CHAPTER 361

Nearshore Berm Performance at Newport Beach, California, USA

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Abstract

In 1992, approximately 1,276,000 cubic yards of littoral material was hydraulically placed into a berm configuration in nearshore water depths at Newport Beach, California, USA. A monitoring program conducted included directional wave measurements, beach and bathymetric profiles, surficial sediment sampling, and controlled aerial photography. Analysis of the bathymetric profiles collectively indicate the berm is experiencing a shoreward-directed dispersal; there is no evidence suggesting offshore or alongshore directed berm movement. Sediment physical characteristics and grain size distribution indicating the berm effects on the seabed are discussed. Recently proposed models for berm stable/active categorization and migration rate are examined. Surfing at the site was significantly enhanced; the berm created breaking wave conditions never before experienced at this location.

Introduction

This paper describes a nearshore disposal monitoring project at Newport Beach, California, USA. The nearshore placement activity was conducted during the period Jan-Nov 1992. Approximately 1,276,000 cubic

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yards of suitable littoral material was hydraulically placed into a berm configuration in water depths ranging from -5 ft to -30 ft MLLW (Note: All elevations and/or depths cited herein are in feet referred to Mean Lower Low Water (MLLW)). These depths are both within and outside the day-to-day surf zone. The purpose of the monitoring plan was to determine the fate of the disposal berm by providing a quantitative and qualitative description of the movement of disposal material in the cross-shore and alongshore directions. The material was obtained as the result of the Lower Santa Ana River flood control channel expansion project.

The project site is located in the City of Newport Beach, California, USA. The shoreline immediately landward of the disposal area is a mixed use area of recreation and residential development. Coastal structures in the project area include three shore perpendicular jetties at the mouth of the Santa Ana River, and a field of eight groins. The disposal site was selected to confine the material between the river mouth system and the groin field.

Monitoring Plan

The monitoring program conducted during the period Dec 91 - May 95 included directional wave measurements, beach and bathymetric profiles, surficial sediment sampling, and controlled aerial photography of the project area (Fig 1).

The nearshore directional wave climate was monitored by installation of a S_{xy} slope array wave recording instrument during the period 3/92 - present. The slope array was placed offshore of Huntington Beach approximately 1.5 miles northwest of the project site at a water depth of 33 ft.

The 24 beach and bathymetric profile lines were established as follows: 8 lines placed throughout the groin field system; 11 higher spatial resolution lines placed at 300 ft intervals over the disposal area; 1 line placed over the Santa Ana River delta; 3 lines spaced at even intervals; 1 line (control) placed approximately 1.5 miles northwest of the project area. The control line is not expected to be influenced by movements of the nearshore disposal material, and acts as an indicator for seasonal or gross shoreline movements. Profiles were measured from a fixed point on the backshore to depths of greater than -40 ft. Profile survey dates were: 12/91 pre-construction; 5/92 1st interim; 7/92 2nd interim; 11/92 1st post-construction; 3/93 2nd post-construction; 5/93 3rd post-construction; 1/94 4th post-construction; 11/94 5th post-construction; and 5/95 6th post-construction.

Sediment samples were obtained by surficial grab sampling techniques along 6 profile lines (Line 1, Line 5, Line 9, Line 14, Line 19, Line 24) at 8 elevations corresponding to +6 ft, 0 ft, -6 ft, -12 ft, -18 ft, -24 ft, -30 ft, and -36 ft.

Controlled aerial photography flown over the project area included: 12/91, 6/92, 11/92, 12/92, 3/93, and 5/93.

Wave Climate Description

Directional wave measurements indicate a multi-directional, seasonally dependent, sea/swell climate is experienced at the project site. The nearshore slope array recorded 6905 observations during the measurement period. The sample histogram of wave heights included a maximum measured wave of 10.6 ft; the mean, mode, and standard deviation are given as 2.7 ft, 2.5 ft and 0.9 ft respectively. The sample histogram of spectral peak period indicates double peaks at T=7 sec and T=15 sec. In southern California this is typically associated with sea and swell respectively (not withstanding the respective classical definitions dependent on the point of origin). The combined sea/swell climate was assumed a priori; a double peaked distribution of wave climate was expected.

Profile Comparison

Repeated bathymetric mapping of the cross-shore profiles indicates the nearshore disposal material formed a significant clearly distinguishable feature on the local seabed relative to the pre-project profile.

Fig 2 illustrates a time series of the cross-shore distribution of berm material at Line 19 (located at the disposal area northwestern boundary). Fig 2 indicates the berm is distributed along the profile approximately between depths of -2 ft and -32 ft. The berm toe appears located at the -32 ft contour; the berm indicates a relatively sharp relief on the seaward side and is diffused gradually towards shallower water. The berm maximum vertical relief (e.g. "centroid") appears located at a depth of -29 ft.

Fig 3 is a time series comparison of the profile *differences* developed by subtraction of the pre-project profile from the post-construction profiles. Inspection of Fig 3 clearly illustrates the berm cross-shore behavior. The berm centroid is located 1900 ft from the survey baseline, or about 1200 ft from the beach. The berm had a maximum vertical relief of 14.5 ft from the pre-project seabed, diminishing successively to 11.5 ft, 9.0 ft, 8.5 ft, and finally diminishing to 8.0 ft by the sixth survey episode (31 months). Thus, the berm vertical relief appears to diminish rapidly initially, with the deflation rate decreasing over time. Close inspection of Fig 3 indicates as the berm crest erodes, the crest material is sheared off in the *landward* direction. The survey data indicates there is significant accretion of material throughout the region between the berm and the foreshore. This landward directed movement is particularly indicated by the accretion of material in a bar formation as indicated in the 5/93 survey episode. Further inspection of Fig 3 indicates the berm centroid location is stationary, and not migratory as the berm erodes. There is no indication the berm migrates as a solitary feature; migration is measured as a function of the crest material dispersal. This observation is relevant to the following discussion of berm migration rate.

There is no evidence in the data to suggest offshore or alongshore directed movement of the berm material. Analysis of all measured profiles indicates no signal within the resolution of the survey data which substantiates seaward berm movement. There is little or no indication of significant alongshore movement of the berm. Due to the prevailing wave climate, net sediment transport is a priori expected to be in the southeasterly direction. Analysis of the profile closest to the disposal area southeastern boundary (Line 8 within the groin field) indicates no signal to substantiate southeasterly alongshore movement. Likewise, there is no significant indication of berm migration in the northwesterly direction. This is unambiguously no movement across the northwesterly control line. The profile closet to the northwestern boundary exhibits some accretionary signal, however, that was determined to be remnant storm flow material from the Santa Ana River.

Sediment Physical Characteristics and Distribution

The sediment characteristics of the nearshore disposal material are known from pre-project geotechnical analyses. The material was approximately 83% sand and 17% fines (defined as passing the #200 U.S. Std sieve), with a d_{50} median diameter of approximately 0.27 mm which is classified as fine sand under the Unified Soils Classification.

Fig 4 illustrates a time series comparison of sediment grain size distribution along a selected profile (Line 19) and depth (-24 ft). The pre-project (12/91) sediment distribution is a poorly graded fine sand material, approximately 17% fines, with a d_{50} median diameter of 0.09 mm. Fig 4 indicates a well behaved coarsening of the grain size distribution between the 1st, 2nd, and 5th survey episodes. At the 5th survey episode (11/94) the sediment achieved its coarsest distribution, a poorly graded fine sand, 1% fines, with a d_{50} median diameter of 0.22 mm. There appears to be a rebound of the grain size distribution at the 6th survey episode.

Fig 5 illustrates a cross-shore time series comparison of d_{50} median diameters at Line 19. The data is fairly well behaved and indicates the coarsest fraction is located on the upper portions of the profile while the fine grained fraction is dispersed towards deeper water. The berm material is coarser than the pre-project seabed and appears to be maintaining its position on the seabed.

Fig 6 illustrates a cross-shore time series comparison of percent fines at Line 19. The data clearly shows the percent fines is significantly higher in water depths greater than -24 ft. Over time the percent fines remain less than or approximately equal to the pre-project seabed condition.

Berm Categorization

Hands & Allison (1991) present a empirically based method to categorize stable or active nearshore berms. The method calculates the long-term distribution of wave-induced, near-bed velocities as an appropriate criterion to discriminate between stable and active behavior. Used conjunctively with the Hallermeier proposed inner and outer limits of profile zonation, the method successfully discriminates between stable and active berms in the "buffer" zone bounded by the inner and outer limits.

The results of the present analysis, shown in Fig 7, delineates the regions of berm stability or activity based on the wave-induced near-bed velocities. The berm in the present analysis is classified as *stable*, particularly at the 75-95 percentile which Hands & Allison describe as possessing the best correlation with berm behavior. It is worth noting that the present berm velocity distribution crosses the boundary delineating the stable-active regions, and also tends to converge towards the active classification near the 99-percentile (indicating a tendency for berm movement during extreme events).

The results using the Hallermeier profile zonation limits, shown in Fig 8, indicate the berm falls in the "buffer" zone. Hands & Allison further showed that berms stable in the buffer zone were less than 50% below the outer limit, while active berms were more than 50%

above the outer limit. Thus, with this methodology the Newport Beach berm gains an *active* classification. This directly contradicts the previously determined *stable* classification based on near-bed velocities. However, it should be noted that the berm could be considered weakly active based on it's relative position as slightly greater than the 50% outer limit within the buffer zone.

Berm Migration Rate

Douglass (1995) proposed a model for landward migration rate estimation of nearshore sand berms. The model is formulated on the assumption that net shoreward sediment transport is due primarily to the velocity asymmetry characteristics of finite amplitude waves. The model parameters can be estimated using a joint probability density function (height-period, direction is assumed onshore) of site-specific wave climate data. The "expected value" of berm migration rate can be estimated as a function of depth.

The results estimate the berm migration rate to be approximately 100 ft/yr (Fig 9). Douglass provides no guidelines for choosing a depth from the functional relationship to use for berm migration estimation. An observation made during this analysis indicates that the results are critically dependent on the depth chosen. The depth used in the current study is the depth at the berm center of mass. However, this depth no longer exists after berm placement. Since the method is based on the velocity asymmetry of finite amplitude waves, the depth used should be the depth at the berm crest. This appears to be an inherent inconsistency, yet still the model appears to produce results that are in reasonable agreement with observed values and are the correct order of magnitude. The decaying semi-logarithmic function of depth appears intuitively correct. However, with decreasing depths at the shore, the model expected value approaches unrealistically high values. The model also assumes landward migration only and does not consider offshore movement.

Surfing

The nearshore berm disposal project temporarily significantly enhanced conditions for the recreational sport of surfing. This study photographically recorded breaking waves never before experienced at this location. The pre-project wave-breaking condition typically consisted of long crested swell waves propagating over straight and parallel contours with wave breaking occurring relatively close to shore. Typical pre-project surfing can be described as beach-break resulting in short, fast spilling/plunging "lefts" and "rights".

The hydraulic placement techniques employed by the construction contractor resulted in a series of small mounds constructed throughout the disposal area footprint. These disposal mounds were dispersed cross-shore throughout the nearshore zone, from near the typical breaker line to upwards of 1,200 feet offshore. Refraction effects focused the wave energy directly onto the individual mounds, which were effectively a severe perturbation to the straight and parallel bathymetric contours, tending to scatter the local wave field (Photo 1). The result was many wave "peaks" throughout the nearshore zone. Due to the extremely sharp relief of the mounds, waves tended to shoal extremely quick, increasing the local wave steepness, and creating a very "fast", "hollow" surfing wave (Photo 2). The surf lasted throughout the period of nearshore disposal, and several months thereafter. The surf was best at lower tidal levels with longer period swell.

Conclusions

In 1992, approximately 1,276,000 cubic yards of littoral material was hydraulically placed into a nearshore berm configuration at Newport Beach, California, USA. The monitoring program established included directional wave measurements, beach and bathymetric profiles, surficial sediment sampling, and controlled aerial photography. Bathymetry measurements indicate the berm is eroding by undergoing dispersal of the crest material shoreward. The berm base appears stable. There is no evidence suggesting either offshore or alongshore movement of the berm material. Sediment physical characteristics indicate the coarser sediments are remaining within the active littoral system, while the berm is not adversely affecting the percentage of fines. Results using recently proposed models for berm stable/active categorization and migration rate are mixed. The berm gained both a stable and active classification. A calculated migration rate of 100 ft/yr appears correct in order of magnitude, but some question remains on functional application based on selection of appropriate water depth. Surfing at the site was significantly improved. Berm influence on the local wave field created shoaling and breaking conditions never before experienced at this location.

Acknowledgments

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References

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Hands, E.B., and Allison, M.C. (1991). "Mound Migration in Deeper Water and Methods of Categorizing Active and Stable Depths." *Proceedings, Coastal Sediments 91 Conference.*, ASCE, New York, N.Y., Vol. 2, 1985-1999.

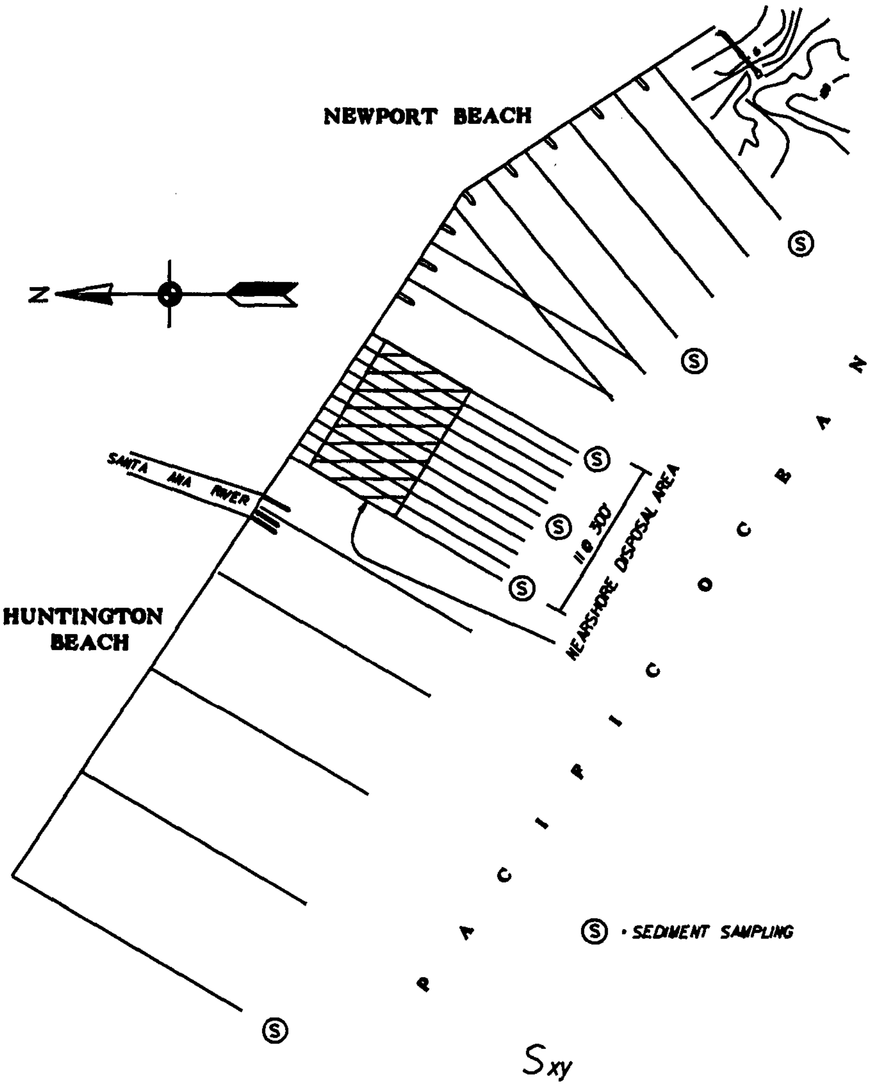

Figure 1. Monitoring Program Schematic.

Note: Survey lines numbered sequentially 1-24 from southeast to northwest.

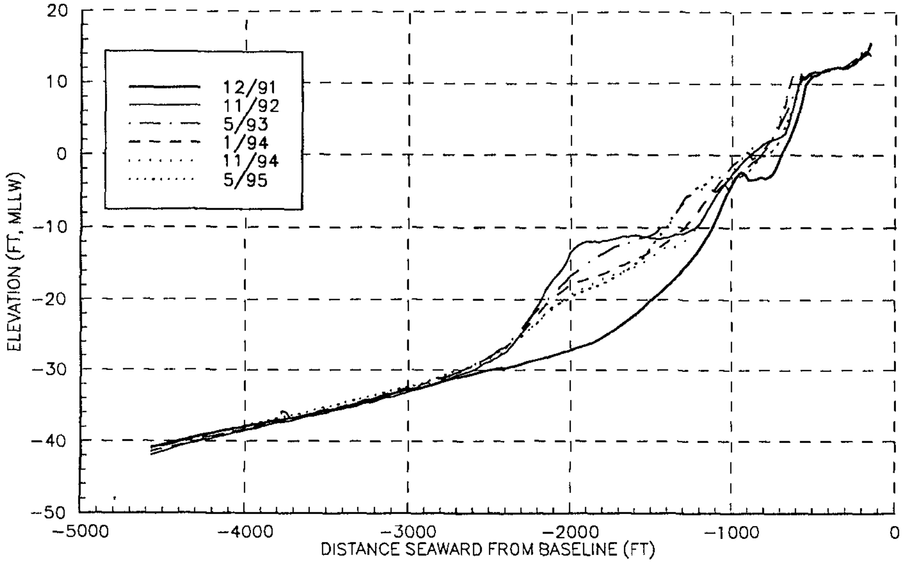

Figure 2. Comparison of Profiles at Line 19.

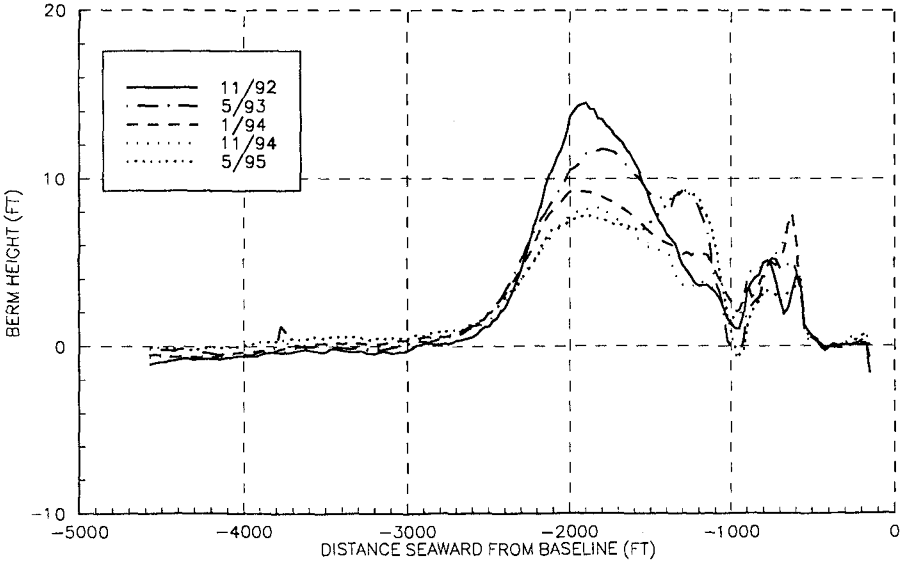

Figure 3. Comparison of Profile Differences at Line 19 Relative to Pre-project Condition (12/91).

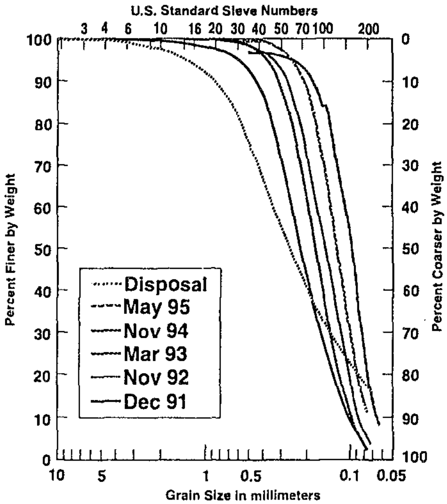

Figure 4. Grain Size Distribution Comparison, Line 19, d = -24 ft

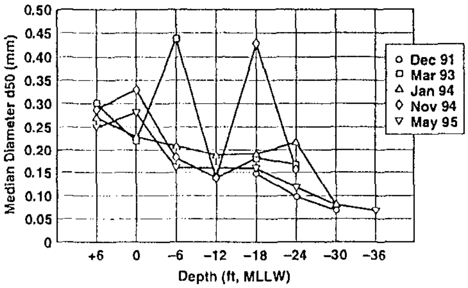

Figure 5. Cross-shore Comparison of d_{50} Median Diameter, Line 19

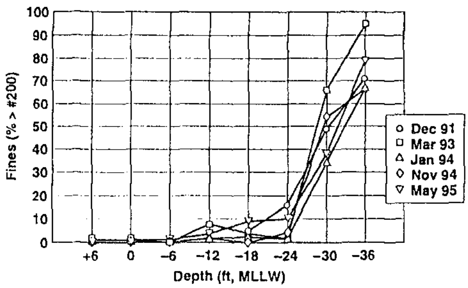

Figure 6. Cross-shore Comparison of Percent Fines, Line 19

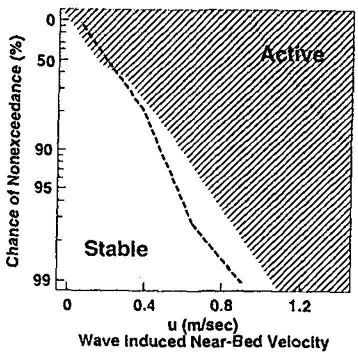

Figure 7. Berm Categorization Based on Wave Induced Near-bed Velocity. Adapted from Hands & Allison (1991).

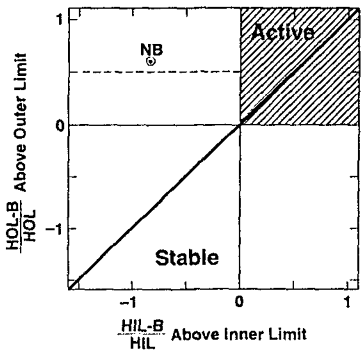

Figure 8. Berm Categorization Based on Hallermeier Limits. Adapted from Hands & Allison (1991).

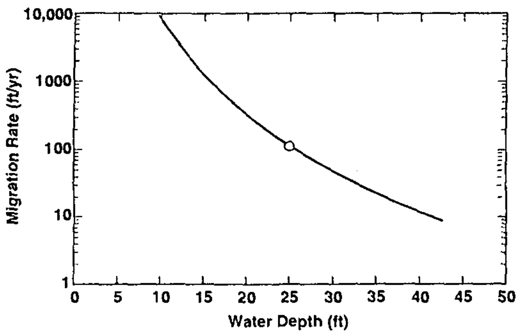

Figure 9. Berm Migration Rate.

Photo 1. Wave Refraction due to Nearshore Berm. 12/92.

Photo 2. Wave Breaking due to Nearshore Berm. Summer 1992.