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PERFORMANCE OF NEARSHORE BERM DISPOSAL AT PORT CANAVERAL, FLORIDA

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ABSTRACT

Selective disposal of sand from the 1992 and 1993 maintenance dredging of Canaveral Harbor resulted in the placement of about 130,000 and 200,000 cy, respectively, in a nearshore disposal area offshore of Cocoa Beach, Florida. Berm material placed in water depths less than about -23 ft, MLW, migrated landward, with the most rapid and significant movement appearing immediately after placement. Berm migration resembled a diffusion process skewed in a shoreward direction. Survey and sediment data indicated little or no alongshore transport, and no offshore transport. The approach of Hands and Allison (1991) accurately predicted the limiting water depth for which shoreward movement of the berm material was expected.

INTRODUCTION

This paper summarizes the physical performance of dredged material from the Port Canaveral Entrance Channel placed in a nearshore disposal area offshore of Cocoa Beach, Florida, in 1992 and 1993. Nearshore disposal of suitable dredged material was inaugurated by the Canaveral Port Authority in 1992 in order to retain beach quality sand in the littoral system which would have otherwise been disposed of at a deepwater offshore site. The project is the first regular, nearshore disposal activity at a federal navigation project along Florida's east coast.

The Canaveral Harbor Federal Navigation Project (a.k.a. Port Canaveral) is located on the Atlantic coast of Florida, in Brevard County, south of the Kennedy Space Center at Cape Canaveral (see Figure 1). The facility includes a man-made inlet and deep-water harbor which were cut into an otherwise continuous sandy barrier island between 1950 and 1954. The federally maintained ocean entrance has a depth of about -46 ft MLW and a bottom width of 400 ft.

The Port's ocean entrance interrupts the area's net southerly littoral drift, and also acts as a complete littoral sink because of the inlet's porous, low, short jetties. Since its construction, the entrance channel has historically shoaled with a mixture of sand, silt and clay. Much of the sand derives from the adjacent beaches and typically deposits in several discrete shoals which form near the landward and seaward ends of the entrance channel's two jetties. Prior to 1992, little note was taken of the disposition of the dredged sand or hopper suction dredges were used (which mix the sand, silt and clay). The dredged material was routinely disposed

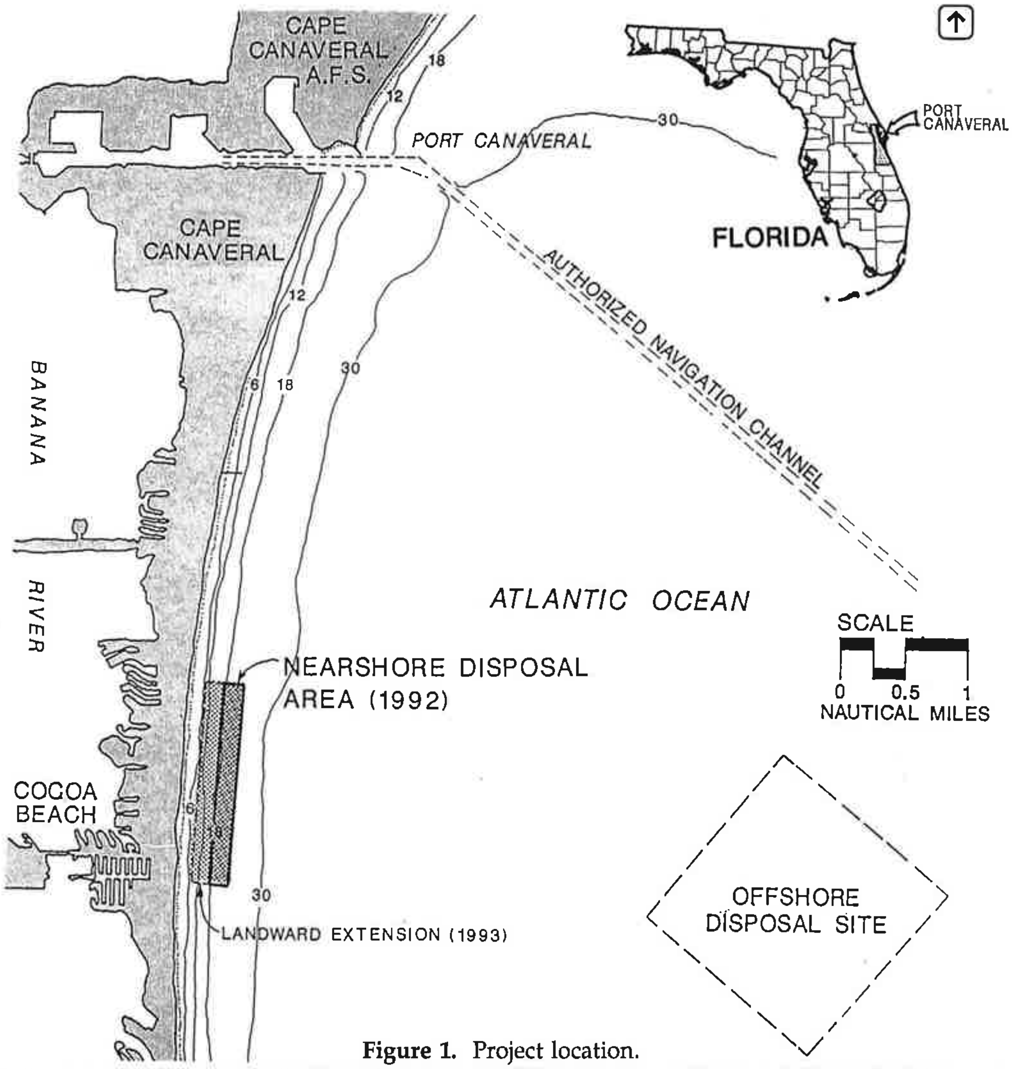

Figure 1. Project location.

of offshore in water depths in excess of 30 or 50 feet. Offshore disposal removes the sand from the active littoral system and thereby exacerbates local beach erosion. Since 1952, maintenance dredging and new construction, respectively, are estimated to have removed about 7,900,000 cubic yards (cy) and 570,000 cy of beach quality sand from the littoral system at Port Canaveral. Beach erosion downdrift (south) of the inlet is severe and is attributed to the inlet's presence (Bodge 1992).

In August 1991, the U.S. Fish and Wildlife Service disallowed hopper suction dreging at Port Canaveral because of its adverse impact to marine turtles. Subsequently, the Jacksonville District Corps of Engineers required that dredging at the port be accomplished by alternate means -- such as by mechanical dredges. Coincidentally, mechanical dredging allows material from the sandy shoals to be segregated from the silts and clays which typically shoal the channel floor.

To recapture a portion of the sand resource which had been previously dredged and disposed of offshore, the Canaveral Port Authority (CPA) initiated, formulated and funded a modification to the 1992 federal maintenance dredging project. The experimental work called for the sandy shoal material to be selectively dredged, transported by scow, and spoiled to a downdrift, nearshore disposal site within the active littoral zone. The intent of the activity was to construct a shore-parallel berm which, over time, would migrate shoreward and benefit the shoreline; or, at the least, would remain within the littoral system and indirectly benefit the shoreline.

The originally permitted nearshore disposal area (1992) is 9,500 ft long and 650 to 800 ft wide in the shore-perpendicular direction (Figure 1), with a landward boundary about 1,750 ft from the shoreline, approximately along the -22 ft NGVD (-20.4 ft MLW) depth contour. The seaward boundary is along the -27 ft NGVD (-25.4 ft MLW) depth contour. The area is 5.2 to 7 miles south of the Port entrance. In 1993, the landward boundary of the permitted site was extended 750 feet shoreward to accomodate disposal in even shallower water (up to -10 ft MLW). Use of this extended area is being considered for 1994-95 activity. The landward boundary of the disposal area shown in this paper reflects the original 1992 limits.

1992 NEARSHORE DISPOSAL ACTIVITY

In the inaugural 1992 project, 103 scowloads of suitable dredged material, estimated to total 158,000 cubic yards (cy), were spoiled to the northwest quadrant of the nearshore disposal area. This volume represents about one-third of the 461,000 cy of material excavated from the entrance channel during the June 6 to July 24 period of the operation. Disposal consistently commenced at the northern boundary of the permitted area and continued southward about 100 ft seaward of the area's landward boundary. The Contractor for the work, Norfolk Dredging Company, employed split-hull scows with 156-ft x 30-ft hoppers, 16-ft laden draft, and 2000 cy nominal capacity. Towing was by G&B Marine, Inc. The project was contracted by the Corps. Olsen Associates, Inc. permitted and directed the work.

Bathymetric survey data were collected to document the pre-project seabed [7/28/92]. Four subsequent performance surveys were collected: 4 days [7/28/92], 4-1/2 months [12/11/92], 9-1/2 months [5/15/93], and 11 months [7/1/93] after construction. The survey dates were influenced by weather and the timing of the 1993 disposal project. Bathymetric profile lines were spaced 125- to 250-ft apart, perpendicular to the disposal area's axis. Data collection extended from 150 ft seaward of the disposal area to about 800 ft landward thereof, or from about the -27.5 to the -11 ft MLW depth contours. Data were also collected closer to shore (to -9 ft depth) along several lines spaced about 1000 ft apart. Distance along the profiles refers to an artificial baseline approximately parallel to and 1740 ft landward of the area's 1992 western boundary, or approx. the NGVD shoreline.

Figure 2 depicts the survey results along two typical profile lines. The seabed profiles within the disposal activity clearly show the initial berm which was constructed, and the subsequent diminution and apparent shoreward movement of the berm. The profiles outside of the area of disposal activity show relatively minor variations in the seabed apparently unrelated to the adjacent berm.

Within the disposal activity, the post-construction survey (7/28/92) indicated a typical berm relief of about 5.4 feet with about a 400-ft wide base located between

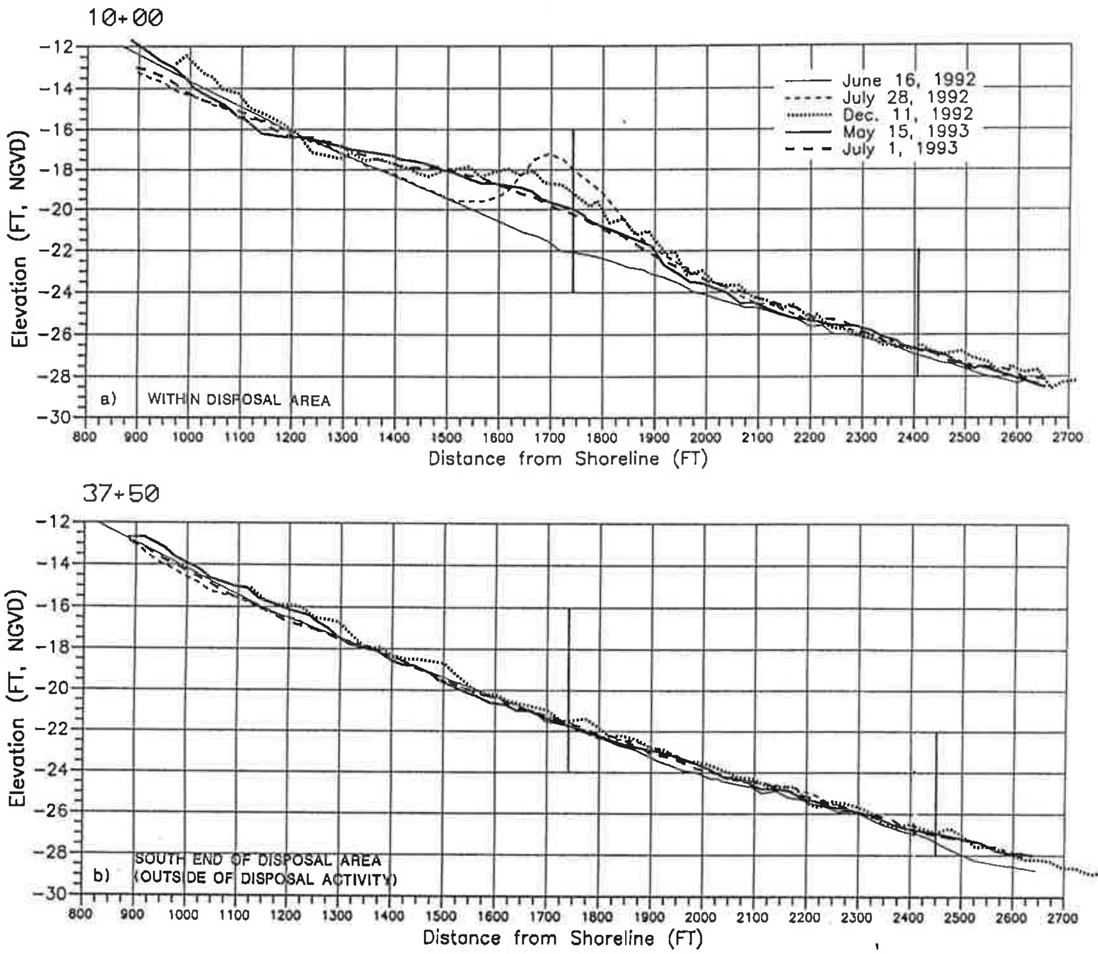

Figure 2: Typical seabed profiles measured (a) within and (b) just south of the berm construction area. The vertical lines are the limits of the 1992 disposal area.

the -23.4 and -17.9 ft MLW pre-project depth contours. The average landward-side slope varied from about 1:24 to 1:54, with 1:35 being fairly typical. The average seaward-side slope varied from about 1:12 (rare) to 1:35.

Survey-related problems precluded the "pre-project" survey's completion until 10 days after nearshore disposal operations commenced. About 55,000 cy of material may have been placed in the nearshore disposal area prior to the survey. Across the 350-ft by 3000-ft area in which disposal activity was mostly concentrated, this volume is conceivably detectable in a standard bathymetric survey. The "pre-project" survey data, however, show no sign of the disposed material. A possible explanation for this is that the disposed material sunk into or displaced the pre-existing, silty seabed. Subsequent disposal would have built upon the sandy foundation established by the early spoil.

The intra-survey data analysis consisted of computing the vertical seabed change along each survey line, measured relative to the "pre-project" condition and expressed as a function of the pre-project seabed depth. The average seabed changes north and south of the disposal activity were assumed to represent "background" seabed changes for each survey event. These "background" signals were then subtracted from all of the measured seabed changes for that survey event -- in order to yield a signal associated with only the nearshore berm activity.

Berm Response. Figure 3 illustrates the average vertical seabed change, plotted as a function of the "pre-project" depth, for each of the four post-construction surveys. The values represent the composite of five evenly-spaced profile lines located near the middle of the disposal activity. The "background" signals have been removed. The results clearly indicate landward migration of the material. No suggestion of seaward movement is noted. There is a significant diminution of the berm relief from about 5.5 ft to 2.5 ft during the 4.5 months after the first post-construction survey. Thereafter, the berm relief diminishes more slowly: to about 1.6 ft within one year after construction. There is also a notable shift of the berm relief toward shallower contours with each survey. Overall, the berm's movement suggests a cross-shore diffusion with shoreward-directed convection.

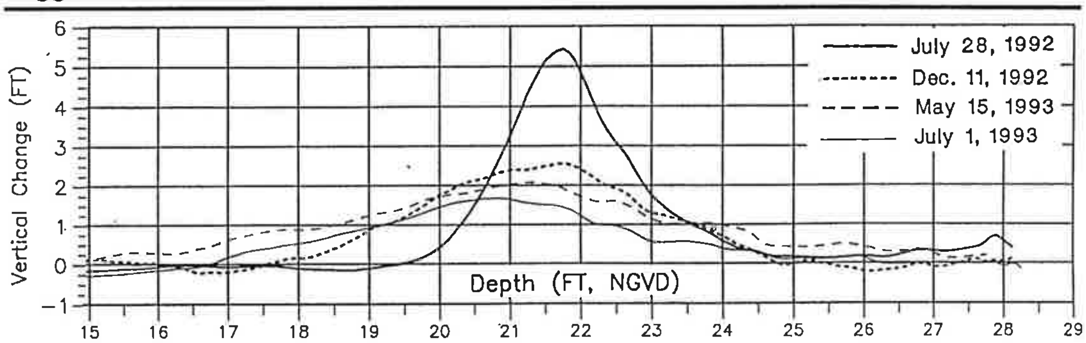

Figure 3: Average vertical seabed change at the middle of the nearshore berm. Results are plotted as a function of the pre-project seabed depth.

Figure 4a depicts the change in the berm's average relief measured at the berm's volumetric centroid. Figure 4b depicts the change in the pre-project seabed depth at which the berm's volumetric centroid is located. It is also interesting to note that the landward edge of the berm was detected at about -19.6 ft NGVD (-18 ft MLW) after the first post-construction survey. Since that survey, the berm's crest

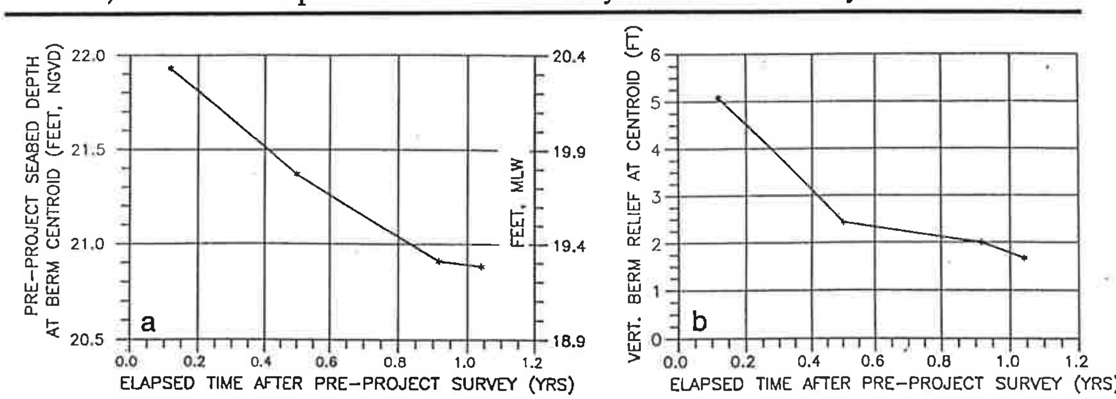

Figure 4: (a) Pre-project seabed depth at which the berm's volumetric centroid was located. (b) Berm's vertical relief above pre-project seabed, measured at the volumetric centroid.

has been reduced to about that same elevation, or about -19.0 ft NGVD (-17.4 ft MLW). It is not certain whether this is a coincidence or whether this depth represents a sort of local limit for the stability of seabed perturbations.

Volume Distribution. In the first post-construction survey, 123,000 to 135,000 cy were detected with and without the "background" signal removed, respectively. This volume is about 10% less than that estimated by scowload. The discrepancy may be due to survey uncertainties and/or the fact that the "pre-project" survey actually occurred several days after disposal had begun.

Of the initially discerned berm volume, only 60% was within the disposal area, and the other 40% was landward thereof. This is a surprising result considering that all of the berm material was dumped *within* the disposal area; specifically, about 100 ft *seaward* of the area's landward boundary. This suggests that a large fraction of the placed material migrated landward very rapidly during the 5 week period between the pre-project and first post-construction surveys.

After one year, the amount of the initial berm material detected within the disposal area limits declined from 60% to about 43%. During this period, the berm volume landward of the disposal area (but seaward of the survey limit, at about -11 ft MLW) declined from 40% to 15% (±10%). Accordingly, after one year, 42% (±10%) of the placed material could not be detected across the survey area. This amounts to about 52,000 cy (±7,000 cy). The survey data show no sign that berm material moved in a net seaward direction nor significantly alongshore. Seabed samples taken before, after, and one year after the disposal activity unambiguously indicate shoreward movement of the berm material, and do not indicate significant seaward movement, alongshore movement, nor "winnowing" of fine sediments. It is therefore reasonable to assume that this 52,000 (±7,000) cy of "undetectectable" volume migrated shoreward and/or alongshore outside of the survey area -- above the -11 ft MLW depth contour.

Onshore (Centroid) Movement. Figure 5 depicts the volumetric centroid of the berm material along the disposal area, computed about the shoreline. In the initial post-construction survey (i.e., 50 days after project commencement and 5 days after completion), the berm's centroid was approximately along the landward border of the disposal area. This represents about a 100-ft landward shift from the alignment along which the berm was constructed. On average, the berm's centroid migrated landward another 50 ft during the next 4.5-month period (July 28 - Dec. 11, 1992). It migrated landward another 30 to 50 ft, on average, during the next 5-month period (Dec. 11, 1992 - May 15, 1993). The results for the last survey are "noisy" because of the smaller berm volume; no average net movement is noted for this interval (May 15 - July 1, 1993). Overall, then, the results suggest a rapid, 100-ft landward migration of the centroid over a 1- to 6-week period during construction -- followed by a slower, lesser landward migration over the next 10 months. The survey data collected along longer survey lines include, in shallow water, the effects of seasonal fluctuations which are much greater than the berm-related migration of sand thought to have occurred across these contours. Both with and without attempts to remove the "background" signal, no conclusions could be drawn from the longer profile lines in regard to onshore movement.

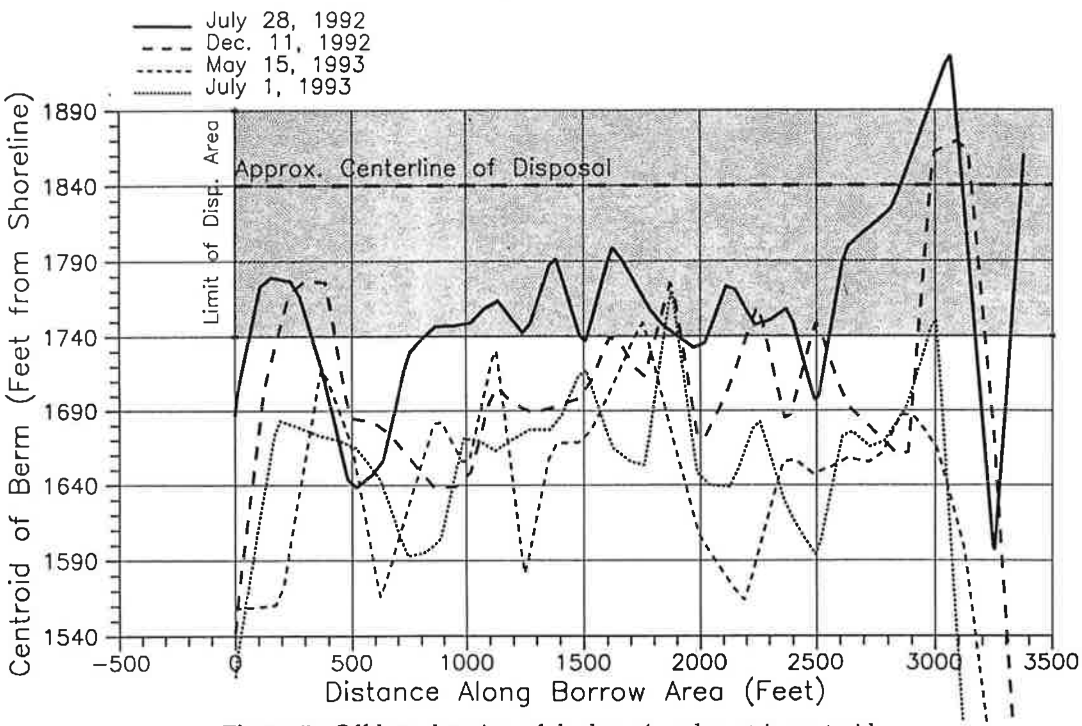

Figure 5: Offshore location of the berm's volumetric centroid.

Alongshore Movement. The alongshore distribution of the detectable berm volume was likewise investigated (see Bodge 1994). Both with and without removal of the "background" signal, there did not appear to be a significant, net shift of volume toward the north or south. No alongshore "diffusion" of the berm's volume was detected by survey or surface sediment data (Raichle and Bodge, 1994).

1993 NEARSHORE DISPOSAL ACTIVITY

The 1992 pilot project was considered viable, and the Corps of Engineers adopted nearshore disposal of suitable material as the least-cost alternative for dredging at Canaveral Harbor. The second such activity was undertaken in 1993. For that job, tracking data from the tugs suggest that about 22% of the nearshore material was deposited 100 to 300 ft *seaward* of the intended site -- in depths greater than about -26 ft MLW. The remainder of the material appears to have been deposited within the *seaward half* of the permitted site; i.e., -22 to -25.5 ft MLW.

An October 1993 survey, conducted about 3/5'ths of the way through the project, revealed the presence of two berm signals: one seaward of the disposal area, and the other along the *landward* edge (Figure 6). The former comprised about 16,200 cy, or 15%, of the discernible material. The other 85% (90,420 cy) was detected within and landward of the disposal area. This was a striking result -- as it was known that little or no material was placed landward of the disposal area's centerline. The distribution of the detected volume strongly suggests that material placed in depths shallower than about -24 ft NGVD (-22.5 ft MLW) migrated significantly and rapidly landward, while material placed in depths greater than about -26.5 ft NGVD (-25 ft MLW) moved comparatively little.

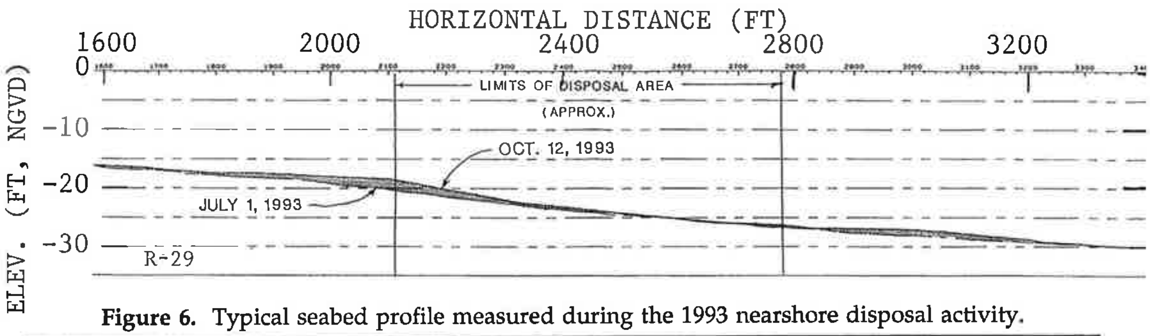

Figure 6. Typical seabed profile measured during the 1993 nearshore disposal activity.

SEDIMENT QUALITY AND CHARACTERISTICS

By permit condition, material intended for nearshore disposal may contain no more than 10% fine sediments (defined as passing the #230 U.S. Std. sieve). Full-time inspectors, stationed aboard the dredge, monitor the loading to determine each scowload's potential suitability for nearshore disposal. The sandy shoal material in the channel contains 1.5% to 6.5% fine sediments -- averaging about 3.5%. Accordingly, some material loaded to the scow could be in excess of 10% fine sediments, and the load could still be deemed suitable for nearshore disposal. This is operationally important because some silt and clay is occassionally encountered when the perimeter and base of the sandy shoals are dredged. In order that a scowload contain less than 10% fine sediments overall, the maximum percentage (U) of unsuitable material in the load is:

$$U \leq (10\%-G) \; / \; (F-G)$$

where G and F are the percent populations of fine sediments in the shoal material and the unsuitable material, respectively. In practice, the inspectors estimate the percentage of unsuitable material in a load (U) by noting the time which elapses during loading of unsuitable material -- relative to the total time required to fill the scow. The percentage of fine sediments in the unsuitable material (F) is estimated by visual inspection of the material and the manner in which it falls. The intersection of the values U and F in Figure 7 aids the inspector in determining the load's suitability. In Figure 7, the dividing line is based upon G=3.5%; the shaded region corresponds to G=1.5% to 6.5%.

The pre-disposal seabed contained 8% to 12.6% fine sediments (10.5% average), with median diameter d_{50}=0.104 mm. Seabed samples collected during and immediately after the 1992 disposal (within the disposal activity) revealed 2.8% fine sediments and a d_{50} of about 0.40 mm, on average. About 14 months after the 1992 disposal (and during the 1993 activity), seabed samples revealed about 3.3% fine sediments and similar (0.4 mm) median diameter. These results reflect the high quality of the placed material. Raichle and Bodge (1994) present the time history of the seabed profile and sediment grain size distribution in detail.

Berm Stability. At the project's outset, a central problem was to determine the maximum disposal depth at which material would migrate landward. Of the three

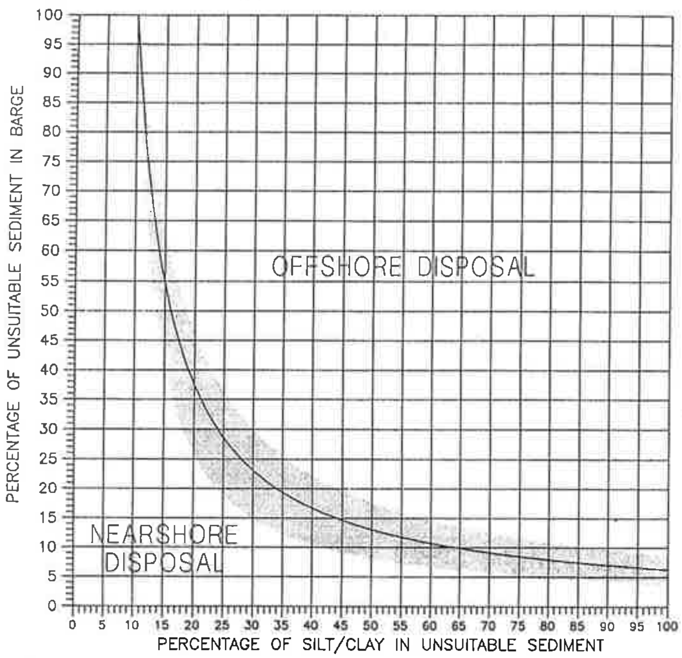

Figure 7. Approximate method to determine suitability of scowload for nearshore disposal.

predictive methods employed, the approach of Hands and Allison (1991) proved most accurate. Hands and Allison correlated observations of prototype berm stability at eleven sites with each site's probabilistic occurrence of the maximum, nearbed horizontal wave orbital velocity. The latter was developed from hindcast data and linear theory. The data suggested a limiting statistical distribution of wave orbital velocities which define whether berm material shall be stable or active. For the present case, disposal in water depths of about -22 ft MLW was predicted to be "active", while disposal greater than about -26 ft MLW was predicted to be "stable". This agrees very well with the results of the 1992 and 1993 projects: material placed in water depths less than about -22.5 ft MLW migrated rapidly landward, while placement in depths greater than about -25 ft MLW appeared stable.

The profile zonation technique of Hallermeier (1981a,b) overpredicted the water depth for which shoreward migration might be expected. (Using hindcast wave data, the HIL and HOL for the site are 28 ft and 67 ft, respectively.) Evaluated at the disposal site's nominal water depth, the fall velocity parameter (H/wT) exceeded a value of 3.2 for 33% of the average annual hindcast wave conditions -- thus suggesting shoreward transport for 1/3'rd of the year. However, this application may be inappropriate since the 3.2 value refers to the surf zone.

SUMMARY AND CONCLUSIONS

The 1992 and 1993 nearshore disposal operations placed suitable sandy material dredged from Port Canaveral Entrance into a berm reaching 5.4-ft relief in water depths of -18 to -27 ft MLW. In each year, about 130,000 to 200,000 cubic yards of material were placed. The material disposed in depths shallower than about -22.5 ft MLW migrated rapidly and significantly shoreward. Material placed in depths greater than about -25 ft MLW moved comparatively little. The approach of Hands and Allison (1991), which involves calculation of the statistical occurrence of nearbed horizontal wave orbital velocities at the disposal site, accurately predicted the site's berm activity as a function of water depth.

From both seabed surveys and sediment samples, neither offshore movement nor significant alongshore movement of the placed material was detected. One year after the project's inaugural 1992 construction, between one-third and one-half (about 40%) of the initial berm volume could not be detected in the survey area. In all likelihood, this material migrated shoreward and/or alongshore -- landward of the -11 ft MLW depth contour. This volume equates to about 52,000 cy. Seasonal "background" changes in the beach profile were too large to allow identification of the relatively small berm signal in the shallow water of the beachface. Furthermore, for quantities on the order of 150,000 cy, surveys of the berm in "active" water depths are of marginal value after 9 months.

If placed in "active" depths, the berm material's volumetric centroid appears to migrate significantly and rapidly immediately after construction; i.e., within days or a few weeks. Thereafter, migration of the centroid slows, but the berm continues to flatten and to skew landward. The combined effect of the shoreward movement and the flattening of the berm's relief suggests that there is an optimum (?) water depth over the berm's crest toward which the placed material's permutations are driven. That is, the 1992 berm's centroid and vertical relief moved landward and diminished, respectively, such that crest elevation of the berm remained at about -17.5 ft MLW.

ACKNOWLEDGMENTS

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