

BURIAL OF DREDGED SEDIMENT BENEATH THE FLOOR OF NEW YORK HARBOR

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Abstract

2. Background

Subaqueous burial of dredged sediment beneath the sea floor may be one way to better isolate and contain contaminated sediments on a disposal site as well as to restore the disposal site to the ambient conditions. The technology is available to construct a deposit of dredged sediment in a pit which might be mined into the sea floor and to cover, or cap, this deposit in the sand using conventional equipment. Such a project has been designed for a disposal site in New York Harbor. The deposit of dredged sediment is to be constructed in three stages and will ultimately contain about 915,000 yd³. The form of the first stage was predicted empirically using isopach maps of dredged sediment mounds in other areas. The first stage has been completed and its form was adequately anticipated.

1. Introduction

Open-water disposal of dredged sediment is the usual method of disposal in the northeast United States. Much consideration, however, is being given to alternative disposal methods [1] mainly for two reasons. One reason is to better contain and isolate contaminated dredged sediment from the environment. Many of the most troublesome contaminants are associated with fine-grained sediment particles and two of the goals in the search for disposal alternatives are to insure that particles will stay at the disposal site and to provide a chemical environment that will enhance the probability that contaminants will not leach out of the sediment. Another reason that disposal alternatives are being investigated is to find constructive uses for dredged sediment. As competition among various uses of our marine resources increases, the need to provide for multiple uses becomes more pressing and, in some cases, the disposal of dredged sediment can be beneficial. Some dredged sediment, for example, can serve for beach nourishment or for the creation of wetlands or islands. In the Town of Hempstead, NY, dredged sediment has been used to fill under-water pits that had been dredged originally to provide sand for construction [2].

In New York Harbor, the submarine burial of dredged sediment may be a disposal alternative to meet both objectives; it is a method for isolating and containing dredged sediment and it provides a mechanism for reclaiming areas of the sea floor that have been disturbed by submarine sand-mining operations. Sand has been mined from the floor of New York Harbor and several large borrow pits remain from these operations. The sand that has been removed from these pits has played a vital role in construction in the New York metropolitan area. There are concerns, however, about the possible adverse environmental effects due to the pits.

One concern is that they may alter the waves and tidal currents and possibly aggravate shore erosion. Mathematical models of the waves and tides in the harbor show that the waves and tidal currents will indeed be measurably affected by the presence of the pits [3,4]. The impact of any changes in the waves or tides on shore erosion, however, is difficult to assess.

Other concerns arise from the fact that several of the largest pits are known to be natural traps for mud. Little or no mud is deposited on the sandy sea floor around the pits; but in them, mud is accumulating at rates that are about 100 times faster than typical natural rates in other estuaries [5]. Not only is this mud as contaminated as the usual harbor sediments but it also has a relatively high organic content and, as a result, there is concern that it may cause the water column to become anoxic at certain times of the year. Measurements show that the pits do affect the oxygen demand. Lower oxygen concentrations are generally found in the pits there and, at times, the water over the pits becomes anaerobic [6]. The muddy pit floor also supports a smaller biological population than that found on the neighboring shoals [7].

The capability to fill these pits in order to reclaim the sandy sea floor would seem to be a desirable goal, but even one of the smallest pits has a volume of over 2 million yd³. The cost of filling such a pit would be prohibitive unless a source of free material was available. Dredging

may provide that material and, in addition, burying dredged sediment in submarine pits has its own advantages. The pits are attractive containment sites because mud is naturally accumulating in them at very rapid rates and the pit wall will help to contain the dredged sediment [8]. If dredged mud was deposited in the pit and covered, or capped, with a blanket of sand, then not only could the harbor floor be restored to its pre-mined condition but also the dredged mud could be buried beyond the reach of most burrowing animals and beyond the depth of disturbance by storm waves. Burial at sea also eliminates the problems of ground-water contamination that may be a concern with upland disposal.

Such a disposal operation is technically feasible. Based on experience at open-water disposal sites, it appears that a compact deposit of dredged mud can be made using standard equipment, that the discharges can be adequately controlled to construct a deposit of suitable size and shape and that it can be capped with sand [9]. Compact deposits have been constructed on the sea floor and documented at several locations. Dredged sediment deposits in Long Island Sound are examples of this. Dredging is usually done here with clam-shell dredges, and point-discharges at a disposal buoy are used. One deposit of dredged mud contains about 1.5 million yd³ within a 270 yd radius [10]. During the discharges of this sediment, less than 1% was lost [11] and losses during disposal operations at other sites were less than 5% [e.g. 12]. Two other deposits there contain 139,000 yd³ and 77,200 yd³ with radii of 110 yd and 220 yd respectively [13]. Both of these deposits are very compact and their compactness is due in part to the use of point-dumping at a special taut-line disposal buoy. The disposal buoy was designed to maintain its position to within 3 ft and barges were discharged as close to the buoy as possible.

Covering, or capping, submarine mounds of dredged mud with a thick layer of sand has been done successfully using conventional techniques. In Long Island Sound a mud deposit was capped with a layer of sand several feet thick [13]. This cap has maintained its integrity to date, three years after it was created, and it is apparently stable mechanically [14]. Another mound of dredged mud was capped with a sand layer about 3 ft thick at the open-water disposal site on the shelf outside of New York Harbor.

Studies of the feasibility of the burial of dredged mud beneath the sea floor have led to the design of a relatively small project in New York Harbor. As I shall explain, this demonstration project was designed to be done in three stages. The first stage has been completed, but the second and third stages have been delayed. After I discuss the objectives and requirements of the project, I will present the results of the first stage of the operation and the plans for the second and third stages.

3. Objectives and Requirements

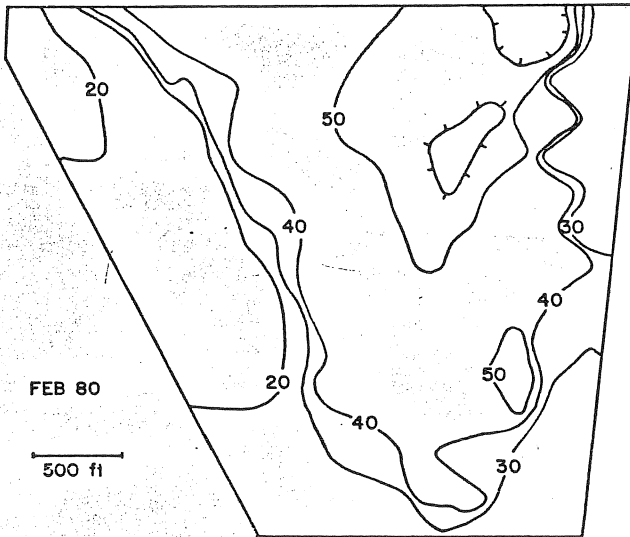
The demonstration project and the monitoring plan were designed to answer many questions; the most basic question to be answered was merely "Can you do it?" As a result, the demonstration project was planned to be as similar as possible to a hypothetical, full-scale burial operation, but it was decided to do it on a relatively small scale for several reasons. It would be easier to maintain control over a small, short-term project and only a relatively small area of the harbor floor would be committed to receiving the dredged sediment. The entire project could be completed in a fairly short time so that the entire procedure could be documented in a timely manner. The composition of the dredged sediment was likely to be more homogeneous in a smaller project than it would be in a larger one; this would facilitate the planned chemical and physical studies of the deposit. It would also be less expensive to do intensive monitoring on a small project than it would be on a large one. Finally, in the event that something should go wrong the effects of a smaller project should be proportionally less than those of a larger operation and, logistically, it would be easier to amend the procedure or to carry out remedial work on a small-scale project. The project was, nevertheless, to be large enough so that changes in the deposit could be monitored.

The demonstration project had the following characteristics. The dredged material was to be fine-grained because fine-grained sediments often have the most serious contamination and, therefore, they are the most likely candidates for this disposal alternative. The mud would be dredged with a clam-shell bucket to insure the creation of a compact deposit [10] and to enhance the internal stability of the deposit [14]. The mud layer was to be at least about 6 ft thick so that the consolidation of the deposit might be detected by comparing precision bathymetric surveys. The cap was to be sand in order to restore the sandy sea floor in the disposal area. In addition, the sand cap would have a high permeability to prevent the build-up of high pore water pressures during consolidation and to allow the escape of gas bubbles. The cap was to be at least 2 ft thick to bury the mud beyond the reach of burrowing organisms and to bury it beyond the depth to which storms disturb the bottom sediment [15]. Finally, at the suggestion of the committee, the final level of the cap was to be slightly below the level of the ambient sea floor because the relief of the sea floor attracts fish.

The disposal site was to be a submarine pit whose floor was at least 9 ft below the ambient sea floor. The disposal area was to be as small as possible; but, because of the way in which dredged sediment is deposited on the bottom after it is released from a scow, the minimum radius of the disposal pit needed to be about 220 yd [9]. As a result of the small size of the disposal area,

the discharges would have to be closely controlled. Point-dumping at a disposal buoy was required. Finally, the disposal area was to be in a region of the harbor that was relatively homogeneous, so that both the disposal site and a control area could be chosen that have similar environmental conditions.

It was not possible to excavate a new pit especially for the demonstration project because of a variety of technical environmental and policy concerns and no existing pit was entirely appropriate. The most attractive area was the southern tip of one pit (Figure 1). In this area, the disposal



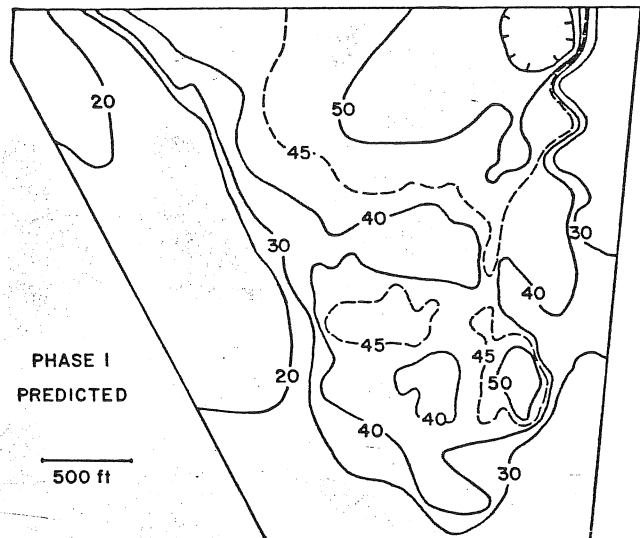
Pre-disposal bathymetry
Figure 1

operation would be done in three stages. In the first stage, dredged sand would be discharged to construct an underwater ridge of sand across the northern part of the disposal area to form a compartment in the southern tip of the pit with the proper dimensions. During the second stage, dredged mud would be deposited to partially fill the compartment. The third stage would be a sand cap to cover the mud deposit.

4. Stage I

Before the project began, the form of the first stage was predicted simply by superimposing isopach maps of dredged sediment deposits in Long Island Sound [13] onto the initial bathymetry of the disposal area. One of the deposits in the Sound had a volume of about 139,000 yd³ and the other, 77,200 yd³; these were created by point discharges of dredged sediment. The geometries of these projects were similar to deposits in other areas where the sediment was dredged with a clam-shell bucket and point-dumping was used. The prediction of the ridge geometry was done by assuming that a large mound would be constructed

to form the ridge's midsection and that two smaller mounds would be constructed to the east and west of the large mound. The resulting deposit contained 293,400 yd³ (Figure 2). I allowed for a

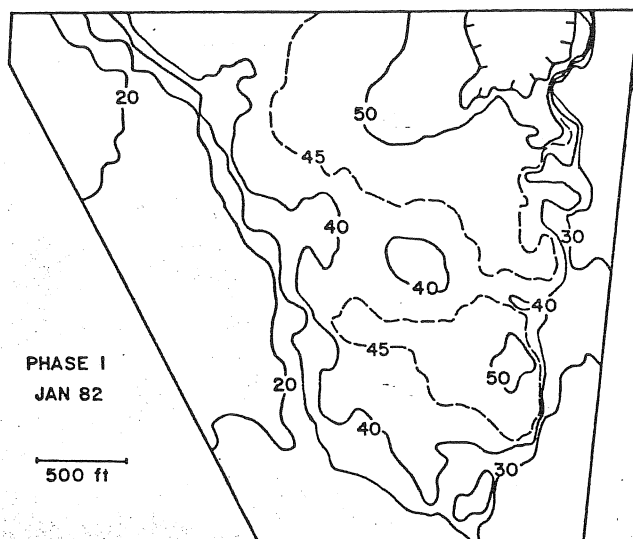


Predicted bathymetry after the
completion of the first stage
Figure 2

5% loss of sediment during the disposal operation so that 308,000 yd³ would be required for the first stage. The average water depth at mean low water over the top of the ridge was predicted to be about 37 ft.

The ridge was constructed in December 1981 by the hopper dredge *Goethals* using sand from Ambrose Channel. Discharges were intended to occur along a line defining the ridge crest with about half of the discharges being made in the center third of this line. Three range buoys were set to the west along the westward extension of this line but the positioning of the dredge at the discharge location was done by microwave navigation. One hundred and sixty-five discharges were made and the exact locations of 85 of these were plotted. More than half of the discharges occurred within 100 ft of the intended discharge line. This is very good accuracy considering that the *Goethals* was 476 ft long and, although there was ample water for the dredge to get into and out of the pit there was little room to maneuver because shoal water was within 1 and 3 boat-lengths to the west and south of the discharge location.

The deposit that was created by the *Goethals* was in a form that was close to the predicted form (Figure 3). The average water depth over the ridge crest was 39 ft; the predicted value was 37 ft. The 50-ft depth contour was displaced about 270 yd to the north as predicted and the locations of the lowest points along the ridge crest were to the east and west of the center as predicted. The volume of the ridge was difficult to determine



Actual bathymetry after the completion of the first stage
Figure 3

because the pre-disposal survey of the pit had a less dense coverage of survey lines than the survey done after the first stage was completed; the ridge contains at least 220,000 yd³ which is close to the predicted value. The actual ridge, however, is more peaked than the predicted form. The compartment that was created south of the ridge has a total volume (to the ambient sea floor) of 735,000 yd³.

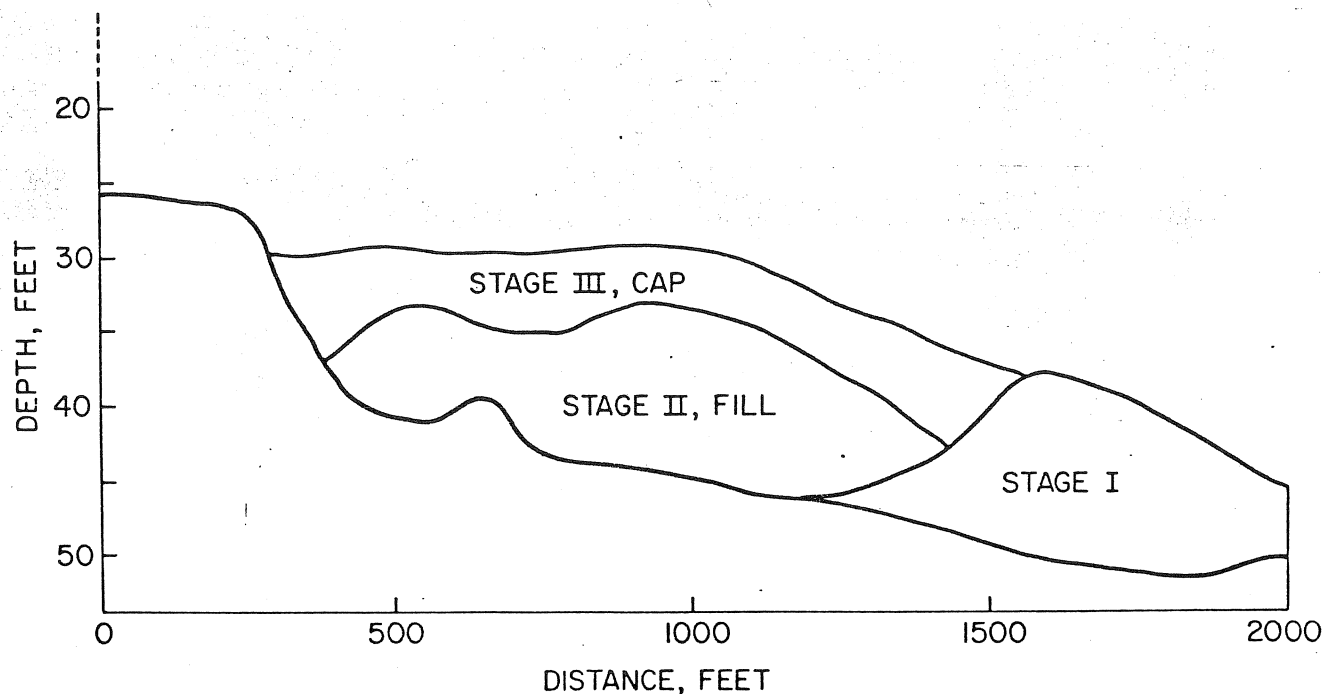
5. Stages II and III

Similar predictions were made of the forms of the second and third stages. The remaining two stages will bring the level of the deposit near to the level of the ambient sea floor in the southern part of the disposal area. As required, a slight depression will be left over the deposit. The sand cap is intended to be at least 2 ft thick over the entire fill deposit. The surface of the sand cap will slope downward to the north to reach the ridge crest. A cross-section of the intended deposit is shown in Figure 4. About 385,000 yd³ of mud and 310,000 yd³ of sand are required for the final two stages.

Dredging projects to supply the required sediment have been identified and arrangements have been made to begin dredging. The work has been delayed, however, because of pending litigation concerning one of the certificates needed to conduct the disposal of the dredged sediment for the second stage.

6. Conclusions

The technology is available to bury dredged sediment beneath the sea floor using usual disposal methods. Such a project is not merely a disposal project but rather an engineering operation to create a particular sediment deposit on the sea floor. For planning purposes, adequate predictions of the forms of the deposit can be made empirically



Predicted cross-section through the completed deposit
Figure 4

using isopach maps from existing deposits. The successful implementation of disposal alternatives, like the one discussed here, demands more careful control of the discharge location than is usually exerted.

7. Acknowledgements

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