SHELF COPY
DO NOT REMOVE

HIG-68-15

POTENTIAL TSUNAMI INUNDATION ZONES FOR THE ISLANDS OF MOLOKAI AND LANAI, HAWAIIAN ISLANDS

By

WM. MANSFIELD ADAMS

AUGUST 1968

Prepared for

the

STATE OF HAWAII

HAWAII INSTITUTE OF GEOPHYSICS
UNIVERSITY OF HAWAII

HIG-68-15

POTENTIAL TSUNAMI INUNDATION ZONES FOR THE ISLANDS OF MOLOKAI AND LANAI, HAWAIIAN ISLANDS

By

Wm. Mansfield Adams

August 1968

Prepared for

the

STATE OF HAWAII

Approved by Director

George P. Woollard

Date: 13 September 1968

ABSTRACT

Maps of potential tsunami inundation have been developed for the islands of Molokai and Lanai, Hawaiian Islands. These maps have been prepared using the same rules previously applied to the islands of Kauai, Oahu, Maui, and Hawaii.

BACKGROUND

Potential tsunami inundation maps for the islands of Kauai, Oahu, Maui, and Hawaii (Cox, 1961) were prepared in response to a recommendation by an ad hoc Tsunami Review Commettee of the Geophysical Society of Hawaii. The emphasis given to expediency limited the gathering and interpreting of historical data and the analyzing of the physical situation for prediction purposes. The results were based on an empirical approach, with subjective and logistical factors occasionally being given considerable weight. The empirical approach used the records of run-up and inundation during the large tsunmmis of 1946, 1952, 1957, and 1960 as reference data.

The difficulties of the task are evident from the complexity of the criteria, the frequent important exceptions, and the incorporation of logistical aspects into the analysis of a geophysical problem.

The criteria used earlier (Cox, 1961), and followed in this report are:

I. On northwest, northeast, and southeast coastlines, for tsunamis of distant origin from any direction; and on designated southwest coastlines for tsunamis from the south or west:

   A. All areas between the shoreline and the intersection with the ground of a surface declining inland with a

slope of 1 percent from a height of 50 feet above mean sea level:

1. At the 10-foot contour below mean lower low water; or
2. At bays, estuaries, harbors, or canals with narrow channels, lines connecting the segments of the minus 10-foot contour across the channels where they are 2,000 feet or less in width, or across the 2,600-foot width of the channel into Kaneohe Bay, or
3. Where the submarine slope seaward of the minus 10-foot contour is slight, lines drawn seaward from the minus 10-foor contour at a distance from it equal to half of the excess of the local distance from the minus 10- to the minus 20-foot contour over 1,000 feet.

B. All additional areas less than 4 feet above mean level and within 400 feet of the shore of the ocean or tidal bodies such as a bay, harbor, estuary, or canal.

C. A few additional areas in which the historical data indicates liability to inundation.

II. On designated [southwest][1] coastlines for tsunamis of distance origin from the south or west:

1 "Northwest", in the original report, was a misprint.

A. Areas defined as in section I.A., but using a 30-foot instead of a 50-foot height offshore.

B. Areas defined as in I.B.

C. Additional areas in which the historical record indicates liability to inundation.

This report applies these criteria to the shoreline areas of the islands of Molokai and Lanai. There are two reasons for doing this. First, these two islands have become increasingly important commercially. Extensive development as planned for the tourist business may be intense. It is important that the investors and the tourists be made aware of the unique tsunami hazard wherever it exists. Second, studies under the Tsunami Research Program, which has been in progress for five years, have included intensive study of certain aspects of tsunamis. Such studies include gathering of data (Iida et al. 1967), instrumentation for deep-sea measurement (Vitousek, 1965), and study of terminal response (Loomis, 1965). Hopefully, these findings can be used to improve the criteria for potential tsunami inundation.

The maps developed here for Molokai and Lanai are found at the back of this report.

METHOD

The following procedure has been used in the application of the crite

CROSS SECTION

I. Land

A. A cross-sectional graph of the land is made from a topographical quadrangle map with a scale of 1:24,000.

B. To graph the land using this scale, measure inland from the selected shoreline point until coming to the first contour interval. (On most maps, this is the 50-foot contour.)

C. Plot this on the graph at the number of inches inland and the number of feet in elevation.

D. Repeat the procedure of B and C, for contours of less than 100 feet elevation.

II. Water

A. Make the same cross-sectional graph for the water from Boat Sheets, if available (see Fig. 1 for an example); otherwise, from hydrographic maps.

B. These will usually be on a different scale, probably 1:20,000. The 1:24,000 scale is taken as the standard.

1. To adjust the difference in scales, make a ruler showing scales of 1:24,000 and 1:20,000. Measure the desired distance on the 1:20,000 map, using the 1:20,000 ruler, and determine where this point would come on the adjacent 1:24,000 ruler.

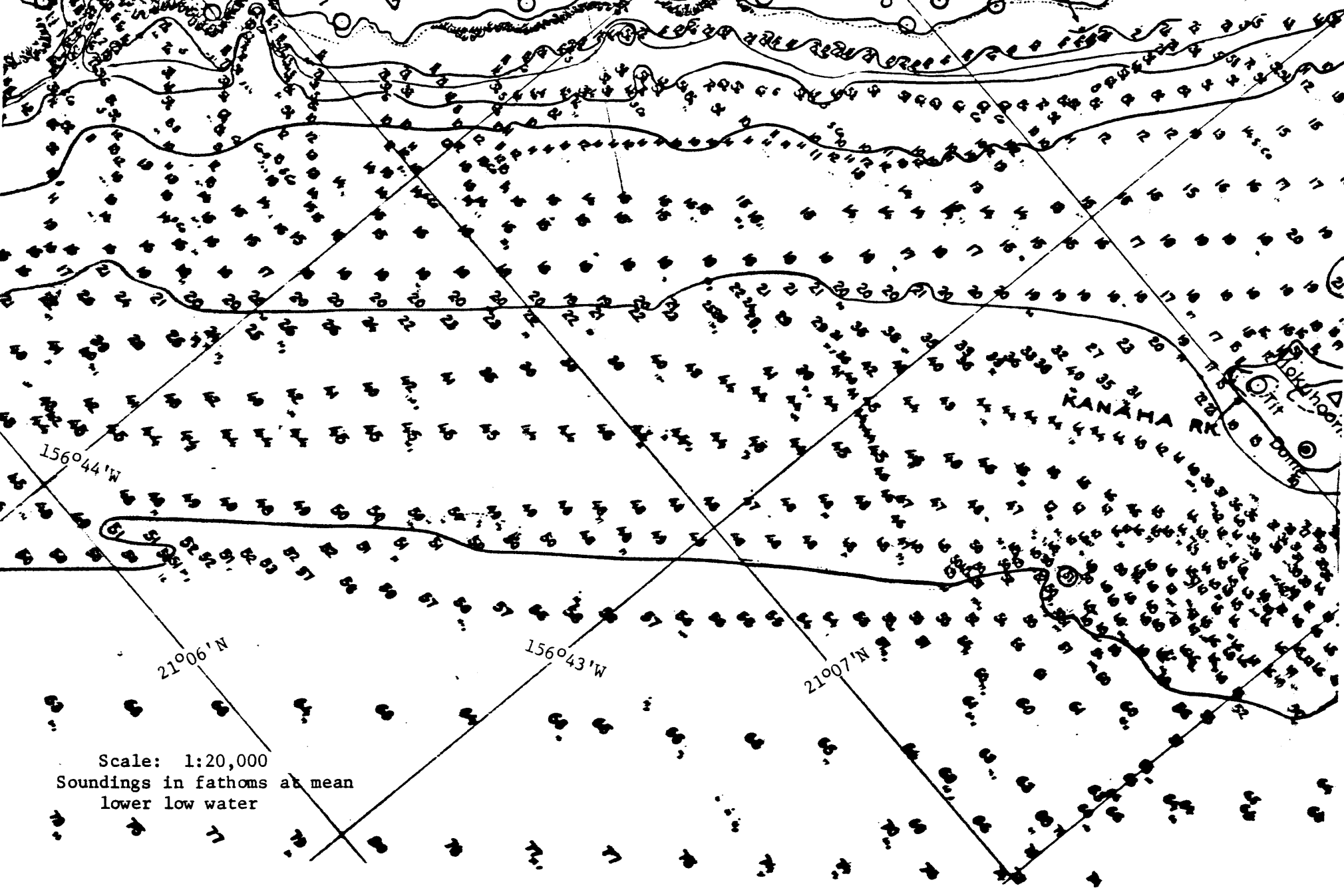

Fig. 1. Puu Nananana, Molokai.

2. This point on the ruler will show the number of inches out from the shore on a 1:24,000 scale.

3. Water Depth will be in fathoms: 6 feet = 1 fathom, so multiply the number of fathoms by 6 to obtain the depth in feet.

4. Plot this point on the cross-sectional graph: inches out from the shore and feet in depth.

5. Plot the land and water from the same shoreline point on the same cross-sectional graph.

6. Connect the points with a curved line. (see Fig. 2 for an example).

RUN-UP CONTOURS

I. Focal Points

A. Draw a line perpendicular to the shoreline on the topographic quadrangle used in graphing the land, thus showing where the cross section was made.

II. Predicted Run-up

A. To obtain run-up for 30-foot or 50-foot wave on minus 10-foor contour.

1. Use the cross section on a 1:24,000 scale made according to the description in the previous section.

2. Find the two points where the water depth is 10 feet and elevation is 30 feet and 50 feet.

3. Plot these two points at x inches from shore (water depth of 10 feet), the coordinates of the points will

(x, 30 feet) and (x, 50 feet).

4. Now draw a line with a 1% slope from each of the two points shoreward, intersecting the land. For example,

a) 1% of 24,000 inches = 240 inches. The land is in feet, so 240 inches/12 inches = 20 feet.

b) From each of the two points (x, 30 feet) and (x, 50 feet), go inland 24,000 inches and down 20 feet. This will give two points through which to draw two lines with a 1% slope.

B. The 50-foot prediction is used on the west, north, east, and southeast shores. The 30-foot is used on the southwest shore.

C. 1. On both the 30-foot and the 50-foot predictions, the l will intersect the land by (y) inches inland.

2. Find this point on the quadrangle (same scale).

3. Draw a dashed line (----) contour at this point. Follow the nearest elevation contour.

III. Historical Run-up

A. The figures of historical run-up are in feet and are found the island map (not a quadrangle), in the chart room of the library of the Hawaii Institute of Geophysics, under TSUNAMIS.

B. Using the cross section, find the point where the land is at an elevation corresponding to the number of feet of historical run-up.

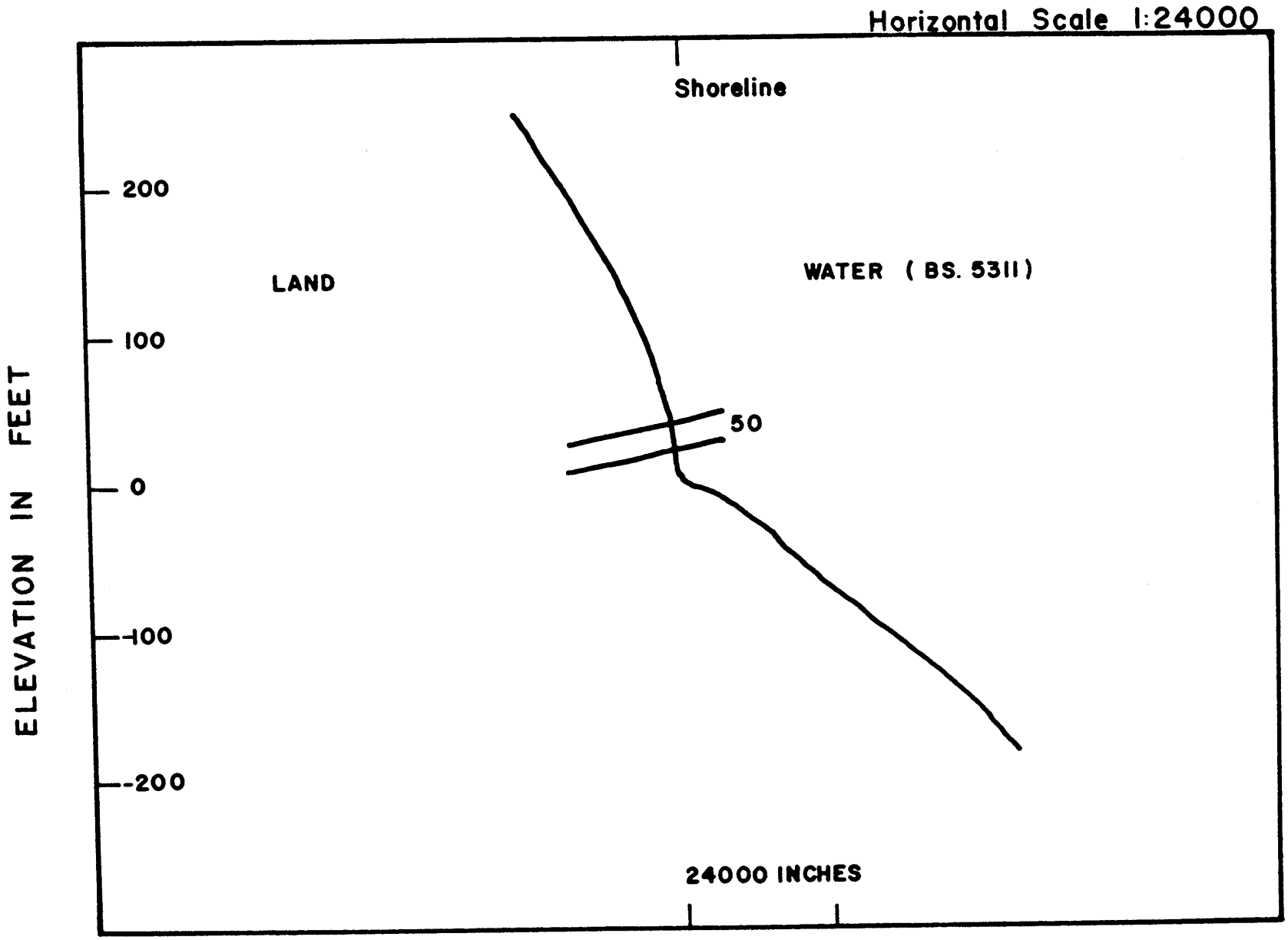

Fig. 2. Cross section of Puu Nananana, Molokai, showing profile both below and above sea level. Empirical construction on this profile locates the potential inundation height.

C. Find this point on the map. It will be inland (z) inches according to scale.

D. Draw a solid line (_____) contour for this, also following the elevation contour.

IV. Special Criteria

A. This indicates areas where the historical run-up has exceeded the usual criterion run-up and is designated by a solid line (_____). About one-third of the areas required special criteria.

Example: Puu Nananana, Molokai

CROSS SECTION

I. Land

A. U.S.C.&G.S. quadrangle No. 2103.75 - W15642/7.5; Scale 1:24,000 (see Fig. 9).

B. The first contour interval is 50 feet and is 2400 inches inland. Plot this point on the graph (2400, 50).

C. Make similar measurements for the 100-foot interval.

II. Water

A. Boat Sheet No. 5311; Scale 1:20,000 (see Fig. 1).

B. Measure to the first depth-contour which is two fathoms (12 feet); this is 7500 inches from the shoreline. Plot this point on the graph (7500, 12).

C. Make similar measurements for other fathom contour intervals.

D. Draw a line connecting the points on the land and one connecting the points in the water (see Fig. 2).

RUN-UP CONTOURS

I. Focal Points

II. A. To obtain maximum run-up based on 30-foot or 50-foot wave at minus 10-foot contour.

1. On the cross section for Puu Nananana the 10-foot depth is at approximately 7200 inches from shore.

2. The two points will be (7200, 30) and (7200, 50).

3. To draw the line with a 1% slope, find the point inland 24,000 inches from these two points and down 20 feet. These will be the points (-16,800 inches, 10) and (-16,800 inches, 30).

B. Since Puu Nananana is on the east coast, the 50-foot wave will be used.

C. 1. The line for the 50-foot wave intersects the land at (2000 inches, 42 feet).

2. Follow the curve of the 50-foot contour interval, draw a contour from the intersection point using a dashed line (-----).

III. Historical Run-up

A. For Molokai, the run-up is listed for the 1946 tsunami on U.S.C.& G.S. map No. 2100-W15640 - topographical map of Molokai (in the "Tsunami" file drawers, HIG library room).

B. Puu Nananana shows a recorded run-up of 34 feet. On the cross section, the elevation of 34 feet is found at the point (1200 inches, 34 feet).

C. Since the historic run-up was less than the predicted run-up, a special contour is not necessary.

IV. Special criteria do not apply in this case as the historical run-up is less than the predicted run-up.

ACKNOWLEDGMENTS

This report was written following the procedure set forth by Dr. Doak C. Cox in his report on the "Potential Tsunami Inundation Areas in Hawaii" (see Cox, 1961). Cox reviewed the manuscript, but the author remains responsible for the opinions expressed. The information was gathered by Marcia Dawson and Aileen Fukuda. The drafting was done by Les Sakumoto and Douglas Gordon.

The field investigation was materially aided by Mr. Joe Lane, Police Chief of Maui County; by Mr. C. T. Cleghorn, Manager of the Dole plantation on Lanai; and Mr. Adolph H. Desha, also of the Dole Company. Mr. Richard Blum of Oceanic Properties, Inc., graciously arranged for transportation during a field trip to the islands of Molokai and Lanai.

REFERENCES

Cox, Doak C., 1961, Potential Tsunami Inundation Areas in Hawaii, Hawaii Institute of Geophysics Report No. 14, University of Hawaii, Honolulu, Hawaii, 21 pp.

Geophysical Society of Hawaii, 1960, Tsunami Warning System Review, Honolulu, Hawaii, 14 pp.

Iida, Kumizi, Doak C. Cox, and George Pararas-Carayannis, 1967, Preliminary Catalog of Tsunamis Occuring in the Pacific Ocean, Hawaii Institute of Geophysics, HIG-67-10, Data Report No. 5, University of Hawaii, Honolulu, Hawaii, pages not numbered.

Loomis, Harold G., 1965, Spectral Analysis of Tsunami Records from Stations in the Hawaiian Islands, Hawaii Institute of Geophysics, HIG-65-8, University of Hawaii, Honolulu, Hawaii, 10 pp.

Vitousek, M. J., 1965, An Evaluation of the Vibrotron Pressure Transducer as a Mid-Ocean Tsunami Gage, Hawaii Institute of Geophysics, HIG-65-13, University of Hawaii, Honolulu, Hawaii, 12 pp.

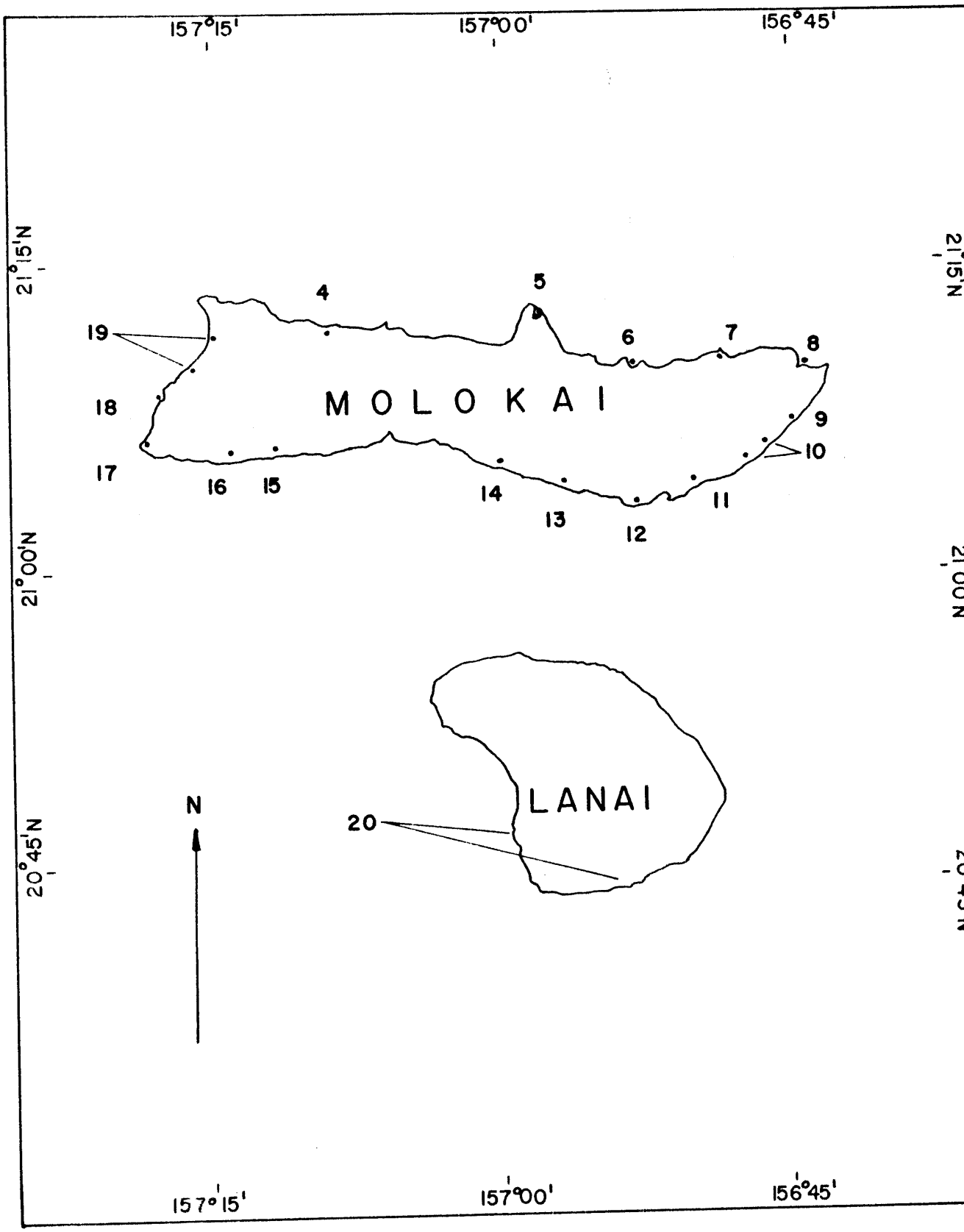

Fig. 3. Index map for local areas on the islands of Molokai and Lanai. Number correspond to reference figures, which follow, giving details of poten tsunami inundation.

REFERENCE FIGURES

Potential tsunami inundation zones, as determined from the empirical criterion, or, if a historical observation exceeds the empirical criterion, then from the historical observations

Zone	Area	Fig. No.
MOLOKAI	Moomomi	4
	Kahui Pt.	5
	Pelekunu Pt.	6
	Kikipua Pt.	7
	Halawa Bay	8
	Puu Nananana	9
	Pauwalu and Pukoo Harbor	10
	Ualapue	11
	Kamalo	12
	Kawela	13
	Kaunakakai	14
	Kolo Wharf	15
	Halena Pt.	16
	Laau Pt.	17
	Kaunalu Bay	18
	Papohaku Bay and Kepuhi	19
LANAI	Manele Bay and Kaumalapau	20

ISLAND MAPS

Molokai (Showing historic run-up)	21
Lanai (Showing historic run-up)	22
Kauai (Showing historic run-up)	23
Oahu (Showing historic run-up)	24
Maui (Showing historic run-up)	25
Hawaii (Showing historic run-up)	26

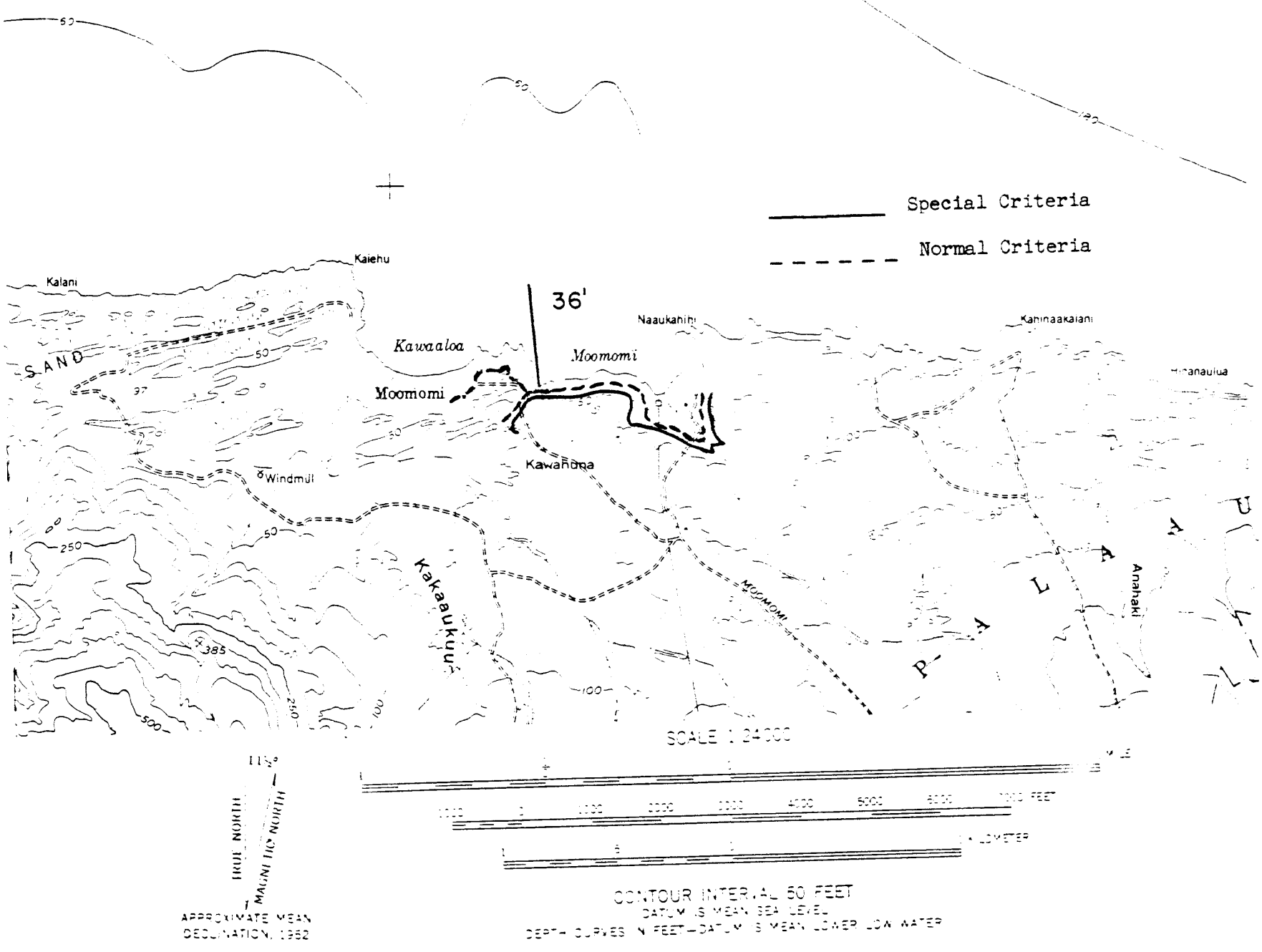

Fig. 4. Moomomi.

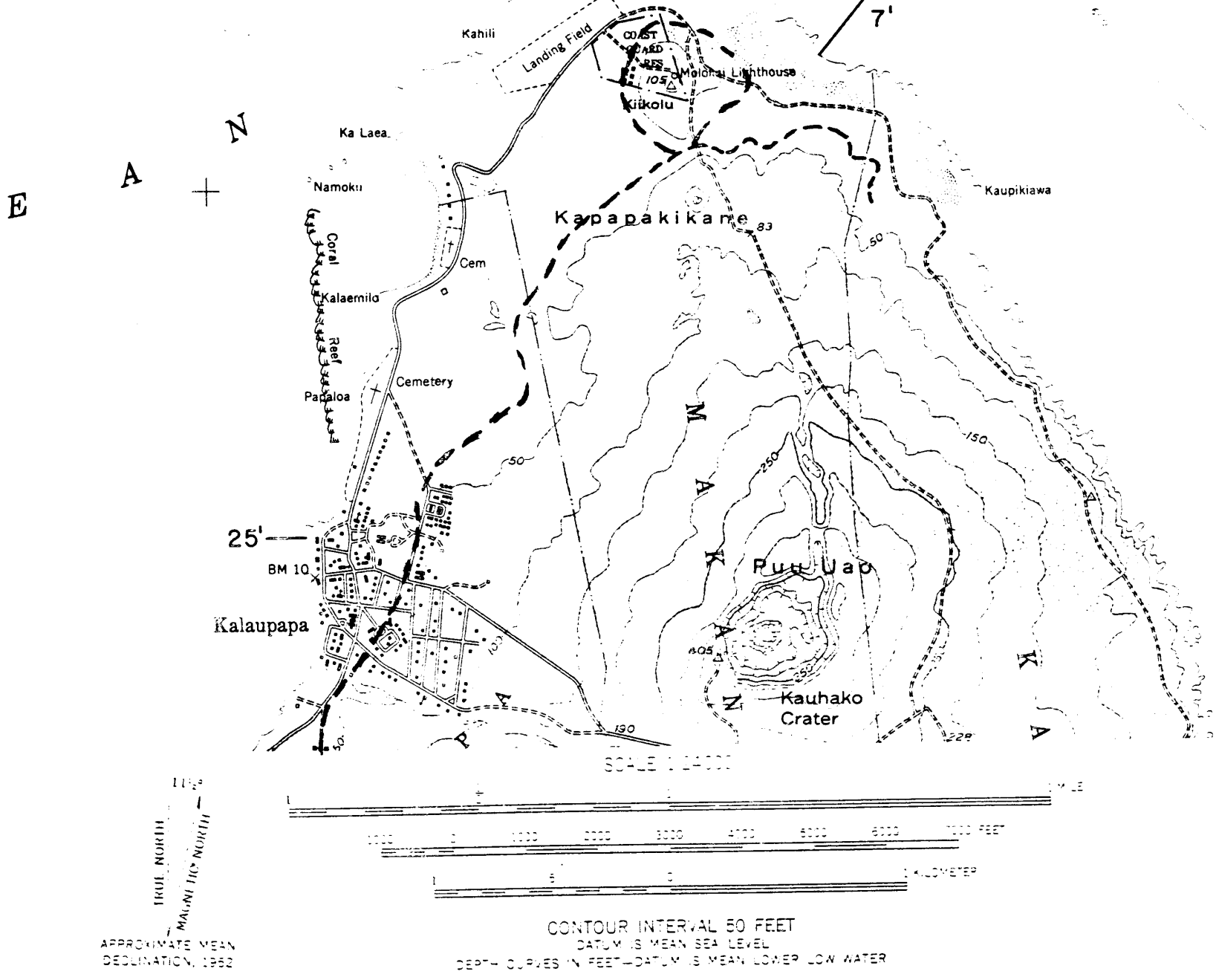

Fig. 5. Kahiu Pt.

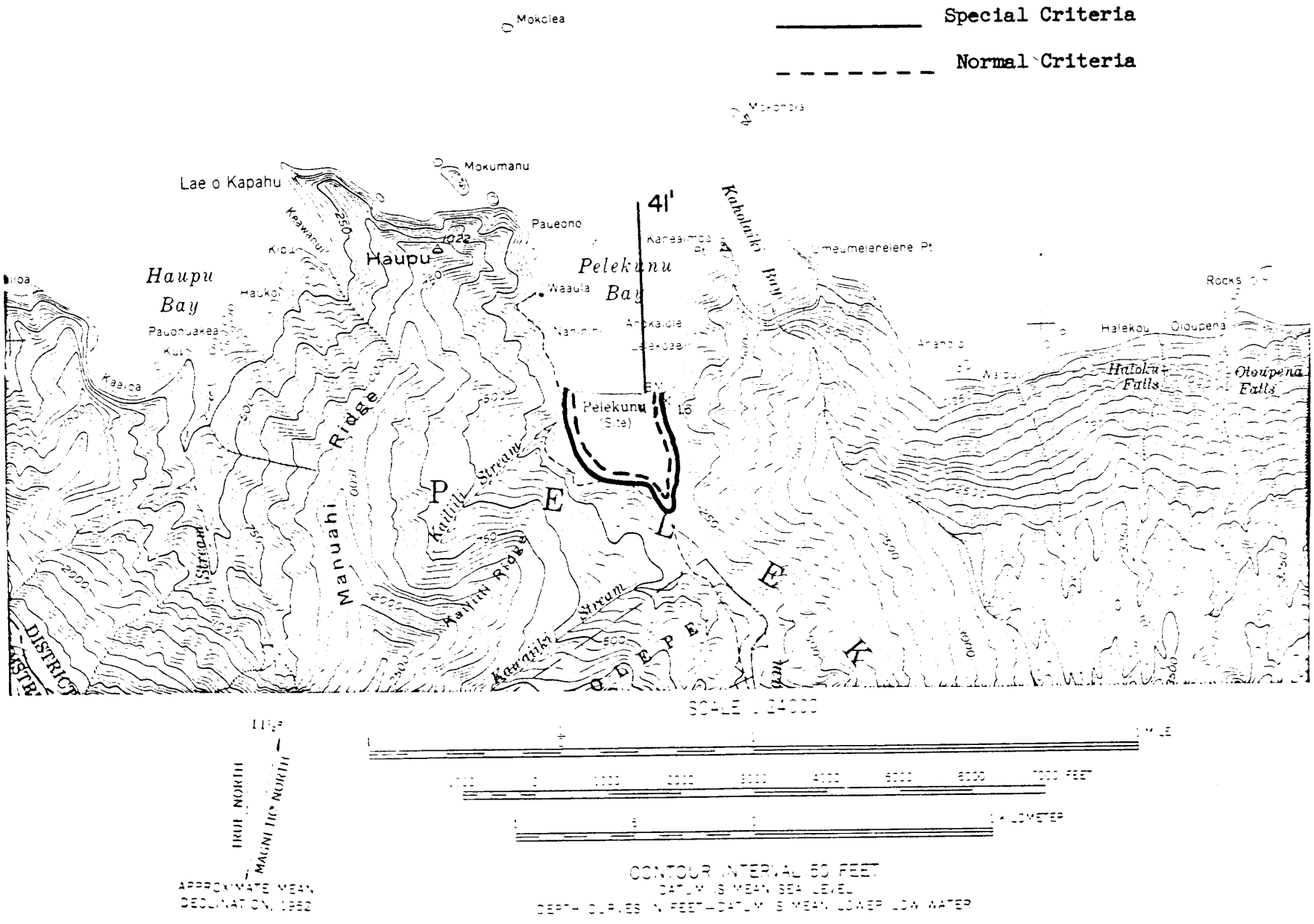

Fig. 6. Pelekunu Pt.

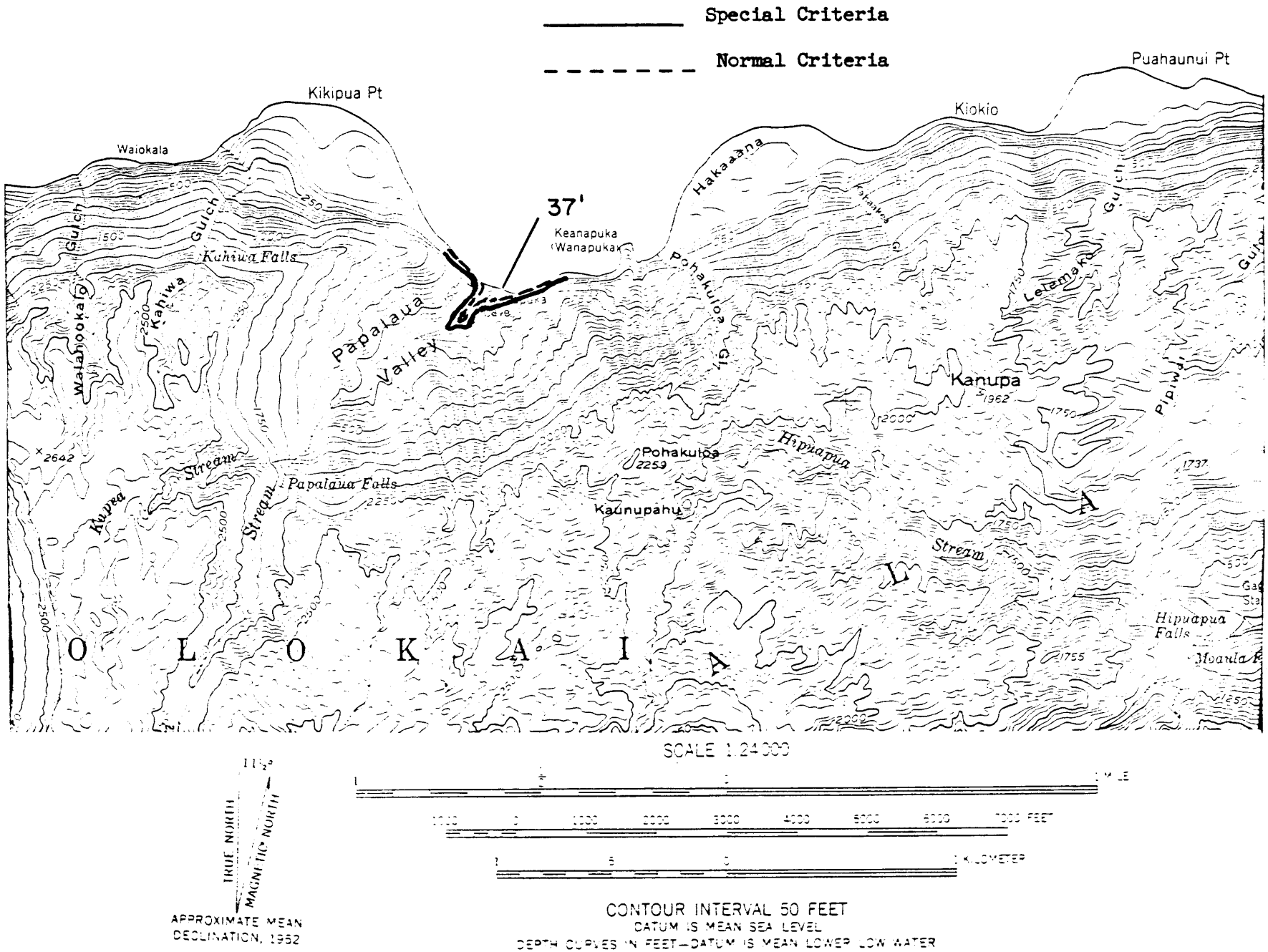

Fig. 7. Kikipua Pt.

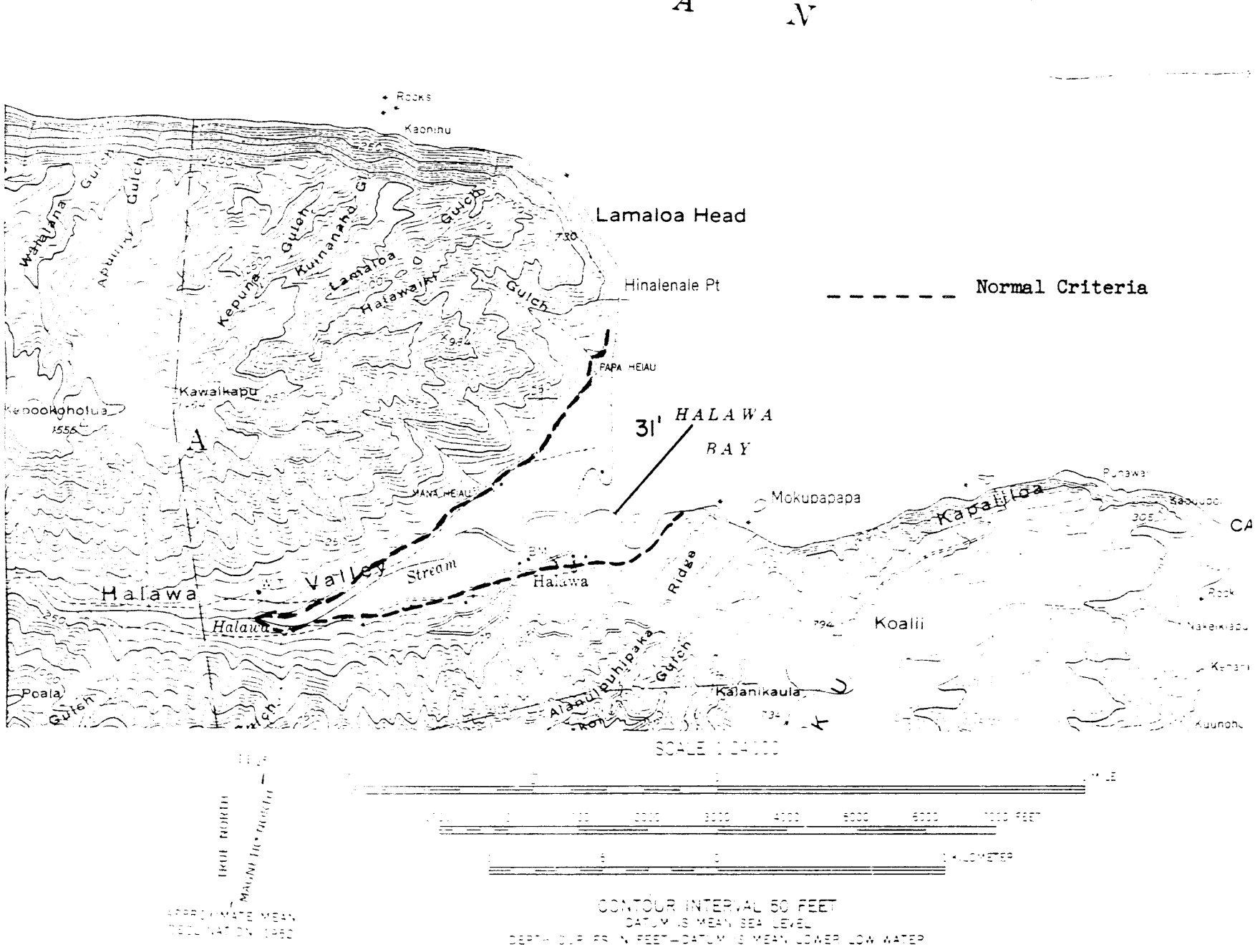

Fig. 8. Halawa Bay.

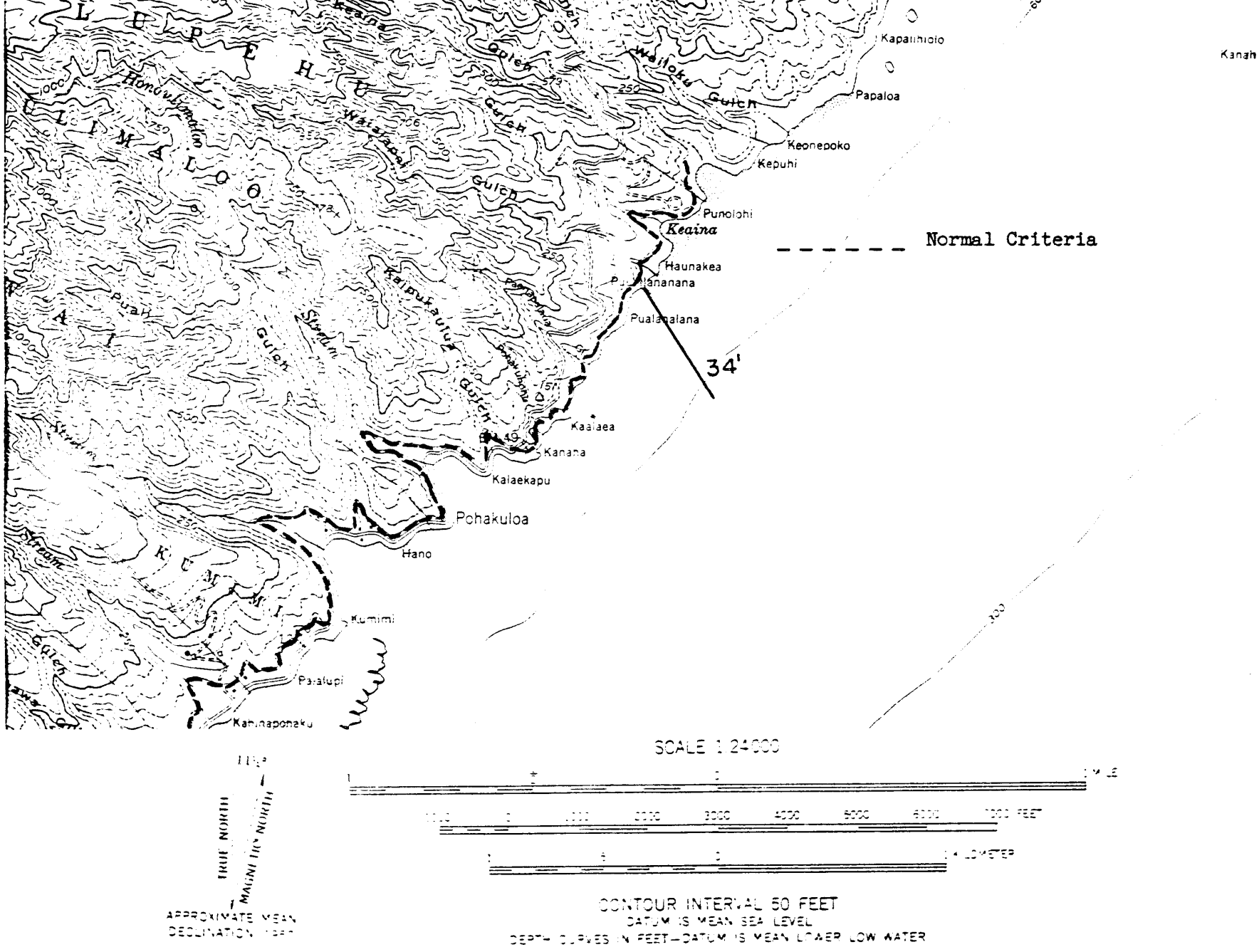

Fig. 9. Puu Nananana.

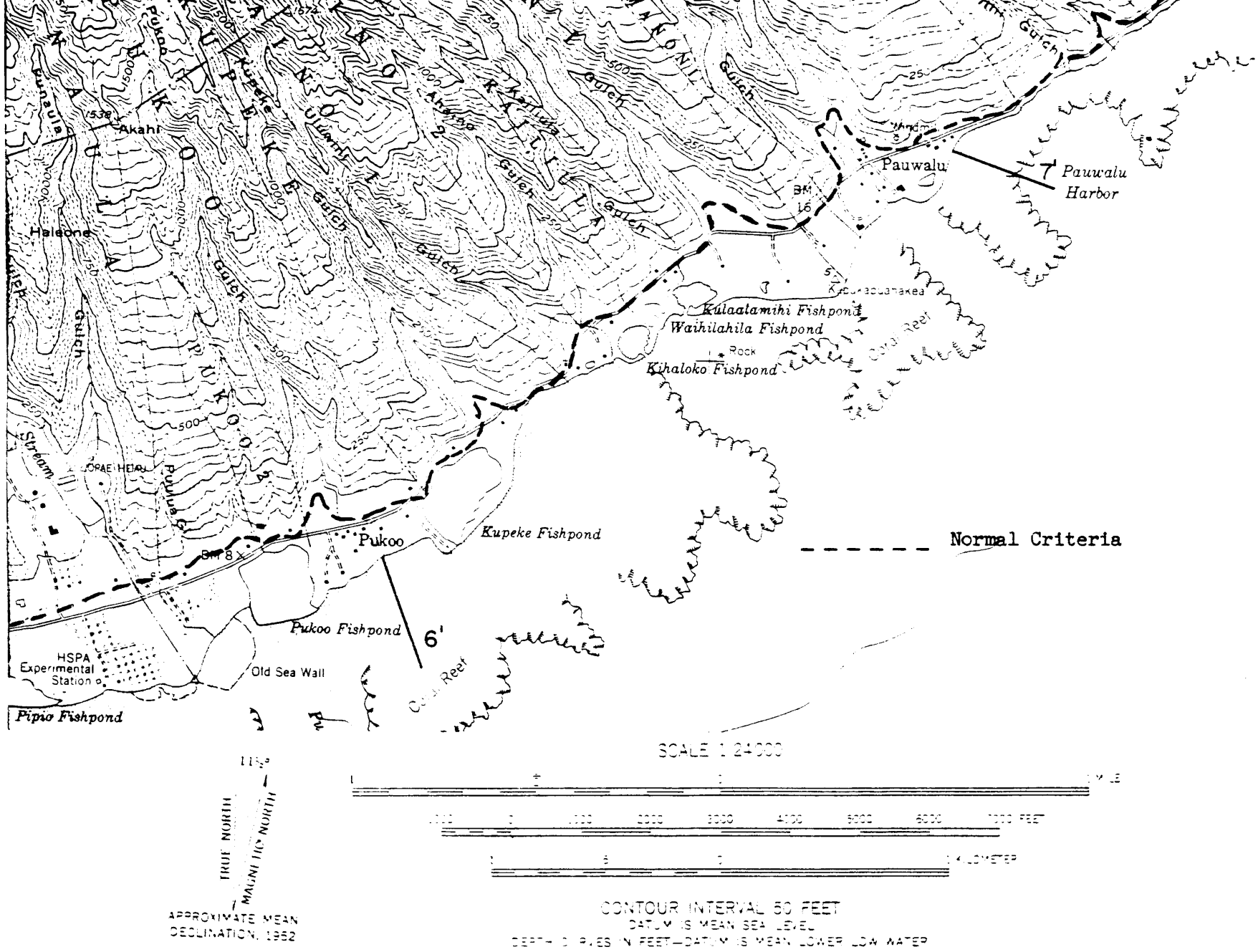

Fig. 10. Pauwalu and Pukoo Harbor.

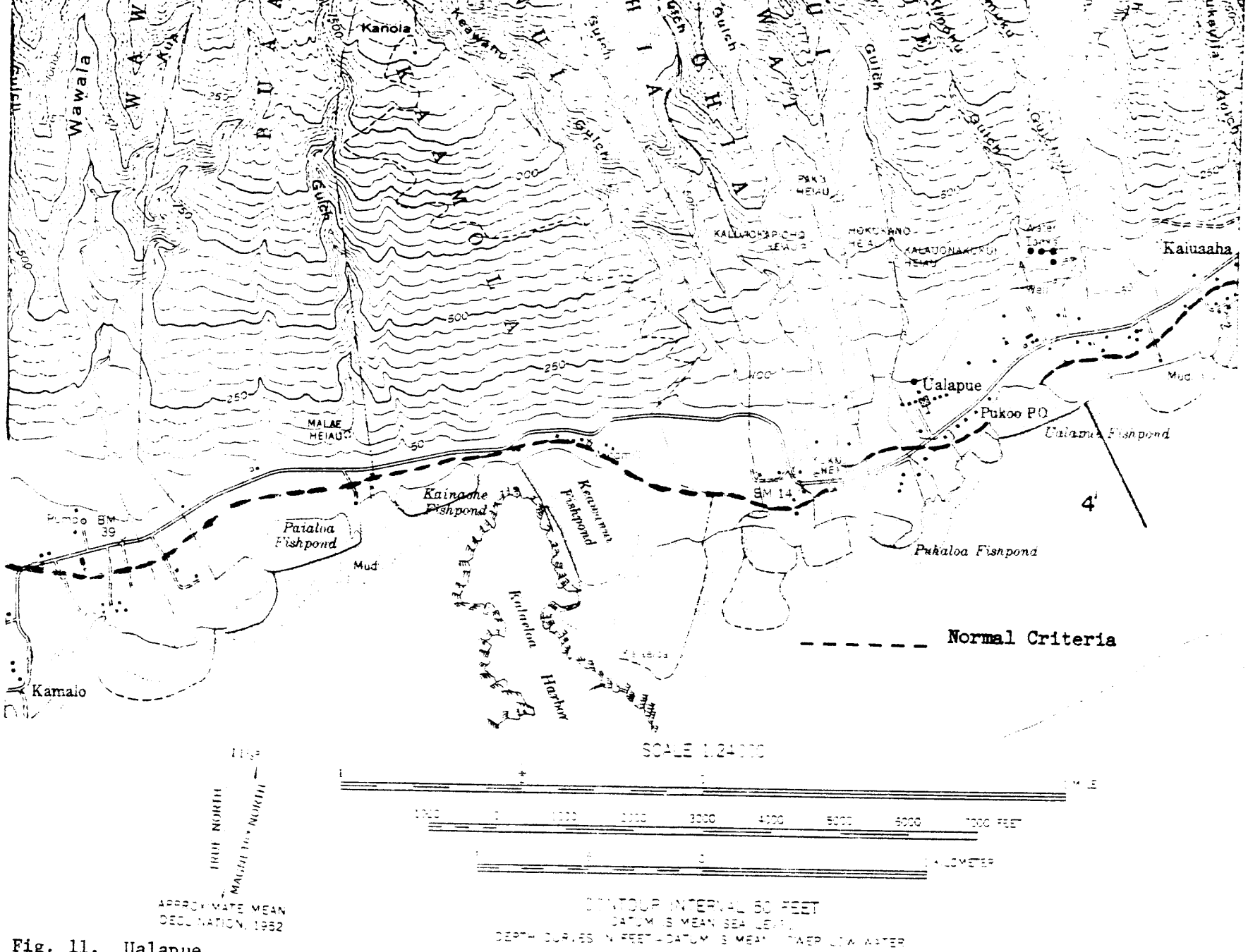

Fig. 11. Ualapue.

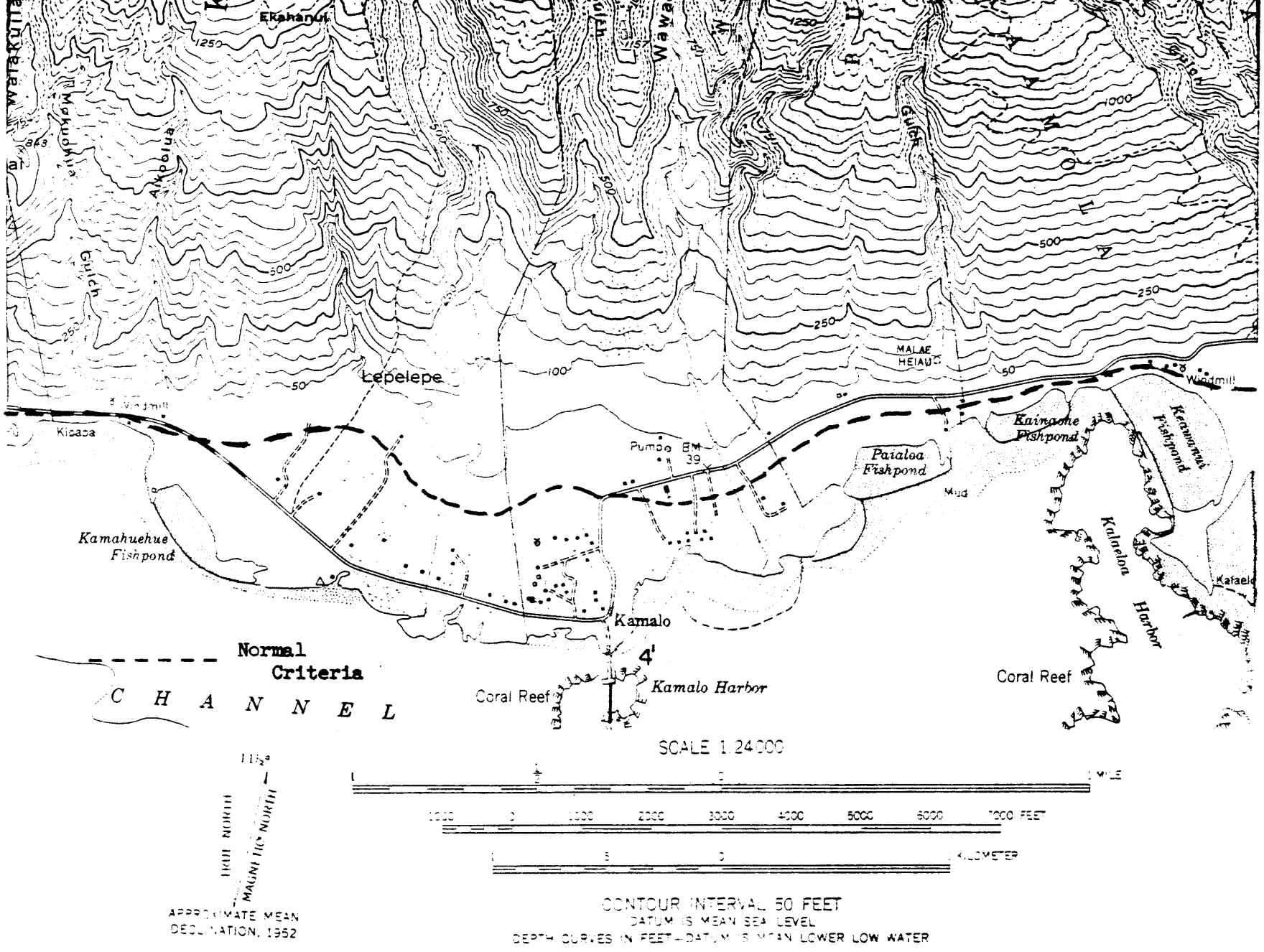

Fig. 12. Kamalo.

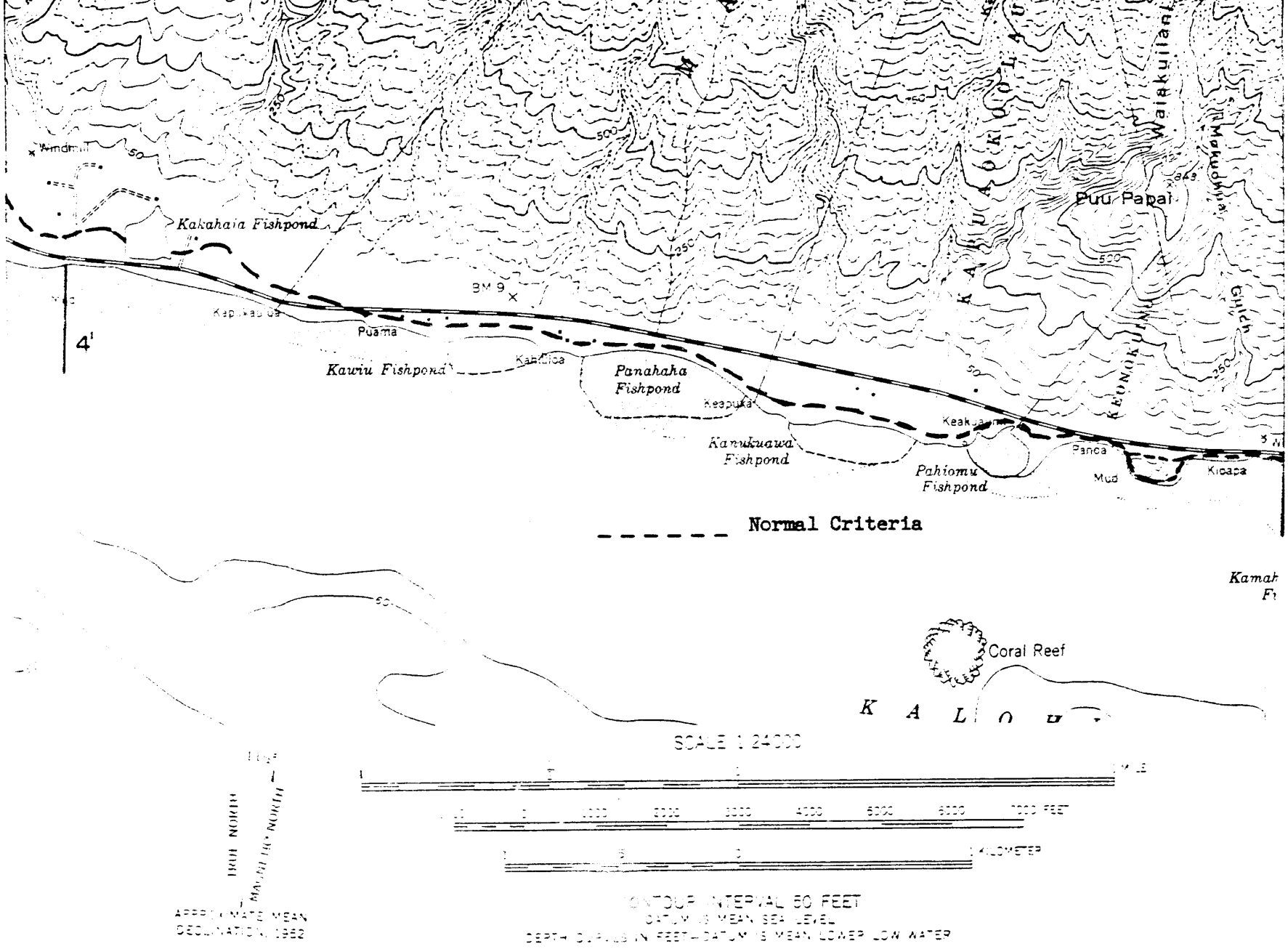

Fig. 13. Kawela.

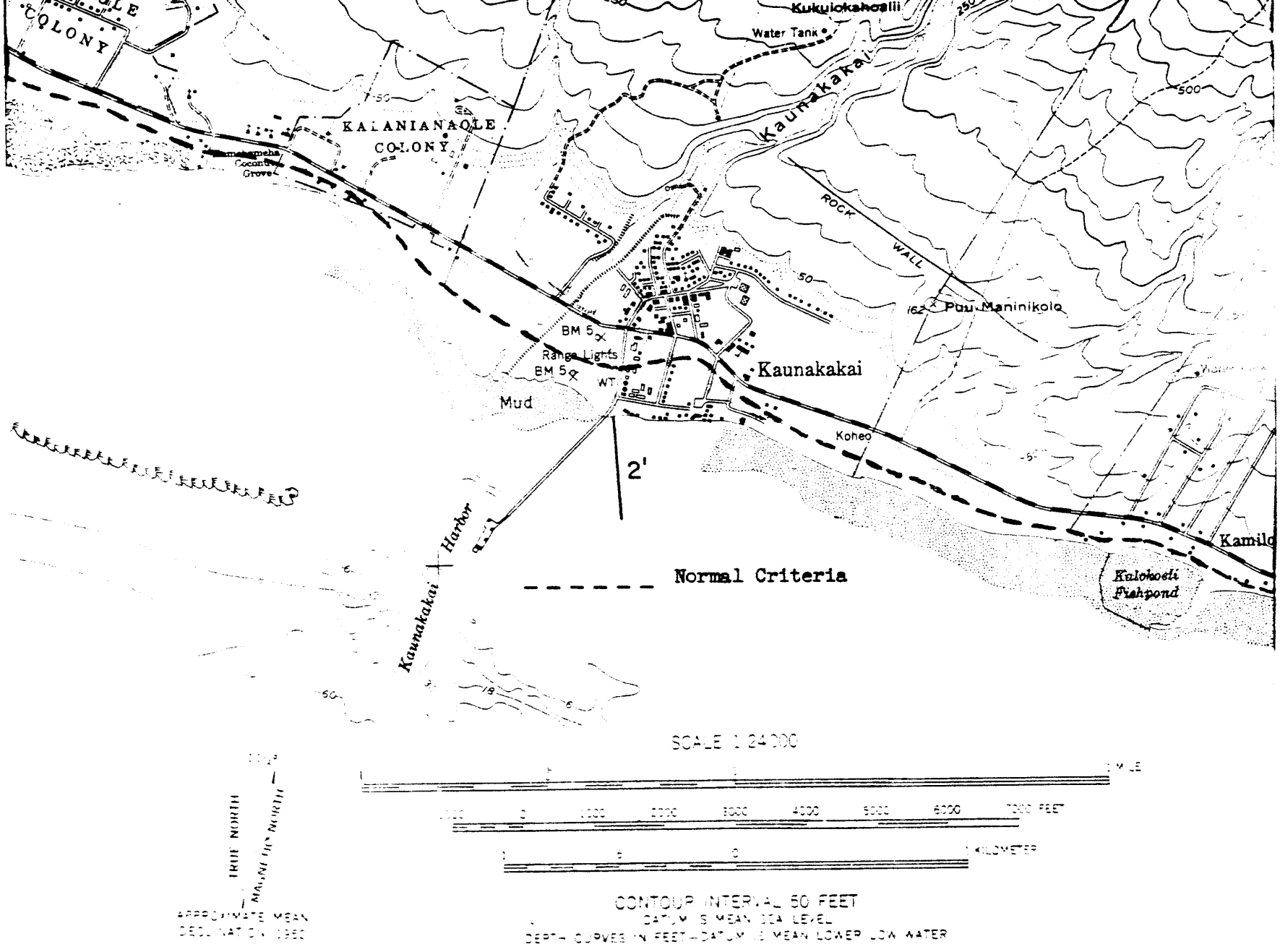

Fig. 14. Kaunakakai.

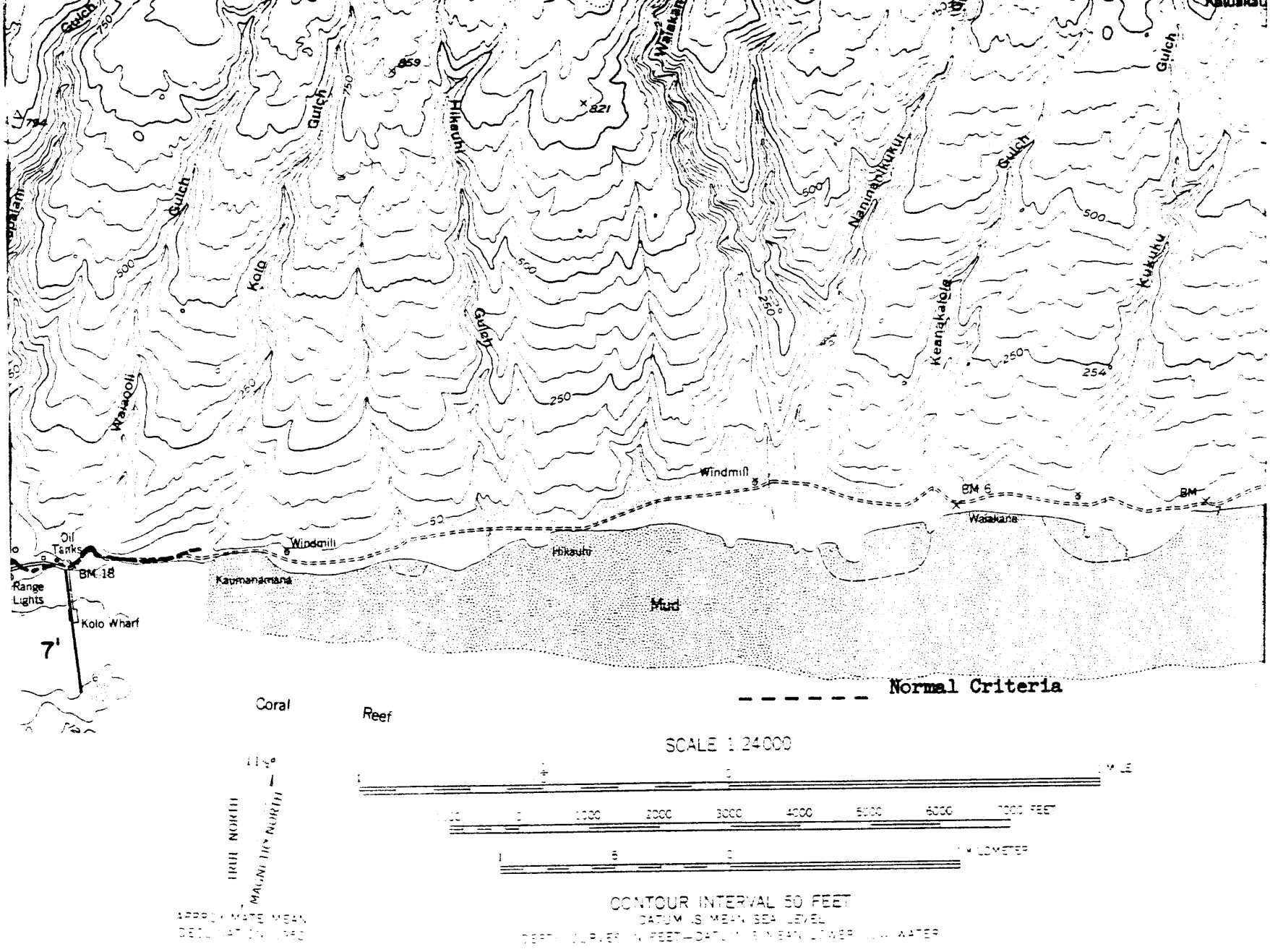

Fig. 15. Kolo Wharf.

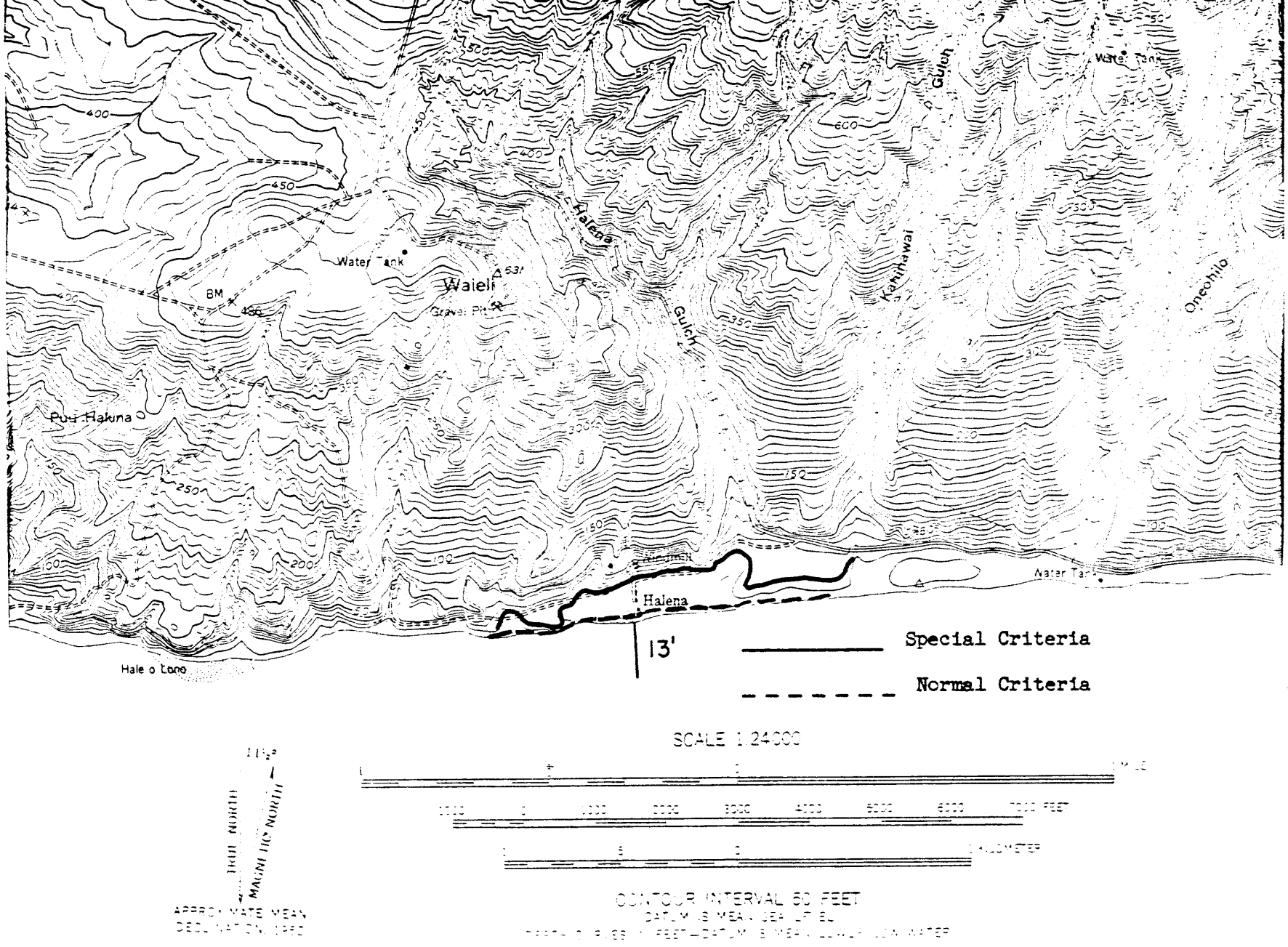

Fig. 16. Halena Pt.

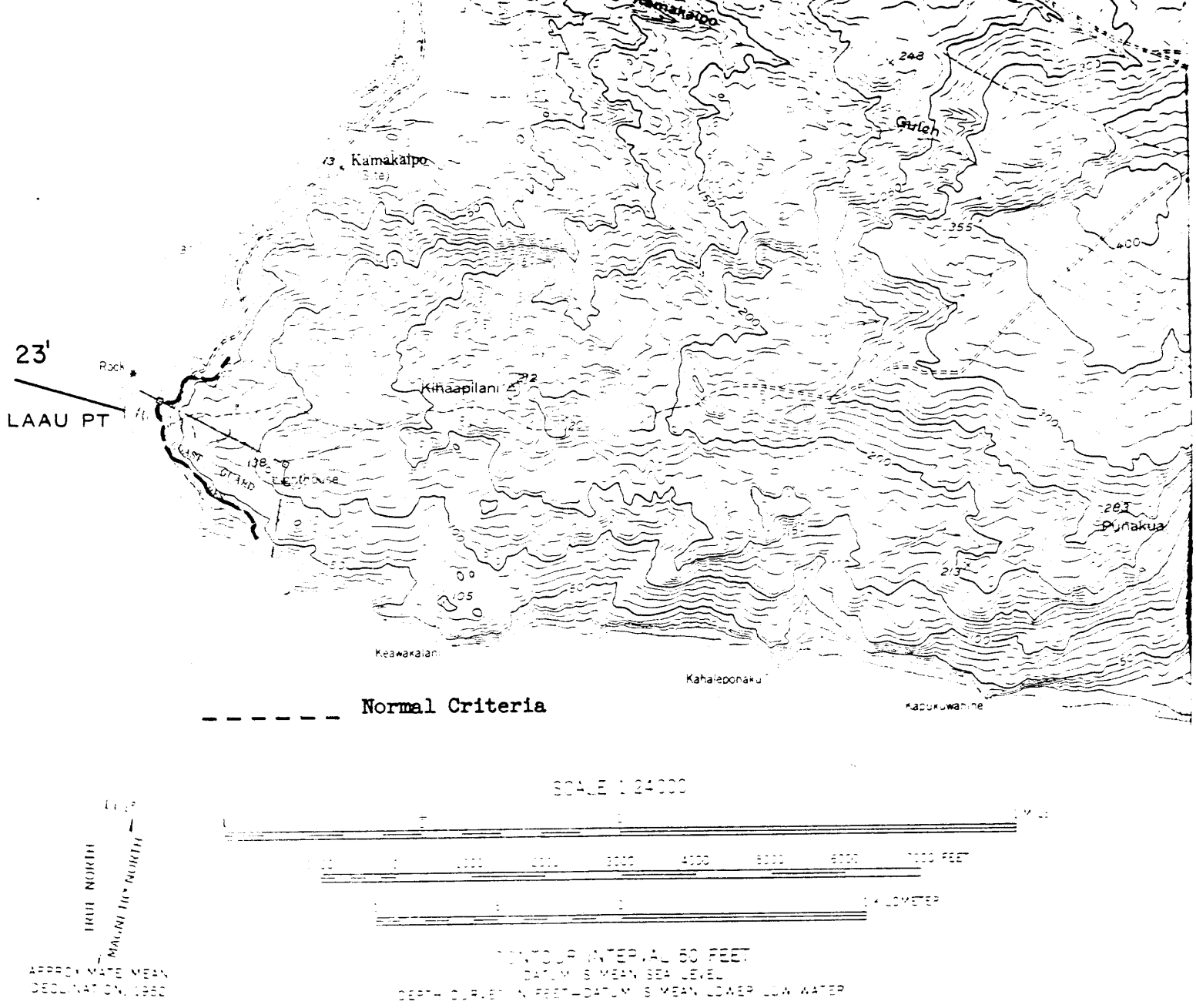

Fig. 17. Laau Pt.

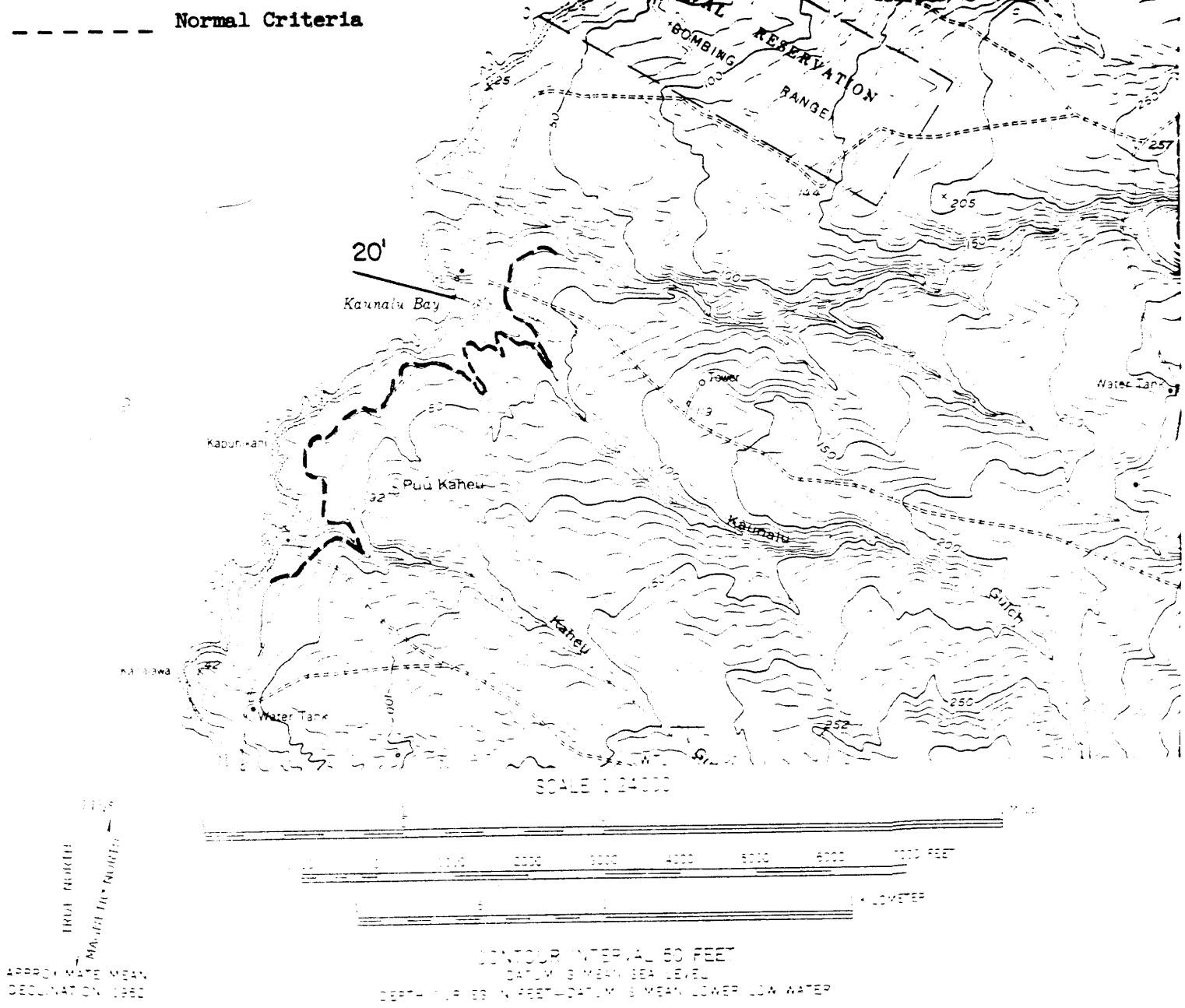

Fig. 18. Kaunalu Bay.

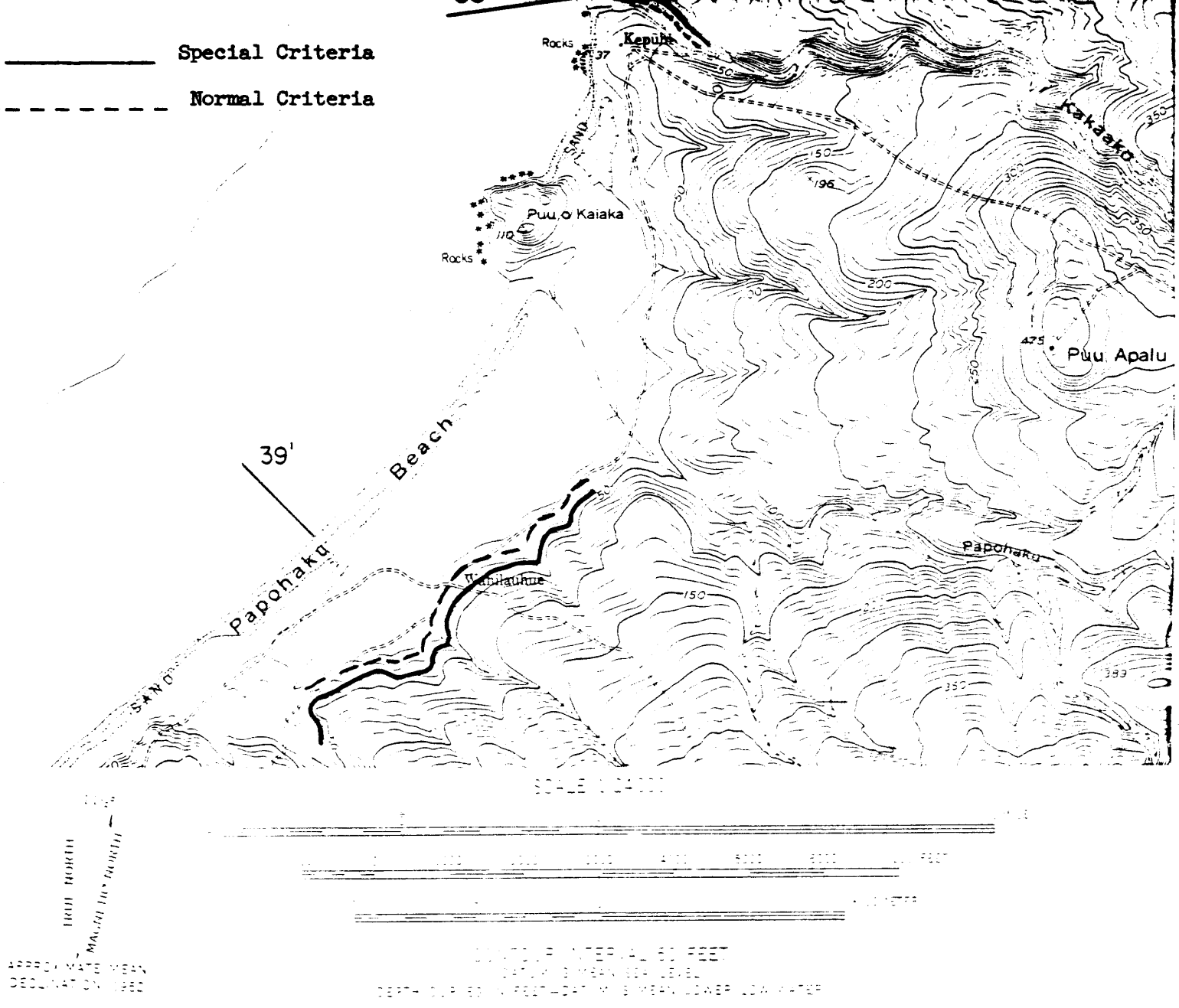

Fig. 19. Papohaku Bay and Kepuhi.

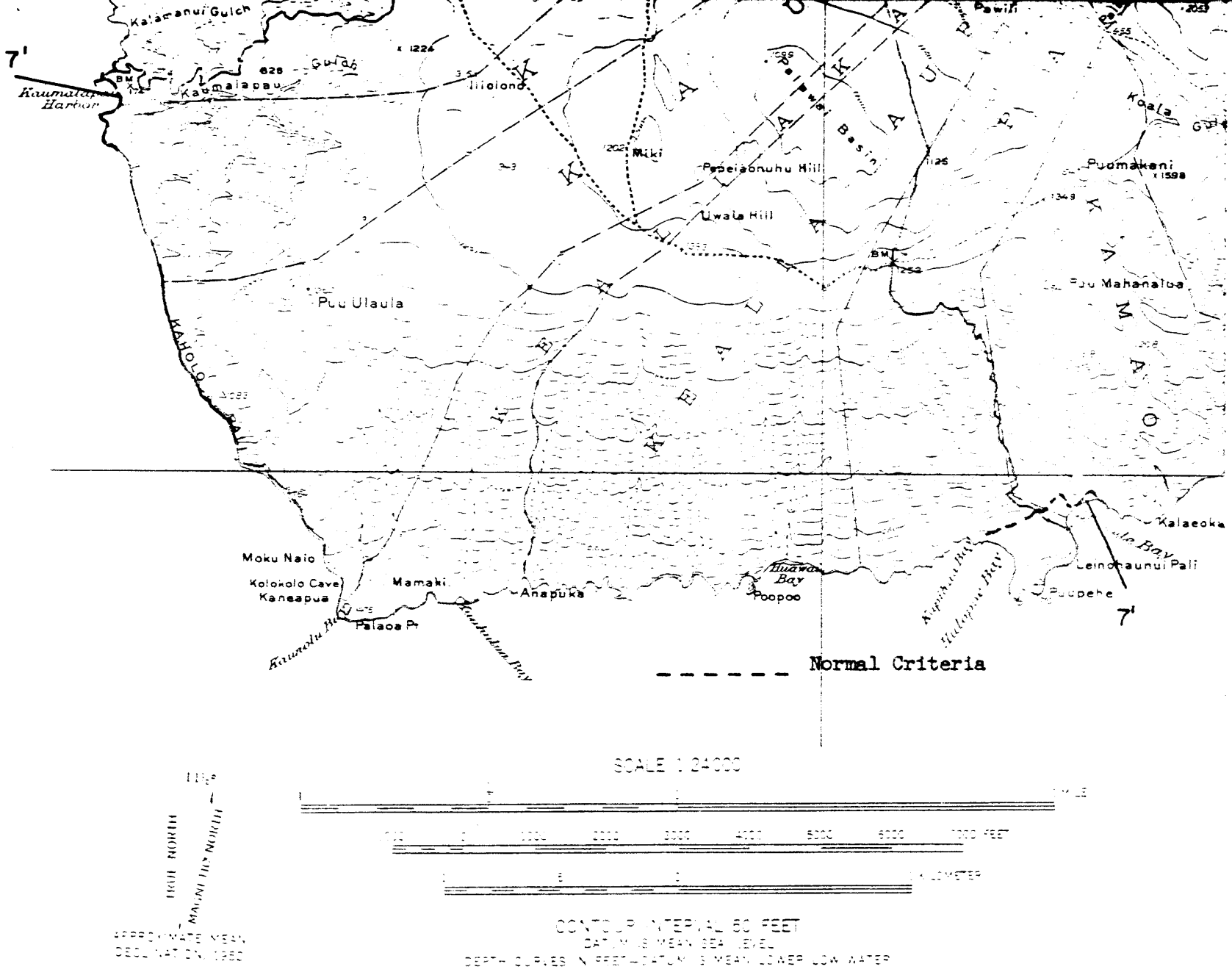

Fig. 20. Manele Bay and Kaumalapau.

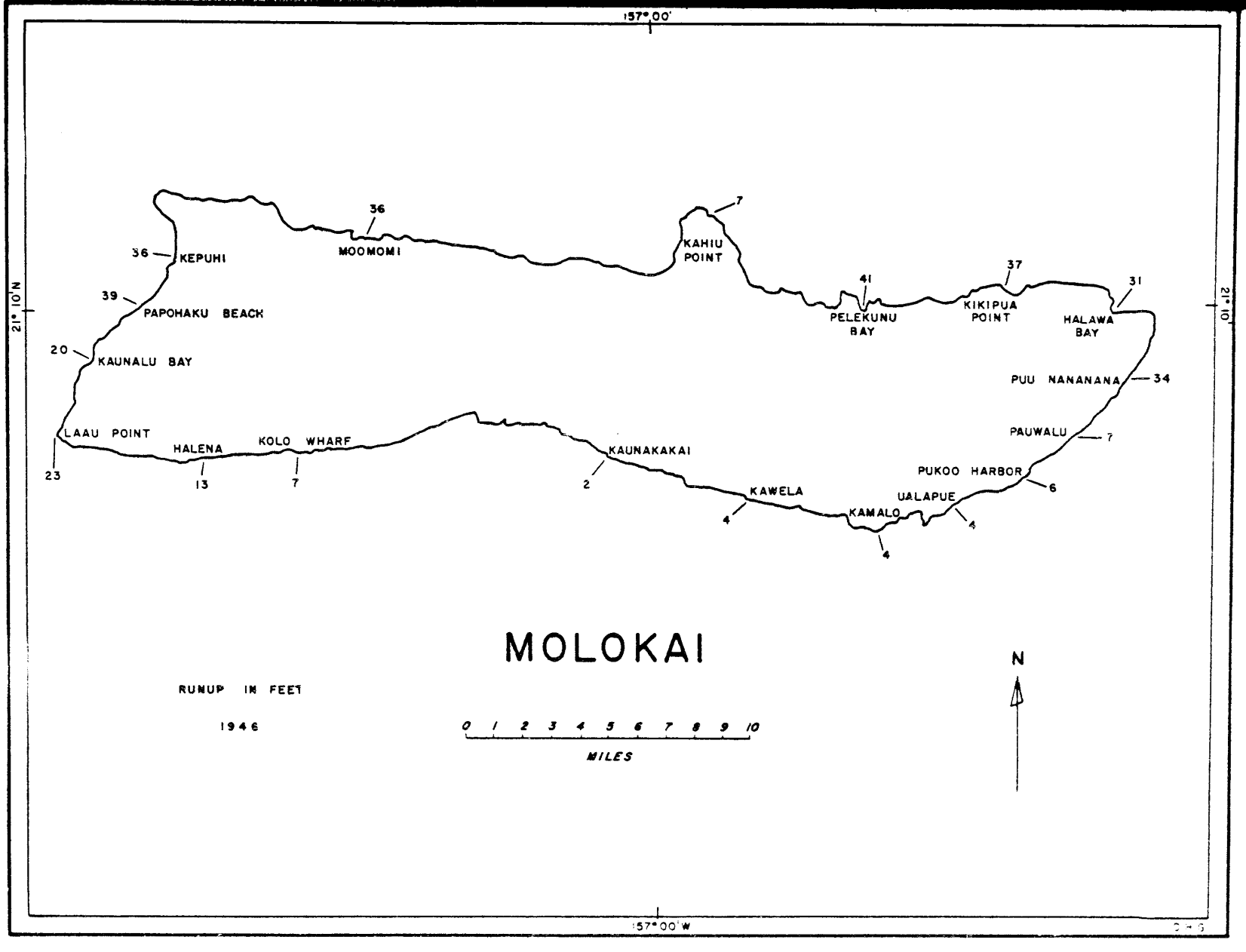

Fig. 21. Molokai (showing historic run-up).

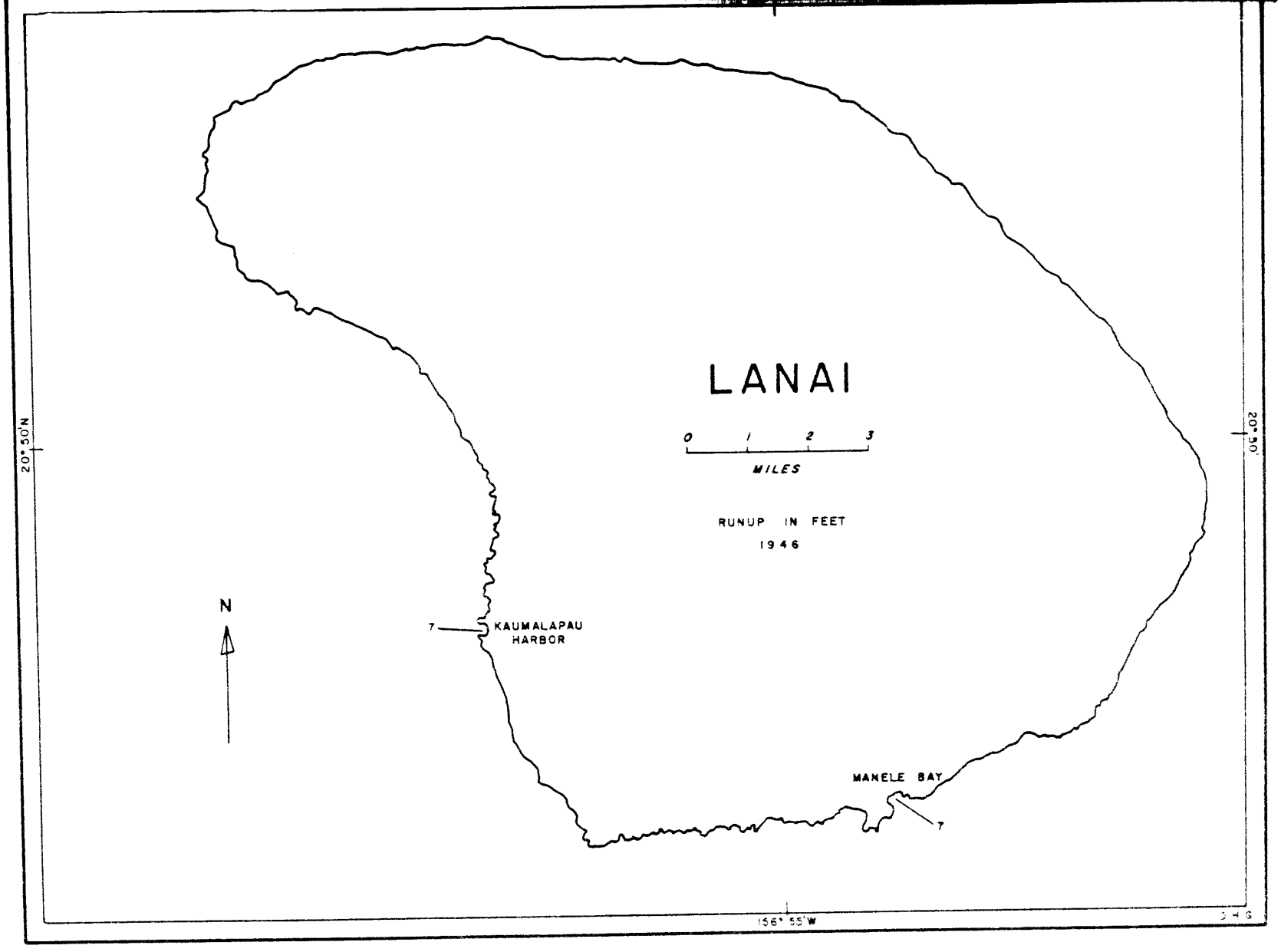

Fig. 22. Lanai (showing historic run-up).

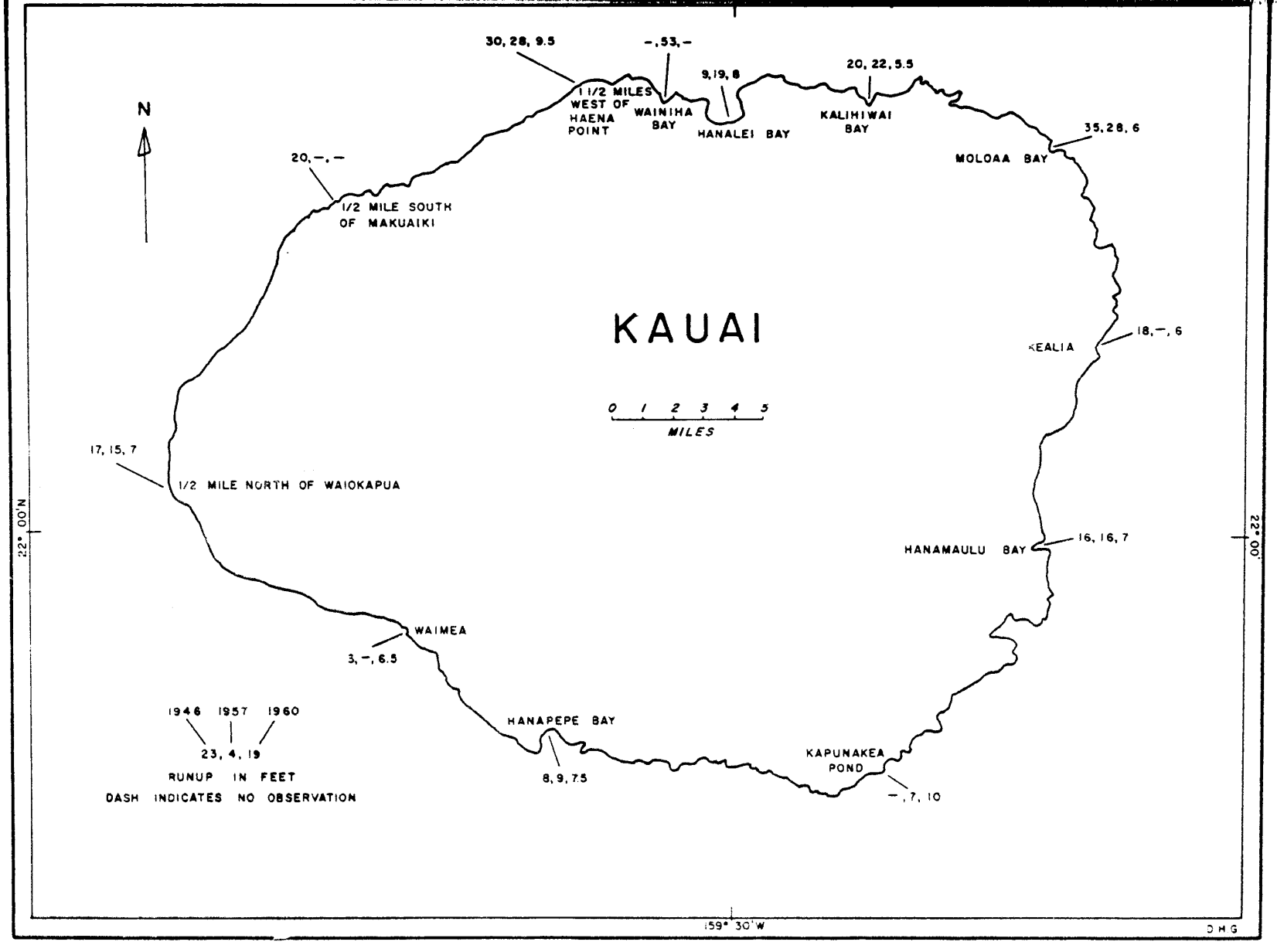

Fig. 23. Kauai (showing historic run-up).

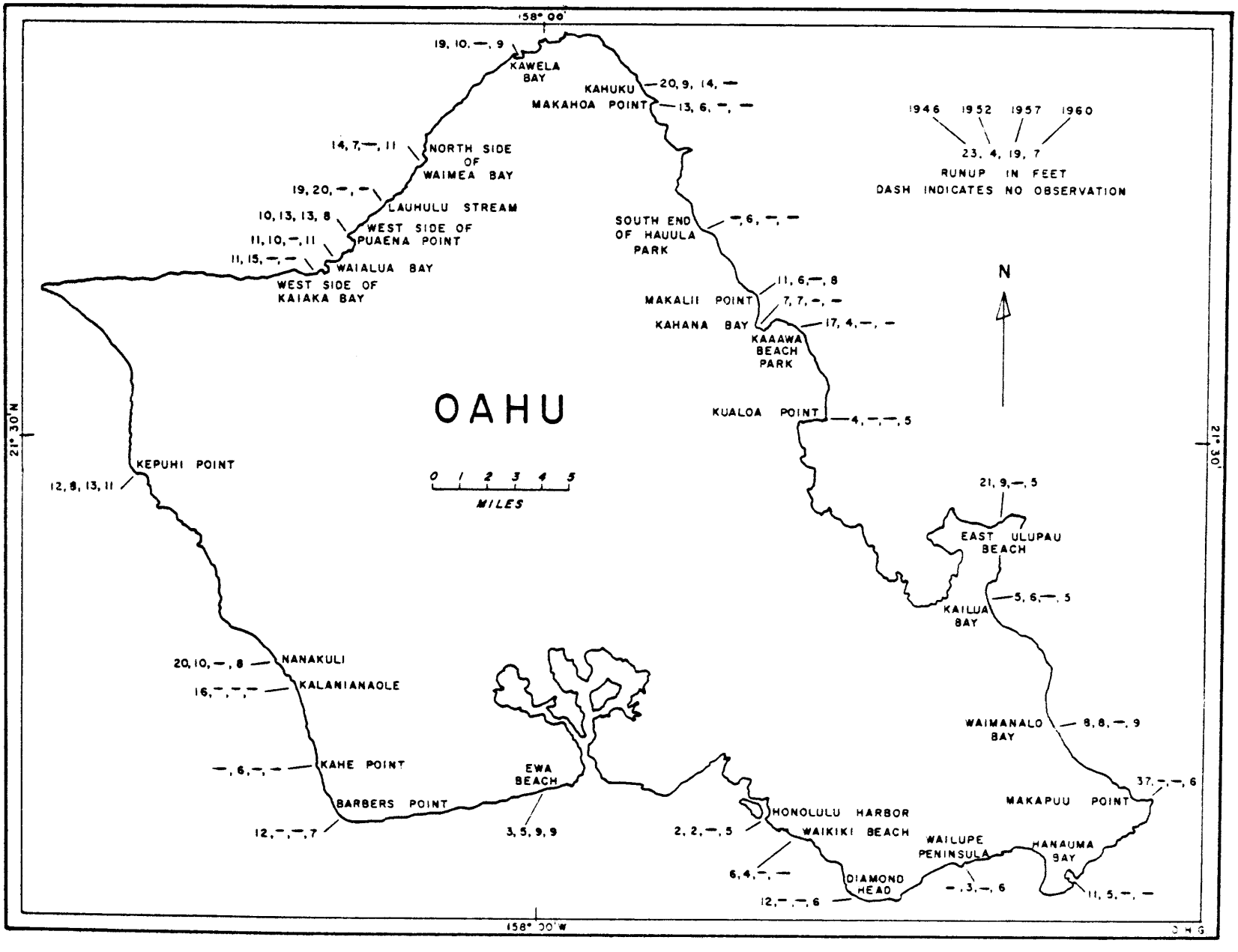

Fig. 24. Oahu (showing historic run-up).

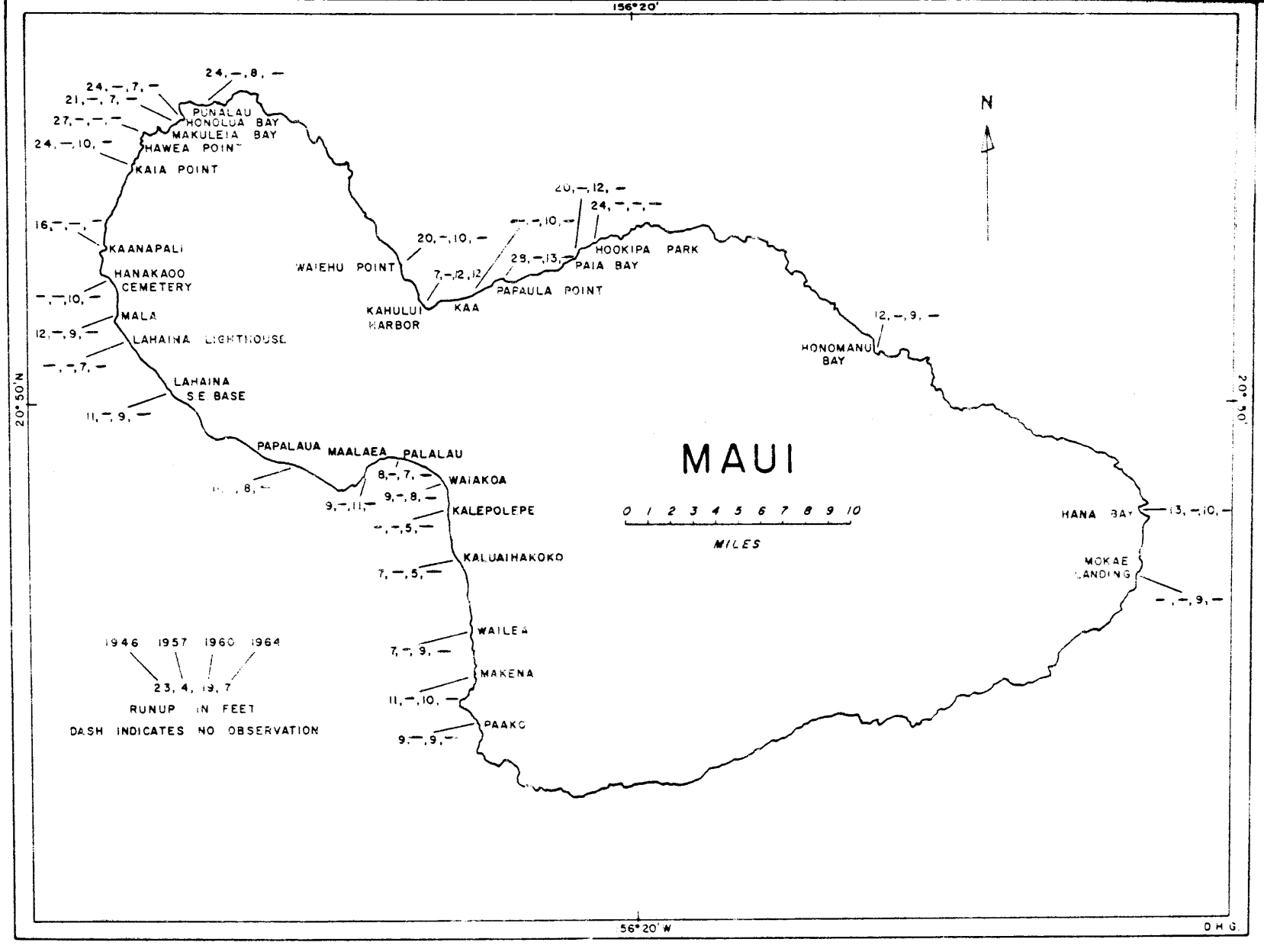

Fig. 25. Maui (showing historic run-up).

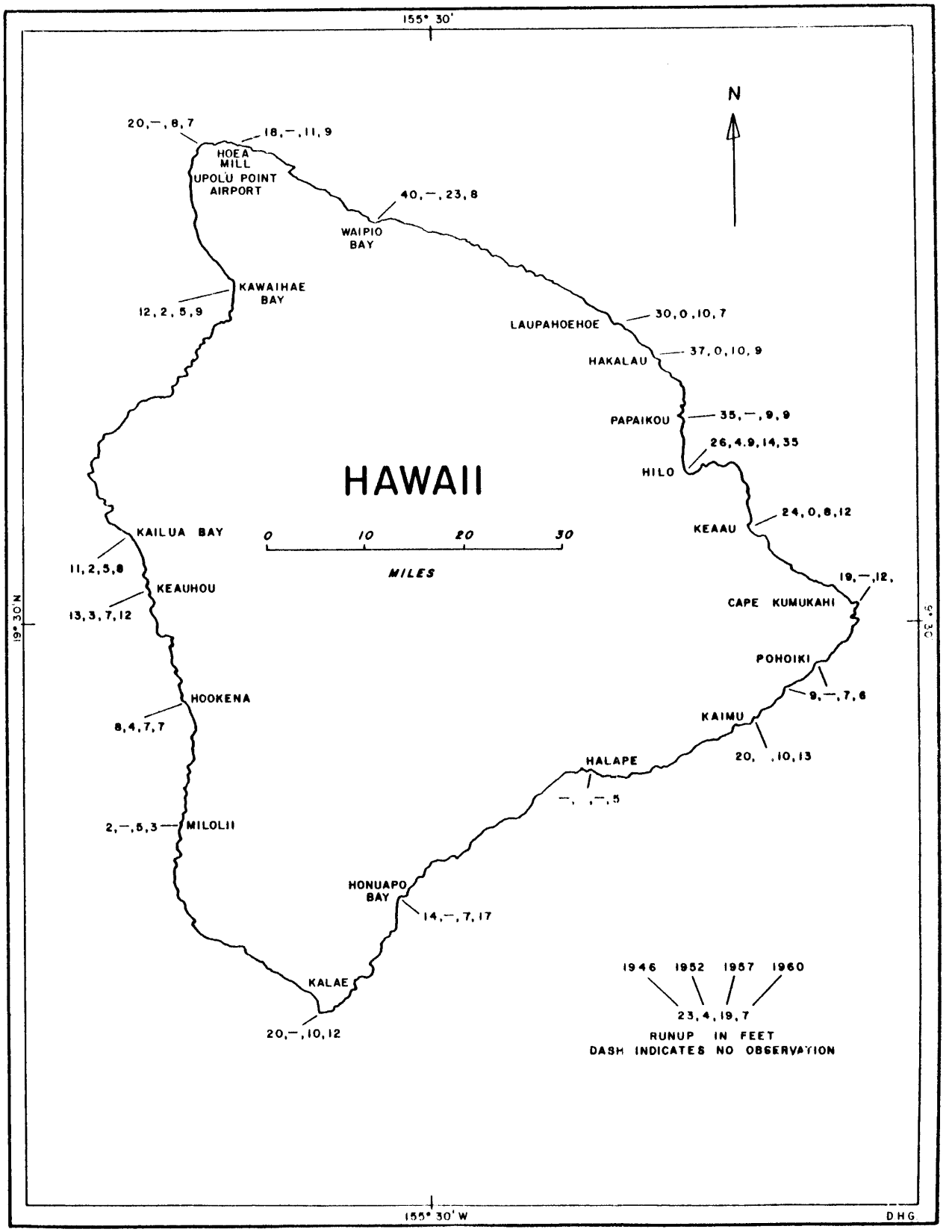

Fig. 26. Hawaii (showing historic run-up).