The use of dredged material in environmental restoration or rehabilitation programs represents an almost unique circumstance where two types of problems are solved with a single action. The need for dredging may be initially prompted by a societal need for continued or new economic development, while the availability of material for new substrate in or near coasts and waterways can produce environmental effects increasing the overall societal benefit associated with the project. Individual projects can move hundreds of thousands of cubic yards of material and result in hundreds of acres of new or rehabilitated wetlands. In Louisiana, even dredging projects in the Chenier Plain remote from the continually dredged Mississippi River, have created almost 500 acres of wetlands within the last several years. However, such 'beneficial uses' do not come easily and require exceptional cooperation among state, federal and local governmental agencies as well as landowners and others interested in solving environmental problems. The movement of large volumes of sediment from one location to another disrupts existing 'habitats' at both the dredging location and the disposal site. Consequently, the environmental effects must be carefully evaluated in the light not just of the proposed benefit for one particular restoration goal but in terms of the habitats that are lost or replaced by the dredging or material placement.

Dedicated dredging for environmental benefits involves the same kind of trade-offs. While many may recognize the need for greater wetland acreage to offset losses associated with development, commercial harvesters who live from catch to catch will not always accept changes in depth and character of dredged waterbodies as well as increased turbidity associated with dredging activities. Education concerning the long-term need to sustain ecosystems to support harvestable species is frequently seen as the solution - more pragmatically, compensation for losses included as part of project costs may be the best short-term solution.

Despite these challenges to implementation, all over the world dredged material is being used to rebuild lost substrate, kick-start restoration projects, and provide habitat for important species. Economic growth and environmental restoration are frequently incompatible objectives in planning and management. Beneficial use of dredged material is an issue where societal and environmental needs can converge - the challenge is in planning material use such that worthwhile environmental projects can be implemented at the time and in the place where the dredging must take place.

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The dredging of ports and harbors is an economic necessity that cannot be avoided. Historically, dredged materials have been used as fill to create upland habitats or placed offshore. Upon realization that filling aquatic habitats with dredged materials was significantly impacting species abundances and environmental quality, finding acceptable disposal options for dredged material became a top priority. The Dredged Material Management Plan (DMMP) has been initiated by the U.S. Army Corps of Engineers, New York District (USACE-NYD), in cooperation with the Port Authority of New York/New Jersey, to investigate cost-effective and environmentally acceptable alternatives for the placement and disposal of contaminated and non-contaminated dredged materials. USACE-NYD produced a technical report under the DMMP describing potential beneficial uses of dredged material from the NY/NJ Harbor for habitat creation and enhancement. The advantages, disadvantages, potential volumes, and estimated costs associated with each creation/enhancement option are analyzed. While beneficial use options in NY/NJ Harbor will not consume all of the material being produced by maintenance dredging, the potential of consuming significant amounts of dredged material in the future, while enhancing the overall environmental quality of the Harbor has become a top priority.

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Instantaneously released sediments form axisymmetric "clouds" resembling self-similar thermals. Current particle cloud models employ thermal theory and an integral approach using constant entrainment (\(a\)), drag (\(C_d\)) and added mass (\(k\)) coefficients. Our aim was to investigate how real sediment characteristics (particle size, water content and initial momentum) affect cloud behavior and hence time variations in \(a\), \(C_d\), and \(k\).

Flow visualization experiments were conducted using a deep glass-walled tank, a quick-opening sediment release mechanisms, and various cohesive and non-cohesive particles. Particle sizes were scaled to real-world dimensions through the cloud number (\(N_c\)) defined as the ratio of the particle settling velocity to the characteristic cloud velocity. An "inverse" integral model was developed in which conservation equations were solved for \(a\), \(C_d\), and \(k\) using measured velocity and radius data.

The non-cohesive sediments rapidly formed "turbulent thermals" with asymptotic deceleration and large growth rates (\(a = 0.2-0.3\)). These turbulent thermals eventually evolved into "circulating thermals" with linear growth rates obeying buoyant vortex ring theory. In this latter phase, large particles (\(N_c > 10^{-4}\)) produced laminar-like vortex rings with smaller \(a\) (0.1 to 0.2). Compared to the cohesive sediments, which exhibited a wide range of growth rates, changes in water content and initial momentum of the non-cohesive particles produced only a 10-20% variation in \(a\).

Inverse integral model results suggest that \(C_d\) and \(k\) are near zero within the "thermal" phase. In the "circulating thermal" phase, the reduction in \(a\) caused by the large particles (\(N_c > 10^{-4}\)) increased \(k\) to a value similar to that of a solid sphere. Integral model results confirm the suitability of using constant coefficients for modeling particle clouds with \(N_c < 10^{-4}\), while for \(N_c > 10^{-4}\), time-varying \(a\) and \(k\) are required to properly simulate cloud behavior in the circulating thermal regime.

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Open-water disposal and capping are promising solutions for disposal of the 14 to 28 million m$^3$ of contaminated sediment dredged annually in the United States. However, such practices raise concerns about the feasibility of accurately placing the material in a targeted area and the loss of material to the environment during disposal.

To investigate the question of sediment loss during disposal, laboratory experiments were conducted in a deep glass-walled tank using a quick-opening sediment release mechanism and a specially-designed curtain shade serving as a "sediment "trap". Both non-cohesive and cohesive sediments were utilized under a variety of release conditions (varying initial momentum, water content, initial stirring, etc.). Data consisted of digital images of particle clouds illuminated by laser-induced fluorescence, and measurement of sediment mass captured on the trap at various stages of cloud descent.

Despite the fact that sediment was released nearly instantaneously, much of the material was never incorporated into the cloud. Most such material formed a narrow "stem" behind the cloud, with the stem containing as much as 30% of the original mass depending on the release conditions. Much of the stem material either re-entered the cloud later in descent or reached the bottom shortly after the cloud. Material not incorporated into either the stem or the cloud could easily be advected off-target by ambient currents. However such material was found to account for less than 1% of the original mass.

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In July 1996, the US Environmental Protection Agency (U.S.EPA) began a Superfund investigation of the 43-square kilometer area of dichloro-diphenyl-trichloroethane (DDT)- and polychlorinated biphenyl (PCB)-contaminated sediments in an area known as the Palos Verdes Shelf near Los Angeles, California. The sediments, termed effluent-affected, are present as a result of discharges from the ocean outfall system operated by the Los Angeles County Sanitation Districts. US EPA's investigation has included an evaluation of human health and ecological risks posed by the DDT- and PCB-contaminated sediments, as well as an evaluation of potential clean-up actions. US EPA looked at a number of options for sediment restoration and identified in-situ capping as the most feasible cleanup action that could be taken in the near term to address human health and ecological risks at the site.

As part of its ongoing evaluation of in situ capping, US EPA undertook a pilot capping project at the site in the summer of 2000. This demonstration project consisted of capping all or a portion of three 0.18 square kilometer (45-acre) cells at water depths ranging from approximately 40 to 60 meters. Two types of cap material were used in the pilot project (a fine-grained sediment and a coarser-grained sand) and a variety of sediment disposal (i.e., cap placement) methodologies were tested.

The overall objective of the field pilot study is to demonstrate that a cap can be placed on the Palos Verdes Shelf and to obtain field data on the short-term processes and behavior of the cap as placed. An extensive environmental monitoring program collected data before, during and after cap placement that will be used by US EPA to address key short and intermediate term questions relative to capping on the Palos Verdes Shelf.

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Environmental dredging windows are a management tool for reducing the environmental impacts of dredging and disposal operations on living resources, aesthetics, and recreation and tourism. Dredging windows are one of a number of management and technological tools that can be used individually or in different combinations to reduce undesirable impacts of dredging and disposal operations. The National Research Council Transportation Research Board's Marine Board, and the Ocean Studies Board are conducting a project on the application of environmental dredging windows in Federal Navigation Projects and is seeking information.

The goals of the NRC project are to review the process by which environmental windows are set, applied, and managed and to recommend ways to improve the process and the effectiveness of environmental windows as one of a set of management and technological tools used in managing dredging and disposal operations.

In the case studies being presented, we are interested in knowing whether, or not, environmental windows were used. If not, were they considered and, if so, why were they rejected? If they were used, what were the driving forces? What resources were threatened? What was the nature of the threat? Did the US Army Corps of Engineers and other Federal and state agencies involved draw upon the best scientific and technological information in setting the windows? Did they agencies cooperate in establishing the windows? I will distribute a short survey instrument to elicit information and recommendations.

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SORPTION AND TRANSPORT OF HYDROPHOBIC CONTAMINANTS THROUGH SEDIMENT CAPS: INCORPORATING THE EFFECTS OF BENTHIC INFAUNA

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Capping is a commonly used method for confining contaminated sediments. However, quantitative theories for determining optimal cap thickness that include the effects of mixing by benthic organisms are lacking. The goal of this study was to develop a mathematical model to predict the fate and transport of contaminants within a sediment cap due to bioturbation by organisms colonizing the capped sediments. The model was used to predict the cap thickness required to isolate contaminants from surface sediment and the water column. Benthic biological data collected in Boston Harbor were used to predict the minimum cap thickness required for a capping project in Boston Harbor. The biological data were collected from a sub-tidal site near the capping area that possessed sandy sediments. Thus, the potential existed for the sand caps to be colonized by a community similar to the one at the nearby sampling site.

The model predicted that a 20-cm thick cap would be sufficient to contain hydrophobic contaminants possessing an organic carbon-water partition coefficient (koc) greater than 106. For contaminants with lower values of koc, a cap as thin as 5 cm would be sufficient to limit surface sediment concentrations.

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Steep gradients in sediment type and contaminant concentrations in Boston Harbor have resulted in strong gradients in benthic community structure. Furthermore, contaminant loadings have changed greatly since the initiation of cleanup efforts in 1991. If benthic communities were responding to these environmental changes, we would expect to observe strong temporal changes in the benthos as well.

We have applied a new variation on a statistical technique broadly referred to as canonical analysis to the MWRA benthic dataset (1991-1998) to examine the spatial and temporal patterns in benthic community structure. The analysis identified the most important environmental factors that determine the observed spatial patterns. We also found that changes in community structure following the initiation of cleanup efforts have been comparatively small.

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