods.
- There is no fringing reef offshore, and the tradewind waves break directly off the beach.

### BACKSHORE

- The Kuhio Highway, the main north-south route, parallels the beach, and is located 50 to 100 feet inland of the vegetation line. There is no development seaward of the highway.

### SHORELINE HISTORY

- Regions 40, 41 and 42 indicate a significant recession of the vegetation line at Kealia Beach. Most of the change occurred between 1950 and 1975. Net erosion along the beach ranges from 21 to 45 feet.
- There were no signs of ongoing or chronic erosion observed during the site visit.
- The 1960 data for this subsector were not used because the photographs were blurry and the vegetation lines were difficult to define.

### SUMMARY

- The cause of the erosion at Kealia Beach is not readily apparent. The beach is a discrete littoral cell, and there are no obvious onshore changes that would have affected the cell. The jetty at the north end of the beach is at the end of the sandy area, and should have little or no impact.
- There is a large sand channel in the nearshore area off the beach. Typically, beaches similar to Kealia, with exposure to significant waves and a large offshore sand channel, are dynamic, but relatively stable over the long term. This is not the case at Kealia. Any development seaward of the highway should be avoided.

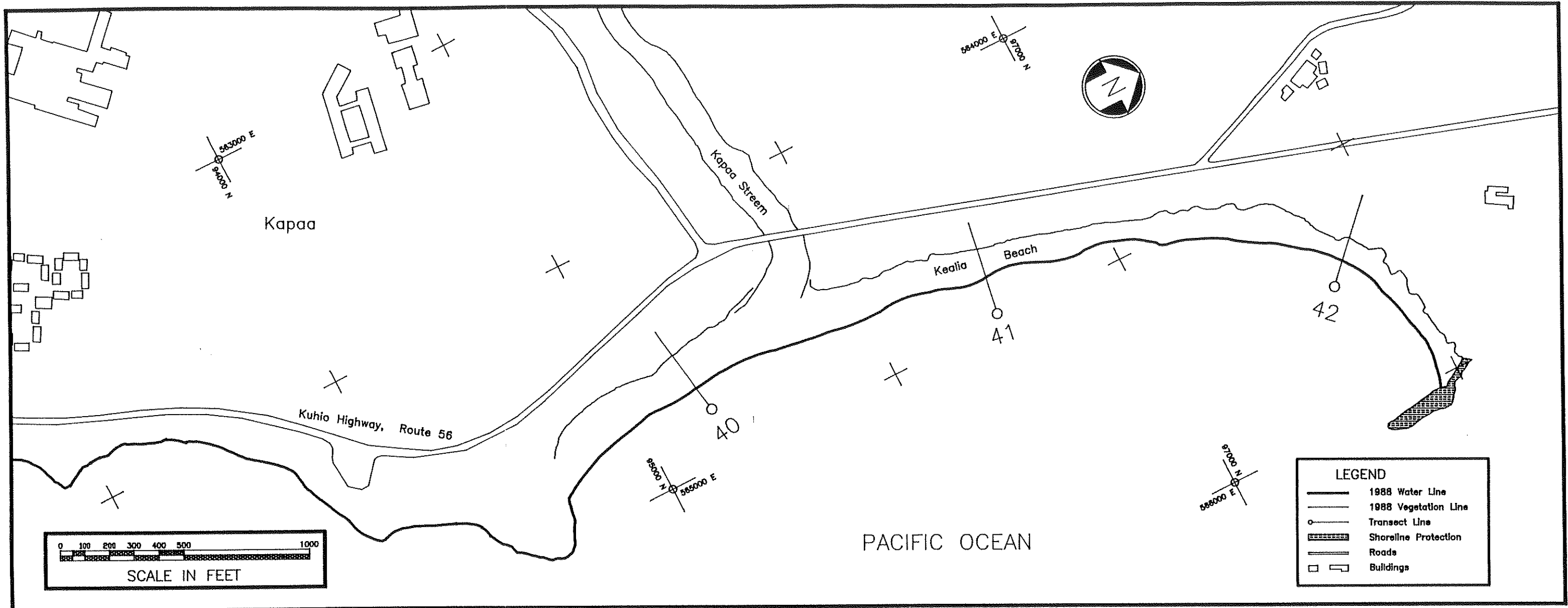
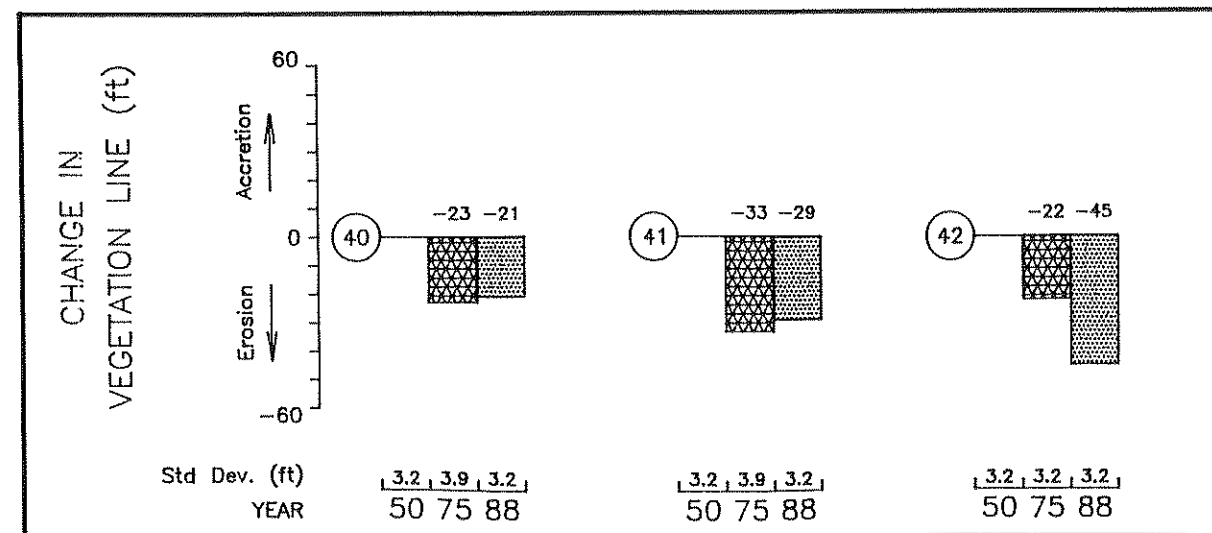


FIGURE KC-8



GRAPH KC-8 Region Number vs Change in Vegetation Line

PHOTOS USED  
 March 1988  
 July 1987  
 April 1975  
 January 1960  
 November 1950

**SECTOR KD:           NORTHEAST KAUAI  
                          ANAHOLA BAY TO PAPA A BAY**

**GENERAL COASTAL CHARACTERISTICS**

This 12,000 foot long sector extends from Anahola Bay to Papaa Bay. The largest beach in the sector is located in Anahola Bay. North of Anahola Bay, the beach becomes very narrow, but it is continuous up to Papaa Bay. A boulder beach at the south headland of Papaa Bay separates the sand beach of Papaa Bay from the beach to the south. The relatively straight stretch of beach between the two bays is known as Aliomanu Beach. A major stream, the Anahola River, discharges across the middle of Anahola Beach. An extensive fringing reef, varying from 500 to 1100 feet in width, extends from the Anahola River to the south side of Papaa Bay.

**LAND USE AND DEVELOPMENT**

Anahola Beach Park occupies most of the backshore south and east of the Anahola River, and extends for a short distance north of the river. There is also an 800 foot long residential development south of the river. A 2000 foot long residential development is located along the north end of Anahola Beach. Another residential development is located north of Kuaehu Point, along Aliomanu Beach. The backshore of Papaa Bay is undeveloped.

**WAVE CLIMATE**

This coastal sector is directly exposed to tradewind generated waves, and indirectly exposed to the winter season north Pacific swell. The fringing reef protects Aliomanu Beach from direct wave approach, but the two bays receive the full force of the incoming waves.

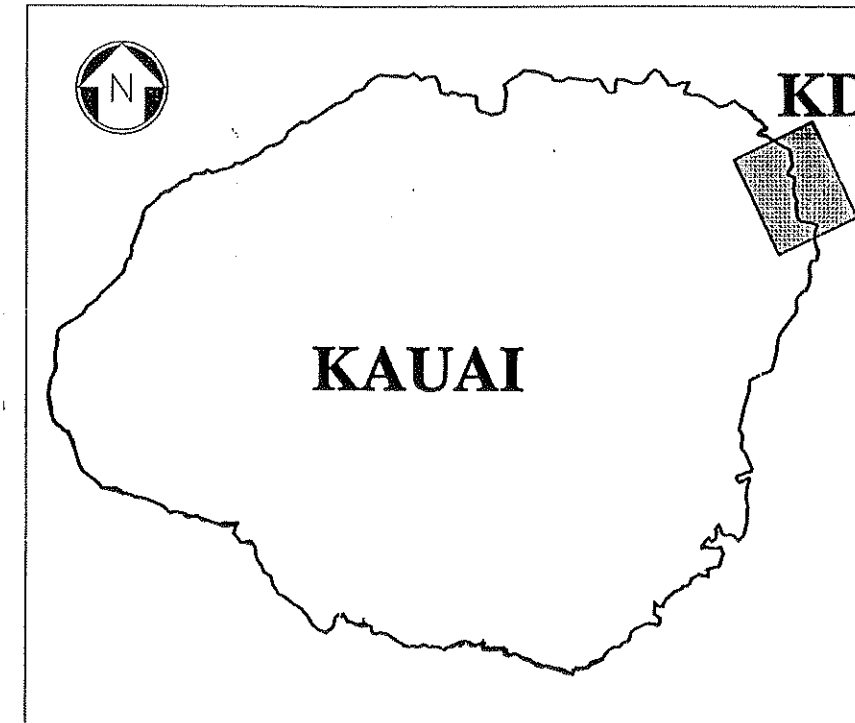
**SHORELINE PROCESSES**

According to the U.S. Army Engineer District (1971), Anahola Beach is subject to seasonal erosion and accretion; the beach erodes slightly during the summer and rebuilds during the winter. The beach is also affected by lateral shifts in the location of the Anahola Stream discharge. In 1963, the stream mouth shifted 500 feet along the beach (Moberly and Chamberlain).

The Aliomanu Beach shoreline eroded 15 to 25 feet during the 1960's and 1970's, and some shore protection was built in response to protect the houses. The refracted North Pacific swell moves the sand to the south along this straight shoreline, toward Kuaehu Point. Tradewind waves then move the sand back to the north, toward the residential area, during the rest of the year.

**BEACH USAGE**

Anahola Park is a popular recreation area and is heavily used for swimming, surfing and fishing. The water use off Aliomanu Beach is limited due to the shallow reef. The reef, however, is used for various types of fishing. Papaa Bay is used for swimming and snorkeling when the surf conditions permit.





PACIFIC OCEAN

**LEGEND**

HYDROGRAPHIC DATUM ..... MEAN LOWER LOW WATER

- Depth curve (meters) \_\_\_\_\_
- Foreshore flats \_\_\_\_\_
- Rocks awash; Reef \_\_\_\_\_
- Wreck: Exposed; Sunk with masts exposed \_\_\_\_\_
- Wharf, pier \_\_\_\_\_
- Seawall \_\_\_\_\_
- Oil/gas rig \_\_\_\_\_

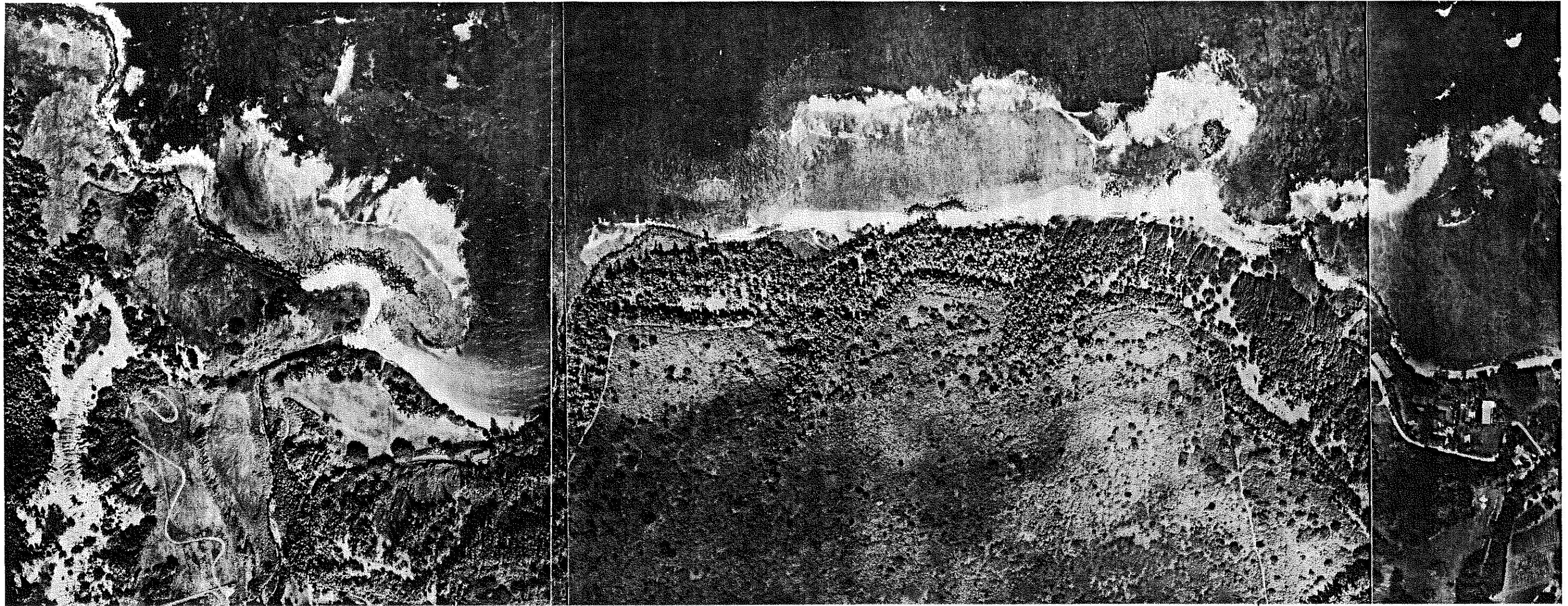


Scale: 1:50,000



**NORTHEAST KAUI**

From U.S. Geological Survey  
MAP INFORMATION AS OF 1983



## **KD-1: PAPA A BAY**

### **BEACH DESCRIPTION**

- There is a small pocket beach, approximately 700 feet long, at the head of Papaa Bay. A stream discharges at the north end of the beach. The south end of the bay is defined by a basalt boulder shoreline.
- South of the bay, there is a 2200 foot long beach, with a typical width of 40 to 60 feet. A fringing reef protects this beach from direct wave attack. It is also stabilized by scattered pockets of basalt boulders at the waterline.

### **BACKSHORE**

- There is no development along the backshore, except for one house at Papaa Bay.

### **SHORELINE HISTORY**

- Both beaches in this subsector are stable or slightly accreting. The beach south of Papaa Bay is stabilized by shallow fringing reefs and the outcroppings of basalt boulders. Although most of the beach at Papaa Bay is stable, the stream discharge influences the beach, and the north end is relatively dynamic.

### **SUMMARY**

- Both beaches in this relatively undeveloped subsector are stable. Any development at Papaa Bay should be sited conservatively, particularly at the north end.

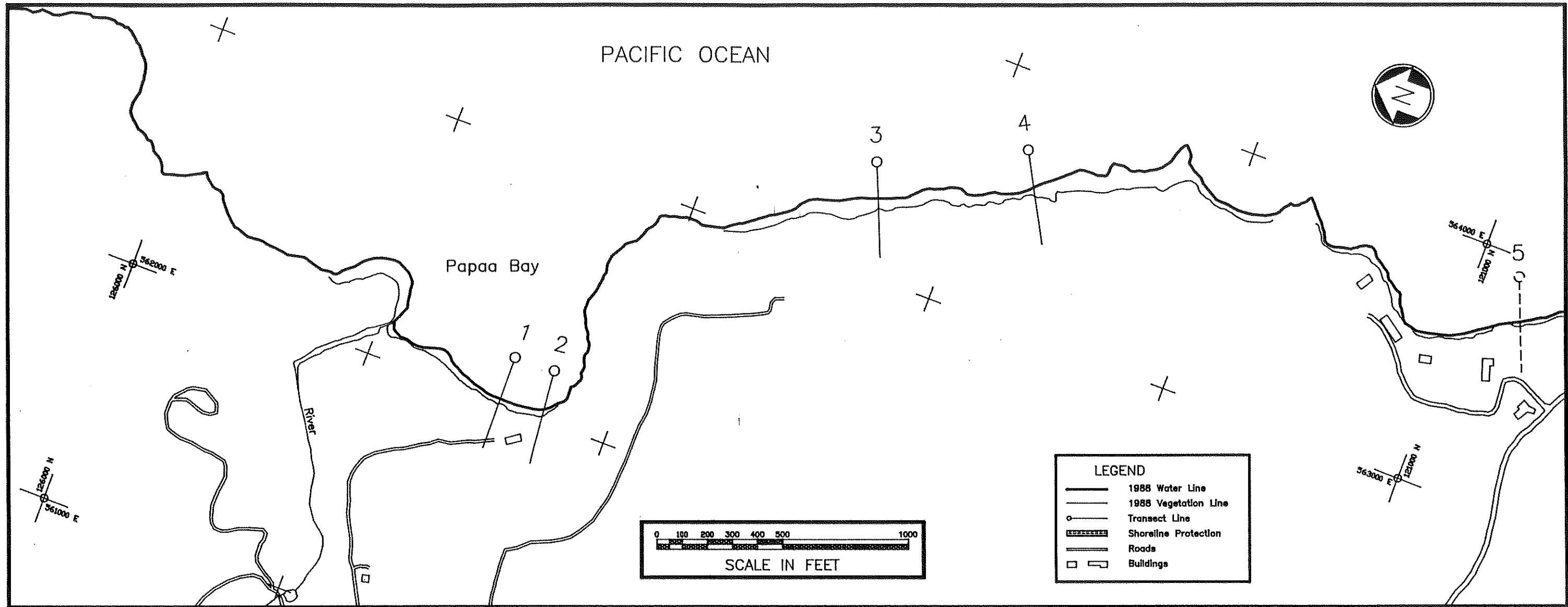
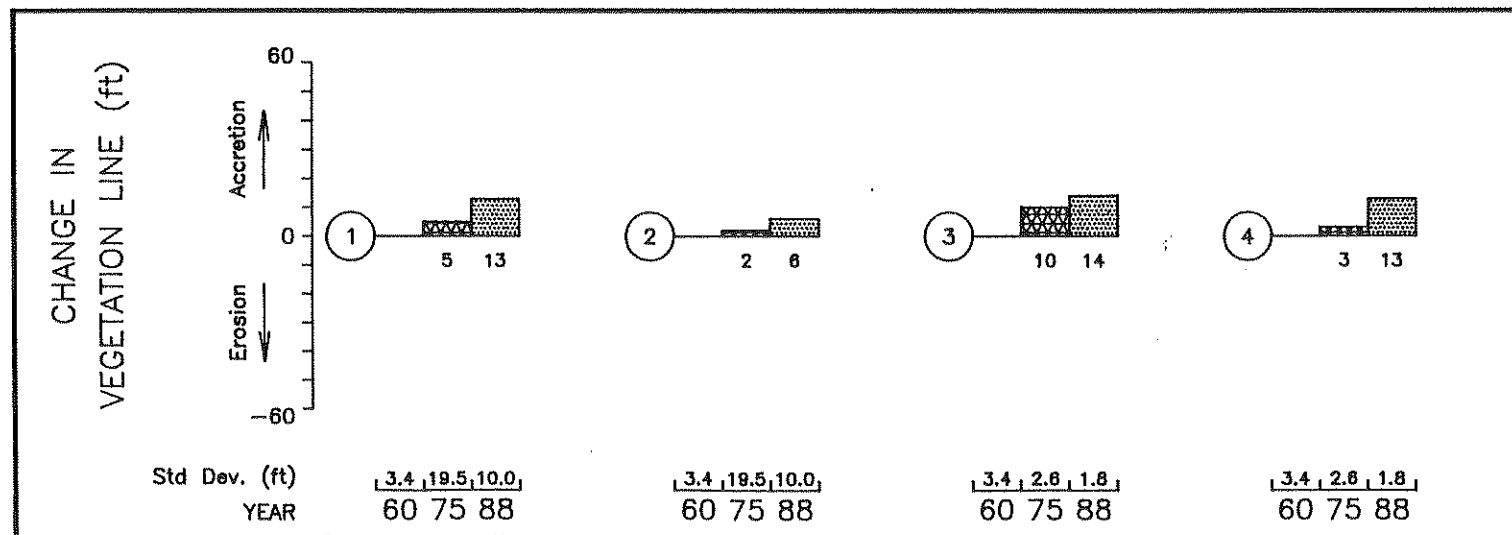


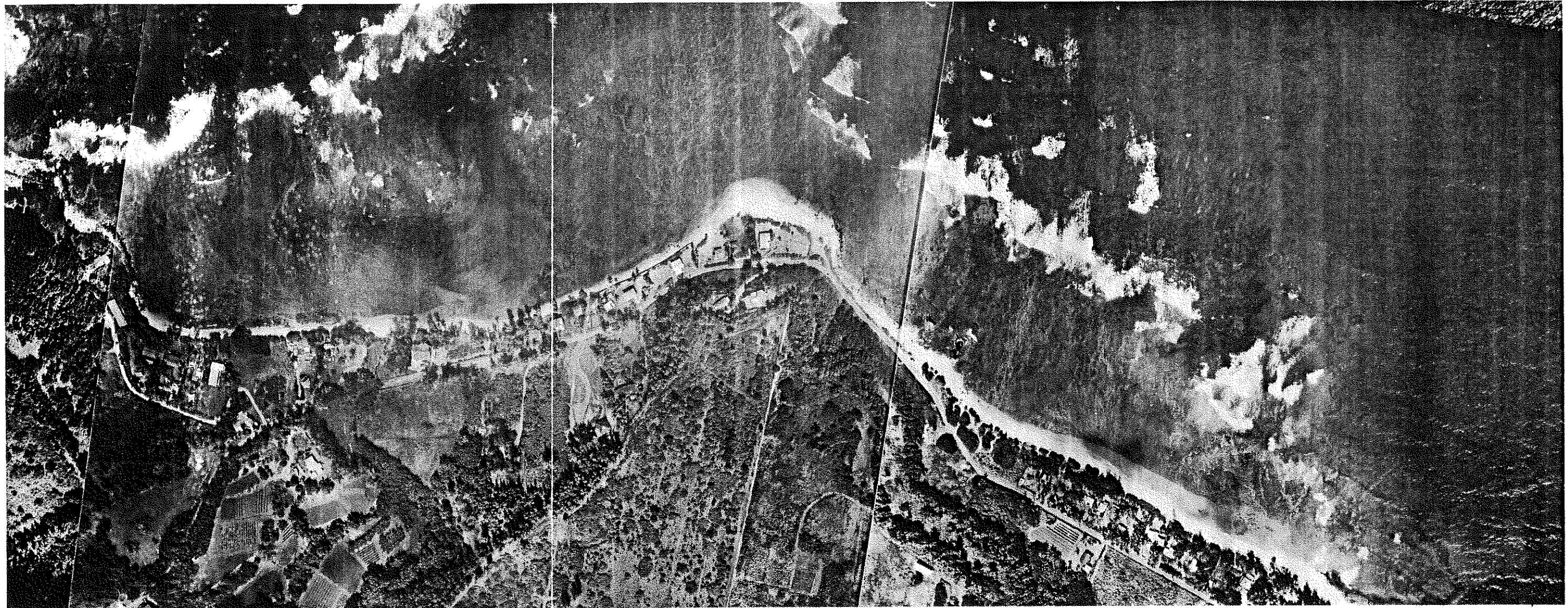
FIGURE KD-1



GRAPH KD-1 Region Number vs Change in Vegetation Line

PHOTOS USED  
 March 1988  
 July 1987  
 April 1975  
 January 1960





## **KD-2: ALIOMANU BEACH AND ANAHOLA BAY (NORTH END)**

### **BEACH DESCRIPTION**

- The calcareous sand beach is continuous through this subsector, but is narrow, with an average width of 30 to 40 feet. There is an extensive fringing reef offshore (500 to 100 feet wide), broken only by a small channel near the south end of Aliomanu beach.

### **BACKSHORE**

- Most of the backshore is developed with single family houses, except for a 700 foot length south of Kuaehu Point where the road parallels the shoreline.

### **SHORELINE HISTORY**

- The Aliomanu residential area, north of Kuaehu Point, was developed after 1975, and several houses were constructed close to the vegetation line. The south end of this beach is eroding (Regions 6 and 7) and there is now a 450 foot long seawall. There is no dry beach in front of the seawall.
- During the site visit, it was observed that the shoreline is now eroding both north and south of the wall. North of the wall, there is no erosion scarp, but the vegetation overhangs the beach. Tree trunks have been placed along the vegetation line as a temporary revetment. A wave cut erosion scarp, 2 to 3 feet high, extends south of the wall for 200 feet.
- The Anahola residential area was developed prior to 1960, and the slight accretion of the shoreline (Region 8), is similar to that occurring at the north end of subsector KD-3 (Region 9).

### **SUMMARY**

- The beaches in this subsector have a relatively small sand volume, making them sensitive to any changes in the sand budget. The shoreline south of Kuaehu Point is stable or slightly accreting.
- The southern part of Aliomanu Beach has a history of erosion and some shore protection has been built. The beach along the entire Aliomanu residential area appears to be stressed and is a potential problem area.

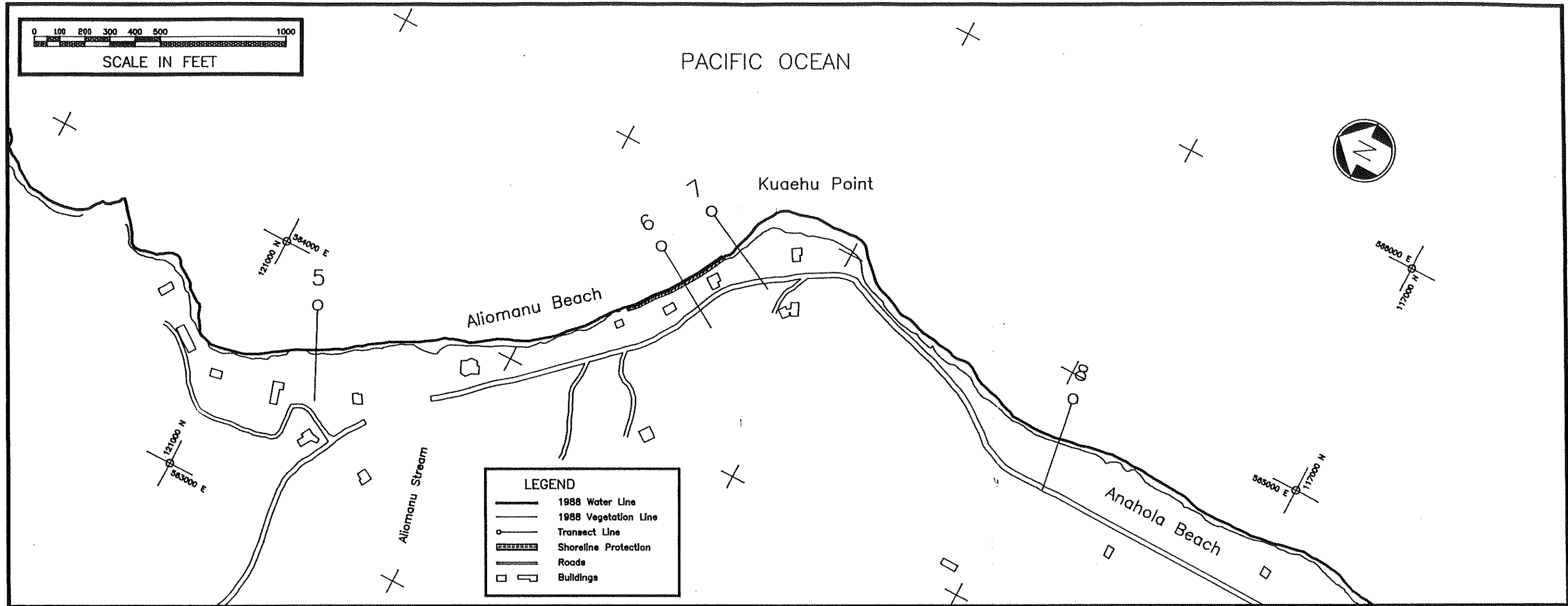
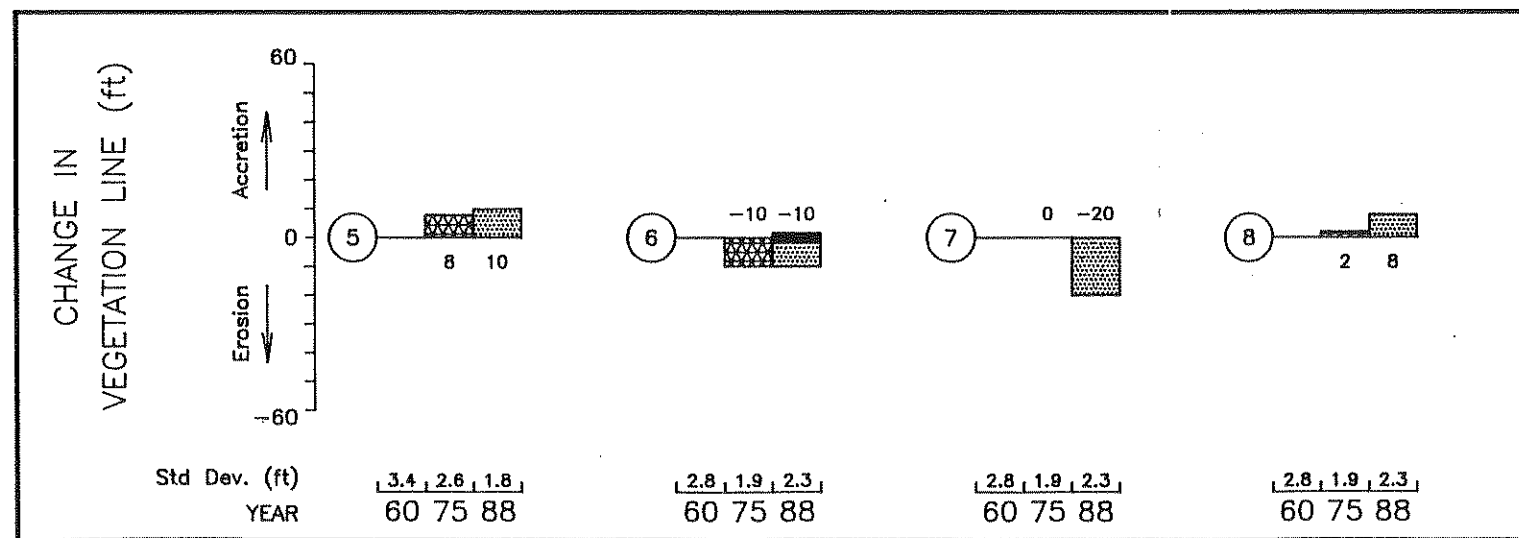
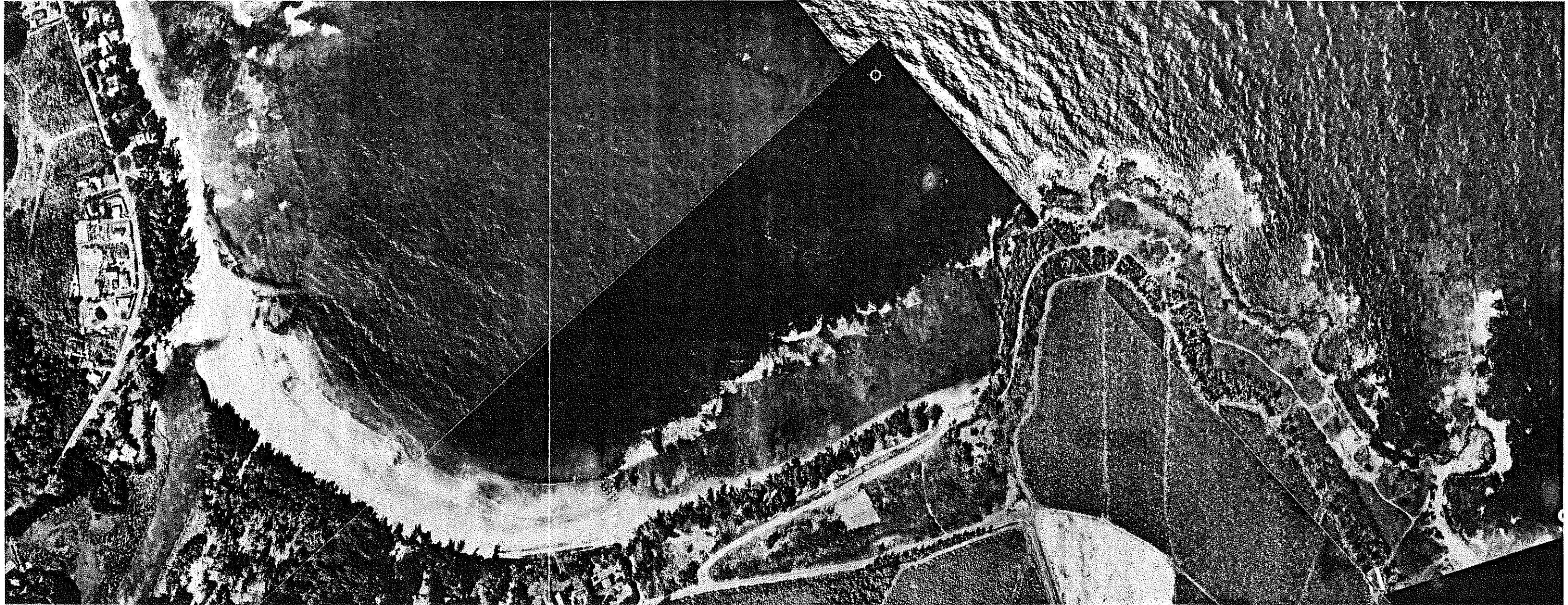


FIGURE KD-2



GRAPH KD-2 Region Number vs Change in Vegetation Line

PHOTOS USED  
 March 1988  
 July 1987  
 April 1975  
 January 1960



## KD-3: ANAHOLA BEACH

### BEACH DESCRIPTION

- Anahola Beach is a long, calcareous sand beach, located at the head of Anahola Bay. The beach width varies from 40 feet at the ends to 150 feet in the center. A shallow fringing reef protects the two ends of the beach but is not present in the center. There is a large offshore sand deposit in the center of the bay, corresponding to the widest part of the beach and Anahola River discharge.

### BACKSHORE

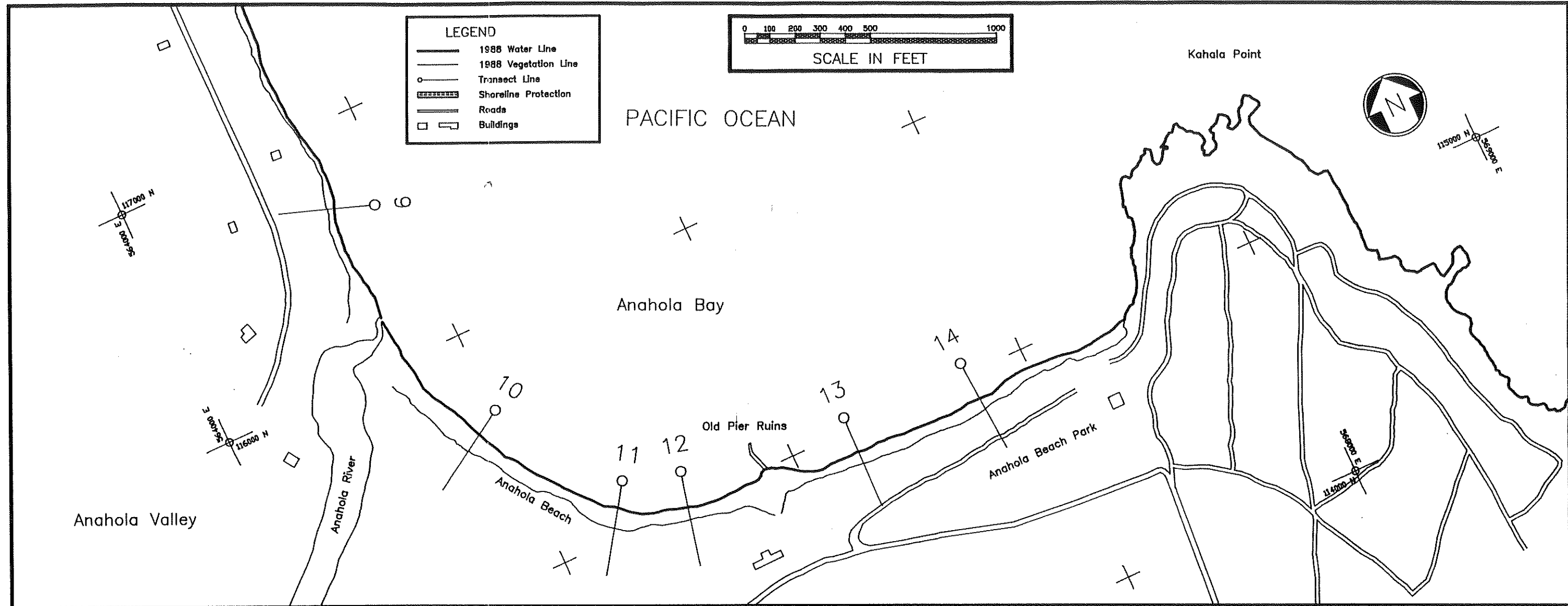
- Anahola Beach Park occupies most of the backshore south of the river, except for an 800 foot long residential development just north of the old pier ruins. The park extends approximately 600 feet north of the river, then gives way to a 1500 foot long residential development.

### SHORELINE HISTORY

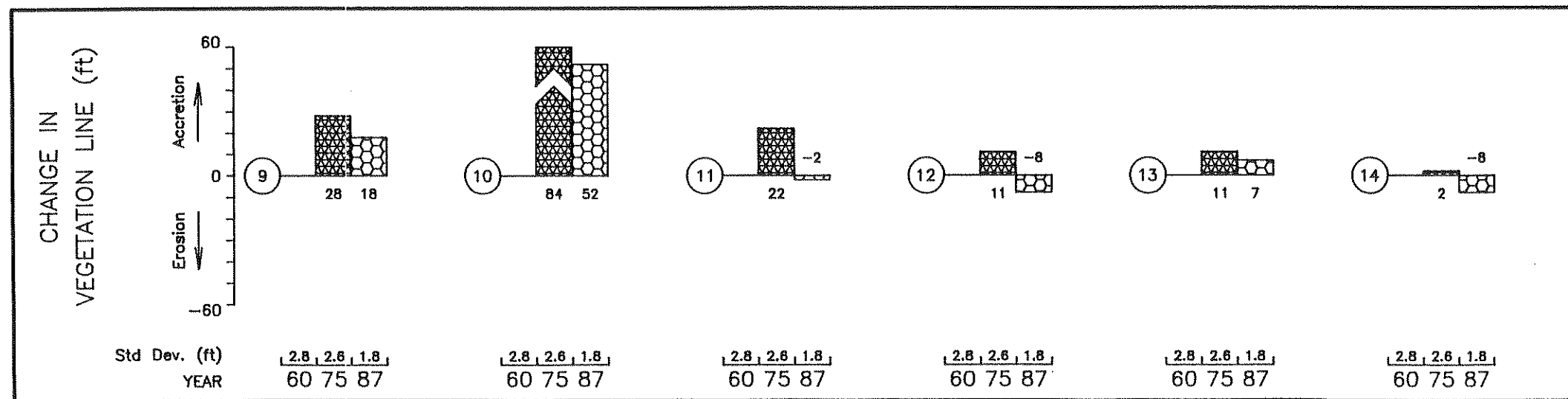
- The beach areas in the vicinity of the river discharge are very dynamic, in part due to the meandering of the river discharge path. Region 10 shows a maximum vegetation line movement of 84 feet.
- The vegetation is relatively stable in front of the south residential area and where the fringing reef limits the wave energy (Regions 11 to 14). North of the river, both the digitized data and the visual evidence indicates that there has been a net accretion of the vegetation line (Region 9).

### SUMMARY

- The center of the beach is dynamic, and park facilities should be kept well back from the shoreline. The residential areas are set back from the shoreline, and there are no apparent erosion problems. There is no shore protection in this subsector.



**FIGURE KD-3**



**GRAPH KD-3 Region Number vs Change in Vegetation Line**

**PHOTOS USED**  
 March 1988  
 July 1987  
 April 1975  
 January 1960

## SECTORS KE AND KF: NORTH KAUAI

### GENERAL COASTAL CHARACTERISTICS

These sectors include two of the four major beach areas of the north shore of Kauai. Kee Beach (KF) and Kalihikai Beach to Anini Beach (KE), as shown on the accompanying sector map. Long term beach changes along two other major areas of the north shore, Hanalei Bay and the Haena-Wainiha area were analyzed by the "Kauai Shoreline Erosion Management Study" completed by DHM, et al in 1990. Some of the longest and widest beaches on Kauai are located along the North shore. The coastline is quite varied and irregular, with embayments, convex beaches on headlands and points, and basalt outcrops and points separating beach areas. Anini Beach extends 8400 feet to the east of Anini Stream. The beach is calcareous and typically 30 to 50 feet wide. Anini Reef, which is up to 1500 feet wide in parts, is located offshore. Kee Beach is a 6100 foot long beach located at the west end of a long sandy shoreline that extends from Wainiha Bay to the Napali Cliffs. The beach is convex, 30 to 150 feet wide and protected by a 500 to 800 foot wide fringing reef.

### LAND USE AND DEVELOPMENT

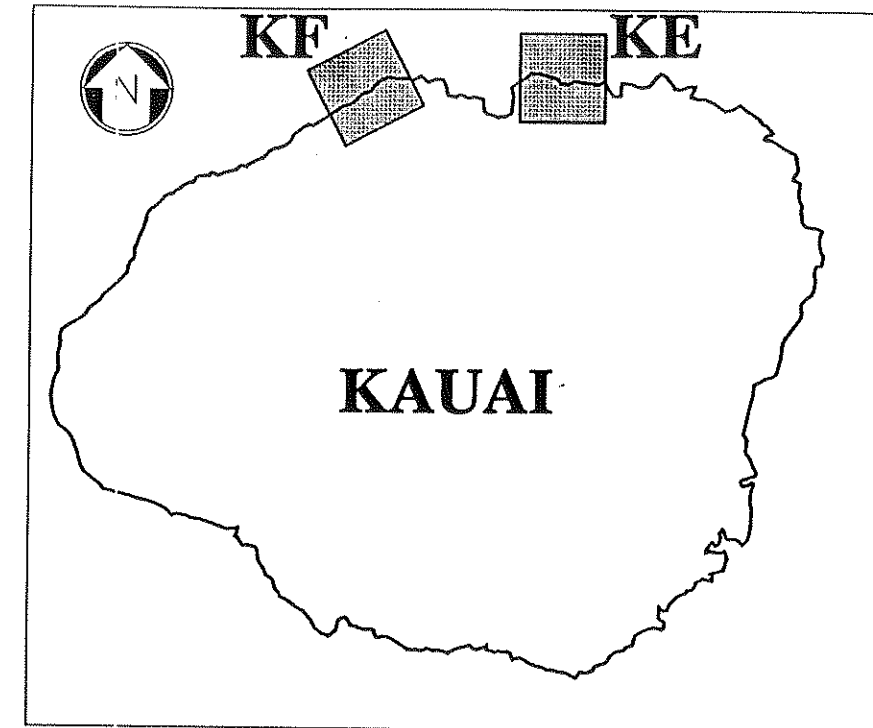
The backshore areas are either undeveloped, in park use, or have been developed for residential use. The residential development is primarily single family housing. Kee Beach is within Haena State Park, while Anini Beach Park occupies the backshore of the eastern half of Anini Beach. A residential development is located on the backshore of the western half of Anini Beach.

### WAVE CLIMATE

The north shore of Kauai is exposed to waves from the northwest, north and northeast, and there is a great seasonal variation in the wave climate. The north Pacific swell occurs during the winter months, while during the summer months, the tradewind generated waves predominate. Wide, fringing reefs protect much of Anini Beach and Kee Beach from direct wave attack. The nearshore wave climate along this coast therefore varies greatly, both seasonally, and also spatially along the coastline. The spatial variation is due to the complex coastline, the intermittent offshore reef, and the resultant shallow water wave modifications due to refraction and shoaling.

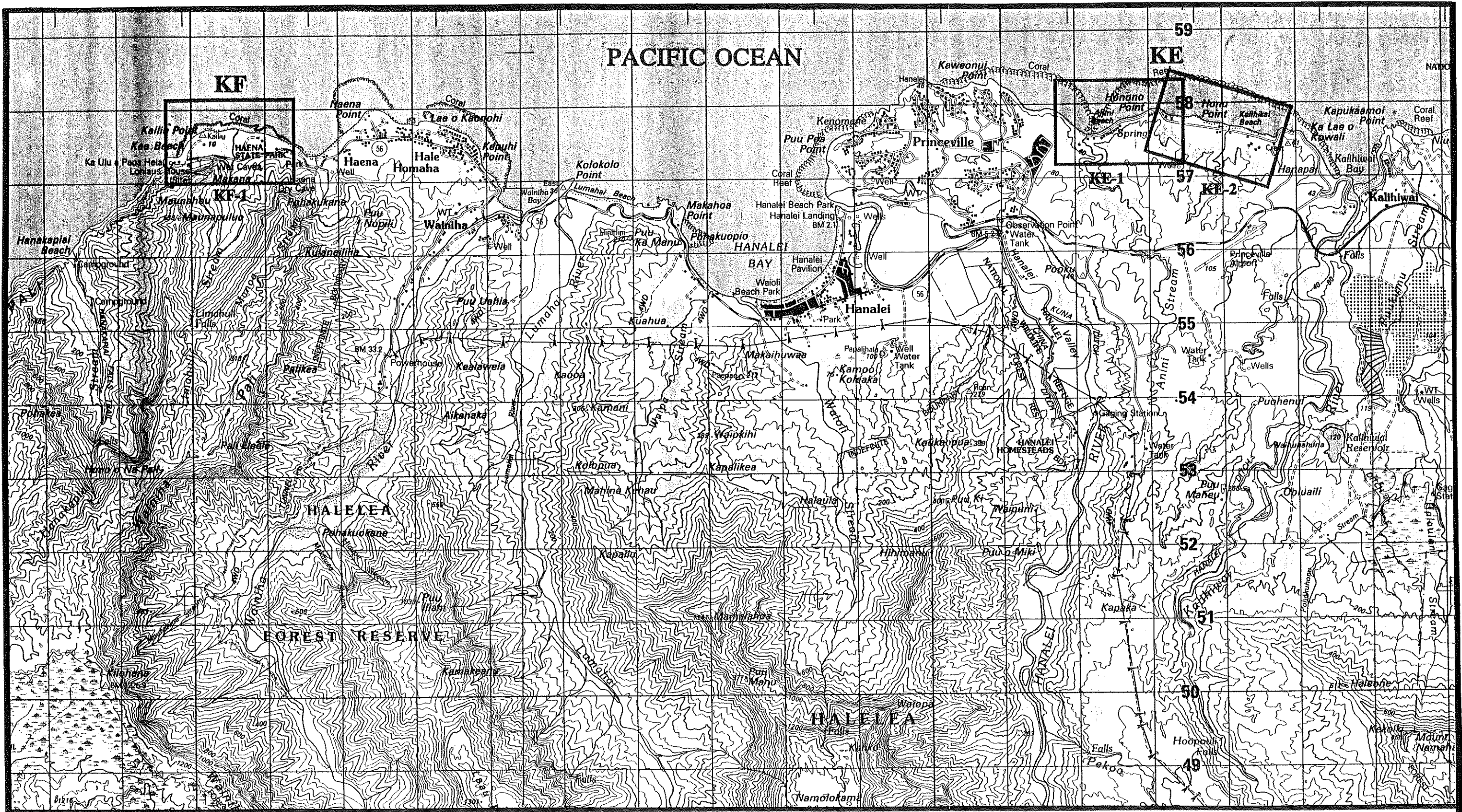
### SHORELINE PROCESSES

In general, most north shore beaches are very dynamic, undergoing erosion in the winter, and then accretion in the summer. The changes are most apparent in the beach width and the location of the waterline. The beaches become relatively narrower and steeper during the winter, and wider and flatter during the summer. The vegetation line is not usually affected by the typical seasonal changes, unless the north swell is so large that the wave runup cuts back the vegetation line. The recent study by DHM (1990), found that there were no consistent trends through long stretches of beach, apparently due to the variation in nearshore wave climate along the shoreline. The results of our study are consistent with these findings. Kee Beach is dynamic; certain regions are accreting while others are eroding. The western half of Anini Beach is stable, while the eastern half is undergoing slow, but chronic erosion. Another factor complicating the analysis of the littoral processes along this coastline is the number of stream discharges and their effect upon the sand volume of the beaches. During flood conditions, a significant volume of sand may be transported seaward, at least temporarily.



### BEACH USAGE

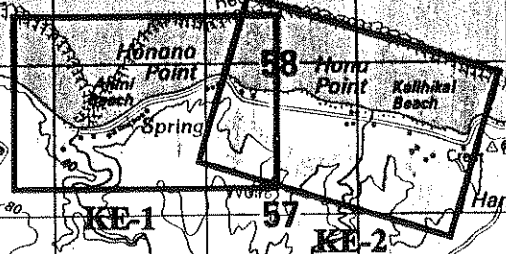
The north shore of Kauai is a prime recreational area. The beaches are very high quality, and shoreline uses include swimming, snorkeling, diving, windsurfing, bodysurfing, board surfing, pole fishing and throw netting. The level of use is intensive enough so that there have been conflicts between some of the user groups.



PACIFIC OCEAN

KF

59  
KE



**LEGEND**

HYDROGRAPHIC DATUM ..... MEAN LOWER LOW WATER

Depth curve (meters) \_\_\_\_\_

Foreshore flats \_\_\_\_\_

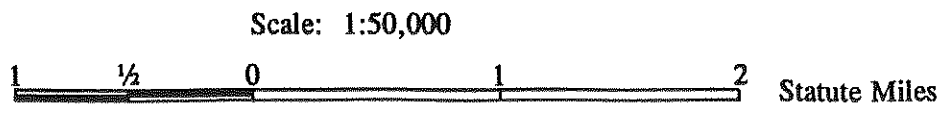
Rocks awash, Reef \_\_\_\_\_

Wreck: Exposed, Sunken with masts exposed \_\_\_\_\_

Wharf, pier \_\_\_\_\_

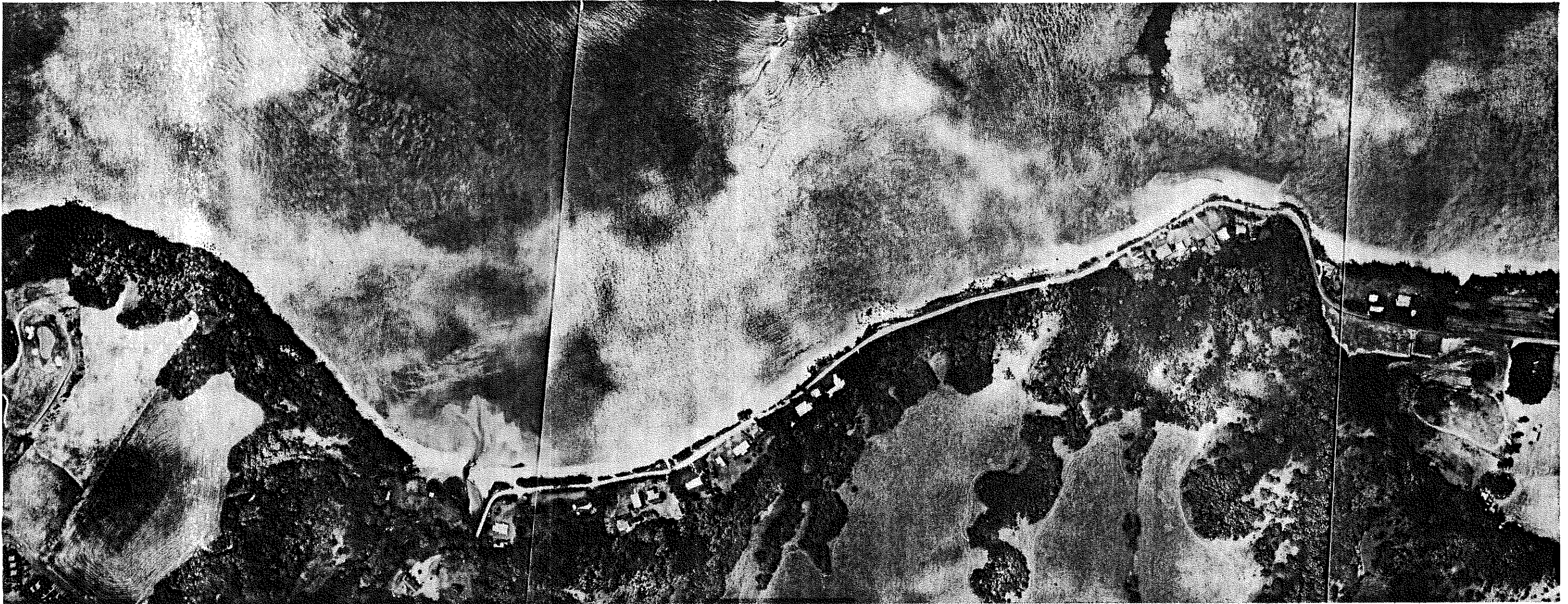
Seawall \_\_\_\_\_

Oil/gas rig \_\_\_\_\_



From U.S. Geological Survey  
MAP INFORMATION AS OF 1983

NORTH KAUAI



## KE-1: ANINI BEACH WEST

### BEACH DESCRIPTION

- The western part of Anini Beach extends for 3200 feet between Anini Stream and Honono Point. The beach is narrow, with an average width of 30 to 40 feet. A man-made boulder revetment along the highway at Honono Point separates the eastern and western reaches of Anini Beach.
- The 1000 foot length of shoreline west of Honono Point consists of basalt boulders with intermixed sand.
- Anini Reef protects this beach from direct wave approach.

### BACKSHORE

- Anini Road parallels the beach. Only a thin strip of vegetation separates the road and the beach. There are no structures seaward of the road.
- Landward of the road, much of the area has been developed with single family houses.

### SHORELINE HISTORY

- The portion of Anini Beach in this subsector has been relatively stable over the 38 year measurement period. Anini Stream discharges at the west end of the beach, and the shoreline in the immediate vicinity (Region 1) showed the greatest change, an accretion of 20 feet.

- For other areas (Regions 2, 3 and 4) the net change over the entire period was 6 feet or less.

### SUMMARY

- This western segment of Anini Beach is stable, and there are no apparent erosion problems. There is no shore protection along the coast.
- All development is landward of the road through this subsector.

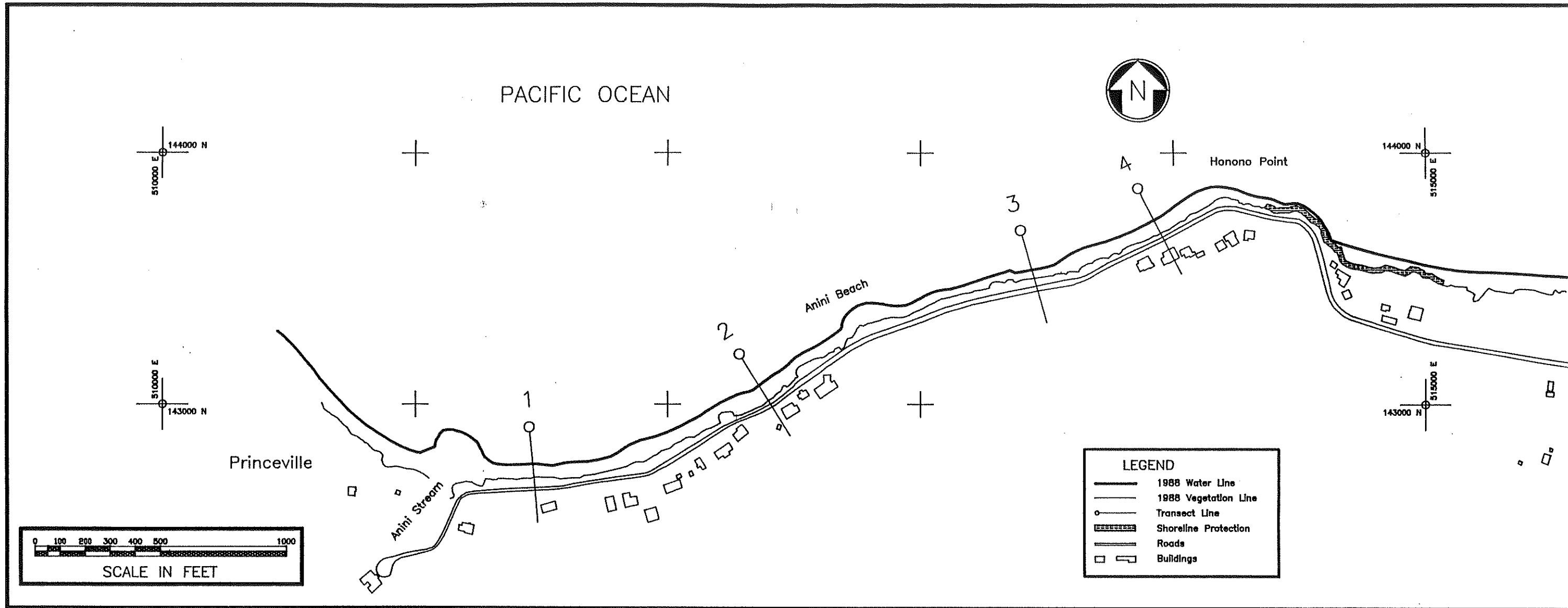
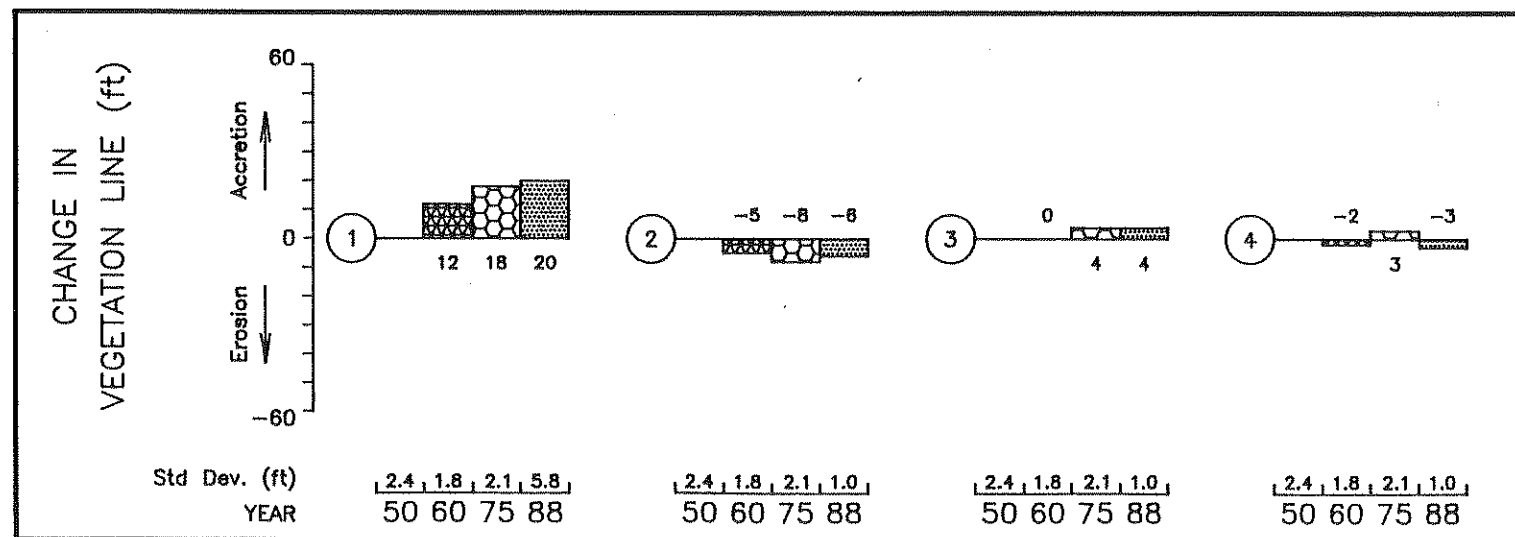


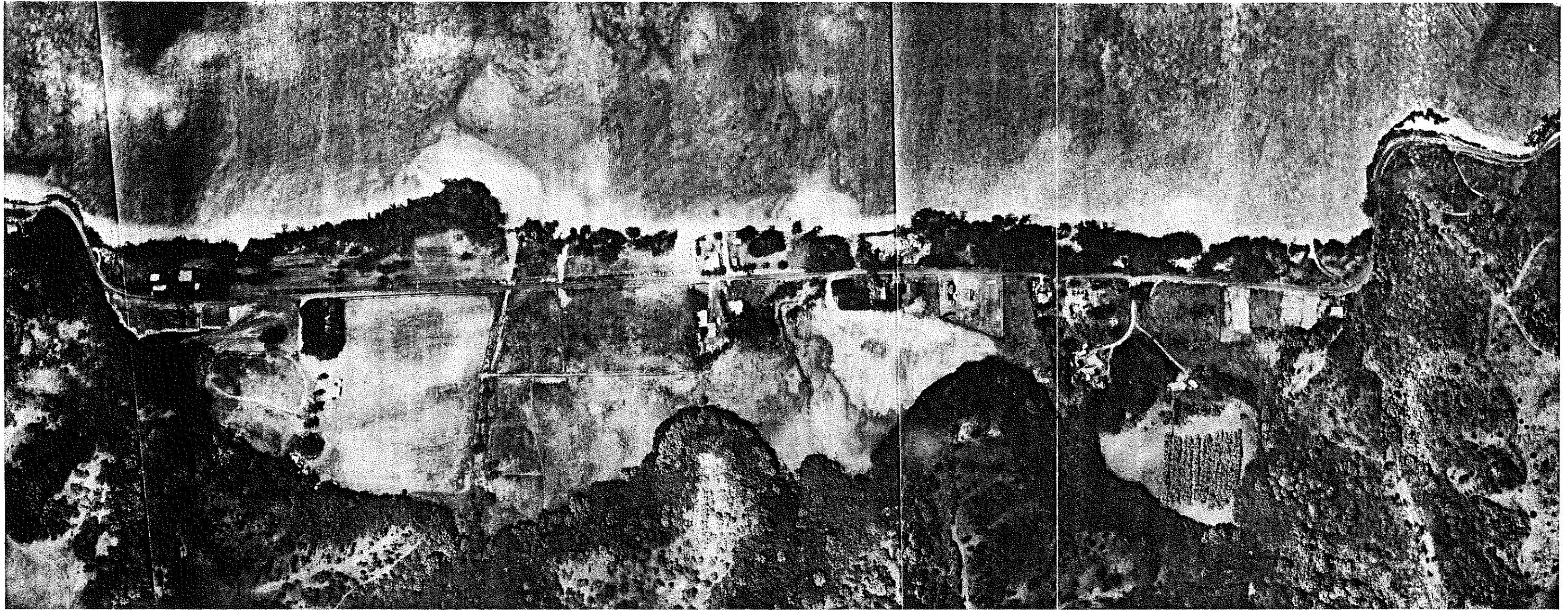
FIGURE KE-1



GRAPH KE-1 Region Number vs Change in Vegetation Line

PHOTOS USED  
 May 1988  
 July 1987  
 April 1975  
 March 1960  
 November 1950





**KE-2: ANINI BEACH EAST**

**BEACH DESCRIPTION**

- The eastern segment of Anini Beach extends 5200 feet to the east of Honono Point. Typical beach width is 50 feet.
- Anini Reef, one of the most extensive fringing reefs in the state, protects the beach from direct wave attack. Two small streams discharge across the beach, and there is a sand delta at the mouth of each stream.

**BACKSHORE**

- Anini Road parallels the beach, and is located approximately 200 feet inland of the vegetation line. Anini Beach Park is located along much of the backshore area. There is a one lane boat ramp in the park.

- The 2200 foot length of beach east of the park (Regions 7 to 10) has undergone rapid development over the past few years and there are single family houses through most of this reach. A 600 foot length of backshore just east of Honohono Point also is developed with single family houses.
- There are two areas of shore protection: a 450 foot seawall at the Park, and a 500 foot long seawall protecting the houses at Honono Point. In addition, a rock revetment at the point protects Anini Road, and is contiguous with the seawall.

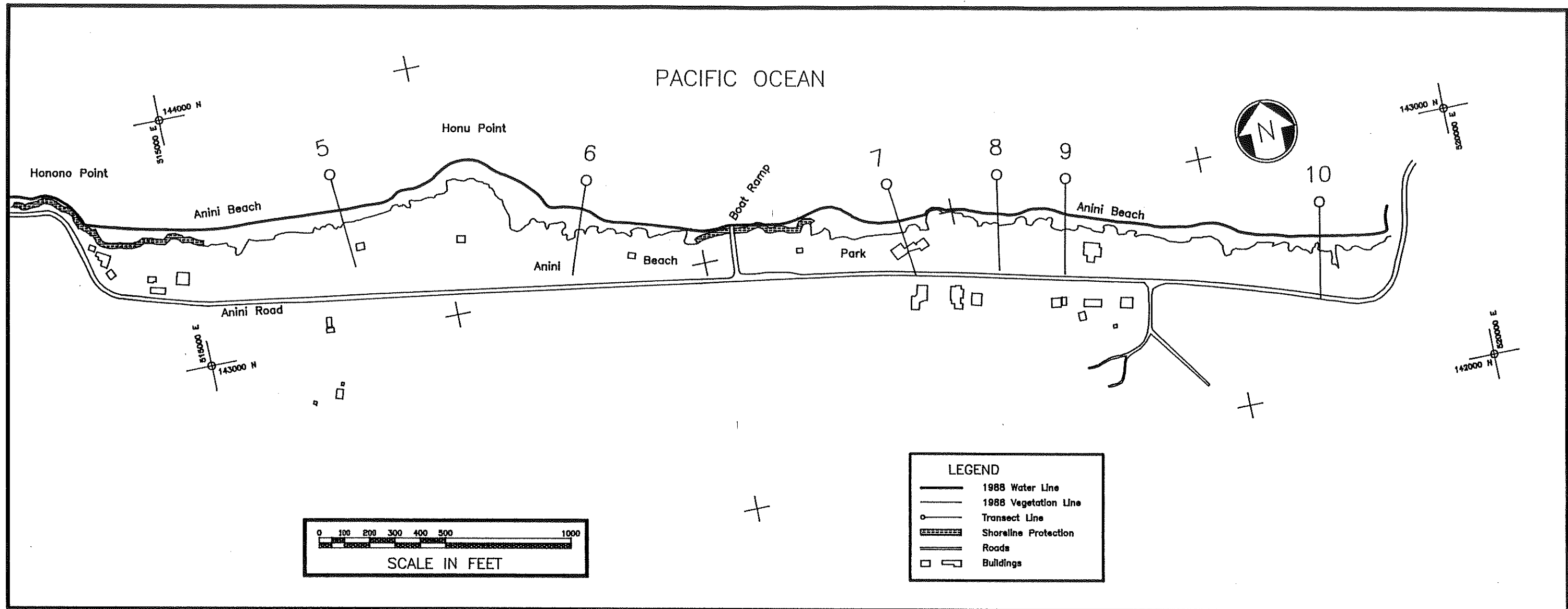
**SHORELINE HISTORY**

- The site visit indicated that most of this shoreline is undergoing slow, but chronic erosion. A one to two foot wave-cut scarp is present through much of the residential area, and in both the park and the residential area, there are ironwood trees located seaward of the vegetation line.

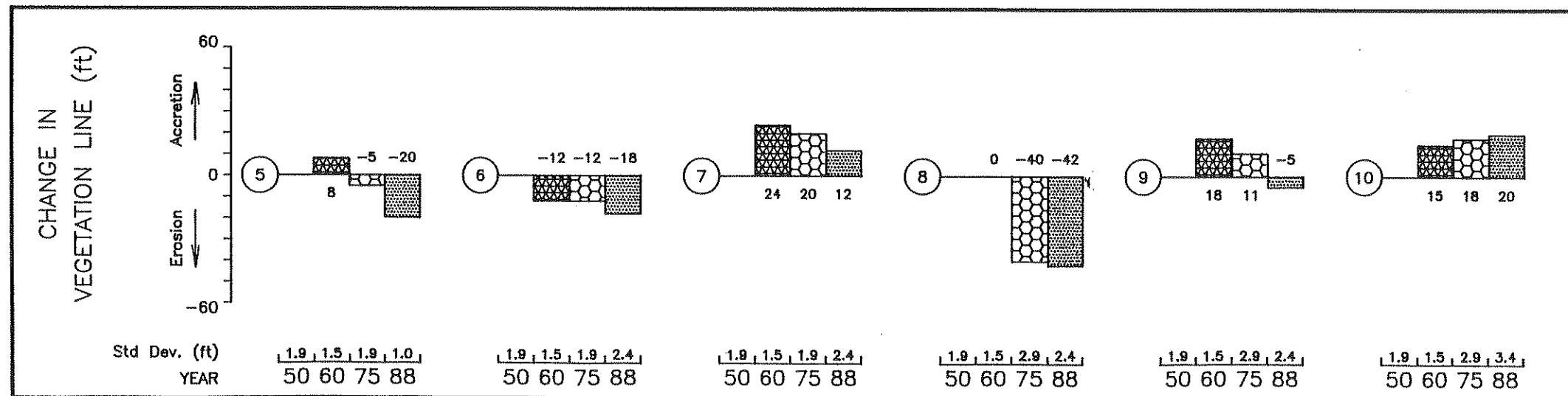
- The aerial photographs showed that some areas accreted in the 1960's and early 1970's, but the recent trend is one of erosion.

**SUMMARY**

- This beach, particularly the residential area east of the park (Regions 7 to 10), is a potential problem area. Erosion is occurring, and given the narrow beach and the proximity of the houses to the vegetation line, permit applications for seawalls should be anticipated.
- The data from the aerial photographs should be considered as approximate due to the ironwood trees overhanging and obscuring the actual vegetation line.

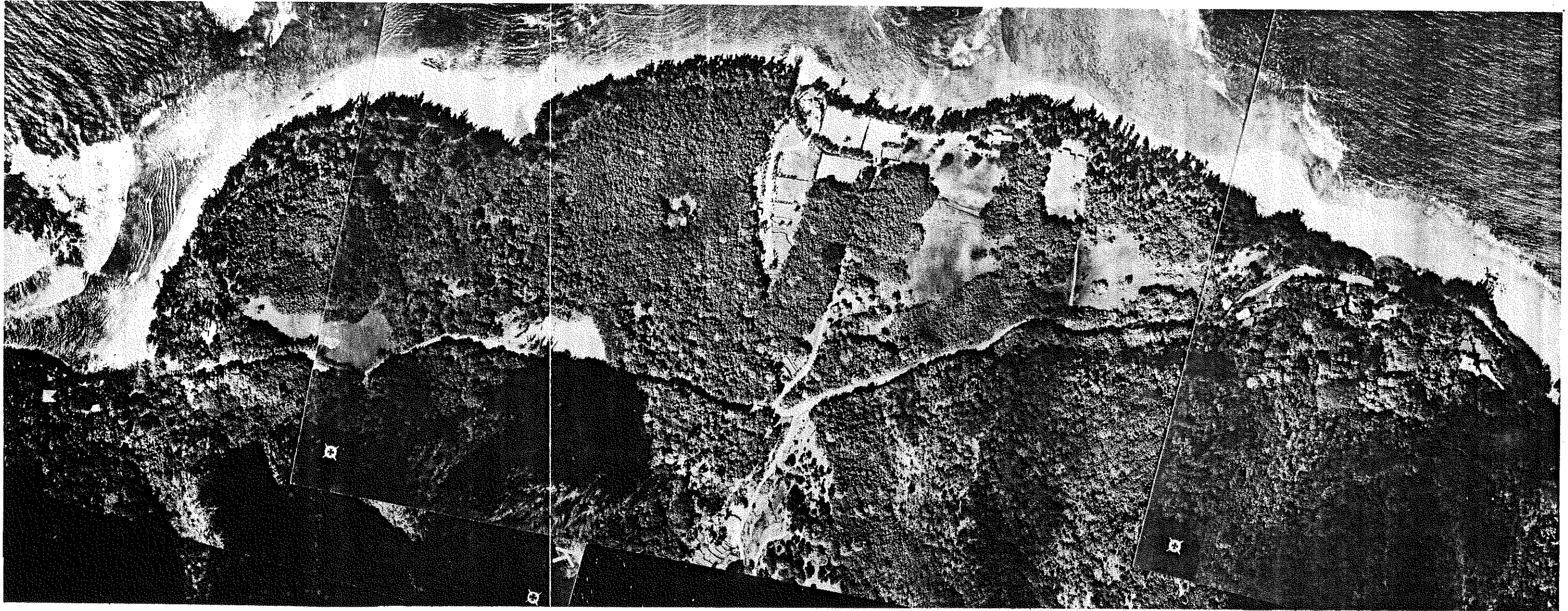


**FIGURE KE-2**



**GRAPH KE-2 Region Number vs Change in Vegetation Line**

PHOTOS USED  
 May 1988  
 July 1987  
 April 1975  
 March 1960  
 November 1950



## KF-1: KEE BEACH

### BEACH DESCRIPTION

- Kee Beach is a 6100 foot long beach located at the west end of a long sandy shoreline that extends from Wainiha Bay to the Napali Cliffs. The beach, composed of calcareous sand, is convex shaped, varies in width from 30 to 150 feet, and is protected by a 500 to 800 foot wide shallow fringing reef. Three small streams discharge across the beach.
- Beach rock outcroppings at the beach toe are common along the western half of the beach and there is an area near the eastern boundary of Haena State Park where the beach is composed of sand intermixed with basalt boulders.

### BACKSHORE

- Haena State Park is located behind the western 4300 feet of Kee Beach. The backshore is open land; there is no development close to the beach.

- There are a few houses along the eastern 1600 feet of the beach, all set well back from the vegetation line.

### SHORELINE HISTORY

- The west end of this subsector (Regions 1, 2 and 3) is a dynamic shoreline with much greater vegetation line changes than the east end. This is also the area where the beach is the widest. The reef is narrower off this end, and the shoreline orientation is different. The maximum vegetation line change in this reach was erosion of 90 feet between 1950 and 1975 in Region 1. In Region 3, however, the beach has accreted 85 feet.
- The east end of the beach is narrower, and less dynamic. The net vegetation line changes over the 38 year period were 23 feet or less (see graph KF-1).

### SUMMARY

- The vegetation line of this subsector was difficult to pinpoint due to ironwood trees overhanging the beach. The 1960 photo series also had shadows of the trees on the beach, making the process even more difficult. As a result, the 1960 series was not used. The data in graph KF-1 should be considered as approximate, indicative of general trends and overall beach dynamics, but not as precise records of shoreline change.
- The vegetation line changes in this subsector follow no consistent trend. This is also typical of the beaches to the east studied by DHM (1990). Due to the locally varying reef and shoreline configurations, the nearshore wave heights and approach directions vary greatly through the subsector, resulting in varying shoreline response.

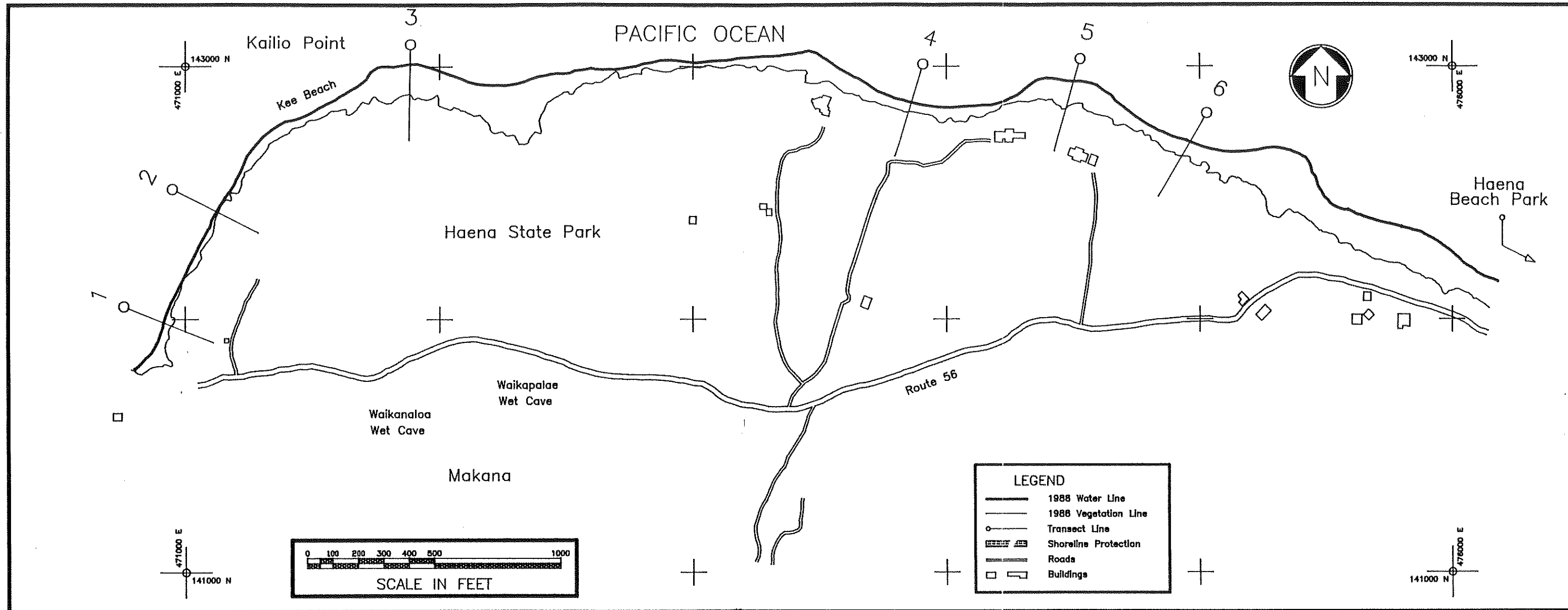
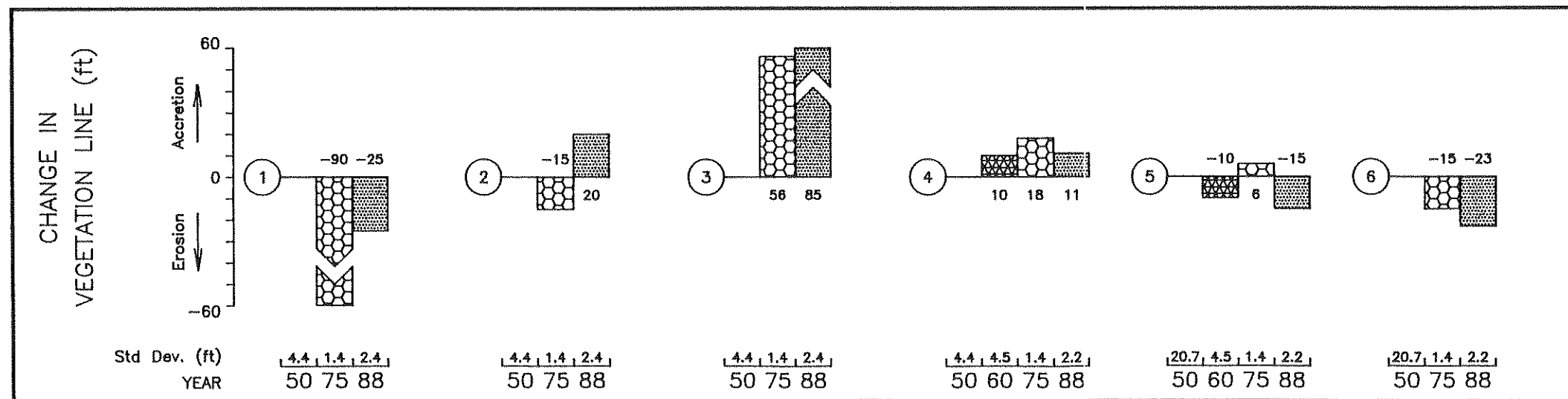


FIGURE KF-1



PHOTOS USED  
 March 1988  
 July 1987  
 April 1975  
 November 1950

GRAPH KF-1 Region Number vs Change in Vegetation Line





**MOLOKAI**

- **West Molokai**  
OA - Papohaku Beach to Kawakiu Beach
- **Southeast Molokai**  
OB - Pukoo to Kumimi Point



## SECTOR OA: WEST MOLOKAI PAPOHAKU BEACH TO KAWAKIU BEACH

### GENERAL COASTAL CHARACTERISTICS

This four mile long coastal sector includes four beaches; Papohaku Beach, Kepuhi Beach, Pohakumauliuli Beach and Kawakiu Beach. Papohaku and Kepuhi are the largest of the beaches, and are two miles and one mile long respectively. The beaches are separated by basalt points or headlands.

### LAND USE AND DEVELOPMENT

There was no residential or resort development along this coastal sector until the mid 1970's, when the Sheraton Molokai Hotel was built at Kepuhi Beach. The hotel is now called the Kaluakoi Resort. This is the largest resort on the island of Molokai. Until the construction of the hotel, the entire west end of the island was owned by Molokai Ranch, Ltd., and access to the shoreline was very restricted. Papohaku Beach is one of the largest white sand beaches in the state (Clark, 1980), and from 1959 to 1975 was the site of the largest sand mining operation in the state. Sand was removed from the south end of the beach and barged throughout the state, primarily for construction purposes. The state legislature banned the mining of beach sand in 1972, and the operation was phased out by 1975. A remnant of the operation, a large concrete tunnel, can still be seen at the south end of the beach. The construction of the hotel opened up this end of the island, and in recent years condominiums have been built near the hotel, and a few single family homes have been built along Papohaku Beach.

### WAVE CLIMATE

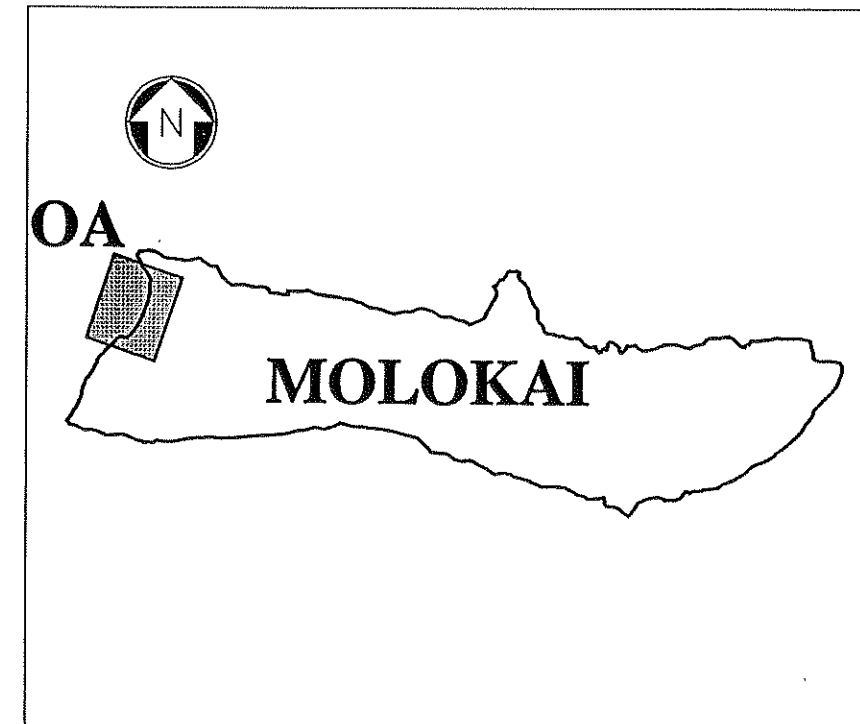
This coastal sector is exposed to wave approach from the southwest, west, and northwest, and therefore to some of the south swell, Kona storm waves and wintertime North Pacific swell. There is no fringing reef and the beaches are exposed to the full force of the incoming waves.

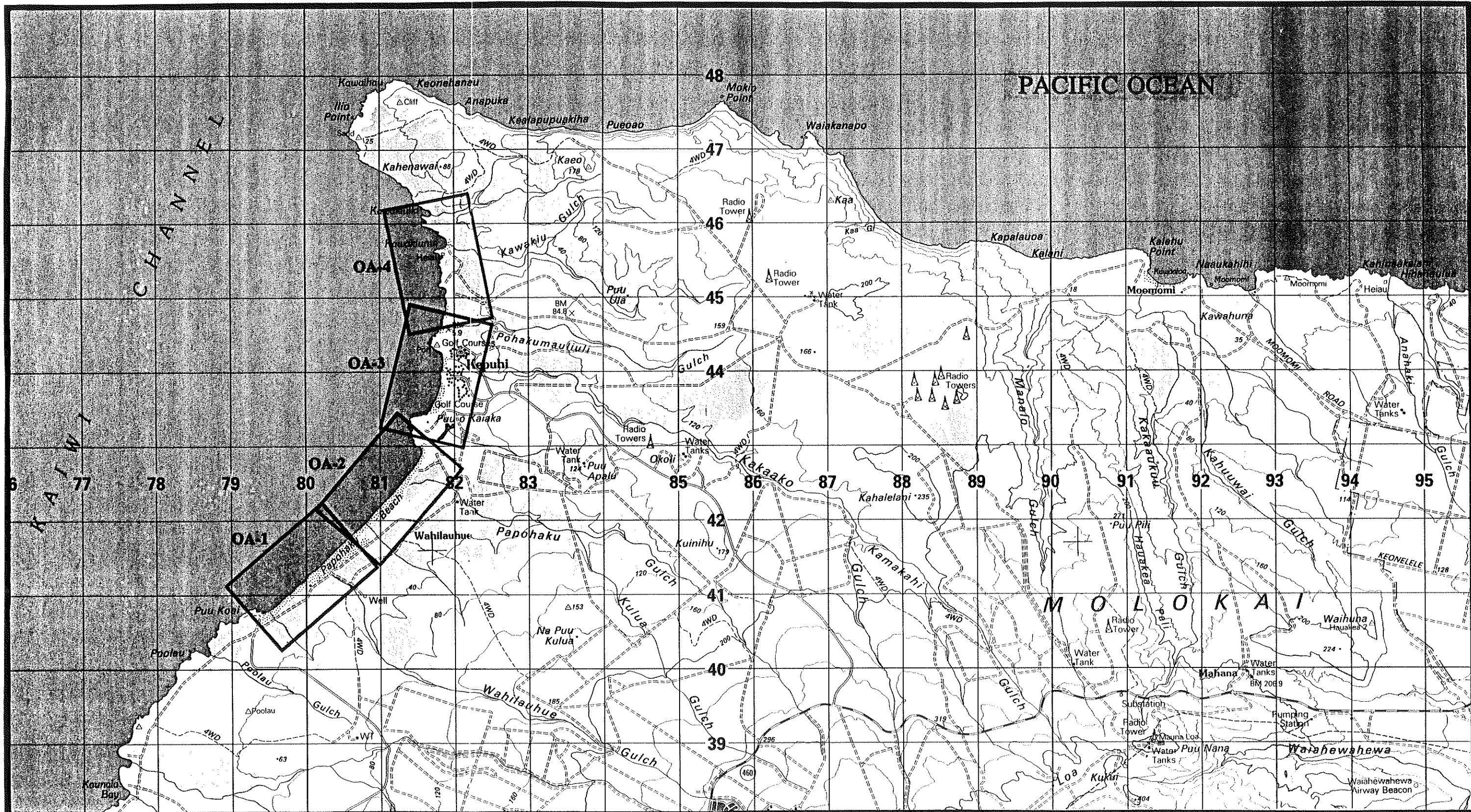
### SHORELINE PROCESSES

The north Pacific swell has a major impact upon the littoral processes in this sector, and moves sand both offshore and to the south. The sand mining operation at Papohaku Beach was situated to take advantage of the predominant southerly transport. Moberly and Chamberlain (1964), during their surveys of Hawaiian beaches, showed a pronounced variation in seasonal beach width at Kepuhi Beach. The average beach width at the end of the winter was 60 feet, increasing to 100 feet at the end of the summer. Papohaku Beach most likely follows the same seasonal pattern. Kona storm waves, because of their infrequent occurrence and severity, cause noticeable temporary erosion of many of the exposed beaches on Kauai, Oahu and Maui. The beaches in this sector are also likely to undergo severe, temporary erosion during Kona storms.

### BEACH USAGE

Swimming along these beaches is marginally safe during the summer months, and unsafe, except for experts, during the winter months. The north Pacific swell results in large shorebreak and strong rip currents. According to Clark (1980), the military practiced landings on Papohaku Beach during World War II. Wire, abandoned vehicles and other metal objects left from these activities can be exposed during heavy surf, presenting another danger to swimmers.





PACIFIC OCEAN

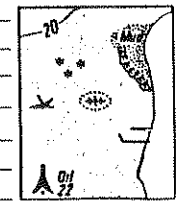
CHANNEL

RAIWI

MOLOKAI

**LEGEND**

- HYDROGRAPHIC DATUM . . . . . MEAN LOWER LOW WATER
- Depth curve (meters) \_\_\_\_\_
- Foreshore flats \_\_\_\_\_
- Rocks awash, Reef \_\_\_\_\_
- Wreck: Exposed, Sunken with masts exposed \_\_\_\_\_
- Wharf, pier \_\_\_\_\_
- Seawall \_\_\_\_\_
- Oil/gas rig \_\_\_\_\_



Scale: 1:50,000



Statute Miles

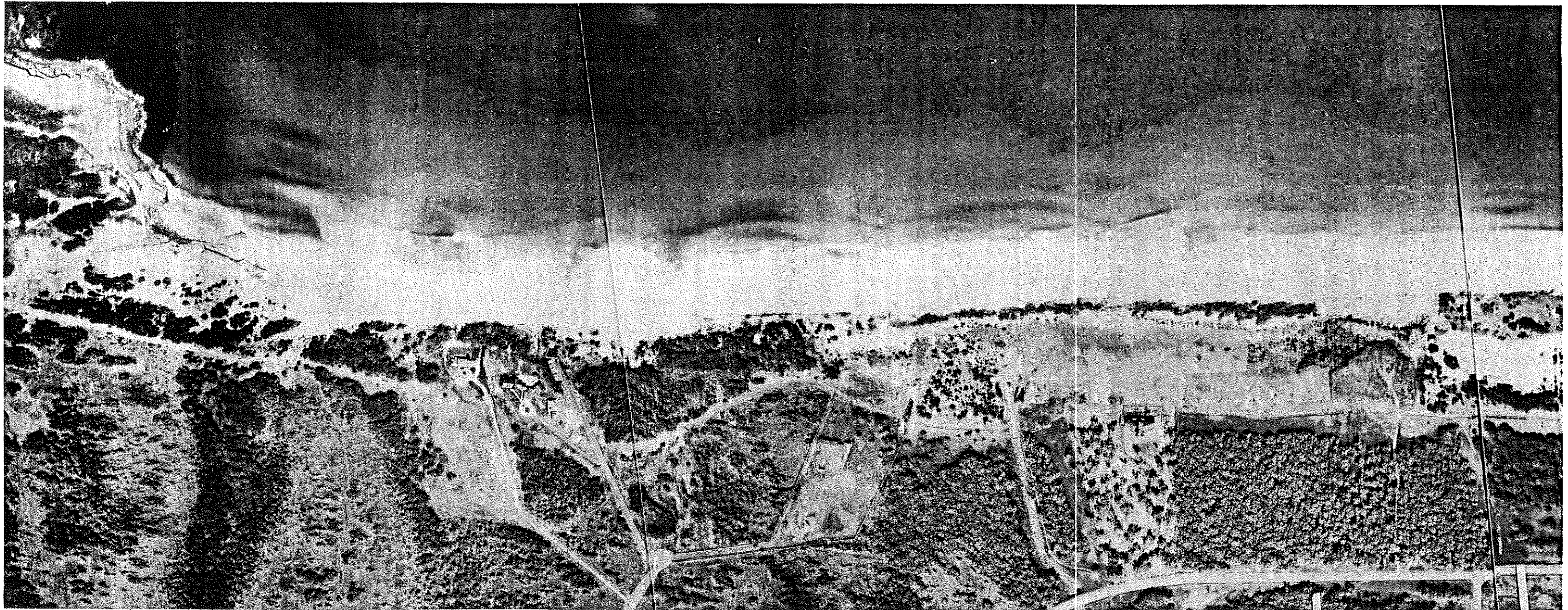


**WEST MOLOKAI**

**Papohaku Beach to Kawakiu Beach**

From U.S. Geological Survey  
MAP INFORMATION AS OF 1983





## OA-1: PAPOHAKU BEACH; SOUTHERN END

### BEACH DESCRIPTION

- This subsector consists of the southern half of Papohaku Beach, a two mile long, calcareous sand beach. The beach is bounded by Puu Koa, a basalt headland on the south, and Puu O Kaiaka, a cinder cone headland on the north.
- The beach is straight and, on average 200 to 300 feet wide.
- There is no protective reef offshore. The beach there is directly exposed to open ocean swells from the northwest, west and southwest.

### BACKSHORE

- The southern half of the beach was the site of the largest sand mining operation in the state from the early 1960's until 1975, when the State legislature banned removal of sand from beaches seaward of vegetation line. The concrete tunnel on the beach is all that remains of the operation.

- The rest of the backshore of the beach was undeveloped until recently. A few single family residences have recently been built along the beach.

### SHORELINE HISTORY

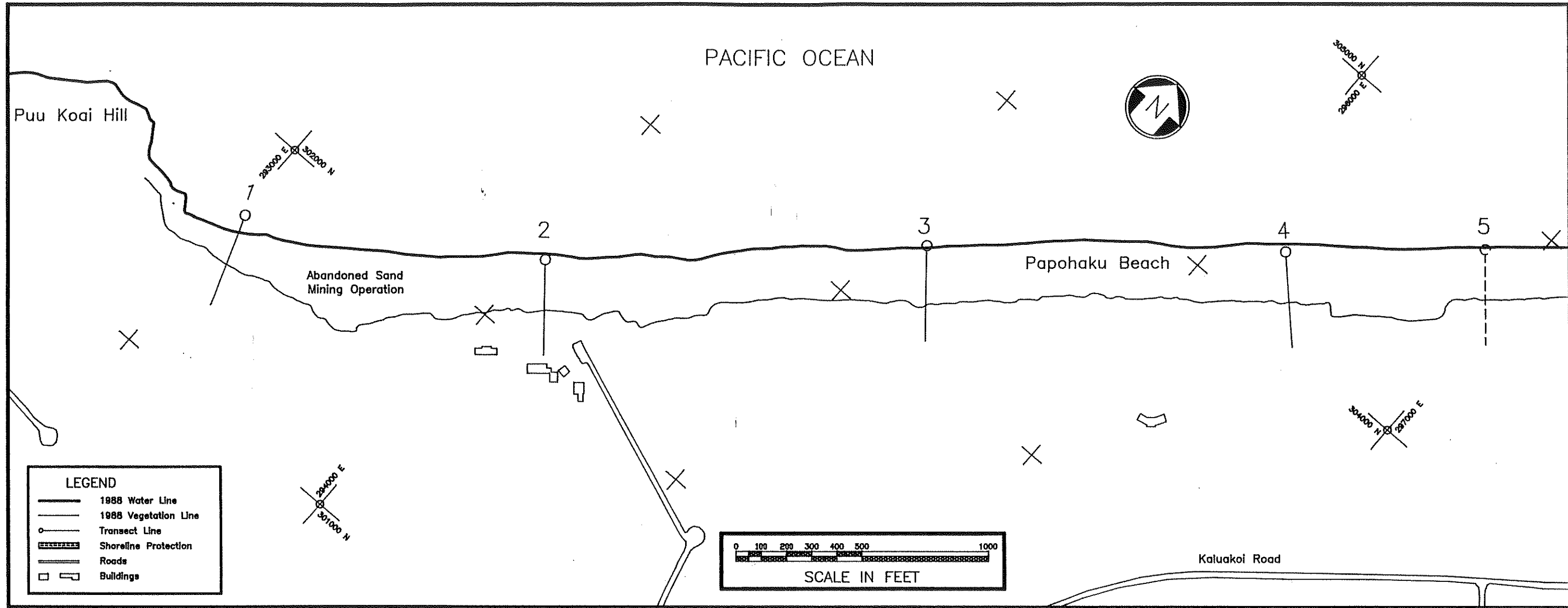
- The predominant littoral transport along Papohaku Beach is from north to south, due to the winter season north Pacific swell. The beach width increases from 200 feet at north end to 300 feet at south end. The sand mining operation was sited to take advantage of the predominant littoral transport.
- The south end of the beach was severely affected by the sand mining operation. The vegetation line receded up to 100 feet (Regions 1 & 2) during the mining operations.
- Regions 2, 3 and 4 all show accretion of the 1968 vegetation line. In this series of photos, all beaches in Sector OA were cut back and beach rock was exposed at the crest of Papohaku Beach. All sand

had been stripped from Kepuhi Beach, located just north of Papohaku. Given the loss of sand from the beach, the reason for the vegetation line accretion is not known.

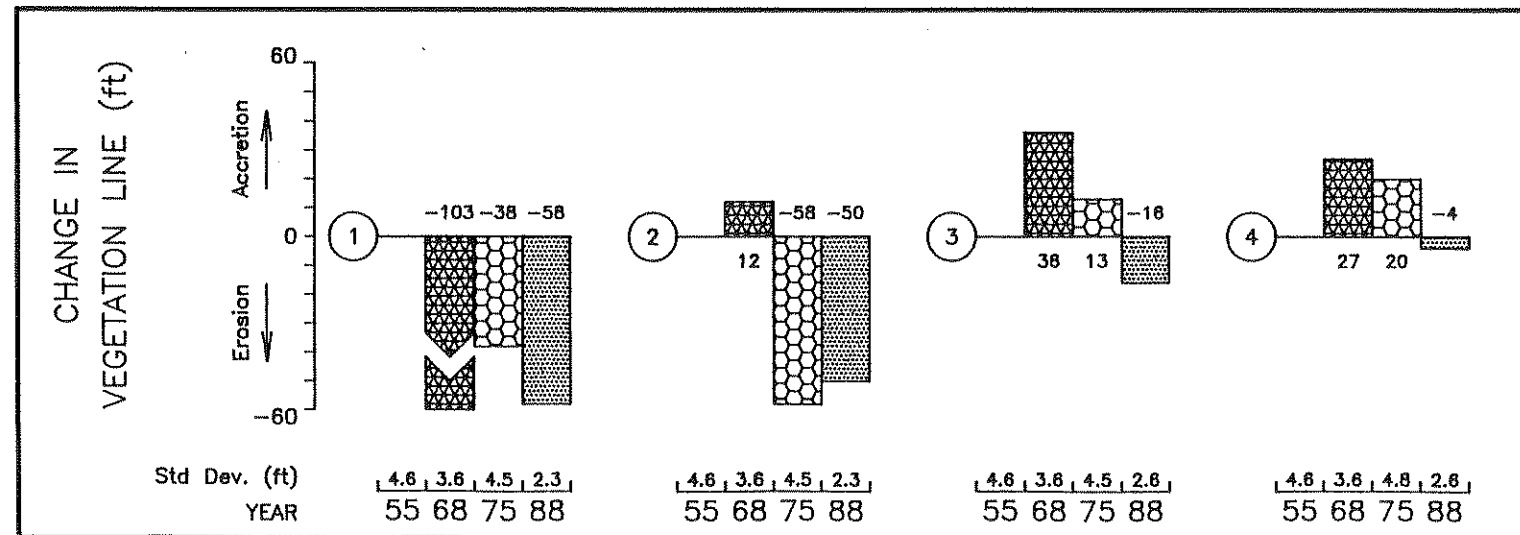
- The vegetation line at the northern end of the subsector has been eroding.

### SUMMARY

- Analysis of the vegetation lines does not show the total effect of sand mining on this beach. Comparing the aerial photos of January 1955 and those of either July 1987 or March 1988, it is apparent that a large amount of sand has been lost to the beach system.
- In 1950, the beach was 250 feet wide at the north end and 450 feet wide at the south end; the 1987 and 1988 photos show widths of 200 feet and 300 feet respectively.



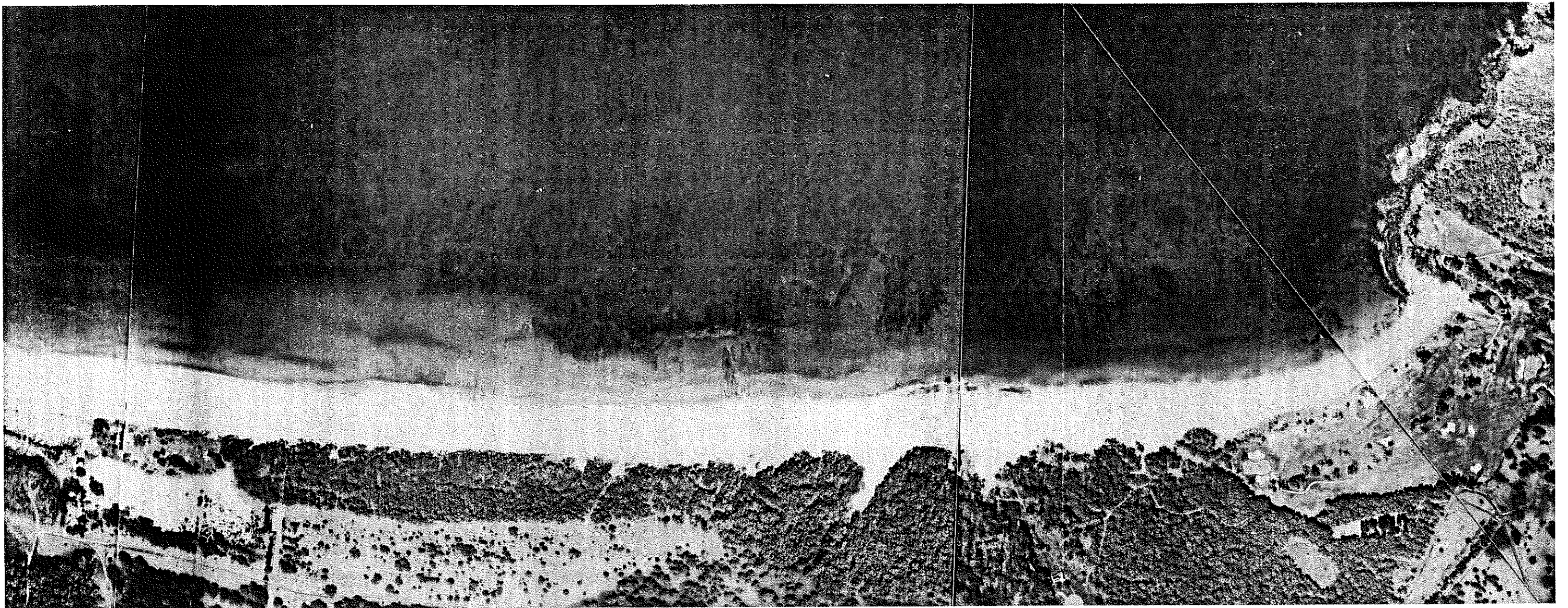
**FIGURE OA-1**



**GRAPH OA-1 Region Number vs Change in Vegetation Line**

**PHOTOS USED**

- March 1988
- July 1987
- March 1975
- November 1968
- January 1955



## OA-2: PAPOHAKU BEACH; NORTH END

### BEACH DESCRIPTION

- This subsector contains the northern half of Papohaku Beach. The typical width through this subsector is 200 feet.

### BACKSHORE

- The backshore was undeveloped until recently. A few single family houses are now being built along the beach. They are set well back from the vegetation line.
- One fairway for the golf course parallels the northern-most 1200 feet of the beach.

### SHORELINE HISTORY

- The southern half of this subsector showed a net erosion of approximately 30 feet (Regions 5 and 6), while the northern half was either accreting (Region 7) or stable (Region 8).

### SUMMARY

- The northern half of Papohaku Beach was not affected by the sand mining to nearly the same extent as the southern half.
- The seasonal variations in wave climate, and the direct exposure to the North Pacific swell, combine to make this a dynamic beach, potentially subject to large vegetation line changes. This should be considered as houses are built along the beach.

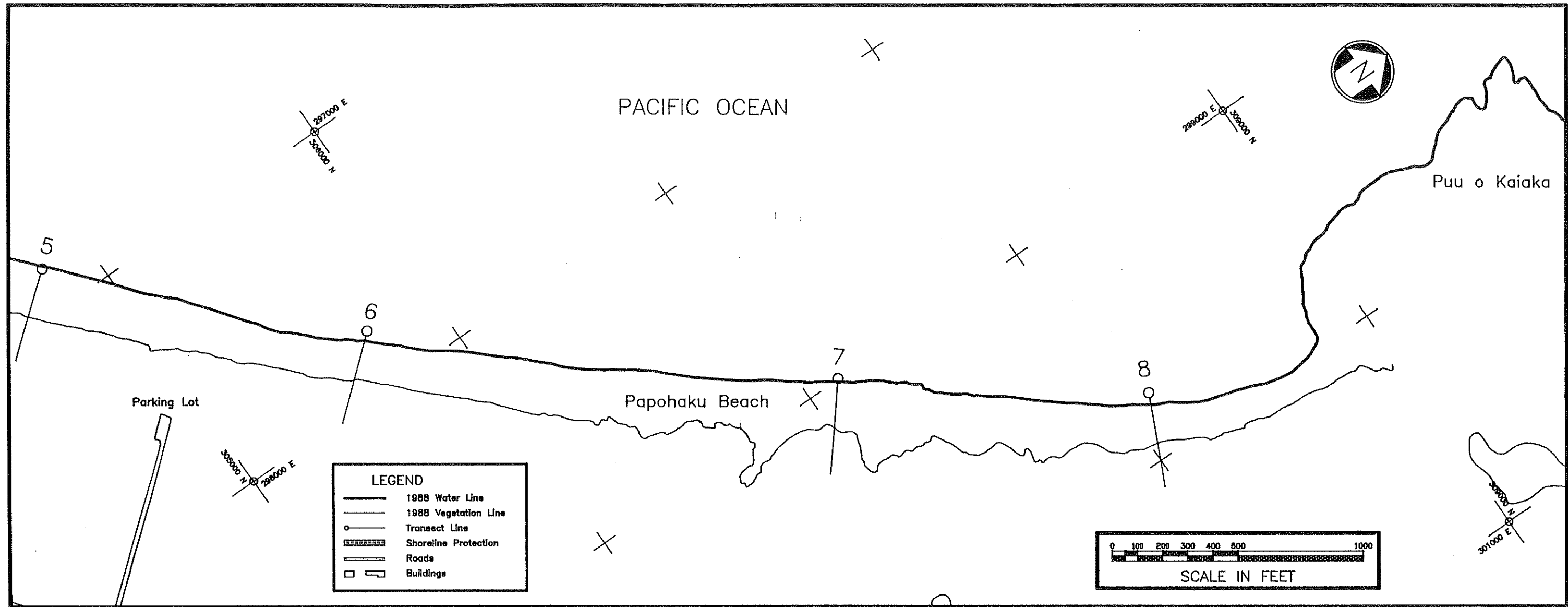
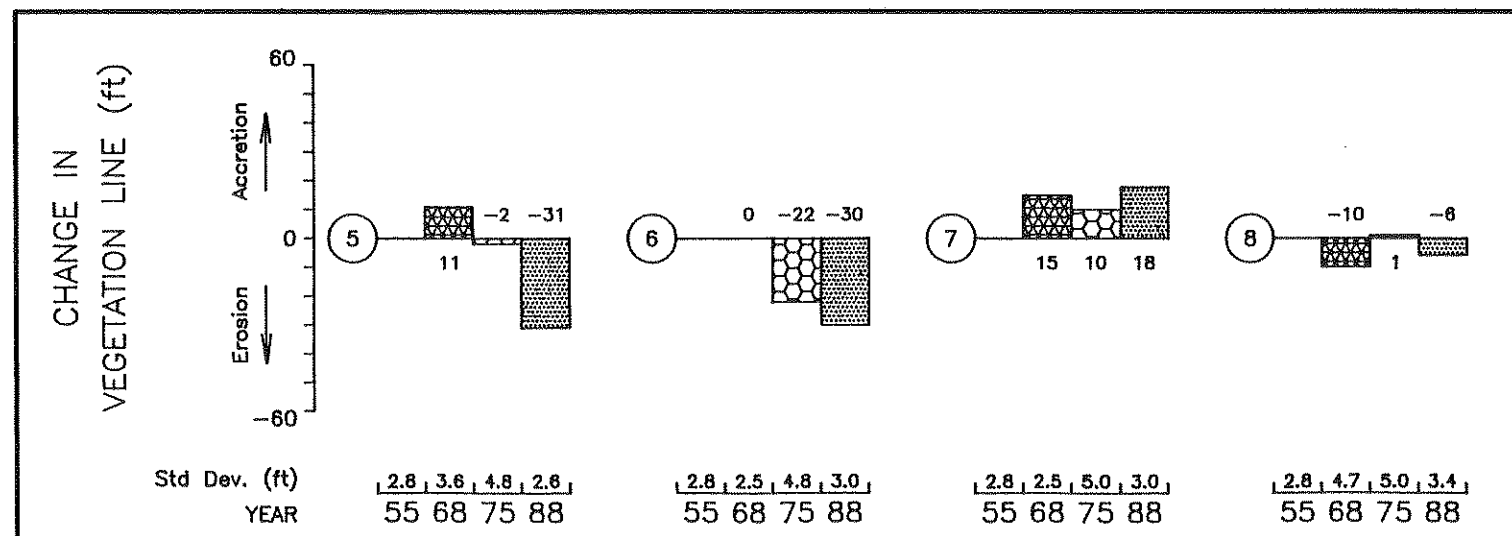
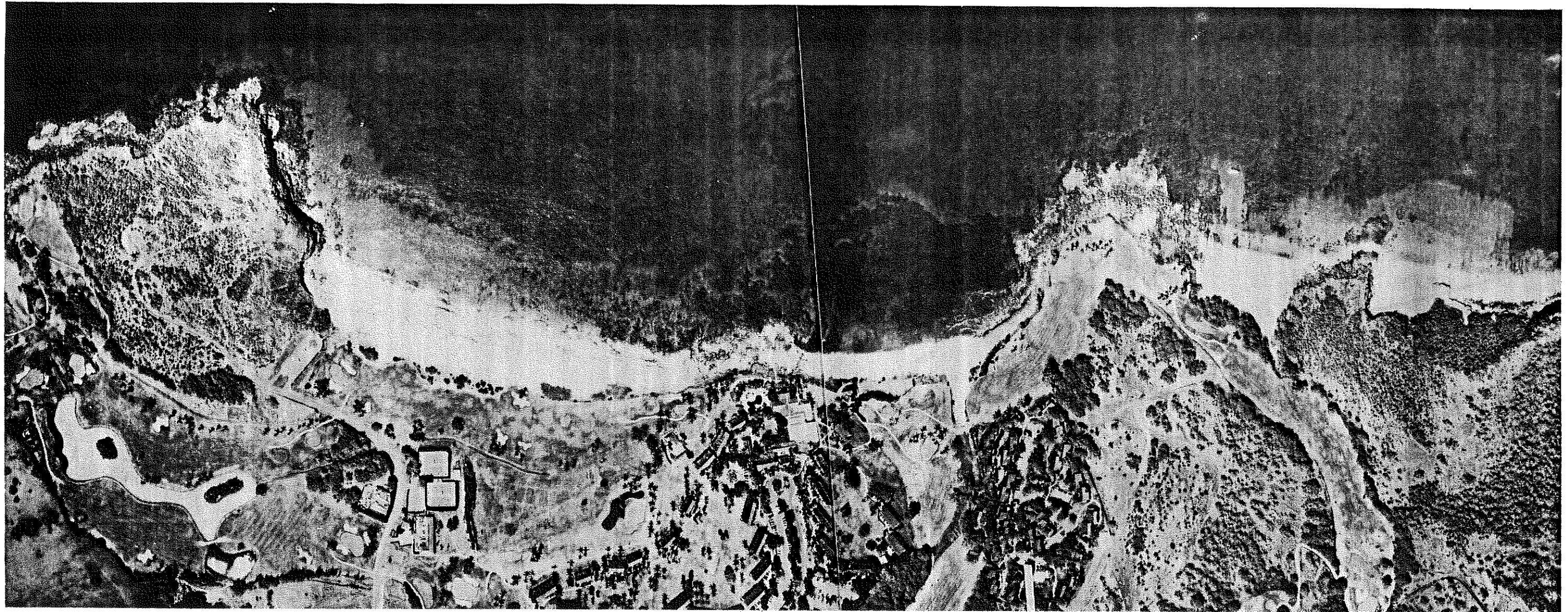


FIGURE OA-2



GRAPH OA-2 Region Number vs Change in Vegetation Line

PHOTOS USED  
 March 1988  
 July 1987  
 March 1975  
 November 1968  
 January 1955



### OA-3: KEPUHI BEACH AND POHAKUMAULIULI BEACH

#### BEACH DESCRIPTION

- Kepuhi Beach is a 2900 foot long sand beach located just north of Puu O Kaiaka. The beach is broken into two subsectors by a naturally occurring outcrop of basalt boulders and ledges in the center of the beach.
- Beachrock is frequently exposed at the toe of the beach, particularly along the southern half.
- Pohakumauliuli Beach is separated from Kepuhi Beach by part of an old cinder cone, which forms a headland between the two. Another part of the cinder cone overhangs the center of the beach, and essentially splits it in two.
- Both beaches are directly exposed to the north Pacific swell, and subsequent erosion and accretion. Beachrock and boulders are commonly exposed along these beaches during the winter months.

#### BACKSHORE

- Kaluakoi Resort occupies the backshore of Kepuhi Beach. Condominiums also have been built in the backshore. The resort structures are centered behind the outcropping in the middle of Kepuhi Beach, and all are well behind the vegetation line.
- Fairways for the golf course parallel the two beaches, except for the northern half of Pohakumauliuli.

#### SHORELINE HISTORY

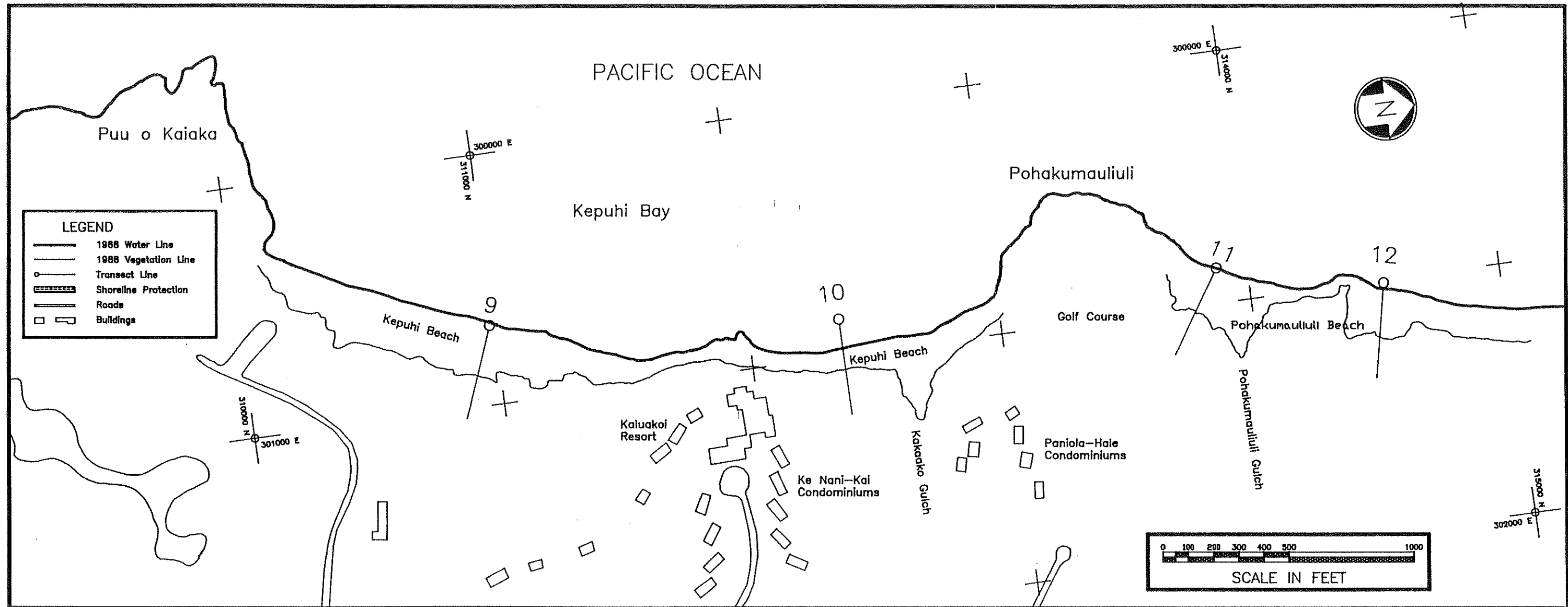
- The vegetation line changes for Kepuhi Beach, which indicate net accretion of 52 to 78 feet (Regions 9 and 10), are probably deceptive. Close inspection of the aerial photographs shows major changes in the vegetation between 1955 and 1975, prior to the construction of the hotel. Most of the trees in the earlier photos were removed, possibly as part of the Molokai Ranch operations.

The vegetation line was modified again during construction of the golf course (between 1975 and 1988). The waterline does not appear to have changed very much between 1955 and 1988.

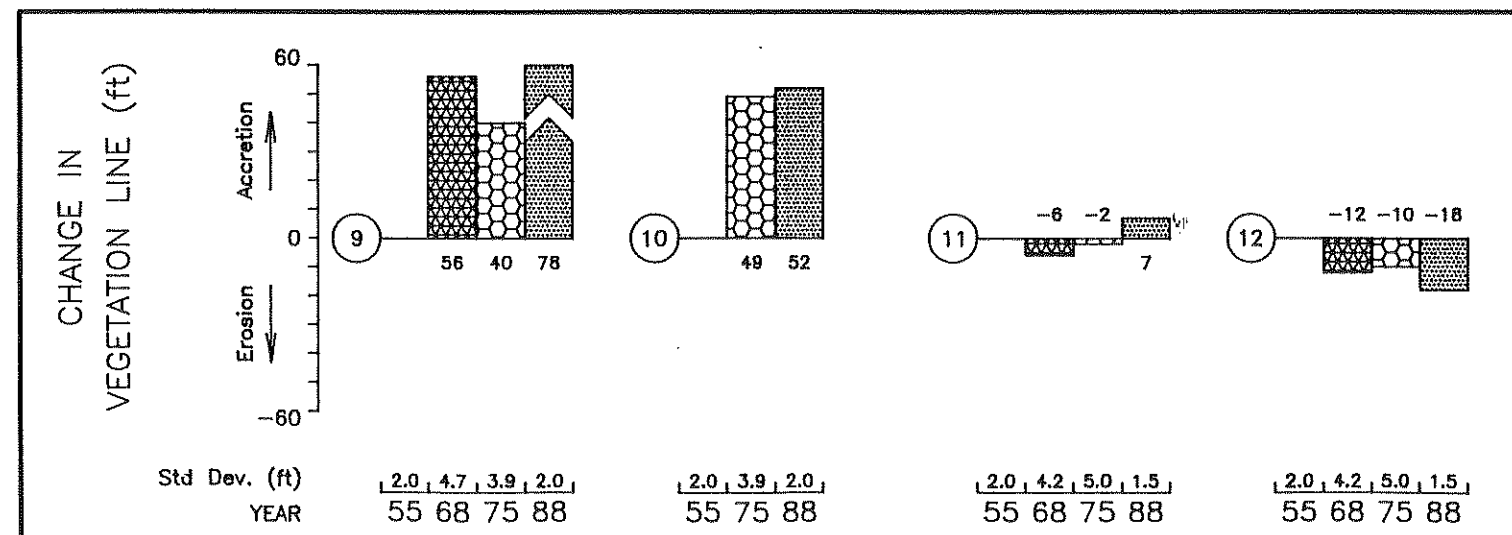
- Pohakumauliuli Beach remained stable over the study period (Regions 11 and 12).

#### SUMMARY

- As at Papohaku Beach to the south, both these beaches had lost most or all of their sand at the time of the 1968 aerial photograph. The reason is not known, but it could have been due to an exceptionally large occurrence of north Pacific swell or a severe Kona storm.
- Both beaches are subject to significant winter/summer changes. Large waves in the winter months cause loss of sand from the beach, and beachrock ledges and boulders are exposed.



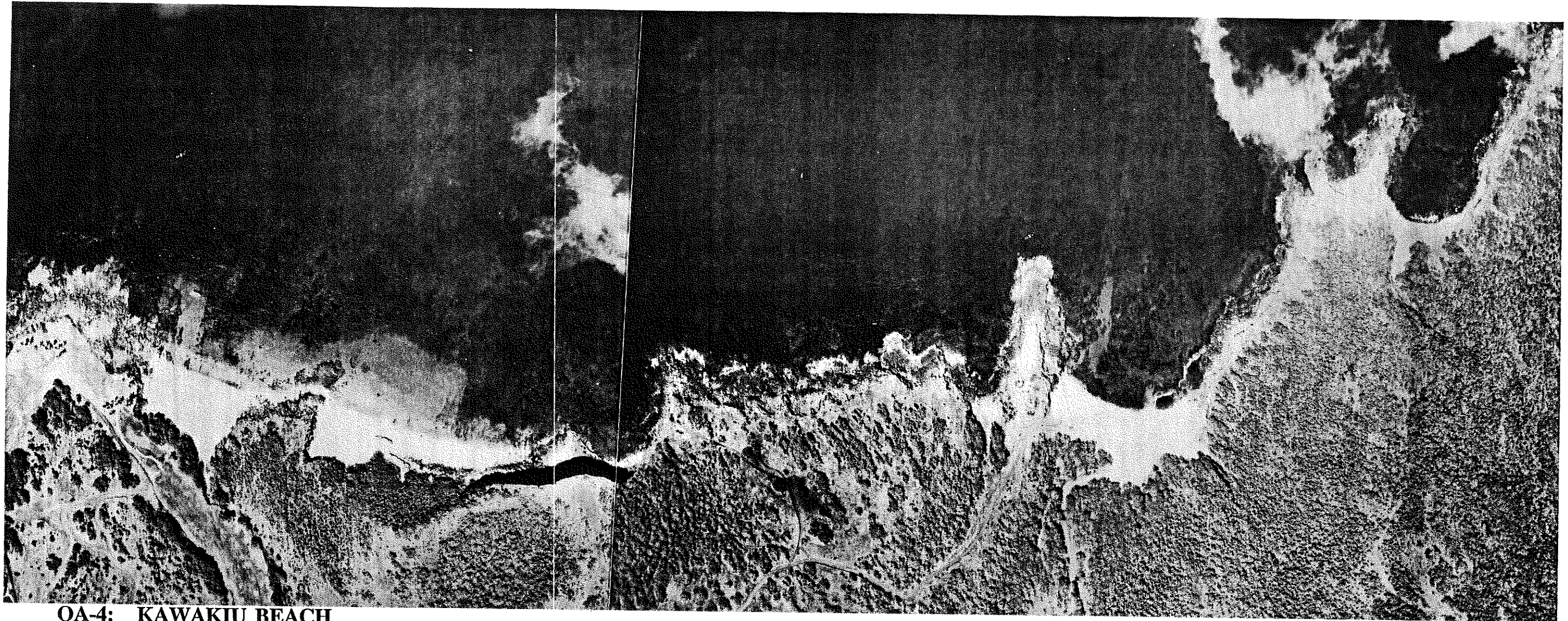
**FIGURE OA-3**



**GRAPH OA-3 Region Number vs Change in Vegetation Line**

**PHOTOS USED**

- March 1988
- July 1987
- March 1975
- November 1968
- January 1955



#### OA-4: KAWAKIU BEACH

##### BEACH DESCRIPTION

- Kawakiu Beach is a small pocket beach located at the head of the Kawakiu Bay.
- The beach is 650 feet long, and typically 100 feet wide.

##### BACKSHORE

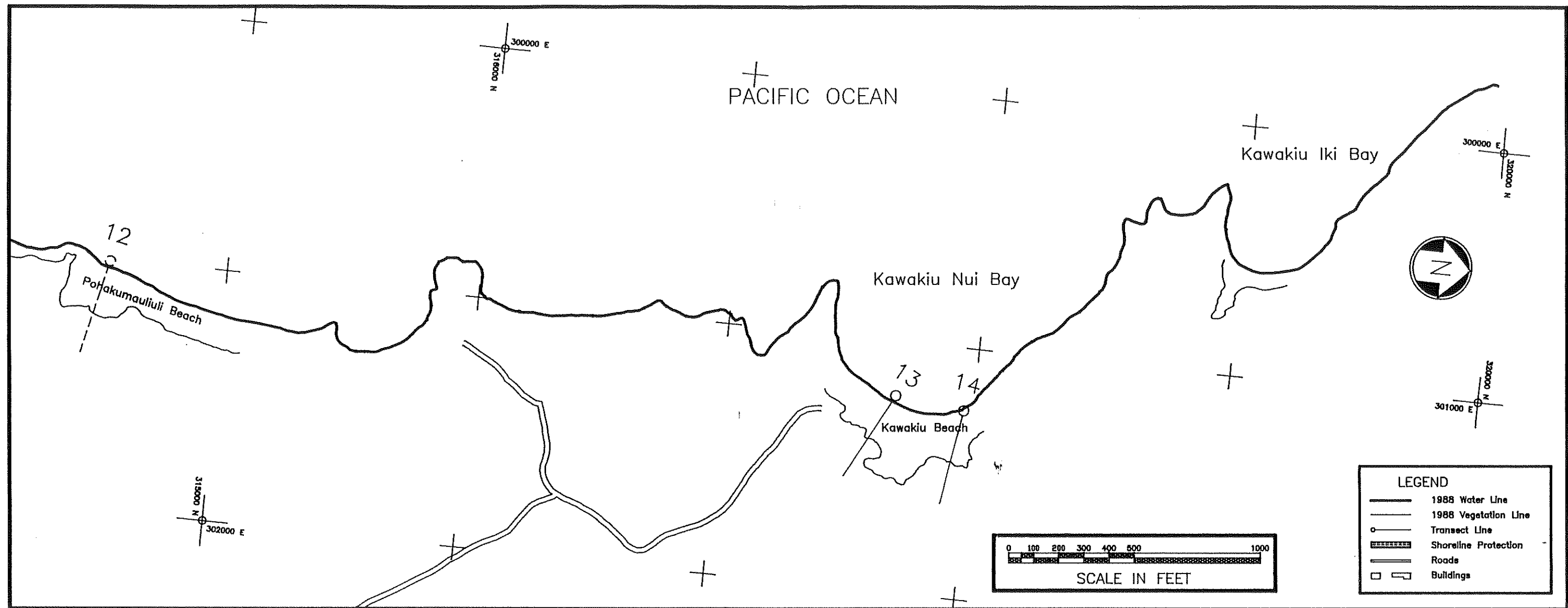
- The backshore is undeveloped, and there is no apparent change between the earliest and latest aerial photos.

##### SHORELINE HISTORY

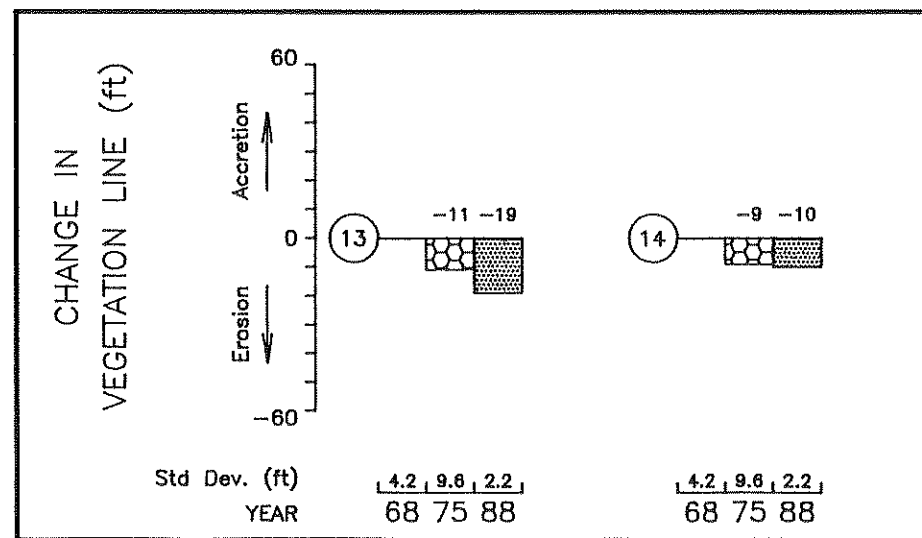
- Both regions (13 and 14) indicate some retreat of the vegetation line. The first available photograph was from the 1968 series, which consistently showed the most seaward vegetation line for the entire OA sector. The beach was relatively stable from 1975 to 1988.

##### SUMMARY

- Kawakui Beach is somewhat protected from wave attack by the rock headlands on each side. Given its location at the head of the bay, it should be relatively stable.



**FIGURE OA-4**



**GRAPH OA-4 Region Number vs Change in Vegetation Line**

**PHOTOS USED**

- March 1988
- July 1987
- March 1975
- November 1968
- January 1955



## SECTOR OB: SOUTHEAST MOLOKAI PUKOO TO KUMIMI POINT

### GENERAL COASTAL CHARACTERISTICS

This five mile long sector has been greatly modified in both ancient and recent times and much of the shoreline reflects these changes. There are numerous ancient fishponds in this sector, built out onto the fringing reef. Relatively small, narrow beaches are located between the fishponds. Although some of the beaches are calcareous, many in this sector are composed of detrital material. Kumimi Point, at the north end of the sector, marks the northern boundary of the wide fringing reef that borders most of the east and south coasts of Molokai. There are several indentations in the reef, some of which form small harbors. The two most notable channels occur at Pauwalu and Pukoo Harbor. At Pukoo, an old fishpond was filled in and a small cloverleaf harbor was dredged.

### LAND USE AND DEVELOPMENT

Kamehameha V Highway closely parallels the shoreline through much of this sector, and in many areas there is only a thin strip of vegetation between the highway and the beach. Other backshore land is in use for either single family homes or agriculture.

### WAVE CLIMATE

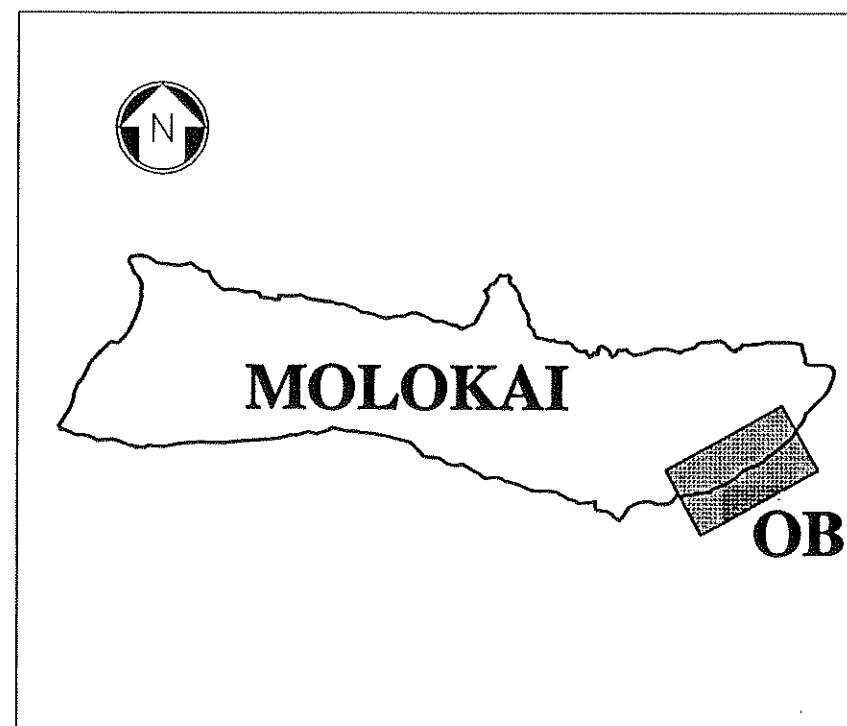
This sector is directly exposed to tradewind waves and is protected from the approach of most other wave types. Depending upon the approach direction, the winter north Pacific swell or the summer south swell could refract enough to propagate into the sector.

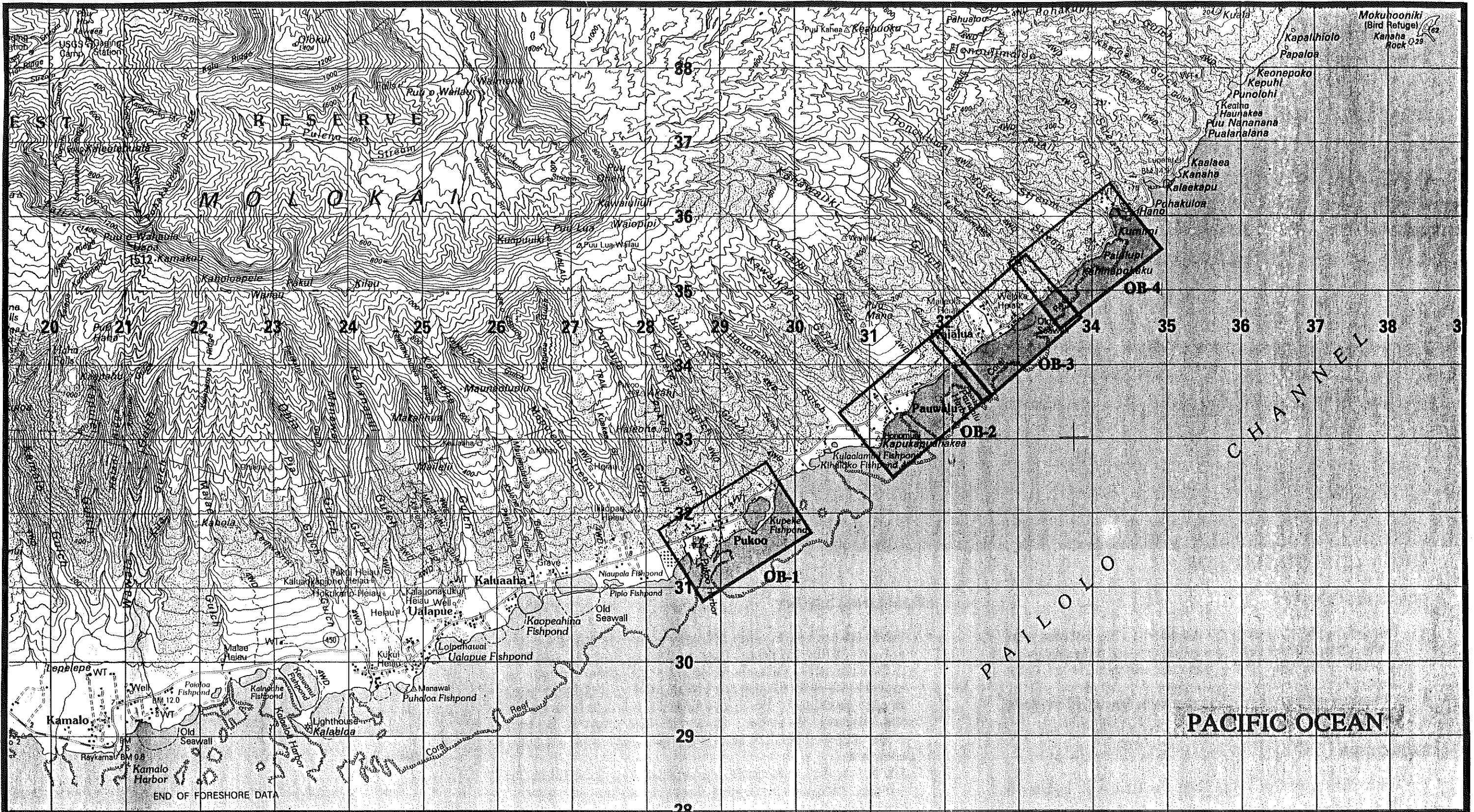
### SHORELINE PROCESSES

The wide, shallow fringing reef reduces much of the incoming wave energy, and in general, the beaches in this sector are not dynamic, either seasonally or in the long-term. The natural processes of the shoreline in this sector have been greatly influenced by man's activities. Fishponds built by the ancient Hawaiians are common along the east and south coast of Molokai. Some are still intact but for others, only the remnants of the walls can be seen. The fishponds are typically hemispheres built out from the shoreline onto the reef. The shoreline inside the walls is obviously stabilized, but in addition, the adjacent beaches are also stabilized to some extent, just as they would be by a series of widely spaced groins. Most beaches in this sector are relatively small and located either between fishponds or rocky outcroppings. The overall volume of sand in the beach system (on the beach and on the reef) appears to be relatively small, and the existing balance for any particular beach could be easily upset. Much of the shoreline inside the fishponds is accreting, due to soil being eroded from the mountains and being washed into the ponds. The area then becomes colonized by mangrove trees. The silt also collects on the inner reef and in the beach areas directly protected by the fishpond walls. Aerial photographs from 1988 were not available for this sector.

### BEACH USAGE

The beaches in this sector are not high quality recreational beaches. Swimming is further constrained by the shallow reef and the prevalence of silt on much of the inner reef. Pole fishing, spearfishing and netting are the most extensive recreational activities in this sector.





**LEGEND**

HYDROGRAPHIC DATUM ..... MEAN LOWER LOW WATER

Depth curve (meters) \_\_\_\_\_

Foreshore flats \_\_\_\_\_

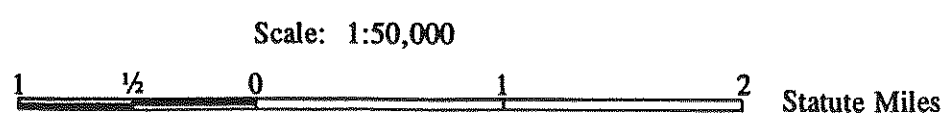
Rocks awash; Reef \_\_\_\_\_

Wreck: Exposed, Sunken with masts exposed \_\_\_\_\_

Wharf, pier \_\_\_\_\_

Seawall \_\_\_\_\_

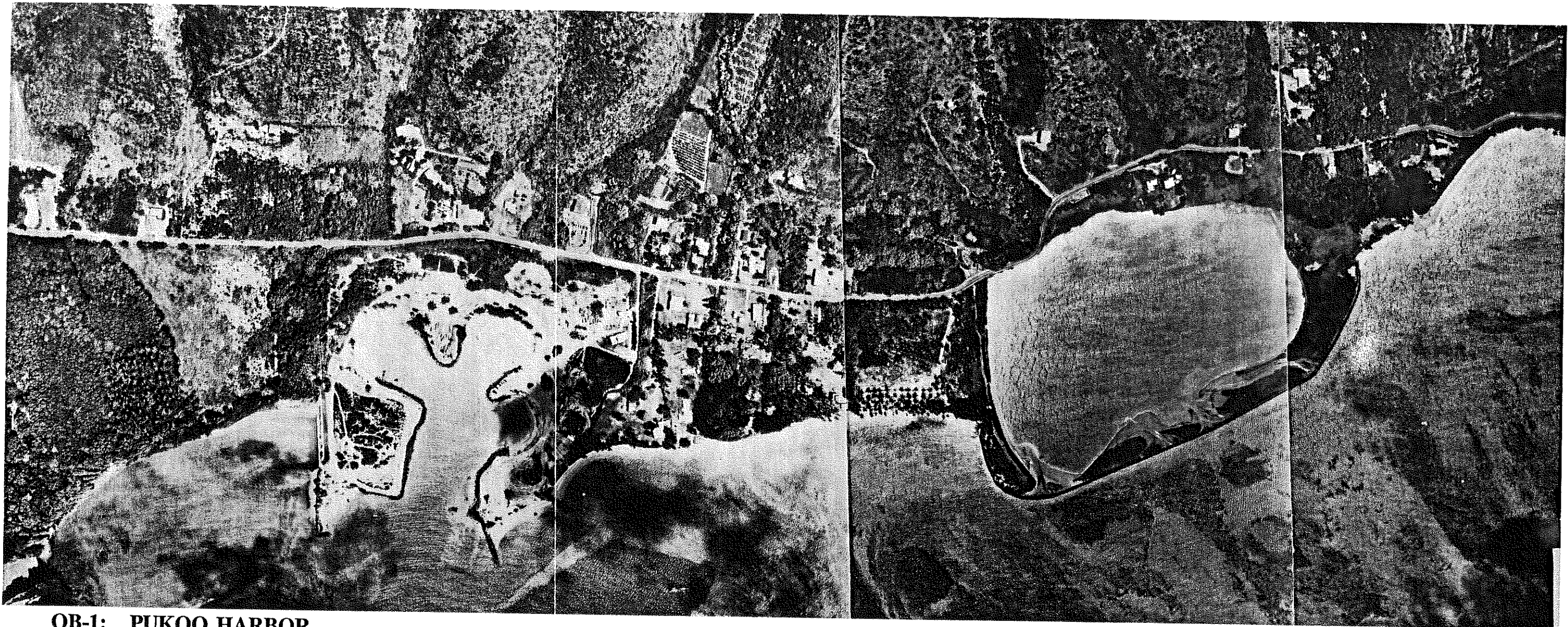
Oil/gas rig \_\_\_\_\_



**SOUTHEAST MOLOKAI**

**Pukoo to Kumimi Point**

From U.S. Geological Survey  
MAP INFORMATION AS OF 1983



## OB-1: PUKOO HARBOR

### BEACH DESCRIPTION

- There are two beach areas in this subsector: a 1700 foot long beach between Pukoo Harbor and Kupeke Fishpond; and three small beach segments at the head of the man-made embayments on Pukoo Harbor.
- All beaches are calcareous sand, with some intermixed terrestrial material.

### BACKSHORE

- The backshore between Pukoo Harbor and the main highway is undeveloped.
- The area between the harbor, Kupeke Fishpond and the highway is primarily single family residences, and public access is limited.

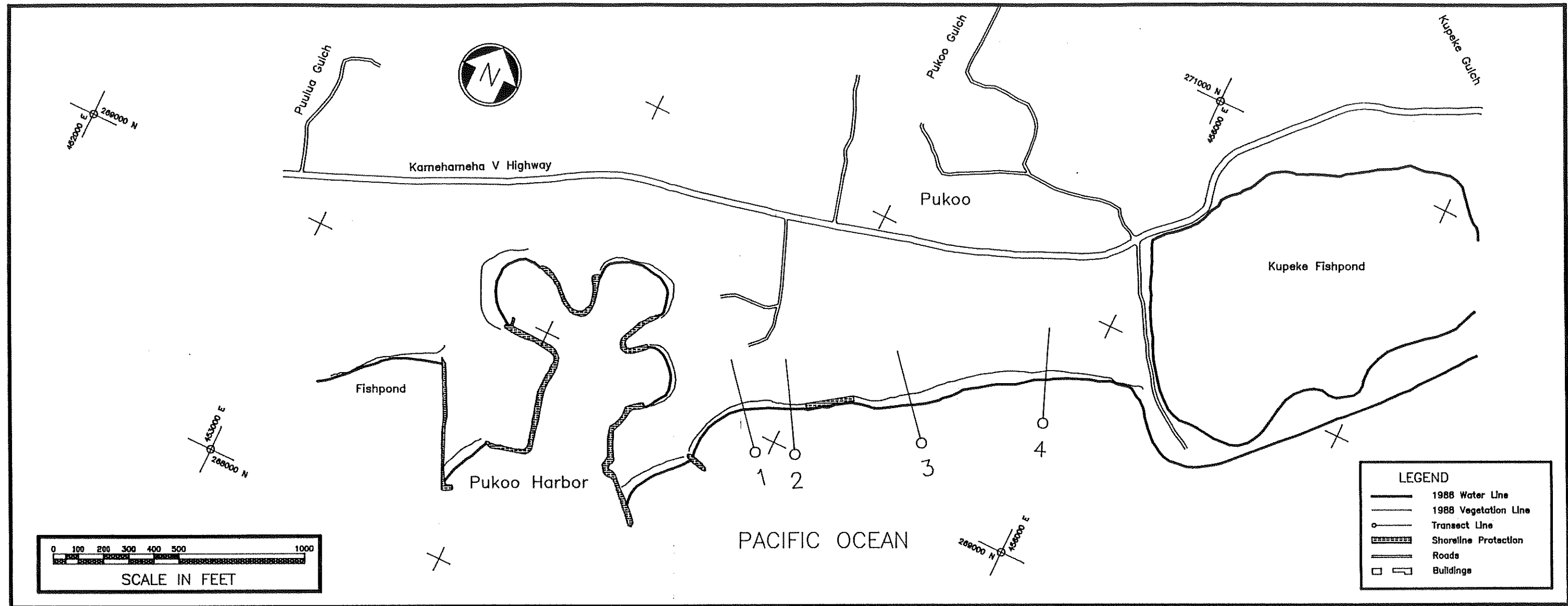
### SHORELINE HISTORY

- Pukoo Harbor was formerly Pukoo Fishpond. In the late 1960's and early 1970's, the fishpond was modified by dredging and filling to form the harbor shown in the accompanying photo and map. A natural break in the fringing reef was enlarged by dredging to create an entrance channel. The dredged material was used to create fast land adjacent to the harbor. The harbor sides, except for the head of the three artificial embayments, were lined with a boulder revetment.
- The Pukoo Harbor shoreline was so extensively modified by the dredging, filling and grading that there is no meaningful vegetation line history.
- The beach between Pukoo Harbor and Kupeke fishpond eroded significantly between 1949 and 1961, with recession of vegetation line ranging up to 30 feet. The small jetty was constructed between 1961 and 1975, probably at the same time as the harbor, and appears to have stabilized the south end of the beach (Region 1).

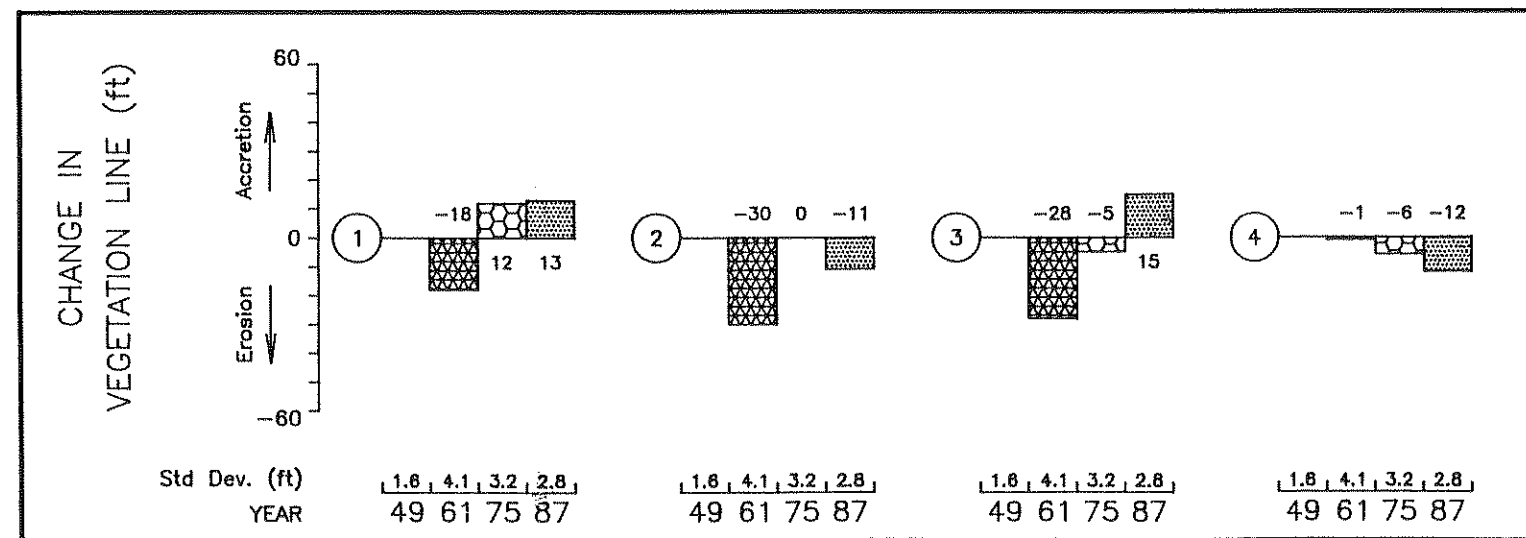
- The data for Region 2 shows recent erosion, and there is approximately 200 feet of shore protection in place. The shore protection is at the discharge of a small drainage channel, so it may have been built to stabilize the shoreline against both wave and flood induced erosion.
- The only evidence of ongoing erosion is in Region 4, where there is a small one to two foot scarp at the vegetation line and coconut tree roots are exposed.

### SUMMARY

- There is no vegetation line history for Pukoo Harbor, but the small beach areas appear stable.
- The beach between the harbor and Kupeke fishpond eroded significantly (up to 30 feet) between 1949 and 1961. The reason is not known. Since construction of Pukoo Harbor, the south end of the beach has been relatively stable, while the north end has eroded slightly.



**FIGURE OB-1**



**GRAPH OB-1 Region Number vs Change in Vegetation Line**

**PHOTOS USED**

- July 1987
- May 1975
- March 1961
- November 1949



## OB-2: PAUWALU

### BEACH DESCRIPTION

- A narrow (10 to 50 feet wide) calcareous sand beach extends from just south of Kapukapuahakea to Kumimi Point (Subsector OB-4), a distance of approximately 3 miles. The beach is frequently interrupted by basalt or boulder outcroppings, and by the remnants of old fishpond walls.
- The fringing reef off this subsector exceeds 200 feet in width in places, but is broken by two natural channels off Pauwalu.
- The remains of a large fishpond, visible on the aerial photos, span the center of the subsector. The southern end of the pond corresponds to the shore protection immediately north of the stream, while the northern end is located between Regions 8 and 9.

### BACKSHORE

- The Kapukapuahakea/Pauwalu area has single family homes and a

high percentage of undeveloped or open space.

- The highway parallels the shoreline through the northern part of the sector.

### SHORELINE HISTORY

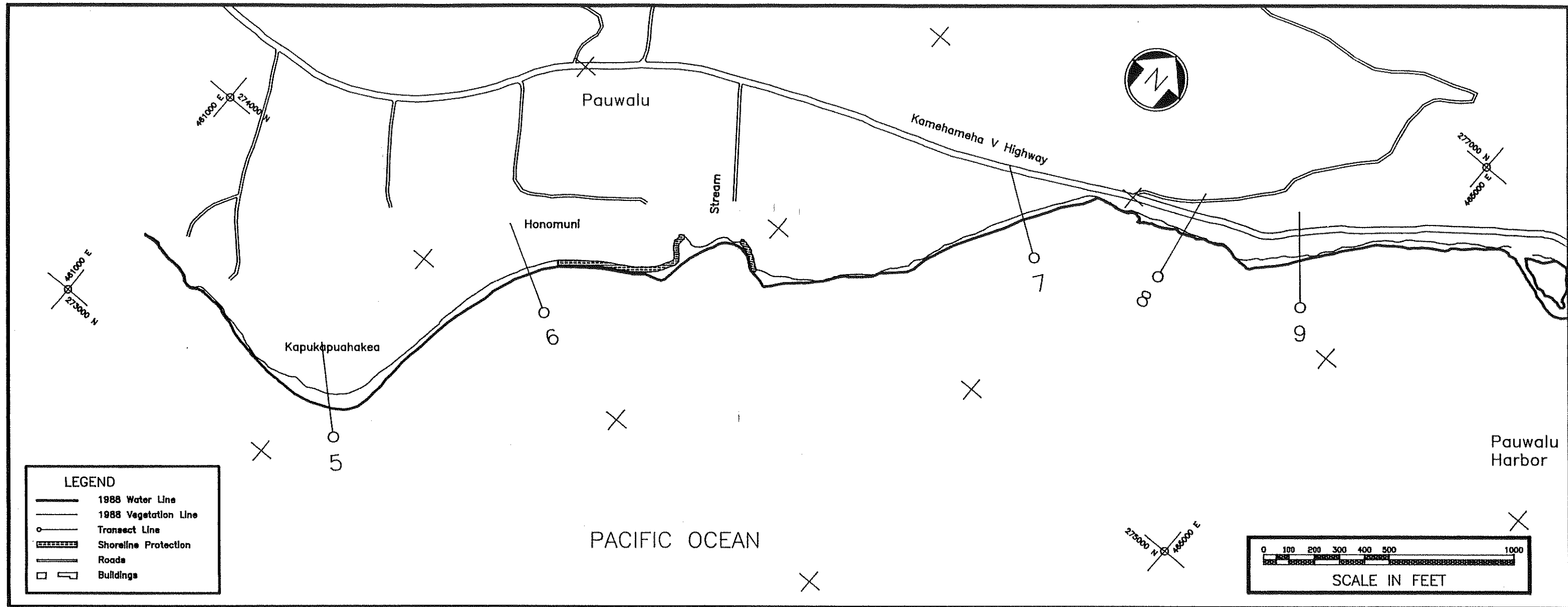
- Aerial photographs from 1949 were not available for Region 6, and photographs from 1949 and 1961 were not available for Region 5.
- The vegetation line in the vicinity of Kapukapuahakea is accreting, with a net gain of 29 feet from 1975 to 1989 (Region 5).
- A small stream discharges off Pauwalu, and the beach in the immediate vicinity is unstable. The shore protection shown north of the stream is actually part of the old fishpond wall. The wall, possibly rebuilt, now stabilizes the shoreline in front of a house.
- South of the stream, there is a 500 foot long boulder seawall. This

seawall was built after 1961, and was apparently placed well out on the reef flat (from the aerial photos, possibly up to 100 feet). The reclaimed land is not vegetated. There is no beach seaward of the wall. The accretion in Region 6 may be due to the effect of the wall.

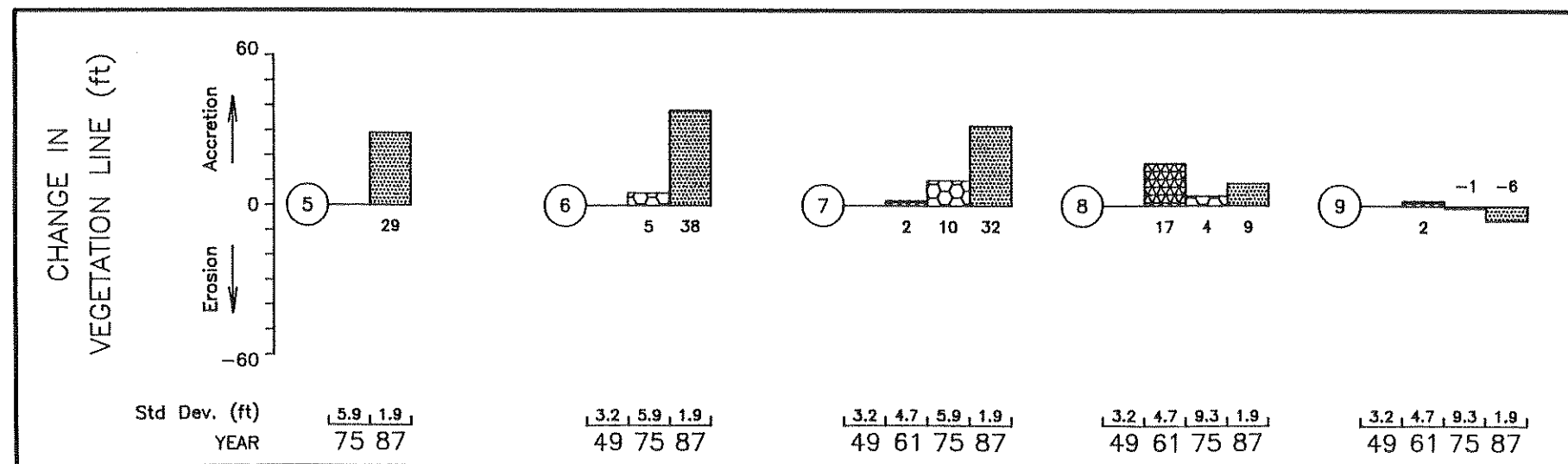
- The shoreline inside the old fishpond is accreting (Regions 7 and 8), with a net gain of up to 32 feet.
- Region 9, where the highway parallels the beach, is essentially stable, with small changes of the vegetation line. There are numerous basalt boulders on the beach and at the waterline that probably help stabilize this area.

### SUMMARY

- The accretion inside the fishpond (Regions 7 and 8) is probably typical of many areas along this coast. Siltation and infilling of the ponds is a common problem. Vegetation may then grow out onto the new land areas.

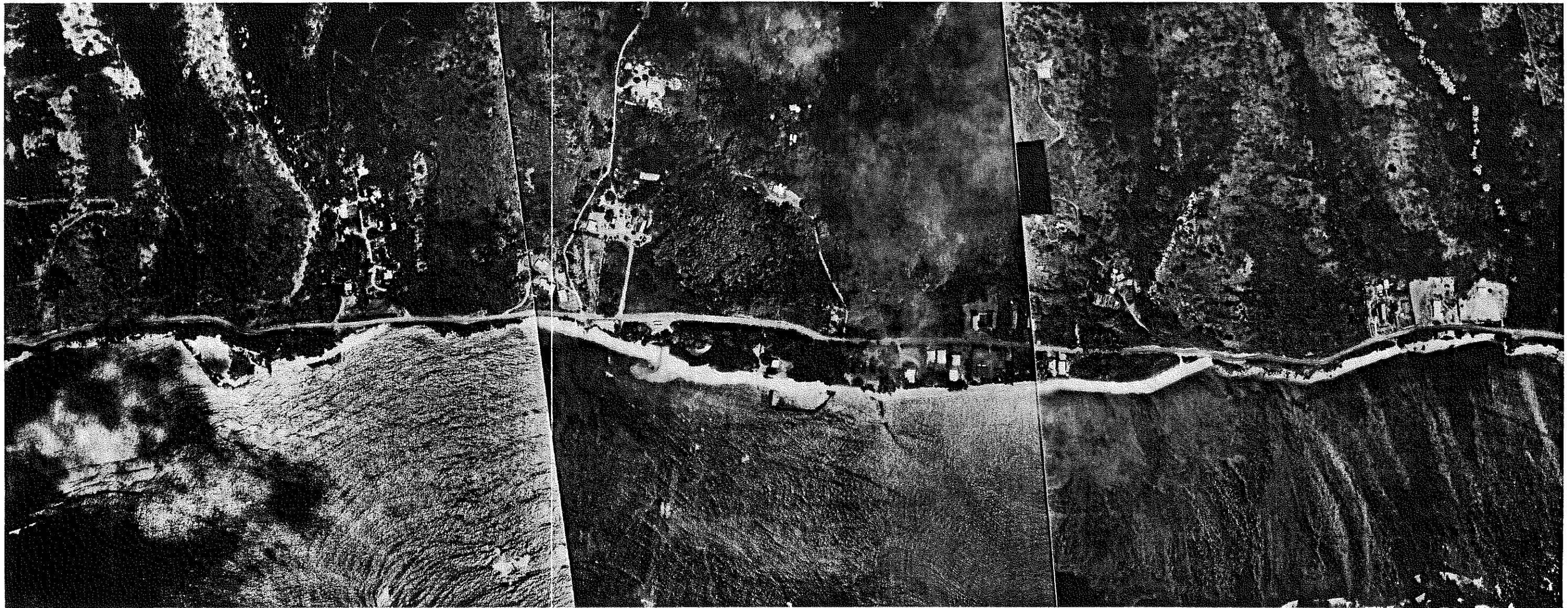


**FIGURE OB-2**



**GRAPH OB-2 Region Number vs Change in Vegetation Line**

**PHOTOS USED**  
 July 1987  
 May 1975  
 March 1961  
 November 1949



### OB-3: WAIALUA

#### BEACH DESCRIPTION

- A narrow beach (40 to 50 feet wide) extends along most of the shoreline of this subsector, except in two locations where the highway is located directly behind the beach. In these areas the shoreline consists of basalt boulders and outcroppings.
- Waialua Stream discharges through the center of the subsector.
- There are the remains of two old fishponds, both small, one located at the south end of the subsector and one just north of Waialua Stream.
- The fringing reef is continuous through this subsector, and is up to 1400 feet wide.

#### BACKSHORE

- The backshore is primarily open space and single family houses, except where the highway closely parallels the shoreline.
- A seawall and rock revetment have been placed between Regions 10 and 11 to help stabilize the shoreline and protect Kamehameha V highway.

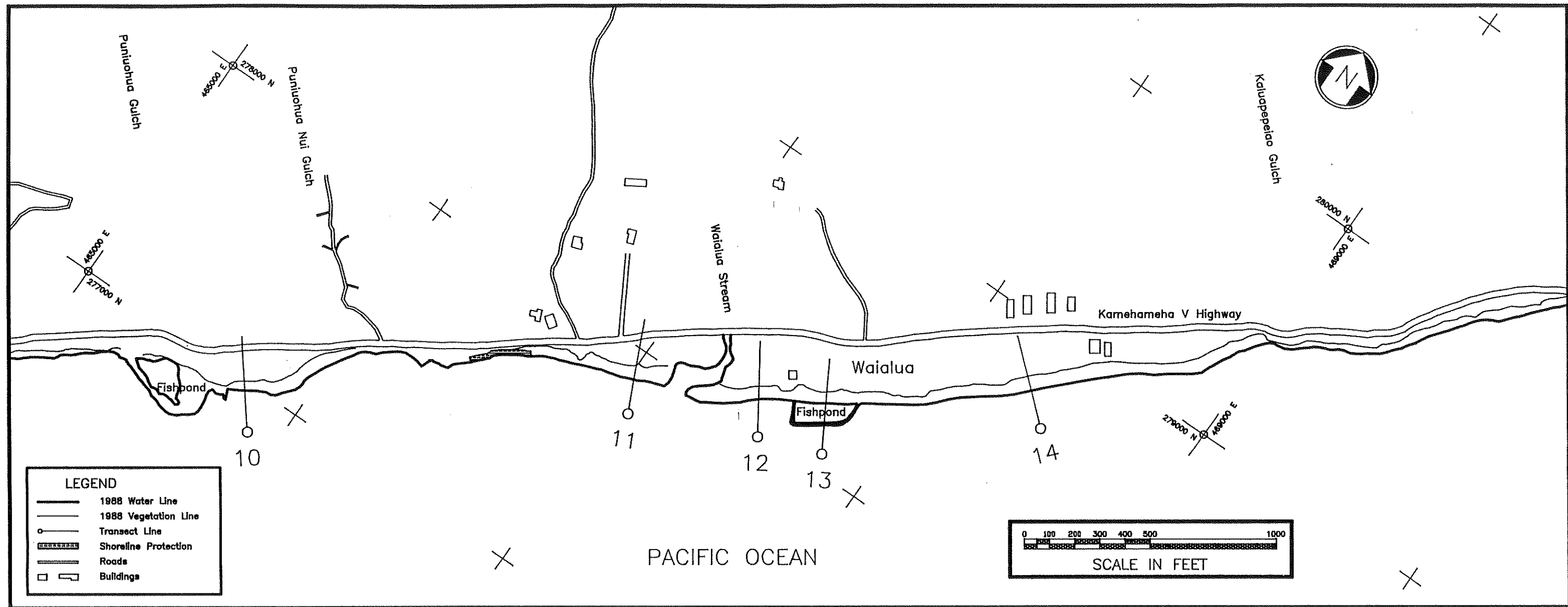
#### SHORELINE HISTORY

- Region 10, the small beach area at the south end of the subsector indicated steady, although minor, erosion over the measurement period. Evidence of erosion was found during the site visit. The toe of the dirt embankment was undercut just north of Region 10. One palm tree had been undercut and had fallen, and the roots were exposed on another because of embankment erosion.

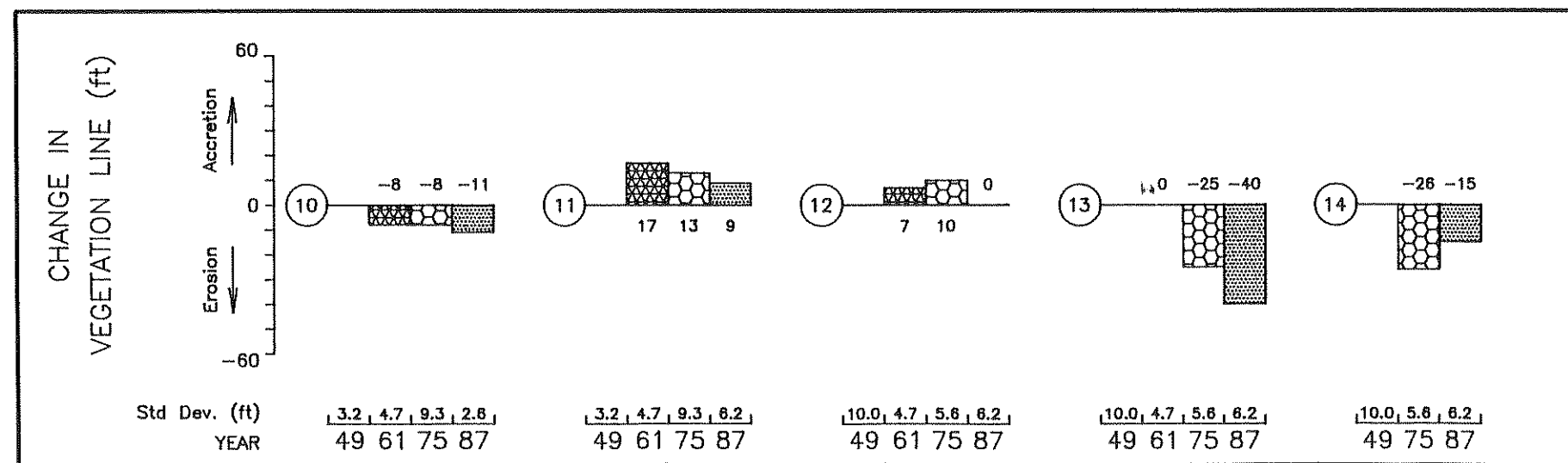
- The beach areas in the vicinity of the stream (Regions 11 and 12) were relatively stable or accreting.
- The beach area to the north (Regions 13 and 14) had significant erosion of the vegetation line over the 38 year period.

#### SUMMARY

- The small beaches in this subsector were relatively stable, except for the area north of the Waialua Stream.
- The 1975 aerial photographs showed a bulldozer on the beach in front of Waialua Stream, apparently engaged in removing sand from the beach. The extent of the sand mining operation is not known, but this may have been the cause of the erosion north of the stream.



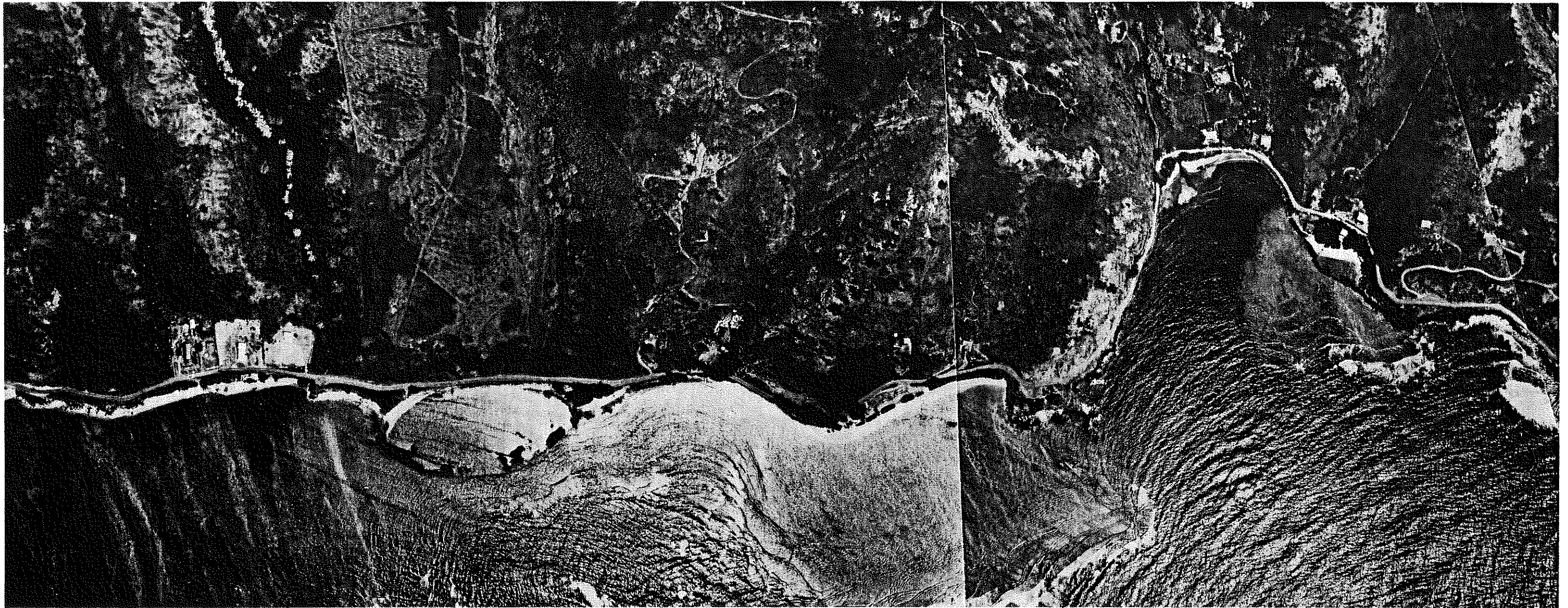
**FIGURE OB-3**



**GRAPH OB-3 Region Number vs Change in Vegetation Line**

**PHOTOS USED**  
 July 1987  
 May 1975  
 March 1961  
 November 1949





## OB-4: WAIALUA TO KUMIMI POINT

### BEACH DESCRIPTION

- There are two beach areas in this subsector: a small 300 foot long beach south of Kahinapohaku Fishpond, and an 1100 foot long beach south of Kumimi Point.
- The beach south of the fishpond is narrow (approximately 35 feet wide) and is composed of a high percentage of terrestrial material.
- The beach south of Kumimi Point is approximately 20 feet wide and consists primarily of calcareous sand.
- There is a shallow fringing reef approximately 1000 feet wide through this subsector.

### BACKSHORE

- Kamehameha Highway closely parallels the beach through this subsector, and there is no development seaward of the highway.
- Murphy Beach Park located between Kumimi Point and Cape Palalupi, has no facilities, but is used as a campsite.
- South of Cape Palalupi, the highway is located right on the beach crest. The State has placed large boulders at this location to help stabilize the shoreline.

### SHORELINE HISTORY

- The aerial photographs from 1961 were not available for this sector.
- The vegetation line has accreted in the vicinity of Region 15, probably due to the accumulation of silt in the lee of the fishpond.

- At the south end of Kahinapohaku Fishpond, there is a scarp in the dirt embankment. The high waterline is within five feet of the embankment.
- The highway in the vicinity of Region 16 is located right at the beach crest and there is only a narrow beach between the waterline and the highway. The aerial photographs show that this has been the case since some time prior to 1949.
- The shoreline at Murphy Beach Park is slowly accreting, with a net gain of 29 feet.

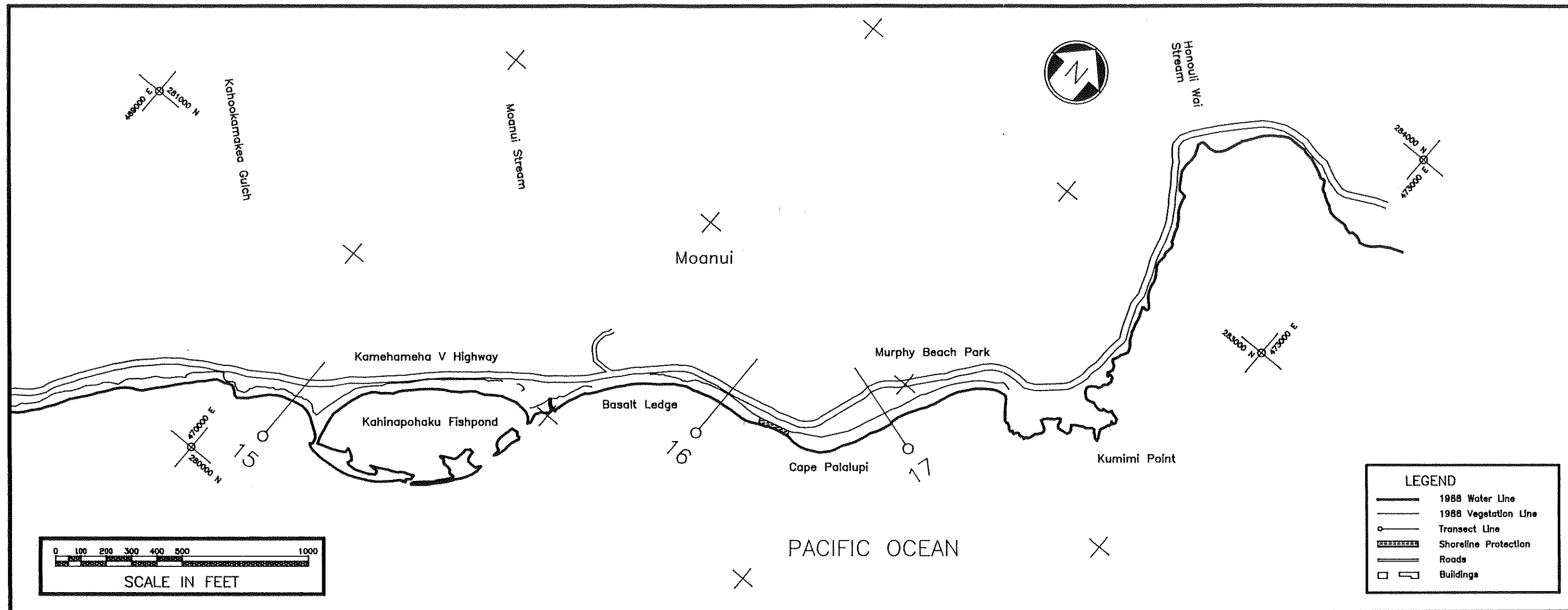
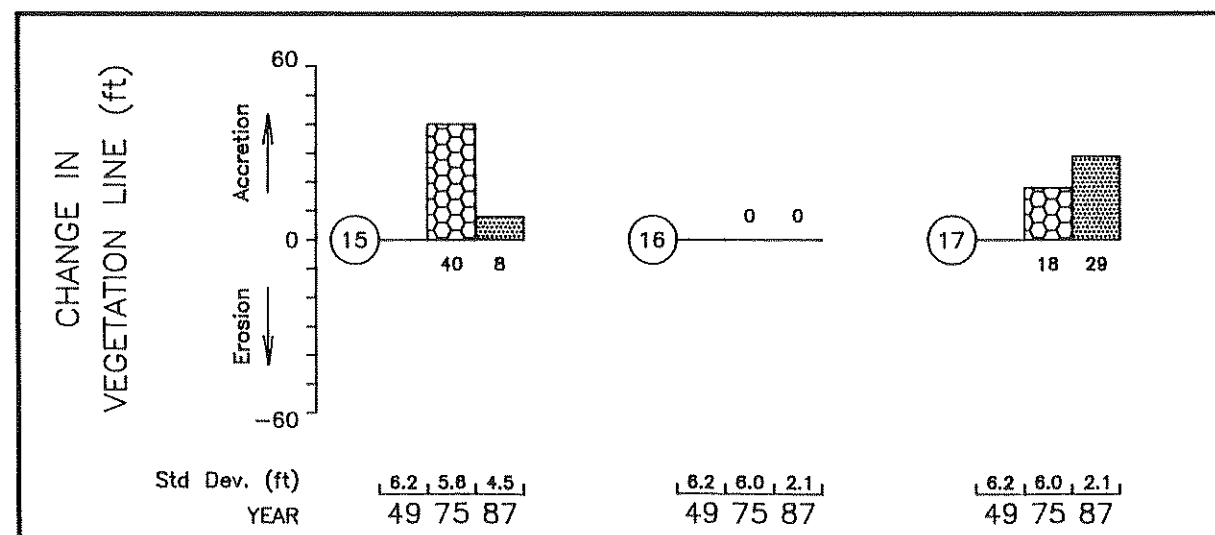


FIGURE OB-4



GRAPH OB-4 Region Number vs Change in Vegetation Line

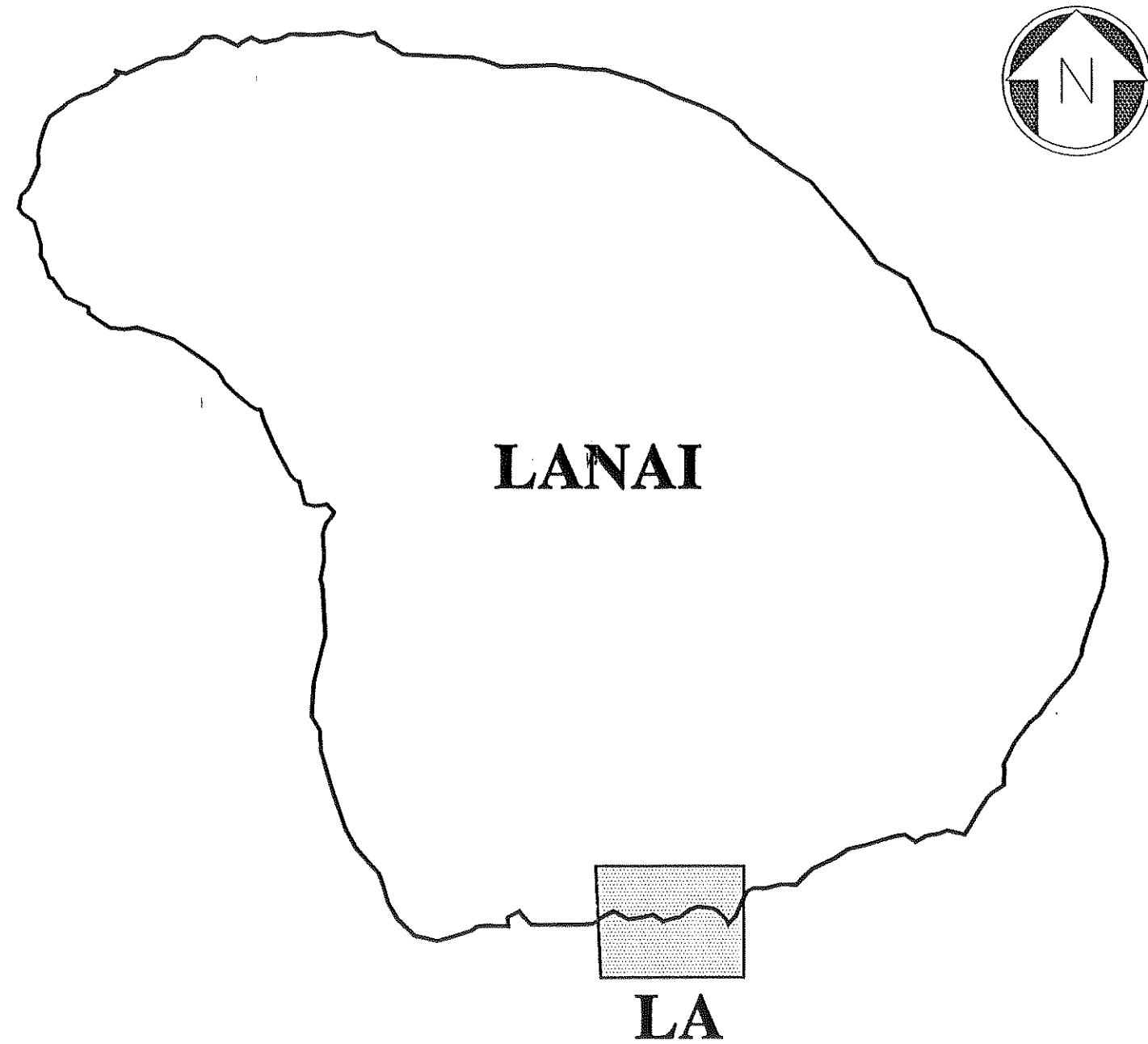
PHOTOS USED

- July 1987
- May 1975
- March 1961
- November 1949



**LANAI**

- **South Lanai**  
LA -Hulopoe Bay



## **SECTOR LA: SOUTH LANAI HULOPOE BAY**

### **GENERAL COASTAL CHARACTERISTICS**

The south coast of Lanai, from Hulopoe to Palaoa Point, consists primarily of basalt sea cliffs, with some boulder beaches in the small embayments. This sector extends from Kaluakoi Point to Puupehe Cove, and contains the only sand beach in the area at Hulopoe Bay. Hulopoe Beach is a 1500 foot long pocket beach, bounded on the east by Manele cinder cone and on the west by a basalt outcropping. There is no fringing reef off this sector, and there is relatively deep water close to shore.

### **LAND USE AND DEVELOPMENT**

Hulopoe Beach Park, a private park owned by Castle and Cooke, Inc. is located along the backshore of the beach. Other than the park facilities, the area was undeveloped until recent years. A major resort hotel, the Manele Bay Hotel, was recently constructed along the western backshore of the bay.

### **WAVE CLIMATE**

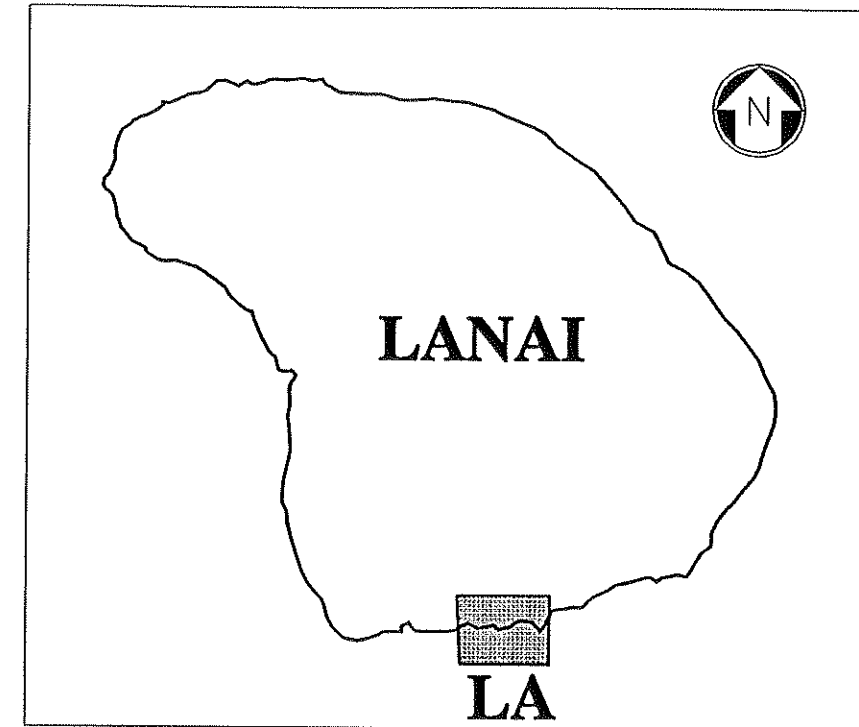
Hulopoe Bay is directly exposed to south swell and Kona storm waves, and is sheltered from the approach of other wave types.

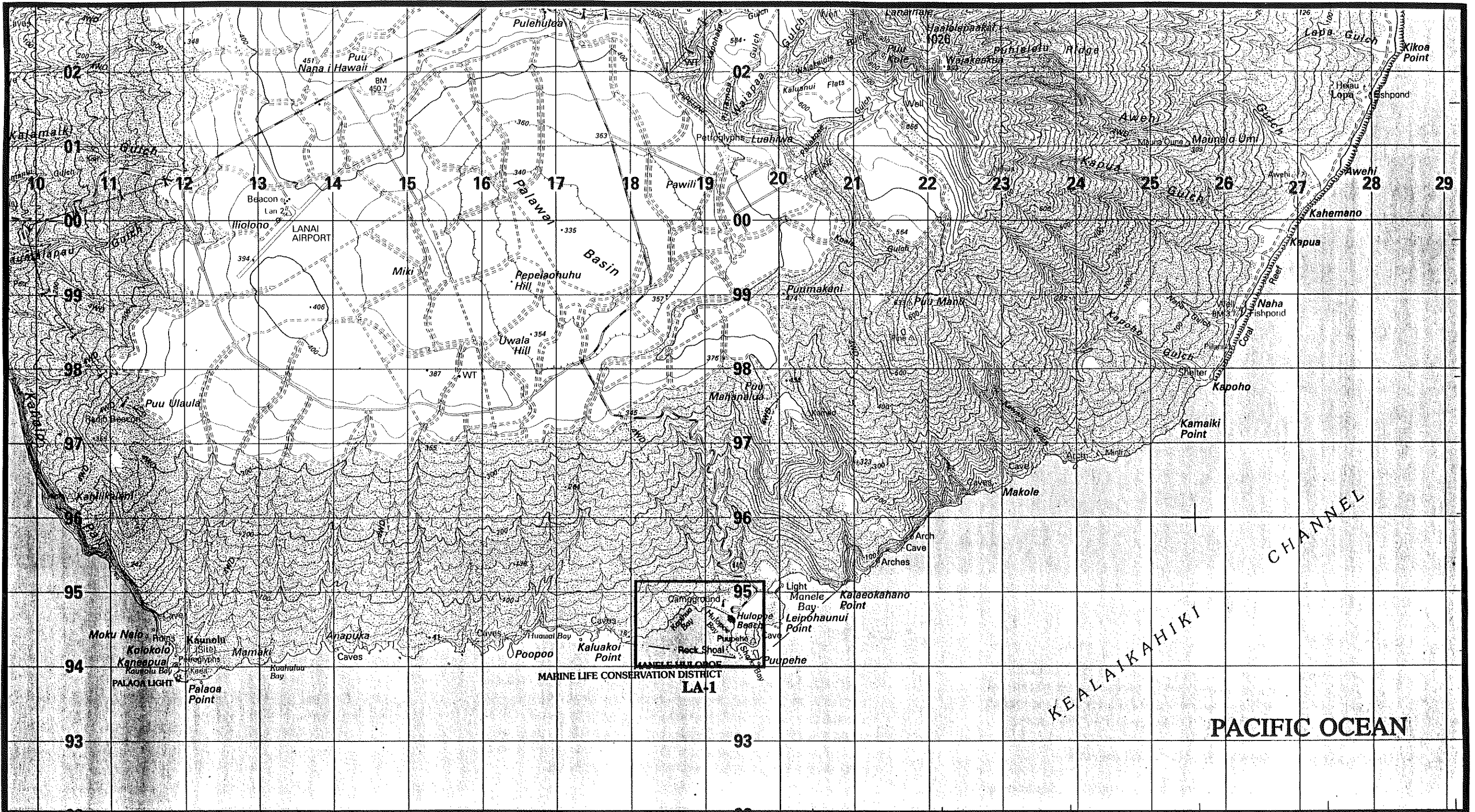
### **SHORELINE PROCESSES**

The foreshore of Hulopoe Beach is moderately steep due to its exposure to the full force of waves approaching from the south. Moberly and Chamberlain (1964) observed seasonal variations in the width of the beach, with accretion in the summer and erosion in the winter.

### **BEACH USAGE**

Hulopoe Beach is the most popular beach on the island of Lanai and the only one with restrooms and showers. The area provides opportunities for swimming, snorkeling, surfing and bodysurfing. Commercial cruises also take advantage of the beach on weekdays during daylight hours.





**LEGEND**  
 HYDROGRAPHIC DATUM ..... MEAN LOWER LOW WATER

- Depth curve (meters) \_\_\_\_\_
- Foreshore flats \_\_\_\_\_
- Rocks awash; Reef \_\_\_\_\_
- Wreck: Exposed; Sunken with masts exposed \_\_\_\_\_
- Wharf, pier \_\_\_\_\_
- Seawall \_\_\_\_\_
- Oil/gas rig \_\_\_\_\_



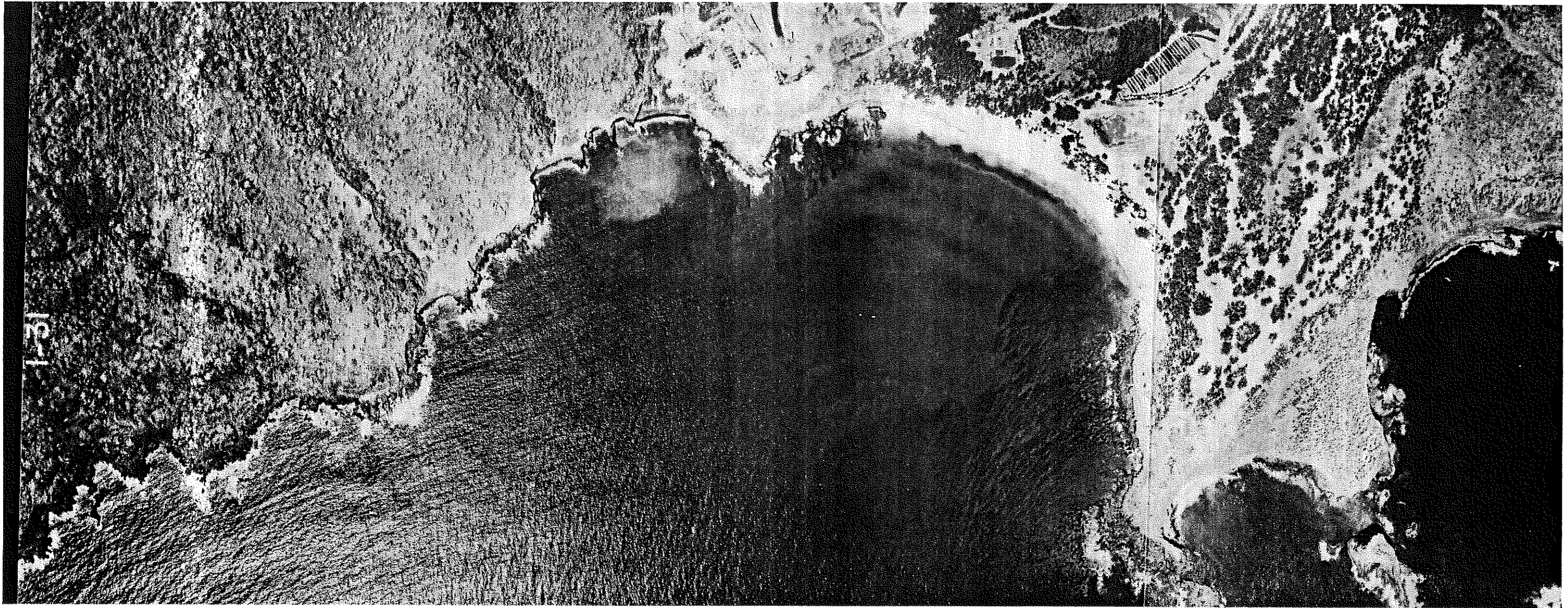
Scale: 1:50,000



From U.S. Geological Survey  
 MAP INFORMATION AS OF 1983

**SOUTH LANAI**

**Hulopoe Bay**



## LA-1. HULOPOE BEACH

### BEACH DESCRIPTION

- Huloepoe Beach is a crescent-shaped, white sand beach bounded to the west by a basalt outcropping and to the east by the remains of Manele cinder cone. The seaward rim of the cone has been eroded away by the ocean, forming a cove known as PuuPehe Cove.
- The beach is 1300 feet long and 100 to 120 feet wide.
- There is no fringing reef, and the water is relatively deep close to shore.
- Huloepoe Bay is directly exposed to south swell and Kona storm waves, and is sheltered from the approach of other wave types.
- The bay is part of the Manele-Huloepoe Marine Life Conservation District, created in 1976 to protect and conserve the marine resources and geologic features in the area.

### BACKSHORE

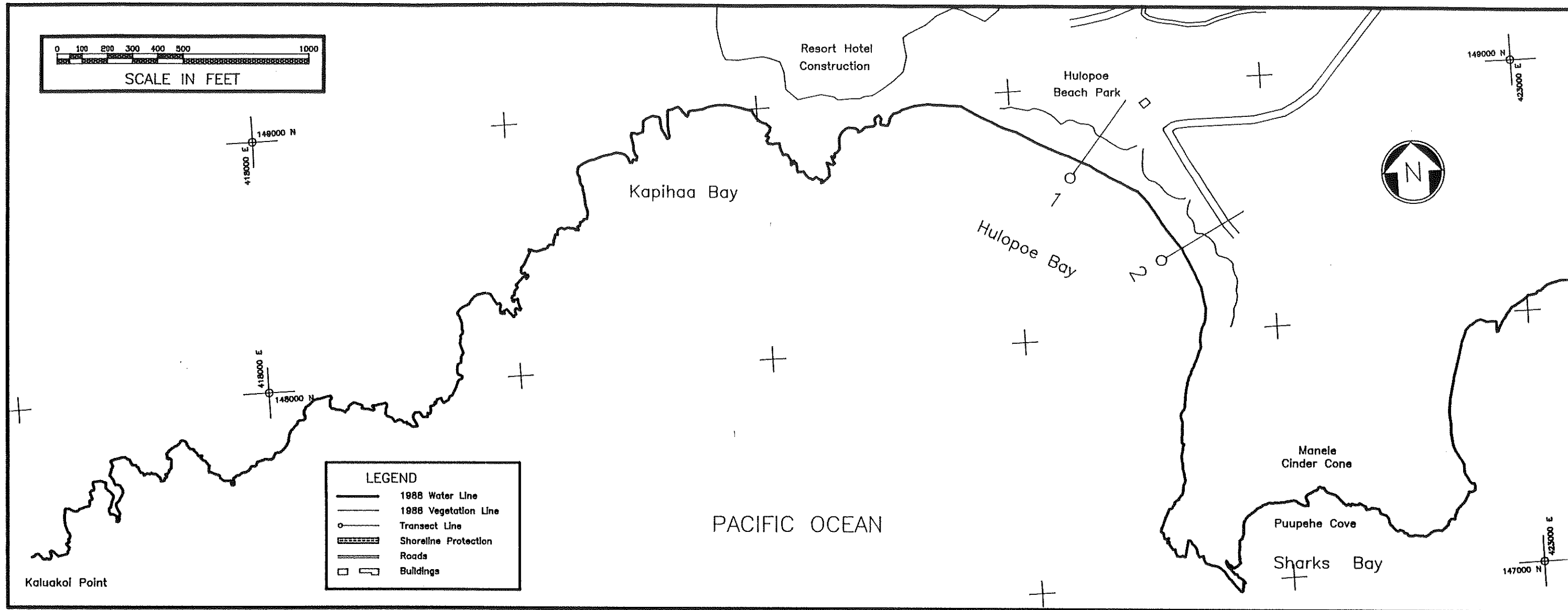
- Huloepoe Beach Park, a private park owned by Castle and Cooke, Inc., is located along the backshore of the beach. The park includes picnic facilities, showers, and restrooms. Use of the park by the public and by commercial boat cruises is regulated by permit. With the exception of the Manele Harbor area, Huloepoe Beach is the only beach on Lanai with restrooms and showers. The beach is the most popular on the island for both swimming and picnicking.
- A large resort hotel, the Manele Bay Hotel, has been constructed recently on the rocky point at the northwest end of the beach.

### SHORELINE HISTORY

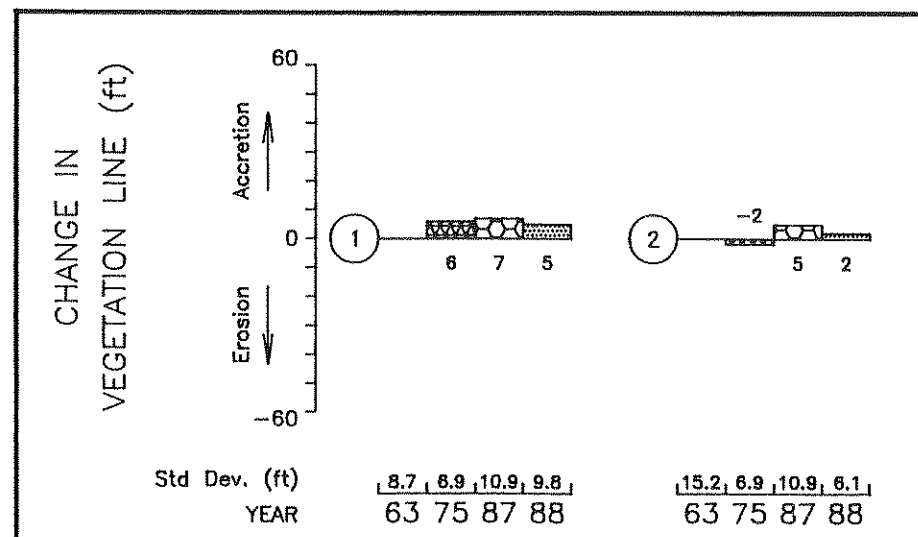
- This beach has been stable during the interval of this study. There was net accretion of only 5 feet and 2 feet in Regions 1 and 2 respectively between 1963 and 1988.

### SUMMARY

- Huloepoe Beach has been stable over the time interval of this study.
- A large resort hotel has been constructed recently on the rocky point at the northwest end of the beach.



**FIGURE LA-1**



**PHOTOS USED**  
March 1988  
June 1987  
July 1975  
October 1963

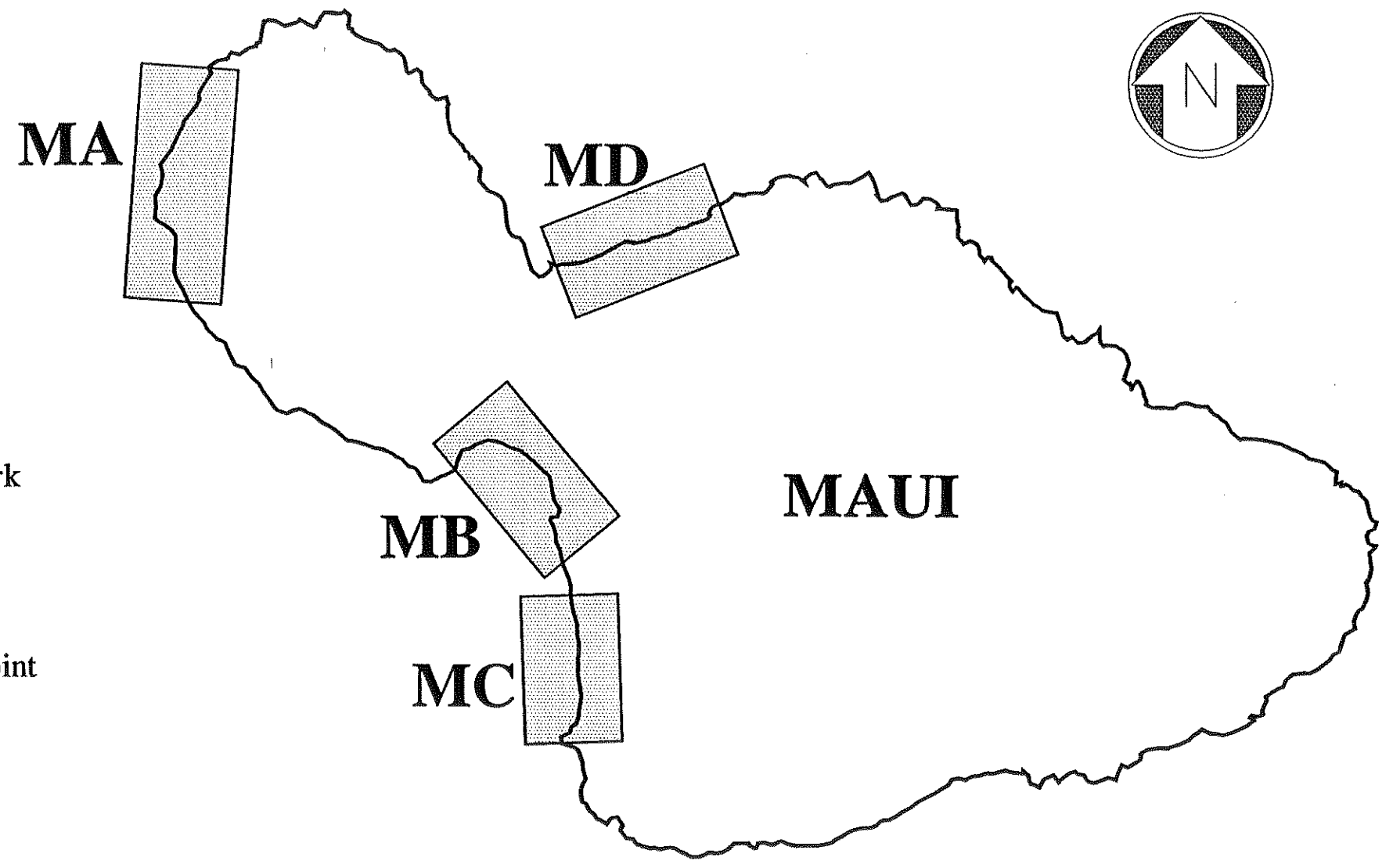
**GRAPH LA-1 Region Number vs Change in Vegetation Line**





**MAUI**

- **West Maui**  
MA - Lahaina to Napili
- **Southwest Maui**  
MB - Maalaea Harbor to Kalama Beach Park  
MC - Kamaole to Makena
- **North Central Maui**  
MD - Kahului Harbor to Hamakua Poko Point



## SECTOR MA: WEST MAUI LAHAINA TO NAPILI

### GENERAL COASTAL CHARACTERISTICS

This nine mile long coastal sector extends from the north end of Lahaina town to Kapalua Beach. Most of this sector consists of long, narrow sandy beaches, separated by basalt outcroppings or reaches of basalt, boulder or protected shoreline. Prominent beach areas include Puunoa Hanakao, Kaanapali, Honokowai, and Kahana.

The northernmost mile of this sector, from Haukoe Point to Napili, consists of a series of small pocket beaches bounded by basalt headlands. Napili and Kapalua are the two largest and best known beaches in this area.

### LAND USE AND DEVELOPMENT

This sector encompasses one of the major resort areas on Maui and in the state of Hawaii. Extensive construction has taken place over the past 30 years, and most of the backshore is now developed. Existing usage includes residential development, both single family houses and condominiums, major resort hotels, golf courses and parks. The only large undeveloped site is the old Kaanapali Airport, and a major resort is in the planning stage.

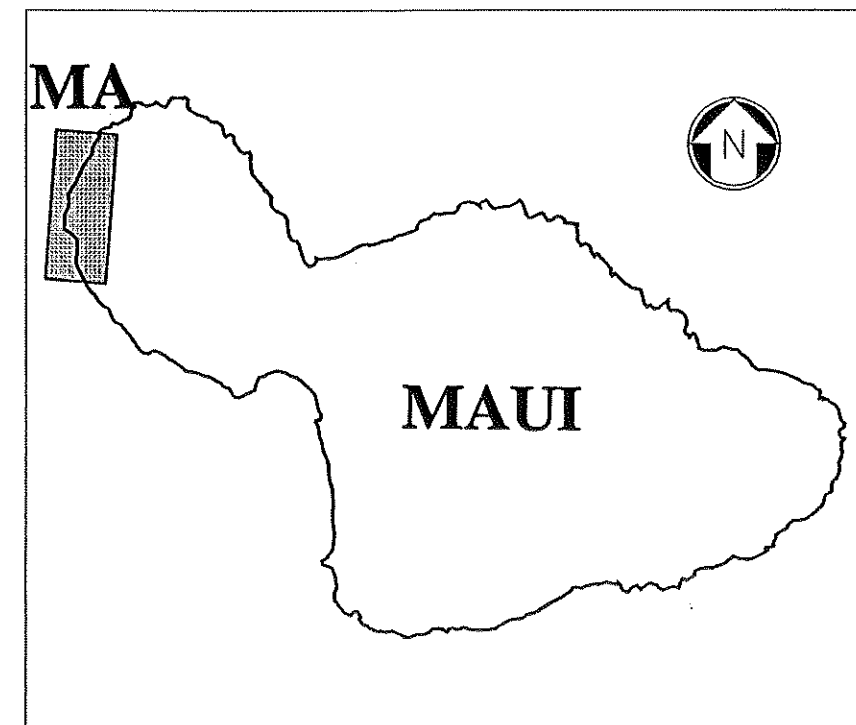
### WAVE CLIMATE

This sector is exposed to the north Pacific swell, south swell, and Kona storm waves. The degree of exposure varies with location within the sector and the shoreline orientation. There is a pronounced seasonal variation in wave climate throughout the sector.

There is fringing reef present only off the prominent points: Puunoa Point, Hanakao Point and Honokowai Point. In all other parts of the sector there is deep water relatively close to shore. As a result, in most places the incoming waves break close to shore, and much of the energy is expended directly on the beaches.

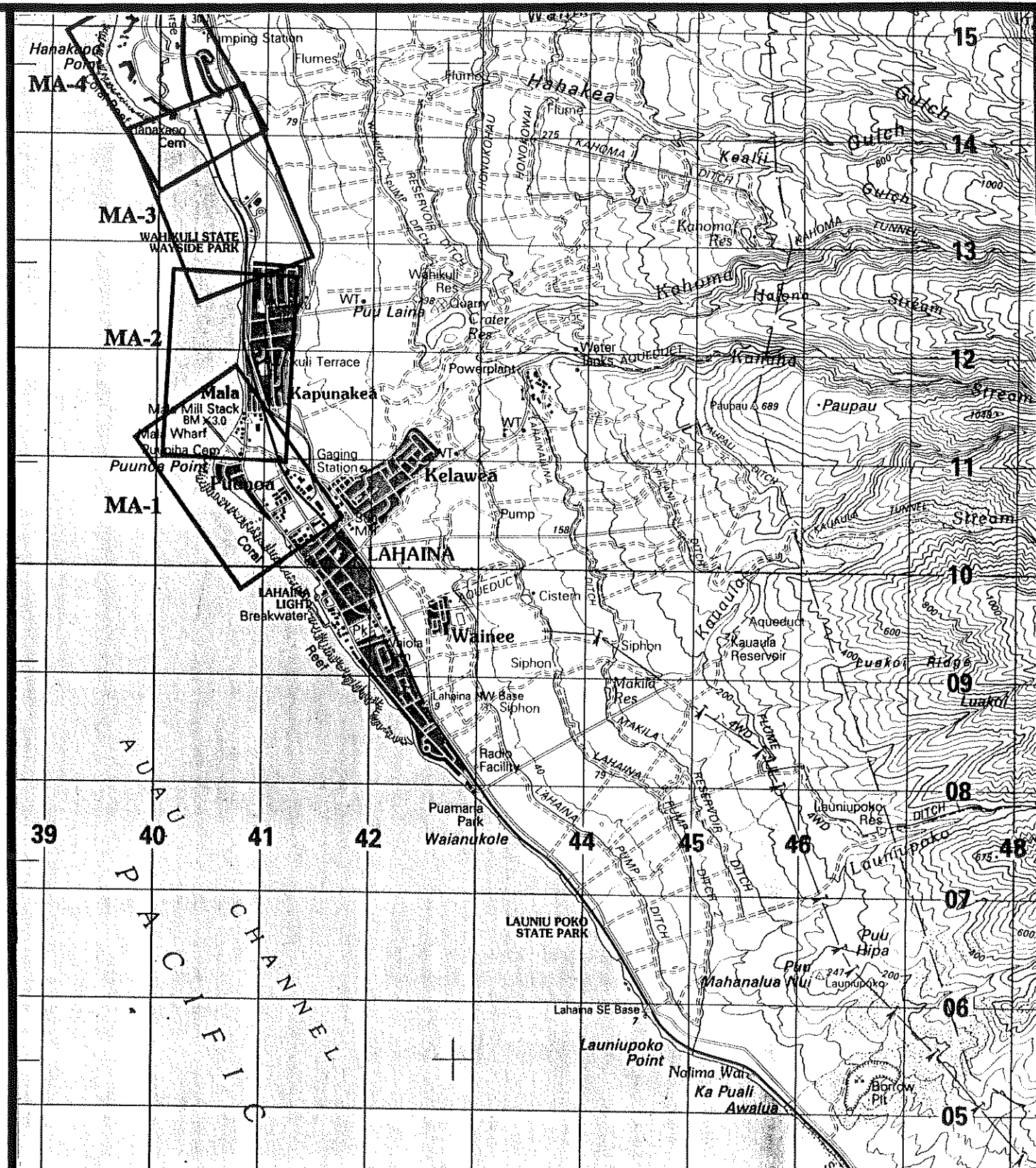
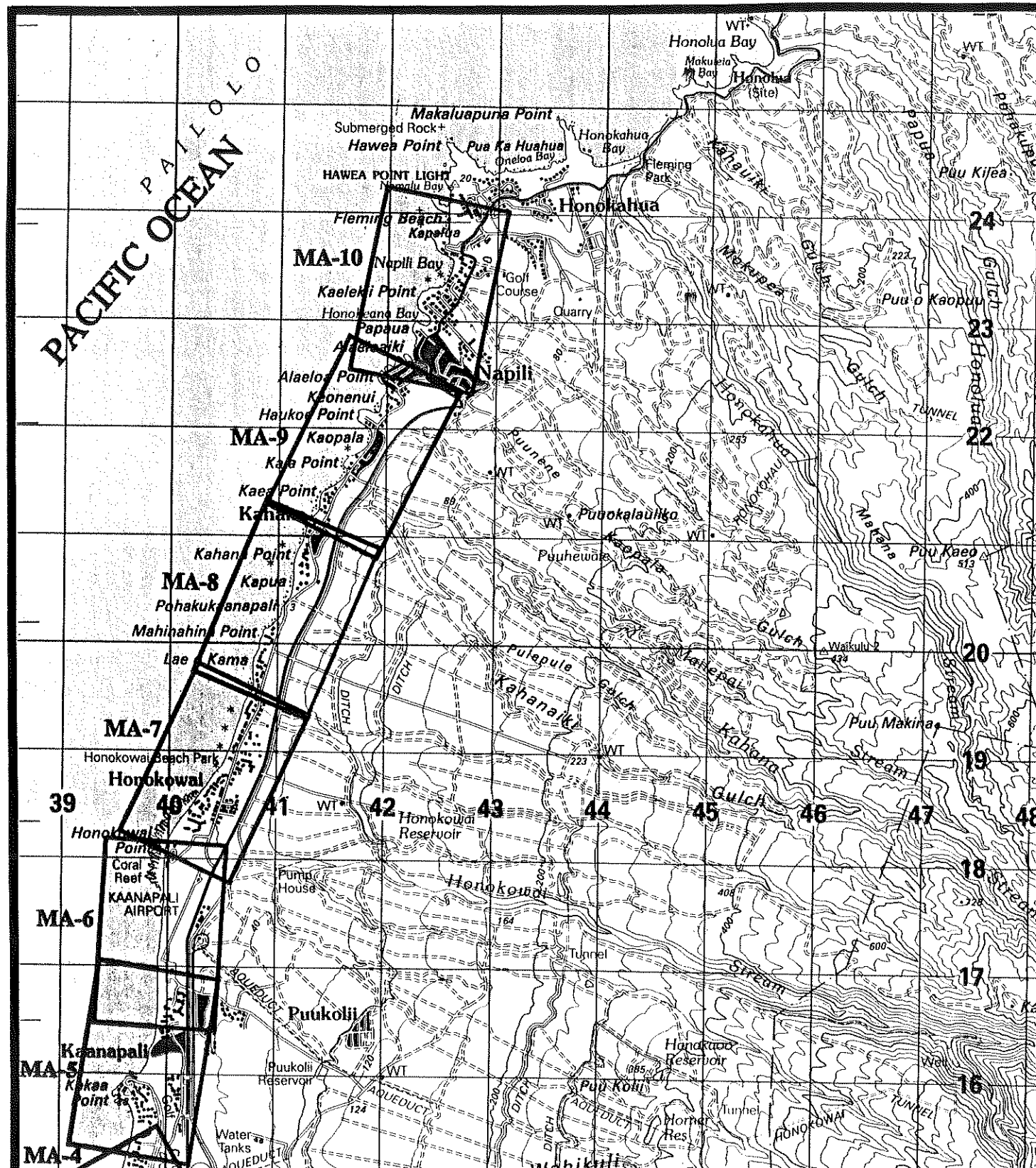
### SHORELINE PROCESSES

Severe erosion has been a recurring problem through much of this sector, and extensive shore protection is now in place. The narrow beaches provide little buffer to the vegetation line during storm events, or even the seasonal alongshore transport variations. The vegetation line history through this sector shows relatively dynamic beaches. Many of the structures built in the 1960's and 1970's were placed within the normal range of vegetation line changes, and when the vegetation line receded shore protection was constructed. There are extensive lengths of formerly sandy shoreline now occupied by rock revetment or vertical seawalls. A prime example of this is the shoreline at and north of Honokowai Point.



### BEACH USAGE

The entire sector has been developed with resorts, condominiums and private residences and, therefore, the beaches are heavily used. Large resorts and condominiums line the coast along the northern two-thirds of the sector, from Hanakao Beach Park to Napili, thereby ensuring heavy and continuous use of the beaches. The coast along the southern one-third of the sector, however, consists of seawalls, revetments and rocky shoreline; there are few sandy areas. Nevertheless, Wahikuli State Wayside Park is one of the most popular beach parks on West Maui because of the good facilities and proximity to Lahaina.



**LEGEND**

HYDROGRAPHIC DATUM ..... MEAN LOWER LOW WATER

- Depth curve (meters)
- Foreshore flats
- Rocks or wash: Reef
- Wreck: Exposed. Sunken with masts exposed
- Wharf, pier
- Seawall
- Oil/gas rig



Scale: 1:50,000



**WEST MAUI**

**Lahaina to Napili**

From U.S. Geological Survey  
MAP INFORMATION AS OF 1983



## MA-1: PUUNOA BEACH

### BEACH DESCRIPTION

- There is a narrow beach in this subsector extending from the seawalls fronting the business district of Lahaina to Mala Wharf. The beach length is 2000 feet.
- There is a 600 foot wide fringing reef off Puunoa Point, decreasing to 300 feet in width at Mala Wharf.

### BACKSHORE

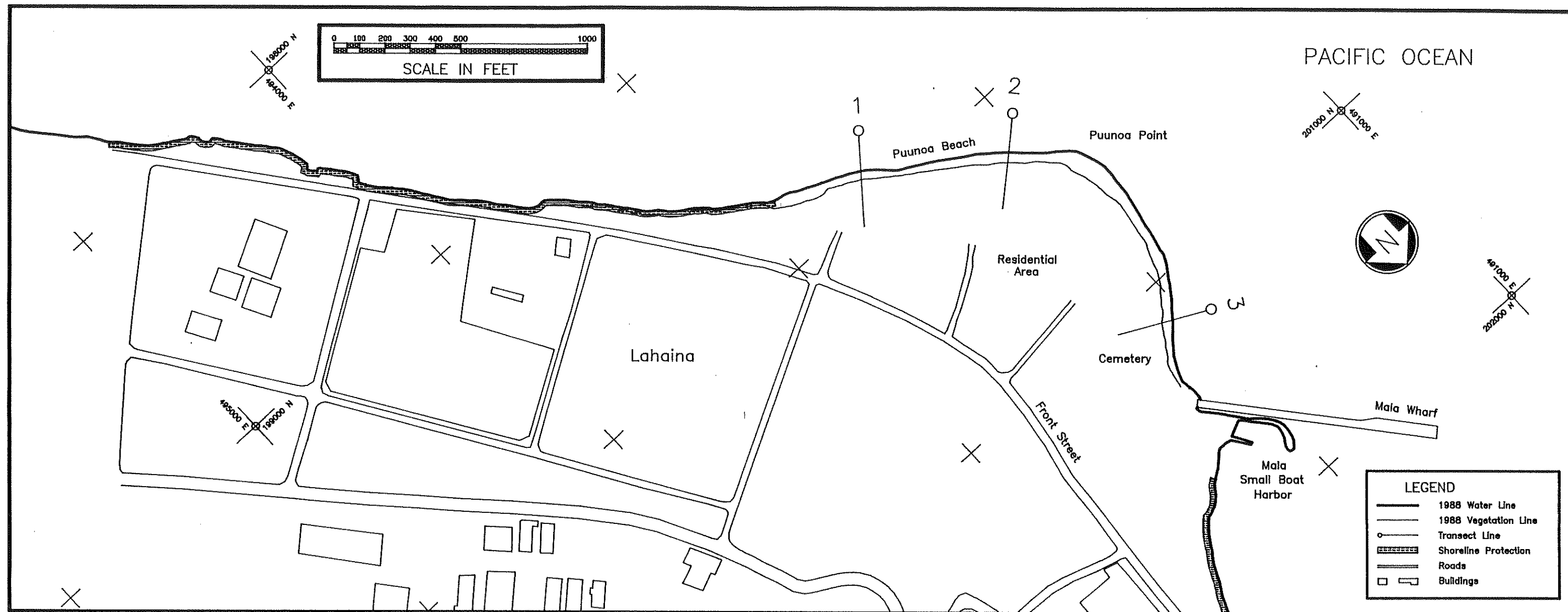
- Mala Wharf, an old inter-island steamer landing built in 1922, marks the north end of the beach and the subsector. The wharf is no longer in use and is closed to the public.
- A cemetery and a residential area lie inshore of Puunoa Point.

### SHORELINE HISTORY

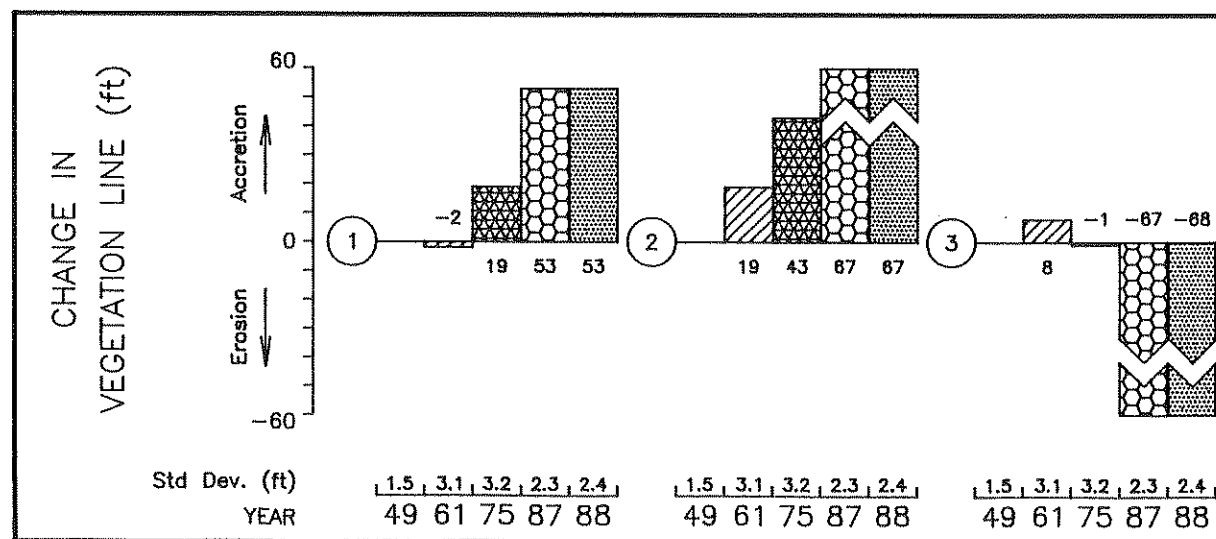
- The 1949 and 1961 aerial photos show Puunoa Beach extending 600 feet further to Lahaina than it does today. By 1975, the shore protection occupied the extent of shoreline shown on the accompanying figure.
- The beach south of the point (Regions 1 and 2) has accreted significantly since 1949. Net seaward movement of the vegetation line was 53 feet in Region 1 and 67 feet in Region 2. The houses in the residential area on the south side of the point are now set well back from the vegetation line, due to the past accretion.
- During the same period, the beach north of the point, fronting the cemetery, eroded severely (loss of 68 feet in Region 3). Erosion is continuing in front of the cemetery. Trees are being undercut, and are falling onto the beach.

### SUMMARY

- The beach at Puunoa Point and to the south is accreting; that to the north is eroding. The shoreline at the point and in the immediate vicinity is dynamic.

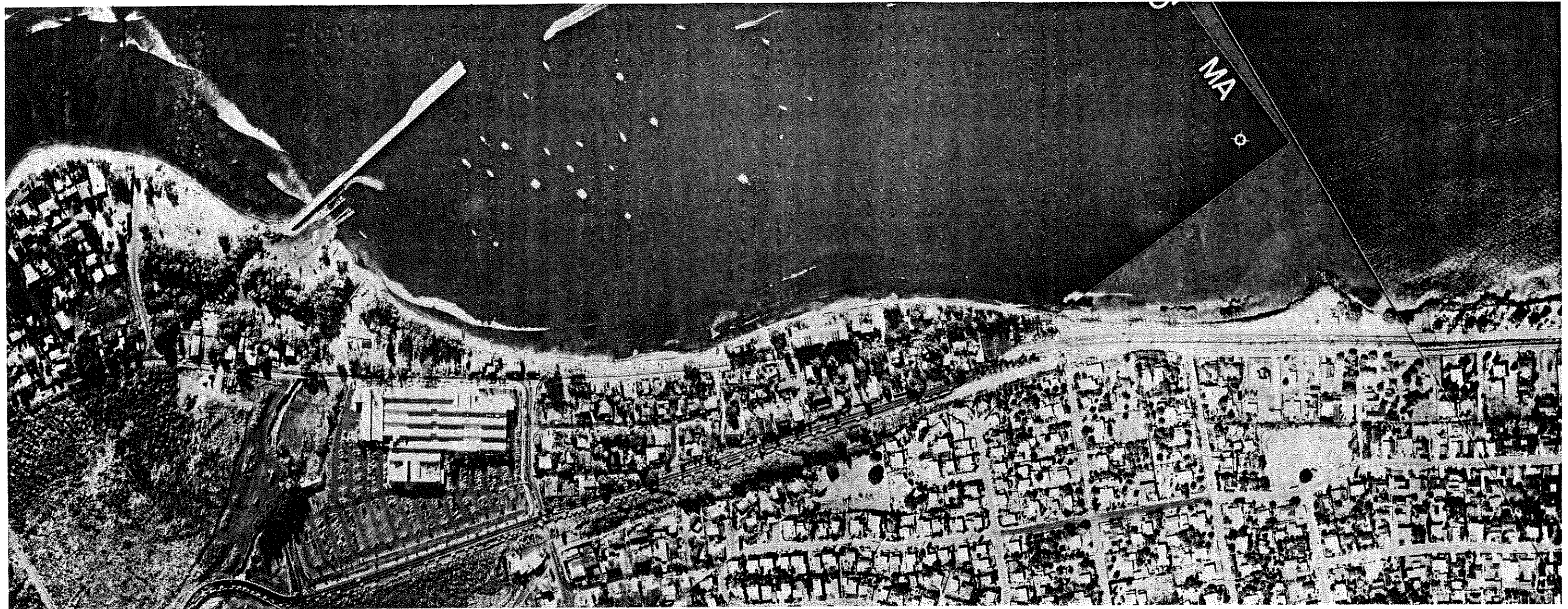


**FIGURE MA-1**



**GRAPH MA-1 Region Number vs Change in Vegetation Line**

**PHOTOS USED**  
 November, 1949  
 December, 1961  
 March, 1975  
 July, 1987  
 March, 1988



## MA-2: MALA WHARF TO WAHIKULI WAYSIDE PARK

### BEACH DESCRIPTION

- There are no sandy beaches in this subsector. The shoreline consists of beach rock, boulder beaches, rock revetments and basalt outcroppings.
- There is no fringing reef in this subsector.

### BACKSHORE

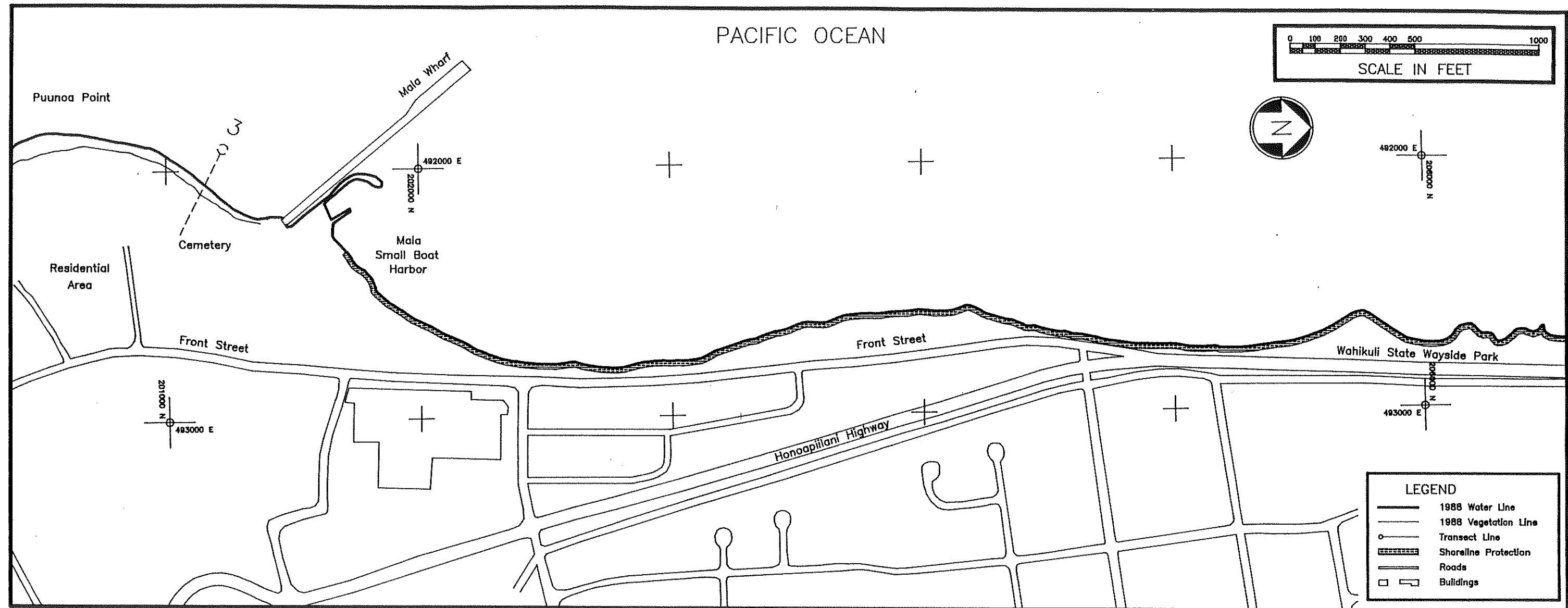
- Single family houses line the backshore from Mala Small Boat harbor to the junction of Front Street and Honoapiilani Highway.
- Wahikuli State Wayside Park is located at the north end of this subsector.

### SHORELINE HISTORY

- A few small sandy areas could be seen on the 1949 aerial photo in what is now the residential area of this subsector. The beach areas were very narrow, and were apparently composed of detrital material. Houses had been constructed by 1961 and the small beach areas had disappeared.

### SUMMARY

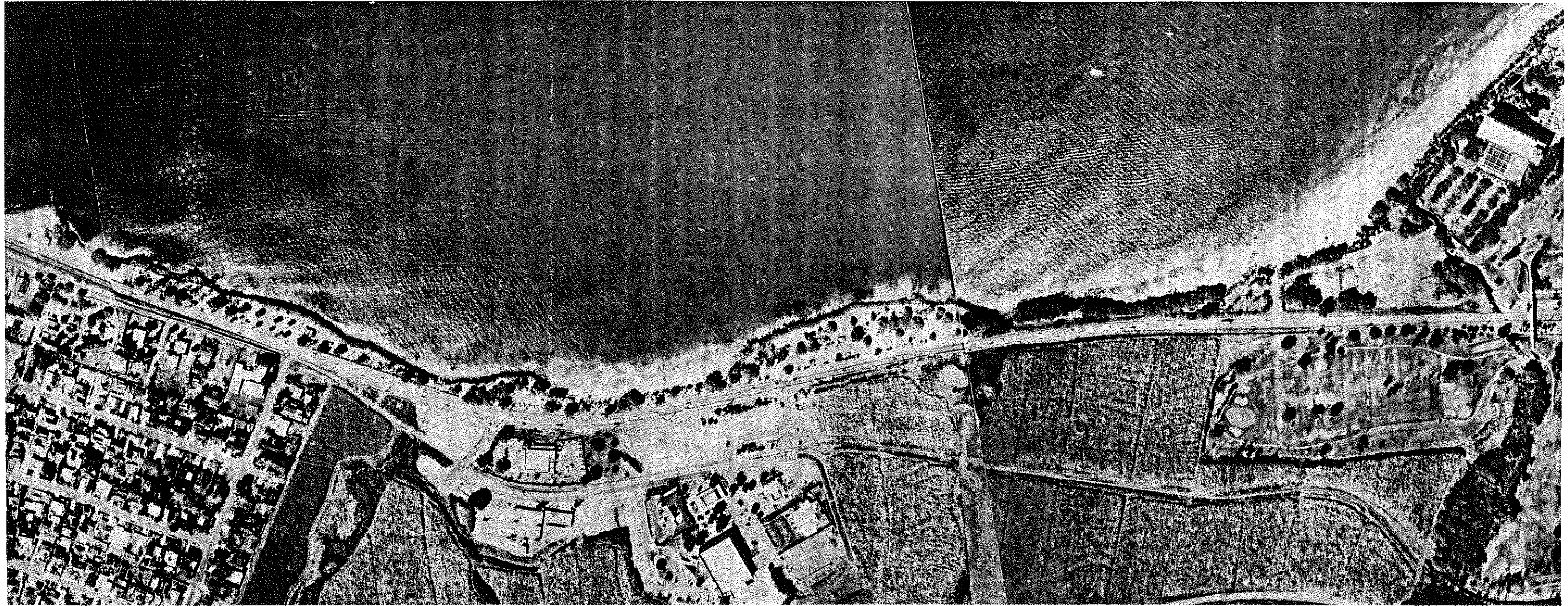
- This subsector contains only a rocky shoreline. There are no beach areas.



**FIGURE MA-2**

**PHOTOS USED**  
 November, 1949  
 December, 1961  
 March, 1975  
 July, 1987  
 March, 1988





### **MA-3: WAHIKULI STATE WAYSIDE PARK**

#### **BEACH DESCRIPTION**

- Most of the shoreline in this subsector consists of either basalt rock shoreline or a boulder revetment. There is one small beach segment, 400 feet long, in the middle of Wahikuli State Wayside Park.

#### **BACKSHORE**

- Wahikuli State Wayside Park occupies the entire backshore of this subsector. The park is located between Honoapiilani Highway and the ocean.

#### **SHORELINE HISTORY**

- The small beach is essentially a pocket beach, stabilized by rock outcroppings (or revetments) on each side.
- The south end of the beach (Region 4) has a rock revetment at the crest of the beach; the north end (Region 5) is relatively stable.

#### **SUMMARY**

- Wahikuli State Wayside Park is a popular park and swimming beach due to its proximity to Lahaina. The south end was subject to slow, steady erosion.

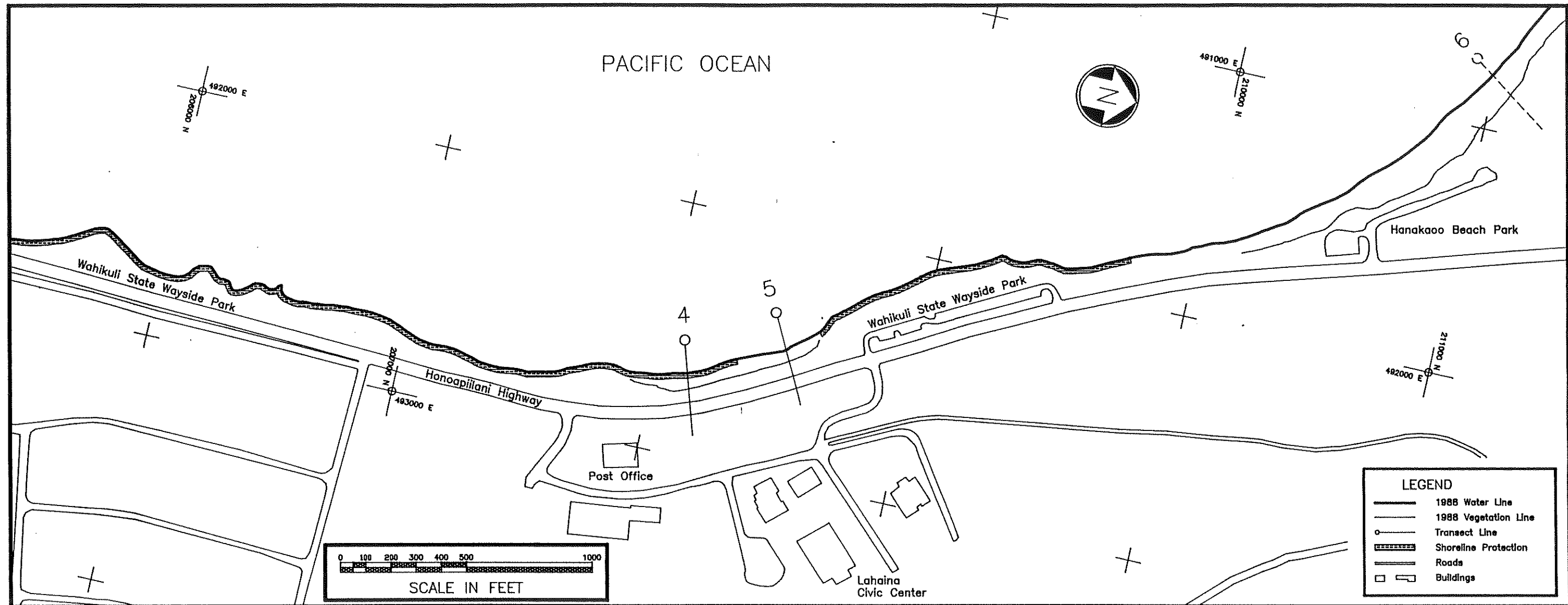
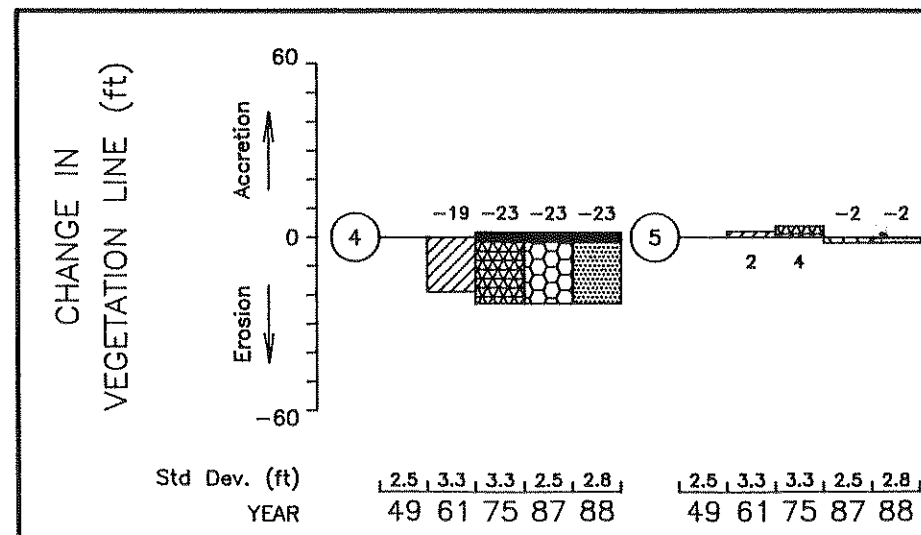
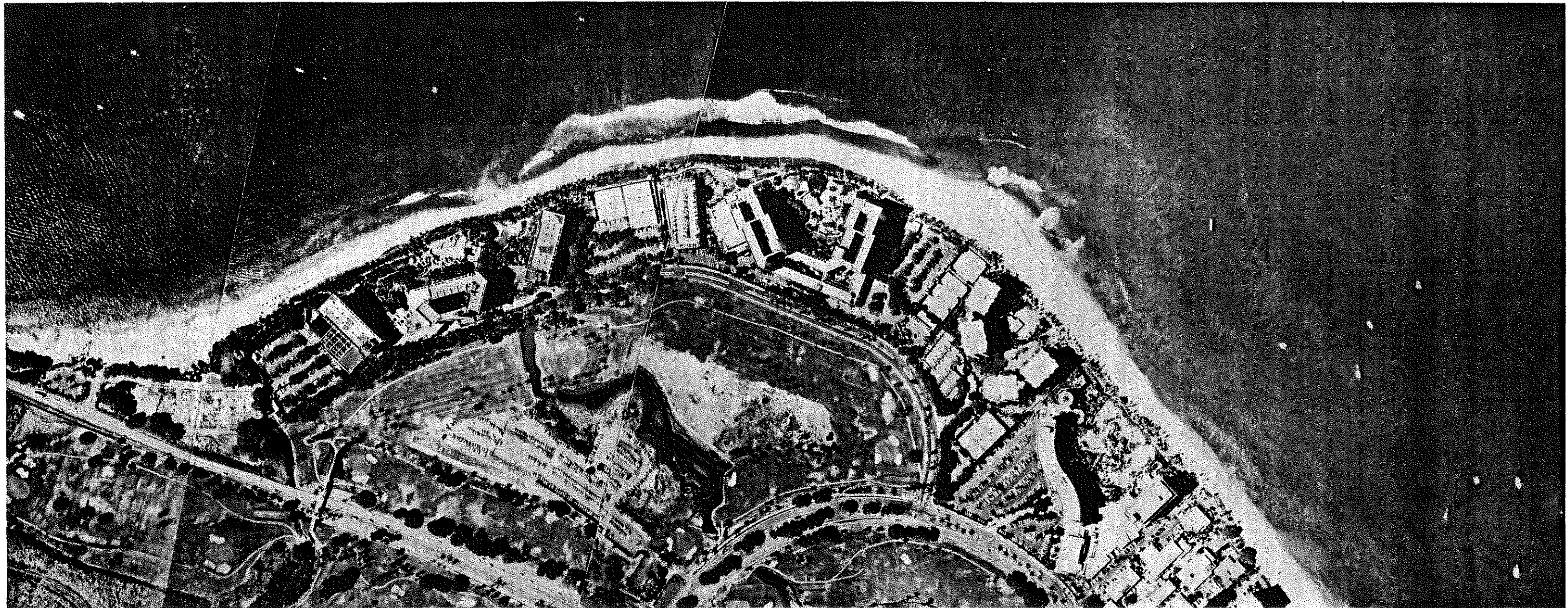


FIGURE MA-3



GRAPH MA-3 Region Number vs Change in Vegetation Line

PHOTOS USED  
 November, 1949  
 December, 1961  
 March, 1975  
 July, 1987  
 March, 1988



## MA-4: HANAKAO BEACH (SOUTH END)

### BEACH DESCRIPTION

- This subsector covers the southern two-thirds of Hanakao Beach, which is an 8000 foot long beach located between Wahikuli Wayside Park and Kekaa Point.
- The south end of the beach is narrow and has a high percentage of terrestrial material and rocks. The beach widens at Hanakao Point where high quality calcareous sand is the primary component.

### BACKSHORE

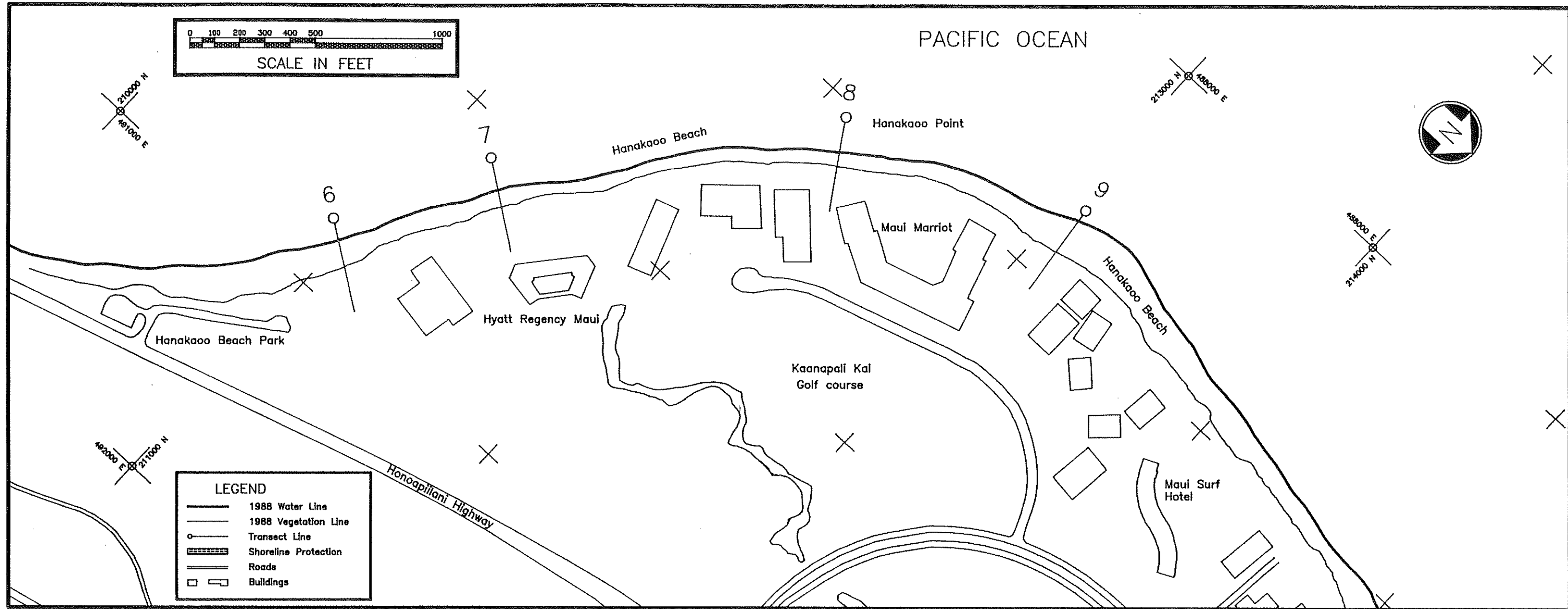
- Honoapiilani Highway curves inland at Hanakao Beach Park.
- Hanakao Beach Park is located at the south end of the subsector. The rest of the backshore area has undergone development as a major resort area, and is occupied by hotels and golf courses.

### SHORELINE HISTORY

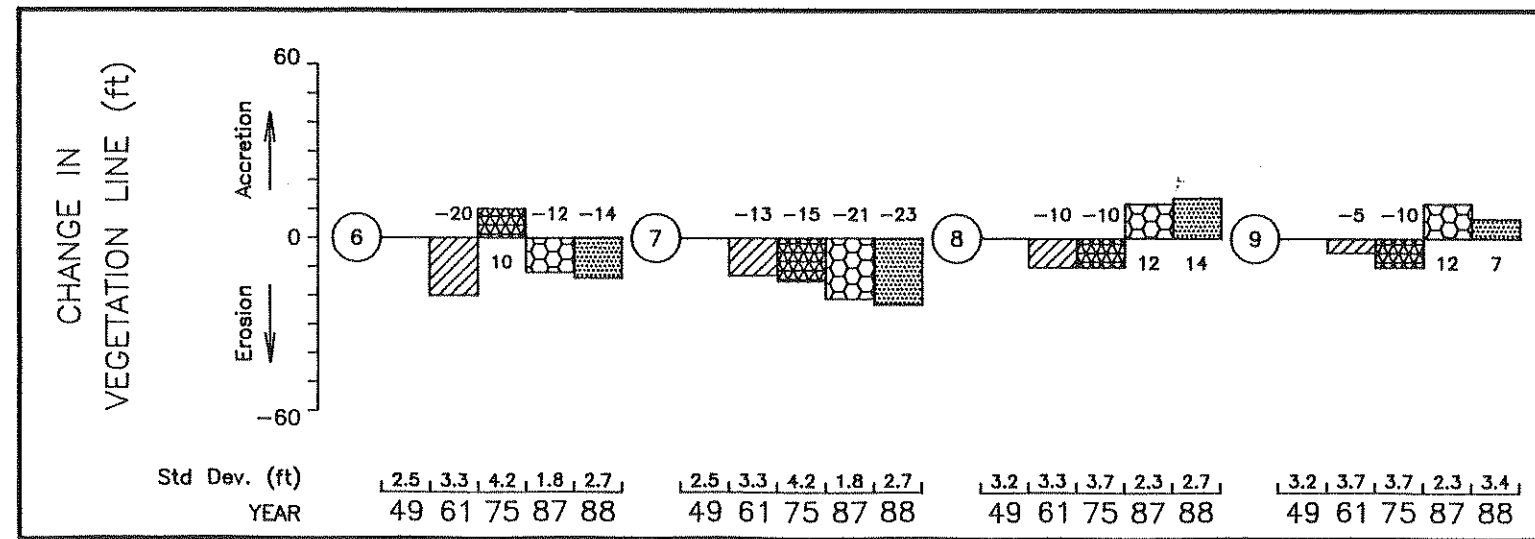
- According to Moberly and Chamberlain (1964), Hanakao Point is seasonally unstable. During the summer, the south swell moves the sand to the north; the point erodes and the north end of the beach accretes. The opposite occurs when the winter north swell moves the sand to the south. The erosion occurs to the extent that a 15 foot wave cut scarp at the point was noted in 1963.
- This subsector is also directly exposed to Kona storm waves, and severe erosion occurred during the January 1980 storm.
- The measurements from the aerial photographs indicate that the beach south of Hanakao Point (Regions 6 and 7) have a tendency toward erosion, and the point (Regions 8 and 9) while dynamic, has a tendency toward overall accretion.

### SUMMARY

- Although there are no major shore protection structures in this subsector, the vegetation line is no longer a natural line, but is part of the landscaped grounds of the hotels.
- Many of the hotels and related facilities were built very close to the vegetation line. Although the vegetation line is not highly dynamic, there is now little area to accommodate naturally occurring vegetation line changes, either long term or storm related. As a result, this subsector is a potential problem area.

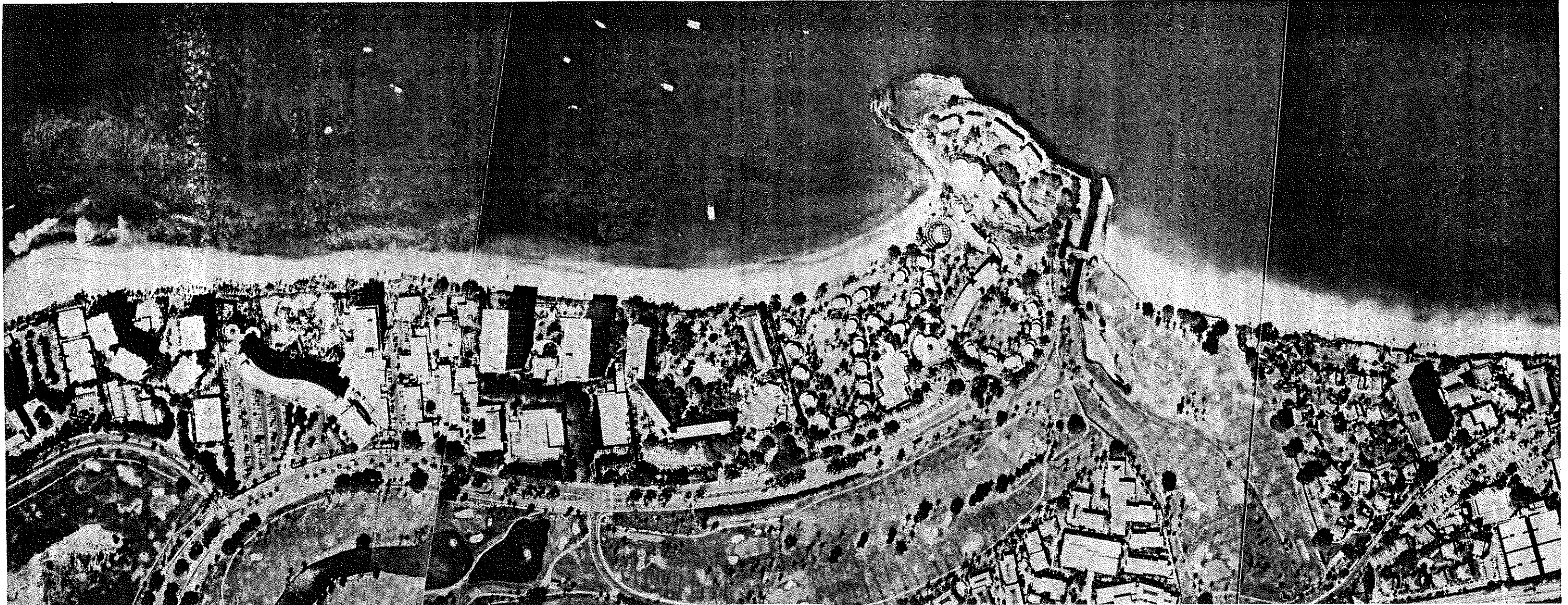


**FIGURE MA-4**



**GRAPH MA-4 Region Number vs Change in Vegetation Line**

**PHOTOS USED**  
 November, 1949  
 December, 1961  
 March, 1975  
 July, 1987  
 March, 1988



**MA-5: HANAKAOO BEACH (NORTH END) AND  
KAANAPALI BEACH (SOUTH END)**

**BEACH DESCRIPTION**

- This subsector, centered around Kekaa Point, includes the northern 3500 feet of Hanakao Beach and the southern 1000 feet of Kaanapali Beach. Kaanapali Beach is separated from Honokowai Beach by Kekaa Point. Together the two form a 12,000 foot long beach.
- Kekaa Point, also known as Black Rock, is a volcanic cinder cone and is the most notable coastal feature.

**BACKSHORE**

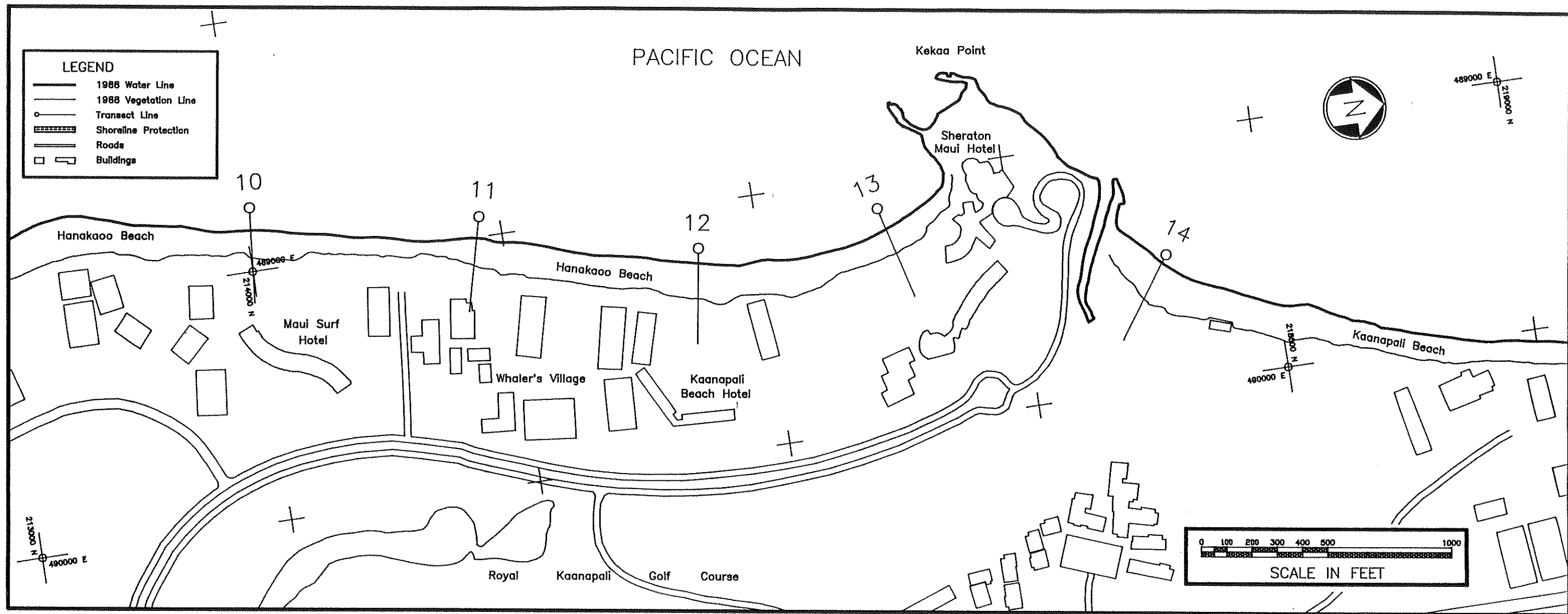
- The entire backshore of this subsector is fully developed with major resort hotels.

**SHORELINE HISTORY**

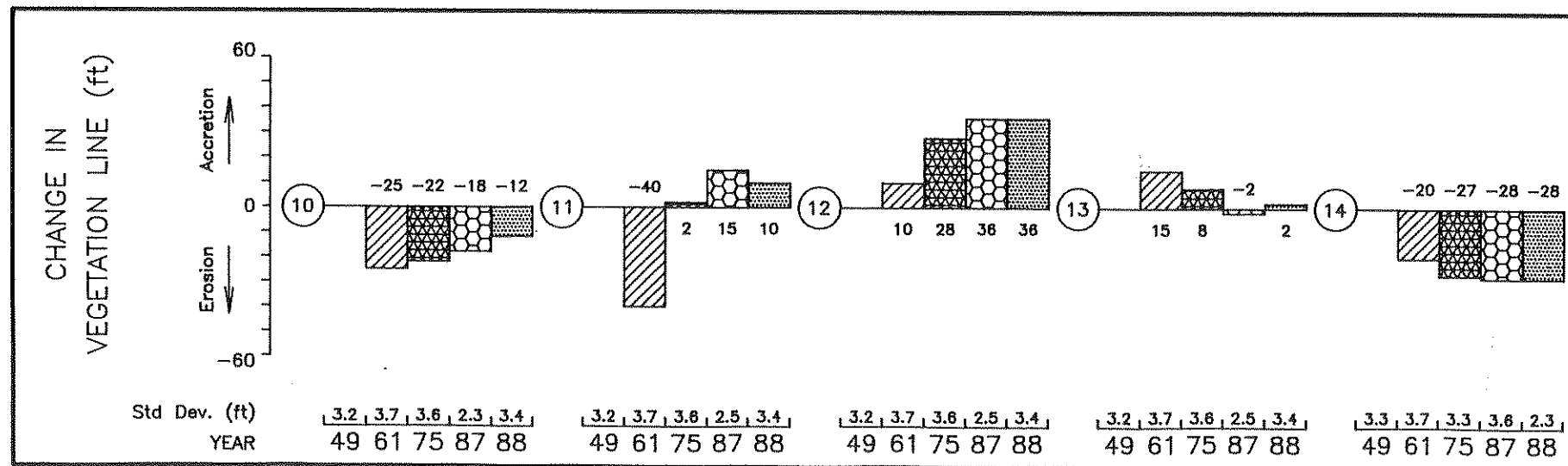
- The vegetation line at the north end of Hanakao Beach had been almost completely bulldozed (in preparation for the resort development) at the time of the 1961 photo. By the time of the later photos (1975, 1987 and 1988), the vegetation was landscaped for the hotels. As a result, for this beach area in particular, the vegetation line cannot be considered representative of erosion or accretion trends.
- The same holds for the small beach segment north of Kekaa Point. It was also bulldozed in 1961, making comparison of vegetation lines irrelevant.
- If 1975, after completion of hotel construction and re-vegetation of the area, is considered as a "base" year, the vegetation line through the entire subsector has been relatively stable.

**SUMMARY**

- As in subsector MA-4, some of the hotels and related facilities have been built very close to the vegetation line. It appears that the beach is stable during typical conditions, but has a history of erosion during severe Kona storms. After the January 1980 Kona storms, at least some of the hotels considered building protective revetments. This is a potential problem area, due to proximity of the structures to the vegetation line.

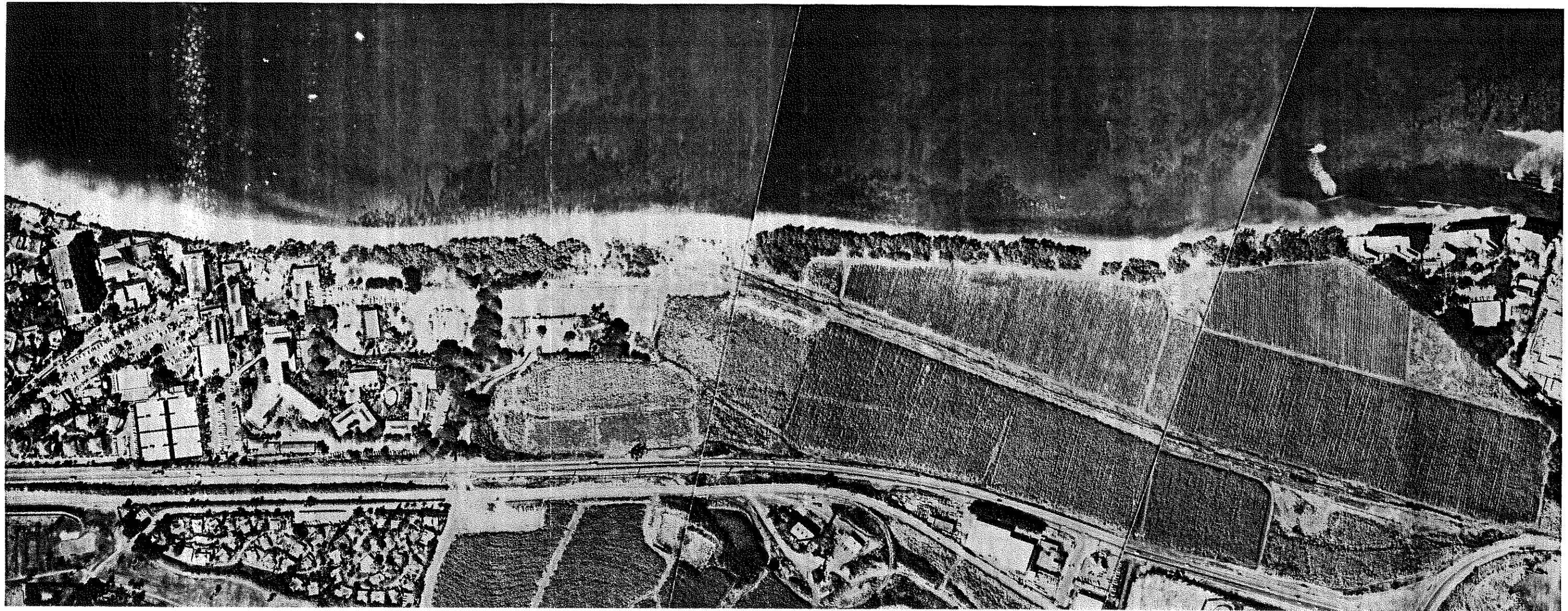


**FIGURE MA-5**



**PHOTOS USED**  
 November, 1949  
 December, 1961  
 March, 1975  
 July, 1987  
 March, 1988

**GRAPH MA-5 Region Number vs Change in Vegetation Line**



**MA-6: KAA NAPALI BEACH AND HONOKOWAI BEACH (SOUTH END)**

**BEACH DESCRIPTION**

- A continuous sandy shoreline extends from Kekaa Point to Honokowai Point, a distance of 8,000 feet. This beach is described by subsectors MA-5, MA-6 and MA-7. The 4,000 feet of beach immediately north of Kekaa Point is known as Kaanapali Beach; the remaining 4,000 feet is known as Honokowai Beach.

**BACKSHORE**

- The old Kaanapali Airport is located along much of the backshore of this subsector. The airport is now closed and a resort development is planned for the site.
- South of the airport, along Kaanapali Beach, there is a large hotel development and a golf course.

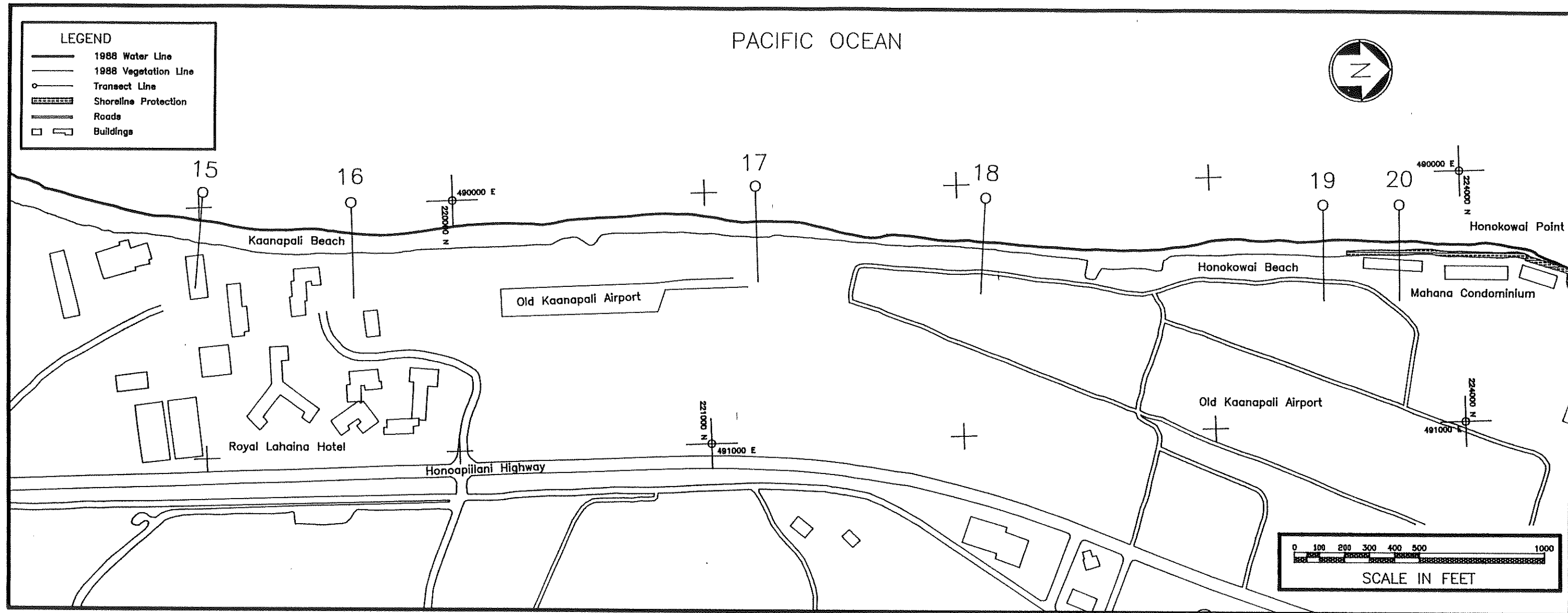
**SHORELINE HISTORY**

- Sand movement along this subsector varies seasonally, depending upon approach of south swell, North Pacific swell and Kona storm waves. With deep water close to shore and no fringing reef, except at Honokowai Point, much of the wave energy is expended on the shoreline. Steep foreshore and well developed backshore berm are typical of beaches exposed to large waves. Past studies (Sea Engineering, Inc., 1986) indicated that the beach toe fronting the old airport had seasonal fluctuations of plus or minus 25 feet relative to the mean shoreline position.
- Past instances of specific, severe erosion are related to the occurrence of Kona storm waves.
- The analysis of the aerial photographs (Regions 15, 16, 17, 18 and 19) indicates a dynamic vegetation line. There is not a clear cut trend, but the two ends of the subsector (Regions 15, 18 and 19 on sheet MA-6 and Region 14 on MA-5) are more dynamic than the center area.

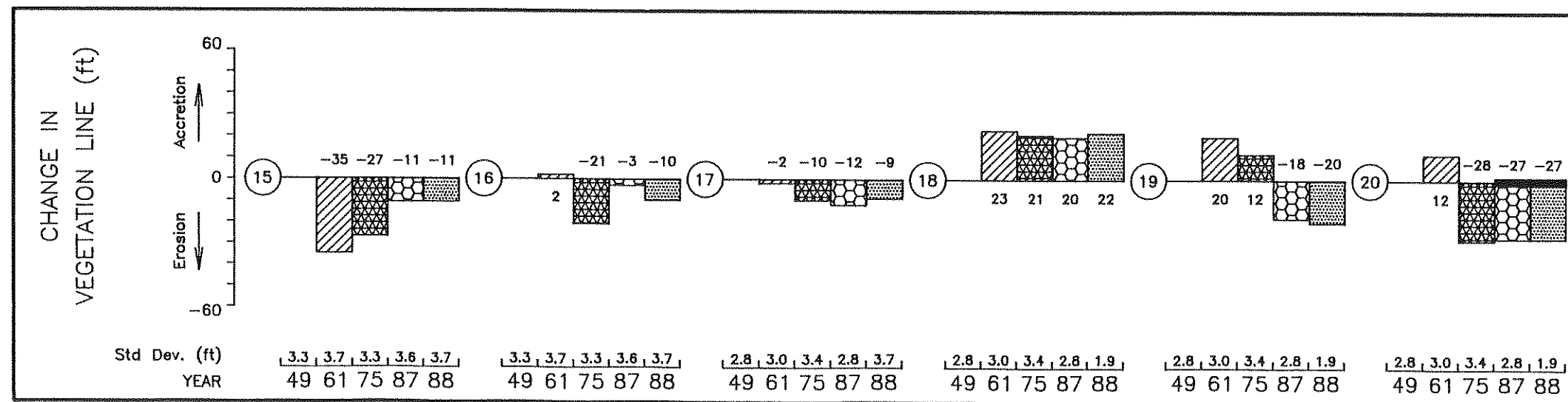
- Only one area, Region 18, had a net accretion over the 39 year period.
- A rock revetment was constructed in 1986 in front of the Mahana Condominium in response to severe shoreline erosion.

**SUMMARY**

- Vegetation line changes are most pronounced at the two ends of the subsector.
- The relatively narrow beach is exposed to varying seasonal waves, and probably does not provide a large amount of buffer before the vegetation line is affected.



**FIGURE MA-6**



**PHOTOS USED**  
 November, 1949  
 December, 1961  
 March, 1975  
 July, 1987  
 March, 1988

**GRAPH MA-6 Region Number vs Change in Vegetation Line**





## MA-7: HONOKOWAI BEACH PARK

### BEACH DESCRIPTION

- Shore protection extends along most of this 6,000 foot long reach. Vertical seawalls are the predominant shore protection type, and in most areas there is no dry beach fronting the walls.
- The only unprotected areas are a 500 foot length of beach at Honokowai Beach Park and a 600 foot length north of Honokowai Point.

### BACKSHORE

- The backshore is completely developed, except for Honokowai Beach Park, with resort hotels and condominiums.

### SHORELINE HISTORY

- The 1949 and 1961 aerial photos show a very narrow (typical widths of 20 to 30 feet) beach in this subsector. Exposed beachrock was common along the shoreline.
- By 1975, most of the area was developed, and shore protection was in place.
- In many areas of this subsector, the 1961 vegetation line was seaward of the 1949 vegetation line. By 1975, the line had returned to the 1949 position, or moved even further inland. The buildings, most of which were placed 40 feet from the vegetation line at the time of construction, were forced to build shore protection to prevent structural loss. Given the limited horizontal space, seawalls were the selected type of shore protection. Due to wave reflection and scour, the beach is now gone from most of this area.

- The unprotected beach at Honokowai Beach Park is severely eroding; there is a two foot wave cut scarp and overhanging trees with exposed roots.

### SUMMARY

- There are limited management options for this subsector, due to the extensive development and associated shore protection.
- The problems in this subsector stem not so much from erosion as from placing structures too close to a temporarily accreted vegetation line.

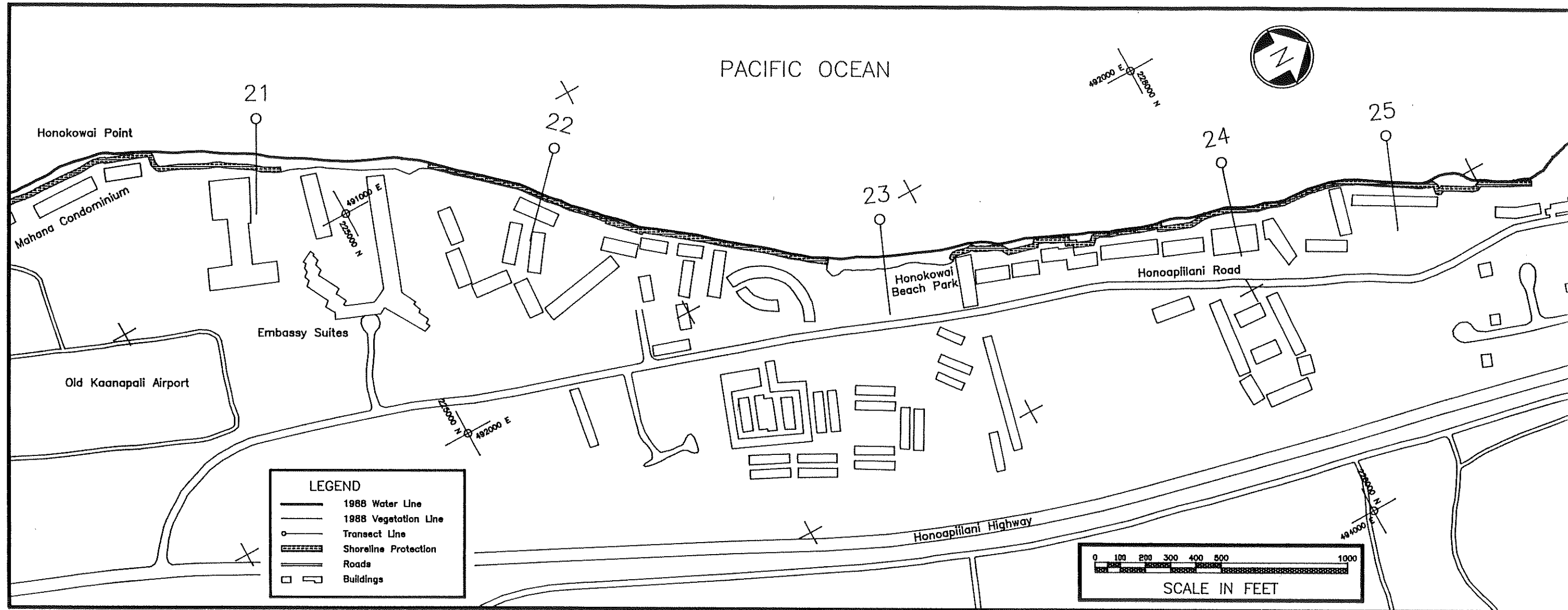
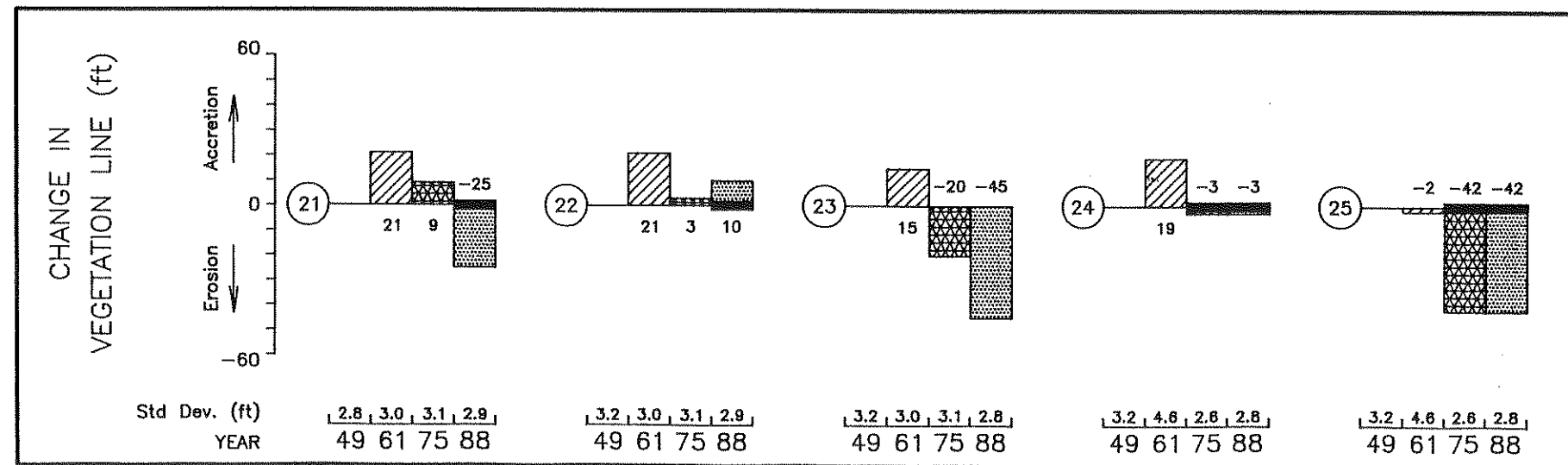
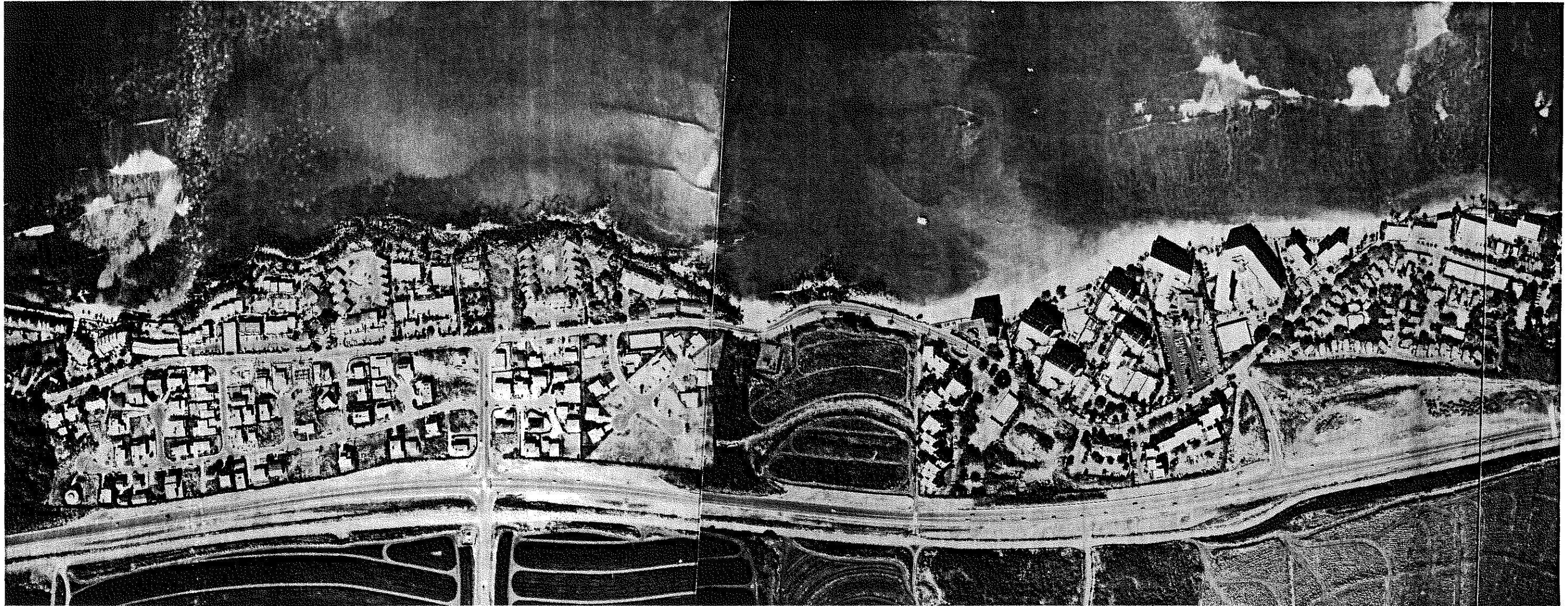


FIGURE MA-7



GRAPH MA-7 Region Number vs Change in Vegetation Line

PHOTOS USED  
 November, 1949  
 December, 1961  
 March, 1975  
 July, 1987  
 March, 1988



## MA-8: KAHANA BEACH

### BEACH DESCRIPTION

- Kahana Beach is a gently curving sand beach beginning where Honoapiilani Road meets the shoreline just north of Mahinahina Point and extending up to and around Kaea Point, a total length of 4200 feet.

### BACKSHORE

- The backshore is developed with resort condominiums and apartments.
- There is public access at the south end of the beach where the highway parallels the beach crest.

### SHORELINE HISTORY

- Kahana Beach eroded significantly between 1961 and 1975 (Regions 26, 27 and 28). The backshore development took place at the same time, and shore protection was built along much of this beach in response to the erosion.
- The unprotected areas of Kahana Beach (Regions 27 and 28) have also eroded from 1961 to 1975, but then recovered somewhat from 1975 to 1988.

### SUMMARY

- Kahana Beach is a dynamic beach, similar to Honokowai Beach to the south. Some of the buildings were placed too close to the shoreline to allow the natural vegetation line fluctuations to occur. Unfortunately, most of the development occurred between 1961 and 1975, when the beach was at or near its maximum seaward position. Shore protection is now common through this subsector.

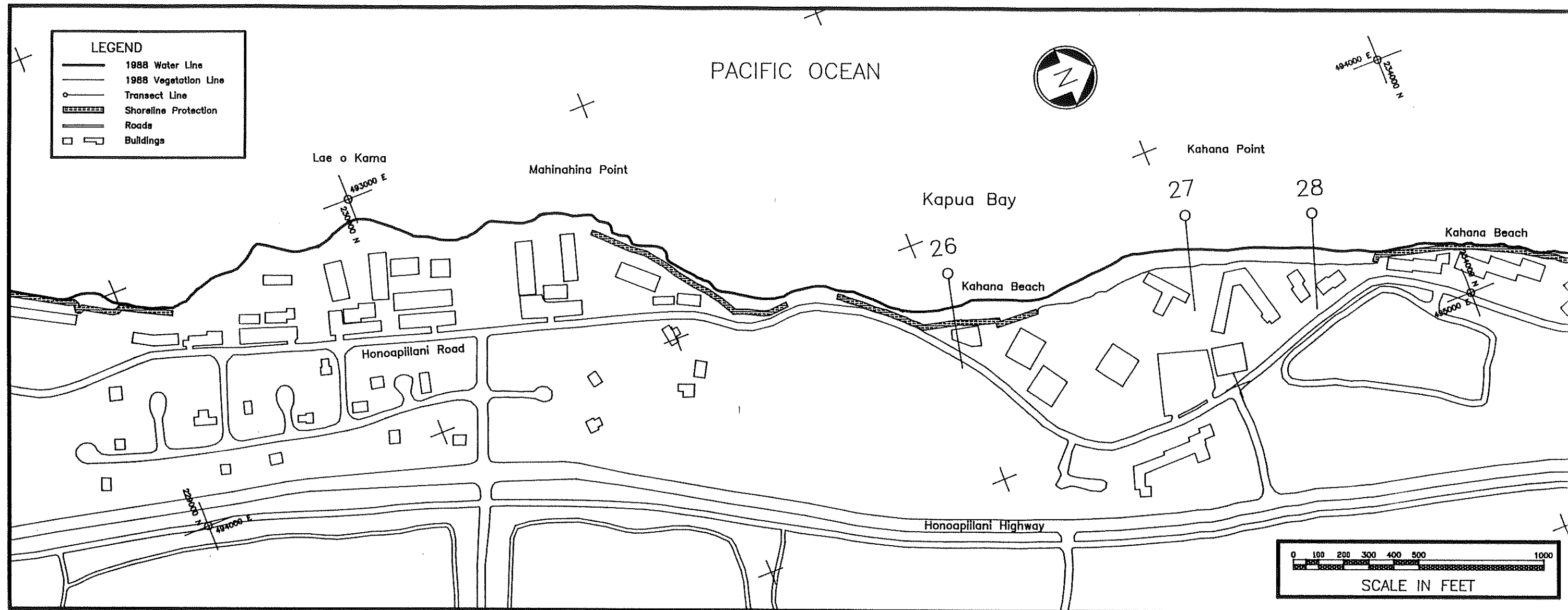
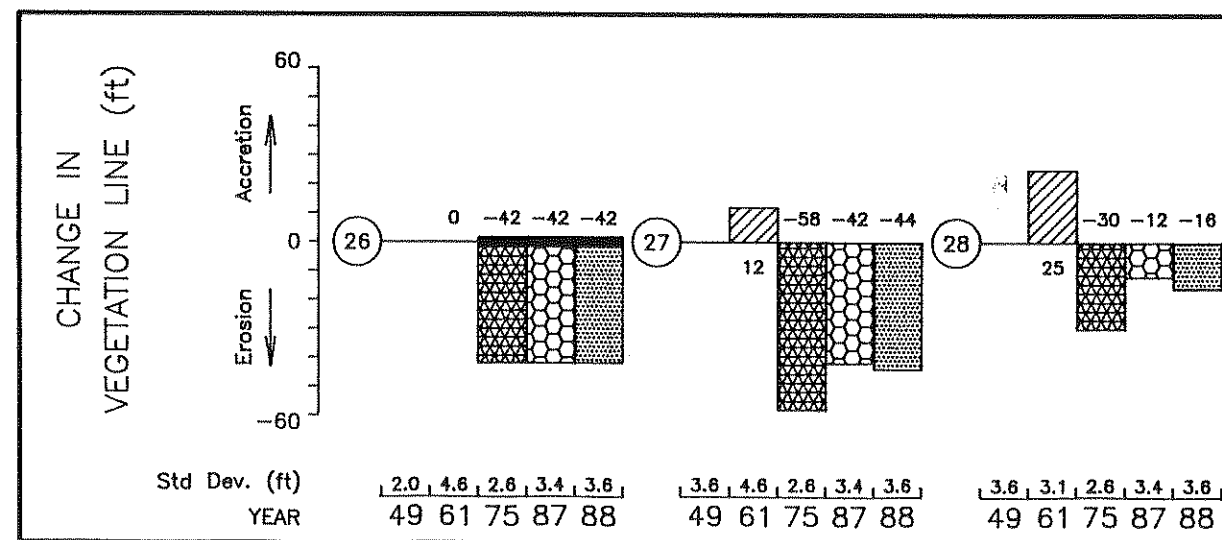
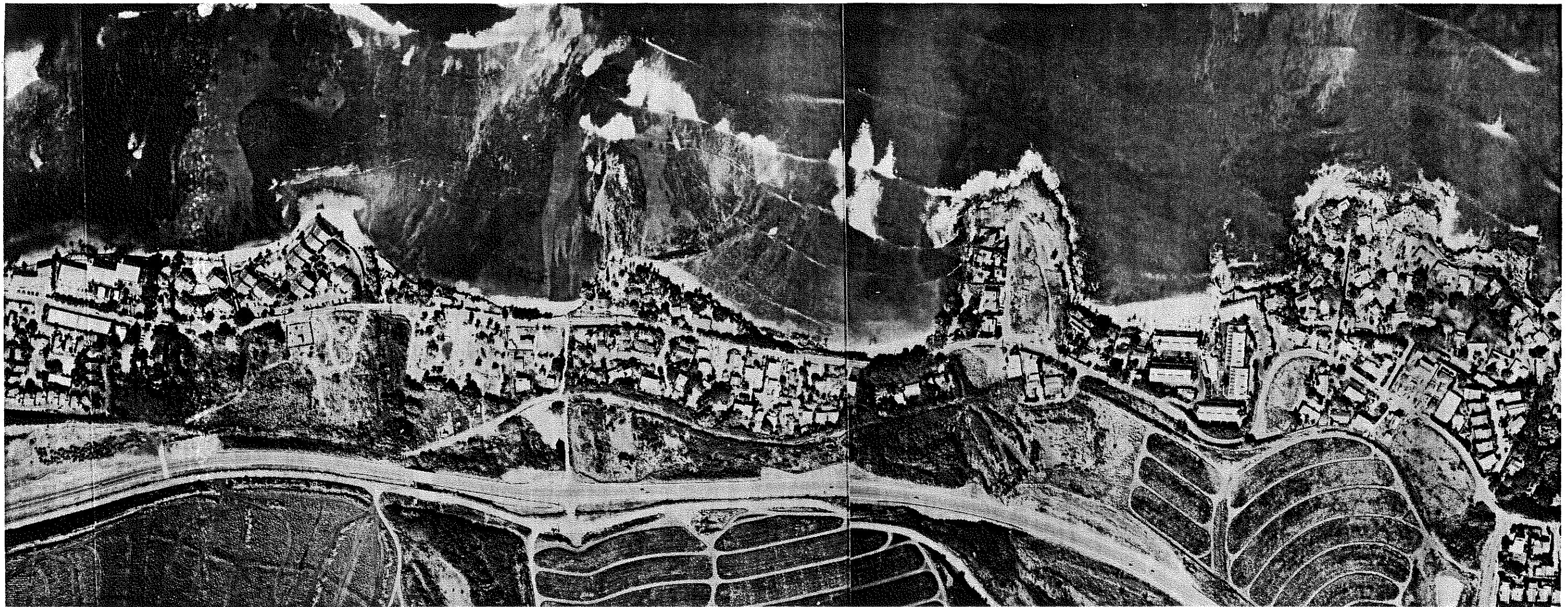


FIGURE MA-8



PHOTOS USED  
November, 1949  
December, 1961  
March, 1975  
July, 1987  
March, 1988

GRAPH MA-8 Region Number vs Change in Vegetation Line



## MA-9: KAHANA BEACH TO ALAELOA POINT

### BEACH DESCRIPTION

- This subsector includes the north end of Kahana Beach and Keonenui Beach. There are also small segments of beach at Kaia Point and Kaopala.

### BACKSHORE

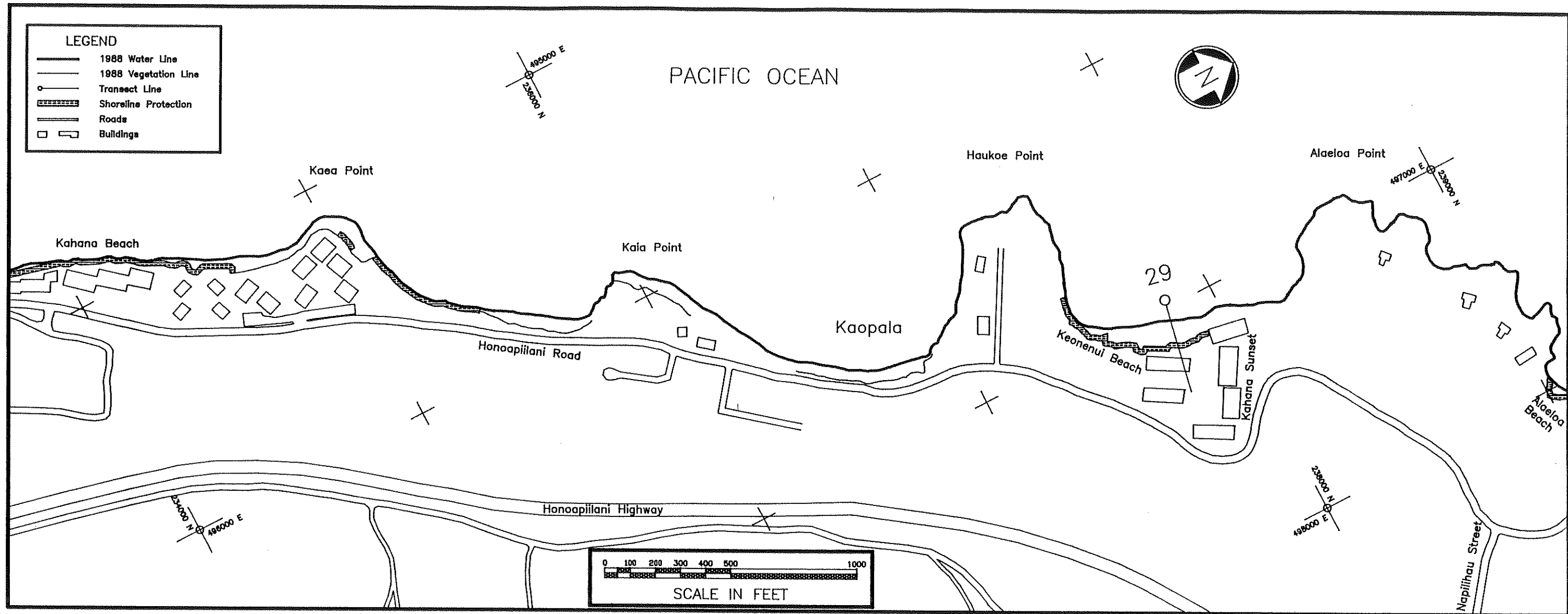
- The north end of Kahana Beach is developed with resort hotels, condominiums and town houses. At the extreme north end, the road is located just behind the beach.
- Kaia Point and Haukoe Point both have single family houses along the backshore.
- At Kaopala, the Honoapiilani Highway is located just behind the beach.
- The Kahana Sunset, a resort condominium, is located behind Keonenui Beach.

### SHORELINE HISTORY

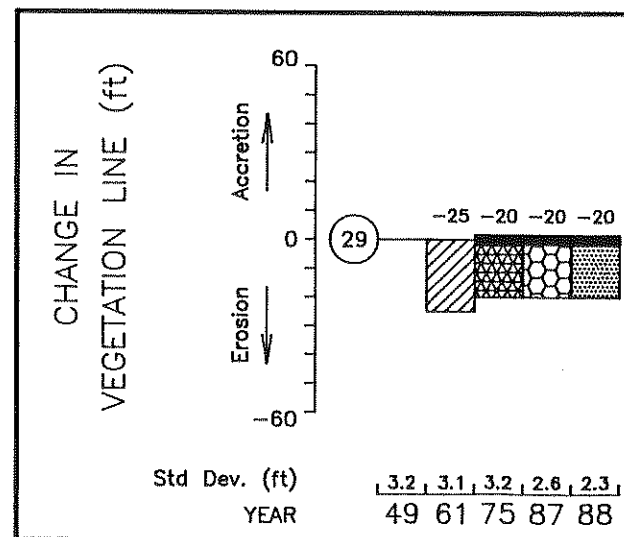
- The Kahana Sunset was constructed at Keonenui Beach prior to 1975. At present, there is a seawall directly in front of the buildings, and little or no vegetation between the building and the wall. The sand beach fronting the buildings is approximately 60 to 70 feet wide.

### SUMMARY

- This subsector has very small reaches of sandy beach, separated by extensive seawalls, revetments and rocky points.



**FIGURE MA-9**



**GRAPH MA-9 Region Number vs Change in Vegetation Line**

**PHOTOS USED**  
 November, 1949  
 December, 1961  
 March, 1975  
 July, 1987  
 March, 1988



## MA-10: ALAELOA POINT TO KAPALUA BAY

### BEACH DESCRIPTION

- This subsector consists of a series of basalt headlands, with small pocket beaches in between. Napili and Kapalua are the best known of these beaches. Alaeloa Beach and the beach at Honokeana Bay are very small pocket beaches.

### BACKSHORE

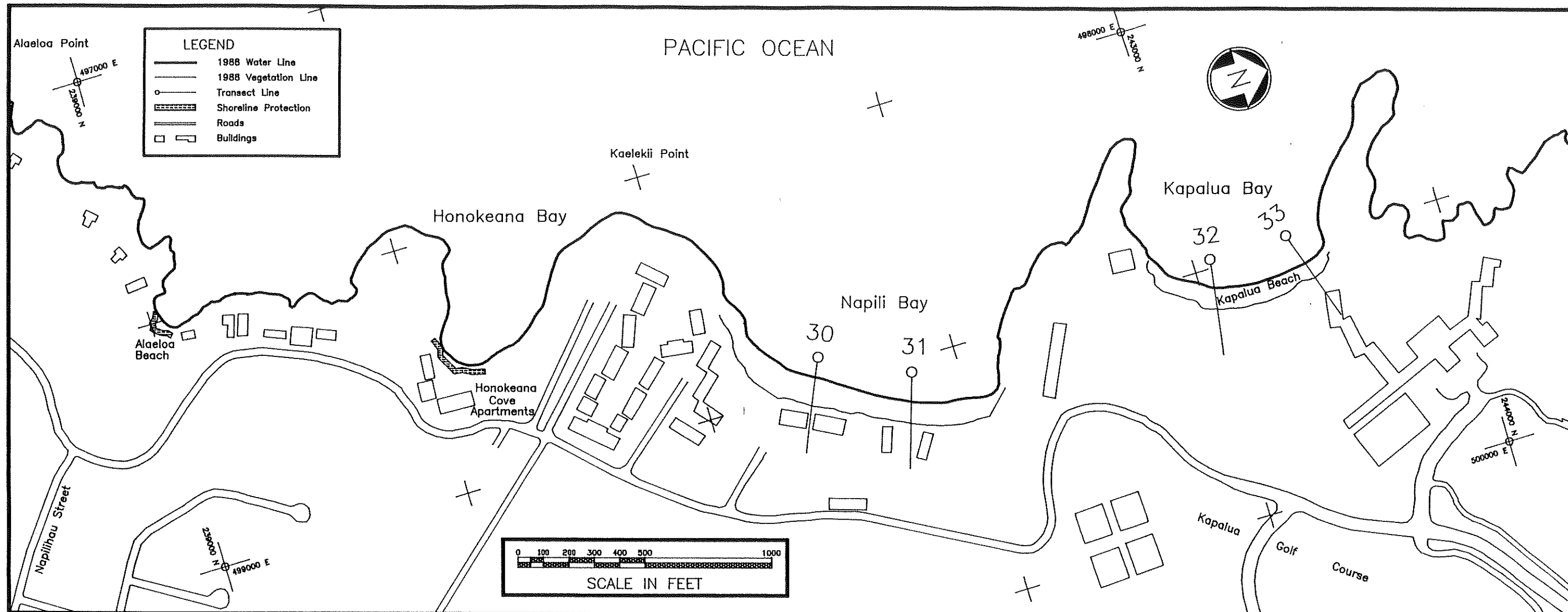
- The backshore of this entire subsector is lined with resort development. Houses and resort condominiums are located close to the vegetation line, except at Kapalua, where the development is at the point and the backshore of the beach is open.

### SHORELINE HISTORY

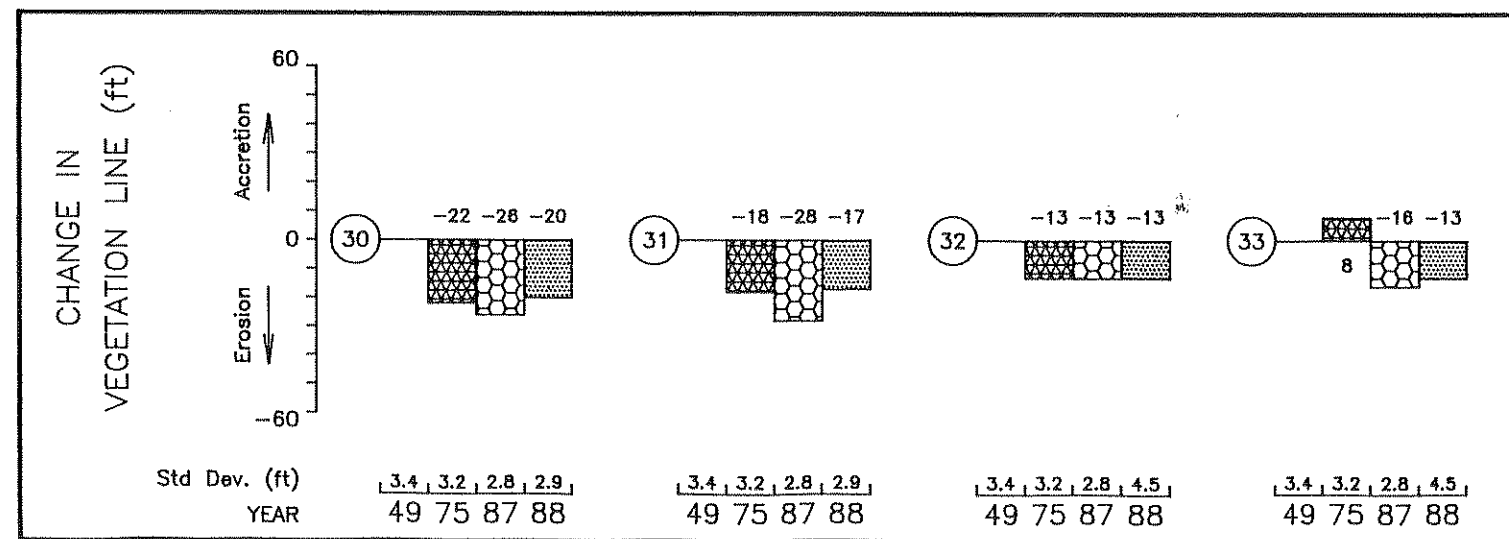
- The vegetation lines at the two small beaches, Alaeloa and Honokeana, are stabilized by retaining walls. The shore protection was in place by 1975.
- The vegetation line is sparse at both Napili and Kapalua Beaches, and data from the aerial photographs should be used carefully. At best, the information should be considered as indicative of general trends only. In addition, the 1961 photo was blurry and the measurements from that year were not used.
- Napili Beach (Regions 30 and 31) has eroded, and during the site visit it appeared that sandbags had been selectively placed to limit the erosion. The beach is steep but there is no scarp.
- Kapalua Beach has a slight net erosion, but is relatively stable.

### SUMMARY

- Four small pocket beaches are located in this subsector. Although some erosion is occurring there are no structures threatened at present.



**FIGURE MA-10**



**PHOTOS USED**  
 November, 1949  
 December, 1961  
 March, 1975  
 July, 1987  
 March, 1988

**GRAPH MA-10 Region Number vs Change in Vegetation Line**



## SECTOR MB: SOUTHWEST MAUI MAALAEA HARBOR TO KALAMA BEACH PARK

### GENERAL COASTAL CHARACTERISTICS

This seven and one half mile long coastal sector extends from Maalaea Harbor in the north to Kaluaehakoko Point in the south. At one time, a continuous sand beach probably lined the coast. today, however, the beach has been eroded away along the 2400 feet of coast to the east of Maalaea Harbor, and along the 1 mile of coast north of Kaluaehakoko. Shore protection structures are continuous throughout these areas. significant beach erosion is occurring throughout much of the rest of the sector.

The beach in the northern half of the sector, from the harbor to the remains of old Kihei Pier, is known as Maalaea Bay Beach. The beach is continuous and straight. Kealia Pond and other marshy areas occupy most of the backshore of Maalaea Bay Beach. Development has occurred only in the 2400 feet east of the harbor and the 2600 feet north of Kihei Pier. The stretch of beach between Palalau and Kihei Pier has been eroding steadily.

The beach in the southern half of the sector has undergone extensive modifications caused by both man-made structures and natural processes. Shore protection lines the southernmost mile of the sector, while groins have been built immediately north of the shore protection to check the severe erosion. By contrast, in the area of Kawililipoa, rapid accretion is occurring due to the convergency of longshore currents from the north and from the south.

The remains of three fishponds lie in the vicinity of Kalepolepo Beach and Kawililipoa. The most intact of the tree surrounds Kalepolepo Beach, creating a protected, safe swimming area.

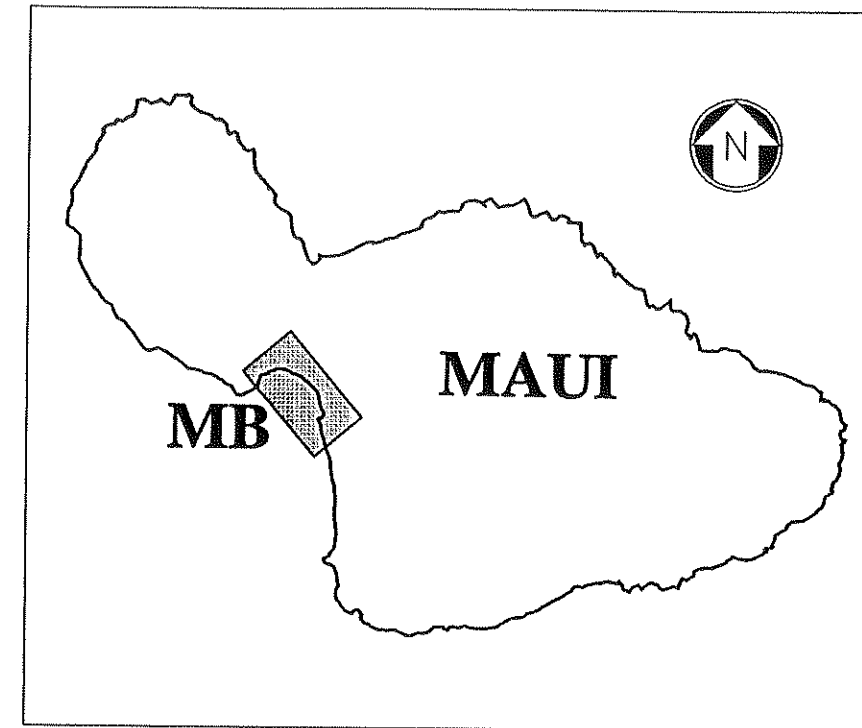
### LAND USE AND DEVELOPMENT

Land use and development differs in the northern and southern halves of the sector. In the norther half of the sector, the backshore has been develop[ed] and only along the 2500 feet of shoreline east of Maalaea Harbor, and along the 2600 feet north of Kihei Pier. Kealia Poind and marshy terrain occupy the 2.5 miles in between the developments. Three hundred acres of Kealia Pond are designated as a wildlife refuge. North Kihei Road runs between the pond and the ocean.

The resort community of Kihei occupies the backshore in the southern half of the sector. Land uses include resort hotels, condominiums, single family residences, two beach parks, and a state beach reserve. The two beach parks are Maipoina Oe Iau and Kalama. South of Koieie Fishpond, the landscaped lawns in front of several resort hotels are designated as a state beach reserve.

### WAVE CLIMATE

A fringing reef extends from Maipoina Oe Iau Beach Park through Kalama Beach Park, offering some protection from the open ocean waves. Nevertheless, the entire sector is subject to erosion damage during severe Kona storms. In addition to waves from the south or southwest, strong onshore winds and heavy rains frequently accompany these storms, and aggravate storm damage.



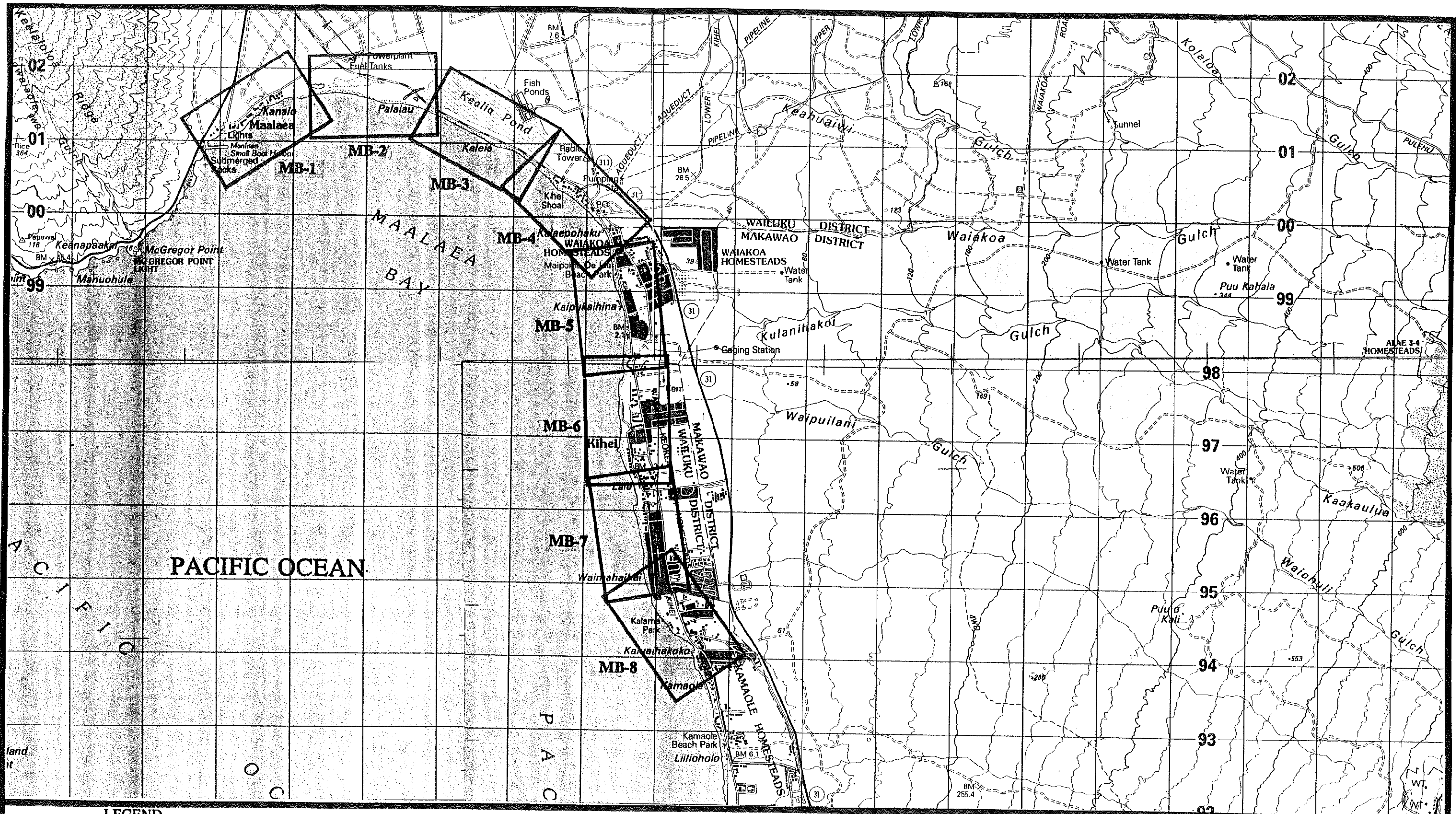
### SHORELINE PROCESSES

Although this sector represents a continuous stretch of coastline, the dominating shoreline processes vary along the coast. Following construction of Maalaea Boat Harbor in 1952, 1500 feet of narrow beach was lost to the east of the harbor. Shore protection now extends 2400 feet to the east of the harbor. The general trend on the rest of Maalaea Bay Beach has been erosion. The cause of the erosion is not known.

The shoreline changes along the southern half of the sector have been controlled by both man-made structures and natural processes. Erosion has been a significant problem. Initially, a 300 feet long revetment was constructed to protect the Kalama Beach Park area from erosion. The revetment aggravated erosion; the beach fronting the park was lost, and shore protection extends a further 2400 feet to the north. A groin has been built recently opposite Kapu Place to check the severe erosion to the north of the shore protection. Further to the north, at Kawililipoa, however, substantial accretion is occurring. This accretion is likely the result of a regional shift of longshore currents that has caused currents from the south and from the north to converge and deposit sand at Kawililipoa.

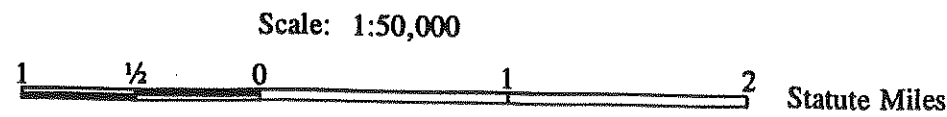
### BEACH USAGE

The beaches within this sector are not as favorable for recreational activities as many beaches on Maui. The beaches are characteristically narrow, subject to erosion and often lined with shore protection. Nevertheless, the presence of the homes, hotels and condominiums of the resort community of Kihei with this sector ensures heavy use of the beaches. Maipoina Oe Iau and Kalama Beach Parks, and the state beach reserve are all popular recreational spots.



**LEGEND**  
 HYDROGRAPHIC DATUM ..... MEAN LOWER LOW WATER

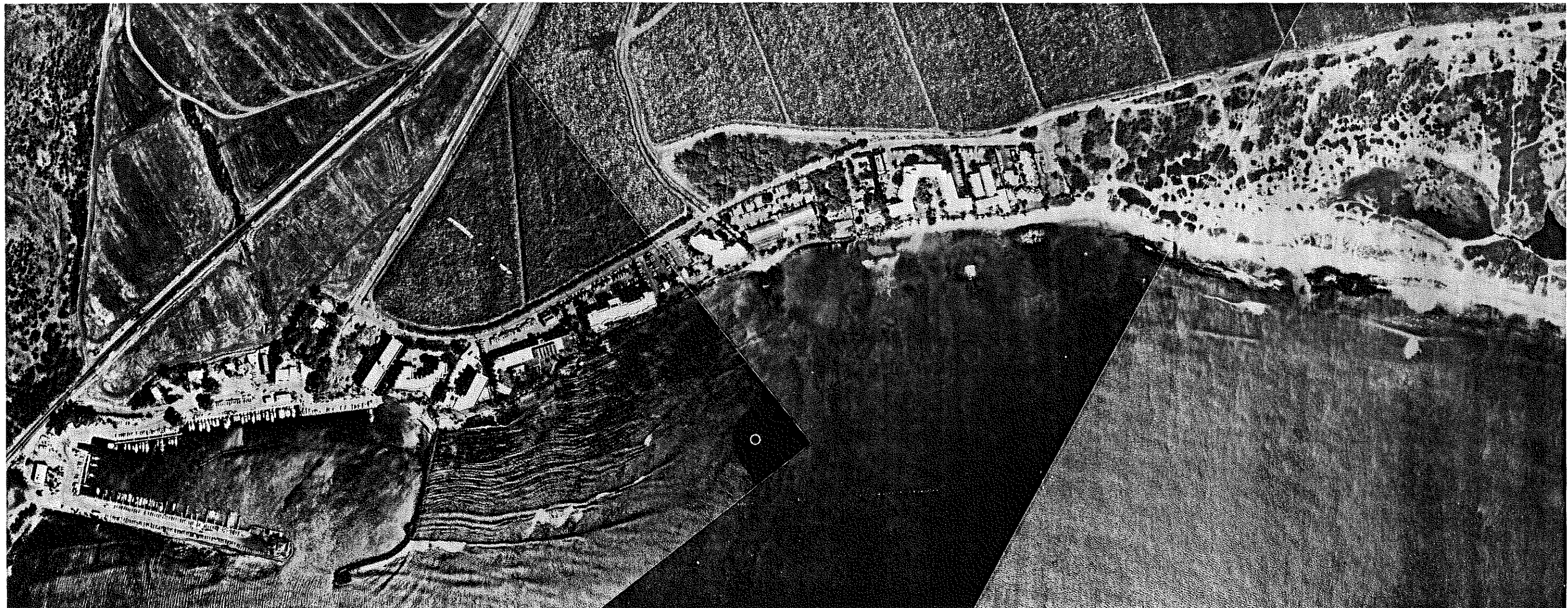
Depth curve (meters)	
Foreshore flats	
Rocks awash; Reef	
Wreck: Exposed, Sunken with masts exposed	
Wharf, pier	
Seawall	
Oil/gas rig	



From U.S. Geological Survey  
 MAP INFORMATION AS OF 1983



**SOUTHWEST MAUI**  
**Maalaea Harbor to Kalama Beach Park**



## MB-1: WEST MAALAEA BAY BEACH

### BEACH DESCRIPTION

- This subsector consists of Maalaea Harbor to the west and the westernmost reach Maalaea Bay Beach, which continues for 3½ miles to the east and south.
- Maalaea Harbor was built in 1952 and includes two breakwaters, a paved wharf, berthing facilities, a launching ramp, and a Coast Guard station.
- Large resorts or apartment complexes have been built along the 2500 feet of shoreline to the east of the boat harbor. Most of the beach in this area has been eroded and revetments have been built to protect property.
- The remaining 2000 feet of coast in this subsector consists of a straight, calcareous sand beach with an average width of 70 feet.

- The offshore fronting the developed area consists of a mixture of limestone rubble and sand, while the offshore fronting the sand beach is a massive rock surface with sand patches.

### BACKSHORE

- Six large, multi-story apartment or hotel buildings occupy the 2500 feet of backshore to the east of the harbor. Seawalls and revetments have been built to protect these properties.
- The backshore of the eastern 2000 feet of coast is undeveloped. Vegetated sand dunes mark the vegetation line, and a low-lying marshy area is located behind the dunes.

### SHORELINE HISTORY

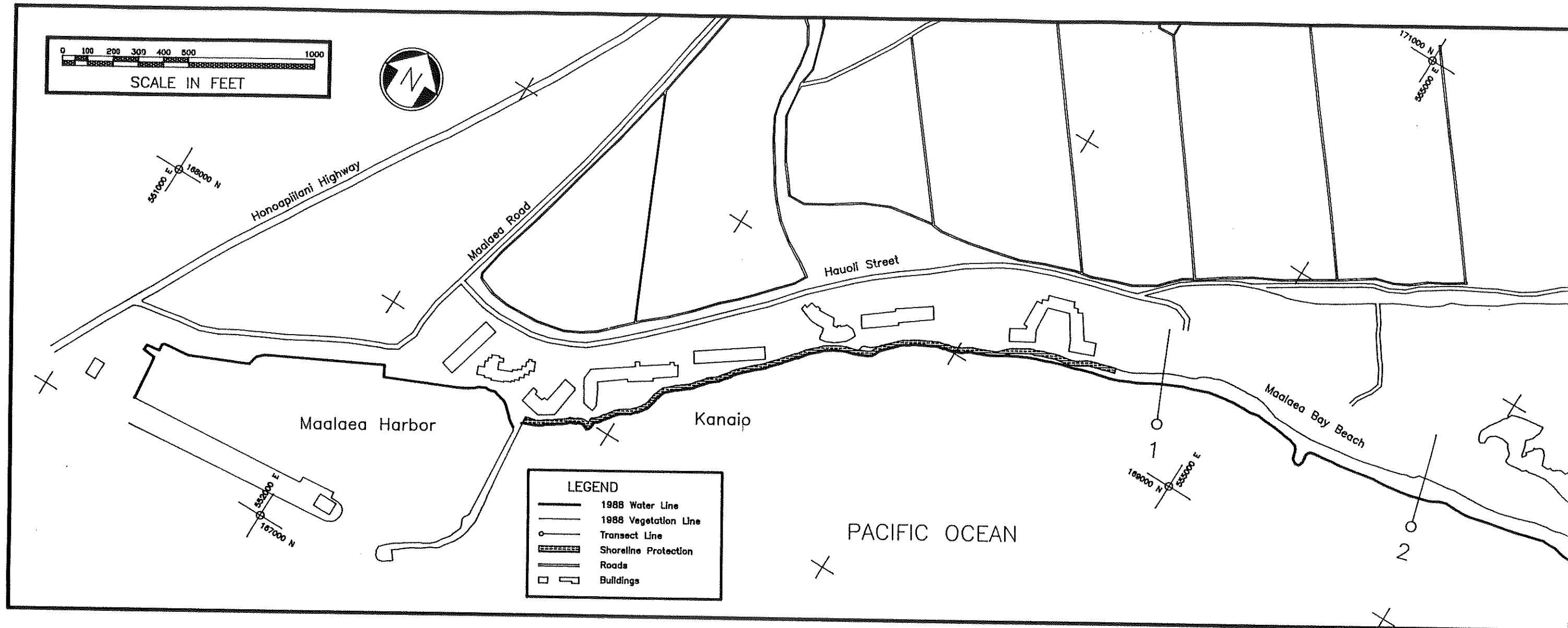
- Aerial photos from 1950 show a narrow beach, approximately 30 feet wide, along the 1500 feet of coast east of the Maalaea Harbor. The harbor was built in 1952. By 1964 this beach was eroded, and

shore protection now extends 2400 feet to the east of the harbor.

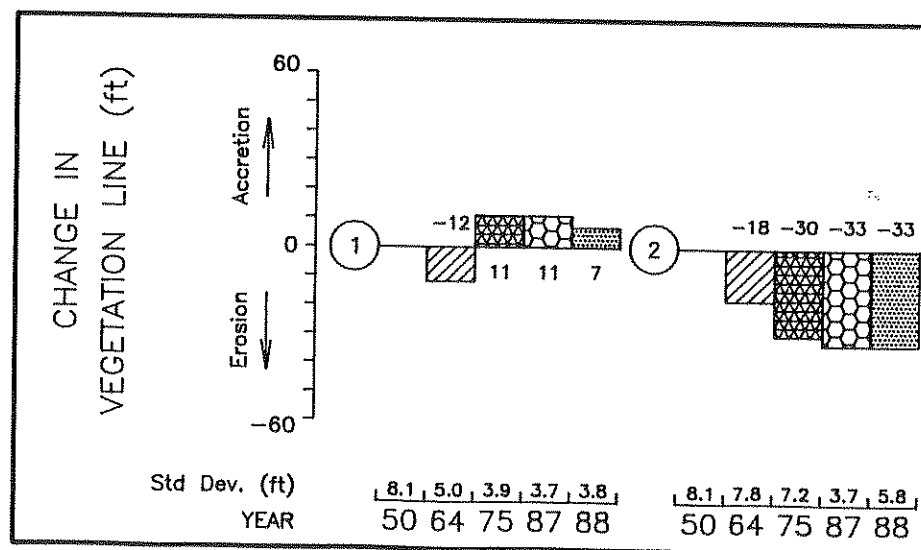
- Regions 1 and 2 show that in the undeveloped area in the eastern part of the subsector the beach was stable. The beach has accreted 7 feet in Region 1 and eroded 33 feet in Region 2 between 1950 and 1988. The vegetation line in both regions has remained stable since 1975, with a maximum change of only 4 feet in Region 2.

### SUMMARY

- Construction of the Maalaea Harbor in 1952 resulted in the loss of 1500 feet of narrow beach to the east of the harbor. Shore protection now extends 2400 feet to the east of the harbor.
- The beach in the eastern part of the subsector has been stable. Maximum net change in the vegetation lines since 1975 in Regions 1 and 2 was 4 feet.

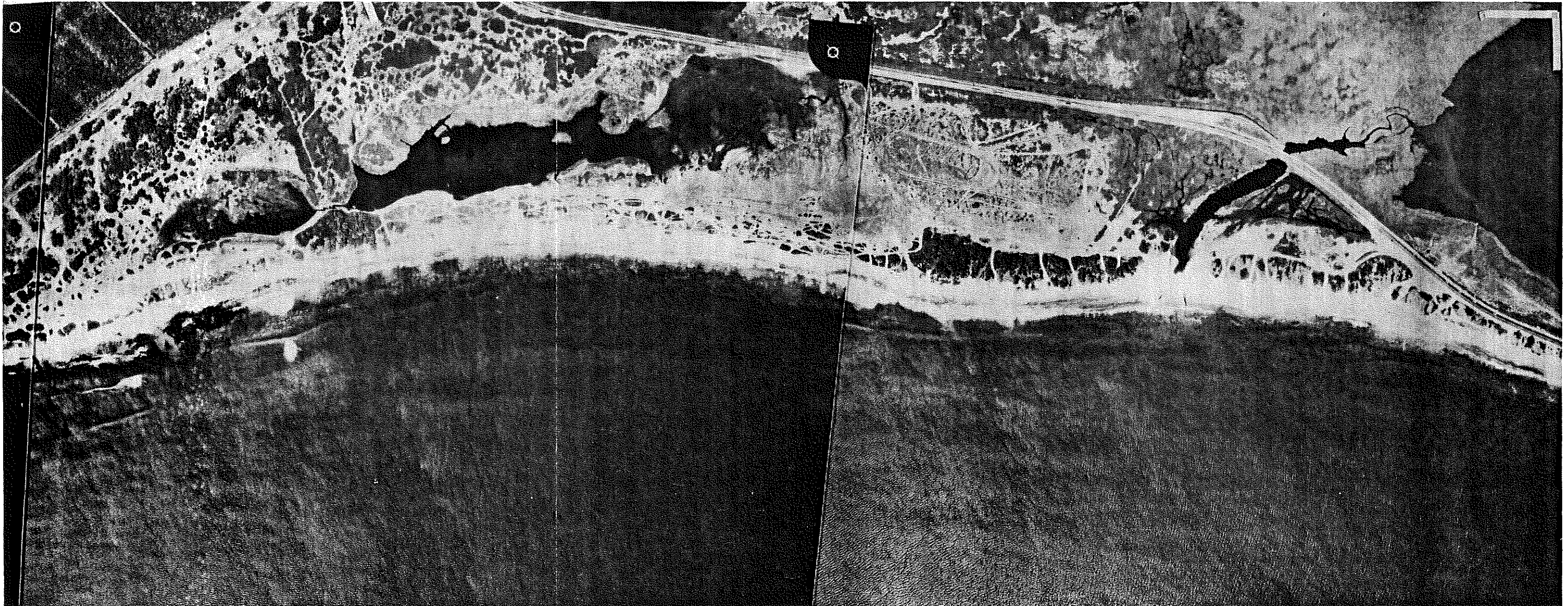


**FIGURE MB-1**



**GRAPH MB-1 Region Number vs Change in Vegetation Line**

**PHOTOS USED**  
 March 1988  
 July 1987  
 March 1975  
 June 1964  
 February 1950



## MB-2: MAALAEA BAY BEACH - PALALAU

### BEACH DESCRIPTION

- Maalaea Bay Beach is continuous through this subsector, interrupted only by two narrow jetties at Palalau that stabilize a drainage outlet from Kealia Pond. The beach is straight, calcareous, and has a typical width of 60 to 80 feet.
- The offshore is a mixture of sandy bottom, and rock bottom with sand pockets.
- Beach rock is exposed at the waterline in the western reach of the subsector.

### BACKSHORE

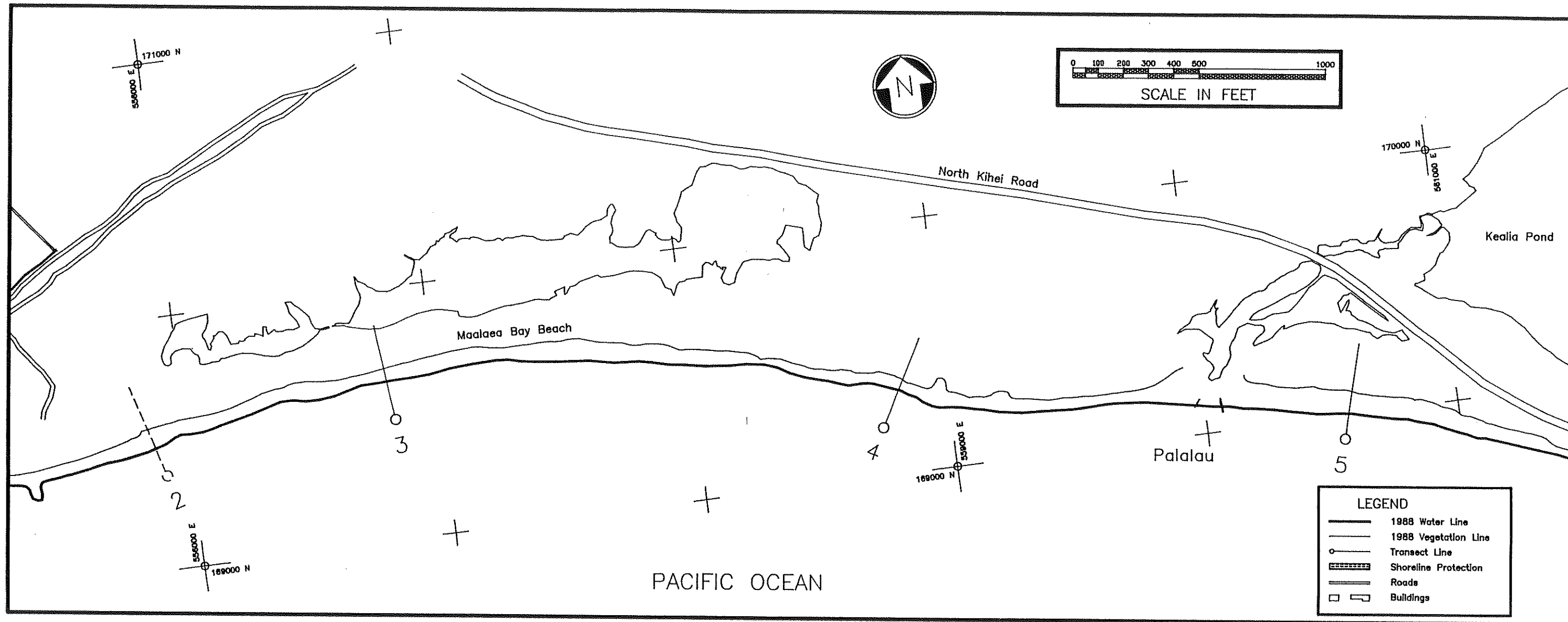
- The backshore of this entire area is undeveloped. Vegetated sand dunes and trees mark the vegetation line. A shallow, seasonal pond that is an important bird habitat is located two hundred feet further inland in the western half of the subsector.

### SHORELINE HISTORY

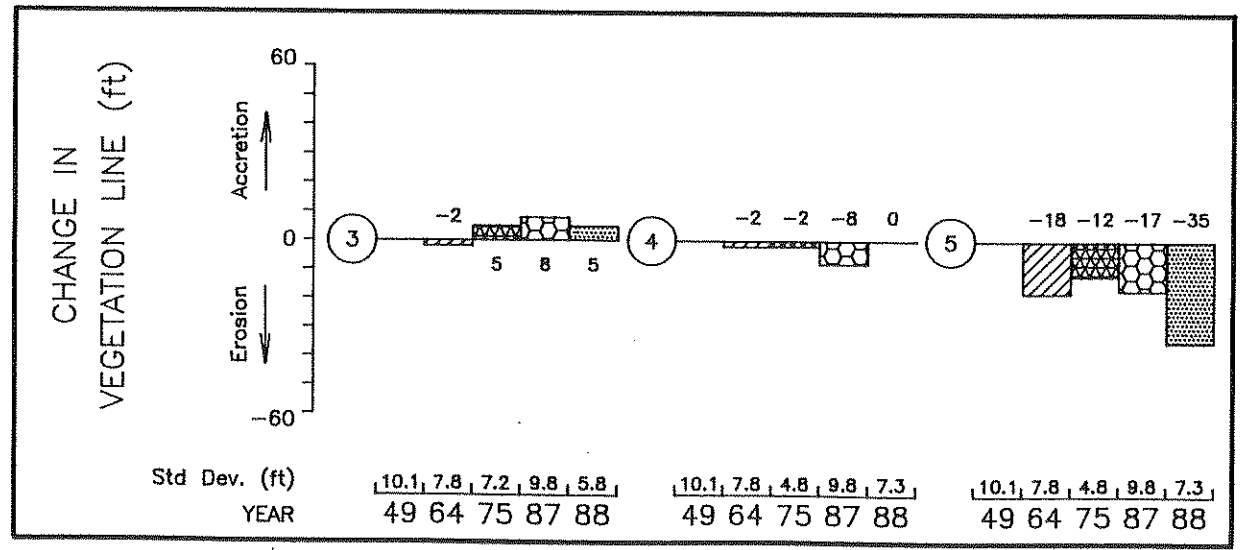
- The beach area to the west of Palalau has been stable. In Region 3 there was net accretion of 5 feet, while in Region 4 there was no net change between 1949 and 1988.
- East of the drainage outlet at Palalau, the beach has been eroding steadily; the 1988 vegetation line has eroded 35 feet relative to the 1949 vegetation line.

### SUMMARY

- The beach west of Palalau has been stable.
- East of Palalau, the beach has eroded steadily.
- There is no backshore development in this subsector.

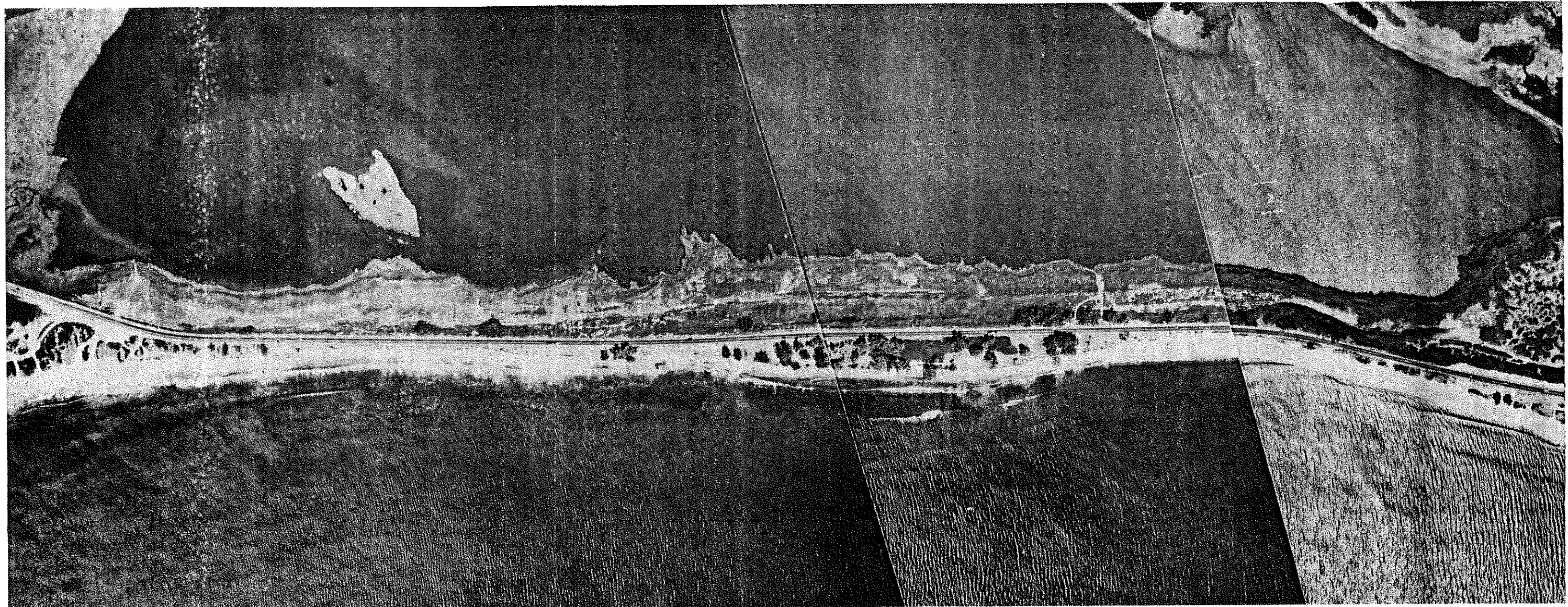


**FIGURE MB-2**



**GRAPH MB-2 Region Number vs Change in Vegetation Line**

**PHOTOS USED**  
 March 1988  
 July 1987  
 March 1975  
 June 1964  
 November 1949



### MB-3: MAALAEA BAY BEACH - KEALIA POND

#### BEACH DESCRIPTION

- Maalaea Beach extends continuously through this subsector as a barrier beach separating Kealia Pond from the ocean. The beach is only 40 feet wide throughout most of the subsector; it widens to 100 feet at the eastern end of Kealia Pond.
- The offshore consists of a rock bottom with sand pockets, grading into predominantly sand 600 feet offshore.

#### BACKSHORE

- In 1953, 300 acres of Kealia Pond, which occupies most of the backshore, were designated as a wildlife refuge. The area has, therefore, remained undeveloped. The southern shoreline of Kealia Pond is approximately 300 feet from the ocean.

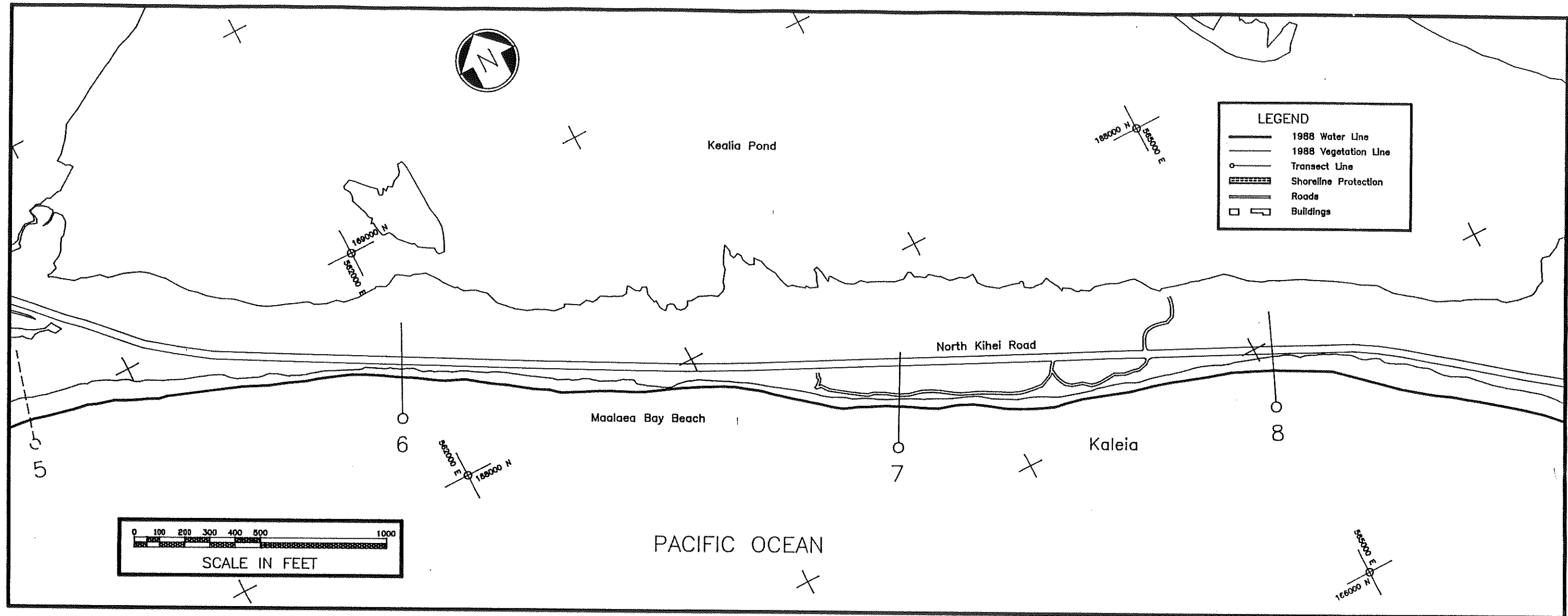
- North Kihei Road lies between the pond and the beach. Toward the west and east ends of the pond, the road is within 50 feet of the ocean waterline.

#### SHORELINE HISTORY

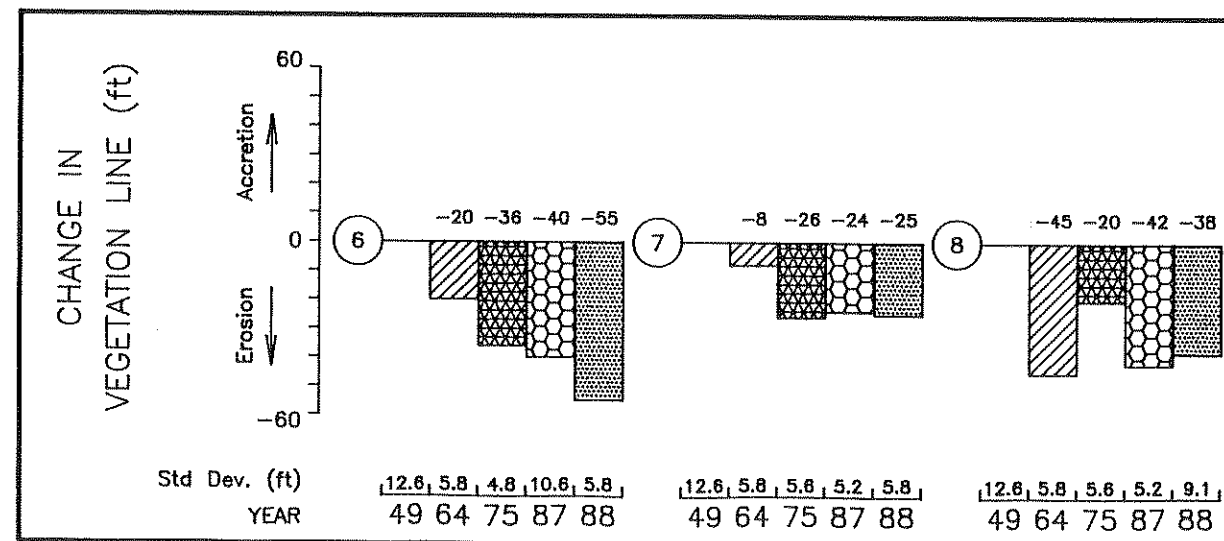
- The entire length of Maalaea Beach within this subsector has been eroding since 1949. Net erosion between 1949 and 1988 ranged from 25 to 55 feet in Regions 6, 7, and 8. The waterline in 1988 was landward of the vegetation line in 1949 along several sections of the beach.
- Oblique aerial photos show erosional scarps in the beach near the western and eastern ends of Kealia Pond. At the west end of the pond, the water is only 20 to 25 feet from the road. Trees lining the road near Region 6 are being undermined by wave action; roots are exposed and hanging above the sand, and trees are beginning to fall into the beach. Additional erosion in these areas could damage North Kihei Road.

#### SUMMARY

- The entire length of Maalaea Beach along Kealia Pond has eroded.
- Net erosion between 1949 and 1988 ranged from 25 to 55 feet.
- Continued erosion could damage North Kihei Road near Region 6, where trees lining the road are already being undercut by waves.



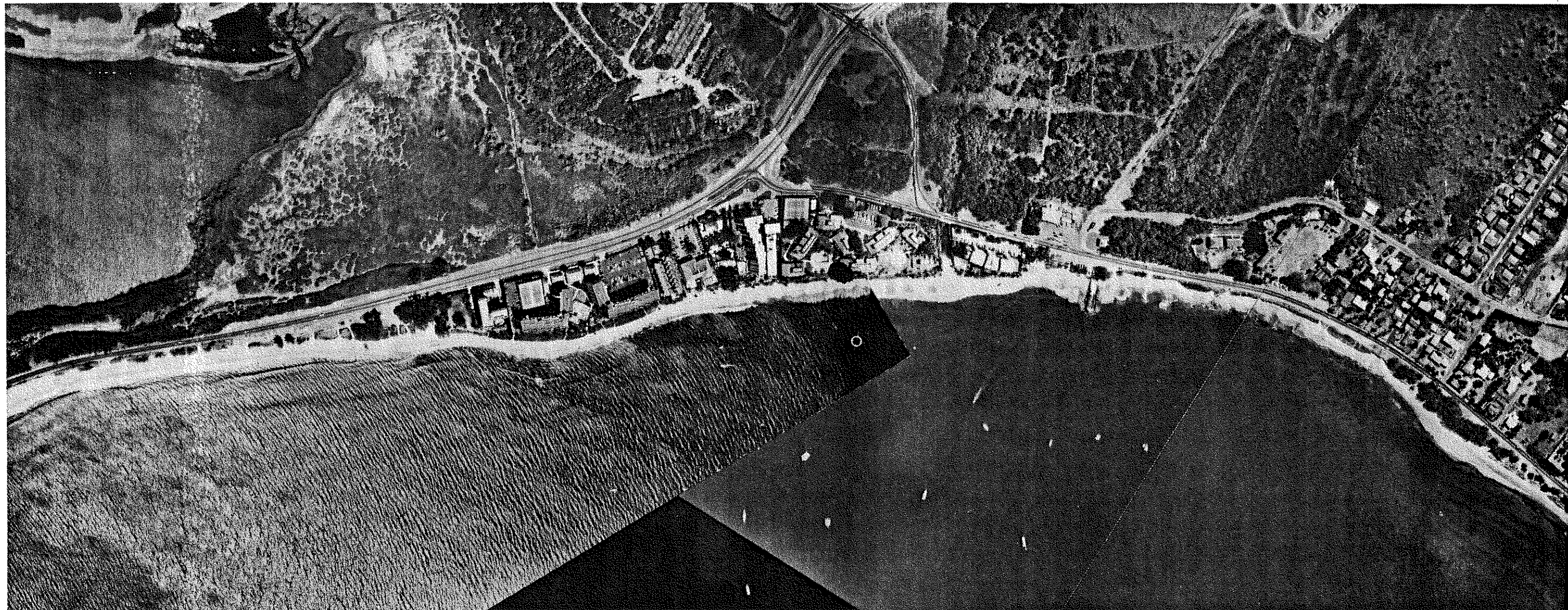
**FIGURE MB-3**



**GRAPH MB-3 Region Number vs Change in Vegetation Line**

**PHOTOS USED**  
 March 1988  
 July 1987  
 March 1975  
 June 1964  
 November 1949





#### MB-4: SOUTH MAALAEA BAY - KIHEI

##### BEACH DESCRIPTION

- The beach in this subsector is an extension of the calcareous, white sand beach of preceding subsectors. Typical widths of the beach narrow from 70 feet in the north to 40 feet in the south.
- The rubblemound remains of Kihei Pier are located in the southern half of the subsector, which is known as Kalaepohaku. The northern half of the subsector is the end of Maalaea Bay Beach.
- The offshore is primarily sandy, except for 600 feet of reef in front of the Sugar Beach Resort Hotel. The shore behind the reef is more protected and, therefore, protrudes slightly seaward.

##### BACKSHORE

- The northern end of this subsector is within the Kealia Pond area, and is undeveloped.
- Seven large resort hotels have been constructed along the 2600 feet of coast north of Kihei Pier. Many of these resorts are within 50 feet of the vegetation line.
- The backshore south of the pier, the Kalaepohaku area, is occupied by South Kihei Road, which parallels the coast occasionally within

60 feet of the waterline. Private residences are located landward of the road.

##### SHORELINE HISTORY

- Beach history has not been consistent throughout this subsector.
- Region 9 has been dynamic; the beach was eroded 45 feet in 1964, but has since accreted. Net erosion between 1949 and 1988 was 17 feet.
- Net accretion of 37 feet has occurred in Region 10. Despite the accretionary trend, shore protection structures have been constructed. This is because the resort hotels were constructed in the dynamic zone of the beach, seaward of the 1949 vegetation line. They are, therefore, subject to erosion damage.
- Region 11 has been relatively stable. The vegetation line accreted 8 feet between 1949 and 1975, and was unchanged between 1975 and 1988.
- Extensive accretion of sand was reported in the early 1900's around Kihei Pier. Evidence of this accretion was not visible in the aerial photos used in this study. Conversely, along the 60 feet of coast

immediately south of Kihei Pier, severe erosion is occurring. A two foot high scarp has been cut into the vegetation. Trees are being undermined and are falling onto the beach. The road is only 15 to 20 feet from the scarp and will be threatened if erosion continues.

##### SUMMARY

- This subsector contains dynamic, accreting and stable regions.
- Region 9 is dynamic, with net erosion of 17 feet. The vegetation line in Region 10 accreted 37 feet between 1949 and 1988. Region 11 has been stable, with net accretion of 8 feet, and no net change since 1975.
- Many of the resort hotels north of Kihei Pier, and the road south of the pier are within 50 feet of the vegetation line. This subsector, therefore, is a potential problem area.
- Erosion is severe just south of Kihei Pier and could threaten the road.

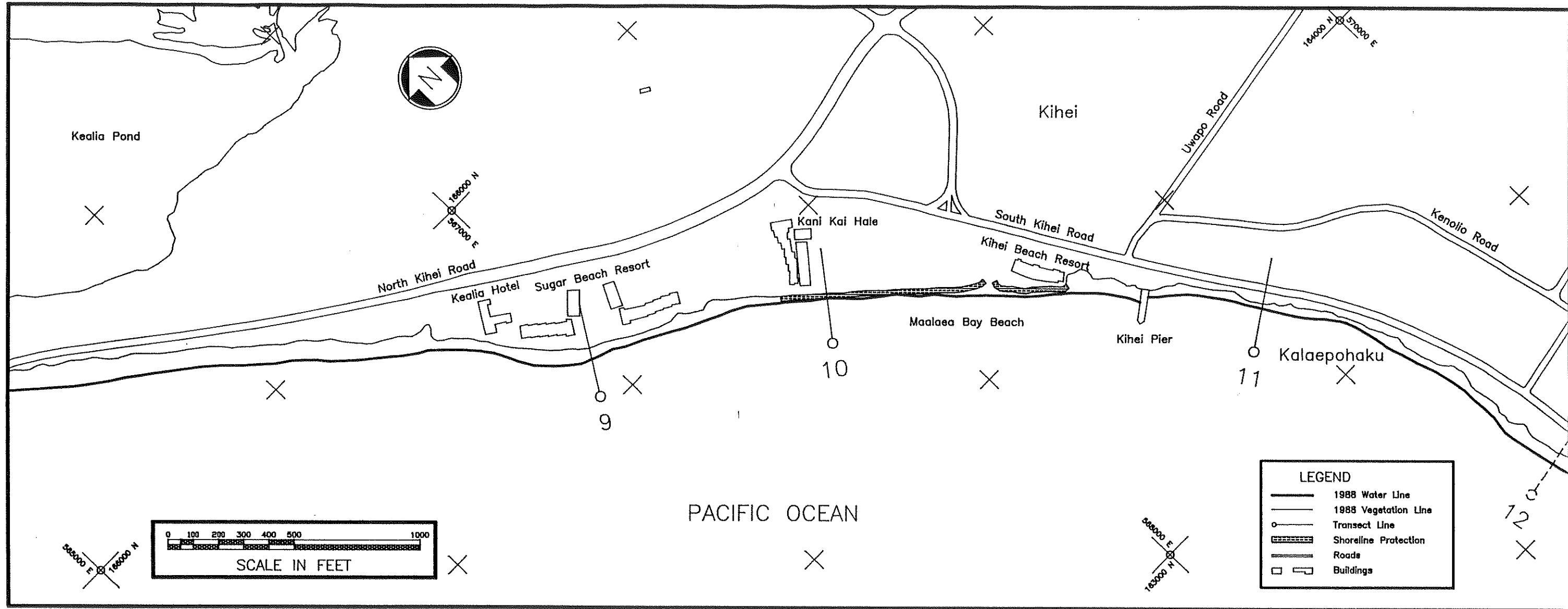
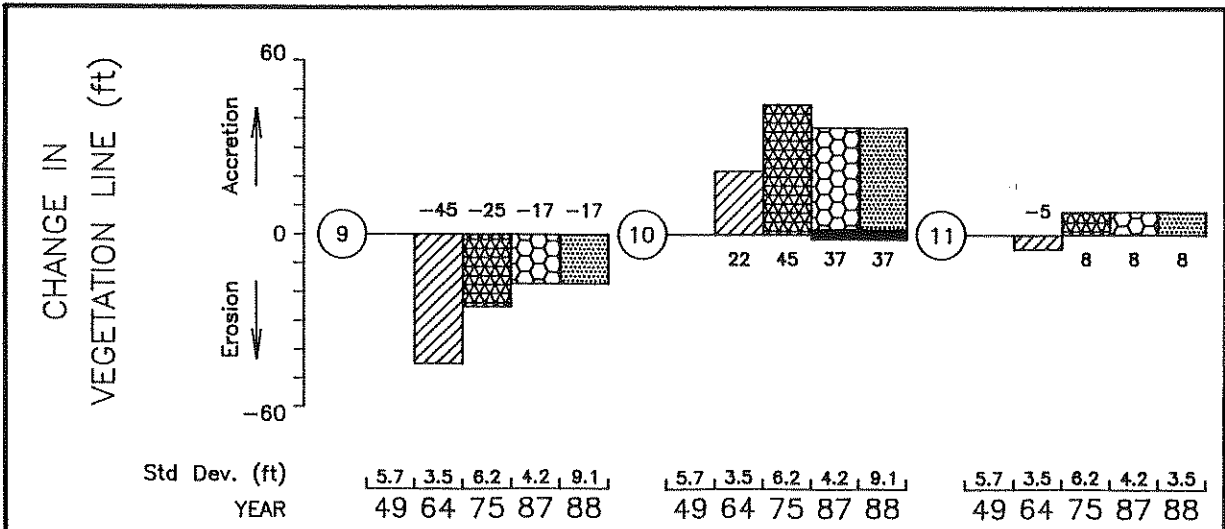
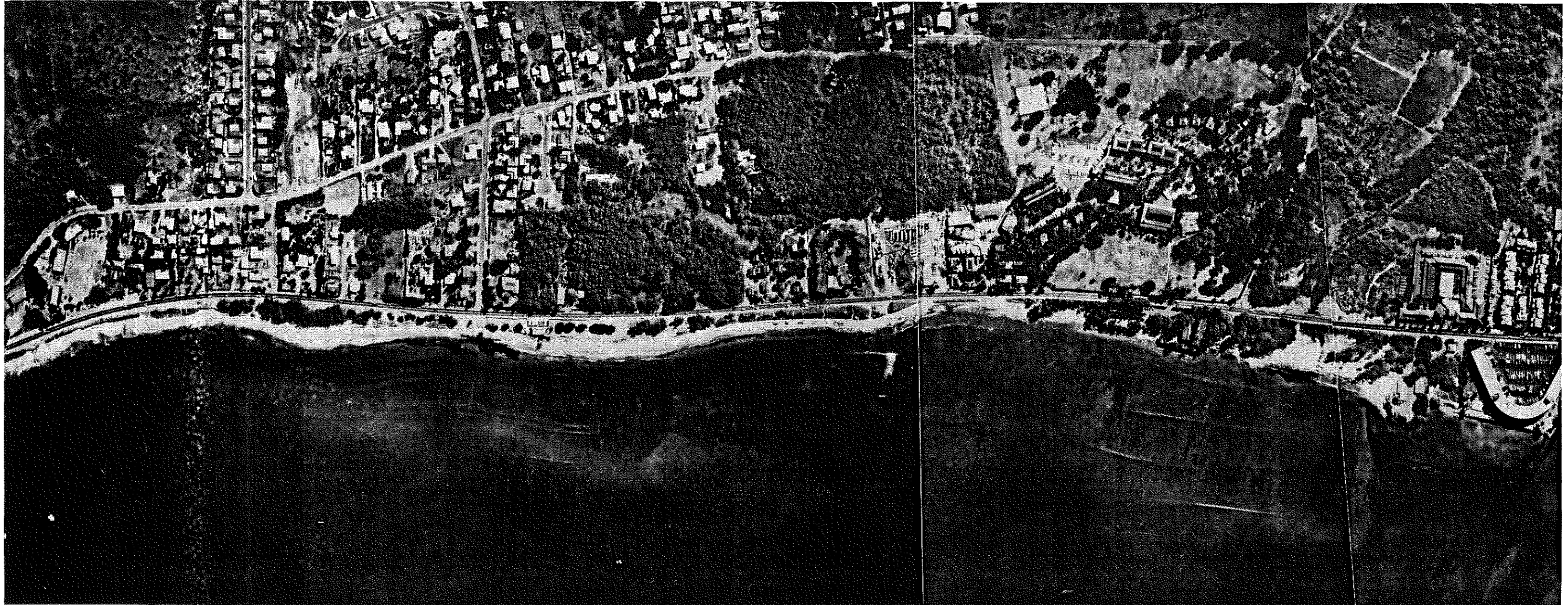


FIGURE MB-4



GRAPH MB-4 Region Number vs Change in Vegetation Line

PHOTOS USED  
 March 1988  
 July 1987  
 March 1975  
 June 1964  
 November 1949



**MB-5: MAIPOINA OE IAU BEACH PARK TO KULANIHAKOI GULCH**

**BEACH DESCRIPTION**

- The beach in this subsector is part of the continuous white sand beach that extends west around the bay to Maalaea Harbor. The narrowing trend evident in the preceding subsector continues through this area; the beach width is often less than 40 feet.
- A fringing reef 500 to 600 feet wide begins at the north end of the beach park and continues south to Kalama Beach Park.

**BACKSHORE**

- Maipoina Oe Iau Beach Park comprises the backshore of the northern two thirds of the subsector. The beach fronting the park varies in width from 30 to 70 feet. Facilities include restrooms, showers, picnic tables and a paved parking lot. The southern end of the park is marked by a statue of George Vancouver, which is protected from erosion damage by a revetment.

- South Kihei Road parallels the coast 20 to 100 feet from the waterline.
- The Koa Lagoon and Maui Lu Hotels occupy the backshore immediately north of Kulanihakoi Gulch.

**SHORELINE HISTORY**

- This subsector has experienced steady erosion since 1949. Regions 12 to 14 indicate that there has been steady erosion throughout the subsector. Net erosion between 1949 and 1988 ranged from 25 to 30 feet.
- In the southern end of the subsector, four revetments have been constructed to protect the road, a monument, and buildings.
- The revetment protecting the road was constructed in 1964. The 1964 aerial photos show that houses constructed where the hotels are presently located were already threatened by erosion.

- Although a protective, fringing reef is present offshore, the road and buildings have been subject to erosion damage because they were constructed too close to the water.
- The oblique aerial photos show that erosion is continuing north of Kulanihakoi Gulch, south of the revetment. A scarp has been cut into the vegetation line exposing roots and causing trees to fall into the beach.

**SUMMARY**

- The beach in this subsector has undergone steady erosion. Net erosion between 1949 and 1988 ranged from 25 to 30 feet.
- South Kihei Road and buildings constructed seaward of the road are often within 30 feet of the waterline and, therefore, threatened by erosion.

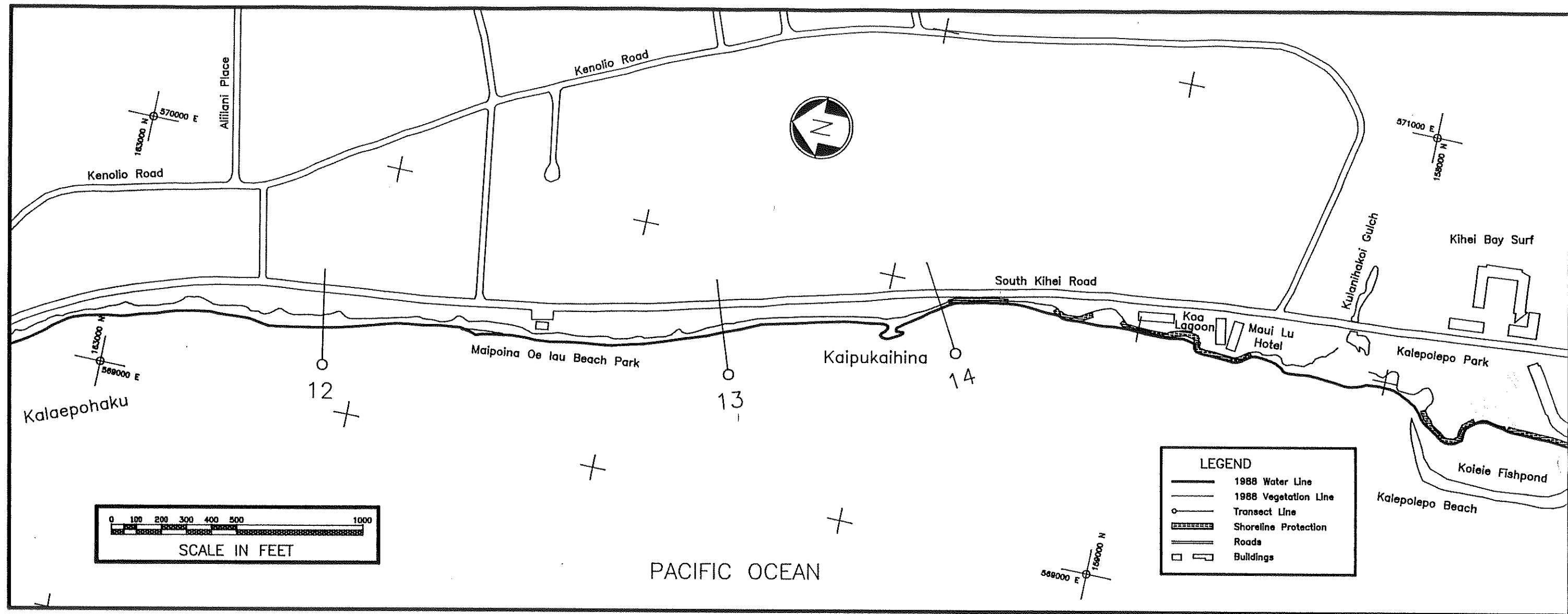
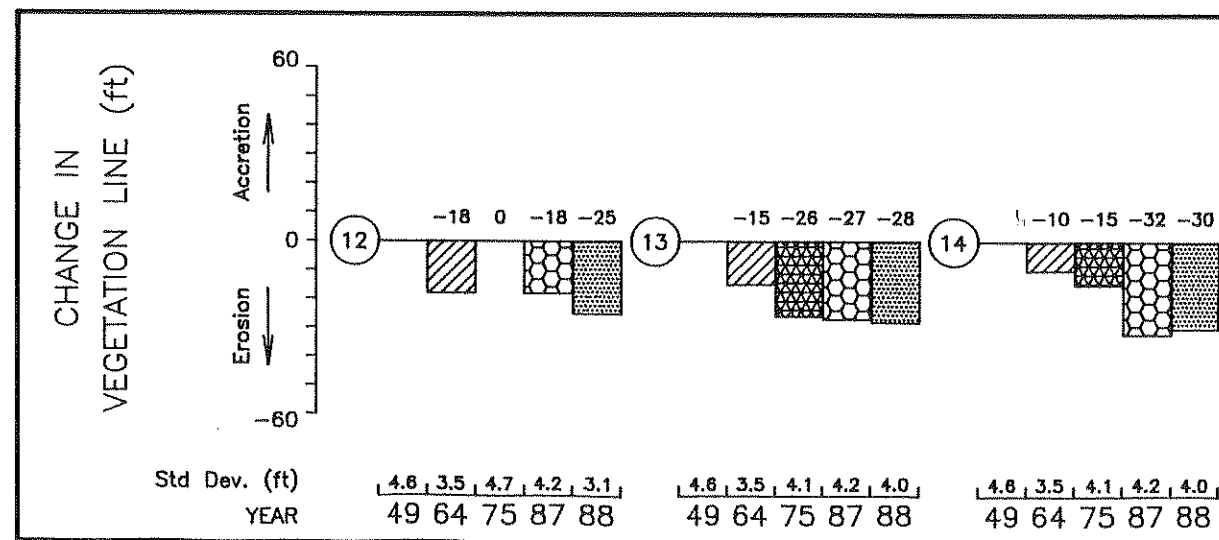
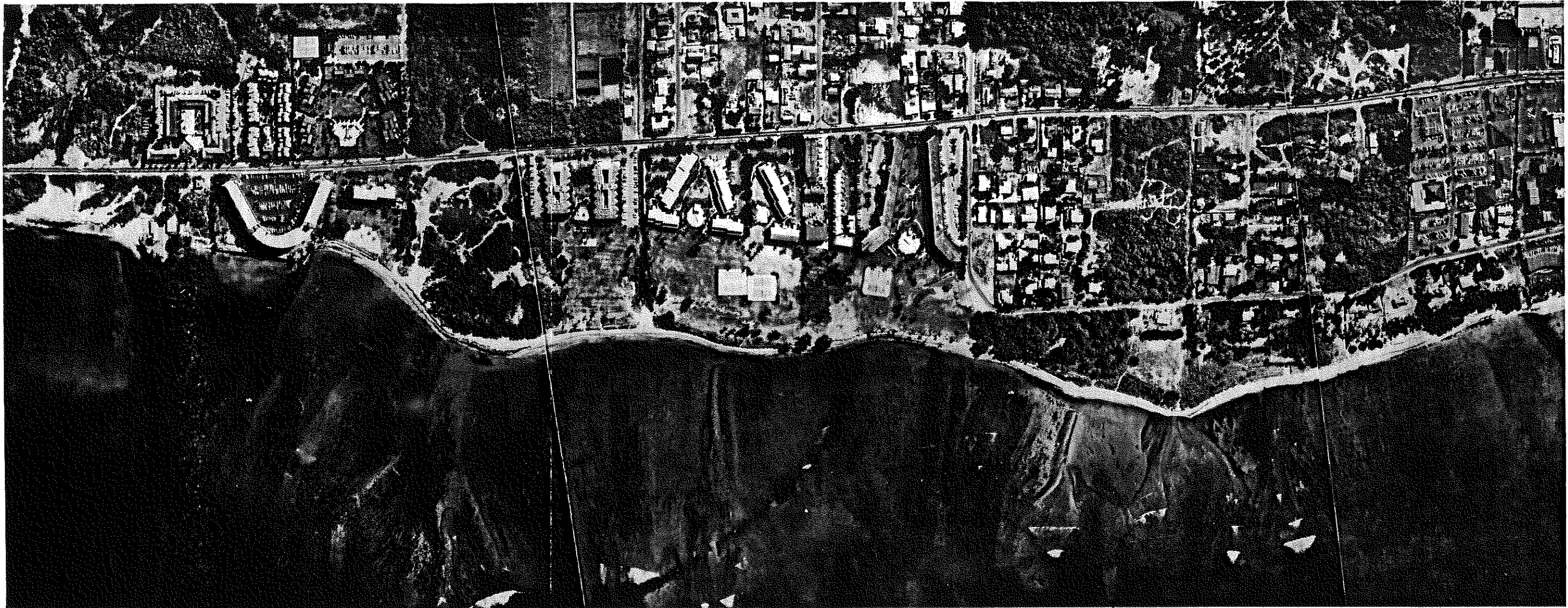


FIGURE MB-5



GRAPH MB-5 Region Number vs Change in Vegetation Line

PHOTOS USED  
 March 1988  
 July 1987  
 March 1975  
 June 1964  
 November 1949



**MB-6: KALEPOLEPO BEACH TO KAWILILIPOA**

**BEACH DESCRIPTION**

- This subsector consists of a stretch of coast, from Kalepolepo Beach to Kawililipoa, that has undergone dramatic changes since 1949. Some reaches have eroded substantially, while others have accreted substantially. The beach today is narrow, 30 to 40 feet wide, and sinuous. The remains of two fishponds are located in the northern half of the subsector, only one of which is shown on the map.
- A shallow reef at least 1000 feet wide is situated offshore.

**BACKSHORE**

- Large resorts or apartment complexes occupy the backshore north of Waipuilani Road. With the exception of the hotel built along the water in back of Koieie Fishpond, these resorts have been built a minimum of 300 feet inland of the waterline. The land backing the beach has been designated as a state beach reserve. Access to this area is along Waipuilani Gulch.

- South of Waipuilani Road, the backshore is occupied by private residences.

**SHORELINE HISTORY**

- The beach in this subsector has experienced dramatic changes since 1949. From 1949 to 1988, the beach has accreted 115 feet, eroded 92 feet, and accreted 284 feet in Regions 15, 16 and 17 respectively.
- These changes are likely due to a regional shift in longshore currents that has caused currents from the south and from the north to converge and deposit sand around Region 17.
- Erosion in Region 16 has cut a scarp into the vegetation, exposing roots and undercutting trees. The erosion, however, is not causing problems because the backshore is a grassy lawn of the state beach preserve.

- The steady nature of the erosion and accretion indicates that the beach is still responding to the shift in currents, and has not reached a stable, equilibrium state.

**SUMMARY**

- The beach in this subsector has changed dramatically since 1949. In Regions 15 to 17 it has accreted 115 feet, eroded 92 feet, and accreted 284 feet.
- The large resort hotels are located over 300 feet from the beach, and thus are not threatened by the erosion in Region 16.

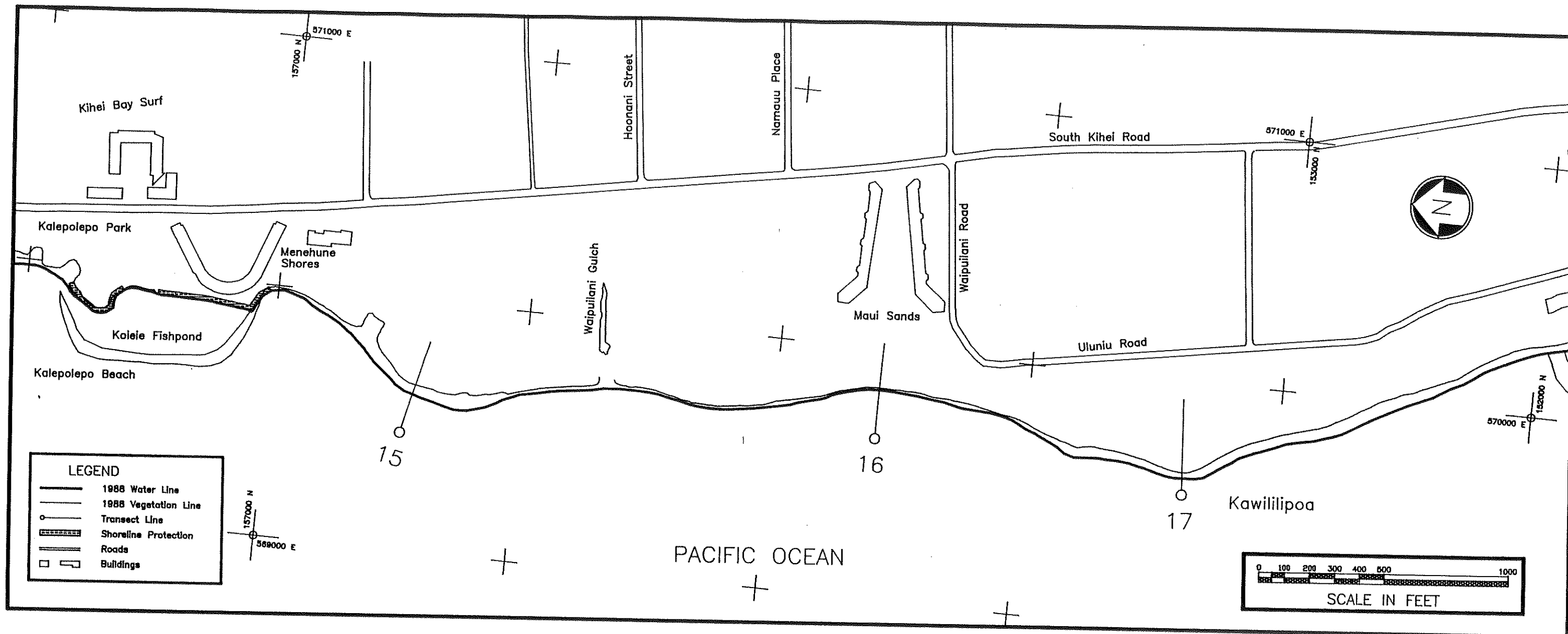
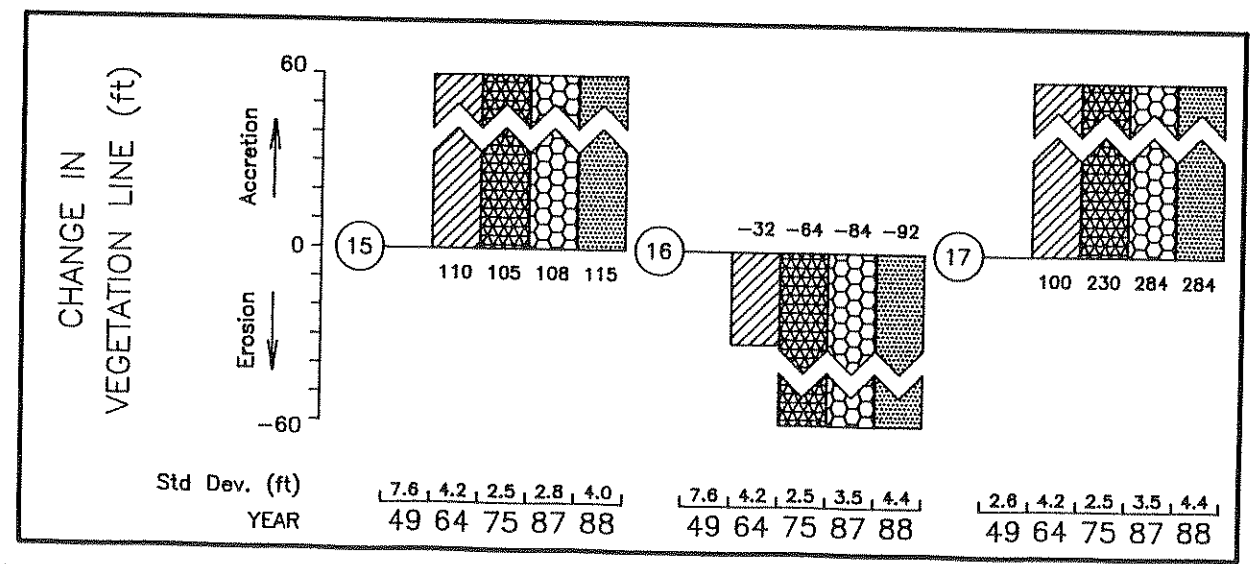
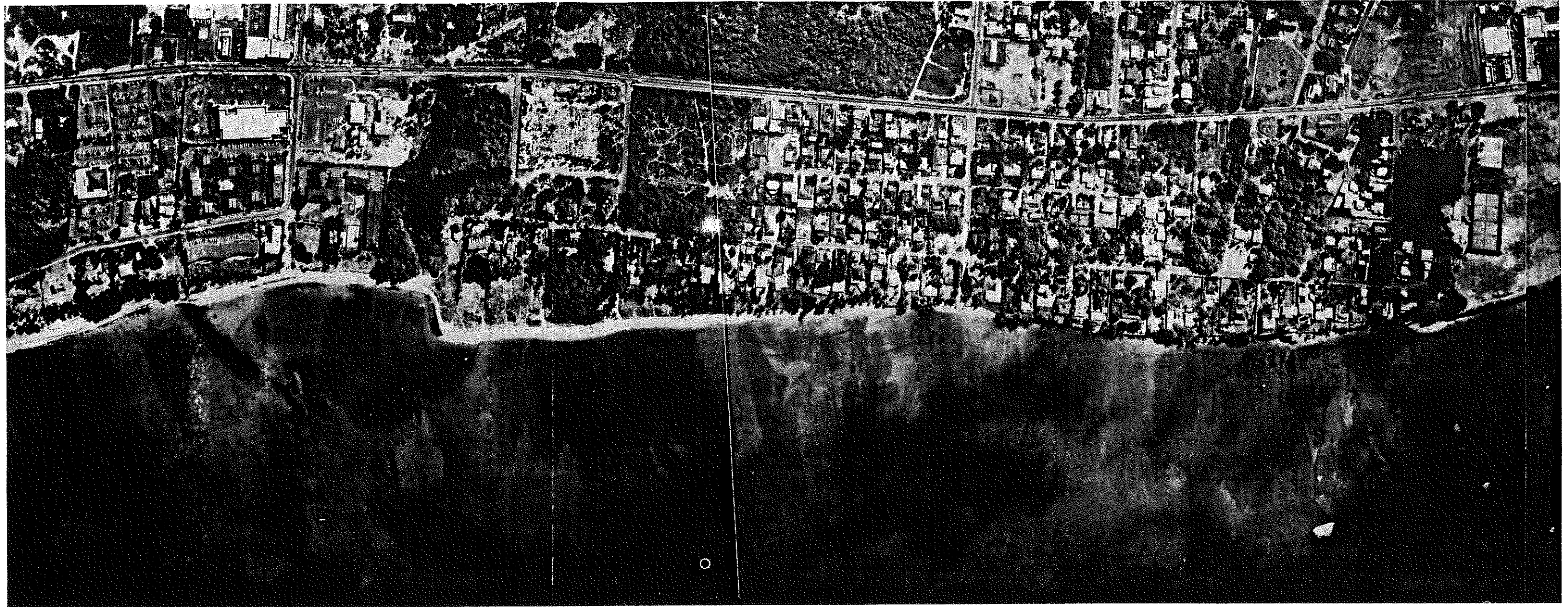


FIGURE MB-6



GRAPH MB-6 Region Number vs Change in Vegetation Line

PHOTOS USED  
 March 1988  
 July 1987  
 March 1975  
 June 1964  
 November 1949



## MB-7: LIPOA STREET TO WAIMAHAIHAI STREET

### BEACH DESCRIPTION

- The beach in this subsector extends from the remains of the fishpond in front of Lipoa Street to approximately 300 feet north of Welakahao Road.
- Shore protection structures were constructed along the entire southern half of the subsector during the 1970's following steady erosion. There is no longer a beach in this area.

### BACKSHORE

- Private residences occupy the entire backshore of this area, with the exception of two resorts in the backshore behind the fishpond ruins.

### SHORELINE HISTORY

- The history of the beach in this subsector has been controlled by

man-made coastal structures. A groin was constructed prior to 1964, at the south end of the fishpond ruins to block the northward transport of sand and build out the beach to the south. The beach therefore accreted 120 feet in Region 19. Sand supply to Region 18, however, was blocked and the beach eroded 60 feet.

- In Region 21, the vegetation line eroded 20 feet from 1949 to 1964. Revetments and seawalls were then constructed in the early 1970's to protect homes from further erosion.
- The beach in Region 20 has been affected by both the groin to the north and the shore protection to the south. Between 1949 and 1975 the beach accreted 18 feet because of sand accumulating behind the groin. Between 1975 and 1988, however, the beach has eroded 45 feet as a result of the revetments and seawalls to the south. Oblique aerial photos from June 1991 indicate the erosion is continuing along the 1000 feet of shore to the north of the shore protection. The photos show an active erosional scarp 1 to 2 feet high along which blocks of vegetated sand are peeling off into the beach swash.

A groin has been built recently opposite Kapu Place to check the severe erosion. More time is required to evaluate the full effects of the groin.

### SUMMARY

- The beach changes in this subsector are the direct result of man-made coastal structures.
- The construction of a groin within the fishpond ruins has caused beach accretion in Region 19, and beach erosion in Region 18.
- Seawalls and revetments protecting property in the southern half of the subsector have resulted in loss of the beach in this area, and severe erosion along the shore to the north of the structures.
- More recently, a groin has been constructed to halt the erosion around Region 20, north of the shore protection.

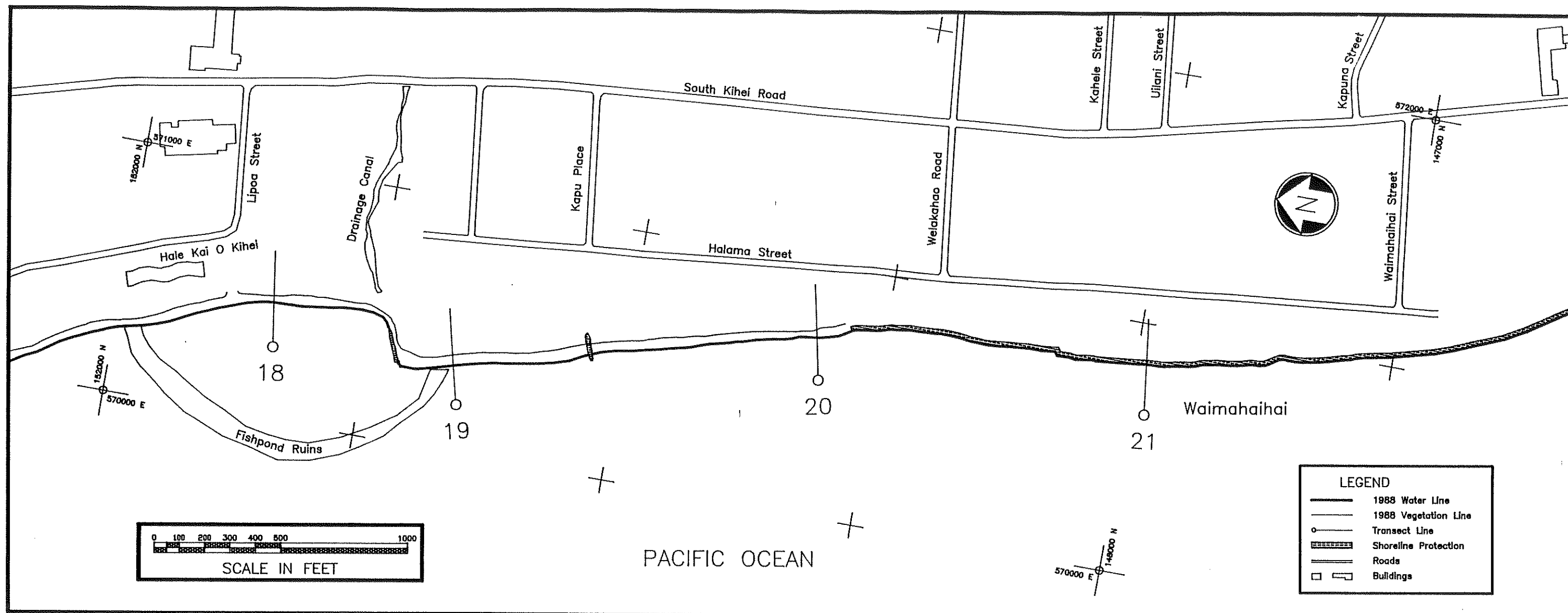
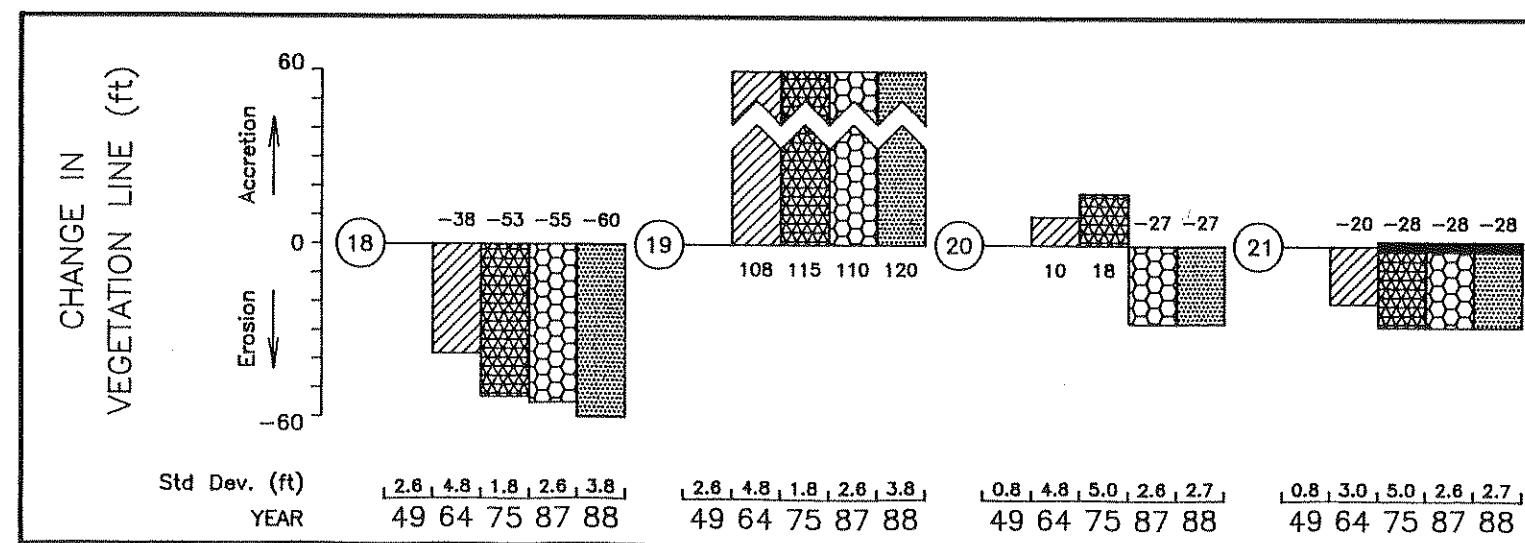


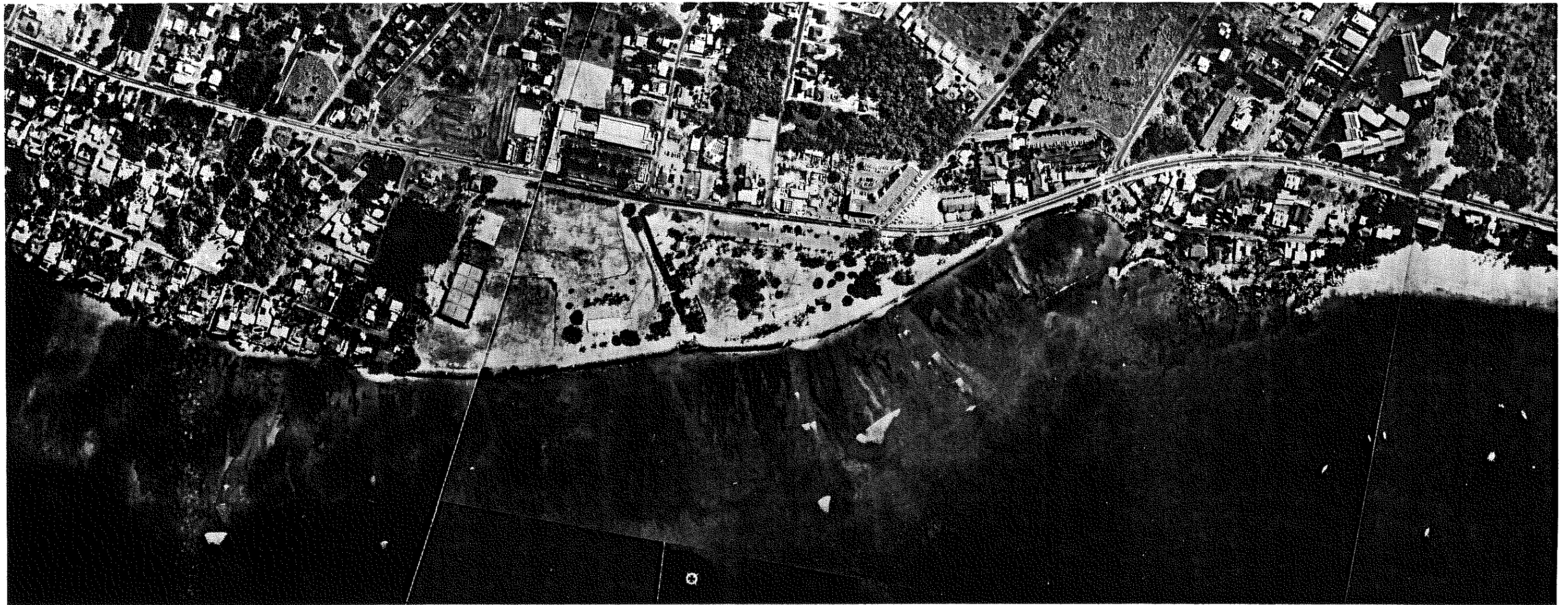
FIGURE MB-7



GRAPH MB-7 Region Number vs Change in Vegetation Line

PHOTOS USED  
 March 1988  
 July 1987  
 March 1975  
 June 1964  
 November 1949





## MB-8: KALAMA BEACH PARK

### BEACH DESCRIPTION

- This subsector consists of Kalama Beach Park. The beach to the south of Kaluaehakoko Point is included in sector MC of this study.
- There is no beach in front of Kalama Beach Park. In the early 1970's, a 3000 foot long revetment was constructed from the southern end of the park where South Kihei Road approaches the water, to the northern margin of the park. The revetment was built seaward of the berm and sloped to encourage accretion of sand. This has not happened, however, and the beach has been lost along the entire length of coastline.
- The offshore consists of a wide fringing reef that begins at Kaluaehakoko Point and continues north through Kihei.

### BACKSHORE

- The backshore in this subsector is occupied entirely by Kalama Beach Park. The park spans 36 acres and includes 12 pavilions, three restrooms, picnic facilities, athletic fields, tennis courts, basketball courts, and a paved parking lot.
- South Kihei Road approaches the water at the southern end of the park.
- Kaluaehakoko Boat Ramp was built in 1964 in the cove at the southern end of Kalama Beach Park.

### SHORELINE HISTORY

- The entire coast in this subsector experienced severe erosion before the shore protection structures were emplaced. Surveys conducted in 1912 and 1961 showed that the beach in front of Kalama Beach Park eroded 300 feet during this time interval.

- To protect against further erosion, a 3000 foot revetment was built in the early 1970's from the boat ramp at the southern end of the park to the northern margin of the park. Although the revetment was designed to encourage sand accretion, the beach has been lost since its construction. Furthermore, the revetment has caused additional erosion to the north; seawalls and revetments have been built to protect private residences in the 2400 feet of coast north of Kalama Beach Park.
- In Region 22, the beach eroded 35 feet between 1949 and 1964. The revetment was then constructed seaward of the beach face in the early 1970's.

### SUMMARY

- There is no beach in this subsector. A 3000 foot long revetment was built in the early 1970's to protect land from further erosion. The revetment has resulted in loss of the beach in the subsector, and continuing erosion problems further to the north.

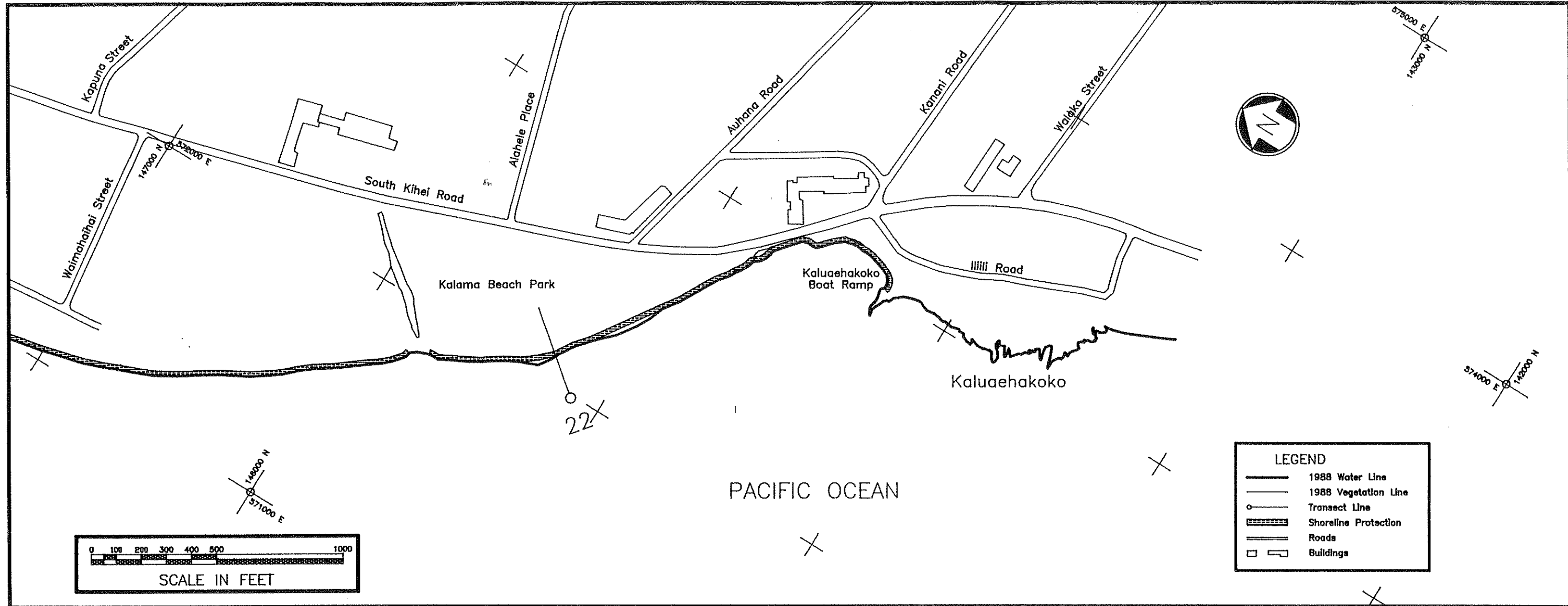
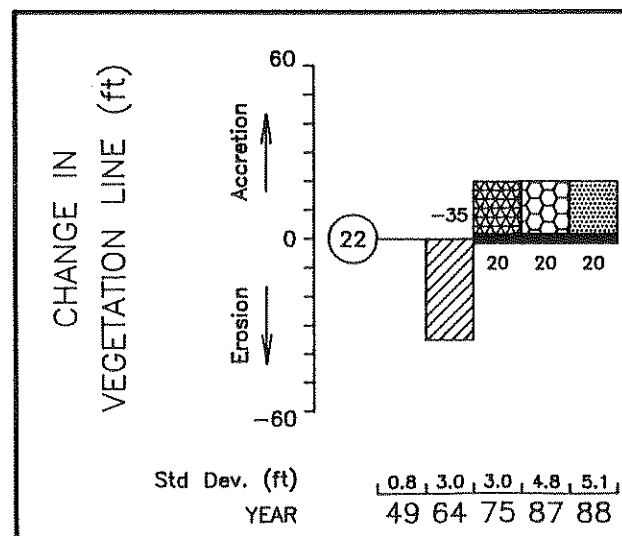


FIGURE MB-8



GRAPH MB-8 Region Number vs Change in Vegetation Line

PHOTOS USED  
 March 1988  
 July 1987  
 March 1975  
 June 1964  
 November 1949

**SECTOR MC:            SOUTHWEST MAUI  
                             KAMAOLE TO MAKENA**

**GENERAL COASTAL CHARACTERISTICS**

This five mile long sector stretches from Kamaole in the north to Nahuna Point in the south. The sector consists of 10 crescent-shaped, wide, calcareous sand beaches bounded by rocky headlands. From north to south these beaches and their lengths are Kamaole I (1800 feet), II (1200 feet) and III (900 feet), Keawakapu (3000 feet), Mokapu (800 feet), Ulua (800 feet), Wailea (1200 feet), Polo (800 feet), Palauea (800 feet), and Poolenalena (2400 feet). Typical widths of these beach are 75 to 150 feet.

**LAND USE AND DEVELOPMENT**

The backshore of this sector has undergone extensive development, and is now occupied by a mix of luxury resort hotels, condominiums and private residences. Three large resorts have recently been built or are being completed in the backshore of Wailea Beach and Polo Beach. The Four Seasons opened in 1990, while the Grand Hyatt and the Kea Lani are still under construction.

**WAVE CLIMATE**

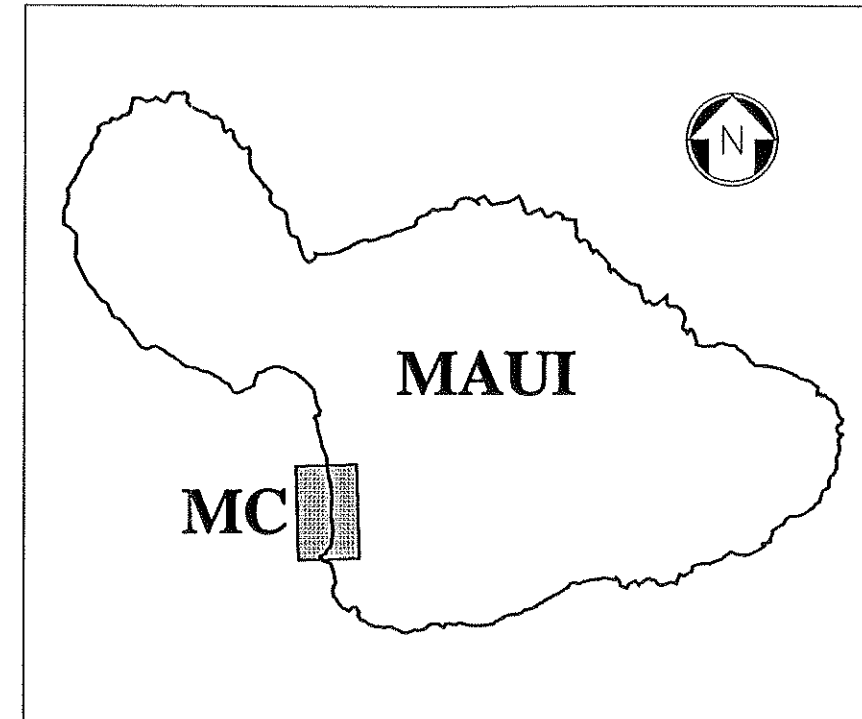
There is no fringing reef offshore in this sector. The beaches, therefore, are exposed to the full force of the incoming waves. Due to the orientation of the coastline and the protection afforded by the other islands, this sector is exposed only to south swell and Kona storm or hurricane waves.

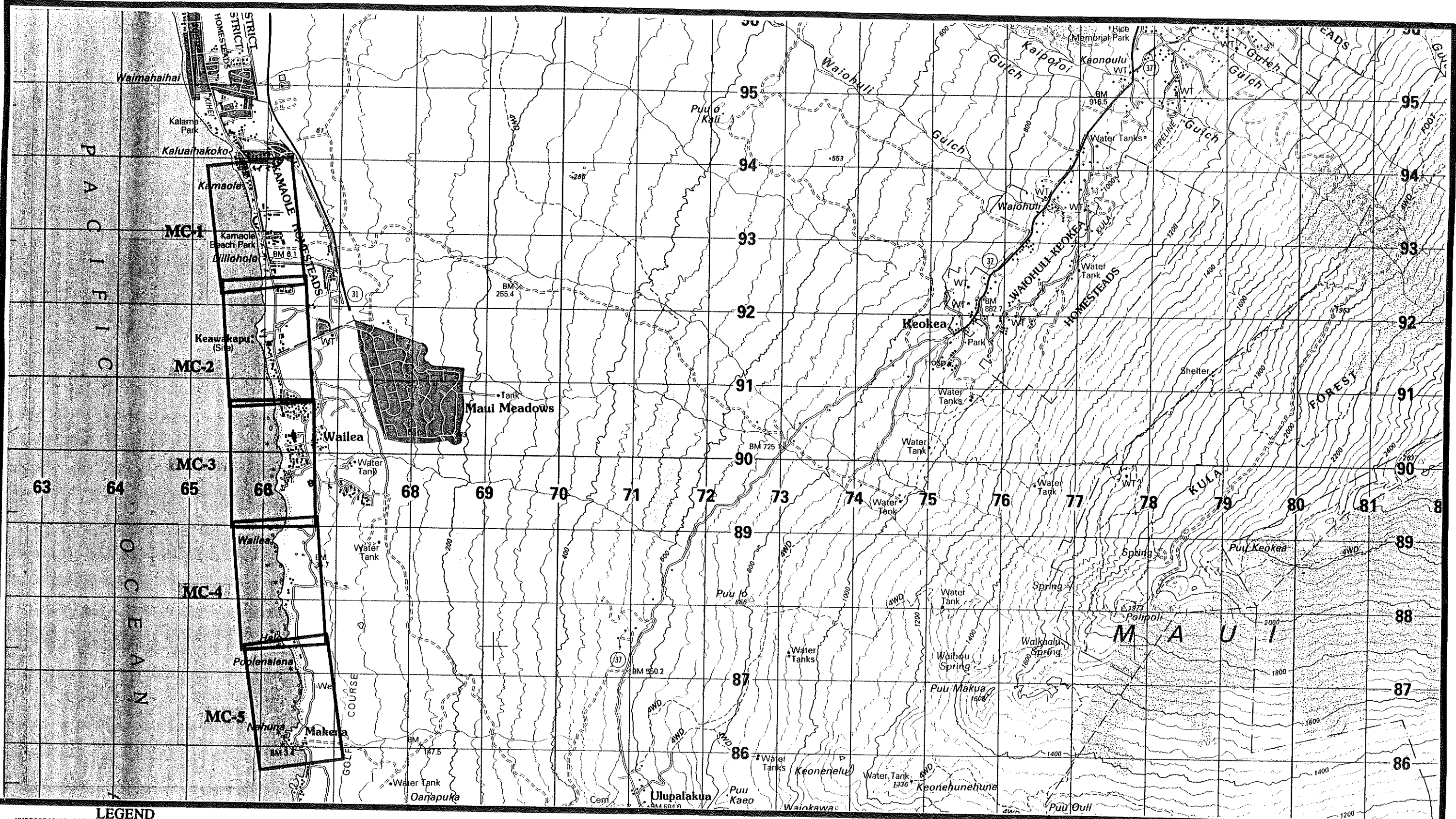
**SHORELINE PROCESSES**

The beaches in this sector are dynamic due to their exposure to the full force of incoming waves. Severe Kona storms periodically cause extensive damage. In January 1959, a Kona storm scoured all the sand from Keawakapu, leaving only exposed beachrock. Additional damaged was caused by storms during the winter of 1962-1963. By 1975, however, most of the beaches had recovered and vegetation lines had accreted to pre-storm positions. Severe storms again eroded the coastline in 1980 and 1982, and many of the beaches have not yet recovered from the erosion damage.

**BEACH USAGE**

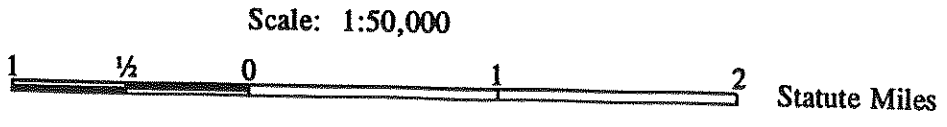
The beaches in this sector are heavily used. Kamaole I, II, and III are each separate beach parks with parking, restrooms, showers, and picnic facilities. Polo, Wailea, Ulua, Mokapu, and Keawakapu beaches are part of the Wailea resort complex, and include landscaped miniparks or public parking and access. Palauea Beach is the only beach in this sector that does not have public access; it is accessible through neighboring Polo or Poolenalena Beaches.





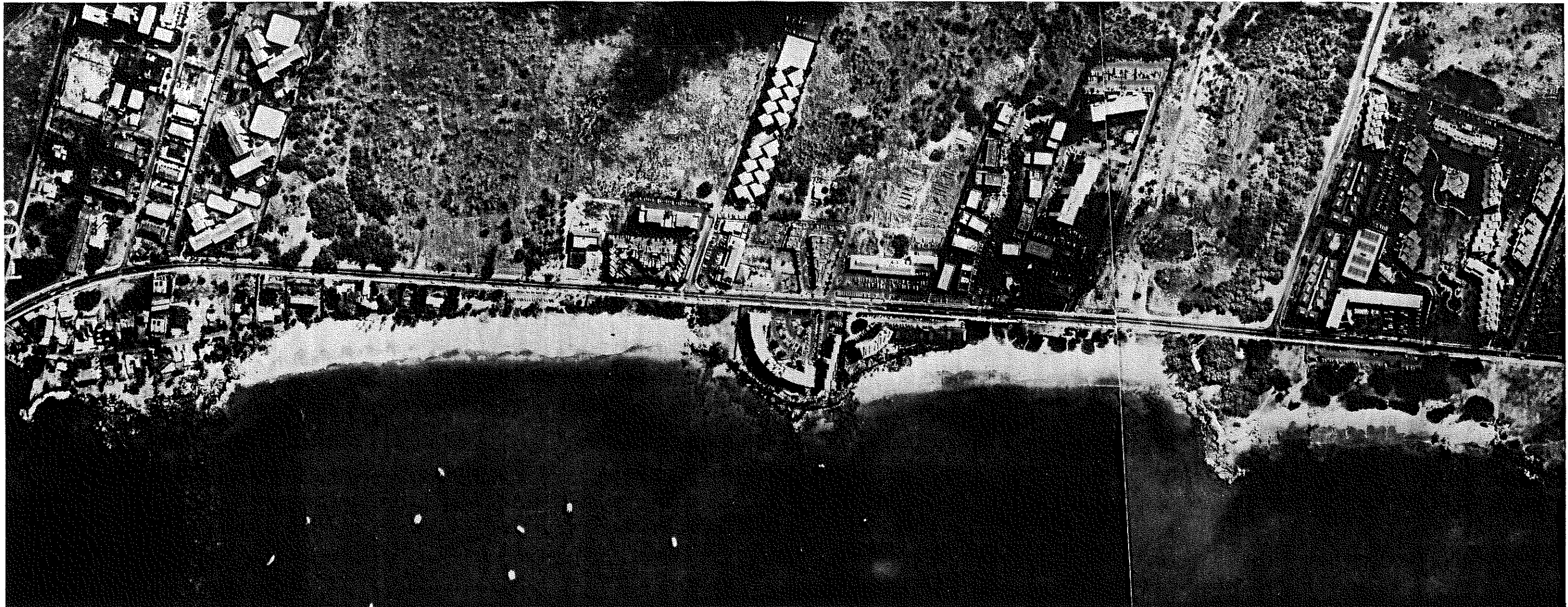
**LEGEND**  
 HYDROGRAPHIC DATUM ..... MEAN LOWER LOW WATER

- Depth curve (meters) \_\_\_\_\_
- Forashore flats \_\_\_\_\_
- Rocks awash; Reef \_\_\_\_\_
- Wreck: Exposed, Sunken with masts exposed \_\_\_\_\_
- Wharf, pier \_\_\_\_\_
- Seawall \_\_\_\_\_
- Oil/gas rig \_\_\_\_\_



**SOUTHWEST MAUI**  
**Kamaole to Makena**

From U.S. Geological Survey  
 MAP INFORMATION AS OF 1983



## MC-1: KAMAOLE BEACH PARK

### BEACH DESCRIPTION

- This subsector consists of three separate beach parks named Kamaole I, II, and III. These calcareous sand beaches are separated by rocky points, and decrease in length and width from north to south.
- Kamaole I is roughly 1800 feet long and 110 feet wide, Kamaole II is 1200 feet long and 75 feet wide, and Kamaole III is 900 feet long and only 40 feet wide. The offshore is primarily a sandy bottom, and there is no protective fringing reef.
- These beaches are fully exposed to south swells and Kona storms.

### BACKSHORE

- The backshores of the three beaches in this subsector consist of heavily used beach parks with paved parking lots, restrooms and showers, and picnic facilities.

- Additionally, the backshore at the northern end of Kamaole I has private residences, small hotels and apartments, while the northern end of Kamaole II contains a large resort hotel, the Royal Mauian Resort.
- South Kihei Road parallels the coast 150 feet behind the beaches.

### SHORELINE HISTORY

- Although Kamaole I, II, and III beaches are probably discrete littoral cells, Regions 1 - 5 suggest they have experienced similar dynamic shoreline histories.
- In general, the vegetation lines indicate there was significant erosion between 1949 and 1964, followed by accretion between 1964 and 1975, and then erosion once again between 1975 and 1988.

- Relative to the 1949 vegetation line, the 1988 vegetation lines were eroded 50 to 90 feet on Kamaole I Beach (Regions 1 and 2), 40 feet on Kamaole II (Regions 3 and 4), and 18 feet on Kamaole III (Region 5).

### SUMMARY

- The beaches in this subsector are dynamic, and have undergone periods of significant erosion and accretion since 1949. This is due to the lack of a protecting fringing reef and full exposure to Kona Storms.
- Periodically, storms severely erode these beaches.

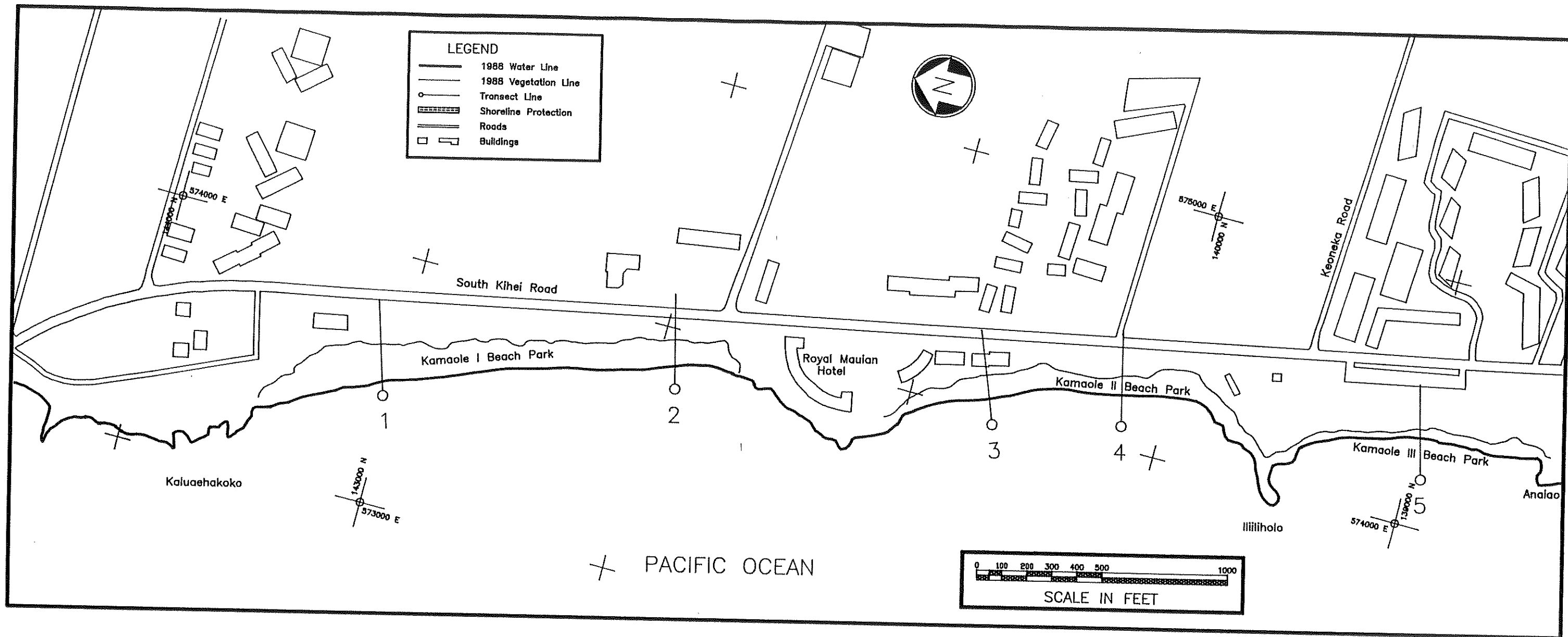
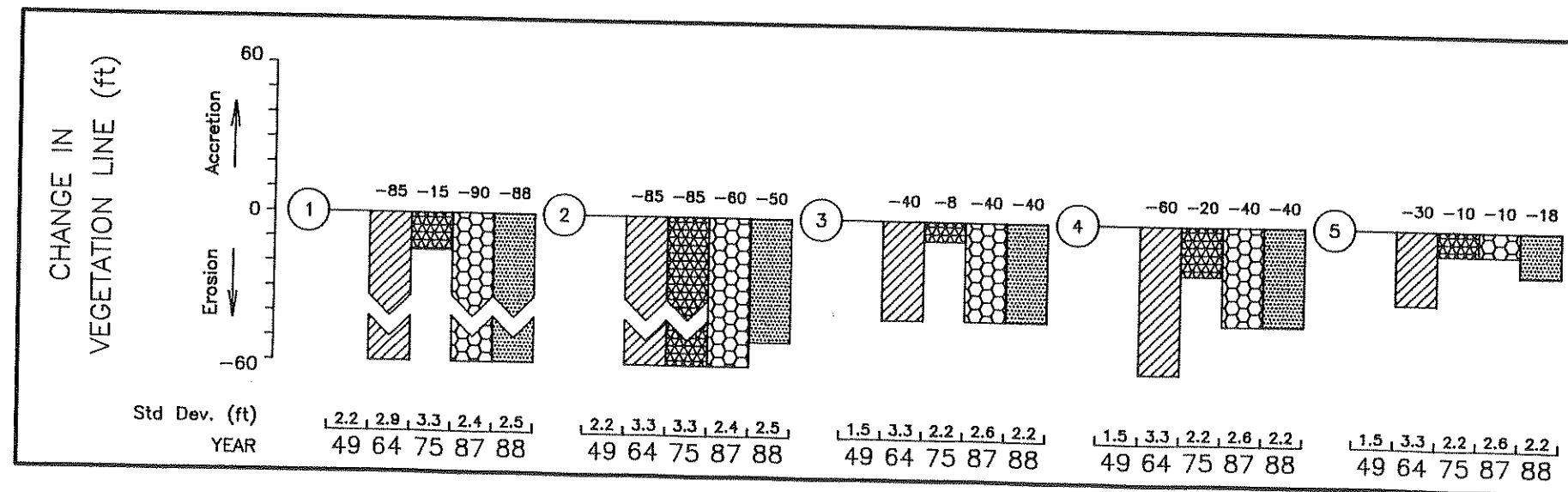
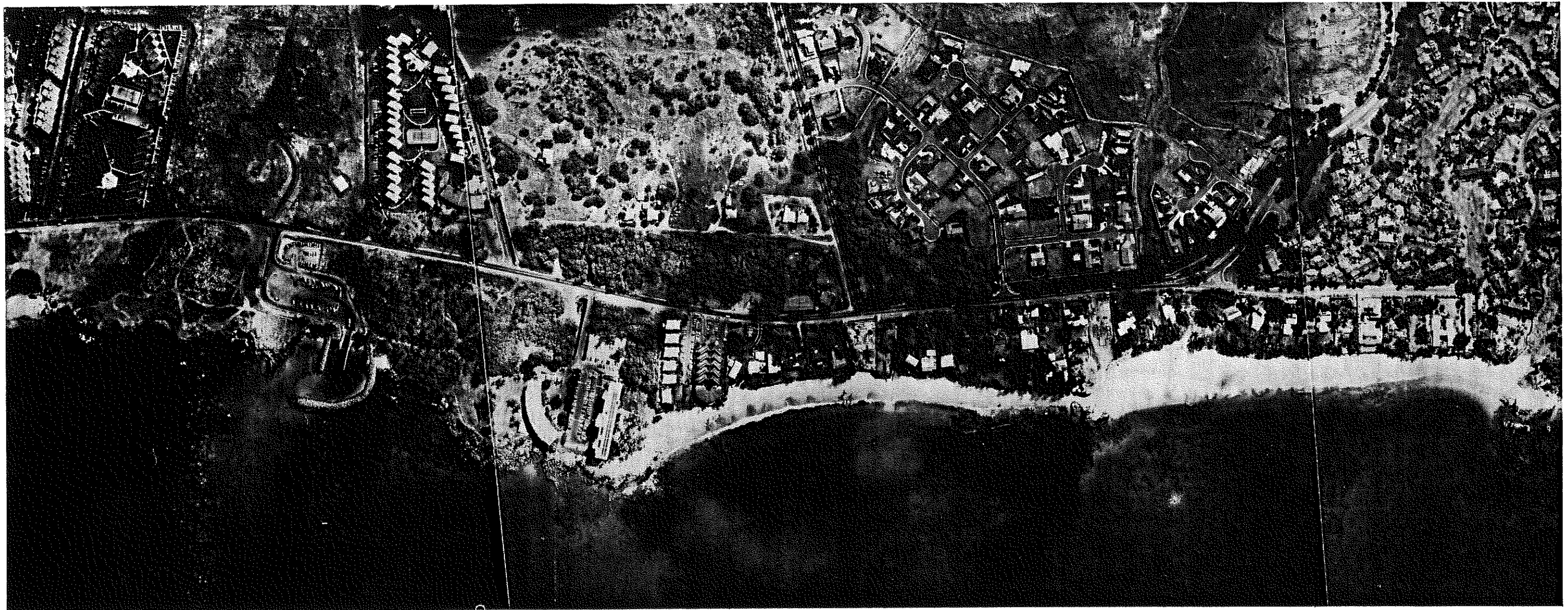


FIGURE MC-1



GRAPH MC-1 Region Number vs Change in Vegetation Line

PHOTOS USED:  
 March 1988  
 July 1987  
 March 1975  
 June 1964  
 May 1963  
 November 1949



## MC-2: KEAWAKAPU BEACH

### BEACH DESCRIPTION

- This subsector consists of 2000 feet of rocky shoreline in the north, and 3000 foot long Keawakapu Beach to the south.
- The rocky shoreline is characterized by low rock outcrops and low cliffs 1 to 10 feet high. Kihei Public Boat Ramp has been built in a small pocket beach within the rocky coast.
- Keawakapu Beach is bounded by rocky points, and is approximately 50 feet wide in the northern reaches and up to 150 feet wide in the southern reaches.
- There is no protective reef offshore; a sandy bottom with rocky patches predominates. Keawakapu beach is therefore subject to erosion damage from Kona storms.

### BACKSHORE

- Private residences occupy the backshore along the entire length of Keawakapu Beach. Resort hotels and large apartment complexes are located at the northern end of the beach.
- South Kihei Road parallels the shoreline and provides easy access to the beach.

### SHORELINE HISTORY

- Regions 6 to 9 indicate that this beach has experienced severe erosion since 1949.
- The 1963 vegetation lines were eroded between 75 and 90 feet, and the 1988 vegetation lines were eroded from 50 to 100 feet relative to the 1949 vegetation line (Regions 6, 8 and 9).
- The northern two-thirds of the beach accreted between 1963 and 1975 by as much as 60 feet (Regions 6 and 8).

- A revetment has been built to protect homes at the southern end of the beach.
- A rock outcrop in the middle of Keawakapu Beach at Region 7 has stabilized the vegetation line; little erosion or accretion has occurred during the period covered by this study.

### SUMMARY

- Keawakapu Beach is an unprotected, dynamic beach subject to severe storm erosion.
- Storms in 1959 and the winter of 1963 caused severe erosion, and left beach rock exposed along the entire length of beach.
- The beach then accreted through 1975.
- Storms in 1980 and 1982 again caused severe erosion along the beach, as is shown by the 1988 vegetation line.

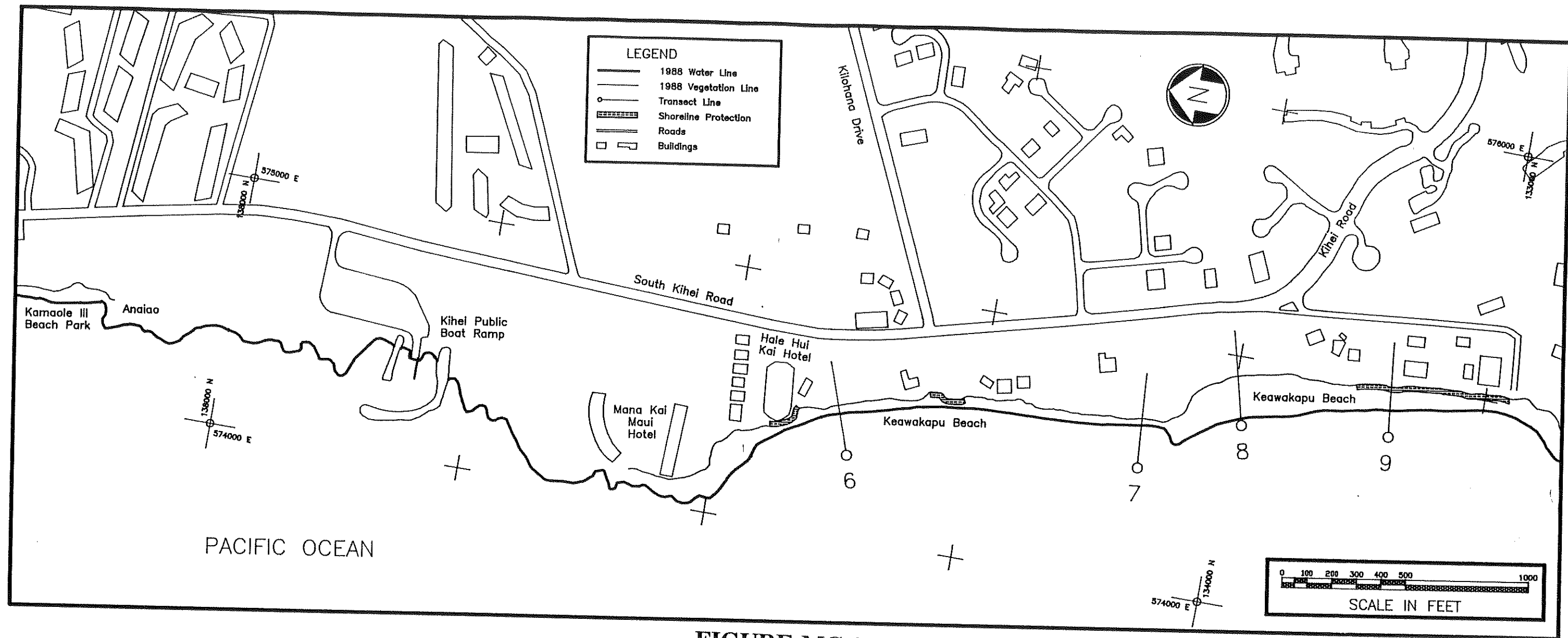
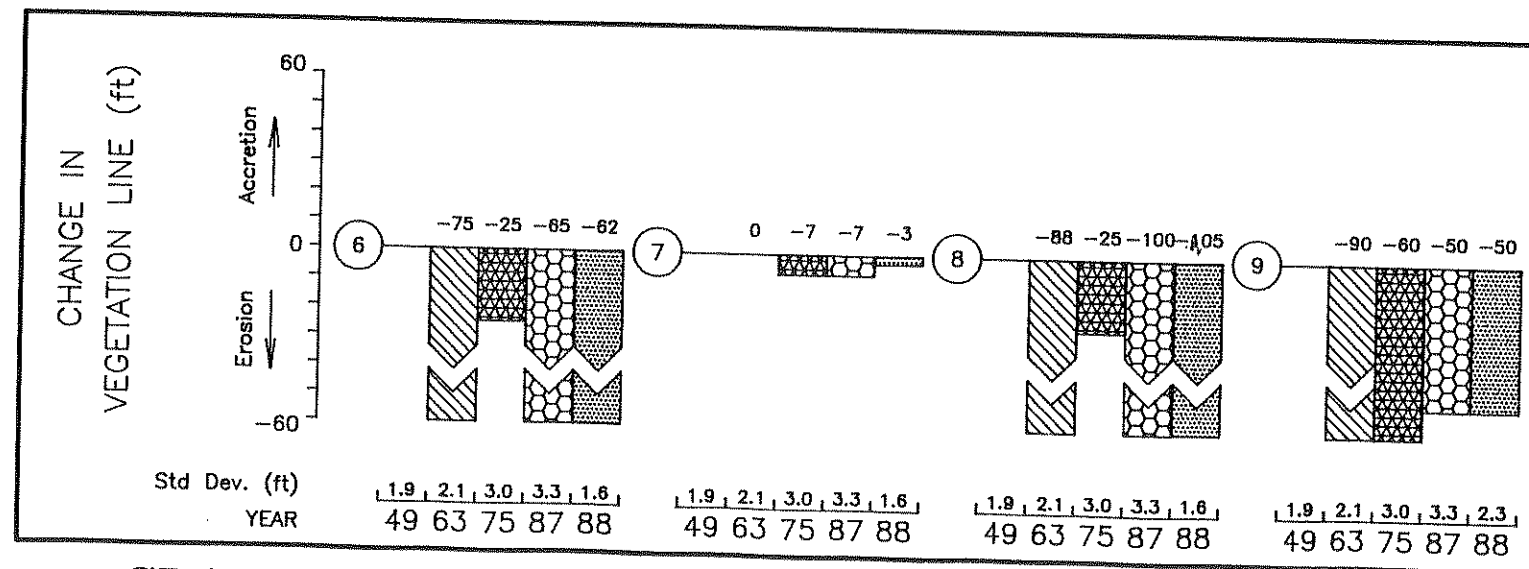


FIGURE MC-2



GRAPH MC-2 Region Number vs Change in Vegetation Line

PHOTOS USED  
 March 1988  
 July 1987  
 March 1975  
 June 1964  
 May 1963  
 November 1949





### MC-3: MOKAPU BEACH TO WAILEA BEACH

#### BEACH DESCRIPTION

- This subsector is comprised of three wide, crescent-shaped beaches separated by rocky points: Mokapu Beach, Ulua Beach, and Wailea Beach.
- Both Mokapu and Ulua Beaches are roughly 800 feet long, with typical widths of 85 feet. Wailea Beach is approximately 1200 feet long, and up to 150 feet wide.
- There is no fringing reef. The offshore bottom is primarily sandy, with patches of rock.

#### BACKSHORE

- Condominiums and resort hotels of the Wailea resort complex occupy the backshore of the three beaches in this subsector.
- The Stouffer Wailea Beach Hotel is located directly behind Mokapu Beach. Condominiums are located behind Ulua Beach. The buildings are a minimum of 100 feet behind the 1988 vegetation line.

- Both Mokapu and Ulua Beach have landscaped mini-parks with paved parking lots, and paved walkways to the shoreline.
- Extensive construction has been undertaken in the backshore of Wailea Beach. The Four Seasons Hotel opened in 1990 at the southern end of Wailea Beach. The Grand Hyatt Hotel is still under construction on the northern backshore of the beach.
- The Wailea Maui Inter-Continental occupies the wide, rocky point between Ulua and Wailea Beach.

#### SHORELINE HISTORY

- Regions 10 to 13 indicate that Mokapu and Ulua Beaches are eroding. They have experienced severe erosion from 1949 to 1963 and from 1975 to 1988, and slight accretion from 1963 to 1975. Net erosion between 1949 and 1988 ranged from 40 to 85 feet in Regions 10 to 12. Region 13 is protected by Wailea Point, and net erosion was 25 feet.
- Oblique aerial photographs of the north end of Mokapu Beach show fallen trees that were undercut by beach erosion. Vegetation

growing seaward of the fallen trees and the scarp indicates that the erosion is not active, but occurred in the past. The net erosion indicated by the 1988 vegetation line is likely the result of severe storms in 1980 and 1982. The beach is currently undergoing the slow process of recovery.

- Wailea Beach is dynamic, and has experienced both accretion and erosion. Region 14 indicates that there has been a net accretion of 30 feet at the northern end of Wailea Beach since 1949. Region 15 shows a net erosion of 20 feet at the southern end of the beach.
- The vegetation line at Wailea Beach has also been influenced by man. Construction was occurring when both the 1975 and 1988 photographs were taken.

#### SUMMARY

- Mokapu and Ulua Beaches are eroding. Net erosion at Mokapu and Ulua Beach ranged from 25 to 85 feet.
- Wailea Beach is dynamic. It has undergone net accretion in its northern reach, and slight erosion in the southern reach.

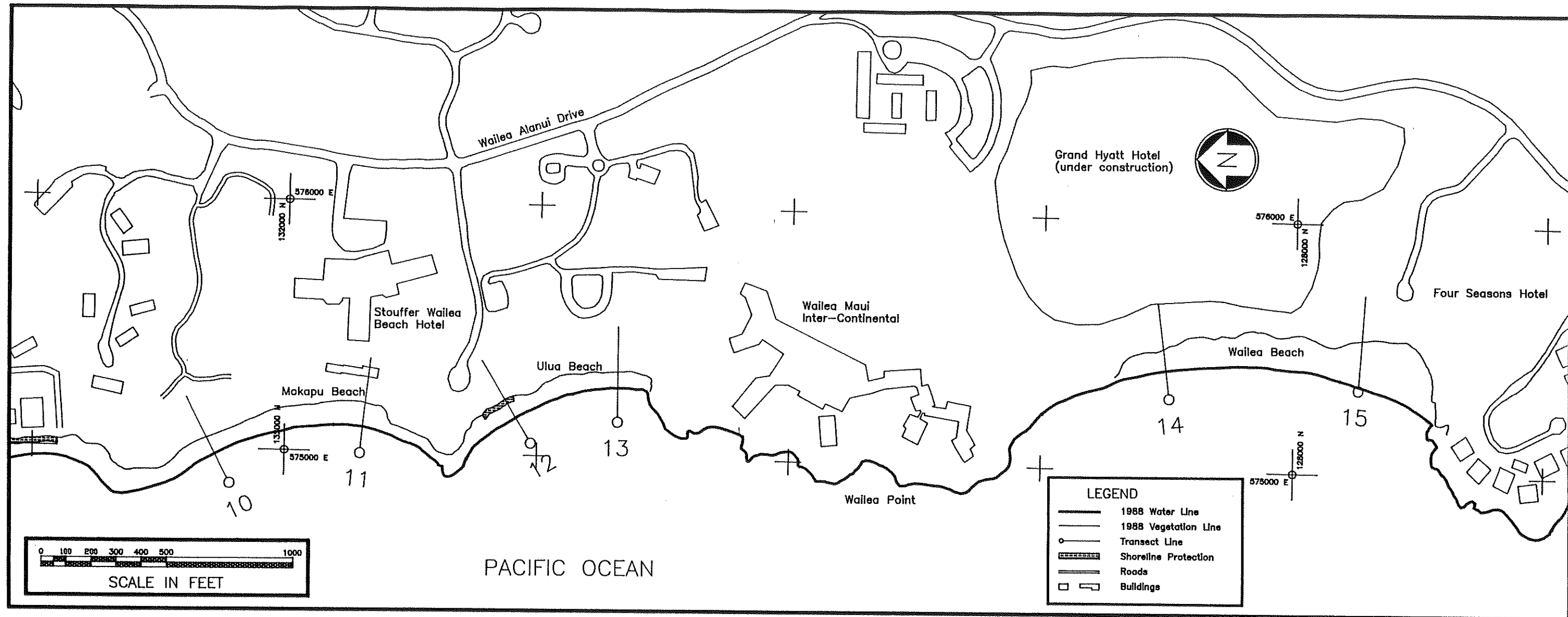
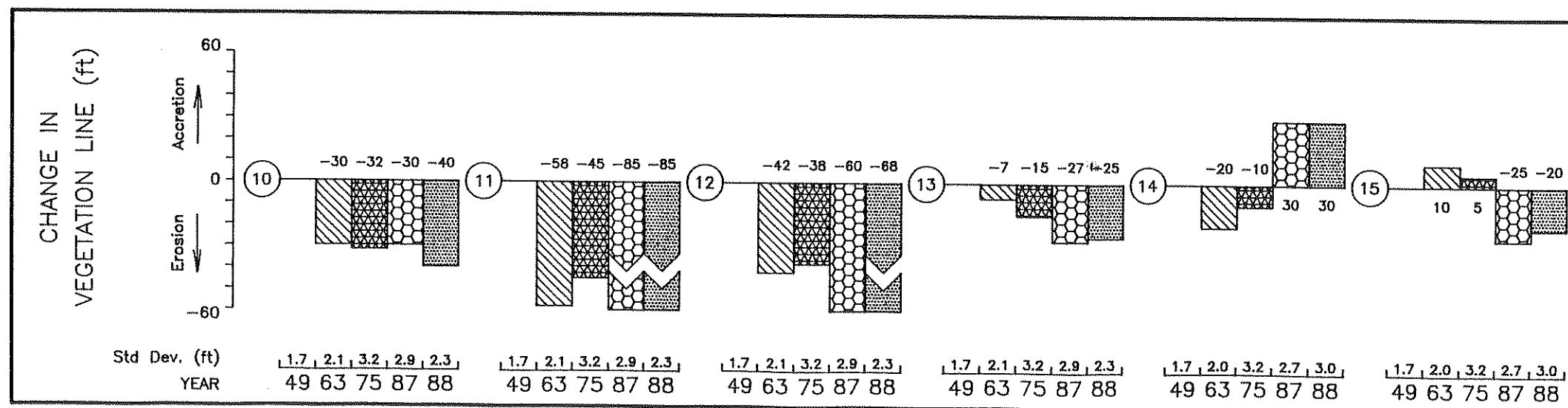
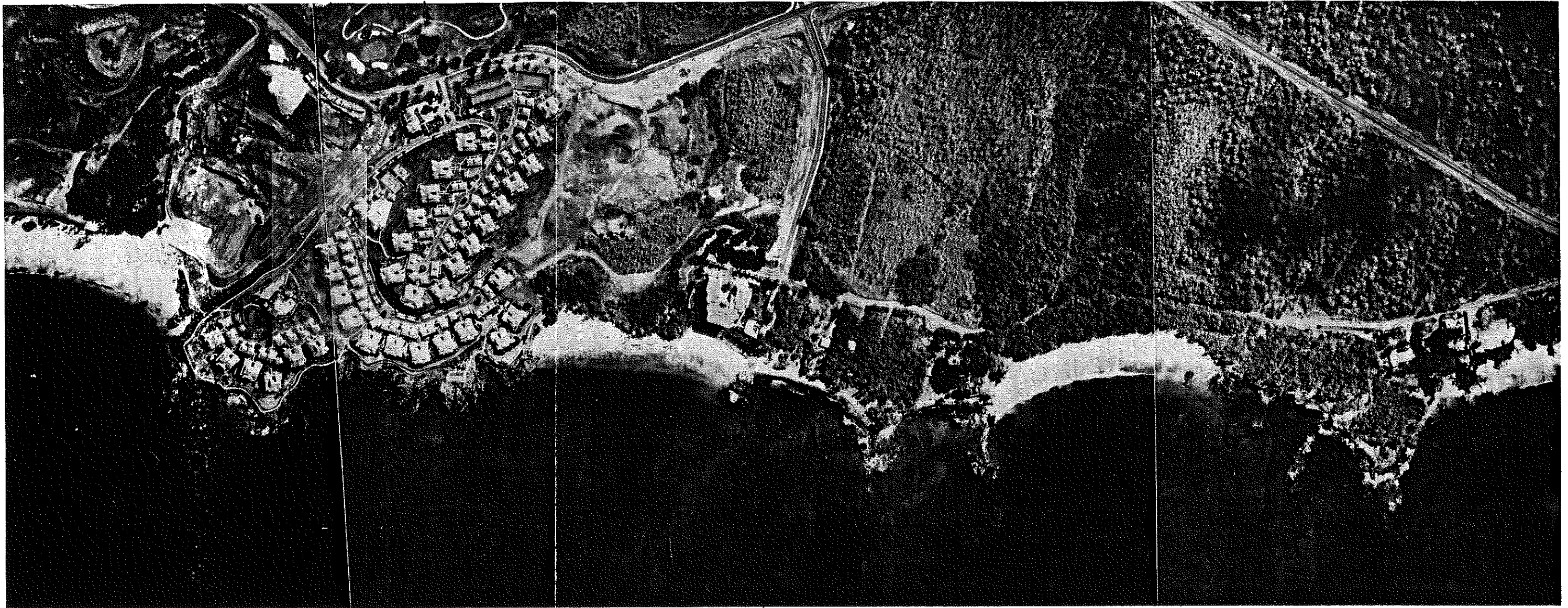


FIGURE MC-3



GRAPH MC-3 Region Number vs Change in Vegetation Line

PHOTOS USED  
 March 1988  
 July 1987  
 March 1975  
 May 1963  
 November 1949



## MC-4: POLO AND PALAUEA BEACH

### BEACH DESCRIPTION

- Polo and Palauea Beach are crescent-shaped, wide, calcareous sand beaches separated by rocky points. Both beaches are approximately 800 feet long, and have typical widths of 100 to 150 feet.
- Beach rock is exposed along the center of Polo Beach.
- A rocky point 1300 feet wide separates Polo Beach from Wailea Beach to the north.
- At the southern ends of both beaches are small cobble and detrital sand beaches.
- There is no fringing reef offshore; these beaches, therefore, are fully exposed to storm waves.

### BACKSHORE

- The backshore uses differ markedly behind the two beaches.
- Polo Beach is part of the Wailea Resort complex. The backshore, therefore, is developed or is being developed. The Wailea Point Condos occupy the point to the north of Polo Beach. A large resort hotel, the Kea Lani, is being constructed behind the northern half of the beach. The Polo Beach Club and private residences occupy the

southern backshore. Polo Beach also has a landscaped mini-park with paved parking and a paved walkway to the beach.

- The backshore of Palauea Beach, on the other hand, is undeveloped, consisting primarily of morning glory growing on the low sand dunes, and kiawe trees.

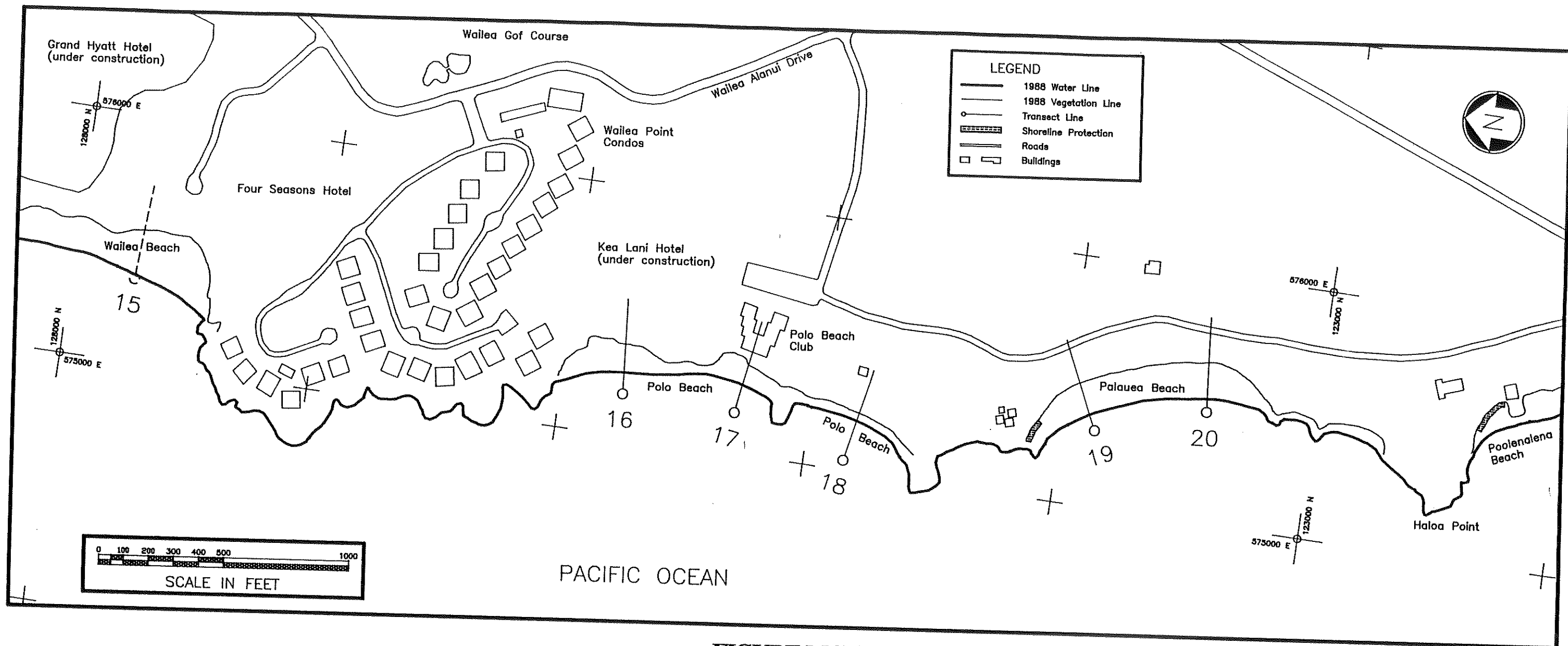
### SHORELINE HISTORY

- Polo and Palauea Beaches are dynamic.
- Regions 16 and 17 indicate that the vegetation line on Polo Beach in 1963 and 1988 was significantly eroded relative to the vegetation lines in 1949 and 1975. Net erosion in Regions 16 and 17 from 1949 to 1988 was 52 and 22 feet respectively.
- At the cobble beach at the southern end of Polo Beach, the vegetation line has accreted 35 feet since 1949 (Region 18).
- Significant erosion occurred at Palauea Beach between 1975 and 1988: 39 feet in Region 19 and 55 feet in Region 20. This was probably due to the severe storms of 1980 and 1982. Net erosion since 1949 in these Regions was 27 and 50 feet.
- The 1963 vegetation line in Regions 19 and 20 represents the sparse seaward limit of vegetation. The aerial photos indicate that erosion

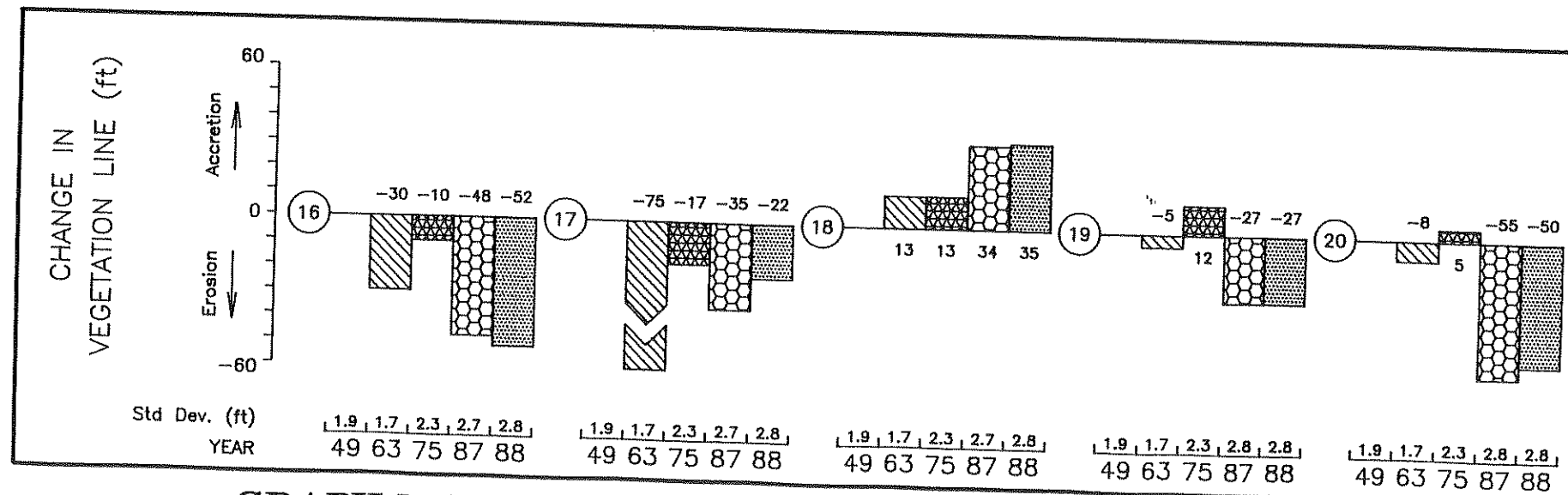
damage in 1963 was significantly greater than indicated by this vegetation line. Vegetation appears to have been destroyed and sand eroded as much as 150 feet behind this vegetation line.

### SUMMARY

- Similar to the other beaches in this sector, Polo and Palauea Beaches are dynamic. These beaches are subject to occasional severe erosion by storms, followed by gradual beach recovery.
- In Regions 16, 17, 19 and 20 net erosion between 1949 and 1988 ranged from 22 to 52 feet.

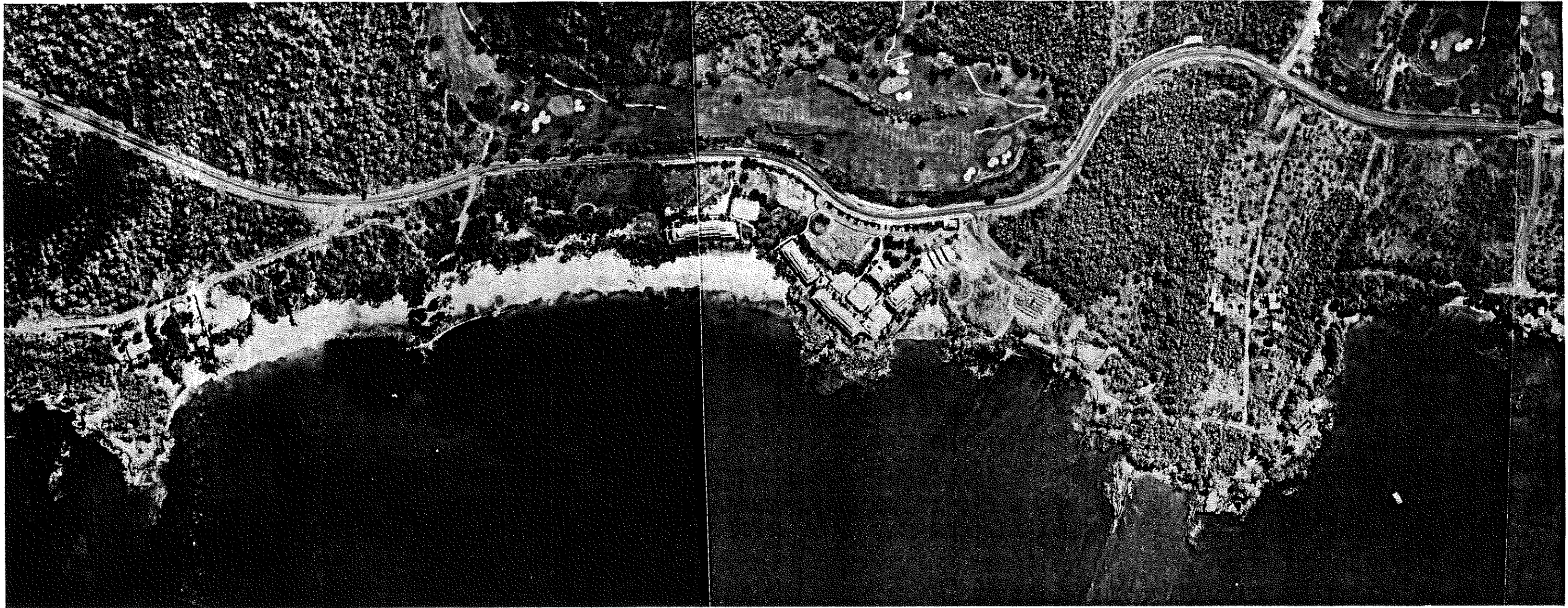


**FIGURE MC-4**



**GRAPH MC-4 Region Number vs Change in Vegetation Line**

**PHOTOS USED**  
 March 1988  
 July 1987  
 March 1975  
 May 1963  
 November 1949



## MC-5: POOLENALENA BEACH

### BEACH DESCRIPTION

- Poolenalena Beach is approximately 2400 feet long, and typically 100 to 150 feet wide. It is bounded to the north by Haloa Point and to the south by another rocky point where the Makena Surf Hotel is located.
- The beach is subdivided by three small rock outcrops. The outcrop in the middle of the beach is called Pepeiaolepo Point.
- There is no protective fringing reef. The offshore bottom is generally hard rock with sand pockets.

### BACKSHORE

- Private residences occupy the backshore north of Pepeiaolepo Point. Several of the residences have been built close to the present day vegetation line. A seawall has been constructed to protect the property at the north end of the beach.

- The backshore extending 800 feet south of Pepeiaolepo Point is largely undeveloped, with only one residence located 150 feet behind the vegetation line.
- The Makena Surf Hotel occupies the backshore in the southern end of the beach.
- Where homes have not been built, the vegetation consists primarily kiawe trees growing on large sand dunes.

### SHORELINE HISTORY

- Poolenalena Beach is dynamic, though it has not experienced the extremes of erosion that occurred on other beaches in this sector. The 1963 vegetation line was eroded less than in other beaches, 12 feet in Region 21 and 22 feet in Region 22.
- Substantial accretion occurred over most of the beach between 1963 and 1975 (Regions 21 to 23).

- Regions 21 and 22 indicate that exposed portions of the beach have undergone net erosion between 1949 and 1988 of 32 and 38 feet respectively.
- The shoreline behind the rock outcrops is protected. In Region 23, for example, net erosion between 1949 and 1988 was only 5 feet, and the maximum change was 10 feet of accretion indicated by the 1975 vegetation line.

### SUMMARY

- Poolenalena Beach is dynamic, although it has not undergone the extreme erosion indicated on the other beaches of the sector.
- Net erosion ranged from 32 to 38 feet in Regions 21 and 22.
- The shorelines are relatively stable behind the rock outcrops along the beach.

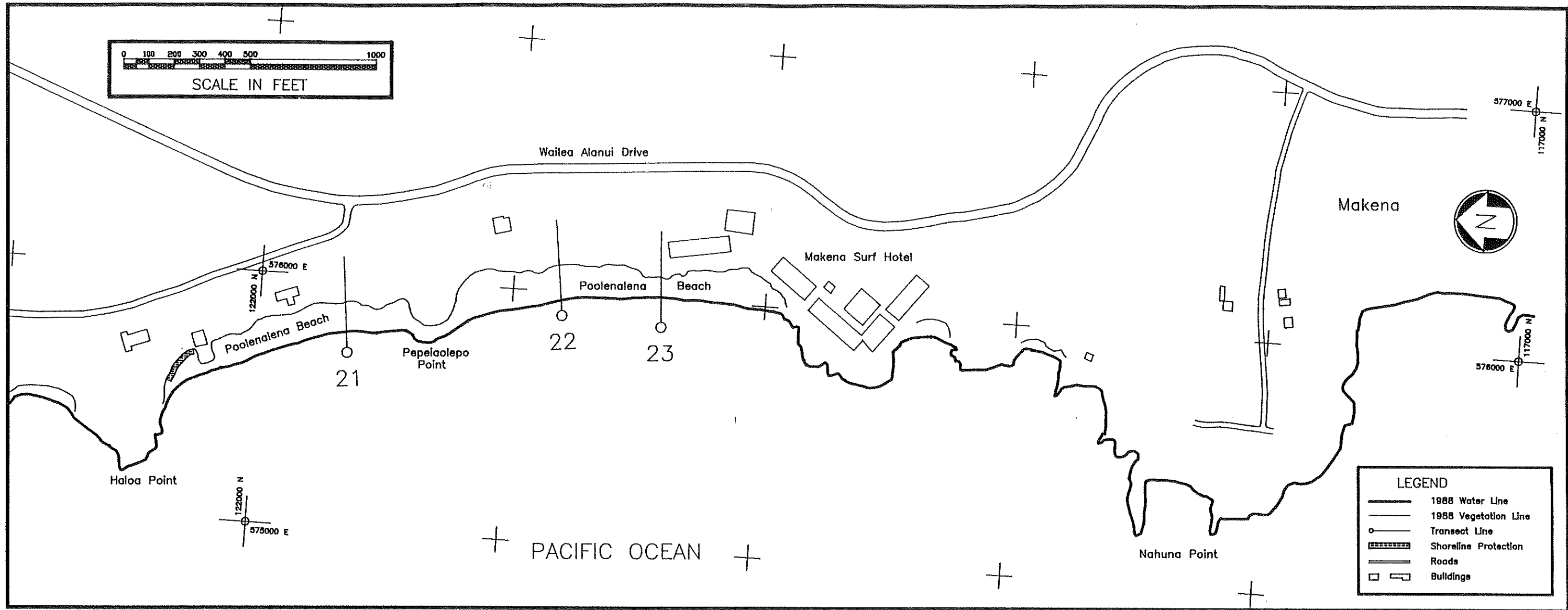
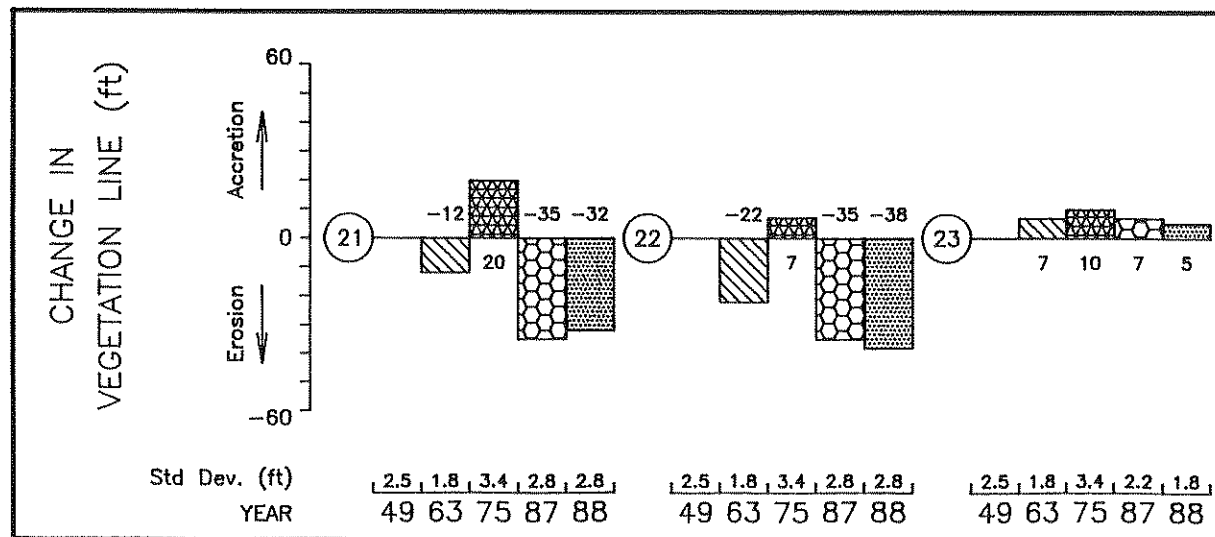


FIGURE MC-5



GRAPH MC-5 Region Number vs Change in Vegetation Line

PHOTOS USED  
 March 1988  
 July 1987  
 March 1975  
 May 1963  
 November 1949

## SECTOR MD: NORTH CENTRAL MAUI KAHULUI HARBOR TO HAMAKUA POKO POINT

### GENERAL COASTAL CHARACTERISTICS

This sector spans seven miles of continuous coastline between Hobron Point to the east of Kahului Harbor and Hamakua Poko Point. Much of the shoreline consists of an almost continuous, narrow, white sand beach that is segmented into smaller beach areas by basalt outcrops, protruding beachrock, and groins and other man-made structures. The easternmost mile of the sector consists of small pocket beaches separated by rocky headlands. The major beach areas in the sector include Kanaha Beach Park, Sprecklesville Beach, H.A. Baldwin Beach Park, and the beaches in Paia, Mantokuji and Kuau Bays.

### LAND USE AND DEVELOPMENT

The backshore development in this sector includes industry, private residences, and beach parks. The industries are located in the western end of the sector and include Kahului Airport and the Wailuku Kahului Wastewater Reclamation Facilities. The beach parks include Kanaha Beach Park, Baldwin Beach Park, and Lower Paia Park. Three residential communities are also located in the backshore: Sprecklesville, Paia, and Kuau. The Maui Country Club Golf Course is located in the backshore east of Sprecklesville.

### WAVE CLIMATE

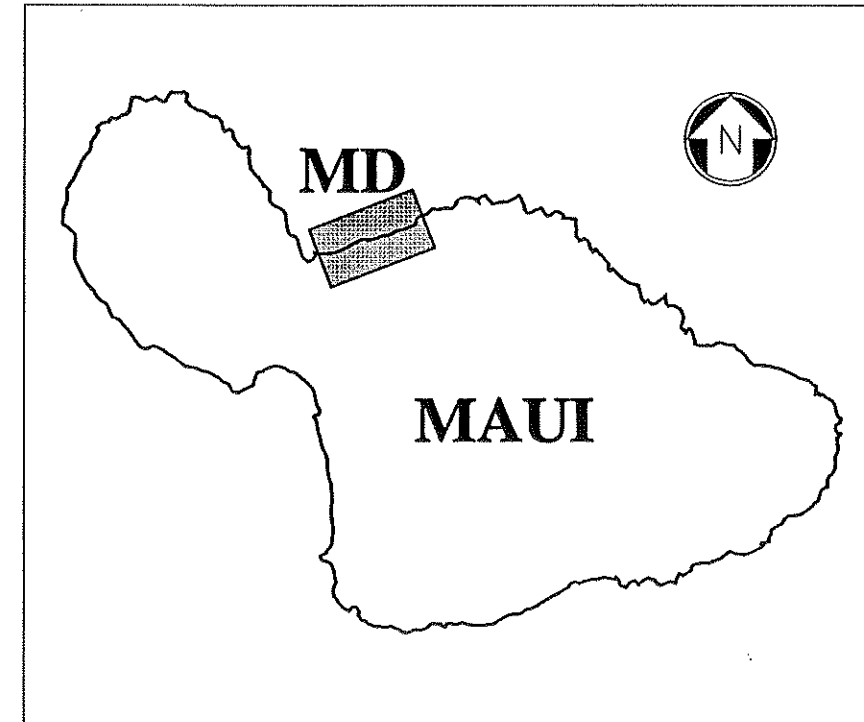
This sector is exposed to tradewind waves and north Pacific swell, and is sheltered from Kona storm waves. A wide fringing reef is located offshore through most of the sector.

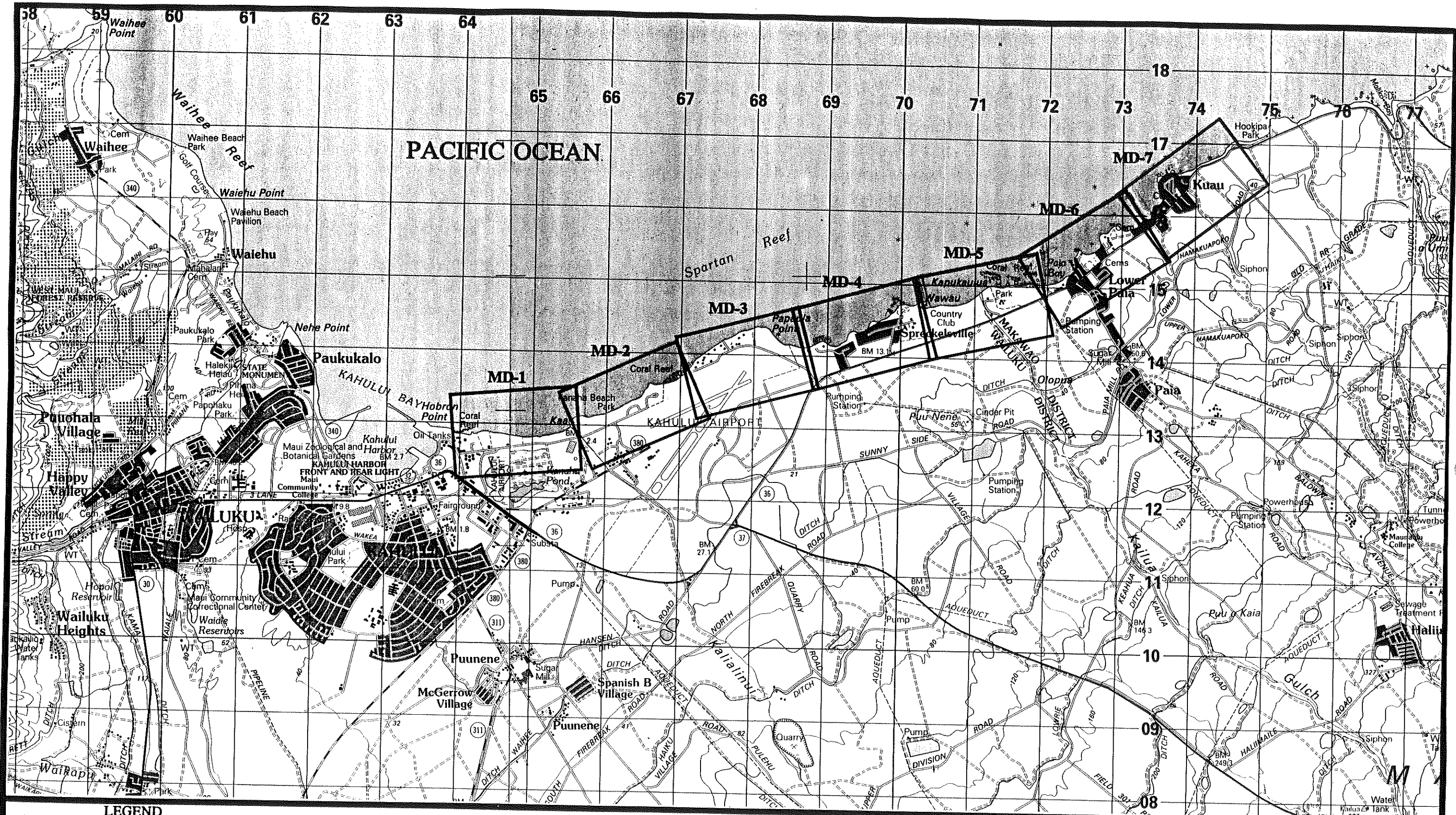
### SHORELINE PROCESSES

The five miles of beach between Kahului Harbor and Paia Bay has a history of severe erosion. According to USAED (1971), the shelves of beachrock exposed 800 feet offshore define the limits of a former shoreline, and are indicative of continued erosion. Consequently, the beaches in this sector are characterized both by natural evidence of severe erosion (exposed beachrock, wavecut scarps, and submerged tree stumps) and by man's efforts to check the erosion (seawalls, revetments and groin fields). Analysis of the aerial photos reveals that the erosion is continuing. The reasons for the erosion are not known. Possible causes include construction of the Kahului Harbor by 1910, sand mining and a lime kiln in the eastern end of the sector, and decreasing productivity in the fringing reef.

### BEACH USAGE

The beach parks in this sector, Kanaha, Baldwin, and Lower Paia, are easily accessible from Kahului, and contain facilities such as paved parking, showers, restrooms, and picnic tables and grills. They are therefore popular and heavily used. Baldwin is the most popular park on the windward side of Maui, and is often crowded with picnickers, swimmers, and wind, body, and board surfers. Sprecklesville and Stables beach are also easily accessible and widely used.





**LEGEND**

HYDROGRAPHIC DATUM ..... MEAN LOWER LOW WATER

Depth curve (meters) \_\_\_\_\_

Foreshore flats \_\_\_\_\_

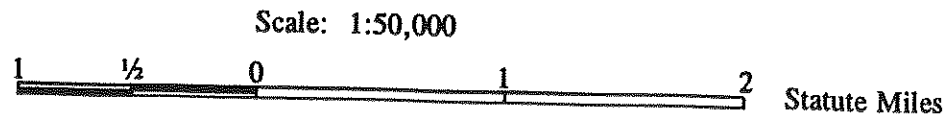
Rocks awash. Reef \_\_\_\_\_

Wreck. Exposed. Sunken with masts exposed \_\_\_\_\_

Wharf, pier \_\_\_\_\_

Seawall \_\_\_\_\_

Oil/gas rig \_\_\_\_\_

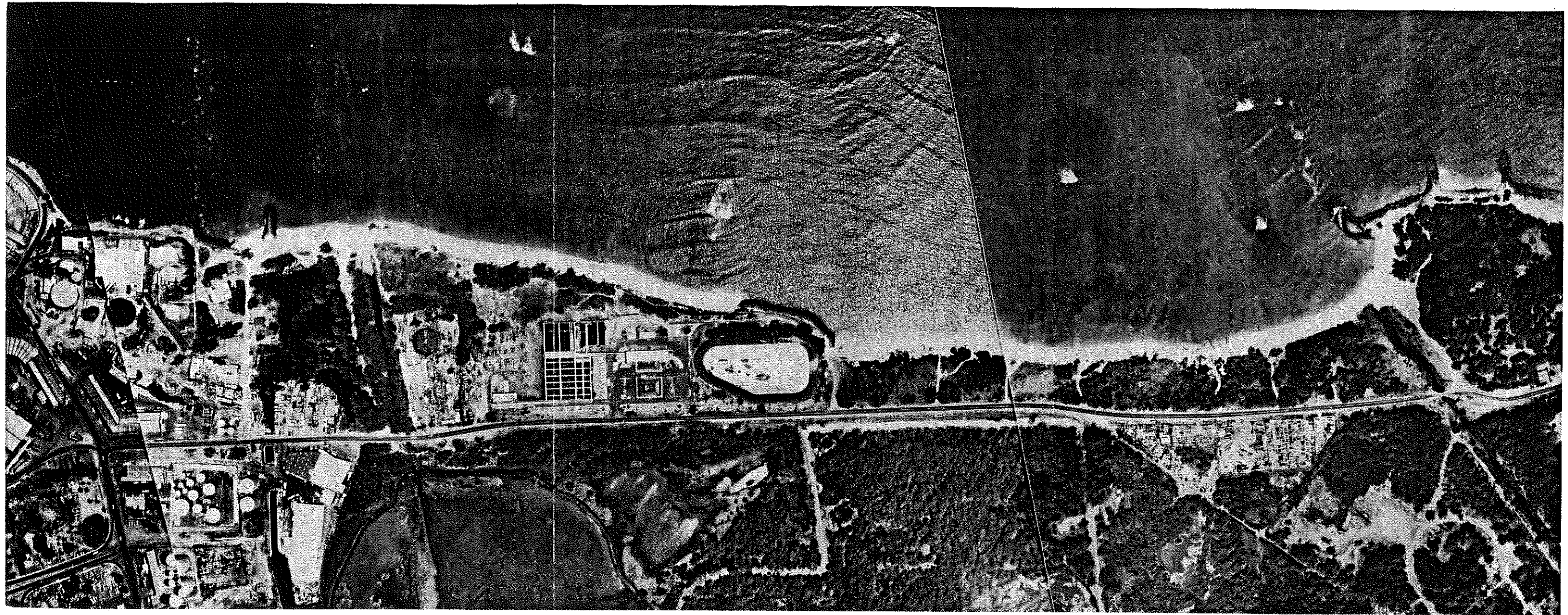


From U.S. Geological Survey  
MAP INFORMATION AS OF 1983



**NORTH CENTRAL MAUI**  
**Kahului Harbor to Hamakua Poko Point**





## MD-1: HOBRON POINT TO KAA

### BEACH DESCRIPTION

- A primarily white calcareous sandy beach approximately 4600 feet long extends from Hobron Point to Kaa, a small rocky headland.
- The beach varies from 8 to 30 feet wide.
- A concrete lined stream channel is present at the east end of the subsector. It appears to have been built since May 1988. This could decrease the sediment volume reaching the shoreline.
- The Kahului Harbor, located to the west of this subsector, was built by 1910. The effects of the harbor on the shoreline are not known.
- A wide, fringing reef is located offshore.

### BACKSHORE

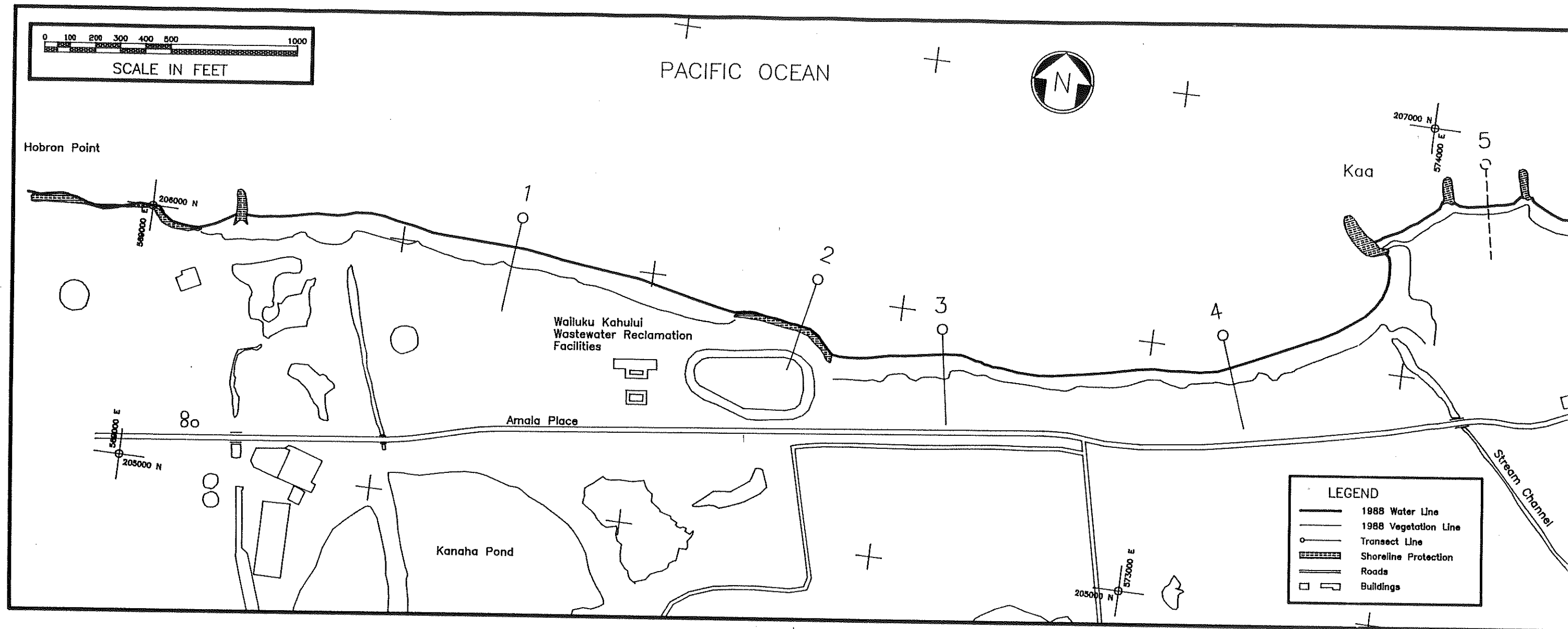
- A fairly well defined vegetation line consisting of naupaka, kiawe trees, and grass lines the backshore area.
- The Wailuku Kahului Wastewater Reclamation Facility is located in the center of the subsector. A rock revetment located at the waterline in front of the large water reservoir, is in place to stabilize the shoreline. The water treatment facility was built between March, 1975 and January, 1977. The revetment was constructed between January, 1977 and July, 1987.
- Low lying sand dunes are present to the west of the treatment facility.
- Kanaha Pond, located landward of the road, is a wildlife refuge and an important bird sanctuary.

### SHORELINE HISTORY

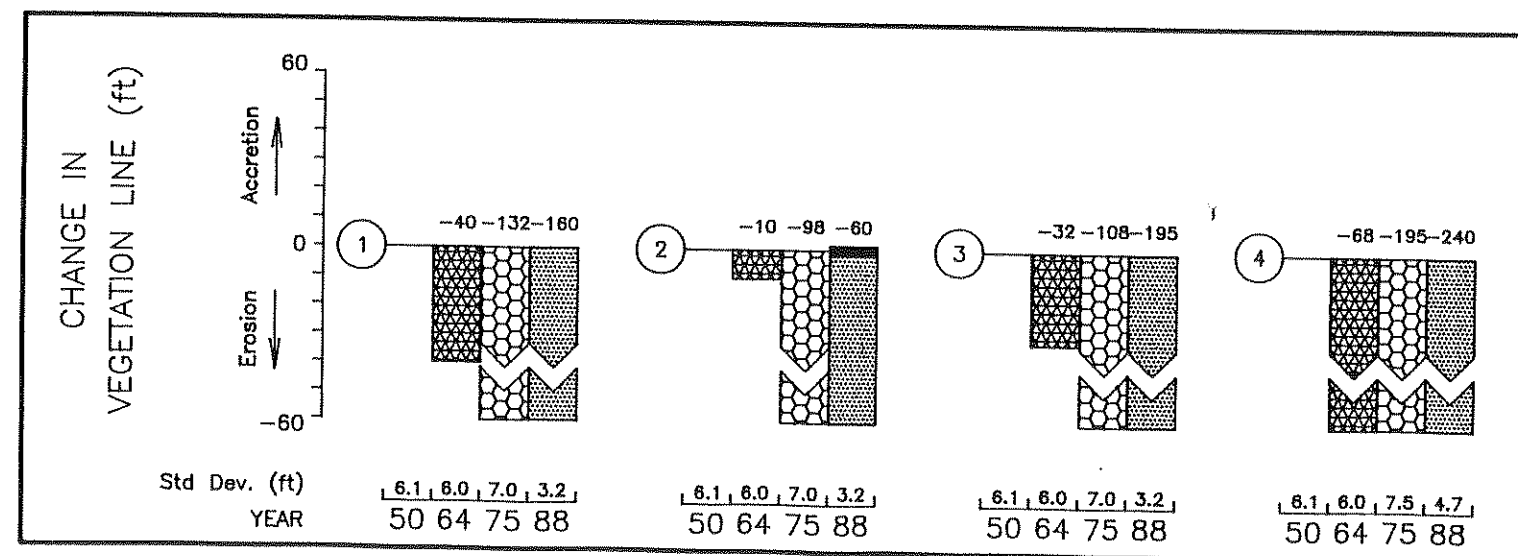
- All four regions in this subsector show severe erosion.
- The erosion is most severe to the east at Region 4 where the beach has eroded 240 feet between 1950 and 1988.

### SUMMARY

- Severe erosion is evident along the entire subsector.
- The beach morphology around the rock groins located at the ends of the subsector exhibits no evidence of alongshore sediment transport.
- Sand is probably transported offshore during large wave climates. The offshore reef also may not be as productive as it was in the past, causing a decrease in the coralline sand washed onshore.

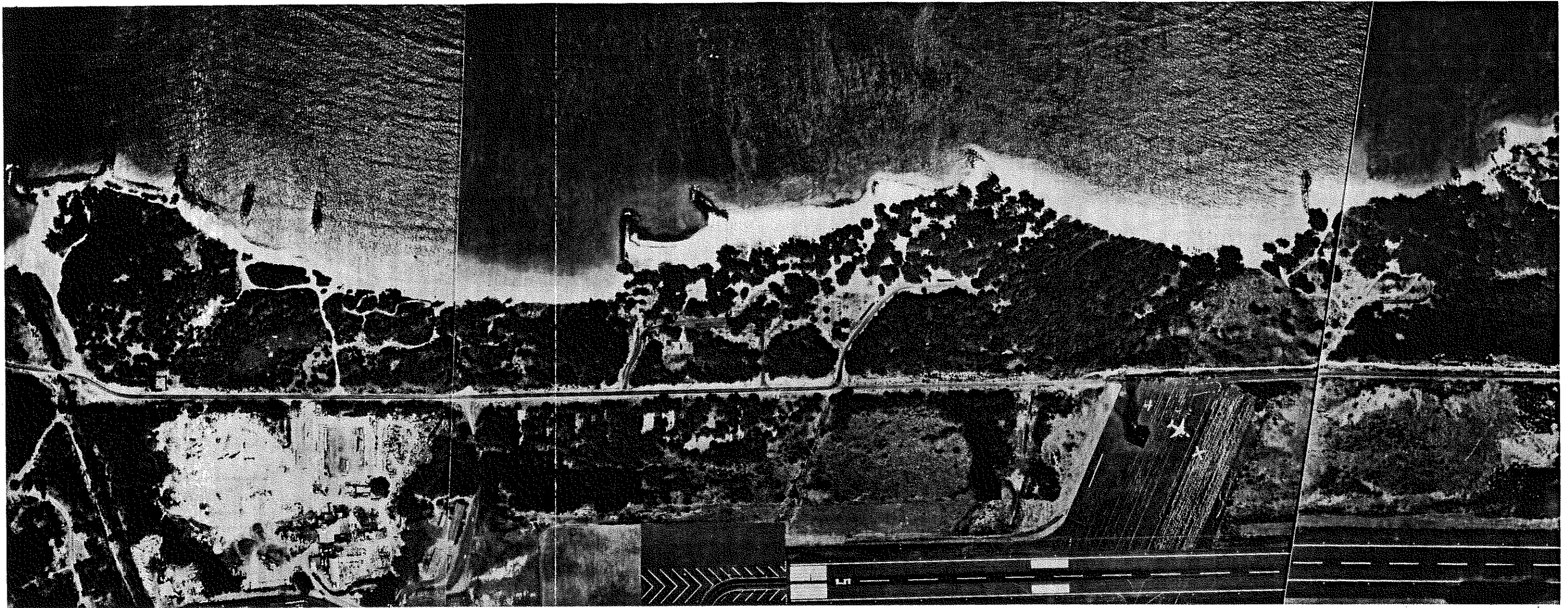


**FIGURE MD-1**



**GRAPH MD-1 Region Number vs Change in Vegetation Line**

**PHOTOS USED**  
 May 1988  
 July 1987  
 March 1975  
 January 1964  
 February 1950



## MD-2: KANAHA BEACH

### BEACH DESCRIPTION

- The white sandy beach extending from Kaa past Kanaha Beach Park is divided into small pocket beaches by numerous boulder groins.
- The beach area is frequented by fishermen, limu pickers and beach goers. The water is shallow, and usually cloudy. The inshore bottom is composed of a mixture of sand and rock.
- Seasonal variations in the beach width are shown in the aerial photos. Sand is transported offshore in the winter months and then back onshore in the summer.

### BACKSHORE

- The Kanaha Beach Park facilities are located in the center of the subsector and include paved parking, restrooms, showers, picnic tables and barbecue grills.

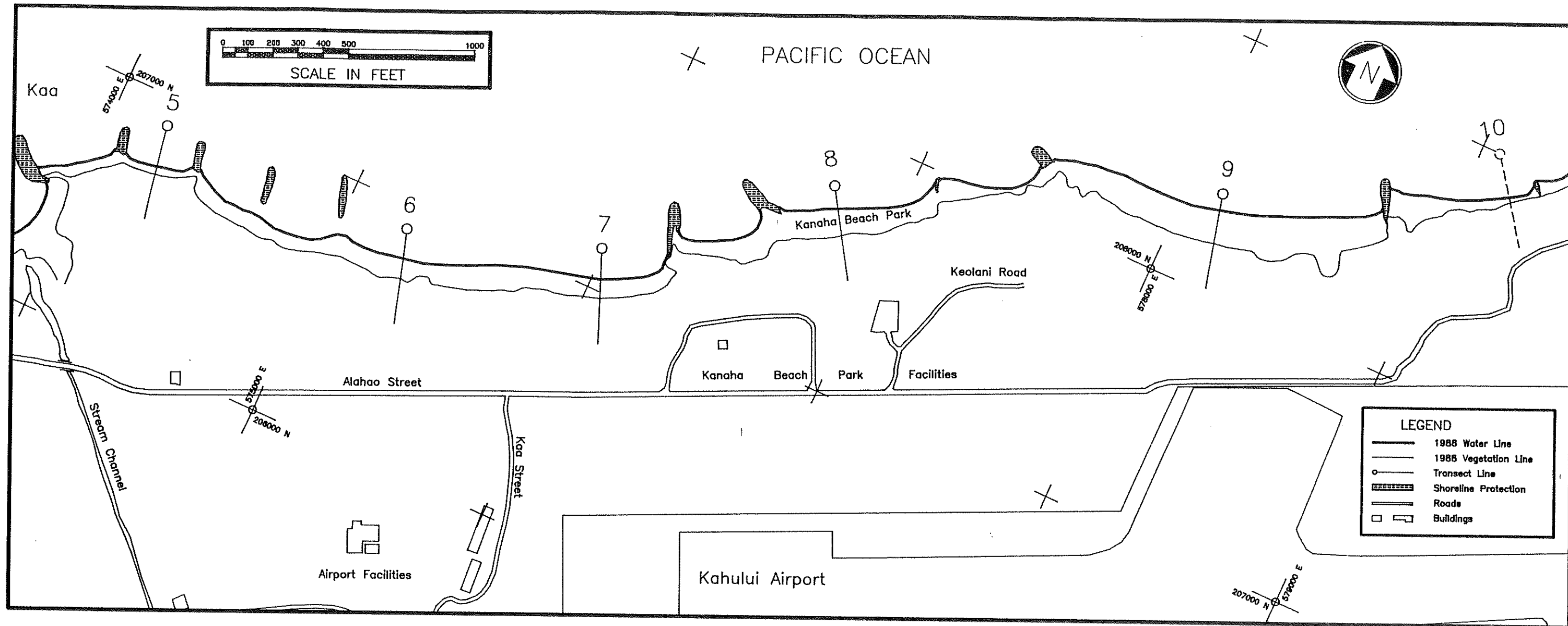
- The vegetation line is fairly well defined but has become less defined in recent years especially in the vicinity of the beach park. Kiawe trees are predominant.
- The Kahului Airport facilities are located landward of this subsector; the edge of the runway is 600 feet from the waterline.

### SHORELINE HISTORY

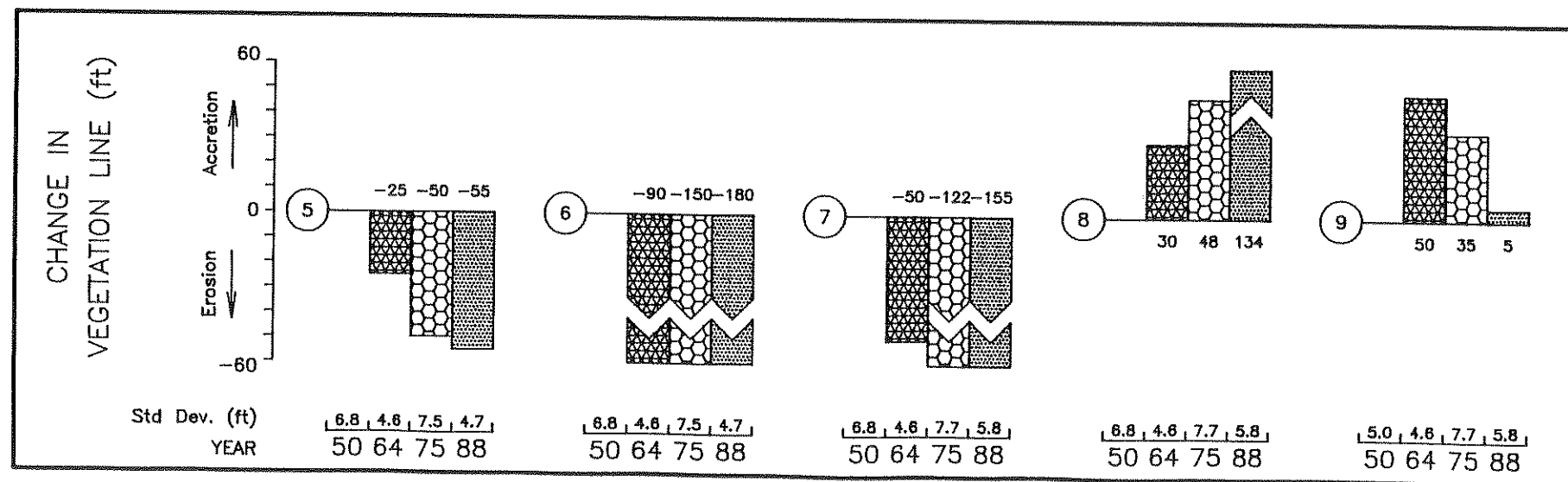
- Boulder groins were constructed prior to 1950. They act as a barrier to the alongshore sediment transport causing erosion along the downdrift side and accretion along the updrift side.
- The two predominant groins are located in the center of the reach between Regions 7 and 8. All regions to the west of these groins show extreme erosion of up to 180 feet at Region 6.
- The reach east of these groins shows a net accretion of up to 134 feet at Region 8.

### SUMMARY

- The localized accretion and erosion along this subsector has been accelerated by the 200 foot long groins present in front of Kanaha Beach Park. Sand by-passes these groins at the tip and by overtopping the structure.
- Eleven groins are located along this subsector. Most are not less than 100 feet in length, and some are absent at the waterline. These groins slow the alongshore sediment transport.

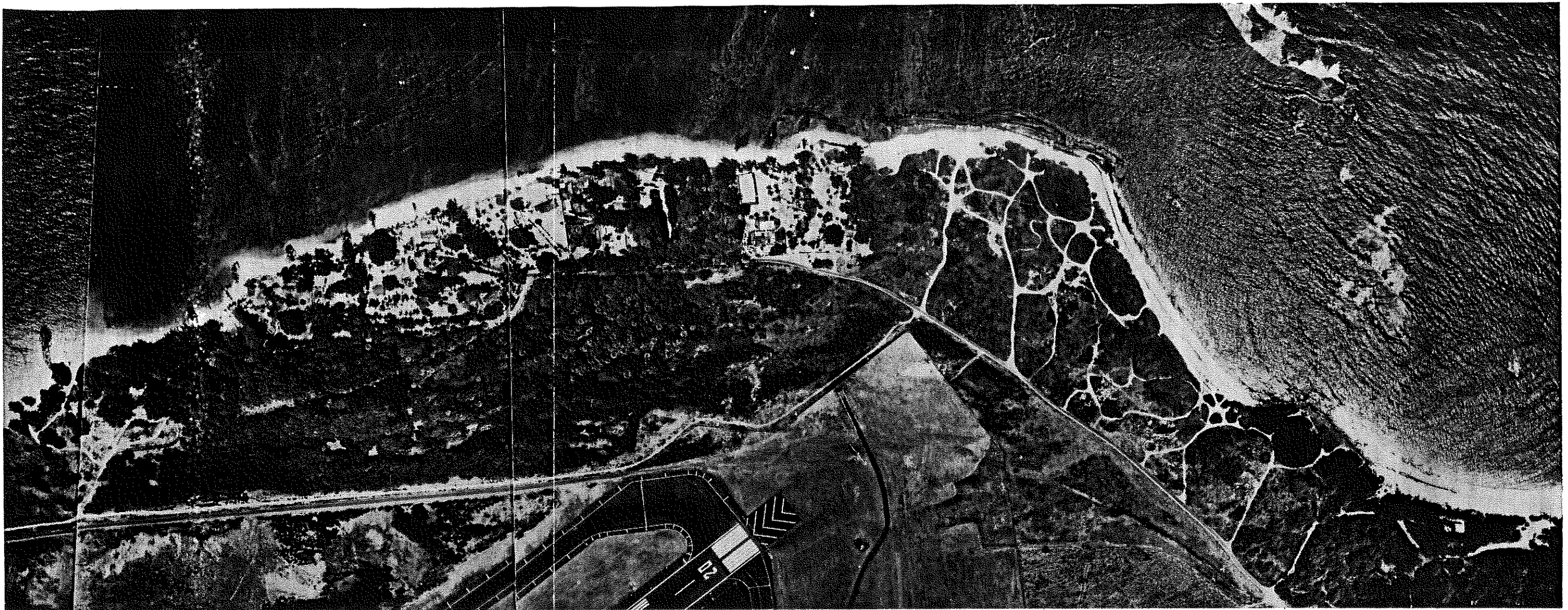


**FIGURE MD-2**



**GRAPH MD-2 Region Number vs Change in Vegetation Line**

**PHOTOS USED**  
 May 1988  
 July 1987  
 March 1975  
 January 1964  
 February 1950



### MD-3: WEST SPRECKELSVILLE BEACH

#### BEACH DESCRIPTION

- Spreckelsville Beach extends from the beach located at the end of Spreckelsville Beach Road to Maui Country Club (see MD-4), a distance of two miles. Part of the beach east of Papaula Point is known as Stables Beach.
- The beach is approximately 50 feet wide and is composed of white calcareous sand. Small boulder groins are present at the west end of the beach.
- West of Papaula Point, a coral bench breaches the surface at the waterline.

#### BACKSHORE

- The Kahului Airport and some private residences are located at the west end of the subsector. The vegetation line is not well defined in front of the residences.

- Public access to the beach is available at Stables Beach as well as at the end of the airport runway. Numerous trails lead from Spreckelsville Beach Road to the shoreline.
- Some evidence of a stressed vegetation line is present just west of the coral bench. Fallen palm trees are shown in the oblique photos as well as undercut tree roots caused by embankment erosion.
- A dirt embankment is exposed and appears to be eroding at the east end of the subsector. Basaltic cobbles line the shoreline at this point producing a small rocky point shown in the map.

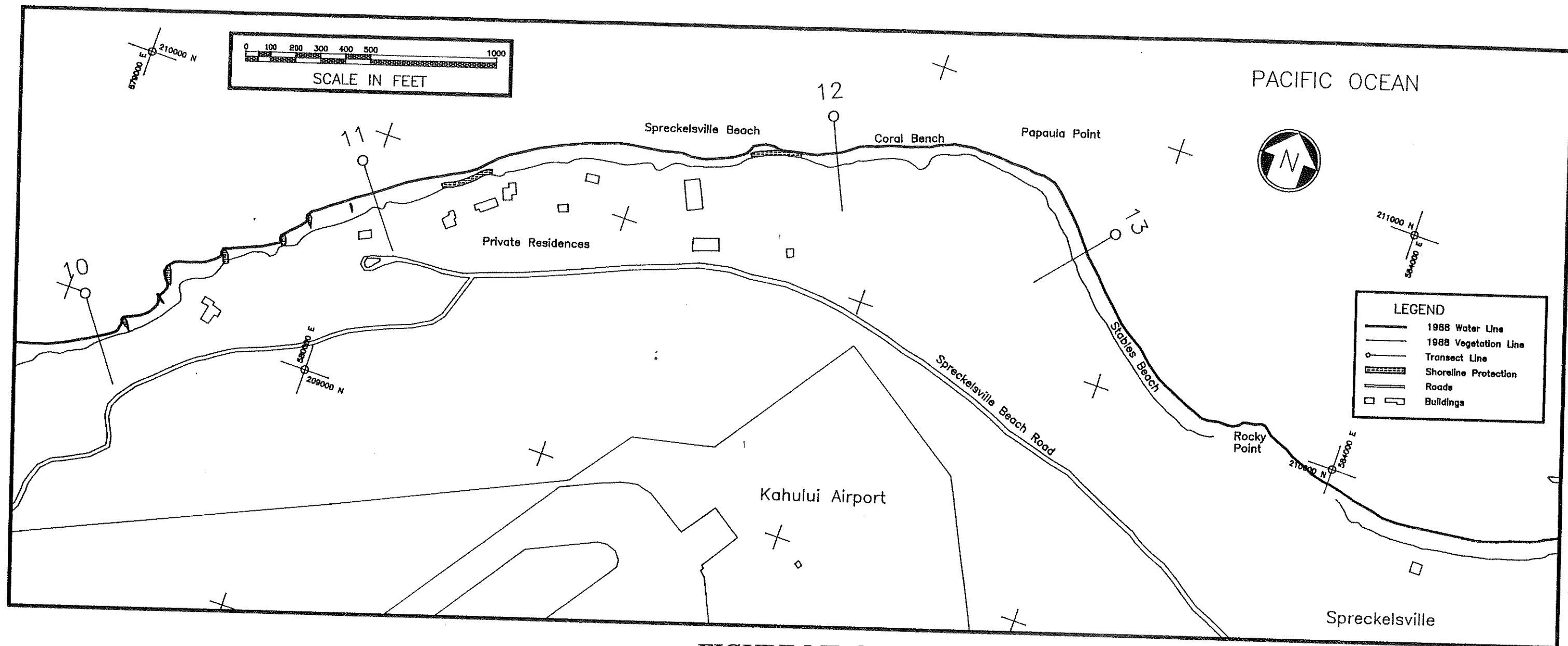
#### SHORELINE HISTORY

- Region 10, located at the west end of the site, shows a fairly significant accretion of the shoreline from 1950 to 1964, and a stable shoreline since 1964. This Region is located on the updrift side of a boulder groin located at the east end of Subsector MD-2.

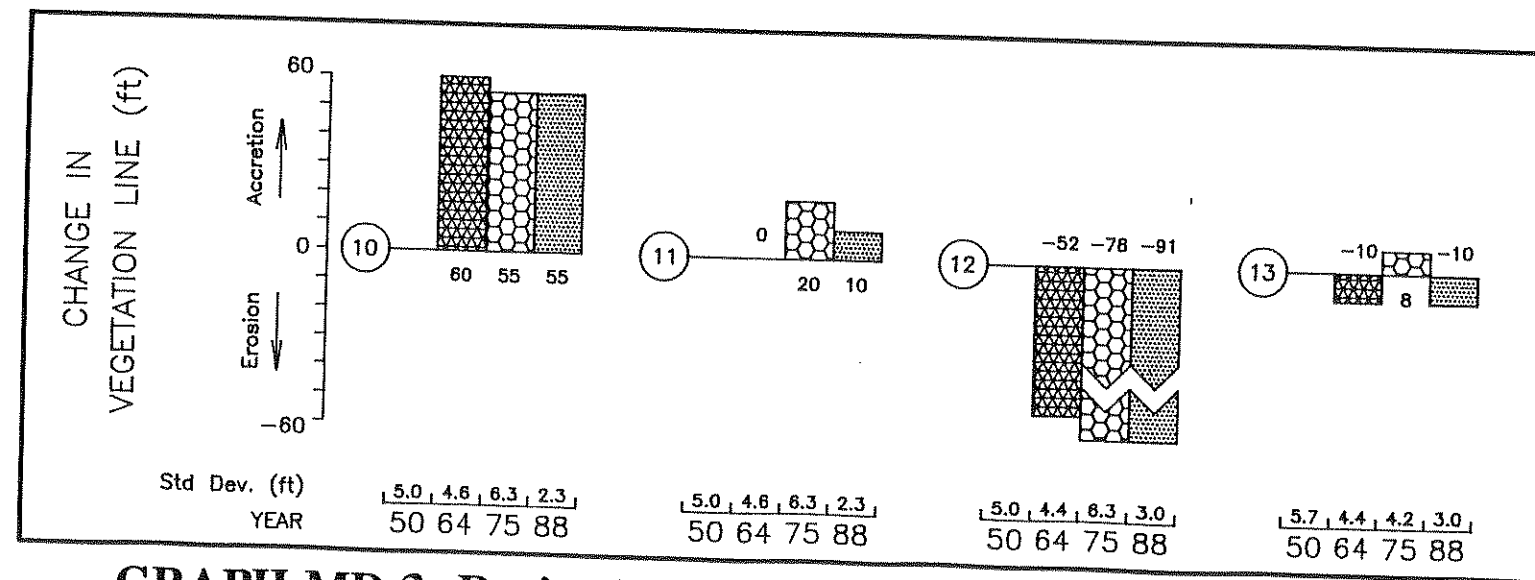
- Region 11 shows the same trend, although the accretion is less significant and occurred between 1964 and 1975. It was probably caused by the series of small groins located to the west.
- Region 12 shows significant erosion both in the historical record and in the oblique photos. A coral bench is located to the east and a revetment to the west. The revetment was built to stabilize the shoreline and is not the cause of the erosion. The coral bench helps stabilize the waterline. It is unclear why such pronounced erosion is occurring here.

#### SUMMARY

- The west end of the subsector is generally accreting and probably influenced by the groins.
- The reach east of Papaula Point is stable with only minor changes (Region 13).



**FIGURE MD-3**



**GRAPH MD-3 Region Number vs Change in Vegetation Line**

**PHOTOS USED**  
 March 1988  
 July 1987  
 March 1975  
 January 1964  
 February 1950



## MD-4: EAST SPRECKELSVILLE

### BEACH DESCRIPTION

- Spreckelsville Beach extends from the beach located at the end of Spreckelsville Road to Maui Country Club, a distance of two miles. This subsector extends from the offshore protective reef around Region 14 to the west end of the Maui Country Club.
- The east end of the subsector is a rocky shoreline devoid of a sandy beach.
- Rock revetments and seawalls have been built in front of a large number of residential homes.

### BACKSHORE

- The vegetation line is fairly well defined but has been stabilized and altered by shore protection structures.
- Residential homes line the shoreline. Public access is limited to the rocky point at the east end of the subsector.

### SHORELINE HISTORY

- All shore protection structures were built because of an eroding shoreline. All structures except for a single seawall were built after 1975.
- Region 15 is located between rock revetments along an unprotected shoreline. This beach is cyclic.

- A dirt embankment is present at Wawau Point and at the west end of the subsector. A wave cut scarp is present at both locations.

### SUMMARY

- The beaches in this subsector are generally eroding. Shore protection structures have been built to help stabilize the vegetation line.

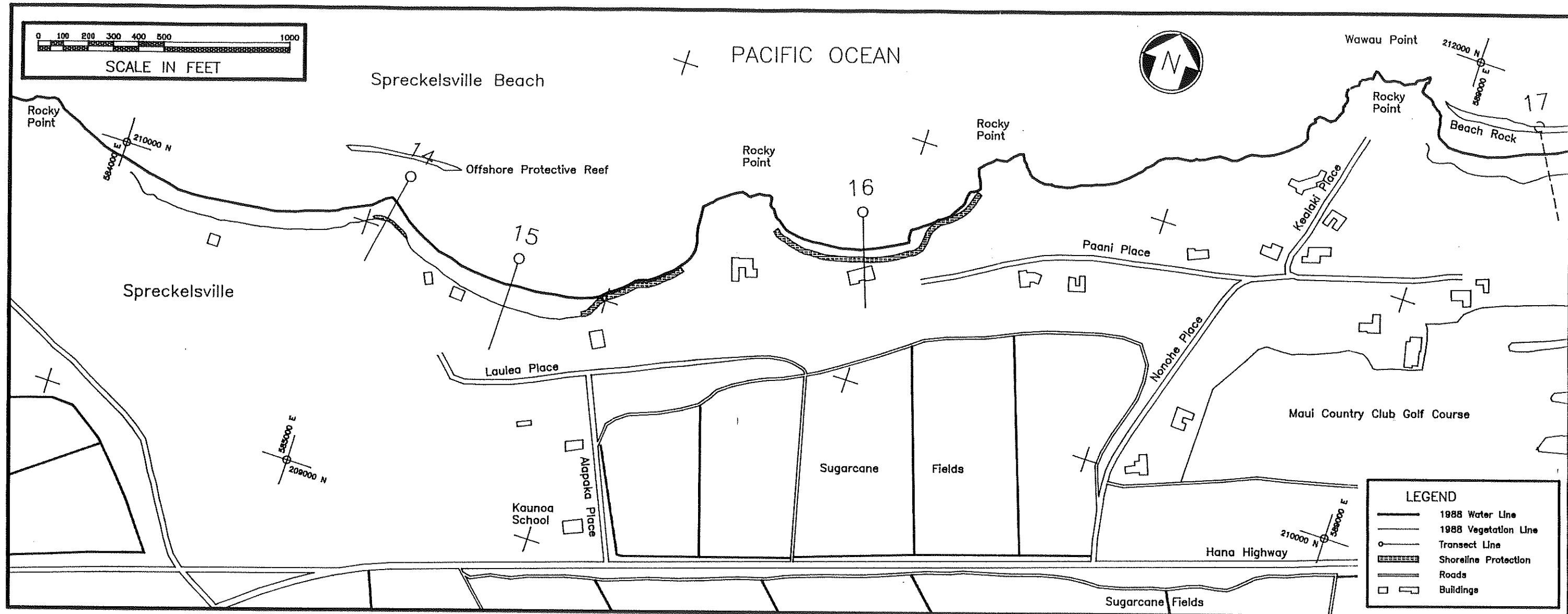
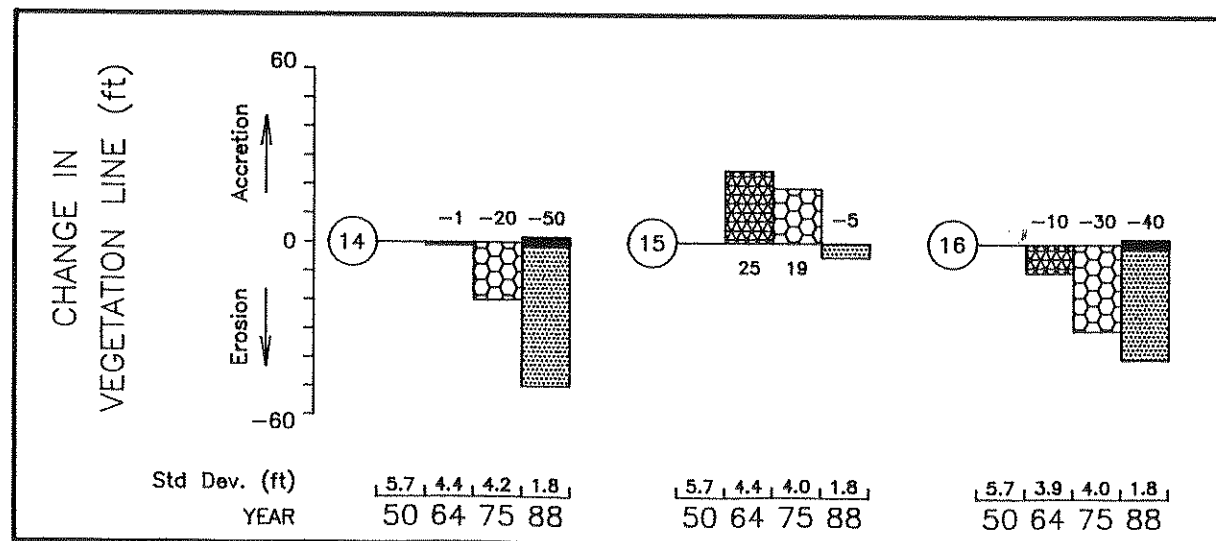


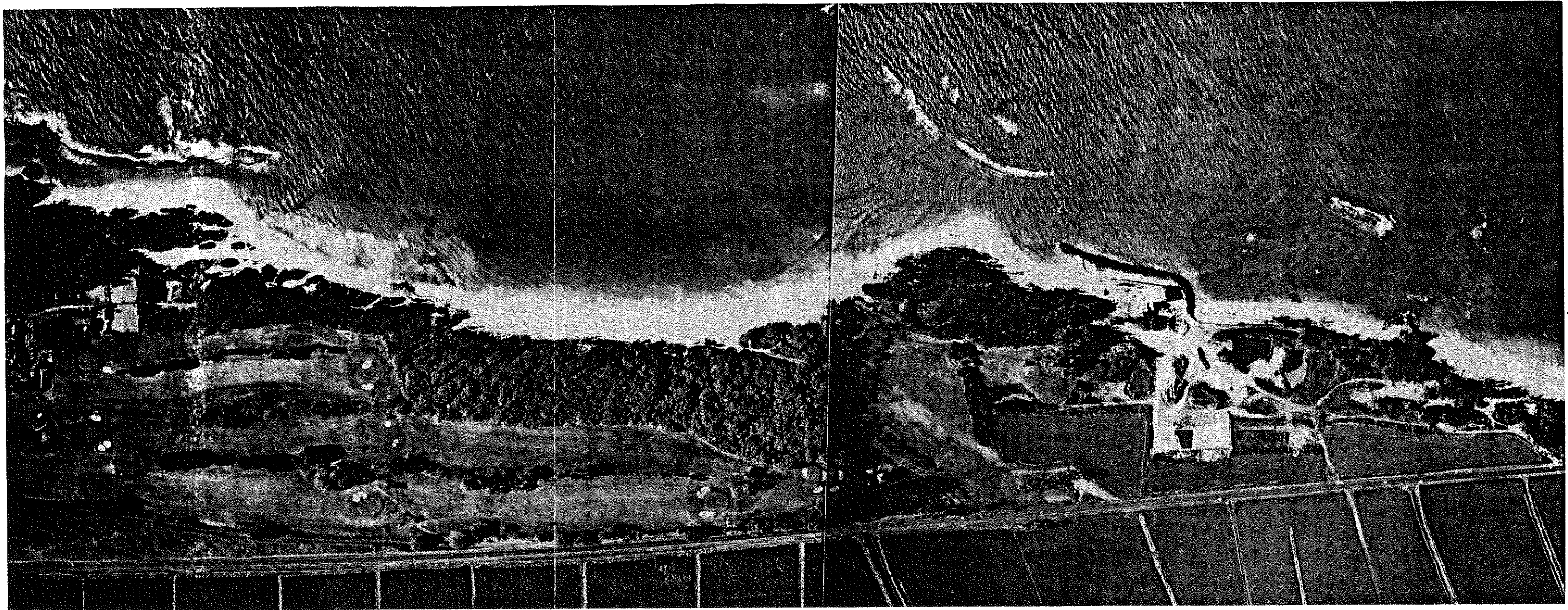
FIGURE MD-4



GRAPH MD-4 Region Number vs Change in Vegetation Line

PHOTOS USED  
 May 1988  
 July 1987  
 March 1975  
 January 1964  
 February 1950





## MD-5: WAWAU POINT TO BALDWIN PARK

### BEACH DESCRIPTION

- This subsector contains H. A. Baldwin Park, the most popular beach park on the windward side of Maui. It is a favorite for bodysurfers because of the consistent shorebreak.
- The beach is approximately 100 feet wide and is protected by offshore beach rock along portions of the subsector. A 900 foot long bench of beach rock, parallel to the shoreline, is located at the west end of the subsector. Another bench is located seaward of the cemetery just east of Baldwin Park. A third bench is located in Paia Bay.
- Other than the sheltered area landward of the offshore rock benches, the beach is unprotected from a north swell.

### BACKSHORE

- The vegetation line is well defined with only minor modifications due to development.

- The Maui Country Club golf course is located at the west end of the subsector.
- H. A. Baldwin Park is located just east of the country club and includes a baseball and soccer field, pavilions, picnic and cooking facilities, paved and unpaved parking, restrooms, and showers.
- The Hawaiian Commercial and Sugar Company lime kiln is located landward of a 650 foot long rock revetment located at the waterline. The revetment was built between 1950 and 1964. The kiln converts beach sand into a lime powder which is then used in processing sugar cane.

### SHORELINE HISTORY

- Some minor accretion is taking place landward of the beach rock in the vicinity of Region 17. Wawau Point, as well as the offshore beach rock, should act as an excellent sand trap to a westerly alongshore sediment transport. However, only minor accretion has occurred since 1950.

- Region 18 exhibits consistent erosion since 1964 and is directly exposed to the waves.
- Region 19 has experienced over 100 feet of erosion from 1950 to 1988. Since sediment transport is to the west, Region 19 is located downdrift of the rock revetment protecting the Hawaiian Commercial and Sugar Company lime kiln. The revetment has increased the localized erosion. The quantity of sand used in the lime conversion process is unknown. However, the kiln is probably contributing to the erosion shown at Region 19.

### SUMMARY

- There is a net westerly alongshore sediment transport in this subsector.
- The beach is, in general, eroding except for some minor accretion landward of the beach rock at the west end of the subsector.
- Region 20, located updrift of the lime kiln revetment, also shows minor erosion, though less than Region 19 by a factor of five.

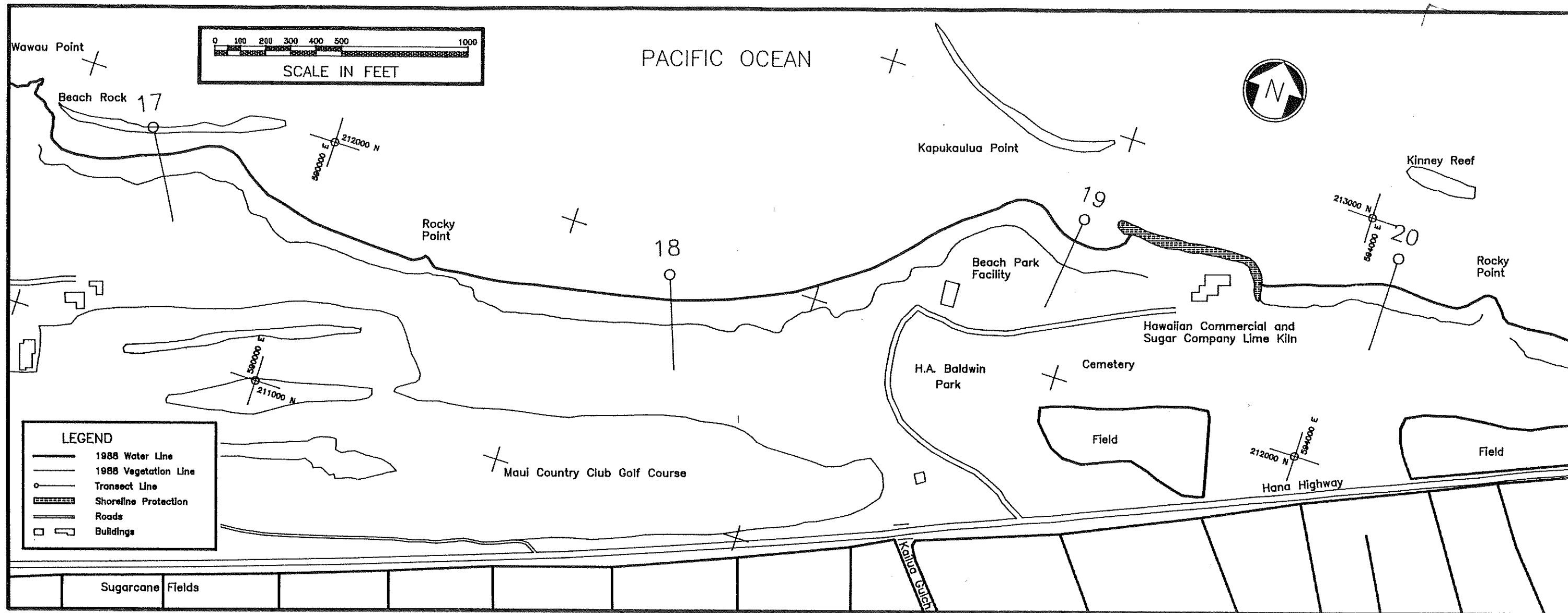
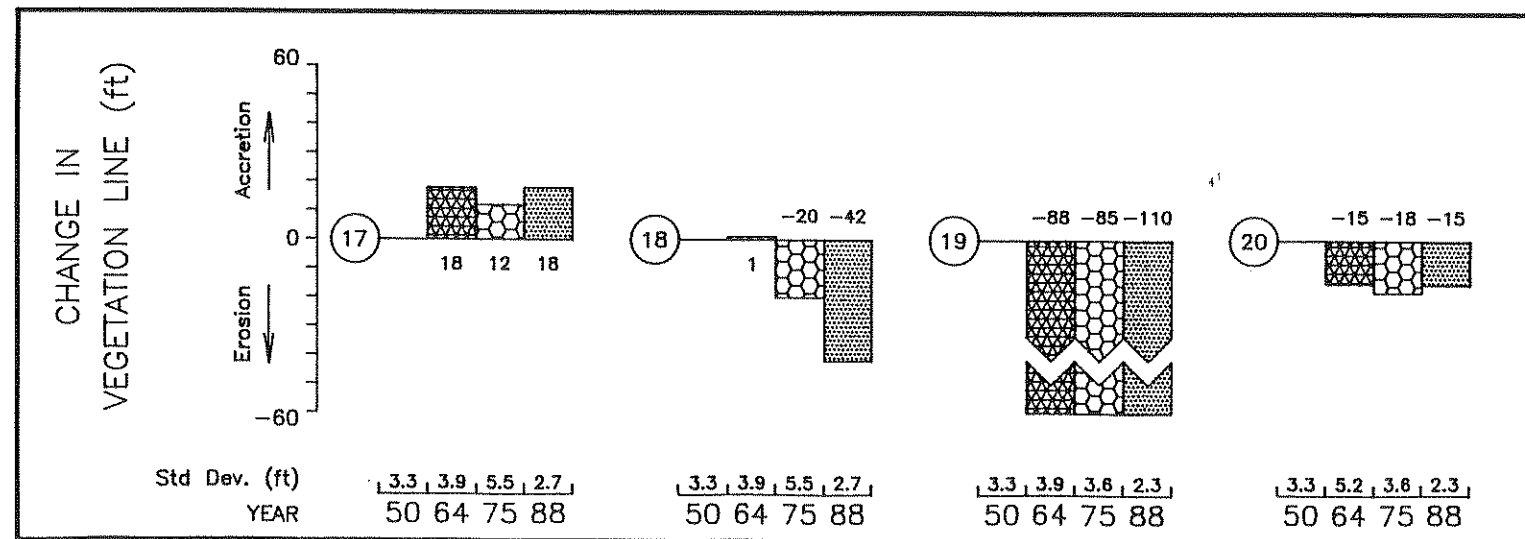


FIGURE MD-5



GRAPH MD-5 Region Number vs Change in Vegetation Line

PHOTOS USED  
 May 1988  
 July 1987  
 March 1975  
 January 1964  
 February 1950



## MD-6: LOWER PAIA AND KUAU BAY

### BEACH DESCRIPTION

- There are three sandy beaches within this subsector. The beach in front of Lower Paia Park is approximately 1800 feet long and 75 feet wide. The second beach, located within Mantokuji Bay, is 700 feet long. Kaulahao Beach is 600 feet long and protected by offshore, intermittent beach rock.
- The water offshore of these areas is often murky. The beach slope is steep, creating a strong shorebreak during large winter swells.
- Swimming is poor in both Mantokuji Bay and Kuau Bay because of a rocky bottom.

### BACKSHORE

- The vegetation line is well defined, although it has been modified slightly due to development.

- The backshore area is heavily developed with the residential areas of Lower Paia and Kuau.
- The Lower Paia Park is located at the west end of the subsector and includes restrooms, picnic tables, a lighted basketball court, a softball field, and a swing set.
- No public access is available to Mantokuji Bay or Kuau Bay.
- Backshore dirt embankments are exposed and wave cut scarps are present at Fly Water Point, at the point between Mantokuji Bay and Kaulahao, and at the east end of Kaulahao.

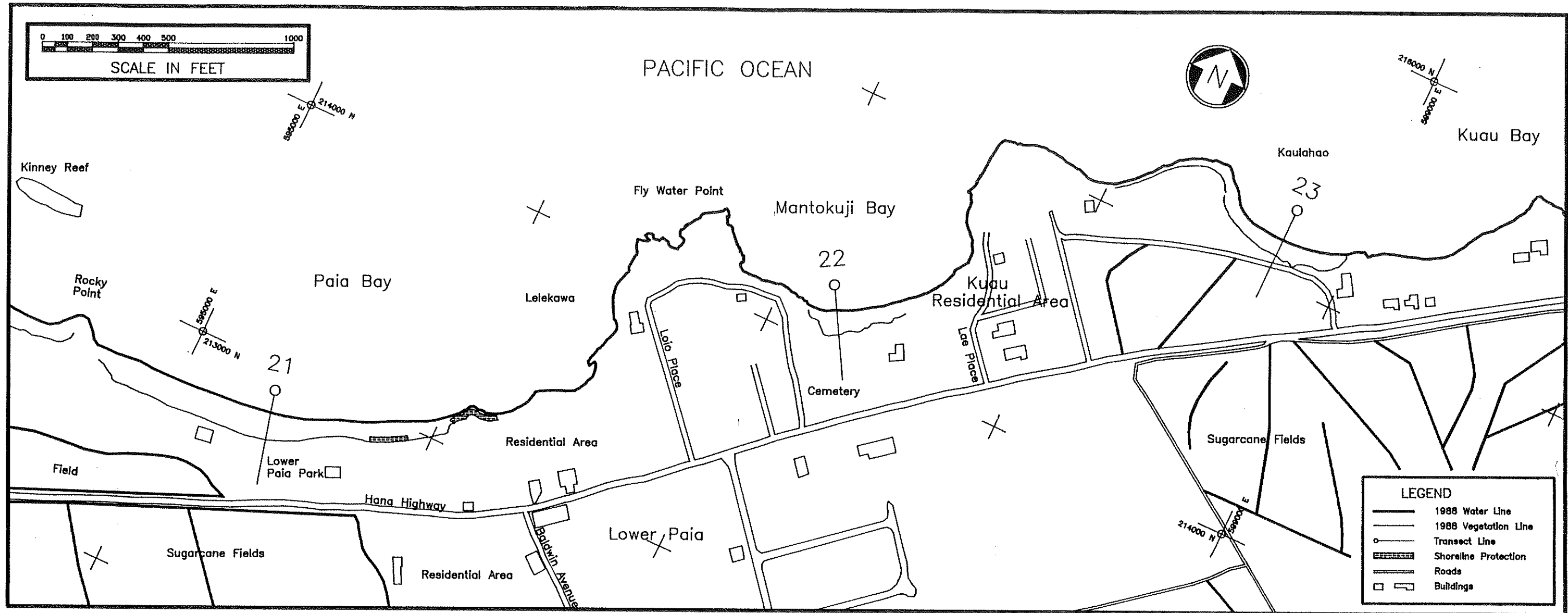
### SHORELINE HISTORY

- Region 21, located at Lower Paia Park, is a stable beach with cyclic periods of minor erosion and accretion.

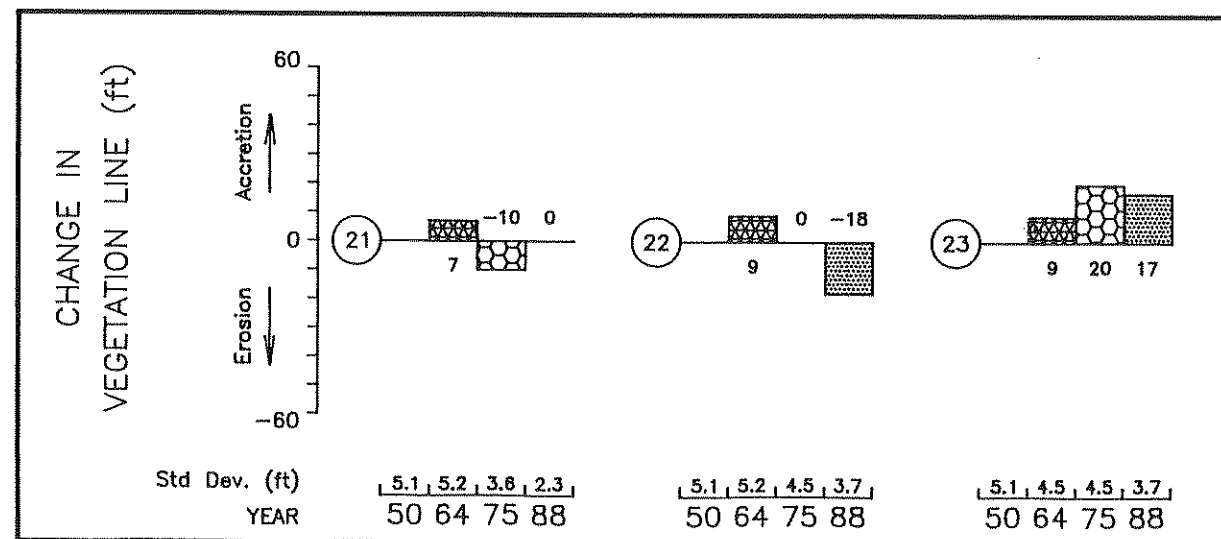
- Two low lying seawalls were built east of Region 21. They are hidden by the trees and, thus, the date of construction is unknown. Both areas show only minor changes.
- Region 22 is cyclic; the vegetation line has fluctuated only slightly.
- Region 23 is accreting slightly. This beach is protected by a beach rock bench along the entire shoreline.

### SUMMARY

- The beaches in this subsector are stable.
- The beach at Mantokuji Bay is a closed littoral system bounded by two rocky points.
- There are signs of erosion of the dirt embankment at the rocky points.



**FIGURE MD-6**



**GRAPH MD-6 Region Number vs Change in Vegetation Line**

**PHOTOS USED**  
 May 1988  
 July 1987  
 March 1975  
 January 1964  
 February 1950



**MD-7: EAST KUAU BAY TO HAMAKUA POKO POINT**

**BEACH DESCRIPTION**

- Four small pocket beaches comprise this subsector. A 200 foot long sandy beach is located at Tavares Bay and a 500 foot long sandy stretch is located at Ako Point. Father Jules Papa and Hamakua Poko Papa Beach are located to the east of Ako Point.
- Small and large rocks line the majority of the shoreline.
- A wide shelf of exposed reef, called a papa in Hawaiian, protects the beaches east of Ako Point.

**BACKSHORE**

- A private, residential area lines the shoreline west of Ako Point. There is no public access to these beaches.
- Ako Point is also lined with private residences with seawalls protecting some homes.

- Access to Father Jules Papa Beach is allowed over a privately owned, unpaved lot to the east of the sandy shoreline.
- The vegetation line is well defined.
- Wave cut scarps are evident in the dirt embankment along the rocky shoreline west of Tavares Bay, at Ako Point, at Father Jules Papa Beach, and east of Hamakua Poko Papa.

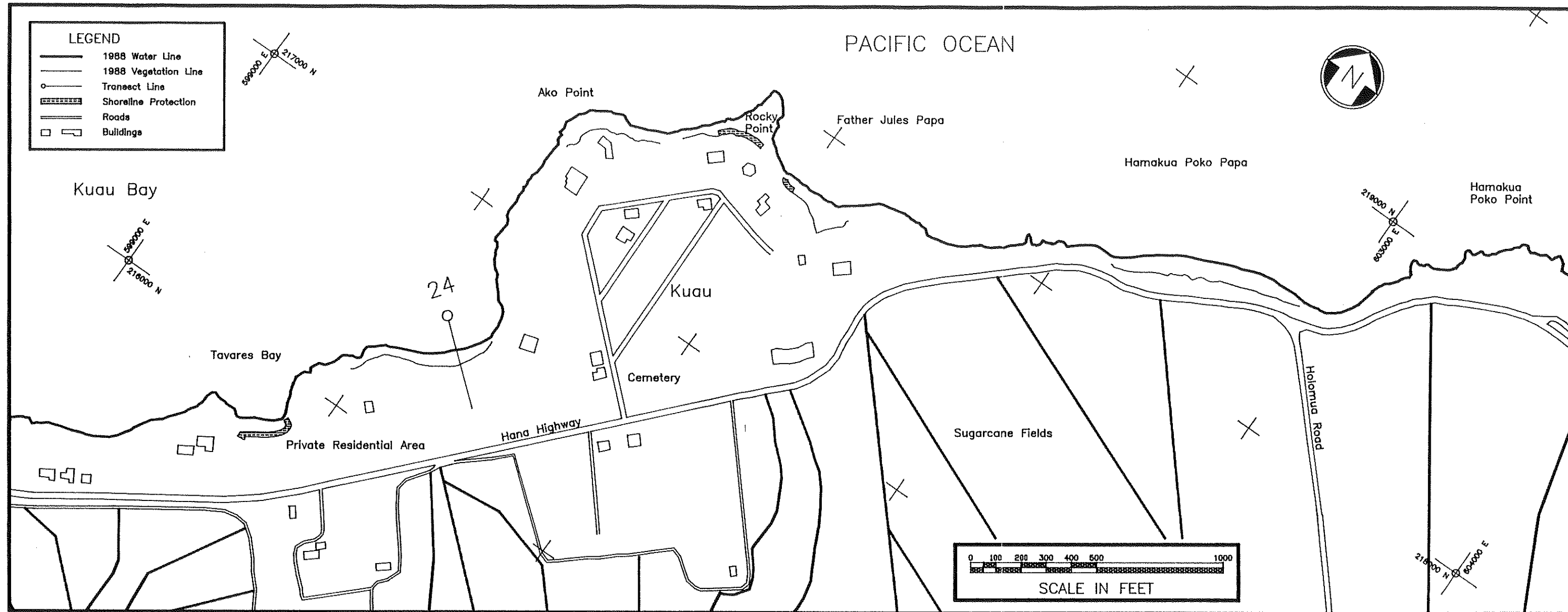
**SHORELINE HISTORY**

- The seawall located along the beach at Tavares Bay was built between 1950 and 1964, and has stabilized the shoreline. No historical data can be retrieved from the vegetation line.
- The sandy beach located at Ako Point is accreting slightly. There is a small volume of sand along this pocket beach. Slight accretion is also occurring in Region 24. The east end of the beach is lined with rock along the backshore area.

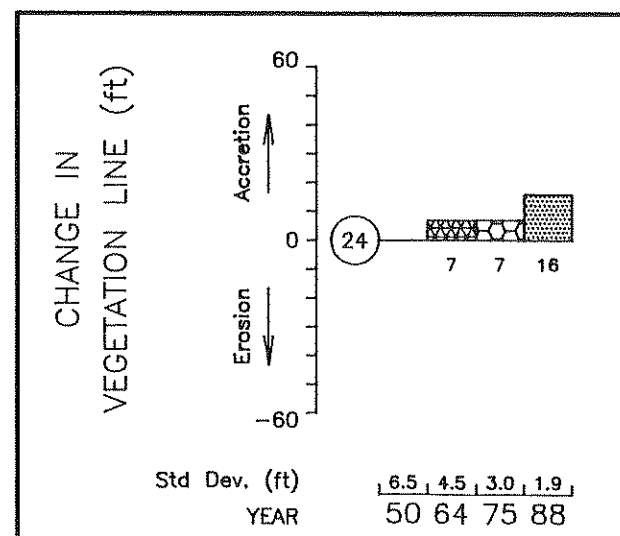
- The beach at Father Jules Papa is a small sandy area behind a reef shelf. This beach is not subject to daily littoral processes.
- The waterline at Hamakua Poko Point is also stabilized by a reef margin. The vegetation line has been stable since 1950 and has undergone only localized erosion and accretion. No general trends are evident.

**SUMMARY**

- There is some indication of wave cut erosion at the rocky points.
- The sandy areas are, in general, stable.



**FIGURE MD-7**



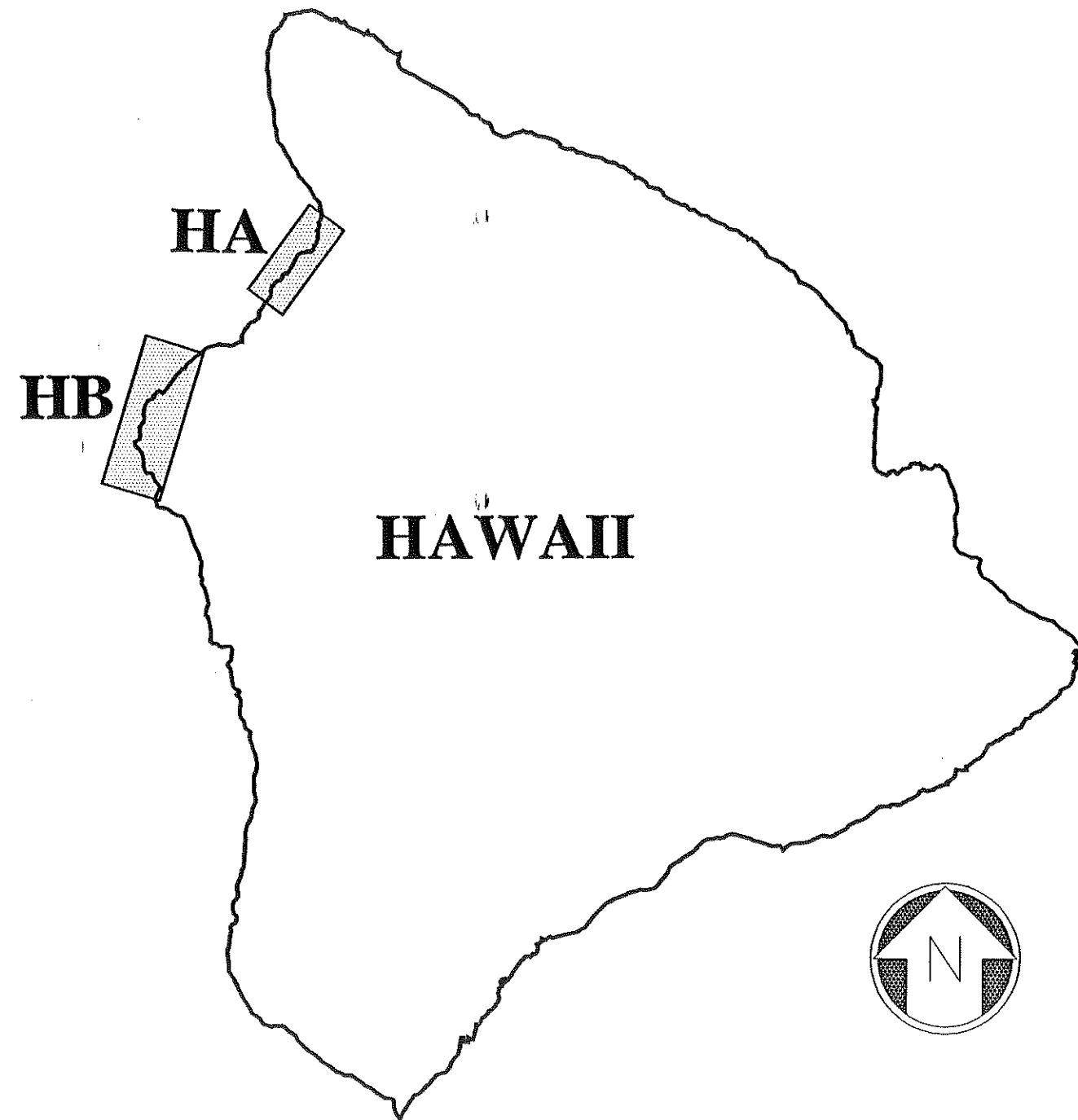
**GRAPH MD-7 Region Number vs Change in Vegetation Line**

**PHOTOS USED**  
 May 1988  
 July 1987  
 March 1975  
 January 1964  
 February 1950



## HAWAII

- **South Kohala**  
HA - Spencer Beach Park to Anaehoomalu Bay
- **North Kona**  
HB - Honokohau Beach to Kaupulehu Beach





## SECTOR HA: SOUTH KOHALA SPENCER BEACH PARK TO ANAEHOOMALU BAY

### GENERAL COASTAL CHARACTERISTICS

This sector consists of three unconnected reaches of coastline on the South Kohala coast of Hawaii from Anaehoomalu Bay to Kawaihae. There are three general shoreline types along this coast: rocky shoreline; sandy, pocket beaches; and perched beaches. The majority of the coast is rocky, formed by relatively recent lava flows. The sandy pocket beaches are located in small embayments formed by lava headlands. These beaches include the beach in Anaehoomalu Bay (1200 feet), Waialea Beach (1400 feet), Hapuna Beach (2000 feet), Kaunaoa Beach (1400 feet), and a number of others beaches less than 500 feet long. The perched beaches usually are located above the high tide line along rocky shores. They are generally formed during storms when large waves throw sand above the high tide line. Numerous tide pools and old fishponds are also found along the coast. The Mauna Lani Resort restored a complex of fishponds and integrated them into the resort development.

### LAND USE AND DEVELOPMENT

The backshore of this sector is characterized by a mix of large resorts, private residences, beach parks, and undeveloped tracts of land. The beach parks include Hapuna Beach Park, Spencer Beach Park and privately owned Parker Ranch Recreation Beach. The large resort hotels include the Royal Waikoloan, the Hyatt Regency Waikoloa, the Mauna Lani Bay, the Ritz-Carlton Mauna Lani, and the Mauna Kea Beach Hotel.

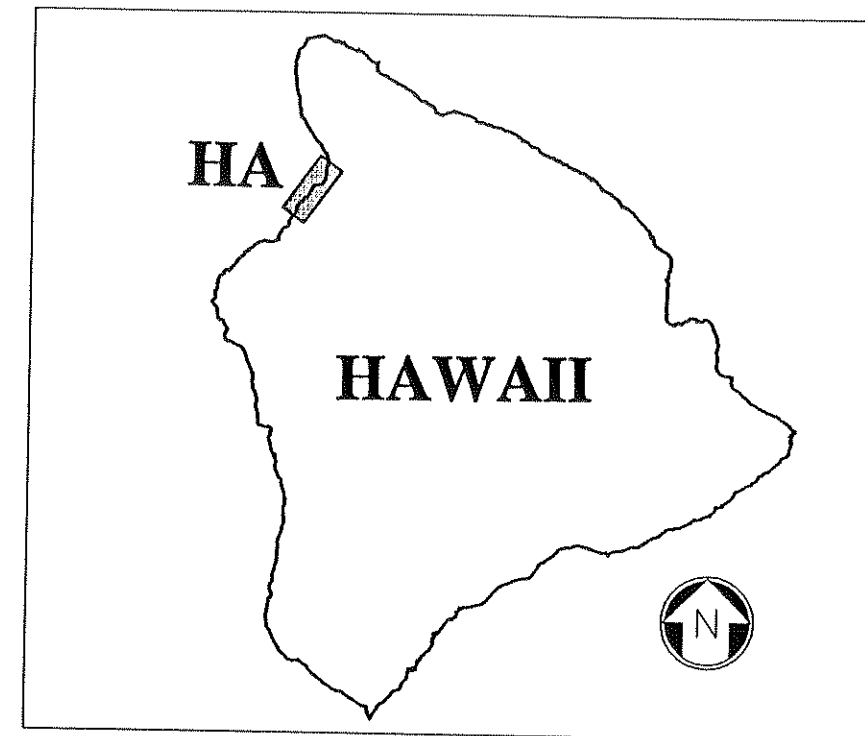
### WAVE CLIMATE

The South Kohala coastline is protected from the tradewind waves, but is exposed to north Pacific swells and Kona storm waves. A protective fringing reef is present only in the vicinity of Spencer Beach Park, near Kawaihae, and south of Puako Point.

### SHORELINE PROCESSES

The pocket beaches in this sector are bounded by rocky headlands, and are probably discrete littoral cells. As a result, the shoreline processes acting on the beaches vary. Most of the beaches have been relatively stable. Erosion has occurred along parts of Waialea Beach and Hapuna Beach. The major changes in the vegetation lines, however, have been a result of resort development.

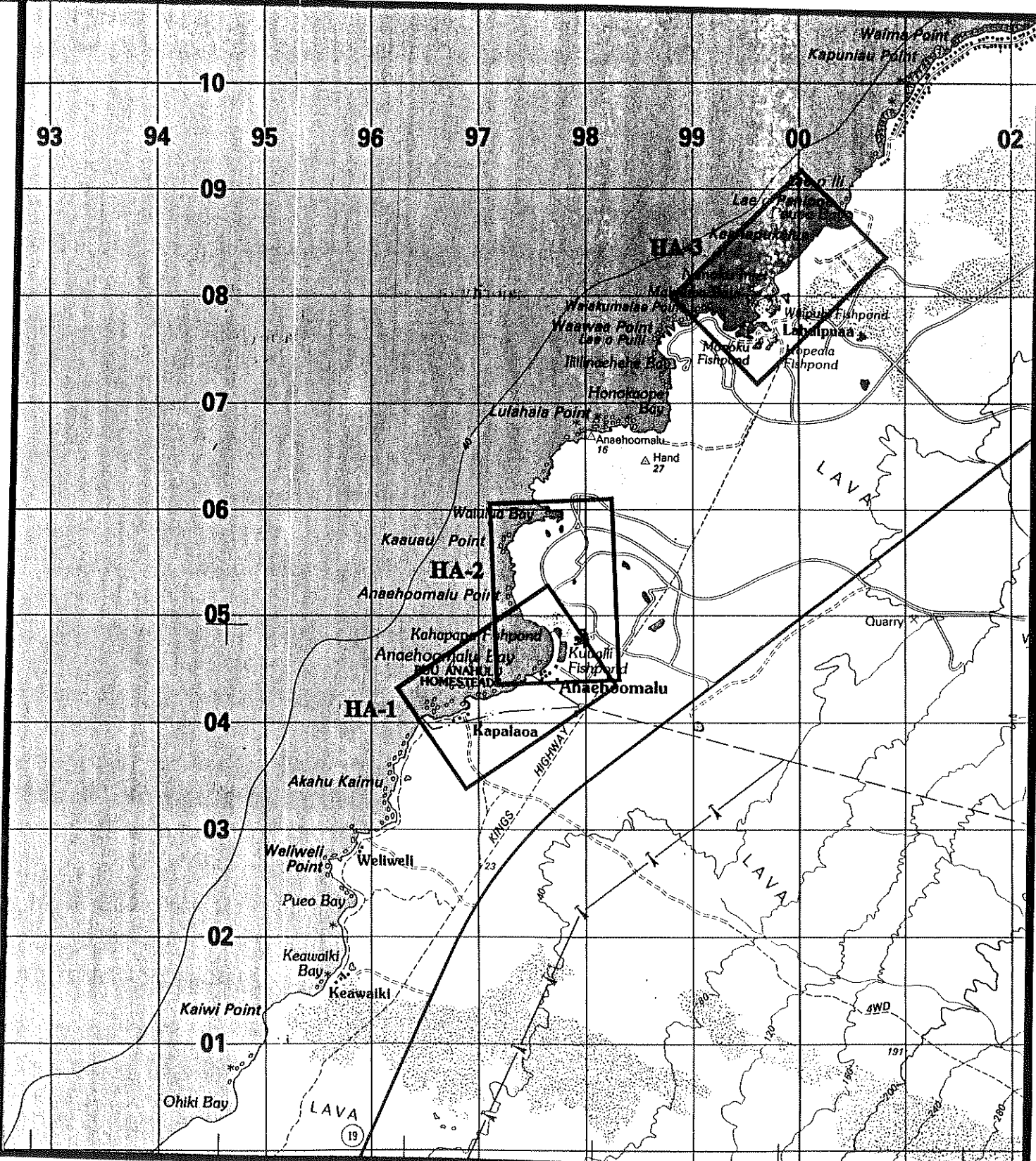
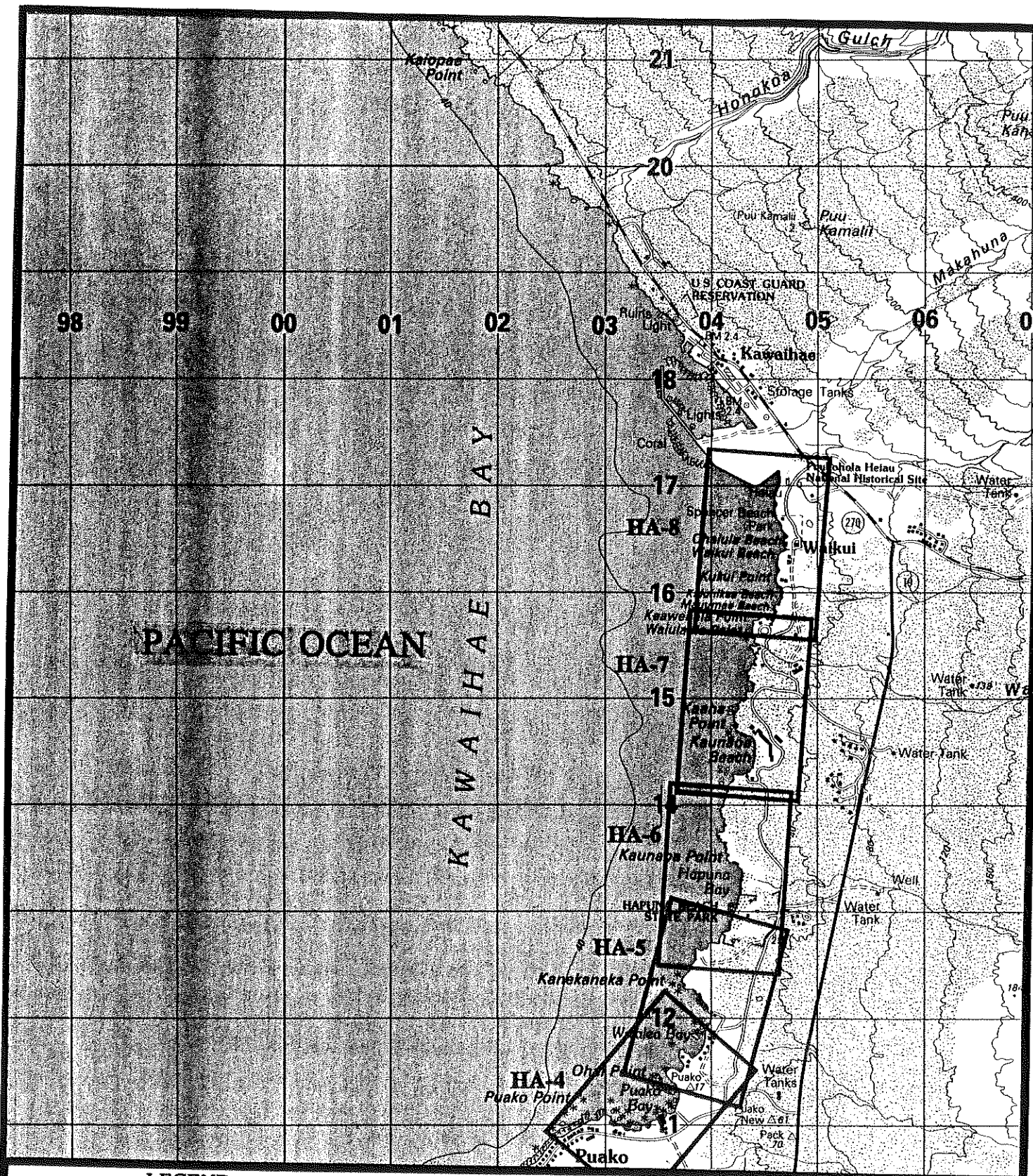
The perched beaches in the sector are stabilized by rocky shores. The vegetation lines along these beaches, therefore, probably reflect changes in rainfall or severe storm conditions.



### BEACH USAGE

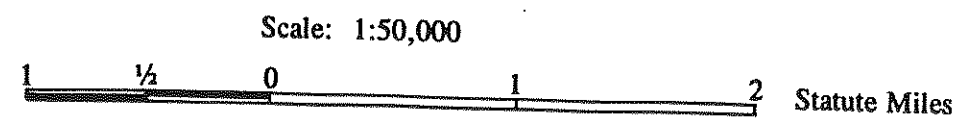
Hapuna Beach Park is the most popular and widely visited beach park on the Big Island. The water is excellent for swimming, snorkeling, and diving. Board surfing is not permitted. During the winter months, high surf, strong rip currents and the lack of professional lifeguard coverage result in extremely hazardous conditions at this beach.

Spencer Beach Park is also popular. A shallow reef offshore shelters the beach area, and hazardous conditions occur only in severe storms. The other beaches in the sector are also widely used by both resort guests and the public.



**LEGEND**  
 HYDROGRAPHIC DATUM ..... MEAN LOWER LOW WATER

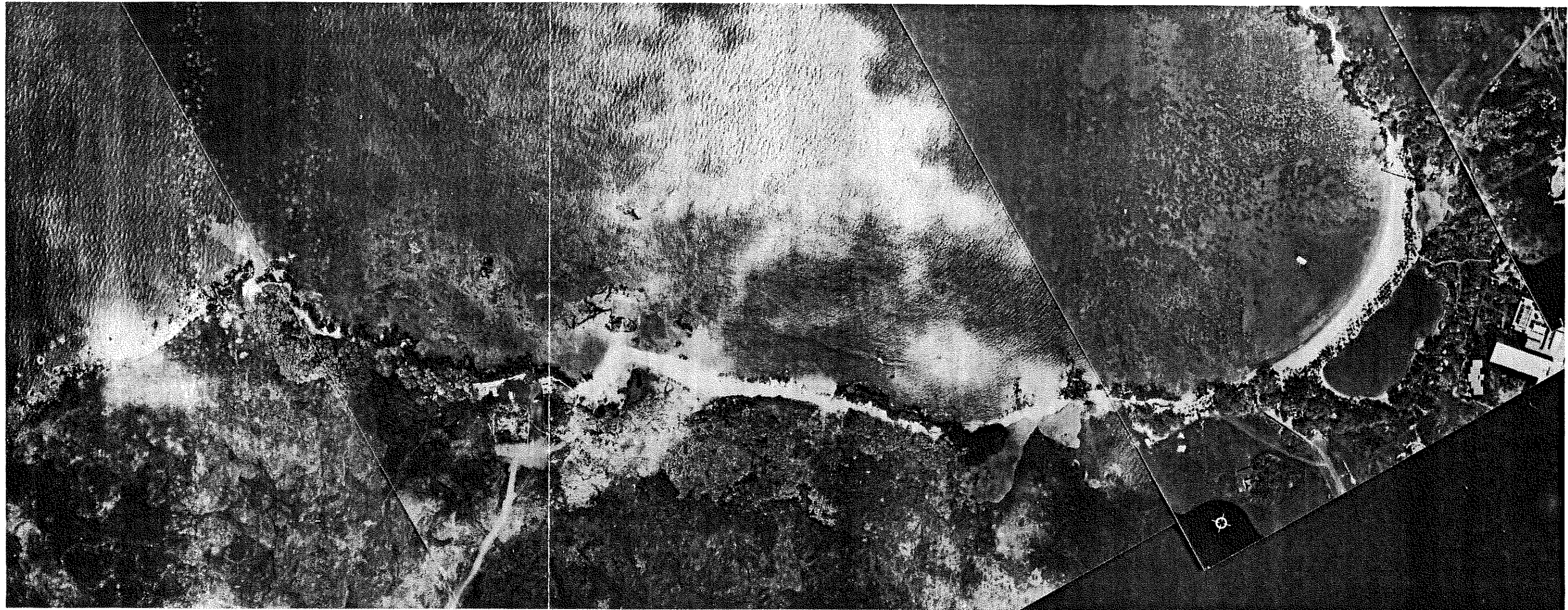
- Depth curve (meters) \_\_\_\_\_
- Foreshore flats \_\_\_\_\_
- Rocks awash, Reef \_\_\_\_\_
- Wreck, Exposed, Sunken with masts exposed \_\_\_\_\_
- Wharf, pier \_\_\_\_\_
- Seawall \_\_\_\_\_
- Dredging rig \_\_\_\_\_



From U.S. Geological Survey  
 MAP INFORMATION AS OF 1983



**SOUTH KOHALA**  
 Spencer Beach Park to Anaeohomalu Bay



## HA-1: ANAEHOOMALU BAY

### BEACH DESCRIPTION

- At the end of Anaehoomalu Bay, there is a 1200 foot long crescent-shaped, white sandy beach.
- Two fishponds, Kuualii and Kahapapa, are located in the backshore area. The Royal Waikoloan is located landward of the ponds.
- South of Kuualii fishpond is Parker Ranch Recreation Beach, a private beach park for employees of Parker Ranch. A white, sandy beach, with intermittent basaltic rock outcrops, extends south to the Puu Anahulu Homesteads.

### BACKSHORE

- The backshore area has a well defined vegetation line comprised of palm trees, grass and kiawe trees. A low lying shoreline is present in front of the Puu Anahulu Homestead area and in front of Kahapapa and Kuualii fishponds.

- Beach access as well as public parking is provided immediately south of The Royal Waikoloan Hotel. The small park complex provides restroom facilities, showers and picnic tables.

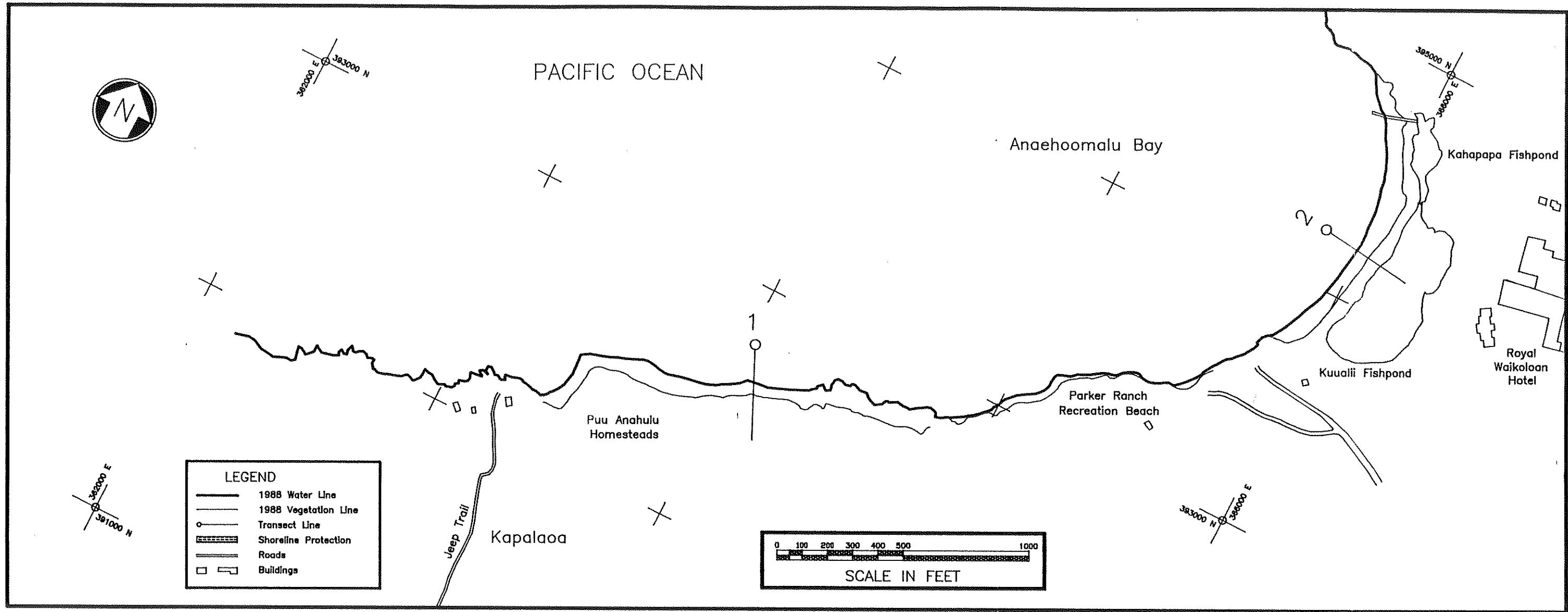
### SHORELINE HISTORY

- A basaltic outcrop breaches the water surface offshore of the Puu Anahulu Homestead located at the south end of the subsector. Waves diffract around the end of the offshore outcrop causing a tombolo. Although the waterline does not appear to have changed, the vegetation line has.
- The beach from Region 1 to the Parker Ranch Recreation Beach shows a general trend of accretion.
- The vegetation line east each of the Parker Ranch Recreation Beach was difficult to discern from the historical photos.

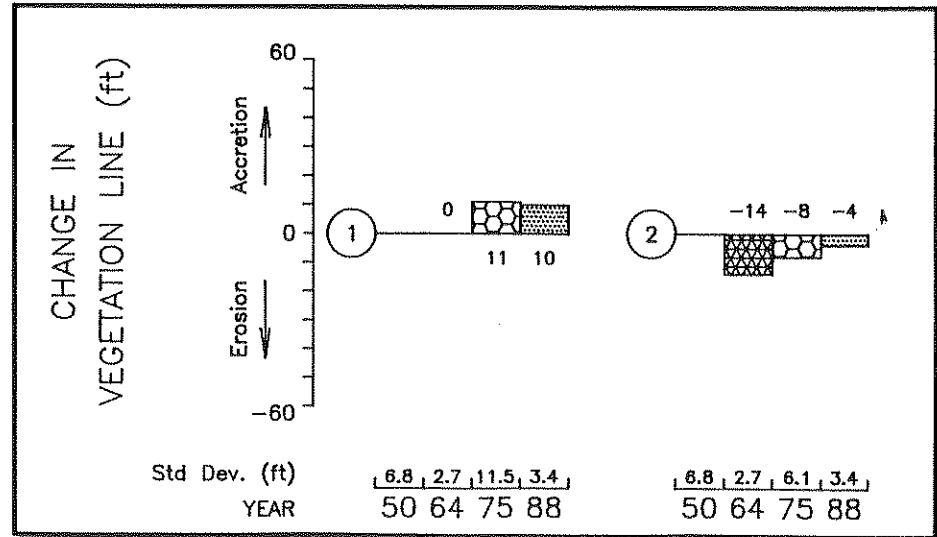
- Region 2 is fairly stable, showing net erosion of only 4 feet.
- An aqueduct is located perpendicular to the beach at the north end of the Kahapapa Fishpond. It appears to circulate ocean water into Kahapapa Fishland. It acts as a natural barrier to the alongshore sediment transport and shows that net transport is to the south.

### SUMMARY

- This is a stable beach with no apparent major changes in the vegetation line.
- Portions of the beach to the west of Parker Ranch Recreation Beach consist of perched beaches behind a basaltic outcrop.
- The waters of Anaehoomalu Bay provide good water recreational opportunities.



**FIGURE HA-1**



**GRAPH HA-1 Region Number vs Change in Vegetation Line**

**PHOTOS USED**  
 May 1988  
 July 1987  
 June 1975  
 July 1964  
 March 1950



## HA-2: KAHAPAPA FISHPOND TO KAAHAU POINT

### BEACH DESCRIPTION

- The subsector north of Kahapapa Fishpond to Kaauau Point consists of a mostly perched beach with a basaltic rock ledge breaching the water surface.
- The beach consists primarily of calcareous sand with basaltic cobbles at the high waterline.
- The water recreational activities are somewhat limited in the area.

### BACKSHORE

- The Royal Waikoloan Hotel is located at the south end of the subsector and the Hyatt Regency Waikoloa at the north end. The area between the two resorts is undeveloped and consists primarily of a lava field.

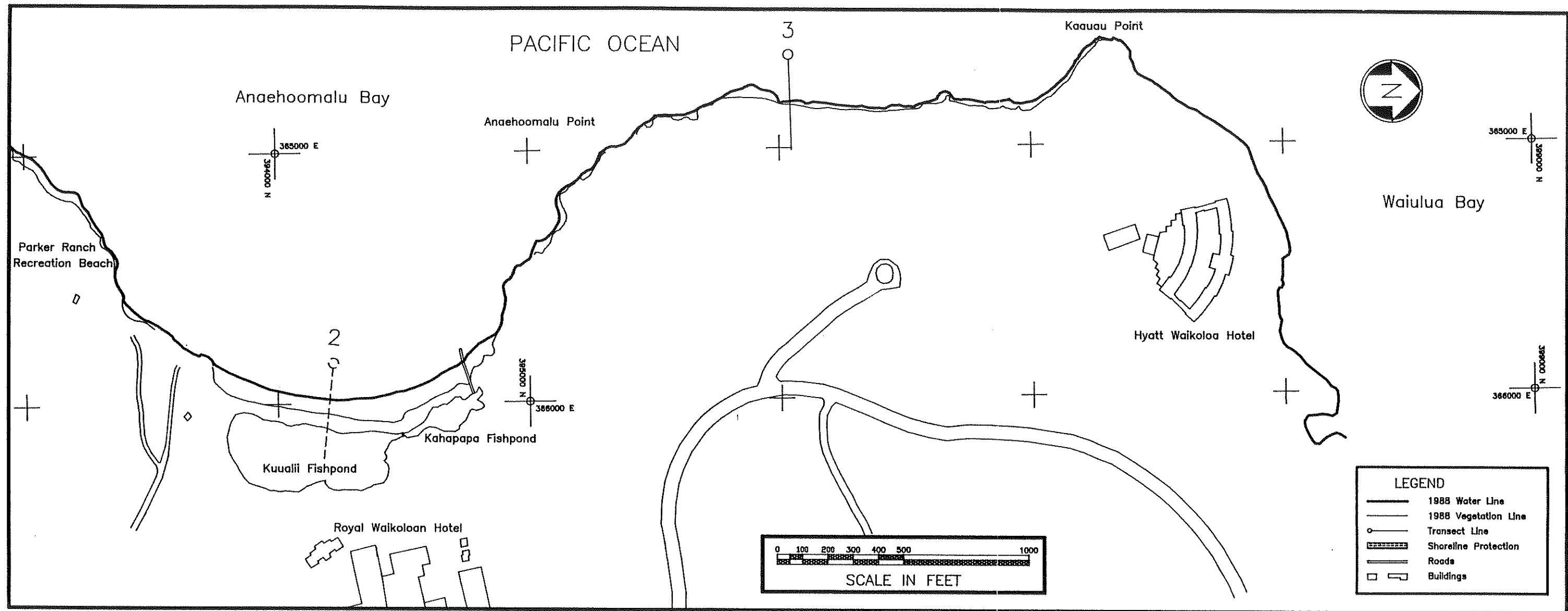
- The vegetation line is sparse and broken by the lava field which, in places, extends into the ocean.

### SHORELINE HISTORY

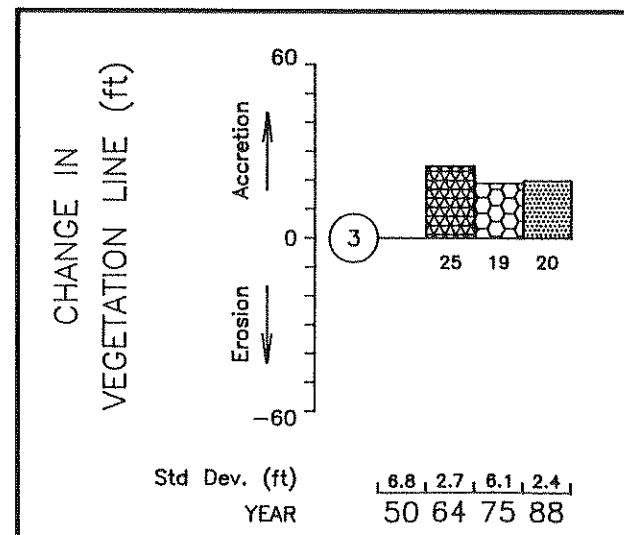
- Region 3, located in the central portion of the subsector, is characteristic of this beach. It is a perched beach with a stable waterline because of the basaltic outcrop at the waterline. The vegetation line has moved seaward since 1950 indicating a narrowing of the beach.
- The north end of the subsector shows a tendency towards a narrowing beach.

### SUMMARY

- This is a perched beach. The basalt outcrop stabilizes the waterline. The vegetation line only indicates if the beach is narrowing or widening. Changes in the vegetation line probably reflect seasonal rainfall or recent storm activity, rather than general wave climate and coastal conditions.

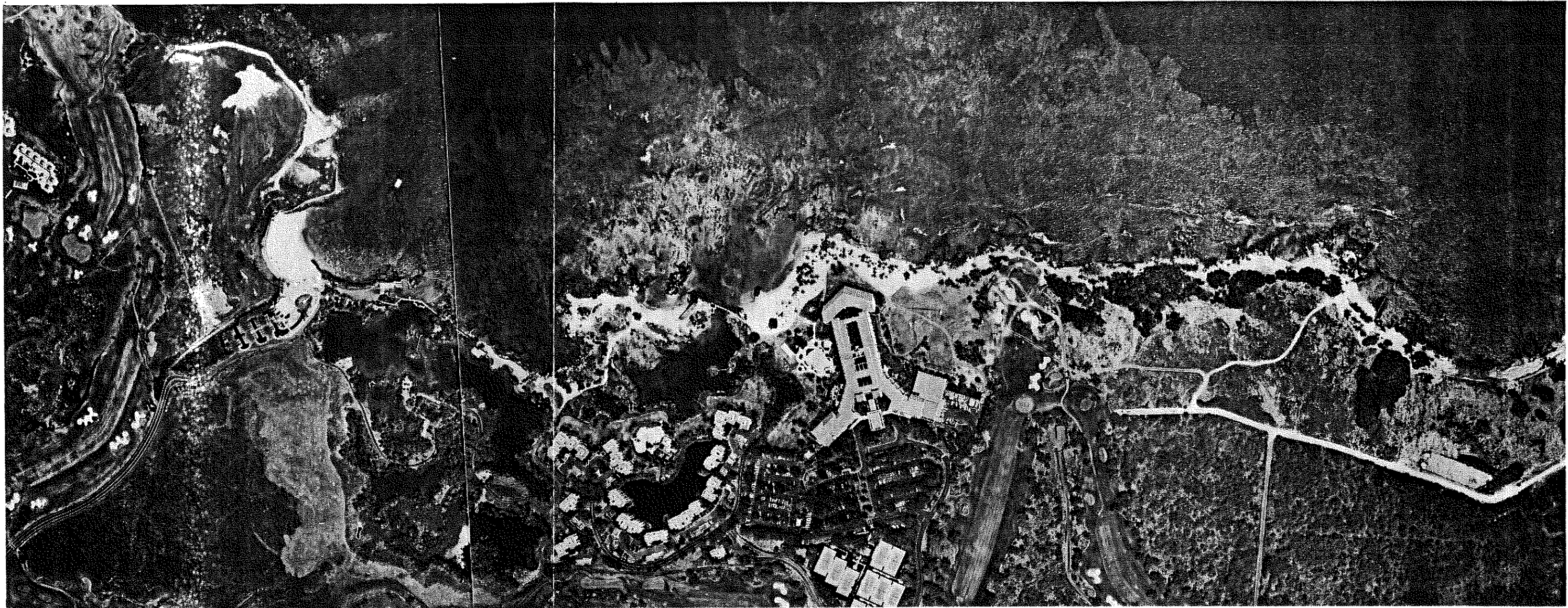


**FIGURE HA-2**



**GRAPH HA-2 Region Number vs Change in Vegetation Line**

**PHOTOS USED**  
 May 1988  
 July 1987  
 June 1975  
 July 1964  
 March 1950



### HA-3: WAIAKUMALAE POINT TO PAUOA BAY

#### BEACH DESCRIPTION

- This subsector extends from Waiakumalae Point to Pauoa Bay.
- The Mauna Lani Resort is located at the south end of the subsector and extends approximately 3000 feet along the shore. Additional buildings have been constructed since 1988 including a restaurant and luxury bungalows north of the hotel.
- The construction of the Ritz-Carlton Mauna Lani began in 1988, and the hotel is now open. It is located at the north end of the subsector at Pauoa Bay.
- Beaches in this area have been modified by the resorts. The beach between the two resorts is primarily calcareous sand mixed with terrogenous material, and interspersed with basaltic outcrops breaching the water surface.

#### BACKSHORE

- The Mauna Lani Resort has extensively modified the backshore area. In 1972, Mauna Lani Resorts purchased the land, improved the fishponds and integrated them into the resort development. The

resort consists of the luxury bungalows, the Mauna Lani Bay Hotel, the Mauna Lani Terrace and new construction at Waiakumalae Point. Golf courses have been built on top of lava fields.

- Palm trees have been planted seaward of the natural vegetation line at both the Mauna Lani resort and the Ritz-Carlton Mauna Lani.
- A low-level seawall is present in front of the Mauna Lani Bay Hotel, Waipuhi Fishpond and Kalahuipuaa Fishpond.
- A rock revetment is located just north of the public beach, and a seawall is located at the waters edge, west of the beach.

#### SHORELINE HISTORY

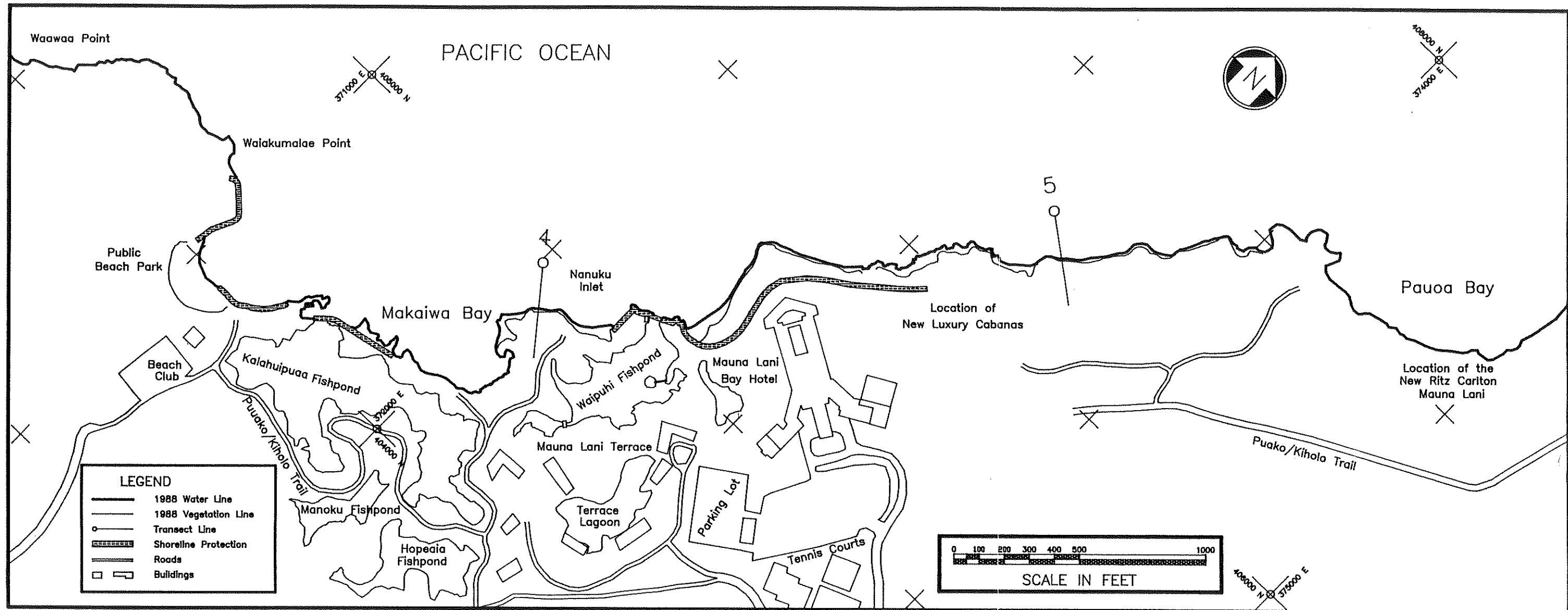
- Beach fill has been used to create a beach at the public beach. This occurred between 1964 and 1975.
- The sandy area from Nanuku Inlet to Makaiwa Bay is mostly a perched beach with a stable waterline and slightly cyclic vegetation line as shown in Region 4.
- The vegetation line has changed 100 feet from 1950 to 1964 at Nanuku Inlet. The inlet is sheltered by an offshore basaltic outcrop and a similar trend is not evident just south of the inlet. The

vegetation line change was probably caused by man.

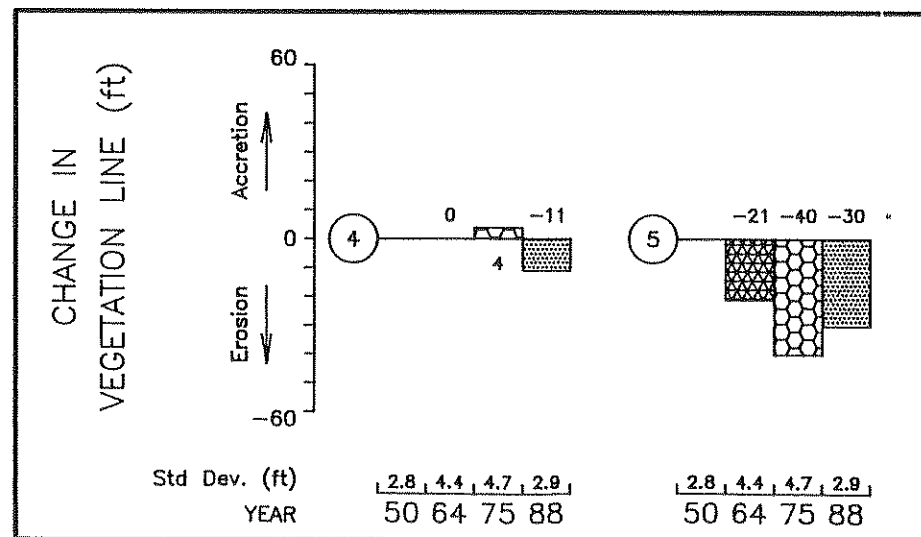
- The beach in front of the Mauna Lani Bay Hotel shows signs of accreting since 1950 but these changes are strictly due to man's intervention.
- North of the new luxury bungalows the beach is, in general, eroding. Region 5 indicates up to 30 feet of erosion.

#### SUMMARY

- Few definitive conclusions can be drawn about the beach fronting the Mauna Lani Resort. Beach fill as well as shore protection structures have been placed to help stabilize the beach. The vegetation line has also been altered.
- The beach between the Mauna Lani Bay Hotel and the Ritz-Carlton Mauna Lani is, however, definitely eroding. The oblique photos show the bases of palm trees being undercut and many trees falling over. A site visit verified this conclusion.



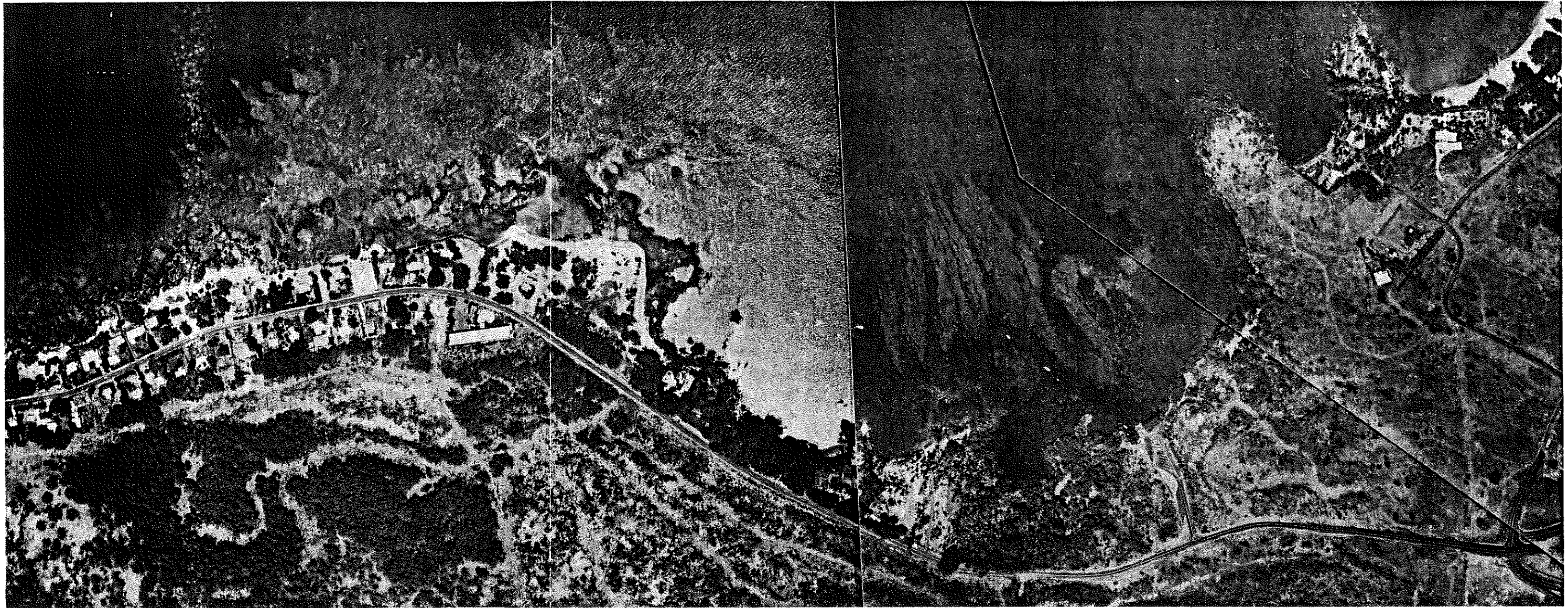
**FIGURE HA-3**



**GRAPH HA-3 Region Number vs Change in Vegetation Line**

**PHOTOS USED**  
 May 1988  
 July 1987  
 June 1975  
 July 1964  
 March 1950





**HA-4: PUAKO BOAT RAMP**

**BEACH DESCRIPTION**

- A sandy beach is not present in this subsector. A rocky shoreline with the vegetation located at the waterline is present from Puako Boat Ramp to Ohai Point.
- A sandy reach is present at the west end of the subsector and is sheltered by a basaltic rock bench present above the water surface. This area is not subject to typical littoral processes. The point appears to be the location of an old fishpond which has since filled in with sand. The 1950 photo is overexposed and the limits of the pond are not evident. In the 1964 photo, the pond is evident but the vegetation line is already encroaching on the pond.

**BACKSHORE**

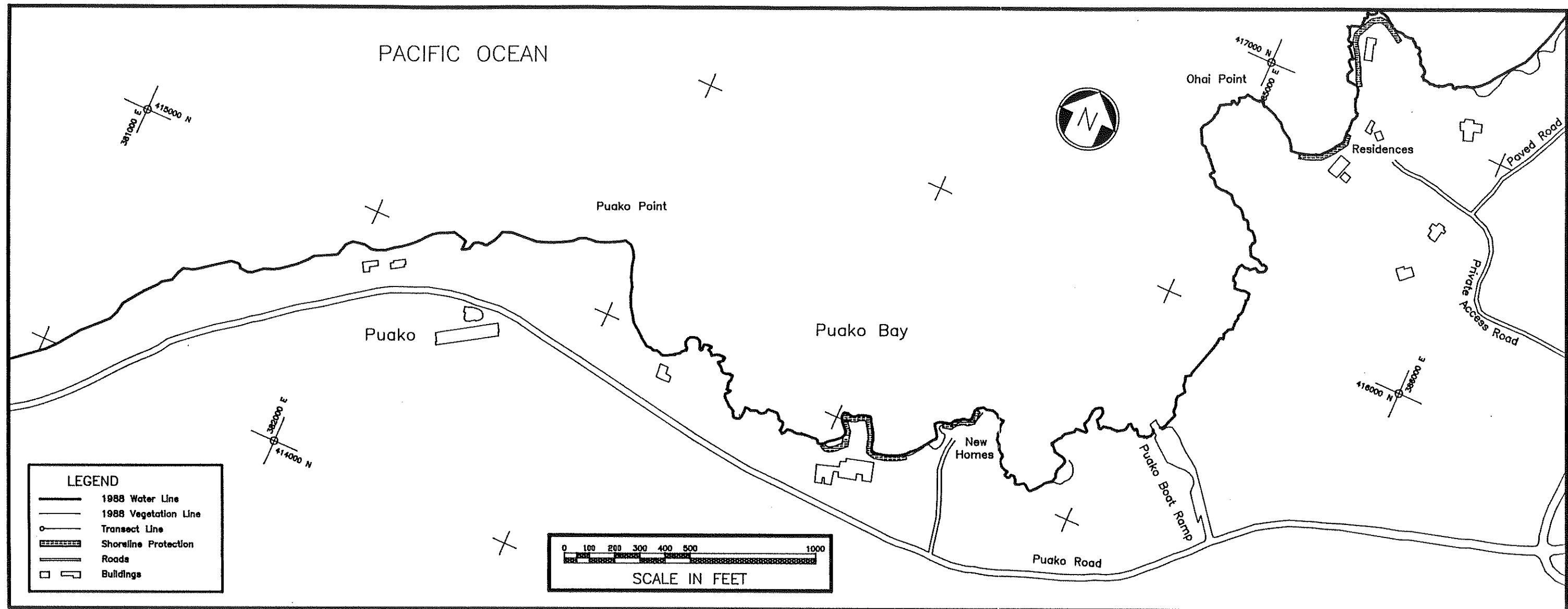
- A well defined vegetation line is present along the majority of the subsector consisting of grass, kiawe and palm trees.
- Public access to the area is provided at Puako Boat Ramp and six right of ways along Puako Road. Water, paved trailor and car parking, and trash cans are present at the boat ramp.
- Numerous private residences line the shoreline with some built since 1988. Many of the homeowners have constructed seawalls which have stabilized the vegetation line.

**SHORELINE HISTORY**

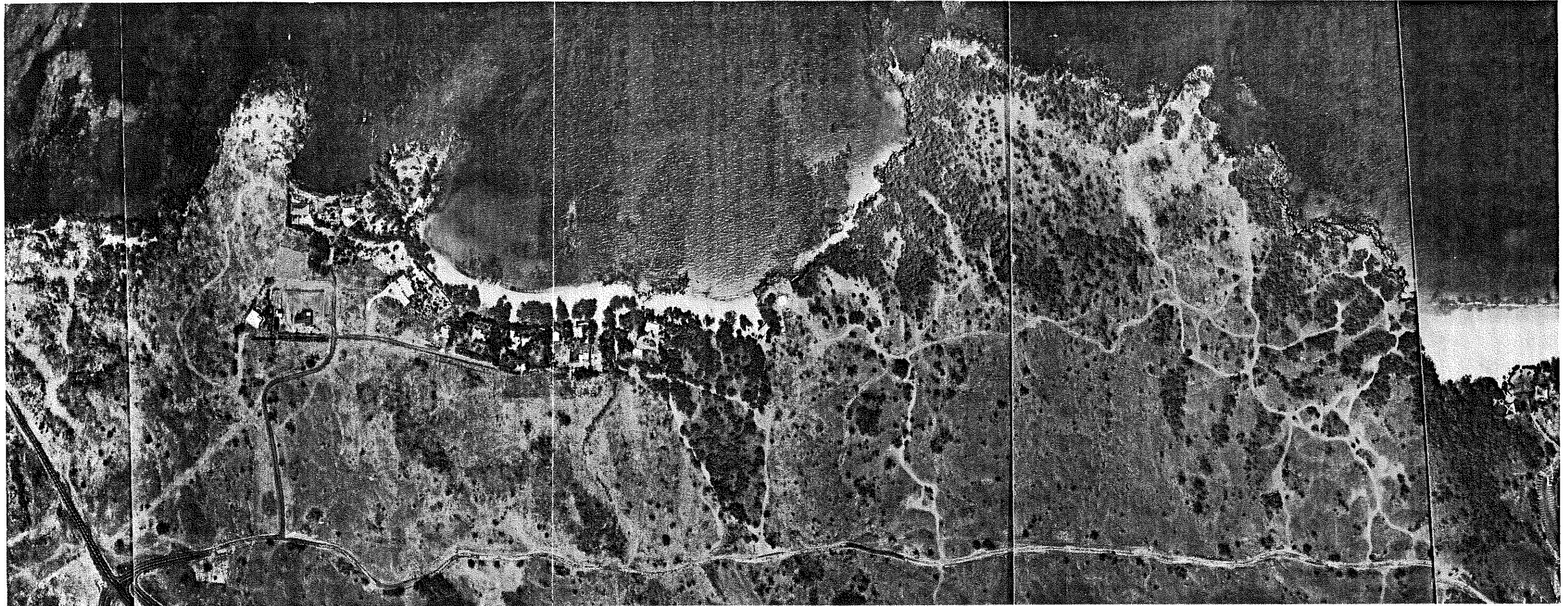
- No beach is present in this subsection.

**SUMMARY**

- The oblique photos also show a scarp in the dirt embankment adjacent to Puako Boat Ramp with some fallen trees. No beach is present at this location and the vegetation line is located right at the waterline.



**PHOTOS USED**  
 May 1988  
 July 1987  
 June 1975  
 July 1964  
 March 1950



**HA-5: WAIALEA BAY**

**BEACH DESCRIPTION**

- Waialea Beach is a 1400 foot long, approximately 50 foot wide, stretch of calcareous sand and located between two rocky points. The thin layer of sand is eroded during the large winter surf exposing basaltic rock below.
- Waialea is commonly referred to as Beach 69 because the closest utility pole to the dirt road leading to Waialea is numbered 69 (Clark 1986).
- Waialea provides excellent water recreational opportunities. The beach slopes gently into deeper water offshore. The beach is a favorite sailing location because of the favorable wind and offshore conditions.

**BACKSHORE**

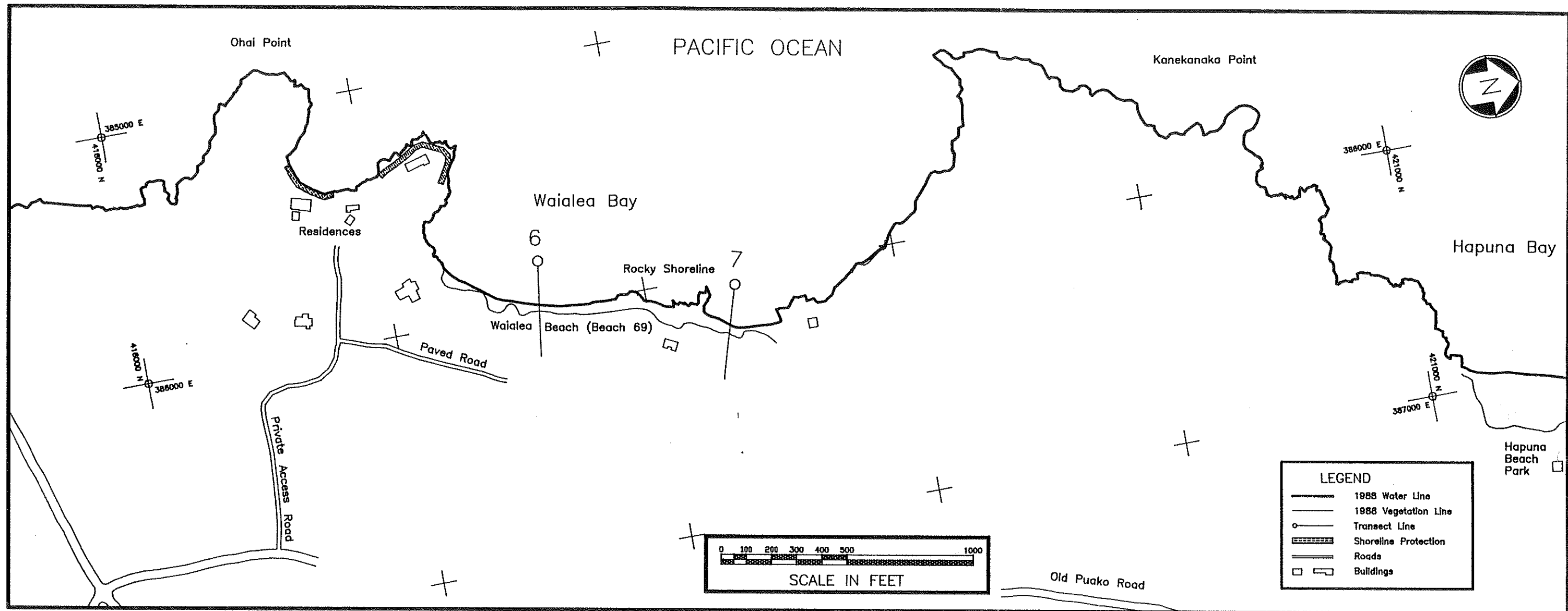
- The vegetation line consists primarily of kiawe trees which have been thinned by the construction of new homes along the beach.
- The beach is accessed by a dirt road. An unpaved parking lot and a portable toilet are the only facilities.

**SHORELINE HISTORY**

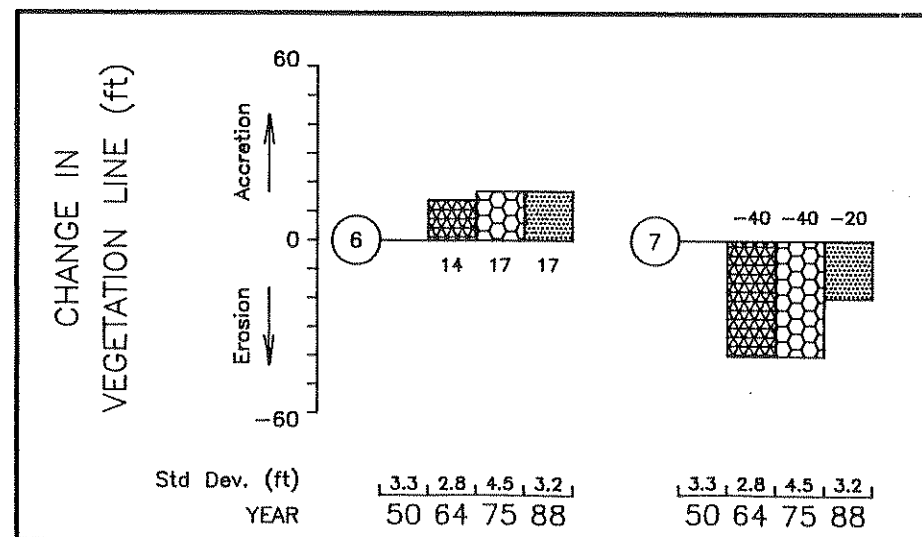
- The only meaningful vegetation lines are located at Waialea Beach.
- The center of the beach is stabilized by a rocky shoreline. Region 7, located to the north of the rocky shoreline, has eroded, while Region 6 to the south has accreted.

**SUMMARY**

- Waialea Beach is a dynamic beach with seasonal changes in the shoreline. There was a net transport of sand to the south that resulted in erosion in Region 7 and accretion in Region 6.

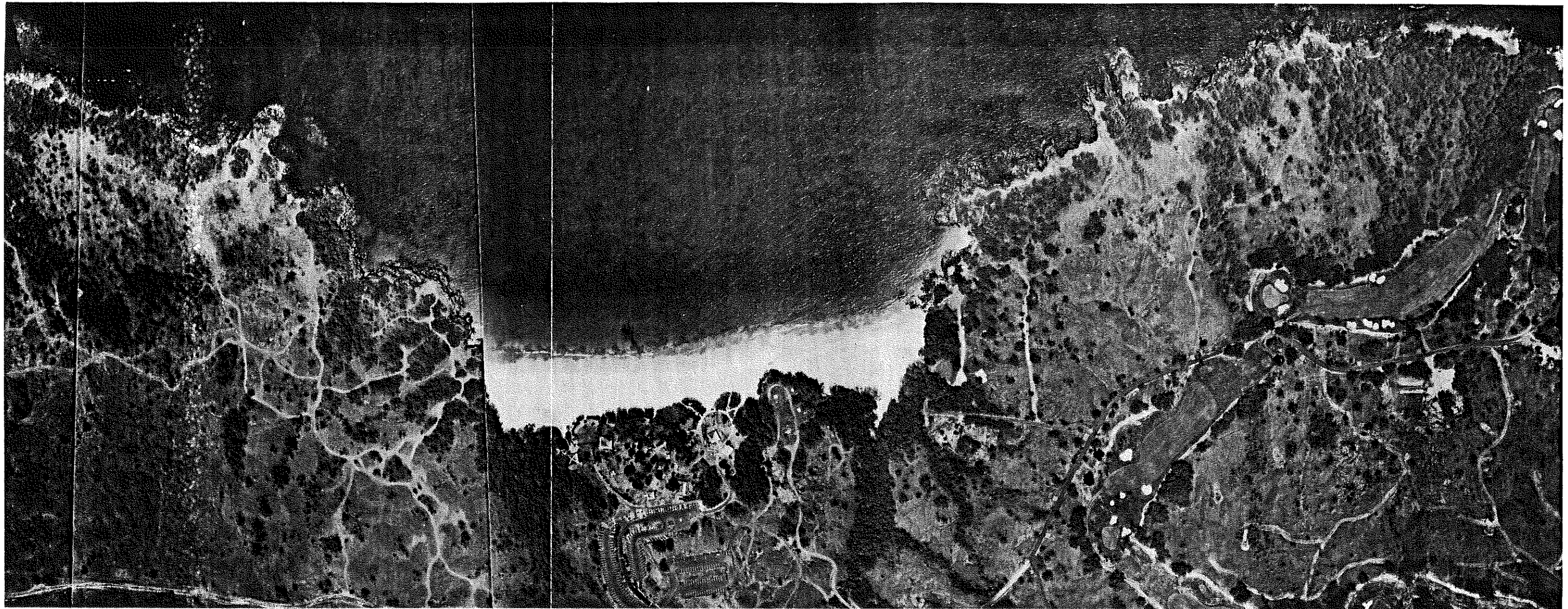


**FIGURE HA-5**



**GRAPH HA-5 Region Number vs Change in Vegetation Line**

**PHOTOS USED**  
 May 1988  
 July 1987  
 June 1975  
 July 1964  
 March 1950



## HA-6: HAPUNA BEACH STATE PARK

### BEACH DESCRIPTION

- Hapuna Beach is a 2000 foot long, beautiful white sand beach which is more than 200 feet wide during the summer months.
- The beach slopes gently into the deeper offshore water where there are excellent opportunities for water activities. A shallow, protected, sand-bottomed cove at the northern end of the beach is an ideal place for children to play in the water.
- Hapuna is subject to high surf and excellent wave conditions during the winter months. State law permits bodysurfing only. The high surf generates a pounding shorebreak and extremely powerful rip current. This area has no professional lifeguard coverage. Hapuna therefore has more drownings than any other developed beach park in the State of Hawaii.

### BACKSHORE

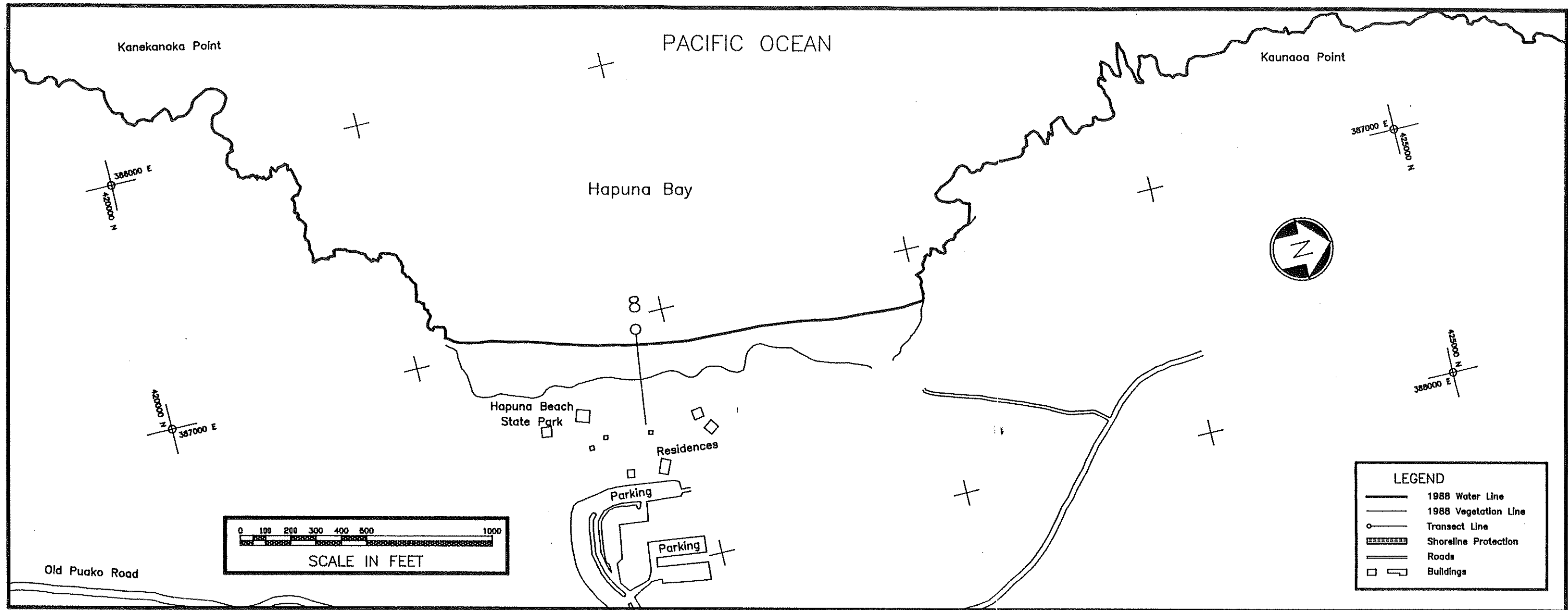
- Hapuna Beach Park, located along the southern half of the shoreline, includes six A-Frame shelters that provide lodging for four persons each, paved parking lots, picnic pavilions, restrooms, showers and paved walkways to the beach.
- Construction of a resort hotel is underway at the north end of the beach.
- The vegetation line is well defined and consists of grass, palm trees and kiawe trees.

### SHORELINE HISTORY

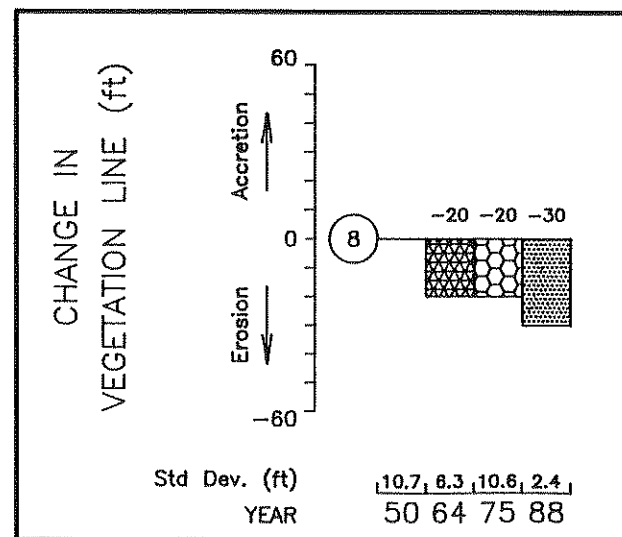
- The central part of Hapuna Beach has consistently eroded over the past 38 years as shown in Region 8.
- An intermittent stream bed is located at the north end of the beach and the vegetation lines show accretion of the beach. This is a localized phenomenon, however, and might be due to rainfall changes.

### SUMMARY

- The beach is directly exposed to large winter waves, and is not protected by an offshore reef.
- Hapuna Beach is a closed littoral cell with sand moving offshore during the winter, and then moving back onshore during the summer months. There has been significant erosion along the beach, with a probable net loss of sand offshore.

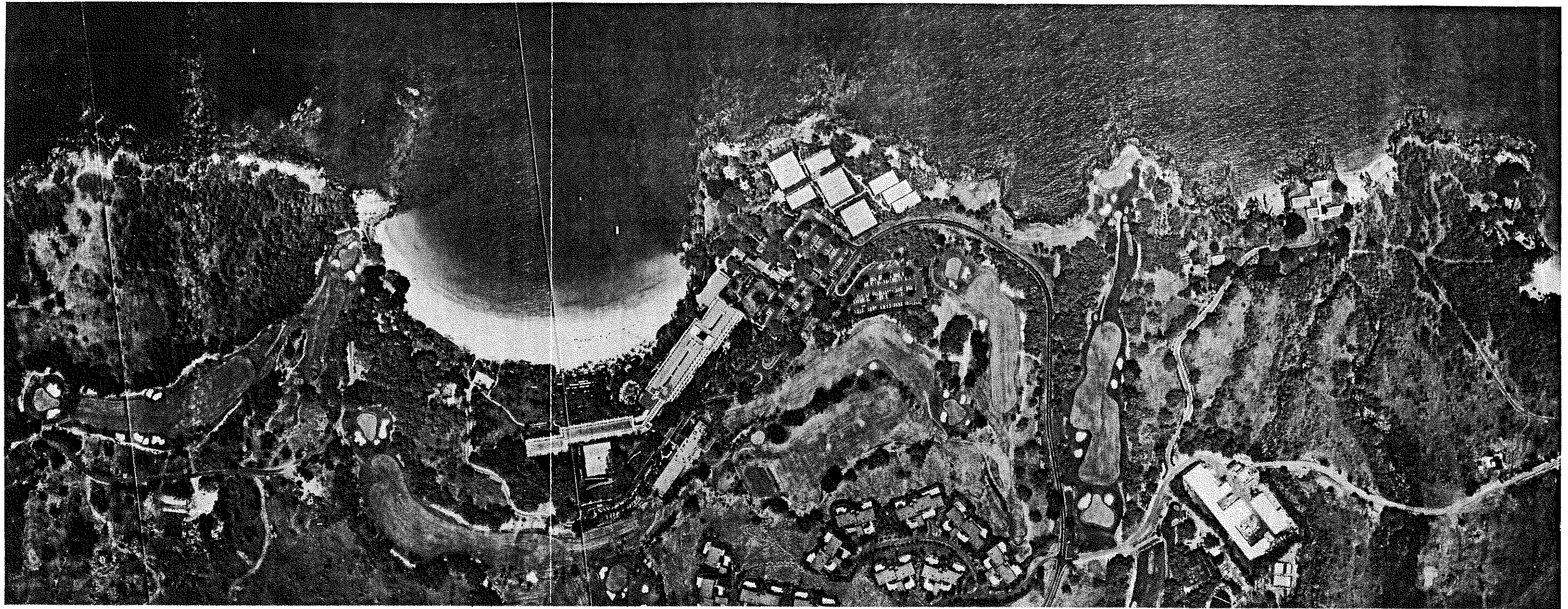


**FIGURE HA-6**



**PHOTOS USED**  
 May 1988  
 July 1987  
 June 1975  
 July 1964  
 March 1950

**GRAPH HA-6 Region Number vs Change in Vegetation Line**



## HA-7: KAUNAOA BAY

### BEACH DESCRIPTION

- Kaunaoa Beach is a 1400 foot long crescent-shaped white sand beach located between two lava points, Kauunaoa Point and Kaaha Point.
- Kauunaoa Bay is best known as the site of the Mauna Kea Beach Hotel.
- The beach provides excellent opportunities for swimming, snorkeling, body surfing and board surfing. During the winter months, high surf and hazardous water conditions periodically make the water activities dangerous.
- A rocky shoreline is present from Kaaha Point to Waiulaula Point.

### BACKSHORE

- Construction of the Mauna Kea Beach Hotel has slightly modified the vegetation line. The vegetation line is fairly well defined, consisting primarily of grass and palm trees.
- Public access and facilities to the beach are located at the southernmost end of the hotel's parking lot. The facilities include parking, restrooms and showers.

### SHORELINE HISTORY

- Construction of the Mauna Kea Beach Hotel began prior to 1964. During construction, the entire vegetation line was extensively modified. It appears that the resort "smoothed" the vegetation line from the uneven line shown in the 1950 photos. Furthermore, the resort maintains the vegetation line.
- Region 9 therefore was drawn in a location that would indicate a stable beach.
- Since 1964, the vegetation line at the north end of the beach moved landward. A small pavilion and outdoor restaurant now sit at the edge of the sandy beach.

### SUMMARY

- The Mauna Kea Beach Hotel has significantly altered and maintained the vegetation line.

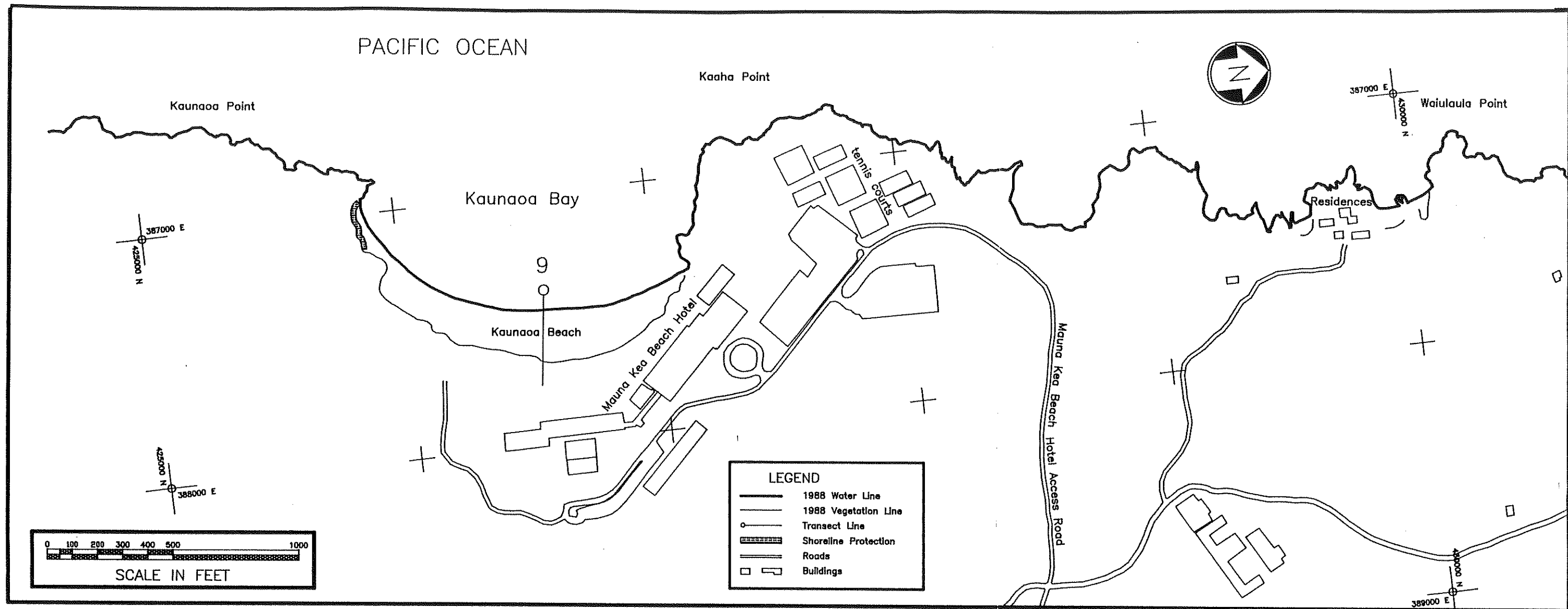
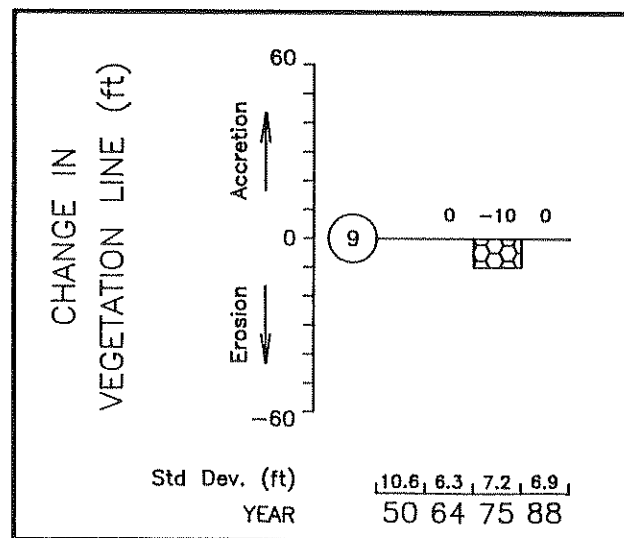


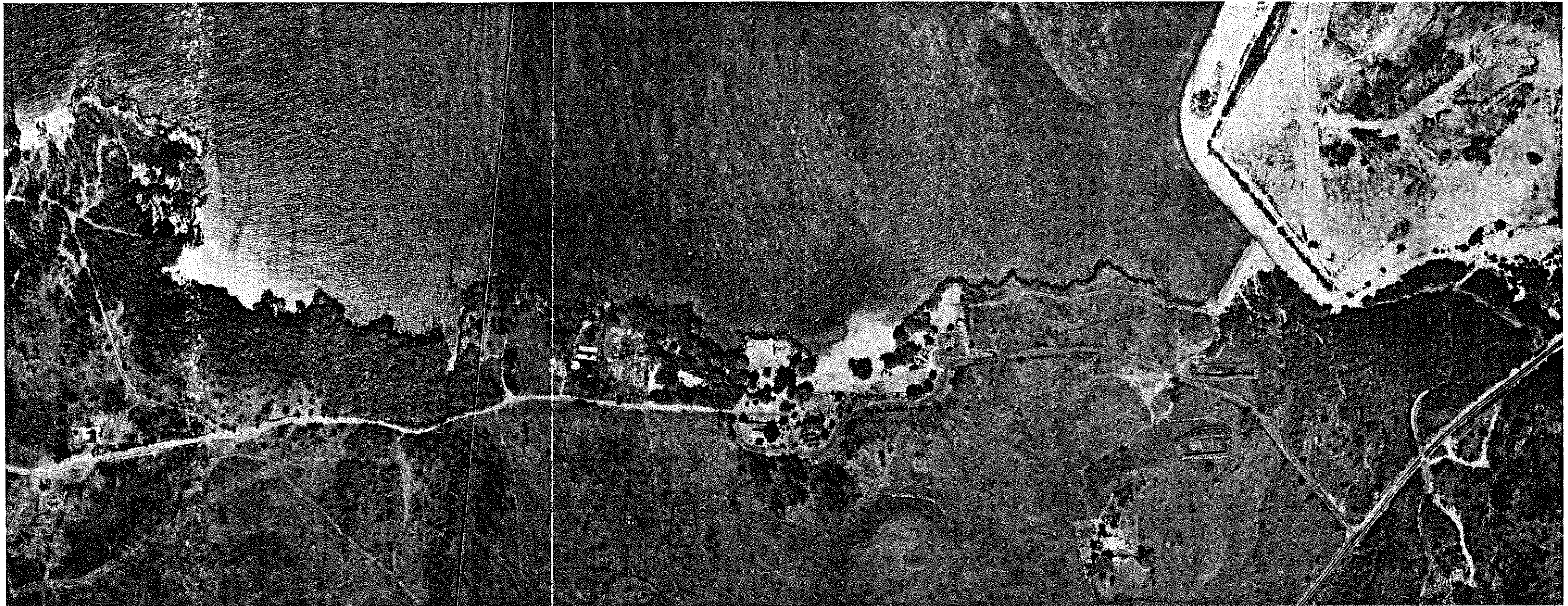
FIGURE HA-7



GRAPH HA-7 Region Number vs Change in Vegetation Line

PHOTOS USED  
 May 1988  
 July 1987  
 June 1975  
 July 1964  
 March 1950





## HA-8: KEAWEHALA POINT TO KAWAIHAE HARBOR

### BEACH DESCRIPTION

- Three small sandy beaches are located along the predominantly rocky shoreline that extends from Keawehala Point to Kawaihae Harbor.
- Mauumae Beach, located at the south end of the subsector, is a 400 foot long, 50 foot wide small pocket beach.
- Ohaiula Beach is also 400 feet long and is located within Spencer Beach County Park located at Spencer Beach County Park. A long shallow reef directly offshore shelters the shoreline from the prevailing offshore waves.
- Pelekane Beach, located at the north end of the subsector adjacent to Kawaihae Harbor, is a short stretch of sand and is a part of Puukohala Heiau National Historic Site. No sunbathing, swimming, picnicking or camping are permitted at the beach.

### BACKSHORE

- The backshore area is primarily undeveloped and kiawe trees line the shoreline.
- Facilities at Spencer Beach Park include restrooms, picnic tables, showers, tennis courts, a pavilion, a parking lot, a camping area and a lifeguard tower.
- Puukohala Heiau National Historic Site, located landward of Spencer Beach Park, is a 77 acre parcel of land which is a part of the National Park Service. Numerous heiaus are located within the park land.

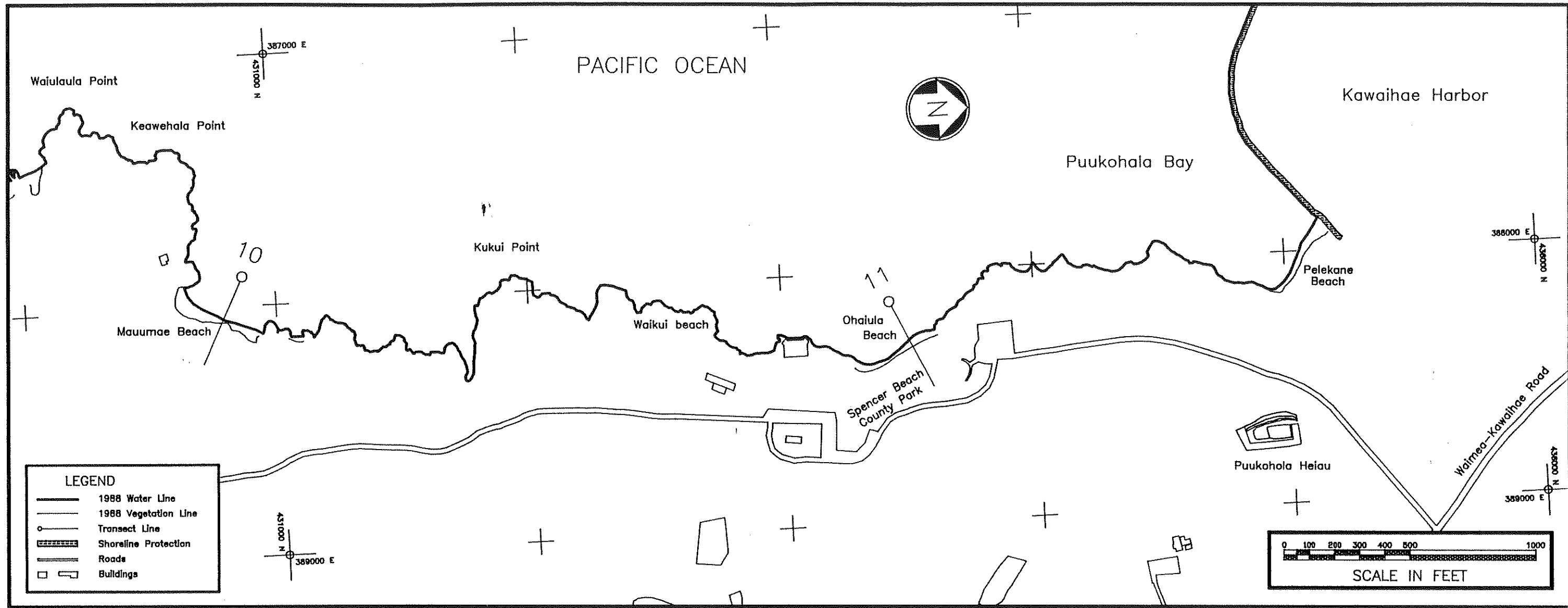
### SHORELINE HISTORY

- The 1950's data for Mauumae Beach and Spencer Park are not reliable and will not be used because the photos were unclear and the vegetation lines were difficult to define.

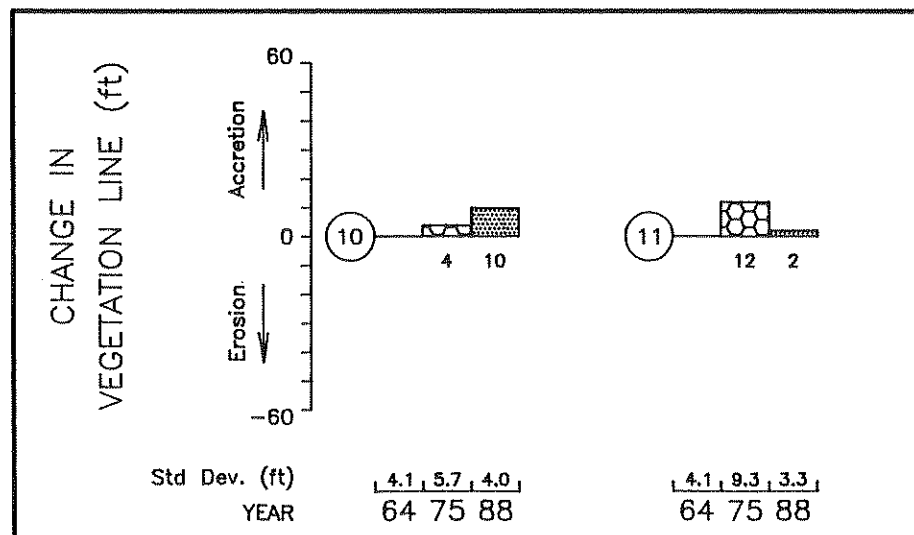
- Region 10 at Mauumae Beach shows a stable vegetation line for this small pocket beach.
- Region 11 at Ohaiula Beach also exhibits few changes.
- Pelekane Beach has changed the most since 1950. Kawaihae Harbor was built between 1950 and 1964. The breakwater for the harbor bisects the beach. A coral rubble landfill is located at the south end of the harbor. This material has leached through the breakwater with a net accretion of the shoreline and deposition along the bottom. The vegetation line has moved seaward 50 feet since 1975.

### SUMMARY

- Both Mauumae and Ohaiula Beach are stable with only minor cyclic changes in the vegetation lines.



**FIGURE HA-8**



**GRAPH HA-8 Region Number vs Change in Vegetation Line**

**PHOTOS USED**  
 May 1988  
 July 1987  
 June 1975  
 July 1964  
 March 1950

## SECTOR HB: NORTH KONA HONOKOHAU BEACH TO KAUPULEHU BEACH

### GENERAL COASTAL CHARACTERISTICS

This sector consists of four unconnected segments of shoreline along 14 miles of coast north of Kailua-Kona, between Honokohau Bay and Kaupulehu. As in Sector HA (South Kohala coast), there are three general shoreline types in the sector: rocky coast; sandy, pocket beaches; and perched or storm beaches. The rocky coast formed by relatively recent lava flows predominates. The sandy pocket beaches include Honokohau Beach (3000 feet), Makalawena Beach (3000 feet), and the northern reach of Kaupulehu Beach. Wawaloli Beach, Kukio Beach and the southern reaches of Kaupulehu Beach are perched beaches that are protected by barely submerged rock ledges. Numerous fishponds and archeological sites also are located in this sector. The fishponds include Aimakapa, Aiopio, and Opaaula.

### LAND USE AND DEVELOPMENT

The backshore of this sector is almost entirely undeveloped and consists of ancient fishponds that are now important bird habitats, archeological sites, lava flows, and thickets of shoreline vegetation. The only developed areas include the Honokohau Small Boat Harbor, the Kona Resort Village and the IDG Hotel in Kaupulehu, and a few modest fishing homes. There is a beach park facility north of Wawaloli Beach along the paved road to the Natural Energy Laboratory.

### WAVE CLIMATE

The coastline in this sector is exposed to north Pacific swell and Kona storm waves, and is sheltered from the tradewind waves. Fringing reefs are present in Honokohau Bay and Kahuwai Bay, and rocky shelves and rocky shores protect much of the rest of the coastline.

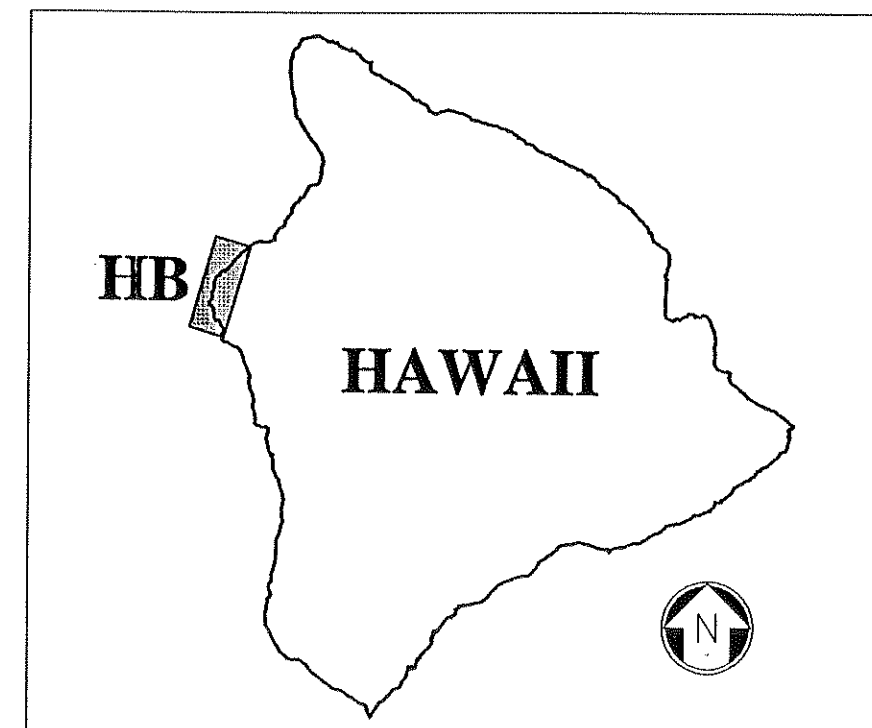
### SHORELINE PROCESSES

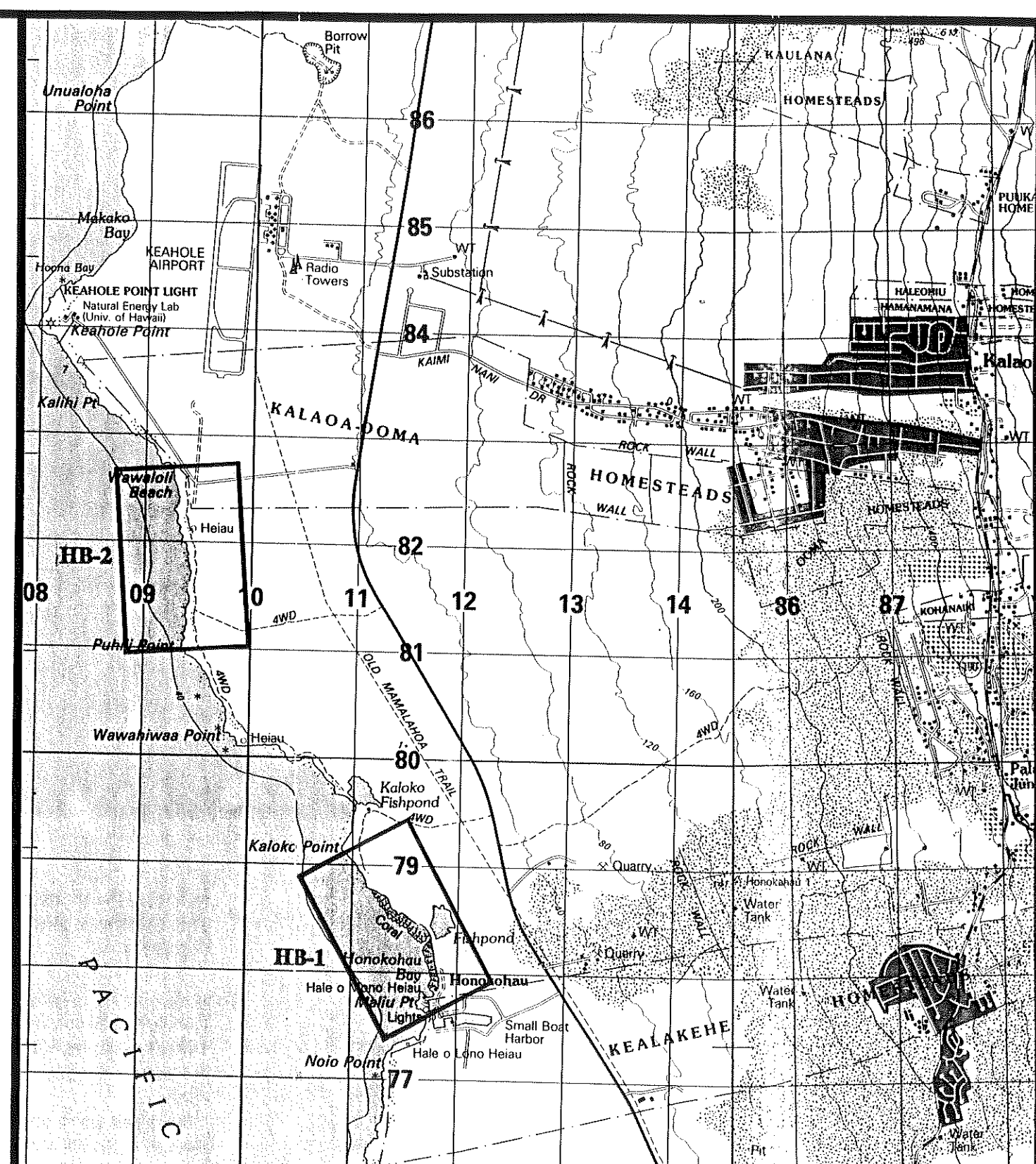
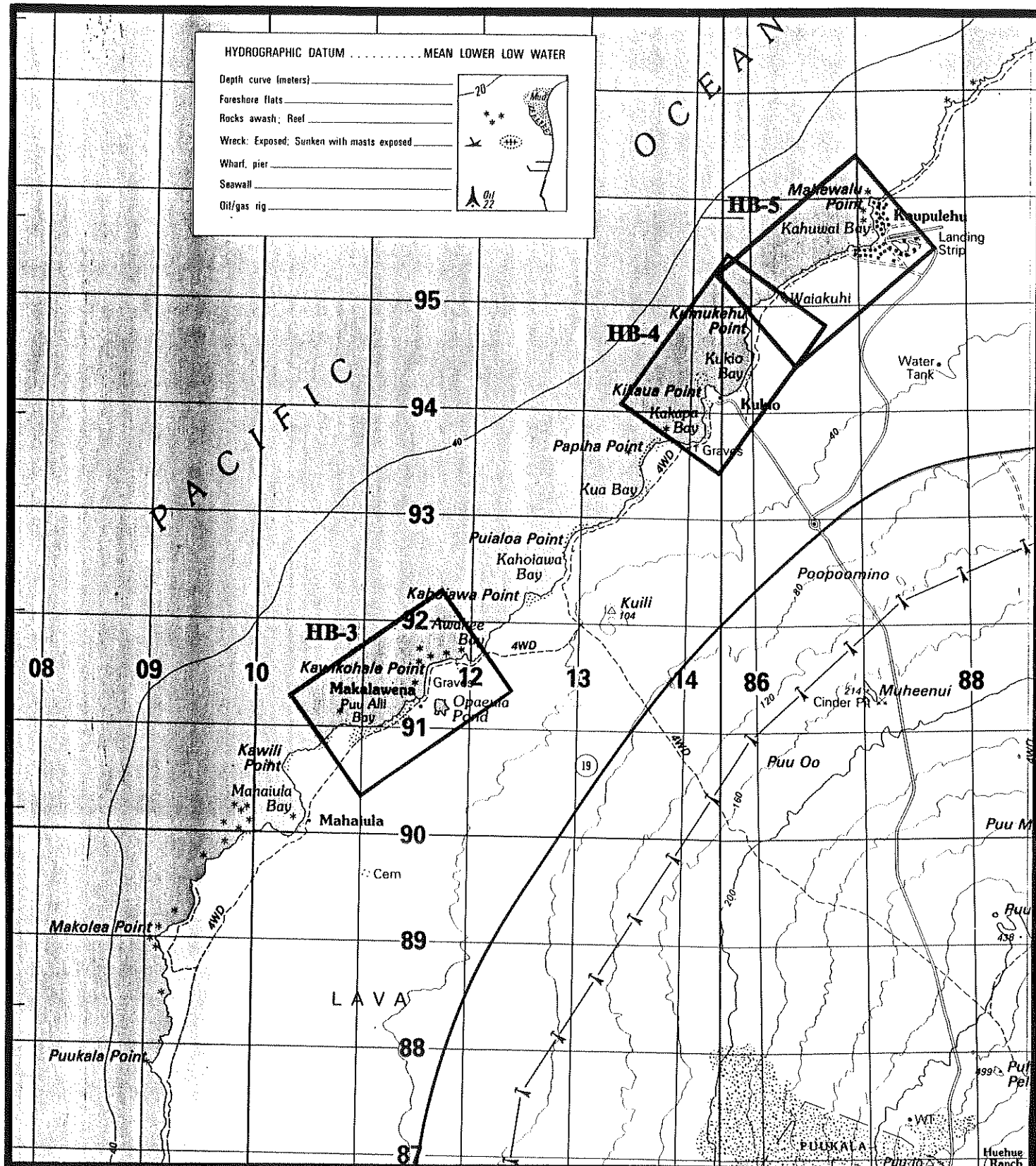
As mentioned previously, the coastline in this sector is exposed to Kona storm waves and north Pacific swell. Only a few reaches of the coastline, however, contain sandy beaches that are controlled by normal littoral processes. These beaches include Honokohau, Kaupulehu, and Makalawena. Honokohau and Kaupulehu are protected by fringing reefs, while Makalawena is partially protected by rocky benches and lava points. Notable erosion has occurred at Makalawena Beach and in the central reach of Honokohau Beach. Significant accretion has occurred at the ends of Honokohau Beach and in parts of Kukio Beach.

The remaining beach areas are perched or storm beaches that form when sand is tossed above the high tide line by severe storm waves. These beaches are not controlled by normal littoral processes.

### BEACH USAGE

Honokohau Beach is the most popular beach in this sector, and is heavily used by fisherman, swimmers, surfers and nudists. Limited accessibility with vehicles and the lack of nice sandy swimming areas restrict usage of most of the other beaches in this sector.





HYDROGRAPHIC DATUM ..... MEAN LOWER LOW WATER

Depth curve (meters) \_\_\_\_\_

Foreshore flats \_\_\_\_\_

Rocks awash; Reef \_\_\_\_\_

Wreck: Exposed; Sunken with masts exposed \_\_\_\_\_

Wharf, pier \_\_\_\_\_

Seawall \_\_\_\_\_

Oil/gas rig \_\_\_\_\_

**LEGEND**

HYDROGRAPHIC DATUM ..... MEAN LOWER LOW WATER

Depth curve (meters) \_\_\_\_\_

Foreshore flats \_\_\_\_\_

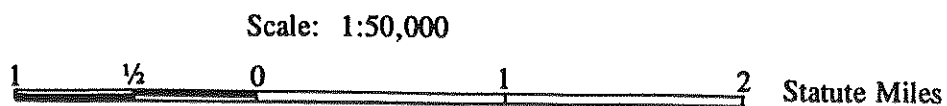
Rocks awash; Reef \_\_\_\_\_

Wreck: Exposed; Sunken with masts exposed \_\_\_\_\_

Wharf, pier \_\_\_\_\_

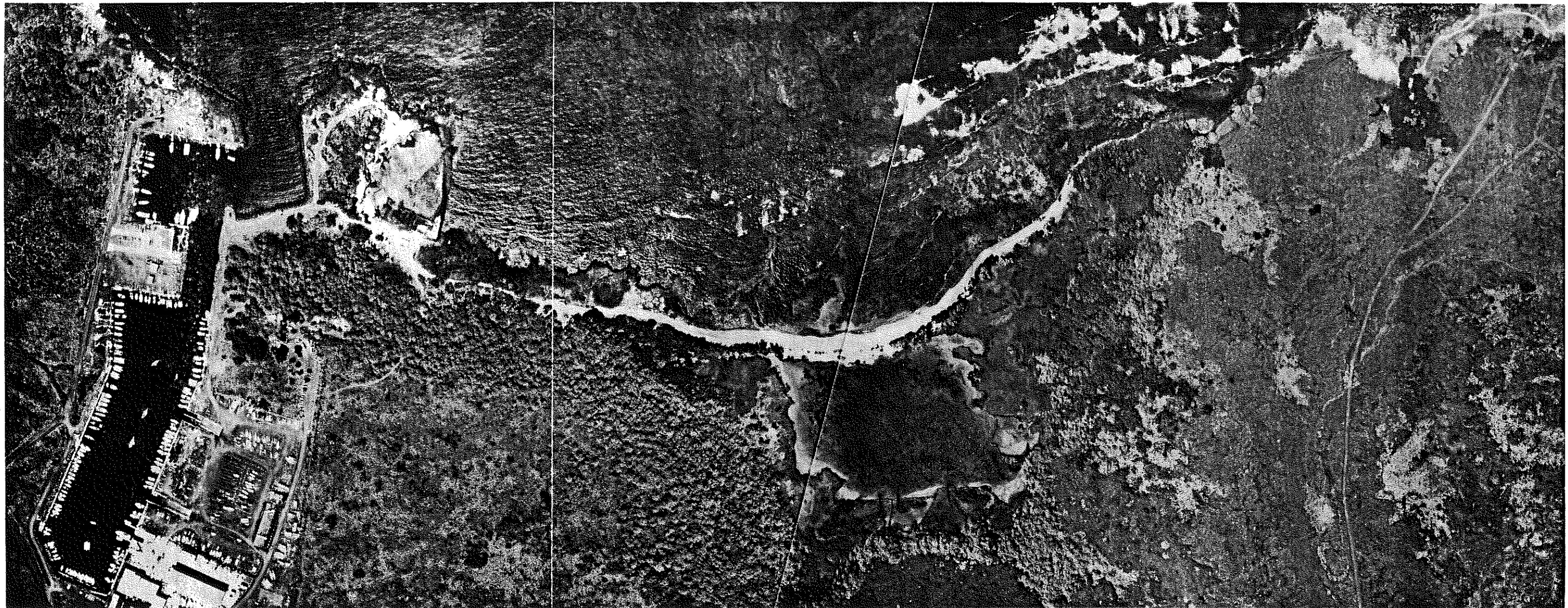
Seawall \_\_\_\_\_

Oil/gas rig \_\_\_\_\_



From U.S. Geological Survey  
MAP INFORMATION AS OF 1983

**NORTH KONA**  
**Honokohau Beach to Kaupulehu Beach**



## HB-1: HONOKOHAU BEACH

### BEACH DESCRIPTION

- Honokohau is a primarily calcareous sand beach approximately 3000 feet in length, with an average width of approximately 40 feet.
- The beach is a closed littoral system bounded by Maliu Point to the south and Kaloko Point to the north.
- The waters of Honokohau Bay are gentle because of a fringing reef extending 1500 feet offshore. The shallow and rocky bottom dissipates most wave energy and decreases the sediment transport rate.
- A lava shelf below the waterline at the water's edge lines the entire beach except for the area in front of Aimakapa fishpond

### BACKSHORE

- The backshore area is undeveloped except for a few modest fishing homes located on the edge of Aiopio fishpond.
- Access is limited with most beachgoers accessing the beach by walking from the entrance to Honokohau Small Boat Harbor and

following the shoreline past Aiopio fishpond.

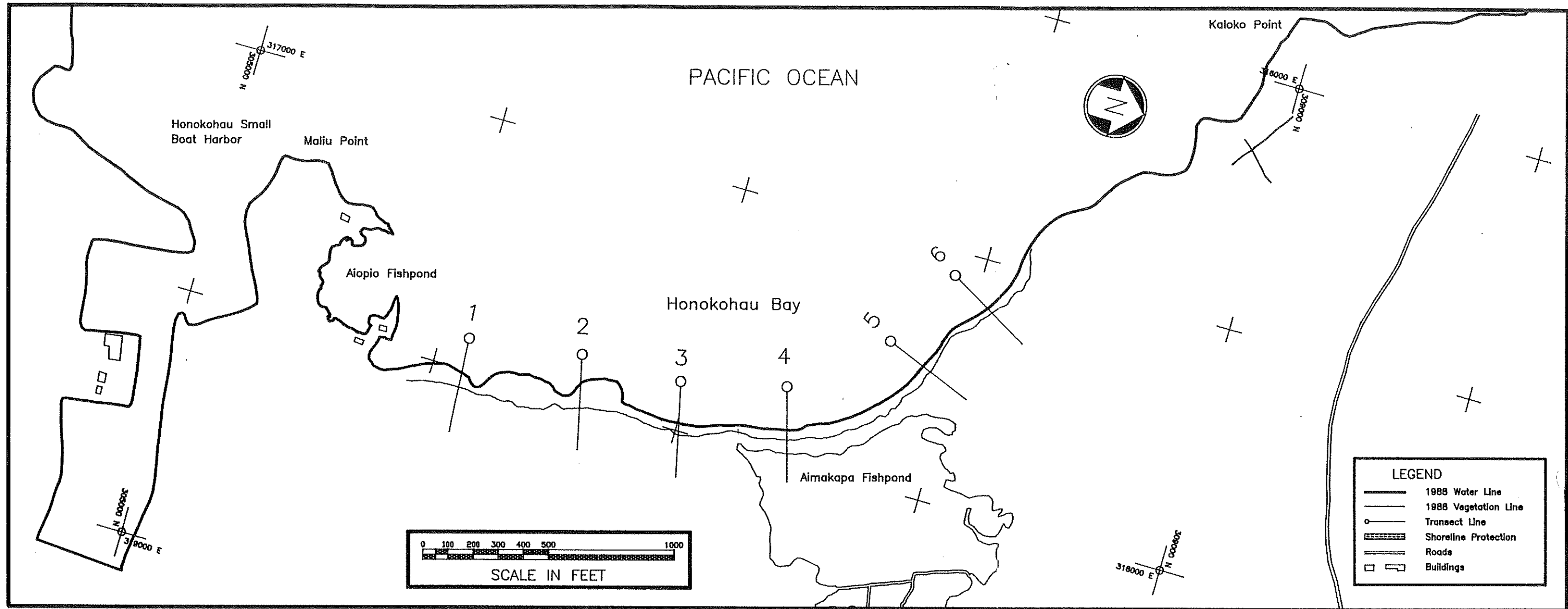
- The backshore area is lined with a dense thicket of shoreline vegetation.

### SHORELINE HISTORY

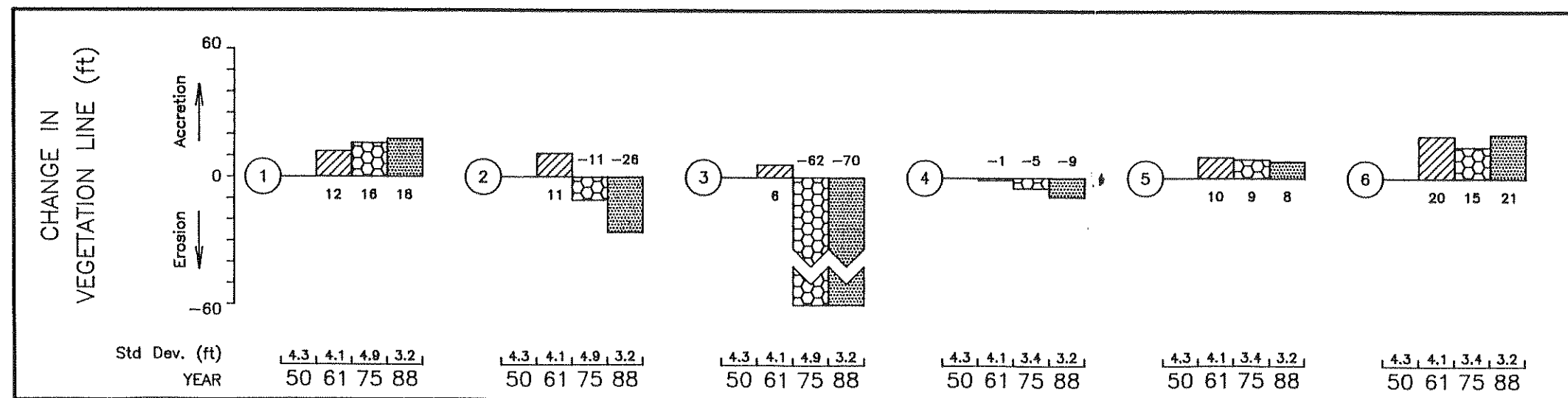
- Honokohau Beach shows evidence of alongshore sediment transport with a net movement of the sand from Region 3 to the north and to the south. Region 3 shows 70 feet of erosion between 1950 and 1988.
- Progressing north and south of Region 3 to Region 4 and Region 2 there is considerably less erosion.
- Moving to the ends of the subsector, to Region 1 located at the south and Regions 5 and 6 to the north, there is a net accretion of the beach with the vegetation line moving approximately 20 feet seaward.

### SUMMARY

- Honokohau Beach shows signs of a net transport of sand from the widest portion of the beach, located in front of and to the south of Aimakapa Fishpond, to the north and to the south. This point is known as a nodal point and should show evidence of erosion.
- The construction of Honokohau Small Boat Harbor in the 1970's appears to have had no influence on Honokohau Beach. Aiopio Fishpond, located just north, limited the impact the harbor had on the beach.
- The vegetation line was clear and easily identifiable in all years. The standard deviation was also low, making the results very accurate.

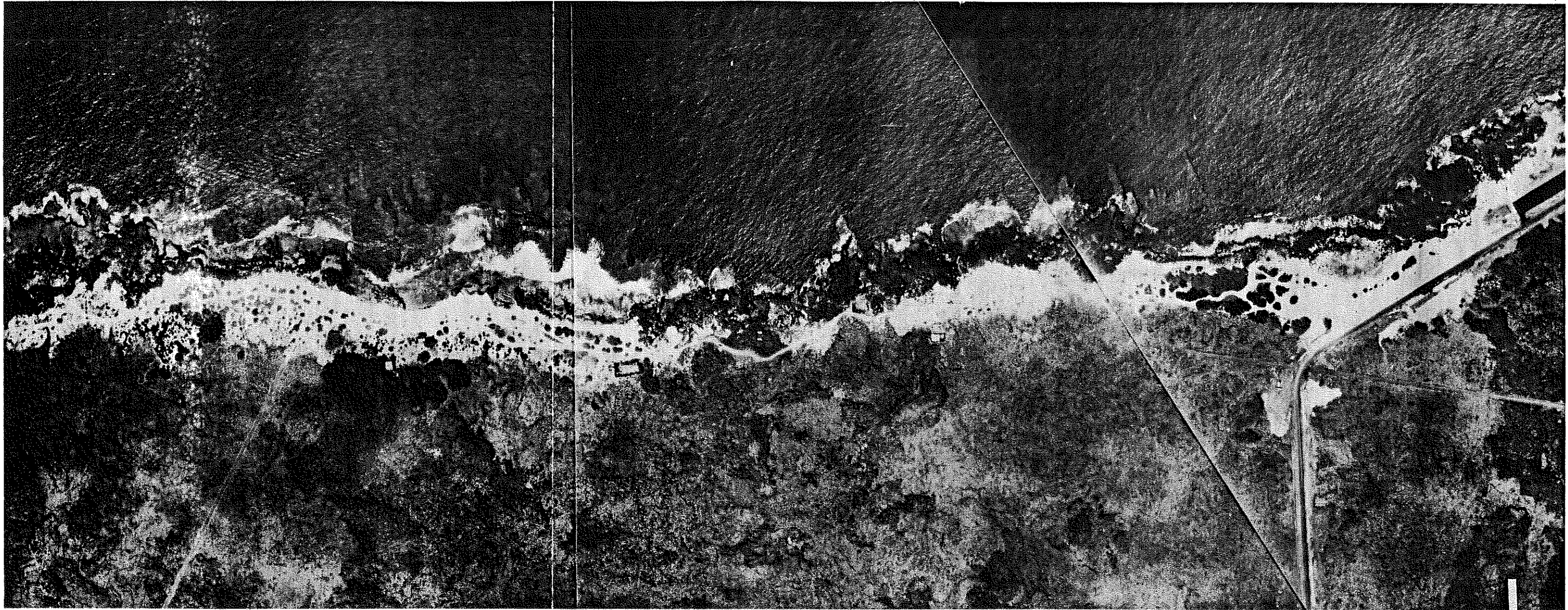


**FIGURE HB-1**



**PHOTOS USED**  
 May 1988  
 July 1987  
 April 1975  
 March 1960  
 November 1950

**GRAPH HB-1 Region Number vs Change in Vegetation Line**



## HB-2: KALIHO POINT TO PUHILI POINT

### BEACH DESCRIPTION

- This beach consists primarily of calcareous sand located landward of a basaltic rock ledge located at the waterline. The widest reach of sand is Wawaloli Beach, located at the northern end of the subsection.
- The sand was "tossed" or transported landward of the rock ledge under storm conditions, forming what is known as a storm or perched beach. The rock ledge limits the usefulness of the beach for water recreation.
- The beach located at the foot of the four wheel drive jeep trail has a 200 foot long reach devoid of the rock ledge.

### BACKSHORE

- The backshore area is sparsely vegetated with kiawe trees and short grasses.
- The area is undeveloped except for a single beach park facility located just north of the bend in the Natural Energy Laboratory road. This road is the only paved access to the entire subsector.

### BEACH HISTORY

- The sparse vegetation line provides limited historical data and is probably influenced as much by rainfall as it is by oceanographic conditions.
- The beach is located landward of the rock shelf and waterline. Littoral transport occurs only during large wave climates.
- The sandy area located at the foot of the four wheel drive jeep trail has a well defined vegetation line with only 5 feet change in almost 40 years.
- The vegetation line for region 8 was drawn from a few kiawe trees and the results are less accurate but indicate approximately 20 feet of erosion from 1950 to 1961 and relatively little change since 1961.
- The reach just south of Region 9 shows both erosion and accretion and is due more to a sparse vegetation line than to localized activities.

- Region 9 shows no significant change.
- The vegetation line in front of Wawaloli Beach has moved approximately 120 feet landward since 1950. This change appears to have been caused by the formation of a small tidal pond after 1961. Thus, the changes in the vegetation line are man-made and not caused by littoral processes.

### SUMMARY

- Almost the entire subsector can be classified as a perched beach. The rock shelf eliminates the day to day changes in the sandy shoreline and stabilizes the location of the waterline.
- The beach shows sign of generally accreting.

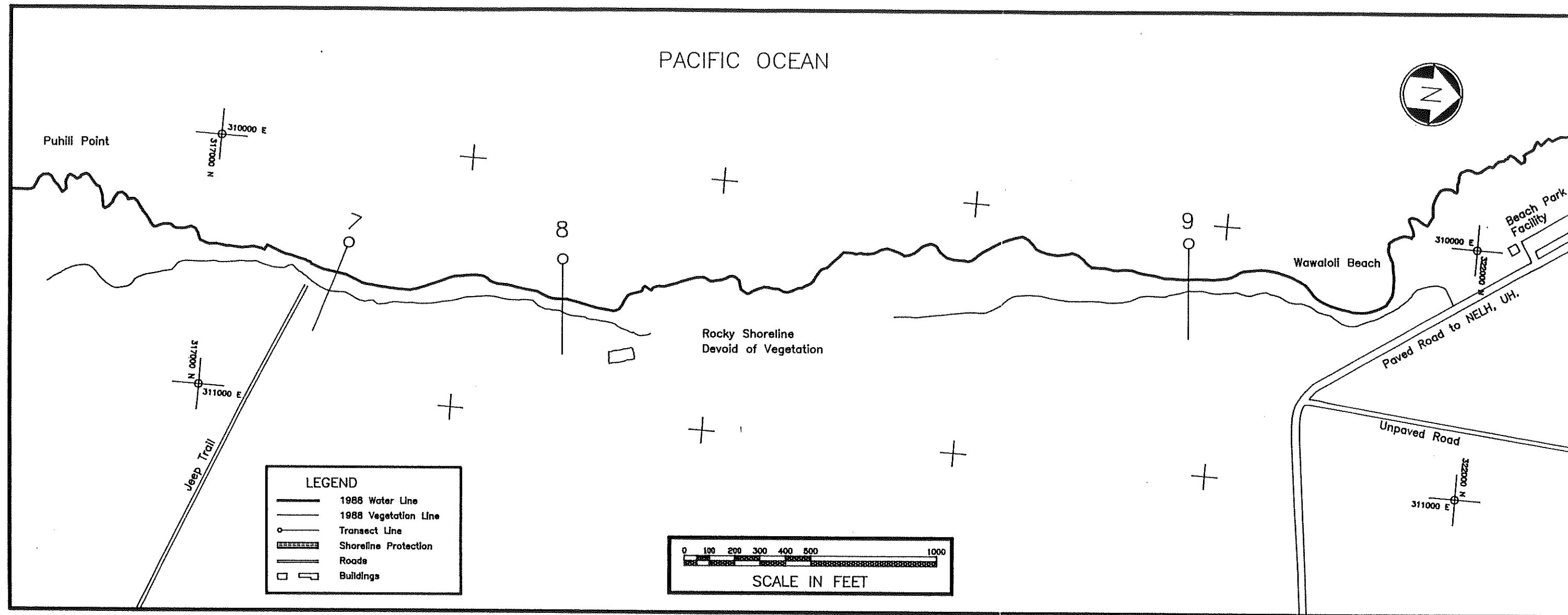
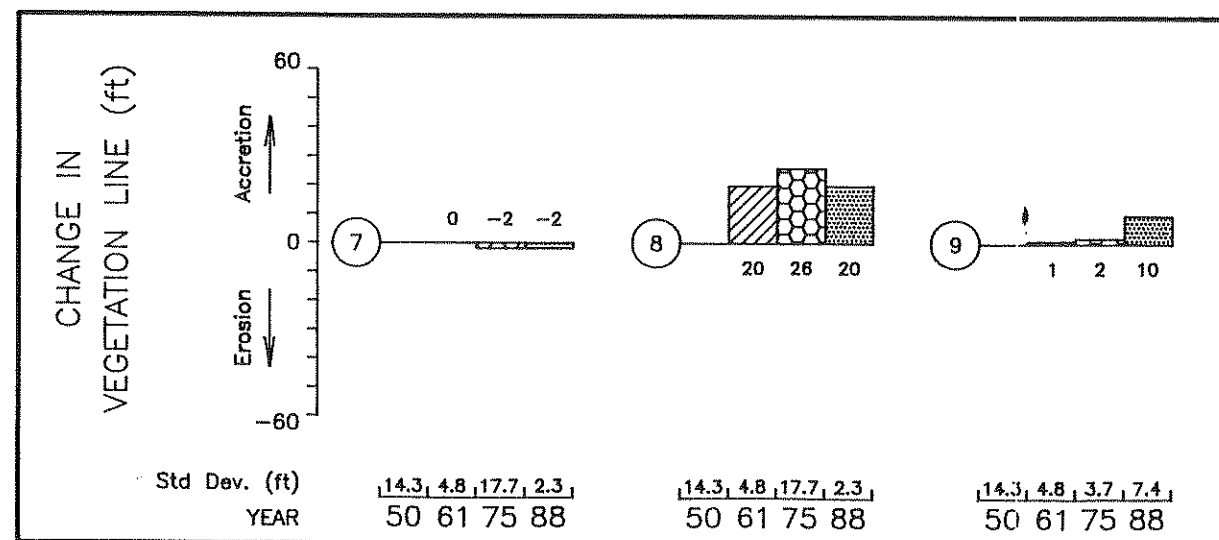


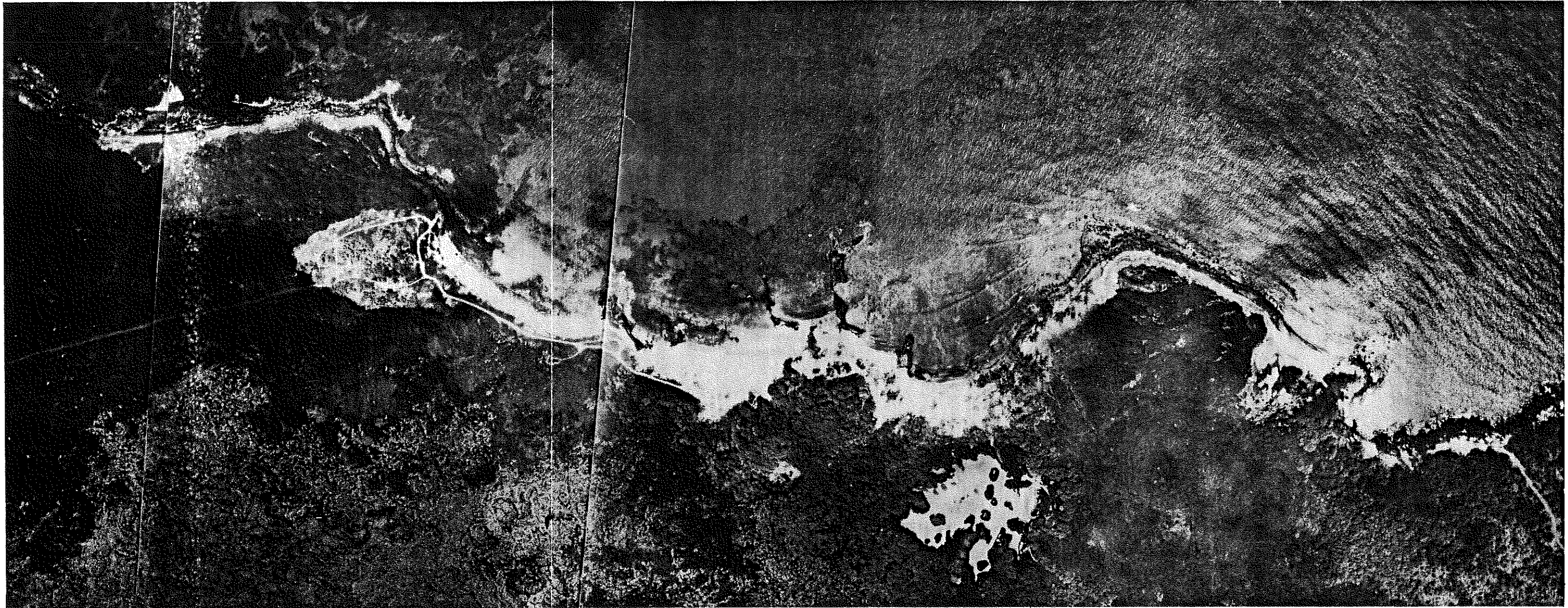
FIGURE HB-2



GRAPH HB-2 Region Number vs Change in Vegetation Line

PHOTOS USED  
 May 1988  
 July 1987  
 April 1975  
 March 1960  
 November 1950





### HB-3: MAKALAWENA BEACH

#### BEACH DESCRIPTION

- The sandy beach from Puu Alii Bay to Kawikohale Point is commonly referred to as Makalawena Beach.
- The 3000 foot long stretch of curving calcareous sand beach contains several coves separated by lava points protruding into the ocean.
- Makalawena Beach is subject to seasonal beach variations. Large winter waves, such as the north Pacific swell and Kona storm waves, cause sand to move offshore.

#### BACKSHORE

- The backshore area of Makalawena Beach is undeveloped except for the Makalawena residences located just south of Opaepa Pond.

- The principle backshore point of interest is Opaepa Pond, an ancient Hawaiian fishpond. The pond covers 12 acres and contains large numbers of red shrimp. It is also an important habitat for endangered birds.

- Sand dunes line the backshore along the south half of the subsector.

#### SHORELINE HISTORY

- Region 10 located at the south end of the site indicates accretion from 1950 to 1960, followed by 31 feet of erosion between 1960 and 1988.
- Region 11 shows a similar trend of accretion from 1950 to 1960, followed by erosion.
- The same general trend occurred at Region 12 in the northern end of the beach.

#### SUMMARY

- There is no indication of a predominate alongshore transport adjacent to the rocky lava points along this subsector.
- There is an overall trend of accretion from 1950 to 1960, followed by erosion of the beach from 1960 onward.
- There are small reaches which are accreting, but these are not significant relative to the general trend in the subsector.
- This subsector has a fairly large supply of sand as is evident by the sand dunes present at the south end of the site.

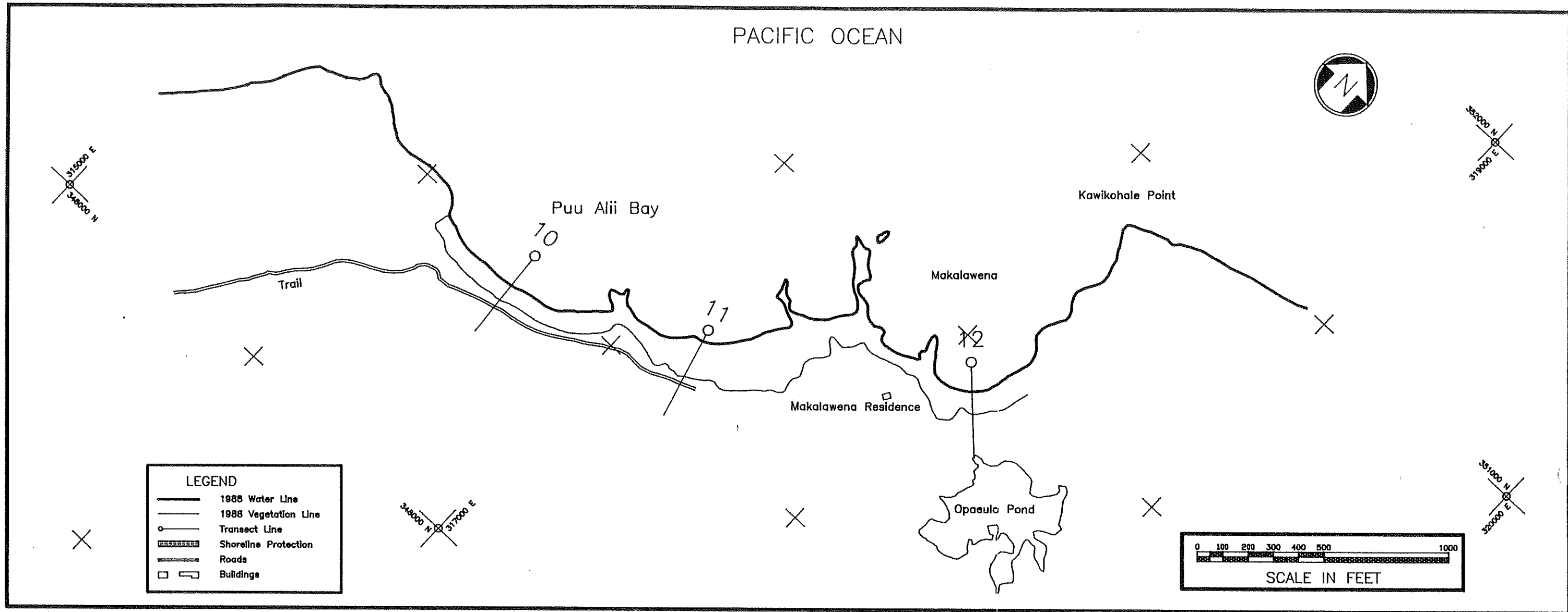
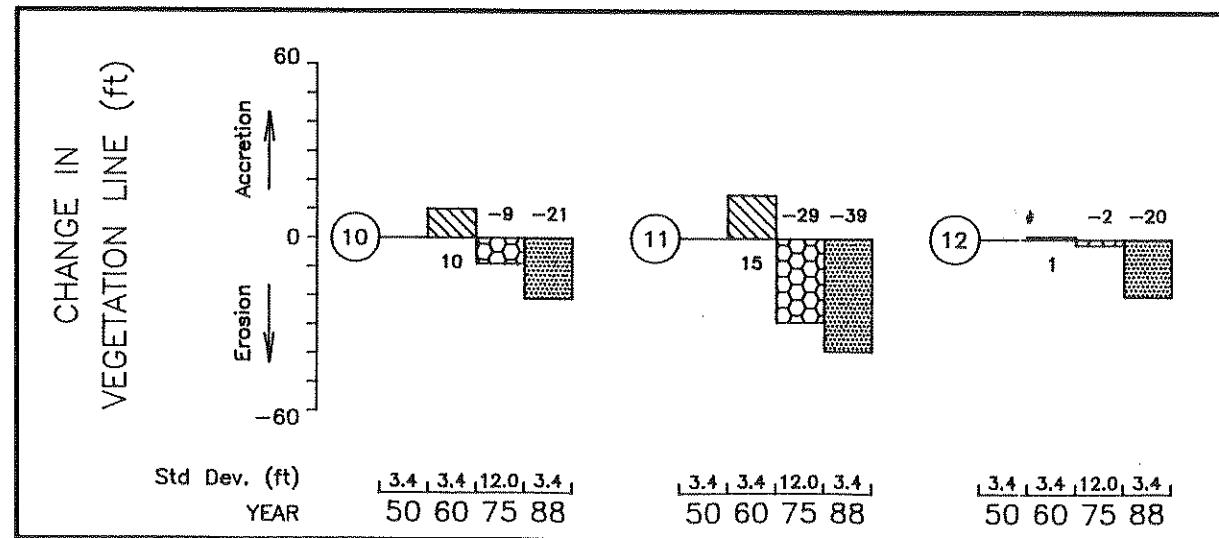
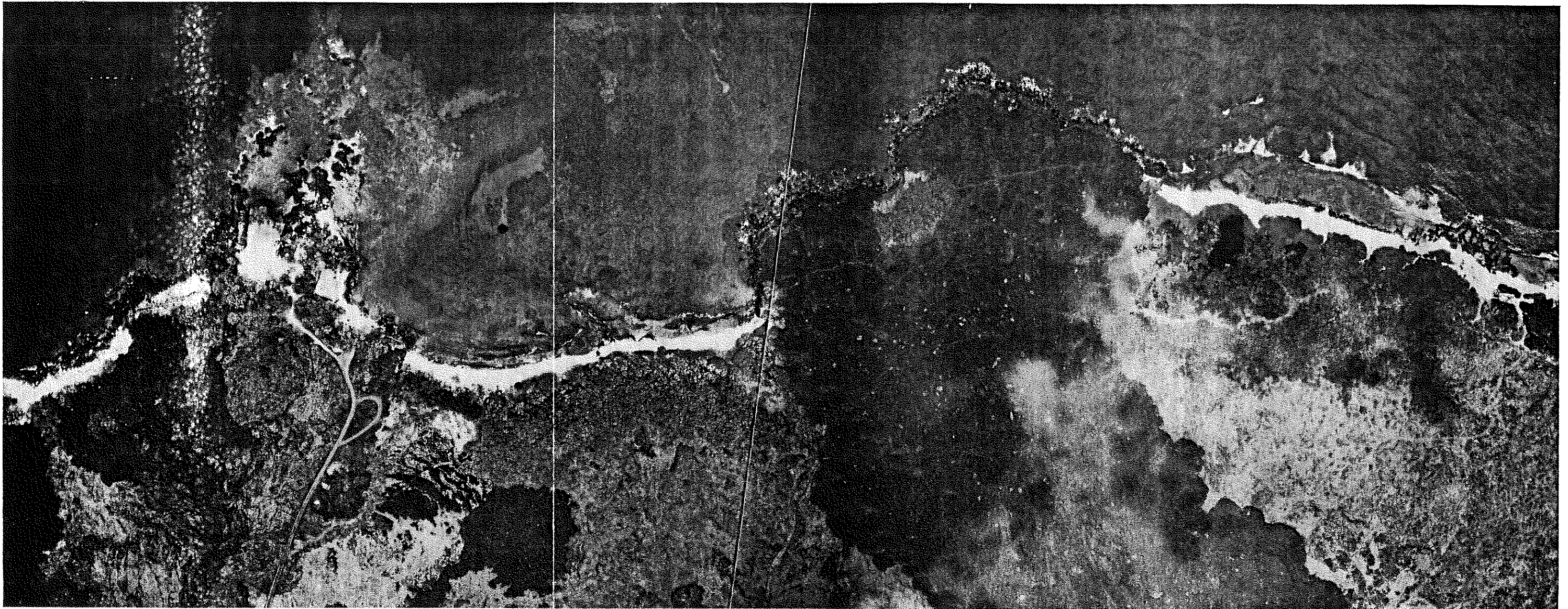


FIGURE HB-3



GRAPH HB-3 Region Number vs Change in Vegetation Line

PHOTOS USED  
 May 1988  
 July 1987  
 April 1975  
 March 1960  
 November 1950



#### HB-4: KUKIO BEACH

##### BEACH DESCRIPTION

- Kukio Beach is 1200 feet long and approximately 50 feet wide. It extends from Kikaua Point located in the south to the 1801 lava flow that forms Kumukehu Point.
- A continuous rock bench lines the shoreline, making access to the water difficult.

##### BACKSHORE

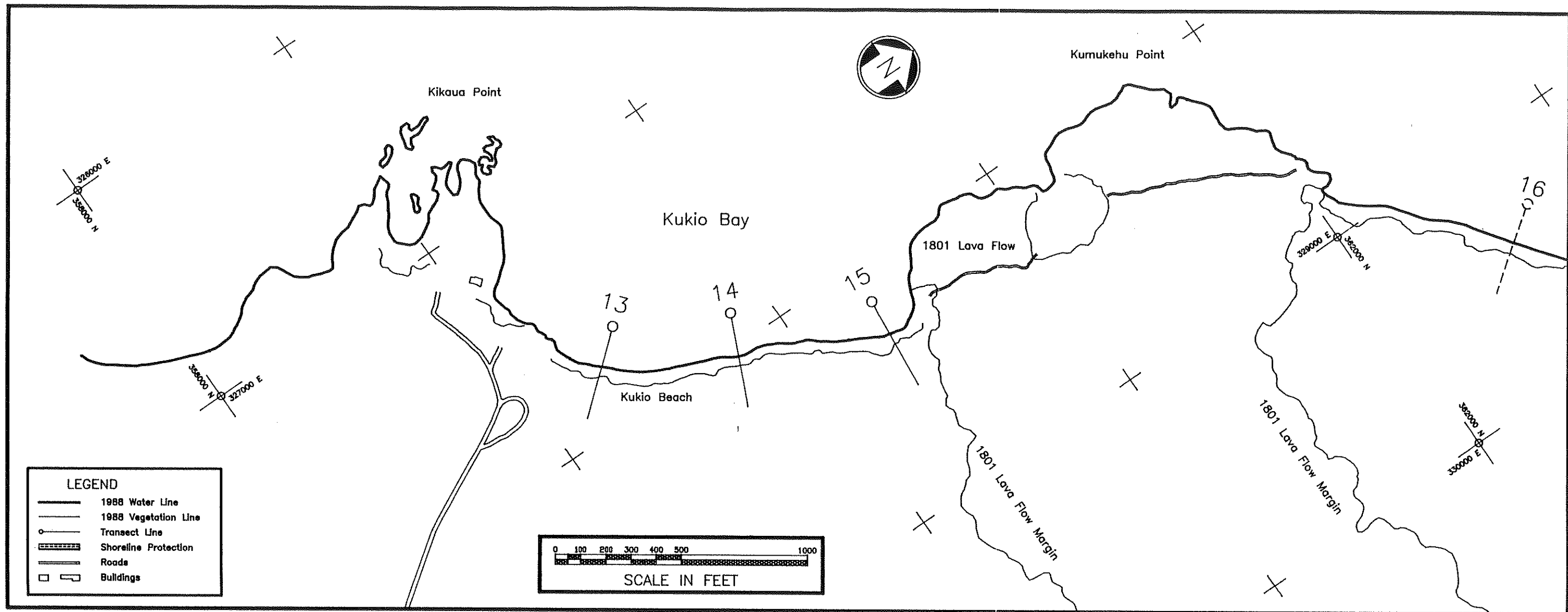
- The backshore area is undeveloped and there is no convenient public access to the shore in this subsector.
- The vegetation line is well defined.

##### SHORELINE HISTORY

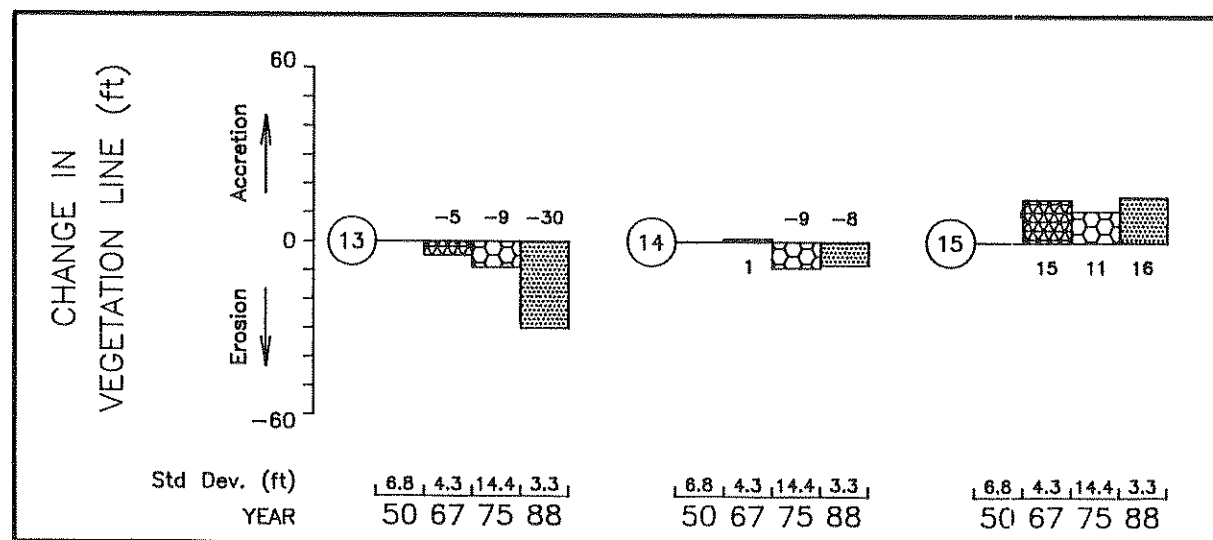
- Kukio Beach has a continuous limestone bench present along most of the beach which is submerged except at low tide. It acts as a barrier to offshore sediment motion.
- Region 13, located at the south end of the beach, shows a net landward migration of the vegetation line which results in a widening of the beach.
- A small isolated beach is located just south of a rock headland at the south end of Kukio Beach. This beach also shows a general landward migration of the vegetation line.
- Region 14, located in the center of the subsector, is fairly stable with less than a 10 foot change in the vegetation line over almost 40 years.
- Region 15 shows a net seaward migration of the vegetation line or narrowing of the beach.

##### SUMMARY

- This subsector shows evidence of alongshore sediment transport and corresponding changes in the vegetation line. The rock bench limits the wave energy reaching the shoreline, but there appears to be a net sediment transport to the north. Region 15 is accreting, and Region 13 is eroding.
- The limestone bench present along the shoreline stabilizes the location of the waterline. Unlike an unprotected sandy shoreline, a landward migration of the vegetation line does not necessarily indicate erosion. On a sandy shoreline erosion of the vegetation line is usually preceded by a net landward movement of the waterline. Widening of the sandy area located landward of the rocky bench is indicative of either more sand being tossed onto the beach or recent storm damage. Changes in the vegetation line could also be indicative of stressed vegetation. Lack of rainfall is one condition that could cause a change in the vegetation line.

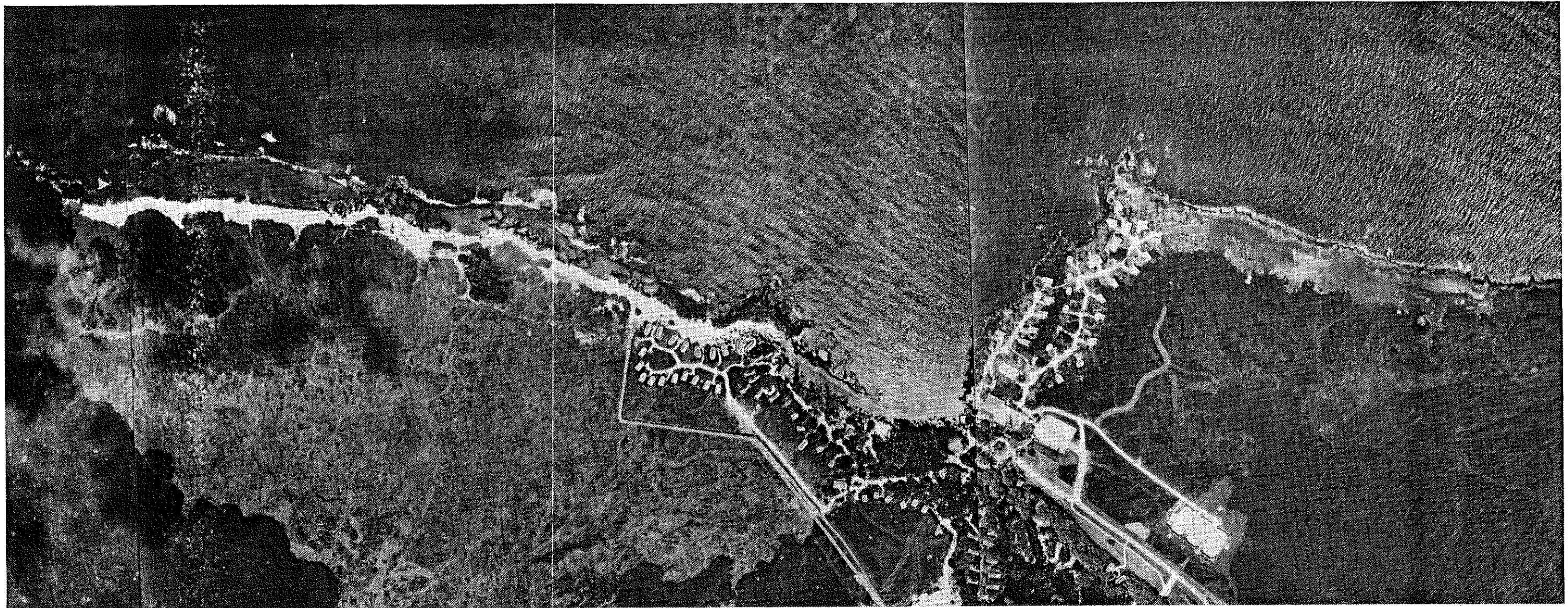


**FIGURE HB-4**



**GRAPH HB-4 Region Number vs Change in Vegetation Line**

**PHOTOS USED**  
 May 1988  
 July 1987  
 April 1975  
 March 1960  
 November 1950



## HB-5: KAUPULEHU BEACH

### BEACH DESCRIPTION

- The beach from Kumukehu Point to Mahewalu Point is generally referred to as Kaaupulehu.
- Construction of the Kona Village Resort located at the north end of the site began in the early 1960's. The beach in front of the resort provides easy access to Kahuwai Bay which has a deep, natural channel to the open ocean.
- The beach located to the south of the Kona Village Resort is a long narrow strip of white sand bordered by a low bench of volcanic rock. The bench is located below the waterline in most areas and the beach is affected by typical littoral processes. At the location where the rock bench breaches the surface, the vegetation line appears to be further seaward. The rock bench becomes more pronounced at the south end of the Kona Village Resort or the north end of the IDG Hotel.

### BACKSHORE

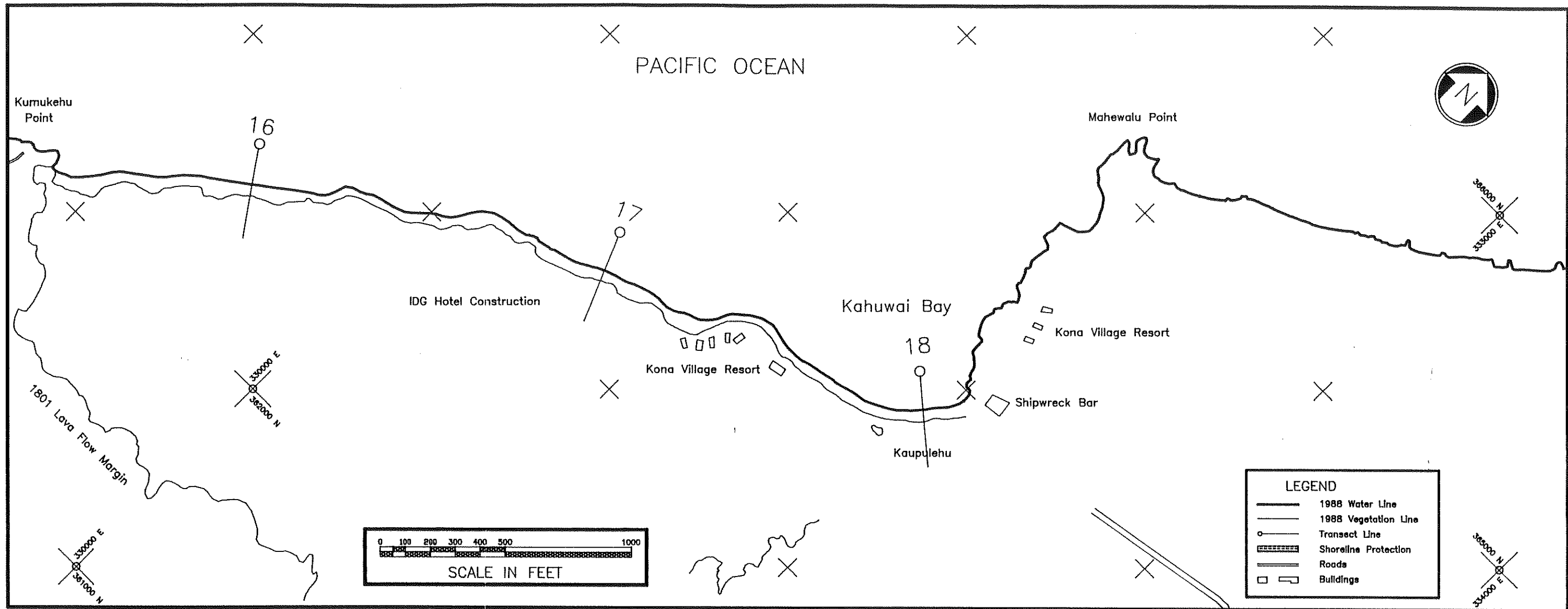
- The Kona Village Resort is located at the northern end of the subsector and construction of the IDG Hotels is underway at the southern end of Kona Village.
- The vegetation line is fairly well defined at present but has likely been altered by construction of the two resorts. Palm trees line the resort area, while naupaka grows at the south end of the subsector.

### SHORELINE HISTORY

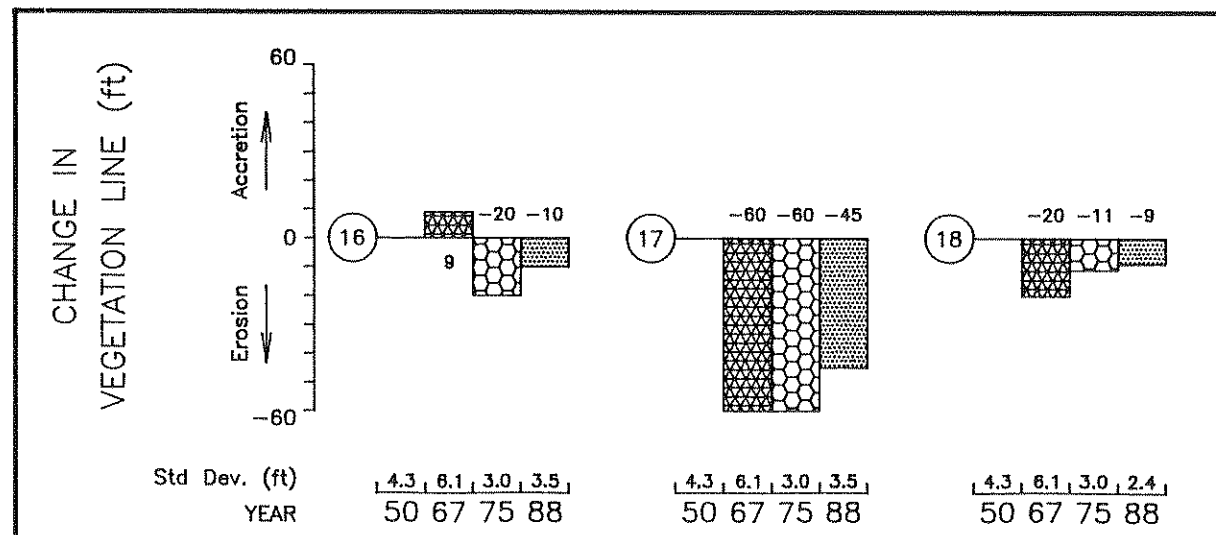
- The beach in the vicinity of Region 16 shows both localized erosion and accretion with a general tendency toward erosion after 1967. The offshore rock ledge is submerged at this region.
- The waterline at Region 17 is stabilized by the rock bench which breaches the water surface. The waterline has remained stable and the vegetation line has moved landward, resulting in a net widening of the beach.
- Region 18 is located on the sandy shoreline of Kahuwai Bay. Although the area is unprotected by a rock bench, the beach has been relatively stable, accreting slightly between 1967 and 1988.

### SUMMARY

- Kaupulehu Beach can be divided into three categories. The beach located at the south end of the subsector is characterized by a 50 foot wide beach subject to typical littoral processes with a submerged rock bench offshore. This area shows both erosion and accretion in certain areas, but tends towards a slightly eroding beach.
- The rock bench is more pronounced at the center of the subsector and shelters the sandy beach from day to day littoral processes. This is a perched beach with a stable waterline and a vegetation line that is moving landward, causing a widening of the beach.
- The sandy areas in front of Kahuwai Bay makes up the third category. It is an unprotected beach that has accreted slightly since 1967.



**FIGURE HB-5**



**GRAPH HB-5 Region Number vs Change in Vegetation Line**

**PHOTOS USED**  
 May 1988  
 July 1987  
 April 1975  
 March 1960  
 November 1950



# REGION SUMMARY TABLES

The following tables show the computed accretion rates between successive photographs for each region in the atlas. There is one table for each of fifteen shoreline sectors presented in this atlas.

For each region the following is provided:

- The beach or area name
- A map reference and region number
- The base year (the first year that aerial photographic data are available)
- The annual accretion rate between two successive photographs.
- The average annual accretion rate based on the earliest and latest photographs available.
- The extrapolated total accretion, relative to 1988, for the next 30 years. This is the extrapolated beach position for the year 2018 relative to 1988.
- A standard deviation of this extrapolated accretion. The derivation method and meaning are discussed below.
- Brief summary comments on each region based both on the information in this table and all other available data.

Both 1987 and 1988 aerial photos were available for most of the beaches but only one of the years has been included in these tables. The vegetation line changes from 1987 to 1988 were usually minimal and an accretion erosion rate based on these two photos (actually 6 months apart) would reflect more the digitizing errors than the actual beach changes. The 1988 data were used in these tables except where only 1987 photos were available. The 1987 data were used in the beach erosion analysis and the digitized data have been included in the GIS files.

In regions where shoreline protection has been added, an \* is shown in the first photograph year in which the protection was observed. The accretion rate provided adjacent to the \* is based on the full number of years between the two photographs, regardless of when the shoreline protection was built (date usually unknown). For subsequent years where the shoreline protection has remained in place, no accretion is tabulated. Furthermore, no 30-year extrapolations are provided for beaches with shoreline protection.

Some photographs were not available and some were of such poor quality that they were unusable. These photographs are marked accordingly in the table.

The 30 year extrapolation of shoreline accretion is based purely on the average rate observed in previous years. It assumes that the past average trends will continue into the future. It does not take into account shoreline variations in sediment composition which could affect erosion nor

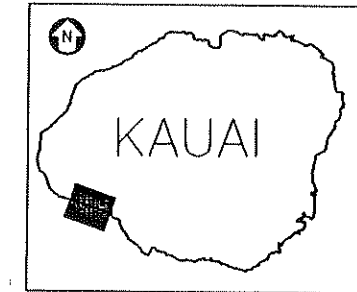
does it take into account changes to the shoreline due to one-time human intervention. These 30-year extrapolations should be treated as a general guideline only. The generation of this 30-year line was not a primary goal of this study.

In order to assess the quality of this 30-year extrapolation, a standard deviation was computed. This standard deviation is proportional to the variability in the accretion rates as measured from historical photographs and also proportional to the variability of any extrapolation into the future based on this same historical data. A probabilistic model was used to determine the probability distribution of the extrapolation. The model assumed that both the future and past are made up of random events, and the future is statistically indistinguishable from the past. By adding thirty years or randomly selected historical years, a possible future scenario could be developed. With a large number of such future accretion scenarios, the mean future accretion rate approaches the mean accretion rate observed historically and the standard deviation of the distribution of possible future accretion values could be determined.

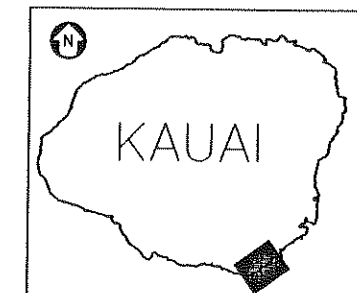
The standard distribution reflected in these tables is valuable in assessing the strength of an accretion or eroding trend. If the standard deviation is large compared to the total accretion or erosion predicted, the predicted value has little significance. In these cases, the large standard deviation generally indicates a dynamic beach subject to both significant erosion and accretion. If, however, the standard deviation is small, the historical trend has been steady and the future is more reliably predicted. Some reported standard deviations are small, but this should not be interpreted to mean that the future of the beach has been predicted within a relatively small margin of error. It should be remembered that these estimates are based on a simple linear extrapolation of often only three or four data points. Beach processes and, in particular, man's influence on these processes are not linear.



KAUAI Sector A			ACCRETION RATE				ft/yr		30-Year Extension		Comments KAUAI Sector A
Beach	Map & Region	Base Yr	1960	1975	1988	Average	yr 2018	Std Dev	ACCRETION, ft Relative to 1988		
Kikiaola Beach	Kauai A1	1	1953	-1.57	0.07	-0.50	-0.47	-15	6	Eroding; boat harbor blocking sand transport.	
Kikiaola Beach	Kauai A1	2	1953	2.14	-0.47	-3.69	-1.14	-35	18	Eroding; boat harbor blocking sand transport.	
Kikiaola Beach	Kauai A1	3	1953	0.71	-1.80	-1.62	-1.23	-38	8	Eroding; boat harbor blocking sand transport.	
Kikiaola Beach	Kauai A1	4	1953	-0.29	-0.53	-0.38	-0.43	-13	4	Eroding; boat harbor blocking sand transport.	
Kikiaola Beach	Kauai A1	5	1953	-0.57	-1.87	-3.15	-2.09	-64	8	Eroding; boat harbor blocking sand transport.	
Waimea Beach	Kauai A2	6	1953	1.86	1.93	3.00	2.31	72	5	Accreting; boat harbor stabilizing beach to east.	
Waimea Beach	Kauai A2	7	1953	-1.29	2.67	4.08	2.40	74	16	Accreting; boat harbor stabilizing beach to east.	
Waimea Beach	Kauai A2	8	1953	1.57	3.27	-1.92	1.00	31	19	Accreting; boat harbor stabilizing beach to east.	
Waimea Beach	Kauai A3	9	1953	-1.86	2.73	0.15	0.86	27	14	Accreting; boat harbor stabilizing beach to east.	
Waimea Beach	Kauai A3	10	1953	-0.86	2.40	-0.77	0.57	18	13	Accreting; boat harbor stabilizing beach to east.	
Waimea Beach	Kauai A3	11	1953	2.57	-0.47	0.69	0.57	18	10	Accreting; boat harbor stabilizing beach to east.	

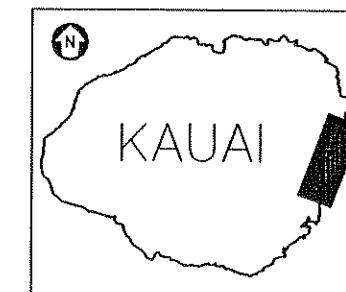


KAUAI Sector B			ACCRETION RATE				ft/yr		30-Year Extension		Comments KAUAI Sector B
Beach	Map & Region	Base Yr	1960	1975	1988	Average	yr 2018	Std Dev	ACCRETION, ft Relative to 1988		
Shipwreck Beach	Kauai B1	1	1953	-1.14	1.07	-2.30	-0.63	-19	13	Dynamic Beach; tendency for erosion.	
Shipwreck Beach	Kauai B1	2	1953	-3.71	0.93	-0.69	-0.60	-19	14	Dynamic Beach; tendency for erosion.	
Shipwreck Beach	Kauai B1	3	1953	-0.43	0.60	-1.77	-0.49	-15	10	Dynamic Beach; tendency for erosion.	
Gillen's Beach	Kauai B2	4	1953	-2.43	1.07	-1.85	-0.71	-22	15	Eroding, but data questionable.	
Gillen's Beach	Kauai B2	5	1953	-1.43	0.53	-1.16	-0.49	-15	8	Eroding, but data questionable.	
Gillen's Beach	Kauai B3	6	1953	0.00	1.00	-1.92	-0.29	-9	13	Stable.	
Gillen's Beach	Kauai B3	7	1953	-0.57	0.73	-1.46	-0.34	-11	9	Stable.	
Kawailoa Beach	Kauai B3	8	1953	-1.14	1.07	0.30	0.34	11	7	Stable.	
Haula Beach	Kauai B3	9	1953	(NA)	0.14	1.15	0.51	13	11	Accreting beach.	



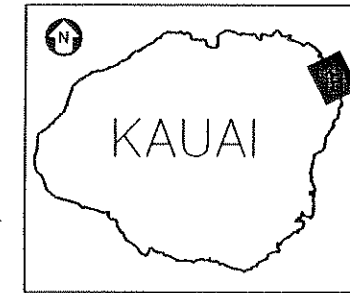
(PQ) Poor quality aerial photograph  
(NA) Aerial photograph not available  
\* Shoreline Protection in place

KAUAI Sector C		ACCRETION RATE ft/yr					30-Year Extension ACCRETION, ft Relative to 1988		Comments KAUAI Sector C
Beach	Map & Region	Base Yr	1960	1975	1988	Average	yr 2018	Std Dev	
Hanamaulu Beach	KAUAI C1 1	1953	2.86	0.00	-1.31	0.09	3	13	Stable beach.
Hanamaulu Beach	KAUAI C1 2	1953	-1.71	-0.67	-0.54	-0.83	-26	5	Chronic erosion.
Hanamaulu Beach	KAUAI C1 3	1953	1.00	0.13	0.15	0.31	10	4	Stable beach.
Nukolii to Wailua River	KAUAI C2 4	1953	-0.71	-1.20	0.92	-0.31	-10	8	Stable beach.
Nukolii to Wailua River	KAUAI C2 5	1953	-2.71	2.47	-0.62	0.29	9	17	Stable beach.
Nukolii to Wailua River	KAUAI C2 6	1953	-1.14	2.53	-1.85	0.17	5	17	Recent erosion in front of hotel.
Nukolii to Wailua River	KAUAI C2 7	1953	-7.00	0.60	-0.08	-1.17	-36	25	Significant erosion.
Nukolii to Wailua River	KAUAI C2 8	1953	-4.29	0.80	-3.08	-1.66	-51	18	Significant erosion.
Nukolii to Wailua River	KAUAI C2 9	1950	-4.50	0.87	*-0.38	*	*	0	Significant erosion; revetment built.
Nukolii to Wailua River	KAUAI C3 10	1950	-2.20	-0.67	* 0.38	*	*	0	Erosion; revetment built.
Nukolii to Wailua River	KAUAI C3 11	1950	-0.20	-0.60	*-3.23	*	*	0	Erosion; revetment built.
Nukolii to Wailua River	KAUAI C3 12	1950	1.10	-1.00	-0.46	-0.26	-8	7	Stable.
Nukolii to Wailua River	KAUAI C3 13	1950	5.00	-0.87	1.62	1.53	47	20	Accreting; influenced by adjacent revetment.
Nukolii to Wailua River	KAUAI C3 14	1950	3.40	1.07	* 0.15	*	*	0	Revetment; built to protect golf green.
Nukolii to Wailua River	KAUAI C3 15	1950	1.00	0.20	-1.00	0.00	0	7	Stable.
Nukolii to Wailua River	KAUAI C3 16	1950	0.20	-0.60	-0.23	-0.26	-8	4	Stable.
Nukolii to Wailua River	KAUAI C4 17	1950	0.00	0.20	-0.08	0.05	2	3	Stable.
Nukolii to Wailua River	KAUAI C4 18	1950	-0.60	-0.20	0.15	-0.18	-6	4	Stable.
Lydgate State Park	KAUAI C4 19	1950	-1.20	3.40	-3.62	-0.21	-6	24	Dynamic Beach
Lydgate State Park	KAUAI C4 20	1950	3.60	-0.87	-0.62	0.39	12	16	Dynamic; near Wailua River discharge.
Wailua Beach	KAUAI C5 21	1950	0.80	-0.07	1.77	0.79	24	7	Accreting; dynamic beach.
Wailua Beach	KAUAI C5 22	1950	0.30	0.93	1.77	1.05	32	5	Accreting; dynamic beach.
Waipoli Beach	KAUAI C5 23	1950	-1.00	0.87	-1.00	-0.26	-8	8	Stable; beach rock at water line.
Waipoli Beach	KAUAI C5 24	1950	(PQ)	-0.60	0.62	-0.18	-6	6	Stable; intermittent erosion.
Waipoli Beach	KAUAI C5 25	1950	(PQ)	0.08	0.46	0.21	6	3	Stable; intermittent erosion.
Waipoli Beach	KAUAI C5 26	1950	(PQ)	-0.08	0.77	0.21	6	4	Stable; intermittent erosion.
Waipoli Beach	KAUAI C6 27	1950	(PQ)	0.24	-0.31	0.05	2	4	Stable.
Waipoli Beach	KAUAI C6 28	1950	(PQ)	-0.52	-0.46	-0.50	-15	4	Eroding.
Waipoli Beach	KAUAI C6 29	1950	-1.90	-1.27	* 1.38	*	*	0	Severe erosion; shore protection built.
Waipoli Beach	KAUAI C6 30	1950	-0.30	0.33	-0.85	-0.24	-7	5	Minor erosion.
Waipoli Beach	KAUAI C6 31	1950	(PQ)	-0.32	-1.08	-0.58	-18	4	Eroding beach; intermittent shore protection.
Waipoli Beach	KAUAI C6 32	1950	(PQ)	-0.24	-0.46	-0.32	-10	4	Severe erosion.
Waipoli Beach	KAUAI C6 33	1950	-0.40	2.20	0.85	1.05	32	9	Accreting; at canal.
Waipoli Beach	KAUAI C6 34	1950	4.00	3.87	-1.46	2.08	64	21	Accreting; at canal.
Kapaa Beach	KAUAI C7 35	1950	0.20	-1.93	-2.38	-1.53	-47	9	Severe erosion.
Kapaa Beach	KAUAI C7 36	1950	0.60	-0.20	0.38	0.21	6	4	Stable.
Kapaa Beach	KAUAI C7 37	1950	-0.60	1.00	0.23	0.32	10	6	Stable.
Kapaa Beach	KAUAI C7 38	1950	-5.00	*-1.47	*	*	*	0	Severe erosion; revetment constructed.
Kapaa Beach	KAUAI C7 39	1950	1.00	1.33	0.38	0.92	28	5	Accreting beach.
Kealia Beach	KAUAI C8 40	1950	(NA)	-0.92	0.15	-0.55	-17	5	Eroding; no facilities threatened.
Kealia Beach	KAUAI C8 41	1950	(NA)	-1.32	0.31	-0.76	-23	7	Eroding; no facilities threatened.
Kealia Beach	KAUAI C8 42	1950	(NA)	-0.88	-1.77	-1.18	-36	4	Eroding; no facilities threatened.

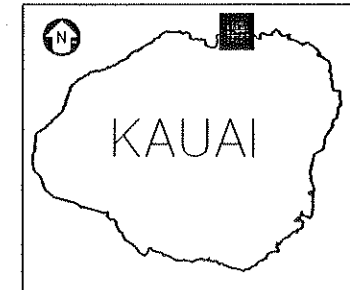


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KAUAI Sector D		ACCRETION RATE ft/yr					30-Year Extension ACCRETION, ft Relative to 1988		Comments KAUAI Sector D
Beach	Map & Region	Base Yr	1975	1988	Average	yr 2018	Std Dev		
Papaa Bay	Kauai D1 1	1960	0.33	0.62	0.46	14	4	Slight accretion; no development.	
Papaa Bay	Kauai D1 2	1960	0.13	0.31	0.21	6	3	Stable beach; no development.	
Papaa Bay	Kauai D1 3	1960	0.67	0.31	0.50	15	4	Slight accretion; no development.	
Papaa Bay	Kauai D1 4	1960	0.20	0.77	0.46	14	4	Slight accretion; no development.	
Aliomanu Beach	Kauai D2 5	1960	0.53	0.15	0.36	11	4	Slight accretion; extreme north end of beach.	
Aliomanu Beach	Kauai D2 6	1960	-0.67	* 0.00	*	*	0	Eroding; shore protection in place.	
Aliomanu Beach	Kauai D2 7	1960	0.00	-1.54	-0.71	-22	7	Eroding.	
Anahola Beach	Kauai D2 8	1960	0.13	0.46	0.29	9	4	Stable beach.	
Anahola Beach	Kauai D3 9	1960	1.87	0.08	1.04	31	11	Accreting.	
Anahola Beach	Kauai D3 10	1960	5.60	1.38	3.64	109	32	Dynamic; affected by river discharge.	
Anahola Beach	Kauai D3 11	1960	1.47	-1.54	0.07	2	14	Stable.	
Anahola Beach	Kauai D3 12	1960	0.73	1.15	0.92	28	10	Accreting beach.	
Anahola Beach	Kauai D3 13	1960	0.73	0.00	0.39	12	5	Stable.	
Anahola Beach	Kauai D3 14	1960	0.13	-0.92	-0.36	-11	5	Stable.	

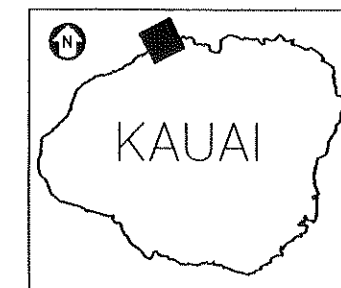


KAUAI Sector E		ACCRETION RATE ft/yr					30-Year Extension ACCRETION, ft Relative to 1988		Comments KAUAI Sector E
Beach	Map & Region	Base Yr	1960	1975	1988	Average	yr 2018	Std Dev	
Anini Beach	Kauai E1 1	1950	1.20	0.40	0.15	0.53	16	5	Accreting beach.
Anini Beach	Kauai E1 2	1950	-0.50	-0.20	0.15	-0.16	-5	4	Stable.
Anini Beach	Kauai E1 3	1950	0.00	0.27	0.00	0.11	3	2	Stable.
Anini Beach	Kauai E1 4	1950	-0.20	0.33	-0.46	-0.08	-2	5	Stable.
Anini Beach	Kauai E2 5	1950	0.80	-0.87	-1.15	-0.53	-16	7	Eroding.
Anini Beach	Kauai E2 6	1950	-1.20	0.00	-0.46	-0.47	-15	5	Eroding.
Anini Beach	Kauai E2 7	1950	2.40	-0.27	-0.62	0.32	10	11	Accreting.
Anini Beach	Kauai E2 8	1950	0.00	-2.67	-0.15	-1.11	-34	10	Severe erosion.
Anini Beach	Kauai E2 9	1950	1.80	-0.47	-1.23	-0.13	-4	10	Dynamic; little net change.
Anini Beach	Kauai E2 10	1950	1.50	0.20	0.15	0.53	16	6	Accreting.

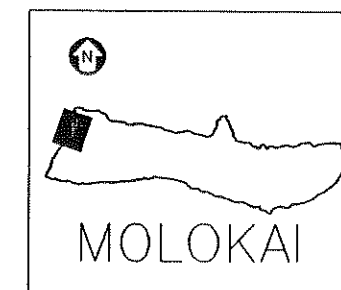


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 \* Shoreline Protection in place

KAUAI Sector F			ACCRETION RATE <i>ft/yr</i>					30-Year Extension ACCRETION, <i>ft</i> Relative to 1988		Comments KAUAI Sector F
Beach	Map & Region	Base Yr	1960	1975	1988	Average	yr 2018	Std Dev		
Kee Beach	Kauai F1 1	1950	(PQ)	-3.60	5.00	-0.66	-20	33	Dynamic beach; large range of vegetation line changes.	
Kee Beach	Kauai F1 2	1950	(PQ)	-0.60	2.69	0.53	16	13	Dynamic beach; large range of vegetation line changes.	
Kee Beach	Kauai F1 3	1950	(PQ)	2.24	2.23	2.24	69	4	Accreting beach	
Kee Beach	Kauai F1 4	1950		1.00	0.53	-0.54	9	6	Relatively stable; some accretion.	
Kee Beach	Kauai F1 5	1950		-1.00	1.07	-1.62	-12	10	Cyclical.	
Kee Beach	Kauai F1 6	1950	(PQ)	-0.60	-0.62	-0.61	-19	4	Eroding.	

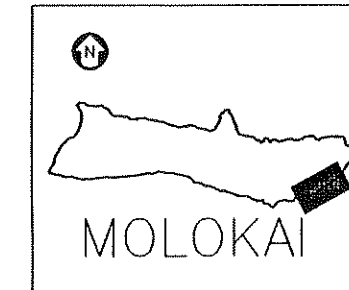


MOLOKAI Sector A			ACCRETION RATE <i>ft/yr</i>					30-Year Extension ACCRETION, <i>ft</i> Relative to 1988		Comments MOLOKAI Sector A
Beach	Map & Region	Base Yr	1968	1975	1988	Average	yr 2018	Std Dev		
Papohaku Beach	Molokai A1 1	1955	-7.92	9.29	-1.54	-1.76	-54	46	Severe erosion caused by sand mining operation.	
Papohaku Beach	Molokai A1 2	1955	0.92	-10.00	0.62	-1.52	-46	36	Severe erosion caused by sand mining operation.	
Papohaku Beach	Molokai A1 3	1955	2.77	-3.29	-2.23	-0.48	-15	21	Dynamic beach; relatively stable over long term.	
Papohaku Beach	Molokai A1 4	1955	2.08	-1.00	-1.85	-0.12	-4	14	Dynamic beach; relatively stable over long term.	
Papohaku Beach	Molokai A1 5	1955	0.85	-1.86	-2.23	-0.94	-28	12	Eroding	
Papohaku Beach	Molokai A2 6	1955	0.00	-3.14	-0.62	-0.91	-27	10	Eroding	
Papohaku Beach	Molokai A2 7	1955	1.15	-0.71	0.62	0.55	16	6	Stable.	
Papohaku Beach	Molokai A2 8	1955	-0.77	1.57	-0.54	-0.18	-5	8	Stable.	
Kepuhi Beach	Molokai A2 9	1955	4.31	-2.29	2.92	2.36	71	19	Accretion; apparently due to resort landscaping.	
Kepuhi Beach	Molokai A3 10	1955	(NA)	2.45	0.23	1.58	47	9	Accretion; apparently due to resort landscaping.	
Pohakumauliuli Beach	Molokai A3 11	1955	-0.46	0.57	0.69	0.21	6	6	Stable.	
Pohakumauliuli Beach	Molokai A3 12	1955	-0.92	0.29	-0.62	-0.55	-16	5	Slight erosion; no backshore development.	
Kawakiu Beach	Molokai A4 13	1968	0.00	-1.57	-0.62	-0.95	-30	5	Steady erosion, undeveloped beach	
Kawakiu Beach	Molokai A4 14	1968	0.00	-1.29	-0.08	-0.50	-16	6	Slight net erosion	

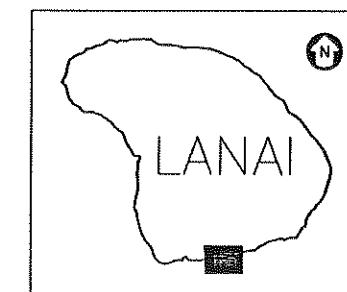


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\* Shoreline Protection in place

MOLOKAI Sector B		ACCRETION RATE <i>ft/yr</i>					30-Year Extension ACCRETION, <i>ft</i> Relative to 1987		Comments MOLOKAI Sector B
Beach	Map & Region	Base Yr	1961	1975	1987	Average	yr 2018	Std Dev	
Pukoo	Molokai B1 1	1949	-1.50	2.14	0.08	0.34	11	12	Stabilized by jetty built prior to 1975.
Pukoo	Molokai B1 2	1949	-2.50	2.14	-0.92	-0.29	-9	16	Dynamic beach
Pukoo	Molokai B1 3	1949	-2.33	1.64	1.67	0.39	12	15	Slight accretion
Pukoo	Molokai B1 4	1949	-0.08	-0.36	-0.50	-0.32	-10	4	Ongoing erosion; one to two foot scarp.
Pauwalu	Molokai B2 5	1975	(NA)	0.00	2.42	2.42	23	9	Accreting.
Pauwalu	Molokai B2 6	1949	(NA)	0.19	2.75	1.00	31	10	Accreting; updrift of seawall.
Pauwalu	Molokai B2 7	1949	0.17	0.57	1.83	0.84	26	6	Accreting; inside old fishpond.
Pauwalu	Molokai B2 8	1949	1.42	-0.93	0.42	0.24	7	8	Accreting; inside old fishpond.
Pauwalu	Molokai B2 9	1949	0.17	-0.21	-0.42	-0.16	-5	4	Stable; boulders at waterline.
Waialua	Molokai B3 10	1949	-0.67	0.00	-0.25	-0.29	-9	4	Ongoing erosion; wave-cut scarp.
Waialua	Molokai B3 11	1949	1.42	-0.29	-0.33	0.24	7	7	Accreting.
Waialua	Molokai B3 12	1949	0.58	0.21	-0.83	0.00	0	6	Stable.
Waialua	Molokai B3 13	1949	0.00	-1.79	-1.25	-1.05	-32	6	Significant erosion; inside fishpond walls.
Waialua	Molokai B3 14	1949	(NA)	-1.00	0.92	-0.39	-12	7	Eroding.
Kahinapohaku Fishpond	Molokai B4 15	1949	(NA)	1.54	-2.67	0.21	6	16	Dynamic shoreline.
Cape Palalupi	Molokai B4 16	1949	(NA)	0.00	0.00	0.00	0	0	Stable; road at beach crest.
Cape Palalupi	Molokai B4 17	1949	(NA)	0.69	0.92	0.76	23	3	Accreting.

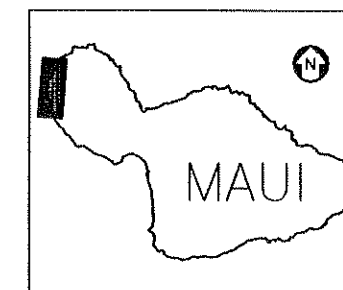


LANAI Sector A		ACCRETION RATE <i>ft/yr</i>				30-Year Extension ACCRETION, <i>ft</i> Relative to 1988		Comments LANAI Sector A
Beach	Map & Region	Base Yr	1975	1988	Average	yr 2018	Std Dev	
Hulopoe Beach	Lanai A1 1	1963	0.50	-0.08	0.20	6	6	Stable beach
Hulopoe Beach	Lanai A1 2	1963	-0.17	0.30	0.08	2	8	Stable beach



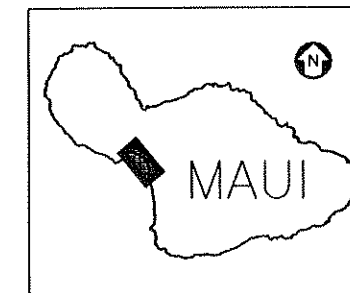
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\* Shoreline Protection in place

MAUI Sector A			ACCRETION RATE ft/yr				30-Year Extension ACCRETION, ft Relative to 1988		Comments MAUI Sector A	
Beach	Map & Region	Base Yr	1961	1975	1988	Average	yr 2018	Std Dev		
Puunoa Beach	Maui A1	1	1949	-0.17	1.50	2.61	1.36	42	10	Net accretion
Puunoa Beach	Maui A1	2	1949	1.58	1.71	1.85	1.72	53	3	Significant accretion
Puunoa Beach	Maui A1	3	1949	0.67	-0.64	-5.15	-1.74	-54	20	Significant erosion in front of cemetery.
Wahikuli State Wayside	Maui A3	4	1949	-1.58	*-0.29	*	*	*	0	Rock revetment at beach crest.
Wahikuli State Wayside	Maui A3	5	1949	0.17	0.14	-0.46	-0.05	-2	4	Stable.
Hanakaoo Beach	Maui A4	6	1949	-1.67	2.14	-1.84	-0.36	-11	16	Dynamic, alternating erosion and accretion.
Hanakaoo Beach	Maui A4	7	1949	-1.08	-0.14	-0.62	-0.59	-18	6	Slow, steady erosion occurring
Hanakaoo Beach	Maui A4	8	1949	-0.83	0.00	1.84	0.36	11	9	Alternating erosion and accretion.
Hanakaoo Beach	Maui A4	9	1949	-0.42	-0.36	1.30	0.18	6	13	Alternating erosion and accretion.
Hanakaoo Beach	Maui A5	10	1949	-2.08	0.21	0.77	-0.31	-11	13	Eroding beach.
Hanakaoo Beach	Maui A5	11	1949	-3.33	3.00	0.61	0.26	8	23	Dynamic; alternating erosion & accretion.
Hanakaoo Beach	Maui A5	12	1949	0.83	1.29	0.62	0.92	28	4	Accreting; stable in recent years.
Hanakaoo Beach	Maui A5	13	1949	1.25	-0.50	-0.46	0.05	2	11	Stable.
Kaanapali Beach	Maui A5	14	1949	-1.67	-0.50	-0.07	-0.72	-22	6	Net erosion, but stable in recent years.
Kaanapali Beach	Maui A6	15	1949	-2.92	0.57	1.23	-0.28	-9	14	Dynamic; fluctuating erosion/accretion.
Kaanapali Beach	Maui A6	16	1949	0.17	-1.64	0.85	-0.26	-6	14	Dynamic; fluctuating erosion/accretion.
Kaanapali Beach	Maui A6	17	1949	-0.17	-0.57	0.07	-0.23	-7	7	Slight erosion; stable compared to rest of beach.
Kaanapali Beach	Maui A6	18	1949	1.92	-0.14	0.08	0.56	17	9	Accreting.
Honokowai Beach	Maui A6	19	1949	1.67	-0.57	-2.46	-0.51	-16	14	Dynamic; fluctuating erosion/accretion.
Honokowai Beach	Maui A6	20	1949	1.00	-2.86	* 0.08	*	*	0	Protective revetment in place.
Honokowai Beach	Maui A7	21	1949	1.75	-0.86	*-2.62	*	*	0	Eroding beach; seawall built
Honokowai Beach	Maui A7	22	1949	1.75	-1.29	* 0.54	*	*	0	Erosion after hotel construction; seawall built
Honokowai Beach	Maui A7	23	1949	1.25	-2.50	-1.92	-1.15	-35	13	Severe erosion occurring.
Honokowai Beach	Maui A7	24	1949	1.58	*-1.57	*	*	*	0	Erosion after condominium construction; seawall built
Honokowai Beach	Maui A7	25	1949	-0.17	*-2.86	*	*	*	0	Eroding; seawall built
Kahana Beach	Maui A8	26	1949	0.00	*-3.00	*	*	*	0	Erosion; seawall built.
Kahana Beach	Maui A8	27	1949	1.00	-5.00	1.07	-1.13	-35	24	Dynamic beach, significant net erosion.
Kahana Beach	Maui A8	28	1949	2.08	-3.93	1.08	-0.41	-13	23	Dynamic beach, net erosion.
Keonenui Beach	Maui A9	29	1949	-2.08	* 0.36	*	*	*	0	Erosion; seawall built
Napili Beach	Maui A10	30	1949	(PQ)	-0.85	0.16	-0.51	-17	10	Eroding.
Napili Beach	Maui A10	31	1949	(PQ)	-0.69	0.08	-0.44	-19	10	Eroding.
Kapalua Beach	Maui A10	32	1949	(PQ)	-0.50	0.00	-0.33	-10	4	Relatively stable beach.
Kapalua Beach	Maui A10	33	1949	(PQ)	0.31	-1.62	-0.33	-10	11	Relatively stable beach.



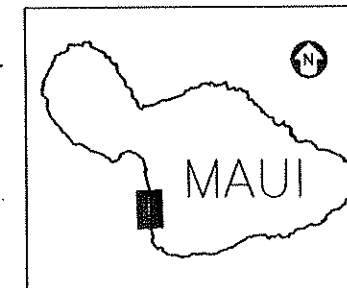
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 \* Shoreline Protection in place

MAUI Sector B			ACCRETION RATE <i>ft/yr</i>				30-Year Extension ACCRETION, <i>ft</i> Relative to 1988		Comments MAUI Sector B	
Beach	Map & Region	Base Yr	1964	1975	1988	Average	yr 2018	Std Dev		
Maalaea Bay Beach	Maui B1	1	1950	-0.86	2.09	-0.31	0.18	6	13	Stable shoreline.
Maalaea Bay Beach	Maui B1	2	1950	-1.29	-1.09	-0.23	-0.87	-26	5	Net erosion, stable since 1975
Maalaea Bay Beach	Maui B2	3	1949	-0.13	0.64	0.00	0.13	4	8	Stable shoreline
Maalaea Bay Beach	Maui B2	4	1949	-0.13	0.00	0.15	0.00	-3	10	Stable shoreline
Maalaea Bay Beach	Maui B2	5	1949	-1.20	0.55	-1.77	-0.90	-17	11	Steadily eroding shoreline.
Maalaea Bay Beach	Maui B3	6	1949	-1.33	-1.45	-1.46	-1.41	-35	10	Steadily eroding shoreline.
Maalaea Bay Beach	Maui B3	7	1949	-0.53	-1.64	0.08	-0.64	-20	7	Steadily eroding shoreline.
Maalaea Bay Beach	Maui B3	8	1949	-3.00	2.27	-1.38	-0.97	-30	20	Eroding beach.
Maalaea Bay Beach	Maui B4	9	1949	-3.00	1.82	0.62	-0.44	-13	17	Dynamic beach.
Maalaea Bay Beach	Maui B4	10	1949	1.47	2.09	* 0.62	*	*	0	Accreting beach.
Kalaepohaku	Maui B4	11	1949	-0.33	1.18	0.00	0.21	6	6	Stable beach
Maipoina Oe Iau Park	Maui B5	12	1949	-1.20	1.64	-1.92	-0.64	-18	14	Eroding beach.
Maipoina Oe Iau Park	Maui B5	13	1949	-1.00	-1.00	-0.15	-0.72	-22	4	Eroding beach.
Maipoina Oe Iau Park	Maui B5	14	1949	-0.67	-0.45	-1.16	-0.77	-24	7	Eroding beach.
Kalepolepo Beach	Maui B6	15	1949	7.33	-0.45	0.77	2.95	89	30	Steadily accreting.
Kawililipoa	Maui B6	16	1949	-2.13	-2.91	-2.16	-2.36	-70	9	Steadily eroding.
Kawililipoa	Maui B6	17	1949	6.67	11.82	4.15	7.28	30	0	Steadily accreting.
Kawililipoa	Maui B7	18	1949	-2.53	-1.36	-0.54	-1.54	-47	12	Eroding beach caused by groin to north.
Waimahaihai	Maui B7	19	1949	7.20	0.64	0.38	3.08	90	29	Accreting beach caused by groin to south.
Waimahaihai	Maui B7	20	1949	0.67	0.73	-3.46	-0.69	-21	16	Eroding beach, active erosion scarp
Waimahaihai	Maui B7	21	1949	-1.33	*-0.73	*	*	*	0	Shore protection, no beach, causing erosion to north.
Kalama Beach Park	Maui B8	22	1949	-2.33	* 5.00	*	*	*	0	Eroding , revetment built in early 1970's.



(PQ) Poor quality aerial photograph  
 (NA) Aerial photograph not available  
 \* Shoreline Protection in place

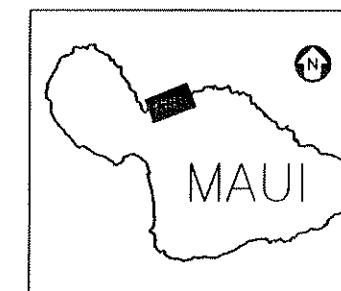
MAUI Sector C			ACCRETION RATE <i>ft/yr</i>						30-Year Extension ACCRETION, <i>ft</i> Relative to 1988		Comments MAUI Sector C
Beach	Map & Region	Base Yr	1963	1964	1975	1988	Average	yr 2018	Std Dev		
Kamaole I Beach	Maui C1	1	1949	(NA)	-5.67	6.36	-5.62	-2.26	-71	42	Dynamic beach.
Kamaole I Beach	Maui C1	2	1949	(NA)	-5.67	0.00	2.69	-1.28	-44	29	Dynamic beach.
Kamaole II Beach	Maui C1	3	1949	(NA)	-2.67	2.91	-2.46	-1.03	-32	20	Dynamic beach.
Kamaole II Beach	Maui C1	4	1949	(NA)	-4.00	3.64	-1.54	-1.03	-32	25	Dynamic beach.
Kamaole III Beach	Maui C1	5	1949	(NA)	-2.00	1.82	-0.62	-0.46	-11	15	Dynamic beach.
Keawakapu Beach	Maui C2	6	1949	-5.36	(NA)	4.17	-2.84	-1.59	-49	33	Dynamic shoreline.
Keawakapu Beach	Maui C2	7	1949	0.00	(NA)	-0.58	0.31	-0.08	-2	9	Stable shore, protected by rock outcrop.
Keawakapu Beach	Maui C2	8	1949	-6.29	(NA)	5.25	-6.15	-2.69	-84	40	Dynamic shoreline.
Keawakapu Beach	Maui C2	9	1949	-6.43	(NA)	2.50	0.77	-1.28	-39	31	Dynamic shoreline.
Mokapu Beach	Maui C3	10	1949	-2.14	(NA)	-0.17	-0.61	-1.03	-27	12	Eroding beach.
Mokapu Beach	Maui C3	11	1949	-4.14	(NA)	1.08	-3.07	-2.18	-67	18	Eroding beach.
Ulua Beach	Maui C3	12	1949	-3.00	(NA)	0.33	-2.30	-1.74	-51	14	Eroding beach.
Ulua Beach	Maui C3	13	1949	-0.50	(NA)	-0.67	-0.77	-0.64	-20	6	Eroding beach.
Wailea Beach	Maui C3	14	1949	-1.43	(NA)	0.83	-1.54	-0.77	20	18	Dynamic beach.
Wailea Beach	Maui C3	15	1949	0.71	(NA)	-0.42	-1.92	-0.51	-16	15	Dynamic beach.
Polo Beach	Maui C4	16	1949	-2.14	(NA)	1.67	-3.23	-1.33	-41	18	Dynamic beach.
Polo Beach	Maui C4	17	1949	-5.36	(NA)	4.83	-0.38	-0.56	-24	35	Dynamic beach.
Polo Beach	Maui C4	18	1949	0.93	(NA)	0.00	1.69	0.90	28	6	Accreting cobble beach.
Palauea Beach	Maui C4	19	1949	-0.36	(NA)	1.42	-3.00	-0.69	-21	15	Dynamic beach.
Palauea Beach	Maui C4	20	1949	-0.57	(NA)	1.08	-4.23	-1.28	-40	22	Dynamic beach.
Poolenalena Beach	Maui C5	21	1949	-0.86	(NA)	2.67	-4.00	-0.82	-25	23	Dynamic beach.
Poolenalena Beach	Maui C5	22	1949	-1.57	(NA)	2.42	-3.46	-0.97	-30	20	Dynamic beach.
Poolenalena Beach	Maui C5	23	1949	0.50	(NA)	0.25	-0.38	0.13	4	6	Shoreline protected by rock outcrops.



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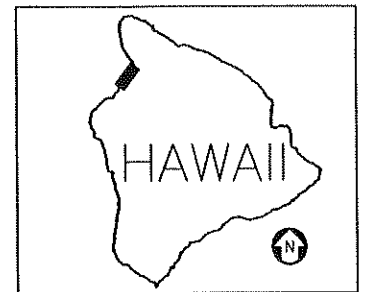


MAUI Sector D			ACCRETION RATE <i>ft/yr</i>				30-Year Extension ACCRETION, <i>ft</i> Relative to 1988		Comments MAUI Sector D	
Beach	Map & Region	Base Yr	1964	1975	1988	Average	yr 2018	Std Dev		
Hobron Pt to Kaa	Maui D1	1	1950	-2.86	-8.36	-2.15	-4.21	-99	3	Severe erosion.
Hobron Pt to Kaa	Maui D1	2	1950	-0.71	-8.00	* 2.92	*	*	0	Severe erosion: revetment built after 1975.
Hobron Pt to Kaa	Maui D1	3	1950	-2.29	-6.91	-6.69	-5.13	-144	8	Severe erosion.
Hobron Pt to Kaa	Maui D1	4	1950	-4.86	-11.55	-3.46	-6.32	-148	2	Severe erosion.
Kanaha Beach Park	Maui D2	5	1950	-1.79	-2.27	-0.38	-1.45	-44	7	Erosion, beach located downdrift of groin.
Kanaha Beach Park	Maui D2	6	1950	-6.43	-5.45	-2.31	-4.74	-138	9	Severe erosion, beach located downdrift of groin.
Kanaha Beach Park	Maui D2	7	1950	-3.57	-6.55	-2.54	-4.08	-123	12	Severe erosion, beach located downdrift of groin.
Kanaha Beach Park	Maui D2	8	1950	2.14	1.64	6.62	3.53	56	0	Accretion, beach located updrift of groin.
Kanaha Beach Park	Maui D2	9	1950	3.57	-1.36	-2.31	0.13	4	21	Cyclic, accreting beach, located updrift of groin.
Kanaha Beach Park	Maui D3	10	1950	4.29	-0.45	0.00	1.45	44	17	Accretion, beach located updrift of groin.
Spreckelsville Beach	Maui D3	11	1950	0.00	1.82	-0.77	0.26	8	8	Accretion, beach located updrift of groin.
Spreckelsville Beach	Maui D3	12	1950	-3.71	-2.36	-1.00	-2.39	-72	9	Localized erosion.
Stables Beach	Maui D3	13	1950	-0.71	1.64	-1.38	-0.26	-8	10	Stable region.
Spreckelsville Beach	Maui D4	14	1950	-0.07	-1.73	* -2.31	*	*	0	Eroding, rock revetment built.
Spreckelsville Beach	Maui D4	15	1950	1.79	-0.55	-1.85	-0.13	-4	13	Unprotected, cyclic beach.
Spreckelsville Beach	Maui D4	16	1950	-0.71	-1.82	* -0.77	*	*	0	Erosion, stabilized by rock revetment.
Wawau Point	Maui D5	17	1950	1.29	-0.55	0.46	0.47	14	7	Accreting beach, stabilized by beach rock.
H. A. Baldwin Park	Maui D5	18	1950	0.07	-1.91	-1.69	-1.11	-33	8	Eroding shoreline.
H. A. Baldwin Park	Maui D5	19	1950	-6.29	0.27	-1.92	-2.89	-87	22	Severely eroding beach downdrift of revetment.
H. A. Baldwin Park	Maui D5	20	1950	-1.07	-0.27	0.23	-0.39	-12	5	Eroding beach somewhat sheltered by Kinney reef.
Lower Paia Park	Maui D6	21	1950	0.50	-1.55	0.77	0.00	0	9	Dynamic beach, only slight net change.
Mantokuji Beach	Maui D6	22	1950	0.64	-0.82	-1.38	-0.47	-14	8	Eroding beach.
Kaulahao Beach	Maui D6	23	1950	0.64	1.00	-0.23	0.45	14	5	Accreting beach.
Tavares Bay	Maui D7	24	1950	0.50	0.00	0.69	0.42	13	4	Accreting beach.

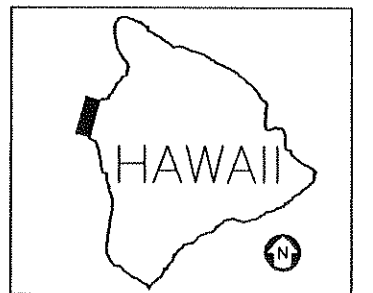


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 \* Shoreline Protection in place

HAWAII Sector A		ACCRETION RATE <i>ft/yr</i>					30-Year Extension ACCRETION, <i>ft</i> Relative to 1988		Comments HAWAII Sector A	
Beach	Map & Region	Base Yr	1964	1975	1988	Average	yr 2018	Std Dev		
Anaehoomalu	Hawaii A1 1	1950	0.00	1.00	-0.08	0.26	8	4	Accreting region.	
Anaehoomalu	Hawaii A1 2	1950	-1.00	0.55	0.31	-0.11	-3	6	Minor erosion	
Anaehoomalu	Hawaii A2 3	1950	1.79	-0.55	0.08	0.53	16	8	Perched beach, stable waterline, accreting vegetation line	
Mauna Lani Hotel	Hawaii A3 4	1950	0.00	0.36	-1.15	-0.29	-9	6	Perched beach, stable waterline, dynamic vegetation line	
Mauna Lani Hotel	Hawaii A3 5	1950	-1.50	-1.73	0.77	-0.79	-24	9	Eroding beach, shallow offshore rock ledge.	
Waialea Beach	Hawaii A5 6	1950	1.00	0.27	0.00	0.45	14	4	Accreting beach.	
Waialea Beach	Hawaii A5 7	1950	-2.86	0.00	1.54	-0.53	-16	15	Eroding shoreline.	
Hapuna Beach	Hawaii A6 8	1950	-1.43	0.00	-0.77	-0.79	-24	5	Eroding vegetation line.	
Kaunaoa Beach	Hawaii A7 9	1950	0.00	-0.91	0.77	0.00	0	6	Vegetation line altered, appears to be a stable beach.	
Mauumae Beach	Hawaii A8 10	1964	0.00	0.36	0.46	0.42	13	4	Accreting pocket beach.	
Ohaiula Beach	Hawaii A8 11	1964	0.00	1.09	-0.77	0.08	3	8	Stable pocket beach.	



HAWAII Sector B		ACCRETION RATE <i>ft/yr</i>							30-Year Extension ACCRETION, <i>ft</i> Relative to 1975		Comments HAWAII Sector B	
Beach	Map & Region	Base Yr	1960	1961	1967	1975	1988	Average	yr 2018	Std Dev		
Honokohau	Hawaii B1 1	1950	(NA)	1.09	(NA)	0.29	0.15	0.47	14	4	Accreting beach.	
Honokohau	Hawaii B1 2	1950	(NA)	1.00	(NA)	-1.57	-1.15	-0.68	-21	9	Eroding shoreline.	
Honokohau	Hawaii B1 3	1950	(NA)	0.55	(NA)	-4.86	-0.62	-1.84	-56	18	Eroding shoreline, sediment movement N and S.	
Honokohau	Hawaii B1 4	1950	(NA)	-0.09	(NA)	-0.29	-0.31	-0.24	-7	3	Eroding shoreline.	
Honokohau	Hawaii B1 5	1950	(NA)	0.91	(NA)	-0.07	-0.08	0.21	6	4	Accreting beach.	
Honokohau	Hawaii B1 6	1950	(NA)	1.82	(NA)	-0.36	0.46	0.55	17	8	Accreting beach.	
North of Puhili Point	Hawaii B2 7	1950	(NA)	0.00	(NA)	-0.14	0.00	-0.05	-2	2	Stable beach.	
North of Puhili Point	Hawaii B2 8	1950	(NA)	1.82	(NA)	0.43	-0.46	0.53	16	8	Accreting beach.	
Wawaloli Beach	Hawaii B2 9	1950	(NA)	0.09	(NA)	0.07	0.62	0.26	8	3	Stable beach.	
Puu Alii	Hawaii B3 10	1950	1.00	(NA)	(NA)	-1.27	-0.92	-0.55	-17	8	Accretion from '50 to '67 and then erosion.	
Puu Alii	Hawaii B3 11	1950	1.50	(NA)	(NA)	-2.93	-0.77	-1.03	-31	14	Accretion from '50 to '67 and then erosion.	
Makalawena	Hawaii B3 12	1950	0.10	(NA)	(NA)	-0.20	-1.38	-0.53	-16	6	Accretion from '50 to '67 and then erosion.	
Kukio Beach	Hawaii B4 13	1950	(NA)	(NA)	-0.29	-0.50	-1.62	-0.79	-24	6	Stable waterline, vegetation line moving landward	
Kukio Beach	Hawaii B4 14	1950	(NA)	(NA)	0.06	-1.25	0.08	-0.21	-6	5	Stable beach, rock beach at waterline.	
Kukio Beach	Hawaii B4 15	1950	(NA)	(NA)	0.88	-0.50	0.38	0.42	13	5	Stable waterline, vegetation line moving seaward	
IDG Hotel	Hawaii B5 16	1950	(NA)	(NA)	0.53	-3.62	0.77	-0.26	-8	14	Cyclic beach, accreting since 1975.	
Kona Village Resort	Hawaii B5 17	1950	(NA)	(NA)	-3.53	0.00	1.15	-1.18	-36	17	Eroding beach located behind a rock bench.	
Kahuwai	Hawaii B5 18	1950	(NA)	(NA)	-1.18	1.12	0.15	-0.24	-7	8	Eroding, unprotected, sandy beach.	



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 (NA) Aerial photograph not available  
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# REFERENCES

- AECOS, Inc., 1982. *Kauai Island Coastal Resource Inventory*. Prepared for the US Army Engineer Division, Pacific Ocean.
- AECOS, Inc., 1979. *Maui Coastal Zone Atlas*. Prepared for the US Army Corps of Engineers, Pacific Ocean Division, Fort Shafter, Hawaii.
- Clark, J.R.K., 1985. *Beaches of the Big Island*. University of Hawaii Press.
- Clark, J.R.K., 1990. *Beaches of Kauai and Niihau*. University of Hawaii Press.
- Clark, J.R.K., 1980. *The Beaches of Maui County*. The University of Hawaii Press.
- Crowell, M., Leatherman, S.P., and Buckley, M., 1990. *Accuracy of Historical Shoreline Change Maps*, Proceedings of the Association of State Floodplain Managers 14th Annual Conference, in press.
- Leatherman, S.P. and B. Clow, 1983. *UMD Shoreline Mapping Project*, IEEE Geoscience and Remote Sensing Society Newsletter, V. 22, p. 5-8.
- Manoa Mapworks, 1983. *Kauai Coastal Resources Atlas*. Prepared for the US Army Corps of Engineers, Pacific Ocean Division.
- Methley, B.D.F., 1986. *Computation Models in Surveying and Photogrammetry*. Blackie; Glasgow and London.
- Moberly and Chamberlain, 1964. *Hawaiian Beach Systems*. Hawaii Institute of Geophysics, State of Hawaii. Prepared for State of Hawaii, Department of Transportation, Harbors Division.
- Sea Engineering, Inc., 1986. *Coastal Engineering Evaluation and Marine Biological Assessment for Kaanapali North Beach, Maui, Hawaii*. Prepared for James and Moore, Honolulu, Hawaii.
- US Army Engineer Division, Pacific Ocean, Corps of Engineers, 1971. *Hawaii Regional Inventory of the National Shoreline Study*.