

CHAPTER 91

PROPOSED "IMPROVEMENT" OF KAIMU BEACH, HAWAII

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Abstract

Proposals to "improve" a pocket beach at Kaimu, Hawaii have been under active consideration for a decade. The beach, which is famous for its jet black color has been receding for at least a century. The plans proposed have called for its enlargement, and most of them for its protection by an offshore breakwater. Advantages of a larger beach area, and of the improvement of swimming conditions if the breakwater were constructed, are undeniable. Loss of surfing sites would, however, have resulted from the adoption of any of the plans involving breakwater. Other disadvantages associated with some of the plans proposed would have included alteration of beach color, other visual impacts, and threats to archaeological sites from the quarrying of breakwater stone. Sand-loss estimates and breakwater construction criteria dependent on them were based on probably erroneous interpretations of historical evidence. Possible alternative sites for the provision of the swimming opportunity were not investigated.

Serious question was raised whether the project would result in overall improvement. However, recent coastal subsidence has rendered all of the plans obsolete and the question is probably moot.



Fig. 1 Photograph of Kaimu Beach in 1968 (Corps of Engineers)

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Introduction

Kaimu beach (fig. 1) is a pocket beach in the Puna District on the southeast coast of the island of Hawaii (fig. 2). Although no more than about a quarter mile in length (fig. 3), the beach would be considered important simply because of the scarcity of beaches on that island and especially in that district. It is in fact famous, but primarily because of the jet black color of its sand. It has been a visitor attraction longer than there has been a recognized tourist industry in Hawaii. However, the beach has long been retreating--indeed measures to control the erosion of its sand were considered as early as the 1910's or 1920's. This paper relates primarily to proposals for its "improvement" dating from 1966 when the Mayor of the County of Hawaii requested the Corps of Engineers to investigate possibilities for its restoration and preservation.

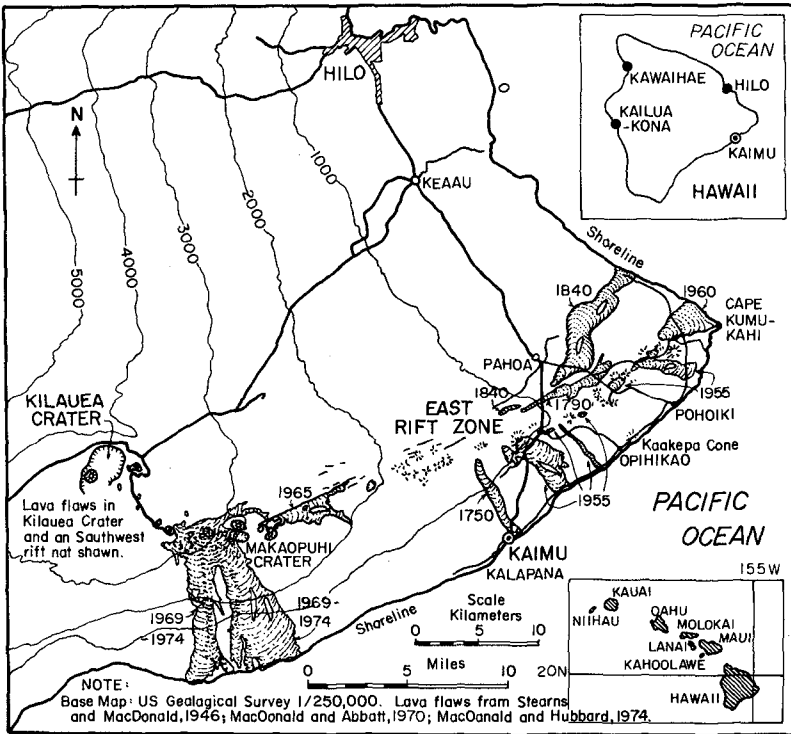


Fig. 2 Topographic and geologic map of Puna District, showing location of Kaimu Beach

Significant geologic events that have affected this district in historic times are listed in table 1 (Stearns and Macdonald, 1946; Macdonald and Abbott, 1970; Macdonald and Hubbard, 1974). As will be noted, several of the historic lava flows reached the coast.

Table 1. Significant historical geologic events in Puna district

<u>Year</u>	<u>Event</u>	<u>Effects</u>
1750	Eruption	Lava flow from rift to S. coast
1790	"	Lava flow on rift
1840	"	Lava flow N. from rift
1868	Earthquake	Subsidence of S. coast
1884	Eruption	Brief shallow submarine eruption
1923	"	Small lava flows on rift
1955	"	Cones and lava flows covering 6 sq. mi., 3 reaching S. coast
1960	"	Cones and lava flow covering 4 sq. mi. and extending to N. and S. coasts near Cape Kumakahi
1961	"	Small lava flows on rift
1962	"	Small lava flows on rift
1963	2 eruptions	Mostly lava fills in pit craters on rift
1965	2 eruptions	Lava flows covering 3 sq. mi. on rift
1968	Eruption	Small lava flows on rift
1969	2 eruptions	Lava flow from first eruption covering 2 sq. mi. near rift. Lava flows from second eruption, which continued into 1971, covering 22 sq. mi., 3 of them reaching the S. coast
1972	Eruption	Lava flows covering 14 sq. mi., one extending to S. coast
1973	3 eruptions	Lava flows covering 4 sq. mi. near rift
1974	Eruption	Lava flows covering 1 sq. mi. on rift
1975	Earthquake	Subsidence of S. coast

Kaimu beach resulted from the entrance of a lava flow into the sea. Upon such entrance, lava often explodes forming deposits of volcanic ash. To the extent these deposits are within wave reach, the ash fragments are subject to reworking and transport. The resulting sand may be deposited, at least temporarily, in a beach at some relatively protected part of the coast. Such a beach is, however, an evanescent feature. The sand is subject to further comminution and transport by waves and wind, and the beach is certain to recede if not covered by a later lava flow.

It is uncertain what lava flow was responsible for the ash from which the black glass sand of Kaimu was derived. The flow may have been a pre-historic one (Stearns and Macdonald, 1946). If so, the ash deposits that were the source of its sand may have been covered by the lava flow of approximately 1750, which entered the sea just northeast of Kaimu beach (fig. 4). In this case the beach has probably been somewhat protected by the coastal extension resulting from the lava flow. Alternatively, the 1750 flow itself may have both been responsible for both the bay in which it was



Fig. 4 Aerial photograph of Kaimu in 1959 (U.S. Navy)

deposited and the source of the sand (COE, 1971). In this case the ash deposits have subsequently been eroded away.

In either case, the beach has been subject to erosion since the sand source was exhausted or covered. Some of the sand has been blown inland at Kaimu, some of it has undoubtedly moved into deep water offshore, and much of it has been transported northwestward to Kalapana (fig. 2) where it has been blown inland to form dunes.

Evidence of the subsidence of Kaimu beach, possibly combined with retreat, was reported as early as the 1870's by Nordhoff (1874) in the form of coconut tree stumps sticking up out of the surf. Photographic evidence of coconut trees being toppled into the water in the 1880's was published by Agassiz (1889) (Fig. 5). Similar photographs have been taken at numerous times since (figs. 6-8); and rough or precise estimates of the rates of retreat may be made by comparisons of shoreline maps dating from 1892 to 1968 and from beach profile surveys made in 1968 and subsequently (fig. 10). By the mid-1960's a rock ledge was exposed near the middle of the beach, and by the mid-1970's this ledge formed a conspicuous promontory (fig. 7).

Table 1 does not include the several tsunamis that may have accelerated the beach retreat temporarily. Tsunamis accompanying the earthquakes of 1868



Fig. 5 Photograph of Kaimu Beach in 1880's (Alexander Agassiz)



Fig. 6 Coconut tree roots exposed by beach erosion, 1972 (Corps of Engineers)



Fig. 7 Underlying lava exposed
by beach erosion (1972)
(Corps of Engineers)



Fig. 8 Kaimu beach in 1973
(Rick Scudder)

and 1975 had runup heights of several tens of feet on the coast farther northwest, but the latter tsunami, at least, was of slight importance at Kaimu. Recent beach erosion was evident after the 1946 tsunami, but it is not clear that any significant addition to rate of retreat resulted.

Project as proposed in 1971

Proposal

In response to the 1966 request of the Mayor of Hawaii for investigation of means to restore and protect Kaimu Beach, the Corps of Engineers issued a favorable reconnaissance report in 1967. Detailed project plans were then prepared which were described in a report issued in September 1971 (COE, 1971).

From shorelines supposedly mapped in 1910 and 1938 and a 1968 shoreline survey, average beach retreat was estimated at about 4 ft. per year, and average sand loss at 2000 cu. yds. per year. The Corps proposed enlargement of the beach, its protection by an offshore breakwater, and periodic replenishment of sand to replace subsequent losses that would occur in spite of the protection.

The enlargement proposed would have required 40,000 cu. yds. of sand, which was to be produced by crushing and screening cinders from a nearby cinder cone, Kaakepa. With this volume, a dry-beach area of 100,000 sq. ft. would have been created. The breakwater proposed would have been about 1350 feet long, extending across the entire bay and would have had a crest height of 2.5 ft. above mean lower low water. Use of stone of at least 6 tons was proposed. The beach enlargement would have been similar and the breakwater alignment identical to those shown in figure 11. Sand losses after breakwater construction, necessitating periodic sand replenishment, were estimated at 600 cu. yds. per year.

The Corps pointed out that this plan would produce, not only an enlarged and protected beach, but a protected swimming area where swimming has been hazardous because of the waves and a rip current. They recognized that the breakwater would have a visual impact, and that its construction would interfere with two surfing sites.

Alternatives to the proposed plan included enlargement of the beach without a breakwater, with a submerged breakwater on the same alignment and with the same length as the proposed exposed breakwater, and a submerged breakwater on the same alignment but extending only 450 feet from the southwest shoreline.

Objections

Although the swimming opportunity that would have been created by the proposed project would clearly have been advantageous, there were expectable objections to the visual impact of the breakwater, the loss of surfing sites, and other alleged detriments. The University of Hawaii Environmental Center, in reviewing the proposal, pointed out the scarcity of surfing sites on the island of Hawaii, and also the traditional importance of surfing at Kaimu as a spectator as well as participant sport (Fig. 9) (Bretschneider et al, 1972).



Fig. 9 Surfing at Kaimu
(Rick Scudder)

In addition, the Center called attention to the effects of using the crushed cinders for the beach enlargement. Spread on the beach, this material would have been harsh underfoot, and because it was brown, the jet black appearance on which the fame of the beach depended, would have been lost. The Center also questioned the Corps estimates of historic rates of beach retreat and sand loss.

The source of the stone for the breakwater was described in the Corps report merely as within 10 miles of Kaimu. It later appeared that the principal source in mind was a lava ledge at Kalapana. The Center pointed out the existence of archaeological sites in the vicinity and questioned whether the quarrying operation could be carried out there without disturbance to these sites or esthetic detriments.

The Center also commented that, although beach enlargement without a breakwater and use of lower or shorter breakwaters on the proposed alignment had been considered as alternatives, there was no evidence of consideration of

alternative modes of beach protection or of alternative sites at which the swimming opportunity could be created. The Center called attention to the opinion of the Look Laboratory of Oceanographic Engineering that the choice among alternative breakwater designs should be based on hydraulic modeling (Bretschneider et al, 1971).

Project as proposed in 1972

Proposal

In response to some of the objections and questions mentioned above, and others, the Corps of Engineers revised its estimates and its proposed plan (COE 1972a) and prepared and issued an environmental impact statement on the project (COE 1972b, 1973). Estimates of beach retreat and sand loss, were revised on the basis of shoreline positions mapped in 1892, 1915, and 1940, and beach surveys in 1968 and 1972. From the description of the 1892 shoreline, it is assumed to have been that dated 1900 in the earlier Corps report (COE 1971). This shoreline and those plotted in the 1972 Project Report (COE 1972a) are shown in figure 10. The histories of the position of the beach front and of the sand volume in the beach as estimated by the Corps are shown in figure 12.

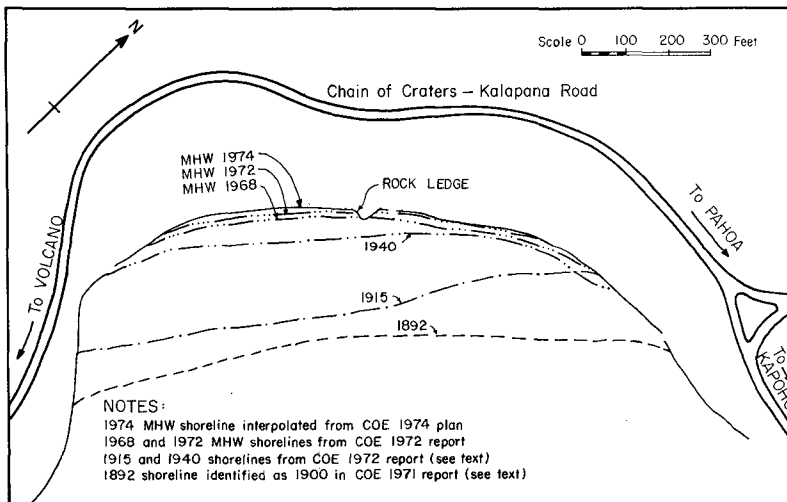


Fig. 10 Shoreline history of Kaimu Beach

The revised plan called, in sequence, for:

- 1) Removal and stockpiling of 5,800 cu. yds. of sand from the beach.
- 2) Adding 38,000 cu. yds. of new sand to the beach.

3) Monitoring for about two years, during which sand loss at a rate of 3000 cu. yds. per year was expected.

4) Construction of the breakwater to the same length and on the same alignment as in the original plan, but with its crest at mean lower low water (fig. 11).

5) Adding an additional 5,000 cu. yds. of new sand to the beach and topping off with the 5,800 cu. yds. of original stockpiled sand.

6) Periodic replenishment of sand, averaging 1,200 cu. yds. per year, to compensate for continuing sand losses.

The dry beach area on completion was estimated at 133,000 sq. ft., an increase of 101,000 sq. ft. over the existing area. It was recognized that the breakwater would still interfere with surfing. It was also recognized that the water inshore of the submerged breakwater (crest at mllw) would not be as quiet as in the case of the exposed breakwater originally proposed (crest at 2.5 ft. mllw), but considered that this would not seriously detract from the swimming opportunity.

Recognizing the importance of the color of the sand, the Corps proposed, as a possible alternative to the use of crushed cinders, the use of greenish-black sand-sized ash derived from shoreline explosions of the 1960 lava flow at Kumukahi (fig. 2).

Objections

In reviewing the 1972 proposal, the Environmental Center called attention to the fact that the original sand removed from the beach, stockpiled, and later replaced on top of new sand, would be most immediately affected by subsequent erosion (Johnson, 1973). The estimation of sand loss rates was again questioned. The Center pointed out that the Corps had assumed that the 1915 and 1940 shorelines were mean high water lines, whereas in Hawaiian usage they were more likely to be wave wash lines, and that the rates of retreat and sand loss had probably slowed as the beach retreated.

The matter of alternatives was again brought to attention. An alternative of gradual sand replenishment without a breakwater, either at a rate just sufficient to balance the erosion or at a larger rate to induce increase in beach width, was pointed out as having seeming economic advantage (Cox, 1973). In addition, the importance of geologic hazards to the beach and the proposed project was discussed, with special reference to the hazards of lava flows and coastal submergence or emergence.

Project as proposed in 1974

Initiation

Weighing the benefits, detriments, and uncertainties, the Environmental Council, advisory to the Governor of the State of Hawaii, recommended initially against the undertaking of the proposed project. However, on the request of the Hawaii County Council, the Environmental Council reconsidered

the matter, and in June 1973 recommended the planning of a project similar to that proposed in 1972, but with the breakwater construction to be contingent on the results of monitoring:

- 1) Construction phase I: Beach enlargement
- 2) Monitoring phase of two or, preferably, three years
- 3) Contingent construction phase II: Breakwater construction
- 4) Periodic replenishment of sand to compensate for continuing losses.

The Corps of Engineers was requested to "apply, whenever possible, the recommendations of geologists, ocean scientists, and other experts from the University of Hawaii" to the design of the first phase, and to consult with University experts on the monitoring program and the design of the breakwater.

First proposal

An initial proposal was presented to the Environmental Council by the Corps in November 1974. Enlargement of the beach (fig. 11) was to be accomplished using 30,000 cu. yds. of sand from the Kalapana ash deposits, which approached the Kaimu sand in color and size distribution. Stability of the enlarged beach was an important consideration in the design configuration (fig. 11). A monitoring period was called for with monthly surveys for three months after completion of sand emplacement, bimonthly for the rest of a two-year period, and annually thereafter for 10 years, unless it were decided earlier to construct the breakwater.

It was proposed that the breakwater would not be constructed if all of the following sand-loss criteria were met:

- a) Initial rate: less than 10,000 cu. yds. per yr.
- b) Rate during each subsequent monitoring interval: less than 3,000 cu. yds. per yr.
- c) Average rate from completion of enlargement to any survey date in the first two years: less than 1,300 cu. yds. per yr.
- d) Rate during any subsequent year: less than 3,000 cu. yds. per yr.
- e) Average rate to any subsequent survey: less than 1,300 cu. yds. per year.

A decision to construct was to be made at the end of two years if any of the first three criteria were not met, and at any time thereafter if either of the last two criteria were not met. The breakwater, if constructed, was to be a submerged one as in the 1972 plan (fig. 11).

Beach-retreat and sand-loss estimation

The Environmental Center considered that, in the light of the Council's recommendation to defer the breakwater construction pending actual observation of the rate of sand loss after beach erosion, the criteria for

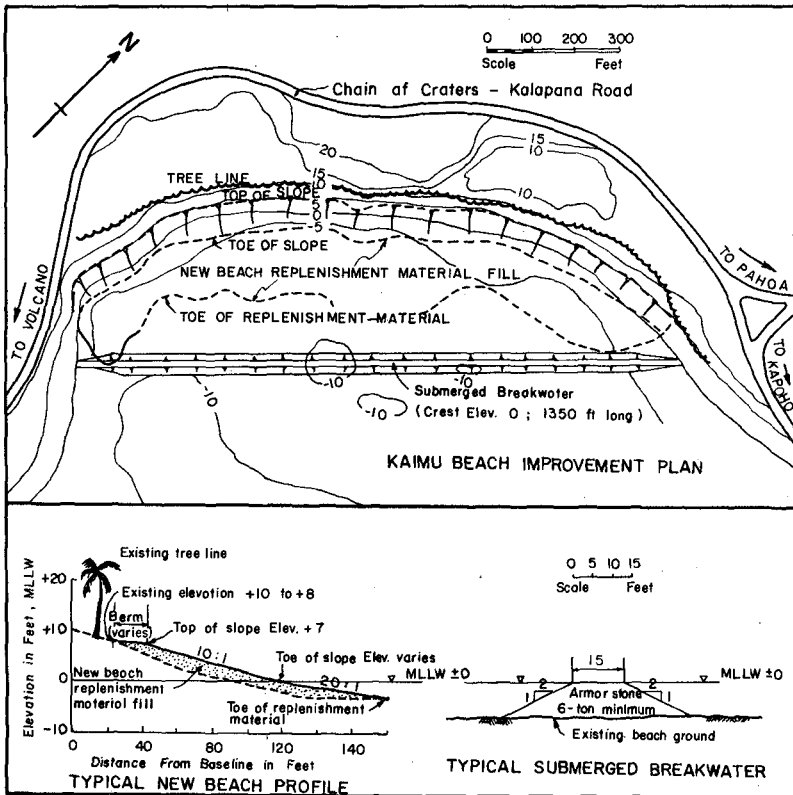


Fig. 11 Kaimu breakwater as proposed in 1972
and beach enlargement as proposed in 1974

determining whether or not the breakwater should be built were critical, and that for this reason the estimates of beach retreat and sand loss should be reexamined. In the Center's opinion, the criteria should exceed, but not exceed greatly, the loss rates expectable considering average natural loss rates at beach front positions equivalent to post-enlargement positions, expectable short-term departures from average loss rates, and some increase over natural loss rates due to non-equilibrium configuration of the beach, especially immediately after construction.

The Center developed estimates of long-term beach retreat and sand loss rates, that were based on Corps of Engineers data, including the approximate position of the shoreline in 1892 and the results of a 1974 survey that had

just been completed (Cox, 1974b). Like the Corps, the Center was forced to assume that, in profile, the shape of the beach at the times when only shorelines had been mapped was similar to the shape when the entire beach front was surveyed in 1968, 1972, and 1974. Beach retreat and sand loss rates were related through use of a smoothed curve of loss-retreat ratios, obtained from Corps data, plotted against shoreline position. However, the Center assumed that the shorelines mapped in 1892, 1915 and 1938 were not the high water line, as assumed by the Corps, but the "kahakai" or mark of the sea, the uppermost reach of waves as indicated by the vegetation line, as was conventional in Hawaiian cadastral surveying.

The histories of beach retreat and sand loss in accordance with the Center assumption are compared with those in accordance with the Corps assumption in figure 12. In this figure the beach-front positions and beach-sand volumes at the times of successive shoreline and beach-front surveys are plotted relative, respectively, to the 1972 position and volume. Beach-retreat and sand-loss rates as estimated by the Center are compared with those estimated by the Corps in figures 13 and 14. In these figures, retreat rates and loss rates are plotted over the respective ranges in beach-front position between successive mapping or survey dates. It will be seen from the latter figures that much more regular relationships between retreat and sand loss rates and beachfront position resulted from the Center estimation than the Corps estimation.

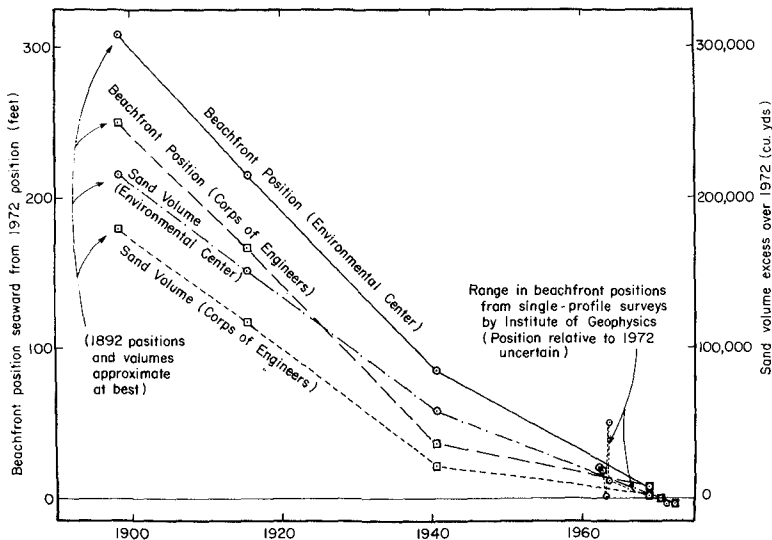


Fig. 12 Historic beach front-positions and sand volumes in accordance with Corps of Engineers and Environmental Center assumptions

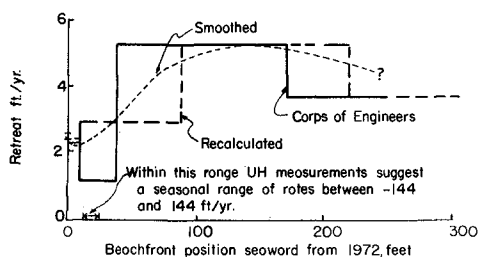


Fig. 13 Beach retreat rates as estimated by Corps of Engineers and Environmental Center assumptions

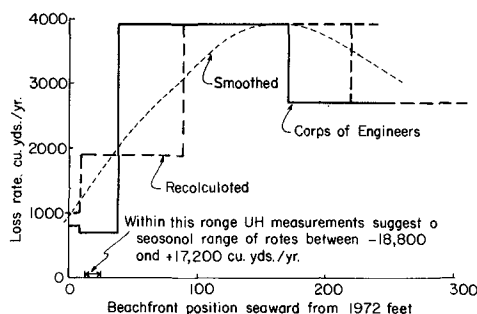


Fig. 14 Sand-loss rates as estimated by Corps of Engineers and Environmental Center in relation to beach-front positions

The Center also made use of profiles of the beach surveyed by the Hawaii Institute of Geophysics in June and September 1962; January, April, and July 1963; and July 1971 (Moberly and Chamberlain, 1964). Because the Institute of Geophysics surveys were made on a single range, it was necessary to assume that, in plan, the shape of the beach was essentially the same on the various survey dates.

Unfortunately, the position of the Institute range was never related to the positions of the ranges used by the Corps. Hence the relation in figure 12 between the beach-front history based on Institute data and the longer term history is somewhat uncertain, and the implications of the Institute data are shown in figures 13 and 14 merely as ranges of uncertainty.

The Institute data were, however, of use, together with the Corps beach surveys of December 1968, May 1972, and February 1974, in estimating short-term departures from long-term beach-retreat and sand-loss rates. From the rates of sand loss indicated by various pairs of surveys, the normal (long-term) rates indicated by figure 14 were subtracted, and the resulting departures were compared, without regard to sign, in a log-log plot against the time intervals between the respective surveys. Retreat rates were treated similarly. The results indicated that departures from normal sand-loss rates

could well be as large as 25,000 cu. yds./yr. over a period of 2 months, 5,000 cu. yds./yr. over a period of 6 months, 1,800 cu. yds. per year over a period of a year, and 600 cu. yds. per year over even a period as long as two years.

The combination of normal rates of sand loss for various beach-front positions as plotted in figure 14, expectable departures from normal rates for periods of various durations, and sand-loss/retreat-rate ratios for various beach front positions, provided a basis for estimating the expectable rates of sand loss after the beach was enlarged and as it subsequently retreated (fig. 15), if it were assumed that the effects of any failure to attain an equilibrium configuration in construction would be small or of short duration. Expectable cumulative sand losses after beach enlargement, estimated as indicated, are shown in figure 15. This figure also shows the losses implied by the criteria for breakwater construction originally proposed by the Corps, and the losses that the representatives of the Corps and Environmental Center agreed jointly should be reflected in revised criteria.

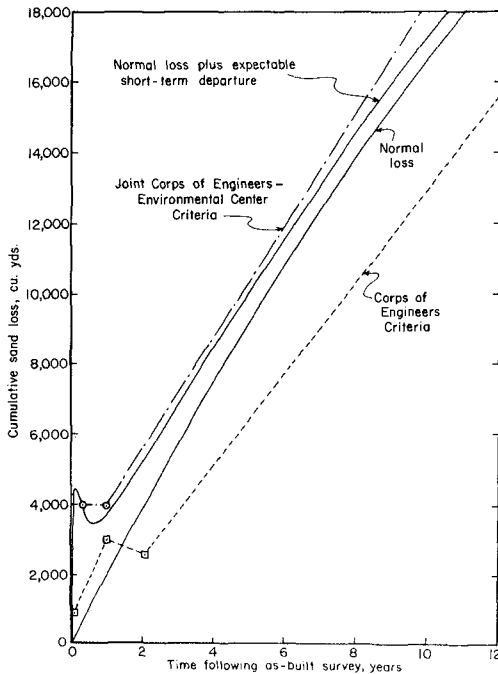


Fig. 15 Expectable cumulative sand loss after beach enlargement and proposed breakwater construction criteria

Revised proposal

The Corps-Center conferees reported back to the Environmental Council in December 1974 (Beishe et al, 1974). In brief their joint recommendations, if the project were to proceed, were as follows:

1. The 30,000 cu. yds. of sand to be placed on the beach should be drawn in accordance with the earlier plan (fig. 11) from the Kalapana ash deposits.
2. A first monitoring survey should be made before beach enlargement, a second as soon as possible after completion of the enlargement, and subsequent surveys at two-month intervals during the first year thereafter, four-month intervals during the second year, and annually thereafter for 10 years.
3. The breakwater would be built if, and only if, the cumulative loss of sand after the as-built-survey exceeded 4,000 cu. yds. at any time during the first year or 2,400 cu. yds. plus the product of 1,600 cu. yds. per year and the time in years elapsing from the as-built-survey (fig. 15).
4. The breakwater, if built, was to be constructed in accord with the submerged breakwater plans (fig. 11) using stone quarried from sites of no archaeological significance where scenic detriments and nuisance would be minimized.

No estimate was reported of the rate of continuing sand loss after the breakwater was constructed, if it were constructed. Assuming the validity of the Corps estimate of the ratio of loss rates with and without the breakwater, the periodic replenishment of sand needed to compensate for sand losses continuing after breakwater construction would have averaged about 1,100 cu. yds. per year.

Independently, the Center suggested that the Council should reconsider its decision to approve any modification of Kaimu Beach, calling attention to some of the objections that had been raised previously but seemingly not adequately considered. However, the joint Corps-Center recommendations were approved by the Council and transmitted to the Governor of the State of Hawaii and the Mayor of the County of Hawaii.

Project as proposed in 1975

Although the County Council of the County of Hawaii had approved the staged project, as proposed by the Corps in 1972, and had not objected to the proposal of the Environmental Council to make the breakwater construction contingent on monitoring results, and in spite of the subsequent planning efforts of the Corps and Environmental Center and endorsement of their recommendations by the Environmental Council, the County Council rejected the recommendations, in favor of a plan in which the breakwater would be constructed first and the beach enlargement accomplished second. In spite of the State Environmental Council's position, the State Department of Land and Natural Resources, which controlled the necessary state funds, concurred with the County Council.

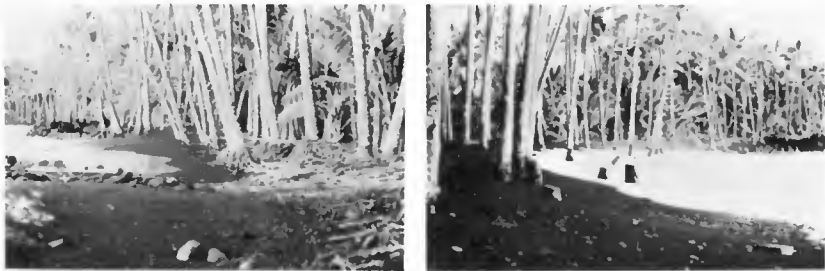
The breakwater was presumably to be a submerged one, and the sand used for beach enlargement was presumably to come from Kumukahi, but it is not clear what volume of sand would have been placed on the beach nor where the breakwater stone would be obtained because, during the long delay, the federal funds originally allocated to the project had been committed elsewhere, and the preparation of revised plans and undertaking of construction had to await a further allocation.

Natural intervention

Nature then intervened. On 29 November 1975 there was an earthquake with a magnitude and effects similar to those of 1868. A tsunami was generated that was responsible for two deaths on the coast southwest of Kaimu. The coast again subsided to a maximum of about 10 feet to the southwest and about 3 feet at Kaimu. Some subsidence seems to have continued since the quake, although the results of surveys have not as yet been published.

As had been reported after the 1868 subsidence, the erosion of Kaimu beach accelerated after the 1975 subsidence (figs. 16 and 17). However, the height of the beach above sea level was reduced by about 3 feet and the depths along the proposed breakwater alignment as well as elsewhere were increased by the same amount. Hence neither the plans for beach enlargement nor those for breakwater protection could be considered at all appropriate. In addition County plans for other aspects of coastal development at Kaimu, private and public, were rendered questionable by the subsidence and the obvious exposure to the effects of earthquakes and tsunamis. Hence the economic justification for the project appeared to need reexamination.

No final decision has yet been made that the construction project affecting Kaimu Beach should not be undertaken. The Corps of Engineers has indicated its possible availability for further planning. However, the County has decided that no further planning effort should be made for a while, at least until the question of continuing coastal subsidence has been settled.



Figs. 16 and 17 Kaimu beach in December 1975 (Joseph Halbig)

Analysis and conclusions

As in the case of most projects intended to modify natural conditions or processes, the Kaimu Beach project, in any of the plans proposed, would have resulted in a combination of benefits and detriments, some of both accruing as side effects, incidental to the benefits for which the project was proposed. The weighing of such benefits and detriments is supposed to be facilitated by the combined availability of project reports and environmental impact statements, after public review and resulting response, to decision makers. The process seldom approaches perfection, and this review of the Kaimu case was undertaken to call attention to some sources of imperfection to which special attention might usefully be paid in reviewing the process or applying it to similar cases.

The benefit originally sought by the County of Hawaii was the restoration and protection of Kaimu Beach. All of the plans called for enlargement of the beach, but in a strict sense none of them could have restored the beach to its natural condition at some time in the past. It is quite doubtful that, without public review, the color change which would have resulted from the implementation of the 1971 plan would have come to general attention until the change had been effected, although there is little doubt that preserving the natural color of the beach was considered important. When the color change detriment was called to attention, the plans were revised to call for the use of sand more nearly matching the natural sand in color.

More or less protection of the beach would have been afforded by any of the plans that incorporated a breakwater, and all of the plans called for sand replenishment after the project was complete to compensate for the lack of complete protection. The loss of surfing sites that would result from breakwater construction was recognized from the outset by the Corps, but the importance of these sites, on account of their traditional and continuing use, was highlighted in the public review process and more or less well recognized in the final environmental statement.

The potential detriments associated with quarrying for breakwater rock, which came to light in the public review process, were circumvented by changes in the plans for quarry sites in response to the review comments.

The swimming opportunity that the breakwater would have provided was identified by the Corps from the outset as a major benefit. Retention of the breakwater in the plans probably resulted from considerable public agreement with the importance of this benefit. However, in spite of the requirement in federal environmental law for the consideration of alternatives, possible alternatives for the provision of this benefit were never investigated because the Corps is not authorized to investigate the creation of beaches or swimming sites, but only their restoration and protection, and the state and county could not have counted on federal support for the investigation or construction where there was not an existing beach.

Some of the detriments of the project that were alleged in the public review process were examined and shown to be of little consequence--an alleged loss of fishing opportunities, for example. Some alternatives suggested in review were, however, brushed aside as being impractical without evidence of adequate investigation, for example, alternative types and alignments of breakwaters. Trial dumping of sand cinders (or of cinders from which sand might be generated) east of the beach to nourish the beach indirectly (Johnson, 1973) was dismissed simply because "this alternative is not a positive approach to the problem and there is a possibility that the introduced sand would bypass the eroded areas completely" (COE, 1973).

The questions initially raised in the first public review about the retreat and sand loss estimates, on which the benefit and cost appraisals of the project depended, were not satisfactorily addressed until the Environmental Council intervened.

Of three geologic hazards, only the least consequential, that of tsunamis, was initially recognized. The lava-flow hazard, to which attention was called in the review process, was never analyzed, although historical statistics on which a reasonable analysis could be based became increasingly available during the planning period. Attention was called in the review process to the hazard of subsidence, but this hazard could not have been analyzed because there had been but one prior incidence of this hazard at Kaimu. Oddly, it was a second incidence of this hazard, that brought the project planning to a halt, at least temporarily.

It seems quite questionable that, if all of the detriments, hazards, and alternatives had been recognized at the outset, any of the plans formally proposed would have been considered as representing, overall, an improvement. During the long planning period, however, increasing public and private commitments were made for land uses in the vicinity under the assumption that the Kaimu beach would be enlarged and a swimming opportunity created there. The decisions in early 1975 were almost certainly biased by developments that were stimulated by the initial proposal of 1971, although this would be difficult to document. Unfortunately the event that led to the halt also hastened the end of Kaimu beach, of which there are left only remnants.

Acknowledgements

Many members of the University of Hawaii community contributed to the Environmental Center reviews on which this paper is based, and several members of the staff of the Corps of Engineers were helpful in supplementing and clarifying the information in official reports in the review process. Information and photographs provided by Joseph Halbig and G. A. Macdonald of the University of Hawaii, Rick Scudder of the Office of Environmental Quality Control, and Clarence Fujii and Karl Keller of the Corps of Engineers were used in the preparation of this paper. The assistance of all, whether here named or not, is gratefully acknowledged.

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