

Figure 2-597. Location map of Kualoa, Hawaii, monitoring site.

(b) Geomorphology, Soils, and Vegetation. The Kualoa site is located on the northeast flank of the prehistoric Koolau Volcano. Several periods of marine and subaerial erosion of the volcano and isostatic sinking of the island have contributed to the present appearance of the core and flanks. In addition to the periods of erosion, a geomorphic pattern of fringing, patch, and barrier reefs developed, and the reefs were modified by changes in sea level resulting from the advance and retreat of continental glaciers. A fringing coral reef extends about 2,000 feet seaward of the eastern park shoreline and about 1,800 feet southward into Kaneohe Bay. A large deposit of sand lies about 1,500 feet southwest of the southern park shore, directly offshore Moli'i Fishpond.

The Kualoa peninsula is a large, dynamic sandpit which was incrementally built in a southward direction into Kaneohe Bay by the net southward movement of sand from the reefs and beaches north of Kualoa. Most of the peninsula consists of unconsolidated marine calcareous sediments, and the very permeable beach sand consists of grains of worn coral, coralline algae, and shells. Vegetation in the immediate area of the monitoring site consists of grass, extending from the top of bluff landward, and a few palm trees randomly spaced behind the bluff.

(c) Waves, Longshore Transport, and Erosion. The LEO data (Table 1-3) indicate that wave heights average 0 to 1 foot with a maximum of 1.7 feet. The wave climate is classified as intermediate. Although the energy-flux analysis indicates a small net potential for southward longshore transport at this site, only 30 observations were made throughout the 3-month analysis period, and the results probably reflect this shortage of basic data. The actual net transport rate appears to be much greater than the analysis indicates. Results of a study of littoral currents at Kualoa Park in August 1979, carried out under the prevailing trade-wind conditions, indicated southward transport at an average speed of 6 feet per minute. On the southern shoreline, the current had a strong westward movement of about 10 feet per minute. Sand-tracing studies concluded that littoral transport of sand moves in a clockwise direction around Kualoa Point. Other causes of erosion at Kualoa Beach have been the building of manmade structures in the area. For example, groins built north of Kualoa Beach may have caused a temporary disruption of the longshore transport of material that provides the area with part of its sand supply.

(d) The Problem. The eastern beach at Kualoa Regional Park has undergone continuous erosion. Resulting shoreline changes are shown in Figure 2-598. The average annual loss of sand from the eastern beach area from 1949 to 1975 was 4,800 cubic yards. During this period, the eastern shoreline had receded at an average rate of about 4 feet per year, and the shoreline near Kualoa Point had receded at about 7 feet per year. Although most of the park's southern shoreline accreted during 1949-75, there was a net loss of 80,000 cubic yards for the whole park. This represents more than 6 acres of parklands lost. Studies have indicated that, from 1949 to 1975, 30,000 cubic yards of sand was lost from the littoral system at Kualoa, probably to the offshore sand deposit south of Moli'i Fishpond. Beach erosion appears almost continuous during trade-wind conditions, and a period of higher than normal tides under typical trade-wind conditions can accelerate shoreline erosion.

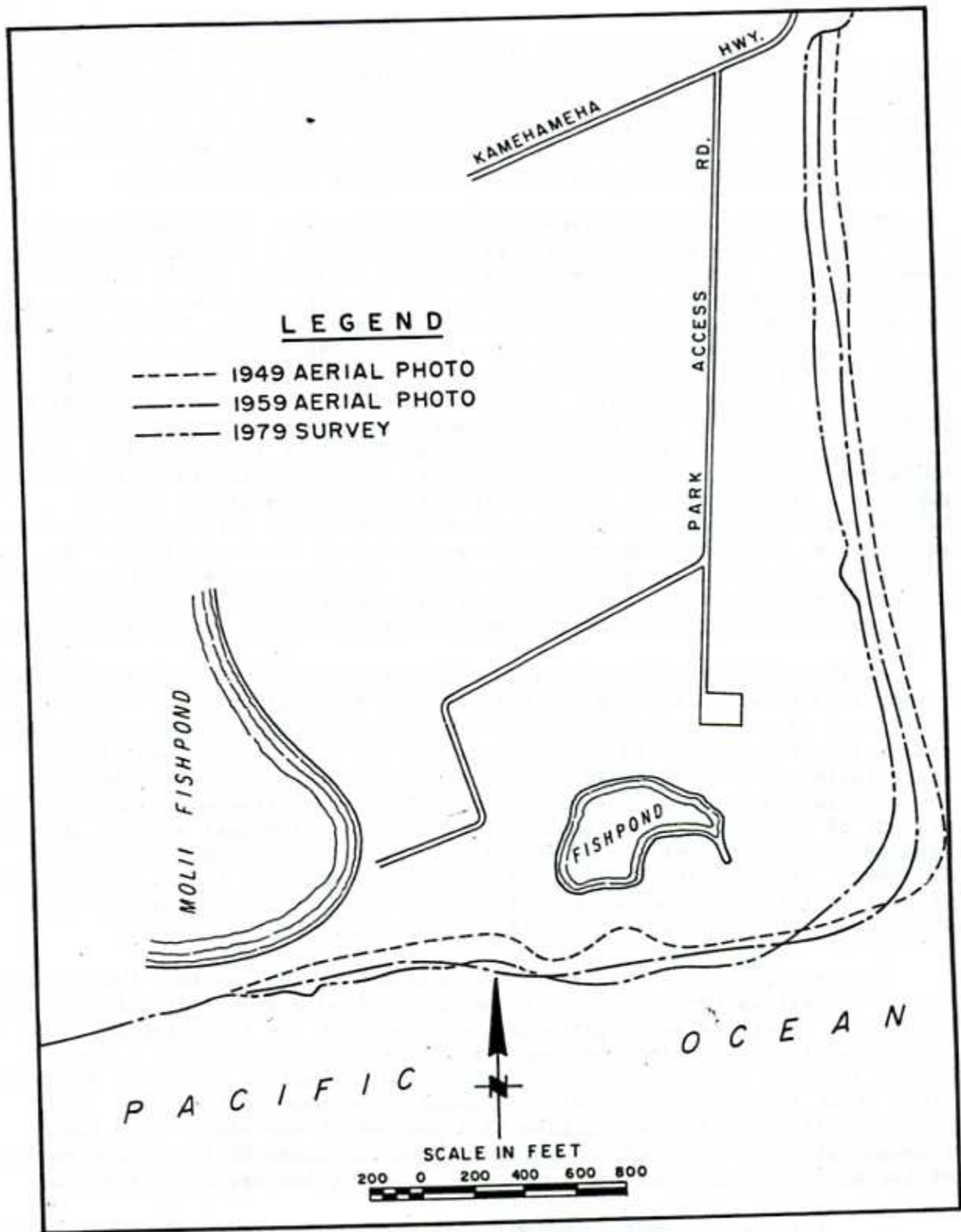


Figure 2-598. Shoreline changes at Kualoa Park.

(2) Monitoring Project. In late fall of 1977, the Department of Parks and Recreation, City and County of Honolulu, had a contractor install a 200-foot-long Sandgrabber just north of Kualoa Point to test its effectiveness in controlling erosion of the park shoreline. A profile of the device is shown in Figure 2-599. After the structure was completed on 5 December 1977, the Department conducted a 2-month study of its performance.

Two problems became apparent almost immediately. The seaward course of blocks consisted largely of red cinder blocks, of a lighter consistency than the blocks used for the main body of the structure. By 26 December 1977, most of these blocks had broken under the effects of wave action, and the structure seemed to be gradually working itself apart. Shortly thereafter, the contractor removed the broken blocks along with the entire seaward course and retightened the loose tie rods. This restored the structural integrity of the Sandgrabber. The second problem which became apparent was that the south end of the Sandgrabber was not curved far enough toward the beach berm to prevent wave attack on the back side of the structure. This southeasterly wave attack was not expected. Aerial photos indicate that it was caused by diffraction of the northeast trade waves around Mokolii Island, and subsequent refraction over the reef. When this occurred, the waves eroded the sand from behind the south end of the Sandgrabber. A protective extension was added to the south end; however, even this extension did not completely solve the problem of wave attack from the southeast. There was continuing evidence that waves were getting in behind the structure.

By the end of the 2-month study, the structure had settled approximately 1 foot into the sand along a 10-foot reach at the south end and along a 15-foot reach near the center. The structure remained intact, and there was a smooth transition from the slumped areas to the rest of the Sandgrabber. Approximately 148 cubic yards of sand accreted both behind and seaward of the structure along its 200-foot length. This was estimated to be about 15 percent of the material available in the littoral transport system. Severe erosion occurred downstream of the structure, extending for a distance of 300 feet. Although the Sandgrabber contributed somewhat to the erosion by retarding littoral transport past the site, it appeared that larger waves than normal, combined with high tides, caused most of the erosion.

In conclusion, the Department of Parks and Recreation felt that longer term observations were needed to allow a more credible determination of the structural stability and functional performance of the installation. The 2-month monitoring period was considered representative only of a typical winter in which the trade winds blow about 63 percent of the time, and Kona winds (from the southwest quadrant), about 20 percent of the time. On a yearly basis, the trade winds blow 82.6 percent of the time. Upon the recommendation of the Division Engineer, Pacific Ocean Division, monitoring of the Kualoa Sandgrabber was continued under the demonstration program.

(3) Performance. Overall, the Sandgrabber remained structurally sound throughout the monitoring period. Differential settlement along its midsection, and of individual blocks, was observed in April 1978 (Figs. 2-600 and 2-601). The entire structure was also rotating downward on the seaward side. The short section on the south end had a seaward slope of 13° (Fig. 2-602). By May, although this short section had continued to settle, the seaward slope was only 8°.

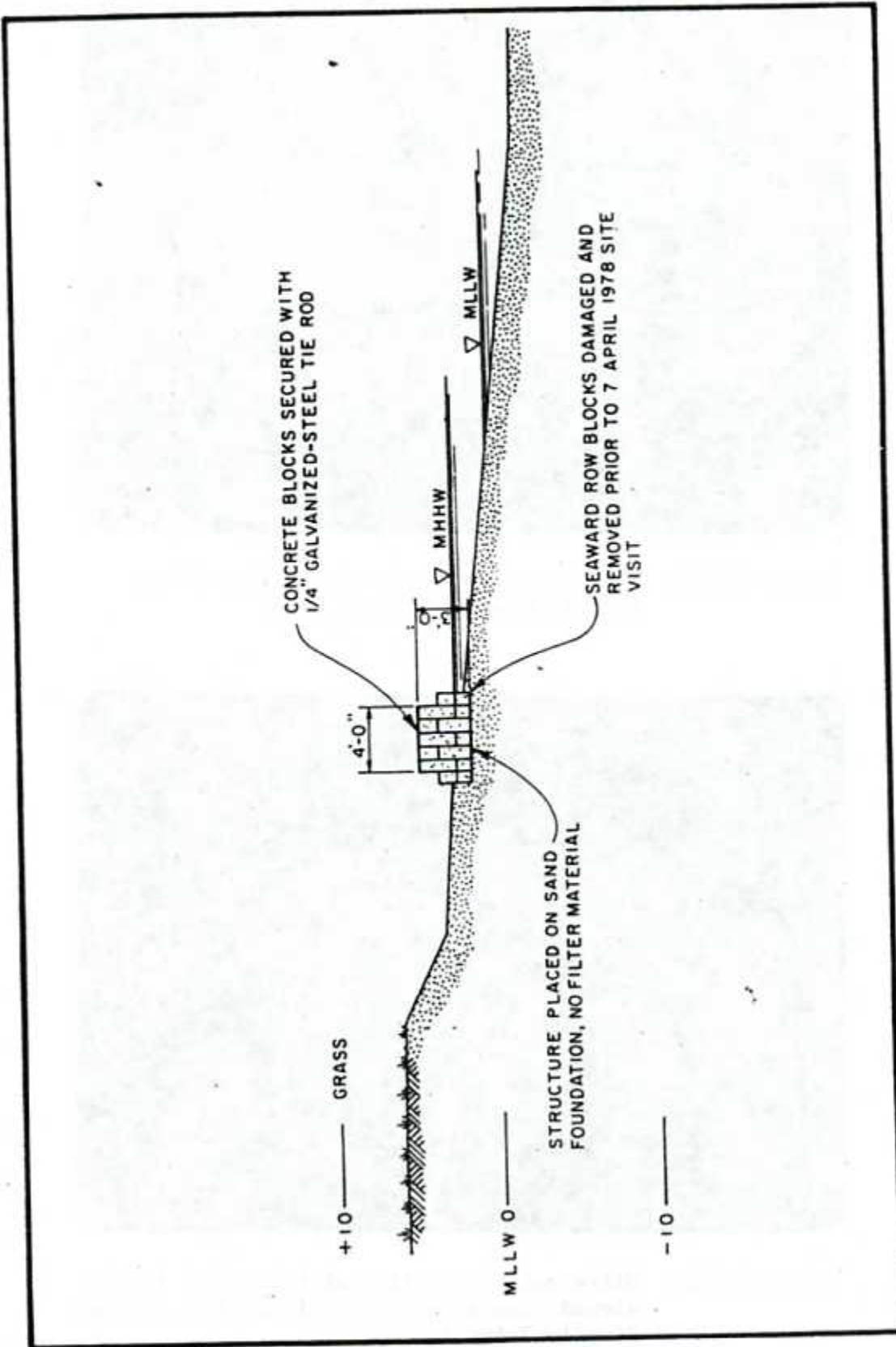


Figure 2-599. Sandgrabber profile at Kualoa site.



Figure 2-600. Settlement of blocks along midsection, Kualoa, Hawaii, 7 April 1978.



Figure 2-601. Differential settling of individual blocks viewed from structure's midsection, Kualoa, Hawaii, 7 April 1978.



Figure 2-602. Seaward slope of south end of Sandgrabber, Kualoa, Hawaii, 7 April 1978.

Differential settlement of individual blocks continued over the following 18 months. Although the tie rods were loosening and many of the blocks on the seaward face broke, the structure ceased to rotate. By January 1979, four blocks had been damaged--two near the south end were vertically displaced, and two near the center of the structure had broken away (Figs. 2-603 and 2-604). By May 1979 most of the tie rods were rusted and loose, and in November 1979 several blocks in the seaward face were broken apart (Figs. 2-605 and 2-606). Despite this component damage, the Sandgrabber remained functionally effective.

By June 1978, the preliminary effects of the Sandgrabber at the Kualoa site were identified. Sand accumulated on the landside of the structure as expected, but not along the seaward face. The northern and southern beach areas near the Sandgrabber accreted somewhat at first, but erosion of the downdrift bank was accelerated (Fig. 2-607). Between June 1978 and August 1979, erosion of the downdrift bank averaged +1 foot per month. The rate of erosion decreased through November 1979. Figure 2-608 shows the progressive erosion downdrift of the Sandgrabber from November 1978 to November 1979. Between November 1979 and January 1980, +10 feet of downdrift shoreline was lost as a result of winter storms.

In January 1979, there was slight accretion along the seaward face (compare Figs. 2-609 and 2-610); however, this trend did not continue. Accretion of sand landward of the structure continued until September 1979, when minor scouring along the central segment of the landward face was observed.

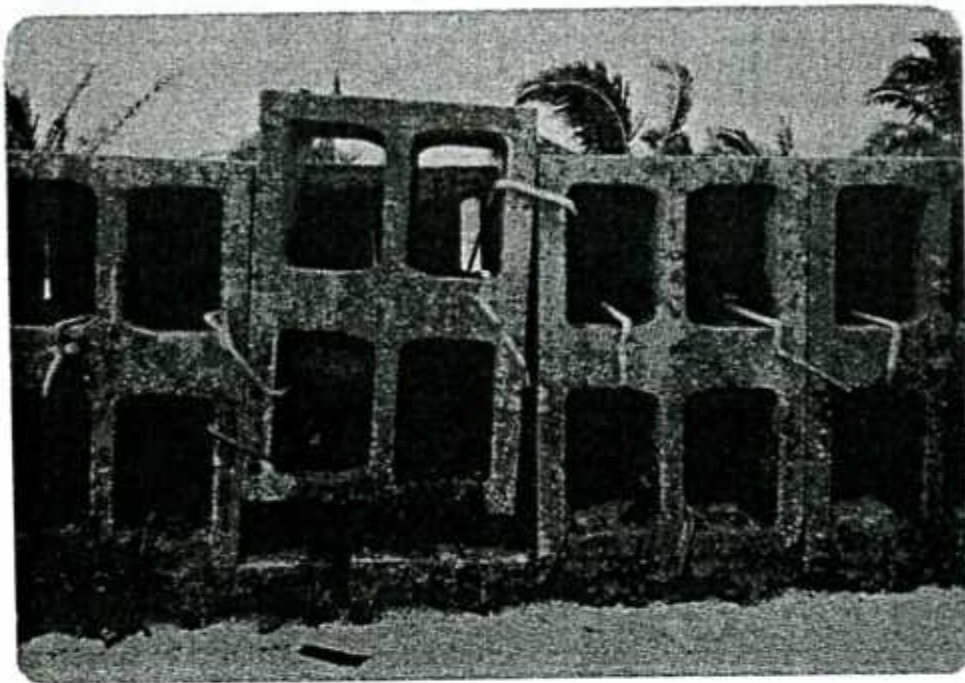


Figure 2-603. Vertically displaced block toward the south end of the structure, Kualoa, Hawaii, 4 January 1979.

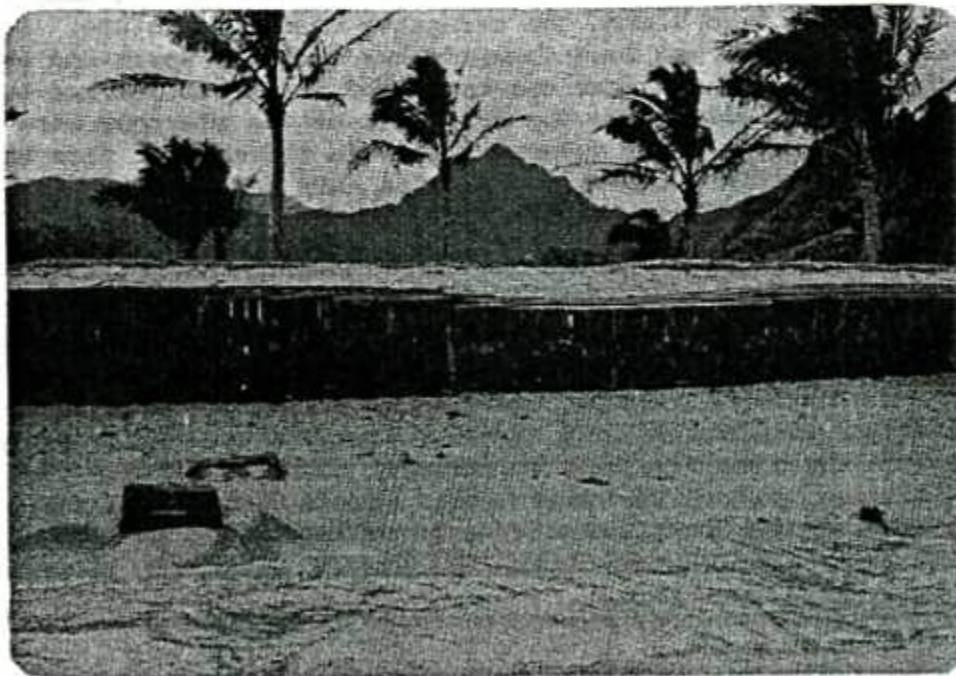


Figure 2-604. Displaced blocks lying in sand along mid-section of the structure, Kauloa, Hawaii, 4 January 1979.



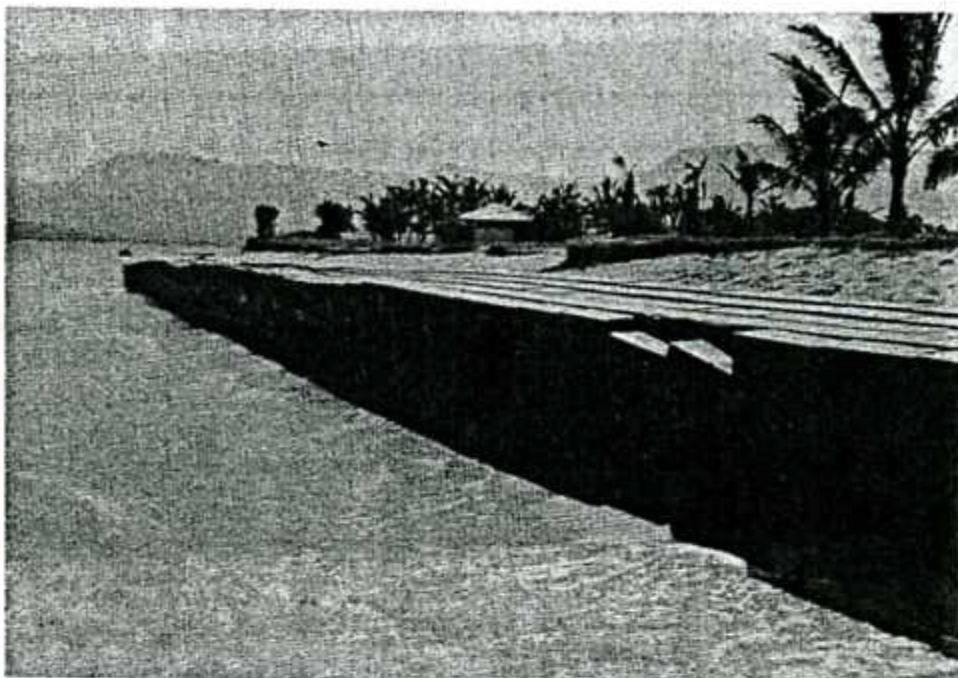


Figure 2-605. Broken blocks viewed from midsection of structure, Kualoa, Hawaii, 8 November 1979.

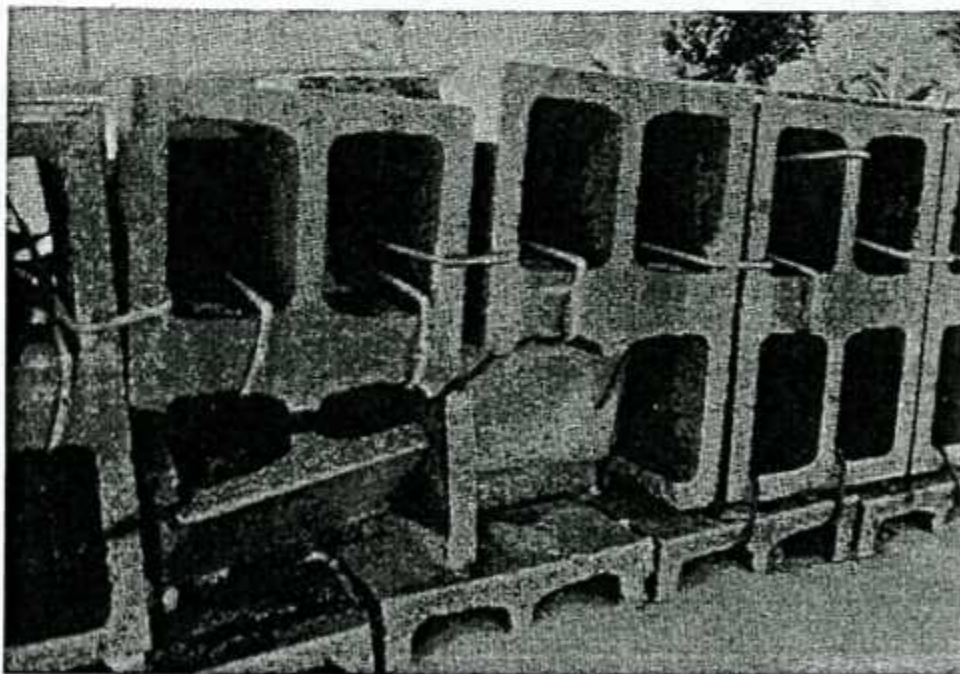


Figure 2-606. Broken blocks near north end of structure, Kualoa, Hawaii, 8 November 1979.



Figure 2-607. Erosion of downdrift bank, Kualoa, Hawaii, 19 June 1978.

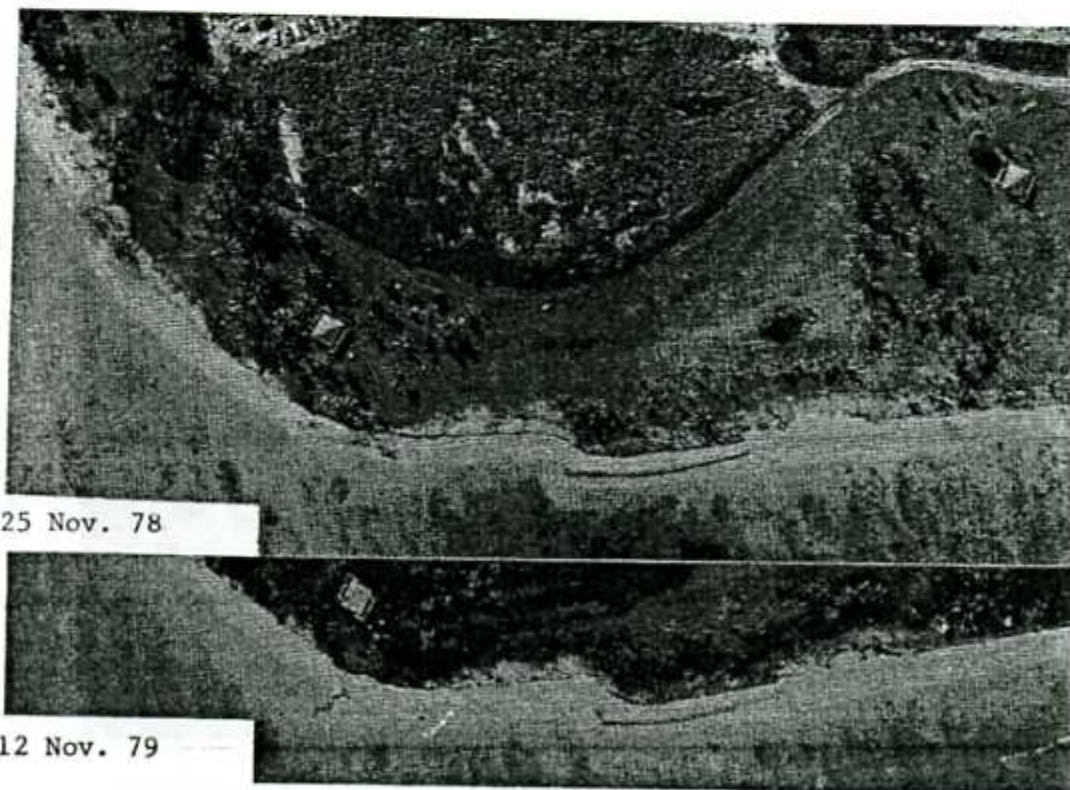


Figure 2-608. Progressive erosion south of Sandgrabber, Kualoa, Hawaii, 25 November 1978 and 12 November 1979.



Figure 2-609. Seaward face of structure, Kualoa, Hawaii, 19 June 1978.



Figure 2-610. Sand accumulation on seaward face of structure, Kualoa, Hawaii, 4 January 1979.

