CHAPTER 38

LITTORAL BYPASSING AND BEACH RESTORATION IN THE VICINITY OF PORT HUENEME CALIFORNIA

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ABSTRACT

Port Hueneme Harbor, California, constructed in 1940, resulted in the average annual erosion of 1,200,000 cubic yards from the shoreline downcoast of the harbor. The cause was diversion by the north jetty of the harbor of littoral sand movement into the Hueneme canyon. A sand bypass system was established in 1960 - 61 by construction, one mile upcoast, of Channel Islands Harbor fronted by an offshore breakwater 2,300 feet in length and located on the 30-foot-depth contour. This breakwater serves a dual function of sheltering the harbor entrance and acting as a littoral sand trap. Three cycles of biennial littoral sand bypassing havebeen successfully completed resulting in supply of 11,000,000 cubic yards of sand to the eroding shoreline at an average annual cost of $0.40 per cubic yard, including annual maintenance and amortization of structures. Comparison of design of the structure to the impounding characteristics experienced during three bypass cycles indicates that the dimensions and capacity of a sand trap formed by an offshore breakwater can be based upon the diffraction patterns of prevailing wave trains at the two ends of the structure and is independent of the depth and dimensions of the entrapment area. Rate of impoundment is equal to the rate of littoral drift at Port Hueneme.

INTRODUCTION

The most important single factor affecting the stability of a shoreline is probably the relationship between supply and loss of littoral sands. Hundreds and even thousands of years are required to achieve a balance of supply and loss in nature. A "works of man," may severely disturb nature's handiwork in a matter of months. Harbor works are the principal offenders; examples of this in the United States are the development of harbor works at Lake Worth, Florida; Manasquan Inlet, New Jersey; Tillamook Bay, Oregon; Santa Barbara, California; and Port Hueneme, California. Shorelines were affected for as much as 20 miles below these harbors and resultant damage amounted to many millions of dollars.

The problem results from a desire to either improve a natural harbor or build a new harbor. Jetties or breakwaters are built in the littoral zone and channels as deep as 50 feet are dredged to inner harbor areas. These works amount to a partial or complete obstacle to the natural littoral movement of sand. There are few areas of no littoral sand movement and the rates of littoral sand movement may vary from a few thousand cubic yards per year to well over 1,000,000.

Construction of harbor works results in accretion of sand in some areas and compensating erosion in others. While some benefits may result from accretion, they are usually far exceeded by the damage caused by erosion.

Sand bypassing, to alleviate the adverse effect of harbor structures, is becoming an increasingly important problem in southern California and in many other areas of the United States. Along the 300 miles of coastline between Point Conception, near Santa Barbara and the boundary between the United States and Mexico, there presently exist 13 harbors and there are potential sites for 16 additional harbors. Nine of the existing harbors have interfered with natural littoral sand movement and 14 of the proposed harbors will require bypassing efforts. The population of this area is increasing at a rate of about 5% per year and the use of recreational boats is increasing even more rapidly. It is very likely that all of these 16 harbor sites will be developed within the next 35 years. Thus, with presently available techniques and an average annual littoral movement of 200,000 cubic yards, southern California is facing an annual bypass cost of $2,500,000. This situation will also be true of other coastlines where population and economic pressures will require full utilization of the shoreline.

The sand bypassing system at Port Hueneme is the most successful presently used in the United States, and according to the 1961 edition of Technical Report No. 4, Shore Protection Planning and Design, published by the Beach Erosion Board, Office of the Chief of Engineers, "This general method of bypassing is considered to provide greater assurance of complete effectiveness than any other thus far considered." Three cycles of bypassing have been accomplished since 1960; navigation depths into the two harbors affected have been maintained; erosion of the adjacent shoreline has been effectively checked; and, for a distance of about 5 miles below Port Hueneme, a portion of the previously eroded area has been recovered.

DESCRIPTION OF PORT HUENEME AREA

Port Hueneme, a deep water commercial and Naval harbor, is located about 60 miles northwest of Los Angeles. Before 1940 the site was known as Point Hueneme and was occupied by a U. S. Coast Guard Lighthouse Station. (Figure 1)

PRIOR TO 1940

The shoreline under consideration forms the coastal edge of the Oxnard Plain, an abandoned flood plain of the Santa Clara River. It consists largely of alluvial deposits of sand, silt and clay. The plain forms a low, flat terrain that extends about 13 miles along the shoreline and 8 miles inland. It is bound on the north by the Sulphur mountains and on the south by the Santa Monica mountains. These mountains terminate at the sea in hard, wave-resistant formations, forming the south bank of the Ventura River and Point Mugu, respectively. The principal drainage features are the Ventura and Santa Clara Rivers.

Offshore slopes in this area are gentle except where the steep-walled Hueneme and Mugu submarine canyons cut the continental shelf to within one-quarter mile of the shore. (Figure 2) It is interesting to note that the shoreline extends over two miles seaward of a straight line connecting the headlands, indicating a tremendous over-supply of beach material.

The wave exposure chart, (Figure 3) shows that much of the wave action is intercepted or modified by Point Conception or the offshore islands. The principal avenues of wave approach are from the west and northwest. Local winds also are primarily from the same direction, hence sea and swell arrive predominantly from the northwest and west. Breaker heights of from 3 to 8 feet are common along this shore and produce strong southward littoral currents. Local winter storms of short duration and a limited amount of summer swell, originating from the south Pacific Ocean, reach the Hueneme area from the southwest and create short periods of northward littoral drift. However, wave studies and long observation of the shoreline processes conclusively show that there is a great preponderance of southward littoral drift.

There are three major sources of littoral material. (Figure 2) Most important is the Santa Clara River which discharges at the upper end of the Oxnard Plain. At irregular intervals of 10 to 30 years, tremendous flood-flows occur that form a large delta at the mouth of the river extending as much as a half mile seaward of the normal alinement of the shore. Over the succeeding years wave action will wear away this delta and, in spite of the sporadic manner in which beach material is carried to the shore, the rate of littoral supply to the area of Port Hueneme is relatively uniform. No accurate measure of the rate at which littoral material is supplied by the Santa Clara River has been made, but based upon sedimentation studies, it is estimated that the average annual rate is in the order of 800,000 cubic yards.

Runoff characteristics of the Ventura River are somewhat similar to the Santa Clara except that it has a smaller drainage area. Average annual supply of littoral material is estimated at about 100,000 cubic yards, but due to the topography at the river mouth, the delta is rapidly removed after a flood and merged with the Santa Clara Delta.

The third source of littoral material is from the upcoast beaches, and the average annual rate of littoral drift from that source has been established at around 270,000 cubic yards.

Thus, in recent years, the littoral supply of sand to the area between the Santa Clara River and Port Hueneme has been in the order of 1,170,000 cubic yards per year. That there has been a surplus of supply is evidenced in that in the interval between 1856 and 1938 the shoreline advanced 500 to 600 feet in the vicinity of the Santa Clara River mouth tapering to approximately no change at Point Hueneme.

At Port Hueneme, the Hueneme submarine canyon extends to within about 1,000 feet of the shore and the profile from mean lower low water

to the -60 foot depth steepens from a normal of 1 on 100 to 1 on 4 into the canyon. The steep slopes of this canyon continue to depths as great as 5,000 feet; and the studies of this and similar submarine canyons along the coast of southern California indicate that, in some fashion not yet completely understood, the shoreward heads of these steep-sloped canyons remain relatively free of littoral material; and sands entering the canyon continue to move seaward into deep water.

The shoreline between Point Hueneme and Point Mugu remained very stable from 1856 to 1938, and it was apparent that sufficient littoral material was rounding Point Hueneme to maintain the downcoast beach. While the rate of drift in this area was not known, it was considerable, as the shoreline configuration around the head of Mugu submarine canyon shows that, again at this point, the maximum shoreline advance, consistent with the steep slope into the submarine canyon, had been achieved; and littoral material was passing along the beach in some quantity with the surplus being lost into the Mugu submarine canyon. Based on surveys at Santa Barbara, Port Hueneme and Santa Monica, it is estimated that the annual rate of littoral sand movement is 270,000 cubic yards from north of the Ventura River, 1,200,000 cubic yards in the Port Hueneme area and 200,000 to 250,000 cubic yards to the south of Point Mugu. It is further concluded that this unbalance of about 1,000,000 cubic yards, is being lost in the depths of the Mugu submarine canyon.

1940 TO 1960

The natives of the Hueneme area had for many years known that the seas were extremely mild in the areas where the heads of the submarine canyons approached Point Hueneme and Mugu Lagoon. Point Hueneme was used to launch small boats through the low surf, and a loading pier had been constructed along the south flank of the canyon. In 1940 a harbor was constructed consisting of two arrowhead jetties and a 35-foot deep channel leading to an interior boat basin. (Figure 4)

This is an ideal harbor so far as navigation is concerned. The entrance between the converging jetties is 1,100 feet wide and, due to the divergence of waves across the head of the submarine canyon, the harbor can be entered under almost any storm condition with an assurance of quiet water berthing in the basin. However, the effect upon the adjacent shoreline was drastic and immediate. Even before construction of the south jetty was completed, the downcoast shoreline was severely eroding and, in 1939 - 40, 1,360,000 cubic yards of material being dredged from the harbor basin was deposited along the shore over a distance of 4,000 feet below the jetty in an attempt to correct this erosion. Continued erosion resulted in construction, in 1942 - 43, of a random stone seawall some 3,000 feet in length to protect the Federal property and the Hueneme Wharf and Warehouse Company. Erosion to the south of this seawall continued and there was a great loss of agricultural and residential property. Detailed studies of this area were initiated by the Corps of Engineers in 1948.

Upcoast accretion. By 1948 accretion against the north jetty had resulted in a seaward advance in the shoreline of 600 feet at that point, tapering to no change at a point 4 miles upcoast. It is apparent that at some point in time between 1940 and 1948 a great portion, or all, of the littoral sand was being diverted offshore into the submarine canyon. There was no appreciable change in this shoreline between 1948 and 1953, but in 1953 - 54 approximately 2,000,000 cubic yards of sand was removed from the beach upcoast of the Port Hueneme jetties and deposited on the beach south of Port Hueneme to prevent further erosion of the shoreline from Port Hueneme to the Navy Pacific Missile Range whose northern boundary was some 4 miles to the south.

Downcoast erosion. Midway through construction of the south jetty at Port Hueneme, severe erosion of the downcoast shoreline was noted. Repeated surveys from 1940 to date show a remarkable consistent annual rate of erosion of 1,200,000 cubic yards. As the Port Hueneme jetties and the submarine canyon constitute a complete littoral barrier, this loss can be accepted as the average annual rate of littoral drift between the Hueneme and Mugu submarine canyons. As the erosion progressed, seawalls were extended some 7,000 feet downcoast but the net effect was simply to shift the area of most severe erosion to immediately below the terminus of the wall. By the time the permanent bypass system was established in 1961, erosion had caused a retreat of shore amounting to nearly 1,000 feet in the city of Port Hueneme, tapering to zero about 8 miles downcoast. (Figure 4) This was in spite of nearly 4,000,000 cubic yards of sand being placed upon this beach between 1940 and 1954. Thus during the 21 years between establishment of the harbor and the permanent bypass system only 4,000,000 of 25,000,000 cubic yards of lost sand was replaced. It is estimated that over 500 acres of valuable industrial, residential and agricultural land was destroyed.

The Corps of Engineers study was completed in 1950, approved by Congress in 1954, and construction was initiated in 1960.

PLAN OF IMPROVEMENT

The plan had two objectives: (1) to develop a solution to the shore erosion problem and (2) to provide the area with a small-craft harbor to supplement the deep water Navy and commercial facility at Port Hueneme. This new harbor was initially known as Ventura County Harbor, but now is officially known as "Channel Islands Harbor." (Figure 5)

At the time of this study (1948) the only local experience with the sand bypass problem was that gained at Santa Barbara and at Santa Monica Harbors. The Santa Barbara situation was not considered a satisfactory solution but it was considered that, based on experience gained at Santa Monica, an entrance to a harbor basin could be located in the shelter of an offshore breakwater parallel to the shore in such a manner as to (1) shelter the entrance from wave action (2) entrap the littoral sand before it shoaled the harbor entrance and (3) provide sufficient shelter from wave action to allow a conventional type hydraulic pipeline dredge to remove this sand and deposit it upon the

beach downdrift of both harbors to resupply the eroding beach.

LOCATION OF SYSTEM

Two factors influence the location of this harbor and sand intercept system, (1) the length of pipeline required to transport sand and (2) the costs of land acquisition needed for the harbor. The commercial hydraulic dredges normally available in southern California have pipeline diameters of 18 to 27 inches and an ability to pump ordinary littoral sand from 7,000 to 15,000 feet. The area immediately north of Port Hueneme had been developed as a residential-type community and acquisition of the 250 to 300 acres considered necessary for harbor development required consideration of the cost of land acquisition. These improved lands extended about 6,000 feet to the north of Port Hueneme. Beyond this point, there was an extensive area inland of the beach consisting of undeveloped marshes and sand dunes of relatively low value. Hence after comparing costs of pumping sand against cost of real estate acquisition, it was determined that the entrance channel should be located not more than 5,000 feet upcoast of the north jetty of Port Hueneme and in order to make maximum use of unimproved land, the entrance channel was turned northward behind the beach front homes and expanded into about 300 acres of land and water intended to serve some 1,100 small craft.

DESIGN OF SAND TRAP

General dimensions of the offshore breakwater and its relationship to the entrance channel were determined to a considerable extent by experience gained at Santa Monica. (Figure 6)

Distance offshore. Because of the long period waves that occur in southern California, often with periods of 14 seconds or greater, all small-craft harbors are designed with entrance channels at least 20 feet deep (MLLW). In order to provide all year round shelter and maneuver area to the 20 foot entrance channel the breakwater was located approximately along the 30 foot depth contour. This was also considered necessary to provide sufficient space (1,800 feet) between the breakwater and the shoreline to adequately store the littoral sands that would be trapped by the structure. A limiting factor is the rapidly increasing costs of a rubble mound breakwater as the water depth increases.

Capacity of sand trap. Two factors must be considered in developing the sand trap. (1) The littoral sand must be intercepted before it seriously shoals the entrance channel to the harbor and (2) there must be an entrapment area of adequate size to hold all of the sand between bypass operations. Measured against this is the high cost per linear foot of breakwater requiring the structure to be no longer than the above design factors require.

Under some conditions a small dredge could perhaps be operated on a continuous schedule and a relatively small sand reservoir required.

This is somewhat true of the present system in use at Santa Barbara. However, in this case, because of the long pumping distance (over 10,000 feet) and the need for a submerged discharge line under both Channel Islands and Port Hueneme Harbors, the larger dredges are required. These dredges must be mobilized from Los Angeles Harbor, some 60 miles distant, or from even more distant ports. This means high mobilization costs and large production rates at low unit costs. It was determined that a sand trap area should be developed with sufficient capacity so as to provide for dredging at 2 year intervals.

When the final design of the system was made in 1957, it was determined by field measurements that the rate of littoral sand movement was at least 800,000 cubic yards per year and probably greater. It was decided to use an initial schedule of bypassing 1,600,000 cubic yards on a biennial schedule.

ANALYSIS OF SAND TRAP DIMENSIONS

Distance offshore of detached breakwater. The distance offshore required consideration of cost of the structure as the water deepened; maneuver area between the breakwater and the entrance channel jetties and between the breakwater and the fillet of impounded sand; and the length of breakwater vs. shadow effect on the shore and littoral drift. Based upon experience and the above factors it was arbitrarily established that the detached breakwater should be built along the 30 foot depth contour about 1,800 feet offshore.

Length and location of jetties defining entrance channel to Channel Islands Harbor. Part of the design concept was to use the offshore breakwater to provide at least partial shelter to the entrance from prevailing and storm waves. Considering the prevailing southward direction of littoral drift, logic called for the entrance to be at the southern end of the trap. Prevailing waves and the majority of storm waves are from the north so it was determined that the southern terminus of the detached breakwater should be directly opposite the south jetty. It was also determined that they should terminate 800 feet from the breakwater to provide adequate maneuver area for boats entering or leaving the harbor. While for a period after bypass dredging vessels may enter or leave from the north, the entrance around the south end of the detached breakwater is the intended navigation entrance. Diffraction diagrams were drawn for both ends of the offshore breakwater. (Figure 6) While short period waves from an azimuth of 215° show appreciable energy entering the entrance channel, this condition does not occur frequently and it was not considered desirable to extend the detached breakwater further south and complicate the navigation problem. As a further precaution, the consulting engineer for Ventura County designed stub jetties at the base of each jetty and a wave absorbing beach on the east bank of the basin immediately opposite the entrance. Since the harbor's completion in 1961 it has been one of the quietest harbor basins in southern California.

Length of detached breakwater. Here again is the engineer's challenge of costs vs. effectiveness. The average costs of this breakwater was $1,450 per linear foot. It was considered during the design of the project in the wave analysis portion that the prevailing wave affecting littoral drift was the 13 second wave with a deep water direction of 280°. This pattern was tested for various lengths of the breakwater and compared with known results at Santa Monica Harbor's detached breakwater and a length of 2,300 feet was established. A review of wave data using 1966 criteria indicates that the design wave should have been a 10 second wave from 270°azimuth which would have reached the structure with anazimuth 9 degrees further to the north than the design wave. This revised wave direction is more compatible with the known high rate of littoral drift in this area and experience to date has not shown that the length of the breakwater should have been different. In fact, if the sand trap requires any further capacity than that to be developed during the 1967 bypass effort a comparison may have to be made between the cost of dredging deeper than 35 feet or extending the length of the breakwater.

Summary. While design of the combined sand trap and harbor was based on a combination of empirical data and theory - and in the absence of the more refined wave theory available today, 3 cycles of bypassing show that the dimensions selected were remarkably effective. Dimensions of the sand trap have been changed in each bypass effort as more is learned about the "system" but Figure 6 shows that as each of the three sand fillet approached full impoundment their configuration was very similar.

Wave design. In order to anticipate the manner in which the littoral sand would deposit, to establish design criteria for stability of the breakwater, and to design the harbor entrance for optimum wave conditions, an analytical study was made of anticipated wave heights and directions. At the time of the final design study in 1957, use was made of Wave Report No. 68, dated 1947, titled "A Statistical Study of Wave Conditions at Five Open Sea Localities Along the California Coast," made by the Scripps Institute of Oceanography. This statistical hindcast-type analysis was based on the years 1936, 1937 and 1938.

With the Scripps 68 report as a basis of wave design and giving due consideration to the avenues of open wave exposure between the Channel Islands, Table 1 gives a summary of the significant waves considered as a basis of design:

TABLE 1
Summary of significant wave heights at structures

Direction	Period	Wave height in deep water	Refraction Coefficient	Wave height at structure: Breakwater	S. Jetty
WNW (280°)	6	10	.941	9.4	1.4
	10	12.5	.928	11.6	2.9
	13	12.5	1.258	15.7[1]	6.3
SW (215°)	7	10	1.031	10.3	12.1[2]
S (175°)	7	10	.810	8.1	

1. Adopted as design wave for offshore breakwater.
2. Adopted as design wave for jetties.

Structural design. The stability design of the structures was based upon a 15.7 foot significant wave height at the offshore breakwater with a deep water direction of 280° and a period of 13 seconds. A 12.1 foot significant wave height was used to design the seaward ends of the jetties with a deep water direction of 215° and a period of 7 seconds.

Because of the availability of good quality stone and suitable foundation conditions it was decided to build both the offshore breakwater and the jetties as rock rubble mound structures. A top elevation of +14 feet MLLW was selected. The breakwater and the outer end of the south jetty were built with seaward slopes of 1 vertical to 2 horizontal.

At the time of original design (1957) the Iribarren equation, which equation as modified by Hudson, was used as a basis of selecting stone sizes and is as follows:

$$W = \frac{78.8\, K'\, S_r\, H^3}{(1.05 \cos a - \sin a)^3\, (S_r - 1.03)^3}$$

where W = minimum weight of stone, in pounds
K' = slope coefficient (.017 for slope of 1 on 2)
S_r = specific gravity of the stone (assumed 2.64)
a = angle between seaward face of structure and horizontal
H = design-wave height at structure (Table 3, App. 3).

The typical rubble mound cross-section for breakwaters used by the Los Angeles District, Corps of Engineers is shown in Figure 7. For the Channel Island breakwater a capstone size of 13 tons was selected for the seaward size with 1 to 3 tons used on the interior and on the land side. Core stone was quarry run and varied from 20 to 2,000 pounds in weight.

SUMMARY OF BYPASS ACTIVITIES

1953 - 54. The first effort to bypass Port Hueneme was accomplished in 1953-54. The concept was to dredge an interior lake in the fillet upcoast of the north jetty and then breach the intervening barrier to the sea with the hydraulic pipeline dredge. The plan called for dredging 4,000,000 cubic yards in this manner, pumping it under the Port Hueneme channel and depositing it on the eroding beach. Standard Dredging Corporation was low bidder at $1,837,865. The plan was only partially successful. After bypassing 2,000,000 cubic yards the project was cancelled due to the difficulty of dredging in the surf zone. This bypass operation gave temporary respite to the eroding shoreline, but by 1958 the city of Port Hueneme was again building emergency seawall to protect residences and the city sewage disposal plant.

1958 to 1961. The plan under discussion was initiated in December 1958 when Connolly Pacific Corporation was awarded a $3,117,250 contract for construction of the 2,300 foot offshore breakwater and the 1,200 foot entrance jetties. The jetties were completed in September 1959 and the detached breakwater in October 1960. Cost of the jetties including Corps of Engineers supervision, engineering and overhead was $669,000. Total cost of the detached breakwater was $3,351,000. The north jetty was constructed first and as soon as the surf zone was penetrated, the littoral sand was impounded to the north and no longer deflected into the Hueneme Submarine Canyon.

After completion of the entrance channel jetties, a contract was awarded Standard Dredging Corporation to dredge a total of 6,335,500 cubic yards; 3,708,500 from the harbor and 2,627,000 from the sand trap. Dredging was started in February 1960. Actually the trap was dredged twice. By February 1961, 1,982,000 cubic yards were removed, but littoral sand was impounded so rapidly that the trap was redredged of 756,000 cubic yards in the spring of 1961 with final completion in June 1961.

BYPASS DREDGING 1963

The first of the biennial sand bypassing programs was accomplished when in June 1963 Franks Dredging Corporation started the dredging and bypassing of 1,986,000 cubic yards to the eroding downcoast beaches. The project was completed by September 1963 at a contract cost of $836,000. (Figure 8)

BYPASS DREDGING 1965

The second biennial dredging was again awarded to Franks Dredging Corporation as low bidder. It was learned from the previous effort that the reserve capacity of the sand trap had to be enlarged, (Figures 9 and 10) as by the end of 1964, sand was spilling around the north jetty and seriously shoaling the entrance to Channel Islands Harbor. Between April and September 1965, 3,527,000 cubic yards were bypassed to substain the beaches downcoast of Port Hueneme at a contract cost of $956,000. (Figure 11)

BYPASS DREDGING 1967

It is planned to further enlarge the sand trap in the spring of 1967 by dredging an additional 3,000,000 cubic yards. Full advantage was taken in 1965 of the total shelter provided by the detached breakwater so further expansion of the trap will be accomplished by either deepening the trap or moving further inshore along the beach boundary. It is anticipated in future dredging after 1967 to reduce the biennial effort to between 2.0 and 2.5 million cubic yards.

SUMMARY

Table 2 summarizes the bypass program to date showing only quantities dredged in the sand trap and including contractor costs, supply of electrical power, and Corps of Engineers engineering, administrative, and supervisory costs.

TABLE 2

Dates	Contractor	Quantity Bypassed	Total Cost	Unit Costs
		Million Cu. Yd.	1,000,000 Dollars	Dollars per Cu. Yd.
May 53 to 54	Standard Dredging Corporation	2.000±	--	--
Jun 60 to Jun 61	" " "	2.627	1.250	0.48
Jun 63 to Sep 63	Franks Dredging Corporation	1.986	0.951	0.48
Apr 65 to Sep 65	" " "	3.527	1.092	0.31
Apr 67 to Sep 67	-----	3.000 (est)	0.50 (est)	(est)

EFFECTS DOWNCOAST OF CHANNEL ISLANDS HARBOR

The beach between the two harbors is about 4,000 feet in length, and construction of the Channel Islands Harbor jetties completely cut off the natural supply of littoral sands to the beach. However, the beach is over 500 feet wide, much more than is needed for recreational bathing. The parking area behind the beach is limited and under present conditions the wind-blown sand is considered a major nuisance to the residents shoreward of the beach. Surveys between 1961 and 1964 showed an average annual loss of sand of 80,000 cubic yards. It is anticipated that this rate will lessen considerably as the shoreline approaches a stable alignment farther inshore and it is more difficult for the littoral sand to travel around the seaward end of the Hueneme jetty into the harbor or the submarine canyon. It is planned to allow this beach to narrow by some 300 feet and if it does not adjust to a stable alignment during future bypass efforts, a minor amount of sand diverted to this area will maintain a minimum beach.

EFFECTS DOWNCOAST OF PORT HUENEME

Since initiation of the sand bypass aspect of this project in 1960, nearly 14,000,000 cubic yards of sand, including 3,700,000 cubic yards from inside Channel Islands Harbor, have been pumped to the feeder beach fronting the city of Port Hueneme. During this same 7-year period some 9,000,000 cubic yards have moved on downcoast as littoral drift. There has been no further damage to the area and comparative surveys in 1960 and 1964 show a definite improvement of the shoreline from the Port Hueneme jetties to the mid portion of the Pacific Missile Range. (Figure 12)

PROBLEMS

The mechanics of operating this sand bypass system has gone very well. Because of the frequency of dredging, the power line and electrical substation remain in place under a standby rental agreement between the Southern California Edison Company and the Corps of Engineers. The placement and operation of submerged discharge pipelines under the entrance to Channel Islands Harbor (depth 20 ft. MLLW) and to Port Hueneme Harbor (depth 35 ft. MLLW) have presented no particular problem.

Some adjustments may eventually have to be made with the timing of the project and the route taken by the discharge line. When the project was initiated the economic status of the area required that costs be kept to an absolute minimum. As a result the dredging was scheduled for summer months to operate under the most favorable weather conditions and the discharge line was routed along the most direct path, along the beach in front of numerous homes. The creation of Channel Islands Harbor with the resultant attraction of recreation-oriented citizens and the stabilization of the beach fronting the city of Port Hueneme has resulted in a major upgrading of the entire area. Local interests are pressing for (a) abstainment from dredging during the summer recreational season, (b) rerouting of the dredge discharge through Navy property, and (c) establishment of an annual program rather than the present biennial dredging program so as to reduce the extreme fluctuation of beach width that presently exists between bypass operations and discourage full development of the area.

ANALYSIS OF COSTS AS A SAND BYPASS SYSTEM

In the original study no attempt was made to separate the harbor and sand bypass functions, and costs and benefits are difficult to assign to each function. However, if this was a sand bypass system only, the offshore breakwater could have been shortened and it could have been located immediately upcoast of the Port Hueneme jetties.

The present offshore breakwater is 2,300 feet in length. It is estimated that it could have been shortened by 600 feet if it was to

serve as a sand trap only. Hence the initial construction cost for a 1,700 foot breakwater would have been $2,190,000.

Shortening of sand pumping distance by 5,000 feet and elimination of the submerged line required under the entrance to Channel Islands Harbor to serve only the bypass effort would reduce the dredging costs shown in Table 2 by an estimated $0.15 per cubic yard.

ESTIMATED COSTS OF SAND BYPASS EFFORT

The present interest rate on Federal structures is 3 1/8 percent. With a 50-year economic life, the capital recovery factor would be 0.039792. The annual charge would be $87,000. The annual maintenance of the structure is estimated at $35,000. Hence, the estimated annual cost of the offshore breakwater is $122,000. If this is charged against an average annual bypass rate of 1,200,000 cubic yards of sand, the average annual cost attributed to the offshore breakwater would be $0.10 per cubic yard. Estimated bypassing cost of pumping sand from a trap immediately north of Port Hueneme is estimated at $0.28 per cubic yard.

The estimated average annual cost of sand bypassing only, including depreciation and maintenance, is $0.38 per cubic yard.

CONCLUSION

The offshore breakwater provides the most positive method of trapping littoral sand, presently known. It will intercept littoral sand moving either upcoast or downcoast and, if of sufficient length in relation to its distance offshore, is nearly 100 percent effective. While initial construction costs are high, it provides an assured shelter behind which standard commercial dredging equipment can be economically and safely used. Experience at Port Hueneme shows that these costs average $0.38 per cubic yard. Dimensioning of such a sand trap is somewhat empirical and depends on thoroughly understanding local conditions. However, it does appear that where the direction of the generally prevailing waves can be developed, a standard diffraction pattern analysis will indicate the shape of the sand salient that will form behind the offshore breakwater. An analysis can then be made of the most economical combination of length and distance from the shore of the offshore breakwater. Capacity of the trap will then depend upon the horizontal and vertical dimensions of the sand trap area, the rate of littoral drift, the slope of the seaward face of the sand salient that forms in the lee of the breakwater, and the desired time interval between sand bypass efforts.


CHANNEL ISLANDS HARBOR
AND
PORT HUENEME HARBOR
26 JANUARY 1965
SCALE IN FEET
0
2500
5000
PORT HUENEME
U.S. NAVAL RESERVATION
PORT HUENEME HARBOR
CHANNEL ISLANDS HARBOR
BREAKWATER
N

Fig. 1.

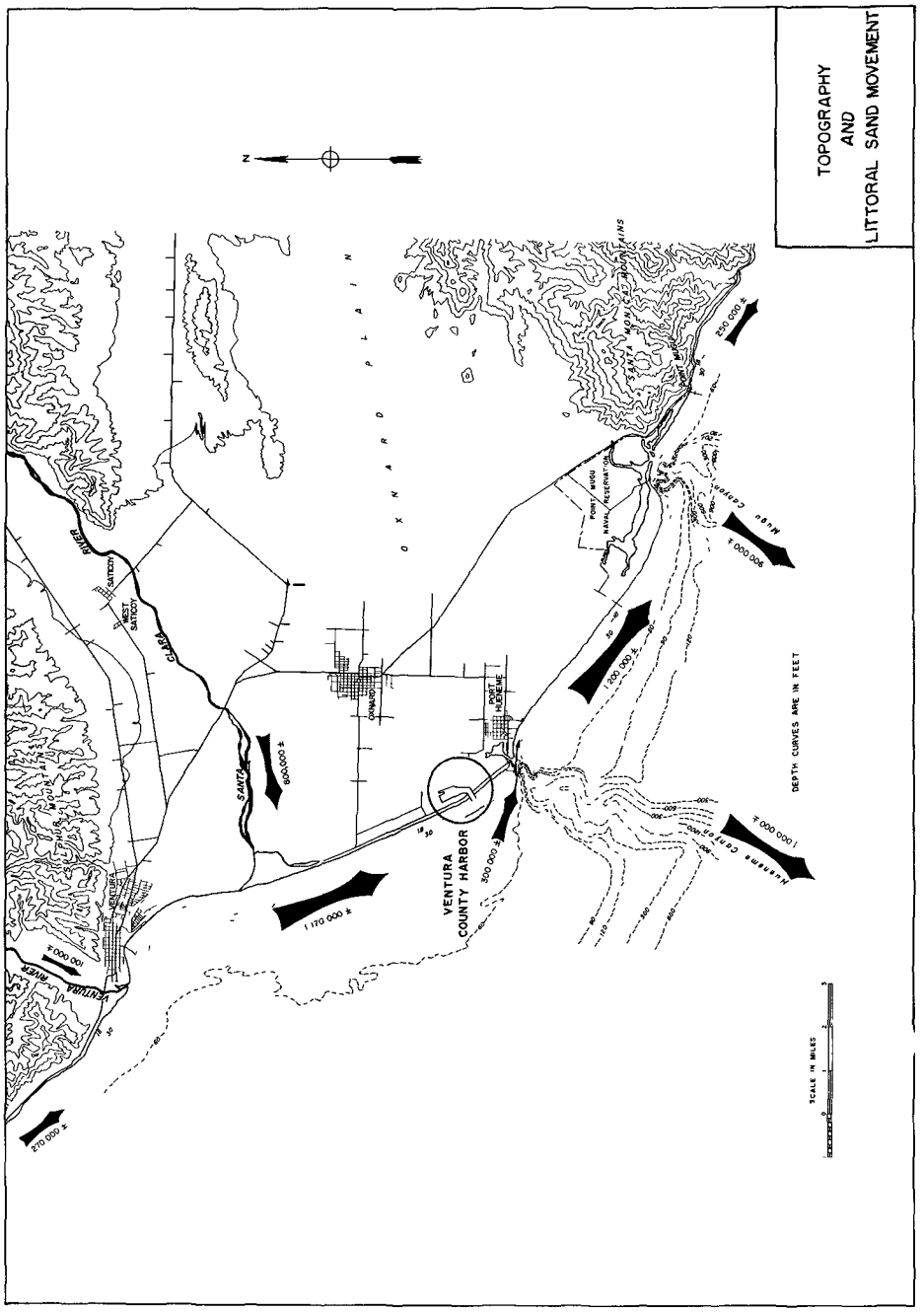
TOPOGRAPHY
AND
LITTORAL SAND MOVEMENT
N
OXNARD PLAIN
SANTA MONICA MOUNTAINS
RIVER
SANTA CLARA
SAN BUENAVENTURA
OXNARD
PORT HUENEME
VENTURA COUNTY HARBOR
PORT HUENEME NAVAL RESERVATION
MUGU CANYON
NAVY'S CENTRAL BOMBING AREA
DEPTH CURVES ARE IN FEET
SCALE IN MILES
270 000 ±
100 000 ±
1 170 000 ±
800 000 ±
300 000 ±
1 000 000 ±
900 000 ±
250 000 ±

Fig. 2.

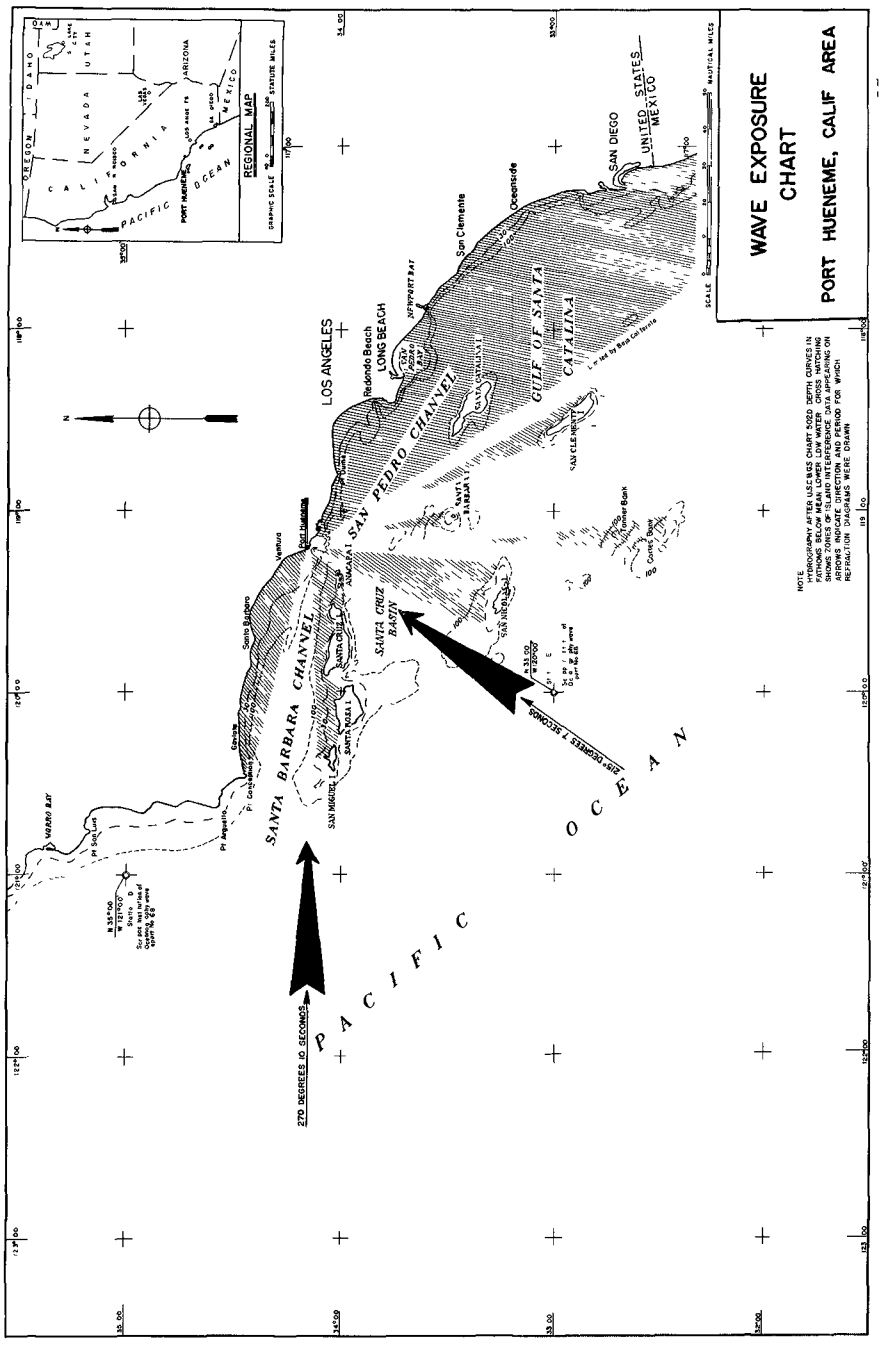
WAVE EXPOSURE CHART
PORT HUENEME, CALIF AREA
REGIONAL MAP
PACIFIC OCEAN
SANTA BARBARA CHANNEL
SAN PEDRO CHANNEL
SANTA CRUZ BASIN
GULF OF SANTA CATALINA
LOS ANGELES
LONG BEACH
SAN DIEGO
UNITED STATES
MEXICO
270 DEGREES 10 SECONDS
315° DEGREES 7 SECONDS

Fig. 3.

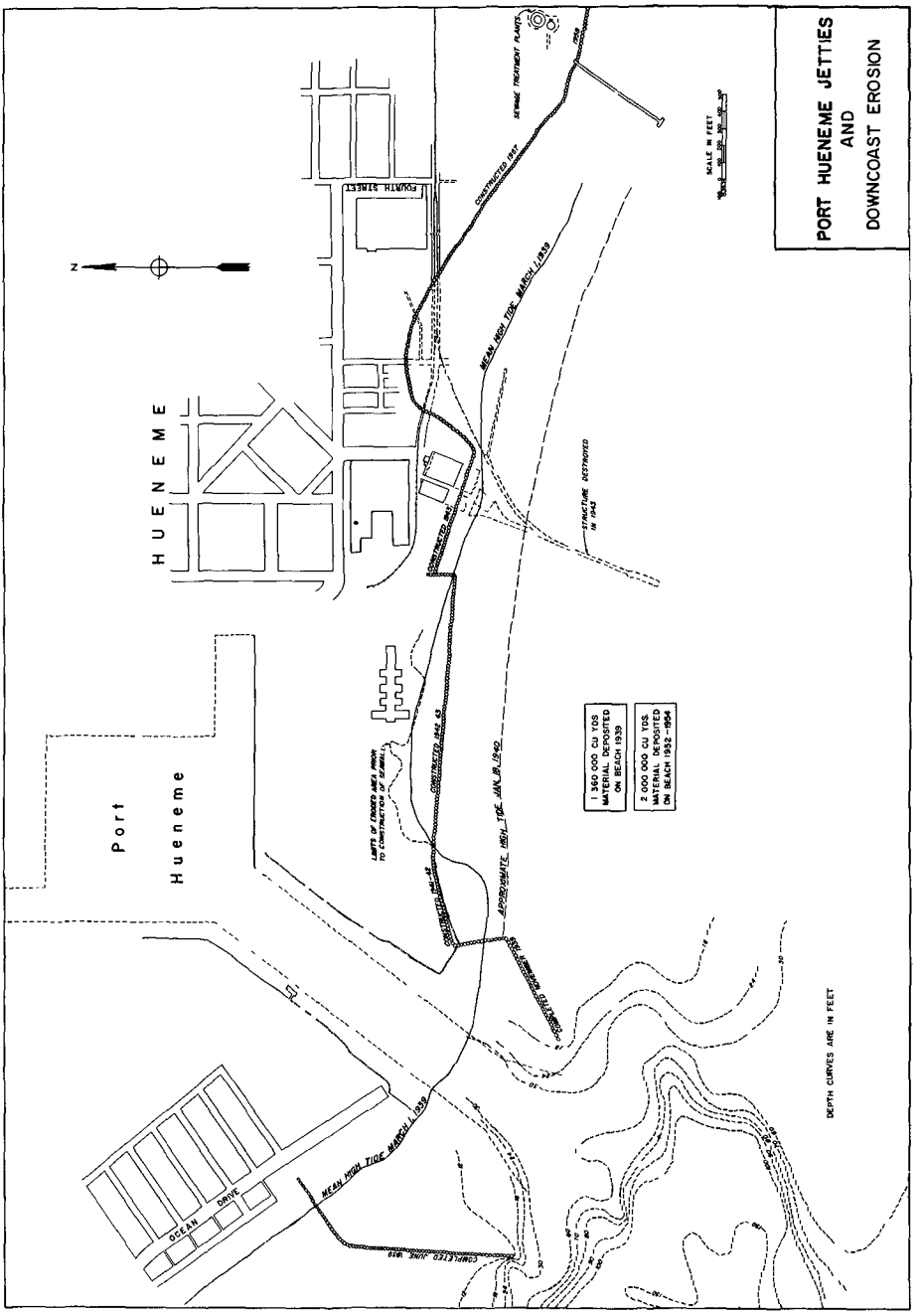
PORT HUENEME JETTIES
AND
DOWNCOAST EROSION
HUENEME
Port
Hueneme
FOURTH STREET
SEWAGE TREATMENT PLANT
CONSTRUCTED 1957
MEAN HIGH TIDE MARCH 1939
STRUCTURE DESTROYED IN 1943
CONSTRUCTED JUNE 43
APPROXIMATE HIGH TIDE JAN. 1940
1 340 000 CU YDS MATERIAL DEPOSITED ON BEACH 1939
2 000 000 CU YDS MATERIAL DEPOSITED ON BEACH 1952-1954
DEPTH CURVES ARE IN FEET
OCEAN DRIVE
COMPLETED JUNE 1940
N

Fig. 4.

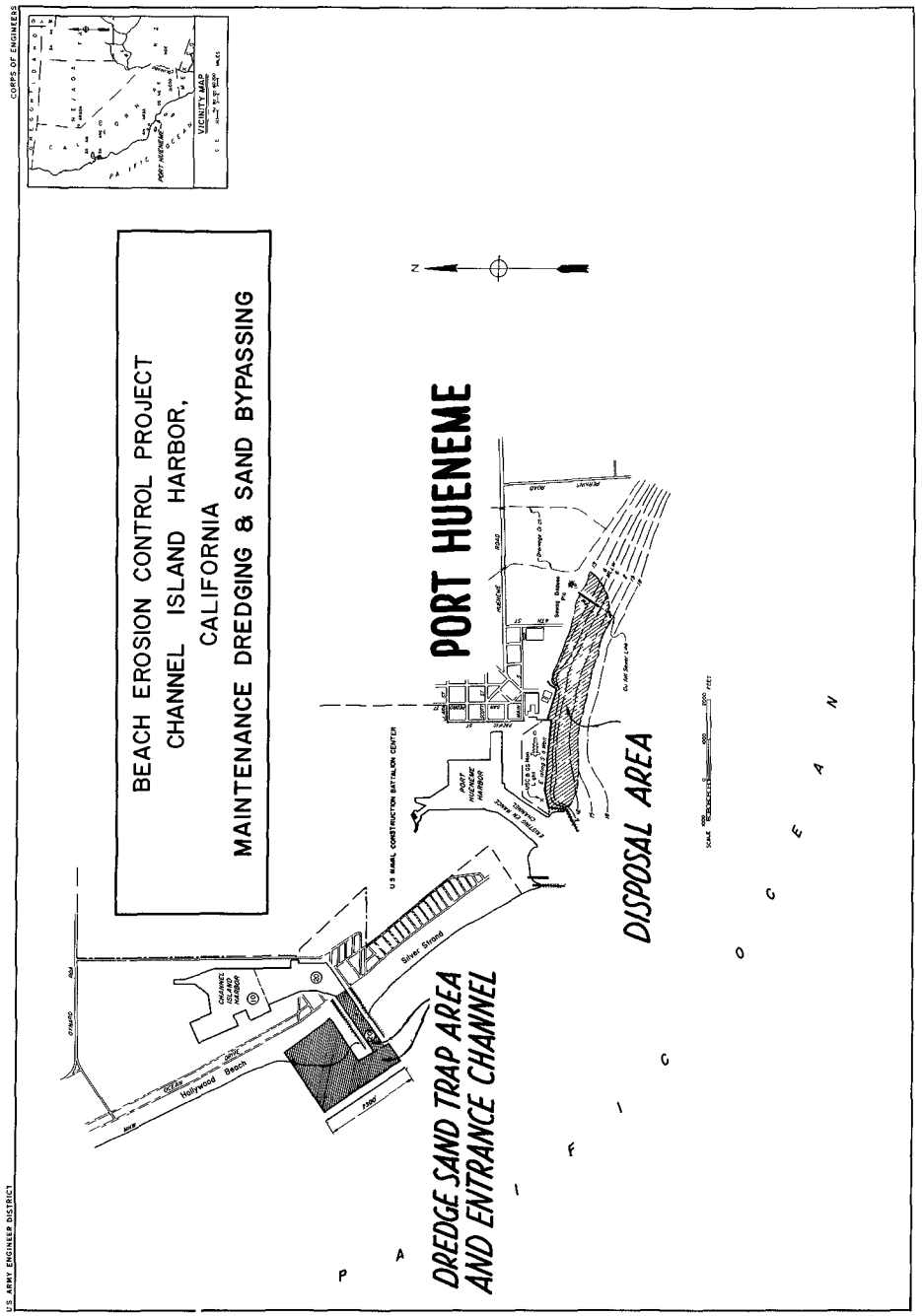
CORPS OF ENGINEERS
U.S. ARMY ENGINEER DISTRICT
BEACH EROSION CONTROL PROJECT
CHANNEL ISLAND HARBOR,
CALIFORNIA
MAINTENANCE DREDGING & SAND BYPASSING
VICINITY MAP
PORT HUENEME
DREDGE SAND TRAP AREA
AND ENTRANCE CHANNEL
DISPOSAL AREA
U.S. NAVAL CONSTRUCTION BATTALION CENTER
PORT HUENEME HARBOR
CHANNEL ISLAND HARBOR
Silver Strand
Hollywood Beach
OCEAN

Fig. 5.

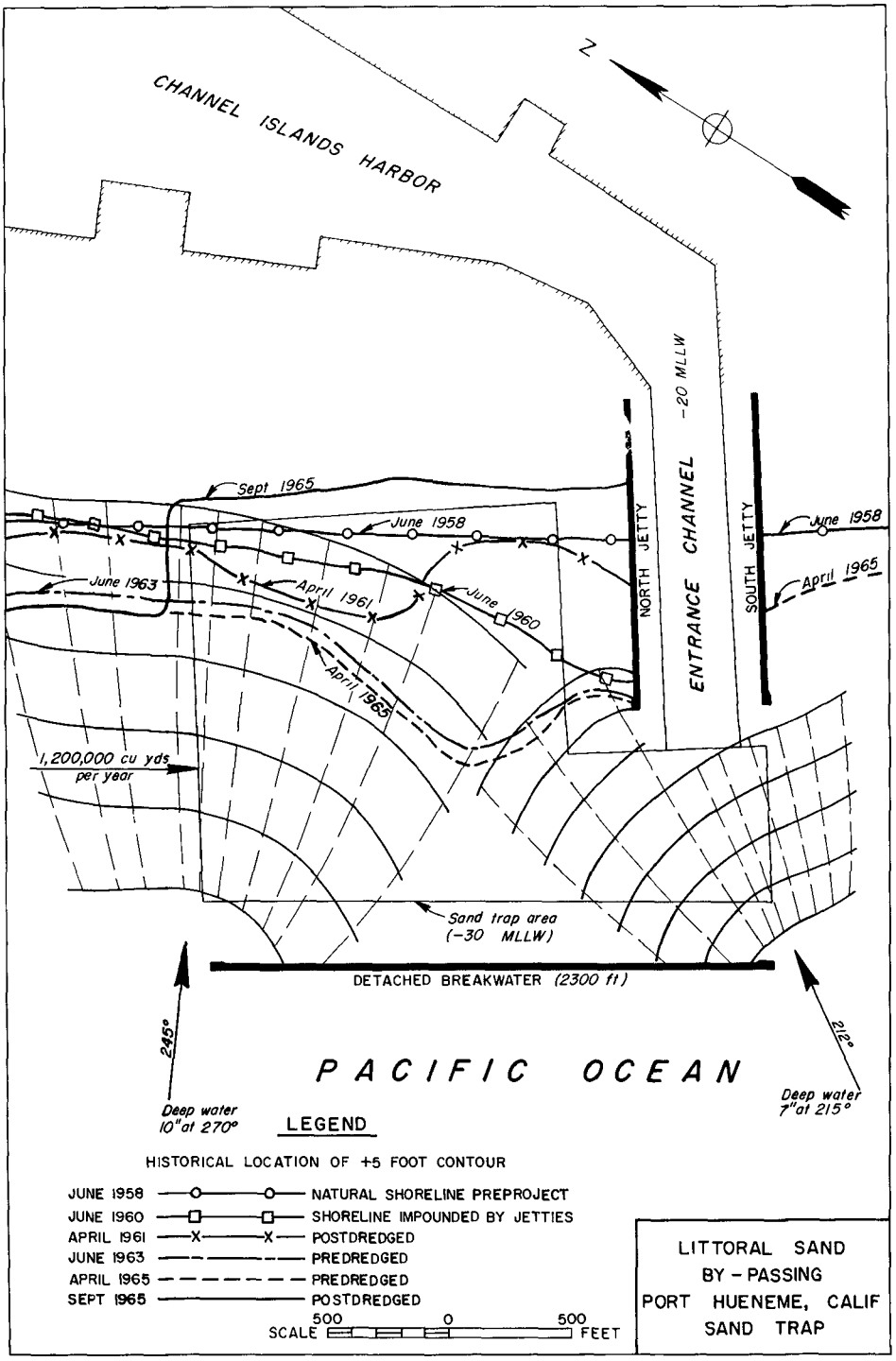
CHANNEL ISLANDS HARBOR
N
-20 MLLW
ENTRANCE CHANNEL
NORTH JETTY
SOUTH JETTY
Sept 1965
June 1958
June 1963
April 1961
June 1960
April 1965
June 1958
April 1965
1,200,000 cu yds per year
Sand trap area (-30 MLLW)
DETACHED BREAKWATER (2300 ft)
245°
212°
PACIFIC OCEAN
Deep water 10" at 270°
Deep water 7" at 215°
LEGEND
HISTORICAL LOCATION OF +5 FOOT CONTOUR
JUNE 1958 NATURAL SHORELINE PREPROJECT
JUNE 1960 SHORELINE IMPOUNDED BY JETTIES
APRIL 1961 POSTDREDGED
JUNE 1963 PREDREDGED
APRIL 1965 PREDREDGED
SEPT 1965 POSTDREDGED
SCALE 500 0 500 FEET
LITTORAL SAND BY-PASSING
PORT HUENEME, CALIF
SAND TRAP

Fig. 6.

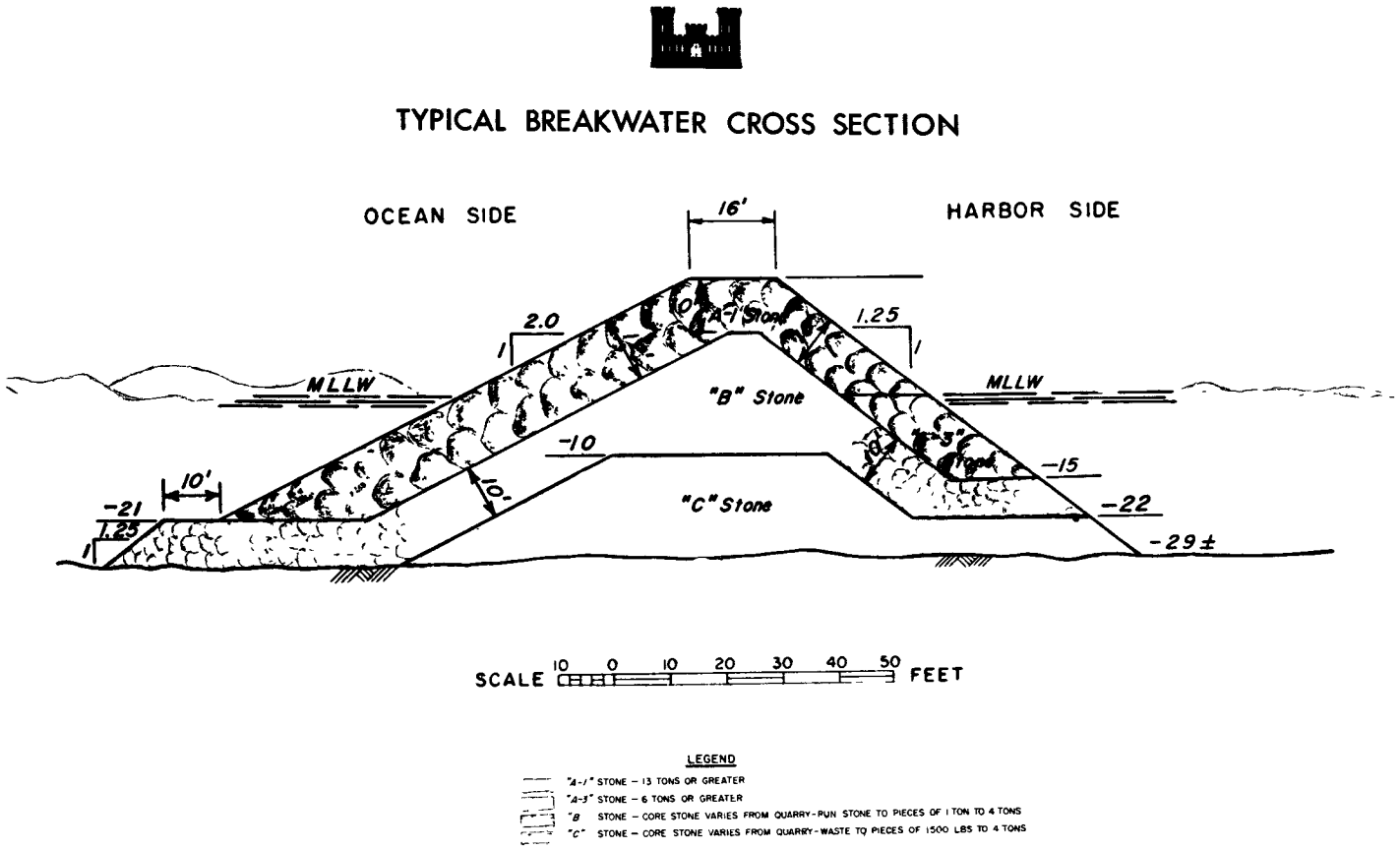
TYPICAL BREAKWATER CROSS SECTION
OCEAN SIDE
HARBOR SIDE
16'
2.0
1
1.25
1
MLLW
MLLW
"A-1" Stone
"B" Stone
"C" Stone
"A-3" Stone
-10
-15
-22
-29±
-21
10'
10'
1.25
1
SCALE 10 0 10 20 30 40 50 FEET
LEGEND
"A-1" STONE – 13 TONS OR GREATER
"A-3" STONE – 6 TONS OR GREATER
"B" STONE – CORE STONE VARIES FROM QUARRY-RUN STONE TO PIECES OF 1 TON TO 4 TONS
"C" STONE – CORE STONE VARIES FROM QUARRY-WASTE TO PIECES OF 1500 LBS TO 4 TONS

Fig. 7.

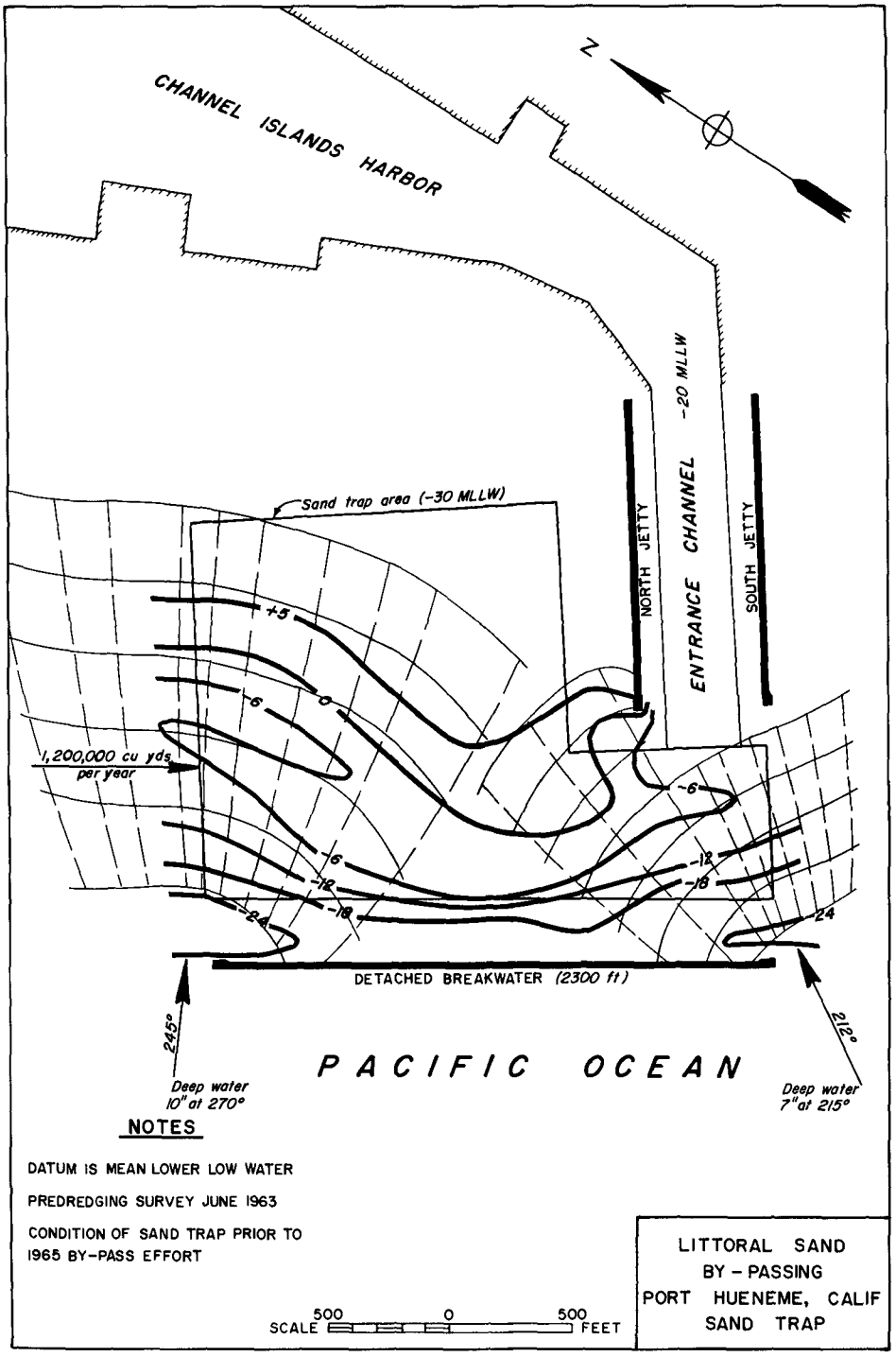
N
CHANNEL ISLANDS HARBOR
NORTH JETTY
ENTRANCE CHANNEL -20 MLLW
SOUTH JETTY
Sand trap area (-30 MLLW)
+5
0
-6
-6
-12
-18
-24
-6
-12
-18
-24
1,200,000 cu yds per year
DETACHED BREAKWATER (2300 ft)
245°
212°
Deep water 10" at 270°
Deep water 7" at 215°
PACIFIC OCEAN
NOTES
DATUM IS MEAN LOWER LOW WATER
PREDREDGING SURVEY JUNE 1963
CONDITION OF SAND TRAP PRIOR TO 1965 BY-PASS EFFORT
SCALE 500 0 500 FEET
LITTORAL SAND BY-PASSING PORT HUENEME, CALIF SAND TRAP

Fig. 8.

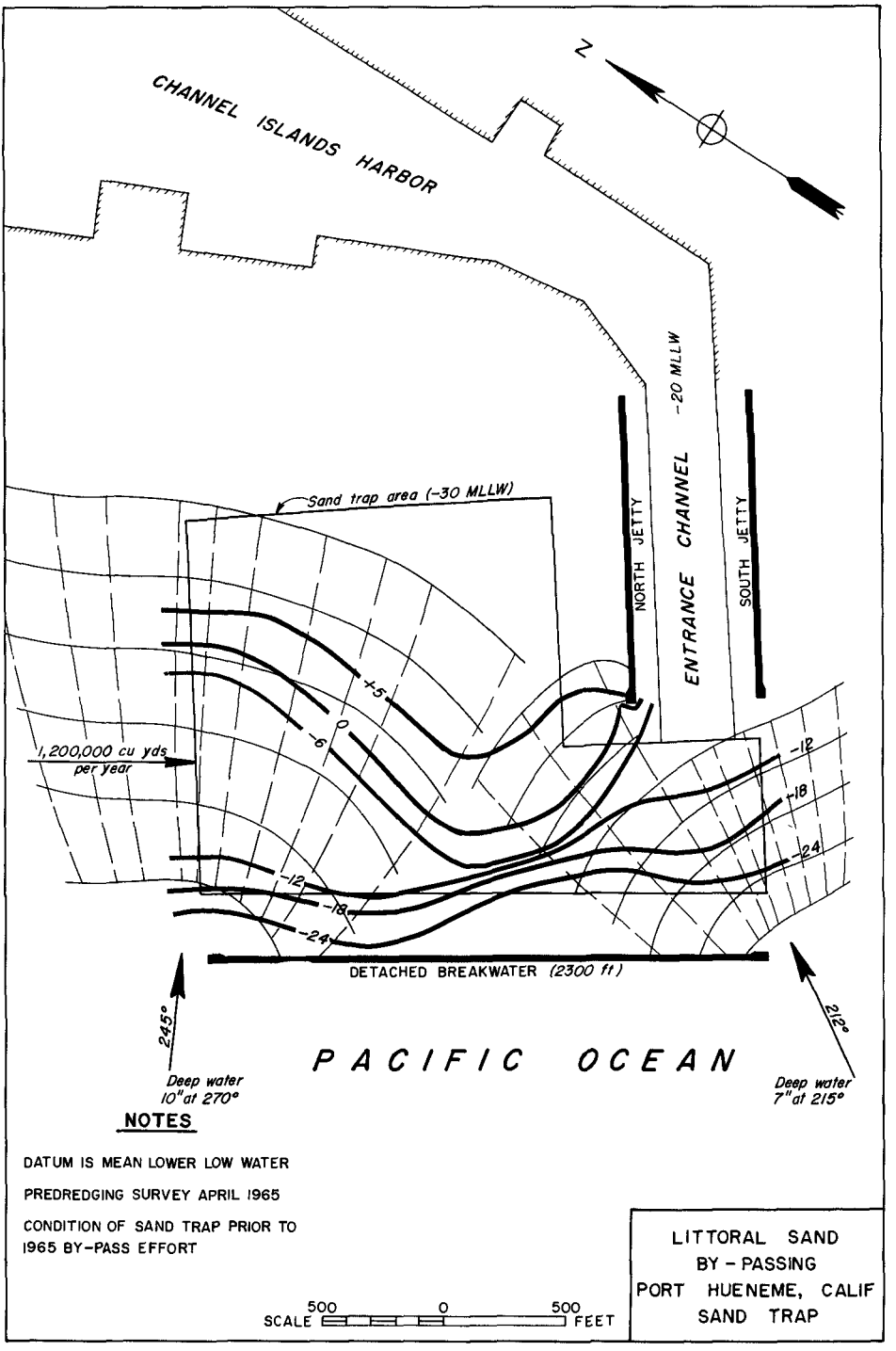
CHANNEL ISLANDS HARBOR
N
-20 MLLW
ENTRANCE CHANNEL
NORTH JETTY
SOUTH JETTY
Sand trap area (-30 MLLW)
+5
0
-6
-12
-18
-24
1,200,000 cu yds per year
DETACHED BREAKWATER (2300 ft)
245°
212°
PACIFIC OCEAN
Deep water 10" at 270°
Deep water 7" at 215°
NOTES
DATUM IS MEAN LOWER LOW WATER
PREDREDGING SURVEY APRIL 1965
CONDITION OF SAND TRAP PRIOR TO 1965 BY-PASS EFFORT
500 0 500
SCALE FEET
LITTORAL SAND BY-PASSING PORT HUENEME, CALIF SAND TRAP

Fig. 9

Fig. 10.

Fig. 11.

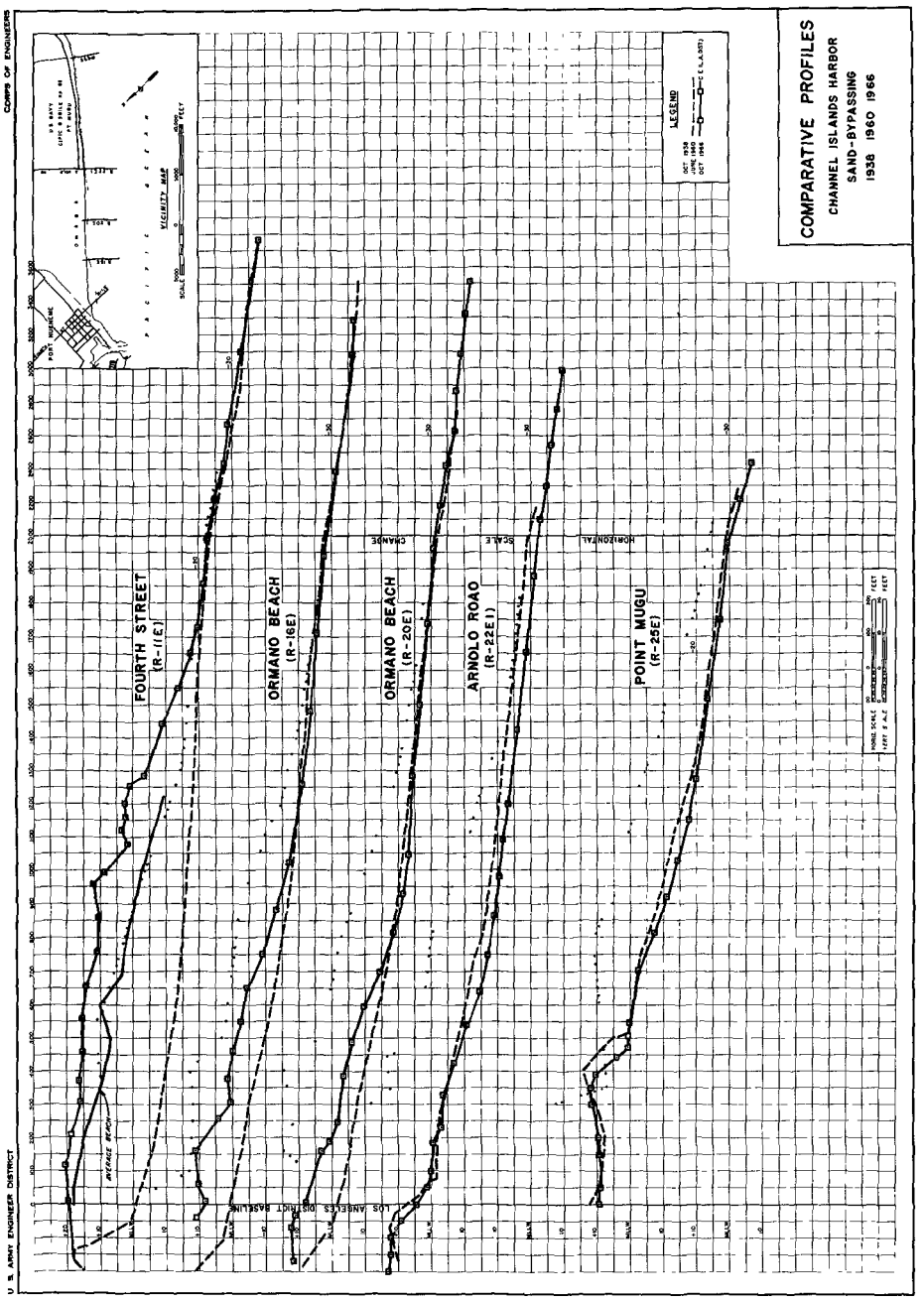
COMPARATIVE PROFILES
CHANNEL ISLANDS HARBOR
SAND-BYPASSING
1938 1960 1966
LEGEND
OCT. 1938
JUNE 1960
OCT. 1966
(L.A.247)
FOURTH STREET
(R-11E)
ORMAND BEACH
(R-16E)
ORMAND BEACH
(R-20E)
ARNOLO ROAD
(R-22E1)
POINT MUGU
(R-25E)
HORIZONTAL SCALE CHANGES
LOS ANGELES DISTRICT BASELINE
MEAN SEA LEVEL
VICINITY MAP
U. S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS

Fig. 12.