A CONCEPTUAL FRAMEWORK FOR ASSESSING DREDGING / DISPOSAL OPTIONS IN CHESAPEAKE BAY

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J. R. Schubel, Director

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TABLE OF CONTENTS

LIST OF FIGURES

INTRODUCTION

Throughout the entire United States more than 400 million cubic yards (300 million m^3) of material are dredged annually by the U.S. Army Corps of Engineers. Over the past decade, an additional 75 million cubic yards (60 million m^3) have been dredged each year by non-federally financed projects (Boyd et al., 1972).

Dredging has been a persistent activity in the Chesapeake Bay since colonial days and will continue to be if shipping channels are to be maintained, and if ports and marinas are to remain accessible. Projects for new work may also be desirable.

The major Federal navigation channels and disposal sites in the Maryland portion of the main body of the Bay and in Baltimore Harbor are shown in Fig. 1. Throughout the Maryland portion of the Chesapeake Bay estuarine system more than 330 million cubic yards (250 million m^3) have been dredged over the past 100 years. The partitioning of this total among the major federal projects and between maintenance and new work are summarized in Fig. 2.

Most materials dredged from Chesapeake Bay are composed of natural sediments from upland areas that are carried into the Bay by rivers and streams; smaller contributions come from shore erosion and primary productivity. The relative strengths of these three source terms vary with position within the estuary and with time at any given location. The shoaling of channels is frequently dominated by a proximate source of sediment--the resuspension of bottoms sediments by tidal scour and wind waves and the transfer of these materials to the channels where they are trapped. Since most of the materials that are dredged are natural soils and organic matter produced locally within the estuary, one would expect that their disposal need not create any serious environmental problems. In general this is true. But pollutants are added to rivers and directly to the estuary by municipal and industrial discharges, and by accidental releases.

The sources of most pollutants are concentrated near cities and ports. Since many contaminants are relatively insoluble in water and have a high affinity for fine-grained particles, they are rapidly scavenged by fine suspended particulate matter and end up on the bottom of the estuary in areas where fine-grained sediments are accumulating. One such locus of sites of accumulation is the network of shipping channels.

For the most part, the quality of material accumulating in a dredged channel is not very dissimilar to that of fine-grained material accumulating in shallower areas contiguous to that channel. The quality of the material, as measured by the levels of a variety of contaminants, does however, vary measurably from one channel to another. In some cases, the material in the channel may be somewhat finer-grained than sediments accumulating in contiguous areas and because of this may have higher concentrations of contaminants. Clearly, materials dredged from different segments of the Bay vary in their "quality" and may require different methods and areas of disposal.

A number of major research programs have been conducted in the United States over approximately the past decade on a variety of dredging and dredged material disposal problems, and on other waste disposal problems. Some of the larger programs have been sponsored by the:

- Dredged Materials Research Program (DMRP), U.S. Army Corps of Engineers
- U.S. Environmental Protection Agency
- Marine Ecosystem Analysis (MESA) Program, National Oceanic and Atmospheric Administration (NOAA)
- United States-Canada International Joint Commission

These programs and many other investigations have resulted in a voluminous

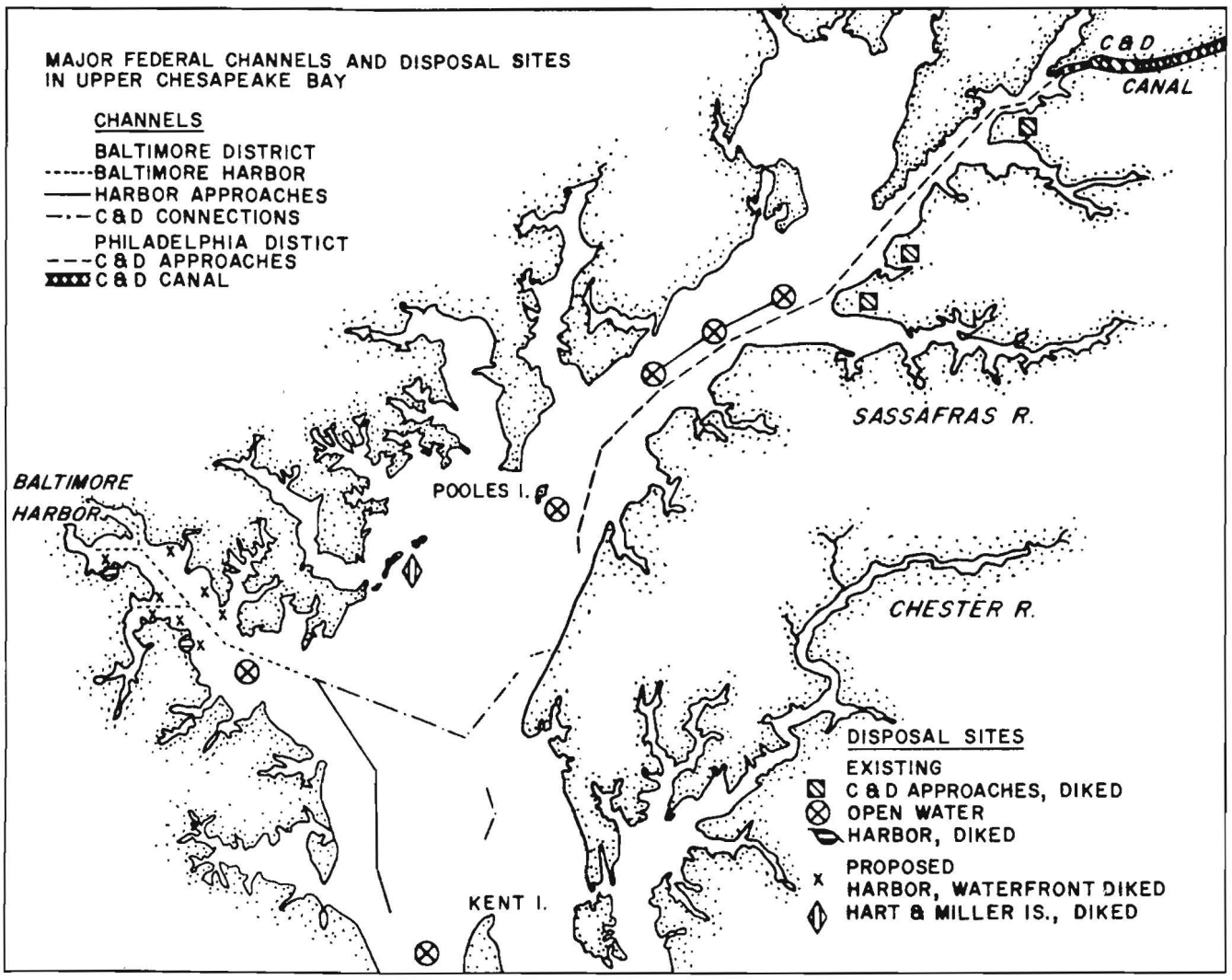

Fig. 1 Major Federal Channels and Disposal Sites in Upper Chesapeake Bay.

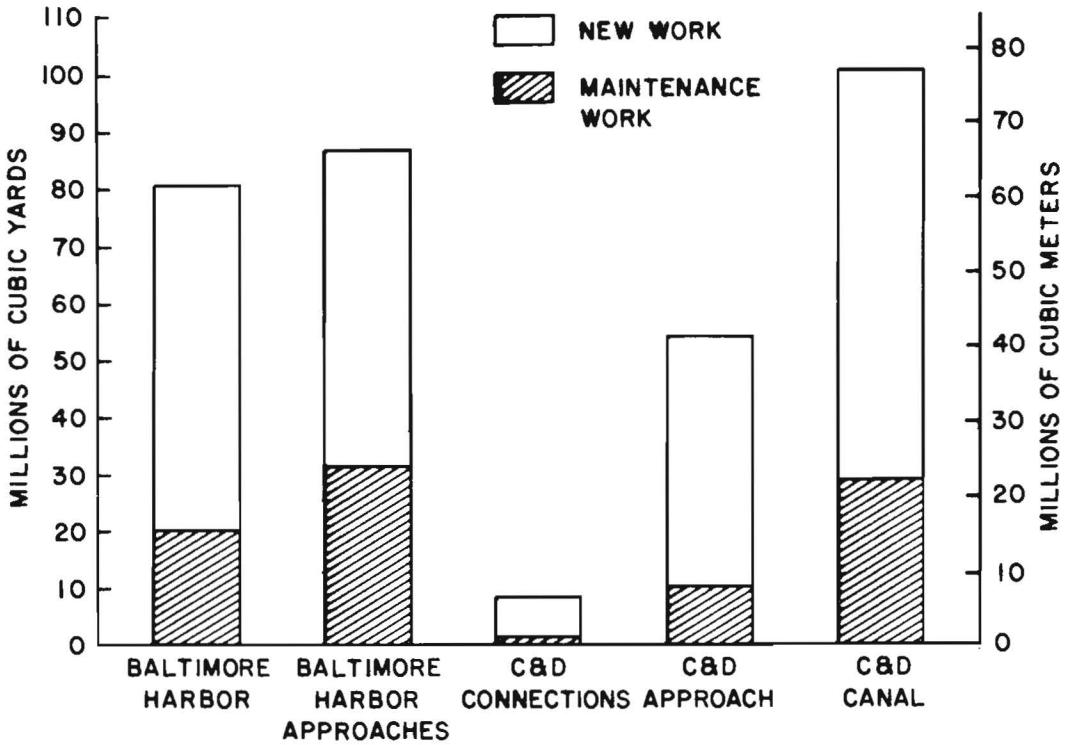

Fig. 2 Volumes of material dredged from major Federal navigation channels in the Maryland portion of Chesapeake Bay, 1870-1976. Data for the C&D Canal are for the *entire* Canal, not just the Maryland portion.

literature on dredging and dredged material disposal, much of which could be applied to the Chesapeake Bay.

The primary purpose of this report is to identify research needs specific to dredged material management in Chesapeake Bay. In some cases these needs could be met by applying existing results of laboratory, field and theoretical studies. In other cases, new programs will be required.

There are a number of distinct actions that should precede any dredging and disposal activity and one that should accompany it and perhaps follow it. These are shown schematically in Fig. 3, and are the subject of this report. We shall identify the questions that should form the basis for each action, assess our ability to answer these questions, and suggest where research is needed.

I. PERMIT APPLICATION

Every dredging operation requires one, or more permits.

Federal

Under section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. S401 et. seq.) the U.S. Army Corps of Engineers is charged with the responsibility of evaluating requests to make physical alterations in the navigable waters of the United States. A dredging operation is such a physical alteration. The District Office serves as a clearing house for other Federal, State, and local agencies concerning the environmental effects of a proposed action. The primary Federal agencies reviewing applications for physical alterations to areas under the aegis of the Baltimore District are the U.S. Environmental Protection Agency, the U.S. Fish and Wildlife Service of the Department of the Interior, and the National Marine Fisheries Service of the Department of Commerce.

The decision whether to issue a permit is based on an evaluation of the probable impact of the proposed activity on the public interest. That decision should reflect the national concern for both protection and utilization of important resources. The benefit which reasonably may be expected to accrue from the proposal must be balanced against its reasonably forseeable detriments. All factors which may be relevant to the proposal are to be considered; among those are conservation, economics, aesthetics, general environmental concerns, historic values, flood damage prevention, land use classification, navigation, recreation, water supply, water quality, and in general, the needs and welfare of the people. No permit will be granted unless its issuance is found to be in the public interest.

State

Any dredging project, except a U.S. Army Corps project, must receive a State wetland license or a private wetland license.

State wetlands include "any land under the navigable waters of the State below mean high tide, affected in the regular rise and fall of the tide" [NR S9-101(m)]. Private wetlands are any wetlands not considered State wetlands bordering on, or lying beneath, tidal waters which are subject to regular or periodic tidal action and support aquatic growth.

In reviewing applications, the State must decide whether the proposal is: "in the best interest of the State, taking into account the varying ecological, economic, developmental, recreational and aesthetic values" of each application.

The Water Resources Administration of the Department of Natural Resources also issues a water quality certificate for any proposed dredging action. U.S. Army Corps of Engineers' projects require only a water quality certificate. A grading and sediment control plan for spoil disposal sites needs to be obtained by an applicant from the local soil conservation district,

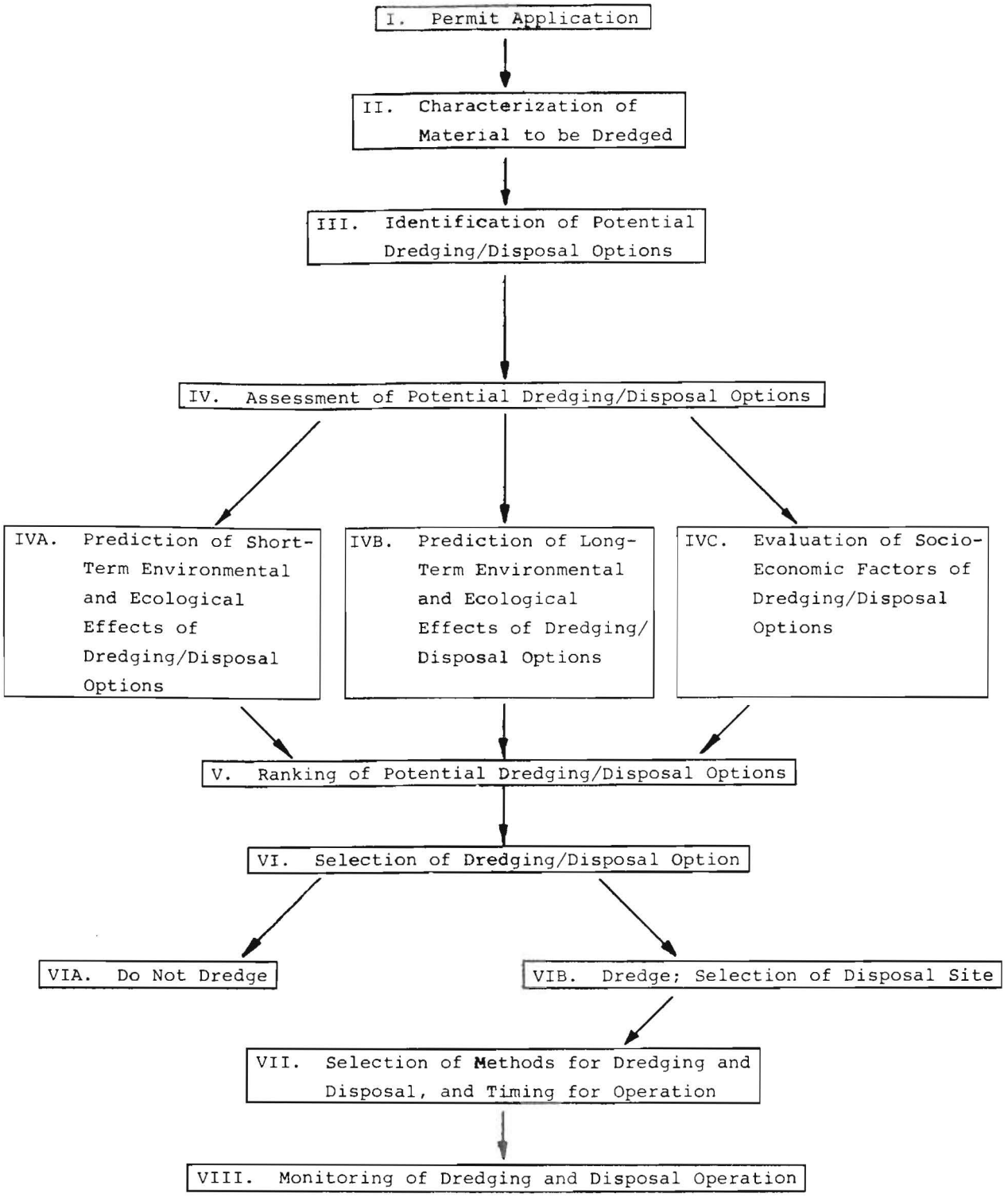

Fig. 3 A conceptual framework for assessing dredging/disposal options in the Maryland portion of Chesapeake Bay.

or the Baltimore City Department of Public Works.

Local

Some local ordinances may require approval of the proposed dreding project by the city engineer's office or similar agency.

In general, the Army Corps of Engineers will not issue a permit for a project unless the applicant can document that he has already received the necessary state and local permits. The average processing time for a dredging application in the Baltimore District Office is usually 2-4 months. If the proposed action becomes at all controversial, it may take much longer to go through the permitting process.

II. CHARACTERIZATION OF THE MATERIAL TO BE DREDGED

A prerequisite to the selection of appropriate disposal strategies and sites is a diagnostic characterization of the materials to be dredged. To attain this goal a number of objectives must be met. As a minimum, these are

(1) Identification of the parameters that should be determined.

The determination of certain parameters is required by law, but laws may change. There are some parameters that should be measured Bay-wide regardless of the location of the specific dredging/disposal project. Others should be added for specific projects based upon a knowledge of land uses of the adjacent coast and of inputs from the local drainage basin. An inventory should be maintained of new industries and other activities and a listing of how they might affect water and sediment quality. This should include a chronicling of direct point sources to the estuary, including additions from rivers that integrate inputs from throughout their drainage basins. A long-term sampling program should be initiated for the lower Susquehanna at, or near, Conowingo. To reduce sampling and analysis to tractable levels the River could be sampled only during the normal spring freshet and other occasional periods of very high discharge when the bulk of the suspended matter is introduced. Each sample should be analyzed for all constituents that have been identified as potential pollutants. A second, paired sample should be frozen for future reference. As new contaminants are identified, these older preserved samples could be analyzed to check for earlier occurrences and levels.

Since many channels require maintenance dredging at fairly frequent intervals, a long-term program of sediment characterization might alleviate the recurrent crises that arise with repeated maintenance dredging projects. Laboratory studies and controlled pilot disposal studies should be conducted to determine the transfer of contaminants from dredged materials to the biota, and to assess the biological responses of the biota to these contaminants. Initiation of a library of frozen samples from maintenance projects could be useful.

The metals for which analyses should be made are well documented; the list of chlorinated hydrocarbons and other organic compounds of concern is constantly changing. The physical properties of importance have been identified and pose no problem.

(2) Selection of the methods and analytical procedures to be used.

It is relatively easy to characterize materials once the parameters have been selected. It is not always clear however, what methods and analytical procedures should be used for many chemical parameters, particularly for chlorinated hydrocarbons and metals.

At present there are three basic methods of analysis: bulk, elutriate, and bioassay. Of these, bioassay analysis, probably has the greatest value in characterizing the polluting potential of dredged materials. Diagnostic bioassay analyses require proper selection of test organisms and measurement of a critical biological response. Mortality, the criterion presently used, is probably not a sufficiently sensitive indicator of pollution potential; measurement of a more subtle physiological response would be more useful. Uptake rates by test organisms and body burdens should also be determined.

(3) Analysis of a sufficient number of samples for an adequate characterization.

To a large extent the number of samples required for an adequate characterization is site specific and depends upon the spatial variability--vertical and horizontal--of the important characteristic properties. These will be affected by point and non-point sources of pollutants and by the history of sedimentation in the area.

III. IDENTIFICATION OF POTENTIAL DREDGING/DISPOSAL OPTIONS

The first option that should be considered for any proposed dredging project is the no dredge option. What would happen if the project were not carried out?

The different kinds of available and *potential* disposal sites--overboard, shallow water confined, upland, marsh creation, island creation, etc.--should be identified, inventoried, and characterized. A master listing should be prepared that could be used for all proposed dredging projects. Characterization should include: physical and chemical nature of natural sedimentary material; volume capacity; fauna and flora; assessment of dispersive mechanisms; cataloging of any unique, or unusual, features or values; present and anticipated uses; hazards to groundwater, etc.

Effective management requires a systematic and critical assessment of all disposal options. In the absence of a comprehensive catalog of disposal sites and options, the conventional mode of crisis-oriented environmental management results in recurrent use of the same sites without a systematic search for potentially better alternatives. Even if the environment has not suffered demonstrable harm from past practices, proper management requires a zero-base approach.

IV. ASSESSMENT OF POTENTIAL DREDGING/DISPOSAL OPTIONS

Each dredging/disposal option including the no dredge option, should be evaluated in terms of its socio-economic effects, short-term and long-term environmental and ecological effects.

A. Prediction of Short-Term and Intermediate-Term Effects of Dredging/Disposal Options

Most short-term effects of the various dredging/disposal options--effects manifested during and in the few weeks subsequent to dumping--can probably be predicted sufficiently well for management purposes. Our ability to predict intermediate effects--effects manifested over the first seasonal cycle after completion of a dredging/disposal operation--is less good, and longer-term effects can not be predicted with acceptable accuracy. We can adequately predict for subaqueous disposal, for example, the sequence of colonization of an area after disposal, but we can not adequately predict to what extent the recolonizing organisms will be affected by any contaminants in the dredged material. The processes and rates of mobilization and the fluxes of contaminants from dredged materials can not be adequately predicted for any of the dredging/disposal options at this time.

B. Prediction of Long-Term Environmental and Ecological Effects Associated with Dredging/Disposal Options

To improve management of dredging and dredged material disposal in the Chesapeake Bay in the future, resources should be allocated to document any long-term effects past dredging and disposal operations may have had on the Bay and its biota and to improve our ability to predict effects of future projects.

One obvious source of potential information on the long-term effects of dredged material disposal that has not been adequately investigated is evidence contained in previously used disposal sites, land and water. Water sites that should be investigated include: Pooles' Island Deep, Kent Island Dumping Ground, and overboard disposal areas in the upper Bay north of Pooles' Island. Some questions that should be addressed are

(1) How much of the material placed in these sites can be accounted for?

(2) Have contaminants been transferred to the marine food web? If so, by what mechanisms?

(3) Have contaminants been released from particles and concentrated in the interstitial waters?

Land and fringing sites that should be investigated include: the Chesapeake and Delaware Canal land disposal sites and Pierce Creek. Two of the questions that should be addressed are

(1) What effects, if any, have leachates had on groundwater and vegetation?

(2) Have contaminants been taken-up by plants?

In selecting virgin disposal sites pilot projects may be very useful in assessing potential impacts on the environment and the biota? Relatively small volumes of material dredged from proposed project areas could be placed in designated sites to assess their behavior in different mileu.

Some additional long-range research objectives that need to be achieved before we can adequately predict the long-term environmental and ecological effects of different disposal options are listed below.

(1) Determine the cumulative effects of progressive modification of the Bay's edges by dredging and filling.

(2) Determine the rates of release of pollutants from subaqueous deposits of dredged material by a combination of diffusion bioturbation (reworking by organisms), expulsion of water and gas, and resuspension. Characterize how the rates will vary with methods and areas of disposal.

(3) Compare these rates with those for natural, in-place, sediments in the different disposal areas.

(4) If the rates are higher in dredged material deposits, determine the effects on water quality.

(5) If there are significant changes in water quality, determine the effects on the ecosystem.

(6) Special attention should be directed at assessing the advantages and disadvantages of using the deep trough south of the Bay bridge at Annapolis as a disposal area.

(7) Determine whether, or not, discontinuation of the present practice of disposal of material dredged from the C&D Approach Channel overboard in the area paralleling the channel would substantially reduce the dredging required to maintain the channel at its project depth.

(8) Map current uses of the Bay bottom and assign relative values per unit area of the various uses.

(9) Assess how these values would be affected by disposal of different kinds (qualities) and quantities of dredged material as a function of the rate of

emplacement.

(10) Map areas of the Bay bottom where dispersal of dredged materials and mobilization of contaminants would be minimal.

C. Evaluation of Socio-Economic Impacts of Dredging/Disposal Options

An evaluation of the socio-economic factors of each dredging/disposal option should include the following:

1. Economic Factors
   (a) assessment of direct costs.
   (b) assessment of long-term costs of maintaining the channel by the proposed methods of dredging and disposal, taking into account the frequency of maintenance dredging required with each option. (The rate of shoaling resulting from transport of dredged material from the disposal area back into the channel must be considered.)
   (c) assessment of the relative costs and benefits resulting from the alteration of topography and sediment characteristics of the disposal area associated with each disposal option.
2. Social Factors
   (a) identification of various interest groups that are likely to be affected by each dredging/disposal option and its associated environmental consequences.
   (b) assessment of how potentially affected special interest groups would *perceive* the impacts of the various dredging/disposal options and their environmental consequences.
   (c) comparison of perceived impacts of each dredging/disposal option with expected impacts of each option on the various special interest groups.

V. RANKING OF POTENTIAL DREDGING/DISPOSAL OPTIONS

Using data from steps II-IV, the potential dredging/disposal options should be ranked on the basis of their

(1) Environmental impact
(2) Economic impact
(3) Social impact (acceptability)

It should be possible to make the economic ranking quantitative. The others will probably be qualitative, or at best, semi-quantitative, but an attempt should be made to indicate at least the degree of difference between individual dredging/disposal options within any ranking.

VI. SELECTION OF DREDGING/ DISPOSAL OPTION

The final selection of the dredging/ disposal option to be adopted is a political decision that must rest with the appropriate decision maker(s). It should be based in large part upon the rankings developed under Step V, but may properly involve other data (facts) and value judgements. The first decision is whether or not to dredge.

A. Do Not Dredge

If the decision is not to dredge, no further action is required.

B. Dredge; Select Disposal Site

If the decision is to dredge, a

a disposal site and strategy must be selected. This selection should be based in large part upon the rankings developed under Step V, but may properly involve other data (facts) and value judgements.

VII. SELECTION OF EQUIPMENT AND METHODS FOR DREDGING AND DISPOSAL, AND TIMING FOR OPERATIONS

The equipment and methods selected for dredging and disposal projects are dictated primarily by the size of the project, the selection of the disposal site, the character of the material, and the economics--the low bid.

Open-water disposal operations in the Maryland portion of the Bay are presently restricted to a "dredging window" that extends from October 1 to April 1. The window is based upon currently best available data; it should be adjusted on the basis of future research to protect the environment and the biota at acceptable costs.

The probability of unacceptable short-term environmental effects of any dredging/disposal operation can be reduced by prudent selection of existing equipment and timing and execution of the project. New developments and research will improve equipment further. A few examples of how selection of particular kinds of equipment and operating procedures can reduce impact are listed below.

(1) If a bottom-dumping scow is used, the deeper the draft of the vessel the smaller the impact on the water column and the less the initial dispersion.

(2) If open-water pipeline disposal is used, discharge below the water surface and perpendicular to it (downward) will reduce the near surface plume. Discharge against a plate may also decrease the dispersal of the material.

(3) If a hopper dredge is used, restriction of over-flow will reduce near-surface turbidity.

(4) If dumping operations by barges and scows are *controlled* by proper navigation systems, the dumping areas can be restricted and the spread of material minimized.

VIII. MONITORING OF DREDGING AND DISPOSAL OPERATIONS

Monitoring of dredging and disposal operations is necessary for political reasons and may serve as an environmental insurance policy against unanticipated effects. The diagnostic value of monitoring in the short-term--*during* dredging and disposal operations--is probably small. Monitoring programs over longer periods can however, if properly designed, provide useful data that will increase our understanding of the effects of these operations on the Bay and its biota, and our ability to effectively manage these activities in the future. We have identified a variety of research objectives; many of which require field observations for their attainment. Carefully designed "monitoring" programs could provide many of the required data.

OTHER CONSIDERATIONS

A. Minimizing Dredging

If the amount of sediment that accumulates in channels and in port and marina facilities could be reduced, then it follows that the amount and frequency of dredging necessary to *maintain* those channels, harbors, and marinas would be substantially reduced. A decrease in the rate of sediment accumulation could

be achieved by

(a) Reducing the inputs of new sediments from rivers, shore erosion and municipal runoff.

(b) Changing the methods of disposal of dredged material to reduce the amount of material that returns to the dredged areas.

(c) Relocating channels and facilities to take advantage of naturally deep areas and of natural processes that minimize the rates of sediment accumulation.

Of these three strategies, the second would probably be the most effective in substantially reducing maintenance dredging requirements in the Maryland portion of the Chesapeake Bay. As far as source control is concerned, the emphasis should be placed on control of erosion and sediment runoff in urban and industrial areas to reduce the volume of dredging. The deposits dredged from such areas are often highly contaminated by metals and organic compounds. These contaminants severely constrain acceptable disposal options. Reduction in the amount of these materials would reduce the need for disposal sites. However, before quantitive estimates can be made of anticipated reductions, additional information must be obtained on the sources of deposits in urban-industrial harbors. Two of the more important questions that should be answered are

(1) What are the locations and strengths of the sources of sediment to Baltimore Harbor?

(2) How could these inputs be reduced?

There is some evidence that indicates that much of the maintenance material placed overboard parallel to channels in the upper Bay, particularly above Pooles' Island, is resuspended by waves and tidal currents and transported back to the channels. If the amount of dredged material that is re-deposited in channels could be reduced by better initial placements of these materials, less maintenance dredging would be required. Moreover, a reduction in the amount of dredging required to maintain existing channels would reduce environmental impacts of disposal operations. Hence, this kind of source control is attractive. One option is the placement of dredged materials in deep areas where they are unlikely to be dispersed by currents or waves. However, before this option is employed, management agencies will require more detailed information on sources of materials dredged during maintenance operations in order to evaluate possible gains from such a strategy. Important questions to be addressed include:

1) What are the dispersal characteristics of dredged materials placed at a variety of open-water sites in Chesapeake Bay?

2) What would be the environmental and biological effects of disposal of dredged materials in the deep trough south of the Lane Bridge at Annapolis?

B. Creative Uses of Dredged Materials

While some attention has been given to possible beneficial uses of dredged materials, the results of those activities have not been fully considered. Detailed economic and engineering feasibility studies need to be made of the more promising ones, such as restoration or protection of islands, wetland creation, bottom modification to cover undesirable types of wastes, and improvement of local productivity of fin fish and shellfish.

It is clear that not all possible beneficial uses of dredged materials

have been identified and properly evaluated.

CONCLUSIONS AND RECOMMENDATIONS

The greatest needs are to remove dredging and dredged material disposal from a crises mode of management where special interests appear to dictate decisions. This requires:

(1) development of a catalog of the available and potential disposal sites and diagnostic characterizations of each of them.

(2) development and documentation of diagnostic characterizations of materials routinely dredged from maintenance projects.

(3) development of the capability to predict long-term effects resulting from placement of different kinds (qualities) of dredged material in different generic kinds of disposal sites and in specific sites.

(4) development of simple and effective management guidelines such as dredging windows and placement of like material on like material (like-on-like).

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