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SEDIMENT HANDLING AND BEACH FILL DESIGN,(U)
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SEDIMENT HANDLING AND BEACH FILL DESIGN

R. D. Hobson[1]

ABSTRACT

Offshore sand and gravel deposits constitute an extensive mineral resource whose importance and economic value increase steadily as onshore and lagoonal sources become unavailable. One major use of these marine deposits is for beach nourishment where the amount of initial fill material needed and the expected periodic renourishment requirements are usually estimated using fill factor and renourishment beach fill models, respectively. Textural properties of borrow site and native beach sediments are used as the basic input for beach fill model calculations. Alterations to borrow sediment texture properties by dredging and handling techniques can significantly affect both the predicted response of the sediments after placement in the beach environment and economic aspects of the project.

Two cases are examined where adequate data are available to quantify some effects of dredging and handling on sediment texture. The first, Rockaway Beach, NY, is a large, ongoing nourishment project while the second case at New River Inlet, NC, is an experiment designed, in part, to provide handling-loss sedimentary data.

At Rockaway, sediments were dredged, barged, rehandled and hydraulically pumped onto the beach. Sediment losses due to elutriation of finer particle sizes during the dredging/barge-filling and rehandling/fill-placement phases of the project produced a fill sediment that was coarser and contained fewer sizes (better sorted) than the bottom sediments dredged. Approximately 10% of the sediments barged to the rehandling station were lost during rehandling and placement on the beach.

Comparisons of dredged and predredged sediment textures at New River Inlet indicate a handling loss of nearly 16% from the medium to fine sand sizes (0.5 to 0.063 mm). These losses resulted in a dredged sand that was about 0.14 mm coarser than predredged bottom sediments.

Conclusions to date from this ongoing research effort are as follows. Both cases studied indicate that the winnowing of fine sediments during handling operations produces fill sands that are generally coarser and better sorted than bottom sediments, and that these changes tend to improve the predicted performance of fill sediments. Volumetric losses are fairly high for the examples presented and such losses deserve consideration when estimating the overfill and renourishment elements of project design.

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INTRODUCTION

Beach nourishment is one engineering solution for protecting coastal regions from the effects of long-term shore erosion and from short-term erosive damage caused by specific storms or hurricanes. It is also a fairly popular shore protection solution in the United States because nourishment tends to maintain the aesthetics and enhance the recreational character of an area, plus the federal government provides substantial funding support for many of these projects. Today, fill sediments are often "borrowed" from offshore areas. Some reasons for this trend are that offshore sources are fairly plentiful; the offshore environment is less affected by dredging operations than more sensative lagoonal environments; and because plants are now being designed that can operate effectively under the highly variable wave and wind conditions common to exposed offshore locations.

A beach fill is shaped during construction to withstand the waves and water levels anticipated during a storm of design intensity. The volume of sand placed within the fill is intended to exceed both erosion losses expected during the design storm as well as the long-term erosion losses characteristic of an area. The fill can thus be thought of as a sand reservoir which may require periodic renourishment in order to perform as designed throughout the life of the project. Two questions that arise are how much sand is needed to provide the intended protection and how often will renourishment of the reservoir be needed? Approximate answers to these questions can be obtained by analyzing the storm and erosion histories of an area and determining from them, the design storm, expected storm erosion losses, and yearly erosion losses. These answers are approximate for beach fill design purposes because the physical and compositional properties of fill sediments are not the same as those found on the native beach. Therefore, more complex solutions are required.

Beach fill models currently employed by the U.S. Army Corps of Engineers use the comparison of textural characteristics of native beach and borrow sediments in an attempt to answer the questions above (James, 1975; Hobson, 1977a). Composite grain size distributions are compared to determine:

(a) Fill factors which are used to estimate the excess volume of fill sediments needed to satisfy project dimensions where material of the same size characteristics as natural beach materials are unavailable, and;

(b) Renourishment factors which predict the stability of potential fill materials to erosion as compared to native beach sediments. The term "composite" is used here to identify the averaged grain size distribution of samples collected from the active native beach surface and from cores (usually) of potential borrow sediments (see Hobson, 1977a, for further discussion of composites).

For both beach fill models the assumption is made that natural winnowing and sorting processes will modify fill sediments until their textural and areal distribution resemble native beach sediments as nearly as possible. A borrow sediment with a composite texture that is finer and more poorly sorted than native beach sediments is expected to be modified by selective removal from the finer grain sizes thus requiring an initial excess of borrow sediments to achieve project dimensions as well as more frequent renourishment than if native-like sediments had been used as fill. Coarser or better sorted borrow sediments would also be modified primarily through loss of the finer fractions although their modified composite texture would probably never completely match the native beach composite. Finally, it should be noted that these models are simplistic approximations of highly complex natural systems and that the quality of either kind of model calculations is only as good as that of the composite properties used.

Dredging and Placement-Induced Sediment Losses: It has been generally assumed that the composite distribution of the fill materials delivered to the beach will be the same as that determined from samples collected at the borrow site. This assumption is not necessarily correct since the texture of borrow sediments is often modified to some degree during handling. Small modifications would probably not affect composite calculations significantly because these calculations are somewhat insensitive to subtle textural variations. Larger variations could affect the calculated composite and thus a fill factor or renourishment calculation as well.

If handling losses are from those size fractions expected to be removed during early fill sediment modification then they can be considered fortuitous and a calculated fill factor would still apply. In this case fill requirements are met by the volume dredged rather than the volume placed on the beach. However, a correction may be necessary if in-place volume were used to satisfy an overfill requirement or if handling losses were from sediment sizes considered stable in the beach environment.

Handling losses are usually caused by sediment elutriation and occur during the dredging and placement phases of a beach fill project. Typically, fill materials are dredged from offshore borrow sites using suction or cutterhead equipment, transported to the beach in hoppers or pipelines and hydraulically placed on the beach. Sediment losses can occur during dredging when a cutterhead or water jets on a dredge head stir up bottom sediments into the surrounding water rather than pumping them into the hopper or pipeline. When hoppers are used the sediment slurry is allowed to overflow until the bins are filled. Sediments in hoppers are usually recharged with water for pumpout, and again, an overflow situation can occur. Finally, suspended sediments are carried down the beach slope and offshore during hydraulic placement of a fill. In each case (dredging, overflowing, recharging, and hydraulic placement) some suspended sediment is either not dredged or not delivered on the beach.

There are few cases where sediment losses of the types mentioned above have been reported. Taney (1965) suggests losses in excess of 80 percent in one experiment with the dredge COMBER where hopper overflow was used to obtain suitable fill materials by washing out silts and clays from a sub-marginal borrow source. In the spring of 1966 the hopper dredge GOETHALS was used to pump approximately 325,000 m^3 of sand onto the beach at Sea Girt, New Jersey. Mauriello (1968) reports that elutriation losses resulted in a mean grain size for pumped sediments that was approximately 0.2 mm larger than for the borrow sediments. These sediment losses occurred as a result of overfilling during dredging, and recharging during pumpout operations.

The handling loss examples cited above are based upon the analysis of very few sediment samples. The remainder of this paper discusses two additional examples where suitable sediment-loss data were obtained. The first, Rockaway Beach, was a beach nourishment project planned and coordinated by the New York Army Corps District Office whereas the second, New River Inlet, was an experiment in North Carolina that was designed to quantify dredge-induced modifications to sediment texture.

ROCKAWAY BEACH, NEW YORK

Project Description: Rockaway Beach is within the Borough of Queens, New York City, and occupies the easterly 9.6 km of the 16 km long peninsula that separates the Atlantic Ocean and Jamaica Bay (Fig. 1). The beach has evolved over the past century in response to multiple phases of artificial nourishment and provides an important recreational facility for the people of New York City.

General erosion and storm damage conditions prompted authorization in 1964 of a multiple purpose beach erosion control and hurricane protection project for the area (Nersesian, 1977, discusses this project in detail). The project was to include construction of a 5.5 m high flood wall along the barrier, a 5.5 m high surge barrier across the entrance to Jamaica Bay, and beach nourishment. Severe erosion conditions in 1973 resulted in re-authorization of just the beach nourishment phase of the project and the first portion of this three-phase restoration work was completed along the central 4.8 km segment of the area during the summer of 1975 ("Contract 1", Fig. 1). The Federal Government's share of the estimated 34.4 million dollar project, including periodic renourishment for a ten year period, is fifty percent.

Three potential offshore borrow areas were investigated (Fig. 1) using geophysical and coring techniques and, based upon grain size comparisons of native beach and cored sediments plus factors such as location, water depth and sand thickness, a borrow area in East Bank Shoal was selected as the most suitable sand source for the Contract 1 phase of nourishment. The method used by the contractor to complete this work was to load scow barges at the borrow site using the 61-cm (24-inch) cutter suction dredge "Puerto Rico"; tow the scows 13 km through Rockaway Inlet to a rehandling station on the landward side of the barrier; recharge the loads using high pressure water jets; suction pump the slurry through a pipeline laid across the barrier; and hydraulically place the fill along the project beach. Payment of \$3.20 per cubic meter was made for the 2,804,082 m^3 placed in this manner. Total fill volume was determined by surveying material in-place on the beach within the elevation limits of +3 m to -5.5 m, sea level datum (s.l.d.).

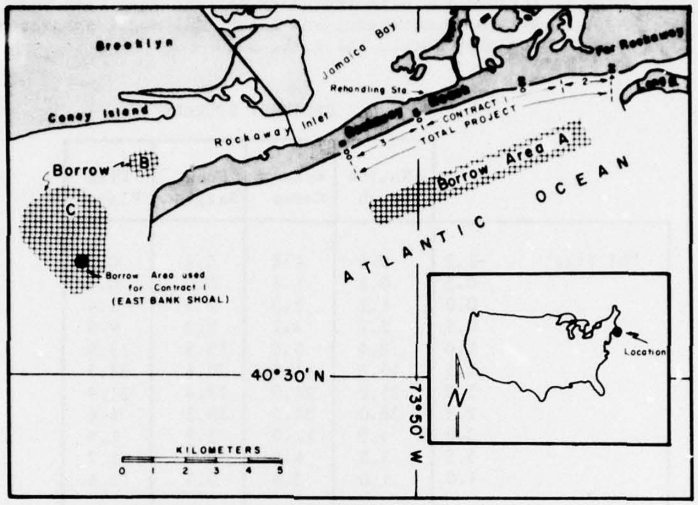

FIGURE 1 Rockaway Beach nourishment - Project Map.

Sampling: Table 1 shows the composite grain size distributions (gsd) for Native Beach, Borrow, Scow-barged and Placed Fill Sediments. These distributions are shown in phi units (Krumbein, 1938, where $\phi = -\log_2 d$, and where d is particle diameter expressed in millimeters). Also included are the mean grain size (in phi and millimeter units) and phi sorting parameters for each composite.

The native beach composite is the averaged gsd for the suite of pre-nourishment beach samples used as the "design sand" in the project Design Memorandum (U.S. Army, 1974, p. B3).

The borrow composite is the averaged gsd of sand samples from cores #203 and #208 taken within the East Bank Shoal borrow area. These sampled cores were 8.5 m and 4.6 m in length respectively.

The scow composite is the averaged gsd from sediments taken from 29 scow loads sampled periodically during construction whereas the fill composite is for sediments collected along the 29 beach profiles where the scow loads were pumped. The profiles are spaced at 150 m intervals along the project area; each profile was surveyed and sampled 5 days (on the average) after fill placement; and sediments were collected at +3, 0, -1.8, -3.6, and -5.5 m elevations (s.l.d.) along each profile.

TABLE I Incremental size frequency percentages; mean and sorting parameters; and beach fill model predictions, Rockaway Beach, New York, 1975

SEDIMENT SOURCE

		Native Beach	Bottom Cores	Scow Barges	Fill Placed
Phi Size	-1.0	3.6	1.2	0.1	0.2
	-0.5	0.6	1.4	0.4	0.3
	0.0	1.1	2.3	2.4	1.4
	0.5	2.7	4.1	8.3	9.9
	1.0	8.5	7.0	15.9	19.9
	1.5	10.5	14.5	30.6	35.7
	2.0	25.0	24.0	27.4	21.9
	2.5	38.0	24.5	10.1	4.6
	3.0	5.5	12.0	3.3	1.5
	3.5	2.5	4.5	0.9	1.7
	4.0	1.0	3.0	0.5	2.6
Mean Size (ϕ)		1.69	1.85	1.31	1.24
Mean Size (mm)		0.31	0.28	0.40	0.42
Sorting (ϕ)		0.72	0.86	0.66	0.64
Fill Factor (R_A)		-	1.24	1.00	1.00
Renourishment Factor (R_J)		-	1.00	0.64	0.56

Discussion: The offshore borrow sediments available for this nourishment project exhibit the common characteristics of being finer grained and more poorly sorted than native beach sediments. This relationship is reflected by a fill factor (R_A, Table I) that is greater than unity (1.24) indicating that a loss of approximately 20% of the original fill can be expected during the initial textural adjustments of the filled section. These losses should be primarily due to the winnowing of materials finer than 2.5 phi (0.18 mm) which constitute a greater proportion of the borrow versus native sediment sizes (Fig. 2). The renourishment factor of unity (R_J) predicts that the borrow sediments should erode at approximately the same rate as native materials. The borrow sediments are finer grained than the beach sediments but their greater sorting value (0.86 vs. 0.72 for the native) reflects a slight excess of some coarser sizes which probably explains the prediction of equal erosion rates.

Both scow and fill sediments are coarser grained and have smaller sorting values than native beach or borrow sediments. From the standpoint of beach fill model predictions, no overage is required if either sediment were used as fill, and both sediments are expected to erode at slower rates than native sediments. The renourishment factors of 0.64 and 0.56 indicate that scow-like sediments would last about 1.6 times as long and fill-like sediments about 1.8 times as long as native beach sediments. Although these differences are small, they could translate into significant savings where large renourishment volumes are anticipated.

Handling losses are difficult to determine from size data alone. Nevertheless the textural data in Table I and Fig. 2 do reflect changes caused by these losses if not the actual magnitudes themselves. Borrow material was dredged, loaded into scows, rehandled, and then pumped onto the beach. These operations could produce three main episodes of sediment loss: (1) during the dredging and loading phase where the water/sediment slurry overflowed the scows until they were full; (2) during the recharging and offloading phases; and (3) during the hydraulic fill placement phase where certain particle sizes were carried seaward beyond the -5.5 m (s.l.d.) depth surveyed for payment purposes. Comparison of the borrow and scow composite gsd's allows an evaluation of the dredging/loading phase while the scow vs. fill comparison can be used to evaluate the combined rehandling and placement phases.

Significant losses during dredging seem to be indicated by the nearly 0.2 mm difference in mean grain size between the scow-barged and bottom sediments (Fig. 2). There is also a decrease in phi sorting associated with the dredging phase. These changes in texture are of the type anticipated since considerable overwashing is required to fill the scows, and losses would be from those finer sediments that are easily elutriated during the overflow process. The volume of sediments lost is difficult to calculate. A survey of the borrow site, after dredging, has been made but, to date, these data have not been evaluated to provide an estimate of the sediment volume dredged.

The magnitude of the textural differences may well be misleading because very few samples from only two cores were available to describe the texture of borrow sediments. This problem of scanty offshore data is fairly common to beach nourishment projects, and the Rockaway project is one of the better sampled projects of this type. Significant expense and effort went into collecting the geophysical (approximately 240 km of trackline) and core data (45 cores) used to evaluate the 47 km^2 potential borrow area. However, only two of these cores and perhaps 2 km of trackline are available to reflect the subbottom characteristics of the actual 1.3 km^2 area selected for the project, suggesting borrow source evaluations studies should include both general area as well as detailed area investigations to adequately assess available fill materials.

The scow and beach fill data are excellent and again, handling losses from the finer sizes can be used to explain the coarser and slightly better sorted (smaller phi sorting) fill materials. The fill sands were collected from 2 to 16 days after placement (average 5.3 days). Beach profile surveys were also conducted before nourishment and at the same time the fill was sampled. Comparisons of the surveyed volume differences and the volume transported by the scows indicate that approximately 10% of the barged sediments were lost during rehandling and placement (e.g. 3,130,854 m^3 barged vs. 2,804,082 m^3 paid for in-place on the beach).

Finally, the elements in these analyses are interdependent and the results are often as good as the weakest element. Model predictions depend upon composite properties, which depend on sampling coverage, etc. The models look promising but are still being tested by monitoring the performance of real beach fills. The scow and fill sampling appears adequate and the loss data reliable during placement. The sampling was weakest for evaluating the offshore borrow sediments and the following paragraphs describe an experiment designed to obtain better offshore data to provide an actual example of dredge and loading losses.

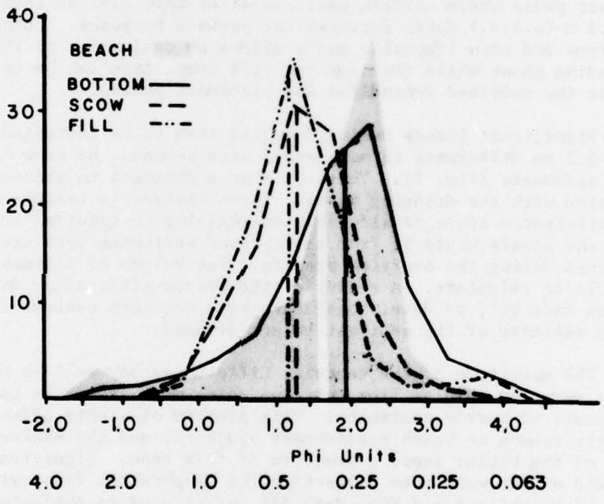

FIGURE 2 Incremental grain size distributions, Rockaway Beach, New York, 1975. Mean grain sizes indicated by vertical lines and gap in native pattern (Data in Table I).

NEW RIVER INLET, NORTH CAROLINA

Description: This field experiment was conducted in conjunction with a maintenance dredging operation conducted by the Wilmington Corps of Engineers District office. The area dredged crosses a shoal complex to provide boat access to New River Inlet, NC (Fig. 3). This area is characterized by high energy waves and currents and usually requires yearly maintenance. Dredging of the channel was performed by the side-caster dredge MERRITT into the split-hull barge *CURRITUCK* which was used to transport and place the sediments in a shallow (approximately 3 m) nearshore dump zone located about 1 km downcast from the inlet.

The dredged sediments were pumped directly into the hopper barge through the sidecaster's discharge pipe as the two vessels, joined bow-to-bow moved through the area. The hopper required about 20 minutes to fill to its 214 m^3 capacity. Overflowing began after about 3 minutes of pumping and continued for the remaining 17 minutes of loading.

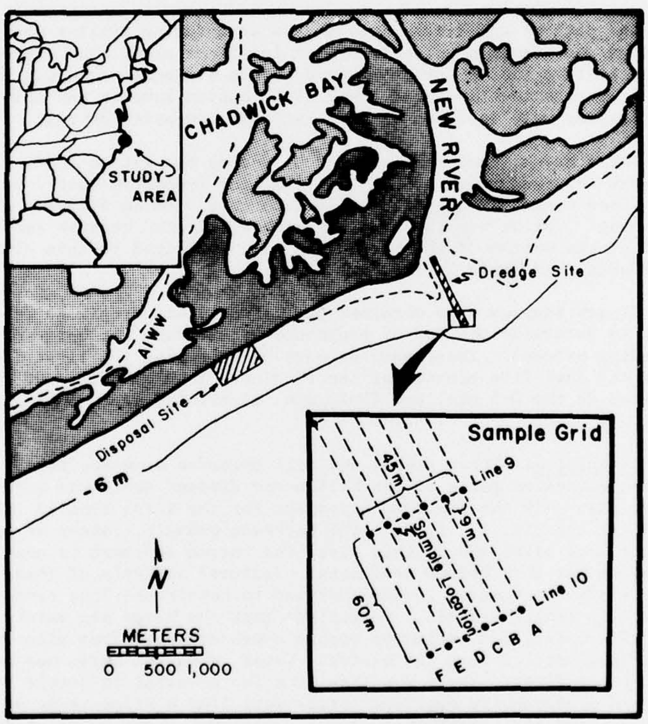

FIGURE 3 Dredge and dump areas, and generalized sampling plan for bottom sediments, New River, NC.

Sampling: Sediments from the native beach, dredged shoal area, hopper barge, and overflow slurry were sampled. See Hobson (1977b) for additional description of the sampling procedures.

Native beach sediments were characterized using forty-five surface samples that were collected at 7.5 m intervals along one profile line located in the area labeled "disposal site" on Fig. 3. This profile line extended normal to the beach from the storm berm offshore to minus 4.5 m MSL. Divers used an anchored polypropelyene line to locate the offshore sampling positions.

SCUBA divers also collected 66 bottom samples from the channel area to be dredged. Sampling was performed one day prior to commencement of dredging. Sampling locations were determined using a 6 by 11 orthogonal grid (Fig. 3, insert) which was established over the area using marker bouys. The samples were collected by inserting a plastic vial approximately 8 cm into the bottom sediment which was selected as a reasonable dredging depth for one pass of the dredge suction head.

The path of the dredge through the area during filling was determined and bottom samples from grid locations along each path were used to obtain composite properties of bottom sediments dredged. Each bottom composite is the averaged gsd of 11 bottom samples and only 3 bottom samples were included in more than one composite average.

Three barge loads were sampled by coring the entire load. These cores were obtained using a SLIC (Suction Line Insertion Corer) coring device (Gold Coast, 1973) which collects a core 5 cm in diameter and up to 3 m long. Coring was the sampling method selected because sediments located at the bottom of the barge load were subjected to less elutriation effects than upper layers.

Slurry samples were obtained during one filling episode in an attempt to determine the gsd of sediments washed from the barge during the loading process. These samples were taken during the first five minutes and last five minutes of the 20 minute loading cycle and are identified as the 0-5 min. and 15-20 min. elutriated sands on Table II and Fig. 4.

Discussion: Three dredge and fill episodes were monitored. However, the composite gsd's of the bottom and dredged sediments were so similar, that only the averaged composite for the three runs is included in Table II and Fig. 4. As with the Rockaway example, losses were from the finer sand sizes and in this case, the barged sediment is nearly 0.14 mm coarser than bottom sediments. Textural analysis of these elutriated sands shows early losses confined to nearly one fine sand size (0.13 mm for sample 0-5 min.) indicating that the barge was mainly filled with water, and sediments washed overboard were from sizes too fine to have settled from the slurry. Later, when the barge was nearly filled with sediment, there was less time for material to settle to the bottom and consequently overflow losses were from a wider range of sizes (0.7 to 0.13 mm for sample 15-20 min.). Although these two elutriated samples are insufficient to determine the composite grain size distribution of all sediments lost during dredging/loading operations, they do support the interpretation that losses should be from the finer sizes and that sediments deposited at the bottom of a load would be less winnowed than those at the top. A third assumption might be that there should exist a coarse size limit to sediments lost during a specific handling operation.

TABLE II Cumulative percentages coarser than phi size; mean and sorting parameters; and beach fill model predictions, New River Inlet, NC, 1975.

SEDIMENT SOURCES

	Elutriated Sands		Native Beach	Bottom Sand	Barged Sand
	0-5min	15-20min			
Phi Size -0.5		0.0	0.0	1.3	3.4
0.0		0.1	0.6	4.5	15.3
0.5		0.6	1.9	12.6	31.7
1.0		2.2	8.9	38.8	55.6
1.5		18.7	12.5	62.5	70.0
2.0		55.3	29.4	76.1	82.6
2.5	0.0	79.2	58.5	87.0	98.3
3.0	83.7	94.6	89.9	96.0	99.9
3.5	100.0	100.0	99.3	100.0	100.0
Mean Size (ϕ)	3.00	2.03	2.39	1.51	1.04
Mean Size (mm)	0.13	0.24	0.19	0.35	0.49
Sorting (ϕ)	0.09	0.58	0.80	0.91	1.02
Fill Factor (R_A)	-	-	-	1.00	1.00
Renourishment Factor (R_J)	-	-	-	0.29	0.13

Textural modifications due to handling have not affected the beach fill model predictions too much in this case since the high energy area dredged contains coarser-than-native beach sediments. Consequently, inspection of Table II shows that the fill factor model (R_A's) predicts that no overfilling is necessary should either bottom or dredged materials be selected as fill, and that both borrow materials would out-last native sediments but that the coarser barged material would last about twice as long as bottom sediments (R_J's).

Dredge production information can be used to estimate the volume of sediments lost during these handling operations. The measured production rate in sand for the dredge MERRITT is 10.8 m^3 per minute. The barge CURRITUCK, equipped with a displacement-type load metering system, took on 9.1 m^3/min averaged over 115 loading cycles needed to dredge the inlet channel to New River. Comparison of these two load rates suggest that 15.7% of the sediments pumped were lost during barge filling. No bulking factors were included in these calculations.

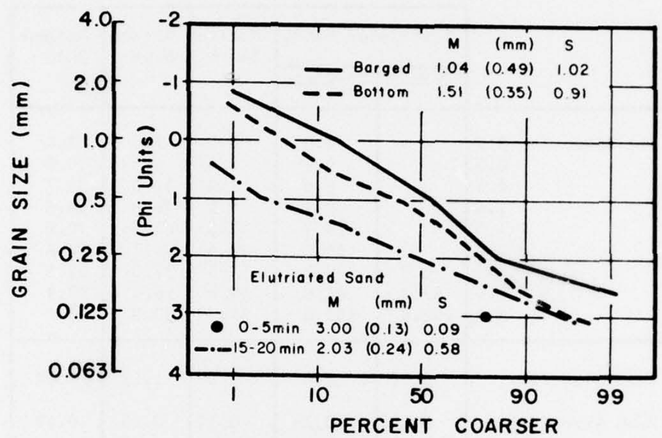

FIGURE 4 Composite grain size distributions for barged, bottom and elutriated sand samples. (Millimeter equivalents of phi mean (M) in parentheses).

CONCLUDING REMARKS

This paper presents results, to date, of an ongoing effort to quantify and predict sediment losses associated with the nourishment of beaches from offshore borrow sources. Therefore, conclusions as such are premature and the following remarks are included to summarize trends that recur in the analysis of the available data.

1. Dredging and handling operations seem to produce significant textural differences between original bottom sediments and sediments delivered to the beach. In general, these differences are an increase in grain size and a decrease in the sorting of delivered vs. bottom sands, which are produced primarily by the winnowing of finer sediments.

2. Textural changes produced through handling can affect the estimates of overfill and renourishment elements of project design. In general, the changes tend to improve the predicted performance of actual sands delivered to the beach.

3. Volumetric losses resulting from winnowing associated with plant operations appear to be fairly high considering that a nearly 16% loss is indicated in the New River example where coarse grained sediments were involved and a 10% loss is indicated at Rockaway Beach for the rehandling and placement phases of that project. Volumetric losses during dredging for Rockaway could not be determined.

4. It is difficult to obtain enough sand samples to adequately describe offshore borrow deposits and thus predicting textural modifications due to dredging becomes difficult as well. These data are needed and one way to improve borrow site evaluation may be to conduct a two phase investigation to first determine the general location and content of sand deposits within a region followed by a second and more detailed sampling of what appears to be the best location(s).

5. Volumes of sediments lost during handling operations can be expected to vary both with the type of equipment used and with the textural properties of bottom sediments dredged. Data that describe the performance of dredging plants are seldom detailed enough to account for the many possible substrate conditions and thus an alternate technique would be useful to assess dredging losses. One approach that seems promising uses composite textural properties of barged and bottom sediments to estimate these losses but results using this approach are too incomplete to discuss in this paper.

ACKNOWLEDGEMENTS

Thanks go to Mr. Gilbert Nersesian, New York District Office, U.S. Army Corps of Engineers, for having the forsight to closely monitor the construction phases of the Rockaway beach fill project and the generosity to share the results of his efforts.

Thanks also go to Dr. Bob Schwartz and Mr. Frank Musialowski, CERC, for their tolerance at New River. They permitted the small dredging experiment described to interrupt their larger field effort at New River of monitoring the performance of beach fill sediments placed in a nearshore dump zone by the split-hull barge CURRITUCK (Fig. 3).

This work was carried out under the Beach Fill Sediment Criteria work unit of the U.S. Army Coastal Engineering Research Center (CERC). The report was prepared under the general supervision of Dr. Craig Everts, Chief, Geotechnical Engineering Branch.

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1. REPORT NUMBER: R 78-10 CERC-REPRINT-78-10	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): 6 SEDIMENT HANDLING AND BEACH FILL DESIGN	5. TYPE OF REPORT & PERIOD COVERED: Reprint
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): 10 R.D./Hobson	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Department of the Army, Coastal Engineering Research Center (CEREN-GE), Kingman Building, Fort Belvoir, Virginia 22060	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: D31235
11. CONTROLLING OFFICE NAME AND ADDRESS: Department of the Army, Coastal Engineering Research Center, Kingman Building, Fort Belvoir, Virginia 22060	11 12. REPORT DATE: February 1978
	13. NUMBER OF PAGES: 14
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report): UNCLASSIFIED 12 15p.
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Beach erosion
Beach nourishment
Coastal engineering
New River Inlet, North Carolina
Rockaway Beach, New York
Shore protection
Sediment

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Offshore sand and gravel deposits constitute an extensive mineral resource whose importance and economic value increase steadily as onshore and lagoonal sources become unavailable. One major use of these marine deposits is for beach nourishment where the amount of initial fill material needed and the expected periodic renourishment requirements are usually estimated using fill factor and renourishment beach fill models, respectively. Textural properties of borrow site and native beach sediments are used as the basic input for → next page

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beach fill model calculations. Alterations to borrow sediment texture properties by dredging and handling techniques can significantly affect both the predicted response of the sediments after placement in the beach environment and economic aspects of the project.

Two cases are examined where adequate data are available to quantify some effects of dredging and handling on sediment texture. The first, Rockaway Beach, NY, is a large, ongoing nourishment project while the second case at New River Inlet, NC, is an experiment designed, in part, to provide handling-loss sedimentary data.

At Rockaway, sediments were dredged, barged, rehandled and hydraulically pumped onto the beach. Sediment losses due to elutriation of finer particle sizes during the dredging/barge-filling and rehandling/fill-placement phases of the project produced a fill sediment that was coarser and contained fewer sizes (better sorted) than the bottom sediments dredged. Approximately 10% of the sediments barged to the rehandling station were lost during rehandling and placement on the beach.

Comparisons of dredged and predredged sediment textures at New River Inlet indicate a handling loss of nearly 16% from the medium to fine sand sizes (0.5 to 0.06 mm). These losses resulted in a dredged sand that was about 0.14 mm coarser than predredged bottom sediments.

Conclusions to date from this ongoing research effort are as follows. Both cases studied indicate that the winnowing of fine sediments during handling operations produces fill sands that are generally coarser and better sorted than bottom sediments, and that these changes tend to improve the predicted performance of fill sediments. Volumetric losses are fairly high for the examples presented and such losses deserve consideration when estimating the overfill and renourishment elements of project design.